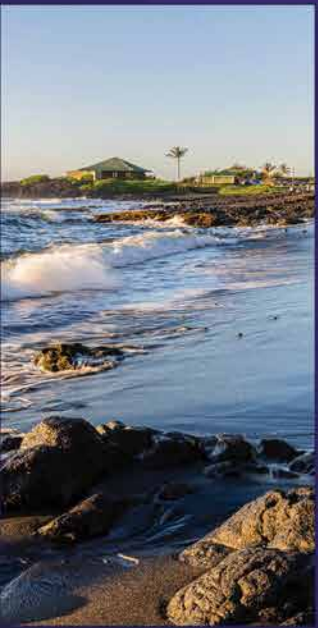
Hawai'i Powered

Integrated Grid Plan

A pathway to a clean energy future





DRAFT

Hawaiian Electric

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Contents

Abbreviations

Abbreviation	Definition
2018$MM	millions of 2018 dollars
AC	alternating current
ADMS	advanced distribution management system
AEG	Applied Energy Group
AMI	advanced metering infrastructure
ARA	Annual Revenue Adjustment
ARD	advanced rate design
ATB	annual technology baseline
BAU	business as usual
BESS	battery energy storage system
C&S	codes and standards
CBRE	community-based renewable energy
CO_2	carbon dioxide
CO_2e	carbon dioxide equivalent
DC	direct current
DER	distributed energy resources
DOE	U.S. Department of Energy
DRC	Designing Resilience Communities: A Consequence-Based Approach for Grid Investment
eBus	electric bus
ECRC	Energy Cost Recovery Clause
EE	energy efficiency
EIA	U.S. Energy Information Administration
EOI	Expression of Interest
EoT	electrification of transportation
EPRM	Extraordinary Project Recovery Mechanism
ETIPP	Energy Transitions Initiative Partnership Project
EUE	expected unserved energy
EV	electric vehicle
GMLC	Grid Modernization Laboratory Consortium
GWh	gigawatt-hour(s)
HNEI	Hawai'i Natural Energy Institute
ICE	Interruption Cost Estimator
IECC	International Energy Conservation Code
IEEE	Institute of Electrical and Electronics Engineers
IIJA	Infrastructure Investment and Jobs Act
IT	information technology
ITC	Income Tax Credit
km	kilometer(s)
km^2	square kilometer(s)
kV	kilovolt(s)
kW	kilowatt(s)
kWh	kilowatt-hour(s)
LBNL	Lawrence Berkeley National Laboratory

Abbreviation	Definition
LDV	light-duty vehicle
LiDAR	light detection and ranging
LMI	low to moderate income
LOLE	loss of load expectation
LOLEv	loss of load events
LOLH	loss of load hours
MT	metric ton(s)
MVA	megavolt-ampere(s)
MVAR	megavolt-ampere(s) reactive
MW	megawatt(s)
MWh	megawatt-hour(s)
N/A	not applicable
NESC	National Electric Safety Code
NIST	National Institute of Standards and Technology
NOSC	Network Operations and Security Center
NPV	net present value
NREL	National Renewable Energy Laboratory
NWA	non-wires alternative
OT	operational technology
PNNL	Pacific Northwest National Laboratory
POET	Power Outage Economics Tool
PPA	power purchase agreement
PPAC	Purchased Power Adjustment Clause
PV	photovoltaic
RBA	Revenue Balancing Account
RDG	renewable dispatchable generation
ReNCAT	Resilient Node Cluster Analysis Tool
Report	Performance Metrics to Evaluate Utility Resilience Investments
REZ	renewable energy zone
RFP	request for proposals
RPS	renewable portfolio standards
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SANDIA	Sandia National Laboratory
SLH	Session Laws of Hawaiʻi
SLR-XA	sea-level rise exposure area
STATCOM	STATic synchronous COMpensator
State	State of Hawaiʻi
STEM	science, technology, engineering, and mathematics
T&D	transmission and distribution
TOU	time of use
VAR	voltage-ampere reactive
WIND	Wind Integration National Dataset
ZEV	zero-emission vehicle

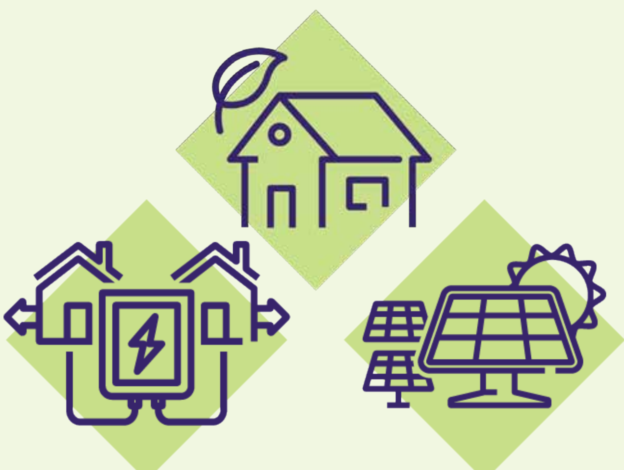
Glossary

Term	Definition
Battery energy storage	A form of chemical storage that is able to store energy for use at another time. For example, a battery energy storage system can charge using solar energy during the day and discharge that energy for use at night.
Decarbonization	To reduce, offset, or eliminate all carbon-producing sources contributing to climate change. Decarbonization is a comprehensive approach to climate resilience that considers all sources of carbon emissions, including electricity generation, transportation, shipping, waste management, agriculture, manufacturing, and land management.
Distributed energy resources	Refers to a behind-the-meter technology or device that can alter a customer's energy use. These technologies include rooftop solar, battery storage, electric vehicles, controllable devices (i.e., grid-interactive water heaters) and energy efficiency. However, in this report it most often refers to rooftop solar and/or battery energy storage located behind a customer's meter.
Firm generation	Refers to a synchronous machine-based technology that is available at any time under system operator dispatch for as long as needed, except during periods of outage and deration, and is not energy limited or weather dependent.
Flexible generation	Power plants that can start up, ramp up and down quickly and efficiently, and run at low output levels.
Grid needs	The specific grid services (including but not limited to capacity, energy and ancillary services) identified through analysis, including transmission and distribution system needs.
Harden	In the context of this report, generally refers to installation of grid infrastructure equipment designed and built to be more resistant to severe events.
Hybrid solar	A solar system (typically referred to in the large-scale context) that uses photovoltaic technology and is paired with battery energy storage, with a typical duration of 4 hours.
Microgrid	A microgrid generates, distributes, and regulates the supply of electricity to customers on a smaller, local scale compared to traditional, centralized grids. Microgrids are a group of interconnected loads and distributed energy resources within clearly defined boundaries. It is normally interconnected to the grid and can disconnect from the grid during emergencies. They are best suited to areas near critical infrastructure (such as hospitals and emergency response centers), have access to renewable energy resources, and are prone to prolonged outages during weather events.
Net present value	The value of a future dollar amount that accounts for the time value of money.
Photovoltaic	Commonly known as solar panels, this technology generates power by absorbing energy from sunlight and converting it into electrical energy.
RESOLVE	A resource investment model developed by E3 that identifies optimal long-term generation investments in an electric system, subject to reliability, technical, and policy constraints.
Resource adequacy	The ability of the electric system to supply the aggregate electrical demand and energy requirements of the end-use customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements.

1. Executive Summary

Hawaiian Electric and our customers are rapidly transforming the ways we generate, transmit, and use electricity. Together, we are creating a resilient clean energy grid powered by resources from Hawaiʻi, for Hawaiʻi. By 2045, our energy system will use 100% renewable resources and produce net-zero carbon emissions, meaning whatever small amount of emissions we emit will be captured or offset. Our work to modernize and decarbonize the grid has never been more urgent as the effects of climate change escalate and existing electrical facilities and infrastructure age. The world is watching as we innovate to scale up clean energy on islands with abundant resources but no option to import renewables from neighbors.

We envision a clean energy future where customers have more choices, more reliable power, and more stable rates. By 2045, clean energy will be there when we need it: behind every light we turn on, each meal we share, and all the ways we get around. Electric cars and buses will get us where we need to go, with a backbone of vehicle chargers at the workplace and community centers. At home and at work, energy-efficient appliances and equipment will electrify our daily lives.



This clean energy transformation will advance social equity and benefit all customers and communities. Enhanced grid capacity will support growth in residential and commercial development, empowering a statewide expansion in affordable housing. In places with new energy facilities, host communities will thrive with benefit packages from developers.

The future grid will look unlike any before, with customers playing a vital role in generating and storing energy. Customer-scale generation and battery storage in customers' homes and communities will seamlessly connect to large-scale generation through a modernized transmission system, providing a consistent stream of energy that can adapt to fluctuations in use. Sourcing energy from a diverse array of local, renewable resources will fortify Hawaiʻi against global swings in oil prices, stabilizing utility costs for customers.

How can we bring this vision to life?

It is possible to live out this vision if we work together and act now.

Hawaiian Electric is pleased to present the Integrated Grid Plan: a pathway to a clean energy future. The Integrated Grid Plan proposes actionable steps to decarbonize the electric grid on the State of Hawai'i's (State's) timeline, with a flexible framework that can adapt to future technologies.

The Integrated Grid Plan is the culmination of more than 5 years of partnership with stakeholders and community members across the islands. Together, we forecasted future energy needs and identified strategies to meet Hawai'i's growing energy demand with 100% renewable resources. Hawaiian Electric is grateful for the collective time, efforts, and insights of the many people involved in Integrated Grid Planning, and we look forward to continued collaboration with customers, community members, and stakeholders as we move beyond planning into implementation.

This report shares our action plan and summaries of the technical analyses and community engagement. It also underscores the urgency of action needed to achieve this future. We hope the findings help drive or supplement other action plans beyond Hawaiian Electric. The Integrated Grid Plan shows that every industry and individual will need to play a role in decarbonizing Hawai'i's economy. This plan can help customers, organizations, and agencies understand the scope of the challenge and their role in meeting it. It's everyone's kuleana to create a sustainable future for Hawai'i.

The Integrated Grid Plan is an important starting point for focusing efforts and measuring progress. Now, it's time to take collective action to create a Hawai'i Powered future where everyone will thrive.

1.1 Customers Are at the Heart of the Energy Transformation

Again and again throughout the planning process, we heard that affordability and reliability are of top concern and interest to our customers, echoing the comments in multiple customer surveys and focus groups conducted for the company.

It is imperative that our future grid delivers on this fundamental need for pricing and power that people can count on.

The Integrated Grid Plan balances our commitment to clean energy with our commitment to stabilizing rates and improving reliability for customers.

The Integrated Grid Plan also shows that ***customer and community participation is essential to decarbonizing Hawai'i's economy.*** Our analysis reveals that we cannot meet projected demands on the grid without customers and communities generating and storing energy and practicing greater energy efficiency (EE). Read more about the role of customers in Section 1.5.2.

Meaningful and sustained engagement with customers, communities, and stakeholders has been central to Integrated Grid Planning. Since planning began in 2018, we have worked to foster partnerships with communities that we are a part of and serve by sharing transparent information and listening, learning, and incorporating their feedback. We are grateful for the involvement of thousands of community members throughout the planning process, and we appreciate the opportunities we have had to collaborate on potential solutions. See Section 4 for more information about outreach activities and how we have incorporated public input.

1.2 Our Commitment to Customers

At Hawaiian Electric, customers are at the heart of our work today and our vision for the future. We are deeply rooted in our communities, and we strive to serve the energy needs of each person in Hawaiʻi with purpose, compassion, empathy, and aloha for our fellow humans and our natural environment. We are committed to empowering our customers and communities with affordable and reliable clean energy, and providing innovative energy leadership for Hawaiʻi.

1.2.1 Climate Change Action Plan

Decarbonizing the electric grid is ultimately about service: caring for our customers and the environment by creating a more prosperous and sustainable Hawaiʻi. To that end, Hawaiian Electric announced a bold Climate Change Action Plan in 2021. Our Climate Change Action Plan sets the ambitious goal of reducing electricity-sector greenhouse gas emissions in 2030 by as much as 70% compared to 2005 levels and reaching net-zero carbon emissions by 2045.

DECARBONIZE:

To reduce, offset, or eliminate all carbon-producing sources contributing to climate change. Decarbonization is a comprehensive approach to climate resilience that considers all sources of carbon emissions, including electricity generation, transportation, shipping, waste management, agriculture, manufacturing, and land management.

This commitment by Hawaiian Electric represents a significant down payment on the economy-wide reduction Hawaiʻi will have to achieve to align with nationwide and global greenhouse gas reduction goals. Statewide decarbonization will require collaboration across sectors, with transportation, agriculture, and other industries working to reduce and offset emissions.

1.2.2 Hawaiʻi Powered

A key strategy to reaching net-zero emissions is generating 100% of our energy from renewable resources. In 2015, Hawaiʻi became the first state in the nation to direct its utilities to generate 100% of their electricity from renewable energy sources by 2045. Hawaiian Electric is dedicated to partnering with customers, communities, and other stakeholders to reach this energy goal.

Hawaiʻi Powered

We call our vision for using 100% renewable resources "Hawaiʻi Powered." Clean energy for Hawaiʻi, by Hawaiʻi:

- Supports our Climate Change Action Plan and the State's decarbonization goals
- Achieves energy independence
- Expands energy choices for customers and helps stabilize rates

1.2.3 Ensuring an Equitable Energy Transformation

We are committed to creating an equitable energy future. As the cost of living in Hawaiʻi continues to rise, we must make electricity affordable and ensure that we ease the burden of the renewable transition on customers with low to moderate income (LMI). We must also ensure that communities that bear the burden of hosting energy infrastructure, both in the past and future, receive benefits.

The Public Utilities Commission recently opened a proceeding to investigate energy equity in response to legislative resolutions. The areas for exploration include:

- High energy rates in Hawaiʻi
- High percentage of people with low and moderate income
- High energy burden
- Lack of universal access to renewable energy initiatives
- Need for utility payment assistance
- Historical siting of fossil-fuel infrastructure
- Land constraints
- Regulatory process burdens

The benefits and burdens of the transformation to a clean energy grid must be equitably shared. All customers stand to benefit if everyone is able to afford electricity and participate in the transition. See Section 10 for more information about our ongoing efforts to address energy inequities and offer solutions for the future.

We use the following definitions from the Public Utility Commission to guide planning for energy equity:

Equity refers to achieved results where advantages and disadvantages are not distributed on the basis of social identities. Strategies that produce equity must be targeted to address the unequal needs, conditions, and positions of people and communities that are created by institutional and structural barriers.

Energy equity refers to the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those historically harmed by the energy system.

People with low to moderate income are those whose income is at or below 150% of the Hawaiʻi federal poverty limit.

Energy burden is the percentage of a household's income spent to cover energy costs.

1.3 Renewable Energy and Reliability Risks Today

Hawaiian Electric has the privilege of serving as Hawai'i's largest electric utility. We serve 95% of Hawai'i's 1.4 million residents on the islands of Hawai'i, O'ahu, Maui, Lāna'i, and Moloka'i, each with separate grids. Since 2010, we have nearly tripled the amount of renewable energy we generate, due in large part to the contributions of our customers. We are proud of the progress we have made, but we still have a long way to go.

1.3.1 Our Current Renewable Energy Portfolio

Today, approximately 32% of our total energy generation comes from renewables. Our renewable energy comes from many local sources with wide-ranging technologies, and each island has a unique composition of clean energy generation. Figure 1-1 shows the 2022 composition of clean energy generation on Hawai'i Island, O'ahu, and Maui, and the consolidated proportions across all three.

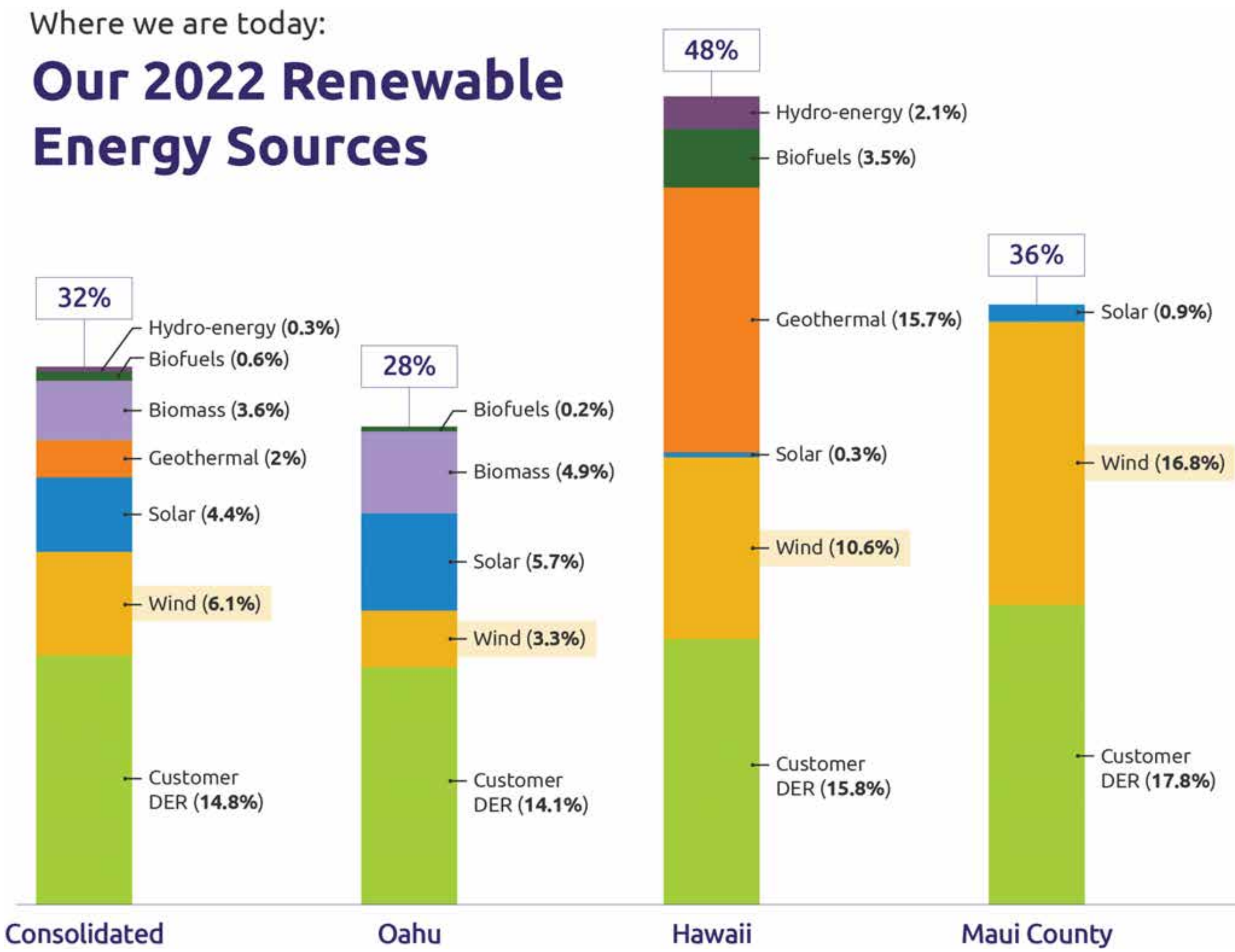


Figure 1-1. Renewable energy portfolios, 2022

1.3.2 Immediate Action to Meet Goals and Maintain Reliability

Creating a resilient, clean energy grid has never been more urgent as the effects of climate change escalate, existing energy infrastructure ages, and our timelines shrink. Customers are at risk of experiencing increasingly frequent outages unless we take immediate action to address threats to reliability.

We must act now to bolster the reliability of our electric grid and prevent significant economic and social disruption for customers. Investing in renewable energy generation and updates to transmission infrastructure is an opportunity to address these risks. See Section 7 and Section 12 for more information about investments and actions to reduce risks to electrical infrastructure.

We must move swiftly to:

Fortify the grid against extreme weather.

Extreme weather hazards are projected to increase in frequency, intensity, and duration because of climate change. Failure to prepare for such events could result in power interruptions, damage to electricity infrastructure, significant economic disruption, and disruption to critical government and private-sector services. Reliability is a matter of safety and state and national security, as our critical infrastructure—like hospitals, communication systems, and emergency services—depends on electricity.

Meet growing energy demands.

Existing fossil-fuel generators on Hawai'i Island, Maui, and O'ahu are 55 to 75 years old. These facilities were never designed to keep up with today's dynamic grid, which far outpace the needs of decades past and continue to grow. We anticipate that the demand for electricity will dramatically increase in the coming years, as other sectors reduce their carbon emissions, and as customers and businesses use more electricity for their transportation, work, and homes. We're in urgent need of more generation capacity to meet this demand.

Cut carbon emissions by 70% in 7 years.

2030 is just around the corner. We need to rapidly develop energy projects and the necessary infrastructure across the islands to meet our Climate Change Action Plan goal of cutting emissions by 70% (compared to 2005 levels). This will take efficient and effective coordination with communities, policymakers, stakeholders, and developers to bring renewables online as we deactivate fossil-fuel generators. Simply put: there's no time to waste.

1.4 Overview of Integrated Grid Planning

Integrated Grid Planning brought many people together to determine how to create a resilient and reliable grid that will meet future energy needs, stabilize costs for customers, and use 100% renewable resources. Hawaiian Electric began the planning process in 2018. Figure 1-2 displays the steps of Integrated Grid Planning.

Figure 1-2. High-level steps of Integrated Grid Planning

1.4.1 Engaging Communities and Stakeholders

We engaged four main stakeholder groups throughout the planning process:

The four main stakeholder groups:

Stakeholder Council. This group consisted of representatives from cities, counties, each island, the State, partner agencies, and developers. It helped align our planning with interests across the islands.

Working Groups. These specialized groups served in an advisory capacity and were focused on topics like social and economic resilience, transmission planning, and the sourcing and evaluation of contractors.

Technical Advisory Panel. This group consisted of experts in energy technologies and engineering who provided an independent source of peer assessment.

The public, including customers and community members across the islands.

The four Integrated Grid Planning stakeholder groups were not working alone—many others have been and continue to be involved in creating a clean energy future. These groups include policymakers, regulators, developers, and community organizations.

1.4.2 Key Considerations

Stakeholders helped us prioritize and connect five key considerations that shape our planning for a clean energy future:

- **Time.** How much time will it take to deliver new energy facilities, and how can we stay on track with our timeline goals?
- **Affordability.** How much will it cost to build and operate? What will resources cost in the future? How will costs affect customer bills?
- **Land use.** Where is there available land? How does this affect other land use priorities?
- **Community impacts.** How will new facilities affect surrounding communities, jobs, and the environment? How can the benefits of the transition to clean energy be equitably shared?
- **Resilience and reliability.** How can we plan for current and future energy needs? Needs evolve based on the number of electric vehicles (EVs), number of private and community-based solar projects, emerging technologies and industries, and preparation for extreme events.

Understanding energy needs of today and tomorrow required many technical analyses and input from stakeholders and community members. Together, we forecasted future energy needs and identified opportunities to meet growing demands.

See Sections 6 and 8 for information about the data and models we used to forecast grid needs. See Section 4 for an overview of outreach strategies and community input we received about potential future energy projects and key considerations.

1.4.3 Guiding Principles

The following principles guided our technical analyses and community conversations as we moved through Integrated Grid Planning.

1. ***Renewable energy is the first option.*** We are pursuing cost-effective renewable resource opportunities that reduce carbon emissions and stabilize customer bills. Getting off imported fossil fuels removes Hawai'i from the volatility of world energy markets and gives future generations a tremendous advantage. It can also create a clean energy research and development industry for our state.

2. ***The energy transformation must include everyone.*** Electricity is essential. Our plans, as well as public policy, should ensure access to affordable electricity, with special consideration given to LMI households. Meaningful community participation must be a key element of renewable project planning.

3. ***The lights have to stay on.*** Reliability and resilience of service and quality of power are vital for our economy, national security, and critical infrastructure. Our customers expect it, deserve it, and pay for it. Our plans must maintain or enhance the resilience of our isolated island grids by relying on a mix of resources and technologies.

4. ***Today's decisions must be open to tomorrow's breakthroughs.*** Our plans keep the door open to developments in the rapidly evolving energy space. We must be able to easily accept new, emerging, and breakthrough technologies that are cost-effective and efficient when they become commercially viable.

5. ***The power grid needs to be modernized.*** Energy distribution is rapidly moving to the digital age. We are reinventing our grid to facilitate a decarbonized energy portfolio and to enable technologies such as demand response, dynamic pricing, aggregation, and electrification of transportation (EoT).

6. ***Our plans must address climate change.*** Our Climate Change Action Plan set a goal to reduce carbon emissions from power generation by 70% by 2030 compared with 2005 levels. Our resilience strategy aims to minimize the impacts of climate change—rising sea levels, coastal erosion, increased temperatures, and extreme weather events—on the energy system.

7. ***There's no perfect choice.*** No single energy source or technology can achieve our clean energy goals. Every choice has an impact, whether it's physical or financial. While we can mitigate those impacts, attaining our clean energy goals has major implications for our land and natural resources, our economy, and our communities. We seek to make the best choices by engaging with community members, regulators, policymakers, and other stakeholders.

1.4.4 Energy Planning on Molokaʻi and Lānaʻi

We tailored our planning and community engagement strategies to each island, recognizing that they have unique energy needs and opportunities. Planning for a clean energy future on Lānaʻi and Molokaʻi was particularly distinct for the following reasons.

Lānaʻi

Much of our grid planning work on Lānaʻi happened in collaboration with the majority landowner on the island. The Hawaiian Electric team recently announced its selection of a developer to build and maintain the island's largest renewable energy project and the first to offer the Shared Solar program on the island. We completed contract negotiations with DG Development & Acquisition, LLC. However, we have not finalized the contract as the majority landowner, Pūlama Lānaʻi notified Hawaiian Electric of its intent to design and construct microgrids to supply the energy demands of the resorts on Lānaʻi, which would significantly impact the electric load and the size of the solar project.

Molokaʻi

Molokaʻi is preparing a Molokaʻi Community Energy Resilience Action Plan: an independent, island-wide, community-led and expert-informed collaborative planning process to increase renewable energy on the island. The Molokaʻi Clean Energy Hui by Sustʻāinable Molokaʻi is coordinating the action plan. Hawaiian Electric is providing technical support to the Molokaʻi Clean Energy Hui in its planning process to develop a portfolio of clean energy projects to achieve 100% renewable energy for the island that is feasible, respectful of Molokaʻi's culture and environment, and strongly supported by the community. Learn more at sustainablemolokai.org/renewable-energy/molokai-cerap.

Hawaiian Electric and Hoʻāhu Energy Cooperative Molokaʻi are moving ahead with the State's first two community-owned and -designed solar plus battery projects. These projects could meet more than 20% of Molokaʻi's energy needs and serve an estimated 1,500 households on the island. The Hoʻāhu Community-Based Renewable Energy (CBRE) projects, Pālāʻau Solar and Kualapuʻu Solar, will be the first on the island to offer the Shared Solar program to help lower the electric bills of customers on Molokaʻi who are unable to install privately owned rooftop solar.

After the completion of a competitive bidding evaluation process, which accounted for the cost of the projects as well as non-price factors including community outreach, Hoʻāhu and Hawaiian Electric entered into negotiations. Once negotiations of the 20-year contracts are finalized, Hawaiian Electric and Hoʻāhu will submit the two applications for approval by the Public Utilities Commission.

1.5 Action Plan at a Glance

Meeting the energy needs of our customers up to and beyond 2045 requires an Integrated Grid Plan based on a short-term action plan and a long-term strategy. First, the Integrated Grid Plan requires us to take immediate action within the next 5 years to achieve our 2030 goals and set a path toward 2045 decarbonization. The proposed 5-year action plan identifies the next foundational steps toward meeting our decarbonization, affordability, and reliability goals for customers. Second, the Integrated Grid Plan also provides the flexibility we need over the long term to realize the benefits of technological advances, respond to changing customer and community needs, and adapt to evolving environmental conditions.

The following is an overview of the Integrated Grid Plan key findings and recommended actions for the short term. See Section 2 for details.

1.5.1 Key Findings and Recommendations

The Integrated Grid Plan points to four high-level actions we must take within the next 5 years to reach statewide decarbonization goals and future energy needs:

Stabilize utility rates and advance energy equity

Grow the marketplace for customer-scale and large-scale renewables

Create a modern and resilient grid

Secure reliability through diverse energy sources and technologies

The following is an overview of these actions. See Section 2 for details.

1.5.2 Action Plan for a Clean Energy Future

Stabilize rates and advance energy equity

Although utility rates will rise in the transition to clean energy, they will be lower and less volatile than if we continue to rely on fossil fuels. Our projections show that customer bills may remain relatively flat, despite growing demands for electricity, integration of renewables, and investments to modernize and strengthen the grid. The addition of customer-scale and large-scale renewable energy is expected to stabilize rates and insulate all customers from volatile fossil-fuel markets. Additionally, the electrification of transportation may drive benefits for all customers by putting downward pressure on rates. Increased electrification of transportation enables the cost of grid investments to be spread over more kilowatt-hours (kWh), reducing per-unit customer costs and introducing opportunities to provide grid services. See Section 9 for more information about impacts to customer bills and the environment.

We are committed to an equitable energy transition that addresses the total energy burden on low- and moderate-income customers.

To that end, the Integrated Grid Plan may help to inform the Energy Equity proceeding that aims to examine forms of relief for LMI customers. Our projections show that the transition to clean energy may reduce the overall energy burden for the typical residential customer on each island through 2050, compared to today's energy burden. See Section 10.3 for more information about affordability and the energy burden.

Grow the marketplace for customer-scale and large-scale renewables

We will need a marketplace for both customer-scale and large-scale renewables to achieve 100% clean energy by 2045. To grow the market for large-scale projects that also benefit host communities, we propose routine cyclical procurements with public input and community benefit packages from developers.

We also propose customer programs and options with incentives to increase customer participation in energy efficiency, rooftop solar, energy storage, and vehicle charging. Customer participation and early community outreach are instrumental to electrifying and decarbonizing the state's economy. Customer-scale generation is also an opportunity to promote energy equity by continuing to develop programs that expand access to a wider range of customers. Programs like Shared Solar (CBRE) are essential for all customers to benefit from generating renewable energy, not only those who own their homes and rooftop solar systems. See Section 11 for more information about customer programs and large-scale procurements.

The Integrated Grid Plan will benefit the environment by reducing carbon emissions by 75% by 2030, relative to 2005 levels. However, achieving net zero will depend on technology advancements.

We forecast that energy generation and storage by customers and communities can provide enough electricity to power the transition to electric vehicles, and it will also reduce the amount of land needed for large-scale renewables.

Create a modern and resilient grid

Renewable generation is just one piece of the energy transformation puzzle. We will also need a modern, resilient system of transmission and distribution (T&D) for customers to power their electric vehicles, connect rooftop solar systems and large-scale renewable generation hubs, support the expansion of affordable housing, and fortify the grid against extreme weather events. This will require investment in distribution, transmission, and grid hardening.

The State's economic and policy goals include developing new housing and commercial development to expand our economy while addressing equity. These homes and businesses will be electrified with clean energy, increasing net demand on the grid. To support this effort, we estimate that over the next 10 years, up to $59.4 million of distribution upgrades and $1.33 billion in renewable energy zone (REZ) enablement and transmission network upgrades are needed.

We will be actively pursuing the opportunity to partner with our customers to shape energy use.

Secure reliability through diverse energy sources and technologies

A diverse grid is a reliable grid. We propose investing in many different resources at various scales, including large-scale renewable and firm generation to replace aging fossil fuel–based generators. A fleet of large-scale renewable and firm generation will ensure that we have a source of stable, consistent power on standby to supplement smaller-scale generation on customers' homes and communities, as well as weather-dependent resources like solar and wind.

The sooner we modernize the generation portfolio with the right types of resources, the sooner we can retire or deactivate our older fossil-fuel plants.

LARGE-SCALE RENEWABLE GENERATION:

Large-scale generation facilities and transmission infrastructure produce and carry a large volume of energy. This includes wind turbines and solar and battery energy storage facilities, as well as electric substations, poles and wires.

FIRM GENERATION:

Firm generation provides a steady, reliable flow of energy because it uses resources that are not weather-dependent. Examples of firm generation are geothermal, waste-to-energy, and green hydrogen.

1.5.3 Timeline of Renewable Energy Procurement

The Integrated Grid Plan outlines the amount of energy generation we will need to procure to meet statewide decarbonization goals. Figure 1-3 displays a high-level timeline of adding renewable generation capacity, retiring fossil fuel–based generation, and reducing carbon emissions. Figure 1-4 shows our Integrated Grid Plan's renewable energy portfolio.

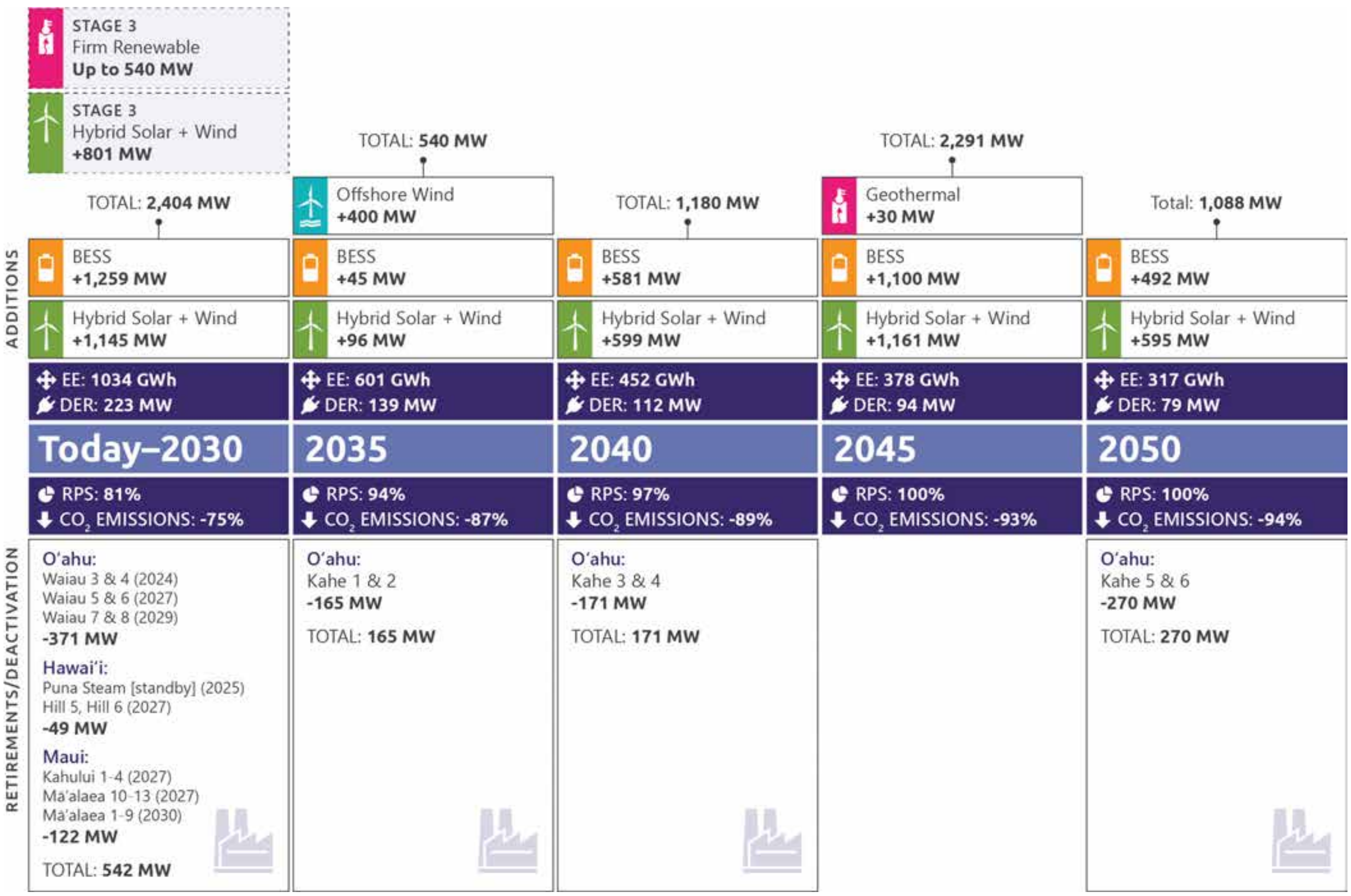


Figure 1-3. Proposed timeline of adding renewable resources, retiring or deactivating fossil fuel–based generation, and reducing carbon emissions

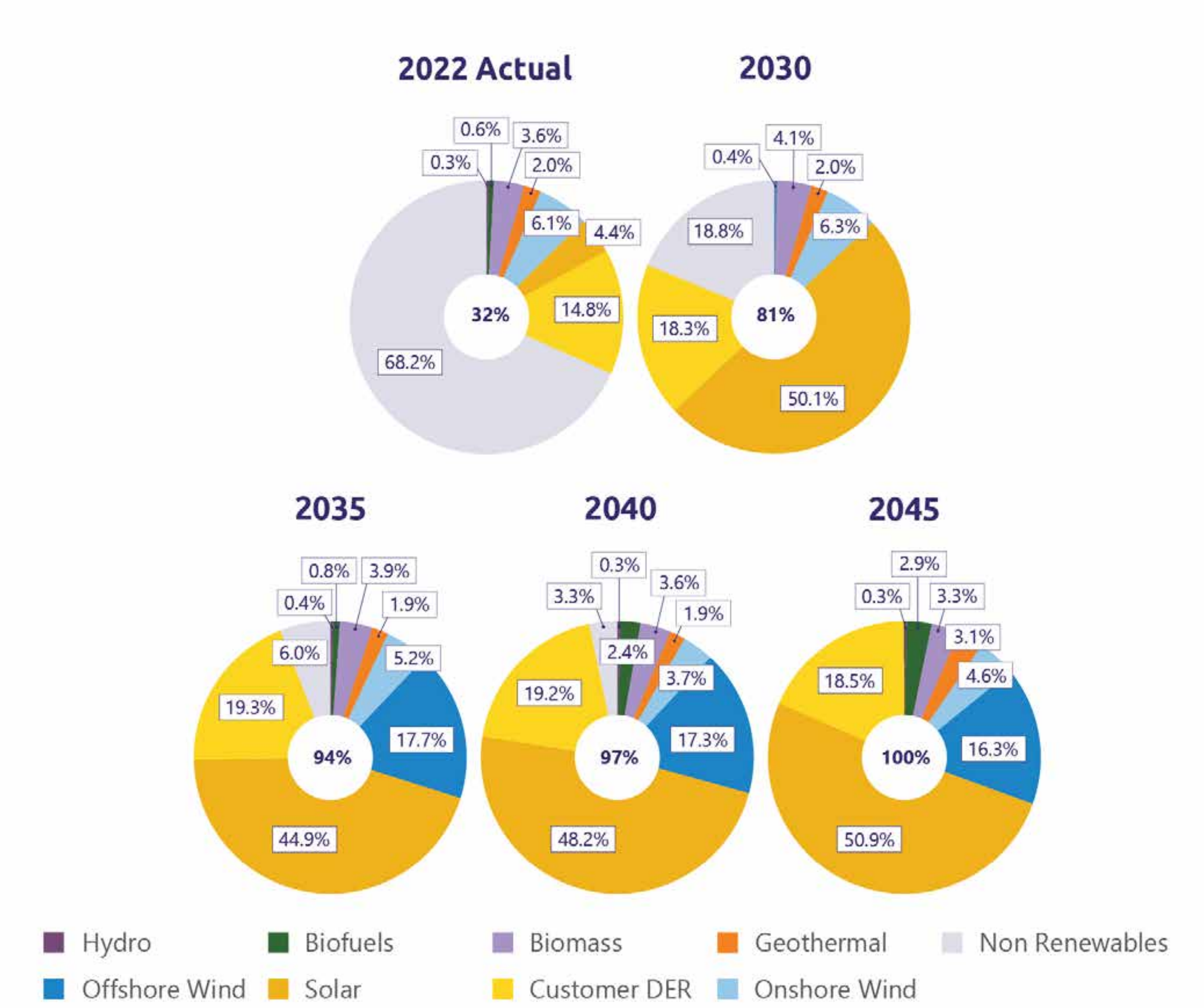


Figure 1-4. Consolidated RPS from today through 2045

Why is rooftop solar not enough?

We need a mix of customer-scale and large-scale renewable generation to supply enough power to meet future energy demands. As much as we value rooftop solar, it is not enough on its own to power the whole grid.

- **A diverse power system is resilient.** Generating electricity from a diverse portfolio of resources benefits our overall energy resilience and customer bills. Diversifying our energy generation to include customer-scale customer and community resources and large-scale renewables (including sources beyond solar) keeps us from depending on any one source for our electricity. This helps us bounce back faster from disasters and shields us from fluctuating costs of resources. For customers, this means reduced risk of outages and more stable utility bills.
- **We need customer-scale and large-scale resources to meet Hawai'i's energy needs.** As much as we value rooftop solar and distributed storage, they are not enough on their own to power the whole grid. This is especially true in a clean, electrified future. For example, to replace just one fossil-fuel generator on O'ahu, we estimate needing new wind and solar resources with a collective footprint 29 times the size of Aloha Stadium. Customer adoption of rooftop solar is not projected to reach the level and reliability to meet all customers' electricity needs. New, large-scale renewable resources will be a significant part of a Hawaii Powered future.
- **Clean energy must be affordable and equitable for all customers.** Electricity affordability is a critical factor to achieve Hawai'i's decarbonization goals. This requires careful consideration of energy equity and the cost-effectiveness of our collective customer, community and large-scale renewable resources and storage options. Each of these resource and storage options have benefits and challenges that need to be assessed. No single renewable technology solution addresses all of Hawai'i's needs. We need to develop a diversified renewable portfolio that is affordable, equitable, and reliable for all customers.

1.6 Moving beyond Planning into Action

Energy planning does not exist in isolation—it's interconnected with many other aspects of life and public policies. It is therefore imperative that any long-term plans for Hawai'i's energy future balance multiple State policy objectives, including affordable housing, food sustainability, land use, and economic development. Effectively implementing the Integrated Grid Plan will depend on:

- Enhanced energy policies and alignment with other State policy objectives
- Streamlined regulatory and county and State process
- Public, stakeholder, and community partnership
- Actions outside of and beyond Hawaiian Electric

None of us can implement the Integrated Grid Plan alone. It will take continued collaboration of customers, communities, utilities, counties, the State, and other industries to meet decarbonization goals and live out a resilient clean energy future.

The longevity of our beloved islands for future generations depends on our ability to come together, get creative, and get to work creating a more sustainable Hawai'i.

The time for action is now.

2. Action Plan

Our **action plan** focuses on efficient strategies to swiftly decarbonize the electric grid and manage risks to affordability, resilience, and reliability. We find that cutting carbon emissions by 70% by 2030 is possible through an "all of the above" approach that seeks to expand customer participation and large-scale generation and infrastructure. Establishing a competitive energy marketplace for both customer-scale and large-scale renewables underpins our ability to create an affordable transition. This will take a statewide effort that involves government, communities, and industry partners. We also describe conditions and policies that we need to successfully meet statewide decarbonization goals, and we recommend next steps to move beyond planning into implementation.

2.1 Key Findings and Recommendations

The Integrated Grid Plan points to four high-level actions we must take within the next 5 years to decarbonize the grid while ensuring reliable power and stable rates for customers:

- Stabilize utility rates and advance energy equity
- Grow the marketplace for customer-scale and large-scale renewables
- Create a modern and resilient grid
- Secure reliability through diverse energy sources and technologies

2.1.1 Stabilize Utility Rates and Advance Energy Equity

It is imperative that our future grid delivers on the fundamental need for pricing and power that people can count on. Although utility rates will rise in the transition to clean energy, they will be lower than if we continue to rely on fossil fuels. We are committed to an equitable energy transition that benefits all customers and communities. *To stabilize rates and advance energy equity, we will need to:*

Pursue the least costly pathway, which maximizes solar, wind, and energy storage. We can stabilize rates and mitigate uncertainties in volatile fossil-fuel pricing by acquiring solar, wind, and energy storage through fixed-price contracts. These contracts will provide predictable rates for 20 years or more.

Provide at least $3,000 per megawatt in community benefits packages per year to host communities of large-scale projects. It's essential that all communities benefit from the transition to clean energy. We propose that developers of new renewable generation provide at least $3,000 per megawatt (MW) per year in community benefits packages to the communities that bear the burden of those energy projects and infrastructure. By 2035, our plan calls for up to 1,640 MW of new renewable resources across our service territories.

Keep rates lower than the status quo of fossil-fuel reliance. Although utility rates will rise in the transition to clean energy, they will be lower and less volatile than if we continue to rely on fossil fuels. Our projections show that customer bills may remain relatively flat, despite growing demands for electricity, integration of renewables, and investments to modernize and strengthen the grid. The addition of customer-scale and large-scale renewable energy is expected to stabilize rates and insulate all customers from volatile fossil-fuel markets. Additionally, the electrification of transportation may drive benefits for all customers by putting downward pressure on rates. Increased electrification of transportation enables the cost of grid investments to be spread over more kilowatt-hours, reducing per-unit customer costs and introducing opportunities to provide grid services. See Section 9 for more information about impacts to customer bills and the environment.

Examine forms of relief for LMI customers. We are committed to an equitable energy transition that addresses the total energy burden on LMI customers. Our projections show that the transition to clean energy may reduce the overall energy burden for the typical residential customer on each island through 2050, compared to today's energy burden. See Section 10.3 for more information about affordability and the energy burden.

Pursue federal funding to expand customer access to renewable technologies and reduce the cost of grid modernization. We must expand access to available federal incentives for customer technologies such as energy efficiency. We also have been encouraged by the U.S. Department of Energy (DOE) to submit funding requests with up to a 50% match to implement our Climate Adaptation Transmission and Distribution Resilience program to harden grid infrastructure and for Phase 2 of our grid modernization program.

Actions we can take to stabilize rates within the next 5 years:

- Use competitive procurements to the extent possible for all types of renewable generation as a means to attract lowest pricing possible for customers
- Pursue federal funding with up to 50% match for climate adaptation program and Phase 2 grid modernization
- Work with stakeholders to address affordability through the Energy Equity docket

2.1.2 Grow the Marketplace for Customer-scale and Large-scale Renewable Generation

We will need a lot more renewable energy to electrify Hawai'i's economy and transportation system by 2045. As we retire fossil fuel–based generation, that volume of energy will come from two primary sources: customer-scale renewable generation and large-scale renewable generation. We must support customers in adopting energy conservation measures, installing rooftop solar and battery storage, and we must also rapidly develop large-scale generation facilities. *To grow a thriving, competitive marketplace for these two types of generation, we will need:*

Greater customer participation in energy generation and storage. Customer adoption of private rooftop solar and energy storage is needed to meet the State's 2030 and 2045 decarbonization goals. By 2030, we will need more than 125,000 residential and commercial private rooftop solar and energy storage systems (1,186 MW) across our service territories. These customer resources, along with energy efficiency will help to offset the energy and capacity needed to power electrification of light-duty vehicles (LDVs), reducing land requirements for large-scale resources.

Customer-scale generation is also an opportunity to promote energy equity by continuing to develop programs that expand access to a wider range of customers. Programs like Shared Solar (CBRE) are essential for all customers to benefit from generating renewable energy, not only those who own their homes and rooftop solar systems. See Section 11 for more information about customer programs and large-scale procurements.

Widespread adoption of energy efficiency. Residential and commercial customers must adopt energy conservation measures to meet the State's 2030 and 2045 decarbonization goals. By 2030, we will need more than 3,400 gigawatt-hours (GWh) of energy efficiency measures implemented in homes and businesses across the islands to reduce carbon emissions. With customer participation in energy efficiency, generation, and storage, the Integrated Grid Plan will benefit the environment by reducing carbon emissions by 75% by 2030 relative to 2005 levels.

Actions we can take to begin increasing customer participation:

- Implement new distributed energy resources (DER) programs: Smart DER Tariff and bring-your-own-device options, targeting 1,186 MW of private rooftop solar capacity by 2030
- Implement community-based renewable energy projects for low- and moderate-income customers and the Tranche 1 procurement
- Implement advanced rate designs and conduct time-of-use (TOU) study
- Procure energy efficiency and other grid services to meet grid needs and reduce supply-side requirements
- Review lessons learned from the Phase 2 Tranche 1 community-based renewable energy procurement, and propose changes, if necessary, for a more robust program

Rapid development of low-cost renewables and transmission. The near-term path toward 70% greenhouse gas reduction by 2030 requires wind, solar, and energy storage enabled by transmission facilities as a relatively low-cost way to scale up renewable energy and displace fossil fuels. On O'ahu alone, we will need nearly 3,200 MW of large-scale solar generation by 2050, built on 20,700 acres of land. Developing renewables and transmission will require community support and streamlined regulatory reviews, permitting, and execution.

Actions we can take to start developing low-cost renewables and transmission:

- Update key assumptions based on current market conditions (i.e., fuel forecasts) during and following the Stage 3 request for proposals (RFP)
- Complete Stage 3 procurement and work with stakeholders to execute the projects that are selected
- Complete Land Request for Information to identify potential sites for large-scale renewable generation and development of renewable energy zones in concert with communities
- Issue an additional competitive procurement for renewable dispatchable generation after Stage 3 and determine market for long lead renewable resources (i.e., offshore wind and other technologies to achieve commercial operations by 2035) and renewable energy zones for each island
- Continue finding solutions to improve the interconnection process, including working with State and county agencies

However, if land for renewable projects is more limited in the future, we will need to consider higher-cost alternatives. If low-cost renewables are not available in sufficient quantities in the Land-Constrained scenario, higher-cost alternatives such as increased use of biofuels will need to be considered to meet decarbonization goals.

2.1.3 Create a Modern and Resilient Grid

Renewable generation is just one piece of the energy transformation puzzle. We will also need a modern system of transmission and distribution for customers to power their electric vehicles, connect rooftop solar systems and large-scale renewable generation hubs, support the expansion of affordable housing, and fortify the grid against extreme weather events. *To create a resilient grid with enough capacity to meet the State's policy goals, we will need:*

Investment of $59.4 million in distribution upgrades over the next 10 years. The State's economic and policy goals include developing new housing and commercial development to expand our economy while addressing equity. These homes and businesses will be electrified with clean energy, increasing net demand on the grid. To support this effort, we estimate that over the next 10 years, $59.4 million in distribution investments may be needed. However, we will be actively pursuing the opportunity to partner with our customers to shape energy use and their solar/storage resources to potentially reduce/defer some of the investment needed.

Near-term actions to upgrade the distribution system:

- Issue expressions of interest for qualified distribution non-wires alternatives opportunities
- Prepare extraordinary project recovery mechanism requests to implement distribution upgrades needed to support electrification and expansion of private rooftop solar hosting capacity, and other requests to support expanded distribution capacity for new housing and commercial developments

Investment of $1.33 billion through 2035 to expand or create new transmission interconnection points between renewable projects. The transmission system remains the backbone of the grid. Creating hubs and enabling transmission facilities for large-scale projects will streamline interconnection and provide access to untapped renewable potential and growth in electrified loads. By 2030, investments are needed to create renewable energy zones that connect generation hubs through a modern system of transmission and distribution. Beyond 2030, major transmission expansion is needed on O'ahu, Hawai'i Island, and Maui to reach areas with untapped renewable potential and to increase the capacity for electrification of transportation.

Near-term actions to develop renewable energy zones:

- Continue community engagement to determine feasibility of developing renewable energy zones
- Create a transmission siting and routing process in collaboration with communities, State, county, landowners, and project developers

Initial investment of $190 million to improve the resilience of the transmission and distribution grid. Resilience grid investments are needed to prepare the grid to withstand natural disasters and support deploying microgrids; for example, hardening critical transmission lines, highway crossings, and critical poles on distribution circuits serving vital community infrastructure. These "least-regrets" investments align with the top stakeholder-identified threats: hurricanes, floods, and extreme wind events.

Near-term actions to improve grid resilience:

- Pending Public Utilities Commission approval, implement and execute a 5-year, $190 million climate adaptation program to harden our grid and implement other resilience measures
- Develop resilience modeling and performance target levels of resilience to inform future hardening and other resilience investments
- Leverage an energy transition initiative partnership program and Resilience Working Group to identify other microgrid opportunities
- Execute North Kohala microgrid and RFP, apply lessons learned, and pursue additional microgrid opportunities to enhance community resilience
- Complete rollout of advanced metering infrastructure and obtain approval of phase 2 grid modernization to enhance system reliability and resilience

2.1.4 Secure Reliability through Diverse Energy Sources and Technologies

A diverse grid is a reliable grid—we must invest in a diverse array of resources to provide power that customers can count on, through rain or shine. Modern firm generation is a critical component of a diverse grid. It will replace fossil fuel–based generation and provide a source of stable, consistent power on standby to supplement resources like solar and wind and "fill in the gaps" at times when solar and wind aren't sufficient. *Creating a reliable clean energy grid will require:*

Developing renewable firm generation that is modern and flexible. It is not possible to ensure a consistent, reliable flow of electricity if the entire grid is powered by weather-dependent, energy-limited resources. Investing in firm generation that is flexible, with the ability to quickly start and ramp up, will enable a reliable source of power when conditions are not optimal for solar or wind generation. It will also address vulnerabilities with today's system, where aging thermal units still supply most of our energy.

Rapidly deploying renewable firm generation is also a solution for managing the deactivation of fossil fuel–based generation. The sooner we transition to modern, flexible firm generation and a critical mass of solar, wind, and storage resources, the sooner we can deactivate and retire fossil fuel–based generation. The O'ahu and Maui systems, in particular, will not be reliable if replacement firm generation is not procured prior to retirement of existing firm generators.

Near-term actions to secure reliability:

- Continue to monitor the condition of an aging generation fleet and prepare contingency plans as necessary; manage prudent and essential capital investments in generating units that could potentially be retired or deactivated in the near future, balanced with ensuring short-term reliability
- Acquire new firm generation and solar/wind and energy storage projects through the Stage 3 procurement to facilitate deactivation and retirement of existing fossil-fuel generation through 2035
- Complete a resource adequacy study to review reliability planning methods and renewable resource accreditation methodologies

Adoption of emerging technologies. Shifting to a highly dynamic, decentralized grid will come with risks and uncertainties. It will require investments that we may not be able to identify today, and it will rely on advancements in current technologies. We anticipate that the system of tomorrow will operate in a much faster time scale than today, requiring resources that can act quickly to stabilize the grid. We will need a critical mass of hybrid solar, wind, and/or standalone energy storage plants with grid-forming capability to replace the fossil fuel–based generation they are displacing. By adding many variable, inverter-based resources in various locations, new challenges will arise in ensuring the security of the system.

Current functionality from rooftop solar and energy storage systems poses a risk to system stability. However, these risks may be mitigated through additions in large-scale renewable resources with grid-forming capability, improved performance of customer rooftop solar and energy storage systems (including legacy systems), and technological advancements in operational technologies that actively manage the grid.

Near-term actions to adopt emerging technologies:

- Continue to monitor and evaluate the performance of new solar and storage projects, including continued assessment of system security risks as more renewable systems are brought online
- Continue to monitor and invest in advanced technologies to operate the high inverter-based grids and seek new grid technologies to improve the reliability of the grid
- Implement IEEE 2800-2022 in future large-scale inverter-based resource projects
- Continue engagement with the DER industry to improve inverter performance to address system security concerns
- Continue evaluating advanced equipment for providing system stability (e.g., grid-forming STATCOM)
- Develop EV standards for vehicle to grid to get ahead of potential system security risks seen today with rooftop solar systems

2.2 Timeline and Renewable Portfolios

The Integrated Grid Plan outlines the amount of renewable resources we will need to procure to meet statewide decarbonization goals. displays a high-level timeline of adding renewable resources, retiring fossil fuel–based generation, and reducing carbon emissions.

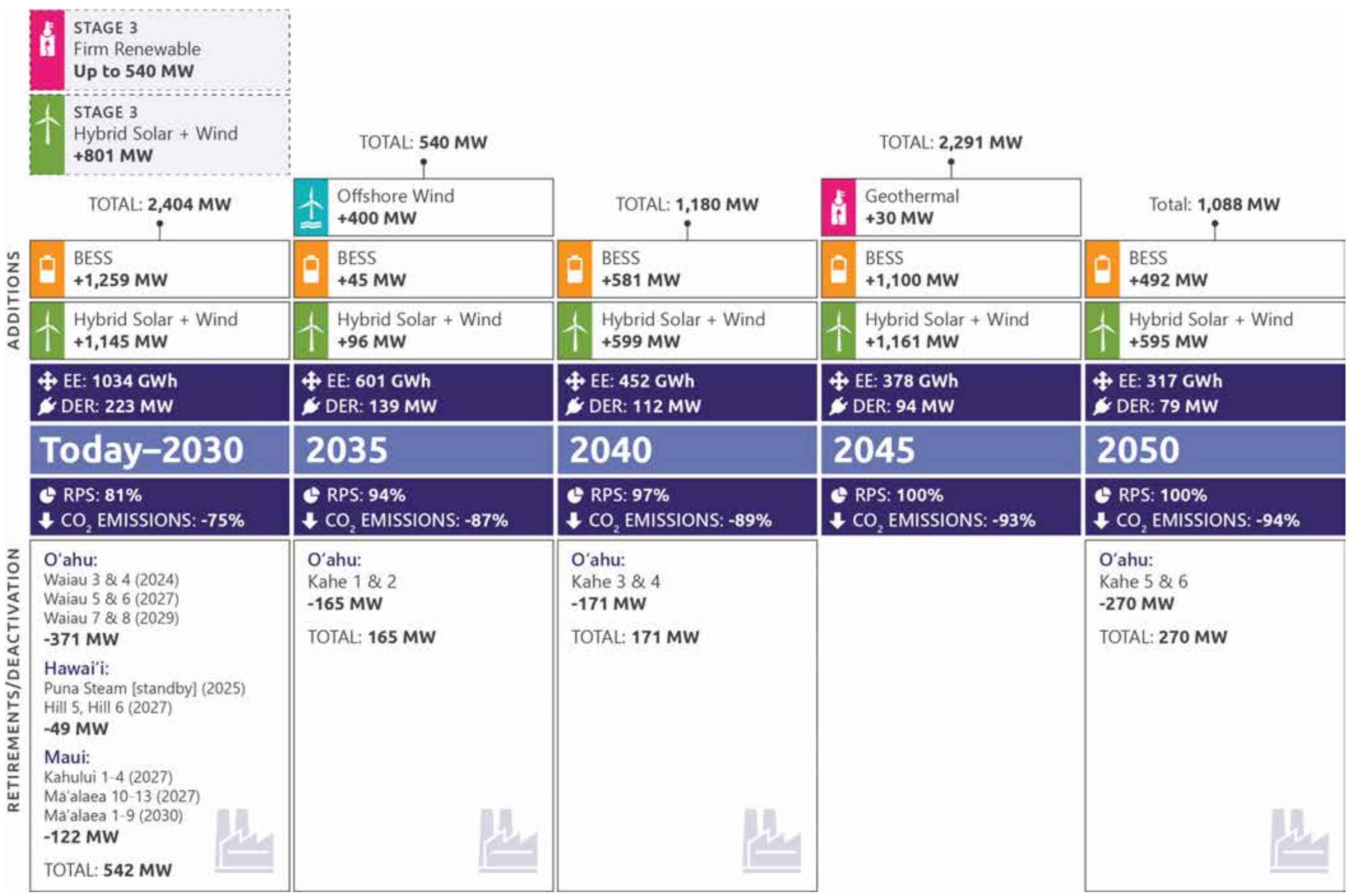


Figure 2-1. Proposed timeline of adding renewable resources, retiring or deactivating fossil fuel–based generation, and reducing carbon emissions

The following is an overview of our plan and the resources we seek to obtain between now and 2035 for each island.

2.2.1 O‘ahu by 2035

- 1,067 MW/2,186 GWh of solar and energy storage or onshore wind
- 400 MW/2,114 GWh of offshore wind
- 240 MW/379 GWh of private rooftop solar
- 1,209 GWh of energy efficiency
- 180 MW of Phase 2 community solar
  - 14 MW LMI and Phase 2 projects have already been selected

Figure 2-2 presents a preferred plan generation mix for O‘ahu (Base).

Figure 2-3 presents a preferred plan generation mix for O‘ahu (Land-Constrained)

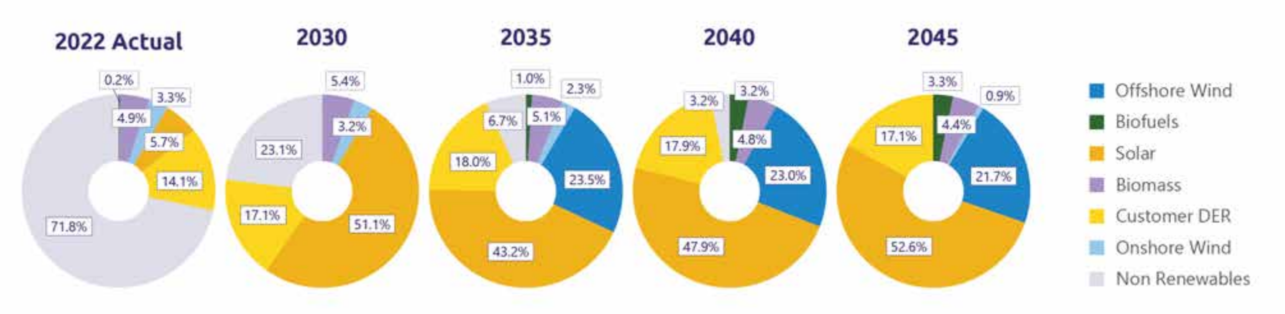


Figure 2-2. Preferred plan generation mix: O‘ahu (Base)

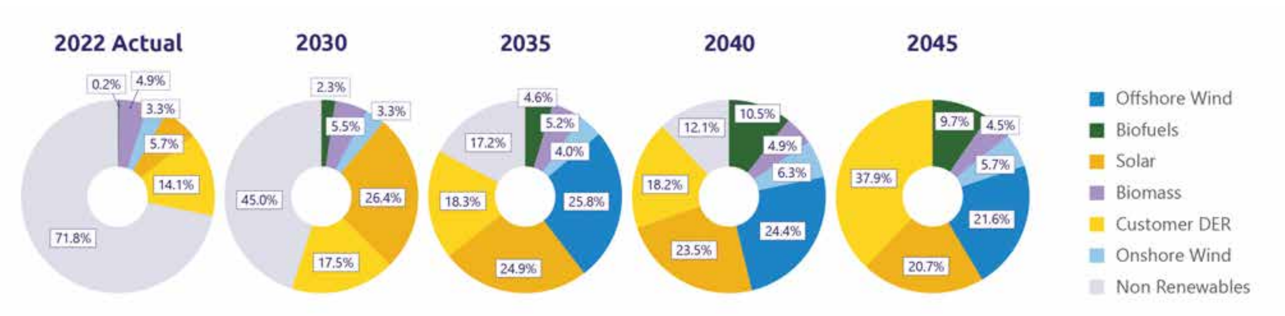


Figure 2-3. Preferred plan generation mix: O‘ahu (Land-Constrained)

2.2.2 Hawai'i Island by 2035

- 51 MW/209 GWh of solar and energy storage or wind
- 58 MW/85 GWh of private rooftop solar
- 218 GWh of energy efficiency
- 33 MW of Phase 2 community solar
  - 15 MW LMI and Phase 2 projects have already been selected

Figure 2-4 presents a preferred plan generation mix for Hawai'i Island.

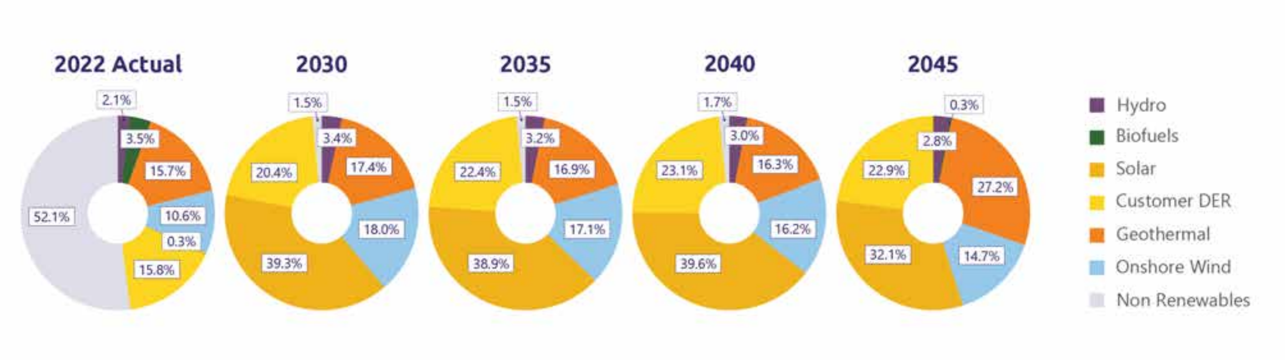


Figure 2-4. Preferred plan generation mix: Hawai'i Island

2.2.3 Maui by 2035

- 103 MW/211 GWh of solar and energy storage or wind
- 62 MW/100 GWh of private rooftop solar
- 206 GWh of energy efficiency
- 33 MW of Phase 2 community solar
  - 8 MW LMI projects have already been selected

Figure 2-5 presents a preferred plan generation mix for Maui.

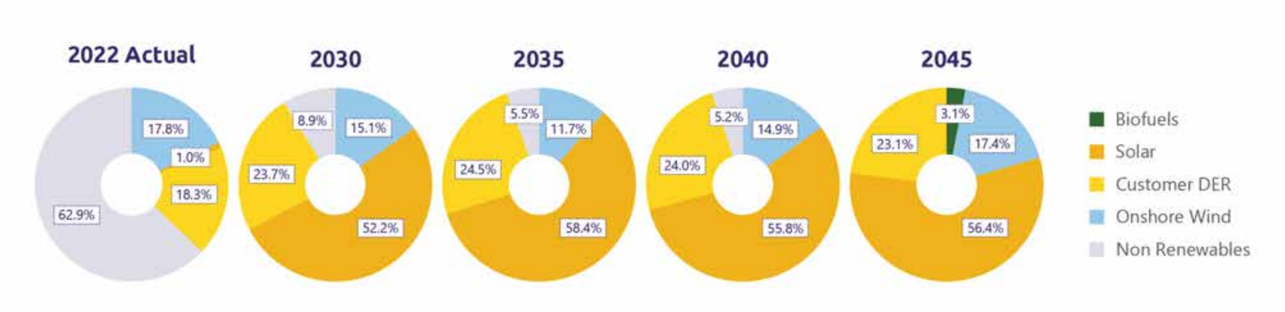


Figure 2-5. Preferred plan generation mix: Maui

2.2.4 Lāna‘i by 2035

- 5.5 MW/5.7 GWh of solar and energy storage or wind
- 17.5 MW/35.8 GWh of community solar (Lāna‘i CBRE request for proposals [RFP])
  - 17.5 MW have already been selected
- 0.6 MW/1.0 GWh of private rooftop solar
- 1.2 GWh of energy efficiency

Figure 2-6 presents a preferred plan generation mix for Lāna‘i.

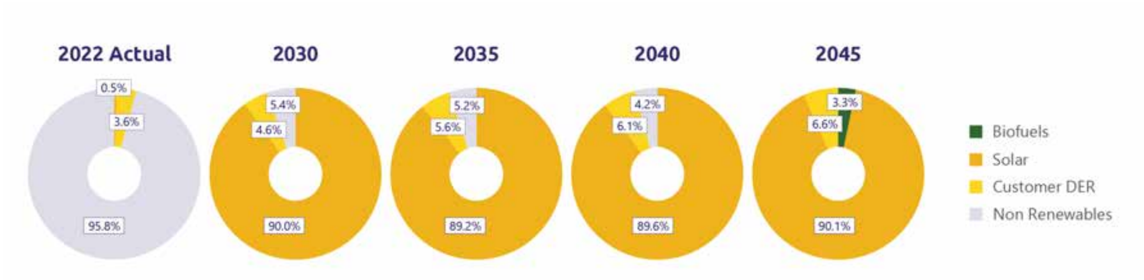


Figure 2-6. Preferred plan generation mix: Lāna‘i

2.2.5 Moloka‘i by 2035

Moloka‘i is preparing a Moloka‘i Community Energy Resilience Action Plan: an independent, island-wide, community-led and expert-informed collaborative planning process to increase renewable energy on the island. The Moloka‘i Clean Energy Hui by Sust‘āinable Moloka‘i is coordinating the action plan. Hawaiian Electric is providing technical support to the Moloka‘i Clean Energy Hui in its planning process to develop a portfolio of clean energy projects to achieve 100% renewable energy for the island that is feasible, respectful of Moloka‘i's culture and environment, and strongly supported by the community.

Figure 2-7 presents a preferred plan generation mix for Moloka‘i. This is subject to change based on the ongoing planning process on Moloka‘i. Hawaiian Electric will continue to work with the Moloka‘i Clean Energy Hui to align our planning efforts.

- 13.8 MW/24.1 GWh of solar and energy storage or wind
- 1.0 MW/1.7 GWh of private rooftop solar
- 1.2 GWh of energy efficiency
- 2.75 MW of Phase 2 community solar
  - 2.45 MW have already been selected to the final award group

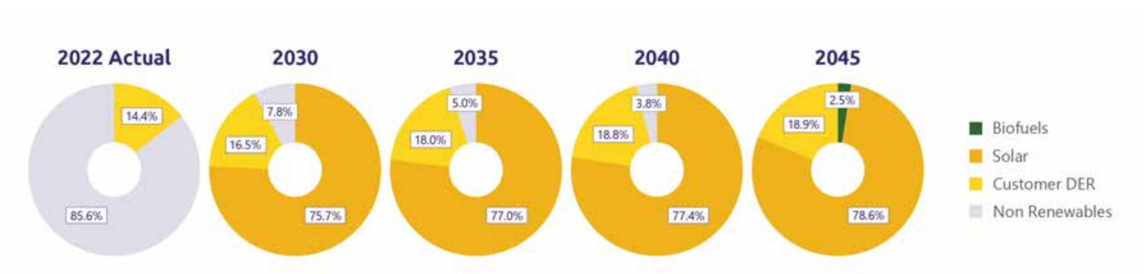


Figure 2-7. Preferred plan generation mix: Moloka‘i

2.3 External Actions and Policies for Successful Implementation

Decarbonizing the electric grid by 2045 will depend on many conditions, actions, and policies beyond Hawaiian Electric. External conditions and actions that will support successful implementation include:

ECONOMIC CONDITIONS AND ACTIONS
Easing of supply chain and inflationary pressures.
Federal funding (e.g., bipartisan infrastructure bill and Inflation Reduction Act) for incentives that remove barriers to customer adoption of EE measures and electric vehicles.
Federal funding to offset the cost of renewable energy projects and transmission and distribution resilience investments.
Investments in grid modernization and advanced technologies to improve operational situational awareness and active management of operational technology.

CUSTOMER AND COMMUNITY ACTIONS
Robust customer and community participation in energy efficiency, generation, and storage.
Customer and community engagement in and acceptance of energy plans and projects.

RESOURCE AND TECHNOLOGICAL CONDITIONS
Better-than-expected performance of large-scale solar, battery storage, and distributed energy resources, especially during transient or contingency events.

POLICIES AND REGULATORY CONDITIONS
Policies that accelerate stock turnover of less efficient appliances, equipment, and combustion vehicles and changes to building codes and standards that encourage zero-emissions appliances and equipment.
Policies that promote affordability and equity.
Efficient regulatory action and decision making.
Land use policies that promote renewable energy development, including other land being made available (e.g., private land, federal lands, etc.)
Policies that remove barriers to siting and permitting large-scale renewable projects and transmission infrastructure. For example, a separate process or entity that coordinates or has the authority to approve a variety of permits needed to execute a renewable project.
Flexibility in air permitting and mandates to manage reliability and transitions to renewable resource replacements.
Policies that provide incentives to communities and residents to host renewable projects and transmission infrastructure.
Policies that provide developers and landowners incentives to develop renewable projects in certain locations.
Policies that support a technical workforce pipeline to continue the work needed to accelerate the transition and transition fossil fuel–related jobs to clean energy jobs.

2.4 Potential Risks and Challenges

Many risks and potential challenges could delay progress toward State decarbonization goals. The primary threat to progress is the status quo and policy inaction to the above-listed recommendations. We have also experienced the acute risks to implementation and execution of renewable projects over the past couple of years because of persistent supply-chain and inflationary pressures (or economic recession) that make customer technologies and large-scale projects unaffordable for customers or that adversely impact the cost of equipment, materials, and labor.

2.5 Next Steps

As we move beyond planning, we are turning our focus to creating an energy marketplace, building upon our efforts to date in acquiring clean energy solutions through competitive procurement for large-scale resource and community-based energy projects, grid services purchase agreements, and customer DER programs.

To create a viable energy marketplace, we will need to routinely conduct procurements and adjust program and pricing mechanisms, in a similar but more efficient and streamlined manner to the procurement activities since 2017. To meet our 70% greenhouse gas reduction goal by 2030, we will need to increase customer participation in energy efficiency, generation, and storage and issue up to two additional competitive procurements. Figure 2-8 shows our proposed near-term actions.

Figure 2-8. Proposed near-term actions, 2023–2035

2.5.1 Public Utilities Commission Requests

To move from planning into implementation, we ask that the Public Utilities Commission:

- Approve the Integrated Grid Plan to serve as a foundational element for Hawaiian Electric and regulatory actions, including in interrelated dockets in the near term
- Open a new docket for competitive bidding related to grid-scale resources, non-wires alternatives, and grid services as described in this report, pursuant to the revised competitive bidding framework previously approved for use in the Integrated Grid Plan

3. Introduction

At Hawaiian Electric, customers are at the heart of our work today and our vision for the future. We are deeply rooted in our communities, and we strive to serve the energy needs of each person in Hawai'i with purpose, compassion, empathy, and aloha for our fellow humans and our natural environment. We are committed to empowering our customers and communities with affordable and reliable clean energy, and providing innovative energy leadership for Hawai'i.

Hawaiian Electric has the privilege of serving as Hawai'i's largest electric utility. We serve 95% of Hawai'i's 1.4 million residents on the islands of Hawai'i, O'ahu, Maui, Lāna'i, and Moloka'i, each with separate grids. Since 2010, we have nearly tripled the amount of renewable energy we generate, in large part due to the contributions of our customers. Figure 3-1 shows our renewable energy portfolio from 2011 through 2022. Customer-sited solar currently accounts for most of our renewable energy generation.

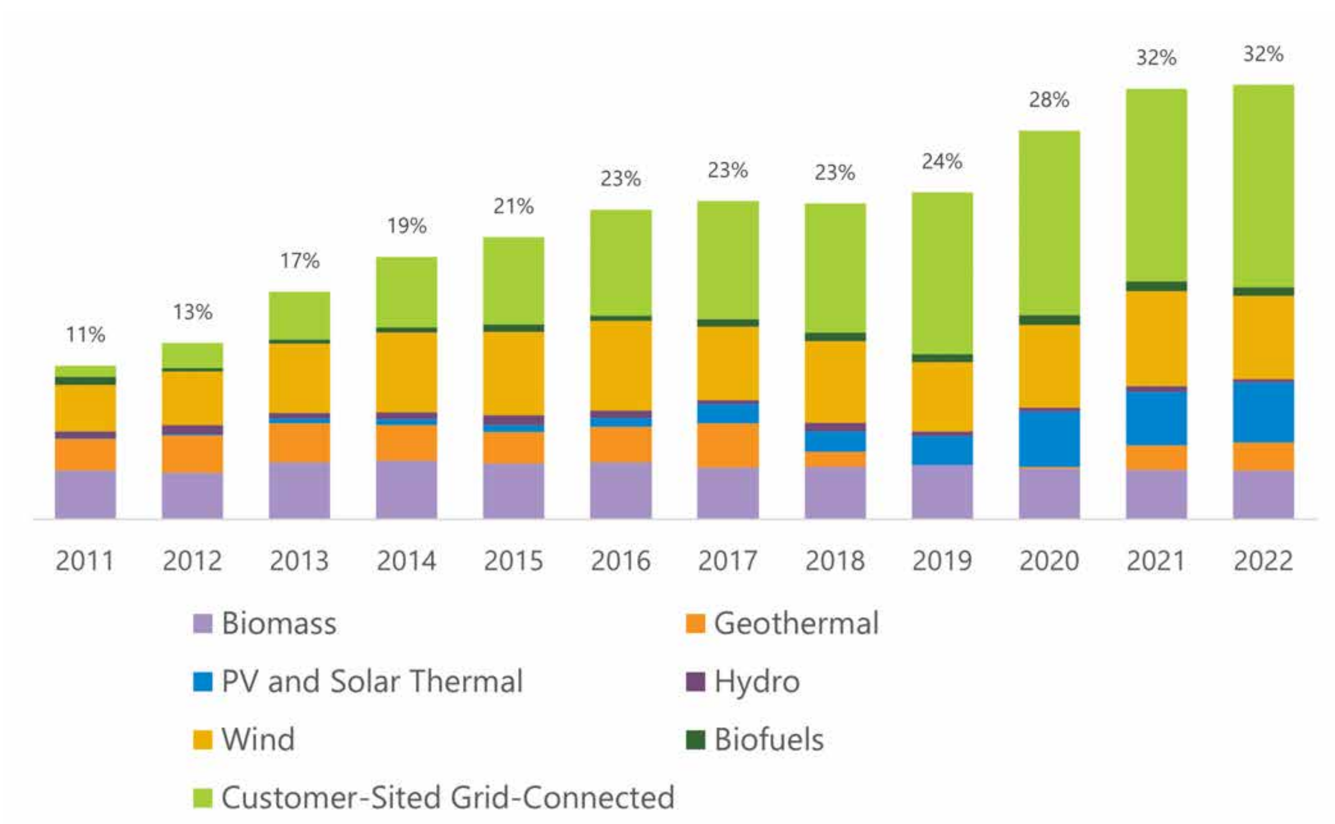


Figure 3-1. Hawaiian Electric renewable energy portfolio, 2011–2022

Together with stakeholders, customers, and communities, we have made significant progress toward our decarbonization goals. Among the accomplishments:

- **35%** of single-family homes have rooftop solar and **4,408** new residential rooftop solar systems.
- Total solar capacity, primarily from customers with rooftop solar, has grown to more than **1,118** MW.
- **91%** of new rooftop solar is being installed with battery energy storage.
- Greenhouse gas emissions have been reduced by **22%** compared to 2005.
- We have expanded customer energy options with innovative programs like Battery Bonus and Shared Solar.
- Installation of public EV charging infrastructure has expanded to **31** chargers at the end of 2022 with plans to have a total of 40 chargers by the end of 2023.
- Advanced meters have been deployed to more than **40%** of customers on O'ahu, Hawai'i Island, and Maui.
- Two stages of competitive procurement for renewable dispatchable generation (RDG) have been executed (referred to as **Stage 1** and **Stage 2**), with the first two large-scale solar plus battery energy storage projects in operation: Mililani 1 Solar, a 39 MW/156 megawatt-hour (MWh) battery and Waiawa Solar, a 36 MW/144 MWh battery. Additional projects are in the pipeline and expected to reach commercial operations over the next couple of years.
- A third stage (**Stage 3**) of competitive procurement for renewable dispatchable generation has been issued and firm generation is currently in progress.

We are proud of the progress we have made, but we still have a long way to go.

3.1 Climate Change Action Plan

The 2021 international summit on climate change made clear that the actions we take this decade will determine whether humanity can slow or stop the warming of the planet. To do our part in cutting global emissions, Hawaiian Electric announced a bold Climate Change Action Plan in 2021.

Our Climate Change Action Plan sets the ambitious goal of reducing electric-sector greenhouse gas emissions in 2030 by as much as 70% compared to 2005 levels. It also sets the goal of reaching net-zero carbon emissions by 2045, meaning whatever small amount of emissions we produce will be captured or offset. Figure 3-2 illustrates the Climate Change Action Plan goals.

Figure 3-2. Hawaiian Electric's Climate Change Action Plan carbon emission goals

This commitment by Hawaiian Electric represents a significant down payment on the economy-wide reduction that Hawai'i will have to achieve to align with nationwide and global greenhouse gas reduction goals. Statewide decarbonization will require collaboration across sectors, with transportation, agriculture, and other industries working to reduce and offset emissions.

3.2 Hawai'i Powered

A key strategy to reach net-zero emissions is generating 100% of our energy from renewable resources. In 2015, Hawai'i became the first state in the nation to direct its utilities to generate 100% of their electricity from renewable energy sources by 2045. Hawaiian Electric is dedicated to partnering with customers, communities, and other stakeholders to reach this energy goal.

We call our vision for using 100% renewable resources "Hawai'i Powered." Clean energy for Hawai'i, by Hawai'i:

- Supports our Climate Change Action Plan and the State's decarbonization goals
- Achieves energy independence
- Expands energy choices for customers and helps stabilize rates

3.3 Overview of Integrated Grid Planning

Integrated Grid Planning brought many people together to determine how to create a resilient and reliable grid that will meet future energy needs, stabilize costs for customers, and use 100% renewable resources. Hawaiian Electric began the planning process in 2018.

Powering a safe, secure, reliable, and resilient grid with Hawai'i's natural resources, whether on a small scale with individual customers, or through large-scale renewable energy providers, will require thoughtful and coordinated energy system planning in partnership with local communities and stakeholders alike. Additionally, the electric grid of tomorrow will look dramatically different from the electric grid of the past, as it will need to efficiently handle complex tasks not originally imagined. With a renewed focus on comprehensive energy planning, we believe that customers will benefit from a process that will identify the best options to affordably move Hawai'i toward a reliable, resilient clean energy future with minimal risk. The Integrated Grid Plan is rooted in customer and stakeholder input. We endeavor to create customer value by:

- Harmonizing resource, transmission, and distribution planning processes
- Evaluating the collective identified system needs
- Coordinating solutions that provide the best value on a consolidated basis

This approach appraises the total needs of the system and considers all alternatives from customers, independent providers, and the utility. It led us to identify solutions that are the lowest cost and/or best fit to create a more resilient, reliable, and sustainable grid that can meet the needs of Hawai'i's residents and businesses.

Integrated Grid Planning diverged from traditional energy planning practices. It streamlined traditionally disparate planning and procurement activities into a unified process. For instance, our planning framework establishes a marketplace for grid solutions that is integrated into the optimization and decision-making process, increasing opportunities for developers and customers to provide energy and grid services.

Throughout the planning process, we maintained transparency through active stakeholder, customer, and community engagement. See

Section 4 for details about our communication and outreach approach.

As illustrated in Figure 3-3, Integrated Grid Planning consisted of four high-level steps:

- **Data collection.** We developed forecasts and input assumptions to drive the planning and procurement process.
- **Plan definition.** We identified resource, transmission, and distribution needs to establish an optimal portfolio of solutions to meet grid needs, policy goals, and system reliability standards. This includes a near-term action plan and directional, long-term pathways to meet policy goals.
- **Growing a clean energy marketplace.** We seek to identify resource, transmission, and distribution solutions and grow the energy marketplace through multiple sourcing mechanisms: procurements, pricing, and programs.
- **Plan refinement.** We evaluated and optimized the resource, transmission, and distribution solutions to identify proposed solutions for review (i.e., investments, third-party contract, programs, and pricing proposals) for review by the Public Utilities Commission.

Figure 3-3. High-level steps of Integrated Grid Planning

3.4 Key Considerations

The core challenge of Integrated Grid Planning was to create a clean energy grid that balanced the key considerations of time, affordability, land use, community, and resilience and reliability, as shown here.

Time

How long will it take to come online?

Affordability

What will it cost to design, build, and maintain?

Land use

What is the footprint? How does this affect other land use priorities?

Community

How will it affect neighbors, jobs, and the environment?

Resilience and reliability

Will it hold up to a natural disaster and can it bounce back? How will it meet future energy demands based on electric vehicles, solar projects, population, and other factors?

Together with stakeholder groups and community members, we worked to prioritize, balance, and connect the key considerations. Figure 3-4 displays the ranking of key considerations by community members who voted on their priorities online and at events on Hawai'i Island, Maui, and O'ahu in 2022.

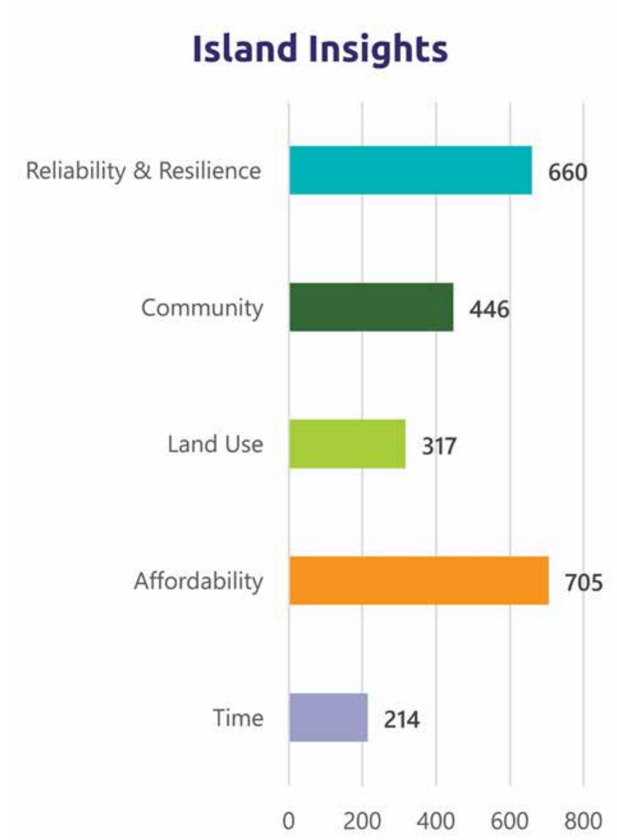


Figure 3-4. Key considerations ranked by community members (voting online and in person)

Throughout Integrated Grid Planning, we focused on the two considerations that we repeatedly heard were of top concern and interest to community members: affordability and reliability/resilience. This report provides the most affordable and reliable pathways to decarbonize our electric system.

3.5 Pathways to 100% Renewable Energy

We evaluated five pathways to achieving 100% renewable energy over a planning horizon to year 2050. On O'ahu we evaluated an additional pathway called "Land-Constrained" to represent the possibility that there would be insufficient land to site large-scale renewable energy projects. The objective of each pathway is to best serve our customers' future needs and preferences, while allowing flexibility to adapt to the inevitable uncertainties ahead, including changes in customer preferences and conditions. This planning approach is customer-centric, as it defines the residual needs of the grid after accounting for customer resources. In developing these possible pathways, we took into account:

- Island-specific conditions
- State policies as described in Section 5
- Customer trends and adoption rates of new technologies
- How future State or federal policies may impact customer choices
- Design and implementation of potential renewable energy zones

The following is an overview of the five pathways. See Section 8 for details on these pathways per island.

Pathway	Overview
Base electricity demand	Customers continue to adopt technologies (private rooftop solar, energy storage, electric vehicles, and energy efficiency) based on current projected market conditions and customer trends. EV owners manage their charging and mostly charge during the day when solar resources are abundant, and electricity is cheapest. At this time, we believe this pathway is the most probable trajectory.
Low electricity demand	Customer adoption of technologies continues at a much higher pace than expected, such as energy efficiency and private rooftop solar, but EV adoption remains slow. In this future, the electricity demand we must serve is much lower than in all other pathways and fewer large-scale resources will be needed to achieve 100% renewable energy.
Faster customer technology adoption	Customer adoption of all technologies, private rooftop solar, and electric vehicles; energy efficiency is higher and accelerated compared to the market forecasts and EV owners manage to charge their vehicles during the day when solar is abundant. In this future, the electricity demand is higher than the Base electricity demand pathway but lower than the High electricity demand pathway.
High electricity demand	Customer adoption of technologies continues at a much slower pace than expected; however, EV adoption accelerates because of aggressive State or federal policies, but owners charge their vehicles when the grid is most stressed (i.e., unmanaged EV charging). In this future, the electricity demand we must serve is much higher than in all other pathways and more large-scale resources will be needed to achieve 100% renewable energy.
Land-constrained	This pathway recognizes the possibility on O'ahu that insufficient land may be available to develop large-scale resources or to produce local biofuels needed to achieve 100% renewable energy, while balancing other State goals of affordable housing and food sustainability. This pathway helps us understand the impact of limited land availability for future solar, onshore wind, and biomass development. In this pathway customer adoption is the same as the Base pathway where customers adopt technologies based on current market and customer trends.

3.6 Renewable Energy Planning Principles

The following principles guided our technical analyses and community conversations as we moved through Integrated Grid Planning:

- ***Renewable energy is the first option.*** We are pursuing cost-effective renewable resource opportunities that reduce carbon emissions and stabilize customer bills. Getting off imported fossil fuels removes Hawaiʻi from the volatility of world energy markets and gives future generations a tremendous advantage. It can also create a clean energy research and development industry for our state.
- ***The energy transformation must include everyone.*** Electricity is essential. Our plans, as well as public policy, should ensure access to affordable electricity, with special consideration given to LMI households. Meaningful community participation must be a key element of renewable project planning.
- ***The lights have to stay on.*** Reliability and resilience of service and quality of power are vital for our economy, national security, and critical infrastructure. Our customers expect it, deserve it, and pay for it. Our plans must maintain or enhance the resilience of our isolated island grids by relying on a mix of resources and technologies.
- ***Today's decisions must be open to tomorrow's breakthroughs.*** Our plans keep the door open to developments in the rapidly evolving energy space. We must be able to easily accept new, emerging, and breakthrough technologies that are cost-effective and efficient when they become commercially viable.
- ***The power grid needs to be modernized.*** Energy distribution is rapidly moving to the digital age. We are reinventing our grid to facilitate a decarbonized energy portfolio and to enable technologies such as demand response, dynamic pricing, aggregation, and electrification of transportation.
- ***Our plans must address climate change.*** Our Climate Change Action Plan set a goal to reduce carbon emissions from power generation 70% by 2030 compared with 2005 levels. Our resilience strategy aims to minimize the impacts of climate change—rising sea levels, coastal erosion, increased temperatures, and extreme weather events—on the energy system.
- ***There's no perfect choice.*** No single energy source or technology can achieve our clean energy goals. Every choice has an impact, whether it's physical or financial. While we can mitigate those impacts, attaining our clean energy goals has major implications for our land and natural resources, our economy, and our communities. We seek to make the best choices by engaging with community members, regulators, policymakers, and other stakeholders.

4. Community and Stakeholder Engagement

Meaningful and sustained community and stakeholder engagement is at the heart of Integrated Grid Planning. It has been instrumental in aligning our planning with statewide priorities and moving Hawai'i toward a more equitable clean energy future. Since planning began in 2018, we have worked to foster partnerships with communities that we are a part of and serve by sharing transparent information and listening, learning, and implementing their feedback into the Integrated Grid Plan.

We are grateful for the involvement of thousands of community members throughout the planning process, and we appreciate the opportunities we have had to collaborate on potential solutions.

In this section, we summarize outreach and engagement with community members and stakeholders, what we heard, and how we implemented the feedback we received. See Appendix A for copies of materials from stakeholder and community engagement.

4.1 Engagement Approach and Stakeholder Groups

We followed an engagement framework for consistent and frequent communication with community members and stakeholders to gather input and share information throughout the planning process. Figure 4-1 illustrates this framework, with the reciprocal flow of information and feedback between Hawaiian Electric and our primary stakeholder groups.

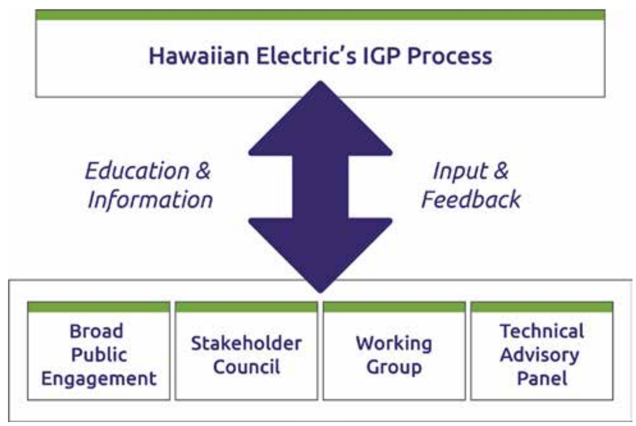


Figure 4-1. Stakeholder engagement framework

We engaged four main groups in planning for a clean energy grid: the Stakeholder Council, the Technical Advisory Council, Working Groups, and the public.

4.1.1 Stakeholder Council

This group helped to ensure that our planning aligned with interests across the islands. It consisted of one representative from the following customer and stakeholder interests:

- City/county and/or community representative (one from each island/county)
- Consumer advocate
- Demand response
- Energy efficiency
- Energy storage
- Environmental advocate
- Hawaiʻi Public Utilities Commission
- Independent power producers (utility-scale resources)
- Large commercial and industrial customers
- Small solar developers
- State of Hawaiʻi Energy Office
- Sustainability advocate (local)
- Technical Advisory Panel Chair
- U.S. Department of Defense

Beginning in fall 2018, we hosted virtual and in-person Stakeholder Council meetings aligned with planning milestones and updates. Figure 4-2 shows Stakeholder Councilmembers and Hawaiian Electric team members at an in-person Stakeholder Council meeting in December 2022.

See Appendix A for presentations and notes from Stakeholder Council meetings.

Figure 4-2. Stakeholder Council meeting, December 2022

4.1.2 Technical Advisory Panel

This group provided an independent source of peer assessment for the technological and engineering considerations of planning for a Hawai'i Powered future. Panel members came from internationally recognized utilities, market operators, and research organizations with engineering expertise in resource, transmission, and distribution planning for large-scale and distributed renewable resources. Their review and recommendations on the technical analyses we performed greatly enhanced the quality of our work, and were relied upon by stakeholders to ensure that our analysis was sound and consistent with leading industry practices.

The Technical Advisory Panel met on an approximately monthly basis, aligned with planning milestones and updates. See Appendix A for presentations and notes from Technical Advisory Panel meetings.

4.1.3 Working Groups

On an as-needed basis, we formed specialized groups of experts who addressed specific topics in an advisory-only capacity. The Working Groups included:

- **Forecast Assumptions Working Group:** Supported development of forecast assumptions and sensitivities for Integrated Grid Plan models. This group concluded in March 2021 when we issued the draft March 2021 Inputs and Assumptions Update. Further updates to the forecast assumptions were discussed in the Stakeholder Technical Working Group.
- **Resilience Working Group:** Supported the development of resilience planning criteria for Hawai'i's energy system including resource, transmission, and distribution in relation to potential community and economic impacts. This group concluded with the issuance of the Resilience Working Group Report in June 2020. It is expected to resume as we continue our resilience planning discussions in 2023.
- **Distribution Planning and Grid Services Working Group:** Supported enhancements to the methods and tools for distribution planning and the integration with resource and transmission planning. This working group concluded with the issuance of the Distribution Planning Methodology and Non-Wires Opportunity Evaluation Methodology in June 2020.
- **Market Working Group**: Comprised four interrelated subgroups to support development of the sourcing and evaluation steps in the planning process:
  - **Standardized Contract Working Group:** Developed standardized contracts and service agreements, beginning with the grid services purchase agreement and our model renewable dispatchable generation power purchase agreement (PPA) and model firm PPA. This group concluded with the review of the model Grid Services Purchase Agreement in March 2019.
  - **Grid Services Working Group:** Identified and defined additional energy, capacity, ancillary, and non-wires services. This group concluded with the completion of the soft launch request for proposal for non-wires alternatives (NWAs) in May 2020.
  - **Solution Evaluation and Optimization Working Group:** Focused on the methods for evaluating and optimizing multiple solutions for multiple grid services. This group concluded in March 2021 when we issued the draft March 2021 Grid Needs Assessment and Solution Evaluation Methodology. Further updates to the

planning methodology were discussed in the Stakeholder Technical Working Group.

- **Competitive Procurement Working Group:** Proposed changes to the Public Utilities Commission's Framework for Competitive Bidding to reduce barriers to market participation and enable alignment with the Integrated Grid Plan. This working group concluded in February 2021 upon filing of the revised competitive bidding framework that will be used during the solution sourcing phase of the process.

- **Stakeholder Technical Working Group:** Formed in June 2021 by combining the Forecast Assumptions, Distribution Planning, Solution Evaluation and Optimization, and Grid Services Working Groups. The Stakeholder Technical Working Group provided and continues to provide input on technical issues and helped increase transparency in the planning process. Consolidating the original Working Group structure streamlined planning efforts by focusing stakeholder time and efforts, providing opportunities for stakeholder presentations, and allowing for robust and comprehensive discussion and collaboration on technical topics.

Working Groups met on an as-needed basis throughout the planning process. See Appendix A for presentations and notes from Working Group meetings.

4.1.4 Public

The public consists of customers and community members across the islands we serve.

We viewed the public as an active and essential partner in Integrated Grid Planning, and we committed to equitable, inclusive, and transparent community engagement each step of the way.

We actualized this commitment by:

- Providing accessible and inclusive opportunities to engage. This included offering multiple ways to engage (both online and in person).
- Prioritizing outreach to underserved and potentially most impacted communities, including people who live in rural areas and people closest to places where new energy facilities may be located. We listened to community members' experiences, priorities, and vision for a clean energy future, and we used their feedback to shape planning outcomes.
- Being accountable to feedback we have received by reviewing and considering public feedback as part of planning decisions, including where to locate new energy facilities.

In the following section, we describe the actions we took to engage the public throughout Integrated Grid Planning.

4.2 Public Engagement Tools and Strategies

We used an array of outreach tools and strategies to meet community members where they were, both online and in person. We tailored our strategies to each island, recognizing that they have unique needs, conditions, and opportunities for decarbonization and public participation.

Most of the Integrated Grid Planning process took place over the course of the COVID-19 pandemic, with community engagement opportunities beginning in March 2020. Public health and safety were our top priority, and we worked to align our outreach with all local, State, and federal guidelines for pandemic safety practices. This included extending the duration of opportunities to share input through virtual/online formats.

4.2.1 Integrated Grid Planning Website, Document Library, and Email

In 2019, we launched the Integrated Grid Planning website (hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning) to share information on planning progress and engagement activities. We also created a project email address (IGP@hawaiianelectric.com), which we maintained and managed throughout the planning process to gather and share information. Community members joined the email list by signing up at public meetings or through the Integrated Grid Planning website.

We updated the website on an ongoing basis throughout the planning process. This included maintaining a document library with copies of technical analyses, reports filed with the Public Utilities Commission, and copies of stakeholder and community presentations and meeting notes. As the planning process evolved, the growing volume of project documents prompted a need for improved library organization. In March 2022, the Public Utilities Commission requested that we improve the clarity and navigability of the library, with a more consistent system for document descriptions, dates, titles, and categories.

We responded to this request by adding new search functions and category tags, as well as consistency in document titling and captioning. We posted notifications about the updated library on the project website homepage and Hawai'i Powered participation site. (See Section 4.2.3, below, for information about the participation site and e-newsletter.) Figure 4-3 displays a screenshot of the updated document library.

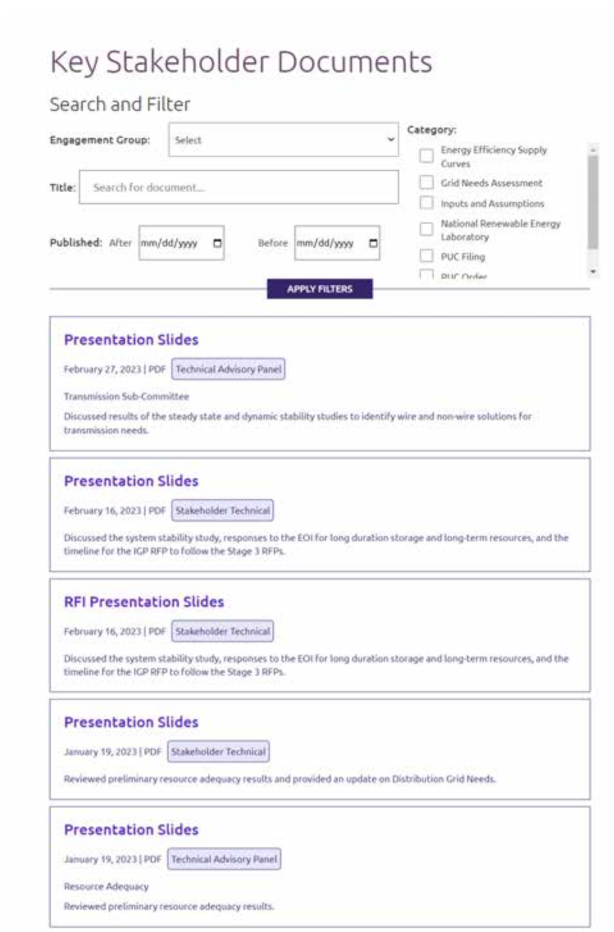


Figure 4-3. Updated document library on the Integrated Grid Planning project website

4.2.2 Public Open Houses

Before the COVID-19 pandemic, in early March 2020, we began our initial campaign of public outreach and engagement, connecting with 1,421 community members in person and online. The engagement goal of this outreach campaign was to connect with the public, provide a general overview of Integrated Grid Planning, and gather input on what is most and least important to consider as part of the planning process. Topics included:

- Grid modernization
- Grid-scale renewables
- Rooftop renewable energy
- Community-based renewable energy (CBRE)
- Electrification of transportation
- Resilience
- Careers at Hawaiian Electric

We invited the public to the open houses by sharing a press release with local media outlets, emailing all Integrated Grid Plan subscribers, and posting advertisements to social media. We also produced a livestreamed social media segment publicizing the open houses and introducing the Hawaiian Electric team and information boards. Additionally, we provided the Stakeholder Council a communications "toolkit" with fliers and messaging for councilmembers to share with their organizations and communities.

A total of 161 participants joined us at four in-person open houses: two on Hawai'i Island, and one each on O'ahu and Maui. Table 4-1 displays the locations and number of participants at each meeting.

Table 4-1. In-person Participation in March 2020 Public Open Houses

Event Information	Participants
3/3/2020 Kealakehe High School, Kailua-Kona, Hawai'i	17
3/5/2020 Hilo High School, Hilo, Hawai'i	52
3/10/2020 Hawai'i Pacific University, Honolulu, O'ahu	61
3/12/2020 Hawaiian Electric, Kahului, Maui	31
Total number of in-person participants	161

At each open house, participants visited stations with information boards and then attended a panel discussion. Figure 4-4 shows community members speaking with Hawaiian Electric team members near informational boards. The panel included community members, representatives from energy organizations, and Hawaiian Electric team members.

See Appendix A for a list of the panelists and copies of open-house materials, including informational boards and handouts. During the panel sessions, participants submitted 127 comments and questions ranging from the role of transportation in energy goals, resilience and domestic security, renewable and energy-efficient programs, connections with smaller communities, and community solar program and energy cost calculations.

Figure 4-4. Community members and the Hawaiian Electric team connect at public open houses, March 2020

Each panel session was filmed and broadcasted by local community television networks, allowing those unable to join the opportunity to watch at their convenience. Hawaiian Electric also posted recordings of the panel sessions to the Integrated Grid Planning website after the events. See Appendix A for a list of the local television networks that broadcasted the open houses, as well as a record of the total views for each video recording posted to the website.

We hosted a virtual open house in tandem with the in-person open houses that shared the same information boards and an online version of the community survey. Virtual open-house participants could also leave a comment or email the project team. More than 1,260 people visited the virtual open house between March 2 and 30, 2020, with peak participation on March 9 and 10.

After the open houses, we consolidated comments from in-person and virtual participants and posted summaries of what we heard to the Integrated Grid Planning website. See Appendix A for copies of the summaries. Key themes included:

- Energy reliability and affordability were of top concern to participants.
- Participants expressed interest in personally helping to increase use of renewable energy and reduce greenhouse gases. Participants supported the effort to reduce greenhouse gases by owning and/or driving electric vehicles, switching to solar, and using energy-efficient appliances. Many expressed interest in having rooftop solar installed, or already had solar installed or were waiting for installation. Participants were interested but looking for more information on advanced meter installation and battery storage installation.
- Very little interest was expressed in using transit or carpooling to reduce emissions, and participants expressed the least interest in exploring new technologies to provide more information and control over energy uses.

This input helped to inform future pathways where we evaluated futures with high adoption of electric vehicles, different levels of rooftop solar adoption, and described the distribution system investments needed to ensure that all customers who want rooftop solar can easily interconnect their system to the grid. We also assessed the reliability of the system to ensure that we have the right type of resources to continue reliable service to customers. See Sections 8 and 12 for details about future pathways and reliability analyses.

Pivoting to an online meeting format during the pandemic, Molokaʻi and Lānaʻi virtual community meetings (live presentation with facilitated question-and-answer session) were held in summer 2020 attended by a total of 31 attendees. The meetings were also recorded and posted online for viewing with thousands of views (Molokaʻi had 4,293 views and Lānaʻi had 3,569 views).

4.2.3 Hawaiʻi Powered Public Participation Site

In March 2022, we launched an online public participation site at hawaiipowered.com. The purpose of this site was to provide a dynamic hub for community engagement, with content that helped humanize the planning effort, convey technical concepts in plain language, and offer multiple opportunities to get involved. The participation site paired with the Integrated Grid Planning project website, where community members could explore the document library and learn more about the technical planning process.

We chose the campaign name, "Hawaiʻi Powered," to convey pride, collective action, and shared responsibility in planning for a future grid powered entirely by local renewable resources. This name helped us lead with less technical language than "integrated grid planning" in communications with the public and celebrate finding local solutions for renewable, resilient energy in partnership with many people—within and outside of Hawaiian Electric.

The Hawaiʻi Powered participation site provided:

- An overview of Integrated Grid Planning goals and commitment to community engagement, with multimedia features including a welcome video.
- Learning modules, such as interactive charts, that depict how much renewable energy comes from various local sources with wide-ranging technologies.
- A community survey about energy priorities and a real-time data visualization of the results collected from online and in-person events.
- Information about recent and upcoming Integrated Grid Planning activities on each island.
- Short forms for people to request a presentation for their community groups, contact the project team, and sign up for email updates. As of February 2023, we received a total of six requests for presentations and 22 messages through the "contact us" feature.
- A blog called *Plugged In*, with monthly posts about Integrated Grid Planning milestones, features on customers and Hawaiian Electric team members, and "deeper dives" on technical subjects. See Table 4-2 for a list of blog posts and their purposes. Copies of these posts are provided in Appendix A.
- Monthly Hawaiʻi Powered e-newsletters sharing Integrated Grid Planning updates and blog post links with all project subscribers. We included statements encouraging readers to share each newsletter with their family and friends. The newsletter gained subscribers with each edition, presumably as recipients shared the email with their networks.

Table 4-2. Hawai'i Powered Blog Posts, March 2022 to February 2023

Purpose	Blog Post Titles, Publication Dates, and Synopses
Provide transparent updates on Integrated Grid Planning	Announcing Hawaii Powered 3/11/2022 Learn how Hawaiian Electric is moving toward a sustainable future and how you can get involved.
	Shared Solar 101 3/11/2022 Explore how solar power generation goes beyond private rooftop solar panels.
Humanize Hawaiian Electric	Aloha from Hawaiian Electric! 4/18/2022 Meet Colton Ching, who leads Hawaiian Electric's efforts to power the grid with 100% renewables by 2045.
Demystify technical topics	What You Need to Know: 2021-2022 Sustainability Report 4/19/2022 See how much power Hawai'i is cleanly generating, how communities are getting involved in a green future, and more!
	Non-wires alternatives 5/31/2022 Learn about the benefits of NWAs and how they fit into our clean energy future.
	Inputs and Assumptions: What does the data really mean? 9/6/2022 Learn about the data and modeling that goes into planning for enough renewable energy to power our future grid.
	Distributed Energy Resources: A diverse grid is a strong grid 7/6/2022 Learn how diversifying energy generation is necessary to a clean energy future.
Promote community-driven clean energy initiatives and community engagement efforts	Molokai residents receive kits to help save energy at home 7/5/2022 Read about the Moloka'i residents who picked up energy saving kits from Hawai'i Energy, the County of Maui Department of Water Supply, and Hawaiian Electric.
	Building Resilience in North Kohala: A collaborative approach to strengthen our communities 8/1/2022 Read more about this community's collaborative approach to energy resilience.
Encourage behavior changes and participation in clean energy planning	Energy Efficiency: The power to change is in our hands 6/1/2022 Get pro tips on how to be your most energy efficient.
	Electrification of Transportation: Driving toward a renewable future 8/2/2022 Check out our EV toolkit and how we're preparing for more electric transportation.
	Renewable Energy Zone (REZ) Maps: You know your community best 11/28/2022 We need your help identifying potential project locations.

a. Hawaiian Electric published the Energy Efficiency, Distributed Energy Resources, and Electrification of Transportation blog posts in advance of launching the inputs and assumptions data dashboard (see information about the dashboard below). These three posts built on one another and provided foundations to help people understand the inputs and assumptions used in modeling. We provided links to these blog posts on the inputs and assumptions data dashboard for readers to reference.

From March 2022 to March 2023, the Hawai'i Powered participation site received 2,928 total visits from 1,765 unique visitors.

4.2.4 Inputs and Assumptions Data Dashboard

In September 2022, we launched a complementary site to Hawai'i Powered to share information about the data and models we use to predict how much clean energy we'll need to meet future customer demand. This site, called the inputs and assumptions data dashboard (hawaiipowered.com/iadashboard), provided interactive learning modules and graphs tied to the data sets we used to model future energy scenarios.

Our intent was to help make this highly technical process more accessible by explaining and visually conveying what scenario planning is, what it involves, and why it matters. See Figure 4-5 for a screenshot of the data dashboard homepage.

See Appendix A for more screenshots of the dashboard.

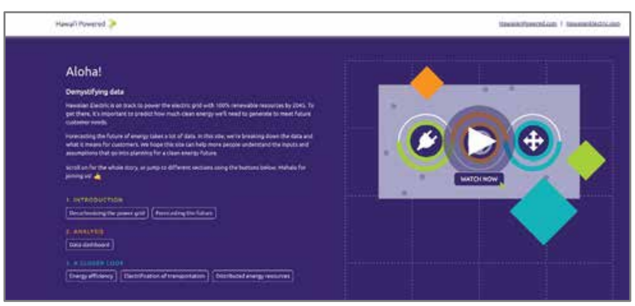


Figure 4-5. Screenshot of the inputs and assumptions data dashboard

To promote the inputs and assumptions data dashboard, we published a blog post, sent an e-newsletter to all subscribers, added a banner notification at the top of the Hawai'i Powered participation site, and posted the welcome video to Hawaiian Electric's social media. We also presented it at a Stakeholder Council meeting and encouraged council members to share it with their networks. The data dashboard received 624 visits from 339 unique visitors from September 2022 to March 2023.

4.2.5 Student and Youth Engagement

We believe it is essential to involve young people in planning for a clean energy future, as they will be its inheritors and stewards.

To that end, we developed a Hawai'i Powered activity book in 2022, with energy exercises, power-up puzzles, creative coloring, and more for learners of all ages. We distributed this activity book at community events on Hawai'i Island, O'ahu, and Maui. Parents and teachers could also download the activity book at hawaiipowered.com. Figure 4-6 shows pages from the activity book. See Appendix A for a copy of the full activity book.

Young people shared their input in ranking the importance of key considerations for the Integrated Grid Plan. See Section 4.2.6 for an overview of the local events and community conversations including the ranking activity.

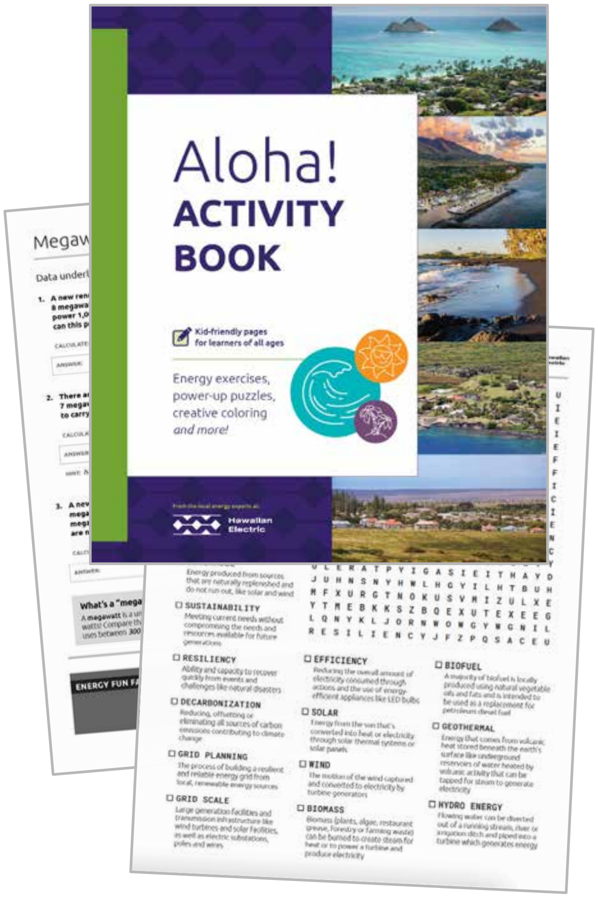


Figure 4-6. Cover and pages from the Hawaiʻi Powered activity book

4.2.6 Local Events and Community Conversations

We conducted our second campaign of community outreach from July 2022 through February 2023. Our goals with this round of outreach were to:

- Tailor our strategies to each island, recognizing that they have unique needs, conditions, and opportunities for decarbonization and public participation
- Connect with community members, listen to and document their ideas, and help answer questions about clean energy planning
- Raise awareness about Integrated Grid Planning and Hawaiʻi's decarbonization goals
- Gather public input on potential future renewable energy zones
- Understand how community members prioritize Integrated Grid Planning key considerations

We participated in local events and hosted community conversations, which were small-group, in-person or virtual events to share information and discuss Hawaiʻi's energy future. Community conversations typically included handouts or display boards with Integrated Grid Planning information, presentations by members of the Hawaiian Electric team, and time for open discussion. Benefits of participating in local events and hosting community conversations included:

- Supporting other local initiatives for clean energy and sustainability outside of Hawaiian Electric. These events included local fairs and festivals, where we staffed booths to reach a broader audience and raise awareness about Integrated Grid Planning and Hawaiʻi's decarbonization goals.
- Focusing our outreach to communities who might be most impacted by energy projects.
- Improving accessibility to our Integrated Grid Planning team by offering more opportunities to connect in more communities, at more places and at more times.

To share information about upcoming opportunities to connect with the Hawaiian Electric team and share input, we maintained an updated list of events per each island on the Hawaiʻi Powered website.

We had the opportunity to connect with community members at 26 events on Hawaiʻi Island, Maui, and Oʻahu in 2022 and early 2023. The following is a summary of the events we attended or hosted on each of the islands.

4.2.6.1 Hawaiʻi Island

We connected with community members at 16 events on Hawaiʻi Island in 2022:

- He Ala Pono Electric Vehicle and Sustainability Fair in Hilo
- Rotary Club of Kona Mauka in Kona
- Kiwanis Club of East Hawaiʻi in Hilo
- AstroDay in Kona
- Girls Scouts STEM Fest in Waikoloa
- Vibrant Hawaiʻi's Resilience Hub Makahiki and Community Resilience Fair in Puna
- Vibrant Hawaiʻi's North Hawaiʻi Resilience Fair in Waimea
- Focus group sessions with Sustainable Energy Hawaiʻi and County of Hawaiʻi mayor's cabinet (two separate events)
- Holualoa Elementary School second-grade class
- Vibrant Hawaiʻi's South Hilo Resilience Fair in Hilo
- Hawaiʻi Island Realtors in Hilo
- Vibrant Hawaiʻi's Kaʻū Makahiki in Kaʻū
- County of Hawaiʻi Senior Lecture Series in Hilo
- Vibrant Hawaiʻi's North Hilo Resilience Fair in Laupahoehoe
- Hamakua Community Development Plan Action Committee in Honokaʻa

We also introduced the Hawaiʻi Powered website at virtual and in-person community meetings in early 2022, prior to the launch of the REZ maps. These events were:

- March to May 2022: County of Hawaiʻi Community Informational Sessions (10 in-person, island-wide events)
- Hawaiʻi Leeward Planning Conference (virtual)
- Waimea Community Association (virtual)

Figure 4-7 shows community members and Hawaiian Electric staff connecting at public events across Hawaiʻi Island, 2022.

Figure 4-7. Participants at engagement events across Hawaiʻi Island

Top to bottom, left to right: *Hawaiian Electric staff discussing renewable energy zones at the 2022 He Ala Pono Electric Vehicle and Sustainability Fair. Girl Scouts with Hawaiian Electric Activity Books at Girl Scouts in STEM event. Community members learning about renewable energy zones at Kiwanis Club of East Hawaiʻi meeting. Community member commenting on renewable energy zones at Vibrant Hawaiʻi event in Puna. Kids with Hawaiian Electric activity books at Vibrant Hawaiʻi in Puna.*

4.2.6.2 Maui

We connected with community members at nine events on Maui in 2022. Figure 4-8 shows community members sharing their priorities for Integrated Grid Planning key considerations at a Hawaiian Electric booth at Maui Arbor Day. Hawaiian Electric team members shared information about the key considerations, and visitors voted on their top priorities using poker chips. We tallied the number of chips at the end of the event, and included the count in our summary of public feedback. See Appendix A for a summary of the ranking of key considerations.

Figure 4-8. Community members use poker chips to vote on the most important grid planning considerations at a Maui Arbor Day event, 2022

We also hosted eight community conversations with 44 representatives of various organizations and interests, including:

- Government officials
- Cultural practitioners
- Community stakeholders/members
- Conservation and environmental advocates and organization representatives
- Businesses
- Agricultural leaders

At these conversations, we shared information about our planning efforts and sought a wide range of perspectives from our Maui community.

4.2.6.3 O‘ahu

From October through December 2022, we held six community conversations across O‘ahu for people to join in person or online. We sent notices about the upcoming conversations to elected officials, neighborhood boards, and energy-related groups and organizations. We also sent a news release to various media outlets and promotional news stories ran in the *Star Advertiser* and *Pacific Business News*.

Each community conversation included an open house (in-person only) followed by a hybrid community workshop (in-person and via Zoom). The workshops were also livestreamed and recorded by ‘Ōlelo Community Media. A total of 105 community members joined us in person.

We collected input about the REZ maps and priorities for O‘ahu energy facilities and services, including microgrids. Figure 4-9 shows community members and the Hawaiian Electric team at the O‘ahu community workshops. See Appendix A for a record of all comments received and a summary of what we heard.

Figure 4-9. Community conversations about microgrids on O‘ahu, fall 2022

O‘ahu microgrid planning was an outcome of Hawaiian Electric’s involvement in DOE's Energy Transitions Initiative Partnership Project (ETIPP) to improve energy resilience and combat climate change. As part of this partnership, Hawaiian Electric helped identify areas on O‘ahu that are optimal for developing microgrids to build a more resilient electric grid. See Section 10.6 for more information on ETIPP.

MICROGRID:

> A microgrid generates, distributes, and regulates the supply of electricity to customers on a smaller, local scale compared to traditional, centralized grids. Microgrids are a group of interconnected loads and distributed energy resources within clearly defined boundaries. They are normally interconnected to the grid and can disconnect from the grid during emergencies. They are best suited to areas near critical infrastructure (such as hospitals and emergency response centers), have access to renewable energy resources, and are prone to prolonged outages during weather events.

We also launched an online interactive map and survey at hawaiipowered.com/etipp about potential locations for future microgrids on O'ahu. The online map and survey helped the public and planners alike consider the technical and practical viability of microgrid development. Figure 4-10 presents a screenshot of the online microgrid survey.

Figure 4-10. Screenshot of the O'ahu microgrids online map and survey

We approached community outreach differently on Lāna'i and Moloka'i, recognizing the unique needs and conditions of energy planning on those islands.

4.2.6.4 Lānaʻi

Much of our grid planning work on Lāna'i happened in collaboration with the majority landowner on the island. The Hawaiian Electric team recently announced its selection of a developer to build and maintain the largest renewable energy project and the first to offer the Shared Solar program on the island. We have completed contract negotiations with DG Development & Acquisition, LLC; however, we have not finalized the contract as the majority landowner, Pūlama Lāna'i, notified Hawaiian Electric of its intent to design and construct microgrids to supply the energy demands of the resorts on Lāna'i.

4.2.6.5 Molokaʻi

Moloka'i is preparing a Moloka'i Community Energy Resilience Action Plan: an independent, island-wide, community-led and expert-informed collaborative planning process to increase renewable energy on the island. The Moloka'i Clean Energy Hui by Sust'āinable Moloka'i is coordinating the action plan. Hawaiian Electric is providing technical support to the Moloka'i Clean Energy Hui in its planning process to develop a portfolio of clean energy projects to achieve 100% renewable energy for the island that is feasible, respectful of Moloka'i's culture and environment, and strongly supported by the community. Learn more at sustainablemolokai.org/renewable-energy/molokai-cerap.

At all community events and talk stories across the islands (as described above), we focused on gathering public input about two topics: Integrated Grid Planning key considerations and the concept of renewable energy zones.

4.2.6.6 Key Planning Considerations

We organized Integrated Grid Planning key considerations into five categories: time, affordability, land use, community, and resilience/reliability. We asked community members to help us understand which considerations are most important to them by ranking their priorities. Figure 4-11 displays the consolidated ranking of key considerations by the people who voted on their priorities at events on Hawai'i Island, Maui, and O'ahu, as well as online at hawaiipowered.com/powerup.

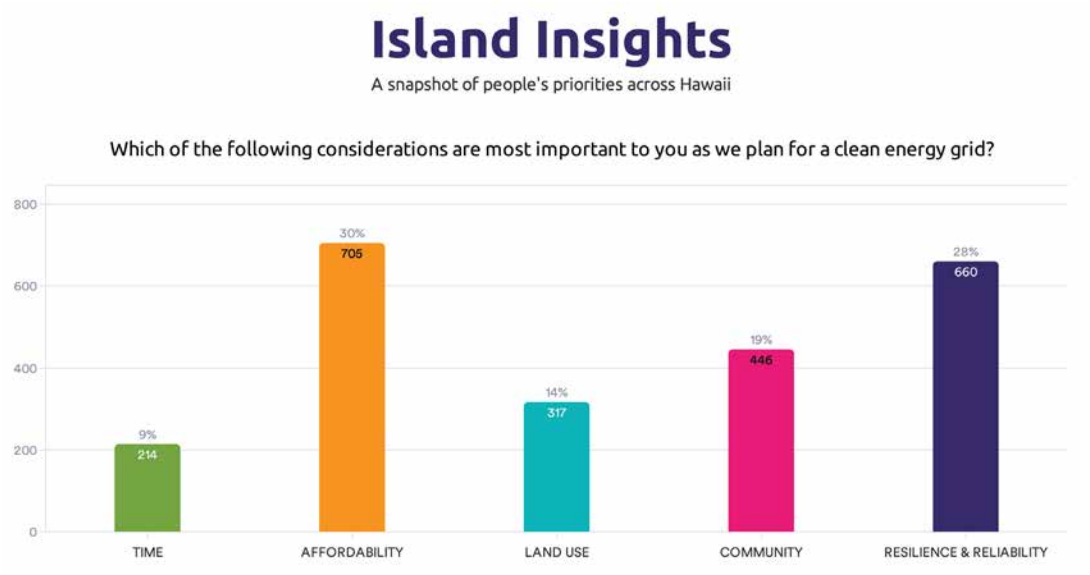


Figure 4-11. Key considerations ranked by community members (voting online and in person)

The ranking activity showed that affordability and reliability are top priorities for many community members. This feedback was consistent with what we heard from community members in our initial phase of public outreach in 2020. This key takeaway informed our Integrated Grid Plan by reaffirming our dedication to finding clean energy solutions that also stabilize customer rates and ensure reliable power that people can count on.

4.2.6.7 Renewable Energy Zones

A core part of the Integrated Grid Planning process was identifying potential future locations for renewable generation facilities and transmission and distribution infrastructure to power the grid with 100% clean energy. Hawaiian Electric partnered with the National Renewable Energy Laboratory (NREL) to estimate the potential for large-scale solar, wind, and distributed rooftop solar developed based on available land, potential capacity, and potential electricity generation for sites across the five islands. This included data about:

- Wind and sun coverage
- Steepness of slopes
- Financial costs
- Access to the site and proximity to existing transmission corridors and grid connections
- Land use and zoning

We identified potential areas called renewable energy zones to complete a high-level analysis of the transmission requirements needed to support the interconnection of each zone to our electric grid.

RENEWABLE ENERGY ZONES:

A renewable energy zone (REZ) is an area that has suitable technical conditions for clean energy generation projects. These projects include cost-effective connections to the existing grid and additional transmission infrastructure required to connect renewable energy generation to customers. A renewable energy zone will enable efficient interconnection of clean energy projects that may include solar, wind, and battery energy storage (among other resources), expanding grid capacity.

We shared information about renewable energy zones with the public online and at the in-person events described above. We invited the public to help us understand the potential impacts, land use opportunities, and community needs and interests within each renewable energy zone on Hawai'i Island, Maui, and O'ahu. Together, public input and technical studies help inform a round of competitive procurements starting to be issued 2023. We will further use the input and data to find synergies between commercial and community interests to refine our grid plans and future competitive procurements in 2024 and beyond.

We launched interactive renewable energy maps at hawaiipowered.com/rez to gather public input. See Figure 4-12 for a screenshot of the interactive map website.

Figure 4-12. Screenshot of the REZ interactive maps

On this site, community members could learn about the development of the potential renewable energy zones and add their input by placing pins with comments on the maps, representing areas of opportunities and challenges. Examples of opportunities and challenges are:

- **Opportunities:** Which areas could be successful sites for future energy projects?
  - Available land/property
  - Access to existing energy grid
  - Vacant building/property
  - Co-location possibilities
- **Challenges:** Which areas would be most challenging?
  - Steep terrain
  - Sensitive species
  - Cultural sensitivities
  - New or planned construction
  - Recreation
  - Agriculture

The REZs input period was open from September 2022 to February 2023. Participants could view other pins and comments on the maps, and the record of comments remained available online once the input period closed.

We conducted a media campaign from January 17 to February 12, 2023, called "Power Up," to promote the REZ website and public input opportunity. The campaign involved placing ads on Instagram and Facebook, sending emails to all stakeholders on the project email list, leveraging Hawaiian Electric's customer communication email system, and publishing a blog post and e-newsletter.

Power Up received 6,334 visits from 5,385 unique visitors, primarily on mobile devices. The campaign was extremely successful, resulting in a lot of visitors, extended time spent on the page (just under 2 minutes), and more than 500 comments.

Figure 4-13 depicts a Power Up Facebook ad. Viewers could click the ad to visit the REZ maps and share their input. See Appendix A for additional copies of the social media ads and information about their reach, as well as copies of the email to stakeholders and e-newsletter to all project subscribers.

Figure 4-13. Social media ad to promote the opportunity to provide input on the renewable energy zones

We also took the REZ maps on the road, soliciting in-person feedback at the public events detailed above, including local fairs and festivals, and community workshops. At these events, we asked participants to place dots on the maps, representing areas of opportunities (green dots) and challenges (yellow dots). Figure 4-14 displays the sticker-dot activity from Maui community workshops in fall 2022.

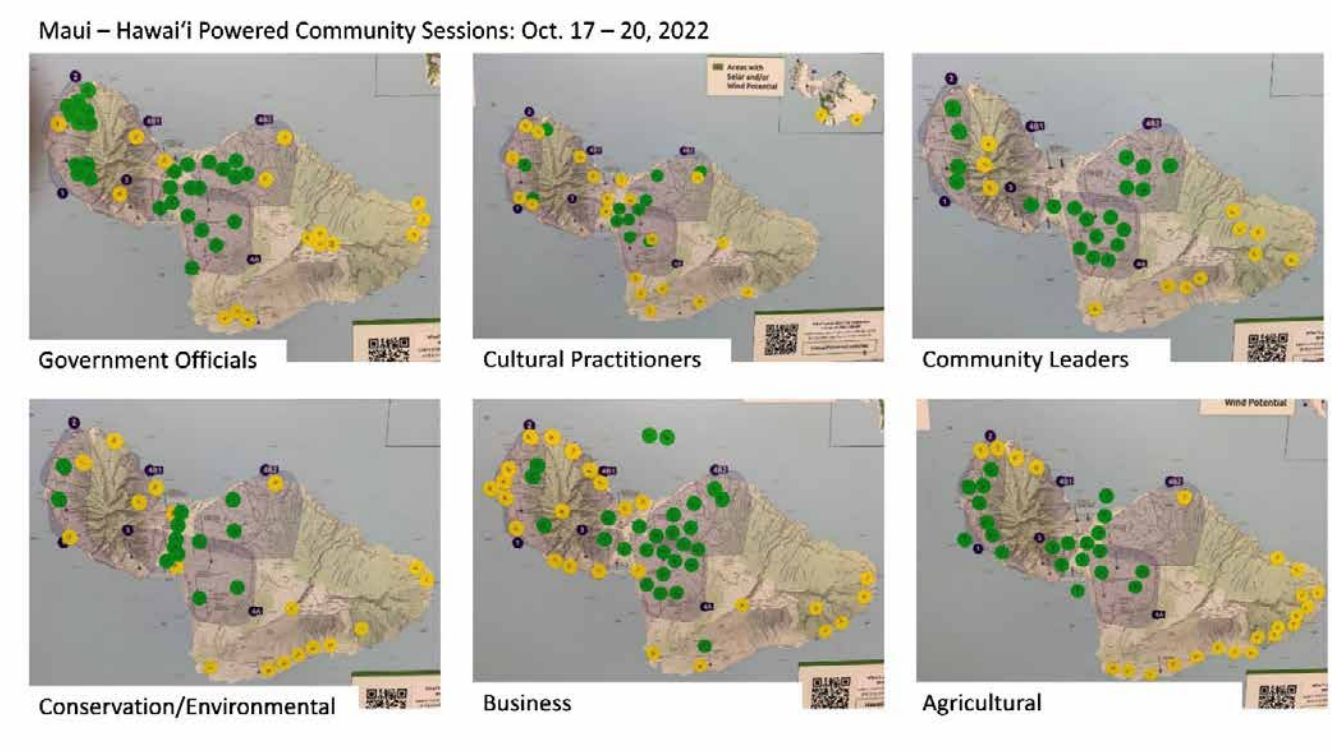


Figure 4-14. Participants at Maui community workshops, fall 2022, placed stickers representing opportunities and challenges within renewable energy zones

We received more than 500 comments on the online and in-person maps. We sorted comments into categories that correspond to key considerations in Integrated Grid Planning: time, affordability, community, land use, and resilience and reliability. See Appendix A for a record of all public comments posted to the REZ interactive maps.

We will consider the comments we received as we work with communities and developers to identify opportunities for future renewable energy projects. See Section 10 for additional discussion on public input as it relates to energy equity.

5. Today's Planning Environment

Since we began the Integrated Grid Planning process in 2018, global and local environmental factors have significantly changed. During 2020, we saw dramatic decreases in electricity usage impacting the operations of our system; in 2022, we started to see recovery to pre-pandemic levels.

Inflation and tight supply chains have plagued progress on renewable energy projects and access to foundational grid equipment. This has caused upwards of 30% increased cost for solar and battery energy storage equipment and short supply of skilled labor. Oil prices spiked in part because of the Russia-Ukraine conflict, resulting in an increase of electricity rates.

Customers continue to affirm through our public engagement that reliability and affordability are most important to them. Intertwined are energy justice and equity issues as certain customers are being left behind, creating a clean energy divide.

Our grid planning is guided by laws and policies enacted by the Hawai'i State legislature, along with the multitude of interrelated proceedings before the Public Utilities Commission. Hawai'i continues to lead the nation in climate and environmental policies, particularly in the electricity sector. Overarching State policies that guide our grid planning include 100% renewable energy by 2045 and statewide greenhouse gas reductions of 50% by 2030 and net negative by 2045 compared to 2005 levels.

5.1 Hawai'i Energy Policy

In 2008, a memorandum of understanding between the State of Hawai'i and DOE launched the Hawaii Clean Energy Initiative, which laid out the foundational elements to achieving Hawai'i's clean energy future. It envisioned that 60% to 70% of future energy needs would be provided by renewable energy, including energy efficiency. Then, in 2014, a re-commitment to the Hawaii Clean Energy Initiative blazed the pathway for the nation's first ever 100% renewable portfolio standard by 2045. The memorandum of understanding between Hawai'i and DOE set forth several key goals:

- To define the structural transformation that will need to occur to transition Hawai'i to a clean energy–dominated economy
- To demonstrate and foster innovation in the use of clean energy technologies, financing methodologies, and enabling policies designed to accelerate social, economic, and political acceptance of a clean energy–dominated economy
- To create opportunity at all levels of society that ensures widespread distribution of the

benefits resulting from the transition to a clean, sustainable energy state

- To establish an "open source" learning model for others seeking to achieve similar goals
- To build the workforce with crosscutting skills to enable and support a clean energy economy

Table 5-1 summarizes the key energy policies enacted by the legislature over the past 15 years, which has led to significant progress in shaping Hawai'i's sustainable energy future. The sum of these policies are considered in our planning as described in this report.

Table 5-1. Key State Policies and Legislation That Drive Energy Planning

Sector	Strategy	State Policy
Electricity	Clean electricity standard Performance incentives	Act 155 (SLH 2009) set an RPS target of 25% by 2020 and 40% by 2030. Act 97 (SLH 2015) modified the RPS to 70% by 2040 and 100% by 2045. Act 5 (SLH 2018) initiated the performance-based regulation proceeding, to establish performance incentives and penalties to accomplish State policy goals (e.g., accelerated RPS achievement).
Climate	Statewide decarbonization Climate emergency	Act 15 (SLH 2018) set a target to sequester more atmospheric carbon and greenhouse gases than the state produces no later than 2045, which was furthered in 2022 by Act 238 to set a target to reduce statewide emissions by 50% by 2030 compared to 2005 levels. Act 23 (SLH 2020) ceased coal burning for electricity operations by 12/31/2022. This led to the closure of the AES coal plant in September 2022. Senate Concurrent Resolution 44 (2021) declaring a climate emergency and requesting statewide collaboration toward an immediate just transition to restore a safe climate.
On-road transportation	Light-duty zero-emissions vehicles (ZEVs)	Act 74 (SLH 2021) Plan and coordinate vehicle acquisition to meet the following clean ground transportation goals: (1) 100% of passenger vehicles in the State's fleet shall be ZEVs by 12/31/2030 and (2) 100% of light-duty vehicles in the State's fleet shall be ZEVs by 12/31/2035.
Buildings	Building electrification Building codes/ appliance standards EE programs DER resources	Act 99 (SLH 2015) set a goal for the University of Hawai'i to achieve net-zero energy usage by 2035. Act 176 (SLH 2016) set a goal for the Hawai'i Department of Education to achieve net-zero energy usage by 2035. Act 204 (SLH 2008) required a solar water heater for all new single-family dwellings. State Building Code Council establishing statewide adoption of 2018 International Energy Conservation Code (IECC) for residential and commercial buildings. Act 141 (SLH 2019) established minimum appliance efficiency standards. Act 155 (SLH 2009) established an EE portfolio standard of 4,300 GWh statewide reduction by 2030. Act 100 (SLH 2015) established a CBRE program.
Resilience	Microgrids	2018 Act 200 (SLH 2019) encouraged the development of the microgrid services, which led to Public Utilities Commission approval of Hawaiian Electric Rule 30.
Equity	Energy equity	Senate Concurrent Resolution 48 (2022) requested the Public Utilities Commission to consider efforts to mitigate high energy burdens for LMI customers and integrate energy equity across its work.

Each county in Hawai'i also has or is in the process of developing sustainability plans in alignment with State policy. For example, the City and County of Honolulu will transition its vehicle and bus fleet to electric as required by Ordinance 20-47. The Department of Transportation Services now has 17 electric buses (eBuses) in service and has installed bus charging equipment to kick-start TheBus transition to 100% electric. It has also stated a goal of 45% reduction in targeted greenhouse gas emissions by 2025 relative to 2015.

5.2 Federal Policies

At the federal level, the Biden Administration has set forth the following climate goals, which are consistent with State policies:

- Reducing U.S. greenhouse gas emissions 50%–52% below 2005 levels in 2030
- Reaching 100% carbon pollution–free electricity by 2035
- Achieving a net-zero emissions economy by 2050
- Delivering 40% of the benefits from federal investments in climate and clean energy to disadvantaged communities

The U.S. Department of Defense is our largest customer, and all branches of the military are represented in our service territory, highlighting the importance of a reliable and resilient electric system in support of the national defense and the Indo-Pacific region. The U.S. Army, Navy, and Marines have set forth climate strategies. The Army Climate Strategy seeks to achieve 50% reduction in Army net greenhouse gas pollution by 2030 compared to 2005 levels; attain net-zero emissions by 2050; install a microgrid on every installation by 2035; provide 100% carbon pollution–free electricity for Army installations by 2030; and electrify light-duty, non-tactical, and tactical vehicles. Similarly, the Department of Navy Climate Action 2030 plan seeks to reduce greenhouse gases by 65% by 2030 from 2008 levels, provide 100% carbon pollution–free electricity by 2030, with half locally supplied, and acquire 100% zero-emissions vehicles (ZEVs) by 2035.

5.2.1 Bipartisan Infrastructure Law and Inflation Reduction Act

In 2022, the U.S. Congress enacted two bills in support of the Biden Administration's goals that will significantly impact the nation's clean energy transition. We along with the State are aggressively pursuing federal funding to ease the financial burden of the clean energy transition on Hawai'i's residents.

Collectively, the Infrastructure Investment and Jobs Act and Inflation Reduction Act represent a fleeting opportunity for the State and our customers and communities to obtain federal funding to advance sustainability and resilience goals. We have identified a portfolio of projects that have the highest impact and chance for success—grid resilience, grid flexibility and modernization, electrification of transportation, and middle mile broadband. The Inflation Reduction Act also provides investment tax credits for standalone storage, which could benefit the Waena and Keahole battery energy storage projects that were selected through the Stage 2 competitive procurement.

Our middle mile broadband application is pending and awaiting award notice, which could come with up to a 69% federal match in funding. In December 2022, we submitted two concept papers to DOE and in February 2023 we received formal notice encouraging submission for a full application for grid resilience and grid flexibility and modernization with a potential for a 50% match in federal funding. These awards could reduce customer costs for our grid modernization and climate adaptation and transmission and distribution resilience programs.

5.3 Interrelated Dockets

Integrated Grid Planning and Performance-Based Regulation proceedings are foundational to implementing State energy policy and achieving its goals. In combination, these two proceedings shape how we will continue to serve Hawai'i with clean, affordable, and reliable energy.

A multitude of ongoing proceedings are currently before the Public Utilities Commission, in collaboration with Hawai'i energy stakeholders, intended to carry out the legislature's policies. The Integrated Grid Plan is foundational to these interrelated proceedings because it sets forth a well vetted common set of assumptions and lays out future pathways as we move toward our decarbonization goals. Having Public Utilities Commission–approved Integrated Grid Plan and priorities set under Performance-Based Regulation (along with a stable financial structure for the utility) allows other dockets to advance more efficiently by reducing protracted discussions on forward-looking assumptions and resource plans. The Integrated Grid Plan sets the direction to implement other initiatives and programs. Throughout this report we note where other dockets are intertwined with the Integrated Grid Plan. The Stakeholder Council discussed the importance of maintaining the interrelationship of the following dockets.

Performance-Based Regulation (Docket 2018-0088). A docket to reform Hawai'i's regulatory framework through regulatory mechanisms focused on utility performance and alignment with public policy goals.

Performance-Based Regulation and the Integrated Grid Plan build upon one another, including but not limited to performance incentives for RPS achievement, interconnection of rooftop solar and large-scale resources, fossil-fuel cost risk sharing, generation reliability, and Extraordinary Project Recovery Mechanism (EPRM) to enable needed investments to transition the grid we need. Priorities outlined in Performance-Based Regulation are areas that the Integrated Grid Plan seeks to address and may also drive future adjustments to Performance-Based Regulation such that the execution of our near- and long-term plans are aligned with Performance-Based Regulation priorities that ultimately accomplish our decarbonization goals.

Community-Based Renewable Energy Program (Docket 2015-0389). A docket to create a market-based framework that enables renewable energy opportunities for customers who are unable to have on-site distributed generation.

CBRE resources acquired through CBRE Phase 1 and assumptions to fulfill the Phase 2 program capacity are part of the planned resources in our plans. The CBRE resources in our plans play an important role in providing essential grid services under a renewable dispatchable PPA while simultaneously expanding customer access to renewable energy for those without a roof to install solar, LMI customers, or renters.

Competitive Bidding Process to Acquire Dispatchable and Renewable Generation (Docket 2017-0352). A repository docket for RFP, PPAs, and other documents related to the procurement of large-scale renewable resources and grid services.

Since the power supply improvement plans in December 2016 we have issued procurements for large-scale renewable dispatchable generation through three stages of procurements, known as Stages 1, 2, and 3. Through Stages 1 and 2, solar paired with battery energy storage and standalone energy storage have been the lowest-cost technologies awarded contracts. Many of these projects have been plagued by supply-chain and other issues caused by the pandemic. A Stage

3 procurement is currently in progress to procure additional renewable energy and also seeks firm renewable generation to enable retirement of existing fossil fuel–based generators. The Stage 3 renewable energy targets are a part of the planned resources in our analysis.

Microgrid Services Tariff (Docket 2018-0163). A docket to establish a greater structure around microgrid interconnection(s) and the value of services provided by microgrids through a microgrid services tariff.

Through this proceeding, we worked with stakeholders to develop a microgrid services tariff that enables communities to build microgrids for added resilience. Enhancements to enable more participation in microgrids are expected to continue in Phase 2 of the proceeding. However, in parallel we have worked with the Resilience Working Group and the Energy Transition Initiative Partnership Project to identify and prioritize critical and vulnerable customers. As discussed in Section 7, microgrids are part of our tools to enhance grid resilience.

Electrification of Transportation Roadmap (Docket 2018-0135). A docket to evaluate the state of EV technology and the EV market in Hawaiʻi and Hawaiian Electric's near- and long-term priorities for electrifying the transportation sector.

As part of the Integrated Grid Planning forecasts and assumptions we have developed EV adoption forecasts with managed charging load usage to determine the benefits of workplace and daytime charging. We also describe the potential distribution infrastructure needed to integrate electrification onto our grids. See Sections 8 and 11.

Distributed Energy Resource Policies (Docket 2019-0323). A docket to investigate technical, economic, and policy issues associated with distributed energy resources and further develop a portfolio of broader DER customer options.

As discussed in Section 6, we have incorporated future DER programs and time-of-use (TOU) rates, including managed EV charging, as part of our forecasted electric load.

An important component of our resource portfolio to date and into the future are customer resources, including private rooftop solar, battery energy storage, electric vehicles, and energy efficiency. These customer technologies are prominently discussed throughout this report.

Investigation of Energy Equity (Docket 2022-0250). A docket to investigate energy equity to further State policy goals, improve energy affordability, reduce energy burdens for vulnerable customers, and ensure that the benefits of the renewable energy transition are equitably distributed, among other things.

We are keen on addressing energy equity, as discussed in Section 10, as we strive to make the transition to our decarbonized future as equitable as possible. In our engagement with customers, we have heard firsthand from communities burdened by hosting energy infrastructure and projects. We have also heard from customers that affordability is their highest consideration.

6. Data Collection

In the data collection phase of the process we engaged with numerous Working Groups made up of industry leaders, economists, and engineers along with our Stakeholder Council and Technical Advisory Panel to collect data to forecast how customers will choose to consume and produce energy in the future. This includes evaluating the propensity for customers to adopt new technologies like private rooftop solar, battery energy storage, electric vehicles, and energy-efficient appliances, among other key inputs and assumptions.

These forecasts allow us to develop scenarios and pathways to understand how energy needs will change over a range of possible futures. For example, we will use a high and low adoption rate of customer technologies to determine the lowest-cost way to deliver renewable energy to customers.

We aim to create the grid as a platform to support both active and passive customers of the grid—for those who desire traditional electric service or for those who want greater control over their energy use. The choices customers make in adopting technologies and the ways they choose to use electricity influence how many large-scale projects we must pursue. We used these forecasts in our analysis to lay out pathways for a grid that works for all.

See Appendix B for more details on the forecasts, assumptions, and methodologies used as part of the Data Collection phase and overall planning process.

6.1 Load Forecast Methodology and Data

The customer load forecast is a key assumption for the planning models that provide the energy requirements and peak demands that must be served by the grid through the planning horizon. Based on the recommendation of the Technical Advisory Panel we developed a High electricity demand and Low electricity demand projection to test how the cost and portfolio of resources would change for a range of peak demand and load profiles. The scenarios described in Section 6.8 provide a range of forecasts to plan for uncertainties in adoption of customer technologies, which ultimately drive the amount of electricity we forecast our customers will consume.

We developed forecasts for each of the five islands and began with the development of the energy forecast (i.e., sales forecast) by rate class (residential, small, medium, and large commercial and street lighting) and by layer (underlying load forecast and adjusting layers: energy efficiency, distributed energy resources, electrification of transportation, and time-of-use rate load shift).

The underlying load forecast is driven primarily by the economy, weather, electricity price, and known adjustments to large customer loads and is informed by historical data, structural changes[1], and historical and future disruptions. The impacts of energy efficiency, distributed energy resources, primarily private rooftop solar with and without storage (i.e., batteries), and electrification of transportation (light-duty electric vehicles and electric buses, collectively "EoT") were layered onto the underlying sales outlook to develop the electric sales forecast at the customer level. Load shifting in response to time-of-use rates was also included as a forecast layer. Because we assumed a net-zero load shift (i.e., load reductions during the peak period are offset by load increases during other periods), there is impact to the peak forecasts, but no impact to the sales forecasts. The *March 2022 Inputs and Assumptions Report* provides additional descriptions of the load forecast assumptions and methodologies.

The modeling process to identify grid needs relies on a set of forecast assumptions to define what we believe the future system could look like. Many of these assumptions have been developed by the forecast assumptions, the solution evaluation and optimization, and the Stakeholder Technical Working Groups.

6.2 Distributed Energy Resources Forecasts

The DER forecast layer, mainly private rooftop solar and battery energy storage systems (BESSs), includes new additions of rooftop solar capacity by island, rate class and program, and projected sales impact from these additions. We used current/near-term pending and approved DER applications and the long-term economic payback of customers installing a private rooftop solar system to develop the forecast.

At the time forecasts were developed, advanced rate designs (ARDs) and long-term DER programs were in the process of being finalized. We assumed that the future customer solar programs compensate for export that is aligned with system needs and allow for controllability during system emergencies. The export compensation and tariff structure for future customer solar programs were based on the Standard DER Tariff for all islands that we proposed in the DER docket[2]. On January 25, 2022, the Public Utilities Commission issued Order 38196 establishing the framework for the Smart DER Tariff[3]. While export compensation, incentives, and tariff structure for the Smart DER Tariff are awaiting final Public Utilities Commission approval, anecdotal conversations with industry experts, customer application, and permit data show that customers are choosing to use battery storage to shift their generation to offset their own load rather than exporting to the grid during the daytime.

In addition, for O'ahu and Maui, we incorporated the current Battery Bonus program[4], and assumed new DER-provided grid services (i.e., bring-your-own-device programs) as part of a long-term DER program. Consistent with the Battery Bonus program, incentives would be paid based on performance and commitment of the customer resource. We assumed customers participating in Battery Bonus export at the battery system's rated capacity (kilowatts [kW]) (if energy is available) for a 2-hour duration during the evening peak window

[1] Structural changes include the addition of new resort loads or new air conditioning loads that have a persistent impact on the forecast.

[2] *See* Hawaiian Electric's DER Program Track Final Proposal filed on May 3, 2021, in Docket 2019-0323, Instituting a Proceeding to Investigate Distributed Energy Resource Policies pertaining to the Hawaiian Electric Companies.

[3] 3 See Order 38196 issued on January 25, 2022, in Docket 2019-0323, Instituting a Proceeding to Investigate Distributed Energy Resource Policies pertaining to the Hawaiian Electric Companies.

[4] *See* Order 37816 issued on June 8, 2021, in Docket 2019-0323, Instituting a Proceeding to Investigate Distributed Energy Resource Policies pertaining to the Hawaiian Electric Companies.

each day. Future retrofits for net energy metering customers assumed both an addition of a battery system, 5 kW/13.5 kWh, and an increase in photovoltaic (PV) capacity, 5 kW[5]. The described methodology and forecast sensitivities appropriately capture the Public Utilities Commission–approved Battery Bonus program targeting 50 MW on O'ahu and 15 MW on Maui.

NREL 2021 Annual Technology Baseline (ATB) forecasts PV and BESS costs to continue to decline and with the rollout of a broad opt-out time-of-use rate, we assumed that most future systems under the future Smart DER Tariff will be paired with storage. Furthermore, the rollout of a broad opt-out time-of-use rate would increase the incentive to pair future systems with storage.

Table 6-1 and Table 6-2 summarize the private rooftop solar and energy storage forecasts by island used in the Base electricity demand scenario.

Table 6-1. Cumulative Distributed PV Capacity (kW)

Year	O'ahu	Hawai'i Island	Maui	Moloka'i	Lāna'i	Consolidated
kW	A	B	C	D	E	F =A + B + C + D +E
2025	723,234	138,801	158,260	3,200	1,050	1,024,545
2030	830,974	164,392	185,501	3,696	1,356	1,185,919
2040	993,411	209,179	227,968	4,476	1,888	1,436,922
2045	1,053,934	227,449	242,917	4,768	2,085	1,531,153
2050	1,104,843	243,258	255,327	4,952	2,266	1,610,646

Table 6-2. Cumulative Distributed BESS Capacity (kWh)

Year	O'ahu	Hawai'i Island	Maui	Moloka'i	Lāna'i	Consolidated
kWh	A	B	C	D	E	F =A + B + C + D +E
2025	317,754	84,230	128,263	1,348	515	532,110
2030	493,412	126,316	179,030	2,308	875	801,941
2040	756,521	196,611	254,943	3,976	1,550	1,213,601
2045	848,456	224,301	282,258	4,588	1,829	1,361,432
2050	923,096	247,272	303,603	5,068	2,072	1,481,111

6.2.1 High and Low Bookend Sensitivities

High and low adoption rates were developed to capture uncertainties associated with the base assumptions. Under these sensitivities, we modified assumptions to the addressable market, incentive structure, and technology costs.

Under the High Sensitivity, we assumed an extension of the federal investment tax credit through 2032, with residential investment tax credits ending and commercial investment tax credits settling at 10% in 2033. These assumptions closely align to the final provisions under the Inflation Reduction Act, signed into law on August 16, 2022. The long-term upfront incentives for a future grid services program on all islands were also increased to $500/kW for the high DER forecast.

NREL 2021 ATB Advanced Scenario cost curves for residential and commercial PV and battery systems were selected for the High DER sensitivity

[5] Order 37816 permits existing PV customers to add up to 5 kW of additional PV generation capacity.

forecast. The ATB Advanced Scenario assumes a rapid advancement in technology innovation and manufacturing at levels above and beyond the current market, resulting in lower projected costs compared to the ATB Moderate Scenario.

The Low DER sensitivity (compared to the Base) assumes a smaller addressable market, no long-term export program, and no additional incentives for distributed energy resources.

The No State Income Tax Credit (ITC) sensitivity was modeled assuming a 0% State ITC starting in 2022, resulting in lower DER uptake compared to the Base forecast. In both sensitivities, DER system costs and tax credit assumptions were updated similarly to the current Base scenario. Figure 6-1 illustrates the revised DER forecasts for O'ahu.

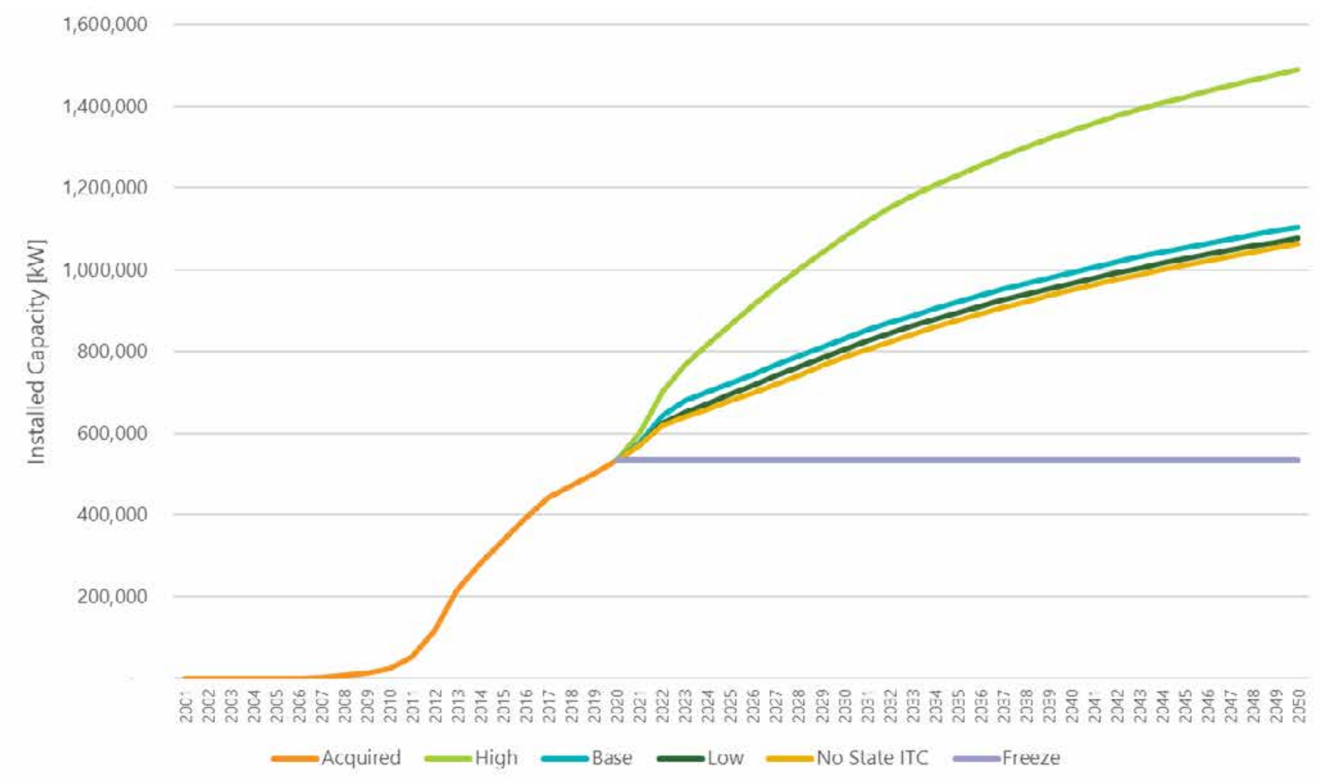


Figure 6-1. O'ahu DER bookend sensitivities

6.3 Advanced Rate Design Impacts

The advanced rate design discussed in the DER docket includes the implementation of default time-of-use rates, with an option to return to the prior rate schedule, applicable also to all new DER customers. Consistent with advanced rate design, each customer that adopts private rooftop solar and energy storage and/or electric vehicles under managed charging scenarios is effectively shaping their consumption aligned with a time-of-use rate. For example, DER customers would charge their energy storage system with rooftop solar during the day and discharge the energy in the evening. This load shifting is captured in the forecasted battery energy storage profiles. Because these kinds of DER customers are already assumed to be shifting their load in a manner consistent with that encouraged by proposed time-of-use rates, minimal to no additional load shift would be expected in response to time-of-use rates for these customers. The managed charging forecast profiles for EV customers reflect customers charging electric vehicles during the day in response to time-of use rates.

We evaluated time-of-use load shifting impact for non-DER and non-EV customers. Table 6-3 was used to develop time-of-use load shift scenarios for residential customers.

Table 6-3. Summary of Assumptions Used to Develop Residential TOU Load Shift Sensitivities

Input	Low	Base	High
Rates	Hawaiian Electric Final ARD Proposal	Hawaiian Electric Final ARD Proposal	DER Parties Final ARD Proposal
Residential customer pool	All non-DER residential customers = residential forecast minus High DER Sch-R forecast	All non-DER residential customers = residential forecast minus Base DER Sch-R forecast	All non-DER residential customers = residential forecast minus Base DER Sch-R forecast
AMI rollout	100% by 2025, straight line from current deployment to 2025	100% by 2025, straight line from current deployment to 2025	100% by 2025, straight line from current deployment to 2025
TOU rollout	Default rate for AMI meters ramps up from 2022 to 2026	Default rate for AMI meters ramps up from 2022 to 2026	Default rate for AMI meters ramps up from 2022 to 2026
Load shift method	Net-zero load shift	Net-zero load shift	Net-zero load shift
TOU opt-out rate (%)	25%	10%	10%
Price elasticity	-0.045	-0.070	-0.070

On October 31, 2022, the Public Utilities Commission issued Decision and Order 38680 under Docket 2019-0323, establishing a framework for the determination of the new time-of-use rates. Under the order, the Public Utilities Commission directed the new time-of-use energy charge to have a price ratio of 1:2:3 for the daytime, overnight, and evening peak periods. While the Public Utilities Commission's order came after the establishment of the forecast we assumed a 1:2:3 ratio in the time-of-use High sensitivity forecast. We will also conduct a study on the customers assigned to the time-of-use rates pilot to understand the impacts and effectiveness of the rate design. We will consider how to incorporate findings from the study into future Integrated Grid Planning cycles. For this cycle, we believe that the High and Low bookend scenario reflects significant load shaping and generally captures unanticipated impacts of rate design changes or behavioral changes for customers who do not have an electric vehicle or rooftop solar and energy storage.

The uncertainty of these and other future changes in customer trends are what the High and Low bookends are intended to capture such that any changes that may occur, that impact the net demand, would fall within the bookends.

6.4 Electrification of Buildings and Energy Efficiency

The EE layer is based on projections from the July 2020 State of Hawaii Market Potential Study prepared by Applied Energy Group (AEG) and sponsored by the Hawaiʻi Public Utilities

Commission.[6] The market potential study considered customer segmentation, technologies and measures, building codes, and appliance standards as well as progress toward achieving the Energy Efficiency Portfolio Standards. The study included technical, economic, and achievable EE potentials. AEG reclassified certain market segments to different customer classes to align with how we forecast sales.

6.4.1 High and Low Bookend Sensitivities

An achievable business-as-usual (BAU) EE potential forecast by island and sector covering the years 2020 through 2045 was provided in February 2020 to use as our Base forecast. The business-as-usual potential forecast represented savings from realistic customer adoption of EE measures through future interventions that were similar in nature to existing interventions. In addition to the business-as-usual forecast, AEG provided a codes and standards (C&S) forecast and an Achievable: High forecast. The Achievable: High potential forecast assumed higher levels of savings and participation through expanded programs, new codes and standards, and market transformation.

The additional EE potentials provided by AEG allowed for the creation of various forecast sensitivities. As a result, we developed three different sensitivities, Low, High, and Freeze. Table 6-4 and Figure 6-2 summarize the EE sensitivities and their forecasted annual sales (GWh).

Table 6-4. Energy Efficiency Bookend Sensitivities

Low	Base	High	Freeze
BAU (Reduced by 25%)+ C&S	BAU + C&S	Achievable: High + C&S	Forecasted BAU capacity fixed at 2021 Base forecast + C&S

[6] *See* https://puc.hawaii.gov/wp-content/uploads/2021/02/Hawaii-2020-Market-Potential-Study-Final-Report.pdf

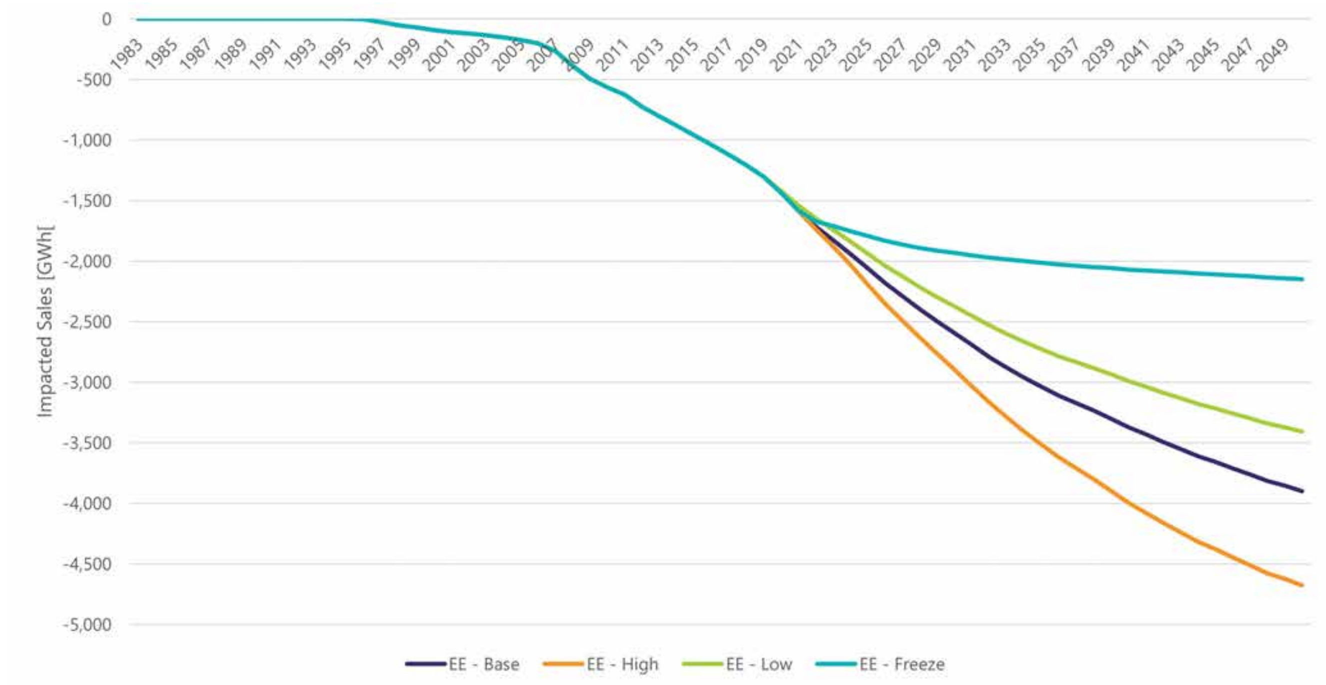


Figure 6-2. O'ahu energy efficiency annual sales forecast impact sensitivities

6.4.2 Energy Efficiency Supply Curve Bundles

EE supply curve bundles were developed to determine the optimal amount of EE measures compared to the assumed forecasted energy efficiency using the results of the market potential study that AEG performed on behalf of the Public Utilities Commission. These supply curves were used in the EE supply curve sensitivity discussed in Section 11.1.3.

6.4.2.1 Energy Efficiency Supply Curve Development Methodology

The supply curves were developed to treat energy efficiency as an available resource to be selected based on its cost and value. This required creating a new level of EE potential, referred to as "achievable technical," before applying any screens for cost-effectiveness.

Peak Impacts

Each EE measure has an island-specific load shape, which was created during the potential study process. By taking the annual savings calculated from the market potential study and distributing it across this shape, impacts in each hour of the year can be calculated for each measure shape. The relative "peakiness" of each measure was considered by comparing its impacts during peak hours to a flat shape. Peak impacts refer to impacts on the average weekday evening peak hour (between 6 and 8 p.m.) and are calculated as the average impacts during such hours.

Figure 6-3 shows the average impacts of all measures within each classification using O'ahu as an example, based on cumulative potential in 2030. As expected, peak-focused measure impacts are strongly concentrated in the weekday evening hours, whereas "other" measure impacts are much flatter.

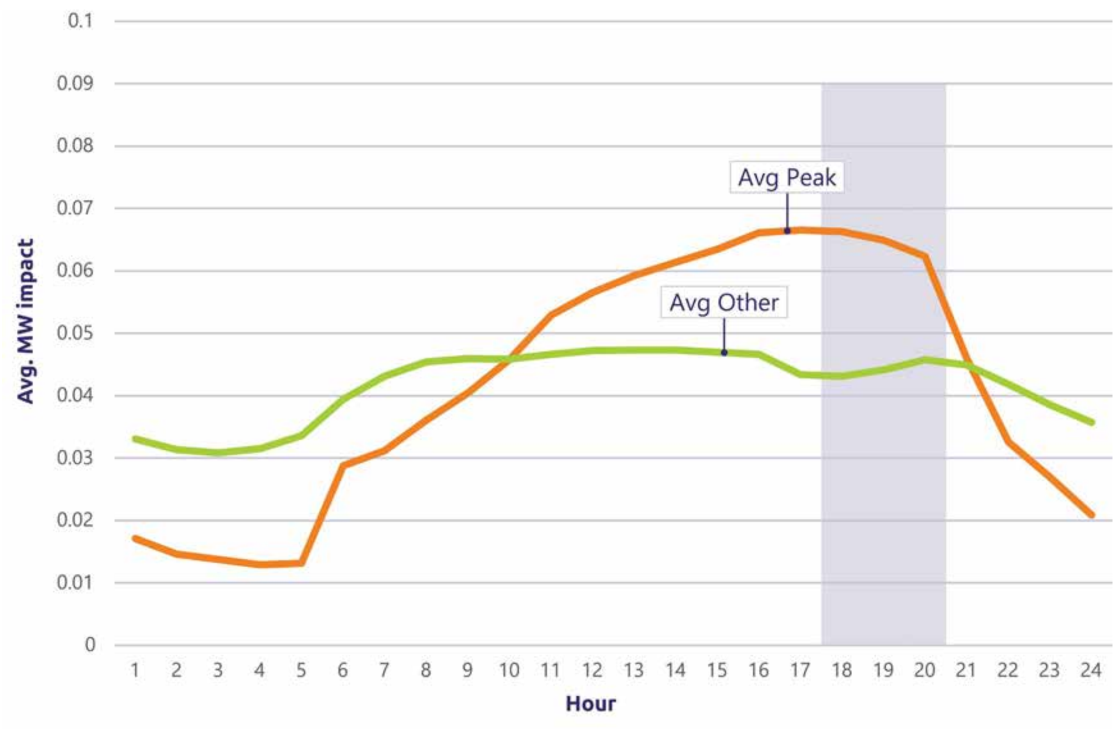


Figure 6-3. Averaged weekday impacts by measure classification, cumulative in 2030 (peak vs. other, O'ahu)

6.4.2.2 Analysis Results

Figure 6-4 shows the incremental energy savings potential for each bundle over the forecast period. The sharp increase in savings in 2025 coincides with an increase in commercial linear lighting installations because of equipment turnover in the potential study modeling. These annual savings values do not include reinstallation of measures that were previously incentivized and may have expired. While these measures will need to be reacquired in later years, they will not increase the total cumulative potential, so those reacquisition savings are excluded from this perspective.

There could be marginal additional savings at the time of reacquisition, such as if technology standards have improved in the intervening years; however, such savings would be difficult to quantify directly using the outputs of the market potential study. The modeled potential without reacquisitions is a conservative estimate to avoid overstating potential.

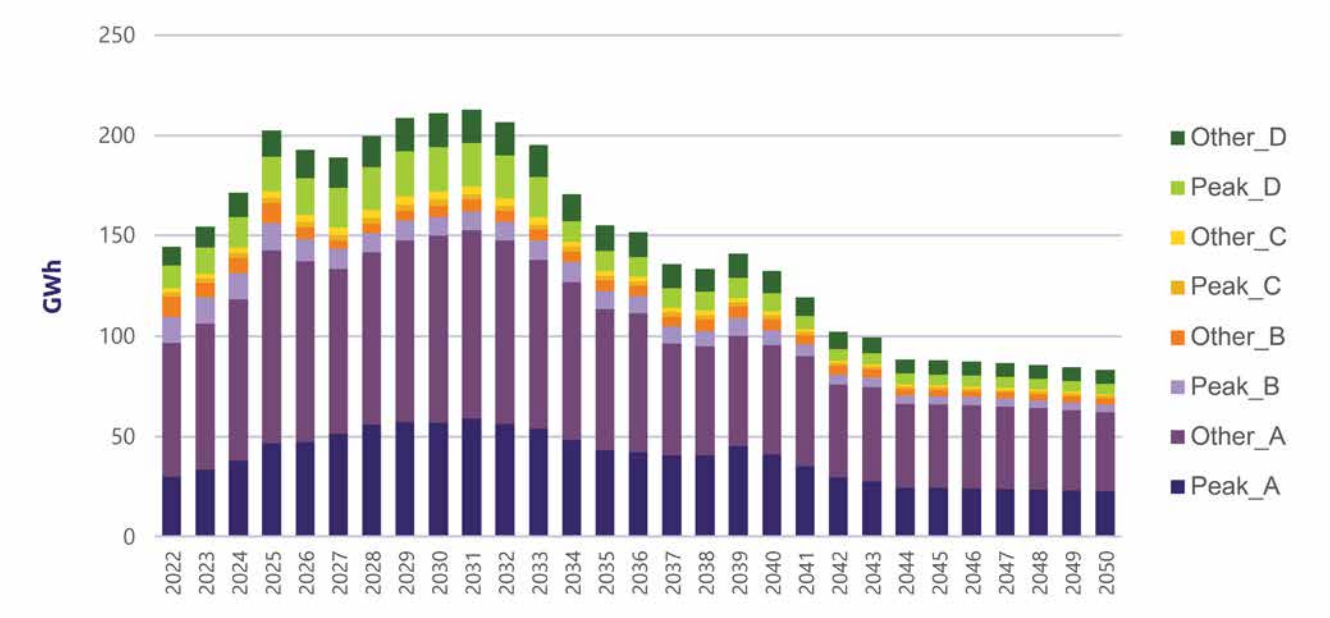


Figure 6-4. Incremental annual energy savings potential (achievable technical) by measure bundle (all islands combined)

The peak bundles are dominated by the cooling end use. The Peak A bundle, which includes the most cost-effective measures from the potential study, gets 77% of its savings from the cooling end use. The "Other" bundles are made up mainly of water heating, lighting, and appliance measures, which tend to have flatter or even morning-focused shapes.

6.5 Electrification of Transportation

The EoT layer consists of impacts from the charging of light-duty electric vehicles and electric buses. A medium and heavy-duty EV forecast has been identified for inclusion for the next Integrated Grid Planning cycle.

6.5.1 Light-Duty Electric Vehicles

The light-duty EV forecast was based on an adoption model developed by Integral Analytics, Inc. as described in Appendix E of the EoT Roadmap[7] to arrive at EV saturations of total light-duty vehicles by year for each island. Historical data for LDV registrations were provided by the State Department of Business, Economic Development, and Tourism and reported at the county level. The development of the EV forecast used the EV saturation by island to arrive at the number of light-duty electric vehicles.[8] Although EV saturations were not specifically consistent with carbon neutrality in Hawai'i by 2045, they are consistent with county goals for converting their fleets to 100% zero-emissions vehicles by 2035.

[7] *See* https://www.hawaiianelectric.com/documents/clean_energy_hawaii/electrification_of_transportation/201803_eot_roadmap.pdf

[8] *See* https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/forecast_assumptions/PUC-HECO-IR-1_att_8_electric_vehicles.xlsx

6.5.2 Electric Buses

The eBus forecast was based on discussions with several bus operators throughout Honolulu, Hawai'i, and Maui Counties. Route information and schedules for weekdays, weekends, and holidays were used to estimate the miles traveled for each bus operator. For each island, the total sales impact for each bus operator was applied to the rate schedule on which each bus operator was serviced.

6.5.3 High and Low Bookend Sensitivities

Three additional light-duty EV forecast sensitivities (Low, High, and Freeze) were developed using varying adoption saturation curves. At the June 17, 2021, Stakeholder Technical Working Group meeting, Blue Planet presented its suggested sensitivity representing a policy of 100% zero-emissions vehicles by 2045 in the Faster Technology Adoption scenario, a change from the previously presented high saturation curve. Following that meeting, we developed a high customer adoption forecast based on the Transcending Oil Report prepared by the Rhodium Group in 2018. The Transcending Oil Report study considered vehicle scrappage rates and the transition rate of vehicle sales to fully electric. The study estimated that all vehicle sales by 2030 would need to be electric to reach 100% EV stock by 2045.[9] A freeze sensitivity was also developed, assuming no new additional electric vehicles above the Base forecast after 2021. Table 6-5 and Figure 6-5 summarize the light-duty EV sensitivities and their forecasted annual sales (GWh).

Table 6-5. Electric Vehicle Forecast Sensitivities

Low	Base	High	Freeze
Low adoption saturation	Market forecast	100% of ZEV by 2045	Forecasted EV counts fixed at 2021 Base forecast

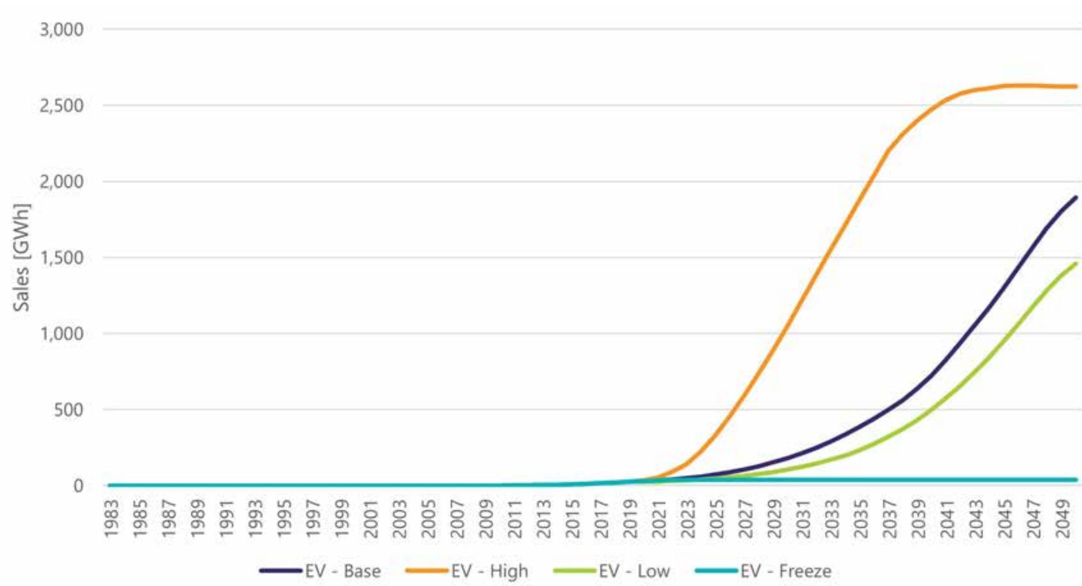


Figure 6-5. O'ahu EV annual sales forecast sensitivities

[9] See Transcending Oil Report by Rhodium Group available at: https://rhg.com/wp-content/uploads/2018/04/rhodium_transcendingoil_final_report_4-18-2018-final.pdf

6.5.4 Managed Electric Vehicle Charging

The managed EV charging profile considers EV driver response to time-of-use rates that were proposed for each island in the EV pilot programs in Docket 2020-0152. A linear optimization was used to model drivers who shift their usage to the daytime to reduce their electricity bill as much as possible, while still retaining enough state of charge to meet their underlying driving profiles. The underlying trip data are the same so the managed and unmanaged charging have the same annual loads. The average managed EV charging profile for select years is provided for Oʻahu in Figure 6-6.

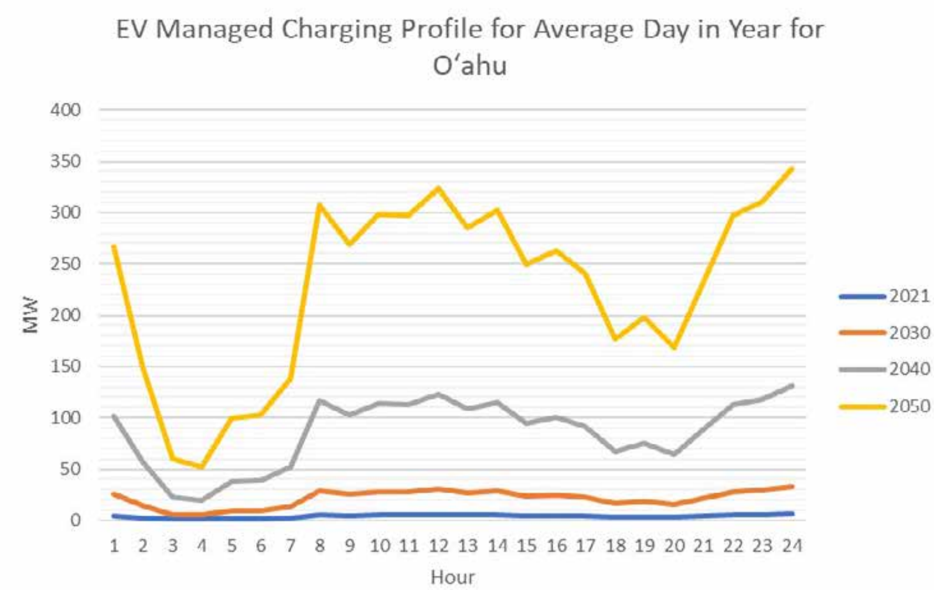


Figure 6-6. Average managed EV charging profile for Oʻahu

6.6 Sales Forecasts

Once all the layers are developed for each island, they are added together to arrive at the sales forecast at the customer level by island as shown in Table 6-6 through Table 6-10.

Table 6-6. Oʻahu Sales Forecast

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	Customer Level Sales Forecast
GWh	A	B	C	D	E = A + B + C + D
2025	9,456	(1,255)	(1,887)	92	6,407
2030	10,133	(1,415)	(2,307)	221	6,632
2040	11,110	(1,642)	(2,917)	789	7,341
2045	11,499	(1,707)	(3,142)	1,366	8,016
2050	11,905	(1,756)	(3,332)	1,964	8,781

Table 6-7. Hawai'i Island Sales Forecast

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	Customer Level Sales Forecast
GWh	A	B	C	D	E = A + B + C + D
2025	1,471	(228)	(268)	10	986
2030	1,535	(263)	(345)	39	967
2040	1,634	(325)	(461)	172	1,020
2045	1,670	(346)	(501)	288	1,110
2050	1,708	(364)	(535)	435	1,244

Table 6-8. Maui Sales Forecast

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	Customer Level Sales Forecast
GWh	A	B	C	D	E = A + B + C + D
2025	1,474	(271)	(300)	14	917
2030	1,572	(312)	(371)	56	945
2040	1,726	(374)	(473)	255	1,134
2045	1,787	(390)	(505)	357	1,248
2050	1,852	(403)	(529)	443	1,363

Table 6-9. Moloka'i Sales Forecast

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	Customer Level Sales Forecast
GWh	A	B	C	D	E = A + B + C + D
2025	36.0	(5.8)	(3.1)	0.1	27.2
2030	36.4	(6.5)	(3.6)	0.3	26.6
2040	37.8	(7.7)	(4.2)	1.1	27.0
2045	38.3	(8.0)	(4.5)	2.1	27.9
2050	38.9	(8.2)	(4.7)	3.2	29.3

Table 6-10. Lāna'i Sales Forecast

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	Customer Level Sales Forecast
GWh	A	B	C	D	E = A + B + C + D
2025	40.8	(1.7)	(1.6)	0.1	37.6
2030	42.2	(2.1)	(2.0)	0.2	38.2
2040	44.1	(2.9)	(2.8)	0.7	39.1
2045	44.7	(3.2)	(3.0)	1.3	39.8
2050	45.6	(3.4)	(3.3)	1.9	40.8

As part of future Integrated Grid Planning cycles, we will consider full economy-wide decarbonization scenarios and their impact on electric sales. This Integrated Grid Planning cycle focused mostly on the decarbonization of buildings, light-duty electric vehicles, and bus segments of the economy. We expect significantly higher electric loads under aggressive electrification scenarios.

6.7 Peak Forecasts

Once the sales forecast is developed by layer (underlying load, rooftop solar and energy storage, energy efficiency, and electric vehicles and buses) for each island, we convert it from a monthly sales forecast into a load forecast at the system level for each hour over the entire forecast horizon. The method converting sales to an hourly load forecast is shown in Figure 6-7. Hourly shapes from class load studies for each rate class or the total system load excluding the impact from solar are used to derive the underlying system load forecast shape. Hourly regression models are evaluated to look for relationships with explanatory variables (weather, month, day of the week, holidays) to accommodate change in the underlying shapes over time for each rate class or total system load. The hourly regression models are used to simulate shapes for the underlying forecast based on the forecast assumptions over the entire horizon. The forecasted energy for the underlying and each adjusting layer is placed under its respective future load shape then converted from the customer level to system level using a loss factor[10] as presented in the July 17, 2019[11] and March 9, 2020[12] Forecast Assumptions Working Group meetings. The result is an hourly net system load for the entire forecast period. The annual peak forecast is the highest value in each year.

Table 6-11 through Table 6-15 show peak forecasts by island.

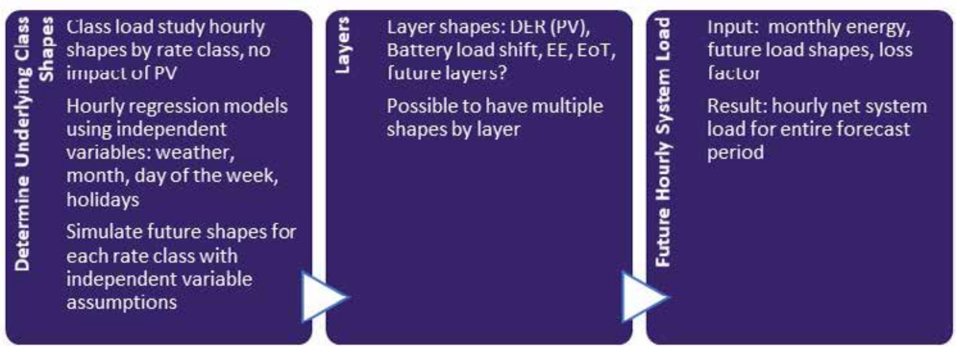


Figure 6-7. Process for converting sales forecast into an hourly demand load forecast

Table 6-11. O'ahu Peak Forecast (MW)

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	TOU	Peak Forecast
MW	A	B	C	D	E	F = A + B + C + D + E
2025	1,579	(60)	(339)	16	(3)	1,193
2030	1,642	(95)	(402)	39	(5)	1,179
2040	1,736	(87)	(454)	145	(4)	1,335
2045	1,702	(43)	(452)	286	(4)	1,490
2050	1,721	(51)	(477)	473	(4)	1,661

[10] The net-to-system factor used to convert customer sales to system level load is calculated as equal to 1/(1-loss factor) and include company use. The loss factors are included below: O'ahu: 4.43%; Hawai'i: 6.76%; Maui: 5.17%; Lāna'i: 4.39%; Moloka'i: 9.07%

[11] *See* https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/forecast_assumptions/20190717_wg_fa_meeting_presentation_materials.pdf

[12] *See* https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/forecast_assumptions/20200309_wg_fa_meeting_presentation_materials.pdf

Table 6-12. Hawai'i Island Peak Forecast (MW)

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	TOU	Peak Forecast
MW	A	B	C	D	E	F = A + B + C + D + E
2025	229.5	(10.0)	(42.6)	2.1	(1.3)	177.6
2030	236.8	(12.5)	(55.5)	8.7	(1.5)	176.0
2040	249.9	(10.8)	(84.2)	39.6	(2.2)	192.3
2045	247.2	(3.4)	(85.3)	64.5	(1.9)	221.2
2050	256.5	(3.8)	(99.6)	99.3	(2.1)	250.3

Table 6-13. Maui Peak Forecast (MW)

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	TOU	Peak Forecast
MW	A	B	C	D	E	F = A + B + C + D + F
2025	245.5	(18.0)	(47.3)	3.4	(0.8)	182.7
2030	260.0	(29.2)	(58.1)	12.5	(1.2)	184.1
2040	240.1	(3.9)	(64.6)	64.5	(0.9)	235.2
2045	254.2	(4.1)	(67.7)	79.0	(0.9)	260.4
2050	259.1	(16.8)	(71.2)	112.7	(1.1)	282.8

Table 6-14. Moloka'i Peak Forecast (MW)

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	TOU	Peak Forecast
MW	A	B	C	D	E	F = A + B + C + D + E
2025	5.8	(0.1)	(0.1)	0.0	(0.0)	5.6
2030	5.7	(0.1)	(0.1)	0.1	(0.0)	5.5
2040	6.1	(0.2)	(0.2)	0.2	(0.0)	5.9
2045	6.3	(0.3)	(0.2)	0.5	(0.0)	6.3
2050	6.5	(0.3)	(0.2)	0.8	(0.0)	6.7

Table 6-15. Lāna'i Peak Forecast (MW)

Year	Underlying	Distributed Energy Resources (PV and BESS)	Energy Efficiency	Electric Vehicles	TOU	Peak Forecast
MW	A	B	C	D	E	F = A + B + C + D + E
2025	6.5	(0.0)	(0.1)	0.0	(0.0)	6.3
2030	6.8	(0.1)	(0.2)	0.0	(0.0)	6.5
2040	7.2	(0.1)	(0.3)	0.1	(0.0)	6.9
2045	7.3	(0.2)	(0.4)	0.3	(0.0)	7.0
2050	7.5	(0.2)	(0.4)	0.4	(0.0)	7.3

6.8 Scenarios and Sensitivities

In collaboration with stakeholders, as documented in the *March 2022 Inputs and Assumptions Report*, we developed several scenarios to identify a range of potential grid needs. The scenarios test whether given uncertain futures the resource mix and direction of the lowest-cost portfolio would change. Table 6-16 describes the various scenarios we analyzed and presented in this report.

Table 6-16. List of Modeling Scenarios and Associated Forecast Assumptions

Modeling Scenario	Purpose	DER Forecast	EV Forecast	EE Forecast	Non-DER/EV TOU Forecast	EV Load Shape	Fuel Price Forecast	Resource Potential
Base Electricity Demand	Reference scenario.	Base	Base	Base	Base	Managed EV charging	Base	NREL Alt-1
Land-Constrained	Understand the impact of limited availability of land for future solar, onshore wind, and biomass development.	Base	Base	Base	Base	Managed EV charging	Base	**Land-Constrained Resource Potential**
High Electricity Demand	Understand the impact of customer adoption of technologies for DER, EVs, EE, and TOU rates that lead to higher loads.	**Low**	**High**	**Low**	**Low**	**Unmanaged EV charging**	Base	NREL Alt-1
Low Electricity Demand	Understand the impact of customer adoption of technologies for DER, EVs, EE, and TOU rates that leads to lower loads.	**High**	**Low**	**High**	**High**	Managed EV charging	Base	NREL Alt-1
Faster Technology Adoption	Understand the impact of faster customer adoption of DER, EV, and EE.	**High**	**High**	**High**	**High**	Managed EV charging	Base	NREL Alt-1
Unmanaged Electric Vehicles	Understand the value of managed EV charging relative to unmanaged.	Base	Base	Base	Base	**Unmanaged EV charging**	Base	NREL Alt-1
DER Freeze	Understand the value of the distributed PV and BESS uptake in the Base forecast. Informative for program design and solution sourcing.	**DER Freeze**	Base	Base	Base	Managed EV charging	Base	NREL Alt-1
Electric Vehicle Freeze	Understand the value of the electric vehicle's uptake in the Base forecast. Informative for program design and solution sourcing.	Base	**EV Freeze**	Base	Base	Managed EV charging	Base	NREL Alt-1
High Fuel Retirement Optimization	Understand the impact of higher fuel prices on the resource plan while allowing existing firm unit to be retired by the model.	Base	Base	Base	Base	Managed EV charging	**EIA High Fuel Price**	NREL Alt-1
Energy Efficiency Resource	Understand the value of energy efficiency as a resource. Informative for program design and solution sourcing.	Base	Base	**EE Freeze + EE Supply Curves**	Base	Managed EV charging	Base	NREL Alt-1

Figure 6-8 and Figure 6-9 illustrate the total sales forecast and peak load of the various scenarios.

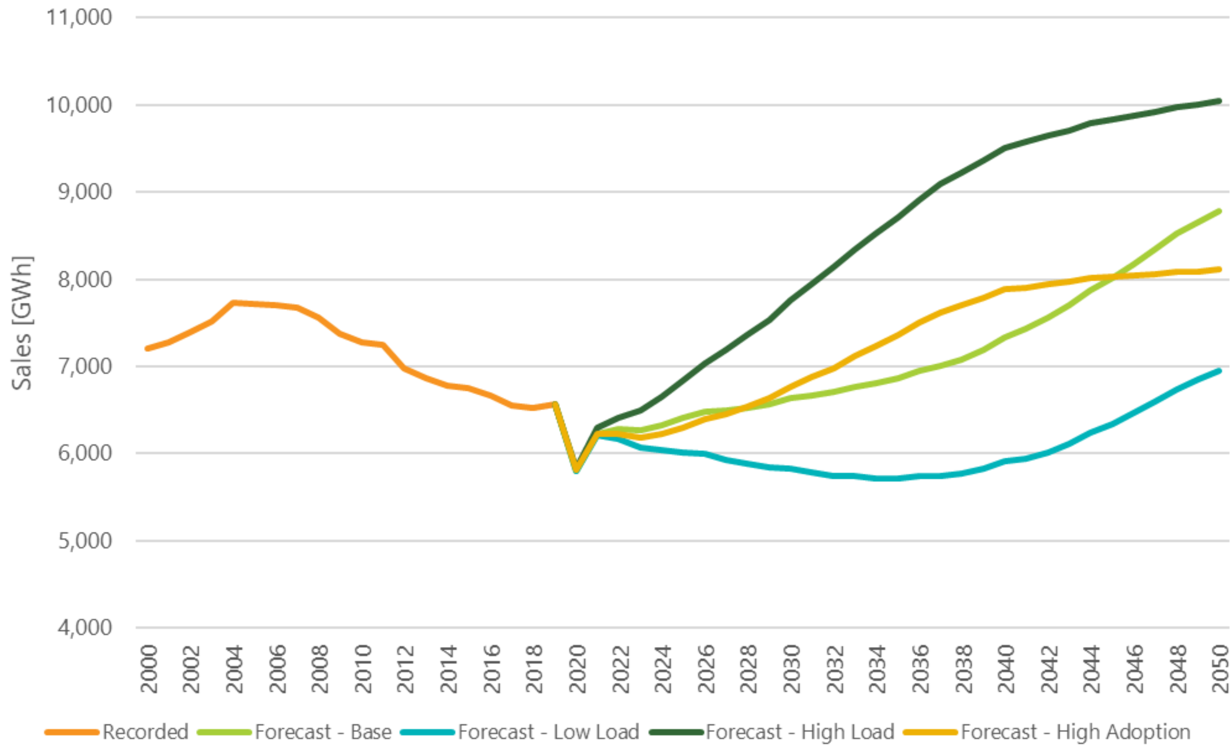


Figure 6-8. O'ahu customer-level sales forecast sensitivities

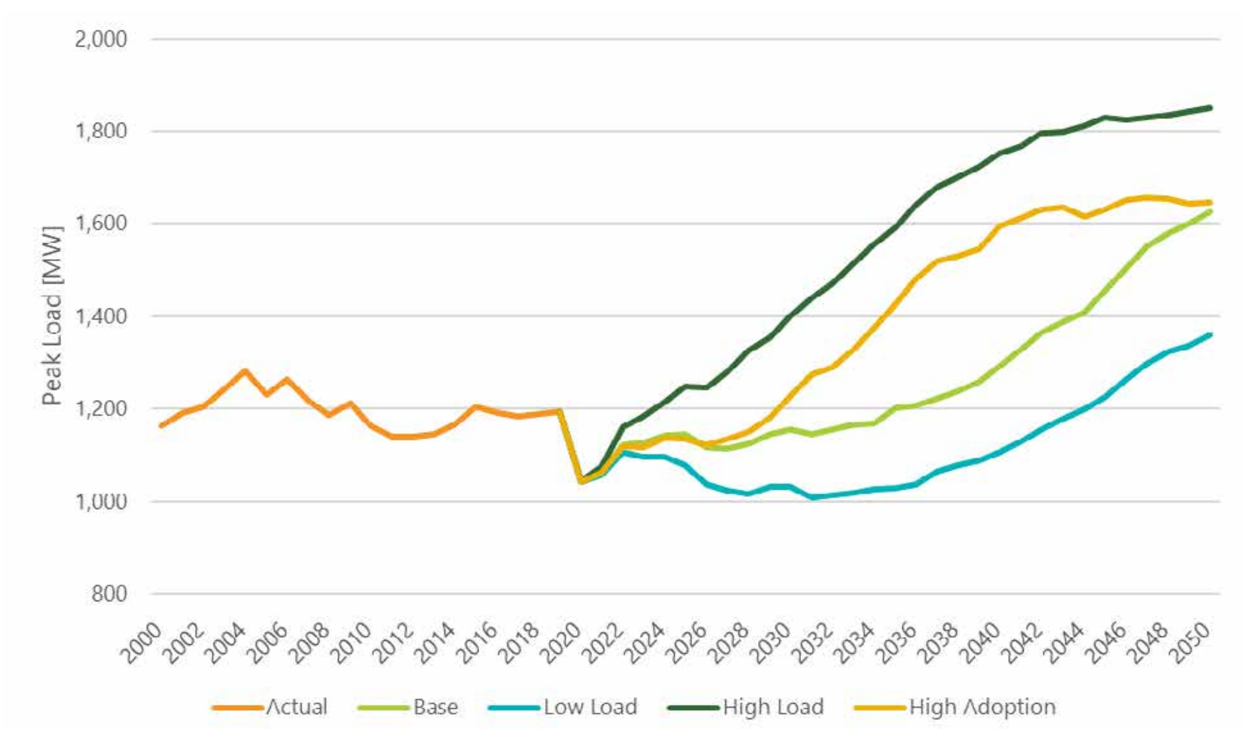


Figure 6-9. O'ahu peak load forecast sensitivities

6.9 New Resource Supply Options

New resources are made available to the model based on commercially ready technologies today, with a focus on technologies that can be acquired within the next 10 years as part of the solution sourcing process. This does not mean that future technologies are not within our long-term plans. Consistent with our renewable energy principles, we strive to make decisions today that do not crowd out future technologies. As future technologies mature those will be considered in future Integrated Grid Plans. This section describes the resource cost projections for the resources made available to the model and the renewable energy potential for solar and wind on each island.

6.9.1 Resource Cost Projections

Resource cost assumptions were based on publicly available data sets, as shown in Table 6-17.

Table 6-17. Resource Cost Data Sources

Data Source	Resources
DOE	Distributed wind [13, 14] Pumped storage hydro [15]
NREL [16]	Large-scale solar Distributed solar Onshore wind Geothermal Biomass Large-scale storage Distributed storage Combustion turbine Combined cycle Synchronous condenser Offshore wind [17]
U.S. Energy Information Administration (EIA) [18]	Waste-to-energy
Hawaiian Electric [19]	Internal-combustion engine

Resource cost assumptions began with a base technology capital cost that was adjusted for:

- Future technology trends through the planning period
- Location-specific capital and operations and maintenance cost adjustments for Hawai'i using data from the U.S. Energy Information Administration (EIA) and RSMeans
- Applicable federal and State tax incentives

Figure 6-10 summarizes the resource forecasts in nominal dollars. The resource cost forecasts from

[13] U.S. Department of Energy, 2017 Distributed Wind Market Report, https://www.energy.gov/eere/wind/downloads/2017-distributed-wind-market-report

[14] U.S. Department of Energy, 2018 Distributed Wind Market Report, https://www.energy.gov/eere/wind/downloads/2018-distributed-wind-market-report

[15] U.S. Department of Energy, 2020 Grid Energy Storage Technologies Cost and Performance Assessment, https://www.energy.gov/energy-storage-grand-challenge/downloads/2020-grid-energy-storage-technology-cost-and-performance#:~:text=Pacific%20Northwest%20National%20Laboratory%E2%80%99s%202020%20Grid%20Energy%20Storage,down%20different%20cost%20categories%20of%20energy%20storage%20systems.

[16] National Renewable Energy Laboratory 2021 Annual Technology Baseline, 2021 ATB Data, https://atb.nrel.gov/electricity/2021/data

[17] National Renewable Energy Laboratory Bureau of Ocean Energy Management, Cost Modeling for Floating Wind Energy Technology Offshore O'ahu, Hawaii, https://www.boem.gov/sites/default/files/documents/regions/pacific-ocs-region/environmental-analysis/HI%20Cost%20Study%20Fact%20Sheet.pdf

[18] U.S. Energy Information Administration, *Cost and Performance Characteristics of New Generating Technologies,* Annual Energy Outlook 2019.

[19] Internal-combustion engine costs are based on the Schofield Generating Station provided in Docket 2017-0213, in response to the Consumer Advocate's information request 19.

2020–2050 can be found in the *March 2022 Inputs and Assumptions Report*.

In the near term, there are price declines after accounting for the investment tax credit schedules for the federal and State investment tax credits. Over the longer term, after the tax credit schedules ramp down and are held constant, the resources costs generally increase over time. As noted in the NREL ATB, all technologies include electrical infrastructure and interconnection costs for internal and control connections and on-site electrical equipment (e.g., switchyard, power electronics, and transmission substation upgrades).[20] Similarly, all technologies also include site costs for access roads, buildings for operation and maintenance, fencing, land acquisition, and site preparation in the capital expenditures as well as land lease payments in the fixed costs for operations and maintenance.[21]

Although the ATB does not discretely break out the percentage of the capital costs or operations and maintenance costs associated with either of these items, their inclusion is consistent with the adjustment made for recent solar, wind, geothermal, and hybrid solar projects as actual project pricing would have accounted for interconnection and land costs.

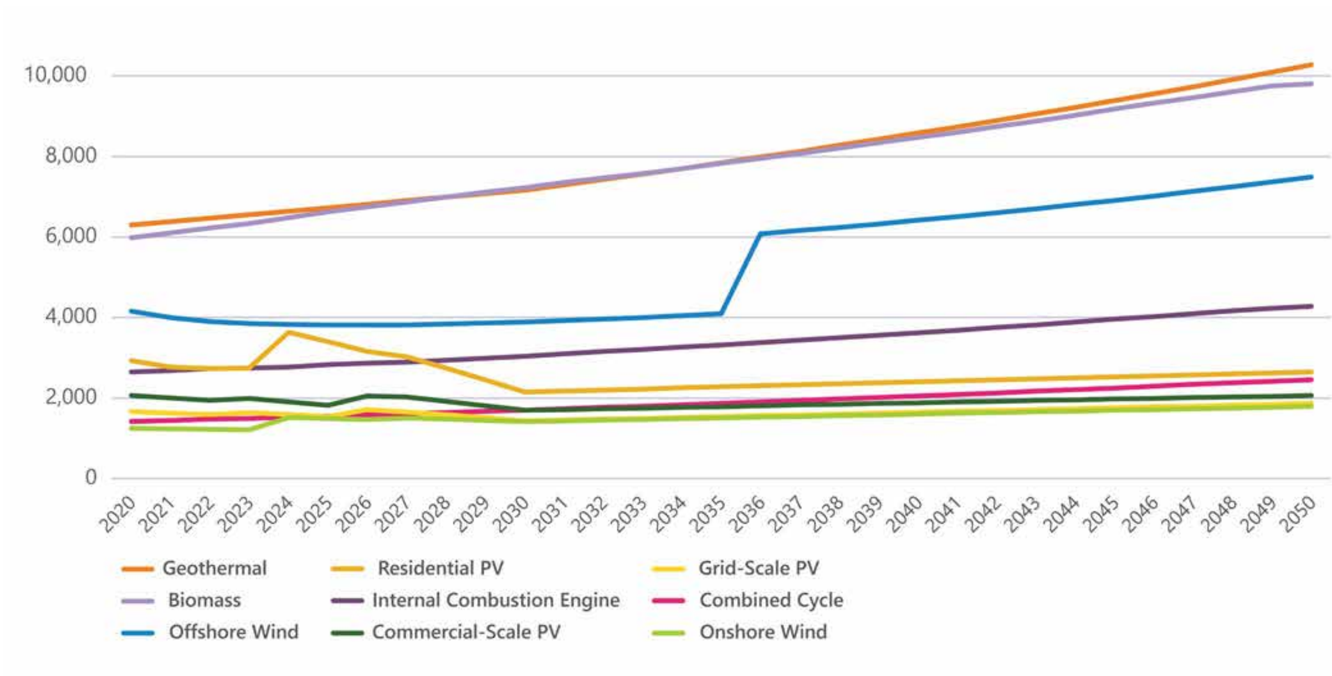


Figure 6-10. Nominal capital costs for candidate resources in $/kW

A comparison of the levelized cost of energy (cents/kWh) for solar and wind resources is shown below in Figure 6-11.

[20] See https://atb.nrel.gov/electricity/2021/definitions#capitalexpenditures

[21] Ibid.

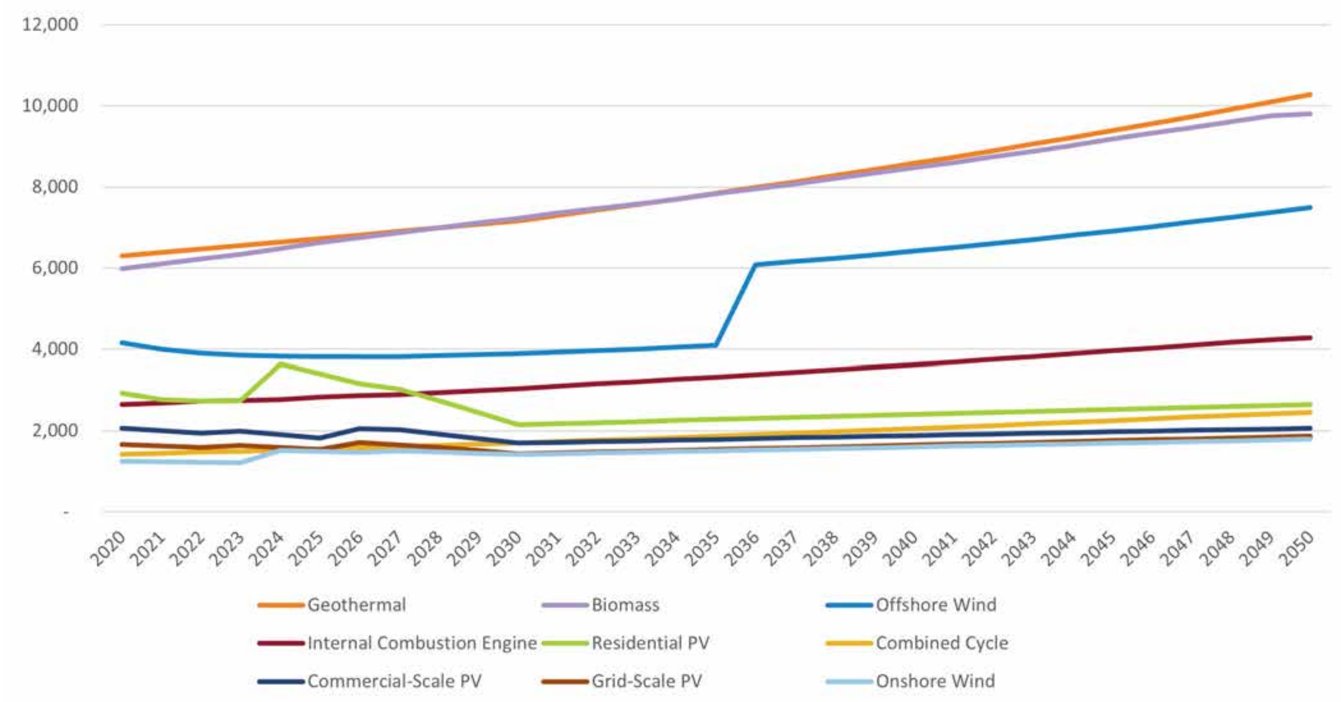


Figure 6-11. Levelized cost of energy for select Integrated Grid Plan candidate resources

6.9.2 Assessment of Wind and Photovoltaic Technical Potential

The developable potential for wind and solar was based on the resource potential study conducted by NREL. Based on stakeholder feedback, NREL revised its study to include additional scenarios described in the *July 2021 Assessment of Wind and Photovoltaic Technical Potential Report*.

6.9.2.1 Private Rooftop Solar

The potential study quantifies the technical potential of solar systems deployed on existing suitable roof areas in our service territory. Technical potential is a metric that quantifies the maximum generation available from a technology for a given area and does not consider economic or market viability. The analysis relies upon light detection and ranging (LiDAR) data. The model will consider LiDAR point clouds, buildings, solar resource from the National Solar Radiation Database, parcels, and tree canopy. The system configurations can also be considered such as fixed roof, losses, tilt, azimuth, panel type, module efficiency, inverter efficiency, and direct current (DC):alternating current (AC) ratio. The results of the analysis are provided in Table 6-18.

Table 6-18. Rooftop Solar Technical Potential Study Results

Island	Developable Plane Areas (Acres)	Capacity (MW)	Generation (GWh)	Capacity Factor (%)
O‘ahu	4,934,292	3,934	6,369	21.23
Hawai‘i	3,845,032	2,163	4,856	19.42
Maui	1,425,330	1,113	1,858	21.05
Lāna‘i	87,724	44	112	21.20
Moloka‘i	93,408	45	112	20.05

Figure 6-12 shows the locations of the O‘ahu rooftop potential. The majority of the potential rooftop locations are in the urban core and populated areas. The technical potential may be needed in later years under the O‘ahu Land Constrained scenario.

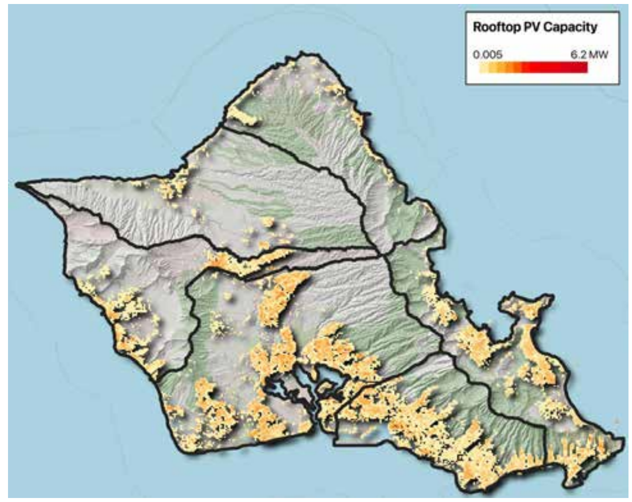


Figure 6-12. Technical potential rooftop solar capacity on O‘ahu

6.9.2.2 Large-scale Wind and Solar

NREL used its Renewable Energy Potential Model (reV) to assess the potential for solar and wind energy deployment. The solar and wind resource data sets will be sourced from the National Solar Radiation Database and the Hawai‘i Wind Integration National Dataset (WIND) toolkit. The solar radiation database has a temporal interval of 30 minutes and nominal spatial resolution of 4 kilometers (km). The WIND toolkit has an hourly temporal interval with a nominal spatial resolution of 2 km. The model will consider land exclusions such as slope, constructed structures, protected areas, and land cover. System configurations can also be considered in the model such as axis tracking, losses, tilt, panel type, inverter efficiency, and DC:AC ratio.

Based on stakeholder feedback the study allowed for solar development on land with up to 15% and 30% slope, among other changes to inputs. Table 6-19, below, shows the large-scale solar potential by island.

Table 6-19. Summarized Installable Capacity in MW for Large-scale 1-axis Tracking Solar Systems up to 30% Slope Land; Input Assumptions Based on Ulupono Input

Island	Large-Scale PV Potential	Land Use (Acres)
O'ahu	3,810	24,711
Moloka'i	10,411	67,708
Maui	13,687	88,960
Lāna'i	9,691	63,013
Hawai'i	76,179	495,456

The large-scale solar potential excludes the following types of land:

- Federal lands, including U.S. Department of Defense lands
- State parks and golf courses
- Wetlands
- Lava flow zones, Flood Zone A, and tsunami evacuation zones
- Urban zones
- Important agricultural land
- Soil ratings of Class A and 90% of Class B and C land
- Road and building setbacks were included

Based on stakeholder feedback the study provided for wind energy potential without limitation for windspeed. Table 6-20 shows the large-scale wind potential by island.

Table 6-20. Summarized Installable Capacity in MW for Large-scale Wind Systems up to 20% Slope Land; Input Assumptions Based on Ulupono Input

Island	Wind-Alt-1 (No Wind Speed Threshold)	Land Use (Acres)
O'ahu	256	21,004
Moloka'i	515	42,503
Maui	767	63,260
Lāna'i	509	42,009
Hawai'i	5,037	414,898

The lands excluded from the potential study are the same as solar, except that land greater than 20% slope was excluded and Class A, B, and C soil ratings were included; however, important agricultural lands were still excluded.

6.9.3 Solar and Wind Potential Assumption

The large-scale solar and wind potential assumption garnered much discussion among stakeholders, with varying perspectives on what can realistically be built because of land use and community concerns.

On the developable resource potential for onshore large-scale solar and wind, stakeholders noted that federal contracting rules would require that the U.S. Department of Defense seek the highest and best use for properties under its control, in addition to deciding whether that land would be made available for renewable energy development. Because of this circumstance, it would be difficult to make a blanket assumption that all U.S. Department of Defense lands are available to develop. Further, stakeholders raised concerns on the ease of developing projects at slopes higher than 10% because of the additional effort and cost involved. However, other stakeholders thought that solar on higher slopes could be developed, up to 30%, with some additional cost adder because some projects have already been developed on steeper slopes.

Taking into consideration the various viewpoints, we used the Alt-1 scenario for wind (no wind speed threshold) and solar potential for various scenarios from the *July 2021 Assessment of Wind and Photovoltaic Technical Potential Report* as shown in the tables above.

It is worth noting that there is substantial overlap between areas with solar resource potential and wind resource potential. And the same system infrastructure can be used to interconnect both wind and solar resources and transfer the renewable energy to the other locations of the system.

We also recognize the realities of solar and wind development in the state. To that end, the "Land-Constrained" scenario reflects the possibility of future limited land availability for solar and wind development and provide a meaningful bookend of analysis that incorporates stakeholder feedback to assume that a lower amount of land is available for project development.

6.9.4 Renewable Energy Zones

Prime locations for grid-scale development, flat land with rich solar and wind resources adjacent to existing transmission, have been developed through the Stage 1 and Stage 2 procurements. In addition to location, transmission capacity is becoming a limiting factor. The current transmission system was not designed for large generator interconnections at various locations, but rather one that supports bulk generation resources supplying power to load centers.

Creating renewable energy zones will enable efficient interconnections to the transmission system to new areas that are prime for development but either is far from existing transmission infrastructure or requires robust transmission upgrades to accommodate the interconnection of generating resources. REZ upgrades are composed of two types: (1) transmission network expansion costs, which are the transmission upgrades not associated with a particular renewable energy zone but are required to support the flow of energy within the transmission system, and (2) REZ enablement costs, which are the costs of new or upgraded transmission lines and new or expanded substations required to connect the transmission hub of each REZ group to the nearest transmission substation. Further details on the renewable energy zones can be found in the Hawaiian Electric Transmission Renewable Energy Zone Study as part of the *September 2022 GNA Methodology Report*.

Section 8 discusses the REZ enablement and transmission expansion infrastructure and costs needed for each island.

7. Resilience Planning

Reliability and resilience is a top priority for our customers. As extreme events increase in frequency, we have seen the devasting impacts to grids that are unable to withstand these impacts have on society. We must act now to make our grid more resilient to better prepare the state for an extreme event. We have proposed an initial Climate Adaptation Transmission and Distribution Resilience Program that focuses on least-regrets hardening of grid infrastructure across all islands we serve. We have a long way to reach our desired target level of grid resilience. In this section we describe a strategy and roadmap to guide future resilience investments that balance affordability and resilience needs.

7.1 Resilience Strategy and Approach

Resilience is the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions. For critical infrastructure including electric power grids, resilience is generally considered to be the ability to anticipate, absorb, adapt to, and rapidly recover from a potentially catastrophic event while sustaining mission-critical functions.

Hawaiian Electric is a critical infrastructure provider. Five of the state's six island power grids are operated by Hawaiian Electric, which serves 95% of Hawai'i's 1.4 million residents. Among those, we serve the headquarters of the U.S. Indo-Pacific Command and the 36,000 active-duty military members in Hawai'i. Hawaiian Electric is the sole electric power provider to the highest geographic concentration of critical defense facilities in the nation. Widespread loss of electricity for extended periods could have significant impacts including disruption to community-lifeline and mission-critical services, loss of life, public health emergencies, environmental damage, and severe economic and social disruption. These impacts grow with increasing electrification of transportation, hybrid/remote work, and digitization of the economy.

Hawai'i and Hawaiian Electric face a unique and diverse set of resilience threats, vulnerabilities, and challenges. Hurricanes, tsunamis, wildfires, lava flows, and earthquakes pose significant threats to our system. And the frequency and intensity of hurricanes are expected to increase because of climate change. The effects of these threats are amplified by the significant geographic remoteness and isolation of Hawai'i. The Hawaiian Islands are the most isolated populated landmass in the world—5 hours from the West Coast by plane, 5 days by ship. As such, there are limited evacuation options, and mutual aid from mainland utilities and material resupply poses significant logistical complexity and long lead times. Additionally, there are no electrical interconnections between Hawaiian Electric's five island grids or to the larger mainland grid, so the generation and delivery of electricity is limited to facilities on each island. Most of Hawaiian Electric's nearly 10,000 miles of transmission and distribution lines are overhead, and a significant portion of these overhead lines were built when needed several decades ago to standards in effect at the time that were generally less robust than current standards to withstand extreme wind events, such as hurricanes. Hawai'i's volcanic islands have some of the most extreme topography found in the nation, with power lines traversing steep, rugged terrain with limited access for repairs or replacement of damaged facilities.

The primary goal of Hawaiian Electric's overall resilience strategy is to reduce the likelihood and severity of severe event impacts. Achieving a target level of resilience will depend on multiple integrated aspects of resilience including emergency response, generation/power supply resilience, transmission and distribution resilience, system/grid operation resilience, cybersecurity, physical security, and business continuity. Each plays a crucial role in safeguarding the supply and delivery of electric power in the face of threats to this critical resource.

Various potential environmental, nation-state, and actor-based physical and cyber threats may create major disruptions on an electric grid. These events result in disruptive impacts having various potential scales and scopes and inform the engineering considerations and requirements to improve the resilience of the electric grid. The scale and scope of these disruptive impacts also shape the economic impact and related value of solutions.

The "bowtie method" (Figure 7-1), as increasingly used in the industry to leverage risk-threat assessments, translates a threat-risk assessment and grid asset vulnerabilities into specific event risk prevention and mitigation analysis and solution identification. A bowtie approach helps identify where and how a portfolio of solutions will have the greatest impact for customers and communities.

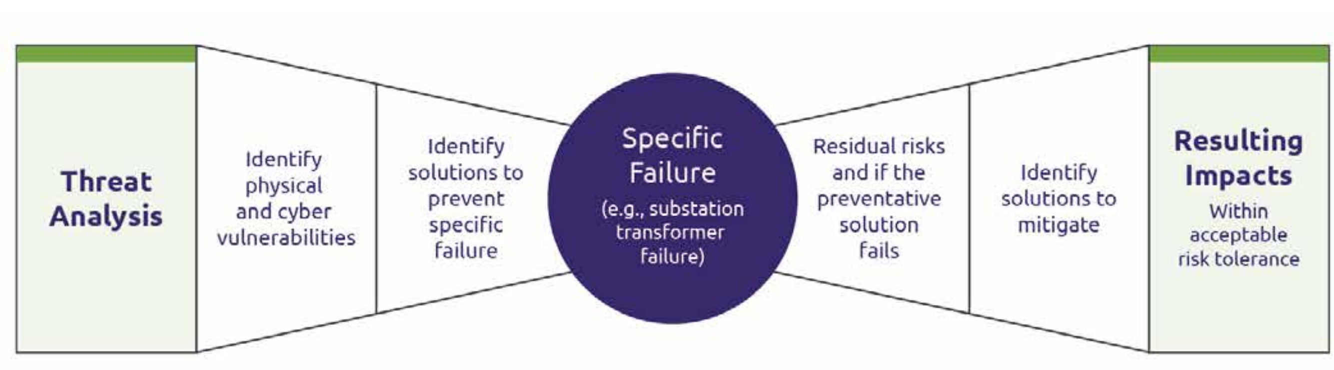


Figure 7-1. DOE resilience bowtie method

First, this method involves identifying solutions to prevent certain events from causing system failures. Preventive measures are considered foundational to ensure that critical transmission lines, substations, and distribution circuits withstand threats to ensure that critical customers and facilities have power and facilitate rapid system recovery for all customers. Preventive measures include grid hardening and can typically take from 15 to more than 20 years to complete. Preventive solutions are shown on the left side of the bowtie above.

Second, mitigation solutions can address locations where preventive solutions cannot physically or cost-effectively address the outage risks. Also, mitigation solutions may be used as near-term solutions to address risks for selected priority customers/critical facilities before the longer-term preventive measures can be implemented. Mitigation solutions are shown on the right side of the bowtie.

The specific prevention and mitigation solutions are identified through both utility asset options and potential third-party solutions (e.g., microgrids). The utility and third-party solutions are evaluated against performance metrics-driven requirements. Additionally, resilience solution prioritization involves assessing the comparative customer and community risk reduction value of the solutions related to associated generation, transmission, substation, and distribution infrastructure.

Therefore, our resilience strategy is designed to address the need to increase our system resilience to a target level of resilience. This metric-based target will be determined through stakeholder engagement supported by severe event simulation modeling and engineering-economic evaluation. The following outlines Hawaiian Electric’s general approach to system resilience enhancement:

1. **Identification and prioritization of system threats.** The Resilience Working Group identified and prioritized system threats in 2019. In alignment with Resilience Working Group priorities, Hawaiian Electric prioritized the Hurricane/Flood/Wind combined threat as the top threat to address and made this threat the primary focus of our initial resilience planning and implementation efforts.
2. **Development of performance targets and rigorous decision-making methods (Section 7.3).** This will support efforts to (1) baseline the current level of grid resilience, (2) identify the target level of resilience needed, and (3) identify and optimize a portfolio of preventive and mitigation solutions to cost-effectively address the resilience gap and reach the target level of resilience. The resulting resilience gap will be addressed by implementing preventive and mitigation solutions over time in a way that seeks to optimize cost-benefit characteristics of the portfolio while aligning with State and community priorities.
3. **System Hardening (Section 7.4).** System hardening includes investments to reduce outages and time to restore grid power via damage prevention/reduction. This includes the initial Climate Adaptation Transmission and Distribution Resilience Program, which will begin to address the most urgent and critical system needs and those that provide the broadest scope of customer and societal benefit. Future phases of foundational system hardening will incorporate performance metrics and quantitative decision-making methods described above to enable metrics-driven and cost-effective grid hardening beyond the initial phase of “no-regrets” investments.
4. **Residual Risk Mitigation (Section 7.5).** This includes investments to address near-term and longer-term residual risks and needs of individual customers and communities, filling gaps that hardening investments cannot fully mitigate cost-effectively. This can include needs that are either planning process-driven or community-driven.

Figure 7-2 below illustrates how this approach will address the resilience gap by implementing preventive and mitigation solutions over time.

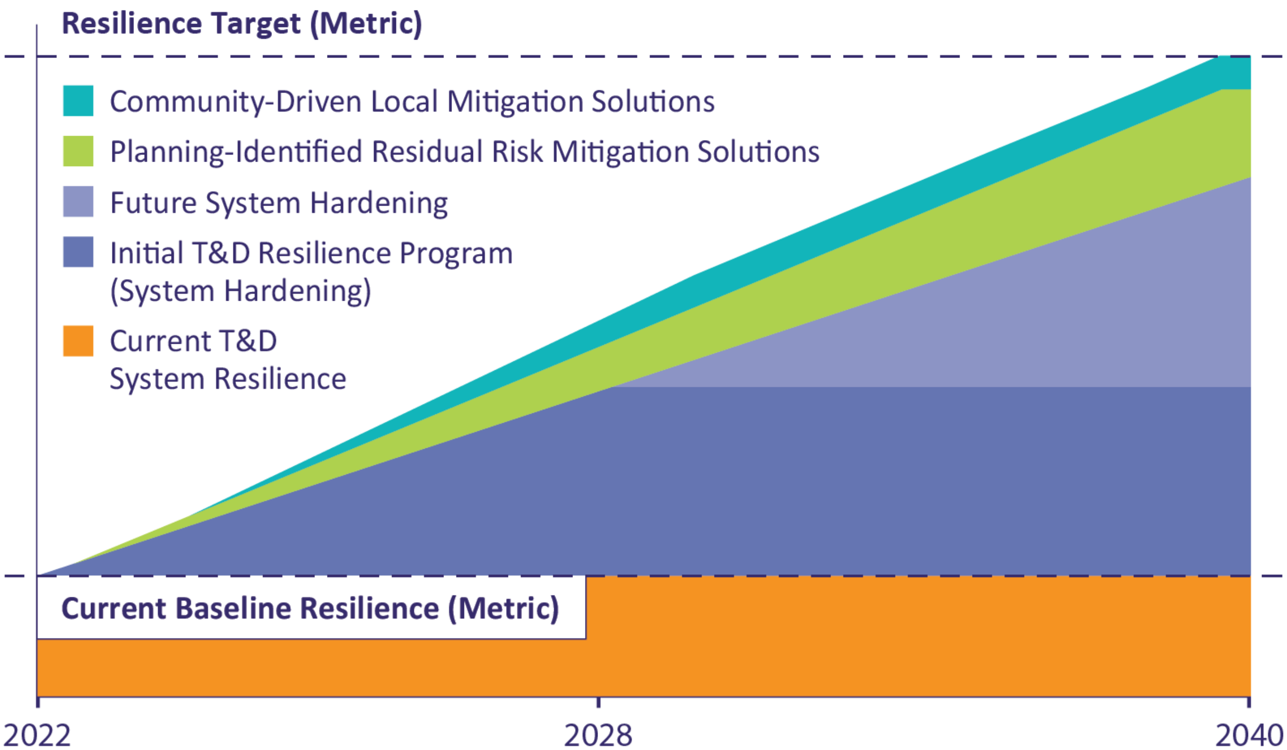


Figure 7-2. Preventive and mitigation solutions to address resilience gap

As shown in Figure 7-2, the system's current level of resilience is represented in magenta (Current T&D System Resilience). Hawaiian Electric's Initial T&D Resilience Program, shown in dark blue, represents the first phase of foundational hardening investments to increase the resilience of the system. Subsequent phases of system hardening are represented in light blue. In parallel to hardening the system, Planning-Identified Residual Risk Mitigation Solutions and Community-Driven Local Mitigation Solutions, represented in green and yellow, respectively, will further increase system resilience by mitigating residual risks that are not fully avoided or prevented by system hardening. Planning-Identified Residual Risk Mitigation Solutions include solutions driven by Hawaiian Electric's planning process (e.g., North Kohala Microgrid), while Community-Driven Local Mitigation Solutions include solutions initiated by customers or communities such as customer and hybrid microgrids. Collectively, the portfolio of complementary resilience solutions will contribute to achieving the target level of resilience over time.

7.2 Identification and Prioritization of System Threats

In 2019, the Resilience Working Group collaborated to identify and prioritize resilience threats to the electric grid. The following were the working group's priority threat scenarios for the Integrated Grid Planning process:

1. Hurricane/Flood/Wind
2. Tsunami/Earthquake
3. Wildfire
4. Physical/Cyber Attack
5. Volcano (Hawai'i Island only)

For each threat, the working group considered moderate and severe reference scenarios to provide a range of potential impacts to consider when assessing proposed solution options. Our initial resilience plans focus largely on the working group's consensus top-priority threat: Hurricane/Flood/Wind, with a secondary focus on preventing and mitigating utility-caused wildfires. As discussed in Section 7.3, specific performance targets with respect to prioritized threats should be developed and informed by stakeholders as well as the results of simulated threat models to ensure that targets are appropriate, achievable, and reasonable.

7.3 Development of Performance Targets and Rigorous Decision-Making Methods

The development of performance targets to define the target level of resilience for the grid and associated decision-making framework are key components in resilience planning.

7.3.1 Establish Target Level of Resilience

After developing and prioritizing system threats, there is a need to quantify and establish the target level of resilience for the system to achieve with respect to these threats. The process for identifying resilience metrics and establishing resilience metric target levels should ensure the following:

1. **Metrics are aligned with stakeholder values and priorities.** The metrics quantifying the "target level of resilience" need to adequately reflect what a "resilient" system looks like to relevant stakeholders.
2. **Targets are reasonably practicable.** The target level of resilience should be physically achievable for a cost that customers are willing to pay.

Establishing the target level of resilience should begin with identifying the categories of metrics that best reflect stakeholder values as the most important metrics to optimize. To begin this process, Hawaiian Electric proposes to implement the Performance Mechanism Development Process outlined in a recent report titled *Performance Metrics to Evaluate Utility Resilience Investments* (Report), which was funded by DOE and conducted as part of the Grid Modernization Laboratory Consortium (GMLC) under the project named Designing Resilience Communities: A Consequence-Based Approach for Grid Investment (DRC).[22] The Report provides a roadmap for the development of performance mechanisms for resilience, a list of principles for developing metrics,

[22] https://www.synapse-energy.com/sites/default/files/Performance_Metrics_to_Evaluate_Utility_Resilience_Investments_SAND2021-5919_19-007.pdf

a menu of suggested metrics for grid resilience as a starting point, and an Excel-based tool for visualizing the proposed metrics in the form of reporting templates. A series of technical sessions should be held (to include Hawaiian Electric, the Public Utilities Commission, Consumer Advocate, and other relevant stakeholders) to review the performance mechanism development process laid out by this Report, review the suggested metrics and identify metrics of interest, populate metrics of interest with available data to the extent feasible, and identify data gaps and how to address these gaps in the short and long terms. The Report notes that while some of the metrics can be produced in the nearer term, it also suggests "more challenging ones for utilities and communities to work towards over the years to come." Hawaiian Electric expects to use well-defined and industry-established reliability metrics (such as the System Average Interruption Duration Index [SAIDI] and System Average Interruption Frequency Index [SAIFI]) as a starting point to supplement vulnerability assessments, resilience solution development, and circuit or critical customer prioritization.

In an ideal world, it would be possible to design a system such that no customers lose power in severe events. However, such a goal is unlikely to be achievable for a cost that customers are willing to pay. It is therefore important to ensure that the target level of resilience is physically achievable for a reasonable cost. This will require (1) quantifying the system's baseline level of resilience with respect to severe event scenarios, and (2) estimating the level of investment needed to achieve the target level of resilience. Because resilience planning inherently deals with unpredictable, low-frequency, high-impact events, quantifying the expected performance of a system under severe event scenarios is possible only through using advanced modeling to derive simulated performance metric output values. Therefore, the resilience performance targets that are established will need to be refined over time based on knowledge gleaned from system performance models, described below.

7.3.2 Develop Decision-Making Methods

As described above, system performance modeling will be required to quantify the baseline level of system resilience and model investment options to achieve the desired target level of resilience.

The system performance model would be used to simulate the impacts of severe events on Hawaiian Electric's systems using a data-driven, bottom-up process. First, system performance vis-à-vis established performance metrics would be used to quantify the baseline level of resilience. Then, subsequent simulations could be run to test various resilience solutions such as hardening, automatic switching, mini-grids, and microgrids, and compare solutions and combinations of solutions against one another in terms of their expected benefits (defined by established performance metrics) versus costs.

This process of testing various resilience solutions and solution portfolios can also provide insight into the achievability and cost reasonableness of performance targets to inform future refinement.

Hawaiian Electric has contracted with the Pacific Northwest National Laboratory (PNNL) to develop and implement a performance system model for Hawaiian Electric's grids. This work will leverage and extend the tools that PNNL developed while working with Puerto Rico.

Hawaiian Electric is also tracking the development of tools and methods to quantify resilience value, such as Lawrence Berkeley National Laboratory (LBNL) and Edison Electric Institute's Interruption Cost Estimator 2.0 Tool (ICE 2.0), LBNL's Power Outage Economics Tool (POET), and Sandia

National Laboratory's (SANDIA) Social Burden Method and associated Resilient Node Cluster Analysis Tool (ReNCAT). While these tools do not themselves model system performance, they can be used to translate the failure and outage data derived from system performance models into a quantified *value* of resilience to further support investment options analysis and justification.

7.3.3 Stakeholder Engagement

Stakeholder engagement in the resilience planning process is also necessary to ensure prudent decision making. For the current hardening program and beyond, Hawaiian Electric will continue to gather stakeholder input from Resilience Working Group members and critical infrastructure partners to understand critical infrastructure priorities within and between various critical infrastructure sectors. This will include refining and maintaining critical load lists and priorities.

For future phases of system hardening and residual risk mitigation investments, stakeholder engagement will be used to understand the needs and priorities of individual communities to help target future investment analyses. The community engagement framework that began under the ETIPP effort can be leveraged, along with input and lessons learned gathered from the community meetings on O'ahu. This input can help Hawaiian Electric identify vulnerabilities and critical infrastructure considerations that are unique to each community and analyze appropriate solution options.

7.4 System Hardening

Given Hawai'i's system resilience vulnerabilities and challenges, significant investment in damage reduction is imperative for resilience improvement. We are the most isolated populated landmass in the world with limited on-island crews, materials, and equipment. This isolation poses significant difficulties to securing inventory resupply and receiving mutual aid from the mainland. In addition, Hawai'i has extreme topographic features with transmission and distribution lines running across steep, rugged terrain with limited access. There are no transmission interties between the separate island grids or to the mainland grid. If a hurricane were to strike the current unhardened grids, customers could be without power for many weeks to many months, as evidenced by the 1992 Hurricane Iniki on Kauai and the 2017 Hurricane Maria that struck Puerto Rico. In long-term outages, backup generators become reliant on fuel resupply (and are typically designed only to operate critical facilities at partial capacity). Renewable energy-based microgrids and customer distributed energy resources that are capable of islanding are typically quite limited in islanding duration capability compared to the long outage durations expected from severe events. Therefore, damage reduction measures are a central need considering the catastrophic scale and duration of outages that these types of events can cause on unhardened island grids. By reducing damage on the grid, system hardening reduces the residual outage gap to be filled by distributed resources and microgrids. Accordingly, system hardening forms the foundation of Hawaiian Electric's resilience strategy.

7.4.1 Initial Climate Adaptation Transmission and Distribution Resilience Program

Hawaiian Electric's initial Transmission and Distribution Resilience Program (Docket 2022-0135) represents the first phase of foundational system hardening investment of approximately $190 million across the islands we serve, with the potential for a 50% match of federal funding.

Because resilience performance targets and advanced decision-making methods have not yet been developed, the focus of this initial program is on "no-regrets" investments. No-regrets hardening investments are those for which there is high confidence that the investment will provide broad system and societal benefit even without the benefit of advanced methods for quantifying benefits and costs discussed in Section 7.3. Examples include hardening critical transmission lines, highway crossings, and critical poles on distribution circuits serving highly critical community lifeline infrastructure (see Figure 7-3).

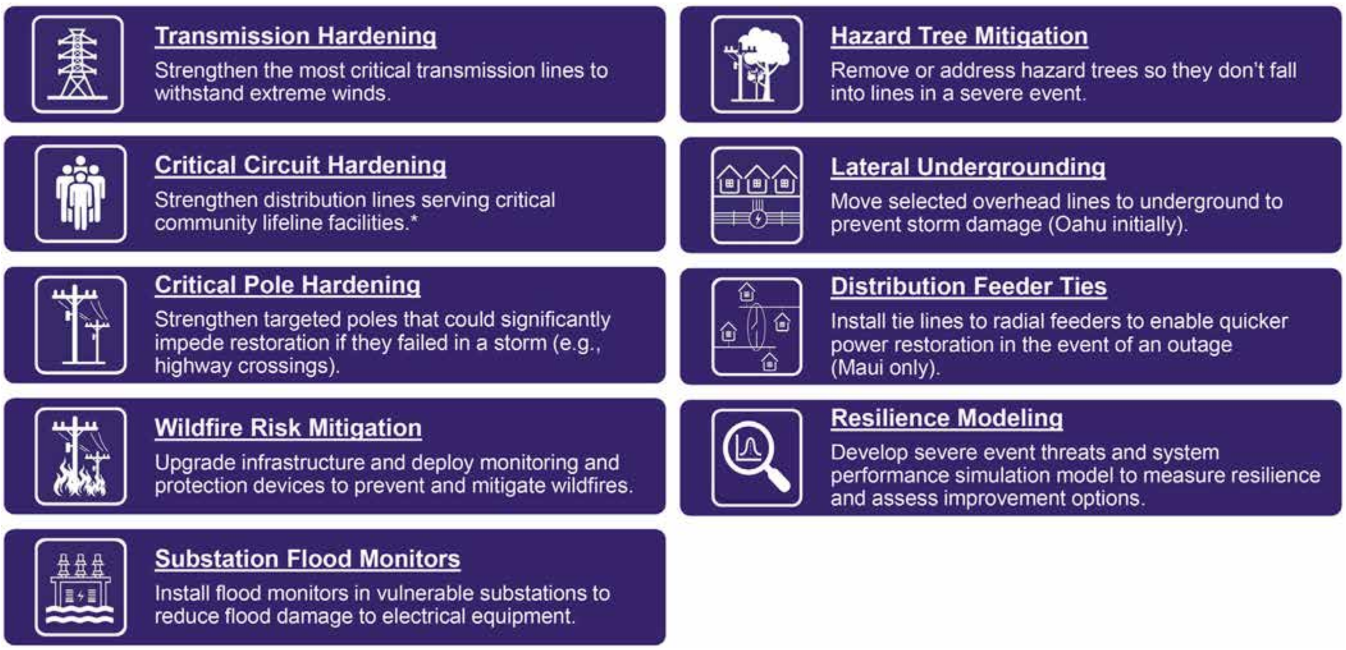


Figure 7-3. Components of initial T&D resilience program

7.4.2 Future System Hardening

Once the performance targets and quantitative decision-making capabilities discussed in Section 7.3 are developed, future phases of system hardening will be shaped by established metrics and quantitative cost-benefit-based analyses. Incorporating these advanced methods will enable Hawaiian Electric to prioritize hardening investments in a way that optimizes progress toward the target level of resilience for dollars spent in a more data-driven manner. Examples may include targeted undergrounding or community feeder hardening, including hardening work intended to pair with microgrid projects (see Section 7.5).

7.4.3 Resilience Standards Development

Improving T&D system resilience will also require evaluating and refining infrastructure equipment and apparatus standards and design policies in relation to the target performance metrics. For example, there are many open questions in power system resilience related to topics such as wind speed design policies, pole and structural material considerations with respect to wind and fire threats, and resource siting.

Hawaiian Electric is currently evaluating its wind speed design policies. Since 2007, Hawaiian Electric has designed structures to withstand wind loadings consistent with those prescribed in National Electric Safety Code (NESC) 2002. However, NESC is a minimum safety code requirement, and Hawaiian Electric is evaluating situations where wind speed design should exceed NESC 2002 requirements.

Hawaiian Electric is also evaluating the costs and benefits of various pole and structural materials. While wood and non-wood structures are designed using the same wind speed ratings, life-cycle cost, accessibility, constructibility, and environmental considerations may influence which types of materials may be ideal for different scenarios. To prevent wildfire damage, Hawaiian Electric has begun installing fire mesh and applying fire paint to poles in wildfire risk areas.

For generating facilities, each of our competitive procurements for renewable generation has an eligibility requirement for the facility's infrastructure. We require the point of interconnection to be located outside the 3.2-foot sea-level rise exposure area (SLR-XA) as described in the Hawai'i Sea Level Rise Vulnerability and Adaptation Report (2017); not located within a Tsunami 27 Evacuation Zone; and not located within the Hawai'i Department of Land and Natural Resources flood map's flood zones A, AE, AEF, AH, AO, or VE based on the Federal Emergency Management Agency's Digital Flood Insurance Rate Maps.

7.5 Residual Risk Mitigation

In addition to the preventive hardening solutions, Hawaiian Electric has initiated efforts to address "Residual Risk Mitigation." This is aimed primarily at addressing risks at the community or customer level that are not fully addressed through the System Hardening investments. While system hardening will reduce the incidence and duration of outage events through damage reduction, even hardened infrastructure can experience failures in a severe event. Therefore, mitigation investments, such as hybrid microgrids for communities or groups of critical loads, will be needed to address these residual risks by reducing the impacts of failures that do occur. Residual Risk Mitigation investments may also be used to fill resilience risk gaps while longer-term System Hardening investments are implemented. The North Kohala microgrid is an example of this type of investment, where a community microgrid is planned to be implemented prior to a longer-term effort to harden the radial sub-transmission line serving the North Kohala community. By installing the microgrid prior to hardening, the microgrid will reduce customer impacts of planned outages to make repairs or upgrades, while also mitigating impacts of unplanned outage events. Once the line is eventually hardened to resilience standards, the hardened line will provide the first line of defense through damage prevention, while the microgrid will continue to provide residual risk mitigation for planned or unplanned outages. Residual risk mitigation can also include community- and customer-driven solutions such as customer and hybrid microgrids.

7.5.1 ETIPP Microgrid Opportunity Map

In 2021, Hawaiian Electric was selected to participate in ETIPP, which provided access to technical support from the National Labs. The project in collaboration with NREL, SANDIA, and the Hawai'i Natural Energy Institute (HNEI) is currently in progress, and plans to complete a hybrid microgrid opportunity map by Quarter 2 of 2023. The objective of the map is to provide customers and Hawaiian Electric to identify areas that have overlapping criteria, such as criticality, vulnerability, and societal impact. Once completed, Hawaiian Electric will be able to leverage the map and underlying data to identify potential areas for utility or hybrid microgrid siting as well as community feeder hardening. See Section 10 for more details.

7.5.2 Resilience Value Quantification Methods

For community-level residual risk mitigation, methods such as SANDIA's Social Burden Method and associated ReNCAT may be especially useful for selecting potential microgrid sites within communities that would represent the highest avoided interruption benefit per dollar spent on microgrid development. As discussed in Section 7.3, Hawaiian Electric is tracking the development of this and other tools/methods for resilience value quantification.

7.6 Grid Modernization Dependency

In addition to foundational grid hardening discussed above, there is a need to incorporate greater grid operational awareness, control, and automated switching flexibility to enhance resilience and reliability. The next phase of our proposed grid modernization program is estimated to cost approximately $63 million[23] (including voltage management devices discussed in Section 8) and is designed to provide system operators with a holistic distribution management solution that will enable reliable and resilient operation of its island grids, while managing high and ever-increasing levels of DER penetration in its pursuit of a fully renewable generation portfolio. To do so, the solution will integrate and leverage existing operational technology (OT) and information technology (IT) systems, an expanded set of smart grid field devices, AMI, customer-sited distributed energy resources, bulk system renewables, and Hawaiian Electric's National Institute of Standards and Technology (NIST)-based Cybersecurity program. The scope of Hawaiian Electric's next grid modernization (Phase 2) 5-year scope includes:

- Advanced distribution management system (ADMS) for grid operators to effectively monitor, visualize, control, and predict conditions on the distribution grid using substation automation and distribution field devices in a coordinated fashion.
- Telecom and OT cybersecurity monitoring solution to converge security feeds from those networks into a centralized Network Operations and Security Center (NOSC) for 24×7 monitoring and response.
- Targeted proactive deployment of field devices (i.e., smart fuses, smart reclosers, motor-operated switches, and smart fault current indictors) to provide enhanced circuit switching flexibility and capability to address the needs of high-risk circuits, often located in disadvantaged communities.
  - Smart fuses and smart reclosers. We plan to install 188 smart fuses and 197 smart reclosers. They provide reclosing and isolating capabilities on distribution lines. These devices sectionalize circuits so that fewer customers experience service interruptions for faults downstream of the device, and can re-establish service automatically after a momentary fault (e.g., vegetation contacting a line), and increase system operator visibility and control.
  - Motor-operated switches. We plan to install 59 motor-operated switches on the transmission and distribution system. These devices provide remote-operated, motor-controlled switching and isolation capability, and can sectionalize circuits so

[23] Final costs to be submitted in a forthcoming application

that fewer customers experience service interruptions downstream of the device.

- Smart fault current indicators. We plan to install 1,251 of these devices to sense fault current to determine the source and location of outages. These devices will allow us to identify specific fault locations, resulting in faster restoration times.

A visual representation of the different components of the project and how they are integrated to provide the full solution is illustrated in Figure 7-4.

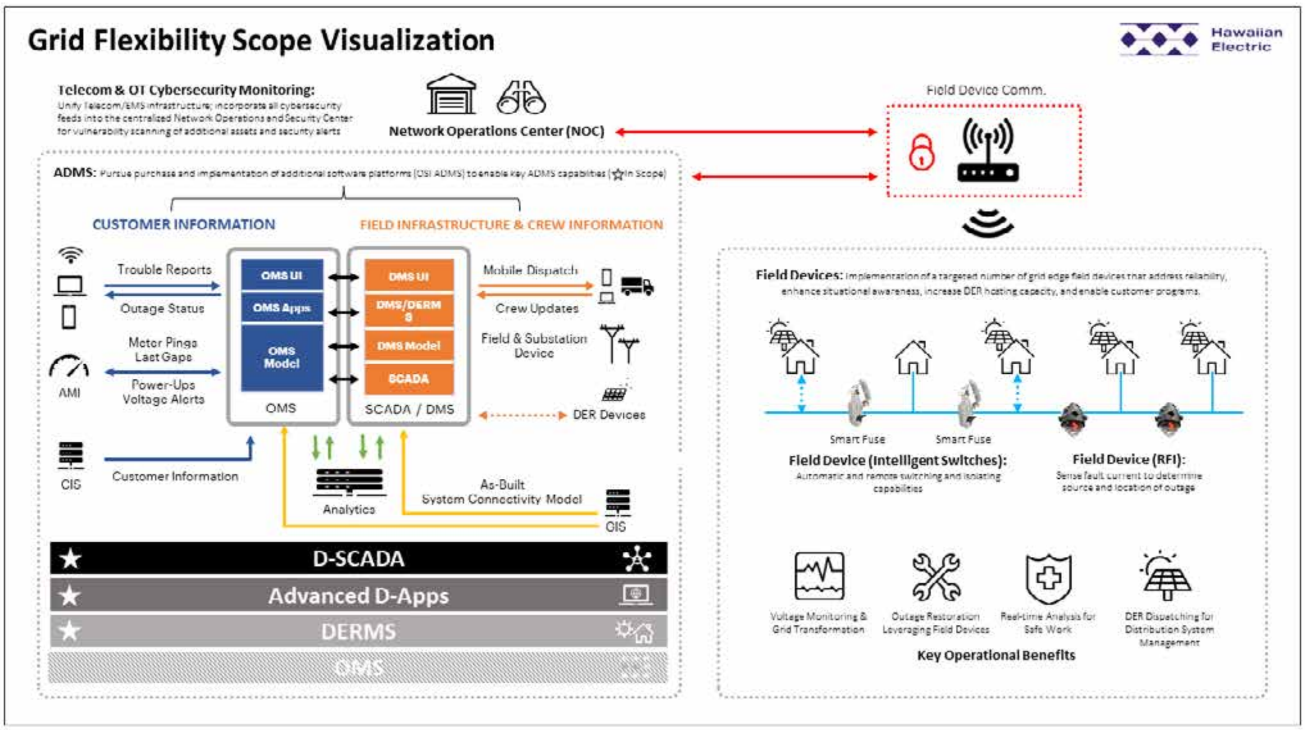


Figure 7-4. Hawaiian Electric Grid Flexibility project components

Grid hardening combined with the proposed field sensing, automated switches in a fault location, isolation and restoration scheme has proved to significantly enhance the resilience of a distribution network. These grid modernization technologies also enable the integration of customer and hybrid microgrid islanding capabilities for resilience and the utilization of their resources for "blue sky" grid services.

As illustrated in the DOE diagram below (Figure 7-5), each of these investment categories, discussed in this strategy, build upon one another to create what DOE refers to as the modern distribution pyramid. This pyramid is founded upon safe, resilient, and reliable designs and equipment standards, as well as replacement of aging and inadequate infrastructure that incorporates appropriate resilience "hardening." These physical grid investments are augmented with operational and information technologies to improve grid operational awareness, protection, controls, and automation that enable DER utilization and microgrid development.

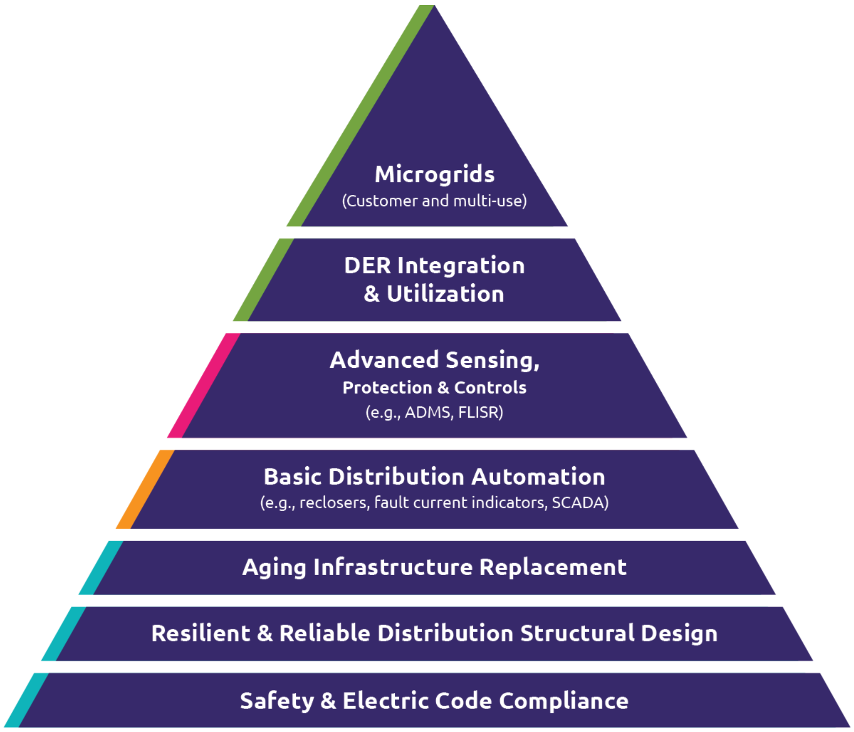


Figure 7-5. DOE distribution investment pyramid

Therefore, grid modernization investments enhance both the prevention and mitigation strategies to reduce customer outages and related impacts. Hawaiian Electric's ability to address the identified resilience and reliability needs as discussed in this strategy is dependent upon the next phase of grid modernization that seeks to significantly improve our distribution operational capabilities commensurate with industry best practices.

7.7 Resilience Working Group

Hawaiian Electric's Resilience Strategy addresses many of the recommendations of the Resilience Working Group[24] by considering threat scenarios such as Hurricane/Flood/Wind (see Section 7.2 above on identifying and prioritizing system threats); key customer and infrastructure priorities (see Section 7.4.1 above on the Initial T&D Resilience Program); elements of resilience such as reducing the probability of outages and restoration times during a severe event (see Section 7.3 above on establishing performance targets and developing decision-making methods); all possible lowest-cost solutions whether best accomplished solely through utility actions or through a combination of utility, customer, and third-party actions (see Sections 7.4 and 7.5 above on System Hardening and Residual Risk Mitigation).

Hawaiian Electric will continue to engage the Resilience Working Group and its members to understand critical infrastructure priorities and to develop and assess resilience metrics.

24 https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/resilience/20200429_rwg_report.pdf

8. Grid Needs Assessment

We define the pathways to 100% renewable energy through use of modeling tools to learn how much clean energy output is needed and from which technologies to meet the expected customer electricity demand over time. Using the scenarios and forecasts from the data collection phase we use multiple models to assess grid needs at the generation resource, transmission, and distribution levels.

In consultation with the public and stakeholders, we use leading-edge practices vetted by the Technical Advisory Panel to lay out the lowest-cost pathway that considers each island's unique needs to achieve an affordable, reliable, and 100% renewable system.

Near-term resource additions, hybrid solar and wind, provide the foundation for the lowest-cost, reliable pathway. Variable renewables (i.e., hybrid solar and wind) procured through planned procurements such as Phase 2 Tranche 2 of the CBRE program and Stage 3 will solicit projects that fulfill the remaining transmission capacity and continue to stabilize rates. In the longer term, transmission network capacity expansion (renewable energy zones) will be needed to integrate higher amounts of variable renewables.

We found that resource diversity will complement weather-dependent resources and shore up reliability. Firm renewables procured through the Stage 3 RFP can effectively diversify the resource portfolio. As existing steam plants continue to age with worsening forced outage rates on Oʻahu and lack of spare parts risks the ability to maintain generating units at Māʻalaea on Maui, reliability can be improved with the addition of the firm renewables targeted through Stage 3 that act as standby generation to be dispatched only during periods of low sun and wind. However, these resources may serve in more than just a standby role and be increasingly relied upon if adoption of electric vehicles accelerates faster than anticipated and forecasted loads increase significantly in the near term.

Additional variable renewables selected and analyzed by the planning models through 2035 will form the targets for future procurements, discussed in Section 11. Bringing these resources to commercial operation will require the development of new renewable energy zones. Transmission non-wires alternatives can cost-effectively manage the buildout of this new transmission, though this may mean that less than the full technical potential for new variable renewables can be developed. Grid modernization of the distribution system will also be needed to increase hosting capacity for distributed energy resources and accommodate new housing and electrification loads to meet statewide housing and decarbonization goals.

If renewable energy zones cannot be developed, future variable renewables after Stage 3 may be delayed until technological advancements or aggregated distributed energy resources become a more cost-effective resource option. In this scenario system stability is a concern with the current state of customer-scale inverter technology. Expanding energy efficiency may also be a cost-effective resource to pursue and solicited through a future procurement.

Ultimately the pathways we lay out serve as a roadmap to grow the customer- and community-centered energy marketplace to determine the specific technologies and projects that allow us to source the solutions we need for the grid that we want. It also identifies the transmission and distribution infrastructure needed to enable the grid as a platform to integrate technologies that we acquire from the marketplace.

8.1 Overview of Grid Needs

We identified resources to meet capacity and energy needs to serve customer demand through a multi-step process. We used a capacity expansion model to select candidate resource options based on forecasted loads, fuel prices, and resource costs to meet renewable portfolio standard and reliability planning criteria and identify a Base scenario of resource additions through the planning horizon ending in year 2050. We evaluated additional scenarios to test the sensitivity of various planning inputs on the resource selection.

- Across different load scenarios, the models consistently selected high levels of solar, wind, and energy storage because of their low cost. These resources are also used to meet load growth due to electrification of transportation and carbon reduction goals.
- In scenarios with higher electricity demand, the same mix of resources were selected in higher amounts and some amount of firm resources were also added to meet the capacity planning criteria.
- In a High Fuel Retirement Optimization scenario, the model accelerated retirements early in the planning horizon. While this may be preferred from a cost optimization perspective, practically, a staggered deactivation schedule would better ensure that replacement resources could be placed into service prior to the thermal unit's planned removal from service.
- On O'ahu, if future onshore renewables are limited in a Land-Constrained scenario, offshore wind and firm renewables will be relied upon to serve demand. Our 2030 greenhouse gas emission reduction goals may be at risk or need to be served with higher-cost renewables such as increased use of biofuels if large-scale solar and wind cannot be developed cost effectively.

We then conducted a resource adequacy analysis to examine key years in the planning horizon. Year 2030 was examined to confirm that the addition of the Stage 3 RFP variable renewable and firm resources results in a reliable system. Year 2035 was examined to identify any capacity and energy shortfalls that would need to be addressed in the next procurement, which is the next step of the Integrated Grid Planning process.

- In 2030, the O'ahu and Maui Base scenarios and the O'ahu Land-Constrained scenario that include 450 MW of hybrid solar and some new firm renewable generation from the Stage 3 RFP achieve a loss of load expectation less than 0.1 day per year. The Hawai'i Island Base scenario that includes some new variable renewable generation from the Stage 3 RFP achieves a loss of load expectation less than 0.1 day per year. Moloka'i and Lāna'i continue to maintain at least a 0.1 day/year loss of load expectation through the addition of variable renewables and storage.
- In 2035, the resources in the Base and Land-Constrained scenarios continue to provide

sufficient reliability. We tested the High electricity demand scenario to examine what additional resources after the Stage 3 RFP may be needed if actual loads are closer to the High electricity demand forecast. This information is provided below in each island's Resource Adequacy section.

After confirming that the Base and Land-Constrained scenarios would meet the reliability standard, we assessed the operations and cost of the resource plan.

- On typical days, the majority of system demand would be served by renewable resources, predominantly large-scale solar, wind, and private rooftop solar.
- By 2030, we could achieve the following renewable portfolio standard on each island: Oʻahu 77%, Hawaiʻi Island 99%, Maui 91%, Lānaʻi 95%, and Molokaʻi 92% with a consolidated renewable portfolio standard of 81% and a consolidated emissions reduction relative to 2005 levels of 75%.
- In 2030, we could achieve 100% renewable energy for the following percentage of hours on each island: Oʻahu 14%, Hawaiʻi Island 89%, Maui 57%, Lānaʻi 79%, and Molokaʻi 80%.
- Use of fossil-fuel firm generation is expected to decline dramatically compared to the status quo.

Additional details, supporting analyses, and resource plan data can be found in Appendix C.

8.1.1 Probabilistic Resource Adequacy

The resource adequacy step examines the reliability of the portfolios built in the RESOLVE model, which is used to optimize the resource portfolio for cost and reliability, among other factors. We then evaluated reliability of the system using metrics such as loss of load expectation (LOLE), loss of load events (LOLEv), loss of load hours (LOLH), and expected unserved energy (EUE) and compared their reliability against a known standard.

We focus primarily on loss of load expectation, which measures the average number of days per year where there is unserved energy (i.e., insufficient electricity supply to meet demand), and expected unserved energy, which is the amount of unserved energy in a given year.

We use the North American standard for loss of load expectation of 0.1 day per year, which means that the probability of unserved energy occurring in a day (regardless of duration or magnitude) is 1 day every 10 years; similarly, a loss of load expectation greater than, for example, 2 days per year, means that the probability of unserved energy occurring is at least 2 days per year. The lower the loss of load expectation is, the more reliable the system is.

We stress tested the portfolios against 5 weather years (2015–2019 solar and wind data) and 50 random thermal unit outage draws for a total of 250 samples of different conditions for available production from variable renewables and availability of firm generation thermal units.

Because the probabilistic resource adequacy is a computing resource-intensive process, select years were examined rather than the entire planning horizon. We selected 2030 and 2035 as the focus years for this analysis. By 2030, we expect that the resources procured through Stage 3 will achieve commercial operations, so studying 2030 will confirm whether the capacity and energy targeted in this procurement will satisfy near-term reliability and will assess the reliability risk if we fall short of acquiring the resources sought in our Stage 3 RFP—we explore this in detail in Section 12.

8.1.2 Grid Operations

We analyzed the Base resource plan in PLEXOS to capture the system cost over the planning horizon and provide a view of how existing and new generators are expected to operate to meet electricity demand. The O'ahu Land-Constrained plan was also analyzed in PLEXOS to determine how the dispatch may change.

We also analyzed separate Status Quo scenarios in PLEXOS and this is presented in Appendix C. At a high level, this scenario assumed the Base forecast for rooftop solar and energy storage, energy efficiency, and electric vehicles; commercial operations of Stage 1, Stage 2, and CBRE Phase 2 Tranche 1 projects; successful renegotiation of PPAs for existing independent power producers projects; and continued operation of most existing thermal units. Future resources selected by RESOLVE were not included.

8.1.3 Transmission and System Security Needs

Transmission and system security needs are identified to address transmission system capacity shortages because of future generation interconnection and load growth, and system dynamic stability needs to maintain future system stability within transmission planning criteria. In this section, we describe summary results for each island system. In Appendix D, details of the transmission analysis for each island are presented. The following summarizes our observations and recommendations from the transmission needs analysis:

- Transmission network expansion is critical for interconnecting significant quantities of large-scale renewable energy and serving future load growth. The Maui system may require transmission network expansion earlier, starting from the Stage 3 procurement, and the O'ahu and Hawai'i Island systems may require transmission network expansion in later years, depending on the location of future projects.
- Location of future generation projects matters. Projects interconnected at the proper locations may defer transmission line upgrades but also mitigate undervoltage issues that cannot be fixed solely by transmission line upgrades. This is especially true for the Hawai'i Island system.
- Grid-forming capability is critical for future system stability. To mitigate stability risks caused by momentary cessation of distributed energy resources or other grid-following resources during a system event, the study identifies minimum requirement of grid-forming resource capacity or "MW headroom" to maintain system stability performance within the planning criteria. The grid-forming resource MW headroom is the available MW capacity before a grid-forming resource generation reaches its contract (usually nameplate or rated) capacity. The MW headroom requirement is directly related to the amount of distributed generation outputting to the system at any given time.
  - It is worth noting that we have yet to obtain actual grid-forming field operation experience to validate the modeling studies. We based our recommendations on observed performance from the grid-forming resource models. Industry experience indicates promising performance of grid-forming resources at utilities such as Kauai Island Utility Cooperative and Australia Energy Market Operator. It will be important to perform model validation and performance reviews based on field operation data once the grid-forming resrouces are online.

8.1.3.1 Important Study Assumptions and Scope Limitations

For future large-scale generation interconnection, the study assumes that current interconnection sites with available grid capacity will be used first. Also, projects that withdrew from the Stage 1 or Stage 2 procurement are assumed to return in some form during the Stage 3 procurement. Once all existing capacity is occupied, future interconnection sites will be selected based on the renewable potential, community feedback, and cost of system upgrades. It is possible that actual project interconnections in future procurements are at different locations. Different interconnection locations can drive very different transmisson system capacity upgrade needs.

For each scenario, load is allocated in proportion to existing substation loads, aggregated at transmission substations. In reality, load may increase at different rates across the system.

It is worth noting that to identify transmission system capacity needs to accommodate future large-scale generation projects, distributed generation is not considered in the steady-state analyses.

Dynamic stability is sensitive to advanced grid technology development; therefore, we focus our analysis on near-term years (i.e., before 2040). New grid technology, on both the generation and customer demand sides, may result in different stability needs.

Additionally, our analysis evaluates very high penetration of inverter-based resource and DER scenarios. For example, in the Maui dynamic stability study, all studied scenarios represent 100% inverter-based resources. Currently, the industry has limited operational experience for the type of system we project to have in the near future. Both the study scope and models used for the dynamic stability study have limitations, and there may be other stability risks that are unknown at this time, and hence, not included in the current study, or represented in current models used for this study.

This analysis is focused on high-level grid needs. Detailed analyses, including fine control tuning for future large-scale generation projects, will be performed as part of the future generation projects' Interconnection Requirements Studies. Additional information on this analysis, including the High electricity demand scenarios, is provided in Appendix D.

8.1.4 Distribution Needs

Distribution grid needs are identified based on the two distribution services defined in the *Distribution Planning Methodology.*[25] To ensure adequate capacity and reliability (back-tie capabilities), the distribution grid needs are identified using two analyses:

- **Hosting capacity grid needs** assessed each circuit's ability to accommodate the forecasted DER growth for that circuit. These grid needs and a description of the hosting capacity analysis were provided in the November 2021 *Distribution DER Hosting Capacity Grid Needs* report [26].
- **Location-based distribution grid needs** assessed the ability of distribution circuits and substation transformers to serve forecasted load growth (i.e., load-driven grid

[25] *See* Hawaiian Electric Companies' Grid Needs Assessment Methodology Review Point, Exhibit 1 Distribution Planning Methodology, filed on November 5, 2021, in Docket 2018-0165.

[26] *See* Hawaiian Electric Companies' Grid Needs Assessment Methodology Review Point, Exhibit 4 Distribution DER Hosting Capacity Grid Needs, filed on November 5, 2021, in Docket 2018-0165.

needs). This analysis is further described in Appendix E.

8.1.4.1 Stakeholder Engagement and Feedback

Throughout the process of developing grid needs, we engaged stakeholders and the Technical Advisory Panel for feedback and refined the methodology as needed.

During development of the hosting capacity grid needs, we met with stakeholders in October 2021 and provided a preliminary report for stakeholder review that included details of the methodology used and preliminary grid needs results. Stakeholder feedback was incorporated into the final version that was filed in November 2021.

Similarly, during development of the load-driven grid needs, we engaged stakeholders throughout the process for feedback on the methodology and preliminary results. The methodology used to develop the location-based forecasts was shared with stakeholders in October 2021 and discussed at the Stakeholder Technical Working Group meeting. Additionally, as grid needs were identified later in the process, we met with the Technical Advisory Panel in November 2022 and the Stakeholder Technical Working Group in January 2023 to discuss the process to identify grid needs and the subsequent NWA evaluation to determine if any grid needs were qualified NWA opportunities.

8.1.4.2 Hosting Capacity Grid Needs

Of the 620 circuits[27] assessed across the five islands, most had sufficient DER hosting capacity or could accommodate the 5-year hosting capacity[28] without infrastructure investments. The remaining circuits where infrastructure investments are required to increase hosting capacity to accommodate the forecasted distributed energy resources are identified as requiring grid needs.

In the Base and Low DER forecasts, infrastructure investments or distribution upgrades (i.e., wires solutions) identified are phase balancing, installing voltage regulators, reconductoring, and installing dynamic load tap changers. The High DER forecast identified similar types of distribution upgrades as in the Base and Low DER forecasts, with the addition of step-down transformer upgrades and converting a feeder section from 4 kilovolts (kV) to 12 kV. The costs to implement these solutions are summarized by island.

8.1.4.3 Location-Based Grid Needs

In the location-based (load-driven) grid needs analysis, 645 circuits[29] and 351 substation transformers[30] were assessed with a study period through year 2030. The analysis finds that most substation transformers and circuits have sufficient capacity to accommodate the forecasted load demand. For substation transformers and circuits where there is insufficient capacity, a grid need is identified.

Most grid needs in the near term are driven by service requests,[31] or new load requests to

[27] The total circuits assessed for each island are: 384 on O'ahu, 137 on Hawai'i Island, 88 on Maui Island, 3 on Lāna'i, and 8 on Moloka'i.

[28] The study period for the hosting capacity analysis was year 2021 through year 2025.

[29] The total circuits assessed for each island are: 393 on O'ahu, 148 on Hawai'i Island, 93 on Maui, 3 on Lāna'i, and 8 on Moloka'i.

[30] The total substation transformers assessed for each island are: 204 on O'ahu, 82 on Hawai'i Island, 62 on Maui, 1 on Lāna'i, and 2 on Moloka'i.

[31] We receive service requests, or new load requests, from residential and commercial developers such as new subdivisions, condominiums, or shopping centers.

support new housing or commercial development, in specific locations on the distribution system. The grid needs driven by the corporate forecast appear to be a small subset of the total grid needs. In these scenarios, total load growth (e.g., a combination of increase in load demand plus electrification of transportation) drives the grid need and occurs mostly in the later time frame (years 2028 to 2030).

Distribution upgrades (i.e., wires solutions) identified vary by scenario. Wires solutions include, but are not limited to, new circuits, reconductoring, new substation transformers, circuit line extensions, and voltage conversions. The costs to implement these solutions are summarized by island and scenario.

8.1.4.4 Distribution Grid Needs Summary

Because the Hosting Capacity Grid Needs analysis was completed separately from the Location-Based Grid Needs analysis, grid needs resulting from both processes were compared to determine if any grid needs overlapped. In other words, it was determined whether a grid need identified for a circuit during the hosting capacity analysis also could provide a common solution to a grid need identified through the location-based process.

This reconciliation process found that the grid needs were mutually exclusive—the hosting capacity grid needs were different from the load-driven grid needs. In general, the needs are different because the load-driven grid needs occur primarily during non-solar hours when loading on circuits and transformers is typically highest, whereas the hosting capacity grid needs are mitigating overloads that occur during solar hours.

Additionally, for the load-driven grid needs, there are situations where a traditional solution is a common solution that could solve multiple grid needs simultaneously. For example, if two circuits are overloaded on the same substation transformer, this is counted as two grid needs in the location-based grid needs tables (see Table 8-7, Table 8-20, and Table 8-29)—one mitigation for each circuit. However, if a new circuit is installed, that one solution could solve both grid needs for the two existing overloaded circuits. In the Distribution Grid Needs Summary tables in the following sections, only one grid need is counted for this type of situation, reflecting the minimum number of grid needs.

8.1.4.5 Non-wires Alternative Opportunities

The NWA opportunity evaluation methodology described in Appendix F is used to determine if the grid needs identified in each island's Distribution Grid Needs Summary are qualified or non-qualified non-wires opportunities based on technical requirements and timing of need. In other words, it was determined whether an NWA procurement was likely and feasible to mitigate the grid need. This evaluation process consists of the three-step methodology shown in Figure 8-1 below.

Figure 8-1. Non-wires alternative opportunity evaluation methodology

In Step 1, qualified projects are those with an in-service date beyond 2 years to allow enough lead time for non-wires procurement. For the purposes of this evaluation, projects with an in-service date of 2025 or later are deemed qualified. Non-qualified projects are those with an in-service date of 2024 or earlier.

In Step 2, additional sourcing criteria are used to evaluate the feasibility of an NWA using performance requirements, forecast certainty, project economics, and market assessment for qualified projects identified in Step 1.

A summary of the sourcing evaluation criteria is shown in Table 8-1 below.

Table 8-1. Summary of Non-Wires Alternative Sourcing Evaluation Criteria

Category	Favorable	Moderate or Uncertain	Unfavorable
Project Economics	$1M and above	Between $500k and $1M	Less than $500k
Performance	Capacity: up to 5 MW *and* Duration: up to 4 hours	Capacity: >5 MW and <10 MW *or* Duration: >4 hours and <8 hours	Capacity: 10 MW and larger *and* Duration: 8 hours or more
Forecast Certainty	Service request	Developer forecast and/or spatial allocation	
Market Assessment	0$–10%	>10%	
Operating Date (Timing)	2025–2027	2028 and later	2024 and earlier (per Step 1)

In Step 3, using the results of the weighted criteria described above, grid needs are sorted into three possible tracks:

- **Track 1**: qualified; high likelihood of NWA success for procurement
- **Track 2**: qualified; pricing/program approach (for projects less than $1 million) or reevaluate NWA opportunity in the future
- **Track 3**: non-qualified opportunities; implement wires solution

Results of the sorting by track is shown in Table 8-2 by scenario.

Table 8-2. NWA Opportunity Projects by Track

Track	Island	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
1 (qualified: procurement likely)	O'ahu	5	3	1	6
2 (qualified: pricing approach or reevaluate later)	O'ahu	1	4	3	1
3 (non-qualified)	O'ahu	1	11	2	3
	Hawai'i Island	-	-	-	1
Total (all tracks)	n/a	7	18	6	11

8.1.5 Grid Modernization

We are also actively pursuing a grid modernization program that is foundational to realizing this Integrated Grid Plan. Phase 1, which includes the rollout of advanced meters and associated infrastructure, is currently being implemented with expected completion by the third quarter of 2024. Phase 2 will be resubmitted to the Public Utilities Commission for approval in conjunction with an application for federal funding through the Infrastructure Investment and Jobs Act (IIJA). In addition to the scope described in Section 7.6, Phase 2 includes voltage management devices to increase circuit hosting capacity on the distribution system as described in this section.

The hosting capacity needs analysis informed the scope of voltage management field devices. We identified 68 voltage regulators and 35 secondary voltage-ampere reactive (VAR) controllers to address hosting capacity at the distribution level between years 2021 and 2025.[32]

8.1.6 System Protection Roadmap

The objectives of system protection are to isolate power system faults, equipment failures, or any other unusual or extreme condition that puts the power system in jeopardy. This includes minimizing the extent and duration of the resulting forced outage and preventing system instability resulting from a system disturbance.

One technical consideration of decreasing system strength is the impact on protection systems. All electric utilities use traditional protection systems to detect and clear faults, and maintain system integrity. The Technical Advisory Panel Distribution Subcommittee was interested in how our protection systems will change in response to the higher levels of inverter-based generation. At the November 16, 2022,[33] Technical Advisory Panel Distribution Subcommittee meeting and the

[32] The updated field devices scope for Grid Modernization Phase 2 also includes projected needs between 2024-2028. The updated Phase 2 field devices scope includes 106 total voltage regulators of which 46 voltage regulators are common to both the distribution grid needs and the Phase 2 scope.

[33] See https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/technical_advisory_panel/20221110_protection_roadmap.pdf

December 1, 2022, Technical Advisory Panel meeting we presented our system protection roadmap, which summarized how the protection systems are anticipated to change and what would trigger those changes. For example, if breaker clearing times are too slow and causing instability, then faster two-cycle breakers or circuit switchers would be needed. If line current differential schemes become slow from lack of system strength, then moving to traveling-wave schemes may mitigate those issues. We are currently in the process of upgrading certain components of our protection scheme; for example, moving from electromechanical relays to more capable microprocessor relays, and upgrading fuses that may not operate timely because of lack of fault current to smart fuses (as part of the grid modernization Phase 2 scope).

The protection system will evolve over time and will be addressed as the system undergoes changes. For example, as large-scale generation is added to the system, protection in that area or region of the grid will be evaluated and addressed to maintain the protection system objectives. Common to the various protection solutions is high-speed communications, which enables protection to act quickly and decisively based on situational awareness. This Integrated Grid Plan does not directly identify future investments needed to mitigate potential protection issues; however, as we learn more about our system and how large-scale and customer-scale inverters perform, we will gain more insight into the protection investments needed for the future.

8.2 O‘ahu

This section describes the results of the grid needs assessment for O‘ahu through the multistep process that includes modeling capacity expansion, resource adequacy, operations of the system, transmission and system security needs, distribution needs, and iterations or adjustments made to determine the preferred plan.

8.2.1 Capacity Expansion Scenarios

In the Base scenario below (Figure 8-2), RESOLVE builds standalone BESS, hybrid solar, and onshore wind, achieving approximately 80% renewable energy by 2030. In 2035 offshore wind is added, and by 2050 biomass is added. The Low Load and Faster Technology Adoption scenarios do not build the biomass by 2050 while the High Load scenario does. Existing fossil fuel–based resources are shown as firm renewable resources in 2050 because of their switch to biofuels in 2045. All cases achieve their RPS targets with consistent increases in utilization of renewable resources. Figure 8-3 shows the annual generation and renewable portfolio standards for O‘ahu for the Base, Low Load, High Load, and Faster Technology Adoption scenarios.

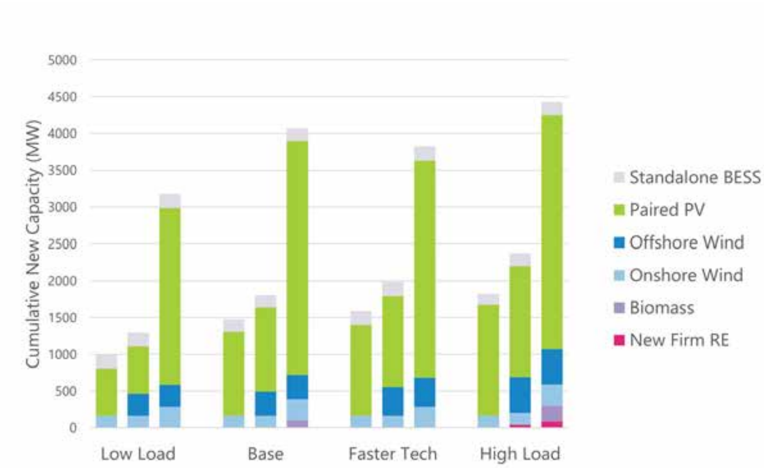


Figure 8-2. O‘ahu: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

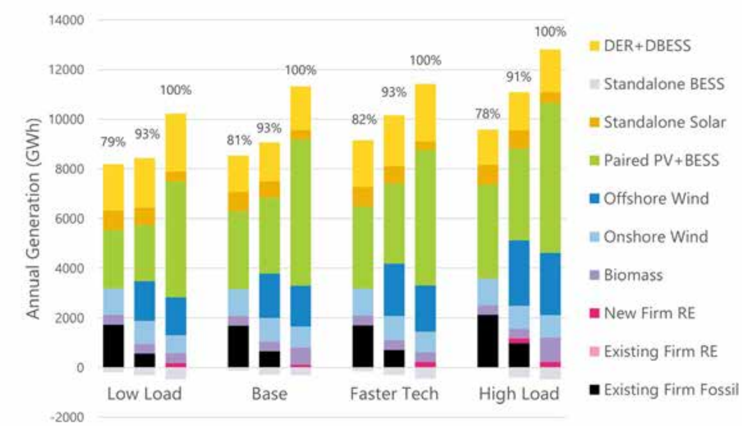


Figure 8-3. O‘ahu: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

8.2.1.1 Land-Constrained Scenarios

In discussing the capacity expansion results of the O'ahu Land-Constrained scenario with the Technical Advisory Panel, they noted that this scenario does not meet our goal of 70% carbon reduction by 2030 and that the assumptions in this scenario to constrain the available large-scale renewables may be closer to reality than other scenarios. When enforcing this constraint in RESOLVE through the RPS target, there is a limited change in resource plan buildout; however, additional generation from new and existing firm renewables (i.e., biodiesel) is used to meet the 70% carbon reduction goal by 2030 compared to the Land-Constrained scenario that is not required to meet that goal. This indicates that the DER aggregator resource (the only remaining resource option that can be built) is a higher-cost option than the incremental biodiesel generation from firm renewables in 2030 when the decarbonization goal must be met. We note that, because the DER aggregator resource is not selected until 2045 and 2050 when we must comply with the 100% renewable energy mandate, new advanced generation technologies could become available prior to 2045 that could accelerate the path to 100% renewable energy in a Land-Constrained scenario.

Figure 8-4 shows cumulative new capacity and Figure 8-5 shows annual generation and renewable portfolio standards for O'ahu for the Land-Constrained scenario with 70% RPS requirement in 2030.

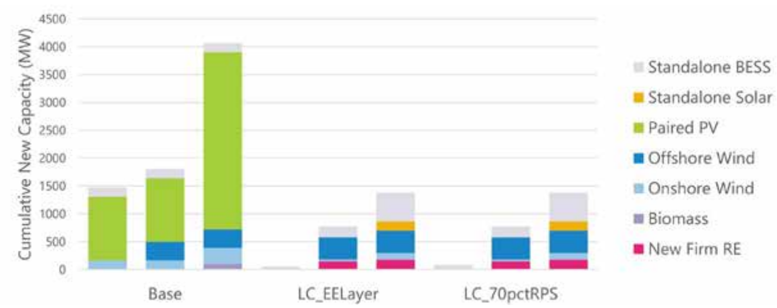


Figure 8-4. O'ahu: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, Land-Constrained, and Land-Constrained with 70% RPS by 2030 constraint

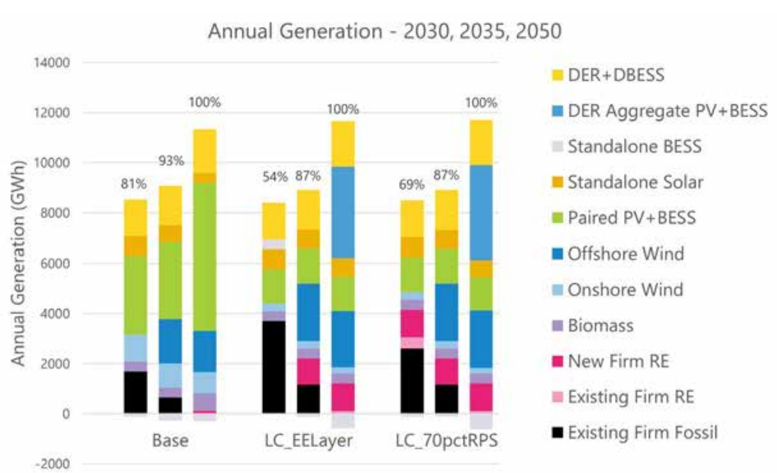


Figure 8-5. O'ahu: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base, Land-Constrained, and Land-Constrained with 70% RPS by 2030 constraint

8.2.1.2 High Fuel Retirement Optimization Scenario

We evaluated a High Fuel Retirement Optimization scenario to determine the impact to our fossil-fuel retirement plans and other resources. In the High Fuel Retirement Optimization scenario, RESOLVE chooses to retire 570 MW of thermal capacity (see Figure 8-6). Because RESOLVE performs a linear optimization, the additional retirements may consist of partial unit retirements. These additional retirements occur early in the planning horizon before 2030 and are replaced with biomass and increased amounts of hybrid solar. By 2050, the High Fuel Retirement Optimization scenario builds less hybrid solar and offshore wind because of the increased amount of biomass installed in 2030.

Because RESOLVE front-loads the removal of units early in the planning horizon, extreme care must be taken to ensure that customers are not adversely affected by an inadequate system. It is anticipated that removal of existing thermal generating units would result in a loss of load expectation greater than 0.1 day per year. Additionally, this scenario significantly accelerates the buildout of hybrid solar compared to the Base scenario, which would require an extraordinary effort by the marketplace to ensure that sufficient resources are built prior to retirement of firm generation. In practice, to ensure that sufficient replacement resources are in service to facilitate the retirements selected in this sensitivity, the unit removals would need to be staggered similar to our proposed removal-from-service schedule. Otherwise, the retirements shown in this sensitivity would increase the risk of unserved energy to our customers.

Figure 8-6 shows cumulative new capacity for O‘ahu, comparing the Base and High Fuel Retirement Optimization scenarios.

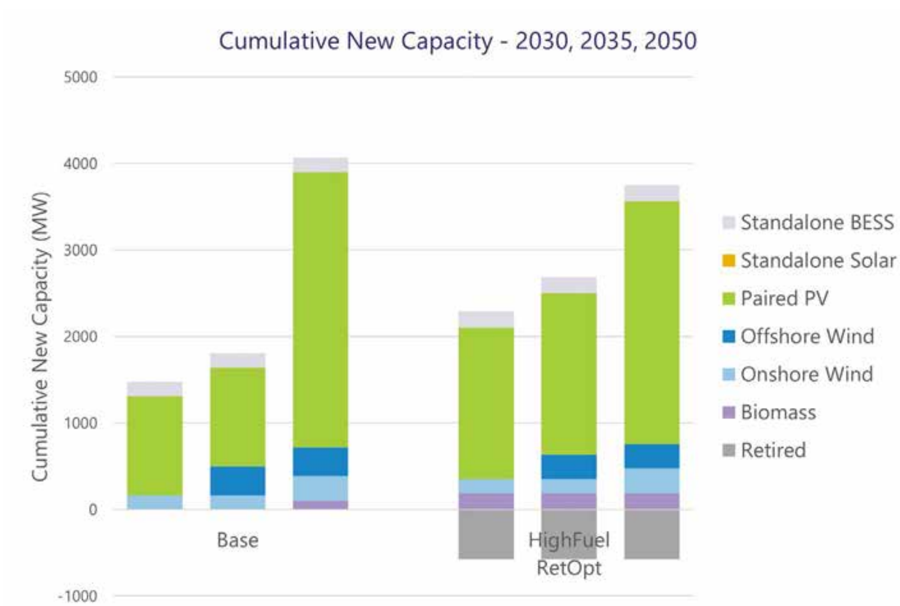


Figure 8-6. O‘ahu: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

However, the High Fuel Retirement Optimization scenario validates a key point, that we must urgently move to integrate lower-cost renewable resources (than the price of fossil fuel) as soon as practicable to lower the cost of electricity. Figure 8-7 shows annual generation and renewable portfolio standards for O'ahu for the Base and High Fuel Retirement Optimization scenarios.

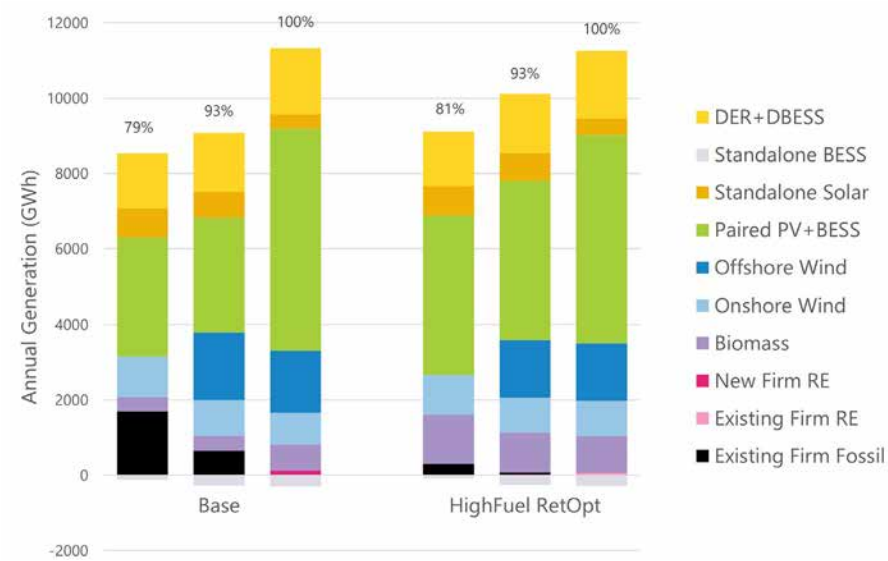


Figure 8-7. O'ahu: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

8.2.2 Resource Adequacy

In 2030, several key decision points are illustrated by the probabilistic resource adequacy analyses. By 2030, 371 MW of existing thermal capacity is planned to be removed from service. The impact of this planned removal is mitigated by the addition of new resources through the Stage 3 RFP. However, if we acquire less than the full Stage 3 targeted need, additional resources may be needed through additional procurements or planned removals of fossil fuel–based generation may be delayed. This is not desirable because of the present risks to the existing generation fleet as discussed in Section 12.

For planning purposes, we have assumed a stepwise approach to retirements or deactivations of our existing fossil-fuel generating fleet on O'ahu, as shown in Table 8-3. The scheduled removal from service for O'ahu is based primarily on the age of the unit.

Table 8-3. Generating Unit Deactivation/Retirement Assumptions

Year	Generating Unit
2024	Waiau 3–4 removed from service (93.5 MW)
2027	Waiau 5–6 removed from service (108.1 MW)
2029	Waiau 7–8 removed from service (169.1 MW)
2033	Kahe 1–2 removed from service (164.9 MW)
2037	Kahe 3–4 removed from service (171.5 MW)
2046	Kahe 5–6 removed from service (269.5 MW)

If development of future large-scale renewables is limited in a Land-Constrained scenario:

- We expect loss of load of less than 0.1 day per year, assuming that the planned deactivations through 2030 and the full target for the Stage 3 procurement is acquired (300 MW of new firm generation by 2029 and 450 MW of new variable renewable generation paired with storage by 2027). Acquisition of the full Stage 3 procurement targets may facilitate the deactivation of additional fossil fuel–based generators by 2030, beyond the planned removals.

- We expect a loss of load greater than 0.1 day per year (less reliable) if less than the full target for firm renewables in the Stage 3 procurement is acquired (e.g., 150 MW of new firm generation by 2029 and 450 MW of new variable renewable generation paired with storage).

If development of future large-scale renewables reaches the target presented in the Base scenario:

- We expect loss of load of less than 0.1 day per year, assuming that the planned deactivations through 2030, the full target for the Stage 3 procurement is acquired (300 MW of new firm generation by 2029 and 450 MW of new variable renewable generation paired with storage by 2027), and the marketplace delivers a combination of resources, consistent with the Base scenario, hybrid solar (1,150 MW), onshore wind (160 MW), and standalone storage (170 MW). Procurement of the full Stage 3 targets and additional variable renewable and storage resources may also facilitate the removal of further existing thermal units.
- We expect loss of load of less than 0.1 day per year if less than the full target for the firm renewables in the Stage 3 procurement is acquired (150 MW of new firm generation by 2029 and 450 MW of new variable renewable generation paired with storage by 2027) and the same combination of Base scenario resources. These resources may also facilitate the removal of additional fossil fuel–based generators by 2030, beyond the planned removals.

By 2035, we assumed deactivation of an additional 165 MW of existing fossil-fuel capacity after deactivating 371 MW by 2030. The reliability impact of this planned deactivation is mitigated by the addition of new resources through the Stage 3 procurement. However, if less than the full Stage 3 target is acquired, additional resources may be needed through the solution sourcing process.

If development of future large-scale renewables is limited in a Land-Constrained scenario:

- We expect loss of load of less than 0.1 day per year, assuming that the planned deactivations through 2035, the full target for the Stage 3 procurement is acquired (300 MW of new firm generation by 2029, an additional 200 MW of new firm generation by 2033, and 450 MW of new variable renewable generation paired with storage by 2027), and the marketplace delivers 400 MW of offshore wind. Procurement of the full Stage 3 targets and offshore wind may also facilitate the deactivation of additional fossil fuel–based generators by 2035.
- We expect loss of load of greater than 0.1 day per year if less than the full target for the firm renewables in the Stage 3 procurement is acquired (150 MW of new firm generation by 2029 and 450 MW of new variable renewable generation paired with storage by 2027) and Kalaeloa Partners' combined cycle plant expires at the end of its amended 10-year contract term. Reliability can be improved to a loss of load expectation of less than 0.1 day per year by reactivating units previously deactivated at Kahe and Waiau.

If development of future large-scale renewables achieves their technical potential in the Base scenario:

- We expect loss of load of less than 0.1 day per year, assuming the planned deactivations through 2035, the full target for the Stage 3 RFP is procured (300 MW of new firm generation by 2029, an additional 200 MW of new firm generation by 2033, and 450 MW of new variable renewable generation paired with storage by 2027), and the marketplace delivers a combination of resources, consistent with the Base scenario, hybrid solar (1,150 MW), onshore wind (160 MW), offshore wind (400 MW), and standalone storage (170 MW). Procurement of the full Stage 3 procurement targets and offshore wind may also facilitate the deactivation of additional steam units by 2035.

- We expect loss of load to be less than 0.1 day per year if we acquire less than the full target for the firm renewables in the Stage 3 procurement (150 MW of new firm generation by 2029 and 450 MW of new variable renewable generation paired with storage by 2027), Kalaeloa Partners' combined cycle plant expires at the end of its amended 10-year contract term, and we acquire the same combination of Base scenario resources.

Probabilistic Resource Adequacy Summary

Table 8-4 shows the 2030 Resource Adequacy results for the Base and Land-Constrained resource plans that were produced by RESOLVE. The results show that, in 2030, both resource plans developed by RESOLVE should meet our reliability targets.

Table 8-4. Probabilistic Analysis: Results Summary, O'ahu, 2030—Summary of Base and Land-Constrained 2030 Resource Adequacy Results

Scenario	Existing Firm (MW)	New Firm (MW)	Stage 3 RFP (MW)	Future Wind (MW)	Future Hybrid Solar (MW)	Future Standalone BESS (MW)	LOLE (Days/ Year)	LOLEv (Event/ Year)	LOLH (Hours/ Year)	EUE (MWh/ Year)	EUE (%)
RESOLVE Base	1,173	300	450	164	1,145	167	0.00	0.00	0.00	0.00	0.000
RESOLVE Land-Constrained	1,173	300	450	0	0	54	0.00	0.00	0.01	0.00	0.000

Table 8-5 shows the 2035 resource adequacy results for the Base and Land-Constrained resource plans that were produced by RESOLVE. In the Land-Constrained resource plan, RESOLVE selected a 153 MW combined cycle to be installed in 2035. In the 2035 probabilistic resource adequacy analysis, however, the 153 MW combined cycle was assumed not to be installed to test whether this firm generator is needed for resource adequacy.

Table 8-5. Probabilistic Analysis: Results Summary, O'ahu, 2035—Summary of Base and Land-Constrained 2035 Resource Adequacy Results

Scenario	Existing Firm (MW)	New Firm (MW)	Stage 3 RFP (MW)	Future Wind (MW)	Future Hybrid Solar (MW)	Future Standalone BESS (MW)	LOLE (Days/ Year)	LOLEv (Event/ Year)	LOLH (Hours/ Year)	EUE (MWh/ Year)	EUE (%)
RESOLVE Base	800	508	450	564	1,145	167	0.00	0.00	0.00	0.00	0.000
RESOLVE Land-Constrained	800	508	450	430	0	194	0.00	0.01	0.01	0.00	0.000
RESOLVE Base, High Load	800	508	450	564	1,145	167	0.00	0.00	0.00	0.00	0.000
RESOLVE Land-Constrained, High Load	800	508	450	430	0	194	0.65	1.42	3.28	0.60	0.007

The results show that, in 2035, both the Base and Land-Constrained plans developed by RESOLVE should meet our reliability targets. However, further analysis is needed for offshore wind addition as it does not have a robust historical record of production in Hawai'i (unlike onshore wind and solar), which could materially impact its reliability contributions.

In 2035, assuming a High electricity demand scenario and all 450 MW of hybrid solar from the Stage 3 RFP:

- Approximately 1,225 MW of new hybrid solar is needed, in addition to the 450 MW of hybrid solar from Stage 3, to bring the system loss of load expectation below 0.1 day per year.
- Approximately 200 MW of new firm generation is needed, in addition to the 500 MW of firm generation from Stage 3, to bring the system loss of load expectation below 0.1 day per year.

See Section 12 for more details on risks of the resource portfolio given uncertainties in procuring and acquiring the optimal mix of resources.

8.2.3 Grid Operations

The transition to 100% renewables will necessitate a change in how the firm thermal generators on our system operate. Scenarios with more renewable resources will use thermal generators less often. This is shown in the daily energy profiles and operational statistics in this section.

8.2.3.1 Status Quo Typical Operations

As stated above, a Status Quo scenario was run through PLEXOS. In this scenario, it assumed the Base forecast, commercial operations of Stage 1, Stage 2, and CBRE Phase 2 Tranche 1 projects; successful renegotiation of existing independent power producers; and continued operation of most existing thermal units. The Status Quo plan excluded CBRE Phase 2 Tranche 2, Stage 3 RFP resources, and future resources selected by RESOLVE. Shown below in Figure 8-8 and Figure 8-9 are the dispatch of the resources in a Status Quo resource plan in 2030 and 2035, respectively, for a few days with average load.

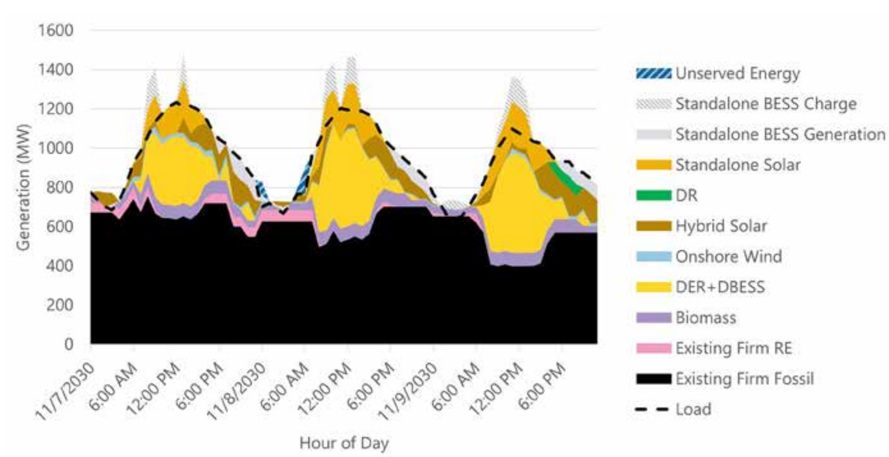


Figure 8-8. O'ahu: detailed Status Quo energy profile, 2030 median load day (November 7–9, 2030)

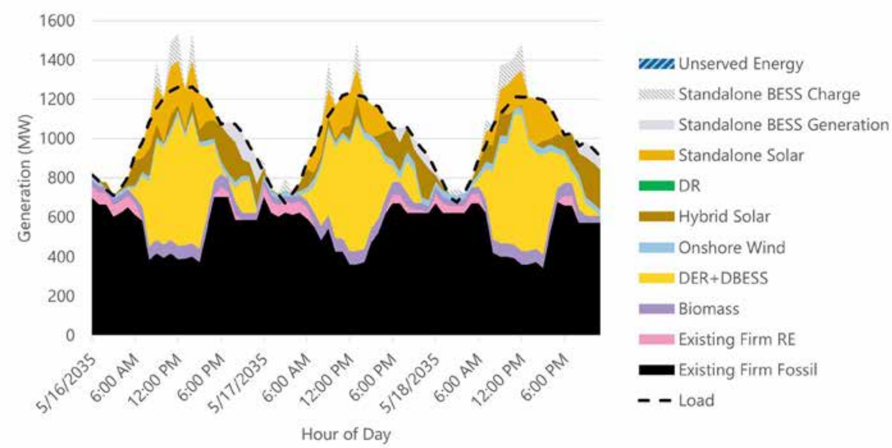


Figure 8-9. O'ahu: detailed Status Quo energy profile, 2035 median load day (May 16–18, 2035)

8.2.3.2 Base Scenario Typical Operations

The dispatch of the resources in the Base resource plan in 2030 and 2035, respectively, for a few days with average load are shown below in Figure 8-10 and Figure 8-11. In the Base resource plan, during midday, most of the load is expected to be met from variable renewable resources. The firm fossil fuel–based generators are used primarily during morning and evening hours.

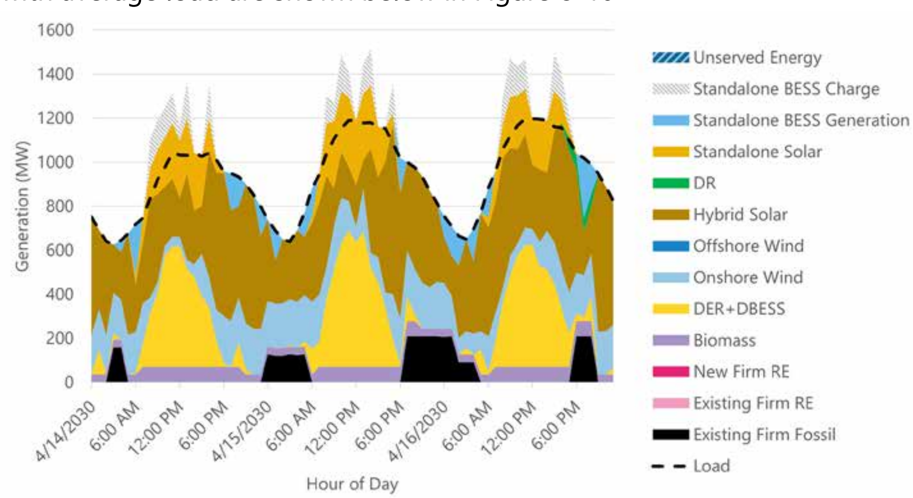


Figure 8-10. O'ahu: detailed Base energy profile, 2030 median load day (April 14–16, 2030)

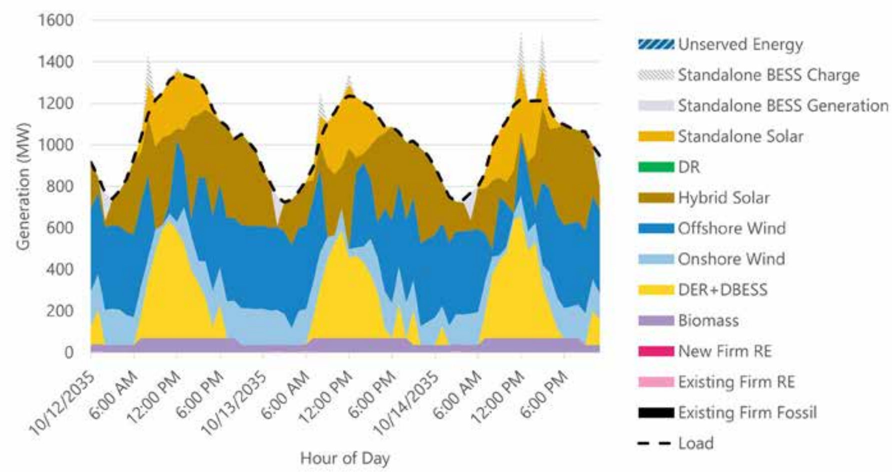


Figure 8-11. O'ahu: detailed Base energy profile, 2035 median load day (October 12–14, 2035)

8.2.3.3 Land-Constrained Scenario Typical Operations

The dispatch of the resources in the Land-Constrained resource plan in 2030 and 2035, respectively, for a few days with average load are shown below in Figure 8-12 and Figure 8-13. In the Land-Constrained scenario, we expect greater fossil fuel–based generation during midday than the Base scenario because of the lower amount of future renewables being added.

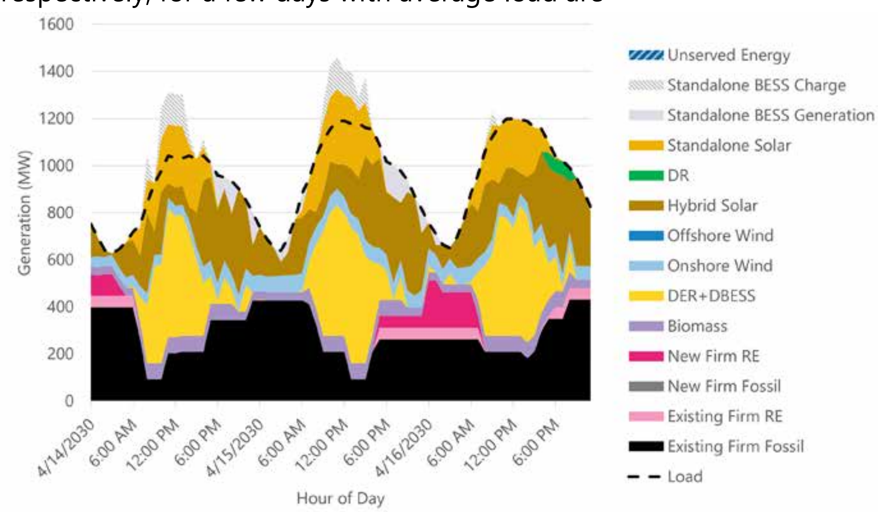


Figure 8-12. O'ahu: detailed Land-Constrained energy profile, 2030 median load day (April 14–16, 2030)

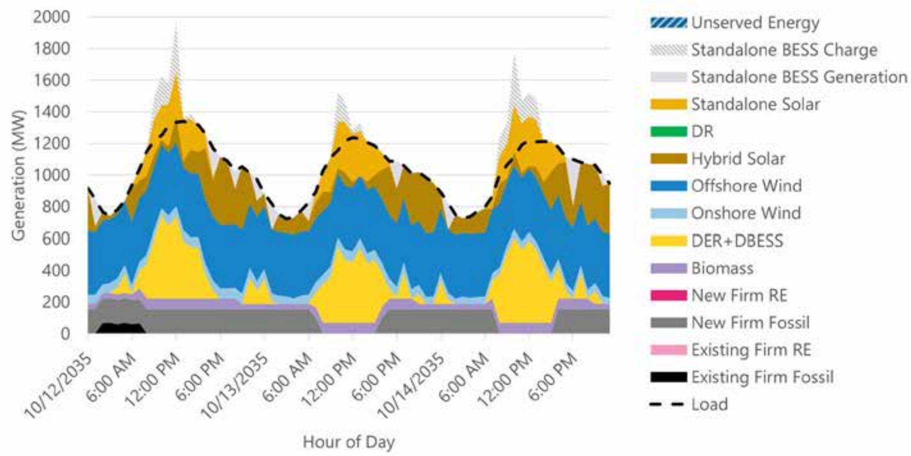


Figure 8-13. O'ahu: detailed Land-Constrained energy profile, 2035 median load day (October 12–14, 2035)

8.2.3.4 Operations of Firm Generation

We can gather insights into the changing role of firm generation by evaluating the number of starts of different types of firm generators and the amount those generators run, or the capacity factor, which is the percentage of hours a generator runs based on its rated capacity. The number of starts and capacity factor, respectively, of the utility-owned thermal generators for the Status Quo, Base, and Land-Constrained resource plans in 2030 and 2035 are shown in Figure 8-14 and Figure 8-15. Capacity factor was averaged for generators with similar operating characteristics. Because the Base resource plan adds more renewable resources in those years than the Land-Constrained plan, the generators have lower capacity factor and starts. Because the Status Quo plan doesn't add any new resources in the future, it has higher capacity factor and starts than the Base and Land-Constrained resource plans.

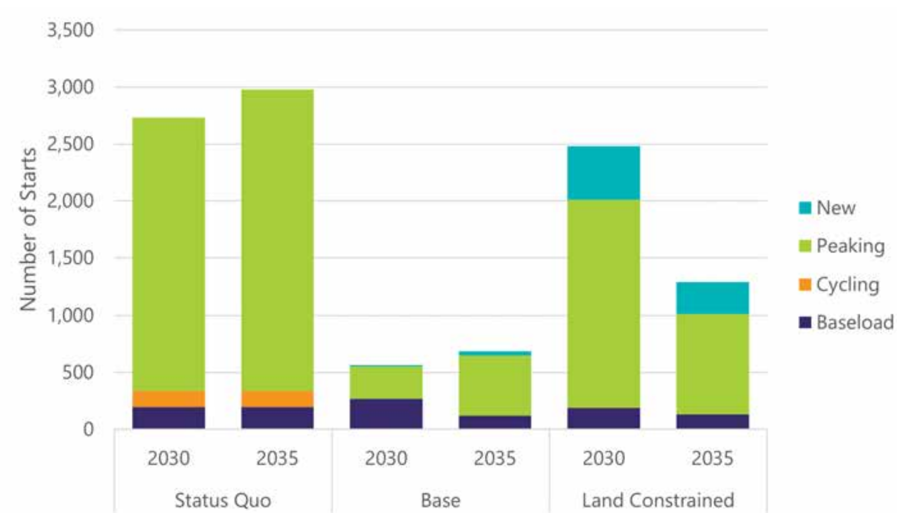


Figure 8-14. O'ahu: utility-owned thermal generators number of starts, 2030 and 2035 for Status Quo, Base, and Land-Constrained scenarios

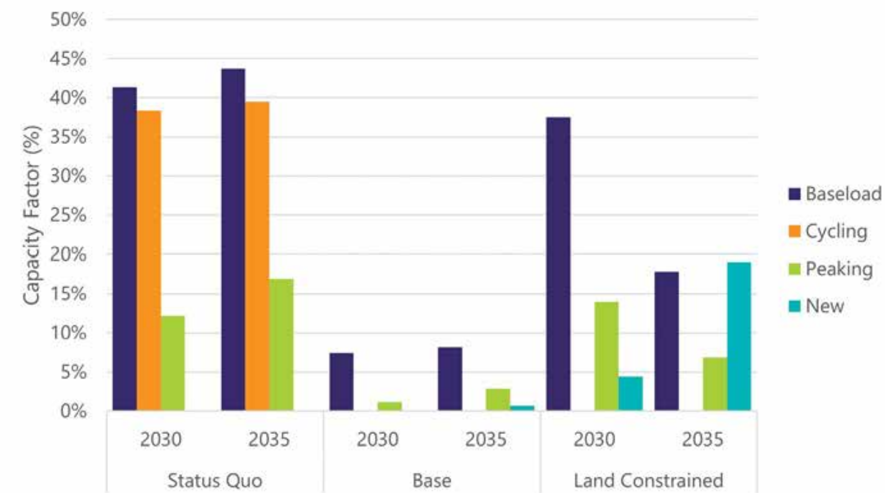


Figure 8-15. O'ahu: utility-owned thermal generators capacity factor, 2030 and 2035 for Status Quo, Base, and Land-Constrained scenarios

8.2.4 Transmission and System Security Needs

We analyzed the O'ahu Base, Land-Constrained, and High electricity demand resource plans to determine transmission and system security needs by performing steady-state and dynamic stability analyses for selected years with major large-scale resource additions, including:

- O'ahu system Base scenario resource plan and Land-Contrained scenario resource plan: 2030, 2035, 2046, and 2050
- O'ahu system High Load scenario resource plan: 2030 and 2035

8.2.4.1 Summary of Base Scenario Resource Plan

In the near term, it is unlikely that the O'ahu transmission system will require transmission network expansion, but beyond 2040 both the interconnection of large-scale generation projects from REZ development and system load increase would trigger transmission network expansion.

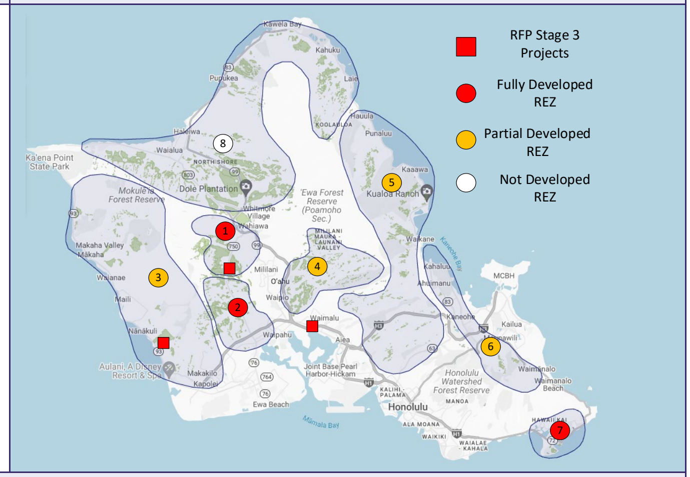
It will be important to consider large-scale battery energy storage, energy efficiency, demand response, and distributed energy resources to reduce loading in the urban core to avoid overloading 138 kV overhead and underground lines. Additionally, the western part of the system already has major generation stations, and further large-scale renewable resources located on the west side of the island would cause generation congestion on the 138 kV system when a contingency of losing one or multiple transmission lines occurs. It is important to note that full development of renewable energy zones on the north shore of the island would require significant transmission network expansion around the Wahiawa 138 kV substation, which is simliar to what was found in the 2021 REZ study report.

For system stability condition in future years, as a result of interconnecting large quantities of hybrid solar with grid-forming control, system stability performance is well within planning criteria. However, system stability performance is highly dependent on future grid-forming resources procured from the development of renewable energy zones. It is strongly recommended to continue to procure resources with grid-forming capability, and provide specific control recommendations during project interconnection requirement studies.

The following tables summarize the study results for the select years of the O'ahu Base scenario resource plan.

Summary	
Studied resource plan	Studied year
Base scenario resource plan	2030

By 2030, the O'ahu system will have new generation from Stage 3 O'ahu RFP procurement and initial REZ development. Specifically, there will be 450 MW RDG and 300 MW firm generation procured through the Stage 3 O'ahu RFP activity; 510 MW RDG development from renewable energy zones 1, 2, and 7; and 543 MW RDG development from renewable energy zones 3, 4, 5, and 6. Most of this new generation will be interconnected at the O'ahu 138 kV system. The REZ development is expected to have both solar and wind generation.
In this time frame, it is also planned to remove 371 MW generation from the Waiau power plant.

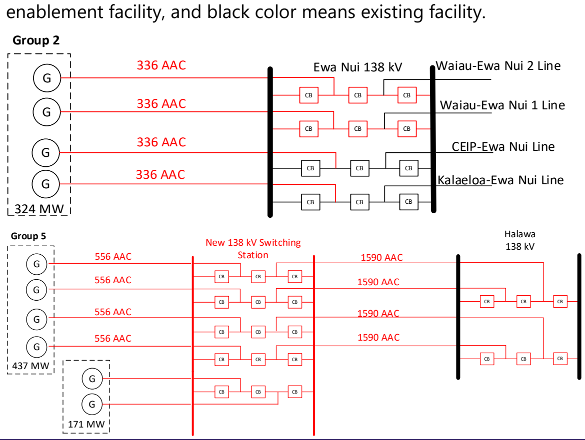


System Resource Summary and Forecasted Demand (MW)

Firm generation	Onshore standalone wind	Standalone grid-scale solar	Grid-scale hybrid solar/BESS	Standalone BESS	DER	System peak load
1,462	257	168	1,573	219	1,171	1,364

REZ Enablement

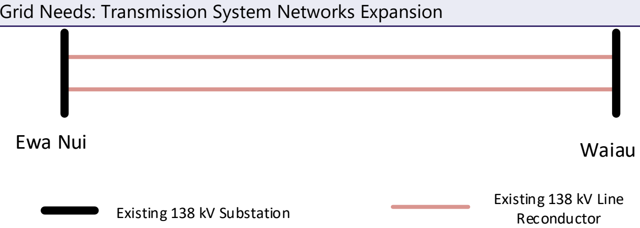
Examples of REZ enablement are shown as following for zones with lower MW potential (upper) and higher MW potential (lower). Red color means new enablement facility, and black color means existing facility.



REZ Enablement Cost Estimate

Renewable energy zone	1	2	3	4	5	6	7
Cost ($MM) per MW	0.21	0.27	1.32	0.82	1.51	0.62	N/A
REZ enablement ($MM)	24.6	87.6	448.4–819.9				N/A

Grid Needs: Transmission System Networks Expansion

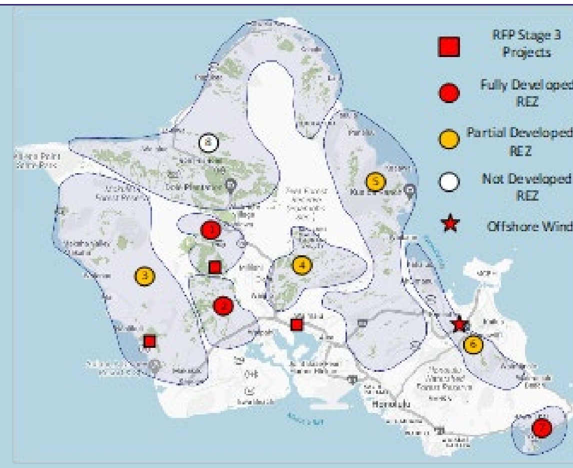


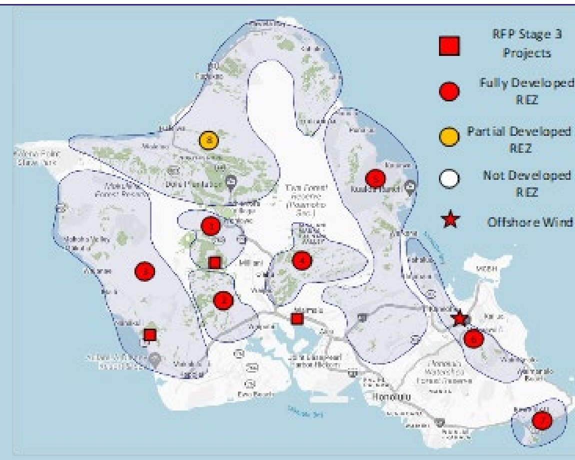
Network expansion cost estimate	$161.4 million

Alternative for this conductor upgrade will be to reduce Ewa Nui REZ generation interconnection from 324 MW to 175 MW.

Grid Needs: System Stability Needs

Grid has sufficient grid-forming resources to maintain system stability but the system must be operated so that grid-forming headroom/DER generation ratio is at least 0.7.

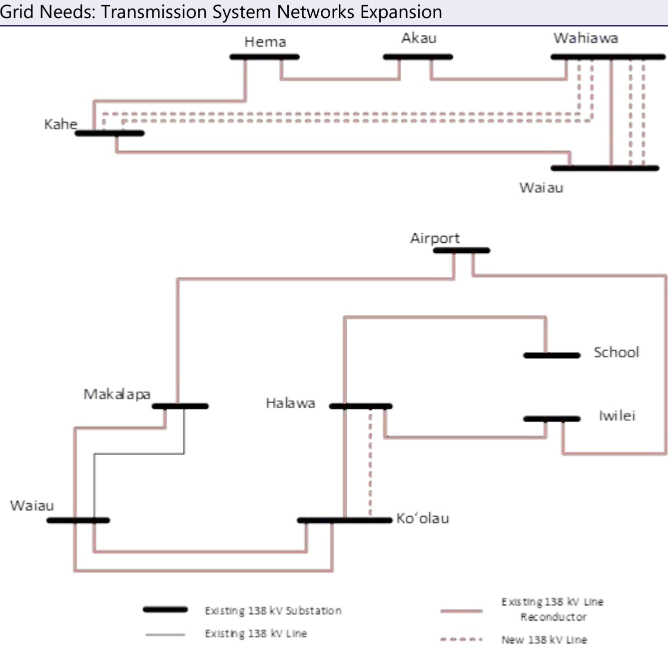
<table>
<tr><th colspan="8">Summary</th></tr>
<tr><td colspan="4">Studied resource plan</td><td colspan="4">Studied year</td></tr>
<tr><td colspan="4">Base scenario resource plan</td><td colspan="4">2035</td></tr>
<tr><td colspan="4">In addition to previous system resource changes by 2030, by 2035, the O’ahu system will have 64 MW large-scale standalone battery energy storage and 509 MW offshore wind. There is no further development of renewable energy zones. We assumed there will be 208 MW firm generation procured and interconnected at the Kalaeloa substation.</td><td colspan="4">
</td></tr>
<tr><td colspan="8">System Resource Summary and Forecasted Demand (MW)</td></tr>
<tr><td>Firm generation</td><td>Onshore standalone wind</td><td>Offshore wind</td><td>Standalone grid-scale solar</td><td>Grid-scale hybrid solar</td><td>Standalone BESS</td><td>DER</td><td>System peak load</td></tr>
<tr><td>1,297</td><td>257</td><td>509</td><td>157</td><td>1,573</td><td>282</td><td>1,295</td><td>1,432</td></tr>
<tr><td colspan="8">REZ Enablement</td></tr>
<tr><td colspan="8">There is no REZ development between 2031 and 2035. In this time frame, the development that requires interconnection facility is the 509 MW offshore wind, which requires expansion of the Ko’olau substation by adding four breakers and a half bay for the offshore wind interconnection. The cost estimate is $50.6 million.</td></tr>
<tr><td colspan="8">Grid Needs: Transmission System Networks Expansion</td></tr>
<tr><td colspan="8">None. But high conductor loading is observed on multiple 138 kV overhead conductors. It is recommended to reduce large-scale generation interconnection at Ko’olau substation by 10 MW.</td></tr>
<tr><td colspan="8">Grid Needs: System Stability Needs</td></tr>
<tr><td colspan="8">Grid has sufficient grid-forming resources to maintain system stability, but the system must be operated so that grid-forming headroom/DER generation ratio is at least 0.70.</td></tr>
</table>

Summary	
Studied resource plan	Studied year
Base scenario resource plan	2045
In addition to previous system resource changes, by 2045, the O'ahu system will finish developing the majority of renewable energy zones 1, 2, 3, 4, 5, 6, and 7, with only 106 MW potential remaining undeveloped. Meanwhile, 452 MW solar potential of renewable energy zone 8 will be developed by 2045. System load is forecasted with significant growth: 1,692 MW peak demand at 2046. Both REZ development and system load growth drive large amount of O'ahu transmission system network expansion.	

System Resource Summary and Forecasted Demand (MW)							
Firm generation	Onshore standalone wind	Offshore wind	Standalone grid-scale solar	Grid-scale hybrid solar	Standalone BESS	DER	System peak load
1,126	287	509	441	2077	315	1,454	1,692

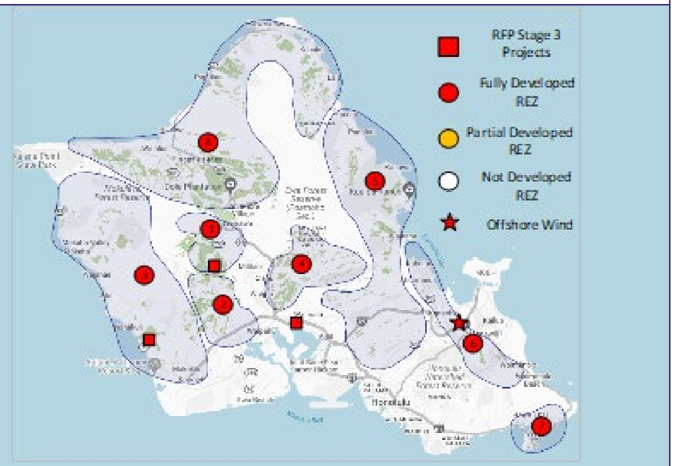
REZ Enablement					
Renewable energy zone	3	4	5	6	8
Cost ($MM) per MW	1.32	0.82	1.51	0.62	1.25
REZ enablement ($MM)	1084.6–1468.5				565.0

Grid Needs: Transmission System Networks Expansion



Network expansion cost estimate	$3,980.5 million

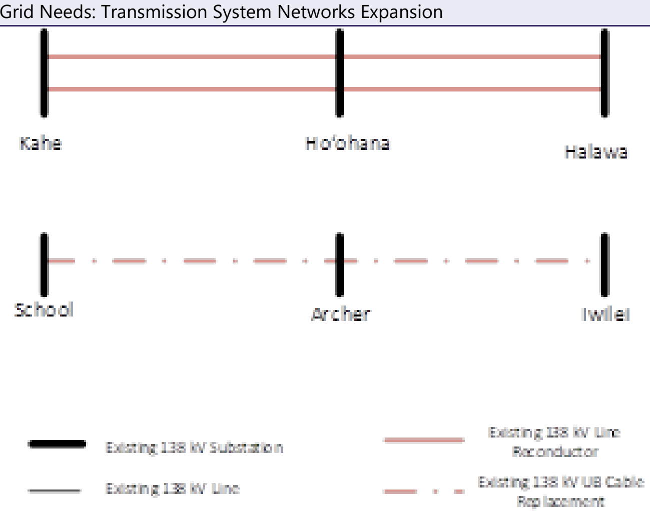
Grid Needs: System Stability Needs
Not studied.

Summary	
Studied resource plan	Studied year
Base scenario resource plan	2050
By 2050, 3,344 MW of all eight renewable energy zones are fully developed. System load is forecasted with significant growth: 1,829 MW peak demand at 2050, which could possibly cause underground cable replacement for 138 kV underground cable among School Street, Iwilei, and Archer 138 kV substations. All Kahe fossil fuel–based generation units are retired by 2050. Besides switching fossil fuel to biodiesel fuel for remaining firm units, 135 MW new firm units will be added to the O‘ahu system by 2050.	

System Resource Summary and Forecasted Demand (MW)							
Firm generation	Onshore standalone wind	Offshore wind	Standalone grid-scale solar	Large-scale hybrid solar	Standalone BESS	DER	System peak load
1,010	287	509	480	3,558	333	1,497	1,829

REZ Enablement					
Renewable energy zone	3	4	5	6	8
Cost ($MM) per MW	1.32	0.82	1.51	0.62	1.25
REZ enablement ($MM)	86.9–160.1				892.5

Grid Needs: Transmission System Networks Expansion



Network expansion cost estimate	$1,208.9 million

Reducing load from 138 kV substations Kamoku, Kewalo, and Archer by 37 MW can avoid cable replacement for the 138 kV underground cable Archer-School, Archer-Iweilei. This can be realized by adding generation such as large-scale energy storage in those substations, or procure demand response on circuits supplied by those substations, or implmenting an EE program.

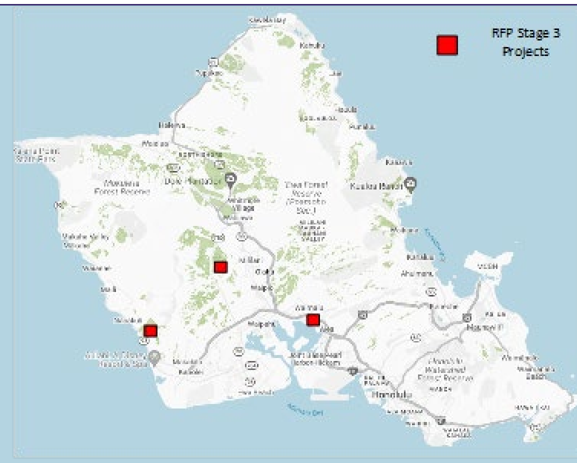
Full development of the north shore renewable energy zone (i.e., zone 8) would also cause overloadings on the 138 kV lines connected with Wahiawa substation. By reducing generation interconnection size at Wahiawa substation by 220 MW, the line overloading will be mitigated.

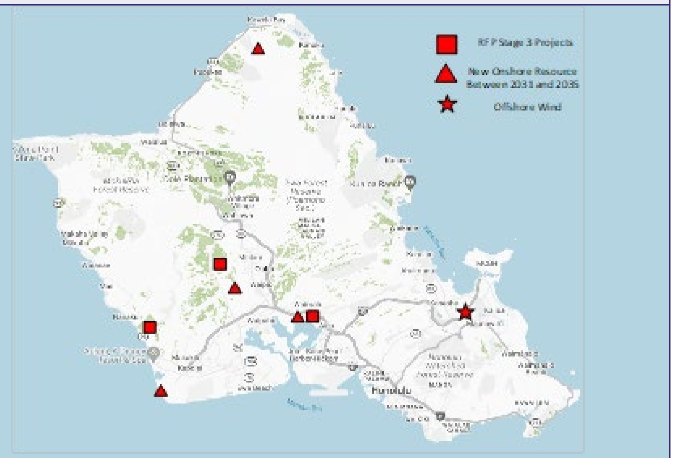
Grid Needs: System Stability Needs
Not studied.

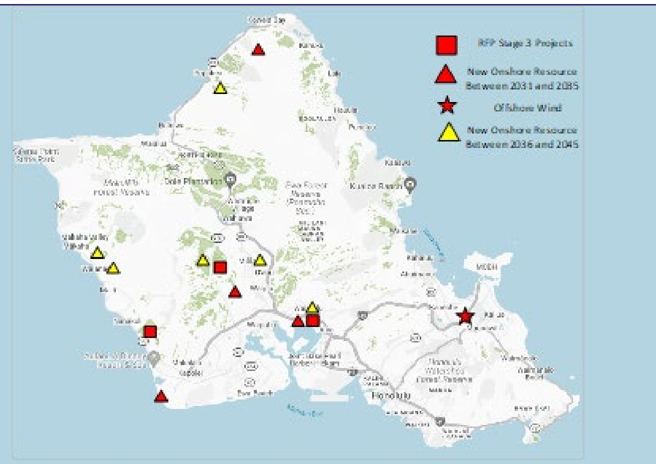
8.2.4.2 Summary of Land-Constrained Scenario Resource Plan

The Land-Constrained scenario resource plan requires much less transmission network expansion needed compared to the Base scenario resource plan. Still, it is suggested to install a large-scale BESS project on the east side of the island, close to the urban core load center, to avoid 138 kV overhead line or underground cable overloading.

Because of the limited amount of large-scale resources in the Land-Constrained scenario, it is likely that additional large-scale grid-forming resources will be needed (i.e., retrofit of existing renewable plants or new standalone energy storage) to maintain system stability within the Oʻahu transmission planning criteria. The study recommends that the minimum requirement of available MW headroom from large-scale grid-forming resource should be 70% of DER generation.

<table>
<tr><th colspan="7">Summary</th></tr>
<tr><td colspan="3">Studied resource plan</td><td colspan="4">Studied year</td></tr>
<tr><td colspan="3">Land-Constrained scenario resource plan</td><td colspan="4">2030</td></tr>
<tr><td colspan="3">By 2030, the Oʻahu system will have all new generation from Stage 3 Oʻahu procurement on the transmission and sub-transmisison side. Specifically, there will be 450 MW RDG and 300 MW firm generation procured through the Stage 3 Oʻahu RFP. Most of these new resources are expected to be interconnected at the Oʻahu 138 kV system. In this time frame, it is also planned to remove 371 MW generation from the Waiau power plant.</td><td colspan="4">
</td></tr>
<tr><td colspan="7">System Resource Summary and Forecasted Demand (MW)</td></tr>
<tr><td>Firm generation</td><td>Onshore standalone wind</td><td>Standalone grid-scale solar</td><td>Large-scale hybrid solar</td><td>Standalone BESS</td><td>DER</td><td>System peak load</td></tr>
<tr><td>1,462</td><td>123</td><td>168</td><td>684</td><td>135</td><td>1,171</td><td>1,364</td></tr>
<tr><td colspan="7">Grid Needs: Transmission System Networks Expansion</td></tr>
<tr><td colspan="7">None</td></tr>
<tr><td colspan="7">Grid Needs: System Stability Needs</td></tr>
<tr><td colspan="7">System may need more grid-forming resource, and it is recommended to maintain MW headroom of grid-forming resource/DER generation ratio of at least 0.7. If the ratio cannot be maintained, it is recommended to dispatch more synchronous machine resources to create more headroom from the grid-forming resource, or curtail DER generation.</td></tr>
</table>

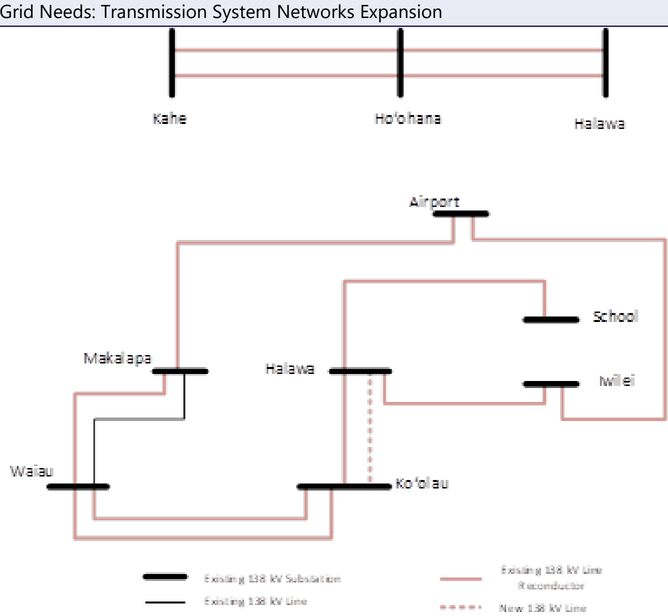
<table>
<tr><th colspan="8">Summary</th></tr>
<tr><td colspan="4">Studied resource plan</td><td colspan="4">Studied year</td></tr>
<tr><td colspan="4">Land-Constrained scenario resource plan</td><td colspan="4">2035</td></tr>
<tr><td colspan="4">In addition to previous system resource changes by 2030, by 2035, the O'ahu system will have 105 MW large-scale standalone battery energy storage and 400 MW offshore wind. 153 MW firm resource will also be added to the system by 2035. There will be 208 MW firm generation procured and interconnected at the Kalaeloa substation. 30 MW wind will be added to the system to meet the system demand.</td><td colspan="4">
</td></tr>
<tr><td colspan="8">System Resource Summary and Forecasted Demand (MW)</td></tr>
<tr><td>Firm generation</td><td>Onshore standalone wind</td><td>Offshore wind</td><td>Standalone grid-scale solar</td><td>Large-scale hybrid solar</td><td>Standalone BESS</td><td>DER</td><td>System peak load</td></tr>
<tr><td>1,450</td><td>123</td><td>400</td><td>157</td><td>684</td><td>240</td><td>1,295</td><td>1,432</td></tr>
<tr><td colspan="8">Grid Needs: Transmission System Networks Expansion</td></tr>
<tr><td colspan="8">None</td></tr>
<tr><td colspan="8">Grid Needs: System Stability Needs</td></tr>
<tr><td colspan="8">System may need more grid-forming resources, and it is recommended to maintain MW headroom of grid-forming resource/DER generation ratio of at least 0.7. If the ratio cannot be maintained, it is recommended to dispatch more synchronous machine-based resource to create more headroom from the grid-forming resource.</td></tr>
</table>

Summary	
Studied resource plan	Studied year
Land-Constrained scenario resource plan	2045
In addition to previous system resource changes, by 2045, the O'ahu system will add another 153 MW firm generation into the system. Also, 169 MW standalone solar and 93 MW wind development from retired solar and wind locations will be completed by 2045. 169 MW new large-scale standalone battery energy storage will be interconnected to the system from transmission substations. System load is forecasted with significant growth: 1,692 MW peak demand at 2046. On the distribution side, 783 MW distributed energy resources coupled with 1,567 MWh distributed energy storage will be added to the system to supply system load demand.	

System Resource Summary and Forecasted Demand (MW)

Firm generation	Onshore standalone wind	Offshore wind	Standalone grid-scale solar	Grid-scale hybrid solar/BESS	Standalone BESS	DER	System peak load
1,432	123	400	169	684	399	3,020	1,692

Grid Needs: Transmission System Networks Expansion



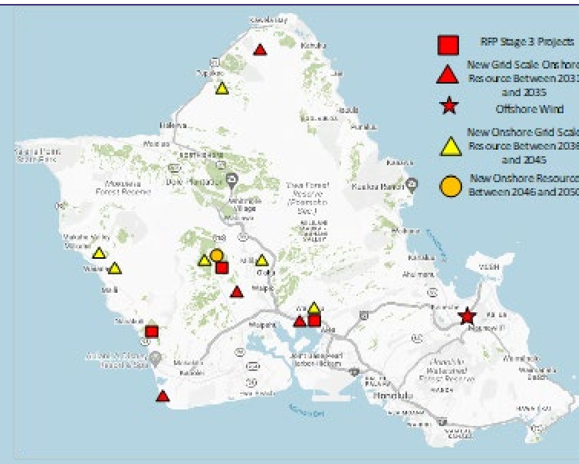
Network expansion cost estimate	$2,291.6 million

Grid Needs: System Stability Needs

The dynamic stability study was not performed. However, according to the available grid-forming resource and significant DER additions, the system may require more large-scale grid-forming resources. This could be more grid-forming energy storage interconnected on the subtransmission or transmission grid, or grid-forming STATCOM interconnected on the transmission grid.

Summary	
Studied resource plan	Studied year
Land-Constrained scenario resource plan	2050

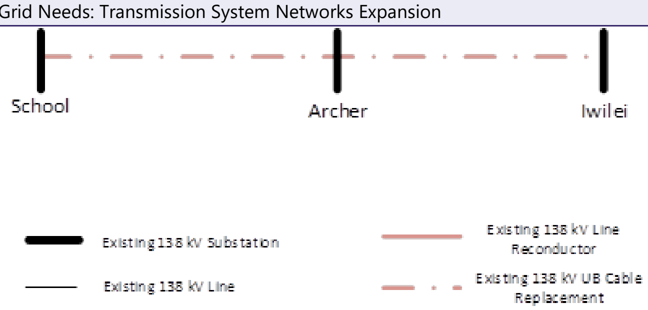
From 2046 to 2050, the only large-scale resource added to the O'ahu system as planned is a 119 MW/1,110 MWh large-scale battery energy storage system. Kahe 5 and 6, the only remaining fossil fuel–based generation at Kahe power plant, will be retired in 2050. It is also planned to add 1,017 MW distributed energy resources, coupled with 2,033 MWh distributed energy storage on the distribution system. System peak load is forecasted to be 1,829 MW by 2050. The load increase will require conductor upgrade to replace the 138 kV underground conductor Archer-School and Archer-Iwilei.



System Resource Summary and Forecasted Demand (MW)

Firm generation	Onshore standalone wind	Offshore wind	Standalone grid-scale solar	Grid-scale hybrid solar/BESS	Standalone BESS	DER	System peak load
1,163	123	400	169	684	519	5,097	1,829

Grid Needs: Transmission System Networks Expansion



Networks expansion cost estimate	$345.1 million

Reducing load from 138 kV substations Kamoku, Kewalo, School St., and Iwilei by 20 MW can avoid cable replacement for the 138 kV underground cables Archer-School and Archer-Iweilei. This can be realized by adding generation such as large-scale battery energy storage at those substations, acquiring demand response on circuits supplied by those substations, or implementing a targeted EE program.

Grid Needs: System Stability Needs

The dynamic stability study for this scenario was not performed. However, the recommendation for the O'ahu system regarding system stability needs is simliar to what is recommended for the 2045 scenario.

8.2.5 Distribution Needs

This section discusses distribution needs as they pertain to the grid needs assessment for O'ahu.

8.2.5.1 Hosting Capacity Grid Needs

Of the 384 circuits assessed on O'ahu, most have sufficient DER hosting capacity or could accommodate the 5-year hosting capacity without infrastructure investments. The remaining circuits where infrastructure investments are required to increase hosting capacity to accommodate the forecasted distributed energy resources are identified as requiring grid needs. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-6.

Table 8-6. O'ahu Hosting Capacity Grid Needs (Years 2021–2025)

Parameter (Nominal $)	Base DER Forecast	High DER Forecast	Low DER Forecast
Number of grid needs	6	16	5
Cost summary (wires solutions)	$792,000	$3,895,000	$648,000

A complete list of the hosting capacity grid needs can be found in the *Distribution DER Hosting Capacity Grid Needs* report.

8.2.5.2 Location-Based Grid Needs

Of the 393 circuits and 204 substation transformers assessed on O'ahu, most have sufficient capacity to accommodate the forecasted load demand. For substation transformers and circuits where there is insufficient capacity, a grid need is identified. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-7.

A complete list of the load-driven grid needs can be found in Appendix E.

Table 8-7. O'ahu Location-Based Grid Needs (Years 2023–2030)

Parameter (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	22	41	19	29
Cost summary (wires solutions)	$95,724,000	$152,426,000	$77,900,000	$165,934,000

8.2.5.3 Distribution Grid Needs Summary

The minimum number of grid needs identified (i.e., minimum wires solutions) by scenario by island is shown in Table 8-8 below. This includes both hosting capacity and location-based grid needs.

Table 8-8. O'ahu Minimum Grid Needs Solutions Identified (Years 2023–2030)

Island (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	18	30	26	30
Cost summary (wires solutions)	$51,806,000	$68,225,000	$52,097,000	$59,999,000

8.2.5.4 NWA Opportunities

Results of applying the NWA opportunity evaluation methodology described in Section 8.1.4.5 are summarized in Table 8-9 through Table 8-12 below for O'ahu by scenario.

Base Scenario

Table 8-9. O'ahu NWA Opportunity Projects by Track: Base

Track	Operating Date	Transformer	Circuit	Description	Cost (Nominal $)
1 (qualified: procurement likely)	2025	CEIP 3	CEIP 46	Reconductor	$3,930,000
	2026	Kapolei 2	Kapolei 4	Circuit line extension	$2,091,000
	2026	Wahiawa 3 (138 kV)	Wahiawa-Waimano	New substation transformer and circuit	$15,012,000
	2027	Kamokila 2	N/A	Circuit line extension	$1,914,000
	2027	Kewalo T3	N/A	New substation transformer	$6,404,000
2 (qualified: pricing approach or re-evaluate later)	2028	Kuilima 2	N/A	New substation transformer	$3,160,000
3 (non-qualified)	2025	Waipio 1	N/A	New substation transformer	$2,880,000

High Load Customer Technology Adoption Bookend Scenario

Table 8-10. O'ahu NWA Opportunity Projects by Track: High Load Customer Technology Adoption Bookend

Track	Operating Date	Transformer	Circuit	Description	Cost (Nominal $)
1 (qualified: procurement likely)	2025	Ewa Nui 2	Ewa Nui 2	New substation transformer and circuit	$3,634,000
	2026	Kuilima 2	N/A	New substation transformer	$2,970,000
	2027	Kewalo T3	N/A	New substation transformer	$6,404,000
2 (qualified: pricing approach or reevaluate later)	2025	Kamokila 2	N/A	Circuit line extension	$2,480,000
	2028	CEIP 2	CEIP 3	Circuit line extension	$5,072,000
	2028	Fort Weaver 1	N/A	New substation transformer	$3,160,000
	2028	Hauula	Hauula	Reconductor	$780,000
3 (non-qualified)	2025	Kapolei 2	Kapolei 4	New substation transformer and circuit	$3,684,000
	2025	Piikoi 4	Piikoi 8	Reconductor	$270,000
	2025	Wahiawa 3 (138 kV)	Wahiawa-Waimano	New substation transformer and circuit	$15,012,000
	2028	Kahuku	Kahuku	Reconductor	$187,000
	2028	Kunia Makai 1	N/A	New switch and transfer load	$26,000
	2029	Ewa Nui 1	Ewa Nui 1	Circuit line extension	$149,000
	2029	Hoaeae 1	Hoaeae 1	New switch	$25,000
	2029	Kaneohe 1	Heeia	Transfer load	$26,000
	2029	Puunui 2	Heights	Reconductor, voltage regulator, and fuse resizing	$473,400
	2030	Makaha 2	N/A	New switch	$26,000

Low Load Customer Technology Adoption Bookend Scenario

Table 8-11. Oʻahu NWA Opportunity Projects by Track: Low Load Customer Technology Adoption Bookend

Track	Operating Date	Transformer	Circuit	Description	Cost (Nominal $)
1 (qualified: procurement likely)	2027	Kewalo T3	N/A	New substation transformer	$6,404,000
2 (qualified: pricing approach or reevaluate later)	2028	CEIP 2	CEIP 3	Circuit line extension	$5,072,000
	2028	Wahiawa 3 (138 kV)	N/A	New substation transformer and circuit	$15,012,000
	2029	Kuilima 2	N/A	New substation transformer	$3,260,000
3 (non-qualified)	2025	Waialae 1 4 kV	Wai-Wilhelmina	Install two 1ph line regulators	$140,000
	2025	Waimanalo Bch 1	Waimanalo	Dynamic LTC	$154,000

Faster Technology Adoption Bookend Scenario

Table 8-12. Oʻahu NWA Opportunity Projects by Track: Faster Technology Adoption Bookend

Track	Operating Date	Transformer	Circuit	Description	Cost (Nominal $)
1 (qualified: procurement likely)	2026	Kamokila 2	N/A	Circuit line extension	$1,857,999
	2026	Kapolei 2	Kapolei 4	Circuit line extension	$2,091,012
	2026	Wahiawa 3 (138 kV)	N/A	New substation transformer and circuit	$15,012,000
	2027	Barbers Pt Tank Farm 2	Industrial	Circuit line extension	$5,071,920
	2027	CEIP 3	CEIP 46	Reconductor	$3,930,000
	2027	Kewalo T3	N/A	New substation transformer	$6,404,000
2 (qualified: pricing approach or re-evaluate later)	2029	Kuilima 2	N/A	New substation transformer	$3,260,000
3 (non-qualified)	2025	CEIP 2	CEIP 3	New switch	$23,330
	2025	Waialae 1 4 kV	Wai-Wilhelmina	Install two 1ph line regulators	$140,000
	2025	Waimanalo Bch 1	Waimanalo	Dynamic LTC	$154,000

8.2.6 Preferred Plan

The capacity expansion modeling conducted in RESOLVE was the starting point for identifying grid needs and developing a resource plan. Probabilistic resource adequacy analyses were then performed to confirm that the portfolio of resources selected in the resource plan were reliable. Based on the results of this analysis, the following changes were made:

- Removed the 153 MW combined cycle selected in 2035 in the Land-Constrained scenario as the system met the loss of load standard without this resource. Removed the 20 MW biomass selected in 2045 in the Base scenario.
- Increased duration of paired and standalone BESS to 4 hours to match current market conditions.
- Updated the Stage 3 RFP variable renewable proxy to reflect the current target, which was adjusted for the withdrawal of Barber's Point Solar.

In parallel, transmission and system security needs were identified, including reductions in the REZ buildout as an NWA to additional transmission expansion. Based on the results of this analysis, the following changes were made:

- Base scenario
  - 2027: 70% grid-forming headroom capacity for dynamic stability
  - 2030: reduce Ewa Nui Group 1 renewable energy zone by 150 MW to avoid conductor overloads
  - 2036: reduce Koolau Group 2 renewable energy zone by 10 MW to avoid conductor overloads
  - 2050: reduce Wahiawa Group 3 renewable energy zone by 220 MW to avoid conductor overloads
- Land-Constrained scenario
  - 2027: 70% grid-forming headroom capacity for dynamic stability
  - 2050: limit Ewa Nui BESS in Group 1 renewable energy zone and Hoʻohana battery energy storage to less than or equal to 142 MW

Additional capital costs were identified to interconnect resources in the renewable energy zones selected in RESOLVE. While the REZ enablement costs were already included as part of the RESOLVE modeling, they are listed here in Table 8-13 for completeness alongside new network expansion costs.

The Status Quo and Land-Constrained scenario transmission network expansion costs reflect estimated transmission needed to expand capacity, as identified in the transmission needs analysis, to serve load growth because of electrification of transportation.

Table 8-13. Oʻahu Transmission Capital Costs

Nominal Transmission Costs ($MM)	Base		Land Constrained		Status Quo	
Year	REZ Enablement	Network Expansion	REZ Enablement	Network Expansion	REZ Enablement	Network Expansion
2029	$114	-	$62	-	-	-
2030	$942	-	-	-	-	-
2035	$62	-	-	-	-	-
2040	$799	-	-	-	-	-
2045	$2,241	$3,482	-	$1,991	-	$529
2050	$1,112	$1,018	-	$293	-	$293

Table 8-14 and Table 8-15 show a comparison of Oʻahu Base and Land-Constrained scenarios, respectively, production costs with and without transmission constraints.

Comparing the production costs with and without the transmission constraints identified above shows that in the Land-Constrained scenario without REZ development, the dynamic stability requirement does not significantly change production costs. In the Base scenario, the reductions in REZ buildout cause higher production costs that would be offset by reduced capital costs for new transmission.

Table 8-14. Comparison of Oʻahu Base Scenario Production Costs with and without Transmission Constraints

NPV ($MM)	With Transmission Constraints	Without Transmission Constraints
(2023–2050)	$16,710	$15,869

Table 8-15. Comparison of Oʻahu Land-Constrained Scenario Production Costs with and without Transmission Constraints

NPV ($MM)	With Transmission Constraints	Without Transmission Constraints
(2023–2050)	$19,439	$19,446

8.3 Hawai'i Island

This section describes the results of the grid needs assessment for Hawai'i Island through the multistep process that includes modeling capacity expansion, resource adequacy, operations of the system, transmission and system security needs, distribution needs, and iterations or adjustments made to determine the preferred plan.

8.3.1 Capacity Expansion Scenarios

In the Base scenario shown in Figure 8-16, initially onshore wind and standalone energy storage are selected. As electricity demand increases over time, the model selects geothermal and hybrid solar as part of the optimal plan. The Low electricity demand scenario selects only onshore wind and standalone energy storage. The Faster Technology Adoption and High electricity demand scenarios select new firm resources in addition to larger quantities of new resources than in the Base scenario. Existing fossil fuel–based resources are shown as firm renewable resources in 2050 because of their switch to biofuels in 2045. All scenarios achieve their RPS targets with consistent increases in the use of renewable resources.

The Hawai'i Island resource portfolio has the most diverse set of resources of any island. This includes solar, wind, energy storage, geothermal, and hydroelectric power. Together these resources will greatly reduce the reliance on fossil fuel–based generators, achieving near 100% renewable energy by 2030. Though the forecast generation varies over the range of scenarios, the types of resources used are consistent, as shown in Figure 8-16.

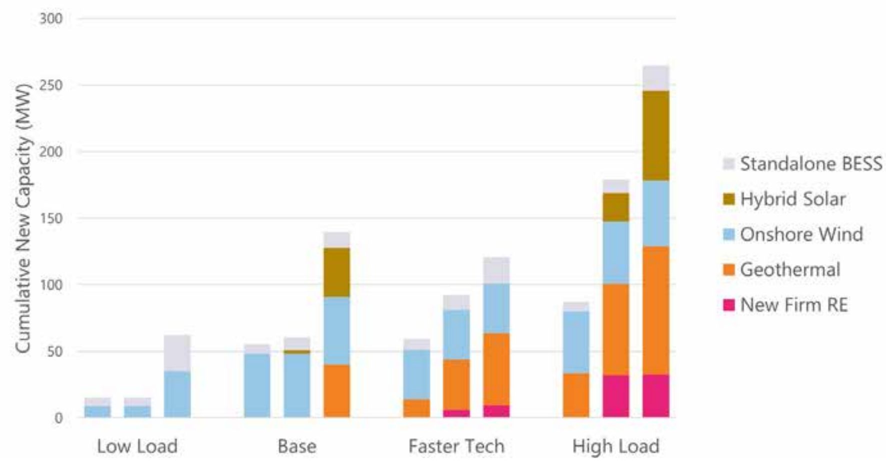


Figure 8-16. Hawai'i Island: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

Figure 8-17 shows each resource type's contribution to the system's annual generation. Even though new firm generators are sometimes selected for capacity reasons, they are rarely used even in the High Load scenario.

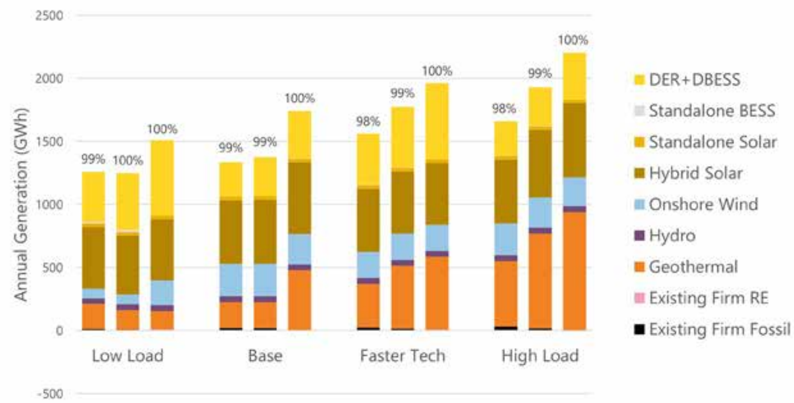


Figure 8-17. Hawai'i Island: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

8.3.1.1 High Fuel Retirement Optimization Scenario

In addition to the planned retirements of Hill 5 and Hill 6 and with Puna Steam on standby status, the High Fuel Retirement Optimization scenario chooses to retire an additional 54 MW of thermal capacity (see Figure 8-18). Because RESOLVE performs a linear optimization, the additional retirements may consist of partial unit retirements. These additional retirements occur early in the planning horizon before 2030 and are replaced with new wind, geothermal, and firm resources. The Hamakua Energy Partners contract is assumed to expire by the end of 2030 for both the Base and High Fuel Retirement Optimization scenarios.

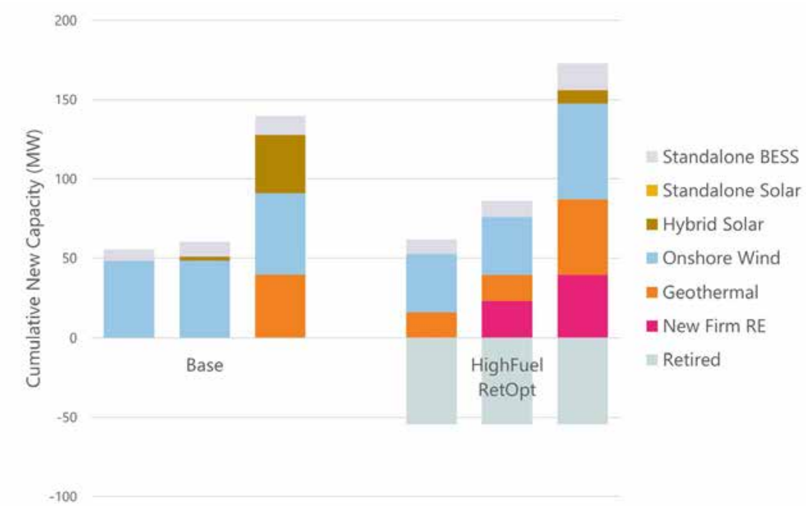


Figure 8-18. Hawai'i Island: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

Even with the additional retirements, the Optimized Retirement scenario annual generation is similar to the Base scenario annual generation as shown in Figure 8-19. It does not appear that the resource plan is particularly sensitive to high fuel costs; that is, the Base scenario significantly reduces our reliance on fossil fuel, and further opportunities to retire fossil fuel–based generators may be available as discussed in Section 12.

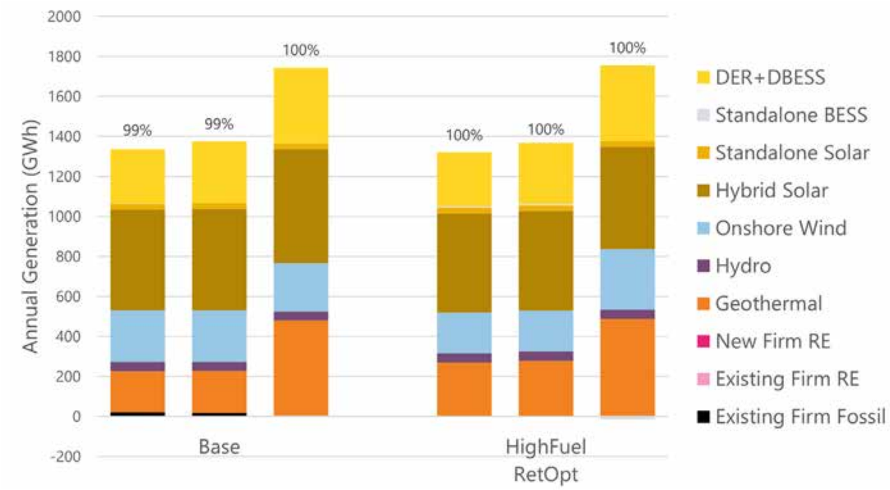


Figure 8-19. Hawai'i Island: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

8.3.2 Resource Adequacy

By 2030, 49 MW of existing fossil fuel–based generators are planned for deactivation and independent power producer Hamakua Energy Partners' PPA is set to expire at the end of 2030. In a Base scenario, the planned system is expected to withstand the loss of these resources. However, if Hawai'i Island is expected to be in a High electricity demand scenario by 2035, additional resources may need to be acquired or planned deactivations may be delayed.

For Hawai'i Island, Puna Steam is assumed on standby status and Hill 5 and 6 is assumed to be retired by 2027, as shown in Table 8-16. This is largely due to compliance with environmental (regional haze) regulations. If these units continue operation past that date, these generating units need to be retrofitted with environmental controls.

Table 8-16. Generating Unit Deactivation/Retirement Assumptions

Year	Generating Unit
2025	Puna Steam on standby (15.5 MW)
2027	Hill 5–6 removed from service (33.8 MW)

Probabilistic Resource Adequacy Summary

The planned Hawai'i Island system in 2030 is expected to meet the Base scenario system load assuming the planned deactivations through 2030 (see Table 8-17). Even if the Stage 3 procurement doesn't meet its target procurement, the 2030 Hawai'i Island system is expected to meet our reliability targets under the Base scenario.

Table 8-17. Probabilistic Analysis: Results Summary, Hawai'i Island, 2030

Scenario	Existing Firm (MW)	New Firm (MW)	Stage 3 RFP (MW)	Future Wind (MW)	Future Hybrid Solar (MW)	Future Standalone BESS (MW)	LOLE (Days/ Year)	LOLEv (Event/ Year)	LOLH (Hours/ Year)	EUE (MWh/ Year)	EUE (%)
Base, 2030	228	0	0	48	0	7/12	0.000	0.000	0.000	0.000	0.000

The planned Hawai'i Island system in 2035 is expected to meet the Base scenario load assuming the planned deactivations through 2035 (see Table 8-18). However, additional resources are needed in a High electricity demand scenario.

Table 8-18. Probabilistic Analysis: Results Summary, Hawai'i Island, 2035

Scenario	Existing Firm (MW)	New Firm (MW)	Stage 3 RFP (MW)	Future Wind (MW)	Future Hybrid Solar (MW)	Future Standalone BESS (MW)	LOLE (Days/ Year)	LOLEv (Event/ Year)	LOLH (Hours/ Year)	EUE (MWh/ Year)	EUE (%)
Base, 2035	228	0	0	48	0	7/12	0.076	0.144	0.220	0.002	0.000
High Load, 2035	228	0	140	0	0	0/0	28.9	64.2	149	4.70	0.454

The results show that, in 2030 and 2035, the Base plans developed by RESOLVE should meet our reliability targets. However, additional resources are needed if Hawai'i Island is in a High Load scenario. In 2030, assuming a Base scenario load forecast with Hamakua Energy Partners combined cycle already retired:

- Even without the full Stage 3 procurement target of 140 MW of hybrid solar, the 2030 system's loss of load expectation is less than 0.1 day per year.
- Though 140 MW of hybrid solar is not needed to meet the reliability target in 2030, acquiring even half of the 140 MW will greatly benefit the system.
- A loss of load less than 0.1 day per year is expected even if Hamakua Energy Partners combined cycle and some additional firm is brought offline unexpectedly.

In 2035, assuming a High electricity demand scenario and all 140 MW of hybrid solar from the Stage 3 RFP:

- Approximately 450 MW of additional hybrid solar is needed to bring the system loss of load expectation down below 0.1 day per year.
- Approximately 50 MW of additional firm generation is needed to bring the system loss of load expectation down below 0.1 day per year.

See Section 12 for more details on risks of the resource portfolio given uncertainties in procuring and acquiring the optimal mix of resources.

8.3.3 Grid Operations

The transition to 100% renewables will necessitate a change in how the thermal generators on our system operate. Scenarios with more renewable resources will use thermal generators less often. This is shown in the daily energy profiles and operational statistics in this section.

8.3.3.1 Status Quo Typical Operations

For the Hawai'i Island Status Quo scenario, Hamakua Energy Partners combined cycle, Hawi wind, Tawhiri wind, and Wailuku hydro are assumed to remain in service. Hill 5 and Hill 6, and Puna Steam are assumed to be retired with Puna Steam on standby status.

The dispatch of resources during the median load day as well as the day directly preceding and following the median load day of the Status Quo scenario in 2030 and 2035, respectively, are shown below in Figure 8-20 and Figure 8-21. This shows how the resource portfolio meets the system load over a typical few days during a given year.

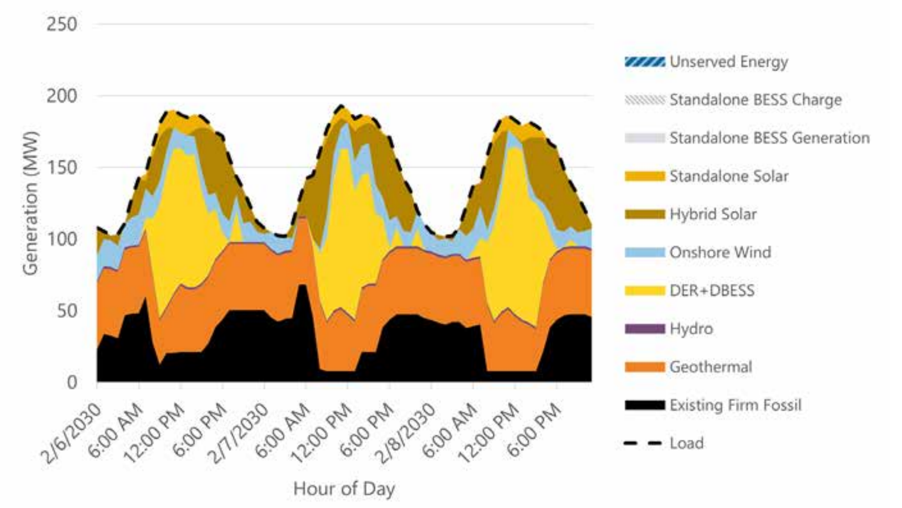


Figure 8-20. Hawai'i Island: detailed Status Quo energy profile, 2030 median load day (February 6–8, 2030)

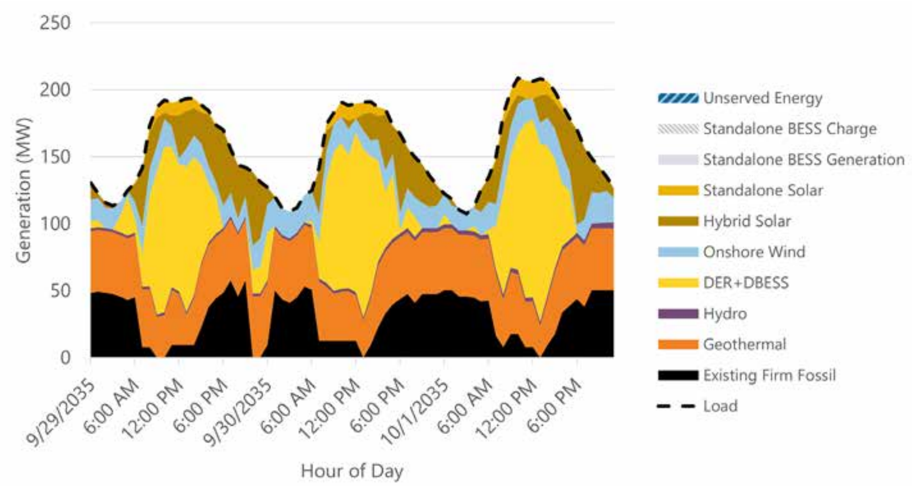


Figure 8-21. Hawai'i Island: detailed Status Quo energy profile, 2035 median load day (September 29–October 1, 2035)

8.3.3.2 Base Scenario Typical Operations

The dispatch of resources during the median load day as well as the day directly preceding and following the median load day of the Base scenario in 2030 and 2035, respectively, are shown below in Figure 8-22 and Figure 8-23. In the Base scenario, during midday, most of the load is expected to be met from variable renewable and geothermal resources. In 2030, firm fossil fuel–based generators are used primarily during morning and evening hours and by 2035 the system is effectively operating on 100% renewable energy.

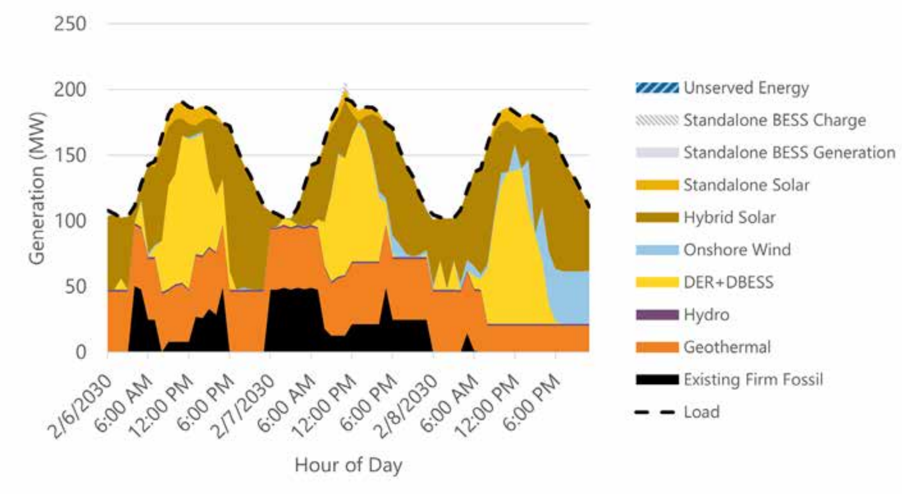


Figure 8-22. Hawai'i Island: detailed Base energy profile, 2030 median load day

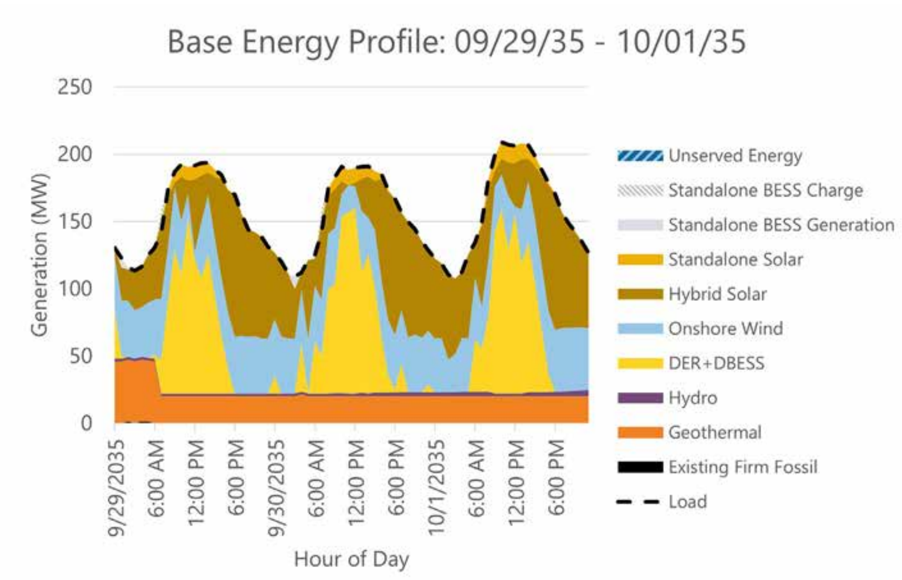


Figure 8-23. Hawai'i Island: detailed Base energy profile, 2035 median load day

8.3.3.3 Operations of Firm Generation

Insights can be gathered into the changing role of firm generation by evaluating the frequency with which different types of firm generators are started and their capacity factor, which is the percentage of hours a generator runs based on its rated capacity. The number of starts and capacity factor, respectively, of the utility-owned thermal generators for the Status Quo and Base resource plans in 2030 and 2035 are shown in Figure 8-24 and Figure 8-25. Because the Status Quo scenario relies more heavily on thermal generators, the generators are started more frequently and operate with a higher capacity factor than in the Base scenario.

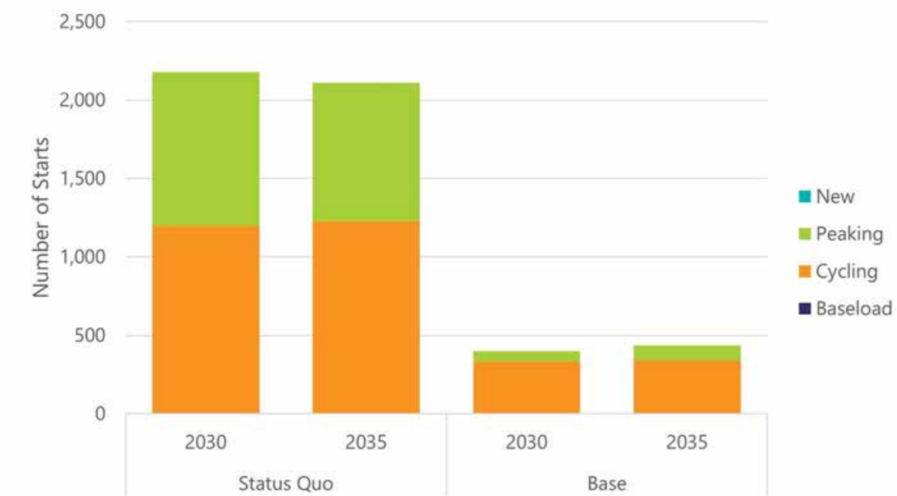


Figure 8-24. Hawai'i Island: utility-owned thermal generator number of starts, 2030 and 2035 for Status Quo and Base scenarios

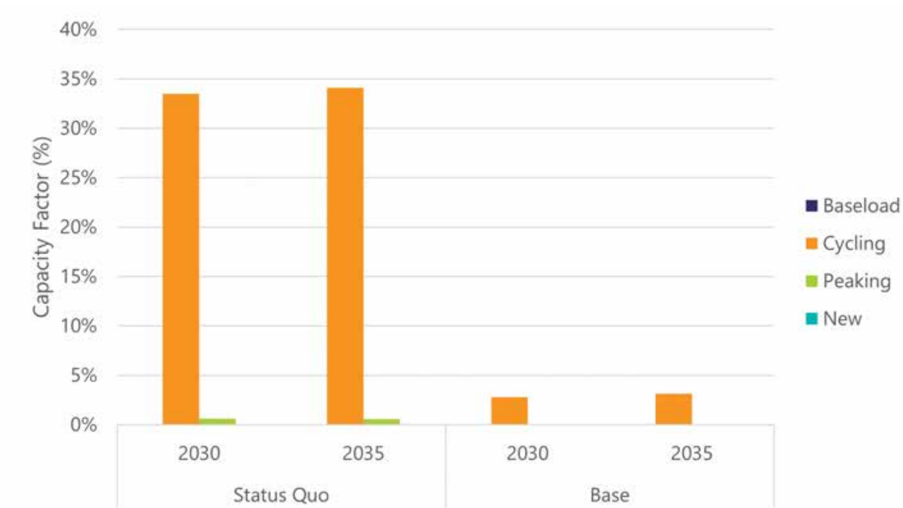


Figure 8-25. Hawai'i Island: thermal generator capacity factor, 2030 and 2035 for Status Quo and Base scenarios

8.3.4 Transmission and System Security Needs

We analyzed Hawai'i Island Base and High electricity demand scenario resource plans to determine transmission and system security needs by performing steady-state analyses and dynamic stability analyses for selected years with major large-scale resource additions, including:

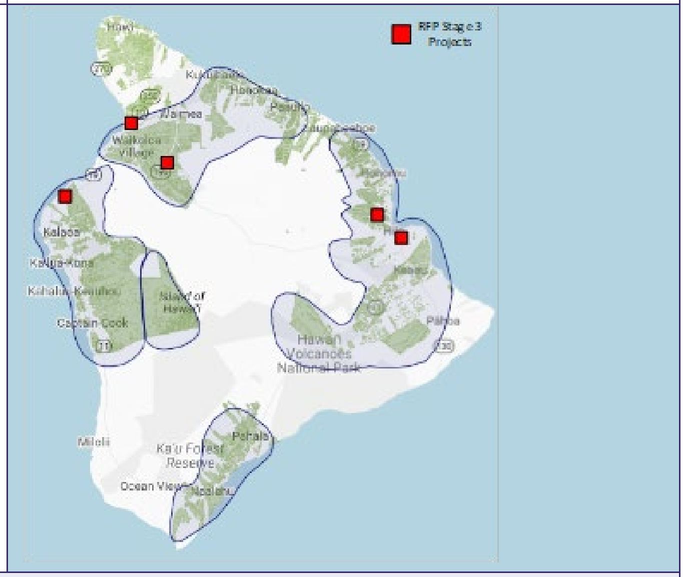
- Hawai'i island system Base scenario resource plan: 2032 and 2050
- Hawai'i island system High Load scenario resource plan: 2032 and 2036

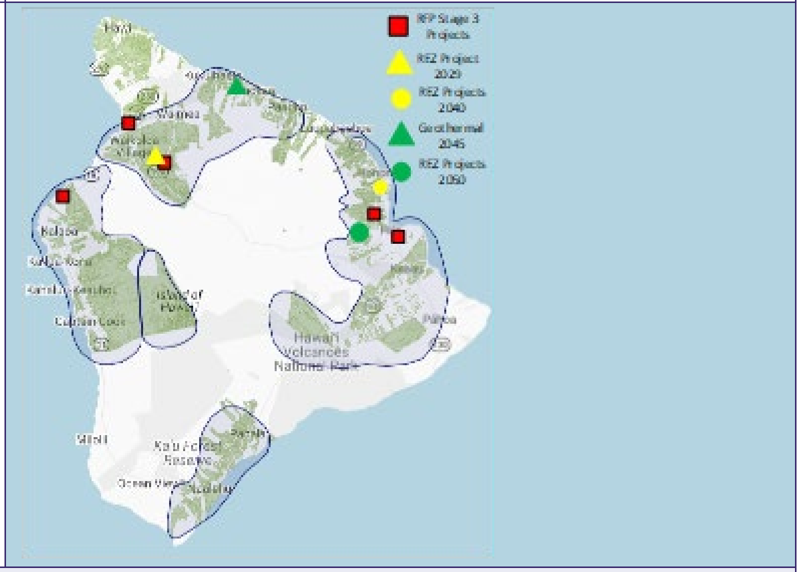
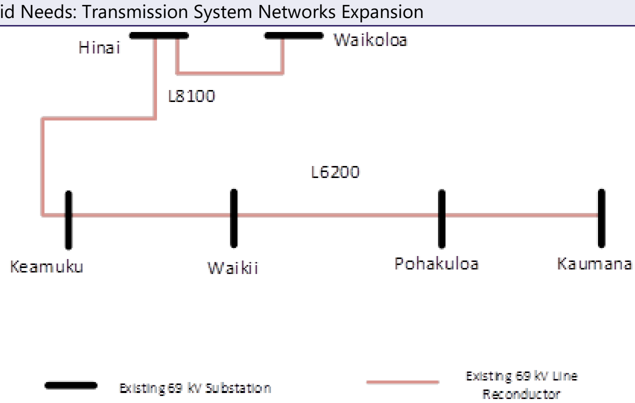
8.3.4.1 Summary of Base Scenario Resource Plan

For the Hawai'i island Base scenario resource plan, the cross-island tie L6200 line and west side L8100/8900 line has risk of overloading condition in both the near term and long term. The cross-island tie L6200 overloading normally happens when there is significant unbalance of generation on the two sides of the island, and because of the contingency, there is a large amount of power flow from the west side of the island toward the east side of the island through a few lines, including the L6200. This overloading can be mitigated by either reconductoring of the L6200 line to 556 AAC or balancing west-side and east-side generation. The overloading of the L8100/8900 line is normally caused by a large flow of power from the east side to the west side of the system when the L6800 line is tripped, especially when there is too much generation interconnected at Keamuku substation.

The steady-state analysis for the Hawaiʻi Island system also showed that unbalanced generation dispatched between the west side and east side of the island would cause a significant undervoltage issue on either the southern or northern part of the system. This undervoltage issue will become much worse when no generation resource is interconnected in south Hawaiʻi. It is recommended that the Hawaiʻi Island system have a resource (capable of providing voltage support) in south Hawaiʻi.

The following tables summarize the study results for the Base scenario resource plan.

<table>
<tr><th colspan="7">Summary</th></tr>
<tr><td colspan="3">Studied resource plan</td><td colspan="4">Studied year</td></tr>
<tr><td colspan="3">Base scenario resource plan</td><td colspan="4">2032</td></tr>
<tr><td colspan="3">By 2030, the Hawai'i system will have new generation from Stage 3 procurement and REZ development, which includes 48 MW wind generation of REZ development by 2029 and 140 MW Stage 3 procurement of hybrid solar generation by 2030, interconnecting at the Hawai'i island 69 kV system. It is also assumed that three firm generation plants will be removed by 2031: the 34 MW Hill 5 and 6 will be removed by 2027, the 21 MW Tawhiri wind generation PPA is assumed to expire by 2028, and the 58 MW Hamakua Energy Partners is assumed to expire by the end of 2030. The system peak load is forecasted to reach 214 MW by 2032.</td><td colspan="4">
</td></tr>
<tr><td colspan="7">System Resource Summary and Forecasted Demand (MW)</td></tr>
<tr><td>Fossil fuel–based generation</td><td>Onshore standalone wind</td><td>Geothermal generation</td><td>Large-scale hybrid solar</td><td>Hydro</td><td>DER</td><td>System peak load</td></tr>
<tr><td>85.8</td><td>58.5</td><td>46</td><td>200</td><td>16.6</td><td>171</td><td>214</td></tr>
<tr><td colspan="7">REZ Enablement</td></tr>
<tr><td colspan="7">Interconnection sites for the 140 MW Stage 3 projects and 48 MW onshore wind generation are as follows:
Keamuku substation: 30 MW, Puueo substation: 30 MW, Kanoelehua substation: 30 MW, Ouli substation: 20 MW, Poopoomino substation: 30 MW
The interconnection of 48 MW wind generation from REZ development is assumed at the Keamuku substation. The estimated REZ enablement cost for the 48 MW onshore wind interconnection at the Keamuku substation is $37.8 million.</td></tr>
<tr><td colspan="7">Grid Needs: Transmission System Networks Expansion</td></tr>
<tr><td colspan="7">None</td></tr>
<tr><td colspan="7">L6200 overloading observed in the study because of maximum west generation dispatches in which the 214 MW system load is solely supplied by generation from the west side of the island. The solution for deferring the L6200 reconductor is to maintain the minimum generation dispatch requirement on the east side of the system. The minimum MW generation dispatched from the east side of the system is calculated by the following equation:
East side minimum generation (MW) = $\frac{System\ total\ load-174}{214-174}\cdot 20$
If the system total load is lower than 174 MW, there is no mimimum MW requirement of generation dispatched on the east side of the system.
Dependent on the system total load and the east-side generation resources chosen to meet this minimum requirement, the east side may require 20 MVAR of additional reactive power capability to resolve potential north/east voltage violations. At the peak load with 20 MW generation on the east side of the island, the following options are viable for mitigating north/east undervoltage violations:
All 3 units of PGV online.
Puna CT3 online with 2.8 MVAR additional reactive capability required at Kanoelehua or Puueo substations.
Stage 3 Kanoelehua with 20 MVAR additional reactive capability required at Kanoelehua.
Stage 3 Kanoelehua and Puueo (split output) with 20 MVAR additional reactive capability required between the two locations. The additional reactive capability at Kanoelehua and Puueo are in addition to the assumed capability of the Stage 3 resources at that location.
To mitigate a high loading condition of L8900/8100, it is recommended to move generation interconnection from Keamuku and the east toward the further west side system (e.g., Keahole substation) when the system total load reaches above 200 MW.
To mitigate undervoltage violation identifed on the south side of the system, it is recommended to have a resource interconnected at Keauhou substation with at least 10.4 MVAR capability or at Kamaoa substation with 13.7 MVAR or 13.3 MW capability. The reactive power capability can be replaced by active power capability, or the combination of reactive power and active power capability.</td></tr>
<tr><td colspan="7">Grid Needs: System Stability Needs</td></tr>
<tr><td colspan="7">After adding 140 MW Stage 3 hybrid solar projects with grid-forming battery energy storage component, it is expected that Hawai'i Island system stability performance will stay within planning criteria, and no additional system stability needs were identified. When Puna Geothermal Venture units are online, at minimum, a total of 60 MW grid-forming hybrid solar project is required. A 30 MW grid-forming hybrid solar project is required on both east and west sides of the Hawai'i Island system, while maintaining grid-forming resource headroom as 24% of DER generation. When Puna Geothermal Venture units are offline, at minimum, a total of 110 MW grid-forming resource is required. The east side of the system will need 50 MW grid-forming resource online and the west side of the system will need 60 MW grid-forming resource online, while together maintaining grid-forming resource headroom as 61% of DER generation.</td></tr>
</table>

<table>
<tr><th colspan="7">Summary</th></tr>
<tr><td colspan="3">Studied resource plan</td><td colspan="4">Studied year</td></tr>
<tr><td colspan="3">Base scenario resource plan</td><td colspan="4">2050</td></tr>
<tr><td colspan="3">In addition to previous system resource changes by 2031, by 2035, the Hawai'i Island system will have 2 MW standalone battery energy storage and 3 MW hybrid solar from the REZ development. It is assumed that both interconnections will be in distribution circuits by considering their MW size. In 2040, there will be another 20 MW hybrid solar generation developed from the renewable energy zone. In 2045, all fossil fuel–based generation will have fuel switch to biodiesel. In the same year, there will be 30 MW geothermal generation and 2 MW standalone battery energy storage interconnected to the system. By 2050, an additional 14 MW hybrid solar and 2 MW onshore wind generation will be developed from the renewable energy zone. The system annual peak load is forecasted to reach 295 MW by 2050.</td><td colspan="4"></td></tr>
<tr><td colspan="7">System Resource Summary and Forecasted Demand (MW)</td></tr>
<tr><td>Fossil fuel–based generation</td><td>Onshore standalone wind</td><td>Geothermal generation</td><td>Large-scale hybrid solar</td><td>Hydro</td><td>DER</td><td>System peak load</td></tr>
<tr><td>85.8</td><td>60.5</td><td>76</td><td>237</td><td>16.6</td><td>271</td><td>295</td></tr>
<tr><td colspan="7">REZ Enablement</td></tr>
<tr><td colspan="7">It is assumed that the geothermal generation in service in 2045 will be interconnected at Haina substation, and the REZ generation will be interconnected at Pepeekeo substation (20 MW) in 2040 and Kaumana substation (17 MW) in 2050.
High-level cost estimate for the 20 MW interconnection REZ enablement at the Pepeekeo substation is $24.5 million, and for the 17 MW interconnection REZ enablement at the Kaumana substation is $27.9 million.</td></tr>
<tr><td colspan="7">Grid Needs: Transmission System Networks Expansion</td></tr>
<tr><td colspan="7">
</td></tr>
<tr><td colspan="6">Network expansion cost estimate</td><td>$100.1 million</td></tr>
<tr><td colspan="7">To mitigate undervoltage violations on the north side of the system, it is recommended to dispatch an east unit (e.g., Puna Geothermal Venture) at 5 MW or higher. To mitigate undervoltage violation on the south and southwest side of the system, it is recommended to have a resource interconnected at Kamaoa with 22.5 MW generation capacity.</td></tr>
<tr><td colspan="7">Grid Needs: System Stability Needs</td></tr>
<tr><td colspan="7">Not studied.</td></tr>
</table>

8.3.5 Distribution Needs

This section discusses distribution needs as they pertain to the grid needs assessment for Hawai'i Island.

8.3.5.1 Hosting Capacity Grid Needs

Of the 137 circuits assessed on Hawai'i Island, most have sufficient DER hosting capacity or could accommodate the 5-year hosting capacity without infrastructure investments. The remaining circuits where infrastructure investments are required to increase hosting capacity to accommodate the forecasted distributed energy resources are identified as requiring grid needs. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-19.

Table 8-19. Hawai'i Island Hosting Capacity Grid Needs (Years 2021–2025)

Parameter (Nominal $)	Base DER Forecast	High DER Forecast	Low DER Forecast
Number of grid needs	2	2	2
Cost summary (wires solutions)	$630,000	$630,000	$630,000

A complete list of the hosting capacity grid needs can be found in the *Distribution DER Hosting Capacity Grid Needs* report.

8.3.5.2 Location-Based Grid Needs

Of the 148 circuits and 82 substation transformers assessed on Hawai'i Island, most have sufficient capacity to accommodate the forecasted load demand. For substation transformers and circuits where there is insufficient capacity, a grid need is identified. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-20.

Table 8-20. Hawai'i Island Location-Based Grid Needs (Years 2023–2030)

Parameter (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	3	3	3	4
Cost summary (wires solutions)	$2,680,000	$2,680,000	$2,680,000	$3,153,000

A complete list of the load-driven grid needs can be found in Appendix E.

8.3.5.3 Distribution Grid Needs Summary

The minimum number of grid needs identified (i.e., minimum wires solutions) by scenario by island is shown in Table 8-21. This includes both hosting capacity and location-based grid needs.

Table 8-21. Hawai'i Island Minimum Grid Needs Solutions Identified (Years 2023–2030)

Island (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	5	5	5	6
Cost summary (wires solutions)	$3,310,000	$3,310,000	$3,310,000	$3,783,000

8.3.5.4 NWA Opportunities

No NWA opportunities were identified for Hawai'i Island in the Base, High electricity demand, and Low electricity demand scenarios. Results for the Faster Technology Adoption scenario are shown in Table 8-22.

Faster Technology Adoption Scenario

Table 8-22. NWA Opportunity Projects by Track: Faster Technology Adoption Bookend

Track	Operating Date	Transformer	Circuit	Description	Cost (Nominal $)
3 (non-qualified)	2030	Waikoloa	N/A	New circuit and tie	$473,000

8.3.6 Preferred Plan

The capacity expansion modeling conducted in RESOLVE was the starting point for identifying grid needs and developing a resource plan.

Probabilistic resource adequacy analyses were then performed to confirm that the portfolio of resources selected in the resource plan were reliable. In parallel, transmission and system security needs were identified. Based on the results of this analysis, the following changes were made:

- 2030: 24% grid-forming headroom capacity with Puna Geothermal Venture online or 61% grid-forming headroom capacity without Puna Geothermal Venture online for dynamic stability
- 2032: minimum east-side generation that scales with system load
  - For the purposes of this analysis, geothermal resources added by RESOLVE and Stage 3 hybrid solar are considered east-side resources.

Additional capital costs were identified to interconnect resources in the renewable energy zones selected in RESOLVE. While the REZ enablement costs were already included as part of the RESOLVE modeling, they are listed here in Table 8-23 for completeness alongside new network expansion costs.

The Status Quo scenario transmission network expansion costs reflect estimated transmission needed to expand capacity, as identified in the transmission needs analysis, to serve load growth because of electrification of transportation.

Table 8-23. Hawai'i Island Transmission Capital Costs

Nominal Transmission Costs ($MM)	Base		Status Quo	
Years	REZ Enablement	Network Expansion	REZ Enablement	Network Expansion
2029	$45	-	-	-
2031	-	-	-	$96
2035	$3	-	-	-
2040	$24	-	-	-
2050	$26	-	-	-

Table 8-24 shows a comparison of the Hawai'i Island Base production costs with and without transmission constraints.

Comparing the production costs with and without the transmission constraints identified above shows that the dynamic stability and minimum east-side generation requirements do not significantly change production costs, and reduced capital cost of transmission upgrades.

Table 8-24. Comparison of Hawai'i Island Base Scenario Production Costs with and without Transmission Constraints

NPV ($MM)	With Transmission Constraints	Without Transmission Constraints
(2023–2050)	$2,122	$2,122

8.4 Maui

This section describes the results of the grid needs assessment for Maui through the multistep process that includes modeling capacity expansion, resource adequacy, operations of the system, transmission and system security needs, distribution needs, and iterations or adjustments made to determine the preferred plan.

8.4.1 Capacity Expansion Scenarios

In the Base scenario shown in Figure 8-26, onshore wind is selected, primarily because of its low cost, achieving 95% renewable energy by 2030 shown in Figure 8-27. As electricity demand increases hybrid solar is added in the later years. In scenarios with Faster Technology Adoption, High electricity demand and Low electricity demand shown in Figure 8-26, similar resources are selected; however, their amounts change with the magnitude of forecasted load. In the High electricity demand scenario renewable firm resources are added in 2035 and increases in magnitude following the load forecast as the years progress. Existing fossil fuel–based resources are shown as firm renewable resources in 2050 because of their switch to biofuels in 2045.

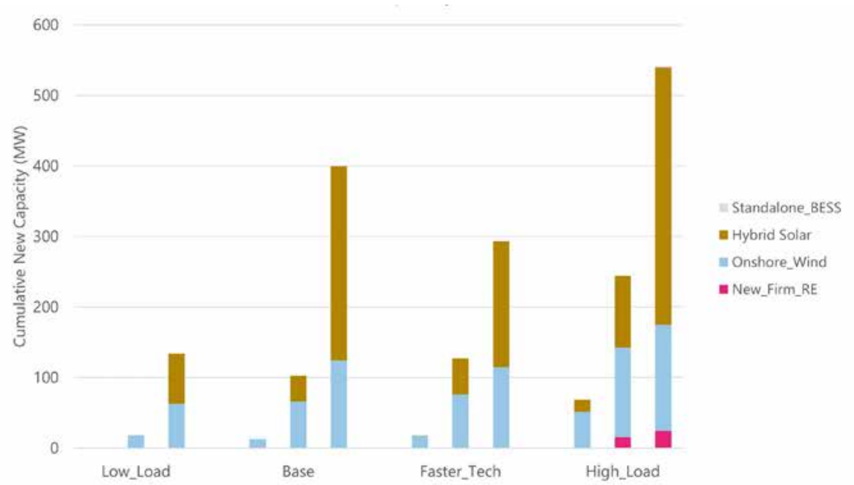


Figure 8-26. Maui: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

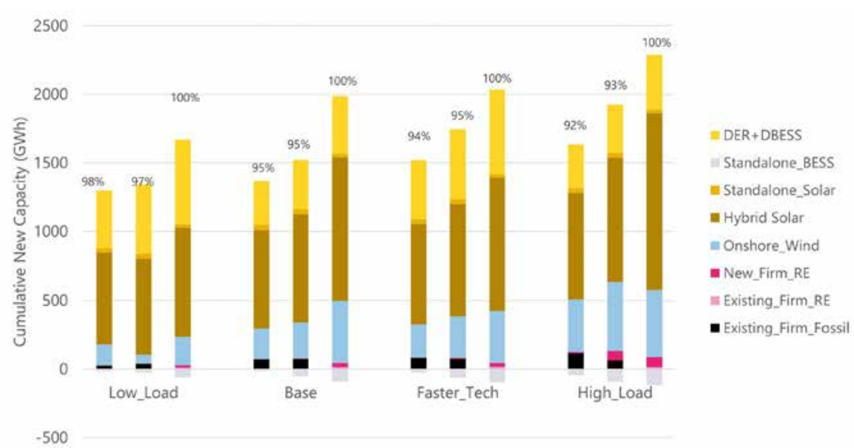


Figure 8-27. Maui: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

8.4.1.1 High Fuel Retirement Optimization Scenario

In addition to the planned retirements of Māʻalaea 1–13 and Kahului 1–4, the High Fuel Retirement Optimization scenario chooses to retire 54 MW of firm generation capacity shown in Figure 8-28. All additional retirements occur early in the planning horizon before and in 2030.

Because the model front-loads the removal of units early in the planning horizon, extreme care must be taken to ensure that customers are not adversely affected by an inadequate system. Additionally, this scenario accelerates the buildout of hybrid solar and adds new firm generating resources compared to the Base scenario. In practice, to ensure that sufficient replacement resources are in service to facilitate the retirements selected in this sensitivity, the unit removals would need to be staggered similar to our proposed removal-from-service schedule. Otherwise, the retirements shown in this sensitivity would increase the risk of unserved energy to our customers. The retirements shown in this sensitivity comprise partial unit retirements because of the linear optimization aspect of the model.

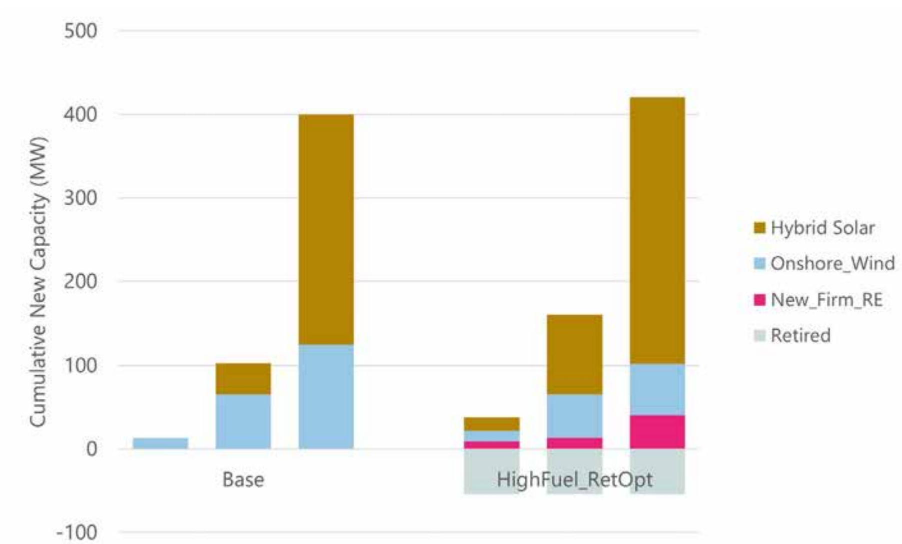


Figure 8-28. Maui: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

Shown in Figure 8-29, the expected renewable energy achievement does not significantly increase under the high fuel price sensitivity (95% compared to 96% in 2030).

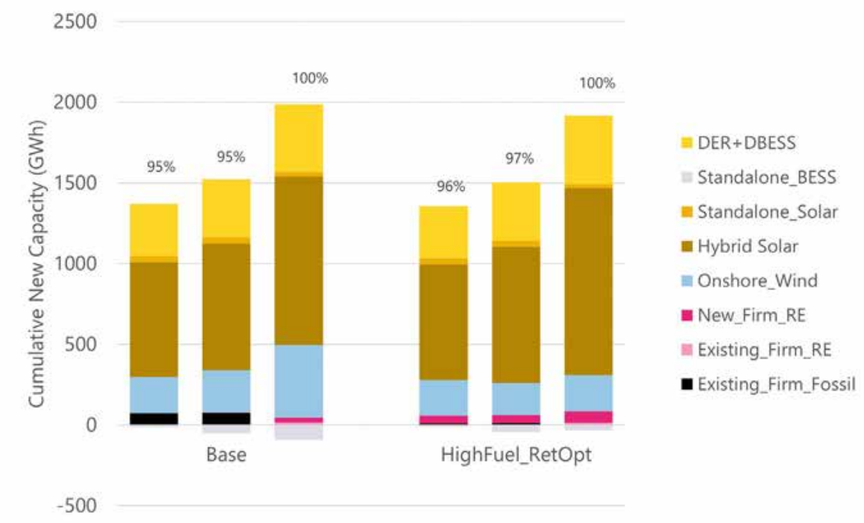


Figure 8-29. Maui: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base and High Fuel scenarios

8.4.2 Resource Adequacy

On Maui, several key decision points are illustrated by the probabilistic resource adequacy analyses. By 2030, we plan for the removal of 122 MW of existing fossil-fuel firm generation. The impact of this planned removal is mitigated by the addition of new resources through the Stage 3 procurement. However, if we acquire less than the full Stage 3 targeted need, additional resources may need to be acquired through additional procurements.

For Maui, Kahului 1–4 and Māʻalaea 10–13 are assumed to be retired by 2027 to comply with regional haze rules and Māʻalaea 1–9 are assumed to be retired by 2030, as shown in Table 8-25. This is largely due to the lack of replacement parts for maintenance.

Table 8-25. Generating Unit Deactivation/Retirement Assumptions

Year	Generating Unit
2027	Kahului 1–2 removed from service (9.47 MW) Kahului 3–4 removed from service (23 MW) Māʻalaea 10–13 removed from service (49.36 MW)
2030	Māʻalaea 1–3 removed from service (7.5 MW) Māʻalaea 4–9 removed from service (33 MW)

If development of future large-scale renewables reaches the target presented in the Base scenario:

- We expect loss of load of less than 0.1 day per year, assuming planned deactivations through 2030 and the full targeted need for the Stage 3 procurement is acquired (40 MW of new firm generation and 191 MW of new hybrid solar or wind by 2027).
- We expect loss of load of less than 0.1 day per year even if we acquire less than the full target for Stage 3 (40 MW of new firm generation and 191 MW of new hybrid solar or wind by 2027). If we fulfill the firm renewable target but the variable renewable target is not, we expect a loss of load of less than 0.1 day per year. If we fulfill the variable renewable target, between 9 and 18 MW of new firm renewables are needed to achieve a loss of load expectation less than 0.1 day per year.

By 2035, we do not assume any additional thermal unit deactivations or retirements. The Stage 3 acquired resources are still needed to maintain reliability.

- We expect loss of load of less than 0.1 day per year, assuming planned deactivations through 2030 and we acquire the full target sought in Stage 3 procurement (40 MW of new firm generation and 191 MW of new variable renewable generation paired with storage by 2027).

Probabilistic Resource Adequacy Summary

Table 8-26 shows the 2030 Resource Adequacy results for the Base resource plans that were produced by RESOLVE. The results show that, in 2030, the resource plan developed by RESOLVE should meet our reliability target.

Table 8-26. Probabilistic Analysis: Results Summary, Maui Island, 2030

Scenario	Existing Firm	New Firm	Stage 3 RFP	Future Wind	Future Hybrid Solar	Future Standalone BESS	LOLE	LOLEv	LOLH	EUE (GWh)	EUE (%)
Base	119	36	191	13	0	0	0.00	0.01	0.02	0.0001	0.00

Table 8-27 shows the 2035 Resource Adequacy results for the Base resource plan with the Base Load and High Load forecast. The results show that, in 2035, the Base resource plan meets the loss of load expectation target but with a high load forecast, the Base plan does not meet the loss of load expectation target.

Table 8-27. Probabilistic Analysis: Results Summary, Maui Island, 2035

Scenario	Existing Firm	New Firm	Stage 3 RFP	Future Wind	Future Hybrid Solar	Future Standalone BESS	LOLE	LOLEv	LOLH	EUE (MWh)	EUE (%)
Base Load	119	41	191	24	37	0	0.013	0.10	0.24	0.00	0.000
High Load	119	41	191	24	37	0	3.58	7.08	14.79	0.32	0.030

In 2035, assuming a High electricity demand scenario and all of Stage 3 RFP (191 MW of hybrid solar and 40 MW of renewable firm) and 37 MW of hybrid solar from the RESOLVE model:

- Approximately 540 MW of additional hybrid solar is needed to bring the system loss of load expectation down below 0.1 day per year.
- Approximately 33 MW of additional firm generation is needed to bring the system loss of load expectation down below 0.1 day per year.

See Section 12 for more details on risks of the resource portfolio given uncertainties in procuring and acquiring the optimal mix of resources.

8.4.3 Grid Operations

The transition to 100% renewables will necessitate a change in how the thermal generators on our system operate. Scenarios with more renewable resources will use thermal generators less often. This is shown in the daily energy profiles and operational statistics in this section.

8.4.3.1 Status Quo Typical Operations

For the Maui Island Status Quo scenario, Māʻalaea 1–9 are assumed to remain in service and Kaheawa Wind Power 1, Kaheawa Wind Power 2, and Auwahi Wind are assumed to have their contracts continued for the study period.

The energy profiles shown in Figure 8-30 and Figure 8-31 show the median load day in 2030 and 2035 of the Status Quo scenario as well as the day directly preceding and following the median load day. This shows how the resource portfolio is meeting the system load over a typical few days during a given year.

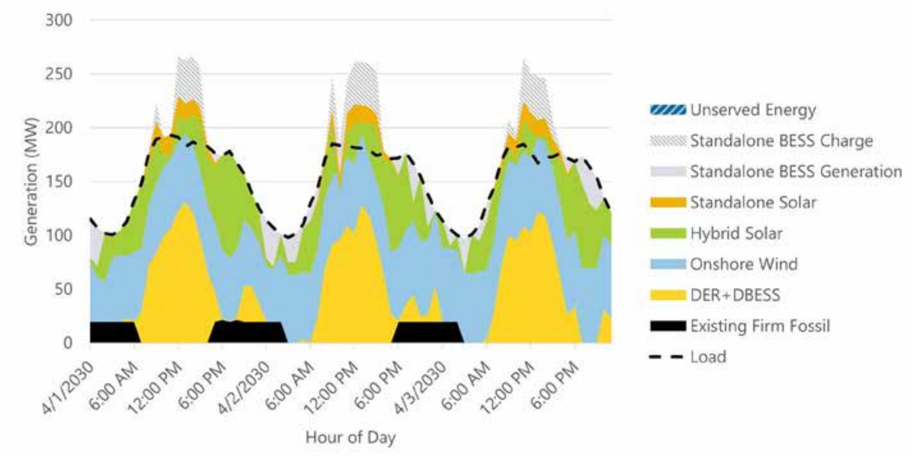


Figure 8-30. Maui: detailed Status Quo energy profile, 2030 median load day (April 1–3, 2030)

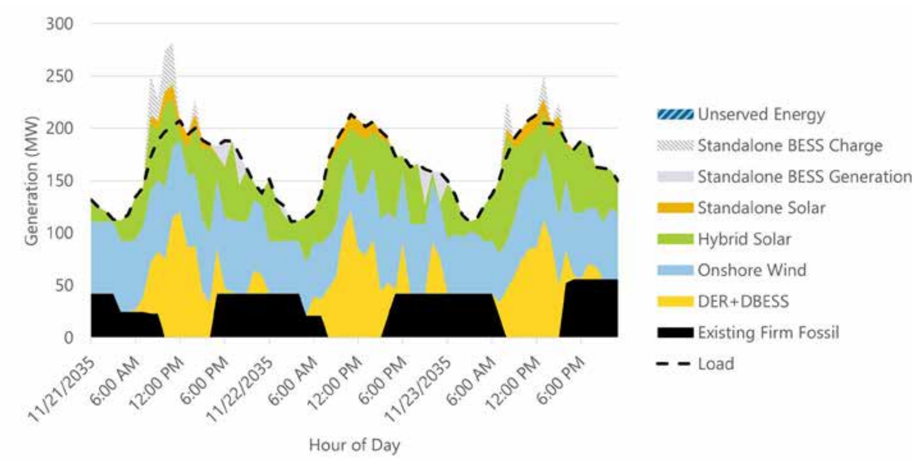


Figure 8-31. Maui: detailed Status Quo energy profile, 2035 median load day (November 21–23, 2035)

8.4.3.2 Base Scenario Typical Operations

The dispatch of the resources in the Base resource plan in 2030 and 2035, respectively, for a few days with average load is shown in Figure 8-32 and Figure 8-33. In the Base scenario, during midday, most of the load is expected to be met from variable renewable resources. In 2030 and 2035 the system is effectively operating on 100% renewable energy.

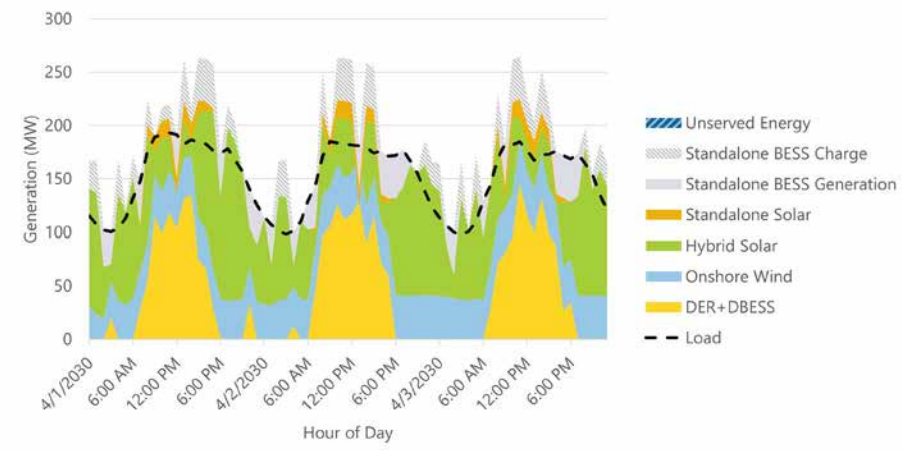


Figure 8-32. Maui: detailed Base scenario energy profile, 2030 median load day

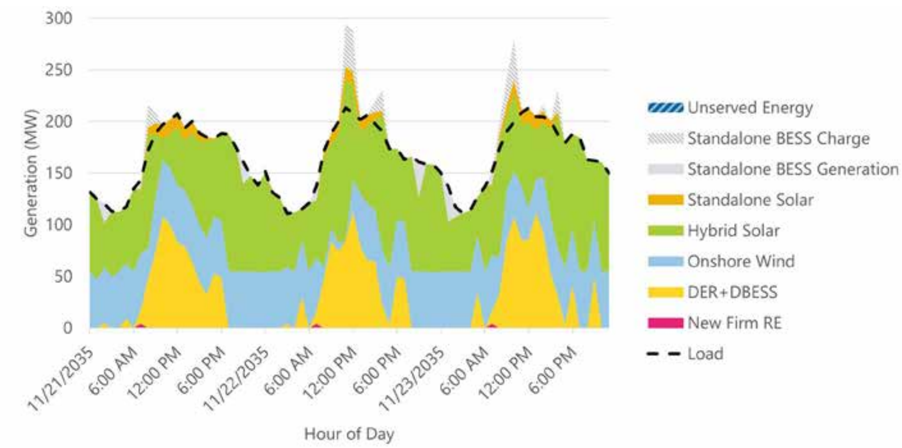


Figure 8-33. Maui: detailed Base scenario energy profile, 2035 median load day

8.4.3.3 Operations of Firm Generation

We can gather insights into the changing role of firm generation by evaluating the number of starts of different types of firm generators and the amount those generators run, or the capacity factor, which is the percentage of hours a generator runs based on its rated capacity. The number of starts and capacity factor, respectively, of the utility-owned thermal generators for the Status Quo and Base resource plans in 2030 and 2035 are shown in Figure 8-34 and Figure 8-35. Because the Status Quo scenario relies more heavily on older thermal cycling generators, the generators are started less frequently and operate with a higher capacity factor than in the Base scenario in 2030. Because the Base scenario has newer internal-combustion units, there are more unit starts initially and decrease as more hybrid solar is added to the system.

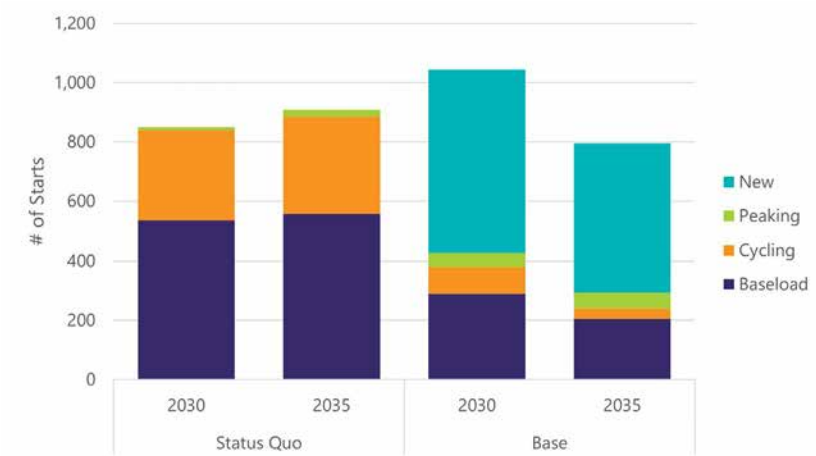


Figure 8-34. Maui: thermal generators number of starts, 2030 and 2035 for Status Quo and Base scenario

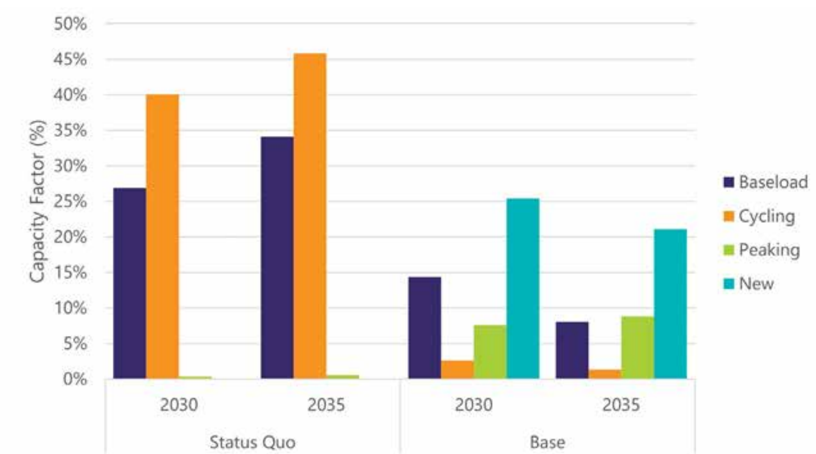


Figure 8-35. Maui: thermal generators capacity factor, 2030 and 2035 for Status Quo and Base scenario

8.4.4 Transmission and System Security Needs

We analyzed the Maui Base and High electricity demand scenario resource plans to determine transmission and system security needs by performing steady-state analyses and dynamic stability analyses for selected years with major large-scale resource additions, including:

- Maui system Base scenario resource plan: 2027, 2035, 2041, 2045, and 2050
- Maui system High load scenario resource plan: 2027, 2030, and 2035

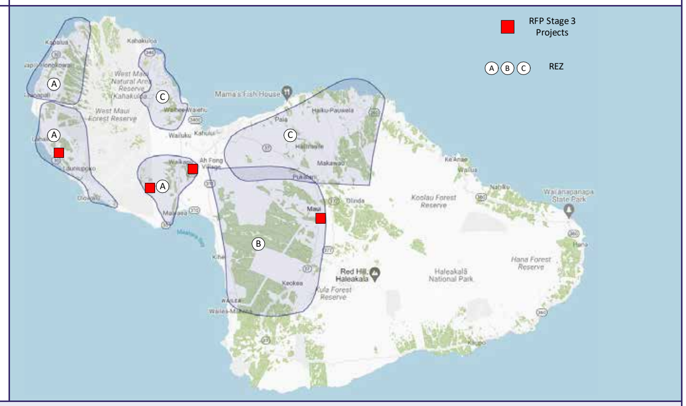
8.4.4.1 Summary of Maui Base Scenario Resource Plan

In the Maui Base scenario resource plan, signficant large-scale resources will be interconnected to the system, requiring transmission network expansion for REZ development and forecasted load increases from electrification.

The large-scale resources in the Base plan provide the system with sufficient grid-forming resources and maintain system stability within the Maui trasmission planning criteria. The following tables summarize the study results for the Maui Base scenario resource plan.

Summary	
Studied resource plan	Studied year
Base scenario resource plan	2027

By 2027, the Maui system will have new generation, which includes 171 MW renewable dispatchable generation and 36 MW firm generation, interconnected at the Maui 69 kV system. Meanwhile, the Maui system will finish Waena switchyard construction, Kahului Power Plant retirement and conversion of units 3 and 4 to synchronous condensers, and retirement of Māʻalaea Power Plant units 10–13. The system peak load is forecasted to reach 207 MW by 2028.

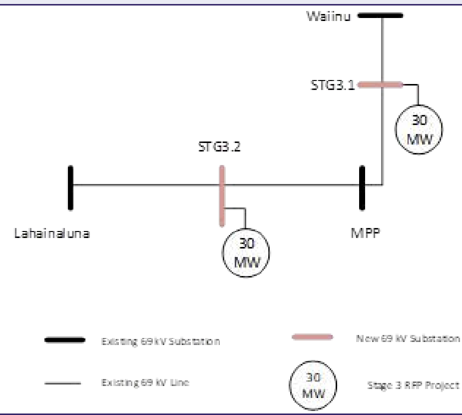


System Resource Summary and Forecasted Demand (MW)

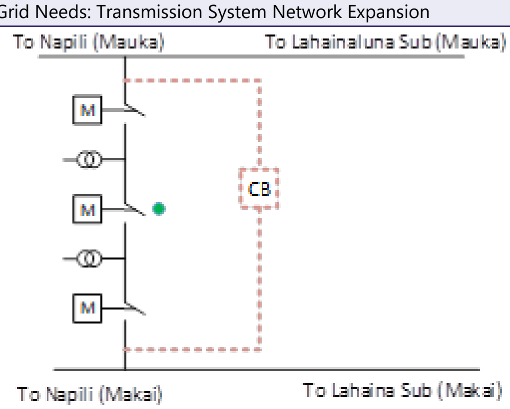
Firm generation	Onshore standalone wind	Large-scale hybrid solar	Standalone BESS	DER	System peak load
197.5	42	296	40	170.7	207

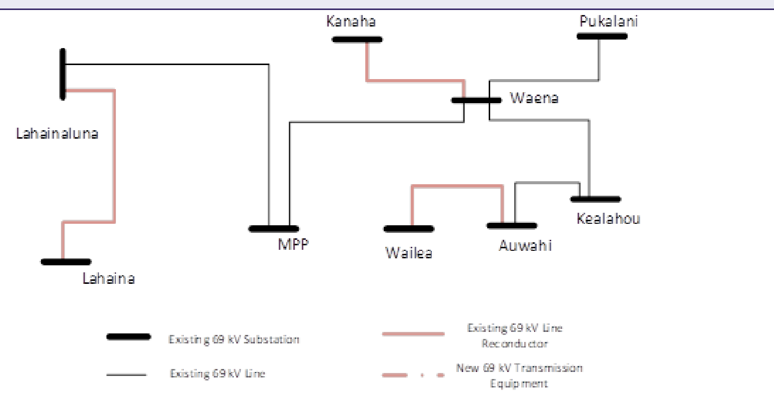
REZ Enablement

No REZ enablement cost estimate because by 2027 existing locations are proposed to be used for Stage 3. Interconnection sites for the 171 MW Stage 3 projects and 36 MW firm generation are as follows:
Substation/switching station interconnections:
Lahainaluna substation station: 60 MW,
KWP 2 substation: 30 MW
Waena switch yard: 40 MW firm generation
Kealahou substation: 21 MW
69 kV transmisison line interconnection:
MPP: Waiinu line interconnection—30 MW, through a new substation STG3.1
MPP: Lahainaluna line interconnection—30 MW, through a new substation STG3.2



Grid Needs: Transmission System Network Expansion



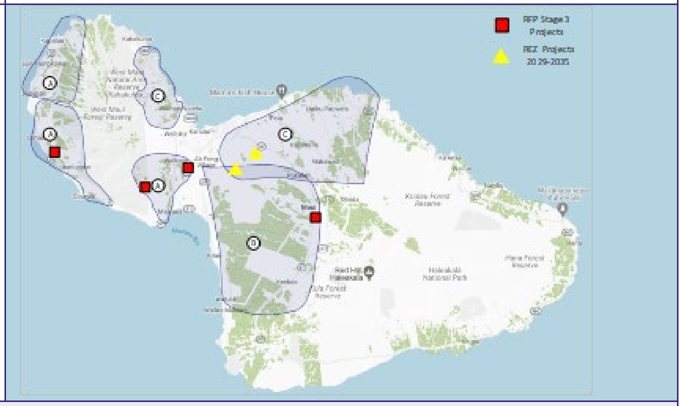


Network Cost Estimate	$10.5 million

Alternative options for above reconductor upgrade include reducing grid-scale resource interconnection MW size by 24 MW on west Maui and reducing grid-scale resource interconnection MW size in Waena switchyard, up-country or south Maui by 16 MW.

Grid Needs: System Stability Needs

After adding 171 MW Stage 3 RDG projects with grid-forming BESS component, it is expected that Maui system stability performance will stay within planning criteria, and no additional grid needs regarding system stability are identified. Maui system single point of failure limit can be increased to 30 MW as well.

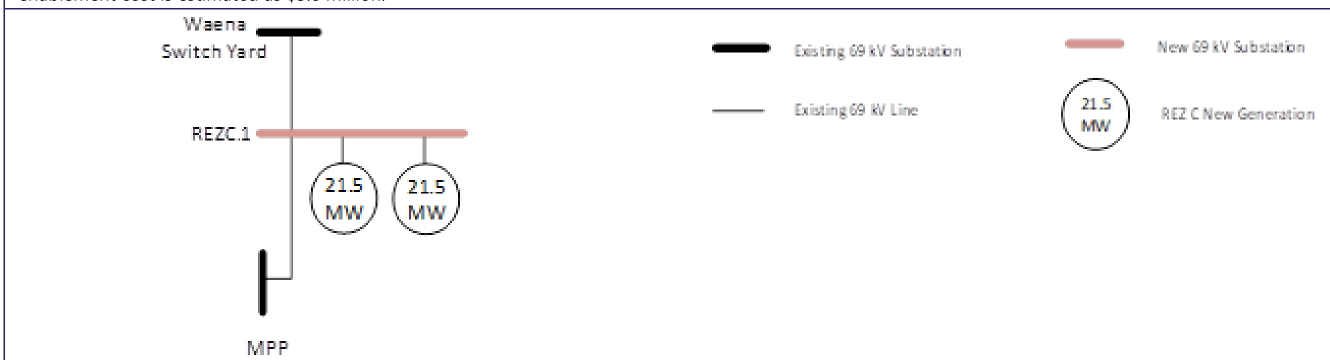
Summary	
Studied resource plan	Studied year
Base scenario resource plan	2035
In addition to previous system resource changes by 2027, by 2035, the Maui system will have 66 MW large-scale onshore wind generation, 37 MW hybrid solar generation interconnected at Maui transmission system. This new generation will be developed in renewable energy zone C. Also, it is planned that the Mā'alaea Power Plant units 1–9 will be removed by 2030, and assumed wind power generation Kaheawa Wind Power 2 and Auwahi will be retired by 2033. The system annual peak load is forecasted to reach 235 MW by 2036.	

System Resource Summary and Forecasted Demand (MW)

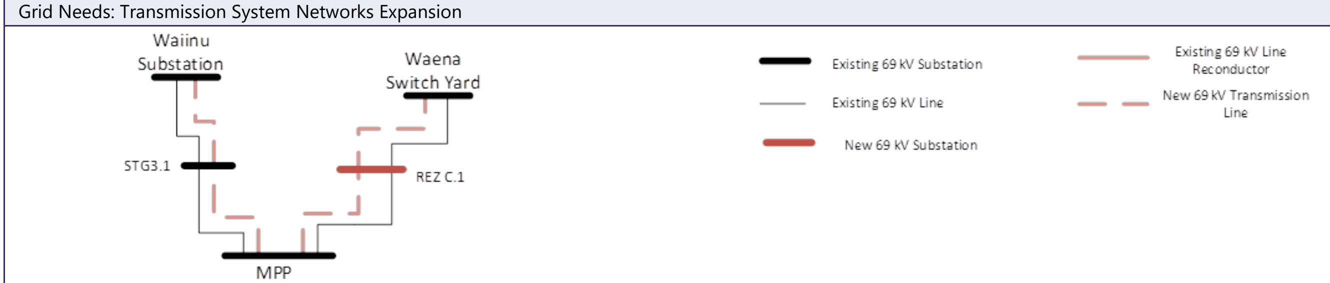
Firm generation	Onshore standalone wind	Large-scale hybrid solar	Standalone BESS	DER	System peak load
152	66	333	40	202	237

REZ Enablement

From 2028 to 2035, 5 MW onshore wind genration in 2029, 8 MW onshore wind generation in 2030, 53 MW onshore wind in 2035, and 37 MW hybrid solar, connected to renewable energy zone C, totaling 103 MW. It is assumed that there will be a new switching station in renewable energy zone C.1 on the MPP-Waena line that will host 43 MW out of 103 MW generation, and the remaining 60 MW will be hosted in the Waena switchyard. The cost of REZ enablement for the 60 MW generation interconnection at the Waena switchyard is estimated as $13.5 million. For the new switching station renewable energy zone C.1, the REZ enablement cost is estimated as $5.8 million.



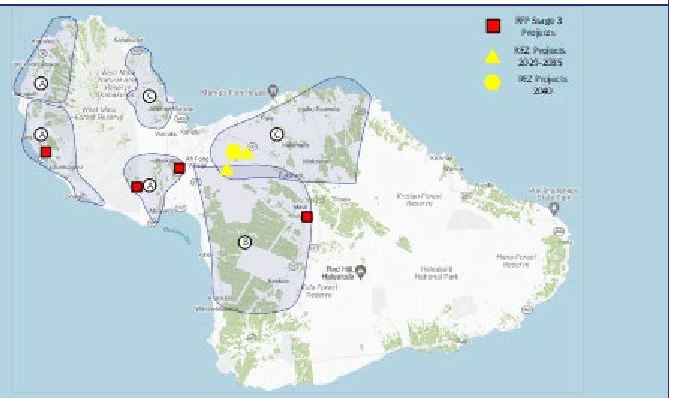
Grid Needs: Transmission System Networks Expansion



Networks expansion cost estimate	$96.2 million

Grid Needs: System Stability Needs

None

Summary	
Studied resource plan	Studied year
Base scenario resource plan	2040
In 2040, another 61 MW renewable energy zone C development will be completed. It is assumed that 61 MW will be interconnected at Waena switchyard. Meanwhile, there will be retirement of existing 5.7 MW distribution interconnected solar. System annual peak demand is forecasted to reach 266 MW in 2041.	

System Resource Summary and Forecasted Demand (MW)

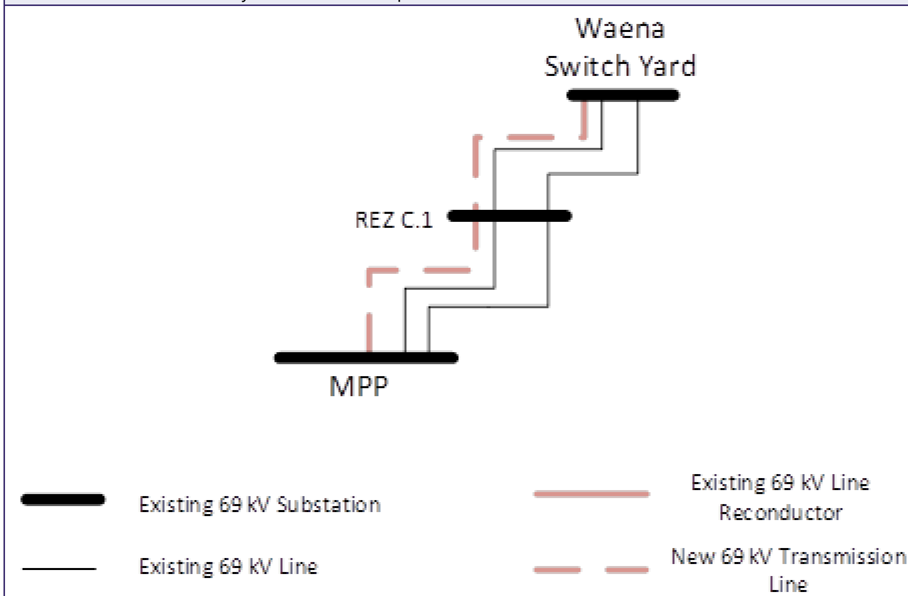
Firm generation	Onshore standalone wind	Large-scale hybrid solar	Standalone BESS	DER	System peak load
152	84	376	40	218	266

REZ Enablement

The new 61 MW of generation in the renewable energy zone C development is assumed to interconnect at the Waena switchyard, which will require two breakers and a half bay for the generation interconnection.

Cost estimate of REZ enablement for 61 MW interconnection is $15.6 million.

Grid Needs: Transmission System Networks Expansion



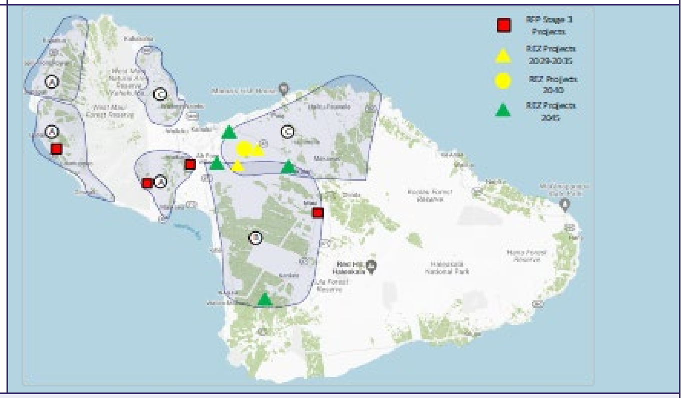
Network expansion cost estimate	$51.9 million

An alternative option for adding a new circuit between Māʻalaea Power Plant and Waena switchyard is to reduce large-scale generation interconnection from the renewable energy zone C development by 48.4 MW.

Grid Needs: System Stability Needs

None

Summary

Studied resource plan	Studied year
Base scenario resource plan	2045
In 2045, 66 MW hybrid solar generation and 41 MW onshore wind generation will be developed in renewable energy zone C; 15 MW hybrid solar generation will be developed in renewable energy zone B. Also, all the remaining fossil-fuel units will switch to biodiesel. The system annual peak demand is forecasted to reach 289 MW in 2046.	

System Resource Summary and Forecasted Demand (MW)

Firm generation	Onshore standalone wind	Grid-scale hybrid solar	Standalone BESS	DER	System peak load
152	125	457	40	229	289

REZ Enablement

According to the resource plan, 15 MW generation from renewable energy zone B and 107 MW generation from renewable energy zone C will be interconnected to the Maui system. In the study, the following interconnection sites are assumed:

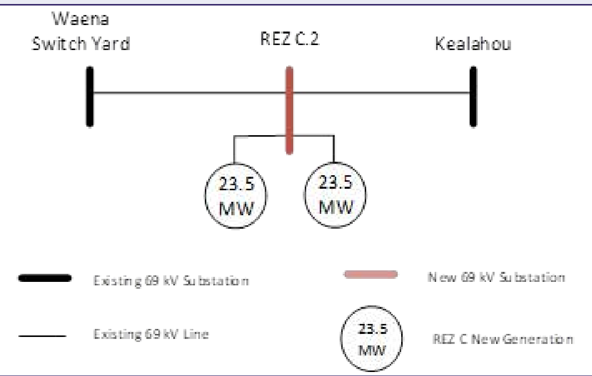
Auwahi substation: 15 MW

STG3.1: 30 MW

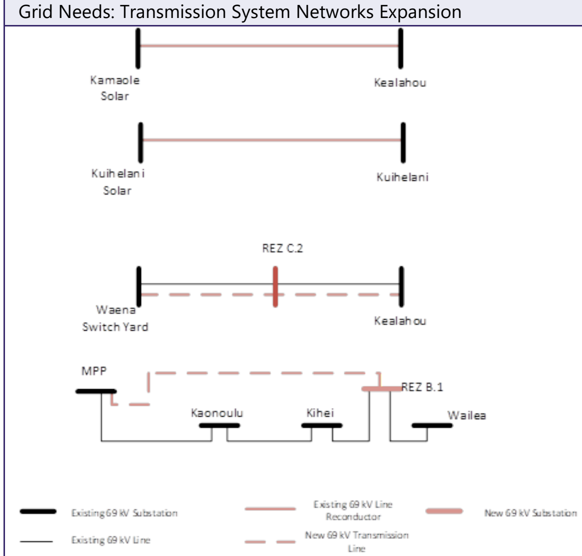
Kanaha substation (23 kV): 30 MW

New switching station, zone C.2, on Waena-Kealahou line: 47 MW

The cost estimate of the REZ enablement for the 30 MW interconnection at the STG 3.1 substation is $3.9 million, for the 30 MW interconnection at the Kanaha substation 23 kV side is $3.8 million, and for the 47 MW interconnection at the new substation renewable energy zone C.2 is $7.8 million. The total estimate for the REZ enablement is $15.4 million.



Grid Needs: Transmission System Networks Expansion

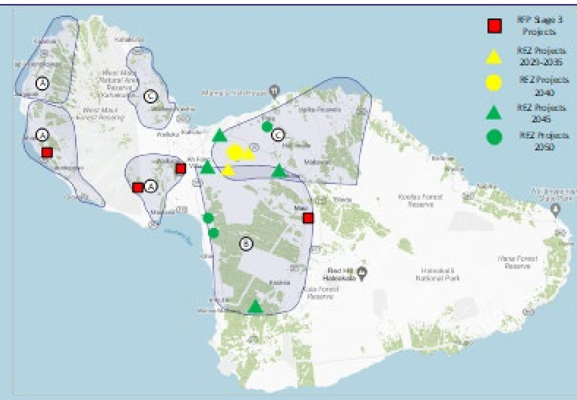


Network expansion cost estimate	$171.2 million

An alternative option for the reconductor of the Kamaole-Kealahou line is to reduce south Maui generation interconnection size by 7 MW.

Grid Needs: System Stability Needs

Not studied.

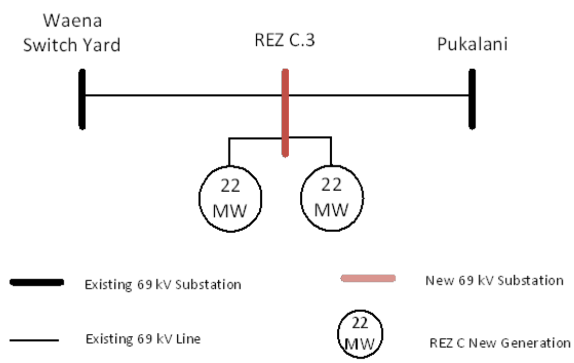
Summary	
Studied resource plan	Studied year
Base scenario resource plan	2050
In 2050, 57 MW hybrid solar generation will be developed in renewable energy zone C; 57 MW hybrid solar generation will be developed in renewable energy zone B. System annual peak demand is forecasted to reach 310 MW in 2050.	

System Resource Summary and Forecasted Demand (MW)					
Firm generation	Onshore standalone wind	Large-scale hybrid solar	Standalone BESS	DER	System peak load
152	125	571	40	240	310

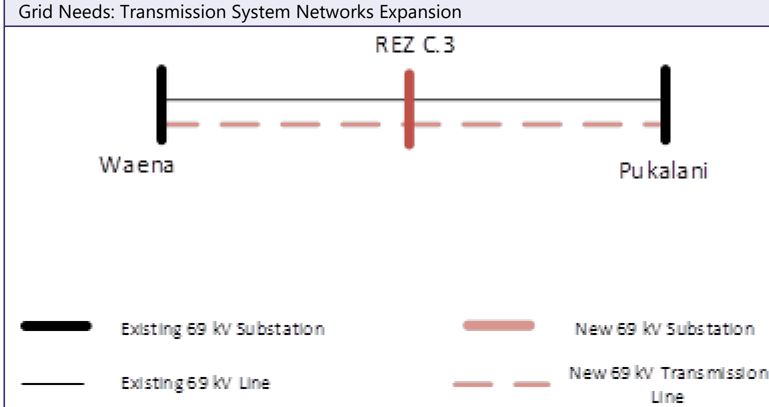
REZ Enablement

In the study, the following interconnection sites are assumed for the 114 MW generation development in renewable energy zones B and C:
Renewable energy zone B.1 Substation: 51 MW
Auwahi Substation: 7 MW
Renewable energy zone C.2 (Waena-Kealahou) Substation: 13 MW
New switching station, renewable energy zone C.3, on Waena-Pukalani line: 44 MW

The estimated cost for REZ enablement in renewable energy zone B.1 substation is $9.0 million and for REZ enablement of building the renewable energy zone C32 is $ 9.0 million. The total REZ enablement estimated cost is $18.0 million. It is assumed in the study that the 7 MW generation interconnection at the Auwahi substation and 13 MW generation interconnection at the renewable energy zone C.2 substation are interconnected without adding a new breaker and a half bay but just expansion of previously developed projects.



Grid Needs: Transmission System Networks Expansion



Besides above adding a new 69 kV line between Waena switchyard and Pukalani substation, it is also proposed to replace the two 69/23 kV tie transformers at Kanaha substation by two units of larger transformers with a forced-air rating of at least 24 MVA.

Network expansion cost, including upgrade of two tie transformers	$123.1 million

An alternative of upgrading two units of the Kanaha tie transformer is to use DER program, or demand response program, or EE program to reduce peak load of the Maui 23 kV network by at least 4 MW.

Grid Needs: System Stability Needs

Not studied

8.4.5 Distribution Needs

This section discusses distribution needs as they pertain to the grid needs assessment for Maui.

8.4.5.1 Hosting Capacity Grid Needs

Of the 88 circuits assessed on Maui, most have sufficient DER hosting capacity or could accommodate the 5-year hosting capacity without infrastructure investments. The remaining circuits where infrastructure investments are required to increase hosting capacity to accommodate the forecasted distributed energy resources are identified as requiring grid needs. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-28.

Table 8-28. Maui Hosting Capacity Grid Needs (Years 2021–2025)

Parameter (Nominal $)	Base DER Forecast	High DER Forecast	Low DER Forecast
Number of grid needs	3	7	3
Cost summary (wires solutions)	$2,500,000	$3,315,000	$2,500,000

A complete list of the hosting capacity grid needs can be found in the *Distribution DER Hosting Capacity Grid Needs* report.

8.4.5.2 Location-Based Grid Needs

Of the 93 circuits and 62 substation transformers assessed on Maui, most have sufficient capacity to accommodate the forecasted load demand. For substation transformers and circuits where there is insufficient capacity, a grid need is identified. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-29.

Table 8-29. Maui Location-Based Grid Needs (Years 2023–2030)

Parameter (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	1	1	1	1
Cost summary (wires solutions)	$63,000	$63,000	$63,000	$63,000

A complete list of the load-driven grid needs can be found in Appendix E.

8.4.5.3 Distribution Grid Needs Summary

The minimum number of grid needs identified (i.e., minimum wires solutions) by scenario by island is shown in Table 8-30. This includes both hosting capacity and location-based grid needs.

Table 8-30. Maui Minimum Grid Needs Solutions Identified (Years 2023–2030)

Island (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	4	4	8	8
Cost summary (wires solutions)	$2,513,000	$2,513,000	$3,377,000	$3,377,000

8.4.5.4 NWA Opportunities

No NWA opportunities are identified for Maui.

8.4.6 Preferred Plan

The capacity expansion modeling conducted in RESOLVE was the starting point for identifying grid needs and developing a resource plan. Probabilistic resource adequacy analyses were then performed to confirm that the portfolio of resources selected in the resource plan were reliable. Based on the results of this analysis, the following changes were made:

- Modified Stage 3 firm renewable proxy to two 8.14 MW units based on 2030 resource adequacy results
- Increased duration of paired and standalone BESS to 4 hours to match current market conditions
- Updated the Stage 3 RFP variable renewable proxy to reflect the current target, which was adjusted for the withdrawal of Kahana Solar.

In parallel, transmission and system security needs were identified. Based on the results of this analysis, the following changes were made:

- 2027: 60% grid-forming headroom capacity for dynamic stability
- 2045: reduce south Maui generation (Paeahu, Kamaole, Auwahi [rebuilt], renewable energy zone Group B) by 7 MW

Additional capital costs were identified to interconnect resources in the renewable energy zones selected in RESOLVE. While the REZ enablement costs were already included as part of the RESOLVE modeling, they are listed here in Table 8-31 for completeness alongside new network expansion costs.

The Status Quo scenario transmission network expansion costs reflect estimated transmission needed to expand capacity, as identified in the transmission needs analysis, to serve load growth because of electrification of transportation.

Table 8-31. Maui Transmission Capital Costs

Nominal Transmission Costs ($MM)	Base		Status Quo	
Years	REZ Enablement	Network Expansion	REZ Enablement	Network Expansion
2030	$50	$11	-	2
2035	$18	$89	-	22
2040	$14	$47	-	-
2045	$13	$131	-	68
2050	$15	$120	-	13

Table 8-32 presents a comparison of Maui Island Base scenario production costs with and without transmission constraints.

Table 8-32. Comparison of Maui Island Base Scenario Production Costs with and without Transmission Constraints

NPV ($MM)	With Transmission Constraints	Without Transmission Constraints
(2023–2050)	$2,229	$2,233

8.5 Moloka‘i

This section describes the results of the grid needs assessment for Moloka‘i through the multistep process that includes modeling capacity expansion, resource adequacy, operations of the system, transmission and system security needs, distribution needs, and iterations or adjustments made to determine the preferred plan.

8.5.1 Capacity Expansion Scenarios

The Base scenario, shown in Figure 8-36 and Figure 8-37, selects high levels of hybrid solar, allowing Moloka‘i to achieve 87% renewable energy by 2030. In the Base, High electricity demand, Low electricity demand, and Faster Technology Adoption scenarios, the types of resources selected by RESOLVE remain the same (hybrid solar and standalone BESS); only the quantity changes proportional to the growth of electricity demand. Existing fossil fuel–based resources are shown as firm renewable resources in 2050 because of their switch to biofuels in 2045. All scenarios achieve their RPS targets with consistent increases in utilization of renewable resources.

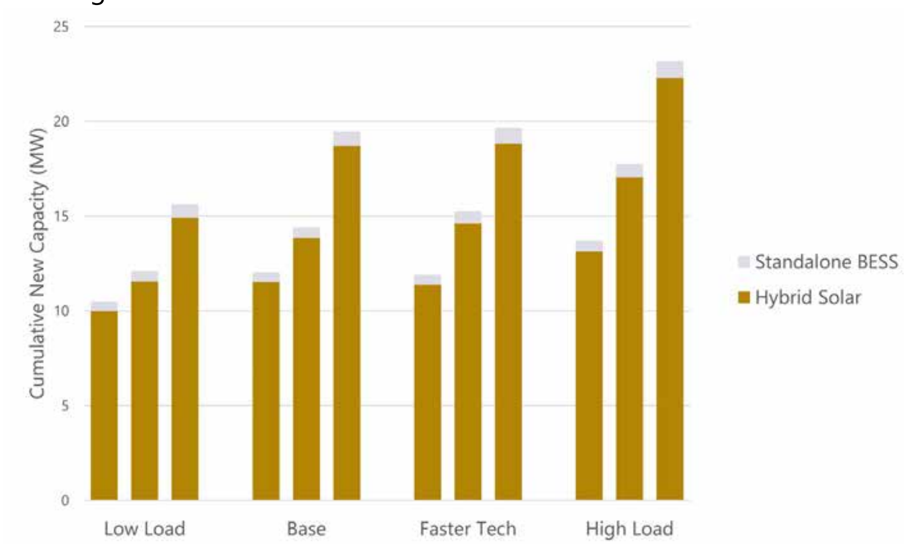


Figure 8-36. Moloka‘i: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

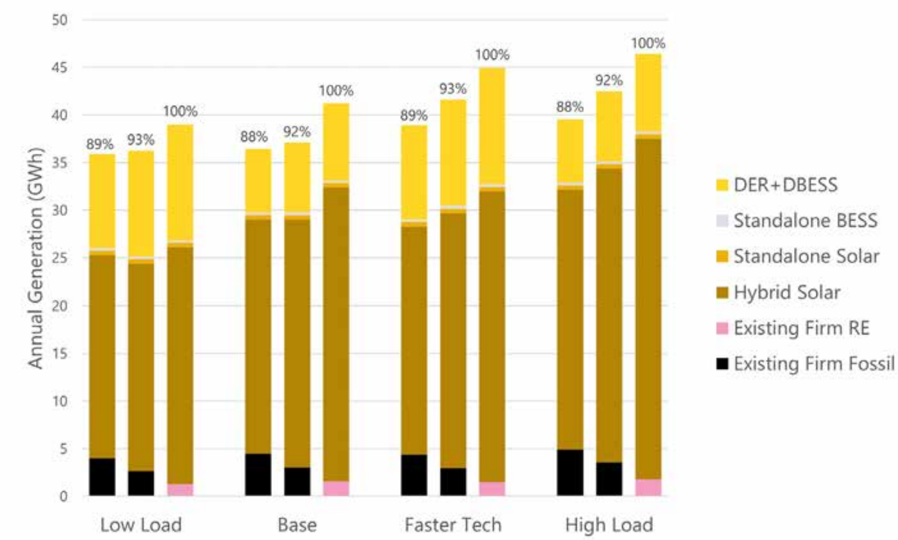


Figure 8-37. Moloka'i: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base, Low Load, High Load, and Faster Technology Adoption scenarios

High Fuel Retirement Optimization Scenario

In the High Fuel Retirement Optimization scenario, shown in Figure 8-38 and Figure 8-39, RESOLVE retires approximately 10.4 MW of existing thermal generation in 2030 and builds more hybrid solar than the Base plan.

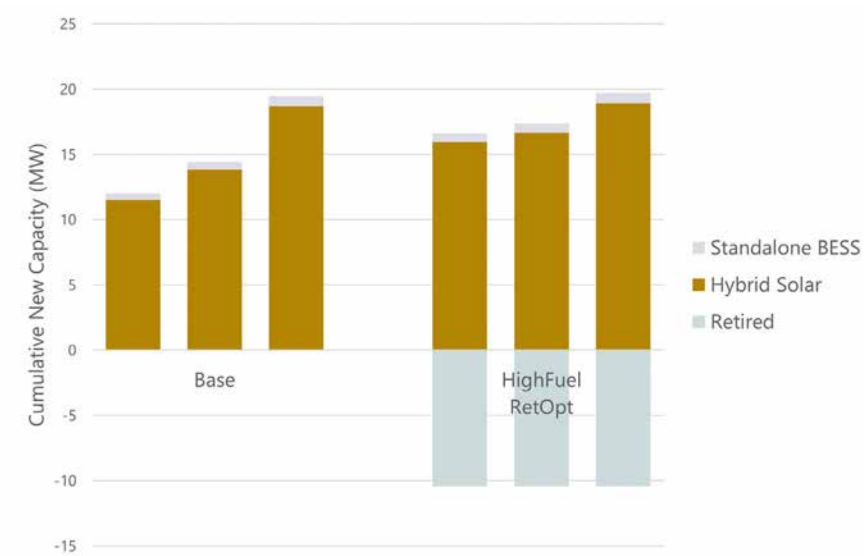


Figure 8-38. Moloka'i: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

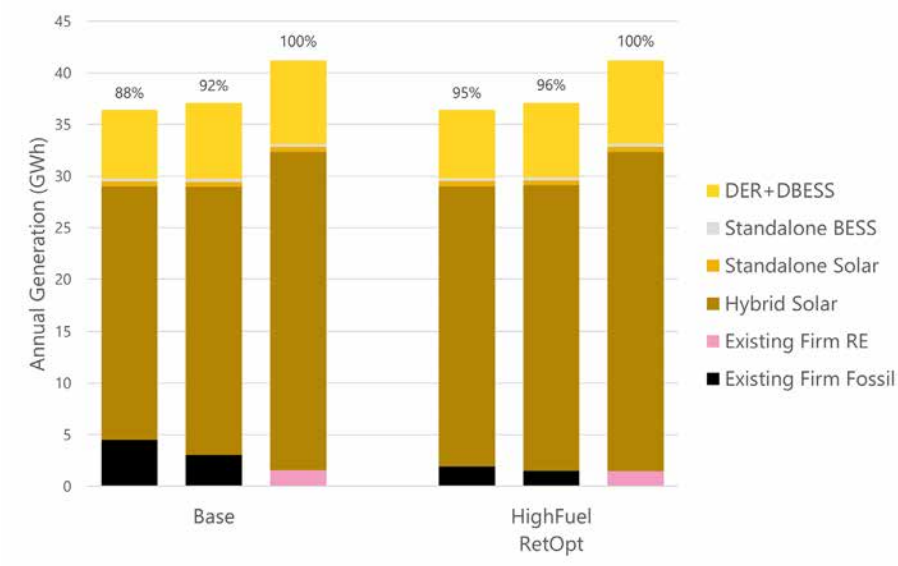


Figure 8-39. Moloka'i: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

8.5.2 Resource Adequacy

We did not make any retirement assumptions for Moloka'i; however, as more renewable resources are brought online, we will continue to assess resource adequacy and determine if system conditions warrant retiring existing fossil fuel–based generators.

Probabilistic Resource Adequacy Summary

The Base scenario, which assumed 15.18 MW of existing firm and 11.5 MW of future hybrid solar, showed a loss of load expectation of 0 days per year, meeting the targeted level of reliability. To create curves to illustrate the relationship between loss of load expectation and variable and firm capacity, different scenarios were run where one type of resource was held constant. In the variable resource sensitivity, the amount of firm capacity was held constant and in the firm resource sensitivity the variable resource was held constant.

The High Load scenario for these resource adequacy runs assumed the same amount of resources as the Base scenario except with a higher load. These runs still showed a loss of load expectation of 0 days per year across the board, meeting the targeted level of reliability. To create curves to illustrate the relationship between loss of load expectation and resource capacity, different scenarios were run where one type of resource was held constant. In the variable resource sensitivity, the amount of firm capacity was held constant and in the firm resource sensitivity the variable resource was held constant.

Table 8-33 presents a probabilistic resource adequacy analysis results summary for Moloka'i.

Table 8-33. Probabilistic Resource Adequacy Analysis: Results Summary, Moloka'i

Scenario	Existing Firm	New Firm	Stage 3 RFP	Future Wind	Future Hybrid Solar	Future Standalone BESS	LOLE	LOLEv	LOLH	EUE (GWh)	EUE (%)
Base 2030	15.18	0	0	0	11.5	0.5	0.00	0.00	0.00	0.00	0.00
Base no future RE 2035	15.18	0	0	0	0	0.5	0.00	0.00	0.00	0.00	0.00
High Load no future RE 2035	15.18	0	0	0	0	0.5	0.00	0.00	0.00	0.00	0.00

See Section 12 for more details on risks of the resource portfolio given uncertainties in procuring and acquiring the optimal mix of resources.

8.5.3 Grid Operations

The transition to 100% renewables will necessitate a change in how the thermal generators on our system operate. Scenarios with more renewable resources will use thermal generators less often. This is shown in the daily energy profiles and operational statistics in this section.

8.5.3.1 Status Quo Typical Operations

The Status Quo scenario does not include the hybrid solar and standalone energy storage from RESOLVE that is included in the Base scenario. Figure 8-40 and Figure 8-41 show the dispatch of the resources in a Status Quo resource plan in 2030 and 2035, respectively, for a few days with average load. With the decreased amount of hybrid solar and standalone storage, the Status Quo system still relies on existing firm units quite heavily. As shown in Figure 8-42 the load is almost completely served by the existing fossil-fuel units.

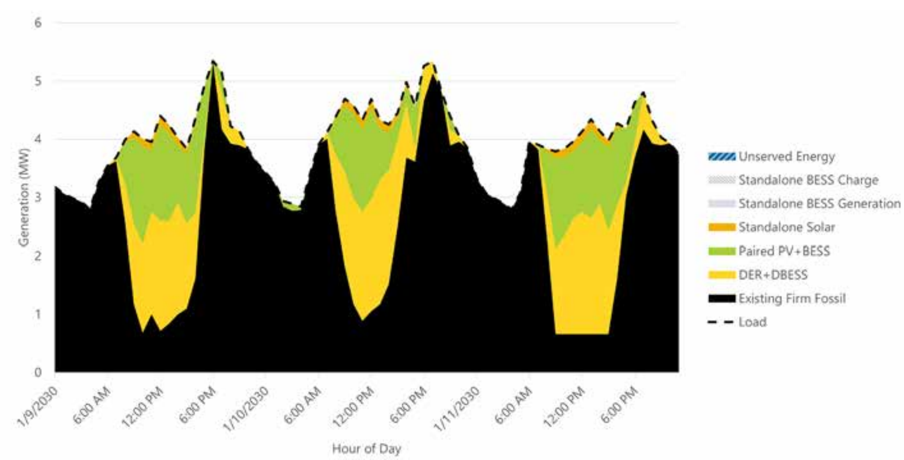


Figure 8-40. Moloka'i: detailed Status Quo energy profile, 2030 median load day (January 9–11, 2030)

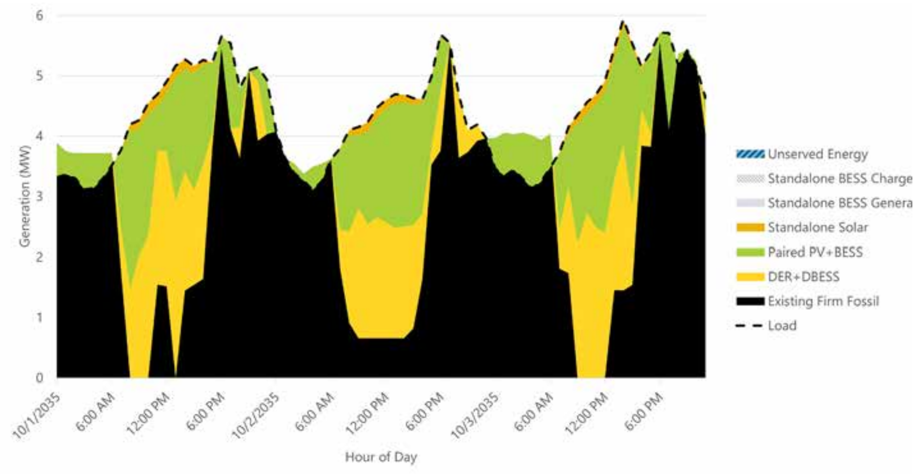


Figure 8-41. Moloka'i: detailed Status Quo energy profile, 2035 median load day (October 1–3, 2035)

8.5.3.2 Base Scenario Typical Operations

Figure 8-42 and Figure 8-43 show the dispatch of the resources in a Base scenario resource plan in 2030 and 2035, respectively, for a few days with average load. Compared to the Status Quo scenario above, the Base scenario shows a much lower reliance on the existing firm fossil units. By 2035 the system uses the existing firm fossil units much less than in the Status Quo scenario.

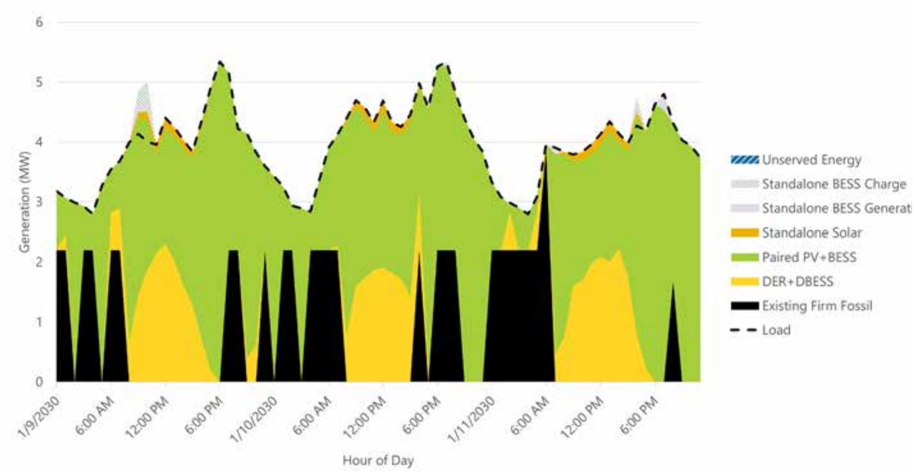


Figure 8-42. Moloka'i: detailed Base energy profile, 2030 median load day (January 9–11, 2030)

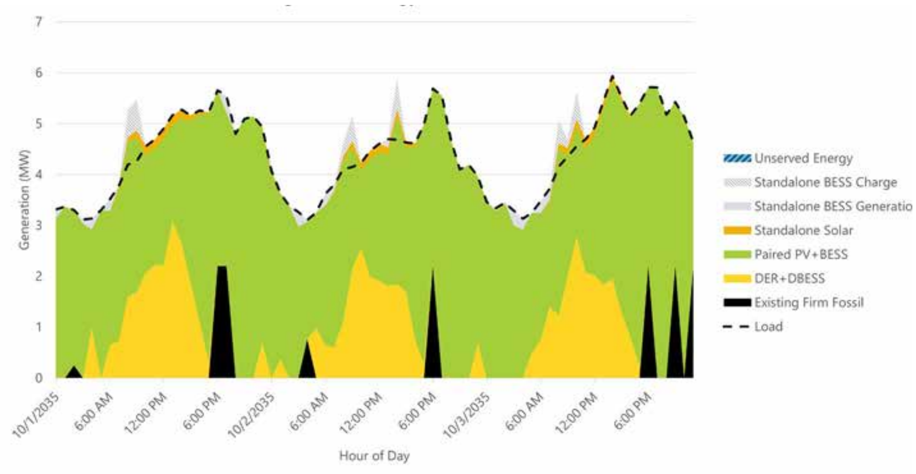


Figure 8-43. Moloka'i: detailed Base energy profile, 2035 median load day (October 1–3, 2035)

8.5.3.3 Operations of Firm Generation

Figure 8-44 and Figure 8-45 show thermal generators capacity factor and number of starts, respectively, for the 2030 and 2035 for Status Quo and Base scenarios. Without the hybrid solar and standalone storage included in the Base scenario, the system in the Status Quo scenario uses the baseloaded and peaking units a lot more, shown by the higher capacity factor of the baseload units increase over time with the load. However, because the Base scenario is less reliant on the firm units, the capacity factor for the baseload units decrease over time.

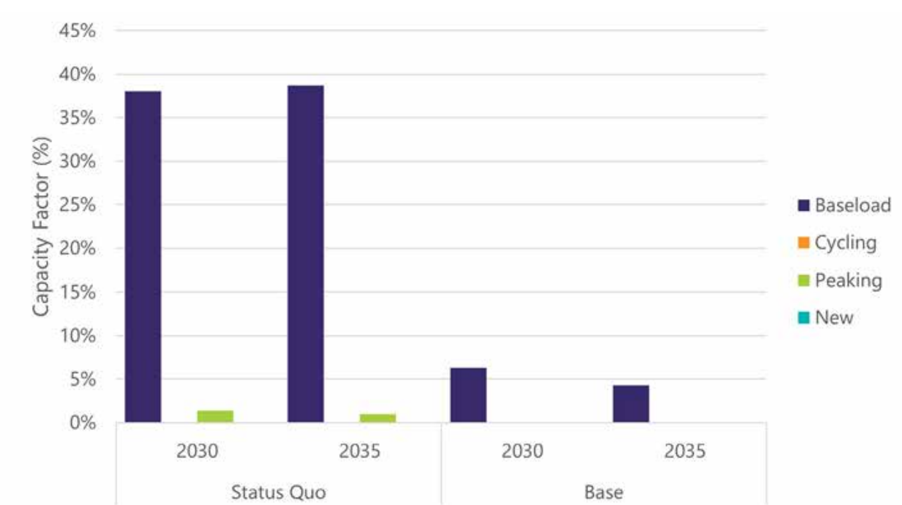


Figure 8-44. Moloka'i: utility-owned thermal generators capacity factor, 2030 and 2035 for Status Quo and Base scenario

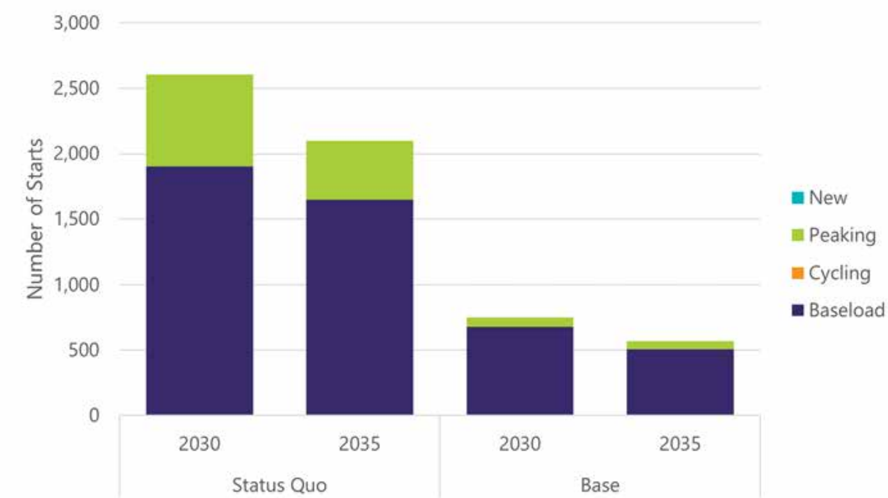


Figure 8-45. Moloka'i: utility-owned thermal generators number of starts, 2030 and 2035 for Status Quo and Base scenario

8.5.4 System Security Needs

Moloka'i does not have a transmission system, so our analysis did not evaluate the REZ concept; however, we performed a system stability analysis. We analyzed the Base scenario resource plan post-Stage 3 procurement and 2050. We also analyzed the High load resource plan for near-term years (i.e., between post-Stage 3 procurement and before 2040), which can be found in Appendix D. We analyzed selected years with major grid scale resource additions, including:

- Moloka'i system Base scenario resource plan: 2029, 2030, and 2050
- Moloka'i system High load scenario resource plan: 2029, 2030, and 2050

8.5.4.1 Summary of Base Scenario Resource Plan

We performed a system dynamic stability review with very low synchronous machine generation or no synchronous machine generation online. We evaluated system stability in the presence of a three-phase to ground fault with zero fault impedance for 2 seconds duration, or in the presence of a single phase to ground fault with 40-ohm fault impedance for 20 seconds duration.

We concluded that when powered by 100% grid-forming inverter-based resources the Moloka'i system exhibits acceptable stability performance in the years from 2030 to 2050; however, the system may experience diesel unit out-of-synchronism issues before 2030 when the system relies on the existing diesel units.

8.5.5 Distribution Needs

This section discusses distribution needs as they pertain to the grid needs assessment for Moloka'i.

8.5.5.1 Hosting Capacity Grid Needs

Of the eight circuits assessed on Moloka'i, most have sufficient DER hosting capacity or could accommodate the 5-year hosting capacity without infrastructure investments. The remaining circuits where infrastructure investments are required to increase hosting capacity to accommodate the forecasted distributed energy resources are identified as requiring grid needs. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-34.

Table 8-34. Moloka'i Hosting Capacity Grid Needs (Years 2021–2025)

Parameter (Nominal $)	Base DER Forecast	High DER Forecast	Low DER Forecast
Number of grid needs	3	5	3
Cost summary (wires solutions)	$1,260,000	$1,764,000	$1,260,000

A complete list of the hosting capacity grid needs can be found in the *Distribution DER Hosting Capacity Grid Needs* report.

8.5.5.2 Location-Based Grid Needs

Of the eight circuits and two substation transformers assessed on Moloka'i, all have sufficient capacity to accommodate the forecasted load demand. No grid needs are identified.

8.5.5.3 Distribution Grid Needs Summary

The minimum number of grid needs identified (i.e., minimum wires solutions) by scenario by island is shown in Table 8-35 below. This includes both hosting capacity and location-based grid needs.

Table 8-35. Moloka'i Minimum Grid Needs Solutions Identified (Years 2023–2030)

Island (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	3	3	5	5
Cost summary (wires solutions)	$1,260,000	$1,764,000	$1,260,000	$1,260,000

8.5.5.4 NWA Opportunities

No NWA opportunities are identified for Moloka'i.

8.5.6 Preferred Plan

The capacity expansion modeling conducted in RESOLVE was the starting point for identifying grid needs and developing a resource plan. Battery duration was increased to 4 hours to match current market conditions. We then performed probabilistic resource adequacy analyses to confirm that the portfolio of resources selected in the resource plan were reliable. No additional system constraints or transmission costs were identified.

8.6 Lānaʻi

This section describes the results of the grid needs assessment for Lānaʻi through the multistep process that includes modeling capacity expansion, resource adequacy, operations of the system, transmission and system security needs, distribution needs, and iterations or adjustments made to determine the preferred plan.

8.6.1 Capacity Expansion Scenarios

The Lānaʻi CBRE request for proposal targeting 35.8 GWh of variable renewable energy, which translates to approximately 16 MW hybrid solar, will bring Lānaʻi to nearly 100% renewable portfolio standard. There could be an additional 5 MW hybrid solar (Base scenario) by 2030 and remain cost-effective. The CBRE request for proposal may also allow for deactivation of fossil fuel–based generation.

Similar amounts of hybrid solar and standalone BESS are selected across the different scenarios in addition to the 16 MW hybrid solar modeled for the CBRE request for proposal.

There is uncertainty surrounding the resorts, which represents nearly 50% of Lānaʻi's load today. The CBRE request for proposal may be oversized if the resorts exit the grid. The hybrid solar proxy resource for the CBRE request for proposal was removed in the No Resorts scenario. The model was allowed to re-optimize and selected approximately 10 MW hybrid solar, a smaller amount than the CBRE request for proposal target.

Figure 8-46 shows cumulative new capacity and Figure 8-47 shows annual generation and renewable portfolio standards for Lānaʻi.

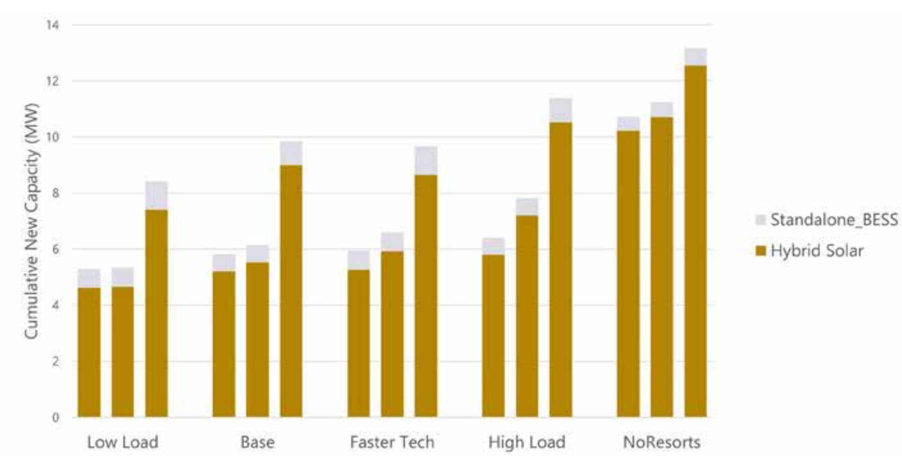


Figure 8-46. Lānaʻi: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, Low Load, High Load, Faster Technology Adoption, and No Resorts scenarios

Lānaʻi achieves nearly 100% renewable portfolio standard with the CBRE request for proposal and additional hybrid solar selected by RESOLVE. The existing fossil fuel–powered firm generation is converted to 100% biofuel by 2045.

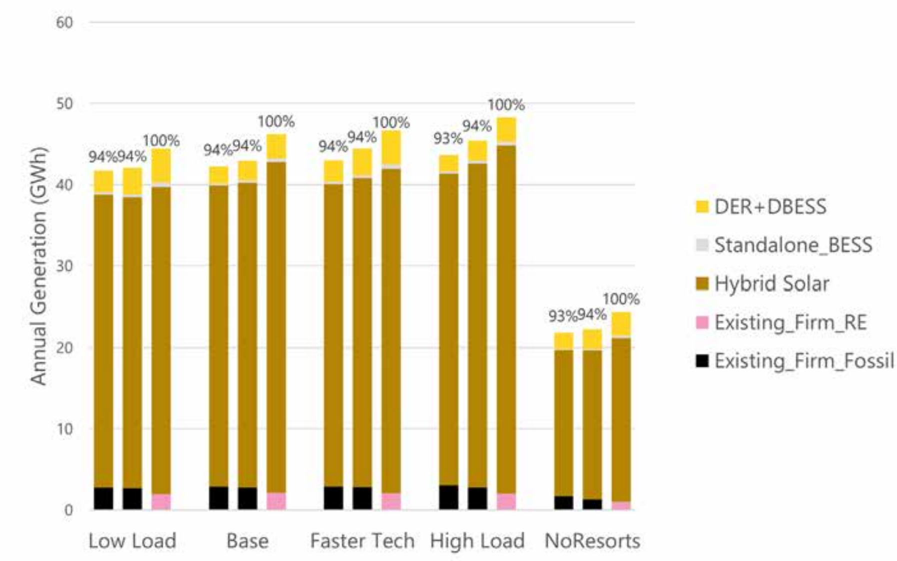


Figure 8-47. Lāna'i: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base, Low Load, High Load, Faster Technology Adoption, and No Resorts scenarios

8.6.1.1 High Fuel Retirement Optimization Scenario

The High Fuel Retirement Optimization scenario retired 5 MW of existing fossil fuel–based generation upfront in 2030. Because RESOLVE performs a linear optimization, the additional retirements may consist of partial unit retirements. RESOLVE builds hybrid solar to replace the retired capacity. RESOLVE builds 0.3 MW biofuel-based generation by 2050. Figure 8-48 shows cumulative new capacity and Figure 8-49 shows annual generation and renewable portfolio standards for Lāna'i.

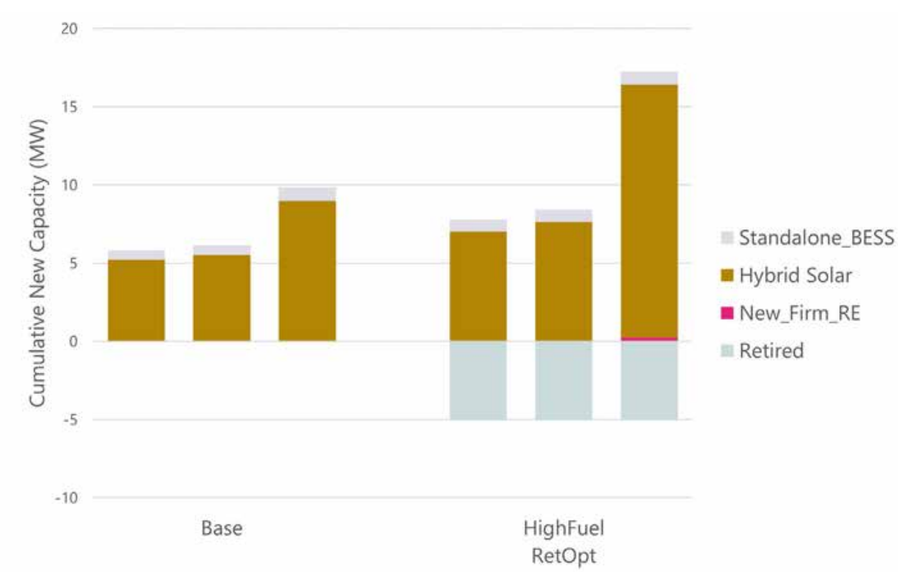


Figure 8-48. Lāna'i: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

Although 5 MW of existing fossil fuel–based generation is removed in the High Fuel Retirement Optimization scenario, the annual generation is similar between the Base and High Fuel scenarios.

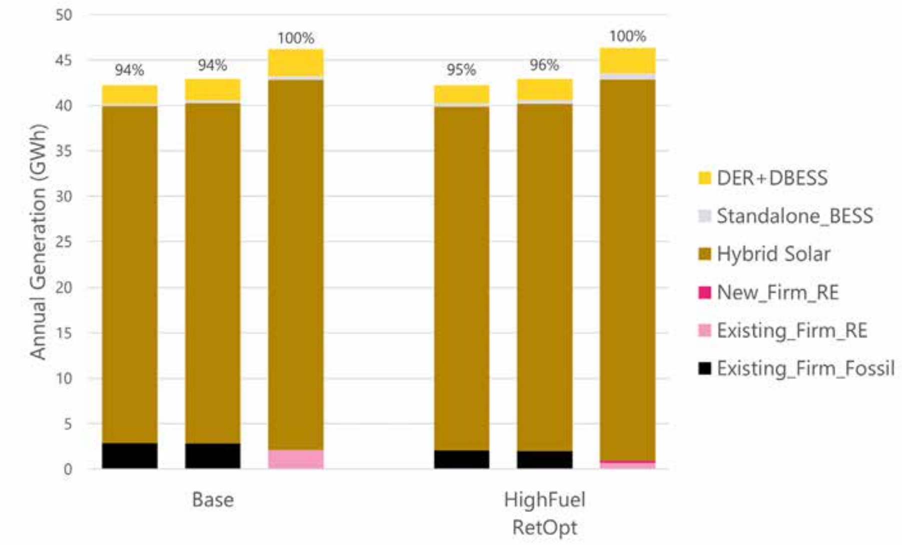


Figure 8-49. Lānaʻi: annual generation and RPS from resources in 2030, 2035, and 2050 for the Base and High Fuel Retirement Optimization scenarios

8.6.2 Resource Adequacy

We did not make any retirement assumptions for Lānaʻi; however, as more renewable resources are brought online, we will continue to assess resource adequacy and determine if system conditions warrant retiring existing fossil fuel–based generators.

Probabilistic Resource Adequacy Summary

The Base resource plan in 2030 includes 10 MW existing firm, 16 MW hybrid solar for the CBRE request for proposal, 5 MW future hybrid solar, and 0.6 MW standalone BESS. The loss of load expectation is 0 days per year and no unserved energy is observed in the 250 samples.

For the 2035 outlook, we analyzed the High Load scenario. The High Electricity demand resource plan in 2035 includes 10 MW existing firm, 16 MW hybrid solar for the CBRE request for proposal, 7 MW future hybrid solar, and 0.6 MW standalone BESS. The loss of load expectation is 0 days per year and no unserved energy is observed in the 250 samples.

Table 8-36 presents a probabilistic resource adequacy analysis results summary for Lānaʻi.

Table 8-36. Probabilistic Resource Adequacy Analysis: Results Summary, Lānaʻi

Scenario	Existing Firm	New Firm	CBRE RFP	Future Wind	Future Hybrid Solar	Future Standalone BESS	LOLE	LOLEv	LOLH	EUE (GWh)	EUE (%)
Base: 2030	10	0	16	0	5.2	0.6	0	0	0	0	0
Base: 2035	10	0	16	0	5.5	0.6	0	0	0	0	0
High: 2035	10	0	16	0	7.2	0.6	0	0	0	0	0

See Section 12 for more details on risks of the resource portfolio given uncertainties in procuring and acquiring the optimal mix of resources.

8.6.3 Grid Operations

The transition to 100% renewables will necessitate a change in how the thermal generators on our system operate. Scenarios with more renewable resources will use thermal generators less often. This is shown in the daily energy profiles and operational statistics in this section.

8.6.3.1 Status Quo Typical Operations

The Status Quo resource plan includes the existing fossil fuel–based generation and a proxy resource for the 17.5 MW hybrid solar project selected through the CBRE RFP. There are no additional future resources.

Figure 8-50 and Figure 8-51 show the dispatch of the resources in the Status Quo resource plan in 2030 and 2035, respectively, for a few days with average load. The load is carried primarily by hybrid solar and BESS. Fossil fuel–based generation is dispatched during the evening and can be dispatched during the day when there is insufficient solar.

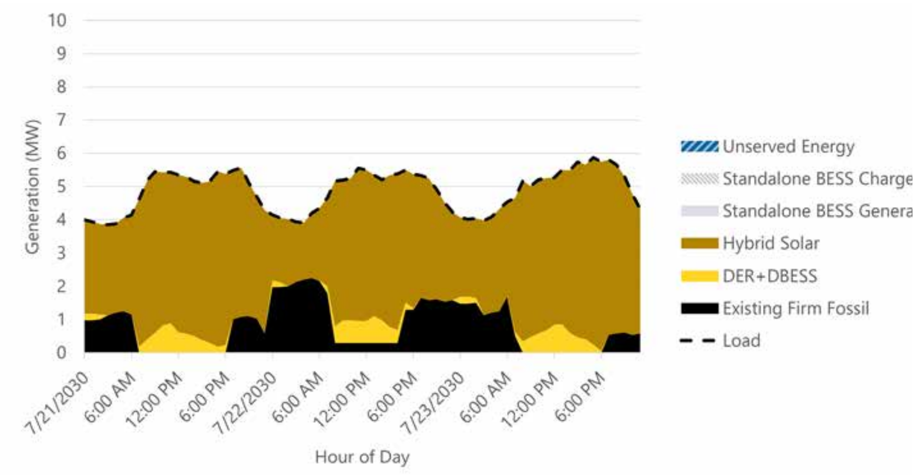


Figure 8-50. Lānaʻi: detailed Status Quo energy profile, 2030 median load day (July 21–23, 2030)

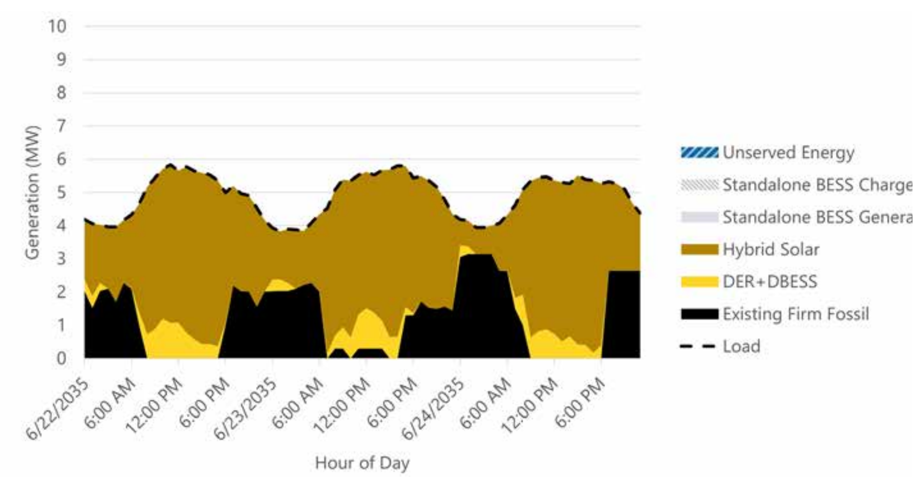


Figure 8-51. Lānaʻi: detailed Status Quo energy profile, 2035 median load day (June 22–24, 2035)

8.6.3.2 Base Scenario Typical Operations

The Base resource plan includes the existing fossil fuel–based generation, the CBRE request for proposal, and additional future resources selected by RESOLVE.

Figure 8-52 and Figure 8-53 show the dispatch of the resources in the Base resource plan in 2030 and 2035, respectively, for a few days with average load. The additional future resources selected by RESOLVE displace almost all of the fossil fuel–based generation seen above for the Status Quo scenario. Fossil fuel–based generation is mostly dispatched at night.

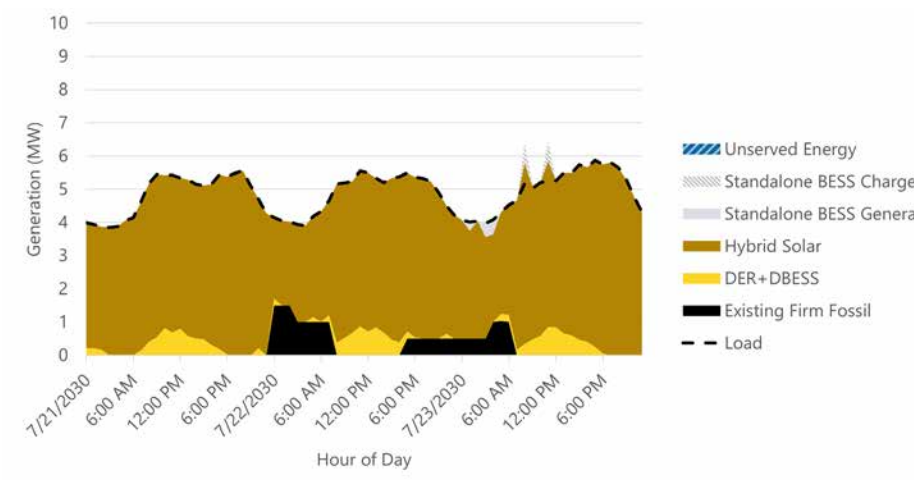


Figure 8-52. Lāna'i: detailed Base energy profile, 2030 median load day (July 21–23, 2030)

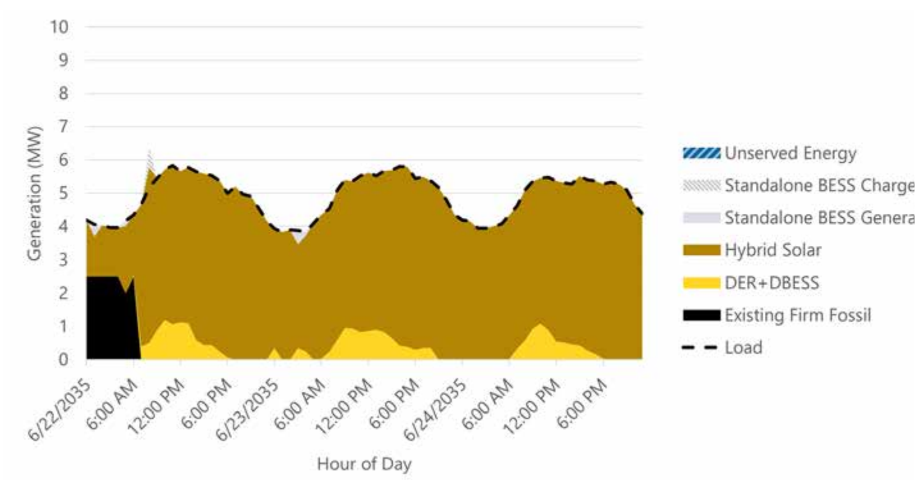


Figure 8-53. Lāna'i: detailed Base energy profile, 2035 median load day (June 22–24, 2035)

8.6.3.3 Operations of Firm Generation

Figure 8-54 and Figure 8-55 show the number of generator starts and the generator capacity factor in 2030 and 2035 for the Status Quo and Base scenarios. Fossil fuel–based generation is dispatched significantly less in the Base scenario compared to Status Quo.

Figure 8-54. Lānaʻi: thermal generators number of starts, 2030 and 2035 for Status Quo and Base scenario

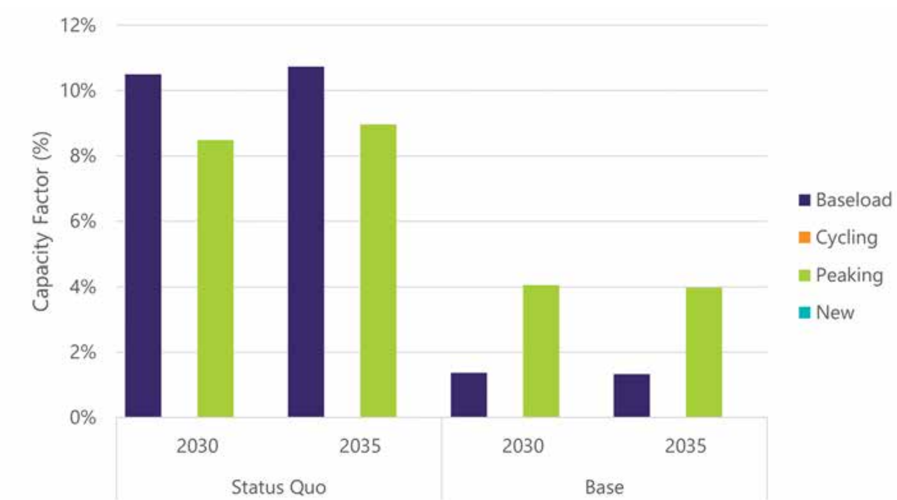


Figure 8-55. Lānaʻi: thermal generators capacity factor, 2030 and 2035 for Status Quo and Base scenario

8.6.4 System Security Needs

Lānaʻi does not have a transmission system, so our analysis did not evaluate the REZ concept; however, we performed a system stability analysis. We analyzed the Base scenario resource plan post-Stage 3 procurement and 2050. We also analyzed the High load resource plan for near-term years (i.e., between post-Stage 3 and before 2040), which can be found in Appendix D. We analyzed selected years with major grid scale resource additions, including:

- Lānaʻi system Base scenario resource plan: 2029 and 2050
- Lānaʻi system High load scenario resource plan: 2029 and 2050
- Lānaʻi system No Resort scenario resource plan: 2029, 2030, and 2050

8.6.4.1 Summary of Base Resource Plan

For Lānaʻi, we performed a system dynamic stability review with very low synchronous machine generation or no synchronous machine generation online. We evaluated system stability in the presence of a three-phase to ground fault with zero fault impedance for 2 seconds duration, or in the presence of a single phase to ground fault with 40-ohm fault impedance for 20 seconds duration.

We concluded that when powered by 100% grid-forming inverter-based resources the Lāna'i system in the scenario without resort load, exhibits acceptable system stability performance in the years from 2030 to 2050. The system may exhibit diesel unit out-of-synchronism before 2029 when the system relies on the exisitng diesel units. In the scenario with the resort load, the system has a large grid-forming inverter-based resource (with 15.8 MW capcity). In this scenario, the system survives both the 2 seconds duration three-phase to ground fault and the 20 seconds high impedance single phase to ground fault.

8.6.5 Distribution Needs

This section discusses distribution needs as they pertain to the grid needs assessment for Lāna'i.

8.6.5.1 Hosting Capacity Grid Needs

Of the three circuits assessed on Lāna'i, two have insufficient DER hosting capacity to accommodate the 5-year hosting capacity without infrastructure investments and require grid needs. Infrastructure investments or distribution upgrades (i.e., wires solutions) to mitigate the grid needs are identified with cost estimates. The grid needs and solutions are summarized in Table 8-37.

Table 8-37. Lāna'i Hosting Capacity Grid Needs (Years 2021–2025)

Parameter (Nominal $)	Base DER Forecast	High DER Forecast	Low DER Forecast
Number of grid needs	2	2	2
Cost summary (wires solutions)	$504,000	$504,000	$504,000

A complete list of the hosting capacity grid needs can be found in the *Distribution DER Hosting Capacity Grid Needs* report.

8.6.5.2 Location-Based Grid Needs

Of the three circuits and one substation transformer assessed on Lāna'i, all have sufficient capacity to accommodate the forecasted load demand. No grid needs are identified.

8.6.5.3 Distribution Grid Needs Summary

The minimum number of grid needs identified (i.e., minimum wires solutions) by scenario by island is shown in Table 8-38. This includes both hosting capacity and location-based grid needs.

Table 8-38. Lāna'i Minimum Grid Needs Solutions Identified (Years 2023–2030)

Island (Nominal $)	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Faster Technology Adoption)
Number of grid needs	2	2	2	2
Cost summary (wires solutions)	$504,000	$504,000	$504,000	$504,000

8.6.5.4 NWA Opportunities

No NWA opportunities are identified for Lānaʻi.

8.6.6 Preferred Plan

The capacity expansion modeling conducted in RESOLVE was the starting point for identifying grid needs and developing a resource plan. Battery duration was increased to 4 hours to match current market conditions. We then performed probabilistic resource adequacy analyses to confirm that the portfolio of resources selected in the resource plan were reliable. No additional system constraints or transmission costs were identified.

9. Customer Impacts

In Section 8, we conducted a grid needs assessment to determine the optimal, Preferred Plans that meet reliability standards while achieving 100% renewable energy by 2045. In this section we examine the financial and environmental impacts to customers of those Preferred Plans by assessing bill impacts and carbon emissions.

Customers continue to stress the importance of affordability, and the State has set ambitious decarbonization targets to achieve economy-wide 50% carbon emissions reduction by 2030 and net negative carbon emissions reductions by 2045 compared to 2005 levels. We found that our Preferred Plans stabilize electric bills and rates and reduce emissions for the good of the environment. Under the Preferred Plans, bills are relatively flat (and in some cases lower) over the long term despite increasing revenue requirements that are needed to enable the grid to integrate more renewables and electrify the transportation sector.

Our ambitious Preferred Plans also have the potential to reduce carbon emissions by 75% in 2030 compared to 2005 levels. However, in 2030 in a Land-Constrained scenario, carbon emissions are nearly two times the Base Preferred Plan. By 2045, our Preferred Plans achieve 94% carbon emissions reductions; achieving net zero will require natural carbon sinks or advancements in negative emissions technologies. Electrification of transportation results in significant carbon reductions through 2050.

9.1 Financial and Bill Analysis

This section provides the financial analyses of the Integrated Grid Plan. It presents the strategies needed to swiftly decarbonize the electric grid and manage risks to affordability, resilience, and reliability and each island's residential customer electricity rate and bill impacts for the Preferred Plans compared to the Status Quo. These analyses should not be used as precise long-term projections of customer rates. The value of these projections is not in the precise values but in the relative results of planning to inform a Preferred Plan. Actual values could vary significantly with changes in assumptions including resource costs, detailed engineering, new renewable technologies, fuel prices, energy efficiency, tax policy, fiscal policy, and other factors.

The following information is provided by island:

- Revenue requirements
- Capital expenditures
- Residential customer bill and rate impacts

9.1.1 Revenue Requirements

The revenue requirement calculations include the investments needed to create a modern and resilient grid for our Preferred Plans and Status Quo scenarios. The calculations include operating and maintenance costs, taxes other than income, and return on existing and future utility asset investments.

Although revenue requirements will increase in the transition to clean energy, they will be lower than if we continue to supply the grid with fossil fuel–based generation.

If land for renewable projects is more limited in the future, we will need to consider higher-cost alternatives. If low-cost renewables are not available in sufficient quantities such as in the Land-Constrained scenario, higher-cost alternatives such as increased use of biofuels will need to be considered to meet decarbonization goals.

9.1.2 Capital Expenditures

Capital expenditure projections in distribution upgrades, expanding or creating new transmission interconnection points between renewable projects, improving the resilience of the transmission and distribution grid, and all other utility capital expenditures (referred to as "balance-of-utility business capital expenditures") are included in the analysis.

- Distribution upgrades are needed to support electrification and expansion of private rooftop solar hosting capacity, and support expanded distribution capacity for new housing and commercial developments.[34]
- Transmission network expansion and infrastructure to enable renewable energy zones are needed to create hubs and enabling transmission facilities for large-scale projects that will streamline interconnection and provide access to untapped renewable potential and growth in electrified loads.
- Resilience grid investments are needed to prepare the grid to withstand natural disasters and support deploying microgrids. This also includes the complete rollout of advanced metering infrastructure of phase 2 grid modernization to enhance system reliability and resilience. The capital expenditures for these two programs assume that we will receive funding through IIJA to offset the program costs.
- Balance-of-utility capital expenditures represent all other utility investments.

9.1.3 Residential Customer Bill and Rate Impacts

The residential customer bill and rate impacts uses the Annual Revenue Adjustment (ARA) approach, illustrating the bill impact of incremental Integrated Grid Plan revenue requirement costs and savings through the Energy Cost Recovery Clause (ECRC), Purchased Power Adjustment Clause (PPAC), and Revenue Balancing Account (RBA) rates. These terms are defined below:

- ARA is an annual adjustment to target revenues based on an ARA formula.
- ECRC includes the cost for utility fuel and purchased energy from independent power producers.
- PPAC includes the payments for capacity and operation and maintenance, and lump-sum payments, to independent power producers.
- RBA, among other items, includes decoupling, the ARA, and the Extraordinary Project Recovery Mechanism (EPRM).

The overall impact on a residential customer's bill is the combination of usage and rates. Residential customer rates were modeled using existing customer and non-fuel energy charges, the ECRC revenue requirement allocated across projected kWh sales, the PPAC revenue requirement for residential allocated across projected residential

[34] We note that while the transmission needs analysis evaluated infrastructure needed to support electrification through 2050, the distribution needs analysis did not evaluate infrastructure required to support electrification beyond 2030.

kWh sales, and the RBA revenue requirement divided by the sum of base and PPAC revenue, to be applied as a percentage to the customer's base and PPAC charges in this illustration. Over the planning period, residential kWh sales are projected to increase as a result of electrification of transportation. As a result of increasing revenue requirement in combination with increasing sales, residential customer bills and rates are projected to remain relatively flat over the planning period, demonstrating the benefits of electrification of the transportation sector.

9.2 Oʻahu Financial Impacts

The data and analyses presented in this section cover the O'ahu service territory and customers. For O'ahu, the Base Preferred Plan shows the lowest overall revenue requirements over the 2023 to 2050 planning period.

9.2.1 Revenue Requirements

Table 9-1 shows the net present value (NPV) of the annual revenue requirements for the Base and Land-Constrained Preferred Plan and Status Quo scenarios.

Table 9-1. Net Present Value of Revenue Requirement

NPV of Revenue Requirement ($000)	($000)	% Increase from Lowest-Cost Scenario
Base scenario	$29,397,330	-
Status Quo scenario	$33,886,081	15%
Land-Constrained scenario	$30,357,218	3%

Figure 9-1 illustrates the annual revenue requirements in nominal dollars for all three scenarios.

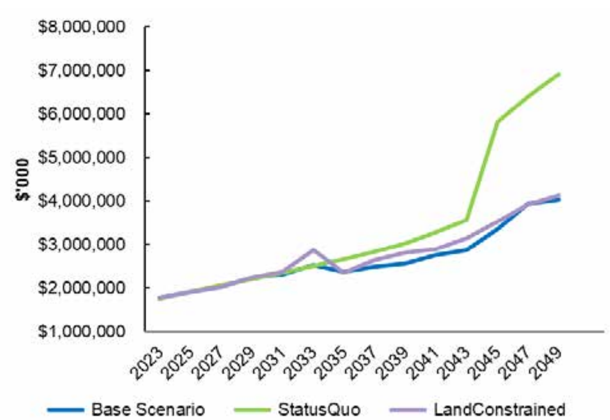


Figure 9-1. O'ahu: comparison of revenue requirement (nominal $)

9.2.2 Capital Expenditure Projections

Table 9-2, Table 9-3, and Table 9-4 summarize the capital expenditures identified in the Base Preferred Plan, Status Quo and Land-Constrained Preferred Plan, respectively.

Table 9-2. Capital Expenditures (Nominal $): Base Scenario Preferred Plan

('000)	2023–25	2026–30	2031–35	2036–40	2041–45	2046–50	Total
Distribution upgrades	$12,527	$39,278	$0	$0	$0	$0	$51,805
Transmission interconnection	$22,794	$1,032,990	$62,456	$798,919	$5,723,323	$2,129,656	$9,770,138
Resilience [a]	$12,768	$36,831	$0	$0	$0	$0	$49,599
Grid mod phase 2 [a]	$14,501	$11,965	$0	$0	$0	$0	$26,466
Balance-of-utility business	$622,756	$914,143	$924,602	$1,032,996	$1,052,278	$1,156,684	$5,703,458
Total	$685,346	$2,035,207	$987,058	$1,831,915	$6,775,601	$3,286,340	$15,601,466

a. Final costs to be submitted in a forthcoming application.

Table 9-3. Capital Expenditures (Nominal $): Status Quo Scenario

('000)	2023–25	2026–30	2031–35	2036–40	2041–45	2046–50	Total
Distribution upgrades	$12,527	$39,278	$0	$0	$0	$0	$51,805
Transmission interconnection	$0	$0	$0	$0	$528,500	$293,100	$821,600
Resilience [a]	$12,768	$36,831	$0	$0	$0	$0	$49,599
Grid mod phase 2 [a]	$14,501	$11,965	$0	$0	$0	$0	$26,466
Balance-of-utility business	$630,153	$1,015,547	$1,105,691	$1,091,971	$1,124,389	$1,191,265	$6,159,017
Total	$669,949	$1,103,621	$1,105,691	$1,091,971	$1,652,889	$1,484,365	$7,108,487

a. Final costs to be submitted in a forthcoming application.

Table 9-4. Capital Expenditures (Nominal $): Land-Constrained Scenario Preferred Plan

('000)	2023–25	2026–30	2031–35	2036–40	2041–45	2046–50	Total
Distribution upgrades	$12,527	$39,278	$0	$0	$0	$0	$51,805
Transmission interconnection	$0	$0	$62,456	$0	$1,990,600	$293,100	$2,346,156
Resilience [a]	$12,768	$36,831	$0	$0	$0	$0	$49,599
Grid mod phase 2 [a]	$14,501	$11,965	$0	$0	$0	$0	$26,466
Balance-of-utility business	$622,756	$914,143	$924,602	$1,032,996	$1,052,278	$1,156,684	$5,703,458
Total	$662,552	$1,002,217	$987,058	$1,032,996	$3,042,878	$1,449,784	$8,177,484

a. Final costs to be submitted in a forthcoming application.

9.2.3 Residential Customer Bill and Rate Impacts

As a result of an increasing revenue requirement in combination with increasing sales because of electrification, residential customer rates and bills are projected to remain relatively flat during the planning period for all scenarios, demonstrating the benefits of electrification of the transportation sector.

Table 9-5 shows the average annual residential bill increases for all scenarios; however, the smallest increase occurs in the Base Preferred Plan scenario. The bill increase in the Land-Constrained Preferred Plan is also less than the increase in the Status Quo scenario.

Table 9-5. Average Annual Residential Bill Increases

Average Annual Bill Increase (2023–2050)	Nominal $
Base scenario	1.28%
Status Quo scenario	3.70%
Land-Constrained scenario	1.32%

Figure 9-2 illustrates the residential customer bill impact in nominal dollars for a typical 500 kWh bill for the three scenarios.

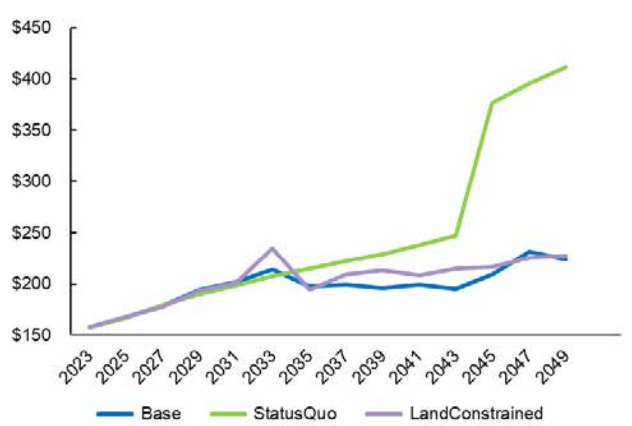


Figure 9-2. O'ahu: typical monthly residential bill (nominal $)

Figure 9-3 illustrates the residential customer rates nominal dollars for the three scenarios.

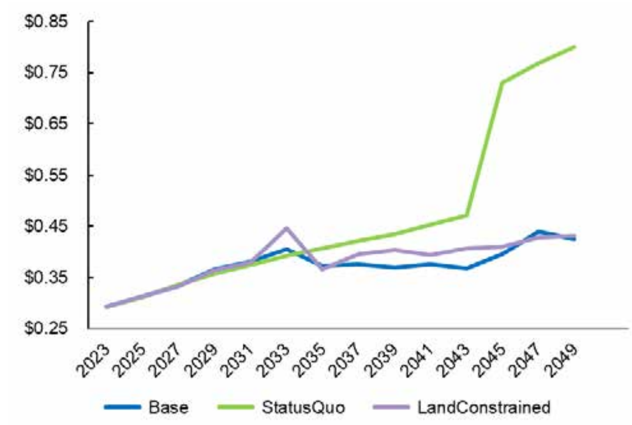


Figure 9-3. O'ahu: residential rates (nominal $)

Figure 9-4, Figure 9-5, and Figure 9-6 illustrate the cost components to residential customer rates in nominal dollars for the Base Preferred Plan, Status Quo, and Land-Constrained Preferred Plan, respectively. The ECRC component of residential rates makes up a larger portion of the total rate in the Status Quo and Land-Constrained scenarios compared to the Base Preferred Plan, and therefore has higher exposure to rate volatility because of fuel prices. In the Base Preferred Plan scenario, PPAC increases while ECRC declines because of the increase in fixed-cost PPAs for hybrid solar, wind, and energy storage, and less dependency on fuel-based generation and energy-based PPAs. The Base Preferred Plan scenario RBA component increases because of the investment needed in transmission and distribution infrastructure to enable renewables and electrification.

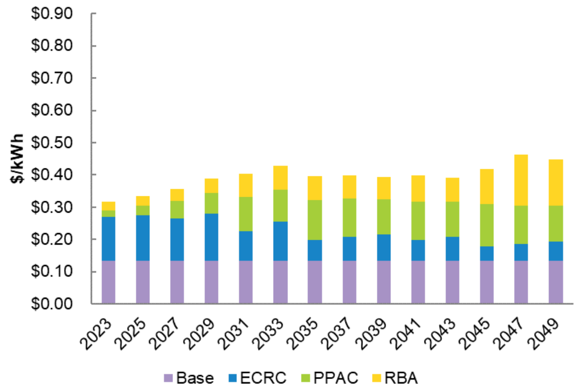


Figure 9-4. O'ahu: cost components to residential rates, Base scenario (nominal $)

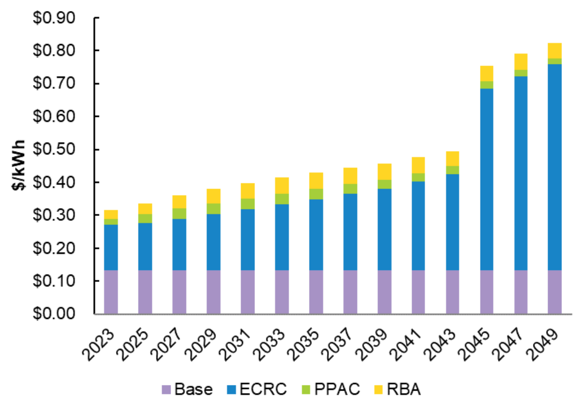


Figure 9-5. O'ahu: cost components to residential rates, Status Quo scenario (nominal $)

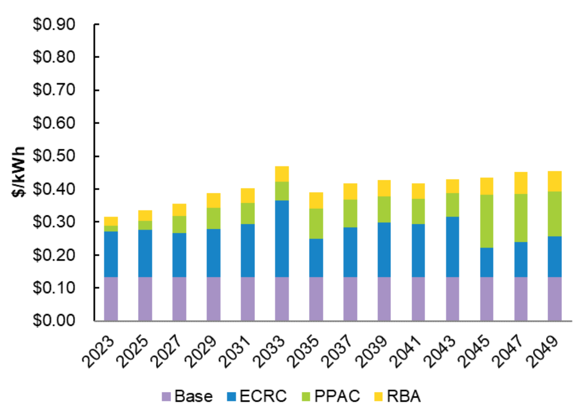


Figure 9-6. O'ahu: cost components to residential rates, Land-Constrained scenario (nominal $)

9.3 Hawai'i Island Financial Impacts

The data and analyses presented in this section cover the Hawai'i Island service territory and customers. For Hawai'i Island, the Base Preferred Plan shows the lowest overall revenue requirements over the 2023 to 2050 planning period.

9.3.1 Revenue Requirements

Table 9-6 shows the NPV of the annual revenue requirements for the Base Preferred Plan and Status Quo scenarios.

Table 9-6. Net Present Value of Revenue Requirement

NPV of Revenue Requirement ($000)	($000)	% Increase from Lowest-Cost Scenario
Base scenario	$4,683,848	-
Status Quo scenario	$5,596,654	19%

Figure 9-7 illustrates the annual revenue requirements in nominal dollars for the two scenarios.

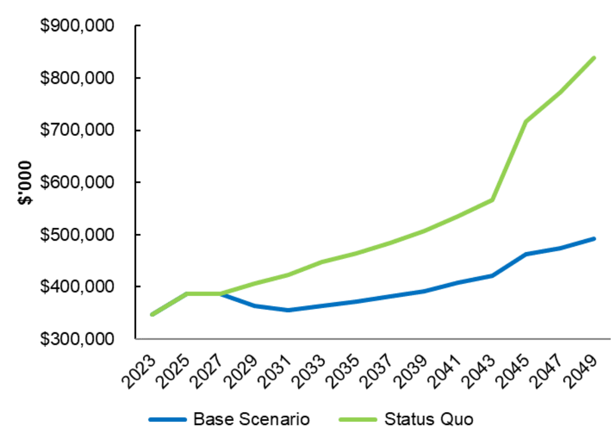


Figure 9-7. Hawai'i Island: comparison of revenue requirement (nominal $)

9.3.2 Capital Expenditure Projections

Table 9-7 and Table 9-8 summarize the capital expenditures identified in Status Quo and Preferred Plan, by category.

Table 9-7. Capital Expenditures (Nominal $): Base Scenario

('000)	2023–25	2026–30	2031–35	2036–40	2041–45	2046–50	Total
Distribution upgrades	$3,310	$0	$0	$0	$0	$0	$3,310
Transmission interconnection	$9,002	$36,010	$3,230	$24,158	$0	$25,848	$98,248
Resilience [a]	$4,401	$12,052	$0	$0	$0	$0	$16,453
Grid mod phase 2 [a]	$2,887	$12,563	$0	$0	$0	$0	$15,450
Balance-of-utility business	$134,806	$226,859	$250,420	$276,484	$305,261	$337,032	$1,530,863
Total	$154,407	$287,484	$253,650	$300,642	$305,261	$362,880	$1,664,324

a. Final costs to be submitted in a forthcoming application.

Table 9-8. Capital Expenditures (Nominal $): Status Quo Scenario

('000)	2023–25	2026–30	2031–35	2036–40	2041–45	2046–50	Total
Distribution upgrades	$3,310	$0	$0	$0	$0	$0	$3,310
Transmission interconnection	$0	$77,026	$19,257	$0	$0	$0	$96,283
Resilience [a]	$4,401	$12,052	$0	$0	$0	$0	$16,453
Grid mod phase 2 [a]	$2,887	$12,563	$0	$0	$0	$0	$15,450
Balance-of-utility business	$134,806	$226,859	$250,420	$276,484	$305,261	$337,032	$1,530,863
Total	$145,404	$328,500	$269,677	$276,484	$305,261	$337,032	$1,662,359

a. Final costs to be submitted in a forthcoming application.

9.3.3 Residential Customer Bill and Rate Impacts

As a result of an increasing revenue requirement in combination with increasing sales because of electrification, residential customer rates and bills are projected to remain relatively flat during the planning period for the Base Preferred Plan, demonstrating the benefits of electrification of the transportation sector. This is especially true on Hawaiʻi Island in 2045 and beyond where, despite an increase in revenue requirement, electric bills decrease.

Table 9-9 shows the average annual residential bill increase in the Status Quo scenario and decrease in the Base Preferred Plan.

Table 9-9. Average Annual Residential Bill Increases

Average Annual Bill Increase (2023–2050)	Nominal $
Base scenario	(0.09)%
Status Quo scenario	2.15%

Figure 9-8 illustrates the residential customer bill impact in nominal dollars for a typical 500 kWh bill for the two scenarios.

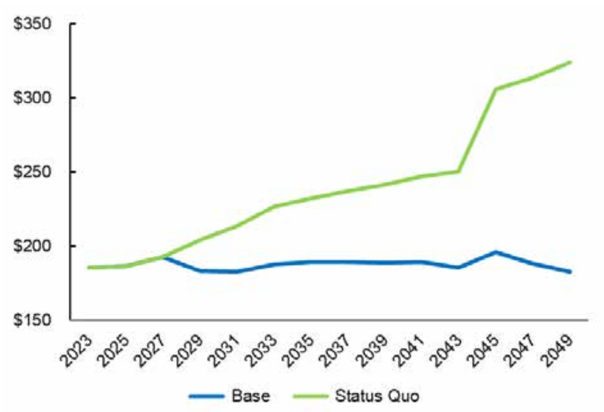


Figure 9-8. Hawaiʻi Island: residential bill (nominal $)

Figure 9-9 illustrates the residential customer rates in nominal dollars for the two scenarios.

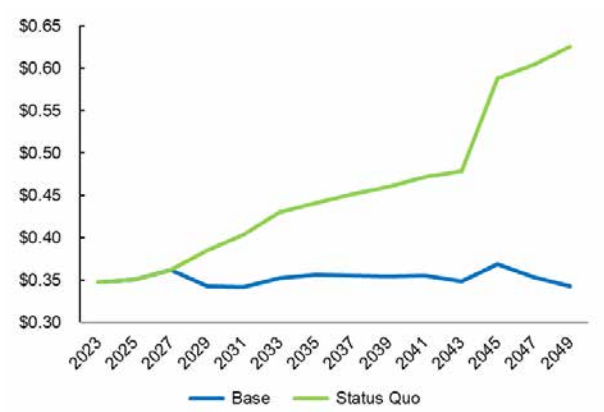


Figure 9-9. Hawaiʻi Island: residential rates (nominal $)

Figure 9-10 and Figure 9-11 illustrate the cost components to residential customer rates in nominal dollars for the Base Preferred Plan and Status Quo, respectively. The ECRC component of residential rates makes up a larger portion of the total rate in the Status Quo compared to the Base Preferred Plan, and therefore has higher exposure to rate volatility because of fuel prices. In the Base Preferred Plan scenario, PPAC increases while ECRC declines because of the increase in fixed-cost PPAs for hybrid solar, wind, and energy storage, and less dependency on fuel-based generation and energy-based PPAs. The Base Preferred Plan scenario RBA component increases because of the investment needed in transmission and distribution infrastructure to enable renewables and electrification.

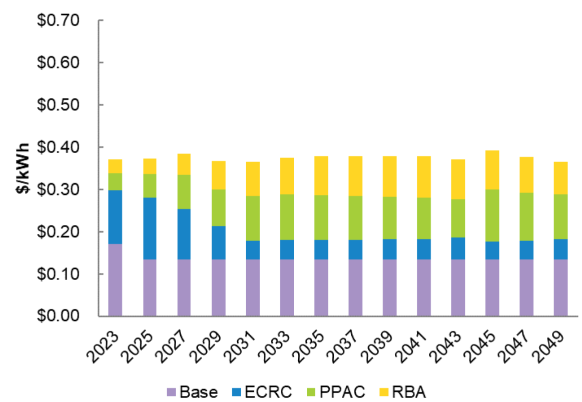


Figure 9-10. Hawaiʻi Island: cost components to residential rates, Base scenario (nominal $)

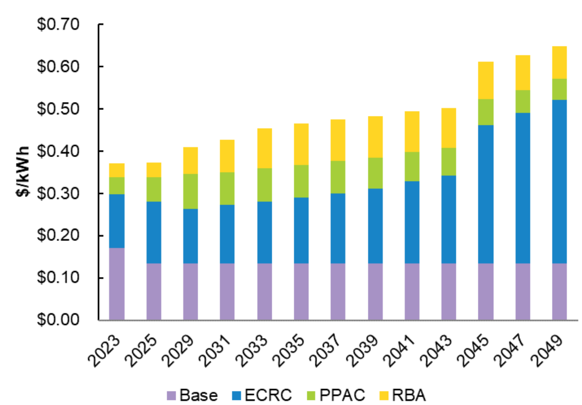


Figure 9-11. Hawaiʻi Island: cost components to residential rates, Status Quo scenario (nominal $)

9.4 Maui County Financial Impacts

The data and analyses presented in this section cover the Maui County service territory and customers, and are broken out individually for Maui, Moloka'i, and Lāna'i, unless clearly noted. The Base scenario shows the lowest overall revenue requirements over the 2023 to 2050 planning period for all three islands.

9.4.1 Revenue Requirements

Table 9-10 shows the NPV of the annual revenue requirements for the Base Preferred Plan and Status Quo scenarios for Maui, Moloka'i, and Lāna'i.

Table 9-10. Net Present Value of Revenue Requirement

NPV of Revenue Requirement ($000)	($000)	% Increase from Lowest-Cost Scenario
Base scenario: Maui	$4,769,387	-
Status Quo scenario: Maui	$5,305,202	11%
Base scenario: Moloka'i	$152,650	-
Status Quo scenario: Moloka'i	$179,995	18%
Base scenario: Lāna'i	$177,201	-
Status Quo scenario: Lāna'i	$190,209	7%

Figure 9-12 illustrates Maui's annual revenue requirements in nominal dollars.

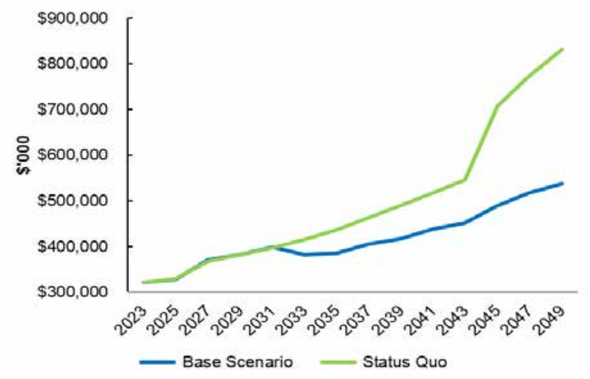


Figure 9-12. Maui: comparison of revenue requirement (nominal $)

Figure 9-13 illustrates Moloka'i's annual revenue requirements in nominal dollars.

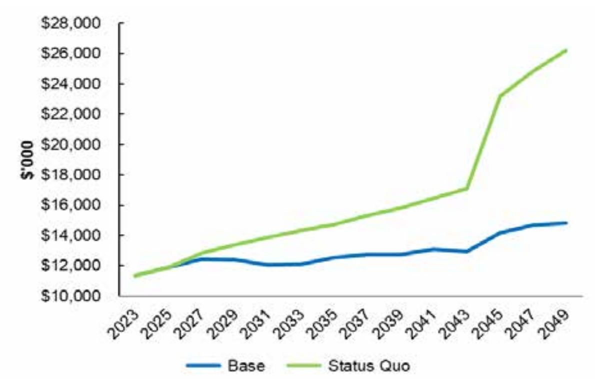


Figure 9-13. Moloka'i: comparison of revenue requirement (nominal $)

Figure 9-14 illustrates Lāna'i's annual revenue requirements in nominal dollars.

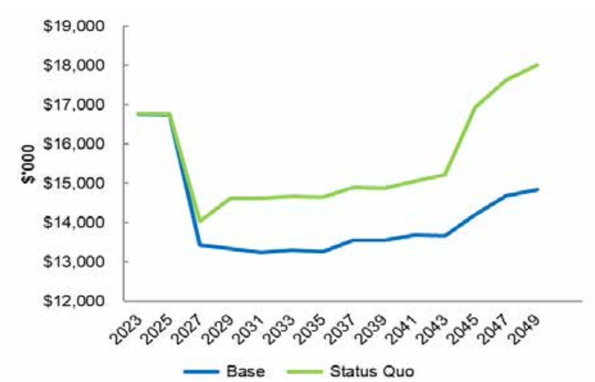


Figure 9-14. Lāna'i: comparison of revenue requirement (nominal $)

9.4.2 Capital Expenditure Projections

Table 9-11 and Table 9-12 summarize the capital expenditures identified in the Status Quo and Preferred Plan, by category, for the Base Preferred Plan and Status Quo scenarios for Maui County, and are not broken out individually for Maui, Molokaʻi, and Lānaʻi.

Table 9-11. Capital Expenditures (Nominal $): Base Scenario—Maui County

('000)	2023–25	2026–30	2031–35	2036–40	2041–45	2046–50	Total
Distribution upgrades	$4,277	$0	$0	$0	$0	$0	$4,277
Transmission Interconnection	$0	$60,554	$106,638	$60,505	$144,392	$135,086	$507,175
Resilience [a]	$5,456	$10,425	$0	$0	$0	$0	$15,881
Grid mod phase 2 [a]	$2,999	$9,717	$0	$0	$0	$0	$12,716
Balance-of-utility business	$224,994	$249,223	$261,531	$288,751	$318,805	$351,986	$1,695,289
Total	$237,726	$329,918	$368,169	$349,256	$463,197	$487,072	$2,235,337

a. Final costs to be submitted in a forthcoming application.

Table 9-12. Capital Expenditures (Nominal $): Status Quo Scenario—Maui County

('000)	2023–25	2026–30	2031–35	2036–40	2041–45	2046–50	Total
Distribution upgrades	$4,277	$0	$0	$0	$0	$0	$4,277
Transmission interconnection	$0	$1,887	$22,462	$320	$68,090	$12,500	$105,259
Resilience [a]	$5,456	$10,425	$0	$0	$0	$0	$15,881
Grid mod phase 2 [a]	$2,999	$9,717	$0	$0	$0	$0	$12,716
Balance-of-utility business	$224,994	$249,223	$261,531	$288,751	$318,805	$351,986	$1,695,289
Total	$237,726	$271,251	$283,993	$289,071	$386,895	$364,486	$1,833,421

a. Final costs to be submitted in a forthcoming application.

9.4.3 Residential Customer Bill and Rate Impacts

As a result of an increasing revenue requirement in combination with increasing sales because of electrification, residential customer rates and bills are projected to remain relatively flat during the planning period in the Base Preferred Plan, demonstrating the benefits of electrification of the transportation sector.

Table 9-13 shows the average annual residential bill increases for Maui and Moloka'i; however, the bill increases are smaller in the Base Preferred Plan scenario compared to the Status Quo scenario. The average annual bill decreases for Lāna'i in the Base Preferred Plan scenario.

Table 9-13. Average Annual Residential Bill Increases

Average Annual Bill Increase (2023–2050)	Nominal $
Base scenario: Maui	0.43%
Status Quo scenario: Maui	2.16%
Base scenario: Moloka'i	0.78%
Status Quo scenario: Moloka'i	3.06%
Base scenario: Lāna'i	(0.25)%
Status Quo scenario: Lāna'i	0.25%

Figure 9-15 illustrates Maui's residential customer bill impact in nominal dollars for a typical 500 kWh bill for the two scenarios.

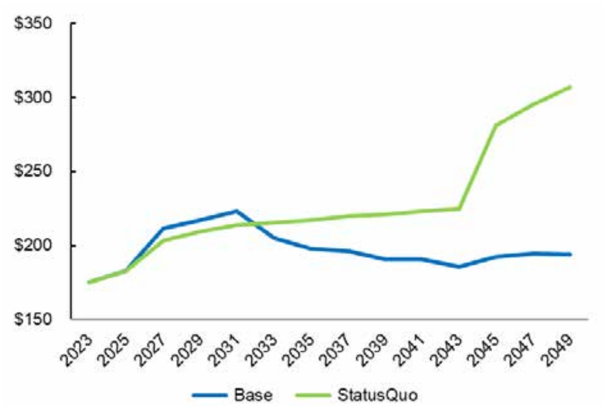


Figure 9-15. Maui: residential bill (nominal $)

Figure 9-16 illustrates Moloka'i's residential customer bill impact in nominal dollars for a typical 400 kWh bill for the two scenarios.

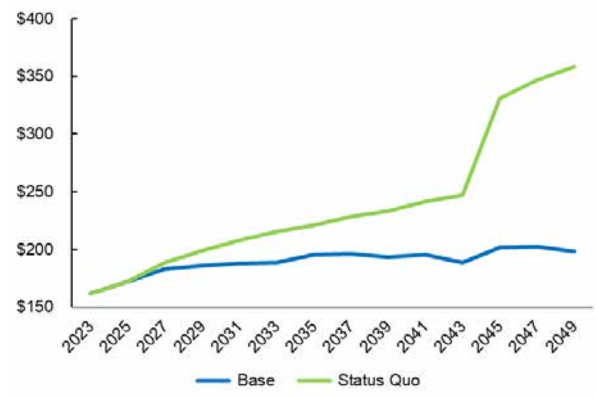


Figure 9-16. Moloka'i: residential bill (nominal $)

Figure 9-17 illustrates Lāna'i's residential customer bill impact in nominal dollars for a typical 400 kWh bill for the two scenarios.

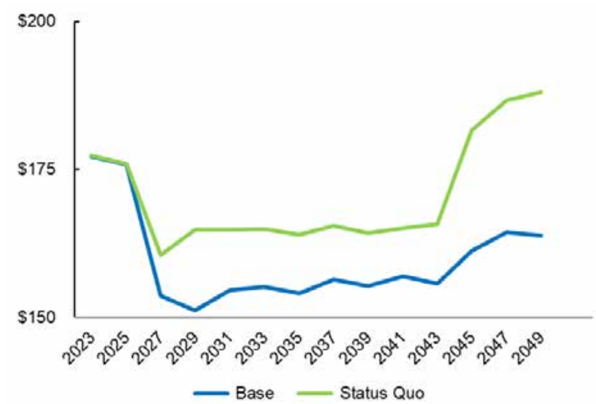


Figure 9-17. Lāna'i: residential bill (nominal $)

Figure 9-18 illustrates Maui's residential customer rates in nominal dollars for the two scenarios.

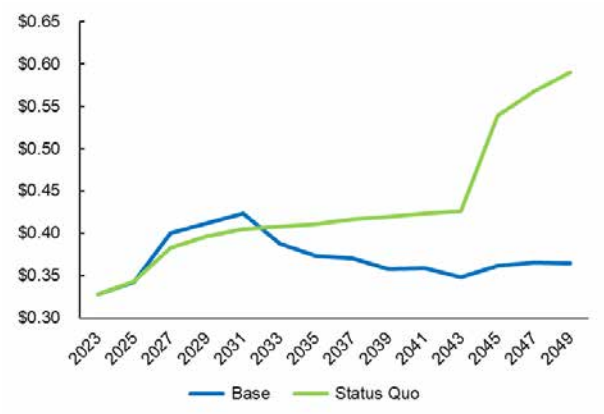


Figure 9-18. Maui: residential rates (nominal $)

Figure 9-19 illustrates Moloka'i's residential customer rates in nominal dollars for the two scenarios.

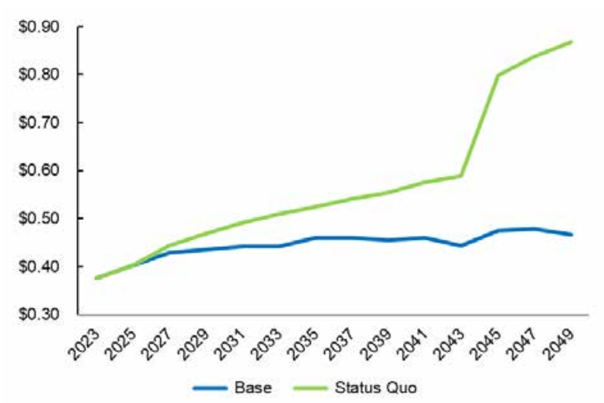


Figure 9-19. Moloka'i: residential rates (nominal $)

Figure 9-20 illustrates Lana'i's residential customer rates in nominal dollars for the scenarios.

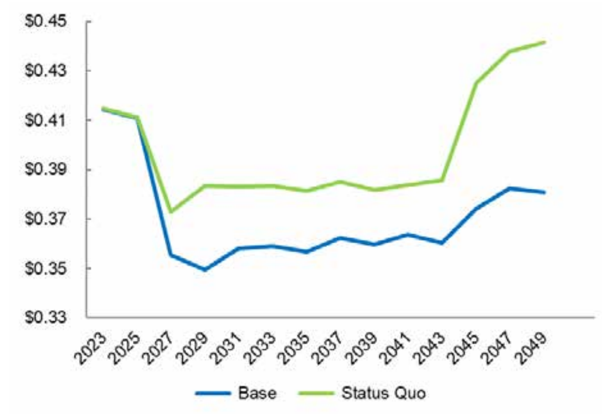


Figure 9-20. Lāna'i: residential rates (nominal $)

Figure 9-21 and Figure 9-22 illustrate the cost components to residential customer rates in nominal dollars for the Maui Base Preferred Plan and Status Quo, respectively. The ECRC component of residential rates makes up a larger portion of the total rate in the Status Quo compared to the Base Preferred Plan, and therefore has higher exposure to rate volatility because of fuel prices. In the Base Preferred Plan scenario, PPAC increases while ECRC declines because of the increase in fixed-cost PPAs for hybrid solar, wind, and energy storage, and less dependency on fuel-based generation and energy-based PPAs. The Base Preferred Plan scenario RBA component increases because of the investment needed in transmission and distribution infrastructure to enable renewables and electrification.

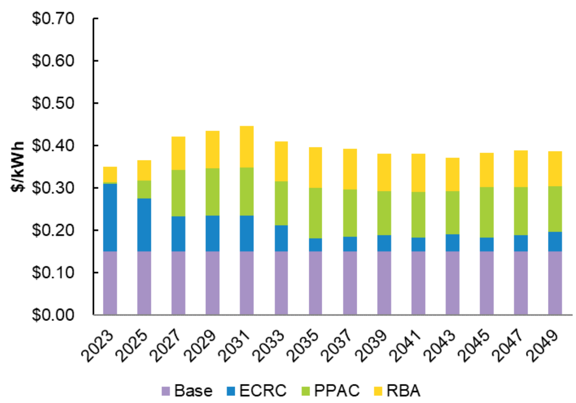


Figure 9-21. Maui: cost components to residential rates, Base scenario (nominal $)

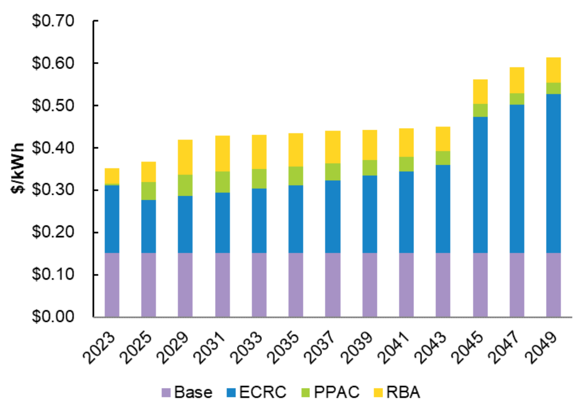


Figure 9-22. Maui: cost components to residential rates, Status Quo scenario (nominal $)

Figure 9-23 and Figure 9-24 illustrate the cost components to residential customer rates in nominal dollars for the Moloka‘i Base Preferred Plan and Status Quo, respectively. The ECRC component of residential rates makes up a larger portion of the total rate in the Status Quo compared to the Base Preferred Plan, and therefore has higher exposure to rate volatility because of fuel prices. In the Base Preferred Plan scenario, PPAC increases while ECRC significantly declines in 2031 as hybrid solar on a fixed-price PPA is added to the system and there is less dependency on fuel-based generation and energy-based PPAs. The Base Preferred Plan scenario RBA component increases because of the investment needed in distribution infrastructure to enable renewables and electrification.

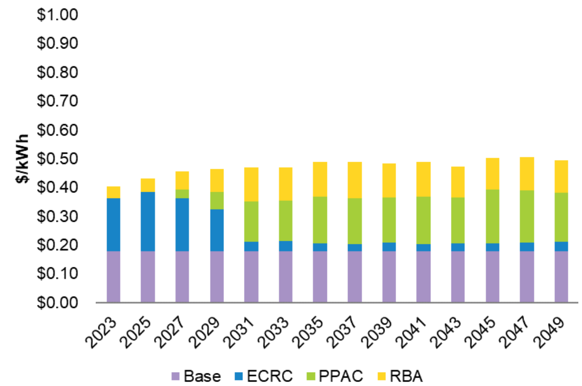


Figure 9-23. Moloka‘i: cost components to residential rates, Base scenario (nominal $)

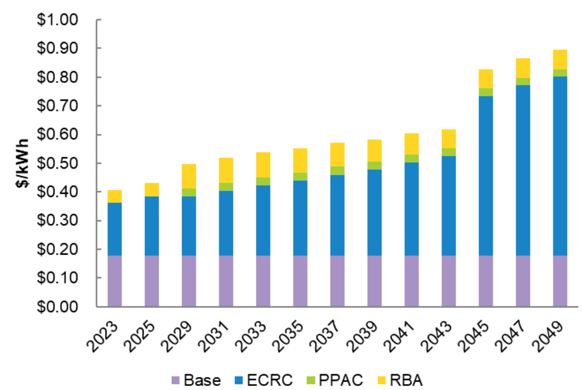


Figure 9-24. Moloka‘i: cost components to residential rates, Status Quo scenario (nominal $)

Figure 9-25 and Figure 9-26 illustrate the cost components to residential customer rates in nominal dollars for the Lānaʻi Base Preferred Plan and Status Quo, respectively. The ECRC component of residential rates makes up a larger portion of the total rate in the Status Quo compared to the Base Preferred Plan, and therefore has higher exposure to rate volatility because of fuel prices. In the Base Preferred Plan scenario, PPAC increases while ECRC significantly declines in 2027 as hybrid solar on a fixed-price PPA is added to the system and there is less dependency on fuel-based generation and energy-based PPAs. The Base Preferred Plan scenario RBA component is relatively flat as the

Base Preferred Plan did not require as much investment in distribution infrastructure compared to other islands.

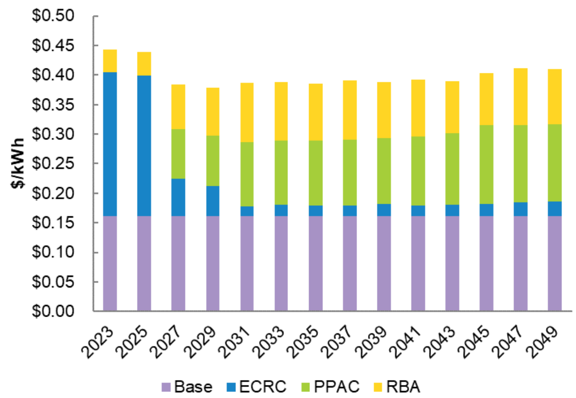


Figure 9-25. Lāna'i: cost components to residential rates, Base scenario (nominal $)

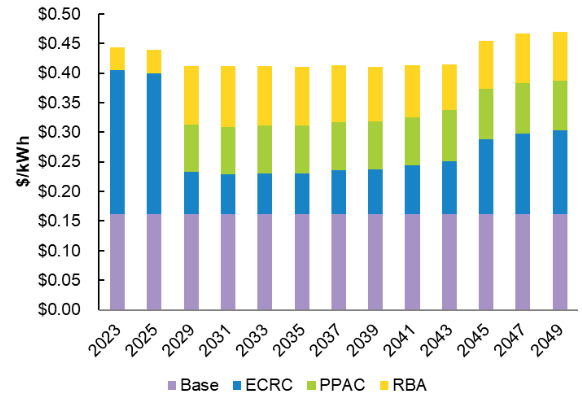


Figure 9-26. Lāna'i: cost components to residential rates, Status Quo scenario (nominal $)

9.5 Emissions and Environmental

This section provides the forecast for future emissions that result from the Preferred Plans for each island and the estimated trajectory for meeting the decarbonization goals.

9.5.1 Greenhouse Gas Emissions

The renewable resources that are added in the Preferred Plans drive down emissions as fossil fuel–based generation is displaced by hybrid solar, wind, and offshore wind. By 2030, we expect to achieve a reduction in greenhouse gas emissions of 75%, relative to 2005 baseline levels. By 2045, some emissions are still produced by H-Power as a byproduct of its waste-to-energy process. Natural carbon sinks, or technologies that can capture carbon dioxide (CO_2) from the generator stack or extract it from the atmosphere, may need to be considered, holistically as a state, to achieve the State's net-zero decarbonization goal. Figure 9-27 summarizes the emissions in the Preferred Plans through 2050.

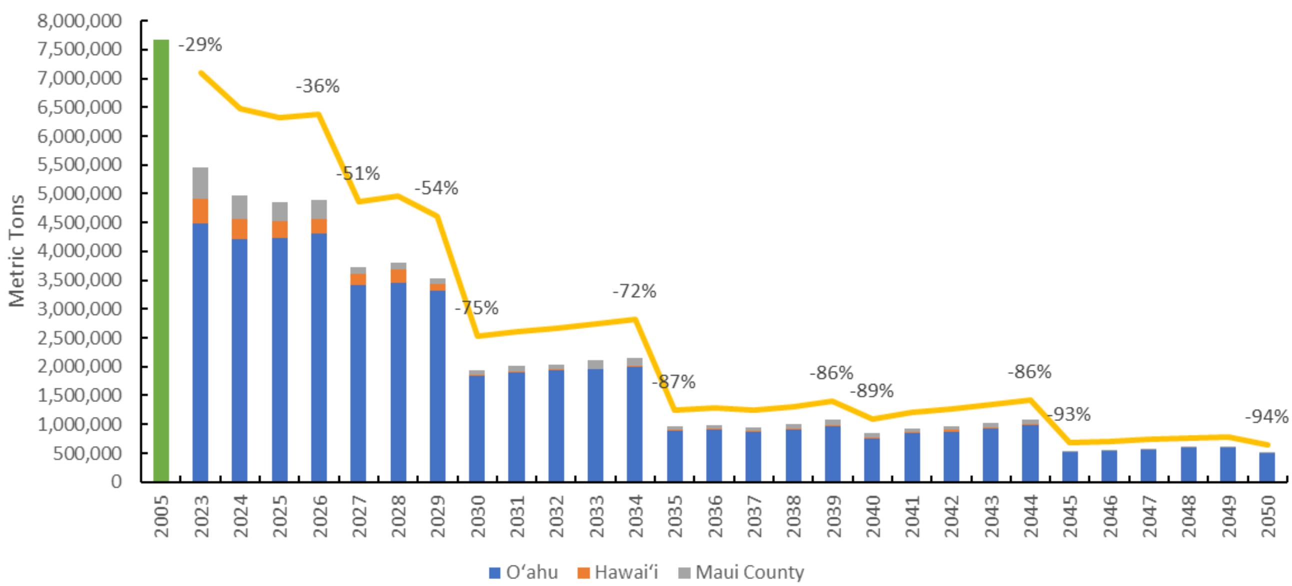


Figure 9-27. Consolidated emissions and percentage reduction compared to 2005 baseline without biogenic CO_2

The emissions for each island are provided below in Table 9-14.

Table 9-14. Preferred Plan Greenhouse Gas Emissions

Emissions (MT CO_2e)	2030	2035	2040	2045	2050
O'ahu	1,836,324	888,921	761,234	525,744	494,213
Hawai'i Island	13,987	14,218	17,325	3	8
Maui	84,672	56,921	58,906	31	26
Moloka'i	2,197	1,567	1,164	1	1
Lāna'i	2,072	2,031	1,694	1	1

Comparing the Base or Land-Constrained scenario to the Status Quo illustrates how effective the Base or Land-Constrained Preferred Plans are at reducing emissions compared to the Status Quo. The Base scenarios have less than half the emissions of the Status Quo by 2030, which enables the achievement of the 70% greenhouse gas reduction goal. However, the Land-Constrained scenario, with its more limited resource options, has mostly the same emissions as the Status Quo in the same year. Table 9-15, Table 9-16, Table 9-17, Table 9-18, and Table 9-19 provide the emissions in select years for O'ahu, Hawai'i Island, Maui, Moloka'i, and Lāna'i, respectively.

Table 9-15. O'ahu Greenhouse Gas Emissions Relative to Status Quo

O'ahu Emissions	2030	2035	2040	2045	2050
Base (MT CO_2e)	1,836,324	888,921	761,234	525,744	494,213
Land-Constrained (MT CO_2e)	3,359,238	1,756,826	1,741,284	798,996	644,545
Status Quo (MT CO_2e)	4,232,203	4,441,825	4,826,553	1,491,483	1,479,260
Base/Status Quo (%)	43%	20%	16%	35%	33%
Land-Constrained/Status Quo (%)	79%	40%	36%	54%	44%

Table 9-16. Hawai'i Island Greenhouse Gas Emissions Relative to Status Quo

Hawai'i Island Emissions	2030	2035	2040	2045	2050
Base (MT CO_2e)	13,987	14,218	17,325	3	8
Status Quo (MT CO_2e)	176,875	179,013	203,871	59	111
Base/Status Quo (%)	8%	8%	8%	5%	7%

Table 9-17. Maui Greenhouse Gas Emissions Relative to Status Quo

Maui Emissions	2030	2035	2040	2045	2050
Base (MT CO_2e)	84,672	56,921	58,906	31	26
Status Quo (MT CO_2e)	203,393	245,526	307,360	308	366
Base/Status Quo (%)	42%	23%	19%	10%	7%

Table 9-18. Moloka'i Greenhouse Gas Emissions Relative to Status Quo

Moloka'i Emissions	2030	2035	2040	2045	2050
Base (MT CO_2e)	2,197	1,567	1,164	1	1
Status Quo (MT CO_2e)	16,976	16,928	17,271	15	15
Base/Status Quo (%)	13%	9%	7%	4%	4%

Table 9-19. Lānaʻi Greenhouse Gas Emissions Relative to Status Quo

Lānaʻi Emissions	2030	2035	2040	2045	2050
Base (MT CO_2e)	2,072	2,031	1,694	1	1
Status Quo (MT CO_2e)	7,627	7,886	8,051	6	6
Base/Status Quo (%)	27%	26%	21%	17%	15%

9.5.2 Emissions Reductions due to Electrification of Transportation

As discussed earlier in this section, electrification of transportation can have positive financial benefits for customers. The adoption of electric vehicles will decrease the statewide emissions of greenhouse gases, furthering the State of Hawaiʻi's achievement of its decarbonization goals. In our Base scenario, electric vehicles forecast through 2050 will avoid significant amounts of fuel being consumed, shown in Figure 9-28, and emissions from burning that fuel, shown in Figure 9-29. While electric vehicles provide a meaningful reduction to statewide emissions, they will need to be charged from the grid, which will increase the demand for electricity and can increase the risk of having inadequate generation in the future, as discussed in Section 12.2.

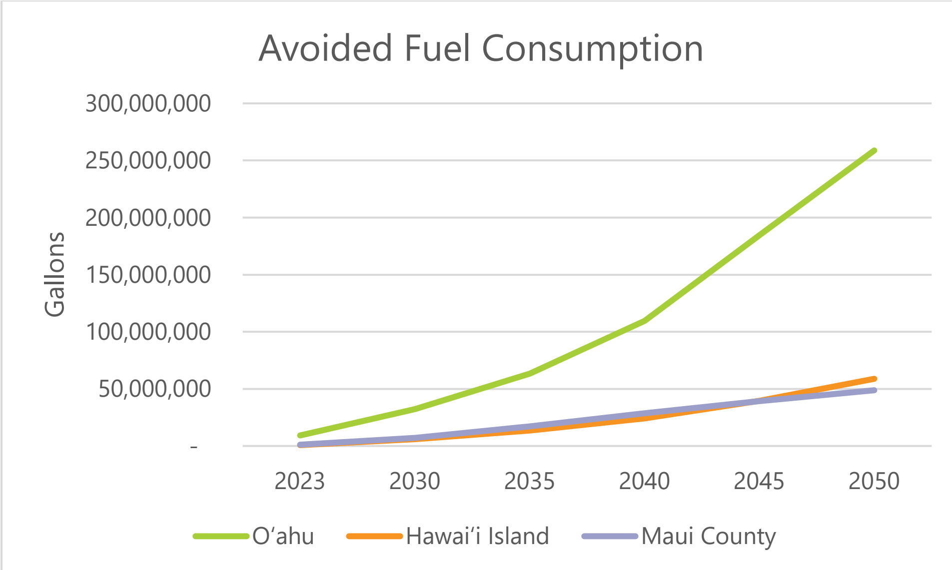


Figure 9-28. Avoided fuel consumption due to electric vehicle adoption

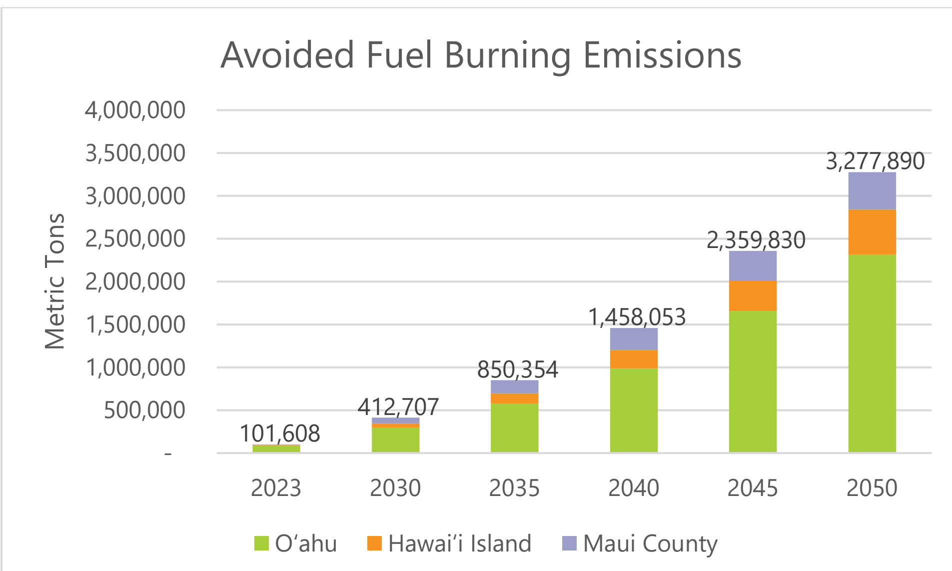


Figure 9-29. Avoided greenhouse gas emissions due to electric vehicle adoption

10. Energy Equity

In this section, we discuss our ongoing efforts to address energy inequities and offer solutions that we can implement and continue to learn from and expand in the future. As the cost of living in Hawaiʻi continues to rise, we must make electricity affordable and ensure that we ease the burden of the renewable transition on low- to moderate-income customers and communities that bear the burden of hosting energy infrastructure in the past and future. The transition increases access to renewable energy and equitability for all.

The Public Utilities Commission recently opened a proceeding to investigate energy equity in response to legislative resolutions. The areas for exploration include high energy rates in Hawai'i, high percentage of LMI persons, high energy burden, lack of universal access to renewable energy initiatives, need for utility payment assistance, historical siting of fossil-fuel infrastructure, land constraints, and regulatory process burdens.

Everyone has in an interest in an equitable energy system. As society continues to electrify all aspects of the economy, all customers stand to benefit if everyone is able to afford electricity and participate in the transition.

10.1 Equity Definitions

The Public Utilities Commission has defined the following key terms to guide equity discussions:

- **Equity** refers to achieved results where advantages and disadvantages are not distributed on the basis of social identities. Strategies that produce equity must be targeted to address the unequal needs, conditions, and positions of people and communities that are created by institutional and structural barriers.
- **Energy equity** refers to the goal of achieving equity in both the social and economic participation in the energy system, while also remediating social, economic, and health burdens on those historically harmed by the energy system.
- **Low- to moderate-income (LMI) persons** are those whose income is at or below 150% of the Hawai'i federal poverty limit.
- **Energy burden** is the percentage of a household's income spent to cover energy cost.

10.2 LMI Programs

We have recently selected CBRE projects (also known as the Shared Solar program) through a competitive procurement for LMI community-based solar projects. While we were required to award a minimum of one project each on O'ahu, Maui, and Hawai'i Island, we awarded seven total projects as shown in Table 10-1, to provide greater access to renewable energy to LMI eligible customers. While these projects may not provide an opportunity to every LMI customer that desires to participate in the renewable transition, it represents a start that will enable us to improve on and expand programs and choices for customers in the future.

Table 10-1. Community-based Solar Projects for LMI Customers

Island	Developer	Project	Shared Solar Megawatt Capacity
O'ahu	Nexamp Solar & Melink Solar Development	Kaukonahua Solar	6 MWh (solar only)
Maui	Nexamp Solar	Lipoa Solar	3 MW + BESS
Maui	Nexamp Solar	Makawao Solar	2.5 MW + BESS
Maui	Nexamp Solar	Piiholo Road Solar	2.5 MW + BESS
Hawai'i Island	Nexamp Solar	Kalaoa Solar A	3 MW + BESS
Hawai'i Island	Nexamp Solar	Kalaoa Solar B	3 MW + BESS
Hawai'i Island	Nexamp Solar	Naalehu Solar	3 MW + BESS

The Shared Solar program embraces the concept of a community project by giving the surrounding community (i.e., census tract) first priority in subscribing to a Shared Solar project. We have also made verification of LMI eligibility easier for customers and require developers to dedicate 100% of the project to LMI eligible customers, reserving at least 60% of the project for residential LMI customers. Each project will have different offerings or subscription fees and arrangements. In exchange for subscribing to a project, LMI customers will receive a monthly bill credit to help reduce their energy costs.

10.3 Affordability and Energy Burden

Energy burden on LMI customers is one of the affordability metrics measured in the Performance-Based Regulation framework. The metric evaluates the typical and average annual bill for a residential customer as a percentage of a low-income household's average income (defined as 150% of the Hawai'i federal poverty level), by island. Using the electric bill and rate projections in Section 9, Figure 10-1 shows the projected affordability metric based on our Preferred Plans through 2050 for the typical residential customer on each island.

Our projections show that the transition to clean energy may reduce the overall energy burden for the typical residential customer on each island through 2050, compared to today's energy burden.

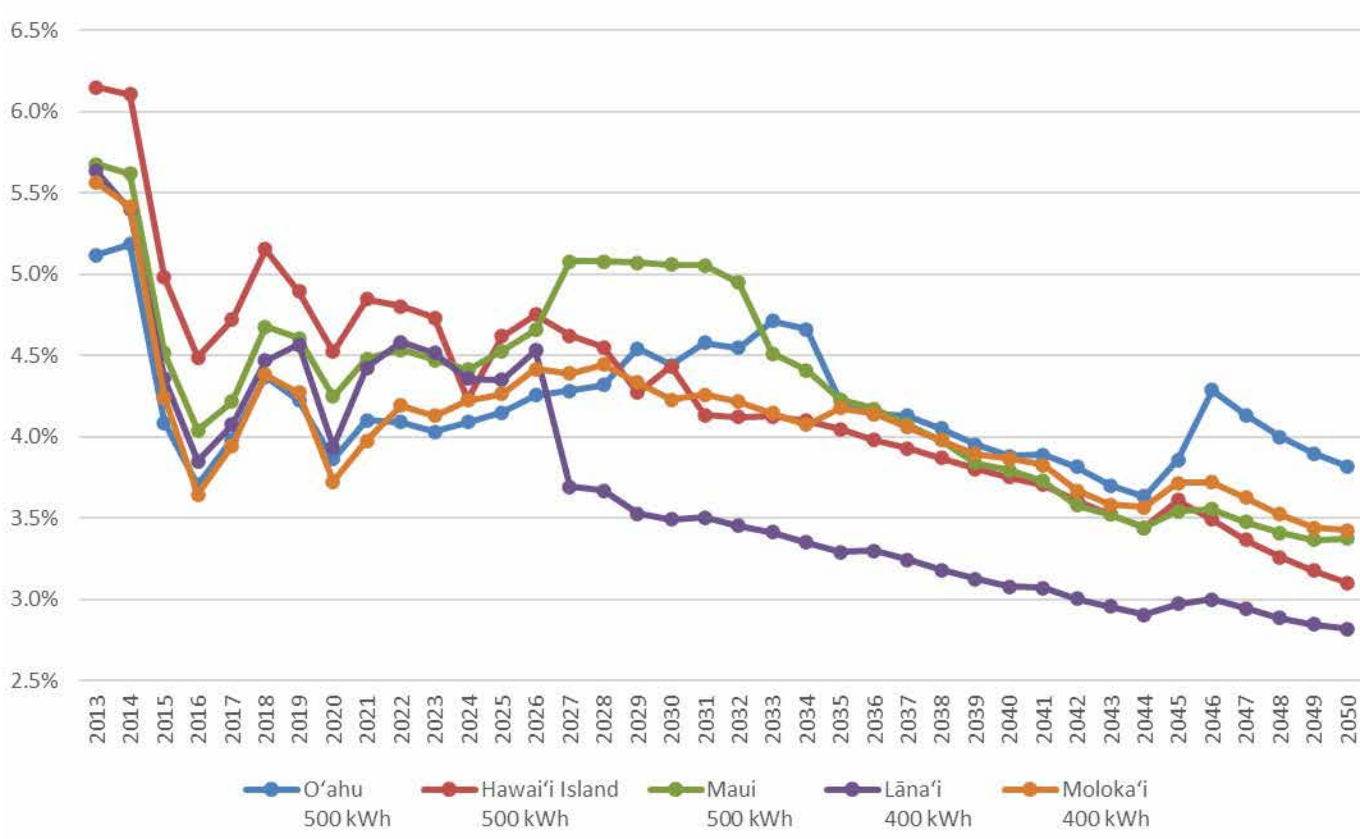


Figure 10-1. Typical residential bill as a percentage of low-income average income per island (150% of the federal poverty level)

10.4 Community Benefits Package for Grid-Scale Projects

Through various forums, we have heard the desire of communities to be more engaged early in the renewable energy project development process. We continue to engage communities around the islands as we develop RFPs and identify future grid needs. Building upon the outreach to stakeholders and communities in developing recent RFPs, we will continue to listen, learn, and work with communities throughout the process of developing the next round of procurements on each island we serve.

Based upon Stakeholder Council recommendations and past community feedback, we have expanded community engagement requirements for prospective project developers by specifying more detailed requirements and by adding a requirement for developers to provide a benefits package for the surrounding communities.

Our ongoing Stage 3 RFPs require project developers to commit to financial community benefits. Developers are required to provide at least $3,000 per MW (based on their proposed project size) per year in community benefits. These funds would be donated for actions and/or programs aimed at addressing specific needs identified by the host community, or to a 501(c)(3) not-for-profit community-based organization(s) to directly address host community–identified needs.

The developers would provide a documented community benefits package highlighting the distribution of funds for our review. This document would be made public on each project's website and demonstrate how funds will directly address needs in the host community.

The community benefits package would also include documentation of each project developer's community consultation and input collection process to define community needs, along with actions and programs aimed at addressing those needs. Preference would be given to projects that commit to setting aside a larger amount or commit to providing other benefits (including but not limited to creating local jobs, payment of prevailing wages, or improving community infrastructure).

In addition, we included the following modifications to the procurement process in response to community feedback:

- Higher scoring to project proposals that are proposed on land zoned commercial or industrial, land with greater impervious cover, or reclaimed land
- Procedural improvements made to further ensure the protection and preservation of cultural resources
- Prioritization of local labor and prevailing wage for proposed projects
- Additional requirements for developers to provide monthly updates to the community prior to and throughout the construction process

10.5 Renewable Energy Zone Development in Collaboration with Communities

The large-scale renewable project community benefits package is intended to address, in part, the burdens put onto communities that host clean energy projects and infrastructure. It does not mitigate all community concerns, nor does it recognize the future needs of the grid to achieve our decarbonization goals.

The most cost-effective path with current technology will require substantially more land to site clean energy projects along with transmission infrastructure. However, that cannot be accomplished without the acceptance of our communities. As the Stakeholder Council advised in discussing this topic, "we must go slow to go fast." Careful and thoughtful planning with our communities is needed to turn our vision into reality.

Stakeholder and public engagement have been a hallmark of this process. Last year we discussed more details of our Hawai'i Powered vision and focused community discussions on REZ development.

As we discuss in Section 4, we have provided multiple options, in-person and virtually, to provide input. The Hawai'i Powered website functions as a centralized hub for public engagement. In seeking this initial round of input on renewable energy zones, hawaiipowered.com/rez/ was made available to the general public. We also conducted in-person meetings, provided a newsletter describing the effort to numerous electronic mailing lists and community organizations, and ran a 3-week social media campaign. The online map includes the ability to drop a pin and add comments identifying those places that may be suitable as well as areas that are undesirable for development of renewable energy projects. The input gathered through this process will be used to refine the REZ analysis, which will guide planning efforts for transmission infrastructure needed to support future renewable resource development, as well as to inform developers regarding potential site suitability for specific renewable energy projects through the procurement process.

A complete list of comments received through our engagement through the Hawai'i Powered website is included in Appendix A, and a summary of common themes related to equity is listed below.

10.5.1 O'ahu

- The Kahuku and West O'ahu communities expressed, some strongly, that no windmills should be built. The Waialua community had similar sentiments, and also commented on the lack of support for offshore wind among the community.
- In general, communities across O'ahu believed that wind turbines should not be allowed to be built near homes, schools, and farms. Wind turbine placement is controversial and should be discussed with communities.
- Renewable technology was raised often in terms of finding technology that requires less land space and has a smaller footprint. We also received suggestions to evaluate hydro or tidal, geothermal, and nuclear energy.
- Equity (as opposed to equality) was raised to ensure distribution of burden for hosting renewable projects.
- A desire was expressed to make sure that electricity generated in a community stays in that community. For example, Will Wai'anae and North Shore side (which have high land

potential) be given higher-priority usage over Waikīkī (which is a high energy user)?

- Many commented that rooftop solar and parking lot solar canopies should be a priority before turning to land for grid-scale projects. This sentiment was a frequently shared comment on all islands.
- Affordability was a common theme; for example, one commenter said, "If you drive the cost of electricity so high that it becomes unsustainable, all effort toward clean energy will be useless. Yes, pursue clean energy options, but do it in a way that puts the burden on [Hawaiian Electric] and the State of Hawai'i, not on customers who are already stretched too thin paying energy bills."
- Affordability and access to energy options was another theme; for example, "As a renter, I feel left out of this process and at the whim of my landlord." And "100% renewable is not feasible and will cost more than you believe you will save. It is unattainable for the majority of people. You are placing a huge burden on the bottom of the income bracket."
- Many advocated for incentives and programs to participate in rooftop solar, such as community buy-back programs, grant programs (especially for lower-income residents), and subsidized re-roofing/re-paneling.
- Utilization of existing infrastructure was discussed, rather than conducting new development.
- Residents expressed a desired expansion of EV charging stations and plug types.

10.5.2 Maui

- A common theme we heard on Maui related to respect for cultural sites and preservation of Maui's natural beauty, such as Haleakala—though some expressed that you could respect the cultural sites while finding opportunities.
  - "Putting up turbines or solar in Central Maui wouldn't bother me, but beyond that should stay untouched."
  - "Ukumehame—the land has been decimated; maybe solar could be used but as long as it doesn't add to the negative effects already being seen in that area."
  - "Concern would be for Hana, lot of sensitivity there, don't recommend putting anything there."
  - The Waihe'e, Honua'ula, and Mauka areas also were raised as having cultural significance.
- Some community members mentioned opportunities for agricultural lands on Maui that are not farmable, which could be good possibilities for renewable projects, such as in central and west Maui.
- Adding solar panels to existing infrastructure was mentioned.
- Renewable technology was raised often in terms of finding technology that requires less land space and has a smaller footprint. We also received suggestions to evaluate hydro, tidal, and nuclear energy.
- Desired expansion of EV charging stations was expressed.

10.5.3 Hawai‘i

- Similar to O’ahu, Hawai’i Island community members want renewable projects sited away from the population so the project does not disrupt anyone.
  - “While I’m not in favor of wind energy, especially anywhere near populated areas, I believe solar panels should be placed on every single public building possible (schools, government buildings, etc.) and over parking lots (covered parking).”
- Concerns were expressed for threats to endangered species due to wind turbine blades:
  - “Renewable energy must not come at the expense of native habitat and species. Use previously developed land and areas that are already covered with non-permeable surfaces.”
- Similar to other islands, we received several comments regarding solar canopies to cover parking lots and more rooftop solar.
- Streamlining the process to participate in rooftop solar was mentioned.
- Desired expansion of EV charging stations was expressed.
- Renewable technology was raised often in terms of finding technology that requires less land space and has a smaller footprint. We also received suggestions to evaluate hydrothermal and geothermal energy generation.

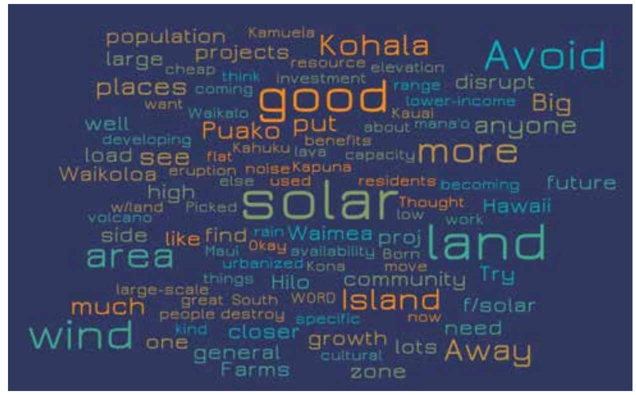


Figure 10-2. Keywords identified from the map comments

Figure 10-2 shows the keywords identified from the REZ map comments. Each island community has identified both opportunities and challenges, which provides insight into siting future additional large-scale projects.

The development of renewable energy zones will take time to conduct proper community engagement, permitting, and siting, among other tasks. Our immediate next step is to acquire information from landowners, through a request for information, who are willing to allow for renewable project development and marry those with the community comments we have received to date. Then we intend to work with specific communities on a renewable energy zone and transmission siting process to potentially develop these areas and to understand the opportunities and challenges.

10.6 Energy Transitions Initiative Partnership Project

We were selected last year as a partner in DOE's ETIPP to improve energy resilience and combat climate change. As part of the partnership, Hawaiian Electric is helping to identify areas on O'ahu that are optimal for developing microgrids to build a more resilient electric grid. Microgrids serve areas that are connected to the electric grid yet can be islanded during an outage to continue providing electricity through a variety of resources, including solar panels, a battery, and/or a backup generator.

We hope to reduce initial barriers and complexities with a map that takes into account the technical and practical viability of microgrid development. Microgrids are best suited to areas prone to prolonged outages during weather events, with clusters of customers and potential availability of renewable energy resources. The map would allow developers to contact potential microgrid participants and work with Hawaiian Electric to apply for the development of a specific microgrid.

Our objective of this effort is to provide customers with a map identifying areas that are good candidates for hosting hybrid microgrids, to improve electrical infrastructure to severe weather with consideration for electric grid layout, customer-sited resources, reliability, equity, among others.

There are several considerations in mapping potential microgrid locations like critical facilities and grid vulnerabilities, but we also explicitly take into account societal impacts such as disadvantaged communities and asset-limited, income-constrained residents, as shown in Figure 10-3.

1 CRITICALITY

Where are the critical loads, facilities and services?

- **Emergency**: emergency shelters, fire stations, EOC
- **Medical**: hospitals, out-patient facilities, surgical centers, skilled care facilities
- **Infrastructure**: water sources & treatment, internet exchange points, transmission towers, dams, bridges, ports, airports

2 VULNERABILITY

What parts of the grid currently and are projected to endure the longest or most frequent outages?

- **Natural hazards and inaccessibility**: flood, sea-level rise (through 2050), landslide, tsunami, remoteness
- **Outages** (2011-2021)

3 SOCIETAL IMPACT

What other locations would significantly impact communities if they lost power?

- Residential care facilities, community homes
- Schools, daycares, libraries
- ALICE program
- Disadvantaged communities

Figure 10-3. Description of the three criteria used to identify microgrid opportunities

Figure 10-4 below illustrates the critical facilities we have included in our initial analysis. As described in Appendix A we sought input from communities around O'ahu to acquire local knowledge to identify critical facilities and vulnerable or societal impact areas.

Included in analysis*

- Wastewater Treatment Plants
- Towers: AM and FM Transmission, Broadband, Cellular, Microwave, TV Analog and Digital Transmitter,
- Emergency Medical Stations
- Fire Stations
- Local, State Emergency Operations Centers
- National Shelter System Facilities
- Internet Exchange Points
- Ports
- Public Refrigerated Warehouses
- Local Law Enforcement Locations
- Hospitals
- Dialysis Centers
- Nursing Homes
- Urgent Care Facilities (ambulatory)
- Airports, Aircraft Landing Facilities

**From Department of Homeland Security*

Figure 10-4. Listing of the types of critical facilities included in the ETIPP analysis

Figure 10-5 and Figure 10-6 illustrate a microgrid map that can show the areas where criticality, vulnerability, and social impact intersect. These locations are prime locations for future microgrid development, which can also inform the hardening of distribution lines that would connect critical customers within that microgrid.

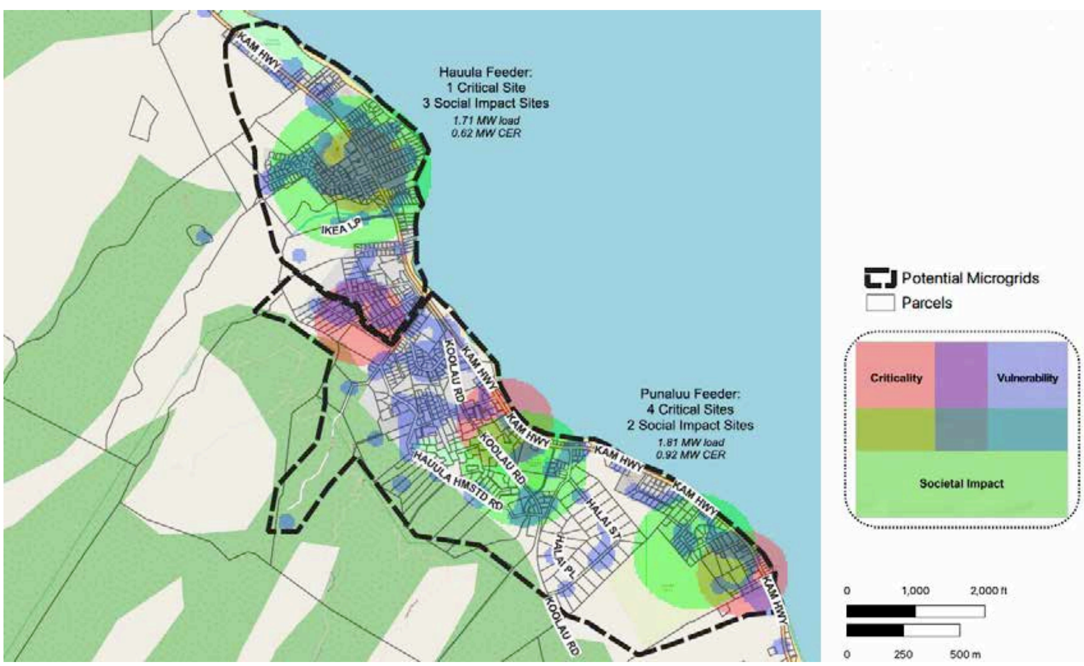


Figure 10-5. Hau'ula potential hybrid microgrids

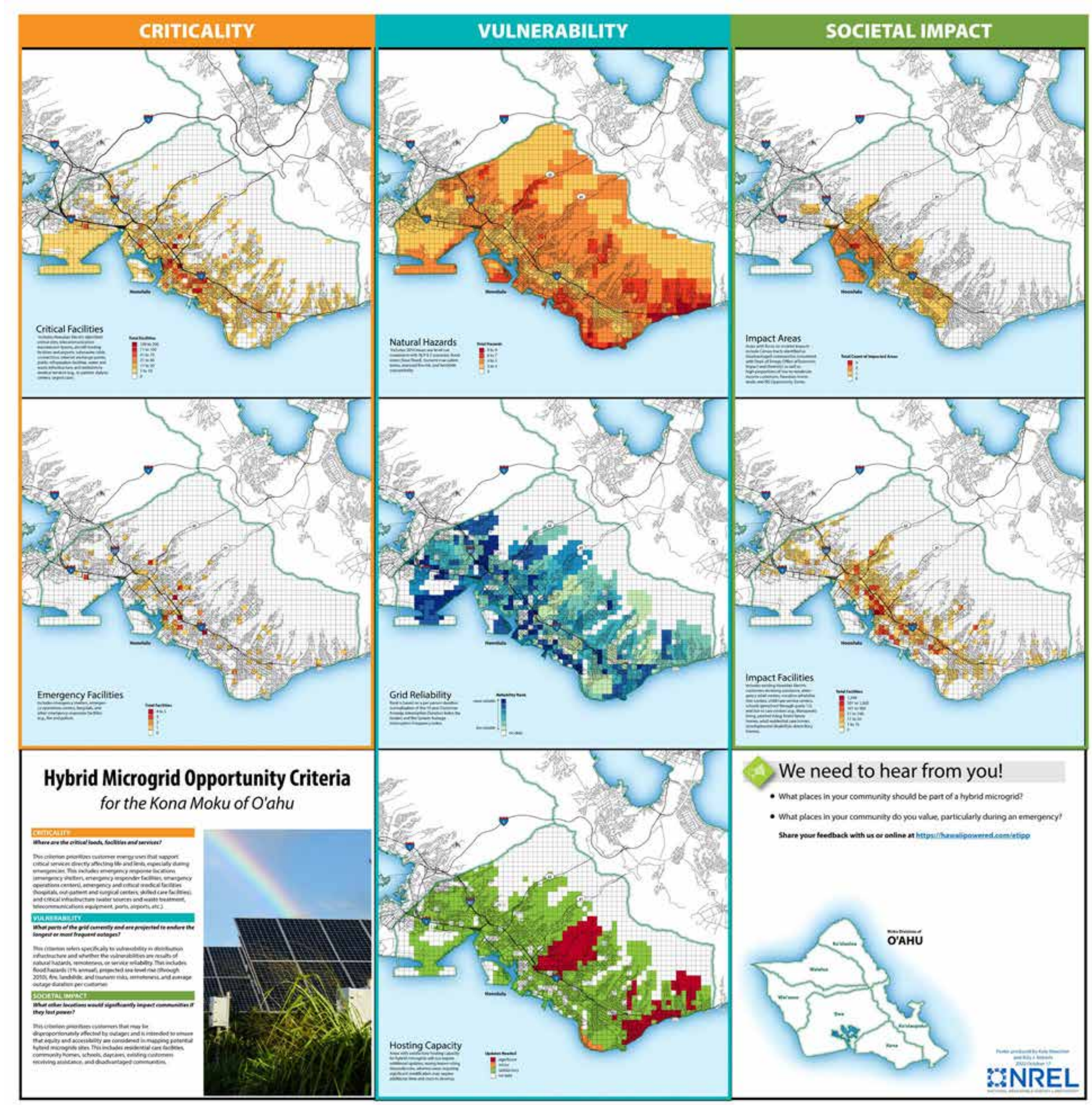


Figure 10-6. Map of the Kona Moku identifying locations for microgrid opportunity by criteria

Through these efforts we hope that more resilient energy can benefit our communities by highlighting areas with critical facilities that serve the greater public, vulnerable areas of the grid, and high social impact areas.

11. Growing the Energy Marketplace

We recognize that customers have choices in the way they use energy, which is why they must be at the center of the way we acquire solutions to the pathways we have laid out.

We want to create and grow a customer- and community-centered marketplace that can seamlessly and quickly deliver solutions to urgently address our climate goals and ease the burdens that fossil fuel has on our customers' bills, environment, and economy. Growing Hawai'i's energy marketplace consists of three main levers: pricing, programs, and procurements. It also allows customers and communities to participate in the process in several ways: by taking advantage of new time-of-use rates, and adopting customer technologies like energy efficiency, electric vehicles, or community solar projects. We also hope to give the community a voice in where and how large-scale projects are located and developed. The energy marketplace will deliver the actual technologies and solutions at the best price through competition.

We believe the energy marketplace, with communities and customers at the center, will deliver the best solutions, with urgency, and provide benefits to all customers. It also sets a framework for inclusive planning of the future grid, one that works for all.

As we describe in this section, we believe in the value that customers can deliver with new technologies, and we also believe that communities should benefit from hosting clean energy projects and infrastructure. Establishing the energy marketplace is a key pillar that will provide the predictability to participants and project partners need to take urgent action.

11.1 Customer Energy Resource Programs

The following sections describe the various mechanisms to grow the marketplace for customer resources and incentivize customer engagement to participate in the clean energy transition. These mechanisms include price signals aligned with system needs and programs with incentives to spur customer adoption of new technologies.

11.1.1 Pricing Mechanisms

We have installed advanced meters to more than 40% of our customers on O'ahu, Maui, and Hawai'i Island and expect to complete the rollout of advanced meters to all customers in our service territory by the end of the third quarter of 2024.

Advanced rate designs, which have been incorporated into our analysis, play an important role in the transition to a decarbonized electric system. Implementation of new time-of-use rates include three primary components: (1) customer charge, (2) grid access charge, and (3) time-of-use energy charges. The customer charge is applied as a fixed monthly charge for the cost of customer metering and billing. The grid access charge is a monthly charge for residential and small commercial customers and a charge based on measured demand for medium commercial customers for customer-related service connection costs. The third component, the time-of-use energy charge, is a $/kWh charge that consists of the cost of fuel, investments and operations of the grid and purchased power, and other surcharges, where the ratio of the daytime period (9 a.m. to 5 p.m.), overnight period (9 p.m. to 9 a.m.), and evening peak period (5 p.m. to 9 p.m.) rate is 1:2:3. Figure 11-1 below illustrates the proposed time-of-use energy charges for residential customers.

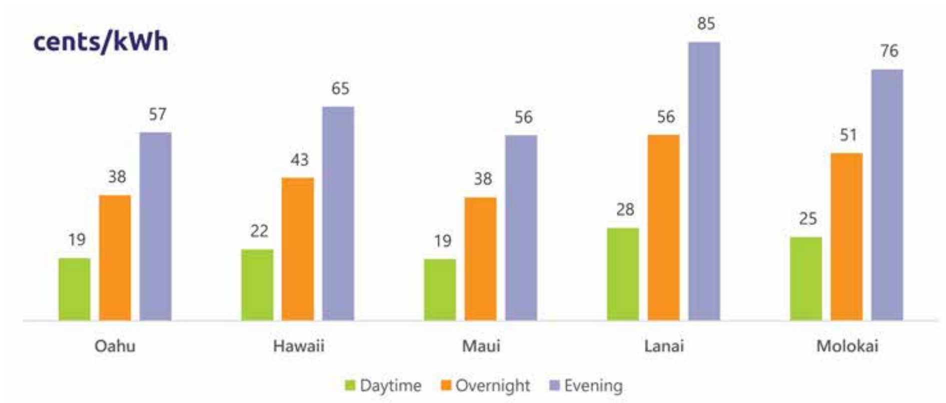


Figure 11-1. Time-of-use energy charges

The new rate structures are intended to encourage customer adoption of technologies such as energy efficiency and rooftop solar and energy storage, incentivizing energy conservation and behavioral changes to use energy away from times when the grid is most stressed (the highest-cost period). This includes ensuring that electric vehicles are not charged during the high demand period in the evening—as assumed in our grid needs analysis under managed vehicle charging. Because these new rates are a fundamental change from traditional electric rates, there will be a rollout period for the first year to a small sample of residential and small/medium commercial customers who have advanced meters to provide critical data and experience with these new rate structures and to determine whether the advanced rate design is working as intended. The next period will build on lessons learned to implement a broader rollout of advanced rate designs.

11.1.1.1 Electric Vehicle Pricing and Programs Mechanisms

We are committed to supporting decarbonization of the economy, and have established pricing and programs to encourage EV adoption. These pricing options and programs are another way in which we will grow the energy marketplace with our customers. These efforts include:

- EV public fast charging
- EV tariffs for electric buses and commercial customers
- eBus make-ready infrastructure pilot, or Charge Up eBus
- Charge Ready Hawaiʻi commercial make-ready infrastructure pilot or Charge Up Commercial

We have established pricing options for non-residential EV charging that are lower during the midday period from 9 a.m. to 5 p.m. daily to align with our system needs to encourage charging when renewable resources are abundant.

Since 2013 we have been providing EV public fast-charging stations for customers, and by the end of 2023 we plan to have 40 chargers installed across our service territory. We have proposed an expansion of this program and revised rates that are cost-competitive with gasoline. These fuel cost savings can help encourage greater EV adoption as it further improves the economics of owning an electric vehicle.

We have also established pricing options of tariffs for electric buses and commercial customers. The tariffs also provide significantly lower demand charges than the corresponding commercial rate schedules, Schedules J and P.

To complement the pricing options, our "Charge Up" programs are intended to reduce the upfront costs of installing charging infrastructure for bus operators, commercial customers, and EV service providers. Participants in these programs are required to use the EV time-of-use rates, which promotes charging during the daytime, but we have received feedback that this can be challenging for operational efficiencies of some participants.

11.1.2 Customer Programs Valuation

The "freeze" scenarios described in Section 6.8 can be leveraged to inform the potential value of achieving the forecasted adoption of a particular technology, similar to the work completed in the DER proceeding that led to the creation of the Battery Bonus program. Customer technologies not only provide choices for customers to control their energy bills, but they also remain critical to reducing the amount of large-scale resources (and land) that is needed to meet our goals. Additionally, we hope to create programs where not only customers benefit but the broader grid as well, and customers are equitably compensated for the services they deliver.

The EE, private rooftop solar, and EV charging adoption forecasts may be evaluated to determine potential value to inform program development that seeks to achieve the levels forecasted. The general framework for the freeze analysis is shown in Figure 11-2.

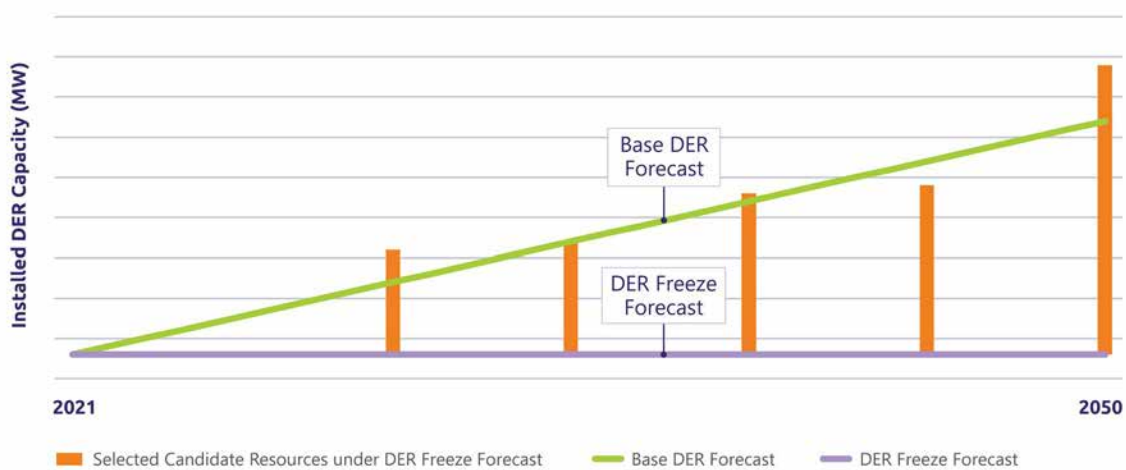


Figure 11-2. Illustration of values derived from freeze analysis

Determining the cost of the system without the forecasted adoption (i.e., frozen at current levels) compared to the cost of the system with the forecasted adoption effectively provides the approximate value of the addition of the customer energy resource. Using the DER Freeze as an example, when the distributed energy resources are frozen at current levels, additional resources will need to be built and selected by the models to replace the customer-sited resources assumed in the forecasted adoption. We can then determine the value of the customer technologies by evaluating the difference in cost between the Base scenario with the forecasted layer and DER Freeze, where the value is effectively avoiding the cost of those additional resources.

The performance characteristics of the resource (i.e., DER capabilities to provide grid services, EV charging profiles, EE supply bundles) are critical to appropriately valuing a program. From a system cost perspective, a program could be deemed cost-effective if the all-in cost of a program is less than the value determined in the freeze analysis. The design of the program should also reflect the performance requirements and services modeled. Any incentives allocated as part of the program should be performance-based to ensure that customers are receiving the commensurate benefits. The freeze analyses are intended to provide high-level guidance to inform more detailed discussions to create new programs or update current ones. The detailed design of programs may include other cost perspectives, aside from the system cost perspective as analyzed here, such as the rate impact to all customers, impact to customers participating in the programs, and impact to non-participating customers, to ensure that programs are being designed equitably.

The results of the Freeze scenarios shown in Table 11-1 indicate that there are cost savings if distributed energy resources (rooftop solar and battery energy storage) or energy efficiency is adopted as forecasted (except on Molokaʻi) and cost increases if electric vehicles are adopted as forecasted.

Table 11-1. Avoided Costs for the Freeze Scenarios, Relative to Base

NPV Avoided Cost (2018$, $MM)	DER Freeze	EV Freeze	Unmanaged EV	EE as a Resource
Oʻahu	580	-1,053	87	196
Hawaiʻi Island	150	-221	13	293
Maui	178	-37	37	72
Molokaʻi	3.7	-1.9	0.2	-1.5
Lānaʻi	1.3	-0.9	-0.1	0.5

Compared to unmanaged EV charging, managed charging does provide cost savings on all islands (except Lānaʻi) but not enough to offset the cost increases due to the overall higher demand from electric vehicles. The NPV avoided cost provides the break-even dollars that can inform incentives or total program costs to incentivize customers to adopt distributed energy resources or to allow the dispatch of their electric vehicles as a resource to serve grid needs.

11.1.2.1O‘ahu

Figure 11-3 shows the resource capacity added for the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios, and Figure 11-4 shows the NPV of the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios. Cost is displayed in millions of 2018 dollars (2018$MM).

The following offers a summary of the valuation of customer resources that may be used to inform the design of future or current program updates:

- The DER Freeze scenario is similar to the Base scenario. Slightly more hybrid solar is selected in the DER Freeze scenario than in the Base scenario to compensate for the lower DER capacity.
    - More resources built results in an NPV that is approximately 7% higher than the Base scenario NPV.
- The EE as a Resource scenario selects the EE supply bundle, standalone solar, and renewable firm in addition to the renewable resources selected in the Base scenario. As shown in Section 11.1.3, the load impact of the EE supply curves is smaller than the EE load forecast. This results in more selected resources and higher generation need for the EE as a Resource scenario than for the Base scenario.
    - More resources built results in an NPV that is approximately 2% higher than the Base scenario NPV.
- The EV Freeze scenario selects fewer resources than the Base scenario, including no biomass resource. This highlights the growing load impact of electric vehicles, especially over time.
    - Fewer resources built results in an NPV that is approximately 12% lower than the Base scenario NPV.
    - The cost of electrification growth is partially offset by the savings from forecasted distributed energy resources and energy efficiency.
- The Unmanaged EV scenario is almost the same as the Base scenario with its managed EV forecast; however, more biomass is built.
    - The minimal NPV difference of 1% also implies little change between the Managed EV and Unmanaged EV scenarios.

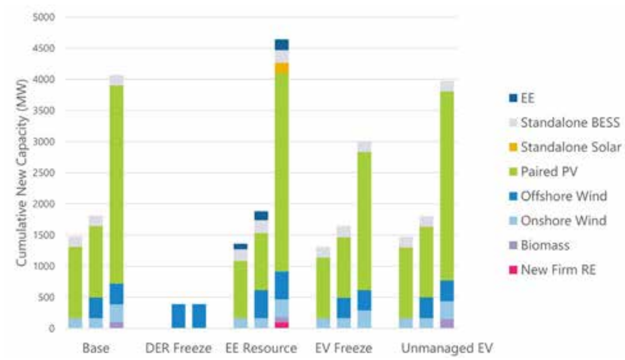


Figure 11-3. O‘ahu: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

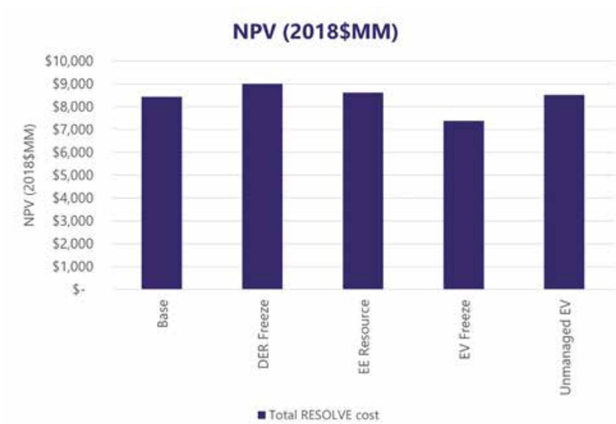


Figure 11-4. O‘ahu: NPV relative to the Base scenario for the DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

11.1.2.2Hawai'i Island

Figure 11-5 shows the resource capacity added for the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios, and Figure 11-6 shows the NPV of the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios. Cost is displayed in millions of 2018 dollars.

The following offers a summary of the valuation of customer resources that may be used to inform the design of future or current program updates:

- The DER Freeze scenario is similar to the Base scenario. More hybrid solar is selected in the DER Freeze scenario than in the Base scenario to compensate for the lower DER capacity.
  - More resources built results in an NPV 11% higher than the Base scenario NPV.
- The EE as a Resource scenario selects the EE resource, stand-alone solar, and renewable firm in addition to the renewable resources selected in the Base scenario. As shown in Section 11.1.3, the load impact of the EE supply curves is smaller than the EE load forecast. This results in more selected resources and a higher generation for the EE as a Resource scenario than for the Base scenario.
  - More resources built results in an NPV 22% higher than the Base scenario NPV.
- The EV Freeze scenario selects fewer resources than the Base scenario. This highlights the growing load impact of electric vehicles, especially over time.
  - Fewer resources built results in an NPV 17% lower than the Base scenario NPV with the added electrification loads.
  - The cost of electrification growth is partially offset by the savings from forecasted distributed energy resources and energy efficiency.
- The Unmanaged EV scenario is almost the same as the Base scenario with its managed EV forecast.
  - The 1% NPV increase also implies little change between the Managed EV and Unmanaged EV scenarios.

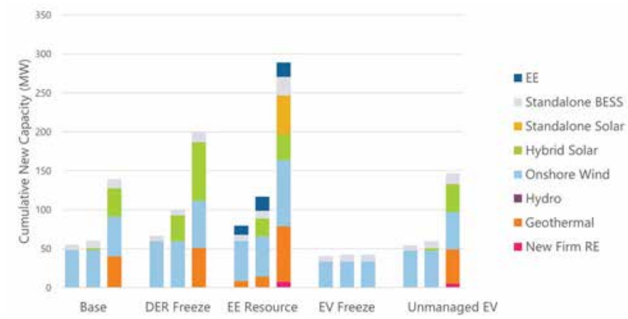


Figure 11-5. Hawai'i Island: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

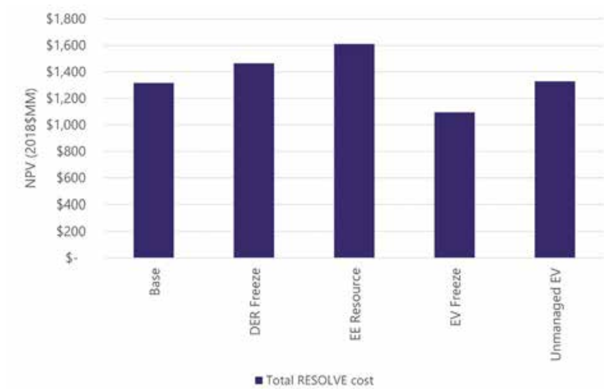


Figure 11-6. Hawai'i Island: NPV relative to the Base scenario for the DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

11.1.2.3Maui

Figure 11-7 shows the resource capacity added for the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios, and Figure 11-8 shows the NPV of the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios. Cost is displayed in millions of 2018 dollars.

The following offers a summary of the valuation of customer resources that may be used to inform the design of future or current program updates:

- The DER Freeze scenario is similar to the Base scenario. More hybrid solar is selected in the DER Freeze scenario than in the Base scenario to compensate for the lower DER capacity.
  - More resources built results in an NPV 8% higher than the Base scenario NPV.
- The EE as a Resource scenario selects the EE supply bundles in addition to the renewable resources selected in the Base scenario. As shown in Section 11.1.3, the load impact of the EE supply curves is larger than the EE load forecast. This results in more selected EE measures than the energy efficiency forecast in the Base scenario.
  - More resources built results in an NPV 3% higher than the Base scenario NPV.
- The EV Freeze scenario selects less hybrid solar and wind resources than the Base scenario. This highlights the growing load impact of electric vehicles, especially over time.
  - Fewer resources built results in an NPV 12% lower compared to the Base scenario with the added electrification loads.
  - The cost of electrification growth is partially offset by the savings from forecasted distributed energy resources and energy efficiency.
- The Unmanaged EV scenario is almost the same as the Base scenario with its managed EV forecast.
  - The minimal NPV difference of 2% also implies little change between the Managed EV and Unmanaged EV scenarios.

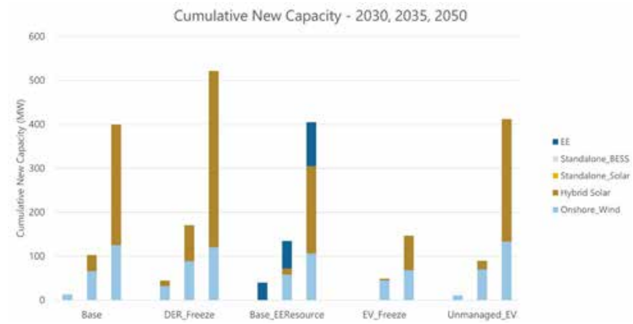


Figure 11-7. Maui: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

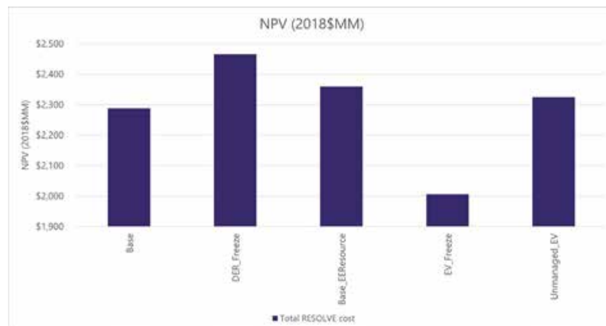


Figure 11-8. Maui: NPV relative to the Base scenario for the DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

11.1.2.4Molokaʻi

Figure 11-9 shows the resource capacity added for the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios, and Figure 11-10 shows the NPV of the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios. Cost is displayed in millions of 2018 dollars.

The following offers a summary of the valuation of customer resources that may be used to inform the design of future or current program updates:

- The DER Freeze scenario is similar to the Base scenario. Slightly more hybrid solar is selected in the DER Freeze scenario than in the Base scenario to compensate for the lower DER capacity.
    - More resources built results in an NPV that is approximately 6% higher than the Base scenario NPV.
- The EE as a Resource scenario selects the EE supply bundle in addition to the renewable resources selected in the Base scenario. As shown in Section 11.1.3, the load impact of the EE supply curves is greater than the EE load forecast. This results in slightly fewer selected resources and lower generation need for the EE as a Resource scenario than for the Base scenario.
    - Fewer resources built results in an NPV that is approximately 2% lower than the Base scenario NPV.
- The EV Freeze scenario selects fewer resources than the Base scenario. This highlights the growing load impact of electric vehicles, especially over time.
    - Fewer resources built results in an NPV that is approximately 3% lower than the Base scenario NPV.
    - The cost of electrification growth is partially offset by the savings from forecasted distributed energy resources and energy efficiency.
- The Unmanaged EV scenario is almost the same as the Base scenario with its managed EV forecast
    - The minimal NPV difference of close to 0% implies little change between the Managed EV and Unmanaged EV scenarios.

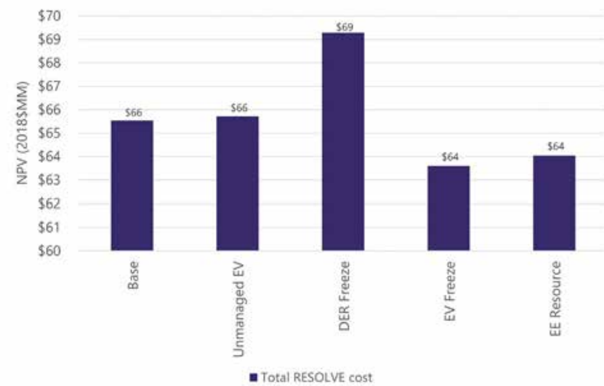


Figure 11-9. Molokaʻi: NPV relative to the Base scenario for the DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

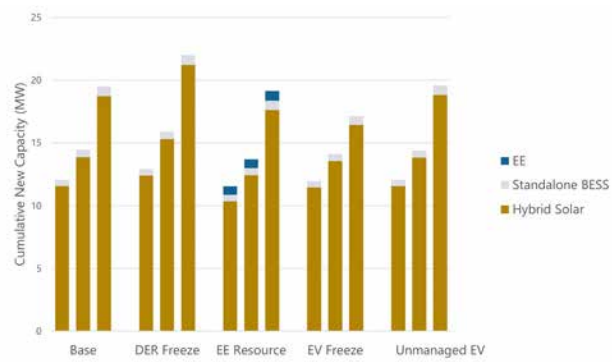


Figure 11-10. Molokaʻi: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

11.1.2.5Lānaʻi

Figure 11-11 shows the resource capacity added for the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios, and Figure 11-12 shows the NPV of the Base, DER Freeze, EE Resource, EV Freeze, and Unmanaged EV scenarios. Cost is displayed in millions of 2018 dollars.

The following offers a summary of the valuation of customer resources that may be used to inform the design of future or current program updates:

- The DER Freeze scenario is similar to the Base scenario. Slightly more hybrid solar is selected in the DER Freeze scenario than in the Base scenario to compensate for the lower DER capacity.
  - More resources built results in an NPV that is approximately 2% higher than the Base scenario NPV.
- The EE as a Resource scenario selects the EE supply bundle and standalone solar in addition to the renewable resources selected in the Base scenario. As shown in Section 11.1.3, the load impact of the EE supply curves is greater than the EE load forecast. Despite this, by 2050, there's slightly more selected resources and higher generation need for the EE as a Resource scenario than for the Base scenario.
  - More resources built results in an NPV that is approximately 1% higher than the Base scenario NPV.
- The EV Freeze scenario selects fewer resources than the Base scenario. This highlights the growing load impact of electric vehicles, especially over time.
  - Fewer resources built results in an NPV that is approximately 1% lower than the Base scenario NPV.
  - The cost of electrification growth is offset by the savings from forecasted distributed energy resources and energy efficiency.
- The Unmanaged EV scenario is almost the same as the Base scenario with its managed EV forecast.
  - The minimal NPV difference of close to 0% implies little change between the Managed EV and Unmanaged EV scenarios.

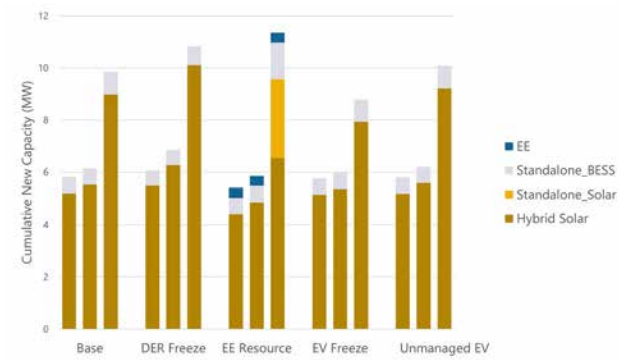


Figure 11-11. Lānaʻi: cumulative new capacity selected by RESOLVE in 2030, 2035, and 2050 for the Base, DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

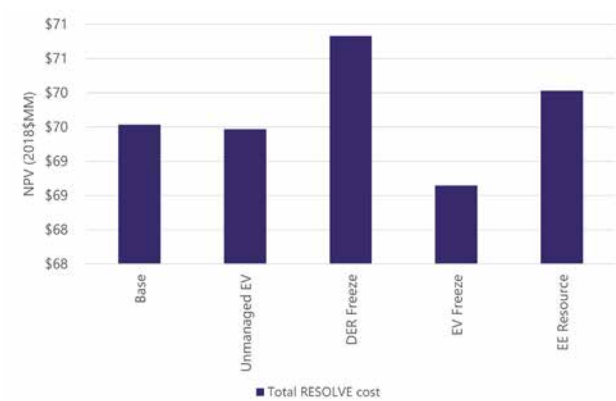


Figure 11-12. Lānaʻi: NPV relative to the Base scenario for the DER Freeze, EE Supply Curve, EV Freeze, and Unmanaged EV scenarios

11.1.3 Energy Efficiency as a Resource

Evaluating energy efficiency as a selectable resource can help to identify the shapes and costs of cost-effective EE measures as well as validate the sets of measures that were screened for cost-effectiveness in the market potential study.

In the supply curve bundling using the market potential study results, the majority of measures were screened to be highly cost-effective in the "A" grouping and flatter "Other" measures provided a significant portion of the energy savings in the Achievable Technical potential. Their selection in the RESOLVE modeling validates the benefit-cost testing in the market potential study, that energy efficiency can be a cost-effective resource alongside other supply-side resources and that peak focused measures are not necessarily desired more than flatter measures.

Across all islands, the same measures that were screened to be cost-effective in the market potential study with benefit-cost ratios greater than 1 were also selected by RESOLVE. On O'ahu and Hawai'i Island, the flatter "Other" bundles were preferred and less energy efficiency was selected than in the Base forecast. On Maui and Moloka'i, "Other" and "Peak" bundles were preferred with more energy efficiency selected than in the forecast. On Lāna'i, only the "Other" bundles were selected with the selected energy efficiency exceeding the forecast.

The model's preference for the "Other" shape mimics a baseloaded firm unit. While the "Peak" shape was also selected on some islands, the "Other" shape was selected in greater quantities, indicating that reducing system costs in all hours is more cost-effective than targeting just the peak hours.

Although the model did not select the exact same amount of energy efficiency as assumed in the Base forecast, the Base forecast provides a reasonable target for energy efficiency to be procured through a grid services type of competitive procurement because other resource, transmission, and distribution needs were based on achieving at least the energy efficiency level forecasted in the Base scenario. The procurement can provide a market test for the cost and performance of energy efficiency and an opportunity to evaluate specific EE proposals rather than the aggregated supply curves considered here. Additionally, more energy efficiency would contribute toward meeting our carbon reduction goals and could reduce land requirements for large-scale resources.

11.1.3.1 O'ahu

In the O'ahu Base forecast, RESOLVE selected the "Other A" bundle, and no Peak bundles were selected. Additionally, as shown in Figure 11-13, combined energy efficiency because of codes and standards and the selected "Other A" bundle is less than the base EE forecast for most hours of the day, especially during the evening.

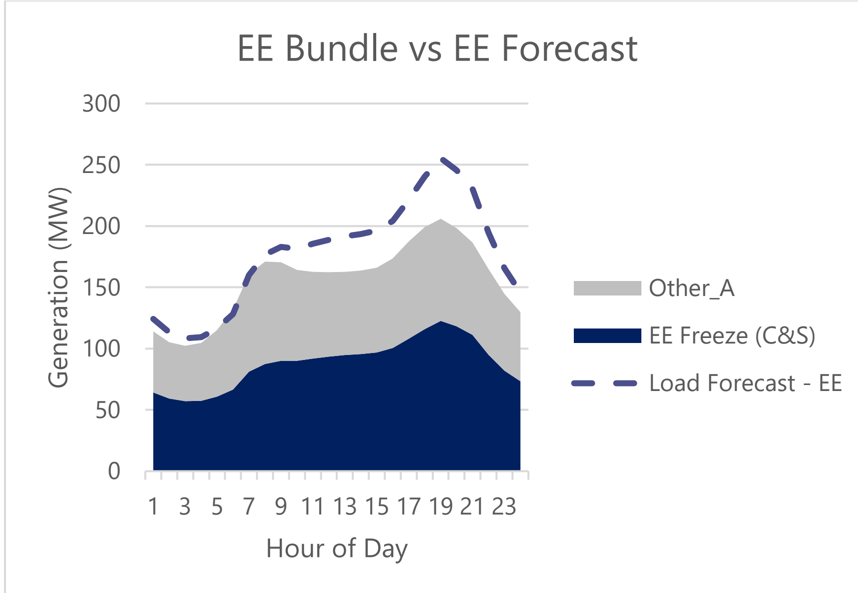


Figure 11-13. O'ahu: EE Base forecast layer vs. EE RESOLVE selected resources, 2030

11.1.3.2 Hawai'i Island

In the Hawai'i Island Base forecast, RESOLVE selected the "Other A" and "Other B" bundles, and no "Peak" bundles were selected. Additionally, as shown in Figure 11-14, combined energy efficiency because of codes and standards and the selected bundles is less than the Base EE forecast for most hours of the day, especially during the evening.

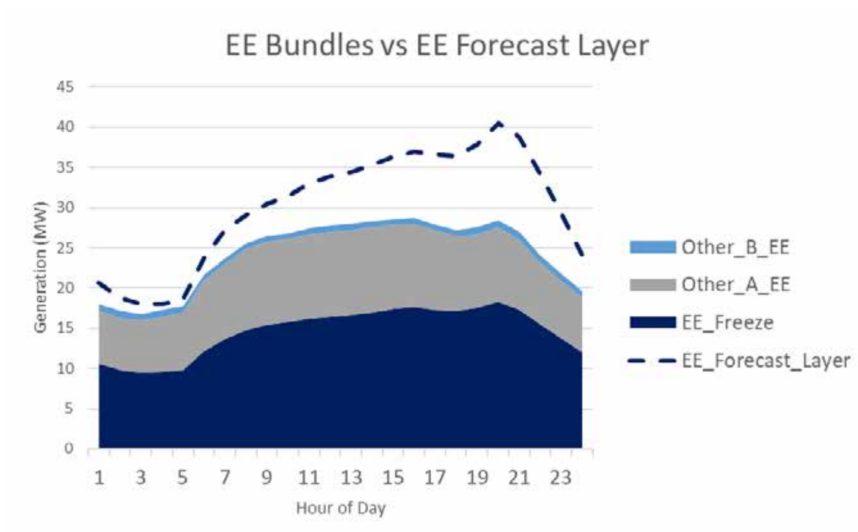


Figure 11-14. Hawai'i Island: EE Base forecast layer vs. EE RESOLVE selected resources, 2030

11.1.3.3Maui

In the Maui Base forecast, RESOLVE selected the “Peak A,” “Peak B,” “Other A,” and “Other B” bundles. As shown in Figure 11-15, the amount of EE bundles selected were greater than the base EE forecast for all hours of the day. This indicates that more energy efficiency than forecasted on Maui would be cost-effective for the system.

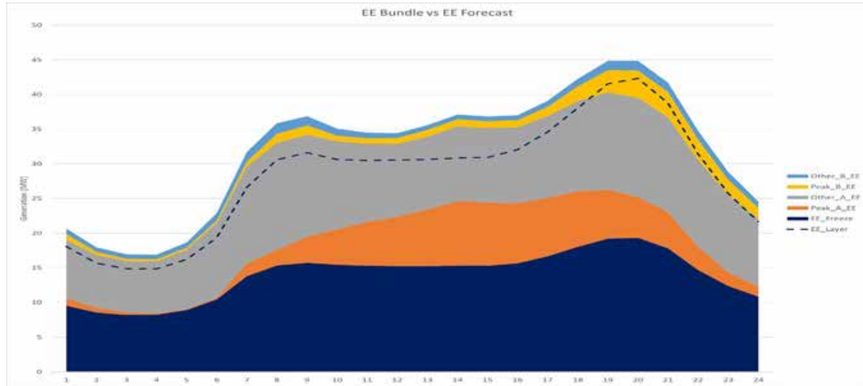


Figure 11-15. Maui: EE Base forecast layer vs. EE RESOLVE selected resources, 2030

11.1.3.4Moloka‘i

In the Moloka‘i Base forecast, RESOLVE selected the “Peak B,” “Other A,” and “Other B” bundles. As shown in Figure 11-16, the amount of EE bundles selected were greater than the Base EE forecast for all hours of the day. This indicates that more energy efficiency than forecasted on Moloka‘i would be cost-effective for the system.

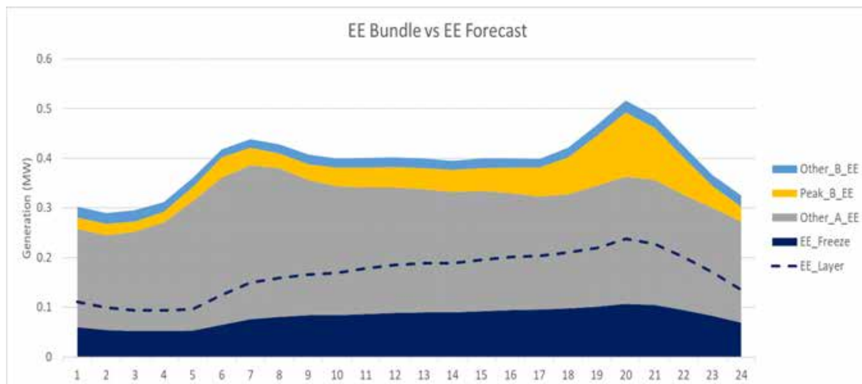


Figure 11-16. Moloka‘i: EE Base forecast layer vs. EE RESOLVE selected resources, 2030

11.1.3.5Lāna‘i

In the Lāna‘i Base forecast, RESOLVE selected the “Other A” and “Other B” bundles. As shown in Figure 11-17, the amount of EE bundles selected were greater than the Base EE forecast for all hours of the day. This indicates that more energy efficiency than forecasted on Moloka‘i would be cost-effective for the system.

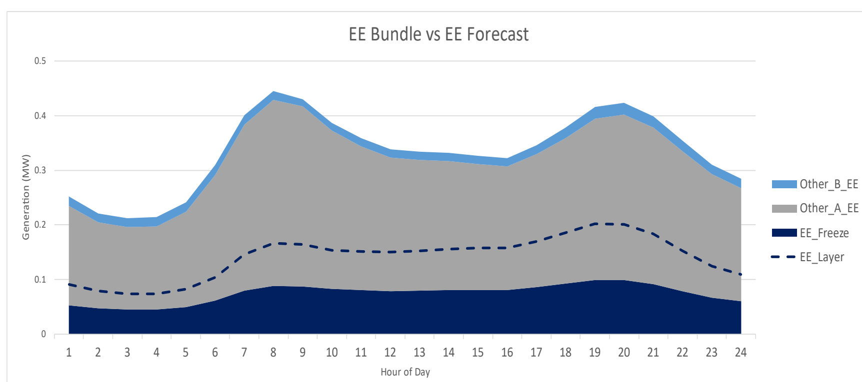


Figure 11-17. Lāna‘i: EE Base forecast layer vs. EE RESOLVE selected resources, 2030

11.2 Procurement Plan

The following sections describe our plans to competitively procure resources aligned with the needs identified in this report. Competitive procurements are governed by the Framework for Competitive Bidding to ensure a fair process, which allows us to seek solutions from the market at the best prices for our customers.

11.2.1 Process

With the preferred resource plans on each island identified, the resource, transmission, and distribution needs will inform various RFPs (or other mechanisms like requests for information or expressions of interest) to seek competitive solutions from the market.

The novelty of Integrated Grid Planning is the seamless integration between planning and sourcing solutions from the energy marketplace. We envision that procurements for various needs are warranted and, as described in this section, we plan to procure large-scale resources, NWAs, and grid services. There are specific locational benefits as identified in the transmission and distribution needs analysis that may also be integrated into the various RFPs.

The Framework for Competitive Bidding, included in Appendix G, which was put forth by the competitive procurement working group and approved by the Public Utilities Commission for use in the Integrated Grid Planning process, was modified to reflect the current planning environment that has evolved in the 14 or more years since the initial framework was created.

The revised Framework for Competitive Bidding considered a few key areas:

- **Grid needs and system resources.** We updated the framework to describe the steps and process broadly to allow for more flexibility to meet grid needs to reflect the current market environment, such as new resource technologies and NWAs.
- **Long-term RFP.** While no specific updates were made for projects that require longer development time (i.e., 8–12 years), the Working Group believed that the updated framework provides sufficient flexibility to issue procurements of this type.
- **Interconnection and procurement scoping.** This is an area that the Working Group agreed could be pursued outside the framework and, therefore, no modifications were made. However, we have been working with stakeholders to improve and streamline the interconnection process and have been doing so through the recent CBRE and Stage 3 procurements as well as through the Performance-Based Regulation proceeding.

Finally, to grow the energy market as intended, we envision routine procurements to urgently address the needs as discussed throughout this report. We have a long way to go to reach our goals with time running short; to that end these Integrated Grid Plans serve as living roadmaps that provide sufficient guidance to acquire solutions to meet our goals. Similar to the progress we have made through Stage 1, 2, and 3 procurements over the past several years, we expect to continue competitive procurements on a routine basis for the years ahead.

11.2.2 Large-scale Competitive Procurements

Competitive procurements are a key way to ensure that we acquire the lowest-cost, best-fit resources for customers to address affordability.

Additionally, consistent with State policy, and in its Inclinations, the Public Utilities Commission stated its intent to pursue a balanced portfolio of energy resources:

> There is clear evidence that pursuing a diverse portfolio of renewable energy resources provides the best long-term strategy to maximize the use or renewables to achieve public policy goals. Project development and system integration costs may rise as higher levels of renewable resources are added to each grid and higher levels of any single energy resource will increase the challenge of adding new projects. Furthermore, as communities with the most abundant indigenous renewable resource are increasingly asked to host energy infrastructure, these communities are understandably concerned with the impacts of these projects and have voiced their opposition in several instances. For these reasons, the Commission supports a balanced and diverse portfolio of energy resources as the best long-term strategy to achieve the state's energy goals.

The challenges identified in the Inclinations have come into sharper focus in recent years. Communities are understandably concerned with the use of land and hosting projects in their neighborhoods. As discussed in this report, community engagement is central to the energy system transformation. A balanced portfolio of resources will ultimately increase reliability and resilience, introduce geographic diversity, and allow for sustainable uses of land.

Through our community engagement efforts and analysis to evaluate renewable energy zones, we are also considering different options to identify communities we can collaborate with to develop renewable energy zones to site future renewable projects. Pre-selecting locations or areas for renewable projects as part of the RFP has potential benefits, including to engage with communities early, plan and build infrastructure needed to enable or expand transmission capacity, and streamline the procurement process.

We also prefer competitive procurements to specify attributes, services, and capabilities required rather than specific technologies. However, recent all-source procurements through the Stage 1 and Stage 2 RFPs have led to the acquisition of exclusively solar paired with 4-hour energy storage and standalone energy storage resources. As described in Section 12.3, as the quantity of solar and storage increases, the value of solar and storage diminishes in their ability to fully replace the firm capacity resources that are expected to be retired over the next decade. To address reliability and resource diversity, a range of technology options should be considered, including variable and firm generation, fuel flexibility, renewable fuels, long-duration storage, offshore resources, and pump storage hydro, among others. These types of projects may take longer to develop than solar and storage projects. In some instances, it may be prudent to specify technologies consistent with the Integrated Grid Plan to send market signals that certain types of attributes are needed to fulfill certain grid needs.

11.2.3 Long-term RFP

To facilitate enabling resource diversity we believe issuing an RFP that allows projects that have longer development times (such as pump storage hydro, offshore wind, geothermal, and projects that require transmission infrastructure) to submit proposals is the prudent course of action. These are the types of resources and technologies that have either been suggested by communities and stakeholders or selected in the capacity expansion modeling. The long-term RFP concept is supported by intervenors in the Integrated Grid Planning proceeding. Progression Hawai'i stated, in response to our first review point, that it supports a "long-term RFP concept as a pathway to integrate other technologies into the resource portfolio other than solar and storage that will enhance the reliability and resilience of the system through resource diversification" (March 4 Reply Comments at 54). Progression Hawai'i further recommended that the solicitation allow commercial operations out to 2035 (June Reply Comments at 5).

In preparation for the long-term RFP, we issued an expression of interest for multi-day energy storage in April 2022, and for projects that require a longer development time frame in July 2022. We received several responses and we discussed the results of the expression of interest at the Stakeholder Technical Working Group meeting in February 2023. In that meeting, we discussed what changes to the RFP process would need to occur to facilitate the inclusion of long-term resources into the first round of Integrated Grid Plan procurements.

We identified numerous RFP terms that would require modification if long-term resources were to be included in the same solicitation as more near-term resources. First, both developers and Hawaiian Electric recognized the challenges of providing and holding to firm pricing for resources that could be years longer away from commercial operation than the projects currently procured. This challenge further impacts the ability to effectively evaluate near-term and long-term resources if the pricing for long-term resources could change. Other examples of modifications that will likely be necessary include the requirements for certain actions at the time of bid submission, such as site control, and model submission. In addition, the overall RFP schedule will likely require modification, and contract terms will also need to be developed to contemplate the longer period between contract execution and commercial operations.

Given the necessary differences identified, it is likely that a separate RFP for long-term resources will be needed. An RFP with terms that contemplate the longer development cycle can be better tailored to the uncertainty surrounding bids with significantly later in-service dates. The idea would be to issue both the near-term and long-term procurements in the same time frame.

In the development of the long-term RFP, the Public Utilities Commission also instructed Hawaiian Electric to assess the "feasibility of using existing power plant sites to locate new, quick-start, fuel-efficient, flexible generation, to leverage existing site transmission and fuel supply infrastructure capacity that would be freed-up by retirements of existing generating units" (Order 32053 at 93). While the long-term RFP has not yet been drafted, we will look to further explore this possibility.

Pursuant to the Public Utilities Commission's guidance, we are also exploring if other company-owned sites could be made available for interconnection of a variety of technologies in our RFPs, and further seeking ways to streamline the interconnection process.

11.2.4 Bid Evaluation

Consistent with the approved Framework for Competitive Bidding and the process employed in the Stage 1, Stage 2, and Stage 3 RFPs, the Integrated Grid Plan RFPs will continue to employ a multi-step evaluation process. Once the proposals are received, they will be subject to a consistent and defined review, evaluation, and selection process. We review each proposal submission to determine if it meets the Eligibility Requirements and Threshold Requirements. Proposals that have successfully met these requirements will then enter a two-phase process for proposal evaluation, which includes the Initial Evaluation resulting in the development of a Priority List, followed by the opportunity for Priority List proposals to provide Best and Final Offers, and then a Detailed Evaluation process to arrive at a Final Award Group.

The Initial Evaluation consists of two parts: a price evaluation and a non-price evaluation. The price and non-price evaluations result in a relative ranking and scoring of all eligible proposals. In the Stage 3 RFP, 11 non-price criteria range from community outreach to experience and qualifications, to financial strength and financing plan. While the criteria for the Integrated Grid Planning RFP have yet to be developed, they will largely be similar to what has been included in previous RFPs.

11.2.5 NWA Competitive Procurement

For the favorable NWA opportunities to address distribution grid needs identified in the distribution planning process, we will first seek Expression of Interest (EOI) from developers and aggregators who are capable of developing grid-scale renewable projects or aggregating distributed energy resources/energy efficiency in locations that will help reduce loading on circuits and transformers that are forecasted to experience overload conditions. Performance requirements in the form of yearly capacity (MW) and energy (MWh) grid needs, along with corresponding hourly peak MW and energy profiles, are provided in the EOI. The NPV replacement or deferral value of the traditional wires solution is also included to provide guidance on the potential cost-competitiveness of NWA solutions.

Upon receiving sufficient interest to develop cost-competitive grid-scale renewable projects or aggregating DER/EE projects in the identified locations to address the distribution grid need, we intend to issue targeted RFPs to procure the grid need resources under the Framework for Competitive Bidding.

11.2.6 Grid Services Competitive Procurement

In addition to programs, there are opportunities to acquire customer energy resources through competitive procurements as we have done over the past several years through grid service purchase agreements.

We plan to continue to seek grid services through contractual agreements. Based on the EE supply curve analysis we believe that including energy efficiency as part of the grid services would help to complement existing EE programs, accelerate adoption of energy efficiency, allow for competitive market pricing, and target location-specific benefits.

Resilience and Microgrids

As discussed in Sections 7 and 10, resilience is an important part of the Integrated Grid Plan. We currently have in place a microgrid services tariff and a utility-owned and -operated microgrid, the Schofield Generation Station, in partnership with the U.S. Army to support critical operations. We are also seeking to develop a microgrid for the North Kohala community through a competitive procurement. In the case of North Kohala, the value of the microgrid includes the deferral of a second sub-transmission line (i.e., an NWA) to supply North Kohala whenever there is an outage on the sub-transmission line that feeds the community. We believe that enhancing the resilience of communities through competitive procurement of resilience services would substantially meet the objectives of Act 200 and the Public Utilities Commission’s microgrid services proceeding. We plan to apply the lessons learned of the North Kohala RFP and implementation to future procurements that would identify potential microgrid opportunities that are aligned with our ETIPP, equity, resilience system hardening program, and Resilience

Working Group efforts. A procurement would also allow the market to determine the value and compensation for resilience services, provide flexibility to determine the performance and capabilities needed for each unique microgrid opportunity, the best way to integrate and use DER for resilience, determine the supply and demand for microgrids in Hawai'i, and identify prospective developers of microgrids. Additional valuations of resilience consistent with methods currently contemplated by the industry as discussed in Section 7 may also be considered.

11.2.7 Revised Portfolio

Following the selection of programs and projects in the Integrated Grid Plan procurements, near-term generic resources identified in the preferred resource plan to meet grid needs will be replaced by the actual procured resource. In the next cycle of Integrated Grid Planning or as part of smaller updates, these resources will be assumed as planned additions and a starting point from which incremental grid needs can be identified.

12. Securing Generation Reliability and Assessing Risks

We performed an in-depth generation reliability analysis to establish conditions and pathways to deactivate, retire, or, in some cases, accelerate retirement of fossil fuel–based generators. This section further describes the risks and uncertainties and potential ways to mitigate them.

In our discussions with customers, reliability remains of paramount importance as we navigate the transition to 100% renewable energy. We must provide reliable service through the transition, especially as we modernize our generation portfolio. To have an unreliable system would undermine the trust we have with our customers and prevent us from achieving our desired goals.

The existing generating fleet is becoming increasingly less reliable because of age and the way we now operate the grid. We need new, modern generators that can more easily adapt to the changing grid that will be dominated by solar, wind, and energy storage resources. New, modern generators also come with higher reliability compared to the existing fossil fuel–based generators.

Generation reliability is an area of concern in Performance-Based Regulation and is intertwined with State policy to retire fossil fuel–based generation as soon as practicable, and the risks associated with continuing to operate our aging generation fleet well past its original design life.

In the Performance-Based Regulation proceeding, the Public Utilities Commission published a Staff Proposal of performance incentive mechanisms to address areas of concern, including grid reliability and timely retirement of fossil fuel–based generation. The Public Utilities Commission staff's objectives in proposing performance incentives in these areas are to ensure adequate planning and operations of grid reliability, and accelerate integration of renewable resources ahead of retirement schedules.

In addition, through Order 32053, Ruling on RSWG Work Product, in Docket 2011-0206, the Public Utilities Commission made the following observations in ordering the development of Power Supply Improvement Plans, which are addressed in this section:

1. The impact each retirement, without replacement, would have on adequacy of power supply and reserve margins under existing capacity planning criteria;

2. An analysis of how the capacity value of solar, wind, energy storage, and demand response resources will be factored into the determination of the adequacy of power supply;
3. An analysis of feasibility of utilizing existing power plant sites to locate new, quick-start, fuel-efficient, flexible generation, to leverage existing site transmission and fuel supply infrastructure capacity that would be freed-up by retirements of existing generating units (Order No. 32053 at 92-93)

Moreover, the 2020 management audit conducted by the Public Utilities Commission noted our current generating fleet operating risk. The auditor states that "despite best efforts, the risk of failures in parts of the plants—including catastrophic failures—will continue to increase … in our estimation this is an important risk that should not be disregarded and contingency plans should be developed." (Hawaiian Electric Management Audit Final Report at 168).

In the following section we use data and analysis to address these issues and offer a path forward to mitigate these risks.

12.1 Deactivation of Fossil Fuel–Based Generators

For the purposes of identifying grid needs our analysis assumed that certain amounts of firm fossil fuel–based generating capacity would be removed from operations. The actual deactivation or retirement of generation from service is conditioned upon several factors, including whether sufficient resources have been acquired and placed into service to provide replacement grid services, underwent a proving period to ensure reliable and stable operation, among other considerations, such as overall system reliability and resilience.

The planned removal-from-service schedules for Oʻahu, Hawaiʻi Island, and Maui are provided below in Table 12-1. These schedules represent initial assumptions made on the timing for the removal of utility-owned, fossil fuel–based generating units based primarily on age or environmental regulations.

Retirement decisions are permanent and irreversible, and in some cases, as described below, are forced by environmental compliance or our ability to obtain spare parts to continue operations of the generator.

Table 12-1. Planned Removal-from-Service Assumptions for Oʻahu, Hawaiʻi Island, and Maui

Year	Oʻahu	Hawaiʻi Island	Maui
2024	Waiau 3–4 removed from service		
2025		Puna Steam on standby	
2027	Waiau 5–6 removed from service	Hill 5–6 removed from service	Kahului 1–4, Māʻalaea 10–13 removed from service
2029	Waiau 7–8 removed from service		
2030			Māʻalaea 1–3, 4–9 removed from service
2033	Kahe 1–2 removed from service		
2037	Kahe 3–4 removed from service		
2046	Kahe 5–6 removed from service		

Deactivation is a state where there is no present intention to run the unit, but it is available for reactivation in an emergency. The unit is laid up and preserved and can be reactivated in a number of months if needed.

The Hill 5 and 6 and Kahului 1–4 generators are slated for retirement in their designated years to comply with the State Implementation Plan associated with the U.S. Environmental Protection Agency's Regional Haze Rule. Likewise, the Puna Steam unit will switch to a cleaner fuel and likely be placed in standby status for the same reasons. Standby status for Puna Steam will improve the resilience of the Hawai'i Island system. In May 2018, as a result of the loss of Puna Geothermal Venture from the Kilauea lava eruption, Puna Steam was brought back from standby status, which was critical to meet customer power demands.

Mā'alaea generating unit 7 will be required to install emission reduction technology by the end of 2027. In the future, other units may be subject to further operational limitations, emission controls, or forced retirements to meet environmental compliance needs.

Mā'alaea generators 10–13 have limited life remaining because the engine manufacturer has declared the engines obsolete and notified Hawaiian Electric that spare parts may no longer be available in the future. Because these are unique engines, aftermarket parts supply is not reliable. At this time we have secured parts to allow for the units to continue to operate for the next few years. At the same time, the Hawai'i Department of Health has identified the need for emission reductions for these units for the U.S. Environmental Protection Agency's Regional Haze rule. Such emission reduction systems would require significant investments in obsolete units as previously described. Therefore, we will be required to retire the units between 2029 and 2035 (one in 2029, one in 2030, and two in 2035). However, because of the obsolescence issue, we believe that the units would reach end of life between 2027 and 2029. Our plans include ensuring that new resources are brought online prior to these generating units reaching end of life. However, given the age of our generating fleet, it is possible that other generating units may be unexpectedly subject to parts obsolescence in the future.

Figure 12-1 through Figure 12-4 illustrate the age of the current Hawaiian Electric–owned generating fleet, which has served customers well over the past 70 years.

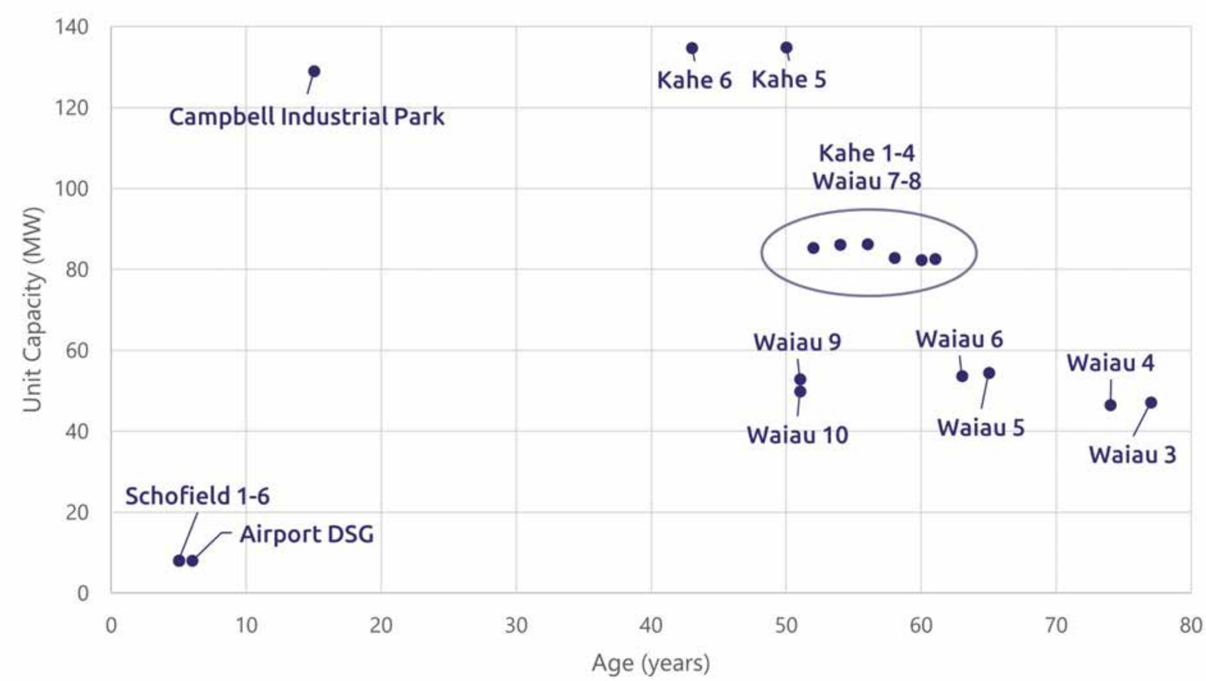


Figure 12-1. O‘ahu: size and age of utility-owned generating units

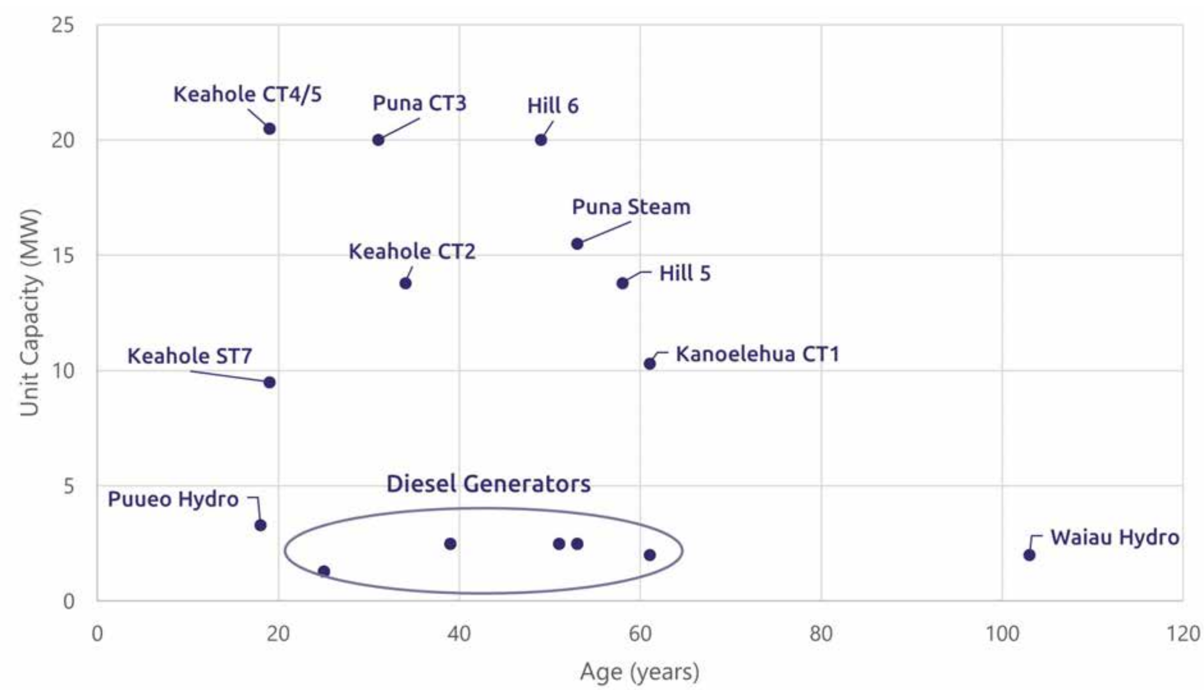


Figure 12-2. Hawai‘i Island: size and age of utility-owned generating units

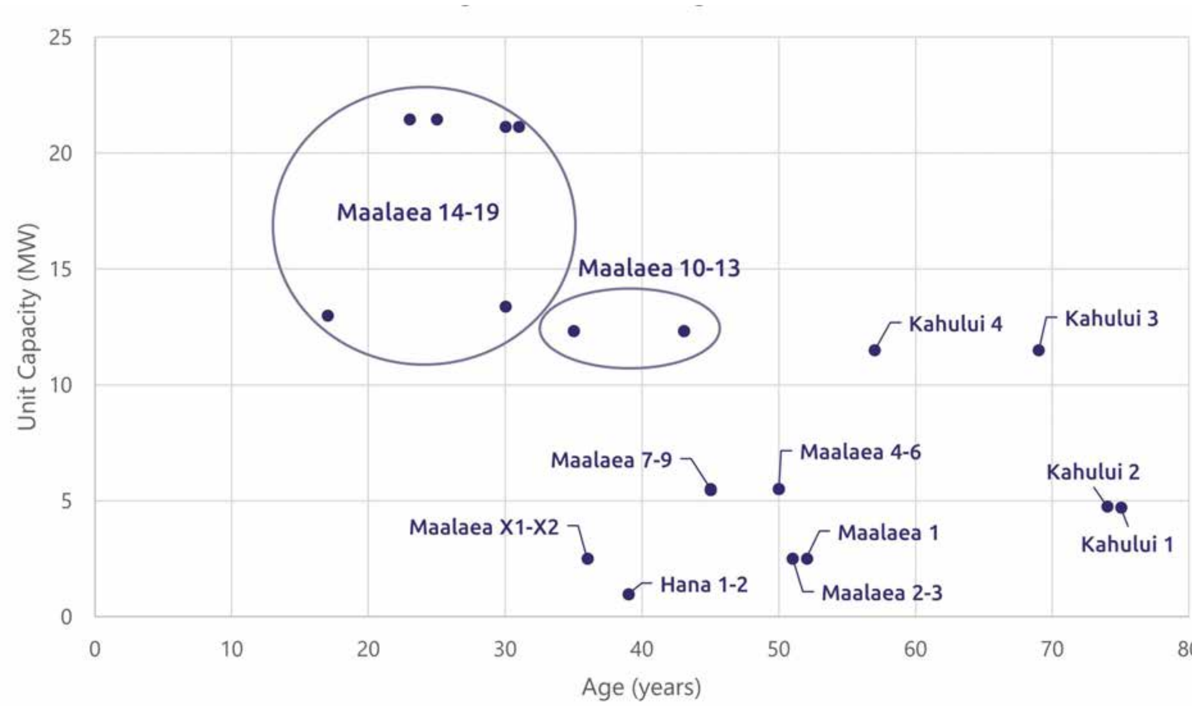


Figure 12-3. Maui: size and age of utility-owned generating units

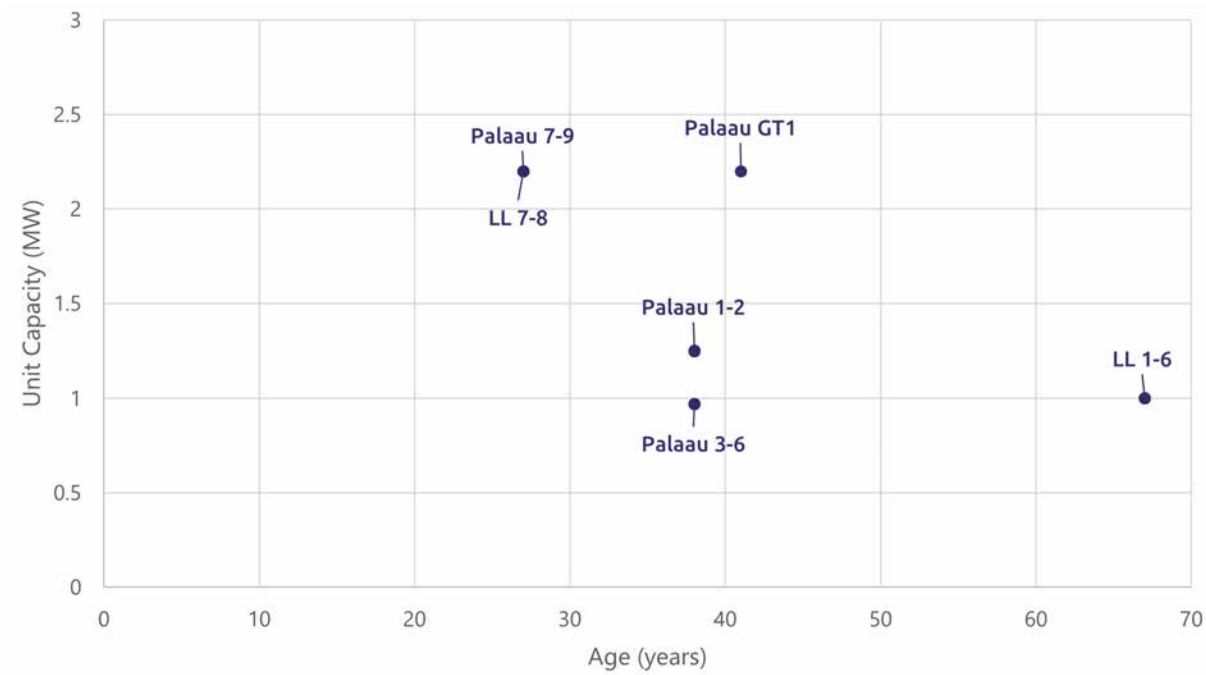


Figure 12-4. Molokaʻi and Lānaʻi: size and age of utility-owned generating units

By necessity, we operate the existing fossil fuel–based generation fleet at lower minimum loads and cycling units more than they were designed to do. As more renewable projects are integrated over the next few years, generating units, especially steam generation units, will be under increasingly variable operations. Operating the 50- to 75-year-old O'ahu fleet, for example, with increased load ramping, low-load operation, and offline cycling accelerates the aging process, which has led to and will continue to cause increasing rates of forced outages and/or derations of firm capacity on a daily basis, as shown in Figure 12-5. These reliability risks must be urgently addressed—this is foundational to achieving the State's decarbonization and renewable energy goals.

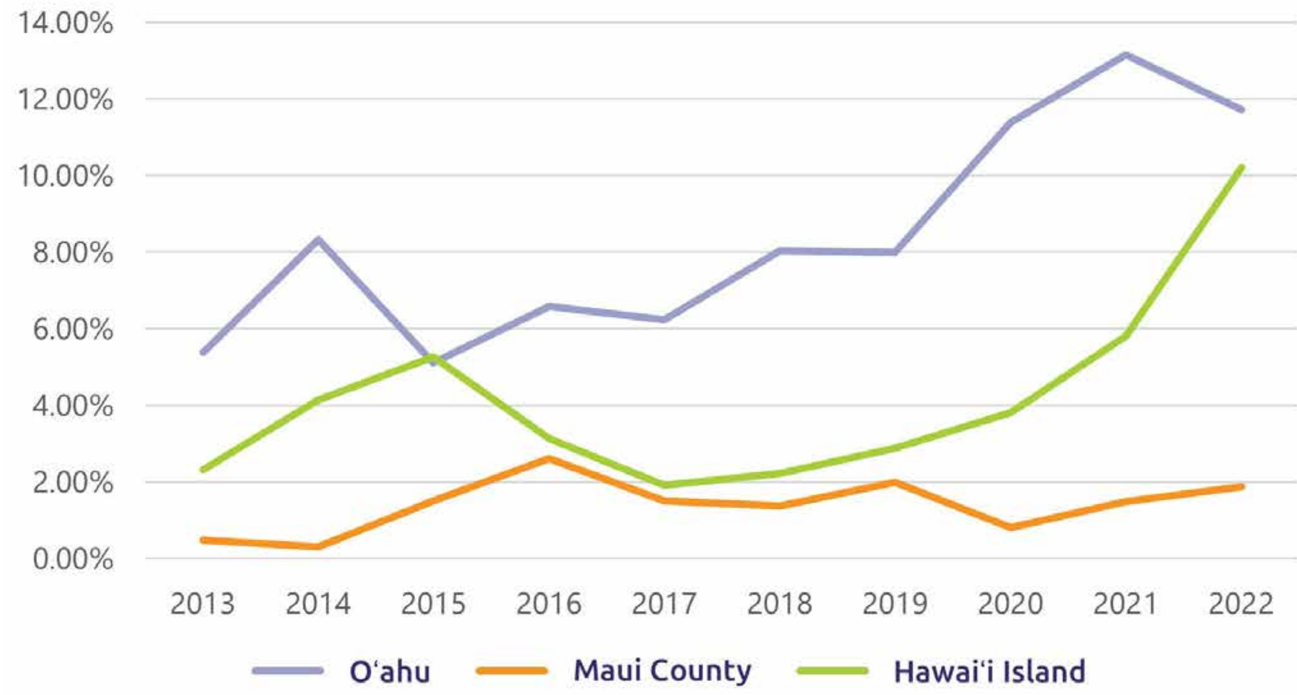


Figure 12-5. Weighted equivalent forced outage rates for O'ahu, Hawai'i Island, and Maui County

Major repairs and maintenance are expected on steam units for the reasons described above. Types of repairs include replacement of major turbine components, boiler tubes sections, major valves, major pumps, and other critical components. Likewise, increased maintenance on valves, boiler refractory, ducts, fans, feed pumps, and other components operating at the edge of their design curves will result in significant increases in operation and maintenance expenses.

To address these acute risks, our resource adequacy analysis identifies pathways to retirement or deactivation of our existing generation fleet as assumed, above, as well as ways to potentially accelerate the retirement or deactivation of our older fossil fuel–based generating units.

In the resource adequacy analysis for Hawai'i Island, we used long-term forced outage rates that may not wholly reflect the upward trend in outages observed in the last few years in Figure 12-5. The Hawai'i Island analysis may need to be revised in future analyses to reflect recent events including significant outages at Hamakua Energy Partners that has prompted calls for conservation.

12.2 Growth in Electric Vehicles

Several drivers for near–term growth of EV adoption also pose risks to ensuring sufficient adequacy of supply. Commitments by car rental companies and vehicle manufacturers will increase the availability and diversity of electric vehicles while County and State commitments will increase the coverage of the EV charging network. These commitments will encourage customers to adopt electric vehicles and as electric vehicles become more prevalent, electric demand will increase as these cars will need to be charged from the grid.

Several trends in EV adoption today already underscore the importance of proactive planning for electric vehicles:

- Standard & Poor's estimates that global EV sales grew by about 36% in 2022[35]
- Hawai'i State Energy Office data show 26% year-over-year growth in new EV/plug-in hybrid registrations in Hawai'i for 2022[36]

Commitments made by car rental companies and vehicle manufacturers as well as County and State governments will impact near-term EV adoption.

- Avis has plans to implement EV charging stations across all Hawai'i airports[37]
- Hertz aims to convert 25% of its fleet to electric by the end of 2024[38]
- General Motors, Ford, and Stellantis pledged 50% of new EV sales by 2030[39]
- The Hawai'i Department of Transportation has committed to deploy EV charging infrastructure and electrify its light-duty fleet[40]
- The City and County of Honolulu is converting its vehicle and bus fleet to all electric by 2035[41]

It's not a matter of if, but when EV adoption accelerates. Given the development time for renewable projects or firm generation, we must have sufficient capacity several years before it's needed. The load growth from accelerated EV adoption could happen quickly; for example, a State or federal policy could quickly ramp up EV adoption like the customer-sited solar boom under net energy metering in the 2010s. Because of this risk, Section 12.3 examines the High Load forecast, which incorporates the High EV load layer where aggressive policies are put into place to decarbonize light-duty vehicles and eBuses in the transportation sector.

[35] https://www.spglobal.com/commodityinsights/en/market-insights/blogs/metals/013123-ev-sales-momentum-to-face-challenges-in-2023-but-long-term-expectations-unaffected

[36] See Vehicle Registrations Fuel Types by Month CSV data set at: https://energy.hawaii.gov/energy-data/

[37] https://www.civilbeat.org/2023/02/honolulus-new-airport-rental-center-has-lots-of-electric-cars-but-only-one-charging-station/

[38] https://www.thedetroitbureau.com/2023/01/rental-car-giant-enterprise-backs-equitable-ev-charging-infrastructure-expansion/

[39] https://www.protocol.com/climate/electric-vehicle-automaker-goals

[40] https://hidot.hawaii.gov/blog/2021/04/14/first-electric-vehicles-picked-up-through-the-statewide-multi-agency-service-contract-arrive/

[41] https://www.resilientoahu.org/transportation

12.3 Generation Reliability Risk Assessment

Based on our experience, acute risks and uncertainties come with large-scale development of both solar and wind generation. We developed reliability curves that provide insight into how reliability may change if the optimal plans (as described in Section 8) are not realized or experience delays. Risks are particularly important to understand as the execution of project development has encountered significant challenges over the past several years and the degrading reliability of our existing generation system.

12.3.1 Oʻahu

Uncertainty in forecasted electricity demand is a large source of risk for O'ahu. Section 8.2.2 shows how the planned O'ahu system meets reliability targets in 2030 and 2035 but requires additional resources in a High electricity demand scenario. This section shows how adding or removing resources from the O'ahu system affects reliability metrics.

12.3.1.1 Hybrid Solar Reliability Impacts

As described earlier, if O'ahu obtains 450 MW of hybrid solar and 300 MW of firm generation by 2030 through the Stage 3 procurement, the system should meet the loss of load expectation target of 0.1 day per year. However, if we do not obtain any new firm generation, the system may not meet the loss of load expectation target depending on how much variable renewable generation is procured and placed into service.

To determine the sensitivity of the loss of load expectation based on the amount of variable renewable generation added in 2030, we removed any new firm generation that we plan to acquire through the Stage 3 procurement and varied the amount of future hybrid solar added in 2030.

As shown in Figure 12-6, in 2030, without any new firm generation, nearly 1,600 MW of hybrid solar is needed to meet the 0.1 day/year target. Shown below is the relationship between the loss of load expectation and future hybrid solar added in 2030. Figure 12-6 shows that as we incrementally add more future hybrid solar in 2030, its contribution toward reliability improvements greatly diminishes (particularly after 600 MW of hybrid solar is integrated onto the system), highlighting the need for a diverse resource portfolio. We expect similar results if we replace large-scale solar with distributed, customer-sited hybrid solar.

Importantly, this chart demonstrates the sensitivity of reliability that O'ahu has to small changes in capacity. For example, 200 MW of hybrid solar results in a significant swing (approximately 8.7 days per year) in reliability. We consider this point a significant consideration in how we plan and procure resources to meet our customers' reliability expectations.

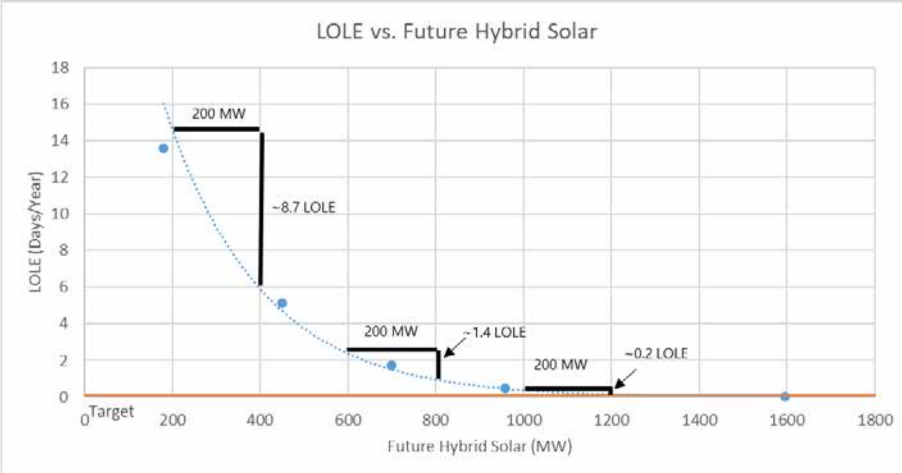


Figure 12-6. O'ahu: relationship between change in loss of load and change in future paired PV hybrid solar capacity, 2030

In Figure 12-7 below we present the unserved energy based on the month and hour of our existing system in 2021 (left) and the scenario where we do not add any new firm generation but obtain 450 MW of hybrid solar (right). With only the 450 MW hybrid solar resource (as targeted in Stage 3 procurement), we may experience significant unserved energy during the morning and evening hours because of the weather-dependent, energy-limited nature of wind, solar, and energy storage.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	1
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	1
17	0	0	0	0	0	0	0	0	0	0	0	4
18	0	0	0	0	0	0	0	0	9	6	3	12
19	0	0	0	0	0	0	0	4	19	9	3	10
20	0	0	0	0	0	0	0	2	10	3	1	7
21	0	0	0	0	0	0	0	1	3	5	1	9
22	0	0	0	0	0	0	0	0	0	1	0	5
23	0	0	0	0	0	0	0	0	0	0	0	3

Max
131 MW
0 MW
Min

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	2	10	53	35	31	13	5	0	2	0	0
1	0	1	2	32	29	20	7	3	1	2	0	0
2	0	1	4	29	21	14	5	3	0	1	0	0
3	1	2	6	64	38	32	20	9	2	3	0	0
4	2	4	17	84	45	36	24	10	3	4	0	0
5	2	3	15	73	42	43	19	12	2	4	0	0
6	5	5	23	124	48	49	17	13	5	6	0	0
7	2	4	8	28	18	17	8	1	1	2	0	0
8	1	0	0	6	4	4	3	0	0	1	0	0
9	0	0	0	1	1	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	1	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	1	0	1	1	0	1	0	0	1	0	0
16	0	1	0	8	3	1	4	0	0	2	0	0
17	1	6	4	36	23	14	12	0	2	8	0	0
18	3	4	4	30	27	16	10	1	3	3	0	0
19	3	14	16	77	74	60	28	0	9	7	0	0
20	0	2	1	32	31	24	18	0	4	2	0	0
21	1	8	7	84	69	45	34	4	4	7	0	0
22	3	12	37	131	97	86	49	1	12	14	0	0
23	3	11	23	84	90	69	29	1	9	8	0	0

Max
131 MW
0 MW
Min

Figure 12-7. O'ahu: 2021 existing system (left); no new firm, add 450 MW hybrid solar (right)

We performed the same analysis for 2035. Unlike the 2030 hybrid solar sensitivity, which assumed the base electricity demand forecast, this 2035 sensitivity assumed the High electricity demand forecast. With future uncertainties in EV adoption, we wanted to understand the reliability risks associated with load growth due to electrification of transportation.

In this sensitivity, we assume that we successfully acquire the 450 MW of hybrid solar and 300 MW in 2029 and 200 MW in 2032 of firm generation from Stage 3 procurement. Additional hybrid solar was then added to determine its impact on reliability in 2035. Shown in Figure 12-8, below, is the relationship between the loss of load expectation and incremental additions of hybrid solar in 2035. Similar to 2030, the figure shows that as we add more hybrid solar in 2035, its contribution toward reliability improvements quickly diminishes. It is important to note that, even with resources procured through the Stage 3 procurement and an additional 1,145 MW of hybrid solar, the system may not meet the 0.1 day/year target under the High Load scenario. Based on the relationship shown below, we would need approximately 1,225 MW of hybrid solar in addition to the Stage 3 procurement.

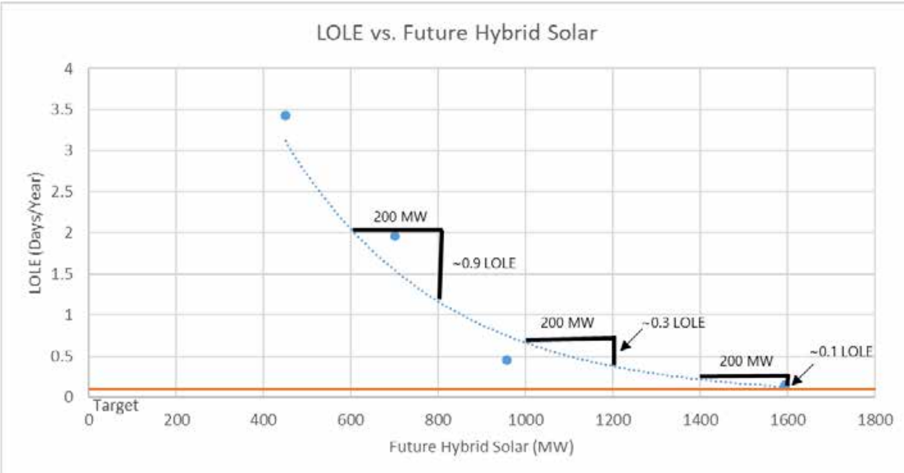


Figure 12-8. O‘ahu; relationship between change in loss of load and change in future hybrid solar capacity (High Load scenario, 2035)

In Figure 12-9, we present the unserved energy based on the month and hour of the scenario with and without the additional 1,600 MW of hybrid solar and 500 MW of firm generation. As shown in the image on the right, under the High Load scenario, even with 500 MW of new firm resources and nearly 1,600 MW of hybrid solar, we may still experience unserved energy.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	1	17	3	17	15	20	8	12	11	13	1	1
1	0	9	0	10	4	18	3	3	2	7	0	0
2	0	7	0	5	5	6	3	1	1	3	0	0
3	0	10	1	9	5	14	6	1	0	6	0	0
4	2	15	1	13	8	23	6	1	1	9	0	0
5	2	29	1	13	9	22	9	2	1	10	1	0
6	4	35	3	17	9	35	13	0	4	15	2	2
7	2	36	1	6	2	2	0	1	2	3	0	1
8	1	12	0	2	0	0	1	0	1	1	0	0
9	0	5	0	1	0	0	0	0	1	0	0	0
10	0	2	0	1	0	0	0	0	0	0	0	0
11	0	1	0	0	0	0	0	0	0	0	0	0
12	0	1	0	0	0	0	0	0	0	1	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	1	1	0	0
15	0	4	0	1	0	1	0	0	5	8	0	0
16	3	13	1	7	2	8	3	1	10	13	1	3
17	7	37	3	21	12	45	13	5	19	28	6	9
18	8	56	3	39	10	96	29	10	21	51	1	5
19	18	114	6	72	34	137	64	6	39	44	3	18
20	2	39	0	44	12	62	32	0	16	13	1	8
21	10	68	4	49	27	62	23	10	26	22	3	7
22	17	85	8	49	26	116	53	12	38	37	9	17
23	13	72	8	59	17	77	28	9	27	38	5	13

Max
137 MW
0 MW
Min

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	2	0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	0	0	0	0	0	0	0	0	0	0
3	0	1	0	0	0	1	0	0	1	0	0	0
4	0	1	0	0	0	1	0	0	1	0	0	0
5	0	1	0	0	0	1	0	0	0	0	0	0
6	0	2	0	0	0	0	0	0	1	0	0	0
7	0	2	0	0	0	0	0	0	0	0	0	0
8	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	1	0	0	0	0	0	0	0	0
17	0	2	0	2	0	1	0	0	3	0	0	0
18	0	6	0	2	0	0	0	0	3	1	0	0
19	0	17	0	4	0	5	1	0	10	2	0	0
20	0	4	0	1	0	0	0	0	0	0	0	0
21	0	9	0	3	0	1	0	0	5	0	0	0
22	0	14	0	7	0	4	0	0	7	1	0	0
23	0	9	0	5	0	4	2	0	7	1	0	0

Max
137 MW
0 MW
Min

Figure 12-9. O‘ahu: add 508 MW firm, add 450 MW hybrid solar, High Load (left); add 508 MW firm, add 1,600 MW hybrid solar, High Load (right)

12.3.1.2Firm Generation Reliability Impacts

We performed an analysis to determine how reliability of the system changes based on the procurement or addition of firm generation. We assume the 450 MW of hybrid solar sought in the Stage 3 procurement and incremented firm generation to determine the impacts to reliability.

As shown in Figure 12-10, in 2030, we may need approximately 200 MW of new firm generation to meet the 0.1 day/year loss of load expectation target. Shown below is the relationship between the 2030 loss of load expectation and varying amounts of firm generation. The figure shows that as more firm generation is added in 2030, the reliability improvements decrease; however, in contrast, significantly less capacity of firm generation is needed to improve reliability by the same measure compared to hybrid solar.

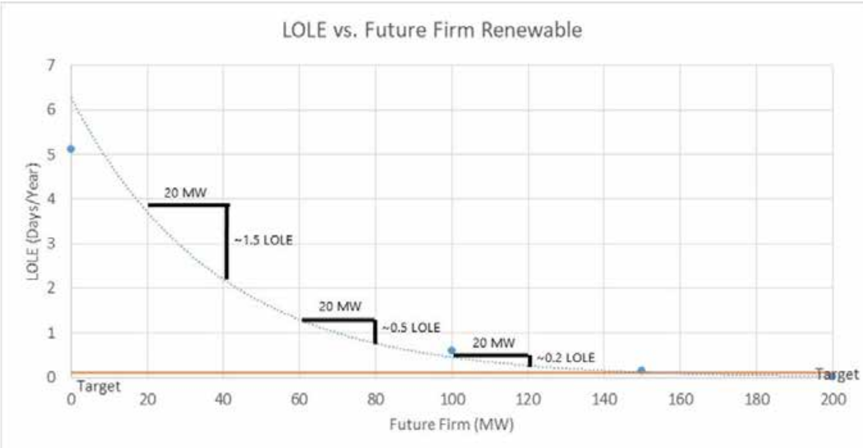


Figure 12-10. O'ahu: relationship between change in loss of load and change in future firm renewable capacity (2030)

In Figure 12-11 below we present the unserved energy based on the month and hour of the scenario where we do not have new firm generation but have the 450 MW of hybrid solar sought in Stage 3 (left), and the scenario where we add 150 MW of new firm generation along with 450 MW of hybrid solar (right). As shown, the addition of 150 MW of firm generation may help significantly reduce the amount of unserved energy, though we still expect unserved energy during the morning and evening hours.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	2	0	0	0	0	0	0	1	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	1	0	0	0	0	0	0	0	0	0	0
3	0	1	0	0	0	1	0	0	1	0	0	0
4	0	1	0	0	0	1	0	0	1	0	0	0
5	0	1	0	0	0	1	0	0	0	0	0	0
6	0	2	0	0	0	0	0	0	1	0	0	0
7	0	2	0	0	0	0	0	0	0	0	0	0
8	0	1	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	1	0	0	0	0	0	0	0	0
17	0	2	0	2	0	1	0	0	3	0	0	0
18	0	6	0	2	0	0	0	0	3	1	0	0
19	0	17	0	4	0	5	1	0	10	2	0	0
20	0	4	0	1	0	0	0	0	0	0	0	0
21	0	9	0	3	0	1	0	0	5	0	0	0
22	0	14	0	7	0	4	0	0	7	1	0	0
23	0	9	0	5	0	4	2	0	7	1	0	0

Max
137 MW
0 MW
Min

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0	0	0	0	0	1	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	1	0	0	0	0	0	0	0
3	0	0	0	0	1	2	0	0	0	0	0	0
4	0	0	0	1	0	3	0	0	0	0	0	0
5	0	0	0	1	2	1	0	0	0	0	0	0
6	0	0	0	0	1	3	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0
16	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	0	0	0	0	0	0	0	0	0	0
18	0	0	0	0	1	1	0	0	0	0	0	0
19	0	0	0	1	0	0	0	0	1	0	0	0
20	0	0	0	0	2	1	0	0	0	0	0	0
21	0	0	0	1	0	0	0	0	0	0	0	0
22	0	0	0	1	1	0	0	0	0	0	0	0
23	0	0	0	1	0	1	0	0	0	0	0	0

Max
131 MW
0 MW
Min

Figure 12-11. O'ahu: no new firm, add 450 MW hybrid solar (left); add 150 MW firm, add 450 MW hybrid solar (right)

We also performed analysis to determine how reliability changes based on the procurement of additional firm generation above the 508 MW targeted in the Stage 3 procurement. Similar to the 2035 variable sensitivity performed, this 2035 firm generation sensitivity assumed the High Load forecast to ensure that the Integrated Grid Plan is capable of reliably serving load growth from accelerated growth of electric vehicles. Similar to the 2035 analysis on hybrid solar, we assume that 450 MW of hybrid solar, and 500 MW of firm generation sought through the Stage 3 procurement are in service.

Shown below in Figure 12-12 is the relationship between the loss of load expectation and increments of new firm generation in 2035. Based on the results, we would need close to 200 MW of additional firm generation above the 500 MW of firm generation sought in the Stage 3 procurement, to meet the 0.1 day/year target under a High electricity demand forecast. We also observe the outsized impact the addition (or forced outage) that 100 MW of firm generation can have on reliability, with a change of approximately 4.6 days per year of loss of load.

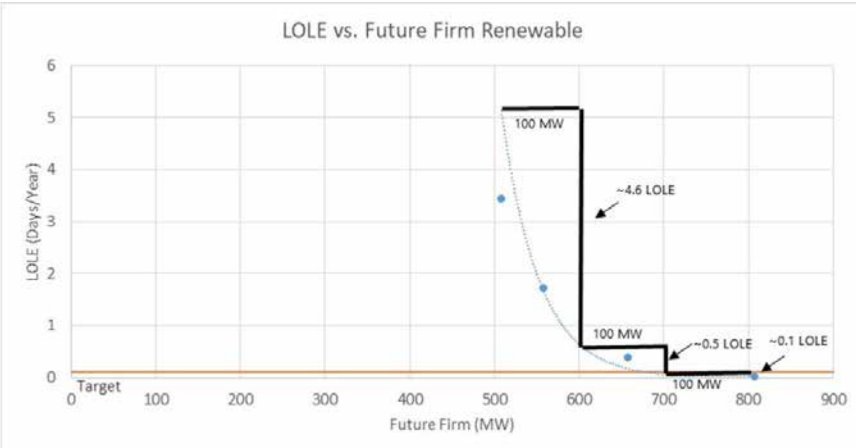


Figure 12-12. O'ahu: relationship between change in loss of load and change in future firm capacity (High Load scenario, 2035)

In Figure 12-13 below we present the unserved energy based on the month and hour of the scenario with and without an additional 650 MW of firm generation. As shown in the image on the right, under the High electricity demand scenario we may still experience unserved energy.

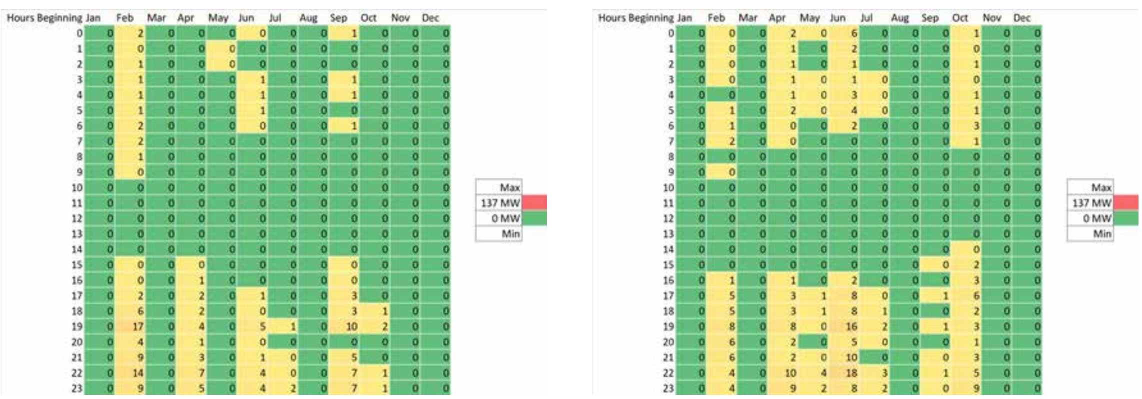


Figure 12-13. O'ahu: add 508 MW firm, add 450 MW hybrid solar, High load (left); add 658 MW firm, add 450 MW hybrid solar, High load (right)

12.3.1.3Fossil Fuel Retirement Risk Assessment

Given that both the Base and Land-Constrained scenario meet the loss of load expectation target in 2030, we completed analyses to determine whether we could deactivate additional fossil fuel–based generators while maintaining reliability. As shown in Table 12-2, in the Base scenario and under the right system conditions, an additional 600 MW of existing fossil-fuel firm generation could be deactivated and still meet the 0.1 day/year loss of load expectation target. In the Land-Constrained scenario, we may be able to deactivate an additional 170 MW of existing fossil-fuel firm generation.

Table 12-2. Probabilistic Analysis: Results Summary, Oʻahu 2030, Retirement Sensitivity

Scenario	Existing Firm (MW)	New Firm (MW)	Stage 3 RFP (MW)	Future Wind (MW)	Future Hybrid Solar (MW)	Future Standalone BESS (MW)	LOLE (Days/ Year)	LOLEv (Event/ Year)	LOLH (Hours /Year)	EUE (MWh/ Year)	EUE (%)
Base	1,173	300	450	164	1,145	167	0.00	0.00	0.00	0.00	0.000
Deactivation of 600 MW of firm gen.	567	300	450	164	1,145	167	0.04	0.08	0.22	0.04	0.001
Land-Constrained	1,173	300	450	0	0	54	0.00	0.00	0.01	0.00	0.000
Deactivation of 170 MW of firm gen.	1,008	300	450	0	0	54	0.06	0.11	0.20	0.02	0.000

Given that both the Base and Land-Constrained scenarios meet the loss of load expectation target in 2035, we completed analyses to determine whether we could deactivate additional generators while maintaining reliability.

Table 12-3 focuses on the Base scenario. If we acquire 500 MW of new firm generation, 1,600 MW of hybrid solar along with 400 MW of offshore wind and 164 MW onshore wind, we may be able to deactivate an additional 440 MW of additional fossil-fuel firm generation. If we acquire only 300 MW of new firm generation from the Stage 3 procurement, an additional 170 MW of fossil-fuel firm generation could be deactivated.

Table 12-3. Probabilistic Analysis: Results Summary, Oʻahu 2035, Retirement Sensitivity, Base Scenario

Scenario	Existin g Firm (MW)	New Firm (MW)	Stage 3 RFP (MW)	Future Wind (MW)	Future Hybrid Solar (MW)	Future Standalone BESS (MW)	LOLE (Days/ Year)	LOLEv (Event/ Year)	LOLH (Hours /Year)	EUE (MWh/ Year)	EUE (%)
Base (incl. 400 MW offshore wind)	800	508	450	564	1,145	167	0.00	0.00	0.00	0.00	0.000
Deactivation of 440 MW firm gen.	359	508	450	564	1,145	167	0.01	0.03	0.04	0.00	0.000
Base (300 MW new firm gen.)	800	300	450	564	1,145	167	0.01	0.02	0.07	0.01	0.000
Deactivation of 170 MW firm gen.	628	300	450	564	1,145	167	0.01	0.02	0.04	0.01	0.000
Deactivation of 440 MW firm gen.	359	300	450	564	1,145	167	0.72	1.60	3.11	0.52	0.007

Table 12-4 focuses on the Land-Constrained scenario. If we acquire 500 MW of new firm generation, 450 MW of hybrid solar along with 400 MW of offshore wind and 30 MW onshore wind, we may be able to deactivate an additional 170 MW of fossil fuel firm generation. If, however, we acquired only 300 MW of new firm generation through the Stage 3 procurement, we may need to reactivate an additional 170 MW of fossil fuel firm generation to meet our reliability target.

Table 12-4. Probabilistic Analysis: Results Summary, O'ahu 2035, Retirement Sensitivity, Land-Constrained Scenario

Scenario	Existing Firm (MW)	New Firm (MW)	Stage 3 RFP (MW)	Future Wind (MW)	Future Hybrid Solar (MW)	Future Standalone BESS (MW)	LOLE (Days/ Year)	LOLEv (Event/ Year)	LOLH (Hours /Year)	EUE (MWh/ Year)	EUE (%)
Land-Constrained (incl. 400 MW offshore wind)	800	508	450	430	0	194	0.00	0.01	0.01	0.00	0.000
Deactivation of 170 MW firm gen.	628	508	450	430	0	194	0.01	0.04	0.06	0.01	0.000
Deactivation of 440MW Firm Gen.	359	508	450	430	0	194	0.44	0.95	2.29	0.37	0.005
Land-Constrained (300 MW new firm gen.)	800	300	450	430	0	194	0.22	0.40	0.86	0.12	0.002
Reactivation of 170 MW existing firm gen.	965	300	450	430	0	194	0.05	0.10	0.21	0.04	0.001

12.3.1.43-Day Energy Profile, High Unserved Energy Day

The reliability analyses are the average of the 250 simulation samples. Even though the loss of load expectation meets or exceeds 0.1 day per year, individual samples of weather and firm generation outage combinations may produce significant unserved energy. We show in Figure 12-14 a sample with significant unserved energy, even with 1,600 MW of future hybrid solar.

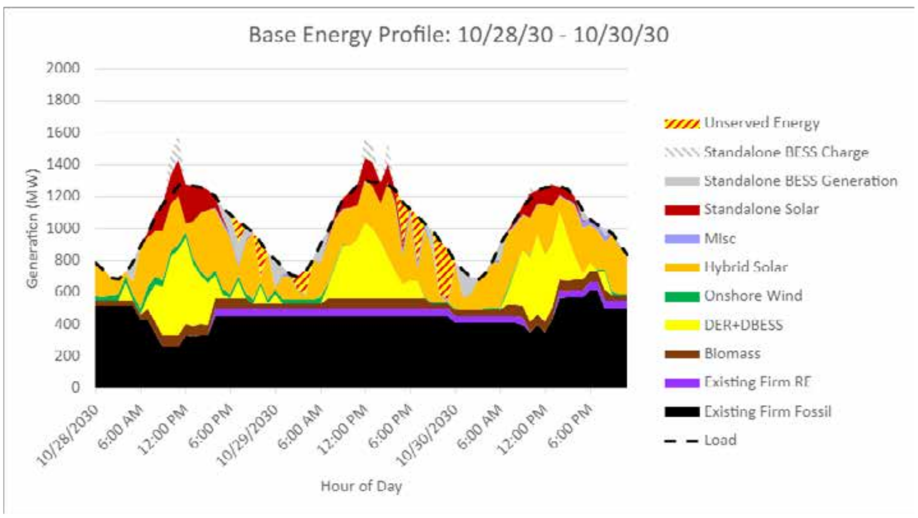


Figure 12-14. O'ahu: detailed energy profile, 2030 high unserved energy load day; no new firm, add 1,600 MW hybrid solar

Figure 12-15 shows another sample with significant unserved energy in the Land-Constrained scenario with 300 MW of new firm generation and the reactivation of 170 MW of firm generation.

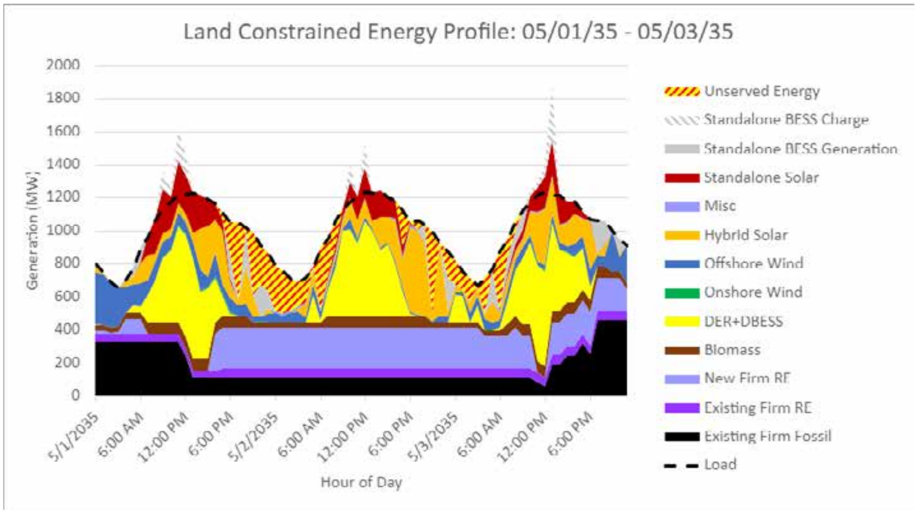


Figure 12-15. O'ahu: detailed energy profile, 2035 high unserved energy load day; add 300 MW firm, add 450 MW hybrid solar, add 400 MW offshore wind, add 170 MW existing firm

In both figures, we see the important role that a resource with the attributes like a firm generator play in the reliability of the system. The significant duration and magnitude of the unserved energy on the system demonstrates the need for a resource with attributes similar to a firm generator.

12.3.2 Hawai'i Island

Uncertainty in forecasted electricity demand is a large source of risk for Hawai'i Island. Section 8.3.2 shows how the planned Hawai'i Island system meets reliability targets in 2030 and 2035 but requires additional resources in a High electricity demand scenario. This section analyzes how adding or removing resources from the Hawai'i Island system affects reliability metrics.

Volcanic activity is an environmental risk unique to Hawai'i Island. Volcanic ash can reduce the effectiveness of solar resources and lava flows can also impact resources in their path.

12.3.2.1Hybrid Solar Reliability Impacts

As described earlier, the Base scenario meets or exceeds the reliability target. Therefore, for the purposes of assessing the reliability risks of the Hawai'i Island system, the scenarios shown below assume the 2030 Base scenario and the removal of the Hamakua Energy Partners plant, whose PPA is set to expire at the end of 2030.

- Even without the full Stage 3 procurement target of 140 MW of hybrid solar, the 2030 system's loss of load expectation is less than 0.1 day per year.

If a system has a high loss of load expectation, even small amounts of added resources can dramatically improve the system's loss of load expectation. However, continually adding resources has diminishing returns. The planned Base 2030 system already has a low loss of load expectation so additional resources would have a minimal benefit to the system's loss of load expectation. Though adding resources to an already stable system may not impact loss of load expectation as much, the resources still act as a safety net should other resources be unexpectedly brought offline (e.g., the 2018 Kilauea eruption that forced Puna Geothermal Venture out of service for an extended period or recent extended outages experienced on Hawai'i Island).

Once loss of load expectation exceeds 0.1 day per year it rises quickly if more resources are brought offline. Though the effects are not as dramatic as when removing comparable amounts of firm resources, there should be caution when removing resources because they have a growing impact on the system's loss of load expectation as more resources are retired.

Figure 12-16 shows the relationship between change in loss of load and change in Stage 3 hybrid solar capacity for the Base Load scenario in 2030 on Hawai'i Island.

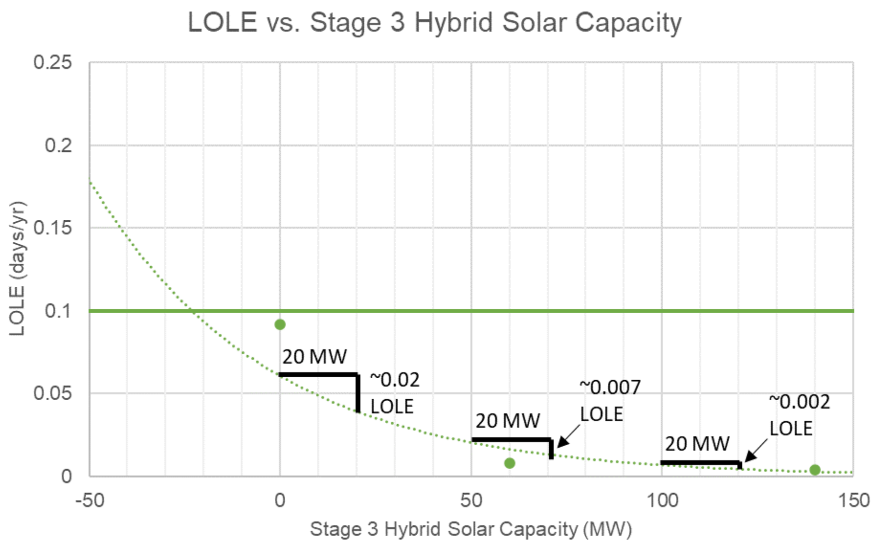


Figure 12-16. Hawaiʻi Island: relationship between change in loss of load and change in Stage 3 paired PV hybrid solar capacity (Base Load scenario, 2030)

The heat map shown in Figure 12-17 below illustrates when we expect unserved energy to occur and at what quantities for the scenario shown in Figure 12-16 with a loss of load expectation around 0.1 day per year (Base scenario, remove 60 MW firm generation, add 0 MW hybrid solar). The quantities shown are an average of all 250 samples. When the Puna Geothermal Venture plant is offline for maintenance we see much of the unserved energy occurring in March during the evening peak and early morning hours.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
2	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
3	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
4	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
5	0.0	0.0	0.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
6	0.0	0.1	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1		
7	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Max	
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1 MW	
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0 MW	
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	Min	
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
17	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
18	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
19	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0		

Figure 12-17. Hawaiʻi Island: remove 60 MW firm, add 0 MW hybrid solar heat map (Base scenario 2030)

We performed the same analysis for 2035. Unlike the 2030 hybrid solar sensitivity, which assumed the Base electricity demand forecast, the 2035 sensitivity assumed the High electricity demand forecast. With future uncertainties in EV adoption, we wanted to understand the reliability risks associated with load growth due to electrification of transportation.

The 140 MW of hybrid solar from Stage 3 was assumed to be in service.

- In a High Load scenario if no new resources are added, the loss of load expectation is above 10 days per year.

We also observe that small changes in hybrid solar capacity can significantly change the reliability of the system, though there are diminishing returns. For example, just 50 MW of hybrid solar at lower penetrations reduces loss of load expectation by approximately 17 days per year and at higher penetrations 1 day per year. The planned High load 2035 system has a high loss of load expectation so if a project selected through a competitive procurement fails to reach commercial operations or an unexpected outage of the solar plant takes place, significant adverse impacts to reliability are expected in a High load scenario. This trend is also evident in the firm resource reliability curves. Figure 12-18 shows the relationship between change in loss of load and change in future hybrid solar capacity on Hawaiʻi Island for the High Load scenario in 2035.

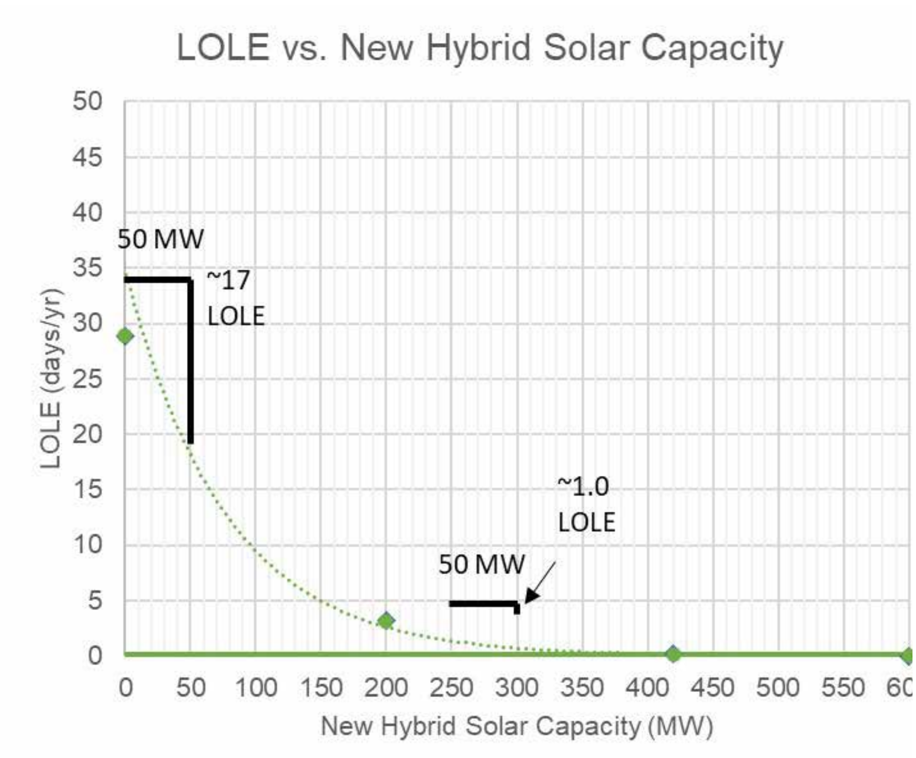


Figure 12-18. Hawaiʻi Island: relationship between change in loss of load and change in new hybrid solar capacity (High Load scenario, 2035)

The heat map in Figure 12-19 shows when we expect unserved energy to occur and at what quantities for the scenario shown in Figure 12-18 above with a loss of load expectation around 0.1 day per year (High electricity demand forecast, no new firm generation, and 420 MW of hybrid solar). The quantities shown are an average of all 250 samples. With fewer firm resources, unserved energy is expected during the early morning hours when firm resources are down for maintenance and during bad solar condition months like December.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.1	0.5
1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.3
5	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.4
6	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.9
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0
15	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.1	0.2
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.3	0.3
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1

Max	
1 MW	
0 MW	
Min	

Figure 12-19. Hawaiʻi Island: add 0 MW firm, add 420 MW hybrid solar; EUE heat map (High Load scenario, 2035)

12.3.2.2Firm Generation Reliability Impact

For the purposes of assessing the reliability risks of the Hawaiʻi Island system, the scenarios shown below assume the 2030 Base load and the removal of the Hamakua Energy Partners plant, whose PPA is set to expire at the end of 2030. The 140 MW of hybrid solar from Stage 3 is assumed to be in service. In a 2030 Base scenario, a loss of load less than 0.1 day per year is expected even if Hamakua Energy Partners and some additional firm is brought offline unexpectedly.

We also observe that even small amounts of added resources can dramatically reduce the system's reliability. However, continually adding resources has diminishing returns on reliability improvements. Though adding resources to an already stable system like the planned Base load 2030 system may not impact loss of load expectation as much, the resources still act as a safety net should other resources be unexpectedly brought offline given the sensitivity the Hawaiʻi Island system has to changes in generation availability. Figure 12-20 shows the relationship between change in loss of load and change in cumulative firm capacity on Hawaiʻi Island for the Base Load scenario in 2030.

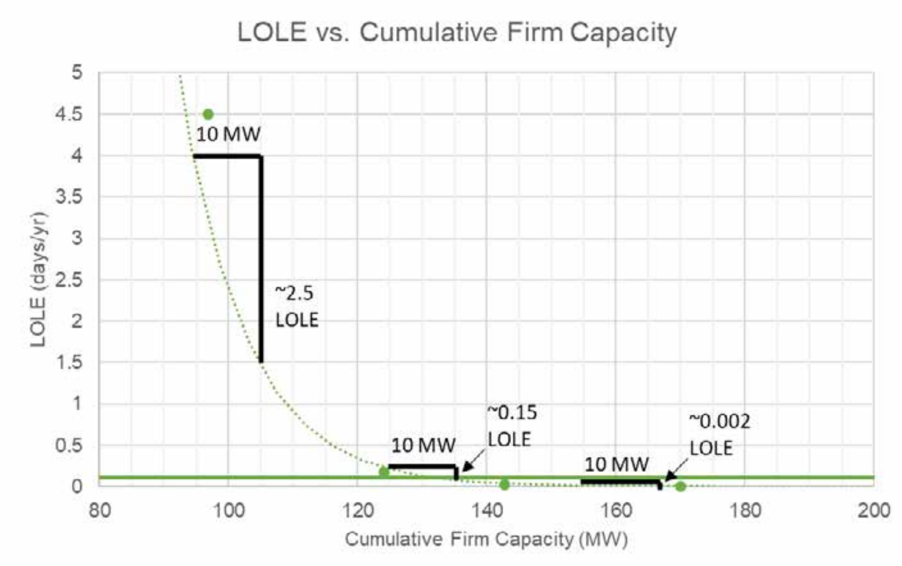


Figure 12-20. Hawai'i Island: relationship between change in loss of load and change in cumulative firm capacity (Base Load scenario, 2030)

The heat map in Figure 12-21 below shows when we expect unserved energy to occur and at what quantities for the scenario shown in Figure 12-20 above with a loss of load expectation around 0.1 day per year (High electricity demand scenario, remove 100 MW firm generation, add 140 MW hybrid solar). The quantities shown are an average of all 250 samples. With fewer firm units online, unserved energy is expected to occur during the early morning hours when firm resources are down for maintenance and during poor solar condition months like December.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
1	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	0.0	0.1	0.0	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1
3	0.0	0.1	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.1
4	0.0	0.1	0.0	0.1	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2
5	0.0	0.1	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.5
6	0.0	0.1	0.1	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.9
7	0.1	0.1	0.0	0.1	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.2
8	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.2
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Max	
1 MW	
0 MW	
Min	

Figure 12-21. Hawai'i Island: remove 100 MW firm, add 140 MW hybrid solar heat map, Base Scenario 2030

Figure 12-22 assumes the 2035 High electricity demand forecast and the planned resource retirements through 2035. The 140 MW of hybrid solar from Stage 3 is assumed to be in service.

- In a High electricity demand scenario a loss of load expectation of 10 days per year is expected if no resources are added to the system.

When comparing the firm capacity graphs with the hybrid solar capacity graphs in Section 12.3.2.1, it's notable that when applied to the same resource portfolio, firm resources have a much larger impact on system reliability than a comparable amount of hybrid solar resources. The system is more sensitive to the addition or removal of firm resources than of hybrid solar resources.

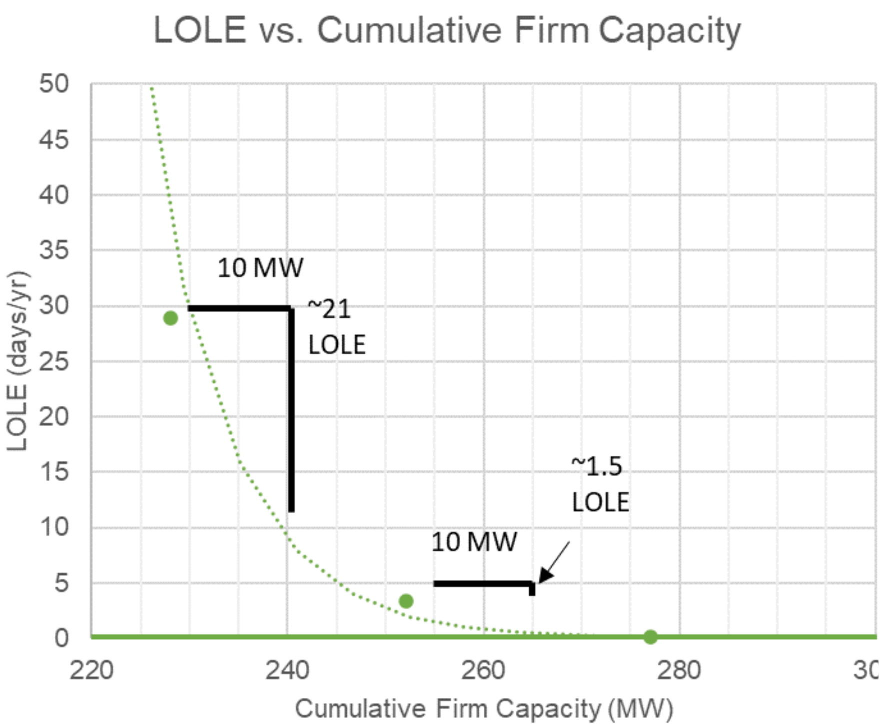


Figure 12-22. Hawai'i Island; loss of load vs. cumulative firm capacity (High Load scenario, 2035, linear y-axis)

The heat map in Figure 12-23 shows when we expect unserved energy to occur and at what quantities for the scenario shown in Figure 12-22 above with a loss of load expectation around 0.1 day per year (High electricity demand scenario, add 50 MW new firm generation, and no hybrid solar additions). The quantities shown are an average of all 250 samples. With fewer solar resources, unserved energy is expected to occur during the early morning and evening peak hours of hot weather, high load months like August.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.1
1	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
7	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
15	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0
16	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
17	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
18	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.9	0.0	0.0	0.0	0.4
19	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.1
20	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.0	0.0	0.0
21	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.7	0.0	0.0	0.0	0.0
22	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.6	0.0	0.0	0.0	0.0
23	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.4	0.0	0.0	0.0	0.0

Max	
1 MW	
0 MW	
Min	

Figure 12-23. Hawai'i Island: add 50 MW firm, add 0 MW hybrid solar; expected unserved energy heat map (High Load scenario, 2035)

12.3.2.33-Day Energy Profile, High Unserved Energy Day

The energy profiles shown in Figure 12-24 and Figure 12-25 show the day from all 250 samples with the greatest unserved energy for the hybrid solar and firm generation sensitivities with loss of load expectation of approximately 0.1 day per year. This shows that even though the reliability target is met, unserved energy may still occur. For both scenarios, loss of load starts around midnight and continues through the morning hours. The system recovers by midday.

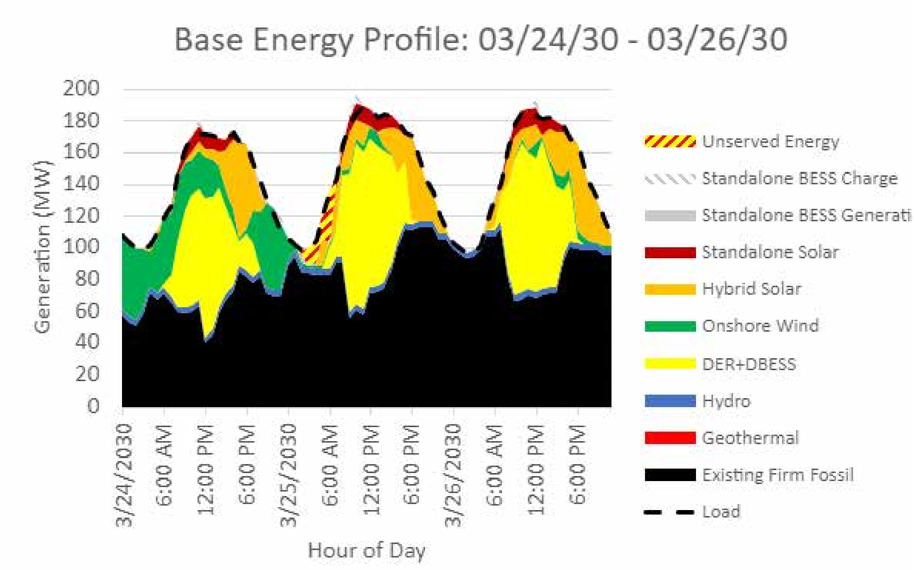


Figure 12-24. Hawai'i Island: Base Load scenario, remove 60 MW firm, add 0 MW hybrid solar heat map; detailed energy profile, 2030 high unserved energy day

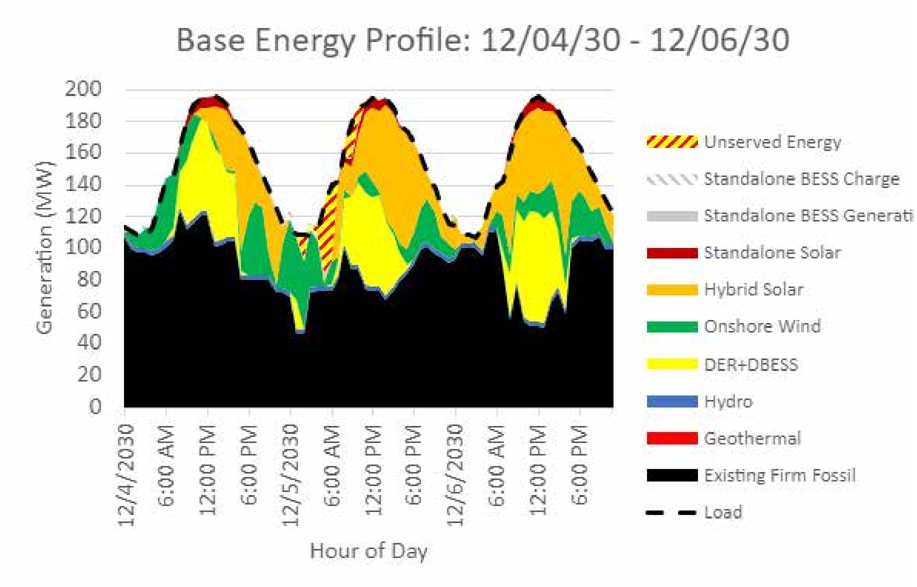


Figure 12-25. Hawaiʻi Island: Base Load scenario, remove 100 MW firm, add 140 MW hybrid solar; detailed energy profile, 2030 high unserved energy day

The energy profiles shown in Figure 12-26 and Figure 12-27 show the day out of all 250 samples with the greatest unserved energy for the hybrid solar and firm generation sensitivities in 2035 with loss of load expectation of approximately 0.1 day per year.

When adding only hybrid solar to the system as shown in Figure 12-26, loss of load starts around midnight and continues through the morning hours. The system recovers by midday.

When adding only firm generation resources to the system as shown in Figure 12-27, loss of load starts around midday and continues through the evening hours. The system recovers by midnight.

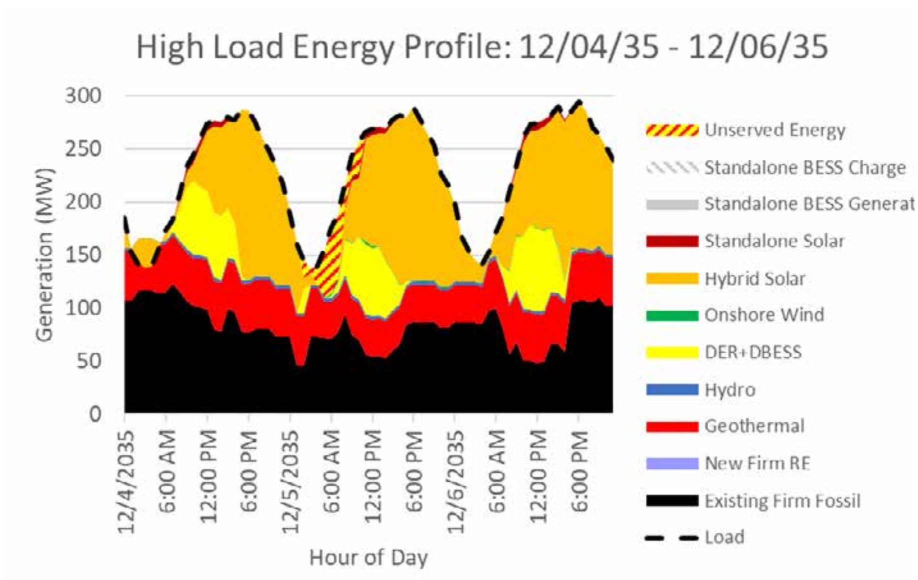


Figure 12-26. Hawaiʻi Island: High Load scenario, add 0 MW firm, add 420 MW hybrid solar; detailed energy profile, 2035 high unserved energy day

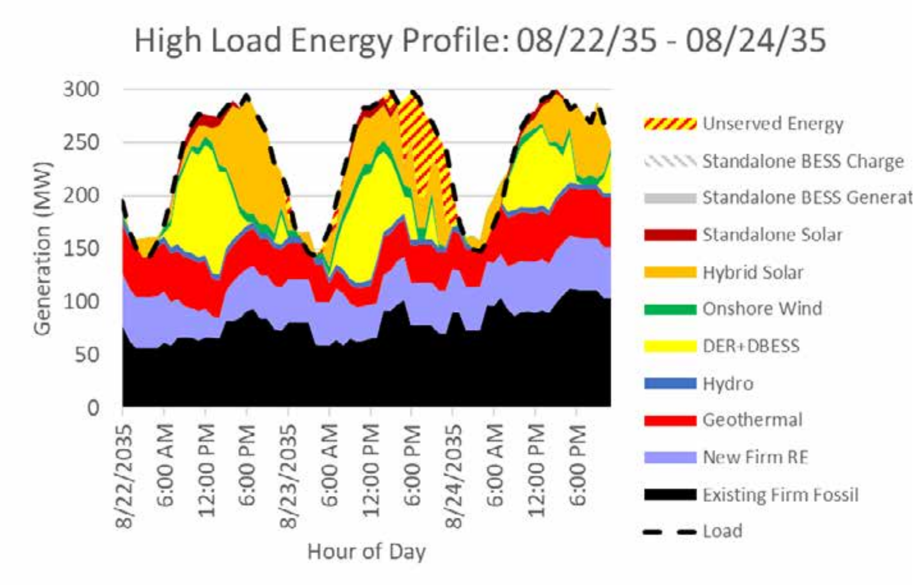


Figure 12-27. Hawai'i Island: High Load scenario, add 50 MW firm, add 0 MW hybrid solar; detailed energy profile, 2035 high unserved energy day

12.3.3 Maui

Uncertainty in forecasted electricity demand is a large source of risk for Maui. Section 8.4.2 shows how the planned Maui system meets reliability targets in 2030 and 2035 but requires additional resources in a High electricity demand scenario. This section shows how adding or removing resources from the Maui system affects reliability metrics.

12.3.3.1Hybrid Solar Reliability Impact

As described earlier, the Maui Base scenario meets the loss of load expectation target of 0.1 day per year. However, if we do not acquire the hybrid solar sought in the Stage 3 procurement, the Maui system still meets the reliability target, in part because of the 40 MW of new firm generation.

To assess the reliability risk based on the amount of hybrid solar added in 2030, we removed the 40 MW firm generation sought in Stage 3 and incremented hybrid solar additions.

We show in Figure 12-28 the relationship between loss of load expectation and increments of hybrid solar. The figure shows that as we add more hybrid solar in 2030, the improvements to reliability diminish.

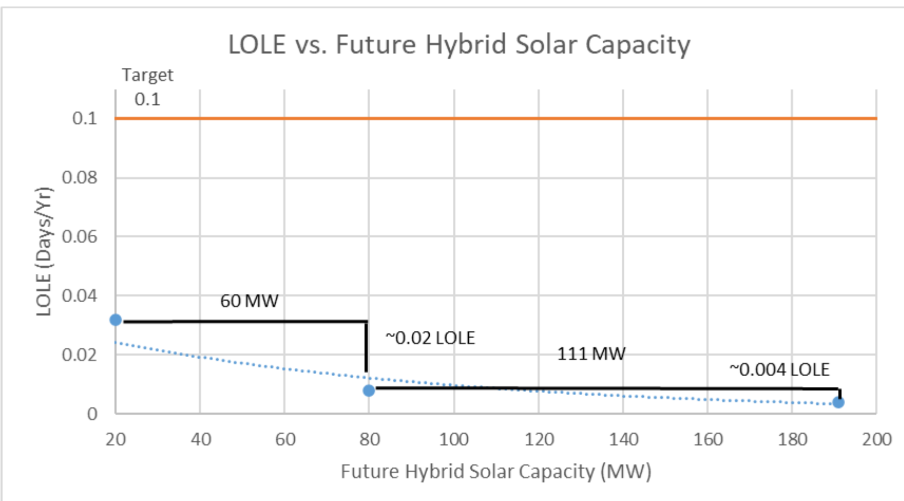


Figure 12-28. Maui: relationship between change in loss of load and change in future hybrid solar capacity, 2030

We performed a similar analysis in 2035. Unlike the 2030 hybrid solar sensitivity, which assumed the Base electricity demand forecast, this 2035 sensitivity assumed the High electricity demand forecast. With future uncertainties in EV adoption, we wanted to understand the reliability risks associated with load growth due to electrification of transportation.

In this sensitivity, we assume that the 40 MW of firm generation sought through Stage 3 is in service. Additional hybrid solar was then added to determine its impact on reliability in 2035. Figure 12-29 shows the relationship between loss of load expectation and incremental additions of hybrid solar. The figure demonstrates that as we add more hybrid solar in 2035, the improvements to reliability diminish. We also note that even with the acquisition of Stage 3 resources, we may not meet the 0.1 day/year loss of load target under the High electricity demand scenario.

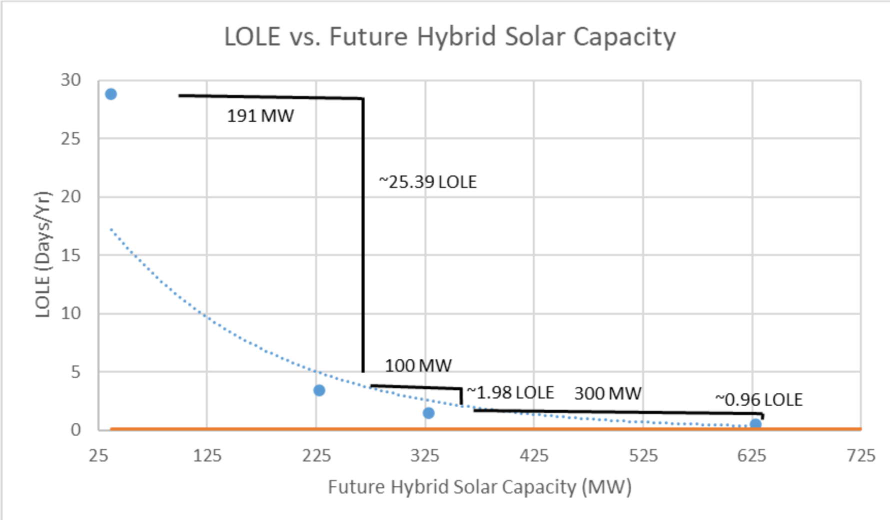


Figure 12-29. Maui: relationship between change in loss of load and change in future hybrid solar capacity (High Load scenario, 2035)

12.3.3.2Firm Generation Reliability Impact

We performed analysis to determine how loss of load expectation changes based on additions of firm generation. In this sensitivity, we assume that the 191 MW hybrid solar from the full Stage 3 target is in service.

Figure 12-30 shows that in 2030, with the Stage 3 hybrid solar, we may need approximately 18 MW of new firm generation to meet the 0.1 day/year loss of load expectation target. The figure shows that as more firm generation is added in 2030, the improvements to reliability diminish; however, in contrast to the hybrid solar sensitivity, smaller changes in firm capacity can significantly impact loss of load expectation. This further highlights the need to modernize our generation fleet with highly reliable generators.

Figure 12-31 shows when we expect unserved energy to occur and at what quantities when no future firm renewable from Stage 3 is assumed, from the scenario shown in Figure 12-30 with a loss of load expectation around 0.75 day per year. The quantities shown are an average of all 250 samples.

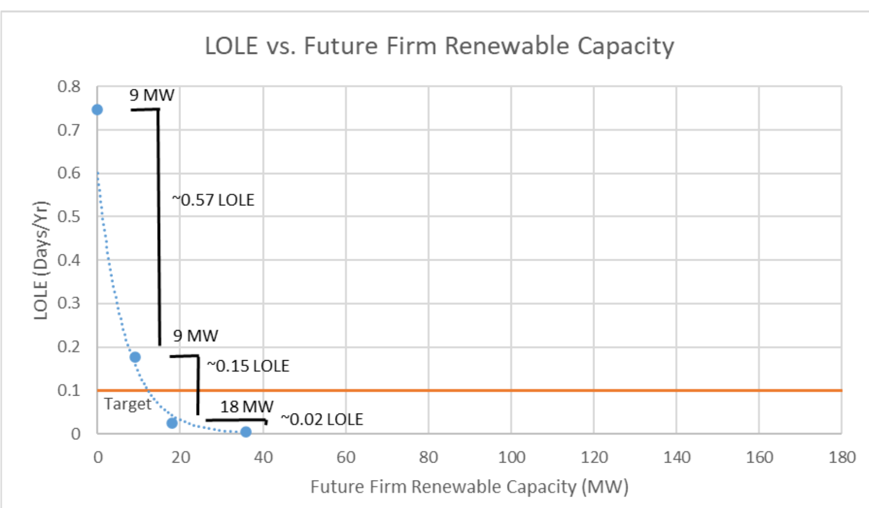


Figure 12-30. Maui: relationship between change in loss of load and change in future firm capacity, 2030

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.20	0.00	1.56	0.17	0.00	0.00	0.00	0.00	0.00	0.00	0.11
1	0.00	0.18	0.00	2.51	0.16	0.00	0.00	0.00	0.00	0.00	0.00	0.09
2	0.00	0.10	0.00	1.26	0.11	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.11	0.00	0.00	1.45	0.09	0.00	0.00	0.00	0.00	0.00	0.00	0.08
4	0.00	0.16	0.00	1.25	0.23	0.00	0.00	0.00	0.00	0.00	0.00	0.03
5	1.00	0.00	0.00	1.01	0.52	0.00	0.00	0.00	0.00	0.00	0.00	0.13
6	3.49	0.03	0.00	1.40	0.25	0.00	0.00	0.00	0.00	0.00	0.00	0.26
7	2.64	0.20	0.02	1.26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.19
8	0.00	0.00	0.00	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.16
9	0.00	0.00	0.00	0.06	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
16	0.00	0.00	0.00	0.22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.12
17	0.00	0.00	0.00	0.90	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.28
18	0.00	0.00	0.00	1.58	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25
19	0.00	0.00	0.00	1.14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.08
20	0.00	0.00	0.00	1.99	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.50
21	0.00	0.00	0.00	1.08	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.15
22	0.00	0.00	0.00	2.51	0.14	0.00	0.00	0.00	0.00	0.00	0.00	0.23
23	0.00	0.00	0.00	1.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.18

Max
3.49 MW
0 MW
Min

Figure 12-31. Maui: no new firm, Base load, 2030

We also performed analysis to assess how reliability changes based on firm generation additions. Similar to the 2035 hybrid solar analysis, this 2035 firm generation analysis assumed the High electricity demand forecast.

Figure 12-32 shows the relationship between loss of load expectation and incremental firm generation additions in 2035. We would need close to 73 MW of new firm generation, to meet the 0.1 day/year target under a High electricity demand forecast.

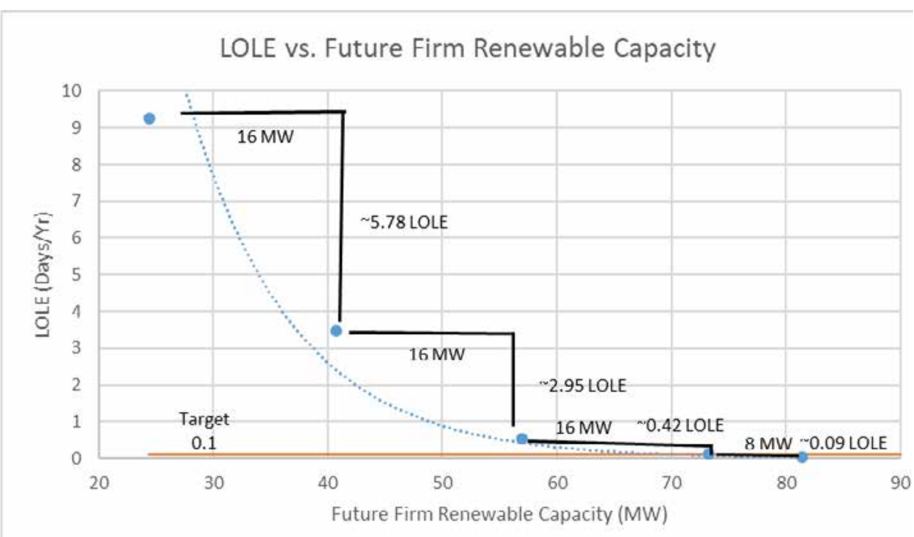


Figure 12-32. Maui: relationship between change in loss of load and change in future firm capacity (High Load scenario, 2035)

12.3.3.33-Day Energy Profile, High Unserved Energy Day

Figure 12-33 shows that even in the Base scenario where 0.1 day/year reliability is met, unserved energy may still occur. The overall trend shows that the existing thermal units ramp up in the evening and ramp down in the morning following the solar resources.

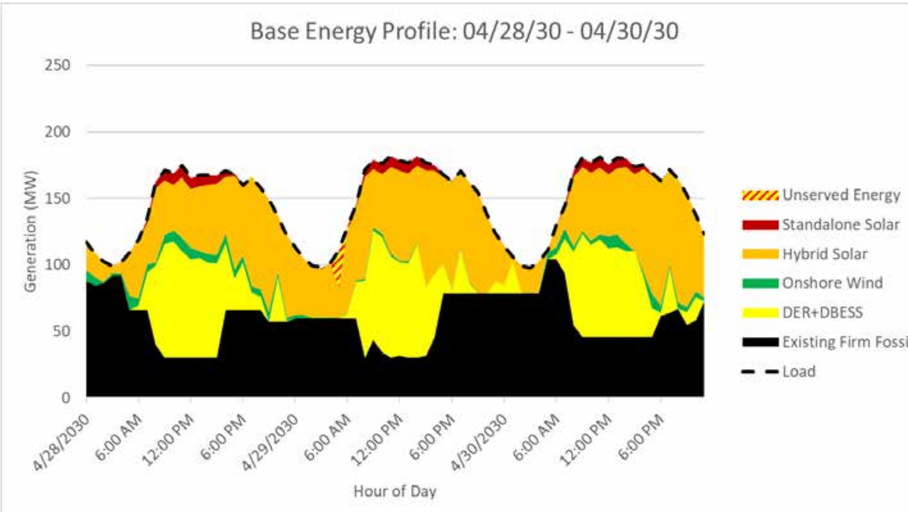


Figure 12-33. Maui: detailed energy profile, 2030 high unserved energy day

Figure 12-34 shows how in the Base scenario with the High load forecast, reliability is not met even with new resources being added. High amounts of unserved energy in the evening and morning hours still occur.

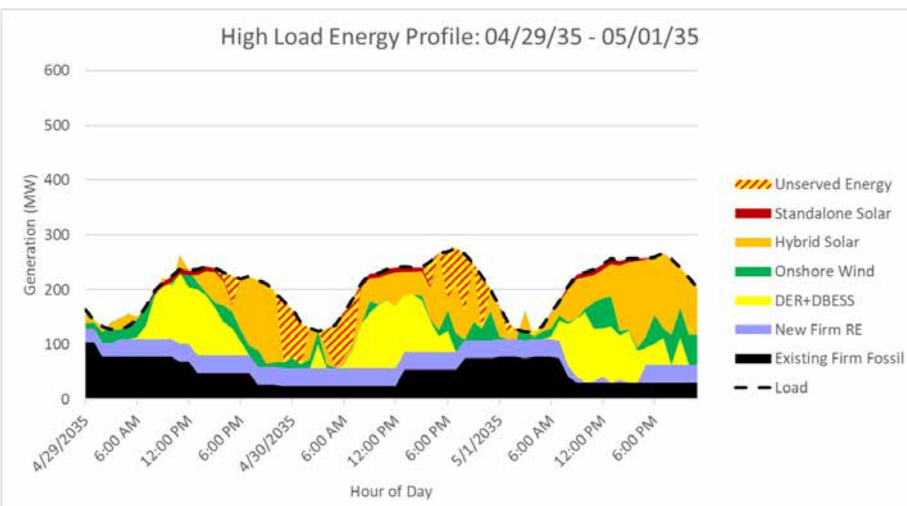


Figure 12-34. Maui: detailed energy profile, 2035 high unserved energy day

12.3.4 Molokaʻi

Uncertainty in forecasted electricity demand is a large source of risk for Molokaʻi. Section 8.5.2 shows how the planned Molokaʻi system meets reliability targets in 2030 and 2035. This section shows how adding or removing resources from the Molokaʻi system affects reliability metrics.

12.3.4.1Hybrid Solar Reliability Impact

We assessed the impact that hybrid solar has on reliability by assuming the Base scenario that includes 4.4 MW of firm generation. We added 3 MW increments of hybrid solar starting at 0 MW. Even with 12 MW of future hybrid solar, 4.4 MW of firm does not meet the loss of load target of 0.1 day per year. Figure 12-35 illustrates the difference in loss of load expectation benefit of 2 MW at different levels of hybrid solar. For example, going from 0 MW to 2 MW provides about 12 days/year loss of load expectation improvement versus a 0.6 day/year improvement going from 7 MW to 9 MW of hybrid solar. If we extrapolate the curve to hit a target of 0.1 day per year, it would take about 13 MW of hybrid solar capacity.

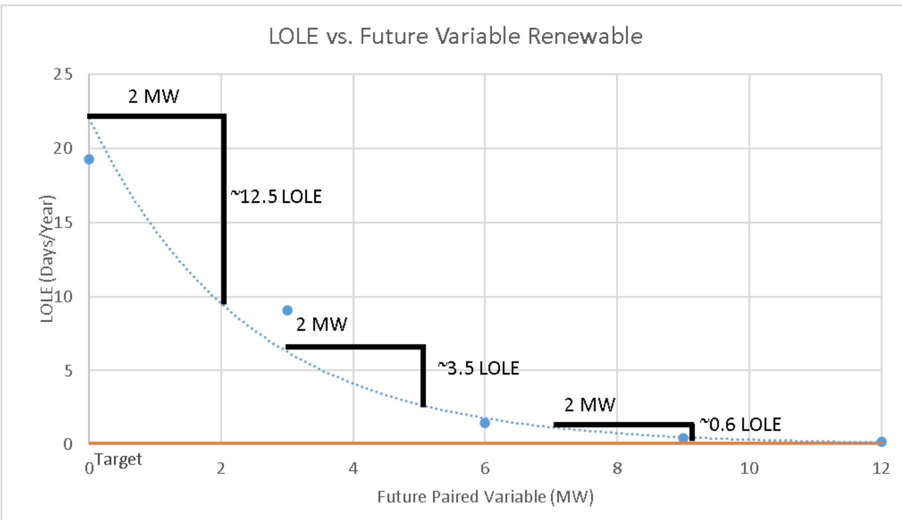


Figure 12-35. Molokaʻi: relationship between change in loss of load and change in future hybrid solar capacity (Base Load scenario, 2030)

The heat map in Figure 12-36 shows the expected unserved energy from 250 simulation samples. This shows that out of the 250 samples, the beginning of the year shows no unserved energy but during the later months, especially September, there is a higher possibility for unserved energy.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.03	0.04	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.06	0.07	0.00	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.05	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.08	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.02	0.09	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.04	0.01	0.02	0.08	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.05	0.06	0.00	0.00	0.01
7	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.02	0.00	0.00	0.02
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.03
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.03
19	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.00	0.02	0.00	0.00	0.02
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.03
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.01

Max
0.1 MW
0 MW
Min

Figure 12-36. Moloka'i: 4.4 MW firm, add 12 MW hybrid solar expected unserved energy heat map (Base Load scenario, 2030)

We also performed analysis in 2035 assuming a High electricity demand forecast to understand the impacts of accelerated EV adoption. Similar to the 2030 scenario we assume 4.4 MW of firm generation and hybrid solar additions in 3 MW increments starting at 0 MW.

Figure 12-37 illustrates the difference in loss of load expectation benefit of 2 MW at different levels of hybrid solar capacity. For example, going from 0 MW to 2 MW provides about 12 days/year loss of load expectation improvement versus a 0.9 day/year improvement going from 7 MW to 9 MW of hybrid solar. If we extrapolate the curve to hit a target of 0.1 day per year, it would take about 15 MW of hybrid solar capacity.

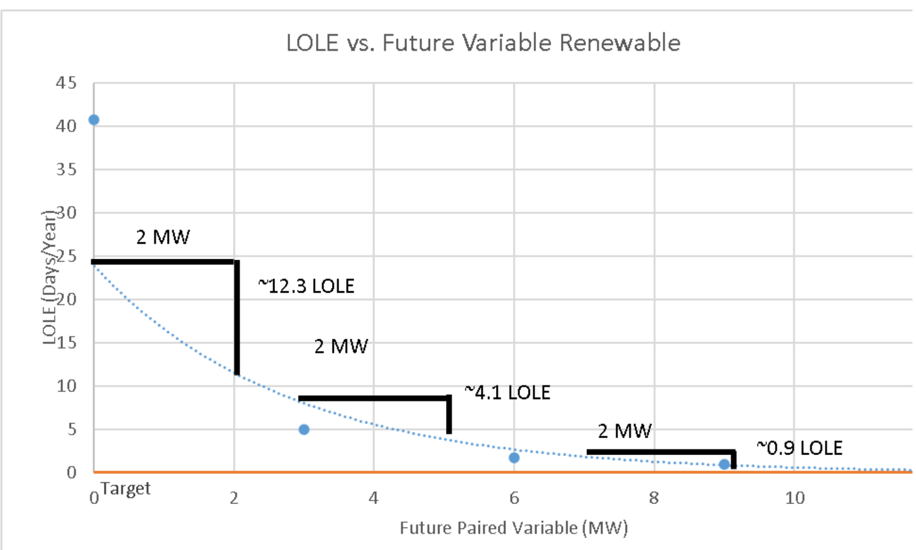


Figure 12-37. Moloka'i: relationship between change in loss of load and change in future hybrid solar capacity (Base Load scenario, 2035)

Figure 12-38 shows the expected unserved energy from 250 simulation samples. This shows that out of the 250 samples, the beginning of the year shows no unserved energy but during the later months, especially December, there is a higher possibility for unserved energy.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.01	0.05	0.16
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.00	0.01	0.37
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.03	0.28
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.14	0.29
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.17	0.30
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.03	0.16	0.24
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.11	0.00	0.03	0.25	0.16
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.02	0.10	0.19
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.04
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.12	0.07
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07	0.00	0.04	0.03	0.12
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.01	0.18	0.12
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.00	0.04
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.05
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.01	0.04	0.08
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.06	0.00	0.09	0.03	0.05

Max
0.4 MW
0 MW
Min

Figure 12-38. Molokaʻi: 4.4 MW firm, add 12 MW hybrid solar expected unserved energy heat map (High Load scenario, 2035)

12.3.4.2Firm Generation Reliability Impact

To assess the impacts of firm generation, we assume 6 MW of hybrid solar and additions of firm generation in 2.2 MW increments starting at 2.2 MW. We based the 2.2 MW increments on existing generator sizes on Molokaʻi.

Figure 12-39 illustrates the difference in reliability benefit of 1 MW at different levels of firm capacity. For example, going from 2.2 MW to 3.3 MW provides about 45 days/year loss of load expectation improvement versus a 2.5 day/year improvement going from 4 MW to 5 MW.

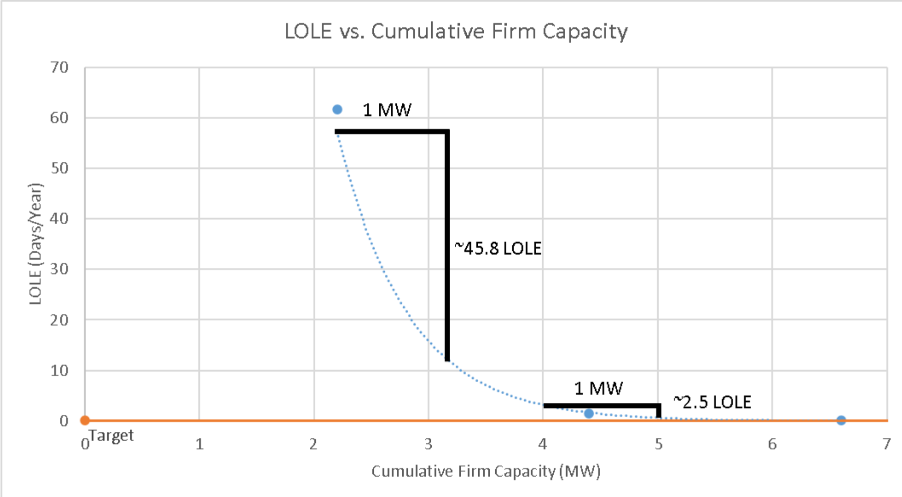


Figure 12-39. Moloka'i: relationship between change in loss of load and change in firm capacity (Base Load scenario, 2030)

Figure 12-40 shows the expected unserved energy from 250 simulation samples. This shows that for almost all the hours, the system does not show any unserved energy within the 250 samples.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Max	
0 MW	
0 MW	
Min	

Figure 12-40. Moloka'i: 6.6 MW firm, 6 MW hybrid solar expected unserved energy heat map (Base Load scenario, 2030)

To assess the firm generation impact on reliability, we assumed that 6 MW of hybrid solar is in service with additions of firm generation in 2.2 MW increments starting at 2.2 MW. We based the 2.2 MW increments on existing generator sizes.

Figure 12-41 illustrates the difference in reliability benefit of 1 MW at different levels of firm capacity. For example, going from 2.2 MW to 3.3 MW provides about 39 days/year loss of load expectation improvement versus a 1.8 day/year improvement going from 4 MW to 5 MW of firm capacity.

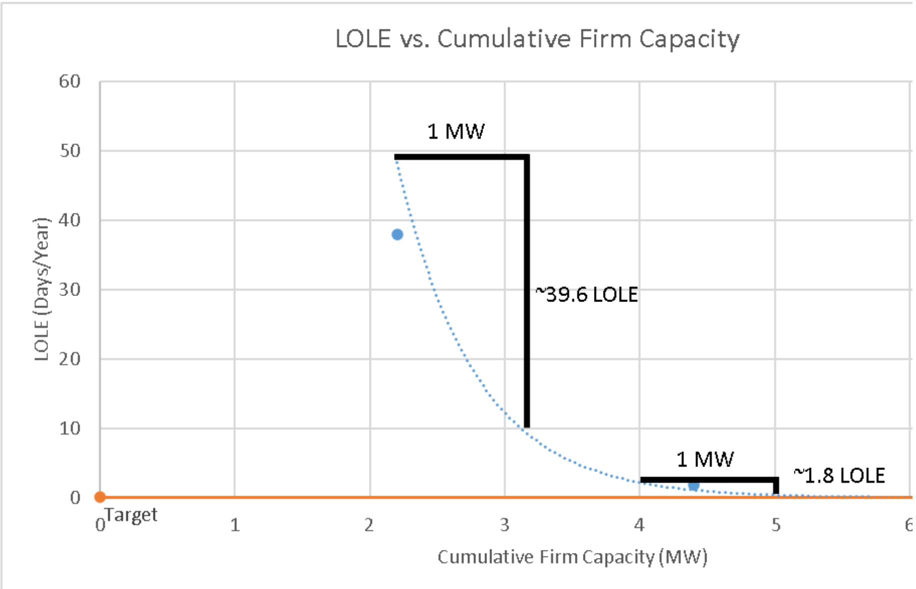


Figure 12-41. Moloka'i: relationship between change in loss of load and change in firm capacity (High Load scenario, 2035)

Figure 12-42 shows the expected unserved energy from 250 simulation samples. This shows that for almost all the hours, the system does not show any unserved energy within the 250 samples.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
2	0.00	0.02	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Max
0 MW
0 MW
Min

Figure 12-42. Moloka'i: 6.6 MW firm, 6 MW hybrid solar expected unserved energy heat map (High Load scenario, 2035)

12.3.4.33-Day Energy Profile, High Unserved Energy Day

The energy profile shown in Figure 12-43 depicts the worst unserved energy day to illustrate what that day would look like. In this scenario, the firm generators are out of service and without them there is significant unserved energy in the late evening and early morning hours.

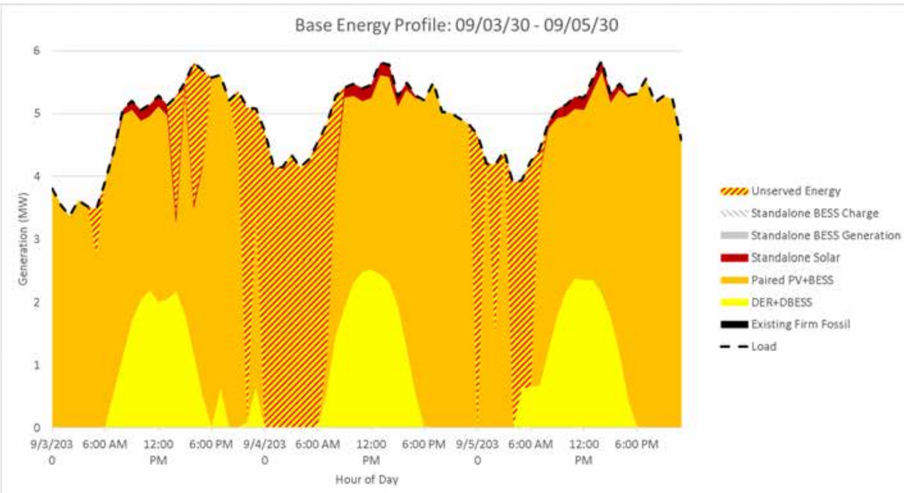


Figure 12-43. Moloka'i: 4.4 MW firm, add 12 MW hybrid solar; detailed energy profile, 2030 high unserved energy day

The energy profile shown in Figure 12-44 depicts the worst unserved energy day to illustrate what that day would look like. In this scenario, the firm generators are out of service and without them there is unserved energy in the late evening and early morning hours.

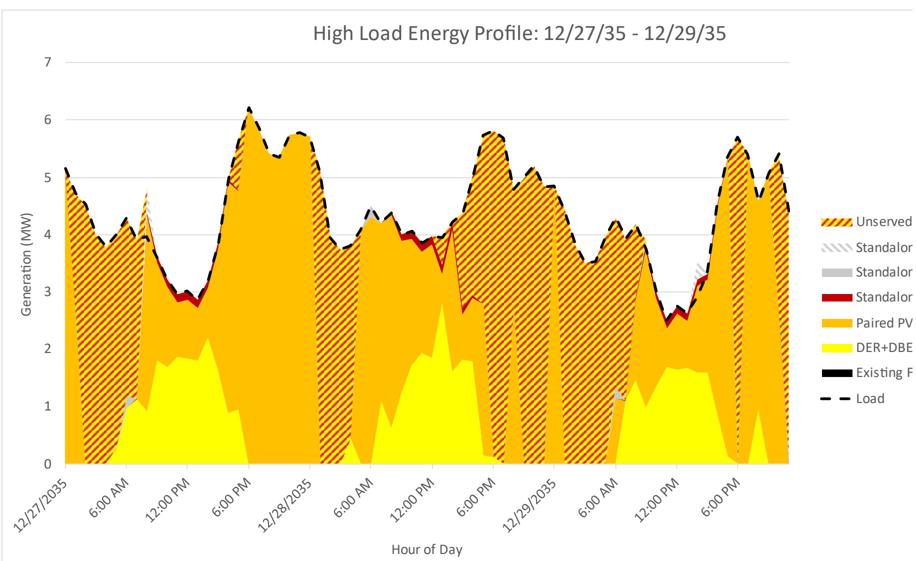


Figure 12-44. Moloka'i: 4.4 MW firm, add 12 MW hybrid solar; detailed energy profile, 2035 high unserved energy day

12.3.5 Lānaʻi

Uncertainty in forecasted electricity demand is a large source of risk for Lānaʻi. Section 8.6.2 shows how the planned Lānaʻi system meets reliability targets in 2030 and 2035. This section shows how adding or removing resources from the Lānaʻi system affects reliability metrics.

12.3.5.1Hybrid Solar Reliability Impacts

We assessed reliability impacts to hybrid solar additions on Lānaʻi in 2030. To determine the sensitivity of the loss of load expectation based on the amount of variable renewable generation added in 2030, we removed future hybrid solar and 2 MW of existing firm generation. We then varied the amount of hybrid solar to see how reliability changed.

As shown in Figure 12-45, in 2030, with 8 MW of firm generation, we need approximately 10 MW of hybrid solar to meet the 0.1 day/year loss of load expectation target. Shown below is the relationship between loss of load expectation and hybrid solar additions in 2030. The figure shows that as we add more hybrid solar, the improvements to reliability diminish.

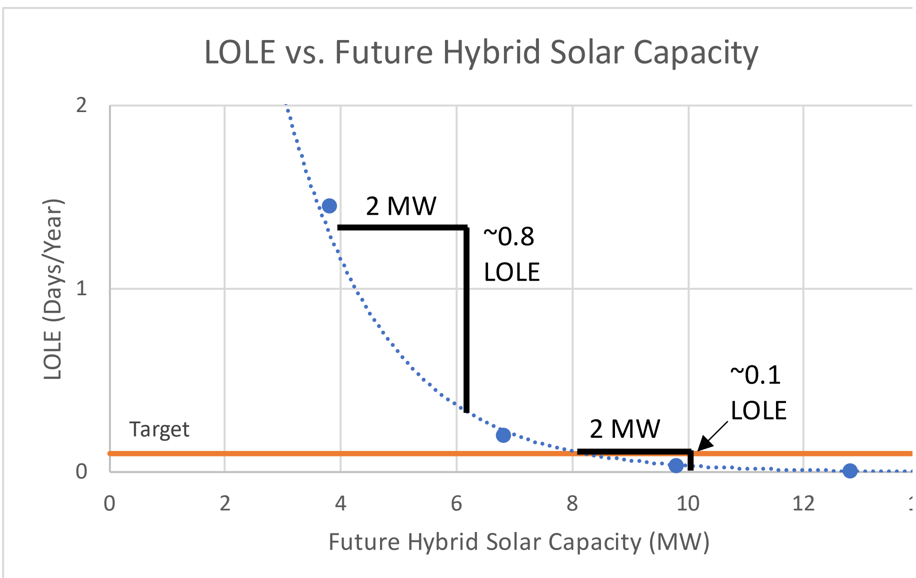


Figure 12-45. Lānaʻi: relationship between change in loss of load and change in hybrid solar (Base Load scenario, 2030)

Figure 12-46 presents the unserved energy based on the month and hour of the system with 8 MW of firm generation and 10 MW of hybrid solar. Unserved energy could be seen in the morning hours of October to December.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Max	
0.03 MW	
0 MW	
Min	

Figure 12-46. Lāna'i: 8 MW firm 10 MW hybrid solar expected unserved energy heat map (Base Load scenario, 2030)

To determine the sensitivity of the loss of load expectation based on the amount of hybrid solar added under the 2035 High electricity demand forecast, we removed the future hybrid solar and 2 MW of existing firm (see Figure 12-47). We then varied the amount of hybrid solar to see how reliability changed. The 2035 High electricity demand forecast is not drastically higher than the 2030 Base electricity demand forecast; therefore, the loss of load expectations between 2030 and 2035 are similar.

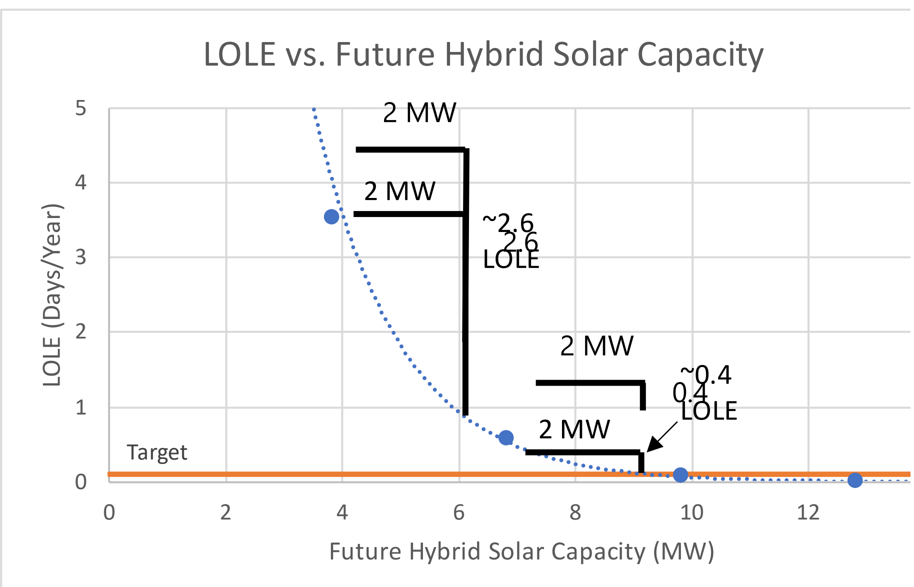


Figure 12-47. Lāna'i: relationship between change in loss of load and change in hybrid solar (High Load scenario, 2035)

Figure 12-48 presents the unserved energy based on the month and hour of the system with 8 MW of firm generation and 10 MW of hybrid solar. We observe unserved energy mostly from October to December.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.02
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.01	0.01
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.00	0.00
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Max	
0.03 MW	
0 MW	
Min	

Figure 12-48. Lāna'i: 8 MW firm, add 10 MW hybrid solar expected unserved energy heat map (High Load scenario, 2035)

12.3.5.2Firm Generation Reliability Impacts

We also performed analysis to analyze how the loss of load expectation changes based on the amount of existing firm generation in 2030. In this sensitivity, we assume that 16 MW from the past CBRE RFP is in service.

In 2030, 6 MW of firm generation is sufficient to meet the 0.1 day/year loss of load expectation target. Figure 12-49 shows the relationship between loss of load expectation and firm generation. The impact to loss of load expectation decreases as the amount of firm generation increases.

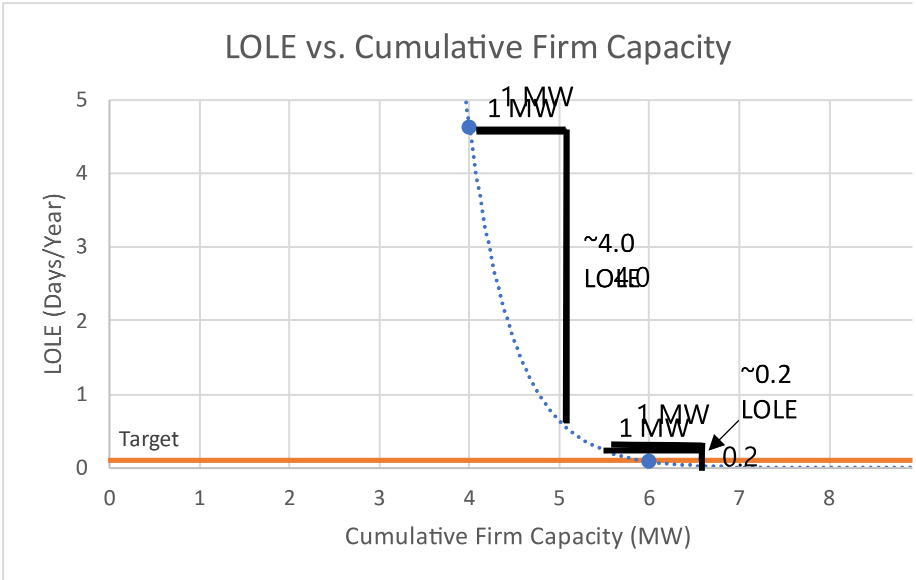


Figure 12-49. Lāna'i: relationship between change in loss of load and change in firm capacity (Base Load scenario, 2030)

Figure 12-50 presents the unserved energy based on the month and hour. Most of the unserved energy is observed in the morning and evening hours.

Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
5	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
6	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01
7	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01
8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.02	0.01
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.02	0.01
18	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.00	0.00	0.01	0.02
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Max
0.02 MW
0 MW
Min

Figure 12-50. Lāna'i: 6 MW firm, add 16 MW hybrid solar expected unserved energy heat map (Base Load scenario, 2030)

We also analyzed the relationship between loss of load expectation and the amount of existing firm generation in the 2035 High electricity demand forecast. In this sensitivity, we assumed that 16 MW of hybrid solar is in service.

As shown in Figure 12-51, in 2035, we will need more than 6 MW of firm generation to meet the 0.1 day/year target. The figure shows the relationship between the loss of load expectation and firm generation.

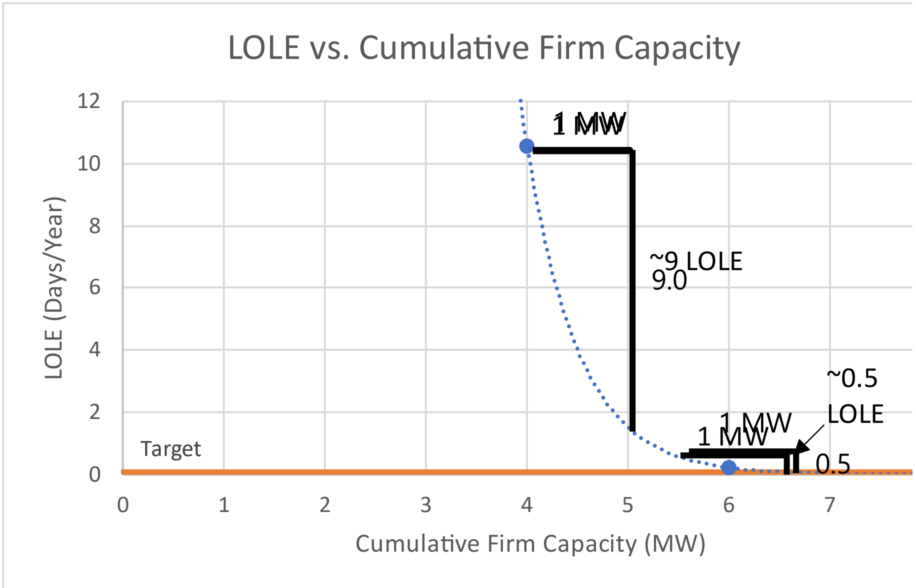
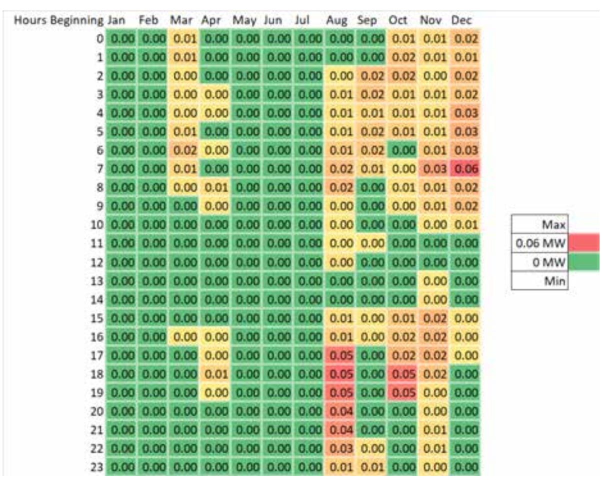


Figure 12-51. Lāna'i: relationship between change in loss of load and change in firm capacity (High Load scenario, 2035)

Figure 12-52 presents the unserved energy based on the month and hour. Most of the unserved energy is observed in the morning and evening hours.



Hours Beginning	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
0	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.02
1	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.01	0.01
2	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.02	0.02	0.00	0.02
3	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.02
4	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.01	0.01	0.03
5	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.01	0.02	0.01	0.01	0.03
6	0.00	0.00	0.02	0.00	0.00	0.00	0.00	0.01	0.02	0.00	0.01	0.03
7	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.02	0.01	0.00	0.03	0.06
8	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.02	0.00	0.01	0.01	0.02
9	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.02
10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01
11	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
12	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.01	0.02	0.00
16	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.02	0.02	0.00
17	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.02	0.02	0.00
18	0.00	0.00	0.00	0.01	0.00	0.00	0.00	0.05	0.00	0.05	0.02	0.00
19	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.05	0.00	0.05	0.00	0.00
20	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.00	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.04	0.00	0.00	0.01	0.00
22	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.03	0.00	0.00	0.01	0.00
23	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00

Figure 12-52. Lāna'i: 6 MW firm, add 16 MW hybrid solar expected unserved energy heat map (High Load scenario, 2035)

12.3.5.33-Day Energy Profile, High Unserved Energy Day

The results shown above are the average of the 250 simulation samples. Figure 12-53 shows a sample in the 2030 Base scenario where unserved energy is experienced in the early morning hours.

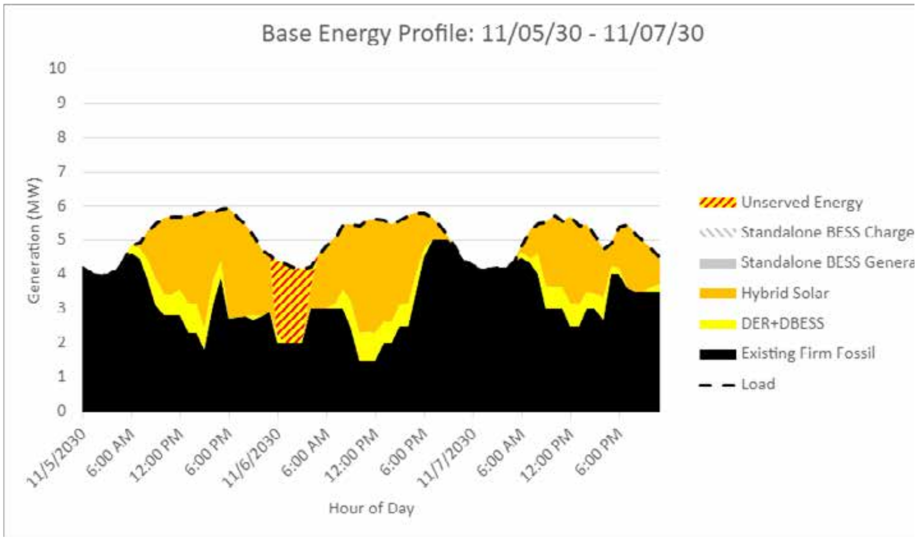


Figure 12-53. Lāna'i: 8 MW firm, add 10 MW hybrid solar; detailed energy profile, 2030 high unserved energy day

Figure 12-54 shows a sample in the 2035 High Load scenario where unserved energy is experienced in the early morning hours and mid-afternoon.

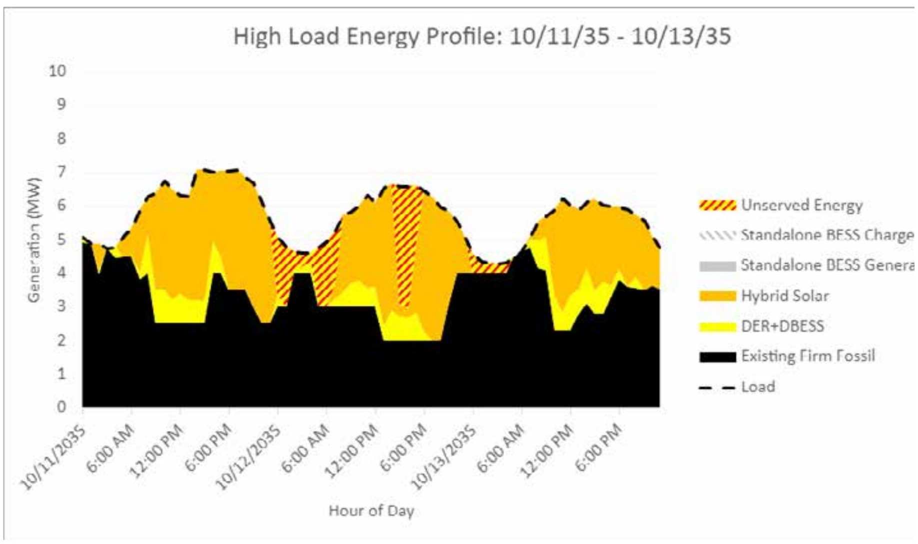


Figure 12-54. Lāna'i: 8 MW firm, add 10 MW hybrid solar; detailed energy profile, 2035 high unserved energy day

Appendices

Appendix A:

Stakeholder Feedback and Public Input

Appendix A:
Stakeholder Feedback and Public Input

1. Stakeholder Feedback and Public Input

1.1 Stakeholder Council

The Stakeholder Council met a total of 23 times between August 2018 and December 2022, discussing various topics on Integrated Grid Planning. The following table includes a list of meeting dates, links to presentation materials and notes. This information is also available within the Key Stakeholder Documents Library.

Meeting Date	Materials	Notes
August 30, 2018	General Presentation	Meeting Summary
November 8, 2018	General Presentation	Meeting Summary
January 22, 2019	General Presentation	Meeting Summary
February 20, 2019	General Presentation	Meeting Summary
May 8, 2019	General Presentation	Meeting Summary
August 23, 2019	General Presentation	Meeting Summary
November 7, 2019	General Presentation	Meeting Summary
January 16, 2020	General Presentation	Meeting Summary
March 12, 2020	General Presentation	Meeting Summary
June 1, 2020	General Presentation	Meeting Summary
August 18, 2020	General Presentation NREL Solar and Wind Resource Final Study NREL Solar and Wind Resource Potential Study	Meeting Summary
March 9, 2021	General Presentation Stakeholder Council Framework Pre-Read Stakeholder Council Meeting Docket 2018-0165	Meeting Summary
March 29, 2021	General Presentation	Meeting Summary
April 27, 2021	General Presentation	Meeting Summary
June 18, 2021	General Presentation SWITCH Analysis Presentation	Meeting Summary
June 23, 2021	General Presentation NREL Assessment of Wind and Photovoltaic Technical Potential Report Preliminary Agenda for June 30, 2021 Island-Wide PSCAD Study Meeting	Meeting Summary
October 28, 2021	General Presentation Technical Advisory Panel Update Presentation	Meeting Summary Meeting Recording
November 9, 2021	General Presentation Resilience Working Group Recap Stakeholder Council Pre-Read	Meeting Summary Meeting Recording
January 24, 2022	General Presentation	Meeting Summary Meeting Recording
May 18, 2022	General Presentation Progress Update Presentation	Meeting Recording
September 29, 2022	General Presentation	Meeting Recording
November 30, 2022	Joint Stakeholder Council and Technical Advisory Panel Meeting Presentation	Meeting Recording
December 5, 2022	General Presentation	Meeting Recording

1.1.1 Stakeholder Toolkit

The purpose of the Stakeholder Toolkit is to provide public-friendly materials for Stakeholder Council Members to use when discussing Hawaii Powered. The use of identical materials throughout engagement helps to provide consistent branding and messaging. Two toolkits were provided to the Stakeholder Council including in 2020 and 2022.

- Toolkit – Overview Presentation with talking points
- Toolkit – FAQs
- Toolkit – Hawaii Powered Handout'

Getting to 100% Renewables

Join Us At Our Public Meetings

5 – 7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

Agenda

PART 1 Open House
5 – 6 pm

PART 2 Panel Discussion
6 – 7:30 pm

Dates & Locations

TUESDAY Mar 03
Kealakehe High School (Cafeteria)
74-5000 Puohulihuli Street
Kailua-Kona, Hawai'i 96740

THURSDAY Mar 05
Hilo High School (Cafeteria)
556 Waiānuenue Avenue
Hilo, Hawai'i 96720

TUESDAY Mar 10
Hawaii Pacific University*
(Multi-Purpose Room 3)
1 Aloha Tower Drive
Honolulu, O'ahu 96813
**Free parking with validation*

THURSDAY Mar 12
Hawaiian Electric (Kahului Auditorium)
210 W. Kamehameha Avenue
Kahului, Maui 96732

- Pupus will be provided
- Check out our careers station

VIRTUAL OPEN HOUSE

Can't join us? Then visit our Virtual Open House between **March 2–20, 2020 at www.hawaiianelectric.com/igp**

WE WANT TO HEAR FROM YOU

We welcome your input! Here are the many ways to stay connected with us.

Email:
IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

Hawaiian Electric

Hawai'i's Renewable Energy Future Series

Getting to 100% Renewables

Join Us At Our Community Meeting

5–7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

TUESDAY **Mar 03** — **Kealakehe High School** *(Cafeteria)*
74-5000 Puohulihuli Street
Kailua-Kona, Hawai'i 96740

THURSDAY **Mar 05** — **Hilo High School** *(Cafeteria)*
556 Waiānuenue Avenue
Hilo, Hawai'i 96720

Pupus will be provided at both community meetings

PART 1 — Open House Stations
5–6 pm

Eight (8) informational stations to browse and ask questions:

1. Integrated Grid Planning (IGP)
2. Grid Modernization
3. Grid Scale Renewables
4. Rooftop Renewable Energy
5. Community-Based Renewable Energy
6. Resilience
7. Electrification of Transportation
8. Careers at Hawaiian Electric

PART 2 — Panel Discussion
6–7:30 pm

Panel Participants

- **Hawaiian Electric** | Colton Ching, Sr. Vice President, Planning and Technology
- **Hawaiian Electric** | Kevin Waltjen, Director, Hawai'i Island
- **Hawaiian Electric** | Lisa Dangelmaier, Director, System Operations, Hawai'i and Maui
- **County of Hawai'i** | Riley Saito, Deputy Director, Research and Development
- **Geometrician Associates** | Ron Terry, Principal
- **Community** | Carol Ignacio

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Hawaiian Electric

Getting to 100% Renewables

Join Us At Our Public Meetings

5–7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

TUESDAY Mar 10

Hawaii Pacific University* *(Multi-Purpose Room 3)*
1 Aloha Tower Drive, Honolulu, O'ahu 96813
**Free parking with validation*

Pupus will be provided

PART 1 Open House Stations
5–6 pm

Eight (8) informational stations to browse and ask questions:

1. Integrated Grid Planning (IGP)
2. Grid Modernization
3. Grid Scale Renewables
4. Rooftop Renewable Energy
5. Community-Based Renewable Energy
6. Resilience
7. Electrification of Transportation
8. Careers at Hawaiian Electric

PART 2 Panel Discussion
6–7:30 pm

Panel Participants

- **Community | Cynthia Rezentes,** Nanakuli Neighborhood Board Chair
- **Ulupono Initiative** | Murray Clay, President
- **O'ahu Economic Development Board** | Pono Shim, President & CEO
- **City & County of Honolulu** | Josh Stanbro, Chief Resilience Officer & Executive Director, Office of Climate Change, Sustainability & Resiliency
- **Hawai'i Farm Bureau** | Brian Miyamoto, Executive Director
- **Hawaiian Electric** | Colton Ching, Sr. Vice President, Planning and Technology

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Hawaiian Electric

Maui's Renewable Energy Future Series

Getting to 100% Renewables

Join Us At Our Community Meeting
5 – 7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

THURSDAY Mar 12

Hawaiian Electric *(Kahului Auditorium)*
210 W. Kamehameha Avenue
Light refreshments will be provided

PART 1 Open House Stations
5 – 6 pm

Eight (8) informational stations to browse and ask questions:

1. Integrated Grid Planning (IGP)
2. Grid Modernization
3. Grid Scale Renewables
4. Rooftop Renewable Energy
5. Community-Based Renewable Energy
6. Resilience
7. Electrification of Transportation
8. Careers at Hawaiian Electric

PART 2 Panel Discussion
6 – 7:30 pm

Panel Participants

- **Rhiannon Chandler-ʻIao**, Executive Director, Waiwai Ola Waterkeepers Hawaiian Islands
- **Colton Ching**, Senior Vice President, Planning and Technology, Hawaiian Electric
- **Rebecca Dayhuff Matsushima**, Director, Renewable Acquisitions, Hawaiian Electric
- **Dick Mayer**, Coordinator, Alliance for Maui Community Associations
- **Michele McLean**, Director, Department of Planning, County of Maui

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Hawaiian Electric

Hawaiian Electric

Integrated Grid Planning

Listening + Integrating + Collaborating to Reach 100% Renewables by 2045

Customer Priorities

We're Listening

In response to engagement, surveys, and focus groups, we were told affordability, reliability, and energy choices are most important to customers.

Affordability
Lower energy bills

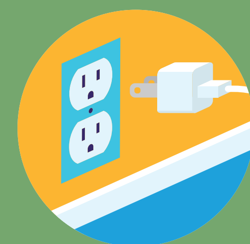
Reliability
Fewer outages

Energy Choices
More control over energy generation and use

Is this true for you?

Let us know if you have different opinions. We're using this information to help make smart future energy decisions for customers.

5 Ways Customers Can Help Hawai'i Reach 100% Renewables



1. Reduce energy use at home and work

2. Upgrade to energy smart appliances

3. Upgrade to an advanced meter

4. Buy an electric vehicle

5. Participate in customer energy options

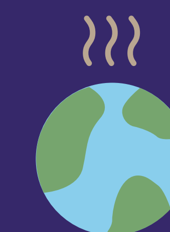
Visit **hawaiianelectric.com/products-and-services/** to learn more ways you can help

What is IGP?

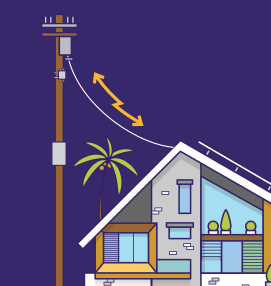
Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

Our Energy Future

Achieve Energy Independence
Reduce oil dependency and volatile fuel costs by increasing renewables

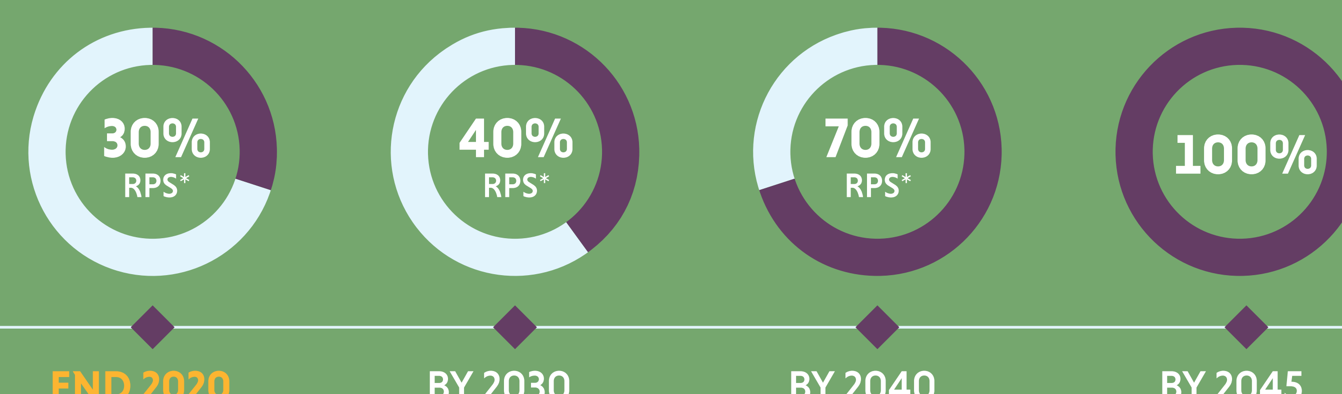


Climate Change Considerations
Add more renewables to reduce greenhouse gas emissions and build a resilient grid



Modernize Our Island Grids
Integrate new technologies to facilitate 100% renewable energy

Our Goal for the Future:
100% Renewables by 2045



*RPS = Renewable Portfolio Standard

WE WANT **TO HEAR** FROM YOU

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Email:
IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

HawaiianElectric

hwnelectric

hawaiianelectric

How Does This Benefit Our Customers?

- More options to control and lower bills
- Time-of-Use rates to save money and lower fuel and maintenance costs
- Financial incentives for purchasing an electric vehicle
- Benefits of solar energy by offsetting bills without installing PV panels on their property
- Integrate higher levels of renewables into the modern grid
- Faster power outage restoration with greater convenience
- Improved efficiencies and integration of renewables

What Do We Need to Consider?

Integrated Grid Planning looks into the best technology options for all aspects of our energy system and identifies energy needs and behaviors of future customers taking into consideration key factors.

- Future customer needs
- Community impact
- Cost to design and build large projects
- Future resource costs
- New technologies
- Number of electric vehicles
- New businesses and industries
- Number of residents installing rooftop solar
- Preparing for extreme events

Participating in the Process

As part of the IGP process, we are collecting your input and considering all our options in planning for our renewable future. Here are the participants Hawaiian Electric is collaborating with:

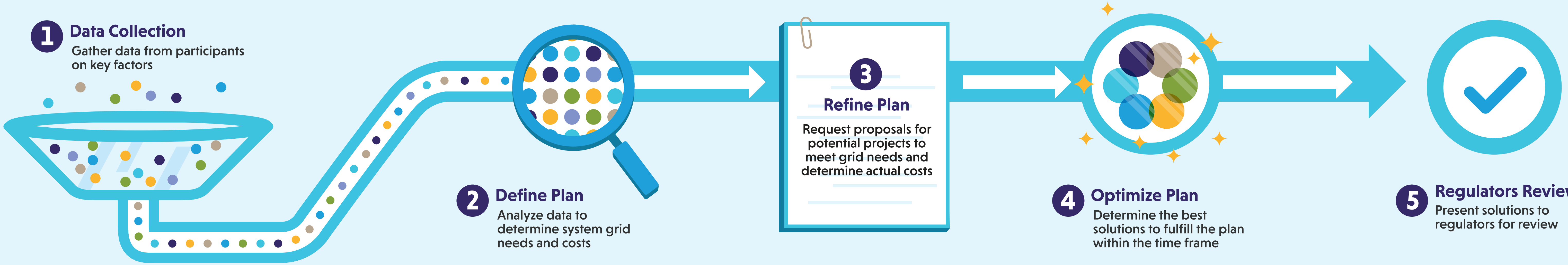
Working Groups
Address specific topics in an advisory capacity and not as a decision-making group

Stakeholder Council
Represents customers and broad stakeholders to review work and provide guidance and insights

The Public
Communication with customers

Technical Advisory Panel
Provides independent evaluation and feedback on the working group activities and review point filings

How Do We Get There? Integrated Grid Planning



Hawaiian Electric

Integrated Grid Planning

Listening + Integrating + Collaborating to Reach 100% Renewables by 2045

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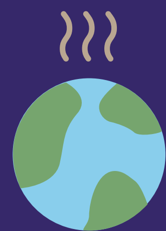
Our Energy Future

Achieve Energy Independence

Reduce oil dependency and volatile fuel costs by increasing renewables



Climate Change Considerations

Add more renewables to reduce greenhouse gas emissions and build a resilient grid

Modernize Our Island Grids

Integrate new technologies to facilitate 100% renewable energy

Our Goal for the Future:
100% Renewables by 2045

END 2020 | BY 2030 | BY 2040 | BY 2045

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How Does This Benefit Our Customers?

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Time-of-Use rates to save money and lower fuel and maintenance costs

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Benefits of solar energy by offsetting bills without installing PV panels on their property

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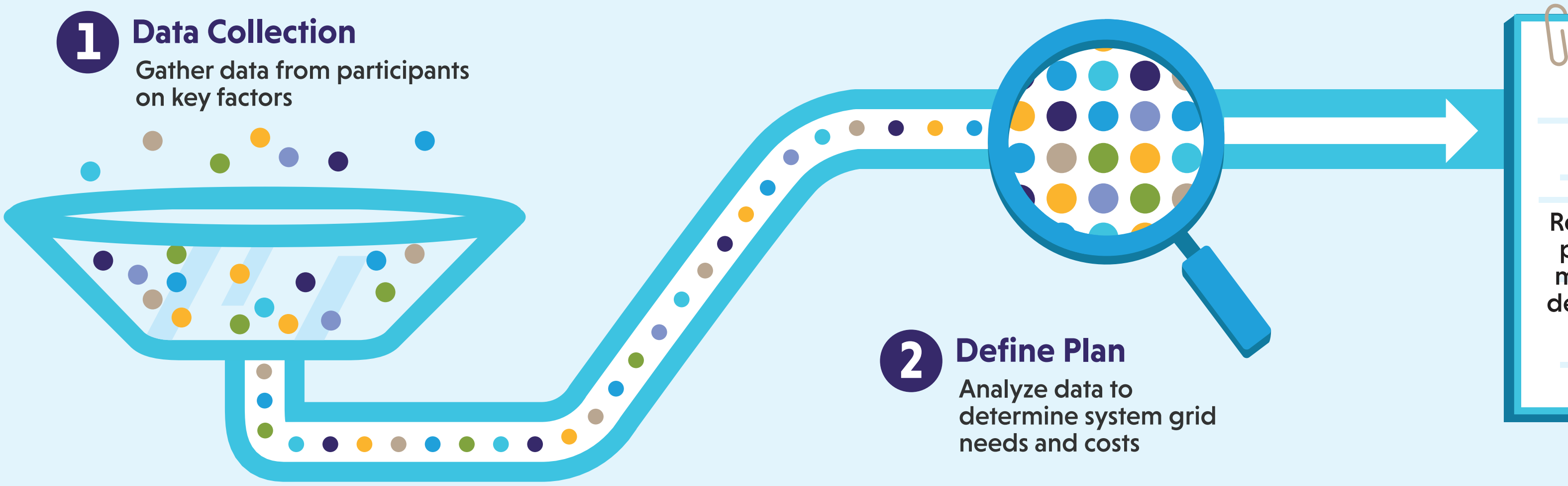
Improved efficiencies and integration of renewables

How Do We Get There? Integrated Grid Planning



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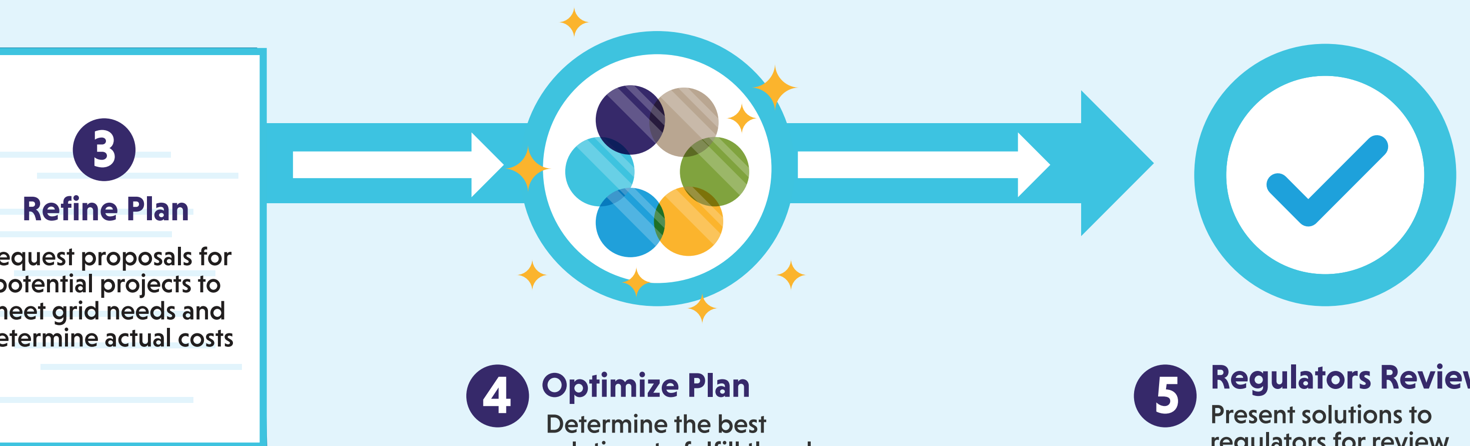

3 Refine Plan
equest proposals for otential projects to neet grid needs and etermine actual costs

4 Optimize Plan
Determine the best solutions to fulfill the plan within the time frame

5 Regulators Review
Present solutions to regulators for review

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Hawaiian Electric

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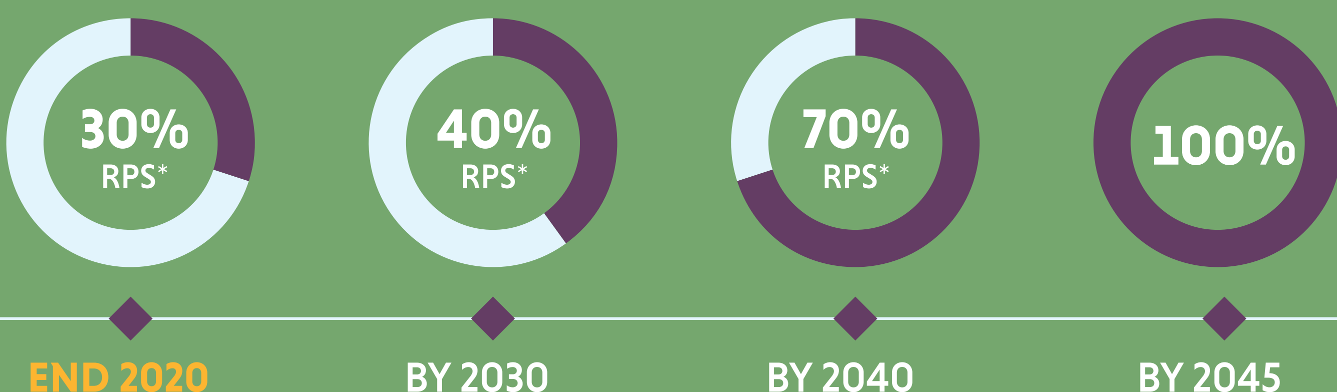

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- Preparing for extreme events

Participating in the Process

As part of the IGP process, we are collecting your input and considering all our options in planning for our renewable future. Here are the participants Hawaiian Electric is collaborating with:

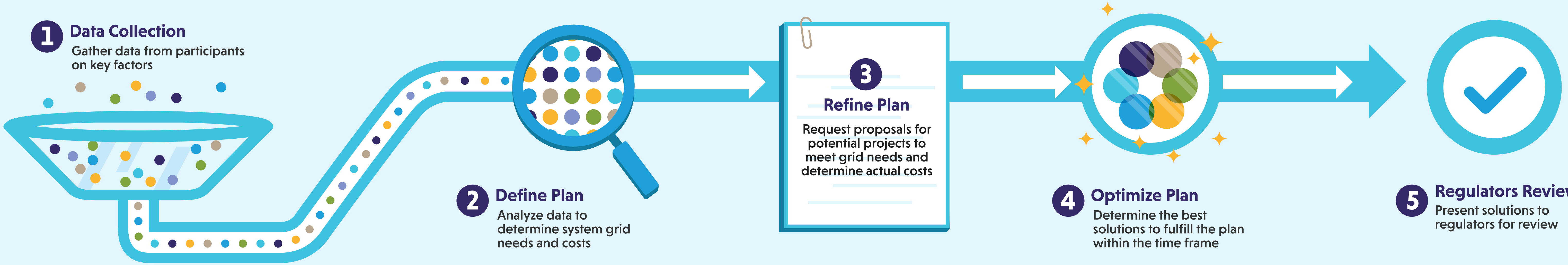
Working Groups
Address specific topics in an advisory capacity and not as a decision-making group

Stakeholder Council
Represents customers and broad stakeholders to review work and provide guidance and insights

The Public
Communication with customers

Technical Advisory Panel
Provides independent evaluation and feedback on the working group activities and review point filings

How Do We Get There? Integrated Grid Planning



Customer Priorities

We're Listening

In response to engagement, surveys, and focus groups, we were told affordability, reliability, and energy choices are most important to customers.

Affordability
Lower energy bills

Reliability
Fewer outages

Energy Choices
More control over energy generation and use

Is this true for you?

Let us know if you have different opinions. We're using this information to help make smart future energy decisions for customers.

5 Ways Customers Can Help Hawai'i Reach 100% Renewables

1. Reduce energy use at home and work
2. Upgrade to energy smart appliances
3. Upgrade to an advanced meter
4. Buy an electric vehicle
5. Participate in customer energy options

Visit **hawaiianelectric.com/products-and-services/** to learn more ways you can help

WE WANT **TO HEAR** FROM YOU

We welcome your input! Here are the many ways to stay connected with us.

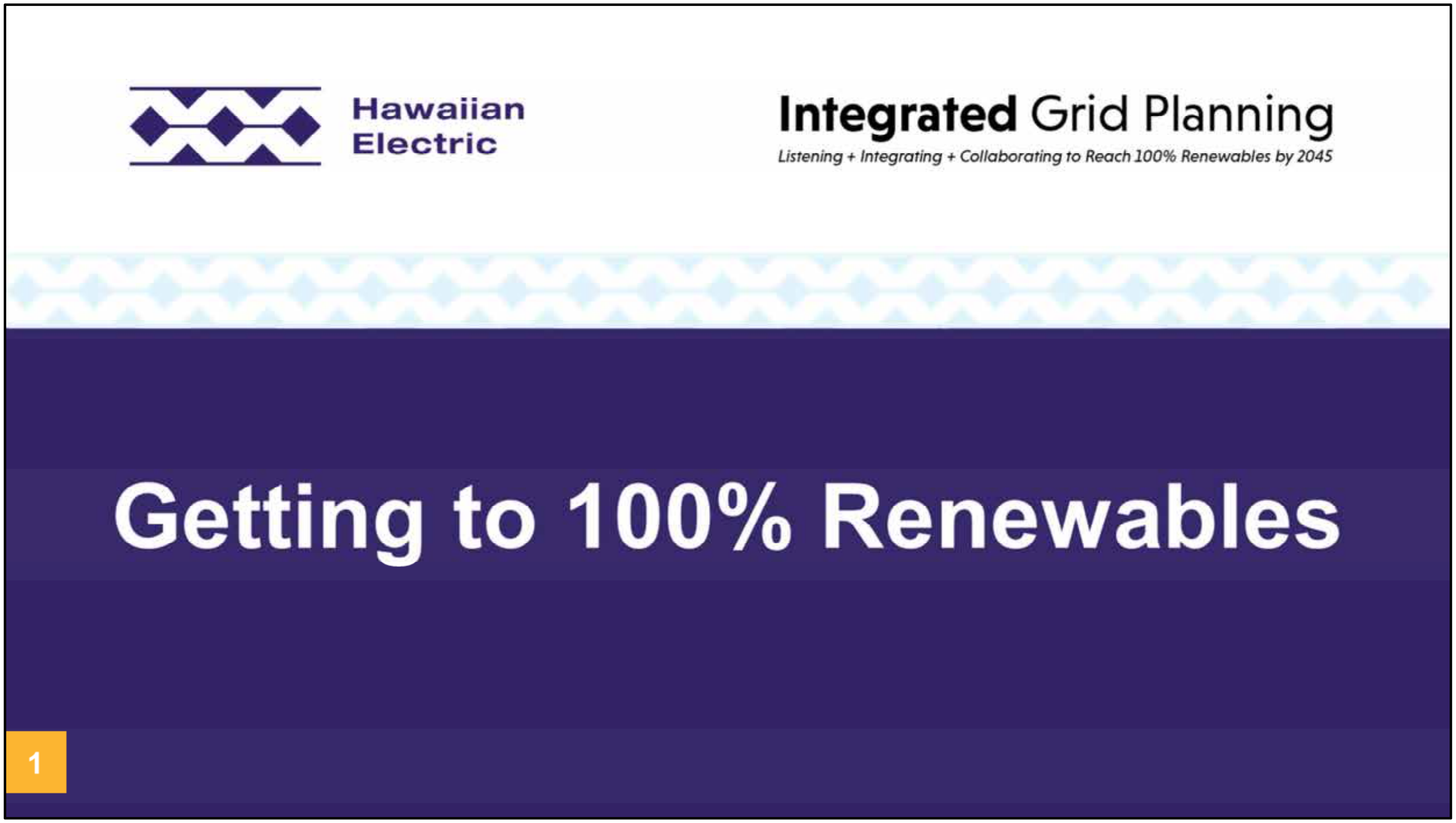
Email:
IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

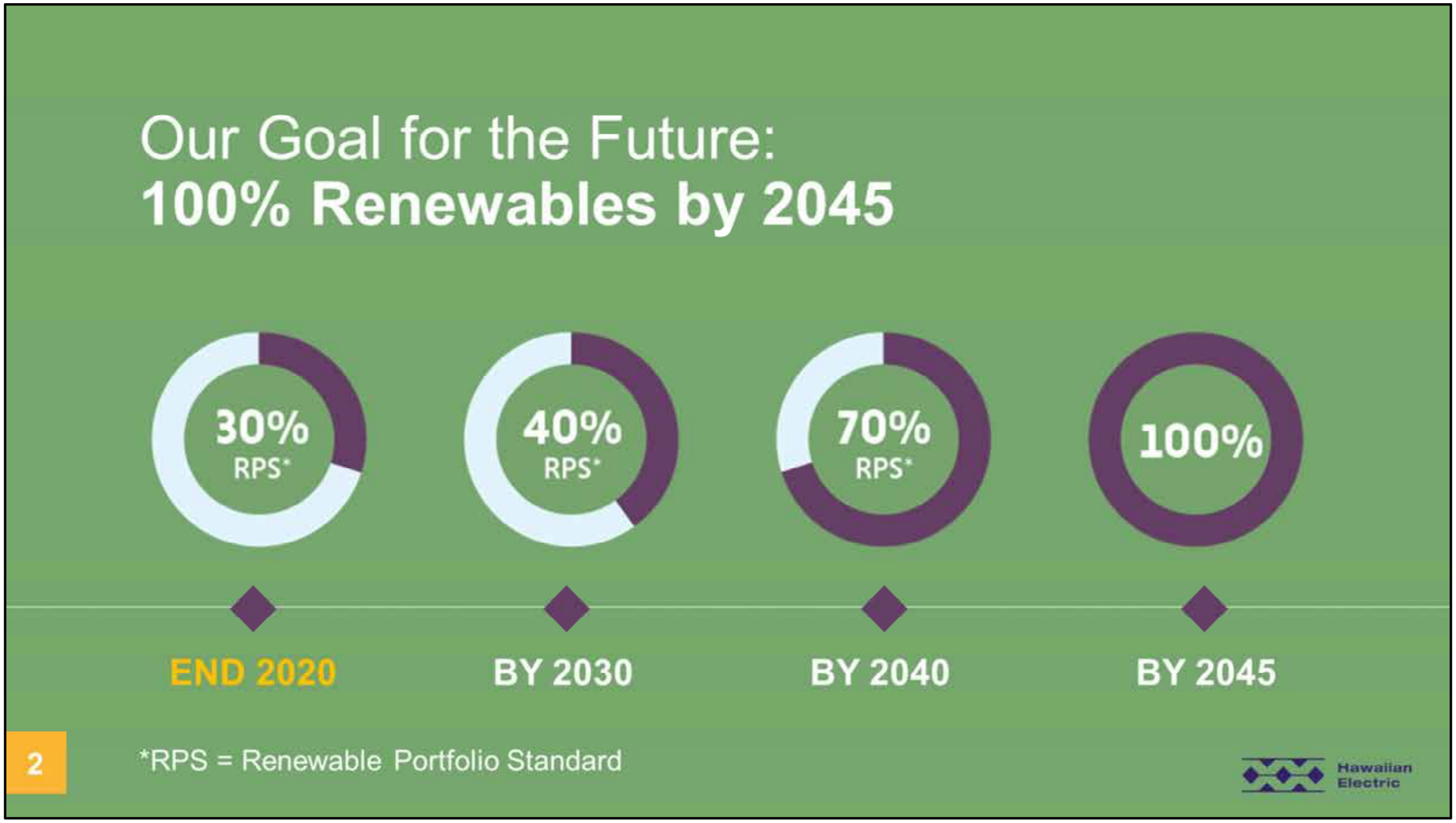
HawaiianElectric

hwnelectric

hawaiianelectric

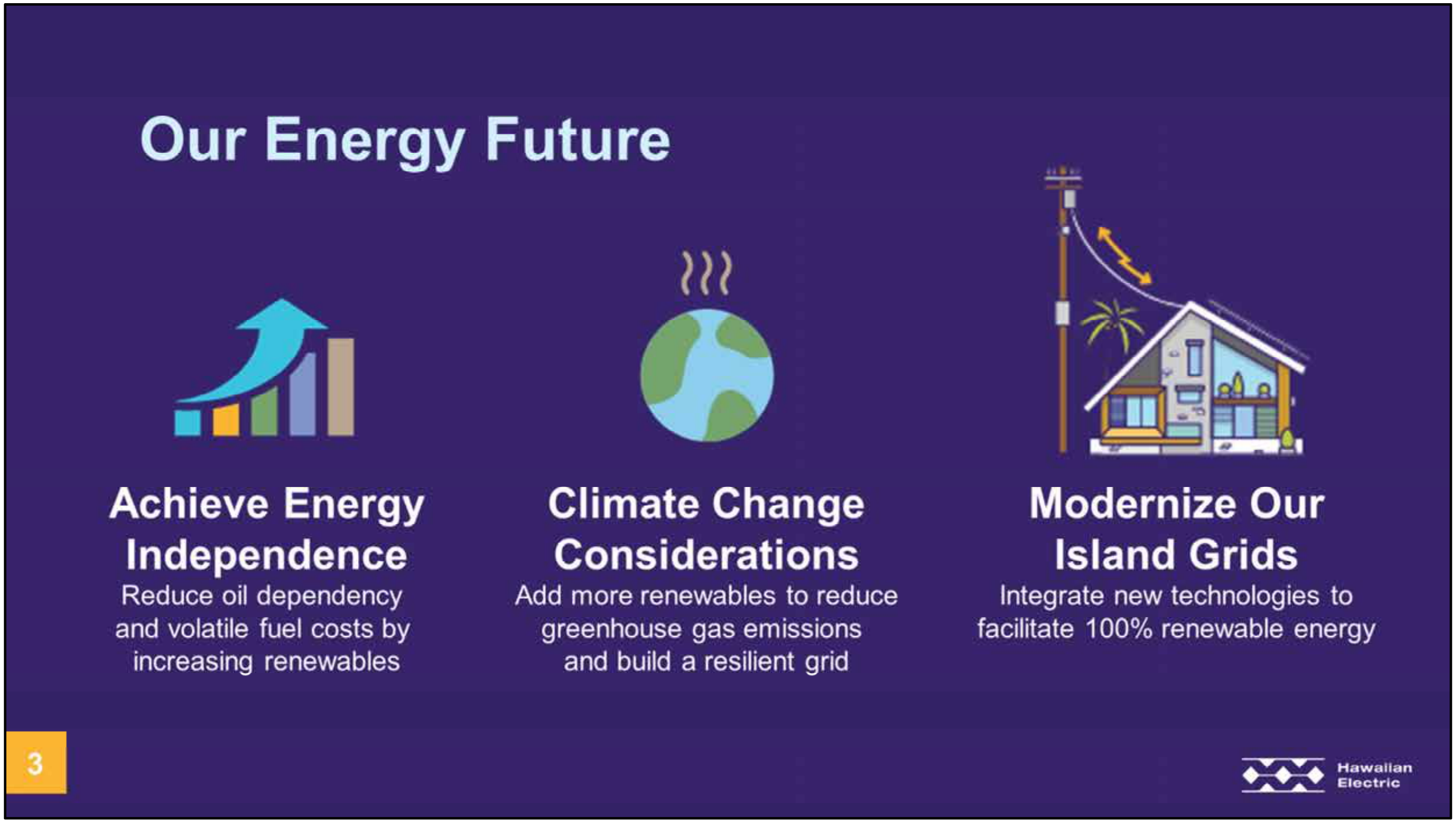


This presentation covers information on Hawaiian Electric's Integrated Grid Planning with a focus on how the process plays a role in helping us reach our 100% renewable energy goal



In 2015, our state made a commitment to our clean energy future of getting to 100% renewables by 2045.

As you can see by this chart – we, collectively, have significant changes to make in order to achieve this goal. It will take a collaborative and integrated process for the state of Hawaii to completely transform the way we generate, transfer and use energy across our state. We need to make changes today and incrementally over the next 25 years to reach our goal.

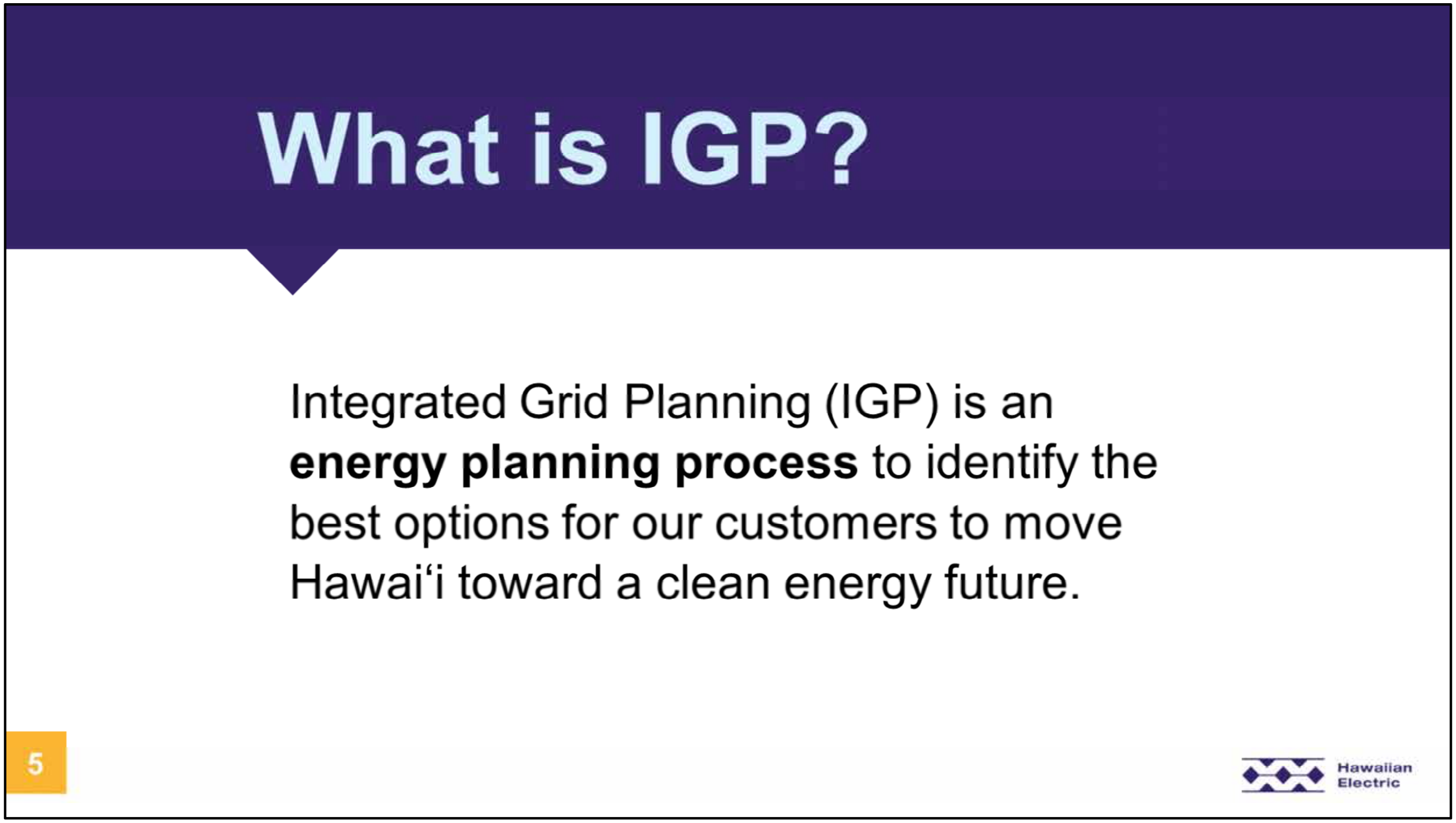


Each of us has a unique vision of our energy future. As Hawaiian Electric looks toward the future – they are looking at three key areas:

- First, achieving energy independence by reducing our dependency on oil and volatile fuel costs by increasing renewables.
- Second, making sure that we're considering climate change by adding more community and large-scale renewables to our energy grid and building a stronger, more resilient grid.
-Third, modernizing our grid. We need to build a smart energy system using new technologies that enable us to transform how we generate, deliver and use our energy. These upgrades will create a smarter and more flexible energy grid allowing us to increase renewables.

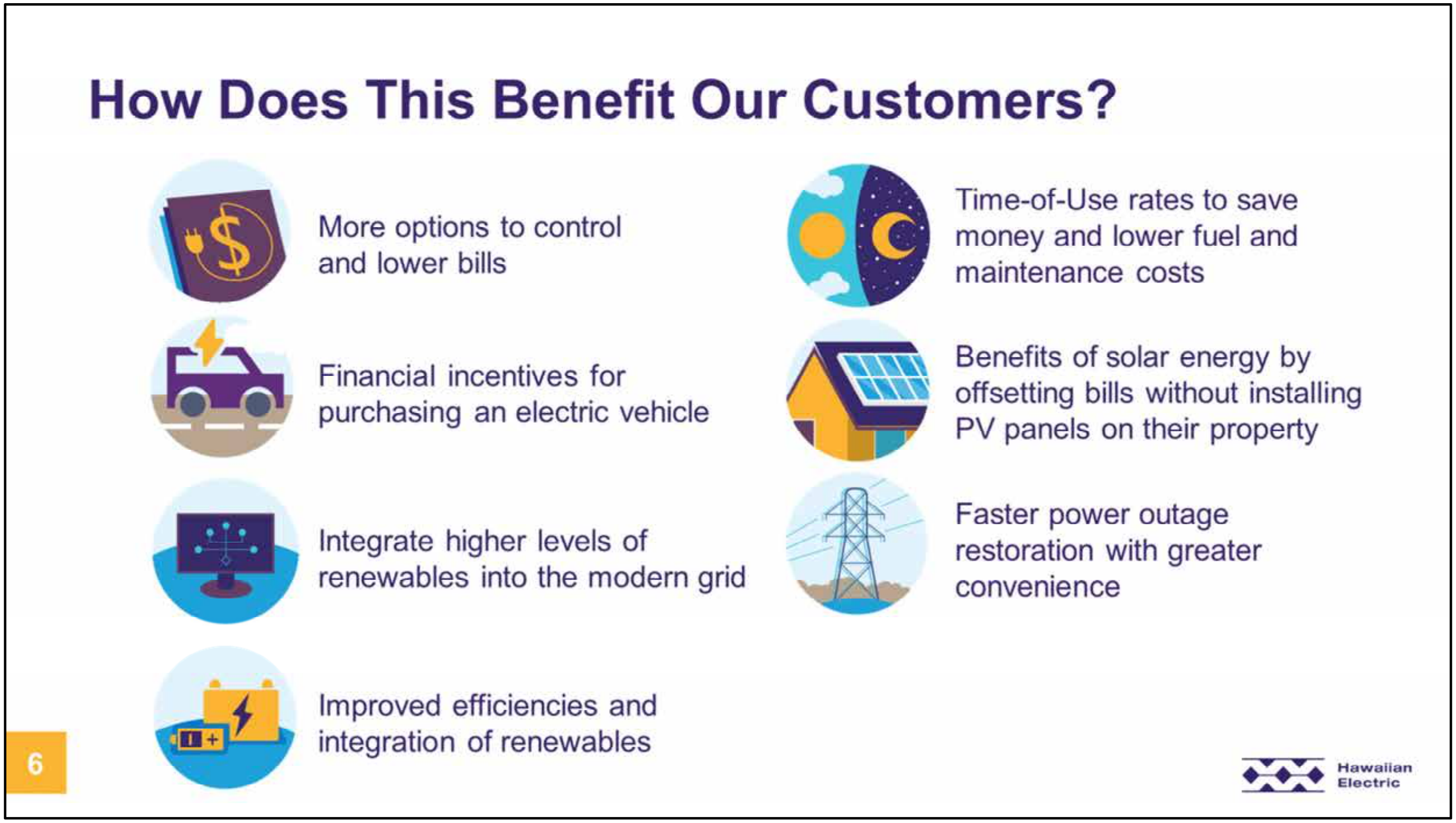
We <u>each</u> play a role in meeting Hawaii's energy goals. It is important for us to think about the energy we produce and use, everyday, as a complete energy system.

Here are five steps – large and small – that will help customers conserve energy, monitor energy use, and generate renewable energy. Visit hawaiianelectric.com/products-and-services/ to learn more ways you can help.



So what is IGP?

It's an energy planning process. Similar to a business strategic planning process, Hawaiian Electric gathers data and develops a plan to provide insights and directions for the future of the utility to meet customer needs, regulatory requirements and clean energy goals.



You may be asking – how does this benefit me/customers?

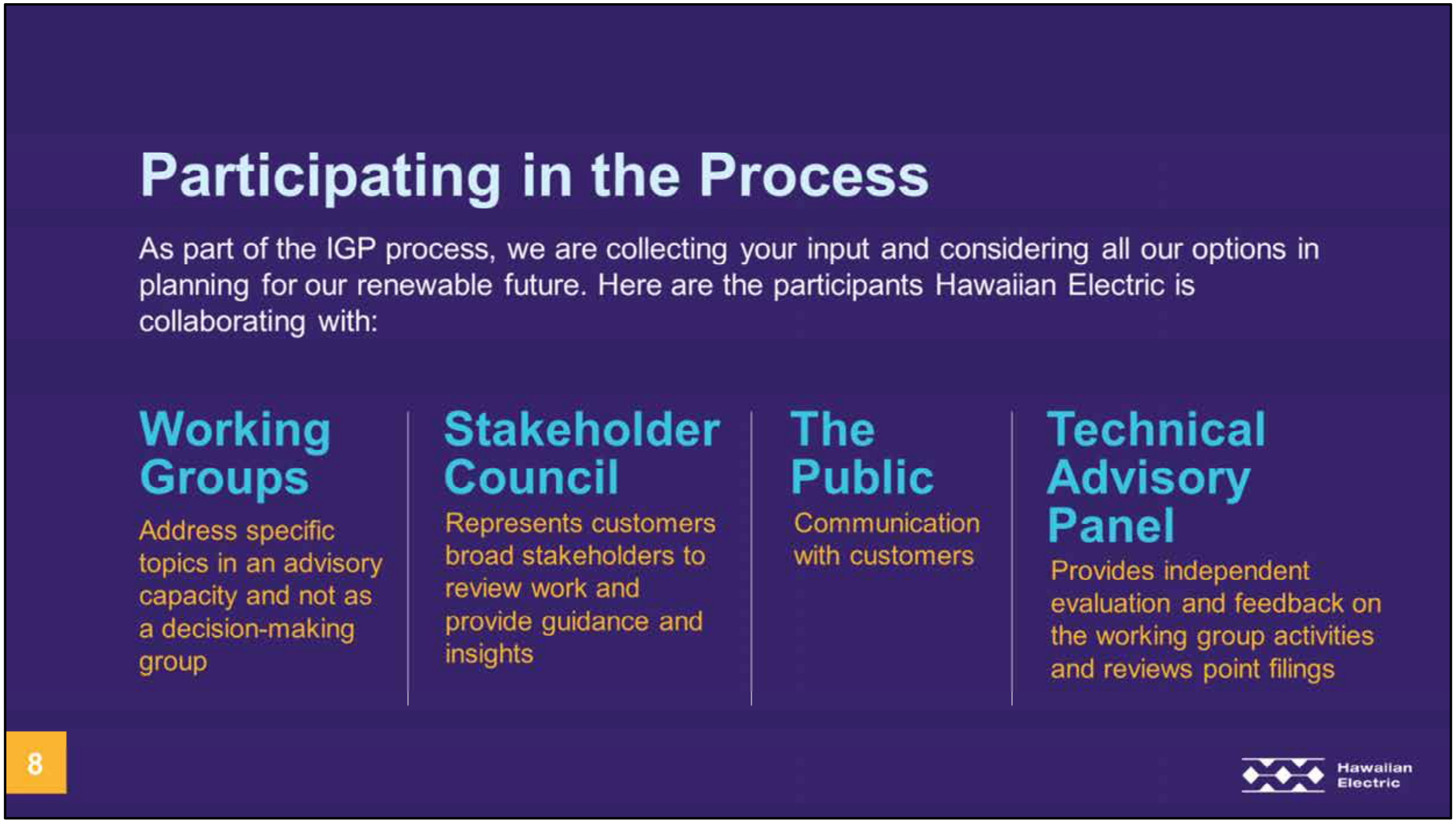
Hawaiian Electric is continually working ways to improve the customer experience including:
- Developing ways to modernize our grid
- Integrating time of use programs to conserve energy and save money
- Installing and integrating more rooftop and community solar
- Supporting the electrification of transportation system
- Identify opportunities and technologies to store energy

They are doing all of this while keeping customer's electric bills and service reliability in mind.

Several factors drive and impact the right solutions as we plan for our clean energy future.

The eight factors listed provide a snapshot of the type of information Hawaiian Electric gathers and considers during the planning process to help identify challenges and opportunities. Future costs for materials and fuel, the number of electric vehicles purchased, and the impact of natural disasters, all garner different solutions for Hawaiian Electric to consider.

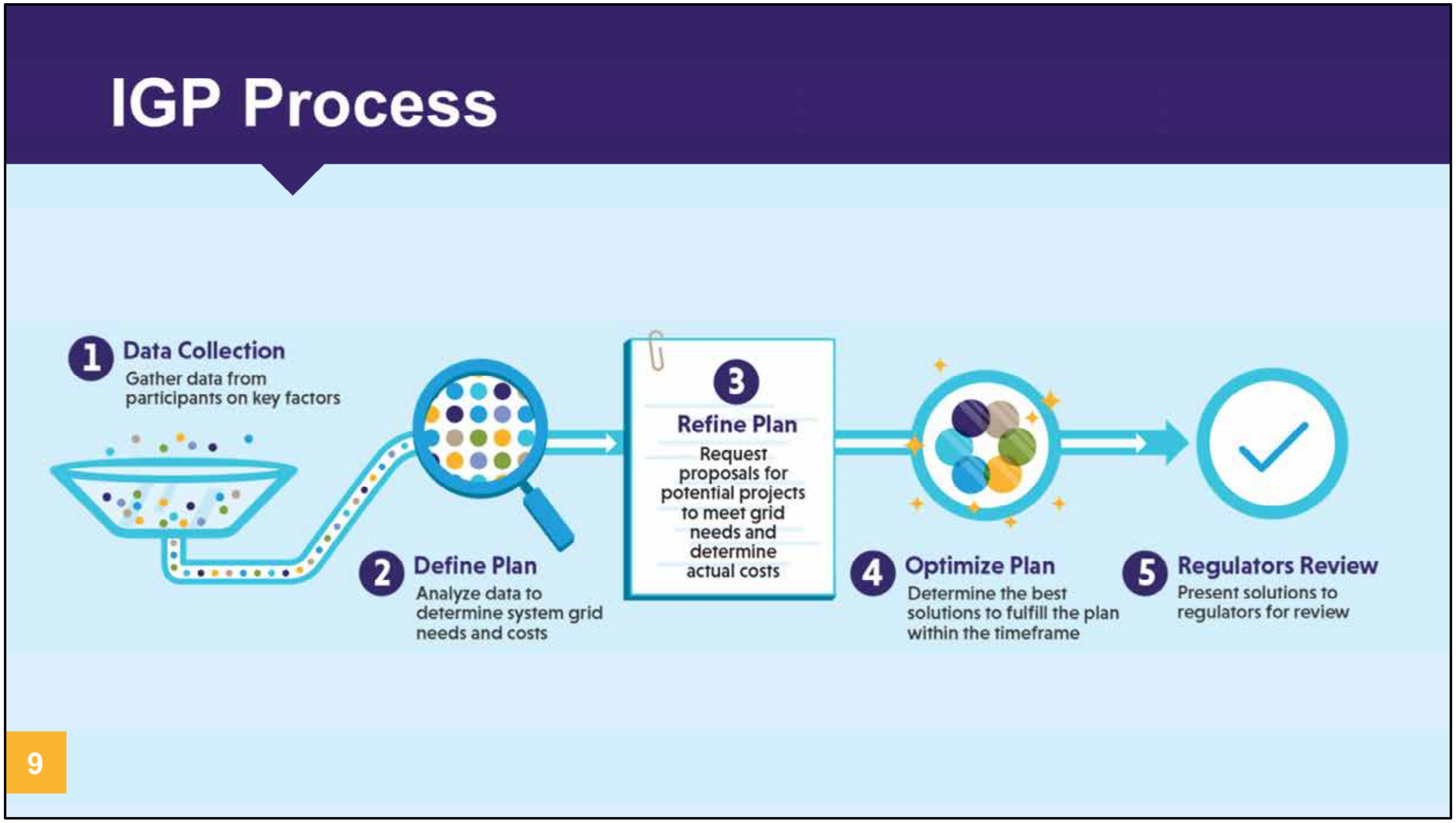
Today, data and models are used to help forecast what these different factors may actually be in the next 5 or 25 years.



An aspect of Integrated Grid Planning is working with several stakeholder groups to collect input and consider various options in planning for Hawaii's renewable future. Here are the participants Hawaiian Electric is collaborating with:

- Working Groups
- The Stakeholder Council
- The public
- A Technical Advisory Panel

Representatives from across Hawaii, Oahu and Maui County participate in meetings, workshops, and review data, methodologies and reports. Participation includes representatives from various groups and organizations bringing different ideas and perspectives to the conversation.



Integrated Grid Planning has five major steps.

This is a two year planning process. Hawaiian Electric collects data from experts and stakeholders, including the public, on the various key factors shown earlier.

Data collected is analyzed and used to determine what the grid needs and may cost.

Then a plan is refined based on proposals for potential projects gathered which include actual costs. For instance, if you were remodeling your kitchen, you may have an idea in mind of what you want and about how much it will cost, but you won't have actual costs until you have a bid put together by a contractor. This is a similar process Hawaiian Electric will undergo in order to gather potential projects and their actual costs.

What is the **Outcome of IGP?**

Filed applications for projects & strategies used for long-term decision making

Hawaiian Electric

In the Integrated Grid Planning process, Hawaiian Electric will develop a long term plan that will be submitted to the PUC for review. This plan will provide insights into long term decisions made for resources (generation), transmission (how power is transferred to customers) and distribution (how customers receive their energy). Hawaiian Electric will use the findings and identified solutions in the long term plan to inform procurements. The projects that emerge from the procurements will also be submitted to the PUC for review and used to update the long term plan.

Working Groups

- **Standardized Contracts (SCWG)**
  Procurement of services through a contracting mechanism between Hawaiian Electric (utility) market operators and third party providers of grid and other ancillary services.
- **Competitive Procurement (CPWG)**
  Procurement of resources in alignment with Hawaiian Electric's grid plans as identified through the IGP process.
- **Forecasts and Assumptions (FAWG)**
  Support development of forecast assumptions and sensitivities as part of pre-IGP planning cycle activity, and provide strategic inputs and feedback on assumptions and methodologies used for load forecast development and results.
- **Distribution Planning (DPWG)**
  Enhancement to the methods and tools for distribution planning and the integration with resource and transmission planning.
- **Grid Services (GSWG)**
  Identify and define additional energy, capacity, ancillary and T&D non-wires alternative services.
- **Resilience (RWG)**
  Support the development of resilience planning.
- **Solution Evaluation and Optimization (SEOWG)**
  Identify needed grid services and review and make recommendations regarding the transparent evaluation and optimization method.

Hawaiian Electric

There are 7 working groups collaborating on various aspects of the planning process. More information on each of these working groups can be found on the IGP website including upcoming scheduled meetings.

Upcoming public meetings will be held in March 2020.

The public meetings will have two parts:

1) The open house will have eight stations to talk with Hawaiian Electric staff
2) The panel will include speakers with various perspectives on getting to 100% renewables. Audience members will have an opportunity to submit or ask questions of the panel members during the facilitated Q&A session.

Dates & Locations

TUESDAY Mar 03

Kealakehe High School (Cafeteria)
74-5000 Puohulihuli Street
Kailua-Kona, Hawai'i 96740

TUESDAY Mar 10

Hawaii Pacific University*
(Multi-Purpose Room 3)
1 Aloha Tower Drive
Honolulu, O'ahu 96813
**Free parking with validation*

THURSDAY Mar 05

Hilo High School (Cafeteria)
556 Waiānuenue Avenue
Hilo, Hawai'i 96720

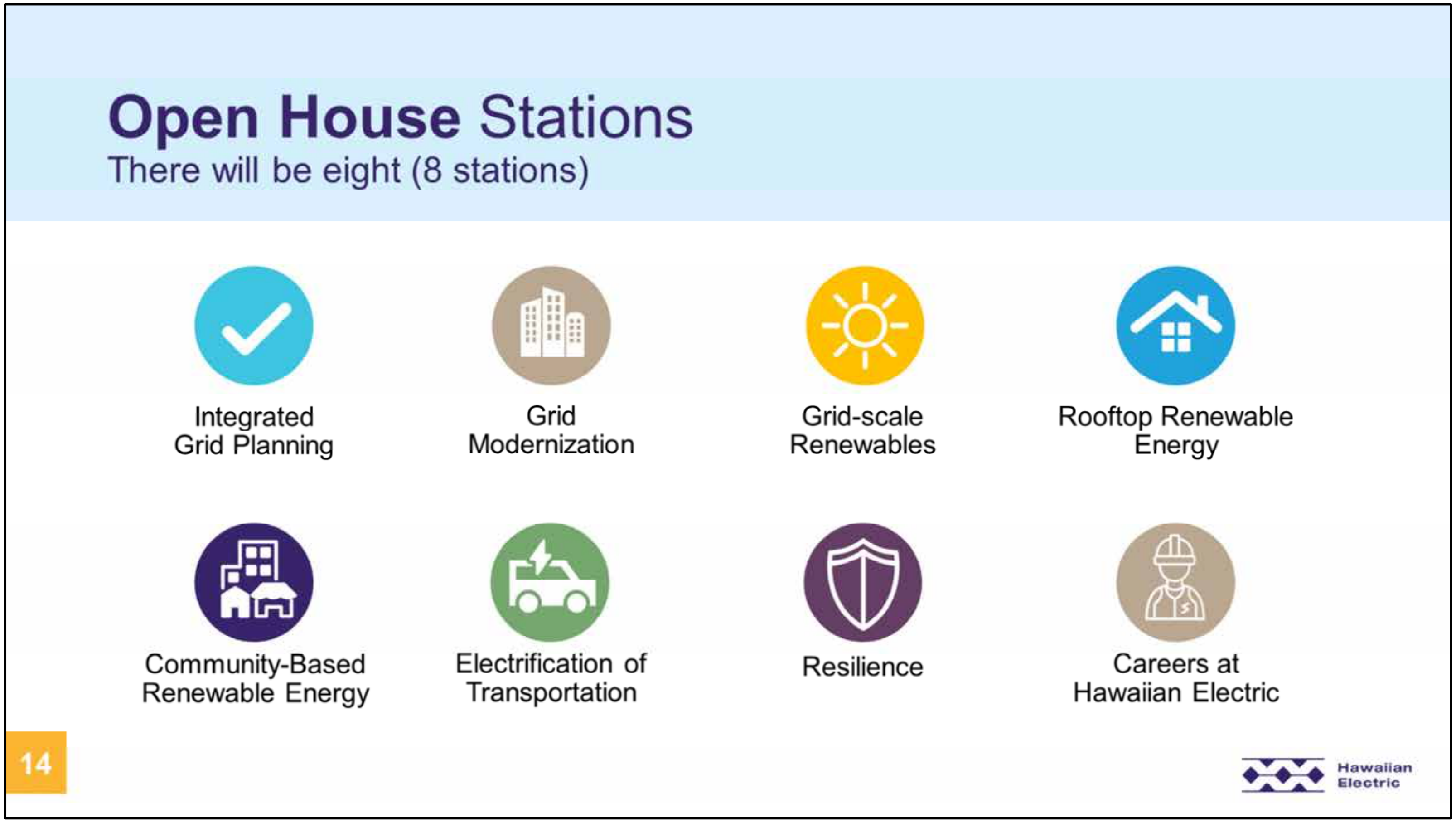
THURSDAY Mar 12

Hawaiian Electric (Maui Auditorium)
210 W Kamehameha Avenue
Kahului, Maui 96732

Hawaiian Electric

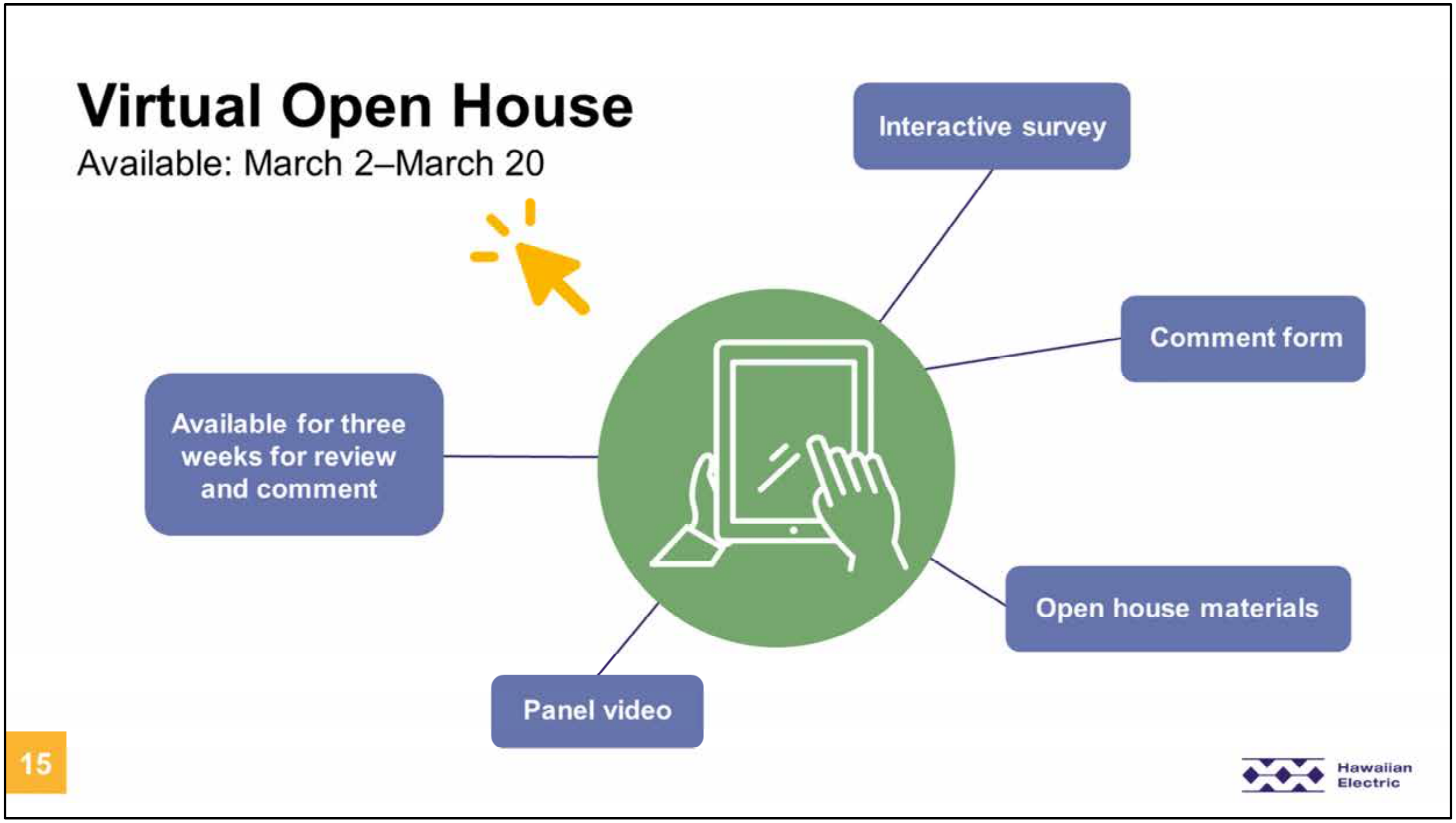
A series of four public meetings will be held on three islands.

We encourage each of your to share information with your networks about the upcoming meetings. It's important for customers to participate in this process for Hawaiian Electric to listen to customer questions or concerns and educate customers on Integrated Grid Planning.



In addition to information on IGP, Hawaiian Electric staff will be available to talk about career opportunities and address questions about advanced meters and customer energy options.

Some of the stations will include survey input opportunities to help verify forecasted data and shape future engagement efforts.



In addition to the four in-person public meetings, a virtual open house will be available with the same information that is presented at each open house station. A panel discussion will be filmed and also available to watch. Visitors will have the opportunity to view materials, answer survey questions, and complete a comment form. The virtual open house will be made available through the IGP website and open March 2 – 20.

Hawaiian Electric's Integrated Grid Planning team is open to input and feedback. Feel free to send the team an email at IGP@hawaiianelectric.com and be sure to visit the IGP website for more information and links to documents, meeting notes and upcoming meetings and engagement opportunities. IGP information is also shared on Hawaiian Electric's social channels.

Hawai'i Powered

Hawaiian Electric

For more information visit:

www.HawaiiPowered.com

Introduction to:

Hawaiian Electric and Hawai'i Powered

What does Hawai'i Powered mean?

Hawaiian Electric calls its vision for using 100% local, clean energy, "Hawai'i Powered." Hawai'i Powered celebrates finding solutions for a clean energy future right here in Hawai'i.

Hawai'i Powered is built on three foundational elements:

1. Local, renewable energy sources
2. Integrating diverse sources and technologies for a resilient grid
3. Robust engagement with stakeholders and the communities we serve

What are benefits of a Hawai'i Powered future?

Clean energy for Hawai'i, by Hawai'i:

- Achieves energy independence
- Expands energy choices
- Supports Hawaiian Electric's Climate Change Action Plan

Why does transitioning to clean energy matter for everyone?

Achieving a resilient, clean energy grid is a complex challenge that will require collaboration, compromise and creativity on customer, community and statewide levels.

- **As a customer,** you'll start seeing more energy choices and programs to incentivize using clean energy. You'll also have opportunities to share feedback with us about your energy priorities and needs to inform our projects and programs.
- **In your community,** you may see development of new energy facilities and grid infrastructure. Your insights are essential in helping us identify and develop projects and create a more equitable clean energy future.
- **On a statewide level,** benefits of a Hawai'i Powered future include achieving energy independence and supporting larger efforts to decarbonize the islands. It will take collective and sustained action to cut carbon emissions across sectors. This includes air and ground transportation, agriculture, shipping, manufacturing and tourism—in other words, every sector, and every type of work can contribute to decarbonizing our state.

Why is it important to have different clean energy sources?

Using a diverse mix of renewable energy sources improves the grid's resilience—it expands our energy options and helps us adapt to evolving needs, bounce back from unexpected events and provide more reliable power and predictable pricing for customers.

For example, relying on a single source of energy (like solar) is not feasible or wise, as it makes us more vulnerable to unexpected events (like earthquakes, storms and other disasters) and natural changes to the energy source (for example, when the sun isn't shining).

Integrated grid planning (IGP)

What is IGP?

Integrated Grid Planning (or "IGP") is our path to a Hawai'i Powered future. This framework brings many people together to build a resilient and reliable grid from local, clean energy sources with various technologies and scales. In this context, "resilience" means adapting to social, environmental, economic and technological changes to meet current and future energy needs.

What challenges is IGP solving?

Our IGP challenge is to create a clean energy grid that:

- Stays on track with the state's timelines
- Stabilizes costs for customers
- Reduces conflicts with other land use priorities
- Minimizes impacts to communities
- Improves our overall energy resilience

This is challenging because these pieces are sometimes in conflict—for example, some renewable resources might have a smaller footprint or fewer impacts to their surroundings, but they might also be more expensive or less reliable.

Together with stakeholder groups and community members, Hawaiian Electric is working to solve this puzzle: prioritizing, considering and connecting those many pieces. This includes the number of electric vehicles, programs for private and community-based solar projects, emerging technologies and industries and preparation for extreme events.

Engaging Stakeholders and Communities

How is Hawaiian Electric connecting with communities?

Hawaiian Electric is committed to equitable, inclusive and transparent community engagement at each step of the planning process. This means:

Providing accessible and inclusive opportunities to engage

- Offering multiple ways to engage, both virtually and in-person
- Connecting with people at events or small group talk sessions to listen and gather community insights
- Providing information in multiple languages and in formats that meet or exceed accessibility standards

Reaching out to and integrating feedback from people who are historically underserved

- Prioritizing outreach to underserved and potentially most impacted communities, including people who live in rural areas and people closest to places where new energy facilities may be located
- Listening to community members' experiences, priorities and vision and using their feedback to shape planning outcomes

Being accountable to feedback we have received

- Reviewing and considering public feedback as part of planning decisions, including where to locate new energy facilities and transmission corridors
- Clearly communicating how community input shapes outcomes throughout the planning process through feedback loops

Safety is their top priority!

Hawaiian Electric's outreach strategies will align with all local, state and federal guidelines for public health and safety.

What types of feedback does Hawaiian Electric consider?

Hawaiian Electric gathers and consider two types of feedback throughout the IGP process:

- **Community:** What are community members' vision and priorities for a clean energy future?
- **Technical:** What needs to happen from scientific, engineering and economic perspectives to meet our carbon goals?

How will Hawaiian Electric use community input this year?

Community input is essential to create projects and programs that are more equitable and responsive to local needs. A transparent, inclusive and accountable community engagement process is planned that includes "feedback loops," showing how community input is collected and considered in Hawaiian Electric decisions and recommendations to the Public Utilities Commission (PUC).

This year, you'll see invitations to share your thoughts online and in person about:

- Locations for future energy projects
- How best to involve your community in project identification and development

We'll use input from community members and technical experts to inform our recommendations to the Public Utilities Commission about these two subjects: where to locate new energy projects (including generation facilities and grid infrastructure) and how to define better processes for involving the public in the selection and development of projects.

We appreciate the opportunity to listen to the community's concerns and collaborate with stakeholders on potential solutions, and we take all feedback seriously. However, there are cases where we are unable to directly integrate all the input we receive into our decisions and recommendations. In those cases, we will follow up by sharing our reasoning for decisions and why we have chosen to integrate certain points.

What is a recent example of Hawaiin Electric utilizing community input?

In the latest round of grid-scale renewable energy procurements, Hawaiian Electric proposed that project developers be required to develop community benefits packages for the areas hosting a project. These benefits would address critical needs that have been identified by the host community itself. Developers would have to seek input from the host communities and donate funds for actions, programs or to 501(c)(3) not-for-profit community-based organization(s) dedicated to the community identified need.

General Information and Definitions

What are Hawaiian Electric's climate change/carbon goals?

Hawaiian Electric's top priority is building a sustainable Hawai'i in which our children and grandchildren, our communities, our customers and our employees will thrive, together.

Together, we are committed to reducing carbon emissions by 70% by 2030 and reaching net zero emissions by 2045.

Reducing carbon emissions by more than two-thirds over this decade will be a stretch. We know it's achievable, and if everyone pitches in, we'll create a cost-effective, sustainable and resilient energy system for future generations.

What does decarbonization mean?

Decarbonization means reducing, offsetting, or eliminating all carbon-producing sources contributing to climate change. It's a comprehensive approach to climate resilience that considers all sources of carbon emissions—including electricity generation, transportation, shipping, waste management, agriculture, manufacturing, and forest management.

What does carbon neutrality mean?

Carbon neutrality means achieving net zero carbon dioxide emissions. There are two general strategies to reach carbon neutrality:

1. Reducing or eliminating emissions - ways to reduce emissions include using renewable energy sources, increasing public transit ridership and swapping gas-powered for electric vehicles
2. Offsetting emissions in one sector by reducing them somewhere else - one way to offset emissions is reforestation to capture and store (or "sequester") carbon; plants, trees, soil and the ocean naturally sequester carbon

What sources of renewable energy does Hawaiian Electric use?

Hawaiian Electric has many options for renewable energy sources on the islands. Today, Hawaiian Electric uses a diverse mix of local, renewable sources including waste-to-energy, biomass, geothermal, hydroelectric, wind, biofuels and solar. Solar currently makes up the largest slice of our clean energy sales (at approximately 62%).

Biofuel and biomass:

Come from organic matter, including plants, algae, forestry or farming waste (like sugar cane fiber), or restaurant grease. When burned, biomass creates steam that can be used for heat or to power a turbine to produce electricity. It can also be converted into liquid biofuel, which can replace petroleum-based diesel.

Geothermal energy:

Comes from volcanic heat stored beneath the earth's surface. Underground reservoirs of water heated by volcanic activity can be tapped for steam to generate electricity.

Hydro energy:

Flowing water—in streams, rivers and irrigation ditches—can be used to generate electricity. Hawai'i uses what are known as "run-of-the-river" hydro plants. Some water is diverted out of a running stream and piped to a building that houses a turbine-generator. After spinning the turbine, the water is returned to the stream.

Ocean energy:

There are two forms of ocean energy:

- Mechanical energy such as waves, currents and tides
- Ocean thermal energy conversion, which takes advantage of the temperature differences between sun-warmed surface water and cold deep water to generate electricity

Solar:

Energy from the sun is converted into heat or electricity through solar thermal systems or photovoltaics (also known as solar panels).

Wind:

The motion of the wind is captured and converted to electricity by wind turbine generators. Many wind turbines grouped together are called a wind farm. Hawaiian Electric is open to both on-island and offshore wind options, in consultation with host communities.

Hawai'i Powered

Hawaiian Electric

Community Engagement

At Hawaiian Electric, we view the public as an active and essential partner in implementing our Climate Change Action Plan. We strive to break down the barriers between our work and the communities we are a part of and serve. We'll continue to build partnerships with community members by listening, learning and integrating ideas and feedback into our planning process.

How will Hawaiian Electric engage the community?

We are committed to equitable, inclusive and transparent community engagement at each step of the planning process. This means:

Providing accessible and inclusive opportunities to engage

- Offering multiple ways to engage, both online and in person
- Hosting talk stories in locations that are accessible by public transportation
- Providing information in multiple languages and in formats that meet or exceed accessibility standards

Reaching out to and integrating feedback from people who are historically underserved

- Prioritizing outreach to underserved and potentially most impacted communities, including people who live in rural areas and people closest to places where new energy facilities may be located
- Listening to community members' experiences, priorities, and vision and using their feedback to shape planning outcomes

Being accountable to feedback we have received

- Reviewing and considering public feedback as part of planning decisions, including where to locate new energy facilities and transmission corridors
- Clearly communicating how community input shapes outcomes throughout the planning process through feedback loops

Safety is our top priority!

Our outreach strategies will align with all local, state and federal guidelines for public health and safety.

What outreach tools does Hawaiian Electric use to connect with communities?

Over the next year, we will use virtual and in-person outreach tools to share information with the public and gather input. These tools include:

Online participation site

Hub for up-to-date information and community feedback, with interactive maps, comment form and survey questions.

Briefings with community organizations

Offering presentations at existing community meetings, either virtually or in person.

Community talk stories

Smaller, informal in-person or virtual conversations with community members to share information and discuss Hawai'i's energy future.

We will tailor our outreach tools and strategies to meet the unique needs of each island.

For more information visit:

www.HawaiiPowered.com

Hawai'i Powered

Hawaiian Electric

Project Process

Data Collection

Engage working groups
Work with specialists (energy industry leaders, economists and engineers) to learn best practices and find energy solutions that can work well for Hawai'i.

Model inputs and assumptions
Develop scenarios to learn how energy needs will change based on the number of electric vehicles, energy efficiency measures, rooftop solar projects, available land and future technology costs.

Procure renewable resources and support customer-sited energy generation
Begin to procure clean energy resources across the islands and developing programs to support private and community-scale energy generation.

Engagement:
Public engagement on Maui, Oahu and Hawai'i Island.
See summaries of what we heard.

Plan Definition

Support the Climate Change Action Plan
Align our clean energy work with the recently announced goal to reduce carbon emissions by 70% in 2030 and to reach net zero carbon emissions by 2045. Moving to 100% local, clean energy is key to meeting bold carbon-reduction goals.

Renewable energy zone and transmission planning
Gather technical and community input to understand potential renewable energy zone locations that connect clean energy facilities to customers through additional electrical lines and substations.

WE ARE HERE

Analyze models
Use data and models to learn how much clean energy output is needed and from which technologies to meet expected demands over time.

Engagement:
- Webpage with information, maps and survey
- Community organization briefings
- Community talk stories (smaller, informal gatherings)

Creating a Clean Energy Marketplace

Identify utility-scale projects
Select potential projects to deliver that align with our goals, timeline and commitments to communities.

Advance customer-sited energy programs
Develop programs to encourage customer-led clean energy projects, such as EV charging incentives, bonus for battery storage and community-based renewable energy projects.

Engagement:
Seek input from stakeholders and communities on selecting utility-scale projects and developing programs for customer-led initiatives. Provide educational opportunities about what's involved in selecting projects.

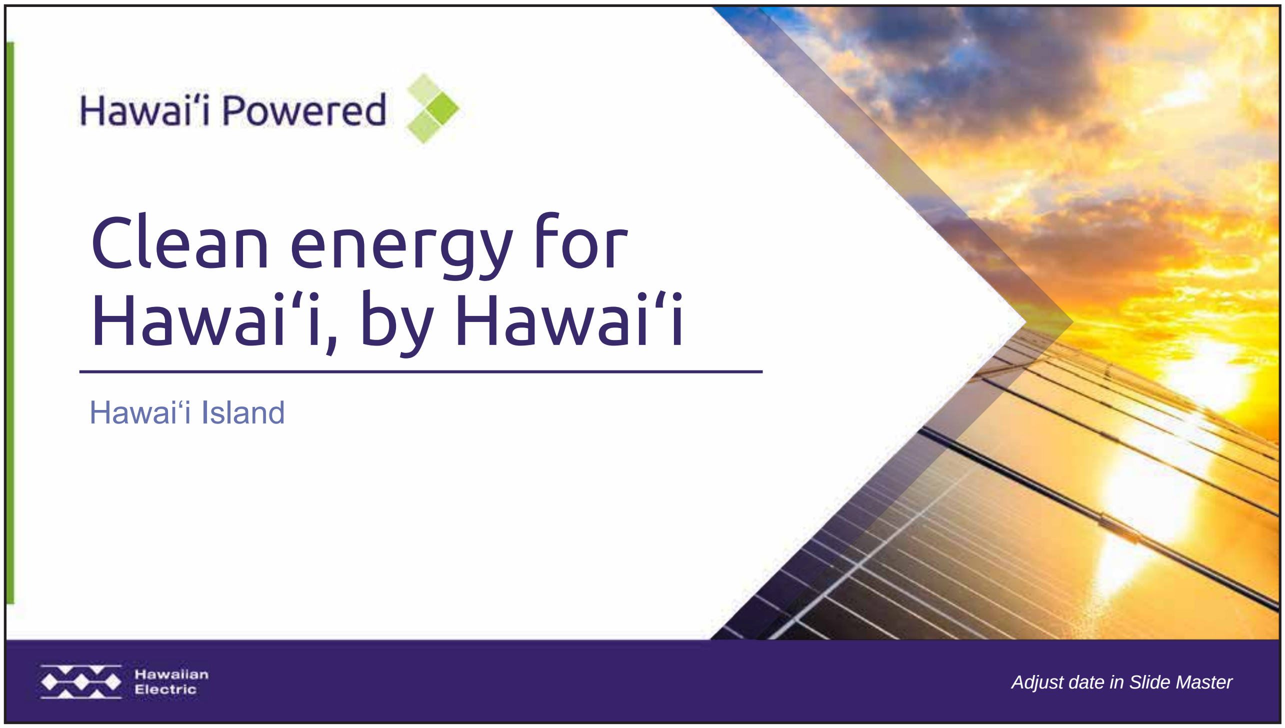
Plan Refinement

Draft a plan
Hawaiian Electric will draft an action plan outlining steps and commitments to deliver clean energy projects that will meet state goals and timelines.

Regulators review
Hawaiian Electric will submit the action plan for review by the Public Utilities Commission.

Engagement:
Keep the community informed about the content and status of the action plan.

Community Engagement *Ongoing throughout the process*



Hello and thank you for having *me/us* here today to share updates about Hawaiian Electric’s planning effort for a clean energy future and my role in the process as a member of Integrated Grid Planning Stakeholder Council.

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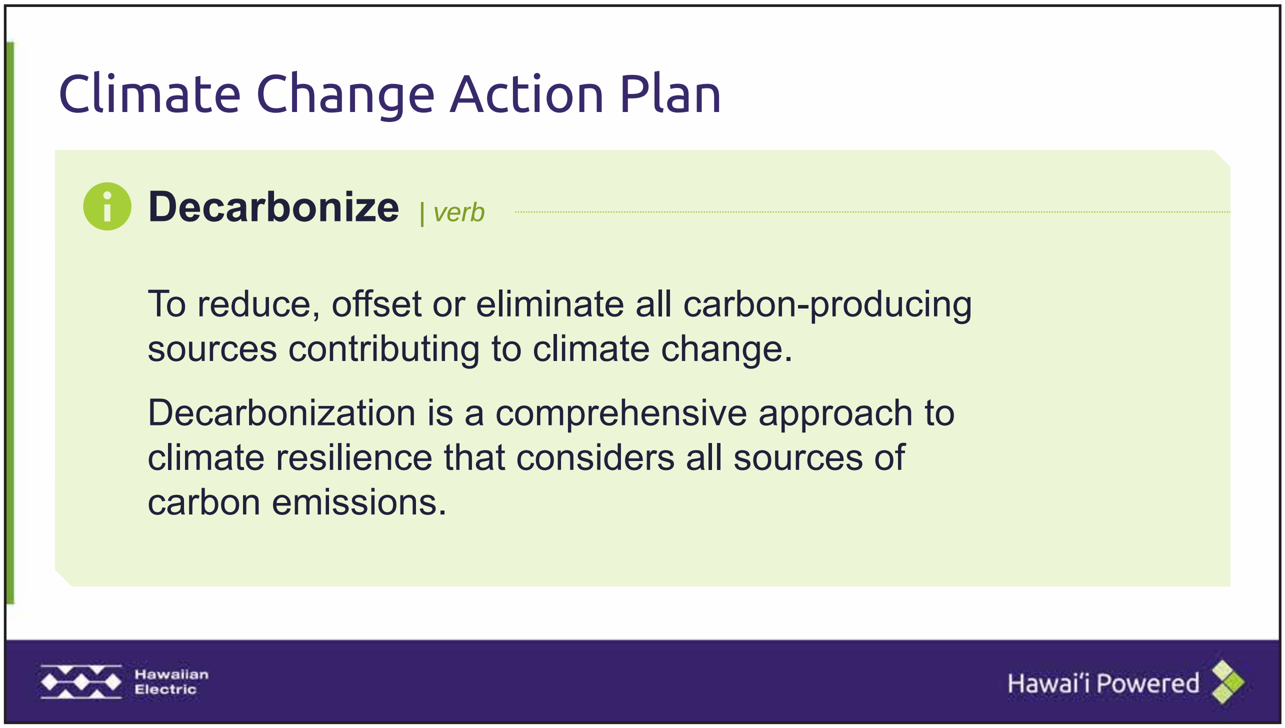

So, what does decarbonization mean?

Decarbonize means reducing, offsetting, or eliminating all carbon-producing sources contributing to climate change.

It's a comprehensive approach to climate resilience that considers all sources of carbon emissions— including electricity generation, transportation, shipping, waste management, agriculture, manufacturing, and forest management.

Hawaiian Electric's Climate Change Action Plan and work to transition to 100% local, clean energy supports a larger, statewide effort to decarbonize the islands.

Achieving a resilient, clean energy grid is a complex challenge that will require collaboration, compromise and creativity on customer, community and statewide levels.

- **As a customer,** you'll start seeing more energy choices and programs to incentivize using clean energy. You'll also opportunities to share feedback with us about your energy priorities and needs to inform our projects and programs.

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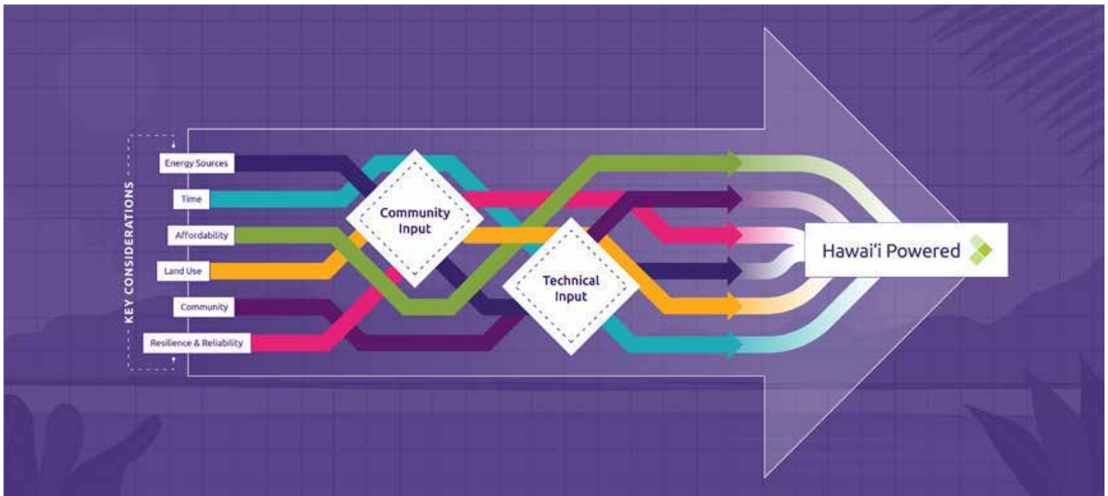
Path to Hawaiʻi Powered



Hawaiian Electric

Hawaiʻi Powered

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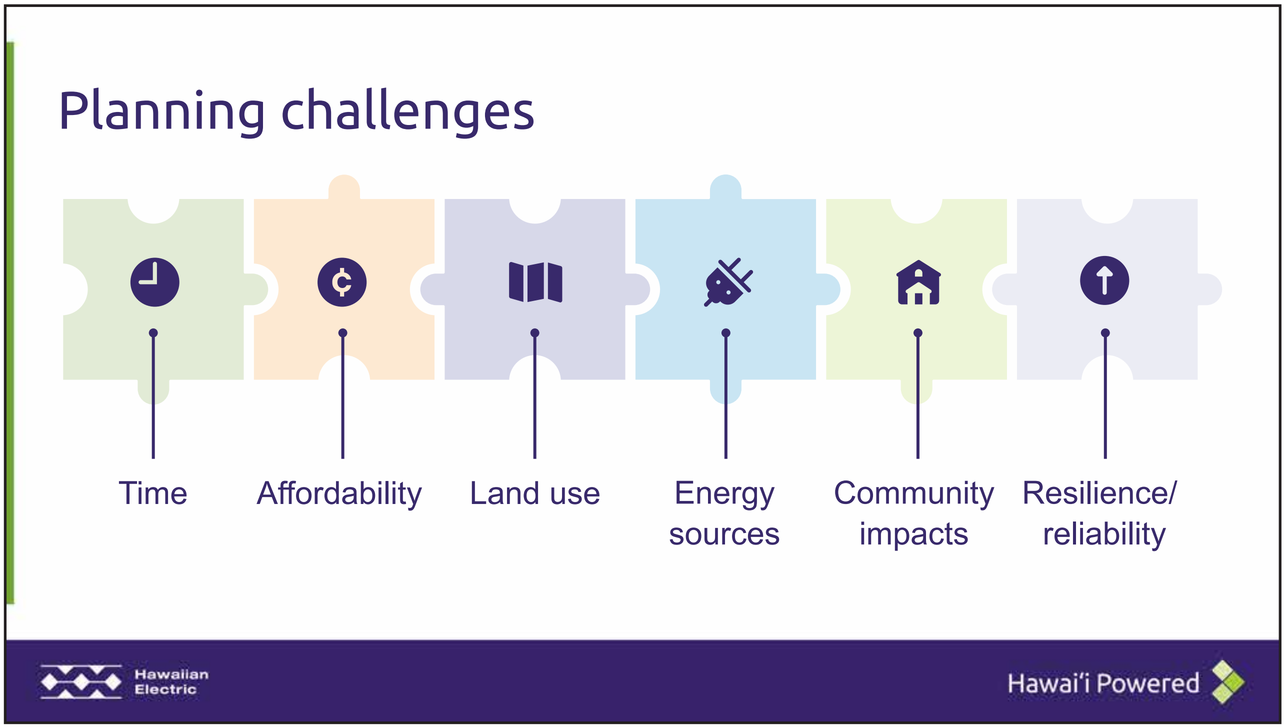


Integrated grid planning is like solving a giant puzzle with new pieces added along the way.

Our IGP challenge is to create a clean energy grid that:

- Stays on track with the state's timelines
- Stabilizes costs for customers
- Reduces conflicts with other land use priorities
- Minimizes impacts to communities
- Improves our overall energy resilience

This is challenging because these pieces are sometimes in conflict—for example, some renewable resources might have a smaller footprint or fewer impacts to their surroundings, but they might also be more expensive or less reliable. **Together with stakeholder groups and community members, Hawaiian Electric works solve this puzzle: prioritizing, considering and connecting those many pieces.**

Hawaiian Electric is grateful for your involvement since our planning began in 2019. They appreciate the opportunity to listen and collaborate with community members on potential solutions, and they value all the feedback received.

Partnering with the Stakeholder Council, Working Groups, Technical Advisory Panel and the broad public is essential to align their planning with statewide priorities and move Hawaii one step closer to a more equitable clean energy future.

Island update:

Hawaii

- Hawaiian Electric currently has four Requests for Proposals (RFPs) to identify new opportunities for renewable energy projects on Hawaii Island.
- Since March, we've been reaching out to communities around the island to provide updates on current and upcoming renewable energy projects on Hawaii Island.
- Our team, along with Hawaii Energy, also participates in the County of Hawaii's island wide Community Informational Sessions to share information about renewable energy, electric bills, energy efficiency, and energy conservation.

Hawaiian Electric

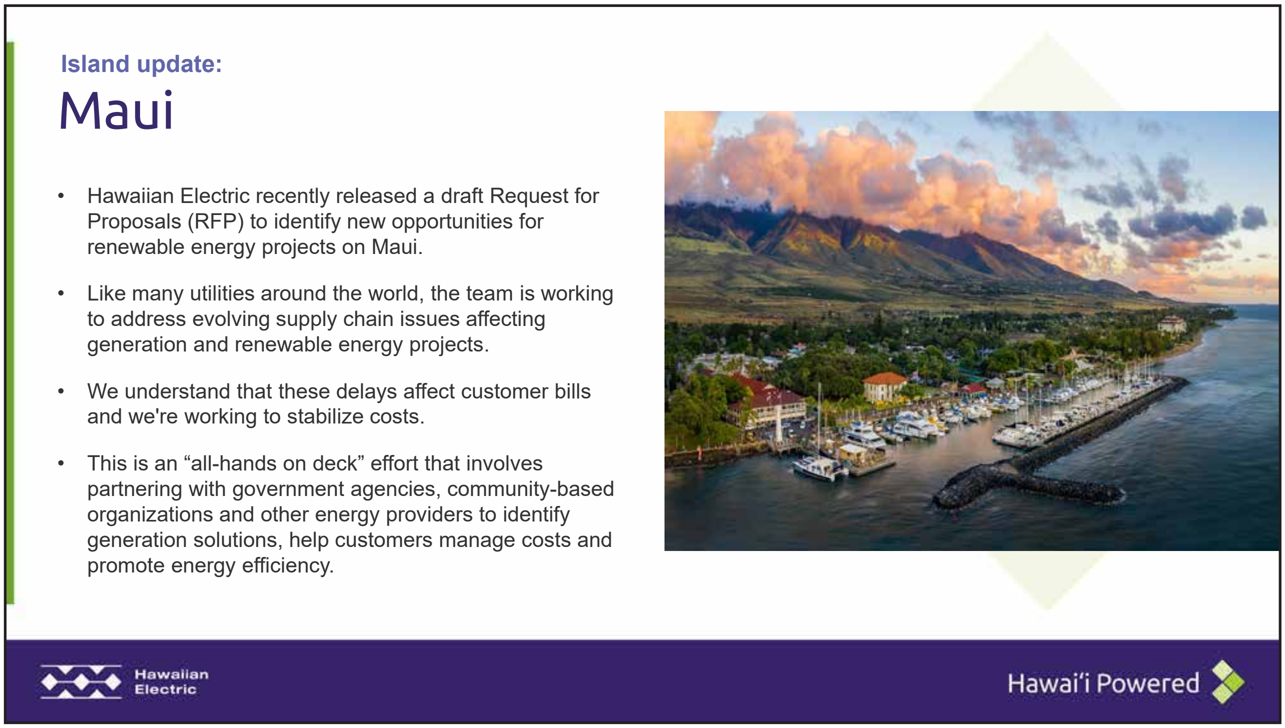
Hawai'i Powered

Hawaiian Electric currently has four Requests for Proposals (RFPs) to identify new opportunities for renewable energy projects on Hawaii Island. RFPs are part of a competitive bidding process where we seek proposals from developers to deliver specific energy projects. RFPs are related to "Expressions of Interest," which is an earlier step where we ask the developer community for feedback to learn more about different technologies and opportunities for potential projects. Learn more about the competitive bidding process and see open RFPs on Hawaii.

Since March, we've been reaching out to communities around the island to provide updates on current and upcoming renewable energy projects on Hawaii Island. Our team, along with Hawaii Energy, also participates in the County of Hawaii's island wide Community Informational Sessions to share information about renewable energy, electric bills, energy efficiency, and energy conservation. Learn how you can take action now to save energy, money and the environment.

Like many utilities around the world, Hawaiian Electric is addressing evolving supply chain disruptions affecting some renewable energy projects. We're committed to working with our partners and communities to bring more lower cost renewable energy projects online to help stabilize costs for all customers.

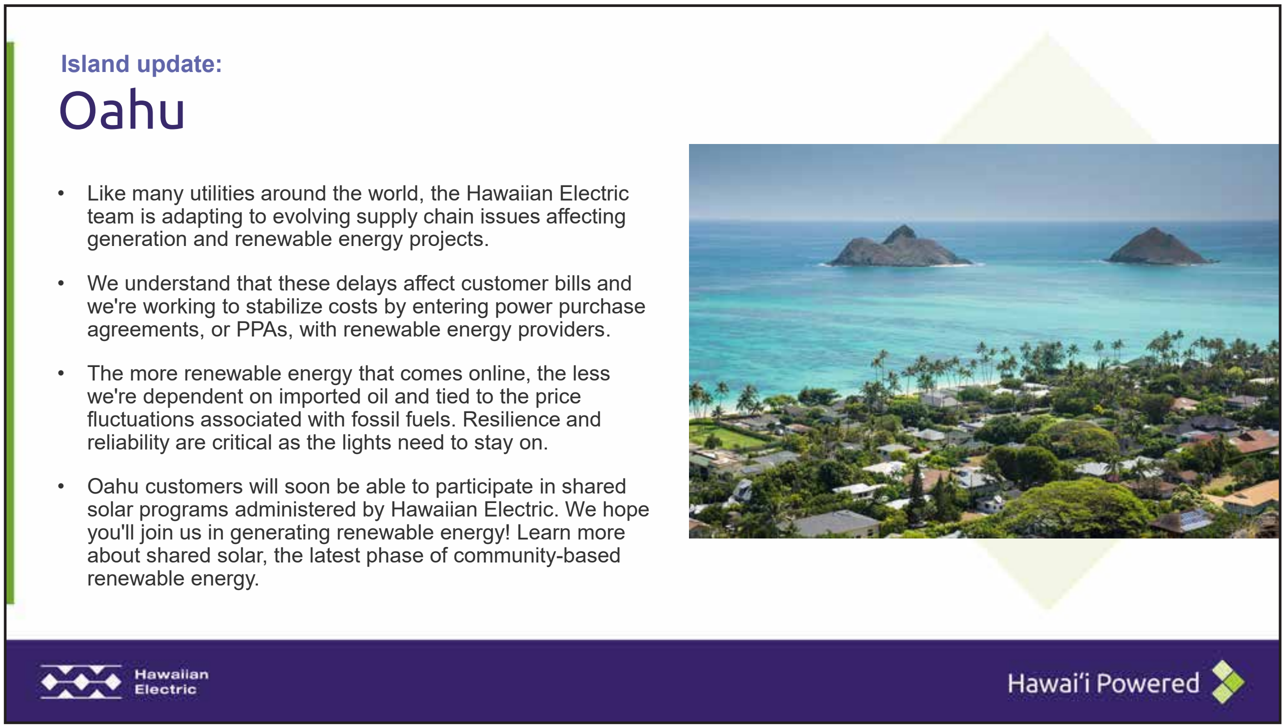
We hope you'll join us in generating renewable energy! Learn how to participate in a community-based renewable energy project near you.



Hawaiian Electric recently released a draft Request for Proposals (RFP) to identify new opportunities for renewable energy projects on Maui. RFPs are part of a competitive bidding process where we seek proposals from developers to deliver specific energy projects. RFPs are related to "Expressions of Interest," which is an earlier step where we ask the developer community for feedback to learn more about different technologies and opportunities for potential projects. Learn more about the competitive bidding process and see open RFPs on Maui.

Like many utilities around the world, the Hawaiian Electric team is working to address evolving supply chain issues affecting generation and renewable energy projects. We understand that these delays affect customer bills and we're working to stabilize costs. This is an "all-hands on deck" effort that involves partnering with government agencies, community-based organizations and other energy providers to identify generation solutions, help customers manage costs and promote energy efficiency. Learn how you can take action now to save energy, money and the environment.

Maui customers can participate in shared solar programs administered by Hawaiian Electric. We hope you'll join us in generating renewable energy! Learn how to participate in a community-based renewable energy project near you.



Like many utilities around the world, the Hawaiian Electric team is adapting to evolving supply chain issues affecting generation and renewable energy projects. We understand that these delays affect customer bills and we're working to stabilize costs by entering power purchase agreements, or PPAs, with renewable energy providers. The more renewable energy that comes online, the less we're dependent on imported oil and tied to the price fluctuations associated with fossil fuels. Resilience and reliability are critical as the lights need to stay on.

This is an "all-hands on deck" effort that involves partnering with government agencies, community-based organizations and other energy providers to identify generation solutions, help customers manage costs and promote energy efficiency. Learn how you can take action now to save energy, money and the environment.

Oahu customers will soon be able to participate in shared solar programs administered by Hawaiian Electric. We hope you'll join us in generating renewable energy! Learn more about shared solar, the latest phase of community-based renewable energy.

Hawaiian Electric currently has four Requests for Proposals (RFPs) to identify new opportunities for renewable energy projects on Oahu. In February, we filed a draft of a renewable firm generation RFP specifically for Oahu. To streamline our energy procurement efforts, Hawaiian Electric combined that RFP with a new RFP for renewable, dispatchable generation on Oahu. RFPs are part of a competitive bidding process where we seek proposals from developers to deliver specific energy projects.

Learn more about the competitive bidding process and see active RFPs on Oahu.

Island update:

Lanai

- The Hawaiian Electric team recently announced its selection of a developer to build and maintain the largest renewable energy project and the first to offer the shared solar program on the island.
- Much of our grid planning work on Lanai is happening in collaboration with the majority landowner on the island.
- We look forward to adding more renewables on Lanai to move forward with the transition to clean energy.
- In the coming months, Hawaiian Electric will start installing advanced meters for Lanai customers. Advanced meters are an important component of our grid modernization efforts.

Hawaiian Electric

Hawai'i Powered

The Hawaiian Electric team recently announced its selection of a developer to build and maintain the largest renewable energy project and the first to offer the shared solar program on the island. The company is now in contract negotiations with Onyx Development LLC and once a contract is finalized for the Mikiola Solar project, it will be submitted to the PUC for approval. Much of our grid planning work on Lanai is happening in collaboration with the majority landowner on the island. We look forward to adding more renewables on Lanai to move forward with the transition to clean energy. See active Request for Proposals (RFPs) on Lanai.

In the coming months, Hawaiian Electric will start installing advanced meters for Lanai customers. Advanced meters are an important component of our grid modernization efforts. You'll receive a notice by email or postal mail at least 60 days before your meter is scheduled to be replaced and another notice at least 30 days out. Learn more about advanced meters.

Island update:

Molokai

- Currently, the island is preparing a Molokai Community Energy Resilience Action Plan (CERAP): an independent, island-wide, community-led and expert-informed collaborative planning process to increase renewable energy on Molokai.
- The CERAP is being coordinated by the Molokai Clean Energy Hui by Sustainable Molokai. The Hawaiian Electric team is excited to provide technical support to the Molokai Clean Energy Hui in their planning process to develop a portfolio of clean energy projects to achieve 100% renewable energy for the island that is feasible, respectful of Molokai's culture and environment and strongly supported by the community.

Hawaiian Electric

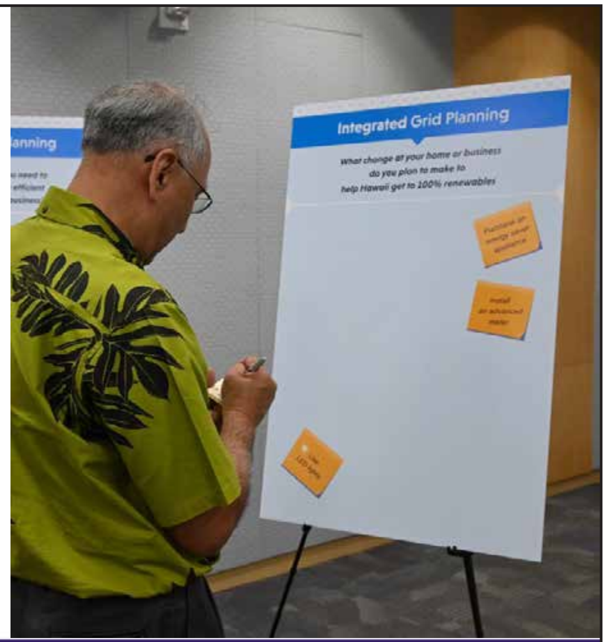
Hawaiʻi Powered

Currently, the island is preparing a Molokai Community Energy Resilience Action Plan (CERAP): an independent, island-wide, community-led and expert-informed collaborative planning process to increase renewable energy on Molokai. The CERAP is being coordinated by the Molokai Clean Energy Hui by Sustainable Molokai. The Hawaiian Electric team is excited to provide technical support to the Molokai Clean Energy Hui in their planning process to develop a portfolio of clean energy projects to achieve 100% renewable energy for the island that is feasible, respectful of Molokai's culture and environment and strongly supported by the community. Learn more at sustainablemolokai.org/clean-energy.

How will we use your input this year?

This year, we'll be inviting you to share your thoughts about:

- Potential locations for future energy projects
- How best to engage you early during project identification and development in your community.



Hawaiian Electric

Hawai'i Powered

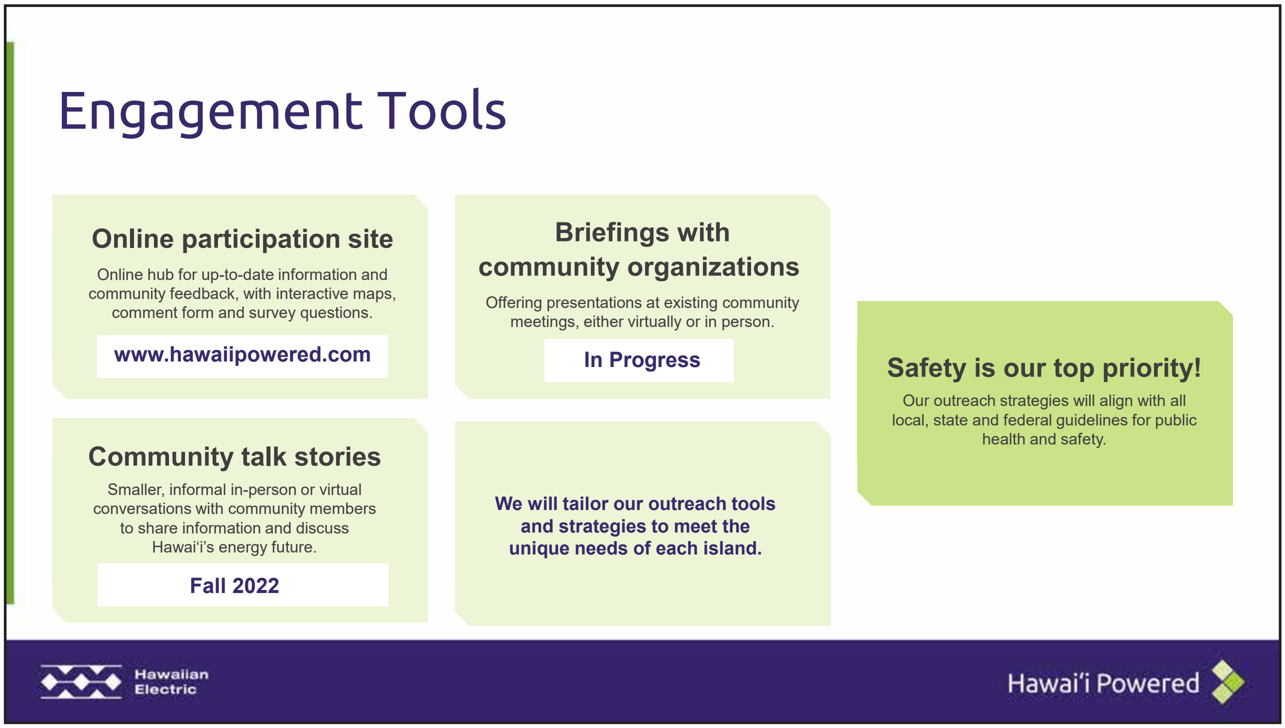
Community input is essential to create projects and programs that are more equitable and responsive to local needs. Hawaiian Electric is committed to a transparent, inclusive and accountable community engagement process that includes "feedback loops," showing how community input is collected and considered in Hawaiian Electric decisions and recommendations to the Public Utilities Commission (PUC).

This year, you'll see invitations to share your thoughts online and in person about:

- Locations for future energy projects
- How best to involve your community in project identification and development.

Input from community members and technical experts will be used to inform Hawaiian Electric's recommendations to the Public Utilities Commission about these two subjects: where to locate new energy projects (including generation facilities and grid infrastructure) and how to define better processes for involving the public in the selection and development of projects.

Hawaiian Electric appreciates the opportunity to listen to the community's concerns and collaborate with stakeholders on potential solutions and takes all feedback seriously. However, there are cases where they are unable to directly integrate all the input received into their decisions and recommendations. In those cases, they will follow up by sharing their reasoning for decisions and why they have chosen to integrate certain points.



A variety of in-person and virtual tools and strategies will be used to share information with the public and gather input. These tools include:

- **Online participation site**: Hub for up-to-date information and community feedback, with interactive maps, comment form, and survey questions. This launched in March 2022
- **Continued briefings with community organizations:** Offering presentations at existing community meetings, either virtually or in person. These are ongoing
- **Community talk stories:** Smaller, informal in-person or virtual conversations with community members to share information and discuss Hawaii's energy future. These are scheduled to begin in early fall 2022

We will tailor our outreach tools and strategies to meet the unique needs of each island.

Due to the continued presence of COVID-19, interactive virtual engagement elements will be the focus of this strategy with the possibility of in-person small-group workshops, outdoor conversations, and one-on-one meetings pending the pandemic status. Hawaiian Electric will continue to follow all local, state, and federal guidelines for public health and safety.

Connect today!

Hawaii Powered launched March 10

Features include:

- Intro Video
- Blog: **Plugged In**
- Vision and Goals
- FAQs
- Process and Timeline
- Community Engagement

Hawaiian Electric

NOTE: The website scrolls in presentation mode.

The public participate site, Hawaiipowered.com, launched in early March 2022. This site will continue to be updated throughout the planning process to provide visitors up-to-date information and engagement opportunities. Some of the site features include an introduction video, the blog – Plugged In, vision and goals, a set of frequently asked questions, the planning process steps and anticipated schedule along with ongoing community engagement activities.

The monthly e-newsletter will help connect recipients to the latest updates on the site. Sign-up today on at hawaiipowered.com to receive email updates to stay current on the IGP process.

We encourage you to stay tuned for opportunities to learn more and share your thoughts by visiting our online participation site, signing up for our email list and reading our blog.

We welcome feedback and questions—email us anytime at IGP@hawaiianelectric.com. You can also request a briefing for your community organizations.

Hawaiʻi Powered

Mahalo for your time

Questions?

Learn More

hawaiianelectric.com/clean-energy-Hawaii/integrated-grid-planning
hawaiipowered.com
igp@hawaiianelectric.com

Hawaiian Electric

[Thank the audience and open the session up for questions]

1.2 Technical Advisory Panel

The Technical Advisory Panel, also referred to as the TAP, has been working together from September 2018 to December 2022, discussing various technical topics supporting the development of the Integrated Grid Plan. The following table includes a list of dates with links to meeting summaries and technical reports. This information along with additional presentations are available within the Key Stakeholder Documents Library.

Date	Notes
September 15, 2018	Meeting Summary
May 7, 2019	Meeting Summary
September 10, 2019	Meeting Summary
October 22, 2019	Meeting Summary
November 19, 2019	Meeting Summary
December 17, 2020	Meeting Summary
February 24, 2021	Meeting Summary
June 1, 2021	TAP Response to Order No. 37730
July 28, 2021	Workplan Update
October 1, 2021	TAP Feedback - Renewable Energy Zone Study
October 4, 2021	TAP Feedback - Transmission Planning Criteria TAP Feedback - System Security Methodology
October 11, 2021	TAP Feedback - Non-Wires Opportunity Evaluation Methodology TAP Feedback - Distribution Planning Methodology
November 1, 2021	TAP Feedback - Proposed Energy Reserve Margin (ERM) Criteria
December 13, 2021	TAP Feedback - System Stability Study
January 20, 2022	TAP Feedback - Additional Evaluation of Hourly Dependable Capacity (HDC) Values
January 21, 2022	TAP Feedback - System Stability Study
February 25, 2022	TAP Feedback - Under Frequency Load Shed (UFLS) Study UFLS Study Discussion
March 10, 2022	TAP Feedback - Order 38253
March 11, 2022	TAP Feedback - Distribution Planning Methodology (Clarifications) Load Forecast Scenario Discussion
April 28, 2022	TAP Feedback
June 2, 2022	TAP Feedback
July 7, 2022	TAP Feedback TAP Feedback Summary
July 12, 2022	TAP Feedback
August 4, 2022	TAP Progress Update
August 11, 2022	TAP Feedback
September 14, 2022	TAP Progress Update
November 15, 2022	TAP Feedback
November 16, 2022	TAP Feedback
December 1, 2022	TAP Feedback

1.3 Stakeholder Technical Working Group

The Stakeholder Technical Working Group, also referred to as STWG, met between June 2021 and February 2023, discussing various technical topics supporting the development of the Integrated Grid Plan. The following table includes a list of meeting dates and links to meeting notes. This information along with supporting documents are available within the Key Stakeholder Documents Library.

Date	Notes
June 2, 2021	Meeting Summary
June 17, 2021	Meeting Summary
July 14, 2021	Meeting Summary
July 16, 2021	Meeting Summary
August 4, 2021	Meeting Recording
September 7, 2021	Meeting Summary
September 23, 2021	Meeting Summary
October 6, 2021	Meeting Summary
October 13, 2021	Meeting Summary
November 19, 2021	Meeting Summary
September 14, 2022	Meeting Summary
November 29, 2022	Presentation
December 15, 2022	Presentation
January 19, 2023	Presentation
February 16, 2023	Presentation

1.4 Public Engagement (2020)

A collection of public engagement notifications, materials and summary documents associated with Hawaiian Electric engagement opportunities.

- Meeting Invites: postcard and fliers
- Media advertisements and social media
- Meeting materials
- Survey questions and input forms
- Virtual open house and statistics
- Graphic summary

Island	Link
Hawaii	Meeting Recording
Oahu	Meeting Recording
Maui	Meeting Recording

Meeting Invites

Hawaiian Electric

Integrated Grid Planning

Listening + Integrating + Collaborating to Reach 100% Renewables by 2045

Getting to 100% Renewables

Join Us At Our Public Meetings

5:00 pm–7:30 pm

See back for details.

Learn how we use **Integrated Grid Planning** (IGP) to plan for our renewable future together.

CAN'T JOIN US?

Visit our Online Open House available March 2–20, 2020
www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning

Public Meeting Agenda

PART 1 **Open House**
5:00 pm-6:00 pm

PART 2 **Panel Discussion**
6:00 pm-7:30 pm

Dates & Locations

TUESDAY **Mar 03**
Kealakehe High School (Cafeteria)
74-5000 Puohulihuli Street
Kailua-Kona, HI 96740

TUESDAY **Mar 10**
Hawaii Pacific University
(Multi-Purpose Room 2)
1 Aloha Tower Drive
Honolulu, HI 96813

THURSDAY **Mar 05**
Hilo High School (Cafeteria)
556 Waianuenue Avenue
Hilo, HI 96720

THURSDAY **Mar 12**
Maui Electric (Auditorium)
210 W Kamehameha Avenue
Kahului, Maui 96732

- Pupus will be provided
- Free parking with validation

Email: **IGP@hawaiianelectric.com**
Website: **www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning**

facebook.com/HawaiianElectric
twitter.com/hwnelectric
instagram.com/hawaiianelectric

Getting to 100% Renewables

Join Us At Our Public Meetings
5–7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

Agenda

PART 1 Open House 5–6 pm

PART 2 Panel Discussion 6–7:30 pm

Dates & Locations

TUESDAY Mar 03
Kealakehe High School (Cafeteria)
74-5000 Puohulihuli Street
Kailua-Kona, Hawai'i 96740

TUESDAY Mar 10
Hawaii Pacific University*
(Multi-Purpose Room 3)
1 Aloha Tower Drive
Honolulu, O'ahu 96813
**Free parking with validation*

THURSDAY Mar 05
Hilo High School (Cafeteria)
556 Waiānuenue Avenue
Hilo, Hawai'i 96720

THURSDAY Mar 12
Hawaiian Electric (Kahului Auditorium)
210 W. Kamehameha Avenue
Kahului, Maui 96732

- Pupus will be provided
- Check out our careers station

VIRTUAL OPEN HOUSE

Can't join us? Then visit our Virtual Open House between **March 2–20, 2020 at www.hawaiianelectric.com/igp**

WE WANT **TO HEAR** FROM YOU

We welcome your input! Here are the many ways to stay connected with us.

Email:
IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

Hawaiian Electric

Hawai'i's Renewable Energy Future Series

Getting to 100% Renewables

Join Us At Our Community Meeting
5 – 7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

TUESDAY **Mar 03** — **Kealakehe High School** *(Cafeteria)*
74-5000 Puohulihuli Street
Kailua-Kona, Hawai'i 96740

THURSDAY **Mar 05** — **Hilo High School** *(Cafeteria)*
556 Waiānuenue Avenue
Hilo, Hawai'i 96720

Pupus will be provided at both community meetings

PART 1 Open House Stations
5 – 6 pm

Eight (8) informational stations to browse and ask questions:

1. Integrated Grid Planning (IGP)
2. Grid Modernization
3. Grid Scale Renewables
4. Rooftop Renewable Energy
5. Community-Based Renewable Energy
6. Resilience
7. Electrification of Transportation
8. Careers at Hawaiian Electric

PART 2 Panel Discussion
6 – 7:30 pm

Panel Participants

- **Hawaiian Electric** | Colton Ching, Sr. Vice President, Planning and Technology
- **Hawaiian Electric** | Kevin Waltjen, Director, Hawai'i Island
- **Hawaiian Electric** | Lisa Dangelmaier, Director, System Operations, Hawai'i and Maui
- **County of Hawai'i** | Riley Saito, Deputy Director, Research and Development
- **Geometrician Associates** | Ron Terry, Principal
- **Community** | Carol Ignacio

VIRTUAL OPEN HOUSE

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IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

Hawaiian Electric

Getting to 100% Renewables

Join Us At Our Public Meetings

5–7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

TUESDAY **Mar 10**

Hawaii Pacific University* *(Multi-Purpose Room 3)*
1 Aloha Tower Drive, Honolulu, O'ahu 96813
**Free parking with validation*

Pupus will be provided

PART 1 Open House Stations

5–6 pm

Eight (8) informational stations to browse and ask questions:

1. Integrated Grid Planning (IGP)
2. Grid Modernization
3. Grid Scale Renewables
4. Rooftop Renewable Energy
5. Community-Based Renewable Energy
6. Resilience
7. Electrification of Transportation
8. Careers at Hawaiian Electric

PART 2 Panel Discussion

6–7:30 pm

Panel Participants

- **Community | Cynthia Rezentes,** Nanakuli Neighborhood Board Chair
- **Ulupono Initiative** | Murray Clay, President
- **O'ahu Economic Development Board** | Pono Shim, President & CEO
- **City & County of Honolulu** | Josh Stanbro, Chief Resilience Officer & Executive Director, Office of Climate Change, Sustainability & Resiliency
- **Hawai'i Farm Bureau** | Brian Miyamoto, Executive Director
- **Hawaiian Electric** | Colton Ching, Sr. Vice President, Planning and Technology

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IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

Hawaiian Electric

Maui's Renewable Energy Future Series

Getting to 100% Renewables

Join Us At Our Community Meeting

5–7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

THURSDAY Mar 12

Hawaiian Electric *(Kahului Auditorium)*
210 W. Kamehameha Avenue
Light refreshments will be provided

PART 1 Open House Stations
5–6 pm

Eight (8) informational stations to browse and ask questions:

1. Integrated Grid Planning (IGP)
2. Grid Modernization
3. Grid Scale Renewables
4. Rooftop Renewable Energy
5. Community-Based Renewable Energy
6. Resilience
7. Electrification of Transportation
8. Careers at Hawaiian Electric

PART 2 Panel Discussion
6–7:30 pm

Panel Participants

- **Rhiannon Chandler-'Iao**, Executive Director, Waiwai Ola Waterkeepers Hawaiian Islands
- **Colton Ching**, Senior Vice President, Planning and Technology, Hawaiian Electric
- **Rebecca Dayhuff Matsushima**, Director, Renewable Acquisitions, Hawaiian Electric
- **Dick Mayer**, Coordinator, Alliance for Maui Community Associations
- **Michele McLean**, Director, Department of Planning, County of Maui

VIRTUAL OPEN HOUSE

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Website:
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Hawaiian Electric

Media advertisements and social media

Hawai‘i's Renewable Energy Future Series

Getting to 100% Renewables

Join Us At Our Community Meeting

5 –7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

TUESDAY **Mar 03** **Kealakehe High School** *(Cafeteria)*
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Kailua-Kona, Hawai‘i 96740

THURSDAY **Mar 05** **Hilo High School** *(Cafeteria)*
556 Waiānuenue Avenue
Hilo, Hawai‘i 96720

Pupus will be provided at both community meetings

PART 1 **Open House Stations** | 5 – 6 pm

- **8 Informational Stations to browse and ask questions**

PART 2 **Panel Discussion** | 6 – 7:30 pm

- **Hawaiian Electric** | Colton Ching, Sr. V.P., Planning & Technology
- **Hawaiian Electric** | Kevin Waltjen, Director, Hawai‘i Island
- **Hawaiian Electric** | Lisa Dangelmaier, Director, System Operations, Hawai‘i and Maui
- **County of Hawai‘i** | Riley Saito, Deputy Director, Research & Development
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Hawaiian Electric

Hawaiʻi's Renewable Energy Future Series

Getting to 100% Renewables

Join Us At Our Community Meeting
5 –7:30 pm

Be part of the **Integrated Grid Planning (IGP)** conversation to shape our renewable energy future together.

TUESDAY **Mar 10**

Hawaii Pacific University
(Multi-Purpose Room 3)
1 Aloha Tower Drive
Honolulu 96813

- *Free parking with validation*
- *Pupus will be provided*

PART 1 Open House Stations | 5 – 6 pm

- 8 Informational Stations to browse and ask questions

PART 2 Panel Discussion | 6 – 7:30 pm

- **Community** | Cynthia Rezentes, Nanakuli Neighborhood Board Chair
- **Ulupono Initiative** | Murray Clay, President
- **Oʻahu Economic Development Board** | Pono Shim, President & CEO
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Website:
www.hawaiianelectric.com/igp

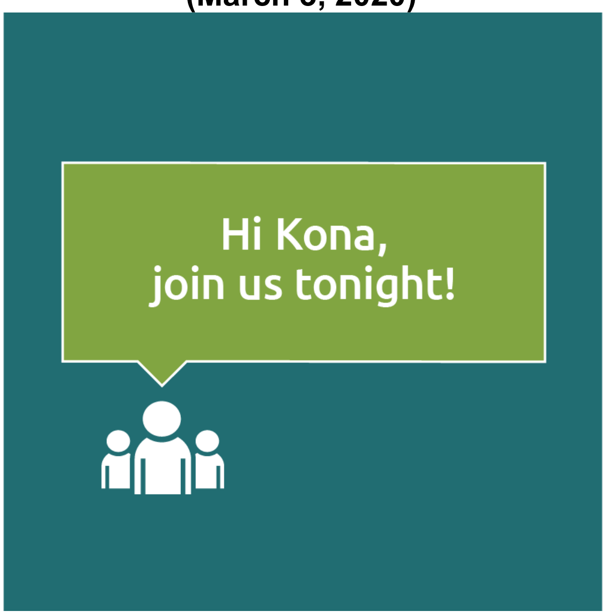
Hawaiian Electric

Event Post (February 19 to March 3, 2020)

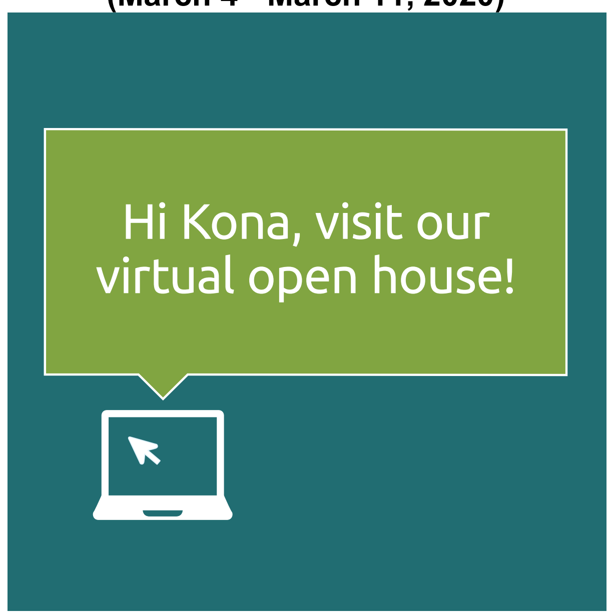
Facebook Day of Post (March 3, 2020)

Facebook After Event Post (March 4 to March 11, 2020)

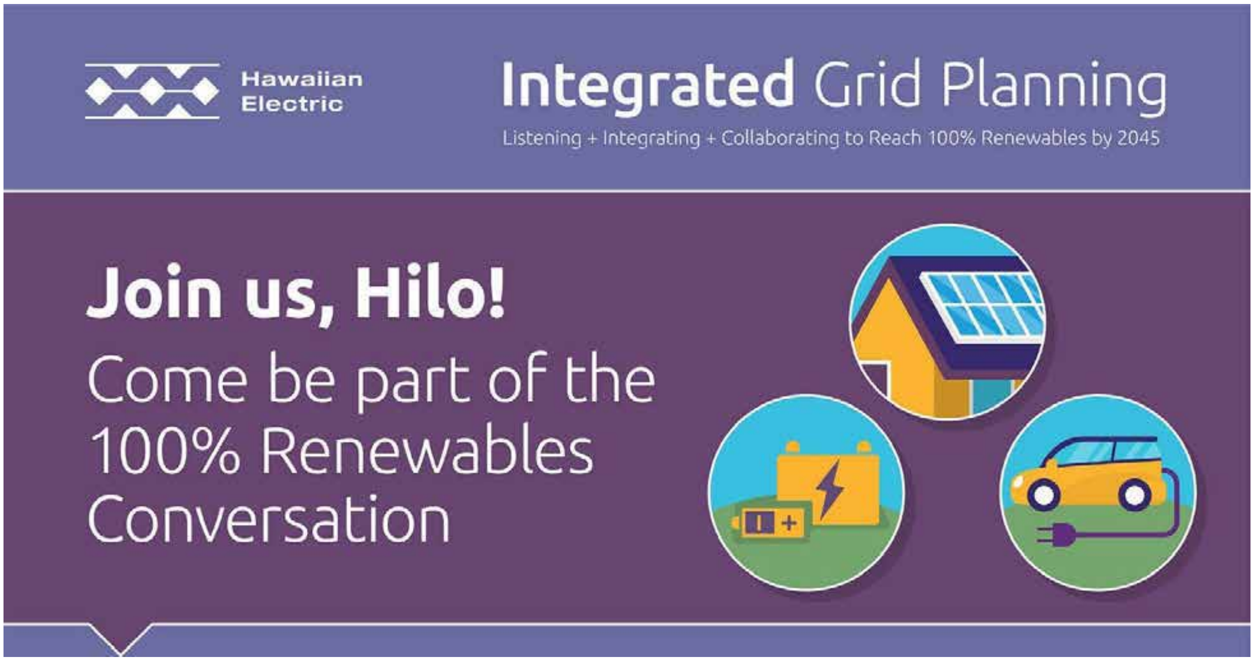
Twitter Day of Post
(March 3, 2020)



Twitter After Event Post
(March 4 - March 11, 2020)



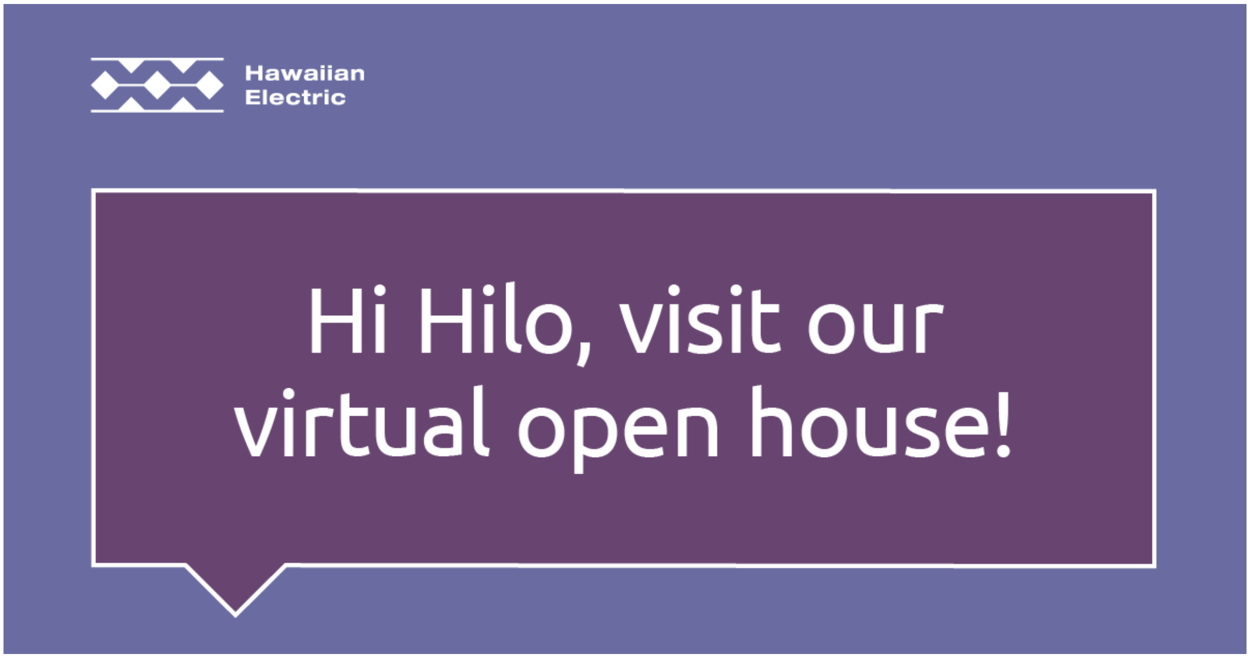
Event Post (February 21 to March 5, 2020)



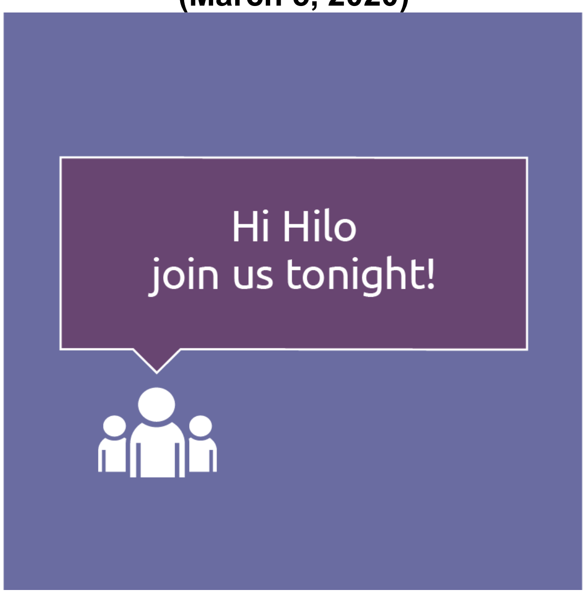
Facebook Day of Post (March 5, 2020)

Hawaiian Electric

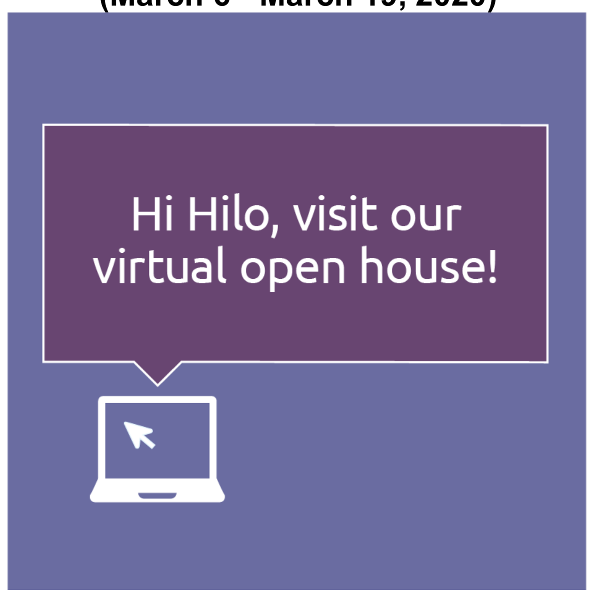
Facebook After Event Post (March 6 to March 19, 2020)



Twitter Day of Post (March 5, 2020)

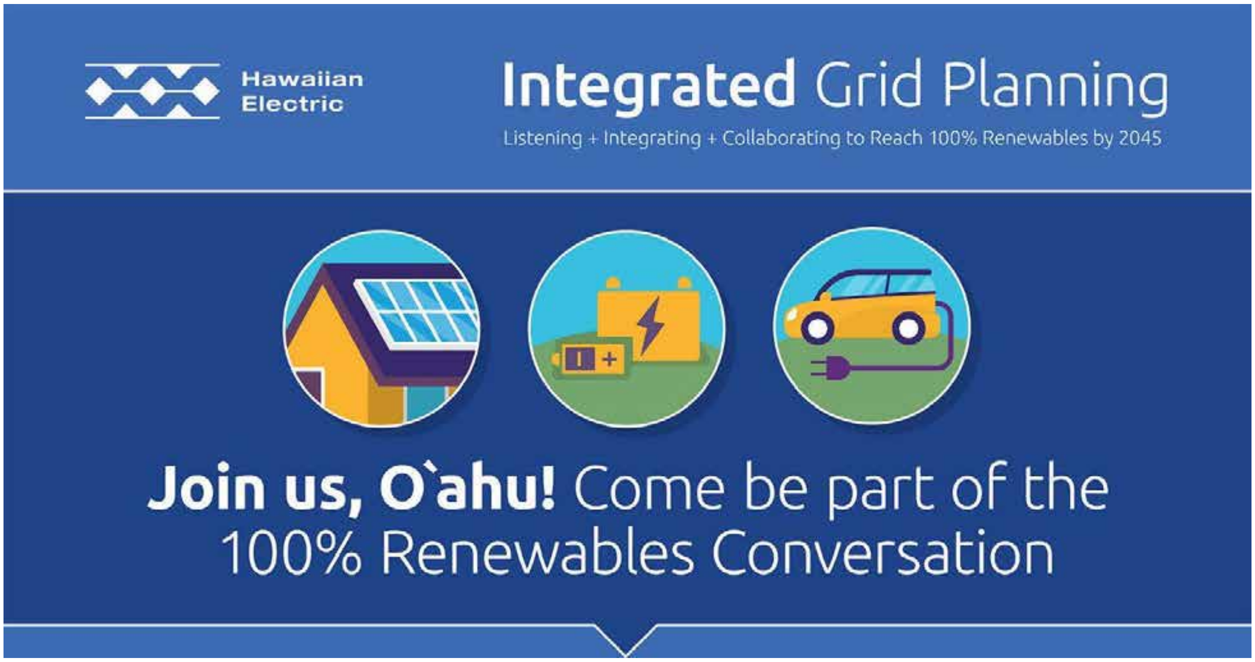


Twitter After Event Post (March 6 - March 19, 2020)



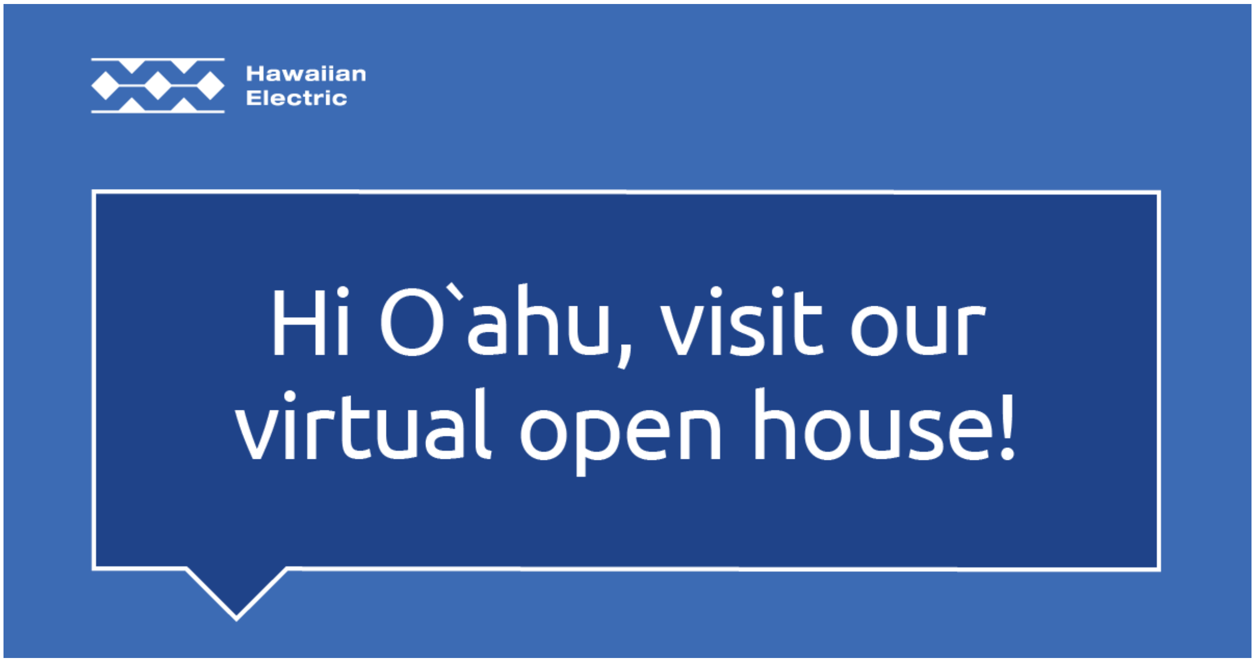
Honolulu Social Media Posts

Event Post (February 25 to March 10, 2020)

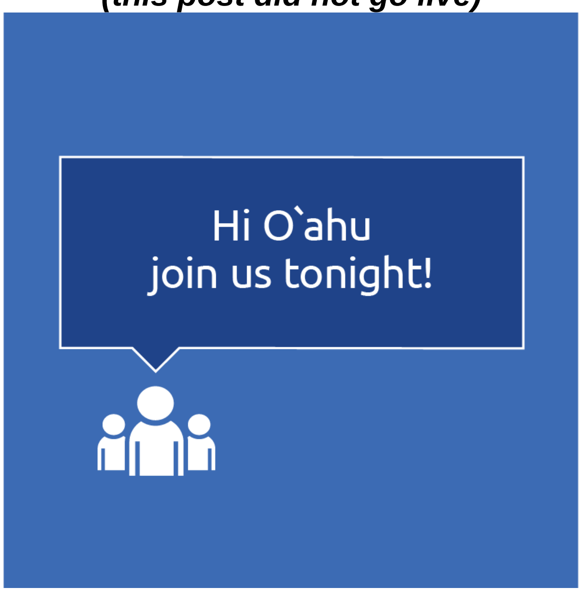


Facebook Day of Post (March 10, 2020)

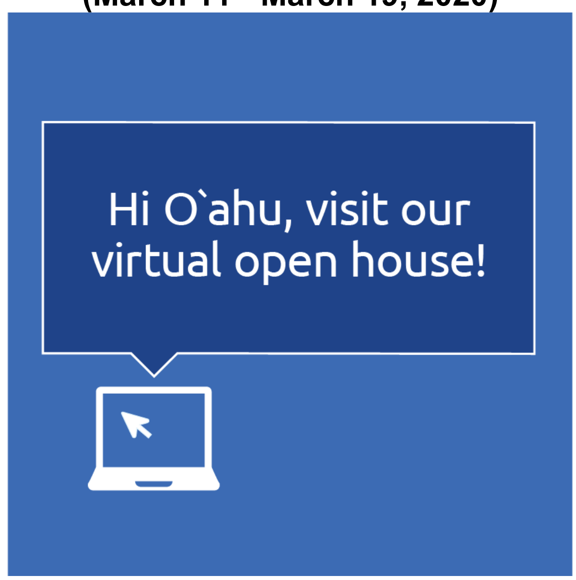
Facebook After Event Post (March 11 to March 19, 2020)



Twitter Day of Post
(this post did not go live)



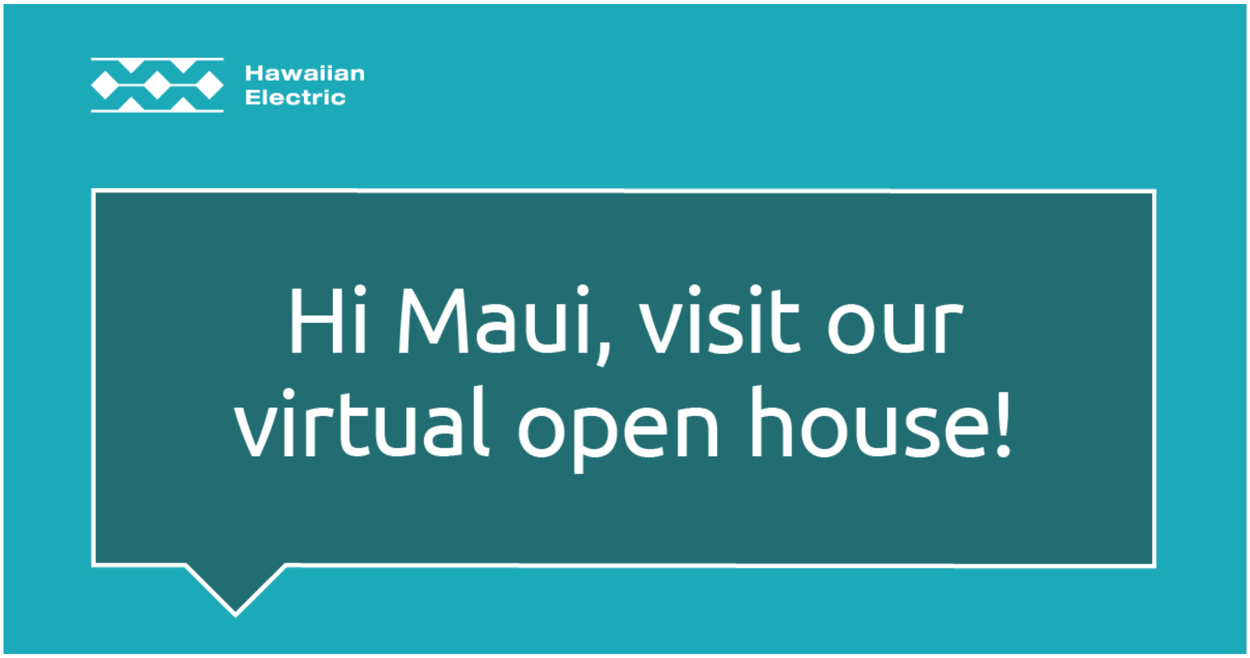
Twitter After Event Post
(March 11 - March 19, 2020)



Event Post (February 26 to March 10, 2020)

Facebook Day of Post ***(this post did not go live)***

Facebook After Event Post (March 13 to March 19, 2020)



Twitter Day of Post
(this post did not go live)

Twitter After Event Post
(March 12 - March 19, 2020)

Meeting Materials

Hawaiian Electric

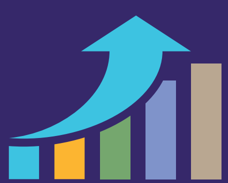
Integrated Grid Planning

Listening + Integrating + Collaborating to Reach 100% Renewables by 2045

What is IGP?

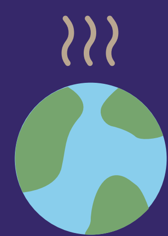
An energy planning process to identify the best options for customers to move Hawai'i toward a clean energy future.

Our Energy Future



Achieve Energy Independence

Reduce oil dependency and volatile fuel costs by increasing renewables



Address Climate Change

Add more customer-sited and grid-scale renewables to reduce greenhouse gas emissions

Modernize Our Island Grids

Integrate new technologies to facilitate 100% renewable energy

Our Goal for the Future:

100% Renewables by 2045

TODAY BY 2030 BY 2040 BY 2045

What We Need to Consider?

Integrated Grid Planning looks into the best technology options for all aspects of our energy system and identifies energy needs and behaviors of future customers.

- Future customer needs
- New technologies
- Cost to design and build large projects
- Future resource costs
- Number of residents installing rooftop solar
- Number of electric vehicles
- New businesses and industries
- Preparing for extreme events

How Does This Benefit Our Customers?

- More options to control and lower bills
- Time-of-Use rates to save money and Lower fuel and maintenance costs
- Financial incentives for purchasing an electric vehicle
- Benefits of solar energy by offsetting bills without installing PV panels on their property
- Integrate higher levels of renewables into the modern grid
- Faster power outage restoration with greater convenience
- Improved efficiencies and integration of renewables

Who is Part of the Process?

As part of the IGP process, we are collecting your input and considering all our options in planning for our renewable future. Here are the groups Hawaiian Electric is collaborating with:

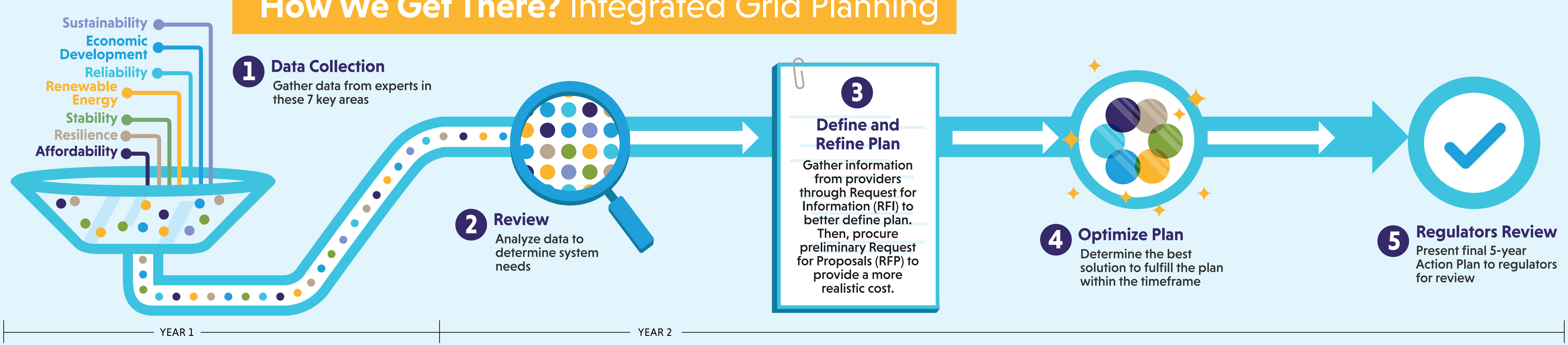
Working Groups
Address specific topics in an advisory capacity and not as a decision-making group

Stakeholder Council
Represents customers and broad stakeholders to review work and provide guidance and insights

The Public
Communication with customers

Technical Advisory Panel
Provides independent evaluation and feedback on the working group activities and review point filings

How We Get There? Integrated Grid Planning



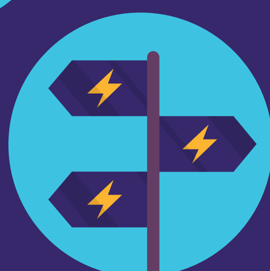
Customer Priorities

We're Listening

In response to engagement, surveys, and focus groups, we were told affordability, reliability, and energy choices are most important to customers.

Affordability

Short description that goes above Affordability.



Reliability

Short description that goes below Reliability.

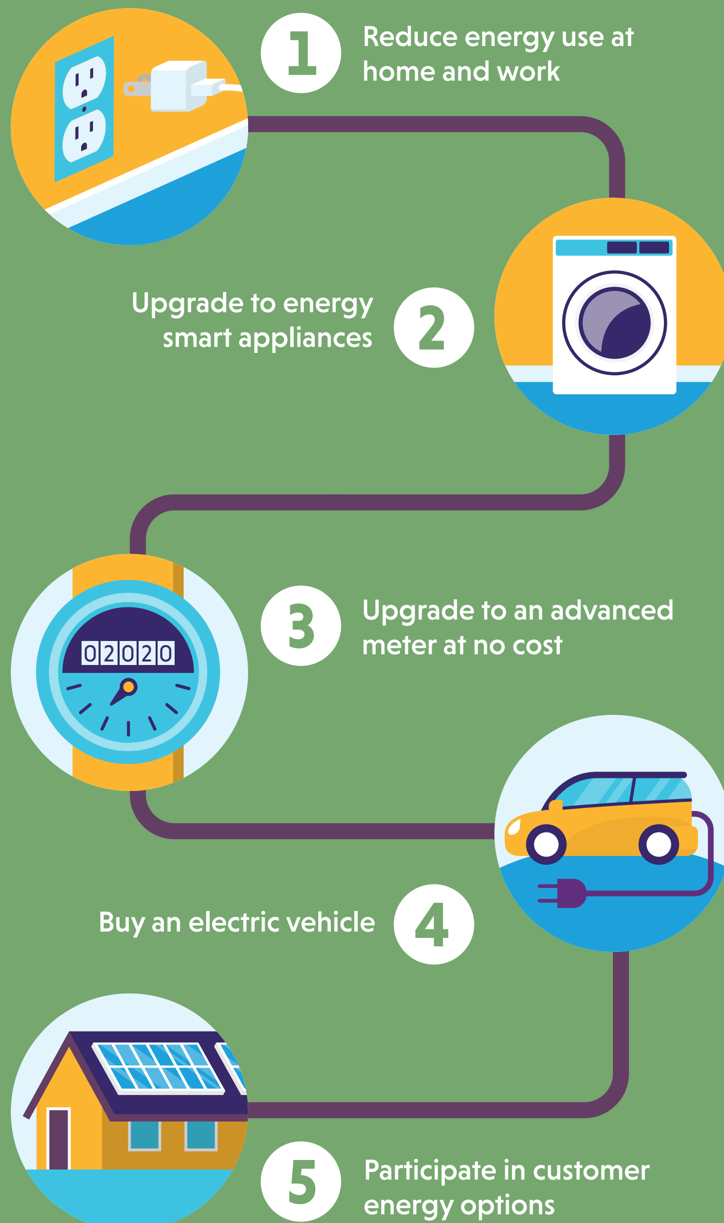
Energy Choices

Short description that goes below Energy Choices.

Is this true for you?

Let us know if you have different opinions. We're using this information to help make smart future energy decisions for customers.

5 Ways Customers Can Help Hawai'i Reach 100% Renewables



Visit **hawaiianelectric.com/products-and-services/** to learn more ways you can help

WE WANT **TO HEAR** FROM YOU

We welcome your input! Here are the many ways to stay connected with us.

Email:
IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

HawaiianElectric

hwnelectric

hawaiianelectric

Integrated Grid Planning

Survey Questions and Input Form

Your input will help us improve future customer communications

How did you hear about this meeting?

- ○ *Social media*
- ○ *Newspaper*
- ○ *Radio*
- ○ *Flyer/banner*
- ○ *IGP Website*
- ○ *Word of Mouth*
- ○ *Other* ______________________

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? (Select up to 3)

- ○ *General updates*
- ○ *Input opportunities*
- ○ *Resilience*
- ○ *Utility scale renewable projects*
- ○ *Electrification of transportation*
- ○ *Incentive programs*
- ○ *Advanced meters*
- ○ *Employment opportunities*
- ○ *Rooftop and community solar renewables*
- ○ *Grid modernization*
- ○ *Other* ______________________

What would be your preferred method to receive future information on Integrated Grid Planning? (Select up to 2)

- ○ *Social media*
- ○ *Newspaper*
- ○ *Radio*
- ○ *Email*
- ○ *IGP Website*
- ○ *Mail*
- ○ *Other* ______________________

Share any additional thoughts. We are listening!

____

____

____

____

____

____

____

Demographic Questions (Optional)

Where is your home or business located?

- ○ *Moloka'i*
- ○ *Lāna'i*
- ○ *O'ahu*
- ○ *Maui*
- ○ *Hawai'i (Big Island)*

What is your age?

Do you make the purchasing decisions for your home or business?

- ○ *Yes*
- ○ *No*

What is your ownership of your home or business location?

- ○ *Own*
- ○ *Rent*

Want a response to your comment?

Name ______________________

Email ______________________

Phone ______________________

Please fold, fasten, and mail - No envelope necessary

PLACE
POSTAGE
HERE

Hawaiian Electric
Integrated Grid Planning Team
PO Box 2750
Honolulu, HI 96840

Working Groups

Standardized Contracts (SCWG)

Procurement of services through a contracting mechanism between Hawaiian Electric (utility) market operators and third party providers of grid and other ancillary services.

Competitive Procurement (CPWG)

Procurement of resources in alignment with Hawaiian Electric's grid plans as identified through the IGP process.

Forecasts and Assumptions (FAWG)

Support development of forecast assumptions and sensitivities as part or pre-IGP planning cycle activity, and provide strategic inputs and feedback on assumptions and methodologies used for load forecast development and results.

Distribution Planning (DPWG)

Enhancement to the methods and tools for distribution planning and the integration with resource and transmission planning.

Grid Services (GSWG)

Identify and define additional energy, capacity, ancillary and T&D non-wires alternative services.

Resilience (RWG)

Support the development of resilience planning.

Solution Evaluation and Optimization (SEOWG)

Identify needed grid services and review and make recommendations regarding the transparent evaluation and optimization method.

	CPWG	DPWG	FAWG	RWG	SEOWG
Blue Planet Foundation		■			■
City and County of Honolulu	■		■	■	
County of Maui				■	
Department of Business, Economic Development and Tourism, State Energy Office				■	
Department of Commerce and Consumer Affairs, Division of Consumer Advocacy	■	■		■	■
Department of Defense					
Hawai'i Island Economic Development Board			■		
Hawai'i Energy	■	■	■		
Life of the Land	■	■	■	■	■
O'ahu Economic Development Board			■		
Public Utilities Commission	■	■	■	■	■
Hawai'i Energy Connection		■			
Ulupono Initiative	■	■		■	■
Organizations (82 total):	23	40	17	29	13
Individuals (171 total):	40	73	24	65	29

Working Group Participants

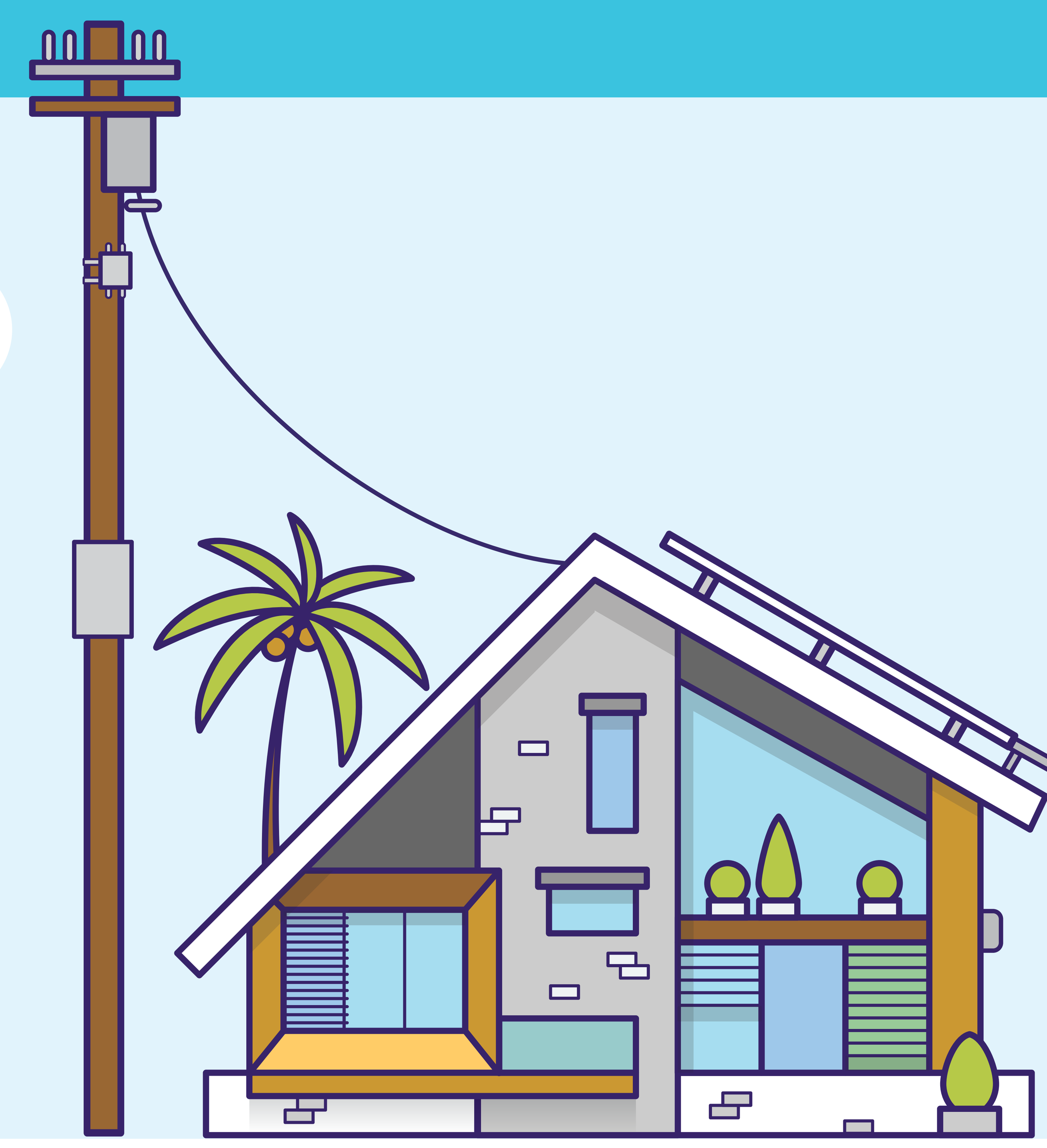
#	174 Power Global Inc.
A	Advanced Microgrid Solutions Applied Energy Group Arizona Public Service Electric Company Australian Energy Market Operator
B	Black & Veach Blue Planet Foundation
C	Chamber of Commerce City and County of Honolulu Community Delegate - Maui Community Delegate - Moloka'i Community Delegrate - Lana'i County of Hawai'i County of Maui
D	Demand Response Department of Business, Economic Development and Tourism, State Energy Office Department of Commerce and Consumer Affairs, Division of Consumer Advocacy Department of Defense Department of Transportation
E	E3 Electric Power Research Institute Electric Reliability Council of Texas Enel X Energy Efficiency Energy Freedom Coalition of America Energy Island EnerNex Enphase Energy
H	Half Moon Power Hawai'i Energy Hawaii Energy Strategists Hawai'i Island Economic Development Board Hawai'i Natural Energy Institute Hawai'i Pacific Solar Hawaii PV Coalition Hawai'i Society of Healthcare Engineers Hawai'i Solar Energy Association Hawaiian Electric - Lead of CPWG Hawaiian Electric - Lead of DPWG Hawaiian Electric - Lead of FAWG (load forecasting) Hawaiian Electric - Lead of FAWG (non-load forecasting assumptions) Hawaiian Electric - Lead of RWG Hawaiian Electric - Lead of SEOWG Hawaiian Telcom Holu Hou Energy LLC Honolulu Board of Water Supply
I	ICF Independent Power Producer
L	Large Commerical and Industrial Customer Life of the Land Local Government - Hawai'i
M	Maui County Community National Renewable Energy Laboratory Nevada Energy Newport Consulting Group - Facilitator
O	O'ahu Economic Development Board Office of State Planning Open Access Technology International
P	Par Hawai'i Portland General Progression HI Offshore Wind Public Utilities Commission Puget Sound Energy
Q	Quanta Technology
R	Renewable Energy Action Coallition of Hawai'i Rocky Mountain Institute (Public Utilities Commission consultant)
S	S&C Electric Company Sacramento Municipal Utility District Shifted Energy Siemens Small Solar and Storage Small Solar and Storage, Hawai'i Energy Connection SolarEdge Southern California Edison Steckley Power Systems Strategies 360 - Facilitator Student at Duke University studying Energy Policy SunRun Sustainability Advocate - National Switched Source
U	Ulupono Initiative United States Coast Guard United States Department of Commerce, National Oceanic and Atmospheric Administration United States Department of Energy, Office of Electricity United States Department of Homeland Security, Federal Emergency Management Agency University of Hawai'i Economic Research Organization
V	Verizon Wireless
W	Where Talk Works - Facilitator WZ Engineering
X	X-elio

Integrated Grid Planning

An energy planning process to identify the best options for customers to move Hawai'i toward a clean energy future.

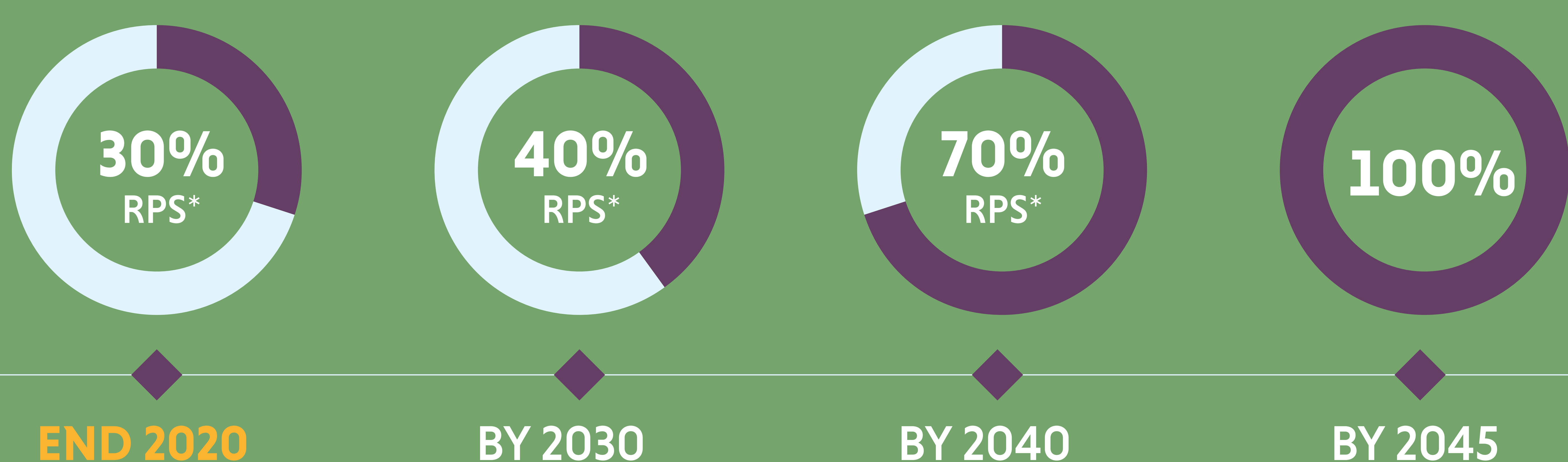
Planning Hawai'i's Grid for **Future Generations**

With a renewed focus on comprehensive energy planning, Hawaiian Electric proposed an Integrated Grid Planning ("IGP") process that we believe will benefit customers by identifying the best options to affordably move Hawai'i toward a reliable, resilient clean energy future with minimal risk. In addition, we believe the State will benefit from expanded market opportunities for resource, grid services, and non-wires alternatives for transmission and distribution ("T&D"), which can foster innovative solutions for a new energy economy.



Our Goal for the Future: **100% Renewables by 2045**

The **Renewable Portfolio Standard (RPS)** percentage estimates the percent of sales that is represented by renewable energy. This is how we are measured in achieving compliance.

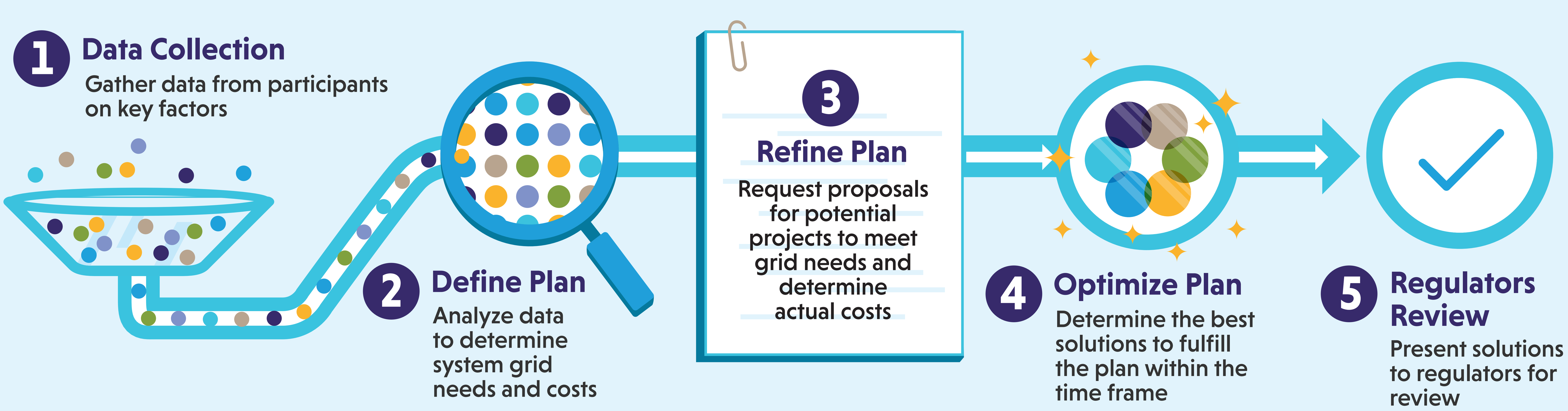


What is our Progress?

This is where we are at in comparison to our goal above.

9% RPS 2010 > 28% RPS TODAY > 30+% RPS END 2020 > 60+% RPS 2030

How Do We Get There?

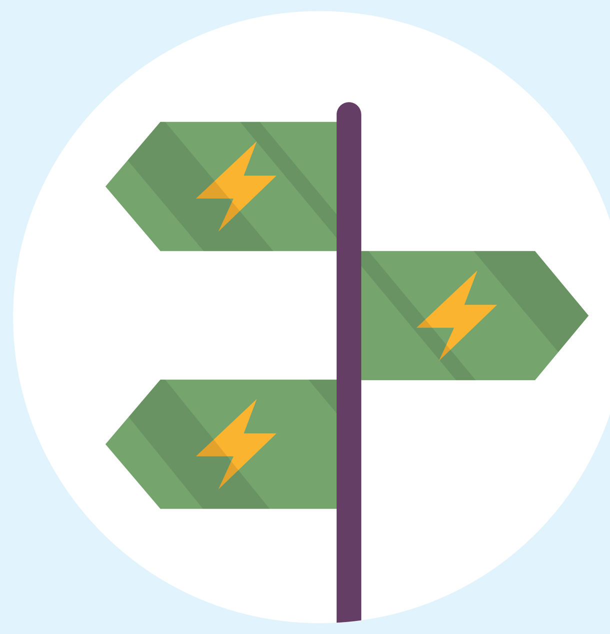


Grid Modernization

Grid modernization is transforming our energy grid to be a dynamic, two way stream of power, shifting back and forth between customers and Hawaiian Electric

What's in it for the Customer?

More information for customers to manage electric bills

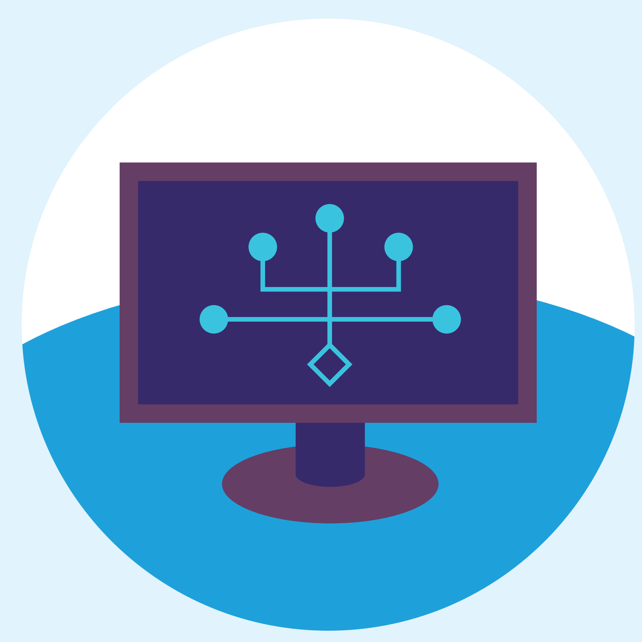


More customer choices

Faster outage restoration

Minimal bill impact

Greater integration of renewable energy



More efficient power production and delivery

Protecting Your Privacy

- **We PROTECT** information and assets from all unauthorized access
- **We MONITOR** networks 24/7 at our Security Operations Center

Grid Modernization | **Advanced Meters**

Advanced meters are an important part of our Grid Modernization Strategy. Along with the other Grid Modernization technologies, advanced meters enable customers to:

- View your daily energy usage from your phone or computer
- Manage your energy use to reduce your bill
- Help to improve restoration times during power outages
- Help Hawai'i reach a 100% clean energy future

For more information visit www.hawaiianelectric.com/advancedmeters

Grid Modernization

Grid modernization is transforming our energy grid to be a dynamic, two way stream of power, shifting back and forth between customers and Hawaiian Electric

How does Grid Modernization Technology Work?

Customers' resources are an important part of the grid. Reliability is critical as more and more customers provide resources to the grid. Learn about the new technology as we move toward changing yesterday's grid to tomorrow's grid.

Line Sensors

Provides data on amount of energy generated by rooftop solar and enables more efficient grid operations.

Remote Intelligent Switch

Utility pole-mounted automated switch enabling faster outage restoration.

Remote Fault Indicators

Provides precise location of faults, enabling faster outage restoration.

Substation Automation

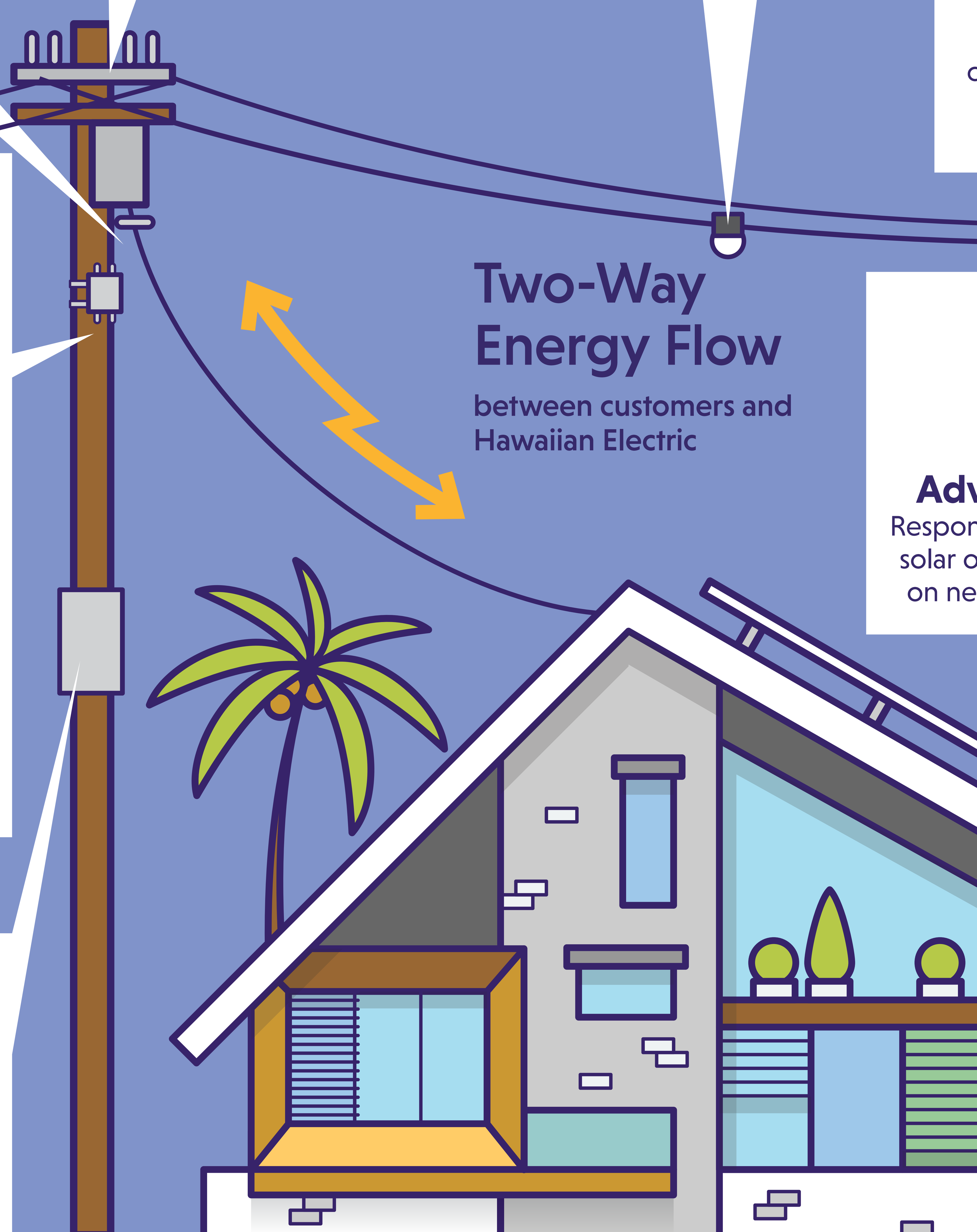
Provides remote control of circuit breakers and access to data enabling more efficient operation and faster outage restoration.

Battery Storage

Stores excess electricity and discharges as needed to enable continued growth of rooftop solar and large renewables.

Wireless Neighborhood Area Network

Enables integration of existing devices with smart meters, intelligent switches, line sensors, fault indicators and secondary var controllers. Supports automatic information gathering and monitoring of the grid for faster fault location, recovery and restoration.



Two-Way Energy Flow

between customers and Hawaiian Electric

Advanced Inverters

Responds to changes in rooftop solar output to reduce impacts on neighbors' service quality.

Secondary Var Controllers (SVC)

Provides additional support beyond inverters' capability to maintain customer service quality. Enables the addition of more customer resources to the grid.

Advanced Meters

Provides measurement of customer's electric use, production, and service quality along with remote service connection switch. Allows customers to make informed energy choices.

www.hawaiianelectric.com/gridmod

Grid-scale Renewables

Process for selecting, evaluating, and contracting new renewable projects.

1. Regulatory Approval process for RFP ★
2. Final RFP Issued
3. Developers Submit Proposals
4. Eligibility and Threshold Evaluation
5. Initial Evaluation
6. Select Priority List
7. Best and Final Offer Submission
8. Detailed Evaluation
9. Selection of Final Award(s)
10. Contract Negotiations / Public Meeting ★
11. Regulatory Approval Process for PPAs ★

★ Public Comment Opportunity

Opportunities for Public Engagement

RFP Development

- PUC Status Conference
- Written comments to PUC

Prior to signing agreement

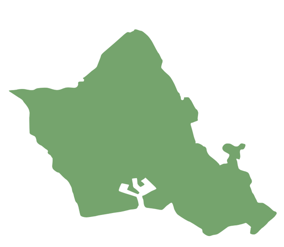
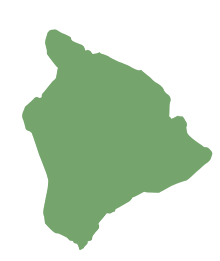
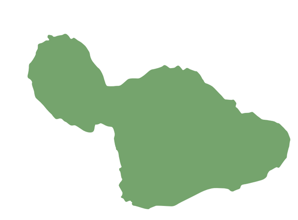
- Required public meeting by selected developer
- Ability to submit written comments which will also be provided to PUC

PUC Approval Process

- Written comments to PUC

Post PUC Approval Process

- Permitting approval processes requiring public comments

	O'AHU 	HAWAI'I ISLAND 	MAUI 
Stage 2 Renewable RFP	1,300,000 MWh + 200 MW Storage 50 MW Contingency Storage	70,000–444,000 MWh + 18 MW Contingency Storage	295,000 MWh + 40 MW Storage
Acres	3,000 (equivalent to 29 Aloha Stadiums)	160–1,000 (equivalent to 2– 10 Aloha Stadiums)	700 (equivalent to 7 Aloha Stadiums)

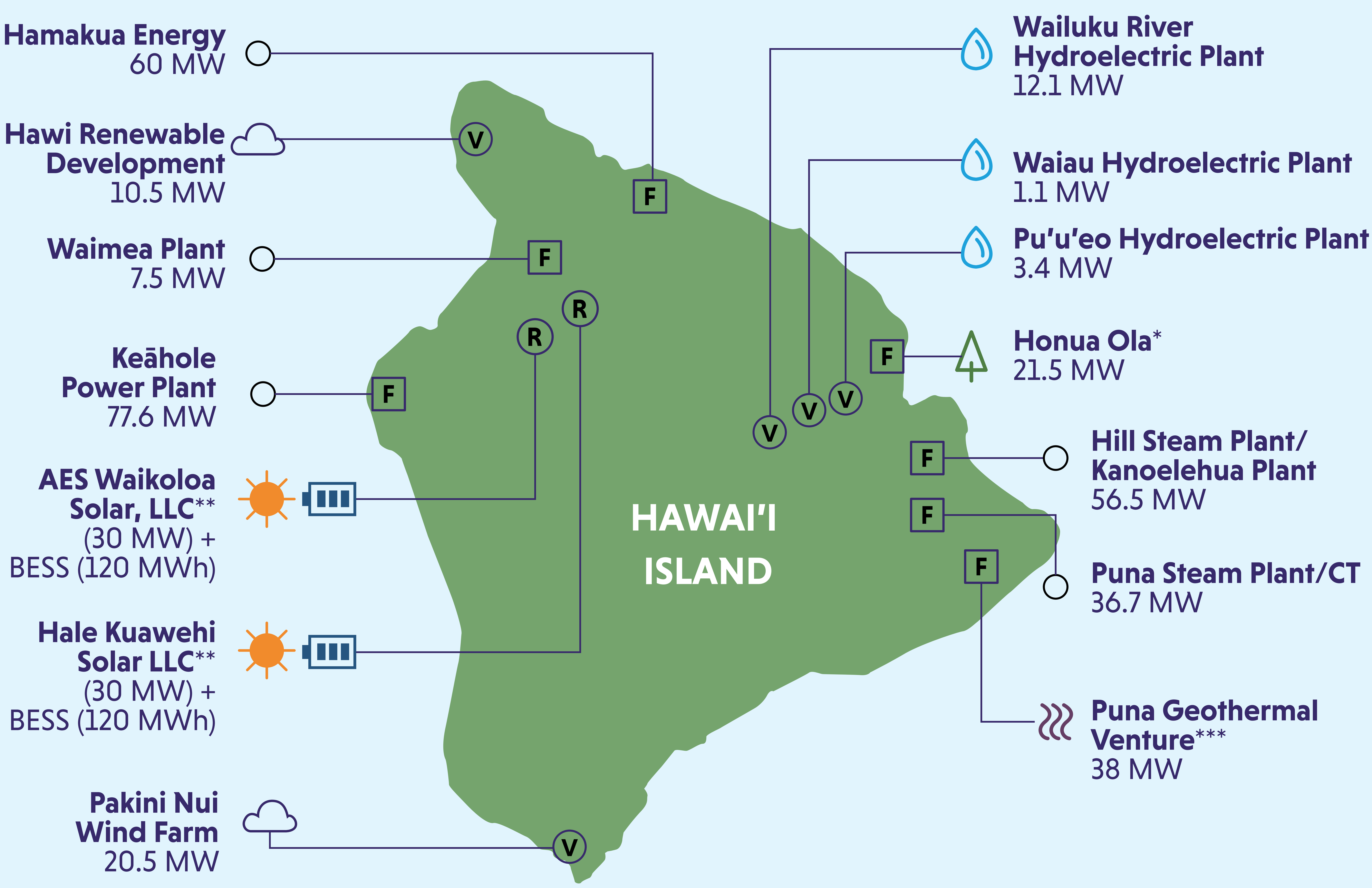
Hawai'i has many factors which must be considered when selecting renewable projects

- Land Availability
- Endangered Species
- Community Interest
- Availability of Materials
- Resilience

Grid-scale Renewables

Existing and planned generating facilities in our service area and the maximum potential power in megawatts (MW) they can produce.

BIOMASS
GEOTHERMAL
HYDRO
GRID-SCALE SOLAR
STORAGE
WIND
OIL



* AWAITING CONSTRUCTION; PUC APPROVAL ON APPEAL

** AWAITING CONSTRUCTION

*** OFFLINE SINCE MAY 2018 DUE TO VOLCANIC ACTIVITY IN LOWER PUNA / AMENDED PPA AWAITING PUC APPROVAL

F — FIRM GENERATION: Energy available on demand, which can be adjusted as needed.

V — VARIABLE GENERATION: Energy that may not always be available or controllable.

R — RENEWABLE DISPATCHABLE GENERATION

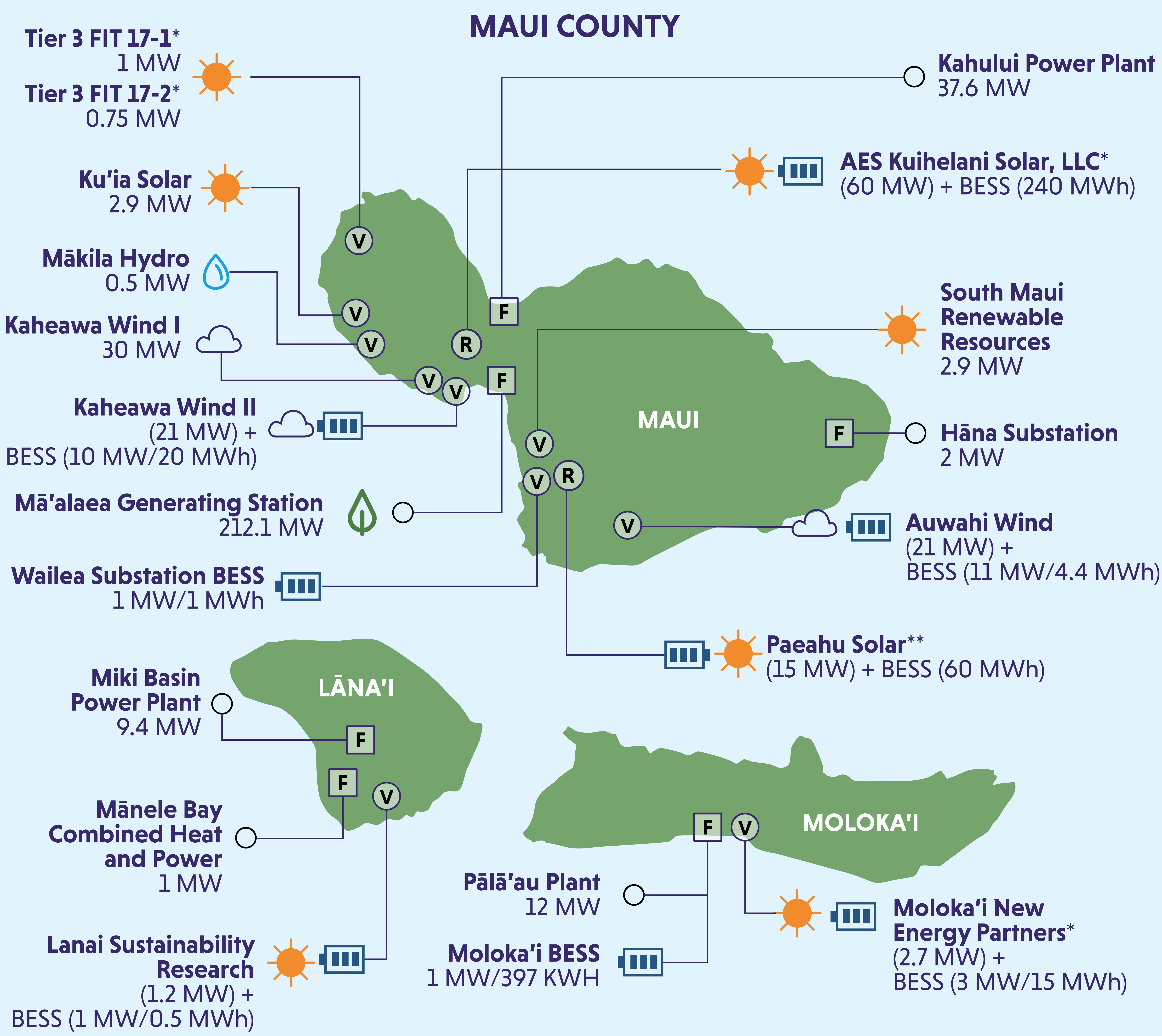
BESS: Battery Energy Storage System

To see the current progress of each of our grid scale renewable projects, visit:
www.hawaiianelectric.com/clean-energy-hawaii/our-clean-energy-portfolio/renewable-project-status-board

Grid-scale Renewables

Existing and planned generating facilities in our service area and the maximum potential power in megawatts (MW) they can produce.

BIOFUELS | HYDRO | GRID-SCALE SOLAR | STORAGE | OIL | WIND



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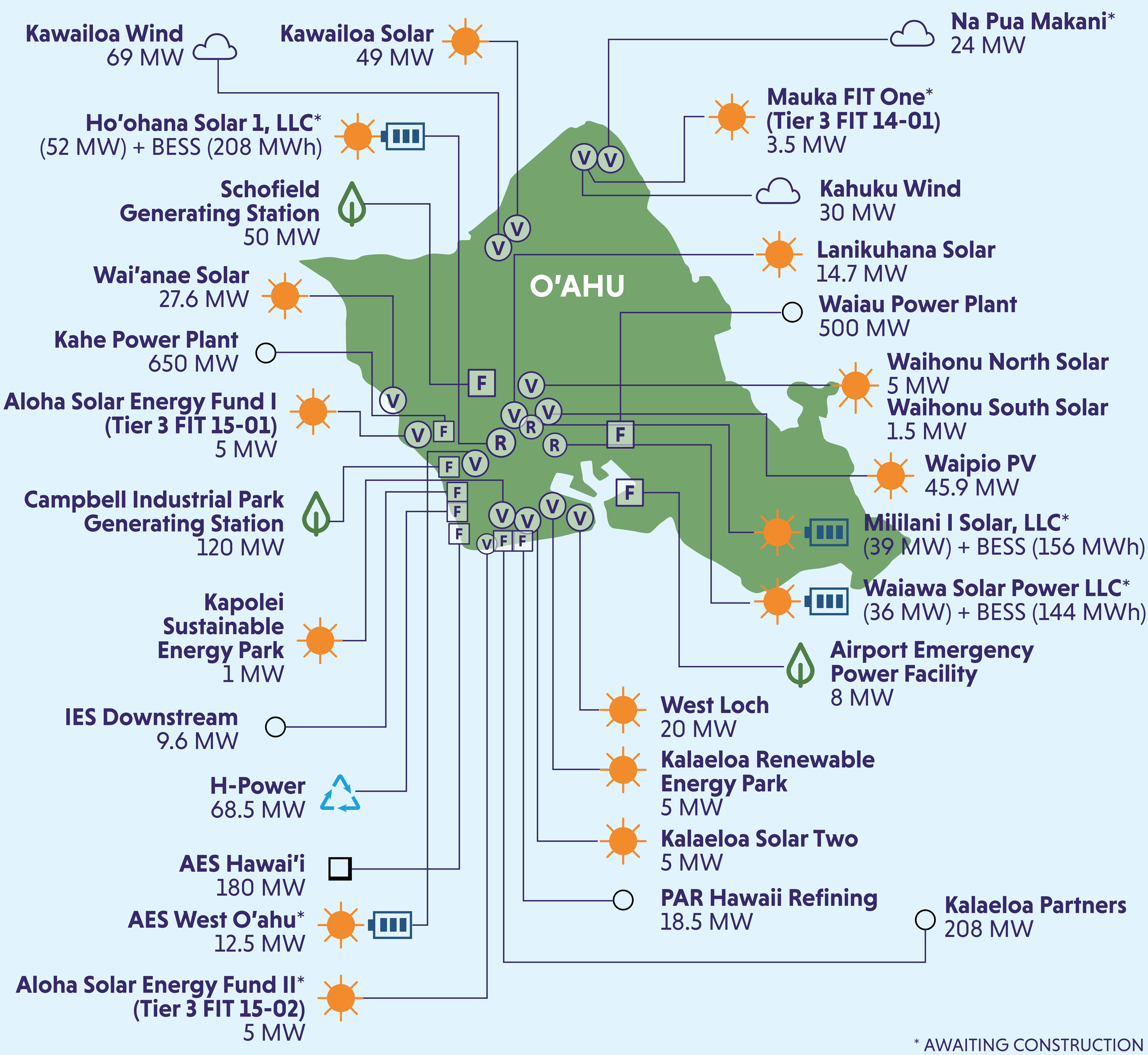
Grid-scale Renewables

Existing and planned generating facilities in our service area and the maximum potential power in megawatts (MW) they can produce.

BIOFUELS | COAL | GRID-SCALE SOLAR | STORAGE | OIL | WIND | WASTE TO ENERGY



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www.hawaiianelectric.com/clean-energy-hawaii/our-clean-energy-portfolio/renewable-project-status-board

Rooftop Renewable Energy

For residential and small business customers who want to reduce their bills by installing solar systems that meet specific program requirements.

Rooftop Solar Options

Many customers already have rooftop solar on homes and businesses. And there are still opportunities and many options for residential and small-business customers to reduce their electric bills and help Hawai'i reach a clean energy future.

Customer Self-Supply (CSS)

Rooftop solar system, with battery optional, designed not to export energy to grid and thus receive no bill credit. Customer pays retail rate for electricity received from grid.

Smart Export

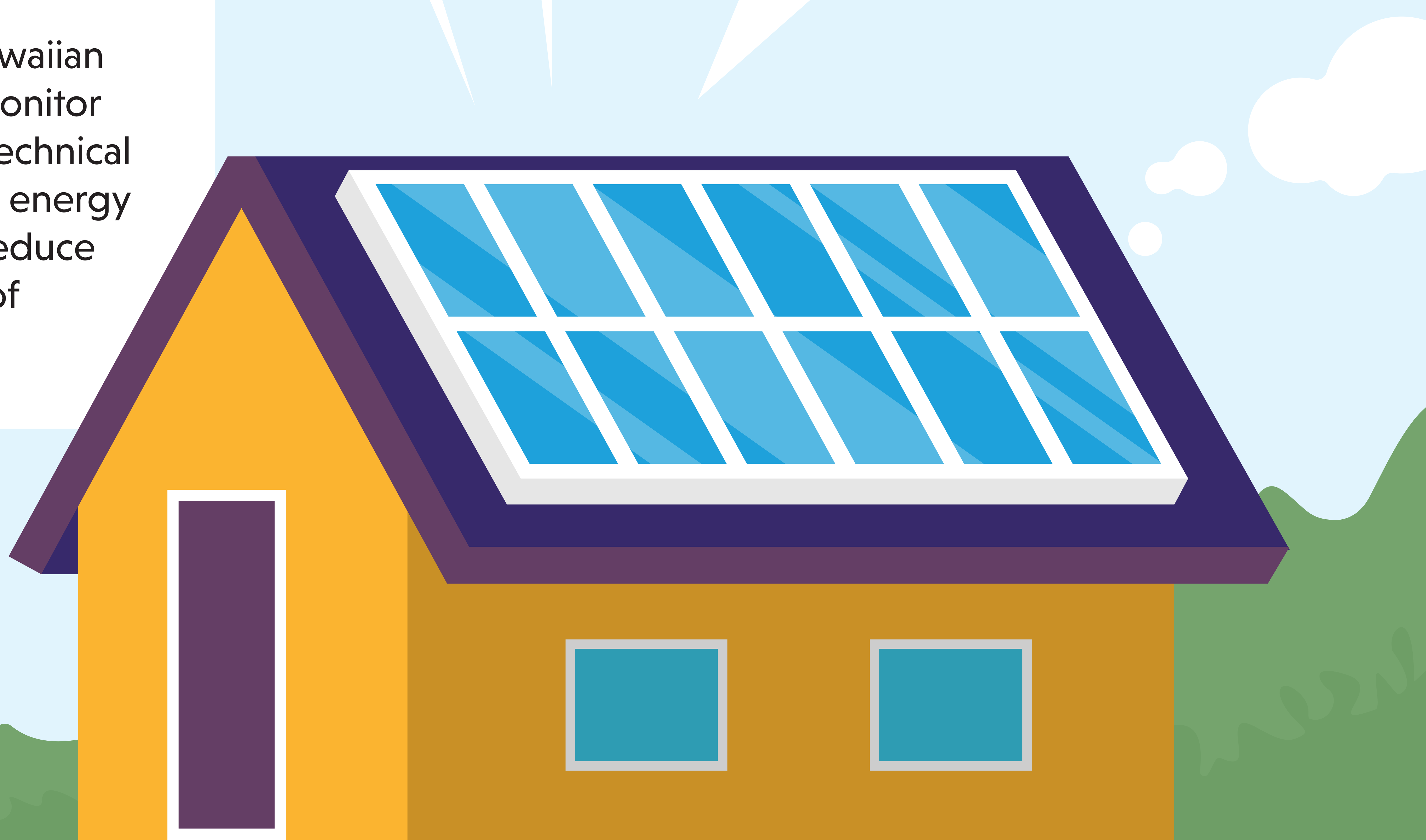
Rooftop solar system with battery storage desirable and option to export energy to grid only 4pm to 9pm. Grid support technology is required.

Customer Grid-Supply (CGS)

Rooftop solar system allowed to send energy to grid for bill credit. Customer pays retail rate for electricity received from grid.

Customer Grid-Supply Plus (CGS Plus)

Rooftop system allowed to send energy to grid for bill credit. Grid support technology allows Hawaiian Electric to remotely monitor generation, provide technical assistance and control energy to grid if needed to reduce outages or overload of system.



Rooftop Renewable Energy

For residential and small business customers who want to reduce their bills by installing solar systems that meet specific program requirements.

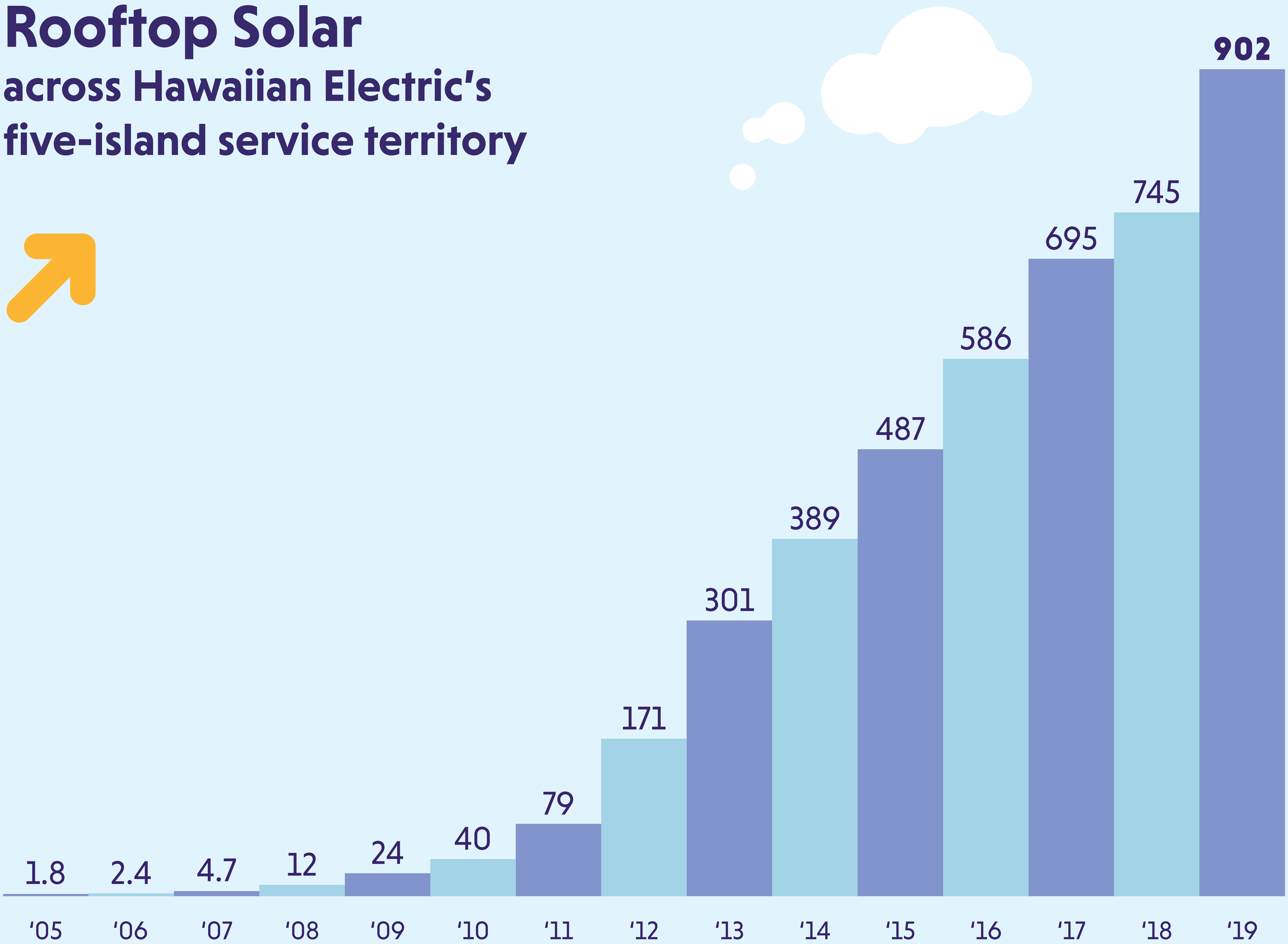
Leading in Rooftop Solar

Thanks to customers, Hawai'i leads the nation in rooftop solar per capita. It's on 20% of houses statewide; 33% on O'ahu. Rooftop solar plays an enormous part in achieving a 28% Renewable Portfolio Standard in 2019.

	Rooftop Solar Systems			Capacity in Megawatts		
	Number	% Residential	% Commercial	Capacity	% Residential	% Commercial
O'ahu	55,353	96%	4%	674	45%	55%
Hawai'i	13,410	94%	6%	103	66%	34%
Maui	13,020	92%	8%	125	57%	43%
Total	81,783			**902**		

Rooftop Solar

across Hawaiian Electric's five-island service territory



Community-Based Renewable Energy

Community-Based Renewable Energy, or community solar, provides a way for participating subscribers without privately-owned rooftop solar to benefit from electricity generated by a renewable energy facility located in their community.

The Next Phase: **'Solar without a Roof'**

Customers who don't own a roof can still save money on their monthly electric bills by joining community solar. Community solar is a hybrid: owned or leased by customers who don't or can't have solar, often because they are renters or live in apartment buildings, but sized and sited like a grid-scale solar facility.

Important Roles

Subscriber

A residential or commercial electric customer who participates, by lease or purchase, in a community solar project and gets monthly bill credits to offset their electricity use.

Subscriber Organization

Company, organization or group of people who own, develop or operate a community solar project.

Administration

Hawaiian Electric administers community solar on O'ahu, Moloka'i, Maui, Lāna'i, and Hawai'i Island, supervised by the Public Utilities Commission.

Electrification of **Transportation**

Why Driving an Electric Vehicle (EV) is Good for our Community and All Customers

- Promotes a clean energy future for Hawaiʻi as clean, renewable energy is increasingly added to the grid
- Reduces need for imported oil
- Reduces fossil fuel emissions and noise pollution

Customer Benefits of Adding More EV

Lower Cost per mile
Save with less maintenance and fueling with electricity

Federal Tax Incentive
Qualify for a credit up to $7,500

Free Parking
At state/municipal garages and metered stalls

High Occupancy Vehicles/ Zipper Lane Access
Use while driving solo

Clean Air
Produce fewer emissions, charge with renewables

Customer Cost Savings
Helps align grid needs, mainly during the day

Incentives for Customers

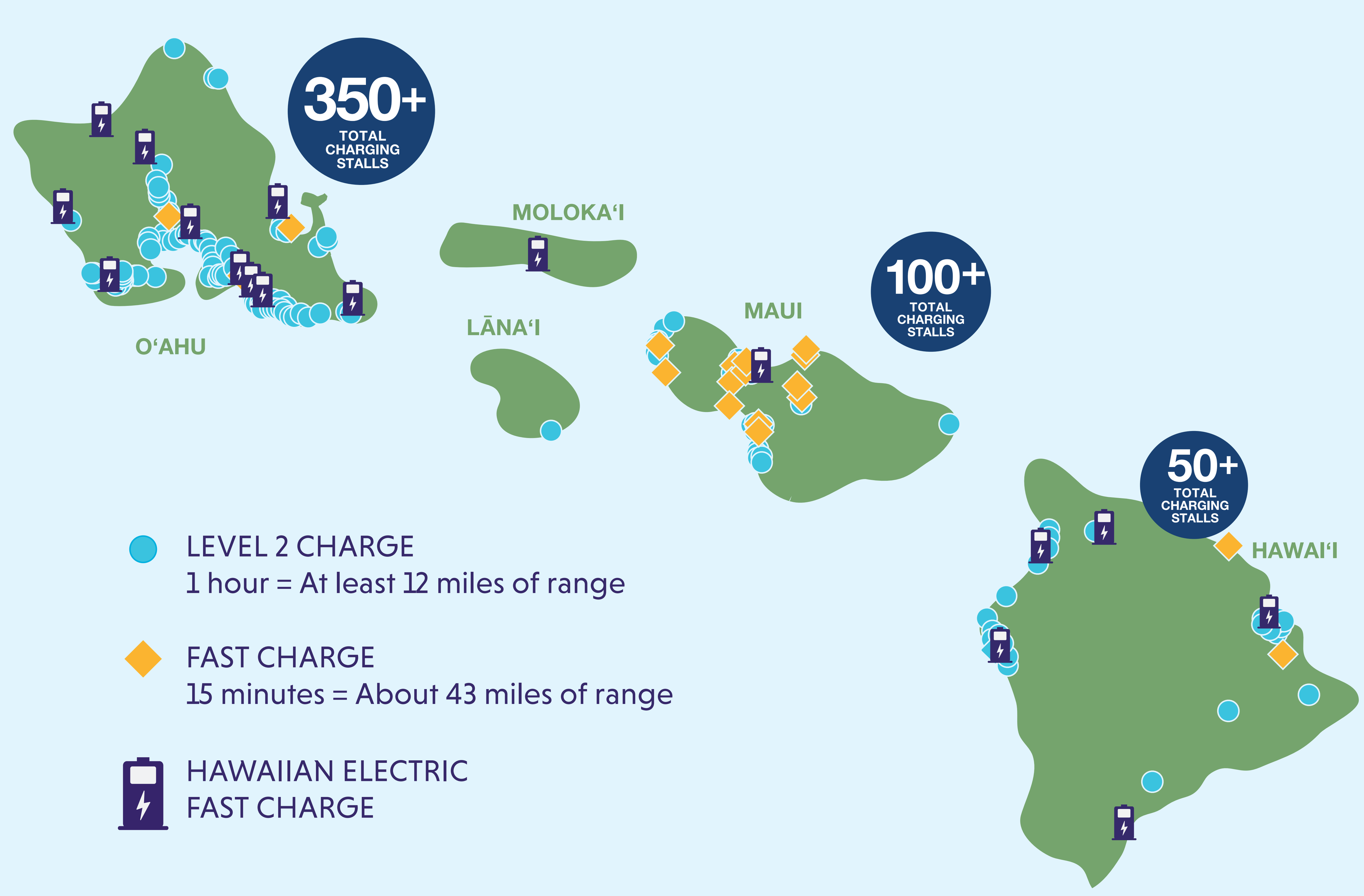
Nissan LEAF Rebate
Show your utility bill and save on a new Nissan LEAF

EV Charging Station Rebate
Offset costs for the commercial installation of charge stations with the state rebate administered by Hawaiʻi Energy.

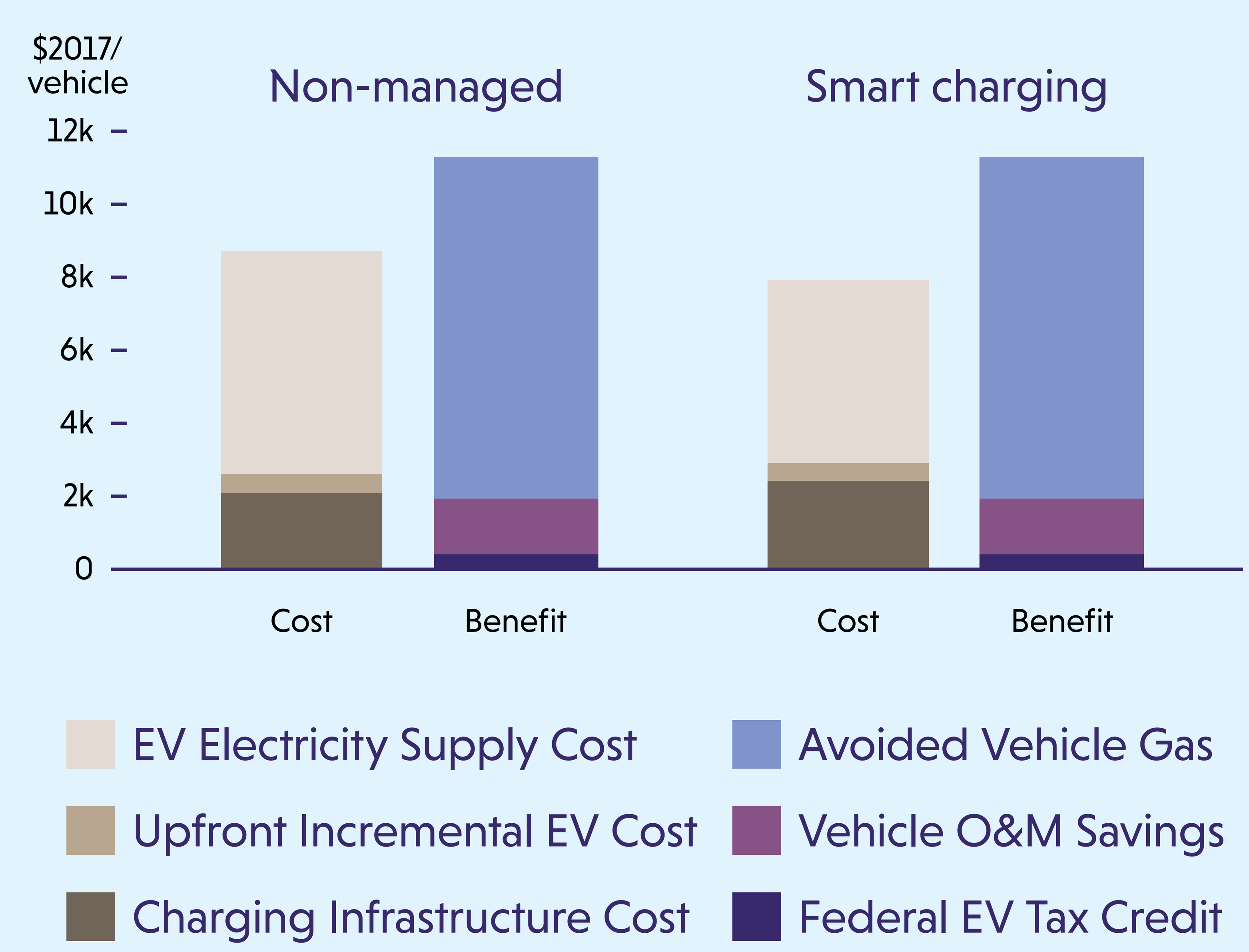
How EVs will Affect Your Electric Bill

- Customers charging EVs at home may stay on their current residential rate or may qualify for a time-of-use rate which provides an opportunity to save by using energy during certain times of day when solar power is most abundant.
- Commercial customers may qualify for a time-of-use rate for one or more charging stations on their own electric service.
- Over time, all customer will save money as more EVs charge on the grid, and have the opportunity to save more as drivers participate in Smart Charging programs that incentivize EV charging to align with grid needs.

EV Charging Locations



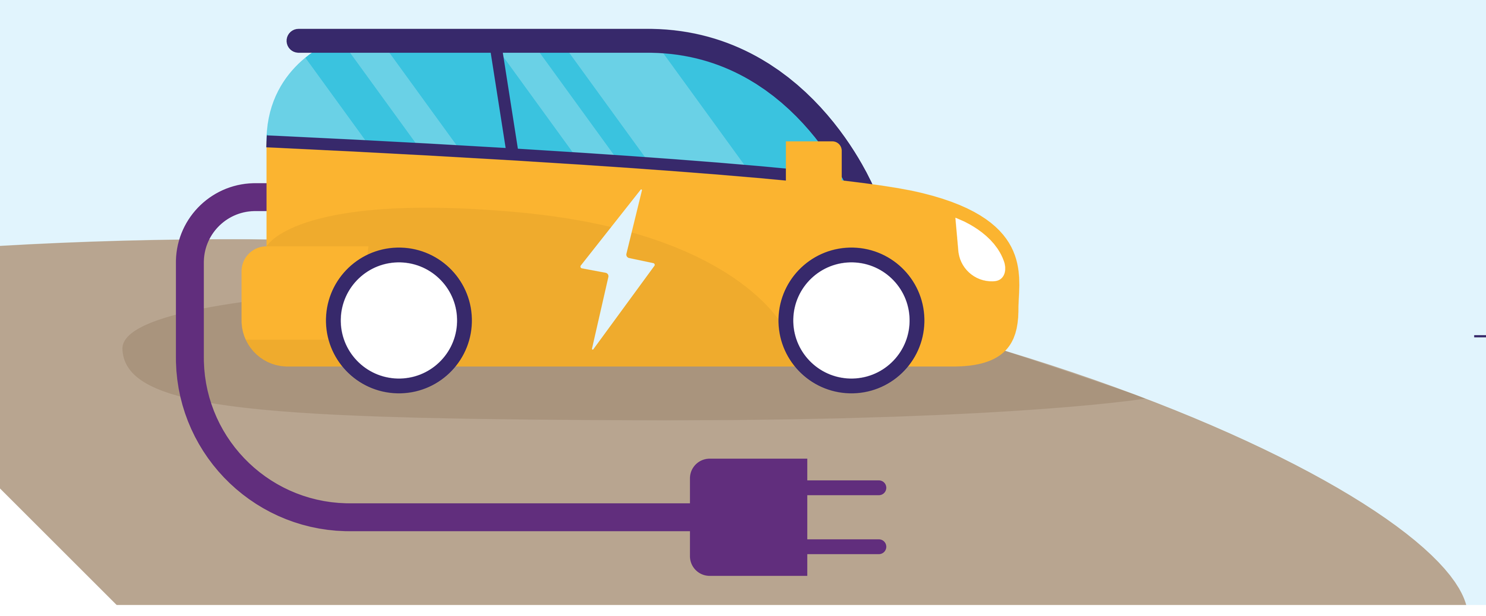
Savings



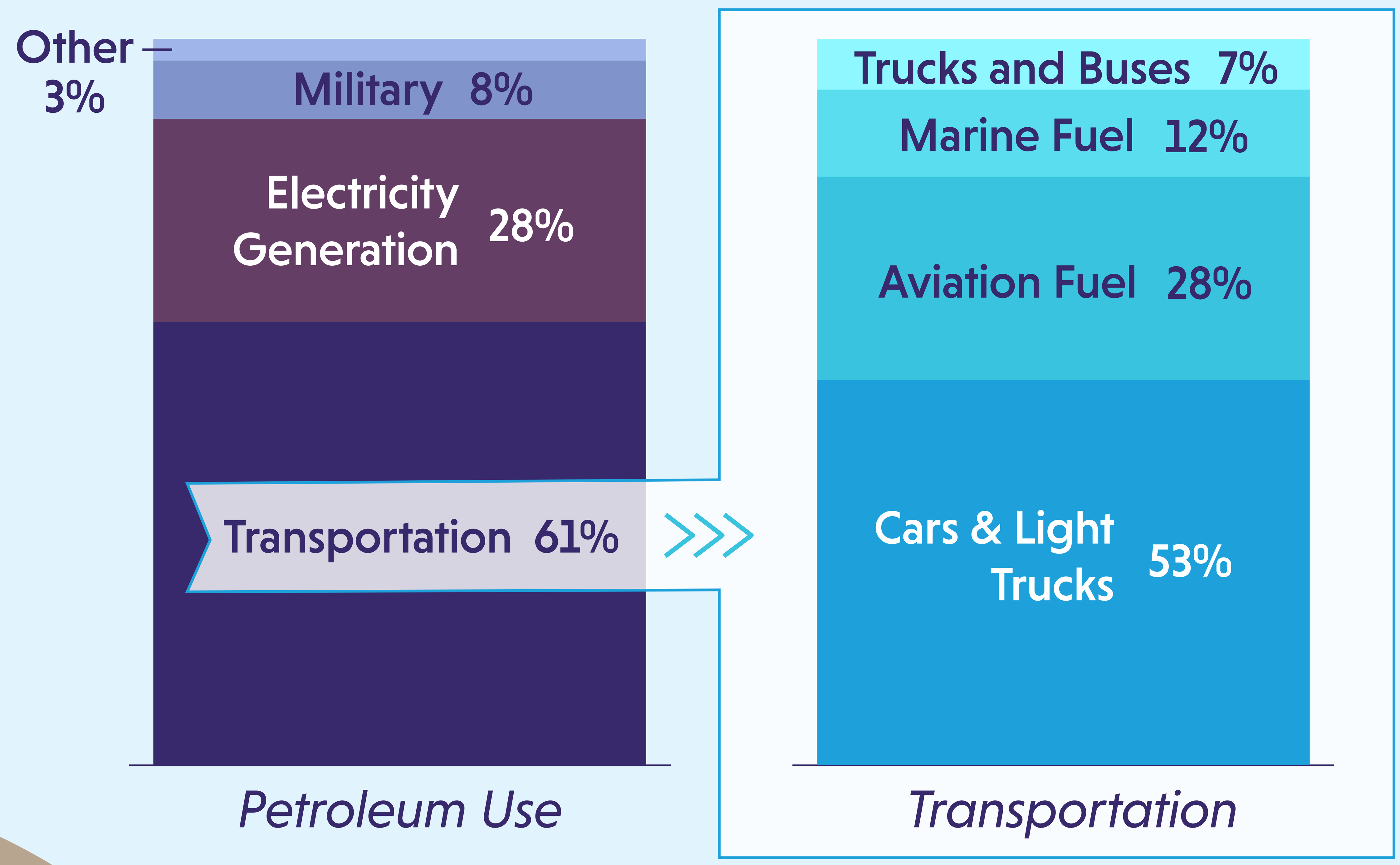
Electrification of **Transportation**

Electrification of Transportation (EoT) plays a key role in allowing us to integrate more renewable energy generation.

Here in Hawai'i, we are uniquely positioned to be a leader in the clean transportation revolution. Hawaiian Electric's **Electrification of Transportation Strategic Roadmap** outlines key initiatives to pave the way and achieve a clean energy future.

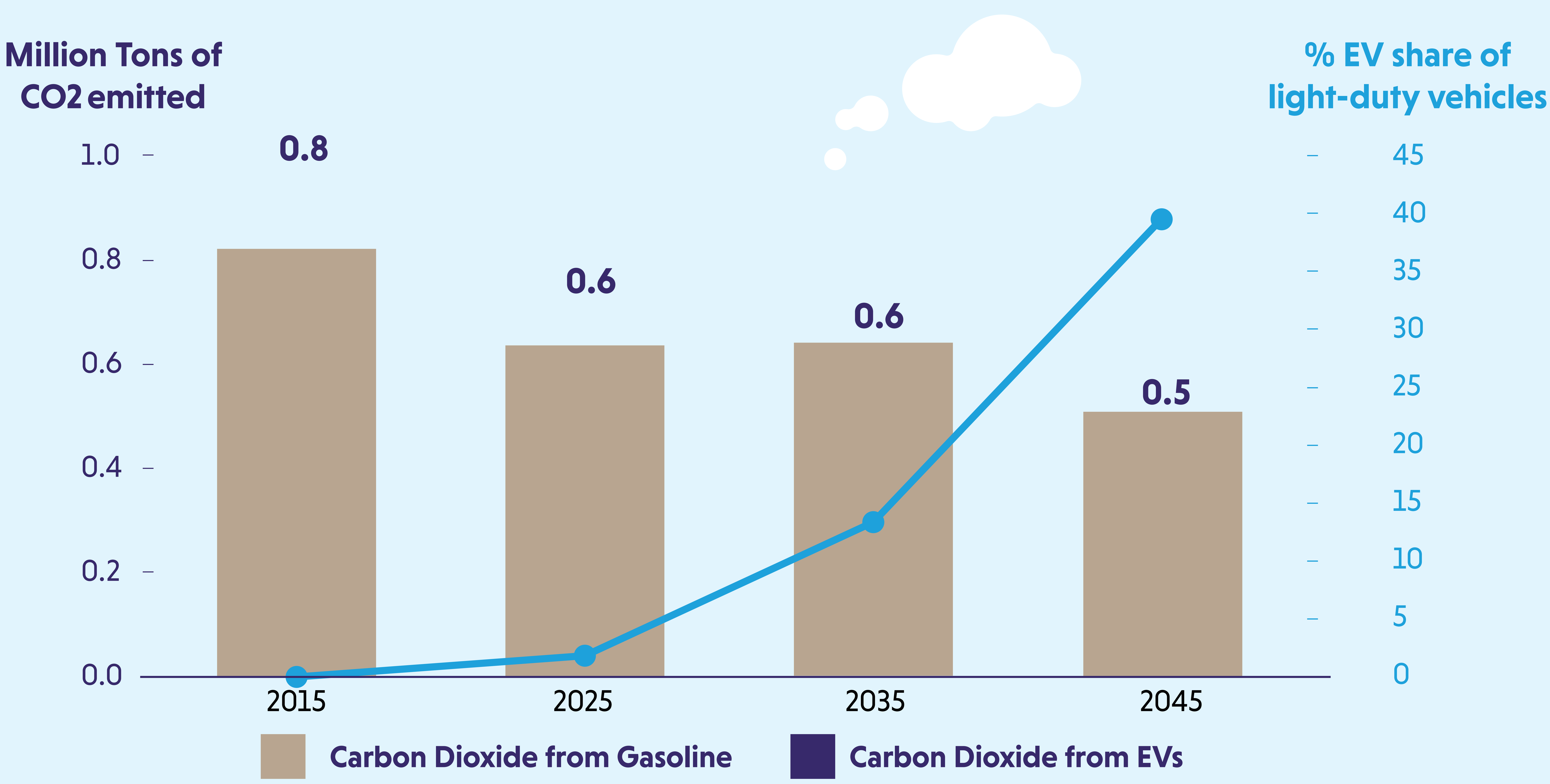


Hawai'i fossil fuel consumption by sector 2015



Reducing CO2 Emissions with Electric Vehicles

Forecasts show roughly 40% of all light-duty vehicles will be electric by 2045 on Hawai'i. This reduces CO2 emissions as the state reaches the 100% Renewable Portfolio Standard goal.



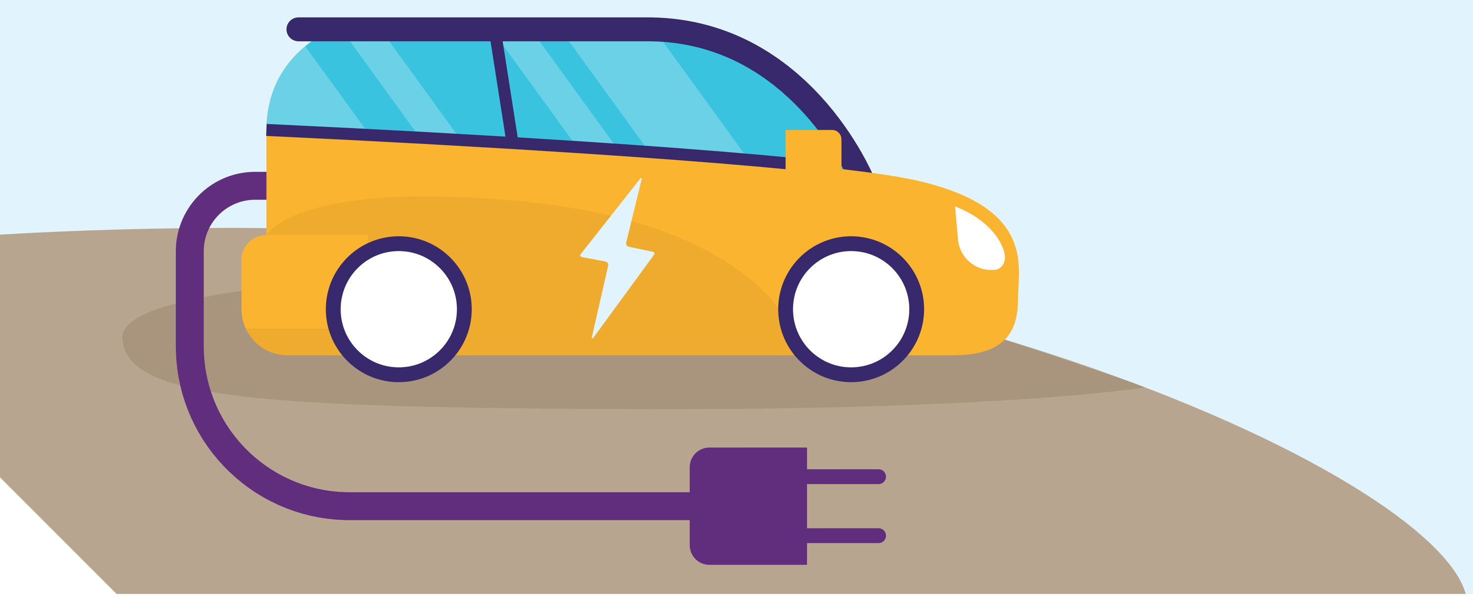
What This Means

- The state's emission of CO2 from gasoline will be reduced as EV adoption increases and there are less gasoline cars on the road.
- As more EVs are on the road and as the state transitions to meet the 100% RPS goal by 2045, CO2 contribution from EVs will decrease over time.
- Benefits not only include decreasing CO2 emissions, but also fossil fuel and noise reduction.

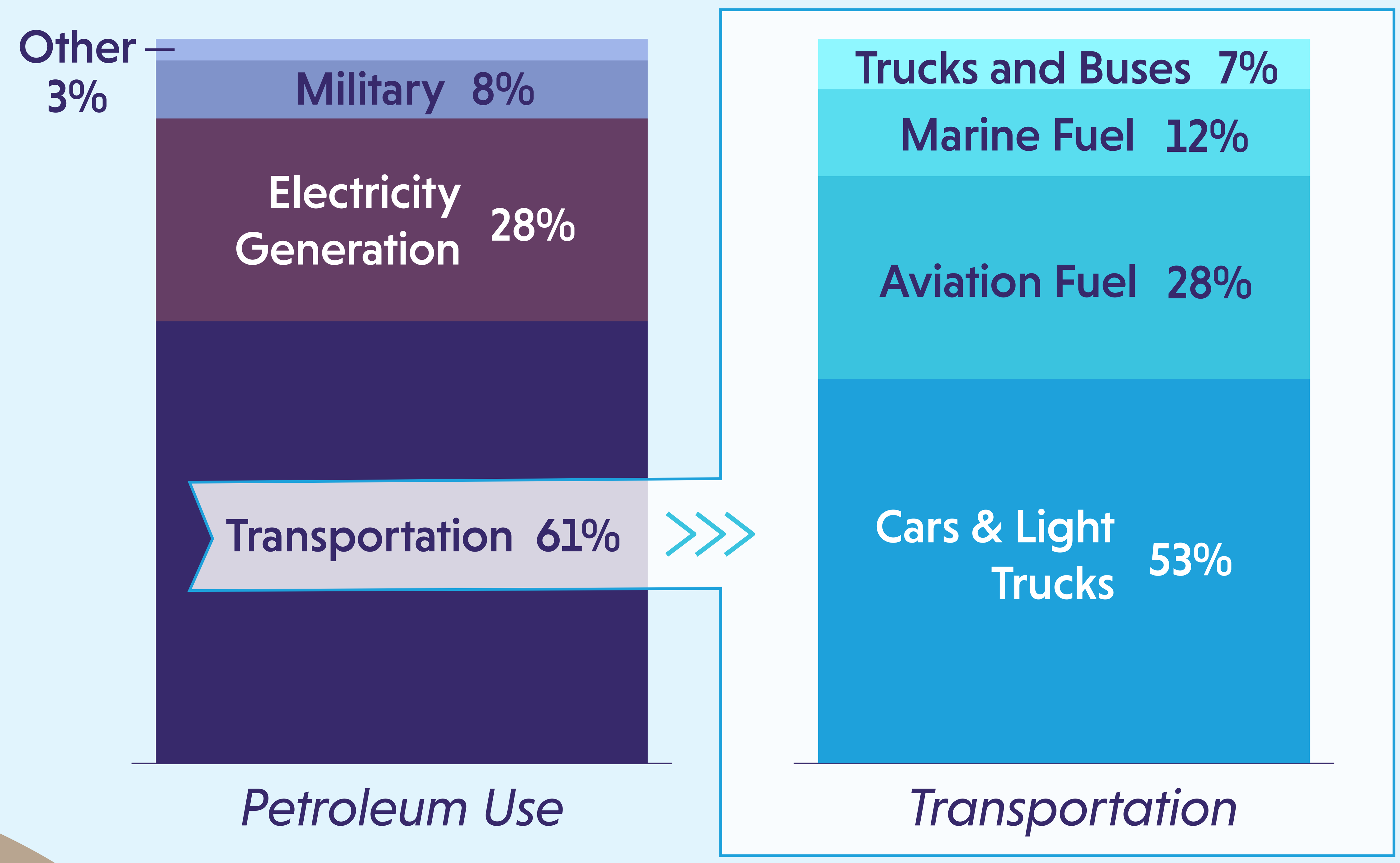
Electrification of Transportation

Electrification of Transportation (EoT) plays a key role in allowing us to integrate more renewable energy generation.

Here in Hawai'i, we are uniquely positioned to be a leader in the clean transportation revolution. Hawaiian Electric's **Electrification of Transportation Strategic Roadmap** outlines key initiatives to pave the way and achieve a clean energy future.

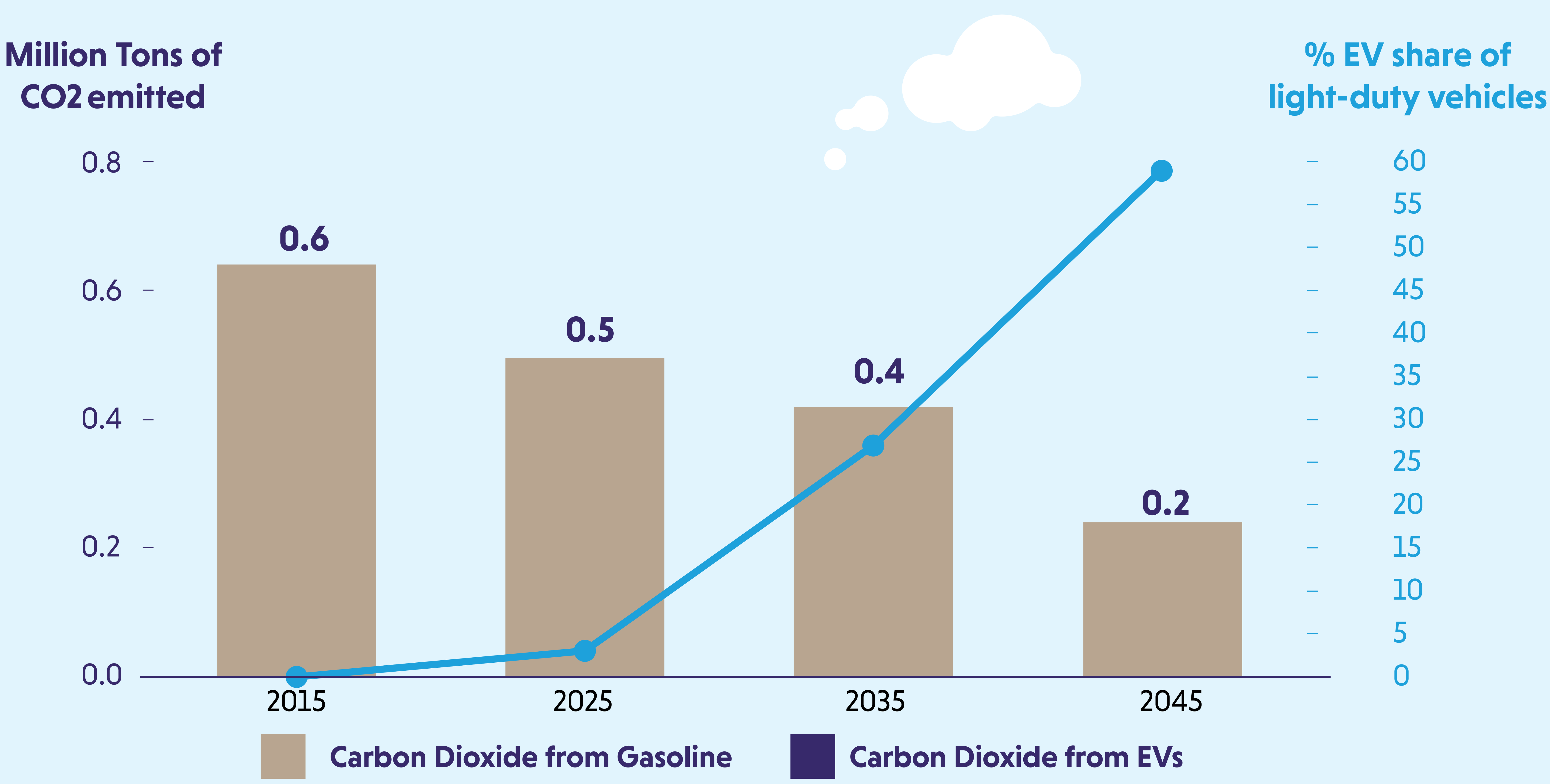


Hawai'i fossil fuel consumption by sector 2015



Reducing CO2 Emissions with Electric Vehicles

Forecasts show nearly 60% of all light-duty vehicles will be electric by 2045 on Maui. This reduces CO2 emissions as the state reaches the 100% Renewable Portfolio Standard goal.



What This Means

- The state's emission of CO2 from gasoline will be reduced as EV adoption increases and there are less gasoline cars on the road.
- As more EVs are on the road and as the state transitions to meet the 100% RPS goal by 2045, CO2 contribution from EVs will decrease over time.
- Benefits not only include decreasing CO2 emissions, but also fossil fuel and noise reduction.

Electrification of Transportation

Electrification of Transportation (EoT) plays a key role in allowing us to integrate more renewable energy generation.

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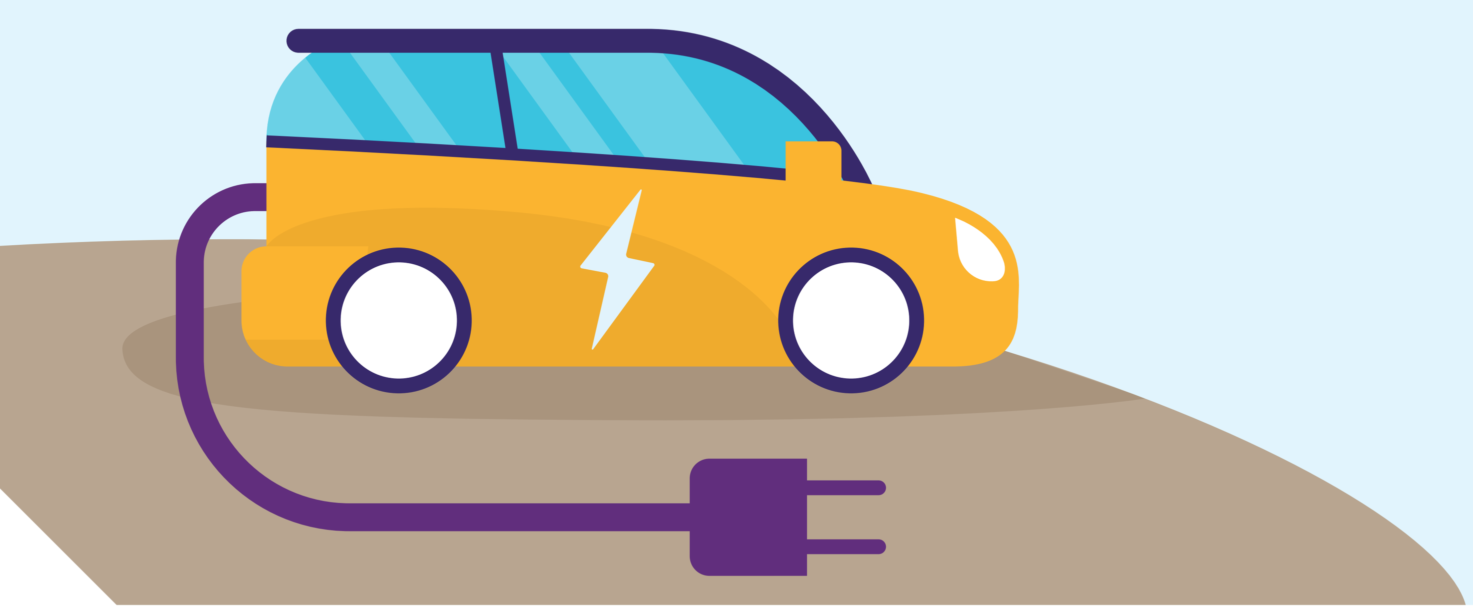
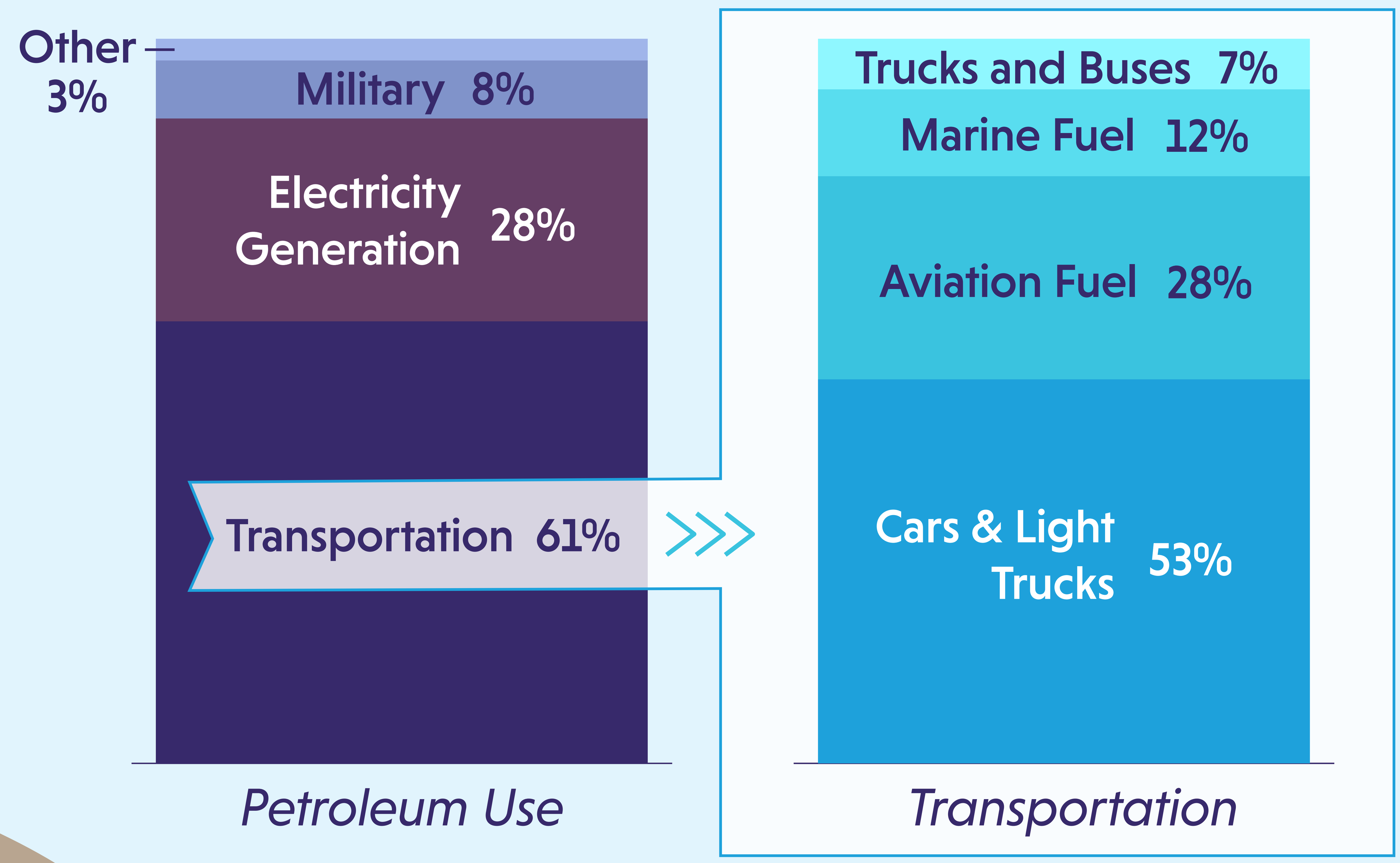
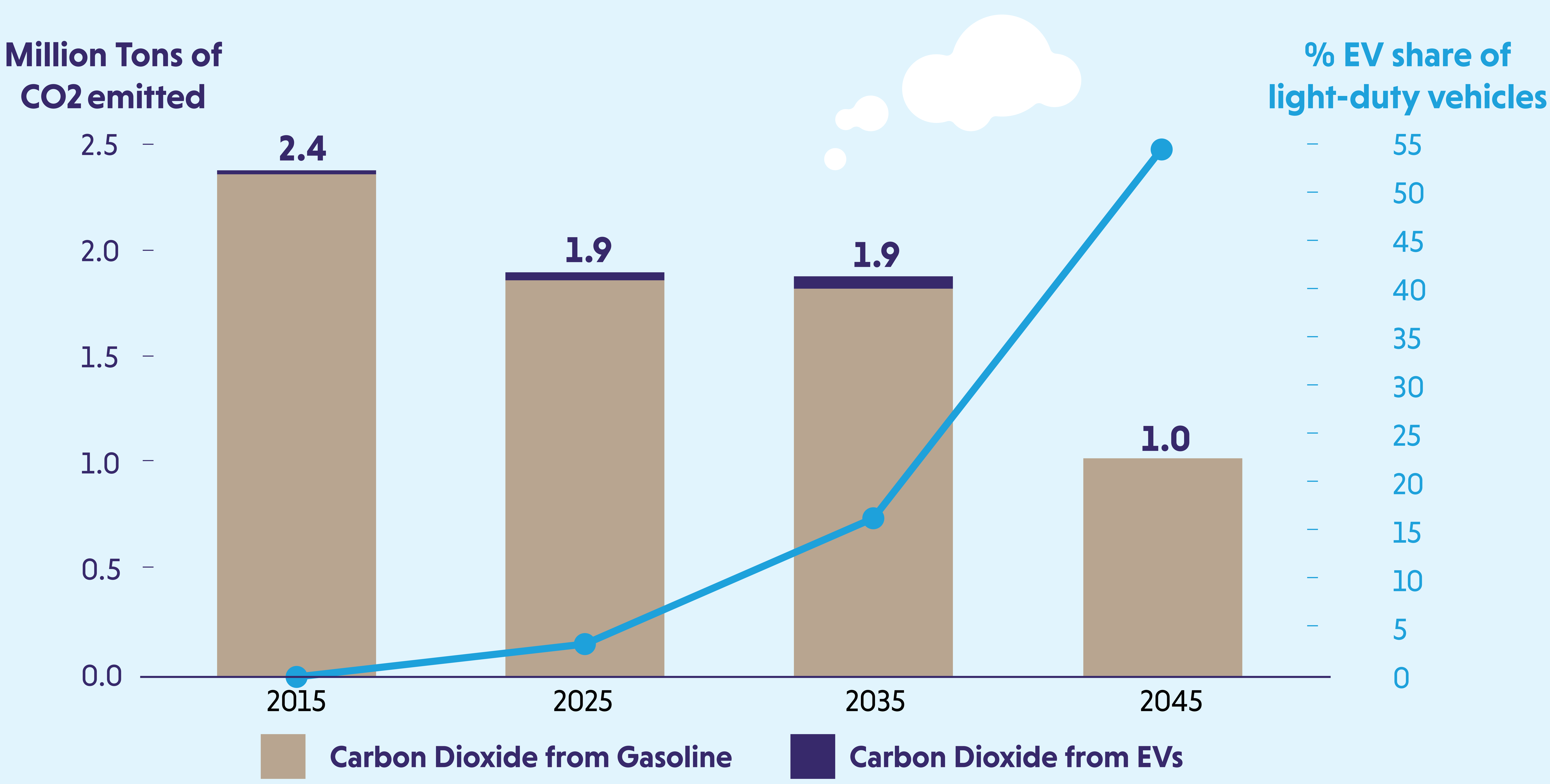


Hawai'i fossil fuel consumption by sector 2015



Reducing CO_2 Emissions with Electric Vehicles

Forecasts show 55% of all light-duty vehicles will be electric by 2045 on O'ahu. This reduces CO_2 emissions as the state reaches the 100% Renewable Portfolio Standard goal.



What This Means

- The state's emission of CO_2 from gasoline will be reduced as EV adoption increases and there are less gasoline cars on the road.
- As more EVs are on the road and as the state transitions to meet the 100% RPS goal by 2045, CO_2 contribution from EVs will decrease over time.
- Benefits not only include decreasing CO_2 emissions, but also fossil fuel and noise reduction.

Resilience

"Resilience is the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions." *– Public Utilities Commission Staff*

Making our Grid More Resilient

Besides strengthening our existing infrastructure and being better prepared for disasters, we must also consider the future as the grid evolves and new technology emerges. As Hawai'i moves toward 100% clean energy, we must ensure that the decisions we make will make the grid even more resilient than it is today.

Kīlauea Volcano Eruption

Key Planning Elements

- » Minimize impacts of severe events
- » Sustain mission critical functions under severe conditions
- » Rapidly recover from a severe event
- » Learn from severe events and continuously adapt

Threat Scenarios

Hurricane

Tsunami/Earthquake

Physical/Cyber Attack

Volcano

Solution Options

Here are some examples of how we can make our grid even more resilient in the future:

- » Increased emergency resources
- » Microgrids
- » Structure hardening
- » Targeted undergrounding
- » Renewable generation diversity
- » Distributed resources
- » Customer programs

Looking for a New Challenge?

A career at Hawaiian Electric is a chance to make a positive impact in Hawai'i while building a career in a fast-moving industry.

Emerging Markets

Cultivate new market opportunities in areas from electric vehicles to cutting edge renewable technologies.

New Concepts

The circular economy (an economic system aimed at continual use of resources), grid modernization, artificial intelligence (intelligence demonstrated by machines), machine learning (communication between computers and humans), and blockchain (encrypted data) are being implemented at Hawaiian Electric to meet the energy needs of our customers.

Innovative Solutions

Help generate unique solutions and use innovation to adapt to changing climate conditions and maintain reliable service for our islands.

JOIN THE TEAM

Hawaiian Electric

Career Information

hawaiianelectric.com/careers

linkedin.com/company/hawaiianelectric

facebook.com/HawaiianElectric

twitter.com/hwnelectric

instagram.com/hawaiianelectric

Together, We Build a Better Hawai'i

Since 1891, we have been entrusted to power these islands and empower its citizens — a responsibility that has been both our mission and our honor.

Community Engagement

Our connection to customers and commitment to build a better future for Hawai'i is what drives our community service initiatives. Each year, we aim to strengthen our ties with the community through increased outreach activities and partnerships.

Educational programs

Hawaiian Electric partners with government and community organizations to reach children of all ages on topics related to energy, renewable energy, technology, engineering, math, science, emergency preparedness, electrical safety, the environment and more.

Generous Benefits

We invest in our employees by providing opportunities for rewarding careers, apprenticeship training and job advancements. We offer a competitive compensation and benefits package that includes a robust wellness program.

JOIN THE TEAM

Hawaiian Electric

Career Information

hawaiianelectric.com/careers

linkedin.com/company/hawaiianelectric

facebook.com/HawaiianElectric

twitter.com/hwnelectric

instagram.com/hawaiianelectric

We Want to **Hear From You**

We welcome your input! Here are the many ways to stay connected with us.

Email:
IGP@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

HawaiianElectric

hwnelectric

hawaiianelectric

Listening + Integrating + Collaborating to Reach 100% Renewables by 2045

Integrated Grid Planning

Rank the following in order of importance, where 5 is the most important to you.

	1 (Least important)	2	3	4	5 (Most important)
Lowering energy costs					
Helping to increase the use of renewable energy					
Adopting new technologies to provide customers with more information and control of their energy usage					
Energy reliability					
Reducing greenhouse gases					

Integrated Grid Planning

How interested are you in doing the following?	Already have/do	Actively pursuing 1–2 years	Waiting 3–5 years	Interested need more info	Not interested
Installing rooftop solar					
Installing an advanced meter					
Installing a battery storage system					
Buying an electric vehicle					
Using transit or carpooling regularly (most trips)					
Installing a grid interactive water heater					

Survey questions and input forms

Integrated Grid Planning
Survey Questions and Input Form

Your input will help us improve future customer communications

How did you hear about this meeting?

- [x] Social media
- [ ] Newspaper
- [ ] Radio
- [ ] Flyer/banner
- [ ] IGP Website
- [ ] Word of Mouth
- [ ] Other ________

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? *(Select up to 3)*

- [ ] General updates
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- [ ] Utility scale renewable projects
- [x] Electrification of transportation
- [x] Incentive programs
- [ ] Advanced meters
- [ ] Employment opportunities
- [x] Rooftop and community solar renewables
- [ ] Grid modernization
- [ ] Other ________

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- [x] Social media
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- [ ] Mail
- [ ] Other ________

Share any additional thoughts. *We are listening!*

Keep up the Good work! Very informational presentation!

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [ ] O'ahu
- [ ] Maui
- [x] Hawai'i (Big Island)

What is your age?

54

Do you make the purchasing decisions for your home or business?

- [x] Yes
- [ ] No

What is your ownership of your home or business location?

- [x] Own
- [ ] Rent

Want a response to your comment?

Name ________

Email ________

Phone ________

Integrated Grid Planning

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- [ ] Word of Mouth
- [x] Other email

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- [ ] Grid modernization
- [ ] Other

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- [ ] Social media
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- [ ] Radio
- [x] Email
- [ ] IGP Website
- [ ] Mail
- [ ] Other

Share any additional thoughts. *We are listening!*

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [ ] O'ahu
- [ ] Maui
- [x] Hawai'i (Big Island)

What is your age?

Do you make the purchasing decisions for your home or business?

- [ ] Yes
- [x] No

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- [ ] Own
- [x] Rent

Want a response to your comment?

Name

Email

Phone

Integrated Grid Planning
Survey Questions and Input Form

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- ○ Other ____________________

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- ○ Employment opportunities
- ✓ Rooftop and community solar renewables
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- ○ Other ____________________

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- ○ Newspaper
- ○ Radio
- ✓ Email
- ○ IGP Website
- ○ Mail
- ○ Other ____________________

Share any additional thoughts. *We are listening!*

I'd like to see programs to support community power generation. One thing we have in abundance on the b.s island is open land. Is there a program that would help (for example) Ocean View to set up solar + wind generation for local community use?

Demographic Questions (Optional)

Where is your home or business located?

- ○ Moloka'i
- ○ Lāna'i
- ○ O'ahu
- ○ Maui
- ✓ Hawai'i (Big Island)

What is your age? 62

Do you make the purchasing decisions for your home or business?

✓ Yes + ✓ No We all work together.

What is your ownership of your home or business location?

- ✓ Own
- ○ Rent

Want a response to your comment?

Name ____________________

Email ____________________

Phone ____________________

Integrated Grid Planning
Survey Questions and Input Form

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- ◯ Radio
- ◯ Flyer/banner
- ◯ IGP Website
- ◯ Word of Mouth
- ✓ Other Email

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? *(Select up to 3)*

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- ◯ Input opportunities
- ◯ Resilience
- ◯ Utility scale renewable projects
- ✓ Electrification of transportation
- ◯ Incentive programs
- ✓ Advanced meters
- ◯ Employment opportunities
- ✓ Rooftop and community solar renewables
- ◯ Grid modernization
- ◯ Other ______

What would be your preferred method to receive future information on Integrated Grid Planning? *(Select up to 2)*

- ◯ Social media
- ◯ Newspaper
- ◯ Radio
- ✓ Email
- ◯ IGP Website
- ◯ Mail
- ◯ Other ______

Share any additional thoughts. *We are listening!*

EDUCATION PROGRAM
FINANCIAL ASSISTANCE

Demographic Questions (Optional)

Where is your home or business located?

- ◯ Moloka'i
- ◯ Lāna'i
- ◯ O'ahu
- ◯ Maui
- ✓ Hawai'i (Big Island)

What is your age?

74

Do you make the purchasing decisions for your home or business?

- ✓ Yes
- ◯ No

What is your ownership of your home or business location?

- ✓ Own
- ◯ Rent

Want a response to your comment?

Name ______

Email ______

Phone ______

Integrated Grid Planning
Survey Questions and Input Form

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- [ ] Input opportunities
- [ ] Resilience
- [ ] Utility scale renewable projects
- [x] Electrification of transportation
- [x] Incentive programs
- [x] Advanced meters
- [ ] Employment opportunities
- [x] Rooftop and community solar renewables
- [x] Grid modernization
- [ ] Other ____________________

What would be your preferred method to receive future information on Integrated Grid Planning? *(Select up to 2)*

- [x] Social media
- [ ] Newspaper
- [ ] Radio
- [x] Email
- [ ] IGP Website
- [ ] Mail
- [ ] Other ____________________

Share any additional thoughts. *We are listening!*

Very interested in some community solar in HOVE. Also interested in the virtual power plant idea

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [ ] O'ahu
- [ ] Maui
- [x] Hawai'i (Big Island)

What is your age? 57

Do you make the purchasing decisions for your home or business?

- [x] Yes
- [ ] No

What is your ownership of your home or business location?

- [x] Own
- [ ] Rent

Want a response to your comment?

Name ____________________

Email ____________________

Integrated Grid Planning

Survey Questions and Input Form

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How did you hear about this meeting?

● Social media ○ Newspaper ○ Radio ○ Flyer/banner ○ IGP Website ○ Word of Mouth

○ Other ______________________

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? *(Select up to 3)*

- ○ General updates
- ○ Input opportunities
- ☒ Resilience
- ○ Other See below
- ○ Utility scale renewable projects
- ● Electrification of transportation
- ○ Incentive programs
- ○ Advanced meters
- ○ Employment opportunities
- ● Rooftop and community solar renewables
- ● Grid modernization

What would be your preferred method to receive future information on Integrated Grid Planning? *(Select up to 2)*

○ Social media ○ Newspaper ○ Radio ● Email ○ IGP Website ● Mail

○ Other ______________________

Why does Hawaiian Electric negotiate bad deals (Hu Honua at 21¢/kwh) when solar is cheaper?

Share any additional thoughts. We are listening!

How much work is going into helping governmental, commercial & hotel operations become more energy efficient? Are they all on LED? Are they room darkening when there is no activity? Are they architecturally efficient to reduce cooling/air conditioning? Gas stations have ridiculous amounts of lighting at night? Sports fields at night Why? Can't we reduce the amount of light produced & stay safe? Also, please provide information about the electric bill increase if charging an electric vehicle.

Also landfill capture to produce hydrogen – please, tell me more

Demographic Questions (Optional)

Where is your home or business located?

○ Moloka'i ○ Lāna'i

○ O'ahu ○ Maui

● Hawai'i (Big Island)

What is your age?

71

Do you make the purchasing decisions for your home or business?

● Yes ○ No

What is your ownership of your home or business location?

● Own ○ Rent

Want a response to your comment?

Name ______________________

Email ______________________

Phone ______________________

Thank you for this very informative meeting.

Integrated Grid Planning

Survey Questions and Input Form

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- ○ Input opportunities
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- ● Rooftop and community solar renewables
- ○ Grid modernization
- ○ Other ______

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- ○ Social media
- ○ Newspaper
- ○ Radio
- ● Email
- ○ IGP Website
- ○ Mail
- ○ Other ______

Share any additional thoughts. *We are listening!*

- Public education on link between climate chaos and energy use. Just as response to virus involves some simple steps - wash hands etc, public needs education on simple steps, e.g. turn off lights when out of room.

- Are you conservative in your assumptions about climate change? e.g. sea level rise of 12-15 feet? or 50'
- Does Hu Honua make any sense? Burning trees when we need for more seems foolish.
- Opening prayer at meetings should be non-denominational, not just Christian
- You need a happiness index - geothermal may make sense from a utility perspective while also making people in the neighborhood very unhappy

Demographic Questions (Optional)

Where is your home or business located?

- ○ Moloka'i
- ○ Lāna'i
- ○ O'ahu
- ○ Maui
- ● Hawai'i (Big Island)

What is your age?

74

Do you make the purchasing decisions for your home or business?

- ○ Yes
- ● No

What is your ownership of your home or business location?

- ○ Own
- ● Rent

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Email ______

Phone ______

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- [x] Grid modernization
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- [ ] Newspaper
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- [ ] Mail
- [ ] Other ______

Share any additional thoughts. *We are listening!*

THESE MEETINGS ARE IMPORTANT TO OUR RURAL NEIGHBOR ISLAND COMMUNITIES. APPRECIATE THAT COMMUNITY MEMBERS ARE INCLUDED. THOROUGH TEAM COVERAGE. LOTS OF INFORMATION. FOOD + PROFESSIONAL FACILITATION CERTAINLY A PLUS!

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [ ] O'ahu
- [ ] Maui
- [x] Hawai'i (Big Island)

What is your age?

Do you make the purchasing decisions for your home or business?

- [ ] Yes
- [ ] No

What is your ownership of your home or business location?

- [ ] Own
- [ ] Rent

Want a response to your comment?

Name ______

Email ______

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- [ ] Mail
- [ ] Other ______

Share any additional thoughts. *We are listening!*

Let's push to make the 100% Renewable by 2035!

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [ ] O'ahu
- [ ] Maui
- [x] Hawai'i (Big Island)

What is your age?

Do you make the purchasing decisions for your home or business?

- [x] Yes
- [ ] No

What is your ownership of your home or business location?

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Want a response to your comment?

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Integrated Grid Planning
Survey Questions and Input Form

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- [x] Email
- [ ] IGP Website
- [ ] Mail
- [ ] Other ______

Share any additional thoughts. *We are listening!*

THIS PROGRAM SEEMED TO HAVE A VERY LIMITED REACH. WAS AMAZED THAT FOLKS AT THE RE-USE CENTERS (KEA'AU, PAHOA, HILO & HILO HABITAT) DID NOT KNOW ABOUT THIS MEETING. THESE EMPLOYEES HAVE WIDE RANGE CONTACT WITH PEOPLE, BOTH BUILDING & REMODELERS, BOTH IN SALES & INTAKE OF MATERIALS.

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [ ] O'ahu
- [ ] Maui
- [x] Hawai'i (Big Island)

What is your age? 63

Do you make the purchasing decisions for your home or business?

- [x] Yes
- [ ] No

What is your ownership of your home or business location?

- [x] Own
- [ ] Rent

Want a response to your comment?

Name T d

Email ______

Phone ______

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- ○ Mail
- ○ Other ______

Share any additional thoughts. We are listening!

Make data county-specific online & at meetings

Demographic Questions (Optional)

Where is your home or business located?

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- ○ Lāna'i
- ○ O'ahu
- ○ Maui
- ● Hawai'i (Big Island)

What is your age?

22

Do you make the purchasing decisions for your home or business?

- ○ Yes
- ● No

What is your ownership of your home or business location?

- ○ Own
- ● Rent

Want a response to your comment?

Name ______

Email ______

Phone ______

Integrated Grid Planning

Survey Questions and Input Form

Your input will help us improve future customer communications

How did you hear about this meeting?

● Social media ○ Newspaper ○ Radio ○ Flyer/banner ○ IGP Website ○ Word of Mouth

○ Other ______

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? *(Select up to 3)*

- ○ General updates
- ○ Input opportunities
- ○ Resilience
- ○ Utility scale renewable projects
- ○ Electrification of transportation
- ○ Incentive programs
- ○ Advanced meters
- ○ Employment opportunities
- ○ Rooftop and community solar renewables
- ● Grid modernization
- ○ Other ______

What would be your preferred method to receive future information on Integrated Grid Planning? *(Select up to 2)*

○ Social media ○ Newspaper ○ Radio ● Email ● IGP Website ● ~~Mail~~

○ Other ______

Share any additional thoughts. We are listening!

it's all new concept - the panelist gave a balanced perspective on IGP!

Demographic Questions (Optional)

Where is your home or business located?

○ Moloka'i ○ Lāna'i

○ O'ahu ○ Maui

● Hawai'i (Big Island)

What is your age?

Do you make the purchasing decisions for your home or business?

● Yes ○ No

What is your ownership of your home or business location?

● Own ○ Rent

Want a response to your comment?

Name ______

Email ______

Phone ______

Integrated Grid Planning
Survey Questions and Input Form

Your input will help us improve future customer communications

How did you hear about this meeting?

- [x] Social media
- [ ] Newspaper
- [ ] Radio
- [ ] Flyer/banner
- [ ] IGP Website
- [ ] Word of Mouth
- [ ] Other ________________

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? *(Select up to 3)*

- [x] General updates
- [x] Input opportunities
- [ ] Resilience
- [ ] Utility scale renewable projects
- [ ] Electrification of transportation
- [ ] Incentive programs
- [ ] Advanced meters
- [ ] Employment opportunities
- [ ] Rooftop and community solar renewables
- [ ] Grid modernization
- [ ] Other ________________

What would be your preferred method to receive future information on Integrated Grid Planning? *(Select up to 2)*

- [ ] Social media
- [ ] Newspaper
- [ ] Radio
- [x] Email
- [ ] IGP Website
- [x] Mail
- [ ] Other ________________

Share any additional thoughts. *We are listening!*

Why is Hawaiian Electric still stating on their website that "To date, there has been no conclusive evidence established by the scientific community confirming a causal link between EMF exposure and adverse health effects," after other residents' and my own testimonies and written submissions of 2017 with links (including the BioInitiative Report of 2012 and numerous other documents) proving your statement is clearly untrue? (Nobody can fool or brainwash me in this respect. Like others I know, I'm electro-sensitive and feel effects of EMFs.)

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [x] O'ahu
- [ ] Maui
- [ ] Hawai'i (Big Island)

What is your age?

Do you make the purchasing decisions for your home or business?

- [ ] Yes
- [x] No

What is your ownership of your home or business location?

- [ ] Own
- [x] Rent

Name

Email

Phone

Integrated Grid Planning
Survey Questions and Input Form

Your input will help us improve future customer communications

How did you hear about this meeting?

- ○ Social media ○ Newspaper ○ Radio ○ Flyer/banner ○ IGP Website ○ Word of Mouth
- ☑ Other Baldwin Science teacher

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? (Select up to 3)

- ○ General updates
- ○ Input opportunities
- ○ Resilience
- ☑ Utility scale renewable projects
- ○ Electrification of transportation
- ☑ Incentive programs
- ○ Advanced meters
- ○ Employment opportunities
- ☑ Rooftop and community solar renewables
- ○ Grid modernization
- ○ Other ______

What would be your preferred method to receive future information on Integrated Grid Planning? (Select up to 2)

- ○ Social media ○ Newspaper ☑ Radio ☑ Email ○ IGP Website ○ Mail
- ○ Other ______

Share any additional thoughts. We are listening!

Project developers should turn back profits to the community.

Demographic Questions (Optional)

Where is your home or business located?

- ○ Moloka'i ○ Lāna'i
- ○ O'ahu ☑ Maui
- ○ Hawai'i (Big Island)

What is your age? 42

Do you make the purchasing decisions for your home or business?

- ☑ Yes ○ No

What is your ownership of your home or business location?

- ○ Own ☑ Rent

Want a response to your comment?

Name ______

Email ______

Phone ______

Integrated Grid Planning
Survey Questions and Input Form

Your input will help us improve future customer communications

How did you hear about this meeting?

- [x] Social media
- [ ] Newspaper
- [ ] Radio
- [ ] Flyer/banner
- [ ] IGP Website
- [ ] Word of Mouth
- [ ] Other ______

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? *(Select up to 3)*

- [x] General updates
- [ ] Input opportunities
- [ ] Resilience
- [x] Utility scale renewable projects
- [ ] Electrification of transportation
- [x] Incentive programs
- [ ] Advanced meters
- [ ] Employment opportunities
- [x] Rooftop and community solar renewables
- [ ] Grid modernization
- [ ] Other Be transparent (Involve) community input

What would be your preferred method to receive future information on Integrated Grid Planning? *(Select up to 2)*

- [x] Social media
- [ ] Newspaper
- [ ] Radio
- [x] Email
- [ ] IGP Website
- [ ] Mail
- [ ] Other ______

Share any additional thoughts. *We are listening!*

Begin With the End In Mind. Where will the inoperable systems be disposed? Our landfills are near capacity. We cannot accommodate turbines in our landfills. We need to invest in systems that will be biodegradable.

Demographic Questions (Optional)

Where is your home or business located?

- [ ] Moloka'i
- [ ] Lāna'i
- [x] O'ahu
- [x] Maui
- [ ] Hawai'i (Big Island)

What is your age?

Do you make the purchasing decisions for your home or business?

- [x] Yes
- [ ] No

What is your ownership of your home or business location?

- [x] Own
- [ ] Rent

Want a response to your comment?

Name

Email

Phone

Virtual Online Meeting

Hawaiian Electric

- Welcome
- Integrated Grid Planning
- Grid Modernization
- Grid-Scale Renewables
- Rooftop Renewable Energy
- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Engagement
- Careers at Hawaiian Electric

COMMENT

Welcome

Welcome to our Virtual Open House

Thank you for your participation in our online engagement! The slides in this session are filled with information about our Integrated Grid Planning, renewables and careers at Hawaiian Electric. Please read the materials and submit your responses to each survey question to help shape our renewable energy future together.

In-Person Public Meetings

You're also invited to join us at our public meetings and learn how Hawaiian Electric uses Integrated Grid Planning to shape our renewable energy future together.

Scheduled Meetings (5:00 p.m. – 7:30 p.m.)

TUESDAY Mar 03
Kealakehe High School (Cafeteria)
74-5000 Puohulihuli Street
Kailua-Kona, Hawai'i 96740

THURSDAY Mar 05
Hilo High School (Cafeteria)
556 Waiānuenue Avenue
Hilo, Hawai'i 96720

TUESDAY Mar 10
Hawaii Pacific University* (Multi-Purpose Room 3)
1 Aloha Tower Drive
Honolulu, O'ahu 96813
**Free parking with validation*

THURSDAY Mar 12
Hawaiian Electric (Maui Auditorium)
210 W Kamehameha Avenue
Kahului, Maui 96732

General Information Survey – 2 Questions

Rank the following in order of importance, where 1 is the most important to you. Drag the options below to change the order.

1: Lowering energy costs
2: Helping to increase the use of renewable energy
3: Adopting energy technology to provide more information and customer control
4: Energy reliability
5: Reducing greenhouse gases

In a few words, what change at your home or business do you plan to make to help Hawaii get to 100% renewables?

Examples: purchase an energy saver appliance, use LED lights, install an advanced meter

Submit Your Response

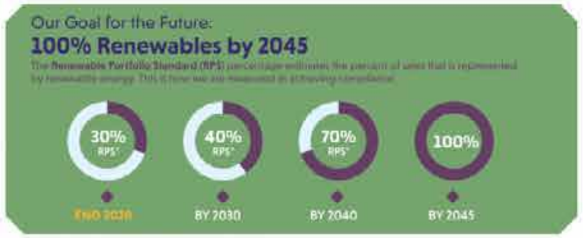
Integrated Grid Planning

An energy planning process to identify the best options for customers to move Hawai'i toward a clean energy future.

Planning Hawaii's Grid for Future Generations

With a renewed focus on comprehensive energy planning, Hawaiian Electric proposed an Integrated Grid Planning ("IGP") process that we believe will benefit customers by identifying the best options to affordably move Hawai'i toward a reliable, resilient clean energy future with minimal risk. In addition, we believe the State will benefit from expanded market opportunities for resource, grid services, and non-wires alternatives for transmission and distribution ("T&D"), which can foster innovative solutions for a new energy economy.

Click each of the three (3) images below to enlarge.



IGP Overview Survey – 7 Questions

How interested are you in installing rooftop solar?
- Already have/do
- Actively pursuing (1–2 years)
- Waiting (3–5 years)
- Interested, need more info
- Not interested

How interested are you in installing an advanced meter?
- Already have/do
- Actively pursuing (1–2 years)
- Waiting (3–5 years)
- Interested, need more info
- Not interested

How interested are you in installing a battery storage system?
- Already have/do
- Actively pursuing (1–2 years)
- Waiting (3–5 years)
- Interested, need more info
- Not interested

How interested are you in buying an electric vehicle?
- Already have/do
- Actively pursuing (1–2 years)
- Waiting (3–5 years)
- Interested, need more info
- Not interested

How interested are you in using transit or carpooling regularly (most trips)?
- Already have/do
- Actively pursuing (1–2 years)
- Waiting (3–5 years)
- Interested, need more info
- Not interested

How interested are you in installing a hot water or grid interactive water heater?
- Already have/do
- Actively pursuing (1–2 years)
- Waiting (3–5 years)
- Interested, need more info
- Not interested

What type of help would you need to make renewable or energy efficient upgrades to your home or business?

Submit Your Response

- Grid Modernization
- Grid-Scale Renewables
- Rooftop Renewable Energy
- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Engagement

Grid Modernization

Grid modernization is transforming our energy grid to be a dynamic, two way stream of power, shifting back and forth between customers and Hawaiian Electric.

What's in it for the Customer?

There are several benefits of grid modernization for Hawaiian Electric customers.

Click each of the two (2) images below to enlarge.

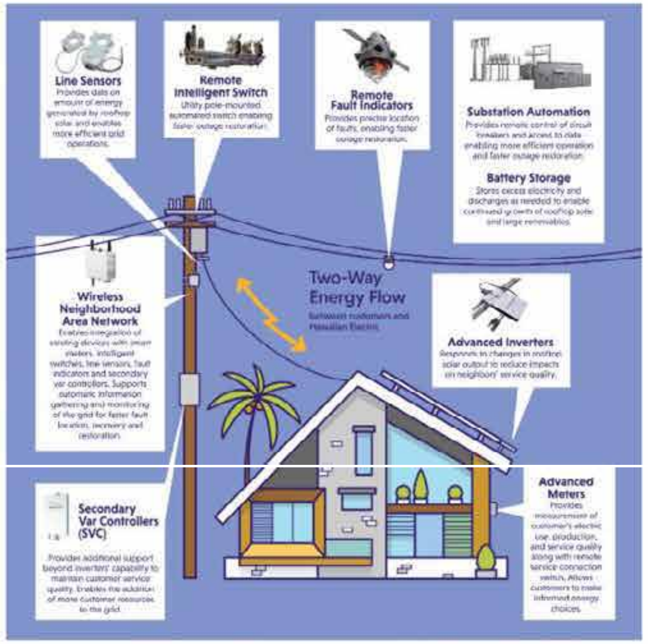
Learn More

Advanced Meters

How does Grid Modernization Technology Work?

Customers' resources are an important part of the grid. Reliability is critical as more and more customers provide resources to the grid. Learn about the new technology as we move toward changing yesterday's grid to tomorrow's grid.

Click the image below to enlarge.



Learn More

Grid Modernization Technologies

Engagement

Hawaiian Electric

- Welcome
- Integrated Grid Planning
- Grid Modernization
- Grid-Scale Renewables
- Rooftop Renewable Energy
- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Engagement

Hawaiian Electric Company, Inc

COMMENT

Grid-Scale Renewables

Existing and planned generating facilities in our service area and the maximum potential power in megawatts (MW) they can produce.

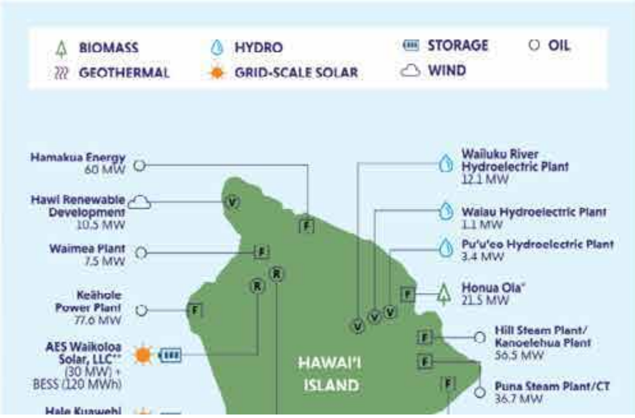
Hawaiian Electric Projects

High-level snapshots of various grid-scale renewable projects around the islands are shown below. To see the current progress of each of our grid scale renewable projects, visit our Clean Energy Portfolio.

Learn More

Clean Energy Portfolio

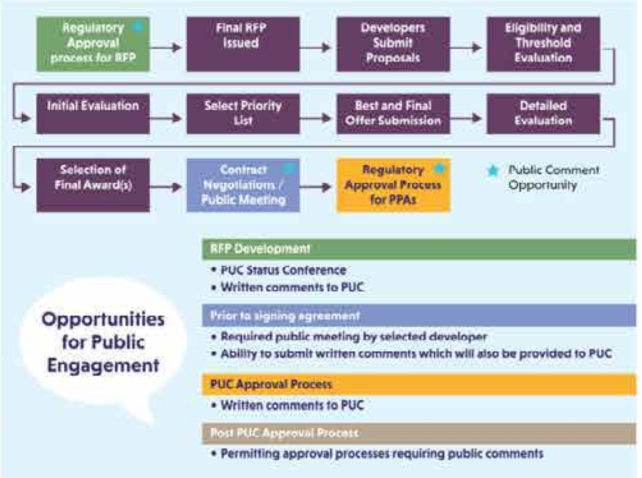
Click each of the three (3) images below to enlarge.



Project Selection Process

We have a process for selecting, evaluating, and contracting new renewable projects. Several parts of the process include opportunities for public engagement and input.

Click the image below to enlarge.

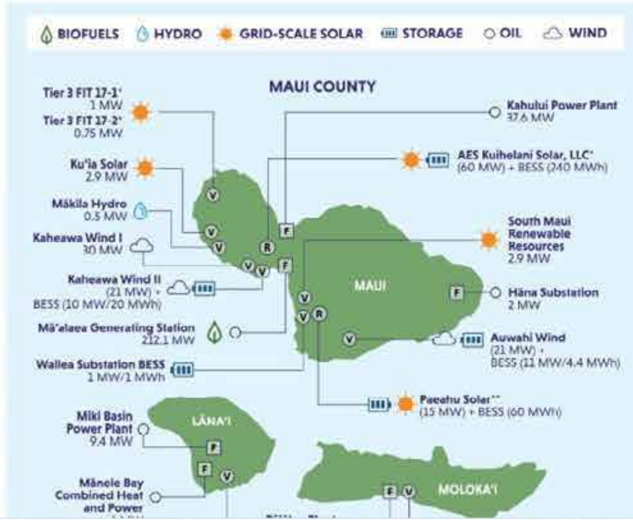


F FIRM GENERATION: Energy available on demand, which can be adjusted as needed.

V VARIABLE GENERATION: Energy that may not always be available or controllable.

R RENEWABLE DISPATCHABLE GENERATION

BESS: Battery Energy Storage System



	O'AHU	HAWAI'I ISLAND	MAUI
Stage 2 Renewable RFP	1,300,000 MWh + 200 MW Storage 50 MW Contingency Storage	70,000–444,000 MWh + 18 MW Contingency Storage	295,000 MWh + 40 MW Storage
Acres	3,000 (equivalent to 29 Aloha Stadiums)	160–1,000 (equivalent to 2–10 Aloha Stadiums)	700 (equivalent to 7 Aloha Stadiums)

Hawai'i has many factors which must be considered when selecting renewable projects

- Land Availability
- Endangered Species
- Community Interest
- Availability of Materials
- Resilience

Hawaiian Electric

- Welcome
- Integrated Grid Planning
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- Grid-Scale Renewables
- Rooftop Renewable Energy
- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Engagement

Hawaiian Electric Company, Inc

Integrated Grid Planning (IGP)

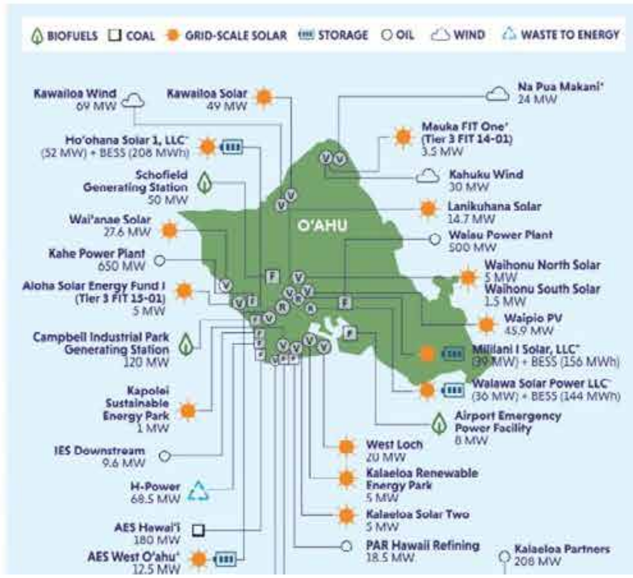
COMMENT

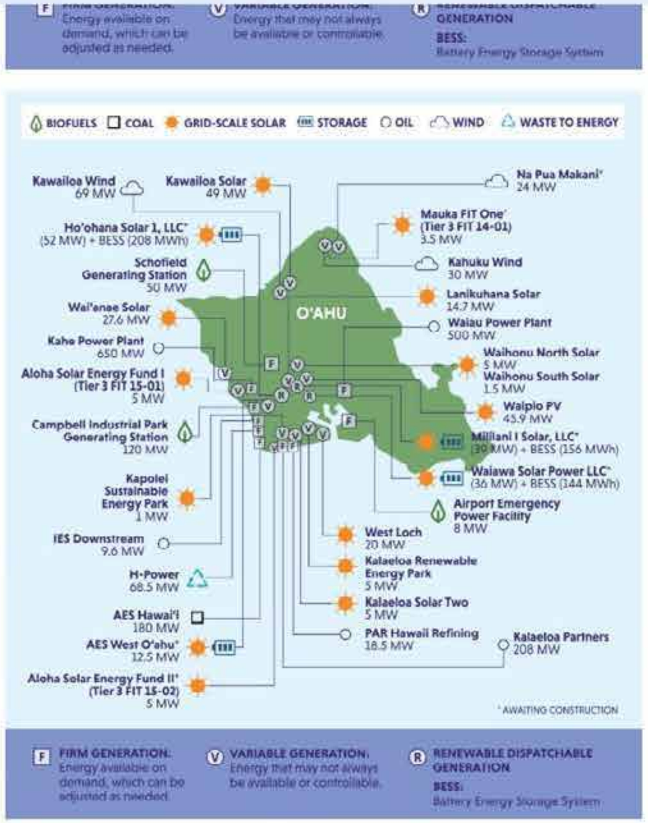
F FIRM GENERATION: Energy available on demand, which can be adjusted as needed.

V VARIABLE GENERATION: Energy that may not always be available or controllable.

R RENEWABLE DISPATCHABLE GENERATION

BESS: Battery Energy Storage System




BIOFUELS
COAL
GRID-SCALE SOLAR
STORAGE
OIL
WIND
WASTE TO ENERGY
O'AHU
Kawailoa Wind 69 MW
Kawailoa Solar 49 MW
Ho'ohana Solar 1, LLC* (52 MW) + BESS (208 MWh)
Schofield Generating Station 50 MW
Wai'anae Solar 27.6 MW
Kahe Power Plant 650 MW
Aloha Solar Energy Fund I (Tier 3 FIT 15-01) 5 MW
Campbell Industrial Park Generating Station 120 MW
Kapolei Sustainable Energy Park 1 MW
IES Downstream 9.6 MW
H-Power 68.5 MW
AES Hawai'i 180 MW
AES West O'ahu* 12.5 MW
Aloha Solar Energy Fund II* (Tier 3 FIT 15-02) 5 MW
Na Pua Makani* 24 MW
Mauka FIT One* (Tier 3 FIT 14-01) 3.5 MW
Kahuku Wind 30 MW
Lanikuhana Solar 14.7 MW
Waiau Power Plant 500 MW
Waihonu North Solar 5 MW
Waihonu South Solar 1.5 MW
Waipio PV 45.9 MW
Mililani I Solar, LLC* (30 MW) + BESS (156 MWh)
Waiawa Solar Power LLC* (36 MW) + BESS (144 MWh)
Airport Emergency Power Facility 8 MW
West Loch 20 MW
Kalaeloa Renewable Energy Park 5 MW
Kalaeloa Solar Two 5 MW
PAR Hawaii Refining 18.5 MW
Kalaeloa Partners 208 MW
* AWAITING CONSTRUCTION
F FIRM GENERATION: Energy available on demand, which can be adjusted as needed.
V VARIABLE GENERATION: Energy that may not always be available or controllable.
R RENEWABLE DISPATCHABLE GENERATION
BESS: Battery Energy Storage System

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» Grid-Scale Renewables
» Rooftop Renewable Energy
» Community-Based Renewable Energy
» Electrification of Transportation
» Resilience
» Engagement

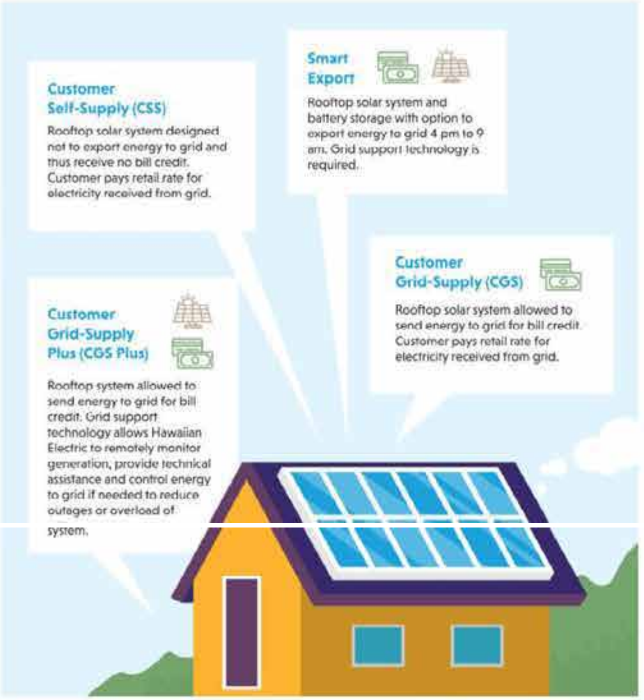
Rooftop Renewable Energy

For residential and small business customers who want to reduce their bills by installing solar systems that meet specific program requirements.

Rooftop Solar Options

These programs are the available options for new solar customers to install PV panels on their rooftops.

Click the image below to enlarge.

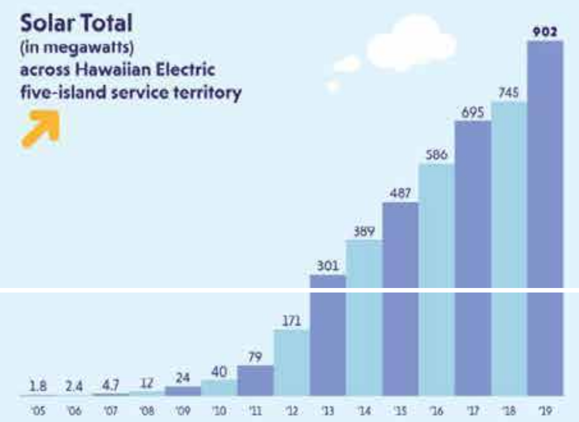


Installation Opportunities

Many customers have rooftop solar system on homes and businesses. And there are still opportunities to install rooftop solar on your residence or business to save money and help Hawai'i reach a clean energy future.

Click the image below to enlarge.

	Number of PV Systems			PV Capacity, MW		
	Number	% Residential	% Commercial	Capacity	% Residential	% Commercial
O'ahu	55,353	96%	4%	674	45%	55%
Hawai'i	13,410	94%	6%	103	66%	34%
Maui	13,020	92%	8%	125	57%	43%
Total	81,783			**902**		



Community-Based Renewable Energy

Community-Based Renewable Energy (CBRE), or community-solar, provides a way for participating subscribers without privately-owned rooftop solar to benefit from electricity generated by a renewable energy facility located in their community.

The Next Phase: 'Solar without a Roof'

Community solar is a hybrid: owned or leased by customers who don't or can't have solar, often because they are renters or live in apartment buildings, but sized and sited like a grid-scale solar facility.

Click the image below to enlarge.

Hawaiian Electric Company, Inc

Hawaiian Electric
Welcome
Integrated Grid Planning
Grid Modernization
Grid-Scale Renewables
Rooftop Renewable Energy
Community-Based Renewable Energy
Electrification of Transportation
Resilience
Engagement
Careers at Hawaiian Electric

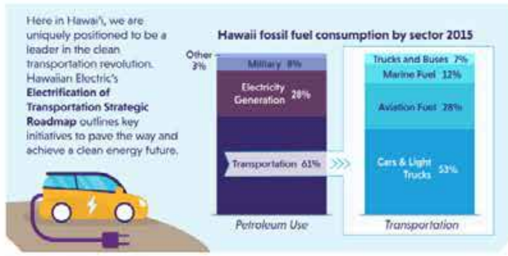
COMMENT

Electrification of Transportation

Electrification of Transportation (EoT) plays a key role in allowing us to integrate more renewable energy generation.

EoT Strategic Roadmap

Click the image below to enlarge.



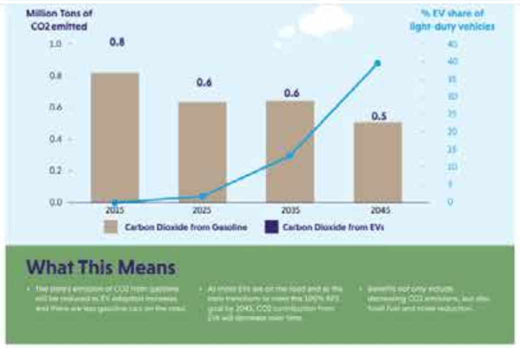
Emissions on Hawai'i

Click the image below to enlarge.

For Community and Customers

Click each of the two (2) images below to enlarge.

Welcome
Integrated Grid Planning
Grid Modernization
Grid-Scale Renewables
Rooftop Renewable Energy
Community-Based Renewable Energy
Electrification of Transportation
Resilience
Engagement
Careers at Hawaiian Electric

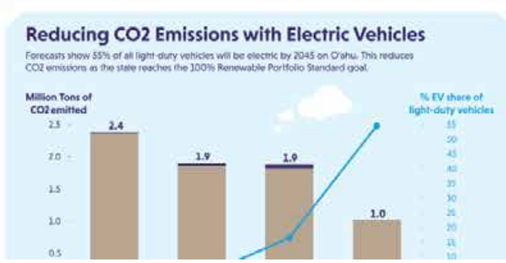


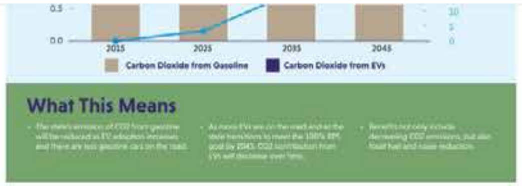
Learn More

EoT Strategic Roadmap

Emissions on O'ahu

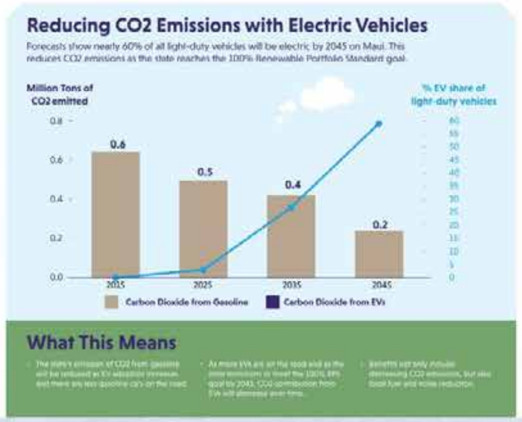
Click the image below to enlarge.





Emissions on Maui

Click the image below to enlarge.



Resilience

Making our grid more resilient with key planning elements.

Definition and Understanding

"Resilience is the ability of a system or its components to adapt to changing conditions and withstand and rapidly recover from disruptions."
—Public Utilities Commission Staff

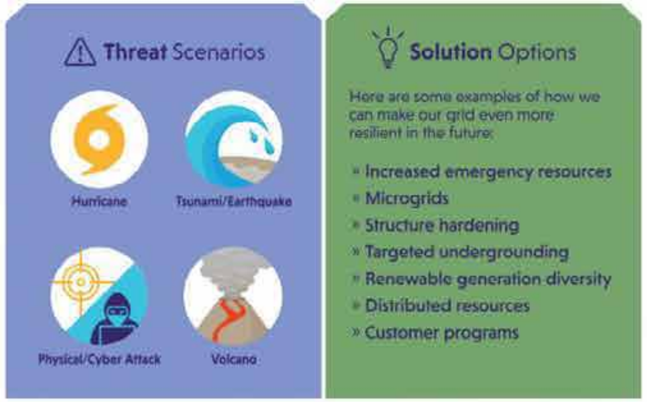
Click the image below to enlarge.

Learn More

Our Vision & Commitment

Resilience on Hawai'i

Click the image below to enlarge.



Resilience on other islands

Click the image below to enlarge.

» Resilience
» Engagement
» Careers at Hawaiian Electric

Hawaiian Electric

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- Grid-Scale Renewables
- Rooftop Renewable Energy
- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Engagement
- Careers at Hawaiian Electric

Integrated Grid Planning (IGP)

COMMENT

Engagement

We Want to Hear From You

We welcome your input! There are many ways to stay connected with us.

Email:
igp@hawaiianelectric.com

Website:
www.hawaiianelectric.com/igp

Social:
HawaiianElectric
hwnelectric
hawaiianelectric

Public Engagement Survey – 8 Questions

How did you hear about this meeting?

- Social media
- Newspaper
- Radio
- Flyer/banner
- IGP Website
- Word of Mouth
- Other

In the future, what type of Integrated Grid Planning information would you be most interested in receiving? (Select up to 3)

- General updates
- Input opportunities
- Advanced meters
- Grid modernization
- Renewables – Rooftop and Community Solar
- Renewables –Utility scale projects
- Electrification of Transportation
- Resilience
- Employment opportunities
- Incentive programs
- Other

What would be your preferred method to receive future information on Integrated Grid Planning? (Select up to 2)

- Social media
- IGP website
- Email
- Mail
- Newspaper
- Radio
- Other

- Welcome
- Integrated Grid Planning
- Grid Modernization
- Grid-Scale Renewables
- Rooftop Renewable Energy
- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Engagement
- Careers at Hawaiian Electric

Share any additional thoughts—we're listening!

The following demographics questions are optional.

Where is your home or business located?

- Hawai'i (Big Island)
- O'ahu
- Maui
- Moloka'i
- Lāna'i

Do you make the purchasing decisions for your home or business?

- Yes
- No

Do you rent or own the location of that home or business?

- Rent
- Own

What is your age?

- Under 18
- 18–24
- 25–34
- 35–44
- 45–54
- 55–64
- 65–74
- 75 and older

Submit Your Response

Contact Us
Privacy Policy
Terms of Use

javascript:setArrow(1);

- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Engagement

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Careers at Hawaiian Electric

Information and opportunities for joining the team.

Click each of the two (2) images below to enlarge.

Learn More

Hawaiian Electric Careers

Welcome

Welcome to our Virtual Open House

Thank you for your participation in our online engagement! The slides in this session are filled with information about our Integrated Grid Planning, renewables and careers at Hawaiian Electric. Please read the materials and submit your responses to each survey question to help shape our renewable energy future together.

In-Person Public Meetings

Thank you to everyone who attended one of our public engagement opportunities March 3–12, 2020 or our virtual open house.

General Information Survey – 2 Questions

These surveys are now closed. Thank you for your interest and participation.

Analytics All Sites
All Web Site Data (master ...

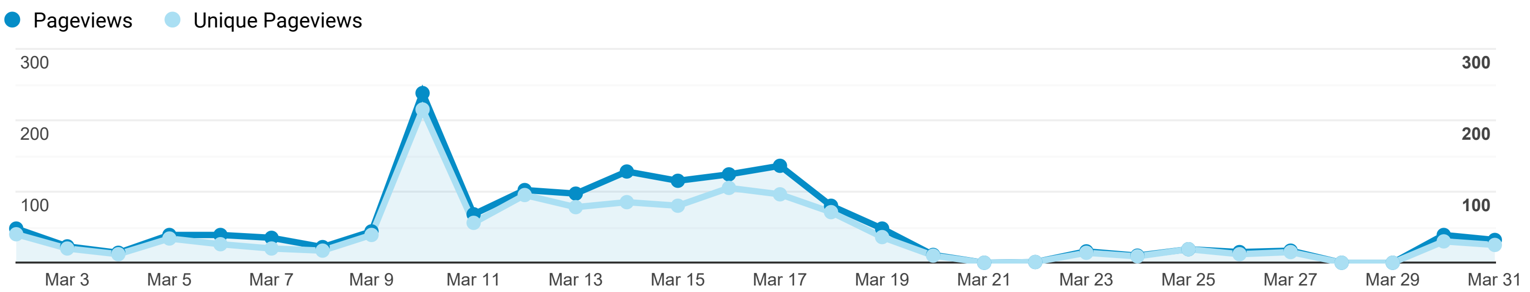
Go to report

igp.hawaiianelectric.com

All Users
0.29% Pageviews

Mar 2, 2020 - Mar 31, 2020

Report Tab



Source	Pageviews	Unique Pageviews
	1,560 % of Total: 0.29% (535,960)	1,260 % of Total: 0.29% (430,363)
1. (direct)	1,081 (69.29%)	835 (66.27%)
2. hawaiianelectric.com	115 (7.37%)	96 (7.62%)
3. m.facebook.com	67 (4.29%)	65 (5.16%)
4. ads-bidder-api.twitter.com	65 (4.17%)	53 (4.21%)
5. google	56 (3.59%)	50 (3.97%)
6. facebook.com	45 (2.88%)	45 (3.57%)
7. bing	15 (0.96%)	14 (1.11%)
8. hawaiielectriclight.com	15 (0.96%)	10 (0.79%)
9. clremail	13 (0.83%)	12 (0.95%)
10. infohana.net	13 (0.83%)	13 (1.03%)
11. igp.hawaiianelectric.com	12 (0.77%)	9 (0.71%)
12. media.hawaiianelectric.com	11 (0.71%)	11 (0.87%)
13. eservice.hawaiianelectric.com	10 (0.64%)	9 (0.71%)
14. instagram.com	9 (0.58%)	9 (0.71%)
15. ad-review-tool.twitter.biz	4 (0.26%)	3 (0.24%)
16. ads.google.com	4 (0.26%)	3 (0.24%)
17. l.facebook.com	4 (0.26%)	4 (0.32%)
18. zoho.hdrstratcomm.com	3 (0.19%)	3 (0.24%)
19. hestaging.ingeniuxondemand.com	2 (0.13%)	1 (0.08%)
20. kuleanasurvey.hawaiianelectric.com	2 (0.13%)	2 (0.16%)
21. mauielectric.com	2	2

		(0.13%)	(0.16%)
22.	page.report	**2** **(0.13%)**	1 (0.08%)
23.	qwant.com	**2** **(0.13%)**	2 (0.16%)
24.	cdnapisec.kaltura.com	**1** **(0.06%)**	1 (0.08%)
25.	ecosia.org	**1** **(0.06%)**	1 (0.08%)
26.	footprint.hawaiianelectric.com	**1** **(0.06%)**	1 (0.08%)
27.	j2dci.hawaiianelectric.net:53600	**1** **(0.06%)**	1 (0.08%)
28.	medium.com	**1** **(0.06%)**	1 (0.08%)
29.	pages.hawaiianelectric.com	**1** **(0.06%)**	1 (0.08%)
30.	sharepoint	**1** **(0.06%)**	1 (0.08%)
31.	t.co	**1** **(0.06%)**	1 (0.08%)

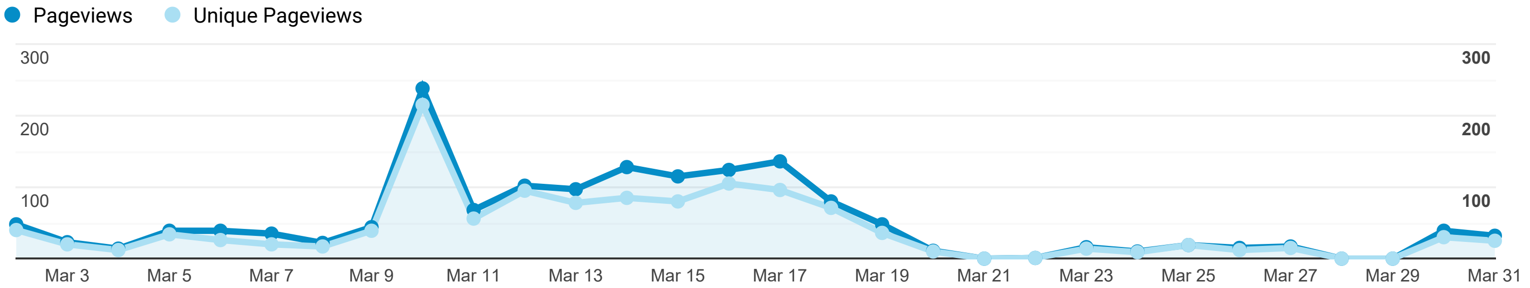
Rows 1 - 31 of 31

igp.hawaiianelectric.com

All Users
0.29% Pageviews

Mar 2, 2020 - Mar 31, 2020

Report Tab



Browser	Pageviews	Unique Pageviews
	1,560 % of Total: 0.29% (535,960)	1,260 % of Total: 0.29% (430,363)
1. Android Webview	476 (30.51%)	270 (21.43%)
2. Chrome	379 (24.29%)	317 (25.16%)
3. Safari (in-app)	261 (16.73%)	253 (20.08%)
4. Edge	162 (10.38%)	153 (12.14%)
5. Internet Explorer	133 (8.53%)	126 (10.00%)
6. Safari	126 (8.08%)	119 (9.44%)
7. Firefox	11 (0.71%)	11 (0.87%)
8. Samsung Internet	8 (0.51%)	7 (0.56%)
9. (not set)	2 (0.13%)	2 (0.16%)
10. Bluebeam Revu Browser - cef version: 57.0.0.0	1 (0.06%)	1 (0.08%)

Rows 1 - 10 of 11

Analytics All Sites

All Web Site Data (master ...

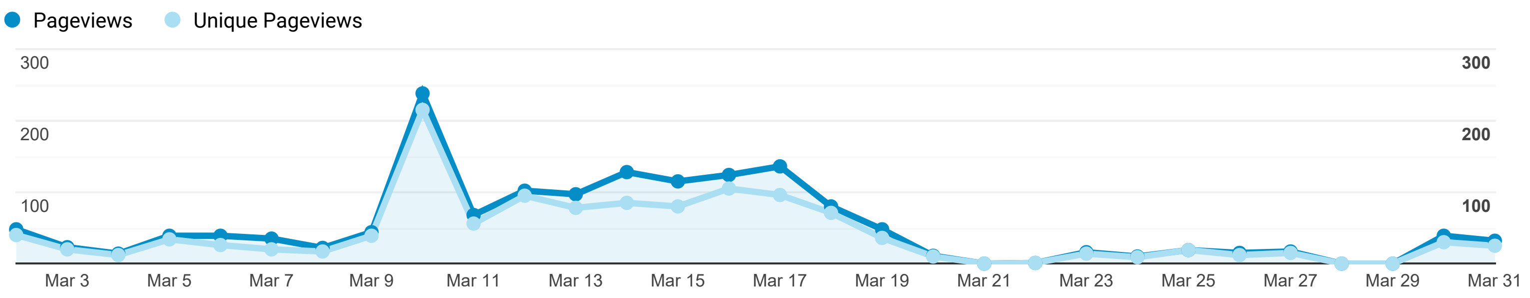
Go to report

igp.hawaiianelectric.com

All Users
0.29% Pageviews

Mar 2, 2020 - Mar 31, 2020

Report Tab



Date	Pageviews	Unique Pageviews
	1,560 % of Total: 0.29% (535,960)	1,260 % of Total: 0.29% (430,363)
1. **20200302**	48 (3.08%)	40 (3.17%)
2. **20200303**	23 (1.47%)	20 (1.59%)
3. **20200304**	14 (0.90%)	12 (0.95%)
4. **20200305**	39 (2.50%)	34 (2.70%)
5. **20200306**	39 (2.50%)	26 (2.06%)
6. **20200307**	35 (2.24%)	20 (1.59%)
7. **20200308**	22 (1.41%)	17 (1.35%)
8. **20200309**	44 (2.82%)	39 (3.10%)
9. **20200310**	238 (15.26%)	215 (17.06%)
10. **20200311**	68 (4.36%)	56 (4.44%)
11. **20200312**	102 (6.54%)	95 (7.54%)
12. **20200313**	97 (6.22%)	78 (6.19%)
13. **20200314**	128 (8.21%)	85 (6.75%)
14. **20200315**	115 (7.37%)	80 (6.35%)
15. **20200316**	124 (7.95%)	105 (8.33%)
16. **20200317**	136 (8.72%)	96 (7.62%)
17. **20200318**	80 (5.13%)	71 (5.63%)
18. **20200319**	48 (3.08%)	36 (2.86%)
19. **20200320**	11 (0.71%)	10 (0.79%)
20. **20200322**	1 (0.06%)	1 (0.08%)
21. **20200323**	16	14

	(1.03%)	(1.11%)
22. **20200324**	10 (0.64%)	9 (0.71%)
23. **20200325**	19 (1.22%)	19 (1.51%)
24. **20200326**	15 (0.96%)	12 (0.95%)
25. **20200327**	17 (1.09%)	15 (1.19%)
26. **20200330**	39 (2.50%)	30 (2.38%)
27. **20200331**	32 (2.05%)	25 (1.98%)

Rows 1 - 27 of 27

Analytics All Sites
All Web Site Data (master ...

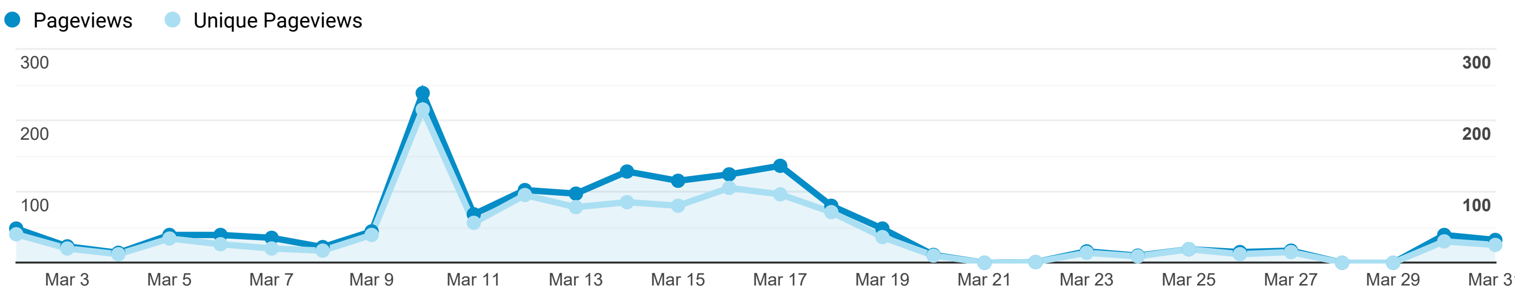
Go to report

igp.hawaiianelectric.com

All Users
0.29% Pageviews

Mar 2, 2020 - Mar 31, 2020

Report Tab



Device Category	Pageviews	Unique Pageviews
	1,560 % of Total: 0.29% (535,960)	1,260 % of Total: 0.29% (430,363)
1. mobile	822 (52.69%)	612 (48.57%)
2. desktop	659 (42.24%)	587 (46.59%)
3. tablet	79 (5.06%)	61 (4.84%)

Rows 1 - 3 of 3

Hawaiian Electric

Integrated Grid Planning

Listening + Integrating + Collaborating to Reach 100% Renewables by 2045

Broad Public Engagement Summary

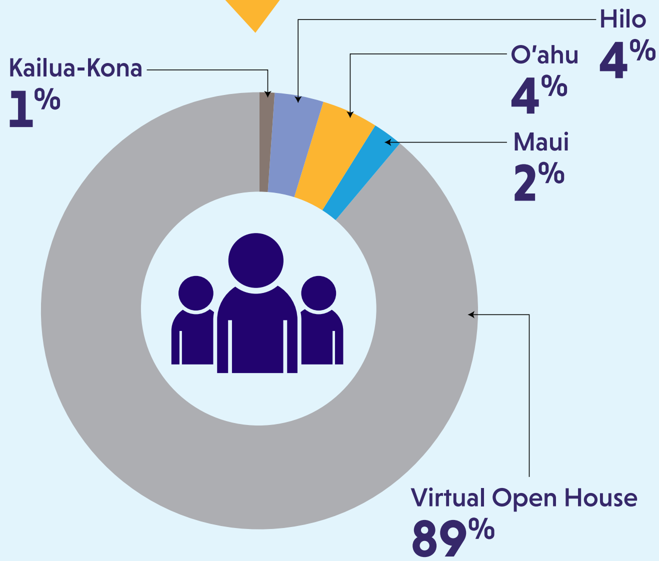
Engagement Goal:

Connect with the public by providing a general overview of the Integrated Grid Plan and gather their input on various topics.

1,421 total connections within the following groups

IGP is about being part of the conversation to shape our renewable energy future together

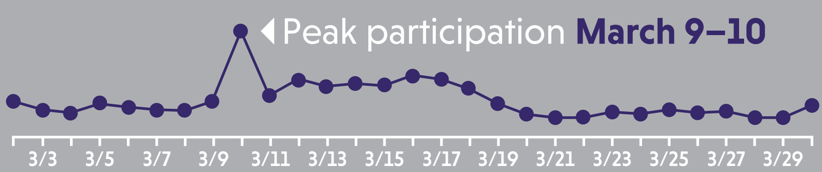
17 Participants	**Kealakehe High School** Kailua-Kona, Hawai'i 03.03.2020
52 Participants	**Hilo High School** Hilo, Hawai'i 03.05.2020
61 Participants	**Hawaii Pacific University** Honolulu, O'ahu 03.10.2020
31 Participants	**Hawaiian Electric** Kahului, Maui 03.12.2020



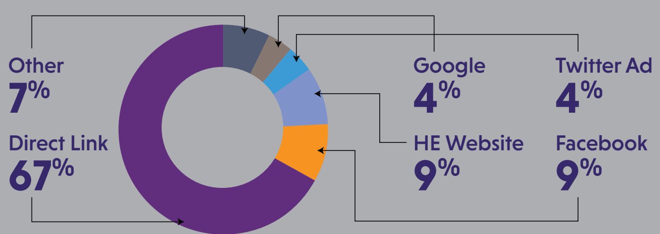
Virtual Open House = 1,260 unique visitors

Mar 02 – Mar 30*

*date extended due to COVID-19

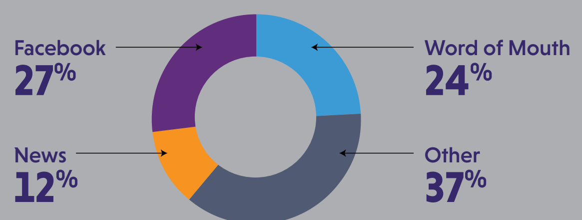


How did people access the Virtual Open House?



How did people hear about the meeting?*

*Not all participants responded to this question



Stations

The public meetings featured several stations staffed by Hawaiian Electric representatives who provided information and answered questions on various aspects of IGP and other customer energy options, including:

- Integrated Grid Planning
- Grid Modernization
- Grid-scale Renewables
- Rooftop Renewable Energy
- Community-Based Renewable Energy
- Electrification of Transportation
- Resilience
- Careers at Hawaiian Electric

What we learned from participants

The following data represents survey and comment input from participants through our in-person and online engagement.

What is most important?

- Reducing greenhouse gases
- Lowering energy costs

Least important?

- Helping to increase use of renewable energy
- Energy reliability
- New technologies to provide more information and control over energy usage

What are you doing or can you do to help?

- Own and drive an electric vehicle
- Switch to solar
- Use energy-efficient appliances

Most common survey responses regarding interest level of the following topics:

Rooftop solar installation: Most have interest and/or already have solar installed, or waiting for installation.

Advanced meter installation: Most have interest but need more information.

Battery storage installation: Most have interest but need more information.

Buying an electric vehicle: Many have interest and/or already own an EV and many indicated they are waiting to purchase.

Regularly using transit or carpooling: Most indicated no interest.

Hot water or grid-interactive water heater installation: Many indicated interest but need more information.

Panel Discussions

The public meetings included a panel discussion with local representatives from various organizations sharing different perspectives on getting to 100% renewables.

127 comments/questions received at in-person meetings

Key discussion topics:

- Role of transportation in energy goals
- Resilience and domestic security
- Renewable and energy-efficient programs
- Connections with smaller communities
- Community solar program
- Energy cost calculations

Kona and Hilo Panelists

- **Community** | Carol Ignacio
- **County of Hawai'i** | Riley Saito, Deputy Director, Research & Development
- **Geometrician Associates** | Ron Terry, Principal
- **Hawaiian Electric** | Colton Ching, Senior Vice President, Planning & Technology
- **Hawaiian Electric** | Kevin Waltjen, Director, Hawai'i Island
- **Hawaiian Electric** | Lisa Dangelmaier, Director, System Operations, Hawai'i & Maui

Honolulu Panelists

- **Community** | Cynthia Rezentes, Nanakuli Neighborhood Board Chair
- **City & County of Honolulu** | Josh Stanbro, Chief Resilience Officer & Executive Director, Office of Climate Change, Sustainability & Resiliency
- **Hawai'i Farm Bureau** | Brian Miyamoto, Executive Director
- **Hawaiian Electric** | Colton Ching, Sr. Vice President, Planning & Technology
- **O'ahu Economic Development Board** | Pono Shim, President & CEO
- **Ulupono Initiative** | Murray Clay, President

Maui Panelists

- **Alliance for Maui Community Associations** | Dick Mayer, Coordinator
- **County of Maui** | Michele McLean, Director, Department of Planning
- **Hawaiian Electric** | Colton Ching, Sr. Vice President, Planning & Technology
- **Hawaiian Electric** | Rebecca Dayhuff Matsushima, Director, Renewable Acquisition
- **Waiwai Ola Waterkeepers Hawaiian Islands** | Rhiannon Chandler-'Iao, Executive Director

1.5 Plugged In

A blog called *Plugged In*, with monthly posts about Integrated Grid Planning milestones, features on customers and Hawaiian Electric team members, and "deeper dives" on technical subjects. A total of 12 blog posts have been posted and are available to read on Hawai'i Powered.

Posting Date	Link	Views (as of 3/1/2023)	Reads (as of 3/1/2023)
March 11, 2022	Announcing Hawaii Powered	124	47
March 11, 2022	Shared Solar 101	93	34
April 18, 2022	Aloha from Hawaiian Electric!	63	25
April 19, 2022	What You Need to Know: 2021-2022 Sustainability Report	43	13
May 31, 2022	Non-wires alternatives	31	10
June 1, 2022	Energy Efficiency: The power to change is in our hands	59	15
July 5, 2022	Molokai residents receive kits to help save energy at home	41	12
July 6, 2022	Distributed Energy Resources: A diverse grid is a strong grid	70	21
August 1, 2022	Building Resilience in North Kohala: A collaborative approach to strengthen our communities	57	24
August 2, 2022	Electrification of Transportation: Driving toward a renewable future	84	26
September 6, 2022	Inputs and Assumptions: What does the data really mean?	61	23
November 28, 2022	Renewable Energy Zone (REZ) Maps: You know your community best	45	14

1.6 Newsletters

Monthly Hawaiʻi Powered e-newsletters sharing Integrated Grid Planning updates and blog post links with all project subscribers. A total of 8 e-newsletters have been released and are available to read on Hawaiʻi Powered.

- March 17, 2022
- April 21, 2022
- June 2, 2022
- July 12, 2022
- August 4, 2022
- September 12, 2022
- November 29, 2022
- February 28, 2023

Hawai'i Powered

Clean energy for Hawai'i, by Hawai'i

Aloha friends!

We know life has been unpredictable lately, and we hope this message finds you well. Mahalo for your involvement since our integrated grid planning process began in 2019. In this newsletter, we're sharing updates on our work to reach net zero carbon emissions and power the grid with 100% local, clean energy by 2045. We call this vision "Hawaii Powered," as it's about finding solutions for a clean energy future right here on the islands

Clean energy for Hawaii, by Hawaii:

- Helps achieve state energy independence
- Expands customer energy choices and stabilizes costs
- Supports statewide efforts to reduce carbon emissions

What's the latest?

- **Visit our new public participation site at hawaiipowered.com!**
  We're excited to announce a new online hub for community members to learn about and get involved in planning for a clean energy future. We invite you to explore the site's blog, community survey, information about renewable resources and answers to frequently asked questions. We'll continue to update the site in the coming months, so stay tuned for more interactive tools and opportunities to share your thoughts. Visit the site
- **Aligning grid planning with Hawaiian Electric's Climate Action Plan**
  Last fall, Hawaiian Electric announced a bold Climate Change Action Plan centered on reducing carbon emissions by 70% by 2030 compared to 2005 levels and reaching net zero carbon emissions by 2045. We are working to align our clean energy planning with these broader carbon goals.
  Learn more

Plugged In – Hawaii Powered News & Updates

One feature of our new public participation site is "Plugged In," a blog that provides a deeper dive on topics related to clean energy, spotlights community stories and brings new voices to the forefront of the energy conversation. Check our latest posts, below.

Announcing Hawaii Powered

Hawaiian Electric employees at a solar panel site in Waianae.

- Learn about the meaning behind "Hawaii Powered," its connection to integrated grid planning and what community members can expect to find on our new public participation site.

  Read about Hawaii Powered

Shared Solar 101

Shared solar project on a business in Kahului, Maui. This 28-kilowatt project came online in 2021.

- Shared solar—also known as community-based renewable energy (CBRE). This program makes it possible for more customers to benefit from clean energy generation in their neighborhoods. But what exactly is shared solar? How do community members participate? And what is Hawaiian Electric doing to encourage more of it?

  Get answers to frequently asked questions about shared solar

We welcome your feedback on blog posts!
Is there a topic you'd like to hear more about? Have a perspective you'd like to share? Let us know by emailing the team.

Connect with our team

- Take our short survey. Help us better understand you and your energy needs.
- Request a presentation for your organization. Invite us to give a short presentation and answer questions at your next community meeting or event.
- **Email the Hawaii Powered team:** IGP@hawaiianelectric.com
- **Share this newsletter with your friends and family!**

Mahalo for helping us move toward a more equitable, clean energy future!

Hawaiian Electric

Hawai'i Powered

Clean energy for Hawai'i, by Hawai'i

Happy Spring!

This is a monthly newsletter from the Hawaii Powered team, where we update you on our work to move toward a clean energy future and the ways you can stay involved. Thank you for engaging with us!

What's the latest?

- **Visit our new online participation site!**
  We invite you to explore our online hub for the latest information on our grid planning. This page includes a new blog, community surveys and answers to frequently asked questions. We'll continue to update this page in the coming months, so stay tuned for more interactive tools and opportunities to share your thoughts. Visit the site
- **Check out new Inputs and Assumptions documents in the Hawaii Powered library.**
  We developed scenarios to learn how energy needs will change based on the number of electric vehicles, energy efficiency measures, rooftop solar projects, available land and future technology costs. Read the report online and stay tuned for more resources that will help make this technical topic easier to understand. Explore new Inputs and Assumptions documents

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Plugged In – Hawaii Powered News & Updates

One feature of our new public participation site is "Plugged In," a blog that provides a deeper dive on topics related to clean energy, spotlights community stories and brings new voices to the forefront of the energy conversation. Check our latest posts, below.

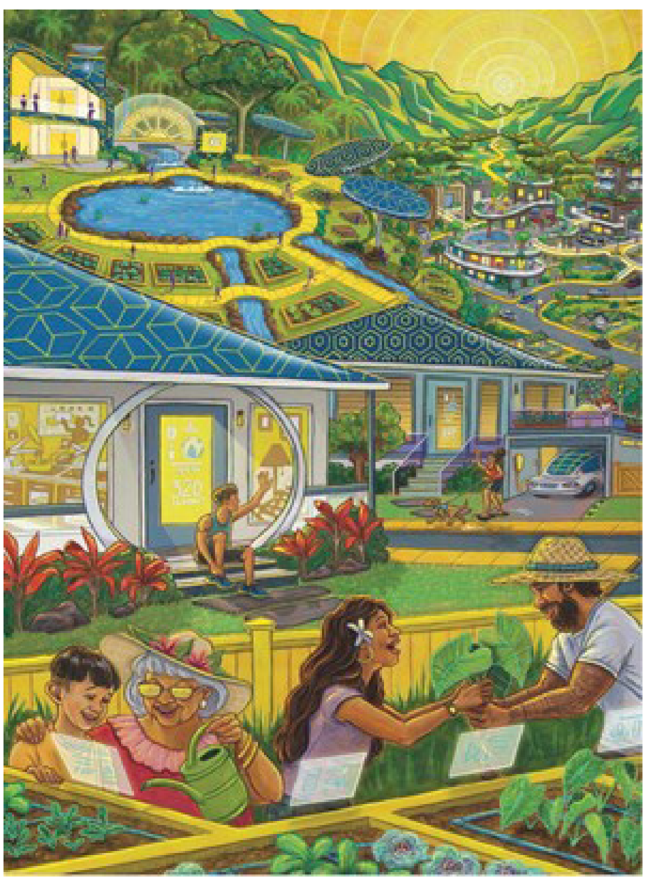
Meet Colton Ching

Colton Ching, Senior Vice President of Planning and Technology

- Meet Colton Ching, who leads Hawaiian Electric's efforts to power the grid with 100% renewables by 2045. Colton's upbringing on Maui and involvement in his communities informs his approach to a Hawaii Powered future.

  Learn more about Colton and his work at Hawaiian Electric

What You Need to Know: 2021—2022 Sustainability Report



Revitalizing Communities with Streams and Sunlight by Kate Wadsworth

Check out more artwork in Hawaii of Tomorrow, which envisions resourceful, sustainable islands that adapt to the challenges of the coming decades, especially climate change.

- In April 2022, Hawaiian Electric published their annual Sustainability Report. This report breaks down our progress, challenges and plans for moving toward a sustainable future. Don't have time to read the whole thing? No problem! We've provided the highlights for you in our latest blog post.

  Get the highlights of the 2021-2022 Sustainability Report.
  Read the full 2021-2022 Sustainability Report.

We welcome your feedback on blog posts!
Is there a topic you'd like to hear more about? Have a perspective you'd like to share? Let us know by emailing the team.

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- **Share this newsletter with your friends and family!**

Thank you for continuing to move us toward a more equitable, clean energy future. Mahalo!

Hawaiian Electric

Hawai'i Powered

Clean energy for Hawai'i, by Hawai'i

Happy Pride Month! We hope you have a wonderful month of June!

This is a monthly newsletter from the Hawaii Powered team, where we update you on our work to move toward a clean energy future and the ways you can stay involved. Thank you for engaging with us!

What's the latest?

- **Visit our online participation site for island-specific updates!** Want to know what's happening on your island? We've added island-specific updates to our participation site so you can keep a pulse on developments in your local community. ***Visit updates by island*** - While you're there, explore our online hub for the latest information on grid planning. This page includes a blog, community surveys and answers to frequently asked questions. We'll continue to update this page in the coming months, so stay tuned for more interactive tools and opportunities to share your thoughts. ***Visit the site***

Plugged In – Hawaii Powered News & Updates

The Hawaii Powered blog, *Plugged In*, provides viewers with a deeper dive on topics related to clean energy, explains technical concepts, spotlights community stories and brings new voices to the forefront of the energy conversation. Check our latest posts, below.

What are non-wires alternatives?

Solar panels on a resident rooftop

Typically, moving electricity involves a complicated network of poles, wires and substations. New energy technologies are providing additional options. Learn about the benefits of non-wires alternatives (NWAs) and what that means for you as a customer.

- *Learn more about Non-Wires Alternatives*.
- *Read the Expressions of Interest for Non-Wires Alternative Grid-Scale*.

Energy efficiency: The power to change is in our hands

Four young adults think about the future of our environment

Energy efficiency is about reducing the overall amount of electricity we consume, especially during the evening peak from 5 to 9 p.m. Reducing our energy use - especially during times of high demand – helps stabilize customer bills, reduce the risk of outages and lower greenhouse gas emissions.

- *Learn how you can become more energy efficient*.
- *Visit our Power to Change site*.

We welcome your feedback on blog posts!
Is there a topic you'd like to hear more about? Have a perspective you'd like to share? Let us know by emailing the team.

Connect with our team

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- **Share this newsletter with your friends and family!**

Thank you for continuing to move us toward a more equitable, clean energy future. Mahalo!

Hawaiian Electric

Hawai‘i Powered

Clean energy for Hawai‘i, by Hawai‘i

Aloha! We hope you’re having a wonderful summer!

This is a monthly newsletter from the Hawaii Powered team, where we update you on our work to move toward a clean energy future and the ways you can stay involved. Thank you for engaging with us!

What’s the latest?

Next Step to Renewable Energy Projects Discussions: To replace fossil-fuel generation, we have submitted a draft request for proposals (RFP) for potentially a broad array of renewable energy projects. Join us as we share, and address community input received on the draft RFP. Participants are encouraged to ask questions and provide feedback during the meeting. These events will be recorded.

- The Oahu meeting will be held from 5:30 to 7 p.m. on Tuesday, July 12
- The Maui meeting will be held from 5:30 to 7 p.m. on Thursday, July 14
- View previously recorded meetings here

Visit our online participation site for island-specific updates! Explore our online hub for the latest information on grid planning. This page includes a blog, community surveys and answers to frequently asked questions. We’ll continue to update this page in the coming months, so stay tuned for more interactive tools and opportunities to share your thoughts. Visit the online participation site

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Plugged In – Hawaii Powered News & Updates

The Hawaii Powered blog, Plugged In, provides viewers with a deeper dive on topics related to clean energy, explains technical concepts, spotlights community stories and brings new voices to the forefront of the energy conversation. Check our latest posts, below.

Energy Saving Kits on Molokai

A volunteer handing out energy-saving kits to Molokai residents

These were just some of the several hundred Molokai residents who came to drive-through events hosted by Hawaiian Electric, in partnership with Hawaii Energy and the County of Maui Department of Water Supply.

Learn more about our event on Molokai.

Distributed Energy Resources: A diverse grid is a strong grid

Aerial photo of downtown Honolulu

Distributed energy resources, also referred to as DER, is about diversifying energy generation to include smaller generators located throughout the energy grid, such as private rooftop solar systems on customers’ homes and businesses.

Learn about the impacts of DER and what it means for you as a customer.

We welcome your feedback on blog posts!
Is there a topic you’d like to hear more about? Have a perspective you’d like to share? Let us know by emailing the team.

Connect with our team

- Take our short survey. Help us better understand you and your energy needs.
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Thank you for continuing to move us toward a more equitable, clean energy future. Mahalo!

Hawai'i Powered

Clean energy for Hawai'i, by Hawai'i

Aloha again! We hope you're having a great summer!

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The Hawaii Powered blog, *Plugged In*, provides viewers with a deeper dive on topics related to clean energy, explains technical concepts, spotlights community stories and brings new voices to the forefront of the energy conversation. Check our latest posts, below.

Building Resilience in North Kohala: A collaborative approach to strengthen our communities

Community forum in North Kohala

Communities have a vital role as we work together to shape our energy future and build a strong Hawaii. One example is the collaboration between Hawaiian Electric and the North Kohala community to build resilience and improve reliability in the area.

Learn more about the work being done in North Kohala.

Electrification of Transportation: Driving toward a renewable future

Electric car driving along Sandy Beach on Oahu

Getting more folks out of their gas-burning cars and into electric vehicles will go a long way toward helping Hawaii meet its decarbonization goals.

Learn more about electric transportation and what it means for you as a customer.

We welcome your feedback on blog posts!
Is there a topic you'd like to hear more about? Have a perspective you'd like to share? Let us know by emailing the team.

Connect with our team

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Thank you for continuing to help us build a more equitable, clean energy future.

Mahalo!

Hawaiian Electric

Hawai'i Powered

Clean energy for Hawai'i, by Hawai'i

Aloha!

This is a newsletter from the Hawaii Powered team with an update on our work to move toward a clean energy future. Mahalo for engaging with us!

Announcing the new Inputs and Assumptions Data Dashboard!

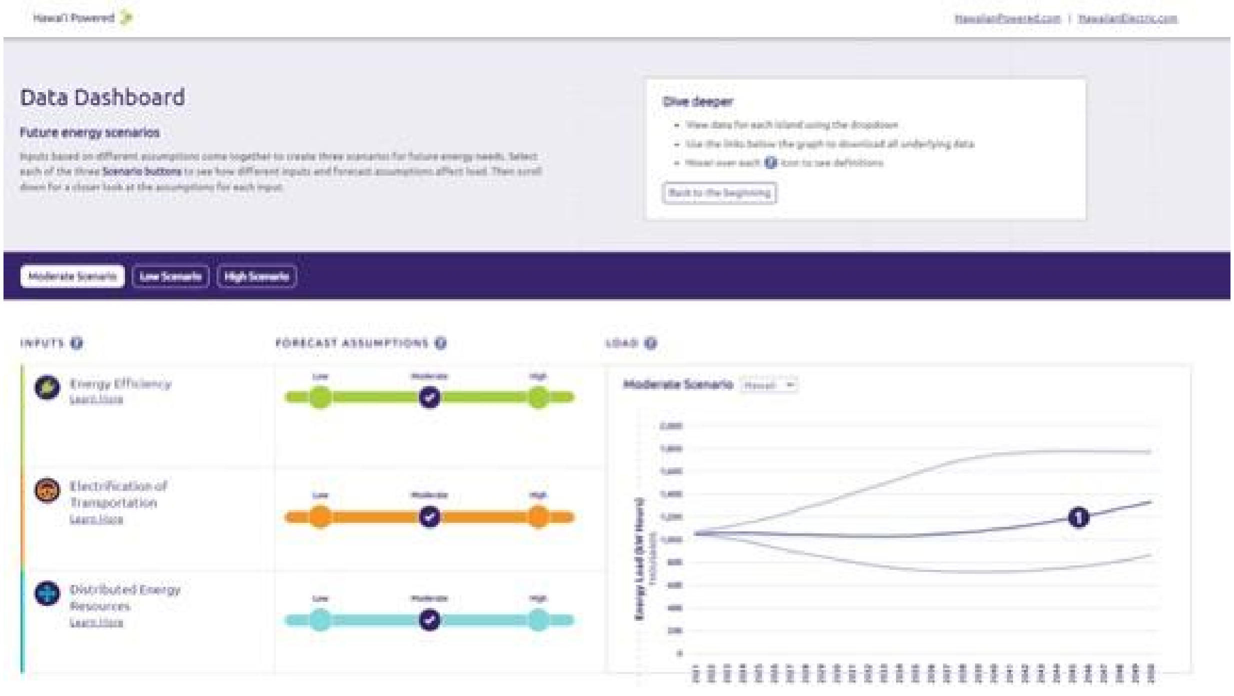
Forecasting the future of energy takes a lot of complicated data, which is why we're breaking down what it means for customers. We hope this tool helps explain how we leverage data to plan for how much clean energy we'll need to generate to meet future customer demand.

[Visit the Inputs and Assumptions Data Dashboard]

Read more about Inputs and Assumptions on *Plugged In*!

The Hawaii Powered blog, *Plugged In*, provides a deeper dive on topics related to clean energy, explains technical concepts, spotlights community stories and brings new voices to the forefront of the energy conversation.

Inputs and Assumptions: What does the data really mean?



Despite the highly technical nature of inputs and assumptions, it's crucial to share data and explain how we're planning to achieve a Hawaii Powered future.

[Learn more about customer impact].

Check out other blog posts related to Inputs and Assumptions!

Energy Efficiency: The power to change is in our hands

[Learn how you can become more energy efficient.]

Electrification of Transportation: Driving toward a renewable future

[Learn more about electric transportation and what it means for you as a customer].

Distributed Energy Resources: A diverse grid is a strong grid

[Learn about the impacts of DER and what it means for you as a customer].

We welcome your feedback on blog posts!

Is there a topic you'd like to hear more about? Have a perspective you'd like to share? Let us know by [emailing the team].

Connect with our team

- [Take our short survey]. Help us better understand you and your energy needs.
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Mahalo!

Hawaiian Electric

Hawaiʻi Powered

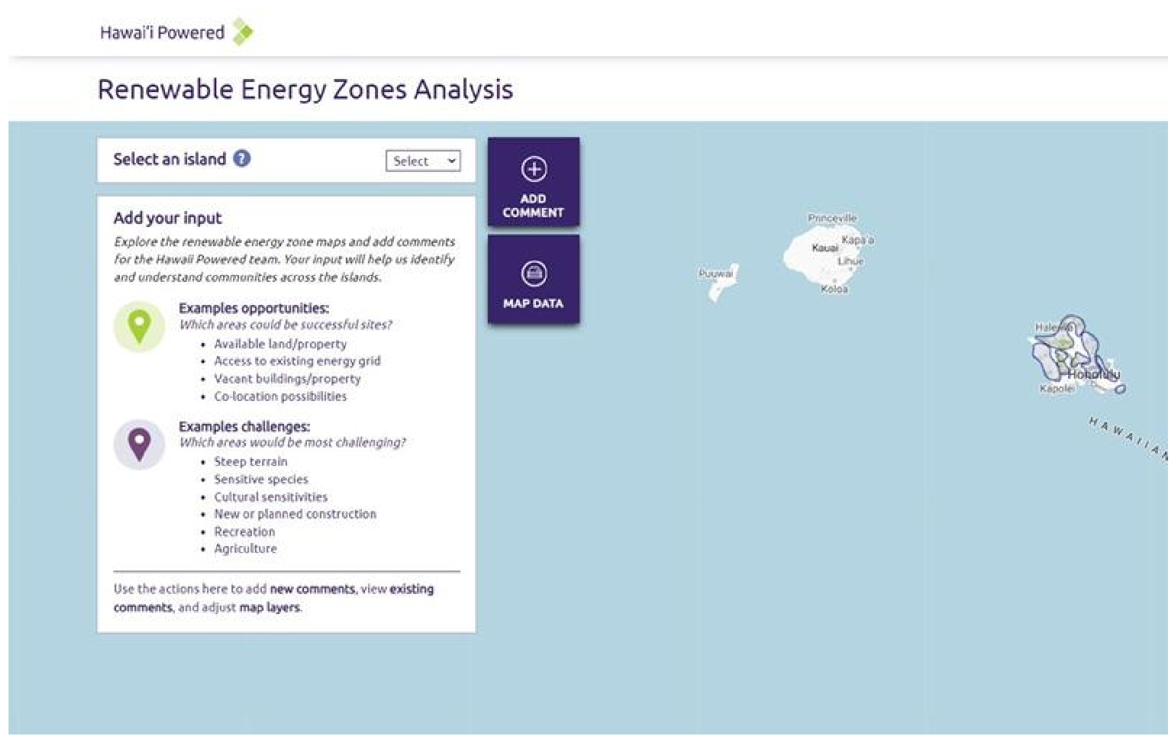
Clean energy for Hawaiʻi, by Hawaiʻi

Aloha!

This is a newsletter from the Hawaii Powered team with an update on our work to move toward a clean energy future. Mahalo for engaging with us!

You know your community best, and we're looking for your insights!

To power the grid with 100% renewables by 2045, Hawaiian Electric and the National Renewable Energy Laboratory conducted a study to identify potential areas that could best host renewable energy projects. These areas are known as Renewable Energy Zones (REZ) and vary by geography, ecology, community needs and access to the energy grid. We need your partnership to deepen our understanding of opportunities and challenges within these zones.

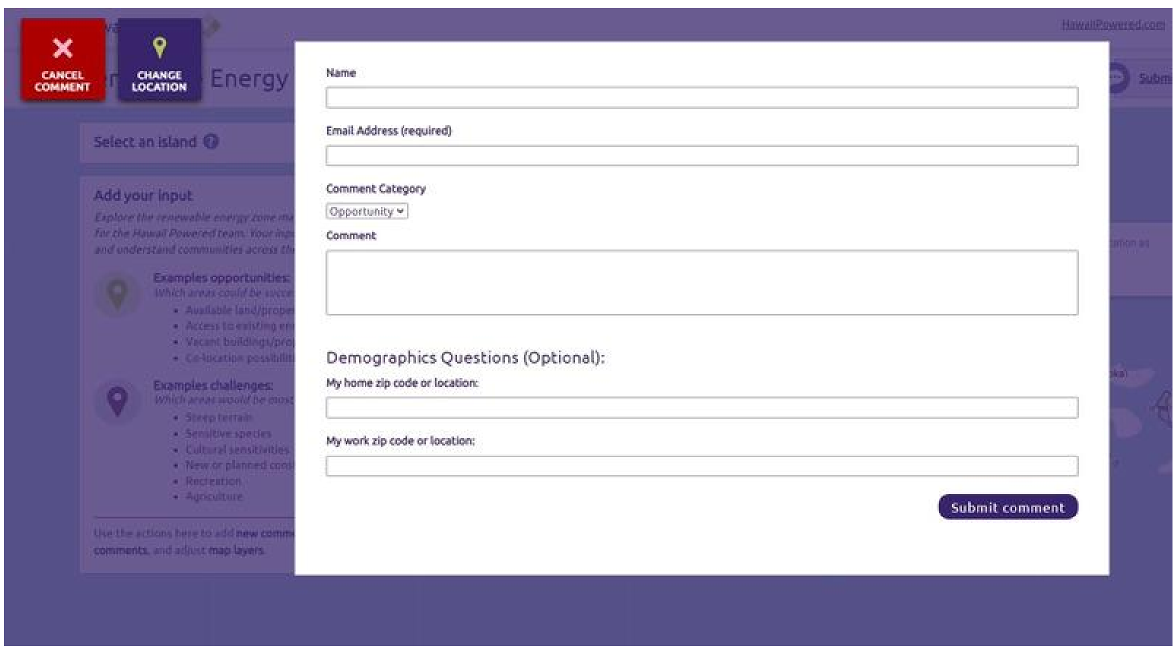


[Visit the site and share your input]

Read more about Renewable Energy Zones on *Plugged In*!

The Hawaii Powered blog, *Plugged In*, provides a deeper dive on topics related to clean energy, explains technical concepts, spotlights community stories and brings new voices to the forefront of the energy conversation.

Renewable Energy Zone (REZ) Maps: You know your community best



[Learn how REZ was developed, what kind of community input we're seeking and answers to frequently asked questions].

We welcome your feedback on blog posts!
Is there a topic you'd like to hear more about? Have a perspective you'd like to share? Let us know by [emailing our team].

Connect with our team

- [Take our short survey]. Help us better understand you and your energy needs.
- [Request a presentation for your organization]. Invite us to give a short presentation and answer questions at your next community meeting or event.
- **Email the Hawaii Powered team:** IGP@hawaiianelectric.com
- **Share this newsletter with your friends and family!**

Thank you for continuing to move us toward a more equitable, clean energy future.

Mahalo!

Hawaiian Electric

View this email in your browser

Hawaiʻi Powered

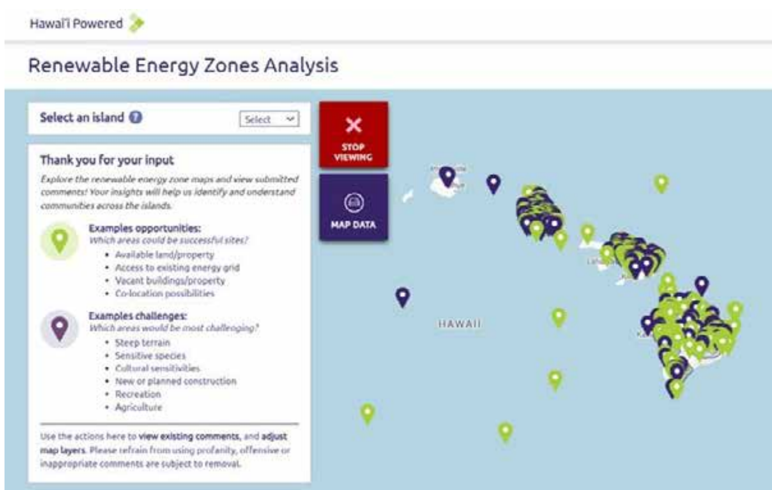
Clean energy for Hawaiʻi, by Hawaiʻi

Aloha,

This is a newsletter from the Hawaiʻi Powered team with an update on our work to move toward a clean energy future. Mahalo!

Over the past several months, we asked you and your community to identify opportunities and challenges for grid-scale renewable energy projects on Oʻahu, Maui, and Hawaiʻi Island. Thanks to your engagement, we received **over 500 comments!** View them now.

Hawaiian Electric and the National Renewable Energy Laboratory (NREL) conducted a study to identify potential areas that could best host renewable energy projects. These areas are known as Renewable Energy Zones (REZ) and vary by geography, ecology, community needs and access to the energy grid. We will use the technical data from the study, as well as your input, to reach our goal of powering the grid with 100% renewables by 2045.



View REZ comments

More ways to stay involved

- Read our blog, Plugged In, for a deep dive on Hawaiʻi Powered related efforts
- Take a short survey on Hawaiʻi Powered
- Request a presentation about Hawaiʻi Powered for your organization
- **Email the Hawaiʻi Powered team:** IGP@hawaiianelectric.com
- **Share this newsletter with your friends and family!**

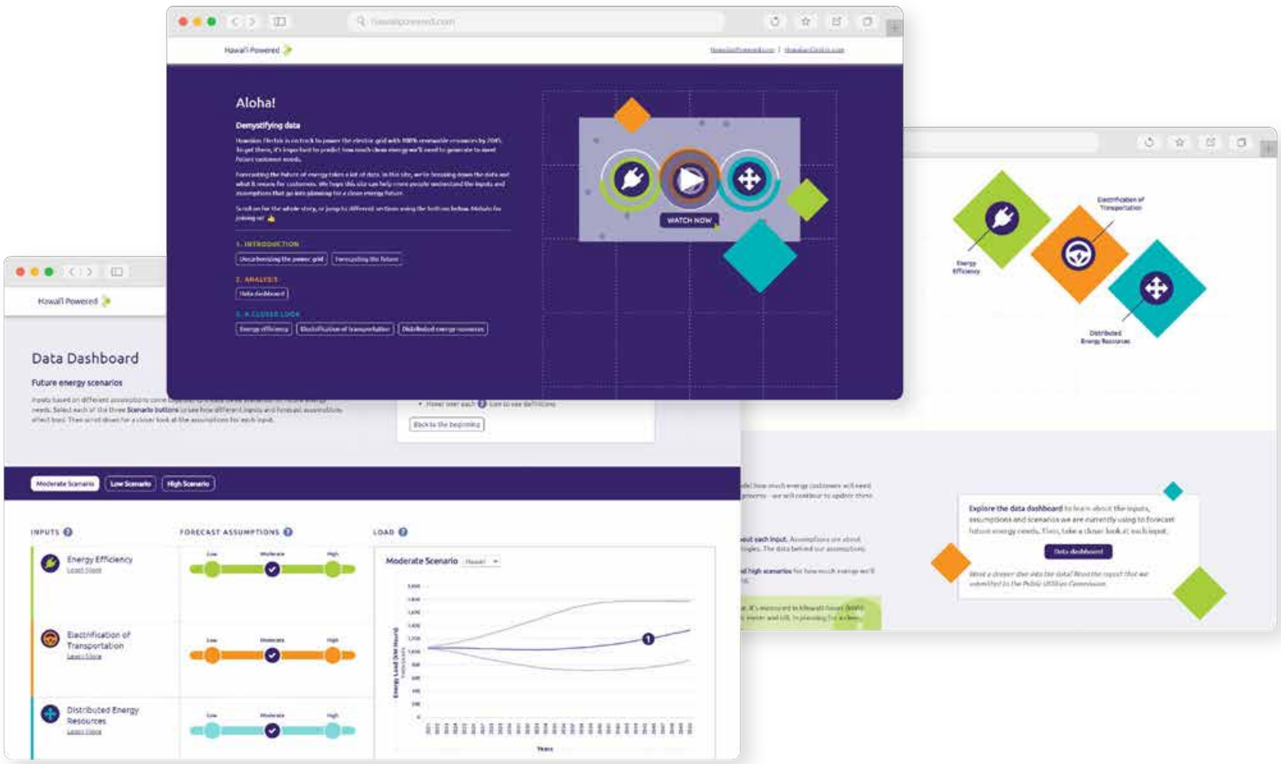
Thank you for continuing to move us toward a more equitable, clean energy future.

Mahalo!

Hawaiian Electric

1.7 Inputs & Assumptions

The inputs and assumptions data dashboard (hawaiipowered.com/iadashboard), provides interactive learning modules and graphs tied to the data sets we used to model future energy scenarios.



1.8 Activity Book

Hawaiʻi Powered activity book with energy exercises, power-up puzzles, creative coloring, and more for learners of all ages. We distributed this activity book at community events on Hawaiʻi Island, Oʻahu, and Maui. Parents and teachers could also download the activity book at Hawaiʻi Powered.

Aloha!
ACTIVITY BOOK

Kid-friendly pages for learners of all ages

Energy exercises,
power-up puzzles,
creative coloring
and more!

From the local energy experts at:

Hawaiian Electric

Word Search

Hawaiian Electric

Locate all 15 of the words below in this grid.

Words are hidden horizontally, vertically or diagonally.

P	P	G	U	I	C	H	R	T	L	G	W	B	I	O	M	A	S	S	U
H	A	W	A	I	I	P	O	W	E	R	E	D	V	X	D	W	I	M	I
L	M	H	C	C	V	P	H	W	Q	O	G	R	I	D	S	C	A	L	E
Z	F	X	D	E	C	A	R	B	O	N	I	Z	A	T	I	O	N	Q	I
W	T	G	N	Q	O	M	Z	E	L	J	N	D	R	G	V	I	T	S	E
I	K	B	W	K	O	I	D	O	A	H	M	X	O	S	K	J	Y	D	F
N	S	R	R	O	X	D	Z	Z	F	W	G	W	Q	U	K	M	L	C	F
D	D	W	Y	B	I	O	F	U	E	L	B	Q	T	S	C	O	J	O	I
P	G	R	I	D	P	L	A	N	N	I	N	G	H	T	M	V	Y	M	C
Y	I	M	T	X	Z	P	D	G	A	Z	K	P	K	A	V	U	R	M	I
H	L	P	C	P	M	D	Y	L	T	B	X	L	H	I	Y	W	E	U	E
K	P	J	Z	G	E	O	T	H	E	R	M	A	L	N	R	M	N	N	N
Q	X	T	H	Y	D	R	O	E	N	E	R	G	Y	A	B	T	E	I	C
R	Z	N	E	H	G	L	B	F	Q	W	R	T	N	B	V	J	W	T	Y
U	L	E	R	A	T	P	Y	I	G	A	S	I	E	I	T	H	A	Y	D
J	U	H	N	S	N	Y	H	W	L	H	G	Y	I	L	H	T	B	U	H
M	F	X	U	R	G	T	N	O	K	U	S	V	M	I	Z	U	L	X	E
Y	T	M	E	B	K	K	S	Z	B	Q	E	X	U	T	E	X	E	E	G
L	Q	N	Y	K	L	J	O	R	N	W	O	W	G	Y	W	G	N	I	L
R	E	S	I	L	I	E	N	C	Y	J	F	Z	P	Q	S	A	C	E	U

WORD LIST

☐ **HAWAII POWERED**
Our vision for using 100% local, clean energy and finding solutions for a clean energy future right here in Hawaiʻi

☐ **COMMUNITY**
A group of people, as well as a feeling of togetherness

☐ **RENEWABLE**
Energy produced from sources that are naturally replenished and do not run out, like solar and wind

☐ **SUSTAINABILITY**
Meeting current needs without compromising the needs and resources available for future generations

☐ **RESILIENCY**
Ability and capacity to recover quickly from events and challenges like natural disasters

☐ **DECARBONIZATION**
Reducing, offsetting or eliminating all sources of carbon emissions contributing to climate change

☐ **GRID PLANNING**
The process of building a resilient and reliable energy grid from local, renewable energy sources

☐ **GRID SCALE**
Large generation facilities and transmission infrastructure like wind turbines and solar facilities, as well as electric substations, poles and wires

☐ **EFFICIENCY**
Reducing the overall amount of electricity consumed through actions and the use of energy-efficient appliances like LED bulbs

☐ **SOLAR**
Energy from the sun that's converted into heat or electricity through solar thermal systems or solar panels

☐ **WIND**
The motion of the wind captured and converted to electricity by turbine generators

☐ **BIOMASS**
Biomass (plants, algae, restaurant grease, forestry or farming waste) can be burned to create steam for heat or to power a turbine and produce electricity

☐ **BIOFUEL**
A majority of biofuel is locally produced using natural vegetable oils and fats and is intended to be used as a replacement for petroleum diesel fuel

☐ **GEOTHERMAL**
Energy that comes from volcanic heat stored beneath the earth's surface like underground reservoirs of water heated by volcanic activity that can be tapped for steam to generate electricity

☐ **HYDRO ENERGY**
Flowing water can be diverted out of a running stream, river or irrigation ditch and piped into a turbine which generates energy

Megawatt Calculator

Hawaiian Electric

Data underlies many utility decisions. *Complete all 5 example calculations below.*

1. A new renewable energy project generates 8 megawatts of energy. If 1 megawatt can power 1,000 homes, how many homes can this project power?

CALCULATE: 8 × 1,000 = ?

ANSWER:

2. There are 5 power lines that are able to carry 7 megawatts at a time. Will the 5 lines be able to carry 60 megawatts total?

CALCULATE: 60 ÷ 5 = ?

ANSWER:

HINT: *Is the number greater or less than 7?*

3. A new solar project will generate 33 megawatts. If a power line can carry 5.5 megawatts at a time, how many power lines are needed to transmit the full 33 megawatts?

CALCULATE: 33 ÷ 5.5 = ?

ANSWER:

What's a "megawatt"?

A **megawatt** is a unit of power equal to a million watts! Compare that to a refrigerator, which uses between ***300 and 800 watts*** of electricity.

4. Using the table below, answer the following questions:

4a. What's the total number of megawatts the projects will generate?

CALCULATE: 40 + 33 + 35 + 39 + 30 + 38 = ?

ANSWER:

4b. Select a pair of projects that will generate a combined total of 68 megawatts.

ANSWER:

PROJECT	TOTAL MEGAWATTS
Solar A	40
Solar B	33
Wind A	35
Wind B	39
Biomass	30
Hydro power	38

5. The school and hospital need 18 megawatts to function at full capacity. They currently receive 6 megawatts from a solar project and 8 megawatts from wind project, how many more megawatts are needed?

CALCULATE: 18 - (6 + 8) = ?

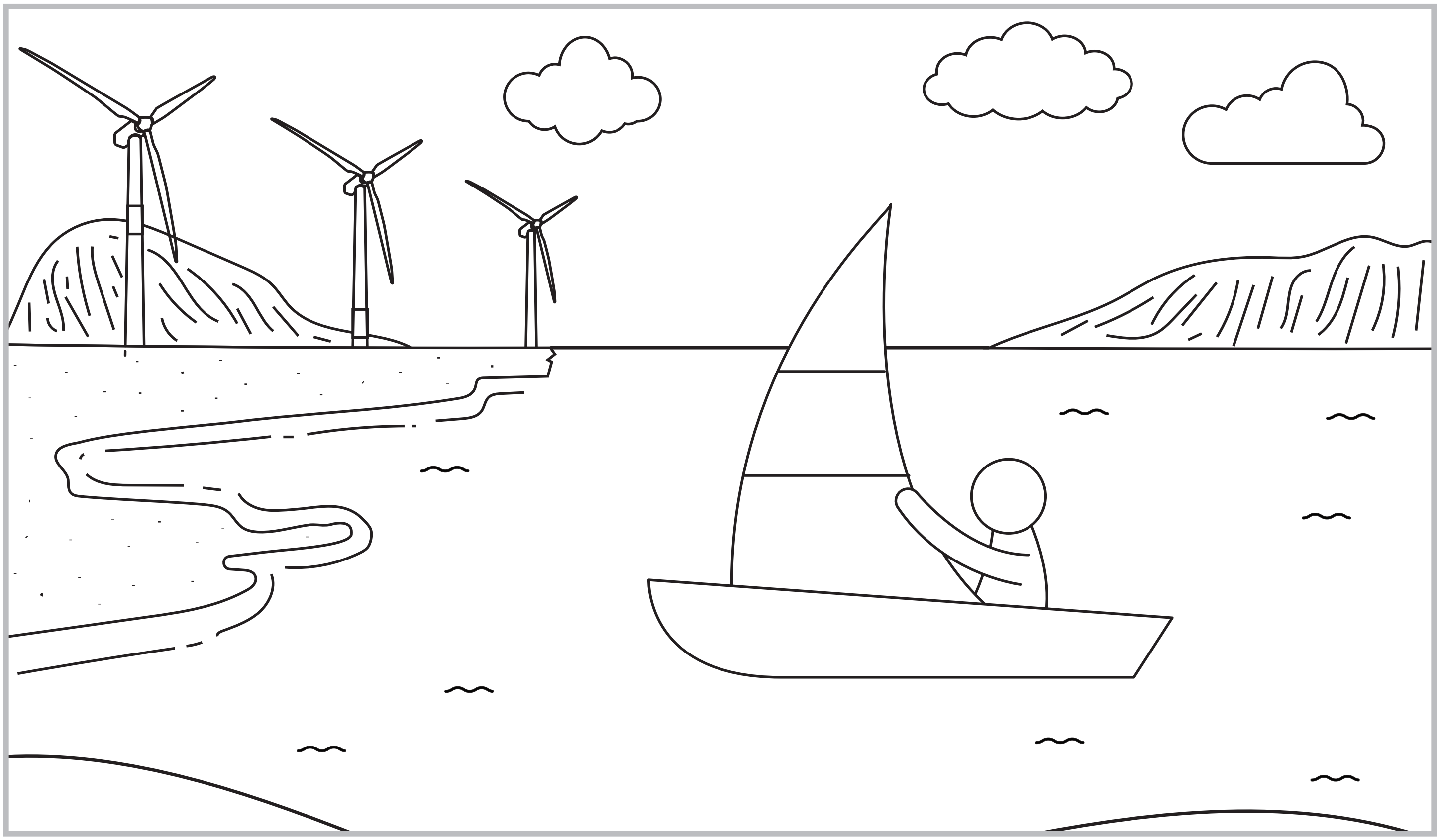
ANSWER:

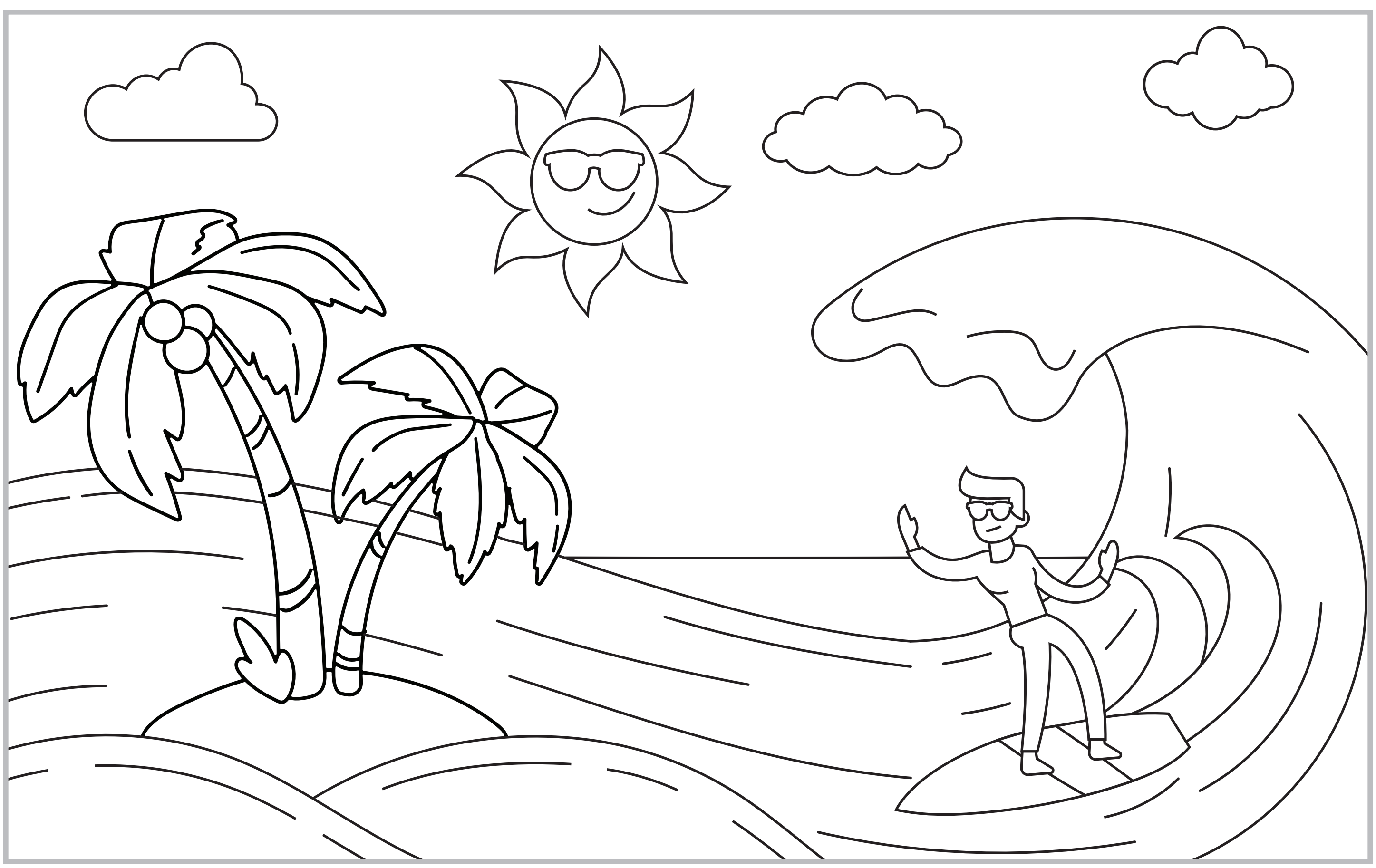
ENERGY FUN FACT

Light Emitting Diode (LED) bulbs use about 6 to 8 watts, but produce the same amount of light as a 60-watt incandescent light bulb!

Answers: *1. 8,000 2. No 3. 6 4a. 215 4b. Solar B, Wind A (33+35) or Biomass, Hydro power (30+38) 5. 4*

Color & Play





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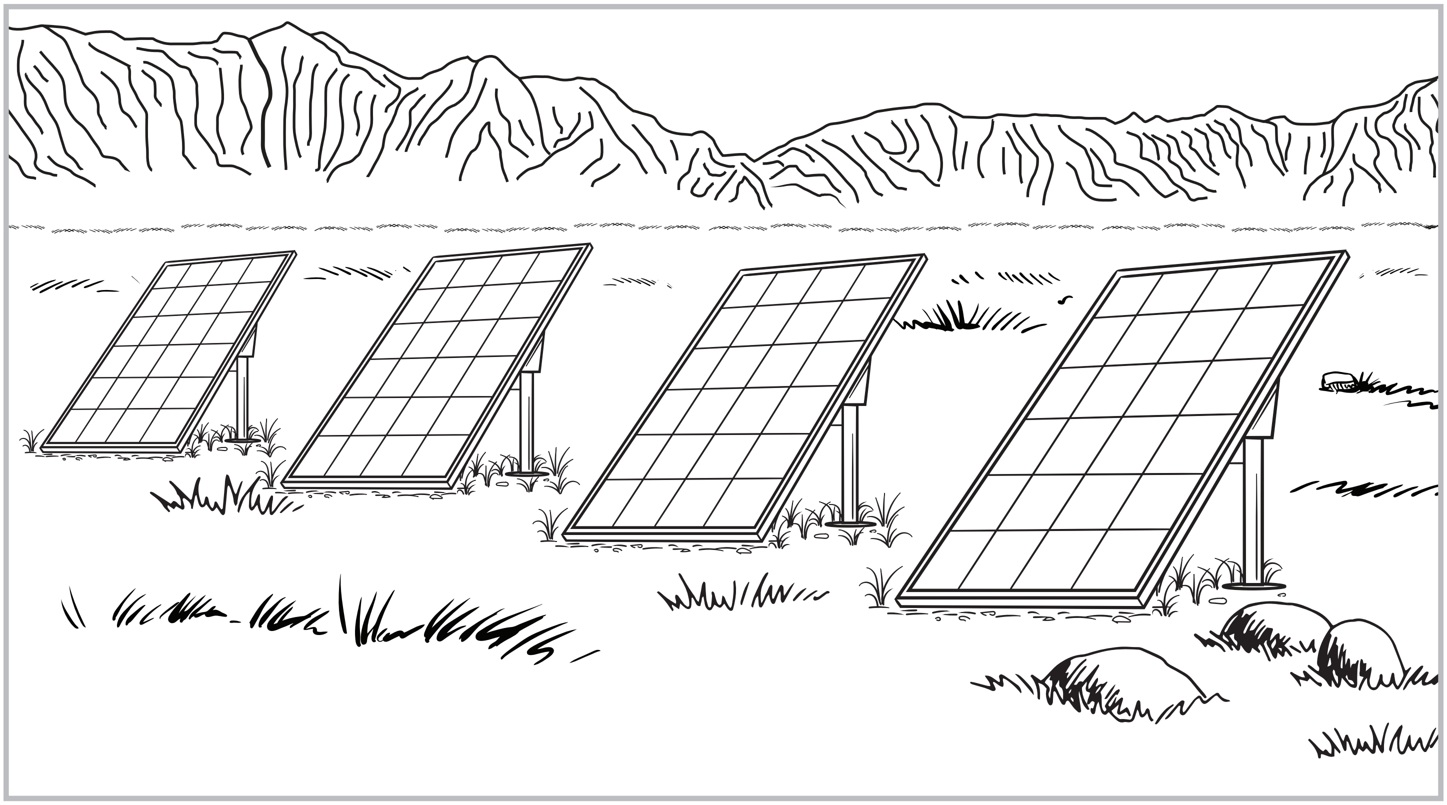


Unscramble all
7 words below

UNS ___

NSDA ____

AOENC _____

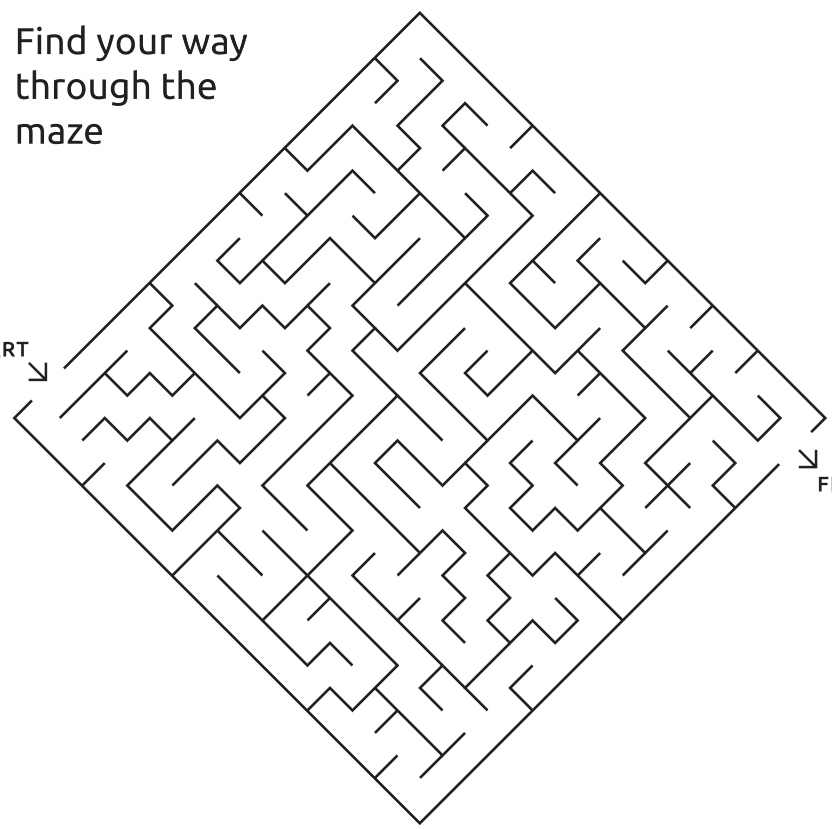
SIADLN ______

EBNWEERAL _________

TSNBUAYIASTILI ______________

RDAZEIIANBOTCNO _______________

Find your way
through the
maze



Answers: *Sun Sand Ocean Island Renewable Sustainability Decarbonization*

Hawaiʻi Powered

Clean energy for Hawaiʻi, by Hawaiʻi

"Hawaiʻi Powered" is our vision for using 100% local, clean energy. It celebrates finding solutions for a clean energy future right here in Hawaiʻi.

GO ONLINE

Visit our public participation website for more information

Scan this code with a smartphone camera

- **Sign up for email updates** about our latest progress and opportunities to get involved.
- **Take a short online survey** to help us better understand you and your energy needs.
- **Request a presentation** from Hawaiian Electric staff to learn more and answer questions at your next community meeting or event.
- **Read "Plugged In" blog posts** for energy insights and stories.

Explore our Inputs & Assumptions Data Dashboard!

This interactive online tool presents...

- Future energy scenarios and forecasts
- Data downloads for each island
- Insights on energy efficiency, electrification of transportation and distributed energy resources
- Customer impacts and resources
- Public input and involvement opportunities

Stay up to date on all things Hawaiʻi Powered

HawaiiPowered.com

1.9 ETIPP

Summary of Oʻahu microgrid planning which was an outcome of Hawaiian Electric's involvement in DOE's Energy Transitions Initiative Partnership Project (ETIPP) to improve energy resilience and combat climate change.

SUMMARY REPORT

Resilient and Renewable Energy Community Workshops

Oʻahu, Hawaiʻi

Hawaiian Electric

October/November 2022

EXECUTIVE SUMMARY

Hawaiian Electric is seeking community input regarding long-term efforts to increase resilience and decarbonize the electrical grid for the island of Oʻahu. The recent destruction caused by hurricanes in Florida and Puerto Rico underscores the need to improve energy resilience as climate change fuels more severe weather events. Hawaiian Electric is working with the U.S. Department of Energy, National Renewable Energy Laboratory, and Hawaiʻi Natural Energy Institute to develop a map that identifies opportunities for development of microgrids across Oʻahu. Microgrids allow grid-connected facilities to operate independent of the grid during a power outage using electricity from local energy resources.

In parallel with efforts to improve resilience, Hawaiian Electric is also working toward decarbonization of the energy system, consistent with their Climate Change Action Plan and the State of Hawaiʻi's goal of 100 percent renewable energy and net-zero carbon emissions economywide by 2045. As an initial step in the long-term planning process, Hawaiian Electric engaged National Renewable Energy Laboratory to conduct a data-based analysis of potential areas on Oʻahu that may be suitable for future grid-scale renewable energy projects. With community input, this analysis will be used to inform developers of potential site suitability as well as to guide planning efforts for the transmission infrastructure needed to support future renewable resource development.

Hawaiian Electric hosted six hybrid community workshops across Oʻahu to share information and solicit community input regarding the microgrid mapping and renewable energy zone analysis. Specifically, the workshops were designed to collect community insight on specific facilities that should be prioritized for microgrid development, as well as factors that should be considered in siting renewable energy resources. The community workshops were held in each of the six moku (districts) across Oʻahu, as listed below. Notices regarding the workshops were sent to elected officials, neighborhood boards, and energy-related groups and organizations. In addition, a news release was sent to various media outlets and promotional news stories ran in the Star Advertiser and Pacific Business News (see Attachment A). Each workshop included an open house (in-person only) followed by a hybrid community workshop (in-person and via Zoom). The workshops were also livestreamed and recorded by ʻŌlelo Community Media.

- Koʻolauloa Moku (Waimea – Kaʻaʻawa): Monday, October 24 at Kahuku Elementary School
- Waiʻanae Moku (Nānākuli – Keawaʻula): Wednesday, October 26 at Agnes Kalanihoʻokahā Community Learning Center
- Kona Moku (Moanalua – East Honolulu): Tuesday, November 1 at Kapiʻolani Community College
- Waialua Moku (Kaʻena – Kapaeloa): Thursday, November 3 at Waialua Elementary School
- Koʻolaupoko Moku (Waimānalo – Kualoa): Tuesday, November 15 at Windward Community College
- ʻEwa Moku (Honouliuli – Hālawa): Thursday, November 17 at Leeward Community College

Community members were able to provide feedback at each of the workshops in various formats, including verbal comments (both in-person and via Zoom), online through the Zoom chat function, as well as through Menti. Additional options for submitting input following the workshops were also provided, including via an interactive website (www.hawaiipowered.com) and email (igp@hawaiianelectric.com).

Overall, community members voiced an interest in increased resilience and energy equity. Key messages related to the following topics:

- Development of microgrids and renewable energy projects must factor in energy equity;
- Siting renewable generation only in locations where resource and land are available will not support energy resilience;
- Grid-scale renewable generation should be hosted in a variety of communities, not just those in rural areas;
- Cost to develop microgrids and renewable energy must be factored into the decision-making process; and
- The concept of hybrid microgrids requires careful explanation to facilitate understanding.

This report includes a synopsis of the technical information shared by Hawaiian Electric at each of the workshops followed by a detailed summary of the community input received.

TECHNICAL PRESENTATION

Introduction

Hawaiian Electric hosted Renewable and Resilient Energy Community Workshops across the island of Oʻahu, one in each of the six moku (districts). Following is a summary of the introductory remarks and technical presentation provided at each workshop; a copy of the presentation slides is contained in Attachment B. Community feedback received at each meeting is summarized in subsequent sections of this report.

Overview

Opening remarks were provided by Kurt Tsue, Director of Community Affairs at Hawaiian Electric. He explained that the purpose of the workshops is to address two separate but related topics relating to increasing resilience and decarbonization of the electric grid: (1) hybrid microgrids and (2) renewable energy zones. The workshops are structured to provide presentation of technical information for these two topics, each followed by an opportunity for community members to ask questions and provide input. He stated that the workshop format is intended to increase accessibility and community participation by allowing for attendance either in-person or online through Zoom, as well as via a live broadcast and recording provided by ʻŌlelo Community Media. He noted that all of the information shared at the open house is also part of the workshop presentation; the benefit of the open house is the opportunity for community members to talk story with subject matter experts. He also emphasized that these are long-range planning efforts and there will be ongoing opportunities to provide input in the future.

He introduced the speakers and others available for questions throughout the workshop, including Ken Aramaki (Director of Transmission, Distribution and Interconnection Planning at Hawaiian Electric), Marc Asano (Director of Integrated Grid Planning at Hawaiian Electric), Katy Waechter (Geospatial Science Researcher at the National Renewable Energy Laboratory), and Colton Ching (Senior Vice President of Planning and Technology at Hawaiian Electric). In addition, he introduced Alani Apio (Kamau LLC) as the workshop facilitator. He also recognized the Center for Resilient Neighborhoods (CERENE) as a partner organization that is engaging with communities at the grassroots level to increase resilience through development of resilience hubs, which dovetails with the concept of microgrids.

Kurt explained that Hawaiian Electric has an obligation to provide reliable electrical service, as well as stabilize energy costs by transitioning off fossil fuels. He acknowledged that this is a very challenging time in terms of electricity costs and stated that Hawaiian Electric is open to continuing conversations on this topic if desired. He explained that the purpose of the Renewable and Resilient Energy Workshops is to address the transition to renewable energy as well as the need for increased resilience in light of climate change. Recent events in Puerto Rico and Florida underscore the importance of addressing these issues as soon as possible, especially given Hawai'i's vulnerability as an island state in the middle of the Pacific Ocean. The first portion of the workshop relates to microgrids; there are different types of microgrids, but the workshop is focused on hybrid microgrids to support disaster and emergency preparedness. Hybrid microgrids improve energy resilience by ensuring backup power to critical facilities (such as medical facilities, community gathering places, food storage facilities) during a grid outage. Implementation of a hybrid microgrid involves islanding (sectioning off) facilities which are typically energized through the island-wide electric grid, allowing for continued power during a grid outage from local energy resources. Hawaiian Electric is seeking input from the community regarding whether microgrids should be considered in their community, and if so, what facilities should be included. The second portion of the workshop relates to efforts to decarbonize O'ahu's energy system by incorporating grid-scale renewable energy generation. He emphasized that a lot of changes will need to be made to fully transition to renewable energy and current efforts are focused on how best to bring renewable energy projects online to achieve decarbonization goals in a manner that meets the community's needs. Hawaiian Electric is seeking community input regarding the factors that should be considered in siting these types of large-scale renewable energy projects.

Kurt acknowledged that these are difficult concepts to navigate but are extremely important to address in planning Hawai'i's energy future. He stated that Hawaiian Electric has traditionally focused on providing technical engineering solutions that ensure a safe and reliable electrical grid but has come to understand the importance of balancing these technical requirements with community priorities and needs. In particular, he acknowledged the importance of understanding how communities may be affected by efforts to improve resilience and decarbonize the energy system, and the need to incorporate community input proactively rather than after the fact. He specifically acknowledged recent efforts by the West O'ahu/Kalaeloa Clean Energy 'Ohana, which involved aligning community interests and filing specific recommendations with the Public Utilities Commission (PUC) to allow for better community involvement in the renewable energy planning and development process. Building on these efforts, he explained that Hawaiian Electric is committed to further improving existing processes to facilitate community engagement. As part of this commitment, Hawaiian Electric is trying to level the playing field by sharing the same information that is used by utility engineers and developers in a format that is more accessible to the community; this information is being shared as part of this workshop with more detail provided at www.hawaiipowered.com. The goal is to make it easier for the community to participate in renewable energy and resilience planning efforts. Input received from the community will be documented in a report that will be submitted to the PUC on behalf of the community and incorporated into the planning process. In addition, the information will be visible to others involved in the planning process including developers and state agencies such as the Hawai'i State Energy Office. Kurt emphasized that this is a long-term effort and there will be continuing opportunities for community input and participation moving forward.

Hybrid Microgrid Mapping Project

Ken Aramaki, Director of Transmission, Distribution and Interconnection Planning at Hawaiian Electric, presented information regarding the hybrid microgrid mapping project, which is a current initiative to improve resilience of Hawaiian Electric's island-wide electrical grid. Grid resilience is critical to maintaining community lifelines, which are those services essential for human health and safety as well as economic security. Community lifelines include things such as energy, communications, health and medical, transportation, food, water and shelter. Community lifelines are generally interdependent; however, energy is central to all community lifelines. As such, Hawaiian Electric is trying to identify opportunities to improve resilience of the electrical grid so that energy availability may be more reliable to maintain community lifelines during emergency situations.

Basic knowledge of the electrical grid structure is helpful for understanding the concept of microgrids. Hawaiian Electric's electrical grid was originally built to provide a one-way flow of energy to customers, originating with bulk generation at various power generation plants. The high voltage energy from these generators is transported through a transmission network with the voltage incrementally stepped down through a series of substations, then is ultimately delivered as low voltage electricity to individual customers. The system has been modified in recent years to accommodate the addition of new energy resources from independent power producers, including solar photovoltaic, wind farms, and energy storage systems; although not originally designed for these additions, the grid has been modified to allow for interconnection at various voltage levels and at different points throughout the system. In addition, customers have also added distributed energy resources (such as rooftop solar, batteries, and diesel generators) to their individual properties through various programs, in many cases to offset electricity costs.

Recent technological advancements have allowed for distributed energy resources to function as a microgrid, which allows customers to continue receiving electricity in the event of a broader grid outage. For example, it is possible for customers with rooftop solar photovoltaic panels and batteries to configure the system behind their electrical meter in a manner that allows for power to be maintained at their individual home or business in the event of an emergency. Other examples include commercial customers that use diesel generation to provide power independent of the grid. These types of microgrids generally serve a single customer and are referred to as customer microgrids. Hawaiian Electric recently created a microgrid services tariff that allows for both customer microgrids as well as larger microgrids involving multiple customers (referred to as hybrid microgrids). A hybrid microgrid consists of a cluster of customers located proximate to one another, each of which is individually served by the utility on a normal day-to-day basis. To develop a hybrid microgrid, the utility infrastructure (e.g., poles and lines) connecting these customers is hardened and electrically sectioned off from the broader electrical grid. During a grid outage, the customers within the hybrid microgrid may be powered using the aggregate of those customers' localized generation resources, delivered across the microgrid via utility infrastructure.

Upon launching the microgrid services tariff, Hawaiian Electric realized that customers may not be able to easily identify opportunities where microgrids are feasible as they are technically complex systems and require an understanding of the electrical grid. Around that same time, Hawaiian Electric applied and was selected to participate in a new program funded by the Department of Energy (DOE), referred to as the Energy Transitions Initiative Partnership Program (ETIPP). The program provides technical assistance to remote and island communities seeking to transform their energy systems and increase energy resilience through strategic energy planning. Through this program, Hawaiian Electric is working with National Renewable Energy Laboratory (NREL), Sandia National Laboratories, and Hawaiʻi Natural Energy Institute (HNEI) to identify specific locations on Oʻahu that may be well suited for a hybrid microgrid based on technical, reliability, and resilience-related characteristics. The results of this analysis will be presented on community-based maps that can be used by customers to understand if a hybrid microgrid is a viable solution for their community and specific locations where microgrids could be used to improve the electrical infrastructure resilience.

Katy Waechter, Geospatial Science Researcher III at NREL, presented additional detail regarding the hybrid microgrid mapping process. She explained that the goal of the mapping effort is to identify potential microgrid locations at the parcel level. Three categories of criteria were initially identified to evaluate site suitability, as described below. She stressed that although potential microgrid sites may be determined based on a single criterion, the goal of the analysis is to identify areas where the criteria overlap as these are locations where microgrids would be expected to have the greatest impact.

- **Criticality** incorporates critical loads, facilities, and services within a given community, particularly those that directly impact human health and safety during an emergency. Specifically, this category includes emergency facilities and services (such as emergency shelters, fire stations, and emergency option centers), medical facilities and services (such as hospitals, surgical centers, and nursing homes), and critical infrastructure (such as water sources, transmission towers, bridges, ports, and airports).
- **Vulnerability** addresses those parts of the grid currently and projected to endure the longest or most frequent outages based on factors including natural hazard risk (such as tsunami evacuation zones, flood hazard zones, and sea-level rise inundation areas), remoteness and accessibility (based on the relative density of transportation and electrical transmission infrastructure in any given area), and grid reliability (based on Hawaiian Electric data regarding grid outages over a 10-year period [2011-2021]).
- **Societal Impact** focuses on locations that would significantly impact communities if they lost power. This category includes residential care facilities, community homes, schools, daycare facilities, and libraries. To ensure equity and accessibility to microgrid opportunities, this category also focuses on populations that may be disproportionately affected by outages including customers receiving assistance (such as the Asset-Limited, Income-Constrained, Employed [ALICE] program), disadvantaged communities (in accordance with DOE's definition which follows the Biden Administration's Justice40 Initiative and incorporates 36 different metrics of burden), as well as Hawaiian homelands, IRS Opportunity Zones and other similar metrics.

The mapping exercise, which covers the entire island of Oʻahu, includes dozens of spatial datasets for these three categories of criteria as well as information specific to Hawaiian Electric's distribution network. In addition, the mapping incorporates a model used to determine where electricity demand is balanced with grid-connected customer energy resources (e.g., rooftop solar panels, batteries, etc.), as these may be locations where microgrids could be most easily developed with minimal upgrades. The maps resulting from this initial effort were shared in the presentation and are available online at www.hawaiipowered.com\etipp; however, the maps are considered incomplete as they do not yet reflect community-based knowledge. As such, Hawaiian Electric is seeking community input regarding additional criteria that should be included in the analysis as well as any specific facilities that should be considered for a hybrid microgrid. Of particular interest are facilities that may not be included in public datasets but are important to the community, such as those locations where people gather during and following emergency events. There are multiple options for providing input including in-person and virtual tools offered during the Renewable and Resilient Energy Workshops as well as online at www.hawaiipowered.com\etipp; details for contributing input are provided below. All input received will be considered and incorporated into the analysis as appropriate. The resulting site-specific maps, which will ideally show where the various criteria and community resources meet, will be shared with the community as a resource for evaluating potential locations for hybrid microgrids.

Renewable Energy Zones

The workshop also included a presentation regarding long-term planning to meet Hawaiʻi's decarbonization goals; this information was presented by Ken Aramaki and Marc Asano, Director of Integrated Grid Planning at Hawaiian Electric. They started by explaining that decarbonization of the energy system is a critical component of mitigating climate change, the effects of which are being increasingly realized in Hawaiʻi and elsewhere around the world. The State of Hawaiʻi has established goals of achieving net zero carbon emissions and 100 percent renewable energy by the year 2045 (with interim targets by 2030). Hawaiian Electric's Climate Change Action Plan includes commitments consistent with these goals to reduce carbon emissions by 70 percent compared to 2005 levels by 2030. Achieving these commitments will require significant changes over the next 20 years, including development of the necessary renewable energy resources as well as the transmission infrastructure needed to deliver those resources. As energy infrastructure typically takes at least 10-15 years to develop, near-term action is needed to work toward these commitments.

Long-term planning to support the transition to a decarbonized electrical system is being addressed as part of Hawaiian Electric's Integrated Grid Planning (IGP) process. The goal of these efforts is to develop and implement a plan for a clean energy grid that meets the established timelines (accounting for the time needed to build the supporting transmission infrastructure to support renewable resource development), stabilizes customer costs, balances competing land uses (including affordable housing and agriculture), minimizes community impacts, and improves overall energy resilience. Given the range of planning considerations and technical complexities, this will require a focused and coordinated effort across the board, including the community.

Currently, Hawaiian Electric has an as-available renewable capacity of approximately 1,143 megawatts on the island of Oʻahu. This capacity includes the various existing renewable energy projects (e.g., solar photovoltaic and wind energy) and is considered as-available because the energy availability is dependent on weather conditions and/or time of day (e.g., when the sun is shining or wind is blowing); the majority of this as-available renewable capacity (763 megawatts) is associated with customer-sited resources such as rooftop solar. An additional 384 megawatts of solar energy resources is currently in development; these are generally large, grid-scale projects that were selected as part of Hawaiian Electric's Stage 1 and 2 competitive procurement processes and are in the process of being brought online. In addition to providing additional renewable energy resources, these projects also include a storage component (e.g., batteries) which allows for the energy to be used during periods with the greatest demand. Despite all of these renewable resources, Hawaiian Electric still heavily relies on firm generation sources to maintain grid reliability; the total firm capacity is approximately 1,614 megawatts, of which only about 126 megawatts is from renewable sources. The goal is to phase out the non-renewable firm capacity, which will need to be offset with either renewable firm capacity or larger amounts of as-available capacity.

To adequately displace existing firm non-renewable resources in order to achieve 100 percent renewable energy by 2045, both distributed energy resources as well as grid-scale resources must substantially increase. To better understand the potential for distributed energy resources, Hawaiian Electric worked with NREL to map opportunities for rooftop solar across Oʻahu. This mapping exercise indicated that there is significant potential for rooftop solar and Hawaiian Electric recognizes that this component is critical to Hawaiʻi's clean energy future. Regardless, it is not possible to achieve a fully decarbonized energy system without grid-scale renewable resources.

Grid-scale renewable energy projects are currently developed through a competitive bidding process in which Hawaiian Electric identifies capacity on their system to receive renewable energy resources and issues a Request for Proposal (RFP). Developers work directly with individual landowners to identify locations for energy resource projects, then submit proposals to Hawaiian Electric in response to the RFP. It is important to understand that for projects to be interconnected with the Hawaiian Electric grid, they can only be sited in areas that have transmission infrastructure with adequate capacity; furthermore, projects are typically sited in close proximity to existing transmission infrastructure to minimize the need for extensive transmission lines.

To better understand the potential for future development of grid-scale renewable resources and to plan for the transmission infrastructure needed to support these resources, Hawaiian Electric conducted a Renewable Energy Zones analysis, which is an industry-standard approach to identify areas where there may be opportunity to site potential renewable resources. In this case, the analysis evaluated the potential for development of solar or land-based and offshore wind energy resources, as these are currently the most affordable and feasible resources for which data are currently available; however, the analysis does not preclude the integration of other types of renewable resources as they become more readily available in the future. To help address known conflicts, areas with certain characteristics or land uses were excluded from the analysis including tsunami inundation and flood hazard zones, productive agricultural lands,[1] urban zones, conservation lands, and areas with slopes greater than 30 percent, among others. The results of the analysis identify areas of technical potential (i.e., areas that may be suitable for renewable energy generation projects); these areas are geographically delineated into specific zones based on potential interconnection points with the existing electrical grid. The preliminary results of the Renewable Energy Zones analysis were shared in the presentation and are available online at www.hawaiipowered.com\oahu. However, the results are entirely based on technical data and do not reflect community priorities. As such, Hawaiian Electric is seeking community input regarding suitability of areas within the Renewable Energy Zones, both in terms of specific locations that may be desirable for development of renewable energy resources as well as those that are not preferred. There are multiple options for providing input including in-person and virtual tools offered during the Renewable and Resilient Energy Workshops as well as online at www.hawaiipowered.com\oahu; the online map includes the ability to drop a pin and add comments identifying those places that may be suitable as well as areas that are undesirable for development of renewable energy projects. The input gathered through this process will be used to refine the Renewable Energy Zones analysis, which will be used to guide planning efforts for transmission infrastructure needed to support future renewable resource development, as well as to inform developers regarding potential site suitability for specific renewable energy projects through the RFP process.

[1] Identification of productive agricultural lands was based on the University of Hawaiʻi's Land Study Bureau (LSB) soil classification system, which rates the productivity of soils throughout the state based on characteristics including texture, slope, salinity, erodibility, and rainfall, and designates areas in categories ranging from A to E (with Class A representing the most productive soils and Class E representing the least productive soils). The analysis excludes all areas with LSB Class A soils and 90 percent of areas with Class B and C soils.

Opportunities for Community Input

Kurt outlined the various options for providing input during the workshops, as listed below. He stated that all comments would be documented in a summary report.

- Verbal comments by participants attending in person and online (via the Zoom hand-raising function)
- Written comments on comment forms (for in-person participants) or via the Zoom chat function (for online participants)
- Menti (online service accessed via personal computer or mobile device, which aggregates and allows meeting participants to see all comments)

He also explained that the following tools are and will remain available, allowing the community adequate time to review and provide input following the workshops. Recordings of the workshops by ʻŌlelo Community Media will also be available on Hawaiian Electric's website.

- Website for hybrid microgrid mapping project (www.hawaiipowered.com\etipp)
- Website for Renewable Energy Zones analysis (www.hawaiipowered.com\oahu)
- Workshop Recordings (https://www.hawaiianelectric.com/clean-energy-hawaii/community-meetings)

In addition to the tools outlined above, comments may also be submitted directly to Hawaiian Electric via email (igp@hawaiianelectric.com).

COMMUNITY FEEDBACK

KOʻOLAULOA MOKU (WAIMEA – KAʻAʻAWA)

OCTOBER 24, 2022

Introduction

The first of six Renewable and Resilient Energy Workshops hosted by Hawaiian Electric was held in the Koʻolauloa moku of Oʻahu, which spans from Waimea to Kaʻaʻawa. The workshop was held on October 24, 2022 at Kahuku Elementary School. There were approximately 13 attendees, as well as Hawaiian Electric staff; a list of attendees is included in Attachment C.

At the request of the community, a follow-up discussion was held on December 1, 2022 at Hauʻula Community Center. The follow-up discussion included approximately 22 attendees, as well as Hawaiian Electric staff; a list of attendees is included in Attachment C.

Hybrid Microgrids: Community Feedback

Based on the presentation of technical information regarding hybrid microgrids (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting hybrid microgrids in Koʻolauloa, including other criteria that should be included in the analysis as well as specific facilities that should be considered because they are important to the community. He highlighted the work that the Koʻolauloa community has done relative to emergency planning and preparedness, emphasizing that Hawaiian Electric wants to learn from these efforts. He explained that Alani would be facilitating the discussion and reminded participants of the various ways that they can ask questions and provide input. Alani stressed that the purpose of the workshop is to gather the community's input to ensure the analysis is aligned with the community's priorities. The questions and input provided by workshop participants is summarized below.

- A workshop participant explained that each community within the Koʻolauloa moku is quite different. For example, she stated that she is from Hauʻula which differs from Kahuku in terms of demographics, community feelings and interests, as well as the physical terrain. She noted that there were no residents of Kahuku in attendance, but that their input should also be obtained. Hauʻula is very close to both the ocean and mountains, without much space between, which means that a lot of the community is within the tsunami inundation zone. The community is accustomed to heading mauka out of the inundation zone during emergency events. There is also a lot of concern about shoreline erosion, which is resulting in loss of beaches, vegetation and eventually homes. Hauʻula residents have been focused on emergency preparedness for a long time, as this community experiences a lot of power outages. The cause of the outages is not always known and the community is often uncertain of how long the outages will last. These types of uncertainties, whether associated with road closures or power outages, takes a toll on the community. Given these concerns, Hui o Hauʻula has been planning a resilience hub for the larger Koʻolauloa community. It is an ongoing effort, but there is a strong desire for the work to be completed. Similar to Hawaiian Electric, they also have a technical assistance grant from ETIPP and have been receiving technical assistance regarding microgrids. She expressed support for microgrids throughout the Koʻolauloa moku and stressed the importance of working together to determine where they should be located. Microgrids would help to maintain energy during emergency situations, which would allow the community to feel more secure. She expressed appreciation for Hawaiian Electric taking time to work through the information with the community and requested more information about the microgrid maps.

- Another workshop participant reiterated that the various communities within Koʻolauloa are slightly different. In general, everyone in Koʻolauloa knows to head mauka during emergency events, although specific gathering locations and individual plans have been refined over time. The community has gotten better about preparing with the proper equipment (batteries, coolers, etc.), but access to power is critical. The other key issue in Koʻolauloa is road access; currently the most vulnerable location is near the school in Kaʻaʻawa. The ocean comes right up to the road in this area, and will be over the road within the next one to two years. He also noted another location with a similar issue at Kukuna Road near Kualoa. He stated that he does not know how the State of Hawaiʻi Department of Transportation (DOT) is planning to address this issue, but noted that Hawaiian Electric's lines run along the road. He emphasized that all of the partners need to be thinking about how to address these issues now. Residents are aware and are alarmed, but nobody is addressing the issues. He expressed the desire for Hawaiian Electric, DOT, and other partners to come together and work with the community to solve problems, and acknowledged Hawaiian Electric's efforts. Alani noted that Hawaiian Electric can help to share these messages with other agencies and organizations. Kurt explained that while Hawaiian Electric is focused on energy, there is a lot of other work occurring in parallel. Hawaiian Electric is directly coordinating with other agencies and organizations, including the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency, Centers for Resilient Neighborhoods (CERENE), and Hawaiʻi Emergency Management Agency (HiEMA); the goal is to elevate concerns, connect the dots, and bring partners together.
- It was stated that critical infrastructure in this area includes the fire station, Kahuku hospital, internet service, and stores. As such, the critical infrastructure is limited but it is important that each community in Koʻolauloa has a microgrid. In terms of siting the microgrids, they should be in central locations where the community typically gathers in the event of an emergency such as a tsunami.
- It was emphasized that although there is limited infrastructure in Koʻolauloa, those few facilities are very important to the community. In addition to the hospital in Kahuku, there is also an Emegency Medical Services (EMS) station and new fire station in Hauʻula. One concern is that the police and fire personnel have not been part of the local emergency planning efforts. The community has an emergency response team that has been actively planning and training for over ten years. In addition to having an identified tsunami evacuation site, they are also working to develop a resilience hub.

However, they have not been successful in their efforts to coordinate with police and fire personnel; it was speculated that the local police and fire crews have been instructed not to talk with the community emergency response team. The community thinks this coordination is critical, because in the event of an emergency, they will need to be their own boots on the ground. Koʻolauloa is far removed from Honolulu and emergency response agencies will likely be overwhelmed, such that the community anticipates needing to be self-sufficient for 30 days for more. In this type of situation, it will take everyone working together; with coordination, the local emergency response team can help support police and fire crews (and vice versa). Alani noted that Hawaiian Electric can help deliver this message to the relevant agencies.

- A workshop participant reinforced the need for microgrids in Koʻolauloa, specifically as part of community resilience hubs; she stated that these planning efforts should be coordinated. She explained that the resilience hub being planned by Hui o Hauʻula will be located on a hillside at an elevation of approximately 60-90 feet (outside of the tsunami and flood inundation zone). Hui o Hauʻula is working with medical partners and plan to include a medical clinic, dialysis capabilities, and other similar services as part of the resilience hub. She requested that the Hauʻula resilience hub and any other similar facilities planned in Koʻolauloa be specifically considered in Hawaiian Electric's microgrid planning efforts. Other facilities that should be included are the hospital and fire stations. She also noted that without power, there is limited access to fresh water; it is critical that microgrids also help to maintain access to water.
- When asked about specific locations where the community gathers during emergency events, one of the workshop participants explained that people go to places located in mauka areas as lowland areas are not likely to be accessible. Specific locations include the Mormon Church in Hauʻula and the area around the dam in Kahana, which is a big open space where families from Kaʻaʻawa and Punaluʻu gather to barbeque/picnic. He stated that others in the community have their own places and things that they do during emergencies, and it is important that there is help for people during the emergency event as well as afterwards during the transition and recovery effort.
- Kurt explained that microgrids require local energy resources to provide power during emergency events (e.g., solar photovoltaics and battery storage, mobile generators, etc.) and asked about the community's priorities for powering microgrids. In response, one of the workshop participants stated that in the event of an emergency involving a major grid outage (such as in Puerto Rico), the community doesn't necessarily care about the source of the power but rather with restoring electricity as quickly as possible. There may be an increased focus on renewable or more efficient energy source moving forward, but during an emergency, people want any form of power.
- As part of planning for the resilience hub, Hui o Hauʻula is considering solar photovoltaics as well as other renewable energy technologies including wind turbines, geothermal, biomass, and possibly hydrogen. They are currently reviewing various opportunities as part of their ETIPP grant. Based on available information, biomass appears to be a promising concept. The particular strategy being considered produces no emissions and is able to use greenwaste (which is abundant in Koʻolauloa).

In addition to the comments discussed during the workshop, additional comments were received via Menti and in writing. Specifically, in response to the prompting question posed via Menti – "Is the proposed criteria aligned with the community's resilience priorities (if not, what's missing?)" – the only comment received stated "yes." A copy of the Menti response is contained in Attachment D.

Questions and comments that were received in writing on the response cards regarding the microgrid mapping and related resilience issues are listed below. Copies of the written response cards are contained in Attachment E.

- What kind of new poles for our erosive highway?
- Punaluʻu contains a large amount of agricultural land. Can those areas still qualify for a microgrid?
- Cost is a big issue for community. How is a microgrid going to impact electric bills?
- Do you start where the hub will be and work out or do you have another method of making the grid?
- We've been asking to have mango tree branches now hanging over our lines cut for months and nothing has been done. It was stressful to think about it during hurricane season.

Comments provided by participants at the follow-up discussion held on December 1, 2022 at Hauʻula Community Center are listed below:

- Impressed with Babcock Florida, they have a resilient community that was not affected during Hurricane Ian. https://babcockranch.com/. Built to highest standards in FL. No houses were damaged, and they had a huge microgrid in place.
- Oakland, CA are pushing their EVs to also charge back the grid (learned through Zoom mtg)
- BYU has done a good job with their solar layout
- We need more than just solar, we need backup.
- RE: Power frequent power outages - The community feels ignored. The community doesn't have much faith. Community has given up. We have an outage at least 1x/wk.

Renewable Energy Zones: Community Feedback

Based on the presentation of technical information regarding the renewable energy zones analysis (as summarized previously in this report), Alani reiterated that Hawaiian Electric is looking for input regarding siting of renewable energy resource development. He acknowledged the previous issues related to siting of wind turbines in Kahuku and emphasized that Hawaiian Electric is trying to improve the renewable energy planning process to avoid similar issues in the future. The questions and input provided by workshop participants is summarized below.

- In response to the previous comment that Hui o Hauʻula is considering wind turbines as part of their resilience hub, Alani noted that wind turbines are controversial and asked if this is something that is being discussed with the community. One of the workshop participants stated that he doesn't think there is anything wrong with turbines, but they must be properly sited. In the case of Kahuku, the turbines were placed too close to the community. Based on research of other wind energy projects, it is understood that wind turbines in Germany are located at least one mile from the nearest residence or farm. We should be learning from others to incorporate the best technology and information regarding health impacts. The people who sited the turbines so close to the school are incompetent, just like those involved in the rail project. He stated that he would like to see wind turbines at the State Capital, Department of Health, and City Hall; they should have to live with the wind turbines as that is what the Kahuku community has to live with 24/7. He noted that he was one of the first people to be arrested when the wind turbines were brought to Kahuku; although he lives in Kahana, this is part of all of our communities. If people aren't willing to put the wind turbines next to a high school in Hawaiʻi Kai, they shouldn't put them in Kahuku.

Kurt acknowledged these concerns and the need for improvements in the renewable energy development process; previous efforts did not adequately include the community and there have been many lessons learned. He explained that these workshops are part of an effort to improve the renewable energy development process, particularly engaging the community earlier in the process. Hawaiian Electric is seeking input from the community to help inform future Requests For Proposals (RFPs), which is the process by which the grid-scale renewable energy projects are identified and selected for development. He stated that Hawaiian Electric has learned a lot from talking to the community, including Hui o Hauʻula and Kukea Kahuku, and recognizes the need for improvements. He explained that significant improvements have resulted from recent efforts by the West Oʻahu community based on their concerns with renewable energy development. In response to an RFP for a shared solar program, community leaders came together and aligned their interests, then submitted a letter to the Public Utilities Commission (PUC) requesting changes to the RFP process. The PUC granted most of the community's requests, which will be incorporated into all RFPs moving forward. Kurt emphasized that this is the type of work that Hawaiian Electric hopes to facilitate with other communities around the island.

- A workshop participant stated that there has always been a lot of wind in the back of the valleys. He emphasized that there is wind in the valleys on both sides of the island but acknowledged that it will be difficult to get transmission lines across the mountains. However, he stated that he thinks wind turbines could be sited in the middle between the mountains, as there are no residents in this area and the turbines could serve the populations on either side. He acknowledged that investors might not like this arrangement, but he thinks this is the best long-term solution for wind and even solar energy projects. He also noted that all houses should be required to have solar photovoltaic systems, with lease programs or other arrangements that are user-friendly and affordable enough to allow for system upgrades.
- A question was asked about the timing of the peak power demand on Oʻahu. Colton explained that the greatest demand for electricity on a daily basis is typically around 7:00pm. Although fairly consistent throughout the year, usage typically peaks in September or October (as this is when it starts getting dark earlier, but is still fairly warm so air conditioning units are still being used). The peak power demand on Oʻahu (around 7:00pm in the September to October timeframe) is

approximately 1,200 megawatts, which far exceeds that of the neighbor islands but is much lower than other states.

- A workshop participant emphasized that there will continue to be development which will occupy a lot of the open areas shown on the map. As such, renewable energy projects should be sited as far back as possible from these areas, in the middle area between the mountains, away from schools and other development.
- A workshop participant stated that she recently attended a presentation hosted by the Board of Water Supply about the Canary Islands, an archipelago similar to Hawaiʻi. She stated that there is an impressive amount of work being done to research and collect data on a wide variety of issues related to water supply as well as renewable energy. She encouraged others to learn more about this work as the Canary Islands are ahead of many other locations and are willing to share information.
- A workshop participant noted that she previously lived on Pacific Heights and that this area was very windy. She stated that she isn't sure how to best capture that wind but emphasized that it funnels through the valleys. She agreed with the approach of talking with communities to figure out how to best approach renewable energy solutions and stressed the need to amplify the voice of communities that feel invisible. She stated that she hopes community members will join these conversations, as it is important to capture their input. She also discussed the value of community centers, such as the community center in Hauʻula which serves everyone in Koʻolauloa. She explained that community centers engage people, day and night; it is a comfortable place where people feel safe and can spend time with their friends. She stated that she hopes Hawaiian Electric will continue trying to engage with the community as it is an important step and she believes that people want to give input.

  Alani noted that although it may not be Hawaiian Electric's kuleana to build a community center, it is important to consider the human element that makes community centers so valuable. If people don't have places to come together and talk about issues, such as these discussions about microgrids and renewable energy, then they won't know what is going on or the appropriate steps to take. The workshop participant explained that the community center in Hauʻula has been there for a long time. It was mothballed but has since been turned into a great facility; unfortunately, it is located in the flood inundation and tsunami evacuation zone. As soon as the resilience hub is built, everything from the community center will be relocated to this location as it will be in a mauka location. She noted that the Federal Emergency Management Agency (FEMA) helps to replace buildings that are located in the flood inundation and tsunami evacuation zone, so Hui o Hauʻula is trying to get their help. She stated that similar efforts are needed to relocate these types of facilities around the island. She also noted the importance of getting input from the community so that the culture can be incorporated and make people feel at home. People who are engaged and spend time together, build social capital, which is the most important thing in the time of emergencies.

In addition to the questions and comments discussed during the workshop, additional questions and comments were received in writing, as listed below. Copies of the written response cards are contained in Attachment E.

- No windmills should be as close to homes, schools and farms as the monster turbines in Kahuku are.
- Kurt was a very informed and informing speaker. Excellent, thank you. Learned a lot. Will be more informed in future to have more meaningful input. Appreciate early community involvement.
- Are horizontal wind turbines less expensive than vertical? How well do they tolerate salt air? No solar farms on agricultural land! No vertical wind turbines!
- No vertical wind turbines! Horizontal turbines are okay.
- Good to know what's going on and all of the changes that affect our electric utilities and how it trickles down to us.

Comments provided by participants at the follow-up discussion held on December 1, 2022 at Hauʻula Community Center are listed below:

- Supportive of horizontal turbines
- Completely against wind turbines

Shellee Kimura, Chief Executive Officer of Hawaiian Electric, provided closing remarks. She expressed her appreciation for community members joining the workshop and engaging with Hawaiian Electric. She emphasized the importance of the community's perspective and encouraged others to participate in the future. She noted that Hawaiian Electric understands that these are complicated topics and it is difficult for many people to engage; however, community knowledge and experience is critical to developing real solutions for Hawaiʻi. Recognizing that the work being discussed may not be built for ten or more years, she stressed that the process is starting now; input obtained through these types of discussions result in decisions that get baked into the plans, which ultimately result in infrastructure being built in people's communities. Therefore, it is important that the community is part of the conversation as the plans are developed. The goal is to create a system that serves the community in alignment with community values. She explained that we all have important work to do to achieve 100 percent renewable energy while ensuring affordability and equitability, both in terms of economics as well as geography. She acknowledged that transforming the entire energy ecosystem is challenging, underscoring the importance of working with the community. Because energy intersects with so many aspects of peoples' lives, changes to the energy ecosystem can both positively and negatively affect the community. The goal is to work with the community to design the system in a way that results in the most positive impacts as possible. She reiterated the importance of the community's input and thanked the participants for their time and interest in the process.

Kurt also acknowledged CERENE and explained that they are engaging with the community at the grassroots level to develop resilience hubs, such as the work being done by Hui o Hauʻula. Miku Lenentine explained that CERENE is based out of Kapiʻolani Community College and works with both the

University of Hawaiʻi Department of Urban and Regional Planning and the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency. She stated that CERENE is working with neighborhood groups and community centers to identify potential locations for resilience hubs across the island. She emphasized the comments shared by one of the community participants about the importance of community centers and the human element of resilience during emergencies. She stated that CERENE would be holding a meeting in Koʻolauloa on November 16, 2022 at which time they would share more details and have follow-up discussions regarding reslience hubs.

COMMUNITY FEEDBACK

WAIʻANAE MOKU (NĀNĀKULI – KEAWAʻULA)

OCTOBER 26, 2022

Introduction

The second of six Renewable and Resilient Energy Workshops hosted by Hawaiian Electric was held in the Waiʻanae moku of Oʻahu, which spans from Nānākuli to Keawaʻula. The workshop was held on October 26, 2022 at Agnes Kalanihoʻokahā Community Learning Center. There were approximately 19 attendees, as well as Hawaiian Electric staff; a list of attendees is included in Attachment C.

Hybrid Microgrids: Community Feedback

Based on the presentation of technical information regarding hybrid microgrids (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting hybrid microgrids in the Waiʻanae moku, including other criteria that should be included in the analysis as well as specific facilities that should be considered because they are important to the community.

He explained that Alani would be facilitating the discussion and reminded participants of the various ways that they can ask questions and provide input. Alani acknowledged the past history of environmental justice and inequity issues experienced along the Waiʻanae coast and stressed the importance of community input to the energy planning process. The questions and input provided by workshop participants is summarized below.

- One of the workshop participants expressed frustration that Hawaiian Electric is addressing the three communities that are currently hosting the majority of the renewable energy projects on O’ahu. She stated that as a member of a community that has been heavily affected, she would rather point to other communities than to identify locations in her community. She emphasized the need to address the injustices associated with all of the existing facilities hosted on the Waiʻanae coast and stated that she doesn’t want to offer up places for more facilities that the community doesn’t want. She stated that the community understands the need for renewable energy but thinks that the rest of the island should share the burden of hosting these facilities.

  Alani clarified that workshop are being held to solicit input from each of the six moku around the entire island of Oʻahu; he emphasized that the feedback received from each workshop would be documented and made available for all stakeholders to review. He also noted that the intent of the microgrids is to provide a benefit to the community by maintaining power at critical facilities during emergency conditions. For example, he suggested that the Waiʻanae Coast Comprehensive Health Center is an important facility that may benefit from a microgrid (but noted that specific facilities should be identified by the local community). The participant acknowledged the potential benefit of microgrids to the community, but emphasized that the rest of the island needs to share the burden – if not in terms of renewable energy projects then in other ways that can improve resilience (such as access roads). If other communities don’t have adequate space or the land is too expensive to site renewable energy facilities, they can instead help with funding to improve resilience in areas that are hosting those facilities. She emphasized that social justice crosses a multitude of community lifelines and the discussion shouldn’t be limited to only energy systems; other issues that should be addressed include transportation systems, food sustainability, and support for the few remaining farms. In summary, she stated that she appreciates the information being requested but instead of identifying where projects should go, she would like to focus on support for Waiʻanae.

- Another workshop participant expressed concern about the resilience of existing infrastructure in the event of a major hurricane. She stated that all infrastructure, including Hawaiian Electric's transmission system along Farrington Highway, needs to be bolstered. Several poles in Nānākuli have been replaced, but there are other locations along the Waiʻanae coast where the system needs to be strengthened. There is no value in establishing microgrids if there isn't a way to transmit power to them. As such, there needs to be a focus on improving the infrastructure to ensure that power can be delivered to microgrids, wherever they might be. She noted that there were previously discussions about undergrounding the transmission lines along Farrington Highway and acknowledged the concerns with cost, degree of disruption, as well as sea level rise. She stressed the need for action to be taken before another disaster strikes, noting that too often progress is not made due to cost or lack of consensus. Action is needed now to provide adequate infrastructure to support microgrids. In terms of specific facilities, she agreed with the need for a microgrid that serves Waiʻanae Coast Comprehensive Health Center as well as the dialysis center in Waiʻanae.

  Colton acknowledged the comments regarding the need for further hardening of the infrastructure. He noted that Hawaiian Electric recently filed an application with the Public Utilities Commission (PUC) for this very purpose. He emphasized that there is no single solution that will address all issues. Although microgrids are the focus of the current discussion, they are only one of piece of the larger puzzle that Hawaiian Electric is trying to solve. Kurt added that this is the exact type of feedback that Hawaiian Electric is seeking. He reiterated that microgrid analysis is just one part of the overall solution, and agreed that other efforts such as hardening existing infrastructure also needs to happen in parallel. He explained that hybrid microgrids are a new concept and this is one of the first times that Hawaiian Electric is discussing this topic with the community. He emphasized that the effort is still in the early stages and the information is incomplete as community input is still needed.

- Alani highlighted one of the comments received via Menti, which states "the concept is fantastic and relevant to the current situation of our energy crisis, but one criteria that I wonder is if cultural sites were included in consideration that may lay in scientifically ideal locations for renewable energy." Kurt responded that the analysis to date has not included this type of information, but that it will be critical to the process moving forward. Specifically, Hawaiian Electric is looking for site-specific information from the community that neither Hawaiian Electric nor potential developers may be aware of. Alani noted that any project that requires PUC approval will need to undergo some level of review by the State Historic Preservation Division (SHPD). However, he provided an example illustrating that SHPD is not always aware of all cultural resource issues that may be important to the community, and thus it is critical to obtain the community's cultural knowledge.

- Kurt also acknowledged another comment received via Menti regarding cost: "Who will pay to develop or construct a microgrid." He explained that the microgrid mapping is part of a larger effort associated with a PUC docket for a microgrid service tariff. As part of this effort, all of the microgrid mapping information including community feedback will be used to develop a Request for Proposal (RFP) for developers to submit bids for construction of microgrids on Oʻahu. Ken clarified that the genesis of the microgrid mapping effort was to support a program in which customers (or a group of customers) could self-fund the development of a microgrid. The data that is generated through the mapping process can also be used to identify opportunities for Hawaiian Electric to improve reliability. For example, Hawaiian Electric could pursue a microgrid as an alternative to building a new transmission line to meet reliability metrics. As such, there are different funding mechanisms that can be used for development of microgrids.

- Alani asked if there are specific locations, particularly in mauka areas, where the community gathers during emergency events. A workshop participant noted that an important mauka area especially for the Nānākuli and Māʻili community is the Lualualei Naval Magazine as it is relatively accessible and is one of the higher spots in the region.
- A workshop participant asked if there is a specific size for microgrids. For example, if a microgrid were developed for the Waiʻanae Coast Comprehensive Health Center, would surrounding areas also be included in the microgrid? Ken responded that under the hybrid microgrid program, the maximum size would be approximately 3 megawatts (which roughly equates to the capacity of a distribution feeder line); microgrids can also be smaller in size. He explained that the size of a microgrid is dependent on the circuit capacity and architecture, as well as the various criteria considered in the mapping analysis. Alani asked Ken to provide an example of an area that could be served by a 3-megawatt microgrid. Ken responded that the circuit that feeds the area between the elementary school in Waiʻanae up to Kaʻena Point is generally about the maximum size of a hybrid microgrid. Another example is illustrated on the map contained in the technical presentation showing two potential hybrid microgrids in Hauʻula, both of which include various homes and businesses. Alani suggested that Hawaiian Electric could compile maps showing potential microgrid locations in the Waiʻanae moku.
- A workshop participant stated that it is possible to identify locations that serve as community gathering areas, but it is also important to have trained community volunteers to receive people that would be coming to these locations. She noted that she lives right down the street from Kaupuni Park; a lot of community members come to this location but it is not always managed in an orderly manner (e.g., vehicle parking, tent placement, etc.). If sites are identified on a map as gathering locations, there needs to be some sort of organization or command so that they can temporarily welcome as many people as possible. Alani noted that Hawaiian Electric directly coordinates with disaster management agencies and other similar groups, and emphasized that this should be part of the discussion moving forward.

Kurt explained that because microgrids can be isolated from the grid, they require a backup power source. Therefore, he asked the community to think about what types of technologies should be considered in powering microgrids in the Waiʻanae moku. He explained that the community can provide feedback on this question moving forward.

In addition to the comments that were raised during the workshop, additional questions and comments were received via Menti. These comments are summarized below; copies of the responses are contained in Attachment D.

The following questions and comments were received via Menti in response to the question: *Is the proposed criteria aligned with the community's resilience priorities (if not, what's missing)?*

- You have done a good job but it needs to remain open for unforeseen scenarios. Also, the Veterans centers need to be included.
- In looking at how and where do we keep the Waiʻanae Moku powered during outages be of man or natural disasters, our distribution points/places - which are still being identified, and could be "Resilience Hubs."
- Which is the most ideal / powerful renewable source of energy you guys are looking at currently that still "works" for the community? Or just the source you have researched the most that works for Hawai'ʻi?
- The concept is fantastic and relevant to the current situation of our energy crisis, but one criteria that I wonder is if cultural sites were included in consideration that may lay in scientifically ideal locations for renewable energy.
- Identified mauka "safe havens" locations in each ahupuaʻa
- What's smallest grid possible? Does it make sense functionally, operationally and financially to try to create small compact ones - to address transmission vulnerability?
- How much of a financial impact would it be to create microgrids in Waiʻanae? Can we afford it? Who pays for it?
- Areas directly around our schools that are emergency and/or hurricane, tsunami shelters
- ʻAe, HECO must consider both oral history not documented by cultural organizations as well as documented written history cultural sites. Many ʻohana have stories and significant places not made public or stories passed down that makes sites kapu.
- Influence the military facilities to become sites
- Military sites (2)

The following questions and comments were received via Menti in response to the question: *What other community facilities are missing or should be included in the analysis?*

- Kaupuni Park in Waianae Valley Homestead
- Community Learning Center in Māʻili
- Military sites indeed

The following questions and comments were received via Menti in response to the question: *How should these microgrids be powered?*

- Firm power sources vs intermittent. Things that don't add environmental disposal hazards.
- Firm power not intermittent. Environmentally safe resources.

Renewable Energy Zones: Community Feedback

Based on the presentation of technical information regarding the Renewable Energy Zones analysis (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting of renewable energy resource development. He acknowledged there are improvements that need to be made to the planning process and this is part of an effort to better include community in that process. The questions and input provided by workshop participants is summarized below.

- A workshop participant referenced the 138kV substations shown on the Renewable Energy Zones maps and noted that these are locations where electrical voltage is increased to allow for transmission across further distances. He asked whether the electricity used for the microgrids could be transmitted at lower voltages, such that it would not need to be increased to the 138kV level. In this case, microgrids could be used to provide electricity for the local community (i.e. more distributed rather than centralized). Colton confirmed that this is the approach being considered for microgrids. Given the anticipated size (up to approximately 3 megawatts), the microgrids would be localized and interconnected at the distribution level (via lower voltage lines). In contrast, the Renewable Energy Zones analysis is looking at opportunities for large-scale renewable energy generation projects that would serve the island-wide grid. As such, the map is intended to show areas with technical resource potential that may be suitable for development. The analysis will help Hawaiian Electric to identify how much renewable energy generation could be developed in any given region to help meet the renewable energy goals for the island. To allow for safe and efficient use of the electricity, these larger-scale projects would need to interconnect at the 138kV level.

- The participant also noted that the analysis is focused on wind and solar photovoltaic technology and asked if geothermal is also being considered. Ken responded that although geothermal power may be possible, there currently is no data available specific to geothermal potential. He explained that the Renewable Energy Zones analysis will help to determine how much energy Hawaiian Electric should plan for in different regions around Oʻahu so they can develop the necessary transmission infrastructure to interconnect future projects. Colton added that there may be potential for geothermal energy, but there is no data regarding specific locations or quantities for the island of Oʻahu. Currently, the only data available relates to wind and solar potential; if and when data regarding geothermal (or other types of renewable energy resources) become available, these can be included in the analysis. Katy noted that the National Renewable Energy Laboratory (NREL) is currently working to incorporate geothermal into their renewable energy potential tool and hopes this will be available for widespread use by 2024. She noted that there are some datasets for other renewable energy technologies such as hydrokinetic marine. The workshop participant asked if there is data available for hydrogen technology; Katy responded that NREL is also working on this information.

- A workshop participant referenced the Renewable Energy Zones map and emphasized that it does not show any resource potential for areas such as Honolulu and Pearl Harbor. She asked about the potential for rooftop solar in these areas, including high-rise buildings. Although rooftop solar involves planning in smaller increments, she stated that there is significant potential especially given recent discussions about allowing for solar panels to exceed maximum building height limits. By excluding this information, she stated that a significant amount of resource potential is being ignored. She emphasized that the community's desire to maximize potential on existing structures rather than focusing on raw land was previously raised by the West Oʻahu/Kalaeloa Clean Energy ʻOhana, and she is disappointed that this input is not reflected in the Renewable Energy Zones analysis. Colton acknowledged the previous input provided by the West Oʻahu/Kalaeloa Clean Energy ʻOhana; he explained that this is being addressed as part of a separate effort and apologized that it is not reflected on the Renewable Energy Zones maps. He committed to sharing this information the next time Hawaiian Electric meets with the community. He explained that the Renewable Energy Zones analysis excludes certain areas (for example, high quality agricultural lands, urban areas, conservation lands, etc.) as a way to limit the potential for conflicting land uses; this is the reason why there is no potential shown for certain parts of the island. Katy also noted that the analysis is based on a 90-meter scale. Another workshop participant emphasized that even if the analysis indicates there is no potential for large-scale projects, it should still indicate that there is potential for rooftop solar; this is critical to help address equity across geographic regions and to encourage rooftop solar and other small-scale projects.
- A workshop participant shared information regarding the Energize Waiʻanae program, which is part of Solarize 808. This program will be rolled out in the Waiʻanae moku starting next month.
- Another workshop participant explained that they are part of the Renew, Rebuild Hawaiʻi committee. On November 17, the committee is hosting a webinar regarding geothermal energy, including representatives from Puna Geothermal, the University of Hawaiʻi, and other similar entities. He stated that this may be a good opportunity to get information and other resources (and can be shared with those who are not able to attend). He noted they recently hosted a webinar regarding ocean thermal conversion technology (OTEC), which is another alternative form of firm power.

- A workshop participant noted that the presentation showed that Oʻahu currently has 1,614 megawatts of firm capacity and 126 megawatts of renewable firm capacity. She indicated that these resources together total approximately 1,700 megawatts and asked if this is the target capacity once other renewable energy resources are brought online. Marc indicated that as other renewable energy projects are integrated into the system, especially projects that include battery storage, Hawaiian Electric will start retiring existing fossil fuel generation units which will decrease the total firm capacity. For example, the recent retirement of the AES coal plant reduced firm capacity by about 180 megawatts. The workshop participant asked what will happen in 20+ years when the system is operating entirely on renewable energy resources, but existing solar panels reach the end of their useful life. Colton explained that when a large fossil fuel generator such as the AES coal plant is taken offline, it does not necessarily need to be replaced with exactly the same amount of generation or energy storage. However, it is critical that the replacement energy is available on a consistent basis to ensure reliability; various ways of addressing this issue include using a mix of different technologies, as well as staggering the onboarding (and associated lifespans) of the various generation sources.
- A workshop participant referenced the increase in electrical prices when the AES coal plant was taken offline and asked how the transition to 100 percent renewable energy will affect prices. Colton explained that although the coal plant produced extremely high levels of greenhouse gas emissions, it also generated relatively cheap electricity. Therefore, increased price is one of the tradeoffs of no longer buying power from the coal plant as part of the effort to comply with state laws and policies. He explained that there have also been unforeseen events (including supply chain issues, economic downturn, and the Russian invasion of Ukraine) that have driven oil prices significantly higher than when the decision was made to retire the AES coal plant. However, he stressed that the goal is to select the right mix of renewable energy technologies to be brought online at a deliberate and efficient pace. Although it may not be possible to bring prices below their previous levels, they will be stabilized such that ratepayers can be protected from external events such as a destabilized oil market.
- A workshop participant asked about measures to protect the electrical grid from terrorist or cyberattacks and whether spare parts are maintained to facilitate system recovery. Colton explained that Hawaiian Electric has an entire team that is dedicated to protecting against terrorist and cyberattacks. He emphasized that this effort is tightly coordinated with multiple agencies at the federal and state level. He explained that although Hawaiian Electric is a small utility, the risk exposure is high because Hawaiian Electric is the only entity that provides power for the entire U.S. Indo-Pacific Command (PACOM); all other commands on the mainland are served by multiple utilities. He confirmed that Hawaiian Electric also maintains various spare parts for its system, including those needed to respond to attacks as well as hurricanes and other types of natural hazards.

In addition to the comments discussed during the workshop, additional questions and comments were received via Menti and in writing. These comments are summarized below; copies of the responses are contained in Attachments D and E (respectively).

The following questions and comments were received via Menti in response to the question: *What are the most important factors to consider for the siting of renewable energy on O'ahu?*

- Diversifying the kinds of renewable energy and not just place such a huge focus on solar
- Finding technology that takes up less land space and has a smaller footprint
- Fair, not necessarily just equal, and pono distribution across ALL communities
- Designing tech and systems for high rises and town areas
- Concentration and permeation of projects within a defined geographic area (identify threshold to manage number of projects, whether large or small)
- Physical security, cyber security, and accessibility for repairs such as large transformers.

The following questions and comments were received via the written comment cards:

- Are the areas of highest potential to host large renewable development be given highest priority usage of that resource? Or will it be sent to the higher usage sites? Example: Will Waiʻanae and North Shore side who have high land potential be given higher priority usage over Waikīkī (who is a high energy user)?
- Do you see your prime prospective locations for large renewable development and microgrids competing with sustainable agriculture plots and prime farming locations? Will you be willing to relinquish prime energy development locations and allow diversified sustainable agriculture to take the spot?
- I appreciate that the meetings are hybrid, that makes it more accessible.

COMMUNITY FEEDBACK

KONA MOKU (MOANALUA – EAST HONOLULU)

NOVEMBER 1, 2022

Introduction

The third of six Renewable and Resilient Energy Workshops hosted by Hawaiian Electric was held in the Kona moku of Oʻahu, which spans from Moanalua to East Honolulu. The workshop was held on November 1, 2022 at Kapiʻolani Community College. There were approximately 36 attendees, as well as Hawaiian Electric staff; a list of attendees is included in Attachment C.

Hybrid Microgrids: Community Feedback

Based on the presentation of technical information regarding hybrid microgrids (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting hybrid microgrids, including other criteria that should be included in the analysis as well as specific facilities that should be considered because they are important to the community. He explained that Alani would be facilitating the discussion and reminded participants of the various ways that they can ask questions and provide input. Alani stressed the important of community-based knowledge and stated that the purpose of the workshop is to gather feedback to ensure the analysis is aligned with the community's priorities. The questions and input provided by workshop participants is summarized below.

- A workshop participant stated that he recently completed a survey from the University of Hawaiʻi Department of Urban and Regional Planning; a key question was about where residents would like to get energy for their specific community. Similarly, he emphasized that the Center for Resilient Neighborhoods has a similar place-based focus on issues such as energy, water, and other resources. The survey included questions similar to those being posed by Hawaiian Electric and led him to think about health-related facilities. He explained that he lives in an area dependent on Kalanianaʻole and Kamehameha highways for access; if those roads are inaccessible, there would be limited options for health care services. As such, he thinks it would be valuable for a microgrid to include the Straub urgent care facility (located in the Hawaiʻi Kai shopping center). He emphasized that local facilities such as urgent care centers may have to handle any medical issues until roads can be safely opened.
- Another workshop participant referenced a City and County of Honolulu initiative to convert their entire fleet to electric vehicles. She stated that based on this initiative, theoretically all emergency response vehicles will be electric vehicles. She asked if the analysis has considered baseyards or other locations where the City and County of Honolulu's vehicle fleets are charged and stated that these are locations that will require energy. Ken responded that vehicle charging stations were not included in the analysis and stated that this is valuable input.
- A workshop participant asked for further definition of microgrids and how these would benefit the community. Alani offered an example based on his neighborhood, located in Kailua near Castle Hospital. He stated that the hospital is a critical facility as it will provide key medical services during an emergency; other critical facilities in this area include Kailua High School (which can serve as an emergency shelter), Olomana Fire Station, and a Hawaiian Electric substation. All of these facilities are located proximate to one another and are interconnected with the Hawaiian Electric grid. Installation of a microgrid would involve reconfiguration and hardening of the electrical system to allow these

facilities to be islanded (or sectioned off) during an emergency. If the island-wide grid were to lose power, local energy resources (e.g., backup generators located at Castle Hospital) could be used to power the various facilities within the microgrid.

Kurt asked representatives from the Center for Resilient Neighborhoods (CERENE) to also summarize the work being done in the Kona moku. Bob Franco explained that CERENE received an Action 15 grant from the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency,

and is partnering with the University of Hawai'i Department of Urban and Regional Planning to identify resilience hubs in each moku across O'ahu. CERENE thinks of a resilience hub as a structure as well as services that can be provided at that structure. In addition to the types of services that Alani referred to in his example (i.e., medical services, emergency shelter, fire station), other critical services relate to food, water, and communications. CERENE is conducting community engagement workshops in each moku and preparing similar maps using data from the University of Hawai'i Department of Urban and Regional Planning. He noted that this work is being done with support from Hawaiian Electric, who provided funding for their resilience core leaders, and CERENE is trying to get this to be part of student's learning experience at Kapi'olani Community College. He highlighted the synergies between Hawaiian Electric and CERENE's efforts, emphasizing that the microgrids could provide the energy lifeline for the resilience hubs. He stated that the power for the microgrid might not be located at the resilience hub as it could come from another nearby source, utilizing solar or other generation resources. He emphasized that CERENE has also spent a lot of time focusing on vulnerable populations, including kūpuna. He noted they also recently had a workshop with Pacific Islander pastors to discuss their response to the COVID epidemic.

- A workshop participant asked for clarification regarding whether microgrids are only for emergencies or whether they are also used for day-to-day conditions. Ken responded that the primary objective of a hybrid microgrid is to provide back-up power in the event of an emergency, which is why the focus is on siting them around critical facilities and/or in areas that are prone to outages. The workshop participant stated that it seems important to have microgrids available in rural areas at all times, not just in emergencies. Alani clarified that once installed, a microgrid is available for use at any time. Bob Franco emphasized that it is important to also remember that a long-term purpose is also to decarbonize the energy system.
- An online participant stated that she recently joined the resilience hub workshop at Waikīkī Community Center. She explained that during the resilience hub workshop, they discussed gathering areas that can be used by the community during an emergency; she stated that these gathering areas

should be considered for microgrids. She noted that her group identified Kapiʻolani Community College as an ideal gathering area.

Another workshop participant subsequently stated that he works at the Chancellor's Office and wanted to clarify that Kapiʻolani Community College is not a designated evacuation center; the nearest evacuation center is Kaimukī Middle School. He also stated that Kapiʻolani Community College is working with Kaimukī Middle School to develop a solar energy backup system across the street. He noted that there are several emergency responders and other entities in the immediate area (including the Red Cross, Department of Defense, Hawaiʻi Emergency Management Agency, Diamond Head State Park, and Department of Accounting and General Services [DAGS]) that can be involved in the discussion of energy needs; he stated that it is important to consider where the emergency responders are located and what type of energy they need.

- An online participant submitted a question via the chat function, asking if there are any plans in place for mobile microgrids to assist emergency response teams or organizations and emergency shelters during natural disasters during times of crisis. Ken responded that there are plans in development that would generally allow this type of response. For example, in the Koʻolaupoko region, Hawaiian Electric worked with the community to conceptually identify areas that could be isolated from the grid in an emergency and could host a mobile generator to provide power to certain critical facilities. He explained that this ability exists, but it takes a lot of planning and engineering to implement. Colton clarified that the generator is the mobile component; the facilities that are part of the microgrid are fixed in place and the electrical components must be modified and hardened to support the microgrid.
- Another online participant asked about the type of power that can be used for a microgrid. Ken responded that hybrid microgrids are designed to aggregate whatever energy generation resources are available for the various customers within the microgrid. As many customers already have rooftop solar and battery storage, this could provide a significant portion of the energy generation for a hybrid microgrid; however, this may be augmented by other types of energy generation resources.
- A workshop participant asked if vacant land is being considered for microgrids. She also asked if microgrids must be configured in a certain way, such as through triangulation. Ken responded that microgrids are generally developed for customers that receive electricity from the utility. Furthermore, a hybrid microgrid would generally include facilities that are served by the same electrical distribution line. To develop a microgrid, isolation points are added to the system to allow for those facilities within the microgrid to be isolated from the grid during an emergency.

  The participant asked whether an area with open land could be used to develop facilities to create a hybrid microgrid. Kurt referenced the work that CERENE is doing to identify resilience hubs; these may have their own source of power or may be connected to a microgrid with other critical facilities. Structures that are hardened and can accommodate people as a gathering place can also be considered; however, facilities such as hospitals should be prioritized for their primary purpose.
- Another workshop participant stated he lives in the Makiki neighborhood and during emergency events, most people shelter in place. He stated that he lives in Kalana Hale on Beretania Street; the

surrounding area includes many buildings with a lot of kūpuna (over 60 or 70 years old) as well as a food distribution center. He explained that there is a Foodland that has been vacant for 12-18 months; he is not sure about the commercial viability but stated that it may be appropriate as a community gathering location (without overwhelming other facilities such as medical centers). He also asked about public utility-private partnerships with commercial kitchens or similar sites (such as Kapiʻolani Community College). These are facilities where chefs can organize, with logistical support from other organizations that may have excess food, to help feed people; he emphasized that power is critical for these types of services.

Alani asked Hawaiian Electric staff to clarify the process for identifying locations for microgrids. Colton explained that existing information in databases and reports has been used to identify institutional facilities that provide various public functions, such as schools, state buildings, and emergency shelters. He emphasized the need for community-based knowledge such as underutilized facilities that may be modified to provide emergency services; he noted the importance of providing specificity to help inform the microgrid development process. In terms of the process moving forward, Colton explained that Hawaiian Electric has started identifying locations for potential microgrids; for example, a microgrid was developed in Hana several years ago and another microgrid is currently being proposed for the North Kohala district of Hawaiʻi Island. The intent is to expand the effort from these singular opportunities addressing infrastructural needs to more broadly address community priorities. The process to identify community priorities for microgrids is just starting; it will take several years to sort through, prioritize, and refine the opportunities based on the available data and community feedback. He also stressed that the need to figure out how individual microgrids will be funded. However, he stated that he believes that microgrids will become an inherent part of Hawaiʻi's energy system in the future as the opportunities are better understood.

- An online participant stated that she is an associate professor at University of Hawaiʻi Department of Urban and Regional Planning, and is working with CERENE and the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency on resilience hub planning projects. She explained that they conducted a community survey in April and gathered community input regarding frequently used community facilities that could be used as resilience hubs. She stated that it is an ongoing effort but they would be happy to share the findings to date. She explained that their effort includes a similar suitability analysis but because the resilience hubs would be community facilities, there is more focus on factors such as hazard vulnerability, transportation accessibility, social vulnerability, and community support; however, there is overlap and opportunities for collaboration.

  She also asked for clarification regarding the microgrid analysis in terms of whether Hawaiian Electric is seeking to identify facilities where microgrid equipment could be sited or facilities that a microgrid could serve; she noted that these could be one in the same or they could be different, depending on the scale. For example, is Hawaiian Electric trying to find sites to put solar panels to serve a microgrid, or the facilities that could be served by those panels? Alani confirmed that the goal is to identify the specific facilities that could be served by a microgrid based on the community's specific priorities and needs. Katy added that it is easier to move around the technology (for example, the customer-sited energy resources such as solar panels or batteries) than it is to move around essential facilities (for example, a community gathering place).

A workshop participant stated that a relatively new issue that should be considered is ransomware or hijacking facilities and asked how Hawaiian Electric would harden the grid to address those situations. She also asked whether a microgrid would decentralize the grid operationally. Colton explained that hardening serves to make the system more resilient; microgrids are only one component of this effort. Ultimately, for a microgrid to function after a major storm or disaster, all components of that microgrid (including the energy resource generation, as well as all of the wires that connect the energy resource generation to the critical facilities) must be able to withstand the disaster. As such, the electrical wires and lines forming the microgrid need to be hardened. He emphasized that it is also important to harden other lines comprising the rest of the grid to help improve overall reliability, as it isn't possible to build a microgrid for every customer. Regarding cyberattacks, Colton explained that this is an ever-growing challenge that many industries face, not just the energy sector. However, he stated that Hawaiian Electric is particularly at risk because electricity is such an important part of our society; in addition, Hawaiian Electric is the sole utility serving the entire U.S. Indo-Pacific Command (PACOM). As such, he emphasized that Hawaiian Electric spends an enormous amount of their resources and works directly with multiple federal and state agencies to ensure the energy system is resilient and resistance to cyber threats.

With respect to the question about whether microgrids will result in a more distributed electrical system, Colton indicated that it is yet to be determined what the future electric system will look like; however, it is fairly certain that it will be more decentralized and microgrids are needed to make this possible. It is unclear whether the system will be completely decentralized as there are certain aspects of a resilient grid that requires larger, centralized resources.

In addition to the comments discussed during the workshop, additional questions and comments were received via Menti and in writing. These comments are summarized below; copies of the responses are contained in Attachments D and E (respectively).

The following questions and comments were received via Menti in response to the question: *What other community facilities are missing or should be included in the analysis?*

- Multi-family homes and large walk-ups with multiple owners that can technically have renewable energy sited and storage but there are implementation barriers to installation.
- Community gardens (2)
- Hawaiian cultural sites
- Homeless shelters and food pantries
- Can you help us understand why microgrids are good for communities? How can this new solution speak to energy justice?
- Large landowners

- Confused why schools were not included when there are so many unused/open parking lots and rooftops that could (should) be generating clean energy which are spread across all communities and are already public resources (not always year-round)
- Open space/parks such as Ala Moana Beach Park or Kapiʻolani Park
- Major grocery/retail stores for medicine and emergency supplies
- Narrow valley neighborhoods with only a few roads (and sub-trans/distribution lines) that lead to entire load centers
- Sites with EV chargers
- Will you be able to explain microgrids again?
- Vulnerable utility lines
- Community centers, both public and private (i.e., within subdivisions)
- Multigenerational homes with elderly
- Domestic violence/women's shelters
- KCC + Leahi + Kaimuki Fire Station + Diamond Head Theatre + Diamond Head movie studio could be resilience hub
- Critical shopping malls and nearby gas stations
- Don't forget about the community parks and pools
- Red Cross Headquarters is also nearby
- Grocery stores and large warehouses
- Language barriers
- Community Centers, Queen Theatre, National Guard Facility
- Security, including cameras to deter looting, which would probably happen in Waikīkī
- Entire school campuses - including student housing
- Convention center, after converted to an emergency shelter, and nearby shops
- Pumps for water treatment facilities and flood control; telecommunication towers
- Is this a way to bring nuclear or other dangerous power systems here?
- What is the span of a microgrid? How large or small of an area can a microgrid support?
- Major food distribution warehouses and non-restaurant kitchens
- Water pumping stations, sewage treatment, and hydroelectric facilities

- Mobile microgrids to support emergency response teams, disaster resilience/response shelters, medical device charging stations, and personal electronic needs
- Facility management centers
- Homeowners associations
- Energy efficiency within the selected grids
- Indigenous sites, areas of cultural importance, churches
- What happening to the energy wheeling law?
- What about allowing for off-grid ecovillage communities that would be less reliant on County services?
- Traffic control center, emergency management center, telecommunication hubs
- What about creating planning department guidelines to allow for ecovillage communities so people can live off-grid, or at least less reliant on county services?
- FED/DOD must pitch in too ....
- Schools, community centers, community health centers, non-profits, areas where community members already gather

The following questions and comments were received via the written comment cards:

- Could a personal microgrid be built so they are moveable (away from lava) or protected (from hurricanes)?
- How will these projects be funded? Will the cost be put on customers?
- How is accountability and transparency built into this process, aside from gathering community input?
- What are additional outreach efforts the team is making to gather community input? Many people from low income or working class backgrounds aren’t able to attend due to competing priorities (e.g., work, family, etc.).
- Great discussion! Glad that the community is being involved. Looking forward to more.
- Are there instances or examples that a microgrid can fail post-disaster?
- How do we pay for the microgrid?
- How long does it take to install a microgrid?
- What about broadband expansion?

Renewable Energy Zones: Community Feedback

Based on the presentation of technical information regarding the Renewable Energy Zones analysis (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting of large-scale renewable energy resource development to decarbonize the energy system. He emphasized that the results are preliminary but are being shared as part of an effort to better include community in the energy planning process. Alani referenced concerns that have been raised with respect to equity and social justice and stated that this is an opportunity for community members to voice their opinion regarding specific factors and site suitability. The questions and input provided by workshop participants is summarized below.

- A workshop participant asked if there is any consideration as part of the competitive bidding process to require cost benefits or other community benefits for the communities hosting the projects. She emphasized that so many communities are having bear the burden with no real recognition or reward. Kurt responded that this is an excellent point and stated that there is important work to be done as part of future procurement processes. He explained that the next Request for Proposal (RFP) will be the Stage 3 RFP for Hawaiʻi Island, followed by the Stage 3 RFP for Maui and Oʻahu; these are currently in the final Public Utilities Commission (PUC) review process. He stated that for the first time, these RFPs include requirements for community benefits; these requirements are largely the result of input received from communities such as West Oʻahu, which have had to bear the burden of much of the infrastructure to date. He explained that this is a relatively new process and isn't likely to be perfect, but the goal is to ensure that the benefits are going directly to the host communities, with the investment addressing needs identified by the community. He also emphasized that there is still work to be done at the community level and there is ongoing discussion about other elements that can be incorporated to make the process as equitable as possible moving forward.
- A workshop participant stated that there is a lot of open space between Kapiʻolani Community College and 22nd Avenue; much of this area is associated with the Department of Defense and could be a good place to site solar energy facilities. He noted that the neighborhood board tends to be concerned about siting anything on Diamond Head, so it would be important to have discussions with that group. He also stated that another location to consider relative to ensuring food availability is the area around the airport, as a way to keep food moving either to supermarkets or other key sites.
- A workshop participant noted that the Renewable Energy Zones analysis is focused on solar and wind, which are currently the main technologies. She asked how Hawaiian Electric's Integrated Grid Planning (IGP) process would incorporate new technologies (such as geothermal, offshore wind, hydrogen as those technologies become more viable in the future. Colton confirmed that the Renewable Energy Zones maps are based on solar and wind potential, because those are the resources for which data is currently available. However, as part of the IGP planning process, the goal is to develop an energy portfolio for the future; other technologies (such as geothermal, biomass, hydrogen) are candidate resources being evaluated as part of that effort. Colton stressed that they are doing their best to factor in advancements and cost of future technologies into the selection portfolio. As the process

moves forward toward development, those technologies will be considered. He noted that the IGP plan is intended to inform decision-making for the future, but what is actually developed in the future will likely differ from the plan as there are many non-technical aspects (such as land use policy) that will also factor into the final implementation plans. The workshop participant stated that there are some technologies that are ready for implementation that haven't necessarily been considered, such as micro-hydropower with dams and pumped storage hydro facilities.

- A question from Menti was discussed: "Will nuclear power or other dangerous technologies be considered as part of this process?" Colton stated that nuclear power is constitutionally banned in the State of Hawaiʻi. As such, planning for the future energy system is not currently considering nuclear power as an option.

In addition to the comments discussed during the workshop, additional questions and comments were received via Menti. These comments are summarized below; copies of the responses are contained in Attachment D.

The following questions and comments were received in response to the question: *What are the most important factors to consider for the siting of renewable energy on O'ahu?*

- Current land cover
- Work in tandem with newer Customer Distributed Customer Energy Resource programs, including aggregators, and Smart DER BYOD
- Will the sites that have highest potential for large renewable development be given high priority access to those resources? (In other words, will they be used for their land but it all goes to high users like Waikīkī/Urban Honolulu?)
- Cost
- Effectiveness of the location
- Community burden
- Cold beer!
- Native Hawaiian lands, no desecration
- Taking into account areas of historical/cultural/indigenous importance and preventing further mistrust
- Areas that lack their own generation
- Proximity to energy use
- The cost especially HOA groups with multi building complexes. How can those communities go solar and be self-sufficient with a reasonable cost to owners?
- Geographic energy balance
- What about allowing for off-grid ecovillage communities that are less reliant on County services?

- Impact on native species and whether the sites will cause a negative impact on indigenous flora/fauna
- Ecological factors
- Vacant lands but close to existing electric infrastructure
- While Honolulu doesn't have space for large development, they are the largest users of energy on the island and waste it haphazardly for aesthetics. Will we charge them more to use the renewable energy farmed in Waiʻanae / North Shore?
- Multiple uses (e.g., agrivoltaics)
- Community residents in that ahupuaʻa have had a chance to express their preferences for siting or the aspects of a clean energy project. Placed on already developed land? Placed out of view? Allow the community to shape the project, to inform location.
- Will this project compete with probable prospective agriculture plots? Will sustainable food planning have to compete with your company striving for renewable energy? In other words, will you be willing to relinquish prime location for agriculture?
- Intersect of cost, renewable project resilience, and environmental impact
- Financial incentives, "Energy Cash Back" incentives
- Locations with wind, wave, and solar resources but avoid negatively impacting cultural, historic, natural and human resources
- Soil health
- Environmental impact and sustainability
- Existing infrastructure
- Community (includes ecological health) benefits
- Thoughts on vertical farming powered by renewable energy?
- Diverse portfolio
- Large scale utility sites should be kept in areas away from the general public
- Not losing efficiency because of a site that is far from the population that is using the energy; more distance often times can lead less efficiency
- Renewable energy is actually clean
- The trade-offs should be well understood. For example, if we use vacant land for renewable energy, that same land will not be available for affordable housing, or for more agricultural activities, etc.
- As we all just saw, an emergency proclamation could mean that dangerous technologies could be implemented without public input.

COMMUNITY FEEDBACK

WAIALUA MOKU (KAʻENA – KAPAELOA)

NOVEMBER 3, 2022

Introduction

The fourth of six Renewable and Resilient Energy Workshops hosted by Hawaiian Electric was held in the Waialua moku of Oʻahu, which spans from Kaʻena to Kapaeloa. The workshop was held on November 3, 2022 at Waialua Elementary School. There were approximately 10 attendees, as well as Hawaiian Electric staff; a list of attendees is included in Attachment C.

Hybrid Microgrids: Community Feedback

Based on the presentation of technical information regarding hybrid microgrids (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting hybrid microgrids, including other criteria that should be included in the analysis as well as specific facilities that should be considered because they are important to the community. He explained that Alani would be facilitating the discussion and reminded participants of the various ways that they can ask questions and provide input. The questions and input provided by workshop participants is summarized below.

- A workshop participant stated that it is possible for residents be off grid if they have adequate resource generation (for example, solar photovoltaic panels and battery storage). To the extent that residents are connected to the grid and have adequate resource generation, it is possible to create a microgrid; however, this costs a lot of money. He stated that when people initially started installing rooftop solar, Hawaiian Electric used to a formula to determine how much power they would buy but this changed over time. He acknowledged that Hawaiian Electric needs to collect enough money to cover their overhead costs but emphasized that consumers don't want to pay any more than necessary; he asked what Hawaiian Electric's formula will be to balance these needs. Ken explained that microgrids can be developed at different scales. For individual customers (such as a single residence), he stated that Hawaiian Electric has programs in place that provide compensation to customers for exporting electricity to the grid at certain times of the day; this also allows customers to use their battery system for backup power. He noted that there is another program currently in place (called "Battery Bonus") which provides extra compensation to customers that add battery systems. The purpose of the microgrid mapping effort discussed in the technical presentation is to identify potentially suitable areas where multiple customers can create a microgrid using their aggregated generation resources. Based on the current approach, this is a customer-based program such that the microgrid would be set up and paid for by the customer; this could be a single resident, a cluster of residents/businesses working together, or agencies that are trying to increase resilience of their system. The participant noted that if the customer is a fire department or hospital (or similar), the cost would come back to the taxpayers.
- A workshop participant stated that she works for the Board of Water Supply (BWS) and asked if Hawaiian Electric has coordinated with BWS or other agencies such as the Department of Education (DOE). She stated that it will be difficult to find a location on the North Shore that the community is comfortable with, depending on the visual impacts associated with the infrastructure. She stated that

it would be beneficial to collocate the infrastructure with other agency facilities that need to be connected with the Hawaiian Electric grid. For example, depending on the size of the infrastructure, it could possibly be collocated near the BWS reservoirs in Pūpūkea. She emphasized that the agencies are typically very supportive of any efforts to assist with disaster preparedness. As a second point, she also highlighted the fact that much of the available land along the North Shore is within the tsunami evacuation zone. For example, Waialua Elementary School is within the tsunami inundation evacuation zone; the only school that is not within the tsunami evacuation zone is the high school. Therefore, any proposed infrastructure should be sited in mauka areas. Specific facilities that should be considered for a microgrid include the hospitals in Kahuku and Wahiawa. Marc responded that Hawaiian Electric has been working with BWS as well as other state agencies such as Hawaiʻi Emergency Management Agency through their resilience working group. He also noted that Hawaiian Electric's Integrated Grid Planning process includes a stakeholder council, and BWS is represented there as well. The workshop participant suggested bringing those entities together with the community as this could make the process more efficient.

In response to the inquiry about the visual impacts, Kurt explained that microgrids typically do not involve highly visible infrastructure. The primary components involve hardening the system, such as replacement of existing wooden poles with new steel poles, to make it more able to withstand a disaster event, as well as electric switching units allow that portion of the grid to be isolated. He explained that they also require an interconnection point for some form of energy generation, whether it is renewable energy resources or a mobile generator. Together, these components allow a portion of the grid to be sectionalized and powered using backup energy in the case of an emergency. He noted that Hawaiian Electric would like input regarding the types of backup power the community would like to use for microgrids. He emphasized that there are no projects designed yet, so this is still a conceptual discussion.

- A participant asked if the microgrids would require a lot of agricultural land. He emphasized that much of the available land on the North Shore is agricultural land, including the land above the pumping station and water tank along Kamehameha Highway. He asked if microgrid infrastructure is allowed on agricultural land. Kurt responded that infrastructure would not be sited on the highest quality (Zone 1) agricultural land, but possibly on lower quality (Zone 2) agricultural land.

  The participant asked more specifically about the need for energy storage as part of microgrids and if needed, whether this would occur on agricultural lands. Kurt explained that the need for energy storage would be based on the generation source. He reiterated that no specific projects have been designed yet, but if the community would like a microgrid powered by solar photovoltaics, then it would likely need to include battery storage. He emphasized that determining the appropriate place for siting energy generation is another part of the microgrid discussion for which Hawaiian Electric would like to get community input.

  Ken clarified that the genesis of the hybrid microgrid mapping effort was to enable customers to identify whether a microgrid makes sense in any given location based on certain factors; however, the data can also be used to site microgrids. Colton explained that there are a number of reasons that microgrids may be developed. In some cases, microgrids are developed by Hawaiian Electric to improve grid reliability in certain service areas. For example, Hawaiian Electric uses the generators that were built at Schofield Barracks to serve a microgrid for surrounding areas. However, Hawaiian microgrids can serve other purposes to meet the needs of customers – either individually or working together, perhaps in combination with a third party. As such, Hawaiian Electric is trying to facilitate that process by creating maps that provide relevant information; he emphasized that community input is needed to inform the analysis. He noted the previous questions regarding use of agricultural lands and types of energy generation, stating that these questions are ripe for discussion if the community is looking to develop a hybrid microgrid. He emphasized that these are decisions that should be made by those who have an interest in developing a microgrid. To further clarify, he explained that if an individual customer that wants to use rooftop solar and battery storage to run their home or business off-grid, this type of microgrid would be implemented and funded by the customer. In cases where Hawaiian Electric believes a microgrid is needed to improve grid resilience, such as in a remote service area, this could be implemented as a utility project (assuming that it is demonstrated to be cost effective in comparison to other alternatives as required by the Public Utilities Commission [PUC]). Hybrid microgrids, in which utility infrastructure is used to connect multiple customers, would be implemented and funded by that group of customers and/or a developer; he emphasized that Hawaiian Electric is trying to provide these opportunities for customers and has a tariff in place to help, but ultimately these actions would be customer-driven.

- An online participant noted that Hawaiian Electric is referring to "customers" but is also referring to a public function for microgrids in terms of disaster preparedness. She asked whether these microgrids would be publicly funded (for example, using federal or state funds) or whether the community would need to pool their resources to provide the necessary funding. Kurt explained that the term "customer" refers to individual residences as well as any other entity that receives electrical service from Hawaiian Electric. In terms of funding, he explained that in addition to customer microgrids, there could be some form of collaboration for larger scale microgrids such that they aren't solely paid for by the community. For example, there could be opportunities for funding to come from the rate base or by issuing a Request for Proposal (RFP) for low-cost microgrid construction based on a competitive bidding process. Alani emphasized that the focus of the current discussion are hybrid microgrids that would support disaster preparedness for the community and would be publicly funded.

  The participant also explained that there are community groups working across the state as part of the Hawaiʻi Hazard Awareness and Resilience Program. She explained that the group in Wahiawa spent approximately a year and a half identifying areas of strengths/weakness and developing a plan for their community. She suggested that Hawaiian Electric review those plans as they provide detailed information from the community about specific structures requiring protection and areas where infrastructure should be hardened. Kurt stated that this will be a valuable resource moving forward; he requested help getting access to the reports. He explained that Hawaiian Electric has been working with Hawaiʻi Emergency Management Agency and other state and local agencies, but that this level of specificity from the community will help to further inform the planning efforts. Both Kurt and Katy emphasized that the goal is to identify specific facilities that are important to the community but may not be in official datasets.

- A workshop participant expressed support for building microgrids in the community. He recommended that the effort include an analysis of areas that may have existing asphalt (especially asphalt in need of repair), as this would provide an additional community benefit. He emphasized that infrastructure maintenance is a major issue on the North Shore, so solutions that incorporate microgrid opportunities with reinforcing existing infrastructure will be well received by the community. He noted that there could be opportunities if the community has plans to reuse the sugar mill, or at shopping centers, or possibly by looking at historic land uses (for example, agricultural land with disposal pits or old structures that may not be suitable for growing food); he noted that these may be small areas but could provide infill opportunities for energy infrastructure with minimal disruption to agriculture.
- A workshop participant stated that the microgrid concept is confusing, as she tends to think of a self-contained power generating unit. If the desire is to have customers work together to form hybrid microgrids, it would be good to identify and connect customers with grant programs and other funding opportunities. For example, Hawaiian Electric's stakeholder group could help to identify these types of resources for the community. She added that definitions are important and encouraged Hawaiian Electric to develop a list of key terms with the specific meaning as a way to improve communications.
- An online participant submitted a question via the chat function, asking if microgrids are a resource that would support emergency management in the event of an emergency. The participant stated that there aren't emergency shelters in the Waialua moku so any effective facility would have to be up the hill towards Wahiawa; however, shelters and emergency facilities are needed before they can be powered. Kurt confirmed that hybrid microgrids would be for critical facilities; in addition to the type of facilities identified in the technical presentation, he also emphasized that it also should include facilities that the community feels are important to have access to emergency power in the event of an emergency. The intent is for microgrids to make the grid more resilient by addressing specific vulnerabilities, thus contributing to emergency preparedness.

  Kurt also explained that the Center for Resilient Neighborhoods (CERENE) is working on efforts related to these community needs. For example, based on a need identified by Hui o Hauʻula, they are currently working to build a resilience hub with the Hauʻula community. Ultimately, CERENE is working toward identifying opportunities for resilience hubs for communities across the island. In looking at the big picture, these two efforts dovetail in that if a community builds a resilience hub, it could be integrated with a microgrid for backup emergency power. He acknowledged that it is a lengthy and complex process but explained that there are a lot of efforts happening in parallel.

- A workshop participant stated that it is not good to ask people what they think and put the cart before the horse. He also stated the microgrid schematic in the technical presentation is pretty conceptual, so he is trying to better understand the design of a microgrid. He also stated that it would be nice if the design could be cookie-cutter and asked about the approximate footprint. He understands that it is early in the process but emphasized that it would be helpful to have more visuals. Alani acknowledged the input and stated that the team would work on providing more concrete information. Marc added that an example of a hybrid microgrid serving multiple critical facilities in the community could include a fire station, hospital, and emergency shelter all located within approximately one-half mile of each other.

In addition to the comments discussed during the workshop, additional questions and comments were received via Menti and in writing. These comments are summarized below; copies of the responses are contained in Attachments D and E (respectively).

The following questions and comments were received via Menti in response to the question: *What other community facilities are missing or should be included in the analysis?*

- Didn't see anything
- What will these micro grids look like?
- No more wind on north shore
- Visual impact on the landscape
- How big will they be?
- No offshore wind
- Looks fairly complete
- Social and economic justice

The following questions and comments were received in writing on the response cards and the online chat function in Zoom:

- Like to see complete emergency kit to store with long shelf life (years)
- Like to see education of real disaster (film); i.e., tsunami, hurricane, etc.
- Politicians need to prioritize the dollars to prepare (i.e., evacuation centers and supplies)
- What would make a microgrid…a poor investment?
- Water is #1 – make sure Department of Water can get water out of the ground (i.e., energy for pumps)
- Need stronger visuals that show footprint
- Microgrid is kind of confusing

- Grants etc. to help customers
- Definition of terms
- Information regarding Hawaiʻi Hazard Awareness and Resilience Program: https://www.representativeamyperruso.com/hharp
- Wahiawā is ready for and needs such support - as we will be a clear evacuation site, and the military has told us many times that they will serve their own purposes first
- The Schofield-Wahiawā resiliency hub raises questions, for me, about that partnership, because we have been told many times that Schofield resources will be used for Schofield first. Can you come to Wahiawa and do a public presentation on that particular grid, please? Waialua definitely needs separate and more geographically accessible resilience support.

Renewable Energy Zones: Community Feedback

Based on the presentation of technical information regarding the Renewable Energy Zones analysis (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting of large-scale renewable energy resource development to decarbonize Oʻahu's energy system. He emphasized that the results are preliminary but are being shared as part of an effort to better include community in the energy planning process. He acknowledged that the North Shore is carrying a heavy load with respect to renewable energy, noting that future RFP processes will incorporate requirements for community benefits as part of a broader effort to improve energy equity. The questions and input provided by workshop participants is summarized below.

- A workshop participant stated that the North Shore Sustainable Communities Plan is currently being updated; this area (including Kahuku) currently has the greatest amount of renewable energy on the island. She stressed that the community does not support wind turbines, particularly offshore wind turbines. Alani noted this same comment on Menti and noted that community members can also add similar comments to the mapping tool at www.hawaiipowered.com/oahu.
- A workshop participant stated that future RFPs should include legal language to ensure that developers are compliant with the specific requirements so that the community doesn't need to hire their own lawyers. He emphasized that Hawaiian Electric should be in a position to make sure these issues are addressed so it doesn't fall to the community. Kurt stated that moving forward, the RFPs will include stronger language that holds developers more accountable. He explained that there will be a requirement for developers to document their dialogue with the community, the needs identified by the community, and the commitments made to the community; these documents will be made public as part of the RFP process and developers will need to comply with their commitments over the full contract term for the project.
- A workshop participant stated that based on discussions at neighborhood board meetings, her understanding is that rooftop solar programs are no longer available for the North Shore, in part because Hawaiian Electric's system cannot handle any more solar energy in this area. She indicated

that this is something that Hawaiian Electric needs to consider if they want to move forward with plans that include rooftop solar for resiliency. She also stated that other locations such as in East Honolulu should be considered for future wind projects. In addition, she emphasized the value of grant programs to help residents fund rooftop solar projects. Kurt acknowledged the comments and referenced the Solarize 808 program, which is a collaboration between Hawaiʻi Energy and Hawaiʻi Green Infrastructure Authority (HGIA). Through this program, community members that want to install rooftop solar can work together and issue an RFP for developers or installers as a way to lower costs. The program is starting in Kahuku and elsewhere in Koʻolauloa but will also be offered to the North Shore and Waianae communities as well. He noted that there is an opportunity to incorporate GEMS funding for people who qualify; in addition, Hawaiʻi Energy will work with homeowners to lower their consumption in parallel with installing rooftop solar. He also highlighted another program for shared solar (also referred to as community based renewable energy [CBRE]) which provides an opportunity for those without the ability for rooftop solar to still get access to solar energy. He noted that there has been a lot of improvements to the RFP process for shared solar based on community input; for example, if a project were to be constructed in the Waialua moku, the community that lives closest to the project would be given the first chance to subscribe such that they would directly benefit from the project. He explained that the shared solar program is still in the RFP process, but Hawaiian Electric will share more information with the community as the process moves forward.

- A workshop participant stated that microgrids seem fairly complex and require a lot of engineering. He suggested that it may be possible to incorporate some of the legacy infrastructure on the North Shore, specifically referencing the network of former plantation irrigation infrastructure (such as reservoirs, canals, and channels) for hydropower. He noted that Dole is in the process of unloading much of this infrastructure, but that water supply is critical to the agricultural community on the North Shore. If there are federal funds and other partners involved, use of this infrastructure as part of microhydro project (for example, a system that pumps water uphill at night with hydro power when it rains while solar isn’t generating) could leverage resources and provide benefits in terms of both energy generation and food sustainability. Marc emphasized that other technologies beyond solar and wind are being considered and explained that the RFPs are structured in a way that allow developers to propose projects using these other technologies.
- An online participant submitted a question via the chat function, stating that they heard offshore wind is being planned off Ka’ena Point and asking if this is just a rumor as they don’t see any offshore wind projects shown on Hawaiian Electric’s map. Colton responded that several developers previously approached Hawaiian Electric regarding their interest in developing offshore wind. He stated that currently there are no proposals being considered by Hawaiian Electric. He noted that he is aware of at least one developer that has been discussing offshore wind with different neighborhood boards, but his understanding is that this would not involve Ka’ena Point.
- A workshop participant noted that solar developers prefer to site solar project in flat areas, which is typically agricultural land. He also noted that in terms of cost efficiency, projects that are proximate to major overhead lines do not require the cost of constructing new transmission infrastructure. He

offered the idea of suspending solar panels under the 46kV transmission lines, as this would solve for issues related to topography and proximity to existing infrastructure.

- A workshop participant asked if Hawaiian Electric stays apprised of housing and other types of development occurring in certain areas. He stated that there is a plan to add a large number of affordable rental housing units in Waialua; he suggested that it would be good for Hawaiian Electric to coordinate with the developers so they can incorporate elements into their development that allow it to be part of the microgrid and other similar planning efforts (rather than something that just gets added on later). Kurt explained that land use and plans for development typically depend on landowner preference. The purpose of these discussions is to capture the community's voice before landowners come forward and agreements are put in place. He explained that for any type of development, whether it is for renewable energy or housing, the developer and landowner would need to address land use as part of the permitting and regulatory process. He also noted that prior to the RFP process, Hawaiian Electric issues a Request for Interest (RFI) to solicit landowners that are interested in developing renewable energy on their land. In terms of adding electric loads as part of a new housing development, Colton explained that Hawaiian Electric works to integrate these into the planning process as much as possible. He explained that they have an entire team focused on providing electrical service to customers, and they proactively work with landowners and development teams to educate them on Hawaiian Electric's processes and to incorporate requirements for electrical service into their development plans.

In addition to the comments discussed during the workshop, additional questions and comments were received via Menti and in writing. These comments are summarized below; copies of the responses are contained in Attachments D and E (respectively).

The following questions and comments were received via Menti in response to the question: *What are the most important factors to consider for the siting of renewable energy on Oʻahu?*

- No more wind on north shore
- Visual impact on landscape
- Solar on rooftops
- Sea level rise and concurrent environmental issues (cesspools, tsunami zone, etc.)
- Equity
- Make sure electricity generated in community stays in community
- Social and economic justice
- Cost effectiveness

The following questions and comments were received in writing on the response cards:

- Like HECO to ensure subcontractors and supplies are legally compliant so community does not need to hire lawyers

- Can HECO help the community fight BOEM plan to develop offshore energy; not a popular idea
- Is there a plan to get energy infrastructure in the ground?
- In 10 years if electrical cars equal 90 percent of vehicles with no gas, how much increase in electrical energy must be developed?
- Regarding agricultural land, we need an island-wide plan for energy land use
- Can land under the existing 46kV powerlines be used for solar? Note: If suspended or cables, the topography will not be so significant.
- North Shore has most amount of renewables
- Solar on rooftops
- Put wind in East Honolulu next

COMMUNITY FEEDBACK

KOʻOLAUPOKO MOKU (WAIMĀNALO – KUALOA)

NOVEMBER 15, 2022

Introduction

The fifth of six Renewable and Resilient Energy Workshops hosted by Hawaiian Electric was held in the Koʻolaupoko moku of Oʻahu, which spans from Waimānalo to Kualoa. The workshop was held on November 15, 2022 at Windward Community College. There were approximately 16 attendees, as well as Hawaiian Electric staff; a list of attendees is included in Attachment C.

Hybrid Microgrids: Community Feedback

As part of the presentation of technical information regarding hybrid microgrids (as summarized previously in this report), Ken described a specific type of microgrid being pursued in the Koʻolaupoko moku based on work done through the Koʻolaupoko Resilience Initiative working group over the last several years. Through that process, certain areas within Koʻolaupoko were identified as critical customer hubs (CCHs). These CCHs include areas with critical facilities that serve multiple community lifelines; by adding switching equipment and other related components, these areas can be isolated from the grid and powered using mobile diesel generators during an emergency event. He explained that the CCHs identified through the Koʻolaupoko Resilience Initiative include multiple locations such as Olomana, Waimānalo, and the Windward Mall area in Kāneʻohe. These CCHs were proposed as part of a FEMA grant (Building Resilient Infrastructure and Communities [BRIC]), which would provide federal funds for construction of the CCHs; although not selected for the original grant, the same CCHs will be re-proposed as part of another upcoming grant opportunity.

Kurt explained that the energy system in Koʻolaupoko is particularly vulnerable because there is no generation in the region and electricity is delivered via three transmission lines that traverse the Koʻolau Mountains. Although Hawaiian Electric is working to harden this infrastructure, it is still possible that it

may not withstand a severe hurricane. He stated that a lot of input was previously provided by community leaders as part of the Koʻolaupoko Resilience Initiative. He explained that Hawaiian Electric is looking to continue these discussions by getting additional input on other criteria that should be included in the microgrid mapping analysis as well as specific facilities that should be considered for a hybrid microgrid because they are important to the community. He explained that Alani would be facilitating the discussion and reminded participants of the various ways that they can ask questions and provide input. Alani stressed that the purpose of the workshop is to gather the community's input to ensure the analysis is aligned with the community's priorities. The questions and input provided by workshop participants is summarized below.

- A workshop participant asked how large of an area a microgrid can serve. Ken responded that hybrid microgrids can generally serve an area equal to the area served by one distribution feeder. At the neighborhood level, this would be about one hundred homes (plus or minus); if considering a large facility (such as Windward Mall), a hybrid microgrid could also include some surrounding areas. He noted that microgrids can also cover smaller areas.
- An online participant asked if there is a timeframe for providing input on the hybrid microgrid mapping effort. Ken explained that this initial effort conducted by the National Renewable Energy Laboratory is scheduled to be complete by approximately March 2023; any input received by early January will be incorporated into the first set of hybrid microgrid maps. Kurt emphasized that this initial effort is just the beginning of the process and will provide a snapshot in time. He explained that the planning process will continue into the future and potentially will be followed by a procurement and development process, all of which would include additional opportunities for community input.
- A workshop participant referenced the parking lots at Windward Community College as being covered with solar photovoltaic panels, noting that France just recently committed to covering all of their parking areas with solar panels. He asked if school facilities with solar panels have been included in the microgrid mapping, noting that solutions for energy storage also need to be considered. Ken responded that the mapping effort identifies both the existing customer energy resources (such as existing solar panels on schools) as well as the energy load in any given area, as locations where resources and loads are balanced are good candidates for a hybrid microgrid. However, he explained that additional energy generation can be added to augment existing resources to support a microgrid, if necessary. The participant noted the value of a microgrid to provide backup power to an emergency shelter during a disaster event, but also emphasized the importance of energy storage for facilities with kitchens and refrigeration; these services are critical for community resilience during an emergency (much more so than individual homes). Ken agreed with the need for energy storage to augment solar photovoltaic energy produced during daylight hours. He explained that the analysis is focused on identifying suitable locations for microgrids based on the full range of criteria to help customers better understand potential opportunities for microgrid development. It is not intended to provide a detailed inventory of energy storage capabilities based on the load profile, but rather to provide an indication of the existing resources relative to the load. Alani stated that one of the prevailing questions is what technology will be used to provide power and storage for the microgrids, explaining that these are questions that require community input. Ken explained that the options to provide power and storage can be customized to fit a given area, such as mobile diesel generators (in the case of the Koʻolaupoko CCHs) which may or may not be augmented with solar photovoltaics and battery storage.
- A workshop participant asked if the microgrid size limit of approximately one distribution circuit is based on an analysis requirement of the ETIPP program or a specific technological or financial constraint. Ken explained that the mapping project originated with the microgrid services tariff, which enables customers to develop hybrid microgrids. Hybrid microgrids are intended to serve at or below the substation distribution feeder level; incorporating substations would significantly increase

microgrid complexity. As the distribution feeders generally serve up to 3 megawatts of load, this is the maximum size of potential microgrids (which aligns with the mapping project).

- Kurt referenced a question posted on Menti regarding what new infrastructure is needed in a neighborhood for a microgrid. Ken explained that development of a microgrid requires addition of switching equipment to allow the designated area to be isolated from the grid, as well as generating resources to provide the backup energy. In addition to these components, it is also important to harden overhead infrastructure within the microgrid (for example, replacing old wooden poles with new steel poles, or possibly undergrounding electrical lines) to maximize the resiliency of the system.
- A workshop participant asked about the scale of electronic infrastructure needed for a microgrid. He asked if it requires build-out of new facilities or if it is as simple as adding switching equipment to existing structures. Ken explained that microgrids are generally not simple systems. Customer microgrids are implemented behind the meter of a single customer using their own infrastructure; customer microgrids can include large facilities such as schools, which may include multiple buildings, but all behind a single meter. In contrast, a hybrid microgrid creates an electrical boundary around multiple customers by adding switches at various points on the surrounding electrical lines. Alani emphasized that every microgrid will be unique, based on the existing infrastructure and resources, and will require its own engineering solution. Ken agreed and explained that the microgrid mapping is just the initial step in a much larger process. The mapping is intended to provide an indication of whether a site is suitable for a microgrid; much more detailed engineering will be needed once the decision is made to pursue a project.
- A workshop participant asked whether the nearby residences would be included in the potential CCHs identified for Koʻolaupoko. For example, she referenced the CCH for Windward Mall and asked whether the houses along the CCH boundaries would also be connected. Ken responded that he does not think that this particular CCH would include houses, but that it is technically possible for homes to be included. Colton reiterated that from an engineering perspective, it is possible to design a microgrid around any combination of commercial structures, community facilities, and private residences. However, the CCHs focus on providing backup power specifically to facilities that provide community services (such as the mall, schools, and medical facilities). Alani noted that if there were to be a publicly funded microgrid that happened to include certain residences, this could benefit those property owners; he asked whether there would be any restrictions for publicly funded microgrids to only include critical facilities or if they could also include residences (for example, if it is not technically possible to add a certain critical facility without also including adjacent residences). Colton responded that there is flexibility and that it is possible for residences to be included. He emphasized that microgrids should be designed specifically around objectives based on the funding sources. For example, the BRIC grant uses FEMA funding, so the focus of the microgrid is to provide backup power for emergency services. If the objective is to provide a microgrid to serve a remote community (such as Hana on Maui), it would be designed to service all of the customers in that area.

- An online participant asked how many microgrids Hawaiian Electric is looking to establish in Windward Oʻahu. Ken explained that the BRIC grant submitted for the CCHs identified through the Koʻolaupoko Resilience Initiative included three proposed sites. There were additional sites that were identified, but those three were prioritized for the grant application.
- Another online participant referenced diesel generators as a storage option and asked for a visual representation of the energy storage associated with a microgrid designed to incorporate resources from approximately 100 residences. Ken referenced the technical presentation, which includes concept photographs of the mobile diesel generators envisioned for use as part of the Koʻolaupoko CCHs. In this case, the mobile generators would be stored elsewhere; in the event of an emergency, the generators (along with a transformer and other electrical equipment) would be transported on trailers and staged in a parking lot near the CCH.
- A workshop participant emphasized that the CCHs identified to date include Waimānalo, Olomana, and Kāneʻohe but do not include any locations in northern Koʻolaupoko. He asked that additional locations be considered in Kahaluʻu, Waiheʻe, and ʻĀhuimanu; critical facilities include a utility baseyard, fire station, a boat ramp, helicopter landing zones, as well as Key Project and other community gathering locations. He noted that there is adequate space for parking trailers, noting the need for adequate diesel supply. He also explained that the housing branch of the state is looking at a new water system in the area between Waiāhole and Kualoa. The community is proposing a water system that is not electrically dependent and would flow from the Waiāhole Ditch tunnel (which is at an elevation of about 750 feet). Every day, water flows from Kahana Valley to Waiāhole, where it then gets allocated to either the leeward or windward side of the island. He emphasized that there is constant kinetic energy in the tunnel and could be used to produce hydroelectric power, which would be like having a diesel generator that doesn't run out of diesel. He stated that this energy could be used to support a microgrid for the surrounding community, including facilities with kitchens, refrigeration, and food distribution.

In addition to the comments discussed during the workshop, additional questions and comments were received via Menti and in writing. These comments are summarized below; copies of the responses are contained in Attachments D and E (respectively).

The following questions and comments were received via Menti in response to the question: *What other community facilities are missing or should be included in the analysis?*

- Supermarkets
- Farms, community kitchens
- Schools as community gathering places
- Food and supplies
- National Guard facilities

- Community Civic centers such as KEY Project (Waiheʻe/Kahaluʻu); Waiāhole Elementary School (high ground, centered in farm area)
- Key Project
- Perhaps Castle High School - its cafeteria has provided shelter during several storms, has a kitchen if needed, and can reduce strain on other shelters
- HiEMA storage facilities
- Correctional facilities
- Military facilities
- Hawaiʻi State Hospital
- In an emergency situation, shelters such as schools, should be included in potential microgrids
- What new infrastructure is needed in a neighborhood for a microgrid
- Due to the inclement weather in Koʻolaupoko, flooding and other negative impacts have to be taken into account
- Wastewater treatment plant
- Windward Community College with kitchen facilities
- Agriculture water reservoirs
- Is there a strategy for linking solar photovoltaic arrays (public and private) as a microgrid energy source?
- Potential hydropower from Waiāhole ditch
- Will microgrids be controlled at the customer level or will the utility company have control? Will they be for emergency use only or can they be used to reduce grid reliance?
- Hydropower

The following questions and comments were received via the written comment cards:

- Recommended resilience hub: 20-acre former Navy landfill in Haiku Valley (naturally protected site; Hawaiian homeland impact area; natural distribution point to the community)
- Why do you use the low emission scenario for sea-level rise vulnerability?
- Remind the presenters that the state's greenhouse gas goal is net negative (not net zero) carbon emissions

Renewable Energy Zones: Community Feedback

Based on the presentation of technical information regarding the Renewable Energy Zones analysis (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting of large-scale renewable energy resource development to decarbonize Oʻahu's energy system. He emphasized that this is just the early stages of a long-range planning effort but the goal is to make information more accessible so the community can more easily provide input. The questions and input provided by workshop participants is summarized below.

- A workshop participant asked if it possible to supply 100 percent of Oʻahu's energy from renewable sources. Marc responded that the analysis to date show that it is possible but emphasized that it is going to take everyone working together as there are a lot of pieces needed to accomplish that goal. He noted that if we rely on solar and wind energy, it will require a lot of land to support those types of projects. He also reiterated that there are also other technologies that may be available for use in the future, depending on the price of those technologies. In addition, biodiesel is also considered a renewable energy source and is used at one of Hawaiian Electric's power plants. As such, there are various ways to achieve 100 percent renewable energy, with each option having a different cost. In any case, it will take coordination and partnership at all levels to achieve this goal.
- A workshop participant acknowledged that the Renewable Energy Zones analysis considered impacts to farmland and other areas that people might be concerned about. He asked whether the analysis has considered the use of urban and other built spaces, such as Windward City Shopping Center or Castle Hospital, and suggested the addition of parking lots covered with solar photovoltaics and other similar projects that ideally would not obstruct viewplanes. Marc explained that Hawaiian Electric has tried to spur this type of activity in several ways, including customer energy programs that enable solar photovoltaics on parking canopies and similar rooftop structures. He also described the shared solar (or community based renewable energy [CBRE] program), through which developers build projects and community members can subscribe to the energy produced by the project. In addition, Hawaiian Electric issues Requests for Interest (RFIs) to solicit landowners that are interested in building parking structure or larger rooftop solar photovoltaic systems. Alani noted that these are solutions that Hawaiian Electric can encourage but they cannot require landowners to construct these types of facilities.
- Alani referenced a comment received via Menti regarding the location of geothermal resources in Koʻolaupoko. Marc stated that there are known geothermal resources on Hawaiʻi Island and studies in the past tried to identify geothermal resources on the other islands. He explained that researchers at University of Hawaiʻi are further investigating geothermal potential and are currently considering more exploratory drilling. However, drilling is expensive and funding needs to be put in place. Although there are ways to guess at where there may be geothermal potential, drilling is the only way to confirm whether there is a viable resource.
- A workshop participant asked if Hawaiian Electric has revisited the hosting capacity limits for larger customers that are behind a meter and are looking to develop more renewable resources. Marc confirmed that Hawaiian Electric updates the capacity analysis each time it issues a Request for Proposal (RFP) and information regarding the remaining capacity on the various transmission lines is made available to developers through the RFP process.

Kurt closed the meeting by acknowledging the work being done by the Center for Resilient Neighborhoods (CERENE). He explained that they are working at the grassroots level with communities to identify locations for resilience hubs. These are structures that can be used as community gathering places and provide key services to the community during an emergency event. These efforts dovetail together, as it would be ideal for the resilience hubs to be connected to other critical facilities as part of a microgrid.

In addition to the comments discussed during the workshop, the following questions and comments were received via Menti in response to the question: *What are the most important factors to consider for the siting of renewable energy on Oʻahu?* Copies of the responses are contained in Attachment D.

- Amount of land needed
- Creating a safe distance from schools and other community facilities
- Every community should have renewable energy to support themselves. Some communities are taking too much of the load. This should also help Hawai'i be more resilient.
- Lifecycle cost to customers
- Where possible build in already disturbed areas as opposed to undeveloped areas.
- Location of geothermal resources in Koʻolaupoko
- Visual obstruction to landscape
- Survivable/resilient
- Agreed on the visual obstruction to landscape.
- Does the amount of renewable energy a community can generate determine its ability to host a microgrid?
- Explore hydro options
- Proximity to Koʻolau Substation so that the resource can flexibly support the most electrical circuits possible at the lowest cost and complexity
- Good idea, building upon already developed areas
- Ecological impact that it will have throughout the entire ahupuaʻa. One small change will have a cascade effect on all components (loʻi, mala, loko iʻa, etc.).
- Acceptable site for nuclear SMR
- Kāneʻohe Bay is a unique natural and cultural resource so should not become used to site any generation sources
- How the state can contribute to siting options – e.g., state buildings, state housing projects - the ability for the state and county to use their existing buildings for energy projects. And fast track them?

COMMUNITY FEEDBACK

ʻEWA MOKU (HONOULIULI - HALAWA)

NOVEMBER 17, 2022

Introduction

The last of six Renewable and Resilient Energy Workshops hosted by Hawaiian Electric was held in the ʻEwa moku of Oʻahu, which spans from Honouliuli to Halawa. The workshop was held on November 17, 2022 at Leeward Community College. There were approximately 11 attendees, as well as Hawaiian Electric staff; a list of attendees is included in Attachment C.

Hybrid Microgrids: Community Feedback

Based on the presentation of technical information regarding hybrid microgrids (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting hybrid microgrids, including other criteria that should be included in the analysis as well as specific facilities that should be considered because they are important to the community. He also noted that the microgrid mapping process considers existing sources of resource generation that can be used for backup power (e.g., rooftop solar panels), but noted that Hawaiian Electric would also like community input on the type of technologies that should be explored if additional generation is needed to power the microgrids. He explained that Alani would be facilitating the discussion and reminded participants of the various ways that they can ask questions and provide input. Alani stressed the important of community-based knowledge and stated that the purpose of the workshop is to gather feedback to ensure the analysis is aligned with the community's priorities. The questions and input provided by workshop participants is summarized below.

- A workshop participant stated that he thinks various places to recharge electric cars should be included and that these locations should be widely distributed.
- A workshop participant asked how Hawaiian Electric will prioritize locations based on the community input that is received. Katy responded that the criteria are currently equally weighted in the analysis. However, the team recognizes that not everything is equally important to the community in the event of an emegency, and emphasized that the goal of these discussions is to identify the criteria as well as specific facilities that are most important to the community. She stated that the team is open to suggestions, but they are thinking that the frequency of responses from the community (for example, around concepts such as food distribution centers, schools, etc.) indicates relative importance for that moku, and thus would be used as the basis for assigning weights. Alani emphasized the importance of community input to determine the highest need.
- Alani referenced a question received via Menti: "Can Waiau Power Plant be repurposed into a microgrid?" Marc explained that Waiau Power Plant is one of Hawaiian Electric's main centralized power plants that serves the island of Oʻahu and has blackstart capability in the event of a widespread blackout. In other words, if Hawaiian Electric needs to restore power to the island-wide grid, Waiau Power Plant would help with this process. Therefore, this power plant would not be used for microgrid purposes as it is used to help maintain the island-wide grid.

Kurt acknowledged the work being done by the Center for Resilient Neighborhoods (CERENE) at the grassroots level, explaining that they are partnering with communities at the neighborhood level to identify locations for resilience hubs. He stated that their work has been informed by lessons learned from disaster incidents around the world and focuses on facilities that can serve as a gathering place and provide key services to the community during emergency events (including food distribution, refrigeration, medical services, etc.). He explained that resilience hubs can be designed to have their own power source, but also are good candidates for microgrids. In addition to partnering with Hawaiian Electric, CERENE is also working with the City and County of Honolulu Office of Climate Change, Sustainability and Resiliency and Hawaiʻi Emergency Management Agency.

In addition to the comments discussed during the workshop, additional questions and comments were received via Menti in response to the question: *What community facilities are missing or should be included in the analysis?* These comments are summarized below; copies of the responses are contained in Attachment D.

- Shopping centers and grocery stores
- Need to add grocery stores to critical facilities
- UHWO and LCC
- Schools
- HART rail transit stations, ROCs, MSFs
- Central Oʻahu Regional Park
- Key military bases
- Filipino community center in Waipahu
- Kroc Center
- Mililani Town Center
- Walmart Kunia Pearl City
- Costco Kapolei and Waipio
- ʻEwa Foodland, Safeway, Longs
- Waipio Costco/Kaiser Waipio/EMS Waipio

- Pearl City High School
- ‘Ewa and Kapolei Library
- Campbell, Kapolei, Mililani, Waipahu High School
- Gas stations
- Don Quijote and Seafood City Waipahu
- Coast Guard Air Station
- Mililani High Tech Park
- Pacific Palisades Community Center
- Can Waiau power plant be repurposed into a micro grid?
- Department of Health on Waimano Home Road
- Sam’s Club Pearl City
- Suggest looking at gaps in existing facilities map to fill in spots so microgrids are well distributed
- Target Kapolei Salt Lake

Renewable Energy Zones: Community Feedback

Based on the presentation of technical information regarding the Renewable Energy Zones analysis (as summarized previously in this report), Kurt reiterated that Hawaiian Electric is looking for input regarding siting of large-scale renewable energy resource development to decarbonize Oʻahu’s energy system. He acknowledged that there are already renewable energy projects sited in the ‘Ewa moku and emphasized the need for community input moving forward. The questions and input provided by workshop participants is summarized below.

- A workshop participant asked if there are still discussions about wind power, particularly offshore projects. Marc explained that Hawaiian Electric’s process to acquire renewable projects involves issuing a Request for Proposals (RFP) which allows developers to submit proposals for projects; these projects may involve a range of different technologies including offshore wind. There are currently no proposals for offshore wind projects in Hawaiʻi but Hawaiian Electric is aware of offshore wind developers that are talking with certain communities about potential projects. Hawaiian Electric has not taken any technologies off the table but is working to determine which technologies would be acceptable in different communities. Alani asked Marc to confirm that Hawaiian Electric cannot restrict the proposals that are submitted as the parameters of the RFP process are set by the Public Utilities Commission (PUC); Marc confirmed these points.
- Alani referenced a question submitted via Menti: “How can nearby residents see direct benefits from energy projects.” Kurt explained that there has recently been community input relative to this topic and relates to the purpose of these workshops. Specifically, Hawaiian Electric has been working with

the West Oʻahu community in response to input shared about the energy burden associated with projects sited in this region. Through this process, various community leaders and organizations aligned their interests and submitted a letter to the PUC with input regarding the Hawaiian Electric RFP process for shared solar (also referred to as community based renewable energy [CBRE]) projects. The shared solar projects allow community members to subscribe and achieve the same benefits as customers with rooftop solar photovoltaic systems. The PUC adopted most of the recommendations submitted by the West Oʻahu community, resulting in requirements for both for the shared solar RFP as well as all other RFPs moving forward. In particular, community members that live closest to a shared solar project will be given access to an energy subscription before other residents around the island. Other requirements include incentives related to hiring local staff and workforce development. Furthermore, based on this input and the support of the PUC and other collaborating agencies, the next round of RFPs will require projects to provide a community benefits package, with a minimum dollar amount based on the size of the project. The RFPs include language requiring developers to work directly with the community to identify specific needs and ensure that the community benefits or funding directly support those needs. He stated that there is more information that can be shared, but these are examples of improvements that have been made to the procurement process to provide direct benefits to the community and illustrate the value of community input. Alani emphasized that when projects are selected through the RFP process, there will be specific opportunities for the community to provide input to the developers regarding community needs and allocation of community benefits.

- A workshop participant asked if there is expected to be any mandates for solar photovoltaics on state and county facilities. More specifically, he stated that he spoke with the branch manager at the Molokaʻi public library who was wondering about the process for getting solar installed on a building such as a library. In terms of the requirements, Marc stated that this is not something that Hawaiian Electric can mandate and would instead require legislative action. There have previously been bills contemplated that would require solar photovoltaics to be added on state and county buildings. There are also policies such as the University of Hawaiʻi's net zero goal, based on which Hawaiian Electric has been working with University of Hawaiʻi to add solar photovoltaic systems at their various campuses around the state. Regarding the question about the Molokaʻi public library, Marc explained that customers typically work with a contractor/installer to enroll in one of Hawaiian Electric's programs.
- Alani referenced a question received via Menti: "Can the site selection be part of the microgrid design and community resiliency?" Ken responded that the Renewable Energy Zones analysis is intended to identify opportunities for larger grid-scale projects to provide energy for the island-wide grid. He noted that these projects could include elements that help to improve community resilience, but these would add layers of complexity and cost.
- Alani identified another question received via Menti: "What kind of community benefits are offered or available?" Kurt explained that based on language currently included in the RFP, there are no specific limitations; it will be up to the community to identify their specific needs and the type of

benefits that would address those needs. The intent is to not be prescriptive and rather to encourage developers to engage meaningfully with communities to develop a community benefits package. The developers will be required to provide a minimum dollar amount for the community benefits, which is currently set at $3,000 per megawatt per year over the full contract term for the project (20+ years). Based on engagement with the community, the developer will be required to document the community input; this information will be made publicly available and used to hold the developers accountable.

- A workshop participant asked how small a microgrid can be to catch Hawaiian Electric's interest. Ken responded that customer microgrids can be as small as a single home, while hybrid microgrids can be as large as 3 megawatts. He explained that Hawaiian Electric is not necessarily seeking microgrids as part of the procurement of larger renewable energy projects, as these are intended to provide energy for the island-wide grid. As such, the larger grid-scale projects do not necessarily need to include microgrid functionality.
- A workshop participant asked about the total consumption or load for the Hawaiian Electric system. He asked about the progress toward reaching the goal of 100 percent renewable energy and asked how much more renewable energy will be needed as the climate gets hotter. Marc explained that Hawaiian Electric's Renewable Portfolio Standard (RPS) for the multiple islands it serves is approximately 38 percent as of 2021. The RPS for Oʻahu is just over 30 percent, while Maui and Hawaiʻi Island are higher (40+ percent and 60 percent, respectively). He noted that the law was recently changed, with a new formula used to calculate the RPS, such that these estimates will be slightly lower at the end of this year. He emphasized that there is still a lot of work needed and that the Renewable Energy Zones analysis is intended to help determine how best to reach 100 percent renewable energy.
- A workshop participant asked how the transition to 100 percent renewable energy will change the cost of energy. Colton explained that the transition started with the most cost-effective resources, which included wind and solar projects; at certain times, the price of these resources has been much lower than the cost of fossil fuel generation while other times it has been more expensive. Nevertheless, the transition to renewable energy provides both environmental benefits as well as price stability. For example, as oil prices are currently much higher than what they were a year ago, the renewable resources purchased five years ago (at a rate that was more expensive than the price of oil) are now cost effective. Moving forward, as more renewable resources are developed, lower cost projects will be exhausted and higher cost projects will need to be developed. Hawaiian Electric is working hard to make sure future renewable energy projects are as cost effective as possible; for example, the Renewable Energy Zones analysis will help inform planning for cost effective infrastructure for interconnection. In addition, it will be important to stay abreast and consider use of new and improved technologies. Moving forward, it is likely that the cost of renewable energy will increase as more is added to the system. However, it is important to recognize that costs will not automatically go up as they will be relative to the price of oil (which can be highly unpredictable). For the renewable energy projects that are being added to the system, Hawaiian Electric is working with

independent power producers and entering into contracts with fixed prices for the 20-25 year contract term; this price stability will be very valuable in the future.

- Alani referenced a question received via Menti: “How can private landowners (shopping centers with big parking lots) be incentivized to get solar, potentially CBRE?” Marc explained that the CBRE program involves issuance of an RFP seeking proposals for procurement; individual landowners work with a developer to prepare and submit a proposal for a project on their land. He explained that an RFP was recently issued and Hawaiian Electric is currently in the process of evaluating those proposals. Colton added that Hawaiian Electric also issues Requests for Interest (RFIs) to identify landowners that may be interested in leasing or selling property for development of renewable energy project. The list of landowners that respond to the RFI is made available to developers and can improve the chance of connecting with a developer.
- Alani highlighted another question received via Menti: “Are there any shared solar projects available today for communities in the ‘Ewa moku?” Kurt responded that there are currently no shared solar projects available in the ‘Ewa moku. However, Hawaiian Electric will actively promote and offer shared solar subscriptions to the community when available in the future. An announcement is expected soon on the selections for the low and moderate income shared solar program, followed by selections for the shared solar RFP issued earlier this year. He clarified that the proposals that are submitted to Hawaiian Electric are based on a partnership between a willing landowner and willing developer, and that Hawaiian Electric does not have any control over the location of the proposed projects.
- Another question submitted view Menti: “How can Hawaiian Electric involve more community members in these kinds of discussions besides these kinds of meetings?” Kurt explained that these workshops are just the beginning of the process and Hawaiian Electric is willing to have additional conversations with community in whatever form is preferred. He also referenced resource tools available at www.hawaiipowered.com/oahu, including a map of Oʻahu where community members can drop pins and add comments regarding suitable and unsuitable locations for potential renewable energy projects. He reiterated that all input will be documented and considered in the planning process.
- A workshop participant asked how the workshops were promoted. Kurt explained that Hawaiian Electric provided notification regarding the current workshops to the neighborhood boards, Hawaiʻi Energy Policy Forum, Star Advertiser, Pacific Business News, and social media channels as well as requested that various elected officials share the information through their channels. He emphasized that much of the success in getting community members to attend is via word of mouth, so asked participants to share the information with their respective circles and offered to have follow-up meetings with the community if desired.
- Alani highlighted another question via Menti: “Can we prioritize selecting projects that are being developed by local organizations and businesses rather than those that are based outside of Hawaiʻi?” Kurt explained that the RFPs currently do not include language to this effect and all

developers are evaluated equally. However, he stated that he thinks this is an important concept to consider; Hawaiian Electric cannot make this decision but it could be recommended to the PUC by the community.

- Kurt referenced a question received via Menti: "How can communities be part of the selection process?" He stated that this is a good question but one for which Hawaiian Electric does not have an answer. He emphasized that this is another concept that can be discussed with the community and stakeholders in terms of how best to capture community sentiment as part of the RFP process. He explained that Hawaiian Electric has been reviewing how this issue is handled by utilities on the mainland but has not yet identified a good model. As of now, the best approach is to continue having open discussions and working through issues together.

  Alani asked for clarification regarding how projects are selected. Kurt explained that selection is based on criteria set forth in the RFP – that is, the extent to which a developer can demonstrate that their project meets the written criteria in the RFP (e.g., ability to interconnect to the grid, reasonable cost per kilowatt hour). Alani asked for clarification regarding who sets the criteria. Kurt explained that are opportunities for public input on the RFPs before they are finalized, noting that this was the way that the West Oʻahu community submitted their recommendations. This work is done in partnership with the PUC, and Kurt emphasized that they are trying to make this a more inclusive process.

- A workshop participant asked if there will be other future workshops on these topics. Kurt responded that there will certainly be future opportunities to provide input relative to both the hybrid microgrid and Renewable Energy Zones analyses. He explained that the hybrid microgrid map is meant to be a snapshot in time and will serve as the foundation for future efforts that will dive deeper into the details of whether microgrids are a good fit in specific locations; there will be continued community engagement as this process moves forward. Similarly, the Renewable Energy Zones analysis is also a preliminary analysis that is being shared to engage the community early in the planning process. Additional information will be shared as it becomes available (for example, inclusion of other renewable energy technologies). He referenced www.hawaiipowered.com/oahu, which includes an interactive map where community members can add pins and comments regarding the suitability of specific sites for renewable energy projects. In addition, there will be continuing discussions with the community moving forward. All input received will be documented and incorporated into the long-term planning process.

In addition to the comments discussed during the workshop, the following questions and comments were received via Menti in response to the question: *What are the most important factors to consider for the siting of renewable energy on Oʻahu?* Copies of the responses are contained in Attachment D.

- How can nearby residents see direct benefits from energy projects?
- Cost-effective and reliable
- Improving reliability

- Multi use land, all parking lots, warehouses, state and county facilities
- Environmental equity and impact on the community
- Minimize overhead wires
- Projects should be sited close to users
- Minimize impact to landscapes, mountain slopes, etc.
- Local jobs and technical education programs
- Can we prioritize selecting projects that are being developed by local organizations and businesses rather than those that are based outside of Hawaiʻi?
- Siting commitments to create public benefits to host communities - plus large-scale storage (CO_2, water/mass lifting, etc.)
- What kind of community benefits are offered or available?
- Good community engagement
- How can the community be part of the selection of sites and projects?
- Can the site selection be part of the microgrid design and community resiliency?
- Help community with resiliency
- Those communities where solar is not ideal (i.e. homes bordering golf courses)
- How can private landowners (shopping centers with big parking lots) be incentivized to get solar, potentially CBRE?
- Are there any shared solar projects available today for communities in ʻEwa Moku?
- Appreciate seeing this on ʻOlelo!
- Make sure some women are involved!
- Utilize brown fields. Partner w/public-private surface parking lots. DO NOT TAKE AWAY ag land or commercial mix use lots.
- How can HECO involve more community members in these kinds of discussions? Besides these kine meetings.
- Diverse sources

ATTACHMENT A

NOTICE OF WORKSHOP

ATTACHMENT B

TECHNICAL PRESENTATION

ATTACHMENT C

WORKSHOP ATTENDEES

Koʻolauloa Moku (Waimea – Kaʻaʻawa)
Monday, October 24, 2022
Kahuku Elementary School

Name	Organization (if any)
In-Person Participants	
Dotty Kelly-Paddock	Hauʻula Community Association
Kendal Leonard	Hawaiʻi Natural Energy Institute
Ben Shafer	Friends of Kahana Community
Stephany Vaioleti	Koʻolauloa Neighborhood Board
On-Line (Zoom) Participants	
Jin US	
Ali Andrews	Shake Energy
Yvonne Hunter	Hunter Communications Inc.
Bob Kagamida	Hitachi
Parker Kushima	Hawaiʻi State Energy Office
Jae-Hyup Lee	South Korean Company (partner w/ HNEI on microgrids for Hawaiʻi Island)
Andrew Okabe	Public Utilities Commission (PUC)
Nick Sinchek	Hawaiʻi State Energy Office
James Vaughn	

Koʻolauloa Moku (Waimea – Kaʻaʻawa)
Thursday, December 1, 2022
Hauʻula Community Center

Name (In-Person)	Organization (if any)
Ginny Alatasi	
Steve Cheney	
Raynae Fonoimoana	
Amanda Ho	Hawaiʻi State Energy Office
Ronnie Huddy	HCA / CERT
Linda Iongi	
Wanda Kamauoha	
Dotty Kelly-Paddock	Hauʻula Community Association
Parker Kushima	Hawaiʻi State Energy Office
Lorraine Matagi	Hauʻula Community Association
Carlos Mozo	
Wade Nakashima	
Debra Parr	
Barbara R	
Dan R	
Dave Siroskey	
Ella Siroskey	
Ailene Sproat	
Barbara Tatsuguchi	
Miriam Young	
On-Line Participants (Zoom)	**Organization (if any)**
Kathy Boyle	
Gregory Weiss	

Waiʻanae Moku (Nānākuli – Keawaʻula)
Wednesday, October 26, 2022
Agnes Kalanihoʻokaha Community Learning Center

Name	Organization (if any)
In-Person Participants	
Chris Fujimoto	University of Hawaiʻi – Kapiʻolani
Sidney Higa	Hooulu Holdings
Kapua Keliikoa-Kamai	Waiʻanae Valley Homestead Community Association
Parker Kushima	Hawaiʻi State Energy Office
Roland Lee	Nānākuli-Māʻili Neighborhood Board
Miku Lenentine	University of Hawaiʻi – Kapiʻolani
Helen Reddy	Center for Resilient Neighborhoods (CERENE)
Cynthia Rezentes	Nānākuli-Māʻili Neighborhood Board
Nicole Shintani	Hawaiʻi State Energy Office
Georgette Stevens	ʻŌlelo Community Media
On-Line (Zoom) Participants	
JMA	
NJUNG	
Ali Andrews	Shake Energy
Amanda Ho	
Yvonne Hunter	Hunter Communications Inc.
Jo Jordan	
Chad Miura	
Andrew Okabe	Public Utilities Commission (PUC)
Sharlette Poe	Waiʻanae Neighborhood Board

Kona Moku (Moanalua - East Honolulu)
Tuesday, November 1, 2022
Kapiʻolani Community College

Name	Organization (if any)
In-Person Participants	
Ali Andrews	Shake Energy
Leo Asuncion	Public Utilities Commission (PUC)
Andrew Calise	Honeywell
Winifred Canney	Center for Resilient Neighborhoods (CERENE)
Stephanie Chang	Stephanie Chang Design Ink
Michele David	
Tristan David	Center for Resilient Neighborhoods (CERENE)
Michael Flores	
Dr. Robert Franco	Center for Resilient Neighborhoods (CERENE)
Sarah Harris	Office of Climate Change, Sustainability & Resiliency
Carol Hoshiko	Kapiʻolani Community College, Office of Continuing Education & Training
Parker Kushima	Hawaiʻi State Energy Office
Miku Lenentine	University of Hawaiʻi – Kapiʻolani
James McCay	DHA Coop
Mary Janell Murro	University of Hawaiʻi, Public Administration
Dean Nishina	Division of Consumer Advocacy
Andrew Okabe	Public Utilities Commission (PUC)
Monique Schafer	Hawaiʻi State Energy Office
Eric Teeples	University of Hawaiʻi at Manoa School of Architecture
Cuong Tran	University of Hawaiʻi, National Disaster Preparedness Training Center
Jose Andres Zavala	Center for Resilient Neighborhoods (CERENE)
On-Line (Zoom) Participants	
Anand	
Marta	
Kodi Benoza-Tabion	
Jenny Brown	Center for Resilient Neighborhoods (CERENE)
Iwalani Clayton	Center for Resilient Neighborhoods (CERENE)
Valarie Cleopas	
Leila Jaffuel	
Yun-Su Kim	
Luke Lenentine	
Chad Miura	
Kelsey Nakagawa	
Jenn Lieu Nickel	
Denise Pierson	Kapiʻolani Community College, Civic & Community Engagement
Suwan Shen	Urban & Regional Planning, UH Manoa
Angela Soto Balmores	Center for Resilient Neighborhoods (CERENE)

Waialua Moku (Ka‘ena - Kapaeloa)
Thursday, November 3, 2022
Waialua Elementary School

Name	Organization (if any)
In-Person Participants	
Andrew Calise	Honeywell
Richard Figliuzzi	North Shore Resident
Alex Kahl	Ala Mai Farmstead
Agnes Leinau	Resident
Bob Leinau	Resident
Reed Matsuura	City Council, Staff
Kathleen Pahinui	North Shore Neighborhood Board
On-Line (Zoom) Participants	
Raquel Hill-Achiu	
Andrew Okabe	Public Utilities Commission (PUC)
Amy Peruso	Representative (Wahiawa, Whitmore Village, Launani Valley)

Koʻolaupoko Moku (Waimānalo - Kualoa)
Tuesday, November 15, 2022
Windward Community College

Name	Organization (if any)
In-Person Participants	
Amra Brightbill	Marine Corps Base Hawaiʻi - Kāneʻohe Bay
Noah Doerr	Coffman Engineers
Malia Hagmann	University of Hawaiʻi at Manoa
Naomi Kuwaye	Public Utilities Commission (PUC)
Adriel Lam	Kāneʻohe Neighborhood Board
Miku Lenentine	University of Hawaiʻi – Kapiʻolani
Amy Luersen	N/A
Paul Luersen	N/A
Jacob Milanczuk	Kalakaua Middle School
Corinne Nishina	N/A
Dean Nishina	Division of Consumer Advocacy
John Reppun	KEY / Waiāhole Neighborhood Board
Jack Shriver	Power Engineers
Maria Tome	Hawaiʻi State Energy Office
Kirsten Baumgart Turner	Hawaiʻi State Energy Office
He Xu-Sadri	Marine Corps Base Hawai'i (MCBH)
On-Line (Zoom) Participants	
Anand	
Demaney	
Lora	
Lisa Kitagawa	Representative (Kāneʻohe, Kahaluʻu, Waiāhole)
Andrew Okabe	Public Utilities Commission (PUC)
Meagan Ostrem	Marine Corps Base Hawaiʻi (MCBH)
iMo Radke	
Nick Sinchek	Hawaiʻi State Energy Office
Matthew Sutton	
Claudine Tomasa	
David Warner	

ʻEwa Moku (Honouliuli - Halawa)
Thursday, November 17, 2022
Leeward Community College

Name	Organization (if any)
In-Person Participants	
Macklin Burnham	N/A
Marcey Chang	Division of Consumer Advocacy
Mark Glick	Hawaiʻi Natural Energy Institute (HNEI)
Amanda Ho	Hawaiʻi State Energy Office
Leila Jaffuel	Ember Media
Parker Kushima	Hawaiʻi State Energy Office
Miku Lenentine	University of Hawaiʻi – Kapiʻolani
Kendal Leonard	Hawaiʻi Natural Energy Institute
Nathan Muramatsu	N/A
On-Line (Zoom) Participants	
Kat K	
Andrew Okabe	Public Utilities Commission (PUC)

ATTACHMENT D

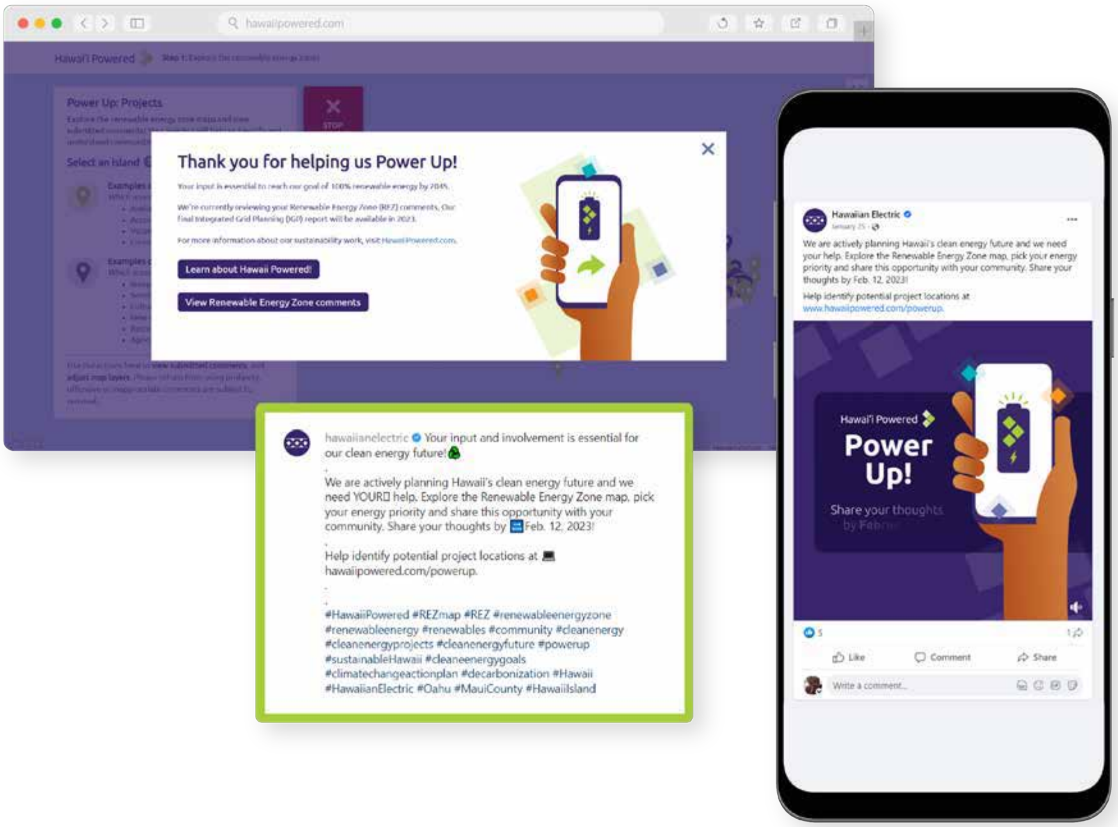
COMMUNITY INPUT RECEIVED VIA MENTI

ATTACHMENT E

COMMUNITY INPUT RECEIVED VIA RESPONSE CARDS

1.10 Power Up

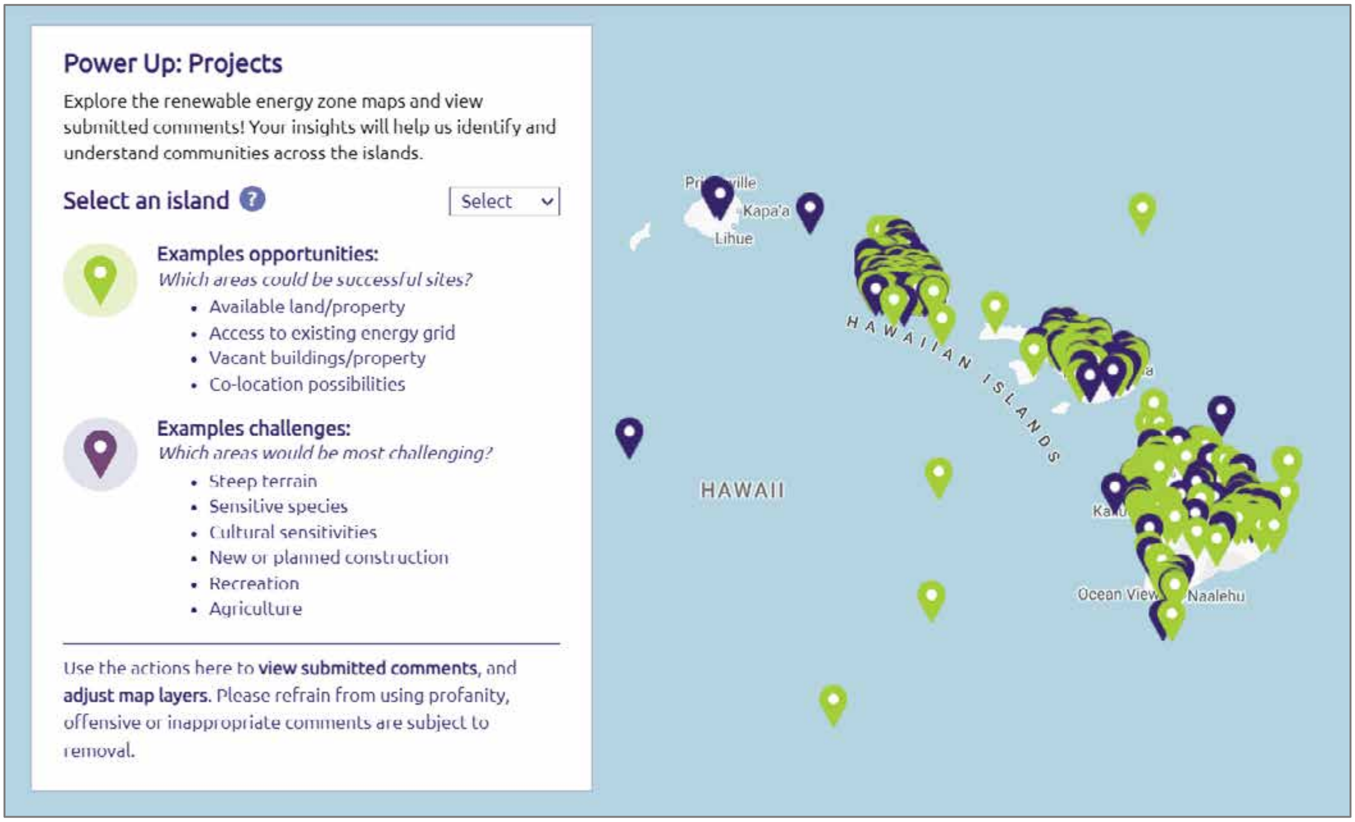
Materials used for the "Powered Up" media campaign from January 17 to February 12, 2023, to promote the REZ website and public input opportunity.



Platform	Total Clicks	Total Impressions
Facebook	3, 257	111,245
Instagram	199	67,608
Meta Story Placement	1,908	348,667

1.11 Renewable Energy Zone Comments

Renewable Energy Zone comments gathered during the input period which was open from September 2022 to February 2023.



REZ Comments Collected
Maybe South (or East) Big Island are good options for future large-scale investment because land is still relatively cheap and there's lots of sunshine. Oahu island is fast becoming urbanized everywhere as well as Kauai and Maui. Many lower-income residents on Hawaii island move out to the Hilo-Ocean View side because costs are now too high in Kona, Kohala, Waimea, and Hamakua. I don't think there'd be as much pushback for new projects as this is one of the last places in Hawaii that have yet to see any kind of major development. If future large energy projects were brought there, it could be a great economic boon for the people in that area. I know the Big Island well because I grew up in Kohala and we own homes in Kohala, Hilo, Kamuela.
Away from population but closer to the load growth. Try to find areas that won't disrupt anyone.
Away from population but closer to the load growth. Try to find areas that won't disrupt anyone.
So much rain on hilo side
If area can actually work with should develop; at elevation but flat and no one will see it
Away from residential areas. Open areas in general, not specific
Picked zone 2 because high potential (360 mw) and lots of space for solar
Land available. Open range to put solar or wind good wind coming down from mountain
Open land, not big need for pasture land
Put more windmills
Avoid residential areas in general
Avoid residential areas - like Kahuku Wind Farms
Avoid volcano areas because eruption would destroy the solar farms
Hakalua waimea area. Land availability avoid areas where lava has flowed
Puako and Waikalo good places f/solar
Puako and Waikoloa good places f/solar

REZ Comments Collected
Everyone should pitch in if it benefits community need more solar because my bill doubled I like in Honoka'a, build more there
good area for solar
Avoid Waipio for large scale - cultural, mana'o + avoid Manalua and Maunaloa
O'okala? Okay
More wind in Waikoloa + happy to see more solar
Kohala good wind zone won't bother anyone
Good resource to have solar. Thought there were [WORD] about developing project in the area
Not healthy with all noise + Kapuna so put proj. away from them
Solar in Puako, want the proj that dropped out - land is dry can't be used for other things
Born + raised Honokaia - community solar or wind ks land
Open land + sunny. Can't do much else w/land. low cattle carrying capacity
Should have never shut down a coal fired power plant without something inplace first. I guess the general public shouldn't expect anything less from a Biden administration.
Nothing is wrong with turbines, but they must be properly sited; in Kahuku, the turbines were placed too close to the community. Based on research of other wind energy projects (Germany), it's understood that wind turbines are located at least one mile from the nearest residence or farm. Should be learning from others to incorporate the best technology and information regarding health impacts. Would like to see wind turbines at the State Capital, Department of Health, and City Hall; they should have to live with the wind turbines as that is what the Kahuku community has to live with 24/7. If people aren't willing to put the wind turbines next to a high school in Hawai'i Kai, they shouldn't put them in Kahuku
A lot of wind in the back of the valleys. Wind in the valleys on both sides of the island, may be difficult to get transmission lines across the mountains. Wind turbines could be sited in the middle between the mountains, as there are no residents in this area and the turbines could serve the populations on either side. Investors may not like that but may be a long-term solution for wind and even solar energy projects
Houses should be required to have solar photovoltaic systems with lease programs or other arrangements that are user-friendly and affordable enough to allow for system upgrades
Development will continue which will occupy a lot of open areas shown on the REZ map, so renewable energy projects should be sited as far back as possible from these areas, in the middle area between the mountains, away from schools and other development
Pacific Heights area is very windy, not sure how to capture that but it funnels through the valleys
Communities need to be engaged for renewable energy solutions, especially those underserved/underrepresented
Supportive of horizontal turbines
Potential for rooftop solar in Honolulu and Pearl Harbor areas, especially on high-rise buildings based on discussions about allowing solar panels to exceed max building height limits. Desire to maximize potential on existing structures, rather than raw land (discussed at West O'ahu/Kalaeloa Clean Energy 'Ohana)
REZ not including Honolulu and Pearl Harbor is excluding a significant amount of resource potential
REZ should show potential for rooftop solar in addition to large-scale projects, so equity across geographic regions can be taken into consideration. Could also encourage rooftop solar and other small-scale projects
Energize Wai'anae program (part of Solarize 808) will be rolled out in the Wai'anae moku starting Nov 2022
Fair, not necessarily just equal, and pono distribution across ALL communities
Designing tech and systems for high rises and town areas
There is a lot of open space between Kapi'olani Community College and 22nd Avenue; much of this area is associated with the Dept. of Defense and could be a good place to site solar energy facilities
Area around the airport is worth considering relative to ensuring food availability
Consider including technologies like micro-hydropower with dams and pumped storage hydro facilities, which are ready for implementation
East Honolulu should be considered for future wind projects
Grant programs to help residents fund rooftop solar projects are valuable
Incorporate legacy infrastructure on the North Shore, specifically the network of former plantation irrigation infrastructure (such as reservoirs, canals, and channels) for hydropower
Dole is currently unloading much of their infrastructure, which is critical to the water supply for North Shore's agricultural community. This could also be used for micro-hydro power
Hawaiian Electric could coordinate with the developers who're planning to add multiple affordable rental housing units in Waialua. This collaboration could encourage developers to incorporate elements that're beneficial to microgrids for example
Put wind in East Honolulu next
To address impacts to farmland, solar panels could be added to urban and other built spaces like Windward City Shopping Center and Castle Hospital
There may be geothermal resources in Ko'olaupoko
Proximity to Ko'olau Substation so that the resource can flexibly support the most electrical circuits possible at the lowest cost and complexity
Solar photovoltaics on state and county facilities like the Molokai public library
Multi use land, all parking lots, warehouses, state and county facilities
Utilize brown fields. Partner w/public-private surface parking lots. DO NOT TAKE AWAY ag land or commercial mix use lots.
Wind turbines are controversial and should be discussed with the community

REZ Comments Collected
No windmills should be as close to homes, schools and farms as the monster turbines in Kahuku are. Appreciate early community involvement.
Are horizontal wind turbines less expensive than vertical? How well do they tolerate salt air? No solar farms on agricultural land! No vertical wind turbines!
No vertical wind turbines! Horizontal turbines are okay
Completely against wind turbines
Diversifying the kinds of renewable energy and not just place such a huge focus on solar
Finding technology that takes up less land space and has a smaller footprint
Concentration and permeation of projects within a defined geographic area (identify threshold to manage number of projects, whether large or small)
Physical security, cyber security, and accessibility for repairs such as large transformers
Are the areas of highest potential to host large renewable development be given highest priority usage of that resource? Or will it be sent to the higher usage sites? Example: Will Wai'anae and North Shore side who have high land potential be given higher priority usage over Waikīkī (who is a high energy user)?
Do you see your prime prospective locations for large renewable development and microgrids competing with sustainable agriculture plots and prime farming locations? Will you be willing to relinquish prime energy development locations and allow diversified sustainable agriculture to take the spot?
Many communities have to bear the burden of hosting new infrastructure without real recognition or reward
The neighborhood board tends to be concerned about siting anything on Diamond Head
North Shore Sustainable Communities Plan is currently being updated; the community does not support wind turbines, especially offshore wind turbines
No more wind on north shore
Kāne'ohe Bay is a unique natural and cultural resource so should not become used to site any generation sources
No solar farm at Nankuli Ranch
No wind farms at Palehua
Put near landfill. Harvest methane and utilize it instead of just burning it off. Is there enough, though? More solar and battery projects. D.O.T. will be needing to charge buses down the road. Looking for areas with a lot of wind. Have you considered wave and ocean technology?
Been in Lahaina during fire, storms.
Water can be a good source of electricity. Green on Haleakala Hwy near truck off-ramp, opportunity for wind power. State DOT owns property there. Look at battery power opportunity at Kahului.
West Maui – solar; more generation there…
North Side – wind
Harness methane gas at the landfill to create power; not sure about the sustainability of a project like that.
Curious about wave technology.
Focused on central valley area because of the population density there; best bang for your buck
Near Maalaea Power Plant – close to infrastructure and serve as fire break.
Potential for every area to be isolated during outages, especially west side and Hana, so distributing the energy would be ideal
Experience with west side being isolated during emergencies and agree with having power out there
Lands that are able being developed or have been disturbed by former ag use
There are hydro opportunities. There are families who have worked really hard to get water back, so I would urge caution. Not the kind of hydro you're thinking about, there are new opportunities. Honokohau is one of the most powerful hydro opportunities. There are community members who have their own personal hydro, need to consult with the families there.
Put green dot by the dump.
Potential in the 700 acres of Hawaiian Homes Lands upcountry.
Ukumehame – the land has been decimated; maybe solar could be used but as long as it doesn't add to the negative affects already being seen in that area.
Hana has two generators to keep power on. We can convert them to biofuel.
Are we considering other resources like ocean/wave tech
High wind potential in the Kaupo area, near the existing windfarm
East Maui – in terms of resiliency, would make sense to have a resource there
Mokulele Hwy – East of the highway, above DHHL lands and heavy industrial zone, may not be usable for anything else and possibly high potential for solar
Behind the Kihei Baseyard, not highly visible
Central Valley, already developed and centrally located
Launiupoko, possibility for wind
Near Kaheawa Wind farms, already disturbed
Above Olinda, downslope of Haleakala
With the seabird work that I do, there is an important pathway for ua'u. Put the green dots in central Maui where there's already a lot of infrastructure.
Green dots in West Maui, good potential for wind and solar.
Putting up turbines or solar in Central Maui wouldn't bother me, but beyond that should stay untouched.
Central Maui has a lot of potential for development or re-development.
Hydroelectric, wave, ocean technology
It has to be many approaches, it can't be just one technology. Met an ocean/wave technology person on a plane 20 years ago and he had me convinced that ocean technology could be a good thing.
A lot cultural sensitivity, but also not a lot of transmission going out there. It's an opportunity there, though, because there's a lot of land available.
We can see where people are okay with projects, in the Central Maui area.
Iao Valley/Wailuku – Rural area right next to the center hub of government

REZ Comments Collected
Central area, so much potential for development/re-development, especially in places that are sitting vacant
Ocean/wave technology potential
South Maui - since the study identified it as a good potential, it may be worth looking at
Green dot in Waikapū, North Kihei, and other site in Central.
Large agricultural land owner has plenty land. Need a partnership with MECO to build projects that Large agricultural land owner can monetize. There are beneficial partnerships that could happen, but that's above our heads (those in the room). There are lands that were excluded in NREL's study. A lot of land in Lahaina won't be farmed again because of water, so those ag lands are opportunities. Cost-prohibitive to farm in Lahaina. Some Class A ag lands are worth re-visiting to see if they can be included in future RE plans.
Need to go to County Council with a plan, prove that the ag land in Lahaina is not farmable, no water, too expensive. Tell them that energy is a form of ag. HECO is allowing the PUC to cause energy sprawl. Ag designation needs to be changed. The powers that be don't always know about the issues. Sugar was grown where it was because it was crap land. Would never grow anything in North Kihei except for kiawe. Waikapū Town planned development wants to build a new wastewater treatment plan, add Māʻalaea. Can pump the millions of gallons of water uphill and then create energy when it goes back downhill?
Methane gas from pig manure; should be capturing methane from landfill
Wave technology, needs to be scaled
Waikapu, North Kihei (Large agricultural land owner) why wasn't that land used before Kuihelani Hwy
A lot of ag lands in Lahaina will never be farmed again because there's no water – Large West Maui Ind owners: This needs to be taken to the council and prove the unfarmable lands so the classification can be changed
Major sewage plant in Maalaea - Pump the water uphill, install hydro, create a lake, if enough water you can supply Large agricultural land owner, or the water from the lake can replenish the Iao aquifer
Kaupō has great wind and solar potential, but it's far from transmission lines.
Put green dot where Mokulele Highway where Humane Society is, there is a heavy industrial area near above where Hawaiian Homes wants to develop. It's dry, no water, there's nothing around there.
Put green dot in waiheʻe, waiehu area. Lots of wind potential.
East Maui is very cloudy, also high in cultural resources. There's wind there in certain areas.
Potential for every area to be isolated during outages, especially west side and Hana, so distributing the energy would be ideal
Concern would be for Hana, lot of sensitivity there, don't recommend putting anything there.
Have had a lot of issues with wind and snow, power has gone down there. It would be difficult to bury cables there.
Cultural and jurisdictional sensitivities from Haleakala down to Hi-Performance center.
Avoid Pali due to fires.
Kapalua airport area due to aircraft approaches, FAA requirements. FAA put a six-mile radius around the airport for them to monitor.
Hana has culturally sensitive sites.
Summit – lots of jurisdictions operating up there.
Ranch lands. Whatever happens up mauka affects the ocean, that would be my concern. A lot of birds travel makai to mauka in that location. There are a lot of birds going makai from mauka in the morning.
South Maui has one of the densest cultural resources.
Waiheʻe because of cultural significance.
Honuaʻula – worried about the desecration.
Maui Lani area because of ʻiwi kūpuna.
Central area due to a lot of conservation area, same thing with Hana. Need to protect those areas. Lahaina already has a solar farm.
East Maui/Haleakala – Franco: protection of our natural environment
East Maui – density in Hana is very low so its hard to envision large projects in that area
West Maui Mountain area – should protect watersheds and natural environment
Haleakala – caution because of historical significance
Haiku, road to east, probably not suitable for solar
Avoid airport
Avoid Mauka areas due to cultural significance, terrain, and protected habitats
Avoid East Maui
Avoid vistas of Mauna Kahalawai
Kahakuloa/Waihee coastlines should be avoided because of sea level rise and possible iwi
Kipahulu Biologic Reserve and Haleakala Wilderness Area
Waihee/Waiehu, very windy but also lots of cultural significance
Makena – lots of archeological sites
Hana thru Kaupo – last untouched place on the island
Anything on the coastline is going to be difficult, shoreline/beach access.
The central area, along Veteran's Highway, is prone to wildfire. Look at what happened in Kahoma Valley, Lahaina, during Hurricane Lane. I didn't see or hear vulnerability mentioned, is that a factor?
There is a lot of unused land up mauka that catches a lot of sun. As long as we're being respectful of future housing sites, cultural features, etc.
North Kihei area has had a lot of negative impacts already.
Upcountry/Makawao, grew up there when it was still paniolo days

REZ Comments Collected
Top of Mount Kahalawai; wind farms are an eyesore, dirt roads created sediment into Maalaea Bay. Did the benefits outweigh the cons. We should avoid mauka development
Haleakalā as a caution area.
Cannot put any resources near the airport.
Fire caution, conservation land, wet terrain. Mostly mauka-oriented comments.
Whenever anything goes up behind the mountain, it's never a good thing. Cuts off access to fishermen, becomes a place for tourists, impacting sacred land.
Grew up in Lahaina where there was a lot of ag. Have a lot of challenges there, it's an island by itself.
Kula, historical area for ag
All of East Maui. – Fishing ground, no transmission lines out there, aesthetics
Too much cloud cover, not good for solar.
Nu'u – large boulders from ancient times.
Waiauku'u (Waihee) – familial generations of taro patches/farming
The input of the solar farms are a great idea- one major item to consider for all of solar is how is it going to be maintained to keep the system making the energy it is supposed to be making the whole time. There are a few companies dedicated to doing such work on the islands but this should be supported further and for open discussion.
If you drive the cost of electricity so high that it becomes unsustainable, all effort toward clean energy will be useless. Yes, pursue clean energy options, but do it in a way that puts the burden on HECO and the state of Hawaii, not on customers who are already stretched too thin paying energy bills.
I love the idea of more solar panels. I would like to see incentives given to businesses and homeowners (including condominium buildings) to add these to their structures.
Alternative energy sources are not reliable and are more expensive. In addition to causing more harm than natural gas. The last few days in Kaneohe and windward side cloudy and rain so good luck if you are dependent on solar. Wind energy is not efficient in producing and transfering electriicy to the grid.
We have a large solar system. Because of our conservation efforts, last year we generated $1,900 more electricity than we used. We were not rebated any of this amount. When I called your office I was told since we are a residence, not a power generator, no refund was available. They suggested we USE MORE electricity if we were concerned about gifting energy to Maui Electric. This seems counter productive if you need the resource.
I love this idea! It's called the WINDWARD side for a reason! Let's use it!
A lot of homes in Diamond Head/Kapahulu/Kaimuki are serviced by underground power lines, and HECO's requirement that homes be upgraded to 200 amp service in order to install residential PV makes installation cost prohibitive due to the cost of digging etc for this upgrade. If 200 amp service wasn't required for residential PV, then less space is needed for utility solar projects due to decreased demand
It would be amazing to have large gyms in HPP, Fern Acres and Hawaiian Acres/Beaches,Pahoa where the equipment is powered by the people using the equipment that would be attached to battery sources that Hawaiian Electric could capture to distribute to the area homes to help cost containment. Gym would be equipped with solar power as well.
There is a lot of untapped potential for solar panel placement on residential roofs. Not just in Pearl City but statewide. HECO should develop strategies to make use of this resource, possibly using partnerships with homeowners where their out-of-pocket costs are minimal but the energy generated by a distributed network of installations helps the surrounding community.
I have a recently installed rooftop PV system with battery storage. On very sunny days, my batteries will be full by noon and the system will stop storing energy. The system then stops producing electricity, even though there is plenty of opportunity. I would be happy to donate the additional energy that could be generated back into the grid to help reduce the demand on the grid, but that doesn't seem to be an option. I understand this is because of the limitations HECO places on PV systems.
As a renter, I feel felt out of this process and at the whim of my landlord.
The cost of my power bill has jumped $300 a month I don't have A/C I put in brand new water heater got rid of my extra fridge and cut everything else back as much as possible and I am paying $700+ every month
Continue to turn trash into power by expanding the power project to burn the thousands of pounds of trash produced on Oahu into energy. This not only produces energy but also reduces the incredible trash problems and landfills taking up space.
We need more EV charging stations operational on Maui There should be operating stations at shopping malls Too many of the stations are closed Mill house. Ma'alea harbour. Kulamalo. None at Maui mall
We have solar panels on our roof and I challenge my neighbors to do the same.
Solar on roofing in Kailua represents a huge potential opportunity given the high amount of sunny days and the lack of large trees or mountains close. The biggest challenge is affordability for most people should consider Hawaiian Electric renting roof space, etc
We are installing 30 panels and 2 batteries to help shoulder the load.
Hawaii Kai Golf Course has a large, flat parking lot that could accommodate solar panels. The panels would shade cars and keep them cool while golfers are using the course. The parking lot paving is old and crumbling. Perhaps a partnership could be made: new paving in exchange for using the space over the parking lot for solar PV?
Hydrothermal utilization and wind is important as alternative forms of energy.
Sun most days
We have solar PV, it would be good for all to be able to add tesla batteries to stabilize the grid and provide for power outages. A recent quote requires additional panels added to use batteries, or I can add batteries, but they aren't part of the grid, so no environmental benefits for all. Would be good to be able to add battery storage to our home.
Can the interior area of the crater be used for PV panels?
Palehua Community

REZ Comments Collected
the large amount of vacant land above the Pulehunui industrial area (southeast of the Maui Humane society) would be a supreme site for a large solar farm. It would be near power lines, near to the location where the State and Hawaiian Homelands are planning to put in a large number of facilities, and most importantly it is an area that receives a very high level of solar radiation with limited cloud cover.
Website that shows power outages as well as updates. Calling in during outages doesn't work. A single website linked to social media would help all. Could be automated as well. With power outages, most customers have cell service for sometime, so this would help all.
PLEASE stop the ridiculous activities that are RAISING our electric bills
There is an unused 18 hole golf course on the mauka side of Ali'i that could make a great solar farm. Was/is part of Kona Country Club courses - now going to waste & overgrown. Connectable to the grid.
The anti-solar rooftops attitude and practices of Hawaiian Power is an insult to the utilities approach to solving social challenges. When I fly over Oahu and Hawaii islands I'm flabbergasted about the lack of rooftop solar. I have tried to expand my current investment in our energy challenge and there is more resistance from Hawaiian Power than the County. I have not heard one word on how we can improve this number but many reasons why we cannot. You work a sheltered market. Live up to it's mission.
Allow rooftop solar with net metering. Don't force us to use a third party like sunrun and stop putting solar farms on arable land.
These clean energy initiatives are not only costing us more in electric bills, but are also horribly misguided and poorly implemented. We won't even dream of building a nuclear power plant (The cleanest form of energy technology available currently) or even building an infrastructure to recycle solar panels.
Water Generator. Think about it. Water flows from Kahanua Valley through tunnels built in the 1890s by mccandless brothers to feed water to sugar fields on the leeward side. But, water flow to Waiahole valley provide taro fields, tenant's, etc. can generate electricity with Down flow instead of pumps. I'm not an electrical engineer. But a system can be created Hawaiian Electric engineers. Electricity from created by water generators can feed to our grid. Thank you. A feedback is requested.
Why do we have the windmills so close to schools in the city of Kahuku
Why do we have the windmills so close to schools in the city of Kahuku
Re-establish energy buy-back programs to foster more solar development, and encourage existing solar customers to participate. This might discourage the practice to "go off-grid" once a home's batteries are fully charged if excess solar power is being produced, because the current compensation structure offered by Hawaiian Electric does not sufficiently benefit the homeowners, who have invested significantly in clean energy. Energy companies on other regions offer much fairer opportunities — why can't HECO?
How can residences who live in condos and townhouses, who share roof space, take advantage of solar/PV energy savings? With all the current renewable energy resources where is the savings going, to the residents or HECO? Can fuel cell technology create electricity?
Energy storage is critical. While batteries at individual homes are important (I already have a Powerwall), infrastructure storage is necessary. With all the land available and water from rain, a water fed gravity energy storage system could make a lot of sense. There may be better places on the island.
Don't put solar in natural areas, only on buildings and parking areas. Otherwise the solar will ruin Hawaii's natural beauty and wildlife. Also many areas are already saturated with solar. They produce too much energy during the day and none at night. We need large scale energy storage otherwise we will never reach the 2045 goal. Also stop making goals that are so far into the future that all current politicians will not have to be held accountable for them. Have realistic short term goals instead.
Not just in Hilo, but over the entire island, parking lots should have solar covers. As we need more electric car charging, this can help facilitate the powering of the chargers.
Net Metering. Pay the same rate for electricity from private PV systems that you charge and the need for larger projects will be less.
Given the volcanic activity on the island, is there any way we can use the geothermal energy to steam water to spin turbines to produce power?
Need to upgrade the grid to return power credits produced by solar homes to the homeowners in a more equal way. I understand cost verses credit, but it is hard to get behind a company that doesn't provide much back to the people that pay for it.
Excellent Choice for solar!
Where are all the depleated batteries going? Are children being used to mine Lithuim in Africa to provide this means of "clean energy"? We also know its cause fires. Its a lie. Have a good day.
There are medical offices in Hilo with solar panel installations installed in parking lots to provide covered parking spots for the staff and patients and electric power for the grid. If this makes economic sense for their businesses, it should make sense for our entire community. One of the smallest benefits would be a public relations win for Hawaiian Electric. Please investigate this option before using precious agricultural land that most local residents can no-longer afford.
Clean energy i Is no more than a talking point right now and climate change is just a hoax and a way for Hawaiian Electric to raise rates and local governments to increase taxes
I have a PV with a NEM agreement. I want to expand as I have more space on my rooftop, but the process is difficult and I am limited to how much I can add. If a homeowner has a NEM, we should be able to expand to the rooftop limit to be able to contribute to the grid.
We installed a Tesla wall so we could take advantage of the money back.program. it has been almost a year, now, and we still gave not received any monies back from this program which HECO endorsed, advertised and encouraged the public to be a part of. Please, 1) explain why you have taken so long and do not say there was a long list of applicants. That is not an excuse. And, please, remit and honor your promise. You can call me at 808 292 8903.
Installation of level 1 chargers to allow for EV charging during peak solar production hours at work sites as people are unable to take advantage of lower rates or solar production.
Instead of utilizing so much limited land for additional solar structures and wind farms, partner with property owners to utilize their unused solar footprint on their home's roof would be a more ideal way to use space. Yes, there are plenty of challenges with adding solar to homes, but if the state wants to really be proactive in improving going renewable, they will make the process easy, available and not a money grab opportunity. Fiscally it is difficult for most home owners to get solar, but if there is incentive of co-sharing costs such as renting the space from then in the form of payment in electricity, etc. It's a win for the community and a win for the home owner. There's more to be said about this than this little space, but developing on green land for wind and solar farms seems to be an unnecessary use of limited space resources. Maximize the use of the space already developed and show the world how it's done right by working as a community.

REZ Comments Collected
Ideology is not good policy! 100% renewable in Hawai'i is not going to make a dent in "saving the planet." There are clean solutions that are affordable, available, and can meet demand. Solar and wind are none of these! They work to an extent, but cannot be the only solution. Use actual science and engineering to help Hawai'i residents enjoy living here. That is your job! This has become a tourist state, but the residents are still paying for it!
I would love to have renewable energy options
Limited number of EV charging available within this commercial zone
There should be an incentive for those with solar to save electricity usage, because as it stands, users are actually encouraged to use more in order to reap monetary benefit. There is no financial gain or savings when we produce extra electricity. The only way to reap any benefits of the credits we earn is by going over what we produce. When I first moved into my home with solar, I asked around other users to understand how it works. The advice I was given is that if I'm used to using very little electricity and always produce extra, then I need to crank it up sometimes, like leave the a/c on, so that I'd go over what I produce, use up my credits, and pay even less then the service fee. I don't understand how come we don't get anything whatsoever for the energy that we produce for HECO. Even if we get a small percentage of the profit from what we're making for HECO, at least it would be an incentive to use as little electricity as we can, even with solar, which equates to producing even more.
100% renewable is not feasible and will cost more than you believe you will save. It is unattainable for the majority of people. You are placing a huge burden on the bottom of the income bracket
Regarding large solar projects on former Ag land; If ground mounted (bifacial) solar arrays are raised 6 to 8 off the ground, they can provide shade or partial shade for new Ag opportunities that could be very efficiently drip irrigated and provide low water use and very low evaporation for suitable crops such as strawberries, many lettuces and herbs such as; Shade-Tolerant Vegetables and Herbs: arugula, endive, lettuce, sorrel, spinach. collards, kale, mustard greens, swiss chard. beets, carrots, potatoes, radishes, rutabaga, turnips. Broccoli and cauliflower, brussels sprouts, cabbage. mint, chervil, chives, coriander/cilantro, oregano, parsley.
Residential townhomes have a limited access to PV/EV amenities. Shared roofline limits the amount of EV panels per occupant. Not sure about available options through HECO.
Residential customers should have opportunity to add, expand, or modify solar panels on their homes with ongoing incentives and without adverse consequences like having to modify their customer agreements that negatively affect them. Battery systems are neat, but not the solution to help the whole community or help the grid. The grid needs to be updated to support more solar and allow those who want to add enable them to. New construction or remodeling also should mandate solar with incentives.
The solar farm you are installing at the base of makakilo is a giant destruction of plant life and waste of our precious land. You should be installing them in parking lots and areas that are already paved over. What is the point of renewable energy if you are killing acres of plant life to install it?
This would not be a good location. Major power production equipment should not be located within the limits of the Sunset Ridge community as indicated by the placement of this marker. Additionally, solar pannels and wind turbines should be located where they will not negitively impact ocean views or unique locational values of ajacent residential properties.
Wind turbines should NOT be near schools or residential areas. These are highly undesirable in Kahuku and have negatively affected the community around there. Would strongly oppose more turbines on windward side unless in remote areas
Frankly, I agree that the coal/oil fired plant in Campbell should never have been shut down. Solar and wind are fine when it works but it's not 24/7 reliable. HECO should've invested in building a nuclear power plant in Campbell as it would allow all other plants to be shut down and have ZERO carbon footprint. Nuclear is VERY SAFE today as it's been 2 decades since the U.S. built a new nuclear plant. Hey, if the City can spend $12 BILLION on a stupid rail, it costs less than that for a nuclear plant that will fill the needs for all Oahu's electrical demands for decades to come. Even the smallest plant has more available capacity than Oahu currently demands (even without solar & wind supplements).
Wind farms are run by electricity. I thought the purpose of wind farms was to use the wind we get naturally to help provide power. Wind farms barely pay for themselves. They are expensive, interfere with birds, and barely contribute. If you want wind power, let the "wind" power the mills, not electric. They don't make sense.
Good idea
Why is the price per KW different everywhere? Is Hawaii's electricity so much better that it costs more? Is the price per KW for electricity in Ohio less because the "quality" of the electricity produced is not as good? Noooo! Electric is electric. It should cost the same across the board. Power companies stop being greedy!
Please stop taking away agricultural land! Get Monsanto out of Hawaii!
Quit taking away agricultural land and we will be able to have plenty of food! We need to bring back a few dairy farms so we can produce our own products here on the islands.
Good idea. Do not take away people's freedom of choice in the process. If people want to be off the grid let them.
Noooo! It isn't worth it! If you want to use wind power, let the wind that naturally happens power it. Why are the "wind" mills powered by electricity? Makes no sense, they barely pay for themselves, take away from the natural beauty, and birds are dying because of them.
In my view it is important to stop wasting green energy which is already produced: I have a photovoltaic system with batteries, but when the batteries are full the photovoltaic system must stop producing energy because HECO does not allow my system to output that excess production to the grid! I would not even expect to be compensated for that energy, I would just want to stop the waste, and I am sure that many new photovoltaic systems are in my same situation.
Please stop destroying Maui's beautiful landscape in the name of climate change. You will destroy one of the most beautiful spots on the planet with ugly wind turbines and solar panels, and the climate will continue on its path.
Kamehameha Schools Trust (KST) has thousands of acres of property tied up in low revenue, methane emitting cattle leases all over the Big Island. What about long term KST leases for renewable energy production that would benefit KST, Hawaiian's education and the public at large? Ag land use and renewable

REZ Comments Collected
energy use are not always mutually exclusive. Does KST --given that they are fundamentally a product of co opted land use --have any desire or obligation to give back to the planet and indigenous peoples who have no access to their schools ?
Until you can Figure out a way to Lower my bill this is Useless. My KWH have been the same for years, and my bill has been The same, Now that the Coal plant has been shut down, My Monthly Bill For the SAME KWH has Almost Doubled, And For what? Heco Made Millions in Profit, and yet we the People who made you Wealthy Suffer.
Wind turbines destroy the beauty of Maui's natural landscape.
Land South of and surrounding Community College has ample empty space and access to electric grid from existing power plant accross the Queen K highway from the airport. Looks like some development directly North of the college is in early stages, perhaps could be a coordinated development opportunity for solar power facilities.
While I'm not in favor of wind energy, especially anywhere near populated areas, I believe solar panels should be placed on every single public building possible (schools, government buildings, etc) and over parking lots (covered parking).
Solar/wind generated electricity should only be backup sources. Since Hawaii/Pearl Harbor/Hicham are home to the Pacific Fleet ALL ENERGY resources should be available for our strategic defense.
My KWH have been the same for Many Many Years. Now My KWH are still the Same and My Monthly Bill has almost Doubled, Yet Heco has the Nerve to Post it's Millions of Dollars in Profit. Seems like this is only helping Heco
Geothermal should be pursued on this island as it is the least intrusive on the environment and requires less outside inputs.
There are abundant opportunities for renewable energy projects in Puna—only each project will need security alarm systems and cameras to deter criminal activity. Susidized Solar on business roofs for a start.
Methane gas burn off from our refineries is energy going to waste. Hawaiian Electric has been stubbornly concerned with the bottom line than with customers. Until all the refinery burn off is used to fire our boilers to create steam and hence electricity you are wasting energy. The product of burning methane is O2 and H2O. Compare that to the carbon foot print of just one windmill.
Closed loop pumped storage hydro power can be a great solution for storage of intermittent renewable energy production (wind/solar) and a more cost effective and environmentally friendly alternative to battery systems. With the natural slopes on Hawaii Island, it seems that these systems would be possible storage solutions and reduce the need to rapidly switch on/off power generators at the fuel oil plants to balance inconsistent renewable power supplies (wind/solar).
In 20 years you expect to go completely green? Impossible, schools are billions of dollars behind in updates and renovations, now they have to go green. How are millions of homes, condos, and business going to go green. Who is going to pay. Will Matson and airlines who bring in all our essentials going to solar and wind power? Will new rail system be updated to run green? Who will pay? Will all our truckers and delivery people going green? Who pays, etc. etc????
Apparently no solar company wants to help off grid areas such as those in Nahiku because they are most interested in making money off of selling electricity they make off your roof back to the grid.
Start looking into putting power lines underground, at least in areas affected by wildfires often, wind and cause mass outages like down veterans highway to kihei
Why did our electric bill go way up after the so called smart meter installation?
Subdivisions along Hwy 137 (i.e. Kehena, Puna Palasades and Seaview) are on the sunny coastline with ample homes that can and do offer rooftop solar PV. Please improve the ability for residents to have grid-tied solar PV systems by upgrading the grid infrastructure for these subdivisions. Many residents in this area have resiliency practices already, so may choose to have onsite battery storage for their solar PV setup. Hence, there are opportunities for distributed energy storage as well as excess solar PV feeding into grid to contribute to upper Puna residents who have less solar opportunities (e.g it is more cloudy along the east rift zone than in the Kalapana coastal area.)
Kihei, Pukalani and Wailuku are full of developments, start working with Hawaiiana and other developers for solar roofs and green roofs with subsidies or incentives so that these complexes become more self sufficient.
I agree with an existing comment that panels over the parking at the Hawaii Kai Golf Course has great potential
Geothermal done "right". When our oil supply becomes compromised, as one day it surely will be! Out of luck!!
Work with animal farmers and keepers for solar panels on ground - generate energy and provide cooled areas for animals to rest. This can be taken to bus rest stops as well. Many bus stops on maui are uncomfortable, hot and sunny. Work with the county to beautify and functionalize rest stops to improve use of public transport and generate power.
Incentive HOAs to install "community" solar on building .... Rebates to individual residents or HOA to encourage solar installations.
Offshore wind!
How can our Haiku Point condo(200 apts) have Electric Vehicle recharging stations installed within our grounds, to each carport and parking space? Is there a pilot project we can volunteer for?
It's unfortunate our city council did not think this out better. Rather than eliminate the Kahi plant, but do so in phases, must people cannot afford the alternative initiated by the progressives who have most of the discretionary funds. But, enact a process that doesn't bite most of the population of Hawaii. However, I do appreciate the Hawaiian Electric initiative to help the population with solar power initiative. Mahalo HEC.
I'm in favor of a well planned electric power supply system that takes into account reliability and the cost to electric customers AND taking into account of the consequential cost impact of your electrical customers, business and government which could increase the cost of living for anyone or organizations that uses electricity. Lately, there has been a lot of outrages in my neighborhood. I was really surprised when HECO seemed to be NOT aware when AES Coal Plant shut down and the consequential increase of the electric rates. In the past, HECO tract cost of fuel and the impact of electrical rates in its Long Range Generation Planning. Isn't HECO still doing this study as new electric generation units are added or subtracted from its system? The cost Electric energy affects all of us so Plan and implement WISELY!
Back up power is needed for renewable solar/wind. In the next several decades it will be impossible to eliminate the need for fossil fuel powered back up generation. It's that or get ready for an increasingly unreliable grid.
the kula ag farm (a maui county project) has vacant land between the current farms as well as rough terrain areas that could support wind turbines as well as photovoltaic pannels

REZ Comments Collected
Many Hawaii residents have bought into solar energy. The time is approaching where roofs with solar panels will need to be replaced or refurbished. The cost of moving panels to replace a roof is crazy expensive. I think subsidizing re-roofing is more than warranted, especially as reroofing is not something a homeowner does but once every 15-20+ years. I am nearing that point when reroofing will be necessary. With my fixed income I will need all the help I can get to make it happen. Anything HEI can do to assist residents with solar panels will be greatly appreciated.
As with most of Hawaii, this area is good for Solar, not as good as the West side of the Island but still pretty good. Geothermal test plant is probably a great option but the location must be perfectly picked. Previous site in Pahoa was damaged 6~8 years ago.
Wind is an excellent renewable energy source—however the latest weatherproof turbines and the latest Plastic bird screened blades or vibration towers must be used to decrease salt damage repairs and harm to birds and bats.
Solar power companies act like its free but their contracts should all be reviewed carefully. They have some fairly nefarious clauses. If in doubt, have them reviewed by somebody, preferably contract attorney before signing!
We should do more air dry/ hang dry our laundries and use our natural sun power! It is difficult for apartment/ condo residents as most condos allow hanging laundries in lanais. Condo AOAOs should allow hang dry even the limited basis. Can HECO voice up?
Please continue to add wind, solar and battery storage as fast as possible to try and help preserve the power supply on our beautiful islands instead of relying on petroleum that has to be shipped in and can easily be interrupted at any time. Think about what would happen to our economy if the oil stopped flowing to the islands unexpectedly.
Honua Ola is a proposed wood-burning plant located in Pepeekeo. The proposed plant wants to cut eucalyptus trees, burn them to generate electricity. The rate Honua Ola plans to charge HELCO. is more than 2x what solar would cost. They're claiming this is renewable but this is a lie. The trees will not be replanted because the major landholder KSBE wants the trees permanently removed. This is a challenge because community members do not want this plant and Honua Ola keeps pushing to open the plant. WE can do WAY better than burning trees in 2023!
Increase grid-tied systems to provide excess power to the system for storage/later use. Net-metering is a good incentive to motivate users to invest in solar systems.
Expand geothermal to ensure lower energy costs for the consumer. These wasteful pet projects for various solar, wind, tree burning fiascos are doing nothing to lower the cost of energy to the consumer and do nothing to help attract true manufacturing jobs which are desperately needed.
Develop micro-grid landscape for rural and remote neighborhoods. Whereby HECO facilitates installation of PV panels n residential properties and battery storage in centralized location (subsidized through grants and public/private partnerships). This would help achieve the renewables goal, along with creating resilience for the community by hardening certain infrastructure and creating redundant sources; if one neighbourhood were to be adversely impacted by an event, the neighbouring communities could divert some electricity.
Grid-tie solar systems. Net-metering was a good motivator for the homeowner/farmer to invest in solar systems.
Are you nuts? Look what has happened to other locations that have tried to go 100% renewable. Utility costs have gone through the roof. How are you going to stop that? How are you going to ensure utility costs are kept down. How are you addressing environmental impact - like killing birds with windmills and the society impact - like child labor in Africa mining rare earth minerals?
I think there is opportunity to seek other companies to compete with HECO to offer energy solutions to Oahu's residents. The poor planning and decision making of HECO and our state representatives has clearly proven, especially in the past twelve months, how detrimental the consequences of poor decisions and planning can have on locals. We need more choices when it comes to such a serious matter such as energy demands required by the state.
battery storage facilities needed to stabilize the grid. More roof top solar panels will help reduce demand but must be coupled with battery storage for load management.
In North America, every electric vehicle manufacturer (except Tesla) uses the SAE J1772 connector, also known as the J-plug, for Level 2 (240 volt) charging. None of the HECO fast charging locations support the SAE J1772 connector thus limiting their usefulness. Additionally, for those that can use the HECO DC fast charging stations, it's not recommended to use them more than once or twice a week, because the high rate of recharging can adversely affect the lifespan of an electric car's battery if done too often. I never see these fast charging stations in use because of these facts.
Military Installations need reduced carbon (ie renewable) electric reliability and resilience. Increased reliability for military installations offers benefits to neighboring communities when transmission & distribution is disrupted (eg lines down during a major storm). Communities should seek to partner with Installations who seek to host Generation resources to improve reliability and resilience for everyone.
How much will the taxpayers be fleeced for this?
How much will the taxpayers be fleeced for this?
I would like to install solar panels on one of my two houses in Volcano but I am not sure it would pay for itself. Volcano is often cloudy and rainy which would eliminate the solar generation of electric power. Still, since electricity is so expensive maybe it is worth the installation. Do you have some potential generation figures for Volcano?
This is the community lot for Fern Forest. This is a ever growing community that could use more infrastructure
This is the entrance for Fern Forest. This is a ever growing community that could use more infrastructure
This is Hirano Store. They used to have a gas station there perhaps they would be open to a charging station and the community nearby would benefit greatly
Could the unused land at the airport provide space for solar panels in addition to the parking areas (covered parking results).
The only way to people completely green is to be off the grid. Let people be off the grid.
The only way to people completely green is to be off the grid. Let people be off the grid.
This whole renewable energy thing is a big farce. I'm not blaming you at Hawaiian electric because it's probably being forced down your throat. In fact, I'm sure it is. This thing is never going to work plain and simple. They're just isn't enough energy in Hawaii at present to accommodate what needs to happen. Like most government programs, it will end up costing more and being of little benefit to the taxpayers
The park here has a decent sized parking lot that could be an excellent site for solar covered parking. It also is in an open area so shade is not a problem.
Nuclear fusion generator that produces power like the sun will be the best option for 100% renewable energy, but so far there are only a few start up companies working on this technology and no government funding provided to them even though they are clean and green. No radioactive waste will be produced like with nuclear fission generators, so there won't be any Toxic Avenger or 3 eyed fish incidents.
Would be possible to get more of the condo buildings in this area to have roof mounted solar panels?

REZ Comments Collected
For almost 40 years my comment is: NOT environmentally friendly next to a neighborhood, too near lava eruptions, Loud noise, no working monitors for emissions, no alarm and evacuation plan for emergencies but I'm sure you have plans to build more plants all the way to the ocean and destroy the peace and beauty of Kapoho. I'm also pretty certain that you will ignore my input. Please alert me for public meetings. Thank you for the opportunity to give input.
Residential rooftop solar.
Hydrothermal as long as it can be done at a reasonable cost. Forget Wind, as it seems to do nothing but disrupt that eco system and kill whales.
Based on the proposed idea of a solar farm on an unused 18 hole golf course I'm in support of this kind of local project and encourage it to move forward.
We are building a self storage facility along the canal. Over 750kw of pv can be installed. We are willing to look at battery storage as needed for grid purposes. I am the principal investor for the LLC. I am familiar with moderate sized pv systems.
Solar panels are not allowed in Hali i Kai condos.
Electric vehicles using batteries are NOT a good option...Where are folks that use batteries going to put them when they no longer work? How will they be recycled? We are on a small island. Furthermore, where does the electricity come from when you are charging those batteries? From the oil fired plants we have in Hawaii.
I installed a new PV system on my house in November 2022 but HECO still has not approved coverage for my ADU which is on a separate meter. My PV system is sized to cover both dwellings but my ADU continues to pull from the grid because HECO takes months and months to approve a simple thing like a meter consolidation. If HECO could speed up their processes a lot more people would stop pulling from the grid.
HECO needs to speed up their approval PV approval process if they want to get people off the grid. It literally takes months to get approvals through HECO.
Could add solar panels in the large undeveloped grounds of the boys prison
Could add solar panels in the large undeveloped grounds of the boys prison
Could add a small solar farm on the undeveloped grounds of the boys prison
In case of hurricane, which will destroy most solar panels and deprive families of electricity until they rebuild, Hawaiian Electric should maintain coal burning plant as backup.
The wind project that powers the water department's pumps looks to be curtailing a lot of potential generation, but apparently there is no PPA in place to allow the export of power to the grid. This project seems like it would benefit from storage, so the pumps could be powered whether or not the wind is blowing, and so that the project could provide peak power to the grid. I know that the ownership and existing operating agreements complicate matters, but amending agreements must be simpler than building a new wind facility.
Hawaii island sits on one of the most active geo-thermal resources in the world. It's stupid not to take advantage of it. Between its solar resources and geo-thermal resources, the island could be energy independent forever; it would never have to worry about running out of electricity; it could wean itself of its dependence on fossil fuels! As a home owner, I look forward to a day when Hawaii is a no longer dependent on fossil fuels.
The challenge is this strange tool. The "Solar Potential" tool shows no data for the Miloli'i area, yet NREL has LOTS of data.
We would LOVE to have solar panels. But they're ridiculously expensive. Looking to buy a RAV 4 plug in hybrid. But don't know if it's feasible since electricity is so high
Stop ripping us off with the smart meters than make our bills double You put in the wind towers that havent done much good because the customers had to pay for that and you stop using them to charge us more
Had solar added and bill dropped from xx to 26. Two years later, solar is still working and it is 2x higher than before solar without AC.
Not enough electric car charging stations in or near densely populated residential areas.
Park and ride rail with EV charging would increase green transport into town, avoiding congestion. Win-win
Why are condos categorized as commercial and takes over a year for solar approval from DPP. The state wants renewable energy but puts roadblocks to people who try to do better. Let's streamline the process and make it easier so people can save money and preserve our island.
Hickam AFB doesn't have a single public EV charger on the whole base except maybe on the HANG side. Further, the base is full of large hangars, building and large parking lots that should all be covered in solar panels to power new EV charging stations and facilities. It's time to get people excited, make it easier to switch to EVs sooner, lower utility bills and help keep our island air clean.
The large parking lots of the Hawaii Kai Shopping Center, Hawaii Kai Towne Center, and Koto Marina Center rather than land could be covered with solar modules. I understand that on some days, more solar energy is produced than HECo can use to satisfy demand, so energy storage would also be needed.
Still concerns about bird interactions with wind generator blades.
Are there opportunities here for a solar farm?
ro have solar on the roof. To sell back energe that I have left over so you can sell to Co. that need it
I agree that the abandoned golf course has potential for a smaller solar farm.
Idea is great and an important component of island sustainability. However, HECO's processing and bureaucratic hassle to initiate.new pv.system is absolutely problermatic and new user initiation and rebates is terrible and unfriendly to new adopters
Idea is great and an important component of island sustainability. However, HECO's processing and bureaucratic hassle to initiate.new pv.system is absolutely problermatic and new user initiation and rebates is terrible and unfriendly to new adopters
Let's not charge a pv solar owning customer $300 for "generation" and "fuel" in a month where they receive from HELCO 22kWh, but send to HELCO 25 kWh.
It still concerns me to have wind generators near the coastline where they endanger birds.
Good opportunity for solar farms
We want to be part of the solution. Our roof gets a lot of sunlight and currently have solar panels for water heating, but we would be interested in setting up an affordable solar system for our other electricity needs.
Allow the Leilani Estates Community to invest in photovlatic cells on building tops and two of its 10 community acres to power the common areas (clubhouse, pavilion, ev charge station). This to be paid for by a partial grant and community members who invest in the infrastructure with payback of savings realized VS the existing power grid.
Big steam engine use old telescope lenses to make the heat to a turbine produce electric
There is abundant open rooftop and parking lot space all over Honolulu. It is south-facing so should get optimal solar generation.

REZ Comments Collected
Let's harness the ocean! Unlike wind and solar the ocean has 2 tides every day. The tides could power turbines that would power the entire ocean and it is a clean source of energy. Keep it simple. https://www.irena.org/Energy-Transition/Technology/Ocean-energy#:~:text=Tides%2C%20waves%20and%20currents%20can,use%20it%20to%20generate%20electricity.
This comment applies to all green energy development, be it wind, solar or whatever comes down the road. Please don't use virgin undeveloped land for any green energy production. Use only existing structures, preferably in already developed areas ie, existing building roofs, walls, express way medians, road beds and adjacent rights of way. All structures are disfiguring to the landscape and take a toll on wildlife. Giant wind and solar farms are a massive eyesore. I'd rather have compact scrubbed coal, hydrogen or oil than untold acres of energy infrastructure. If worse comes to worse teach people how to cut down on energy use so we need less infrastructure rather than more.
Why not install PV panels on top of condominium parking structures, they're everywhere like schools did in their parking lots. Do condo owners and renters want to contribute to this, lower their bills, of course
This entire state is prime for solar (photovoltaic) energy creation (and this isn't even considering newer tech including transparent photovoltaics) where a lot of home rooftops are still devoid of PV due to the challenge of not enough storage capacity for excess power to be fed back into our island/state locked power grid. IMHO, HECO and its subsidiaries should be prioritizing this (excess storage capacity). Why? Because more off-grid solutions are coming and economies of scale will inevitably make them feasible. I've been following RV/camping car off-grid solutions both in the US and Japan for awhile now. Ecoflow has several turnkey solutions including a modular solar generator system (you can link two Delta Pro's together along with appropriate PV panels) that I've been pricing out to see if it made sense to implement in order to just power home AC units and the refrigerators (the largest kWh consumers besides powering up the oven, dryer, microwave). Each Delta Pro is 3.6kWh that can have an additional 3.6kWh battery added; thus linking two of them together, can yield close to 11kWh of usable power generation; overkill for most situations unless also taking into account emergencies). The pricing has dropped dramatically in the past year to the point where I may pull the trigger for one unit as a starter (since the cost of one unit with additional battery plus say 1.2kW of PV), could pay for itself in 2 years if running a bunch of wall AC's or split AC units for most of the day/humid evenings as well as two refrigerator/freezers). And while I don't own an EV (the pricing and lack of infrastructure never made sense), the fact that I can use this as a charger, would make moving to EV finally attractive as more auto options are now becoming available. HECO should be making it far easier for residents to get onboard (rooftop PV) before the company starts finding itself losing to actual feasible turnkey (mostly plug-and-play) off-grid solutions that don't require a technical background to setup.
It's not reasonable! Please use common sense! We are already having issues switching from 3 different power sources. It's not a seamless transition, I do appliance repair and have never replaced so many computer boards as I have in the last few years. Thanks Dave
All new C&C construction and public projects should be required to use solar energy. The new Civic center will lay down lots of new concrete and asphalt. The roofs could be for solar and green space.
Looks like good location however, please make it un-viewable from the driving road unlike the Palm Springs California Area that has wind farms that absolutely destroy the natural scenery as well as highway to Las Vegas from Los Angeles - gigantic solar farm that is viewable from the freeway.
I own 19 Solar panels and have a back up battery. I have been told that HECO takes a percentage of my stored battery power and sells it. Is this true? I hope this is just bad information. Please clarify. James
Wind is not a sensible energy solution, especially compared to solar. The turbines are extremely large and costly to produce and maintain, especially near Big Island the water is deep to install, and they are an awful eyesore to coastal residents and ocean users.
Great open lava lands for a solar farm!
I think a small nuclear reactor located on Schofield could provide clean power to the entire island.
When is this so called green energy going to lower our rates? Go back to coal and lower our rates. What good is renewable energy if our rates keep going up?
Electric prices are way to high
Electric prices are way to high
Get the Home Owners Associations under control. They are denying homeowners' requests to install new solar panels for arbitrary reasons. These requests were developed by professional companies and were approved in the past.
At this point, "affordability" is the most common concern. Maybe 100% renewable energy is not the future your customers are looking for, unless you can show that it will not negatively impact affordability.
Please have a counter that shows how much more Hawaiians are paying now that the coal plant was shut down. This should be a running total.
In Orkney, they generate power using tidal energy. The tide is rising or falling 24 hours a day, spinning the turbine. They generate 104% of what they need! Have we looked into these turbines to see how to apply this technology in our island state? Orbital Marine Power in Orkney
I think it's a big mistake to go green without having a backup. Solar is a joke and only works during the day with clean panels. Look at how much dirt are on the panels just installed In Kapolei, they are covered in red dirt, last time I checked the panels don't work very well when covered in red dirt. The windmills are a whole other story, built close to residential areas, killing wildlife, environmental unfriendly. Don't get me started with the closing of our only coal powered, what was the problem with clean coal? China is building a new coal plant every week, and they aren't even near as clean as ours was. Hawaii's whole energy direction is political driven by the tree huggers and are forcing the rest of us to pay for their political agenda.
Would like to have a commitment to have the electric vehicle charging stations a high priority to have them working. The one next to Tommy Bahamas in Mauana Lani has not been operational for some time. I drive a Tesla but my next car will be a gas car due to frustrations in charging. This is especially true on Hawaii where distances are great and may need a charge before driving home.
Placing charging stations in park areas would help to serve the local communities and keep traffic away from commercial stores
Placing charging stations in park areas would help to serve the local communities and keep traffic away from commercial stores
I don't see any comments or considerations regarding the best energy source—- nuclear power.
Bring back the NEM program, and create more free EV charging stations. There are not enough on this island!
I concur with so many other commenters that there is great opportunity to increase solar use and to add battery power, but that there needs to be additional incentives to install new solar plants or improve existing ones. This would have the added impact of preparing the neighborhood for the days when electric cars are the norm and not an expensive novelty.

REZ Comments Collected
Pacific Paradise Mountain View Manor off of Oshiro road is a fast growing community. There are more sunny days than before and the potential for solar seems to be increasing.
Forget green. Rely on nat gas
Affordability should be a top priority for HECo as the Islands people are already suffering financially. Too many other economic issues making it hard for residents to afford to stay here and live. Everyday basic needs should not be hard for everyone to afford.
Place solar panels on the RAIL guide way. That will use available space, it will be non-obtrusive, it will be near the primary user, the maintenance will be easier and excess power can be stored under the rail where space is available. Alternate wind (small scale) and (vibration) power generators could provide power at night. As it become successful, freeways and viaducts will also become an options.
We'd love the opportunity to install roof top solar panels to help with home electrical cost and to help save our planet. What are the Hawaii county incentives to help us achieve this with our home and electric vehicles?
Co-locating solar and/or storage with the new water well infrastructure that is going in would make sense. The pumps are high-demand loads that could be mitigated by having generating capacity close by. The large electrical feeders also make for a good conduit to feed power back into the grid. The area is largely out of view from other areas, which helps to minimize visual disturbance.
Ideal location for offshore wind power farm
Ideal location for offshore wind farm. Offshore wind installations have an added benefit as a fish aggregator. Offshore wind power is good for energy and food sovereignty.
Good location for deep geothermal power plant.
How about you quit the bulls bit and recognize you have geothermal like Iceland quit trashing the islands with solar and wind turbines and support nuclear/fossil fuels while getting the real research done. This is crap buying into “climate change” the height or arrogance and at worst the decimation of our freedoms and our islands.
Please stop forcing this on everyone! Your rates are already insane and without the coal plant, doubt they will ever go down. This will do nothing except raise rates more, our grid cant handle it and will make any power outage increase. This isnt a way to reduce costs to residents, thats a lie. If people want to be more green, let them but stop forcing this until you can make it cost effective for all and the grid can manage.
Ag Zoning not specifically approved for BESS battery storage. Could be legal challenges. Naalehu Solar Project not in line with Kau CDP. Site infrastructure (connection to roadway, paving, left turn lane off highway, could cause significant cost to project. Panels will reflect a significant amount of light towards residences in Waiohinu and Kiolaka'a. Surrounding property owners do not support this project.
I want you to provide the least expensive energy you can, regardless of the source. Don't push what you call "clean" energy before it's time. When "clean" energy sources become less expensive (without subsidies) than conventional sources, they will automatically become the norm. Your job should be to provide the best service possible at the best price.
So many people can only afford the cost of townhomes. We aren't able to get fiber and obviously cannot get solar with shared roofs because of HOA rules. Let's get the HOA on board and it's unfair that people in townhomes have to pay higher costs for electricity and internet because of something they cannot control
We need Hydrogen as a power source and part of our infastructure
To encourage more roof top solar, Helco needs to allow the solar credits generated to be applied to the entire electric bill, specifically the minimum charge. If I generate more KWH than I use in a year, I should not have to pay a minimum charge every month. Hello is getting the benefit of free KWHs, they should not be greedy and still billl a minimum charge on top of receiving free electricity from the consumer.
have studies been done for hydro pumped storage to better store excess wind and solar energy?
Big hurricane, solar panel wiped out, wind turbines destroyed. Where does power come from?
Big hurricane, solar panel wiped out, wind turbines destroyed. Where does power come from?
Seems like a few SMRs (Small Modular Reactors) could take care of Oahu's energy needs with minimal footprint and almost zero cost for fuel transportation and no carbon footprint. Is this possibility being examined?
Lots of vacant or little used land here for a solar farm. It would be hidden from the road by trees. Those who want to go back to coal are fooling themselves about what coal does to our island. We need to get off of coal completely. Also there are quite a few opportunities for geothermal production that should be explored.
Please continue to do all that you are doing, setting and reaching goals within as reasonable time of as possible. Battery storage is good, but can the average household afford it and, if not, what then is the answer.
Include geothermal in the forefront of discussino.
Partner with DOE to install solar canopies over existing parking lot which is located near the street for easy connection to HECO grid.
I recently got an email about a new meter, which I greatly appreciate this advancement I wonder if there has been a discussion of installing "smart meters." This would greatly aid power management, a key component of a grid based on renewable sources.
Kaiser High School has a huge parking lot and adjacent field which could be used for solar canopies or a small-scale solar farm. Close proximity to the street for HECO grid connection and nearby fire station for added security and safety.
Parking lot solar canopy which has been done at other DOE campuses. Win-win! Provides shade for vehicles and generates solar power to help lower rates for the community. Close proximity to street provides convenient and unimpeded connection to HECO grid.
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REZ Comments Collected
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Install more EV chargers! There are NO public chargers from temple valley all the way to turtle bay. Yet, there are plenty of people that commit along this route and more and more are switching to electric vehicles. Incentivize at home charging with better rates for EV owners to charge during off peak hours!
Install more wind turbines in highly productive areas.
Install a traffic circle right here for all the people that like to turn left in the evenings. 😓
Do many of the warehouses/businesses have solar panels on the roof?
I know there are going to be electric vehicle charging stations in the new parking garage. Is there a plan to put car port structures with solar panels on the top floor? Keeps the cars cooler, and provides electricity at the same time.
If feasible, erecting micro-grids with solar PV panels and battery storage.
I commissioned electric solar panels in October 2023. They are installed and sitting on my roof NOT connected due to lack of movement on the part of MECO and HI Electric. When will we ever get our government and utility officials to become efficient and effective in their jobs?
I have lots of room on my roof (in addition to my 28 PV panels) to make a micro grid.
I have lots of room on my roof (in addition to my 28 PV panels) to make a micro grid.
I have first hand experience in alaska with all aspects of power generation. The only good reliable power is hydro and thermo. You have a resource that could power all of hawaii with thermo from your valcano. Solar and wind have been a waste of time and money. and are very expensive to own operate and it takes 12 times the minerals that need to be mined to build. Hawaii is being lied to. Its a money makin scam. you don t build anything here you don t mine anything. so you don t see the fact that all you are doing is changing where you burn diesel. So I don t support your effert to lie about the truth.
Go back to the old power station. HECO was not ready to transition yet. You're putting the cart before the horse. Like anything else in this world you don't get rid of something until you know it is working. This is plain idiocy and childish. You're letting a bunch of people decide for you what is best to transition. Transition is slowly moving from one condition to the other not abrupt change. You didn't really transition did you? Because you don't have any full resources to back up power in the event of an island power shut down do you?
Bring back the original net metering like in the past. So many homes could feed our grid the energy needed if HECO develops storage solutions for the energy being fed back to the grid. Then during peak periods, the grid could draw from the HECO batteries.
Solar is only for the wealthy, as panels with battery are unreasonable for the poor. Tax breaks and energy savings do not payback debt, so the poor must incur greater debt, that is in addition to their mortgages and higher taxes. If the energy savings and tax breaks were SO big, then all these solar companies would NOT be sprouting out of the woodwork like mold and thriving in a million dollar median house market. Higher taxes will punish the poor, who cannot buy solar; but the rich can take advantage of the tax cuts.
Solar is only for the wealthy, as panels with battery are unreasonable for the poor. Tax breaks and energy savings do not payback debt, so the poor must incur greater debt, that is in addition to their mortgages and higher taxes. If the energy savings and tax breaks were SO big, then all these solar companies would NOT be sprouting out of the woodwork like mold and thriving in a million dollar median house market. Higher taxes will punish the poor, who cannot buy solar; but the rich can take advantage of the tax cuts.
I believe it is too much to ask that the island of Oahu be totally reliant on renewable energy by 2050. I think there needs to be a compromise at some point. There need to be more consideration to unintended consequences. Mark James 3025 Wailani Rd Hon HI 96813
Good place for high speed EV charger. High speed EV chargers will make EV rental fleet practical.
Good place for fast EV charging stations. A network of fast EV chargers in several popular locations on the island will make EV rental viable.
All public & private surface parking lots could be utilized for PV & energy storage. Reduce heat island effect, selective trees/green spaces. PPA or UESC etc.
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REZ Comments Collected
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If solar powered (not just solar charged) vehicles are developed, using the sun to propel the vehicles, motor fuel consumption will drop to almost nothing. potentially saving billions of barrels per year.
All public & private surface parking lots could be utilized for PV & energy storage. Reduce heat island effect, selective trees/green spaces. PPA or UESC etc.
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All public & private surface parking lots could be utilized for PV & energy storage. Reduce heat island effect, selective trees/green spaces. PPA or UESC etc.
Very poor decision making from the leadership of HECO monopoly in Oahu has brought increased electricity prices to residents. The recent closure of major coal powered plant generating cheaper electricity here in Oahu, and replacing it with buying expensive oil, hence passing the increased bill to residents is not representative of a leadership that looks after their own people but instead puts political motives as priority. Change in leadership is the real opportunity.
We shut down the coal-fired plant TOO SOON!
Stop taking all my solar credits when you "reconcile" my account every July. It's bad and it's why I have a hard time really supporting anything HECO does aside from becoming a CO-OP. Your grumbles about maintaining the grid and how homeowners with P.V. don't maintain the grid......Where does all the money go from the kW's I give you and you sell at 100% mark up but come December you have no problem when you take $600 of wholesale electricity value from me
Stop taking all my solar credits when you "reconcile" my account every July. It's bad and it's why I have a hard time really supporting anything HECO does aside from becoming a CO-OP. Your grumbles about maintaining the grid and how homeowners with P.V. don't maintain the grid......Where does all the money go from the kW's I give you and you sell at 100% mark up but come December you have no problem when you take $600 of wholesale electricity value from me
I had recently contacted you about getting an energy audit. You informed me you don't do it, but I can do it myself. Today I found out there is $150 tax credit, rebate, for getting one. I cannot do that for myself. We are in Makaha Valley and really want to lesson our carbon foot print. Very disappointed in how you do things. I bought better surge protectors, but don't know if I am using it right. I am 65 years old and didn't grow up with technology so having new items doesn't register with my abilities. I need someone who can teach me how to use my smart plugs and new surge protectors correctly. The jealousy windows should be outlawed as so much air conditioner cooled air leaks out. People need incentives to change. We are so progressive in many ways but we are so behind in others.
I purchased my home for the calming, panoramic ocean view and beautiful, relaxing natural surroundings & have resided in it for over 35 years. I do not want the gigantic, unsightly wind turbines or large-scale mass of solar panels to negatively impact my daily life.
Put nuclear power plants on 2-3 islands and stop wasting our money on unreliable “renewables”. Provide tax credits for energy efficient windows and doors. Windmills kill birds. Solar panels and batteries use toxic metals and enrich China. And bring back cheap coal energy. Wake up to real science and stop believing the climate change narrative.
Power magazine reports that fossil fuel plants like AES Kalaeloa were available 90% of the time; for wind & solar, it's 17%. So to replace Kalaeloa would require 180MW x 90%/17% = 964 MW. When does HECO plan to have that much? Also how long can all plants run 24/7 without overhaul ?
Once every 20 years, we should reenact the battle of Nu'uanu. This would pay tribute to the cultural heritage and history of our aina and reduce carbon emissions by 50% every generation.
Tidal energy, please
Renewable energy must not come at the expense of native habitat and species. Use previously developed land and areas that are already covered with non-permeable surfaces.
older apt building has roof-top solar but benefits only the owner of the solar panels not the apt owners. Would like to see a direct benefit to the apt owners by a discounted diverter installation device.
older apt building has roof-top solar; solar panels' credit belongs to/benefits roof-top solar panel owner; unable to divert credit to apt owners who really need the break to high electricity bills. Building already installed LED lighting on premise, and not much savings to the apt owners. Would like to see some type of relief to the apt owners.
I like the idea of owning an EV, however living in a condo, at home charging is not an option. It would be nice to see more super charger availability, powered by renewable sources.
Make PV panels available for homes. Rotating panels in open pasture.
All new housing to include townhouses, not just in Ocean Point but all of Oahu, should have mandatory minimum solar installation. If the purchaser wants more solar, the developer can add it to the price of the home but at a minimum the home will have solar. For example, a 1700sq ft home should have a minimum of 7KwH system.
I concur with having a Nuclear Power Plant. For all that say it is too dangerous, we have floating Nuclear Power Plant (aka Navy Ships and submarines) docked in Pearl Harbor all the time. Oahu emergency power plan is based on connecting those nuclear ship or submarine to the power grid.
A lot of these comments, the way they are written and the context used, are not from local people, get real. All those charges on our bill is the problem. The only thing that change is the rate, and do cable companies pay the electric co to use their poles etc... if so why can't we the customer of electric get a discount since we are the ones who paid for the poles etc.. in our bill
Every home could be nearly 100% self sufficient with subsidized solar systems. Currently, an on-grid solar system is quite expensive and people cannot afford this among other bills.
Not sure why the dot on the map is out where there is currently no infrastructure.
Resilience would be my best choice because the project will need that to meet and address all of the projects planned in a way to meet everyone's needs which I feel will need lot of give and take.
It's good that you are pursuing purchasing power from homes with battery back up to cover peak power surges, but if you really want to save life on Earth, bring back net metering. Incentivising the purchase of solar panels/battery packs by buying electricity from individuals and businesses is the fastest way to get to net zero. Many states do it successfully and we have optimal conditions. Don't develop land, disperse not centralize.

REZ Comments Collected
It should be embarrassing that HELCO cannot keep a Level 3 charger working ON ITS OWN SITE! This charger is frequently (as in every time I've ever been there) not working. If we want to encourage EV use then adequate charging needs to be available. Keeping this charger up and working should be a project given to a team of people who check on it daily.
I do not subscribe to the eminent disaster rhetoric of "climate change", nor is there any data to suggest that humans contribute to or can change climate. If people want to generate their own power to get off the grid, I would encourage them to do so; however forcing everyone to do so is costly, unnecessary and just another tool to control people who are not harming anyone. The components of batteries that are needed to store the various alternatives create toxic waste and contribute to the enslavement of the poor in the countries where they are mined.
I do not want to live with chainsaws, logging trucks, increased degradation of our neighborhoods, towns, and highways, clearcuts, polluted air and water, higher electric bills, and corrupt political back-room deals, and entitled - arrogant billionaire investors. I want Hawli Electric to wake up to reality and tell Hu Honua to bugger-off.
There is space to plant trees for shade and reduce the heat from the road.
Solar is currently supplying full house power and do not need to connect to the grid, however the incentive to give solar back to the grid is small. Getting a 4 to 1 ratio of solar kWh in credit seems to be inadequate to incentivize trying to help us. I am pretty sure the electric company would prefer no solar as they are losing money with every house becoming self-sustaining. I agree that you do need to be able to initially come up with a good sum of money to pay for the solar installation and the interest rates are ridiculous for solar loans. The tax breaks are pretty good though. For a 10 kWh system you can claim $10,000.00 in tax credits for state and depending on the cost of the complete system, 30% of that can be claimed in tax credits for federal. Lets get together on this solar plan and make sure the customers are #1 if they choose to go with solar and really make it worth while. Otherwise we are talkiing out of both sides of our mouth.
We are long overdue to start thinking long-term and begin development of generation 3 nuclear power. We are not going to meet our needs with windmills and solar panels. The future is nuclear and we must begin making up for lost time. An energy poor island is simply poor. The situation on Oahu is already untenable. Add to that premature decommissioning of power plants without replacement energy is foolish. Bad decisions all around!
I like the community solar farm concept like the one being built in Makakilo. These need to be done with adequate battery backup. I would like to hear about plans to recycle old solar panels and storage batteries too as this is important to truly consider these systems green. I would also like to see more hydrogen infrastructure. Hydrogen should be used initially to power commercial and municipal vehicles that return to a central facility.
solar and pumped hydro storage on koko headlands
Look into retrofitting old fossil fuel facilities for long duration energy storage. Can do either retrofit or build new. Look at "cryostorage" or "compressed air storage" as that technology looks very useful and easily implemented for long duration energy storage!
At a minimum solar canopies over the parking lot of the planned stadium. The maximum is build a mini SoFi stadium and install solar panels and batteries. Contract full retail net metering for 25 years as a incentive.
Install solar canopy over whole Hikimoe Street making it the first solar street. Being a bus hub connecting to the rail station makes perfect sense to provide cover for commuters. It also perfect for charging stations for electric buses.
This part of Waikele Center parking lot has become a food truck hub and has a blood donation truck. Put a solar canopy here to soak up the sun instead of the asphalt. Bring out nearby charging station from hiding by the trash area and install several charging stations here.
All new build construction, (commercial or residential) should be required to install solar panels to help mitigate general fuel usage. All residential areas should also be encouraged to plant a tree or two within the property to keep the environment clean and green, a very small way but attainable.
Government policy inquiry/commentary. Please consider the future of energy production in Hawaii. A diversity of power generation resources is critical. Committing to a "renewable-only" strategy could leaves us vulnerable when weather isn't optimal, eg, storm conditions and storm related damage to panels, prolonged cloudy conditions (has happened a few times over the years), etc. Can a non-fossil fuel grid handle the load when every vehicle is required to charge? If every electrical demand is reliant on solar panels and wind turbines, what is the current capacity of those renewables and what is the current demand including vehicles that currently don't rely on electric charging? It's understandable that HECO is subject to government policy and regulation. The PR of converting to renewables is a good strategy given the one-sided conversation of energy future. Is the discussion about fuel elimination, or emission reduction, or developing an solar/wind industry over fossil fuel? Cost benefit analysis has to be more transparent beyond "we should do this because we'er saving the planet". It's understandable for HECO's business future to relent to government dictate, but is that the best future not just for perceived world saving, but for cost saving? Hawaii's COL is the highest in the US. A single option solution is never good for preparation or for efficiency. Plus most people can't afford extra energy cost when everything else is already costly. If the goal is to weed out those who can't afford to live here, that goal is well underway. And it's understandable how HECO and Hawaii's government would think that less people here is the goal. That is not sustainable.
I'm a retired oil company engineer and my stake in Oahu's energy future is much the same as yours - seeking practical, non-polluting, long-term energy solutions. That said, it is a very good bet that HECO will NEED spinning turbine-power to provide a reliable 24/7 power grid well past 2045 (in other words, HCEI's "bold goal" of 100% renewables by '45 will NOT be met). If we (You) don't plan for that eventuality, the good people of Hawaii will continue to burn expensive / polluting liquid hydrocarbons while much of the world flares (see link below) unwanted natural gas (methane) because they do not have a "local" market. Liquified Natural Gas (LNG) regassification on Oahu is already done on a tiny scale. "Regas" is the easy part, making the Oahu-based infrastructure small in comparison to the LNG cryo facilities that put LNG into special LNG tankers & ship it to us. This is a very-well understood technology and HECO is well-positioned to be the champion of large-scale LNG. IMHO HECO was foolish not to continue its 2016 LNG project with Hawaii Gas. Every day not spent developing large-scale LNG for Oahu is a day that we burn dirty oil instead of much-cleaner natural gas. Be the leader. https://thedocs.worldbank.org/en/doc/1692f2ba2bd6408db82db9eb3894a789-0400072022/original/2022-Global-Gas-Flaring-Tracker-Report.pdf
1. Use former fuel tanks at Red HIll for pumped hydro storage. 2. Lease roof space on warehouses, state and county buildings, for HECO solar panels. 3. When building solar panels on ag land, make them high enough for shade-tolerant crops to be grown underneath, and for animals to graze to keep the foliage down.
Aloha Hawaiian Electric, Thank you for asking for our input. When I was younger I watched computing transition from “really big machines” (mainframes) to “Massively Distributed

REZ Comments Collected
Processing" (servers). I believe the future of Renewable Energy will follow a similar path, and we will soon see the birth of Massively Distributed Energy Farms. These farms will be owned, operated and managed by local public utility companies, but the collection of energy will take place throughout the community. Below are a couple of ideas I've been thinking about. 1) Work with the County to modify the existing, or create new, public utility easements to allow Hawaiian Electric to install Energy Collection Devices (i.e. solar, wind, rain) as well as Storage Capacity (batteries) and Energy Distribution Devices (EV and/or other battery charging mechanisms.) Collection devices and charging stations could be placed a) along certain County roadways b) County recreation facilities c) County, State and Federal public parking areas d) Privately owned parking lots over a certain size (Residential, retail, hospitality) 2) Reach out and work with landlords/owners of Large Paved Parking lots. a) Most landlords/property owners don't want to become "Solar Experts" b) Storage capacity and distribution capacity could also be included c) How many landlords, owners, tenants and customers would love: i) high-shade over their parking lot ii) EV (and other) charging capacity in their parking lot iii) Reliable, safe, worry-free Renewable energy 3) For the Off Grid community: Replace propane canisters with battery capacity a) Build out community charging stations, similar to transfer stations and water stations. b) Customer can plug-in their battery and wait for it to charge; or c) Customer can "swap" drained battery for fully charged battery i)HECO could charge batteries off-site and transport 4) Residential Off grid or On: Offer a "carport" configured as a Renewable Energy Collection System a) Homeowners want solar; b) Homeowners don't want to become solar experts; or get stuck with a product that might not be supported in the future. c) Homeowners want to TRUST their energy supply! d) Charge a flat monthly rate (off grid) and/or standard electric rate (on grid) e) HECO would Own, Manage and Maintain all of the equipment f) Customer gets a carport : HECO grows it's Massively Distributed Energy Farm
Provide method to encourage rental homeowners to install solar panels on their rental units. Could set it up as HECO owns the panels and "rents" roof space or provide the homeowner a monthly stipend based on the power utilized from those panels.
Maximized surplus energy. Citizens as partners. Durable neighborhood energy and conservation. Minimize battery cost. Maximize clean fuel production for short and long term energy storage, stable ship and air fuels, hydrogen and gas turbines and fuel cell power. Waste to energy adapted, collocated for thermal efficiency, potable water, mining land fills, conversion sewage and wastewater, Geothermal high and low temperature , floating wind, tidal, ground source. Multifamily charging and offsite energy. Micro turbine CCHP incentives. Delivery vehicle electrification. Highest efficiency solar. Merge or partner with experienced company like Engie for rapid evolution of Electric company into clean generation, fuels, and waste conversion, high efficiency clean power generation, and export potential of energy and byproducts of processes.
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Invest a community solar in this long undeveloped land that has no claimed ownership. The lure of cheap electric will hopefully give landowners around this land incentive to give up their potential stake in the land. Installing a large solar canopy over this land and batteries for each landowner and offering the community an opportunity to invest and benefit from lower electric bills will give this barren land a purpose. It is my hope these landowners follow their neighbor across the street, Highway Inn in their investment of solar and batteries on their business.
Put large solar canopies, batteries and EV charging stations in this large parking lot.
Want to vote for the fast EV charging stations, especially at locations that are centrally walkable to destination attractions (like the Azeka marketplaces, and the major beach parks in this area, and grocery stores). Incentivize large businesses to host charging stations /more charging stations and keep them running. (Maui Brewing is a good example of a success story there.) There are some charging stations that are not operable and haven't been for months - how to ensure that they stay running?
Consider viability of ocean-based reneweable energy. This bay specifically gets very high wind and wind-wave action because of the funneling effect between the west maui mountains and Haleakala - can we harness some of that energy via wind mills (like in the northern seas around the UK and scandinavia?) or via wave power bouys? Understand that these options might not be worth the additional environmental effects on the ocean... but not sure?
Put windmills on Mauna Loa and/or Pala'au plains. Previous efforts to this effect were very badly planned and communicated because all the power was going to get shipped off-island with no benefit for Molokai residents. Ensure all Molokai residents get this power FIRST and pitch the idea of selling power to the neighboring islands for the benefit of Molokai residents (i.e. residents get free power paid for by the sale of power to neighboring island grids, which are more power-hungry/consume more power. Neighboring islands get more sustainable power to help bring their costs down, and the Molokai community will be incentivized to support the plan for their own benefit.)
Consider incentive programs for homeowner/homestead sized windmills. Like this: https://www.energy.gov/energysaver/small-wind-electric-systems Need the county/state planning departments to make permitting for installing these windmills simpler and easier, or make blanket exceptions or something. Is it possible to have these in dense neighborhoods like Kahului/Wailuku/Kihei, or do you need bigger homesteads like < 1 acre, or what? There are very small ones that are designed for home use applications, and larger horizontal access ones that might be good for farms/ranches that have more space. Even the small ones can generate a significant amount of power for the average home consumer, and just add reliability/redundancy to the grid.

Appendix B:

Forecasts, Assumptions and Modeling Methods

Appendix B:

Forecasts, Assumptions and Modeling Methods

1. Forecasts and Assumptions

1.1 Load Forecast and Methodology

The load forecast is one of the many assumptions that the resource planners use in their models to stress test the various plans under varying conditions. Multiple scenarios and sensitivities were developed to plan around uncertainties surrounding adoption of behind-the-meter technologies, which ultimately drive the load forecast and peak demand. Additional sensitivities were also identified in the resource planning stage.

Forecasts were developed for the five islands beginning with the development of the energy forecast (i.e., sales forecast) by rate class (residential, small, medium, and large commercial and street lighting) and by layer (underlying sales forecast and adjusting layers – energy efficiency, distributed energy resources, and electrification of transportation, and time-of-use rate load shift).

The underlying sales forecast is driven by the economy, weather, electricity price, and known adjustments to large customer loads and is informed by historical data, structural changes[1], and historical and future disruptions. The impacts of energy efficiency (EE), distributed energy resources (DER), primarily photovoltaic systems with and without storage (*i.e.,* batteries), and electrification of transportation (light duty electric vehicles (EV) and electric buses (eBus), collectively "EoT") were layered onto the underlying sales outlook to develop the sales forecast at the customer level. Load shifting in response to time-of-use rates (TOU) was also included as a forecast layer. Since the load shift was assumed to be net zero (i.e. load reductions during the peak period are offset by load increases during other time periods), there is impact to the peak forecasts, but no impact to the sales forecasts. An illustration of the components that contribute to the customer sales forecast is shown in Figure B-1.

[1] Structural changes include the addition of new resort loads or new air conditioning loads that have a persistent impact on the forecast.

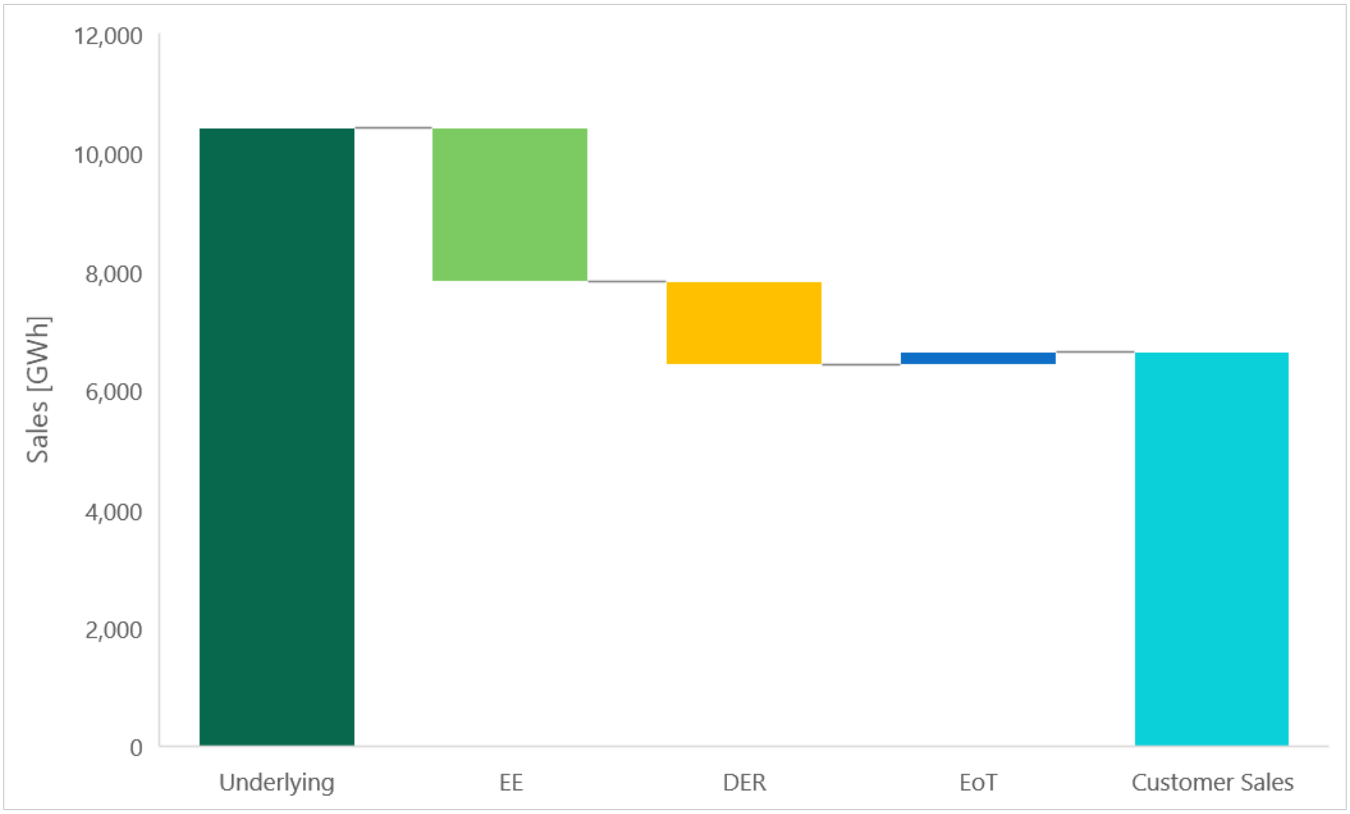

Figure B-1. Oahu Customer Sales Forecast by Layers[2]

The residential and commercial sectors are forecasted separately as each sector's electricity usage has been found to be related to a different set of drivers as described in the approved March 2022 Inputs and Assumptions filing. To summarize, historical recorded sales used in econometric models are adjusted to remove sales impact of DER, EE and EoT, which are treated as separate layers. Input data sources for developing the underlying sales forecast include economic drivers, weather variables, electricity price and historical data from the Company, as shown in Table B-1 below.

Table B-1. Input Data Sources for Underlying Forecast

Source	Data
University of Hawaii Economic Research Organization	Real personal income Resident population Non-farm jobs Visitor arrivals
NOAA – Honolulu, Kahului, Hilo and Kona Airports	Cooling degree days Dewpoint Temperature Rainfall

[2] Time-of-Use layer is not shown due to the assumption that customer sales [kWh] during peak load hours we shifted to other hours of the day resulting in net-zero change to sales.

Itron, Inc.	Commercial energy intensity trend for Pacific Region for non-heating/cooling end uses.
Hawaiian Electric	Recorded kWh sales Recorded customer counts Large load adjustments Real electricity price

The underlying sales forecast was based on a combination of multiple models and methods (i.e., certain models/methods are more appropriate for near-term time horizons and others for long-term trends). Methods for the underlying layer include:

- Market analysis: A ground up forecast evaluating individual customers (particularly large commercial customers), projects, and events that may merit a specific carve out if significant, i.e., new large projects or loss of large loads.
- Customer service: An analysis of recent trends in customer counts, sales and use per customer and applies knowledge of local conditions such as construction activity, state of the visitor industry, trends in weather including impacts of storms and volcanic eruptions.
- Trending models: Uses historical data series to project future sales or customer counts. Works well when historical data series has identifiable patterns and future trends aren't expected to vary from the past.
- Econometric models: Relates sales or customers' use of electricity to macroeconomic variables such as personal income, jobs, population, and visitor arrivals as well as other variables such as temperature, humidity or electricity price. Econometric models may also incorporate time series parameters such as lagged dependent variables or an autoregressive term. The quantification of the impact of changes in the economic and other variables on use is the strength of these models.
  The econometric model is specified in the following form:

$$Y = \beta 0 + \sum_{i=1}^{n} (\beta i \; x \; Xi)$$

where the dependent variable, Y, is kWh sales or use per customer and is related to the independent (explanatory) variables, Xi, which represent economic or other variables.

Variables βi represent the regression model coefficients. The constant variable $\beta 0$ represents the Y-intercept.

1.2 DER Forecasts

The DER layer includes impacts of behind the meter PV and battery energy storage systems as well as known projects for other technologies (e.g., wind). This forecast adjustment estimated new additions of DER capacity in each month by island, rate class and program, and projected the resulting monthly sales impact from these additions. The DER adoption forecasts included stakeholder suggestions to develop several sensitivities including a high and low forecast for the bookend scenarios.

Future DER capacity modeling considered two time horizons:

- Near term (approximately next three years) reflects the current pace of incoming applications and executed agreements, existing program (NEM, NEM+, SIA, CGS, GSP, CSS and ISE)[3] subscription level and caps, feedback from the Companies' program administrators, PV system installers, customer input and any studies or upgrades being done to address short-term hurdles (e.g. circuit study, equipment upgrades) that affect the installation pace; and
- Longer term forecast, which is model-based as the detailed application information is not available.

To extend the DER forecast from the short-term through the full planning period, an economic choice model using payback considers a set of assumptions such as the installed cost of PV and battery, incentives, electricity price, program structure that affect the economic benefit to the customer which is the primary driver of their decision to adopt the system.

Storage size assumptions for each island and rate class were optimized based on return on investment for an average customer. By modeling average customer's optimal pairing size, the amount of forecasted storage was appropriately captured for the overall rate class as customers with larger storage requirements offset those with smaller or no storage requirements. DER customers store excess generation during the midday that is then used to reduce their load (and additionally export to the grid in the case of future export programs such as Scheduled Dispatch) during the peak period daily. As a result, DER customers are shifting their load in a manner consistent with proposed TOU rates and no additional load shift would be expected in response to TOU rates.

Monthly DER capacity factors for each island were used to convert installed capacity to customer energy reductions. The monthly capacity factors recognize the variations in solar irradiance throughout the year rather than using a single average annual capacity factor to reflect monthly variations more accurately in the energy production of DER systems. A degradation factor of 0.5% per year[4] was applied to the sales impacts to recognize that the DER system's performance degrades over time.

To develop a high and low DER forecast, a number of factors were considered based on stakeholder feedback. As a result, Table B-2 summarizes the assumptions used to develop the DER forecasts.

Table B-2. Summary of assumptions used to develop DER forecast sensitivities

Input	No State ITC	Low	Base	High
Synopsis	Revised lower DER uptake below market forecast	Market Forecast based on self-consumption	Revised uptake based on DER docket proposals (The Company), include EDRP (Oahu, Maui),	Revised uptake based on DER docket proposals (DER Parties), include EDRP, updated resource costs, expanded addressable market

[3] Existing programs include Net Energy Metering, Net Energy Metering Plus, Standard Interconnection Agreement, Customer Grid Supply, Customer Grid Supply Plus, Customer Self Supply, and Interim Smart Export.

[4] Median degradation rate from NREL "Photovoltaic Degradation Rates – An Analytical Review", D.C. Jordan and S.R. Kurz, 2012, http://www.nrel.gov/docs/fy12osti/51664.pdf

			expanded addressable market	
Cost Projections	NREL ATB - Moderate	NREL ATB - Moderate	NREL ATB - Moderate	NREL ATB Advanced
Federal Tax Credits	Dec 2020 COVID-19 Relief	Dec 2020 COVID-19 Relief	Dec 2020 COVID-19 Relief	10-year extension
State Tax Credits	0%	Increased 2021 to 35%	Increased 2021 to 35%	Increased 2021 to 35%
Includes EDR Program	No	No	Yes (Oahu, Maui)	Yes
Long Term Upfront Incentives	None	None	$250/kW (Oahu, Maui)	$500/kW
Long Term Export Program	NA	NA	Standard DER Tariff (All Islands) with Scheduled Dispatch (Oahu, Maui)	Smart Export+ with Scheduled Dispatch
Addressable Residential Market	Single Family/2-4 Unit Multi- Family/Owner Occupied/Consumption Threshold	Single Family/2-4 Unit Multi- Family/Owner Occupied/Consumption Threshold	Single Family/2-4 Unit Multi- Family/Owner Occupied/Consumption Threshold	Single Family/2-49 Unit Multi-Family/Consumption Threshold
Addressable Commercial Market	Public or Private Owned/<6 stories/Consumption Thresholds	Public or Private Owned/<6 stories/Consumption Thresholds	Public or Private Owned/<6 stories/Consumption Thresholds	Public or Private Owned/<6 stories/Consumption Thresholds/Expand Sch-P Customer Pool to 100%
Add-Ons	NEM+	NEM+	Sch-R NEM above minimum bill customers from 2021-2023 (Oahu, Maui), NEM+[5]	Sch-R NEM customers from 2021-forward

For incentives, the Base forecast assumed the following for Federal and State investment tax credits shown in Table B-3 and Table B-4.

Table B-3. Federal Tax Incentive Rate Schedule

Class	2019	2020	2021	2022	2023	2024+
Residential	30%	26%	26%	26%	22%	0%
Commercial	30%	26%	26%	26%	22%	10%

Table B-4. State Tax Incentive Rate Schedule

2019	2020	2021	2022	2023	2024	2025	2026	2027+
35%	35%	35%	25%	25%	20%	20%	20%	15%

- State cap on residential PV-only systems: $5,000 in all years
- State cap on residential PV+storage systems: $5,000 in 2019-2021, $10,000 in 2022-forward

[5] Customers participating in NEM+ is included in the Base case scenario for all islands, but only from 2024-forward for Oahu and Maui because Schedule-R NEM customers were re-introduced in the customer pool for 2021-2023.

One of the key drivers in the long-term DER forecast is the addressable market, including customers that can add-on to existing systems. The addressable market for residential customers included single family and multi-family homes with a maximum of four units that were owner occupied and with a high enough energy consumption to utilize at least a 3 kW PV system, as shown in Table B-5. Historically, only 15-20% of residential PV installations have been below 3 kW. From a practical perspective, customers with low consumption are less likely to make an investment in rooftop PV. Smaller systems are also less cost-effective due to fixed portions of the installation and material costs being spread out over smaller total capacity and savings potential.

Existing NEM customers who were not reaching a minimum bill were added to the addressable market from 2021 through 2023 for O'ahu and Maui, as shown in Table B-6. In addition, comments from stakeholders indicated that there might be DER customers who only install a battery. However, others may increase their PV capacity to capture the total value of tax credits. Considering these comments, future retrofits for NEM customers assumed both an addition of a battery system, 5 kW/13.5 kWh, and an increase in PV capacity, 5kW[6].

Table B-5. Addressable Market for Residential Customers

Island	Percent of Schedule R Customers	Average PV System Size (KW)	Average Storage Size (KWH)
O'ahu	37%	7.0	15.5
Hawai'i Island	41%	6.0	11.0
Maui	43%	7.0	15.0
Lāna'i	24%	4.0	9.0
Moloka'i	30%	4.0	12.0

Table B-6. NEM Customers Added to Residential Addressable Market

Island	Percent of Schedule-R NEM Customers	Average PV System Size (KW)	Average Storage Size (KWH)
O'ahu	85%	5	13.5
Maui	71%	5	13.5

For commercial customers, public and private building ownership was considered in defining the addressable marketand structures greater than six stories were excluded. Similar to residential customers, small and medium commercial consumption needed to be above a set energy usage threshold. Commercial thresholds were established using rate class customers' previous 12-months usage, historical PV installation data, and business types. PV and non-PV customer segmentation by business type. Distributions for total energy usage[7] were created for PV customers. Usage at the lower 1/8th quantile was used as the threshold for business types that had five or more customers who already installed PV. The default thresholds of 500kWh for Schedule G and 5,000 kWh for Schedule J are

[6] Order No. 37816 permits existing PV customers to add up to 5 kW of additional PV generation capacity.

[7] Total usage is the sum of the previous 12-months sales plus the sum of the previous 12-months estimated PV generation.

used for business types with less than five existing customers with PV already installed. The resulting addressable market for the commercial sector can be seen in Table B-7 through Table B-10.

Table B-7. Addressable Market for Commercial Customers

Island	Percent of Schedule G Customers	Percent of Schedule J Customers	Percent of Schedule P Customers
O'ahu	37%	53%	78%
Hawai'i	35%	68%	44%
Maui	41%	63%	68%

Table B-8. Addressable Market, Average PV System Size, and Average Storage Size for Schedule G Customers

Island	Percent of Schedule G Customers	Average PV System Size (KW)	Average Storage Size (KWH)
O'ahu	37%	7.0	12.5
Hawai'i	35%	5.5	9.5
Maui	41%	7.0	14.5

Table B-9. Addressable Market, Average PV System Size, and Average Storage Size for Schedule J Customers

Island	Percent of Schedule J Customers	Average PV System Size (KW)	Average Storage Size (KWH)
O'ahu	53%	76.0	40.0
Hawai'i	68%	64.0	15.0
Maui	63%	59.0	45.0

Table B-10. Addressable Market, Average PV System Size, and Average Storage Size for Schedule P Customers

Island	Percent of Schedule P Customers	Average PV System Size (KW)	Average Storage Size (KWH)
O'ahu	78%	330.0	0.0
Hawai'i	44%	64.0	0.0
Maui	68%	330.0	0.0

1.3 Time-of-Use Rates

We evaluated and included Time-of-Use (TOU) load shifting impact for non-DER customers and non-EV load into the load forecast. Generally, TOU rates are thought to be a mechanism to encourage customers to modify their consumption patterns (ex. shift evening peak usage to other hours of the day) by reacting to different energy price signals. Stakeholders stated that residential TOU load shift scenarios should be included in the IGP base forecast and bookend forecasts even if impacts are relatively small because it is likely that TOU rates will be implemented. Based on the proposal presented and stakeholder input, assumptions in Table B-11 were used to develop TOU load shift scenarios for residential customers.

Table B-11. Summary of assumptions used to develop residential TOU load shift sensitivities

Input	Low	Base	High
Rates	Hawaiian Electric Final ARD Proposal	Hawaiian Electric Final ARD Proposal	DER Parties Final ARD Proposal
Residential Customer Pool	All Non-DER Residential Customers = Residential Forecast Minus High DER Sch-R Forecast	All Non-DER Residential Customers = Residential Forecast Minus Base DER Sch-R Forecast	All Non-DER Residential Customers = Residential Forecast Minus Base DER Sch-R Forecast
AMI Rollout	100% by 2025, Straight line from current deployment to 2025	100% by 2025, Straight line from current deployment to 2025	100% by 2025, Straight line from current deployment to 2025
TOU Rollout	Default rate for AMI meters ramps up from 2022 to 2026	Default rate for AMI meters ramps up from 2022 to 2026	Default rate for AMI meters ramps up from 2022 to 2026
Load Shift Method	Net Zero Load Shift	Net Zero Load Shift	Net Zero Load Shift
TOU Opt-Out Rate [%]	25%	10%	10%
Price Elasticity	-0.045	-0.070	-0.070

One of the key components of the Advanced Rate Design ("ARD") discussed in the DER docket includes the implementation of TOU rates, including mandatory TOU for DER customers. Consistent with Advanced Rate Design ("ARD") discussions, each customer that adopts DER (solar paired with storage) and/or electric vehicles under managed charging scenarios is effectively shaping their consumption to operate consistent with a TOU rate. For example, DER customers would charge their energy storage system with rooftop solar during the day and discharge the system in the evening. This load shifting is captured in the DER forecasts battery storage profiles. Since these DER customers are shifting their load in a manner consistent with proposed TOU rates, no additional load shift would be expected in response to TOU rates. The managed charging forecast profiles reflect customers charging electric vehicles during the day in response to TOU rates. On October 31, 2022, the Commission issued PUC Order No. 38680 established future TOU rates will include three daily time periods with a 1:2:3 price ratio. While specific rates, charges, and timing may deviate from the Base assumptions, the forecast sensitivities adequately capture the potential load shift due to TOU rates.

We assumed new DER customers would be defaulted into a Three-Part TOU rate that includes a $3/kW monthly demand charge. Referencing the Company's Bill Comparison of 2017 TY and Proposed Three-Part TOU Rates under the ARD Track Initial Proposal[8], a 300 kWh monthly usage and 3.336 kW peak residential customer's monthly bill, including the demand charge, would be an estimated $5.86 higher under the proposed TOU rate compared to the 2017 TY rates. For a 600 kWh monthly usage and 3.336 kW peak residential customer, their estimated monthly bill would be $3.69 lower under the ARD rates compared to 2017 TY rates. This small difference would not affect the economic choice model DER uptake forecast in either direction for the average customer with the assumed average PV and battery system size. Stakeholders commented that prospective DER customers looking toward purchasing a future EV may be dissuaded from adopting DER because of the potential impact of a large demand charge from vehicle charging. While a demand increase would lead to a higher demand charge under the Company's proposed ARD rates, DER uptake would not necessarily be decreased under this scenario. The DER uptake model assumes a system size for PV and storage based on average customer usage. Introduction of an EV load would require adjusting the assumed PV and storage system size to account for the planned load increase, which ultimately adjusts the payback period.

1.3.1 Literature Review

Key takeaways from the Companies' literature review, including California studies[9], and estimated load shift for residential customers were presented to the STWG on September 23, 2021.

On October 1, 2021, the Consumer Advocate ("CA") submitted comments on the TOU analysis presented in the September 23, 2021 STWG. The CA made suggestions as potential input to development of commercial TOU forecasts.

- Review three commercial TOU studies sited by the CA for consideration that may provide relevant information to estimate commercial TOU impacts.
- Review historical data for the Companies' commercial customers enrolled in TOU.
- If no "reasonable Hawaii-based or comparable studies" provide sufficient data to support a forecast, consider a pilot to provide understanding of the potential impacts.
- The CA notes that they do not suggest delay or suspension of the IGP process to pursue this path.

In response to the CA's comments, we investigated additional studies on TOU and customer response summarized below.

[8] *See* Hawaiian Electric's Advanced Rate Design Initial Proposal filed on December 17, 2020 in Docket No. 2019-0323, Instituting a Proceeding to Investigate Distributed Energy Resource Policies pertaining to the Hawaiian Electric Companies.

[9] Sacramento Municipal Utility District (2014), SmartPricing Options for Final Evaluation, research-SmartPricing-options-final-evaluation.ashx (smud.org)

In Aigner and Hirschberg (1985),[10] the summer period time-of-use energy (kWh) pricing subsection of the study may be comparable to the ARD proposals, although considered with caution due to changes in customer loads and efficiency that have occurred since the time of the study. The authors' conclusion from their analysis of covariance is, "For the time-of-use energy rates, no perceptible shifting behavior is predicted in either season."[11] The elasticity for the TOU energy rates in both seasons resulting from their econometric analysis also suggests there is no price responsive load shifting because the result "indicates that an increase in peak-to-off peak price ratio will cause an increase in the proportion of peak kWh consumption."[12] The authors note several limitations of the study that may have impacted the results and speculate that customers will shift load if the price signal is large enough. However, the actual statistical results of the study support the conclusion that the IGP load forecasts are reasonable as proposed without a commercial TOU load shift layer.

The Qui et al. (2018)[13] study was conducted in the summer in Phoenix, Arizona. It is characterized by the authors as a study that "reveals how business customers respond to TOU pricing under relatively extreme weather conditions – summer in the Phoenix metropolitan area, where the average high temperature is above 100 degrees and air conditioner (AC) usage in the summer peak hours is a major portion of the system load."[14] The conditions of the study are not comparable to conditions in Hawaii.

The California Statewide Pricing Pilot (SPP)[15] studied small commercial and industrial (C&I) customers' demand response to time variant rates in the Southern California Edison service territory. The C&I peak period was from noon to 6pm on weekdays. The observed peak period reductions were highly dependent upon smart thermostats as an enabling technology for customers with central air conditioning.[16] The results for the two-part TOU treatment group varied significantly across the two years of the study and the authors state that results of that treatment group, "should be viewed cautiously, however, in light of the small sample size and significant variation in the underlying model coefficients across summers."[17] The peak period in the Companies' final ARD proposal is 5pm-10pm and the lowest rates would be during the proposed midday period of 9am-5pm. Because of the differences in the time periods of when the highest (and lowest) rates occur and the significant dependence of the California SPP results on enabling technology, the California SPP results are not directly applicable to commercial customers under ARD rate proposals in the Companies' service territory.

[10] Aigner, D. and Hirschberg, J. (1985). Commercial/Industrial Customer Response to Time-of-Use Electricity Prices: Some Experimental Results. RAND Journal of Economics, 16(3), 341-355.

[11] At 349

[12] At 352

[13] Qiu, Y., Kirkeide, L., and Wang, Yi. (2018). Effects of Voluntary Time-of-Use Pricing on Summer Electricity Usage of Business Customers. Environ Resource Econ 69, 417-440.

[14] At 418

[15] Charles River Associates (2005). Impact Evaluation of the California Statewide Pricing Pilot. *See* https://www.smartgrid.gov/document/impact_evaluation_california_statewide_pricing_pilot

[16] At 119-120

[17] At 13

Current participation rates in commercial TOU rates is extremely low: 16 customers on O'ahu, 2 customers on Maui island, 2 customers on Hawai'i island, all on either Schedule TOU-G or Schedule TOU-J. There is insufficient customer data to guide or project the response from commercial TOU customers. In addition, the existing commercial TOU rates, as with all existing TOU rate options, are voluntary, while the proposed TOU rates in Advanced Rate Design are opt-out default rates. Based on commercial customers' historically low participation in TOU rates in the Companies' service territory and the results of referenced studies, it is unlikely that implementing an opt-out commercial TOU rate in and of itself will result in load shifting.

The Company will evaluate the response of residential and commercial customers that are assigned in the ARD TOU Roll Up Period study[18]. This information will be used to inform forecasts in future IGP cycles.

1.4 Energy Efficiency

The energy efficiency layer is based on projections from the July 2020 State of Hawaii Market Potential Study prepared by Applied Energy Group (AEG) and sponsored by the Hawai'i Public Utilities Commission.[19] The market potential study considered customer segmentation, technologies and measures, building codes and appliance standards as well as the progress towards achieving the Energy Efficiency Portfolio Standards. The study included technical, economic, and achievable energy efficiency potentials which allowed the development of different EE forecast sensitivities.

An achievable Business As Usual (BAU) energy efficiency potential forecast by island and sector represented savings from realistic customer adoption of energy efficiency measures through future interventions that were similar in nature to existing interventions. In addition to the BAU forecast, AEG provided a Codes and Standards (C&S) forecast and an Achievable – High forecast. The C&S forecast included the impacts of new codes and standards set to take effect in future years that were known and codified by June 2020. The Achievable - High potential forecast assumed higher levels of savings and participation through expanded programs, new codes and standards, and market transformation.

For the High Load Bookend scenario, the EE Low sensitivity forecasts were updated to include C&S savings for all islands. To represent the potential for lower EE savings, the EE Low sensitivity reduced the programmatic Business-As-Usual component by 25%. Additionally, the EE Freeze sensitivity was updated to include future C&S savings, aligning with the EE Base, Low, and High sensitivities. No modifications were made to Business-As-Usual component of the EE Freeze sensitivity. Shown in Table B-12 is a revised summary of the EE forecast sensitivities.

[18] PUC Order No. 38680 issued October 31, 2022 under Docket 2019-0323, Instituting a Proceeding to Investigate Distributed Energy Resource Policies Pertaining to The Hawaiian Electric Companies

[19] *See* https://puc.hawaii.gov/wp-content/uploads/2021/02/Hawaii-2020-Market-Potential-Study-Final-Report.pdf

The impacts from AEG were derived at an annualized level and included free riders which reflected savings for all measures as if they were all installed in January and provided savings for the whole year. The annualized impacts were adjusted to reflect ramping in of measures throughout the year to arrive at energy efficiency impacts by month for each forecasted year. For simplicity, the installations were assumed to be evenly distributed throughout the year.

Table B-12. Summary of Energy Efficiency Forecast Sensitivities

Low	Base	High	Freeze
BAU (Reduced by 25%) + C&S	BAU + C&S	Achievable High + C&S	BAU capacity fixed at 2021 levels + C&S

1.4.1 Energy Efficiency Supply Curve Bundles

Energy efficiency supply curve bundles were developed to determine the optimal amount of energy efficiency measures compared to the assumed forecasted energy efficiency using the results of the Hawaii Statewide market potential study ("MPS") that AEG performed on behalf of the Public Utilities Commission. In the modeling, energy efficiency was treated either as a reduction to load within the energy efficiency sales layer, or included in the supply curve bundles as a supply side resource.

1.4.1.1 Energy Efficiency Supply Curve Development Methodology

The supply curves were developed to treat energy efficiency as an available resource to be selected based on its cost and value. This required creating a new level of energy efficiency potential, referred to as "achievable technical," before applying any screens for cost-effectiveness.

Developing Achievable Technical Potential

Achievable technical potential is a subset of technical potential, accounting for likely customer adoption of energy efficiency measures without consideration of cost-effectiveness. To develop the achievable technical potential, the customer participation rates from the "Future Achievable – High" case from the MPS, which account for market barriers, customer awareness and attitudes, program maturity, and other factors that may affect market penetration of energy efficiency measures.

Differences from the Hawaii statewide potential study

Figure B-2 illustrates the levels of potential assessed in the MPS. Striped layers show impacts that are contained in the baseline forecast and therefore not part of the energy efficiency supply curves. These categories include naturally occurring efficiency, codes & standards impacts, and the lingering effects of past program achievement.

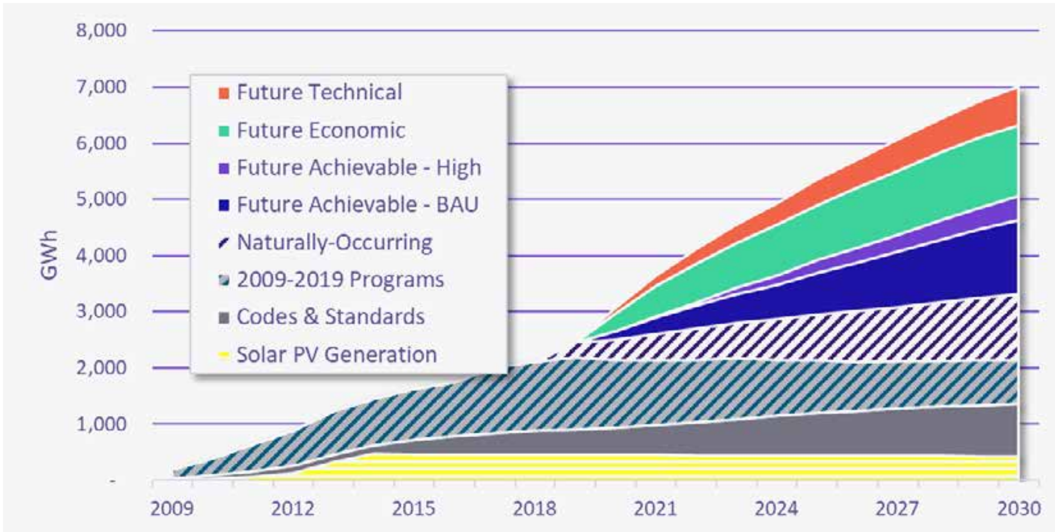

Figure B-2. Cumulative Persistent Energy Savings through 2030, EEPS Perspective[20]

Because the achievable technical potential used to develop the supply curves does not consider cost-effectiveness, it is not the same as any of the levels of potential shown in Figure B-2. Rather, the amount of available achievable technical potential would fall between the "Future Technical" and "Future Achievable – High" potentials.

Peak Impacts

Each energy efficiency measure has an island-specific load shape, which was created during the potential study process. By taking the annual savings calculated from the MPS and distributing it across this shape, impacts in each hour of the year can be calculated for each measure shape. The relative "peakiness" of each measure was considered by comparing its impacts during peak hours to a flat shape. Peak impacts refer to impacts on the **average weekday evening peak hour** (between 6:00 PM and 8:00 PM) and are calculated as the average impacts during such hours.

Figure B-3 shows the average impacts of all measures within each classification using Oahu as an example, based on cumulative potential in 2030. As expected, peak-focused measure impacts are strongly concentrated in the weekday evening hours, whereas "other" measure impacts are much flatter.

[20] See State of Hawaii Market Potential Study, Executive Summary page iv, Figure ES-3 (https://puc.hawaii.gov/wp-content/uploads/2021/02/Hawaii-2020-Market-Potential-Study-Final-Report.pdf)

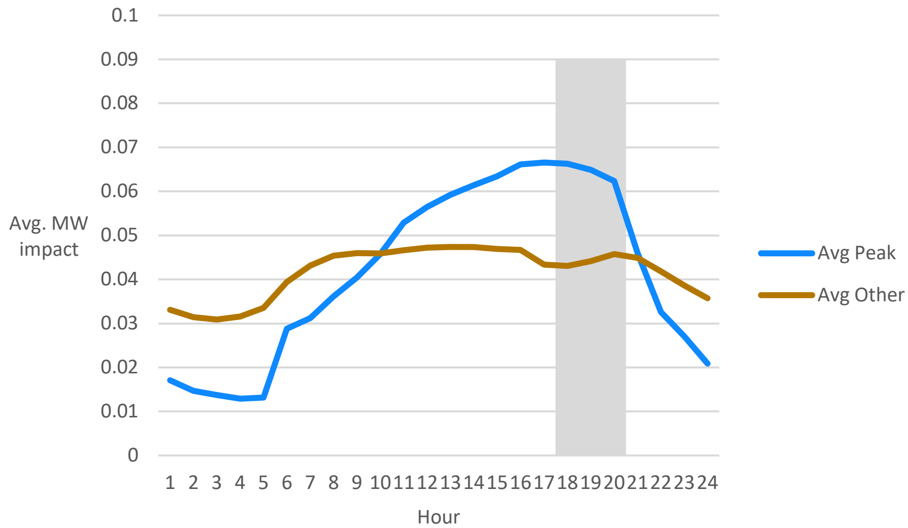

Figure B-3. Averaged Weekday Impacts by Measure Classification, Cumulative in 2030 (Peak vs Other, Oahu)

Cost-Effectiveness

The next consideration for bundling measures was the cost of savings. Although the levelized cost of conserved energy ($/MWh), which annualizes costs across each measure's lifetime, is one means of understanding resource costs, grouping solely based on energy saved may not allow the model to efficiently target measures with higher benefits due to contributions to peak reduction. Because the benefit-cost ratios (using the Total Resource Cost test perspective) from the MPS captured both energy and capacity benefits, these ratios represent a convenient metric for bundling measures considering both cost and value. Table B-13 shows the ranges used for bundle classification, which serve to separate measures that are highly cost effective (A) from borderline cost effective and not cost effective measures (B and C) to very non-cost-effective measures (D) to avoid them skewing the overall cost of the more attractive groups.

Table B-13. Benefit-Cost Ratio Ranges Assigned to Bundle Groups

Bundle	Benefit-Cost Ratio Range
A	>1.2
B	1.0 - <1.2
C	0.8 - <1.0
D	< 0.8

It is important to note that many of the measures in group A could have absolute costs ($/MWh) that are *higher* than measures in group B or C. In those cases, the greater benefit of peak-focused resources offsets the costs in the MPS methodology. Depending on how the shape of bundles meets the RESOLVE model's needs, it might choose lower absolute costs first, which could produce differences between the

RESOLVE model selections and the MPS. This flexibility is an expected feature of the chosen methodology.

Bundle Costs

To allow energy efficiency resources to compete against other supply side resources, the model is provided a levelized cost of conserved energy (LCOE) for each model based on the measure-level costs from the Statewide MPS, in $ per MWh. This is a Total Resource Cost **net** value which includes not only the installed cost of the measure, but net effects from non-energy impacts, O&M costs or savings, and possible avoided replacement costs, annualized over the life of the measure. Because non-energy impacts are netted out of the cost, it is possible for a measure to have a negative LCOE if the benefits are greater than the cost of the measure. Each bundle's LCOE is calculated as the savings-weighted average of the LCOEs of the measures within the bundle. To further inform the planning process, the peak MW impact of each bundle was also noted (as calculated from the annual energy and load shape) and a value of $/MW was derived by multiplying the levelized cost of energy ($/MWh) by the annual savings (MWh) and dividing by the associated peak savings (MW).

1.4.1.2 Analysis Results

Figure B-4 below shows the incremental energy savings potential for each bundle over the forecast period. The sharp increase in savings in 2025 coincides with an increase in commercial linear lighting installations, due to equipment turnover in the potential study modeling. Note that these annual savings values do not include re-installation of measures that were previously incentivized and may have expired. While these measures will need to be reacquired in later years, they will not increase the total cumulative potential, so those reacquisition savings are excluded from this perspective.

There could be marginal additional savings at the time of re-acquisition, such as if technology standards have improved in the intervening years, however such savings would be difficult to quantify directly using the outputs of the MPS. The modeled potential without re-acquisitions is a conservative estimate to avoid overstating potential.

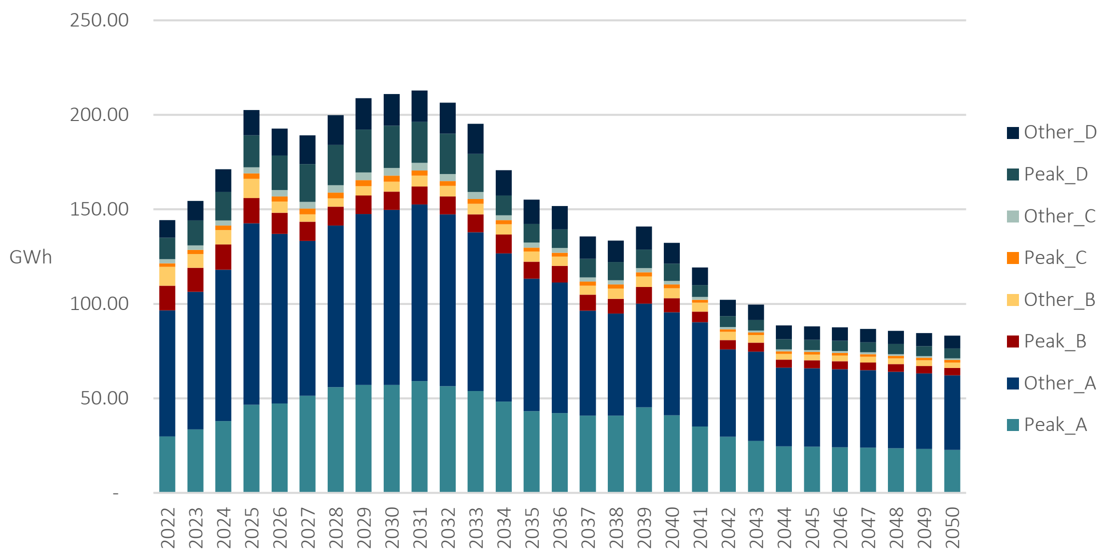

Figure B-4. Incremental Annual Energy Savings Potential (Achievable Technical) by Measure Bundle (All Islands Combined)

Table B-14 and Figure B-5 below show the cumulative energy savings by end use for each bundle. The savings here represent the total Achievable Technical Potential in 2045 from the MPS.[21]

The Peak bundles are dominated by the cooling end use. The Peak A bundle, which includes the most cost-effective measures from the potential study, gets 77% of its savings from the cooling end use. The Other bundles are made up mainly of water heating, lighting, and appliance measures, which tend to have flatter or even morning-focused shapes.

Table B-14. Technical Potential Energy Savings (GWh) by Measure Grouping and End Use (All Islands Combined)

	Peak					Other			
End Use	A	B	C	D		A	B	C	D
Cooling	17.5	2.3	0.5	2.9		5.3	0.1	0.2	1.2
Ventilation	2.0	0.2	0.3	0.4		2.8	0.1	0.3	0.8
Water Heating	2.1	0.2	0.1	0.2		11.5	2.2	0.0	0.4
Interior Lighting	0.2	1.1	0.1	0.4		11.2	0.0	0.0	0.2
Exterior Lighting	0.1	0.1	0.0	0.0		1.0	0.0	0.0	0.3
Res Appliances	0.1	0.0	0.2	1.0		0.5	0.5	0.1	2.6
Com Refrigeration	0.2	0.0	0.0	0.2		1.9	0.0	0.2	1.0
Electronics	0.2	0.0	0.0	0.0		0.1	0.0	0.0	0.0
Food Preparation	0.0	0.0	-	-		0.2	0.0	-	0.0
Miscellaneous	0.2	0.0	0.1	0.0		5.0	0.1	0.2	0.3
Total	22.7	3.9	1.3	5.2		39.4	3.0	0.9	6.7

[21] The Statewide MPS study period only ran to 2045. Annual potential from 2046-2050 was calculated based on the year-over-year trend from 2040-2045.

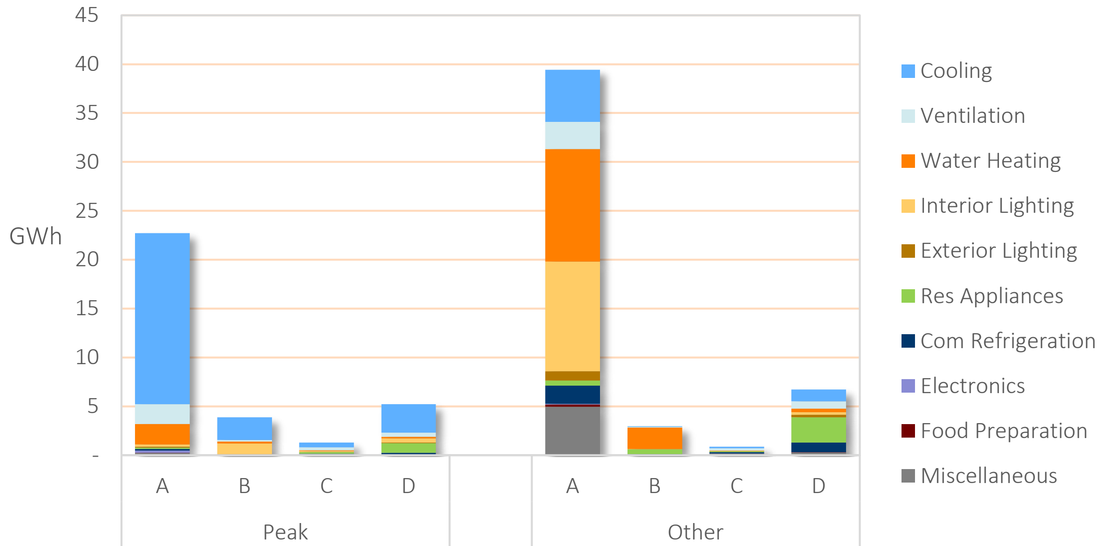

Figure B-5. Achievable Technical Energy Savings (GWh) by Measure Grouping and End Use (All Islands Combined)

As noted in Order No. 38482, the energy efficiency supply curves must be revisited to adjust the peak window used in the bundling process to 5-10 p.m. Also, clear explanation of the bundling process and rationale must be provided to clarify for peak bundles, whether the majority of savings are coincident with system peak or the measure's maximum savings occur during peak hours.

In the O'ahu charts below, there is some shifting of the supply curve shapes for the adjusted peak window but generally, the shapes are the same.

- Peak bundles retain the same profiles where their savings steadily increase and concentrate impacts at or near the peak window
- Other bundles do not have a concentrated impact at the peak window and instead have oscillating savings above and below the flat shape (black reference line).
- During the peak period, the Other bundles also have a smaller peak savings contribution compared to the Peak bundles.
- The clear difference in shape observed between the measures bundled as Peak and Other was a factor in assessing the appropriateness of the bundles because it is more informative to the resource plan development to know if certain energy efficiency shapes are preferred by the models.

Based on these results, it does not appear that the adjusted peak window makes a material impact on the bundle shape and the energy efficiency supply curves do not need to be revised.

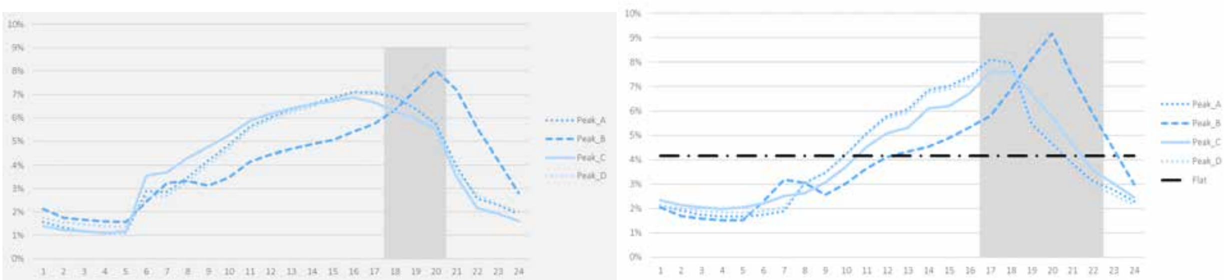

Figure B-6. Before (Left) and After (Right) Peak Window Adjustment for Peak Bundles

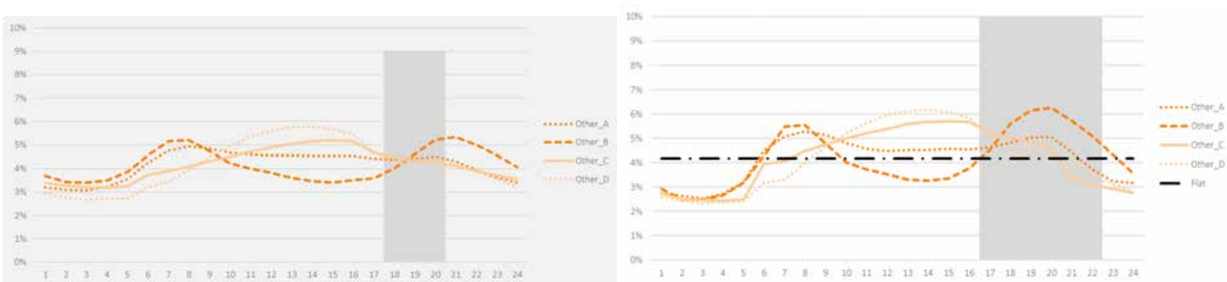

Figure B-7. Before (Left) and After (Right) Peak Window Adjustment for Other Bundles

1.5 Electric Vehicles

The electrification of transportation layer consists of impacts from the charging of light duty electric vehicles (LDEV) and electric buses.

1.5.1 Light Duty Electric Vehicles

The light duty electric vehicle forecast was based on an adoption model developed by Integral Analytics, Inc. as described in Appendix E of the EoT Roadmap[22] to arrive at EV saturations of total light duty vehicles (LDV) by year for each island. Historical data for light duty vehicle registrations were provided by the Department of Business, Economic Development, and Tourism (DBEDT) and reported at the county level. The total light duty vehicle forecast for each county was estimated using a regression model driven by population and jobs based on UHERO's October 2019 economic forecast. The development of the LDEV forecast utilized the EV saturation by island as shown on tab "EV Saturation" in Attachment 8 of PUC-HECO-IR-1 and applied the saturation to the light duty vehicle forecast for each island to arrive at the number of LDEVs.[23] Although EV saturations were not specifically consistent with carbon neutrality in Hawaii by 2045 in the Base LDEV forecast, they are consistent with County goals for 2035.

To estimate the sales impact from EV charging for each island, the annual kWh used per vehicle was calculated based on the following equation:

$$Annual\ kWh\ per\ vehicle\ = \frac{\big(Annual\ VMT * (kWh\ per\ mile)\big) * 10^6}{Total\ LDV\ Forecast}$$

where

- *Annual VMT* is the annual vehicle miles travelled
- *kWh per mile* is a weighted average of fuel economies of electric vehicles registered

Annual VMT is forecasted by applying the baseline economic growth rate developed by the Federal Highway Administration for light duty vehicles to DBEDT's reported vehicle miles travelled for each county.[24] For Lānaʻi and Molokaʻi, vehicle miles travelled were developed based on information from DBEDT and on-island sources.

[22] *See* https://www.hawaiianelectric.com/documents/clean_energy_hawaii/electrification_of_transportation/201803_eot_roadmap.pdf

[23] *See* https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/forecast_assumptions/PUC-HECO-IR-1_att_8_electric_vehicles.xlsx

[24] *See* https://www.fhwa.dot.gov/policyinformation/tables/vmt/vmt_forecast_sum.pdf

Historical *kWh per mile* was obtained using the weighted average fuel economy of registered electric vehicles by island. For Lānaʻi and Molokaʻi, the fuel economy from the Nissan Leaf represented each island's average. Fuel economy and vehicle registration by type data were obtained from the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy and Electric Power Research Institute (EPRI), respectively[25]. *Annual kWh per vehicle* was forecasted by applying a reference growth rate developed using the U.S. Energy Information Administration's (EIA) Annual Energy Outlook to the historical weighted average fuel economies.[26] The reference fuel economy growth rate expected battery technology will improve and more larger vehicles will be produced.

Car registration data at the ownership level was not available to determine whether a car was a personally or commercially owned vehicle. Therefore, a ratio between residential and commercial PV installations in historical years was used to allocate the number of EVs between residential and commercial customers for each island. Within the commercial EVs, a percentage based on PV capacity installed by commercial rate Schedules G, J, and P was applied to the total commercial EV count to calculate the number of EVs at the commercial rate schedule level. The sales impact by rate schedule was calculated by multiplying the number of EVs by sales impact per vehicle for each island.

1.5.1.1 Light Duty Electric Vehicles Charging Profiles

Previous unmanaged charging profiles were developed using third party and public charging station telemetry, load research conducted by several utilities in California, as well as Hawaiian Electric specific advanced metering infrastructure (AMI) data. The unmanaged residential and commercial light duty electric vehicle charging profiles were updated by leveraging data from the Company's DC fast charging network and a case study[27] conducted through the deployment of EnelX's Level 2 chargers in Hawaiʻi. Figure B-8 below highlights the revised residential and commercial charging profiles compared to the previous IGP profiles, including a demand reduction during the evening peak hours in the residential charging profile.

[25] *See* http://www.fueleconomy.gov

[26] *See* https://www.eia.gov/outlooks/aeo/data/browser/#/?id=113-AEO2019&cases=ref2019&sourcekey=0

[27] *See* Smart Charge Hawaiʻi Case Study, In partnership with Hawaiian Electric & Elemental Excelerator, EnelX

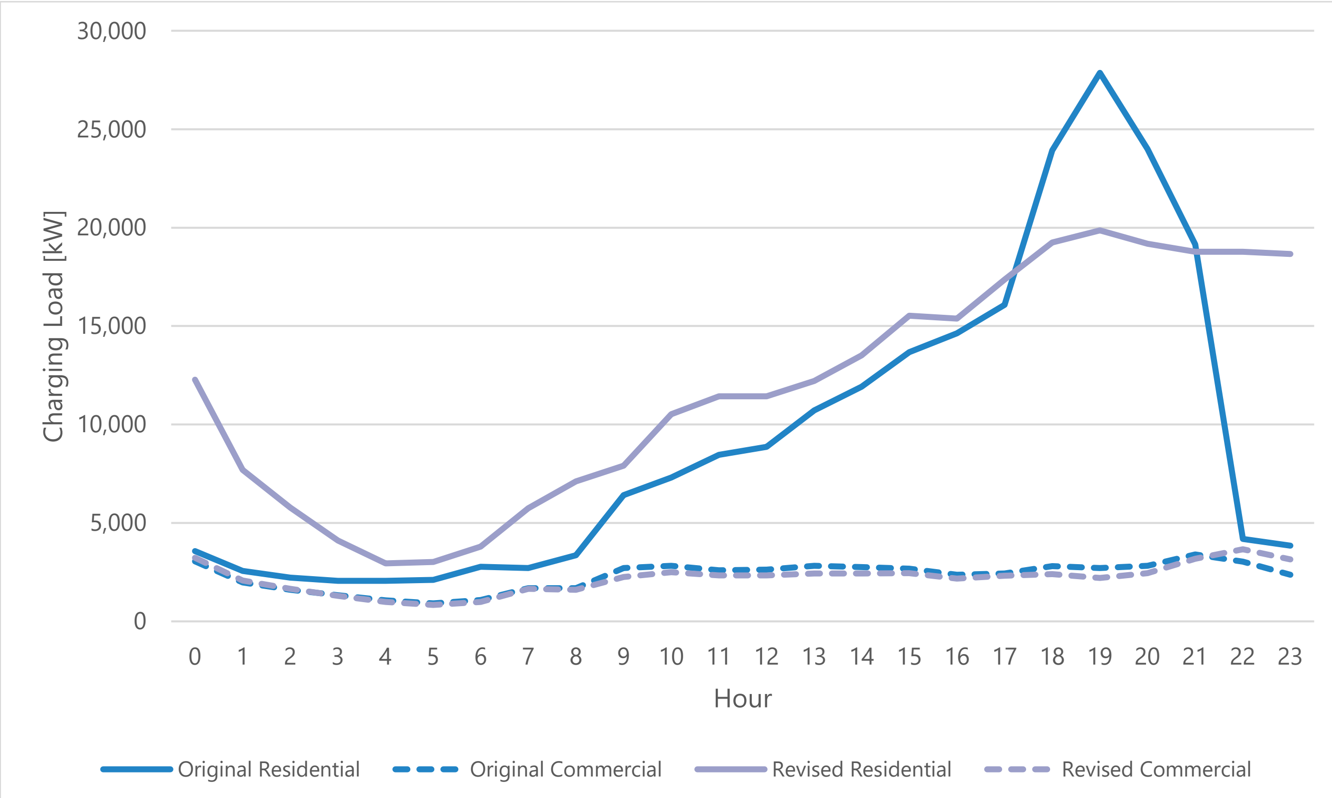

Figure B-8. Light Duty Electric Vehicle Charging Profiles

1.5.2 Electric Buses

The electric bus forecast was based on information provided by the Company's Electrification of Transportation team following discussions with several bus operators throughout Honolulu, Hawai'i and Maui counties. Route information and schedules for weekdays, weekends and holidays were used to estimate the miles traveled for each bus operator. Since specific information on the buses were not available for most operators, we used the average bus efficiency (kWh per mile) for two different Proterra models. For each island, the total sales impact for each bus operator was applied to the rate schedule on which each bus operator was serviced.

1.5.3 Electric Vehicle Forecast Sensitivities

Three additional light duty electric vehicle forecast sensitivities (Low, High, and Freeze) were developed using varying adoption saturation curves. A Low Sensitivity forecast was developed using a slower and lower adoption rate forecast from Integral Analytics, Inc's adoption model. The High Sensitivity forecast used the Transcending Oil Report, prepared by the Rhodium Group in 2018, which considered vehicle scrappage rates and the transition rate of vehicle sales to fully electric. The report estimated all vehicle sales by 2030 would need to be electric to reach 100% electric vehicle stock by 2045.[28] A freeze sensitivity was also developed, assuming no new additional electric vehicles above the Base forecast after 2021. Table B-15 summarizes the light duty electric vehicle sensitivities.

Table B-15. Electric Vehicle Forecast Sensitivities

Low	Base	High	Freeze
Low Adoption Saturation	Market Forecast	100% of ZEV by 2045	Forecasted EV counts fixed at 2021 Base forecast

[28] See Transcending Oil Report by Rhodium Group available at: https://rhg.com/wp-content/uploads/2018/04/rhodium_transcendingoil_final_report_4-18-2018-final.pdf

1.6 Sales Forecast

Shown below in Figure B-10 through Figure B-14 is the sales forecast for the base scenario and bookend sensitivities for the five islands.

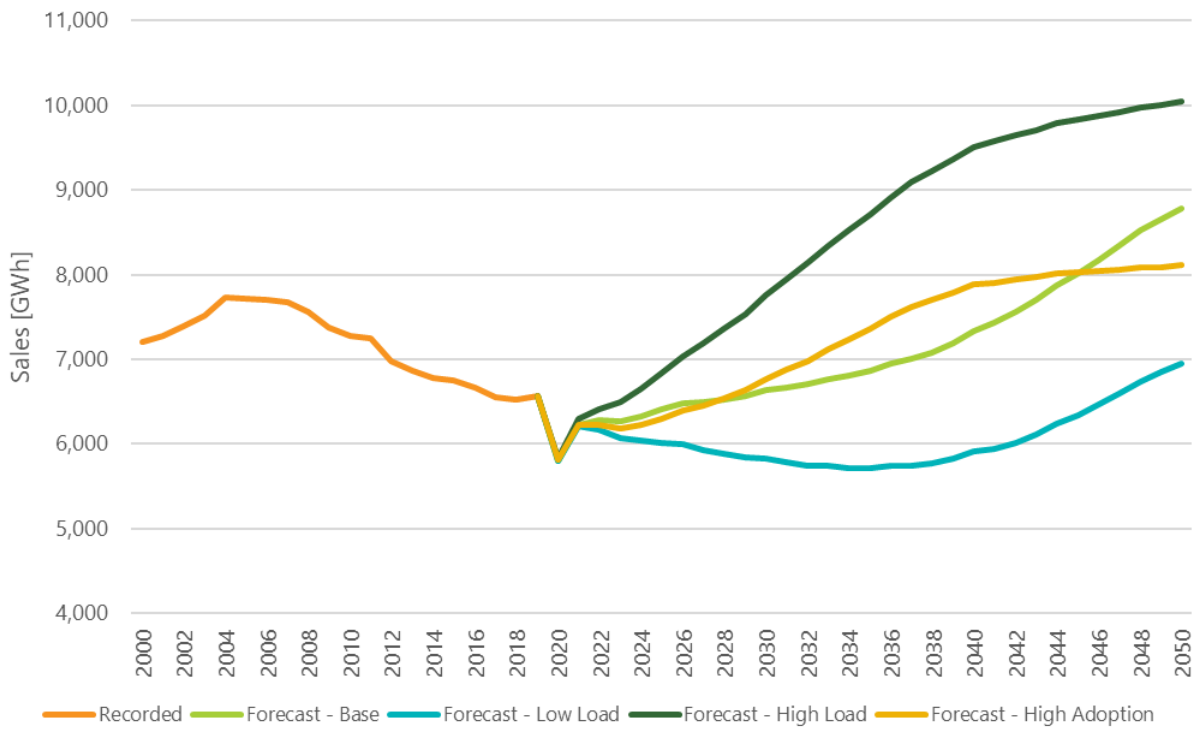

Figure B-9. O'ahu Sales Forecast Bookend Sensitivities

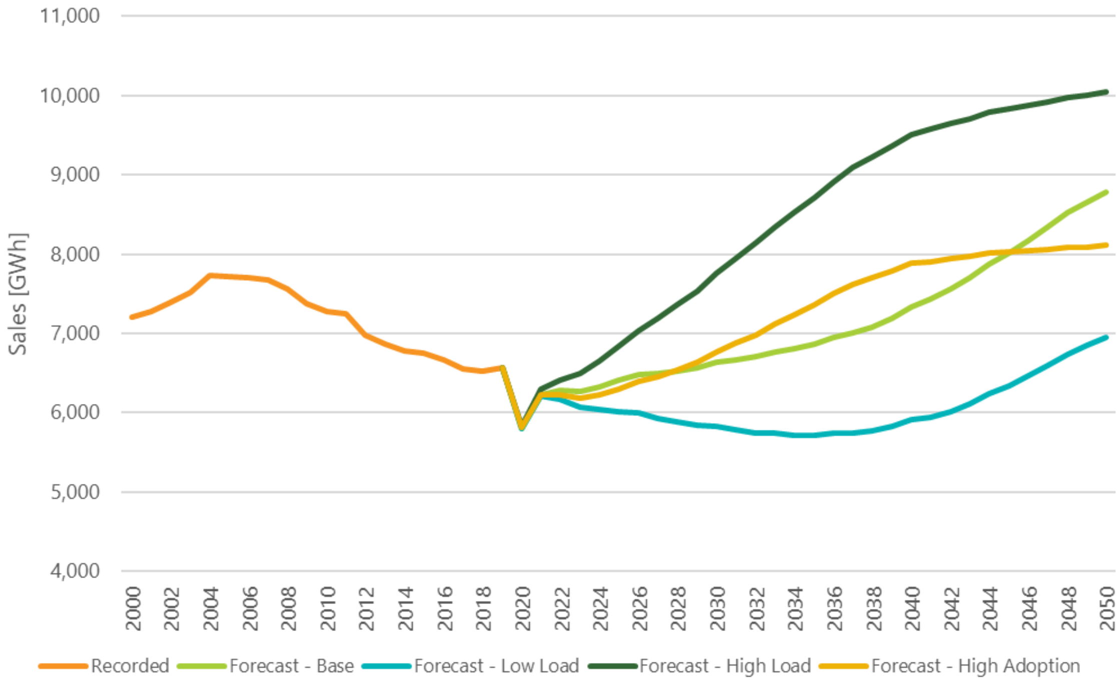

Figure B-10. Hawai'i Island Sales Forecast Bookend Sensitivities

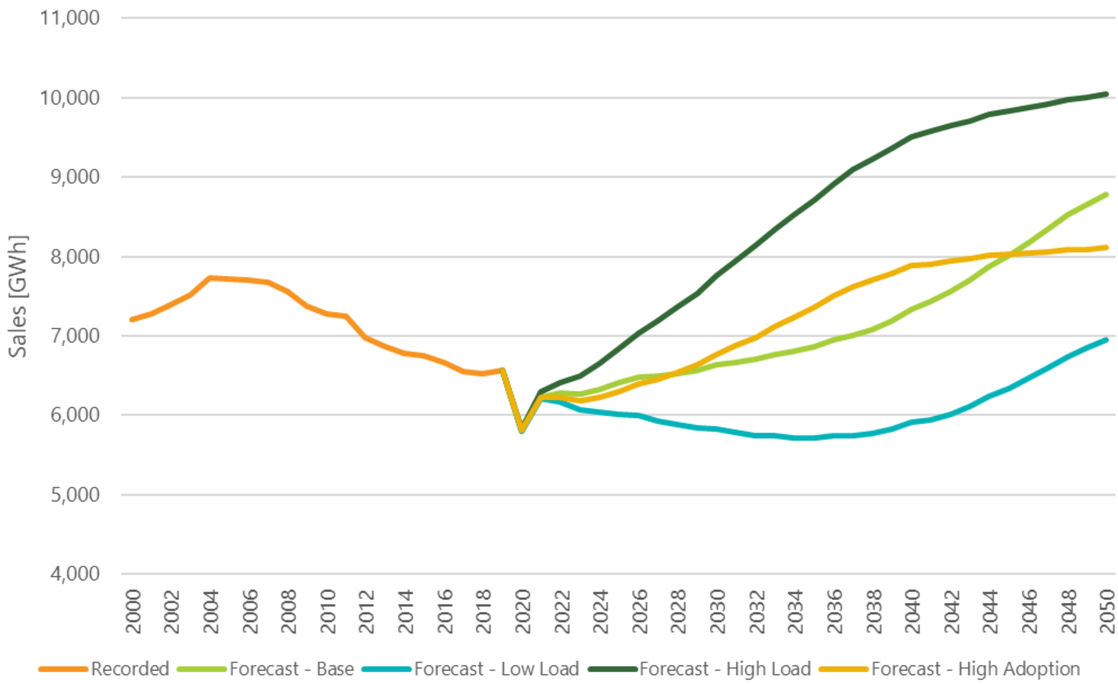

Figure B-11. Maui Sales Forecast Bookend Sensitivities

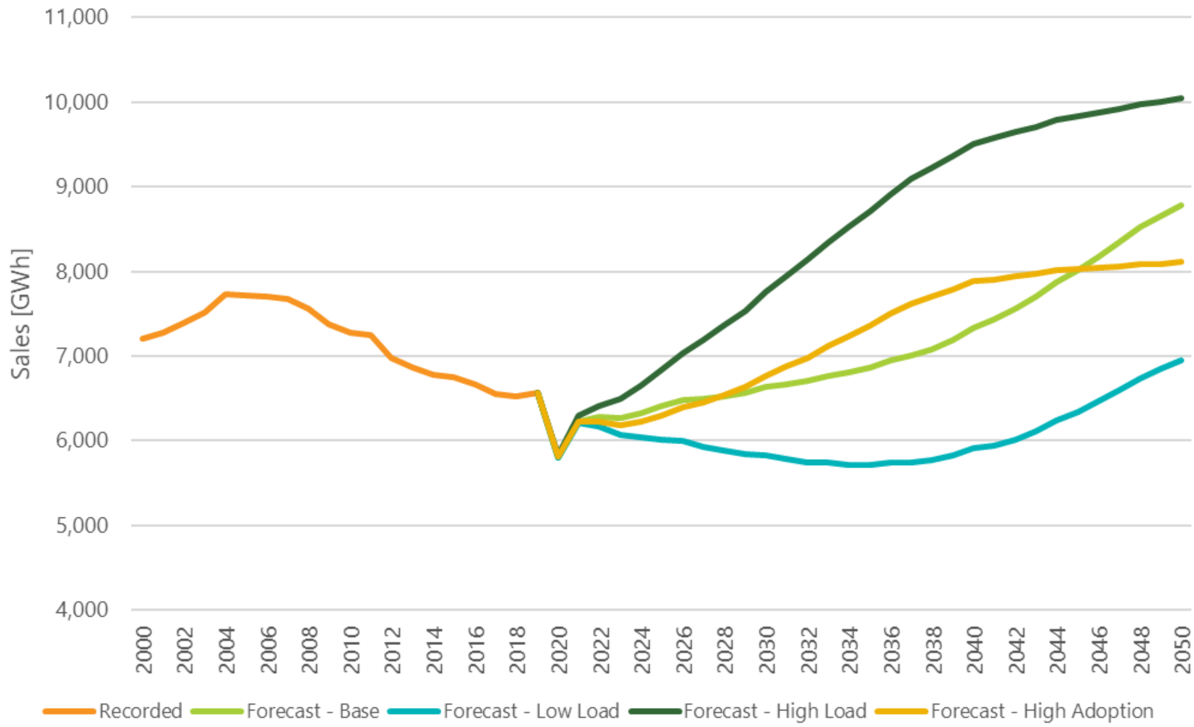

Figure B-12. Moloka‘i Sales Forecast Bookend Sensitivities

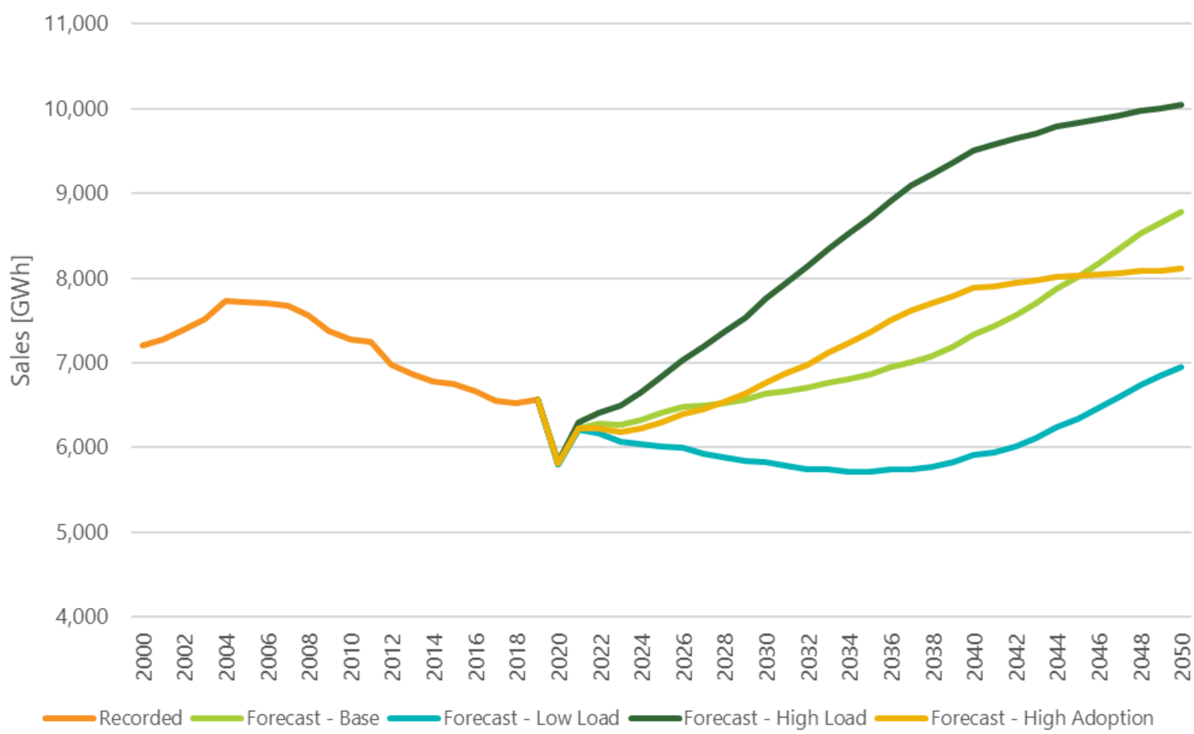

Figure B-13. Lāna‘i Sales Forecast Bookend Sensitivities

1.7 Peak Forecast

Shown below in Figure B-15 through Figure B-19 is the peak forecast for the base scenario and bookend sensitivities for the five islands.

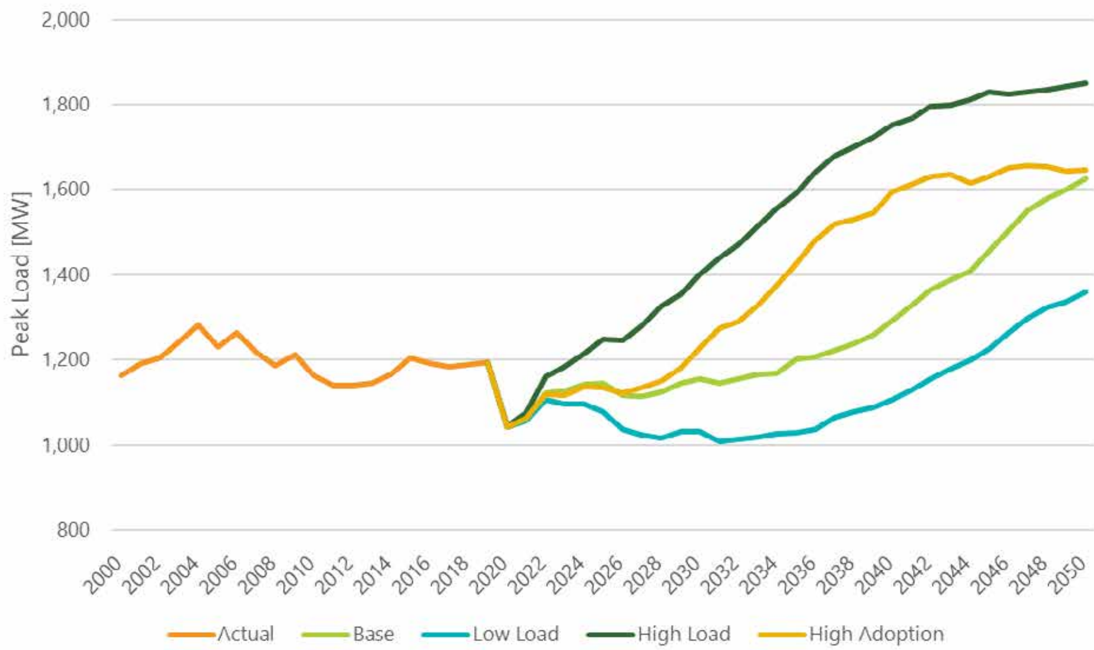

Figure B-14. O'ahu Peak Forecast Bookend Sensitivities

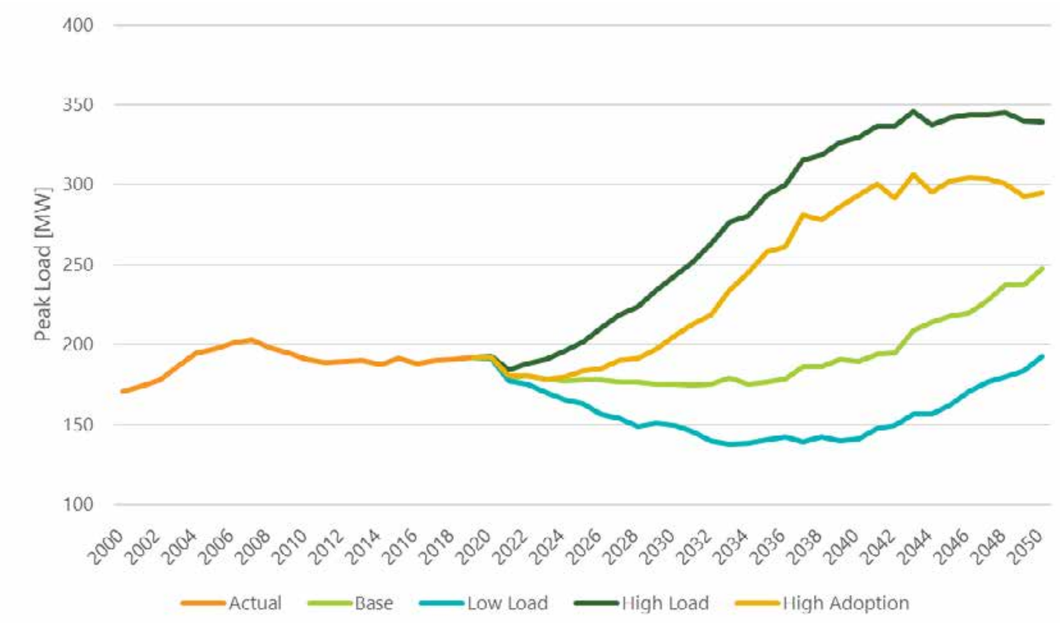

Figure B-15. Hawai'i Island Peak Forecast Bookend Sensitivities

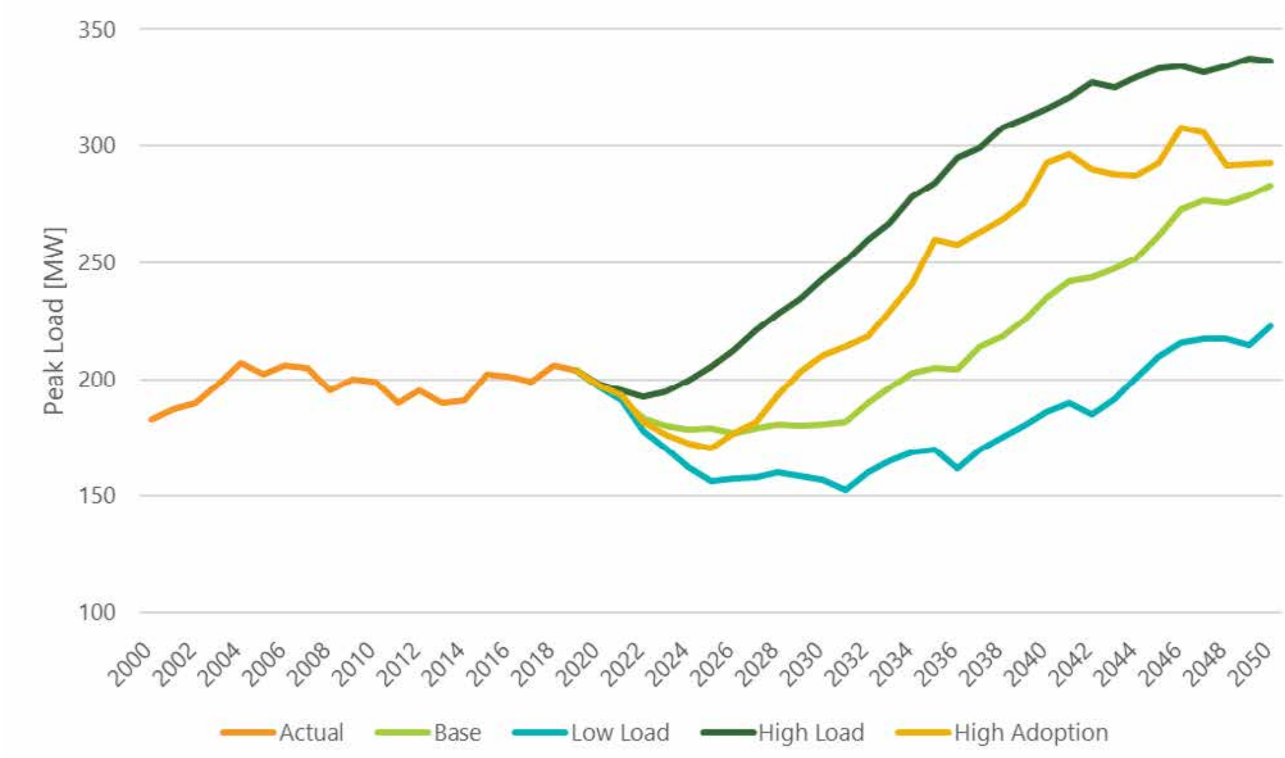

Figure B-16. Maui Peak Forecast Bookend Sensitivities

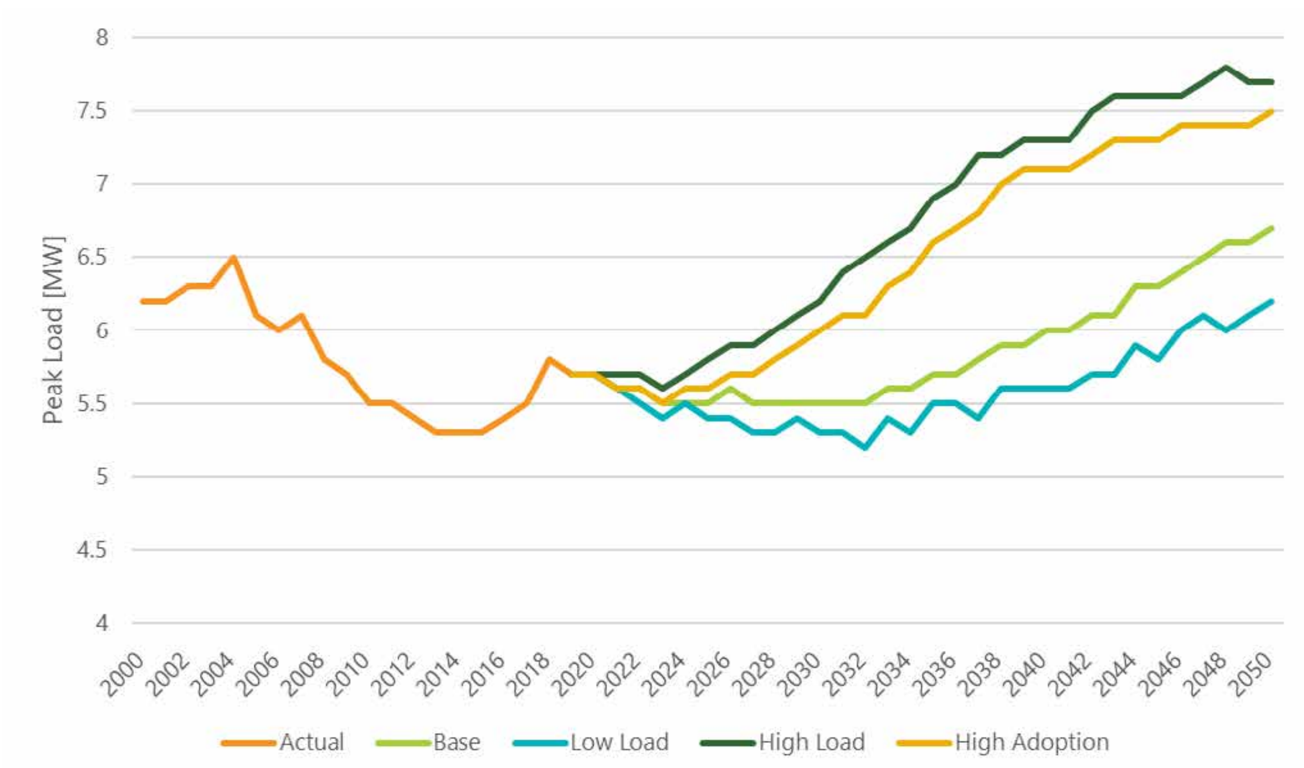

Figure B-17. Moloka'i Peak Forecast Bookend Sensitivities

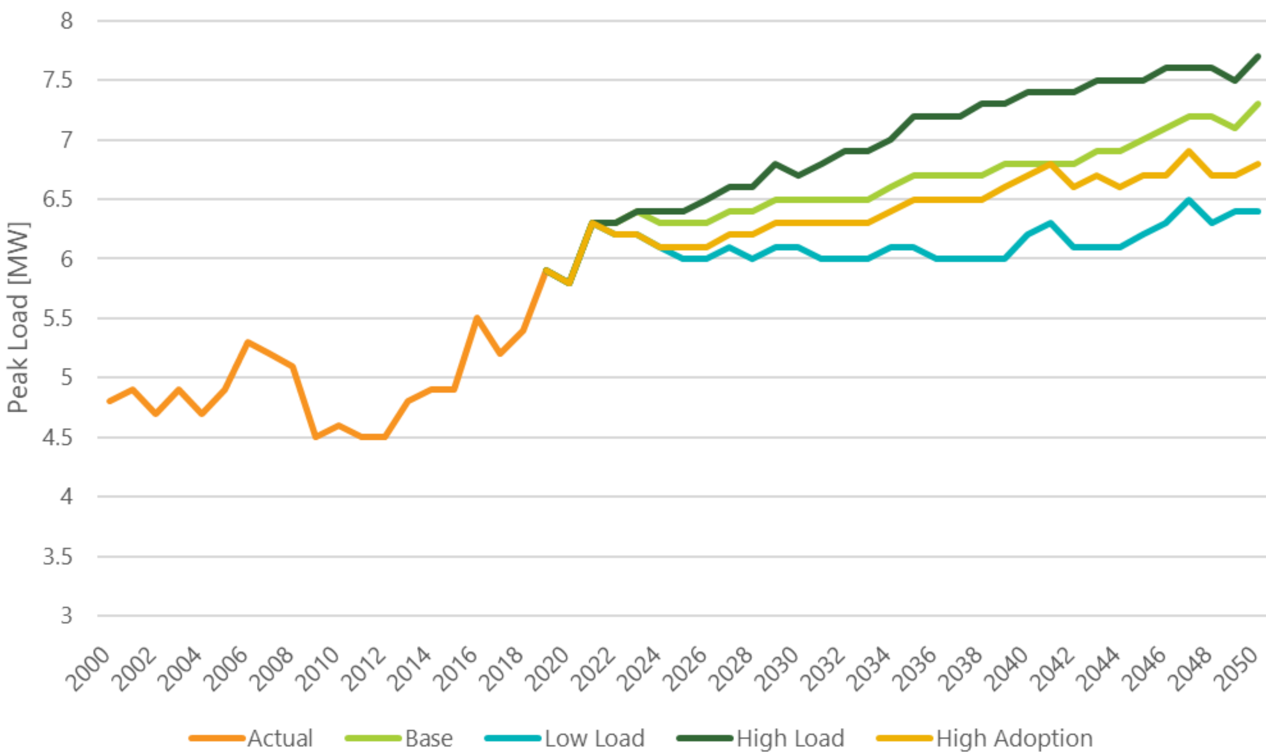

Figure B-18. Lānaʻi Peak Forecast Bookend Sensitivities

2. IGP Modeling Methodology

This section describes the analytical methodology used to identify the needs of the future grid to meet various policy objectives. We used a suite of modeling tools to assess the grid needs, which set out to:

1. Identify the near-term quantity and timing of Grid Needs that will drive future program development and procurement in each IGP cycle over the next decade;
2. Develop resource plans to identify potential pathways to solve for near-term needs and long-term objectives such as achieving 100% renewable energy and net zero carbon emissions by 2045; and
3. Evaluate proposed solutions through the creation of an energy marketplace in Hawaii.

We worked extensively with the Solution Evaluation Optimization Working Group ("SEOWG"), the Stakeholder Technical Working Group ("STWG"), the Technical Advisory Panel ("TAP"), and the Stakeholder Council to develop the methodologies. The following sections describe the overall process flow and modeling framework to derive the Grid Needs to inform solution sourcing and to evaluate or select solutions.

2.1 Modeling Objectives

We considered six overarching objectives to deliver reliable, clean, and cost-effective service to customers.

- Renewable Portfolio Standards
- System Reliability
- Affordability
- Environmental Carbon Impact Reduction
- Grid Resilience
- Community Impacts and Land Use

2.1.1 Renewable Portfolio Standards (RPS)

The Grid Needs Assessment will seek to achieve and accelerate the State of Hawai'i's Renewable Portfolio Standards ("RPS") mandate of achieving 100% renewable energy by year 2045, with breakout targets shown in Figure B-20.

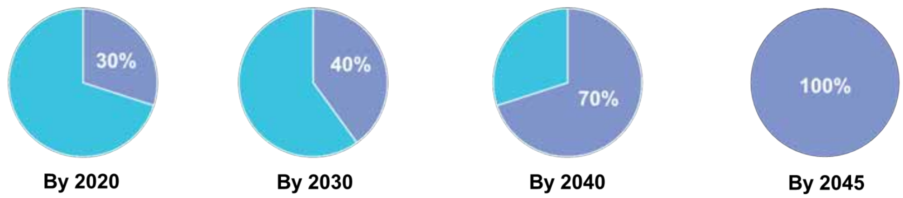

Figure B-19. State of Hawaiʻi Renewable Portfolio Standard (RPS) Targets by Year

Under performance based regulation, we are incentivized to accelerate renewable energy achievement through annual renewable energy targets. As recommended by the Stakeholder Council, the Grid Needs Assessment should seek a portfolio that recognizes the RPS-A performance incentive mechanism. RPS achievement simultaneously meets our carbon reduction goals.

2.1.2 System Reliability

The Grid Needs Assessment will account for multiple factors that assure system reliability; for example, system balancing, system security, and T&D reliability. Additionally, we are accountable for Adequacy of Supply, which is the ability of the electric system to supply the aggregate electrical demand and energy requirements of our customers at all times, taking into account scheduled and reasonably expected unscheduled outages of system elements. Aspects of reliability will be evaluated through the Grid Needs Assessment for adherence to various reliability related planning criteria and guidelines.

2.1.3 Affordability

The capacity expansion modeling tool will develop a resource portfolio to solve for RPS and system reliability objectives in a least-cost manner. In the development of the resource plans, the model will also consider the costs of installing new resources as well as the costs of operating existing resources. The resource plan will provide insight into resource procurement and system investment decisions needed to achieve 100% renewable energy over the next 25 years.

2.1.4 Environmental Carbon Impact Reduction

With increasing renewable generation on the grid and the retirement of fossil fuel generating units, the expectation is that greenhouse gas ("GHG") emissions will significantly decline. Long-term plans can be qualitatively and quantitatively assessed for GHG reduction. Quantitative GHG reduction assessments of resource plans may also incorporate achievement of certain GHG reduction targets or estimated reductions from an energy ecosystem perspective to include estimated reductions gained through electrification of other sectors, including transportation, buildings, etc.

2.1.5 Grid Resilience

There are two primary ways of looking at grid resilience. The first involves hardening of existing grid infrastructure (*e.g.,* upgrades to utility poles, transmission and distribution line monitoring, transformers, etc.) and the second includes the ability of the system to return to service in a major outage event (*e.g.,* hurricane, tsunami, flooding, etc.). As outlined in the *Resilience Working Group Report for Integrated Grid Planning,*[29] comments from first responders, other infrastructure owners, and other RWG participants will be used to inform transmission and distribution planning needs, priorities for resilience improvements, and options to achieve those identified planning needs and priorities. Notably, this includes consideration of resilience enhancing microgrids to provide local, emergency power generation when parts of the system's transmission and/or distribution system are out of service due to emergency conditions.

2.1.6 Community Impacts and Land Use

The viability of a long-term plan will depend on an assessment of community impacts and land use in Hawaii. It is imperative that any long-term plans balance multiple state policy objectives, such as housing, energy, and food sustainability.

Stakeholder Council used feedback on community impacts and land use to inform a key model input. As an example, the resource potential for land-based resources that define the maximum capacity of each resource that can be developed on each island. As part of the modeling input development, we engaged NREL to perform a solar and wind resource potential study. The stakeholder council provided specific parameters such as land slope and exclusions of certain type of land that could be developed for grid-scale solar.

2.2 Overview & Purpose of Modeling Tools

We use several modeling tools to identify the grid needs across our generation, transmission, and distribution systems, and worked with the Hawaii Natural Energy Institute ("HNEI") and the Technical Advisory Panel to establish a modeling framework, as shown in Figure B-21, for the Grid Needs Assessment methodology that will be used throughout the various phases of the IGP process.

[29] *See* https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning/stakeholder-engagement/working-groups/resilience-documents

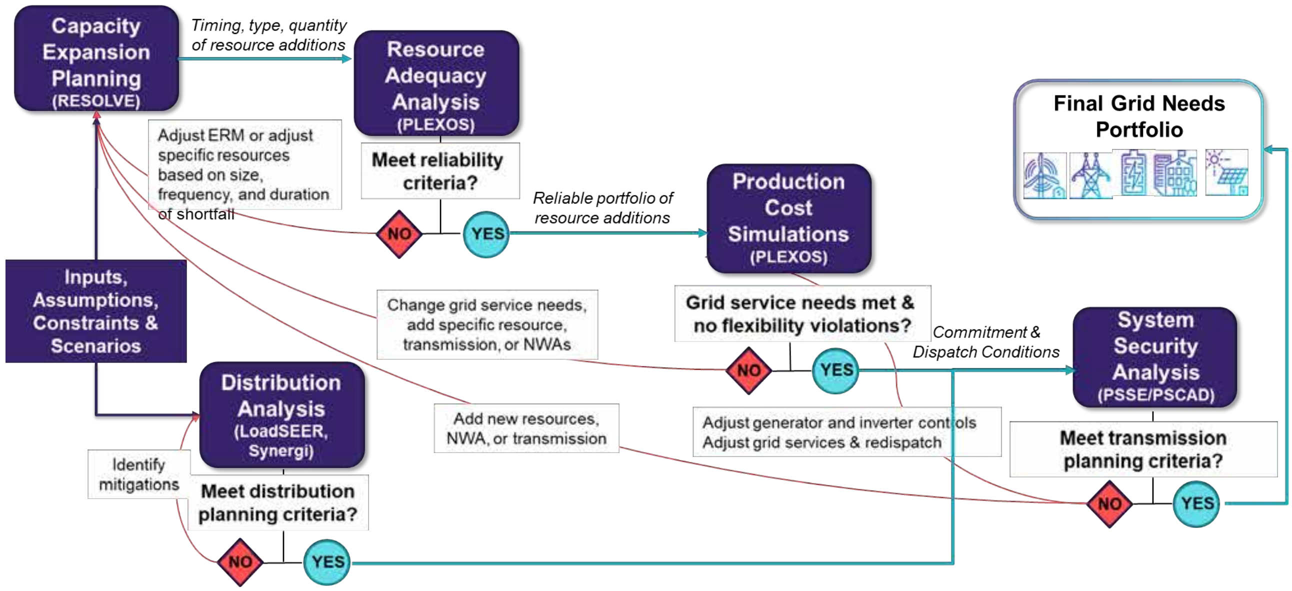

Figure B-20. Grid Needs Assessment Modeling Framework (Adapted from HNEI)

Two computer models that layout the pathways to identify the Grid Needs are the RESOLVE model and the PLEXOS model. RESOLVE produces an optimized resource plan of proxy resources that can fulfill the Grid Needs. The primary objective of this phase of the process is to identify Grid Needs using proxy resources; the actual technologies and solutions are determined during the solution sourcing which could consist of projects, procurements, or programs. In other words, the Grid Needs Assessment is not intended to select or express a preference for a technology; rather identify what is needed for the system and allow the market to propose solutions to meet those needs. In addition to the RESOLVE base case that is developed using a base set of planning assumptions, further sensitivities are run in RESOLVE to better understand how certain assumptions influence outcomes that informs a robust action plan.

The resource adequacy of a resource plan is then evaluated in PLEXOS.The operations and cost to operate the system are simulated through an hourly production simulation to ensure that the Grid Needs continue to be met on an 8760 hourly basis through year 2050. The results of the production simulation in PLEXOS are then used as inputs into the System Security analysis. The System Security analysis will be completed in PSS/E, PSCAD, and/or ASPEN Oneliner to evaluate needs for short circuit current, inertia, frequency response, voltage support, and assess inverter control interactions, weak grid/system strength issues. If the System Security step (or any of the other steps) identifies any shortfalls in the Grid Needs, the resource plan may be iterated upon to meet those residual needs. To address shortfalls in the Grid Needs, the proxy resources identified in the resource plan may be increased or accelerated from future years. It should be noted that the Capacity Expansion model and Resource Adequacy step is initially run unconstrained, which means there are no system security or operational rules assumed. With this approach, iteration of these steps are likely needed given the dynamic environment of a high-inverter based resource portfolio.

2.2.1 Modeling Framework

Each step in the modeling framework has a different objective. The TAP advised that the full suite of modeling tools should be utilized in assessing the Grid Needs. For example, in its independent review, the TAP stated:[30]

> RESOLVE provides limited fidelity and should be used only as a technology screening tool. Subsequent determination of reliability, analysis of multi-year weather data, retirements, and avoided costs, etc. requires the use of other modeling tools. It was emphasized more than once that the other models should be an integral part of the overall process, NOT just a check on the output from RESOLVE.

Figure B-22 describes an overview of the objectives, key inputs, and outputs of each modeling step and tool. Each modeling software tool is described in the following sections, including a discussion of when adjustments or iterations may be made in each step. These decisions cannot be quantified solely by a set of criteria. Engineering judgment is needed when making decisions to adjust or iterate a modeling step. Adjustments or iterations could include a decision on whether a shortfall in capacity to meet reliability criteria is needed. On this issue, we posed the following questions to the TAP: What is the level of tolerance to decide when to go back and iterate and is it necessary to always rerun the full process or can estimations serve to backfill shortfalls? The TAP's response is summarized below.

> TAP did not provide a hard and fast answer to these questions, noting the need for 'engineering judgment' and 'experience' to determine what needs to be done. While TAP recognizes that engineering judgment can reduce the requirement for the full process to be used for all iterations, TAP recommends that solutions be vetted by the full process before proceeding to the procurement phase.[31]

[30] *See* Grid Services and Planning Criteria Feedback filed in Docket No. 2018-1065 on June 1, 2021 at 4.

[31] *Id.* at 4.

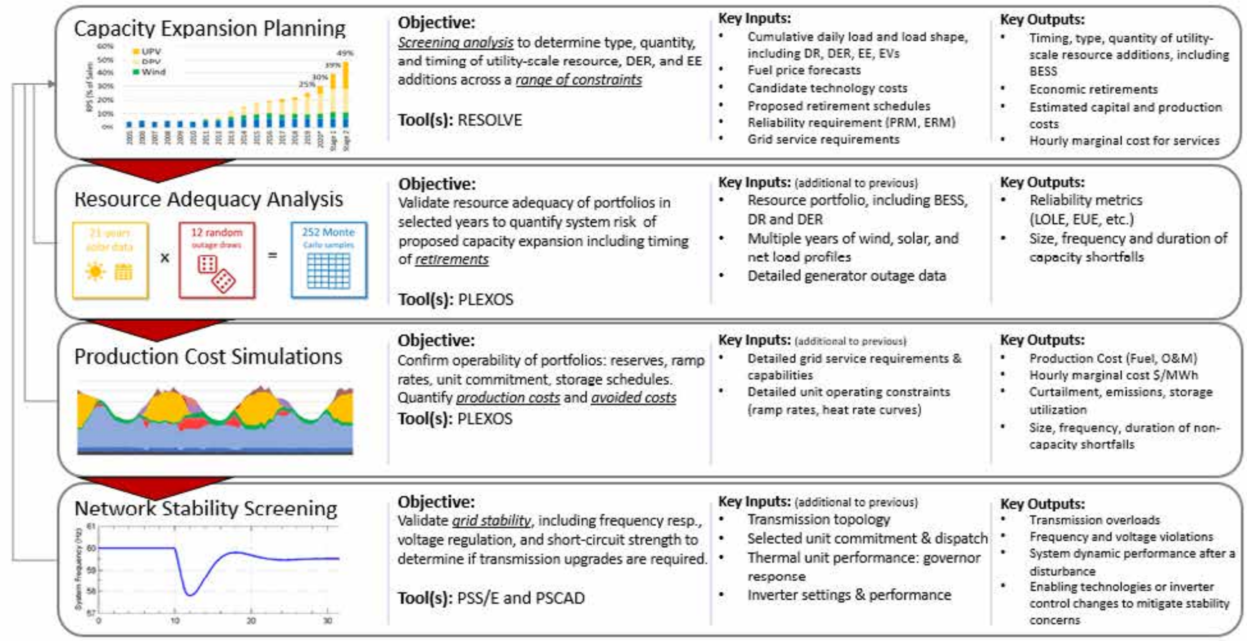

Figure B-21. Key Inputs and Outputs of Modeling Steps

2.2.2 Capacity Expansion (RESOLVE) overview

The grid needs assessment uses the planning assumptions from the approved March 2022 Inputs and Assumptions. The primary objective of this phase of the process was to identify the optimal mix of proxy resources that are built to represent the system's grid needs. RESOLVE is intended to provide directional guidance as to the optimal mix of resources; it is not intended to be a prescriptive pathway that must be strictly followed during solution sourcing activities.

2.2.3 Resource Adequacy (PLEXOS) overview

The Resource Adequacy step includes a probabilistic analysis consistent with industry best practices, including recommendations we adopted from the TAP. The resource adequacy analysis is probabilistic and evaluates the reliability of the system using 5 weather years based on meteorological data and 50 randomized generator outages for a total of 250 iterations. Specifically, PV reliability was based on five years of NREL data, from 2015 through 2019, which was provided as part of the NREL Resource Potential study. Wind reliability was based on historical measured data from existing wind plants for the same five years. DER used historical monthly capacity factor measurements also from the same five years. Thermal generators had 50 random outage samples with each sample modeled as an independent production simulation. A total of 250 (50 outage samples per year for five weather years) samples were modeled.

The results are then used to calculate various reliability metrics including loss of load expectation (LOLE), loss of load events (LOLEv), loss of load hours (LOLH) and expected unserved energy (EUE) to assess reliability. If a portfolio is found to be short of capacity, specifically in the near-term, adjustments to the resource portfolio may be made during this step.

Loss of Load Expectation (LOLE) is the number of days per year where there is unserved energy. The unserved energy within the day is quantified as Loss of Load Events (LOLEv) defined as the number of unserved energy events per year. The difference between LOLE and LOLEv is that multiple unserved energy events can occur in a single day. Loss of Load Hours (LOLH) is the number of hours of unserved energy. One unserved energy event can last for one or more hours, and therefore, an LOLE of 0.1 days/year is not necessarily the same result as an LOLH of 2.4 hours/year. Expected Unserved Energy (EUE) is the amount of unserved energy. Examples of the various metrics and their interrelationship were shared in the Stakeholder Technical Working Group meeting on June 9, 2022 and recapped below in Figure B-23. As shown, while the day has unserved energy, the magnitude, duration, and frequency of that unserved energy affects the various metrics.

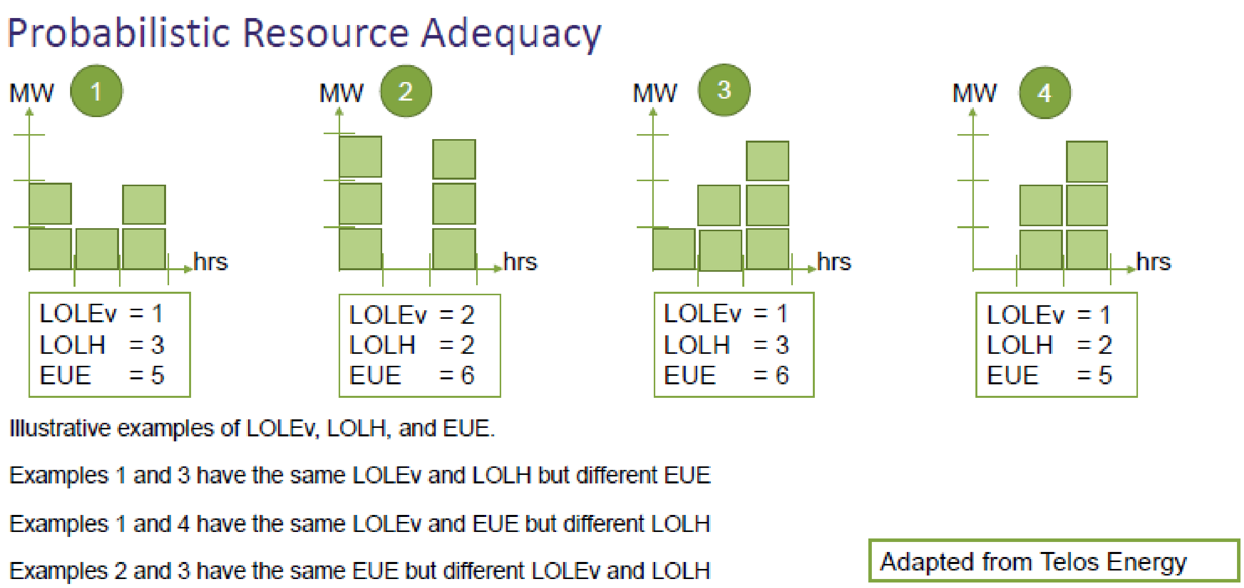

Figure B-22. Probabilistic resource adequacy metrics examples

2.2.4 **Production Cost and Operational Flexibility (PLEXOS) overview**

The PLEXOS modeling software is used to perform production cost simulations. The objective of the production cost simulation is to confirm operability of the portfolios by modeling the operation of the electric system, accounting for regulating reserves, ramp rates, unit commitment, and storage charging and discharging through economic dispatch. This provides insight into how the new resources will be operated and dispatched in future years. More accurate costs of long-term plans will be developed as part of the solution sourcing process when actual market solutions are proposed with current market pricing. Total production costs and avoided costs are quantitative outputs of the production cost simulations.

2.2.5 System Security (PSSS/E and PSCAD) overview

Transmission Needs will be analyzed by the applicable system models. Identified needs, as described in this section, include the following transmission grid services:

- Inertia
- Voltage support
- Fast frequency response (FFR)
- Primary frequency response (PFR)
- Short-circuit current
- Transmission Capacity

There are two major components to inform transmission needs – system security analysis and steady-state analysis which builds upon the Renewable Energy Zone (REZ) study. These analyses are guided by the transmission planning criteria for each island. The TAP conducted a review of the transmission planning criteria and the system security process. The incorporation of their recommendations and feedback is included in the *September 2022 GNA Methodology Report*.

Steady-state analysis is performed in PSS/E, which analyzes system steady state voltages and transmission line loading. For each island, transmission networks, including trasmission lines, generation, substation transformers and loads, are modeled in PSS/E. Selected system generation dispatches with system load scenarios are represented in PSS/E, by modifying generation parameters (i.e., MW and MVar). The distribution system (distribution circuits, customer loads, and DER) is not modeled in detail in this steady state analysis, but represented as aggregated load and generation in each distribution bus of distribution substation transformers (for Hawaiʻi island system and Maui system) and each substransmission bus of transmission substation transformers (for Oʻahu system). Modeling of the full transmission network allows us to identify any equipment overloads or voltage violations per the transmission planning criteria.

The other component of system security study evaluates system dynamic stability conditions and determines related grid needs. Traditionally, the dynamic stabilty can be studied in the PSS/E as well. However, PSS/E dynamic stability simulation capability is more suitable for traditional synchronous machine dominated power systems in which electric-mechanical dynamics are the core component of system dynamic stability. Because our power system today and in the future is increasingly dominated by inverter-based systems (for solar, wind and battery energy storage), instead of synchronous machine based generation, a different type of software, PSCAD/EMTDC, is used to perform system dynamic stabilty. The PSCAD/EMTDC is one of few commercial avaiable utility grade software specifically designed for performing electromagnectic transient (“EMT”) simulation. This is the most popular EMT software currently among utilities, equipment manufactureres and research institutes in North America. A PSCAD simulation normally represents one system planning event (e.g., a generator trip) in one pre-defined system dispatch (e.g., daytime peak load high DER generation dispatch). We normally simulate 30 seconds of real time of an event like a storm causing a transmission line to unexpectedly trip offline. 10-14 hours are some times needed to complete these highly complex simulations.

The analysis will produce the following key deliverables:

- Strategies and mitigations required for safe and reliable operation of the grid based on resource portfolio(s)
- Typical and/or boundary dispatch and operational requirements for grid operation based on resource portfolio(s)
- Frequency stability, voltage stability, control stability and rotor angle stability (if applicable) performance of the future grid
- Evaluation of the need for grid forming technology and demonstration of system performance with this technology when and if needed for the future grid
- Evaluation of weak grid issues and development of a "weak grid" definition for each of the island grids, which includes investments or mitigation strategies to operate a grid with limited to no synchronous generation. Weak grid conditions could include low short circuit current availability, low inertia, and limited reactive power support.
- Identification of additional transmission grid services needed over the near-term 5-year planning horizon

2.2.5.1 Renewable energy zones

The second component in assessing transmission needs is the development of renewable energy zones (REZ), which includes development of transmission capacity needs to integrate higher levels of renewable energy. The transmission needs assessment leverages the *July 2021 Assessment of Wind and Photovoltaic Technical Potential Report* to identify long term transmission capacity needs to harness renewable energy potential on each island.

The REZ concept[32] will require an extensive planning process centered around community and stakeholder engagement; however, the intent of the renewable energy zone analysis is to identify the cost of potential transmission upgrades that will allow RESOLVE to determine whether generation in various areas on each island and transmission buildout decisions are least-cost compared to other alternatives or alternate sites and resources. If determined to be directionally cost-effective then developing renewable energy zones may be pursued further.

[32] *See* NREL's renewable energy zone guidebook, https://www.nrel.gov/docs/fy17osti/69043.pdf and the process undertaken at AEMO, https://aemo.com.au/-/media/files/major-publications/isp/2020/appendix--5.pdf?la=en

2.2.6 Synergi and LoadSEER overview

The distribution system analysis step will primarily use two different modeling tools: (1) LoadSEER, an agent-based forecasting engine, and (2) Synergi software, a steady-state distribution power flow modeling tool.

LoadSEER creates local, distribution level forecast by distribution substation and circuit. This electric load forecasting software incorporates our corporate load forecasts and a multitude of other inputs to create forecasts at the circuit and substation transformer level.

The objective of LoadSEER is to statistically represent the geographic, economic, and weather diversity across our service territory, and to use that information to forecast how circuit- and transformer-level hourly load profiles will change over the next 30 years. Because of the complexity of the forecasting challenge, LoadSEER employs multiple statistical methods, including hourly load modeling, macro-economic modeling, customer-level economic modeling, and geospatial agent-based modeling, which taken together increase the validity and reduce uncertainty associated with the forecasts.

The bottom-up parcel level methodology used by LoadSEER aligns with corporate-level forecasts, such that stakeholders are assured that these scenarios are grounded in a shared vision of the service territory, in aggregate.

Hourly customer class and feeder load shapes, distribution energy resource ("DER") shapes, and DER forecasts are jointly overlaid within the base load, agent model growth, and known new load service requests to derive the overall forecast load profile for each circuit, such that all resource and load factors contributing to the circuit's load at risk can be accurately assessed.

These bottom-up simulations provide circuit-by-circuit forecast. The circuit level data is then readily aggregated up to the transformer and substation levels, and input from local knowledge to fine tune the model. This helps improve the scenario forecast's quality and usability.

The Synergi modeling tool is a steady-state power flow software that is able to model each distribution substation and circuit. The tool is used to assess circuit-level loading and hosting capacity utilizing the circuit-level forecasts generated by LoadSEER. Synergi then determines if a distribution planning capacity or voltage criterion is violated. Then mitigations can be identified to allow integration of the forecasted amount of load and DER. Although the secondary wires are not included in the model, behind the meter customer assets such as rooftop solar and battery energy storage are modeled and aggregated at the distribution service transformer.

2.2.6.1 Distribution Planning Process and Methodology

As the power supply and electrical distribution systems transition to an integrated system, the planning processes must also transition. Hence today's distribution planning methodology must ensure the orderly expansion of the distribution system and fulfill the following core functions:

- Plan the distribution system's capability to serve new and future electrical load growth, including electric vehicle (EV) growth
- Safely interconnect DER, such as photovoltaic (PV) systems and energy storage systems that transmit power across the system in a two-way flow, while maintaining power quality and reliability for all customers
- Incorporate the locational benefits of DER in the evaluation of grid needs and system upgrades

We engaged with customers and stakeholders to seek input and feedback on the distribution planning methodology as part of the Distribution Planning Working Group. This has afforded opportunities for stakeholders to collaborate and co-develop the distribution planning methodology for identifying grid needs, as described in the *September 2022 GNA Methodology Report.*

The distribution grid needs will be the foundation that drives solution options, including non-wires alternative (NWA) opportunities.

Overview

The distribution planning process occurs annually and includes four stages: Forecast, Analysis, Solution Options, and Evaluation (see Figure B-24).

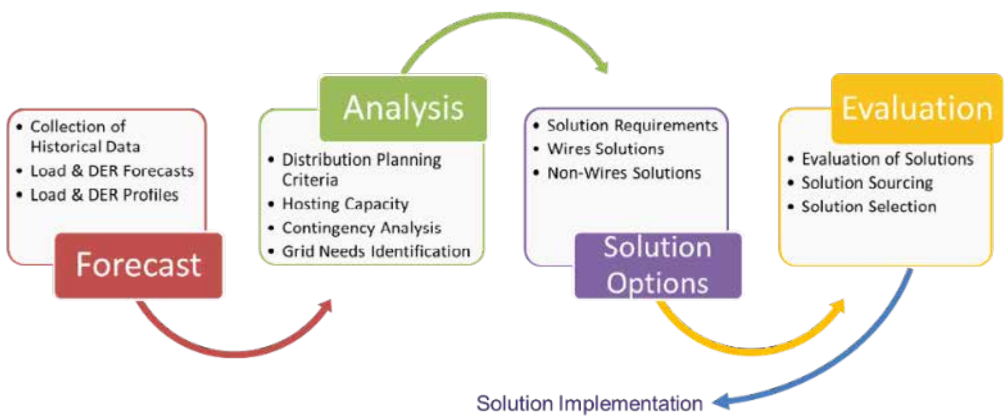

Figure B-23. Stages of the Distribution Planning Process

Stages

The forecast stage begins at the start of the calendar year when the prior year's circuit and transformer load data and the corporate demand and DER forecasts are available for input in the LoadSEER tool to create circuit- and transformer-level load forecasts.

The analysis stage involves the analysis of the electrical distribution system to ensure that there is adequate capacity and reliability (back-tie capabilities) to accommodate the load and DER forecasts. Planning criteria have been established that provide the basis for determining the adequacy of the electric distribution system. In situations where the criteria are not met, grid needs are identified.

In the solution options stage, requirements to meet the grid needs are determined, and wires and non-wires options are developed. The *Non-Wires Opportunity Evaluation Methodology* report attached in Appendix F describes the process to identify favorable NWA opportunities.

These options are evaluated in the fourth stage of the distribution planning process, with the most cost-effective, feasible solution selected that meets the grid need requirements and needby date.

It is worth noting that during the calendar year, it is expected that new service requests, DER, or projects will arise that will require modifications to the circuit- and or transformer-level forecasts. We continually evaluate grid needs throughout the year and make decisions on when to address any grid deficiencies identified outside of the forecast and analysis stages.

3. Reliability Criteria

3.1 Resource Adequacy Criteria

Within the IGP process the energy reserve margin or ERM along with the hourly dependable capacity or HDC is used as an input to the RESOLVE capacity expansion modeling to ensure that the optimization ensures a reliable system. The ERM and HDC methodology is described in the September 2022 GNA Methodology Report.

The ERM is the percentage of system load by which the system capacity must exceed the system load in each hour. The energy reserve margin for each island is listed in Table B-16 below.

Table B-16. Energy Reserve Margin Percentages by Island

Island	Energy Reserve Margin
Oʻahu	30%
Hawaiʻi	30%
Maui	30%
Molokaʻi	60%
Lānaʻi	60%

Energy reserve margins are derived from an assessment of historical data. Identified 'at risk' hours were evaluated to determine minimum energy reserve targets for planning purposes. The loss of largest unit, multiple forced outages, and unplanned maintenance were some of the largest contributing factors for hours considered to be at-risk. Energy reserve margin targets plan for the loss of largest unit and an additional hourly reserve for emergencies. However, it does not directly assign specific reserves to cover different events discretely. The ERM is intended to mitigate a variety of risks including the loss of the largest unit. As an example of the dynamics, the loss of a 180 MW (largest) unit for a peak load of 1,200 MW represents 15%; the loss of the same unit during a shoulder peak load of 600 MW represents 30%. Therefore, the ERM does not explicitly allocate a percentage to the loss of the largest unit and the other portion to other specific type of events that may occur.

The size of generating units on each island are contributing factors to energy reserve margin targets. For instance, on Molokaʻi and Lānaʻi, the largest generating units on the island have the capability to produce roughly 60% of each island's average daily energy usage. For comparison to the current planning criteria described above, which is to meet the peak load with the loss of the largest available unit, the 60% energy reserve margin target for Molokaʻi and Lānaʻi is to plan for resources that can generate enough energy throughout the day to meet the island's energy load without the largest available unit.

The Hourly Dependable Capacity ("HDC") for variable renewable resources is calculated as the typical day in the month and is the minimum expected capacity from variable generation resources based on empirical data. Based on feedback from the TAP, the HDC (MW) is calculated as an 80 percent probability of exceedance by hour, i.e. for each hour of the month, 80 percent of the analyzed distribution of variable renewable resource generation was at or above its stated HDC.

To assess the adequacy of a resource plan, probabilistic reliability metrics are used in the resource adequacy step. Four metrics are reported and used to compare the various cases -- loss of load expectation (LOLE), loss of load events (LOLEv), loss of load hours (LOLH) and expected unserved energy (EUE). Consistent with the typical North America guideline for LOLE, we use 0.1 days per year LOLE in our assessment of various resource portfolios. The lower the LOLE (i.e., (≤0.1) the more reliable a resource plan will be in its ability to serve the electric demand. This provides a useful frame of reference when evaluating resource plans that consider different additions of variable renewables and thermal resources. Stricter reliability thresholds may be warranted to address generation resilience on isolated island grids as high impact, low frequency events increase in frequency.

3.2 Operating Reserves (Reg Reserve)

The regulating reserve requirements were based on the methodology described in the S*eptember 2022 GNA Methodology Report* . This analysis included both the 1-minute and 30-minute regulating reserve requirements. The purpose of the regulation criteria is to establish guidelines to minimize the risk of supply and demand imbalances by ensuring sufficient regulating reserves are available to the system in long-range planning studies. This criterion applies to private rooftop solar systems, standalone grid-scale solar resources, standalone grid-scale wind resources, and gross system load.

3.3 Transmission Criteria

The transmission planning criteria for the O'ahu, Maui and Hawai'i island transmission system establish guidelines to ensure safe and reliable service to its customers for current and future system needs. These criteria also apply to facilities that interconnect to the transmission system. The primary objectives of these criteria to maintain reliable Transmission System operation (i.e., continuity of service) include the following:

- Ensure public safety.
- Maintain system stability under a wide range of operating onditions.
- Maintain equipment operating limits under a wide range of operating conditions.
- Minimize losses where cost effective.
- Pereserve the reliability of the existing transmission infrastructure.
- Maintain an acceptable level of impact to customers for contingencies and events as defined within planning criteria.

- Prevent cascading outages or system failure following credible contingencies and events.

These criteria are intended to be used as a general guide in planning the three islands' transmission systems, for which transmission needs for reinforcement, enhancements and mitigations will be determined.

The Moloka'i and Lana'i system do not have a transmission system, and therefore, do not have a transmission planning criteria. However, in this study, maintaining system dynamic stability for a three-phase bolted fault with 2 seconds duration and for a single-phase to ground fault with 40 ohm fault impedance and 20 seconds duration is used as criteria to evaluate system dynamic stability.

3.3.1 Thermal limits

For the O'ahu transmission system, with any generating unit offline for maintenance, all transmission system elements will operate within their normal ratings while mainaining voltage leves within planning criteria limits for any single transmission element outage. If any transmission line out of service for maintenance happens together with any generating unit offline for maintenance, all trasmission system elements will operate within their emergency ratings while maintainning voltage levels within their limits. Any generating station must be able to operate at maximum normal rating with no transmission system element loading exceeding its emergency rating while maintaining voltage levels within limits for any of the transmission system element outages.

For Maui and Hawai'i island, with any generating unit offline for maintenance, outage of any transmission system element or another generating unit will trigger remaining transmission system elements oprate within their emergency ratings. Simliar for any generation station operating at maximum normal rating, all transmission system element will operate at emergeny limit when there is a transmission elment outage.

3.3.2 Voltage levels

Transmission voltage levels shall be kept within the prescribed limits for any condition for which the transmission system is planned. These limits apply after automatic corrective action has been taken by LTC and/or switched capacitors. For O'ahu, 138 kV system voltage should be maintained between 126.5 kV to 145 kV, and 46 kV system voltage should be maintained between 45 kV and 48 kV. For Maui and Hawai'i island, 69 kV system voltage should be maintained between 62.1 kV and 72.5 kV, 34.5 kV system voltage should be maintained between 31.05 kV and 36.2 kV, and 23 kV system voltage should be maintained between 20.7 kV and 24.15 kV.

3.3.3 System stability

For all three systems, system stability includes steady state voltage stability, control stability, rotor angle stability and frequency stability. Accoridng to previous studies, system critical clearing time ("CCT") is recommended to be no longer than 24 cycles. In recent system dynamic stability studies, frequency stability study is the focus. According to these planning criteria, for the O'ahu transmission system, under frequency load sheding ("UFLS") is not allowed for planning events P1 to P5; for the Maui and Hawai'i island transmission system, certain amount of UFLS is allowed for single contingency with generation trip and multiple contingency.

3.4 Distribution Criteria

During the analysis stage of the distribution planning process, distribution planning criteria have been established as technical guidelines to ensure that the distribution system has adequate capacity and reliability to accommodate forecasted load and DER growth.

3.4.1 Normal Conditions

The distribution system, or a subset of the distribution system, is operating under normal conditions when all circuits and transformers in the subject area are configured as designed. Under this normal condition, the circuits and transformers are planned to have adequate capacity to serve electrical peak load, and with DER, the circuits and transformers are also planned to be adequate for the backflow of generation caused by the DER.

3.4.2 Contingency Conditions

The distribution system, or a subset of the distribution system, is operating under contingency conditions when a single circuit or transformer is out of service. This is also referred to as an N-1 scenario. A circuit or transformer may be out of service or de-energized because of equipment failure or planned maintenance. As such, a level of capacity must be available on the circuits and transformers to be available to serve customers during these N-1 scenarios. For instance, because an adjacent circuit or transformer is often used as a backup source for another circuit or transformer, N-1 scenarios also need to be analyzed to ensure that back-tie capacity is available.

3.4.3 Normal and Contingency Overloads

Normal overload occurs when the load exceeds the normal equipment rating of distribution circuits or distribution substation transformers under normal operating conditions. Normal overload is identified by comparing the forecasted load with the equipment rating.

Contingency (N-1) overload occurs when the load exceeds the emergency equipment ratings of a piece of equipment under scenarios when other equipment fail or is out for maintenance. Contingency overload is identified by studying the forecasted load for possible contingency situations.

3.4.4 Overload and Voltage Issues

The overload of a circuit or transformer may lead to overheating issues that will damage equipment; hence, overloads are considered thermal issues. When circuit or transformer loading exceeds the equipment thermal ratings, damage may occur to the equipment. This damage may lead to extended service interruptions and high maintenance expenses.

In addition to thermal overloads, the electrical system is also analyzed to ensure that there are no voltage issues. In general, the voltage level must be maintained within 5% of the nominal voltage at any point on the distribution system (primary and secondary)[33].Low or high voltage may lead to power quality issues that could damage customer-owned equipment or cause nuisance electrical issues, such as flickering light or tripping of equipment.

3.5 Existing Customer energy resource programs

Our plans integrate our vast offerings of customer programs that have contributed towards the high penetration of customer resources that include private rooftop solar, battery energy storage, direct load control (i.e., demand response) and community based renewable energy offerings. The resources acquired through these programs are an important and significant portion of our renewable portfolio.

Our programs are predominantly made up of less than 100 kW solar systems:

Net Energy Metering ("NEM"): is closed to new applicants. However, customers with renewable energy systems (predominantly private rooftop solar) are credited on their electric bill the retail rate of electricity for every kWh exported to the grid.

Net Energy Metering Plus ("NEM Plus"): allows current NEM customers with a signed agreement to add additional non-export capacity to their system.

Standard Interconnection Agreement ("SIA"): is designed for larger customers who wish to offset their electricity bill with on-site generation. No compensation is allowed for exported energy.

Smart Export: customers with a renewable system and a battery energy storage system have the option to export energy to the grid from 4 p.m. – 9 a.m. Systems must include grid support technology to manage grid reliability and system performance.

Customer Self-Supply ("CSS"): intended only for private rooftop solar installations that are designed to not export any electricity to the grid. Customers are not compensated for any export of energy.

Customer Grid-Supply ("CGS"): participants receive a Commission-approved credit for electricity sent to the grid and are billed at the retail rate for electricity they use from the grid. The program remains open until the installed capacity has been reached.

Customer Grid-Supply Plus ("CGS Plus"): systems must include grid support technology to manage grid reliability and allow the utility to remotely monitor system performance, technical compliance, and

[33] Hawaiian Electric is required to manage the voltage to within limits prescribed in Rule No. 2 Character of Service. *See* https://www.hawaiianelectric.com/documents/billing_and_payment/rates/hawaiian_electric_rules/2.pdf

if necessary, control for grid stability. Participants receive a commission-approved credit for electricity sent to the grid.

Community Based Renewable Energy ("CBRE"): provides an additional option for customers who are not already enrolled in a DER program to benefit from electricity generated by a renewable energy facility in their utility service territory.

Interim Time-of-Use ("TOU-RI"): an opt-in program for residential customers that is designed for customers to save money if they use more power during the day -- when solar energy production is the highest -- and less at night.

The capacity of our customer programs is illustrated in Figure B-25.

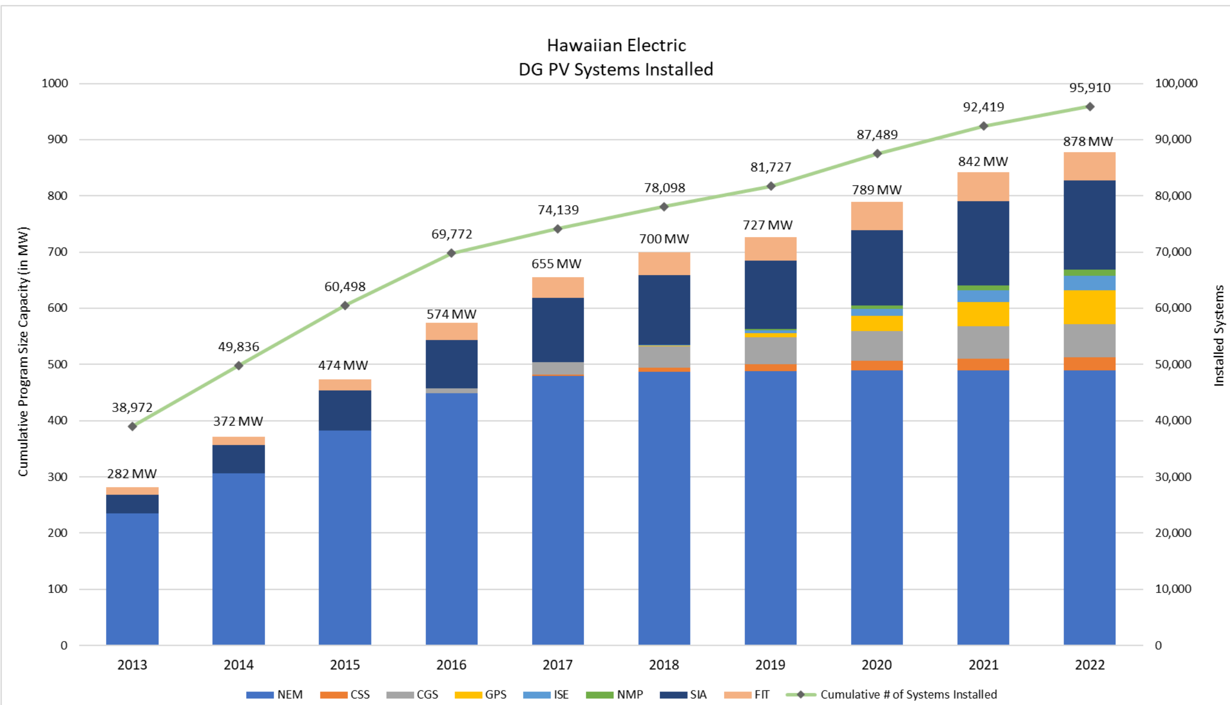

Figure B-24. Hawaiian Electric DGPV Systems Installed

Grid Service Programs

In addition to customer programs where customers may export excess energy that they do not consume, we also have program offerings where customers can provide certain grid services to the grid. Customers are compensated for the provision of services which may be administered through a third-party aggregator or Hawaiian Electric. We have several grid service purchase agreements with third party aggregators. Many of these programs are not fully subscribed as aggregators continue to recruit customers. We also have legacy demand response programs.

Grid Services Purchase Agreements – Actively Recruiting

GSPA contracts specify the delivery of Capacity Reduction, Capacity Build, and Fast Frequency Response Grid Services. These services are delivered by aggregators who we have contracted with. We currently have two GSPAs on O'ahu that have been actively enrolling participants since 2020. We have two active GSPAs on Maui that have been actively enrolling participants since 2020, and have one GSPA on Hawai'i Island that has been actively enrolling participants since 2022. We continue to focus on supporting and aiding the aggregators to achieve their contracted target amount.

Grid Services Purchase Agreements – Recent and on-going procurements

We conducted a third round of GSPA procurements for the island of O'ahu. This resulted in a negotiated contract with an aggregator to deliver 97.4 MWs of grid services.

We recently issued a Maui GSPA RFP to acquire Grid Services to address the recently advanced end-of-life forecast for the four 12.5 MW Mitsubishi-MAN generating units on Maui.

Battery Bonus – Actively Recruiting

The Battery Bonus Program on Oahu and Maui is designed to provide scheduled export of power for 2 hours during the evening peak intended to address times where generation reserves may be tight due to the retirement of the AES coal plant and the forthcoming retirement of generation on Maui. The program pays upfront and monthly incentives to customers in exchange for export during the peak demand period for electricity. The program is currently limited to 50 MW on Oahu and 15 MW on Maui island.

Fast Demand Response (Fast DR)

On Oahu, the Fast DR program currently has a capacity of 4.0 MW from 16 customers in the military, hospitality, condominium, education, and office sectors. On Maui, the targeted 2023 impact for the Fast DR Program is 4.3 MW (customer level), and currently has 27 participants from the hospitality, water, education, and retail sectors.

EnergyScout Residential (RDLC) - In Maintenance (O'ahu)

The residential direct load control program currently has approximately 29,000 water heaters and 3,700 air conditioner direct load control devices enrolled with 26,000 participants for a capacity of 13.6 MW. We will continue existing operations to maintain customer participation and MW impacts for RDLC.

EnergyScout Commercial (CIDLC) - In Maintenance

The commercial industrial load control program currently has a capacity of 11.4 MW from 25 commercial and industrial customers in the military, hospitality, condominium, education, and office sectors. In addition, the small business direct load control program currently has a capacity of 1.0 MW from 175 small and medium business customers in the retail, restaurant, and office sectors. We will continue the existing operations to maintain customer participation and MW impacts for CIDLC.

EnergyScout Residential Technology Replacement

We are currently pursuing a programmatic solution to transition the existing EnergyScout Program participants to a new program(s) technology that offers grid service delivery. Specifically, existing EnergyScout Program participants would potentially be able to deliver a variety of grid services by relying on smarter, two-way communicating devices/equipment.

We issued an RFP in early 2022 and selected multiple vendors to update technology for its EnergyScout program. The RFP requested that vendors provide a replacement technology to the current direct load control device, a software system to manage and aggregate the fleet of water heaters, and an administrator to enable and monitor the replacement of the existing devices and provide ongoing program maintenance.

3.6 Existing generation portfolio

The current generation portfolio contains a mix of utility-owned generation as well as generation from independent power producers (IPPs) that includes, solar, wind, geothermal, hydro, biofuel and diesel powered generators, along with oil fired steam generation. This section describes our current generation portfolio on each island that we serve.

3.6.1 O'ahu

Utility-Owned Generation

Kahe Generating Station. The Kahe generation station has six steam units, all baseload generation, with a combined nameplate capacity of 650 MW, with 606 MW net generation. These are our most efficient units. The station has black start capability.

Waiau Generating Station. The Waiau generating station has eight units: six are steam units and two are diesel. Two are baseload units; four are cycling units; and two are quick-start combustion turbines. Their combined nameplate capacity is 500 MW, with 474 MW net generation. The station has black start capability.

Campbell Industrial Park (CIP). The CIP generating station has one combustion turbine, CT-1, which runs on diesel but capable of running on biodiesel. It provides 129 MW net firm generation. The unit is both quick-start capable and black start capable. This peaking unit runs approximately 10% of the time to address peak load times.

Schofield Generating Station. The Schofield generating station has six combustion engines for a total of 48.6 MW which run on biodiesel. The individual units are quick-start capable and black start capable. The Schofield generation station also has the ability to power the U.S. Army facilities in an emergency for critical missions. In normal operations this unit serves the broader grid and is a used as a peaking unit.

Honolulu Generating Station. The Honolulu generating station, located in the downtown load center, has two steam units with a combined nameplate capacity of 113 MW, with 107 MW net generation. Both are cycling units. These units were deactivated in January 2014, and are expected to be retired by the end of 2023.

Our baseload units average 54 years of age, while the cycling units average 70 years. The combined average age of all steam units is 59 years. While our existing generation fleet does well in serving stable, predictable, consistent loads, they are not as capable as modernized generation in effectively managing system stability with higher levels of variable generation.

As the role of firm generation assets evolve, the technical and operational capabilities of these units must match their new use pattern. To meet the future requirements, many existing generators must be modified or replaced in order to cost-effectively supply supplemental energy, fast balancing services, and other requirements identified for reliable and secure power delivery in the future. Among other attributes, new assets need to have operational flexibility: the ability to start quickly, ramp up and down at high rates, and must be designed to regularly start and stop multiple times daily even after long periods of being offline. The baseload steam units in our fleet do not fully possess these characteristics and will need replacement with modern units that do.

Independent Power Producer (IPP) Generation

H-POWER. The Honolulu Program of Waste Energy Recovery (H-POWER) is a municipal solid waste refuse to energy plant that generates 68.5 MW of baseload, firm generation.

Kalaeloa. The Kalaeloa cogeneration (combined-cycle) plant burns LSFO to generate 208 MW of baseload generation.

3.6.2 Hawaiʻi Island

On Hawaii Island we currently own and operate 23 firm generating units, totaling about 181.6 MW (net, maximum capacity), at five generating stations and four distributed generation sites. Three steam units (fueled with No. 6 fuel oil–MSFO) are located at the Hill, and Puna generating stations. Ten diesel engine generators (fueled with diesel) are located at the Waimea, Kanoelehua, and Keahole generating stations. Our five combustion turbines (CTs–fueled with diesel) are located at the Kanoelehua, Keahole, and Puna generating stations. Two of the Keahole CTs are configured to operate in combined cycle with a heat recovery steam turbine. Four distributed generation diesel engines fueled with diesel fuel are located individually at the Panaewa, Ouli, Punaluʻu, and Kapua substations (the Panaewa and Kapua units are temporarily located at Kapoho as part of a lava mitigation plan to serve customers potentially isolated by the flow, and will be restored for grid operation).

Two independent power producers (IPPs) provide firm capacity power to our grid. One is a combined-cycle power plant, Hamakua Energy Partners (HEP), owned and operated by Pacific Current; the other is a geothermal power plant owned and operated by Puna Geothermal Venture (PGV).

Our generation fleet has the following capabilities:

- Quick/fast start generation including simple cycle combustion turbines (SCCT) and ICEs that provide emergency replacement power and peaking generation, but at a higher cost than the larger resources. The simple cycle combustion turbines can be used as black start resources.
- Combined-cycle units, comprised of two CTs, two HRSGs, and one ST with high efficiency and relatively low cost. These assets provide cycling capability with a 1–2 hour start time, and have fast ramping capability.
- Older conventional steam units have offline cycling capability, but longer start-up times and less ramping capability when compared to the combined-cycle units.
- Geothermal IPP provides firm energy.

3.6.3 Maui County

In Maui County we own and operate three island electric grids on the islands of Maui, Molokaʻi, and Lanaʻi. Each island as its own unique physical grid design based on system load, demand, and customer needs. Our generation portfolio is composed of a mix of renewable and firm resources.

We generate the majority of our power from combined-cycle and internal combustion engine units, as well as a growing portfolio of renewable energy. Maui's total firm capacity is 251.7 MW (gross). Lanaʻi's total firm capacity is 9.40 MW (gross). Molokaʻi's total firm capacity is 15.18 MW (gross).

The Maui grid includes a growing portfolio of variable renewable energy that includes wind, solar photovoltaic, and hydropower. Our firm generation resources include centralized generating stations comprised of combined cycle and internal combustion engine units, oil-fired steam units, and biomass.

Maui Island's existing dispatchable generation fleet comprises two main power plants at Kahului and Maʻalaea. These plants include:

- Quick-start internal combustion engines (ICEs) that provide emergency replacement power and peaking generation.
- Combined-cycle units, comprised of two combustion turbines (CTs), two heat recovery steam generators (HRSGs) or once-through steam generators (OTSGs), and one steam turbine (ST) that provide high efficiency and relatively low cost cycling capability with a one- to two-hour start time, and fast ramping response. These combined-cycle units support the integration of variable renewables resources needed to achieve the 100% RPS goal by 2045.

Molokaʻi and Lānaʻi have existing dispatchable generation fleet which comprises quick-start internal combustion engines (ICEs) at Pālāʻau and Miki Basin, respectively. Molokaʻi also has a combustion turbine, also located at Pālāʻau.

Appendix C:

Data Tables

Appendix C:
Data Tables

Contents

1. Data Tables

1.1 Fuel Price Forecast

The cost of producing electricity is dependent upon, in part, the cost of fuels utilized to generate power. Hawaiian Electric uses the following fuel types:

- Low Sulfur Fuel Oil (LSFO): A residual fuel oil similar to No. 6 fuel oil that contains less than 5,000 parts per million of sulfur; about 0.5% sulfur content
- No. 2 Diesel Oil
- Ultra-Low Sulfur Diesel (ULSD)
- Naphtha
- High Sulfur Fuel Oil (HSFO): Also called Industrial Fuel Oil (IFO), HSFO contains less than 2% sulfur

The fuel price forecast was developed using a correlation between historical, actual fuel prices and the Brent North Sea Crude Oil Benchmark (Brent) from 1983-2019. The R^2 value for petroleum fuels was greater than 0.93. Hawaiian Electric's 2021 forecast was based on the Brent forecast provided by the Energy Information Administration ("EIA") Annual Energy Outlook ("AEO").[1] Shown below in Table C-1, Table C-2, and Table C-3 is the fuel price forecast for Oʻahu, Hawaiʻi Island, and Maui County, respectively.

[1] Hawaiian Electric updated its assumptions to use the fuel price forecast provided by the EIA AEO instead of FGE in response to stakeholder feedback to use publicly available, non-proprietary sources.

Table C-1. O'ahu Fuel Price Forecast

Year $/MMBTU	LSFO	Diesel	ULSD - CIP	ULSD - SGS	Biodiesel
2021	8.73	11.49	11.93	12.72	28.55
2022	9.43	12.24	12.71	13.51	29.32
2023	10.51	13.38	13.87	14.68	30.39
2024	11.36	14.28	14.80	15.62	31.37
2025	12.14	15.14	15.68	16.52	32.41
2026	13.03	16.11	16.68	17.54	33.60
2027	13.82	16.99	17.58	18.46	34.78
2028	14.67	17.94	18.56	19.46	36.04
2029	15.49	18.85	19.50	20.42	37.30
2030	16.36	19.82	20.49	21.45	38.60
2031	17.14	20.69	21.38	22.36	39.82
2032	18.03	21.67	22.40	23.40	41.12
2033	18.74	22.47	23.22	24.25	42.29
2034	19.47	23.29	24.07	25.11	43.45
2035	20.10	24.02	24.81	25.88	44.56
2036	20.90	24.90	25.72	26.82	45.77
2037	21.76	25.86	26.70	27.82	47.03
2038	22.63	26.82	27.69	28.83	48.31
2039	23.18	27.46	28.35	29.52	49.37
2040	24.37	28.76	29.69	30.88	50.91
2041	25.34	29.83	30.79	32.00	52.32
2042	26.15	30.75	31.74	32.98	53.65
2043	27.22	31.93	32.95	34.22	55.21
2044	28.16	32.99	34.04	35.34	56.73
2045	28.65	33.59	34.66	36.00	57.99
2046	29.99	35.08	36.19	37.56	59.92
2047	31.08	36.31	37.46	38.86	61.72
2048	32.03	37.40	38.59	40.03	63.49
2049	33.05	38.57	39.79	41.28	65.38
2050	34.10	39.79	41.05	42.57	67.35

Table C-2. Hawai'i Island Fuel Price Forecast

Year $/MMBTU	IFO	Diesel	ULSD	Naphtha	Biodiesel
2021	7.45	12.16	12.68	13.71	28.55
2022	8.06	12.98	13.52	14.50	29.32
2023	8.99	14.21	14.78	15.69	30.39
2024	9.72	15.18	15.78	16.65	31.37
2025	10.40	16.10	16.73	17.56	32.41
2026	11.17	17.15	17.81	18.61	33.60
2027	11.85	18.09	18.77	19.56	34.78
2028	12.59	19.11	19.82	20.58	36.04
2029	13.29	20.09	20.83	21.58	37.30
2030	14.05	21.13	21.91	22.63	38.60
2031	14.71	22.06	22.87	23.57	39.82
2032	15.48	23.13	23.96	24.64	41.12
2033	16.10	23.99	24.85	25.52	42.29
2034	16.72	24.86	25.75	26.41	43.45
2035	17.27	25.64	26.55	27.21	44.56
2036	17.96	26.59	27.53	28.17	45.77
2037	18.70	27.62	28.59	29.20	47.03
2038	19.45	28.65	29.65	30.24	48.31
2039	19.93	29.34	30.36	30.96	49.37
2040	20.96	30.74	31.80	32.35	50.91
2041	21.79	31.88	32.98	33.50	52.32
2042	22.50	32.87	34.00	34.51	53.65
2043	23.42	34.14	35.31	35.78	55.21
2044	24.23	35.28	36.48	36.94	56.73
2045	24.65	35.92	37.15	37.64	57.99
2046	25.81	37.52	38.79	39.24	59.92
2047	26.75	38.84	40.15	40.59	61.72
2048	27.57	40.01	41.37	41.81	63.49
2049	28.44	41.27	42.66	43.11	65.38
2050	29.35	42.57	44.01	44.46	67.35

Table C-3. Maui County Fuel Price Forecast

Year	Maui				Moloka'i	Lāna'i
$/MMBTU	IFO	Diesel	ULSD	Biodiesel	ULSD	ULSD
2021	7.09	11.75	12.09	28.55	12.91	16.08
2022	7.69	12.58	12.94	29.32	13.76	16.95
2023	8.62	13.85	14.23	30.39	15.04	18.26
2024	9.33	14.85	15.26	31.37	16.07	19.33
2025	10.00	15.78	16.22	32.41	17.03	20.35
2026	10.75	16.85	17.31	33.60	18.13	21.51
2027	11.42	17.80	18.28	34.78	19.12	22.58
2028	12.14	18.83	19.34	36.04	20.19	23.73
2029	12.83	19.82	20.36	37.30	21.22	24.84
2030	13.57	20.88	21.44	38.60	22.31	26.02
2031	14.22	21.82	22.40	39.82	23.29	27.08
2032	14.97	22.89	23.50	41.12	24.40	28.28
2033	15.57	23.76	24.39	42.29	25.31	29.27
2034	16.19	24.65	25.30	43.45	26.23	30.27
2035	16.72	25.43	26.10	44.56	27.05	31.17
2036	17.39	26.39	27.09	45.77	28.05	32.26
2037	18.12	27.43	28.15	47.03	29.12	33.41
2038	18.85	28.48	29.22	48.31	30.21	34.58
2039	19.31	29.16	29.93	49.37	30.93	35.39
2040	20.33	30.59	31.39	50.91	32.40	36.94
2041	21.14	31.75	32.58	52.32	33.60	38.23
2042	21.83	32.75	33.60	53.65	34.64	39.36
2043	22.73	34.03	34.92	55.21	35.97	40.79
2044	23.52	35.18	36.09	56.73	37.16	42.09
2045	23.93	35.81	36.74	57.99	37.84	42.90
2046	25.07	37.43	38.40	59.92	39.52	44.70
2047	25.98	38.76	39.76	61.72	40.90	46.22
2048	26.78	39.93	40.97	63.49	42.14	47.60
2049	27.63	41.19	42.26	65.38	43.46	49.07
2050	28.51	42.49	43.60	67.35	44.83	50.60

1.2 Existing Resource Portfolios

Hawaiian Electric's thermal generating unit capacity is provided by a mix of utility-owned generation and independent power producers (IPPs). Shown below are some general info about these resources. Further information can be found in the *August 2021 IGP Inputs and Assumptions*.

1.2.1 O'ahu

1.2.1.1 O'ahu Firm Generation Portfolio

Shown below in Table C-4 are the various firm thermal generators on O'ahu, along with their minimum and maximum capacity, fuel type, and age.

Table C-4. O'ahu Minimum and Maximum Capacity, Fuel Type, and Age of Thermal Resources

Unit	Type	Operating Minimum (Net MW)	Normal Top Load (Net MW)	Fuel Type	Age (Years)
Kahe 1	Baseload	23.2	82.6	LSFO	61
Kahe 2	Baseload	23.3	82.4	LSFO	60
Kahe 3	Baseload	23.1	86.1	LSFO	54
Kahe 4	Baseload	23.1	85.4	LSFO	52
Kahe 5	Baseload	50.4	134.9	LSFO	50
Kahe 6	Baseload	50.4	134.7	LSFO	43
Waiau 3	Cycling	23.5	47.1	LSFO	77
Waiau 4	Cycling	23.5	46.5	LSFO	74
Waiau 5	Cycling	23.4	54.4	LSFO	65
Waiau 6	Cycling	23.5	53.7	LSFO	63
Waiau 7	Baseload	23.1	82.9	LSFO	58
Waiau 8	Baseload	23.1	86.3	LSFO	56
Waiau 9	Peaking	5.9	52.9	Diesel	51
Waiau 10	Peaking	5.9	49.9	Diesel	51
Campbell Industrial Park	Peaking	41.2	129.0	Diesel	15
H-Power	Baseload	35.0	68.5	Refuse	
Kalaeloa Energy Partners	Baseload	65.0	208.0	LSFO	
Airport DSG	Peaking	4.0	8.0	Biodiesel	6
Schofield 1	Peaking	4.0	8.1	ULSD / Biodiesel	5
Schofield 2	Peaking	4.0	8.1	ULSD / Biodiesel	5
Schofield 3	Peaking	4.0	8.1	ULSD / Biodiesel	5
Schofield 4	Peaking	4.0	8.1	ULSD / Biodiesel	5
Schofield 5	Peaking	4.0	8.1	ULSD / Biodiesel	5
Schofield 6	Peaking	4.0	8.1	ULSD / Biodiesel	5

1.2.1.2 Oʻahu Variable Renewable, Storage, and Grid Service Resource Portfolio

Shown below in Table C-5 are O'ahu's variable renewable, storage, and grid service resources, their first year in service, along with their maximum capacity, and their capacity factor.

Table C-5. Oʻahu Variable Renewable, Storage, and Grid Service Resources

Unit	Year in Service	Capacity (MW)	Storage Capacity (MWh)	Capacity Factor (%)
Kapolei Sustainable Energy Park	2012	1.0	-	21.9%
Kalaeloa Solar Two	2013	5.0	-	25.7%
Kalaeloa Renewable Energy Park	2014	5.0	-	20.5%
Kahuku Wind	2011	30.0	-	27.2%
Kawailoa Wind	2013	69.0	-	19.7%
West Loch	2019	20.0	-	25.1%
Lanikuhana Solar	2019	14.7	-	27.1%
Waipio PV	2019	45.9	-	27.1%
Kawailoa Solar	2019	49.0	-	27.1%
Na Pua Makani	2020	24.0	-	42.5%
Waianae Solar	2017	27.6	-	27.1%
Feed-In-Tariff Tier 1 and 2		24.8	-	19.3%
Feed-In-Tariff Tier 3		20.0	-	
Aloha Solar Energy Fund 1 & 2	2020	10.0	-	19.3%
Mauka FIT 1	2020	3.5	-	19.3%
Waihonu Solar	2016	6.5	-	19.3%
CBRE Phase 1	2023	5.0	-	24.5%
CBRE Phase 2	2027/2029	180.0	-	-
Stage 1				
Hoohana Solar 1	2024	52.0	208.0	25.1%
AES West Oahu Solar	2023	12.5	50.0	25.2%
Mililani 1 Solar	2023	39.0	156.0	27.2%
Waiawa Solar Power	2023	36.0	144.0	27.9%
Stage 2				
Waiawa Phase 2 Solar	2024	30.0	240.0	20.5%
Mountain View Solar	2024	7.0	35.0	17.3%
Kupono Solar	2024	42.0	168.0	25.3%
Kapolei Energy Storage	2023	185.0	565.0	-
Grid Services RFP				
Load Build	2021	14.8	-	-
Load Reduce	2021	26.3	-	-
Load Build 3	2023	60	-	-
Load Reduce 3	2023	60	-	-
FFR 3	2023	12	-	-
Demand Response				
Fast Demand Response (FDR)	2018	5.5	-	-
Residential Direct Load Control	2018	13.2	-	-
Commercial Direct Load Control	2018	7.8	-	-

Small Business Direct Load Control	2018	1.6	-	-

1.2.2 Hawai'i Island

1.2.2.1 Hawai'i Island Firm Generation Portfolio

Shown below in Table C-6 are the various firm thermal generators on Hawai'i Island, along with their minimum and maximum capacity, fuel type, and age.

Table C-6. Hawai'i Island Minimum and Maximum Capacity, Fuel Type, and Age of Thermal Resources

Unit	Type	Operating Minimum (Net MW)	Normal Top Load (Net MW)	Fuel Type	Age (Years)
Puna Geothermal Venture (2024)	Baseload	20	46	Geothermal	31
Puna Geothermal Venture (2021, off-peak)	Baseload	22.0	38.0	Geothermal	31
Puna Geothermal Venture (2021, on-peak)	Baseload	33.9	38.0	Geothermal	31
Hill 5	Cycling	5.0	13.8	IFO (2021-2024) / ULSD(2025+)	58
Hill 6	Cycling	8.0	20.0	IFO (2021-2024) / ULSD(2025+)	49
Kanoelehua CT1	Peaking	2.0	10.3	Diesel	61
Kanoelehua D11	Peaking	2.0	2.0	ULSD	61
Kanoelehua D15	Peaking	2.4	2.5	ULSD	48-51
Kanoelehua D16	Peaking	2.4	2.5	ULSD	48-51
Kanoelehua D17	Peaking	2.4	2.5	ULSD	48-51
Kapua D27	Peaking	1.3	1.3	ULSD	24-25
Keahole CT2	Peaking	6.0	13.8	Diesel	34
Keahole D21	Peaking	2.4	2.5	ULSD	35-39
Keahole D22	Peaking	2.4	2.5	ULSD	35-39
Keahole D23	Peaking	2.4	2.5	ULSD	35-39
Ouli D25	Peaking	1.3	1.3	ULSD	24-25
Panaewa D24	Peaking	1.3	1.3	ULSD	24-25
Puna	Cycling	6.0	15.5	IFO	53
Puna CT3	Peaking	8.0	20.0	Diesel	31
Punaluu D26	Peaking	1.3	1.3	ULSD	24-25
Waimea D12	Peaking	2.4	2.5	ULSD	51-53
Waimea D13	Peaking	2.4	2.5	ULSD	51-53
Waimea D14	Peaking	2.4	2.5	ULSD	51-53
Keahole CT4	Cycling	8.0	20.5	Diesel	19/13
Keahole CT5	Cycling	8.0	20.5	Diesel	19/13
Keahole ST7	Cycling	1.0	9.5	-	19/13
Hamakua Energy Partners CT1	Cycling	7.0	20.8	80% Naphtha / 20% Biodiesel	23

Hamakua Energy Partners CT2	Cycling	7.0	20.8	80% Naphtha / 20% Biodiesel	23
Hamakua Energy Partners ST	Cycling	5.5	16.4	-	23

1.2.2.2 Hawai'i Island Variable Renewable, Storage, and Grid Service Resource Portfolio

Shown below in Table C-7 are Hawai'i Island's variable renewable, storage, and grid service resources, along with their first year in service, their maximum capacity, and their capacity factor.

Table C-7. Hawai'i Island Variable Renewable, Storage, and Grid Service Resources

Unit	Year in Service	Capacity (MW)	Storage Capacity (MWh)	Capacity Factor (%)
Small Hydros		0.2	-	85.7%
Wailuku Hydro	1993	12.1	-	18.9%
HRD Wind	2006	10.5	-	42.4%
Tawhiri	2007	20.5		63.6%
Feed-In-Tariff		9.1		18.1%
Puueo Hydro	2005	3.3	-	54.8%
Waiau Hydro	1920	2.0	-	53.2%
CBRE Phase 1	2023	0.75	-	16.9%
CBRE Phase 2	2027/ 2029	20/ 12.5	-	-
Stage 1 RFP				
Hale Kuawehi Solar	2024	30.0	120.0	33.2%
Waikoloa Solar	2023	30.0	120.0	30.9%
Grid Services RFP				
Load Reduce	2023	4.0	-	-
Load Build	2023	3.2	-	-

1.2.3 Maui

1.2.3.1 Maui Firm Generation Portfolio

Shown below in Table C-8 are the various firm thermal generators on Maui, along with their minimum and maximum capacity, fuel type, and age.

Table C-8. Maui Minimum and Maximum Capacity, Fuel Type, and Age of Thermal Resources

Unit[2]	Type	Operating Minimum (Net MW)	Normal Top Load (Net MW)	Fuel Type	Age (Years)
Kahului 1	Peaking	2.26	4.71	IFO	75
Kahului 2	Peaking	2.28	4.76	IFO	74
Kahului 3	Baseload	3.00	11.50	IFO	69
Kahului 4	Baseload	3.00	11.50	IFO	57
Maalaea 1	Peaking	2.50	2.50	ULSD	52
Maalaea 2	Peaking	2.50	2.50	ULSD	51
Maalaea 3	Peaking	2.50	2.50	ULSD	51
Maalaea 4	Peaking	1.86	5.51	Diesel	50
Maalaea 5	Peaking	1.86	5.51	Diesel	50
Maalaea 6	Peaking	1.86	5.51	Diesel	50
Maalaea 7	Peaking	1.86	5.51	Diesel	45
Maalaea 8	Peaking	1.86	5.48	Diesel	45
Maalaea 9	Peaking	1.86	5.48	Diesel	45
Maalaea 10	Cycling	7.87	12.34	Diesel	43
Maalaea 11	Cycling	7.87	12.34	Diesel	43
Maalaea 12	Cycling	7.87	12.34	Diesel	35
Maalaea 13	Cycling	7.87	12.34	Diesel	35
Maalaea X1	Peaking	2.50	2.50	ULSD	36
Maalaea X2	Peaking	2.50	2.50	ULSD	36
Maalaea 14	Baseload	5.88	21.13	Diesel	31
Maalaea 15	Baseload	3.73	13.38	-	30
Maalaea 16	Baseload	5.88	21.13	Diesel	30
Maalaea 17	Cycling	5.93	21.47	Diesel	25
Maalaea 18	Cycling	2.96	12.99	-	17
Maalaea 19	Cycling	5.93	21.47	Diesel	23
Hana 1	Peaking	0.00	0.97	ULSD	34/39
Hana 2	Peaking	0.00	0.97	ULSD	34/39

1.2.3.2 Maui Variable Renewable, Storage, and Grid Service Resource Portfolio

Shown below in Table C-9 are Maui's variable renewable, storage, and grid service resources, along with their first year in service, their maximum capacity, and their capacity factor.

Table C-9. Maui Variable Renewable, Storage, and Grid Service Resources

Unit	Year in Service	Capacity (MW)	Storage Capacity (MWh)	Capacity Factor (%)
Feed-In-Tariff		6.9	-	17%
Kaheawa Wind Farm I	2006	30.0	-	43%
Kaheawa Wind Farm II	2012	21.0	-	47%
Auwahi Wind Farm	2012	21.0	-	51%
South Maui Renewable Resources	2018	2.9	-	29%
Kuia Solar	2018	2.9	-	29%
CBRE Phase 1	2021	0.02832	-	28%
CBRE Phase 2	2027/2029	33.475	-	-
Stage 1 RFP				
Kuihelani	2024	60.0	240.0	31%
Paeahu Solar	2025	15.0	60.0	31%
Stage 2 RFP				
Kamaole Solar	2025	40.0	160.0	35%
Waena BESS	2023	40.0	160.0	-
Grid Services RFP				
Load Build	2023	2.0	-	-
Load Reduce	2023	7.2	-	-
FFR1	2023	6.1	-	-
Demand Response				
Fast Demand Response	2021	4.9	-	-

1.2.4 Molokaʻi

1.2.4.1 Molokaʻi Firm Generation Portfolio

Shown below in Table C-10 are the various firm thermal generators on Molokaʻi, along with their minimum and maximum capacity, fuel type, and age.

Table C-10. Molokaʻi Minimum and Maximum Capacity, Fuel Type, and Age of Thermal Resources

Unit	Type	Operating Minimum (Net MW)	Normal Top Load (Net MW)	Fuel Type	Age (Years)
Palaau 01	Peaking	0.31	1.25	ULSD	38
Palaau 02	Peaking	0.31	1.25	ULSD	38
Palaau 03	Peaking	0.25	0.97	ULSD	38/32
Palaau 04	Peaking	0.25	0.97	ULSD	38/32
Palaau 05	Peaking	0.25	0.97	ULSD	38/32
Palaau 06	Peaking	0.25	0.97	ULSD	38/32
Palaau 07	Baseload	0.66	2.20	ULSD	27
Palaau 08	Baseload	0.66	2.20	ULSD	27
Palaau 09	Baseload	0.66	2.20	ULSD	27
Palaau GT1	Peaking	1.1	2.20	ULSD	41

1.2.4.2 Molokaʻi Variable Renewable, Storage, and Grid Service Resource Portfolio

Shown below in Table C-11 are Molokaʻi's variable renewable, storage, and grid service resources, along with their first year in service, their maximum capacity, and their capacity factor.

Table C-11. Molokaʻi Variable Renewable, Storage, and Grid Service Resources

Unit	Year in Service	Capacity (MW)	Storage Capacity (MWh)	Capacity Factor (%)
CBRE Phase 1	2023	0.25	-	21.8%
CBRE Phase 2	2027	2.75	-	25.7%

1.2.5 Lāna‘i

1.2.5.1 Lāna‘i Firm Generation Portfolio

Shown below in Table C-12 are the various firm thermal generators on Lāna‘i, along with their minimum and maximum capacity, fuel type, and age.

Table C-12. Lāna‘i Minimum and Maximum Capacity, Fuel Type, and Age of Thermal Resources

Unit	Type	Operating Minimum (Net MW)	Normal Top Load (Net MW)	Fuel Type	Age (Years)
LL 1	Peaking	0.5	1.0	ULSD	67
LL 2	Peaking	0.5	1.0	ULSD	67
LL 3	Peaking	0.5	1.0	ULSD	67
LL 4	Peaking	0.5	1.0	ULSD	67
LL 5	Peaking	0.5	1.0	ULSD	67
LL 6	Peaking	0.5	1.0	ULSD	67
LL 7	Baseload	0.3	2.2	ULSD	27
LL 8	Baseload	0.3	2.2	ULSD	27

1.2.5.2 Lāna‘i Variable Renewable, Storage, and Grid Service Resource Portfolio

Shown below in Table C-13 are Lāna‘i’s variable renewable, storage, and grid service resources, along with their first year in service, their maximum capacity, and their capacity factor.

Table C-13. Lāna‘i Variable Renewable, Storage, and Grid Service Resources

Unit	Year in Service	Capacity (MW)	Storage Capacity (MWh)	Capacity Factor (%)
CBRE Phase 2	2027	15.8	63.2	25.8%

1.3 Resource Plans

This section provides the resource plans for each island that was analyzed in Section 8 of the Integrated Grid Plan Report. The resource plans include the Status Quo, Base, and Land-Constrained resource plans produced by RESOLVE, and the preferred Base and Land-Constrained resource plans which includes adjustments based on the Resource Adequacy analysis and Transmission and System Security analysis.

1.3.1 O‘ahu

1.3.1.1 Status Quo Resource Plan

Shown below in Table C-36 are the Status Quo resource plan, which assumed the Base forecast, commercial operations of Stage 1, Stage 2, and CBRE Phase 2 Tranche 1 projects; successful renegotiation of existing independent power producers; and continued operation of most existing thermal units. The Status Quo plan excluded CBRE Phase 2 Tranche 2, Stage 3 RFP resources, and future resources selected by RESOLVE.

Table C-14. O‘ahu – Status Quo resource plan.

O‘ahu: Status Quo		
	Planned	**New Additions**
2022		
2023	Installed 3 MW of CBRE Ph 1 PV Installed 12.5 MW West Oahu Installed 39 MW Mililani Solar Installed 36 MW Waiawa Solar Installed 185 MW Kapolei Energy Storage Installed 60 MW Load Build 3 Installed 60 MW Load Reduce 3	
2024	Installed 2 MW of CBRE Ph 1 PV Installed 52 MW Hoohana Solar Installed 7 MW Mountain View Solar Installed 30 MW Waiawa Ph 2 Solar Installed 42 MW Kupono Solar Removed 93.5 MW Waiau 3-4	
2025		
2026	Removed 15 MW Load Build Removed 26 MW Load Reduce	
2027	Installed 75 MW of CBRE Ph 2 RFP PV Installed 30 MW of CBRE Ph 2 Small PV	
2028		
2029		
2030		
2031		
2032		
2033	Removed 60 MW Load Build 3 Removed 60 MW Load Reduce 3	
2034		
2035		
2036		
2037		
2038		
2039		

2040		
2041		
2042		
2043		
2044		
2045	Biodiesel Conversion on all firm units	
2046		
2047		
2048		
2049		
2050		

1.3.1.2 Base Resource Plan

Shown below in Table C-37 is the Base resource plan produced by RESOLVE.

Table C-15. O'ahu – Base resource plan.

O'ahu: Base		
	Planned	**New Additions**
2022		
2023	Installed 3 MW of CBRE Ph 1 PV Installed 12.5 MW West Oahu Installed 39 MW Mililani Solar Installed 36 MW Waiawa Solar Installed 185 MW Kapolei Energy Storage Installed 60 MW Load Build 3 Installed 60 MW Load Reduce 3	
2024	Installed 2 MW of CBRE Ph 1 PV Installed 52 MW Hoohana Solar Installed 7 MW Mountain View Solar Installed 30 MW Waiawa Ph 2 Solar Installed 42 MW Kupono Solar Removed 93.5 MW Waiau 3-4	
2025	Installed 15 MW Barbers Point Solar	
2026	Removed 15 MW Load Build Removed 26 MW Load Reduce	
2027	Installed 75 MW of CBRE Ph 2 RFP PV Installed 30 MW of CBRE Ph 2 Small PV Installed 450 MW RFP 3 Hybrid Solar Removed 108.1 MW Waiau 5-6	
2028		
2029	Installed 75 MW of CBRE Ph 2 RFP PV Installed 300 MW RFP 3 CT Removed 169.1 MW Waiau 7-8	Installed 82 MW 155 MWh Standalone BESS Installed 82 MW Group 1 Onshore Wind Installed 82 MW Group 2 Onshore Wind
2030		Installed 85 MW 158 MWh Standalone BESS Installed 84 MW 140 MWh Group 1 Hybrid Solar 15% Slope BESS Installed 84 MW Group 1 Hybrid Solar 15% Slope Installed 344 MW 553 MWh Group 1 Hybrid Solar 30% Slope BESS Installed 344 MW Group 1 Hybrid Solar 30% Slope Installed 282 MW 674 MWh Group 2 Hybrid Solar 15% Slope BESS Installed 282 MW Group 2 Hybrid Solar 15% Slope Installed 435 MW 923 MWh Group 3 Hybrid Solar 15% Slope

		BESS Installed 435 MW Group 3 Hybrid Solar 15% Slope
2031	Removed 30 MW Kahuku Wind	
2032	Removed 1 MW Kapolei Sustainable Energy Park	
2033	Removed 5 MW Kalaeloa Solar Two Removed 164.9 MW Kahe 1-2 Removed 60 MW Load Build 3 Removed 60 MW Load Reduce 3 Removed 208 MW KPLP Installed 208 MW RFP 3 CC	
2034	Removed 5 MW Kalaeloa Renewable Energy Park	
2035		Installed 76 MWh Group 2 Hybrid Solar 15% Slope BESS Installed 151 MWh Group 3 Hybrid Solar 15% Slope BESS Installed 400 MW New Offshore Wind
2036		
2037	Removed 171.5 MW Kahe 3-4	
2038	Removed 69 MW Kawailoa Wind	
2039	Removed 27.6 MW Waianae Solar	
2040	Removed 24 MW Na Pua Makani Wind	Installed 157 MW 340 MWh Group 2 Hybrid Solar 15% Slope BESS Installed 157 MW Group 2 Hybrid Solar 15% Slope Installed 273 MW 755 MWh Group 2 Hybrid Solar 30% Slope BESS Installed 273 MW Group 2 Hybrid Solar 30% Slope Installed 86 MW 88 MWh Group 3 Hybrid Solar 30% Slope BESS Installed 86 MW Group 3 Hybrid Solar 30% Slope
2041	Removed 109.6 MW Clearway Projects	
2042		
2043		
2044	Removed 20 MW West Loch Solar	
2045	Biodiesel Conversion on all firm units	Installed 20 MW Biomass Installed 45 MWh Group 2 Hybrid Solar 15% Slope BESS Installed 912 MW 1631 MWh Group 2 Hybrid Solar 30% Slope BESS Installed 912 MW Group 2 Hybrid Solar 30% Slope Installed 108 MW 106 MWh Group 3 Hybrid Solar 30% Slope BESS Installed 108 MW Group 3 Hybrid Solar 30% Slope Installed 22 MW Recovered Wind Potential
2046	Removed 269.5 MW Kahe 5-6	
2047		
2048		
2049		
2050		Installed 80 MW Biomass Installed 5 MWh Group 2 Hybrid Solar 15% Slope BESS Installed 50 MW 161 MWh Group 2 Hybrid Solar 30% Slope BESS Installed 50 MW Group 2 Hybrid Solar 30% Slope Installed 449 MW 911 MWh Group 3 Hybrid Solar 30% Slope BESS Installed 449 MW Group 3 Hybrid Solar 30% Slope Installed 101 MW Recovered Wind Potential

Shown below in Table C-38 is the Preferred Base resource plan. This plan incorporates any adjustments based on the Resource Adequacy analysis and Transmission and System Security analysis.

Table C-16. Oʻahu – Preferred – Base resource plan.

O'ahu: Preferred – Base		
	Planned	**New Additions**
2022		
2023	Installed 3 MW of CBRE Ph 1 PV Installed 12.5 MW West Oahu Installed 39 MW Mililani Solar Installed 36 MW Waiawa Solar Installed 185 MW Kapolei Energy Storage Installed 60 MW Load Build 3 Installed 60 MW Load Reduce 3	
2024	Installed 2 MW of CBRE Ph 1 PV Installed 52 MW Hoohana Solar Installed 7 MW Mountain View Solar Installed 30 MW Waiawa Ph 2 Solar Installed 42 MW Kupono Solar Removed 93.5 MW Waiau 3-4	
2025	-	
2026	Removed 15 MW Load Build Removed 26 MW Load Reduce	
2027	Installed 75 MW of CBRE Ph 2 RFP PV Installed 30 MW of CBRE Ph 2 Small PV Installed 470 MW RFP 3 Hybrid Solar Removed 108.1 MW Waiau 5-6	
2028		
2029	Installed 75 MW of CBRE Ph 2 RFP PV Installed 300 MW RFP 3 CT Removed 169.1 MW Waiau 7-8	Installed 82 MW 328 MWh Standalone BESS
2030		Installed 85 MW 340 MWh Standalone BESS Installed 84 MW 336 MWh Group 1 Hybrid Solar 15% Slope BESS Installed 84 MW Group 1 Hybrid Solar 15% Slope Installed 276 MW 1104 MWh Group 1 Hybrid Solar 30% Slope BESS Installed 276 MW Group 1 Hybrid Solar 30% Slope Installed 272 MW 1088 MWh Group 2 Hybrid Solar 15% Slope BESS Installed 272 MW Group 2 Hybrid Solar 15% Slope Installed 435 MW 1740 MWh Group 3 Hybrid Solar 15% Slope BESS Installed 435 MW Group 3 Hybrid Solar 15% Slope
2031	Removed 30 MW Kahuku Wind	
2032	Removed 1 MW Kapolei Sustainable Energy Park	
2033	Removed 5 MW Kalaeloa Solar Two Removed 164.9 MW Kahe 1-2 Removed 60 MW Load Build 3 Removed 60 MW Load Reduce 3 Removed 208 MW KPLP Installed 208 MW RFP 3 CC	
2034	Removed 5 MW Kalaeloa Renewable Energy Park	
2035		Installed 400 MW New Offshore Wind

2036		
2037	Removed 171.5 MW Kahe 3-4	
2038	Removed 69 MW Kawailoa Wind	
2039	Removed 27.6 MW Waianae Solar	
2040	Removed 24 MW Na Pua Makani Wind	Installed 167 MW 668 MWh Group 2 Hybrid Solar 15% Slope BESS Installed 167 MW Group 2 Hybrid Solar 15% Slope Installed 263 MW 1052 MWh Group 2 Hybrid Solar 30% Slope BESS Installed 263 MW Group 2 Hybrid Solar 30% Slope Installed 86 MW 344 MWh Group 3 Hybrid Solar 30% Slope BESS Installed 86 MW Group 3 Hybrid Solar 30% Slope
2041	Removed 109.6 MW Clearway Projects	
2042		
2043		
2044	Removed 20 MW West Loch Solar	
2045	Biodiesel Conversion on all firm units	Installed 912 MW 3648 MWh Group 2 Hybrid Solar 30% Slope BESS Installed 912 MW Group 2 Hybrid Solar 30% Slope Installed 108 MW 432 MWh Group 3 Hybrid Solar 30% Slope BESS Installed 108 MW Group 3 Hybrid Solar 30% Slope Installed 22 MW Recovered Wind Potential
2046	Removed 269.5 MW Kahe 5-6	
2047		
2048		
2049		
2050		Installed 50 MW 200 MWh Group 2 Hybrid Solar 30% Slope BESS Installed 50 MW Group 2 Hybrid Solar 30% Slope Installed 311 MW 1244 MWh Group 3 Hybrid Solar 30% Slope BESS Installed 311 MW Group 3 Hybrid Solar 30% Slope Installed 101 MW Recovered Wind Potential

1.3.1.3 Land-Constrained Resource Plan

Shown below in Table C-39 is the Land-Constrained resource plan produced by RESOLVE.

Table C-17. Oʻahu – Land-Constrained resource plan.

	Oʻahu: Land-Constrained	
	Planned	**New Additions**
2022		
2023	Installed 3 MW of CBRE Ph 1 PV Installed 12.5 MW West Oahu Installed 39 MW Mililani Solar Installed 36 MW Waiawa Solar Installed 185 MW Kapolei Energy Storage Installed 60 MW Load Build 3 Installed 60 MW Load Reduce 3	
2024	Installed 2 MW of CBRE Ph 1 PV Installed 52 MW Hoohana Solar Installed 7 MW Mountain View Solar Installed 30 MW Waiawa Ph 2 Solar	

	Installed 42 MW Kupono Solar Removed 93.5 MW Waiau 3-4	
2025	Installed 15 MW Barbers Point Solar	
2026	Removed 15 MW Load Build Removed 26 MW Load Reduce	
2027	Installed 75 MW of CBRE Ph 2 RFP PV Installed 30 MW of CBRE Ph 2 Small PV Installed 450 MW RFP 3 Hybrid Solar Removed 108.1 MW Waiau 5-6	
2028		
2029	Installed 75 MW of CBRE Ph 2 RFP PV Installed 300 MW RFP 3 CT Removed 169.1 MW Waiau 7-8	Installed 29 MW 55 MWh Standalone BESS
2030		Installed 25 MW 47 MWh Standalone BESS
2031	Removed 30 MW Kahuku Wind	
2032	Removed 1 MW Kapolei Sustainable Energy Park	
2033	Removed 5 MW Kalaeloa Solar Two Removed 164.9 MW Kahe 1-2 Removed 60 MW Load Build 3 Removed 60 MW Load Reduce 3 Removed 208 MW KPLP Installed 208 MW RFP 3 CC	
2034	Removed 5 MW Kalaeloa Renewable Energy Park	
2035		Installed 140 MW 261 MWh Standalone BESS Installed 153 MW LM6000 2x1 CC Installed 30 MW Recovered Wind Potential Installed 400 MW New Offshore Wind
2036		
2037	Removed 171.5 MW Kahe 3-4	
2038	Removed 69 MW Kawailoa Wind	
2039	Removed 27.6 MW Waianae Solar	
2040	Removed 24 MW Na Pua Makani Wind	Installed 12 MW 24 MWh Standalone BESS Installed 39 MW Recovered PV Potential Installed 93 MW Recovered Wind Potential
2041	Removed 109.6 MW Clearway Projects	
2042		
2043		
2044	Removed 20 MW West Loch Solar	
2045	Biodiesel Conversion on all firm units	Installed 182 MW 800 MWh Standalone BESS Installed 1310 MW 2619 MWh Aggregated DER BESS Installed 1310 MW Aggregated DER Installed 129 MW Recovered PV Potential
2046	Removed 269.5 MW Kahe 5-6	
2047		
2048		
2049		
2050		Installed 127 MW 920 MWh Standalone BESS Installed 947 MW 1894 MWh Aggregated DER BESS Installed 947 MW Aggregated DER

Shown below in Table C-40 is the Preferred Land-Constrained resource plan. This plan incorporates any adjustments based on the Resource Adequacy analysis and Transmission and System Security analysis.

Table C-18. Oʻahu – Preferred – Land-Constrained resource plan.

	O'ahu: Preferred – Land-Constrained

	Planned	New Additions
2022		
2023	Installed 3 MW of CBRE Ph 1 PV Installed 12.5 MW West Oahu Installed 39 MW Mililani Solar Installed 36 MW Waiawa Solar Installed 185 MW Kapolei Energy Storage Installed 60 MW Load Build 3 Installed 60 MW Load Reduce 3	
2024	Installed 2 MW of CBRE Ph 1 PV Installed 52 MW Hoohana Solar Installed 7 MW Mountain View Solar Installed 30 MW Waiawa Ph 2 Solar Installed 42 MW Kupono Solar Removed 93.5 MW Waiau 3-4	
2025		
2026	Removed 15 MW Load Build Removed 26 MW Load Reduce	
2027	Installed 75 MW of CBRE Ph 2 RFP PV Installed 30 MW of CBRE Ph 2 Small PV Installed 470 MW RFP 3 Hybrid Solar Removed 108.1 MW Waiau 5-6	
2028		
2029	Installed 75 MW of CBRE Ph 2 RFP PV Installed 300 MW RFP 3 CT Removed 169.1 MW Waiau 7-8	Installed 29 MW 116 MWh Standalone BESS
2030		Installed 25 MW 100 MWh Standalone BESS
2031	Removed 30 MW Kahuku Wind	
2032	Removed 1 MW Kapolei Sustainable Energy Park	
2033	Removed 5 MW Kalaeloa Solar Two Removed 164.9 MW Kahe 1-2 Removed 60 MW Load Build 3 Removed 60 MW Load Reduce 3 Removed 208 MW KPLP Installed 208 MW RFP 3 CC	
2034	Removed 5 MW Kalaeloa Renewable Energy Park	
2035		Installed 140 MW 560 MWh Standalone BESS Installed 30 MW Recovered Wind Potential Installed 400 MW New Offshore Wind
2036		
2037	Removed 171.5 MW Kahe 3-4	
2038	Removed 69 MW Kawailoa Wind	
2039	Removed 27.6 MW Waianae Solar	
2040	Removed 24 MW Na Pua Makani Wind	Installed 12 MW 48 MWh Standalone BESS Installed 39 MW Recovered PV Potential Installed 93 MW Recovered Wind Potential
2041	Removed 109.6 MW Clearway Projects	
2042		
2043		
2044	Removed 20 MW West Loch Solar	
2045	Biodiesel Conversion on all firm units	Installed 182 MW 728 MWh Standalone BESS Installed 1310 MW 2619 MWh Aggregated DER BESS Installed 1310 MW Aggregated DER Installed 129 MW Recovered PV Potential
2046	Removed 269.5 MW Kahe 5-6	
2047		
2048		
2049		

2050		Installed 127 MW 508 MWh Standalone BESS Installed 947 MW 1894 MWh Aggregated DER BESS Installed 947 MW Aggregated DER

1.3.2 Hawai‘i Island

1.3.2.1 Status Quo Resource Plan

Shown below in Table C-41 is the Status Quo resource plan, which assumed the Base forecast, commercial operations of Stage 1, Stage 2, and CBRE Phase 2 Tranche 1 projects; successful renegotiation of existing independent power producers; and continued operation of most existing thermal units. The Status Quo plan excluded CBRE Phase 2 Tranche 2, Stage 3 RFP resources, and future resources selected by RESOLVE.

Table C-19. Hawai‘i Island – Status Quo resource plan.

Hawai'i Island: Status Quo		
Year	**Planned**	**New Additions**
2022		
2023	Installed 0.75 MW CBRE_PV_1 Installed 30 MW PV_Waikoloa_Supply Installed 30 MW 120 MWh PV_Waikoloa_Battery	
2024	Installed 30 MW PV_Hale_Kuawehi_Supply Installed 30 MW 120 MWh PV_Hale_Kuawehi_Battery	
2025	Removed 15.5 MW Puna_Steam	
2026	Removed 3.17 MW Load_Build Removed 4 MW Load_Reduction Waiau capacity increased to 2 MW PGV capacity increased to 46 MW	
2027	Installed 12.5 MW CBRE_PV_Phase_2_T1_RFP_Supply Installed 12.5 MW 50 MWh CBRE_PV_Phase_2_T1_RFP_Battery Installed 7.5 MW CBRE_PV_Phase_2_Small Removed 33.8 MW Hill5-6	
2028		
2029		
2030		
2031		
2032		
2033		
2034		
2035		
2036		
2037		
2038		
2039		
2040		
2041		
2042		
2043		
2044		

2045	Biodiesel Conversion on all firm units	
2046		
2047		
2048		
2049		
2050		

1.3.2.2 Base Resource Plan

Shown below in Table C-42 is the Base resource plan produced by RESOLVE. There were no adjustments based on the Resource Adequacy analysis and Transmission and System Security analysis, therefore this is also the preferred plan.

Table C-20. Hawai'i Island – Base resource plan.

Hawai'i Island: Base		
Year	**Planned**	**New Additions**
2022		
2023	Installed 0.75 MW CBRE_PV_1 Installed 30 MW PV_Waikoloa_Supply Installed 30 MW 120 MWh PV_Waikoloa_Battery	
2024	Installed 30 MW PV_Hale_Kuawehi_Supply Installed 30 MW 120 MWh PV_Hale_Kuawehi_Battery	
2025	Removed 15.5 MW Puna_Steam	
2026	Removed 3.17 MW Load_Build Removed 4 MW Load_Reduction Waiau capacity increased to 2 MW PGV capacity increased to 46 MW	
2027	Installed 12.5 MW CBRE_PV_Phase_2_T1_RFP_Supply Installed 12.5 MW 50 MWh CBRE_PV_Phase_2_T1_RFP_Battery Installed 7.5 MW CBRE_PV_Phase_2_Small Removed 33.8 MW Hill5-6	
2028	Removed 7 MW Tawhiri-A_Wind Removed 13.5 MW Tawhiri-B_Wind	
2029	Installed 12.5 MW CBRE_PV_Phase_2_T2_RFP_Supply Installed 12.5 MW 50 MWh CBRE_PV_Phase_2_T2_RFP_Battery	Installed 7 MW 12 MWh Standalone BESS Installed 48 MW Wind_New_AggA
2030	Installed 140 MW PV_Stage_3_RFP_Supply Installed 140 MW 560 MWh PV_Stage_3_RFP_Battery	
2031	Removed 57.6 MW HEP Combined Cycle	
2032		
2033		
2034		
2035		Installed 3 MW Hybrid Solar AggA_Supply Installed 2 MW 5 MWh Standalone BESS Installed 3 MW 3 MWh Hybrid Solar AggA_Battery
2036		
2037		
2038		

2039		
2040		Installed 20 MW Hybrid Solar AggA_Supply Installed 1 MW 1 MWh Standalone BESS Installed 20 MW 20 MWh Hybrid Solar AggA_Battery Installed 1 MW Wind_New_AggA
2041		
2042		
2043		
2044		
2045	Biodiesel Conversion on all firm units	Installed 2 MW 4 MWh Standalone BESS Installed 30 MW Geothermal_New
2046		
2047		
2048		
2049		
2050		Installed 15 MW Hybrid Solar AggA_Supply Installed 15 MW 15 MWh Hybrid Solar AggA_Battery Installed 2 MW Wind_New_AggA

1.3.3 Maui

1.3.3.1 Status Quo Resource Plan

Shown below in Table C-43 is the Status Quo resource plan, which assumed the Base forecast, commercial operations of Stage 1, Stage 2, and CBRE Phase 2 Tranche 1 projects; successful renegotiation of existing independent power producers; and continued operation of most existing thermal units. The Status Quo plan excluded CBRE Phase 2 Tranche 2, Stage 3 RFP resources, and future resources selected by RESOLVE.

Table C-21. Maui – Status Quo resource plan.

Maui: Status Quo		
Year	**Planned**	**New Additions**
2022		
2023	Installed 6.07 MW FFR Grid Service Installed 7.15 MW Load Reduce Grid Service Installed 1.98 MW Load Build Grid Service Installed 40MW/ 160 MWH Waena BESS	
2024	Installed 60 MW/ 240 MWH Kuihelani Solar + Battery	
2025	Installed 40 MW/ 160MWh Kamaole Solar Installed 15 MW/ 60 MWH Paeahu Solar + Battery Removed 2.42 MW Load Reduce Grid Service Removed 0.1 MW Load Build Grid Service	
2026	Removed 6.07 MW FFR Grid Service Removed 4.73 MW Load Reduce Grid Service Removed 1.88 MW Load Build Grid Service	

2027	Removed 9.47 MW Kahului 1-2 Removed 23 MW Kahului 3-4 Removed 49.36 MW Maalaea 10-13 Installed 12.5 MW CBRE Phase 2 RFP Paired Installed 8.475 MW CBRE Phase 2 Small Projects	
2028		
2029		
2030		
2031		
2032		
2033		
2034		
2035		
2036		
2037		
2038		
2039		
2040		
2041		
2042		
2043		
2044		
2045	Biodiesel Conversion on all firm units	
2046		
2047		
2048		
2049		
2050		

1.3.3.2 Base Resource Plan

Shown below in Table C-44 is the Base resource plan produced by RESOLVE.

Table C-22. Maui – Base resource plan.

Maui: Base		
Year	**Planned**	**New Additions**
2022		
2023	Installed 6.07 MW FFR Grid Service Installed 7.15 MW Load Reduce Grid Service Installed 1.98 MW Load Build Grid Service Installed 40MW/ 160 MWH Waena BESS	
2024	Installed 60 MW/ 240 MWH Kuihelani Solar + Battery	

2025	Installed 40 MW/ 160MWh Kamaole Solar Installed 15 MW/ 60 MWH Paeahu Solar + Battery Removed 2.42 MW Load Reduce Grid Service Removed 0.1 MW Load Build Grid Service	
2026	Removed 6.07 MW FFR Grid Service Removed 4.73 MW Load Reduce Grid Service Removed 1.88 MW Load Build Grid Service	
2027	Removed 30 MW Kaheawa Wind Power 1 Removed 9.47 MW Kahului 1-2 Removed 23 MW Kahului 3-4 Removed 49.36 MW Maalaea 10-13 Installed 16.28 MW ICE S3 RFP Installed 191 MW Hybrid Solar with 764 MWh Battery S3 RFP Installed 12.5 MW CBRE Phase 2 RFP Paired Installed 8.475 MW CBRE Phase 2 Small Projects	
2028		
2029	Installed 12.5 MW CBRE Phase 2 RFP Paired	Installed 5 MW Onshore Wind (AggC)
2030	Removed 33 MW Maalaea 4-9 Removed 7.5 MW Maalaea 1-3	Installed 7.6 MW Onshore Wind (AggC)
2031		
2032		
2033	Removed 21 MW Kaheawa Wind Power 2 Removed 21 MW Auwahi Wind	
2034		
2035		Installed 53 MW Onshore Wind (AggC) Installed 37 MW 148 MWh Hybrid Solar Battery (AggC)
2036		
2037		
2038		
2039		
2040	Removed 5.7 MW SMRR PV	Installed 18 MW Onshore Wind (AggC) Installed 43 MW 172 MWh Hybrid Solar Battery (AggC)
2041		
2042		
2043		
2044		
2045	Biodiesel Conversion on all firm units	Installed 15 MW 60 MWh Hybrid Solar Battery (AggB) Installed 66 MW 264 MWh Hybrid Solar Battery (AggC) Installed 41 MW Onshore Wind (AggC)
2046		
2047		
2048		
2049		
2050		Installed 57 MW 228 MWh Hybrid Solar Battery (AggB) Installed 57 MW 228 MWh Hybrid Solar Battery (AggC)

Shown below in Table C-45 is the Preferred Base resource plan. These plans incorporate any adjustments based on the Resource Adequacy analysis and Transmission and System Security analysis.

Table C-23. Maui – Preferred – Base resource plan.

Maui: Base		
Year	**Planned**	**New Additions**
2022		
2023	Installed 6.07 MW FFR Grid Service Installed 7.15 MW Load Reduce Grid Service Installed 1.98 MW Load Build Grid Service Installed 40MW/ 160 MWH Waena BESS	
2024	Installed 60 MW/ 240 MWH Kuihelani Solar + Battery	
2025	Installed 40 MW/ 160MWh Kamaole Solar Installed 15 MW/ 60 MWH Paeahu Solar + Battery Removed 2.42 MW Load Reduce Grid Service Removed 0.1 MW Load Build Grid Service	
2026	Removed 6.07 MW FFR Grid Service Removed 4.73 MW Load Reduce Grid Service Removed 1.88 MW Load Build Grid Service	
2027	Removed 30 MW Kaheawa Wind Power 1 Removed 9.47 MW Kahului 1-2 Removed 23 MW Kahului 3-4 Removed 49.36 MW Maalaea 10-13 Installed 16.28 MW ICE S3 RFP Installed 191 MW Hybrid Solar with 764 MWh Battery S3 RFP Installed 12.5 MW CBRE Phase 2 RFP Paired Installed 8.475 MW CBRE Phase 2 Small Projects	
2028		
2029	Installed 12.5 MW CBRE Phase 2 RFP Paired	Installed 5 MW Onshore Wind (AggC)
2030	Removed 33 MW Maalaea 4-9 Removed 7.5 MW Maalaea 1-3	Installed 7.6 MW Onshore Wind (AggC)
2031		
2032		
2033	Removed 21 MW Kaheawa Wind Power 2 Removed 21 MW Auwahi Wind	
2034		
2035		Installed 53 MW Onshore Wind (AggC) Installed 37 MW 148 MWh Hybrid Solar Battery (AggC)
2036		
2037		
2038		
2039		
2040	Removed 5.7 MW SMRR PV	Installed 18 MW Onshore Wind (AggC) Installed 43 MW 172 MWh Hybrid Solar Battery (AggC)
2041		
2042		
2043		
2044		

2045	Biodiesel Conversion on all firm units	Installed 8 MW 32 MWh Hybrid Solar Battery (AggB) Installed 66 MW 264 MWh Hybrid Solar Battery (AggC) Installed 41 MW Onshore Wind (AggC)
2046		
2047		
2048		
2049		
2050		Installed 57 MW 228 MWh Hybrid Solar Battery (AggB) Installed 57 MW 228 MWh Hybrid Solar Battery (AggC)

1.3.4 Molokaʻi

1.3.4.1 Status Quo Resource Plan

Shown below in Table C-46 is the Status Quo resource plan, which assumed the Base forecast, commercial operations of Stage 1, Stage 2, and CBRE Phase 2 Tranche 1 projects; successful renegotiation of existing independent power producers; and continued operation of most existing thermal units. The Status Quo plan excluded CBRE Phase 2 Tranche 2, Stage 3 RFP resources, and future resources selected by RESOLVE.

Table C-24. Molokaʻi – Status Quo resource plan.

Molokaʻi: Status Quo		
	Planned	New Additions
2022		
2023	Install 0.25 MW Standalone PV (CBRE Phase 1)	
2024		
2025		
2026		
2027	Install 2.75 MW 11 MWh Hybrid Solar Storage Install 2.75 MW Hybrid Solar (CBRE Phase 2)	
2028		
2029		
2030		
2031		
2032		
2033		
2034		
2035		
2036		
2037		
2038		
2039		
2040		
2041		
2042		
2043		

2044		
2045	Biodiesel Conversion on all firm units	
2046		
2047		
2048		
2049		
2050		

1.3.4.2 Base Resource Plan

Shown below in Table C-47 is the Base resource plan produced by RESOLVE.

Table C-25. Molokaʻi – Base resource plan.

Molokaʻi: Base		
	Planned	**New Additions**
2022		
2023	Install 0.25 MW Standalone PV (CBRE Phase 1)	
2024		
2025		
2026		
2027	Install 2.75 MW 11 MWh Hybrid Solar Storage Install 2.75 MW Hybrid Solar (CBRE Phase 2)	
2028		
2029		Installed 0.4 MW 0.7 MWh Standalone BESS Installed 3 MW 3 MWh Hybrid Solar Storage Installed 3 MW Hybrid Solar
2030		Installed 0.1 MW 0.3 MWh Standalone BESS Installed 8.5 MW 29.7 MWh Hybrid Solar Storage Installed 8.5 MW Hybrid Solar
2031		
2032		
2033		
2034		
2035		Installed 0.1 MW 0.1 MWh Standalone BESS Installed 2.3 MW 1.9 MWh Hybrid Solar Storage Installed 2.3 MW Hybrid Solar
2036		
2037		
2038		
2039		
2040		Installed 0.1 MW 0.1 MWh Standalone BESS Installed 1.1 MW 2.8 MWh Hybrid Solar Storage Installed 1.1 MW Hybrid Solar
2041		
2042		
2043		
2044		
2045	Biodiesel Conversion on all firm units	Installed 0.1 MW 0.2 MWh Standalone BESS Installed 2.6 MW 6.9 MWh Hybrid Solar Storage Installed 2.6 MW Hybrid Solar
2046		
2047		

2048		
2049		
2050		Installed 0 MW 0.1 MWh Standalone BESS Installed 1.2 MW 2.9 MWh Hybrid Solar Storage Installed 1.2 MW Hybrid Solar

In the Preferred Base resource plan, battery duration was increased to 4 hours to match current market conditions.

1.3.5 Lāna'i

1.3.5.1 Status Quo Resource Plan

Shown below in Table C-48 is the Status Quo resource plan, which assumed the Base forecast, commercial operations of Stage 1, Stage 2, and CBRE Phase 2 Tranche 1 projects; successful renegotiation of existing independent power producers; and continued operation of most existing thermal units. The Status Quo plan excluded CBRE Phase 2 Tranche 2, Stage 3 RFP resources, and future resources selected by RESOLVE.

Table C-26. Lāna'i – Status Quo resource plan.

Lāna'i: Status Quo		
Year	**Planned**	**New Additions**
2022		
2023		
2024		
2025		
2026		
2027	Install 15.8 MW 63.2 MWh Hybrid Solar Storage Install 15.8 MW 63.2 MWh Hybrid Solar (CBRE RFP)	
2028		
2029		
2030		
2031		
2032		
2033		
2034		
2035		
2036		
2037		
2038		
2039		
2040		
2041		
2042		
2043		
2044		
2045	Biodiesel Conversion on all firm units	
2046		
2047		
2048		
2049		

2050		

1.3.5.2 Base Resource Plan

Shown below in Table C-49 is the Base resource plan produced by RESOLVE.

Table C-27. Lānaʻi – Base resource plan.

Lānaʻi: Base		
Year	**Planned**	**New Additions**
2022		
2023		
2024		
2025		
2026		
2027	Install 15.8 MW 63.2 MWh Hybrid Solar Storage Install 15.8 MW 63.2 MWh Hybrid Solar (CBRE RFP)	
2028		
2029		Installed 0.6 MW 1.1 MWh Standalone BESS Installed 0.3 MW 0.3 MWh Hybrid Solar Storage Installed 0.3 MW Hybrid Solar
2030		Installed 4.9 MW 4.9 MWh Hybrid Solar Storage Installed 4.9 MW Hybrid Solar
2031		
2032		
2033		
2034		
2035		Installed 0 MWh Standalone BESS Installed 0.3 MW 0.3 MWh Hybrid Solar Storage Installed 0.3 MW Hybrid Solar
2036		
2037		
2038		
2039		
2040		Installed 0 MW Standalone BESS Installed 1 MW 1 MWh Hybrid Solar Storage Installed 1 MW Hybrid Solar
2041		
2042		
2043		
2044		
2045	Biodiesel Conversion on all firm units	Installed 0.2 MW 0.3 MWh Standalone BESS Installed 1.5 MW 1.5 MWh Hybrid Solar Storage Installed 1.5 MW Hybrid Solar
2046		
2047		
2048		
2049		
2050		Installed 0.1 MW 0.1 MWh Standalone BESS Installed 0.9 MW 0.9 MWh Hybrid Solar Storage Installed 0.9 MW Hybrid Solar

In the Preferred Base resource plan, battery duration was increased to 4 hours to match current market conditions.

1.4 Resource Adequacy

This section provides additional details to the resource adeqaucy analysis provided in Section 8 and Section 12 of the Integrated Grid Plan Report. We provide the relationship between the 2030 LOLE and firm capacity or hybrid solar capacity for each island under the base forecast. This section also provides the relationship between the 2035 LOLE and firm capacity or hybrid solar capacity for each island under the high load forecast. For forecasts where additional firm capacity is needed to achieve the reliability target, resources are presented in terms of the amount of firm capacity added to the system. For forecasts where existing firm capacity is sufficient to meet the reliability target, resources are presented in terms of the cumulative firm capacity in the system.

1.4.1 O‘ahu

1.4.1.1 2030 Outlook

Variable Resource Curve Fit

Shown below in Figure C-1 is the relationship between the LOLE in 2030 and the amount of future hybrid solar capacity that is added after Stage 3.

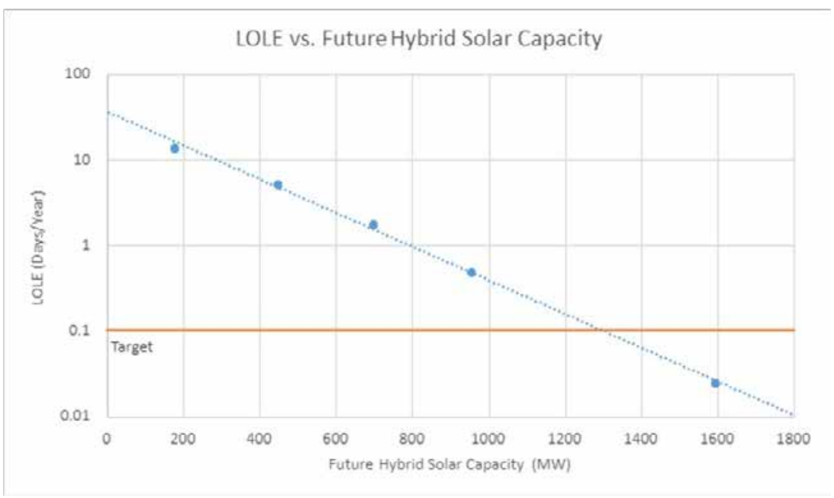

Figure C-1. O‘ahu – Loss of Load vs Future Hybrid Solar Capacity. 2030.

Firm Resource Curve Fit

Shown below in Figure C-2 is the relationship between the LOLE in 2030 and the amount of future firm capacity that is added after Stage 3.

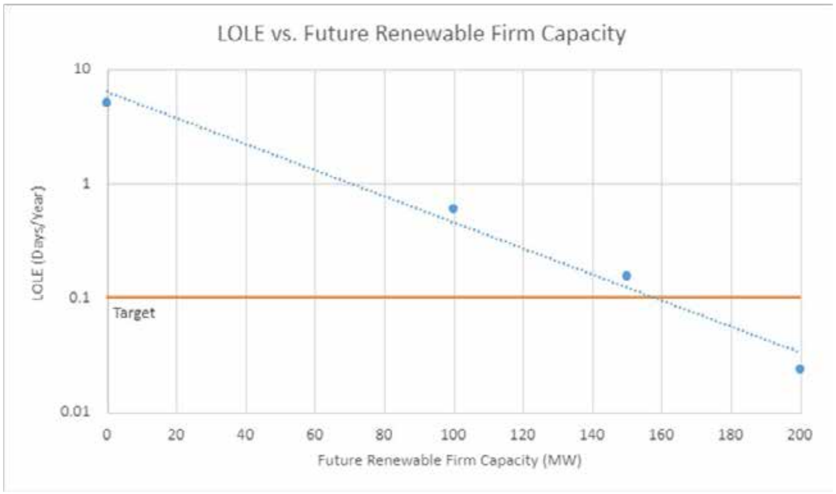

Figure C-2. O'ahu – Loss of Load vs Future Renewable Firm Capacity. 2030.

1.4.1.2 2035 Outlook

Variable Resource Curve Fit

Shown below in Figure C-3 is the relationship between the LOLE in 2035 and the amount of future hybrid solar capacity that is added after Stage 3, assuming the high-load forecast.

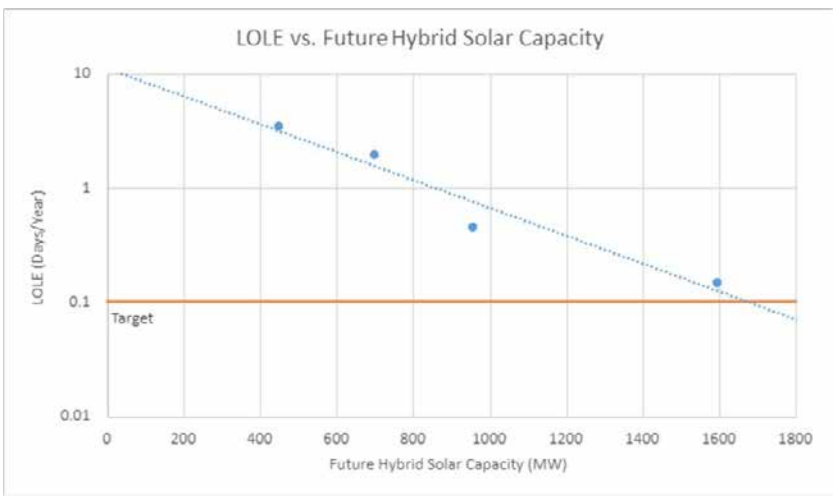

Figure C-3. O'ahu – Loss of Load vs Future Hybrid Solar Capacity. High Load Case, 2035.

Firm Resource Curve Fit

Shown below in Figure C-4 is the relationship between the LOLE in 2035 and the amount of future firm capacity that is added after Stage 3, assuming the high-load forecast.

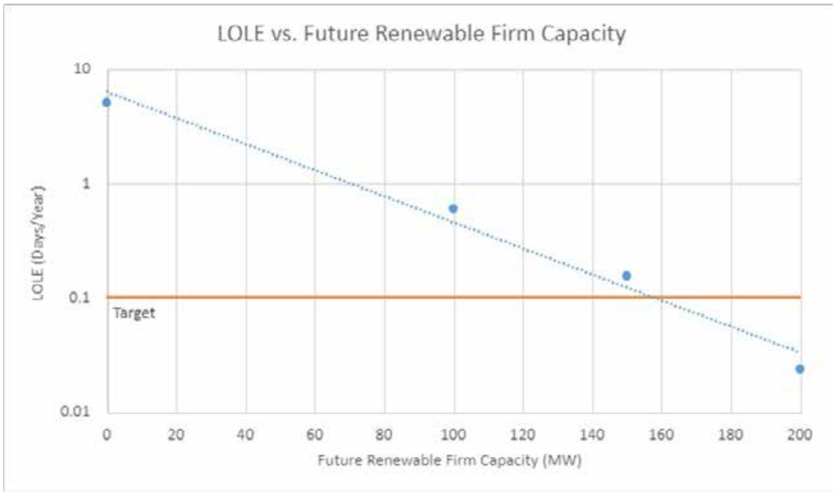

Figure C-4. O'ahu – Loss of Load vs Future Renewable Firm Capacity. High Load Case, 2035.

1.4.2 Hawai'i Island

1.4.2.1 2030 Outlook

Variable Resource Curve Fit

Shown below in Figure C-5 is the relationship between the LOLE in 2030 and the amount of future hybrid solar capacity that is added in Stage 3.

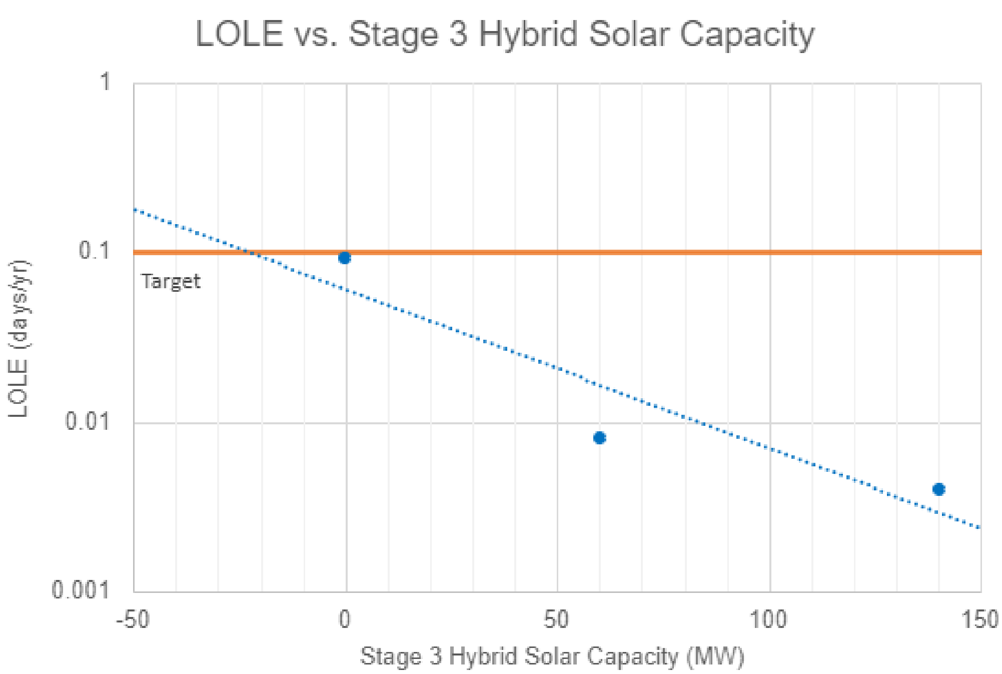

Figure C-5. Hawai'i Island – Loss of Load vs Stage 3 Hybrid Solar Capacity. Base Case, 2030.

Firm Resource Curve Fit

Shown below in Figure C-6 is the relationship between the LOLE in 2030 and the amount of firm capacity remaining on the system after Stage 3.

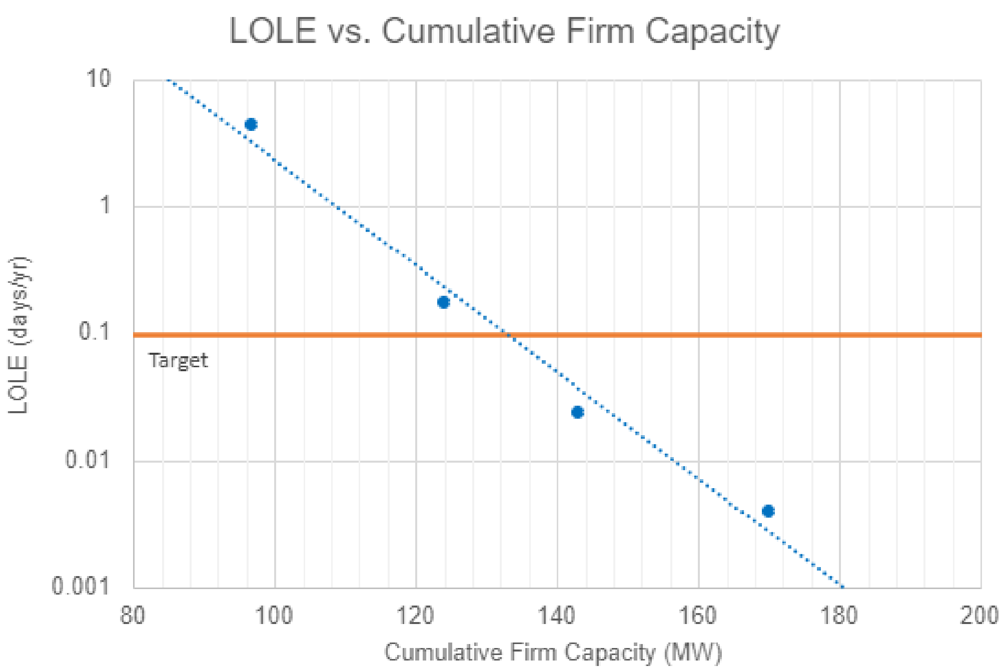

Figure C-6. Hawai'i Island – Loss of Load vs Cumulative Firm Capacity. Base Case, 2030.

1.4.2.2 2035 Outlook

Variable Resource Curve Fit

Shown below in Figure C-7 is the relationship between the LOLE in 2035 and the amount of future hybrid solar capacity that is added after Stage 3, assuming the high-load forecast.

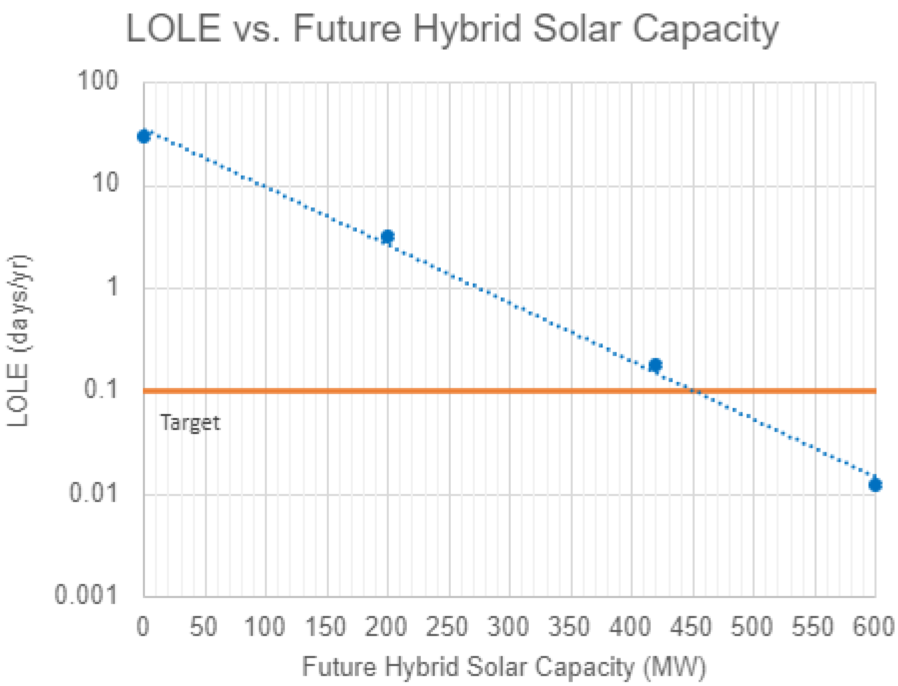

Figure C-7. Hawai'i Island – Loss of Load vs Future Hybrid Solar Capacity. High Load Case, 2035.

Firm Resource Curve Fit

Shown below in Figure C-8 is the relationship between the LOLE in 2035 and the amount of future firm capacity that is added after Stage 3, assuming the high-load forecast.

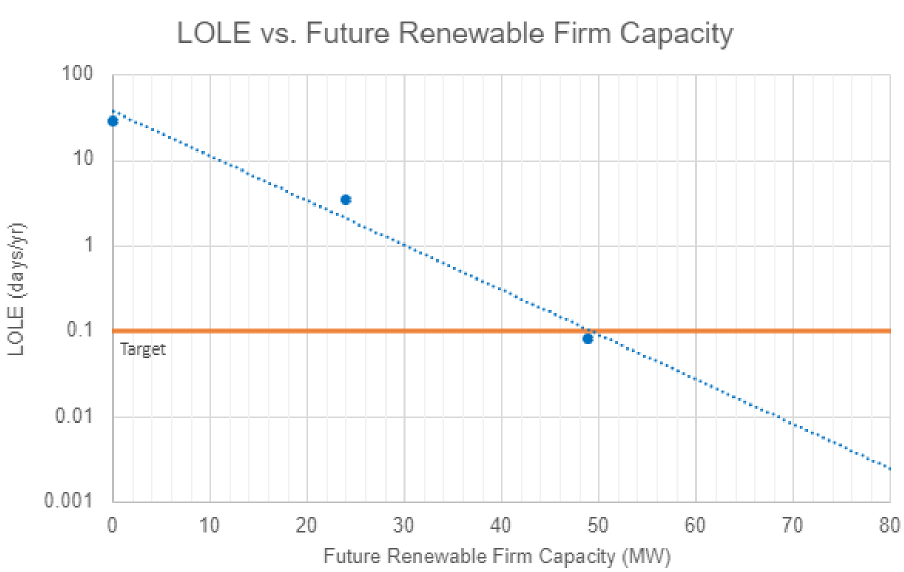

Figure C-8. Hawai'i Island – Loss of Load vs Future Renewable Firm Capacity. High Load Case, 2035.

1.4.3 Maui

1.4.3.1 2030 Outlook

Variable Resource Curve Fit

Shown below in Figure C-9 is the relationship between the LOLE in 2030 and the amount of future hybrid solar capacity that is added in Stage 3.

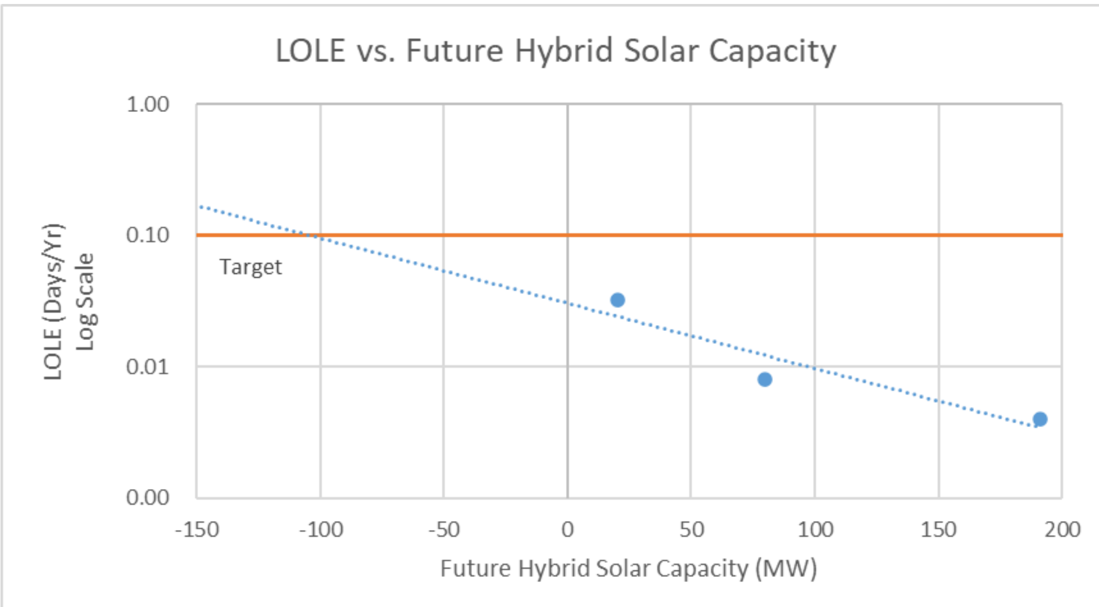

Figure C-9. Maui – Loss of Load vs Future Hybrid Solar Solar Capacity. Base Case, 2030.

Firm Resource Curve Fit

Shown below in Figure C-10 is the relationship between the LOLE in 2030 and the amount of future firm capacity that is added in Stage 3.

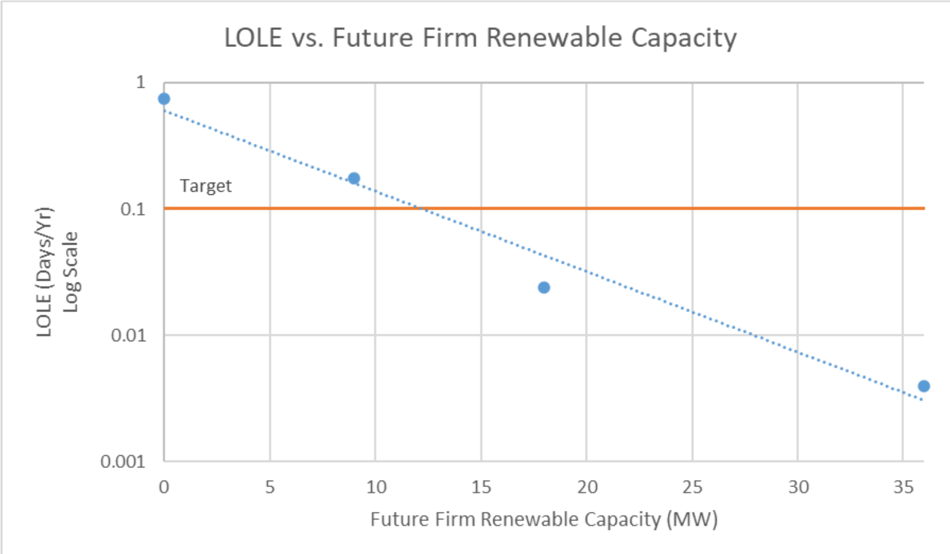

Figure C-10. Maui – Loss of Load vs Future Renewable Firm Capacity. Base Case, 2030.

1.4.3.2 2035 Outlook

Variable Resource Curve Fit

Shown below in Figure C-11 is the relationship between the LOLE in 2035 and the amount of future hybrid solar capacity that is added in Stage 3, assuming the high-load forecast.

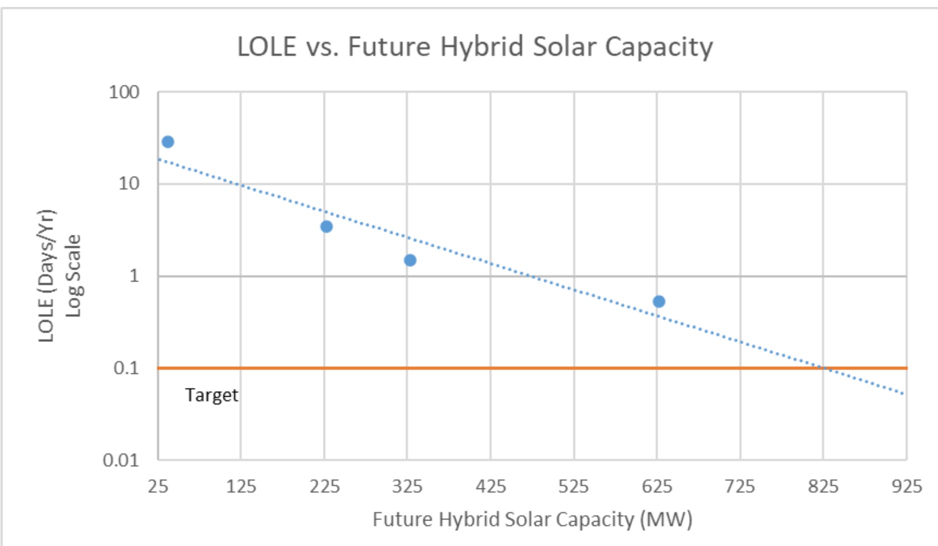

Figure C-11. Maui – Loss of Load vs Future Hybrid Solar Capacity. High Load Case, 2035.

Firm Resource Curve Fit

Shown below in Figure C-12 is the relationship between the LOLE in 2035 and the amount of future firm capacity that is added after Stage 3, assuming the high-load forecast.

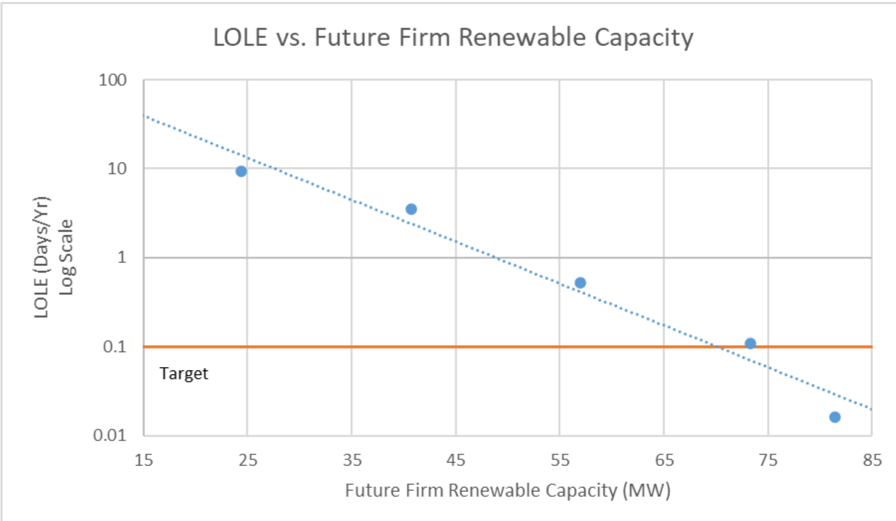

Figure C-12. Maui – Loss of Load vs Future Renewable Firm Capacity. High Load Case, 2035.

1.4.4 Moloka‘i

1.4.4.1 2030 Outlook

Variable Resource Curve Fit

Shown below in Figure C-13 is the relationship between the LOLE in 2030 and the amount of future hybrid solar capacity that is added after Stage 3.

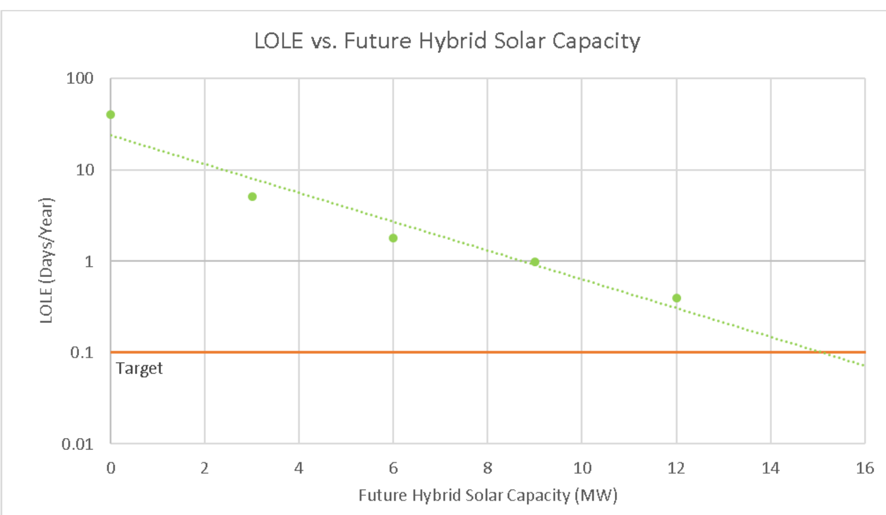

Figure C-13. Moloka'i – Loss of Load vs New Hybrid Solar Capacity. Base Load Case, 2030.

Firm Resource Curve Fit

Shown below in Figure C-14 is the relationship between the LOLE in 2030 and the amount of firm capacity remaining on the system after Stage 3.

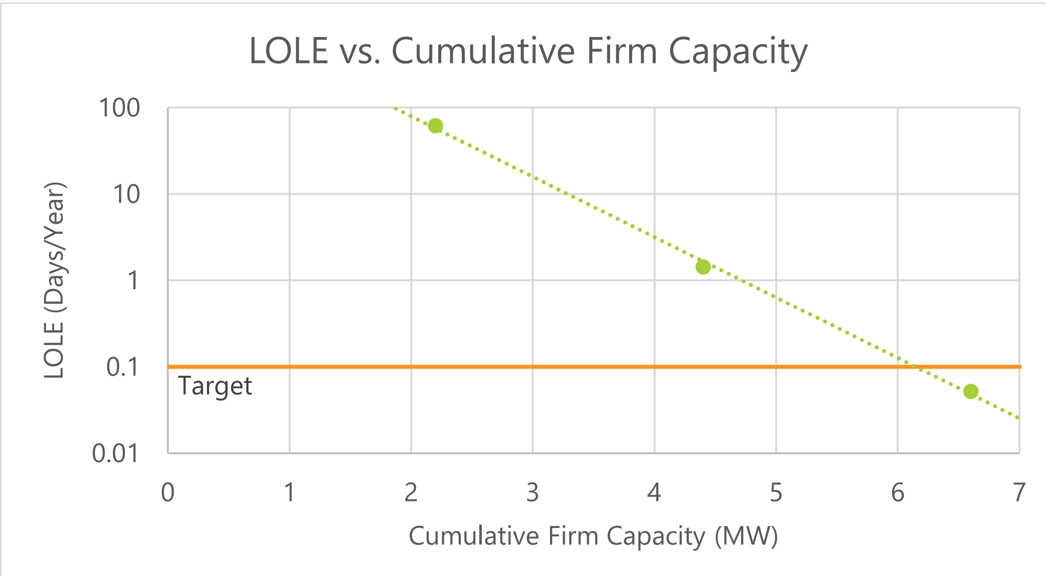

Figure C-14. Moloka'i – Loss of Load vs Future Renewable Firm Capacity. Base Case, 2030.

1.4.4.2 2035 Outlook

Variable Resource Curve Fit

Shown below in Figure C-15 is the relationship between the LOLE in 2035 and the amount of future hybrid solar capacity that is added after Stage 3, assuming the high-load forecast.

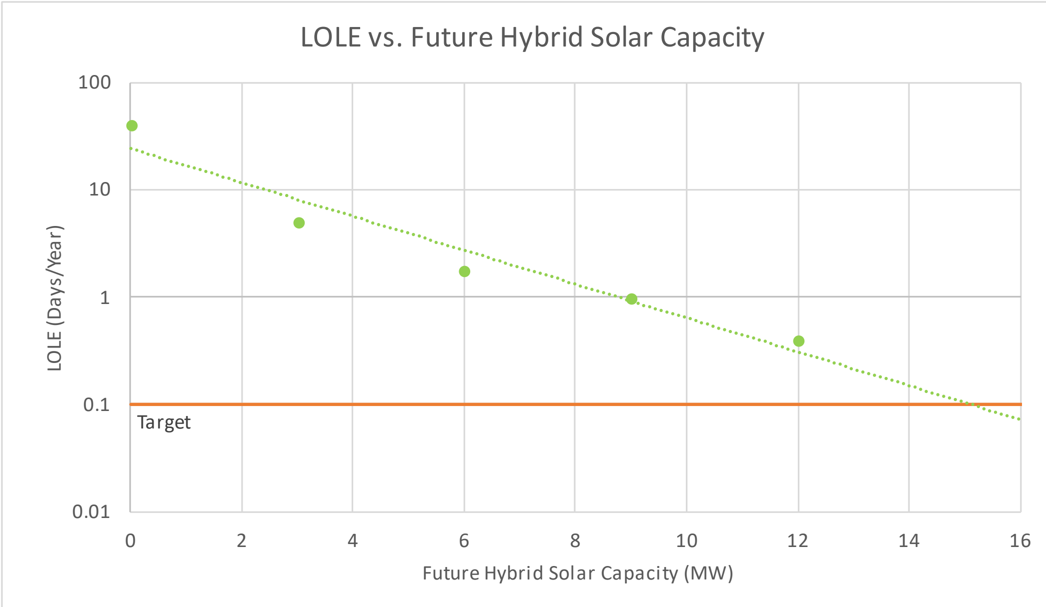

Figure C-15. Moloka'i – Loss of Load vs Future Hybrid Solar Capacity. High Load Case, 2035.

Firm Resource Curve Fit

Shown below in Figure C-16 is the relationship between the LOLE in 2035 and the amount of firm capacity remaining on the system after Stage 3, assuming the high-load forecast.

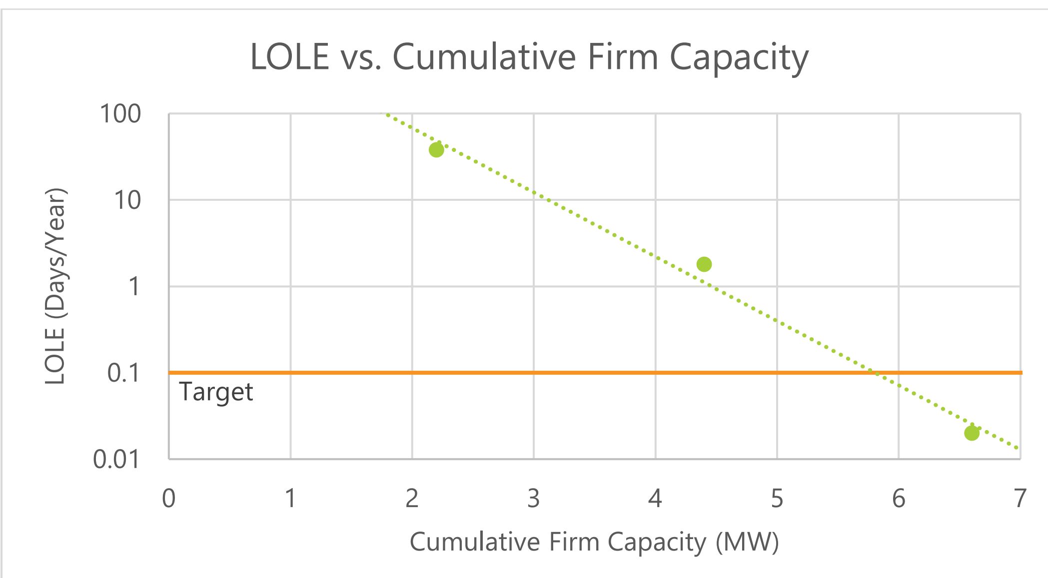

Figure C-16. Moloka'i – Loss of Load vs Future Renewable Firm Capacity. High Load Case, 2035.

1.4.5 Lānaʻi

1.4.5.1 2030 Outlook

Variable Resource Curve Fit

Shown below in Figure C-17 is the relationship between the LOLE in 2030 and the amount of future hybrid solar capacity that is added after Stage 3.

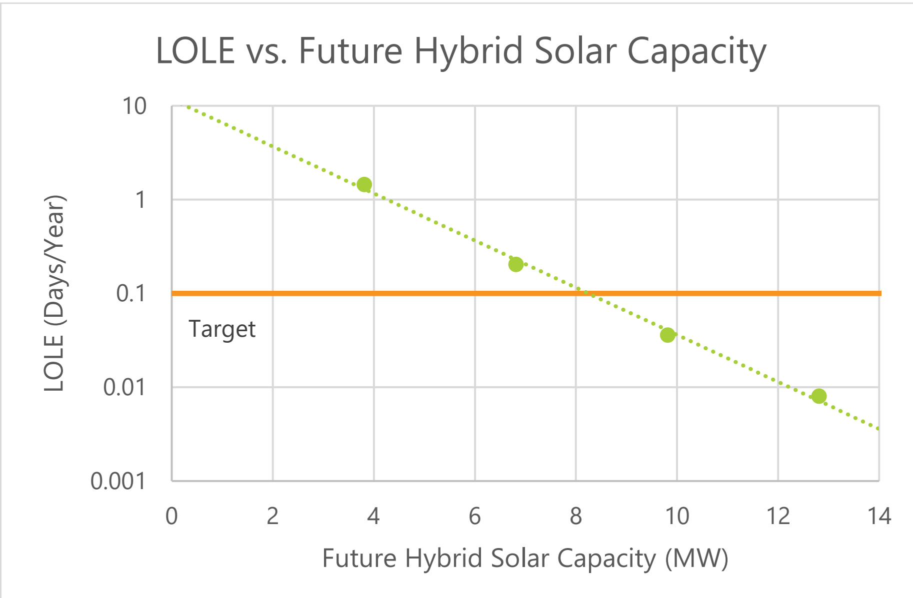

Figure C-17. Lānaʻi – Loss of Load vs New Hybrid Solar Capacity. Base Load Case, 2030.

Firm Resource Curve Fit

Shown below in Figure C-18 is the relationship between the LOLE in 2030 and the amount of firm capacity remaining on the system after Stage 3.

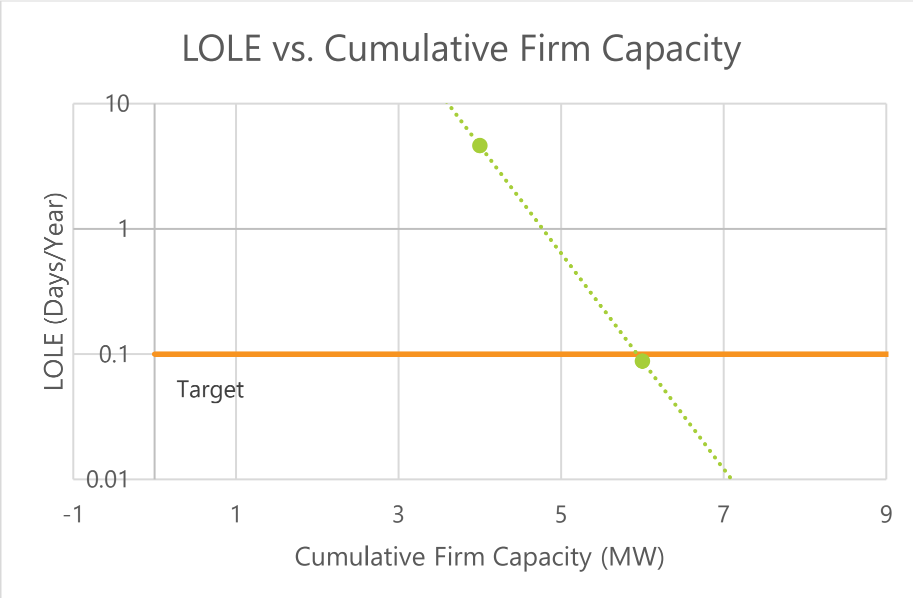

Figure C-18. Lāna'i – Loss of Load vs Future Renewable Firm Capacity. Base Case, 2030.

1.4.5.2 2035 Outlook

Variable Resource Curve Fit

Shown below in Figure C-19 is the relationship between the LOLE in 2035 and the amount of future hybrid solar capacity that is added after Stage 3, assuming the high-load forecast.

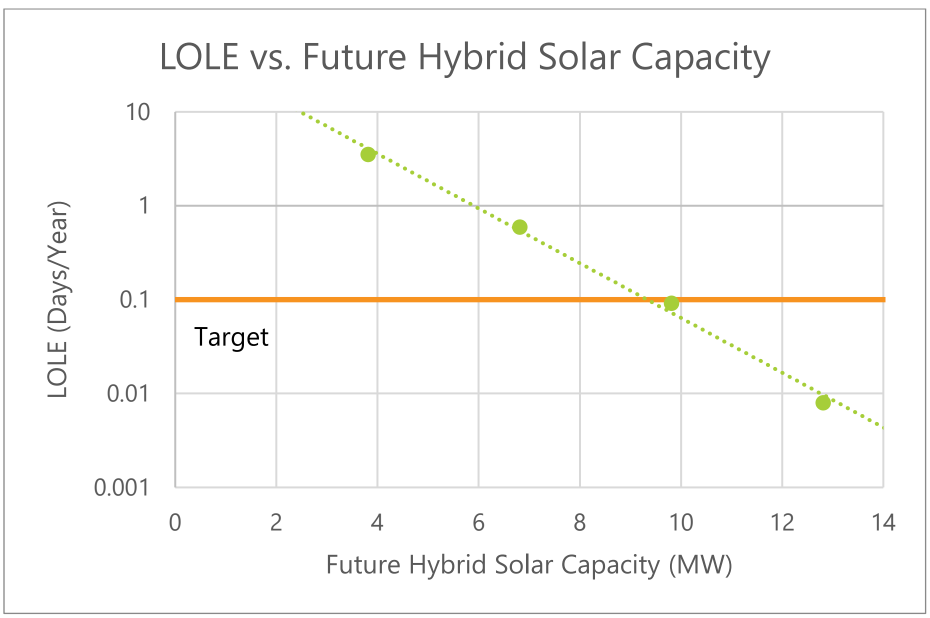

Figure C-19. Lāna'i – Loss of Load vs Future Hybrid Solar Capacity. High Load Case, 2035.

Firm Resource Curve Fit

Shown below in Figure C-20 is the relationship between the LOLE in 2035 and the amount of firm capacity remaining on the system after Stage 3, assuming the high-load forecast.

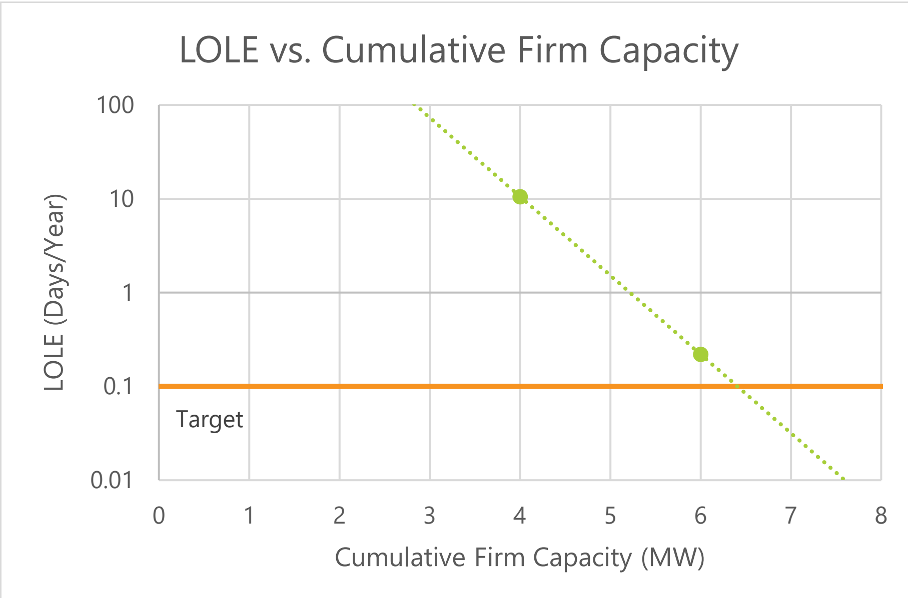

Figure C-20. Lāna'i – Loss of Load vs Future Renewable Firm Capacity. High Load Case, 2035.

1.5 Operational Statistics

The transition to 100% renewables will necessitate a change in how the thermal generators on our system operate. Scenarios with more renewable resources will use thermal generators less often. This is shown in the operational statistics provided in this section. The system operations statistics shown in this section use the resource plans that were modeled before including the transmission constraints identified in the transmission needs analysis.

1.5.1 O'ahu

1.5.1.1 System Operations – Status Quo

Shown below in Table C-14 and Table C-15 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Status Quo resource plan.

Table C-28. Oʻahu – Number of Starts for existing utility-owned thermal generators under the Status Quo resource plan.

Number of Starts	2030	2035
Kahe 1	42	35
Kahe 2	28	41
Kahe 3	38	29
Kahe 4	25	26
Kahe 5	3	4
Kahe 6	3	3
Waiau 3	Deactivated	Deactivated
Waiau 4	Deactivated	Deactivated
Waiau 5	65	71
Waiau 6	74	68
Waiau 7	29	31
Waiau 8	29	28
Waiau 9	218	223
Waiau 10	191	201
CIP CT	224	298
Airport DSG	68	112
Schofield (6 units)	1693	1810

Table C-29. Oʻahu – Capacity Factor for existing utility-owned thermal generators under the Status Quo resource plan.

Capacity Factor (%)	2030	2035
Kahe 1	62	62
Kahe 2	61	47
Kahe 3	38	57
Kahe 4	66	66
Kahe 5	7	14
Kahe 6	7	10
Waiau 3	Deactivated	Deactivated
Waiau 4	Deactivated	Deactivated
Waiau 5	42	43
Waiau 6	35	35
Waiau 7	66	65
Waiau 8	65	66
Waiau 9	24	25
Waiau 10	15	19
CIP CT	6	11
Airport DSG	7	10
Schofield (6 units)	15	21

1.5.1.2 System Operations – Base

Shown below in Table C-16 and Table C-17 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Base resource plan.

Table C-30. O‘ahu – Number of Starts for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Number of Starts	2030	2035
Kahe 1	72	Deactivated
Kahe 2	73	Deactivated
Kahe 3	49	59
Kahe 4	73	57
Kahe 5	2	3
Kahe 6	2	3
Waiau 3	Deactivated	Deactivated
Waiau 4	Deactivated	Deactivated
Waiau 5	Deactivated	Deactivated
Waiau 6	Deactivated	Deactivated
Waiau 7	Deactivated	Deactivated
Waiau 8	Deactivated	Deactivated
Waiau 9	25	52
Waiau 10	12	38
CIP CT	23	21
Airport DSG	4	2
Schofield (6 units)	220	412
300MW CT – RFP3 Firm (6 units)	9	13
208MW CC – RFP3 Firm	N/A	26

Table C-31. Oʻahu – Capacity Factor for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Capacity Factor (%)	2030	2035
Kahe 1	13	Deactivated
Kahe 2	14	Deactivated
Kahe 3	7	17
Kahe 4	19	21
Kahe 5	0	1
Kahe 6	1	2
Waiau 3	Deactivated	Deactivated
Waiau 4	Deactivated	Deactivated
Waiau 5	Deactivated	Deactivated
Waiau 6	Deactivated	Deactivated
Waiau 7	Deactivated	Deactivated
Waiau 8	Deactivated	Deactivated
Waiau 9	2	5
Waiau 10	1	3
CIP CT	0	0
Airport DSG	0	0
Schofield (6 units)	3	7
300MW CT – RFP3 Firm (6 units)	0	0
208MW CC – RFP3 Firm	N/A	2

1.5.1.3 System Operations – Land-Constrained

Shown below in Table C-18 and Table C-19 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Land-Constrained resource plan.

Table C-32. Oʻahu – Number of Starts for existing utility-owned thermal generators and future thermal generators under the Land-Constrained resource plan.

Number of Starts	2030	2035
Kahe 1	57	Deactivated
Kahe 2	33	Deactivated
Kahe 3	51	57
Kahe 4	42	66
Kahe 5	4	4
Kahe 6	4	4
Waiau 3	Deactivated	Deactivated
Waiau 4	Deactivated	Deactivated
Waiau 5	Deactivated	Deactivated
Waiau 6	Deactivated	Deactivated
Waiau 7	Deactivated	Deactivated
Waiau 8	Deactivated	Deactivated
Waiau 9	167	101
Waiau 10	168	87
Schofield (6 units)	1,274	586
CIP CT	180	85
Airport DSG	29	21
300MW CT – RFP3 Firm (6 units)	471	34
208MW CC – RFP3 Firm	N/A	89
151MW CC	N/A	161

Table C-33. Oʻahu – Capacity Factor for existing utility-owned thermal generators and future thermal generators under the Land-Constrained resource plan.

Capacity Factor	2030	2035
Kahe 1	62	Deactivated
Kahe 2	63	Deactivated
Kahe 3	38	31
Kahe 4	68	43
Kahe 5	12	7
Kahe 6	12	4
Waiau 3	Deactivated	Deactivated
Waiau 4	Deactivated	Deactivated
Waiau 5	Deactivated	Deactivated
Waiau 6	Deactivated	Deactivated
Waiau 7	Deactivated	Deactivated
Waiau 8	Deactivated	Deactivated
Waiau 9	25	12
Waiau 10	18	9
Schofield (6 units)	28	16
CIP CT	4	1
Airport DSG	0	0
300MW CT – RFP3 Firm (6 units)	4	0
208MW CC – RFP3 Firm	N/A	4
151MW CC	N/A	77

1.5.2 Hawaiʻi Island

1.5.2.1 System Operations – Status Quo

Shown below in Table C-20 and Table C-21 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Status Quo resource plan.

Table C-34. Hawaiʻi Island – Number of Starts for existing utility-owned thermal generators under the Status Quo resource plan.

Number of Starts	2030	2035
Hill5	Deactivated	Deactivated
Hill6	Deactivated	Deactivated
Kanoelehua CT1	6	5
Kanoelehua D11	11	4
Kanoelehua D15	11	7
Kanoelehua D16	4	3
Kanoelehua D17	1	3
Kapua D27	184	157

Keahole CT2	26	27
Keahole D21	2	3
Keahole D22	0	4
Keahole D23	4	4
Ouli D25	120	124
Panaewa D24	306	272
Puna CT3	168	157
Puna Steam	Deactivated	Deactivated
Punaluu D26	213	199
Waimea D12	31	18
Waimea D13	14	10
Waimea D14	50	43
Keahole CT4	346	376
Keahole CT5	380	367
Keahole ST7	303	327

Table C-35. Hawai'i Island – Capacity Factor for existing utility-owned thermal generators under the Status Quo resource plan.

Capacity Factor (%)	2030	2035
Hill5	Deactivated	Deactivated
Hill6	Deactivated	Deactivated
Kanoelehua CT1	0	0
Kanoelehua D11	0	0
Kanoelehua D15	0	0
Kanoelehua D16	0	0
Kanoelehua D17	0	0
Kapua D27	5	4
Keahole CT2	0	0
Keahole D21	0	0
Keahole D22	0	0
Keahole D23	0	0
Ouli D25	3	3
Panaewa D24	8	7
Puna CT3	2	1
Puna Steam	Standby status	Standby status
Punaluu D26	5	5
Waimea D12	0	0
Waimea D13	0	0
Waimea D14	1	1
Keahole CT4	51	50

Keahole CT5	42	44
Keahole ST7	43	44

1.5.2.2 System Operations - Base

Shown below in Table C-22 and Table C-23 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Base resource plan.

Table C-36. Hawai‘i Island – Number of Starts for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Number of Starts	2030	2035
Hill5	Deactivated	Deactivated
Hill6	Deactivated	Deactivated
Kanoelehua CT1	0	2
Kanoelehua D11	0	1
Kanoelehua D15	0	0
Kanoelehua D16	0	0
Kanoelehua D17	0	0
Kapua D27	1	4
Keahole CT2	1	1
Keahole D21	0	0
Keahole D22	0	0
Keahole D23	0	0
Ouli D25	1	4
Panaewa D24	53	69
Puna CT3	23	34
Puna Steam	Standby status	Standby status
Punaluu D26	11	13
Waimea D12	0	0
Waimea D13	0	1
Waimea D14	0	0
Keahole CT4	92	98
Keahole CT5	103	101
Keahole ST7	114	107

Table C-37. Hawai‘i Island – Capacity Factor for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Capacity Factor (%)	2030	2035
Hill5	Deactivated	Deactivated

Hill6	Deactivated	Deactivated
Kanoelehua CT1	0	0
Kanoelehua D11	0	0
Kanoelehua D15	0	0
Kanoelehua D16	0	0
Kanoelehua D17	0	0
Kapua D27	0	0
Keahole CT2	0	0
Keahole D21	0	0
Keahole D22	0	0
Keahole D23	0	0
Ouli D25	0	0
Panaewa D24	1	2
Puna CT3	0	0
Puna Steam	Standby status	Standby status
Punaluu D26	0	0
Waimea D12	0	0
Waimea D13	0	0
Waimea D14	0	0
Keahole CT4	4	5
Keahole CT5	4	4
Keahole ST7	3	4

1.5.3 Maui

1.5.3.1 System Operations – Status Quo

Shown below in Table C-24 and Table C-25 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Status Quo resource plan.

Table C-38. Maui – Number of Starts for existing utility-owned thermal generators under the Status Quo resource plan.

Number of Starts	2030	2035
Hana	0	0
Kahului1	Deactivated	Deactivated
Kahului2	Deactivated	Deactivated
Kahului3	Deactivated	Deactivated
Kahului4	Deactivated	Deactivated
Maalaea01	30	38
Maalaea02	2	9

Maalaea03	16	22
Maalaea04	85	141
Maalaea05	50	69
Maalaea06	23	36
Maalaea07	16	38
Maalaea08	35	50
Maalaea09	66	120
Maalaea10	Deactivated	Deactivated
Maalaea11	Deactivated	Deactivated
Maalaea12	Deactivated	Deactivated
Maalaea13	Deactivated	Deactivated
Maalaea14cc	304	289
Maalaea15cc	0	0
Maalaea16cc	232	269
Maalaea17cc	154	157
Maalaea18cc	47	45
Maalaea19cc	103	126
MaalaeaX1	6	15
MaalaeaX2	4	8

Table C-39. Maui – Capacity Factor for existing utility-owned thermal generators under the Status Quo resource plan.

Capacity Factor (%)	2030	2035
Hana	1	1
Kahului1	Deactivated	Deactivated
Kahului2	Deactivated	Deactivated
Kahului3	Deactivated	Deactivated
Kahului4	Deactivated	Deactivated
Maalaea01	1	2
Maalaea02	0	1
Maalaea03	1	1
Maalaea04	3	6
Maalaea05	2	2
Maalaea06	1	1
Maalaea07	0	1
Maalaea08	2	2
Maalaea09	4	7
Maalaea10	Deactivated	Deactivated
Maalaea11	Deactivated	Deactivated

Maalaea12	Deactivated	Deactivated
Maalaea13	Deactivated	Deactivated
Maalaea14cc	43	53
Maalaea15cc	0	0
Maalaea16cc	28	37
Maalaea17cc	46	51
Maalaea18cc	36	39
Maalaea19cc	37	45
MaalaeaX1	0	1
MaalaeaX2	0	0

1.5.3.2 System Operations – Base

Shown below in Table C-26 and Table C-27 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Base resource plan.

Table C-40. Maui – Number of Starts for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Number of Starts	2030	2035
9 MW RICE 1	311	249
9 MW RICE 2	305	253
Hana	0	0
Kahului1	Deactivated	Deactivated
Kahului2	Deactivated	Deactivated
Kahului3	Deactivated	Deactivated
Kahului4	Deactivated	Deactivated
Maalaea01	Deactivated	Deactivated
Maalaea02	Deactivated	Deactivated
Maalaea03	Deactivated	Deactivated
Maalaea04	Deactivated	Deactivated
Maalaea05	Deactivated	Deactivated
Maalaea06	Deactivated	Deactivated
Maalaea07	Deactivated	Deactivated
Maalaea08	Deactivated	Deactivated
Maalaea09	Deactivated	Deactivated
Maalaea10	Deactivated	Deactivated
Maalaea11	Deactivated	Deactivated
Maalaea12	Deactivated	Deactivated
Maalaea13	Deactivated	Deactivated

Maalaea14cc	164	122
Maalaea15cc	0	0
Maalaea16cc	126	83
Maalaea17cc	74	27
Maalaea18cc	0	1
Maalaea19cc	15	7
MaalaeaX1	26	27
MaalaeaX2	23	27

Table C-41. Maui – Capacity Factor for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Capacity Factor (%)	2030	2035
9 MW RICE 1	26	21
9 MW RICE 2	25	21
Hana	0	1
Kahului1	Deactivated	Deactivated
Kahului2	Deactivated	Deactivated
Kahului3	Deactivated	Deactivated
Kahului4	Deactivated	Deactivated
Maalaea01	Deactivated	Deactivated
Maalaea02	Deactivated	Deactivated
Maalaea03	Deactivated	Deactivated
Maalaea04	Deactivated	Deactivated
Maalaea05	Deactivated	Deactivated
Maalaea06	Deactivated	Deactivated
Maalaea07	Deactivated	Deactivated
Maalaea08	Deactivated	Deactivated
Maalaea09	Deactivated	Deactivated
Maalaea10	Deactivated	Deactivated
Maalaea11	Deactivated	Deactivated
Maalaea12	Deactivated	Deactivated
Maalaea13	Deactivated	Deactivated
Maalaea14cc	20	12
Maalaea15cc	0	0
Maalaea16cc	18	9
Maalaea17cc	6	2
Maalaea18cc	0	0
Maalaea19cc	1	1

MaalaeaX1	11	13
MaalaeaX2	10	11

1.5.4 Moloka'i

1.5.4.1 System Operations – Status Quo

Shown below in Table C-28 and Table C-29 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Status Quo resource plan.

Table C-42. Moloka'i – Number of Starts for existing utility-owned thermal generators under the Status Quo resource plan.

Number of Starts	2030	2035
Palaau 1	12	1
Palaau 2	91	22
Palaau 3	6	0
Palaau 4	9	4
Palaau 5	13	6
Palaau 6	568	417
Palaau 7	364	262
Palaau 8	510	466
Palaau 9	1,029	920
Palaau GT	3	1

Table C-43. Moloka'i – Capacity Factor for existing utility-owned thermal generators under the Status Quo resource plan.

Capacity Factor (%)	2030	2035
Palaau 1	0	0
Palaau 2	1	0
Palaau 3	0	0
Palaau 4	0	0
Palaau 5	0	0
Palaau 6	11	9
Palaau 7	4	3
Palaau 8	64	65
Palaau 9	46	48
Palaau GT	0	0

1.5.4.2 System Operations – Base

Shown below in Table C-30 and Table C-31 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Base resource plan.

Table C-44. Molokaʻi – Number of Starts for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Number of Starts	2030	2035
Palaau 1	0	0
Palaau 2	1	8
Palaau 3	0	0
Palaau 4	0	0
Palaau 5	4	2
Palaau 6	68	53
Palaau 7	6	2
Palaau 8	547	445
Palaau 9	126	59
Palaau GT	0	0

Table C-45. Molokaʻi – Capacity Factor for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Capacity Factor (%)	2030	2035
Palaau 1	0	0
Palaau 2	0	0
Palaau 3	0	0
Palaau 4	0	0
Palaau 5	0	0
Palaau 6	0	0
Palaau 7	0	0
Palaau 8	18	13
Palaau 9	1	0
Palaau GT	0	0

1.5.5 Lānaʻi

1.5.5.1 System Operations – Status Quo

Shown below in Table C-32 and Table C-33 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Status Quo resource plan.

Table C-46. Lānaʻi – Number of Starts for existing utility-owned thermal generators under the Status Quo resource plan.

Number of Starts	2030	2035
LL1	105	123
LL2	43	62
LL3	217	233
LL4	268	273
LL5	202	197
LL6	229	251
LL7	74	60
LL8	366	344

Table C-47. Lānaʻi – Capacity Factor for existing utility-owned thermal generators under the Status Quo resource plan.

Capacity Factor (%)	2030	2035
LL1	1	2
LL2	12	12
LL3	17	17
LL4	9	9
LL5	15	15
LL6	1	2
LL7	18	18
LL8	0	0

1.5.5.2 System Operations – Base

Shown below in Table C-34 and Table C-35 are the estimated number of starts and capacity factor, respectively, for thermal generators in 2030 and 2035 with the Base resource plan.

Table C-48. Lānaʻi – Number of Starts for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Number of Starts	2030	2035
LL1	123	115
LL2	94	95
LL3	152	139
LL4	212	216
LL5	137	126
LL6	190	164

LL7	0	1
LL8	17	18

Table C-49. Lānaʻi – Capacity Factor for existing utility-owned thermal generators and future thermal generators under the Base resource plan.

Capacity Factor (%)	2030	2035
LL1	3	2
LL2	5	4
LL3	7	7
LL4	4	4
LL5	6	6
LL6	0	0
LL7	0	0
LL8	0	0

Appendix D:

System Security Study

Hawaiian Electric

Appendix D:
System Security Study

2022 IGP System Security Study
Study Report

Prepared By: Hawaiian Electric Transmission Planning
Version: 1
Date: March 2023

EXECUTIVE SUMMARY

To accomodate future transmission grid-scale generation interconnection and system load growth according to the Company Integrated Grid Planning ("IGP") resource plans, a study which consists of both steady state and dynamic stability analyses is performed for the Company's five island systems for selected near term and long term years considering forcasted system resource and load. The study identifies system transmission level grid needs to accommodate various future plans in accordance with transmission system planning criteria, which include wire solutions (transmission network expansion and renewable energy zone enablement to identified desired potential), portfolio alternatives (limiting locational capacity to reduce the necessary transmission upgrades), and dynamic stability needs (e.g., grid-forming BESS, grid-forming STATCOM). High level cost estimates for wire solution based grid needs are also provided in the study.

With these new resource plans and impending reductions of synchronous machines on the system, the Company is truly embarking on a future of uncertainty ripe with technical challenges. As these analyses are sensitive to attributes outside of the Company's full control, (e.g., resource type, location, size, capabilities, etc.), transmission needs will need to be modified as resources are planned and added to the system. In addition, the future will heavily rely on the capabilities of grid-forming resources, which are the current latest and greatest inverter-based technologies available. Such resources are not yet operational on the Hawaiian Electric system, vary in capabilities, and will continue to evolve as much R&D related to grid-forming resources are currently on-going.

For each island system, both IGP base load scenario resource plan and high load scenario resource plan are studied. In the high load scenario resource plan, only near-term years (i.e., before 2040) are studied. Study years were selected according to major grid-scale resource commissioned year and the IGP resource plans. In each selected year, system dispatches representing annual system peak load without DER generation are identified and analyzed in the steady state analyses to determine steady state grid needs, and a system dispatch representing daytime high load and high DER generation with a short list of high-risk contingencies are analyzed to identify system dynamic stability grid needs.

A summary of findings for each island system are listed below. **These study findings are sensitive to the future grid-scale resource interconnection locations and size, as well as system load growth and system DER growth.** Therefore, it is necessary to update study when grid scale resource procurement plans are identified and finalized. Detailed study results with recommended system upgrade for each studied year are also summarized the Appendix A of this report.

O'ahu Transmission System Grid Needs Summary

In the near term, it is possible that the O'ahu transmission system will not require transmission network expansion.[1] Beyond 2040, both the interconnection of grid-scale generation projects from REZ development and system load increase will require transmission network expansion.

[1] Transmission network expansion refers to upgrades (e.g., reconductoring, new transmission lines, new switching stations, etc.) to the transmission network required to address the increase in capacity required to support addition(s) of grid-scale

It is important to continue exploring the use of grid-scale BESS, energy efficiency, demand response programs, and DER to reduce loading in the urban core to avoid overloading 138 kV overhead and underground lines. Additionally, the west side of system already has major generation stations, and further grid-scale renewable resources from REZ development located on the west side of the island will cause generation congestion on the 138 kV system for a contingency that results in losing one or multiple transmission lines. Full development of the REZ on the north shore of the island will require significant transmission network expansion around the Wahiawa 138 kV substation, which is consistent with the 2021 REZ study report.

For system stability condition in future years the system stability performance is within the planning criteria for the base scenario resource plan, and is attributed to interconnecting large amounts of PV paired with BESS with grid-forming ("GFM") control. For the land constrainted scenario resouce plan, due to the limited amount of grid-scale resources, it is likely addtional grid-scale GFM resources will be needed (i.e., retrofit of existing renewable plants or new standalone energy storage) to maintain system stability within the Oʻahu transmission planning criteria. To maintain system stability within the planning criteria, the study recommends the minimum requirement of contingency reserve provided by available MW headroom from grid-scale GFM resource at anytime should be 70% of DER generation being produced. System stability performance is highly dependent on the performance of future GFM resources, and is strongly recommended to continue to procure resources with GFM capability, provide specific control recommendations during project interconnection requirement studies, and continue through work with industry and operational experience, to improve our planning and operational expertise in best utilizing the emerging GFM technology .

Maui Transmission System Grid Needs Summary

From the study results, it is likely the new renewable resource procurements, including Stage 3 procurements, requires additional transmission system capacity. The capacity needs will likely be met by a combination of reconductoring 69 kV lines and adding new 69 kV lines and substations, the specifics of which are highly dependent on the locations of future grid-scale projects interconnection. In addition to these 69 kV requirements, overloading of Maui 69/23 kV tie transformers is identified in multiple study scenarios. This can be mitigated by solutions such as reducing the transfer, by adding grid-scale generation or energy at Maui 23 kV systems, replacing 69/23 kV tie transformers or reducing the 23 kV system load, or by increasing the tie transfer capability.

The grid-scale resources identified in the base scenario resource plan provide the system stability in accordance with the planning criteria, providing s a minimum MW headroom from GFM resources is held as contingency reserve. This minimum is a reserve equal to at least 60% of DER generation being produced . The study does not identify any addtional needs to maintain system stability within the planning criteria for this portfolio.

Hawaiʻi Island Transmission System Grid Needs Summary

The cross-island tie L6200 line and west side L8100/8900 line has risk of overloading condition in both near-term year and long-term. The cross-island tie L6200 overloading particularly for base scenarios

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resources to the network. Transmission network expansions are different from renewable energy zone enablements, which are transmission resources (e.g., new transmission lines, new switching stations, etc.) required to connect new utility-scale resources to the existing transmission network.

with a significant imbalance of energy production between the East and West sides of the island. Overloads occurred for single contingencies conditions, particularly for base case generation scenarios with a large west to east flow. This overloading could be mitigated by either reconductoring of the L6200 line to 556 AAC or resource procurements to meet requirements of a balanced generation dispatch between west side and east side of the system. The overloading of the L8100/8900 line also occurred, particularly for base scenarios involving large flow of power from east side to west side of system when L6800 line is tripped, especially when there is significant generation interconnected at Keamuku substation.

The steady state analysis for the Hawaiʻi Island system also showed that imbalance of generation production between west and east side of island would cause a significant undervoltage issue on either southern or northern part of the system. This undervoltage issue will become much worse if there is no generation resource interconnected in south Hawaiʻi Island. All these identified issues are more severe in the high load scenario resouce plan. It is recommended to have grid-scale resource (capable of providing voltage support regardless of active power generation) in south Hawaiʻi Island if voltage regulation from the Tawhiri wind plant is unavailable.

The dynamic stability study results indicate that the future grid-scale generation procurement the GFM resources assumed in the resouce plan, can maintain system stability within the planning criteria.

Molokaʻi and Lanaʻi System Grid Needs Summary

For the Molokaʻi and Lanaʻi system, a system dynamic stability review with very low and zero synchronous machine generation online was performed. Theminimum performance criteria used in the analyses for these two island systems is maintaining system stability when the system has a three-phase to ground fault with zero fault impedance for 2 seconds duration, or when the system has a single phase to ground fault with 40 ohm fault impedance for 20 seconds duration.

The Molokaʻi system study concluded that system has acceptable stability performance in the years from 2030 to 2050 when the system is powered by 100% GFM inverter based resources, but have out of synchronism issues for the existing diesel units before 2030 when the system still need rely on the existing diesel units.

For the Lanaʻi system in the scenario without the resort load, a simliar conclusion as Molokaʻi is identified – system has acceptable stability performance once the system is solely supplied by the GFM inverter-based resources, during the years from 2030 to 2050, and system will have risk of existing unit out of synchronism issues for the existing diesel units before 2029 when system still need rely on the exisitng disel units. For the scenario with the resort load and large GFM inverter based resource (with 15.8 MW capacity), the system can survive both the 2 seconds duration three-phase to ground fault and the 20 seconds high impedance single phase to ground fault.

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1. INTRODUCTION

As part of Company's Integrated Grid Planning process, Transmission Planning Department commenced with the 2022 IGP system security study in November 2022, in which both steady state and dynamic stability analyses are conducted to identify the transmission system of O'ahu, Maui and Hawai'i island and Moloka'i and Lana'i system grid needs in order to accomodate the Company's various resource plans, including both future grid-scale generation interconnection and load increase, to achieve 100% decarbonize Company's all systems by 2045.

The studied resource plans include base scenario resource plans for all five island systems, high load scenario resource plans for all five island systems, and O'ahu land constrained resource plan. For each island system, several study years are selected according to the resource plan. Steady state analyses, performed in PSS/E, is conducted for each selected year. Considering future advance grid technology developments' impact on grid dynamic stability, the dynamic stability analyses are only performed for the selected near-term years (i.e., before 2040) in PSCAD/EMTDC for high-risk system dispatches and high-risk contingencies.

Past studies conducted in recent years are used as important inputs for this study. The past studies are Hawaiian Electric Transmission Renewable Energy Zone ("REZ") Study[2], Hawaiian Electric Island-Wide PSCAD Studies (Stage 2 System Impact Study)[3], 2021 system stability studies[4], Hawai'i Island RFP Stage 3 grid needs assessment[5], and RFP Stage 3 injection study for O'ahu system, Maui system and Hawai'i Island[6]. From these past studies, general information regarding system available capacity for future generation interconnection is obtained. These past studies inform selection of the high-risk system dispatches and high-risk contingencies for the 2022 IGP system security study dynamic stability analyses.

This study assesses system capacity and stability needs. Based on these needs, traditional wire solutions and non-wire solutions for certain wire solutions are identified and provided to resource expansion and production simulation to determine grid needs cost.

[2] Available at https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/solution_evaluation_and_optimization/20211105_transmission_renewable_energy_zone_study.pdf

[3] Available at https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/stakeholder_technical/20210630_electranix_report.pdf

[4] See Dkt. No. 2018-0165, filed Feb. 13, 2023

[5] See Dkt. No. 2017-0352, filed July 15, 2021

[6] See Dkt. No. 2017-0352 - Hawaii Island injection study filed Nov. 2, 2022, Oahu and Maui injection studies filed Dec. 22, 2022, and Maui injection update filed March 16, 2023.

In this report, section 2 describes the studied resource plan, section 3 summarizes study methodology, and section 4 lists study results. In section 5, feedback from the Technical Advisory Panel, with Company's review, is provided.

2. STUDIED SYSTEM RESOURCE PLANS

From Company's resource planning study, different resource plans are provided for this study. A high-level description of the provided resource plans is shown in the Figure 1. For all five islands transmission systems, both base scenario resource plans and high load resource plans are studied; additionally, the land constrained resource plan is also studied for O'ahu transmission system. In every resource plan, grid-scale resource retirement, new resources (both grid-scale and DER) adding into system, as well as system load forecast are provided from the resource planning results and hourly production simulation profiles, from 2024 to 2050. The study is performed from the year of the RFP Stage 3 projects guaranteed commercial operation date ("GCOD") to 2050.

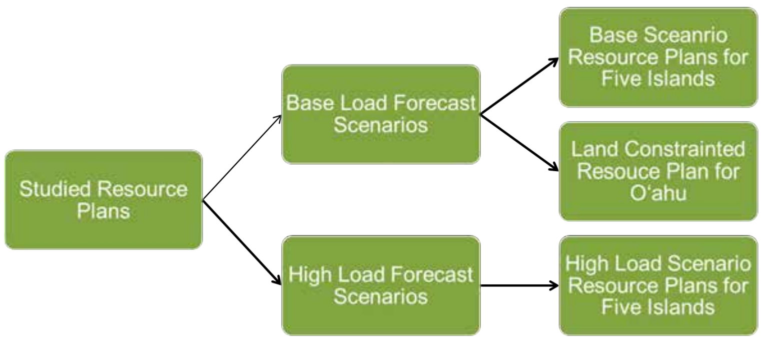


Figure 1 High-level description of the studied resource plans

2.1. Oʻahu Resource Plans

Three Oʻahu resource plans are analyzed in this study – Oʻahu base scenario resource plan, Oʻahu land constrained resource plan, and Oʻahu high load resource plan. In the base resource plan, Renewable Energy Zone ("REZ") development is included. Hence, large amounts of grid-scale resource interconnection is described in the base resource plan. The land constrained resource plan has the same system load forecast as the base resource plan; however, grid-scale generation from the REZ development is reduced and replaced by DER generation from distribution side. Therefore, after RFP Stage 3 procurement, grid-scale generation interconnection described in the land constrained resource plan is less than that in the base resource plan. In the high load resource plan, higher system load forecast is constructed in the resource plan. And only near term years in this resource plan is analyzed in this study. All three resource plans are summarized in following figures. For the high load resource plan, only near-term years are selected for the study.

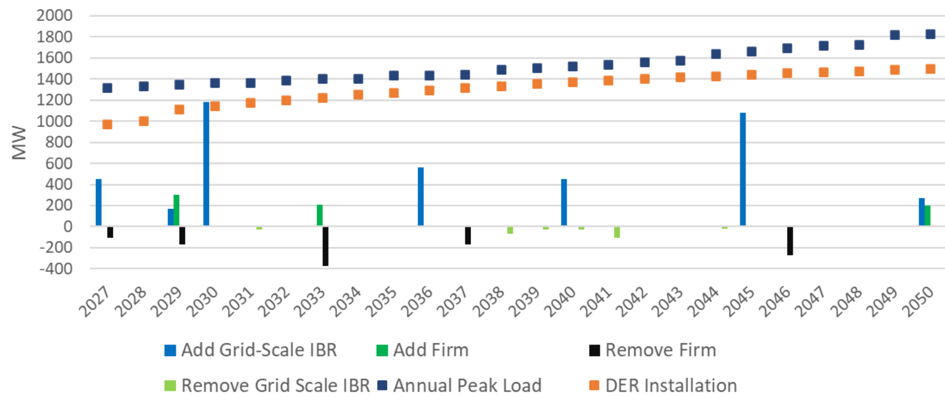


Figure 2 O‘ahu base scenario resource plan

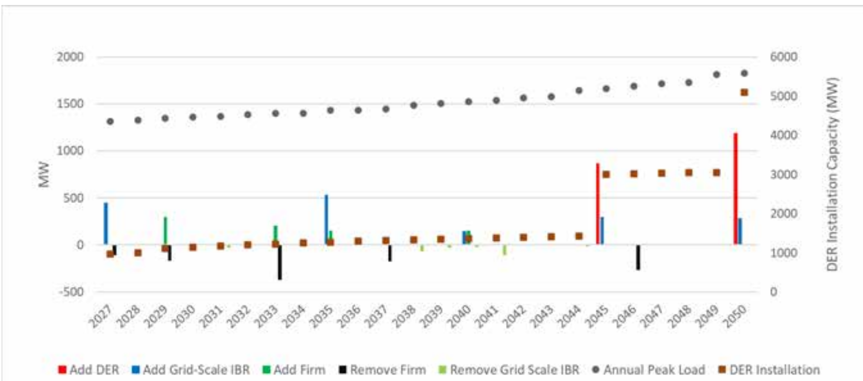


Figure 3 O‘ahu land constrained scenario resource plan

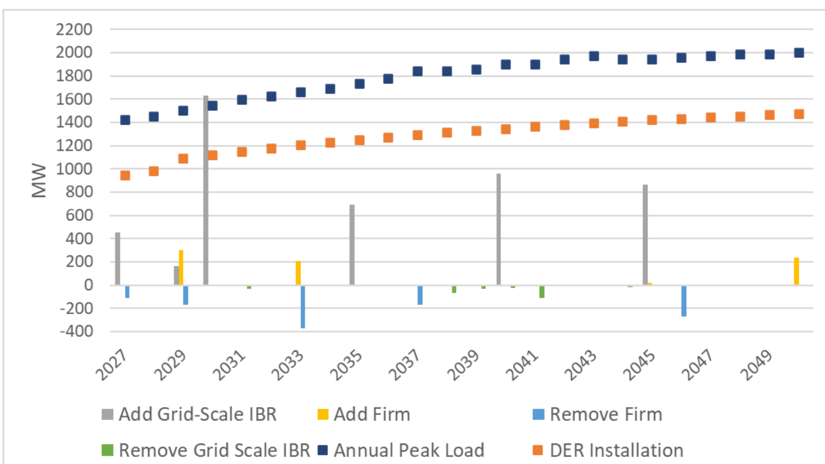


Figure 4 O‘ahu high load scenario resource plan

Based on the grid-scale generation projects online time, the following years are selected for the study.

- O‘ahu system base scenario resource plan and land contrained scenario resource plan – 2030, 2035, 2046 and 2050.
- O‘ahu system high load scenario resource plan – 2030 and 2035.

2.2. Maui Resource Plans

Two Maui resource plans are analyzed in this study – Maui base scenario resource plan and high load scenario resource plan. Both resource plans have grid-scale generation interconnections for future years. The high load resource plan has faster system load increase than the base scenario resource plan. High level descriptions for the two studied resource plans are shown in follwing figures.

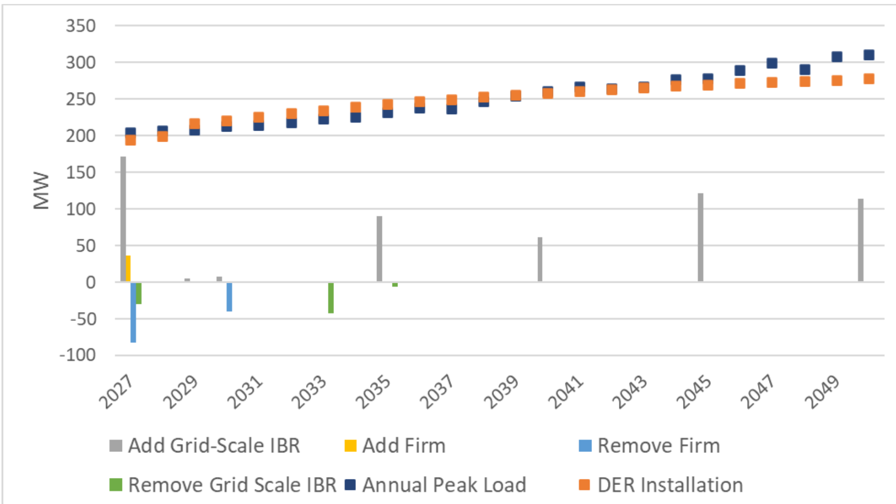


Figure 5 Maui base scenario resource plan

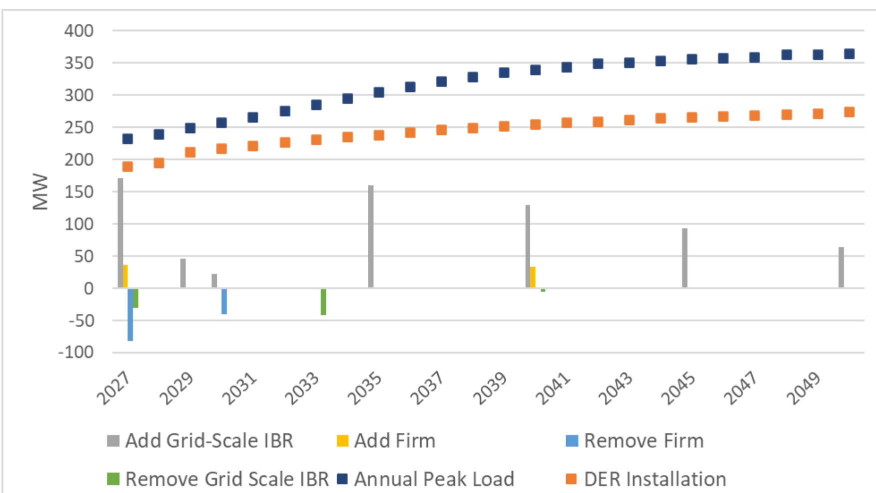


Figure 6 Maui high load scenario resource plan

Based on the grid-scale generation projects online time, following years are selected for the study.

- Maui system base scenario resource plan – 2027, 2035, 2041, 2045 and 2050.
- Maui system high load scenario resource plan – 2027, 2030 and 2035.

2.3. Hawaiʻi Island Resource Plans

Similiar as Maui system, two resource plans are analyzed for Hawaiʻi island system in this study – Hawaiʻi island base scenario resource plan and high load scenario resource plan. Both resource plans have grid-scale generation interconnections for future years. The high load resource plan has faster system load increase than the base scenario resource plan. High level descriptions for the two studied resource plans are shown in follwing figures.

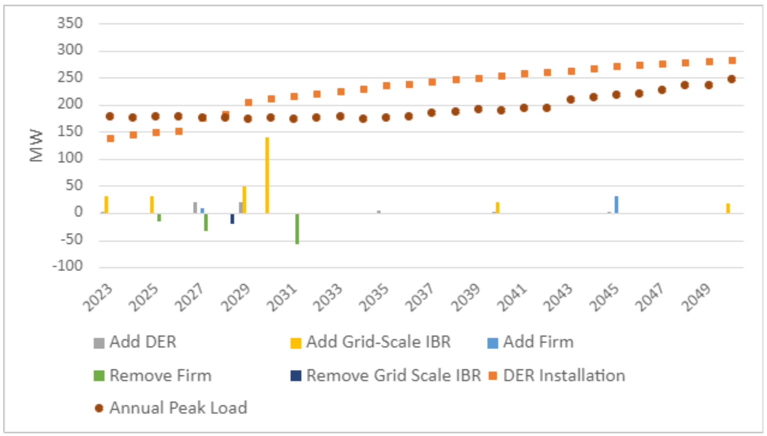


Figure 7 Hawaiʻi island base scenario resource plan

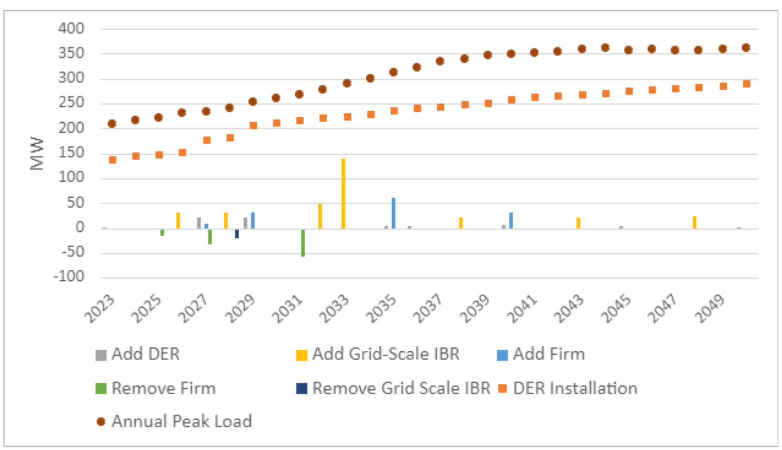


Figure 8 Hawaiʻi island high load scenario resource plan

Based on the grid-scale generaiton projects online time, following years are selecte for the study.

- Hawaiʻi island system base scenario resource plan – 2032 and 2050.
- Hawaiʻi island system high load scenario resource plan – 2032 and 2036.

2.4. Molokaʻi and Lanaʻi Resource Plans

Molokaʻi and Lanaʻi are much smaller systems for which Company which, due to the smaller size, follow different reliability criteria than the other islands. Grid-scale generation projects must be interconnected through the system 12 kV substation bus. Both base scenario resource plans and high load scenario resource plans are studied for these two systems. Addtionally, without resort load resource plan is also studied for the Lanaʻi system. The studied Molokaʻi and Lanaʻi resource plans are described in the Table 1 .

Table 1 Molokaʻi System Base and High Load Scenario Resource Plans

Year	Resource Added to System in Base/High Load Scenario Resource Plan
Pre-2029	CBRE Phase 1 – 0.25 MW PV CBRE Phase 2 – 2.75 MW 11 MWh PV-BESS
2029	0.4 MW/0.7 MWh SA BESS 3 MW/3MWh PV-BESS
2030	0.1 MW/0.3 MWh SA BESS 8.5 MW/29.7MWh PV-BESS
2035	0.1 MW/0.1 MWh SA BESS 2.3 MW/1.9 MWh PV-BESS
2040	0.1 MW/0.1 MWh SA BESS 1.1 MW/2.8 MWh PV-BESS
2045	0.1 MW/0.2 MWh SA BESS 2.6 MW/6.9 MWh PV-BESS
2050	0.1 MW/0.2 MWh SA BESS 1.2 MW/2.9 MWh PV-BESS

Table 2 Lanaʻi System Base and High Load Scenario Resource Plans, and without Resort Load Resource Plan

Year	With Resort Load Base/High Load Scenario Resource Plan	Without Resort Load Resource Plan
Pre-2029	RFP Phase 2 – 15.8 MW/63.2 MWh PV-BESS	No new resource
2029	0.6 MW/1.1 MWh SA BESS 0.3 MW/0.3MWh PV-BESS	0.7 MW/1.3 MWh SA BESS 3.9 MW/3.9 MWh PV-BESS
2030	4.9MW/4.9 MWh PV-BESS	6.4 MW/24.5 MWh PV-BESS
2035	0.3 MW/0.3 MWh PV-BESS	0.4 MW/1.4 MWh PV-BESS
2040	0.3 MW/0.3 MWh PV-BES	0.3 MW/0.9 MWh PV-BESS
2045	0.2 MW/0.3 MWh SA BESS 1.5 MW/1.5 MWh PV-BESS	0.1 MW/0.1 MWh SA BESS 1.1 MW/2 MWh PV-BESS
2050	0.1 MW/0.1 MWh SA BESS 0.9 MW/0.9 MWh PV-BESS	0 MW/0.2 MWh SA BESS 0.5 MW/1.1 MWh PV-BESS

Years that are selected in each scenario for the study are:

- Molokaʻi system base scenario resource plan – 2029, 2030 and 2050.
- Molokaʻi system high load scenario resource plan – 2029, 2030 and 2050
- Lanaʻi system base scenario resource plan – 2029 and 2050.
- Lanaʻi system high load scenario resource plan – 2029 and 2050
- Lanaʻi system No Resort scenario resource plan – 2029, 2030 and 2050

3. STUDY METHODOLOGY

3.1. Past Studies

In recent years, Transmission Planning Department has performed several studies that addressed both near term and long term plans. These studies provide important inputs to the the 2022 IGP System Security Study, such as system available injection capacity, system stability related high-risk generation dispatch and high-risk contingencies, and importance of grid-forming ("GFM") resource. A brief summary of the referenced past studies is provided in this subsection.

3.1.1 Hawaiian Electric Transmission Renewable Energy Zone ("REZ") Study

In November 2021, Company released the first version of transmission REZ study report. In this report, high level cost estimate for both REZ enablment (e.g., interconnection facilities) and transmission network expansions are identified, based on assumptions of resource procurement targets by 2040 and a fix rate of system load increase, for O'ahu, Maui and Hawai'i island systems. The cost per MW REZ enablement for each studied interconnection substation is used in the 2022 IGP System Security Study for the REZ enablment cost esitmate with new resource plan and system load forecast. Also, several transmission networks expansion solutions identified in the 2021 REZ study are used in the 2022 IGP System Security Study.

3.1.2 Hawaiian Electric Island-Wide PSCAD Studies (Stage 2 System Impact Study)

In June 2021, Company released a report regarding system-wide dynamic stability condition assessment for post RFP Stage 2 system conditions. This is the first island-wide system stabilty study performed in electromagnetic transient ("EMT") simulation enviroment via a tool called PSCAD/EMTDC for O'ahu, Maui and Hawai'i island system. The dynamic stability study was performed for a few selected generation dispatch with a list of high-risk contingency. The report summerizes system stability performance issue caused by the high penetration of inverter-based resource ("IBR") and distributed energy resources ("DER") and the displacement of synchronou machine-based resource after the RFP Stage 2 projects online. From the study, it is also recommended that Company should continue to require and implement GFM technology in all battery energy storage system ("BESS") devices for future projects and continue to perform EMT study to evaluate future system stability risks.

3.1.3 2021 System Stability Study

A more comprehensive system stability study for near-term years before the RFP Stage 3 projects online was conducted for all five islands from summer of 2021 to end of 2022. The study looked into more stability related topics than what was studied in the Stage 2 System Impact Study. Both PSS/E and PSCAD were used as simulation tool; however, as part of study results, it is confirmed that at current stage, PSS/E has great limitation to be used for performing dynamic stability study for systems with high IBR and DER penetration and for GFM resource modeling and simulation. Important study recommendations that are used in the 2022 IGP System Security Study are:

- Company should continue to require GFM control for generation paried with BESS component and procure enough GFM resource to make sure system stability performance within planning criteria.

- DER momentary cessation poses high risk to system stability. Daytime peak load high DER generation with low wind generation dispatch currently poses the highest risk on syste stability.
- Existing O'ahu standalone solar grid-scale generation projects have fault ride-through issue, which cannot recovery pre-event active power generation within 1 second after clearing fault. According to the historical performance recording, these plants may take more than 20 seconds to recover 90% of the pre-event generation. It is recommend to manual trip these plants during the dynamic stability study simulation.
- O'ahu, Maui and Hawai'i Island high-risk contingency list is generated, which will be used for future dynamic stability studies.
- Substation interconnected GFM resource is critical for Moloka'i and Lana'i system stability once the existing diesel units are retired.
- System critical clearing times ("CCT") should be no longer than 24 cycles.

The study also concludes qualitive way to describe impacts from various resources on system stability performance, which is shown as Figure 9.

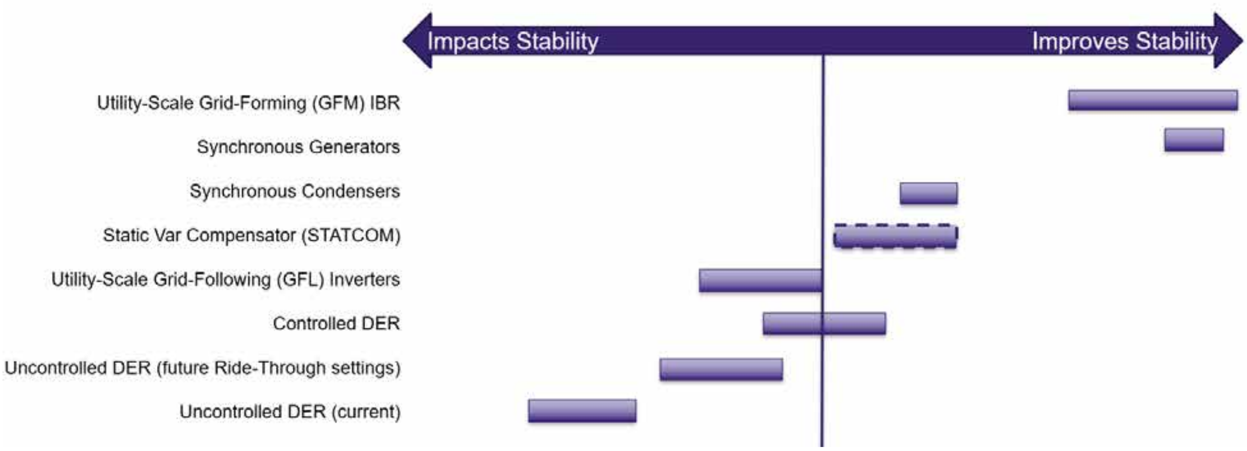


Figure 9 Relative range of system stability contribution by resource type

3.1.4 Waena BESS Stability Study

In 2022, per Commission's request, a dynamic stability study was conducted in PSCAD/EMTDC to evaluate impacts from various MW sizes of Waena BESS project on Maui system dynamic stability. The study results indicates that Maui system could have excessive under-frequency load shedding ("UFLS") or even system collapse if the RFP Stage 2 projects power purchase agreement ("PPA") or applications are not approved, or project withdrawal happens.

3.1.5 Hawai'i Island RFP Stage 3 Grid Needs Assessment

In July 2021, per Commission's request, a high-level grid needs assessment was performed for Hawai'i island system in order to allow existing system resource retirement and RFP Stage 3 resource interconnected into the Hawai'i island transmission system. From the high-level analysis based on the proposed RFP Stage 3 resource plans, the near-term steady-state concerns are identified as follows:

- Immediate voltage support needs in East Hawai'i island caused by removal of existing generating units.

- Potential voltage support needs in South Hawaii caused by the absence of nearby local generation and dynamic voltage regulation (i.e., Tawhiri/Apollo wind plant).
- Potential future thermal overloads in the Waikoloa area if additional future generation is connected near the area.

In addition to the needs identified in the system security assessment and the high-level steady-state analysis, system security study needs will need to be assessed after RFP Stage 3 projects are selected. Also, the RFP Stage 3 resources should be procured in strategic locations to maintain past levels of resource locational diversity and provide a balanced generation portfolio supplied from different areas of the island to avoid planning criteria violations such as voltage violations or potential cross-island line overloads.

3.1.6 RFP Stage 3 injection capacity studies

In 2022, an injection capacity study was performed for O'ahu, Maui and Hawai'i island separately, which is part of Company's RFP Stage 3 activities. In the injection capacity studies, locations (i.e., transmission lines and substations) with available injection capacity are identified to help project bidders prepare their proposals. In the 2022 IGP System Security Study, it is assumed that future grid-scale generation procured in the near-term years take the location with available injection capacity first, and later years' generation interconnections rely on Company's transmission system expansion.

3.2. Important Assumptions and Scope Limitations

For future grid-scale generation interconnection, the study assumes current interconnection sites with avaiable grid capacity will be used first. Also, awarded projects that were withdrew from the RFP Stage 2 procurement are assumed to come back to system during the RFP Stage 3 procurement. Once all existing capacity is occupied, future interconnection sites will be selected based on the renewable potential, community feedback and cost of system upgrades. It is possible that actual project interconnections in future procurements are at different locations. Different interconnection locations can drive very different transmisson system ` capacity upgrade needs.

In each studied case, load is allocated in proportion to existing substation loads, aggregated at transmission substations, instead of using spatial load forecast. In reality, load may increase at different rates across the system.

To identify Company's transmission system needs for accommodating future grid-scale generation projects as well as system load per the load forecast, DER generation is not considered in the steady state analyses.

Dynamic stability study is senstive to advanced grid technology development. Therefore, only near term year scenarios (i.e., before 2040) are analyzed for system dynamic stability. New grid technology, on both generation side and customer load side, can possibly drive different grid needs regarding stability. Also, detailed control tunning for future grid-scale generation projects are not included in the scope of this study, which will be addressed by future generation projects' interconnection requirements study.

In this study systems with very high penetration of inverter-based resource ("IBR") and distributed energy resource ("DER") are studied. For example, in the Maui dynamic study, all studied scenarios represent 100% IBR and DER system scenarios. Currently, industry has very limited operational experience for a system with 100% IBR and DER. Both study scope and models used for the dynamic stability study have limitations. As such, there may be other stability risks that are unknown currently, and hence, not included in the current study, or represented in current models used for this study.

Modeling

In this study, PSS/E is used for steady state analyses which determines studied system networks expansion needs and steady state voltage regulation needs; PSCAD/EMTDC is used for dynamic stability analyses which determine system dynamic stability needs, such as minimum requirement of GFM resource in a system.

For the steady state analyses, all the PSS/E models which represent studied future year scenarios are developed based on 2021 benchmarked system power flow cases. Future system demand is modeled by scaling up load in a fixed rate across the system to match the forecast system total demand. Future system DER is modeled in a similar way. Future grid-scale generation projects are modeled in an aggregated way without a detailed modeling for in-plant feeders but one aggregated generation unit with a properly sized generator step-up transformer ("GSU").

The PSCAD/EMTDC models are built based on a model conversion process of converting a PSS/E model into a PSCAD/EMTDC model. This process is performed in a commercially available software called E-Tran. All the future PV paired with BESS generation projects are represented by the same inverter model which were provided by an inverter OEM and assumed to have GFM control. Because of the limited time frame of performing this study, sensitivity study of using different inverter models from different inverter OEM for future projects is not performed.

Model preparation and related assumptions are the same as what was used in the 2021 system stability study, with one addition – P4 type DER. Per Company's Customer Energy Resource team, for all DER inverters that are online later than October 1st, 2022, inverter ride-through capability should comply with Company's Utility Required Profile ("URP"). According to this rule, a new type of DER, P4 DER, is created to represent the DER that are online later than October 1st, 2022, for transmission planning study purpose. The P4 type DER ride-through and trip settings are listed in Table 3, Table 4, and Table 5.

Table 3 P4 DER Voltage Ride-Through and Trip Settings Included in the PSCAD Models

Remain Connected (pu)	Over-Voltage		Under-Voltage	
	Voltage (pu)	Delay (s)	Voltage (pu)	Delay (s)
0.1 < V > 1.1	V>1.1 V>1.2	13 0.16	V<0.88 V<0.1	21 2

Table 4 P4 DER Frequency Ride-Through and Trip Settings Included in the PSCAD Models

Remain Connected (Hz)	Over-Frequency		Under-Frequency	
	Frequency (Hz)	Delay (s)	Frequency (Hz)	Delay (s)
0.1 < V > 1.1	f>63 f>65	180 0.16	f<57 f<50	180 0.16

Table 5 P4 DER Momentary Cessation Assumptions

UV Block Limit (Vmc, PU)	UV Unblock Limit (Vmc, PU)	Recovery Delay (Δtsr, s)	Recovery Ramp Rate (during Δtrr, pu/s)
0.5	0.5	0.033	2.2

3.3. Study Generation Dispatches

From the resource plans and production simulation results of the selected study years, various generation dispatches are generated for the study. Every selected generation dispatch represents a snapshot of system operated under certain degree of stress, which is used to identify if system has enough capacity or stability resources in the studied situation.

For steady state analysis, the way of creating study dispatch is demonstrated by using Maui system with addition and retirement of resource in 2035 according to the base scenario resource plan. A simplified system one-line diagram with REZ is shown in Figure 10. In the study for the 2035, system load, forecasted for 2036 as 237 MW, is used for the study.

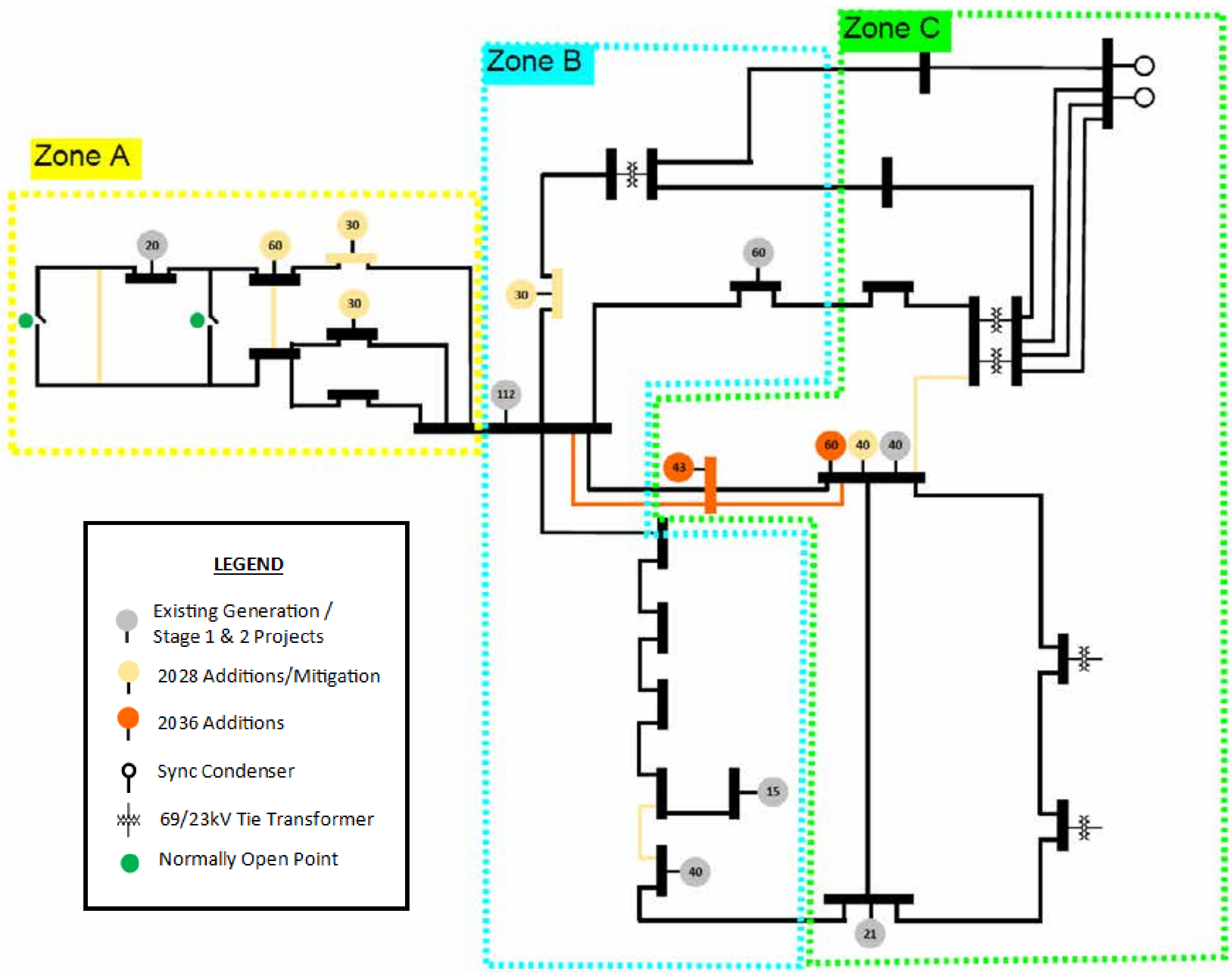


Figure 10 Simplified Maui system single line diagram with future resources and REZ

It can be found that system load can be supplied by generation from one REZ (i.e., Zone B), combination of two different zones (i.e., Zone A+B, Zone B+C and Zone A+C), or all three zones. Therefore, system generation dispatches are created to cover those combinations of zones for performing steady state analyses. The studied system generation dispatches for the 2035 of Maui base resource plan are summarized in Table 6. All studied system generation dispatches are listed in Section 4 study results.

Table 6 System Generation Dispatches Studied for Maui Base Scenario Resource Plan, Year 2035

Max Rating		Zone A	Zone B*	Zone C	Zone A+C	Zone B+C	All Zones
Zone A	140	140	0	0	118	0	77.5
Zone B	257	97.3	237.3	33.3	0	116.3	85.5
Zone C	204	0	0	204	119.3	121	74.3
Total Load	237.3	237.3	237.3	237.3	237.3	237.3	237.3

For dynamic stability study, since previous studies indicate daytime peak load high DER low wind generation dispatch poses the highest risk toward system stability and island wide PSCAD simulation is extremely time consuming, the study will only focus on a few selected scenarios of daytime peak load, high DER, with low wind generation dispatch. The process of identifying system load, DER generation and other grid-scale generation in this studied dispatch is the same as the process described in the 2021 system stability study report. All studied system generation dispatches for the dynamic stability study are described in Section 4 as well.

3.4. Study Criteria

Company’s transmission planning criteria of O’ahu, Maui and Hawai’i island are used as primary study criteria. For Molokaʻi and Lanaʻi systems, smaintaining system dynamic stability for a three-phase bolted fault with 2 seconds duration and for a single-phase to ground fault with 40 ohm fault impedance and 20 seconds duration is used as the criteria to evlaluate system dynamic stability condition.

4. STUDY RESULTS

In this section, both steady state analyses and dynamic stability analyses for each selected study year in each resource plan are presented. For the scenarios with planning criteria violation, mitigation solutions are also discussed.

4.1. Oʻahu System Study Results

4.1.1 Steady state analyses

Base scenario resource plan, year 2030

Study descriptions

According to the base scenario resource plan, by 2030, the Oʻahu system will have new generation from Stage 3 Oʻahu RFP procurement and initial REZ development. Specifically, there will be 450 MW renewable dispatch generation ("RDG") and 300 MW firm generation procured through the Stage 3 Oʻahu RFP activity, 510 MW RDG development from the REZ zone 1, 2 and 7, and 543 MW RDG development from the REZ zone 3, 4, 5 and 6. The grid-scale generation projects from the REZ development are assumed interconnected at various Oʻahu 138 kV substations and 46 kV substations, same as assumed in the 2021 REZ study. Specifically, REZ zone 1 interconnection location is Hoʻohana substation, REZ zone 2 interconnection location is Ewa Nui substation, REZ zone 3 interconnection location is Kahe substation, REZ zone 4 interconnection location is Waiau substation, REZ zone 5 interconnection location is Halawa substation, REZ zone 6 and 7 interconnection location is Koʻolau substation, and REZ zone 8 interconnection location is Wahiawa substation. The REZ development is expected to have both solar and wind generation. In this timeframe, it is also planned to remove 371 MW generation from Waiau power plant. High-level locations of the RFP Stage 3 projects assumed in the study and developed REZ zones are shown in Figure 11. The detailed system grid-scale resources changes are summerized in Table 7 and Table 8. By 2031, system annual peak load forecast is 1,364 MW, which is used for the study for this year. System resource summary and the forecasted system load is summarized in Table 9.

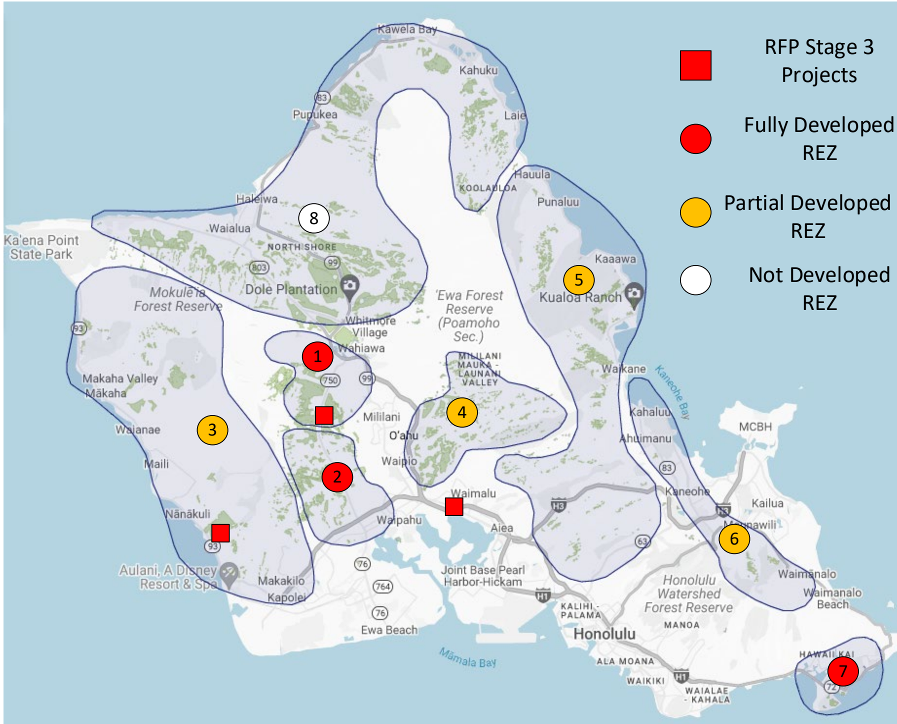


Figure 11 High-Level Oʻahu map for assumed RFP Stage 3 project locations and REZ zone development by 2030

Table 7 Oʻahu Grid-Scale Generation Project Development by 2030, after RFP Stage 2, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 Oʻahu RFP	Renewable Dispatchable Generation	450	2027	Central Oʻahu, West Oʻahu
	Firm Generation	300	2029	Central Oʻahu
REZ Development	Renewable Dispatchable Generation	510	2030	Zone 1, 2, and 7
		543	2030	Zone 3, 4, 5 and 6
Other	Standalone BESS	84	2030	138/46 kV substations

Table 8 Oʻahu Grid-Scale Generation Removal by 2030

Removal	Generation Type	MW Capacity	Year	Location
Waiau 3, 4	Fossil Generation	94	2024	Waiau Power Plant
Waiau 5, 6		108	2027	
Waiau 7, 8		169	2029	

Table 9 Oʻahu System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2030

Firm Generation	Onshore Standalone Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,462	257	168	1,573	219	1,171	1,364

To evaluate O‘ahu transmission system needs, various system dispatches are generated to stress the system during normal configuration and contingency configurations, which are listed in Table 10. For the 543 MW RDG development from the REZ zone 3, 4, 5 and 6, the study investigated two sensitivities: study case A and E in which all the 543 MW projects interconnected at west side of system, and study case D in which all the 543 MW projects interconnect at east side of system.

Table 10 Studied System Generation (MW) Dispatches, O‘ahu Base Scenario Resource Plan, Year 2030

Region	Substation	Study Cases					
		A	B	C	Cm1a	D	E
West	HP, CIP	35	35	198	198	35	35
	CEIP	0	177	202	202	0	0
	Ewa Nui	324	336	336	256	0	0
	Kalaeloa	0	0	208	208	0	0
	Kahe	543	271	270	270	0	821
North	Hema/Akau	39	39	0	0	0	0
	Wahiawa	0	22	0	0	0	142
Central	Ho‘ohana	232	232	0	80	276	0
	Mahi	120	120	0	0	120	0
	Waiau	5	66	150	150	300	366
East	Halawa	0	0	0	0	396	0
	Koolau	66	66	0	0	237	0
System Total Demand		1,364	1,364	1,364	1,364	1,364	1,364

Study results

Power flow simulations are performed for all the system generation dispatches, for system under normal configuration and contingency configurations (i.e., N-1 and N-2). The simulation results show that there is no voltage criteria violation, no 138 kV transmission line overloading in either system normal configuration or N-2 contingency configuration. However, overloading is identified on Ewa Nui-Waiau #1 & #2 138 kV lines during one N-1 contingency in study case C. The overloading is caused by too large an amount of generation dispatched from West region of system, which causes high level power flowing from the west region to Waiau substation via the Ewa Nui-Waiau #1 & #2 138 kV lines. When one of these two lines is out of service, the other line will have overloading condition.

Mitigation study – transmission networks expansion

The identified trasmission line overloading can be mitigated by reconductoring the Ewa Nui-Waiau #1 and #2 line as double bundle 795 AAC conductor. High level cost estimate to reconductor these two 138 kV lines is $161.4 million.

Mitigation study – portfolio alternatives

An alternative for the Ewa Nui – Waiau #1 and #2 line reconductor could be reducing REZ zone 2 interconnection MW size by 150 MW.

REZ Enablement

In the 2021 REZ study, REZ enablement cost estimate in term of $MM/MW is obtained for each REZ zones of Oʻahu. Based on these estimate, REZ enablement cost estimate by year 2030 is listed in Table 11. Since there is no detailed information regarding a breakdown of the 543 MW development from zone 3 to 6 for each zone, only a range of cost estimate is provided by assuming the 543 MW development come from the lower cost zones or higher cost zones.

Table 11 Oʻahu REZ Enablement Cost Estimate for REZ Development by 2030

REZ Zone	1	2	3	4	5	6	7
Cost ($MM) per MW	0.21	0.27	1.32	0.82	1.51	0.62	N/A
REZ Enablement ($MM)	24.6	87.6	448.4-819.9				N/A

Base scenario resource plan, year 2035

Study descriptions

In addition to previous system resource changes by 2030, by 2035, the Oʻahu system will have addition of 64 MW grid-scale standalone BESS and 509 MW offshore wind. There is no further development of REZ during this time frame. There will be 208 MW firm generation procured and interconnected at the Kalaeloa substation once the Kalaeloa power plant contract expires. High-level locations of the new grid-scale generation projects added into system between 2031 and 2035 assumed in the study are shown in Figure 12. The detailed system grid-scale resources changes are summerized in Table 12 and Table 13. By 2036, system annual peak load forecast is 1,432 MW, which is used for the study for this year. System resource summary and the forecasted system load is summarized in Table 14.

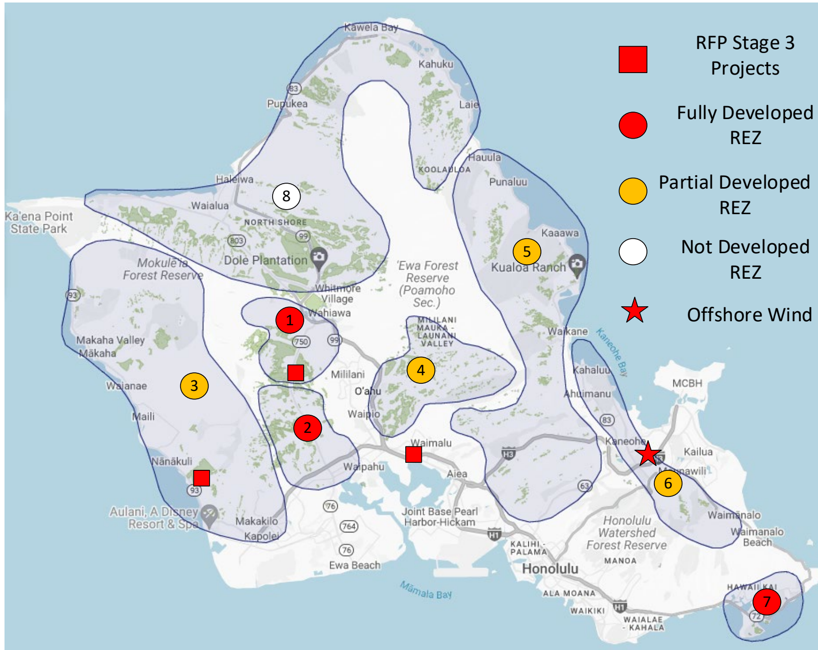


Figure 12 High-Level Oʻahu map for assumed generation projects' locations by 2035

Table 12 Oʻahu Grid-Scale Generation Project Development between 2031 and 2035, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
Others	Firm Generation	208	2033	Kalaeloa Substation
	Standalone BESS	64	2035	138/46 kV substations
	Offshore wind	509	2035	Koʻolau 138 kV substation

Table 13 Oʻahu Grid-Scale Generation Removal between 2031 and 2035

Removal	Generation Type	MW Capacity	Year	Location
Kahuku Wind	Onshore Wind	30	2031	Kahuku 46 kV substation
Kapolei Sustainable Energy Park	Solar	1	2032	Kahe 46 kV substation
Kalaeloa Solar	Solar	5	2032	KS substation
Kahe 1, 2	Fossil	165	2033	Kahe substation
Kalaeloa Power Plant	Fossil	208	2033	KPLP substation
KREP	Solar	5	2034	KREP substation

Table 14 Oʻahu System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2035

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,297	257	509	157	1,573	282	1,295	1,432

Table 15 summarizes studied system generation dispatches for the 2035. It is worth noting that the conductor upgrade mitigation solution identified in the 2030 study is not included in the model for the study for 2035.

Table 15 Studied System Generation (MW) Dispatches, O‘ahu Base Scenario Resource Plan, Year 2035

Region	Substation	Study Cases							
		A	B	C	Cm1	Cm1a	D	Dm1a	E
West	HP, CIP	35	35	198	198	198	35	35	35
	CEIP	0	177	202	202	202	0	0	0
	Ewa Nui	336	336	336	336	186	0	0	0
	Kalaeloa	0	0	208	0	208	0	0	0
	Kahe	543	339	396	396	396	0	0	845
North	Hema/Akau	39	39	0	0	0	0	0	0
	Wahiawa	0	22	0	0	0	0	0	142
Central	Ho‘ohana	257	232	0	0	120	0	10	0
	Mahi	120	120	0	0	0	0	0	44
	Waiau	36	66	92	300	92	255	255	366
East	Halawa	0	0	0	0	0	396	396	0
	Koolau	66	66	0	0	30	746	736	0
System Total Demand		1,432	1,432	1,432	1,432	1,432	1,432	1,432	1,432

Study results

According to the power flow simulation results, overloading is identified for the Ewa Nui-Waiau #1 and #2 138 kV lines from the study case C when system is under N-1 contingency configuration, and high loading condition (96% of emergency rating) is identified for Koolau-Waiau #1 and #2 line, and Halawa-Koolau line from the study case D when system is under N-2 contingency configuration. It is worth noting that study case D represents a scenario that majority part of system load (79%) is supplied from REZ generation and offshore wind farm interconnected at east side of system. The identified high loading condition indicates the dispatched generation in east side is close to system transfer limit.

Mitigation study – transmission network expansion

Besides the reconductor of Ewa Nui-Waiau #1 and #2 circuits as identified in the 2030 study, there is no addtional transmission network expansion identified.

Mitigation study – portfolio alternatives

In addition to reducing REZ zone 2 interconnection MW size by 150 MW to avoid overloading the Ewa Nui-Waiau transmission lines, the REZ zone 6 or 7 interconnection size can be reduced by 10 MW to avoid high load conditions on the Koolau-Waiau #1 and #2 line, and Halawa-Koolau line.

REZ Enablement

There is no onshore REZ development between 2031 to 2035. However, the offshore wind development that requires interconnection facility is the 509 MW offshore wind, which requires expansion of the Koʻolau substation by adding 4 BAAH bay for the offshore wind interconnection. The cost estimate is $50.6 million.

Base scenario resource plan, year 2045

Study descriptions

In addition to previous system resource changes, by 2045, the Oʻahu system will finish developing the majority of REZ zone 1, 2, 3, 4, 5, 6 and 7, only 106 MW potential remaining undeveloped. Meanwhile, 452 MW solar potential of the REZ zone 8 will also be developed by 2045. System load is forecasted with significant growth, reaching 1,692 MW peak demand at 2046, which is used for the study. High level system map with REZ development is shown in Figure 13. The detailed system grid-scale resources changes are summerized in Table 16 and Table 17. System resource summary and the forecasted system load is summarized in Table 18.

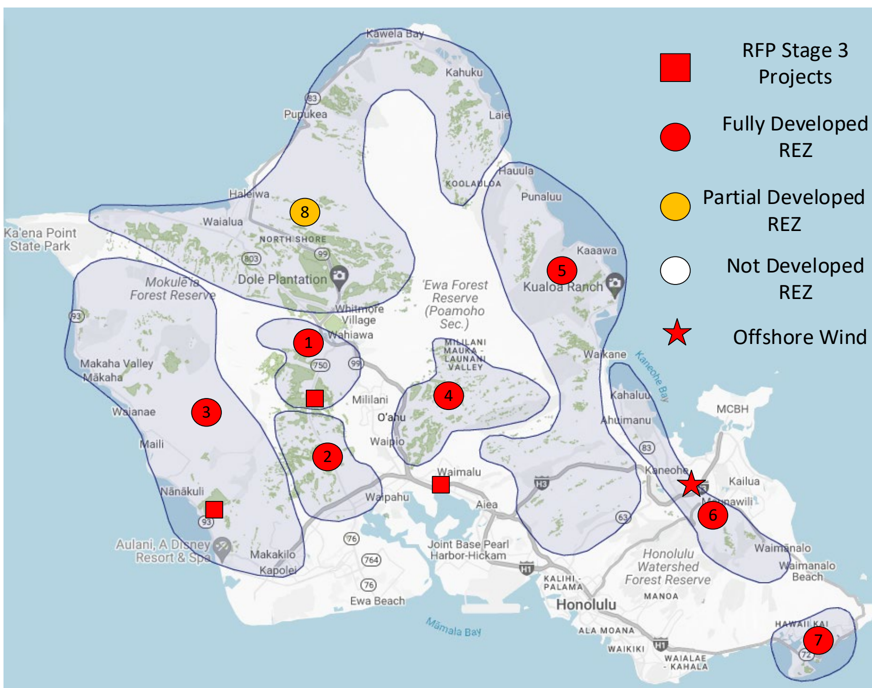


Figure 13 High-Level Oʻahu map for assumed generation projects' locations by 2045

Table 16 Oʻahu Grid-Scale Generation Project Development between 2036 and 2045, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Renewable Dispatchable Generation	521	2040	REZ zone 3, 4, 5, and 6
		504	2045	
		452	2045	REZ zone 8
Other	Standalone BESS	1	2040	Hoʻohana substation
		32	2045	Hoʻohana substation

Recovered Solar	Standalone Solar	168	2045	Waiver project locations
Recovered Wind	Wind	123	2045	Removed wind locations

Table 17 Oʻahu Grid-Scale Generation Removal between 2036 and 2045

Removal	Generation Type	MW Capacity	Year	Location
Kahe 3, 4	Fossil	172	2037	Kahe substation
Kawailoa Wind	Wind	69	2038	Wahiawa 46 kV
Waianae Solar	Solar	27.6	2039	Kahe 46 kV
Na Pua Makani Wind	Wind	24	2040	Koʻolau 46 kV
Waiver Clearway Projects	Solar/Wind	110	2041	Various 138 kV and 46 kV substations
West Loch Solar	Solar	20	2044	CEIP 46 kV

Table 18 Oʻahu System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2045

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,126	287	509	441	2,777	315	1,454	1,692

Table 19 summarizes studied system generation dispatch for the 2045. By comparing with previous study cases, a case (i.e., study case E) with much higher generation from Wahiawa substation (i.e., REZ zone 8) is considered in the study for 2045.

Table 19 Studied System Generation (MW) Dispatches, Oʻahu Base Scenario Resource Plan, Year 2045

Region	Substation	Study Cases						
		A	B	C	Cm1	Cm1a	D	E
West	HP, CIP	35	35	198	198	198	35	35
	CEIP	0	177	202	202	202	0	0
	Ewa Nui	324	336	336	336	226	0	0
	Kalaeloa	0	0	208	0	208	0	0
	Kahe	588	599	656	656	656	0	588
North	Hema/Akau	0	39	0	0	0	0	99
	Wahiawa	0	22	0	0	0	0	623
Central	Hoʻohana	120	232	0	0	110	3	0
	Mahi	0	120	0	0	0	0	0
	Waiau	331	66	92	300	92	300	347

East							
East	Halawa	228	0	0	0	0	608	0
	Koolau	66	66	0	0	0	746	0
System Total Demand		1692	1692	1692	1692	1692	1692	1692

Study results

Significant 138 kV line overloading and high loading conditions is identified in both N-1 system contingency configurations and N-2 system contingency configurations from multiple study cases. A detailed summary of the conductor overloading and high loading is provided in Table 20. 138 kV line overloading is not identified in the normal system configuration study. Also, there is no steady state voltage planning criteria violation from the study results.

Table 20 138 kV Line Overloading Summary, Oʻahu Base Scenario Resource Plan, Year 2045

Study Case	N-1 Contingency		N-2 Contingency	
	Overloading/High loading Line	Max. Loading (%)	Overloading/High loading Line	Max. Loading (%)
A	None		Makalapa-Airport	99
			Halawa-Iwilei	98
			Halawa-School	97
B	Halawa-Hoʻohana #1	101	Halawa-Hoʻohana #1	110
	Halawa-Hoʻohana #2	99	Halawa-Hoʻohana #2	107
	Ewa Nui-Waiau #1 and #2	98	Makalapa-Airport	98
			Halawa-Iwilei	97
			Halawa-School	96
C	Ewa Nui-Waiau #1 and #2	124	Halawa-Koʻolau	108
	Kahe-Hoʻohana #1 and #2	101	Koolau-Waiau #1 and #2	108
			Ewa Nui-Waiau #1 and #2	108
			Kahe-Hoʻohana #1 and #2	103
			Halawa-Hoʻohana #1 and #2	99
			Makalapa-Airport	98
			Halawa-Iwilei	97
			Halawa-School	96
Cm1	Ewa Nui-Waiau #1 and #2	99	Halawa-Koʻolau	108
	Makalapa-Waiau	97	Koolau-Waiau #1 and #2	108
			Makalapa-Airport	102
			Makalapa-Waiau	101
			Iwilei-Airport	99
			Halawa-Iwilei	97
			Halawa-School	97
D	None		Makalapa-Airport	99
			Halawa-Iwilei	98
			Halawa-School	97
E	Wahiawa-Waiau	150	Wahiawa-Waiau	131
	Kahe-Hema	149	Kahe-Hema	130
	Akau-Hema	136	Akau-Hema	118
	Wahiawa-Akau	122	Makalapa-Airport	109
	Makalapa-Waiau	104	Halawa-Koʻolau	108
			Koʻolau-Waiau #1 and #2	108

			Wahiawa-Akau	107
			Iwilei-Airport	106
			Makalapa-Waiau	105
			Halawa-Hoʻohana #1 and #2	103
			Kahe-Hoʻohana #1 and #2	97
			Halawa-Iwilei	96
			Halawa-School	96

Mitigation study – transmission networks expansion

Significant transmission networks expansion will be required in order to interconnect all the grid-scale generation projects and host the forecasted system load. The transmission networks expansion option 2 identified in the 2021 REZ study is adopted here as the mitigation solution for the overloading and high loading conditions listed in the study results, which is shown in Table 21. A high-level single line diagram which represents the proposed transmission networks expansion is shown in Figure 14.

Table 21 Transmission Networks Expansion and High-Level Cost Estimate, Oʻahu Base Scenario Resource Plan, Year 2045

No.	Transmission Line	Upgrade Type	Conductore Requirements	Cost Estimate ($MM)
1	Kahe-Akau-Hema-Wahiawa	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	314.1
2	Wahiawa-Kahe	New Line, 138 kV	Two circuits, with double-bundled 795 AAC	875.3
3	Wahiawa-Waiau	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	214.1
4	Wahiawa-Waiau	New Line, 138 kV	Two circuits, with double-bundled 795 AAC	962.8
5	Waiau-Makalapa #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	72.3
6	Halawa-Ko`olau	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	172.1
7	Halawa-Ko`olau	New Line, 138 kV	One circuit, with 1590 AAC conductor	195.3
8	Ko`olau-Waiau #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	233
9	Ko`olau-Waiau #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	247.4
10	Makalapa-Airport #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	32.1
11	Halawa-School #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	92.8
12	Halawa-Iwilei #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	248.7

13	Airport-Iwilei #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	161.2

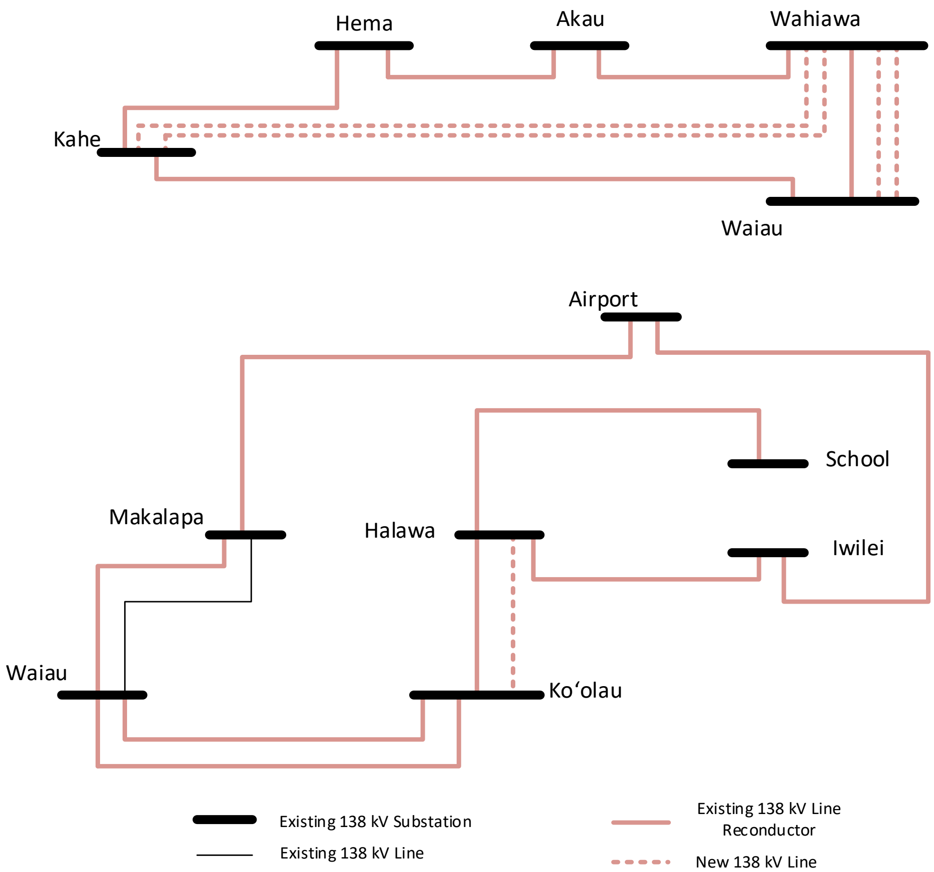


Figure 14 High-Level single line diagram for proposed transmission networks expansion, O‘ahu base scenario resource plan, year 2045

Mitigation study – portfolio alternatives

Considering the degree of identified overloading conditions and scale of proposed transmission networks expansion, it is determined that there is no alternative to fully replace the proposed wire solution considering current electric grid technology developments and renewable procurement needs.

REZ Enablment

According to the REZ development MW target and the per MW cost estimate for REZ enablement identified in the 2021 REZ study, a high-level REZ enablment cost for REZ development between 2036 and 2045 is provided in Table 22.

Table 22 O‘ahu REZ Enablement Cost Estimate for REZ Development between 2036 and 2045

REZ Zone	3	4	5	6	8

Cost ($MM) per MW	1.32	0.82	1.51	0.62	1.25
REZ Enablement ($MM)	1084.6-1468.5				565.0

Base scenario resource plan, year 2050

Study descriptions

By 2050, 3,344 MW of all eight REZ zones will be fully developed. System load is forecasted with significant growth: 1,829 MW peak demand at 2050, which could possibly cause underground cable overloading for 138 kV underground cable among School Street, Iwilei and Archer 138 kV substations. All Kahe fossil generation units will be retired by 2050. Besides switching fossil fuel to biodiesel fuel for remaining firm units, 153 MW new firm units will be added to the Oʻahu system by 2050. A high-level system map with REZ development status is shown in Figure 15. The detailed system grid-scale resources changes are summerized in Table 23 and Table 24. System resource summary and the forecasted system load is summarized in Table 25.

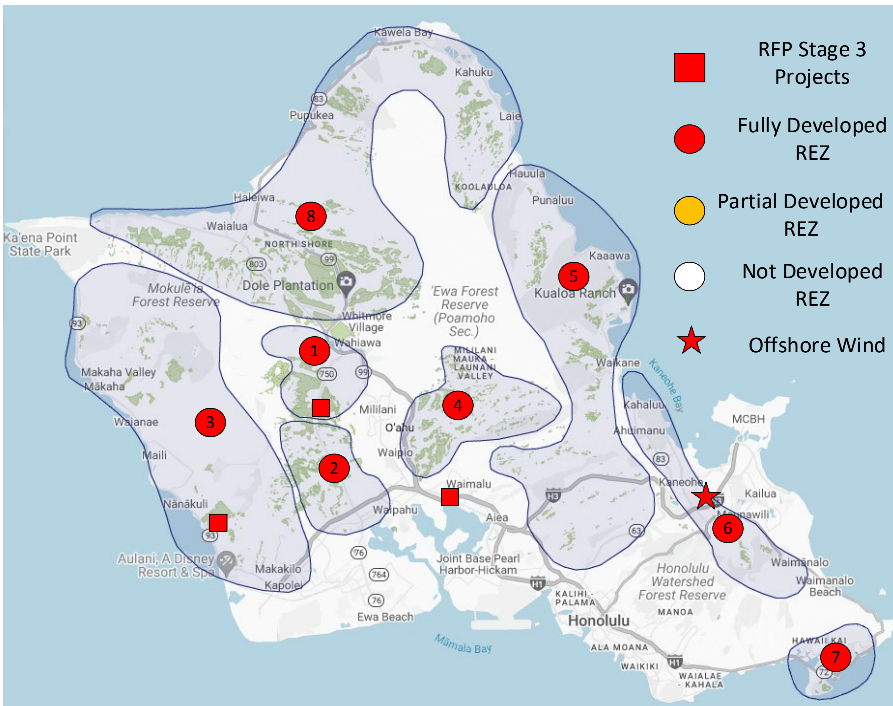


Figure 15 High-Level Oʻahu map with REZ development status by 2050

Table 23 Oʻahu Grid-Scale Generation Project Development between 2046 and 2050, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Renewable	106	2050	REZ zone 3, 4, 5, and 6
	Dispatchable Generation	714	2050	REZ zone 8
Other	Standalone BESS	18	2050	138 kV Substation
Other	Firm Generation	153	2050	Kahe Substation

Table 24 Oʻahu Grid-Scale Generation Removal between 2046 and 2050

Removal	Generation Type	MW Capacity	Year	Location
Kahe 5, 6	Fossil	270	2046	Kahe substation

Table 25 Oʻahu System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2050

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,010	287	509	480	3,558	333	1,497	1,829

Table 26 summarizes studied system generation dispatch for the 2050. It is worth noting that all the transmission networks expansion identified in the 2045 study is included in the system model for the 2050 study.

Table 26 Studied System Generation (MW) Dispatches, Oʻahu Base Scenario Resource Plan, Year 2050

Region	Substation	Study Cases							
		A	B	C	Cm1	Cm1a	D	E	Em1a
West	HP, CIP	35	35	198	198	198	35	35	35
	CEIP	0	177	202	202	202	0	0	0
	Ewa Nui	324	336	336	336	186	0	0	0
	Kalaeloa	0	0	208	0	208	0	0	0
	Kahe	588	736	793	793	793	0	358	358
North	Hema/Akau	0	39	0	0	0	0	99	99
	Wahiawa	0	22	0	0	0	0	1337	1117
Central	Hoʻohana	120	232	0	0	120	140	0	0
	Mahi	0	120	0	0	0	0	0	0
	Waiau	331	66	92	300	92	300	0	0
East	Halawa	218	0	0	0	0	608	0	220
	Koolau	213	66	0	0	30	746	0	0
System Total Demand		1,829	1829	1829	1829	1829	1829	1829	1829

Study results

After the transmission networks expansion proposed for 2045, transmission line high loading and overloading conditions are still identified from all study cases. A summary of identified high loading and overloading conditions are listed in Table 27. There is no steady state voltage violation identified from the study.

Table 27 138 kV Line Overloading Summary, Oʻahu Base Scenario Resource Plan, Year 2050

Study Case	N-1 Contingency	N-2 Contingency

	Overloading/High loading Line	Max. Loading (%)	Overloading/High loading Line	Max. Loading (%)
A	Archer-School	100	None	
	Archer-Iwilei	100		
B	Archer-School	99	Halawa-Hoʻohana #1	97
	Archer-Iwilei	99		
	Halawa-Hoʻohana	96		
C	Ewa Nui-Waiau #1 and #2	112	Kahe-Hoʻohana #1	101
	Archer-School	99	Kahe-Hoʻohana #2	100
	Archer-Iwilei	99		
	Kahe-Hoʻohana #1	97		
	Kahe-Hoʻohana #2	96		
Cm1	Archer-School	99	Makalapa-Waiau #1	97
	Archer-Iwilei	99	Makalapa-Airport	96
D	Archer-School	100	Halawa-Makalapa	99
	Archer-Iwilei	100		
E	Makalapa-Waiau #1	101	Wahiawa-Waiau #3	125
	Makalapa-waiau #2	99	Wahiawa-Waiau #2	114
	Archer-School	98	Wahiawa-Waiau #1	103
	Archer-Iwilei	98	Makalapa-Airport	102
			Makalapa-waiau #2	101
			Iwilei-Airport	99
Em1a	None		None	

Mitigation study – transmission networks expansion

Study results indicate the high loading and potential overloading on the 138 kV underground cables: Archer-Iwilei and Archer-School. As a wire solution, cable repalcement for these two underground line is recommended. Meanwhile, overloading and high loading conditions are also identified on Kahe-Hoʻohana #1 and #2 lines and Hoʻohana-Halawa #1 and #2 lines. The proposed transmission networks expansion is summarized in Table 28.

Table 28 Transmission Networks Expansion and High-Level Cost Estimate, Oʻahu Base Scenario Resource Plan, Year 2050

No.	Transmission Line	Upgrade Type	Conductore Requirements	Cost Estimate ($MM)
1	Kahe-Hoʻohana #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	174.4
2	Kahe-Hoʻohana #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	158.5
3	Hoʻohana-Halawa #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	258.3
4	Hoʻohana-Halawa #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	272.6
5	Archer-School #1	Cable Replacement	2 cables per phase of 3000KCM CU XLPE	166.6

6	Archer Iwilei #1	Cable Replacement	2 cables per phase of 3000KCM CU XLPE	178.5

The results of the study case E, in which all REZ zone 8 capacity is dispatched, shows overloading on the new lines and reconductored lines that connect with Wahiawa substation. Wire-based solution is not identified for mitigating this overloading, instead, non-wire solution is identified, which will be discussed in next subsection.

Mitigation study – portfolio and non-wire solutions

To avoid overloading the transmission lines that connect with the Wahiawa substation, it is recommened to reduce interconnection size of REZ zone 8 by 220 MW. Also, to avoid the 138 kV underground cable Archer-Iwilei and Archer-School overloading, would require reduction of peak demand in areas supplied by Archer substation, Kewalo substation and Kamoku substation by 37 MW (assuming 0.95 inductive power factor).

REZ Enablement

The high-level cost estimate for the REZ enablement of the REZ development between 2046 and 2050 is summarized in Table 29.

Table 29 Oʻahu REZ Enablement Cost Estimate for REZ Development between 2046 and 2050

REZ Zone	**3**	**4**	**5**	**6**	8
Cost ($MM) per MW	1.32	0.82	1.51	0.62	1.25
REZ Enablement ($MM)	86.9-160.1				892.5

Land Constrained scenario resource plan, year 2030

Study descriptions

By 2030, the Oʻahu system will have all new generation from Stage 3 Oʻahu RFP procurement on transmission and sub-transmisison side. Specifically, there will be 450 MW renewable dispatch generation ("RDG") and 300 MW firm generation procured through the Stage 3 Oʻahu RFP activity, which is the same as this in the base scenario resource plan. Most of these new generation are expected to be interconnected at Oʻahu 138 kV system. In this time frame, it is also planned to remove 371 MW generation from Waiau power plant. There is no REZ development in the land constrained scenario resoruce plan. High-level system map with the new grid-scale generation projects coming online by 2030 is shown in Figure 16. The assumptions regarding RFP Stage 3 project interconnection locations are the same as what are used in the base scenario resource plan studies.

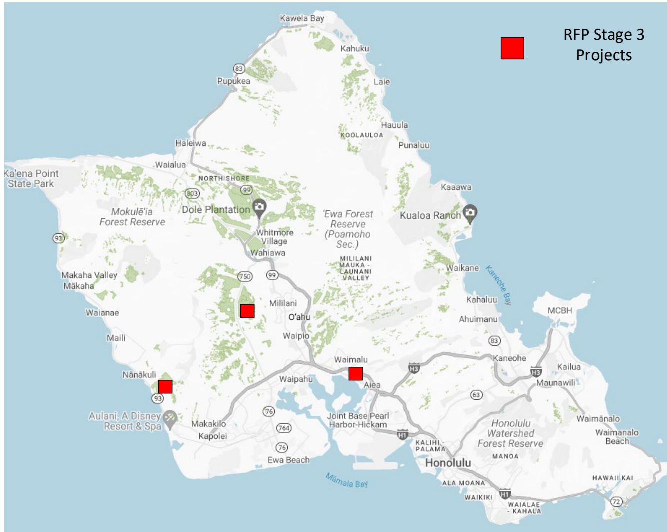


Figure 16 High-Level Oʻahu map, land constrained scenario resource plan, by 2030

The detailed system grid-scale resources changes are summerized in Table 30 and Table 31. By 2031, system annual peak load forecast is 1,364 MW, which is used for the study for this year. System resource summary and the forecasted system load is summarized in Table 32.

Table 30 Oʻahu Grid-Scale Generation Project Development by 2030, after RFP Stage 2, Land Constrained Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 Oʻahu RFP	Renewable Dispatchable Generation	450	2027	Central Oʻahu, West Oʻahu
	Firm Generation	300	2029	Central Oʻahu

Table 31 Oʻahu Grid-Scale Generation Removal by 2030

Removal	Generation Type	MW Capacity	Year	Location
Waiau 3, 4	Fossil Generation	94	2024	Waiau Power Plant
Waiau 5, 6		108	2027	
Waiau 7, 8		169	2029	

Table 32 Oʻahu System Resource Summary and Forecasted Demand (MW), Land Constrained Scenario Resource Plan, Year 2030

Firm Generation	Onshore Standalone Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,462	123	168	684	135	1,171	1,364

Table 33 summarizes studied system generation dispatches for the land constrained scenario resource plan in 2030.

Table 33 Studied System Generation (MW) Dispatches, Oʻahu Land Constrained Scenario Resource Plan, Year 2030

Region	Substation	Study Cases

		A	B	F
West	HP, CIP	35	198	35
	CEIP	202	202	67
	Ewa Nui	12	12	12
	Kalaeloa	0	208	208
	Kahe	302.6	270	302
North	Hema/Akau	99.4	0	0
	Wahiawa	141	0	157
Central	Hoʻohana	112	54	112
	Mahi	120	120	120
	Waiau	316	300	351
East	Halawa	0	0	0
	Koolau	24	0	0
System Total Demand		1,364	1,364	1,364

Study results

Power flow simulation results for the three system generation dispatches show that there are no steady state voltage or transmission line loading planning criteria violations. Hence, there is no discussion regarding mitigation solutions.

Land Constrained scenario resource plan, year 2035

Study descriptions

In addtion to previous system resource changes by 2030, by 2035, the Oʻahu system will have 105 MW grid-scale standalone BESS and 400 MW offshore wind. 153 MW Firm resource will also be added to system by 2035. There will be 208 MW firm generation procured and interconnected at the Kalaeloa substation once the Kalaeloa power plant is removed. 30 MW wind recovered wind resource from the retired wind power plant will be added to system to meet the system demand as well. According to the forecast, system annual peak demand will reach 1,432 MW by 2036, which is used for the study. High-level system map with the addtion of the grid-scale resources is shown in Figure 17. The detailed system grid-scale resource changes are summarized in Table 34 and Table 35. System resource summary and the forecasted system load is summarized in Table 36.

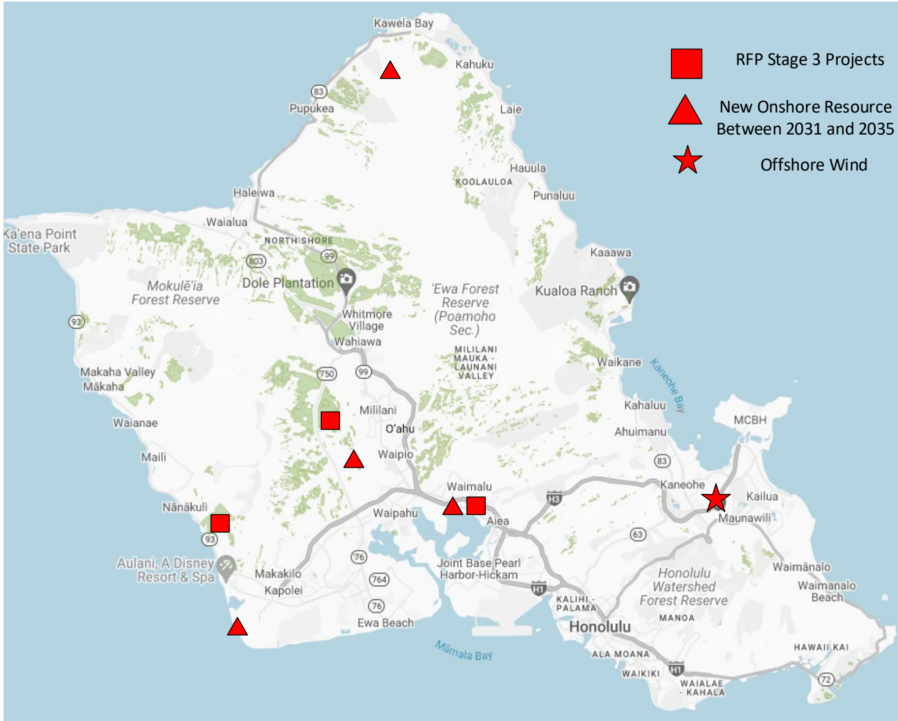


Figure 17 High-Level O'ahu map, land constrained scenario resource plan, by 2035

Table 34 O'ahu Grid-Scale Generation Project Development by 2035, Land Constrained Scenario Resource Plan

Generation Type	MW Capacity	GCOD	Location
Firm Generation	208	2033	Kalaeloa Substation
Firm Generation	153	2035	Waiau Power Plant
Standalone BESS	105	2035	138/46 kV substations
Offshore wind	400	2035	Ko'olau 138 kV substation

Table 35 O'ahu Grid-Scale Generation Removal by 2035

Removal	Generation Type	MW Capacity	Year	Location
Kahuku Wind	Onshore Wind	30	2031	Kahuku 46 kV substation
Kapolei Sustainable Energy Park	Solar	1	2032	Kahe substation
Kalaeloa Solar	Solar	5	2033	Kahe 46 kV substation
Kahe 1, 2	Fossil	165	2033	Kahe substation
Kalaeloa Power Plant	Fossil	208	2033	KPLP substation
KREP	Solar	5	2034	KREP substation

Table 36 O'ahu System Resource Summary and Forecasted Demand (MW), Land Constrained Scenario Resource Plan, Year 2035

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,450	123	400	157	684	240	1,295	1,432

Table 37 summarizes the studied system generation dispatches for the land constrained scenario resource plan in 2035. New system generation dispatches are added to evaluate system resource changes.

Table 37 Studied System Generation (MW) Dispatches, O'ahu Land Constrained Scenario Resource Plan, Year 2035

Region	Substation	Study Cases				
		A	B1	B2	C	F
West	HP, CIP	35	198	198	35	35
	CEIP	197	202	202	177	67
	Ewa Nui	12	12	117	12	12
	Kalaeloa	0	208	208	0	208
	Kahe	297	270	270	20	370
North	Hema/Akau	99	0	0	39	0
	Wahiawa	141	0	0	22	157
Central	Ho'ohana	217	122	17	217	112
	Mahi	120	120	120	120	120
	Waiau	290	300	300	366	351
East	Halawa	0	0	0	0	0
	Koolau	24	0	0	424	0
DER		0	0	0	0	0
System Total Demand		1,432	1,432	1,432	1,432	1,432

Study results

Power flow simulation results for aforementioned system generation dispatches show that there are no steady state voltage or transmission line loading planning criteria violations. Hence, there is no discussion regarding mitigation solutions.

Land Constrained scenario resource plan, year 2046

Study descriptions

In addtion to previous system resource changes, by 2045, the O'ahu system will add another 153 MW firm geneartion into the system. Also, 169 MW standalone solar and 93 MW wind development from retired solar and wind locations will be completed by 2045. 169 MW new Grid-scale standalone BESS will be interconnected to system from transmission substations. System load is forecasted with significant growth: 1,692 MW peak demand at 2046. 783 MW DER coupled with 1,567 MWh DER BESS will be added to the system to supply system load demand. A high-level map for O'ahu system with addtion of grid-scale resource since 2036 is shown in Figure 18. The detailed system grid-scale resources changes are summarized in Table 38 and Table 39. System resource summary and the forecasted system load is summarized in Table 40.

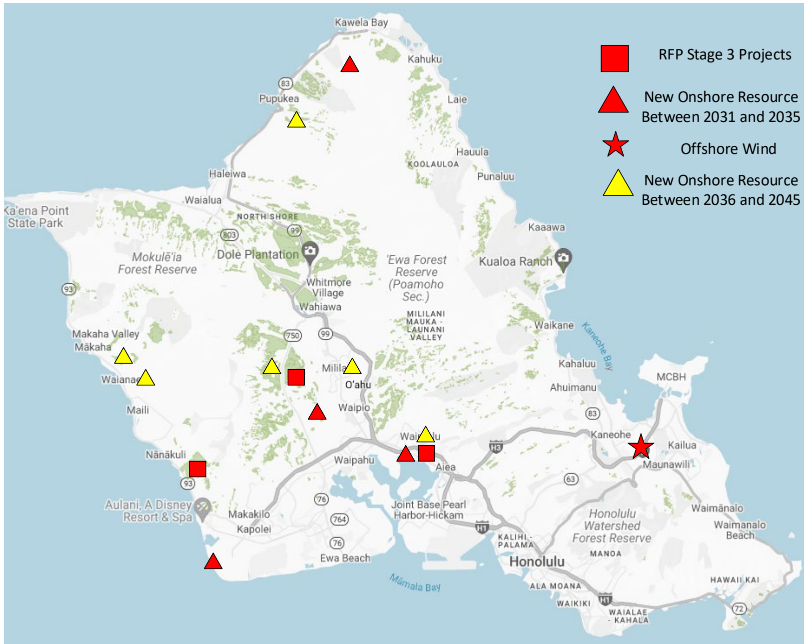


Figure 18 High-Level Oʻahu map, land constrained scenario resource plan, by 2045

Table 38 Oʻahu Grid-Scale Generation Project Development by 2045, Land Constrained Scenario Resource Plan

Generation Type	MW Capacity	GCOD	Location
Standalone BESS	14	2040	Hoʻohana substation
Firm Generation	153	2040	Waiau substation
Standalone Solar	39	2040	Waiver project locations
Wind	93	2040	Retired wind locations
Standalone BESS	145	2045	Hoʻohana substation
Standalone Solar	130	2045	Waiver project locations

Table 39 Oʻahu Grid-Scale Generation Removal by 2045

Removal	Generation Type	MW Capacity	Year	Location
Kahe 3, 4	Fossil	172	2037	Kahe substation
Kawailoa Wind	Wind	69	2038	Wahiawa 46 kV
Waianae Solar	Solar	27.6	2039	Kahe 46 kV
Na Pua Makani Wind	Wind	24	2040	Koʻolau 46 kV
Waiver Clearway Projects	Solar/Wind	104	2041	Various 138 kV and 46 kV substations
West Loch Solar	Solar	20	2044	CEIP 46 kV

Table 40 O'ahu System Resource Summary and Forecasted Demand (MW), Land Constrained Scenario Resource Plan, Year 2045

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,432	123	400	169	684	399	3,020	1,692

Table 41 summarizes studied system generation dispatches for the land constrained scenario resource plan in 2045. By assuming DER technology maturity, system level monitoring and control being ready, and Company has sufficient DER program, two study cases (i.e., D and E) are created to represent scenarios where the majority system load is supplied by DER on distribution side. For this case creation spacial forecast of DER adoption across system is not used, instead, a flat rate of DER adoption across the system is assumed. Also, neither 46 kV subtransmission circuits nor distribution circuits (25 kV, 12 kV and 4 kV) are modeled in the PSS/E models used for this study. So, it is likely that potential sub-transmission and distribution system capacity needs in the study case D and E are not captured.

Table 41 Studied System Generation (MW) Dispatches, O'ahu Land Constrained Scenario Resource Plan, Year 2045

Region	Substation	Study Cases						
		A	B1	B2	B2m1a	C	D	E
West	HP, CIP	35	198	198	198	35	35	35
	CEIP	202	202	202	202	177	0	0
	Ewa Nui	12	12	276	246	12	0	0
	Kalaeloa	0	208	208	208	0	0	0
	Kahe	302.6	328	328	358	121	0	0
North	Hema/Akau	99.4	0	0	0	39	0	0
	Wahiawa	171	0	0	0	22	0	0
Central	Ho'ohana	376	324	60	60	376	0	0
	Mahi	120	120	120	120	120	0	0
	Waiau	350	300	300	300	366	0	0
East	Halawa	0	0	0	0	0	0	0
	Koolau	24	0	0	0	424	0	400
DER		0	0	0	0	0	1,657	1,257
System Total Demand		1,692	1,692	1,692	1,692	1,692	1,692	1,692

Study results

High loading and overloading conditions on many 138 kV lines are observed in several study cases. A summary of the findings regarding transmission line high loading and overloading conditions are listed in Table 42. There is no voltage planning criteria violation identifed from the study.

Table 42 138 kV Line Overloading Summary, O'ahu Land Constrained Scenario Resource Plan, Year 2045

Study Case	N-1 Contingency		N-2 Contingency	
	Overloading/High loading Line	Max. Loading (%)	Overloading/High loading Line	Max. Loading (%)
A	Halawa-Hoʻohana #1	99	Halawa-Hoʻohana #1	111
	Halawa-Hoʻohana #2	96	Halawa-Hoʻohana #2	108
			Halawa-Koʻolau	105
			Koʻolau-Waiau #1 and #2	103
			Halawa-Iwilei	98
			Halawa-School	97
			Makalapa-Airport	98
B1	Halawa-Hoʻohana #1	104	Halawa-Koʻolau	112
	Halawa-Hoʻohana #2	101	Koʻolau-Waiau #1 and #2	109
	Halawa-Hoʻohana	96	Halawa-Hoʻohana #1	108
			Halawa-Hoʻohana #2	106
			Halawa-Iwilei	99
			Halawa-School	98
			Makalapa-Airport	99
B2	Ewa Nui-Waiau #1	98	Halawa-Koʻolau	112
	Ewa Nui-Waiau #2	97	Koʻolau-Waiau #1 and #2	109
	Makalapa-Waiau #1	99	Makalapa-Airport	105
			Makalapa-Waiau	104
			Iwilei-Airport	102
			Halawa-Iwilei	99
			Halawa-School	98
C	None		Halawa-Iwilei	99
			Makalapa-Airport	99
			Halawa-School	98
D	None		None	
E	None		None	

The reason of the high loading and overloading condition is generation congestion and system load increase. The results of study case A, B1 and B2 indicate that interconnecting future generation projects, including standalone BESS, in west side or west central part of system could cause generation congestion on transmission lines. Instead, interconnecting those project on east side of system would avoid certain transmission line overloading or high loading conditions.

Study results for case D and E also demonstrate that DER resources supplying system load would not cause transmission line overloading. However, for this case creation instead of using spatial DER adoption forecast a flat rate of DER adopton increase on top of existing DER adopton across system is used for modeling future years' DER generation. To fully demonstrate that adopting DER can avoid transmission networks expasion, more detailed study will be performed, and system level monitoring and control of DER will be required.

Mitigation study – transmission networks expansion

According to the study results, following transmission line upgrades summarized in Table 43 are proposed to mitigate the identified transmission line high load conditions or overloading conditions. A simplified single line diagram as Figure 19 shows the proposed line upgrade.

Table 43 Transmission Networks Expansion and High-Level Cost Estimate, O'ahu Land Constrained Scenario Resource Plan, Year 2045

No.	Transmission Line	Upgrade Type	Conductore Requirements	Cost Estimate ($MM)
1	Waiau-Makalapa #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	72.3
2	Halawa-Ko`olau	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	172.1
3	Halawa-Ko`olau	New Line, 138 kV	One circuit, with 1590 AAC conductor	178.3
4	Ko`olau-Waiau #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	233
5	Ko`olau-Waiau #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	247.4
6	Makalapa-Airport #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	32.1
7	Halawa-School #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	92.8
8	Halawa-Iwilei #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	248.7
9	Airport-Iwilei #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	161.2
10	Kahe-Hoʻohana #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	150.5
11	Kahe-Hoʻohana #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	136.7
12	Hoʻohana-Halawa #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	222.8
13	Hoʻohana-Halawa #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	235.1

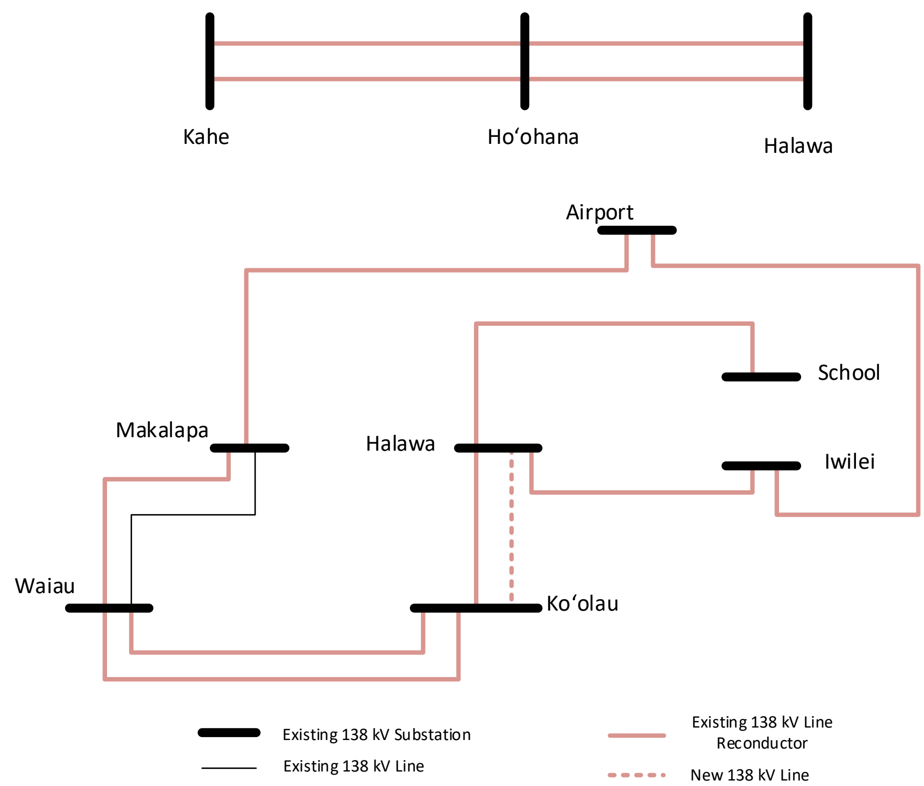


Figure 19 Simplified single line diagram for proposed transmission networks expansion, O'ahu land constrained scenario resource plan, by 2045

Mitigation study – non-wire alternatives

Considering the degree of identified overloading condition and scale of proposed transmission networks expansion, it is determined that there is no non-wire alternative to fully replace the proposed wire solution in current electric grid technology development condition.

Land Constrained scenario resource plan, year 2050

Study descriptions

From 2046 to 2050, the only grid-scale resource added to the O'ahu system as planned is a 119 MW/1,110 MWh grid-scale BESS. Kahe 5, 6, which will be the only remaining fossil generation at Kahe power plant by 2050, will be retired in 2050. It is also planned to add 1,017 MW DER, coupled with 2,033 MWh DER BESS into system distribution side. System peak load is forecasted to be 1,829 MW by 2050. A high-level map for O'ahu system with addtion of grid-scale resource is shown in Figure 20. The detailed system grid-scale resources changes are summerized in Table 44 and Table 45. System resource summary and the forecasted system load is summarized in Table 46.

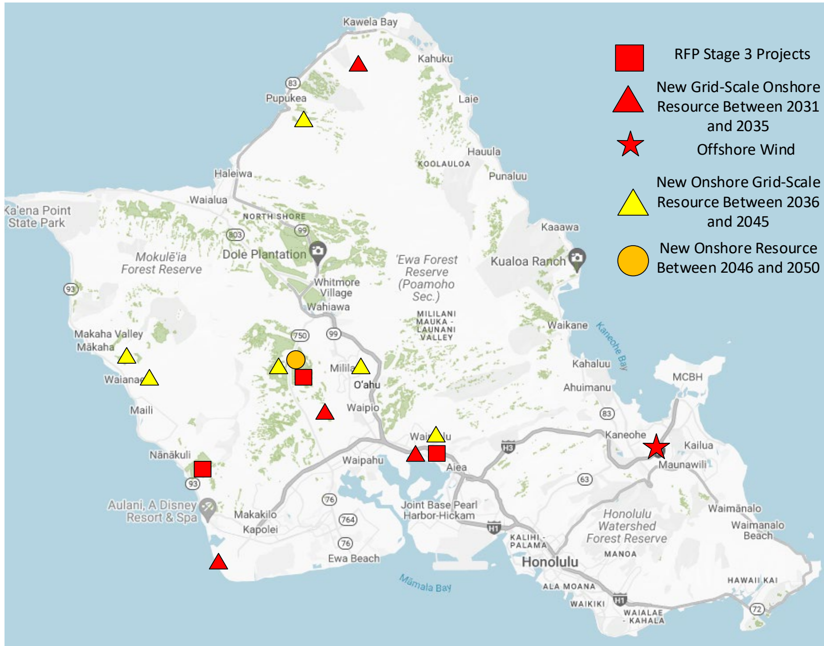


Figure 20 High-Level O‘ahu map, land constrained scenario resource plan, by 2050

Table 44 Grid-Scale Generation Project Development by 2050, Land Constrained Scenario Resource Plan

Generation Type	MW Capacity	GCOD	Location
Standalone BESS	119	2050	138 kV Substation

Table 45 O‘ahu Grid-Scale Generation Removal by 2050

Removal	Generation Type	MW Capacity	Year	Location
Kahe 5, 6	Fossil	270	2050	Kahe substation

Table 46 O‘ahu System Resource Summary and Forecasted Demand (MW), Land Constrained Scenario Resource Plan, Year 2050

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,163	123	400	169	684	519	5,097	1,829

Table 47 summarizes studied system generation dispatches for the land constrained scenario resource plan in 2050. All the transmission networks expansion identified in the 2045 study is included in the models for study cases listed in the Table 47.

Table 47 Studied System Generation (MW) Dispatches, O‘ahu Land Constrained Scenario Resource Plan, Year 2050

Region	Substation	Study Cases						
		A	B1	B2	B2m1a	C	D	E
West	HP, CIP	36	198	198	198	35	35	35

	CEIP	202	202	202	202	177	0	0
	Ewa Nui	12	12	396	206	12	0	0
	Kalaeloa	0	208	208	208	0	0	0
	Kahe	302.6	345	345	345	138	0	0
North	Hema/Akau	99.4	0	0	0	39	0	0
	Wahiawa	171	0	0	0	22	0	0
Central	Hoʻohana	496	444	60	250	496	0	0
	Mahi	120	120	120	120	120	0	0
	Waiau	366	300	300	300	366	0	0
East	Halawa	0	0	0	0	0	0	0
	Koolau	24	0	0	0	424	0	400
DER		0	0	0	0	0	1,794	1,394
System Total Demand		1,829	1,829	1,829	1,829	1,829	1,829	1,829

Study results

High loading and overloading conditions are still observed on a few 138 kV lines in several study cases. A summary of the findings regarding transmission line high loading and overloading conditions are listed in Table 48. There is no voltage planning criteria violation identifed from the study.

Table 48 138 kV Line Overloading Summary, Oʻahu Land Constrained Scenario Resource Plan, Year 2050

Study Case	N-1 Contingency		N-2 Contingency	
	Overloading/High loading Line	Max. Loading (%)	Overloading/High loading Line	Max. Loading (%)
A	Archer-School	100	Halawa-Hoʻohana #1	99
	Archer-Iwilei	100	Halawa-Hoʻohana #2	98
B1	Archer-School	100	Halawa-Hoʻohana #1	98
	Archer-Iwilei	100	Halawa-Hoʻohana #2	97
	CEIP-Ewa Nui	96		
B2	Ewa Nui -Waiau #1	114	Ewa Nui-Waiau #1	100
	Ewa Nui -Waiau #2	113	Ewa Nui-Waiau #2	99
	Archer-School	100	Makalapa-Waiau #1	97
	Archer-Iwilei	100	Makalapa-Waiau #2	96
B2m1a	Archer-School	100	None	
	Archer-Iwilei	100		
C	Archer-School	101	None	
	Archer-Iwilei	100		
D	None		None	
E	None		None	

High loading and overloading is identified on the 138 kV underground cable Archer-School and Archer-Iwilei in several study cases. This is due to the system load increase. Simliar to what is observed and recommended in the base scenario resource plan 2050 study, either cable replacement (2 cables per phase of 3000KCM CU XLPE) for these two lines or peak load reduction by 37 MW (assuming load power factor is inductive 0.95) will mitigate the overloading and high loading issues.

Regarding the overloading and high loading on the remaining 138 kV overhead lines, by comparing study case A, B1, B2 and B2m1a, it is observed that relocating part of new 138 kV standalone BESS from Ewa Nui substation or Hoʻohana substation to east side of system, such as Halawa substation or Koʻolau substation will mitigate those high loading or overloading issue.

Mitigation study – transmission networks expansion

To mitigate the high loading and overloading on the 138 kV underground cables, cable replacement is recommended as Table 49, which is the transmission networks expansion solution for the 2050 in land constrained resource plan.

Table 49 Transmission Networks Expansion and High-Level Cost Estimate, Oʻahu Land Constrained Scenario Resource Plan, Year 2050

No.	Transmission Line	Upgrade Type	Conductore Requirements	Cost Estimate ($MM)
1	Archer-School #1	Cable Replacement	2 cables per phase of 3000KCM CU XLPE	166.6
2	Archer Iwilei #1	Cable Replacement	2 cables per phase of 3000KCM CU XLPE	178.5

Mitigation study – non-wire alternatives

Simliar as what is recommended in the base scenario resource plan 2050 study, an alternative for the cable replacement mitigation listed in the Table 49, could be a reduction in peak demand in areas supplied by Archer substation, Kewalo substation and Kamoku substation by 37 MW (assuming 0.95 inductive power factor). Also, generation congestion is identified on the west side and west central part of the system, interconnecting the grid-scale standalone BESS project on the east side of system will mitigate the generation congestion issue if dispatched to reduce west side generation.

High load scenario resource plan, year 2030

Study descriptions

By 2030, the Oʻahu system will have new generation from Stage 3 Oʻahu RFP procurement and initial REZ development. Specifically, there will be 450 MW RDG and 300 MW firm generation procured through the Stage 3 Oʻahu RFP activity, 510 MW RDG development from the REZ zone 1, 2 and 7, and 1,225 MW RDG development from the REZ zone 3, 4, 5 and 6. Most of these new generation will be interconnected at Oʻahu 138 kV system. The REZ development is expected to have both solar and wind generation. In this time frame, it is also planned to add 60 MW standalone BESS into system and remove 371 MW generation from Waiau power plant. System peak load will reach 1,595 MW in 2031, according to the forecast. The high load scenario resource plan has much more aggresive grid-scale generation projects interconnection schedule than that in the base scenario resource plan and land constrained scenario resource plan.

A high-level map for Oʻahu system with addtion of grid-scale resource is shown in Figure 21. The detailed system grid-scale resources changes are summerized in Table 50 and Table 51. System resource summary and the forecasted system load is summarized in Table 52.

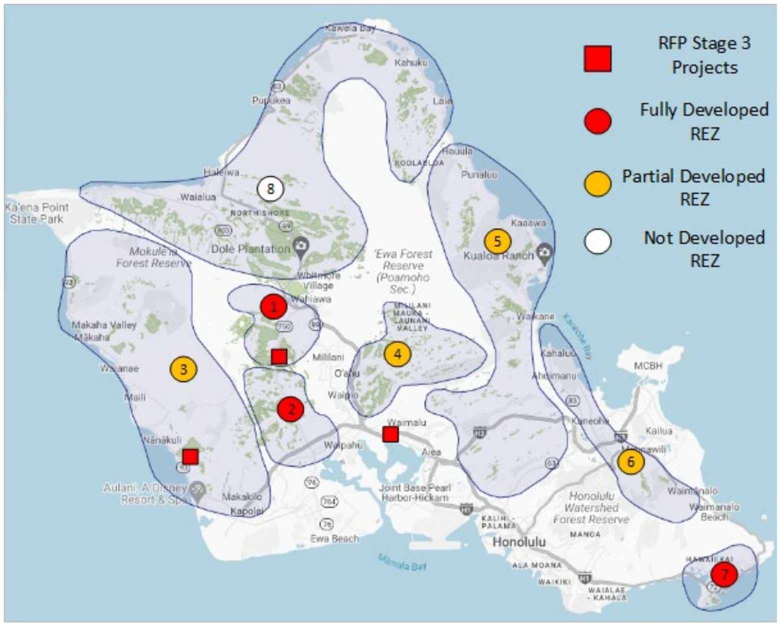


Figure 21 High-Level O‘ahu map, high load scenario resource plan, by 2030

Table 50 O‘ahu Grid-Scale Generation Project Development by 2030, High Load Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 O‘ahu RFP	Renewable Dispatchable Generation	450	2027	Central O‘ahu, West O‘ahu
	Firm Generation	300	2029	Central O‘ahu
REZ Development	Renewable Dispatchable Generation	510	2030	Zone 1, 2, and 7
		1,225	2030	Zone 3, 4, 5 and 6
Other	Standalone BESS	60	2030	138/46 kV Substations

Table 51 O‘ahu Grid-Scale Generation Removal by 2030

Removal	Generation Type	MW Capacity	Year	Location
Waiau 3, 4	Fossil Generation	94	2024	Waiau Power Plant
Waiau 5, 6		108	2027	
Waiau 7, 8		169	2029	

Table 52 O‘ahu System Resource Summary and Forecasted Demand (MW), High Load Scenario Resource Plan, Year 2030

Firm Generation	Onshore Standalone Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,462	123	168	2,419	195	1,147	1,595

Table 53 summarizes studied system generation dispatch for the 2030.

Table 53 Studied System Generation (MW) Dispatches, Oʻahu High Load Scenario Resource Plan, Year 2030

Region	Substation	Study Cases					
		A	B	C	Cm1a	D	E
West	HP, CIP	35	35	198	198	35	35
	CEIP	0	177	202	202	0	0
	Ewa Nui	324	336	336	276	0	0
	Kalaeloa	0	0	208	208	0	0
	Kahe	588	502	351	351	0	845
North	Hema/Akau	0	39	0	0	0	0
	Wahiawa	0	22	0	0	0	142
Central	Hoʻohana	120	232	0	0	232	87
	Mahi	0	120	0	0	120	120
	Waiau	331	66	300	300	363	366
East	Halawa	131	0	0	0	608	0
	Koolau	66	66	0	60	237	0
System Total Demand		1,595	1,595	1,595	1,595	1,595	1,595

Study results

Transmission line high loading and overloading conditions are identified in serval study cases, which are simliar to the findings in the base scenario resource plan, however, in later years. A summary of the high loading and overloading results are listed in Table 54. There is no steady state voltage violation identified from the study.

Table 54 138 kV Line Overloading Summary, Oʻahu High Load Scenario Resource Plan, Year 2030

Study Case	N-1 Contingency		N-2 Contingency	
	Overloading/High loading Line	Max. Loading (%)	Overloading/High loading Line	Max. Loading (%)
A	None		None	
B	Halawa-Hoʻohana #1	96	Halawa-Hoʻohana #1	103
			Halawa-Hoʻohana #2	101
C	Ewa Nui-Waiau #1	102	Halawa-Koʻolau	105
	Ewa Nui-Waiau #2	101	Makalapa-Airport	104
	Makalapa-Waiau #1	98	Koʻolau-Waiau #1	102
			Koʻolau-Waiau #2	102
			Makalapa-Waiau #1	101
			Iwilei-Airport	100
D	None		None	
E	None		Halawa-Koʻolau	104

			Koʻolau-Waiau #1	102
			Koʻolau-Waiau #2	102
			Halawa-Hoʻohana #1	98
			Halawa-Hoʻohana #2	96

Mitigation study – transmission networks expansion

To mitigate high loading and overloading issue identified fromt the study, transmission networks expansion, including both reconductor and adding new circuit, are proposed as listed in Table 55.

Table 55 138 kV Line Overloading Summary, Oʻahu High Load Scenario Resource Plan, Year 2030

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line	Upgrade Type	Conductor Requirements	
Waiau-Makalapa #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	46.4
Halawa-Ko`olau	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	110.5
Halawa-Ko`olau	New Line, 138 kV	One circuit, with 1590 AAC conductor	114.4
Ko`olau-Waiau #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	149.6
Ko`olau-Waiau #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	158.8
Kahe-Hoʻohana #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	96.6
Kahe-Hoʻohana #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	87.7
Hoʻohana-Halawa #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	143
Hoʻohana-Halawa #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	150.9
Ewa Nui – Waiau #1	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	80.5
Ewa Nui – Waiau #2	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	80.9

Mitigation study – portfolio alternatives

Same as previous study results, a non-wire alternative for deferring the reconductor of Ewa Nui-Waiau #1 and #2 reconductoring is to reduce interconnection MW size at Ewa Nui substation of future generation projects from REZ zone 2 development by 150 MW.

REZ Enablement

Based on the REZ enablement cost estimate for each MW generation in all REZ zones, a REZ enablement cost estimate for REZ project interconnection by year 2030 is listed in Table 56. Since there is no detailed inforamtion regarding a breakdown of the 1,225 MW development from zone 3 to 6 for each zone, only a range of cost estimate is provided by assuming the 1,225 MW development come from the lower cost zones or higher cost zones.

Table 56 Oʻahu REZ Enablement Cost Estimate for REZ Development by 2030

REZ Zone	1	2	3	4	5	6	7
Cost ($MM) per MW	0.21	0.27	1.32	0.82	1.51	0.62	N/A
REZ Enablement ($MM)	24.6	87.6	1,378.8-1,718.0				N/A

High load scenario resource plan, year 2035

Study descriptions

In addtion to previous system resource changes by 2030, by 2035, the Oʻahu system will have 95 MW grid-scale standalone BESS and 600 MW offshore wind. There is no further development of REZ between 2031 and 2035. There will be 208 MW firm generation interconnected at the Kalaeloa substation. By 2035, the BESS MWh of the PV/BESS projects developed in REZ zones in 2030 will be increased as well. According to the forecast, system annual peak load will reach 1,776 MW by 2036. A high-level map for Oʻahu system with addtion of grid-scale resource is shown in Figure 22. The detailed system grid-scale resources changes are summerized in Table 50 and Table 51. System resource summary and the forecasted system load is summarized in Table 52.

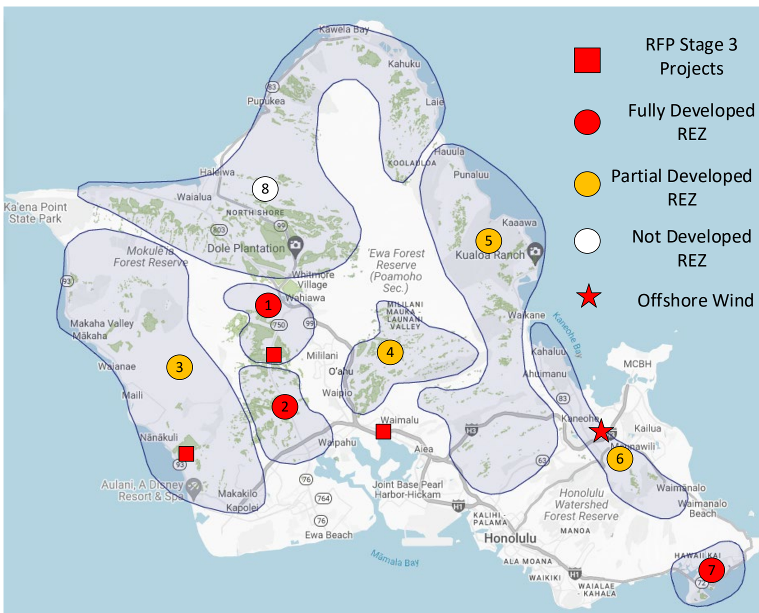


Figure 22 High-Level Oʻahu map, high load scenario resource plan, by 2030

Table 57 Oʻahu Grid-Scale Generation Project Development by 2035, High Load Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
Others	Firm Generation	208	2033	Kalaeloa Substation
	Standalone BESS	95	2035	138/46 kV substations
	Offshore wind	600	2035	Koʻolau 138 kV substation

Table 58 Oʻahu Grid-Scale Generation Removal by 2035

Removal	Generation Type	MW Capacity	Year	Location

Kahuku Wind	Onshore Wind	30	2031	Kahuku 46 kV substation
Kapolei Sustainable Energy Park	Solar	1	2032	Kahe substation
Kalaeloa Solar	Solar	5	2032	KS substation
Kahe 1, 2	Fossil	165	2033	Kahe substation
Kalaeloa Power Plant	Fossil	208	2033	KPLP substation
KREP	Solar	5	2034	KREP substation

Table 59 O'ahu System Resource Summary and Forecasted Demand (MW), High Load Scenario Resource Plan, Year 2030

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,297	93	600	157	2,419	290	1,271	1,776

Table 60 summarizes studied system generation dispatch for the 2035. Study case D represents a scenario in which the 600 MW offshore wind is dispatched, and majority of system load is supplied by the east side generation. Also, it is worth noting that the transmission network expansion in the 2030 study is included in the model for this 2035 study.

Table 60 Studied System Generation (MW) Dispatches, O'ahu High Load Scenario Resource Plan, Year 2035

Region	Substation	Study Cases						
		A	B	C	Cm1	Cm1a	D	E
West	HP, CIP	35	35	198	198	198	35	35
	CEIP	0	177	202	202	202	0	36
	Ewa Nui	324	336	336	336	306	0	0
	Kalaeloa	0	0	208	0	208	0	0
	Kahe	588	683	551	551	551	0	845
North	Hema/Akau	0	39	0	0	0	0	0
	Wahiawa	0	22	0	0	0	0	142
Central	Ho'ohana	120	232	0	0	0	0	232
	Mahi	0	120	0	0	0	0	120
	Waiau	331	66	281	489	281	296	366
East	Halawa	305	0	0	0	0	608	0
	Koolau	73	66	0	0	30	837	0
System Total Demand		1,776	1,776	1,776	1,776	1,776	1,776	1,776

Study results

Significant transmission line high loading and overloading conditions are identified from the study results, which are summarized in Table 61. The high loaded and overloaded transmission lines indicate both generation congestion and high system loading issue. More importantly, the study results also indicates that when system load reach closing to 1.8 GW magnitude, system generation dispatch should maintain certain balance between east, central and west of system, or large amount of power transfer from one side to another side of system would cause trasmission line overloading. Study does not identify any steady state voltage planning criteria violation.

Table 61 138 kV Line Overloading Summary, O'ahu High Load Scenario Resource Plan, Year 2035

Study Case	N-1 Contingency		N-2 Contingency	
	Overloading/High loading Line	Max. Loading (%)	Overloading/High loading Line	Max. Loading (%)
A	Archer-School	97	Makalapa-Airport	105
	Archer-Iwilei	97	Halawa-Iwilei	103
			Halawa-School	103
			Iwilei-Airport	101
B	Ewa Nui-Waiau #1 and #2	101	Makalapa-Airport	104
	Archer-School	96	Halawa-Iwilei	102
	Archer-Iwilei	96	Halawa-School	102
			Iwilei-Airport	100
			Waiau-Mahi	97
C	Ewa Nui-Waiau #1	112	Makalapa-Airport	108
	Ewa Nui-Waiau #2	111	Halawa-Iwilei	103
	Archer-School	96	Halawa-School	102
	Archer-Iwilei	96	Iwilei-Airport	103
			Ewa Nui-Waiau #1	96
			Ewa Nui-Waiau #2	96
Cm1	Archer-School	96	Makalapa-Airport	114
	Archer-Iwilei	96	Halawa-Iwilei	103
			Halawa-School	102
			Iwilei-Airport	111
			Makalapa-Waiau	97
D	Archer-School	97	Makalapa-Airport	104
	Archer-Iwilei	97	Halawa-Iwilei	103
			Halawa-School	102
			Iwilei-Airport	101
E	Archer-School	96	Makalapa-Airport	103
			Halawa-Iwilei	102
			Halawa-School	101
			Iwilei-Airport	99
			Waiau-Mahi	96

Mitigation study – transmission networks expansion

To mitigate high loading and overloading issue identified fromt the study, transmission networks expansion, including both reconductor and adding new circuit, are proposed as listed in Table 62.

Table 62 138 kV Line Overloading Summary, O'ahu High Load Scenario Resource Plan, Year 2035

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line	Upgrade Type	Conductor Requirements	
Makalapa-Airport	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	23.9
Halawa-School	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	69.1
Halawa-Iwilei	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	185
Airport-Iwilei	Re-conductor	One circuit, re-conductor to double-bundled 795 AAC	119.9

For the high loading condition on Archer-Iwilei and Archer-School lines, it is recommend to keep monitoring on the two lines, and prepare solutions to reduce peak load on the related substations (i.e., Archer, Kewalo and Kamoku) to avoid these two underground cable having overloading issue.

Mitigation study – portfolio and/or non-wire alternatives

Due to the magnitude of overloading conditions, identification of portfolio change or non-wire alternative of the proposed mitigation solution in Table 62 is not pursued in this study. The non-wire alternative can be re-evaluated when more detailed information regaridng system is obtained, such as detailed load forecast and future generation interconnection locations.

REZ Enablement

There is no REZ development between 2021 and 2035. The cost for interconnecting 600 MW offshore wind at Koʻolau substation is $50.6 million, without the cost of transmisison networks expansion, which was estimated in the 2021 REZ study.

4.1.2 Dynamic Stability Study

The O’ahu system in near-term years 2027 and 2035 for both the base scenario resource plan and land constrained resource plan are selected for performing dynamic stability study to evaluate system dynamic stability performance. Considering the O’ahu system has similar grid-scale generation resources by the RFP Stage 3 GCOD in both plans, only the base scenario resource plan is studied for 2027. Both resource plans are studied for the 2035.

System generation dispatch for daytime peak load with high DER generation, which poses the highest risk to the system stability according to the past studies, is modeled for the dynamic stability study, with simulations of a high-risk contingency. The high-risk contingencies for O’ahu system are 1) P3 planning event - the largest GFM resource is out-of-service, and a three-phase fault happens at gentie of another grid-scale GFM resource resulting in the loss of the GFM resource, and 2) P5 planning event - delayed fault clearing of a three-phase fault on a transmission line close to load center.

Base scenario resource plan, year 2027

Study descriptions and study results

According to the resource plan, a system generation dispatch that represents daytime peak load with high DER generation scenario is created (as Table 63) and modeled in PSCAD/EMTDC.

Table 63 System Generation Dispatch for Daytime Peak Load High DER Generation Scenario, O’ahu Base Scenario Resource Plan, Year 2027

Generation Station	Dispatched (MW)	Gen/System Load (%)	Capacity (MW)
H-Power	35	2.8	68.5
Waiver Standalone PV	117	17.2	168
Stage 1 PV/BESS (GFL)	101		140
KES (GFM)	0	27	135
Stage 2 PV/BESS (GFM)	69		94
Stage 3 PV/BESS (GFM)	273		450
Wind	0	0	123
DER	670	53	1,004
System Load (MW)	1,265		
GFM MW Headroom (Excluding KES)/DER Generation	0.3		

PSCAD simulations with a total simulation time of 25 seconds are performed with three-phase to ground faults applied at 10 seconds. For the simulated P3 planning event, it is assumed that the KES is out of service before the fault happens. Simulation results for the P3 planning event are shown in Figure 23 and for the P5 planning event are shown in Figure 24.

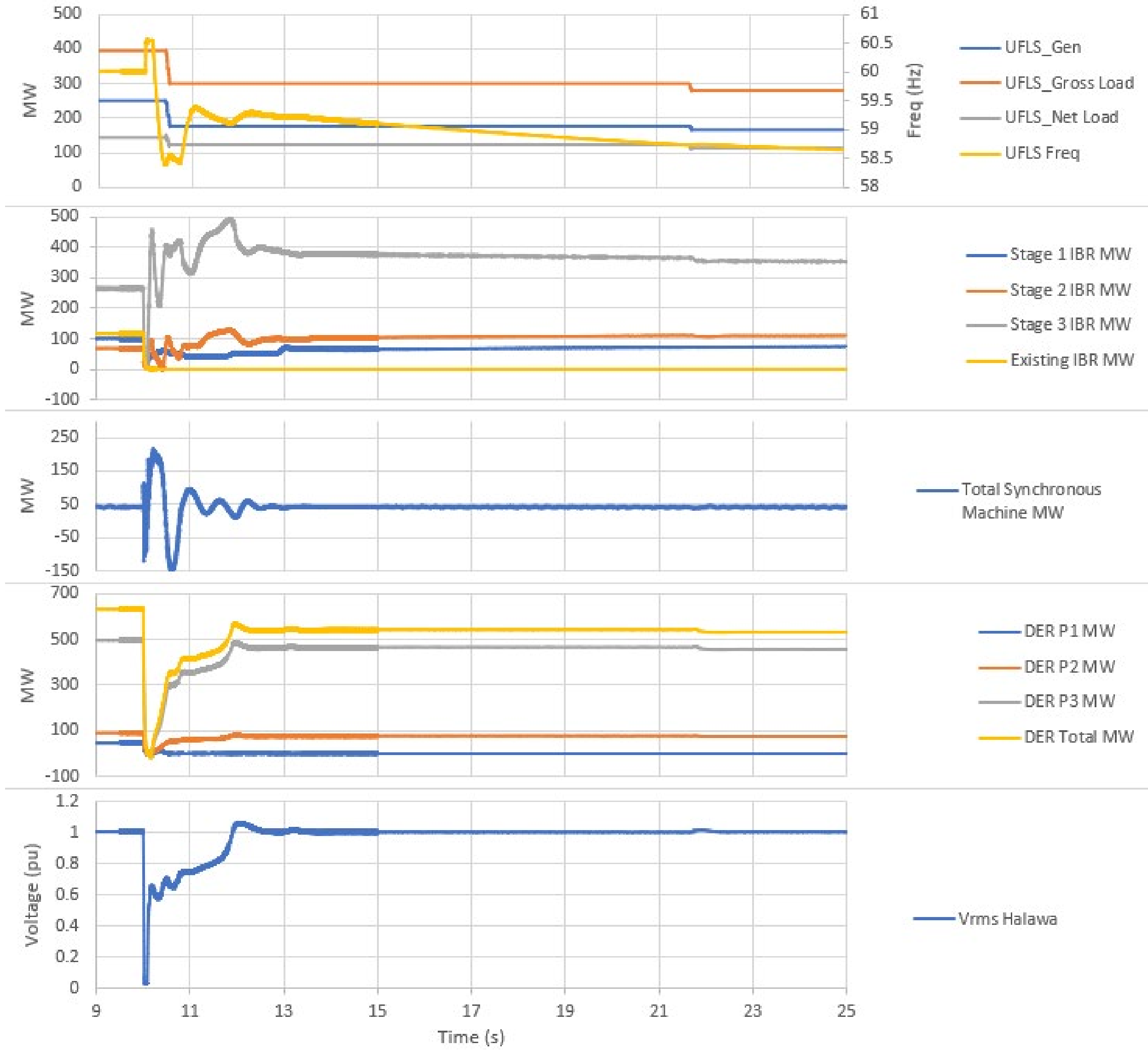


Figure 23 Dynamic stability simulation results, O'ahu base scenario resource plan, year 2027, P3 planning event

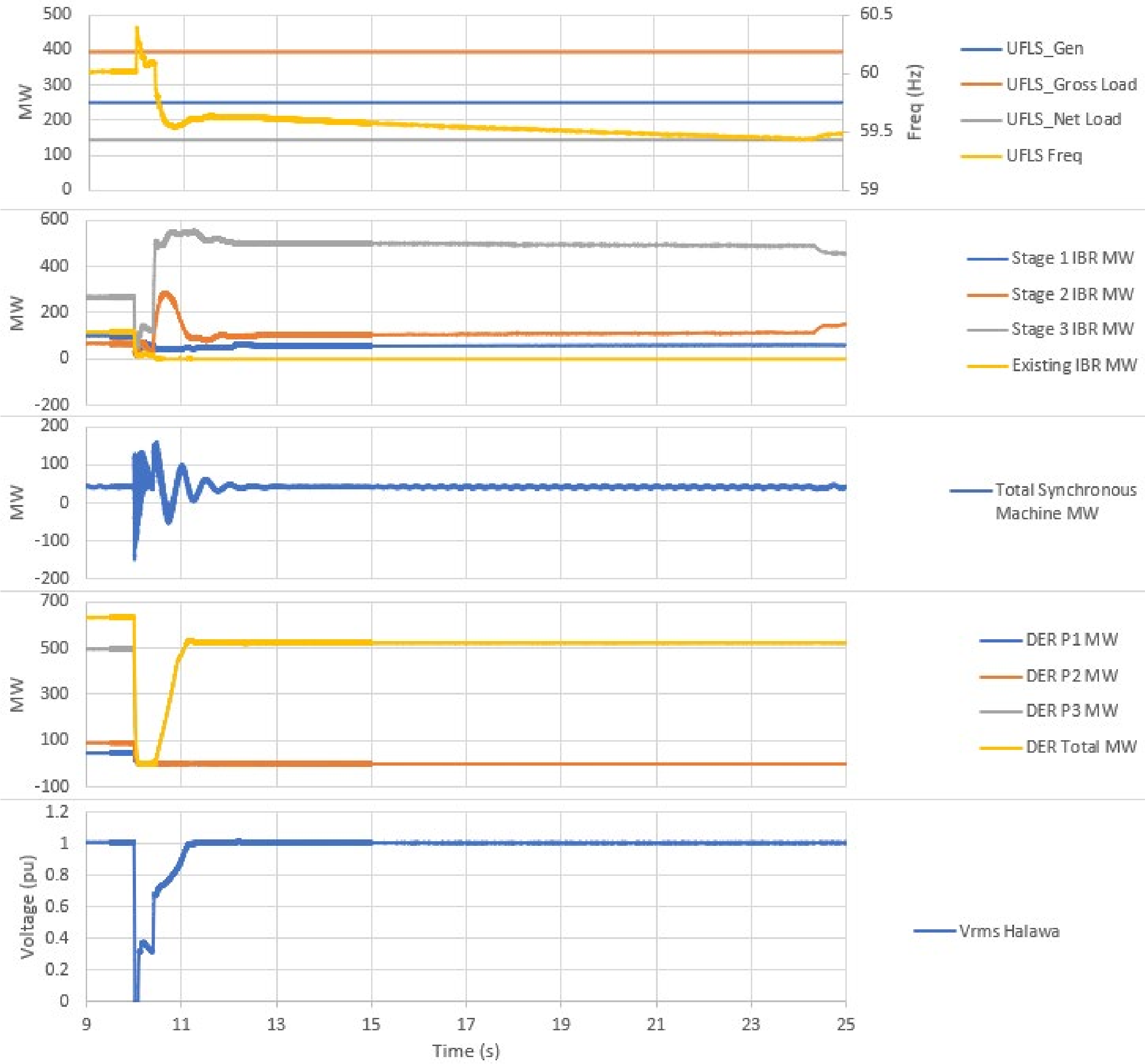


Figure 24 Dynamic stability simulation results, O'ahu base scenario resource plan, year 2027, P3 planning event

The PSCAD simulation results indicate two stages of UFLS in the P3 planning event, which is a severe planning criteria violation. Acceptable dynamic stability performance is observed in the P5 planning event. In the P3 planning event, frequency nadir reaches below 58.5 Hz; however, in the P5 planning event, frequency nadir still maintains above 59.5 Hz, which indicate sufficient stability margin during the event. The results comparison between the studied P3 planning event and the studied P5 planning event indicates the P3 planning event poses higher stability risk to the O'ahu system.

According to the past studies, maintaining available contingency reserve in the form of MW headroom (i.e., contract MW capacity minus dispatched MW generation) on GFM resources is critical for maintaining system stability and avoiding excessive UFLS. To mitigate the planning criteria violation identified from the P3 planning event, system generation is re-dispatched by turning on more synchronous machine-based generation and reducing the dispatch of the Stage 2 and 3 project GFM generation to ensure contingency reserve from GFM resources. The re-dispatched system generation dispatch is shown in Table 64. After the re-dispatch, system available MW headroom from GFM resource (excluding KES) over DER generation increase to 0.5 from the previous 0.3. The P3 planning event results with this updated system generation dispatch. Simulation results are shown in Figure 25. For GFM provided from paired energy resources, operational interfaces to support management of contingency reserve may be require additional consideration over that considered in the present requirements. The simulation results indicate that after the system generation re-dispatch (i.e., dispatching more synchronous machine generation to provide contingency reserve from GFM resources), system stability can be maintained within planning criteria. However, system frequency nadir is still below 59 Hz (the triggering point of the first stage of the instantanous UFLS is 58.9 Hz), which indicates very limited stability margin of the system during the simulated system event.

It is worth noting that even though the minimum contingency reserve has been defined as a ratio of available MW headroom from GFM resources over DER generation, to achieve the desired ratio required more synchronous machine-based resources be online in order create the reserve headroom on GFM, assuming the available GFM IBR in the resource plans. Therefore, the results represent the response of the increased GFM contingency reserve and required online synchronous machine-based resources which also provide effective contribution toward maintaining system stability. It is possible that adding more GFM resource into the resource plans may provide the needed system stability without requiring operation of synchronous machines; this could be confirmed through additional study.

Table 64 System Generation Dispatch for Daytime Peak Load High DER Generation Scenario, O'ahu Base Scenario Resource Plan, Year 2027

Generation Station	Dispatched (MW)	Gen/System Load (%)	Capacity (MW)
H-Power, KPLP	168	13	277
Waiver Standalone PV	117	17	168
Stage 1 PV/BESS (GFL)	101		140
KES (GFM)	0	17	135
Stage 2 PV/BESS (GFM)	0		94
Stage 3 PV/BESS (GFM)	209		450
Wind	0	0	123
DER	670	53	1,004
System Load (MW)	1,265		
GFM MW Headroom (Excluding KES)/DER Generation	0.5		

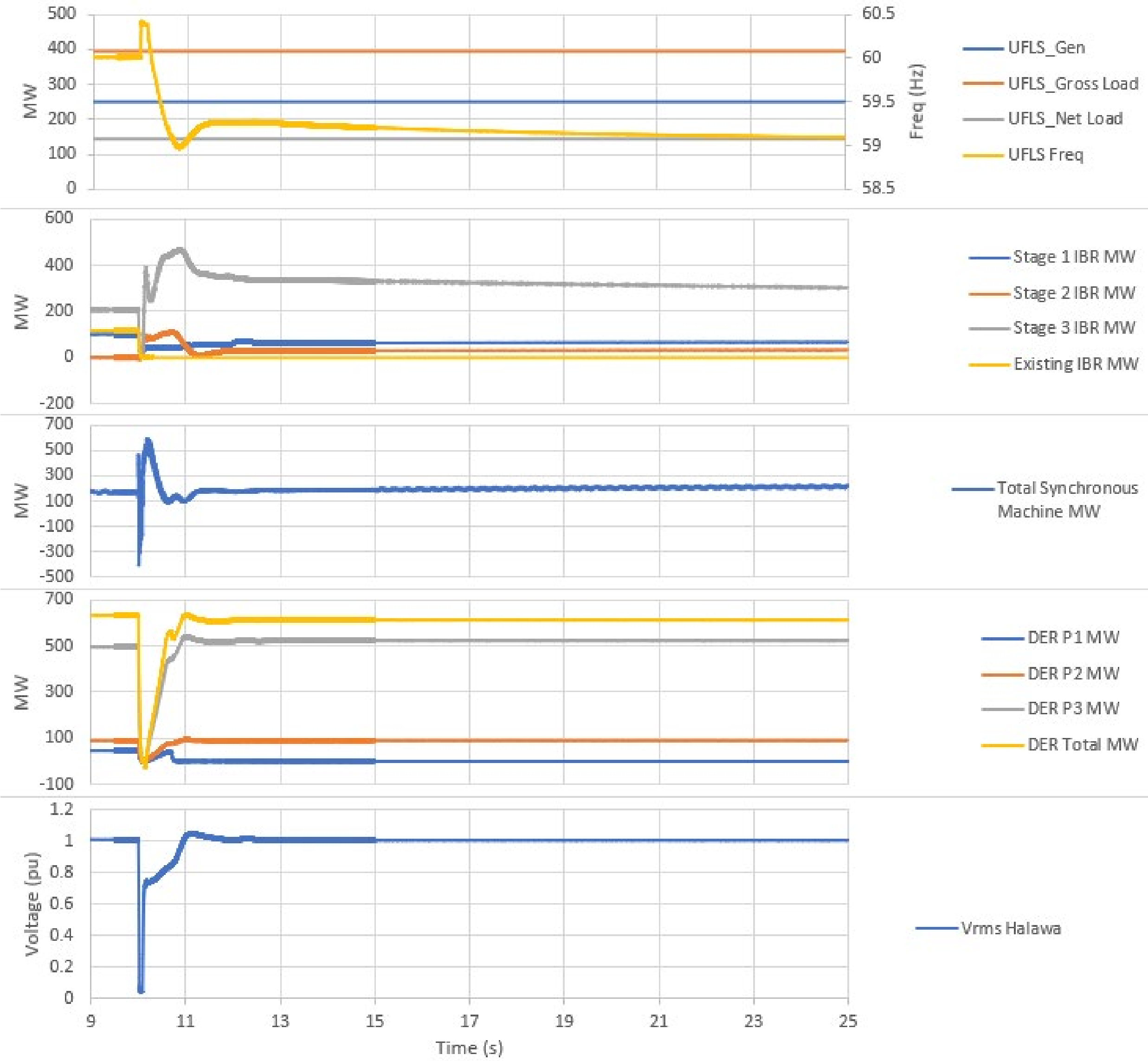


Figure 25 Dynamic stability mitigation study results, O'ahu base scenario resource plan, year 2027, P3 planning event, with system re-dispatch

Base scenario resource plan, year 2035

Study descriptions and study results

According to the resource plan, a system generation dispatch that represents daytime peak load with high DER generation scenario for 2035 is created (as Table 65) and modeled in PSCAD/EMTDC. In this dispatch, due to the REZ development and new grid-scale standalone BESS interconnected to the system, the O'ahu system has much more grid-forming resources than in 2027. The ratio of available MW headroom from GFM resources (exclude KES) over DER generation reaches 1.65. The P3 planning event is simulated in this system model, and results are shown in Figure 26.

Table 65 System Generation Dispatch for Daytime Peak Load High DER Generation Scenario, O'ahu Base Scenario Resource Plan, Year 2035

Generation Station	Dispatched (MW)	Gen/System Load (%)	Capacity (MW)
H-Power	47	3	68.5
Waiver Standalone PV	117	10	168
Stage 1 PV/BESS (GFL)	19		140
KES (GFM)	0	13	135
Stage 2 PV/BESS (GFM)	13		94
Stage 3 PV/BESS (GFM)	167		450
REZ	148	11	1,053
New Standalone BESS (GFM)	0	0	147
Wind	0	0	123 + 400
DER	858	63	1,295
System Load (MW)	1,369		
GFM MW Headroom (Excluding KES)/DER Generation	1.65		

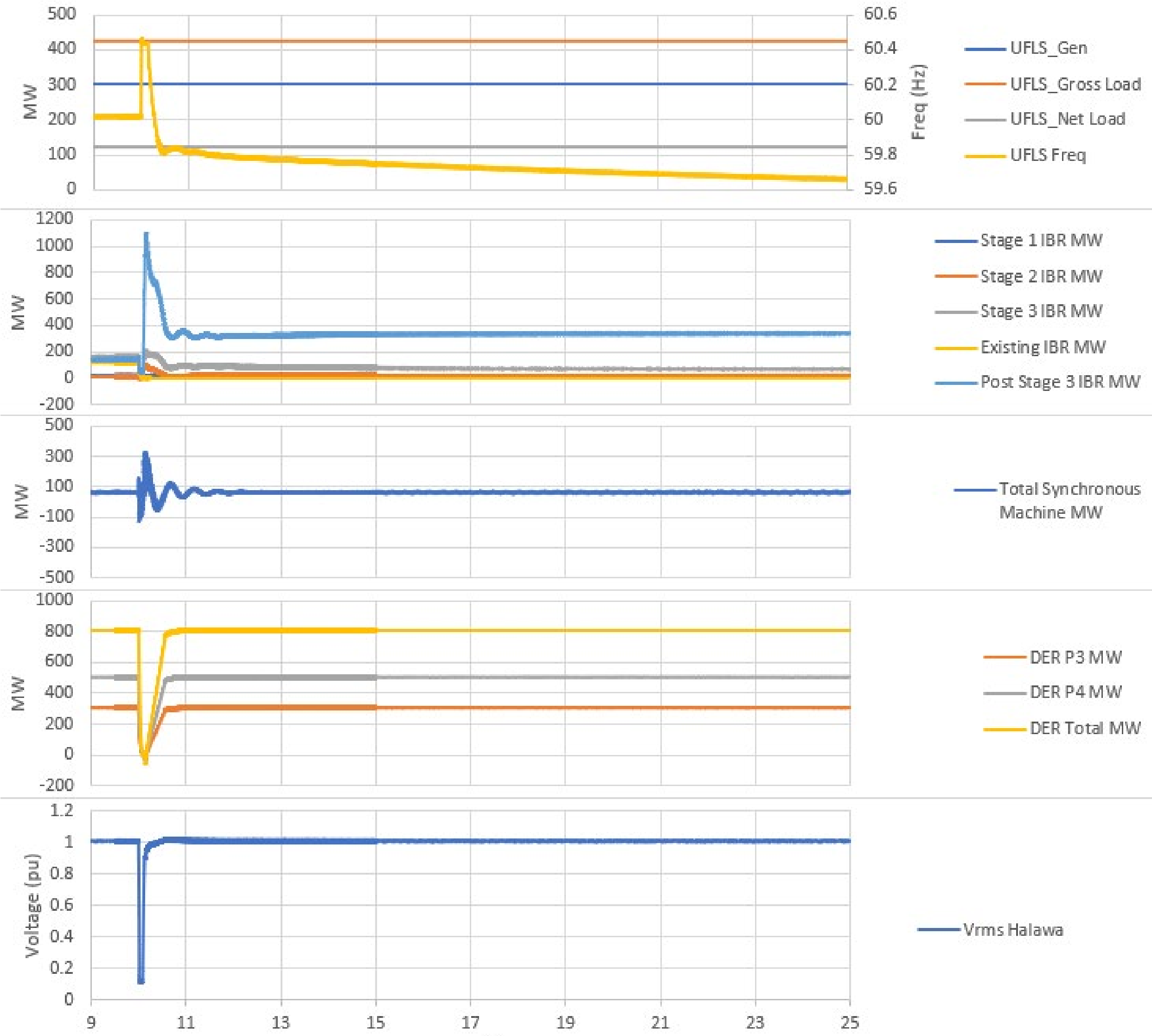


Figure 26 Dynamic stability study results, O'ahu base scenario resource plan, year 2035, P3 planning event

Simulation results indicate that the O'ahu system stability performance is within planning criteria limit and has sufficient stability margin.

Land constrained scenario resource plan, year 2035

Study descriptions and study results

In the land constrained scenario resource plan, it is assumed that the REZ development will not happen. Instead, after the RFP Stage 3 GCOD, grid-scale resources will be only offshore wind and standalone BESS. Since at the time of performing this study, offshore wind GFM technology is not commercially available, it is assumed that the offshore wind will not provide GFM type stability response in the study scope. According to the resource plan, a system generation dispatch that represents daytime peak load with high DER generation scenario for 2035 is created (as Table 66) and modeled in PSCAD/EMTDC. The P3 planning event is simulated in this system model, and results are shown in Figure 27.

Table 66 System Generation Dispatch for Daytime Peak Load High DER Generation Scenario, O'ahu Land Constrained Scenario Resource Plan, Year 2035

Generation Station	Dispatched (MW)	Gen/System Load (%)	Capacity (MW)
H-Power	68	5	68.5
Waiver Standalone PV	117	14	168
Stage 1 PV/BESS (GFL)	79		140
KES (GFM)	0	22	135
Stage 2 PV/BESS (GFM)	52		94
Stage 3 PV/BESS (GFM)	243		450
New Standalone BESS (GFM)	0	0	147
Wind	0	0	123 + 509
DER	810	59	1,295
System Load (MW)	1,369		
GFM MW Headroom (Excluding KES)/DER Generation	0.44		

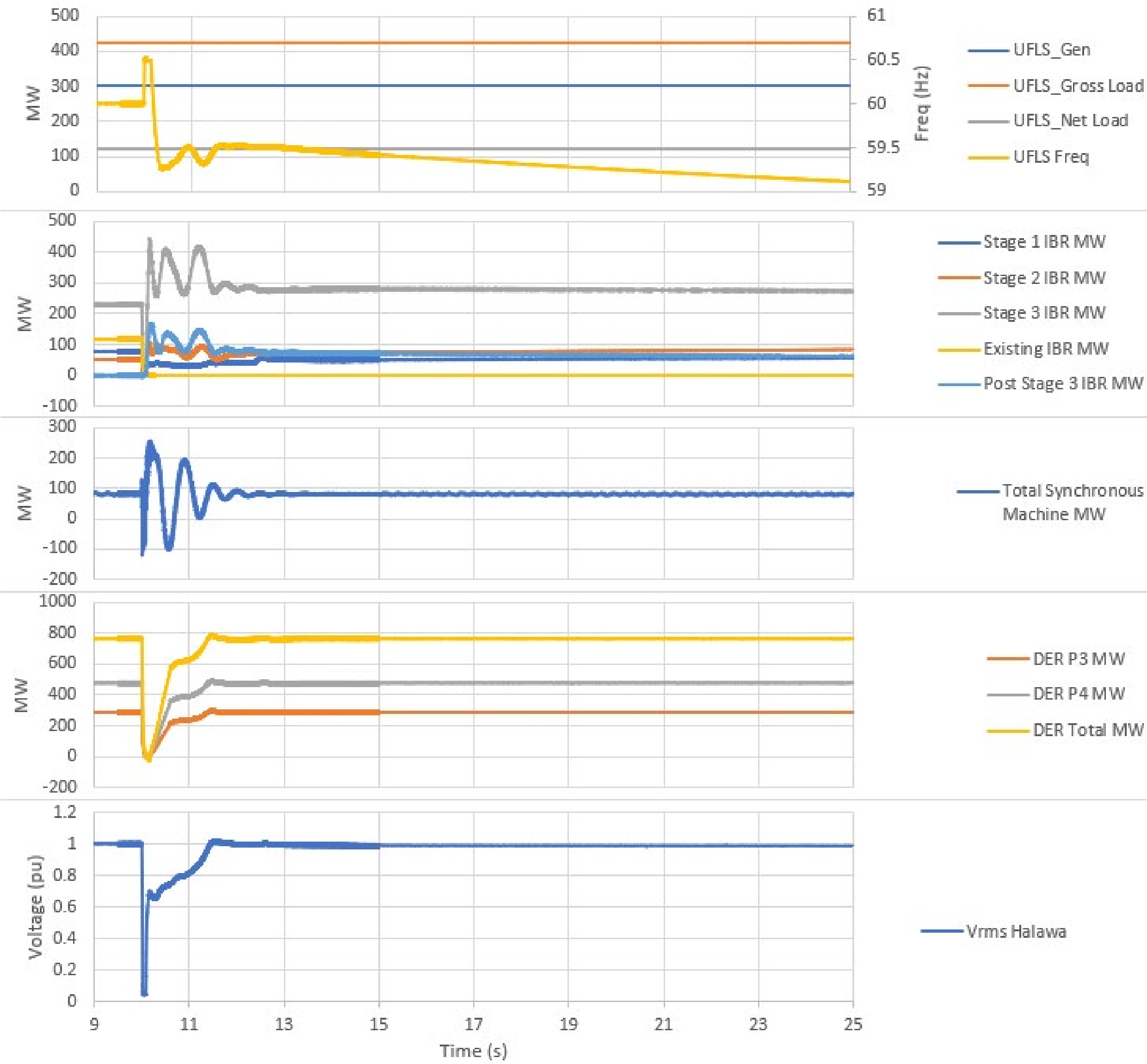


Figure 27 Dynamic stability study results, O'ahu land constrained scenario resource plan, year 2035, P3 planning event

UFLS is not identified from the 25 seconds simulation results, which means system stability performance stays within the planning criteria. However, considering the trend of the frequency, without adding more active power generation to the grid, the frequency my trigger the kicker block or the first block of UFLS if the simulation time is longer than 25 seconds.

To better understand the stability margin of the study case for the year 2035 in the land constrained scenario resource plan, the same P3 planning event is simulated with one more GFM resource offline due to maintenance prior to the system event. In this case, the ratio of available MW headroom from GFM resources over DER generation reduces to 0.36 from 0.44. Simulation results are shown in Figure 28.

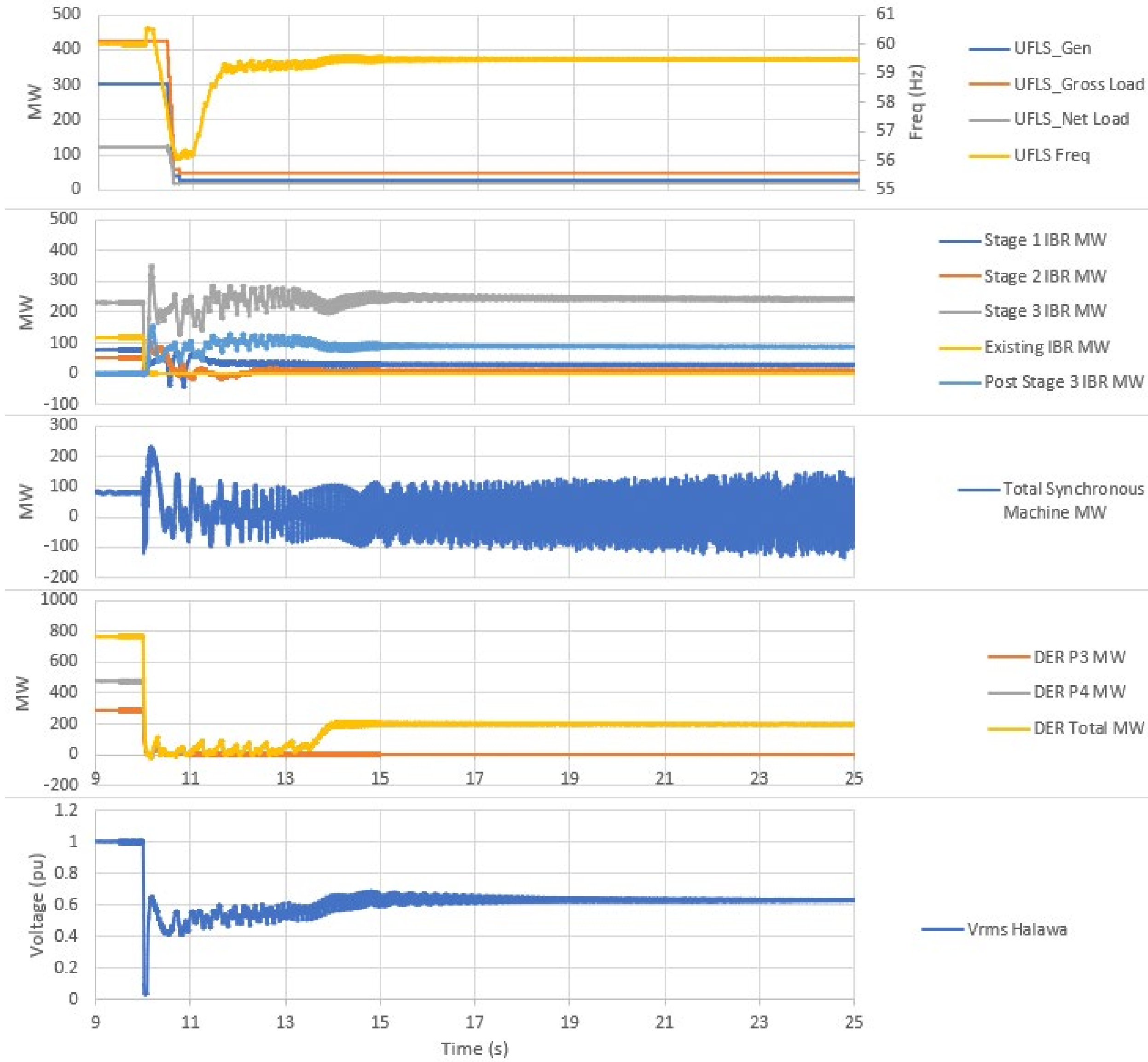


Figure 28 Dynamic stability study results, O'ahu land constrained scenario resource plan, year 2035, P3 planning event, with one more GFM resource out-of-service

For the examined case, system collapse was observed. These results indicate that even though for a regular P3 planning event the system does not have any UFLS load shedding (as Figure 27), the system would not survive the same fault with one more GFM resource pre-event outage. Therefore, system stability margin is limited and a higher ratio of available MW headroom from GFM resource over DER generation is required.

During the Stage 3 Quick Stability Study, a PSCAD simulation was performed for system generation dispatch with daytime peak load high DER generation in 2030 with a P3 planning event. The system generation dispatch is created according to an outdated land constrained scenario resource plan which has more grid-scale standalone BESS resources and achieve 0.7 of avaiable MW headroom from GFM resource over DER generation. This can be observed by comparing the system generation dispatch (in Table 67) studied in the Stage 3 Quick Stability Study and the dispatched studied in the current 2022

IGP system security study (shwon in Table 66). The simulation results obtained in the Stage 3 Quick Stability Study are shown in Figure 29, which indicates system stability performance within planning criteria and sufficient stability margin.

Table 67 System Generation Dispatch for Daytime Peak Load High DER Generation Scenario, O'ahu land constrained scenario resource plan (GNA Stage 3), year 2030

Generation Station	Dispatched (MW)	Gen/System Load (%)	Capacity (MW)
H-Power, New Firm (assumed as LM6000 unit)	102	8	211
Waiver Standalone PV	117	10	168
Stage 1 PV/BESS (GFL)	11		140
KES (GFM)	0	20	135
Stage 2 PV/BESS (GFM)	0		94
Stage 3 PV/BESS (GFM)	262		450
New Standalone BESS (GFM)	0	0	321
Wind	15	1	123 + 509
DER	770	60	1,030
System Load (MW)	1,279		
GFM MW Headroom (Excluding KES)/DER Generation	0.7		

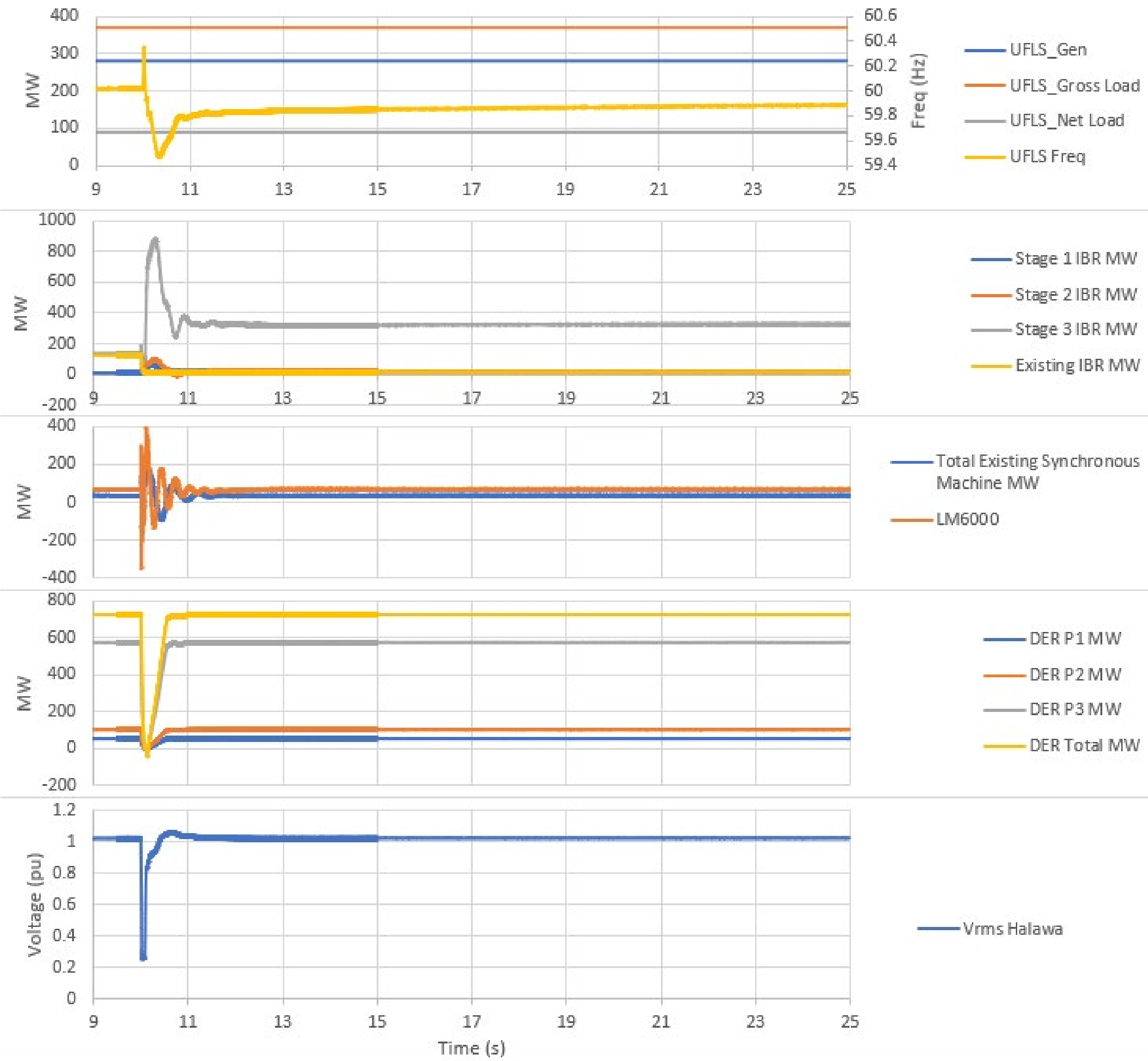


Figure 29 Dynamic stability study results, O'ahu land constrained scenario resource plan (GNA Stage 3), year 2030, P3 planning event

In addition to short term frequency stability, the systems voltage recovery performance post fault clearing is also analyzed by comparing the rms voltage at the Halawa bus from all forementioned simulation cases for the P3 planning event. Generally, with faster voltage recovery, generation resources can recover to pre-disturbance generation levels faster and the system has better stability performance as well as a lower chance of having fault induced delayed voltage recovery ("FIDVR"). The comparison is shown in Figure 30, which illustrates different system voltage recovery performance under different amount of available grid forming resources. With more available GFM resources (i.e., higher the ratio of available MW headroom from GFM resource over DER generation), system voltage recovery is faster. The fewer GFM resource, voltage recovery is slower. Once the recovery time is beyond a certain limit, system will have high risk of not being able to recover voltage post fault clearing, which means system collapse. Based on this observation, and past studies, it is recommended that at any time for O'ahu system the ratio of available MW headroom from GFM resources over DER generation should be no lower than 0.7. This study assumes that the GFM resources have adequate energy (MWh) to support and ride through the examined contingencies. Additionally, because of existing limitations in the "state of the art" of EMT modeling of IBR the DC energy source representation is idealized for the GFM resources. To provide adequate dynamic support the GFM resources should be operated to maintain adequate energy (MWh) to respond to system events.

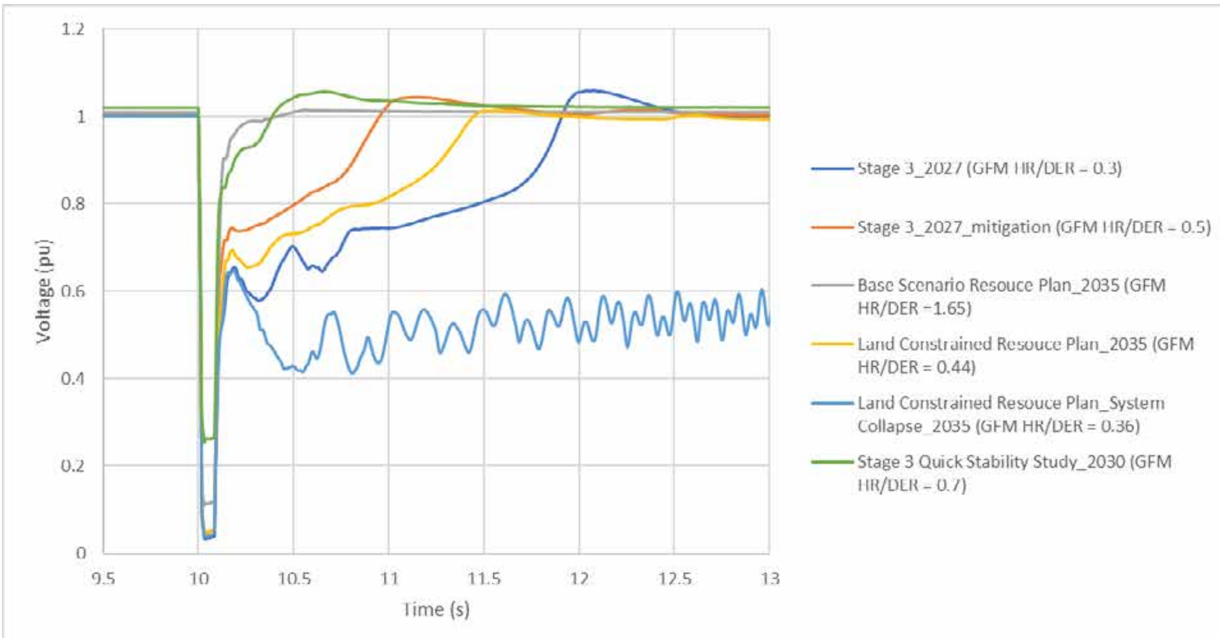


Figure 30 Comparison of system voltage recovery performance post fault clearing

4.2. Maui System Study Results

4.2.1 Steady state analyses

Base scenario resource plan, year 2027

Study descriptions

By 2027, the Maui system will have new generation from Stage 3 RFP procurement which will be 171 MW RDG and 36 MW firm generation, interconnected to Maui 69 kV system. Meanwhile, by 2027, the Maui system will finish Waena switchyard construction, Kahului Power Plant ("KPP") retirement and conversion of KPP K3 and K4 units to synchronous condensers, and Maalaea Power Plant ("MPP") unit 10-13 retirement. The system peak load is forecasted to reach 207 MW by 2028. High-level locations of the RFP Stage 3 projects assumed in the study and planned REZ zones are shown in Figure 31. It is assumed in the study that the RFP Stage 3 projects will be interconnect at Lahainaluna substation (60 MW), MPP-Waiinu line (30 MW via a new substation STG 3.1), MPP-Lahainaluna line (30 MW via a new substation STG 3.2), KWP 1 substation (30 MW) and Kealahou substation (21 MW). The 60 MW line interconnection generation is shown in a high-level one line diagram as Figure 32. The 36 MW firm generation is assumed to be interconnected at Waena switchyard. The detailed system grid-scale resources changes are summerized in Table 68 and Table 69. By 2028, system annual peak load forecast is 207 MW, which is used for the study for this year. System resource summary and the forecasted system load is summarized in Table 70.

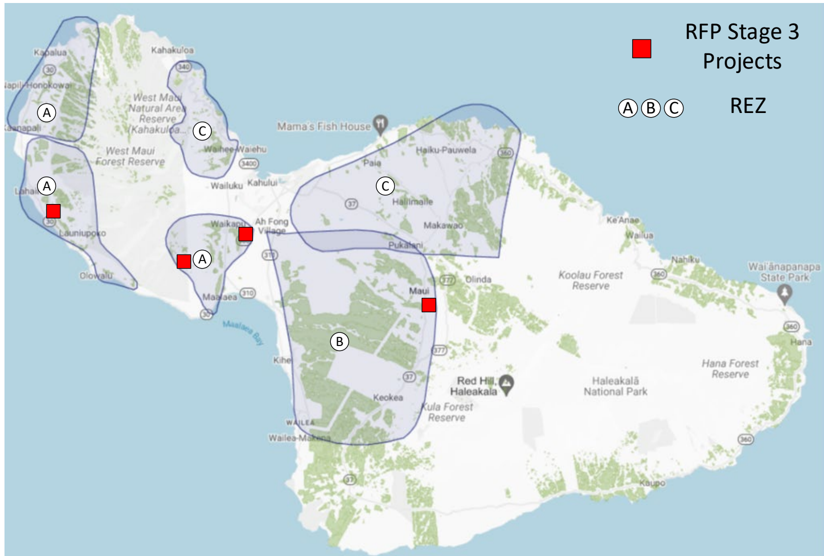


Figure 31 High-Level Maui map for assumed RFP Stage 3 project locations by 2027

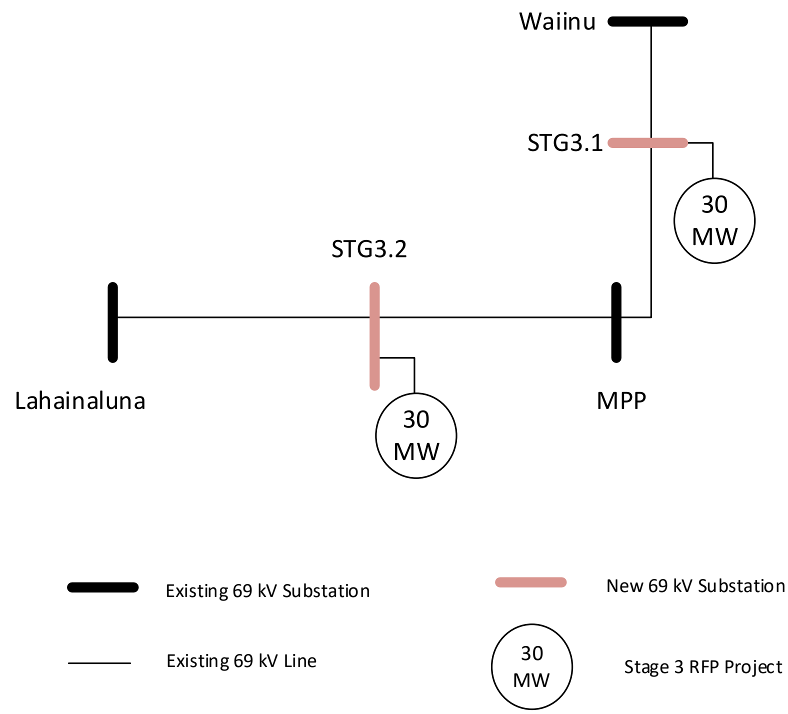


Figure 32 High-Level single line diagram for the two line interconnection RFP Stage 3 projects, Maui system base scenario resource planning, year 2027

Table 68 Maui Grid-Scale Generation Project Development by 2027, after RFP Stage 2, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location

Stage 3 Maui RFP	Renewable Dispatchable Generation	171	2027	West Maui, Central Maui and South Maui
	Firm Generation	36	2027	Central Maui

Table 69 Maui Grid-Scale Generation Removal by 2027

Removal	Generation Type	MW Capacity	Year	Location
Kaheawa Wind Power 1	Wind Generation	30	2027	KWP 1 substation
Kahului 1-4	Fossil Generation	32.5	2027	Kahului Power Plant
Maalaea 10-13	Fossil Generation	49.4	2027	Maalaea Power Plant

Table 70 Maui System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2027

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
197.5	42	296	40	170.7	207

Table 71 summarizes studied system generation dispatches for the 2027. The studied dispatches represent all possible combinations of differnt REZ zones supplying Maui system load.

Table 71 Studied System Generation (MW) Dispatches, Maui Base Scenario Resource Plan, Year 2027

Aggregated Generation Capacity Rating (MW)		Zone A	Zone B*	Zone C*	Zone A+C	All Zones
Zone A	161	161	0	0	160	70
Zone B	313.5	46	207	106	0	70
Zone C	101	0	0	101	101	67
Total Load	207	207	207	207	207	207

*Studied variation of dispatches in the zone

Study results

Power flow simulations are performed for all stuided system generation dispatches with normal system configuration and N-1 contingency configurations. From the study results for system with normal configuration, there are no steady state voltage planning criteria violations or transmission element loading violations. For the system with N-1 contingency configurations, transmission line overloadng is identified, which is shown as percentage of conductor emergency rating. Steady state voltages are within planning criteria acceptable limits. A brief summary of identified overloading results are listed in Table 72.

Table 72 List of Overloaded Transmission Elements, Maui Base Scenario Resource Plan, Year 2027

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	Overloading Element	Max. Loading (%)	Overloading Element	Max. Loading(%)
Zone A	None		Lahaina-Lahainaluna 69kV Line	126

Zone B_1	None	None	
Zone B_2	None	None	
Zone C_1	None	None	
Zone C_2	None	Wailea-Auwahi 69kV Line	102
Zone A+C	None	None	
All Zones	None	None	

Mitigation study – transmission networks expansion

To mitigate the transmission line overloading conditions listed above, reconductoring of the overloading transmisison lines is proposed. The interconnecting 60 MW at the Lahainaluna substation in west Maui would also result in a Single Point of Failure MW value of 60 MW occurring when the MPP-Lahaina line is out of service. To solve this issue, it is propsed to add a normally closed circuit breaker at Mahinahina Substation to connect the west Maui Lahainaluna-Mauka and Lahainaluna-Makai two radial lines as a normal closed loop. A list of transmission networks expansion proposed for Maui system is listed in Table 73. A high-level one line diagram in Figure 33 demonstrates the proposed transmission networks expansion.

Table 73 Transmission Networks Expansion and High-Level Cost Estimate, Maui Base Scenario Resource Plan, Year 2027

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line	Upgrade Type	Conductor Requirements	
Lahaina-Lahainaluna	Re-conductor	One circuit, re-conductor to 556 AAC	2.5
Waena-Kanaha	Re-conductor	One circuit, re-conductor to 556 AAC	6.1
Wailea-Auwahi	Re-conductor	One circuit, re-conductor to 556 AAC	1.8
Mahinahina Substation	Expand West network	Install one 69kV circuit breaker	2.7

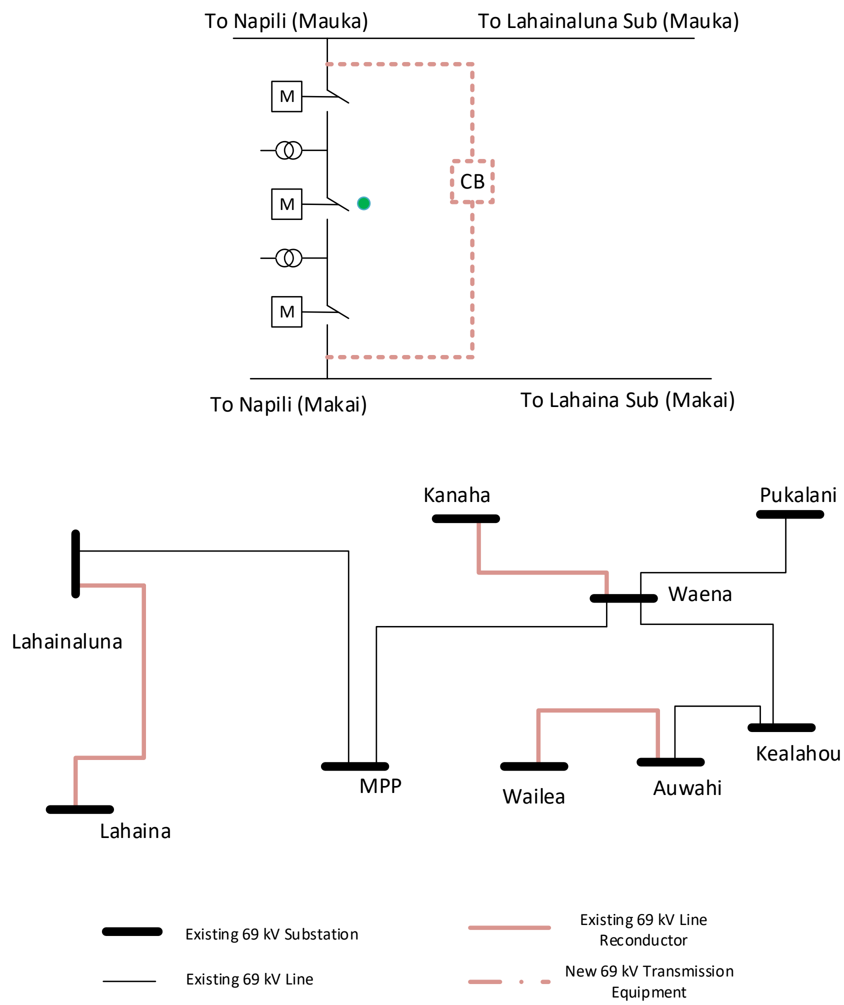


Figure 33 High-Level single line diagram for proposed transmission networks expansion, Maui base scenario resource plan, year 2027

Mitigation study – portfolio alternatives and non-wire solutions.

The transmission line Lahiana-Lahainaluna reconductoring work could be avoided by reducing MW interconnection total at the west Maui side (at Lahainaluna substation, KWP 1 substation, Lahainaluna-MPP line interconnection) by 24 MW. Waena-Kanaha and Wailea-Auwahi reconductor can be avoided by reducing the interconnection total at Waena switchyard and Kealahou substation by 18 MW. Reducing MW interconnections in these locations would require additional procurements somewhere else in the system, which, depending on size and location, might also require new or upgraded transmission. There is no non-wire alternative solution for deferring adding a circuit breaker in the Mahinahina substation to close west Maui loop.

REZ enablment

There is no REZ development by 2027, hence, there is no REZ enablement cost estimate.

Base scenario resource plan, year 2035

Study descriptions

In addtion to previous system resource changes by 2027, the Maui system resource plan provides 66 MW grid-scale onshore wind generation and 37 MW PV/BESS generation as addtional generation interconnected at Maui transmission system by 2035. This new generation will be developed in the Maui REZ zone C. Also, it is planned that the MPP unit 1 to 9 will be removed by 2030 and wind power generation KWP 2 and Auwahi will be retired by 2033. The system annual peak load is forecasted to reach 235 MW by 2036. A high-level Maui system map with locations of the RFP Stage 3 projects assumed in the study and developed REZ zones by 2035 is shown in Figure 34. In the total 103 MW new grid-scale generation project from the REZ zone C development, it is assumed that 60 MW generation will be interconnected at Waena switchyard, and the remaining 43 MW will be interconnected at a new substation REZ C.1 on the Waena-MPP line, which is shown as Figure 35.

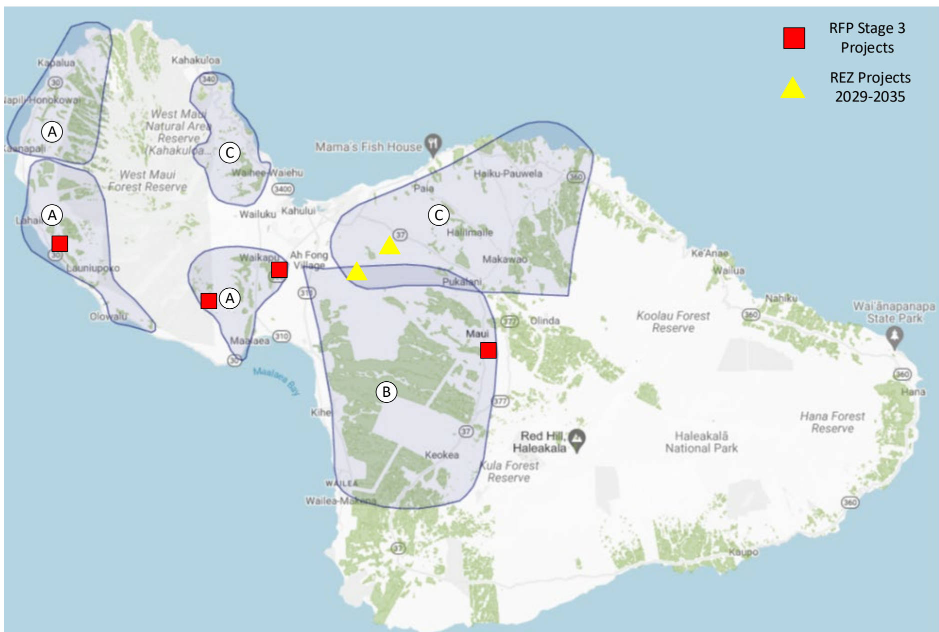


Figure 34 High-Level Maui map for assumed future grid-scale project interconnection locations by 2035

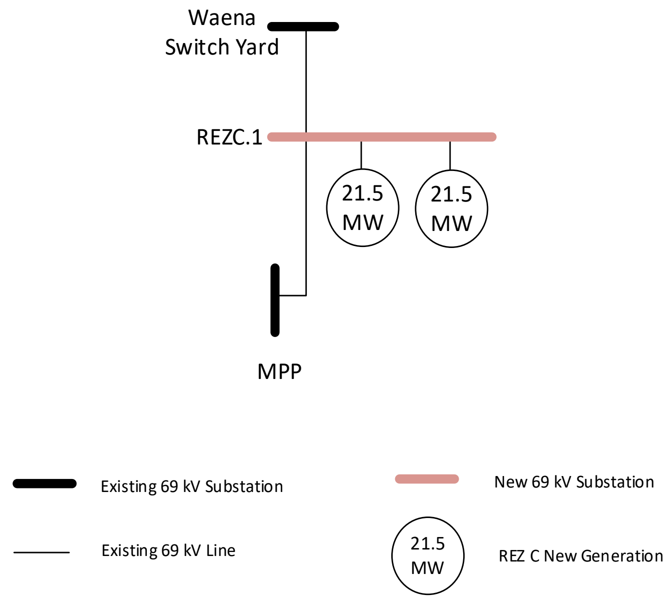


Figure 35 High-level single line diagram for the 43 MW line interconnection project, Maui base scenario resource planning, year 2035

The detailed system grid-scale resources changes are summarized in Table 74 and Table 75. System resource summary and the forecasted system load is summarized in Table 76.

Table 74 Maui Grid-Scale Generation Project Development between 2028 and 2035, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Onshore Wind Generation	5	2029	REZ Zone C
	Onshore Wind Generation	8	2030	REZ Zone C
	Onshore Wind Generation	53	2035	REZ Zone C
	Solar/BESS	37	2035	REZ Zone C

Table 75 Maui Grid-Scale Generation Removal between 2028 and 2035

Removal	Generation Type	MW Capacity	Year	Location
Maalaea Power Plant Units 1-9	Fossil	40.5	2030	MPP
Kaheawa Wind Power 2	Onshore Wind Generation	21	2033	KWP 2 Substation
Auwahi Wind	Onshore Wind Generation	21	2033	Auwahi Substation

Table 76 Maui System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2035

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	66	333	40	202	237

Table 77 summarizes studied system generation dispatches for the 2035. It is worth noting that the transmission networks expansion requirement identified in the 2027 study is assumed to be implemented before 2027 to mitigate the transmission line overloading issues.

Table 77 Studied System Generation (MW) Dispatches, Maui Base Scenario Resource Plan, Year 2035

Aggregated Generation Capacity Rating (MW)		Zone A	Zone B	Zone C	Zone A+C	Zone B+C	All Zones
Zone A	140	140	0	0	118	0	77.5
Zone B	257	97	237	33	0	116	85.5
Zone C	204	0	0	204	119	121	74
Total Load	237	237	237	237	237	237	237

Study results

Power flow simulations are performed for all the system generation dispatches, for normal configuration and N-1 contingency configurations. Simulation results show that there is no transmission equipment overloading issue or steady state voltage planning criteria violation for the system with normal configuration. However, both transmission equipment overloading and undervoltage violations are identified for N-1 contingency configurations. In Table 78, a summary of overloading results is listed. There are three 69/23 kV tie transformers currently supplying the Maui system 23 kV networks. For the contingencies of losing one 69 kV feed for the tie transformers, the remaining two tie transformers have an overloading issue when they need supply all the 23 kV networks load. Additionally this condition results in voltages outside planning criteria limits. An example shown in Figure 36 illustrates the tie transformer overloading issue and the undervoltage issue.

Table 78 List of Overloaded Transmission Elements, Maui Base Scenario Resource Plan, Year 2035

Generation Dispatch	N-1 Contingency Configuration	
	Overloading Element	Max. Loading(%)
Zone A	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	112
Zone B	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	112
Zone C	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	111
Zone A+C	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	108
Zone B+C	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	109
All Zones	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	109

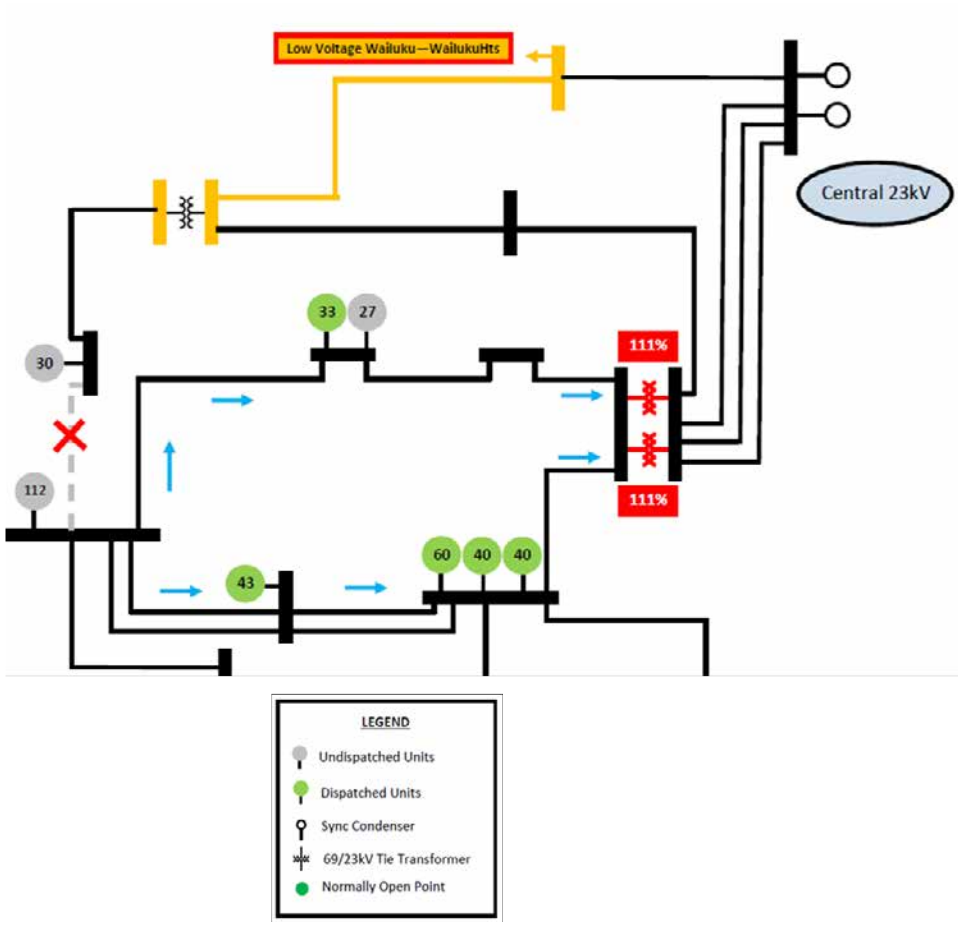


Figure 36 Overloading on tie transformers and undervoltage in 23 kV networks when losing one 69 kV feed for the 23 kV networks

Mitigation study – transmission networks expansion

To mitigate the tie transformers' overloading issue and the 23 kV networks undervoltage issue, it is proposed to add another 69 kV line between MPP and STG 3.1 substation, and from STG 3.1 to Waiinu substation. It is worth noting that there are other options to mitigate the tie transformers' overloading issue and the 23 kV networks undervoltage issue, such as replacing the tie transformers or adding generation in the 23 kV networks. Adding this new line can remove losing the 69 kV feed for the 23 kV networks from the N-1 contingency list and allow for increased future grid-scale generation interconnecting to the Maui transmission system via the STG 3.1 substation.

It is also proposed that a new line is added between Waena switchyard and MPP as well as adding a new substation, REZ C.1, interconnecting both lines between the Waena switchyard and MPP. This new substation also can be used for future grid-scale generation interconnection in the REZ development.

All aforementioned mitigation solutions are illustrated in Figure 37. Cost estimate for the proposed solution is listed in Table 79.

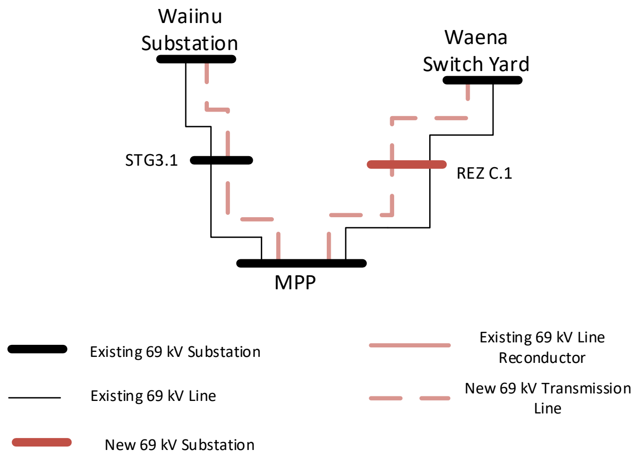


Figure 37 Proposed Maui transmission networks expansion, Maui base scenario resource plan, year 2035

Table 79 Transmission Networks Expansion and High-Level Cost Estimate, Maui Base Scenario Resource Plan, Year 2035

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Upgrade Requirements	
MPP – REZC.1 Sub – Waena	New Transmission Line	One circuit, 556 AAC	25.0
MPP Substation	New Transmission Line	Install One 69kV circuit breaker	2.9
REZ C.1 Substation	New Substation	Adding 3 BAAH Bays less 2 breakers	27.7
1 BAAH Bay in Waena	Adding 1 BAAH Bay	Adding 1 BAAH bay less 1 breaker	6.7
MPP – STG3.1 – Waiinu	New Transmission Line	One circuit, 336 AAC	18.4
MPP Substation	New Transmission Line	Install One 69kV circuit breaker	2.9
STG3.1 Substation	Adding 1 BAAH Bay	Adding 1 BAAH Bay	9.6
Waiinu Substation	New Transmission Line	Install One 69kV circuit breaker	2.9

Mitigation study – portfolio or non-wires solutions

Considering that the proposed portfolio additions are critical to meet the transformation goals, and the new lines and substations are critical to reliably interconnect these future grid-scale generation projects, there were no portfolio or non-wire alternatives identified in this study.

REZ Enablement

According to the resource plan, total 103 MW grid-scale generation from REZ zone C development will be interconnected to the Maui transmission system by 2035. It is assumed that 43 MW will be interconnected at the new substation REZ C.1, and remaining 60 MW will be interconnected at the

Waena switchyard. The 60 MW Waena switchyard interconnection enablement cost is $13.5 million. The estimate to allow 43MW interconnection at the new substation REZ C.1 cost estimate is $5.8 million. So, the total REZ enablement cost estimate is $19.3 million.

Base scenario resource plan, year 2040

Study descriptions

In 2040, another 61 MW REZ zone C development will be completed. It is assumed that 61 MW will be interconnected at Waena switchyard. Meanwhile, there will be retirement of existing 5.7 MW distribution interconnected PV. System annual peak demand is forecasted to reach 266 MW in 2041. A high-level Maui system map with locations of the future grid-scale project interconnection locations by 2040 are shown in Figure 38.

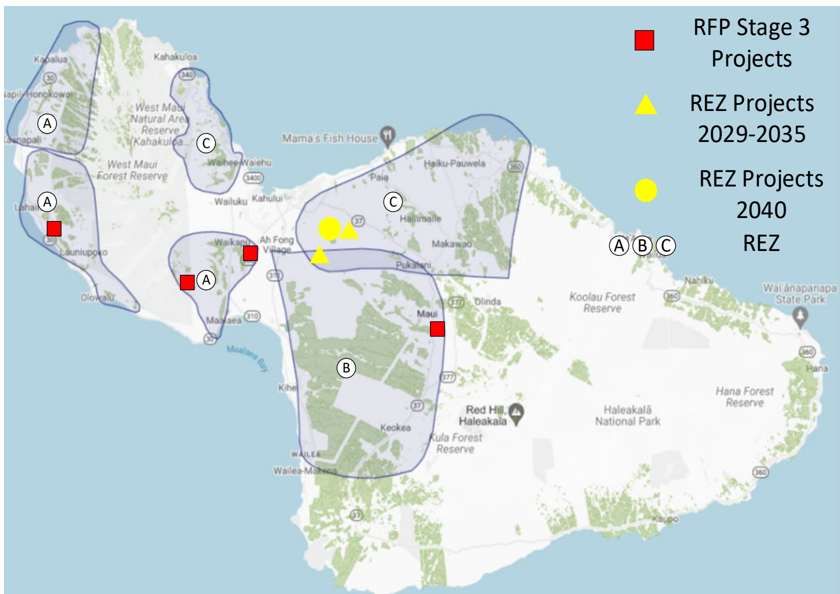


Figure 38 High-Level Maui map for assumed future grid-scale project interconnection locations by 2040

The detailed system grid-scale resources changes are summerized in Table 80 and Table 81. System resource summary and the forecasted system load is summarized in Table 82.

Table 80 Maui Grid-Scale Generation Project Development between 2036 and 2040, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Onshore Wind Generation	18	2040	REZ Zone C
	PV/BESS Generation	43	2040	REZ Zone C

Table 81 Maui Grid-Scale Generation Removal between 2028 and 2035

Removal	Generation Type	MW Capacity	Year	Location
Distribution Interconnected PV	Solar	5.7	2040	12 kV Distribution System

Table 82 Maui System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2040

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	84	376	40	218	266

Table 83 summarizes studied system generation dispatches for 2040. The transmission networks expansion requirement identified in the 2035 study is assumed to be implemented before 2035 to mitigate the transmission line overloading issues. Therefore, all the networks expansion listed in the Table 79 are included in the 2040 study models.

Table 83 Studied System Generation (MW) Dispatches, Maui Base Scenario Resource Plan, Year 2040

Aggregated Generation Capacity Rating (MW)		Zone A	Zone B	Zone C	Zone A+C	Zone B+C	Zone A+B	All Zones
Zone A	140	140	0	0	134	0	140	85
Zone B	257	126	257	1	0	130	126	88
Zone C	265	0	9	265	132	136	0	93
Total Load	266	266	266	266	266	266	266	266

Study results

Results of power flow simulations for all the studied dispatches for system with both normal configuration and N-1 contingency configurations show undervoltage violation on Pukalani-Hana 23 kV circuit for both normal and N-1 contingency configurations and 69 kV transmission line overloading and high loading condition when system is with N-1 contingency configurations. The worst undervoltage violation is 0.75 p.u. during normal conditions and 0.67 p.u. during N-1 contingency. The undervoltage issue is caused by load growth on the Pukalani-Haiku 23 kV line. A summary of the 69 kV line overloading is provided in Table 84.

Table 84 List of Overloaded Transmission Elements, Maui Base Scenario Resource Plan, Year 2040

Generation Dispatch	N-1 Contingency Configuration	
	Overloading Element	Max. Loading(%)
Zone A	Kealahou-Kamaole 69kV Line	97
Zone B	None	
Zone C	MPP-REZC.1 Ckt 1 or Ckt 2 69kV Line	114
Zone A+C	Kealahou-Kamaole 69kV Line	96
Zone B+C	None	
Zone A+B	None	
All Zones	None	

Mitigation study – transmission networks expansion

To mitigate the identified undervoltage issue, it is proposed to add one 3.6 Mvar (at 69 kV) capacitor bank at Keanae substation and another 3.6 Mvar (at 69 kV) capacitor bank at Kailua substaton. To mitigate the transmission line overloading issue, it is recommend to add one 69 kV line from MPP to the Waena switchyard via the REZ C.1 substation, which is shown in Figure 39. The high leve cost estimate for adding this new line is $51.9 million.

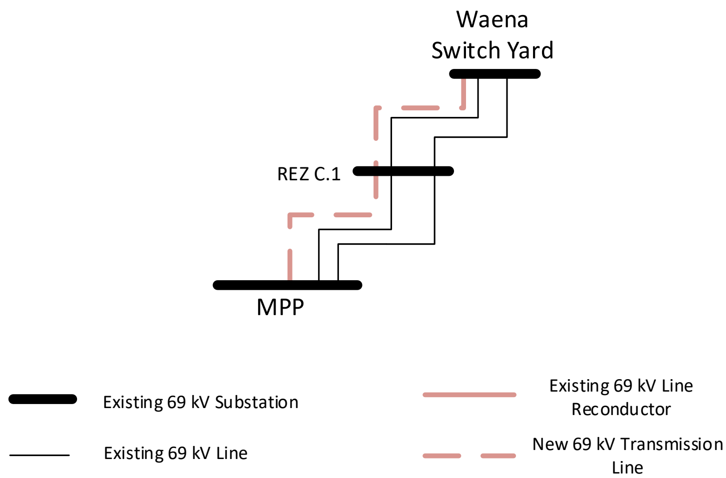


Figure 39 Proposed Maui transmission networks expansion, Mau i base scenario resource plan, year 2040

Mitigation study – portfolio mitigation

To defer the addtion of the new line from MPP to the Waena switchyard, would require 48 MW interconnection size reduction at the Waena switchyard. The needs for additional infrastructure for alternate resources would depend on the location(s).

REZ Enablement

According to the resource plan, total 61 MW grid-scale generation from REZ zone C development will be interconnected to the Waena switchyard. The 61 MW Waena switchyard interconnection enablement cost is $15.6 million.

Base scenario resource plan, year 2045

Study descriptions

Between 2041 and 2045, 66 MW PV/BESS generation and 41 MW onshore wind generation will be developed in REZ zone C; 15 MW PV/BESS generation will be developed in REZ zone B. Also, all the remaining fossil units will switch to biodiesel. The system annual peak demand is forecasted to reach 289 MW in 2046. A high-level Maui system map with locations of the future grid-scale project interconnection locations by 2045 are shown in Figure 40. Assumptions of future grid-scale generation interconnection locations are:

- Auwahi substation – 15 MW (REZ zone B)
- STG3.1 – 30 MW (REZ zone C)
- Kanaha substation (23 kV) – 30 MW (REZ zone C)
- New switching station, REZ C.2 (see Figure 41), on Waena-Kealahou line – 47 MW (REZ zone C)

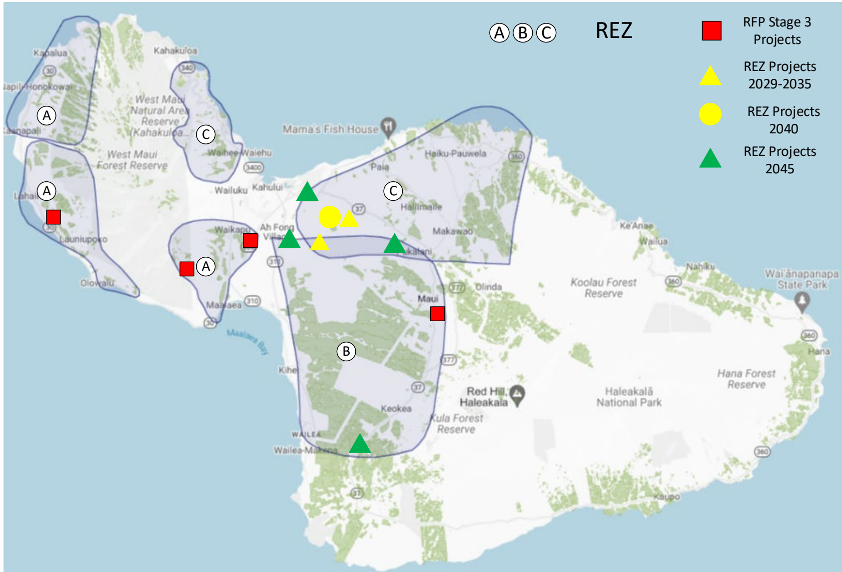


Figure 40 High-Level Maui map for assumed future grid-scale project interconnection locations by 2045

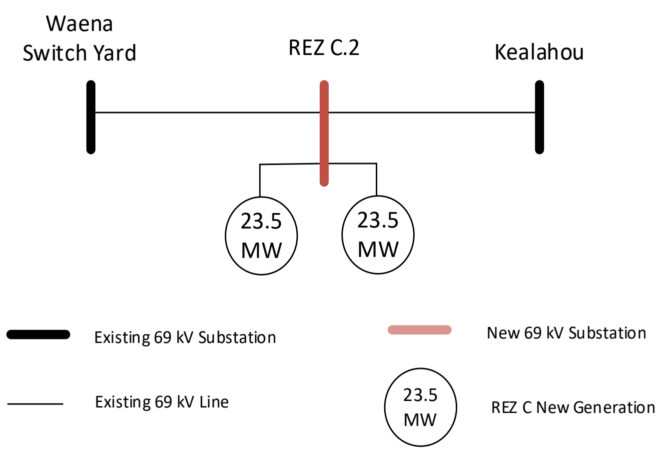


Figure 41 High-Level single line diagram for a new substation REZ C.2, Maui base scenario resource plan, year 2045

The detailed system grid-scale resources changes are summerized in Table 85Table 68 Maui Grid-Scale Generation Project Development by 2027, after RFP Stage 2, Base Scenario Resource Plan. System resource summary and the forecasted system load is summarized in Table 86.

Table 85 Maui Grid-Scale Generation Project Development between 2041 and 2044, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	PV/BESS Generation	15	2045	REZ Zone B
	PV/BESS Generation	66	2045	REZ Zone C

	Onshore Wind Generation	41	2045	REZ Zone C

Table 86 Maui System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2045

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	125	457	40	229	289

Table 87 summarizes studied system generation dispatches for the 2045. It is worth noting that all the networks expansion identified in the 2040 study are included in the 2045 study models.

Table 87 Studied System Generation (MW) Dispatches, Maui Base Scenario Resource Plan, Year 2045

Aggregated Generation Capacity Rating (MW)		Zone A	Zone B	Zone C	Zone A+C	Zone B+C	Zone A+B	All Zones
Zone A	140	140	0	0	140	0	140	93
Zone B	272	149	272	0	0	135	149	105
Zone C	372	0	17	289	149	139	0	91
Total Load	289	289	289	289	289	289	289	289

Study results

Power flow simulation results indicate 69 kV line overloading issue in all the studied system generation dispatch cases when system is with N-1 contingency configurations, which is shown in Table 88. These violations are caused by both system load increase and generation congestion. Voltage planning criteria violation is not identified in the study.

Table 88 List of Overloaded Transmission Elements, Maui Base Scenario Resource Plan, Year 2045

Generation Dispatch	N-1 Contingency Configuration	
	Overloading Element	Max. Loading(%)
Zone A	Kealahou-Kamaole 69kV Line	102
Zone B	MPP-Kaonoulu and Kaonoulu-Kihei 69kV Lines	101
Zone C	MPP-Kaonoulu and Kaonoulu-Kihei 69kV Lines	101
Zone A+C	MPP-Kaonoulu and Kaonoulu-Kihei 69kV Lines	103
Zone B+C	MPP-Kaonoulu and Kaonoulu-Kihei 69kV Lines	101
Zone A+B	MPP-Kaonoulu and Kaonoulu-Kihei 69kV Lines	103

All Zones	MPP-Kaonoulu and Kaonoulu-Kihei 69kV Lines	103

Mitigation study – transmission networks expansion

To address the identified overloading issue, a set of mitigation solutions, including reconductor, adding new 69 kV line and substations are proposed. The proposed solutions are listed in Table 89 with high-level cost estimate and shown in Figure 42. The adding of new substatino REZ C.2 on the Waena-Kealahou line and REZ B.1 on south Maui provide benefit for the grid-scale generation projects interconnection between 2046 and 2050.

Table 89 Transmission Networks Expansion and High-Level Cost Estimate, Maui Base Scenario Resource Plan, Year 2045

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Upgrade Requirements	
Kamaole – Kealahou	Re-conductor	One circuit, re-conductor to 556 AAC	17.4
Waena – REZ C.2 – Kealahou	Add New Circuit	One circuit, 556 AAC	21.4
REZC.2 (Waena-Kealahou) Sub	New Substation	Adding 3 BAAH bays less 2 breakers	37.6
Waena Substation	Add new circuit	Install one 69kV circuit breaker	3.9
Kealahou Substation	Add new circuit	Add 1 BAAH bay less 1 breaker	9.9
New Substation REZ B.1	Adding a new 69 kV substation between Kihei substation and Wailea substation. • Add new substation (REZB.1) between Kihei Sub 35 and Wailea Sub 25 with (3) BAAH less 3 breaker.		32.5
MPP - REZ B.1	Adding New Circuit	One circuit, 556 AAC	42.0

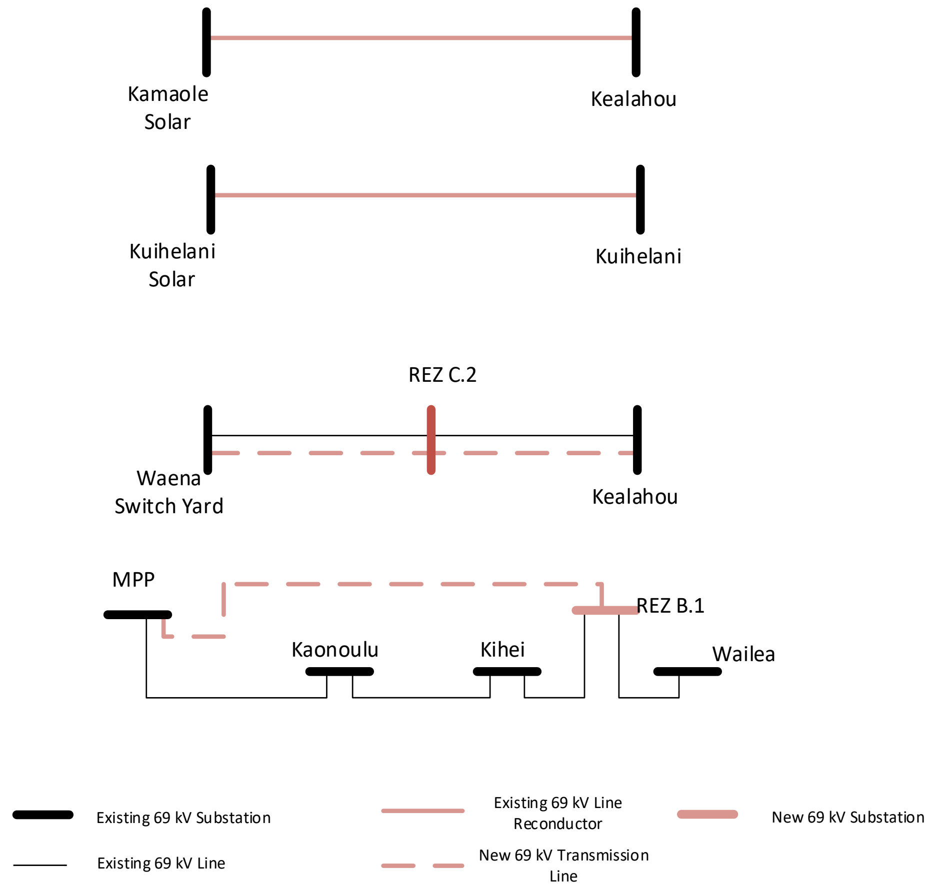


Figure 42 Proposed Maui transmission networks expansion, Mau i base scenario resource plan, year 2045

Mitigation study – alternative resource portfolio

The Kamaole-Kealahou line reconductoring. can be deferred by reducing south Maui generation interconnection size by 7 MW.

REZ Enablement

According to the resource plan, 15 MW generation from REZ zone B and 107 MW generation from REZ zone C will be interconnected to the Maui system between 2041 and 2045. It is assumed in the study that the total 122 MW generation will be interconnected at Auwahi substation (15 MW), STG 3.1 substation (30 MW), Kahana substation (23 kV, 30 MW), and the new substation REZ C.2 (47 MW). The high-level cost estimate for these REZ enablement is listed in Table 90.

Table 90 REZ Enablement and High-Level Cost Estimate, Maui Base Scenario Resource Plan, Year 2045

Enablement Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Upgrade Requirements	
Kanaha Substation	REZC development	Install one 23kV breaker	3.8
STG 3.1 POI (MPP-Waiinu) Sub	REZC development	Install one 69kV breaker	3.9
REZC.2 (Waena-Kealahou) Sub	REZC development	Install two 69kV breakers	7.8

Base scenario resource plan, year 2050

Study descriptions

In 2050, 57 MW PV/BESS generation will be developed in REZ zone C and another 57 MW PV/BESS generation will be developed in REZ zone B. System annual peak demand is forecasted to reach 310 MW in 2050. A high-level Maui system map with locations of the future grid-scale project interconnection locations by 2050 are shown in Figure 43.

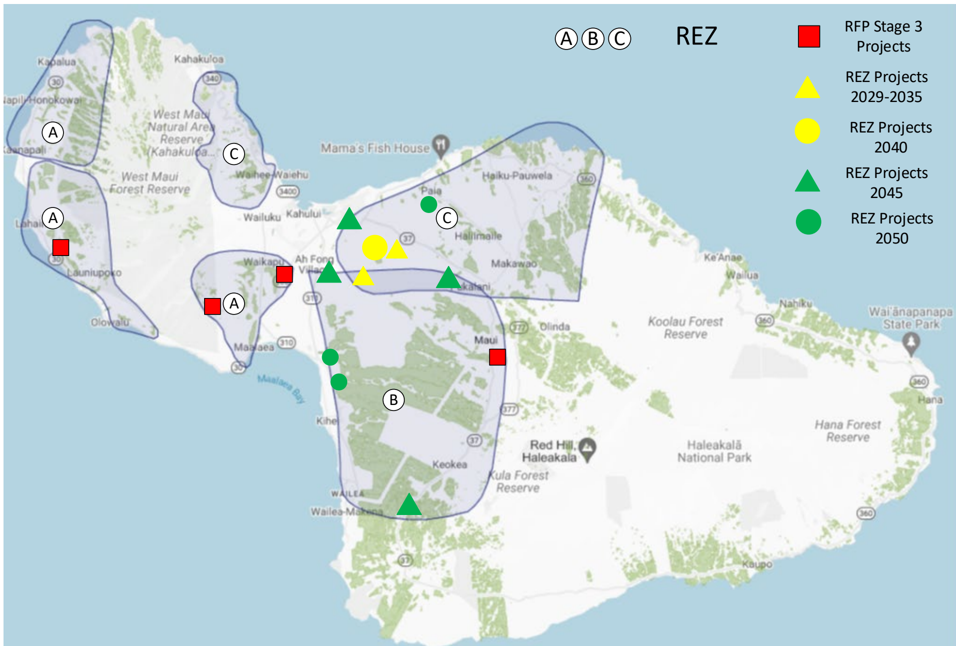


Figure 43 High-Level Maui map for assumed future grid-scale project interconnection locations by 2050

Interconnection locations for the total 114 MW grid-scale interconnection are assumed as following:

- REZ B.1 Substation – 51 MW (REZ zone B)
- Auwahi Substation – 7 MW (REZ zone B)
- REZ C.2 (Waena-Kealahou) Substation - 13MW (REZ zone C)
- New switching station, REZ C.3 (shown in Figure 44), on Waena-Pukalani line – 44 MW (REZ zone C)

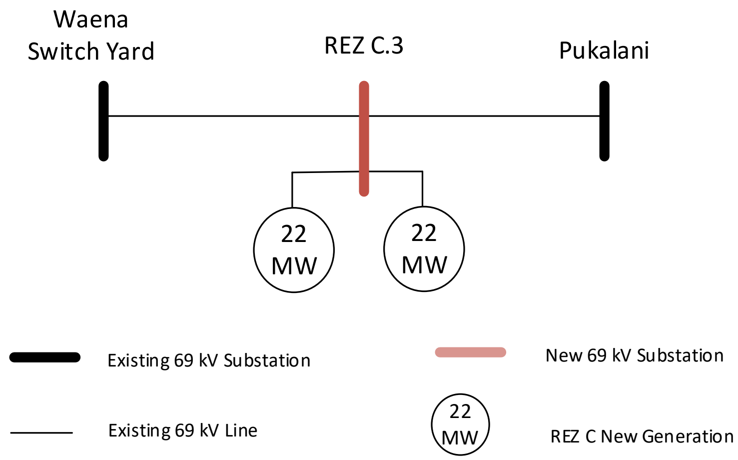


Figure 44 High-Level single line diagram for a new substation REZ C.3, Maui base scenario resource plan, year 2050

The detailed system grid-scale resources changes are summarized in Table 91Table 68 Maui Grid-Scale Generation Project Development by 2027, after RFP Stage 2, Base Scenario Resource Plan. System resource summary and the forecasted system load is summarized in Table 92.

Table 91 Maui Grid-Scale Generation Project Development between 2046 and 2050, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	PV/BESS Generation	57	2050	REZ Zone B
	PV/BESS Generation	57	2050	REZ Zone C

Table 92 Maui System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2050

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	125	571	40	240	310

Table 93 summarizes studied system generation dispatches for the 2050. It is worth noting that all the networks expansion identified in the 2045 study are included in the 2050 study models.

Table 93 Studied System Generation (MW) Dispatches, Maui Base Scenario Resource Plan, Year 2050

Aggregated Generation Capacity Rating (MW)		Zone A	Zone B	Zone C	Zone A+C	Zone B+C	Zone A+B	All Zones
Zone A	140	140	0	0	140	0	140	96
Zone B	329	170	310	0	0	152	170	113
Zone C	429	0	0	310	170	158	0	101
Total Load	310	310	310	310	310	310	310	310

Study results

Undervoltage violation is not observed from the power flow simulations for all the system generation dispatches, with either system normal configuration or N-1 contingency configurations. Transmission line overloading is not observed, either. The only planning criteria violation observed is overloading on 62/23 kV tie transformers during N-1 system contingency configurations. A summary of observed overloading is listed in Table 94.

Table 94 List of Overloaded Transmission Elements, Maui Base Scenario Resource Plan, Year 2050

Generation Dispatch	N-1 Contingency Configuration	
	Overloading Element	Max. Loading(%)
Zone A	None	
Zone B	69/23 kV Tie transformer	96
Zone C	None	
Zone A+C	69/23 kV Tie transformer	97
Zone B+C	69/23 kV Tie transformer	100
Zone A+B	69/23 kV Tie transformer	97
All Zones	69/23 kV Tie transformer	96

Mitigation study – transmission networks expansion

To mitigate the potential overloading on the tie-transformers, it is recommend to replace the two units of tie transformer in Kanaha substations with higher emergency rating, at least 24 MVA forced air rating. To mitigate transmission line overloading, adding the second 69 kV line between the Waena switchyard and the Pukalani substation via the REZ C.3 is proposed. The proposed mitigation solution is summerzied in Table 95, with high-level cost estimate.

Table 95 Transmission Networks Expansion and High-Level Cost Estimate, Maui Base Scenario Resource Plan, Year 2050

Enablement Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Upgrade Requirements	
Waena – REZC.3 – Pukalani	Add New Circuit	One circuit, 336 AAC	31.2
Waena Substation	Add New Circuit	Install one 69kV circuit breaker	4.5
Pukalani Substation	Add New Circuit	Rebuild Sub—add 2 BAAH bays less one breaker	25.5
REZC.3 (Waena-Pukalani) Sub	New Substation	Add 3 BAAH bays less 2 breakers	46.9
Transformer	Transformer Upgrade Description		
New 69/23 kV Tie Transformer	Upgrade both Kahana Tie Transformers with FA rating of at least 24 MVA		15.0

Mitigation solution – non-wire alternatives

Non-wire alternatives are identified for deferring the tie-transformers upgrade. To bring down the tie transformer loading limit no higher than 95% of emergency loading during N-1 contingency configurations, 4 MW peak load reduction is required.

REZ Enablement

According to the resource plan, 57 MW generation from REZ zone B and another 57 MW generation from REZ zone C will be interconnected to the Maui system between by 2050. It is assumed in the study that the total 114 MW generation will be interconnected at Auwahi substation (7 MW), REZ B.1

substation (51 MW), REZ C.2 (13 MW), and the new substation REZ C.3 (44 MW). The high-level cost estimate for these REZ enablement is listed in Table 96.

Table 96 REZ Enablement and High-Level Cost Estimate, Maui Base Scenario Resource Plan, Year 2050

Enablement Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Upgrade Requirements	
REZB.1 (Kihei-Wailea) Sub	REZB development	Install two 69kV circuit breakers	9.0
REZC.3 (Waena-Pukalani) Sub	REZC development	Install two 69kV circuit breakers	9.0

High load scenario resource plan, year 2027

Study descriptions

By 2027, the Maui system will have new generation from Stage 3 RFP procurement which will be 171 MW RDG PV/BESS and 36 MW firm generation, interconnection at at Maui 69 kV system. Meanwhile, the Maui system will finish Waena switchyard construction, KPP retirement and conversion of KPP K3 and K4 units to synchronous condensers, and MPP unit 10-13 retirement. The system peak load is forecasted to reach 239 MW by 2028. A high-level locations of the RFP Stage 3 projects assumed in the study and developed REZ zones are shown in Figure 45. The assumptions regarding locations of the RFP Stage 3 projects are the same as what are used in the base scenario resource plan study. System grid-scale resource change in this high loare scenario resource plan by 2027 is the same as what is shown in the base scenario resource plan (i.e., Table 68 and Table 69). There are two differences, by comparing the 2027 base scenario resource plan and 2027 high load scenario resoiuce plan: 1) System peak load becomes 239 MW, instead of 207 MW in the base scenario resource plan, and 2) DER adoption forecast is 194 MW, instead of 170.7 MW in the base scenario resource plan.

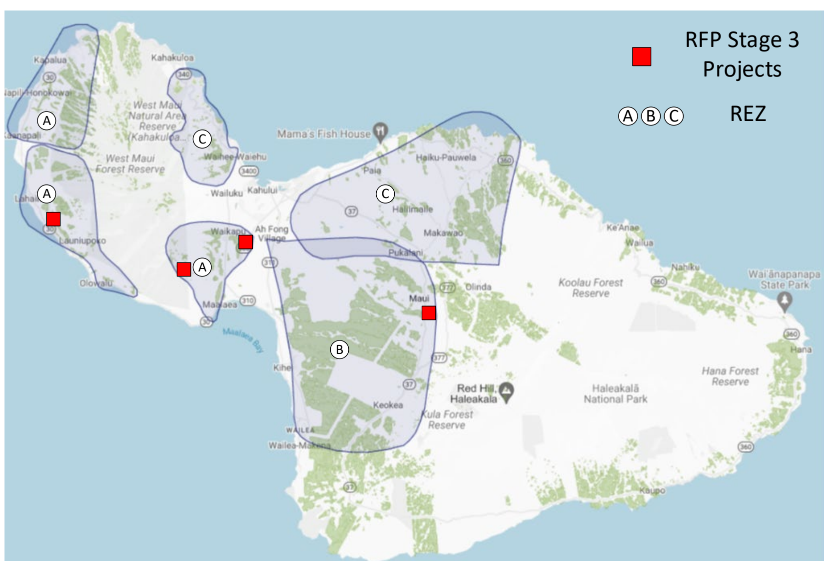


Figure 45 High-Level Maui map for assumed RFP Stage 3 project locations by 2027

Table 97 summarizes studied system generation dispatches for the 2027.

Table 97 Studied System Generation (MW) Dispatches, Maui High Load Scenario Resource Plan, Year 2027

Aggregated Generation Capacity Rating (MW)		Zone A*	Zone B_1	Zone B_2	Zone A+C	Zone B+C	All Zones
Zone A	161	161	0	55	138	0	70
Zone B	313.5	78	239	184	0	138	70
Zone C	101	0	0	0	101	101	67
Total Load	239	239	239	239	239	239	239

*Studied variation of dipatch zone

Study results

Power flow simulation results indicate that 1) 69 kV lines experience high loading condition during normal configuration for one generation dispatch, 2) overloading conditions are identified on 69 kV lines and 69/23 kV tie transformers when system is under N-1 contingency configurations, and 3) voltage planning criteria violations are observed, with worst undervoltage issues at 0.75-0.76 p.u.. Summary of transmission element overloading is listed in Table 98.

Table 98 List of Overloaded Transmission Elements, Maui High Load Scenario Resource Plan, Year 2027

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	Overloading Element	Max Loading (%)	Overloading Element	Max. Loading(%)
Zone A_1	KuihelaniSolar-Kuihelani 69kV Line	97	KuihelaniSolar-Kuihelani 69kV Line	117
Zone A_2	None	None	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	110
Zone B_1	None	None	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	110
Zone B_2	None	None	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	110
Zone A+C	None	None	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	110
Zone B+C	None	None	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	110
All Zones	None	None	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	110

Mitigation study – transmission networks expansion

To mitigate the transmission line overloading conditions, reconductoring of the overloading transmisison lines are proposed. Besides fixing the transmission line overloading issue, simimilar to what is proposed in the base scenario resource plan, closing west Maui loops is proposed for the high load scenario resource plan. A list of transmission networks expansion proposed for Maui system is listed in Table 99. A high-level one line diagram in Figure 46 demonstrates the proposed transmission networks expansion.

Table 99 Transmission Networks Expansion and High-Level Cost Estimate, Maui High Load Scenario Resource Plan, Year 2027

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line	Upgrade Type	Conductor Requirements	
Mahinahina Substation	Expand West network	Install one 69kV circuit breaker	2.7
Lahaina-Lahainaluna	Re-conductor	One circuit, re-conductor to 556 AAC	2.5
MPP – Waiinu #2	New Transmission Line	One circuit, 336 AAC	13.6
1 BAAH Bay in STG3.1	Adding 1 BAAH Bay	Adding 1 BAAH Bay	7.8
Waiinu Substation	New Transmission Line	Install One 69kV circuit breaker	2.4
MPP Substation	New Transmission Line	Install One 69kV circuit breaker	2.4

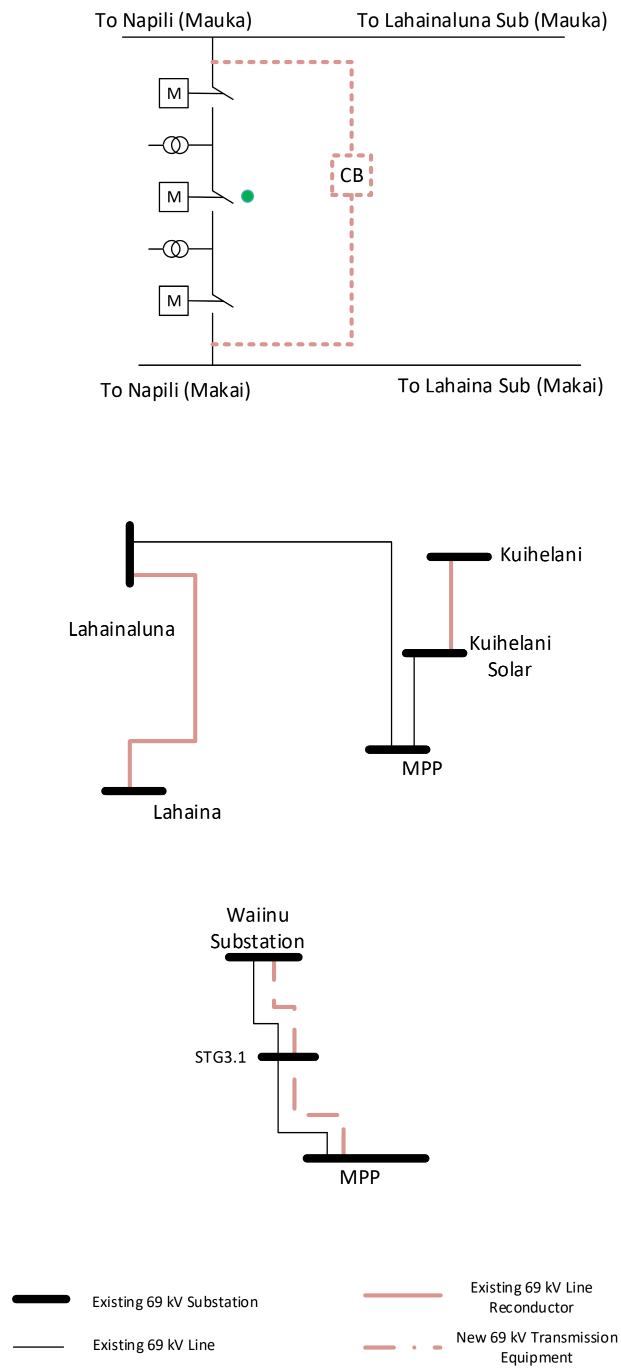


Figure 46 High-Level single line diagram for proposed transmission networks expansion, Maui high load scenario resource plan, year 2027

REZ enablment

There is no REZ development by 2027, hence, there is no REZ enablement cost estimate.

High load scenario resource plan, year 2030

Study descriptions

By 2030, the Maui system will have 69 MW grid-scale renewable generation from REZ zone C development. Also, it is planned that MPP unit 1 to 9 will be removed by 2030. The system annual peak load is forecasted to reach 266 MW by 2031. A high-level Maui system map with locations of all the future grid-scale generation projects by 2030 are shown in Figure 47. In total 69 MW of new grid-scale generation project from the REZ zone C development, it is assumed that 52 MW generation will be interconnected at the Waena switchyard, and the remaining 17 MW will be interconnected at a new substation REZ C.1 on the Waena-MPP line, which is shown as Figure 48.

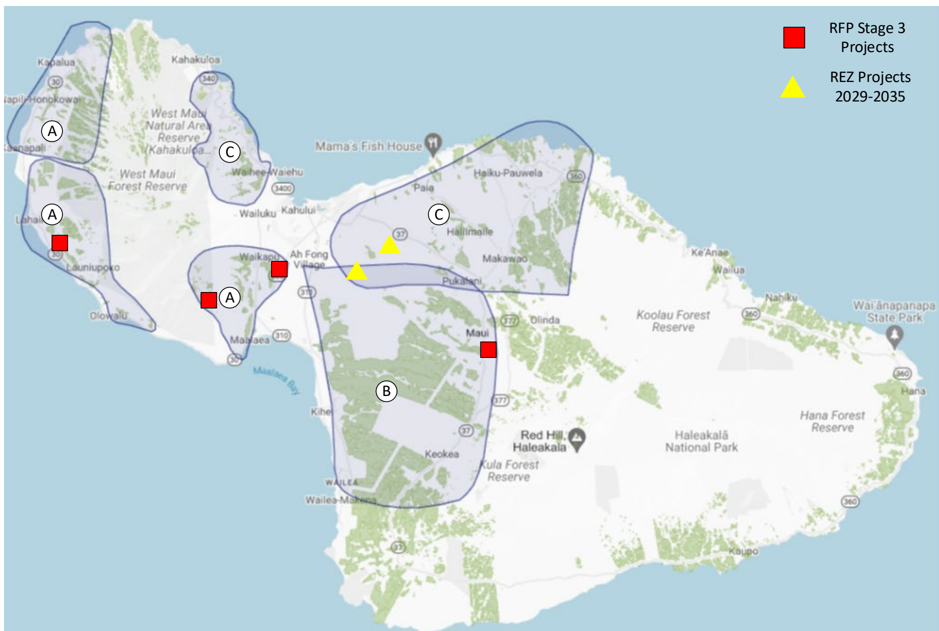


Figure 47 High-Level Maui map for assumed future grid-scale project interconnection locations by 2030, high load scenario resource plan

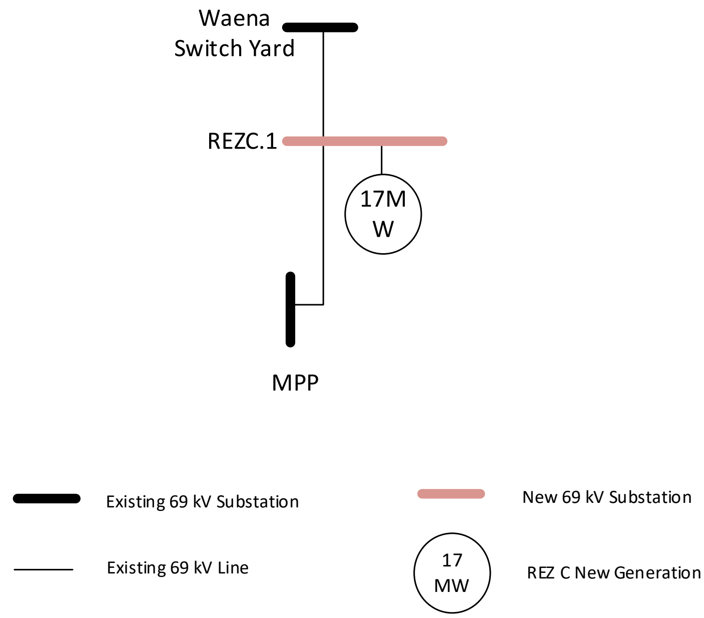


Figure 48 High-level single line diagram for the 17 MW line interconnection project, Maui high load scenario resource planning, year 2030

The detailed system grid-scale resources changes are summerized in Table 100. System resource summary and the forecasted system load is summarized in Table 101. Regarding system grid-scale resource retirement, both base scenario resource plan and high load scenario resource plan have the same resource retirment schedule.

Table 100 Maui Grid-Scale Generation Project Development between 2028 and 2030, High Load Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Onshore Wind Generation	6	2029	REZ Zone C
	Onshore Wind Generation	46	2030	REZ Zone C
	Solar/BESS	17	2030	REZ Zone C

Table 101 Maui System Resource Summary and Forecasted Demand (MW), High Load Scenario Resource Plan, Year 2030

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	94	313	40	217	266

Table 102 summarizes studied system generation dispatches for the 2030.

Table 102 Studied System Generation (MW) Dispatches, Maui Base Scenario Resource Plan, Year 2030

Aggregated Generation Capacity Rating (MW)		Zone A+B*	Zone B_1	Zone B_2	Zone B+C*	Zone A+C	All Zones
Zone A	140	140	0	124	0	134	88
Zone B	257	126	257	142	97	0	88

Zone C	170	0	9	0	170	132	90
Total Load	266	266	266	266	266	266	266

*Studied variation of dipatch zone

Study results

Power flow analyses are performed for the above system generation dispatches. Analyses results indicate transmission element overloading happen in both normal and N-1 contingency configurations. Undervoltage violation and voltage collapse (i.e., power flow simulation does not converge) are identified during N-1 contingency configurations. A summary of undervoltage violations,voltage collapse issues, and transmission element overloading issues identified from the analyses are shown in Table 103 and Table 104.

Table 103 List of Undervoltage Violation and Voltage Collapse, Maui High Load Scenario Resource Plan, Year 2030

Generation Dispatch	N-1 Contingency Configuration	
	Low Voltage Element	Lowest Voltage (p.u.)
Zone A+B_1	Haiku Substation	0.83
Zone A+B_2	Haiku Substation	0.83
Zone B_1	Haiku Substation	0.84
Zone B_2	Haiku Substation	0.83
Zone B+C_1	Haiku Substation	0.86
Zone B+C_2	Haiku Substation	0.85
Zone A+C	Haiku Substation	0.83
All Zones	HHaiku Substation	0.85

Table 104 List of Overloaded Transmission Elements, Maui High Load Scenario Resource Plan, Year 2030

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	Overloading Element	Max. Loading(%)	Overloading Element	Max. Loading(%)
Zone A+B_1	KuihelaniSolar-Kuihelani 69kV Line	105	KuihelaniSolar-Kuihelani 69kV Line	126
Zone A+B_2	None	None	None	None
Zone B_1	None	None	None	None
Zone B_2	None	None	MPP-KuihelaniSolar 69kV Line	121
Zone B+C_1	None	None	Waena-Kanaha 69kV Line	127
Zone B+C_2	Wailea-Auwahi 69kV Line	97	Waena-Kanaha 69kV Line	160
Zone A+C	None	None	None	None
All Zones	None	None	None	None

Mitigation study – transmission networks expansion

By adding one more 69 kV circuit between MPP and Waena switchyard, via the new substation REZ C.1, multiple 69 kV line overloading issues (i.e., MPP-REZC, MPP-Kuihelani Solar, KuihelaniSolar-Kuihelani, Waena-Kanaha, Wailea-Auwahi) are mitigated. Also, by converting Pukalani-Haiku 23 kV line to a 69 kV line and adding a capacitor bank at Kailu substation and Keanae substation, undervoltage and potential voltage collapse issue on the Pukalani-Haiku-Hana 23 kV line, as well as the Pukalani 69/23 kV transformer overloading will be mitigated. A summary of the proposed transmission networks expansion, with high-level cost estimate are listed in Table 105, with a simplified single line diagram shown in Figure 49.

Table 105 Transmission Networks Expansion and High-Level Cost Estimate, Maui High Load Scenario Resource Plan, Year 2030

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line	Upgrade Type	Conductor Requirements	
MPP – Waena #2	New Transmission Line	One circuit, 556 AAC	21.6
REZ C.1 (MPP-Waena) Substation	Adding 3 BAAH Bay	Adding 3 BAAH Bays less 2 breakers	23.7
MPP Substation	New Transmission Line	Install one 69kV circuit breaker	2.5
Waena Substation	New Transmission Line	Install one 69kV circuit breaker	5.8
Converting Pukalani-Haiku line to 69 kV line; converting Makawao, Kauhikoa, Haiku substations to 69/12 kV substations; converting Kamole Weir, H'poko substaions 85, 86 and 87 to 69/23 kV substation; adding a tie transformer 12/16/20 MVA at Haiku substation; remove Pukalani 69/23 kV tie transformer; reconductor Pukalani-Haiku as 556 AAC			86.2
Add cap bank (1.2MVAR or greater) at Kailua substation and Keanae substation.			0.3

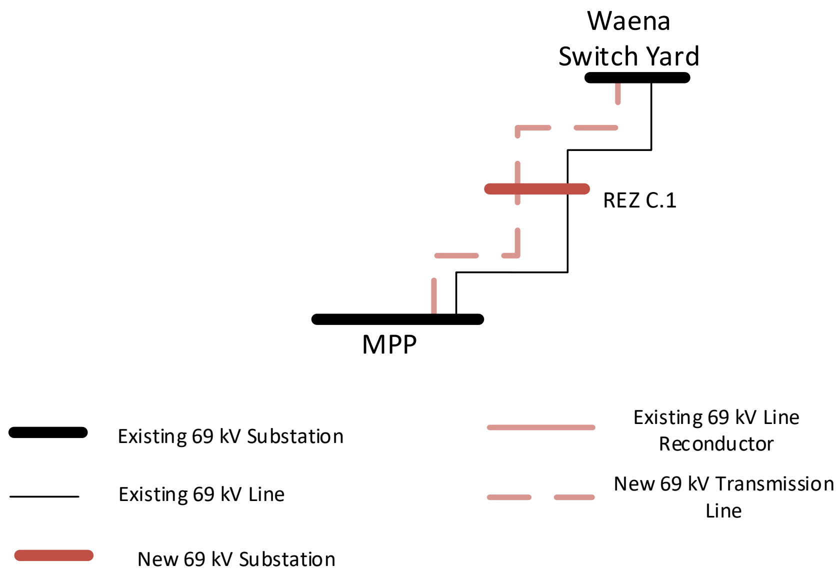


Figure 49 High-Level single line diagram for proposed 69 kV transmission networks expansion, Maui high load scenario resource plan, year 2030

REZ enablment

For the 2030 REZ development, 69 MW generation will be developed from REZ zone C and interconnected with Maui's 69 kV system. It is assumed that 52 MW will be interconnected at Waena switch yard, and 17 MW will be interconnected at a new substation REZ C.1 as shown in Figure 48. According to the REZ enablement cost identified in the 2021 REZ study, the estimate of REZ enablement for the 52 MW interconnection at the Waena switch yard is $45.8 million. A high-level cost estimate for the REZ enablement is listed in Table 106.

Table 106 REZ Enablement and High-Level Cost Estimate, Maui High Load Scenario Resource Plan, Year 2030

Enablement Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Upgrade Requirements	
REZ C.1 (MPP-Waena)	REZC development	Install one 69kV circuit breaker	2.5
Waena Substation	REZC development	Add 2 BAAH bays less 2 breakers	11.6

High load scenario resource plan, year 2035

Study descriptions

In 2035, another 159 MW REZ zone C development will be completed. It is assumed that 38 MW generation will be interconnected at Waena switchyard, 60MW generation interconnected at REZC.1, 30MW generation interconnected at STG3.1 and 30MW generation interconnected at Kanaha Substation on the 23kV bus. In addition, system will have existing 42 MW wind contract expires. The system annual peak demand is forecasted to reach 313 MW in 2036. A high-level Maui system map with locations of all the future grid-scale generation projects by 2035 are shown in Figure 50.

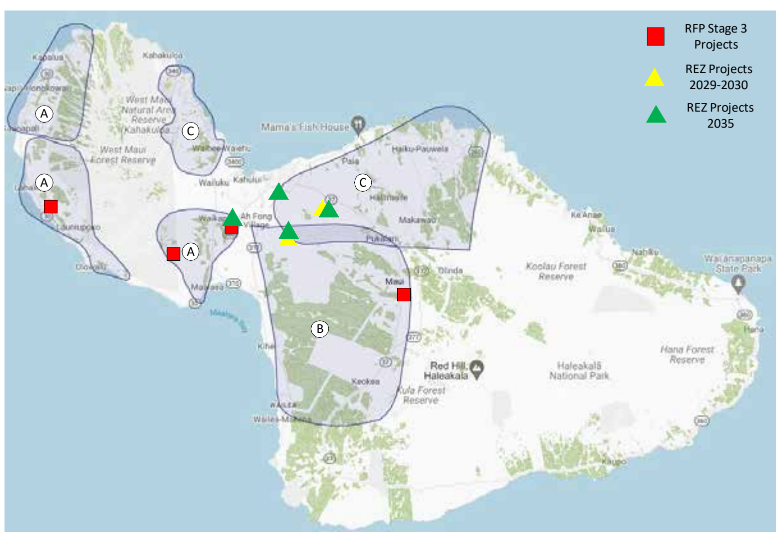


Figure 50 High-Level Maui map for assumed future grid-scale project interconnection locations by 2035, high load scenario resource plan

The detailed system grid-scale resources changes are summerized in Table 107. System resource summary and the forecasted system load is summarized in Table 101.

Table 107 Maui Grid-Scale Generation Project Development between 2030 and 2035, High Load Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Onshore Wind Generation	76	2035	REZ Zone C
	PV/BESS Generation	84	2035	REZ Zone C

Table 108 Maui System Resource Summary and Forecasted Demand (MW), High Load Scenario Resource Plan, Year 2035

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	127	396	40	242	313

Table 109 summarizes studied system generation dispatches for the 2035. It is worth pointing out that the transmission networks expansion requirements identified in previous years are all assumed to be implmented per the schedule, and are all considered as availble in the models for the 2035 analyses.

Table 109 Studied System Generation (MW) Dispatches, Maui Base Scenario Resource Plan, Year 2035

Aggregated Generation Capacity Rating (MW)		Zone A+B*	Zone B	Zone C	Zone B+C*	Zone A+C	All Zones
Zone A	140	140	0	0	0	140	104
Zone B	257	173	257	0	155	0	104
Zone C	330	0	56	313	158	173	105
Total Load	313	313	313	313	313	313	313

*Studied variation of dipatch zone

Study results

According to the power flow analyses performed for all the studied system generation dispatches, high loading on 69/23 kV tie transformers and 69 kV line are observed in normal configuration, and 69 kV line and 69/23 kV tie transformer overloading are observed during system N-1 contingency configurations. A summary of transmission elements with high loading and overloading conditions is provided in Table 110.

Table 110 List of Overloaded Transmission Elements, Maui High Load Scenario Resource Plan, Year 2035

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	Overloading Element	Max. Loading(%)	Overloading Element	Max. Loading(%)
Zone A+B_1	KuihelaniSolar-Kuihelani 69kV Line	98%	Kanaha 69/23kV Tie Tsf 1 or Tie Tsf 2	100%
Zone A+B_2	Waiinu 69/23kV Tie Tsf	98%	Kanaha 69/23kV Tie Tsf 1 or Tie Tsf 2	97%
Zone A+B_3	KuihelaniSolar-Kuihelani 69kV Line	104%	KuihelaniSolar-Kuihelani 69kV Line	102%
Zone B	None	None	Kanaha 69/23kV Tie Tsf 1 or Tie Tsf 2	103%
Zone C	None	None	MPP-REZC Ckt 1 or Ckt 2	114%

Zone B+C_1	None	None	Kanaha 69/23kV Tie Tsf 1 or Tie Tsf 2	105%
Zone B+C_2	None	None	Kanaha 69/23kV Tie Tsf 1 or Tie Tsf 2	103%
Zone B+C_3	None	None	Kanaha 69/23kV Tie Tsf 1 or Tie Tsf 2	110%
Zone A+C	None	None	Kanaha 69/23kV Tie Tsf 1 or Tie Tsf 2	104%
All Zones	None	None	Kanaha 69/23kV Tie Tsf 1 and Tie Tsf 2	96%

Mitigation study – transmission networks expansion

To mitigate the overloading and undervoltage issues identified from the study, following networks expansion is proposed. It is worth noting that adding a new line between Waena switchyard and MPP through REZ C.1 provides potential of interconnecting future grid-scale generation project at the REZ C.1 substaiton. High-level cost estimate is also provided along with the description of the proposed networks expansion.

Table 111 Transmission Networks Expansion and High-Level Cost Estimate, Maui High Load Scenario Resource Plan, Year 2035

Networks Expansion Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Conductor Requirements	
Kamaole Solar – Kealahou	Reconductor	One circuits, 556 AAC	12.9
Kuihelani Solar- Kuihelani	Reconductor	One circuits, 556 AAC	2.7
MPP – Waena #3	Adding New Circuit	One circuits, 556 AAC	29.3
REZ C.1 (MPP-Waena)	Adding 1 BAAH Bay	Adding 1 BAAH Bay	9.6
MPP Substation	Adding New Circuit	Install One 69kV circuit breaker	2.9
Waena Substation	Adding New Circuit	Install One 69kV circuit breaker	2.9
Increase 1.2 Mvar cap bank to 3.6 Mvar cap bank at Keanae substation to mitigate undervoltage issue.			0.2
Increase 1.2 Mvar cap bank to 3.6 Mvar cap bank at Kailua substation to mitigate undervoltage issue.			0.2

REZ enablement

For the total 159 MW grid-scale generation interconnection from the development of REZ zone C, it is assumed that 38 MW generation will be interconnected at Waena switchyard, 60MW generation interconnected at REZC.1, 30MW generation interconnected at STG3.1 and 30MW generation interconnected at Kanaha Substation on the 23kV bus. The REZ enablment and high-level cost estiamte is listed in Table 112.

Table 112 REZ Enablement and High-Level Cost Estimate, Maui High Load Scenario Resource Plan, Year 2035

Enablement Descriptions			Cost Estimate (Million Dollars)
Transmission Line/Substation	Upgrade Type	Upgrade Requirements	
Waena Substation	REZC development	Add 2 BAAH bays less 2 breakers	13.5
REZC.1 (MPP-Waena)	REZC development	Install one 69kV circuit breaker	2.9
STG3.1 (MPP-Waiinu)	REZC development	Install one 69kV circuit breaker	2.9
Kanaha Substation	REZC development	Install one 23kV circuit breaker	2.8

4.2.2 Dynamic stability study

The Maui system in near-term years 2028 and 2036 for the base scenario resource plan are selected for performing dynamic stability study to evaluate system dynamic stability performance. Similar to the steady state analyses, the following assumptions are used in the Maui dynamic stability study:

- KPP K3 an K4 units are converted as synchronous condenser in the study.
- Puunene substation is removed, and the tie transformer #2 in Kanaha substation is in service.
- Stage 1 projects (Kuihelani Solar and Paeahu Solar, both in GFL model) are in service.
- Stage 2 projects (Kanaha Solar, Kamaole Solar, and Waena BESS, all in GFM model) are in service.

The system generation dispatch for daytime peak load with high DER generation, which poses the highest risk to the system stability according to the past studies, is modeled for the dynamic stability study, with simulations of high-risk contingencies. The high-risk contingencies for Maui system is 1) P3 planning event - the largest GFM resource is out-of-service due to maintenance, and a three-phase fault happens at gentie of another grid-scale GFM resource and results in the loss of this gentie, and 2) P5 planning event - delayed fault clearing (24 cycles) of a three-phase fault on a 69 kV transmission line that cause the whole system experience low voltage condition during the fault.

Base scenario resource plan, year 2028

Study descriptions and study results

According to the resource plan, a system generation dispatch that represents daytime peak load with high DER generation scenario in 2028 is created (as Table 113) and modeled in PSCAD/EMTDC. In this dispatch there is no synchronous machine-based generation dispatched.

Table 113 System Generation Dispatch for Daytime Peak Load High DER Generation Scenario, Maui Base Scenario Resource Plan, Year 2028

Generation Station	Dispatched (MW)	Gen/System Load (%)	Capacity (MW)
Existing Standalone PV	5.3	2.9	5.7
Existing Wind	2.2	1.2	42
Stage 1 PV/BESS (GFL)	30	16.4	75
Stage 2 PV/BESS (GFM)	10	10.4	50
Waena BESS (GFM)	0		40
Stage 3 PV/BESS (GFM)	9		171
DER	126.2	69.0	198.6
System Load (MW)	183		

GFM MW Headroom /DER Generation	2

PSCAD simulations with a total simulation time of 25 seconds are performed with three-phase to ground faults applied at 10 seconds. For the simulated P3 planning event, it is assumed that the Waena BESS one POI is out of service before the fault occurs. Simulation results for the P3 planning event are shown in Figure 51 and for the P5 planning event are shown in Figure 52.

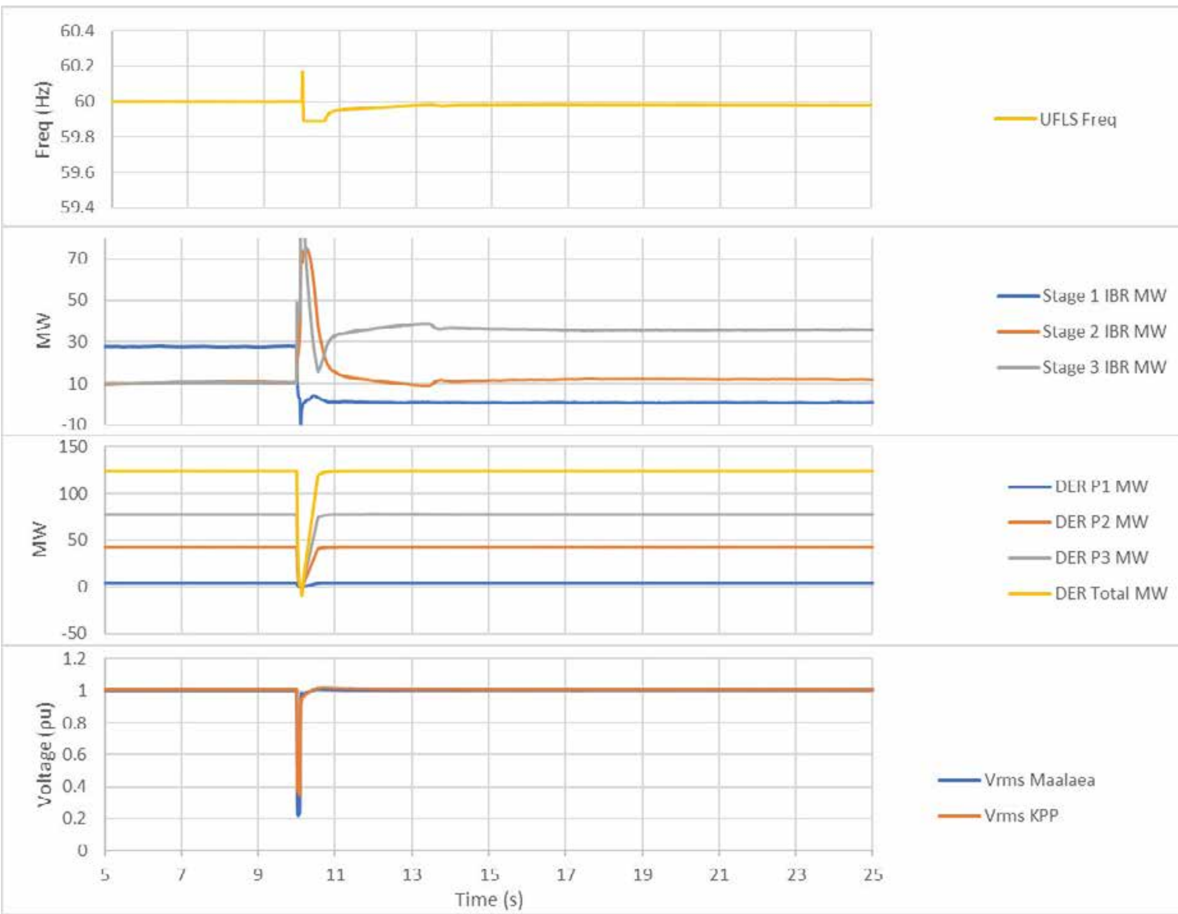


Figure 51 Dynamic stability simulation results, Maui base scenario resource plan, year 2028, P3 planning event

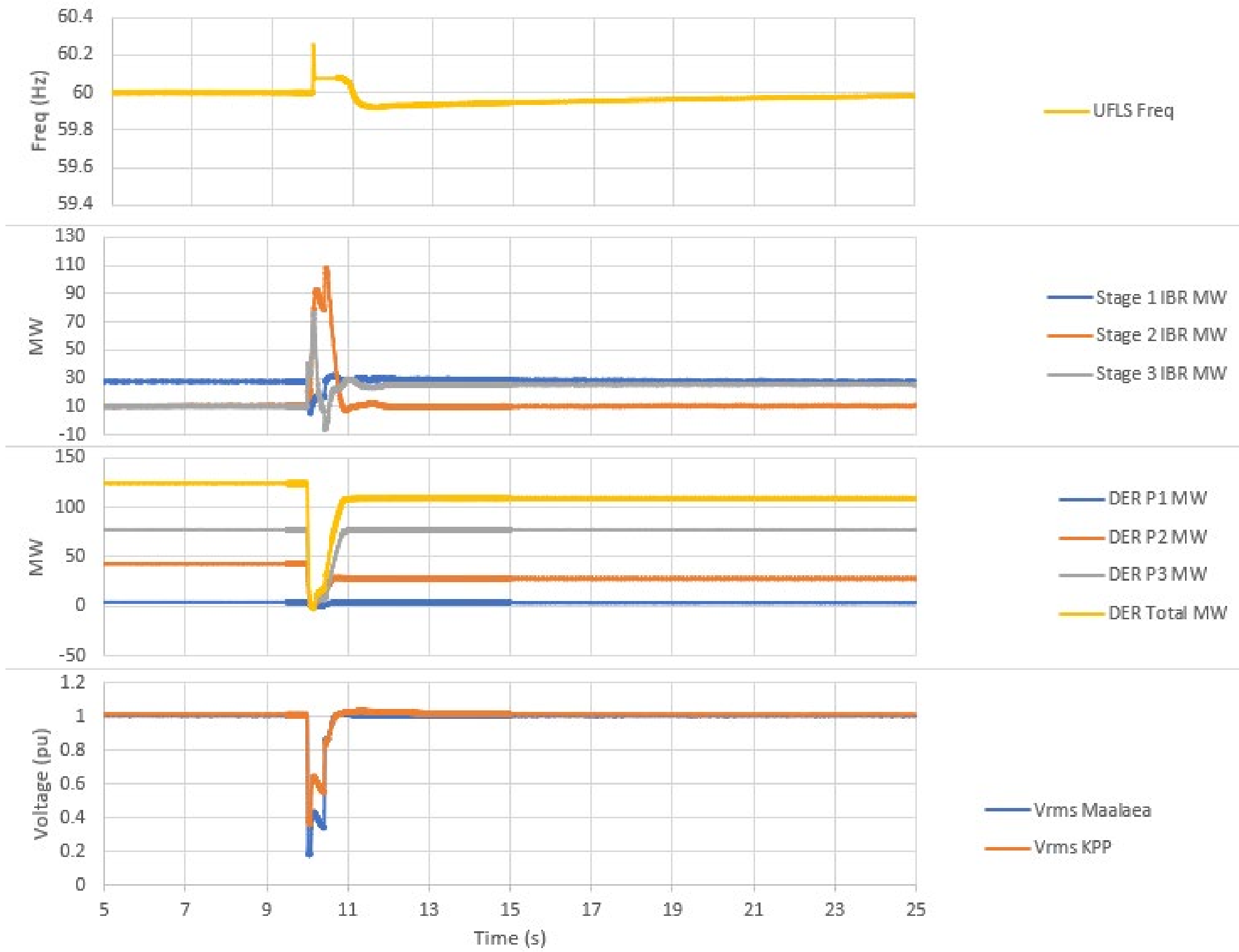


Figure 52 Dynamic stability simulation results, Maui base scenario resource plan, year 2028, P3 planning event

From above simulation results, UFLS is not identified, and system frequency nadir is well above the first block of UFLS trigger limit, 59 Hz. According to the Maui transmission planning criteria for the P3 planning event 20% of system net load UFLS is the acceptable limit and for the P5 planning event 15% of system net load UFLS is the acceptable limit.

Base scenario resource plan, year 2036

Study descriptions and study results

According to the resource plan, a system generation dispatch that represents daytime peak load with high DER generation scenario in 2036 is created (as Table 114) and modeled in PSCAD/EMTDC. It is worth noting that in this dispatch there is no synchronous machine-based generation dispatched.

Table 114 System Generation Dispatch for Daytime Peak Load High DER Generation Scenario, Maui Base Scenario Resource Plan, Year 2036

Generation Station	Dispatched (MW)	Gen/System Load (%)	Capacity (MW)
Existing Standalone PV	5.3	2.5	5.7
Existing Wind	2.2	1.1	42
Stage 1 PV/BESS (GFL)	0	0	75
Stage 2 PV/BESS (GFM)	10	9.2	60
Waena BESS (GFM)	0		40

Stage 3 PV/BESS (GFM)	9		171
REZ Wind	0	0	60
REZ PV/BESS (GFM)	30	14.5	43
DER	151.8	73.3	246
System Load (MW)	207		
GFM MW Headroom /DER Generation	1.7		

PSCAD simulations with a total simulation time of 25 seconds are performed with three-phase to ground faults applied at 10 seconds. For the simulated P3 planning event, it is assumed that the Waena BESS one POI is out of service before the fault occurs. In this P3 event, another GFM resource with 30 MW generation is tripped. Simulation results for the P3 planning event are shown in Figure 53 and for the P5 planning event are shown in Figure 54.

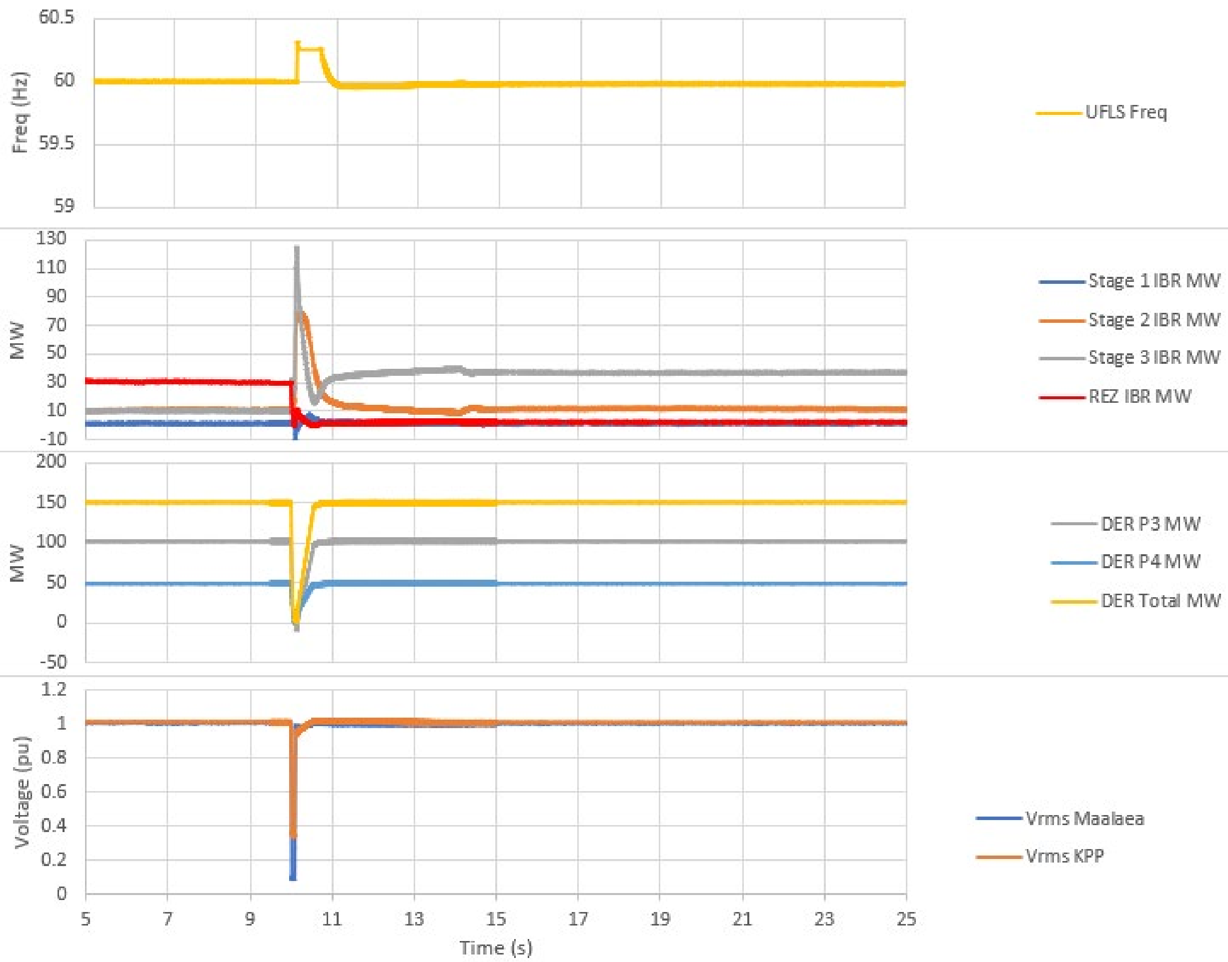


Figure 53 Dynamic stability simulation results, Maui base scenario resource plan, year 2036, P3 planning event

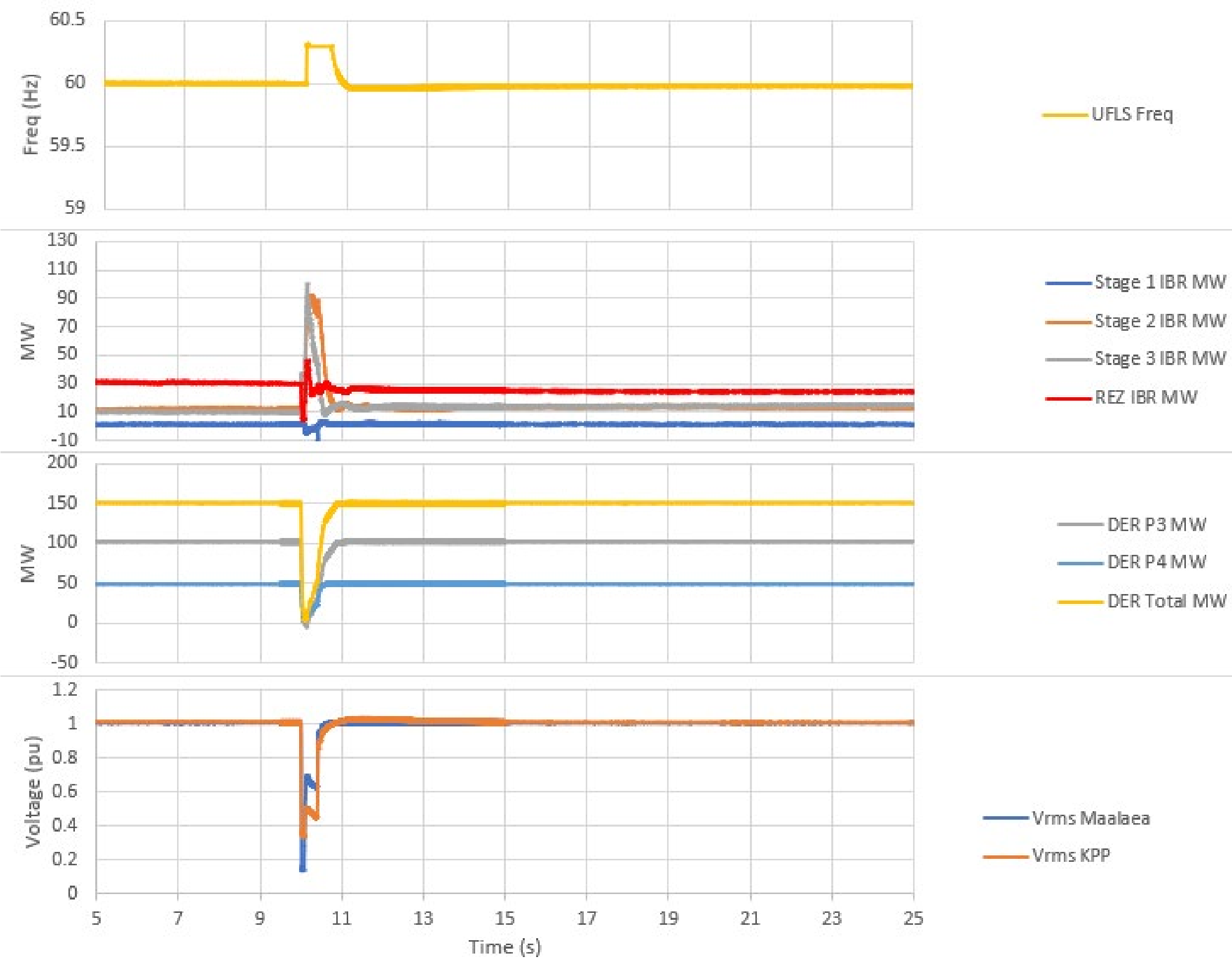


Figure 54 Dynamic stability simulation results, Maui base scenario resource plan, year 2036, P3 planning event

From above simulation results, UFLS is not identified, and system frequency nadir is well above the first block of UFLS trigger limit, 59 Hz. It can be concluded that system has sufficient GFM resource to maintain system stability within planning criteria.

Currently, industry has very limited operational experience for a system with 100% inverter-based resource. Though planning criteria violation is not observed from the PSCAD study, both study scope and models used for the study have limitations. And there may be other stability risks that are unknown currently, and hence not included in the current study, or represented in current models.

To identify the minimum capacity requirement of GFM resource procurement in RFP Stage 3 and REZ development to maintain Maui system stability within the planning criteria, the P3 and P5 planning events are simulated considering reduction of GFM resource in the studied 2028 and 2026 scenarios, until excessive UFLS is observed from the simulations. From the study, it is observed that for the year 2028, Maui system would require at least 90 MW contract capacity GFM resource. This include both Stage 2 and Stage 3 projects. For the year 2036, the Maui system would need at least 140 MW contract capacity of GFM resource. For the minimum requirement of the ratio of available MW headroom of GFM resource over DER generation, Maui system will need maintain this ratio as 0.6. It is worth noting that MWh energy and a realistic DC side model is not included in the dynamic stability study, and sufficient MWh energy in the battery side of GFM resource should always be available for the GFM resource contingency reserve.

4.3. Hawai‘i Island System Study Results

4.3.1 Steady state analyses

Base scenario resource plan, year 2032

Study descriptions

By 2030, the Hawai‘i system will have new generation from Stage 3 RFP procurement and REZ development, which will be 48 MW wind generation of REZ development by 2029 and 140 MW Stage 3 RFP PV/BESS generation by 2030. All of them will be interconnected at the Hawai‘i island 69 kV system. Also, three existing generation plants will be removed by 2031: the 34 MW Hill 5 and 6 will be removed by 2028; the 21 MW Tawhiri wind generation PPA is expected to expire by 2028; and the 58 MW Hamakua Energy Partners (“HEP”) contract is expected to expire by 2031. The system peak load is forecasted to reach 214 MW by 2032. A high-level map with locations of the grid-scale generation projects assumed in the study by 2032 is shown in Figure 55. For the 48 MW onshore wind generation from REZ zone A development, it is assumed that interconnection of the project is at the Keamuku substation. For the 140 MW RFP Stage 3 generation projects, it is assumed the generation interconnection locations are Puueo (30 MW), Kanoelehua (30 MW), Ouli (20 MW), Poopoomino (30 MW), and Keamuku (30 MW).

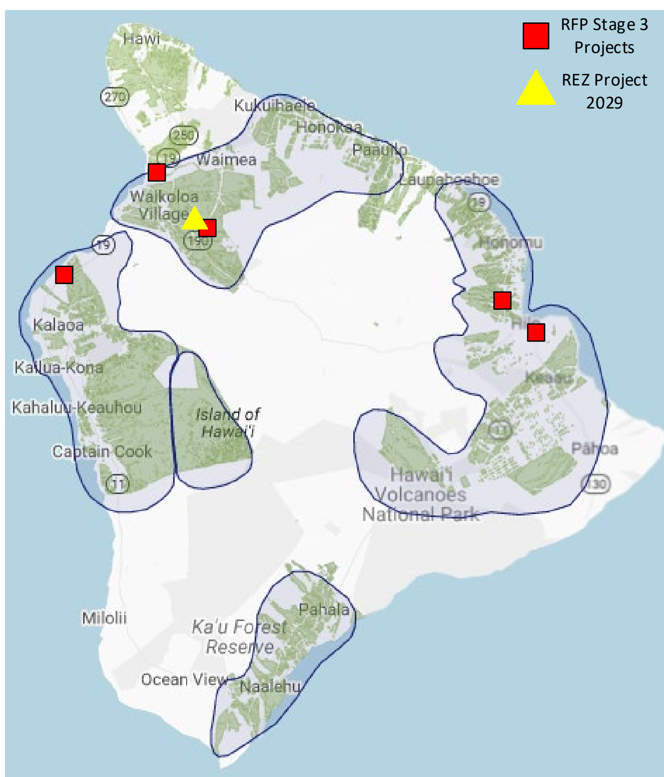


Figure 55 High-Level Hawai‘i island map with assumed future grid-scale project interconnection locations by 2032, base scenario resource plan

The detailed system grid-scale resources changes are summerized in Table 115 and Table 116. After the retirement of HEP and Tawhiri wind generation, by assuming no new generation added in north and south of system, or no contract renew, there will not be any grid-scale generation on south or northeast side of the Hawaiʻi island system. The system resource summary and the forecasted system load is summarized in Table 117.

Table 115 Hawaiʻi Island Grid-Scale Generation Project Development by 2032, after RFP Stage 2, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Wind Generation	48	2029	West Hawaiʻi island
Stage 3 Hawaiʻi Island RFP	Solar/BESS Generation	140	2030	West and east side of Hawaiʻi island

Table 116 Hawaiʻi Island Grid-Scale Generation Removal by 2032

Removal	Generation Type	MW Capacity	Year	Location
Hill 5, 6	Fossil Generation	34	2027	Kanoelehua substation
Tawhiri Generation	Wind Generation	21	2028	Kamaoa substation
HEP	Fossil Generation	49.4	2031	Haina substation

Table 117 Hawaiʻi Island System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2032

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load
85.8	58.5	46	200	16.6	174	214

To evaluate 69 kV transmission system adequacy to host both grid-scale generation interconnection and the forecasted load according to the resource plan, various system generation dispatches are created for the study, which is shown in Table 118.

Table 118 Studied System Generation (MW) Dispatches, Hawaiʻi Island Base Scenario Resource Plan, Year 2032

Area	Max Capability	System Generation Dispatches							
		Max West 1	Max West 2	Max West 3	West Gen Only	Max East 1	Max East 2	East Gen Only	Max PV/BESS
North	n.a.	0	0	0	0	0	0	0	0
West	264	214	214	146	146	71	119	0	140
East	143	0	0	69	0	143	95	143	74
South	n.a.	0	0	0	0	0	0	0	0
Total	407	214	214	214	146	214	214	143	214

Study results

Power flow simlations are performed for all studed system generation dispatches with system normal configuration and N-1 contingency configurations. From the simulation results, transmission line overloading is identified from several system generation dispatches with system N-1 contingency configurations; undervoltage planning criteria violations are identified when system is under both normal configuration and N-1 contingency configurations. A summary of transmission line overloading is provided in Table 119, and a summary of undervoltage planning criteria violation is listed in Table 120. Max West 1 and 2 have 8 contingencies each that have non-divergent issues that do not solve and most likely result in voltage collapse cases.

Table 119 List of High Loading and Overloaded Transmission Lines, Hawai'i Island Base Load Scenario Resource Plan, Year 2032

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	High Loading/Overloading Element	Max. Loading(%)	High Loading/Overloading Element	Max. Loading(%)
Max West 1	None	None	L6200	147
Max West 2	None	None	L6200	148
Max West 3	None	None	None	None
West Gen Only	None	None	None	None
Max East 1	None	None	L8900	97
Max East 2	None	None	L8900	99
East Gen Only	None	None	L6200	98
Max PV/BESS	None	None	None	None

Table 120 List of Undervoltage Violations, Hawai'i Island Base Load Scenario Resource Plan, Year 2032

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	Minimum Voltage (pu)	Substation	Minimum Voltage (pu)	Substation
Max West 1	None	None	0.266	Keauhou
Max West 2	None	None	0.240	Keauhou
Max West 3	None	None	0.810	Keauhou
West Gen Only	None	None	0.923	Keauhou
Max East 1	None	None	0.829	Keauhou
Max East 2	None	None	0.816	Keauhou
East Gen Only	None	None	0.900	Keauhou
Max PV/BESS	None	None	0.803	Keauhou

Mitigation study – transmission networks expansion

To mitigate the overloading issue on the L6200, a minimum requirement of reconductor is replacing the L6200 line from Keamuku substation to Kaumana substation by 556 AAC conductor. To mitigate the high loading condition on the L890 line, from Keamuku substation to Waikoloa distribution substation, the reconductor requirement is also to replace the line by 556 AAC conductor. A high-level cost estimate for the L6200 reconductor is $89.2 million, and for L8900 is $10.9 million.

Though the high loading and overloading conditon on the L6200 and L8900 is fixed by the reconductor, the undervoltage issues still exist, which cannot be mitigated by the reconductor. The undervoltage issue is mainly caused by the resource retirement in the south and north/east side of the Hawai'i island system.

Dependent on the system total load and the east side generation resources chosen to meet this minimum requirement, the east may require 20 MVAR of additional reactive power capability to resolve potential north/east voltage violations. At the peak load with 20 MW generation on east side of island, the following options are viable for mitigating north/east undervoltage violations:

- All 3 units of PGV online
- Puna CT3 online with 2.8 MVAR additional reactive capability required at Kanoelehua or Puueo substations
- Stage 3 Kanoelehua with 20 MVAR additional reactive capability required at Kanoelehua
- Stage 3 Kanoelehua & Puueo (split output) with 20 MVAR additional reactive capability required between the two locations. The Additional reactive capability at Kanoelehua and Puueo are in addition to the assumed capability of the Stage 3 resources at that location

To mitigate undervoltage violation identifed on south side of system, it is recommend to have a resource interconnected at Keauhou substation with at least 10.4 Mvar capability or at Kamaoa substation with 13.7 Mvar or 13.3 MW capability. The reactive power capability can be replaced by active power capability, or the combination of reactive power and active power capability.

Mitigation study – portfolio options

From the power flow analyses for various system generation dispatches, it can be concluded that:

- Overloading on the L6200 line will occur with higher levels of generation dispached on west side of system pre-contingency, and large volumn of cross island power flow through it during post contingency. This cross island power flow from west to east side of the system if generation resources are located to balance production in East and West Hawaii. It is also observed that system load is below 174 MW, the overloading on the L6200 is unlikely to happen.
- Reconductoring the L6200 line does not mitigate the undervotlage issue on north/east side and south side of the system. Generation resources and reactive power resources will be required on the east and south side of the system. Procuring resources on both the East and South side is required for the voltage constraint, which also improves the L6200 overload.

Therefore, reconductoring the L6200 is required for unconstrained use of resources identified in the portfolio. The resource acquisition would need to procure MW generation on the east side of Hawaii Island, at the levels needed to avoid overloading the L6200 line for single contingencies. The minimum requirement of MW generation on the east side of the system was calculated by following equation:

East side minimum generation (MW) = $\frac{System\ total\ load - 174}{214-174} \cdot 20$

The L8900 line high loading condition is caused by high production from the east side and Keamuku substation. By shifting of generation on further west side of system (e.g., Keahole, Poopoomino, Ouli), the overloading on the L8900 can be avoided.

The planning study did not consider beyond N-1 conditions, however, the reconductoring and procuring resources distributed around the island's transmission system, will improve resilience, in addition to removing dispatch constraints on the present base resource portfolio that otherwise would be necessary.

REZ Enablement

The interconnection of 48 MW wind generation from REZ development is assumed at the Keamuku substation. The estimated REZ enablement cost for the 48 MW offshore wind interconnection at the Keamuku substation is $37.8 million.

Base scenario resource plan, year 2050

Study descriptions

In addition to previous system resource changes by 2031, the Hawai‘i island system will have 2 MW standalone BESS and 3 MW Solar/BESS from the REZ development by 2035. It is assumed that both interconnection will be in distribution circuits by considering their MW size. In 2040, there will be another 20 MW Solar/BESS generation developed from REZ. In 2045, all fossil generation will have fuel switch to biodisel. In the same year, there will be 30 MW geothermal generation and 2 MW standalone BESS interconnected to the system. By 2050, an additional 14 MW Solar/BESS and 2 MW onshore wind generation will be developed from REZ. The system annual peak load is forecasted to reach 295 MW by 2050. A high-level map with locations of the grid-scale generation projects assumed in the study by 2050 is shown in Figure 56. For the 20 MW PV/BESS generation from REZ zone A development by 2040, it is assumed that interconnection of the project is at the Pepeekeo substation. For the 30 MW geothermal generation project, it is assumed the generation interconnection is at Haina substation. For the 17 MW PV/BESS project, it is assumed the generation interconnection is at Kaumana substation.

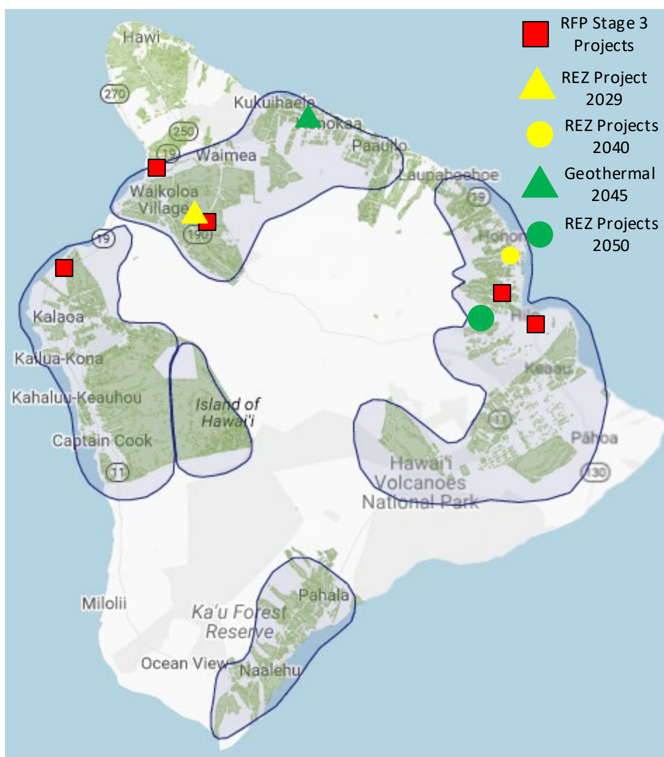


Figure 56 High-Level Hawai‘i island map with assumed future grid-scale project interconnection locations by 2050, base scenario resource plan

The detailed system grid-scale resource changes are summerized in Table 121. The system resource summary and the forecasted system load is summarized in Table 122.

Table 121 Hawai'i Island Grid-Scale Generation Project Development by 2050, Base Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Solar/BESS	3	2035	REZ, distribution interconnected
Other	Standalone BESS	2	2035	Distribution interconnected
REZ Development	Solar/BESS	20	2040	REZ, east side of Hawai'i island
Other	Geothermal	30	2045	North side of Hawai'i island
REZ Development	Solar/BESS	14	2050	REZ, east side of Hawai'i island
	Onshore wind	2	2050	

Table 122 Hawai'i Island System Resource Summary and Forecasted Demand (MW), Base Scenario Resource Plan, Year 2032

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load
85.8	60.5	76	237	16.6	243	295

To evaluate 69 kV transmission system adequacy to host both grid-scale generation interconnection and the forecasted load according to the resource plan, various system generation dispatches are created for the study, which is shown in Table 123.

Table 123 Studied System Generation (MW) Dispatches, Hawai'i Island Base Scenario Resource Plan, Year 2032

Area	Max Capability	System Generation Dispatches			
		Max West	Max East	East Gen Only	Max PV Paird
North	30	30	30	0	6
West	264	264	86	0	192
East	180	0	180	180	97
South	n.a.	0	0	0	0
Total	474	294	294	294	294

Study Results

Similiar to what is observed in the base scenario resource plan year 2032 study, transmission line overloading, undervoltage violation and voltage collapse are also observed from the power flow analyses performed for the system generation dispatches. A summary of transmission line overloading condition is provided in Table 124. A summary of undervoltage planning criteria violation and voltage collapse is listed in Table 125. Max East case has 1 non-divergent issue, Max PV/BESS has 2 non-divergent issues, and Max West has 2 non-divergent issues. These cases with non-divergent issues have contingencies that do not solve and most likely result in voltage collapse.

Table 124 List of High Loading and Overloaded Transmission Lines, Hawaiʻi Island Base Load Scenario Resource Plan, Year 2050

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	High Loading/Overloading Element	Max. Loading(%)	High Loading/Overloading Element	Max. Loading(%)
Max West	None	None	L6200	137
Max East	None	None	L8900	127
East Gen Only	None	None	L8600	128
Max PV/BESS	None	None	L8600	122

Table 125 List of Undervoltage Violations, Hawaiʻi Island Base Load Scenario Resource Plan, Year 2050

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	Minimum Voltage (pu)	Substation	Minimum Voltage (pu)	Substation
Max West	0.848	PGV	0.161	Keauhou
Max East	None	None	0.414	Keauhou
East Gen Only	None	None	0.891	Keauhou
Max PV/BESS	None	None	0.235	Keauhou

Mitigation study – transmission networks expansion

Reconductoring L6200 and L8900 to 556 AAC is recommended to mitigate overloading issues. The estimated cost for reconductoring L6200 is $89.2 million, and the estimated cost for reconductoring L8900 is $10.9 million. To mitigate undervoltage violations on the north side of the system, it is recommended to dispatch an East unit (e.g., PGV, etc.) at 5 MW or higher.

To mitigate undervoltage violation on south and southwest side of the system, it is recommend to have a resource interconnected at Kamaoa with 22.5 MW generation capacity.

REZ Enablement

It is assumed that the geothermal generation in service in 2045 will be interconnected at Haina substation, and the REZ generation will be interconnected at Pepeekeo substation (20 MW) in 2040 and Kaumana substation (17 MW) in 2050.

High level cost estimate for the 20 MW interconnection REZ enablement at the Pepeekeo substation is $24.5 million, and for the 17 MW interconnection REZ enablement at the Kaumana substation is $27.9 million.

High load scenario resource plan, year 2032

Study descriptions

According to the resource plan, by 2030, the Hawaiʻi system will have new generation from Stage 3 RFP procurement, REZ development and a new geothermal generation plant, which will be 48 MW wind generation of REZ development and 30 MW geothermal generation by 2029 and 140 MW Stage 3 RFP

PV/BESS IBR generation by 2030. All of these new generation will be interconnected at Hawaiʻi island 69 kV system. Meanwhile, three generation plants will be removed by 2031: the 34 MW Hill 5 and 6 will be removed by 2028; the 21 MW Tawhiri wind generation will be removed by 2028; the 58 MW Hamakua Energy Partners ("HEP") will be removed from system by 2031. Accoridng to the forecast, system peak load will reach 280 MW by 2032. A high-level map with locations of the grid-scale generation projects assumed in the study by 2032 is shown in Figure 57. For the 48 MW onshore wind generation from REZ zone A development and the 140 MW generation projects from the RFP Stage 3 procurement, the assumptions regarding the generation interconnection locations are the same as what is used in the base scenario resource plan. For the 30 MW geothermal generation project, it is assumed that it will be interconnected at Haina substation.

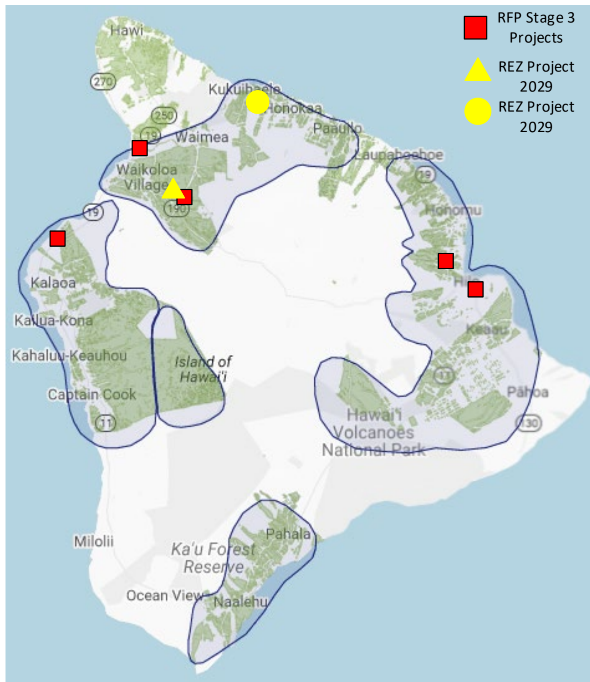


Figure 57 High-Level Hawaiʻi island map with assumed future grid-scale project interconnection locations by 2032, high load scenario resource plan

The detailed system grid-scale resources changes are summerized in Table 126. The system resource summary and the forecasted system load is summarized in Table 127. System resource retirement schedule in the high load scenario resource plan is the same as that in the base scenario resource plan.

Table 126 Hawaiʻi Island Grid-Scale Generation Project Development by 2032, High Load Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Wind Generation	48	2029	West Hawaiʻi island
Other	Geothermal Generation	30	2029	North of Hawaiʻi island
Stage 3 Hawaiʻi Island RFP	Solar/BESS Generation	140	2030	West and east side of Hawaiʻi island

Table 127 Hawai'i Island System Resource Summary and Forecasted Demand (MW), High Scenario Resource Plan, Year 2032

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load
85.8	58.5	76	200	16.6	174	280

To evaluate 69 kV transmission system adequacy to host both grid-scale generation interconnection and the forecasted load according to the resource plan, various system generation dispatches are created for the study, which is shown in Table 128.

Table 128 Studied System Generation (MW) Dispatches, Hawai'i Island Base Scenario Resource Plan, Year 2032

Area	Max Capability	System Generation Dispatches			
		Max West	Max East	Max North/East	Max PV Paird
North	30	16	30	30	21
West	264	264	107	107	199
East	142	0	143	143	60
South	n.a.	0	0	0	0
Total	437	280	280	280	280

Study results

Significant transmission line overloading, undervoltage planning criteria violations and voltage collapse issues are identified from power flow analyses performed for all the studied system generation dispatches. A summary of transmission line overloading conditions are provided in Table 129. Asummary of undervoltage planning criteria violation and voltage collapse are listed in Table 130. Max East case has 1 non-divergent issue, Max PV/BESS has 1 non-divergent issue, and Max West has 18 non-divergent issues. These cases with non-divergent issues have contingencies that do not solve and most likely result in voltage collapse and show 0 PU minimum voltage.

Table 129 List of High Loading and Overloaded Transmission Lines, Hawai'i Island High Load Scenario Resource Plan, Year 2032

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	High Loading/Overloading Element	Max. Loading(%)	High Loading/Overloading Element	Max. Loading(%)
Max West	L8600	95	L6200	126
Max East	None	None	L8900	121
Max North/East	None	None	L8600	100
Max PV/BESS	None	None	L8600	99

Table 130 List of Undervoltage Violations, Hawai'i Island High Load Scenario Resource Plan, Year 2032

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	Minimum Voltage (pu)	Substation	Minimum Voltage (pu)	Substation
Max West	0.787	PGV	0.645	PGV
Max East	None	None	0.771	Panaewa

Max North/East	None	None	0.835	Panaewa
Max PV/BESS	None	None	0.815	PGV

Mitigation study – transmission networks expansion

Reconductoring to 556 AAC for the L8100 line is recommended to mitigate the overloading on the L8100 line. The estimated cost for reconductoring L8100 is $10.9 million. Regarding the L6200 line overloading, it is recommended to defer the reconductor to further year by requiring minimum generation dispatch on the east side of the system.

Simliar as discussed in the base scenario resource plan study, generation resource and reactive power resource is required to mitigate the overvoltage and voltage collapse issues. Depending on the system total load and the East side generation resources chosen to meet this minimum requirement, the East may require 28 MVAR of additional reactive power capability to resolve potential North/East voltage violations. 14 MVAR at Kanoelehua and 14 MVAR at Puueo are recommended to be installed (in addition to the assumed capability of Stage 3 resources at that location).

To mitigate undervoltage violation identifed on south side of system, it is recommend to have a resource interconnected at Kamaoa substation with at least 24 MW generation capability, with var capability independent of active power generation. If a minimum MW is required this may require some resource to ensure it is available if the resource is variable, or define the requirement in terms of MVAR.

Mitigation study – Portfolio alternative

Reconductoring L6200 line to 556 AAC is required to accommodate the base portfolio without dispatch constraints. A minimum generation requirement on the east side of the system can be described as:

East side minimum generation (MW) = $\frac{System\ total\ load - 174}{214 - 174} \cdot 20$

If the system total load is lower than 178 MW, there is no mimimum MW requirement of generation dispatched on east side of the system.

REZ Enablement

The interconnection of 48 MW wind generation from REZ development is assumed at the Keamuku substation. The estimated REZ enablement cost for the 48 MW offshore wind interconnection at the Keamuku substation is $37.8 million.

High load scenario resource plan, year 2036

Study descriptions

In addtion to previous system resource changes, by 2035 the Hawaiʻi island system will have another 30 MW geothermal generation, 30 MW firm generation and 22 MW solar/BESS generation from REZ development. Accoriding to the forecast, system annual peak load will be reached at 323 MW by 2036. A high-level map with locations of the grid-scale generation projects assumed in the study by 2032 is shown in Figure 58. For the 22 MW PV/BESS generation from REZ zone A development, it is assumed to be interconnected at Pepeekeo substation; for the 30 MW firm generation, it is assumed to be interconnected at the Kanoelehua substation; and for the second 30 MW geothermal generation project, it is assumed to be interconnected at the Haina substation. The detailed system grid-scale resources changes are summerized in Table 131. The system resource summary and the forecasted system load is summarized in Table 132. System resource retirement schedule in the high load scenario resource plan is the same as that in the base scenario resource plan.

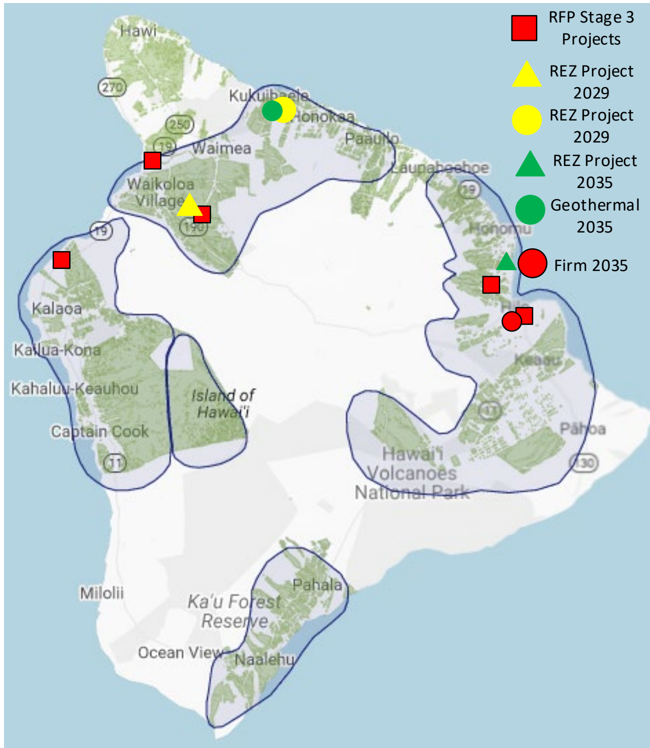


Figure 58 High-Level Hawai'i island map with assumed future grid-scale project interconnection locations by 2036, high load scenario resource plan

Table 131 Hawai'i Island Grid-Scale Generation Project Development by 2036, High Load Scenario Resource Plan

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Solar/BESS	22	2035	East side of Hawai'i island system
Other	Geothermal	30	2035	North side of Hawai'i island system
Other	Firm	30	2045	East side of Hawai'i island system

Table 132 Hawai'i Island System Resource Summary and Forecasted Demand (MW), High Load Scenario Resource Plan, Year 2036

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load
115.8	58.5	106	220	16.6	230	323

To evaluate 69 kV transmission system adequacy to host both grid-scale generation interconnection and the forecasted load according to the resource plan, various system generation dispatches are created for the study, which is shown in Table 133.

Table 133 Studied System Generation (MW) Dispatches, Hawaiʻi Island High Load Scenario Resource Plan, Year 2036

Area	Max Capability	System Generation Dispatches			
		Max West	Max East 1	Max East 2	Max Renewable
North	30	58	60	60	21
West	264	264	69	119	199
East	195	3	195	145	0
South	n.a.	0	0	0	0
Total	519	325	325	325	220

Study results

Power flow analyses are performed for all the system generation dispaches, when the Hawaiʻi island system is with normal configuration and when the system is with N-1 contingency configuration. Analysis results indicate significant trasmission line overloading on the cross-island line L6200 and undervoltage violation with voltage collapse potential, which is simliar as what is observed in the high load scenario resource plan year 2032 study. Additonally, overloading on the L8600 is also identified. This is due to the generation retirement, as well as load growth on the south side of the system. A summary of transmission line overloading condition is provided in Table 134. A summary of undervoltage planning criteria violation and voltage collapse is listed in Table 135. Max East 1 case has 4 non-divergent issue, Max East 2 has 3 non-divergent issues, Max Renewable has 4 non-divergent issues, and Max West has 20 non-divergent issues. These cases with non-divergent issues have contingencies that do not solve and most likely result in voltage collapse and show 0 PU minimum voltage.

Table 134 List of High Loading and Overloaded Transmission Lines, Hawaiʻi Island High Load Scenario Resource Plan, Year 2036

Generation Dispatch	Normal Configuration		N-1 Contingency Configuration	
	High Loading/Overloading Element	Max. Loading(%)	High Loading/Overloading Element	Max. Loading(%)
Max West	L8600	100	L8600	118
Max East 1	None	None	L8900	167
Max East 2	None	None	L8900	131
Max Renewable	None	None	L8900	123

Table 135 List of Undervoltage Violations, Hawaiʻi Island High Load Scenario Resource Plan, Year 2036

Generation Dispatch	Normal Configuration	N-1 Contingency Configuration

	Minimum Voltage (pu)	Substation	Minimum Voltage (pu)	Substation
Max West	None	None	0.658	Kilauea
Max East	None	None	0.256	Keauhou
Max East 2	None	None	0.316	Keauhou
Max Renewable	None	None	0.815	Capt Cook

Mitigation study – transmission networks expansion

To mitigate the transmission line overloading issues, reconductor of L6200 line to 556 AAC and L8600 line to 336 AAC is proposed. The estimated cost for reconductoring the L6200 is $89.2 million, and the estimated cost for reconductoring the L8600 is $32.3 million.

To mitigate undervoltage violations on the north side of the system, it is recommended to dispatch an East unit (e.g., PGV, etc.) at 14 MW or higher.

To mitigate undervoltage violation on south and southwest side of the system, , it is recommended to have a resource interconnected at Kamaoa with at least 24 MW active power generation capacity and 7.5 Mvar reactive power capability.

To mitigate undervoltage violations on the west side of the system during dispatches with high east generation, it is recommended to dispatch Keahole at 10 MW or higher.

REZ Enablement

Between 2033 and 2036, there is 20 MW PV/BESS generation project from the REZ zone A development, which is assumed to be interconnected at the Pepeekeo substation. The estimated cost for the REZ enablement in Pepeekeo substation is $24.5 million.

4.3.2 Dynamic stability study

The Hawai'i Island system in near-term years 2026 and 2032 of base scenario resource plan are selected for performing dynamic stability study to evaluate system dynamic stability performance. Similar to the O'ahu and Maui studies, the Hawai'i Island system dynamic stability study is performed in PSCAD/EMTDC for the high-risk system generation dispatch, which is also the daytime peak load with high DER generation, with a short list of high-risk system contingency.

The Hawai'i Island system high-risk contingency consists of a contingency for each category of planning events from P1 to P5. Also, due to the system topology and interconnection of existing grid-scale generations, for each selected year, dynamic stability study is performed for a base dispatch, in which most synchronous machine-based generation is dispatched from east side of the system, and a sensitivity dispatch, in which most of synchronous machine-based generation is dispatched from west side of the system.

Base scenario resource plan, year 2026

Study descriptions and study results

According to the resource plan, in 2026, there is no additional grid-scale generation resource interconnected to the system beyond RFP Stage 1 projects. So, the study of 2026 benchmarks system dynamic stability performance. A base system generation dispatch and a sensitivity system generation dispatch, both representing daytime peak load with high DER generation scenario in 2026 with different system topology, are created (as Table 136) and modeled in PSCAD/EMTDC. In these two dispatches, there is no GFM IBR resources in the system. Study results are summarized in Table 137. From the simulation results, it can be concluded that the Hawai'i Island system does not have sufficient resource to maintain system stability within planning criteria for the selected dispatch scenarios before the RFP Stage 3 projects interconnected online.

Table 136 System Generation Dispatches (Base Dispatch and Sensitivity Dispatch) for Daytime Peak Load High DER Generation Scenario, Hawai'i Island Base Scenario Resource Plan, Year 2026

Generation Station	Capacity (MW)	Base Dispatch (MW)	Sensitivity Dispatch (MW)
PGV	38	38	0
Keahole DTCC	52	0	38
Hill 5&6	34	13	13
Hydro Generation	17	5	5
Wind Generation	31	5	5
Stage 1 PV/BESS (GFL)	60	36	36
DER	143	103	103
System Load (MW)		200	200

Table 137 Hawai'i Island System Dynamic Stability Study Results Summary, Hawai'i Island Base Scenario Resource Plan, Year 2026

Planning Event	2026 Base Dispatch						2026 Sensitivity Dispatch					
	UFLS (MW)	DER Trip (MW)	Freq. Nadir (Hz)	UFLS Blocks Shed	Planning Criteria Violation?	Notes	UFLS (MW)	DER Trip (MW)	Freq. Nadir (Hz)	UFLS Blocks Shed	Planning Criteria Violation?	Notes
P1/P3	6	5	58.8	B1	Yes	1	32	41	58.5	B1-3	Yes	1,2
P2	57	47	58.1	B1-4	Yes	1,2	57	47	58.0	B1-4	Yes	1,2
P4	0	8	59.3	None	No	3	0	1	59.5	None	No	3
P5	32	31	58.2	B1-3	Yes	1	57	46	58	B1-4	Yes	1

Note:
1. UFLS caused by DER momentary cessation during transmission fault voltages.
2. Legacy DER trip due to overfrequency overshoot caused by excessive UFLS.
3. Small synchronous machine power oscillations caused by unbalanced tripping of DER

Detailed simulation results for selected planning events (a P5 event for base dispatch and a P3 event for sensitivity dispatch) are shown in Figure 59 and Figure 60.

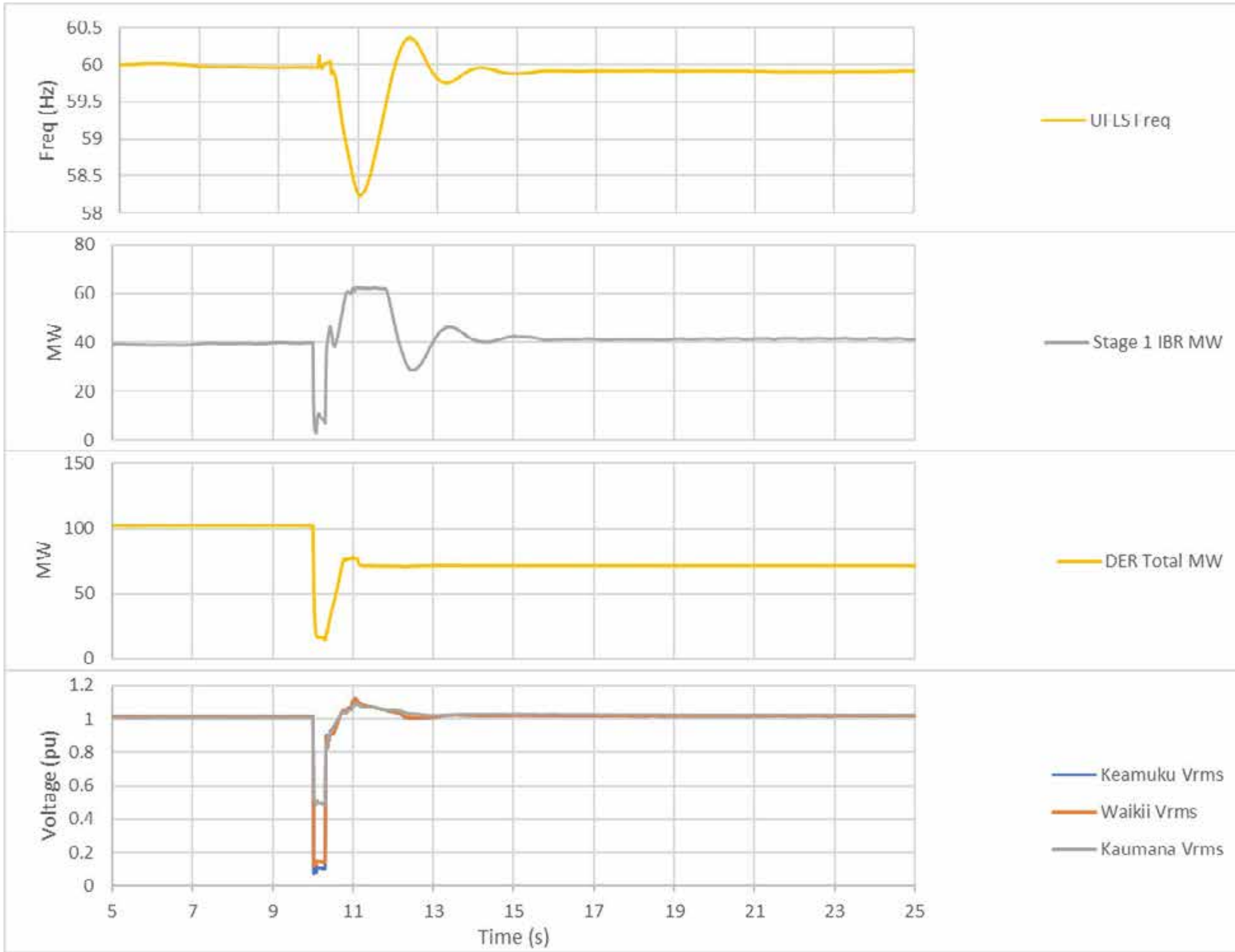


Figure 59 Dynamic stability simulation results, Hawai'i Island base scenario resource plan, year 2026, base dispatch, P5 planning event

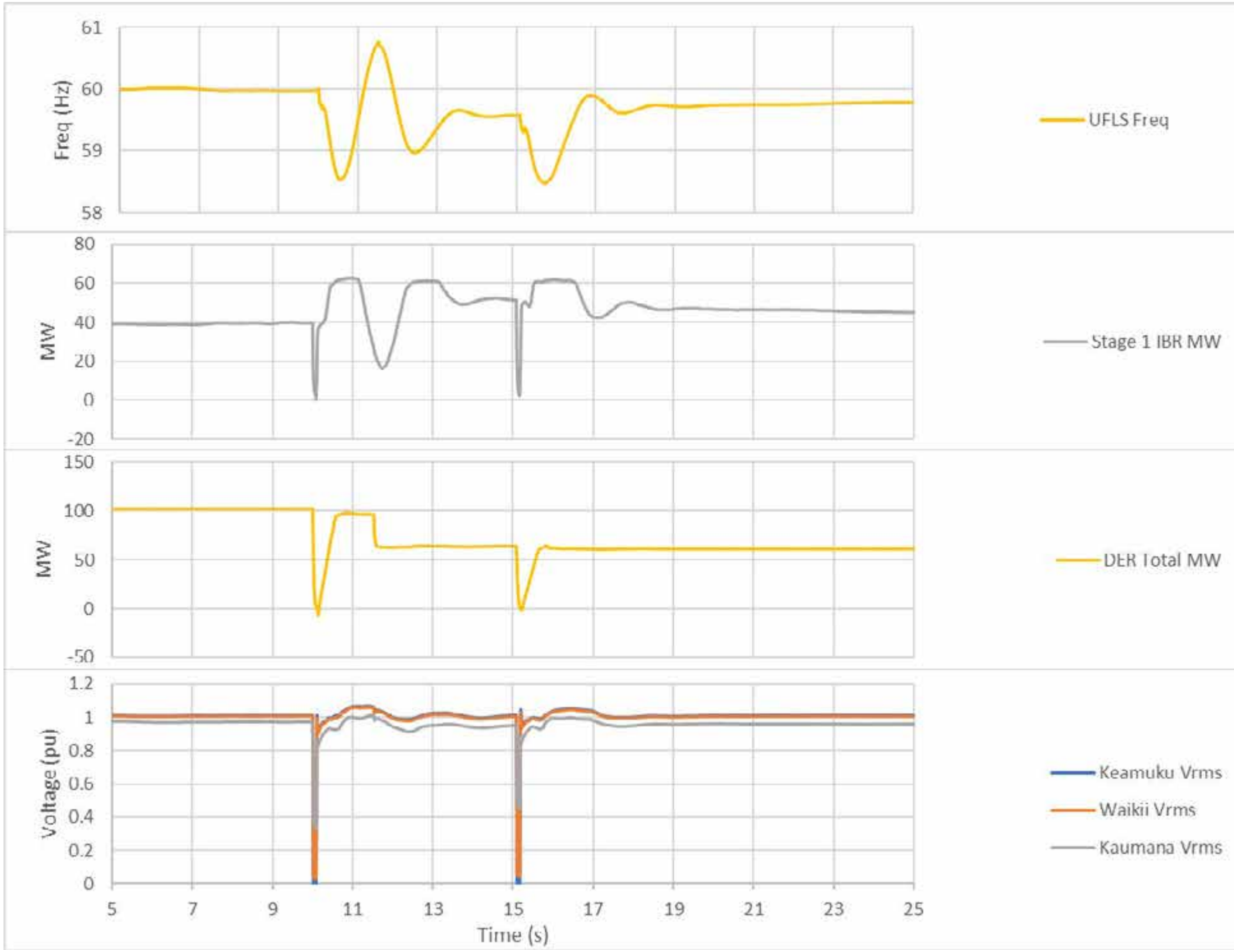


Figure 60 Dynamic stability simulation results, Hawai'i Island base scenario resource plan, year 2026, sensitivity dispatch, P3 planning event

Base scenario resource plan, year 2032

Study descriptions and study results

According to the resource plan, a base system generation dispatch and sensitivity system generation dispatch, both representing daytime peak load with high DER generation scenario in 2032 with RFP Stage 3 projects, are created (as Table 138) and modeled in PSCAD/EMTDC.

Table 138 System Generation Dispatches (Base Dispatch and Sensitivity Dispatch) for Daytime Peak Load High DER Generation Scenario, Hawai'i Island Base Scenario Resource Plan, Year 2032

Generation Station	Capacity (MW)	Base Dispatch (MW)	Sensitivity Dispatch (MW)
PGV	46	20	0
Keahole STCC	26	0	20
Hydro Generation	17	4	4
Wind Generation	59	0	0
Stage 1 PV/BESS (GFL)	60	20	20
Stage 3 PV/BESS (GFM)	140	28	28
DER	214	134	134
System Load (MW)		206	206
GFM Available MW Headroom/DER Generation		0.84	0.84

PSCAD simulation results are summarized in Table 139. After adding the 140 MW GFM resource from the RFP Stage 3 procurement, planning criteria violation is not identified, and according to the frequency nadirs of all simulated system events, the Hawai'i Island system has sufficient stability margin. From the simulations, sustained oscillations in real power are also observed in the Stage 3 IBR responses and synchronous machine responses. This may come from the untuned models which are used for representing the RFP stage 3 projects. Detailed simulation results for selected planning events (a P5 event for base dispatch and a P3 event for sensitivity dispatch) are shown in Figure 59 and Figure 60.

Table 139 Hawai'i Island System Dynamic Stability Study Results Summary, Hawai'i Island Base Scenario Resource Plan, Year 2032

Planning Event	2032 Base Dispatch						2032 Sensitivity Dispatch					
	UFLS (MW)	DER Trip (MW)	Freq. Nadir (Hz)	UFLS Blocks Shed	Planning Criteria Violation?	Notes	UFLS (MW)	DER Trip (MW)	Freq. Nadir (Hz)	UFLS Blocks Shed	Planning Criteria Violation?	Notes
P1/P3	0	0	59.6	None	No		0	0	59.2	None	No	
P2	0	0	59.6	None	No	1	0	0	59.2	None	No	1
P4	0	0	59.8	None	No	1	0	0	59.8	None	No	1
P5	0	0	59.6	None	No		0	0	59.6	None	No	1
Note: 1. Steady state real power oscillations in RFP Stage 3 projects and synchronous machines.												

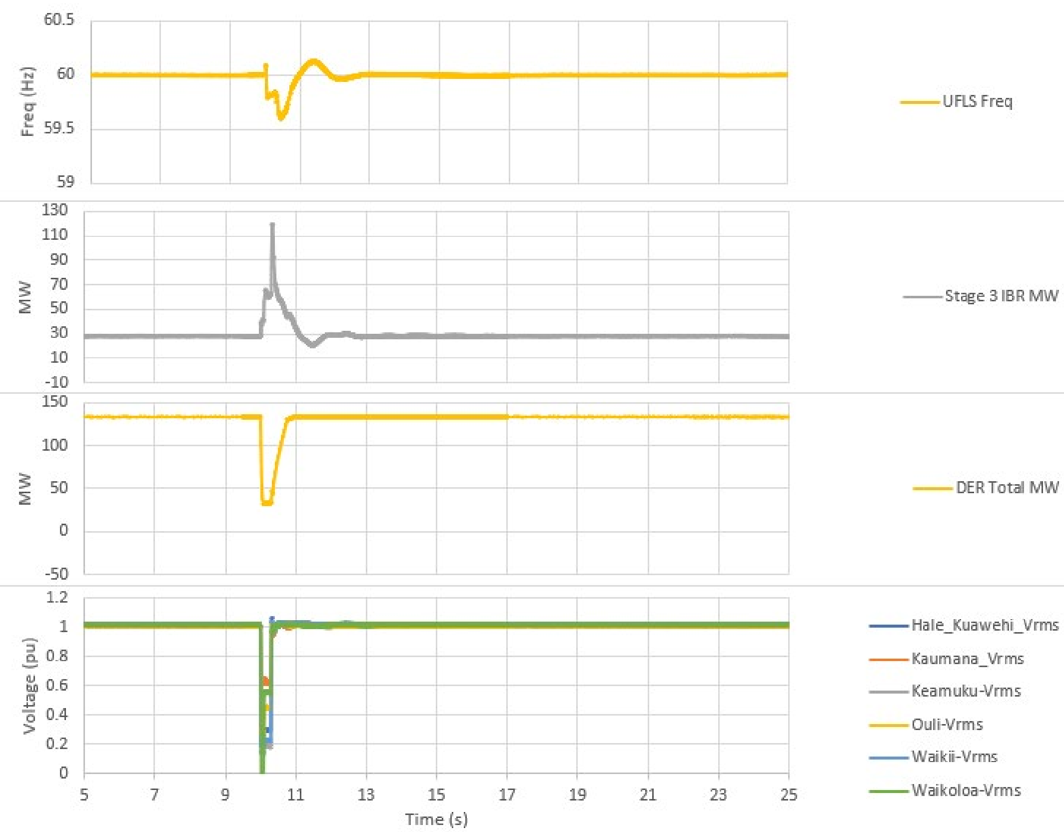


Figure 61 Dynamic stability simulation results, Hawai'i Island base scenario resource plan, year 2032, base dispatch, P5 planning event

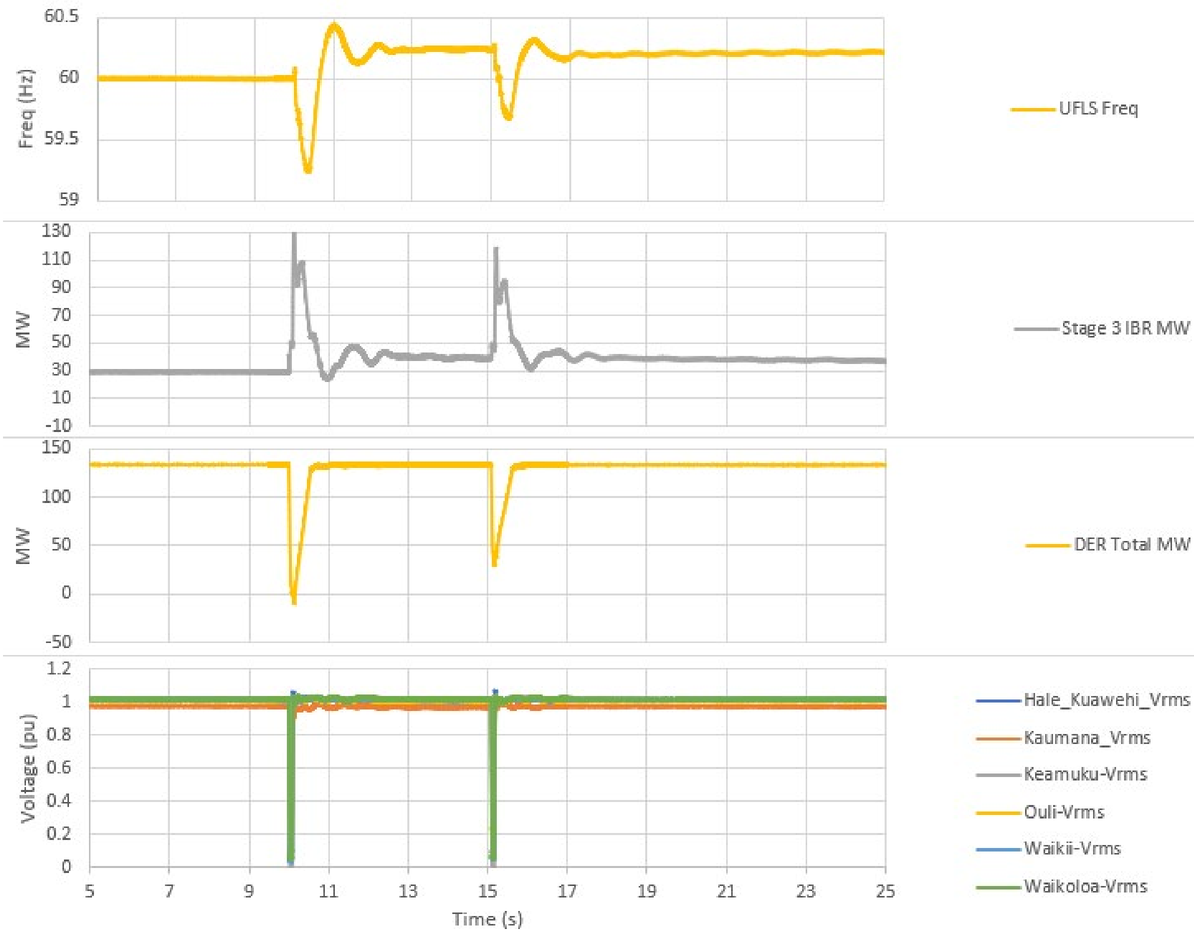


Figure 62 Dynamic stability simulation results, Hawai'i Island base scenario resource plan, year 2032, base dispatch, P3 planning event

Further study is also performed to identify minimum requirement regarding GFM resource procurement in order to maintain the Hawai'i Island dynamic stability within planning criteria, by step reducing the size of future GFM resource and creating different combinations of east side interconnection size and west side interconnection size. This study is performed for both base dispatch (i.e., major synchronous generation dispatched on east side) and sensitivity dispatch (i.e., major synchronous generation dispatched on west side), with the same high-risk contingency list. Study results for the base dispatch and sensitivity dispatch are summarized as following tables. From the study, it can be concluded that the minimum GFM requirements are dependent on system available GFM resource and synchronous generation and it is important to have a balanced interconnection of grid-scale GFM resources between east and west side of Hawai'i Island system. By 2032, the minimum requirement for Hawai'i Island system may be between 60MW – 110MW of GFM capacity on the system, and the ratio of available MW headroom from GFM resource to DER generation should be roughly 0.24 to 0.61 depending on system dispatch. All these requirements are based on the model performance used in the study to represent future GFM generation, and hence these requirements will be updated according to the future procured resource performance.

Table 140 Hawai'i Island System Minimum GFM Requirement Study Results Summary, Hawai'i Island Base Scenario Resource Plan, Year 2032, Base Dispatch

MW Size of GFM Resource		Total GFM MW Size	GFM Headroom/ DER Generation	Contingency			
West side	East side			1	2	3	4
80	60	140	0.84	No Identified Issues	Steady-state oscillations	Steady-state oscillations	Steady-state oscillations
80	0	80	0.39	**No Identified Issues**	**Steady-state oscillations**	**No Identified Issues**	**No Identified Issues**
30	30	60	0.24	**No Identified Issues**	**Steady-state oscillations**	**Steady-state oscillations**	**No Identified Issues**
50	0	50	0.16	UFLS observed	UFLS observed	No Identified Issues	No Identified Issues
30	0	30	0.01	UFLS observed	UFLS observed	No Identified Issues	UFLS observed

Table 141 Hawai'i Island System Minimum GFM Requirement Study Results Summary, Hawai'i Island Base Scenario Resource Plan, Year 2032, Sensitivity Dispatch

MW Size of GFM Resource		Total GFM MW Size	GFM Headroom/ DER Generation	Contingency			
West side	East side			1	2	3	4
80	60	140	0.84	No Identified Issues	Steady-state oscillations	Steady-state oscillations	Steady-state oscillations
60	50	110	0.61	**No Identified Issues**	**Steady-state oscillations**	**No Identified Issues**	**Steady-state oscillations**
20	60	80	0.39	UFLS observed	UFLS observed Steady-state oscillations	No Identified Issues	No Identified Issues
20	30	50	0.16	UFLS observed	UFLS observed	No Identified Issues	No Identified Issues
0	30	30	0.01	UFLS observed	UFLS observed	No Identified Issues	UFLS observed

4.4. Moloka'i and Lana'i Study Results

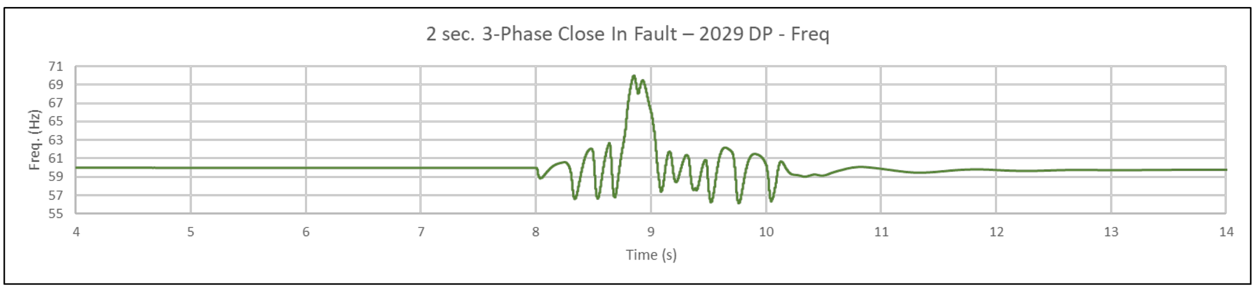
Both Moloka'i and Lana'i are much smaller systems by comparing with the remaining three island systems. Neither the Moloka'i nor the Lana'i system has a transmission planning criterion since there is no transmission system there. In the scope of this study, only dynamic stability of the Moloka'i and Lana'i system based on the resource plan is reviewed. The criteria used for this study is that the two systems can survive a primary circuit (12 kV or 33 kV) three-phase bolted fault with 2 seconds duration and single phase to ground high impedance fault with 40 Ohm fault impedance with 20 seconds duration. For each selected year for the study, for both the three-phase fault and the single line to ground fault, both close in fault, which is the fault applied at the beginning of the circuit, and far end fault, which is the fault applied at the end of a circuit, are simulated. All simulations are performed in PSCAD/EMTDC. The years that are selected for the study are:

- Molokaʻi system base scenario resource plan – 2029, 2030 and 2050.
- Molokaʻi system high load scenario resource plan – 2029, 2030 and 2050
- Lanaʻi system base scenario resource plan – 2029 and 2050.
- Lanaʻi system high load scenario resource plan – 2029 and 2050
- Lanaʻi system No Resort scenario resource plan – 2029, 2030 and 2050

4.4.1 Molokaʻi Study Results

Base scenario resource plan, year 2029

Daytime peak load low DER and low diesel generation dispatch is selected for the study. In this dispatch, system load is 5.4 MW, supplied by DER (1 MW), existing diesel unit (D8, generating 2 MW), and centralized IBR (5.75 MW GFM BESS capacity and 6 MW PV generation capacity). Simulation results for a three-phase close in fault are shown in Figure 63, and for a three-phase far end fault is shown in Figure 64. From the close in fault results, it can be observed that system can survive the 2 seconds duration fault by successfully recovering system voltage and frequency; however, system may have diesel unit out of synchronism during the far end three-phase fault. In both cases, the GFM IBR resources demonstrate stability of ride-through the fault.



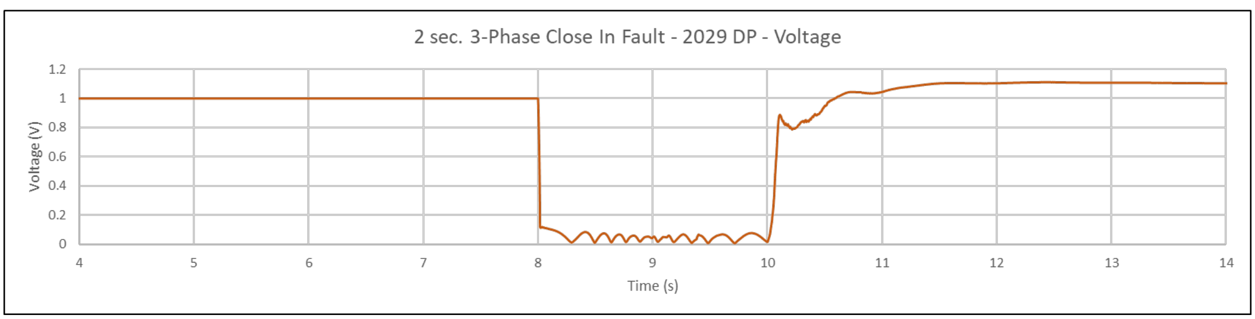


Figure 63 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2029, three-phase close in fault

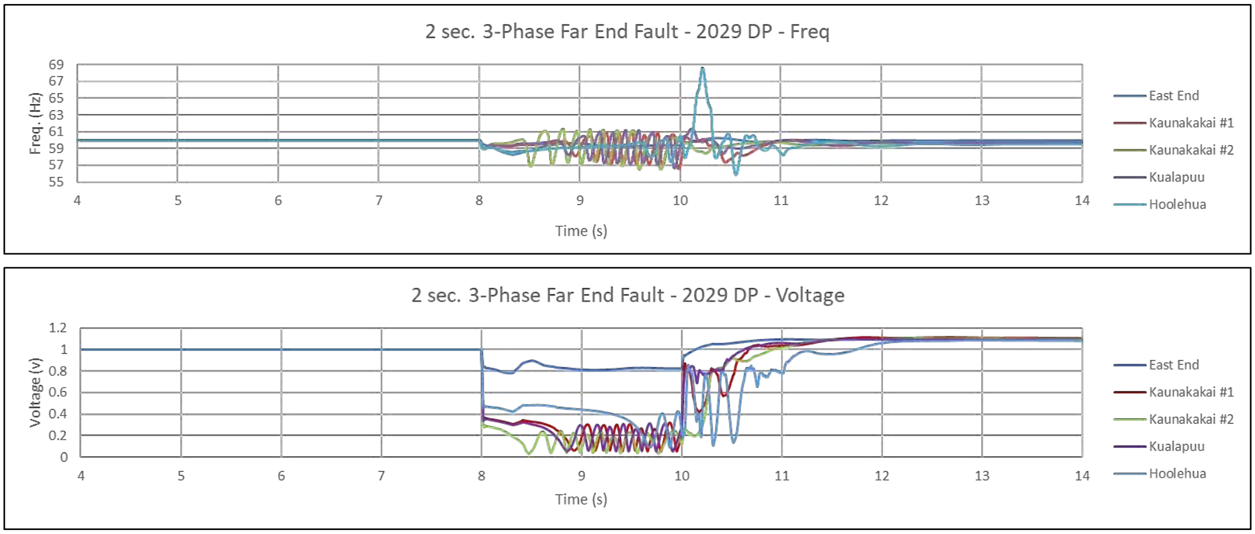


Figure 64 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2029, three-phase close in fault

For the single phase to ground high impedance fault, a case with a far end high impedance single phase to ground is shown in Figure 65. From the simulation, it can be found that Moloka'i Palaau substation could experience voltage dip down to 0.5 pu, and system frequency could swing between 56 Hz to 64 Hz. Once again, the diesel unit become out of synchronism 3 seconds after the fault inception, which causes system frequency reach 64 Hz. After fault clearing, the system voltage and frequency can recover within acceptable limits. It is worth noting that in the current system, there is no out of synchronism protection for the diesel unit. Once system has enough GFM resource to pick up load supplied by the synchronous machine pre-event, system protection should be configured to let the synchronous machine trip, in order to reduce disturbance in the system.

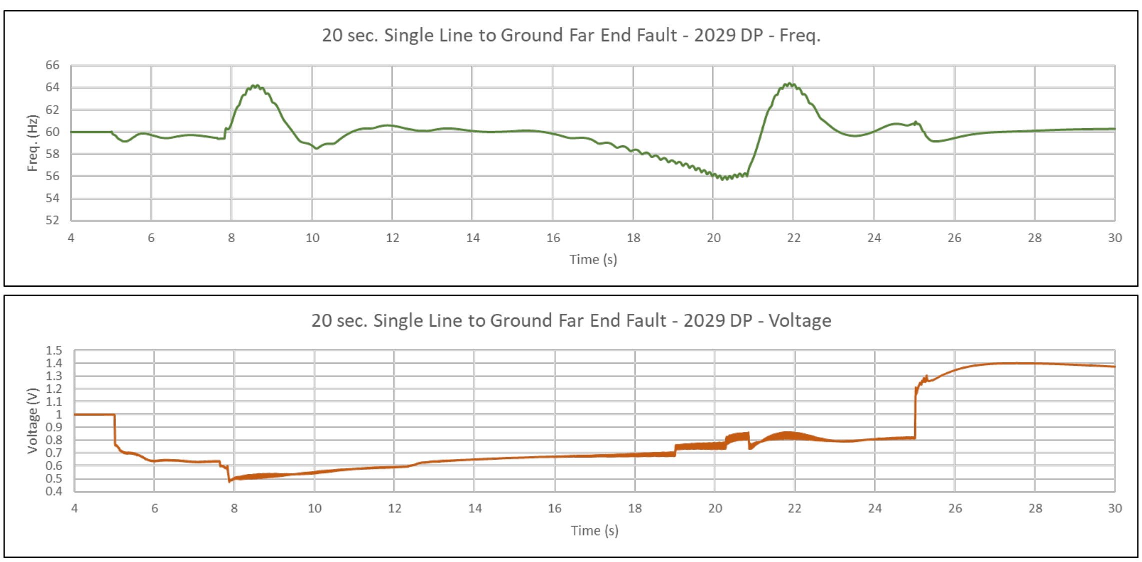


Figure 65 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2029, single phase far end fault with high fault impedance

Base scenario resource plan, year 2030

Daytime peak load low DER and low diesel generation dispatch is selected for the study. In this dispatch, system load is 5.4 MW, supplied by DER (1 MW), existing diesel unit (D8, generating 1.1 MW), and centralized IBR (14.25 MW GFM BESS capacity, and 14.5 MW PV generation capacity). Simulation results of system voltage and frequency for a close in three-phase bolted fault with 2 seconds duration are shown in Figure 66, and for a far end three-phase fault are shown in Figure 67. The simulation results indicate system can maintain stable during the fault and after fault clearing. The large capacity of GFM resource can quickly recovery system voltage and frequency after the fault clearing. Simulation results for a far end high impedance single line to ground fault are shown in Figure 68 which indicates the same conclusion that system has sufficient stability to survive the 20 seconds duration high impedance fault.

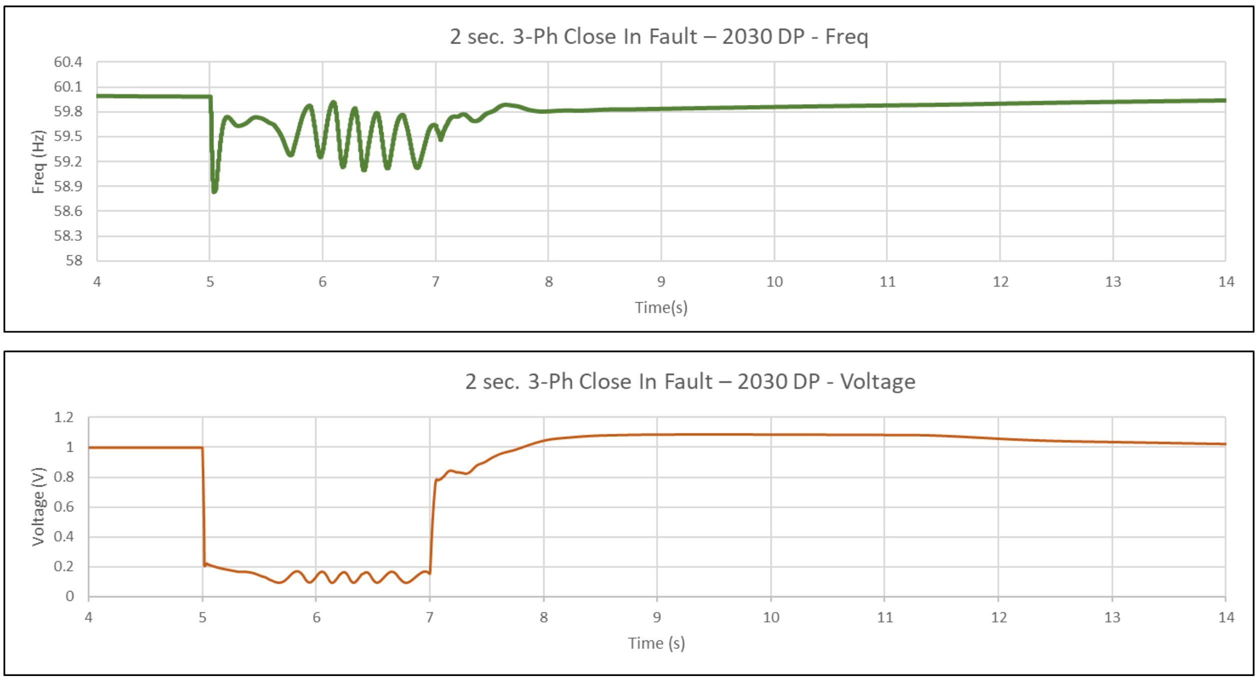


Figure 66 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2030, three-phase close in fault

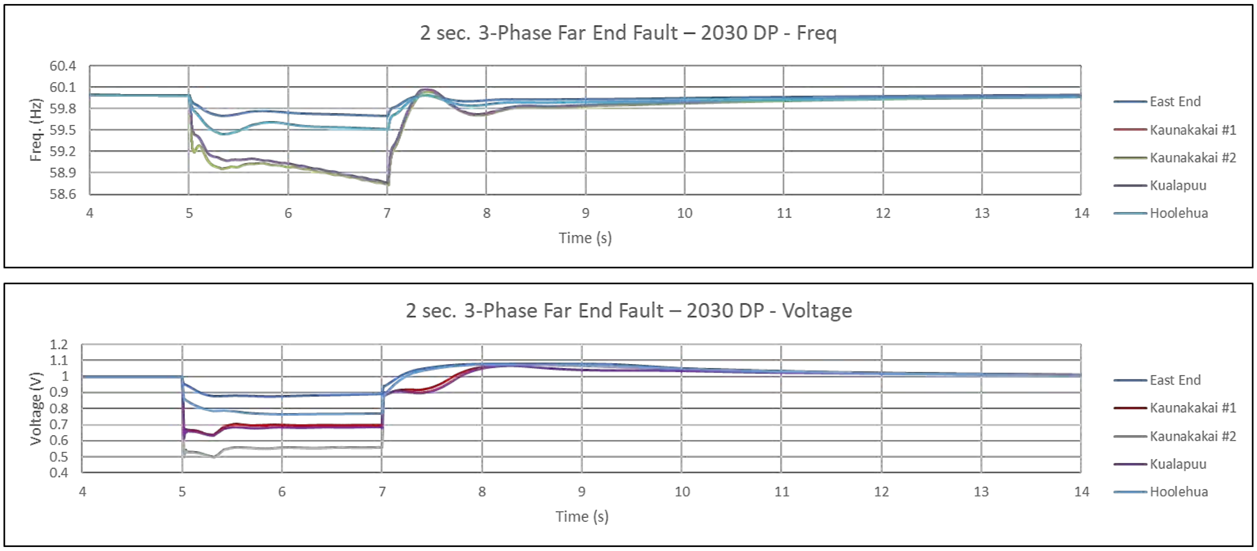


Figure 67 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2030, three-phase far end fault

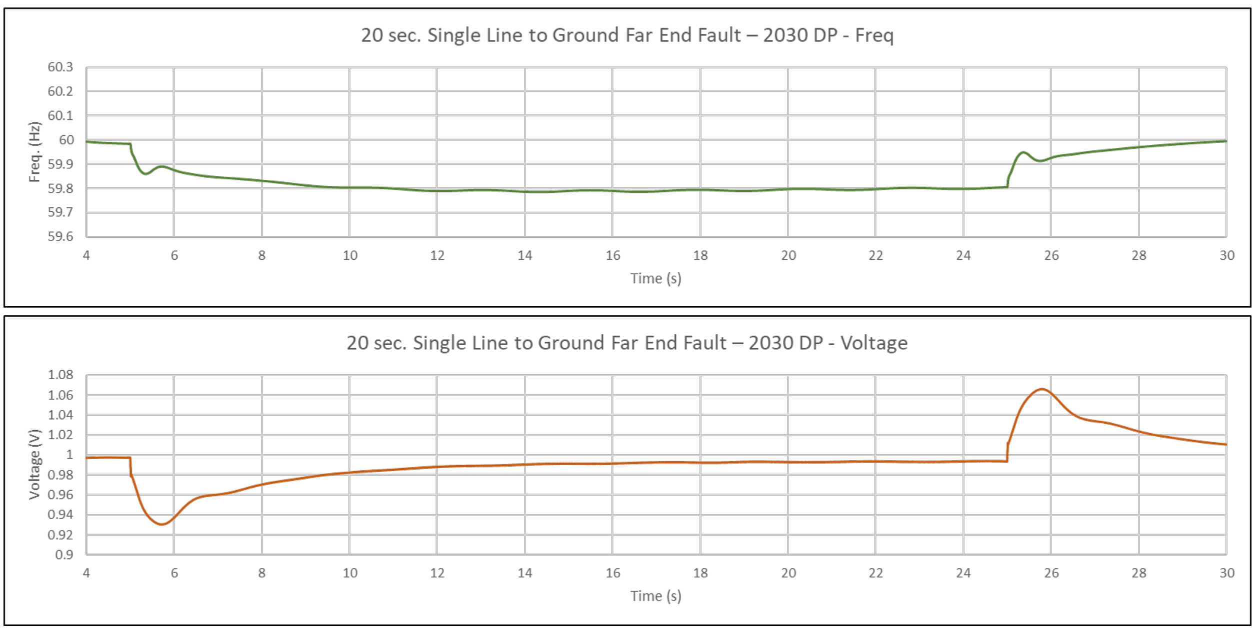


Figure 68 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2030, high impedance far end fault

Base scenario resource plan, year 2050

For the 2050 case, system evening peak load no DER no diesel unit generation dispatch is created for the study. In this scenario, all of the system load, which is 6.29 MW, is supplied by the centralized GFM BESS resources (with 21.5 MW capacity). Same three-phase faults and the far end high impedance single line to ground fault are studied. The simulation results indicate that the system can survive both the three-phase fault and the high impedance single line to ground fault. Simulation results are shown in Figure 69, Figure 70, and Figure 71.

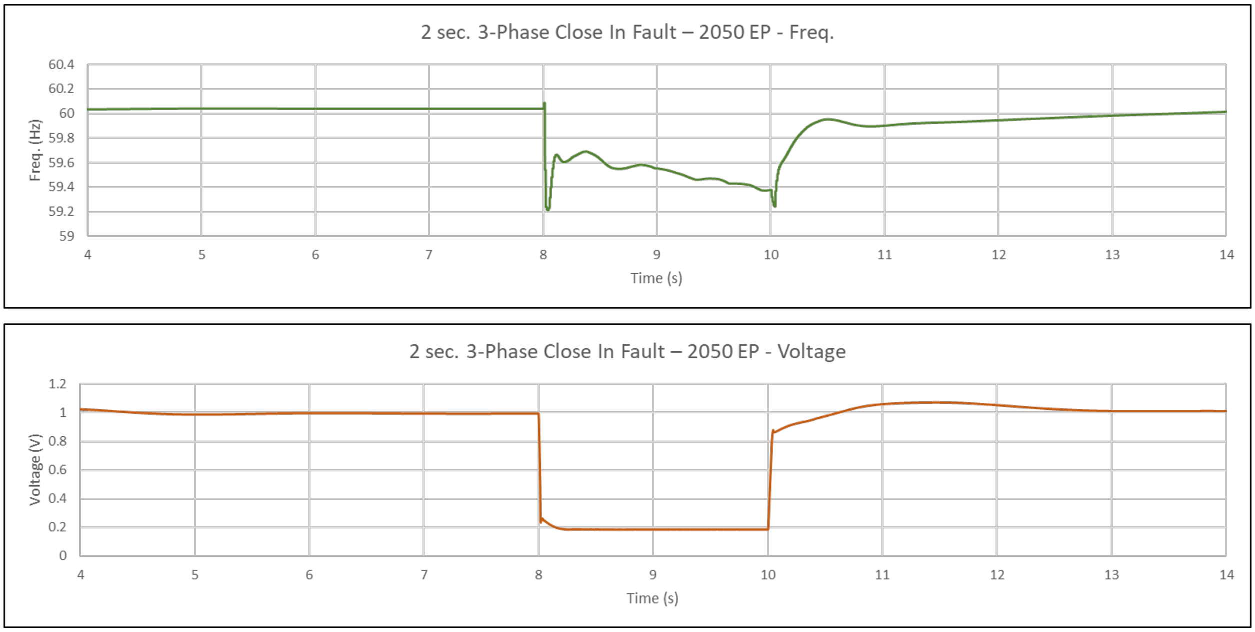


Figure 69 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2050, three-phase close in fault

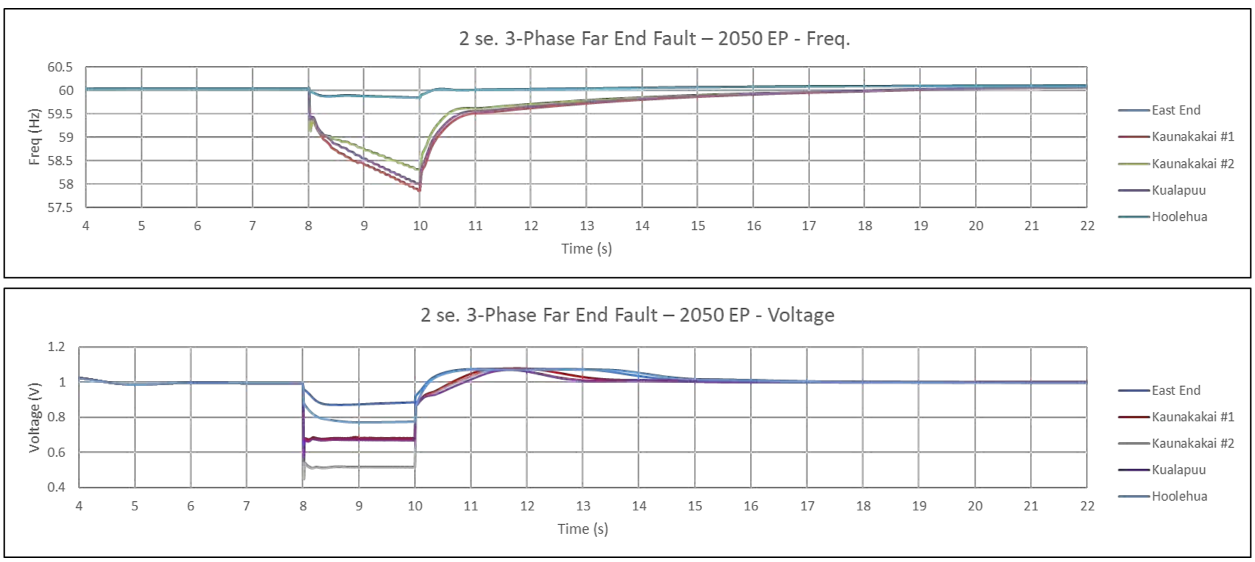


Figure 70 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2050, three-phase far end fault

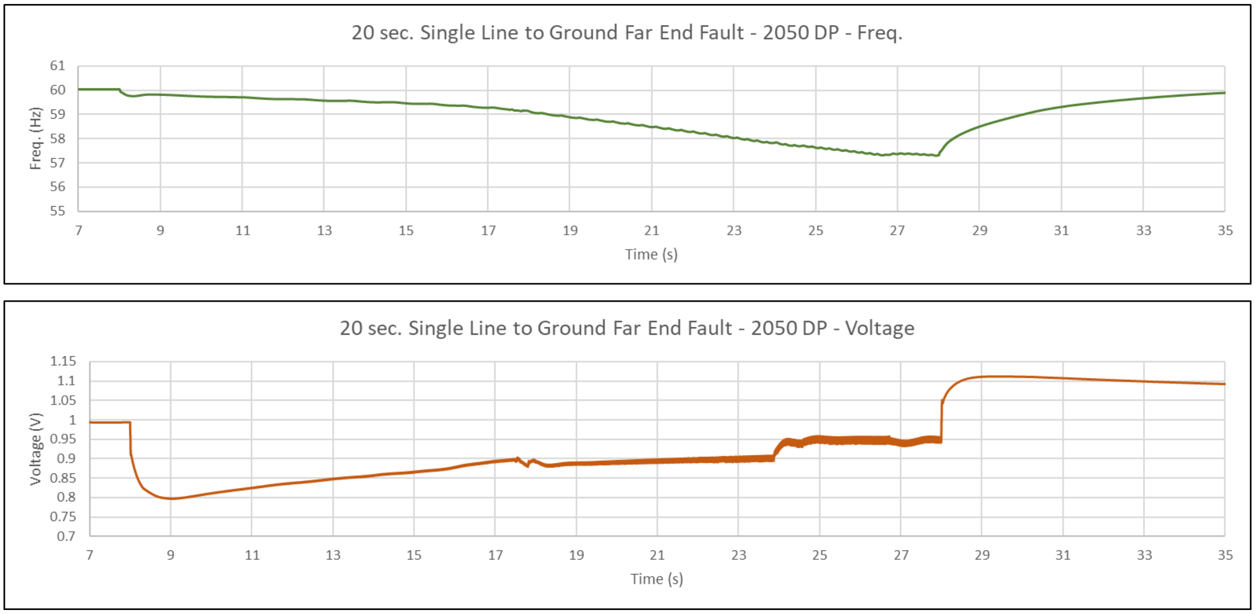


Figure 71 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2050, high impedance far end fault

In summary, it is found from the studies that sufficient centralized GFM resource interconnected at the Palaau substation can maintain system stability (i.e., surviving the 2 second three-phase bolted fault and the 20 seconds high impedance single line to ground fault) without need of the existing diesel unit. The existing diesel unit is likely to be out of synchronism during the fault, which could cause the system to experience large voltage or frequency swing. It is recommended that once system has sufficient GFM resource (from 2030), out-of-step protection should be installed for the existing diesel unit to make sure the machine can be tripped during the fault to avoid system voltage and frequency swing and equipment damage. This conclusion and recommendations are very similar as what is concluded in the 2021 System Stability Study.

High load scenario resource plan study

The Moloka'i system high load scenario resource plan is the same as the base scenario resource plan, but with different load forecast. According to the high load scenario resource plan, the Moloka'i system load is normally 1-2 MW higher than the same year load forecast in the base scenario resource plan. Exact same generation dispatches are studied for the same selected years (2029, 2030 and 2050), with the same fault events. Simulation results indicate the same conclusion as what is found for the base resource scenario that GFM resource in 2030 and further years is sufficient to maintain system stability, and out-of-step protection should be installed for the existing diesel units to avoid system voltage and frequency swing caused by the diesel units out of synchronism.

4.4.2 Lana'i Study Results

Base scenario resource plan, year 2029

Daytime peak load low DER and low diesel generation dispatch is selected for the study. In this dispatch, system load is 5.9 MW, supplied by DER (0.33 MW), existing diesel unit (D8, generating 0.5 MW), centralized IBR (16.1 MW GFM BESS capacity, and 16.1 MW PV generation capacity). Simulation results for a three-phase close in fault are shown in Figure 72, and for a three-phase far end fault is shown in Figure 73. From the close in fault results, it can be observed that system can survive the 2 seconds duration fault by successfully recovering system voltage and frequency. In both cases, the GFM IBR resources demonstrate stability and the ability to ride-through the fault.

Figure 72 Dynamic stability simulation results, Lana'i base scenario resource plan, year 2029, three-phase close in fault

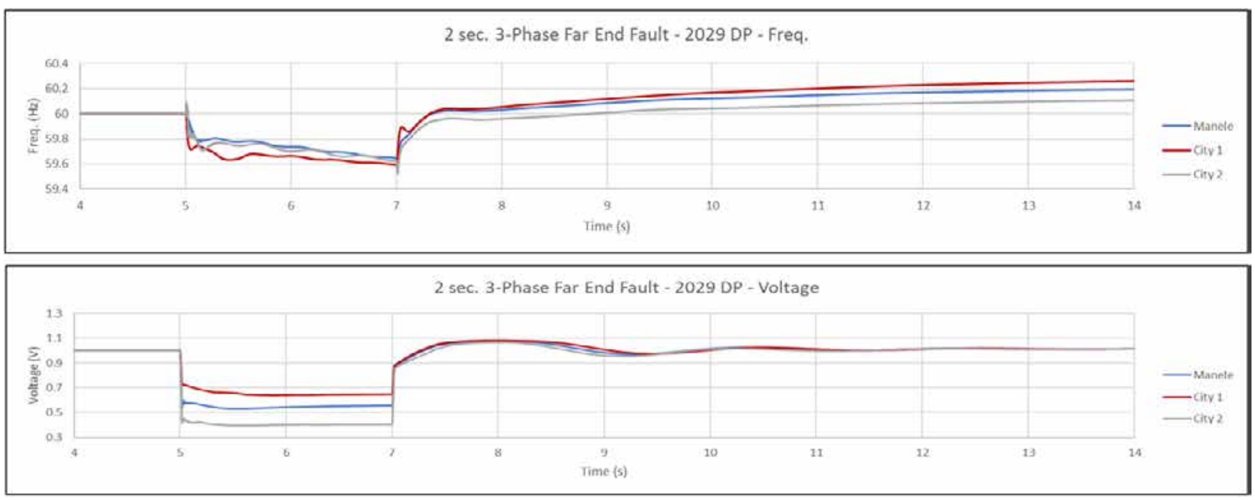


Figure 73 Dynamic stability simulation results, Moloka'i base scenario resource plan, year 2029, three-phase close in fault

Figure 74 shows the simulation results of system voltage and frequency for a far end high impedance single phase to ground fault scenario. From the simulation, it can be found that the Miki Basin substation voltage could experience voltage dip down to 0.75 pu, and system frequency could be maintained between 59.5 Hz and 60 Hz. System can immediately recover voltage and frequency after clearing the fault. The system stability performance is well within acceptable range.

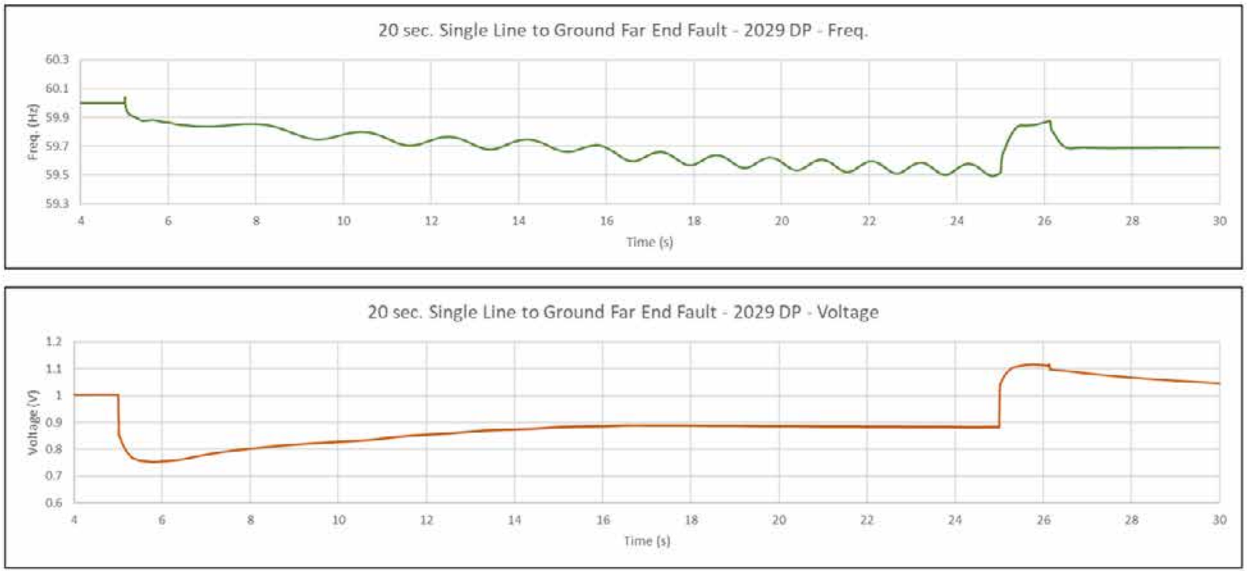


Figure 74 Dynamic stability simulation results, Lana'i base scenario resource plan, year 2029, single phase far end fault with high fault impedance

Base scenario resource plan, year 2050

Daytime peak load low DER and low diesel generation dispatch is selected for the study. In this dispatch, system load is 5.83 MW, supplied by DER (0.34 MW), existing diesel unit (D8, generating 2 MW), centralized IBR (24.8 MW GFM BESS capacity, and 24.8 MW PV generation capacity). The same fault scenarios as studied in the 2029 case are also simulated in the study for the 2050 case. Simulation results indicate that the 24.8 MW GFM resource is sufficient to maintain system stability during both the three-phase fault and the high impedance single phase fault. The simulation results are shown in Figure 75, Figure 76, and Figure 77.

Figure 75 Dynamic stability simulation results, Lana'i base scenario resource plan, year 2050, three-phase close in fault

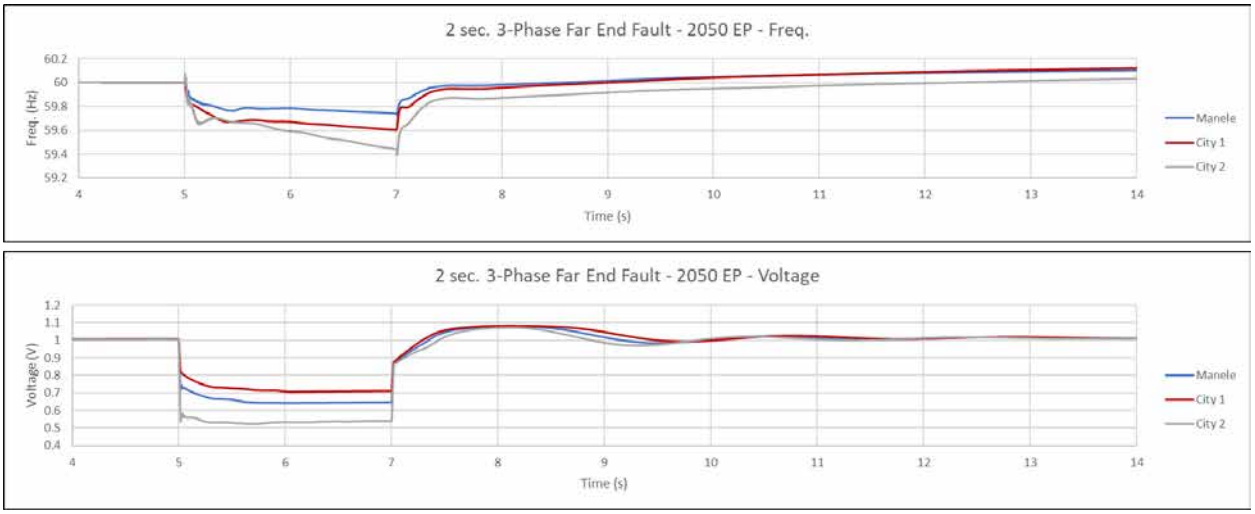


Figure 76 Dynamic stability simulation results, Lana'i base scenario resource plan, year 2050, three-phase close in fault

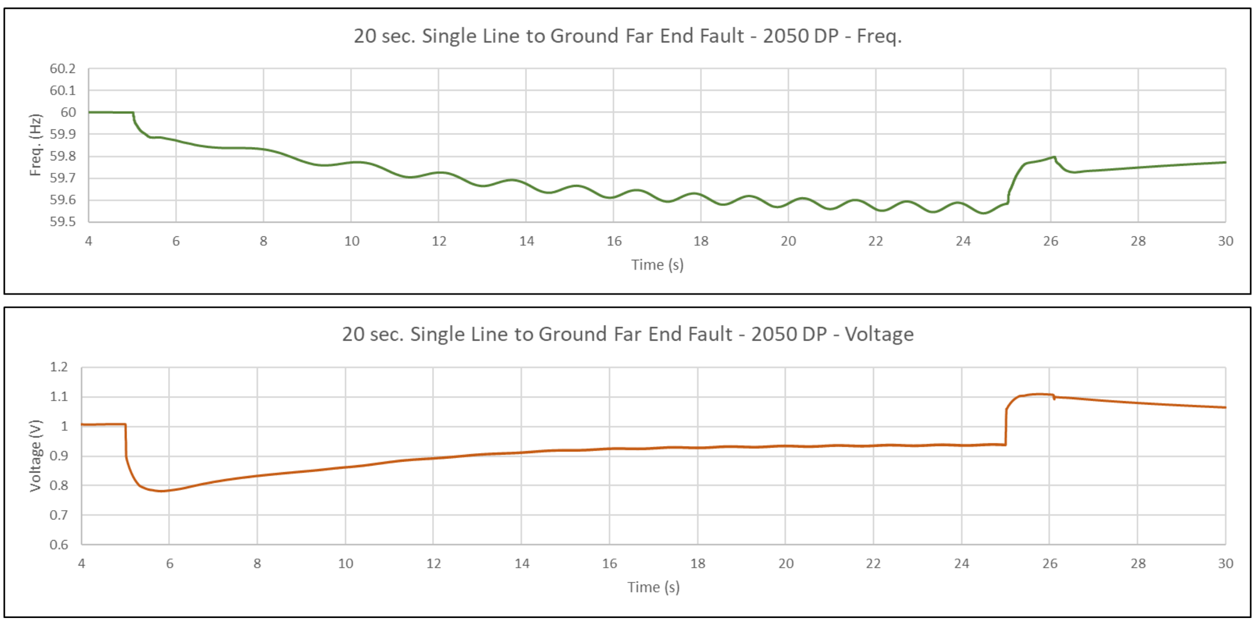


Figure 77 Dynamic stability simulation results, Lana'i base scenario resource plan, year 2050, single phase far end fault with high fault impedance

High load scenario resource plan study

Lana'i system high load scenario resource plan is the same as the base scenario resource plan, but with higher load forecast. Exact same generation dispatches are studied for the same selected years (2029 and 2050), with the same fault events. Simulation results indicate the same conclusion as what is found for the base resource scenario that GFM resource in 2029 and further years is sufficient to maintain system stability.

No resort load scenario resource plan, year 2029

In this resource plan, it is assumed that a big part of system load will be off grid. Hence, system load forecast is much smaller than what is shown in the base scenario and high load scenario resource plans. The load reduction also causes much smaller centralized resource planned for the system. For 2029, daytime peak load low DER and low diesel generation dispatch is selected for the study. In this dispatch, system load is 2.9 MW, supplied by DER (0.28 MW), existing diesel unit (D8, generating 1.02 MW), centralized IBR (3.9 MW GFM BESS capacity, and 3.9 MW PV generation capacity). The same three-phase faults and single line to ground faults are simulated in the PSCAD. Simulation results are shown as Figure 78, Figure 79, and Figure 80. From the three-phase fault simulation results, it can be observed that the dispatched diesel unit would not be able to ride-through the 2 seconds duration fault. Instead, the diesel unit shows out of synchronism from the simulation, which could cause system frequency swing after clearing the fault. Also, the 3.9 MW GFM resource is not big enough apparently to absorb disturbance caused by the diesel unit out of synchronism. However, the 3.9 MW GFM unit can survive from both the three-phase fault and the high impedance single line to ground fault.

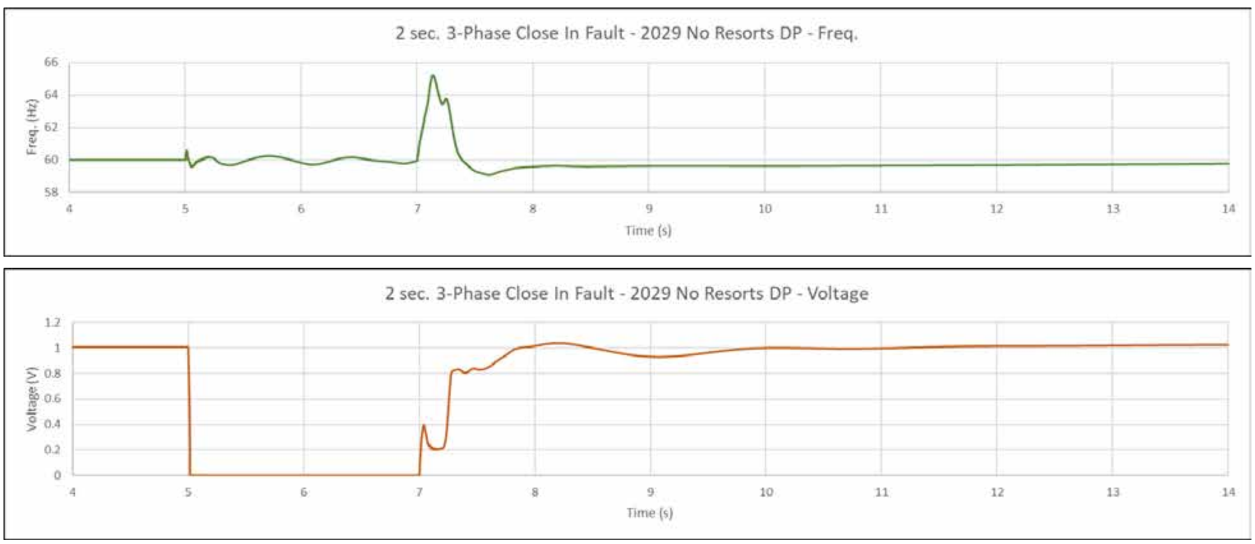


Figure 78 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2029, three-phase close in fault

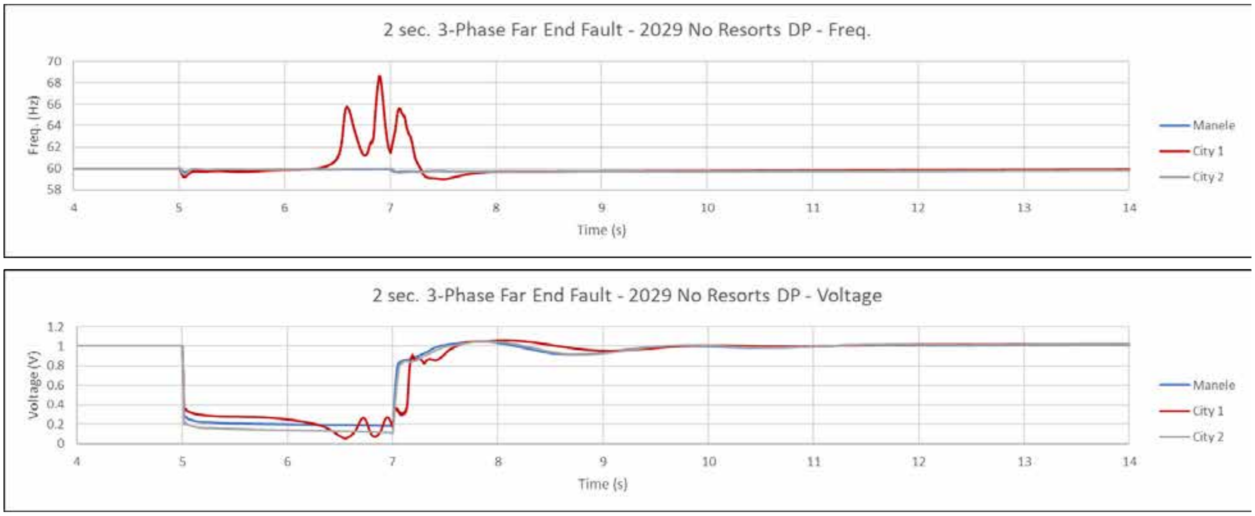


Figure 79 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2029, three-phase close in fault

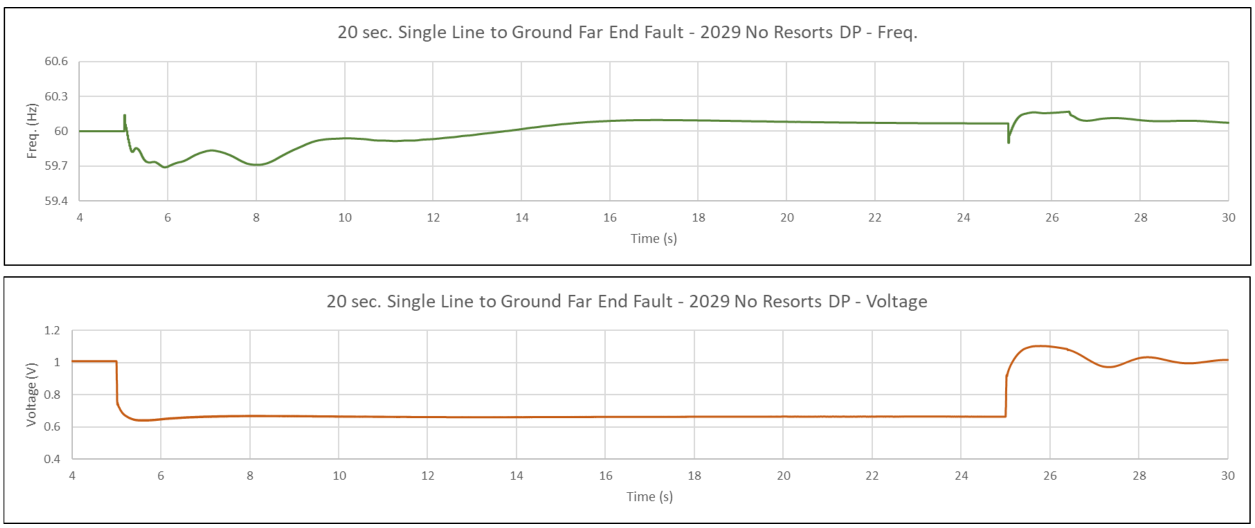


Figure 80 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2029, single phase far end fault with high fault impedance

No resort load scenario resource plan, year 2030

According to the resource plan, in 2030, 6.3 MW GFM resource will be added into the system. System peak load forecast is 3.0 MW. Daytime peak load low DER and low diesel generation dispatch is selected for the study. In this dispatch, system load (3 MW) is supplied by DER (0.28 MW), existing diesel unit (D8, generating 0.5 MW), centralized IBR (10.2 MW GFM BESS capacity, and 10.2 MW PV generation capacity). The same three-phase faults and high impedance single line to ground fault as what are studied previously are simulated in the PSCAD/EMTDC. From the simulation results, it is concluded that system stability can be maintained by the GFM resource, and system voltage and frequency can be recovered after clearing the fault. Simulation results are shown in Figure 81, Figure 82, and Figure 83.

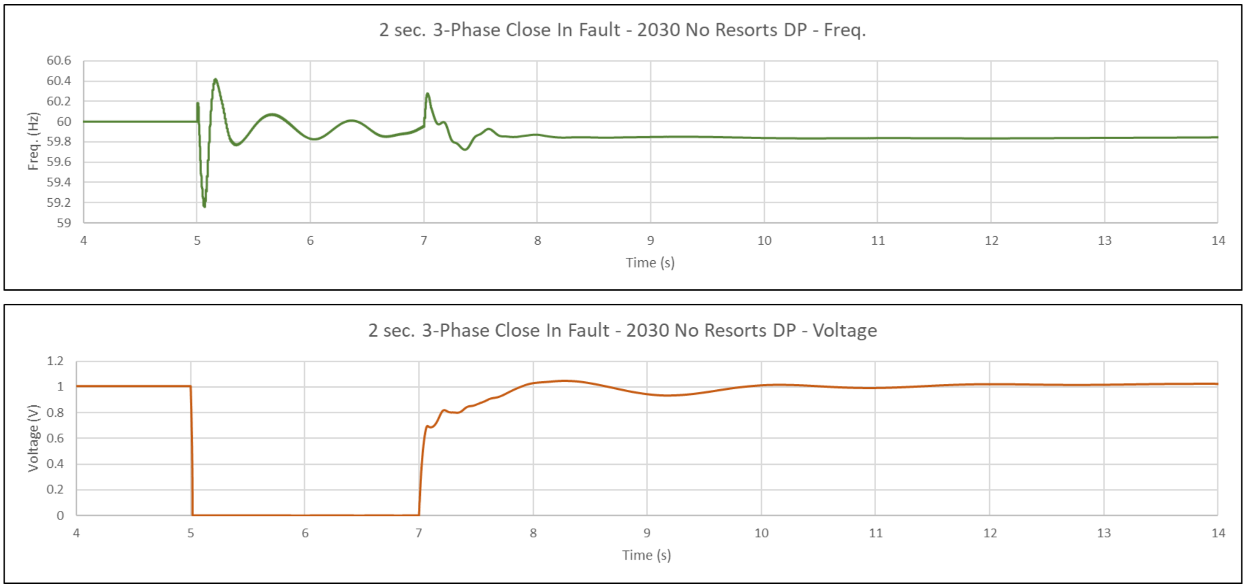


Figure 81 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2030, three-phase close in fault

Figure 82 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2030, three-phase close in fault

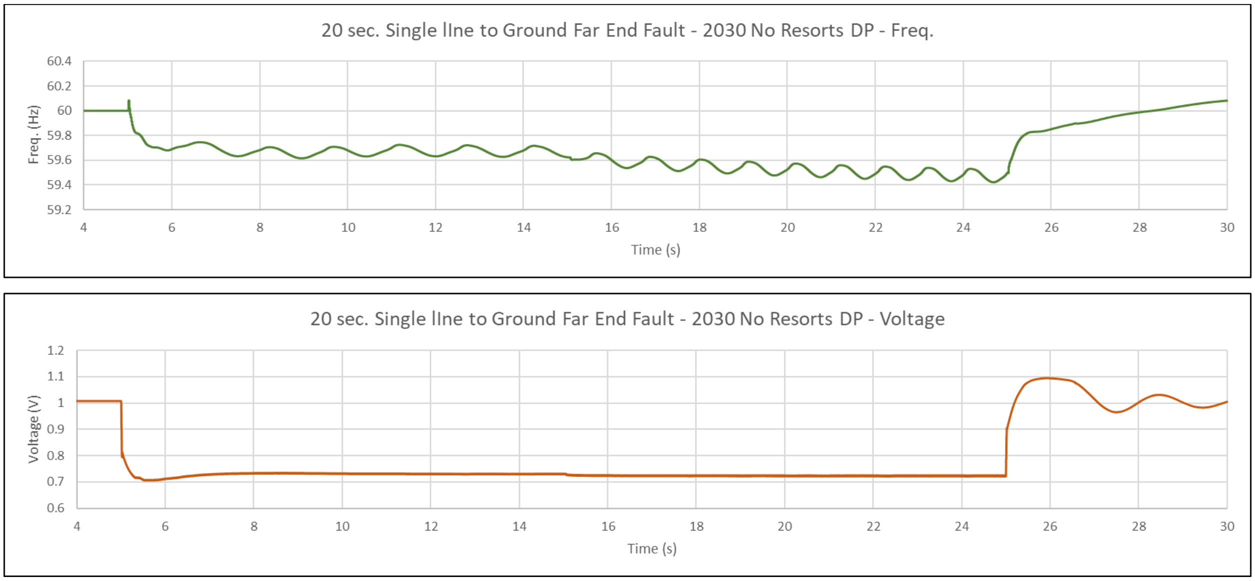


Figure 83 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2030, single phase far end fault with high fault impedance

No resort load scenario resource plan, year 2050

Another 2.3 MW GFM resource is added to system by 2050, with system peak load forecast as 3.3 MW. A daytime peak load with low DER and low diesel generation dispatch is selected for year 2050 study. In this dispatch, system load (3.3 MW) is supplied by DER (0.34 MW), existing diesel unit (D8, generating 1.0 MW), and centralized IBR (12.5 MW GFM BESS capacity, and 12.5 MW PV generation capacity). The same three-phase faults and high impedance single line to ground fault as what are studied previously are simulated in the PSCAD/EMTDC. Simulation results indicate that the 12.5 MW GFM resource is sufficient to maintain system stability during both the three-phase fault and the high impedance single phase fault. The simulation results are shown in Figure 84, Figure 85 and Figure 86.

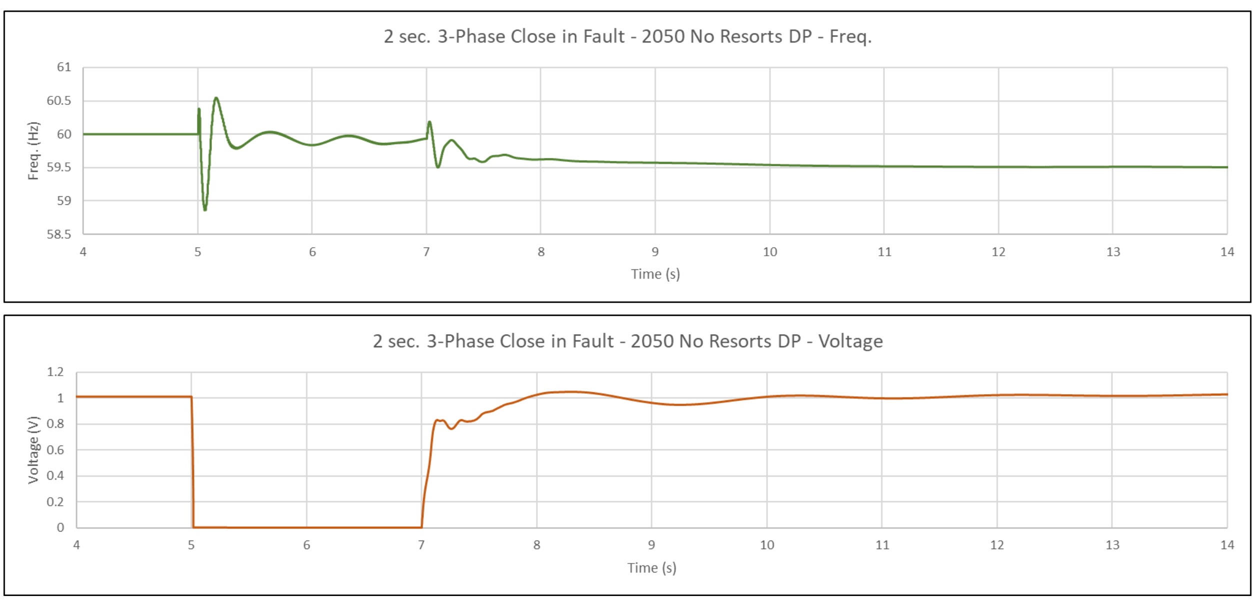


Figure 84 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2050, three-phase close in fault

Figure 85 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2050, three-phase close in fault

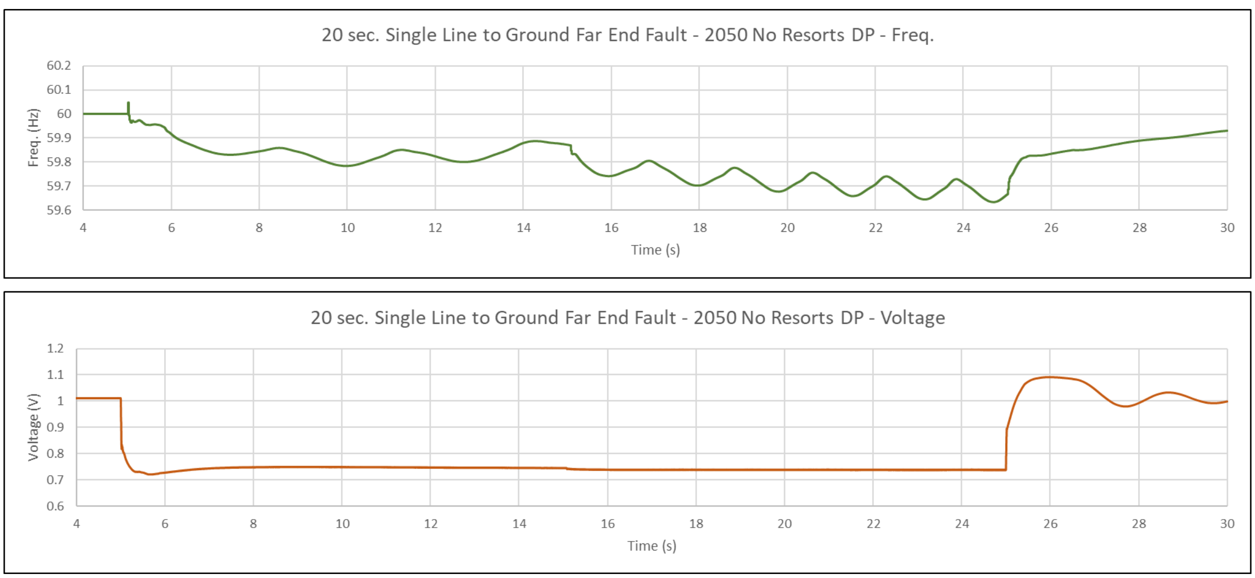


Figure 86 Dynamic stability simulation results, Lana'i no resort scenario resource plan, year 2050, single phase far end fault with high fault impedance

5. TECHNICAL ADVISORY PANEL FEEDBACKS

During the study, the IGP Technical Advisory Panel transmisison sub-committee met three times with Company to review the study methodology and results from December 2022 to February 2023. Summary of TAP's feedback are listed as following, and the detailed TAP feedback of each meeting are available from Company's IGP website[7].

In general, the TAP agrees with study methodology and findings. The following is a list of comments or questions on the details of the study, which were raised by the TAP as suggestion for future discussion or consideration.

1) The TAP agreed that the uncertainties in the inputs to the study are very high due to project timelines and withdrawals, future generation location uncertainty, load growth uncertainty, and DER growth uncertainty. The TAP noted that proactive construction of transmission to enable renewable resources has been very successful in California, Colorado, Texas, and other regions. HECO is already considering this and is encouraged to continue.
Company is currently reviewing options of proactive construction of transmission system to enable renew energy zone development.
2) In the land-constrained scenario resource plan, the TAP agrees that it is a good idea to consider using grid-forming STATCOM to mitigate system stability issue when there is not sufficient grid-scale grid-forming resource. The TAP recommends to use Grid Needs Assessment process to do the cost/benefit analysis by comparing grid-forming STATCOM sulotion with a grid-forming BESS solution.
Company identified system stability risk from the Oʻahu land-constrained scenario resource plan, and currently is running model iteration according to the stability needs to determine if more synchronous machine based resource can be dispatched to maintain system stability or more grid-forming resources need to be procured in near term years. Company expects that in long term years under the land-constrained scenario resource plan, Oʻahu system will need more grid-forming resources (e.g., grid-forming BESS and grid-forming STATCOM), and agrees with the TAP team's advice that a Grid Needs Assess process will be needed for the prcurement of grid stability related resource.
3) For Hawaiʻi Island, HECO presented the issue of unbalanced generation on the two sides of the island, which can lead to voltage collapse. The TAP supports continuing the discussion of potential solutions to the reliability issue of cross-island energy imbalance on Hawaiʻi Island. The TAP agreed with HECO that an active power resource is likely to be very helpful in the southern portion of Hawaiʻi Island given the severe undervoltage conditions identified, especially if/when the Pakini Nui wind plant retires. The dynamic portion of the study can further inform what type of resource is needed in that location.
In the study, Company addressed generation balance issue between east and west side of the Hawaiʻi Island system, and identified requirements from both steady state analyses and dynamic stability analyses. Company also identifies minimum resources needs (both active and

[7] https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning

reactive resource) to maintain south part of the Hawaiʻi Island system voltage within planning criteria.

4) The TAP strongly supports working towards obtaining grid-forming capacity as soon as possible, including by converting Stage 1 plants and executing Stage 2 and Stage 3 plants, as well as by other means as appropriate.
In this study, Company identifies minimum requirements of grid-forming capacity for each island system in order to maintain system stability within planning criteria. Meanwhile, Company has been working with developers to negotiate PPA amendments regarding converting grid-following projects to grid-forming projects.
5) The TAP agree that using ratio of available MW headroom in GFM plants to DER generation (“GFM HR/DER”) is a reasonable metric, and can easily be applied in production cost models. The TAP also suggested that some other metrics may also be needed for other times of day when DER generation is low. Such metrics could include a minimum online capacity of GFM and/or a minimum available energy (SOC) from GFM plants. The TAP looks forward to continuing to discuss metric development to improve resource planning and production cost modeling with HECO as industry learns more. Meanwhile, the TAP understands the metric (GFM HR/DER) is primarily proposed to improve the stability of schedules developed from production cost simulations, but could potentially also be used for operations in the future.
Company is actively looking into ways to integrate this GFM MW headroom/DER generation minimum contingency reserve requirement into the production cost models. Meanwhile, Company will include a MW/MWH requirement in the model for the GFM BESS component for responding system event. Regarding how to apply this requirement in future system operations, Company will look into ways to implment this contingency reserve requirement from the eligible GFM resources into the future EMS system.
6) As HECO begins to rely on GFM inverter-based plants for system security, the TAP advises HECO to be alert for potential signs that GFM plants could fail to perform as designed, especially if failure modes could affect multiple plants. GFM inverters for transmission-connected applications are still a relatively new technology, and initial results from plants in the field have generally been positive but have also required troubleshooting. Achieving reliable GFM performance to meet Hawaii’s needs will likely require close monitoring of field performance and an ongoing collaborative relationship with the GFM plant owners and their inverter manufacturers. Arrangements with GFM plant owners should be designed and managed to promote collaboration rather than adversarial relationships as much as possible.
Company expects a great deal of additional study, monitoring, and evaluation of actual field performance will need to be done in order to assure GFM IBR is an effective solution to provide stability to the Company’s systems. Besides refining GFM performance requirements for the RFP Stage 3 procurement, Company will also rely on generation technical model review process to make sure high quality generation facility models are obtained, and will require all the plants to install ditigal fault recorder (“DFR”) to monitor plant performance during system events. Company will also use those measured data from the DFRs to validate the plant models and determine if the plant performan reached PPA performance standards. Company will work with plant owners if issues are identified.
7) The TAP agree that improved grid-supportive performance from DERs would be beneficial and may be feasible in the 2035 timeframe.

Company agrees to look for ways to obtain better grid support from DERs.

A. SUMMARY OF STUDY RESULTS

A.1 Oʻahu Study Results Summary

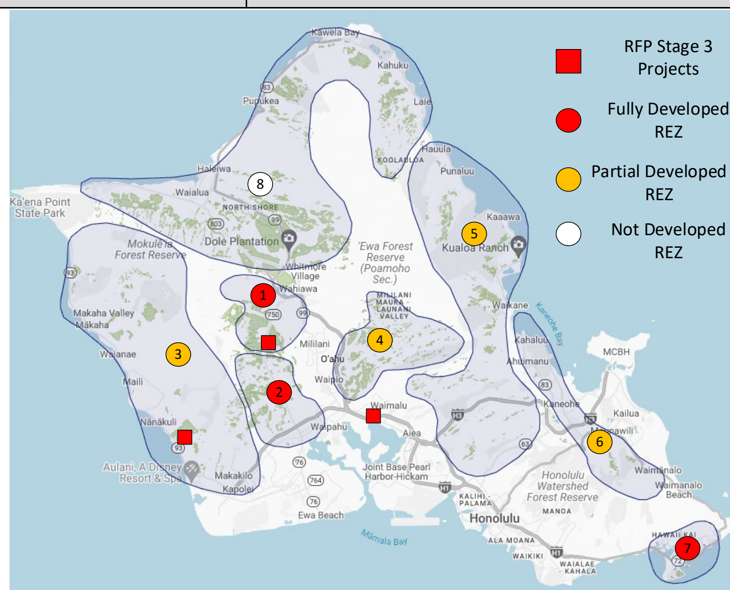
Summary of study results for the select years of Oʻahu base scenario resource plan, land constrainted scenario resouce plan and high load scenario resouce plan are shown as following tables.

Table A 1 Oʻahu Transmission System Grid Needs - Base Load Scenario, Year 2030

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2030**

By 2030, the Oʻahu system will have new generation from Stage 3 Oʻahu RFP procurement and initial Renewable Energy Zone ("REZ") development. Specifically, there will be 450 MW renewable dispatch generation ("RDG") and 300 MW firm generation procured through the Stage 3 Oʻahu RFP activity, 510 MW RDG development from the REZ zone 1, 2 and 7, and 543 MW RDG development from the REZ zone 3, 4, 5 and 6. Most of these new generation will be interconnected at Oʻahu 138 kV system. The REZ development is expected to have both solar and wind generation.

In this timeframe, it is also planned to remove 371 MW fossil generation from Waiau power plant.



System Grid Scale Resource Changes

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 Oʻahu RFP	Solar/BESS and Wind	450	2027	Central Oʻahu, West Oʻahu
	Firm Generation	300	2029	Central Oʻahu
REZ Development	Solar/BESS and Wind	510	2030	Zone 1, 2, and 7
		543	2030	Zone 3, 4, 5 and 6
Other	Standalone BESS	84	2030	138/46 kV Substations

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2030**

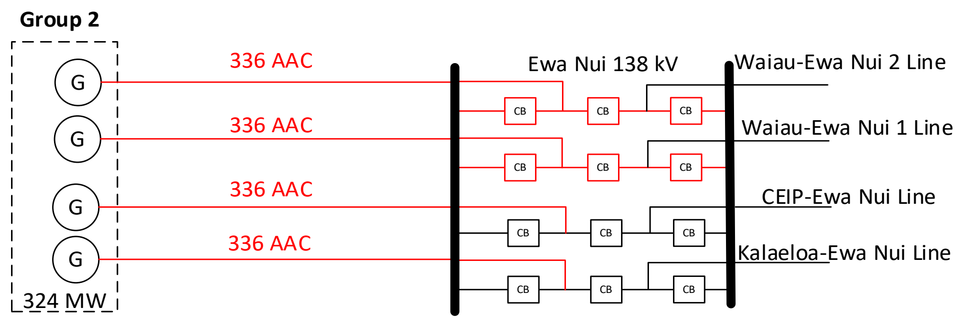
Removal	Generation Type	MW Capacity	Year	Location
Waiau 3, 4	Fossil Generation	94	2024	Waiau Power Plant
Waiau 5, 6		108	2027	
Waiau 7, 8		169	2029	

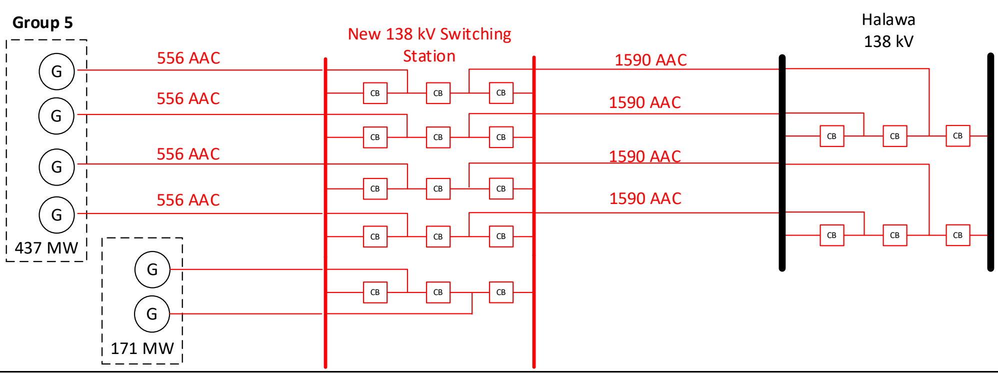
System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,462	257	168	1,573	219	1,171	1,364

REZ Enablement

Examples of REZ Enablment are shown as following for zones with lower MW potential (upper) and higher MW potential (lower). Red color means new enablment facility, and black color means existing facility.



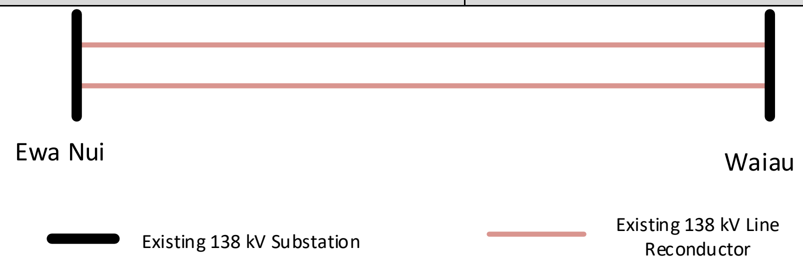


REZ Enablement Cost Estimate

REZ Zone	1	2	3	4	5	6	7
Cost ($MM) per MW	0.21	0.27	1.32	0.82	1.51	0.62	N/A
REZ Enablement ($MM)	24.6	87.6	448.4-819.9				N/A

Grid Needs - Transmission System Networks Expansion

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2030**

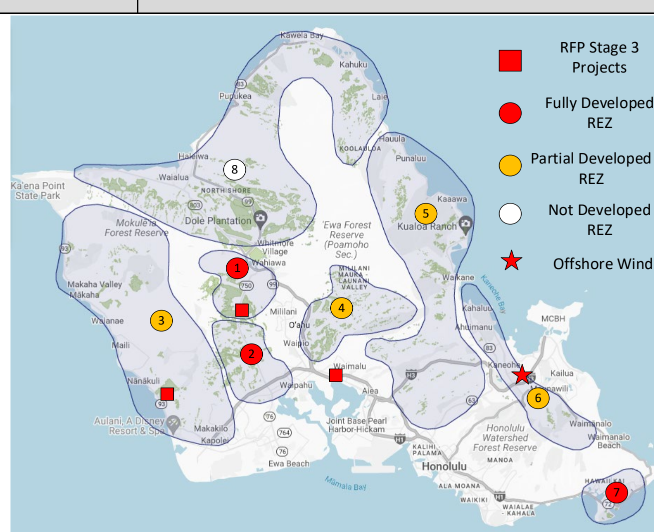


Networks Expansion Descriptions			Cost Estimate ($MM)
Transmission Line	Upgrade Type	Conductor Requirements	
Waiau-Ewa Nui 1&2	Re-conductor	Two circuits, re-conductor to double-bundled 795 AAC	161.4
Alternative for this conductor upgrade will be reduce Ewa Nui REZ generation interconnection from 324 MW to 175 MW.			
Grid Needs – System Stability Needs			
Grid has sufficient GFM resources to maintain system stability, but the system must be operated so that GFM Headroom/DER Generation ratio is at least 0.7.			

Table A 2 O‘ahu Transmission System Grid Needs - Base Load Scenario, Year 2035

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2035**

In addtion to previous system resource changes by 2030, the O‘ahu system will have 64 MW grid-scale standalone BESS and 509 MW offshore wind, by 2035. There is no futhur development of REZ. There will be 208 MW firm generation procured and interconnected at the Kalaeloa substation once the Kalaeloa power plant is removed.



System Grid Scale Resource Changes since 2031

Development	Generation Type	MW Capacity	GCOD	Location
Others	Firm Generation	208	2033	Kalaeloa Substation

Studied Resource Plan			Studied Year	
Base Scenario Resource Plan			2035	
	Standalone BESS	64	2035	138/46 kV substations
	Offshore wind	509	2035	Ko'olau 138 kV substation
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kahuku Wind	Onshore Wind	30	2031	Kahuku 46 kV substation
Kapolei Sustainable Energy Park	Solar	1	2032	Kahe 46 kV substation
Kalaeloa Solar	Solar	5	2032	KS substation
Kahe 1, 2	Fossil	165	2033	Kahe substation
Kalaeloa Power Plant	Fossil	208	2033	KPLP substation
KREP	Solar	5	2034	KREP substation

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,297	257	509	157	1,573	282	1,295	1,432

REZ Enablement

There is no REZ development between 2031 to 2035. In this time frame, the development that requires interconneciton facility is the 509 MW offshore wind, which requires expansion of the Ko'olau substation by adding 4 BAAH bay for the offshore wind interconnection. The cost estimate is $50.6 million.

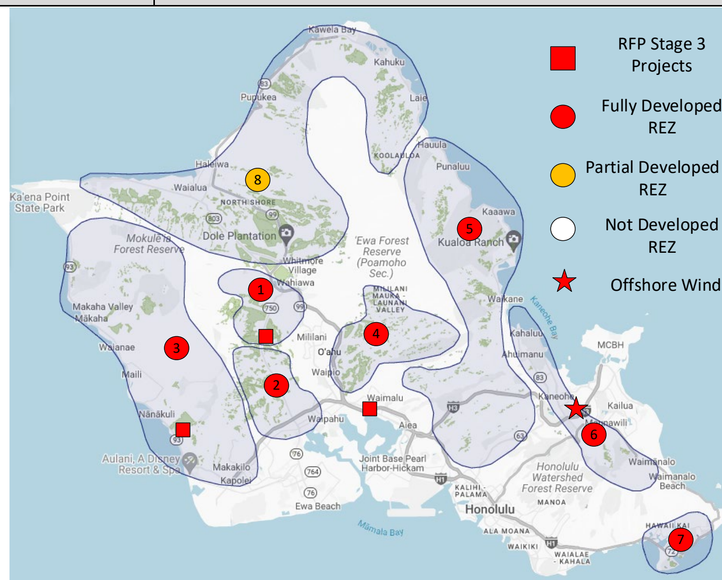
Grid Needs - Transmission System Networks Expansion

None. But high conductor loading is observed on multiple 138 kV overhead conductors. It is recommend to reduce grid-scale generation interconnection at Ko'olau substation by 10 MW.

Grid Needs – System Stability Needs

Grid has sufficient GFM resources to maintain system stability, but the system must be operated so that GFM Headroom/DER Generation ratio is at least 0.70.

Table A 3 O‘ahu Transmission System Grid Needs - Base Load Scenario, Year 2045

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2045**
In addtion to previous system resource changes, by 2045, the O‘ahu system will finish developing the majority of REZ zone 1, 2, 3, 4, 5, 6 and 7, only 106 MW potential remaining undeveloped. Meanwhile, 452 MW solar potential of the REZ zone 8 will be developped by 2045. System load is forecasted with significant growth: 1,692 MW peak demand at 2046. Both REZ development and system load growth drive large amount of O‘ahu transmission system network expansion.	

System Grid Scale Resource Changes since 2036

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Renewable Dispatchable Generation	521	2040	REZ zone 3, 4, 5, and 6
		504	2045	
		452	2045	REZ zone 8
Other	Standalone BESS	1	2040	Ho‘ohana substation
		32	2045	Ho‘ohana substation
Recovered Solar	Standalone Solar	168	2045	Waiver project locations
Recovered Wind	Wind	123	2045	Removed wind locations
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kahe 3, 4	Fossil	172	2037	Kahe substation
Kawailoa Wind	Wind	69	2038	Wahiawa 46 kV
Waianae Solar	Solar	27.6	2039	Kahe 46 kV
Na Pua Makani Wind	Wind	24	2040	Ko‘olau 46 kV
Waiver Clearway Projects	Solar/Wind	110	2041	Various 138 kV and 46 kV substations
West Loch Solar	Solar	20	2044	CEIP 46 kV

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2045**

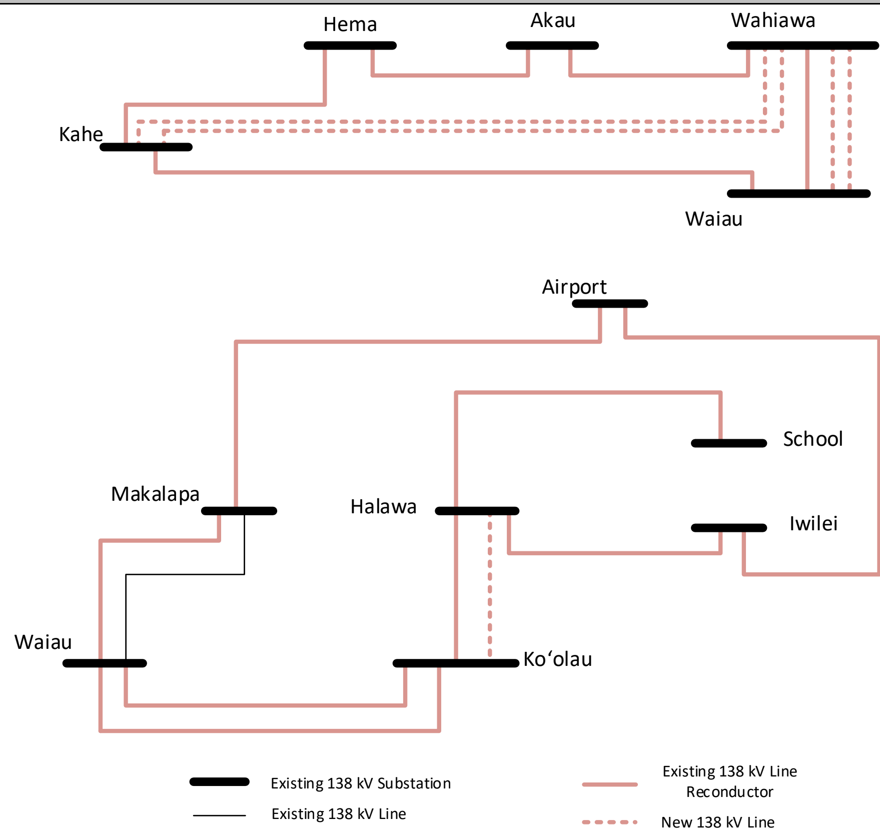
System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,126	287	509	441	2,777	315	1,454	1,692

REZ Enablement

REZ Zone	**3**	**4**	**5**	**6**	8
Cost ($MM) per MW	1.32	0.82	1.51	0.62	1.25
REZ Enablement ($MM)	1084.6-1468.5				565.0

Grid Needs - Transmission System Networks Expansion



The total estimated cost for these transmission networks expansion is $3,980.5 million.

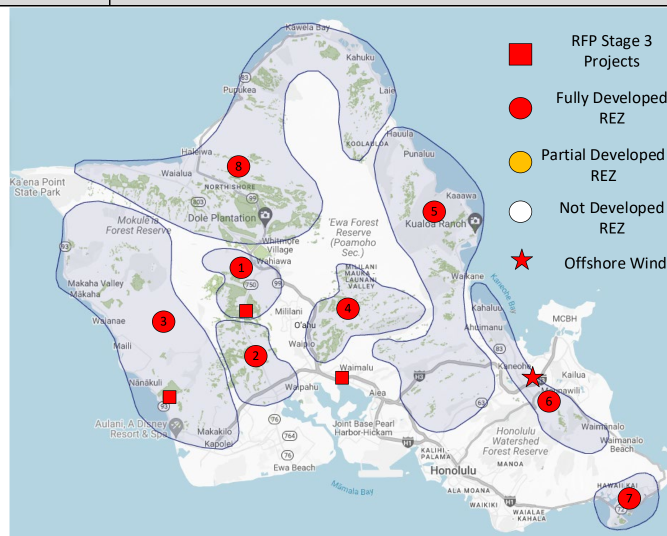
Grid Needs – System Stability Needs

Not studied.

Table A 4 O‘ahu Transmission System Grid Needs - Base Load Scenario, Year 2050

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2050**

By 2050, 3,344 MW of all eight REZ zones will be fully developed. System load is forecasted with significant growth: 1,829 MW peak demand at 2050, which could possibly cause underground cable replacement for 138 kV underground cable among School Stree, Iwilei and Archer 138 kV substations. All Kahe fossil generation units will be retired by 2050. Besides switching fossil fuel to biodiesel fuel for remaining firm units, 135 MW new firm units will be added to the O‘ahu system by 2050.



System Grid Scale Resource Changes since 2046

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Renewable Dispatchable Generation	106	2050	REZ zone 3, 4, 5, and 6
		714	2050	REZ zone 8
Other	Standalone BESS	18	2050	138 kV Substation
Other	Firm Generation	153	2050	Kahe Substation
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kahe 5, 6	Fossil	270	2046	Kahe substation

System Resource Summary and Forecasted Demand (MW)

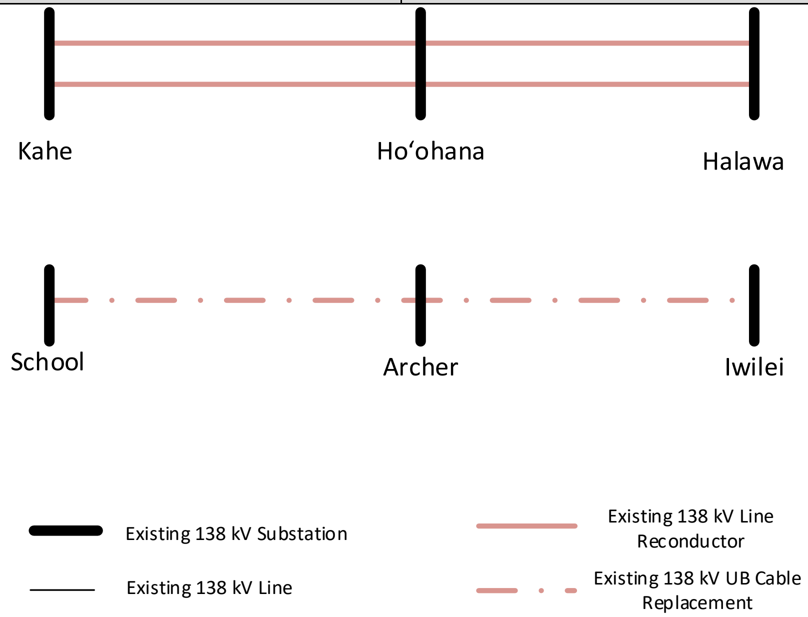
Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,010	287	509	480	3,558	333	1,497	1,829

REZ Enablement

REZ Zone	3	4	5	6	8
Cost ($MM) per MW	1.32	0.82	1.51	0.62	1.25
REZ Enablement ($MM)	86.9-160.1				892.5

Grid Needs - Transmission System Networks Expansion

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	2050



The total estimated cost for these transmission networks expansion is $1,208.9 million.

Reducing load from 138 kV substations Kamoku, Kewalo, School St. and Iwilei by 20 MW can avoid cable replacement for the 138 kV underground cable Archer-School, Archer-Iweilei. This can be realized by adding generation such as grid-scale BESS in those substations, or procure demand response on circuits supplied by those substations, or implmenenting energy efficiency program.
Fully development of the north shore REZ zone (i.e., zone 8) would also cause overloadings on the 138 kV lines connected with Wahiawa substation. By reducing generation interconnection size at Wahiawa substation by 220 MW, the line overloading will be mitigated.

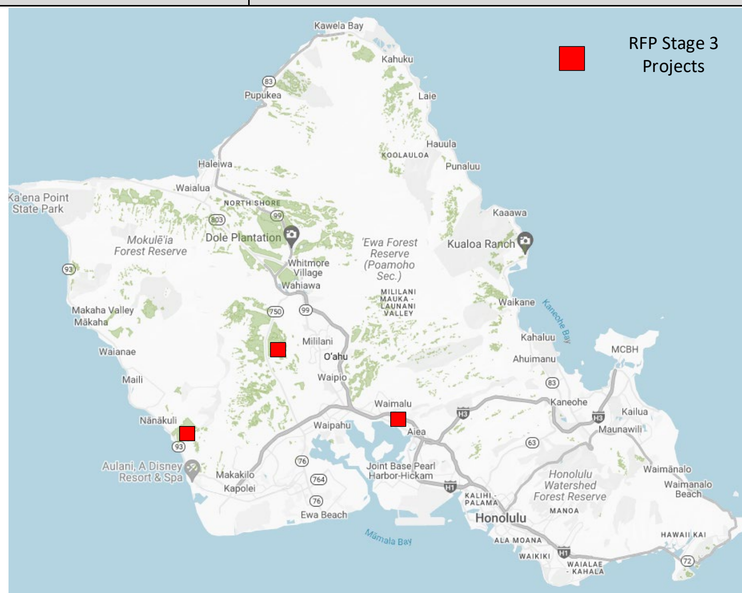
Grid Needs – System Stability Needs

Not studied.

Table A 5 O‘ahu Transmission System Grid Needs – Land Constrained Scenario, Year 2030

Studied Resource Plan	Studied Year
Land Constrained Scenario Resource Plan	**2030**

By 2030, the O‘ahu system will have all new generation from Stage 3 O‘ahu RFP procurement on transmission and sub-transmisison side. Specifically, there will be 450 MW renewable dispatch generation (“RDG”) and 300 MW firm generation procured through the Stage 3 O‘ahu RFP activity. Most of these new generation are expected to be interconnected at O‘ahu 138 kV system. In this time frame, it is also planned to remove 371 MW generation from Waiau power plant.



System Grid- Scale Resource Changes

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 O‘ahu RFP	Renewable Dispatchable Generation	450	2027	Central O‘ahu, West O‘ahu
	Firm Generation	300	2029	Central O‘ahu
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Waiau 3, 4	Fossil Generation	94	2024	Waiau Power Plant
Waiau 5, 6		108	2027	
Waiau 7, 8		169	2029	

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,462	123	168	684	135	1,171	1,364

Grid Needs - Transmission System Networks Expansion

None

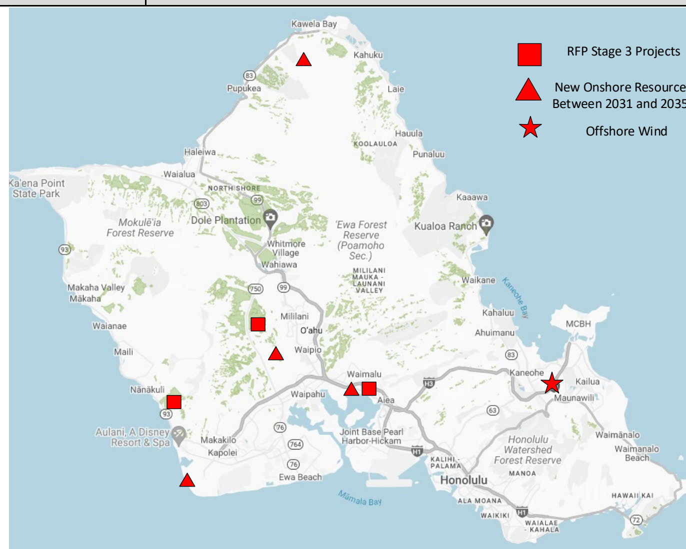
Grid Needs – System Stability Needs

System may need more GFM resource, and it is recommended to maintain MW headroom of GFM resource/DER generation ratio at least 0.7. If the ratio can‘t be maintained, it is recommend to dispatch more synchronous machine resources to create more head room from the GFM resource, or curtail DER generation.

Table A 6 Oʻahu Transmission System Grid Needs – Land Constrained Scenario, Year 2035

Studied Resource Plan	Studied Year
Land Constrained Scenario Resource Plan	**2035**

In addtion to previous system resource changes by 2030, the Oʻahu system will have 105 MW grid-scale standalone BESS and 400 MW offshore wind, by 2035. 153 MW Firm resource will also be added to system by 2035. There will be 208 MW firm generation procured and interconnected at the Kalaeloa substation once the Kalaeloa power plant is removed. 30 MW wind recovered wind resource from the retired wind power plant will be added to system to meet the system demand as well.



System Grid- Scale Resource Changes since 2031

Development	Generation Type	MW Capacity	GCOD	Location
Others	Firm Generation	208	2033	Kalaeloa Substation
	Firm Generation	153	2035	Waiau Power Plant
	Standalone BESS	105	2035	138/46 kV substations
	Offshore wind	400	2035	Koʻolau 138 kV substation
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kahuku Wind	Onshore Wind	30	2031	Kahuku 46 kV substation
Kapolei Sustatinable Energy Park	Solar	1	2032	Kahe substation
Kalaeloa Solar	Solar	5	2033	Kahe 46 kV substation
Kahe 1, 2	Fossil	165	2033	Kahe substation
Kalaeloa Power Plant	Fossil	208	2033	KPLP substation
KREP	Solar	5	2034	KREP substation

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,450	123	400	157	684	240	1,295	1,432

Studied Resource Plan	Studied Year
Land Constrained Scenario Resource Plan	2035

Grid Needs - Transmission System Networks Expansion

None

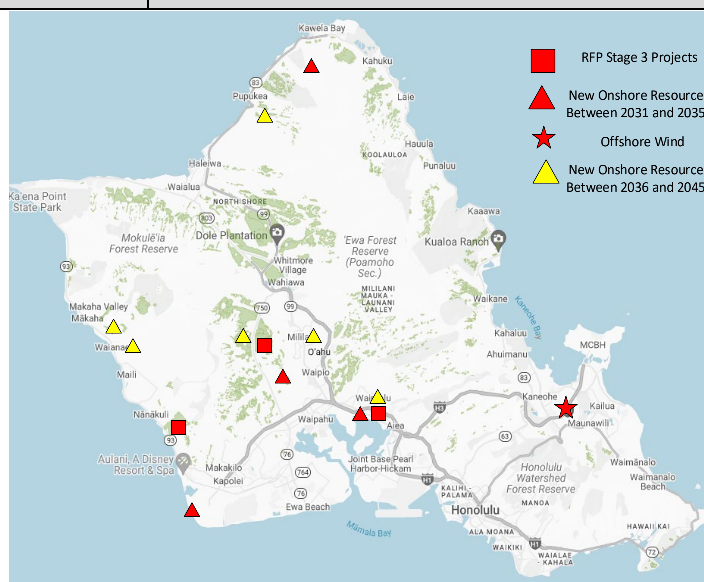
Grid Needs – System Stability Needs

System may need more GFM resources, and it is recommended to maintain MW headroom of GFM resource/DER generation ratio at least 0.7. If the ratio can't be maintained, it is recommended to dispatch more synchronous machine based resources to create more head room from the GFM resource.

Table A 7 O'ahu Transmission System Grid Needs – Land Constrained Scenario, Year 2045

Studied Resource Plan	Studied Year
Land Constrained Scenario Resource Plan	2045

In addtion to previous system resource changes, by 2045, the O'ahu system will add another 153 MW firm generation into the system. Also, 169 MW standalone solar and 93 MW wind development from retired solar and wind locations will be completed by 2045. 169 MW new Grid-scale standalone BESS will be interconnected to system from transmission substations. System load is forecasted with significant growth: 1,692 MW peak demand at 2046. On the distribution side, 783 MW DER coupled with 1,567 MWh DER BESS will be added to the system to supply system load demand.



System Grid- Scale Resource Changes since 2036

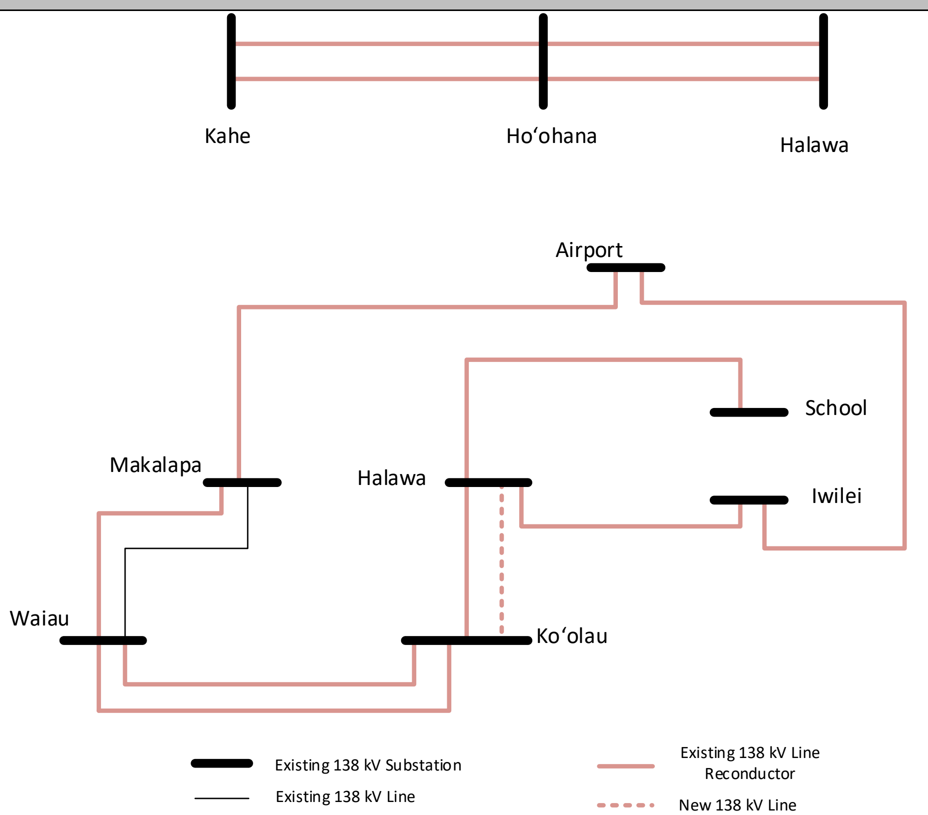
Development	Generation Type	MW Capacity	GCOD	Location
Other	Standalone BESS	14	2040	Ho'ohana substation
	Firm Generation	153	2040	Waiau substation
Recovered Solar	Standalone Solar	39	2040	Waiver project locations
Recovered Wind	Wind	93	2040	Retired wind locations
Other	Standalone BESS	145	2045	Ho'ohana substation
Recovered Solar	Standalone Solar	130	2045	Waiver project locations
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**

Studied Resource Plan			Studied Year	
Land Constrained Scenario Resource Plan			**2045**	
Kahe 3, 4	Fossil	172	2037	Kahe substation
Kawailoa Wind	Wind	69	2038	Wahiawa 46 kV
Waianae Solar	Solar	27.6	2039	Kahe 46 kV
Na Pua Makani Wind	Wind	24	2040	Ko‘olau 46 kV
Waiver Clearway Projects	Solar/Wind	104	2041	Various 138 kV and 46 kV substations
West Loch Solar	Solar	20	2044	CEIP 46 kV

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,432	123	400	169	684	399	3,020	1,692

Grid Needs - Transmission System Networks Expansion

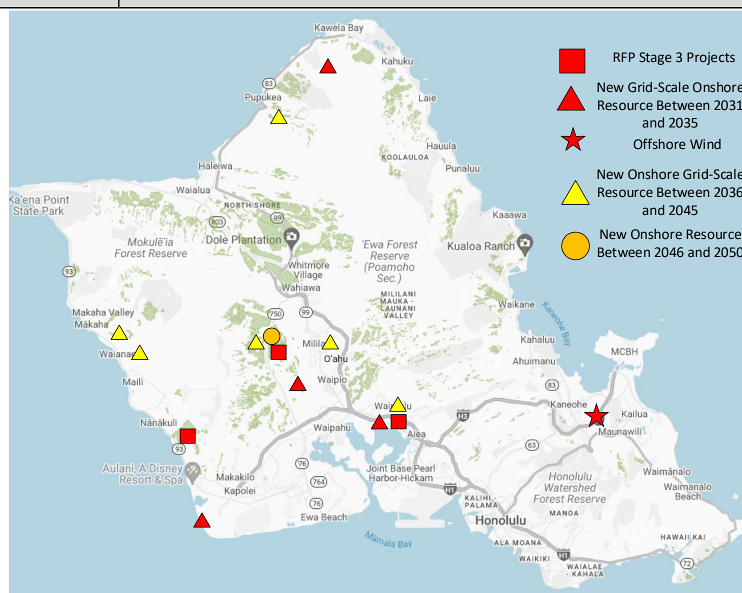


Studied Resource Plan	Studied Year
Land Constrained Scenario Resource Plan	**2045**
The total estimated cost for these transmission networks expansion is $2,291.6 million.	
Grid Needs – System Stability Needs	
The dynamic stability study is not performed. However, according to the avaiable GFM resource and signification growth of DER, the system may require more grid-scale GFM resource. This could be more GFM BESS interconnected on subtransmission or transmission grid, or GFM STATCOM interconnected on the transmission grid.	

Table A 8 O'ahu Transmission System Grid Needs – Land Constrained Scenario, Year 2050

Studied Resource Plan	Studied Year
Land Constrained Scenario Resource Plan	**2050**

From 2046 to 2050, the only grid-scale resource added to the O'ahu system as planned is a 119 MW/1,110 MWh grid-scale BESS. Kahe 5, 6, which will be the only remaining fossil generation at Kahe power plant by 2050, will be retired in 2050. It is also planned to add 1,017 MW DER, coupled with 2,033 MWh DER BESS into system distribution side. System peak load is forecasted to be 1,829 MW by 2050. The load increase will require cable replacement for the 138 kV underground conductors Archer-School and Archer-Iwilei.



System Grid- Scale Resource Changes since 2036

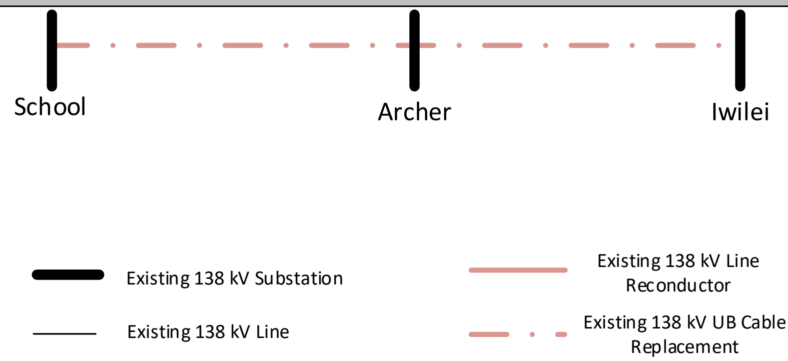
Development	Generation Type	MW Capacity	GCOD	Location
Other	Standalone BESS	119	2050	138 kV Substation
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kahe 5, 6	Fossil	270	2046	Kahe substation

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,163	123	400	169	684	519	5,097	1,829

Studied Resource Plan	Studied Year
Land Constrained Scenario Resource Plan	**2050**

Grid Needs - Transmission System Networks Expansion



The total estimated cost for these transmission networks expansion is $345.1 million.

Reducing load from 138 kV substations Kamoku, Kewalo, School St. and Iwilei by 20 MW can avoid cable replacement for the 138 kV underground cable Archer-School, Archer-Iweilei. This can be realized by adding generation such as grid-scale BESS at those substations, acquiring demand response on circuits supplied by those substations, or implementing a targeted energy efficiency program.

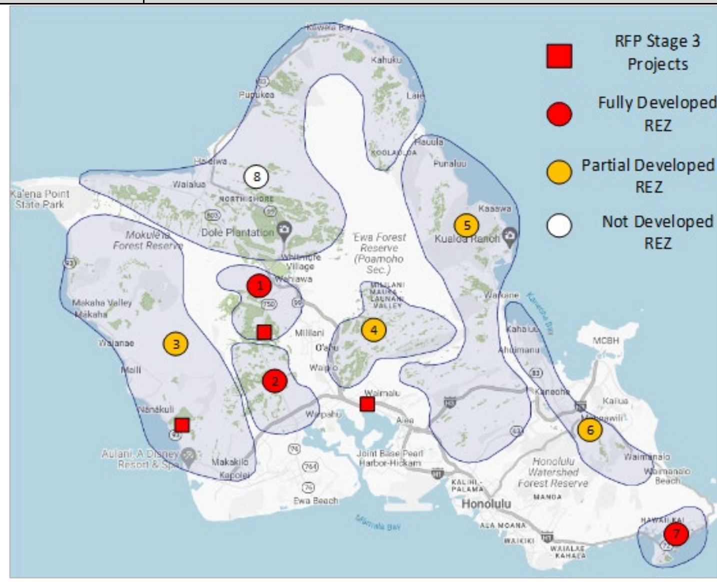
Grid Needs – System Stability Needs

The dynamic stability study for this scenario is not performed. However, the recommendation for the O‘ahu system regarding system stability needs are simliar as what is recommended for the 2045 scenario.

Table A 9 O‘ahu Transmission System Grid Needs – High Load Scenario, Year 2030

Studied Resource Plan	Studied Year
High Load Resource Plan	**2030**

By 2030, the O‘ahu system will have new generation from Stage 3 O‘ahu RFP procurement and initial Renewable Energy Zone (“REZ”) development. Specifically, there will be 450 MW renewable dispatch generation (“RDG”) and 300 MW firm generation procured through the Stage 3 O‘ahu RFP activity, 510 MW RDG development from the REZ zone 1, 2 and 7, and 1,225 MW RDG development from the REZ zone 3, 4, 5 and 6. Most of these new generation will be interconnected at O‘ahu 138 kV system. The REZ development is expected to have both solar and wind generation.
In this time frame, it is also planned to add 60 MW standalone BESS into system and remove 371 MW generation from Waiau power plant.



System Resource Changes

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 O‘ahu RFP	Renewable Dispatchable Generation	450	2027	Central O‘ahu, West O‘ahu
	Firm Generation	300	2029	Central O‘ahu
REZ Development	Renewable Dispatchable Generation	510	2030	Zone 1, 2, and 7
		1,225	2030	Zone 3, 4, 5 and 6
Other	Standalone BESS	60	2030	138/46 kV Substations
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Waiau 3, 4	Fossil Generation	94	2024	Waiau Power Plant
Waiau 5, 6		108	2027	
Waiau 7, 8		169	2029	

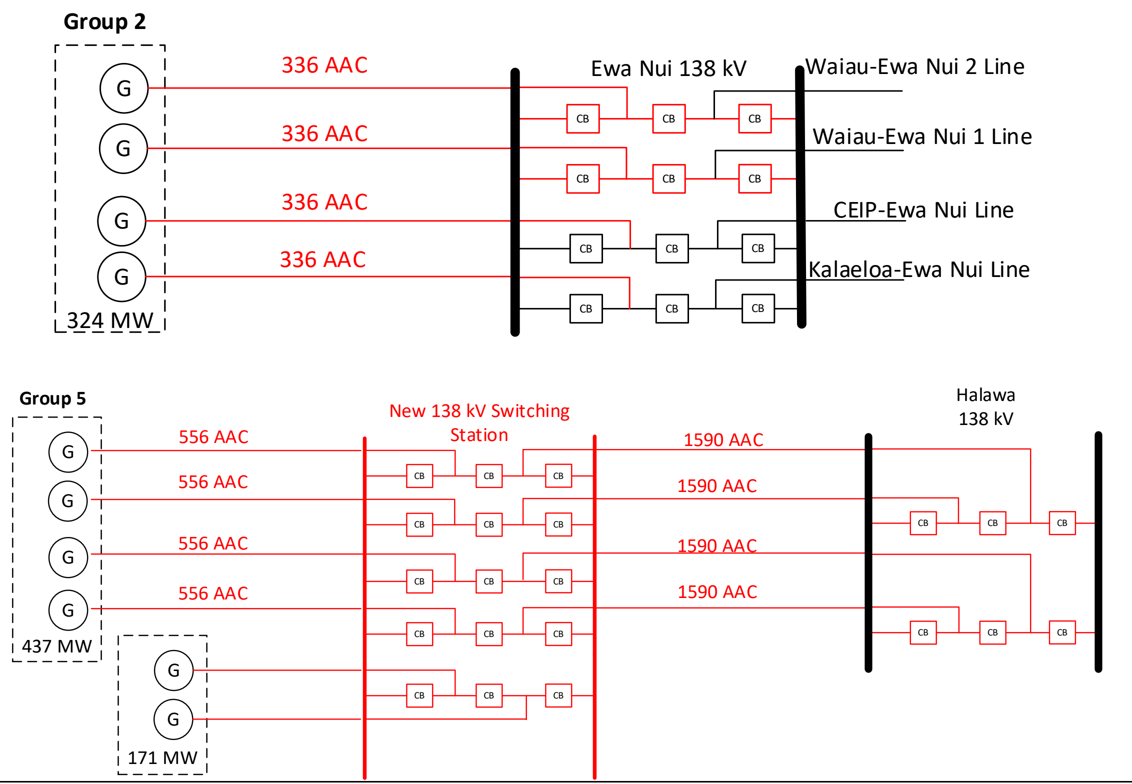
System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,462	123	168	2,419	195	1,147	1,595

REZ Enablement

Examples of REZ Enablment are shown as following for zones with lower MW potential (upper) and higher MW potential (lower). Red denotes new enablment facility, and black denotes existing facility.

Studied Resource Plan	Studied Year
High Load Resource Plan	**2030**

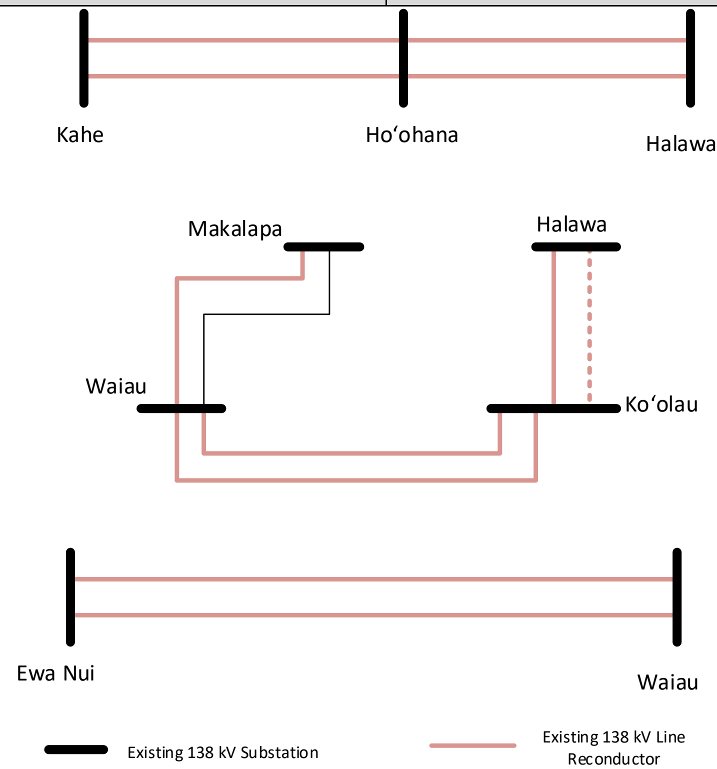


REZ Enablement Cost Estimate

REZ Zone	1	2	3	4	5	6	7
Cost ($MM) per MW	0.21	0.27	1.32	0.82	1.51	0.62	N/A
REZ Enablement ($MM)	24.6	87.6	1,378.8-1,718.0				N/A

Grid Needs - Transmission System Networks Expansion

Studied Resource Plan	Studied Year
High Load Resource Plan	**2030**



The total estimated cost for these transmission networks expansion is $1,289 million.

Alternative option for deferral reconductor of Ewa Nui – Waiau #1 & #2 is reducing REZ zone 2 interconnection MW size at Ewa Nui substation by 150 MW, and dispatch more generation on the east side of island.

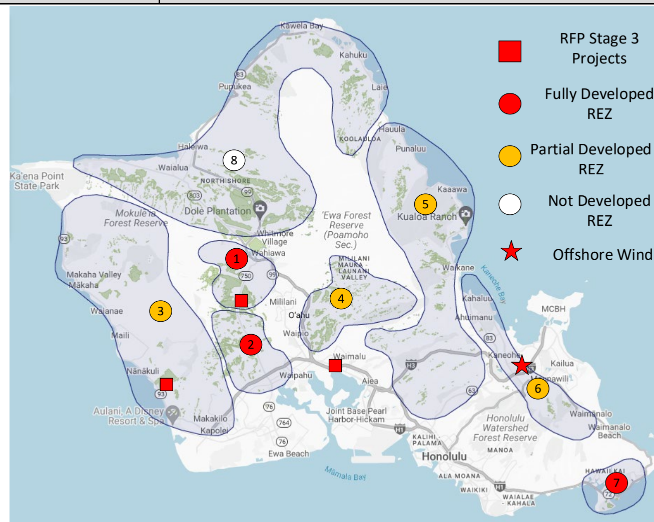
Grid Needs – System Stability Needs

Not studied.

Table A 10 Oʻahu Transmission System Grid Needs – High Load Scenario, Year 2035

Studied Resource Plan	Studied Year
High Load Resource Plan	**2035**

In addtion to previous system resource changes by 2030, the Oʻahu system will have 95 MW grid-scale standalone BESS and 600 MW offshore wind, by 2035. There is no further development of REZ. There will be 208 MW firm generation interconnected at the Kalaeloa substation. By 2035, the BESS MWh of the PV/BESS projects developed in REZ zones in 2030 will be increased as well.



System Resource Changes since 2031

Development	Generation Type	MW Capacity	GCOD	Location
Others	Firm Generation	208	2033	Kalaeloa Substation
	Standalone BESS	95	2035	138/46 kV substations
	Offshore wind	600	2035	Koʻolau 138 kV substation
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kahuku Wind	Onshore Wind	30	2031	Kahuku 46 kV substation
Kapolei Sustainable Energy Park	Solar	1	2032	KREP substation
Kalaeloa Solar	Solar	5	2032	KS substation
Kahe 1, 2	Fossil	165	2033	Kahe substation
Kalaeloa Power Plant	Fossil	208	2033	KPLP substation
KREP	Solar	5	2034	KREP substation

System Resource Summary and Forecasted Demand (MW)

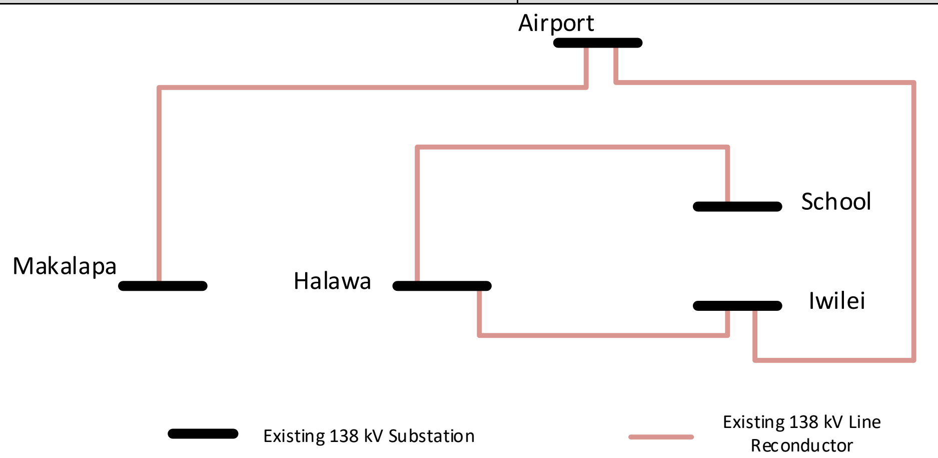
Firm Generation	Onshore Standalone Wind	Offshore Wind	Standalone Grid-Scale Solar	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
1,297	93	600	157	2,419	290	1,271	1,776

REZ Enablement

There is no REZ MW potential development between 2031 to 2035. In this timeframe, the development that requires interconneciton facility is the 600 MW offshore wind, which requires expansion of the Koʻolau substation by adding 4 BAAH bay for the offshore wind interconnection. The cost estimate is $50.6 million.

Grid Needs - Transmission System Networks Expansion

Studied Resource Plan	Studied Year
High Load Resource Plan	**2035**



The total estimated cost for these transmission networks expansion is $397.9 million.

In addition, 138 kV underground cable Archer-Iwilei, Archer-School also have high loading condition during contingencies. It is recommended to install a standalone BESS project in east side of island close to the urban core load center to reduce load, in order to avoid reconductoring or potential cable repalcement. Alternative options can be using DER programs, demand response programs, or energy efficiency programs to reduce load on east side of system.

Grid Needs – System Stability Needs

Not studied.

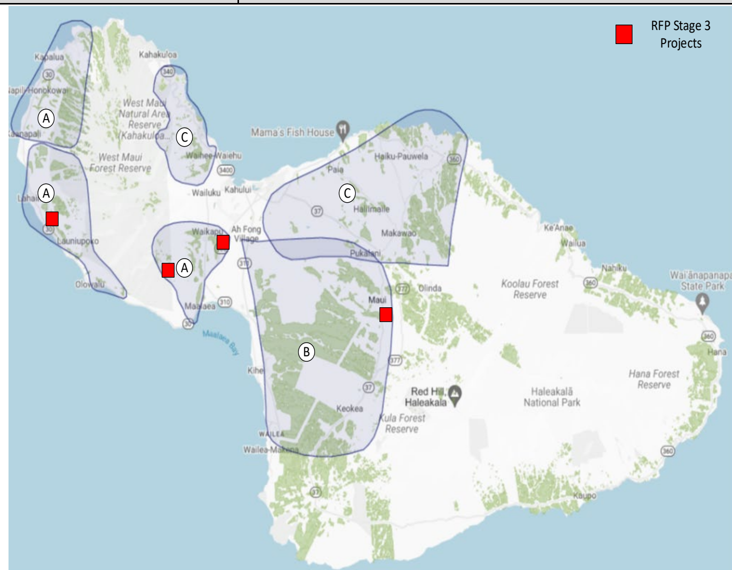
A.2 Maui Study Results Summary

Summary of study results for the Maui base scenario resource plan and high load scenario resouce plan are listed as following.

Table A 11 Maui Transmission System Grid Needs – Base Scenario, Year 2027

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2027**

By 2027, the Maui system will have new generation from Stage 3 RFP procurement which will be 171 MW renewable dispatchable generation ("RDG") PV/BESS and 36 MW firm generation, interconnected at Maui 69 kV system. Meanwhile, the Maui system will finish Waena switchyard construction, Kahului Power Plant ("KPP") retirement and conversion of KPP K3 and K4 units to synchronous condensers, and Maalaea Power Plant ("MPP") unit 10-13 retirement. The system peak load is forecasted to reach 207 MW by 2028.



System Grid Scale Resource Changes

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 Maui RFP	Renewable Dispatchable Generation	171	2027	West Maui, Central Maui and South Maui
	Firm Generation	36	2027	Central Maui
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kaheawa Wind Power 1	Wind Generation	30	2027	KWP 1 substation
Kahului 1-4	Fossil Generation	32.5	2027	Kahului Power Plant
Maalaea 10-13	Fossil Generation	49.4	2027	Maalaea Power Plant

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
197.5	42	296	40	170.7	207

REZ Enablement

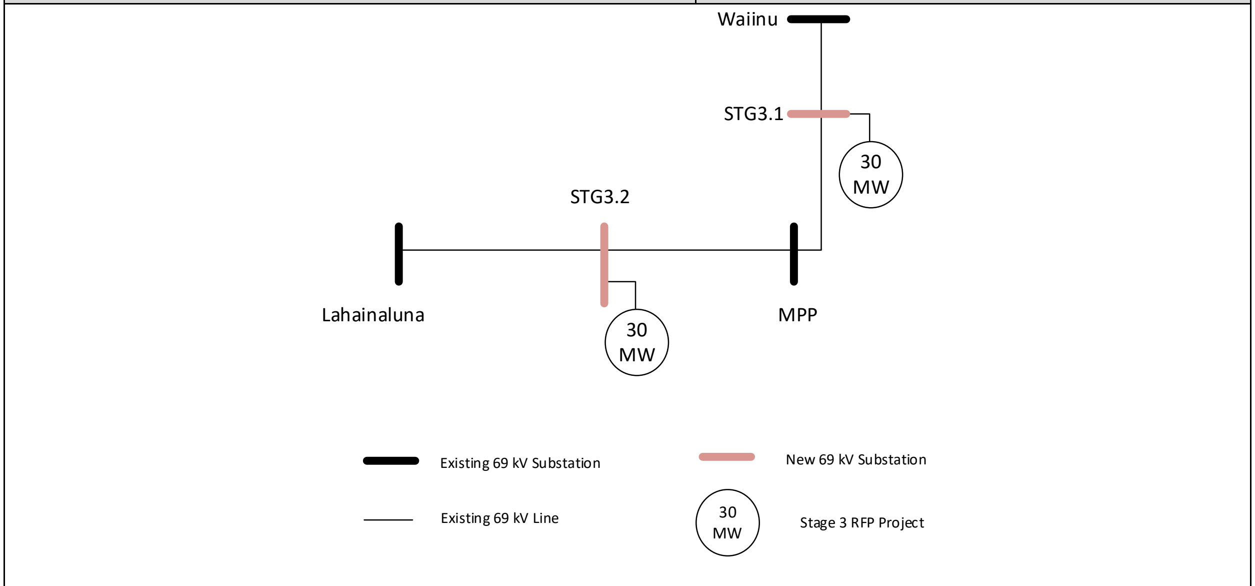
No REZ enablment cost estimate since by 2027 there will be only Stage 3 development but no REZ development. Interconnection sites for the 171 MW Stage 3 RFP projects and 36 MW firm generation are as following.
Substation/Switching station interconnections:

- Lahainaluna substation station – 60 MW
- KWP 2 substation – 30 MW
- Waena switch yard – 40 MW firm generation
- Kealahou substation – 21 MW

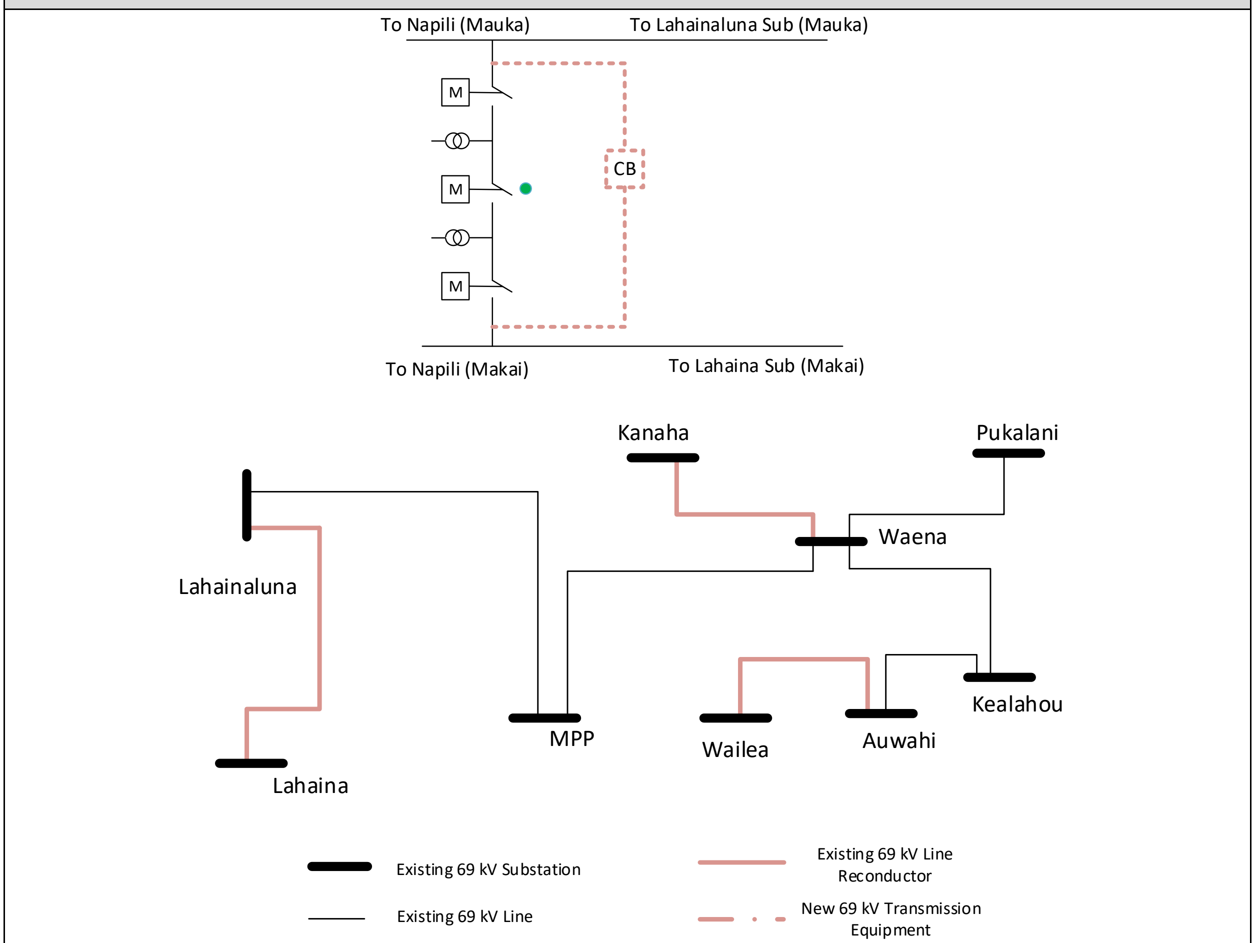
69 kV Transmisison line interconnection:

- MPP – Waiinu line interconnection – 30 MW, through a new substation STG3.1
- MPP – Lahainaluna line interconnection – 30 MW, through a new substation STG3.2

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	2027



Grid Needs - Transmission System Networks Expansion

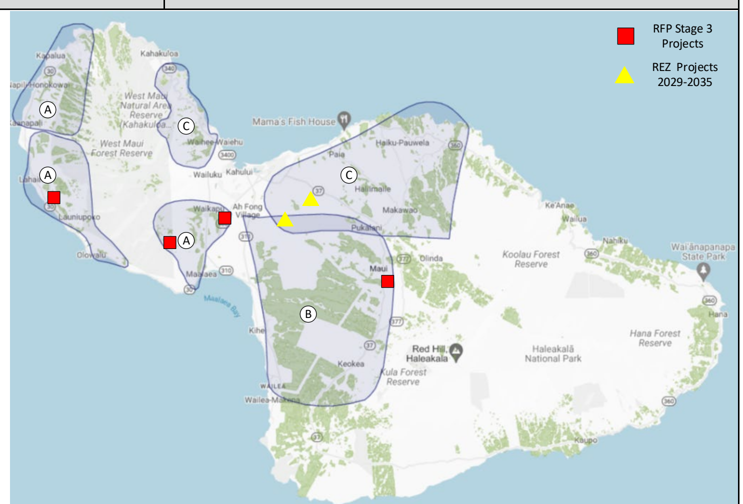


Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2027**
The total estimated cost for these transmission networks expansion is $10.5 million.	
Alternative options for above re-conductor upgrade include reducing grid-scale resource interconnection MW size by 24 MW on west Maui and reducing grid-scale resource interconnection MW size in Waena switch yard, up-country or south Maui by 16 MW.	
Grid Needs – System Stability Needs	
After adding 171 MW Stage 3 RDG projects with grid forming ("GFM") BESS component, it is expected that Maui system stability performance stay within planning criteria, and no addtional grid needs regarding system stability is identified. Maui system single point of failure ("SPOF") limit can be increased to 30 MW as well.	

Table A 12 Maui Transmission System Grid Needs – Base Scenario, Year 2035

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2035**

In addtion to previous system resource changes by 2027, by 2035, the Maui system will have 66 MW of grid-scale onshore wind generation and 37 MW of PV/BESS generation as addtional generation interconnected to the Maui transmission system. This new generation will be developed in the REZ zone C. Also, it is planned that MPP unit 1 to 9 will be removed by 2030, and wind power generation KWP 2 and Auwahi will be retired by 2033. The system annual peak load is forecasted to reach 235 MW by 2036.



System Resource Changes since 2031				
Development	**Generation Type**	**MW Capacity**	**GCOD**	**Location**
REZ Development	Onshore Wind Generation	5	2029	REZ Zone C
	Onshore Wind Generation	8	2030	REZ Zone C
	Onshore Wind Generation	53	2035	REZ Zone C
	Solar/BESS	37	2035	REZ Zone C
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Maalaea Power Plant Units 1-9	Fossil	40.5	2030	MPP
Kaheawa Wind Power 2	Onshore Wind Generation	21	2033	KWP 2 Substation

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2035**

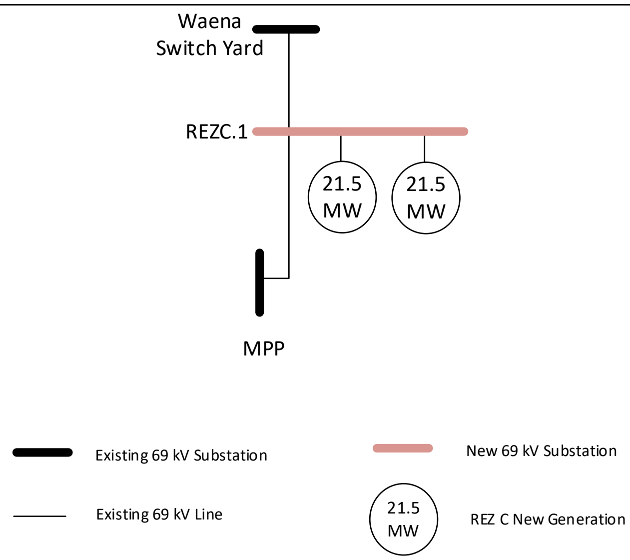
Auwahi Wind	Onshore Wind Generation	21	2033	Auwahi Substation

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	66	333	40	202	237

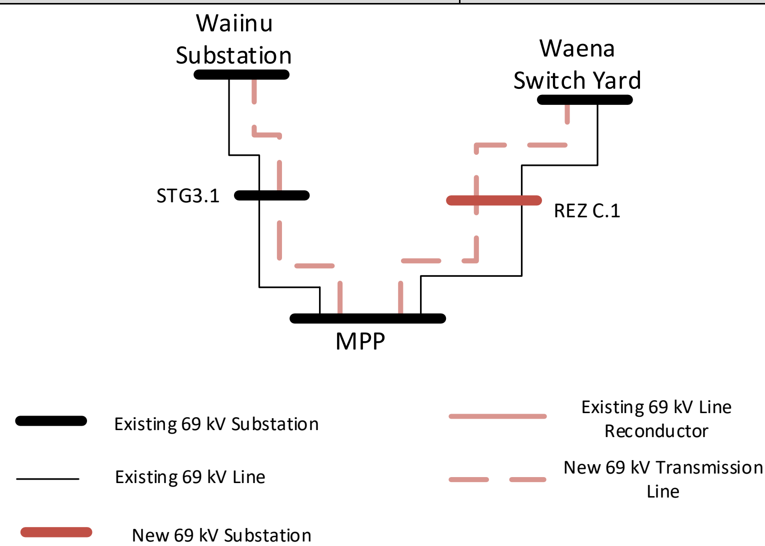
REZ Enablement

From 2028 to 2035, 5 MW onshore wind genration in 2029, 8 MW onshore wind generation in 2030, 53 MW onshore wind in 2035, and 37 MW PV/BESS, connected to zone C, totaling 103 MW. It is assumed that there will be a new switching station on the MPP-Waena line which will host 43 MW out of 103 MW generation, and the remaining 60 MW will be hosted in the Waena switchyard. The cost of REZ enablement through the Waena switchyard is estimated as $13.5 million. For the new switching station REZ C.1, the REZ enablement cost is estimated as $5.8 million.



Grid Needs - Transmission System Networks Expansion

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2035**



The total estimated cost for these transmission networks expansion is $96.2 million.

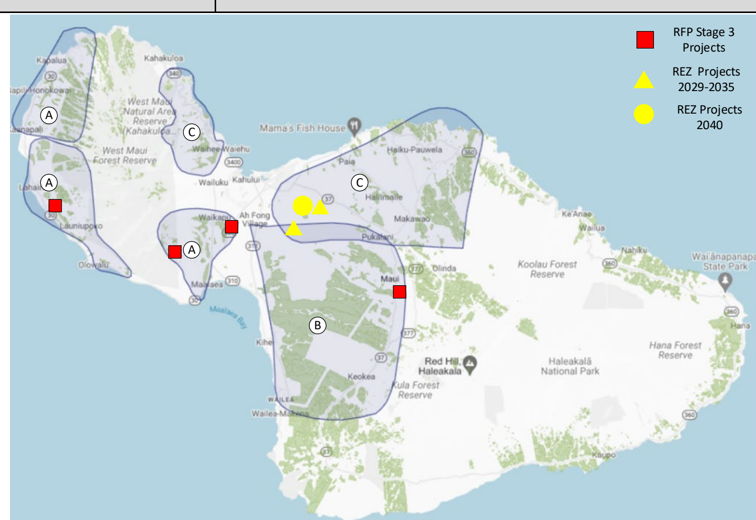
Grid Needs – System Stability Needs

None

Table A 13 Maui Transmission System Grid Needs – Base Scenario, Year 2040

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2040**

In 2040, another 61 MW REZ zone C development will be completed. It is assumed that 61 MW will be interconnected at Waena switchyard. Meanwhile, there will be retirement of existing 5.7 MW distribution interconnected PV. System annual peak demand is forecasted to reach 266 MW in 2041.



System Resource Changes since 2036

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Onshore Wind Generation	18	2040	REZ Zone C

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2040**

	PV/BESS Generation	43	2040	REZ Zone C
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Distribution Interconnected PV	Solar	5.7	2040	12 kV Distribution System

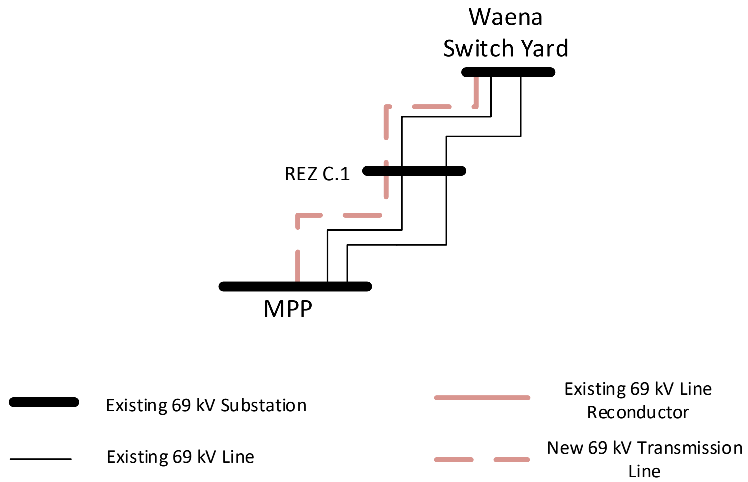
System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	84	376	40	218	266

REZ Enablement

The new 61 MW of generation in the REZ zone C development is assumed to interconnec at the Waena switchyard, which will require two BAAH bays for the generation interconnection.
The estimated cost of REZ enablement for 61 MW generation from REZ zone C development interconnected at the Waena switchyard is $15.6 million.

Grid Needs - Transmission System Networks Expansion



The total estimated cost for these transmission networks expansion is $51.9 million.

An alternative option for adding a new circuit between MPP and Waena switchyard is to reduce grid-scale generation interconnection from the REZ zone C development by 48.4 MW.

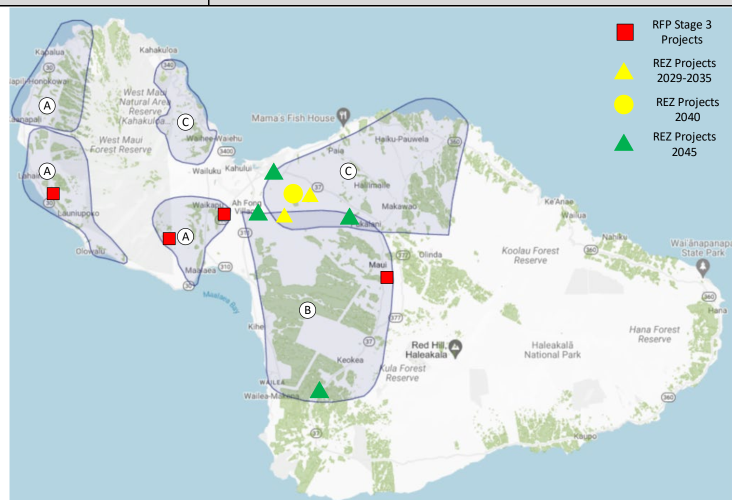
Grid Needs – System Stability Needs

None

Table A 14 Maui Transmission System Grid Needs – Base Scenario, Year 2045

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2045**

In 2045, 66 MW PV/BESS generation and 41 MW onshore wind generation will be developed in REZ zone C; 15 MW PV/BESS generation will be developed in REZ zone B. Also, all the remaining fossil units will switch to biodiesel. The system annual peak demand is forecasted to reach 289 MW in 2046.



System Resource Changes since 2041

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	PV/BESS Generation	15	2045	REZ Zone B
	PV/BESS Generation	66	2045	REZ Zone C
	Onshore Wind Generation	41	2045	REZ Zone C

System Resource Summary and Forecasted Demand (MW)

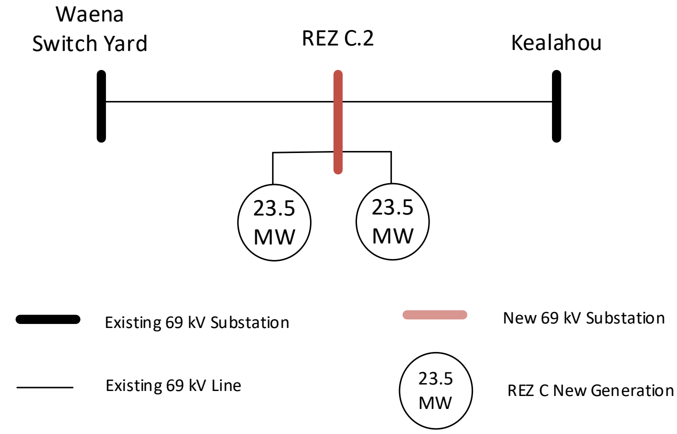
Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	125	457	40	229	289

REZ Enablement

According to the resource plan, 15 MW generation from REZ zone B and 107 MW generation from REZ zone C will be interconnected to the Maui system. In the study, following interconnection sites are assumed.

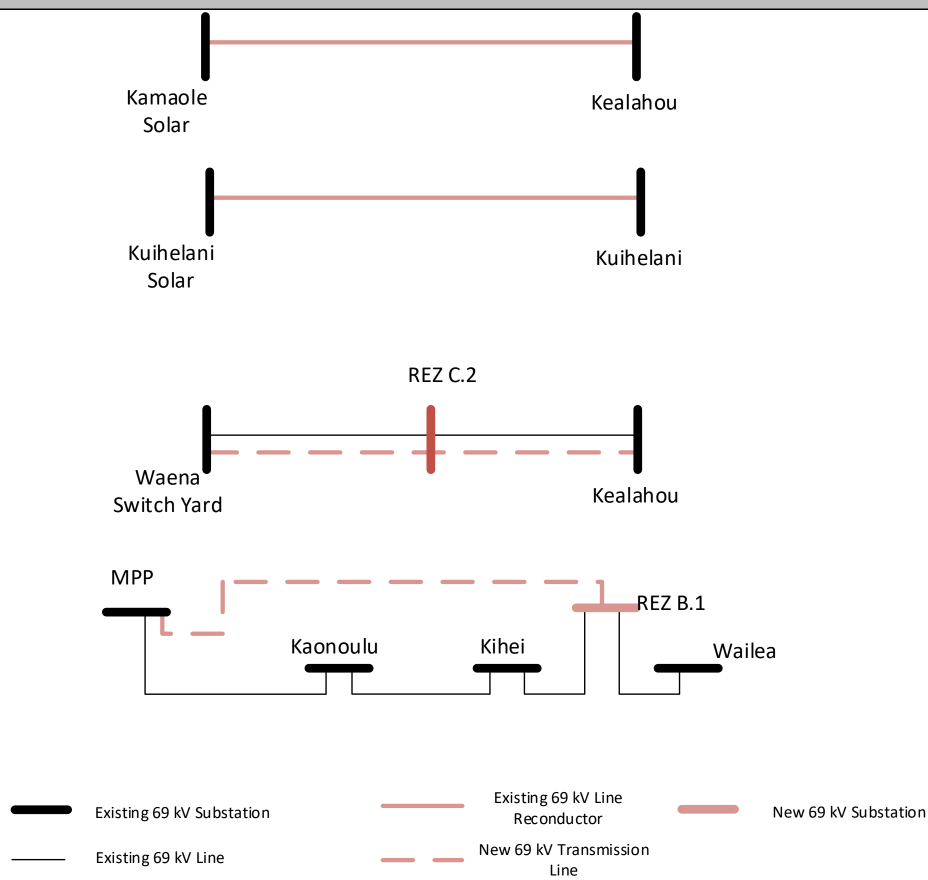
- Auwahi substation – 15 MW
- STG3.1 – 30 MW
- Kanaha substation (23 kV) – 30 MW
- New switching station, REZ C.2, on Waena-Kealahou line – 47 MW

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	2045



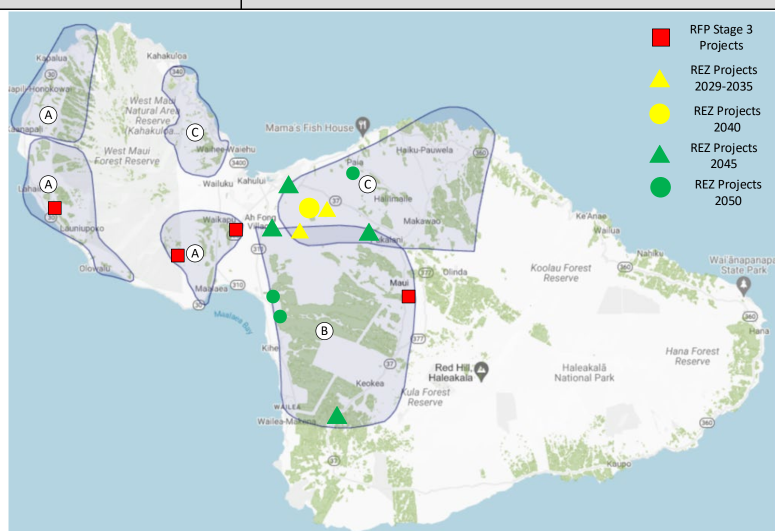
The cost estimate of the REZ enablement for the 30 MW interconnection at the STG 3.1 substation is $3.9 million, for the 30 MW interconnection at the Kanaha substation 23 kV side is $3.8 million, and for the 47 MW interconnection at the new substation REZ C.2 is $7.8 million. The total estimate for the REZ enablement is $15.4 million.

Grid Needs - Transmission System Networks Expansion



Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2045**
The total estimated cost for these transmission networks expansion is $171.2 million.	
An alternative option for reconductor of Kamaole-Kealahou line is to reduce south Maui generation interconnection size by 7 MW.	
Grid Needs – System Stability Needs	
Not studied.	

Table A 15 Maui Transmission System Grid Needs – Base Scenario, Year 2050

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2050**
In 2050, 57 MW PV/BESS generation will be developed in REZ zone C; 57 MW PV/BESS generation will be developed in REZ zone B. System annual peak demand is forecasted to reach 310 MW in 2050.	

System Resource Changes since 2036

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Solar/BESS Generation	57	2050	REZ Zone B
	Solar/BESS Generation	57	2050	REZ Zone C

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	125	571	40	240	310

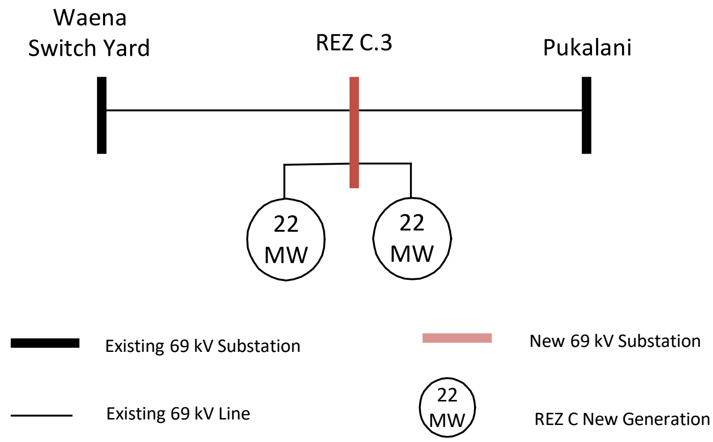
REZ Enablement

In the study, it is assumed following interconnection sites for the 114 MW generation development in the REZ zone B and C:

- REZ B.1 Substation – 51 MW

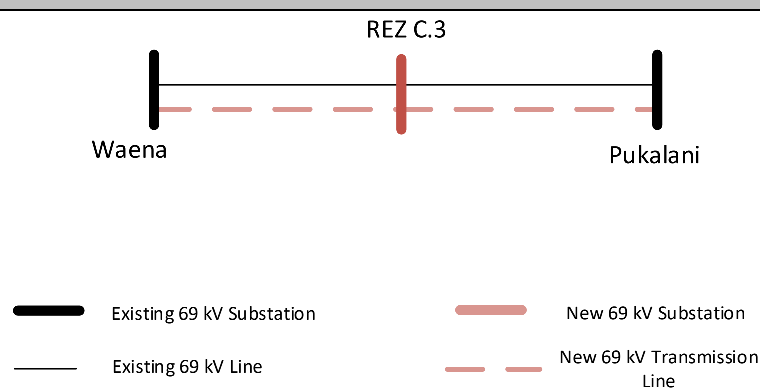
Studied Resource Plan	Studied Year
Base Scenario Resource Plan	2050

- Auwahi Substation – 7 MW
- REZ C.2 (Waena-Kealahou) Substation = 13MW
- New switching station, REZ C.3, on Waena-Pukalani line – 44 MW



The estimated cost for REZ enablement in REZ B.1 substation is $9.0 million and for REZ enablement of building the REZ C32 is $9.0 million. The total REZ enablement estimated cost is $18.0 million. It is assumed in the study that the 7 MW generation interconnection at the Auwahi substation and 13 MW generation interconnection at the REZ C.2 substation are interconnected without adding new BAAH bay but just expansion of previous developed projects.

Grid Needs - Transmission System Networks Expansion



Besides above adding a new 69 kV line between Waena switchyard and Pukalani substation, it is also proposed to replace the two 69/23 kV tie transformers at Kanaha substation by two units of larger transformers with at least FA rating as 24 MVA. The total estimated cost for these transmission networks expansion is $123.1 million.

An alternative of upgrading two units of the Kanaha tie transformer is to use DER program, or demand response program, or energy efficiency program to reduce peak load of the Maui 23 kV network by at least 4 MW.

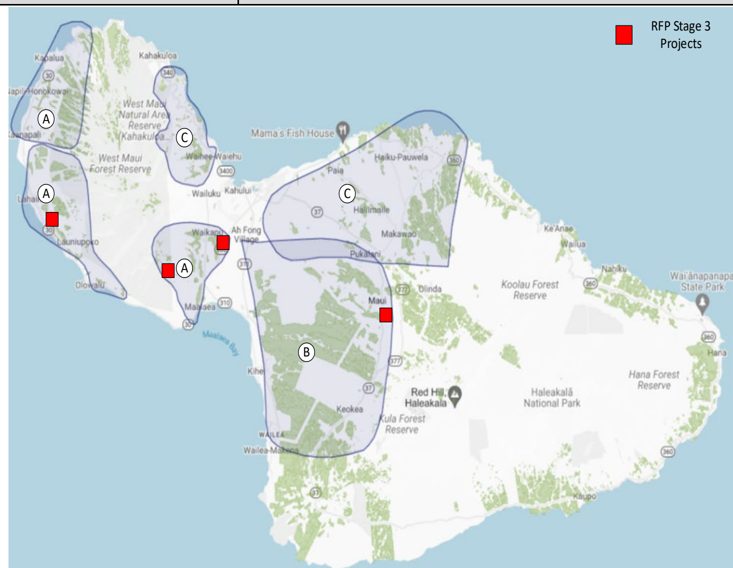
Grid Needs – System Stability Needs

Not studied

Table A 16 Maui Transmission System Grid Needs – High Load Scenario, Year 2027

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	2027

By 2027, the Maui system will have new generation from Stage 3 RFP procurement which will be 171 MW renewable dispatchable generation ("RDG") PV/BESS and 36 MW firm generation, interconnection at at Maui 69 kV system. Meanwhile, the Maui system will finish Waena switchyard construction, Kahului Power Plant ("KPP") retirement and conversion of KPP K3 and K4 units to synchronous condensers, and Maalaea Power Plant ("MPP") unit 10-13 retirement. The system peak load is forecasted to reach 239 MW by 2028.



System Grid Scale Resource Changes

Development	Generation Type	MW Capacity	GCOD	Location
Stage 3 Maui RFP	Renewable Dispatchable Generation	171	2027	West Maui, Central Maui and South Maui
	Firm Generation	36	2027	Central Maui
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kaheawa Wind Power 1	Wind Generation	30	2027	KWP 1 substation
Kahului 1-4	Fossil Generation	32.5	2027	Kahului Power Plant
Maalaea 10-13	Fossil Generation	49.4	2027	Maalaea Power Plant

System Resource Summary and Forecasted Demand (MW)

Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
197.5	42	296	40	194	239

REZ Enablement

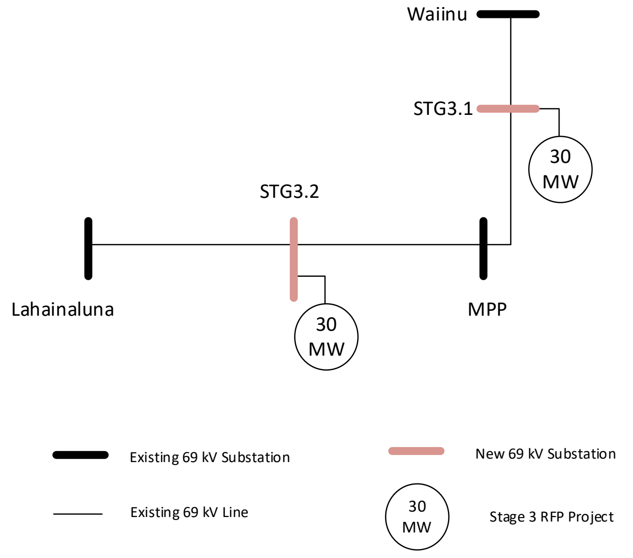
No REZ enablment cost estimate since by 2027 there will be only Stage 3 development but no REZ development. Interconnection sites for the 171 MW Stage 3 RFP projects and 36 MW firm generation are as following. Substation/Switching station interconnections:

- Lahainaluna substation station – 60 MW
- KWP 2 substation – 30 MW
- Waena switch yard – 40 MW firm generation
- Kealahou substation – 21 MW

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2027**

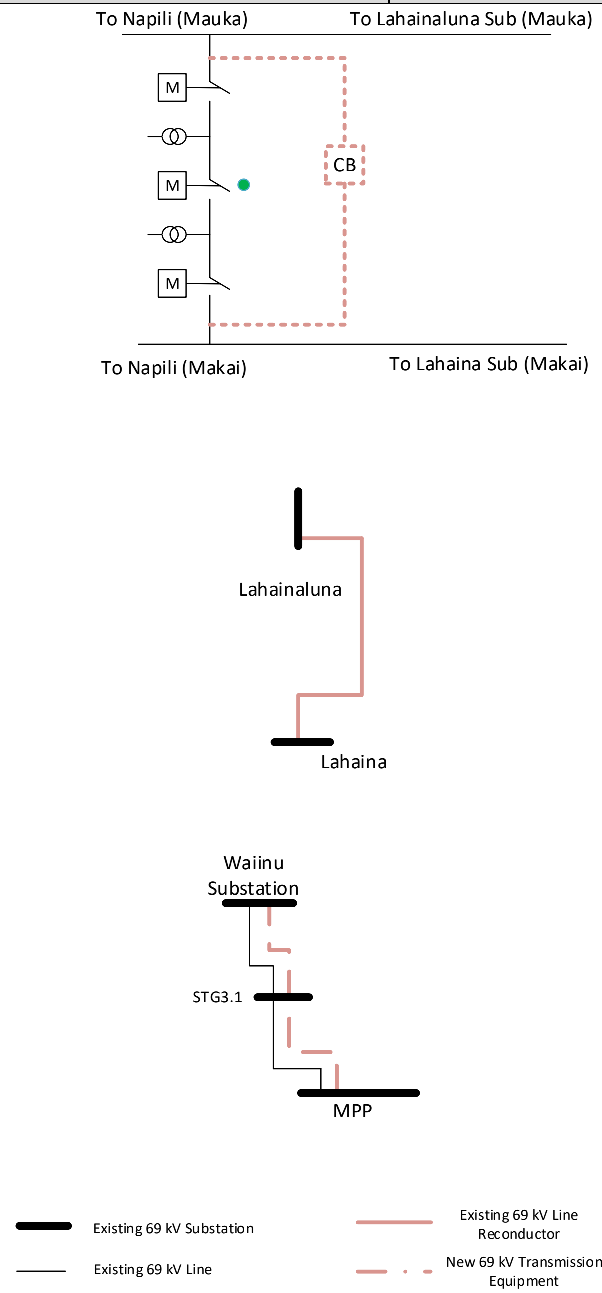
69 kV Transmisison line interconnection:

- MPP – Waiinu line interconnection – 30 MW, through a new substation STG3.1
- MPP – Lahainaluna line interconnection – 30 MW, through a new substation STG3.2



Grid Needs - Transmission System Networks Expansion

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2027**



The total estimated cost for these transmission networks expansion is $28.7 million.

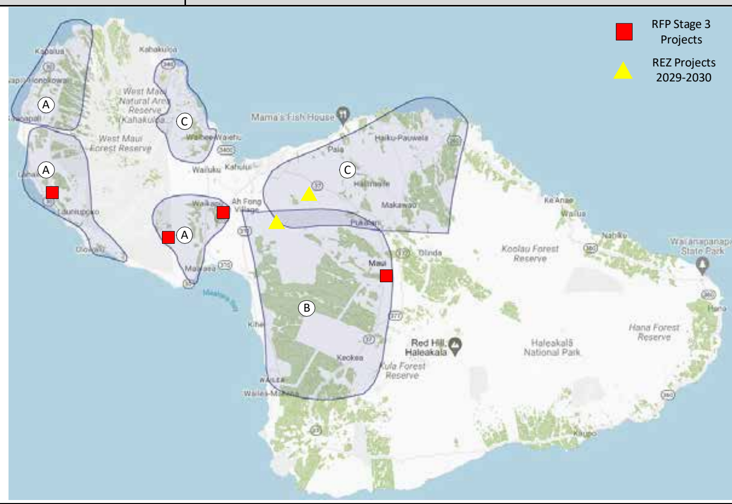
Grid Needs – System Stability Needs

Not studied

Table A 17 Maui Transmission System Grid Needs – High Load Scenario, Year 2030

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2030**

By 2030, the Maui system will have 69 MW grid-scale renewable generation from REZ zone C development. Also, it is planned that MPP unit 1 to 9 will be removed by 2030. The system annual peak load is forecasted to reach 266 MW by 2031.



System Resource Changes since 2031

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Onshore Wind Generation	6	2029	REZ Zone C
	Onshore Wind Generation	46	2035	REZ Zone C
	Solar/BESS	17	2035	REZ Zone C
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Maalaea Power Plant Units 1-9	Fossil	40.5	2030	MPP

System Resource Summary and Forecasted Demand (MW)

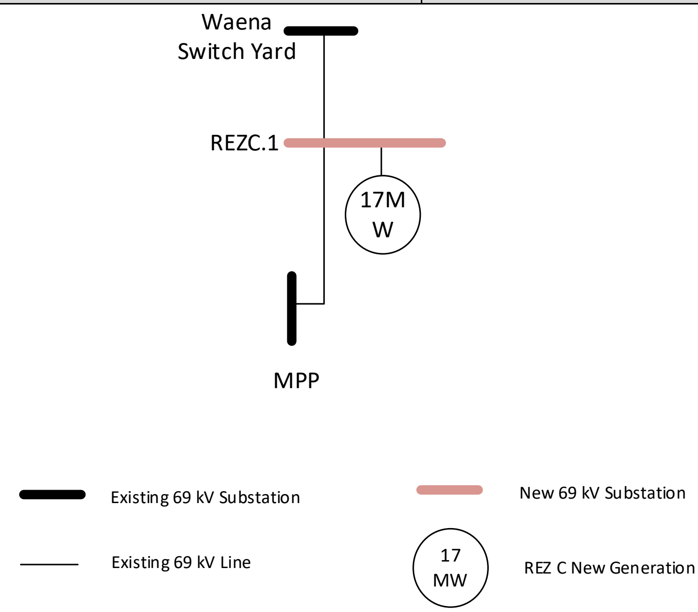
Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	94	313	40	217	266

REZ Enablement

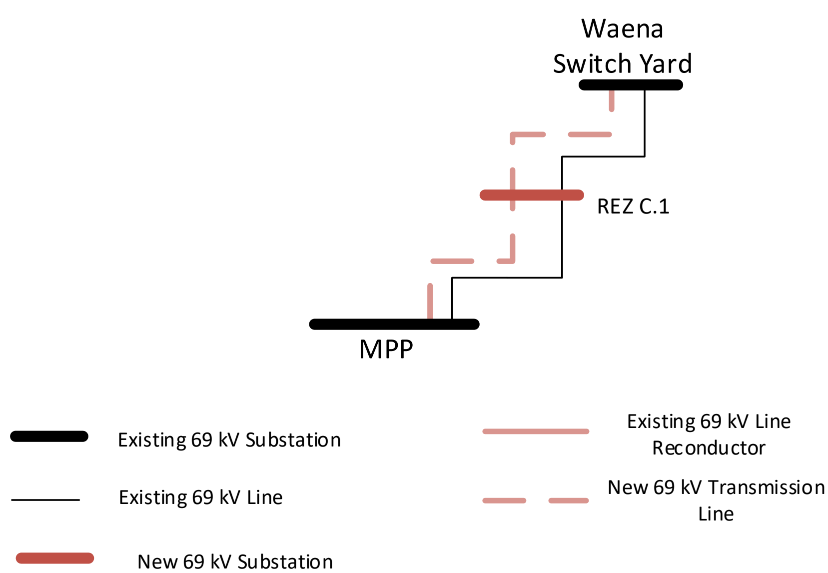
For the 2030 REZ development, 69 MW generation will be developed from REZ zone C and interconnected with Maui's 69 kV system. It is assumed that 52 MW will be interconnected at Waena switchyard, and 17 MW will be interconnected at a new substation REZ C.1 as shown in the following diagram. The estimated cost of REZ enablement for the 52 MW interconnection at the Waena switchyard is $11.6 million; the estimated cost of REZ enablement for the 17 MW interconnection at the REZ C.1 substation is $2.5 million.

REZ Enablement Cost Estimat for 17 MW Generation Interconnected at a new switching station REZC.1

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2030**



Grid Needs - Transmission System Networks Expansion



Besides adding the new 69 kV line from MPP to Waena via the REZ C.1 substation, converting Pukalani-Haiku 23 kV line into a 69 kV line and adding 1.8 Mvar cap bank at Kailu substation and Keanae substation are also proposed as part of the required trasmission networks expansion. The total estimated cost for these transmission networks expansion is $134.0 million.

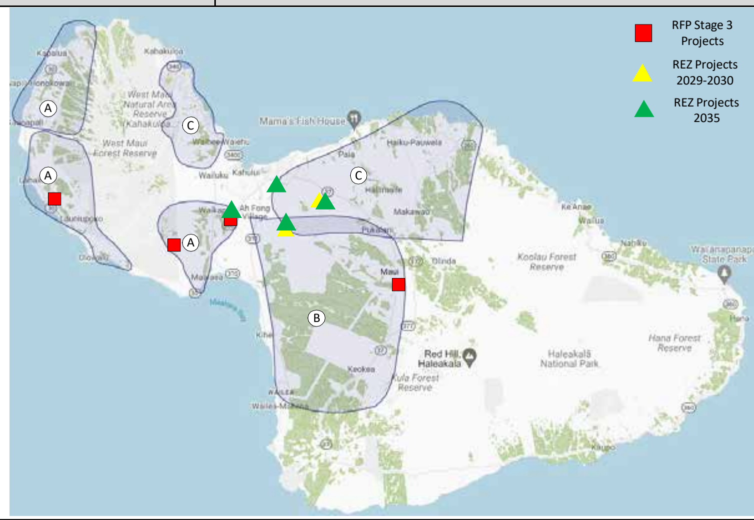
Grid Needs – System Stability Needs

Not studied.

Table A 18 Maui Transmission System Grid Needs – High Load Scenario, Year 2035

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2035**

In 2035, another 159 MW REZ zone C development will be completed. 38 MW will be interconnected at Waena switchyard, 60MW interconnected at REZC.1 30MW interconnected at STG3.1 and 30MW interconnected at Kanaha Substation on the 23kV bus. In addition, it is assumed the existing 42 MW wind contract expires. The system annual peak demand is forecasted to reach 313 MW in 2036.



System Resource Changes since 2036

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Onshore Wind Generation	75	2035	REZ Zone C
	PV/BESS Generation	84	2035	REZ Zone C
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Kaheawa Wind Power 2	Onshore Wind Generation	21	2033	KWP 2 Substation
Auwahi Wind	Onshore Wind Generation	21	2033	Auwahi Substation

System Resource Summary and Forecasted Demand (MW)

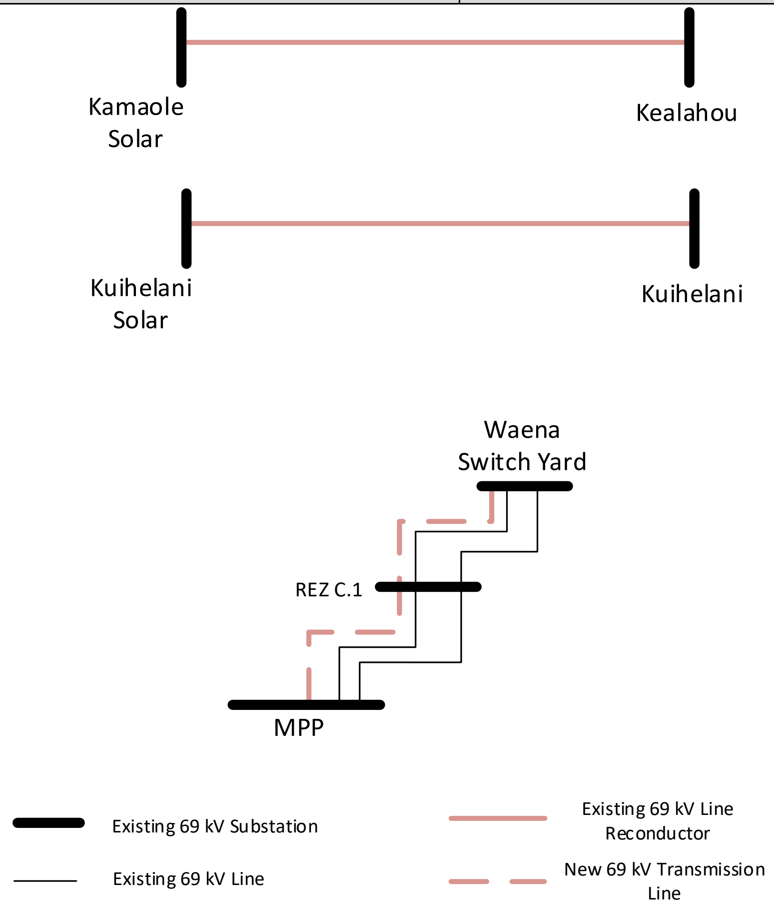
Firm Generation	Onshore Standalone Wind	Grid-Scale Hybrid Solar/BESS	Standalone BESS	DER	System Peak Load
152	127	396	40	242	313

REZ Enablement

It is assumed that 38 MW generation will be interconnected at Waena switchyard (with estimated REZ enablement cost as $13.5 million), 60MW generation interconnected at REZC.1 (with estimated REZ enablement cost as $2.9 million), 30MW generation interconnected at STG3.1 (with estimated REZ enablement cost as $2.9 million), and 30MW generation interconnected at Kanaha Substation on the 23kV bus (with estimated REZ enablement cost as $2.8 million). The total estimated cost for the REZ enablement regarding the 158 MW generation from the REZ development is $22.1 million.

Grid Needs - Transmission System Networks Expansion

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2035**



Besides above mitigation solutions, it is also proposed to replace the two 69/23 kV tie transformers at Kanaha substation by two units of larger transformers with at least FA rating as 24 MVA. The total estimated cost for these transmission networks expansion is $70.0 million.

Grid Needs – System Stability Needs

Not studied.

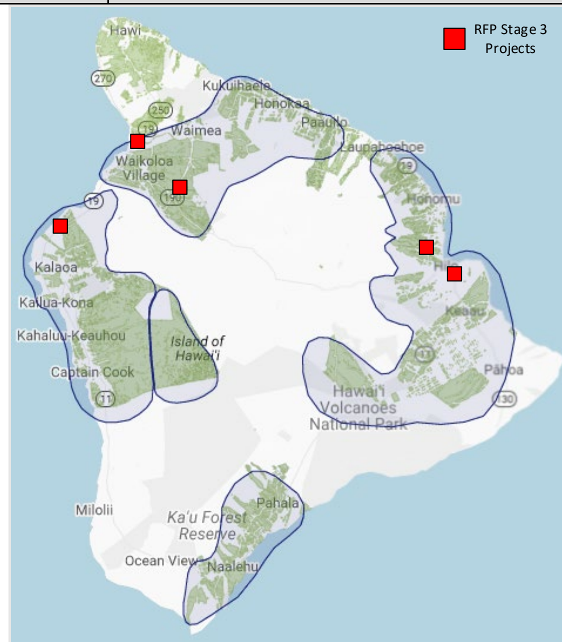
A.3 Hawaiʻi Island Results Summary

Summary of the study results for the Hawaiʻi Island base scenario and high load resource plan is as following.

Table A 19 Hawai'i Island Transmission System Grid Needs – Base Scenario, Year 2032

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2032**

By 2030, the Hawai'i Island system will have new generation from Stage 3 RFP procurement and REZ development, which will be 48 MW wind generation of REZ development by 2029 and 140 MW Stage 3 RFP PV/BESS generation by 2030. All of them will be interconnected to the Hawai'i Island 69 kV system. Also, three existing generation plants will be removed by 2031: the 34 MW Hill 5 and 6 will be removed by 2027; the 21 MW Tawhiri wind generation PPA is expected to expire by 2028; and the 58 MW Hamakua Energy Partners ("HEP") contract is expected to expire by 2031. The system peak load is forecasted to reach 214 MW by 2032.



System Grid Scale Resource Changes

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Wind Generation	48	2029	West Hawai'i island
Stage 3 Hawai'i Island RFP	Solar/BESS Generation	140	2030	West and east side of Hawai'i island
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Hill 5, 6	Fossil Generation	34	2027	Kanoelehua substation
Tawhiri Generation	Wind Generation	21	2028	Kamaoa substation
HEP	Fossil Generation	49.4	2031	Haina substation

System Resource Summary and Forecasted Demand (MW)

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load
85.8	58.5	46	200	16.6	214	214

REZ Enablement

Interconnection sites for the 140 MW Stage 3 RFP projects and 48 MW onshore wind generation are as following.

- Keamuku substation – 30 MW Stage 3 project
- Puueo substation – 30 MW
- Kanoelehua substation – 30 MW

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2032**

- Ouli substation – 20 MW
- Poopoomino substation – 30 MW

The interconnection of 48 MW wind generation from REZ development is assumed at the Keamuku substation. The estimated REZ enablement cost for the 48 MW offshore wind interconnection at the Keamuku substation is $37.8 million.

Grid Needs - Transmission System Networks Expansion

None

L6200 overloading observed in the study due for maximum west generation dispatches in which the 214 MW system load is solely supplied by generation from west side of island. This would be required for unconstrained use of the modeled base portfolio resources. The L6200 reconductor is not required if there is a minimum MW generation provided from east side of the system. as calculated by following equation:

East side minimum generation (MW) = $\frac{System\ total\ load - 174}{214 - 174} \cdot 20$

If system total load is lower than 178 MW, there is no mimimum MW requirement of generation on east side of the system.

Dependent on the system total load and the east side generation resources chosen to meet this minimum requirement, the east may require 20 MVAR of additional reactive power capability to resolve potential north/east voltage violations. At the peak load with 20 MW generation on east side of island, the following options are viable for mitigating north/east undervoltage violations:

- All 3 units of PGV online
- Puna CT3 online with 2.8 MVAR additional reactive capability required at Kanoelehua or Puueo substations
- Stage 3 Kanoelehua with 20 MVAR additional reactive capability required at Kanoelehua
- Stage 3 Kanoelehua & Puueo (split output) with 20 MVAR additional reactive capability required between the two locations. The Additional reactive capability at Kanoelehua and Puueo are in addition to the assumed capability of the Stage 3 resources at that location

To mitigate high loading condition of L8900/8100, it is necessary to move the generation resource interconnection location from Keamuku and the East towards the further west side system (e.g., Keahole substation) when the system total load reaches above 200 MW.

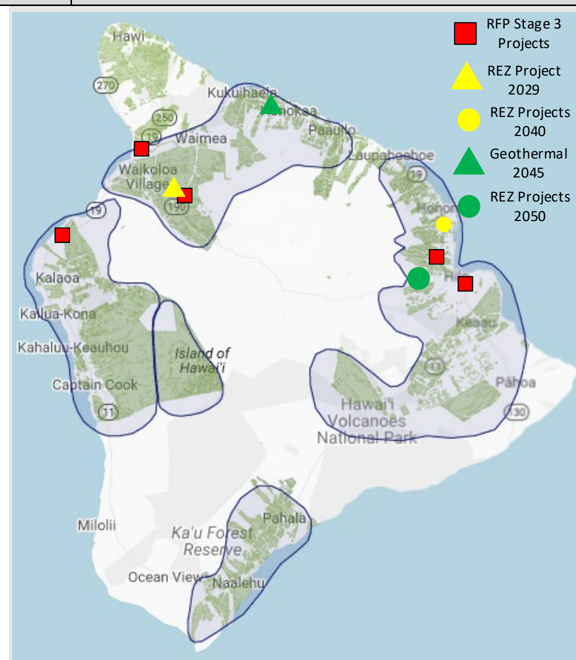
To mitigate undervoltage violation identifed on south side of system, it is recommend to have a resource interconnected at Keauhou substation with at least 10.4 Mvar capability or at Kamaoa substation with 13.7 Mvar or 13.3 MW capability. The reactive power capability can be replaced by active power capability, or the combination of reactive power and active power capability.

Grid Needs – System Stability Needs

After adding 140 MW Stage 3 PV/BESS projects with grid forming ("GFM") BESS component, it is expected that Hawaiʻi island system stability performance will stay within planning criteria, providing sufficient contingency reserve can be held on these resources - and no addtional grid needs regarding system stability were identified. When PGV units are online, at minimum, a total of 60 MW GFM PV/BESS project is required. A 30 MW GFM PV/BESS project is required on both East and West side of the Hawaiʻi island system, while maintaining GFM

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2032**
resource headroom as 24% of DER generation. When PGV units are offline, at minimum, a total of 110 MW GFM resource is required. The east side of the system will need 50 MW GFM resource online and west side of the system will need 60 MW GFM resource online, while together maintaining GFM resource headroom as 61% of DER generation.	

Table A 20 Hawai'i Island Transmission System Grid Needs – Base Scenario, Year 2050

Studied Resource Plan	Studied Year
Base Scenario Resource Plan	**2050**
In addition to previous system resource changes by 2031, the Hawai'i island system will have 2 MW standalone BESS and 3 MW Solar/BESS from the REZ development by 2035. It is assumed that both interconnections will be in distribution circuits considering their MW size. In 2040, there will be another 20 MW Solar/BESS generation developed from REZ. In 2045, all fossil generation will have fuel switch to biodiesel. In the same year, there will be 30 MW geothermal generation and 2 MW standalone BESS interconnected to the system. By 2050, an additional 14 MW Solar/BESS and 2 MW onshore wind generation will be developed from REZ. The system annual peak load is forecasted to reach 295 MW by 2050.	

System Resource Changes since 2031

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Solar/BESS	3	2035	REZ, distribution interconnected
Other	Standalone BESS	2	2035	Distribution interconnected
REZ Development	Solar/BESS	20	2040	REZ, east side of Hawai'i island
Other	Geothermal	30	2045	North side of Hawai'i island
REZ Development	Solar/BESS	14	2050	REZ, east side of Hawai'i island
	Onshore wind	2	2050	

System Resource Summary and Forecasted Demand (MW)

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load

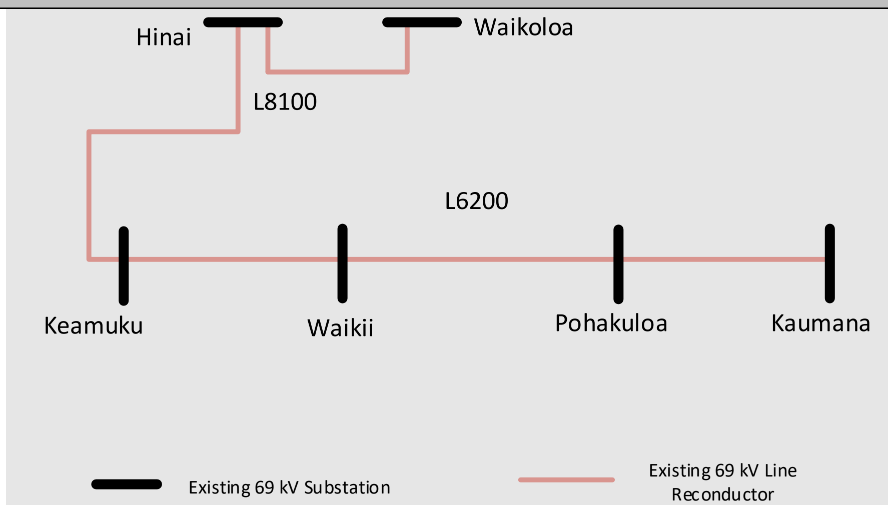
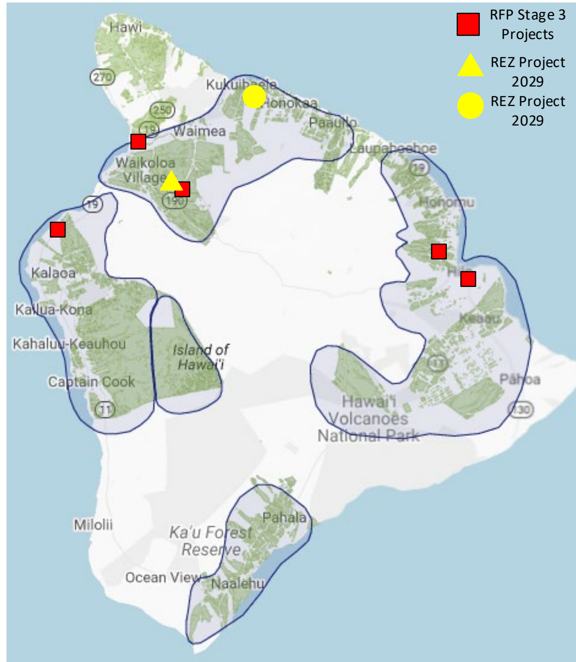
Studied Resource Plan				Studied Year		
Base Scenario Resource Plan				**2050**		
85.8	60.5	76	237	16.6	271	295
REZ Enablement						
It is assumed that the geothermal generation in service in 2045 will be interconnected at Haina substation, and the REZ generation will be interconnected at Pepeekeo substation (20 MW) in 2040 and Kaumana substation (17 MW) in 2050. High level cost estimate for the 20 MW interconnection REZ enablement at the Pepeekeo substation is $24.5 million, and for the 17 MW interconnection REZ enablement at the Kaumana substation is $27.9 million.						
Grid Needs - Transmission System Networks Expansion						
 The estimated cost for the two line reconductor is $100.1 million.						
To mitigate undervoltage violations on the north side of the system, it is recommended to dispatch an East unit (e.g., PGV, etc.) at 5 MW or higher. To mitigate undervoltage violation on south and southwest side of the system, it is recommend to have a resource interconnected at Kamaoa with 22.5 MW generation capacity and/or a minimum reactive power requirement (defined on further study when resouces are known).						
Grid Needs – System Stability Needs						
Not studied.						

Table A 21 Hawaiʻi Island Transmission System Grid Needs – High Load, Year 2032

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2032**

According to the resource plan, by 2030, the Hawaiʻi system will have new generation from Stage 3 RFP procurement, REZ development and a new geothermal generation plant, which will be 48 MW wind generation of REZ development and 30 MW geothermal generation by 2029 and 140 MW Stage 3 RFP PV/BESS IBR generation by 2030. All of this new generation will be interconnected to the Hawaiʻi island 69 kV system. Meanwhile, three generation plants will be removed by 2031: the 34 MW Hill 5 and 6 will be removed by 2027; the 21 MW Tahiri wind generation will be removed by 2028; the 58 MW Hamakua Energy Partners ("HEP") will be removed from system by 2031. According to the forecast, system peak load will reach 280 MW by 2032.



System Grid Scale Resource Changes

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Wind Generation	48	2029	West Hawaiʻi island
Other	Geothermal Generation	30	2029	North of Hawaiʻi island
Stage 3 Hawaiʻi Island RFP	Solar/BESS Generation	140	2030	West and east side of Hawaiʻi island
Removal	**Generation Type**	**MW Capacity**	**Year**	**Location**
Hill 5, 6	Fossil Generation	34	2027	Kanoelehua substation
Tawhiri Generation	Wind Generation	21	2028	Kamaoa substation
HEP	Fossil Generation	58	2031	Haina substation

System Resource Summary and Forecasted Demand (MW)

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load
85.8	58.5	76	200	16.6	214	280

REZ Enablement

Interconnection sites for the 140 MW Stage 3 RFP projects and 48 MW onshore wind generation are as following.

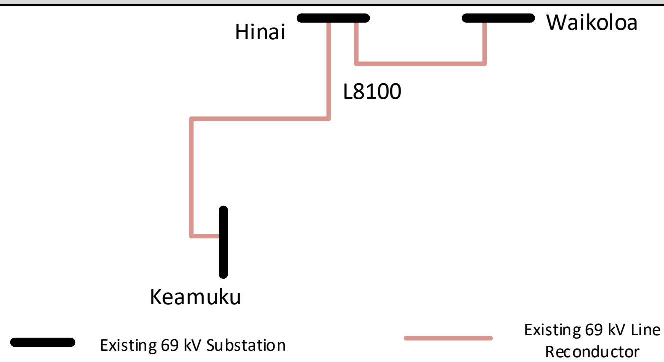
- Keamuku substation – 30 MW Stage 3 project

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	2032

- Puueo substation – 30 MW
- Kanoelehua substation – 30 MW
- Ouli substation – 20 MW
- Poopoomino substation – 30 MW

Also, it is assumed that the interconnection of 48 MW wind generation from REZ development is at the Keamuku substation and the interconnection of the 30 MW geothermal generation is at the Haina substation. The estimated REZ enablment cost for the 48 MW onshore wind interconnected at the Keamuku substation is $37.8 million.

Grid Needs - Transmission System Networks Expansion



The estimated cost for reconductoring L8100 is $10.9 million.

The alternative non-wire solution for deferring L6200 reconductor is to maintain minimum generation dispatch requirement on east side of the system. The minimum MW generation dispatched from east side of the system is calculated by following equation:

East side minimum generation (MW) = $\frac{System\ total\ load - 174}{214 - 174} \cdot 20$

If system total load is lower than 178 MW, there is no mimimum MW requirement of generation dispatched on east side of the system.

Depending on the system total load and the East side generation resources chosen to meet this minimum requirement, the East may require 28 MVAR of additional reactive power capability to resolve potential North/East voltage violations. 14 MVAR at Kanoelehua and 14 MVAR at Puueo are recommended to be installed (in addition to the assumed capability of Stage 3 resources at that location).

To mitigate undervoltage violation identifed on south side of system, it is recommend to have a resource interconnected at Kamaoa substation with at least 24 MW generation capability.

When the 30 MW geothermal is installed at Haina in 2029, there will be a total of 88 MW of generation capacity at Haina substation. During the time period between when the geothermal resource comes online and when HEP is removed in 2031, operational mitigation will be needed such that the total generation at Haina substation is limited to the existing capacity of 58 MW.

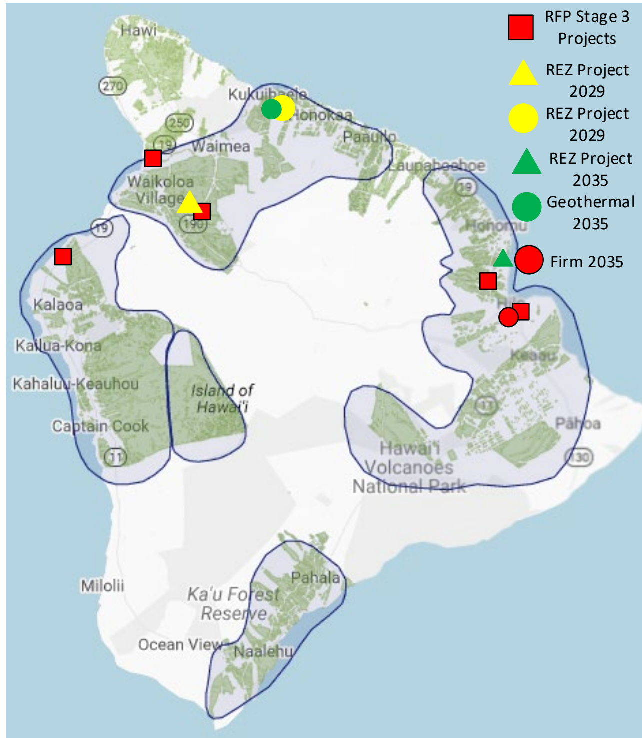
Grid Needs – System Stability Needs

Not studied.

Table A 22 Hawaiʻi Island Transmission System Grid Needs – High Load, Year 2036

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2036**

In addtion to previous system resource changes, by 2035 the Hawaiʻi island system will have another 30 MW geothermal generation, 30 MW firm generation and 22 MW solar/BESS generation from REZ development. Accoriding to the forecast, system annual peak load will be reached at 323 MW by 2036.



System Resource Changes since 2031

Development	Generation Type	MW Capacity	GCOD	Location
REZ Development	Solar/BESS	22	2035	East side of Hawaiʻi island system
Other	Geothermal	30	2035	North side of Hawaiʻi island system
Other	Firm	30	2035	East side of Hawaiʻi island system

System Resource Summary and Forecasted Demand (MW)

Fossil Generation	Onshore Standalone Wind	Geothermal Generation	Grid-Scale Hybrid Solar/BESS	Hydro	DER	System Peak Load
115.8	58.5	106	220	16.6	230	323

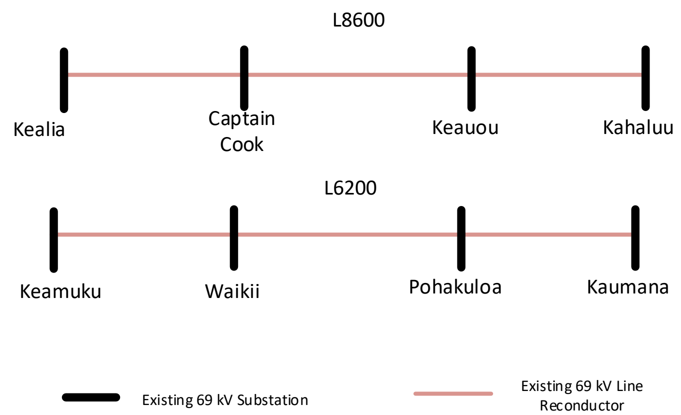
REZ Enablement

It is assumed that the geothermal generation in service in 2035 will be interconnected at Haina substation, and the REZ generation will be interconnected at Pepeekeo substation (22 MW) in 2035 and the firm generation will be interconnected at Kanoelehua substation (30 MW) in 2035.

Studied Resource Plan	Studied Year
High Load Scenario Resource Plan	**2036**

For the 22 MW Solar/BESS interconnection at the Pepeekeo substation, the estimated cost for REZ enablement is $24.5 million.

Grid Needs - Transmission System Networks Expansion



The estimated cost of reconductoring L8600 and L6200 is $121.5 million.

To mitigate undervoltage violations on the north side of the system, it is recommended to dispatch an East unit (e.g., PGV, etc.) at 14 MW or higher.
To mitigate undervoltage violation on south and southwest side of the system, , it is recommended to have a resource interconnected at Kamaoa with at least 24 MW active power generation capacity and 7.5 Mvar reactive power capability.
To mitigate undervoltage violations on the west side of the system during dispatches with high east generation, it is recommended to dispatch Keahole at 10 MW or higher.

Grid Needs – System Stability Needs

Not studied.

Appendix E:

Location-Based Distribution Grid Needs

Appendix E:
Location-Based Distribution Grid Needs

Hawaiian Electric

Location-Based Distribution Grid Needs

March 2023

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Table of Figures

1. Introduction

This document describes the development of the location-based distribution grid needs that are derived from the Distribution Planning process and will be used as part of the Integrated Grid Planning ("IGP") process. The Distribution Planning Process is comprised of four stages: forecast, analysis, solution options, and evaluation.

1. **Forecast Stage**: Develop circuit-level forecasts based on the corporate demand forecast.
2. **Analysis Stage**: Determine the adequacy of the distribution system.
3. **Solution Options Stage**: Identify the grid needs requirements.
4. **Evaluation Stage**: Evaluation of solutions.

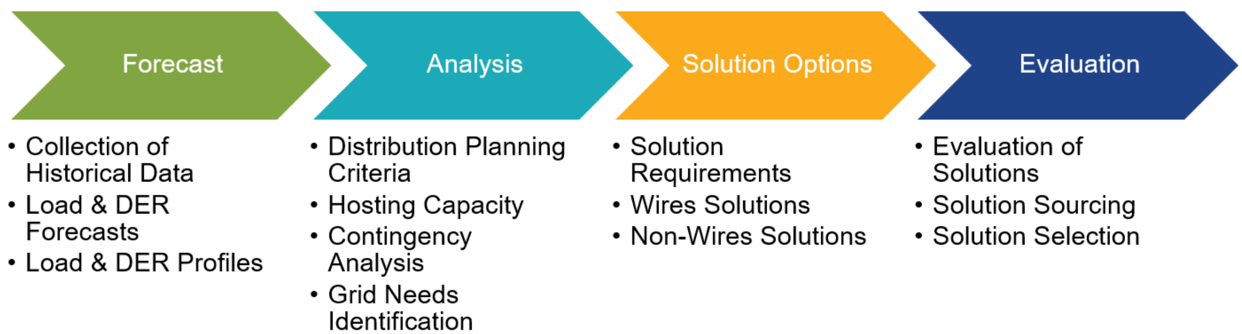

Figure 1-1: Stages of the Distribution Planning Process

On November 5, 2021, the Companies submitted their Location-Based Distribution Forecasts ("November 2021 Forecasts") in the IGP Grid Needs Assessment Methodology Review Point filed under Docket No. 2018-0165.[1] That document described the first stage, the Forecast Stage. It included the methodology to develop substation transformer and circuit location-based forecasts in accordance with the Distribution Planning Process described in the *Distribution Planning Methodology* document, updated to address the Technical Advisory Panel comments and questions.[2] On March 3, 2022, the

[1] *See* Hawaiian Electric Exhibit 3 – Location-Based Distribution Forecasts filed on November 5, 2021 in Docket No. 2018-0165, Instituting a Proceeding to Investigate Integrated Grid Planning.

[2] *See* Hawaiian Electric Companies' Grid Needs Assessment Methodology Review Point, Exhibit 1 Distribution Planning Methodology, filed on November 5, 2021 in Docket No 2018-0165.

Commission stated it "is satisfied with how Hawaiian Electric described the purpose and functionality of its modeling tools and accepts Hawaiian Electric's explanation of the modeling tools it uses…".[3]

This document describes the subsequent process (see "Analysis" in Figure 1-1) to identify the grid needs required based on the November 2021 Forecasts. For this analysis, the adequacy of the electric distribution system is assessed by comparing the location-based distribution forecasts against the distribution planning criteria described in the *Distribution Planning Methodology* to determine if the distribution circuits and substation transformers can serve the forecasted load growth (includes layers for distributed energy resources, electric vehicles, energy efficiency, and time of use). If the planning criteria is not met, grid needs required to meet the planning criteria are identified. This process differs from the hosting capacity grid needs which assesses each circuit's ability to accommodate DER growth specifically and as described in the *Distribution DER Hosting Capacity Grid Needs.*[4] These two analyses have the potential to overlap in requirements, since both consider contributions from DER to different extents; however, in this current planning horizon there were no circuits found with differing grid needs for the location-based distribution forecast and DER hosting capacity.

This Distribution Planning Process is incorporated into the IGP process as it uses the corporate forecasts that include planned electrical demand and DER developed through IGP as an input to the distribution planning analyses to identify distribution grid needs. These distribution grid needs are then used as an input into the IGP process which will select portfolios of solutions to address resource, transmission, and distribution needs.

The location-based distribution forecasts filed in November 2021 were developed using the corporate forecasts and scenarios provided in the Hawaiian Electric Revision to Updated and Revised Inputs and Assumptions ("August Update") filed on August 19, 2021.[5] The forecasts were based on three scenarios to provide a range of higher and lower loads: the Base, High Load Customer Technology Adoption Bookend, and the Low Load Customer Technology Adoption Bookend. On March 3, 2022, the Commission requested a fourth scenario, Fast Customer Technology Adoption, to "reflect a plausible future aligned with the State's RPS and emissions reductions goals".[6]

The corporate forecasts include specific layers for the underlying load growth, distributed energy resources ("DER"), energy efficiency ("EE"), and electric vehicles ("EV")[7]. These layers that are provided at

[3] *See* Order No. 38253 issued on March 3, 2022 in Docket No. 2018-0165, Approving, with Modifications, Hawaiian Electric's Revised Inputs and Assumptions.

[4] *See* Hawaiian Electric Companies' Grid Needs Assessment Methodology Review Point, Exhibit 4 Distribution DER Hosting Capacity Grid Needs, filed on November 5, 2021 in Docket No 2018-0165.

[5] *See* Hawaiian Electric Revision to Updated and Revised Inputs and Assumptions filed on August 19, 2021 in Docket No 2018-0165.

[6] *See* Order No. 38253 issued on March 3, 2022 in Docket No. 2018-0165, Approving, with Modifications, Hawaiian Electric's Revised Inputs and Assumptions

[7] This analysis uses the forecast for light duty electric vehicles but does not consider the forecast for eBus.

the system level are disaggregated to create a total demand forecast for each substation transformer and circuit. The four scenarios and the associated corporate forecast layers are summarized below.

Table 1-1. Forecast Layer Mapping of Modeling Scenarios and Sensitivities

No.	Modeling Case	DER Forecast	EV Forecast	EE Forecast	TOU Load Shape
1	Base	Base Forecast	Base Forecast	Base Forecast	Managed EV Charging
2	High Load Customer Technology Adoption Bookend	Low Forecast	High Forecast	Low Forecast	Unmanaged EV Charging
3	Low Load Customer Technology Adoption Bookend	High Forecast	Low Forecast	High Forecast	Managed EV Charging
4	Fast Customer Technology Adoption	High Forecast	High Forecast	High Forecast	Managed EV Charging

Since the November 2021 Forecasts were developed, the Company has received various service requests for new loads and the November 2021 Forecasts were updated to reflect these changes. The analysis herein references the updated forecasts that are referred to as the November 2021 Forecast Update in this document.[8]

1.1 Location-Based Grid Needs

The overall process and methodology, using modeling tools such as LoadSEER[9] to develop the grid needs driven by location-based demand forecasts is provided herein. Since this report addresses the location-based grid needs specifically, the distribution planning process figure discussed at the Stakeholder Technical Working Group meeting in June 2021[10] was streamlined to show details related only to this analysis and is shown in Figure 1-2. Potential wires and non-wires alternative ("NWA")

8 The updated forecasts are voluminous and therefore not provided in this report in table format. The files are available on the Company website in Excel workbooks. See Section 5 for a description of the files provided.

9 *See* Hawaiian Electric, *Distribution Planning Methodology*, November 2021 for an overview of the LoadSEER and Synergi models.

10 *See* Hawaiian Electric, *Distribution Planning Methodology*, November 2021 for descriptions of the distribution planning criteria.

solutions opportunities using the *Non-Wires Opportunity Evaluation Methodology*[11] will be evaluated separately as part of the IGP process.

The distribution planning criteria establishes technical guidelines to ensure the distribution system has adequate capacity to serve load growth and reliability (e.g., back-tie capability) for the Company's customers. Thus, planning for operation under both normal and contingency conditions is necessary as described in the *Distribution Planning Methodology*.

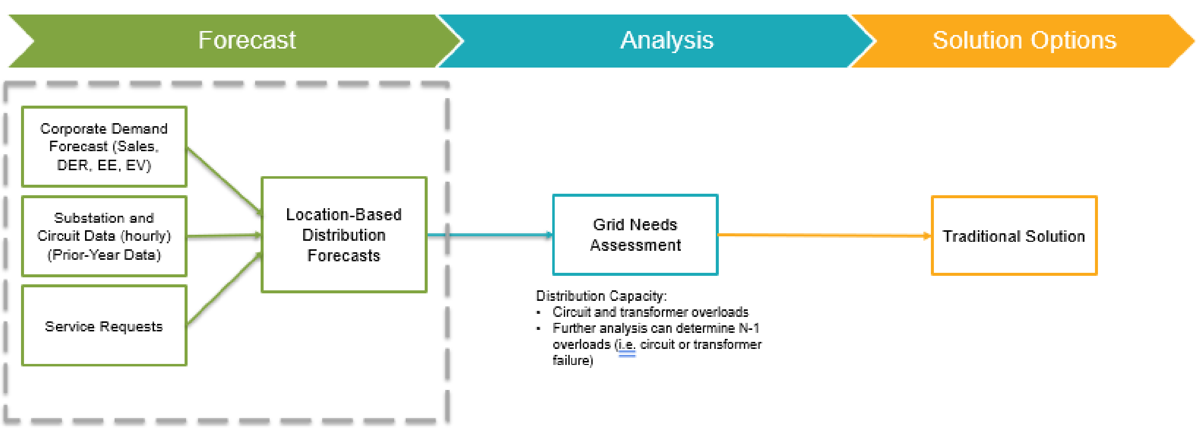

Figure 1-2 Location-Based Distribution Grid Needs Identification Stages

The following steps are used to identify substation transformers and circuits with planning criteria violations in the study period based on the forecast scenarios described above:

1. Determine the demand forecast (kW) by substation transformer and circuit.
2. Screen substation transformers and circuits for analysis.
3. Perform hourly grid needs analysis.
4. Identify solution options.

The first step above was described in the November 2021 Forecasts. That process developed the net peak forecast by substation transformer and circuit. Initially, when the distribution planning process started in year 2021, the study period spanned the next ten years (year 2021 through 2030). For the purposes of this report, the study period was adjusted to align with the current year and spans year 2023 through 2030. This report focuses on steps 2 and 3 to describe the analysis to identify the grid needs resulting from the demand forecasts.

[11] The Non-Wires Opportunity Evaluation Methodology was filed in the Grid Needs Assessment (Nov. 2021, Dkt. No. 2018-0165). An updated methodology is provided in Appendix F: NWA Opportunity Evaluation Methodology March 2023 Update of this filing to reflect the first time applying this methodology in the IGP cycle and additional feedback received from the Technical Advisory Panel such as defined thresholds for the NWA evaluation criteria.

2. Analysis

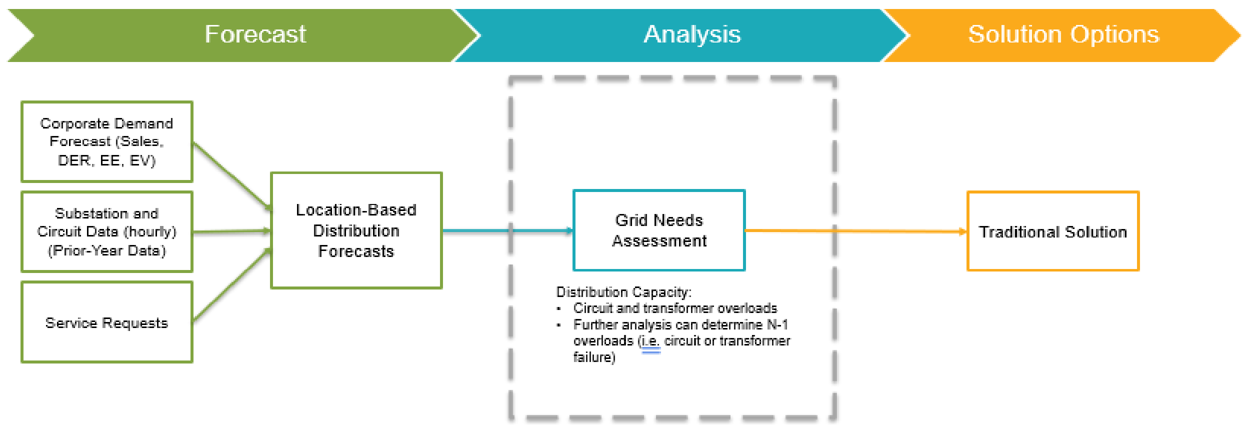

Figure 2-1 Analysis Stage of the Distribution Planning Process

This section describes steps 2 and 3 used to identify circuits and transformers that violate the distribution planning criteria indicating a grid need:

1. Determine the demand forecast (kW) by substation transformer and circuit.
2. **Screen transformers and circuits for analysis.**
3. **Perform hourly grid needs analysis.**
4. Identify solution options.

Planning criteria violations occur when there is existing or forecasted thermal loading or voltage levels on the Company's circuits or substation transformers that are outside of the acceptable range identified in the *Distribution Planning Methodology*.[12] An assessment for planning criteria violations was conducted for both normal condition and contingency (N-1) condition.

2.1 Screening Circuits and Transformers

Initially, substation transformers and circuits are screened to determine if there are violations based on the forecasted annual peak demand. If there is insufficient capacity to serve the forecasted demand,

[12] Distribution planning criteria applied to 46 kV and below for circuits on O'ahu and 12 kV and below for circuits on Hawai'i Island, Maui, Lāna'i, and Moloka'i. Distribution substation transformer planning criteria applied to 46 kV to 12 kV transformers.

additional hourly analysis is performed to determine if there is a grid need. This process is summarized in the following figure.

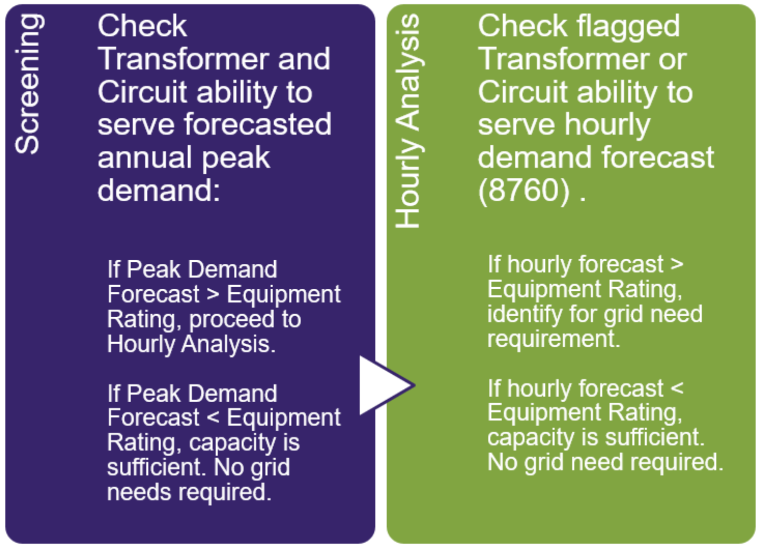

Figure 2-2: Summary of Screening and Hourly Analysis Process

The steps described in this section to select the substation transformers and circuits for analysis were repeated for each of the forecast scenarios: Base, High Load Customer Technology Adoption, Low Load Customer Technology Adoption, and Fast Customer Technology Adoption.

The screening process flags substation transformers and circuits for planning criteria violations to determine if there is a potential for identifying a grid need. The thermal rating or equipment rating is compared against the respective annual forecast in the November 2021 Forecast Update. Transformers and circuits are selected for further analysis if the forecast is greater than the thermal or equipment rating. This comparison is done for each year of the forecast to determine in what year(s) the violation(s) occur.

If the Demand Forecast by Transformer is less than the Transformer Rating or the Demand Forecast by Circuit is less than the Equipment Rating, there are no potential grid needs and no further analysis is required.

2.2 Screening Examples with No Potential Grid Needs

For the following substation transformer, the total demand forecast for that transformer is lower than the transformer rating for the entire period. Similar to the circuit example above, there are no potential grid needs and no further analysis required.

Table 2-1: Substation Transformer Screening Example – No Grid Needs

Substation Transformer	Equipment Rating (MVA)	Demand Forecast by Transformer (MW)									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
KEWALO 1	12.5	5.997	6.045	6.613	6.621	6.625	6.607	6.618	6.603	6.625	6.614

For the following circuit, the total demand forecast is lower than the equipment rating for the entire period. Therefore, there are no potential grid needs and no further analysis is required.

Table 2-2: Circuit Screening Example – No Grid Needs

Circuit	Equipment Rating (MVA)	Demand Forecast by Circuit (MW)									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
KEWALO 1	9.1	2.077	2.109	3.330	3.330	3.314	3.308	3.306	3.304	3.302	3.297

The screening process is performed for operation under normal conditions and operation under contingency conditions with separate criteria for each type.

2.2.1 Normal Condition

The screening criteria to flag substation transformers and circuits for planning criteria violations and subsequent analysis is based on the normal equipment rating (e.g., thermal rating). Circuits are selected for analysis if the thermal rating of the main conductor out of the substation under normal conditions is lower than the total demand forecast for that circuit (i.e. "Demand Forecast by Circuit"). Substation transformers are selected for analysis if the equipment rating[13] is lower than the total demand forecast for that transformer (i.e. "Demand Forecast by Transformer"). This comparison is done for each year of the forecast to determine in what year(s) the violation(s) occur.

In general, analysis occurs if:

- **Substation Transformer**: Demand Forecast by Transformer (MW) is greater than the Transformer Rating (MVA)[14]
- **Circuits**: Demand Forecast by Circuit (MW) is greater than Equipment Rating (MVA)[15]

[13] Equipment rating is the larger rating with fans operating ("FA") if applicable; otherwise, the rating with fans off ("OA") is provided. Equipment rating is the highest installed nameplate capacity rating (OA/FA) of the distribution substation transformer (MVA).

[14] Highest installed nameplate capacity rating (OA/FA) of the distribution substation transformer. If available, a 0% loss of life rating is used for normal conditions.

[15] Thermal rating of the main conductor out of the substation under normal conditions.

If the Demand Forecast by Transformer is less than the Transformer Rating or the Demand Forecast by Circuit is less than the Equipment Rating, there are no grid needs and no further analysis is required.

If a transformer or circuit is flagged for analysis, the hourly grid needs are determined using the approach described in Section 2.3.

<u>Normal Condition Screening Example</u>

An example of the substation transformer selection process is shown below for the Kewalo T3 substation transformer on O'ahu using the Base Scenario. The 50 MVA Equipment Rating is compared against the Demand Forecast by Circuit (MW) for each year of the forecast (years 2021 through 2030). From year 2027 through 2030, the forecast is higher than the Equipment Rating as shown highlighted in orange. Therefore, the transformer is selected for further analysis.

Table 2-3: Substation Transformer Screening Example – Normal Condition

Substation Transformer	Equipment Rating (MVA)	Demand Forecast by Transformer (MW)									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kewalo T3	50	24.483	25.171	24.995	32.411	36.316	45.101	59.946	60.019	60.049	60.074

An example of the circuit selection process is shown below for the Kewalo 7 circuit on O'ahu using the Base Scenario. The 17 MVA Equipment Rating is compared against the Demand Forecast by Circuit (MW) for each year of the forecast (years 2021 through 2030). From year 2026 through 2030, the forecast is higher than the Equipment Rating as shown highlighted in orange. Therefore, the circuit is selected for further analysis.

Table 2-4: Circuit Screening Example – Normal Condition

Circuit	Equipment Rating (MVA)	Demand Forecast by Circuit (MW)									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kewalo 7	17.0	8.459	8.775	8.631	10.143	12.491	19.016	34.547	34.688	34.659	34.628

2.2.2 Contingency Condition (N-1)

Because there may be various switching options for contingency conditions, it isn't feasible to evaluate each N-1 loading scenario against equipment ratings. Instead, the initial screening criteria to flag transformers and circuits for planning criteria violations under contingency conditions (N-1) is to compare the forecast against 75% of the equipment rating. Seventy-five percent of equipment rating was selected based on engineering judgement to select transformers and circuits for more detailed analysis. The equipment with demand exceeding the 75% threshold would be limited in the amount of backup capacity that it provides in a contingency scenario. This estimate was shown to be rather conservative since at most 64 out of 351 transformers and 90 out of 635 circuits were flagged for further analysis in a scenario[16], which is about 18% and 14%, respectively.

Transformers and circuits are selected for analysis if Demand Forecast by Transformer or Demand Forecast by Circuit is greater than 75% of the respective Equipment Rating. This comparison is done for each year of the forecast to determine in what year(s) the violation(s) occur.

In general, analysis occurs if:

- **Substation Transformer**: Demand Forecast by Transformer (MW) is greater than 75% of Transformer Rating (MVA)[17]
- **Circuits**: Demand Forecast by Circuit (MW) is greater than 75% of Equipment Rating (MVA)[18]

If the Demand Forecast by Transformer is less than 75% of the Transformer Rating or the Demand Forecast by Circuit is less than 75% of the Equipment Rating, there are no grid needs and no further analysis is required.

If a transformer or circuit is flagged for additional analysis, the hourly grid needs are determined using the approach described in Section 2.3.

2.3 Hourly Grid Needs Analysis

Once a substation transformer or circuit is identified for further analysis using the screening criteria described in Section 2.1, the next step is to perform a more detailed analysis to determine if there is a criteria violation and if there is, define the hourly grid needs in technology-neutral terms: capacity (MW), energy (MWh), and duration (hours). This is done by creating an hourly ("8760") profile[19] derived from the annual peak demand forecast using the November 2021 Forecast Update. The 8760 profile is compared against the equipment rating to determine the hourly grid needs as was described above in the screening process using the annual forecast.

The capacity (kW) need or magnitude of the overload is calculated by the greatest difference between the forecasted demand and the equipment rating. The annual energy requirement (MWh) is calculated by summing the magnitude of overload hours in a calendar year. Lastly, the duration (hours) is calculated based on the maximum hours in a single day where there are overloads.

[16] The highest number of flagged transformers and circuits occurred in the High Load Customer Technology Adoption Bookend case, or Scenario 2.

[17] Highest installed nameplate capacity rating (OA/FA) of the distribution substation transformer. If available, a 1% loss of life rating is used for contingency conditions.

[18] Thermal rating of the main conductor out of the substation under normal conditions.

[19] An 8760-hour profile represents all 365 days of the year at a 1-hour resolution.

Defining the hourly grid needs is similar in concept for all islands, but performed using different tools. As mentioned in the November 2021 Forecasts, LoadSEER was used to develop the location-based forecasts for O'ahu, but was unavailable for the neighbor island modeling.[20] Thus, LoadSEER was used to perform the analysis to determine the hourly grid needs for O'ahu. A process to create similar 8760 profiles for the neighbor islands was developed using a scaling method. These two processes are described in the following sections.

2.3.1 LoadSEER

The 8760 profiles are developed using LoadSEER and are based on the annual demand forecasts.[21] LoadSEER creates an 8760 profile of the forecasted demand for each transformer and/or circuit from years 2023 to 2030. Similar to the screening process described in Section 2.1, the hourly forecasted demand (kW) is compared against the equipment rating. If the forecasted demand is greater than the equipment rating, that hour is noted as having an overload.

2.3.2 Scaling Method

In the absence of LoadSEER modeling to develop 8760 profiles, a scaling method is used to mimic the process done in LoadSEER to create hourly demand forecasts by circuit and transformer.

This process starts with the historical hourly profile for the circuit used to determine the circuit peak loads.[22] The unitized profiles for EV, PV, BESS, EE, and load were extracted from LoadSEER and scaled to the allocated values determined in the location-based forecast. The resulting profiles for each layer were then added to the base load profile to get the hourly forecasted demand shape for each year. This is the profile that is compared to the equipment rating to determine the grid need. To get the transformer hourly forecasted demand, the shapes for each feeder fed from that transformer are summed together.

This process was completed for both normal and contingency conditions.

[20] The implementation of LoadSEER for the neighbor islands is targeted for early 2023 as reported in Exhibit 2 of Hawaiian Electric's Quarterly DER Technical Report filed on December 28, 2022 in Docket No 2019-0323.

[21] The process to derive the 8760 profiles is described in Hawaiian Electric Exhibit 3 – Location-Based Distribution Forecasts filed on November 5, 2021 in Docket No. 2018-0165, Instituting a Proceeding to Investigate Integrated Grid Planning.

[22] *Id*, Section 2.1.

2.3.3 Hourly Grid Needs Analysis Example

Using the example discussed in Section 2.2.1, the Kewalo 7 circuit on O'ahu was selected for further analysis in the Base Scenario. The hourly forecasted demand (8760 profile) was compared to the equipment rating for each hour of each year in the analysis timeframe. A sample day with an overload is shown in the plots below for two different years. The red line represents the forecasted demand (kW) and the dashed gray line represents the equipment rating (kW) for the circuit. The red shaded area is the overload.

The earliest year the overload occurs is in year 2026. In the chart below, on this particular day forecasted in year 2026, the plot illustrates an overload duration of approximately two hours (from hour 20 to hour 21) with a capacity need of approximately 2,000 kW and energy requirement of about 3,000 kWh.

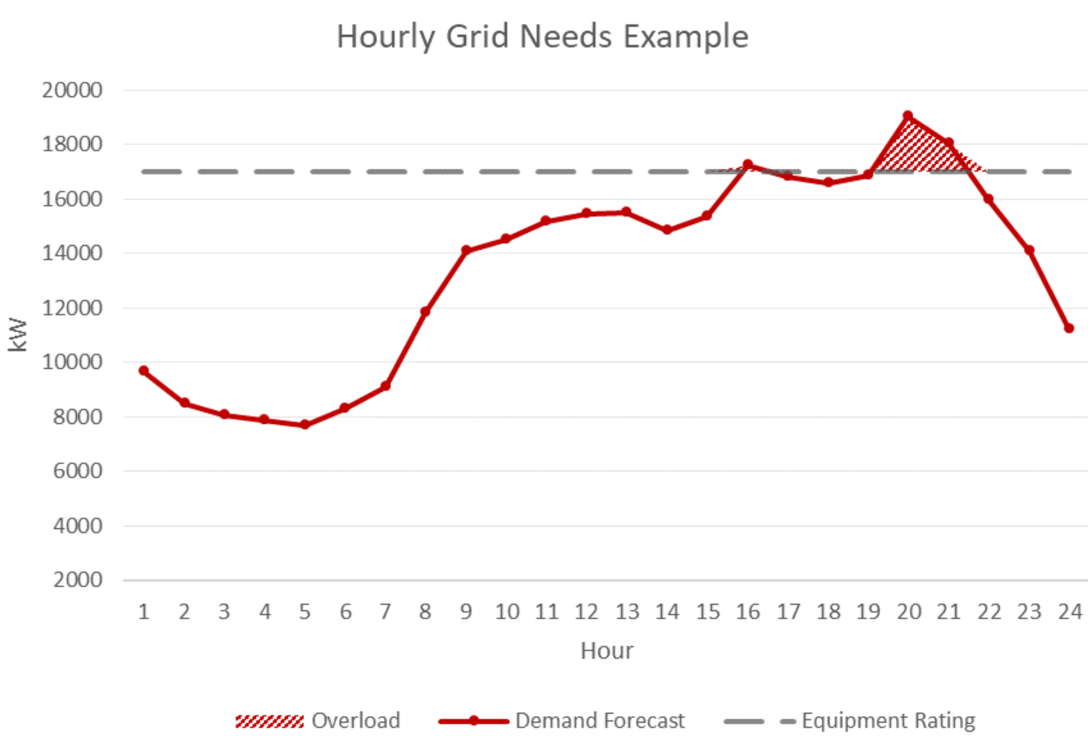

Figure 2-3: Hourly Grid Needs Example – Kewalo 7 Circuit (Year 2026)

The forecasted overload for this circuit grows in the following year. In the chart below, on this day forecasted in year 2027, the plot illustrates an overload duration of approximately 17 hours (from hour 8 to hour 24) with a peak capacity need of approximately 17,500 kW and energy requirement of 164,000 kWh.

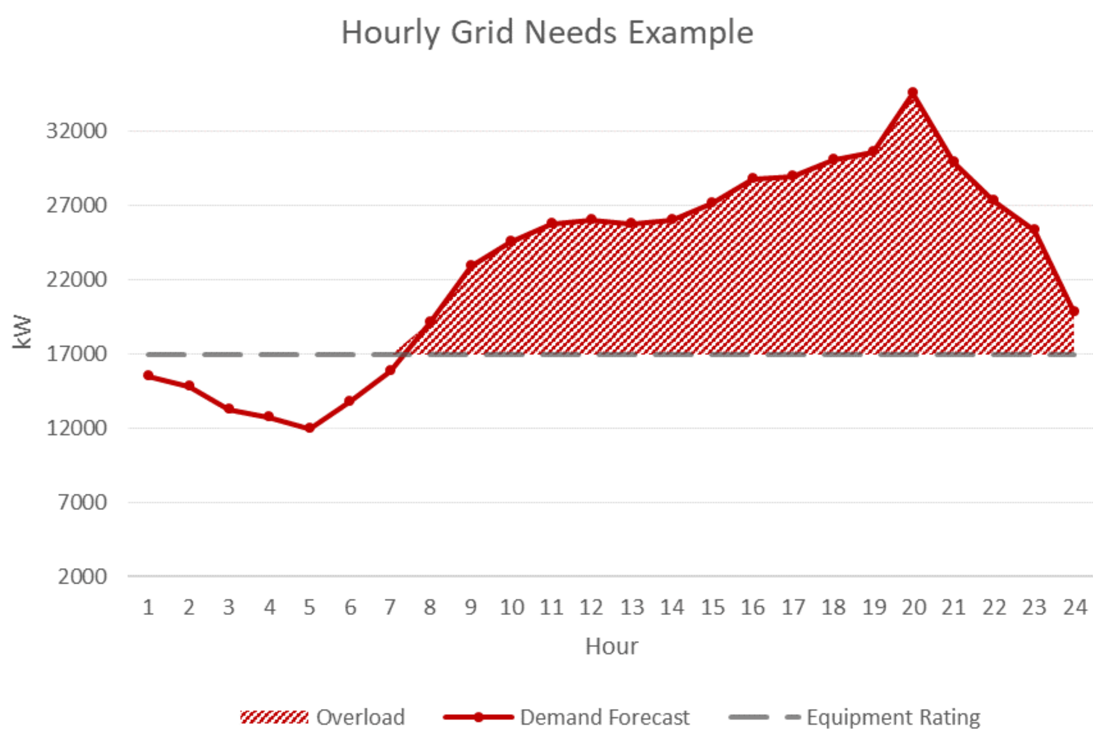

Figure 2-4: Hourly Grid Needs Example – Kewalo 7 Circuit (Year 2027)

2.4 Hourly Grid Needs Analysis Summary

The number of substation transformers and circuits flagged for hourly analysis and the grid needs identified are summarized in the following tables by island. Mitigation options for the identified grid needs are discussed further in Section 3.

O‘ahu

The table below is a summary of the transformers that were identified for hourly analysis. Through the hourly analysis, the transformers with grid needs were identified.

Table 2-5: O‘ahu Hourly Grid Needs Summary – Substation Transformers

Substation Transformer	Normal		Contingency	
	Identified For Hourly Analysis	Grid Need Identified	Identified For Hourly Analysis	Grid Need Identified
Scenario 1 (Base)	5	2	31	8
Scenario 2 (High Load)	12	3	61	12

Scenario 3 (Low Load)	7	3	29	6
Scenario 4 (Fast Adoption)	10	4	39	8

The table below is a summary of the circuits that were identified for hourly analysis. Through the hourly analysis, the circuits with grid needs were identified.

Table 2-6: O'ahu Hourly Grid Needs Summary – Circuits

Circuits	Normal		Contingency	
	Identified For Hourly Analysis	Grid Need Identified	Identified For Hourly Analysis	Grid Need Identified
Scenario 1 (Base)	8	3	46	9
Scenario 2 (High Load)	20	6	84	20
Scenario 3 (Low Load)	8	3	42	7
Scenario 4 (Fast Adoption)	12	5	58	12

For O'ahu, an hourly grid need analysis was performed on 472 transformers and circuits that were identified in the four scenarios for both normal and contingency conditions. Of these, 111 grid needs were identified through the analysis across all four scenarios.

Hawai'i Island

The tables below is a summary of the transformers that were identified for hourly analysis. Through the hourly analysis, the transformers with grid needs were identified.

Table 2-7: Hawai'i Island Hourly Grid Needs Summary – Substation Transformers

Substation Transformer	Normal		Contingency	
	Identified For Hourly Analysis	Grid Need Identified	Identified For Hourly Analysis	Grid Need Identified
Scenario 1 (Base)	2	0	2	0
Scenario 2 (High Load)	2	0	2	0
Scenario 3 (Low Load)	2	0	2	0
Scenario 4 (Fast Adoption)	2	0	2	1

The table below is a summary of the circuits that were identified for hourly analysis. Through the hourly analysis, the circuits with grid needs were identified.

Table 2-8: Hawai'i Island Hourly Grid Needs Summary – Circuits

Circuits	Normal		Contingency	
	Identified For Hourly Analysis	Grid Need Identified	Identified For Hourly Analysis	Grid Need Identified
Scenario 1 (Base)	0	0	5	3
Scenario 2 (High Load)	0	0	5	3
Scenario 3 (Low Load)	0	0	5	3
Scenario 4 (Fast Adoption)	0	0	5	3

For Hawai'i Island, an hourly grid need analysis was performed on 36 transformers and circuits that were identified in the four scenarios for both normal and contingency conditions. Of these, 13 grid needs were identified through the analysis.

Maui Island

The tables below is a summary of the transformers that were identified for hourly analysis. Through the hourly analysis, the transformers with grid needs were identified.

Table 2-9: Maui Island Hourly Grid Needs Summary – Substation Transformers

Substation Transformer	Normal		Contingency	
	Identified For Hourly Analysis	Grid Need Identified	Identified For Hourly Analysis	Grid Need Identified
Scenario 1 (Base)	0	0	1	0
Scenario 2 (High Load)	0	0	1	0
Scenario 3 (Low Load)	0	0	1	0
Scenario 4 (Fast Adoption)	0	0	1	0

The table below is a summary of the circuits that were identified for hourly analysis. Through the hourly analysis, the circuits with grid needs were identified.

Table 2-10: Maui Island Hourly Grid Needs Summary – Circuits

Circuits	Normal		Contingency	
	Identified For Hourly Analysis	Grid Need Identified	Identified For Hourly Analysis	Grid Need Identified
Scenario 1 (Base)	0	0	1	1
Scenario 2 (High Load)	0	0	1	1
Scenario 3 (Low Load)	0	0	1	1
Scenario 4 (Fast Adoption)	0	0	1	1

For Maui Island, an hourly grid need analysis was performed on 8 transformers and circuits that were identified in the four scenarios for both normal and contingency conditions. Of these, 4 grid need was identified through the analysis.

Lānaʻi

No substation transformers or circuits were flagged for hourly analysis on Lānaʻi. Therefore, no grid needs are identified.

Molokaʻi

No substation transformers or circuits were flagged for hourly analysis on Molokaʻi. Therefore, no grid needs are identified.

3. Grid Needs

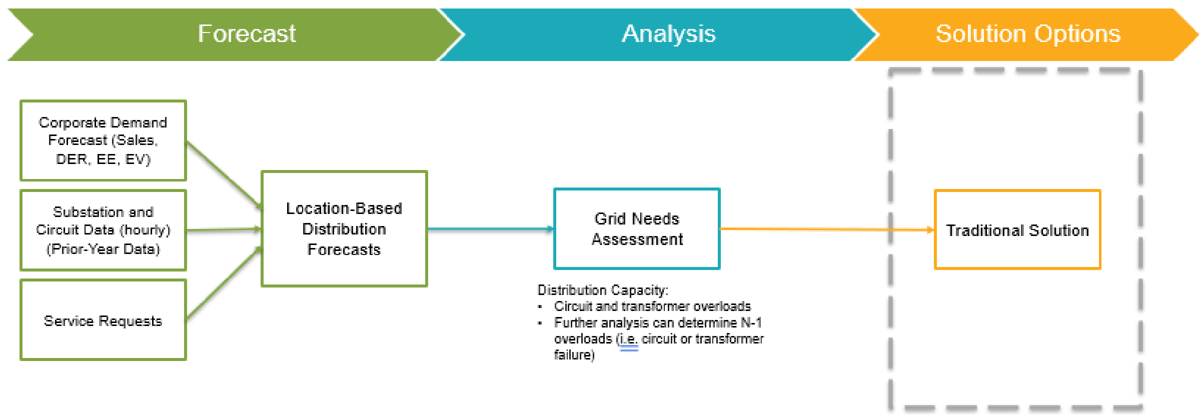

Figure 3-1: Solution Options Stage of the Distribution Planning Process

This section describes the last step to identify distribution grid needs:

1. Determine the demand forecast (kW) by substation transformer and circuit.
2. Screen substation transformers and circuits for analysis.
3. Perform hourly grid needs analysis.
4. **Identify solution options.**

3.1 Solutions Assessment

Solutions are identified for substation transformers and circuits requiring mitigation resulting from the hourly grid needs analysis. As described in Section 2, solutions are required if the equipment rating or transformer rating is lower than the demand forecast. The year(s) where the forecast is higher than the equipment rating are the year(s) where there is a grid need and mitigation is required.

As described in the *Distribution Planning Methodology*, a traditional solution will be defined for each grid need identified and include:[23]

- **Substation**: Transformer asset identification
- **Circuit**: Feeder asset identification

[23] Hawaiian Electric, *Distribution Planning Methodology*, November 2021 at 20.

- **Distribution Service Required**: Distribution capacity or distribution reliability (back-tie) service
- **Primary Driver of Grid Need**: Defines whether the identified grid need is primarily driven by DER growth, demand growth, other factor(s), or a combination of factors
- **Operating Date**: The date at which traditional infrastructure must be constructed and energized, in advance of the forecasted grid need to maintain safety and reliability
- **Equipment Rating**: Equipment's rated capacity
- **Peak Load**: Peak loading on asset for given year
- **Deficiency**: Deficiency divided by the rating for each of the forecasted years
- **Traditional Solution**: Traditional solution identified for mitigation (Solution Options)
- **NWA Qualified Opportunity**: Defines whether the grid need is a qualified opportunity for further evaluation based on technical requirements and timing of need
- **Cost Estimate**: Estimated cost to provide traditional solution identified

The location-based distribution grid needs assessment tables shown in the following sections are simplified and do not include all the fields defined above as some are not applicable for these grid needs, or the fields are consistent for all islands for all years. The following fields are applicable to all islands and are not replicated in the tables in the subsequent sections:

- Distribution Service Required: Distribution capacity or distribution reliability (back-tie) service
- Primary Driver of Grid Need: Demand growth

A summary of the total number of circuits and transformers requiring grid needs is shown below for each scenario. The number of grid needs is highest in the High Load Scenario followed by the Fast Customer Technology Adoption Scenario. The number of grid needs are lower in the Base and Low Load Scenarios. Some grid needs may be required in two or more scenarios.

Table 3-1: Grid Needs Assessment Summary

Island	Total Substation Transformers	Total Circuits	Total (Tsf and Ckt)	Total Grid Needs			
				Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Fast Adoption)
O'ahu	204	393	597	22	42	19	29
Hawai'i Island	82	148	230	3	3	3	4
Maui Island	62	93	155	1	1	1	1
Lana'i	1	3	4	-	-	-	-
Moloka'i	2	8	10	-	-	-	-
Total (All Islands)	351	645	996	26	46	23	34

3.1.1 Traditional Solution Selection

Once the hourly grid needs analysis is performed and the grid needs are defined in technology-neutral terms, wires solutions that meet the grid needs are identified. This provides a baseline comparison for future evaluation of solution options in the IGP process. The following procedure is used to select the traditional solution that best mitigates the grid need; this is typically the least-cost traditional solution. The solution development process is similar for both normal and contingency conditions.

The following options are assessed and typically progress from evaluating the simpler, lower-cost solution first, then to more complex, highest-cost solutions if necessary:

1. Circuit or transformer load balancing or load shifting
2. Sectionalizing load
3. Circuit reconductoring
4. Installing new infrastructure (i.e. new circuit, transformer, or substation which may include an upgrade or additional unit installed)

The first option to eliminate a circuit or transformer overload is to assess if load balancing is feasible by assessing available capacity on adjacent circuits for load shifting capability. In other words, can a portion of or the entire load (MW/MVA) be transferred to another circuit or transformer using existing sectionalizing devices to eliminate the overload on the circuit or transformer of study. Load balancing is the first option as it's typically a low- or minimal cost solution.

The second option is to sectionalize load in the area if load balancing is not feasible. This is done by installing a switch that transfers the entire load or a portion of the load to another circuit or transformer to eliminate the overload. In some cases, installing one or more switches to create multiple section ties may be required to eliminate the overload.

The third option is to evaluate reconductoring if load balancing and sectionalizing is not feasible. Upgrading cables in the overloaded section is evaluated to determine if the overload is eliminated. If so, the type and length of cable required is selected.

Lastly, if none of the first three options are feasible in eliminating the overload, new infrastructure is evaluated. This may include new circuiting, the installation of a new transformer and/or a new substation. This is typically the costliest solution.

High-level cost estimates for circuit and transformer mitigations based on unit cost information from previous similar projects are provided.

3.1.2 Base Scenario

The grid needs by transformer and circuit identified by island using the Base Scenario are provided in the following tables.

O‘ahu

Table 3-2: O‘ahu Grid Needs and Traditional Solutions Using the Base Scenario – Normal Condition

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
KEWALO T3	KEWALO 7	Capacity	2026	New circuits
KEWALO T3	N/A	Capacity	2027	New substation transformer
WAIPIO 1	N/A	Capacity	2025	New substation transformer
WAIPIO 1	WAIPIO 1	Capacity	2027	New circuit
WAIPIO 1	WAIPIO 2	Capacity	2026	New circuit

Table 3-3: O‘ahu Grid Needs and Traditional Solutions Using the Base Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
CEIP 3	CEIP 46	Reliability	2025	Reconductor
IWILEI T3	IWILEI 9	Capacity, Reliability	2023	New circuits
KAMOKILA 2	N/A	Reliability	2027	Circuit line extension
KAPOLEI 2	KAPOLEI 4	Reliability	2026	Circuit line extension
KEWALO T3	KEWALO 7	Reliability	2027	New circuits
KEWALO T3	N/A	Reliability	2027	New substation transformer
KUILIMA 2	N/A	Reliability	2028	New substation transformer
WAHIAWA 3 (138kV)	N/A	Reliability	2028	New substation transformer and circuit
WAHIAWA 3 (138kV)	WAHIAWA-WAIMANO	Reliability	2026	New substation transformer and circuit
WAIAU A	N/A	Reliability	2024	Split bus
WAIAU B	N/A	Reliability	2024	Split bus
WAIPIO 1	N/A	Reliability	2025	New substation transformer
WAIPIO 1	WAIPIO 1	Reliability	2026	New circuit
WAIPIO 1	WAIPIO 2	Reliability	2026	New circuit
WAIPIO 2	N/A	Reliability	2025	New substation transformer
WAIPIO 2	WAIPIO 3	Reliability	2026	New circuit
WAIPIO 2	WAIPIO 4	Reliability	2026	New circuit

Hawaiʻi Island

There are no grid needs for Hawaiʻi Island in the Base Scenario under normal condition.

Table 3-4: Hawaiʻi Island Grid Needs and Traditional Solutions Using the Base Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HALAULA	HALAULA 2	Reliability (back-tie)	2023	New switch and recircuiting
HONOMU	HONOMU 1	Reliability (back-tie)	2023	Voltage conversion and tie
OOKALA	OOKALA 11	Reliability (back-tie)	2023	Voltage conversion and tie

Maui Island

There are no grid needs for Maui in the Base Scenario under normal condition.

Table 3-5: Maui Island Grid Needs and Traditional Solutions Using the Base Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HUELO	Huelo 74A/Huelo	Reliability (back-tie)	2023	Upgrade substation transformer

Lanaʻi

There are no grid needs for Lānaʻi in the Base Scenario.

Molokaʻi

There are no grid needs for Molokaʻi in the Base Scenario.

3.1.3 High Load Customer Technology Adoption Bookend Scenario

The grid needs by transformer and circuit identified by island using the High Load Customer Technology Adoption Bookend Scenario are provided in the following tables.

O'ahu

Table 3-6: O'ahu Grid Needs and Traditional Solutions Using the High Load Scenario – Normal Condition

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
CEIP 3	CEIP 46	Capacity	2025	Reconductor
KAMOKILA 2	N/A	Capacity	2029	Circuit line extension
KEWALO T3	KEWALO 7	Capacity	2026	New circuits
KEWALO T3	N/A	Capacity	2027	New substation transformer
PUUNUI 2	HEIGHTS	Capacity	2029	Reconductor, voltage regulator, and fuse resizing
WAIAU A	WAIAU-MILILANI	Capacity	2028	New substation transformer and circuit
WAIPIO 1	N/A	Capacity,	2025	New substation transformer
WAIPIO 1	WAIPIO 1	Capacity,	2027	New circuit
WAIPIO 1	WAIPIO 2	Capacity,	2026	New circuit

Table 3-7: O'ahu Grid Needs and Traditional Solutions Using the High Load Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
CEIP 2	CEIP 3	Reliability	2028	Circuit line extension
CEIP 3	CEIP 46	Reliability	2023	Reconductor
EWA NUI 1	EWA NUI 1	Reliability	2029	Circuit line extension
EWA NUI 2	EWA NUI 2	Reliability	2025	New substation transformer and circuit
FORT WEAVER 1	FORT WEAVER 2	Reliability	2028	New circuit
FORT WEAVER 1	N/A	Reliability	2028	New substation transformer
HAUULA	HAUULA	Reliability	2028	Reconductor
HOAEAE 1	HOAEAE 1	Reliability	2029	New switch
IWILEI T3	IWILEI 9	Reliability	2023	New circuits
KAHUKU	KAHUKU	Reliability	2028	Reconductor
KAMOKILA 2	KAMOKILA 4	Reliability	2030	Circuit line extension
KAMOKILA 2	N/A	Reliability	2025	Circuit line extension
KANEOHE 1	HEEIA	Reliability	2029	Transfer load
KAPOLEI 2	KAPOLEI 4	Reliability	2025	New substation transformer and circuit
KAPOLEI 2	N/A	Reliability	2027	Circuit line extension

KEWALO T3	KEWALO 7	Reliability	2027	New circuits
KEWALO T3	N/A	Reliability	2027	New substation transformer
KUILIMA 2	N/A	Reliability	2026	New substation transformer
KUNIA MAKAI 1	N/A	Reliability	2028	New switch and transfer load
MAKAHA 2	N/A	Reliability	2030	New switch
WAHIAWA 3 (138kV)	N/A	Reliability	2028	New substation transformer and circuit
WAHIAWA 3 (138kV)	WAHIAWA-WAIMANO	Reliability	2025	New substation transformer and circuit
WAIALUA 2	KAENA PT	Reliability	2023	Reconductor
WAIAU A	N/A	Reliability	2024	Split bus
WAIAU A	WAIAU-MILILANI	Reliability	2026	New substation transformer and circuit
WAIAU B	N/A	Reliability	2024	Split bus
WAIPIO 1	N/A	Reliability	2024	New substation transformer
WAIPIO 1	WAIPIO 1	Reliability	2026	New circuit
WAIPIO 1	WAIPIO 2	Reliability	2026	New circuit
WAIPIO 2	N/A	Reliability	2024	New substation transformer
WAIPIO 2	WAIPIO 3	Reliability	2026	New circuit
WAIPIO 2	WAIPIO 4	Reliability	2026	New circuit

Hawaiʻi Island

There are no grid needs for Hawaiʻi Island in the High Load Scenario under normal condition.

Table 3-8: Hawaiʻi Island Grid Needs and Traditional Solutions Using the High Load Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HALAULA	HALAULA 2	Reliability (back-tie)	2023	New switch and recircuiting
HONOMU	HONOMU 1	Reliability (back-tie)	2023	Voltage conversion and tie
OOKALA	OOKALA 11	Reliability (back-tie)	2023	Voltage conversion and tie

Maui Island

There are no grid needs for Maui in the High Load Scenario under normal condition.

Table 3-9: Maui Island Grid Needs and Traditional Solutions Using the High Load Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HUELO	Huelo 74A/Huelo	Reliability (back-tie)	2023	Upgrade substation transformer

Lanaʻi

There are no grid needs for Lānaʻi in the High Load Scenario.

Molokaʻi

There are no grid needs for Molokaʻi in the High Load Scenario.

3.1.4 Low Load Customer Technology Adoption Bookend Scenario

The grid needs by transformer and circuit identified by island using the Low Load Customer Technology Adoption Bookend Scenario are provided in the following tables.

Oʻahu

Table 3-10: Oʻahu Grid Needs and Traditional Solutions Using the Low Load Scenario – Normal Condition

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
KEWALO T3	KEWALO 7	Capacity	2026	New circuits
KEWALO T3	N/A	Capacity	2027	New substation transformer
WAHIAWA 3 (138kV)	N/A	Capacity	2028	New substation transformer and circuit
WAIPIO 1	N/A	Capacity	2026	New substation transformer
WAIPIO 1	WAIPIO 1	Capacity	2027	New circuit
WAIPIO 1	WAIPIO 2	Capacity	2027	New circuit

Table 3-11: O'ahu Grid Needs and Traditional Solutions Using the Low Load Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
CEIP 2	CEIP 3	Reliability	2023	Circuit line extension
IWILEI T3	IWILEI 9	Reliability	2023	New circuits
KEWALO T3	KEWALO 7	Reliability	2023	New circuits
KEWALO T3	N/A	Reliability	2023	New substation transformer
KUILIMA 2	N/A	Reliability	2028	New substation transformer
WAIAU A	N/A	Reliability	2023	Split bus
WAIAU B	N/A	Reliability	2027	Split bus
WAIPIO 1	N/A	Reliability	2027	New substation transformer
WAIPIO 1	WAIPIO 1	Reliability	2029	New circuit
WAIPIO 1	WAIPIO 2	Reliability	2024	New circuit
WAIPIO 2	N/A	Reliability	2024	New substation transformer
WAIPIO 2	WAIPIO 3	Reliability	2024	New circuit
WAIPIO 2	WAIPIO 4	Reliability	2026	New circuit

Hawai'i Island

There are no grid needs for Hawai'i Island in the Low Load Scenario under normal condition.

Table 3-12: Hawai'i Island Grid Needs and Traditional Solutions Using the Low Load Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HALAULA	HALAULA 2	Reliability (back-tie)	2023	New switch and recircuiting
HONOMU	HONOMU 1	Reliability (back-tie)	2023	Voltage conversion and tie
OOKALA	OOKALA 11	Reliability (back-tie)	2023	Voltage conversion and tie

Maui Island

There are no grid needs for Maui in the Low Load Scenario under normal condition.

Table 3-13: Maui Grid Needs and Traditional Solutions Using the Low Load Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HUELO	Huelo 74A/Huelo	Reliability (back-tie)	2023	Upgrade substation transformer

Lanaʻi

There are no grid needs for Lānaʻi in the Low Load Scenario.

Molokaʻi

There are no grid needs for Molokaʻi in the Low Load Scenario.

3.1.5 Fast Customer Technology Adoption Scenario

The grid needs by transformer and circuit identified by island using the Fast Customer Technology Adoption Scenario are provided in the following tables.

Oʻahu

Table 3-14: Oʻahu Grid Needs and Traditional Solutions Using the Fast Scenario – Normal Condition

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
CEIP 2	CEIP 3	Capacity	2025	New switch
KEWALO T3	KEWALO 7	Capacity	2026	New circuits
KEWALO T3	N/A	Capacity	2027	New substation transformer
WAHIAWA 3 (138kV)	N/A	Capacity	2026	New substation transformer and circuit
WAIAU A	N/A	Capacity	2030	New substation transformer and circuit
WAIAU A	WAIAU-MILILANI	Capacity	2029	New substation transformer and circuit
WAIPIO 1	N/A	Capacity	2026	New substation transformer
WAIPIO 1	WAIPIO 1	Capacity	2027	New circuit
WAIPIO 1	WAIPIO 2	Capacity	2026	New circuit

Table 3-15: Oʻahu Grid Needs and Traditional Solutions Using the Fast Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
CEIP 2	CEIP 3	Reliability	2027	Circuit line extension
CEIP 3	CEIP 46	Reliability	2027	Reconductor
IWILEI T3	IWILEI 9	Reliability	2027	Reconductor
KAMOKILA 2	N/A	Reliability	2023	New circuits
KAPOLEI 2	KAPOLEI 4	Reliability	2026	Circuit line extension
KEWALO T3	KEWALO 7	Reliability	2026	Circuit line extension
KEWALO T3	N/A	Reliability	2027	New circuits
KUILIMA 2	N/A	Reliability	2027	New substation transformer
WAHIAWA 3 (138kV)	N/A	Reliability	2029	New substation transformer
WAHIAWA 3 (138kV)	WAHIAWA-WAIMANO	Reliability	2029	New substation transformer and circuit
WAIAU A	N/A	Reliability	2026	New substation transformer and circuit
WAIAU A	WAIAU-MILILANI	Reliability	2024	Split bus
WAIAU B	N/A	Reliability	2028	New substation transformer and circuit
WAIPIO 1	N/A	Reliability	2024	Split bus
WAIPIO 1	WAIPIO 1	Reliability	2024	New substation transformer
WAIPIO 1	WAIPIO 2	Reliability	2026	New circuit
WAIPIO 2	N/A	Reliability	2026	New circuit
WAIPIO 2	WAIPIO 3	Reliability	2024	New substation transformer
WAIPIO 2	WAIPIO 4	Reliability	2026	New circuit

Hawaiʻi Island

There are no grid needs identified for Hawaiʻi Island in the Fast Scenario under normal condition.

Table 3-16: Hawaiʻi Island Grid Needs and Traditional Solutions Using the Fast Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HALAULA	HALAULA 2	Reliability (back-tie)	2023	New switch and recircuiting
HONOMU	HONOMU 1	Reliability (back-tie)	2023	Voltage conversion and tie
OOKALA	OOKALA 11	Reliability (back-tie)	2023	Voltage conversion and tie

WAIKOLOA	N/A	Reliability	2030	New circuit and tie

Maui Island

There are no grid needs identified for Maui in the Fast Scenario under normal condition.

Table 3-17: Maui Island Grid Needs and Traditional Solutions Using the Fast Scenario – Contingency Condition (N-1)

Substation Transformer	Circuit	Distribution Service Required	Operating Date	Traditional Solution
HUELO	Huelo 74A/Huelo	Reliability (back-tie)	2023	Upgrade substation transformer

Lanaʻi

There are no grid needs for Lānaʻi in the Fast Scenario.

Molokaʻi

There are no grid needs for Molokaʻi in the Fast Scenario.

3.1.6 Traditional Solutions Summary

The traditional solutions listed above in Sections 3.1.2 through Section 3.1.5 include one solution for each circuit and transformer with a grid need. However, there are situations where a traditional solution is a common solution that could solve multiple grid needs simultaneously.

For example, in Table 3-2 and Table 3-3, a new circuit is identified as a solution for the Waipio 1 circuit under normal condition in year 2027 and for the Waipio 3 circuit under contingency condition in year 2026. Each new circuit has a cost estimate of approximately $2.9M. If a new circuit is installed in the area to mitigate the Waipio 3 contingency overload, which occurs in the earlier year, that new circuit would also solve the overload projected for Waipio 1 circuit.

The list of traditional solutions was reviewed for any situations where mitigation would provide a common solution. This resulted in a shorter list of resulting wires projects (i.e. minimum wires solutions).

Table 3-18: Minimum Grid Needs Solutions Identified

Island	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Fast Adoption)
O'ahu	12	25	10	14
Hawai'i Island	3	3	3	4
Maui	1	1	1	1
Lāna'i	-	-	-	-
Moloka'i	-	-	-	-
Total	16	29	14	19

The total cost of distribution upgrades needed for the minimum wires solutions is summarized below.[24]

Table 3-19: Minimum Grid Needs Solutions Identified – Cost Summary (Wires Solutions)

Island	Scenario 1 (Base)	Scenario 2 (High Load)	Scenario 3 (Low Load)	Scenario 4 (Fast Adoption)
O'ahu	$47,173,000	$67,576,000	$48,201,000	$56,103,000
Hawai'i Island	$2,680,000	$2,680,000	$2,680,000	$3,153,000
Maui	$63,000	$63,000	$63,000	$63,000
Lāna'i	-	-	-	-
Moloka'i	-	-	-	-
Total	$49,916,000	$70,319,000	$50,944,000	$59,319,000

3.1.7 Base Scenario Summary

The minimum wires solutions by island using the Base Scenario are provided in the following tables.

O'ahu

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
CEIP 46 – Circuit Upgrade	CEIP 3	CEIP 46	2025	Reconductor	$3,930,000
Iwilei – New Circuits (25 KV)	IWILEI T3	IWILEI 9	2023	New circuits	$3,960,000
Kamokila 2 – Line Extension	KAMOKILA 2	N/A	2027	Circuit Line Extension	$1,913,740

[24] Cost estimates were prepared in Q4 2022 and will be updated as more detailed engineering design is completed.

Kapolei 4 – Line Extension	KAPOLEI 2	KAPOLEI 4	2026	Circuit Line Extension	$2,091,012
Kewalo – New Transformer and Circuits (25 KV)	KEWALO T3	KEWALO 7	2026	New circuits	$4,865,000
	KEWALO T3	N/A	2027	New substation transformer	$6,404,000
Kuilima – Transformer Upgrade	KUILIMA 2	N/A	2028	Upgrade substation transformer	$3,160,000
Ewa Nui – New Transformer and Circuits	WAHIAWA 3 (138kV)	WAHIAWA-WAIMANO	2026	New substation transformer and circuits	$15,012,000
	WAIAU A	N/A	2024		
Waipio – New Transformer and Circuits	WAIPIO 1	N/A	2025	New substation transformer	$2,880,000
	WAIPIO 1	WAIPIO 1	2027	New circuit	$2,957,000
	WAIPIO 1	WAIPIO 2	2026		
Total					$47,173,000

Hawaiʻi Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Halaula – Recircuiting	HALAULA	HALAULA 2	2023	New switch and recircuiting	$65,000
Honomu – Voltage Conversion	HONOMU	HONOMU 1	2023	Voltage conversion and tie	$999,000
Ookala – Voltage Conversion	OOKALA	OOKALA 11	2023	Voltage conversion and tie	$1,616,000
Total					$2,680,000

Maui Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Huelo – Transformer Upgrade	HUELO	Huelo 74A/Huelo	2023	Upgrade substation transformer	$63,000
Total					$63,000

Lanaʻi

There are no grid needs for Lānaʻi in the Base Scenario.

Molokaʻi

There are no grid needs for Molokaʻi in the Base Scenario.

3.1.8 High Load Customer Technology Adoption Bookend Scenario Summary

The minimum wires solutions by island using the High Load Customer Technology Adoption Bookend Scenario are provided in the following tables.

Oʻahu

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
CEIP 3 – Line Extension	CEIP 2	CEIP 3	2028	Circuit line extension	$5,072,000
CEIP 46 – Circuit Upgrade	CEIP 3	CEIP 46	2023	Reconductor	$3,930,000
Ewa Nui 1 – Line Extension	EWA NUI 1	EWA NUI 1	2029	Circuit line extension	$149,000
Ewa Nui – New Transformer and Circuits	EWA NUI 2	EWA NUI 2	2025	New substation transformer and circuit	$3,634,000
Fort Weaver – New Transformer and Circuits	FORT WEAVER 1	FORT WEAVER 2	2028	New circuit	$1,109,000
	FORT WEAVER 1	N/A	2028	New substation transformer	$3,160,000
Hauula – Circuit Upgrade	HAUULA	HAUULA	2028	Reconductor	$780,000
Hoaeae 1 – Circuit Upgrade	HOAEAE 1	HOAEAE 1	2029	New switch	$25,000
Iwilei - New Circuits (25 KV)	IWILEI T3	IWILEI 9	2023	New circuits	$3,960,000
Kahuku – Circuit Upgrade	KAHUKU	KAHUKU	2028	Reconductor	$187,000
Kamokila 2 – Line Extension	KAMOKILA 2	N/A	2025	Circuit line extension	$2,480,000
Heeia – Load Transfer	KANEOHE 1	HEEIA	2029	Transfer load	$26,000

Kapolei – New Transformer and Circuits	KAPOLEI 2	KAPOLEI 4	2025	New substation transformer and circuit	$3,684,000
Kewalo - New Transformer and Circuits (25 KV)	KEWALO T3	KEWALO 7	2026	New circuits	$4,865,000
	KEWALO T3	N/A	2027	New substation transformer	$6,404,000
Kuilima – New Transformer	KUILIMA 2	N/A	2026	New substation transformer	$2,970,000
Kunia Makai – Circuit Upgrade	KUNIA MAKAI 1	N/A	2028	New switch and transfer load	$26,000
Makaha 2 – Circuit Upgrade	MAKAHA 2	N/A	2030	New switch	$26,000
Heights – Circuit Upgrade	PUUNUI 2	HEIGHTS	2029	Reconductor, voltage regulator, and fuse resizing	$473,000
Ewa Nui – New Transformer and Circuits (46kV)	WAHIAWA 3 (138kV)	WAHIAWA-WAIMANO	2025	New substation transformer and circuit	$15,012,000
Kaena PT – Circuit Upgrade	WAIALUA 2	KAENA PT	2023	Reconductor	$17,000
Waiau – Bus Upgrade	WAIAU A	N/A	2024	Split bus	$965,000
Waipio – New Transformer and Circuits	WAIPIO 1	N/A	2024	New substation transformer	$2,790,000
	WAIPIO 1	WAIPIO 1	2026	New circuit	$2,916,000
	WAIPIO 1	WAIPIO 2	2026	New circuit	$2,916,000
Total					$67,576,000

Hawaiʻi Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Halaula 2 – Circuit Upgrade	HALAULA	HALAULA 2	2023	New switch and recircuiting	$65,000
Honomu 1 – Circuit Upgrade	HONOMU	HONOMU 1	2023	Voltage conversion and tie	$999,000
Ookala 11 – Circuit Upgrade	OOKALA	OOKALA 11	2023	Voltage conversion and tie	$1,616,000

Total	$2,680,000

Maui Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Huelo – Transformer Upgrade	HUELO	Huelo 74A/Huelo	2023	Upgrade substation transformer	$63,000
Total					$63,000

Lanaʻi

There are no grid needs for Lānaʻi in the High Load Scenario.

Molokaʻi

There are no grid needs for Molokaʻi in the High Load Scenario.

3.1.9 Low Load Customer Technology Adoption Bookend Scenario Summary

The minimum wires solutions by island using the Low Load Customer Technology Adoption Bookend Scenario are provided in the following tables.

Oʻahu

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
CEIP 3 – Line Extension	CEIP 2	CEIP 3	2028	Circuit line extension	$5,072,000
Iwilei – New Circuits (25 KV)	IWILEI T3	IWILEI 9	2023	New circuits	$3,960,000
Kewalo – New Transformer and Circuits (25 KV)	KEWALO T3	KEWALO 7	2026	New circuits	$4,865,000
	KEWALO T3	N/A	2027	New substation transformer	$6,404,000
Kuilima – New Transformer	KUILIMA 2	N/A	2029	New substation transformer	$3,260,000
Ewa Nui – New Transformer and Circuits (46kV)	WAHIAWA 3 (138kV)	N/A	2028	New substation transformer and circuit	$15,012,000

Waiau – Bus Upgrade	WAIAU A	N/A	2024	Split bus	$965,000
Waipio – New Transformer and Circuits	WAIPIO 1	N/A	2024	New substation transformer	$2,790,000
	WAIPIO 1	WAIPIO 1	2026	New circuit	$2,916,000
	WAIPIO 1	WAIPIO 2	2027	New circuit	$2,957,000
Total					$48,201,000

Hawai'i Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Halaula 2 – Circuit Upgrade	HALAULA	HALAULA 2	2023	New switch and recircuiting	$65,000
Honomu 1 – Circuit Upgrade	HONOMU	HONOMU 1	2023	Voltage conversion and tie	$999,000
Ookala 11 – Circuit Upgrade	OOKALA	OOKALA 11	2023	Voltage conversion and tie	$1,616,000
Total					$2,680,000

Maui Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Huelo – Transformer Upgrade	HUELO	Huelo 74A/Huelo	2023	Upgrade substation transformer	$63,000
Total					$63,000

Lana'i

There are no grid needs for Lāna'i in the Low Load Scenario.

Moloka'i

There are no grid needs for Moloka'i in the Low Load Scenario.

3.1.10 Fast Customer Technology Adoption Bookend Scenario Summary

The minimum wires solutions by island using the Fast Customer Technology Adoption Bookend Scenario are provided in the following tables.

O'ahu

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Industrial – Line Extension	BARBERS PT TANK FARM 2	INDUSTRIAL	2027	Circuit line extension	$5,072,000
CEIP 3 – Circuit Upgrade	CEIP 2	CEIP 3	2025	New switch	$23,000
CEIP 46 – Circuit Upgrade	CEIP 3	CEIP 46	2027	Reconductor	$3,930,000
Iwilei - New Circuits (25 KV)	IWILEI T3	IWILEI 9	2023	New circuits	$3,960,000
Kamokila 2 – Line Extension	KAMOKILA 2	N/A	2026	Circuit line extension	$1,858,000
Kapolei 4 – Line Extension	KAPOLEI 2	KAPOLEI 4	2026	Circuit line extension	$2,091,000
Kewalo – New Transformer and Circuits (25 KV)	KEWALO T3	KEWALO 7	2026	New circuits	$4,865,000
	KEWALO T3	N/A	2027	New substation transformer	$6,404,000
Kuilima – New Transformer	KUILIMA 2	N/A	2029	New substation transformer	$3,260,000
Ewa Nui – New Transformer and Circuits (46kV)	WAHIAWA 3 (138kV)	N/A	2026	New substation transformer and circuit	$15,012,000
Waiau – Bus Upgrade	WAIAU A	N/A	2024	Split bus	$965,000
Waipio – New Transformer and Circuits	WAIPIO 1	N/A	2024	New substation transformer	$2,790,000
	WAIPIO 1	WAIPIO 1	2026	New circuit	$2,916,000
	WAIPIO 1	WAIPIO 2	2026	New circuit	$2,957,000
Total					$56,103,000

Hawaiʻi Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Halaula 2 – Circuit Upgrade	HALAULA	HALAULA 2	2023	New switch and recircuiting	$65,000
Honomu 1 – Circuit Upgrade	HONOMU	HONOMU 1	2023	Voltage conversion and tie	$999,000
Ookala 11 – Circuit Upgrade	OOKALA	OOKALA 11	2023	Voltage conversion and tie	$1,616,000
Waikoloa – New Circuit	WAIKOLOA	N/A	2030	New circuit and tie	$473,000
Total					$3,153,000

Maui Island

Project	Substation Transformer	Circuit	Operating Date	Traditional Solution	Cost Estimate (Nominal $)
Huelo – Transformer Upgrade	HUELO	Huelo 74A/Huelo	2023	Upgrade substation transformer	$63,000
Total					$63,000

Lanaʻi

There are no grid needs for Lānaʻi in the Fast Scenario.

Molokaʻi

There are no grid needs for Molokaʻi in the Fast Scenario.

3.2 Hourly Grid Needs

For the grid needs identified earlier in Section 3.1.2 through Section 3.1.5, solution requirements are defined in technology-neutral terms (e.g., amounts of energy, time(s) of day, and days of the year). The hourly grid needs summary includes:

- **Substation**: Transformer asset identification

- **Circuit**: Feeder asset identification
- **Capacity**: Amount of power required to mitigate the grid need
- **Energy**: Amount of energy required to mitigate the grid need
- **Delivery Time Frame**: Months/hours when the planning criteria violations occur
- **Duration**: Length of time of the grid need
- **Maximum Number of Calls Per Year**: Maximum number of days in the year requiring mitigation.

A complete list of the hourly grid needs for each circuit and transformer is available in the Distribution Grid Needs Workbook.[25] An example of the data provided in the workbook is explained below.

3.2.1 Hourly Grid Needs Example

Hourly overloads identified in each year are aggregated and the corresponding grid needs are shown in the following tables. The Kewalo 7 circuit has a forecasted capacity (MW) need from year 2026 through 2030. The need ranges from about 2 MW starting in year 2026 and grows to about 17.5 MW in years 2027 through 2030.

Table 3-20: Kewalo 7 Capacity Need (kW)

Circuit	Equipment	Demand Forecast by Circuit (MW)									
	Rating (MVA)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kewalo 7	17.0	0	0	0	0	0	2.039	17.57	17.711	17.682	17.651

The corresponding energy need (MWh) for years when the circuit is overloaded is shown below.

Table 3-21: Kewalo 7 Circuit Energy Need (MWh)

Circuit	Equipment	Demand Forecast by Circuit (MWh)									
	Rating (MVA)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kewalo 7	17.0	0	0	0	0	0	3.3	166.6	168.5	168.1	167.7

The number of hours each year when the circuit is overloaded is shown below.

Table 3-22: Kewalo 7 Circuit Need (Hours)

Circuit	Equipment	Demand Forecast by Circuit (Hours)									
	Rating (MVA)	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kewalo 7	17.0	0	0	0	0	0	5	19	19	19	19

[25] The hourly grid needs are voluminous and therefore not provided in this report in table format. The complete list of distribution grid needs is available on the Company website in an Excel workbook. See Section 5.

The maximum number of calls each year is shown below.

Table 3-23: Kewalo 7 Circuit Maximum Number of Calls Per Year

Circuit	Equipment Rating (MVA)	Maximum Number of Calls Per Year									
		2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Kewalo 7	17.0	0	0	0	0	0	34	365	365	365	365

4. Summary and Next Steps

Using the location-based forecasts for substation transformers and primary distribution circuits, grid needs to serve load growth through year 2030 are identified in this analysis. During this process, 351 substation transformers and 645 circuits were assessed across all five islands and less than 5% have grid needs identified. A summary of the grid needs by scenario are shown below. This list includes

Table 4-1: Grid Needs Summary

Scenario	Description	Total Grid Needs (All Islands)	Total Cost ($)
1	Base	16	$49.9 M
2	High Load Customer Technology Adoption	29	$70.3 M
3	Low Load Customer Technology Adoption	14	$50.9 M
4	Fast Customer Technology Adoption	19	$59.3 M

Consistent with the *Non-Wires Opportunity Evaluation Methodology,* cost estimates are developed for traditional wires solutions identified to solve distribution grid needs. These estimates will be used as an input to evaluate if the grid need may qualify as a favorable NWA opportunity, and if so, be procured as part of the overarching IGP process where a portfolio of solutions will be selected to address the identified grid needs.

5. Workbook Index

The grid needs assessment, hourly grid needs, and revised location-based forecasts for each scenario by island are available on the Company's website in Excel workbooks as the tables are too voluminous to provide in table format herein.[26]

A summary of the workbooks is provided below.

Table 5-1: Location-Based Distribution Grid Needs Workbook Index[27]

No.	Workbook[28]
1	Location-Based Grid Needs (EXCEL)

Table 5-2: November 2021 Forecast Update Workbook Index

Island	No.	Scenario	Workbook[29]
O'ahu	1	Base	Oahu Location-Based Forecasts Scenario 1 (EXCEL)
	2	High Load Customer Technology Adoption Bookend	Oahu Location-Based Forecasts Scenario 2 (EXCEL)
	3	Low Load Customer Technology Adoption Bookend	Oahu Location-Based Forecasts Scenario 3 (EXCEL)
	4	Fast Customer Technology Adoption	Oahu Location-Based Forecasts Scenario 4 (EXCEL)
Hawai'i Island	1	Base	Hawaii Island Location-Based Forecasts Scenario 1 (EXCEL)
	2	High Load Customer Technology Adoption Bookend	Hawaii Island Location-Based Forecasts Scenario 2 (EXCEL)

[26] *See* https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning/stakeholder-and-community-engagement/key-stakeholder-documents

[27] Includes grid needs assessment and hourly grid needs.

[28] File name as it appears on the Company website.

[29] File name as it appears on the Company website.

	3	Low Load Customer Technology Adoption Bookend	Hawaii Island Location-Based Forecasts Scenario 3 (EXCEL)
	4	Fast Customer Technology Adoption	Hawaii Island Location-Based Forecasts Scenario 4 (EXCEL)
Maui Island	1	Base	Maui Location-Based Forecasts Scenario 1 (EXCEL)
	2	High Load Customer Technology Adoption Bookend	Maui Location-Based Forecasts Scenario 2 (EXCEL)
	3	Low Load Customer Technology Adoption Bookend	Maui Location-Based Forecasts Scenario 3 (EXCEL)
	4	Fast Customer Technology Adoption	Maui Location-Based Forecasts Scenario 4 (EXCEL)
Lānaʻi	1	Base	Lanai Location-Based Forecasts Scenario 1 (EXCEL)
	2	High Load Customer Technology Adoption Bookend	Lanai Location-Based Forecasts Scenario 2 (EXCEL)
	3	Low Load Customer Technology Adoption Bookend	Lanai Location-Based Forecasts Scenario 3 (EXCEL)
	4	Fast Customer Technology Adoption	Lanai Location-Based Forecasts Scenario 4 (EXCEL)
Molokaʻi	1	Base	Molokai Location-Based Forecasts Scenario 1 (EXCEL)
	2	High Load Customer Technology Adoption Bookend	Molokai Location-Based Forecasts Scenario 2 (EXCEL)
	3	Low Load Customer Technology Adoption Bookend	Molokai Location-Based Forecasts Scenario 3 (EXCEL)
	4	Fast Customer Technology Adoption	Molokai Location-Based Forecasts Scenario 4 (EXCEL)

Appendix F:
NWA Opportunity Evaluation Methodology

Appendix F:
NWA Opportunity Evaluation Methodology

Hawaiian Electric

Non-Wires Opportunity Evaluation Methodology

March 2023 Update

Contents

1. Introduction

As it strives to provide 100 percent renewable energy by 2045, Hawaiian Electric (Company) faces a comprehensive transformation of our five electric power grids. Attaining our state's renewable energy goals represents uncharted territory for both short-term and long-term resource planning. Performing the analyses necessary to attain this goal is a complicated resource planning process, requiring new tools and new processes. This report defines and explains the methodology involved in evaluating grid needs as possible non-wires alternatives opportunities. This process is essential to support the transformation to a clean energy future that leverages the continuous advancement in power technology.

The Company believes customers should have opportunities to deliver energy and other services to the electrical distribution system (commonly referred to as the distribution grid). In addition, the Company believes it should enable significant numbers of diverse providers to participate, and should facilitate competition to the benefit of all customers. By using a broad definition of distributed energy resources (DER), which include a variety of asset types, the Company is providing an increasing number of customers with the opportunity to participate in the DER marketplace. Expanding opportunities for DER services is essential to meeting renewable energy needs without sacrificing the reliable delivery of electricity, which customers deem a top priority.

This strategy is consistent with the Commission's direction to fully and fairly consider non-transmission alternatives (NTA) and non-distribution alternatives (NDA), otherwise known as non-wires alternatives (NWA), when evaluating transmission and distribution (T&D) system upgrades.[1] The Commission also indicated that it will scrutinize whether NWA "solutions, regardless of ownership, are evaluated as part of any economic justification for new utility distribution system investment projects in the same fashion as it currently evaluates NTAs with respect to new transmission projects."[2]

In 2019, the Commission reiterated its expectation that the distribution planning process "must transition and evolve accordingly, such that the locational benefits of customer-sited distributed energy resources are included and evaluated on a comparable basis as utility-sited NDAs as part of any economic justification for distribution system upgrades.[3] The Commission further directed the Company to "strive to make their non-wires alternatives analysis more transparent and thorough."[4]

[1] HPUC Docket No. 2018-0055, Decision and Order No. 36288 Ka'aahi Substation, filed May 3, 2019, at 22.

[2] HPUC Docket No. 2015-0070, Decision and Order No. 33584, filed March 11, 2016, at 46.

[3] HPUC Docket No. 2018-0055, Decision and Order No. 36288 Ka'aahi Substation, filed May 3, 2019, at 22.

[4] HPUC Order No. 36725 Docket No. 2018-0165, Proceeding To Investigate Integrated Grid Planning, filed November 4, 2019, at 9.

Additionally, the Company is expanding options for broad DER participation necessary to grow a viable market, and for customers to directly benefit from competition. The Company's strategy is to offer a range of proven and innovative options to expand access for all customers—not just for a few.

This approach recognizes that the market for NWAs is nascent but represents a tangible opportunity for reducing customer costs and enabling a lower-carbon electricity grid.[5] As such, procurements may not fully enable a range of DER-based solutions. The Company's approach to NWAs specifically includes consideration of pricing through customer rates and programs in addition to procurement opportunities. This will enable customers to better manage their electricity use and provide grid services. As a result, the Company believes that customers, DER developers, and aggregators will have the potential to fully realize the value of DER for Hawaiʻi.

The Company has engaged, and will continue to engage, with customers and stakeholders to seek input and feedback on the Integrated Grid Planning (IGP) development and subsequent planning and sourcing. As part of the IGP development effort, the Distribution Planning Working Group (DPWG) is to inform and educate stakeholders on various aspects of distribution planning at the Company, and to afford stakeholders opportunities to collaborate on and co-develop the Company's methodologies to identify distribution grid needs as well as a framework to evaluate NWA opportunities. As described in the *Distribution Planning Methodology* report, grid needs will be identified through the distribution planning process and then evaluated for NWA opportunity suitability as discussed in this *Non-Wires Opportunity Evaluation Methodology* report.

The DPWG deliverables, as described in the IGP Workplan accepted by the Commission,[6] include identifying NWA opportunities and the related information requirements to effectively and efficiently procure and evaluate potential solutions. However, the need for an NWA opportunity evaluation methodology was not identified in the original IGP Workplan.[7] The Company and stakeholders subsequently recognized the need to incorporate a screening process, based on the leading industry practices and practical considerations, into the IGP and annual distribution planning cycles. This *Non-Wires Opportunity Evaluation Methodology* report addresses this additional scope and deliverable discussed by the DPWG.

Specifically, this *Non-Wires Opportunity Evaluation Methodology* report discusses the Company's industry survey and stakeholder feedback on best practices for NWA opportunity evaluation and sourcing, defines NWAs and grid services, presents the Company's NWA opportunity evaluation methodology, and provides case examples that the Company and stakeholders used to jointly validate the proposed NWA opportunity evaluation methodology. Two of the case examples were used in the Company's IGP Soft Launch, which was conducted to demonstrate the distribution planning process

[5] M. Dyson, J. Prince, et al., "The Non-Wires Solutions Implementation Playbook," Rocky Mountain Institute, 2018.

[6] HPUC Order No. 36218, Accepting the IGP Workplan and Providing Guidance, Docket No. 2018-0165.

[7] HECO, IGP Workplan, December 2018 filed December 14, 2018 in HPUC Docket No. 2018-0165 https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/dkt_20180165_20181214_igp_workplan.pdf.

from circuit-level load forecasting to solution evaluation to defer an actual capital investment to solve a grid need. The two examples used in the soft launch were the Ho`opili and East Kapolei cases, later described in Section 5.3. Through that effort, the Company gained invaluable experience that will help improve the full-scale IGP planning and sourcing effort. This report reflects a key milestone in the Company's efforts to comply with the Commission's guidance regarding systematic and transparent consideration of NWAs, leveraging industry best practices, and stakeholder engagement.[8]

March 2023 update. This Non-Wires Opportunity Evaluation Methodology is being submitted with the IGP Grid Needs Assessment and Solution Evaluation Methodology (Dkt. No. 2018-0165, dated March 31, 2023) and supersedes previously filed versions. This update incorporates the Company's learnings from recent NWA activities, as well as discussions with the IGP TAP. Notable updates include 1) additional definition to the NWA sourcing evaluation (Section 1.4.2) to classify whether potential solutions are considered favorable, moderate, or unfavorable across the various dimensions, and 2) additional case examples of experiences with the NWA process (Section 1.5).

1.1 Industry Survey

In 2019, the Company engaged the Pacific Energy Institute to conduct an industry survey[9] of best practices for NWA opportunity evaluation and sourcing in seven states (including California, Connecticut, Hawaii, Maine, New Hampshire, New York, and Rhode Island) as well as to review documents prepared by several organizations, including Rocky Mountain Institute (RMI),[10] Northeast Energy Efficiency Partnerships,[11] Smart Electric Power Alliance (SEPA),[12] and ICF.[13] Additionally, an NWA workshop was held on March 26, 2019,[14] where the Company sought to learn from experienced practitioners (that is, utility and DER solution providers). The industry survey findings are summarized in Section 2.1.

The Company also held 10 stakeholder working group meetings in 2019 where stakeholders discussed NWA services definitions, distribution grid needs identification, NWA opportunity evaluation, and information requirements. Stakeholder feedback is summarized in Section 2.2.

[8] HPUC Order No. 33584, Maui Elec. Co., Ltd., Docket No. 2015-0070, filed March 11, 2016, at 45-46, and HPUC Order No. 36288, Ka'aahi Substation application, Docket No. 2018-0055, at 22-25.

[9] P. De Martini and A. De Martini, NWA Opportunity Evaluation Survey of Current Practice, Pacific Energy Institute, March 2020.

[10] M. Dyson, J. Prince, et al., "The Non-Wires Solutions Implementation Playbook," Rocky Mountain Institute, 2018..

[11] Northeast Energy Efficiency Partnerships, State Leadership Driving Non-Wires Alternatives Projects and Policy, 2017.

[12] SEPA, PLMA and E4The Future, Non-Wires Alternatives: Case Studies From Leading U.S. Projects, November 2018.

[13] ICF presentation in Michigan PSC workshop, June 2019 https://www.michigan.gov/documents/mpsc/062719_PDF_Presentations_660616_7.pdf.

[14] IGP Soft Launch WG Meeting speaker presentations: https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/soft_launch/20190326_igp_soft_launch_wg_meeting_presentation_materials.pdf.

1.1.1 Industry Survey Findings

Based on the industry survey and observations of industry analysts, the use of NWAs for distribution grid needs is at an early stage. The industry is still learning and refining approaches to improve on the early mixed success to-date.[15] However, commonalities are emerging from these early states' and utilities' lessons learned that provide valuable insights for Hawai'i's success.

The Company has considered the following key findings from this survey in the development of its NWA opportunity evaluation process:

The NWA opportunity evaluation should be integrated into standard, open, and transparent utility planning processes to encourage the effective engagement of market participants to best meet regulatory and utility-level objectives.[16]

Traditional (T&D) planning processes can better support NWA solutions if screening criteria are used to determine when alternatives should be considered for a given need.

Information should be shared with stakeholders regarding an NWA opportunity, including engineering analysis, performance requirements, and other data needed to assess the opportunity.

Evaluation of opportunities is done on a technology agnostic, comparable basis as part of the economic justification for distribution system upgrades.[17]

Evaluation processes focus on identifying high-confidence recommendations for DER solicitations that are likely to result in successful, cost-effective investment deferrals.[18]

NWA opportunities to date have initially addressed grid needs for capacity increases.

Reliability, voltage/reactive power, and resilience have been identified for future consideration.

The type of T&D need, time frame for in-service date, and reference T&D project cost are common criteria used by all states surveyed to evaluate NWA opportunities.

Not all T&D capital projects are suited for an NWA opportunity. T&D capital projects involving break-fix, outage replacements, aging infrastructure replacement, infrastructure relocation, or customer service connections should be excluded.

Procurements may not be best suited for all NWA opportunities (for example, smaller value projects and/or reaching certain customer classes), instead other programmatic options may be considered, such as:

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[15] Reported California initial NWA procurement results and ICF 2019.

[16] M. Dyson, J. Prince, et al., "The Non-Wires Solutions Implementation Playbook," Rocky Mountain Institute, 2018and SEPA, PLMA and E4The Future, 2018.

[17] HPUC Order No. 36725 Docket No. 2018-0165, Proceeding To Investigate Integrated Grid Planning.

[18] CPUC Decision on the Distribution Investment and Deferral Process (D.18-02-004).

Targeted energy efficiency (EE)/demand-side management programs are employed.

DER services tariffs are under discussion in a few states.

States and utilities should first consider no-cost (capital) operational options (for example, circuit reconfiguration and phase balancing) as well as low-cost grid technology alternatives (for example, sensing and analytics, and power flow controllers) as an alternative to traditional capital projects.

Additionally, the survey identified several themes regarding the evaluation criteria. As noted above, the type of T&D need, timing for in-service date, and reference T&D project cost are common criteria. The type of grid needs and the related performance requirements are considered. The timing for in-service includes consideration of the procurement/program development process, regulatory approval, and implementation timelines. Project cost is based on the capital cost of the traditional wires project.

However, the application of these criteria differs among states and utilities. The states in the Northeast have clearly defined the types of T&D projects that are suitable for NWA opportunities and have defined minimum thresholds for timing and project cost. These minimums have been developed through stakeholder discussions and consideration of the timing in that state. An example is provided in Figure 1.

Figure 1: National Grid's New York NWA Opportunity Evaluation Criteria

Criteria	Potential Elements Addressed	
Project Type Suitability	Project types include Load Relief and Reliability. Other types have minimal suitability and will be reviewed as suitability changes due to State policy or technological changes.	
Timeline Suitability	Large Project	36-60 months
	Small Project	18-24 months
Cost Suitability	Large Project	Greater than or equal to $1M
	Small Project	Greater than or equal to $500K

Source: National Grid 2017

Like New York, as shown in Figure 1, California also employs these three criteria and adds two: forecast uncertainty of timing and scope, and market assessment. California's evaluation is focused on whether an NWA procurement should be pursued and uses a tiered prioritization approach to identify the ripest opportunities (Tier 1), opportunities that may be less certain (Tier 2), and opportunities that are not suitable for NWAs (Tier 3). This is illustrated in the Southern California Edison (SCE) example in Figure 2. As seen in other states, California utilities each have their own version of the criteria and a slightly different prioritization tier structure.

Figure 2: SCE NWA Opportunity Prioritization

Tier	Project	Cost Effective	Forecast Certainty	Market Assessment
1	Nogales 66/12 (D)			
	Lockheed 66/16 (D)			
	Sun City 115/12			
	Mira Loma 66/12 (D)			
2	Newhall 66/16 (D)			
	Crater 66/16 (D)			
	MacArthur 66/12 (D)			
	Mariposa 66/12 (D)			
	Moorpark 'A' 220/66 (S)			
	Saugus 'C' 220/66 (S)			
	Elizabeth Lake 66/16 (D)			
	Elizabeth Lake 66/16 (D)			
3	Vera 66/12 (D)			
	Hathaway 66/12			
	Rector 220/66 (S)			
	Springville 220/66 (S)			
	Garnet 115/33 (D)			
	Lindsay 66/12 (D)			
	Live Oak 66/12 (D)			
	Mira Loma 220/66 (S)			

The California NWA evaluation methodology offers useful additional criteria to evaluate opportunities as compared to the states in the Northeast. However, the California methodology is overly complex in its attempt to quantify the metrics. In practice, California's prioritization is effectively based on a smaller set of factors similar to the northeastern states.[19] That is, the T&D grid need requirements (including timing), related grid service, and project-related avoided cost were used to determine whether a procurement makes sense. The California process is also singularly focused on evaluating procurement opportunities, so it does not consider alternative sourcing options, such as programs.

The Company does think the use of the California metrics for forecast certainty and market assessment are useful in the context of considering alternative NWA sourcing options involving programs and pricing, or reconsideration of procurement at a later date.

Based on the insights drawn from the industry survey and practitioners, simplicity and flexibility appear to be important considerations in developing NWA opportunity evaluation criteria. Simplicity is important in terms of the ability to implement a fair and repeatable process, and to provide clarity to the market. Flexibility is important in terms of allowing opportunities to pursue viable NWAs through sourcing means other than all-or-nothing procurements. For example, consideration should be given to the role that programmatic options may provide for opportunities that might otherwise not make sense economically for a procurement. The Company has incorporated these findings into its approach.

[19] Cite to PG&E and SCE 2019 Distribution Deferral Opportunity Reports.

1.1.2 Stakeholder Feedback

As mentioned at the beginning of Section 2, the Company held 10 stakeholder working group meetings in 2019 where stakeholders discussed NWA services definitions, distribution grid needs identification, NWA opportunity evaluation, and information requirements. These discussions included the findings from the industry survey and NWA workshop, discussed in Section 2.1. This stakeholder engagement also included using specific grid needs in Hoʻopili and East Kapolei as case examples to shape the IGP Soft Launch.

Importantly, these discussions considered the development of the IGP methodology to identify and assess NWA opportunities as a key step in the handoff from grid needs to NWA sourcing (for example, procurements and programs). Stakeholders' input and feedback is reflected in the NWA opportunity evaluation process and criteria. The stakeholder feedback received in the DPWG and Soft Launch working group meetings is summarized in the following sections.[20]

The Company also presented the NWA Methodology along with more detailed evaluation threshold criteria and additional sample evaluations to the Technical Advisory Panel (TAP) on November 16, 2022 and received generally positive feedback.

1.1.2.1 Overall Process

Stakeholders shared that the NWA opportunity evaluation process needs to be transparent and less restrictive with respect to screening criteria at this initial stage in Hawaiʻi to open up the potential market for procurements. Stakeholders also shared that a technology agnostic approach to assessing opportunities is needed and that it is important to not prejudge what the market may provide.

Stakeholders support consideration of other sourcing mechanisms beyond procurement (programs, tariffs) and flexibility in sourcing to achieve the most cost-effective outcome. This includes the potential to participate in multiple non-conflicting grid services opportunities. Additionally, the IGP process should continue to reassess projects in subsequent planning cycles that are initially assessed as uncertain because of the constant changing nature of the distribution system. The T&D grid needs and NWA opportunity evaluations and supporting analysis should be shared publicly as part of the IGP process.

1.1.2.2 Defining Grid Needs

The output of the distribution planning process is a set of grid needs. Stakeholders should have sufficient information on these needs to consider potential solutions and understand the application of the evaluation criteria. This includes technical performance requirements, including quantity (MW, MWh), dispatch frequency and time (month/day/hour), duration, and in-service date. The supporting engineering analysis, and a description and technical details of the wires solution are also desired (for

[20] Drawn from DPWG minutes: https://www.hawaiianelectric.com/clean-energy-hawaii/integrated-grid-planning/stakeholder-engagement/working-groups/distribution-planning-and-grid-services-documents

example, information on type of infrastructure location, timing, and avoided cost). Stakeholders suggested simplifying the requirements to the extent possible to allow for more potential NWA solutions.

1.1.2.3 Opportunity Criteria

Stakeholders appreciate the simplicity of the three-criteria approach used by the states in the Northeast but also like aspects of the California prioritization model. Stakeholders suggested using clearly defined metrics for minimum timing for in-service date and project economics criteria for procurements, as follows:

- Timing: in-service date – minimum of 2 years to provide enough time to run a procurement and regulatory process, and install NWAs
- Project economics: minimum of $1 million capital project cost threshold for NWA procurements

Stakeholders also suggested consideration of greenhouse gas emissions reductions and other societal criteria (for example, community impact) in prioritizing NWA opportunities. The question of whether to consider greenhouse gas emissions was not resolved in the working group discussion, but stakeholders recognized that greenhouse gas benefits are important, but not necessary, for NWA opportunity sourcing evaluation. Stakeholders suggested that NWA societal value considerations may be better suited to evaluating the specific proposed NWA solutions resulting from procurements/programs as is done in New York. The recommendation is for this issue to be taken up in the Solution Evaluation and Optimization Working Group.

1.1.2.4 Sourcing Options

Stakeholders noted that across the industry, NWAs have largely not been successful thus far. Stakeholders recognize that procurements are one type of NWA sourcing mechanism and that programs and pricing options should be considered as well. A programmatic approach that looks to fulfill more global power system needs was suggested. Programs also may be easier for customers to understand. Stakeholders agree that an NWA program, as with procurements, must be cost-effective for all customers.

During the Soft Launch discussion regarding Hoʻopili, stakeholders recognized the NWA procurement challenge for new real estate developments: that NWA solutions may need to be sited and ready to go at the same time the house is built. Stakeholders suggested that a programmatic approach (including EE and other DER) through the collaboration of the real estate developer and the Company may be the best option.

Additionally, stakeholders seek to maximize the potential participation opportunities for NWAs and grid services in the aggregate. For example, a stakeholder shared that a $50,000 per year NWA opportunity may not be worth a procurement or program, but it may have potential after being aggregated with other potential grid services opportunities.

1.2 T&D Non-Wires Alternatives

The definitions of NWA and grid services presented in this section, including the specific wording for each of the terms, are derived from the industry research and stakeholder input and feedback discussed in Section 2.

1.2.1 NWA Definition

NWAs generally are non-traditional solutions that may defer, delay, or avoid traditional T&D investments (for example, a new substation or feeder). Non-traditional solutions can include a single solution or a combination of solutions at the grid-scale or distribution level, such as solar photovoltaic (PV), other renewable generation, energy storage, EE, and demand response (including price responsive demand). The following NWA definition was developed in concert with the DPWG:

> *An electricity grid project that uses non-traditional transmission and distribution (T&D) solutions, such as distributed generation (DG), energy storage, energy efficiency (EE), demand response (DR), and grid software and controls, to defer or avoid the need for conventional transmission and/or distribution infrastructure investments.*

This definition adapts several aspects developed by Navigant,[21] the US Department of Energy,[22] and others.[23]

1.2.2 NWA Grid Services

A wide range of grid services are needed as Hawaiʻi decarbonizes the electricity sector with ultimately more than half its resources at the edge of the system. Already, DERs have the opportunity to provide bulk system ancillary services, including frequency response, replacement reserves, and regulation on a technology agnostic basis.[24] Additionally, in support of the IGP planning cycle and Commission direction,[25] the Company has identified and defined initial T&D NWA services in technology agnostic terms, building on the work developed for the Demand Response portfolio in Docket No. 2015-0412. An example of where the Company will apply the NWA evaluation process are the projects identified though the distribution planning process, as described in the *Distribution Planning Methodology* report. Using the outline detailed in this report, these projects are candidates to be evaluated for NWA opportunity.

Specifically, these initial NWA services are focused on those with the greatest potential value involving T&D capital deferral services (for example, distribution capacity deferral and reliability services). Capital

[21] B. Feldman, Non-Wires Alternatives: What's up next in utility business model evolution, UtilityDive, July 12, 2017.

[22] Electricity Advisory Committee, Recommendations on Non-Wires Solutions, US Department of Energy, October 17, 2012.

[23] SEPA, PLMA & E4TheFuture, "*Non-wires Alternatives: Case Studies from Leading US Projects*", 2018.

[24] See Docket No. 2015-0412, Decision and Order No. 35238, issued on January 25, 2018.

[25] HPUC Order No. 33584, Maui Elec. Co., Ltd., Docket No. 2015-0070, filed March 11, 2016, at 45-46.

deferral is the primary focus of the Federal Energy Regulatory Commission for transmission[26] and the leading states' use for distribution, as found in the industry survey discussed in Section 2.

The service descriptions and definitions in Sections 3.2.1 and 3.2.2 are based on IGP stakeholder input and feedback leveraging references from California's Competitive Solicitation Working Group.[27]

1.2.3 T&D Capacity Deferral

T&D capacity deferral opportunities involve the potential to defer capital investment that may otherwise be needed to address grid needs that are identified through area capacity analysis and/or hosting capacity analysis. This may include deferring substations, new lines/reconductoring, transformers, and other equipment by reducing forecast loading of the infrastructure to within ampacity/load ratings under normal operating conditions. Loading in this context relates to the current and/or power (bi-directional) carrying capability of specific conductor, transformer, and/or other equipment. Therefore, increases in forecast loading may arise from new loads and/or energy injections from distributed resources (that is, reverse power flow).

The following definition of T&D capacity service was developed with the DPWG to describe these types of opportunities:

> *A supply and/or a load modifying service that DERs provide as required via reduction or increase of power or load that is capable of reliably and consistently reducing net loading[28] on desired transmission and/or distribution infrastructure. T&D capacity service can be provided by a single DER and/or an aggregated set of DERs that reduce the net loading on a specific distribution infrastructure location coincident with the identified operational need in response to a control signal from the utility.*

This definition combines both NTAs and NDAs into a single service in recognition of the potential to yield optimized benefits across T&D opportunities from NWA solutions.

1.2.4 Distribution Reliability (Back-Tie)

In addition to NWA opportunities under normal grid operating conditions, there are potential opportunities under contingent conditions. Contingent operating conditions involve emergency reconfigurations of the distribution system that result in transferring the load (that is, bi-directional current/power) from one circuit/transformer to another to mitigate an outage. These contingent opportunities arise when combined loading exceeds the emergency ampacity/power rating of the conductor, transformer, and/or other equipment. This is a reliability-oriented service because it enables

[26] E. Watson and K. Colburn, Looking Beyond Transmission, Public Utilities Fortnightly, April 2013.

[27] California Competitive Solicitations Framework Working Group https://drpwg.org/sample-page/ider/.

[28] Net loading refers to the net amount of bi-direction current on specific grid infrastructure.

safe transfer of one circuit/transformer's load to another during an emergency by creating sufficient headroom or reducing the transferring load to within emergency ratings.

The following definition of distribution reliability service was developed in the DPWG:

> *A supply and/or load modifying service capable of improving local distribution reliability under abnormal conditions. Specifically, this service reduces contingent loading of grid infrastructure to enable operational flexibility to safely and reliably reconfigure the distribution system to restore customers.*

This type of distribution service is relatively new in the industry; the Company's procurement for this service in the IGP Soft Launch was one of the first, if not the first. In a future IGP cycle, the Company may evaluate a wider set of T&D NWA services. For example, voltage support and resiliency services may be identified and defined through the process of documenting the T&D needs and services requirements. Resiliency services are currently being discussed in the Resiliency Working Group and through Docket No. 2018-0163, which is intended to produce a Microgrid Services Tariff.

1.3 NWA Opportunity Evaluation Methodology

1.3.1 Overview

The Company has considered the NWA opportunity evaluation approaches and lessons learned from other states as well as stakeholder feedback to develop a holistic methodology. The multi-state lessons and stakeholder feedback support RMI's recommendation that *"traditional planning processes can better support non-wires solutions if screening criteria are used to determine when alternatives should be considered for a given need."*[29]

The Company intends to use such a common NWA opportunity evaluation framework to identify T&D projects that are most likely to be suitable for NWA solutions. This evaluation methodology is intended to provide greater clarity, certainty, and transparency to the market going forward. Such criteria incorporated into the IGP process will also facilitate systematic consideration of NWAs by T&D planners going forward as directed by the Commission. The goals of this NWA opportunity evaluation methodology are as follows:

- Identify all potential candidate T&D projects that may be cost-effectively deferred through the identified and defined DER services.
- Productively engage the market for NWAs by helping DER aggregators and developers efficiently allocate resources to the best opportunities.

[29] M. Dyson, J. Prince, et al., "The Non-Wires Solutions Implementation Playbook", Rocky Mountain Institute, 2018.

Further, Commission guidance and stakeholder feedback outlined the following objectives in the development of an NWA opportunity evaluation framework:

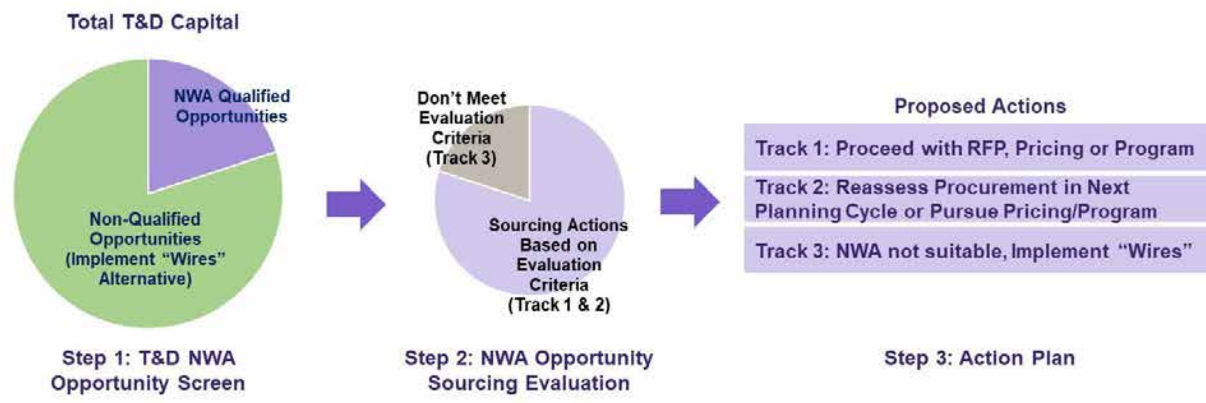
- Adopt/adapt leading practices to develop candidate T&D NWA opportunity evaluation.
- During initial NWA opportunity screens, create over-inclusive, rather than overly restrictive, candidate NWA project shortlists.
- Use a simple initial NWA opportunity screen to identify shortlist candidate opportunities and assess sourcing options (procurement, programs, and pricing).
- Remember that not all NWA opportunities make economic sense to source via competitive procurement. Therefore, price signals through rate design and DER programs will also be considered to achieve the most affordable solutions for customers.

These goals and objectives shaped the development of the NWA opportunity evaluation methodology described in Section 4.2. The Company believes that this opportunity screen and prioritization approach will support development of an NWA market. Recognizing that NWA procurements and use are at a relatively nascent stage of implementation across the industry, the Company expects this evaluation methodology to evolve as the industry collectively gains more NWA experience. This NWA opportunity evaluation methodology is not meant to be an NWA solution evaluation as would be done in a procurement; rather this is an assessment of the potential T&D projects that qualify for an NWA opportunity.

1.3.2 Opportunity Evaluation Methodology

The Company has developed a three-step methodology that incorporates 1) an initial NWA opportunity screen, 2) an NWA opportunity sourcing evaluation and 3) an action plan. The initial opportunity screen is intended to quickly and simply identify "qualified" and "non-qualified" T&D opportunities based on technical requirements. The opportunity sourcing evaluation in the second step further evaluates and prioritizes the "qualified" opportunities in terms of the grid project avoided cost (economics), timing of need, and performance requirements to support a procurement. This three-step approach, shown in Figure 3, is based on leading practices from states in the Northeast and from California as well as stakeholder feedback tailored to Hawaiʻi's needs.

Figure 3: NWA Opportunity Evaluation Methodology



This methodology is designed to identify a wider set of potential NWA opportunities than methodologies in other states. Step 1 does not include a dollar threshold, unlike the states in the Northeast; instead, program or pricing options may be considered viable in the Step 2 evaluation. The incorporation of program and pricing options in the Step 2 sourcing evaluation is for those opportunities considered too financially small for procurement. Step 2 methodology also includes a clearly defined minimum dollar threshold for procurements identified by stakeholders that is similar in approach to that of the states in the Northeast. This is a more transparent method than the overly complex California approach[30,31] that also effectively uses the project capital avoided cost as the primary economic threshold. The resulting T&D action plan in Step 3 is intended to enable a range of potential NWA sourcing options via procurement, programs, and pricing consistent with another RMI recommendation.[32]

1.3.2.1 Step 1: NWA Opportunity Screen

The intent of the NWA opportunity screen is to categorize all T&D capital budget projects by applying a technical screen and to identify those T&D projects that are most suitable for further NWA opportunity evaluation. As discussed with stakeholders and identified by other states, certain T&D projects with the greatest NWA opportunity include the following three grid needs categories:

1. Expanding distribution system capacity to meet load and/or hosting capacity needs (that is, new substation, new feeders, reconductoring)
2. Ensuring a reliability requirement for circuit back-tie upgrade deferral

[30] Pacific Gas & Electric, Request for Approval to Issue Competitive Solicitations for Distributed Energy Resource (DER) Procurement for Electric Distribution Deferral Opportunities. November 15, 2019. CPUC Advice Letter 5688-E.

[31] Southern California Edison, Southern California Edison Company's Request for Approval to Launch the 2020 Distribution Investment Deferral Framework, November 15, 2019 Solicitation. CPUC Advice Letter 4108-E.

[32] M. Dyson, J. Prince, et al., "The Non-Wires Solutions Implementation Playbook", Rocky Mountain Institute, 2018, page 39.

3. Enhancing system resilience[33]

As the Company has identified in the IGP, consistent with best industry practices, these types of T&D needs may be met by new NWA grid services, including T&D capacity deferral service, reliability back-tie service, and resiliency service. The Soft Launch pursued procurement of distribution capacity deferral and reliability back-tie services. The Company's reliability back-tie service is a first for the industry. These three types of T&D needs will form the initial screen.

Conversely, certain T&D projects cannot, or are unlikely to, be deferred or avoided by DER. These "required" projects include those necessary to comply with public works or other customer requests, such as the following:

- Line/pole relocation or undergrounding due to street widening, relocation clauses, or overhead-to-underground conversions
- Emergency and preventative equipment and infrastructure replacement to restore power after outages, avoid outages, avoid catastrophic failures, and ensure public safety
- Replacement of physical apparatus, such as circuit breakers, relays, and transformers, because of asset condition
- Replacement of damaged or failed equipment/poles/conductor
- New customer requests for new physical connection to the electric grid

The Step 1 screen will categorize all T&D opportunities in the Company's capital budget into two groups based on the project type:

- T&D projects with an NWA opportunity involving one or more of the three grid needs categories described earlier in this section.
- T&D projects that address "required" needs outside of the three NWA opportunity categories. This step can be done in conjunction with the Company's annual capital budgeting process to ensure that consistency is applied across the enterprise. Those T&D projects identified as required in this initial screen will be pursued as utility wires solutions in the appropriate regulatory approval procedure (that is, general rate case or a cost recovery mechanism such as a GO7 application).

Focusing on the most viable NWAs by categorizing opportunities by these specific capital project types is employed in every state currently pursuing NWAs.

1.3.2.2 Step 2: NWA Opportunity Sourcing Evaluation

The Company, through the use of NWAs, seeks to expand options for broad participation in support of growing a viable DER market to meet Hawai'i's goals. It is also important for all customers to directly benefit from the use of DER. As such, the Company's approach is to consider a range of competitive market-based procurement, program, and pricing options to expand access for all customers—not just

[33] Reliability scoped to be redundant, such as a second feeder and its associated infrastructure, would be qualified opportunities. However, hardening, or physically strengthening critical infrastructure, would not be considered a qualified opportunity.

for a few. This approach is different than what California and other states consider in their NWA procurement-focused opportunity evaluations.

While the Company's methodology adapts aspects of California's[34] evaluation criteria, it is done here in the context of assessing other sourcing options, such as programs and retail pricing, as well as procurements on the basis of favorable, uncertain, or unfavorable attributes. The implied precision of California's complex quantitative approach, in practice, does not identify more NWA procurement opportunities than the simpler methods employed in other states. Based on the six mainland states surveyed, NWA opportunities for procurement averaged approximately 1 to 2 percent of all T&D capital projects[35] and about 5 to 10 percent of initially screened distribution upgrade projects.[36]

The Company is adapting elements of the California approach as such elements are useful in considering sourcing options other than procurements. Therefore, the intent of this second step is to evaluate candidate T&D NWA opportunities in greater detail to identify those with the highest likelihood of success and related solution sourcing options. This NWA opportunity sourcing evaluation is technology agnostic, consistent with the Company's IGP process.

The following three criteria is used to evaluate NWA opportunities:

- **Timing** of the grid need
- **Performance requirements** in relation to operational performance requirements of the identified T&D grid need
- **Project economics** in terms of the deferral value of a qualified T&D capital project and any other relevant avoided costs to determine sourcing options

The following criteria were considered to evaluate NWA opportunities but is currently not included in the evaluation due to lack of quality market data, and to broaden the NWA opportunities that can move to Step 3. These criteria may be reassessed with further NWA experience and market responses to future RFPs.

- **Forecast certainty** of the forecasted growth driving the grid need
- **Market assessment** based on the potential for successful NWA procurement versus programs or retail pricing options in the immediate local area related to the grid need

Each grid project will be assessed in relative terms within each criterion. The criteria are further explained below.

[34] California PUC Decision on the Distribution Investment and Deferral Process (D.18-02-004).

[35] California utilities' distribution deferral opportunities reports for 2018 and 2019 are consistent with this finding.

[36] P. De Martini and A. De Martini, NWA Opportunity Evaluation Survey of Current Practice, Pacific Energy Institute, March 2020

Timing

Timing of the grid need is an important factor. Sufficient lead time is required to allow for a procurement (including contract negotiations) or program development, regulatory approval, and NWA solution deployment by the in-service date, as required by the forecasted operational date, to meet the grid need. Based on the Company's experience with sourcing other grid services, and consistent with stakeholder feedback and industry practice, a starting point of a 2-year lead time is used.

One lesson learned from the industry survey was that the time needed for NWA procurement contract negotiations and subsequent regulatory approval are key factors in the time required. In addition, depending on the complexity of the contingent wires solution in the event the NWA sourcing does not yield a viable solution, more lead time may be needed. The minimum timing threshold may be adjusted as the Company, the market, and the Commission learn from future NWA opportunities.

Timing criteria are defined as follows:

Favorable:
- 2-5 year lead time

Moderate or Uncertain:
- Greater than 5 year lead time

Unfavorable:
- Less than 2 year lead time

Grid needs with lead times greater than 5 years are considered Moderate or Uncertain and will be reassessed during the next IGP cycle.

Performance Requirements

The performance requirements criterion will be used to determine whether NWA solutions can reasonably meet the performance requirements of the identified grid need (capacity expansion, reliability back-tie, or resiliency). Projects that target critical needs with high operational risks are more likely to require more stringent performance requirements and contract terms for NWA solutions. In general, opportunities with more lenient requirements are more viable for NWAs. For example, if the opportunity has a smaller peak capacity, shorter duration needs, and fewer calls, then the ability to meet the performance requirements will be considered more favorable for an NWA.

Performance criteria are defined as follows:

Favorable:
- Capacity: Up to 5 MW and
- Duration: Up to 4 hours

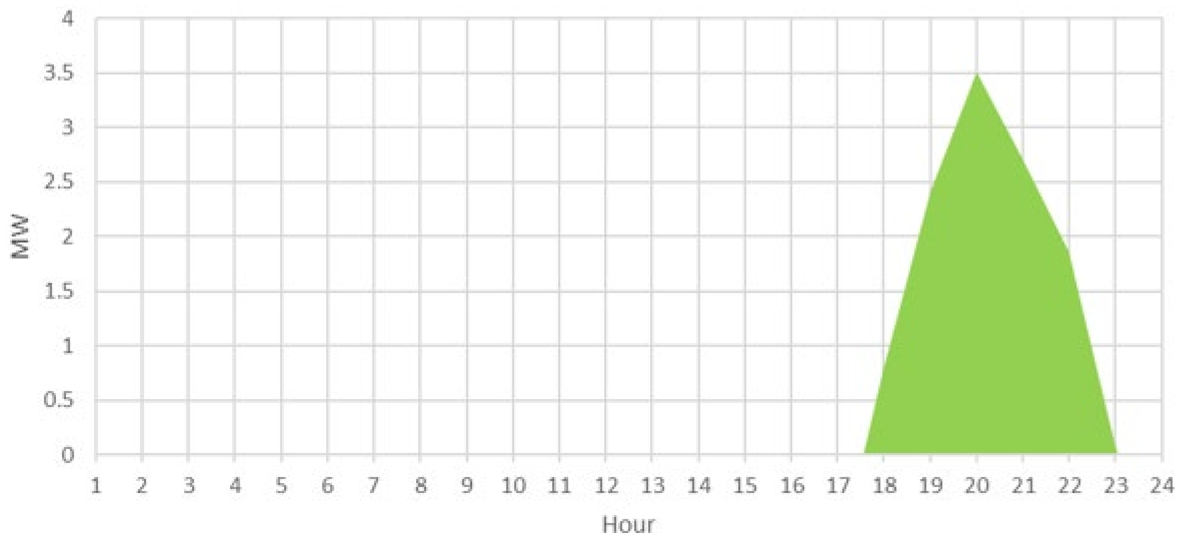
Moderate or Uncertain:
- Capacity: > 5 MW and < 10 MW or
- Duration: > 4 hours and < 8 hours

Unfavorable:

- o Capacity: 10 MW and larger
- o Duration: 8 hours or more

The grid need will be clearly described as illustrated in Figure 4, along with supporting engineering and operational analyses as provided in the Soft Launch[37] and case examples[38] discussed with the DPWG in August and October 2019.

Figure 4: Example Engineering Analysis and Performance Requirements



Equipment	MW Peak	MWH	Delivery Months	Delivery Hours	Duration (Hr)	Max # of Days
Tsf/Circuit	3.5	11.4	Jan - Dec	5PM - 11PM	6	365

These performance requirements are intended to provide as complete a picture as possible of the grid need and operational performance required of solutions to transparently inform stakeholders.

Project Economics

The project economics criterion will be used to evaluate opportunities for procurement, programs, and/or pricing, and to identify opportunities that are unlikely to be cost-effective. The project economics include the deferral value of a qualified T&D capital project and any other relevant avoided costs. Based on stakeholder feedback, projects with an economic value (that is, capital cost) of $1

[37] DPWG Meeting August 8, 2019 "Review of Soft Launch Opportunity" presentation: https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/distribution_planning/20190808_dpwg_meeting_presentation_materials.pdf.

[38] DPWG Meeting October 9, 2019 "Review of T&D NWA Opportunity Identification & Evaluation Process" presentation: https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/distribution_planning/20191009_dpwg_meeting_presentation_materials.pdf.

million or greater will be seen as favorable in this criteria. Projects with an economic value less than $1 million may be considered for targeted DER programs to address specific NWA needs consistent with the Company's Advanced Rate Design Strategy.[39]

Project Economic criteria are defined as follows:

Favorable: $1M and above
Moderate or Uncertain: Between $500K and $1M
Unfavorable: Less than $500K

Forecast Certainty

Forecast certainty criterion is important to avoid investment in grid needs that may be premature or not required if the forecasted load growth does not materialize. However, this forecast certainty criterion is currently not used to evaluate grid needs because the Company has yet to determine the evaluation metrics for this. The Company may consider qualitative factors in the future such as, but not limited to, the following:

- **Favorable:** If the forecasted load growth is driven by actual electric service requests received, which may signal higher certainty of developer plans driving a grid need.
- **Moderate or Uncertain:**
  - If the forecasted load growth is driven by conceptual or high-level master plans, which may signal moderate certainty of developer plans.
  - If the forecasted load growth is driven by spatial allocation of the Company system-wide growth forecast, which may signal moderate certainty of growth in an area.

Market Assessment

The market assessment criterion is used to assess the following two aspects in terms of procurement/program sourcing options:

- Technical potential based on the number of customers available for behind-the-meter solutions and land availability for ahead-of-the-meter solutions
- Supplier and solution diversity to ensure competitiveness and reliability

The opportunity for a DER-based alternative is dependent on sufficient existing or new customers and/or land availability in the appropriate locations associated with the circuits and/or substation(s) to develop an NWA solution sufficient to meet an identified grid need. Also, as procurements are intended to foster competitive solutions, it is beneficial to identify whether sufficient customers and/or land opportunity exists to support competitive proposals from more than one provider. These factors may

[39] Hawaiian Electric Companies, Advanced Rate Design Strategy, September 25, 2019. https://www.hawaiianelectric.com/documents/clean_energy_hawaii/grid_modernization/dkt_2018_0141_20190925_cos_ARDS.pdf

be used to evaluate the potential success of an NWA procurement/program and any mitigation measures that may be needed to realize a successful outcome for customers. For instance, as proposed by stakeholders, an NWA program may provide a better outcome for a new residential development than a procurement.[40]

However, currently the Company lacks quality market data to properly assess this criteria. Therefore this criteria is not used in this evaluation. This criteria may be reassessed based on market response to future RFPs.

1.3.2.3 Step 3: Action Plan

The NWA opportunity sourcing evaluation discussed in Section 4.2.2 results in a T&D action plan that assigns specific T&D projects to one of three action plan tracks. The assigned action plan track will provide the path the Company will use to pursue a solution. Competitive procurement is the primary means of sourcing opportunities $1 million or greater. However, based on stakeholder discussion in the DPWG, the Company sought to expand the potential for NWAs by including the option for programs and pricing for opportunities under $1 million and for those opportunities that do not lend themselves to procurement, such as new real estate developments. As such, this sourcing approach adapts the California model by explicitly incorporating the option for programs and pricing options in Track 2 to expand the potential for NWA solutions for grid needs less than $1 million in economic value.[41] The three tracks are as follows:

- **Track 1:** Procurement of favorable NWA opportunities (that is, greater than $1 million in economic value with in-service need in 2 to 5 years) with performance requirements that can reasonably be met by NWAs.
- **Track 2:** Reassess if factors indicate reevaluating in the future for potential procurement (that is, moderate/uncertain or favorable performance and economic criteria and timing greater than 5 years); or a program or pricing if the economic value is less than $1 million but greater than $500K and potential timing of need is favorable (2 to 5 years) for customer adoption.
- **Track 3:** Non-qualified opportunities that have criteria (for example, performance, timing, or economics) that cannot be reasonably met by NWA solutions. In these instances, the wires solution will be implemented.

The action plan will include a summary list of T&D project opportunities evaluated and the proposed course of action on solutions for each grid need. In addition, the supporting evaluation for each NWA opportunity will be discussed.

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[40] Stakeholder comments on programmatic approach for NWA in DPWG meetings beginning in July 17, 2019 meeting: https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/distribution_planning/20190717_dpwg_meeting_summary_notes.pdf

[41] Note that in the Northeast and California, the utilities employ demand side management programs funded by existing customer public surcharges to mitigate grid needs before pursuing NWA procurements.

Figure 5: T&D NWA Opportunity Evaluation

Track	Timing	Overall Performance	Economics
1	**Favorable**	**Favorable** or **Moderate/Uncertain**	**Favorable**
2 (Pricing)	**Favorable**	**Favorable** or **Moderate/Uncertain**	**Moderate/Uncertain**
2 (Reassess)	**Moderate/Uncertain**	**Favorable** or **Moderate/Uncertain**	
3	One or more are **Unfavorable**		

Figure 5 identifies potential distribution opportunities in one of the three tracks described above, along with a corresponding color code—green (favorable), yellow (uncertain), and red (unfavorable)—to highlight the assessment of each criterion to indicate why the opportunity was placed into the given track.

1.3.2.4 Contingency Plan

The primary goal of action plans Track 1 and Track 2, as mentioned in section 4.2.3, is to pursue successful deferral of the grid project with a NWA. However, for the Company to meet its obligation to provide electric service, there may be a need to develop a contingency plan based on grid investment or another alternative to ensure that the in-service date and lead time to implement those solutions may be met.

During NWA procurement and/or program implementation, solicitation/program development, NWA deployment/customer adoption, or NWA commercial operation, several scenarios may occur that could cause the NWA solution to not viably solve the grid need. For example, if there are no cost-effective NWA bids that meet the distribution need, or if contracts are not approved by the Commission, implementation of the Company's contingency solution will be needed. This contingency solution may include the wires project originally intended for deferral. For this reason, it will be necessary to continue preliminary engineering solution development activity, such as wires project engineering and other related activity. This challenge was discussed with the IGP TAP on November 16, 2022,[42] which the TAP suggested the Company also assess the risk of a non-performing NWA, and the impact should be considered in identifying NWA opportunities.

As the NWA process and market mature, a framework may need to be developed that covers contingency planning for NWAs similar to what has been developed for competitive bidding of

[42] See https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/technical_advisory_panel/20221116_tap_feedback.pdf

generation.[43] As part of the Competitive Procurement Working Group within the IGP process, the Company is revising the competitive bidding framework to cover procurement of NWAs. Modifications to contingency planning will be covered by those revisions as well as processes and procedures to facilitate the procurement of NWAs.

If NWA bids meet most of the distribution need, but not all of the need required for a full deferral, the Company may develop short lead time mitigation alternatives that supplement the NWA portfolio for the total solution where feasible. Depending on how early in the procurement process the shortcoming is known and the amount that will be insufficient, the Company may initially attempt to use NWAs as a contingency measure to supplement the deficiency or may consider smaller wires solutions and/or operational constraints to temporarily remedy a deficiency. If a cost-effective solution does not exist, the Company may need to pursue the contingency plan's alternative solution. This may include operating solutions, up to pursuing the initial traditional solution. For example, if an NWA solution can resolve a distribution line overload, but the location leaves a portion unmitigated, that smaller remaining portion may still be reconductored to supplement the NWA solution. Such contingency solutions may require the Company to seek expedited approval by the Commission.

If the NWA provider is unable to install NWAs according to the contract, the Company may develop short lead time mitigation alternatives that supplement the NWA portfolio for the total solution where feasible in accordance to the wire solutions development[44] steps. The supplemental solution would be the least complex solution that addresses the shortcoming. This could include an operating solution, like switching, that uses existing equipment or load balancing. If a cost-effective NWA mitigation solution does not exist, the Company may pursue the contingency solution.

If the NWA fails during field commissioning or underperforms during operations based on commissioning and performance verification protocols agreed to in the contract, the Company will determine emergency limitations, if applicable, and will work with system operations on potential grid reconfiguration or load drop for all scenarios above. The Company will determine the reason for NWA underperformance, assess any equipment damage or outage impacts, assess whether new mitigation is required, and determine expedited solution options. If issues such as these arise and result in adverse impacts on reliability (that is, system average interruption duration index and system average interruption frequency index metrics), then any associated impacts on performance incentives/penalties must also be considered.

The absolute latest a decision can be made for a distribution project intended for deferral is directly after final design is complete and before the scheduling, permitting, and construction of the project begins. This varies depending on the project being deferred, but typically distribution projects that do not require permitting require a project commencement decision to be made at least 12 to 48 months

[43] See, Decision and Order No. 23131 filed on December 9, 2006 in Docket No. 03-0372, Instituting a Proceeding to Investigate Competitive Bidding for New Generating Capacity in Hawaii. Available at, http://files.hawaii.gov/dcca/dca/dno/dno2006/23121.pdf

[44] Seethe *Distribution Planning Methodology* report, Section 6.

prior to the need date (as described in the *Distribution Planning Methodology* report, Section 5.3). The timing of the contingency decision process may change over time as the Company continues to understand the impact of scheduling traditional and DER solutions in parallel.

Cost recovery of preliminary engineering costs for contingency solutions is another issue that may need to be raised with the Commission in the future. The Company acknowledges that the issue of preliminary engineering costs that are expended to produce contingency or parallel plans to third-party contracted NWA services may be discussed in the performance-based regulation proceeding as part of the discussion on adjustments to the major project interim recovery mechanism.

1.4 Case Examples

The Company shared several identified grid needs with stakeholders at the October 9, 2019, DPWG meeting for the purpose of jointly validating the proposed NWA opportunity evaluation methodology with real examples.[45] These real T&D projects have been identified and scoped by the Company for consideration. These illustrative projects were discussed with stakeholders to refine the NWA opportunity evaluation methodology and to jointly assess each opportunity. For this reason, a representative set of examples that includes projects that are typically screened out of NWA consideration in California and the Northeast were included for the DPWG discussion. As such, this list is not the complete list of potential grid projects, nor does it represent a final list of evaluated NWA opportunities as is found in the California Distribution Deferral Opportunity Report, for example. However, the results of the DPWG's feedback and application of this methodology in the Soft Launch and in the DPWG meetings is consistent with the California and Northeast approaches to identifying viable NWA opportunities for procurement.[46] The following includes example projects discussed during the October 9, 2019 DPWG meeting[47]. Additional example projects discussed during the November 2022 TAP presentation[48] on the NWA opportunity evaluation process are also included.

1.4.1 Step 1: NWA Opportunity Screen

Several case example T&D projects were discussed with stakeholders. The projects presented in this section are examples of capital projects that do not represent viable NWA opportunities and, as such,

[45] October 9, 2019, DPWG meeting presentation, see slides 19-54 https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/distribution_planning/20191009_dpwg_meeting_presentation_materials.pdf.

[46] Note: In 2019, PG&E and SCE identified a combined total of over 800 grid needs that were screened to only 10 projects (6 for SCE and 4 for PG&E) for NWA procurement. This is consistent with the experience in the Northeast.

[47] October 9, 2019, DPWG Meeting Summary Notes https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/distribution_planning/20191009_dpwg_meeting_summary_notes.pdf.

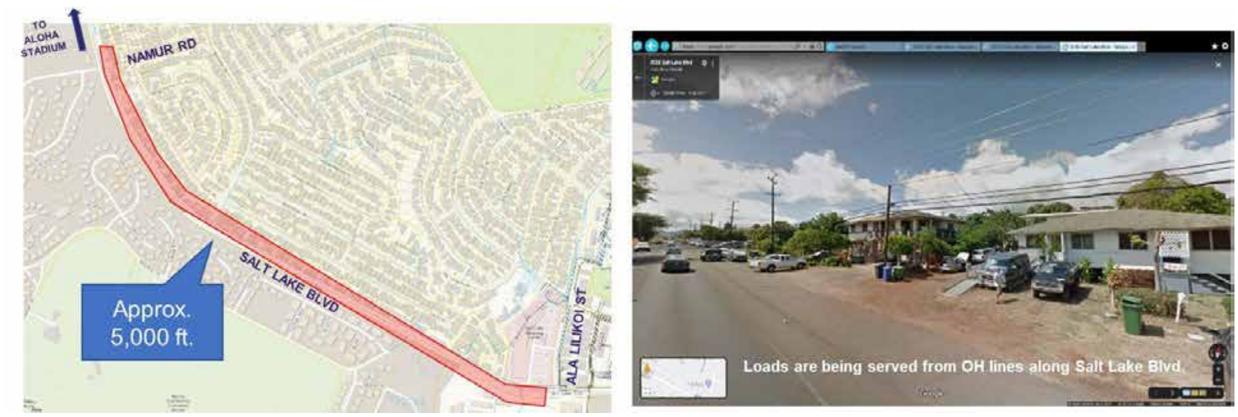
[48] November 16, 2022, DPWG Meeting Summary Notes IGP Technical Advisory Panel Distribution Grid Needs Assessment & Non-Wires Alternatives (hawaiianelectric.com)

would be screened out in Step 1 of the process. The projects that passed Step 1 screening are discussed under Step 2 in Section 5.2.

1.4.1.1 Salt Lake Boulevard Overhead Line Relocation

This project involved an overhead (OH) to underground (UG) line conversion and relocation of Salt Lake Boulevard OH lines requested by public works, as illustrated in Figure 6.

Figure 6: Salt Lake Boulevard Overhead Line Relocation

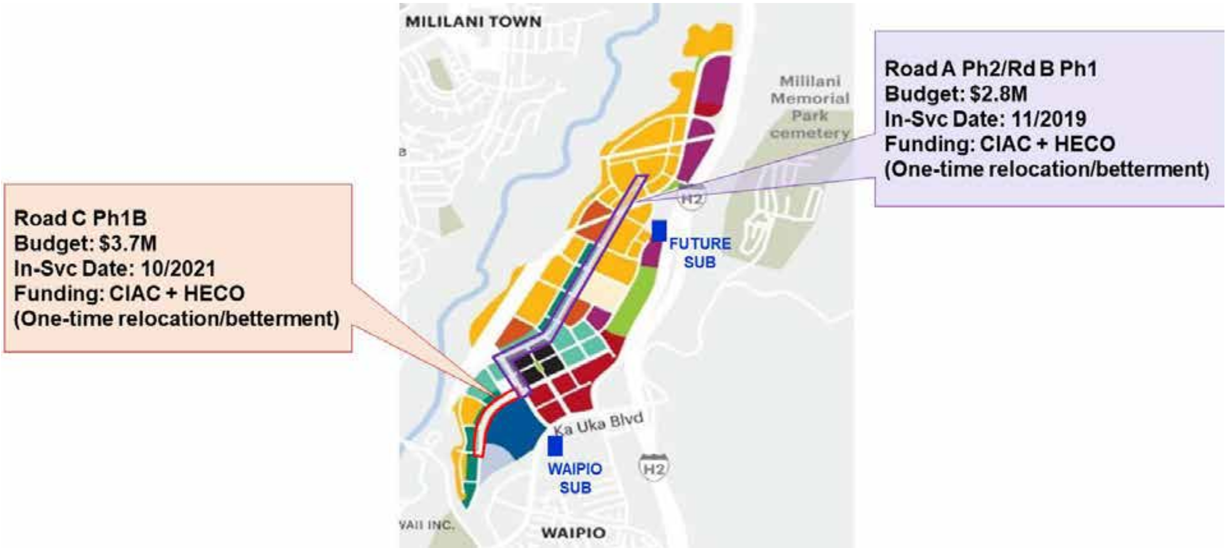


This project involved relocating a portion of an existing line; therefore, the alternative is to remove that line. This means that downstream loads would need to be removed from the grid. Stakeholder consensus in the meeting was that this type of project is not a feasible NWA opportunity. This type of project requested by public works would be put into the non-qualified category in Step 1.

1.4.1.2 Waiau-Mililani 46 kV OH to UG Conversion

A customer requested OH to UG conversion projects for betterment in support of the Koa Ridge Development, as shown in Figure 7. The scope of work includes installation of OH transitions and UG electrical facilities and then removal of existing OH electrical facilities once UG facilities are energized. The total project cost is $6.5 million, with the developer contributing the majority of the funding through contributions in aid of construction (CIAC). The Company’s cost after the customer’s contributions is about $800,000. In-service dates vary between 2020 and 2021.

Figure 7: Waiau–Mililani 46 kV OH to UG Conversion



Stakeholders agreed that this type of customer-requested betterment OH to UG conversion project is not a feasible NWA opportunity. Customer-requested betterment conversion projects will be put into the non-qualified category in Step 1.

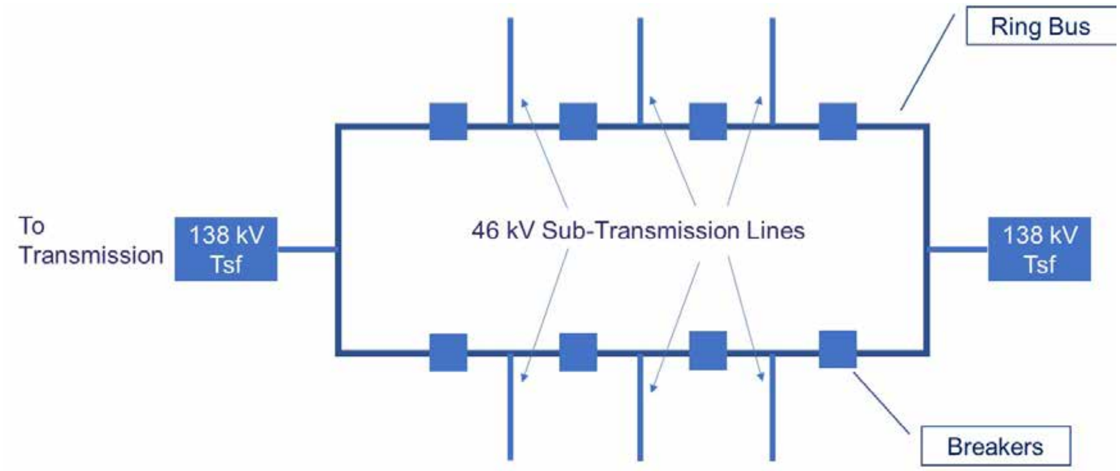
1.4.1.3 Waiau 46 kV GIS Bus Replacement

This project is proposed to replace the existing deteriorated 46 kV air-insulated switchyard with a new 46 kV gas-insulated substation (GIS). This major 46 kV switching station provides service to Waiau, Ewa, Mililani, Pearl City, and Waipahu through eight sub-transmission lines with a total bus load (2018) of 92 MW. Findings from Black & Veatch's *Waiau 46 kV Substation Engineering Study* dated 2013 are as follows:

- Substation that is well beyond its design life (66+ years in marine environment)
- Bus configuration that creates risk of major outage and is expensive to operate
- Severely corroded steel structure
- Inadequate grounding system creating potential hazard to public
- Aged, obsolete, and unreliable equipment providing unreliable service
- Inadequate housing for modern protective relays

The scope of work includes installing a new 46 kV GIS ring bus (circuit breakers are connected to form a ring, with isolators on both sides of each breaker) and constructing a new 46 kV control house, with provisions for future 138 kV relays, as shown in Figure 8. The estimated project cost is $60 million to $80 million, with an in-service date of September 2024.

Figure 8: Waiau 46 kV GIS Bus



Stakeholder consensus was that this type of aging infrastructure project is not an NWA opportunity because there is not a viable approach to avoid the ring bus and breaker replacement. Also, the 46 kV substation bus provides system benefits by allowing renewable projects and DER to export renewable energy to other parts of the grid in support of Hawai'i's 100 percent renewable objective. As such, this project would be screened out in Step 1.

The three example projects screened out in Step 1, which include line relocation, line OH to UG conversion, or bus replacement of aging infrastructure, represent projects where the alternative is to remove that section of the line or bus. This means that downstream loads would either result in losing a backup source or need to be removed from the grid.

1.4.2 Step 2: NWA Opportunity Sourcing Evaluation

The following case example T&D projects that passed Step 1 screening were discussed with the IGP Technical Advisory Panel on November 16, 2022 in the joint application of the Step 2 evaluation criteria.

1.4.2.1 Koa Ridge

Koa Ridge Development in Central O'ahu near Mililani, built by Castle & Cooke Hawai'i, includes 3,500 new homes, a medical center, commercial and light industrial development, parks, and schools. The developer estimated an additional 40.7 MW of load at the completion of the development. Additional distribution capacity would be needed by 2025 to address the new development growth, as shown in Figure 9.

Figure 9: Waipio Substation and Koa Ridge Load Forecast

Year	Load (kW)
2023	6,280.5
2024	5,299.8
2025	4,594.8
2026	9,782.7
2027	3,397.9
2028	4,091.7
2029	4,293.3
2030	2,255.7
2031	737.1
Total	40,733.5

The load growth will result in an overload of substation transformers under normal and emergency conditions, as presented and discussed with the stakeholders.

The proposed wires T&D project is to install a 10 MVA 46-12 kV transformer and associated equipment at Waipio Substation with an estimated cost of $2.9 million, with an in-service date of 2025.

The Koa Ridge project is categorized as an expansion of distribution system capacity in Step 1. The following is the assessment for Step 2:

- Performance Requirements: Performance requirements are a potential challenge given the long-duration and high-magnitude overloads, and given the results of the Soft Launch (see Section 5.3) it is uncertain if a procurement will be successful (red).
- Timing: The in-service date is more than 2 years away (Green).
- Economic Assessment: The T&D project cost is greater than $1 million (Green).

Transformer	Timing	Overall Performance	Economics
Waipio 1 (Normal, Base)	2025	• Capacity: 10.6 MW • Duration: 23 hours • 365 calls per year	$ 2.9M
Waipio 1 (N-1, Base)	2025	• Capacity: 11.5 MW • Duration: 14 hours • 365 calls per year	$ 2.9M

Due to the large performance needs to address the projected overloads with capacity needs greater than 10 MW and duration longer than 8 hours, this Koa Ridge project's overall performance needs is deemed to be unfavorable and placed into Track 3 which indicates a non-qualified NWA opportunity that cannot be reasonably met by NWA solutions and the wires solution is to be implemented.

1.4.2.2 CEIP 46 Sub-tranmission Circuit Reconductoring

The CEIP 46 sub-transmission system serves a large portion of mid-west O'ahu from Ewa to Kapolei. It also serves as the backup in contingency scenarios to the Kahe, Ewa Nui, and Waiau sub-transmission systems. See Appendix A for map of the service area. There are a number of new loads forecasted to be served from the CEIP 46 sub-transmission system. The load for these projects total approximately 53 MW of new load growth. Additional distribution capacity would be needed by 2025 to address the load growth.

The proposed T&D project is to reconductor a section of the CEIP 46 sub-transmission circuit and associated equipment at an estimated cost of $3.93 million, with an in-service date of 2025

The load growth will result in an contingency overload of the current carrying capacity of the cable/conductor. This project is categorized as ensuring a reliability requirement for circuit back-tie upgrade deferral in Step 1. The following is the assessment for Step 2:

- Performance Requirements: Performance requirements are considered favorable given a potential challenge given its short-duration and low-magnitude overloads (Green).
- Timing: The in-service date is more than 2 years away (Green).
- Economic Assessment: The T&D project cost is greater than $1 million (Green).

Transformer	Timing	Overall Performance	Economics
CEIP/CEIP 46 (N-1)	2025	• Capacity: 4.7 MW • Duration: 3 hours • 14 calls per year	$ 3.9M

Due to all evaluation criteria being favorable this project is placed into Track 1.

1.4.2.3 Kakaako and Ala Moana Development Areas

New residential/commercial projects have been proposed in the Kakaako and Ala Moana area due to the Transit-Oriented Development (TOD) Special District Design Guidelines, which promote "intense and efficient use of land" near the rail stations, as shown in Figure 11. The Company received six TOD-related service requests in the Ala Moana area, and two more appeared to be in development per news reports and feedback from the City. The Ala Moana TOD need was previously identified as a Track 2 opportunity because the performance requirements and timing were uncertain. The opportunity would be reconsidered in the next planning cycle based on further information on the need, including refinement of performance requirements, timing of in-service date(s), and scoping and estimation of a wires solution. Since then, several projects have not materialized and the refinement of the forecast shows more growth in the Kakaako area instead.

Figure 10: Kakaako and Ala Moana Area

The Kakaako area under development is focused between Kamakee Street and Keawe Street and is served by a 25 kV distribution system fed by the Kewalo Substation (in Kakaako), Kamoku Substation (near Iolani School), and /or Iwilei Substation. With the projected loads based on service requests and developer plans, overloads will occur as illustrated in Figures 12 and 13.

Figure 11: Kewalo T3 Yearly Peak Forecast

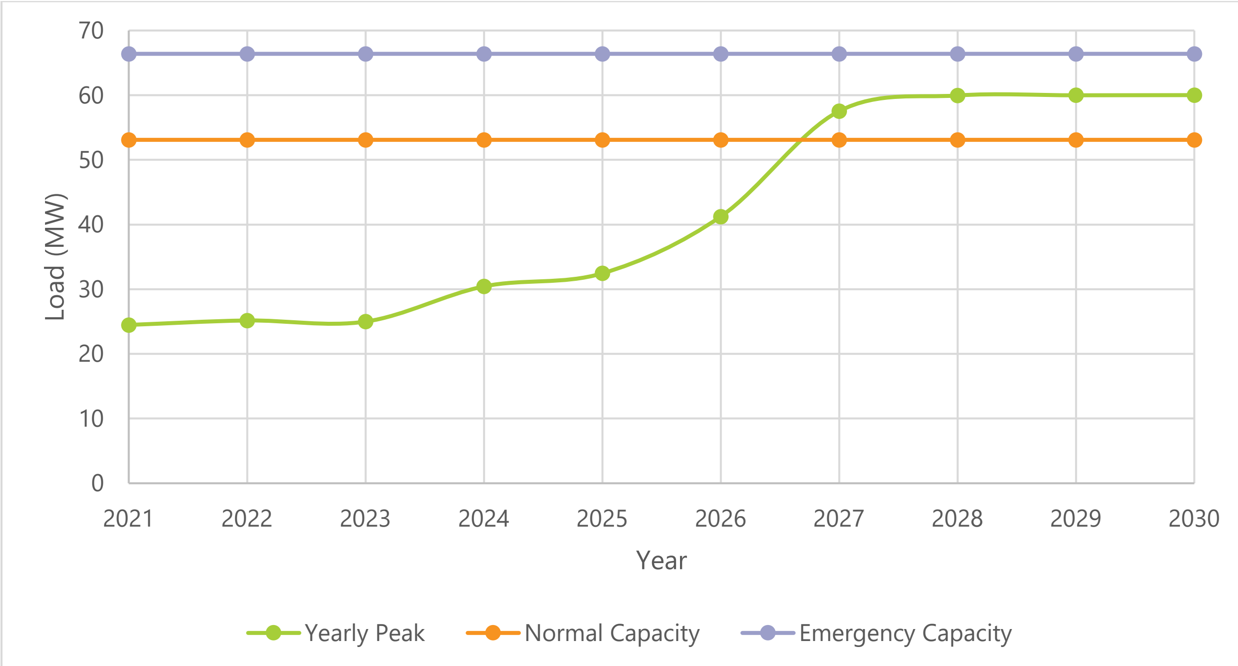


Figure 12: Kewalo T3 2027 Peak Day Overload

The proposed wires T&D project is to install a 50 MVA 138-25 kV transformer at Kewalo Substation and extend new circuits to the Kakaako development area at an estimated cost of $22 million, with an in-service date of 2026.

The Kewalo T3 project is a qualified NWA opportunity based on the Step 1 criteria. The project is considered expansion of the distribution system capacity.

The following is the assessment from Step 2:

- Performance Requirements: Transformer loading requirements are favorable (Green).
- Timing: The in-service date is more than 2 years away (Green).
- Economic Assessment: The T&D project cost is greater than $1 million (Green).

Transformer	Timing	Overall Performance	Economics
Kewalo T3 (Normal, Base)	2027	• Capacity: 4.43 MW • Duration: 3 hours • 12 calls per year	$ 22M

Based on the evaluation criteria this project is placed into Track 1.

1.4.3 Step 3: Action Plan

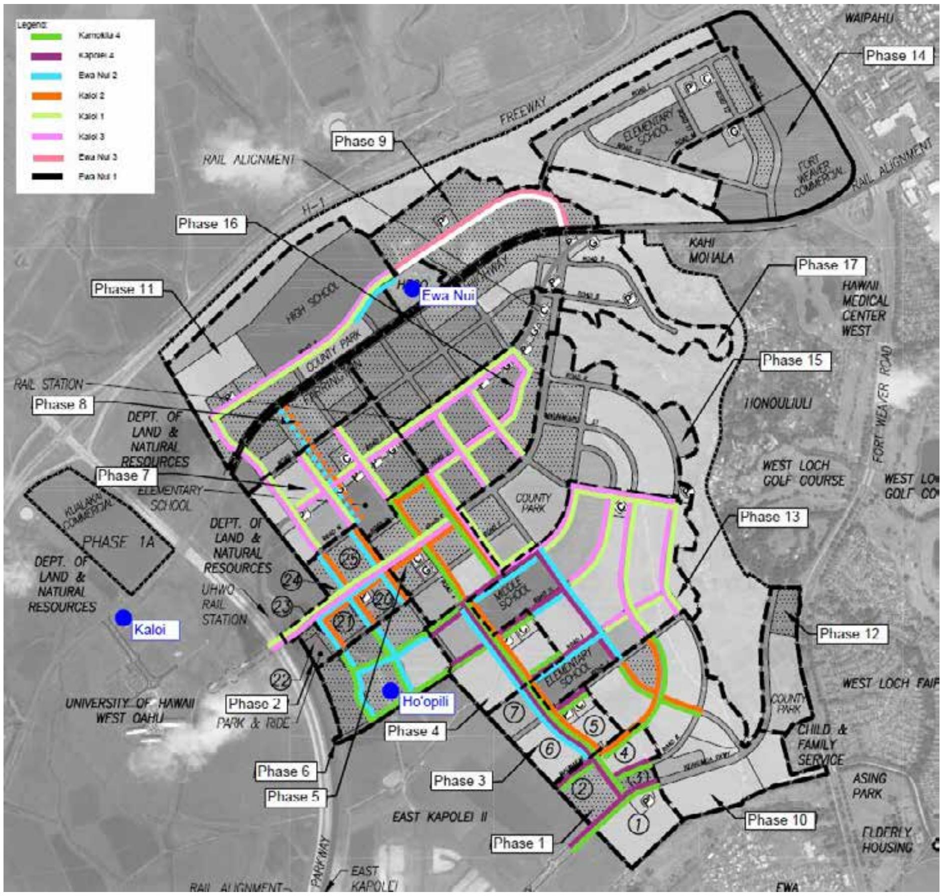
The following are example steps the Company took to seek NWA solutions for projects that were placed in Track 1. The Company conducted a Soft Launch and several Expression of Interests (EOI) to demonstrate the grid needs assessment, NWA opportunity evaluation, sourcing process, and solution evaluation methods for NWAs by using real-world examples. These examples also allowed the Company to gain experience identifying needs for resource choices while being subjected to an evaluation and construction time line. The lessons learned in the Soft Launch and EOIs are being used to help inform development of the full-scale IGP planning and sourcing effort.

1.4.3.1 IGP Soft Launch RFP – Hoʻopili and East Kapolei Area

The Company identified two T&D NWA opportunities to source through a competitive procurement as part of the IGP Soft Launch. These two opportunities were effectively identified as Track 1 opportunities to pursue for procurement. The following discussion summarizes the opportunities and results.

Hoʻopili is a mixed-use master-planned community developed by D.R. Horton in west Oʻahu located north of Ewa Beach and east of Kapolei, as shown in Figure 14. The plans for this new community include 11,750 new residential homes, 7 community and recreation centers, over 200 acres of commercial farms and community gardens, up to 3 million square feet of commercial space, and 5 Department of Education public schools. In addition to Hoʻopili, there are currently over 20 additional customer service requests in the area with completion dates within the next few years. Due to an estimated load growth of 83.4 MWA, overloads under contingency conditions are forecasted to occur in 2022, with normal overload conditions beginning in 2023.

Figure 134: Planned Ho'opili Development



The load growth will result in an overload of substation transformers and distribution circuits under normal and emergency conditions, as shown in Figures 15 and 16. From these overloads, two NWA opportunities were identified. The first NWA opportunity was to defer the Kapolei 4 Circuit Extension project with a commercial operation date (COD) of February 1, 2022. The second NWA opportunity was to defer the Ho'opili Substation project with a COD of January 1, 2023.

Figure 15: Summary of Normal Overloads

Deferral Opportunity	Equipment	MW Peak	Operational Date	Delivery Months	Delivery Hours	Duration (Hr)	Max # of Days	MWH
Ho'opili Substation	Kaloi 1 Tsf	4.7	Jan 2023	Jan–Dec	1PM–11AM	10	365	21.5
	Kaloi 3 Ckt	0.3	Aug 2023	Aug–Oct	7PM–9PM	2	69	0.4

Figure 16: Summary of Contingency Overloads

Deferral Opportunity	Equipment	MW Peak	Operational Date	Delivery Months	Delivery Hours	Duration (Hr)	Max # of Days	MWH
Kapolei 4 Circuit Extension	Kapolei 2 Tsf	3.5	Feb 2022	Jan–Dec	5PM–11PM	6	365	11.4
Ho'opili Substation	Ewa Nui 2 Ckt	5.1	Jan 2023	Jan–Dec	11AM–12AM	13	365	30.9
	Kaloi 1 Tsf	9.7	Jan 2023	Jan–Dec	6AM–8AM, 9AM–12AM	17	365	62.8
	Kaloi 3 Ckt	2.6	Jan 2023	Jan–Dec	5PM–11PM	6	365	8.5
	Kamokila 4 Ckt	1.0	May 2023	Jan–Dec	5PM–10PM	5	226	2.9

Figure 17 shows the loading of the peak day by month on the Kaloi #1 Transformer in the year 2023. Figure 18 shows the associated grid need for Kaloi #1 Transformer. These, along with graphic representation for all other overloads, were identified in the RFP, Appendix J, for NWA services for the Ho'opili Area, dated November 8, 2019.

Figure 17: Kaloi #1 Transformer Loading – Monthly Peak Day in 2023

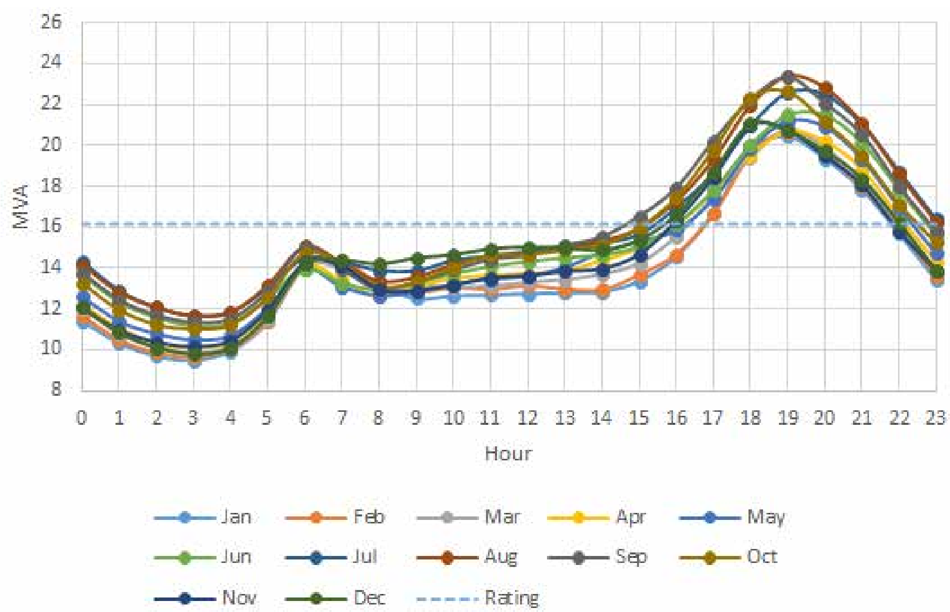
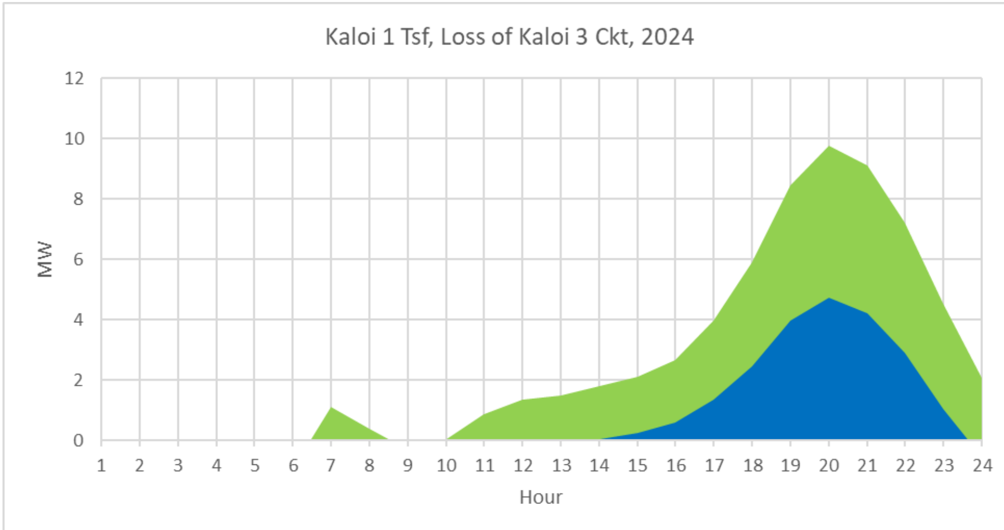


Figure 18: Kaloi #1 Transformer Overload



The most cost-effective T&D project proposed for comparison to an NWA solution is the construction of a new substation site and associated equipment located in the Ho'opili development. This would result in minimal distribution circuit installation costs because of the location of new loads to serve. Estimated costs for this project are approximately $12.7 million with provisions for up to four 46-12 kV, 10/12.5 MVA distribution transformers to allow for future load growth in the area.

The IGP Soft Launch RFP process resulted in low response from the market. Because of insufficient response to the RFP to meet the performance and operations requirements for either of the deferral opportunities, the Company, in consultation with the Independent Observer, decided not to move forward with the IGP Soft Launch RFP. As a result, the Company is moving forward with the identified traditional solution. As indicated in Hawaiian Electric's *Ho'opili Area Study* dated 2019, the proposed project will allow for the timely installation of critical infrastructure to the electrical system, which will provide necessary capacity to serve projected loads and provide essential reliable power under contingency conditions.

Although a traditional solution will be initially pursued for the Ho'opili area, future NWA opportunities remain to enable Ho'opili's growth. The Company will evaluate the viability of a programmatic DER effort for the Ho'opili and East Kapolei area to reduce longer-term needs for distribution upgrades in the area. The Company will reevaluate options as load grows (around 2024 or 2025) and will determine if future NWA opportunities become available. The Company has also recognized the challenge and need of exploring ways to cost-effectively mitigate the impact of large new real estate development loads.

The Company was one of the first, if not the first, to procure for a distribution reliability (back-tie) service nationally and gained valuable experience while proceeding through the Soft Launch process. The Company will continue to improve the IGP process going forward and will conduct future NWA procurements for distribution opportunity based on lessons learned from the Soft Launch. Some lessons learned that will be applied to the IGP process include the following[49]:

- Leverage the NWA evaluation framework developed by the DPWG to determine opportunities best suited for procurements
- Continue to pursue market solutions to acquire least cost, best fit solutions for customers, but consider tariff and program options to complement procurements
- Continue discussion in examining opportunities to capture multiple services from resources at longer-duration contracts
- Pursue standard form RFP for NWAs and streamline the process for short lead time/near-term needs.

Expression of Interest for NWA Opportunities

In the years 2022 and 2023, EOIs were issued for three T&D NWA opportunities which were identified as Track 1 opportunities based on the NWA methodology. The objective of the EOIs were to identify interested parties who are able to develop cost competitive utility-scale renewable projects or aggregating DER/EE projects in specific locations to fulfill grid service performance requirements. As part of the EOIs, the performance requirements, net present value (NPV) of the deferral or avoidance cost of the traditional wires solution, and a map of the areas where the NWA projects are required were provided.

The information obtained from responses would help the Company determine if there are viable cost competitive NWA projects, to move forward with issuance of an RFP or alternative means of procurement, subject to approval by the Hawaiʻi Public Utilites Commission. The following discussions summarizes the opportunities and results.

Ewa Nui B Transformer NWA

The Company forecasts significant load growth in central Oʻahu in the coming years. The load is forecasted to increase by approximately 70 MVA by 2030 triggering overloads beginning in 2026 during a contingency condition.   Therefore, the Company has identified a capacity and reliability grid need and issued an EOI in 2/2023 to developers or aggregators who are capable of developing utility-scale renewable projects or aggregating DER/EE in the Central Oʻahu area.

The traditional wires solution consists of installing a new 80MVA 138-46kV transformer and associated equipment at Ewa Nui Substation with a new 46kV circuit. This solution is preliminarily estimated to cost $15.0M.

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[49] March 9, 2020, DPWG Presentation Slides https://www.hawaiianelectric.com/documents/clean_energy_hawaii/integrated_grid_planning/stakeholder_engagement/working_groups/soft_launch/20200309_igp_soft_launch_wg_presentation_materials.pdf.

To address these grid needs, the Company sought capacity (MW) and energy (MWH) annual grid needs shown in Figure 19 to defer the need for the wires project by five years.

Figure 19: Annual Grid Needs

	2026	2027	2028	2029	2030
Capacity (MW)	7.2	9.5	12.2	15.1	16.5
Energy (MWH)	8.5	15.5	31.1	65.0	87.8

This project is intended to defer a T&D solution to provide capacity to the 46 kV system for five years. The NPV of the deferral value is: $7.0M.

The Company did not receive any responses to this EOI and will be pursuing the traditional wires solution.

CEIP 46 Reconductoring NWA

The Company forecasts significant load growth in west Oʻahu from Ewa to Kapolei areas in the coming years. The load is forecasted to increase by approximately 53 MVA by 2030 triggering overloads of existing electrical infrastructure beginning in 2025 during a contingency condition. Therefore, the Company has identified a capacity and reliability grid need and issued an EOI in 2/2023 to developers or aggregators who are capable of developing utility-scale renewable projects or aggregating DER/EE in the Ewa and Kapolei areas of Oʻahu.

The traditional wires solution consists of installing approximately 520 ft of new 1500KCM cables parallel to existing cables and reconductoring approximately 1.91 miles of 556 conductor to 795 conductor. This solution is preliminarily estimated to cost $3.93M.

To address this grid need, the Company sought the aggregate NWA amount of 5.71MW/13.9MWH in 2025 for the expected 30-year lifespan of a wires project to avoid the cost of the wires project. Figure 20 shows the capacity (MW) and energy (MWH) annual grid needs.

Figure 20: Annual Grid Needs

	2025	2026	2027	2028	2029
Capacity (MW)	5.71	5.71	5.71	5.71	5.71
Energy (MWH)	13.9	13.9	13.9	13.9	13.9

This project is intended to avoid a T&D solution to provide capacity to the 46 kV system. The NPV to avoid the wires project is $4.57M.

The Company did not receive any responses to this EOI and will be pursuing the traditional wires solution.

Kewalo T4 Transformer NWA

The Company forecasts significant load growth in the Kakaako and Kewalo area in the coming years. The forecasted load growth totals approximately 30 MVA by 2030 triggering normal and contingency overloads of existing electrical infrastructure beginning in 11/2025. Therefore, the Company identified a capacity and reliability grid need and issued an EOI in 3/2023 to developers or aggregators who may be interested and capable of developing utility-scale renewable projects or aggregating DER/EE in the Kakaako and Kewalo areas of O’ahu.

The traditional wires solution consists of installing a 138-25 kV, 50 MVA transformer and associated equipment at Kewalo Substation and four new 25 kV circuits. The solution is preliminarily estimated to cost $22M.

To address these grid needs, the Company sought aggregate NWA amounts for two scenarios below. Figure 21 shows the capacity (MW) and energy (MWH) annual grid needs.

1. 2.0MW/3.3MWH in 2025-2026 to defer the wires project by one year; or
2. 2.0MW/3.3MWH in 2025-2026 and 17.7MW/168.5MWH in 2027 to avoid the need for the wires project.

Figure 21: Annual Grid Needs

	11/2025	2026	2027	2028	2029	2030
Capacity (MW)	2.0	2.0	17.6	17.7	17.7	17.7
Energy (MWH)	3.3	3.3	166.6	168.5	168.1	167.7

The NWA is intended to defer or avoid a T&D solution to provide capacity to the distribution system. The approximate NPV for the two NWA scenarios were:

1. NPV to defer the wires project by one year: $3.17M.
2. NPV to avoid the wires project: $25.6M

The Company is currently waiting for responses.

Appendix G:

Revised Framework for Competitive Bidding

Hawaiian Electric

Appendix G:

Revised Framework for Competitive Bidding

FRAMEWORK FOR COMPETITIVE BIDDING
__________, 2020

STATE OF HAWAII PUBLIC
UTILITIES COMMISSION

Exhibit A

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STATE OF HAWAII PUBLIC UTILITIES COMMISSION

FRAMEWORK FOR COMPETITIVE BIDDING

__________, 2020

I. DEFINITIONS

As used in this Framework, unless the context clearly requires otherwise:

"Affiliate" means any person or entity that possesses an "affiliated interest" in a utility as defined by Section 269-19.5, Hawai'i Revised Statutes ("HRS"), including a utility's parent holding company but excluding a utility's subsidiary or parent which is also a regulated utility.

"Agreement" means an agreement or contract for an electric utility to purchase a System Resource from a third party, pursuant to the terms of this Framework.

"CIP Approval Requirements" means the procedure set forth in the Commission's General Order No. 7, Standards for Electricity Utility Service in the State of Hawaii, Paragraph 2.3(g), as modified by In re Kauai Island Util. Coop., Docket No. 03-0256, Decision and Order No. 21001, filed on May 27, 2004, and In re Hawaiian Elec. Co., Inc., Hawaii Elec. Light Co., Inc., and Maui Elec. Co., Ltd., Docket No. 03-0257, Decision and Order No. 21002, filed on May 27, 2004. "In general, [the] commission's analysis of capital expenditure applications involves a review of whether the project and its costs are reasonable and consistent with the public interest, among other factors. If the commission approves the [electric] utility's application, the commission in effect authorizes the utility to commit funds for the project, subject to the proviso that 'no part of the project may be included in the utility's rate base unless and until the project is in fact installed, and is used and useful for public utility purposes."' Decision and Order No. 21001, at 12; and Decision and Order No. 21002, at 12.

"Code of Conduct" means a written code developed by the host electric utility and approved by the Commission to ensure the fairness and integrity of the competitive bidding process, in particular where the host utility or its Affiliate seeks to advance its own System Resource proposal in response to an RFP. The "Code of Conduct" is more fully described in Part IV.H.9.c of the Framework.

"Commission" means the Public Utilities Commission of the State of Hawaiʻi.

"Competitive bid" or "competitive bidding" means the mechanism established by this Framework for acquiring a future System Resource or a block of System Resources by an electric utility.

"Consumer Advocate" means the Division of Consumer Advocacy of the Department of Commerce and Consumer Affairs, State of Hawaiʻi.

"Contingency Plan" means an electric utility's plan to provide either temporary or permanent solutions to address a reliability or statutory need (including, for example, the need to comply with reliability standards as discussed in Hawaiʻi Revised Statutes ("HRS") §§ 269-0141 through 269-0144 and with the State of Hawaiʻi's Renewable Portfolio Standards law, as codified in HRS §§ 269-91 through 269-95) as may result from an actual or expected failure of an RFP process to produce a project selected in an RFP or a viable project proposal (including any project not completed or delayed). The utility's Contingency Plan may be different from the utility's bid. The term "utility's bid," as used herein, refers to a utility's proposal advanced in response to a System Resource need that is addressed by its RFP.

"Electric utility" or "utility" means a provider of electric utility service that is regulated by and subject to the Commission's jurisdiction pursuant to Chapter 269, Hawaiʻi Revised Statutes.

"Framework" means the Framework for Competitive Bidding dated ________, 2020, adopted by the Commission in Docket No. ________.

"Grid Needs" means the specific grid services (including but not limited to capacity, energy and ancillary services) identified in the Grid Needs Assessment, including transmission and distribution system needs that may be addressed through a Non-Wires Alternative. Grid Needs that are subject to the Framework generally does not apply to utility equipment (i.e., transmission and distribution infrastructure, flexible AC transmission devices, materials, etc.) that are normally procured through the utility's procurement process for goods and services.

"Grid Needs Assessment" means the process step in the IGP where the technical analyses are conducted to determine the generation, transmission, and distribution grid service(s) needs to meet state policy objectives, reliability standards, among other goals, and presented to the Commission for review and approval or acceptance.

“IGP” or “Integrated Grid Planning” means an electric utility's planning process that aims to integrate the Grid Needs Assessment planning analyses with the sourcing of market-based solutions, which may include competitive bidding, to meet near and long-term customer needs.

"Independent Observer" means the neutral person or entity retained by the electric utility or Commission to monitor the utility's competitive bidding process, and to advise the utility and Commission on matters arising out of the competitive bidding process, as described in Part III.C of the Framework.

“Non-Wires Alternative” means an electricity grid project that uses non-traditional transmission and distribution (T&D) solutions, such as distributed generation (DG), energy storage, energy efficiency (EE), demand response (DR) and grid software and controls, to defer or avoid the need for conventional transmission and/or distribution infrastructure investments.

"Provider" means a System Resource provider that is not subject to the Commission's regulation or jurisdiction as a public utility including, for example, developers and aggregators.

"PURPA" means the Federal Public Utility Regulatory Policies Act of 1978, as amended.

"QF" means a cogeneration facility or a small power production facility that is a qualifying facility under Subpart B of 18 Code of Federal Regulations §§ 292.201 - 292.211. See also 18 Code of Federal Regulations § 291.201(b)(l) (definition of "qualifying facility").

"RFP" means a written request for proposal issued by the electric utility to solicit bids from interested third-parties, and where applicable from the utility or its Affiliate, to supply a future System Resource or a block of System Resources to the utility to meet the utility’s Grid Needs pursuant to the competitive bidding process.

“System Resources” are the specific resources that will be acquired to meet the Grid Needs.

II. CONTEXT FOR COMPETITIVE BIDDING

A. USE OF COMPETITIVE BIDDING

1. This Framework applies to electric utilities regulated by and subject to the Commission's jurisdiction pursuant to Chapter 269, Hawaiʻi Revised Statutes and any participants in any competitive bidding process that this Framework is applied to.

2. Competitive bidding, unless otherwise determined by the Commission, is established as the required mechanism for acquiring System Resources necessary to meet the Grid Needs. The following conditions and possible exceptions apply:

   a. Competitive bidding will benefit Hawaiʻi when it: (i) facilitates an electric utility's acquisition of System Resources in a cost-effective and systematic manner; (ii) offers a means by which to acquire new System Resources that are overall lower in cost, better performing or installed sooner than the utility could otherwise achieve; (iii) does not negatively impact the reliability and resilience or unduly encumber the operation or maintenance of Hawaiʻi's unique island electric systems; (iv) promotes electric utility system reliability by facilitating the timely acquisition of needed System Resources and allowing the utility to adjust to changes in circumstances; (v) is consistent with the IGP process; and (vi) is consistent with Hawaiʻi's renewable energy portfolio standards.

   b. Under certain circumstances, to be considered by the Commission in the context of an electric utility's request for waiver under Part II.A.3, below, competitive bidding may not be appropriate. These circumstances include: (i) when competitive bidding will unduly hinder the ability to add needed System Resources in a timely fashion; (ii) when the utility and its customers will benefit more if the System Resource is owned by the utility rather than by a third-party (for example, when system reliability or safety will be jeopardized by the utilization of a third-party resource); (iii) when more cost-effective or better performing System Resources are more likely to be acquired more efficiently through different procurement processes; or (iv) when competitive bidding will impede or create a disincentive for the achievement of IGP goals, renewable energy portfolio standards or other government objectives and policies, or conflict with requirements of other controlling laws, rules, or regulations.

c. Other circumstances that could qualify for a waiver include (but are not limited to): (i) the expansion or repowering of existing utility generating units or other System Resources; (ii) the acquisition of near-term System Resources for short-term needs; (iii) the acquisition of power from a non-fossil fuel facility (such as a waste-to-energy facility) that is being installed to meet a governmental objective; (iv) the immediate acquisition of System Resources needed to respond to an emergency situation; or (v) the lack of a sufficient market to support a competitive procurement.

d. Furthermore, the Commission may waive this Framework or any part thereof upon a showing that the waiver will likely result in the acquisition of a System Resource, leading to a lower cost to the utility's general body of customers, increase the reliability of a utility’s system to the utility's general body of customers, facilitate the transition to renewable generation, or is otherwise in the public interest.

e. This Framework does not apply to any procurements ongoing, any existing programs or tariffs, or any projects submitted for approval to the Commission before this Framework was adopted, such as the Kalaeloa Partners, L.P. 208 MW project (which is the subject of Docket 2011-0351), the Hu Honua Bioenergy, LLC 21.5 MW project (which is the subject of Docket No. 2017-0122), the Puna Geothermal Venture 46 MW project (which is the subject of Docket No. 2019-0333), the Paeahu Solar LLC 15 MW project (which is the subject of Docket No. 2018-0433) and projects selected pursuant to the utility’s RFPs for Variable Renewable Dispatchable Generation Paired with Energy Storage (Docket Nos. 2017-0352 and 2019-0178).

f. This Framework also does not apply to System Resources with respect to: (i) System Resources with a net output of 5 MW or less on the island of O‘ahu, 2.5 MW or less on the islands of Maui and

Hawaiʻi, and 250 kW or less on Molokaʻi and Lānaʻi; (ii) System Resources at substations and other sites installed by the utility on a temporary basis to help address reserve margin shortfalls or to enhance resiliency during emergency operations; (iii) customer-sited, utility-owned System Resources that have been approved by the Commission; (iv) System Resources under 1 MW installed for "proof-of-concept" or demonstration purposes; (v) extensions of an Agreement for three years or less on substantially the same terms and conditions as the Agreements and/or on more favorable terms and conditions if it can be demonstrated that the extensions are in the public interest; (vi) modifications of an Agreement to acquire additional firm capacity or firm capacity from an existing facility, or from a facility that is modified without a major air permit modification if it can be demonstrated that the modifications are in the public interest; and (vii) renegotiations of Agreements in anticipation of their expiration, approved by the Commission.

g. When a competitive bidding process will be used to acquire a future System Resource or a block of System Resources, the System Resources acquired under a competitive bidding process must meet the needs of the utility in terms of the reliability of the System Resource, the characteristics of the System Resource required by the utility, and the control the utility needs to exercise over operation and maintenance of such System Resource in order to reasonably address system integration and safety concerns.

3. The procedure for seeking a waiver is as follows:

a. For all proposed projects included in, or consistent with, identified Grid Needs developed through a Grid Needs Assessment that have not yet been filed with the Commission for approval or acceptance as of the effective date of this Framework, and are subject to the Framework pursuant to the terms set forth herein, any waiver request shall be submitted to the Commission for approval no later than the time the application for approval of such project is submitted to the Commission.

b. An electric utility that seeks a waiver shall take all steps reasonably required to submit its application for waiver as soon as practicable such that, in the event the Commission denies the request, sufficient time remains to conduct competitive bidding without imprudently risking system reliability.

c. In no event shall a Commission decision granting a waiver be construed as determinative of whether an electric utility acted prudently in the matter.

d. Proposed projects included in, or consistent with, a Grid Needs Assessment conducted prior to the effective date of this Framework, proposed projects procured under a previously approved or accepted mechanism, or projects being submitted under approved programs and/or tariffs, shall not be required to seek a waiver of this Framework and this Framework shall not apply to such projects.

4. Exemption - ownership structure of an electric utility. Upon a showing that an entity has an ownership structure in which there is no substantial difference in economic interests between its owners and its customers, such that the electric utility has no disincentive to pursue new projects through competitive bidding, the Commission will exempt such entity from this Framework.

B. SCOPE OF COMPETITIVE BIDDING

1. An electric utility's Grid Needs identified in a Grid Needs Assessment that is reviewed and approved or accepted by the Commission, shall inform the proposed scope of any RFP, or group of RFPs to be developed for the identified System Resources to be procured. This Framework defines which System Resource or block of System Resources are subject to competitive bidding.

2. Competitive bidding shall enable the comparison of a wide range of System Resource options that are capable individually or as a portfolio of meeting the specific requirements of the RFPs.

3. Each electric utility shall take steps to provide notice of its RFPs, and to

encourage participation from a full range of prospective bidders. PURPA qualifying facilities, Providers, the host utility, and its Affiliates, and other utilities shall be eligible to participate in any RFP seeking System Resources.

4. Competitive bidding processes may vary, provided those processes are consistent with this Framework. An electric utility may establish a separate process (such as a "set side" (for example, a special program approved by the Commission, i.e. the Phase 2 Community Based Renewable Energy tariff program for projects under 250 kW)," separate RFP process, or standard form RFP) to acquire System Resources where such mechanisms or processes are deemed more suitable to meet IGP objectives.

5. RFP processes shall be flexible and shall not include unreasonable restrictions on sizes and types of projects considered, taking into account the appropriate Grid Needs identified in a Grid Needs Assessment.

C. RELATIONSHIP TO INTEGRATED GRID PLANNING

1. The Grid Needs Assessment, presented to stakeholders and the Commission for review and comment, shall identify Grid Needs. The identified Grid Needs applicable to each electric utility shall continue to be used to set the strategic direction of resource planning by the electric utilities. In order for competitive bidding to be effectively and efficiently integrated into a utility's IGP process, stakeholders must work cooperatively to identify and adhere to appropriate timelines, which may from time to time need to be expedited.

2. This Framework is intended to complement the IGP process.

3. A determination shall be made by the Commission as to whether a competitive bidding process shall be used to acquire a System Resource or a block of System Resources that are identified as Grid Needs in the Grid Needs Assessment. Actual competitive bidding for System Resources will normally occur after the Grid Needs are identified, reviewed and accepted or approved by the Commission.

4. Integration of competitive bidding into the IGP process. The general approach to integration has four parts, in sequence:

   a. The electric utility conducts a Grid Needs Assessment, which will identify those Grid Needs for which the utility proposes and recommends to procure through competitive bidding or other mechanisms or processes, and those resources for which the utility seeks a waiver from competitive bidding.

   b. The Commission accepts, approves, modifies, or rejects the Grid Needs Assessment and the Grid Needs recommended to be acquired through this Framework.

   c. The electric utility conducts a competitive bidding process, for System Resources to meet all or a portion of the Grid Needs recommended for competitive bidding identified in the Grid Needs Assessment step of the IGP process; such competitive bidding process shall include the advance filing of a draft RFP with the Commission.

   d. The electric utility selects a winner from the bidders. But see Part II.C.6, below, concerning the process when there are no bidders worth choosing.

5. An evaluation of bids in a competitive bidding process may reveal desirable projects that were not included in the Grid Needs identified through the Grid Needs Assessment. These projects may be selected if it can be demonstrated that the project is consistent with an approved or accepted Grid Needs Assessment and that such action is expected to benefit the utility and/or its customers.

6. An evaluation of bids in a competitive bidding process may reveal that the acquisition of any of the requested System Resources in the bid will not assist the utility in fulfilling its obligations to its customers. In such a case, the utility may determine not to acquire such System Resources and shall notify the Commission accordingly.

D. MITIGATION OF RISKS ASSOCIATED WITH COMPETITIVE BIDDING

1. To carry out its competitive bidding obligations consistently with its resource sufficiency obligations, the electric utility must conduct, or consider conducting, two types of activities: self-build and contingency planning. The utility's self-build obligation is addressed in Parts VI.A.1, VI.C and VI.E, below. The electric utility's contingency planning activities are discussed in Part II.D.2 below.

2. In consideration of the isolated nature of the island utility systems, the utility may use a Contingency Plan option to address a near-term reliability or statutory need as results from an actual or expected failure of an RFP process to produce a viable project proposal, or of a project selected in an RFP. The electric utility shall use prudent electric utility practices to determine the nature, amount, and timing of the contingency planning activities and take into account (without limitation) the cost of contingency planning and the probability of third-party failure. The electric utility's Contingency Plan may differ from that proposed in the electric utility's self-build bid. For each project that is subject to competitive bidding, the electric utility shall submit a report on the cost of contingency planning upon the Commission's request.

3. The electric utility may require bidders (subject to the Commission's approval with other elements of a proposed RFP) to offer the utility the option to purchase the project under certain conditions or in the event of default by the seller (i.e., the bidder), subject to commercially reasonable payment terms.

III. ROLES IN COMPETITIVE BIDDING

A. ELECTRIC UTILITY

1. The role of the host electric utility in the competitive bidding process shall include:

    a. Designing the solicitation process, establishing evaluation criteria consistent with its overall IGP process, and specifying timelines;

b. Designing the RFP documents and proposed forms of Agreements and other contracts;

c. Implementing and managing the RFP process, including communications with bidders;

d. Evaluating the bids received;

e. Selecting the bids for negotiations based on established criteria;

f. Negotiating contracts with selected bidders;

g. Determining, where and when feasible, the interconnection facilities and transmission and distribution upgrades necessary to accommodate new System Resources;

h. Competing in the solicitation process with a self-build option at its discretion; and

i. Providing the Independent Observer with all requested information related to the relevant procurement.

2. Access to Utility Sites. The utility shall consider, on a case-by-case basis before an RFP is issued, offering at its sole discretion one or several utility-owned or controlled sites to bidders in an applicable competitive bidding process. The utility shall consider such factors as:

a. The anticipated specific non-technical terms of potential proposals.

b. The feasibility of the installation. Examples of the factors that may need to be examined in order to evaluate the feasibility of the installation may include, but are not be limited to the following:

(i) Specific physical and technical parameters of anticipated non-utility installations, such as the technology that may be installed, space and land area requirements, topographic, slope and geotechnical constraints, fuel logistics, water requirements, number of site personnel, access requirements, waste and emissions from operations, noise profile, electrical interconnection requirements, and physical profile; and

(ii) How the operation, maintenance, and construction of each installation will affect factors such as security at the site, land ownership issues, land use and permit considerations (e.g., compatibility of the proposed development with present and planned land uses), existing and new environmental permits and licenses, impact on operations and maintenance of existing and future facilities, impact to the surrounding community, change in zoning permit conditions, and safety of utility personnel.

c. The utility's anticipated future use of the site. Examples of why it may be beneficial for the utility to maintain site control may include, but are not limited to the following: (i) to ensure that System Resources can be constructed to meet system reliability requirements; (ii) to retain flexibility for the utility to perform crucial contingency planning for a utility owned option to back-up any potential unfulfilled commitments, if any, of third-party developers of System Resources; and (iii) to retain the flexibility for the utility to acquire the unique efficiency gains from expansion of existing transmission and distribution facilities or combined-cycle conversions and repowering projects of existing utility simple-cycle combustion turbines and steam fired generating facilities, respectively.

d. The effect on competitive forces of denying bidders the ability to use the site, taking into account whether the unavailability of adequate sites for non-utility bidders gives the electric utility a competitive advantage.

e. Where the utility has chosen not to offer a site to a third-party, the electric utility shall present its reasons, specific to the project and sites at issue, in writing to the Independent Observer and the Commission.

3. The utility shall submit to the Commission for review and approval

(subject to modification if necessary), a Code of Conduct described in Part IV.H.9.c, below, with the draft RFP. The utility shall follow the Code of Conduct prior to the commencement of the RFP drafting even while such Code of Conduct is pending before the Commission for review and approval.

4. The utility shall ensure third party bidders be provided the same type of information to develop proposals as is provided to those developing self-build or Affiliate-bid proposals.

B. HAWAII PUBLIC UTILITIES COMMISSION

1. The primary role of the Commission is to ensure that: (a) each competitive bidding process conducted pursuant to this Framework is fair in its design and implementation so that selection is based on the merits; (b) System Resources selected through competitive bidding processes are consistent with the Grid Needs identified in the Commission approved/accepted Grid Needs Assessment; (c) the electric utility's actions represent prudent practices; and (d) throughout the process, the utility's interests are aligned with the public interest even where the utility has dual roles as designer and participant.

2. The Commission may review, and at its option, approve or modify, each proposed RFP before it is issued, including any proposed form of contracts and other documentation that will accompany the RFP. The Commission may determine in certain applications that it may pre-approve a form RFP in lieu of approving each individual RFP. If a form RFP is approved, any modifications to such form, other than insertion of the specific Grid Needs being procured, would require approval by the Commission.

3. The Commission shall be the final arbiter of disputes that arise among parties in relation to a utility's competitive bidding process, to the extent described in Part V, below.

4. The Commission shall review, and approve or reject, the contracts that result from competitive bidding processes conducted pursuant to this Framework, in a separate docket upon application by the utility

in which the expedited process in Part III.B.7 shall not apply. In reviewing such contracts, the Commission may establish review processes that are appropriate to the specific circumstances of each solicitation, including the time constraints that apply to each commercial transaction.

5. If the utility identifies its self-build project for Grid Needs as superior to third party bid proposals, the utility shall seek Commission approval in keeping with established CIP Approval Requirements.

6. The Commission shall review any complaint that the electric utility is not complying with the Framework, pursuant to Part V.

7. Timely Commission review, approval, consent, or other action described in this Framework is essential to the efficient and effective execution of this competitive bidding process. Accordingly, to expedite Commission action in this competitive bidding process, whenever Commission review, approval, consent, or action is required under this Framework, the Commission may do so in an informal expedited process. The Commission hereby authorizes its Chair, or his or her designee (which designee, may be another Commissioner, a member of the Commission staff, Commission hearings officer, or a Commission hired consultant), in consultation with other Commissioners, Commission staff, and the Independent Observer, to take any such action on behalf of the Commission.

C. INDEPENDENT OBSERVER

1. An Independent Observer is required whenever the utility or its Affiliate seeks to advance a project proposal (i.e., in competition with those offered by bidders) in response to a need that is addressed by its RFP, or when the Commission otherwise determines. Unless otherwise determined by the Commission, an Independent Observer will monitor the competitive bidding process and will report on the progress and results to the Commission, sufficiently early so that the Commission is able to address any defects and allow competitive bidding to occur in time to meet the utility's Grid Needs. Any interaction between a utility and bidder, including a utility's self-build team or Affiliate during the course of a solicitation process, beginning with the preparation of the

RFP, shall be closely monitored by the Independent Observer. Specific tasks to be performed by the Independent Observer shall be identified by the utility in its proposed RFP and as may be required by the Commission.

2. Independent Observer obligations. The Independent Observer will have duties and obligations in two areas: Advisory and Monitoring.

a. Advisory. The Independent Observer shall:

(i) Certify to the Commission that at each of the following steps, the electric utility's judgments created no unearned advantage for any bidder, or, when applicable, the electric utility or any Affiliate:

(1) Pre-qualification criteria;
(2) RFP;
(3) Model Agreements to be attached to the RFP;
(4) Selection criteria;
(5) Evaluation of bids;
(6) Final decision to purchase System Resources or proceed with self-build option when applicable; and
(7) Negotiation of contracts.

(ii) Advise the electric utility on its decision-making during, and with respect to, each of the electric utility's actions listed in the preceding item;

(iii) Review stakeholder comments submitted in response to draft RFP and model Agreements and advise the utility on the consideration of proposed changes that may improve the process or results of the RFP;

(iv) Report immediately to the electric utility's executive in charge of ensuring compliance with this Framework, and the Commission, any deviations from the Framework or violations of any procurement rules;

(v) After the electric utility's procurement selection is completed, provide the Commission with:

(1) An overall assessment of whether the goals of the RFP were achieved, such goals to include without limitation the attraction of a sufficient number of bidders and the elimination of actual or perceived utility favoritism for its own or an Affiliate's project; and

(2) Recommendations for improving future competitive bidding processes.

(vi) Be available to the Commission as a witness if required to evaluate a complaint filed against an electric utility for non-compliance with this Framework, or if required in a future regulatory proceeding if questions of prudence arise.

b. Monitoring. The Independent Observer shall:

(i) Monitor all steps in a competitive bidding process, beginning upon Commission's approval or acceptance of the Grid Needs Assessment;

(ii) Monitor communications (and communications protocols) with bidders;

(iii) Monitor adherence to Codes of Conduct;

(iv) Monitor contract negotiations with bidders;

(v) Monitor all interactions between the electric utility and any bidder during all events affecting a solicitation process; and

(vi) Report to the Commission on monitoring results during each stage of the competitive process sufficiently early so that the Commission can correct defects or eliminate uncertainties without endangering project milestones.

3. The Independent Observer shall have no decision-making authority, and no obligation to resolve disputes, but may offer to mediate between disputing parties.

4. The Independent Observer shall provide comments and recommendations to the Commission, at the Commission's request, to assist in resolving disputes or in making any required determinations under this Framework.

5. Independent Observer qualifications. The Independent Observer shall be qualified for the tasks the observer must perform. Specifically, the Independent Observer shall:

   a. Be knowledgeable about, or be able rapidly to absorb knowledge about, any unique characteristics and needs of the electric utility;

   b. Be knowledgeable about the characteristics and needs of small, non-interconnected island electric grids, and be aware of the unique challenges and operational requirements of such systems;

   c. Have the necessary experience and familiarity with utility modeling capability, transmission and/or distribution system planning, operational characteristics, and other factors that affect project selection;

   d. Have a working knowledge of common operational, technical and contract terms applicable to System Resources as well as appropriate contract negotiation processes applicable to System Resource procurement;

   e. Be able to work effectively with the electric utility, the Commission, and its staff during the bid process; and

   f. Demonstrate impartiality.

6. Selection and contracting. The electric utility or the Commission shall: (a) identify qualified candidates for the role of Independent Observer (and also shall consider qualified candidates identified by prospective participants in the competitive bidding process); (b) seek Commission

and electric utility approval of the final list of qualified candidates; and (c) select an Independent Observer from among the final list of qualified candidates. The contract with the Independent Observer shall be acceptable to the electric utility and the Commission, and provide, among other matters, that the Independent Observer: (a) report to the Commission and carry out such tasks as directed by the Commission, including the tasks described in this Framework; (b) cannot be terminated and payment cannot be withheld without the consent of the Commission; and (c) can be terminated by the Commission without the utility's consent, if the Commission deems it to be in the public interest in the furtherance of the objectives of this Framework to do so. In the event the electric utility contracts with the Independent Observer, the utility is allowed to defer prudently incurred Independent Observer costs (included in a deferred debit account), and the balance would be amortized to expense over five years (or a reasonable period determined by the Commission), beginning when rates that reflect such costs are effective (when a separate cost recovery mechanism is effective, or interim or final rates in a general rate case). Carrying charges, based on the utility’s allowance for funds used during construction (“AFUDC”) rate, would apply monthly for the cost in the deferred debit account and included in the deferred debit account until the onset of amortization. The amortization expense would be included in the utility revenue requirement and the unamortized balance would be included in rate base when there is a general rate case. In the event that a general rate case is replaced by another Commission approved regulatory process or mechanism, the utility may recover prudently incurred Independent Observer costs upon Commission approval through the Commission approved regulatory process or mechanism. Subject to Commission approval, the utility may also recover such costs through the major project interim recovery (“MPIR”) adjustment mechanism, Exceptional Project Recovery Mechanism (“EPRM”), renewable energy infrastructure program (“REIP”) surcharge or other recovery mechanism until such costs are recovered through effective rates approved in a rate case or other Commission approved regulatory process or mechanism.

7. As part of the RFP design process, the utility shall develop procedures to be included in the RFP by which any participant in the competitive bidding process may present to the Commission, for review and resolution, positions that differ from those of the Independent Observer

(i.e., in the event the Independent Observer makes any representations to the Commission upon which the participant does not agree).

IV. THE REQUEST FOR PROPOSALS PROCESS

A. GENERAL

1. Competitive bidding shall be structured and implemented in a way that facilitates an electric utility's acquisition of System Resources identified in a utility's Grid Needs Assessment. Direct costs and benefits incurred or received by the utility and its customers shall be taken into account in the bid evaluation and selection process.

2. Competitive bidding shall be structured and implemented in a flexible and efficient manner that promotes electric utility system reliability by facilitating the timely acquisition of needed System Resources and allowing the utility to adjust to changes in circumstances.

   a. The implementation of competitive bidding cannot be allowed to negatively impact reliability of the electric utility system.

   b. The System Resources acquired under a competitive bidding process must meet the needs of the utility in terms of the reliability of the System Resources, the characteristics of the System Resources required by the utility, and the control the utility needs to exercise over operation and maintenance in order to minimize system integration concerns.

3. The competitive bidding process shall ensure that proposals and bidders are judged on the merits, without being unduly burdensome to the electric utilities or the Commission.

   a. The competitive bidding process shall include an RFP and supporting documentation by which the utility sets forth the requirements to be fulfilled by bidders and describes the process by which it will: (i) conduct its solicitation; (ii) obtain consistent and accurate information on which to evaluate bids; (iii) implement a consistent and equitable evaluation process;

and (iv) systematically document its determinations. The RFP shall also describe the role of the Independent Observer and bidders' opportunities for challenges and for dispute resolution.

b. When a utility advances its own project proposal (i.e., in competition with those offered by bidders) or accepts a bid from an Affiliate, the utility shall take all reasonable steps, including any steps required by the Commission, to mitigate concerns over an unfair or unearned competitive advantage that may exist or reasonably be perceived by other bidders or stakeholders.

4. If a Provider or Affiliate proposal is selected as a result of the RFP process, one or more contracts are the expected result. Proposed forms of Agreements and other contracts that may result from the RFP process shall be included with each RFP. The RFP shall specify whether any opportunity exists to propose or negotiate changes to the proposed form of Agreement or contract.

B. DESIGN OF THE COMPETITIVE BIDDING SOLICITATION PROCESS

1. The competitive bidding solicitation process shall include the following:

   a. Design of the RFP and supporting documents;

   b. Issuance of the draft and final RFP;

   c. Development and submission of proposals by bidders;

   d. A "multi-stage evaluation process" to reduce bids down to a short list and/or "award group" as appropriate for a particular RFP (i.e., a process that may include, without limitation: (i) receipt of the proposals; (ii) completeness check; (iii) threshold or minimum requirements evaluation; (iv) initial evaluation including price screen/non-price assessment; (v) selection of a short list; (vi) detailed evaluation or portfolio development; and

(vii) selection of final award group for contract negotiation);

e. Contract negotiations (when a third-party bid is selected); and

f. Commission approval of any resulting contract or selected self-build project, if required by the Commission.

2. The RFP shall identify any unique system requirements and provide information regarding the requirements of the utility, important resource attributes, desired options and criteria used for the evaluation. For example, if the utility values dispatchability or operating flexibility, the RFP shall:
(a) request that a bidder offer such an option; and (b) explain how the utility will evaluate the impacts of dispatchability or operational flexibility in the bid evaluation process.

3. The RFP (including the response package, proposed forms of Agreements and other contracts) shall describe the bidding guidelines, the bidding requirements to guide bidders in preparing and submitting their proposals, the general bid evaluation and selection criteria, the risk factors important to the utility, and, to the extent practicable, the schedule for all steps in the bidding process.

4. The utility may charge bidders a reasonable fee, to be reviewed by the Independent Observer, for participating in the RFP process.

5. Other Content of RFP. The RFP shall also contain:

a. The circumstances under which an electric utility and/or its Affiliates may participate;

b. An explanation of the procedures by which any person may present to the Commission positions that differ from those of the Independent Observer; and

c. A statement that if disputes arise under this Framework, the dispute resolution process established in this Framework will control.

6. The process leading to the distribution of the RFP shall include the following steps (each step to be monitored and reported on by the Independent Observer), unless the Commission modifies this process for a particular competitive bid:

   a. The utility designs a draft RFP, then files its draft RFP and supporting documentation with the Commission;

   b. The Commission holds a status conference, where the utility presents the details of the RFP and interested parties (which may include potential bidders) are provided the opportunity to ask questions regarding the draft RFP;

   c. Interested parties submit comments on the draft RFP to the utility and the Commission;

   d. The utility determines, with advice from the Independent Observer, whether and how to incorporate recommendations from interested parties in the draft RFP;

   e. The utility submits its final, proposed RFP to the Commission for its review and approval (and modification if necessary) according to the following procedure:

      (i) The Independent Observer shall submit its comments and recommendations to the Commission concerning the RFP and all attachments, simultaneously with the electric utility's proposed RFP.

      (ii) The utility shall have the right to issue the RFP if the Commission does not direct the utility to do otherwise within thirty (30) days after the Commission receives the proposed RFP and the Independent Observer's comments and recommendations.

7. A pre-qualification requirement is a requirement that a bidder must satisfy to be eligible to bid. A pre-qualification process may be incorporated in the design of some bidding processes, depending on the specific circumstances of the utility and its resource needs.

Any pre-qualification requirements shall apply equally to independent bidders, the electric utility's self-build bid, and the bid of any utility's Affiliate.

8. As part of the RFP design process, the utility shall develop and specify the type and form of threshold criteria that will apply to all bidders, including the utility's self-build proposals. Examples of potential threshold criteria include requirements that bidders have site control, maintain a specified credit rating, and demonstrate that their proposed technologies are mature.

9. The RFP design process shall address credit requirements and security provisions, which apply to: (a) the qualification of bidders; and (b) bid evaluation processes.

10. The utility shall have the discretion to modify the RFP or solicit additional bids from bidders after reviewing the initial bids, provided that such discretion is clearly identified in the RFP and any modification is reviewed by the Independent Observer and submitted to the Commission along with the Independent Observer's comments. The electric utility may issue the modified RFP thirty (30) days after the Commission has received these materials, unless the Commission directs otherwise.

11. All involved parties shall plan, collaborate, and endeavor to issue the final RFP within ninety (90) days from the date the electric utility submits the draft RFP to the Commission.

C. FORMS OF CONTRACTS

1. The RFP shall include proposed forms of Agreements and other contracts, with commercially reasonable terms and conditions that properly allocate risks among the contracting parties in light of circumstances. The terms and conditions of the contracts shall be specified to the extent practical, so that bidders are aware of, among other things, performance requirements, pricing options, key provisions that affect risk allocation (including those identified in sub-paragraph 2 below), and provisions that may be subject to negotiation. Where

contract provisions are not finalized or provided in advance of RFP issuance (e.g., because certain contract provisions must reflect features of the winning bidder's proposal such as technology or location), the RFP shall so indicate.

2. The provisions of a proposed contract shall address matters such as the following (unless inapplicable): (a) reasonable credit assurance and security requirements appropriate to an island system that reasonably compensates the utility and its customers if the project sponsor fails to perform; (b) contract buyout and project acquisition provisions; (c) in-service date delay and acceleration provisions; and (d) liquidated damage provisions that reflect risks to the utility and its customers.

3. The RFP shall specify which terms in the proposed forms of contract, if any, are not subject to negotiation or alternative proposals, subject to approval of the RFP by the Commission. Bidders may submit alternative language as part of their bids, provided that any such variation is not inconsistent with any identified Grid Needs.

D. ISSUANCE OF THE RFP AND DEVELOPMENT OF PROPOSALS

1. Each electric utility shall take steps to provide notice of its RFPs to, and encourage participation from, the full community of prospective bidders.

2. Bidders may be required to submit a "notice of intent to bid" to the electric utility.

3. The electric utility shall develop and implement a formal process to respond to bidders' questions.

4. The electric utility may conduct a bidders' conference.

5. The electric utility shall provide bidders with access to information through a website where it can post documents and information.

6. The process shall require all third-party bids to be submitted by the deadline specified in the RFP, except that the utility’s self-build bid shall be submitted one day in advance.

7. Bids may be deemed non-conforming if they do not meet the RFP requirements or provide all of the material information requested in an RFP. At the utility's discretion, in consultation with the Independent Observer, the utility may elect to: (i) consider a non-conforming bid as eligible in the RFP provided it is not inconsistent with any identified Grid Needs; (ii) give proposals that are non-conforming additional time to remedy their non-conformity; or (iii) decline to consider any bid that is non-conforming.

E. BID EVALUATION / SELECTION CRITERIA

1. The utility, monitored by the Independent Observer, shall compare bids received.

2. The evaluation criteria and the respective weight or consideration given to each such criterion in the bid evaluation process may vary from one RFP to another.

3. The bid evaluation process shall include consideration of differences between bidders with respect to proposed contract provisions, and differences in anticipated compliance with such provisions, including but not limited to provisions intended to ensure:

    a. System Resource and electric system reliability;

    b. Appropriate risk allocations;

    c. Counter-party creditworthiness; and

    d. Bidder qualification.

4. Proposals shall be evaluated based on a consistent and reasonable set of economic and fuel price assumptions, to be specified in the RFP.

5. Both price and non-price evaluation criteria, shall be described in the RFP, and shall be considered in evaluating proposals.

6. In evaluating competing proposals, all relevant incremental costs to the

electric utility and its customers shall be considered. These may include transmission costs, distribution costs and system impacts, and the reasonably foreseeable balance sheet and related financial impacts of competing proposals.

7. The impact of service(s) from System Resources that a utility already has on its system, in terms of reliability and dispatchability, and the impacts that increasing the amount of service(s) from new System Resources may have, in terms of reliability and dispatchability, shall be taken into account in the bid evaluation. The RFP shall specify the methodology for considering this effect. Such methodology shall not cause double-counting with the financial effects discussed in sub-paragraph 6, above, and sub-paragraph 8, below.

8. The impact of System Resource costs on the utility's balance sheets, and the potential for resulting utility credit downgrades (and higher borrowing costs), may be accounted for in the bid evaluation. Where the utility has to restructure its balance sheet and increase the percentage of more costly equity financing in order to offset the impacts of purchasing service(s) from a third party owned System Resource on its balance sheet, this rebalancing cost shall also be taken into account in evaluating the total cost of a proposal for a new System Resource if third party owned, and it may be a requirement that bidders provide all information necessary to complete these evaluations. The RFP shall describe the methodology for considering financial effects.

9. The type and form of non-price threshold criteria shall be identified in the RFP. Such threshold criteria may include, among other criteria, the following:

    a. Project development feasibility criteria (e.g., siting status, ability to finance, environmental permitting status, commercial operation date certainty, engineering design, fuel supply status, bidder experience, participant acquisition strategy, conformance with utility information assurance and security policies and reliability of the technology);

    b. Project operational viability criteria (e.g., operation and maintenance plan, financial strength, environmental compliance, and environmental impact);

c. Operating profile criteria (e.g., dispatching and scheduling, coordination of maintenance, operating profile such as ramp rates, and quick start capability); and

d. Flexibility criteria (e.g., in-service date flexibility, expansion capability, contract term, contract buy-out options, fuel flexibility, and stability of the price proposal).

10. The weights for each non-price criterion shall be fully specified by the utility in advance of the submission of bids, as they may be based on an iterative process that takes into account the relative importance of each criterion given system needs and circumstances in the context of a particular RFP. The Commission, however, may approve of less than full specification prior to issuance of the RFP. Since the subjectivity inherent in non-price criteria creates risk of bias and diminution in bidders' trust of the process, the RFP must specify likely areas of non-price evaluation, and the evaluation process must be closely monitored and publicly reported on by the Independent Observer.

F. EVALUATION OF THE BIDS

1. The evaluation and selection process shall be identified in the RFP, and may vary based on the scope of the RFP. In some RFP processes, a multi-stage evaluation process may be appropriate.

2. The electric utility shall document the evaluation and selection process for each RFP process for review by the Commission in approving the outcome of the process (i.e., in approving an Agreement or a utility self-build proposal).

3. A detailed system evaluation process, which uses models and methodologies that are consistent with those used in the utility's Grid Needs Assessment, may be used to evaluate bids. In anticipation of such evaluation processes, the RFP shall specify the data required of bidders.

G. CONTRACT NEGOTIATIONS

1. There may be opportunities to negotiate price and non-price terms to enhance the value of the contract for the bidder, the utility, and its customers. Negotiations shall be monitored and reported upon by the Independent Observer.
2. The electric utility may use competitive negotiations among short-listed bidders.

H. FAIRNESS PROVISIONS AND TRANSPARENCY

1. The competitive bidding process shall judge all bidders on the merits only.

2. During the bidding process, the electric utility shall treat all bidders, including any utility Affiliate, the same in terms of access to information, time of receipt of information, and response to questions.

3. A "closed bidding process" is generally anticipated, rather than an "open bidding process." Under one type of closed bidding process, bidders are informed through the RFP of: (a) the process that will be used to evaluate and select proposals; (b) the general bid evaluation and selection criteria; and (c) the proposed forms of Agreements and other contracts. However, bidders shall not have access to the utility's bid evaluation models, the detailed criteria used to evaluate bids, or information contained in proposals submitted by other bidders.

4. If the electric utility chooses to use a closed process:

   a. The utility shall provide the Independent Observer, if an Independent Observer is required, with all the necessary information to allow the Independent Observer to understand the model and to enable the Independent Observer to observe the entire analysis in order to ensure a fair process; and

   b. After the utility has selected a bidder, the utility shall meet with the losing bidder or bidders to provide a general assessment of the losing bidder's specific proposal if requested by the losing bidder within seven (7) days of the selection.

5. The host electric utility shall be allowed to consider its own self-bid proposals in response to Grid Needs identified in its RFP.

6. Procedures shall be developed by the utility prior to the initiation of the bidding process to define the roles of the members of its various project teams, to outline communications processes with bidders, and to address confidentiality of the information provided by bidders. Such procedures shall be submitted in advance to the Independent Observer and the Commission for comment.

7. If the IGP process indicates that a competitive bidding process will be used to acquire a System Resource or a block of System Resources to meet all or a portion of the Grid Needs, then the utility will indicate, in the submittal of its draft RFP to the Commission for review, which of the RFP process guidelines will be followed, the reasons why other guidelines will not be followed in whole or in part, and other process steps proposed based on good solicitation practice; provided that the Commission may require that other process steps be followed.

8. If proposed, utility self-build projects or other utility-owned projects, or projects owned by an Affiliate of the host utility, are to be compared against third party proposals obtained through an RFP process. The Independent Observer shall monitor the utility's conduct of its RFP process, advise the utility if there are any fairness issues, and report to the Commission at various steps of the process, to the extent prescribed by the Commission. Specific tasks to be performed by the Independent Observer shall be identified by the utility in its proposed RFP submitted to the Commission for approval. The Independent Observer will review and track the utility's execution of the RFP process to ascertain that no undue preference is given to an Affiliate, the Affiliate's bid, or to self-build or other utility-owned facilities. The Independent Observer's review shall include, to the extent the Commission or the Independent Observer deems necessary, each of the following steps, in addition to any steps the Commission or Independent Observer may add: (a) reviewing the draft RFP and the utility's evaluation of bids, monitoring

communications (and communications protocols) with bidders; (b) monitoring adherence to codes of conduct, and monitoring contract negotiations with bidders; (c) assessing the utility's evaluation of Affiliate bids, and self-build or other utility-owned projects; and (d) assessing the utility's evaluation of an appropriate number of other bids. The utility shall provide the Independent Observer with all requested information. Such information may include, without limitation, the utility's evaluation of the unique risks and advantages associated with the utility self-build or other utility-owned projects, including the regulatory treatment of construction cost variances (both underages and overages) and costs related to equipment performance, contract terms offered to or required of bidders that affect the allocation of risks, and other risks and advantages of utility self-build or other utility-owned projects to consumers. The Independent Observer may validate the criteria used to evaluate Affiliate bids and self-build or other utility-owned facilities, and the evaluation of Affiliate bids and self-build or other utility-owned facilities. In order to accomplish these tasks, the utility, in conjunction with the Independent Observer, shall propose methods for making fair comparisons (considering both cost and risks) between the utility-owned or self-build facilities and third-party facilities.

9. Where the electric utility is responding to its own RFP, or is accepting bids submitted by its Affiliates, the utility will take additional steps to avoid self-dealing in both fact and perception.

   a. The following tasks shall be completed as a matter of course (i.e., regardless of whether the utility or its Affiliate is seeking to advance a proposal), including: (i) the utility shall develop all bid evaluation criteria, bid selection guidelines, and the quantitative evaluation models and other information necessary for evaluation of bids prior to issuance of the RFP; (ii) the utility shall establish a website for disseminating information to all bidders at the same time; and (iii) the utility shall develop and follow a Procedures Manual, which describes: (1) the protocols for communicating with bidders, the self-build team, and others; (2) the evaluation process in detail and the methodologies for undertaking the evaluation process; (3) the documentation forms, including logs for any communications with bidders; and (4) other information consistent with the requirements of the solicitation process.

b. The following tasks shall be completed whenever the utility is seeking to advance a System Resource proposal, including: (i) the utility shall submit its self-build bid one day in advance of the deadline specified in the RFP, and provide substantially the same information in its proposal as other bidders; (ii) the utility shall follow the Code of Conduct; and (iii) the utility shall implement appropriate confidentiality agreements prior to the issuance of the RFP to guide the roles and responsibilities of utility personnel.

c. The Code of Conduct shall be signed by each utility employee involved either in advancing the self-build project or implementing the competitive bidding process, and shall require that:

(i) Whenever staffing and resources permit, the electric utility shall establish internally a separate project team to undertake the evaluation, with no team member having any involvement with the utility self-build option;

(ii) During the RFP design and bid evaluation process, there shall be no oral or written contacts between the employees preparing the bid and the electric utility's employees responsible for bid evaluation, other than contacts authorized by the Code of Conduct and the RFP;

(iii) Throughout the bidding process, the electric utility shall treat all bidders, including its self-build bid and any electric utility Affiliate, the same in terms of access to information, time of receipt of information, and response to questions.

d. A company officer, identified to the Independent Observer and the Commission, shall have the written authority and obligation to enforce the Code of Conduct. Such officer shall certify, by affidavit, Code of Conduct compliance by all employees after each competitive process ends.

e. Further steps may be considered, as appropriate, or ordered by the Commission.

10. Where the utility seeks to advance its proposed facilities in addition to, or instead of other developers' bids in its RFP, its proposal must satisfy all the criteria applicable to non-utility bidders, including but not limited to providing all material information required by the RFP, and being capable of implementation.

11. Bids submitted by Affiliates shall be held to the same contractual and other standards as projects advanced by other bidders.

I. TRANSMISSION INTERCONNECTION AND UPGRADES

1. A winning bidder has the right to interconnect its System Resource to the electric utility's transmission and distribution system, and to have that transmission and distribution upgraded as necessary to accommodate the output of its System Resource.

2. With respect to procedures and methodologies for:

   a. Designing interconnections;

   b. Allocating the cost of interconnections;

   c. Scheduling and carrying out the physical implementation of interconnections;

   d. Identifying the need for transmission and distribution upgrades;

   e. Allocating the cost of transmission and distribution upgrades; and

   f. Scheduling and carrying out the physical implementation of transmission and distribution upgrades;

   the electric utility shall treat all bidders, including its own bid and that of any Affiliate, in a comparable manner.

3. Upon the request of a prospective bidder, the electric utility shall

provide general information about the possible interconnection and transmission and distribution upgrade costs associated with project locations under consideration by the bidder.

4. To ensure comparable treatment, the Independent Observer shall review and monitor the electric utility's policies, methods and implementation and report to the Commission.

V. DISPUTE RESOLUTION PROCESS

The Commission will serve as an arbiter of last resort, after the utility, Independent Observer, and bidders have attempted to resolve any dispute or pending issue. The Commission will use an informal expedited process to resolve the dispute within thirty (30) days, as described in Part III.B.7. There shall be no right to hearing or appeal from this informal expedited dispute resolution process. The Commission encourages affected parties to seek to work cooperatively to resolve any dispute or pending issue, perhaps with the assistance of an Independent Observer, who may offer to mediate but who has no decision-making authority. The utility and Independent Observer shall conduct informational meetings with the Commission and Consumer Advocate to keep each apprised of issues that arise between or among the parties.

VI. PARTICIPATION BY THE HOST UTILITY

A. Where the electric utility is addressing a system reliability issue or statutory requirement, the utility shall develop one or more project proposals that are responsive to the System Resource need identified in the RFP.

B. If the utility opts not to propose its own project, the utility shall request and obtain the Commission's approval. In making this request, the utility shall demonstrate why relying on the market to provide the needed resource is prudent.

C. Where the RFP process has as its focus something other than a reliability-based need, the utility may choose (or decline) to advance its own project proposal.

D. If the RFP process results in the selection of non-utility (or third-party) projects to meet a system reliability need or statutory requirement, the utility shall develop and periodically update a Contingency Plan to address the risk that the third-party projects may be delayed or not completed. In this situation, the electric utility shall separately submit, to the extent practical, a description of such activities and a schedule for carrying them out. Such description shall be updated as appropriate.

1. The plans may include the identification of milestones for such projects, and possible steps to be taken if the milestones are not met.
2. Pursuant to the plans, it may be appropriate for the utility to proceed to develop a utility-owned project or projects until such action can no longer be justified as reasonable. The utility-owned project(s) may differ from the project(s) advanced by the utility in the RFP process, or the resource(s) identified in its Grid Needs Assessment.
3. The contracts developed for the RFP process to acquire third-party resources shall include commercially reasonable provisions that address delays or non-completion of third-party projects, such as provisions that identify milestones for the projects, seller (i.e., bidder) obligations, and utility remedies if the milestones are not met, and may include provisions to provide the utility with the option to purchase the project under certain circumstances or events of default by the seller (i.e., the bidder).

E. A utility may submit more than one proposal or may supply options for a specific proposal as dictated by the RFP needs, such as submitting variations of a proposal and/or offering options in a proposal.

VII. RATEMAKING

A. The costs that an electric utility reasonably and prudently incurs in designing and administering its competitive bidding processes are recoverable through rates to the extent reasonable and prudent.

B. The costs that an electric utility incurs in taking reasonable and prudent steps to implement Contingency Plans are recoverable through the utility's rates, to the extent reasonable and prudent, as part of the cost of providing reliable service to customers.

C. The reasonable and prudent capital costs that are part of an electric utility's Contingency Plans shall be accounted for similar to costs for planning other capital projects (provided that such accounting treatment shall not be determinative of ratemaking treatment):

1. Such costs would be accumulated as construction work in progress, and AFUDC would accrue on such costs. If the Contingency Plans, as implemented, result in the addition of planned resources to the utility system, then the costs incurred and related AFUDC would be capitalized as part of the installed resources (i.e., recorded to plant-in-service) and added to rate base. The costs would be depreciated over the life of the resource addition.

2. If implementation of the Contingency Plans is terminated before the resources identified in such plans are placed into service, the costs incurred and related AFUDC included in construction work in progress would be transferred to a miscellaneous deferred debit account and the balance would be amortized to expense over five years (or a reasonable period determined by the Commission), beginning when rates that reflect such amortization expense are effective (when a separate cost recovery mechanism is effective, or interim or final rates in a general rate case). Carrying charges, based on the AFUDC rate, would apply monthly for the costs in the miscellaneous deferred debit account and included in the miscellaneous deferred debit account until the onset of amortization. The amortization expense would be included in the utility's revenue requirement and the unamortized balance would be included in the utility’s rate base. In the event that a general rate case is replaced by another Commission approved regulatory process or mechanism, the utility may recover prudently incurred costs of the Contingency Plans upon Commission approval through the Commission approved regulatory process or mechanism. Subject to Commission approval, the utility may also recover such costs through the EPRM or MPIR adjustment mechanism, REIP surcharge or other recovery mechanism until such costs are recovered

through effective rates approved in a rate case or other Commission approved regulatory process or mechanism.

D. The regulatory treatment of utility-owned or self-build projects will be cost-based, consistent with traditional cost-of-service ratemaking, wherein prudently incurred capital costs including associated AFUDC and/or carrying costs are included in rate base; provided that the evaluation of the utility's bid must account for the possibility that the operational costs actually incurred, and recovered from customers, over the project's lifetime, will vary from the levels assumed in the utility's bid. The utility will not, however, be allowed to recover any capital costs that exceed the bid amount. Any utility-owned project selected pursuant to the RFP process will remain subject to prudence review in a subsequent rate proceeding with respect to the utility's obligation to prudently implement, construct or manage the project consistent with the objective of providing reliable service at the lowest reasonable cost. Subject to Commission approval, the utility-owned or self-build project costs, including operations and maintenance expenses, deferred costs, and taxes, may also be recovered through the EPRM or MPIR adjustment mechanism, REIP surcharge or other recovery mechanism, until such costs are recovered in base rates.

VIII. QUALIFYING FACILITIES

A. For any resource to which the competitive bidding requirement does not apply (due to waiver or exemption), the utility retains its traditional obligation to offer to purchase capacity and energy from a QF at avoided cost upon reasonable terms and conditions approved by the Commission.

B. For any resource to which the competitive bidding requirement does apply, the utility shall apply to the commission to waive or modify the time periods described in Hawaii Administrative Rules § 6-74-IS(c) (1998) for the utility to negotiate with a QF pursuant to the applicable provisions of Hawaii Administrative Rules § 6-74-IS(c) (1998), and upon approval of the Commission, the utility's obligation to negotiate with a QF shall be deferred pending completion of the competitive bidding process.

1. If a non-QF is the winning bidder:

a. A QF will have no PURPA right to supply the resource provided by a non-QF winning bidder.

b. If a non-QF winner does not supply all the capacity needed by the utility, or if a need develops between RFPs that will not be satisfied by an RFP due to a waiver or exemption, a QF, upon submitting a viable offer, is permitted to exercise its PURPA rights to sell at avoided cost. The Commission's determination of avoided cost will be bounded by the price level established by the winning non-QF.

2. Where the winning bidder is the utility's self-build option, a QF will not have a PURPA right to supply the resource provided by the utility's self-build option.

3. If a QF is the winning bidder, the QF has the right to sell to the electric utility at its bid price, unless the price is modified in the contract negotiations that are part of the bidding process.