Report on Resilience Investments

Executive Summary

Hawaiian Electric has notable experience developing programs targeted at increasing grid resilience, in line with resilience objectives defined by the GRIP FOA. The most notable of these past and existing programs are the company's wood pole replacement and underground cable replacement programs that are designed to ensure transmission and distribution infrastructure is proactively replaced to better manage the overall asset population. While these programs have been the historic cornerstone of the company's approach to grid resiliency, Hawaiian Electric has been evolving its approach to enable smarter grid resilience solutions (e.g., field devices, grid modernization programs) and further engage community stakeholders through initiatives such as the Resilience Working Group and Ko'olaupoko Resiliency Initiative. Community engagement will continue to be a critical part of Hawaiian Electric's current and future approach to resiliency, as exemplified by the company's microgrid mapping efforts. The proposed "Climate Adaptation Resilience Program" that the company is applying for GRIP funding will potentially be a significant addition to Hawaiian Electric's future approach to initiative given its comprehensive approach to overall system resiliency and complement its future targeted black-start development initiatives.

Overview of Hawaiian Electric's Historic Resiliency Efforts

Traditionally, Hawaiian Electric's wood pole replacement and underground cable replacement programs have made up the majority of the company's efforts regarding grid resiliency. These proactive replacements of aging T&D infrastructure allow Hawaiian Electric to better manage the risk of poles and wires failing during severe events and causing severe outages. Hawaiian Electric has also engaged in some targeted effort towards wildfire risk mitigation and reducing the risk of asset failures along highway crossings. Further information on these programs can be found below:

Wildfire Mitigation

Estimated Cost: $1,287,400

In 2019, Hawaiian Electric began conducting inspections of wildfire risk areas (e.g., "fly-by" inspections, field visits, etc.) to identify issues and potential mitigation actions.

Based on these inspections, Hawaiian Electric has started making investments in system hardening (e.g., addressing conductor sag, tension, and clearance issues; upgrading poles and structures; replacing single-strand copper conductor; installing reclosers) and situational awareness (e.g., weather stations, video cameras, secondary line monitoring devices with smoke detectors, fault current indicators with communications) to prevent utility-caused wildfires and enable quicker fire response.

The following areas have projects completed or currently in progress: West O'ahu, East Honolulu, Kapolei, and 'Aikahi-Mōkapu (on O'ahu); Waikoloa Village (on Hawai'i Island); and West Maui (in Maui County).

A summary of costs incurred for wildfire mitigation for years 2020 thru 2022 is shown in the table below:

	2020 ($K)	2021 ($K)	2022 ($K)	Total ($K)
O'ahu	$106.5	$596.1	$235.8	$938.4
Hawai'i Island	$0	$100.1	$5.0	$105.1
Maui County	$2.6	$67.4	$173.9	$243.9

Wood Pole Replacement Program

Estimated Cost: $106.5M (includes other utility pole infrastructure work)

Non-conforming wood poles identified during inspections were proactively replaced. Additionally, each operating area's asset strategy included a recommendation to proactively replace wood poles above a certain age to better manage the asset population over time. The asset strategies for O'ahu, Maui County, and Hawai'i Island recommended the proactive replacement of wood poles over the age of 75 years, 65 years, and 60 years, respectively. Since 2020, Hawaiian Electric has replaced an average of about 1,570 poles per year through 2022.

The table below provides a summary of costs that include wood pole replacements for 2020-2022. For 2020-2021, the costs shown also include capital upgrades such as insulators, crossarms, service transformers, and replacements of non-wood poles, while 2022 includes only wood pole replacements:

	2020 ($M)	2021 ($M)	2022 ($M)	Total ($M)
O'ahu	$19.6	$17.1	$14.2	$50.9
Hawai'i Island	$16.2	$4.4	$2.9	$23.5
Maui County	$13.8	$11.0	$7.2	$32.0

Underground Cable Replacement Program

Estimated Cost: $45.8M

Hawaiian Electric's underground cable replacements included corrective and preventive primary cable in conduit and direct buried cable replacements and included the replacement of all remaining direct buried cable on each system programmatically. From 2020-2022, Hawaiian Electric has spent an average of $15.3M per year to replace an average of 30.2 combined miles of primary cable in conduit and direct buried cable.

A summary of costs incurred for underground cable replacements for years 2020 thru 2022 is shown in the table below:

	2020 ($M)	2021 ($M)	2022 ($M)	Total ($M)
O‘ahu	$15.4	$10.8	$5.4	$31.6
Hawai‘i Island	$2.9	$5.4	$1.5	$9.8
Maui County	$3.8	$0.4	$0.3	$4.5

138 kV Structure Replacements

Estimated Cost: $43.7M

Historically, Hawaiian Electric replaced non-conforming 138 kV structures that were identified during inspections and, depending on the circuit criticality, proactively replaced wood pole structures that reached an age of 50-60 years. Annual 138 kV structure replacements have ramped up since 2013, the asset sustainment program’s inception. From 2020-2022, Hawaiian Electric spent nearly $44M to replace seventy-two 138 kV structures.

A summary of costs incurred for 138kV structure replacements for years 2020 thru 2022 is shown in the table below:

	2020 ($M)	2021 ($M)	2022 ($M)	Total ($M)
O‘ahu	$17.4	$10.2	$16.1	$43.7

O‘ahu Highway Crossings

Estimated Cost: $1,295,500

Hawaiian Electric’s historical approach to hardening highway crossings has been focused on the island of O‘ahu. The purpose of this work was to harden the 46 kV and 12 kV highway crossings at major freeways and highways, and to meet minimum strength requirements as prescribed by the 2002 NESC for Grade B crossing structures and for a change in the grade of construction. The scope of this work was limited to wood pole crossings and prioritized limited-access roadways.

A summary of costs incurred for O‘ahu highway crossing for years 2020 thru 2022 is shown in the table below:

	2020 ($K)	2021 ($K)	2022 ($K)	Total ($K)
O‘ahu	$652.0	$220.0	$423.5	$1,295.5

Overview of Hawaiian Electric's Current Resiliency Efforts

While wood pole replacement and underground cable replacement programs continue to be the cornerstone of Hawaiian Electric's resiliency efforts, the company has evolved its practices to incorporate new smart technologies and engage local stakeholders. Through the development of the Resilience Working Group (RWG) and Ko'olaupoko Resiliency Initiative, Hawaiian Electric has been gathering community feedback on electric resilience needs and has been using this engagement process to develop new programs. The field devices that are deployed through the company's reliability and grid modernization programs incorporate smarter more intelligent solutions to better manage the grid and potential outages during both severe events and blue-sky conditions. However, one of the biggest pushes in resiliency has been Hawaiian Electric's microgrid developments. Microgrids can play a key role in maintaining electric resiliency given the isolated nature of the populations amongst the different islands that make up the company's service territory. Hawaiian Electric is in the progress of reaching out to stakeholders to identify areas of greatest needs and has already implemented a microgrid services tariff designed to better incentivize development of future microgrids. These programs are described in further detail below:

Key Initiatives

Wood Pole Replacement Program

The current wood pole replacement programs for each operating area continues to focus on addressing non-conforming poles identified through inspections. Beginning in 2023, the Company is forecasted to spend an average of $23.4M per year to replace an average of about 1,050 wood poles from 2023 through 2027.

A summary forecasted spend for wood pole replacements for years 2023 thru 2027 is shown in the table below:

	2023 ($M)	2024 ($M)	2025 ($M)	2026 ($M)	2027 ($M)	Total ($M)
O'ahu	$9.6	$8.9	$8.7	$9.2	$9.2	$46.0
Hawai'i Island	$10.4	$5.5	$4.9	$5.7	$5.7	$32.2
Maui County	$7.4	$7.6	$7.7	$7.9	$8.0	$38.7

Underground Cable Replacement Program

The current underground cable replacement programs cover the preventive and corrective replacement of primary cable in conduit and primary direct buried cable. Beginning in 2023, Hawaiian Electric is forecasted to spend an average of $8.8M per year to replace an average of 16.5 combined miles of primary cable in conduit and direct buried cable per year from 2023 through 2027.

A summary of forecasted spend for underground cable replacements for years 2023 thru 2027 is shown in the table below:

	2023 ($M)	2024 ($M)	2025 ($M)	2026 ($M)	2027 ($M)	Total ($M)
O‘ahu	$4.5	$5.8	$1.7	$3.5	$6.1	$21.6
Hawai‘i Island	$1.6	$1.7	$1.2	$3.8	$5.7	$14.2
Maui County	$1.8	$1.7	$0.8	$1.1	$3.1	$8.5

Reliability Programs / Distribution and Sub-transmission Reliability Team

Hawaiian Electric’s reliability work is focused on investments to improve reliability performance in each operating area by reducing the number of customers affected by an event, shortening the duration of an event, or preventing a sustained outage. Hawaiian Electric reviews the worst-performing circuits in each of its operating areas based on the circuits’ contribution to system SAIDI and SAIFI and develops customized solutions to cost-effectively improve reliability performance. Typical solutions include fusing unfused laterals, replacing faulty reclosers, installing lateral and mainline reclosers and other sectionalizing devices, and replacing structures and hardware in failure-prone areas. Other projects can also be identified by areas that are affected by a high number or long duration outages which lead to investigations.

A summary of forecasted spend for reliability work for years 2023 thru 2027 is shown in the table below:

	2023 ($M)	2024 ($M)	2025 ($M)	2026 ($M)	2027 ($M)	Total ($M)
O‘ahu	$13.6	$8.3	$8.6	$9.1	$9.4	$49.0
Hawai‘i Island	$6.1	$3.7	$3.8	$3.9	$4.0	$21.4
Maui County	$4.5	$3.5	$3.4	$3.6	$3.7	$18.7

Resilience Working Group (RWG)

Since 2019, Hawaiian Electric has engaged key stakeholders in the Resilience Working Group (RWG) for its comprehensive Integrated Grid Planning (IGP) process. The goal of the RWG is to support the development of resilience planning inputs for Hawai‘i’s power system (including resource, transmission, and distribution assets) to minimize impacts of severe events on society and the economy.

The RWG met initially over a six-month period and made recommendations in such areas as prioritization of threats, and prioritization of key customers and infrastructure. In 2020, Hawaiian Electric released a RWG Report which summarized the efforts and findings of the RWG to date.

Hawaiian Electric expects to continue to engage stakeholders in the RWG to inform its resilience efforts. Potential topics to address in future RWG meetings include development of resilience performance metrics, and advanced performance modeling (among others).

Koʻolaupoko Resiliency Initiative

Koʻolaupoko is the name of a *moku* ("district"), on the island of Oʻahu that encompasses about half of the windward (Northeast-facing) side of the island. Koʻolaupoko is one of the most vulnerable areas on the island to disruptions in electricity from severe weather events. The region has no local grid-scale generation resources and is served by a single transmission substation, which is connected to generation resources on the opposite side of the Koʻolau Mountain Range by three transmission lines. The Koʻolau Mountain Range's most characteristic feature is its serrated, rugged precipice, the Pali ("cliff"), which rises abruptly on its eastern side and reaches varying heights (500 to 2,500 feet) 2 miles from the sea. The transmission lines running across the Koʻolau Mountain Range require helicopters to access, and damage to these lines in a hurricane could take months to repair.

To address these vulnerabilities, the Koʻolaupoko Resiliency Initiative (Initiative) was developed as part of a multiyear collaboration with Koʻolaupoko community leaders, residents, technical experts, and emergency management to advance solutions and measures that ensure safe recovery for critical services and residents in the aftermath of current and future grid disruptions. Meetings commenced in 2018 with workshops held subsequently throughout 2019. The Initiative is modeled after the Community Resilience Building Workshop Guide, which was developed through community-based experience by The Nature Conservancy, National Oceanic and Atmospheric Administration (NOAA) Office for Coastal Management, and various other partners.

From the initiative, a concept to develop Critical Customer Hubs (CCHs) was developed to reduce risk to community lifelines from prolonged power outages in the Koʻolaupoko region of Oʻahu. A CCH is a variant of the microgrid concept that allows for quick grid configuration and enables islanding and powering of geographically proximate groups of critical community lifeline facilities (e.g., hospitals, fire/police stations, shelters) in key locations using mobile microgrid control systems. In the event of prolonged power outage, the utility would be able to minimize downtime and quickly restore power to community lifelines that provide critical services to the community during emergencies.

The CCHs will rely on mobile microgrid control systems which are designed to operate with various power system topologies, integrate with various types of mobile generators (e.g., battery, diesel), increase project flexibility by reducing the need for land rights to install fixed equipment, and combine step-up transformers, voltage regulators, reclosers, and microgrid controllers on a single trailer to interconnect to the distribution grid.

Grid Modernization

As part of its overall grid modernization strategy, Hawaiian Electric is looking to develop a smarter and more resilient grid. As part of Phase 2 of its grid modernization strategy, the company will install an Advanced Distribution Management System (ADMS) and a suite of field devices. The ADMS solution will help improve resilience by allowing grid operators to quickly adapt to changing grid conditions and rapidly recover following power outages and disruptions by enhancing situational awareness and assisting in restoration triage. The existing outage management processes will also be modernized to leverage ADMS reporting and automation features that improve customer communications, incident response, and operational efficiency.

Similarly, the field devices improve the system's ability to adjust the dynamic conditions imposed on the grid. A subset of these devices are intelligent switches (e.g., smart reclosers, motor operated switches) which can react to a fault by interrupting electrical flow and automatically reconnecting the circuit topology a short time later. Intelligent switches can function as circuit breakers on the circuit and are primarily located throughout the distribution network. These autonomous devices mitigate the outage impact of faults which may occur during extreme weather events.

Microgrids

Hawaiian Electric recognizes that microgrids will play a key role in advancing resiliency and energy transitions within the state and has undertaken multiple efforts to spur future growth.

Microgrid Services Tariff

In 2021, Hawai'i became the second state with a formal microgrid services tariff. These tariffs are designed to ensure fair compensation for existing microgrids and incentivize future development. This tariff has been developed for two types of microgrids:

- **Customer microgrids**, where a customer's infrastructure is exclusively used to supply all their own electric needs during emergencies
- **Hybrid microgrid**, in which an operator may combine utility and customer infrastructure to supply electricity to microgrid members during an emergency

Microgrid Stakeholder Outreach & ETIPP Mapping Effort

As part of its efforts to support its grid resilience, Hawaiian Electric sought technical assurance to develop a hybrid microgrid map for O'ahu and was selected in a national solicitation under the DOE's Energy Transitions Initiative Partnership Program (ETIPP). Hawaiian Electric's ETIPP project will result in a static map showing areas on O'ahu that are optimal for developing microgrids. Hawaiian Electric is collaborating in this effort with the ETIPP Regional Partner, the Hawai'i Natural Energy Institute (HNEI), and the National Renewable Energy Laboratory, as the lead national laboratory overseeing the

map design. Hawaiian Electric hopes to reduce initial barriers and complexities with a map that takes into account the technical and practical viability of microgrid development.

Planned community outreach regarding the O'ahu microgrid map will discuss the process to identify areas in Hawaiian Electric's service territory appropriate for microgrid development that supports critical services and infrastructure during outages. Once developed and operational, Hawaiian Electric intends to expand development and publication of similar maps to other locations.

Performance-Based Regulation – Resilience Metrics

In 2021, the Hawai'i Public Utilities Commission approved a portfolio of scorecards and reported metrics as part of its Performance-Based Regulation (PBR) proceeding. Scorecards track the progress of reported metrics against specific benchmarks (or targets), and reported metrics serve as a standard unit of measurement used to assess Hawaiian Electric's performance

The PUC approved three reported metrics for the category of Resilience:

1. Critical Load Reported Metric: This metric is defined as the aggregated total sum of hours that critical loads are without power from Hawaiian Electric in a year.
2. NIMS Certification Reported Metric: This metric is defined as the total number and percent of National Incident Management System (NIMS) Incident Command System 100, 200, and 300 certification trainings annually.
3. Emergency Response Training Reported Metric: This metric is defined as the total number and percent of employees that have attended emergency response training annually.

Hawaiian Electric tracks these reported metrics and updates them annually on its website at https://www.hawaiianelectric.com/about-us/performance-scorecards-and-metrics/resilience

Hawaiian Electric plans supplement these metrics with other metrics by undergoing a metrics-development process which will involve selecting metrics of interest, collecting data on those metrics, and reporting on them.

Overview of Future Plans for Resiliency

In addition to the Climate Adaptation T&D Resilience Program that the company is applying for DOE funding, Hawaiian Electric is also planning several key initiatives to advance grid resiliency. As part of Hawaiian Electric's efforts to further develop more comprehensive grid resilience strategies, the company is engaging with resilience system modeling in conjunction with a national laboratory. There are several planned microgrid-type projects to better support black start capabilities, namely the North Kohala Microgrid project, Keāhole BESS project, and the

Koʻolaupoko Critical Customer Hub initiative. These initiatives are described in further detail below:

Resilience Modeling

Hawaiian Electric has contracted Pacific Northwest National Laboratory (PNNL) to assist with development and implementation of a resilience system performance model of its grid. This work will leverage and extend the tools that PNNL developed while working with Puerto Rico. The system performance model will be used to simulate the performance of the power system under severe event scenarios and will generate outputs that will be used to test different investments. This resilience modeling work will support efforts to establish the baseline current level of grid resilience and optimize a portfolio of solutions to cost-effectively address the resilience gap and reach the target level of resilience.

Hawaiian Electric plans to complete full implementation within two years and to apply the resilience models to work prioritization during and beyond the initial years of intended use.

Keāhole Battery Energy Storage Station (BESS) Project

Hawaiian Electric is looking to execute on a self-build proposal to build, own, and operate a 12MW/12MWh battery energy storage station at the Keāhole Generation Station for a 20-year term. The energy storage system would be grid-tied via the Keāhole switching station. The BESS will consist of 12 pad-mounted Tesla Megapacks, 6 pad-mounted medium voltage transformers, a Tesla site controller system, medium voltage switchgear, and a single step-up transformer. The facility will provide frequency regulation, fast frequency response, contingency reserve capabilities and will also have black-start and grid-forming capabilities.

North Kohala Microgrid

Hawaiian Electric is developing a microgrid project to improve reliability and resilience in North Kohala on Hawaiʻi Island. It would be the first utility microgrid based on storage in the state of Hawaiʻi, if approved. North Kohala is served by a 34.5kV sub-transmission line built in the 1950s and is the only line sending electricity to North Kohala. Since 2007, Hawaiian Electric has worked closely with local stakeholders to develop a solution that meets the needs of both the local community and Hawaiian Electric. The microgrid project will lead to fewer outages & shorter outage durations when an outage is necessary.

Koʻolaupoko CCH BRIC Grant Application

The Koʻolaupoko Critical Customer Hub (CCH) Building Resilient Infrastructure and Communities (BRIC) Grant Application is an application for funding from the Federal Emergency Management Agency (FEMA) that Hawaiian Electric submitted in 2022 to support the Koʻolaupoko CCH project as part of its Koʻolaupoko Resilience Initiative (described above). Hawaiian Electric plans

to execute this project within a three-year timeframe spanning September 2023 through September 2026.