



Utility Solar Grid Forming Technology TECHNICAL VOLUME

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1.0 PROJECT OVERVIEW

1.1 Background

Hawai'i is a national leader in climate and renewable energy policy. With the passage of Act 15 or 2018 Hawai'i set a statutory zero emissions clean economy target in **§225P-5 (a)** "..., a statewide target is hereby established to sequester more atmospheric carbon and greenhouse gases than emitted within the State as quickly as practicable, but no later than 2045." §225P-5 (a) builds upon Hawai'i renewable national energy leadership being the first state to adopt a one hundred percent renewable portfolio standard by December 31, 2045¹ through Act 97 of 2015. The duties of the Hawai'i State Energy Office (HSEO) as stated in **HRS §196-71 (b) (3)** include "Provide renewable energy, energy efficiency, energy resiliency, and clean transportation project deployment facilitation to assist private sector project completion when aligned with state energy goals". Specific statutory responsibilities of the chief energy officer under HRS §196-72 (d), that guide HSEO in the development and submittal of this application, include "(5) Identify market gaps and innovation opportunities, collaborate with stakeholders, and facilitate public-private partnerships to develop projects, programs, and tools to encourage private and public exploration, research, and development of energy resources, distributed energy resources, and data analytics that will support the State's energy and decarbonization goals."

Kaua'i has the highest adoption of renewable energy in Hawai'i reporting an RPS or just over 60% for 2022. Kaua'i Island Utility Cooperative (KIUC) is the exclusive provider of utility electric service to the residences and businesses on the island of Kaua'i, the fourth largest island of the state of Hawai'i. There are no interconnections to other electrical systems or other islands. KIUC produces and distributes power for 80,000 residents and an average daily census of 30,000 visitors, serving nearly 30,000 residences, 5,000 commercial consumers, and 118 large power consumers. The power system is comprised of solar and hydroelectric renewable resources, thermal power generation, and battery energy storage, providing for the electric energy requirements of the island that reached as high as 458,000 megawatt-hours (MWh) in 2022.

1.2 Project Goal

The goal of the **Utility Solar Grid Forming Technology (USGFT)** project on the island of Kaua'i is to increase the capability of the KIUC electrical system to effectively transition to 100% renewable energy. The USGFT project is a Combination Systems application that uses assets in one sector (resources integrated with the transmission system) to provide services to the other

¹ §269-92 (a) (6)

(distribution system) in a manner that reduces upgrade or expansion requirements, improves communications across sectors and allows for more complete optimization of grid operations. The goal is further represented in the *Statement of Project Objectives*².

This project involves a technology application and activities to provide grid-forming capability of the two large solar energy production facilities owned and operated by KIUC. USGFT will enhance and expand the operation of high penetration distributed renewable generation on the island grid. The project will provide significant regional and community benefits by reducing the likelihood and consequence of disruptive events to the grid and provides a reference case for duplication of the conversion technology by others. The likelihood and consequence of disruptive events to the grid are reduced because the project will enhance renewable resource adequacy, reduce outages, and enable grid reliability and resilience by assurance of continuity in the delivery of renewable energy and electrical service.

The USGFT project on the island of Kauaʻi will enable effective operation of the electric grid when dispatching a variety of electric generation sources and dispatchable loads. On Kauaʻi, these include two KIUC-owned fossil fuel power stations, located at Port Allen and Kapaia, two KIUC-owned 12 MW solar farms, a 6.7 MW biomass plant, a number of mostly plantation legacy hydroelectric units, some smaller solar farms, and three large solar/battery sites, ranging in size from 13 MW to 20 MW. To manage the Kauaʻi grid effectively, KIUC must not only regulate system frequency by proper MW dispatch, but must manage the grid voltage. The USGFT will purchase, install, and interconnect to existing substations 12 MW of grid-forming inverters and battery energy storage at each of the utility-owned solar sites, KRS1 and KRS2.

1.3 DOE Impact

DOE funding reduces barriers to deploy an innovative technology to support a grid that is moving in the near term to 100% renewable energy. KIUC qualifies as a small utility³ for which a significant portion of the DOE project funding is set-aside (see Addendum B) and is also a consumer-owned nonprofit electric cooperative in a high electric rate environment. As discussed in Section 2.7.2 below Hawaiʻi has the highest electricity rates, has the highest cost of living, and has the second highest cost of housing in the nation. Capital expenditures are therefore highly scrutinized. Although the USGFT is an appropriate system addition, moving forward with construction is a management decision of KIUC's consumer member cooperative board, and the availability of the DOE funding will help alleviate rate impact concerns. Furthermore, supplemental funding from DOE for the USGFT project will bolster the case for approval from the Hawaiʻi Public Utilities Commission (HPUC), required for each capital project greater than \$2.5 million, by showing federal support for, and the value of, expanded

² Application TA3-049-E, Statement of Project Objectives, [SOPD.docx](#).

³ KIUC's retail sales to ultimate customers in 2022 were 458,054 MWh. That amounts to just 11% of the reference level of 4,000,000 MWh or less of electricity sales which defines small utility entities.

renewables utilization and improved economic well-being and opportunity throughout the region. DOE support of this project will contribute to the advancement of cost-effective renewable energy for the greatest benefit of the community, supplementing the other efforts undertaken by KIUC.

1.4 Community Benefits Plan: Job Quality and Equity

The Project will provide significant community benefits through enhanced utilization of existing renewable resources and the potential for additional renewables. The region will receive the benefit of reduced frequency and impact of power disruptions and expand clean energy utilization. As a not-for-profit member-owned cooperative, KIUC regularly engages with government, community, labor, and business organizations to ensure the success of projects and initiatives. The Project will contribute to community employment through short-term construction jobs. Most of the work is expected to be contracted out, and KIUC would encourage contractors and subcontractors to recruit from the local Kaua'i workforce whenever possible. KIUC recently completed an \$8.5 million construction project in Anahola, and both contractors who were engaged were Kaua'i-owned and operated. KIUC participates in the State of Hawai'i "Good Jobs Hawai'i" coalition. This is a coalition of businesses, educators, and community partners that will help people in Hawai'i get high quality jobs and careers, while ensuring employers meet their needs for a skilled, local workforce. The emphasis on job quality and equity is described further in the *Community Benefits Plan* ⁴.

1.5 Strategy for Sharing Benefits and Community Engagement

The USGFT system improvement provides a system-wide benefit through the expanded use of renewable energy resources and utilization of existing sites. Renewable energy resources reduce the impact of price volatility in the oil markets as shown in Figure 2-5 below. Utilization of existing sites lowers costs and mitigates impacts on communities, particularly disadvantaged communities that historically have felt a bigger impact from infrastructure buildout. Disadvantaged areas in particular have higher marginal value from reduced electricity costs than other areas, and the Kaua'i County administration, along with the communities, have routinely been involved in evaluation of options for enhanced infrastructure, recognizing the value of efficient operation with renewables. Residents and community leadership will be updated and involved in the progress of the improvements to be undertaken. In addition, a Resiliency Advisory Committee (RAC), on which HSEO is a participant, will help guide progress on USGFT and enhance opportunities for the project to share benefits throughout the island of Kaua'i. Plans for the RAC are detailed in the USGFT Community Benefits Plan.

⁴ Application TA3-049-E, Community Benefits Plan, [CBenefits.pdf](#)

1.6 No Long-Term Constraints on Access to Natural Resources

As a community-owned provider, cultural and natural resource stewardship is foundational to KIUC's progressive leadership in service standards. The USGFT project furthers this stewardship by expanding the use of existing infrastructure for the project as opposed to new, greenfield, developments that impact the natural environment of Hawai'i.

1.7 Climate Resilience Strategy

The project supports the states statutory goals of a net-negative carbon economy and 100% renewable portfolio standard by 2045. It is consistent with the purpose of the Hawai'i state energy office "...to promote energy efficiency, renewable energy, and clean transportation to help achieve a resilient clean energy economy." The project supports achieving 100% renewable energy thereby reducing generation from fossil resources for Kaua'i and the state as a whole. The project supports this by adding capability for frequency control from passive contributors (inverters and BESS) otherwise provided by fossil generation. The intent is to reduce the likelihood and consequences of impacts to the grid from extreme weather and natural disaster, as well as provide for expanded implementation of distributed renewable resources.

2.0 TECHNICAL DESCRIPTION, INNOVATION, AND IMPACT

The Technical Description identifies the character of the project in several ways.

2.1 Relevance to the FOA Goals of Grid Innovation

The USGFT project is a high-value innovative undertaking for KIUC that demonstrates a technological solution for expanded renewables dispatch and reliable island operations. The adding of battery storage and grid forming inverters to the solar power plants creates a hybrid power supply with enhanced dispatchability, greater resource availability, and will provide important ancillary services including frequency regulation, reactive power and voltage control, and operating reserves. The grid regulation service will generate significant community benefit by furthering the capability of the system to accommodate 100% renewable generation sources and provide a more reliable and resilient island grid. This innovative technology will demonstrate an installation of grid-forming technology that could be replicated for local, regional, and interregional grid enhancement adding value to legacy solar installations.

Planning for such improvements by KIUC has included several years of evaluating alternatives to system development⁵ to provide improved reliability, operability, flexibility in provision of electric service and enhanced system resilience. The grid-forming technology will demonstrate:

- Improved utilization of distributed generation assets;
- Load point flexibility enhancement;
- Energy storage systems flexibility enhancements;
- Grid sensing and control technology advancement;
- Grid-forming power system electronics;
- Optimized integrated management of transmission and distribution systems;
- Systems design for improving renewables integration;
- Grid sensing and control technology advancement;
- Technology that can provide improved resiliency by providing real-time situational awareness; and,
- Innovative planning that provides for minimal environmental impact by use of brownfield locations.

While providing both transmission and distribution benefits, the USGFT project contributes significantly to the objectives of Topic 3. The project demonstrates infrastructure utilization that enhances resiliency and reliability, and demonstrates an approach that may be replicated region-wide. The USGFT demonstration contributes to the Topic 3 objectives by:

- Ensuring reliable grid operations by increasing system inertia and reducing the frequency, scale, and duration of disruptions that otherwise destabilize the system;
- Improving overall grid resiliency through improved utilization of distributed and renewable resources across the transmission and distribution system;
- Enhancing collaboration among entities and private and public sector owners and operators on grid resilience by a statewide alliance and support for a regional strategy and the establishment of a Kauaʻi-based Resiliency Advisory Committee (RAC);
- Contributing to the decarbonization of electricity and broader energy system by improved access to technologically and geographically diverse energy sources, including distributed sources, renewable resources, and electrification opportunities; and,
- Providing enhanced system value and delivering economic benefits to the residences and business of Kauaʻi – the members of the cooperative – and other island communities and ratepayers of other utilities that can improve the system contribution of legacy solar installations.

⁵ Long Range Engineering Plan, April 2015; and Construction Work Plan 2021-2024, November 2020.

Specifically, the USGFT project will meet the requirements of the FOA Topic 3 area as an innovative approach with public benefits by offering a clear path to replication, improved ability to impact decarbonization, equitable access using existing utility facilities, and involvement of multiple communities currently served in part by legacy solar facilities. The USGFT project:

- Is of a scale that brings a differentiated value to the subject area, enabling the legacy solar installations to operate in virtual machine mode providing synthetic inertia, voltage support, and black-start capability;
- Demonstrates a replicable, scalable technology application that can be incorporated into utility planning and financing evaluations;
- Provides an estimated value in offsetting fossil fuel generation costs for inertial energy and relative values by advanced utilization of existing system assets;
- May be measurable in impact by offsetting non-renewable resources, expanding the capability of distributed sources, contributing to reduce system losses and other grid outcomes (such as reduced outages or renewables displacement);
- Is readily deployable using assets for which local knowledge is established, and may be implemented within the operational framework of an existing grid;
- Will be managed by KIUC, or in replication by others, using the professional skills and capabilities of a seasoned work force;
- With federal funding contribution, reduces the regulatory hurdle associated with HPUC (or other regulatory processes, including environmental) approval for construction; and,
- Invests in America's utility system workforce, and engages the community of cooperative membership and other grid stakeholders, while advancing opportunities with diversity, equity, inclusion and accessibility.

2.2 Detailed Project Description

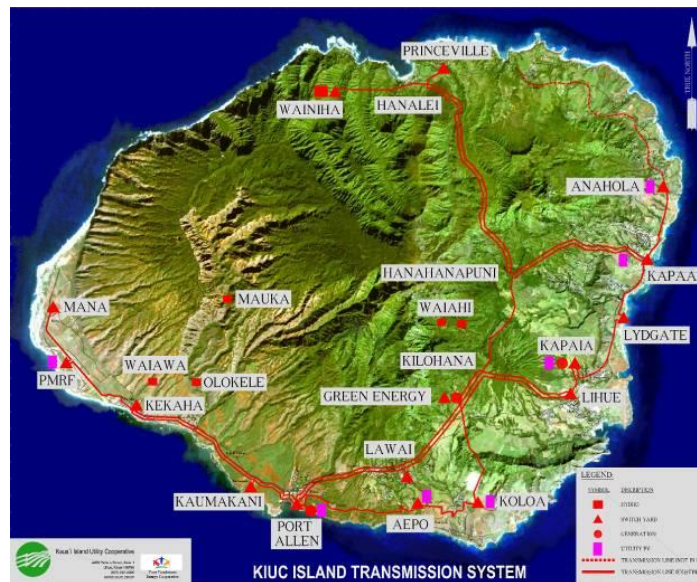
The USGFT project specifically addresses the FOA Topic 3 area of interest with a combination system application that improves functionality in both transmission and distribution. The USGFT provides advanced functionality by furthering the: 1) utilization of dispatchable distributed generation, load and storage on the grid to provide backup power and reduce transmission requirements, 2) optimizing integrated management of the transmission and distribution system, and 3) advanced control technology that provides improved resilience, and extends grid visibility through real-time situational awareness across the system.

Service Area and Project Site(s):

The KIUC service area is depicted in Figure 2-1. KIUC's service area encompasses the entire island, with the majority of the population and commercial activity located along the southern, eastern, and northern coastline. The extreme western portion of the island is primarily parkland and unoccupied. KIUC's generation and transmission system consists of clusters of distribution networks connected over miles of greenspace by lengthy spans of transmission line, often

traversing remote/mountainous areas where vegetation grows rapidly in Kauaʻi's tropical climate. Maintaining system reliability in a corrosive marine environment with dense vegetation and dispersed populations center is a continual challenge.

Figure 2-1 KIUC Service Area

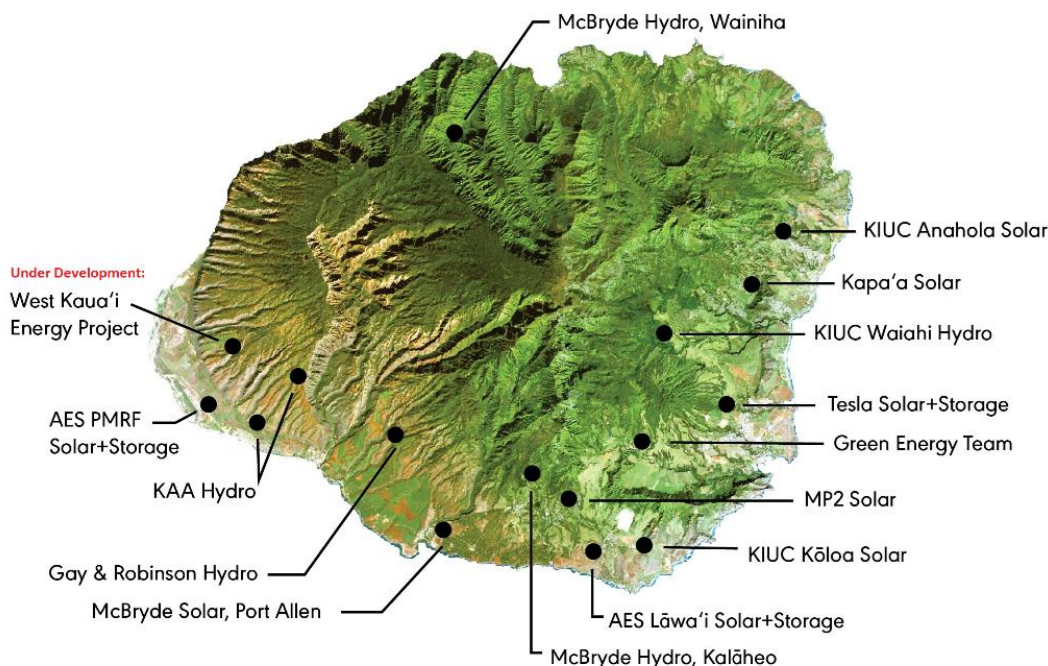


Kauaʻi's electrical generation has been transformed over the past decade or so. What used to be an island powered by over 90% conventional fossil fueled generation has morphed into an island powered by up to 70% renewable generation⁶. Advanced Metering Infrastructure was installed by KIUC in 2012 to help enable effective system monitoring and control of distributed generation, in association with the KIUC Supervisory Control and Data Acquisition system. Just as this paradigm shift has resulted in positive results like lower rates and a substantial reduction in greenhouse gas emissions; it has also resulted in challenges like grid resiliency and resource intermittency.

Renewables Development: While KIUC has recorded the best reliability statistics of any island in the State of Hawaiʻi in 2020 and 2021, distributed renewable resources may be utilized to a larger extent by provision of grid-forming infrastructure that will be demonstrated by the USGFT project. Figure 2-2 shows the renewable resources available to KIUC other than the on-site residential and commercial renewable resource of rooftop or adjacent photovoltaic systems. Since 2012, seven new utility-scale renewable generation facilities have come on-line, while more than 6,000 residential and commercial rooftop systems have been interconnected. Note that the West Kauaʻi Energy Project is currently under development and is not expected to be operational prior to 2026.

⁶ https://www.kiuc.coop/sites/default/files/documents/annual_reports/AnnualReport21.pdf

Figure 2-2 KIUC Renewable Resources



USGFT Installation: One of the main obstacles for KIUC to operate the grid with no fossil fuel units to date has been grid voltage and stability. The USGFT project will alleviate the grid challenges resulting from expanded solar resource contribution and fossil generation displacement. All solar power comes to the grid via inverters. Legacy inverters are limited by how much grid support they can provide during fault conditions and provide little to no inertia to the island system. To put this in perspective, most legacy inverters can achieve 110% of rated output during a fault, some even 150%. The grid forming inverters with fast-response BESS can far exceed the 150% level, providing a means to keep the grid operational in the split second between the fault occurring and electrical protection engaging to isolate the fault. As Kauaʻi's grid becomes more renewable, and conventional units idled under the of 100% renewable dispatch, the benefit of grid-forming inverters and BESS has become more apparent.

The USGFT project will include both of the existing KIUC solar power production facilities, KRS1 and KRS2. Each installation will consist of grid-forming inverters and BESS adding incremental value to the system. KRS1 is located near Anahola in the northeast region of the island as shown in Figure 2-3 (and also on Figure 2-2). The second site is KRS2 near Kōloa shown on Figure 2-4 (and Figure 2-2), located in the southern region of the island, providing regional diversity of the grid-forming technology throughout the integrated system.

Figure 2-3 KRS1 Anahola



Figure 2-4 KRS2 Kōloa



The USGFT project, with a 12 MW BESS at each site, is estimated to cost \$32.5 million. The installation can be completed in one year following project approval and acquisition of the necessary parts and equipment. If approved, KIUC may quickly proceed with development.

2.3 Desired Grid Outcomes

The USGFT project will deliver grid-benefitting outcomes in a variety of ways. The project will provide reliability and continuity of service under a variety of operating and maintenance scenarios, resiliency to disturbances on the transmission and distribution system, and increase the ability of KIUC's system to provide voltage stability to the island. The project provides:

- Additional opportunities island-wide for renewable resource contributions, and operation under conditions of 100% renewable energy sources;

- Decarbonization of the grid by fully displacing fossil fueled generation that would otherwise be deployed for system inertia;
- Better utilization of energy storage facilities and combination systems of solar/storage/pumped hydro such as the West Kaua'i Energy Project.

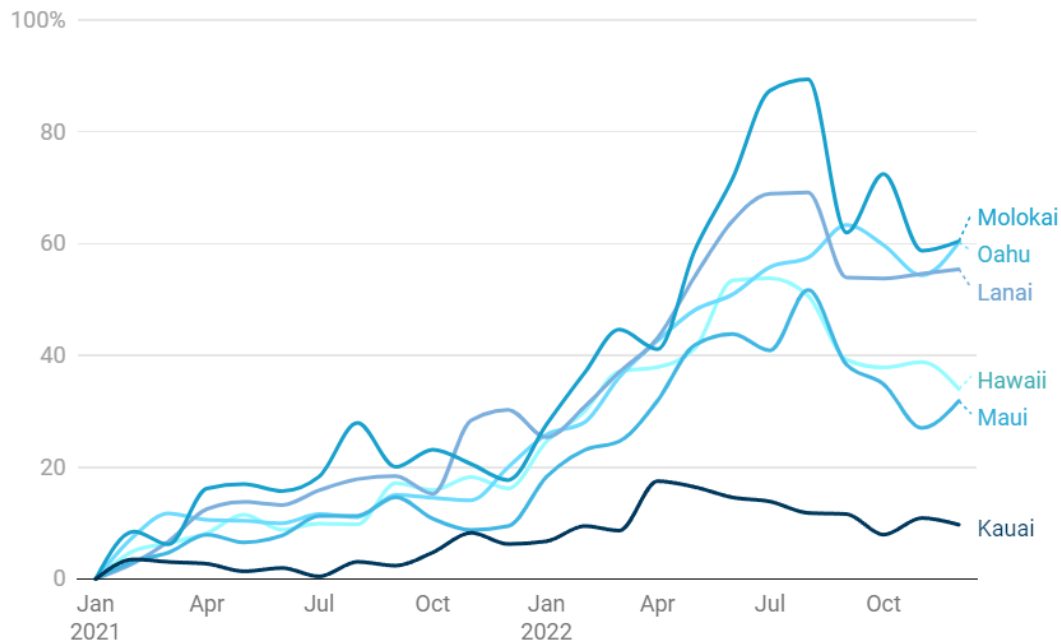
Adding grid-forming inverters and BESS to both KRS1 and KRS2 solar sites will provide a solution to the voltage stability and fault tolerance issues by offering the following solutions:

- Mitigation of frequency instability that occurs through balancing of renewable power;
- Support for the grid with inertia and offload reactive power;
- Removes limitations in the power infeed caused by low short-circuit level;
- Provides short-circuit capacity to strengthen the grid and remedy voltage collapse; and,
- Provides dynamic voltage support, rather than from on-off switched reactive sources.

The USGFT will provide the means to deliver reliable and resilient renewable energy throughout the island and enable effective operation of the grid when dispatching a variety of electric generation sources and dispatchable loads. The use of renewables has been demonstrated to help reduce the island's (and the state's) reliance on fossil fuels, reducing price volatility, the export of funds for fuel imports, fuel supply reliability risk, and greenhouse gas emissions.⁷

Figure 2-5 Percent Change in Residential Electricity Price

% change over Jan 2021 baseline



⁷ HPUC Application Kilohana Switchyard Project, Docket 2022-0230, Nov. 15, 2022, p. 9

As seen in Figure 2 – 5 above Kauaʻi’s high levels of renewable penetration served to insulate KIUC members from the geopolitical induced price shock in the oil market in 2022. The exposure to volatility in electricity prices from the oil market was correlated to the level of renewable penetration.

2.4 Feasibility – Technical and Environmental

Technical Feasibility: There are no identifiable or preemptive technical risks associated with the USGFT project. The technical feasibility is founded upon the KIUC research and planning activities over the last several years and is a reasonable and appropriate use of available infrastructure. The inverter equipment is readily available for retrofit to an existing site. BESS technology has advanced rapidly, and appropriate units of size and operating character are readily available. Many legacy solar facilities use older BESS systems, based upon conditions at the time of installation. The USGFT project demonstrates the feasibility of the retrofit solution that resolves grid issues and expands the capability to rely on renewable sources.

Environmental Feasibility: There are no identifiable environmental **risks** in demonstrating the installation of advanced inverters and BESS to legacy solar installations. The solar sites of interest for the installation are all pre-existing, and the changes will take place within the exclusion zone of the facility. There will be no changes required to the existing transmission and distribution facilities. There will, however, be **rewards** from the beneficial environmental impacts of offsetting thermal generation that would otherwise provide system inertia and protective response, but with significant greenhouse gas emissions.

2.5 Innovation, Impacts and Risk

Innovation: The electric grid development by KIUC has been ahead of the industry in promoting and implementing state-of-the art technology that provides energy security, reliability and resiliency for the island. KIUC has been recognized for leadership in renewable power supply and battery energy storage,⁸ and has routinely met or exceeded the renewable energy goals set for the cooperative by the state of Hawaiʻi and its own board of directors. The USGFT project will continue that legacy of innovation and further advance technology on the utilization of renewable energy sources by demonstrating the ability to operate entirely on renewables to a greater extent and more economically. Success with the USGFT project will promote similar

⁸ KIUC earned its award in the category of Electric Cooperative of the Year for demonstrating industry leadership through unique innovation in an effort to significantly accelerate the transformation to a clean and modern energy system. In its award announcement, the Smart Electric Power Alliance (SEPA) said, “KIUC is unique in the world in achieving 100% renewable on nearly a daily basis.” SEPA further noted, “KIUC’s transition to renewables has resulted in more stable and lower rates, as members are increasingly buffered from the financial impacts of volatile oil pricing and benefit from a majority of their power being supplied via long-term power purchase agreements that are competitively- or lower-priced compared to fossil fuel.”

<https://sepapower.org/knowledge/sepa-announces-2021-power-players-award-winners/>

applications that can be scaled in accordance with the system development requirements in other regions and for other utilities.

Impacts: The availability of a more secure renewable energy supply by the USGFT project will serve to promote economic well-being throughout Hawai'i that other locations with the high penetration of renewables and legacy solar installations can replicate. The improvement in electric service will help to advance private sector investments, not only in renewable energy resources, but beneficial electrification and general economic activities that support employment and workforce development. Community engagement will provide awareness of the incremental benefit in renewables integration and acceptance of the project as a model for others on the advantage of this approach to advance renewable energy penetration, providing economically feasible resource options, and advance energy security.

Risk: The primary risk to timely project completion is regulatory approval of the project⁹. However, DOE funding for 50% of the project cost will offset rate impacts and increase the probability of approval. Additional risk mitigation is provided by KIUC's record of financial stability with management systems and standards to provide quality oversight of the project, history of performance in grant-funded project completion¹⁰, and effectively implementing statutory, regulatory, or other requirements imposed on non-federal entities.

An advantage of the USGFT project over other current and emerging technologies is the utilization of existing infrastructure and enhancing the operability and functionality of legacy solar installations. The improvements available for the site and the contribution to grid reliability and resiliency reduces waste and avoids the environmental impacts associated with construction of new, greenfield installations. Overall, by demonstrating the beneficial aspects of upgrades to legacy systems, the project will promote wide-spread application of the option among all utilities current undergoing transformation from fossil generation to renewable power supply, particularly those that were early adopters of solar generation.

2.6 Support of State, Local, Regional Resilience and Decarbonization

KIUC has a history of successful improvements in system operation enhancing system operating facilities and equipment to improve island-wide service reliability. The USGFT project supports the State's statutory goals for a net-negative carbon economy and 100% renewable portfolio standard by filling an essential grid need traditionally provided through fossil fueled generation. A system improvement shown on Figure 2-2 that is currently under development is the West

⁹ KIUC is subject to regulatory approval by the Hawai'i Public Utilities Commission (HPUC) for each capital project that exceeds \$2.5 million in cost.

¹⁰ An example includes successful installation of Advanced Metering Infrastructure under the DOE-funded Smart Grid Demonstration Project, DE-OE000222. Project report Nov. 2013

Kaua'i Energy Project (WKEP), a combination solar energy production and hydroelectric pumped storage project that will supplement the renewable energy portfolio of KIUC, offsetting fossil fuel generation currently produced at Kapaia and Port Allen which would increase Kaua'i's RPS to roughly 80%. The USGFT improves the capability of the entire Kaua'i grid to accommodate energy from WKEP. Additional renewables will be more readily accommodated to accomplish the goal of 100% renewable power supply for KIUC by 2033.

HSEO can utilize the knowledge gained from the project to explore deployment throughout Hawai'i as well as share lessons learned on a national basis. HSEO participates in the resource planning proceedings at the HPUC and will gain first-hand experience with a technology that could be deployed throughout Hawai'i's independent island grids. HSEO is also an active member of the National Association of Energy Officials (NASEO) and serves as the Chair of NASEO's Electricity Committee positioning it to share Kaua'i's experience with the USGFT as a cost-effective technology to increase renewable energy adoption.

2.7 Topic Area 3 Specific Information

2.7.1 USGFT Addresses Innovative Approaches, Deployment Goals

As discussed in Section 2.1, The USGFT demonstration contributes to the Topic 3 objectives by:

- Ensuring reliable grid operations by increasing system inertia and reducing frequency, scale, and duration of disruptions that would otherwise destabilize the system;
- Improving overall grid resiliency through improved utilization of distributed and renewable resources across the transmission and distribution system;
- Enhancing collaboration among entities and private and public sector owners and operators on grid resilience by a statewide alliance and support for a regional strategy, and the establishment of a Kaua'i-based Resiliency Advisory Committee for KIUC;
- Contributing to the decarbonization of electricity and broader energy system by enhanced ability to integrate a broad range of technologically and geographically diverse energy sources, including distributed sources, renewable resources, and beneficial electrification opportunities; and,
- Providing enhanced system value and delivering economic benefits to the residences and business of Kaua'i – the members of the cooperative – and other island communities and ratepayers of other utilities that can improve the system contribution of legacy solar installations.

2.7.2 DOE Funding Increases Likelihood of Securing Additional Investment

DOE funding assists in alleviating project risk in approval of the capital investment by the KIUC consumer member cooperative board of directors by alleviating the concerns over rate impacts. Hawai'i, including Kaua'i, has some of the highest electricity rates in the country. There is no

interconnected natural gas delivery system available to Kauaʻi consumers to alleviate costs making the sensitivity to electric rates even greater. In addition, Hawaiʻi has one of the highest costs of living in the country resulting in a highly cost-conscious consumer. According to the U.S. News in 2023 Hawaiʻi ranked 50th in Cost of Living and 49th in Housing Affordability nationally¹¹. All of this raises scrutiny for approval of capital investments, in particular innovative technologies. The ability to demonstrate to the KIUC board and electricity consumers USGFT is a viable low cost means to integrate renewables is all the more valuable.

DOE funding also mitigates concerns of regulatory approvals. The project will exceed the \$2.5 million threshold and is to be subject to HPUC for capital project approval. The DOE grant funding contributes significantly to the consumer benefits of undertaking these infrastructure additions by minimizing the potential rate impacts and bolstering support for the large investment required before the HPUC. By helping enable the project to proceed, funds will be supplementally available through investment by USDA RUS, the National Utilities Cooperative Finance Corporation and CoBank. A successful USGFT project will further capital investment in other regions and for other utilities by demonstrating the beneficial use of existing infrastructure and avoiding the environmental impacts of new site development.

2.7.3 USGFT Provides Economic Benefits, Mitigating Impacts of Disruptions

Expanded utilization of distributed renewable resources has the impact of mitigating the impacts of disruptions by providing for localized power supply operation (e.g., a microgrid-type impact). While KIUC has been actively working on methods of enhancing resilience, investing roughly \$28 million in resilience upgrades from 2020-2023, the USGFT project furthers that goal of resilience.

2.7.4 USGFT Delivers Near-Term Economic Impacts

At the current time, KIUC operates a synchronous condenser associated with the combustion turbine located at Kapaia. In 2020, the Kapaia unit ran as a synchronous condenser over 1,000 hours, costing on the order of \$150-\$300 per hour of operation. The displacement of the synchronous condenser parasitic load may amount to as much as \$300,000 in near-term economic impacts. Furthermore, the advanced inverters and additional BESS will allow KIUC to operate the island's electric grid on renewable power longer and more often, avoiding the marginal cost of thermal generation used to otherwise provide inertia.

2.7.5 USGFT Readiness, Viability, and Expected Timing

The USGFT project is a well-planned and economically supportable infrastructure development for providing improved electric service to the island of Kauaʻi. The benefits of full use of the

¹¹ <https://www.usnews.com/news/best-states/rankings/opportunity/affordability>

renewable resources available in Hawai'i include resiliency through the reliance on indigenous resources within the state and mitigation of the impacts of price spikes in the fossil fuel markets due to market or geopolitical issues. As a result, planning for the improvements has included several years of evaluating alternatives to system development¹² to provide improved reliability, operability, flexibility in provision of electric service and enhanced system resilience. The USGFT project has been examined for viability and is subsequently under consideration for budgeting and work planning by KIUC and reflects KIUC's ongoing efforts to find ways to improve the system while taking advantage of incremental improvements through better use of existing resources. Consequently, the USGFT project is ripe for implementation on a schedule that could provide for construction to begin as early as 2024, with contemplated completion within a two to three-year window.

3.0 WORKPLAN

3.1 Project Objectives

The USGFT Project is a Combination Systems application that uses assets in one sector (resources integrated the transmission system) to provide services to the other sector (distribution system) in a manner that reduces upgrade or expansion requirements, improves communications across sectors, and allows for more complete optimization of grid operations. USGFT involves a technology application and activities to provide grid-forming capability of one or both of two large solar energy production facilities owned and operated by KIUC. USGFT will enhance the operation of high penetration distributed renewable generation on the island grid.

The objective of the USGFT Project is to enable effective operation of the electric grid when dispatching a variety of electric generation sources and dispatchable loads. On Kaua'i, these include two KIUC-owned fossil fuel power stations, located at Port Allen and Kapaia, two KIUC-owned 12 megawatt (MW) solar farms (KIUC Anahola Solar [KRS1] and KIUC Kōloa Solar [KRS2]), a 6.7 MW biomass plant, a number of mostly plantation legacy hydroelectric units, some smaller solar farms, and three large solar/battery sites, ranging in size from 13 MW to 20 MW. To manage the Kaua'i grid effectively, KIUC must not only regulate system frequency by proper MW dispatch, but must also manage the grid voltage. The USGFT project is to purchase, install, and interconnect to existing substations 12 MW of grid-forming inverters and battery energy storage at each of the utility-owned solar sites, KRS1 and KRS2. This innovative technology will demonstrate grid-forming technology that could be replicated for local, regional, and interregional grid enhancement while advancing electric system decarbonization by reducing fossil generation and adding value to legacy solar installations.

¹² Long Range Engineering Plan, April 2015; and Construction Work Plan 2021-2024, November 2020.

3.2 Technical Scope Summary

Performance Period 1 (Year 1):

- Hold meeting (s) of the Resiliency Advisory Committee
- Project Management and Planning
 - Submit Project Management Plan
 - Satisfy PUC Approval and NEPA Compliance
 - Complete Go/No-Go decision points
- Commence procurement activities for BESS equipment and associated components, supplies and contractual services that successfully pass the Go/No-Go decision points

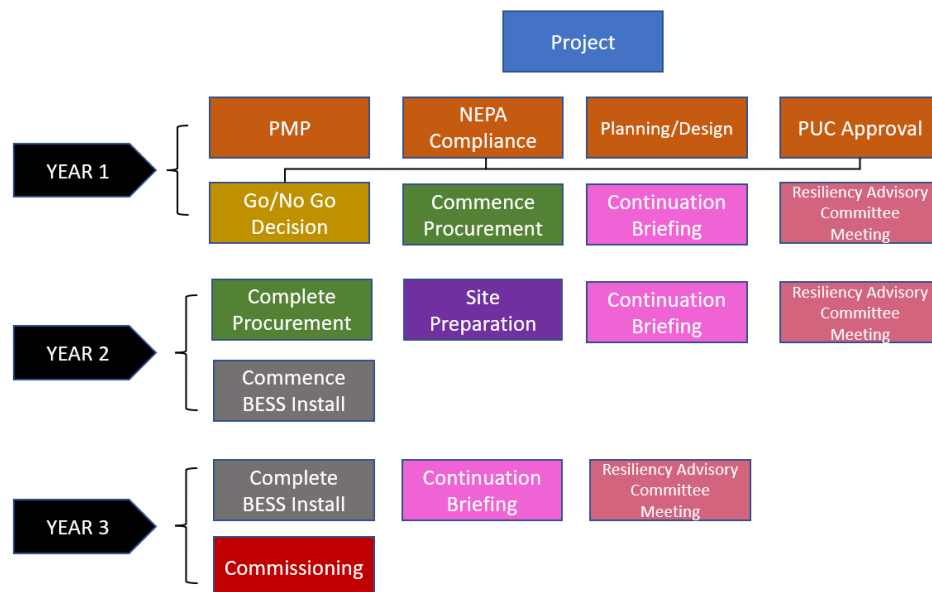
Performance Period 2 (Year 2):

- Hold meeting(s) of the Resiliency Advisory Committee
- Complete procurement activities for BESS equipment and associated components, supplies and contractual services
- Begin Site Preparation Activities
- Commence Installation and Interconnection of the BESS equipment and components

Performance Period 3 (Year 3):

- Hold meeting(s) of the Resiliency Advisory Committee
- Complete Installation and Interconnection of the BESS equipment and components
- Commissioning of the BESS

3.3 WBS and Task Description Summary



3.4 Milestone Summary

Year 1:

- Q1: Project Management Plan completed
- Q2: Resilience Advisory Committee (RAC) meeting held and appropriate recommendations incorporated into Project design/execution
- Q3: Results of PUC approval and NEPA compliance are identified and Go/No Go decision points are made; Project adjustments made based on Go/No Go decision points
- Q4: Procurement plan and timeline established for Project and Commence Procurement

Year 2:

- Q1: Complete Procurement and Commence Site Preparation
- Q2: Contracts awarded to successful bidders while procurement activities continue
- Q3: Resilience Advisory Committee (RAC) meeting held and appropriate recommendations incorporated into Project design/execution
- Q4: Commence BESS installation

Year 3:

- Q1: Continue BESS installation
- Q2: Complete BESS installation
- Q3: Resilience Advisory Committee (RAC) meeting held and appropriate recommendations incorporated into Project design/execution
- Q4: Project Commissioning

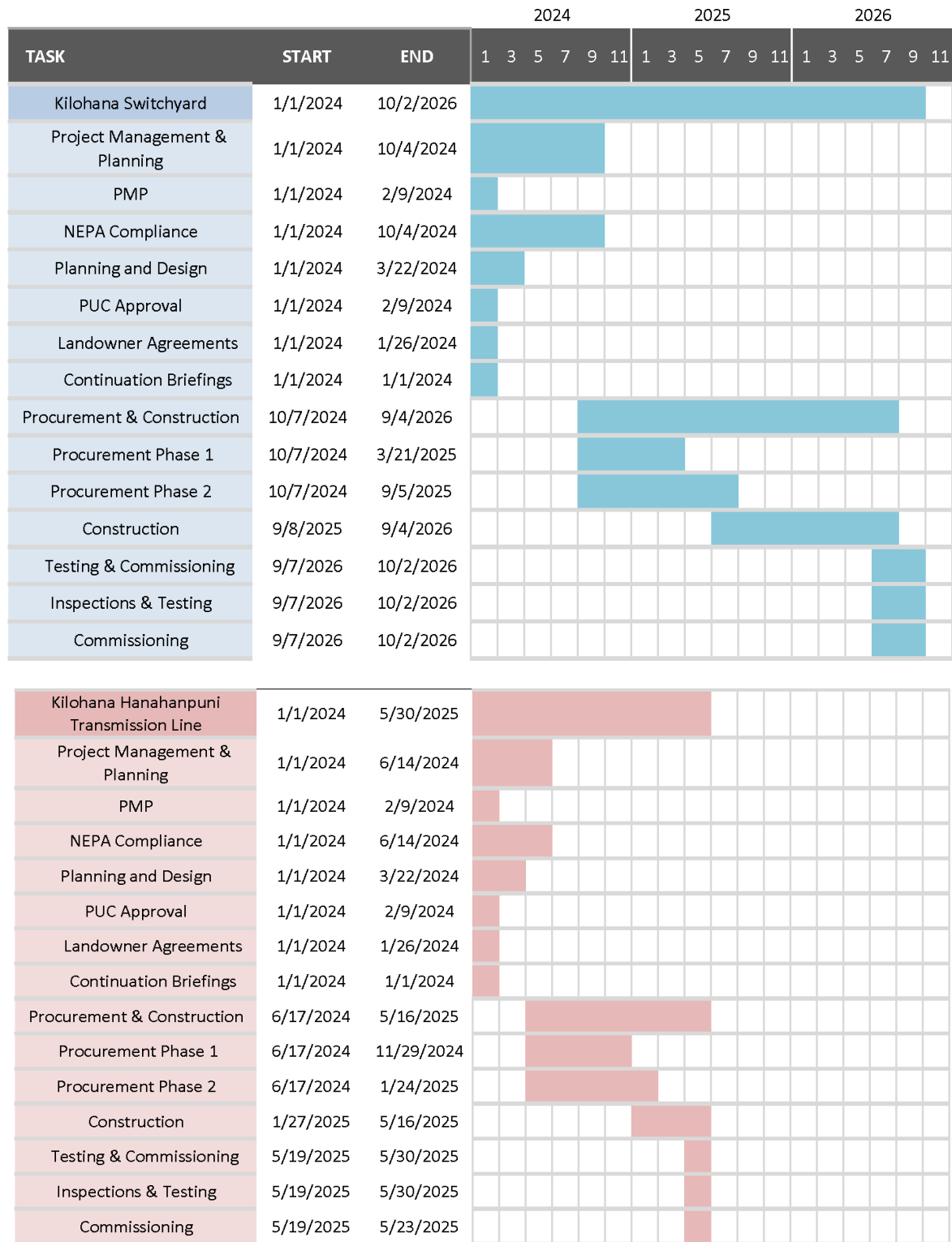
3.5 Go/No-Go Decision Points

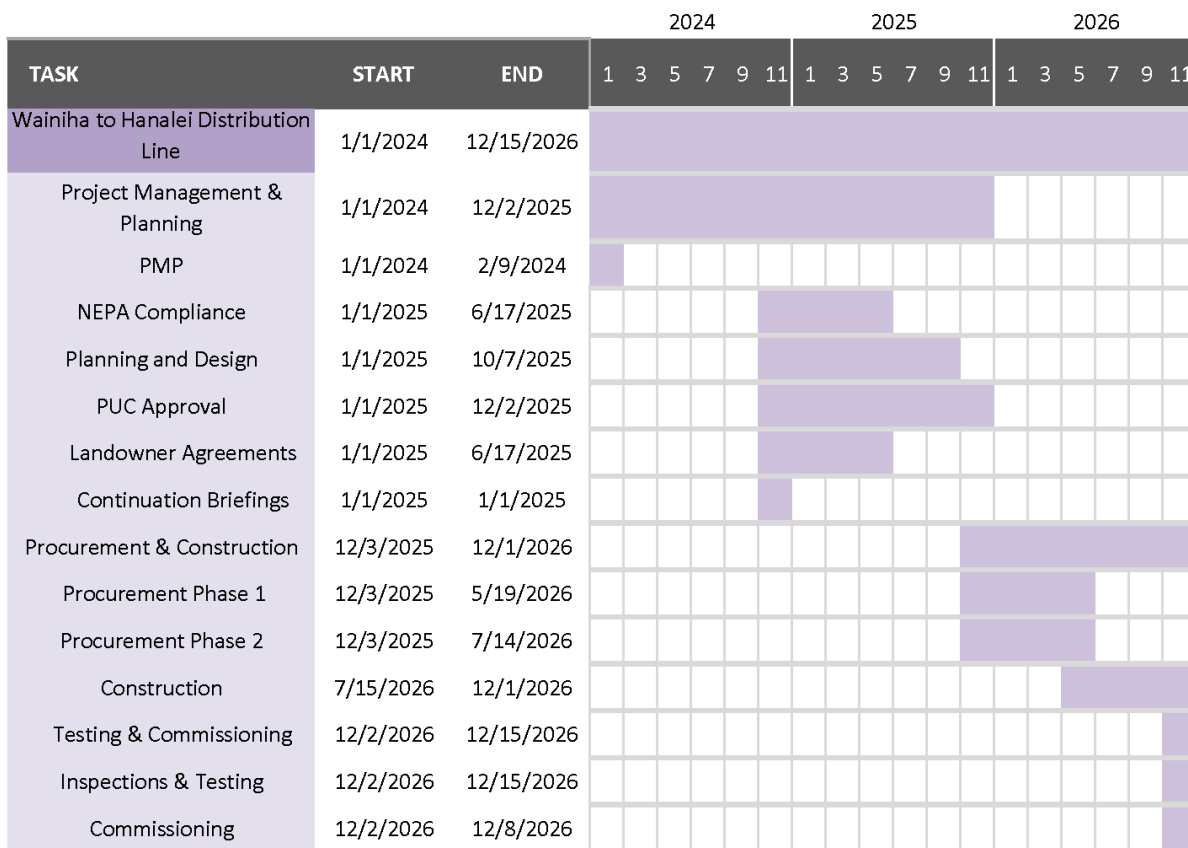
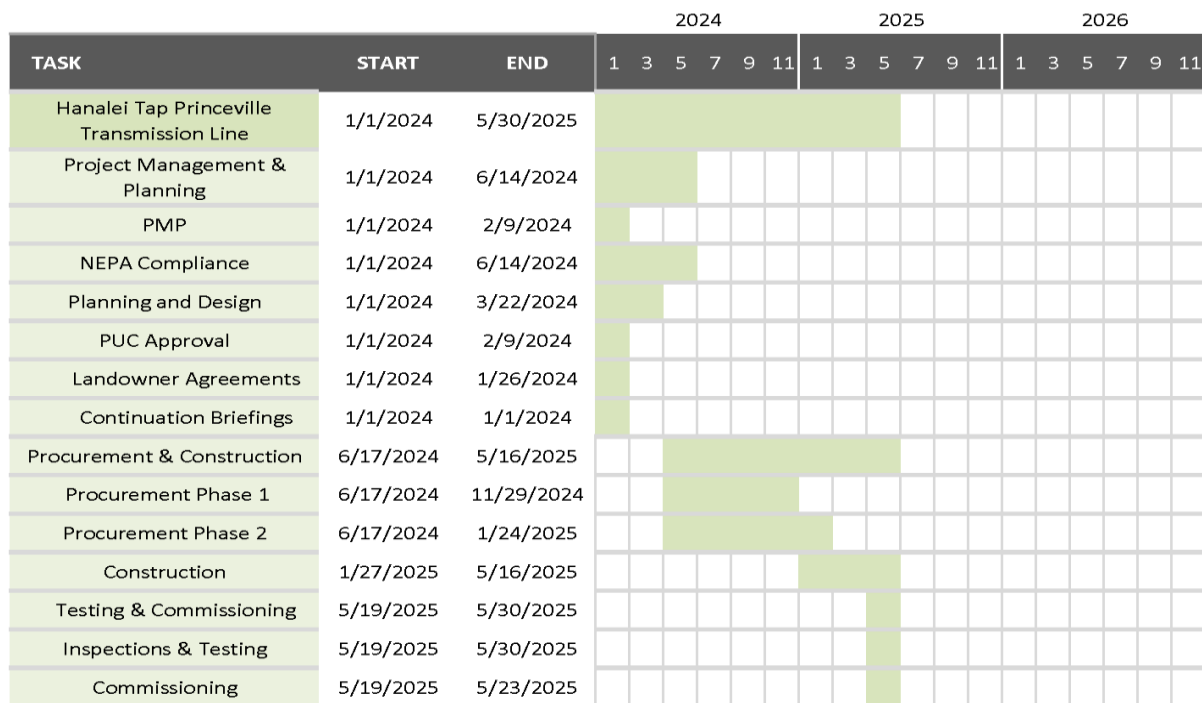
This project contains three **Go/No-Go Decision Points**. Subtask 1.2 will require a Go/No-Go decision if the Project fails to complete NEPA compliance. Subtask 1.4 will require a Go/No Go decision if the Project fails to receive approval from the Hawai'i Public Utilities Commission (PUC). Subtask 2.2 will require a Go/No-Go decision if Project finances are not sufficient to complete the work.

3.6 End of Project Goal

The USGFT project is a high-value undertaking for KIUC that demonstrates a technological solution for expanded renewables dispatch and reliable island operations. The adding of battery storage and grid forming inverters to the solar power plants creates a hybrid power supply with enhanced dispatchability, greater resource availability, and will provide important ancillary services including frequency regulation, reactive power and voltage control, and operating reserves. The grid regulation service will generate significant community benefit by furthering the capability of the system to accommodate 100% dispatch of renewable generation sources and provide a more reliable and resilient island grid.

3.7 Project Schedule





3.8 Buy America Requirements for Infrastructure Projects

The Project will involve the construction and alteration of public critical infrastructure and KIUC intends to follow Buy American requirements for all aspects of the Project.

3.9 Project Management

The Project Team will handle various aspects of Project Management.

Administration of the grant will be provided by HSEO's Managing Director, Operations including responsibility for compliance with grant terms and conditions and overseeing procurement, contracting and fiscal operations for conducting a successful project. Technical oversight of the project will be provided by HSEO's Managing Director, Resilience Clean Transportation, and Analytics to ensure that the project aligns with state energy policy objectives including decarbonization and resiliency.

Oversight of Project implementation will be provided by KIUC in coordination with HSEO. Project oversight for KIUC will be provided by the Member Services and Communications Manager (administration and reporting) and the Chief of Operations (all other activities). Five team members will contribute to oversight on various elements of the Project and their roles are defined in Section 4.1. Administration and reporting to HSEO to fulfill DOE requirements will be handled primarily by the Administrative Lead and the Finance Accounting Lead, with assistance from the Operations Lead. Other elements of the project, such as planning/design, NEPA approvals, PUC approvals, landowner agreements, procurement, construction, inspection/testing and commissioning, will be a collaborative effort among the Operations Lead, Engineering Lead and Construction Lead, with the assistance of the Administrative Lead and Finance/Accounting Lead as necessary.

Currently KIUC utilizes National Information Solutions Cooperative (NISC) for project tracking. NISC is a cooperative specific software solution used by KIUC for accounting, billing, work order tracking, estimating, mapping and financial preparation. KIUC uses this integrated single platform solution to project manage every project from the beginning of the job starting with the estimate to the work order cost reconciliation and then to the final mapping of as-builts. NISC allows KIUC to track project specific expenses as they relate to direct payroll costs with fringe benefits, equipment expenditures, subcontractor expenses and other indirect costs.

The primary risk to timely project completion is associated with completion of NEPA requirements and necessary approvals from the PUC. Go/No Go decision points have been incorporated into the Project to account for these variables. There are no other environmental or technical risks, in part as a result of use of existing infrastructure to the maximum extent possible and pre-existing rights-of-way. KIUC has a record of financial stability with management systems and standards to provide quality oversight of the project, as well as history of performance in grant-funded project completion, and a recognized ability to effectively implement statutory, regulatory, or other requirements of non-federal entities.

KIUC tracks project changes through the NISC work order tracking system. Original estimates are input into the NISC system and tracked throughout the duration of the project. The

estimates are input through a specific work order module and are tracked with meticulous detail which includes tracking specific equipment units, labor direct hours worked, fringe benefits, indirect labor, and subcontractor expense. As costs are incurred, they are matched and applied to the work order estimate and specific cost units. Variations from the original cost estimate are tracked and logged in the system and changes are captured and tracked. Changes occur when variances in original estimates and actual dollars, parts and direct labor are found. These changes are tracked and monitored through our monthly reconciliation process. They are then timely communicated to the estimator and project manager.

In order to maintain effective communication, the HSEO and KIUC Project Team will hold monthly meetings to discuss Project status, next steps, current challenges and anticipated issues. However, HSEO has regular contact with KIUC to execute its statutory responsibilities and the KIUC Project Team works in close proximity with each other and are in contact on a daily basis for ongoing cooperative business and operations, so emerging issues will be discussed and addressed as they arise, without need to wait for monthly meetings. Documents related to the Project will be maintained to allow KIUC team members immediate access to Project information at all times and brief HSEO as required.

4.0 TECHNICAL QUALIFICATIONS AND RESOURCES

Section 4 includes descriptions of the technical qualifications and expertise, facilities, equipment, experience, and commitment to the USGFT Project.

4.1 Project Team Unique Qualifications and Expertise

The project team for the USGFT Project is comprised of seasoned professionals employed by HSEO and KIUC, including engineers, administrators, construction managers, project accountants, financial analysts, and general supervisory staff. Project planning, scheduling, construction planning, and construction oversight will be provided by HSEO and KIUC staff and, as necessary, contractors selected by KIUC staff for specific expertise and skills.

HSEO currently administers eight (8) federal grants and subawards including responsibility for compliance with terms and conditions and overseeing procurement, contracting and fiscal operations for conducting a successful project. HSEO subject matter experts have extensive experience in energy planning, project deployment facilitation, energy policy, and community engagement covering topics including renewable generation, system security, and resiliency.

KIUC has a history of successful system development in generation, transmission, distribution, renewable energy source development, and energy storage applications. This includes component vendor and contractor selection, acquisition of materials, oversight of site preparation, construction and erection, and functional and acceptance testing. After installation phases are completed, KIUC staff are responsible for and accomplish successful operation of existing and new plant and facilities with the circumstances and conditions of a remote,

islanded electric grid. The principal team members include senior staff members with specific responsibilities:

- Administrative Lead: Donna Mau Is responsible for the administration all federal grants and subawards including responsibility for compliance with grant terms and conditions and overseeing procurement, contracting and fiscal operations for projects.
- State Technical and Policy Lead: Chris Yunker has led HSEO energy system planning efforts including participation in resource planning dockets at the HPUC, administering Hawai'i's 40101(d) funds, and serving as an expert witness on finance, energy procurement, cost allocation, and rate design for San Diego Gas & Electric;
- HSEO Outreach and Community Engagement Lead: Parker Kushima leads HSEO's community engagement initiatives including the Clean Energy Wayfinders program to raise community awareness and increase participation in statewide energy planning.
- Operations Lead: Oversight and Project Management will be the responsibility of Brad Rockwell, Chief of Operations at KIUC. Mr. Rockwell has served in several capacities at KIUC, including Executive Manager, Operations and Production Manager, with power systems experience at General Electric;
- Engineering Lead: Engineering Management will be provided by Cameron Kruse;
- Construction Lead: Oversight of construction activity will be the responsibility of John Cox, Transmission and Distribution Manager;
- Administration Lead: Project Administrative oversight will be provided by Beth Amaro, Member Services and Communications Manager for KIUC; and,
- Finance/Accounting Lead: Project accounting and financial reporting will be provided by Stacie Dellamano, KIUC's Chief Financial Officer.

4.2 Project Team Equipment and Facilities

Design/engineering, competitive bid development, contract management and other administrative functions will be conducted in the following facilities: 1. KIUC's headquarters at 4463 Pahe'e Street in Lihu'e. Equipment/supply storage and field operations/construction will be conducted as necessary utilizing KIUC's warehouse facilities at the transmission and distribution offices in 'Ele'ele and the Anahola Service Center. There are no unusual technological aspects to the USGFT Project that will require access to specialized or unavailable equipment and facilities to accomplish successful completion of the Project. While Hawai'i is a remote location relative to the contiguous United States, equipment or facility availability has not hindered prior construction projects of a similar nature.

4.3 Project Team Relevant Work Experience

Prior projects completed at KIUC by staff have included substation upgrades and additions, utility-scale generation and transmission additions (including solar energy and battery energy

storage facilities), and all aspects of projects necessary for continued successful operation of the island grid and system improvements. They have successfully overseen installation of facilities by contractors supplying facilities under purchased power agreements and contractors supplementing the KIUC workforce on isolated projects. To the extent team members are added to the project (as may be determined), KIUC has experience in contract management and construction oversight, evidenced by the successes to date in system development.

4.4 Time Commitment of Key Team Members

- Grant administration/Donna Mau, HSEO Managing Director, Operations: Anticipates spending 10 hours per quarter on compliance with grant terms and conditions.
- Technical and policy oversight/Chris Yunker, HSEO Managing Director, Resilience, Clean Transportation, and Analytics: Anticipates 10 hours per quarter on coordination and project review activities.
- HSEO community engagement and outreach/Parker Kushima: Anticipates 60 hours per quarter on community engagement activities.
- Implementation oversight and project management/Brad Rockwell, KIUC Chief of Operations: Anticipates spending 40 hours per quarter on activities for the Project.
- Engineering management/Cameron Kruse, KIUC Engineering Manager: 20 hours per quarter on activities related to the Project
- Oversight of construction activity/John Cox, KIUC Transmission and Distribution Manager: 80 hours per quarter during construction of the project.
- Project administrative oversight/Beth Amaro, KIUC Member Services and Communications Manager: Anticipates commitment of 10-20 hours per quarter.
- Project accounting and financial reporting/Stacie Dellamano, KIUC Chief Financial Officer: Anticipate spending 10-15 hours per month.

4.5 Technical Services to be Provided by DOE/NNSA FFRDCs

HSEO and KIUC have successfully partnered with the National Renewable Energy Laboratory (NREL) in recent years, advancing statewide energy decarbonization planning and integrating a high percentage of renewable generation into the grid within a relatively short timeframe. The project partners' relationship with NREL is strong, and they have a deep understanding of the state and utility's goals relating to grid resiliency and decarbonization. NREL has agreed to provide technical support and resources to KIUC relative to this Project in furtherance of its resiliency, reliability and equity goals. HSEO and KIUC have received a letter of support from NREL. The letter will be made available upon DOE's request.