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Kalaeloa Energy System Redevelopment Options Including Advanced Microgrids

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Abstract

In June 2016, the Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) in collaboration with the Renewable Energy Branch for the Hawaii State Energy Office (HSEO), the Hawaii Community Development Authority (HCDA), the United States Navy (Navy), and Sandia National Laboratories (Sandia) established a project to 1) assess the current functionality of the energy infrastructure at the Kalaeloa Community Development District, and 2) evaluate options to use both existing and new distributed and renewable energy generation and storage resources within advanced microgrid frameworks to cost-effectively enhance energy security and reliability for critical stakeholder needs during both short-term and extended electric power outages.

This report discusses the results of a stakeholder workshop and associated site visits conducted by Sandia in October 2016 to identify major Kalaeloa stakeholder and tenant energy issues, concerns, and priorities. The report also documents information on the performance and cost benefits of a range of possible energy system improvement options including traditional electric grid upgrade approaches, advanced microgrid upgrades, and combined grid/microgrid improvements. The costs and benefits of the different improvement options are presented, comparing options to see how well they address the energy system reliability, sustainability, and resiliency priorities identified by the Kalaeloa stakeholders.

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NOMENCLATURE

BESS	Battery Energy Storage System
BRAC	Base Realignment and Closure
CCHP	Combined Cooling Heating and Power
DHHL	Department of Hawaiian Home Lands
Distributed Generation	small-scale energy generation and storage technologies - batteries, fuel cells, diesel generators, microturbines – located on the electrical distribution system
DoD	Department of Defense
DOE	Department of Energy
FAA	Federal Aviation Administration
FBI	Federal Bureau of Investigation
Feeder	common name for a distribution-level power line (nominally12kV to 35kV)
G	Generator – generally a diesel generator
HARNG	Hawaii Army National Guard
HCDA	Hawaii Community Development Authority
HDOT	Hawaii Department of Transportation
HECO	Hawaiian Electric Company
KHP	Kalaeloa Heritage Park
HSEO	Hawaii State Energy Office
Hunt	Hunt Companies
KIMPU	Kalaeloa Infrastructure Master Plan Update
KMP	Kalaeloa Master Plan
kV	Kilovolt
kWh	kilowatt hours
M	Million
Microgrid	integration of local energy generation resources on an electrical distribution system capable of operating as a small independent electric grid
MW	Megawatt (1,000,000 watts)
MWh	Megawatt hours
O&M	Operations and maintenance
Parks	City and County of Honolulu Department of Parks and Recreation
PCC	Point of Common Coupling
PPA	Power Purchase Agreement
PV	Photovoltaics
R	Recloser
Recloser	Electrical component that acts as a switch to disconnect and reconnect distribution level power lines

ROM	Rough Order of Magnitude
RUS	Rural Utility Service
Sandia	Sandia National Laboratories
SSA	Substation A
SSB	Substation B
Substation	Electrical power system location where electric grid power voltage is reduced, divided, and routed to customers through the electrical distribution system
VA	Veterans Affairs
USCG	United States Coast Guard
USDA	United States Department of Agriculture
WWII	World War II
$	Dollars
%	Percent
24/7	24 hours/7 days a week (continuous)

1. EXECUTIVE SUMMARY

The Kalaeloa Community Development District (Kalaeloa) is an approximately 3700-acre redevelopment parcel established on the former Naval Air Station-Barbers Point in West Oahu, Hawaii. The Naval Air station was closed in 1999 through the Department of Defense Base Realignment and Closure (DoD BRAC) process. Because the Navy no longer has an active military mission at Kalaeloa, they are interested in transferring or selling the electrical system in its entirety to another entity in the next few years. At transfer, the entity that obtains the electric grid will be required to maintain service to the current users, while also upgrading the system to modern commercial electric utility operational and safety standards. In the past, the Hawaiian Electric Company, Inc. (HECO) has expressed an unwillingness to accept the existing Navy system due to concerns regarding the condition, compliance, and potential environmental liabilities associated with the electrical system.

Since the 1999 BRAC, the Navy has not made any investments into the electric system, making repairs only as needed, such that the current system does not meet industry standards and the overall reliability of the system is considered of marginal quality by the current tenants. Most tenants complain of multiple power outages each month that often last more than an hour, and sometimes as much as eight hours, with most tenants experiencing approximately 40 hours of power outages a year. These outages have impacted critical services at some tenant buildings such as elevators and safety lighting, and critical capabilities for some tenants such as at the airport, the National Guard, and the Coast Guard. Replacement of the existing electrical system is needed, which will be significant from a cost, time, and electric service reliability standpoint to anyone taking over control of the electric grid. These issues have been a major stumbling block over the last two decades in the timely redevelopment of Kalaeloa.

To support Kalaeloa in identifying innovative approaches to move the District forward and accelerate redevelopment, the Department of Energy's (DOE's) Office of Energy Efficiency and Renewable Energy (EERE) initiated a collaboration in July 2016 with the Hawaii State Energy Office (HSEO), the Hawaii Community Development Authority (HCDA) at Kalaeloa, the United States Navy (Navy), and Sandia National Laboratories (Sandia) to 1) assess the current functionality of the energy infrastructure at Kalaeloa, and 2) evaluate options to use both existing and new distributed and renewable energy generation and storage resources within advanced microgrid frameworks with the goal of efficiently and cost effectively accelerating redevelopment of the electric system while enhancing overall energy system reliability and improving critical tenant operational resiliency and performance, especially during extended power disruptions.

For this project, Sandia was tasked to assist staff from HSEO, HCDA, and the Navy to:

- Assess and gather data on Kalaeloa's electrical distribution system, existing backup generation, and renewable generation use and opportunities.
- Conduct a workshop and meet with Kalaeloa Stakeholders to discuss and identify

    - current energy system issues, challenges, and priorities;
    - emerging energy system sustainability, reliability and cost goals;
    - expected redevelopment timeframes and plans; and
    - design and collaboration needs to ensure delivery and operational safety compatibility with HECO's grid.
- Develop conceptual designs for grid improvements that will enhance overall energy system reliability, be compatible with individual tenant energy upgrades, and improve operational resiliency and performance for all tenants especially for extended power disruptions.
- Evaluate the cost and performance benefits of the general conceptual designs for the different options considered.

The priorities identified by the Kalaeloa stakeholders included high power reliability, high power quality, stabilized power costs, and the ability to handle critical loads. Other areas of interest mentioned were the ability to support the larger Oahu grid, and integration of renewable generation resources to support Hawaii's clean energy goals.

Using the Stakeholders' priorities identified above and additional technical information collected from the Navy and HECO, Sandia developed several energy system upgrade options ranging from traditional to non-traditional approaches to assess ways to accelerate the improvement of the Kalaeloa electric system while enhancing energy reliability, sustainability, and security at reduced costs.

Because the Navy wants to dispose of the Kalaeloa energy system in total and not piece meal, we focused on innovative solutions that could be done district-wide almost simultaneously, as a brown-fields redevelopment. This is difficult since the electric infrastructure needs to be replaced while the tenants maintain access to high reliability power. We considered three approaches to reduce costs and increase energy reliability. These included:

1. A phased approach to traditional energy infrastructure upgrades, such as new substations, feeders, and distributed generation integration. In this approach, rather than do all upgrades simultaneously, we focused improvements in higher priority development areas first (years 1-5) to increase reliability in these areas, then add additional upgrades as other areas grow (years 6-10). This does not try to upgrade all parts of the Kalaeloa energy grid at the same time and requires development of a fair cost structure for tenants in different upgrade phases.
2. Consideration of several ways to island Kalaeloa from the grid utilizing various types and levels of distributed and renewable energy generation resources. Advanced microgrids can easily support higher energy reliability, often at lower costs because of a major focus on optimal integration of local generation. But again, these efforts would focus on priority development areas first, leaving some areas with lower reliability power. Options considered varied from a single independent Kalaeloa grid using only on-site power, to several smaller microgrids that were locally networked.
3. A hybrid approach using traditional and advanced microgrid energy system upgrades. This may enable lower-cost distributed energy improvements to be implemented in

priority areas first to support critical energy reliability needs. This would provide high energy reliability for most of the district as a whole, while the more traditional distribution system upgrades could be developed.

Sandia developed conceptual upgrade designs and layouts for each of these options. The conceptual designs were used to assess the relative cost and performance benefits of each approach and option. The cost estimates developed are Rough Order of Magnitude (ROM) estimates of +/- 30%, but do include the consideration of capital, construction, engineering, and contingency costs to provide a consistent framework of the expected implementation costs for each energy system upgrade approach at Kalaeloa.

There are additional costs and incentives that should be considered in more detail in the future, such as environmental, permitting, tax incentives, and renewable incentives that could drive the optimization of future designs. The results presented though can be used to assess the general viability and relative cost and performance of each of the options considered. It should be noted that significant additional engineering analyses will be needed to fully implement a design, but the conceptual designs can be used to identify the general level of funding needed, the possible upgrade schedule, and energy costs of redevelopment.

Based on the cost and performance benefits of the different options evaluated and summarized in this report, the best option appears to be the hybrid phased feeder/advanced microgrid approach.

To implement this option, the following is recommended:

1. During the next one to two years, HCDA should work closely with other entities <u>to establish an alternative electric utility (such as a cooperative or public power utility) to help fund and manage the operations and maintenance of the current electric system</u> and implement the required upgrades over the next 10 years. At the same time, HCDA should work closely with the Navy to successfully transfer the Navy electric grid.
2. During the next one to two years, HCDA should work to support the design and construction of advanced microgrids and distributed generation resources at four priority Kalaeloa locations – USCG, Downtown and Airport, Hunt, and HARNG to reduce average outage times from 40 hours per year to less than an hour per year, at a total installed cost to the new alternative electric utility of approximately $24M. Coordination with planned energy improvements by stakeholders in these four priority locations could be leveraged to help reduce HCDA and tenant overall implementation costs.
3. Accelerate the development of up to four 5-MW solar energy projects on Kalaeloa over a twenty-year period to specifically support on-site tenant energy demands. Utilize Power Purchase Agreements (PPAs) with solar power developers, Independent Power Producers, or investors that could support distribution system improvements and lower power costs. Integrate the solar energy projects with the priority microgrids identified to enhance renewable energy availability during a power outage. At full electric system build out, Kalaeloa would have about 30% renewable energy penetration.

4. Within two to three years of establishing the Kalaeloa alternative electric utility, add a new 40-MW, 46-kV substation at the Northwest end of Kalaeloa, with up to six 12-kV underground feeders to support electric upgrades for existing and new tenants in western Kalaeloa. Integrate these improvements with the new microgrids to enhance overall system reliability as well as full-utilization of the identified renewable generation projects.
5. Within 6-10 years of establishing the Kalaeloa alternative utility, add a second 40-MW, 46-kV substation at the Northeast end of Kalaeloa with up to six 12-kV underground feeders to support the electric system upgrades as needed for both new western and eastern tenants. This will provide a total Kalaeloa energy import capacity of 80-MW, with up to 20-MW of on-site renewable generation capacity.
6. Finally, coordinate the identified energy improvements with other regional power system improvements to make sure they are consistent to help reduce regional integration and upgrade costs, while also supporting the broader regional energy resiliency and energy assurance improvement needs.

If this approach is implemented as recommended, Kalaeloa would significantly improve its energy reliability and resiliency, and reduce critical load outages from 40 hours per year to only a few minutes per year. The associated costs for a Kalaeloa operated system would range from $0.28/kWh for years 1-10 and $0.25/kWh for years 16 and beyond. By years 11-15, the system could be fully updated, and could be sold to HECO or another entity, with the sale price used to reimburse the tenants for the infrastructure capitalization, effectively reducing the transitional energy system upgrade costs to all the tenants and the District.

2. CURRENT KALAELOA POWER SYSTEM CHALLENGES

Both the Navy and Kalaeloa stakeholders provided extensive background information on the Kalaeloa electric power system for this effort. HCDA provided Sandia with the 2006 Kalaeloa District Master Plan (KMP) and the 2010 Kalaeloa District Infrastructure Master Plan Update Draft (KIMPU). Both plans provide a good overview of the redevelopment priorities proposed, but the details of the specific infrastructure redevelopment plans and approaches have not yet been fully developed.

The KMP suggests a redevelopment peak load of about 45-60 MW for the expected full development of the site, which is expected to take place in phases over an approximately 7-year to 20-year time horizon. An additional build out of a proposed 11 million square feet in the district with a similar mix and load profile as the current tenants would increase the load to about 45 MW from the current 24 MW load. Increasing tenant square footage or adding more energy intensive development would lead to a higher power demand estimate. Therefore, Sandia discussed potential development and load growth with current major tenants and landowners to identify the likely load growth trends, focusing on near-term development. These discussions are summarized as part of the landowner visits.

The Navy provided Sandia with one line diagrams for the current electrical system in Kalaeloa, as well as provided maps of feeder and substation locations. Unfortunately, as observed during a tour of the site, not all of the maps are up to date, and many abandoned lines and substations are not noted on the drawings. The Navy also provided load, line loss, and power outage information for the different feeders and areas in Kalaeloa District. The Navy currently provides about 24 MW of power to Kalaeloa through two 46 kV substations, with power provided by the Hawaiian Electric Company (HECO).

Since the 1999 BRAC, the Navy wants to dispose of the energy system and has not made any investments in the Kalaeloa electric grid, making repairs only as needed, such that the current system does not meet current utility standards and the overall reliability of the system is considered of marginal quality by tenants. Therefore, the current electric system experiences routine scheduled power outages that can last 4 to 12 hours, and several monthly non-scheduled outages that can last 1 to 4 hours, with some tenants seeing outages of as much as 40 hours per year. This equates to an average energy availability of 99.5 percent, with most systems expected to have a maximum system outage of only 8 hours per year or 99.9 percent energy availability.

Therefore, major energy infrastructure replacement and maintenance and operational changes are needed to bring the existing electrical system at Kalaeloa into compliance with current utility standards. This will be significant from a cost, time, and liability standpoint for anyone taking over the electric grid. These issues have been a major stumbling block over the last two decades between the Navy and HECO, and have negatively impacted the timely redevelopment of Kalaeloa.

2.1 6th Kalaeloa Landowners Summit "Establishing Energy Reliability and Resiliency"

The Summit took place on Tuesday, October 18, 2016 at the University of Hawaii West Oahu Campus. The Summit was attended by about 60 stakeholders including; tenants, landowner representatives, Navy, state agency and elected official representatives, developers, and electric utility providers. The Summit was divided into morning and afternoon sessions.

The morning session was designed to provide:

- Presentations by the seven major landowners on their redevelopment goals and energy issues, challenges, needs, and opportunities;
- A presentation by Sandia on emerging energy assurance and resiliency design approaches, such as the use of advanced microgrids, and how they are being used to improve renewable and distributed energy generation and storage resource use, while also enhancing local energy reliability, sustainability, and resiliency, and;
- A presentation by Sandia on examples of similar redevelopment efforts, such as the evaluation of advanced microgrids at the Philadelphia Navy Yard redevelopment.

The afternoon session included two major breakouts sessions where the Summit attendees were separated into three small discussion groups. The groups discussed and identified:

- Energy system redevelopment priorities and goals – such as energy reliability, quality, cost, safety, renewable integration, etc.;
- Priority near-term and long-term energy redevelopment needs, and;
- Redevelopment zone priorities for energy infrastructure improvements.

At the Summit, the seven major landowners including the Navy, U.S. Coast Guard (USCG), Veterans Affairs/Cloudbreak Communities (VA), Hawaii Army National Guard (HARNG), Hawaii Department of Transportation – Kalaeloa District Airport (Kalaeloa Airport), Department of Hawaiian Home Lands (DHHL), Hunt Companies (Hunt). Other landowners that participated in the Summit but did not give presentations, included the Federal Bureau of Investigation (FBI), the Federal Aviation Administration (FAA), the City and County of Honolulu Department of Parks and Recreation (Parks), the Kalaeloa Heritage Park (KHP) and HECO.

As noted above, Breakout Session 1 was designed to discuss energy system priority performance goals and stakeholder needs. The three different discussion groups identified surprisingly similar priority energy goals. These included:

- Stakeholder Priority System Performance Goals
    - Higher power reliability - reduce number of power interruptions and outage durations.
    - Higher power quality - reduce voltage frequency variability.
    - Reduce/stabilize electric power cost and cost structure.
    - Make sure critical loads are served during any power outage.
    - Safety operations and public safety are requirements of all improvements.

- Additional interests of stakeholders and state government representatives
    - Ability to support the larger Oahu grid.
    - Integration of renewable generation resources to support State of Hawaii statutory requirement of a 100% Renewable Portfolio Standard by 2045 for the electricity sector.

The second part of Breakout Session 1 was set up to identify priority areas to focus initial energy surety improvements. Overall, the consensus of the three groups was also similar and their suggestions are shown in Figures 1 and 2. The highest priority areas identified for initial and near-term energy improvements (Years 1-5) included:

- Area A - Beach front – Navy bungalows, USCG, Parks campground, HCDA and C&C Honolulu Property
- Area B - Downtown – Hunt, Hawaiian Home Lands, VA, National Guard, Kalaeloa Airport
- Area C - Coral Sea/Saratoga – FAA outer marker
- Area D - Roosevelt/Saratoga corridor west of Enterprise – FBI, Hunt

Follow on energy improvement (Years 6-10) priority areas identified by the stakeholders included:

- Area E - Roosevelt/Saratoga corridor east of Enterprise – FBI, Hunt, new development, C&C Honolulu Parks – WWII memorial, stables and Navy golf course
- Area F - West of airport – Hawaiian Home Lands, Airport hangar expansion, new development
- Area G - Coral Sea renewable energy corridor

Breakout Session 2 was designed to discuss stakeholder input on the existing KMP relative to energy system needs and development timelines. Again, the three discussion groups identified similar challenges and priorities that included:

- Kalaeloa redevelopment opportunities and needs are significantly nearer term than the current KMP and KIMPU suggest, with major improvements needed in the 1-10 year time frame rather than the 7-20 year focus in existing plans.
- Current infrastructure issues are significantly hampering redevelopment:
    - Water, wastewater, electric power, and roadways are the biggest concerns.
    - Currently the Navy is divesting the water and wastewater systems to a private operator. Therefore, an improved electric power grid to increase power reliability is the largest near-term priority.
    - Energy reliability and assurance is a major need for Kalaeloa landowners (i.e. FBI, military rapid deployment operations, commercial airport operations) to support their individual expansion plans and needs.

Overall, the summit included a wide range of stakeholders and state representatives who provided a generally uniform consensus of the major needs and directions for the redevelopment of Kalaeloa. Accelerating energy system improvements was the major priority to address existing energy challenges and better support regional development in West Oahu.

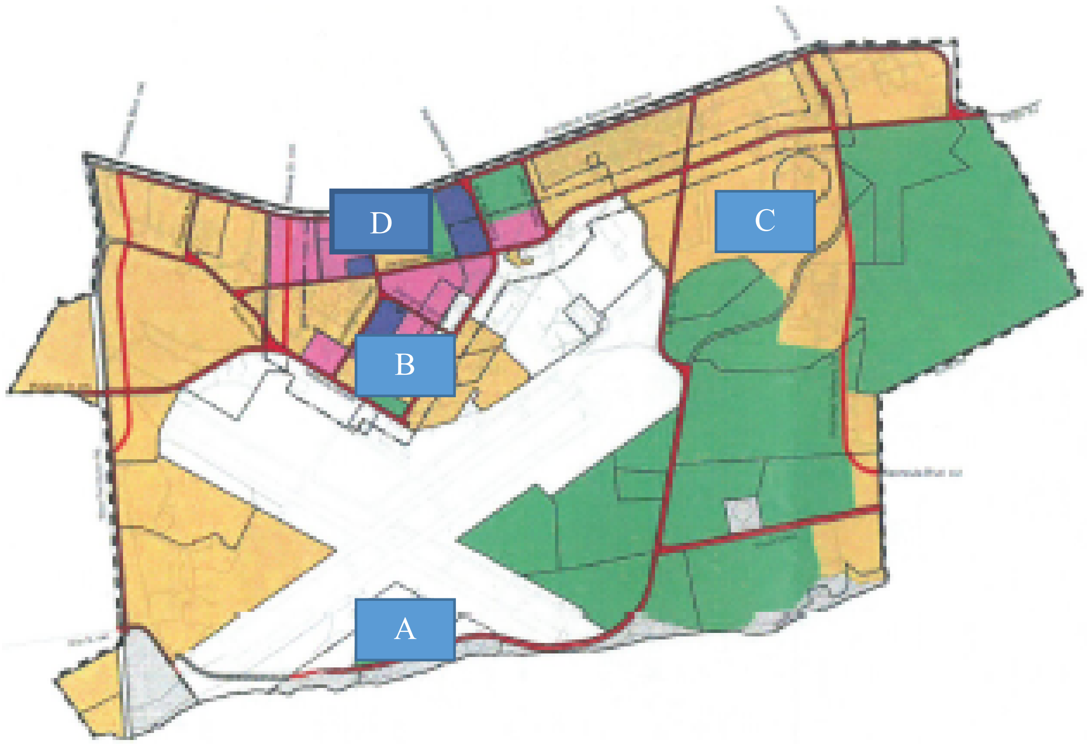

Figure 1. Identified Initial Priority (Years 1-5) Energy Improvement Zones

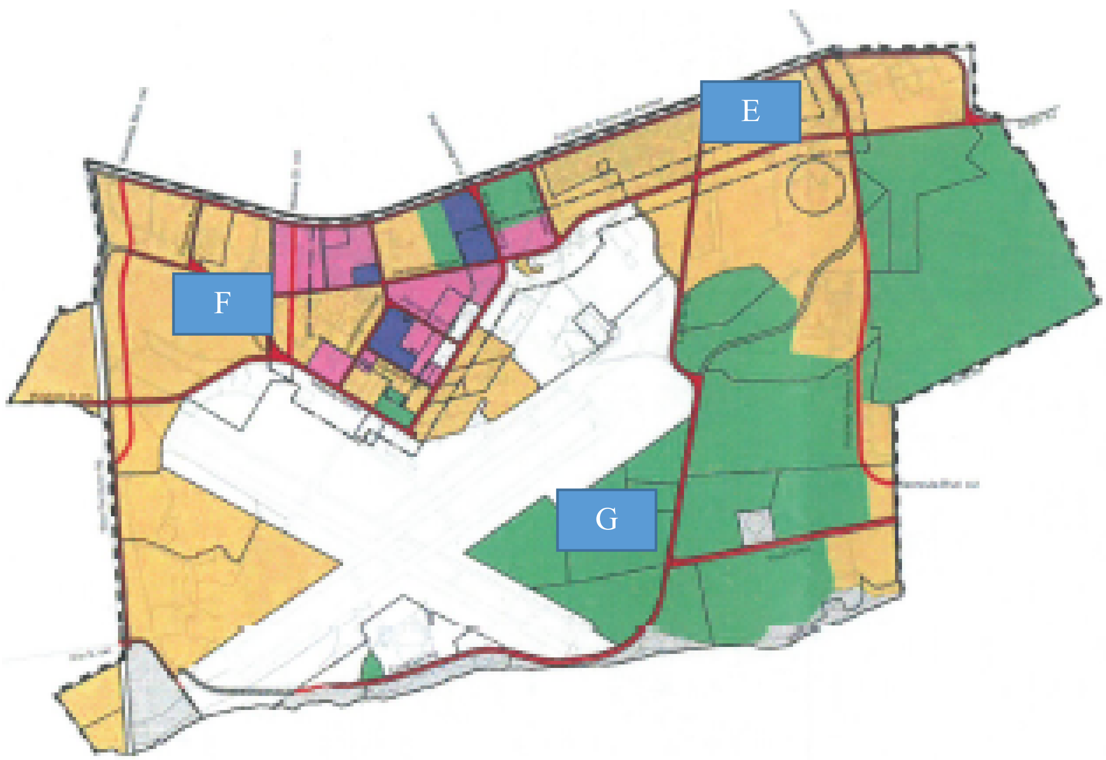

Figure 2. Identified 6-10 Year Energy Improvement Zones

2.2 Kalaeloa Landowner Site Visits

Sandia, HSEO, and HCDA staff conducted a review of the Kalaeloa electric system on Monday, October 17, 2016, and Sandia and the HSEO conducted visits and discussions with major landowners and tenants on Wednesday and Thursday, October 19 and 20, 2016. Sandia reviewed the existing distribution system condition, site distributed generation, facility load data, identified critical mission loads, and discussed planned tenant energy improvements and additional load requirements. Table 1 provides estimates of current and projected future average power demands for the various landowners and areas.

Table 1. Current and Expected Kalaeloa Electric Power Demands

Landowner/ Tenants	Current Power Demand	Years 1-5 Power Demand	Years 6-10 Power Demand	Current On-site Generation
Hunt	2 MW	4 MW	5 MW	-
Kalaeloa Airport	2 MW	3 MW	4 MW	0.5 MW
HARNG	5 MW	7 MW	8 MW	4 MW
USCG	1 MW	2 MW	3 MW	0.8 MW
FBI	1 MW	1 MW	2 MW	1 MW
VA	1 MW	2 MW	3 MW	-
Downtown	2 MW	3 MW	6 MW	-
DHHL	2 MW	3 MW	6 MW	-
Other Eastside Tenants	3 MW	3 MW	4 MW	0.2 MW
Other Westside Tenants	3 MW	3 MW	4 MW	0.3 MW
Total	22 MW	31 MW	45 MW	6.8 MW

Table 1 shows the existing Kalaeloa average power demand of about 22 MW for the landowners and tenants (with a system line loss of 2 MW identified by the Navy, this matches the current Navy purchased power from HECO of 24 MW). The results suggest that the mix of major landowners and associated tenants are expecting a future average load requirement in excess of approximately 50 MW. This compares closely with the KMP suggested redevelopment load of about 60 MW and a minimal 45 MW load estimated from the KMP proposed build out of an additional 11 million square feet in the district using a similar mix and load profile as current tenants. Therefore, the analyses suggest using a future average power demand of between 50-60 MW to estimate energy infrastructure improvement needs at Kalaeloa over the next 10-20 years, and the associated capital, operation, maintenance, and energy costs that will have to be included in establishing near-term, mid-term, and long-term energy rates for the District to pay for the proposed energy improvements.

All of the tenants interviewed considered energy reliability and the age of the existing system as issues they believe are negatively impacting their existing operations. Most tenants complain of multiple power outages each month that often last more than an hour, and sometimes as much as eight hours, with most tenants experiencing up to 40 hours of power outages a year. As noted previously, this equates to an average energy availability of 99.5 percent, with most modern utility systems expected to have a system outage of less than 8 hours per year or 99.9 percent energy availability. Good energy utilities commonly have regional energy availability values of 99.99 percent, or about one-hour of outages a year. In general, the tenants all believed that the existing Kalaeloa energy system needs to be significantly updated or replaced so it can function at a level commensurate with standard electric utility power availability and reliability metrics.

The site visits highlighted several major additional issues, including:

- There is a significant deficiency of distributed generation resources for most landowners to meet even existing critical energy needs, much less meet future increased critical power projections, as noted in Table 1.
- Planned new energy upgrades by some landowners, such as the USCG and the HARNG, should be coordinated with any proposed Kalaeloa energy improvements to share costs where possible and enhance final energy system performance for all stakeholders.
- The estimated 50-60 MW build out at Kalaeloa suggests that two 46 kV substations (capable of 40 MW each, but can be upgraded to support additional capacity) will be required to meet industry standard energy distribution system designs. These substations would easily support all of Kalaeloa with up to six 12-kV feeders from each substation, and each feeder designed to support 6-8 MW of load, using appropriate conductors.
- Any approach to address current and even some mid-term energy demands would require between 6-10 MW of additional distributed and/or renewable generation on-site to improve power reliability while electric system improvements are made.
- Any distributed generation added, if located properly, could also be used to support critical mission loads for the different landowners as part of long-term electric system improvements, helping increase energy availability and reliability to critical operations.
- While the major landowners and tenants at Kalaeloa currently use about half the power, smaller users must be considered in making future improvements and to insure their power reliability and quality is not negatively impacted during any upgrades.

2.3 Kalaeloa Energy Issues and New Solutions

It is clear that the Kalaeloa electric infrastructure will inevitably be transitioned from the Navy and ultimately turned over to a new electric power provider, whether it be the utility – HECO, an independent operator like a power cooperative, or a third party manager that could manage and make upgrades and eventually turn it over to a utility or an independent operator. See Appendix A for further discussion on different management options.

In general, any approach would require that a new energy system operator make modifications to the existing infrastructure, stay connected to the local utility (HECO) at the current locations, and run the system as the improvements are being made. However, this could pose several challenges. First, the improvements should comply with HCDA and/or other applicable rules. These include provisions to put permanent utilities underground, including power lines. Second, the existing distribution feeder system was designed for customers and loads associated with the layout of the former Barbers Point Naval Air Station, and even if the same lines could be used, they are likely inadequately sized and inefficiently routed to meet new tenant locations and needs as outlined in the KMP and KIMPU. Therefore, as noted by the current landowners and tenants and confirmed by a tour and inspection of the existing electrical system by Sandia, it is likely that the Kalaeloa electric distribution system will need to be totally replaced.

HECO had estimated that the required power system upgrades at Kalaeloa could be as much as \$300-400M, which could have a significant impact on tenant electricity rates. Therefore, Sandia worked with HSEO and HCDA to develop innovative approaches to improve the Kalaeloa energy system from both a utility management and utility upgrade approach to reduce costs. The focus was to find approaches to accelerate reliability and cost improvements to meet tenant and stakeholders needs, as well as create an energy system that will provide a more cost-effective electric rate structure with higher electric reliability to help attract new tenants. The major options identified and the associated benefits and costs for of each option were evaluated and are discussed in the following sections of this report.

3. KALAELOA ENERGY UPGRADE OPTION ANALYSES

Based on the energy system data provided by the Navy, the directions in the KMP and KIMPU, results of the Summit breakouts, stakeholder site visits and discussions, and meetings with HECO, Sandia identified a range of options that could accelerate energy system improvements in a way that would enhance current stakeholder energy reliability while also reducing both short-term and long-term capital and operating costs and stabilize tenant overall energy rates.

Because the Navy wished to dispose of the Kalaeloa energy system in total and not piece meal, we were limited to innovative solutions that could be done district-wide almost simultaneously, in a brown-fields redevelopment rather than a green-fields development, which is much more difficult and can have hidden costs such as environmental remediation, relocation of other utilities, etc. This is especially true when the electric infrastructure needs to be replaced while the tenants maintain access to high reliability power. We considered three approaches to reduce costs and increase tenant energy reliability. These included:

1. Consideration of a phased approach to traditional energy infrastructure upgrades, such as new substations, feeders, and distributed generation integration. In this approach, rather than do all upgrades simultaneously, we focused on improvements in higher priority development areas first (years 1-5) to increase reliability in these areas, then add additional upgrades as other areas grow (years 6-10). This does not try to upgrade all parts of the Kalaeloa energy grid at the same time, and requires development of a fair cost structure for tenants in different upgrade phases.
2. Consideration of options to island Kalaeloa from the grid utilizing various types and levels of on-site distributed and renewable energy generation resources. Advanced microgrids can easily support higher energy reliability, often at lower costs because of a major focus on good integration of local generation. But again, these efforts would be focused first on priority development, leaving some areas with lower reliability power. Options considered varied from a single independent Kalaeloa grid using only on-site power, to several smaller microgrids that were locally networked.
3. Consideration of combinations of traditional and advanced microgrid energy system upgrades. This may enable lower-cost distributed energy improvements to be implemented first in priority areas to support critical energy reliability needs. This would provide high energy reliability for most of the district as a whole, while the more traditional distribution system upgrades could be developed.

Sandia developed conceptual upgrade designs and layouts for each of these options. The conceptual designs were used to assess the relative cost and performance benefits of each approach and option. The cost estimates provided in the following sections are Rough Order of Magnitude (ROM) estimates of +/- 30%. But the analyses do include the consideration of capital, construction, engineering, and contingency costs to provide a consistent framework of the expected implementation costs for each energy system upgrade approach considered.

There are additional costs and incentives that must be considered in more detail in the future, such as environmental, permitting, tax credits, and renewable incentives that can drive the optimization of any future designs. The results presented though can be used to assess the general viability of and relative cost and performance of each of the different options considered**. It should be noted that significant additional engineering analyses will be needed to fully implement a design, but the conceptual designs can be used to identify the general level of funding needed, the upgrade schedule, and energy costs of likely redevelopment.**

3.1 Phased Feeder Upgrade Conceptual Design

A phased feeder approach to provide power to Kalaeloa is a traditional approach that was identified to consider as a good baseline. This approach is similar to other approaches entertained by HCDA, such as studies looking at adding new energy corridors proposed by HECO, or studies to develop various energy corridors to meet the needs of particular customers. For example, a general energy infrastructure improvement and development plan suggested by HECO acknowledges the need for two 46 kV substations and proposes a series of future combined 12kV and 46 kV temporary overhead distribution lines compatible with the proposed redevelopment plans highlighted in the 2010 KIMPU. At later dates, these new lines would be replaced with underground lines as appropriate to comply with HCDA and/or other applicable rules.

The concern with a traditional approach like this is the amount of funding needed up-front to complete the upgrades. To save funds, any distribution system temporary upgrades will need to be eventually replaced at a later date, increasing the full redevelopment costs. Therefore, Sandia tried to establish a slightly different traditional upgrade approach using phased-feeder upgrades that can save time and costs, while improving major Kalaeloa tenant energy reliability and fastest growth areas first during the proposed upgrades.

The Sandia phased-feeder approach can be summarized as follows:

- Continue to utilize the existing Navy grid to feed current landowners until more reliable energy corridors are developed.
- HECO will continue to supply generation to Kalaeloa.
- Using local distributed generating resources for dispatchable generation, such as PV/BESS, was not considered.
- In parallel, phase in reliable energy corridors, consisting of new 46 kV distribution substations and 12 kV distribution feeders, based on which landowners will need the additional power demands first, until the entire district is provided with power from the new energy corridors.
- Priority upgrades would be in first focused in areas A, B, and D shown in Figure 1.
- This would be followed by upgrades in areas C, E, F, and G as shown in Figures 1 and 2.
- Upgrades would be coordinated with groups like the HARNG, Airport, Hunt, and the USCG that are already evaluating and trying to fund or funding energy system upgrade projects. As completed, the Navy grid can be abandoned or refurbished in completed areas, if and where appropriate.

- The improved areas will have a customer base and design that may make it attractive to transfer to a utility provider. The funding from the sale or transfer of the upgraded infrastructure to an operational utility provider could then be used to fund the second phase of the Kalaeloa energy system upgrades. This approach reduces up-front costs and spreads the funding requirements for the upgrades between public and private sources.
- The phased feeder approach does not include costs associated with obtaining right-of-way from the Navy, so obtaining the electric system from the Navy and the associated easements is necessary to install these new feeders most cost-effectively.

Figure 3 illustrates where specific energy corridors could be located relative to current landowners' parcels and address the high priority redevelopment and energy reliability areas of Kalaeloa. Figure 3 illustrates one of many potential routes or options for getting new power into Kalaeloa. It shows where new 46 kV substations (SSA and SSB) as well as distribution feeders (A1-A4 and B1-B2) from these substations could be routed based on available corridors (following streets, avoiding historical areas, airport, etc., where distribution lines can't be located). There are several potential alternate routes and locations for the main 46 kV substations, which won't be evaluated, since the main purpose of this report is to show a general concept for incorporating higher reliability power while the Navy distribution system continues to operate and is eventually retired. Note that Feeder A2, A3 and A4 follow the same energy corridor from SSA, so A3 is longer than A2, and A4 is longer than both A2 and A3. Other specific variations of this approach are appropriate and should also be evaluated to look at ways to minimize the overall implementation costs of this concept.

As discussed, this approach provides Kalaeloa with new energy corridors consisting of 46 kV substations and 12 kV distribution feeders over time. Sandia has suggested this combination of 46 kV substations and 12 kV feeders, because it aligns with providing power to the priority areas first and at the lowest capital cost. As these customers are connected to the new feeders, existing service feeders can be retired or refurbished.

A phased feeder approach allows Kalaeloa to implement new power distribution infrastructure to the most immediate existing needs and new growth, and then add additional infrastructure as additional growth occurs, while maintaining service to existing customers with the current Navy system. This may make it easier to justify and obtain funding for the improvements, since they will be brought on line to service specific needs. Sandia fully recognizes that this is only one way to prioritize the development of new infrastructure, and it is up to HCDA as well as landowners to determine priorities and the types of structured coordination necessary to implement them. It is intended to map out how a phased infrastructure improvement plan could be done.

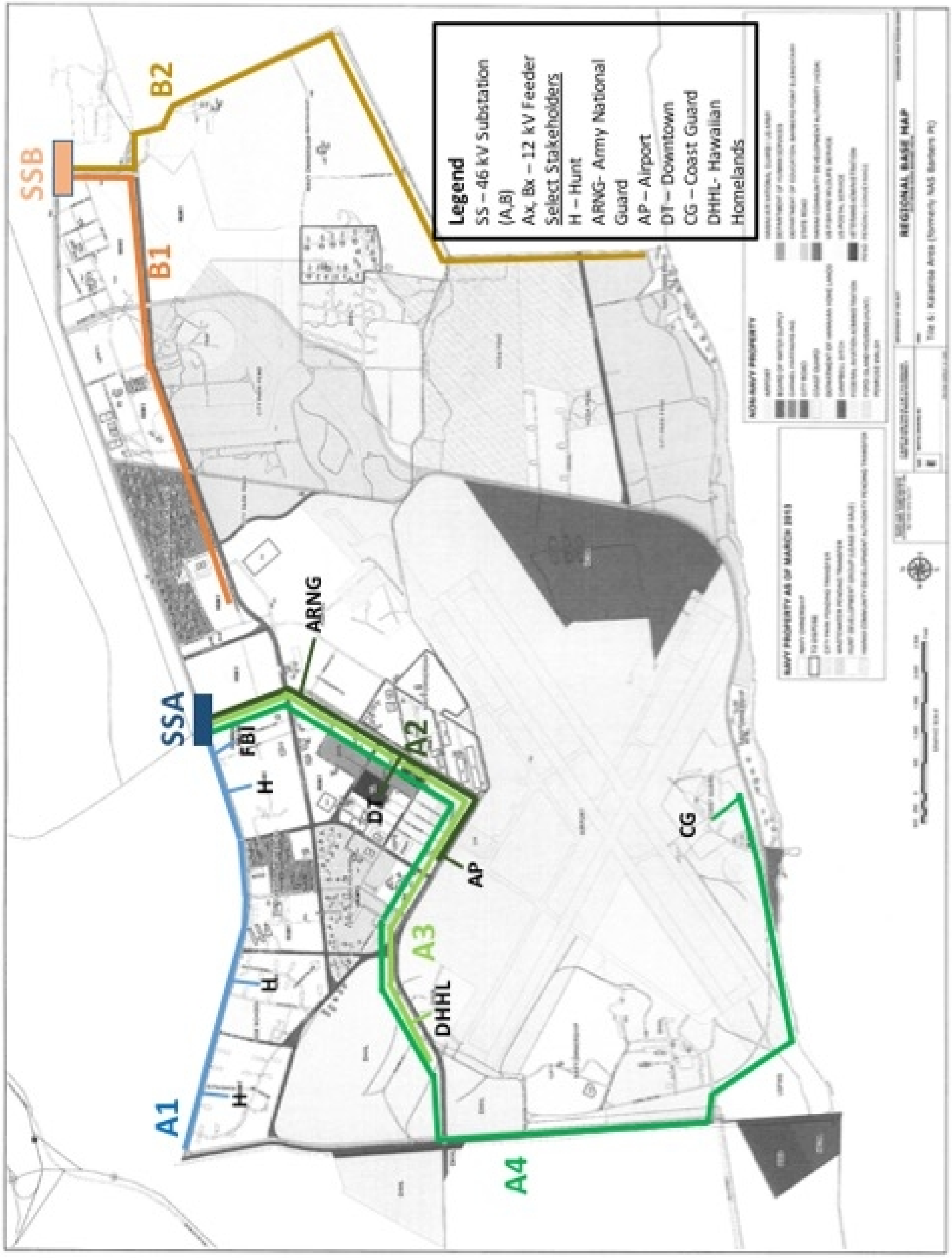

Figure 3. Phased Feeder Upgrade Approach

One of the major cost assumptions in this approach is that new distribution energy corridors will be placed underground, in order to comply with HCDA and/or other applicable rules for Kalaeloa. This has potential historical and environmental issues that could be encountered, and underground lines near the beach will need to be protected from inundation. All these concerns can increase costs and should be fully considered when undertaking a final implementation and construction strategy. Sandia also assumed that the infrastructure would be built in accordance with current utility construction guidelines, even if HECO doesn't become the owner/operator of the infrastructure. Utilizing utility construction standards will make it easier to connect to the HECO grid if needed, though this doesn't require that HECO be the builder or owner.

We received information from HECO on their typical sizes for underground conductors and substations to use in our analyses. Essentially 12 kV conductors have different capacities depending on the conductor and wire size. A high capacity rated 12kV underground conductor has the capacity for about 10-11 MW according to HECO, but will vary in size depending on the conductor used. Using typical HECO designs of 75% of capacity for operations, the 12kV feeders could each nominally carry about 7-8 MW of load.

HECO cost estimates for feeders and substations include:

- A 12 kV underground feeder cost of $4.3M/mile,
- A 46 kV distribution substation cost that can support up to 4-6 feeders is $11M.

We used these values for estimating phased feeder costs, so the longer the feeder, the higher the cost.

One likely phased approach based on the corridors shown in Figure 4 would include two substations. Substation A (SSA) would be built at 46 kV to support approximately five fedderes, Feeders A1-A5, at 12kV and serves as the primary input from the HECO grid. Feeder A1 supports the expected new Hunt development and existing FBI building plus other loads along this corridor. Feeders A2-A4 run along the Enterprise Corridor on Enterprise Avenue. Feeder A2 supports the most critical loads of the National Guard, loads for facilities in the downtown area such as the VA, and the existing Airport loads. Feeder A2 could utilize the partially built Enterprise Corridor.

Feeder A3 running along the same corridor would support the remaining less critical National Guard loads, and Airport and Downtown expansion. Feeder A4 also running along the same corridor would support further expansion, but primarily be used to pick up Department of Hawaiian Home Lands, and to provide primary power to the Coast Guard, as well as other new and existing loads in the southwest portion of Kalaeloa. Feeder A5 is not shown, but would be added to support additional new development if needed.

Substation B (SSB) would be built later (about year 6) at 46 kV to support three feeders, Feeders B1-B3, at 12kV to serve as the primary input from the HECO grid for the east and northeast part of Kalaeloa. Feeder B1 supports later expected Hunt development on the east side, the city part and other loads along the northeast portion of Kalaeloa. Feeder B2 running along the eastern edge of the Kalaeloa, supports all the new and existing loads for the eastern side of Kalaeloa. Feeder B3 is not shown, but would be added as needed to support additional new development. This reserves at least two feeders to be utilized in the future to support either renewable energy development or increased system expansion.

The phased approach is to build out SSA and Feeders A1–A5, followed by SSB and Feeders B1-B3, is only one example approach that could be considered. A more detailed final analysis should include a more complete understanding of expected new development so that feeders are sized with adequate capacity, and routed to make the most efficient use of resources. The phased approach shown is based on expected initial concentrated development and load growth in Kalaeloa and where power reliability will be most needed. This approach allows for sequential implementation of newer and more reliable feeders where needed first, while the existing system remains running to support tenants during a multi-year upgrade and construction plan.

3.1.1 Phased Feeder Implementation Cost Analysis

Table 2 provides an estimate of base infrastructure costs for the substation and feeder trunks to these areas. Costs include feeder taps as well as step-down transformers, metering, and design, construction, and engineering oversight. The total cost is often about twice the capital equipment costs. So SSA and feeders and equipment, along with SSB and feeders and equipment will probably cost close to $190M for the system over a10 year period.

Table 2. Base Infrastructure Costs for Phased Feeders

Equipment	Infrastructure Installed Costs ($M)	Service
SSA	11	46 kV Distribution Substation for Feeders A1-A4
Feeder A1	5	Hunt new development, FBI
Feeder A2	5	HARNG (part), Airport (existing), Downtown
Feeder A3	8	HARNG (remaining), Airport (expansion), Downtown (expansion)
Feeder A4	19	Airport (expansion), DHHL, Coast Guard
Feeder A5	5	Additional feeder to support further expansion as needed similar to A2 in size
Total Costs	**$53x2 = $106**	**Substation A plus 5 – 8 MW, 12 kV Feeders (Construction years 1-5)**
SSB	11	46 kV Distribution Substation for Feeders B1-B2
Feeder B1	7	Hunt later development, City Park, WWII Park
Feeder B2	11	East portion of Kalaeloa District – golf course, new development
Feeder B3	11	Additional feeder to support further expansion as needed similar to B2 in size
Total Costs	**$40 x2 = $80**	**Substation B plus 3 – 8 MW, 12 kV Feeders (Construction years 6-10)**

Further reliability enhancements such as looped feeders, where one feeder can back feed and support another, as well as advanced metering of feeders and end use in buildings would add some additional costs. Four, 5-MW PV developments at Kalaeloa were included but were assumed to use power purchase agreements with renewable energy developers and investors to finance the renewable energy development and help meet state renewable portfolio standards. Renewable incentives and renewable energy siting cost recovery as part of the PPA could help reduce some capital and therefore overall operational costs depending on the structure of the PPAs.

HECO has estimated power system upgrades at Kalaeloa to be between $300-400M. Part of the difference in our evaluation is that in our approach the substations are on the perimeter of Kalaeloa, reducing the underground utility costs of 46 kV feeders to the substations. We also eliminated a transmission substation, and have chosen to use a larger number of smaller feeders to address loads, and use feeders more compatible with the new 5 MW solar installations. But both evaluations suggest that the energy system upgrade cost to meet modern standards and move to underground utilities will likely cost somewhere between $200-300M.

The electric system upgrade costs include:

- Annual operational and maintenance costs,
- Financing costs for energy upgrade funding,
- Bulk energy costs from purchases from HECO or onsite renewable PPAs
  - Assuming little initial renewable energy PPA's for on-site solar power,
  - Increasing to 5 MW or 15% on-site renewable penetration with a 25% capacity factor by the end of the 5th year, 10 MW by year 10, 20 MW by year 20, and
- Average power demands of 30MW for years 1-5, 40 MW for years 6-10, 50 MW for years 11 to 15, and 60 MW for years 16 to 40.

The estimated fixed costs included:

- Financing – 3% interest for 35 years,
- HECO bulk energy costs of $0.20/kWh, 5 MW solar PPA's at $0.10-0.13/kWh, and
- O&M costs – 10% of bulk infrastructure costs, with an additional 1% profit.

Based on the estimated costs and the build out for the approach identified in Table 2, we calculated overall energy costs per kWh for Years1-5, Years 6-10, and Years 16 and beyond, and are highlighted in Table 3 below. As noted in Table 2, the major projected energy upgrades are constructed between years 1-10, with on-site solar power integrated into the system over a 15 year period so renewable penetration does not exceed 33 percent. As the second substation and associated feeders are constructed from Years 6-10, the capital cost of debt service increases, but the unit cost begins to decrease as more customers are added to the system from Years 11-15. The average energy availability and reliability increases over time as the Kalaeloa energy upgrades replace the existing grid and modernize the energy infrastructure. By Year 15, most of the major upgrades are expected to be made and the major redevelopment completed. Example cost calculations for Table 3 are provided in Appendix B.

Table 3. Phased Feeder Upgrade Approach Estimated Energy Costs

Average Energy Load	Annual Capital Cost ($/kWh)	O&M Cost ($/kWh)	Weighted Purchased Power Cost ($/kWh)	Total Energy Cost ($/kWh)	Solar Power	Average Power Outage (hrs/yr)
Years 1-5 30 MW	0.022	0.053	0.182	0.26	5 MW	15
Years 6-10 40 MW	0.028	0.067	0.174	0.27	10 MW	5
Years 16 and above 60MW	0.017	0.039	0.168	0.24	20 MW	2

3.1.2 Phased Feeder Upgrade Option Summary

In discussions with Kalaeloa tenants, they estimated their current energy costs at approximately $0.30-0.32/kWh, though they discussed how the costs varied on a two-year cycle. The Navy chose not to provide us with actual energy billing information, but acknowledged that the general billed costs varied by their purchased energy costs, but were likely in the range noted by the tenants. Since local energy costs in Oahu are around $0.21-$0.24/kWh, we were trying to establish approaches that could provide a competitive cost structure, knowing that smaller operations will likely be more expensive because of the lack of economies of scale. Therefore, the estimated costs identified with this option seem to suggest that the approach is relatively cost effective considering the needs of the District.

Unfortunately, this approach does not immediately reduce the current power reliability issues for all tenants. As shown in Table 3, the expected outage durations in the first 5 years will drop by a factor of two or more, but will still not be at nominal utility level energy reliability. But as upgrades take place over a 10 year time frame, most tenants will have been connected to a newer and smarter electric system, which will inherently begin to improve power reliability over time as shown in Table 3.

3.2 Microgrid Approaches for Kalaeloa

Since it would take time to fully implement and phase in a set of new energy corridors to provide more reliable power to Kalaeloa, other options were considered. Development of microgrids to serve particular landowners with more reliable power than the current Navy system is one option. Microgrids integrate existing and new backup energy generation and storage and renewable energy resources onto the electrical distribution system to function as a small power grid. Microgrids are more efficient and cost effective, providing higher reliability power since distributed generation is integrated rather than being only building-tied, enabling better use and management of all generation resources. If for example, a generator breaks down and cannot operate, other generators will pick up the load.

Advanced microgrids utilize automated electrical switchgear and computer controls to be able to operate either islanded or grid-tied. This enables the microgrid and its distributed generation resources to separate from the grid during a power outage to meet local power needs, but also operate the generation resources when grid-tied to reduce peak power demands or provide power to the grid to support the utility in addressing transmission congestion, powerline damage, etc. Sandia has developed many advanced microgrid designs at over 30 military sites and communities. The use of advanced microgrids has many benefits, including:

- Improved energy assurance for critical mission needs,
- Enhanced energy resiliency in extended power outages,
- Improved utilization of distributed and renewable generation,
- Reduce grid congestions and provide other ancillary grid services, and
- Reduce size and costs of emergency generation needed.

There are several different microgrid design approaches, each having their own pros and cons that are summarized in the following discussions.

3.2.1 Advanced Microgrids – Islanded and Grid-tied Operations

In advanced microgrids, all distributed generation resources - renewables, energy storage, diesel or natural gas gen-sets, etc. - are connected together on the local distribution system, as well as connected to the sub-transmission system through a point of common coupling (PCC). As shown in Figure 4, you have flexibility in the size of the microgrids, from a partial feeder, full feeder, or even a full substation microgrid, depending on local needs.

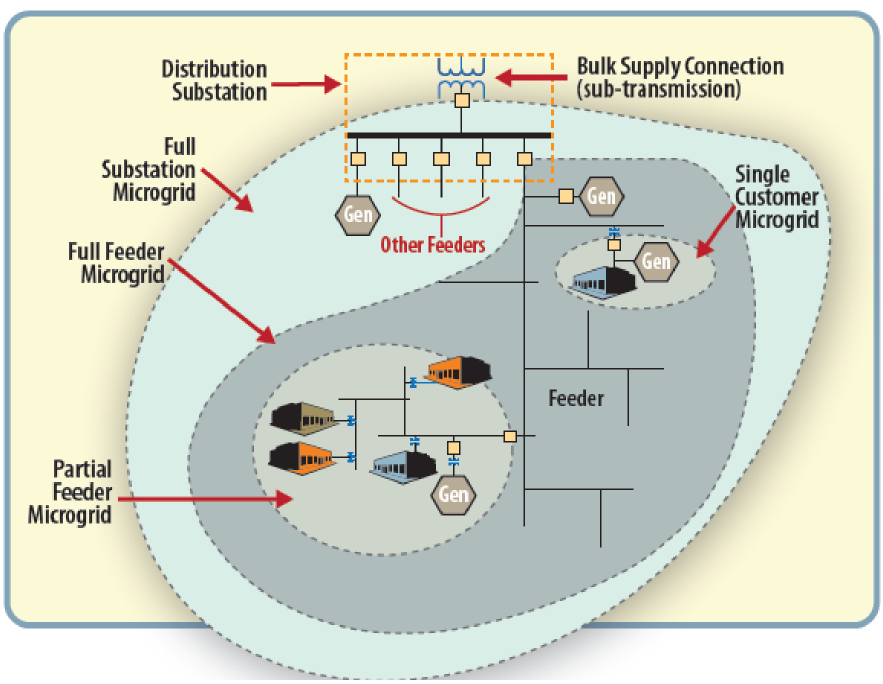

Figure 4. Advanced Microgrid Approaches

Microgrids have been considered before for Kalaeloa, HECO has even developed a conceptual microgrid approach. The HECO conceptual design considered two full substation microgrids with two looped segments on the east and west side of Kalaeloa connected to a transmission substation in the center of Kalaeloa. This conceptual design though did not specifically identify the high priority or critical loads. At large sites like Kalaeloa, it is not uncommon to develop many small microgrids, each being a different size depending on the distribution system topology and the location of the critical loads and services that require high reliability power.

The major operational benefit of an advanced microgrid is that the distributed generation can operate when tied to the grid to reduce peak load, etc., but also operate together during a power outage to safely support local critical loads. In this way, energy costs are minimized by using often lower cost utility power most of the time, but using the renewable and distributed generation resources when appropriate – power outages, peak shaving of power demand to lower energy costs, etc. This optimizes the operation of the distributed generation and lowers operational costs. This is often the lowest cost, highest reliability approach, supporting 20-40% of renewable penetration without expensive energy storage.

There is often minimal operations and maintenance cost associated with advanced microgrids since the existing distribution system infrastructure is often used. This approach has the most flexibility in managing loads and generation resources as situations vary, improves local energy assurance and resiliency in both short and extended power outages, enhances the utilization of renewables to provide emergency power, and enables load shedding and other grid services with distributed and renewable generation. Advanced microgrids can be a relatively inexpensive option, often paying for themselves in a single major power outage because of the avoided economic loss of critical operations or services, by reducing costs through load shedding, and by generating income by providing ancillary services to the local utility when needed.

In considering advanced microgrids at Kalaeloa, the microgrid improvements would be utilized primarily to improve the landowner and tenant power reliability when the grid goes down. The advanced microgrid approach enables any distributed or renewable energy systems installed by tenants to continue to operate during a power outage, making those investments more cost effective. Because the advanced microgrids would be managed as a part of the larger Kalaeloa grid, there would be less regulatory, utility, and safety issues with their implementation.

3.2.2 Islanded Microgrids – Stand-alone Operations

For islanded microgrids, all distributed generation resources, renewables, energy storage, diesel or natural gas gen-sets, etc. are tied to the local distribution system, but the microgrid is not tied to the larger sub-transmission system or transmission grid. Therefore, the system operates as a stand-alone or islanded system, and the microgrid manages all generation and load management. This is a common approach at college or industrial campuses, where heating and cooling loads or industrial process create significant heat to also generate enough on-site thermoelectric power to satisfy local demands and grid power is not really required. Islanded microgrids also occur in many small islands or remote areas where there is no transmission grid to connect to.

In other than Combined Cooling Heating and Power (CCHP) applications, islanded microgrids are often an expensive option because the use of local distributed and renewable generation resources often requires extensive energy storage systems to be able to maintain high quality and high reliability power without the support of a large grid. In islanded microgrids, all operations and maintenance (O&M) costs are born by the microgrid operator, with fuel costs often being higher than for a large utility unless the economies of combined heat and power are integrated within the islanded microgrid system.

If an all-renewable islanded microgrid is required, then the costs can be even higher. This is because the use of intermittent renewables such as wind and solar have extra generation and extensive energy storage requirements to provide the high reliability and high quality electric power needed. This need is highlighted in Figure 5 for a 2 MW fully solar PV powered microgrid system design that requires significant energy storage and large PV arrays to address the power needs for morning and evening power loads, and loads for a few days without sunshine.

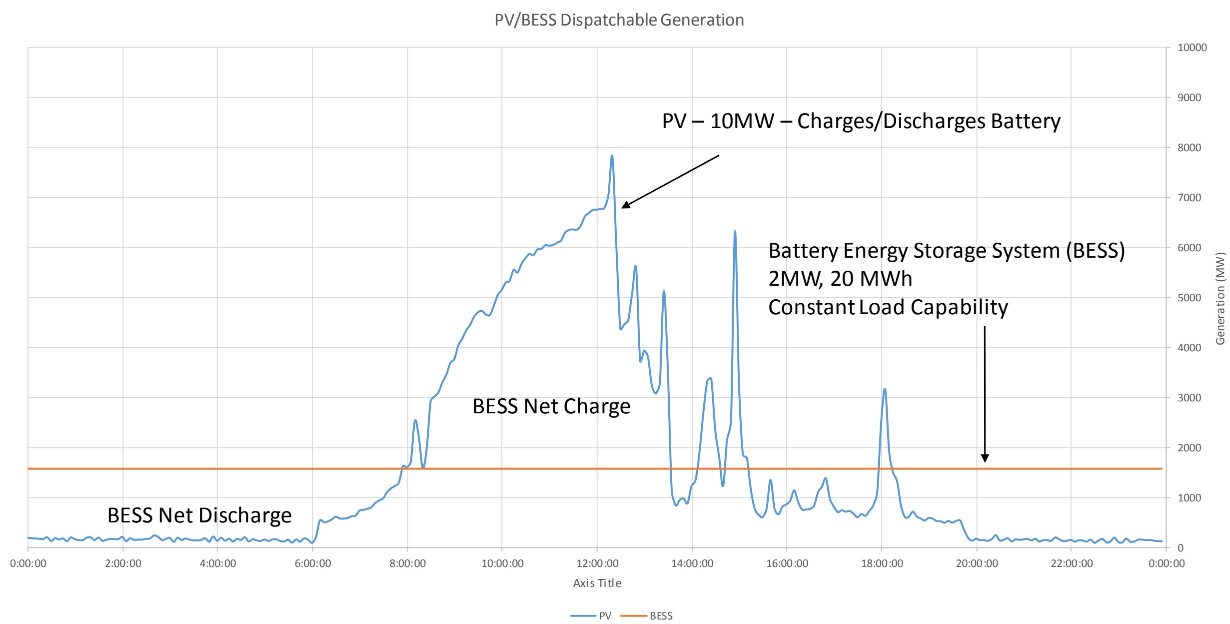

Figure 5. PV/BESS Dispatchable Generation System

If the only source of generation is PV, the capacity of the PV system and Battery Energy Storage System (BESS) would need to consider the possibility of days with low or a lack of solar irradiance. Thus, the total PV output needs to support not only a full 24-hour demand, but also needs a battery that can support the full power demand for a potential one or two-day power outage. Essentially, the BESS supplies generation to the system when the PV is unavailable, and is charged with the excess power provided by the PV, when available, so the total system can act as dispatchable generation, similar to a diesel or natural gas generator.

3.3 Islanded System Conceptual Design

Given the uncertainties of transition of the Navy energy distribution system and reconnection with a new provider such as HECO, Sandia evaluated an islanded energy system upgrade option utilizing advanced microgrids as a possible mechanism for providing reliable power to Kalaeloa without connecting to the existing grid. This approach would allow Kalaeloa to be totally off the HECO grid and operated through an independent authority (reference Appendix A for discussion on various types of electric utility frameworks). Under the control of this authority, any number of advanced microgrids can be networked to provide an efficient and reliable power grid that shares local energy generation and feeders with all tenants to ensure local control over power quality and reliability. This approach is often more expensive than using available utility power, but if negotiations with the Navy and alternative energy providers fail to reach a reasonable outcome for Kalaeloa, this could be an option that might be required.

The islanded operational approach can be summarized by the following:

- Utilize the existing Navy grid to feed current landowners until new networked microgrids are developed, and Navy services are decommissioned.
- Each microgrid would include from two to four, 2MW generators, with an 8 MW capacity feeder to supply prime power to users within each microgrid. Designing with higher feeder capacity allows future growth to occur in each microgrid.
- Each microgrid would be built in phases as needed to meet new demand growth.
- The microgrids can be built with either new underground infrastructure or with refurbished Navy infrastructure, if and as appropriate.
- The microgrids can be designed for up to 5MW PV and 2MW BESS.
- Linking microgrids would create a microgrid network so that generation can be shared and distributed and renewable resources are most efficiently utilized.
- Additionally, using a networked microgrid approach does not preclude future connectivity with HECO. The microgrids can be designed to eventually connect with HECO with the proper controls. This could provide an additional generation resource for Kalaeloa, similar to the use of host nation power in some military microgrid applications, and provide more energy resilience for Kalaeloa.

Figure 6, shows a possible framework for networked islanded microgrid systems. This is one of several possible alternative frameworks where microgrids could be developed and distributed generation would include PV and BESS resources. Alternative layouts and locations are appropriate and can be evaluated in the future to determine the most efficient and economical locations. In the example configuration shown, the microgrids labeled FA, FB…FH, are developed in phases with distributed generation to support up to 2MW of load and fully cover all loads within each microgrid, and as load grows, more generation would be added.

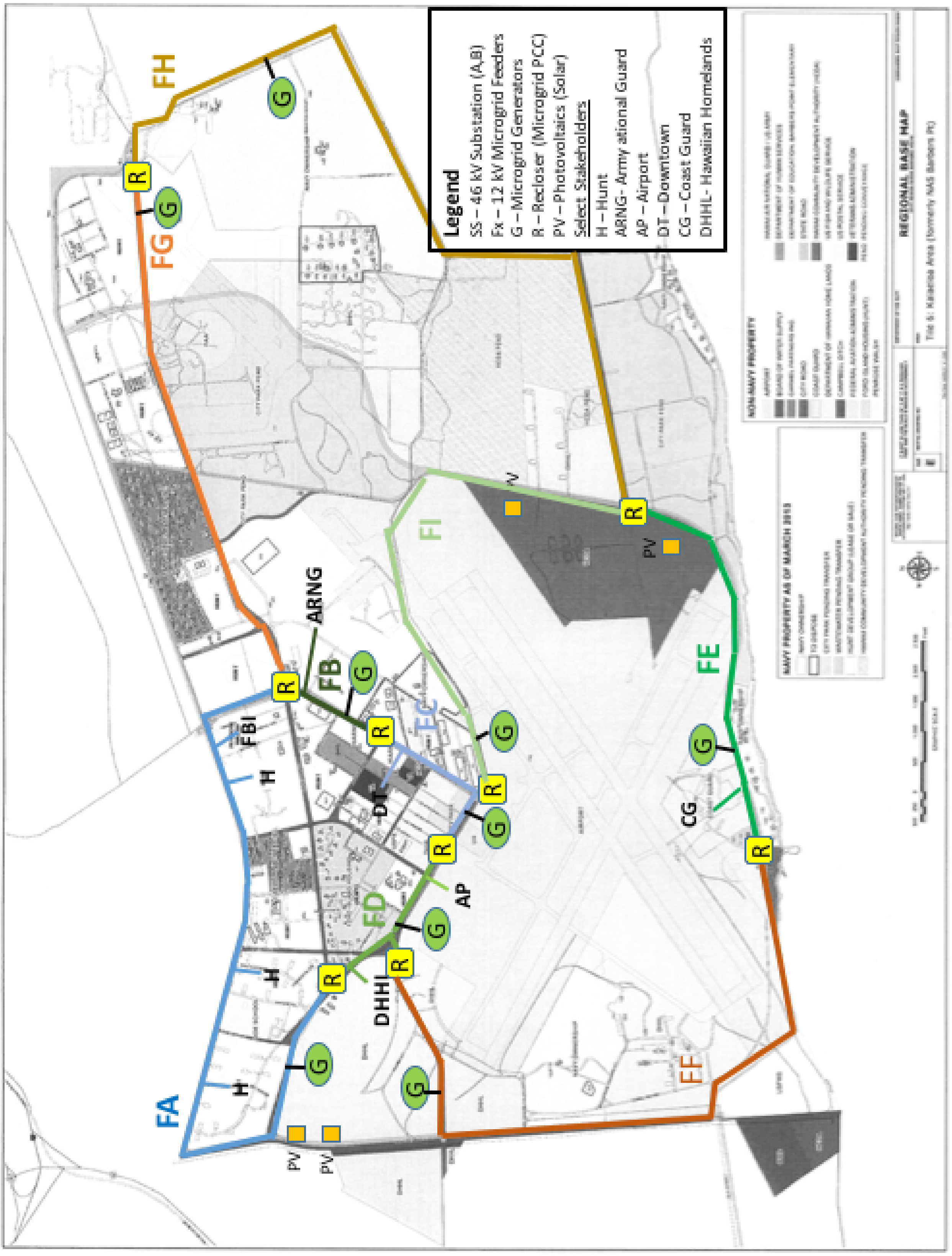

Figure 6. Islanded System Approach Using Networked Microgrids

If feeder capacity is exceeded, new parallel feeders can be added to the system. If designed as an advanced microgrid, each one can be segregated from another via a point of common coupling (PCC), as designated in Figure 6 as a recloser (R). These PCC devices, when open, separate each microgrid from the rest of the system and pick up the loads within each microgrid. When PCC devices are closed, they connect microgrids with each other, so power can be distributed and shared between microgrids. Each advanced microgrid would contain its individual controls and monitoring, as well as distributed controls between microgrids, so that when microgrids are interacting, all generation resources can be dispatched efficiently across Kalaeloa. When completed, the energy system at Kalaeloa as a whole would have multiple redundant paths to manage and move power during disruptions, generator resource damage or failures, or even severe events and extended power outages.

For example, microgrid FB in Figure 6, could utilize power from microgrids FA, FG, or FC, by opening and closing various reclosers (R), so power availability and reliability is higher and the overall resiliency of the energy system is improved over microgrids operated separately. Therefore, in this approach, generation can be shared across Kalaeloa, and the reliability benefits shared throughout the entire community.

Another benefit of the networked advanced microgrid approach is that it allows Kalaeloa to utilize HECO as an Independent Power Producer, feeding into the microgrids in the future. Provided proper controls are implemented, power can be purchased from HECO or sold to HECO in an arranged manner to help support HECO with ancillary demand support during high demand periods, and reduce costs to Kalaeloa when power can be purchased for less, without loss of reliability.

Figure 6 shows each of the 12kV advanced microgrids, each initially built with a 2MW generation capacity. Some locations where PV systems have been proposed are shown as well. We evaluated options of supplying each 2MW of distributed generation with diesel generators, PV/BESS, or both as described below. This generation represented by a green circled G in Figure 6, supports each microgrid, but the locations for the generation is not set at the locations shown, they are put there to show generation supporting each microgrid. In this proposal, FA, FB…FH are built in sequence, or independently to provide power to existing landowners and new load growth, and support landowner loads noted in Table 1.

As each microgrid is completed, and the landowners in the region are fed by each microgrid, the existing Navy system can be demolished or replaced. This coupled approach allows each microgrid to be built as needs exist. And the entire extent of each microgrid does not need to be developed entirely. Only when two microgrids connect, will coupled microgrids exist and allow sharing between areas. It is better if these activities are coordinated to occur in sequence, but not strictly necessary. For example, parts of FA, for Hunt, FB for Army National Guard, and FE for the Coast Guard could be constructed with smaller feeder lengths than shown in Figure 6, and then expanded later when growth occurs, to connect the systems together as needed.

3.3.1 Islanded System Implementation Cost Analysis

Two sets of cost analyses were made for the islanded microgrid option – one for the base infrastructure costs and one for the generation/fuel costs. The base infrastructure cost represents the capital costs for feeders, switchgear, controls, etc., necessary to support the islanded microgrids. These costs are decoupled to compare both the costs of underground versus overhead base infrastructure, and to compare costs for different suites of generation – diesel generators, diesel and PV/BESS, and PV/BESS only. For initial cost estimates, some basic cost assumptions outlined below were used.

For reclosers and controls we relied upon estimates of recent costs for the equipment needed. We utilized HECO provided costs for overhead and underground 12kV feeders. We made assumptions for refurbished overhead conductors, versus new conductors, that it would cost ~1/3 less per mile to refurbish existing lines than rebuild new ones. Another major assumption is that the total cost is two times the equipment costs, to account for all of the other costs for the base infrastructure for the microgrids – other equipment, construction, engineering, contingency, etc. The actual costs may be somewhat higher or lower depending on the nature of the costs. The base infrastructure costs were evaluated similar to the phased feeder approach shown in Table 2.

Cost assumptions for the infrastructure upgrades include:

- Underground Microgrid Conductors – 12 kV, 8 MW capacity, $4.5M/mile
  - $4.3 M/mile for conductors and $0.2M/mile for communication and controls
- New Overhead Conductors – 12 kV, 8 MW capacity, $1.2M/mile
  - $1.1M/mile for new overhead lines and $0.1M/mile for communications and controls
- Refurbished Overhead Conductors – 12 kV, 8 MW capacity, $0.8M/mile
  - $0.7M/mile average for refurbished lines and $0.1 M/mile for communications and controls
- Reclosers – 12 kV, 8 MW interrupt capability, $0.2M/each
  - Includes communications and controls
- Total Costs –2X total equipment costs
  - Includes additional infrastructure, engineering, construction contractor, taxes, contingency, etc. (sum of infrastructure costs) (construction and contingency)

Table 4 shows the cost of the base infrastructure for islanded microgrids built using different types of conductors for the feeders. Using only underground feeders for Kalaeloa, a rough order of magnitude (ROM) for the base infrastructure is $128M. With new overhead feeders the ROM for base infrastructure is $37M and with refurbished overhead feeders it reduces to $27M. Not all areas have existing energy distribution lines and corridors that can be utilized and refurbished into a microgrid, so refurbishing overhead feeders might not be available in some areas.

If part of the advanced microgrid feeders can be refurbished, then the costs for each microgrid will likely range between the values shown in Table 4. As stated, each microgrid can be initially built to cover a smaller footprint. For example, if the FA feeder is much more restricted initially, its feeder costs and overall costs will be reduced accordingly.

The nine microgrids identified could provide up to 72 MW of generation capacity for Kalaeloa, but with networking and sharing the number would be reduced. Overall, the islanded microgrids were evaluated and designed to have enough generation to meet the maximum expected long-term load of 60 MW for Kalaeloa. Therefore, the maximum load capacity of this option is similar to the phased feeder approach discussed previously.

Table 4. Islanded Operations Infrastructure Costs - Underground versus Overhead

12 kV Microgrid	Underground Cost ($M)	Overhead Cost ($M)	Overhead Refurbished Cost ($M)	Service
FA	23	7	5	Hunt new development, FBI, DHHL
FB	3	1	1	HARNG
FC	5	2	1	Downtown
FD	5	1.5	1	Airport, Hunt
FE	12	4	3	Coast Guard, HCDA
FF	22	6.5	5	DHHL, Southwest Kalaeloa District
FG	16	4	3	Hunt later development, City Park
FH	26	7	5	East portion of Kalaeloa District
FI	16	4	3	Mid – East portion of Kalaeloa District
Total	**128**	**37**	**27**	**Nine 8 MW Advanced Microgrids**

Next we evaluated the generation costs for each of the networked microgrids using diesel generation, PV/BESS systems, and hybrid diesel/PV approaches. While considering stakeholder interests in supporting Hawaii's goal of using100% renewables by 2045, an evaluation of the land area needed for using only onsite PV and battery storage would require about 300 MW of onsite solar and a land area of about 1800 acres. The estimated undeveloped land available in Kalaeloa is only about 1700 acres. This suggests that Kalaeloa cannot meet the state renewable energy goals by using only onsite solar energy.

Therefore, we focused on approaches using onsite diesel generators and hybrid diesel/PV/battery storage options. Assuming renewables from only onsite sources, a maximum of about 100 MW of solar PV covering about 600 acres was considered. This tries to optimize the amount of on-site solar PV used, which is over five times the PV considered in the phased feeder upgrade option, and is considered the likely limit of land available for PV. General assumptions included:

- Diesel Generators – 2MW each (typical scale of large/continuous applications)

- PV/BESS – in increments of 10MW PV (20% capacity factor), 2MW/20MWh BESS to make PV dispatchable (see Figure 5 example)
- Hybrid system – 70% diesel and 30% PV/BESS

Below are cost assumptions made for the distributed generation options, based on recent cost data for typical installed costs for each of these resources. To compare costs equally, we include diesel generator operational lifetime of 10 years, fuel costs at $4/gal, current PV PPA costs for larger systems in Hawaii, and BESS systems with a 10 year lifetime.

- Switchgear/Controls - $0.3/W – for either diesel, PV/BESS
- Construction/Contingency - 1.5X total costs (sum of capital costs)
- PV PPA - $0.09/kWh
- BESS (Battery Energy Storage System) - $2/Wh ($3.4/Wh including switchgear and construction/contingency)
- Diesel Generator - $0.7/W ($1.5/W including switchgear and construction/contingency)
- Diesel Fuel Costs - $2.5/W ($4/gal diesel fuel) (2MW uses average of 120 gal/hour)

Consideration of running these systems full-time creates a significant operations and maintenance cost that has to be included in the analysis. Also, replacement of the distributed generation resources - diesel and battery systems – must be considered, since they would likely have to be replaced about every 10 years because of the heavy operational use. Therefore, the cost estimates provide an indication of the expected energy costs for up to 20 years if an islanded Kalaeloa grid approach is utilized. Example cost analyses for this approach are provided in Appendix B.

Table 5. Islanded System Upgrade Option Energy Costs

Microgrid Option	Generator Capital Costs ($M)	Fuel Costs ($M/yr)	PV/PPA Costs ($/kWh)	BESS Capital Costs ($M)
Diesel Only Years 1-10, 35 MW	54	76	NA	NA
Diesel Only Years 11-20, 60 MW	100	133	NA	NA
Diesel/PV/BESS Years 1-10, 35 MW 70% diesel/30% PV/ 100 MWh BESS	38	53	$0.09	340
Diesel/PV/BESS Years 11-20, 60 MW 70% diesel/30% PV/ 150 MWh BESS	70	93	$0.09	510

Each advanced microgrid allows connectivity with existing backup generation with some modifications to the generators as well as switching devices that can provide enhanced generation capacity above and beyond the 2 MW new generation provided by each microgrid. From Table 1, this might be as much as 6-7 MW of existing diesel generators could be included.

We did not take into account the costs associated with using the existing generators or associated infrastructure to integrate these systems into the microgrids, but commonly it takes $100K to upgrade existing generators into a microgrid. We do discuss some of these potential considerations in Section 3.4 when discussing other types of upgrade options with advanced microgrids where the existing generation can be utilized because of reduced operational requirements built into the design and operation strategy.

3.3.3 Islanded System Operational Cost Summary

We outlined above a fully islanded energy system upgrade approach for Kalaeloa using only onsite generation. The options considered included using only renewables and batteries, only standard diesel generators, and a combination of both diesel generators and renewables. Tables 4 and 5 show estimated electric generation costs for the networked advanced microgrid options. In these tables, we have translated these installed and operational costs into equivalent unit energy costs of $/kWh. The costs are based on the same assumptions used for the phased feeder approach and include:

- Loan period - 35 years for distribution and 10 years for generation and batteries
- Interest Rate - 3%
- O&M and Profit Costs - 11% per year

Table 6 below summarizes the energy costs for the various options assuming the distribution system is installed underground, as assumed for the phased feeder option. The cost capital and operating costs from Tables 4 and 5 have been translated into energy costs in terms of $/kWh. Example analyses of the assumptions and how these costs are calculated are provided in Appendix B.

Table 6. Cost Comparison for Islanded System Approaches

Microgrid Approach	**Annual Capital Costs ($/kWh)**	**O&M Costs ($/kWh)**	**Fuel Costs ($/kWh)**	**Weighted PV/PPA Cost ($/kWh)**	**Total Energy Cost ($/kWh)**	**Average Power Outage (hrs/yr)**
Diesel Only Years 1-10, 35 MW	0.039	0.065	0.248	NA	0.35	< 2
Diesel Only Years 11-20, 60 MW	0.035	0.048	0.253	NA	0.34	< 2
Diesel/PV/BESS Years 1-10, 35 MW 70% diesel/30% PV 100 MWh BESS	0.164	0.182	0.173	0.03	0.55	< 2
Diesel/PV/BESS Years 11-20, 60 MW 70% diesel/30% PV 150 MWh BESS	0.140	0.148	0.176	0.03	0.50	< 2

3.3.2 Islanded System Upgrade Option Summary

From Table 6 the total cost of an islanded microgrid using only on site generation with underground feeders will likely vary from \$0.34/kWh to as high as \$0.55/kWh. These costs are all higher than the phased feeder approach, primarily because of the higher costs of distributed generation, fuel, and battery storage systems. Potential challenges with the islanded approach are concerns about the generators being able to meet environmental and noise permitting requirements (see Appendix A.5 pertaining to Hawaii Administrative Rules 11-60.1 – Air Pollution Control). The generation costs for islanded microgrids depend on whether diesel generation with or without PV/BESS supply each microgrid.

The results show that though PV costs have come down considerably, the need for either on site generation or battery storage to firm up the intermittency of renewables is still relatively expensive. So while the costs for diesel generators, PV, and BESS continue to go down, for the near term, they remain high when relied upon to provide 24/7 electric power independent of a connection to a utility. Additionally, the costs and land area needed to create a grid-independent energy system at Kalaeloa using only onsite solar is simply not feasible. As other types of renewables may become available in the future, this option could be reconsidered.

3.4 Hybrid Phased Feeder/Advanced Microgrids Conceptual Design

We also considered a hybrid system, implementing phased feeders with a few strategically placed advanced microgrids, which has some advantages of both approaches. In this approach, we can utilize PV systems as well as new and existing diesel generators (or other resources like natural gas generators) as needed when the power goes down, so the fuel costs and the need for extensive battery storage is significantly reduced. This could make energy more cost effective while also improving energy availability and reliability for critical or import Kalaeloa community services or specific tenants.

A hybrid phased feeder with selected advanced microgrids upgrade option for Kalaeloa is defined below. The approach has similarities with other approaches previously entertained by the HCDA, such as studies associated with adding new energy corridors, with or without microgrids proposed by HECO, or studies for development of various energy corridors in various areas of the Kalaeloa to meet the needs of particular customers. But the approach does combine some of the cost benefits of the phased feeder approach with the energy reliability and availability benefits of using advanced microgrids previously discussed.

In this option, advanced microgrids were selectively integrated on the existing distribution system with local distributed generation resources - renewables, energy storage, diesel, or natural gas generators. These advanced microgrids would be tied to specific feeders through a point of common coupling (PCC). In this application, the advanced microgrids would be used to provide power to priority or critical community services and tenants during a power disruption or outage. This would include conditions and disruptions expected while the existing distribution system and sub-transmission infrastructure is being improved, modified, and replaced. In this approach, initial microgrid capital improvements, such as controls and distributed and renewable generation resources, are designed to be incorporated into the operation of the upgraded power infrastructure, enabling the microgrids to provide high reliability power to the District.

This supports the phased modification of the energy infrastructure since the microgrids can insure local power quality and reliability to high priority areas or tenants, such as the USCG, HARNG, commercial ventures, or the airport for example. We have used this approach at military bases and communities where the funding for a full system improvement is prohibitively expensive and needs to be staged over a 5 or 10-year period. The approach tries to optimize the use of the existing distribution grid and distributed energy resources to reduce microgrid costs but maintain energy assurance as the distribution grid is being improved. For what is often a generally small initial capital investment, power reliability can be greatly improved.

The hybrid phased feeder/advanced microgrid approach can be summarized by the following:

- Utilize the existing Navy grid to feed current landowners until more reliable feeders and corridors are developed.
- In parallel, (1) phase-in reliable energy corridors, consisting of new 46 kV distribution substations and 12 kV distribution feeders, according to priority landowners needs, and (2) install advanced microgrids to serve these critical tenants and corridors so that when power is lost, onsite generation can support the critical power demand. After the Navy grid is replaced, the advanced microgrids can continue to support the Kalaeloa energy distribution system to provide additional critical power if the power goes down, thus significantly increasing critical load reliability.
- The advanced microgrids can connect to the existing Navy system and the new energy corridors, operating in both grid-tied and islanded mode, and will utilize both conventional diesel/gas generators, and PV/BESS to supply energy. The microgrids can remain fully operational and enable on-site renewable energy resources to continue to operate safely to support the District during a power outage.

Figure 7 illustrates where advanced microgrids would be located to maximize priority energy assurance, as identified by the reclosers (R) located on feeders A1-A4. Figure 7 shows several potential microgrid locations in high priority power service areas. The microgrids can support the high priority areas, as well as support the phased feeder approach shown in Figure 3.

Figure 7 also shows the location of a proposed new 46 kV substation (SSA), located to support both microgrid and phased feeder upgrade efforts. Feeders could be routed based on available corridors (following streets, avoiding historical areas, airport, etc., where distribution lines can't be located). While there are several alternate feeder routes and locations for the main 46 kV substation, we have focused on one option in this report to provide and idea of the cost and performance benefits of this hybrid feeder/microgrid approach.

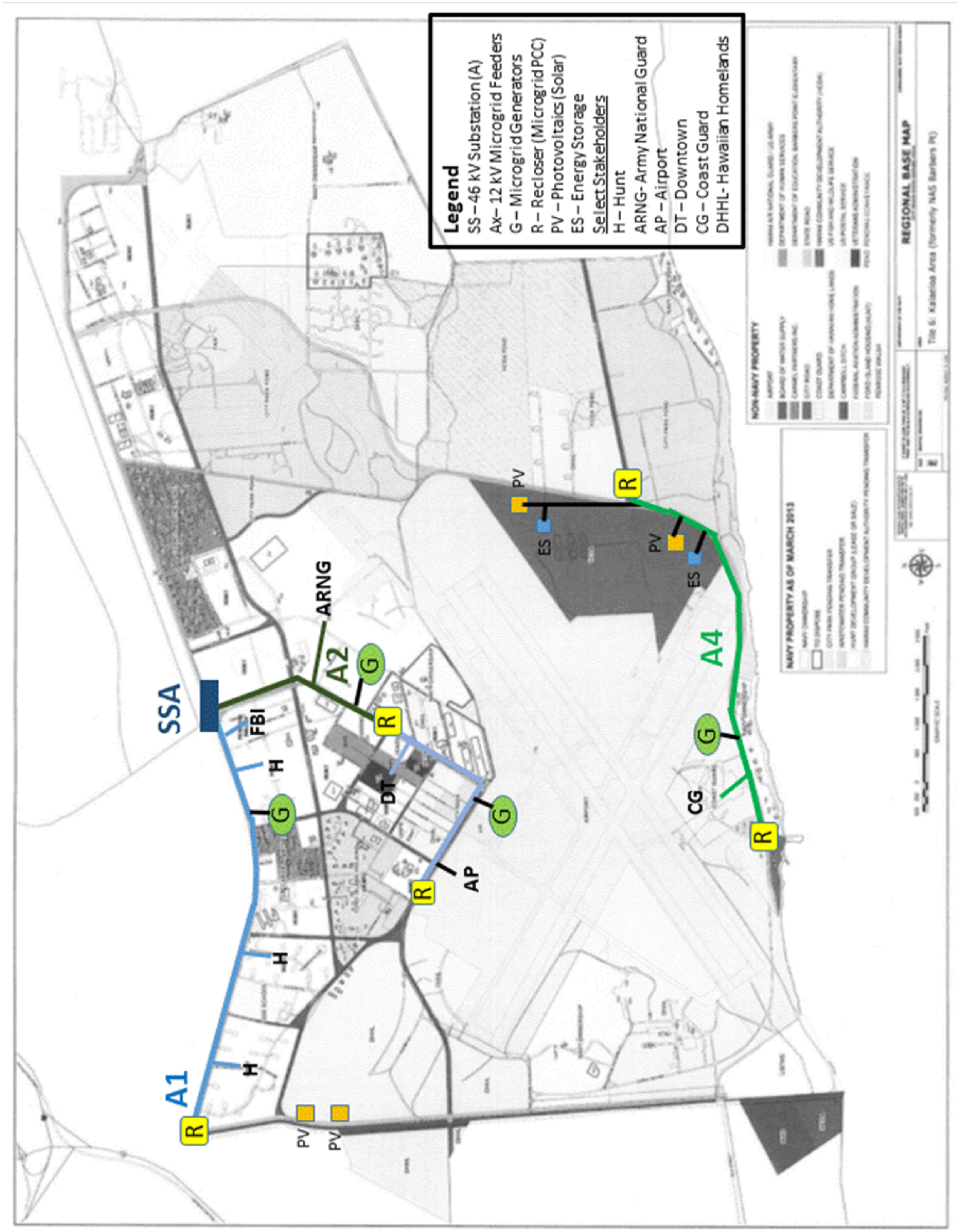

Figure 7. Advanced Microgrids to be Integrated with Phased Feeders

3.4.1 Hybrid Feeder/ Microgrid Implementation Cost Analysis

To assess the cost/benefits of the hybrid phased feeder/advanced microgrid approach, a cost versus reliability improvements analysis was conducted. The costs analysis included:

- Use of the phased feeder upgrade approach and schedule for electrical infrastructure costs, including substation, feeders, and renewables,
- Add 2 MW of diesel generation for microgrids FA, FB, FC, and FE, and
- Add additional switchgear and controls to implement the microgrids – such as reclosers that are shown in Figure 7.

Each advanced microgrid would be implemented with 2MW of new diesel generation capacity, supplemented by new on site PV as it is installed, and the use of the existing 6 MW of generator capacity as available and noted in Table 1. Since each microgrid could be implemented quickly in the first 2-3 years of this effort before the initial new phased feeders improvements can be accomplished, we would connect them initially to the existing Navy grid. In this application the microgrid generators would only be needed for backup power when there is a power outage, requiring a generator to operate only about 40 hours per year to cover existing power outage profiles, which is less than one percent of the time.

With these assumptions, the additional costs for the advanced microgrids shown in Figure 7, including new generation and controls, construction, engineering, design, and contingencies are presented in Table 7.

Table 7. Advanced Microgrid Implementation Costs

Microgrid	Generator Costs ($M)	Other Microgrid Costs ($M)	Fuel Costs ($K/yr)	Service
FA	3	3	20	Hunt new development, FBI
FB	3	3	20	HARNG
FC	3	3	20	Downtown, Airport, Hunt
FE	3	3	20	Coast Guard, HCDA
Total	**12**	**12**	**80**	**Four 2 MW Advanced Microgrids**

Table 7 shows four - 2 MW microgrids that would be supplemented with existing generation as available. In most cases the critical load is only about 20-25 percent of the maximum power demand. Therefore, we really do not need to provide power for all loads, only the identified critical loads and only in emergency situations. Finally, as highlighted in Table 8, when these costs are converted to equivalent costs in $/kWh with the same pay period and interest rate assumptions, the microgrids using generators would only add about $0.01 to 0.02/kWh to the calculated phased feeder approach shown in Figure 3.

Table 8. Hybrid Phased Feeder/Advanced Microgrid Approach Energy Costs

Average Energy Load	Annual Capital Cost ($/kWh)	O&M Cost ($/kWh)	Weighted Purchased Power Cost ($/kWh)	Total Energy Cost ($/kWh)	Solar Power	Average Power Outage (hrs/yr)
Years 1-5 25 MW	0.022	0.053	0.182	0.26	5 MW	15
Years 1-5 Additional Microgrid Costs	0.005	0.012	NA	0.02	NA	< 2
Year 1-5 with Feeder/Microgrid Option	0.027	0.065	0.182	0.28	5 MW	<2

In the phased feeder approach, up to 20 MW of PV were included in the electric grid replacement cost analyses for that option so they do not need to be included as part of the microgrid costs. As such, the only real additional costs for the hybrid feeder/advanced microgrid approach is the cost differential to initially integrate about 8 MW of additional on-site distributed generation with existing diesel generators to create the microgrids. Appendix B provides an example of how the microgrid cost assumptions were calculated.

3.4.2 Hybrid Feeder/Microgrid Upgrade Option Summary

This energy system upgrade approach would enable Kalaeloa to quickly enhance energy system reliability while final discussions and decisions about the operation and management structure of the Kalaeloa electric grid are completed. The microgrids could then be integrated into the overall phased feeder approach and continue to support the Kalaeloa grid with high reliability power in out years.

The big advantage of this hybrid approach is that the funding required could be obtained in smaller increments as needed to reduce financing costs and be more flexible with available funding resources while still making progress in reducing energy reliability and availability concerns. With microgrids, if the Kalaeloa infrastructure is upgraded more gradually, the advanced microgrids can buffer the power reliability concerns of the Kalaeloa tenants until an updated and more reliable grid is constructed and fully operational.

Additionally, the amount of diesel generation required can be supplemented by the use of any of the approximately 6.5 MW of existing generation noted in Table 1 and available in each of the microgrid locations. For example, the Coast Guard inventory of backup diesel generators is ~800 kW, distributed across several units. Similarly, the Army National Guard has several MW of backup generation, and several more planned, that could be integrated into an advanced microgrid as well to offset the need and cost of additional generators.

4. SUGGESTIONS AND RECOMMENDATIONS

To support Kalaeloa in identifying innovative approaches to move the District forward and accelerate redevelopment, Sandia worked closely with HCDA, HSEO, and the Navy to:

- Assess and gather data on Kalaeloa's electrical distribution system, existing backup generation, and renewable generation use and opportunities.
- Conduct a workshop and meet with Kalaeloa Stakeholders to discuss and identify
  - current energy system issues, challenges, and priorities;
  - emerging energy system sustainability, reliability and cost goals;
  - expected redevelopment timeframes and plans; and
  - design and collaboration needs to ensure delivery and operational safety compatibility with HECO's grid.
- Develop conceptual designs for grid improvements that could enhance overall energy system reliability, and improve critical tenant operational resiliency and performance especially during extended power disruptions.
- Evaluate the cost and performance benefits of the general conceptual designs for the different options considered.

As discussed, Sandia looked at several energy system improvement approaches, all focused on the premise that the Navy would only dispose of the Kalaeloa energy system in its entirety, not phased over several years. This limited consideration of simple phased energy system upgrade solutions, and required consideration of more complicated approaches. Therefore, Sandia chose to look at a range of improvement options that included both rather traditional approaches and some innovative approaches such as advanced and networked microgrids. The major options reviewed included 1) a phased feeder approach, 2) an islanded approach using networked microgrids, and 3) a hybrid phased feeder/advanced microgrid approach.

Included in the evaluation was the consideration of both on-site distributed and renewable generation resources and opportunities that could be utilized to reduce costs and support enhanced energy assurance and energy sustainability for Kalaeloa. A summary of the estimated cost and reliability performance of each option with some variations is presented in Table 9 below. The results are shown in terms of expected energy costs in $/kWh and average power outage durations. Because of slightly different upgrade and retirement costs for the different upgrade approaches, the timing and average loads as slightly different, but we have tried to make the cost analyses chronologically consistent. The highlights of the summary include:

- While the phased feeder and hybrid phased feeder/advanced microgrids have similar costs, the hybrid phased feeder/advanced microgrid option provides higher reliability under nominal power outages. For extended power outages the reliability results are even better.
- The islanded networked microgrids using only on-site generation are higher in costs than other options. Unfortunately, the total reliance on diesel generators will likely pose significant environmental permitting issues, and conflicts with Hawaii's clean energy goals.

Table 9. Summary Estimate of Kalaeloa Energy Upgrade Costs and Performance

Option	Average Energy Load	Capital Costs ($/kWh)	O&M Costs ($/kWh)	Fuel Costs ($/kWh)	Weighted Purchased Power Costs ($/KWh)	Capital and O&M Microgrid Costs ($/kWh)	Total Energy Costs ($/kWh)$	Critical Load Outage Duration (hrs/yr)
Phased Feeder 5 MW PV	Year 1-5 25 MW	0.022	0.053	-	0.182	-	0.26	15
Phased Feeder 10 MW PV	Year 6-10 35 MW	0.028	0.067	-	0.174	-	0.27	5
Phased Feeder 20 MW PV	Year 16+ 60 MW	0.017	0.039	-	0.168	-	0.24	2
Islanded Microgrids Diesel	Year 1-10 35 MW	0.039	0.065	0.248	-	-	0.35	<2
Islanded Microgrids Diesel	Year 11-20 60 MW	0.035	0.048	0.253	-	-	0.34	<2
Islanded Microgrids Diesel/PV/BESS 100 MW PV 100 MWh BESS	Year 1-10 35 MW	0.164	0.182	0.173	0.03	-	0.55	<2
Islanded Microgrids Diesel/PV/BESS 100 MW PV 100 MWh BESS	Year 11-20 60 MW	0.140	0.148	0.176	0.03	-	0.50	<2
Hybrid Phased Feeders/Microgrids	Year 1-5 25 MW	0.022	0.053	-	0.182	0.02	0.28	<2
Hybrid Phased Feeders/Microgrids	Year 6-10 35 MW	0.028	0.067	-	0.174	0.012	0.28	<2
Hybrid Phased Feeders/Microgrids	Year 16+ 60 MW	0.017	0.039	-	0.168	0.007	0.25	<2

- Additionally, a 100% reliance on solar PV and battery storage for Kalaeloa is unlikely based on the land requirement and associated battery costs to support the intermittent PV proposed.
- At full build out by years 10 -15, which would be about 60 MW of electric power demand, the phased feeder/advanced microgrid approach provides a system cost very competitive with other options but with the highest initial power reliability.
- Overall, the hybrid phased feeder/advanced microgrid approach provides the best cost/performance benefits for Kalaeloa and can provide a high reliability electric power advantage for the District that could attract future tenants.

4.1 Recommendations

Based on the cost and performance benefits of the different options that are summarized in this report, the best option is the hybrid phased feeder/advanced microgrid approach. To implement this option the following steps need to be taken to make this a reality. These include:

High Priority

1. Therefore, identifying seed funding to initiate the microgrid designs and implementation is important as a way to reduce energy reliability concerns in only a few years.
2. During the next one to two years, HCDA should work closely with other entities to establish an alternative electric utility (such as a cooperative or public power utility) to help fund and manage the operations and maintenance of the current electric system and implement the required upgrades over the next 10 years. At the same time, HCDA should work closely with the Navy to successfully transfer the Navy electric grid. This may require state and national efforts to help accelerate the transfer.
3. During the next one to two years, HCDA should work to support the design and construction of advanced microgrids and distributed generation resources at four priority Kalaeloa locations – USCG, Downtown and Airport, Hunt, and HARNG to reduce average outage times from 40 hours per year to less than an hour per year, at a total installed cost to the new alternative electric utility of approximately $24M. Coordination with planned energy improvements by stakeholders in these four priority locations could be leveraged to help reduce HCDA and tenant overall implementation costs.

Medium Priority

1. Accelerate the development of up to four 5-MW solar energy projects at Kalaeloa specifically for onsite energy use using Power Purchase Agreements with solar developers or Independent Power Producers. Integration of PV for onsite use is included in these evaluations. They have considerable impact on reducing energy costs. If planned correctly, the PPAs might be structured to help reduce Kalaeloa feeder upgrade costs.
2. Within 6-10 years of establishing the Kalaeloa alternative utility, add a second 40-MW, 46-kV substation at the Northeast end of Kalaeloa with a capacity of up to six 12-kV underground feeders to support the electric system upgrades as needed for both new

western and eastern tenants. This will provide a total Kalaeloa energy import capacity of 80-MW, with up to 20-MW of on-site renewable generation capacity.

3. Finally, coordinate the identified energy improvements with other regional power system improvements to make sure they are consistent to help reduce regional integration and upgrade costs, while also supporting the broader regional energy resiliency and energy assurance improvement needs.

If this approach is implemented as recommended, Kalaeloa would significantly improve its energy reliability and resiliency, and reduce critical load outages from 40 hours per year to only a few minutes per year. The associated costs for a Kalaeloa operated system would range from \$0.28/kWh for years 1-10 and \$0.25/kWh for years 16 and beyond. By years 11-15, the system could be fully updated, and could be sold to HECO or another entity, with the sale price used to reimburse the tenants for the infrastructure capitalization, effectively reducing the transitional energy system upgrade costs to all the tenants and the District.

5. REFERENCES

1. Belt Collins Hawaii, *Kalaeloa Master Plan*, Hawaiian Community Development Authority, March 1, 2006.

2. Belt Collins Hawaii, *Kalaeloa Master Plan – Infrastructure Master Plan Updates – October 2010 Draft*, Ford Island Ventures, October 2010.

3. Kalaeloa Average Power Demand – 2013-2015, U.S. Navy, NAVFAC-Hawaii, September 2016.

APPENDIX A: SUPPLEMENTAL INFORMATION TO SANDIA'S ANALYSIS FOR KALAELOA

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The following supplemental information was developed by the Hawaii State Energy Office and is intended to provide supplemental information to Sandia National Laboratories' technical analysis of potential options to redevelop the electric system in the Kalaeloa Community Development District. Various regulatory, environmental, funding, and operational policy considerations, as well as local utility design standard considerations are presented. This information should be an integral part of the discussions about selecting an approach to accelerate the redevelopment the Kalaeloa electric grid, and in managing and operating the system in an efficient and cost effective manner.

A.1 Alternative Electric Utility Models

Three types of electric utility business models include: public power utilities, electric cooperatives, and investor-owned utilities; Hawaii has two of these. The electric utility on Kauai, Kauai Island Utility Cooperative, is an electric cooperative. The electric utilities on the islands of Oahu, Maui, Molokai, Lanai, and Hawaii are investor-owned, and are owned by Hawaii Energy Industries. These utility business models are discussed further in the following sections.

A.1.1 Public Power Utility

Public power utilities are entities of local or state government. The public power business model is based on public ownership and local control, a not-for-profit motive, and focus on its customers. Because they are public entities, public power utilities do not pay federal income taxes of most state taxes, but they support the local government through payments in lieu of taxes or transfers to the general fund. Establishing a power public utility may take several years and will depend on the circumstances of each case.[1]

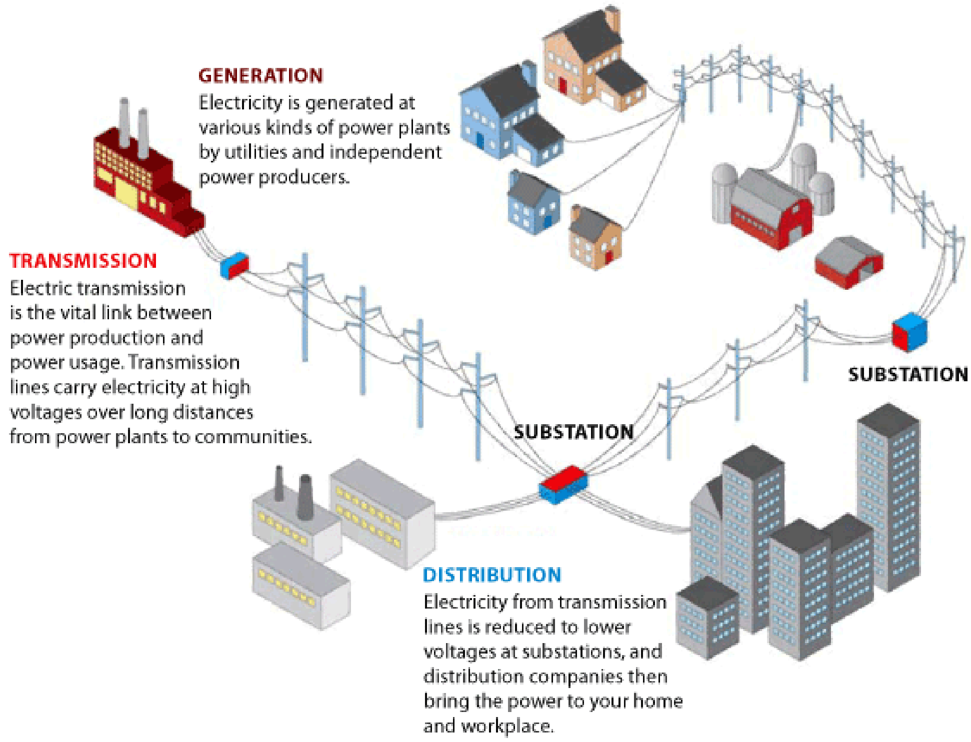
> Note: In 2012, the American Public Power Association (APPA) examined the laws for the 50 states. Their research concluded that Hawaii does not have any specific provisions in the Hawaii Constitution or statutes that provide the right for a municipality to establish or acquire an electric system to serve customers or the residents and businesses within the municipal corporate limits or for determining the price of acquiring existing facilities.[2]

APPA - Public Power for Your Community[3]

Since the 1880's, communities have chosen to own or operate a public power utility. The majority of public power utilities are owned by cities and towns, but many are also owned by counties, public utility districts, and even states. Hawaii is the only state that does not have a public power utility.

Most public power utilities are distribution-only utilities, meaning they do not generate or transmit their own generation. Instead, they purchase power and transmission services from wholesale to distribute to their customers. In other words, distribution-only utilities manage the electric system from the substation to the customer, which is similar to the Navy's operations in Kalaeloa.

[1] APPA. Public Power for Your Community: Local control. Local priorities. A stronger local economy. 2016.
[2] APPA. Survey of State Municipalization Laws. 2012.
[3] APPA. Public Power for Your Community. 2016



Source: U.S. Department of Energy. "Benefits of Using Mobile Transformers and Mobile Substations for Rapidly Restoring Electric Service: A Report to the United States Congress Pursuant to Section 1816 of the Energy Policy Act of 2005." 2006.

If a community in Hawaii decides to pursue the formation of a public power utility, they could reference the steps outlined by APPA:

1. Start with a Leader
2. Feasibility Study
3. Legal Analysis
4. Valuation
5. Community Education
6. Referendum
7. Price Negotiation and Condemnation
8. Public Service Commission Proceedings
9. Evaluation of Financing Alternatives
10. Prepare to Begin Operations

The cost and length of this process will depend on the various challenges that each community encounters. One of the significant challenges that they will face in Hawaii is the lack of specific provisions in the Hawaii Constitution or statutes that provide the right for a municipality to establish or acquire an electric system to serve customers or the residents and businesses within the municipal corporate limits; or for determining the price of acquiring existing facilities. Contrary, in most states, citizens have the right to determine whether to own and operate their own public power utility or to grant an electric franchise to a private utility.[4]

Additional challenges may also come from the incumbent utility. In many cases, for-profit electric utilities have attempted to prevent the formation of a public power utility though actions such as lawsuits, political campaigns, public relations attacks, etc.

Alternatively, the incumbent utility may respond to the competitive pressure by offering valuable concessions to the community such as lowered rates, improved service, performance standards for reliability, investment in the community, or a settlement fee. Often the concessions offered by the incumbent utility are sufficient to persuade the community to abandon effort to form a public power utility.

A.1.2 Electric Cooperatives

Electric cooperatives are private, not-for-profit businesses. They are owned by their consumer-members, who elect governing board members and are required to return any excess revenue (above what is needed for operating costs) to their members. The local government and broader community generally have no involvement in the governance of the utility. Most electric cooperatives are exempt from federal income tax, and may pay neither taxes nor payments-in-lieu-of-taxes to support the local government.[5] Establishing a cooperative typically takes 1 to 2 years, although this can vary depending on each situation.[6]

USDA's Publications for Cooperatives

The United States Department of Agriculture (USDA) has categorized their publications for cooperatives under three different series: Cooperative Information Series (CIR), Research Reports (RR), and Service Reports (SR). Below are two publications that may be pertinent to the redevelopment of Kalaeloa if an electric cooperative were to be pursued.[7]

How to Start a Cooperative[8]

This guide outlines the process of organizing a cooperative business and provides information on the potential steps involved and some important aspects of cooperative development. It is intended to be an educational resource for co-op development practitioners or to help other learn about the process for starting a cooperative.

USDA's proposed process has four development phases, which are made of steps and sub-steps. USDA does note that depending on the specific situation these steps can be completed in a different order.

The following is their proposed process for organizing a cooperative:

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[4] APPA. Survey of State Municipalization Laws. 2012.

[5] APPA. Public Power for Your Community. 2016.

[6] USDA. Vital Steps: A Cooperative Feasibility Study Guide. Nov 3, 2016.

[7] USDA's publications can be found at: https://www.rd.usda.gov/publications/publications-cooperatives

[8] USDA. How to Start a Cooperative. Nov 8, 2016.

Phase 1: Identify Economic Need

1. Determine the economic need
2. Hold an exploratory meeting
    a. Sub-step: Select a steering committee

Phase 2: Deliberate

3. Conduct a member-use analysis and initial market analysis
    a. Sub-step: Hold a second member exploratory meeting
4. Conduct a feasibility study
    b. Sub-step: Hold a third member exploratory meeting
5. Prepare a business plan

Phase 3: Implement

6. Employ a legal counsel to draft and complete legal papers
    a. Sub-step: Hold fourth member exploratory meeting
7. Hold the first stakeholder meeting

Phase 4: Execute

8. Convene first board of directors meeting
9. Hold a membership drive
10. Acquire capital
11. Hire a manager
12. Acquire equipment and facilities, begin operations

Vital Steps: A Cooperative Feasibility Study Guide[9]

This publication focuses on the fourth step in USDA's process for organizing a cooperative—conducting a cooperative feasibility study. The cooperative feasibility study occurs during the deliberation stage and results in an assessment on whether the proposed business concept is technically and economically feasible. This allows each potential member to evaluate how the cooperative business model would enhance their potential business. The USDA suggests that a cooperative feasibility study will take 3 to 6 months, but will vary depending on the complexity of the situation.

NRECA International – Guides for Electric Cooperative Development and Rural Electrification

National Rural Electric Cooperative Association (NRECA) partnered with the United States Agency for International Development to publish, *Guides for Electric Cooperative Development and Rural Electrification*.[10] This publication provides a better understanding for rural electrification development through ten different modules that address the issues of electric cooperative development and rural

[9] USDA. Vital Steps: A Cooperative Feasibility Study Guide. Nov 3, 2016.

[10] NRECA International Ltd. Guides for Electric Cooperative Development and Rural Electrification. http://www.nrecainternational.coop/what-we-do/cooperative-development/cooperative-development-guide/

electrification program design. The following modules were based on NRECA's experience in rural electrification development:

1. Legal and Institutional Enabling Systems for Sustainable Electric Cooperative Development
2. Guide for the Creation of Electric Cooperatives
3. Roles and Responsibilities of Electric Cooperative Boards of Directors
4. Business Plan for Electric Cooperatives
5. Methodology for Evaluating Feasibility of Rural Electrification Projects
6. Consumer Willingness to Pay and Economic Benefit Analysis of Rural Electrification Projects
7. Distribution Line Design and Cost Estimation for Rural Electrification Projects
8. Financial Analysis of Rural Electrification Projects
9. Productive Uses of Electricity
10. Design and Implementation Guidelines for Stand-Along Photovoltaic Systems for Rural Electrification Projects

Although this publication is written for an international audience, most of the concepts discussed can be used or altered and applied to different situations, such as the redevelopment of the electric system in Kalaeloa.

Module 2: Guide for the Creation of Electric Cooperatives

Module 2 of this publication provides a step-by-step guide to starting an electric cooperative. Again, although this was written for developing countries the methodology discussed can be altered for other applications.

The following are NRECA's 18 steps required to organize an electric cooperative:

1. Conduct a leadership meeting to discuss the need for a cooperative.
2. Meet with people who have expressed interest in forming an electric cooperative. Vote to determine if process should continue. If affirmative, select a Provisional Committee.
3. Survey potential members to determine interest in the creation of an electric cooperative.
4. Conduct a General Meeting to discuss the results of the survey. Vote to decide whether or not to proceed.
5. If the decision is to proceed, choose a Steering Committee.
6. Contact government and regulatory organizations, e.g. the Ministry of Energy
7. Conduct a feasibility study.
8. Hold a General Meeting to discuss the results of the feasibility study. Take a secret vote to decide whether to proceed.
9. Develop a business plan and financial analysis.
10. Hold a General Meeting to discuss the results of the financial analysis and the business plan. Vote on whether to proceed.
11. Prepare the necessary legal documentation and initiate the incorporation process.
12. Carry out a member registration campaign.
13. Conduct a Founding Assembly with all the potential charter members to approve the Bylaws and choose a Board of Directors.

14. Conduct Board Meetings to elect officers and assign responsibilities to implement the business plan.
15. Implement the necessary legal steps, e.g. incorporation, service territory concession, construction authorization or transfer of existing electrical infrastructure, and tariff approval.
16. Prepare a capitalization plan and loan applications.
17. Prepare to start operations by hiring a General Manager and acquiring the necessary infrastructure, tools, and equipment.
18. Commence operations

A.1.3 Investor Owned Utility

Investor-owned utilities are private, for-profit enterprises. They are owned by investors or shareholders, who generally are not customers of the utility or members of the community, and their primary motivation is to increase the value to shareholders. As private businesses, investor-owned utilities do pay taxes to local governments, but customers have no voice in the operation of the utility.[11]

[11] APPA. Public Power for Your Community. 2016.

A.1.4 Privatization of a DoD Electric Utility System in Hawaii

If the United States Navy opted to privatize their electric utility system in Kalaeloa, they could pursue a similar process to the one used to privatize the electric utility systems of another Department of Defense entity in Hawaii.

In April 2016, the United States Army and the Department of Logistics Agency (DLA) Energy posted a solicitation for the privatization of the electric utility systems at U.S. Army Garrison – Hawaii, Island of Oahu Hawaii. The following is the synopsis from that solicitation.
Links: https://www.fbo.gov/spg/DLA/J3/DESC/SPE600-16-R-0809/listing.html

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Privatization of the Electric Distribution System at U.S. Army Garrison-Hawaii, Island of Oahu
Solicitation Number: SPE600-16-R-0809

Synopsis (modified on April 8, 2016)
DLA Energy, in conjunction with the United States Army, plans to offer the privatization of the Electric (NAICS 221122) utility systems at U.S. Army Garrison - Hawaii, Island of Oahu Hawaii.

Utilities Privatization (UP) is defined as the transfer of ownership and responsibility to a municipal, private, regional, district, or cooperative utility company or other entity, for the operations, maintenance, repair, future upgrades, and future utility systems replacements. The conveyance may consist of all right, title, and interest of the United States in the utility system. UP will be accomplished in accordance with 10 U.S.C. §2688 - Utility Systems: Conveyance Authority.
As a result of this solicitation, the firm(s) will be selected to assume ownership of the Electric utility system. The new owner shall operate and maintain the system and provide utility services to the Government. Any resulting contract, if awarded, will require the Contractor to furnish all facilities, labor, materials, tools, and equipment necessary to own, maintain, and operate the utility system. All responsibility for maintaining reliable service, including such items as environmental compliance, maintenance costs, major system renovations, construction, equipment, manpower, and overhead costs shall become the utility system owner's responsibility. The Contractor shall manage the maintenance, repairs, replacement, etc., of the system to ensure continuous, adequate, and dependable service for each Government or tenant connection within the service area. The Contractor shall be responsible for funding all capital investments required to acquire, maintain, and operate the utility system in a safe, reliable condition and to meet the requirements listed in the contract.

Real property interests will be conveyed in the form of a Right to Access or an Easement as a reference to the resultant contract. The utility system will be conveyed via a Bill of Sale upon award of the contract. Past performance information from potential offerors shall be submitted as directed in the solicitation.

A Sources Sought Notice for this requirement was previously publicized under solicitation number SP0600-15-R-0806 on December 31, 2014. DLA Energy issued a new Sources Sought Notice under SPE600-16-R-0809 on February 4, 2016. The Sources Sought Notice has closed and market research is complete. This requirement will be unrestricted. All responsible sources are encouraged to submit an offer.

A.2 Federal Funding Opportunities

Opportunity: Community Economic Adjustment Assistance for Realignment or Closure of a Military Installation
Agency: U.S. Department of Defense, Office of Economic Adjustment
Number: 12.607
Description: Project grants to assist State and local governments to plan and carry out adjustment strategies; engage the private sector in order to plan and undertake community economic development and base redevelopment; and, partner with the Military Departments in response to the proposed or actual expansion, establishment, realignment or closure of a military installation by the Department of Defense (DoD). Uses and restrictions: Plan and carry out local economic adjustment programs, including, but not limited to: base redevelopment and business/financial plans; infrastructure assessments and feasibility studies; organizational staffing, operating, and administrative expenses; redevelopment and economic development capacity-building; architecture and engineering activities; land use plans; specialized environmental and legal services; public outreach; and, other activities necessary for a community to capably respond to a wide range of adverse impacts of Defense actions on local economies, schools, housing markets and central business districts, etc. Assistance may not be used to negate or contravene DoD activities in carrying out an expansion, establishment, realignment, closure, or disposal of a military installation.
Amount: Range: $79,560 - $2,331,240. Average grant: $648,093.
Application Deadline: Contact the headquarters or regional office, as appropriate, for application deadlines.
Link:
https://www.cfda.gov/index?s=program&mode=form&tab=step1&id=6fe0891548a684978c5c4dc543450d7a

Opportunity: FY 2016 Economic Development Assistance Programs (EDAP) Application submission and program requirements for EDA's Public Works and Economic Adjustment Assistance programs
Agency: U.S. Department of Commerce, Economic Development Administration (EDA)
Number: EDAP2016
Description: Under this FFO, EDA solicits applications from applicants in rural and urban areas to provide investments that support construction, non-construction, technical assistance, and revolving loan fund projects under EDA's Public Works and EAA programs. Grants and cooperative agreements made under these programs are designed to leverage existing regional assets and support the implementation of economic development strategies that advance new ideas and creative approaches to advance economic prosperity in distressed communities. EDA provides strategic investments on a competitive- merit-basis to support economic development, foster job creation, and attract private investment in economically distressed areas of the United States.
Amount: $100,000 - $3,000,000
Application Deadline: There are no submission deadlines, proposals and application will be accepted on an ongoing basis until the publication of a new EDAP Federal Funding Opportunity (FFO).
Link: http://www.grants.gov/web/grants/view-opportunity.html?oppId=279842

Opportunity: Electric Programs
Agency: U.S. Department of Agriculture (USDA), Rural Development
Description: Under the authority of the Rural Electrification Act of 1936, the Electric Program makes direct loans and loan guarantees (FFB), as well as grants and other energy project financing to electric utilities (wholesale and retail providers of electricity) that serve customers in rural areas.
Link: https://www.rd.usda.gov/programs-services/all-programs/electric-programs

> **Opportunity: Electric Infrastructure Loan & Loan Guarantee Program (FFB)**
> **Agency:** U.S. Department of Agriculture (USDA), Rural Development
> **Description:** The electric program makes insured loans and loan guarantees to nonprofit and cooperative associations, public bodies, and other utilities. The loans and loan guarantees finance the construction of electric distribution, transmission, and generation facilities, including system improvements and replacement required to furnish and improve electric service in rural areas, as well as demand side management, energy conservation programs, and on-grid and off-grid renewable energy systems.
> **Application Deadline:** Applications for these programs are accepted year-round through a General Field Representative (GFR). USDA also notes to check with a GFR to determine whether the proposed service area qualifies as rural.
> **Link:** https://www.rd.usda.gov/programs-services/electric-infrastructure-loan-loan-guarantee-program

Opportunity: Energy Programs
Agency: U.S. Department of Agriculture (USDA), Rural Development
Description: Authorized by the Agricultural Act of 2014, USDA offers funding to complete energy audits, provide renewable energy development assistance, make energy efficiency improvements and install renewable energy systems. They have programs that help convert older heating sources to cleaner technologies, produce advanced biofuels, install solar panels, build bio refineries, and much more. USDA Rural Development is at the forefront of renewable energy financing, with options including grants, guaranteed loans and payments.
Application Deadline: Depends on funding opportunity. See further details below.
Link: https://www.rd.usda.gov/programs-services/all-programs/electric-programs

> **Opportunity:** Repowering Assistance Program
> **Agency:** U.S. Department of Agriculture (USDA), Rural Development, Energy Programs
> **Description:** Provides funding for up to 50% of the total eligible project costs for bio refineries to install renewable biomass systems for heating and power at their facilities; or, to produce new energy from renewable biomass.
> **Amount:** Up to 50% of the total eligible project costs.
> **Link:** https://www.rd.usda.gov/programs-services/repowering-assistance-program

Opportunity: Rural Energy for America Program Energy Audit & Renewable Energy Development Assistance Grants
Agency: U.S. Department of Agriculture (USDA), Rural Development
Description: Grantees assist rural small businesses and agricultural producers by conducting and promoting energy audits, and providing renewable energy development assistance (REDA). Assistance provided must consist of: energy audits; renewable energy technical assistance; and renewable energy site assessments.
Amount: Applicants are limited to one energy audit and one REDA per year. The maximum aggregate amount of an energy audit and REDA grant in a Federal fiscal year is $100,000.
Link: https://www.rd.usda.gov/programs-services/rural-energy-america-program-energy-audit-renewable-energy-development-assistance

Opportunity: Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans & Grants
Agency: U.S. Department of Agriculture (USDA), Rural Development
Description: Provides guaranteed loan financing and grant funding to agricultural producers and rural small businesses for renewable energy systems or to make energy efficiency improvements.
Amount: Loan guarantee up to $25 million. Renewable Energy System grants up to $500,000. Energy Efficiency grants up to $250,000.
Link: https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency

Opportunity: Title XVII Innovative Clean Energy Loan Guarantee Program: Renewable Energy & Efficient Energy Projects Solicitation
Number: DE-SOL-0007154
Agency: U.S. Department of Energy, Loan Programs Office (LPO)
Description: Provides loan guarantees to accelerate the deployment of innovative clean energy technology. The LPO is seeking projects that utilize renewable energy and energy efficiency technologies that are new or significantly improved. Technology area 1 is advanced grid integration and storage, which could include projects such as: renewable energy generation, including distributed generation, incorporating storage; micro grid projects that reduce CO_2 emissions at a system level; and storage projects that clearly enable greater adoption of renewable generation.
Amount: $2.5 B
Application Deadline: The last round of applications was due on March 2, 2016. However additional rounds may be announced in a supplement to this Solicitation.
Link: http://www.energy.gov/lpo/services/solicitations/renewable-energy-efficient-energy-projects-solicitation

Opportunity: Energy Savings Performance Contracts for Federal Buildings
Agency: U.S. Department of Energy
Description: Energy savings performance contracts (ESPCs) allow federal agencies to procure energy savings and facility improvements with no up-front capital costs or special appropriations from Congress. An ESPC is a partnership between an agency and an energy service company (ESCO). The Federal Energy Management Program (FEMP) provides agencies with expert assistance, guidance, and training to help them implement ESPC projects that are technically excellent, legally sound, and a good deal for the government.
Link: http://energy.gov/eere/femp/energy-savings-performance-contracts-federal-agencies

Opportunity: Federal Energy Management Program (FEMP) 2017 Funding Opportunity Announcement "Assisting Federal Facilities with Energy Conservation Technologies (AFFECT) 2017"
Number: DE-FOA-0001667
Agency: U.S. Department of Energy, FEMP
Description: Provides grants to federal agencies for projects in three topic areas: (1) Combined Heat and Power, (2) Renewable Energy and (3) Energy Efficiency Deep Retrofits. Applicants will be asked to show how the proposed project results are conducive to broader adoption at other Federal facilities, impacting the direction, strategy, and thinking of the agency to engage in similar efforts.
Amount: The anticipated total funding level for AFFECT 2017 is $3.0 million, subject to appropriations, with anticipated funding per award to be between approximately $100,000 and $1.0 million.
Application Deadline: Letters of intent (LOI) are due by December 22, 2016, and full applications are due by January 30, 2017.
Link: https://eere-exchange.energy.gov/Default.aspx?Search=&SearchType=#FoaIdfcefb174-96f4-4036-a35f-186208c92d37

Opportunity: American Battlefield Protection Program (ABPP) – 2017 Battlefield Planning Grants
Number: P16AS00603
Agency: U.S. Department of the Interior, National Park Service
Description: Annually the ABPP provides seed money for projects that lead directly to the identification, preservation and interpretation of battlefield land and/or historic sites associated with battlefields.
Amount: $150,000
Application Deadline:
Link: https://www.nps.gov/abpp/grants/planninggrants.htm

A.3 Bonds

In the case of public sector projects, debt financing generally refers to a variety of types of bank loans (sometimes with credit guarantees), "project finance," and bonds. A bond is a debt investment that an *issuer* such as a corporate or governmental borrower, owes a *holder* such as an investor. Bonds are a type of interest-bearing long-term security, which are defined for a period of time at a variable of fixed interest rate. Bonds can be issued by the government, local authorities, banks, other financial institutions, and companies.

The issuance of bonds has certain limitations and risks. For example, a public government entity (municipality, state administration) may only issue bonds if it has sufficient borrowing capacity. In order to issue bonds, a city or state may also be required to receive a credit rating by an internationally recognized institution, such as Fitch, Moody's, or Standard and Poor's (S&P).

Additionally, issuing bonds may require a relatively long preparatory period that could include drafting the issue leaflet, obtaining approval from the respective state authority, and selecting an investment broker. In addition, in the event of an unsuccessful issue (for instance, if the bond issue is called off because the minimum target amount was not raised), the issuer must still pay for the preparation expenditures and the interest due on bonds already issued.

For any issued bonds there must be trust and confidence that improvements would be able to cover bond payments.

A.3.1 State Issued Bonds

Opportunity: Qualified Energy Conservation Bonds
Agency: U.S. Department of the Treasury is the source of the bonds, which are issued by the State (in Hawaii's Case, the bond is issued by Budget and Finance) as explained below.
Description: Qualified Energy Conservation Bonds ("QECBs") are a type of qualified tax credit bond that state and local governments may use to finance various qualified energy projects, including particularly those that promote energy efficiency and renewable source technologies.

QECBs are taxable bonds—meaning that investors must pay federal taxes on QECB interest they receive. Issuers may choose between structuring QECBs as tax credit bonds (bond investors receive federal tax credits in lieu of interest payments) or as direct subsidy bonds (bond issuers receive cash rebates from the U.S. Department of the Treasury to subsidize their net interest payments). Both tax credit and direct payment bonds subsidize borrowing costs—most QECBs are expected to be issued as direct subsidy bonds due to the current lack of investor appetite for tax credit bonds.

The U.S. Congress authorized $3.2 billion of QECB issuance capacity, which has been allocated to states, local governments, and tribal governments based upon population. The amount allocated to a large local government may be reallocated by the large local government to the state where the large local government is located.[12] Within each statewide and large local governmental sub-allocation, at least seventy percent (70%) of the amount must be dedicated to public purpose projects, while the remaining thirty percent (30%) may be applied to private activity bonds.[13]

If Hawai'i desires to implement a QECB program, then Hawai'i must first sub-allocate the aggregate allocation of $13,364,000 under the QECB program[14] among the large local governments in the state (i.e., those counties and municipalities that have populations of 100,000 or more). Using U.S. Census Bureau data for 2008,[15] all but two Hawai'ian counties[16] have populations of 100,000 or more, which results in an allocation to the state of only $661,935.03:

Jurisdiction	Population*	Total Allocation	70%	30%
Hawai'i County	175,784	$1,823,615.14	$1,276,530.60	$547,084.54
Honolulu County	905,034			
Urban Honolulu CDP	374,676	$3,886,956.87	$2,720,869.81	$1,166,087.06
Balance of County	530,358	$5,502,030.21	$3,851,421.15	$1,650,609.06
Maui County	143,574	$1,489,462.75	$1,042,623.93	$446,838.83
Balance of State**	63,806	$661,935.03	$463,354.52	$198,580.51
Totals	**1,288,198**	**$13,364,000.00**	**$9,354,800.00**	**$4,009,200.00**

* City and County population figures are from the official U.S. Census Bureau 2008 estimates.

** Counties with populations less than 100,000 (i.e., County of Kalawao (population of 117) and County of Kauai (population of 63,689)

Please note that the allocation to Honolulu County will be sub-allocated to Urban Honolulu CDP[17] and the balance of Honolulu County because Urban Honolulu CDP has a population of greater than 100,000.[18]

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12 Code section 54D(e)(2)(B), 26 U.S.C. § 54D(e)(2)(B).
13 Code section 54D(e)(2)(B), 26 U.S.C. § 54D(e)(3).
14 Treasury Notice 2009-29 at page 11.
15 Code section 54D(g)(1) provides that "[t]he population of any State or local government shall be determined for purposes of this section … for the calendar year which includes the date of the enactment of this section." Code section 54D(g)(1), 26 U.S.C. § 54D(g)(1).
16 According to the U.S. Census data for 2008, the population of the County of Kalawao was 117, and the population of the County of Kauai was 63,689.
17 Hawai'i is the only state that has no incorporated places recognized by the U.S. Census Bureau. Through an agreement with the U.S. Census Bureau, Urban Honolulu Census Designated Place (CDP) is the only sub-county area in Hawai'i estimated by the Bureau on an annual basis. Urban Honolulu CDP encompasses an area bordered by Nimitz Highway, Aliamanu Drive, the Koolau Ridge, Waialae Nui Stream and Waialae Nui Canal. *See* Hawaii Department of Business, Economic Development & Tourism, *2014 Subcounty and Housing Estimates*, available at http://census.hawaii.gov/whats-new-releases/2014-subcounty-and-housing-estimates/ (posted May 21, 2015).
18 Code section 54D(g)(2) provides that "[i]n determining the population of any county for purposes of this section, any population of such county which is taken into account in determining the population of any municipality which is a large local government shall not be taken into account in determining the population of such county." Code section 54D(g)(2), 26 U.S.C. § 54D(g)(2).
[t]he population of any State or local government shall be determined for purposes of this section … for the calendar year which includes the date of the enactment of this section." Code section 54D(g)(1), 26 U.S.C. § 54D(g)(1).

As previously stated, the amounts allocated to large local governments may be reallocated by large local governments to the state.[19]

A basic requirement of a QECB is that one hundred percent (100%) of the available project proceeds will be used for one or more "qualified conservation purposes." Pursuant to Section 54D(f) of the Internal Revenue Code, qualified conservation purposes can include (but are not limited to) the following:

- Reducing energy consumption in public buildings by at least twenty percent (20%).
- Implementing green community programs.
- Supporting research facilities or research grants relating to energy reduction and efficiency technologies and production of non-fossil fuels.
- Supporting mass commuting facilities and pollution reduction expenditures.
- Promoting commercialization of green building technology, waste-to-fuel conversion, and various other technologies through demonstration projects.
- Conduction public education campaigns to promote energy efficiency.[20]

The foregoing list is not meant to be exhaustive, and additional types of energy projects may qualify. For private activity bonds that are QECBs, qualified conservation purposes are limited to capital expenditures.

Note: Hawaii's Budget and Finance has not issued QECB. Beyond this, there may be other practical implementation challenges, including there may not be an established mechanism for the Counties' portion of QECB to be transferred to the State should the Counties not want their allocation.

Links:
http://energy.gov/eere/slsc/qualified-energy-conservation-bonds
https://www.irs.gov/pub/irs-drop/n-12-44.pdf

[19] Code section 54D(e)(2)(B), 26 U.S.C. § 54D(e)(2)(B).
[20] Code section 54D(f), 26 U.S.C. § 54D(f).

Opportunity: General Obligation Bonds and Special Facility Revenue Bonds
Agency: Hawaii Department of Budget and Finance (B&F) & Hawaii Community Development Authority (HCDA)
Description: Hawaii Revised Statutes (HRS) Chapter 39 provides authority to B&F to issue General Obligation Bonds. Section 206E-21 of the Hawaii Revised Statutes allows the director of finance to issue general obligation bonds pursuant to Chapter 39 in such amounts as may be authorized by the legislature, for the purposes of HRS Section 206E. Also, Sections 206E-181 to -186 allows HCDA with specified restrictions to issue special facility revenue bonds that may be necessary to yield all or portion of the cost of any construction, acquisition, remodeling, furnishing, and equipping of any special facility. Whereby, a special facility as defined in Section 206E-181 HRS, "means one or more buildings or structures and the land thereof for the construction of facilities that provides benefits to the community at large including, without limitation, an ocean science center that incorporates research and education programs and which is the subject of a special facilities lease."
Links:
http://www.capitol.hawaii.gov/hrscurrent/Vol04_Ch0201-0257/HRS0206E/
http://www.capitol.hawaii.gov/hrscurrent/Vol01_Ch0001-0042F/HRS0039/HRS_0039-.htm

A.3.2 City & County of Honolulu Issued Bonds

Opportunity: Community Facilities District Bonds
Agency: The Council of the City and County of Honolulu (C&C Honolulu)
Description: Chapter 34 of the Revised Ordinances of Honolulu 1990 (ROH), Community Facilities Districts, allow the counties to establish community facilities districts for the purpose of financing special improvements through the issuance of bonds. Section 34-7.1 ROH authorizes the council of C&C Honolulu to issue bonds that utilize a special tax to finance the special improvements. Section 34-1.5 ROH lists potential special improvements which include the undergrounding of: facilities for the transmission or distribution of electrical energy; water systems; wastewater facilities; and any other facilities which the city is authorized by law to contribute revenue to construct, own, maintain, or operate.
Links: http://www.honolulu.gov/rep/site/ocs/roh/ROHChapter34.pdf

A.4 Hawaiian Electric Company Rule No. 13: Line Extensions and Substations

Line extensions and substations necessary to furnish service to applicants for permanent service will be made by Hawaiian Electric (HECO) in accordance with their Rule No.13.[21]

Generally, HECO will construct, own, operate, and maintain electric lines and Equipment, which also includes substations, under, along, upon, and over public streets, roads, and highways where it has the legal right to do so, and on public lands and private property across which it has otherwise obtained rights of way or other necessary right satisfactory to HECO.

A.4.1 Line Extensions

Overhead Line Extensions to Serve Individual Applicants

Overhead line extensions will be made by HECO at its expense provided the cost of the line required does not exceed sixty months' estimated revenue of the applicant.

For overhead line extensions whose estimated cost exceeds the sixty month's estimated revenue, the applicant will be required to make an advance equal to the difference between the estimated cost and the sixty month's estimated revenue. The estimated cost for the line extension does not include line transformers, service drops and meters, and will be based on the route determined by HECO.

If within ten years from the date service is first rendered, new permanent customers or additional permanent loads are added to the line for which an advance was made, a refund will be made to the customers who made the original advance. This refund will be the amount of residual from the extension allowance over the cost of the line extension for the new permanent customer or additional permanent load. This refund shall be credited sequentially from the new permanent customer's or load's point of service toward the source of supply and shall be applicable only to the section of line used for the new customer or load.

Overhead Line Extensions to Subdivision or Developments

Overhead line extensions to and/or in subdivision or developments will be constructed, owned and maintained by HECO after the developer makes an advance of the entire estimated cost of the line extension.

Refunds will be made to the developer making the advance when permanent customers within the subdivision are connected to the lines based on the estimated revenues for sixty months from such permanent customers in the subdivision. The developers shall only be entitled to a refund in the amount of a permanent customer's extension allowance less the cost of the line extension to serve that customer. The total amount of refunds is limited to the original amount of the advance, and limited to ten years from the date of the advance.

[21] HECO Rule No. 13. Line Extensions and Substations https://www.hawaiianelectric.com/Documents/my_account/rates/hawaiian_electric_rules/13.pdf

Underground Line Extensions
Underground extensions are done in accordance with HECO's Policy on Underground Lines (December 2009) and the Cost Contribution for Placing Overhead Distribution Lines Underground, Guideline Summary (December 2009).

For underground extensions to serve individual applicants, applicants are required to make a contribution of the difference between the estimated underground extension cost and estimated equivalent overhead extension cost. When feasible the applicant will also provide the trenching, backfill, and necessary duct work to meet engineering construction standards of the Company.

For underground extensions to a subdivision or development in advance of applications for service the ultimate user, the subdivider or developer makes a contribution equal to the difference between the estimated cost of the underground systems and the estimated cost of an equivalent overhead system.

When replacing overhead with underground facilities, the customer requesting the change makes a contribution of the estimated cost installed of the underground facilities less the estimated net salvage of the overhead facilities removed. However, in certain circumstances discussed under HECO's Policy on Underground Lines (December 2009), HECO will pay the cost differential.

A.4.2 Substations

HECO will install a dedicated or system substation in accordance with the Dedicated and System Substation Guideline (March 2006). As defined by the Guideline, a system substation serves the load of two or more customers, while a dedicated substation serves the load of only one customer.

Dedicated Substation
A dedicated substation is one that is dedicated to serving the load of only one customer. A dedicated substation may be installed for reasons that include, but are not limited to:

- If customer's load characteristics may cause a degradation of service to HECO's other distribution customers based on the highest distribution voltage available at that location.
- If the new load is located in a remote location where service from HECO's distribution system is unavailable.
- If the customer requests dedicated service.
- If the customer's near-term (five years or less) new load is larger than five MVA.[22]

Generally, HECO will install, at its cost, only those facilities that it deems necessary. Based on the load HECO initially installs the appropriate equipment to meet the customer's current and near term (5 years or less) loads. Also, a Service Contract as provided in Rule 4 of HECO's Tariff[23], shall be prepared, when required, for all customers that are subject to this policy.

[22] 5 MVA is used as a threshold number because that is the normal maximum load that HECO's 12 kV circuits are designed to carry.
[23] HECO Rule. No 4. Service Contracts.
https://www.hawaiianelectric.com/Documents/my_account/rates/hawaiian_electric_rules/4.pdf

The distribution system from the specified point of interconnection is owned, operated, and maintained by the customer. The customer is responsible for providing a suitable site, at its expense. The customer pays for Special Facilities that are in addition to or in substitution for the standard facilities that HECO would normally install, such as redundant equipment.

System Substation
A system substation is one that serves the loads of two or more customers. A new system substation will be required if there are insufficient existing system substations or subtransmission capacity to serve the ultimate system loads related to multiple customers, based on projected land use in the area.

Based on long-range planning, HECO will design a system substation that can expand to meet the ultimate load for an area. But will only install, at their expense, the equipment necessary to serve the near-term load plus redundant equipment consistent with HECO planning criteria.

The customer shall install, own, operate, and maintain the primary distribution system beyond the metering point or negotiated location. If one or more customers request Special Facilities, they will be responsible for the cost to those facilities.

HECO's general practice is to acquire the system substation sites in fee. However, there may be instances in which HECO may pursue alternative arrangements. If lease arrangements are unavoidable as in the case of government-owned property, HECO will attempt to minimize the relocation rights, to the extent feasible. If the customer is a developer of a large subdivision or a portion of a larger subdivision that is expected to result in ultimate loads greater than 5 MVA, HECO may require the developer to provide a system substation site that HECO will purchase in fee.

A.5 Hawaii Administrative Rules 11-60.1 – Air Pollution Control

Chapter 60.1 of the Hawaii Administrative Rules (HAR)[24], Air Pollution Control, includes requirements for Air Pollution Control Permits and Greenhouse Gas Emissions Rules. These rules may apply to the proposed generation in Kalaeloa, as it will be depending on the type and operations of the proposed generators.

Air Pollution Control Permits

Air Pollution Control Permits are required prior to constructing, reconstructing, modifying, or operating a stationary air pollution source. There are two types of Air Pollution Control Permits: Covered Source Permits and Noncovered Source Permits. In general, covered sources include major sources of air emissions and sources subject to a federal performance or control technology standard. Noncovered sources are all other stationary sources that are not covered sources.

The permit applicability requirements for noncovered sources and covered sources are specified in HAR §11-60.1-62 and §11-60.1-82, respectively. While applicable fees for covered and noncovered sources can be found in Subchapter 6 of Chapter 11-60.1 HAR.

Greenhouse Gas (GHG) Emissions

Subchapter 11 of Chapter 11-60.1 HAR establishes GHG Emissions rules that are applicable to sources with the potential to emit GHG emissions equal to or above 100,000 tons of carbon dioxide emissions equivalent (CO2e) per year. In 2014, these affected sources represented about 88% of Hawaii's stationary source GHG emissions.

With the purpose of ensuring that Hawaii returns to 1990 GHG emission levels by 2020, these rules require applicable sources to reduce their GHG emissions a minimum of 16% by the year 2020.

[24] Hawaii Administrative Rules, Title 11, Department of Health, Chapter 60.1, Air Pollution Control. http://health.hawaii.gov/opppd/files/2015/06/11-60.1.pdf

A.6 Hawaii Administrative Rules 15-215 – Kalaeloa Community Development District

The purpose of Chapter 215 of the Hawaii Administrative Rules (HAR)[25], Kalaeloa Community Development District Rules, is to provide guidance in developing Kalaeloa.

§15-215-2 <u>Purpose.</u>

(a) The rules carry out through complete, integrated, effective and concise land development regulations, the vision and concepts of the Kalaeloa master plan ("KMP") by classifying and regulating the types and intensities of development and land uses within the Kalaeloa CDD consistent with, and in furtherance of, the policies and objectives of the KMP and chapter 206E, Hawaii Revised Statues ("HRS").

(b) The rules are adopted to protect and promote the public health, safety, and general welfare of the community and to protect and preserve places and areas of historical, cultural, architectural, or environmental importance and significance, as set forth in the KMP and chapter 206E, HRS.

As rules are modified from time to time, they are not replicated in this report. However, the most current rules can be found on Hawaii Community Development Authority's website, http://dbedt.hawaii.gov/hcda/plans-rules/.

[25] Hawaii Administrative Rules, Title 15, Department of Business, Economic Development, and Tourism. Chapter 215, Kalaeloa Community Development District Rules. http://dbedt.hawaii.gov/hcda/files/2013/02/Ch.-215-Kalaeloa-CDD-Rules-EFF-2012-10-27.pdf

APPENDIX B: EXAMPLE KALAELOA ELECTRIC SYSTEM UPGRADE COST ANALYSES

As noted in the report, the Sandia developed conceptual upgrade designs and cost estimates developed are Rough Order of Magnitude (ROM) estimates of +/- 30%, but do include the consideration of capital, construction, engineering, and contingency. There are additional costs and incentives that should be considered in more detail in the future, such as environmental, permitting, tax, and renewable incentives that could drive the optimization of a final design. The examples below show the cost analysis approach used to evaluate the different options.

B.1 Phased Feeder Approach Example Cost Analysis

For this option, the total feeder, switchgear, substation, and customer meter and connection upgrade costs were estimated at slightly less than $200M, phased over the first ten years as shown in the table below. The power demand for Kalaeloa was estimated to increase from 25 MW to 60 MW within 15 years. The on-site PV development was estimated to be about 5MW for each five-year period up to 20 MW, or about 30% renewable penetration.

YEAR	Average Power Demand (MW)	Utility Purchased Power (MW)	PV PPA (MW)	Capital Investment Cost ($M)
1-5	25-30	25	5	106
6-10	30-40	30	10	80
11-15	40-50	35	15	-
16-40	60	40	20	-

Year 1-5 Estimated Annual Costs:

Capital Recovery Cost - $106M (.04654; 3%; 35 years) = $ 4.93M
O&M Cost - $106M (11%) = $11.66M

Year 1-5 Estimated Power Purchases

Utility Power Purchase Costs - $0.20/kWh (25 MW)
PV PPA Power Purchase Costs - $0.11/kWh (5 MW)

Year 1-5 Estimated annual power purchased – 30 MW (8760 hr/yr) = 262,800,000 kWh/yr

Year 1-5 Estimated Average power cost = $0.25-0.26/kWh

Similar analyses were done for years 6-10, 11-15 and 16-40, but with the additional capital costs included from Years 6-10 included in the capital recovery factor, and the additional O&M costs for the additional capital investment also included.

B.2 Islanded Option Example Cost Analysis

For this option, upgrade costs were estimated $ 480M in capital costs and $480 M in fuel costs for the generator only option with new power lines over 40 years, assuming a generator lifetime of 10 years when running full-time. The annual fuel costs vary by demand and range from $76M to $133M per year at $4.00/gal or $2.5/W assuming 2-MW prime generators. The generator, switchgear, and construction costs were estimated at $1.50/W.

For the 70% diesel/30%PV/BESS the capital costs are significantly higher, about $2.4 B because of the high battery costs. The power demand for Kalaeloa was estimated to increase from 25 MW to 60 MW within 20 years.

YEAR	Average Power Demand (MW)	Diesel Generator Installed Costs (MW)	Fuel Costs ($M/yr)	PV PPA (MW)	Battery Storage Installed Costs	Feeder Capital Costs ($M)
1-10	35	54	76	-	-	128
11-20	60	100	133	-	-	-
21-30	60	100	133	-	-	-
31-40	60	40	133	-	-	-
1-10	35	38	53	10	340	128
11-20	60	70	93	18	510	-
21-30	60	70	93	18	510	-
31-40	60	70	93	18	510	-

Year 1-10 Estimated Annual Diesel Only Costs:

Capital Recovery Feeder Costs - $128 M (.04654; 3%; 35 years) = $ 8.47 M
Capital Recovery Generator Costs - $54 M (0.11723; 3%; 10years) = $ 6.32 M
O&M Cost - $182 M (11%) = $ 20.02M
Fuel Costs = $ 76.00M

Year 1-10 Estimated annual power purchased – 35 MW (8760 hr/yr) = 306,600,000 kWh/yr
Year 1-10 Estimated average diesel only power cost = $0.35-0.36kWh

Year 1-10 Estimated Annual Diesel/PV/BESS Costs:

Capital Recovery Feeder Costs - $128 M (.04654; 3%; 35 years) = $ 8.47 M
Capital Recovery Gen/BESS Costs - $378 M (0.11723; 3%; 10years) = $ 44.32 M
O&M Cost - $1 M (11%) = $ 55.66 M
Fuel Costs - = $ 53.00M
Weighted PV PPA costs - $0.03/kWh

Year 1-10 Estimated average diesel/PV/BESS power cost = $0.55-0.56kWh

Similar analyses were conducted for each of the other time periods.

B.3 Hybrid Approach Example Advanced Microgrid Cost Analysis

For this option, the only addition to the phased feeder cost analysis is the development of several microgrids in the first five years of the effort to improve power reliability. The microgrid installed costs would be about $24 M, with fuel cost of only about $80 K per year since the generators would only be operating during power outages, or around 40 hours per year based on current tenant identified outage periods. Since the microgrid generation would only operate for short periods, the is no need to replace the generators in the 15-20 year period, and therefore are a single one-time investment.

YEAR	Average Power Demand (MW)	Annual Microgrid Fuel Costs ($M/yr)	Microgrid Investment Cost ($M)
1-5	25-30	0.08	24
6-10	30-40	0.08	-
11-15	40-50	0.08	-
16-40	60	0.08	-

Year 1-5 Estimated Annual Costs:

Capital Recovery Cost - $24 M (.04654; 3%; 35 years) = $ 1.12M

O&M Cost - $24 M (11%) = $ 2.64M

Year 1-5 Estimated annual power purchased – 30 MW (8760 hr/yr) = 262,800,000 kWh

Year 16+ Estimated annual power purchased – 60 MW (8760 hr/yr) = 525,600,000 kWh

Year 1-5 Estimated average microgrid power cost = $0.015/kWh

Year 16+ Estimated average microgrid power cost = $0.007/kWh

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