SIEMENS

# Parker Ranch Community Electric Supply Options

**April 3, 2014**


## *Abstract*

The state of Hawai'i has the highest residential electricity rates in the United States with rates almost double those of the second highest state, Rhode Island, and three times higher than the national average[1]. The similarly high costs of commercial and industrial rates across the state of Hawai'i mirror that of residential rates on a relative basis. The rates on the island of Hawai'i are even higher than the average rates across the state, creating a significant economic challenge to Parker Ranch's operations, nearby communities, and other businesses.

Parker Ranch engaged a team of consultants comprised of Siemens Industries, Inc. (Siemens)[2] and Booz, Allen, Hamilton Inc. (collectively, Siemens Team) to identify and evaluate potential options for reducing the cost of electricity to Parker Ranch and surrounding communities. The Siemens Team completed an Integrated Resource Plan (IRP) that focused on Parker Ranch's energy needs and those of the surrounding communities in Waimea and North Kohala, on the North-Western side of the island of Hawai'i. The analysis reviewed four, predominantly renewable, generation portfolios with different electric grid options that would allow the Waimea and North Kohala communities to operate substantially independent from the local, vertically integrated utility, Hawaii Electric Light Company, Inc. (HELCO).

The results of the IRP indicate that Parker Ranch has a range of generation and grid portfolio options that could lower the cost of electricity to Parker Ranch and the surrounding communities of Waimea and North Kohala. The portfolios that are most economic range from those that create "energy districts" that utilize the existing HELCO distribution system to supply electricity to existing customers from new generation sources and enhance the capacity and resilience of the existing energy infrastructure, to others that involve construction of a completely new electric


---

[1] Rankings based on Average Retail Price of Electricity to Residential Sector for December 2013, Energy Information Administration website, accessed on April 1, 2014. National average calculated based on data presented on the website, www.eia.gov/state/rankings/?sid=HI#/series/31.
[2] The Siemens Industry, Inc. participants included senior consultants from Siemens Power Technologies International and Pace Global, a Siemens business

distribution system, or microgrid, added to an energy district, that could operate independent of the existing utility's distribution system.

### *The Challenge*

The availability of affordable and reliable electricity is fundamental to the lifestyle and economy of any developed country. Unfortunately, the residents of Hawai'i are burdened with the highest electricity costs in the nation. As of December 2013, data shows that residential electricity rates in Hawai'i exceeded the second highest state, Rhode Island, by almost two fold (an average of 37 versus 21 cents/kWh for Rhode Island) and were three times the national average (the national average was calculated to be 12 cents/kWh)[3]. In addition, the outer islands, including Hawai'i, Maui, Moloka'i and Kaua'i, all pay higher costs than the state average, with residential customers on the island of Hawai'i paying over 42 cents/kWh in 2012[4].

The high cost of electricity in Hawai'i is principally due to the reliance on oil as the primary fuel for the utility-owned generation throughout the state. In addition, while HELCO has long term power purchase contracts with non-utility generators that utilize a mix of technologies and fuels, much of the purchased energy is based on pricing that is tied to the long-term avoided cost of HELCO's oil fueled generation. HELCO's filing of its 2013 IRP Plan[5] indicates the utility expects a continued strong reliance on oil as a fuel and a continued upward trajectory of electricity rates. The figures below present the residential electric rate projections from the HELCO 2013 IRP. Although HELCO's IRP included four future electric rate trajectories or scenarios, the two scenarios below (Figures 1 and 2) capture the range, and bracket 2033 rates at 48 cents/kWh to 100 cents/kWh, with all scenarios showing steady upward growth.

[3] Rankings based on Average Retail Price of Electricity to Residential Sector for December 2013, Energy Information Administration website, accessed on April 1, 2014. National average calculated based on data presented on the website, www.eia.gov/state/rankings/?sid=HI#/series/31.
[4] Average Electricity Prices for Hawaiian Electric, Maui Electric, and Hawaii Electric Light Company, Accessed on 31 March 2014, http://www.heco.com/heco/Residential/Electric-Rates/Average-Electricity-Prices-for-Hawaiian-Electric,-Maui-Electric,-and-Hawaii-Electric-Light-Company
[5] Hawai'i PUC Docket No. 2012-0036.

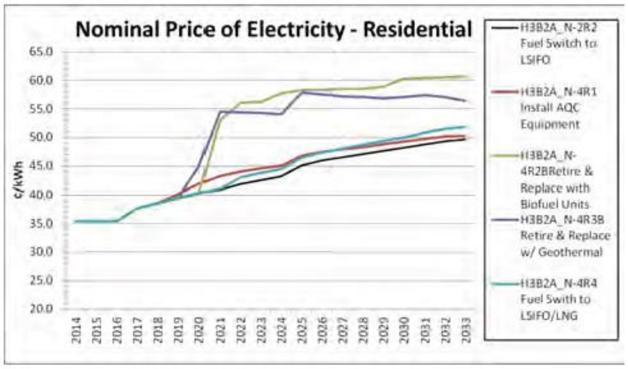


Figure 1: HELCO No Burning Desire[6]

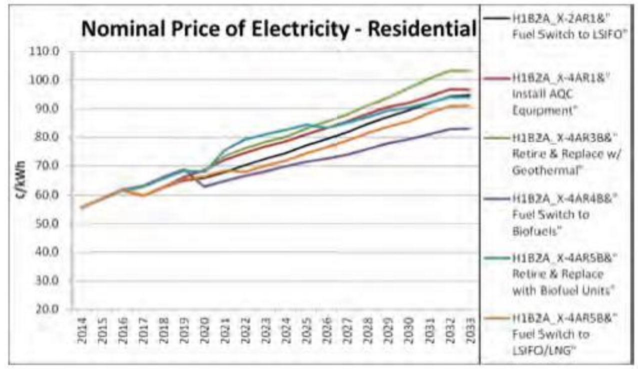


Figure 2: HELCO Blazing a Bold Frontier[7]

Parker Ranch initiated this IRP to identify potential solutions with more favorable future energy pricing compared to HELCO's projections. Parker Ranch believed it could potentially contribute to a solution to lower the costs of electricity on the island of Hawai'i through the use of its large land holdings (over 130,000 acres on the island of Hawai'i) that incorporate arguably some of the best wind and solar resource areas in the state (wind resources are estimated to exceed 300 MW on Parker Ranch lands), and the large elevation differences (over 7,000 feet in elevation change on Parker Ranch lands which sit on the side of Mauna Kea[8]) that could be used for pumped storage hydroelectric generation.

## *Study Methodology*

Overview

The Siemens Team, worked collaboratively with the Parker Ranch leadership to define options for analyses that included: four generation portfolios, five future scenarios and two distribution grid configurations, totaling 40 separate options. In addition, a status quo case was evaluated for each future scenario. The scenarios included two options to deliver electricity to existing retail customers in the Waimea and North Kohala communities:

1. Community Energy District – This option would replace the energy supply to the community by creating an energy district for Waimea and North Kohala with electricity supplied from new Parker Ranch generation. The Parker Ranch generation would include sufficient capacity, controls and HELCO system upgrades to operate largely

[6] Ibid, Fig 233, p 9-62.
[7] Ibid, Fig 231, p 9-61.
[8] Mauna Kea is a volcano on the Island of Hawai'i with a peak elevation of 13,796 feet above sea level.

 

independently of the HELCO system. Parker Ranch would have access to the HELCO transmission and distribution (T&D) assets to deliver power from Parker Ranch owned generation to existing retail customers in the Waimea and North Kohala communities. In exchange for access to the HELCO distribution system, Parker Ranch would pay HELCO a T&D wheeling rate and HELCO would continue to operate and maintain the T&D system within the Energy District, or

2. Community Energy District + Microgrid - This option would replace both the energy supply and the HELCO distribution system in the community by constructing new T&D infrastructure for a new microgrid[9] along with new Parker Ranch generation. The additions would include stand-alone controls and support infrastructure, suitable to operate as an independent generation and distribution system without using HELCO owned assets.

The study's primary goal was to evaluate the economic feasibility of options for self-provision of electricity to the Waimea and North Kohala communities, and to test the robustness of the economic feasibility through a range of plausible future scenarios.

Identification of Key Objectives

The portfolios of generation and grid options were each evaluated against a number of objectives, both economic and non-economic, that Parker Ranch valued. The Parker Ranch leadership team worked in a collaborative workshop with the Siemens Team to define the key project objectives, their associated measures, and their relative priority. The highest priority was assigned to lowering electricity costs for Parker Ranch, its Beneficiaries, and the surrounding communities of Waimea and North Kohala. The key project objectives for Parker Ranch included the following broad categories:

1. Lower Energy Costs to PRI, Beneficiaries, and Community
2. Preserve Electrical System Reliability and Power Quality
3. Preservation of Cultural Values and Rural Way of Life
4. Minimize Environmental Impact
5. Support Self-Reliance and Self-Sufficiency

[9] In this paper, the microgrid refers to a new distribution system to serve existing retail distribution customers in the Waimea and North Kohala communities.

## Technology Screening

The selection of generation technologies for each portfolio emphasized renewable options, to the extent possible. The generation technologies in the portfolios ranged from 100% renewable generation, using only wind and pumped storage generation, to portfolios that combined varying amounts of fossil-fueled resources with renewable resources (mixed portfolios). To capitalize on the superior wind resources and elevation differences on Parker Ranch lands, each portfolio included both wind generation and pumped storage hydroelectric resources. In addition, a geothermal centric portfolio was included to represent the recent research indicating the potential for geothermal heat sources at the edge of Parker Ranch lands, which may offer viable geothermal generation options.

Since HELCO has begun curtailing wind-generated energy during periods of low system loads, the advantages of pumped storage hydro was considered as a uniquely beneficial addition to the current island supply mix. Pumped storage hydro releases water to a lower reservoir at a lower elevation to generate power as needed. This technology provides a potentially zero emission, low cost, dispatchable, renewable resource option, that also leverages cost differentials from generation through each 24-hour period.

Power from renewable intermittent sources, such as wind and solar, can be used to pump water back to an upper reservoir to be used as needed. Generally, pumped storage systems operate to fill an upper reservoir during periods of low system load when excess, low cost generation is available. They then release the stored energy potential in the upper reservoir water to generate electricity during periods of peak demand when costs are generally higher. For the island of Hawai'i, the energy used to recharge the pumped storage system could come from either Parker Ranch generation or from wind resources elsewhere on the island which could eliminate the need for HELCO to interrupt the current and future wind generators' delivery of renewable energy to the island.

The Siemens Team conducted an extensive review of potential locations for pumped storage systems, including utilizing existing reservoirs on Parker Ranch, Hawai'i County-owned reservoirs and, locations with favorable terrain features and elevation features. For pumped storage technology, favorable terrain translates to reduced construction costs to create the upper and lower storage ponds.

This pumped storage review identified a total of 48 potential reservoir location sites (upper or lower), with 49 different project configurations for upper and lower reservoirs and the connecting pipeline routes. Each site was evaluated based on estimated construction costs and other criteria. Ultimately, five pumped storage options were recommended as viable options for the IRP's generation portfolios. These pumped storage projects ranged in size from 10 to 50 MW with sufficient water storage to sustain generation for 5 hours.

Portfolio Development

After identifying feasible technology options, four distinct portfolio combinations were considered for modeling:

1. A pure renewable portfolio (wind generation in combination with pumped storage);
2. A geothermal centric portfolio;
3. A mixed portfolio with a combination of renewables and reciprocating engines fueled with ultra-low sulfur diesel (ULSD); and
4. A sustainable mixed portfolio with a combination of renewables and combustion turbines fueled with Liquefied Natural Gas (LNG).

Wind generation and pumped storage were included in all the portfolios. In addition, 1 MW of solar photovoltaic generation was included in all portfolios since a solar project of this size is currently in the planning stages for one of Parker Ranch's beneficiaries. No further solar photovoltaic was added, since the lower costs of wind generation and favorable wind resources provided a more economic option than solar for the generation sizes and timeframes considered.

Each of the four portfolio combinations included analysis of both grid connected (GC) and grid independent (GI) versions of the portfolios. In this study, GC implied that balancing operations were performed on an island-wide basis by HELCO; and GI implied that balancing operations were performed independently by a new operating entity for the system encompassing Waimea and North Kohala. The GI portfolio versions included batteries connected to the grid and a greater generation capacity in order to perform the balancing function independent of HELCO. The balancing function requires sufficient reserves to balance instantaneous generation and load requirements, regulate frequency and fulfill generation and transmission contingencies with no load shedding.

While HELCO did not directly participate in the IRP, results from the recently filed Hawaiian Electric Companies 2013 IRP, 2012 HELCO PUC Annual Utility Report[10], the HELCO 2012 Rate case filing[11], the 2013 HELCO Geothermal RFP[12] and other publicly available data on the HELCO system were used as inputs to the study. Further study input was acquired via discussions with vendors to procure competitive cost information on fuels, generation and transmission technologies.

For each of the portfolios, generation was added in two phases: the first in 2019, with sufficient firm capacity to meet the energy needs of Parker Ranch and the greater Waimea and North Kohala communities (approximately 18 MW), and the second in 2024 with sufficient excess firm capacity to serve approximately 75% of the load on the western side of the island (approximately an additional 70 MW). The large contribution to west Hawai'i was thought to be potentially beneficial to not only provide a lower-cost energy source to the island, but to also alleviate the current transmission constraint connecting the generation on the eastern side of the island to the growing loads on the western side of the island. The final capacity of each of the portfolios after the 2024 generation additions ranged in sizes with most of the portfolios producing a capacity of over 200 MW. The large total capacity relative to the 88 MW of load served (18 MW for Waimea and North Kohala plus 70 MW sold to HELCO) is due to the need to provide firm power with the large contribution of renewable, intermittent resources in each of the portfolios.

The existing portfolio assumes the continuation of the purchase of integrated electric service from HELCO under existing tariffs. The Siemens Team selected the HELCO system average rate as the estimate for the status quo costs under the existing HELCO tariffs, with the assumption that the 18 MW Waimea and North Kohala load profile would be substantially similar to HELCO's average system load profile. The system average rate was based on data for revenue from sales divided by the total MWh sales recorded in the 2012 HELCO PUC Annual Report. The escalation of this rate in future years was based on the forecasted rates presented in the Hawaiian Electric Companies 2013 IRP.

[10] Filed with the HI PUC on May 22, 2013.
[11] HI PUC Docket No. 2012-0099 - Note this 2012 rate case filing, using a 2013 test-year, was subsequently withdrawn by HELCO.
[12] HI PUC Docket No. 2012-0092.

To assess the option of a Community Energy District and new generation, the Siemens Team developed an estimate of a HELCO T&D wheeling rate based on the system costs contained in the 2012 HELCO rate case filing. The Siemens Team used this T&D wheeling rate as an alternative for distributing power from Parker Ranch generation to retail customers in the Waimea and North Kohala communities. This cost-based T&D rate included O&M, depreciation expense, an estimated allocation of administrative and general costs and a return on net plant. The T&D wheeling rate in future years was based on the forecasted rates presented in the Hawaiian Electric Companies 2013 IRP. The Siemens Team developed the T&D wheeling rate to serve as a representation of the costs for either a T&D wheeling rate, a rate based on the lease and operation of the HELCO assets, or a rate equivalent to financing the purchase of the HELCO T&D net plant and the associated operating costs. Cost estimates further included upgrades to HELCO's system, external to these communities, to mitigate negative impacts to the HELCO system, caused by the new Parker Ranch generation.

In order assess the option of a Community Energy District + Microgrid, the Siemens Team estimated the costs of a microgrid system that could operate independently from the HELCO system. The Siemens Team estimated the cost of constructing, operating and maintaining a new microgrid system comprised of transmission, distribution and control components (including distribution system components down to the customer meters). This system was designed to distribute power from new Parker Ranch generation sources to individual retail customers within the Waimea and North Kohala communities, and eliminate the need for the existing HELCO T&D assets in these communities. Cost estimates further included upgrades to HELCO's system, external to these communities, to mitigate negative impacts to the HELCO system, caused by the new generation. No removal costs for HELCO's assets were factored into the analysis.

<u>Future Scenario Development</u>

The future scenarios in which each portfolio was evaluated were defined to describe a range of plausible future external environments. The variations across the five scenarios focused on the price of oil, electricity demand, T&D access (i.e., whether electricity was delivered via HELCO assets to a Community Energy District or through the construction of a new Community Energy District + Microgrid), and the possibility of a drought affecting water resources which would prolong the time to initially fill the pumped storage reservoirs. The high oil scenario assumed low electricity demand growth, and the low oil scenario assumed a high demand growth. The high oil scenarios were also assumed to have greater additions of renewable generation. For each high and low oil scenario, two distinct T&D access scenarios were considered, one in which access to wheeling across the HELCO T&D system is available (Community Energy District), and the other with no T&D access and Parker Ranch builds its own microgrid to serve retail customers in the Waimea and North Kohala communities (Community Energy District + Microgrid).

The future scenarios describing the external operating environments are summarized in Figure 3, below.

| T&D Access | Low Oil + High Demand | High Oil + Low Demand | Steady Oil |
|---|---|---|---|
| **Energy District** - Access to HELCO T&D System to Wheel Power From Parker Generation to Community Loads | **1 - "Low Oil – No Microgrid"**<br>• Low Oil Prices<br>• High Demand Growth<br>• Fewer Renewable Builds | **2 - "High Oil – No Microgrid"**<br>• High Oil Prices<br>• Low Demand Growth<br>• More Renewable Builds | |
| **Energy District + New Microgrid** - No Access to HELCO System to Wheel Power to Community Loads | **3 - "Low Oil + Microgrid"**<br>• Low Oil Prices<br>• High Demand Growth<br>• Fewer Renewable Builds | **4 - "High Oil + Microgrid"**<br>• High Oil Prices<br>• Low Demand Growth<br>• More Renewable Builds | **5 – "Dry Island + Microgrid"**<br>• Steady Oil Price<br>• High Demand<br>• Pumped Storage Reservoirs Take Longer to Fill |

Figure 3: Scenario Definition

<u>Analysis Approach</u>

Each generation and grid option was assessed using a system modeling approach that separated the island into three distinct regions as follows:

1. Parker Ranch, together with its surrounding Waimea and North Kohala communities
2. The west side of the island, where most of the island's recent demand growth has occurred
3. The east side of the island, where most of the island's generation is located

 

Figure 4 below provides a map of the three regions defined for the IRP.

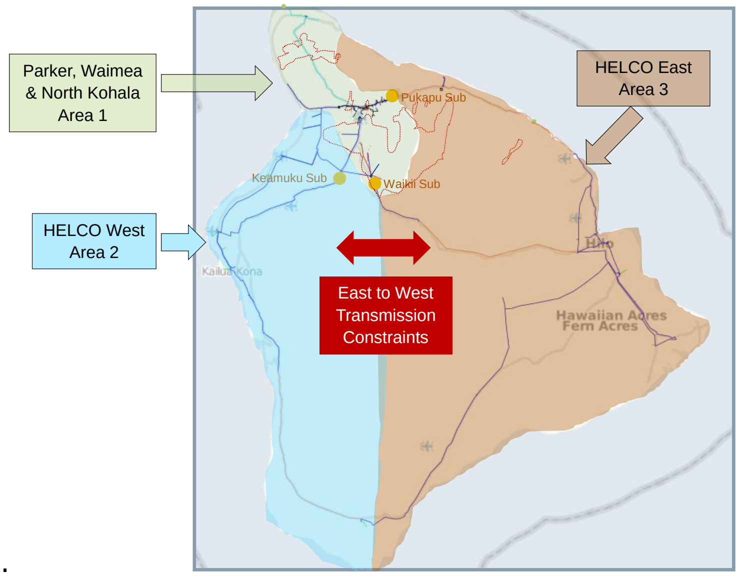


Figure 4: System Modeling Regions

The assessment incorporated regionally-located generation and loads, as well as the transmission transfer capability between regions. The island currently has excess generation, on the east side while recent demand growth has occurred on the west side, creating a transmission constraint to optimally dispatch generation against island demand. The primary connection and source of constraint, between the east and west sides of the island, is a 69 kV transmission line. HELCO has located recent generation resource additions on the west side, nearer loads, to reduce the impact of the island's transmission constraints.

### *Findings*

The Siemens Team found that:

- Four of the eight portfolio options reviewed provided lower electricity costs compared to the status quo.
- Two of the portfolio options reviewed resulted in lower costs to the Waimea and North Kohala communities across all five future scenarios considered when compared to the status quo costs.

The resulting costs from each portfolio-scenario combination are presented in Figure 5. The results are shown as levelized $/MWh costs across the 30-year study term from 2014 to 2043.

 

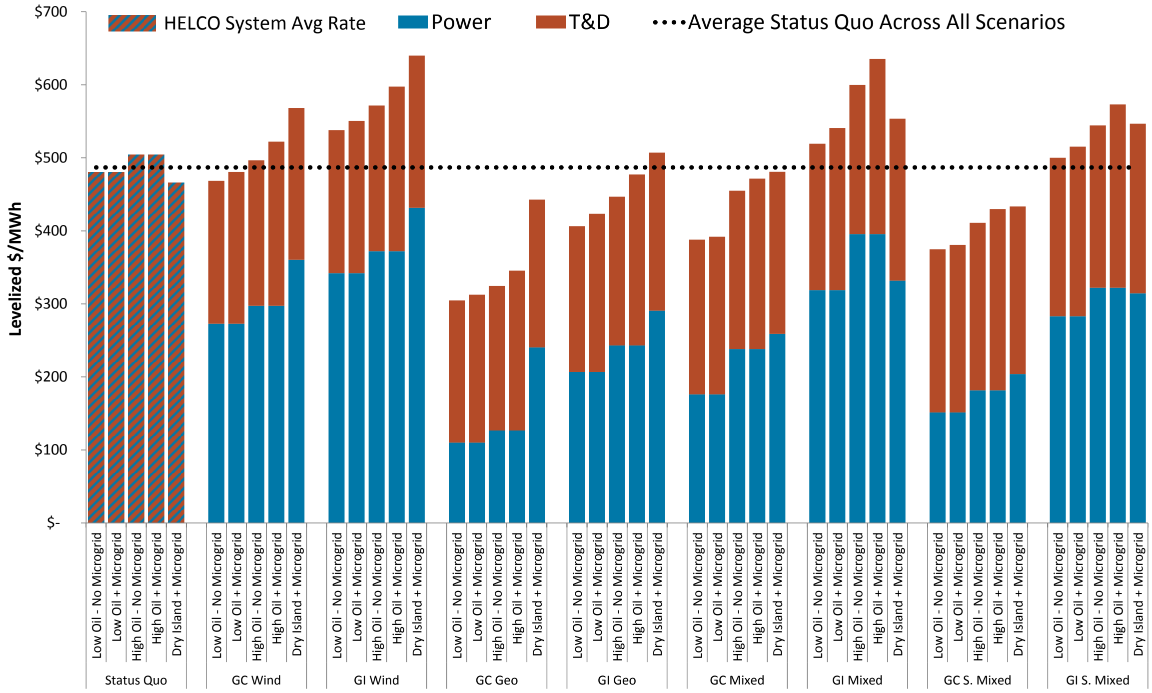


Figure 5: Levelized Costs For Each Portfolio (Real 2013$)

Significant sales of energy to HELCO are assumed in the modeling. Each portfolio included sufficient generation to serve the Waimea and North Kohala communities in addition to approximately 70 MW of west island load. The modeling assumes Parker Ranch is able to sell between 56% and 76% of the total energy it generates to HELCO due to the low average cost of production for the new Parker Ranch generation units compared to HELCO's cost of production. Power is assumed to be sold to HELCO by Parker Ranch when the variable cost of Parker energy production is less than the HELCO variable costs of energy production. The revenue from sales of excess generation to HELCO reduced the cost of power for customers of the system.

As a further test of the results, the study included the evaluation of a portfolio in which capacity was added only sufficient to serve Waimea and North Kohala. This smaller portfolio of generation sized to serve only the Waimea and North Kohala communities resulted in lower levelized energy costs as compared to the larger generation portfolio sized to sell 70 MW of excess power to HELCO.

The Siemens Team also evaluated each portfolio in terms of project objectives identified on the study's scorecard. The two portfolios with the best economic results also provided the best combined results on the project scorecard objectives; these were, the grid connected geothermal portfolio and the grid connected sustainable mix portfolio.

The results across the portfolios indicate that grid connected portfolios have lower costs than the corresponding generation portfolios with grid independent systems. This results from the lower generation capacity requirements, and thus the lower capital expenditure requirements, required for the grid connected systems. The grid connected portfolios require lower reserve capacity to operate reliably, since these portfolios are assumed to operate in conjunction with the HELCO system to provide mutual load-supply balancing and operating reserves to provide support across the two systems.

The portfolio results consistently indicate that microgrid costs are approximately 2-6% higher than comparable HELCO T&D wheeling rates, depending on the portfolio and scenario. This minimal difference is below the confidence level of the results. However, the marginally higher microgrid costs are still more than overcome by the savings from new Parker Ranch generation supply for four of the eight portfolios, thus providing a net savings to the community electricity customers. The findings associated with the relative costs of building a new micro-grid versus paying HELCO a wheeling rate cannot be considered conclusive without a more detailed analysis of the required O&M and capital costs and the regulatory and legal pathways associated with each option. In addition, an actual HELCO T&D rate may be greater than the current estimated wheeling rate if HELCO shifts higher overhead allocations or stranded generation costs to the T&D wheeling rate.

The geothermal centric portfolios are highly dependent on the actual costs associated with the geothermal energy resource (temperature, pressure, etc.) These costs are highly uncertain because of the unknowns of exploration, development and longevity of the geothermal resources.

### *Recommended Steps Forward*

Based on the results obtained, it would be prudent for Parker Ranch to further refine the cost estimates and explore the development options and legal and regulatory paths that could support the distributed generation combined with the Community Energy District or Community Energy District + Microgrid concepts in the options identified.

Parker Ranch recently learned of the potential for geothermal resources within its land holdings, and supports further study of the resource for the Big Island. However, with the high uncertainty of geothermal resources and the extensive development timelines to bring them into production, the sustainable mixed portfolio offers a compelling alternative in the near term. The sustainable mixed portfolio includes LNG which can be a bridge fuel into the future in terms of even lower cost energy portfolios. Technological break-throughs in low-cost battery storage may also provide the potential for the future reduction in energy costs in the portfolios and options identified. The technology and resources available to Parker Ranch justifies a strong focus on new distributed generation additions in order to lower the cost of electricity to the region.

This study was designed to evaluate both the economic and technical merits of opportunities to lower energy costs for Parker Ranch and the surrounding areas, including the potential of a Community Energy District or a Community Energy District combined with a new community microgrid. The findings of this study indicate that electricity prices could be reduced below those projected in the 2013 integrated resource plans produced by the island's electric utility, HELCO[13].

The transformation of the energy landscape for Waimea and North Kohala region of the Big Island would require significant commitment in time and resources. Critical next steps necessary to pursue this transformational energy strategy include:

- Conduct further measurement of wind and geothermal energy resources
- Secure an operating partner that could operate and maintain the planned additions
- Attract the necessary investment capital to fund the planned additions
- Advocate for the necessary regulatory support for the plans
- Evaluate the impact to the remaining electrical customers on the Big Island that are not within Waimea and North Kohala

Conducting further measurement of the wind and geothermal energy resources would require 6 to 12 months of additional data collection, some of which is underway. The attractiveness of the opportunity to third parties would depend on the relative quality of the renewable energy resources. Parker Ranch and other data sources have provided better data on the existing wind

[13] Integrated Resource Plan and Five Year Action Plans filed by the Hawaiian Electric Companies with the Hawai'i Public Utilities Commission on June 28, 2013 available at: http://www.hawaiianelectric.com/heco/Clean-Energy/Integrated-Resource-Planning

resources than the geothermal resources to date. While preliminary pumped-storage hydroelectric (PSH) sites have been identified in the current study, potential PSH resources still require additional extensive assessments in order to refine the current estimates and preliminary designs. While further data and analysis is desirable, for the sustainable mixed portfolio (which does not include geothermal resources), no technical or energy resource obstacle appears insurmountable as much is already known regarding all the technologies and resources in this portfolio.

# APPENDIX A

***Key Cost Assumptions and Inputs***

Generation costs were developed with input from the Hawaiian Electric Companies' 2013 IRP and estimates from other sources. These sources included recent Siemens Pace Global projects and vendor quotes and estimates. The Siemens Team estimates included a construction premium for all projects due to higher engineering, procurement and construction (EPC) costs in Hawai'i.

Generation technology capital recovery rates were calculated inclusive of fixed costs. While the estimated life of the generation technologies are different, all technologies have been assigned an asset book life of 25 years. No Production Tax Credit (PTC) has been assumed for wind, as the wind projects are likely to commence operation past the current PTC expiration date. Further, no Renewable Energy Credit value has been assumed for any technology alternative. The discount rate (WACC) assumes a cost of debt of 5.3%, and a cost of equity of 13% and a 50:50 debt to equity ratio. The MACRS schedule is based on IRS publication 946 (2012 version). Debt is amortized over a 20 year period. No terminal value is assumed at the end of the 25 year life of the asset. Additional cost assumptions utilized in determining distribution costs are included in Figure A1.

| | **Energy District - Wheeling On HELCO System To Move Energy From Parker Generation To Waimea & N. Kohala Load – "Access"** | **Energy District + Microgrid To Move Energy From Parker Generation To Waimea & N. Kohala Load - "No Access"** |
|---|---|---|
| 2019 Generation Additions | • Generation interconnection costs<br>• Pay HELCO for wheeling power to Waimea & N. Kohala loads | • Generation interconnection costs<br>• Micro-grid costs for 20 MW of demand |
| 2024 Generation Additions | • Additional interconnection costs for more generation<br>• T&D wheeling charge for export to HELCO<br>• Network upgrades on HELCO system for reliability | • Additional interconnection costs for more generation<br>• Incremental micro-grid costs for higher levels of interconnected generation<br>• Network upgrades on HELCO system for reliability |

Figure A1: T&D Cost Considerations over Time

The costs for all infrastructure, except the generation additions, are summarized in Figure A2. The Community Energy District plus Microgrid costs include the possibility of constructing new T&D infrastructure, to replace the electricity deliver function of the HELCO T&D system in the community, or a Community Energy District, only, which assumes payment of wheeling rates to use HELCO's T&D system. Generation Interconnection costs are the costs associated with adding distribution infrastructure to connect the new Parker generation asset to the distribution or transmission grid. Control and Communication costs are required to add control to the grid. The system upgrade costs for HELCO's system are also included as the Siemens analysis indicated that new power flow profiles will impose voltage constraints on the system at locations where none exist today.

| No. | Portfolio | Community Microgrid ($M) | Generation Interconnection Costs ($M) | Control and Communications ($M) | HELCO System Upgrade ($M) | TOTAL ($M) |
|---|---|---|---|---|---|---|
| 1 | Business As Usual | $109.4 | - | - | - | $109.4 |
| 2 | Grid Connected Wind | $109.4 | $37.2 | $1.4 | Not Estimated | $147.9 |
| 3 | Grid Independent Wind | $109.4 | $37.5 | $1.4 | Not Estimated | $148.2 |
| 4 | Grid Connected Geothermal | $109.4 | $31.8 | $1.4 | $1.4 | $143.8 |
| 5 | Grid Independent Geothermal | $109.4 | $42.2 | $1.4 | $1.5 | $154.4 |
| 6 | Grid Connected Mixed | $109.4 | $50.0 | $1.4 | Not Estimated | $160.7 |
| 7 | Grid Independent Mixed | $109.4 | $46.7 | $1.4 | Not Estimated | $157.4 |
| 8 | Grid Connected Sustainable Mixed | $109.4 | $61.2 | $1.4 | $1.8 | $173.8 |
| 9 | Grid Independent Sustainable Mixed | $109.4 | $59.4 | $1.4 | $1.4 | $171.5 |

Figure A2: Microgrid Cost estimates

Portfolio Descriptions

Generation Portfolio 1 is the status quo or business as usual baseline to which each of the other portfolio options are compared. The remaining portfolios 2 – 9 are presented in pairs, where the even numbered portfolio is evaluated under the presumption that access to HELCO's distribution system is possible (Community Energy Districts), and the odd numbered portfolio is evaluated under the presumption that an independent microgrid must be constructed (Community Energy District + Microgrid). In the Grid Connected (GC) portfolios, Parker Ranch continues to rely on HELCO for balancing the combined HELCO-Parker instantaneous system demand with the generation resources. Each portfolio has been sized to meet the requirements of Waimea and North Kohala by 2019 and, then an additional 70 MW of the HELCO system by 2024. This capacity, together with demand for Waimea and North Kohala, constitutes approximately 75-80% of current west Hawai'i Island demand. Parker's sales are assumed to be priced at variable costs of HELCO's generation. The portfolios are as follows:

| | |
|---|---|
| Portfolio 1: | Status Quo |
| Portfolios 2 and 3: | Pure renewable with wind and pumped storage hydro |
| Portfolios 4 and 5: | Pure renewable combining geothermal wind and pumped storage. |
| Portfolios 6 and 7: | A mix of wind, pumped storage and reciprocating engines fueled with ULSD |
| Portfolios 8 and 9: | A mix of wind, pumped storage and combustion turbines fueled with LNG. |

Fuel Price Assumptions

Figure A3 below provides a summary of the fuel price projections used in the analysis.

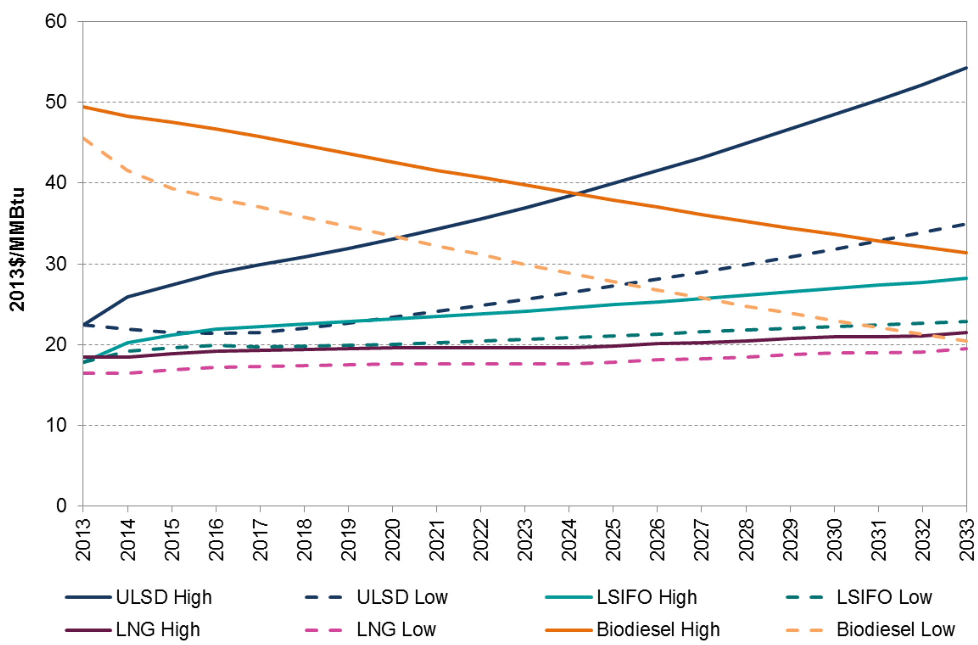


Figure A3: Fuel Price Projections

 