5.0 Project Characterizations

Based on the recommendations of the previous section and discussion with KIUC, it was determined that the following technologies would be examined in the remainder of this report:

- Direct fired biomass
- Municipal solid waste mass burn
- Hydroelectric
- Wind
- Landfill Gas

5.1 Characterization Approach

Prototypical projects have been characterized for each technology class. For most technologies, this required a screening assessment of potential project options to determine optimum size, appropriate location, configuration, and other characteristics:

- **Biomass** – Project sizes from 5 to 30 MW were considered, and an optimum size was picked based on preliminary technical and economic analysis. The fuel mix changes based on the project size. Smaller projects can utilize lower cost waste biomass resources, while larger projects would need to rely on dedicated energy crops. The location for the biomass project has not been specified yet. A stoker boiler was selected as the basis for the project conceptual design due to its good mix of technical maturity, efficiency, and cost.
- **Municipal solid waste mass burn** – The previous sections compared various technology options for waste to energy, and it was determined that mass burn was the preferred conversion technology. The size of the MSW plant is limited to the available waste on the island. However, due to uncertainties in population, economic growth, and recycling trends, the amount of MSW available in the future is difficult to predict accurately. Therefore two project sizes, 200 and 300 tons per day, were compared, and the best size picked for additional analysis. As with biomass, the location for the MSW project has not been specified yet.
- **Combined biomass and MSW plant** – In addition to standalone biomass and MSW, a plant that combines both fuels was considered. Different equipment configurations were evaluated and a preferred approach and size characterized.

- **Hydroelectric** – Previous assessments identifying potential hydro projects on Kauai were reviewed and 49 possible project sites were cataloged. From this list, six promising projects were selected and characterized. The projects are located throughout the island and consist of new sites and upgrades of existing facilities.
- **Wind** – Eleven potential project areas were identified from the latest validated wind resource map for Kauai. These sites were screened for development potential. Two sites were identified as high potential, and five sites were identified as moderate potential. The other sites were dropped from consideration. Project size was limited to 7 MW based on direction from KIUC. Turbine sizes were restricted to less than 1 MW to ensure the machines could be erected and serviced with cranes available on the islands.
- **Landfill gas** – There is only one viable landfill gas project on Kauai, located at the Kekaha landfill. Black & Veatch estimated the energy production of this project after landfill closure in 2009. A project based on reciprocating engine technology could produce about 800 kW.

Due to their possible synergy, assessment of the biomass and MSW options is covered in a single section, 7.0 Biomass and Municipal Solid Waste. The other technologies are covered in the subsequent individual sections. Each technology section has the following subsections:

1. Basis for Assessment
2. Assessment of Contributing Resource
3. Project Option Screening
4. Technical Description
5. Power and Energy Production
   - 5.1 Plant Performance
   - 5.2 Operating Profile
6. Cost of Energy
   - 6.1 Capital Cost
   - 6.2 Operating and Maintenance Costs
   - 6.3 Incentives
   - 6.4 Life-cycle economics
7. Advantages and Disadvantages of Technology
   - 7.1 Fit to KIUC Needs
   - 7.2 Environmental Impact
   - 7.3 Socioeconomic Impact

7.4 Incentives / Barriers

8. Next Steps

5.2 General Assumptions

The following general assumptions were made in carrying out the project assessments. Financing assumptions are specified in the next section, and additional assumptions are documented in the respective technology sections.

- KIUC's will develop, own and operate all projects. Black & Veatch has also included economic analysis of private ownership to model the impacts of various financial incentives.
- Land purchase cost is $100,000 per acre.
- Insurance cost is 0.1 percent of the direct capital cost per year.
- Wind, landfill gas, and hydro projects have minimal permanent O&M staff (one person or less per project). Significant maintenance and repair work will be on a contract basis.
- Annual average fully burdened labor cost for plant O&M staff is $90,000 per year.
- There is sufficient available transmission capacity for projects. Other than transmission tie lines and project substations, no other T&D upgrade costs are included.
- Net power output estimates are for normal top load, adjusted for typical losses and degradation (that is, not "new and clean"). Transmission line losses are not included in the power output estimates.
- All cost estimates are in 2005 dollars and assume overnight construction.
- Levelized cost comparisons are done in 2009, the assumed on-line date of all projects.
- Hawaii general excise tax (4 percent) is included in cost estimates.
- Capital cost estimates are based on Black & Veatch experience with other projects, vendor quotes for major equipment items, and review of reference literature.
- Shipping is included in capital cost estimates.
- Construction labor rates and productivity have been adjusted for Hawaii conditions.
- Indirect project capital costs generally include (i) 10 percent for KIUC project management and administration and (ii) a project specific allowance for

project development and start-up expenses (feasibility studies, permitting, legal, engineering, construction management, spare parts, training, etc.).

5.3 Economic Modeling Approach

Based on the characteristics developed for each project, Black & Veatch calculated a levelized busbar generation cost ($/MWh). The levelized busbar cost is a method for comparison of the life-cycle costs of generating power from various projects on an equal economic basis. This cost considers the project performance, capital cost, fixed and variable operating costs, and fuel costs (if applicable). The levelized busbar cost can vary considerably based upon the financing and economic assumptions for a particular project. To capture the range of possible development scenarios for KIUC, the levelized cost of developing projects with KIUC financing and developer financing were considered. Under developer financing the power would be sold to KIUC under a power purchase agreement (PPA). Therefore, the levelized busbar cost represents the cost of a levelized price PPA. Developer financing offers the advantage of eligibility for tax-based federal renewable energy incentives, while KIUC funded projects offer the advantage of lower financing costs.

5.3.1 Economic Assumptions

The economic assumptions for the KIUC and developer financing scenarios are provided in Table 5-1 and Table 5-2, respectively. The assumptions are project specific and vary due to differing project life estimates. These assumptions supercede those in Table 2-1, which were used for the general technology screening.

Table 5-1. KIUC Financing Assumptions

	Hydro	Wind	LFG	Biomass	MSW
Debt to Equity Ratio	100 : 0	100 : 0	100 : 0	100 : 0	100 : 0
Cost of Debt, %	5.00%	5.00%	5.00%	5.00%	5.00%
Discount Rate, %	5.00%	5.00%	5.00%	5.00%	5.00%
Project Life, years	50	25	15	25	25
Debt Term, years	25	25	15	25	25
Fixed O&M Escalation, %	3.0%	3.0%	3.0%	3.0%	3.0%
Variable O&M Escalation, %	3.0%	3.0%	3.0%	3.0%	3.0%
Fuel Cost Escalation, %	3.0%	3.0%	3.0%	3.0%	3.0%
Levelized Fixed Charge Rate, %	5.12%	7.10%	9.63%	7.10%	7.10%
Capacity Credit	0%	0%	100%	100%	100%

5.3.2 Avoided Cost Assumptions

The avoided cost is the cost of installing and generating power from conventional sources that a utility avoids by installing renewable energy resources. The avoided cost includes both an avoided energy and capacity cost component.

Table 5-2. Developer Financing Assumptions

	Hydro	Wind	LFG	Biomass	MSW
Debt to Equity Ratio	60 : 40	60 : 40	60 : 40	60 : 40	60 : 40
Cost of Debt, %	8%	8%	8%	8%	8%
Cost of Equity, %	16%	16%	16%	16%	16%
Depreciation Life, years	20	5	5	7	7
Discount Rate, %	11.20%	11.20%	11.20%	11.20%	11.20%
Project Life, years	50	25	15	25	25
Debt Term, years	25	25	15	25	25
Fixed O&M Escalation, %	3.0%	3.0%	3.0%	3.0%	3.0%
Variable O&M Escalation, %	3.0%	3.0%	3.0%	3.0%	3.0%
Fuel Cost Escalation, %	3.0%	3.0%	3.0%	3.0%	3.0%
Tax Rate, %	35.00%	35.00%	35.00%	35.00%	35.00%
Production Tax Credit (PTC), $/MWh	9.00	18.00	9.00	9.00	9.00
PTC Term, years	5.00	10.00	5.00	5.00	5.00
PTC Escalation, %	2.50%	2.50%	2.50%	2.50%	2.50%
Levelized Fixed Charge Rate, %	12.58%	11.80%	14.23%	12.16%	12.16%
Capacity Credit	0%	0%	100%	100%	100%

The avoided energy cost is the cost of supplying each MWh of energy from an alternate source. In practice, this cost can be thought of as the cost of supplying energy from an alternative portfolio of generation resources (e.g., an alternative expansion plan). The avoided energy cost for this report was based on recent projections performed for KIUC by LCG Consulting.

The avoided capacity cost is the value to the electric system of a unit of capacity being available to serve load during peak conditions. Conceptually, the value of this capacity is equal to the capital carrying charge of the avoided generation resource (the next unit planned for addition to the system). As with the avoided energy value, the avoided capacity value was based on recent analysis by LCG Consulting.

Assumed avoided energy and capacity values are shown in Table 5-3. These values are based on the moderate load growth and fuel price case developed by LCG. It can be seen that for the next ten years, there is no value for capacity because KIUC already has sufficient capacity to meet needs. LCG Consulting only provided estimates through 2024, but most of the project lives will extend beyond this date. A 2 percent escalation was assumed for energy cost beyond 2024, and 2.4 percent escalation was assumed for capacity cost.

Table 5-3. Avoided Energy and Capacity Assumptions.

Year	Avoided Capacity Cost, $/kW	Avoided Energy Cost, $/MWh		Year	Avoided Capacity Cost, $/kW	Avoided Energy Cost, $/MWh
2009	0.00	111.89		2034	241.44	199.37
2010	0.00	121.46		2035	246.27	203.36
2011	0.00	131.10		2036	251.20	207.43
2012	0.00	133.40		2037	256.22	211.58
2013	0.00	139.93		2038	261.35	215.81
2014	160.34	146.48		2039	266.57	220.12
2015	162.00	155.09		2040	271.91	224.53
2016	160.15	159.54		2041	277.34	229.02
2017	192.08	155.25		2042	282.89	233.60
2018	192.80	164.57		2043	288.55	238.27
2019	192.35	168.47		2044	294.32	243.03
2020	183.14	166.80		2045	300.21	247.90
2021	203.74	163.22		2046	306.21	252.85
2022	200.11	168.86		2047	312.33	257.91
2023	196.32	159.73		2048	318.58	263.07
2024	214.88	164.41		2049	324.95	268.33
2025	202.03	166.83		2050	331.45	273.70
2026	206.07	170.16		2051	338.08	279.17
2027	210.19	173.57		2052	344.84	284.75
2028	214.40	177.04		2053	351.74	290.45
2029	218.68	180.58		2054	358.77	296.26
2030	223.06	184.19		2055	365.95	302.18
2031	227.52	187.87		2056	373.27	308.23
2032	232.07	191.63		2057	380.73	314.39
2033	236.71	195.46		2058	388.35	320.68

Not all renewable resources provide firm capacity. For example, wind and hydro are intermittent resources. To account for these variations, the avoided capacity value is modified by a capacity credit factor. The capacity credit is a measure of the percent of a project's capacity that contributes towards increasing the reliability of the electric system. For baseload, dispatchable renewable technologies such as biomass, MSW and landfill gas, the capacity credit is roughly equal to that for conventional fossil fueled plants. For intermittent renewable resources (wind and hydro), the capacity value is assumed to be zero for the purposes of this study. Although widespread implementation of these resources may be able to provide some probabilistic measure of firm capacity in larger interconnected grids, KIUC's small isolated grid has a greater need for generator reliability.