Appendix B: Electricity Assumptions and Methodology

Listed below are the applied assumptions and methodologies for calculating both the projected supply and demand in the electricity sector for Kaua`i from 2010 to 2030, in the Draft Report. All assumptions and methodologies may not apply to the Final Report.

A. Baseline Electricity Sector Assumptions and Methodology

1. Due to concerns that record high oil prices in 2008 may have lead to an atypical reduction in electricity demand, data from the 2007 DBEDT Data Book was used to prepare the electricity demand baseline for the Kaua`i Energy Sustainability Plan (KESP).
2. According to the Kaua`i Island Cooperative Integrated Resource Plan, Black & Veatch, November 2008, the KIUC will need to generate 515 GWh of electricity to meet the demand for 2009. Therefore, 515 GWh was used as the baseline or starting point for projecting the four electricity demand growth scenarios in GWhs.
3. According to the Kaua`i Island Cooperative Integrated Resource Plan, Black & Veatch, November 2008, the KIUC will need to generate 82 MW of electricity to meet peak demand requirements for 2009. Therefore, 82.0 MW of peak demand was used as the baseline or starting point for projecting the electricity demand growth scenarios in MWs.

B. Electricity Demand-Side Assumptions and Methodology

The following demand scenarios were developed for the Kaua`i Energy Sustainability Plan (KESP). Each scenario includes a different projected growth rate, or an average annual growth rate (AAGR). Below are the parameters of the KESP demand scenarios:

1. The Net Zero Growth Scenario applies an AAGR of 0.0%, or assumes that electricity demand is held constant from 2010 to 2030 in this scenario.
2. The Population Growth Scenario assumes an AAGR of 1.1%. This AAGR is based on population growth data obtained from the Population Division, U.S. Census Bureau for Kaua`i. The AAGR of 1.1% was applied to the baseline of 515 GWh of electricity generation (in 2009) in order to project electricity demand from 2010 to 2030.
3. The Base IRP Projected Growth Scenario applies a 2.3% AAGR. This growth rate is based on data from the Kaua`i Island Cooperative *Integrated Resource Plan*, Black & Veatch, November 2008. The AAGR of 2.3% was applied to the baseline of 515 GWh of electricity generation (in 2009) in order to project electricity demand from 2010 to 2030.
4. The Aggressive IRP Projected Growth Scenario assumes an AAGR of 3.1%. This growth rate is based on data from the Kaua`i Island Cooperative *Integrated Resource Plan*, Black & Veatch, November 2008. The AAGR of 3.1% was applied to the baseline of 515 GWh of electricity generation (in 2009) in order to project electricity demand from 2010 to 2030.
5. The Sentech Hawai`i Team identified the projected energy demand scenario based on the most defensible data set behind it—namely the Population Growth + *Energy Efficiency and Conservation* Scenario based on U.S. Census historic population growth rate for Kaua`i.
6. The Population Growth Scenario incorporates an annual average growth rate (AAGR) of 1.1%. The population growth rate data is based solely on data from the Population Division, U.S. Census Bureau, which shows an 8.9% increase in the population of Kaua`i over the past 8 years. The percentage increase of 8.9% is divided by the number of years (8) to get the AAGR of 1.1%. This AAGR is then applied to the baseline demand for electricity in order to project the demand from 2010 to 2030 for Kaua`i. The Electricity Population Growth demand scenario projects that Kaua`i requires approximately 648 GWh of electricity generation to meet demand in 2030.
7. The Electricity Population Growth + Energy Efficiency and Conservation scenario projects potential energy savings of 30% by 2030 based on energy efficiency and conservation savings assumptions in the KIUC Integrated Resource Plan, the KEMA Energy Efficiency Potential Study,

as well as advancements in Smart-Grid technologies. The Population Growth + Energy Efficiency and Conservation scenario projects the total demand for electricity to decline from the projected 648 GWh in the previous scenario to 452 GWs in 2030 for Kaua`i.

C. Electricity Supply-Side Assumptions and Methodology

1. Applied a capacity factor of 32% to Concentrating Solar Power (CSP) projects for the KESP. Source: KIUC spreadsheet listing future projects. Calculated the capacity factor using the MW and annual production (MWh) data provided by KIUC.
2. Applied a capacity factor of 20% to future KLUC Photovoltaic (PV) projects. Source: KIUC spreadsheet listing future projects. Calculated the capacity factor using the MW and annual production (MWh) data provided by KIUC.
3. Applied a capacity factor of 86% to future KIUC Biomass projects. Source: KIUC spreadsheet listing future projects. Calculated the Capacity Factor using the MW and annual production (MWh) data provided by KIUC.
4. Applied a capacity factor of 89% to future Landfill Gas projects. Source: KIUC spreadsheet listing future projects. Calculated the Capacity Factor using the MW and annual production (MWh) data provided by KIUC.
5. Applied a capacity factor of 52% to future Hydropower projects. Below are specifics regarding the basis for using this capacity factor:
    a. Several future Hydropower projects were listed in the KIUC spreadsheet. The majority of the future KIUC Hydropower projects have a capacity factor rated at 52%. Note that one project, with a capacity factor of 28%, was treated as a statistical outlier for this analysis.
    b. Source: KIUC spreadsheet listing future projects. Calculated the capacity factor using the MW and annual production (MWh) data provided by KIUC.
6. Biodiesel Assumptions (including production, supply, etc.).
    a. All locally grown biodiesel will first be allocated towards meeting electricity demand. If any biodiesel surplus is available it will be allocated towards the Transportation Sector.
    b. According to a recent Biofuels/Bioenergy presentation by the State of Hawai`i Department of Business, Economic Development & Tourism, Kaua`i has approximately 81,056 acres of potential oil crop land based on soil suitability & other factors.
    c. Crop yield information for Kaua`i is listed below in the following tables:

	Palm Oil		Jatropha		
Available Acres	Warm/Wet	Warm/Moist	Warm/Wet	Warm/Moist	
32,915	12,836,850	7,438,790	5,924,700	3,752,310	(1)
43,300	16,887,000	9,785,800	7,794,000	4,936,200	(2)
81,056	31,611,840	18,318,656	14,590,080	9,240,384	(3)
Palm Oil: Warm/	Palm Oil: Warm	Jatropha: Warn	Jatropha: Warm/Moist		

Palm Oil (g/acre)		Jatropha (g/acre)	
Warm/Wet	Warm/Moist	Warm/Wet	Warm/Moist
390	226	180	114

Sources: (1) BioEnergy Master Plan, (2) Biofuels Summit Briefing Book, (3) Biofuels/Bioenergy presentation by the State of Hawai`i Department of Business, Economic Development & Tourism

    d. For this analysis, it is assumed half of the available acres on Kaua`i are warm/moist and the other half are warm/wet. Applying this assumption to the available acres on Kaua`i results in approximately 25 million gallons of biodiesel production per year.
    e. Gallons of biodiesel must be converted to GWhs in order to determine the available biodiesel supply for the electricity sector. Below is the methodology for converting 1 gallon of biodiesel to kWh of electricity.

Average density of Biodisel	0.88	g/ml
Metric Tonne of Biodiesel	37800	MJ
1 kWh	3.6	MJ
1 liter	0.264172	Gallon
1 gram	0.002205	lbs
1 metric tonne	2,204.62	lbs

SO….

1 Gallon of biodiesel weighs:				**7.34396**	**lbs**
0.88	g/ml	x	1000 =	880.00000	g/l
880	g/l	x	0.002205 =	1.94007	lbs/liter
1.9400679	lbs/liter	/	0.264172 =	**7.34396**	lbs/gallon
1 Gallon of biodiesel produces:				**34.9772049**	**kWh**
7.3439559	lbs	/	2,204.62 =	0.00333	metric tonnes
0.0033312	m. tonnes	x	37800 =	125.91794	MJ
125.91794	MJ	/	3.6 =	**34.97720**	kWh

f. Energy inputs must also be accounted for when converting gallons of biodiesel to GWh of electricity. Energy input assumptions are listed below:

   i. 3.5 energy units are gained for every unit of fossil energy it requires to make biodiesel-which takes into account the planting, harvesting, fuel production and fuel transportation to the end user.

   ii. The chart below lists the Penetration Schedule and Net Energy Output (MWh) for locally produced biodiesel.

Penetration %	
Year	%
2018	*10%*
2020	*50%*
2030	*100%*

MWh/Gallon	0.0350

Soil Composition	
Warm/Wet	*50%*
Warm/Moist	*50%*

Energy Output Ratio:	1 Unit of energy input equals	3.5	units of output

YEAR	Max Biofuel Production	*% of Total Production Capacity*	Projected Biofuel Production (Gallons)	Projected Energy Produced (MWh)	Necessary Energy Input (MWh)	Net Energy Output (MWh)
2009	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2010	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2011	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2012	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2013	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2014	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2015	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2016	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2017	24,965,248.0	*0.00%*	0.0	0.0	0.0	0.0
2018	24,965,248.0	*10.00%*	2,496,524.8	87,321.5	24,949.0	62,372.5
2019	24,965,248.0	*30.00%*	7,489,574.4	261,964.4	74,847.0	187,117.4
2020	24,965,248.0	*50.00%*	12,482,624.0	436,607.3	124,744.9	311,862.4
2021	24,965,248.0	*55.00%*	13,730,886.4	480,268.0	137,219.4	343,048.6
2022	24,965,248.0	*60.00%*	14,979,148.8	523,928.8	149,693.9	374,234.8
2023	24,965,248.0	*65.00%*	16,227,411.2	567,589.5	162,168.4	405,421.1
2024	24,965,248.0	*70.00%*	17,475,673.6	611,250.2	174,642.9	436,607.3
2025	24,965,248.0	*75.00%*	18,723,936.0	654,910.9	187,117.4	467,793.5
2026	24,965,248.0	*80.00%*	19,972,198.4	698,571.7	199,591.9	498,979.8
2027	24,965,248.0	*85.00%*	21,220,460.8	742,232.4	212,066.4	530,166.0
2028	24,965,248.0	*90.00%*	22,468,723.2	785,893.1	224,540.9	561,352.2
2029	24,965,248.0	*95.00%*	23,716,985.6	829,553.9	237,015.4	592,538.5
2030	24,965,248.0	*100.00%*	24,965,248.0	873,214.6	249,489.9	623,724.7

g. After applying all of the above assumptions it was determined that 623.73 GWh of electricity can be generated from 25 million gallons of locally produced biodiesel in 2030 for Kaua`i.

7. The U.S. Census-Based Population Growth scenario "generation wedge" projects that an electricity demand of approximately 648 GWh in 2030 can be met via the following energy supply portfolio:
   - Local Biodiesel – 259 GWh, or 39.03% of demand;
   - Biomass – 161.2 GWh, or 24.88% of demand;
   - Hydropower – 130.3 GWh, or 20.10% of demand;
   - Solar Thermal – 56.1 GWh, or 8.65% of demand;
   - Solar PV – 35 GWh, or 5.41% of demand; and

  - Landfill Gas – 12.5 GWh, or 1.92% of demand.
  - A total of 395.1 GWh of electricity is generated by clean or renewable technologies. The remaining demand (252.9 GWh) is met by locally grown biodiesel, with a surplus available to contribute approximately 7.7 million gallons to the ground transportation sector.
8. The U.S. Census-Based Population Growth + Energy Efficiency and Conservation scenario "generation wedge" projects that an electricity demand of approximately 452 GWh in 2030 can be met via the following energy supply portfolio:
   - Biomass – 161.2 GWh, or 35.67% of demand;
   - Hydropower – 130.3 GWh, or 28.82% of demand;
   - Local Biodiesel – 259 GWh, or 12.60% of demand;
   - Solar Thermal – 56.1 GWh, or 12.40% of demand;
   - Solar PV – 35 GWh, or 7.75% of demand; and
   - Landfill Gas – 12.5 GWh, or 2.76% of demand.
   - A total of 395.1 GWh of electricity is generated by clean or renewable technologies. The remaining demand (57 GWh) is met by locally grown biodiesel, with a surplus available to contribute approximately 16.2 million gallons to the ground transportation sector.

All spreadsheets are available upon request.