

## **2.0 Introduction**

The objective of this study is to identify the best renewable energy options for development on the island of Kauai. Kauai Island Utility Cooperative (KIUC) has retained Black & Veatch to undertake this assessment of renewable energy technologies and resources. This section provides an overview of the project objectives, project background, study approach, and general introduction to renewable energy including a description of Kauai's current use of renewable resources.

### **2.1 Background**

In 2003, over 94 percent of Kauai's electricity was generated from imported fossil fuels – the highest level of fossil fuel dependence in over 25 years. Kauai's rising dependence comes during a period of record oil prices, political and military strife, and concerns about impacts on the global environment from increased consumption of fossil fuels. At the same time, Kauai is blessed with spectacular natural wonders, rich indigenous resources, and historical experience using renewable energy sources to meet a large share of its energy needs. This study examines a return to renewable energy resources as part of KIUC's integrated planning framework.

Kauai Island Utility Cooperative has been directed by the Hawaii Public Utilities Commission to update the Integrated Resource Plan (IRP) for the recently acquired Kauai Electric (KE). KE's IRP was last updated in 1997. Recognizing the important role of energy diversity, KIUC has decided to assess and address the potential role of renewable energy resources to meet the future needs of Kauai in its IRP. In addition, KIUC anticipates utilizing the results of this study to develop a strategy to meet the renewable portfolio standard (RPS) established by the Hawaiian legislature.

In June 2004, with the signing of SB2474, Hawaii's RPS goal was replaced with an enforceable standard. The standard requires that 20 percent of electricity be generated from renewable sources by 2020, with the following interim targets:

- 7 percent of net electricity sales by December 31, 2003
- 8 percent of net electricity sales by December 31, 2005
- 10 percent of net electricity sales by December 31, 2010
- 15 percent of net electricity sales by December 31, 2015
- 20 percent of net electricity sales by December 31, 2020

KIUC is currently ahead of this implementation timeline. In 2003, KIUC sourced 7.5 percent of its energy from renewable sources (including credit for solar thermal water heating).<sup>2</sup>

Applicable technologies for the RPS include wind, solar energy, hydropower, landfill gas, waste to energy, geothermal, ocean thermal energy conversion, wave energy, biomass (including municipal solid waste, biofuels, or fuels derived from organic sources), hydrogen fuels derived from renewable energy, or fuel cells where the fuel source is derived from renewable sources. Cofiring renewable fuels with non-renewable fuels is allowed under the RPS, but only the electricity generated from renewable fuels counts towards the RPS. This study examines all of these resources.

## **2.2 Objective**

The objective of this project is to assess the technical, economic and market potential for reducing fossil-fueled electricity generation and peak supply on Kauai by implementing a wide range of renewable energy resource technologies. This report further aims to identify specific, promising, and actionable renewable energy projects and provide the necessary technical and economic details to support informed decision making. It is perceived that this report will form the basis of a successful and cost effective renewable energy development program over the short to mid-term.

## **2.3 Approach**

This study is being undertaken in two phases. This Final Report is a comprehensive account of both. A previous Interim Report covered Phase 1, describing the existing use of renewable energy on the island, generation technology options, and the developable potential of the different resources. Twenty-six different technology applications are assessed in this report in the following ten categories:

1. Solid biomass
2. Biogas
3. Biofuels
4. Waste to energy
5. Hydroelectric
6. Ocean energy
7. Solar
8. Wind
9. Geothermal

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<sup>2</sup> Alan Oshima of Oshima Chun Fong & Chung LLP, "Kauai Island Utility Cooperative 2003 Renewable Portfolio Standards Status Report", March 30, 2004.

10. Multi-fuel generation technologies

The Interim Report concluded with the scoring of the renewable energy technology options and recommendations for further study in Phase 2 of the project. Based on the recommendations of Phase 1 and discussion with KIUC, it was determined that the following technologies would be examined in Phase 2:

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

Phase 2 of the project characterizes the most promising options in greater detail and identifies specific project features. The findings of this project will support development of KIUC's IRP.

**2.3.1 Assumptions**

This report is based on hundreds of assumptions related to resource availability, costs, economic impacts and other factors. These assumptions have been developed based on Black & Veatch experience, industry inquiries, and review of literature in the field. Careful analysis of similar recent studies aided in the development of appropriate assumptions, and it is felt that the assumptions made in the report are generally conservative in nature.

Cost estimates included in this report reflect project development and installation in Hawaii. Estimates for Phase 1 of the project should be considered screening level accuracy and should not be used for definitive planning or budgeting purposes. The accuracy of the Phase 2 estimates varies by project, as more supporting details were available for some projects.

Common economic assumptions for Phase 1 were provided by KIUC and are shown in Table 2-1. Additional assumptions for Phase 2 are documented in Section 6. All costs in this document are in 2005 dollars unless otherwise noted.

**Table 2-1. Economic Assumptions.**

Debt Term	25
Economic Life	25
Escalation Rate	3.00%
Cost of Debt	5.00%
Cost of Equity	N/A
Debt / Equity Ratio	100 : 0
Discount Rate	5.00%
Levelized Fixed Charge Rate *	7.095%
Notes:	
* Fixed charge rate is calculated by assuming 5.0 percent cost of debt with a 25 year term, 0 percent insurance, and 0 percent taxes.	

### 2.3.2 Report Organization

This Final Report is a comprehensive documentation of all work undertaken for this project. The Final Report includes Sections 2-4 of the Interim Report (identified below), and additional sections as follows:

1. **Executive Summary** – summary of the main findings of the project.
2. **Introduction** – project background, project objective, approach, overview of renewable energy, and a review of current renewable energy use on Kauai.
3. **Renewable Technology Options** – characterization of the renewable technology options identified above including principles of operation, applications, resource characteristics, cost and performance, environmental impacts, and outlook for Kauai
4. **Renewable Energy Technology Screening** – quantitative comparison and screening of the technology options based on defined criteria (cost of electricity, resource potential, etc.). Includes summary conclusions and recommendations for Phase 2 of the project.
5. **Project Characterizations** – introduction to Phase 2, overview of approach, general assumptions for Phase 2, and economic modeling approach.
6. **Renewable Energy Financial Incentives** – overview of various tax credits, loans, grants, and other programs offering financial assistance to renewable energy projects.
7. **Biomass and Municipal Solid Waste** – Characterization of a standalone biomass plant, a standalone municipal solid waste plant, and a plant combining the two fuels.
8. **Hydro** – Identification and characterization of 6 promising hydro sites.

9. **Wind** – Identification and characterization of 7 promising wind areas.
10. **Landfill gas** – Characterization of potential landfill gas opportunity at Kekaha landfill.
11. **Final Renewable Energy Project Scoring** -- quantitative comparison and ranking of the project options based on defined criteria (cost of electricity, incentives/barriers, etc.).
12. **Conclusions** – project summary and recommendations for next steps.

## 2.4 Overview of Renewable Energy

Renewable energy generation technologies are based on energy sources that are practically inexhaustible in that most are solar derivatives. Such technologies are often favored by the public over conventional fossil fuel technologies because of the perception that renewable technologies are more environmentally benign. Renewable energy options include wind, solar, biomass, biogas, geothermal, hydroelectric, and ocean energy. Table 2-2 shows the power conversion technologies that have been developed to harness each of these energy sources.

<b>Table 2-2. Renewable Energy Conversion Technologies</b>	
<b>Renewable Resource</b>	<b>Energy Conversion Technology</b>
Solar	Photovoltaic Thermal Energy Capture
Wind	Wind Turbines
Water	Hydroelectric Turbines
Ocean	Wave Energy Devices Tidal/Current Energy Turbines Thermal Energy Conversion
Geothermal	Steam Turbines Direct Use Geothermal Heat Pumps
Biomass	Combustion (direct fired, co-firing with coal) Gasification / Pyrolysis
Biogas, Biodiesel, Ethanol	Engine generators Combustion turbines Microturbines Fuel cells

Excluding hydro, renewables only supply about 2 percent of the United States' current electrical energy needs. However, the field is rapidly expanding. The following

figures demonstrate the current trends for renewable energy in the United States. Perhaps more telling, more wind capacity has been installed in Europe in the last two years than any other energy generation technology. Further, worldwide wind energy additions have outpaced nuclear power additions for the past four years.

Renewable energy technologies are most competitive in niche markets (for example, off-grid electrification) or when public sentiment will support government subsidies or special pricing mechanisms such as “green” pricing.

It should be noted that almost all renewable energy technologies have high initial capital costs and low operating costs. This fact makes financing terms for renewable energy projects very important. Access to low cost capital can have a significant impact on life-cycle costs and improve the economics of these projects substantially.

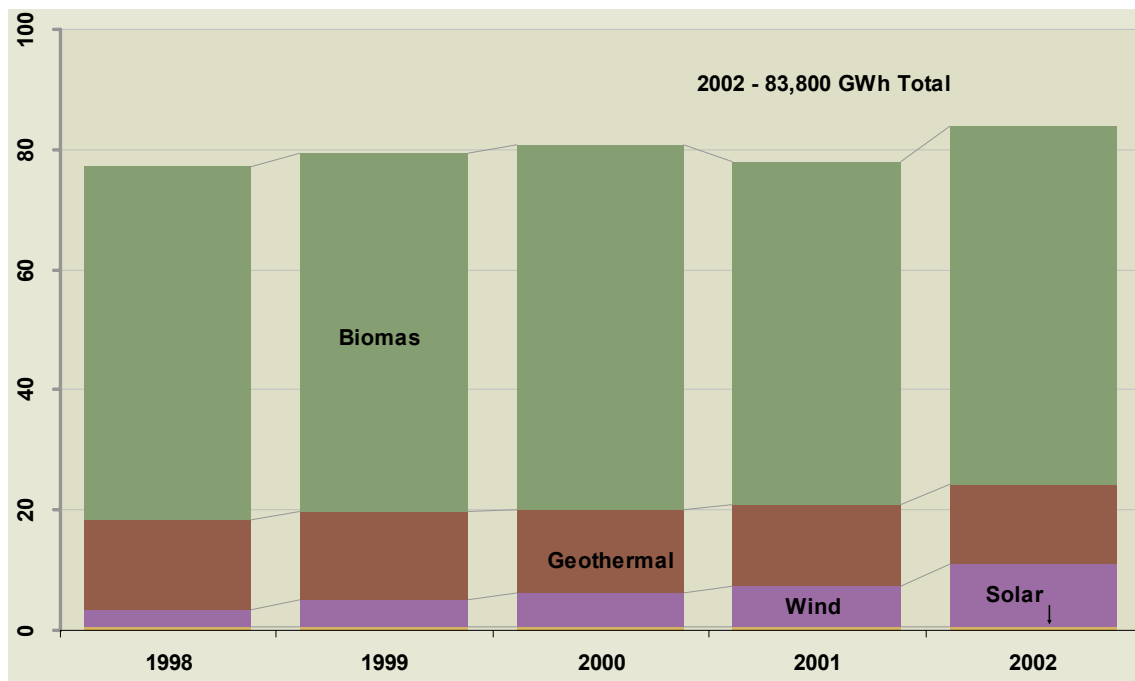


Figure 2-1. US Net Renewable Electricity Generation, GWh (1000's). (EIA 2002)

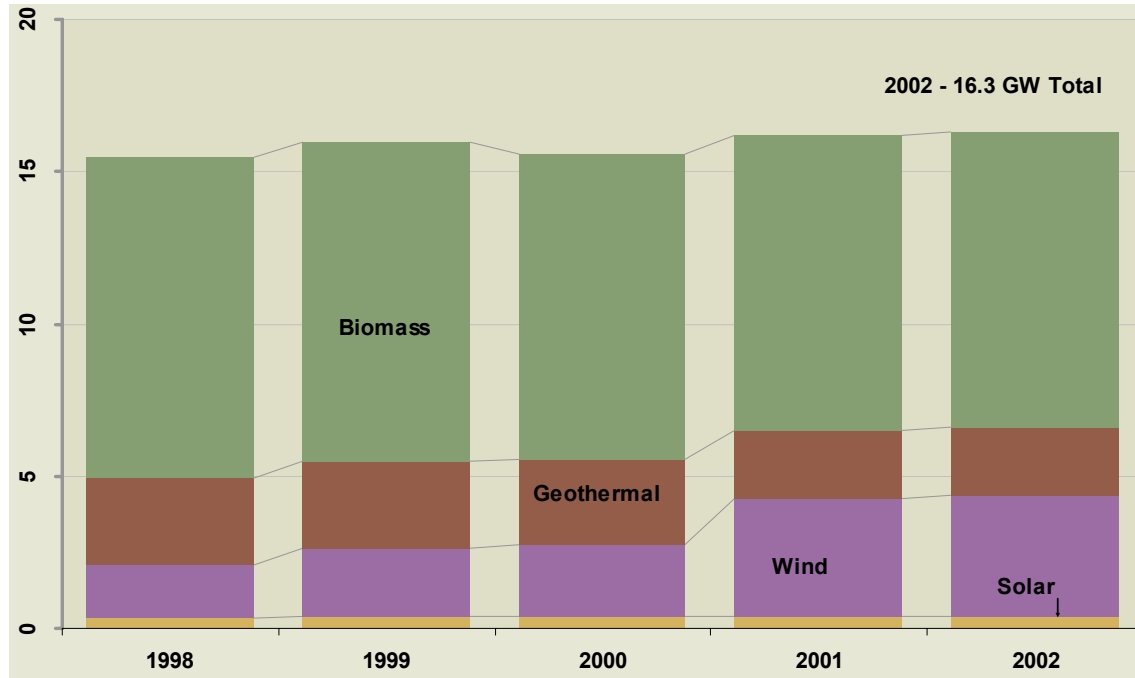
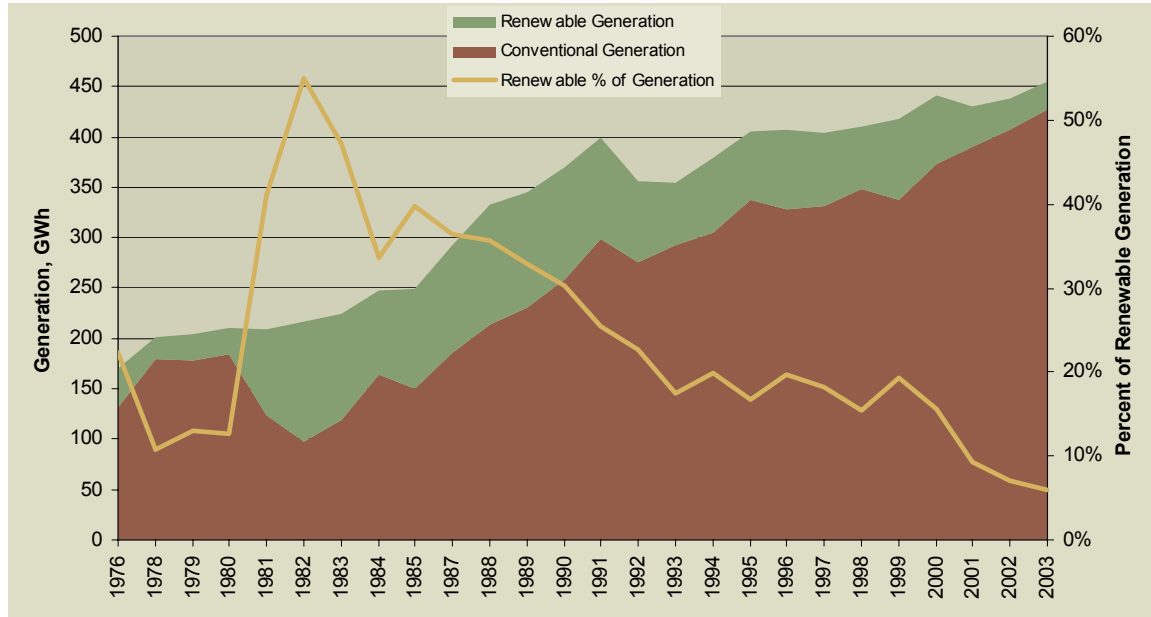


Figure 2-2. US Net Renewable Electrical Capacity, GW. (EIA 2002)

## 2.5 Review of Current Renewable Energy Use on Kauai

Kauai has historically relied upon a mix of renewable and conventional energy sources for power generation. There are no fossil fuel resources on the island; consequently all fuel is imported. The lack of fossil fuel resources initially spurred development of biomass and hydroelectric projects to power the island's sugar industry, the first major electric consumer on the island. In fact, Kauai's original electric company started as a subsidiary of McBryde Sugar Co. Several hydroelectric and biomass fueled power plants were developed to provide electricity for irrigation, milling and production operations. In the past, electricity from these sources has been a substantial source of energy for the island. In the early 1980s, hydro and biomass accounted for upwards of 40 to 50 percent of electricity generated on the island. However, in 2003, KIUC only sourced 7.5 percent of its energy from renewable sources.<sup>3</sup> The amount of renewable energy generation has been in a state of decline since the early 1980s, see Figure 2-3.

<sup>3</sup> Alan Oshima of Oshima Chun Fong & Chung LLP, "Kauai Island Utility Cooperative 2003 Renewable Portfolio Standards Status Report", March 30, 2004. Includes credit for solar water heating, which displaces electricity production.



**Figure 2-3. Historic Electricity Generation in Kauai (Data: KIUC).**

The amount of renewable energy supplied by industrial producers has declined as sugar production has declined on the island. In 2002, the Lihue Plantation’s bagasse power plant was shut down, which removed 14 MW of firm renewable energy from KIUC’s portfolio. This power purchase agreement had supplied an average of 44,000 MWh per year and had accounted for 9 to 12 percent of annual energy sales.

In addition to the declining output from renewable facilities, the need for electricity on the island has steadily grown. As fossil fuel prices were relatively low during the 1990s, there was little economic impetus to examine renewable alternatives for new generation. Today’s higher fossil fuel prices coupled with the new state RPS has recast the decision making environment.

Table 2-3 shows the installed capacity of renewable energy generation on the island of Kauai. Table 2-4 shows that the majority of electricity is currently produced by fossil fuel sources on Kauai.

**Table 2-3. Installed Kauai Renewable Energy Generating Capacity.**

Plant	Owner	Technology	Capacity, kW
Waimea Mauka Hydro	State ADC <sup>a</sup>	Hydro	1,000
Waiawa Hydro	State ADC <sup>a</sup>	Hydro	500
Lihue Lower	KIUC	Hydro	600
Lihue Upper	KIUC	Hydro	800
Wainiha Hydro	Kauai Coffee	Hydro	3,700
Kalahea Hydro	Kauai Coffee	Hydro	1,000
Waiahi Hydro	Gay & Robinson	Hydro	1,300
Lihue Plantation <sup>b</sup>	Lihue Plantation	Biomass Comb.	21,800
Gay & Robinson	Gay & Robinson	Biomass Comb.	4,000
Solar PV Systems	Various	Solar PV	42
<b>Total</b>			<b>38,742</b>

Source: KIUC, DBEDT.

Notes:

<sup>a</sup> State Agribusiness Development Corporation

<sup>b</sup> Currently not operating.

**Table 2-4. 2003 Kauai Electricity Generation.**

Generation Source	Generation, MWh	Percent
<b>Fossil Fuels</b>		
Steam Plant	9,324	2.1
Diesel 1-5	158,100	34.8
Diesel 6-9	1,304	0.3
Gas T1 Hitachi	16,829	3.7
Gas T2 JBE	28,316	6.2
KPP Diesel	14,236	3.1
KPP Naphtha	<u>199,495</u>	<u>43.9</u>
Fossil Fuels Subtotal	427,604	94.1
<b>Renewable</b>		
Waiahi	588	0.1
Kekaha Sugar / ADC	2,192	0.5
McBryde / Kauai Coffee	21,422	4.7
Olokele / Gay & Robinson	<u>2,656</u>	<u>0.6</u>
Renewable Subtotal	26,858	5.9
<b>Total</b>	<b>454,462</b>	<b>100</b>

Source: KIUC