SECTION 6: RECOMMENDATIONS FOR THE ELECTRICITY SECTOR

In making the recommendations for the electricity sector, the SENTECH Hawai`i Team did its utmost to follow *The Natural Step Principles of Sustainability*, namely that in a sustainable society[1]:

- Nature is not subject to systematically increasing:
    - Concentrations of substances extracted from the Earth's crust,
    - Concentrations of substances produced by society, or
    - Degradation by physical means and, in that society.
- People are not subject to conditions that systematically undermine their capacity to meet their needs.

The Team also adhered to the following guiding principles based on its stakeholder and public meetings, objective energy analysis, and follow-on community input:

- Community priorities and acceptance
- Sound scientific principles and analysis
- Available energy resources
- Commercial, least-cost technologies
- Reduce demand, increase supply of local & sustainable energy/fuels.

As the SENTECH Hawai`i Team worked with stakeholders and the public in developing these recommendations, the following highlights became apparent:

- Greater impact from ***increased supply*** of sustainable electricity could be achieved—and the community can still realistically reach 100% energy sustainability.
- ***Demand reduction*** is essentially less of an opportunity since homeowners don't use much electricity, solar water heating is widespread, and it is fairly difficult to influence many small business owners.
- Success in reaching the 100% goal is highly dependent on community acceptance of higher upfront costs for long-term benefits.

Recommendations 6.1-6.3 follow. Each recommendation is broken down into:

1. **Rationale**—to explain why the recommendation was made.
2. **Impact**—to give some idea of the recommendation's impact on Kaua`i ratepayers, the County, KIUC, developers, landowners, etc.
3. **Relevant Policies**—to show what other policies could leverage, interfere with, or otherwise effect the recommendation.
4. **Implementation**—including recommended actions, costs, responsible parties, and timeline.
5. **Funding Source**—to show how the costs of each recommendation would be paid for.

[1] Natural Step (n.d.). *The Four System Conditions*. Retrieved on 7/27/10 from http://www.naturalstep.org/the-system-conditions.

RECOMMENDATION 6.1: To Decrease Electricity Demand, Divert 7.5% of KIUC Franchise Tax to Enable County to Lead Energy Efficiency Initiatives

1. Rationale

Energy demand in the residential market is fairly small on Kaua`i for several reasons, including:

- KIUC reports an average of 500 kWh's/month/home, presumably because of Kaua`i's temperate climate and corresponding low percentage of homes with air conditioning or heating.
- Kaua`i has a fairly high market penetration of solar water heating in the residential market—KIUC reports a 33% market share—and there is probably a trend of diminishing returns in allocating additional monetary resources to market further solar water heating at this time. Not all homes have the correct orientation to take advantage of solar water heating and enough available roof space to install solar water heating panels. Additionally, not all home owners will commit to a technology that endangers roof integrity.
- A lot of electronic equipment is becoming more efficient. One flat-screen television on the market takes as much energy as a 68-Watt light bulb, for example.

Because of these reasons, the SENTECH Hawai`i Team does not feel it prudent to suggest energy efficiency or conservation measures in the residential market.

There are several ways the County could decrease electricity demand in the public building market, however:

- Assessments of the County's buildings over the last few years have shown significant potential for energy savings. Lessons learned from the public building sector could also be replicated across State and Federal buildings as well as private sector buildings, e.g. in hotels.
- In 2010, the County adopted the 2009 International Energy Conservation Code (IECC), with some small changes. The 2009 IECC is a national, consensus-based, model code and provides a level playing field for builders, a common foundation for manufacturers and suppliers, and a standard for training and qualifying building officials and inspection personnel. Among them, the new code gives options for roof insulation including cool roofs, advanced ventilation, and low-emittance roofs by testing or specification. Newly constructed buildings will need to meet this code; existing buildings could be retrofitted to meet the code as well.
- New energy saving technologies are continuously improving and the County would be well served to stay informed about those technologies.
- Federal and state policies, including funding and incentives, can make energy efficiency measures more cost-effective and leverage County investments.

To take advantage of these energy saving measures, the County could undertake energy efficiency measures but its energy staff is already stretched thin from the current workload. A temporary 7.5% diversion of the existing KIUC Franchise Tax would raise approximately $255,000/year—enough to hire two County employees—for two years until the KIUC Franchise Tax could be raised permanently through interaction with the Hawai`i State Legislature.

These two high-priority County positions would include the following:

1. ***Energy Manager***. This person would develop and manage Requests for Proposals (RFPs) for Energy Savings Performance Contract (ESPC) projects, manage the ESPC projects, enforce codes and standards such as the 2009 International Energy Conservation Code (IECC), and engage with DBEDT and PUC on energy policy.
2. ***Facilities Energy Specialist.*** This person would manage public building retrofits, pass on lessons learned to the private building market, and assess new energy-savings technologies.

Figure 6-1: Variable Speed Drive

The Facilities Specialist should, as one of his/her first duties, engage with the Department of Water—the third largest energy consumer on island. Variable speed/frequency drive pumps (such as that pictured in Figure 6-1[2]), auto start, off-peak pumping, and other controls may increase efficiency, and offer additional gains from ensuring pipe integrity. The SENTECH Hawai`i Team recommends that the County, KIUC, and solution providers engage Department of Water to assess and implement energy saving measures as a top priority.

Energy savings can also be identified in emerging technologies such as the *Global Energy Management for Sustainability (GEMS)* product that enables many buildings to be "wired" to control energy use and identify energy savings opportunities. GEMS achieved over 12-25% energy savings from installations in New Mexico university buildings and in retail chain stores in Mexico.

Another promising demand reduction technology is solar thermal air conditioning and dehumidification which can take a significant amount of a building's cooling load off the grid.

- Air conditioning can account for up to 50% of a building's energy use over a year. The same energy that heats buildings up can also cool them down with solar thermal energy-driven absorption chillers. Solar collectors use highly reflective mirrors, polished aluminum, or polymers to heat water or oil up to 500ºF—plenty of heat to drive an absorption chiller. Absorption chillers use heat instead of mechanical energy to provide cooling.
- Energy use related to dehumidification in warm, humid climates can account for up to 80% of a building's energy use. Solar thermal energy-driven desiccant dehumidification systems dry out building intake air, which makes cooling the air more efficient, and reduces mold and other excess moisture problems.

2. Impact

To form an energy reduction strategy for the KESP, the SENTECH Hawai`i Team assessed the best available data from recent studies to build a solid foundation. In 2005, KIUC commissioned California-based consultant KEMA to assess the island's technical, economic, and "achievable" electric energy-efficiency potential for the residential and commercial sectors on Kaua`i. The final report analyzed two energy-efficiency funding scenarios:

- Base, or current, funding. Assumes an approximate continuation of the current program funding levels over 10 years, an investment of approximately $1 million per year.
- Advanced efficiency. Explores additional program potential that could be achievable if program funding levels were doubled. Program energy and peak demand savings, as well as program cost-effectiveness, were assessed under these two funding scenarios.[3]

A second perspective and potential scenarios on energy efficiency potential come from *KIUC's Demand Side Management (DSM)* potential data from their 2008 Integrated Resource Plan (IRP) completed by Black & Veatch.[4]

[2] The Online Pump Magazine (September 23, 2005). *New Grundfos Multistage Pumps with Integrated Variable Speed Drive*. Retrieved on 8/6/10 from http://www.impeller.net/magazine/news_en/doc3236x.asp.
[3] KEMA, Inc. (April 26, 2005). *Energy Efficiency Potential Study, Final Report prepared for KIUC*. Retrieved on 8/3/10 from http://www.kiuc.coop/pdf/Kaua`i%20EE%20Report%20Final.pdf.
[4] Black & Veatch (November, 2008). *Integrated Resource Plan*. Retrieved on 8/3/10 from http://www.kiuc.coop/IRP/Tariff/IRP2008_2008%20KIUC%20IRP.PDF.

There is insufficient data from the County, from the IECC 2009, from KIUC, and other resources to accurately estimate demand reduction from specific recommended measures such as ESPC projects, enforcement of the 2009 IECC, assessment and utilization of energy efficiency technologies listed above, and leveraging opportunities from State and Federal policies—yet each stands on its own merits. For example, ESCOs will conduct rigorous analysis of energy savings potential from ESPC work since their profit margin depends on accurate data. In general, building codes and standards have proven effective in reducing energy demand for years.

The County should endeavor to keep the community apprised of the feasibility and energy savings potential of recommended measures as the data becomes available, and explain to the community why each measure was identified as a solid investment. Energy efficiency is a logical first step before investments in renewable energy and fuel are made.

3. Relevant Policies

On June 25, 2009, Governor Lingle signed Act 155 into law, which requires every existing public building that is over 5,000 square feet and/or uses more than 8,000 kWh of electricity/year will be benchmarked by the end of calendar year 2010, then retro-commissioned at least once every five years thereafter. Information acquired during benchmarking will influence investments in retrofits and renovations to improve the efficiency of the public building stock, and will often lead to departments entering into ESPCs to cover the capital costs of energy-efficiency measures and distributed generation.[5] This source of data should help the County determine its energy efficiency investment strategies.

Energy efficiency retrofits of existing buildings would be appropriately incorporated into the "County or local" amendments in adopting the appropriate "national" Building Code, Plumbing Code, and Electrical Codes into Chapters 12, 13, and 14 of the Kaua`i County Code. Chapters 12, 13, and 14 are administered by the Department of Public Works' Building Division. The County typically amends these chapters of KCC every 2 – 4 years dependent on updates of national codes. The County is currently processing amendments to these chapters to comply with recent adoption of State HRS amendments for energy efficiency standards.

Mechanical Air distribution & supply (HVAC) is regulated and administered by the State Department of Health (DOH) under DOH Rules.

4. Implementation

The following table lays out recommended actions, costs, responsible parties, and timeline to implement the recommendation.

Implementation of Recommendation 6.1: To Decrease Electricity Demand, Divert 7.5% of KIUC Franchise Tax to Enable County to Lead Energy Efficiency Initiatives

Recommended Action	Responsible Parties	Costs
6.1: Divert 7.5% of KIUC Franchise Tax to allow County to Lead Energy Efficiency Efforts	County to fund Energy Manager, and Facilities Specialist in OED by temporary diversion of KIUC Franchise Tax. County to work with HI State Legislature to permanently raise KIUC Franchise Tax.	$255,000/year

[5] Renewable Energy; Energy Efficiency, House Bill 1464 (2009). http://www.capitol.hawaii.gov/session2009/bills/HB1464_CD1_.pdf.

6.2: Permanently Raise KIUC Franchise Tax to Mandate *Open Source Project Development Process* for Large-Scale Renewable Energy	• County to fund Renewable Energy Project Facilitator in OED • County to conduct Environmental Impact Assessments • *Sustainable Energy Team* to conduct community outreach.	• $150,000/year • $150,000/year • $300,000/year
6.3: Property Assessed Clean Energy Bonds for Distributed Energy	County to fund PACE Bonds Manager in Real Property office.	$122,500/year
TOTAL COSTS		$977,500/year

5. Funding Source

To pay for the County's increased capacity, Kaua`i could dedicate an energy-related 2.5% Franchise Tax that KIUC pays to the County for the right to operate within the County. Section 14 of Act 165, H.B. 1010, first approved in 1928, amended in 1961 as Act 134, reads:

> "**Section 14. Annual statement, payment to government**. The corporation [Kaua`i Energy, at that time] shall, within one month after the expiration of each calendar year, file with the treasurer of the county of Kaua`i, a detailed statement showing all of its receipts and expenditures during the preceding calendar year, and shall, at that time, pay to the treasurer of the said county of Kaua`i, for and on behalf of said county, two and one-half per centum of the gross receipts of the corporation from all electric current or power furnished to consumers on the island of Kaua`i during the preceding year; and all it books, papers, records and accounts shall at all reasonable times be open to inspection by the treasurer of said county, and his respective agents appointed for such purposes."

Since it is an energy-related tax, it could be considered logical to dedicate a small portion of the Franchise Tax to energy-related actions that would save energy and money, as well as increase sustainable energy. A temporary 7.5% diversion of the KIUC Franchise Tax would raise approximately $255,000/year—enough to hire for two County employees—for two years until the KIUC Franchise Tax could be raised permanently through interaction with the Hawai`i State Legislature.

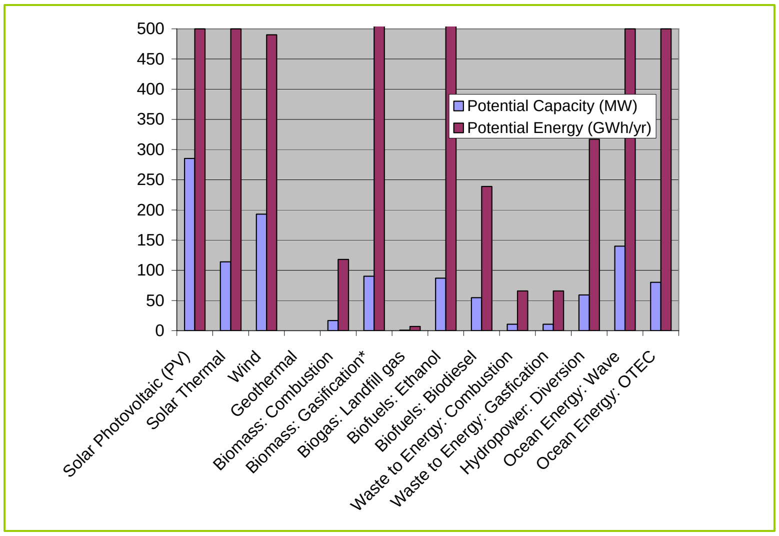
Within two years, the County should have worked with the Hawai`i State Legislature to permanently raise the KIUC Franchise Tax by 30%.

RECOMMENDATION 6.2: To Increase Large-Scale Renewable Energy, Increase KIUC Franchise Tax by 30% to Facilitate *Open Source Project Development Process*

1. Rationale

The base case of local, renewable energy use in 2007 was 5.8%, so Kaua`i needs to close a gap of 94.2% if it is to reach its 100% sustainable energy goals for the electricity sector by 2030. KIUC purchases its renewable energy (mainly hydro, biomass, and PV) from independent power producers (IPPs). These IPPs are entities that own facilities that generate electric power for sale to utilities and end-users. IPPs may be privately-held facilities, cooperatives such as rural solar or wind energy producers, or non-energy industrial entities capable of feeding excess energy into the system.

Figure 6-2: Theoretical Renewable Energy Resources on Kaua`i



A handful of respected studies have shown that Kaua`i has, in theory, the potential to greatly increase its renewable energy generation. In March of 2005, Black & Veatch completed a "Renewable Energy Technology Assessments" report for KIUC. The report assessed 26 renewable and advanced energy technologies, in the following categories: solid biomass, biogas, biofuels, waste to energy, hydroelectric, ocean energy, solar, wind, geothermal and multi-fuel generation technologies (engines, turbines, and fuel cells). [6] The theoretical potentials of renewable energy resources are shown in Figure 6-2, which illustrates that ***photovoltaics, solar thermal, biomass gasification, ethanol, wave and OTEC resources EACH have potential of over 500 GWh/yr, which would meet Kaua`i's 2007 energy requirement of 489 GWh/year***. [7] It should be noted that these potentials are "theoretical" in that they don't include any technical, economic, land-use, environmental or other limitations on the resource.

Many potential renewable energy projects have been identified that have been met with a variety of barriers including:

- Community resistance or environmental litigation that made projects uneconomic,
- A lack of willingness for landowners to commit their land due to competing uses that could yield higher returns,
- Insufficient return on investment for energy projects,
- Time-consuming and expensive project permitting,
- Confusing land use zoning,
- Little understanding of what types of renewable energy projects were deemed desirable by KIUC,
- Lack of transparency in negotiations between KIUC and developers,

[6] Black & Veatch (March 2005). *KIUC Renewable Energy Technology Assessments*. Retrieved on 8/3/10 from http://www.kiuc.coop/pdf/KIUC%20RE%20Final%20Report%201%20-%20Executive%20Summary.pdf.
[7] Ibid.

- Lack of understanding by developers of what data is needed by KIUC to efficiently evaluate proposed projects.

In 2010, the SENTECH Hawai`i Team heard the following concerns about draft recommendations from the community:

- Feed-in Tariffs are too general and don't take into account site specificity, e.g. if the sun was more plentiful on the western side of the Island, compared to the eastern side of the Island.
- Hydropower target is too high.
- Siting and capacity information on CSP is missing.

Furthermore, in April 2010, a couple of renewable energy and biofuels projects ran into financing trouble.

To address these barriers and community feedback, and to make renewable energy projects more viable from 2010-2030, the SENTECH Hawai`i Team strongly recommends an ***Open Source Project Development Process*** which would include the following elements:

- Early community engagement
  - The community would be engaged by the Sustainable Energy Team to encourage early buy-in, identify barriers, and assess overall opportunity to reduce risk to developers.
- Environmental assessments
  - Could rule out risky projects.
- Developer's project data checklist
  - KIUC would develop and post on their website a Developer's Data Checklist that details data points that any renewable energy project development group would need to bring to KIUC in order to enter into negotiations. Data points may include capacity, total annual energy, secured land, secured financing, point of grid interconnect, etc.
- KIUC grid data share
  - KIUC would develop and post on their website data on their grid infrastructure, single line drawings, substations, additional capacity needs, and KESP renewable energy targets.
- Standardized project technical/economic feasibility study specifications
  - KIUC assesses the feasibility of hundreds of renewable energy projects, with varying feasibility study specifications; a standardized form, developed by KIUC and posted on their website, would greatly expedite its project review process.
- Sustainable Electricity Capacity Targets and Price Targets
  - KIUC will agree on capacity targets that will meet KESP sustainability targets.
  - KIUC will make available on their website projected non-generation + generation rate targets (with reasonable return) as a starting point for Power Purchase Agreement (PPA) negotiations.
- Open-book Power Purchase Agreement Negotiations
  - PPA negotiation parties will open their financial books to expedite negotiations and reduce risks/costs to all parties.
- Streamlined project permitting
  - Streamlined permitting processes being recommended by DBEDT, with technical assistance from SENTECH Hawai`i, will allow developers to know exactly how to navigate through complex permitting processes on Federal, State, and County levels.
  - Kaua`i County, with additional capacity, will be able to react to an increasing permitting work load brought about by an accelerated pace of renewable energy project development.
  - Renewable energy projects that are deemed bankable by KIUC and that advance the County's KESP renewable energy targets will get preferential treatment at all County permitting, siting, building and construction agencies.

Following up on specific data from the above list, recommended *Sustainable Electricity Capacity Targets* include:

Resource / Technology	Capacity (MW)	Electricity (GWh/yr)	Capacity Factor (%)	Initial Install Year	SENTECH LCOE ($/kWh)	KIUC LCOE ($/kWh)	Assumed LCOE
Concentrating Solar Power (with storage)	50	140.3	32%	2011	0.143	0.125	0.125
Photovoltaics Farms (with storage)	15	26.3	20%	2010	0.182	0.138	0.138
Hydropower	22	100.3	52%	2013	0.087	0.110	0.110
Biomass/Biodiesel	45	339.2	86%	2012	0.072	0.167	0.167
Landfill Gas/Engine	1.6	12.5	89%	2011		0.116	0.116
TOTALS	**133.6**	**618.6**					

Recommended *Sustainable Electricity Price Targets* that the Team developed using national averages, regionalized factors, and discussions with KIUC and developers include:

Resource / Technology	CSP with storage	PV Farms with storage	Hydropower	Biomass / Biodiesel	Landfill Gas / Engine
Generating Costs	$0.125/kWh	$0.138/kWh	$0.110/kWh	$0.167/kWh	$0.116/kWh

Firming up Renewable Energy

The power grid on Kaua`i is small and not connected to other larger grids, which is common practice in Europe and the Mainland US. This fact translates into the need for KIUC to have large reserve generation capacity and redundancy. If a generator fails on one of the systems, it must be backed up by an available high amount of reserves on the island. Generally, the minimum load service criteria is to have enough reserve for the largest unit to be on maintenance and for the next largest unit to have an unscheduled outage, and still be able to meet peak demand. In addition, as documented in the aftermath of the recent earthquake occurring off the Big Island, power generation is vulnerable to events like earthquakes, hurricanes, etc.[8]

Since renewable energy is not "dispatchable" or "firm," it represents an additional technical challenge to KIUC. Firm power can perhaps best be described as predictable and guaranteed to be available to be delivered over the power grid to meet customers' energy demands when needed. The more dispatchable or firm energy is, the higher its value. Diesel-driven power plants are highly dispatchable, but renewable energy is generally not since no one can guarantee that the sun will shine or rivers flow. To make renewable energy more firm, several approaches can be taken:

- Renewables, paired with energy storage.
- Variable renewables (e.g. solar) firmed up by dispatchable renewables (e.g. biomass, hydro or pumped hydro) or fossil fuel.
- Variable renewables, paired with energy storage for short-term supply, backed up by dispatchable renewables and/or liquid fuel.
- Matching load and generation profiles.

[8] Guidry, M.W. & Mackenzie, F.T. (October 27, 2006). *Energy Sustainability in the Pacific Basin: Emphasis on the State of Hawaii and the Island of Oahu.* Retrieved on 8/5/10 from http://www.soest.hawaii.edu/UHMEnergy/Energy%20Case%20Study%20Exec%20Summary.pdf.

- Loads can be adjusted to match the varying supply of renewable energy with "demand response" programs.

KIUC would need to be assured of energy reliability and safety on the power grid with sufficient planning and resources committed to energy storage, dispatchable biomass or biofuels, and matching of load and generation profiles. Fossil or renewable fuels will undoubtedly be needed to guarantee total dispatchability.

In discussions between KIUC and the SENTECH Hawai`i Team, a mutual decision was made not to pursue demand response due to the nature of KIUC's generation stock which can be turned on and off to essentially match loads. In Europe, loads can be shed in response to diminished renewable energy capacity. As renewable energy increases in its total capacity to be integrated onto the KIUC grid, the utility will reassess demand response according to KIUC officials.

Facilitating the Process on the County Side

To facilitate the County's role in facilitating the *Open Source Project Development Process*, the County would need to:

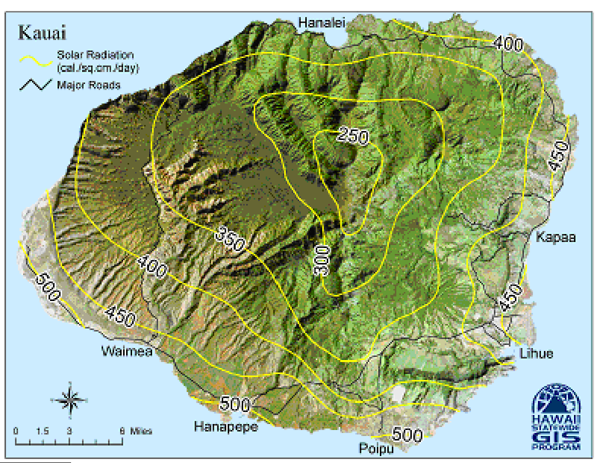
- Enable the *Sustainable Energy Team* to conduct **community outreach**, including assessing which projects the community would resist or accept.
- Create and fund a ***Renewable Energy Facilitator*** position in the Office of Economic Development, modeled after DBEDT's position which focuses on helping developers navigate the permitting process, provide general guidance on financing, etc.
- Have the ability to conduct high-priority ***Environmental Impact Assessments*** in order to increasingly assist the developer**.**

A few notes on resources and technologies follow.

Concentrating Solar Power (CSP) and Photovoltaics (PV)

- Latest maps from DBEDT show maximum solar radiation in western arid region of island (see Figure 6-3).[9]

Figure 6-3: Solar Radiation Map of Kaua`i



[9] DBEDT (n.d.). *Kauai Solar Radiation Map*. Retrieved on 8/5/10 from http://hawaii.gov/dbedt/info/energy/publications/solardata/kauai_solar_map.pdf.

- In response to questions about land use requirements for CSP, a conservative estimate is 8-10 acres/MW (with 3-4 hours of storage)[10], meaning 400-500 acres are needed for 50 MW as recommended for Kaua`i. Figure 6-4 shows a thousand CSP solar collectors covering 3.8 acres and generating approximately 2 MW of thermal energy on the Big Island.[11]
    - State Agriculture Lands are underutilized, and are zoned for CSP—but leases may prevent siting. Land use and zoning are key needs that can be addressed by the County, KIUC, and the Sustainable Energy Team proposed in Section 9. These groups will need to engage DLNR, DHHL, Land Use Commission, etc.

Figure 6-4: CSP

- The KESP final recommendations include 50 MW of CSP with thermal storage. A very similar installation exists in Spain—called Andasol 1—pictured in Figure 6-5.[12]
    - It cost $380 million to build.
    - Total area needed is 126 acres (far less than the 400-500 acres needed as a rule of thumb noted above—primarily due to Spain's high insolation rates).
    - The electricity supplied is ideal for meeting the demand during the afternoon when the power demand reaches its peak.
    - A molten salt thermal energy storage system provides 7.5 hours of storage.
    - The developer is *Grupo ACS (Actividades de Construcción y Servicios, S.A.)*, a Spanish company dedicated to civil and engineering construction.

Figure 6-5: Andasol 1

- Developers need distribution capacity and access to the grid.
- Although the 10-MW CSP plant proposed for Kaua`i has met some economic troubles, CSP should not be abandoned. It can be built in a range of sizes, from a few MW up to several hundred MW. It can be configured with varying levels of storage to suit local weather conditions and to meet the requirements of the local grid operator – concentrating solar power's optional heat storage means power can be generated when the sun is not shining. And it can be used in co-firing arrangements where the 'back-end' steam turbines and electrical generation/transmission components are powered by burning gas.
- Dispatchability enabled by energy storage will become a larger and larger factor as more renewable energy is integrated onto the KIUC grid. Although photovoltaics (PV) have come down in price over the period of 2008-2010, PV's energy storage system will become less and less feasible as more renewable energy comes online. Converting electrical energy into potential energy or chemical energy in this way, then back again, is inefficient.
- Robert Palgrave reviewed CSP technology developments in late 2008 to conclude the following merits and attributes of CSP:[13]

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[10] National Renewable Energy Laboratory Website (2009). *Concentrating Solar Power: TroughNet*. Retrieved on 8/5/10 from http://www.nrel.gov/csp/troughnet/faqs.html#land.

[11] Alter, Lloyd (December 23, 2009). *The "Holy Grail for Renewable Energy": Solar Power Makes Electricity Day and Night.* Retrieved on 8/5/10 from http://www.treehugger.com/files/2009/12/the-holy-grail-for-renewable-energy.php.

[12] Wikipedia (2009). *Andasol Solar Power Station.* Retrieved on 8/5/10 from http://en.wikipedia.org/wiki/Andasol_Solar_Power_Station.

- CSP offers a more efficient storage mechanism – the high-grade heat captured by its solar collectors can be processed immediately into electrical power, or it can be stored as heat and converted at a later time. With current technology, storage of heat is much cheaper and more efficient than storage of electricity. Reliability can further be improved by installing a back-up system that uses fossil energy.
- Thermal storage has been one of CSP's differentiators, offering the utility "power shifting" and dispatchability to help balance their systems. It also allows parabolic trough projects to achieve capacity factors greater than 50%.
  - The most well known variant is the indirect thermal energy storage technique – it uses molten potassium and sodium nitrate salt in a two-tank system. Salt from the cold tank is heated by the heat transfer fluid (oil) coming out of the solar collector field, and is then transferred to the hot tank. To recover the stored energy to create steam for the turbine, salt is pumped from the hot tank to the cold tank to reheat the oil. It's referred to as an indirect system because the fluid used as the storage medium is different from that circulated in the solar field. The Andasol 1 parabolic trough plant will use this technique to run its 50 MW steam turbine for up to 7.5 hours after dark. Tanks will store the 28,500 tons of molten salt.
  - Power towers currently have the advantage that it's possible to use the molten salt itself as the heat transfer fluid. Heating the salt directly instead of using oil as an intermediate carrier gives higher efficiency because the salts can be safely heated well beyond the 400°C limit of synthetic heat transfer oils.
  - But for trough plants, some believe that a single-tank thermocline-type energy storage system could turn out to be the most cost effective option. In thermocline systems the hot storage fluid is held at the top of a tank with the cold fluid on the bottom. The zone between the hot and cold fluids is called the thermocline. This type of storage system has an additional advantage – much of the storage fluid can be replaced with a low-cost filler material.
  - Other non-salt storage techniques have been developed. The PS10 power tower near Seville in Spain has relatively small-scale and technically straightforward storage to keep the plant operational during cloudy periods. Its saturated water thermal storage system has a thermal capacity of 20 MWh and comprises four tanks that are sequentially operated in relation to their charge status. During full load operation of the plant, some of the steam produced by the saturated steam receiver at the top of the tower is used to load the thermal storage system. When energy is needed to cover a transient period, energy from saturated water is recovered at 20 bar to run the turbine at a 50% partial load.
  - A very different design has emerged from down under. Cloncurry in Queensland, Australia is to get a 10 MW concentrating solar power tower plant in early 2010, which will use graphite blocks at the focal point of the solar field. Steam is produced by running water through pipes embedded in the 540 tons of graphite. This steam (at very high temperatures) is then used to drive the turbine. The heat stored in the graphite will run the turbine at full capacity for 8 hours.
- Storage gives concentrating solar power plants the power to produce electricity when sunshine is not available. Co-firing or hybridization with gas or other fuels also allows the power plant side of the concentrating solar power site to be productive up to 24 hours a day.

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[13] Palgrave, Robert (December 1, 2008). *Innovation in Concentrating Thermal Solar Power.* Retrieved on 8/5/10 from http://www.renewableenergyfocus.com/view/3272/innovation-in-concentrating-thermal-solar-power-csp/.

  - The World Bank has suggested that investors and decision-makers will see hybrid solar-gas plants as being less risky than an all-solar plant, and therefore more likely to attract investment. In theory, as confidence in solar grows, more solar collectors could be added to existing hybrid plants.
  - In the solar field itself, developments are targeting the optical performance of mirrors, their longevity, the support structures, the durability of the heat collection elements used in trough systems, and the electrical/electronic systems used to direct heliostats.
    - Instead of steel for framing its solar troughs, the Solargenix collector is made from extruded aluminum. The lower weight collector has a unique organic hubbing structure, initially developed for buildings and bridges. Manufacturing is simplified and no field alignment is needed.
    - SkyFuel's SkyTroughs are made from mylar-like ReflecTech film which can bring down the cost of a solar system by 25% with this material.
    - eSolar makes prefabricated modular solar-thermal power plants (typically 33 MW) and locates them near towns and cities. Multiple modules could be configured together on one site to increase capacity. Their design uses direct steam generation with relatively short towers, to keep down the cost. Heliostats are small and low to the ground, reducing their wind profile and the company believes high volume manufacturing and reduced installation effort will drive costs further down.
    - Ausra is another leader in design optimization for cost. Its Linear Fresnel designs use lower cost mirrors than troughs, and avoid the need for the expensive heliostats inherent in a power tower design.
- Google, the Internet search engine company, has been investing in companies and doing research of its own to produce affordable renewable energy since 2007, and wants to cut the cost of making heliostats, the fields of mirrors that track the sun for CSP.
  - Google claims its new technology will drop the cost of electricity from 18¢/kWh to just under ***5¢/kWh***.[14]

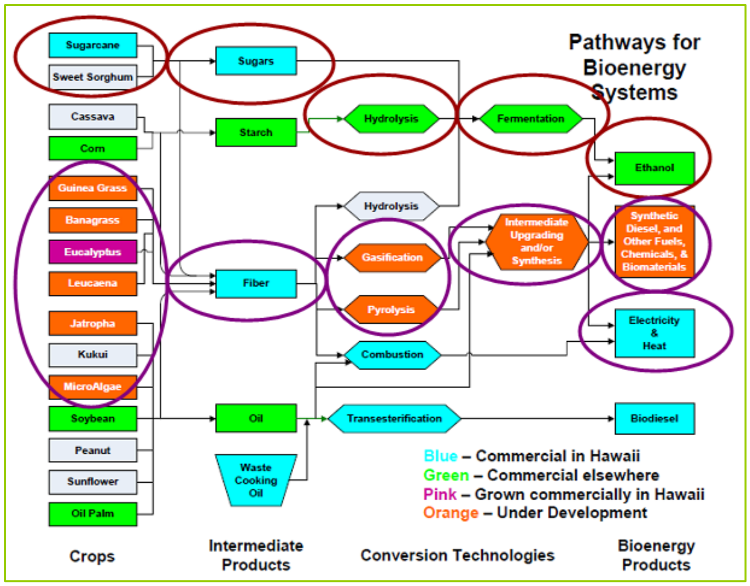
Hydropower

- Earlier recommendations included 45 MW of hydropower capacity due to high theoretical potential indicated in the Black and Veatch report. Yet, endangered aquatic species regulations will slow scale and pace of hydropower on Kaua`i, so the SENTECH Hawai`i Team reduced hydro capacity target from 45 to 22 MW after talking further with KIUC and developers.

Biomass/Biodiesel

[14] Alternative Energy (March 8, 2010). *Google Plans New Solar Mirror Technology*. Retrieved on 8/5/10 from http://www.alternative-energy-news.info/google-solar-mirror/.

Figure 6-6: Bioenergy Pathways



- Figure 6-6, from the *Hawai`i Bioenergy Master Plan* (circled regions done by the SENTECH Hawai`i Team), shows a diverse and perhaps confusing array of bioenergy pathways. [15]
- The biomass-to-ethanol pathway (red circles in Figure 6-6) should be based on sugar cane and sweet sorghum feedstock for Kaua`i—as the proposed Pac West project will do—due to proven feedstock, competitive yields, and a well understood <u>sugars/hydrolysis/fermentation</u> conversion pathway.
- Several different Biomass-to-Liquids technologies are currently either under development or being implemented for other outputs such as synthetic diesel, or biodiesel. They differ as to the way the biomass is treated and gasified and in the synthesis process. After mechanical preparation, the biomass is either treated thermally or subjected to direct gasification. The synthetic gas extracted in entrained-flow gasification or fluidized bed gasification is purified, conditioned and finally synthesized to fuel. The best-known methods for this are the Fischer-Tropsch process, which is already under use throughout the world in coal-to-liquid and gas-to-liquid plants, and processes which produce methanol at an intermediate stage.
- The SENTECH Hawai`i Team recommends that Kaua`i choose Biomass-to-Liquids gasification conversion pathway (shown in Figure 6-6 as purple circles indicating a variety of biomass <u>crops/fiber/gasification</u> pathway) for several reasons:
  - Gasification converts any carbon-containing material into a synthesis gas ("syngas") that can be used as a feedstock to make value-added biofuels and biochemicals, as a fuel for combined cycle power generation, or as a replacement for fossil fuels. This variety of inputs will allow developers to utilize many crops, including bagasse, trees, and even algae remnants if an algae-to-fuels industry is commercialized on the island.
  - Due to Kaua`i's small energy economy, it is important to maintain any economies of scale from one conversion pathway, rather than two or more pathways.
  - Oil crops do not appear to be economically feasible at this time, for a variety of reasons. Palm oils, for example, have high yields/acre, yet require significant amounts of low-paying manual labor to make them cost-effective—and there is little low-paying labor force on Kaua`i. Jatropha can grow on marginal lands and avoid the food/fuel debate perhaps, but yields from this plant will not allow large-scale production at any economy of scale.

Emerging yet commercial Biomass-to-Liquid gasification technologies from companies such as ThermoChem Recovery International, Inc. (TRI) will turn a variety of crops and even Municipal Solid Waste (MSW) into biodiesel—or ethanol or power—depending on what pencils out the best at any particular time period. Features of the TRI gasification system, available on O`ahu, include:

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[15] Hawaii Natural Energy Institute (2009). *Hawaii Bioenergy Master Plan Project*. Retrieved on 7/20/10 from http://www.hnei.hawaii.edu/bmpp/stakeholders.asp.

- Feedstock flexibility including wood waste, agricultural wastes, energy crops, refuse derived fuels (RDF), and MSW.
- A system that is fully scalable from 500 dry tons per day of biomass (dtpd) to 2000 dtpd of biomass with a single steam reforming reaction vessel.
- A high quality synthesis gas (H2 and CO) output that can be customized to meet the feedstock needs of the downstream gas to liquids (GTL) or combined cycle (CC) process.[16]

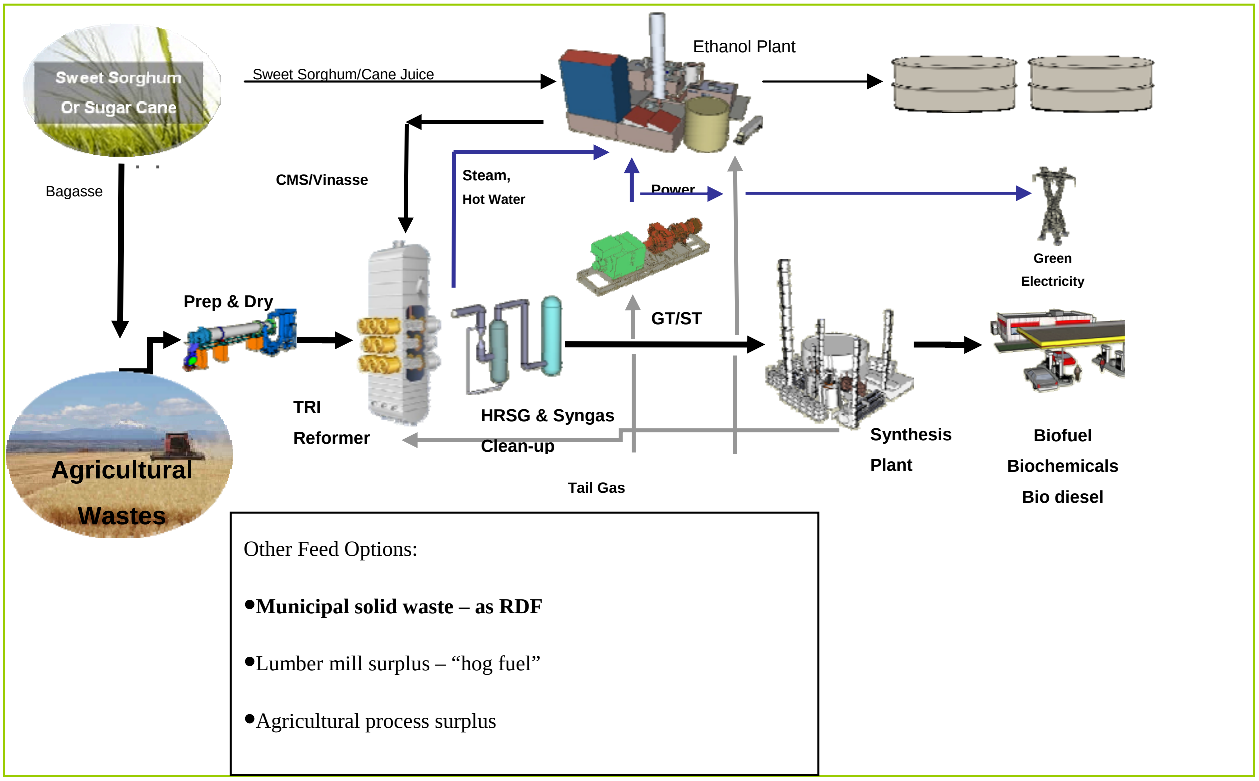
The biomass or MSW feedstock reacts in the gasifier with steam and oxygen in a reducing (oxygen-starved) atmosphere to produce syngas made up primarily of hydrogen, carbon monoxide, carbon dioxide and smaller quantities of methane and other hydrocarbons. The hot combustion gases leaving the pulsed heaters can be sent to a heat recovery steam generator (HRSG) to generate steam. The hot syngas from the reformer is passed through cyclones to remove particulate matter, cooled in a second HRSG, and then quenched and scrubbed.[17]

TRI gasification technology provides wide biomass feedstock flexibility coming in, with a broad range of potential end products going out—including ethanol, biodiesel, and/or energy. By producing multiple products, a biorefinery can take advantage of the differences in biomass components and intermediates and maximize the value derived from the biomass feedstock. With the appropriate design and technologies in place, biorefineries can produce a wide array of renewable biofuels, green energy and electricity and high-value chemicals, all on a carbon neutral basis, which is an environmental improvement over the burning of fossil fuels.

The SENTECH Hawai`i Team believes that the algae-to-liquid fuels pathway will become more economically feasible in the not-too-distant future and could supply enough biodiesel to provide for the Island’s ground transportation and electricity generation needs.

[16] ThermoChem Recovery International, Inc. Website (2009). Retrieved on 8/5/10 from http://www.tri-inc.net/index.html.
[17] Ibid.

Figure 6-7: Ethanol and Biofuel Pathways



Landfill Gas/Engine

Landfill gas typically contains contaminants such as siloxanes from soap and shampoo. The SENTECH Hawai`i Team believes these contaminants should be "scrubbed" with the latest remediation technology.

Further, the Team believes the scrubbed gas should be ignited in an advanced gas engine that has been engineered for landfill gas. GE, Waukesha, and Cummins make such engines. The Waukesha engine is ideal for landfills because:[18]

- The engines can operate well on filtered methane gas, normally a low energy-content fuel.
- Lean-burn models are available that feature a low draw-through fuel design - for operation on low gas-delivery pressure.
- The engines are available in pre-packaged engine/generator combinations from 75 - 3250 kW.
- Waukesha Engines are clean-burning - making them easily permitted in most areas.

If thermal energy (heat) can be recovered from the engine's jacket and exhaust for a useful purpose, e.g. in a Combined Heat and Power (CHP) system that provides hot water to an industrial process or to drive an absorption chiller, that CHP configuration would be preferred due to its higher efficiency.

[18] Kraft Power Website (2009). *Generator Sets, Waukesha.* Retrieved on 8/5/10 from http://www.kraftpower.com/waukesha/waukesha_generators.html.

OTEC

Ocean Thermal Energy Conversion (OTEC) is a renewable energy technology which holds promising potential to supply Kauai with a cost-competitive, sustainable base-load energy source in the not-too-distant future. Utilizing seemingly limitless ocean waters right off Kaua`i's coastline, OTEC can provide a stable energy economy for the island and remove future concerns over the price volatility of imported oil.

One of the predominant challenges to KIUC is to find a renewable energy source which can successfully and reliably integrate into the local utility grid while providing a substantial portion of the island's energy requirements. This is a difficult problem on Kaua`i and other small, tropical island grids as they try to meet the growing community demand for more responsible energy choices. In addition to grid loading issues, the smaller grid and customer base pays a premium for this intermittent energy because the utility must now own and maintain non-revenue generating reserve power generators for times when the renewable resource is unavailable. OTEC can provide a firm base load, capable of operating 24/7 while providing stable power which should reduce the need for back-up generation.

OTEC may play a significant role in charging electric or plug-in hybrid electric vehicles if Kaua`i takes this KESP recommendation to heart.

Wind

Wind will not be part of the Sustainable Electricity Targets, as discussed in Section 8, since there are strict Federal ESA regulations protecting Newell Shearwater and other endangered species. There is significant community opposition to visual impacts of wind turbines, and the best potential sites are usually in remote areas that would be expensive to develop and to build the necessary transmission infrastructure. *(See Section 8 for more details.)*

2. Impact

100% sustainable energy on Kaua`i, enabled by the recommended Open Source Project Development Process, can be achieved in the electricity sector by 2030. Based on estimates for the total cost to install, maintain, and operate the proposed mix of renewable energy systems, SENTECH Hawai'i projects that a total of ***$1.5 billion*** of private capital will be needed over 20 years. If KIUC wants to own some or all of particular projects, it could perhaps be funded by low-interest loans from the Rural Utilities Service.

Impact on the everyday ratepayer can be calculated in this case by adding **average costs of generation** (equivalent to the Levelized Cost of Energy or LCOE) including a **guaranteed return on investment** to mitigate risk to investors + **non-generation costs** (or energy distribution and management costs to the utility) as seen in Figure 6-8.

Figure 6-8: Electric Rates for Various Renewable Energy Technologies

Resource / Technology	LCOE / Generating Costs ($/kWh)	+ 15 % Return on Investment ($/kWh)	+ Non-Generating Costs ($/kWh)	Full Electricity Rate Charged to Consumer ($/kWh)
Concentrating Solar Power (solar thermal energy, with thermal storage)	$0.125	$0.144	$0.150	**$0.294**
Photovoltaic Farms (solar electric energy, with battery storage)	$0.138	$0.159	$0.150	**$0.309**
Hydropower	$0.110	$0.127	$0.150	**$0.277**
Biomass/Biodiesel	$0.167	$0.192	$0.150	**$0.342**
Landfill Gas (ignited in diesel engine or CHP system)	$0.116	$0.133	$0.150	**$0.283**
Weighted Average	*$0.144*	*$0.166*	*$0.150*	***$0.316***

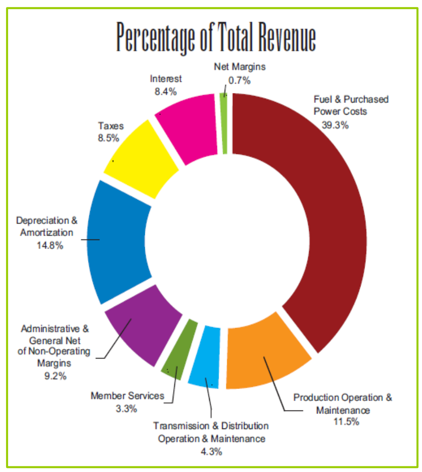
The generating costs align with *Sustainable Electricity Price Targets* that the Team developed using national averages, regionalized factors, and discussions with KIUC and developers. The following factors influence generating costs and therefore should be taken into account as part of a Levelized Cost of Energy (LCOE) calculation that accounts for full life-cycle costing over 20 years:

- Capital expenses for the actual generating technologies and systems
- Other costs related to the project, such as expenses for grid interconnect, and licensing procedures
- Operation and maintenance (O&M) and other annual recurring costs
- Fuel costs (in the case of biomass, biofuels, and landfill gas)
- Inflation
- Interest and principal payments for the invested capital
- In the United States, federal tax credits, capital subsidies, and other supports where applicable, must be carefully accounted for.

A reasonable return on investment for one land owner or developer may not be for another, but lessons learned from Europe indicate that a 15% IRR has achieved considerable success without exorbitant costs being passed on to ratepayers.[19]

Figure 6-9, from a recent KIUC *Currents* magazine, shows that at one point in time when rates were around 30¢/kWh, the non-generating portion of the rates was around 50%, or 15¢/kWh—so the SENTECH Hawai`i Team used this number for an average of non-generating costs.

Figure 6-9: Percentage of KIUC Total Revenue



[19] Dr. Thomas Ackermann (one of Europe's leading renewable energy integration consultants). Personal Communication with: Doug Hinrichs (SENTECH Hawai`i Team). July 2009.

The DOE has projected that the price of oil will steadily increase through to 2035, as shown in Figure 6-10.[20] If, for the sake of comparing the cost of electricity from imported oil vs. electricity from renewable resources, we cut DOE's crude oil commodity annual price increase to 2% just to be conservative, and Kaua`i hedged its energy bet with renewable energy at 32¢/kWh (with both prices including 1% inflation) the chart in Figure 6-11 shows that ***renewable energy would be the better bet around year 11.***

Figure 6-10: DOE Energy Prices: Historical and Projected

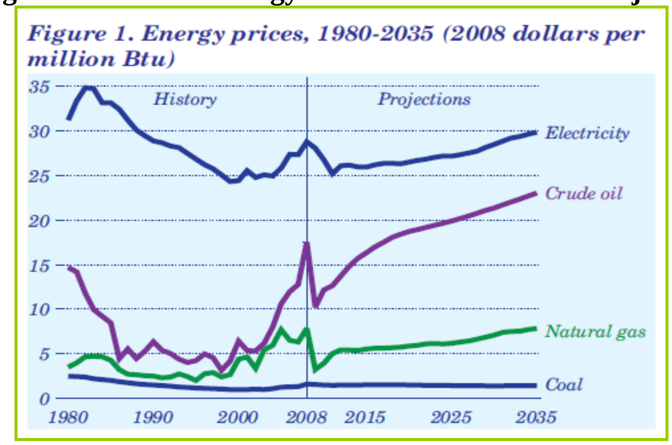
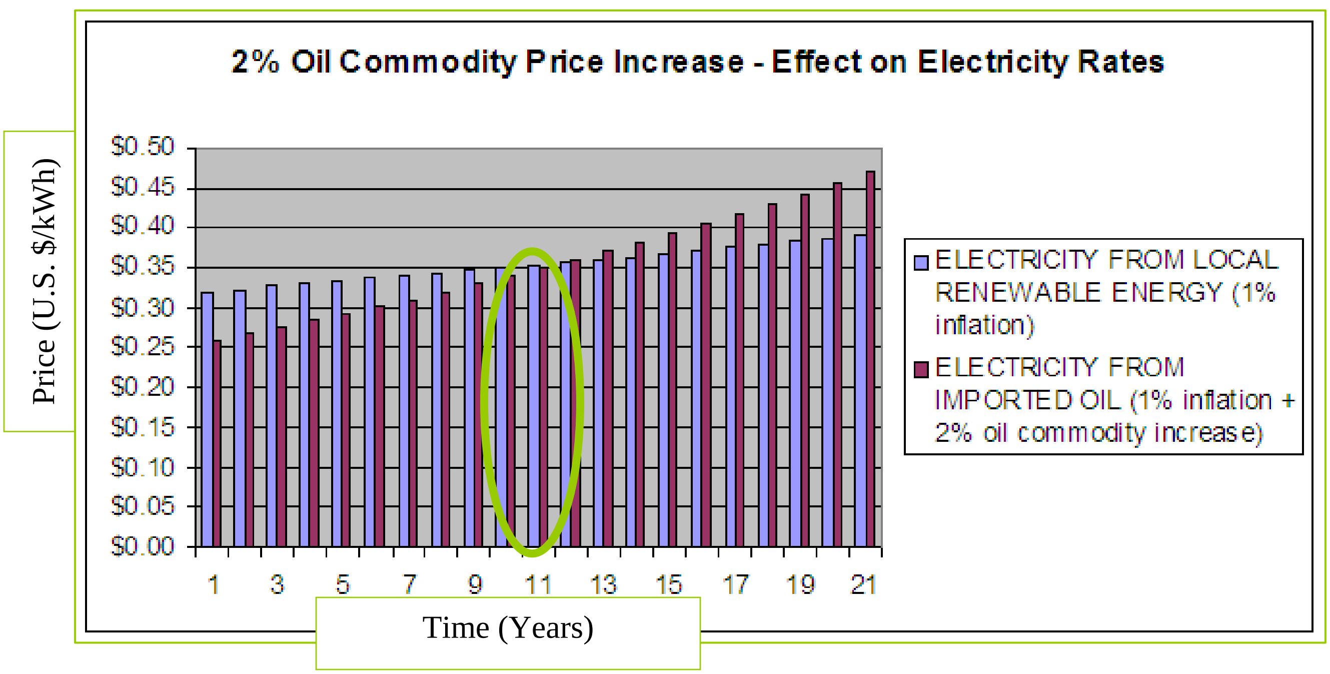


Figure 6-11: Electricity Price Projections for Renewables and Imported Oil Over Time (With a 2% Oil Commodity Price Increase)



If we stuck to DOE's crude oil commodity annual price increase of 3.5%, the chart in Figure 6-12 shows that ***renewable energy would be the better bet around year 7.*** Note that in this scenario, Kaua`i would be paying over ***60¢/kWh*** for imported oil by year 2030.

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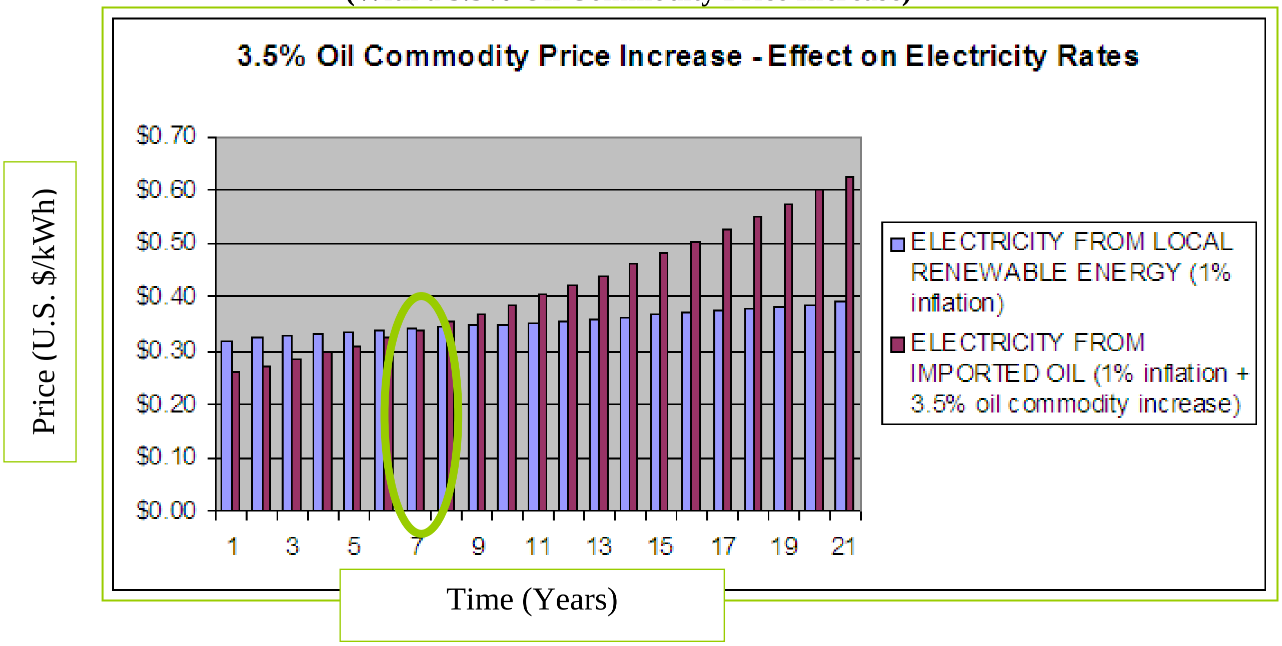
[20] Department of Energy, U.S. Energy Information Administration (March 2008). *Annual Energy Outlook 2008 (Early Release)*. Retrieved on 8/5/10 from http://www.eia.doe.gov/oiaf/aeo/prices.html.

Figure 6-12: Electricity Price Projections for Renewables and Imported Oil Over Time (With a 3.5% Oil Commodity Price Increase)



3. Relevant Policies

Hawai`i's Renewable Portfolio Standard (RPS) mandates cost-effective renewable energy development with goals of 10% renewable net electricity sales by 2010, 15% by 2015, and 20% by 2020.

Hawai`i's Greenhouse Gas (GHG) legislation requires a reduction in GHG emissions to 1990 levels by 2020, which led KIUC to drive toward a 50% clean energy goal.

The Hawai`i Clean Energy Initiative has set a 30% energy efficiency goal, and a 40% clean energy goal.

4. Implementation

The following table lays out recommended actions, costs, responsible parties, and timeline to implement the recommendation.

Implementation of Recommendation 6.2: To Increase Large-Scale Renewable Energy, Increase KIUC Franchise Tax by 30% to Facilitate Open Source Project Development Process

Recommended Action	Costs	Responsible Parties	Timeline
Work with the Hawai`i State Legislature and Hawai`i Public Utilities Commission to permanently raise the KIUC Franchise Tax paid to the County by 30% to solidify funding needed to help the community achieve its renewable energy goals.	NA	• Kaua`i County Council • KIUC • Hawai`i State Legislature • Hawai`i Public Utilities Commission	2010-2012
Enable the Sustainable Energy Team to conduct	$150,000/year	• Kaua`i County Office of	2012-2030

community outreach, including assessing which projects the community would resist or accept.		Economic Development • Sustainable Energy Team	
Create and fund a Renewable Energy Facilitator position in the Office of Economic Development, modeled after DBEDT's position which focuses on helping developers navigate the permitting process, provide general guidance on financing, etc.	$150,000/year	• Kaua`i County Office of Economic Development	2012-2030
Have the ability to conduct 2-3 high-priority Environmental Impact Assessments/year by qualified consultants.	$300,000/year	• Kaua`i County Office of Economic Development • Environmental impact consultants	2012-2030

While full details are not available at this time, the Pacific Missile Range Facility (PMRF) represents a unique opportunity for significant renewable energy development and utilization. PMRF is planning to utilize valid renewable energy concepts (to include hybrids) to meet its current and future electrical load demands as well as comply with federal, state, and Department of Navy mandates and directives. Proven renewable energy generating concepts have higher considerations over non-established systems. Current house load at PMRF is 2MW; and near-term future house load is expected to rise to 6.5MW. It may be possible in the not-so-distant future for power demand to exceed 40-50 MW in support of potential increased mission requirements.

5. Funding Source

To address these concerns and real-world barriers, the Team is now recommending that the KIUC Franchise Tax be increased to fund an ***Open Source Project Development Process*** which would make large-scale renewable energy projects more "bankable" by reducing risk, costs, and time-to-develop factors to investors.

Currently, the KIUC Franchise Tax is paid to the County at a rate of 2.5% of KIUC gross receipts. KIUC expects to have gross annual receipts of $137,268,331 in 2010[21] so the KIUC Franchise Tax owed to the County in 2010 would be $3,431,708. A 30% increase would yield **$1,029,512/year** (in 2010).

[21] Public Utilities Commission of the State of Hawaii (June 30, 2009). *Docket No. 2009-0050.* Retrieved on 8/5/10 from http://www.kiuc.coop/pdf/Application%20%282009_06-30%29%20%28FINAL%29.pdf.

RECOMMENDATION 6.3: Participate in *PACE* Program to Increase Distributed Energy Capacity

1. Rationale

PACE (Property Assessed Clean Energy) financing uses a bond or lien where the proceeds are lent to residential property owners to finance energy retrofits and small renewable energy systems and who then repay their loans over 15-20 years via an annual or semi-annual assessment on their property tax bill. PACE bonds can be issued by municipal financing districts or finance companies and the proceeds can be used to retrofit both commercial and residential properties. This type of financing solves the traditional barrier of home owners needing to come up with a significant sum of money to pay down upfront costs for energy efficiency or renewable energy systems.

Kaua`i currently has ~3.8MW of PV (largest per capita rate in U.S.). Kaua`i could participate in the PACE program to increase PV, solar thermal water hearing, micro-hydro, and even energy efficiency projects. Of note is that some micro-hydro companies are offering their own capital to develop projects.

2. Impact

There are approximately 160 metered PV systems on Kaua`i, of which about 89% are residential and 11% are commercial systems. PACE could increase this capacity.

The State of Hawai`i is interested in legislating a Statewide PACE program that may put additional stress on the County's capacity to administer such a program. To handle the new administrative duties, the County would need to create and fund a PACE Bonds Manager position in the Real Property office.

3. Relevant Policies

The State of Hawai`i is interested in legislating a Statewide PACE program. Hawai`i counties have the ability to launch PACE programs, and would be encouraged to move rapidly if assistance with operating, set-up costs, support for initial loans, and debt reserve is provided through a federal grant. Federal approval would indicate that this type of financing is a priority on the national level and would assist the counties and the State in the marketing of the program. The State is seeking funds for start-up costs for the four Hawai`i counties to implement sustainable PACE programs, following the best practices outlined in the White House document *Policy Framework for PACE Financing programs*.

Total power producing capacity from customer-generators, such as homeowners who use PV, is capped at 1% of KIUC's peak system demand. KIUC became fully subscribed shortly after the Hawai`i Public Utility Commission (PUC) approved the 1% cap. Due to the speed in achieving the 1% cap, a significant number of customer-generators were waitlisted and offered an energy purchase by KIUC under the Schedule Q Modified Tariff ("Schedule Q"). Schedule Q offers the same physical interconnection opportunities as net metering, but imposes a more significant monthly metering charge. Also, instead of selling electricity back to KIUC for a retail rate, Schedule Q customers receive a wholesale rate. As of

November 2008, 203 applications for Schedule Q were received and 17 customers had interconnected to provide a total generation capacity of 152 kW.[22]

4. Implementation

The following table lays out recommended actions, costs, responsible parties, and timeline to implement the recommendation.

Implementation of Recommendation 6.3: Participate in PACE Program to Increase Distributed Energy Capacity

Recommended Action	Costs	Responsible Parties	Timeline
Work with the Hawai`i State Legislature and Hawai`i Public Utilities Commission to permanently raise the KIUC Franchise Tax paid to the County by 30% to solidify funding needed to help the community achieve its renewable energy goals.	NA	• Kaua`i County Council • KIUC • Hawai`i State Legislature • Hawai`i Public Utilities Commission	2010-2012
Create and fund a PACE Bonds Manager position in the Real Property office.	$150,000/year	• Kaua`i County Office of Economic Development • Real Property office	2012-2030

5. Funding Source

The KIUC Franchise Tax is paid to the County at a rate of 2.5% of KIUC gross receipts. KIUC expects to have gross annual receipts of $137,268,331 in 2010[23] so the KIUC Franchise Tax owed to the County in 2010 would be $3,431,708. A 30% increase would yield **$1,029,512/year** (in 2010).

[22] Black & Veatch (November, 2008). *Integrated Resource Plan*. Retrieved on 8/3/10 from http://www.kiuc.coop/IRP/Tariff/IRP2008_2008%20KIUC%20IRP.PDF.
[23] Public Utilities Commission of the State of Hawaii (June 30, 2009). *Docket No. 2009-0050.* Retrieved on 8/5/10 from http://www.kiuc.coop/pdf/Application%20%282009_06-30%29%20%28FINAL%29.pdf.