SECTION 3: GROUND TRANSPORTATION SECTOR ENERGY ANALYSIS

The results of energy analysis in the ground transportation sector performed in conjunction with community engagement are presented in detail below to add data and a greater understanding of the sector on Kaua`i. This understanding adds technical merit to the recommendations that are made in following sections.

A. Current Demand

1. Highways

Kaua`i has a single perimeter road that circles most of the island, the Kuhio and Kaumuali`i Highways. There are a few short bypasses and they provide an alternate route when the corresponding highway is blocked with an accident; however bypasses are few and only relieve local blockages, and they do little to increase through capacity. The Kuhio and Kaumuali`i Highways also dead-end in the north at Ha`ena and in the west near Kekaha.

Because of blockages such as the one described above, traffic congestion has been called "one of the biggest problems facing the garden isle today."[1] Quality of life surveys conducted in 2006 and 2009 showed that Kaua`i residents feel the most important issues that government should address are traffic and congestion.[2] Not only does traffic congestion waste time, reducing regional economic health, it also wastes fuel, increasing air pollution and carbon dioxide emissions. For example, a study from the Texas Transportation Institute showed that on average for small urban areas (population under 250,000) traffic congestion consumes 595,000 gallons of excess fuel and costs $20 million.[3]

The congestion problem is typical of American towns and cities over the last fifty years, where low-density land use patterns[4] and auto-centered transportation infrastructure have dominated. Population growth and automobile dependency bring roads to their limit quickly. Adding more lanes and bypasses at a huge cost usually moves the congestion point to another location and/or encourages more car use that leads to more congestion. One only needs to look to Honolulu to see how effective building more roads has been in reducing congestion.

[1] Ako, Diane (n.d.). *Relief for Kaua`i traffic slow to come.* KHNL. Retrieved on 7/20/10 from http://www.khnl.com/global/story.asp?S=6153106.
[2] Kaua`i Planning & Action Alliance, "Measuring What Matters for Kaua`i - Community Indicators Report 2006" and "Measuring What Matters for Kaua`i - Community Indicators Report 2008," Available at www.kauainetwork.org.
[3] Texas Transportation Institute (2009). *Annual Urban Mobility Report*, Table 2: What Congestion Means to Your Town, 2007 Urban Area Totals. Retrieved on 7/20/10 from http://mobility.tamu.edu/ums/congestion_data/tables/national/table_2.pdf
[4] Namely, single-family suburbs and large-lot subdivisions ("ag subdivisions" on Kaua`i) located far from work places

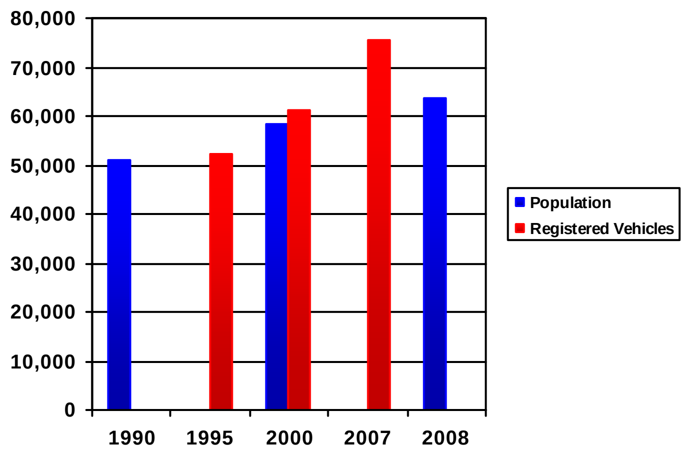
2. Vehicular Traffic

According to the 2008 U. S. Census, there were 63,689 residents on Kaua`i, 75,594 registered motor vehicles on Kaua`i, and 51,504 drivers' licenses in force in 2007.[5] How many vehicles were visitor car rentals is not clear; nor is it clear whether rental cars are even included in the above statistics. Total vehicle miles traveled were 696 million in 2008 and highway fuel consumption was 32 million gallons.[6]

While the lack of relevant land travel data makes transportation analysis and planning difficult, existing indicators suggest a rapidly growing dependence on the automobile on Kaua`i. The number of vehicles on Kaua`i increased by 23% between 2000 and 2006, far more than the growth rate of jobs (12.9%), population (7.0%) or visitor count (6.6%) during that same period of time.[7]

Not only did the number of vehicles skyrocket, but the miles per vehicle increased from 10,081 in 2005 to 11,059 in 2007, and the average miles per gallon fell from 26.6 in 2005 to 22.0 in 2008.[8] All of this is discouraging news if the goal is to move toward increasing efficiency (more mobility per dollar spent), sustainability (reduced CO2 emissions) and reduced demand (for fossil fuels).

Figure 3-1: Kaua`i Population and Registered Vehicles (2007)



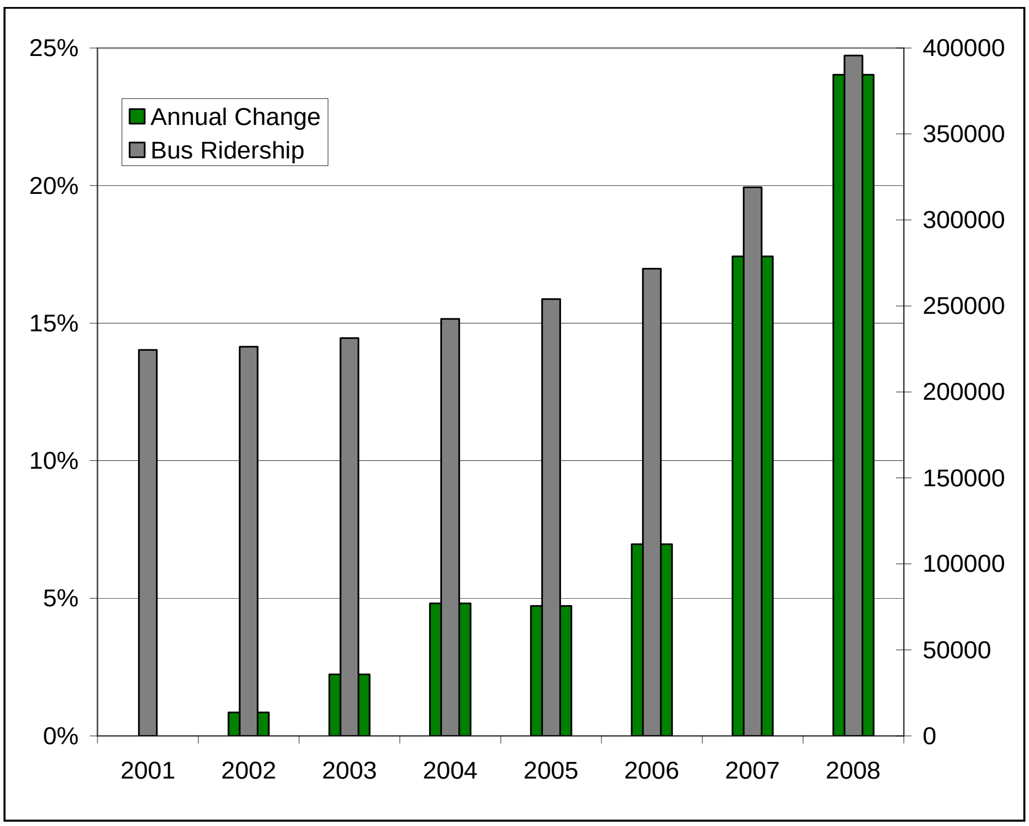
[5] U.S. Census Bureau (2008). Kaua`i County, Hawaii. Retrieved on 7/20/10 from http://factfinder.census.gov/servlet/NPTable?_bm=y&-geo_id=05000US15007&-qr_name=ACS_2008_3YR_G00_NP01&-ds_name=&-redoLog=false.
[6] [DBEDT] Department of Business, Economic Development & Tourism (2008). *2008 State of Hawaii Data Book*, Section 18: Transportation. Retrieved on 7/20/10 from http://hawaii.gov/dbedt/info/economic/databook/db2008/.
[7] DBEDT (2008). *2008 State of Hawaii Data Book*. Retrieved on 7/20/10 from http://hawaii.gov/dbedt/info/economic/databook/db2008/.
[8] DBEDT (2008). *2008 State of Hawaii Data Book*, Section 18: Transportation. Retrieved on 7/20/10 from http://hawaii.gov/dbedt/info/economic/databook/db2008/.

3. Public Transportation

Kaua`i has had a public transportation system since 1990. The Kaua`i Bus operates a public fixed route bus service and a paratransit (door-to-door) bus service from Hanalei to Kekaha daily except on Sundays. The Kaua`i Bus currently provides service to the Lihu`e Airport and limited service to Koloa and Po`ipu. The fixed route service is offered Monday through Friday 5:27 AM to 7:50 PM and Saturday from 6:21 AM to 5:50 PM. Bus fares for the mainline are $2.00/trip (discounted to $1.00/trip for youth and seniors), and $.50/trip for shuttle service (discounted to $.25 for youth and seniors). A Frequent Rider month bus pass cost $20. There's also a 6-month bus pass and a year bus pass at $90 and $180 respectively.[9]

The increase in bus ridership over the past 4 years has been exponential and dramatic. The rate of increase has risen from 5% between 2004 and 2005 to 24% between 2007 and 2008, as shown in Figure 3-2. This is a hopeful sign if the goal is to move the number of trips made daily on Kaua`i from the automobile mode to the transit mode. Paratransit trips have declined from 66,743 to 64,343, but this is a good sign as the goal is to integrate as many paratransit trips into the regular bus route as possible. As routes and service frequency and convenience of the regular bus system expand, paratransit clientele who are mobile are able to use the regular bus service, which gives them more options and lowers the cost to the county.

Figure 3-2: Kaua`i Bus Ridership



[9] County of Kaua`i Website (n.d.). The Kaua`i Bus. Retrieved on 7/20/10 from http://www.kauai.gov/Government/Departments/TransportationAgency/tabid/58/Default.aspx.

Not only has bus ridership on Kaua`i increased over the last decade, the rate of increase has also grown. Kaua`ians are discovering that they can rely on the bus for their travel needs, that riding the bus can be pleasant and comfortable and that they can save a lot of money in doing so. If the bus could achieve some funding equity with roads and cars, improve its bus stops and information infrastructure, and expand its frequency and availability, there is a large potential for a shift in travel mode to the bus, which will be enhanced as the price of oil rises inevitably over time.

4. Biking Facilities and Use

There are few bicycling facilities on Kaua`i. There are no official bike lanes on the island, although the shoulders along the main highways (Kuhio and Kaumuali`i) are often wide enough for bicyclists. There are a few bike routes which are marked as such by signage to indicate that bicyclists are sharing the road with motorists.

The one outstanding bicycle facility on Kaua`i is a "state of the art" mixed use path known as the Ke Ala Hele Makalae which runs through Lydgate Park and from Lihi Beach to Donkey Beach in Kealia. Recently constructed, it is attracting a wide assortment of enthusiastic users, from bicyclists and mothers with baby carriages to runners and walkers of all ages and ethnic backgrounds. Work is underway for this mixed use path to extend 16 miles from Lihu`e to Anahola.

5. Land Use

Land use patterns influence the number of vehicle miles traveled within a community, and therefore have a major impact on energy demand.

B. Projected Demand

1. Highways

In January of 2009, Governor Linda Lingle, together with Senate Transportation Chair Kalani English, House Transportation Chair Joe Souki and State Transportation Director Brennon Morioka, unveiled a $4.2 billion six-year Highways Modernization Plan (HMP). The statewide plan would implement critical highway projects and programs aimed at reducing traffic congestion, improving highway safety, maintaining roads, and saving motorists time and money.

The HMP includes 22 projects on Kaua`i with a total cost of $263 million. About $115 million of this cost is for projects aimed to address congestion issues. A map of the HMP is included in Figure 3-3.[10] Implementation of the HMP is pending the Hawai`i State Legislature's approval, which was not achieved in the 2009 legislative session.[11]

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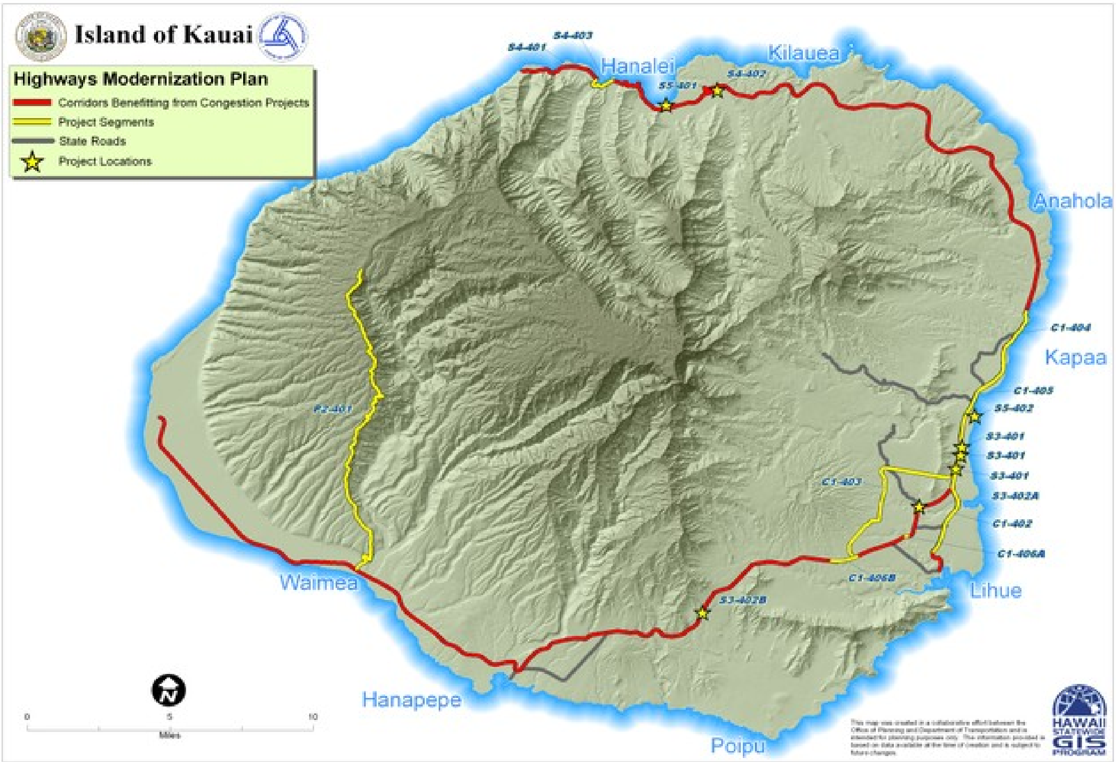
[10] State of Hawaii Department of Transportation. *Highways Modernization Plan: Kaua`i Projects.* Retrieved on 7/20/10 from http://hawaii.gov/dot/highways/modernization/kauai.

[11] State if Hawaii Department of Transportation (2009). *Highway Modernization Plan*. Retrieved on 7/20/10 from http://Hawai`i.gov/dot/highways/modernization

Figure 3-3: Map of Kaua`i Highway Modernization Plan



The HMP emphasizes roadway vehicular travel, which most likely encourages greater utilization of private passenger vehicles. For example, expanding roadway capacity may help reduce congestion but it can also increase total vehicle traffic, which increases downstream congestion, parking problems, accidents and sprawl. Congestion solutions provided by the Texas Transportation Institute include:

- **Get as much service as possible from existing resources** – Many low-cost improvements have broad public support and can be rapidly deployed. These management programs require innovation, constant attention and adjustment, but they pay dividends in faster, safer and more reliable travel. Rapidly removing crashed vehicles, timing the traffic signals so that more vehicles see green lights, improving road and intersection designs, or adding a short section of roadway are relatively simple actions.
- **Add capacity in critical corridors** – Handling greater freight or person travel on freeways, streets, rail lines, buses or intermodal facilities often requires "more." Important corridors or growth regions can benefit from more road lanes, new streets and highways, new or expanded public transportation facilities, and larger bus and rail fleets.
- **Change the usage patterns** –There are solutions that involve changes in the way employers and travelers conduct business to avoid traveling in the traditional "rush hours." Flexible work hours, internet connections or phones allow employees to choose work schedules that meet family needs and the needs of their jobs.
- **Provide choices** – This might involve different routes, travel modes or lanes that involve a toll for high-speed and reliable service – a greater number of options that allow travelers and shippers to customize their travel plans.
- **Diversify the development patterns** – These typically involve denser developments with a mix of jobs, shops and homes, so that more people can walk, bike or take transit to

more, and closer, destinations. Sustaining the “quality of life” and gaining economic development without the typical increment of mobility decline in each of these sub-regions appear to be part, but not all, of the solution.

- **Realistic expectations are also part of the solution** – Large urban areas will be congested. Some locations near key activity centers in smaller urban areas will also be congested. But congestion does not have to be an all-day event. Identifying solutions and funding sources that meet a variety of community goals is challenging enough without attempting to eliminate congestion in all locations at all times.[12]

2. Vehicular Traffic

The State Department of Transportation (DOT) has identified the following key strategies to reduce traffic congestion: operational improvements (Intelligent Transportation System and Vanpool Hawai`i), increasing capacity and removing bottlenecks (Kaumuali`i and Kuhio Highway widening), and improving reliability of commerce.

The Victoria Transport Policy Institute report “Win-Win Transportation Solutions” considers the benefits and costs of a number of traffic solutions.[13] All of their “no regrets” measures have been evaluated to ensure they provide multiple economic, social and environmental benefits. Conventional planning, which considers just a few impacts at a time, tends to undervalue strategies that provide multiple benefits. For example, more fuel-efficient vehicles help conserve energy but by making driving cheaper they tend to increase congestion, accidents and sprawl.[14] Because the Win-Win Solutions reduce total vehicle travel and increase walking and cycling, they support many planning objectives.

However, strategies such as Parking Cashing Out and Pay-As-You-Drive vehicle insurance return to individual motorists the savings that result when they drive less, offering motorists a new opportunity to save money that does not currently exist. Even strategies that apply negative incentives, such as parking pricing, road pricing or fuel taxes are offset by reductions in other consumer costs and taxes that currently subsidize road and parking facilities, and petroleum production. Motorists then also benefit from reduced traffic congestion. Similarly, traffic calming reduces vehicle speeds, which is a cost to motorists, but a benefit to pedestrians and local residents, and reduces motorist crash risk. If fully implemented to the degree that is economically justified, Win-Win Solutions could reduce motor vehicle costs by 25-50%, although exact impacts are difficult to predict and vary depending on geographic, demographic and economic conditions.[15]

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[12] Texas Transportation Institute (July 2009). *Urban Mobility Report 2009.* Retrieved on 7/20/10 from http://tti.tamu.edu/documents/mobility_report_2009_wappx.pdf.

[13] Litman, Todd (January 2007). *Win-Win Transportation Solutions*, Victoria Transport Policy Institute,. Retrieved on 7/20/10 from www.vtpi.org.

[14] Litman, Todd (March 2005). *Efficient Vehicles Versus Efficient Transportation: Comparing Transportation Energy Conservation Strategies*. Transport Policy, Volume 12, Issue 2 Pages 121-129. Retrieved on 7/20/10 from www.vtpi.org/cafe.pdf.

[8] Litman, Todd (January 2007). *Win-Win Transportation Solutions*. Victoria Transport Policy Institute. Retrieved on 7/20/10 from www.vtpi.org.

3. Public Transportation

Mass transit, or public transportation, can consist of buses, subways, light rail, monorails, commuter trains, van pool services, paratransit for senior citizens and people with disabilities, ferries, and water taxis. Studies have shown that in densely populated areas public transportation is able to decrease energy consumption per capita due to a decrease in private vehicle use.

In response to Act 254, 2007 Session Laws of Hawai`i, the Hawai`i Energy Policy Forum (HEPF) at the University of Hawai`i at Manoa conducted a study on energy-efficient transportation strategies to reduce the demand for fuel in Hawai`i's transportation sector and, in so doing, reduce Hawai`i's dependence on imported fossil fuel. [16] The Forum convened a steering committee to plan the scope of the work and identify the major stakeholders. The stakeholders comprised the Energy Efficiency in Transportation Strategies Working Group ("Working Group"). The Working Group decided to initially focus on energy efficiency in ground transportation and published a Phase 1 report in January of 2008.[17]

The Working Group established three goals on which the study would focus its efforts:

1. Increase choices for modes of travel because multiple modes of travel permit greater public choice for efficient and flexible trip planning.
2. Increase fuel efficiency of vehicle population by using incentives to influence consumer behavior in favor of buying and using more efficient vehicles.
3. Diversify energy sources available to meet transportation energy needs.

Most of the Working Group's attention focused on the first two goals, since they were seen as having a direct impact upon the energy efficiency of the transportation system. One of the key goals that emerged was to increase choices of travel modes to encourage the public to choose more efficient travel. This is consistent with efforts worldwide. Wherever cities are achieving some success in curtailing demand, they have focused on reducing auto dependency, and a big part of that effort has been to increase the quality and availability of public transportation.

One of the major findings of the Working Group is that there is a lack of data upon which to establish goals and to track progress in meeting those goals. There are significant gaps in the types of data needed to assess energy efficiency in transportation, and the lack of coordination among agencies in the collection and use of energy-related data. This lack of data makes it impossible to establish a baseline by which to measure goals and outcomes, or to analyze various transportation options. [18]

4. Biking

According to the State Department of Transportation, the *Bike Plan Hawai`i* was originally developed in 1977 and recently updated in 2003, after a process which involved extensive public input to develop a prioritized list of projects. The Department is currently executing contracts to implement high priority projects identified in Bike Plan Hawai`i. Kimura International is

[16] [HEPF] Hawai`i Energy Policy Forum (January 15, 2008). *State of Hawai`i Energy Efficiency in Transportation Strategy Studies – Phase 1.* Retrieved on 7/20/10 from http://Hawai`ienergypolicy.Hawai`i.edu/Act254/PDFs/Final_Report.pdf

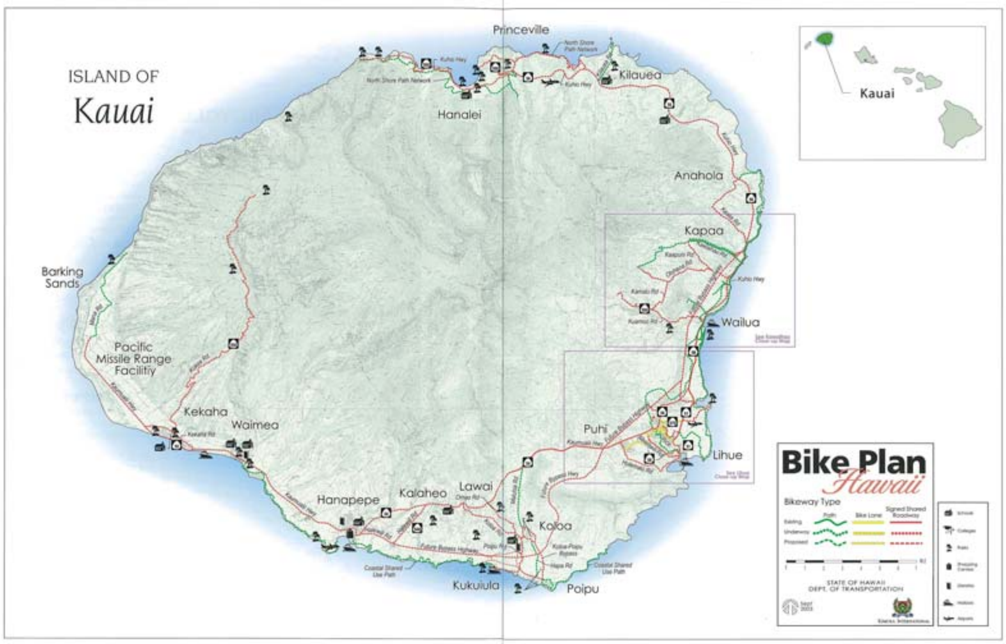
[17] HEPF (January 15, 2008). *State of Hawai`i Energy Efficiency in Transportation Strategy Studies – Phase 1*. Retrieved on 7/20/10 from http://Hawai`ienergypolicy.Hawai`i.edu/Act254/PDFs/Final_Report.pdf

[18] Ibid.

developing an implementation plan, which will include bike accommodations in highway widening road improvements, i.e. the Kuhio/Kaumuali`i Highways widening project. [19] Figure 3-4 illustrates bike plan specifics in Kaua`i, according to the Bike Plan Hawaii Master Plan.[20]

The County of Kaua`i has been working on constructing a 16-mile coastal bike and pedestrian trail running from Nawiliwili to Anahola since 1994. Construction on the bike/pedestrian trail began in 1999 and is being completed in six phases, expected to be completed within 10 years.[21] Each phase requires its own environmental assessment report process and design/build process. The total cost of the entire trail system is anticipated to be in the range of $30 million and is illustrated in Figure 3-5.[22]

Figure 3-4: Bike Plan Hawai`i



[19] Presentation given to KESP Transportation Stakeholder group by Hawai`i Deputy Director State Department of Transportation (April 28, 2009).
[20] State of Hawaii Department of Transportation (1994). *Bike Plan Hawaii*. Retrieved on 7/20/10 from http://hawaii.gov/dot/highways/Bike/bikeplan/index.htm#bikeplan.
[21] Doug Haigh (County of Kaua`i). Personal Communication with: Doug Hinrichs (SENTECH Hawai`i Team). July 2009.
[22] MacDougall and Associates (June 2005). *Bike Path Overview, Nawiliwili to Anahola Bike/Pedestrian Path*,. Retrieved on 7/20/10 from http://www.kauai.gov/Government/Departments/PublicWorks/BuildingDivision/BuildingDivisionProjects/AhukiniLydgateBikePathProject/tabid/335/Default.aspx

Figure 3-5: Nawiliwili to Anahola Bike and Pedestrian Path, Phases of Development

5. Land Use

Smart growth is a pattern of development that concentrates growth in the center of cities to avoid urban sprawl, promote multi-modal transportation, and expand the range of employment and housing choices within a community. Compact, mixed-use, interconnected, and pedestrian-friendly neighborhoods have proven to reduce the need to drive, and therefore the amount of energy used within a given area.

A study for Kaua`i conducted by the American Institute of Architect's Sustainable Design Assessment Team (SDAT) recommended the following six specific land use/smart growth projects to implement in Kaua`i in order to preserve land and energy use:

- Create a stronger town center/marketplace/part redevelopment
- Develop blueways/ greenways as open space connections
- Increase housing and civic land use
- Create a skill center/ business incubator
- Initiate natural systems restoration

- Redevelop streetscapes and traffic patterns[23]

The SDAT land use group recommended concentrating implementation efforts on a few initial model projects in order to focus community attention on visible locations, maximize available resources, and demonstrate the principles and practices outlined in this report.[24]

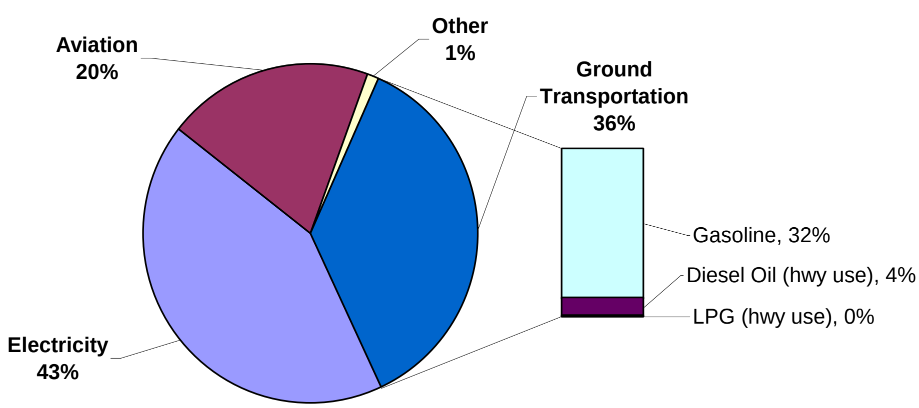
C. Baseline Supply

The KESP Energy Analysis Summary primarily uses 2007 data for analysis. The reason for this is that the following year saw extreme price fluctuations in the cost of energy. In 2008, the price of diesel rose above $180 per barrel at the highest peak. The current price of diesel is approximately $60 to $70 per barrel. Effects from this spike in the cost of energy can be seen throughout the report wherever historical data is presented. High fuel prices affected every sector of the economy, including reducing demand for transportation fuels and electricity. For these reasons, the SENTECH Hawai`i team determined that using 2007 as the baseline year for analyses would be the most accurate approach.

1. Liquid Fuels

A 2007 summary of the liquid fuel types being used by Kaua`i is shown in Figure 3-6. The total amount of 2007 liquid fuels was approximately 96 million gallons.[25]

Figure 3-6: Overall Kaua`i Liquid Fuel Usage Percentages (2007) with Ground Transportation Detail



The main ground transportation fuels utilized on Kaua`i are gasoline, diesel and liquefied petroleum gas (LPG or "auto propane"). Ground transportation fuels account for 41% of all liquid fuel usage on Kaua`i. The fuels used for ground transportation are further broken down into

[23] Sustainable Design Assessment Team (November 2008). *Lihu`e, Kaua`i, HI SDAT: Building a framework for a sustainable future.*
[24] Ibid.
[25] DBEDT (2008). *Monthly Energy Data*, Retrieved in July 2009 from http://Hawai`i.gov/dbedt/info/economic/data_reports/energy-trends

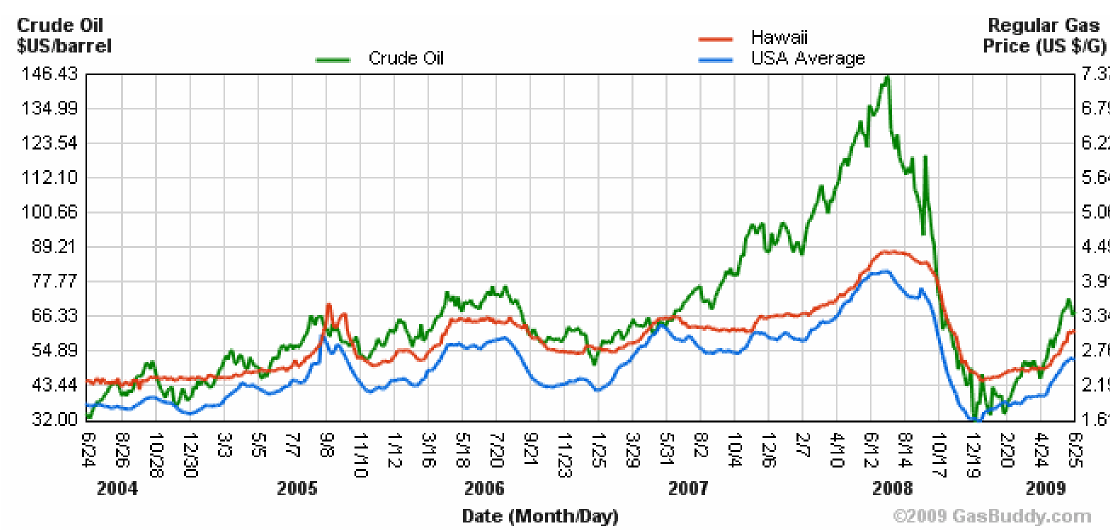
gasoline, diesel and LPG, as percentages of total liquid fuels. The fuel percentages are calculated from the energy content, or Btu's, of each fuel type. Aviation fuel usage is a significant piece of transportation fuel usage, but is outside the scope of this analysis. The 2007 volume (gallon) amounts of these fuels are shown in the table below. "Other" fuel consists of diesel for non-highway and non-KIUC use, small boat fuel and gasoline for agricultural use.

Table 3-1: Overall Kaua`i Liquid Fuel Usage by Volume (2007) with Ground Transportation Detail

Liquid Fuel	Volume (Gallons)	Energy Content (MMBtu)
Gasoline	27,678,116	3,213,153
Diesel Oil (highway use)	2,987,357	383,726
LPG (highway use)	4,457	379
Total Ground Transportation	**30,669,929**	**3,852,307**
Total Other	**903,888**	**122,836**
Total Electricity	**32,859,899**	**4,526,045**
Total Aviation	**16,966,415**	**2,120,802**

Figure 3-7 shows the historic variability in gasoline prices since 2004.[26]

Figure 3-7: Gasoline and Crude Oil Prices (2004 to Current)



[26] Gas Buddy Website (2009). *Historical Price Charts*. Retrieved in July 2009 from http://www.gasbuddy.com/gb_retail_price_chart.aspx?time=24.

D. Projected Supply

1. Liquid Fuels

Ground transportation vehicles that typically run on gasoline and diesel can also be powered by renewable fuels, such as cellulosic ethanol and biodiesel derived from various forms of biomass. These fuels can be used in pure form or blended into conventional fuels at any level. Blended fuels are typically abbreviated according to the percentage of alternative fuel preceded by an "E" for ethanol or "B" for biodiesel. For example, E20 is a blend of 20% ethanol and 80% gasoline, and B99 is 99% biodiesel and 1% diesel. Biofuels have been the largest U.S. renewable energy source for liquid fuels every year since 2000 and they can provide a viable renewable fuel alternative for ground transportation on Kaua`i.

Biofuel potential for Hawai`i has been examined in the *Bioenergy Master Plan* report from the State of Hawai`i Department of Business, Economic Development, and Tourism (DBEDT), which was completed in December 2009.[27] There are a number of organizations currently working on renewable fuels within the state of Hawai`i as well as within Kaua`i.

<u>Biodiesel</u>

Biodiesel is made by transforming animal fat or vegetable oil with alcohol and can be directly substituted for diesel either as neat fuel (B100) or as an oxygenate additive [typically 20% (B20)]. In the United States biodiesel is usually made from soybean oil, but it can also be made from any plants that contain high amounts of vegetable oil, such as palm oil, jatropha, or algae. In 2005, about 75 million gallons of biodiesel were produced in the U.S., tripling the 25 million gallons produced in 2004.[28]

Pacific Biodiesel, Inc. is headquartered in Kahului, Hawai`i and was conceived in 1995 in response to serious environmental and health concerns surrounding unmanageable quantities of used cooking oil at the Central Maui Landfill. In 2000, Pacific Biodiesel built a facility in Honolulu with a current capacity double that of the Maui plant. Pacific Biodiesel supplies B20 to fuel all the fleet vehicles of the City and County of Honolulu Department of Facility Maintenance, and provides biodiesel fuels ranging from B20 to B99 to two stations on Maui and seven on Oahu.[29]

The County of Kaua`i is working to establish residential used cooking oil collection points at the Lihu`e and Hanapepe Transfer Stations. Kaua`i Grease Traps has been contracted to haul the used oil for processing to Kaua`i Farm Fuels, which has been producing biodiesel in Hanapepe since 2007.[30] The anticipated start date of oil collection and processing is August of 2009.[31]

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[27] Hawaii Natural Energy Institute (2009). *Hawaii Bioenergy Master Plan Project*. Retrieved on 7/20/10 from http://www.hnei.hawaii.edu/bmpp/stakeholders.asp.
[28] U.S. Department of Energy – Office of Science (2009). *Biofuels for Transportation*. Retrieved on 7/20/10 from http://genomicscience.energy.gov/biofuels/transportation.shtml.
[29] Pacific Biodiesel Website (2009). Retrieved in July 2009 from http://www.biodiesel.com/.
[30] Eagle, Nathan (March 16, 2008). *County to explore using biodiesel for its vehicles*. The Garden Island. Retrieved in July 2009 from http://thegardenisland.com/news/article_b337bbe6-9a75-5a23-b78d-eacb7a1d0daa.html.
[31] Allison Fraley (Solid Waste Program Coordinator, County of Kaua`i). Personal Communication with: Doug Hinrichs (SENTECH Hawai`i Team). July 2009.

Ethanol

Ethanol can be used either as an alternative fuel or as an octane-boosting, pollution-reducing additive to gasoline. The U.S. ethanol industry produced more than 3.4 billion gallons in 2004, up from 2.8 billion gallons in 2003 and 2.1 billion gallons in 2002.[32] Ethanol is produced from the fermentation of crops that contain high levels of sugar or starch (such as sugar cane or corn) or cellulose. Cellulosic ethanol is produced from non-food based feedstocks, including crop residues. Using cellulosic feedstocks has a variety of benefits, including alleviating concerns of diverting potential food resources to produce fuel. However, the production of cellulosic ethanol is more difficult technically and comes with higher costs.

The state of Hawai`i has an ethanol mandate currently requiring ethanol to be blended into 10% of petroleum fuels (this blended fuel is known as E10). The mandate increases to 20% by 2020. Based on a 2007 gasoline consumption level of over 45 million gallons of gasoline on Kaua`i[33], the 20% mandate would require over 9 million gallons of ethanol for the transportation sector alone.

Hawai‘i BioEnergy (HBE) is a corporation established by three of Hawai‘i's largest landowners: Kamehameha Schools, Grove Farm Company, Inc., and Maui Land & Pineapple Company, Inc. HBE is actively researching all technically, economically, and environmentally viable processing techniques and distribution channels for a variety of energy crops, including but not limited to sugarcane, woody biomass, and algae. HBE states that they could eventually provide 100% of all future ethanol required for E20 fuels consumed in Hawai‘i plus a significant percentage of energy for the utility sector.[34] HBE is developing a process development unit sited on Kaua`i.

Pacific West Energy, through its subsidiary Gay & Robinson Ag-Energy (Ag-Energy) is developing an integrated energy bio-refinery producing ethanol and electricity on the island of Kaua`i. The project entails converting the Gay & Robinson sugar mill by adding a fuel ethanol plant and integrated electricity production facility. The plant has a planned capacity of 12 million gallons/year and approximately 25 MW of electricity. It will be located at Kaumakani, about four miles west of Hanapepe.[35]

The Kaua`i ethanol plant is designed to produce fuel ethanol for sale in the Hawai`i transportation and electricity generation markets. In addition, the sugar mill may produce sugar for local consumption or refining and electricity for sale to KIUC. Ag-Energy intends to control a large percentage of its own feedstocks for the ethanol and power plants through the lease of existing sugar cane lands and expansion into former cane lands on Kaua`i. Cane juice processed from the sugarcane will provide feedstock for the ethanol plant, while bagasse (the sugarcane fiber remaining after water and sugar is eliminated in the mill) will provide fuel for the power plant.[36]

Algae-to-Fuels

[32] U.S. Department of Energy – Office of Science (2009). *Biofuels for Transportation*. Retrieved on 7/20/10 from http://genomicscience.energy.gov/biofuels/transportation.shtml.

[33] DBEDT (2008). *2008 State of Hawaii Data Book*, Section 18: Transportation. Retrieved on 7/20/10 from http://hawaii.gov/dbedt/info/economic/databook/db2008/.

[34] Hawai`i BioEnergy Website (2009) Retrieved in July 2009 from http://www.hawaiibioenergy.com/.

[35] Gay & Robinson Inc and Pacific West Energy, LLC (July 9, 2007). *New Energy Partnership Will Develop Hawaii's First Ethanol Plant*. Retrieved on 7/20/10 from http://pacificwestenergy.com/Documents/Press%20Release%2007.09.07.pdf.

[36] Pacific West Energy Website. *Kaua`i Project.* Retrieved in July 2009 from http://pacificwestenergy.com/kauaiproject.aspx.

The record oil price increases since 2003, competing demands between foods and other biofuel sources, and the world food crisis, have ignited interest in algaculture (farming algae) for making vegetable oil, biodiesel, bioethanol, biogasoline, biomethanol, biobutanol and other biofuels. Among algal fuels' attractive characteristics: they do not affect fresh water resources, can be produced using ocean and wastewater, and are biodegradable and relatively harmless to the environment if spilled. Algae can yield over 30 times more energy per acre than other, second-generation biofuel crops. According to Exxon Mobil, algae could yield more than 2,000 gallons of fuel per acre of production per year. [37] Approximate yields for other fuel sources are far lower; sugar cane produces 450 gallons per year (gpy), corn produces 250 gpy, and soy only 50 gpy for every acre planted.[38]

HR BioPetroleum, Inc. (HRBP) is a Hawai`i-based renewable energy technology company focused on utilizing marine microalgae to produce biofuel feedstocks and other valuable products. HRBP currently operates a demonstration facility on the Kona coast of Hawai`i Island and in July of 2008 signed a Memorandum of Understanding with Alexander & Baldwin, HECO, and MECO to jointly develop a commercial-scale microalgae facility on Maui.[39]

Kuehnle AgroSystems is another Hawai`i-based company working with algae-to-fuels. The company performs research on algae strains that can be used for making biofuels, aquaculture feeds and chemicals and is based at the Manoa Innovation Center.[40] The Defense Advanced Research Projects Agency (DARPA) is funding two separate efforts involving Hawai`i BioEnergy and Kuehnle AgroSystems, local companies in partnership with SAIC and General Atomics. Hawai`i BioEnergy is developing a process development unit sited on Kaua`i.

Kai BioEnergy Corp. is another algal biofuel company currently performing research in Kona, HI and San Diego, CA.[41]

As of 2008, algae-based fuels remain too expensive to replace other commercially available fuels. But several companies and government agencies are funding efforts to reduce capital and operating costs and make algae oil production commercially viable. Thus, although algae-to-fuels will not be considered further in this report due to lack of current economic viability, it shows promise as a potential future fuel source for Kaua`i in the long-term.

2. Electricity for Transportation

Part of the transportation solution for Kaua`i may include not only replacing fossil fuels with renewable fuels, but also shifting the end-use from liquid-fueled vehicles to electric and hybrid electric vehicles. Electric vehicles (EVs) operate on only electrical power, and include the category of plug-in hybrid electric vehicles (PHEVs). Hybrid electric vehicles (HEVs) typically operate on a combination of batteries and liquid fuels, and are already commercially available from a variety of auto manufacturers. The batteries in these vehicles are re-charged directly from the engine through combustion of liquid fuels. PHEVs differ from hybrid electric vehicles in that

[37] ExxonMobil (n.d.) *Algae Biofuels Research and Development Program*. Retrieved in July 2009 from http://www.exxonmobil.com/corporate/files/news_pub_algae_factsheet.pdf.
[38] Ibid.
[39] HR Biopetroleum Website (2008). Retrieved in July 2009 from http://www.hrbp.com/index.html.
[40] Pacific Business News (April 18, 2008). *Scientist sees commercial potential for her company*. Retrieved on 7/20/10 from http://pacific.bizjournals.com/pacific/stories/2008/04/21/focus21.html.
[41] Personal correspondence, Mario Larach, Kai BioEnergy Corp., July 10, 2009

they typically have much larger battery packs, allowing for greater electric range, and that they must be connected to the electric grid to re-charge their battery packs.

EVs or PHEVs can utilize excess grid electricity to increase total grid efficiency. Shifting transportation fuel demand from liquid fuels to electricity has the potential to utilize already available off-peak electricity generation capability, for example, through the night-time charging of vehicles. However, PHEVs or EVs will benefit the renewable energy situation on Kaua`i only as far as renewable resources are integrated into the electricity grid.

A 2007 report[42] from Pacific Northwest National Laboratory (PNNL) found that for the United States overall, over 70% of the existing light-duty vehicle fleet could be fueled with available off-peak electric capacity. This percentage decreases to 43% if vehicles are only charged at night-time. In addition to the potential for displacement of net oil imports, the massive introduction of electric vehicles would decrease carbon dioxide emissions, decrease electricity rates due to increased sales using the same infrastructure, and create vast electricity storage potential for the grid. These benefits are only realized when off-peak electricity is used for vehicle charging. If vehicles are charged at peak times it would require addition of new generation, transmission and distribution, and would drive electricity rates higher.

Implementing a smart grid with smart vehicle chargers would allow communication of price signals to the vehicle charger, and would help to mitigate reliability concerns. In the long-term, it is envisioned that PHEVs could utilize smart chargers with a smart grid to provide high-value energy storage for the grid. Vehicle batteries could not only be used to supply the grid on a real-time, as-needed basis, but could also provide backup power to homes during emergencies or grid blackouts. Some energy experts envision using PHEVs as a way to provide energy storage to the grid or to islanded microgrids. Having these types of functionality would require implementation of a smart grid.

Electric Vehicles

EVs store electricity in an energy storage device, such as a battery. The electricity powers the vehicle's wheels via an electric motor. EVs have limited energy storage capacity, which means they must be plugged into an electrical source after a certain number of miles, depending on the size of the battery. Even though electricity production would contribute to air pollution unless renewable energy sources are used, EVs are considered zero-emission vehicles because their motors produce no exhaust or emissions.

In December 2008, Hawai`i Governor Linda Lingle announced a plan to bring all-electric vehicles and an electric vehicle infrastructure by 2009 to the island of Maui through a partnership with Phoenix Motorcars. Phoenix Motorcars signed a memorandum of understanding with MECO for a test program using Phoenix Motorcars' electric pick-up trucks in the utility fleet.[43]

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[42] Pratt, Rob, et. al (June 2007). *Potential Impacts of High Penetration of Plug-In Hybrid Vehicles on the U.S. Power Grid*. Pacific Northwest National Laboratory. Presentation at the DOE/EERE PHEV Stakeholder Workshop. Retrieved on 7/20/10 from http://www1.eere.energy.gov/vehiclesandfuels/avta/pdfs/phev/pratt_phev_workshop.pdf.

[43] State of Hawai`i Website (December 9, 2008). *Governor Lingle, Mayor Tavares and Phoenix Motorchars announce intent to bring electric vehicles to Maui by 2009.* Retrieved on 7/20/10 from http://hawaii.gov/gov/news/releases/2008/governor-lingle-mayor-tavares-and-phoenix.

Better Place also has a partnership with the state, with a goal of mass-market availability of EVs by 2012. A Memorandum of Understanding (MOU) was signed with Hawaiian Electric Companies in December of 2008 to collaborate on the infrastructure and energy needs. Better Place is developing a system of "EV driver services", which will allow customers to access network charge spots and "switch stations" to swap out depleted batteries.[44]

<u>Plug-In Hybrid Electric Vehicles</u>

PHEVs combine the propulsion capabilities of a traditional combustion engine with an electric motor. PHEVs can provide 50 to 90% of EV fuel displacement.[45] The batteries in PHEVs can be recharged by using an external power source, such as a home electrical outlet. The most sustainable approach to charge PHEVs is to charge them at night using the output of off-peak wind or other energy.

PHEVs are gaining in popularity because of their ability to travel nominal distances using little to no petroleum-based fuel in their all-electric range. According to the Electric Power Research Institute (EPRI), half of the cars in the U.S. are driven just 25 miles a day or less. PHEVs can be less expensive to operate than conventional vehicles because using grid electricity to recharge the vehicle is cheaper than petroleum fuels.

Major automotive companies are actively working to get EVs and PHEVs to the marketplace. For example, General Motors (GM) recently released information about the Chevy Volt that will be released in 2011. GM claims that the Volt will travel 40 miles on battery power alone, and that it can achieve 230 MPG on highways, or over 100 MPG for a combined city/highway average. GM estimates the Volt's total driving range to be 640 miles, which is about double that of most conventional hybrids. The Volt will include an "intelligent" control module that allows plugging in to either 120 or 240 volt household circuits. GM estimates the Volt's battery can be charged in less than three hours via a 240 volt outlet, or in about eight hours with a 120 volt outlet.[46] GM's claims will need to be validated after the Volt is released.

Toyota has also indicated that they will add plug-in capability to the Prius as early as 2011.[47] With the number of HEV options increasing, buyers will be able to weigh all the "green car" options with regard to initial cost versus payback time, and even potentially consider net environmental impacts.

3. Hydrogen

The most common method of production for hydrogen, which can be used in fuel cells or engines, is steam methane reforming from hydrocarbons, such as natural gas. Hydrogen can also be produced using renewable energy resources, such as solar, wind, and biomass, and from nuclear energy. Hydrogen can be used as a transportation fuel by combustion in modified internal combustion engines (ICE) or through electrochemical conversion in a fuel cell. Converting the energy stored in hydrogen directly from chemical energy to electricity (rather than losing energy

[44] Better Place Website. Retrieved in July 2009 from http://www.betterplace.com/global-progress/hawaii/
[45] Gremban, Ronald (June 2007). *PHEVs: The Technical Side*. California Cars Initiative. Retrieved in July 2009 from http://www.calcars.org/downloads.html.
[46] Poole, Chris (March 2009). *2011 Chevrolet Volt Review and Prices*. Consumer Guide Automotive.
[47] Toyota Website (December 2, 2009). *2010 Prius Plug-in Hybrid makes North American debut at Los Angeles Auto Show*. Retrieved on 7/20/10 from http://pressroom.toyota.com/pr/tms/toyota/2010-prius-plug-in-hybrid-makes-149402.aspx.

by converting to thermal and then mechanical energy) allows fuel cell vehicles to be twice as efficient as gasoline-powered ICEs. Reducing cost and improving durability are the two most significant challenges to fuel cell commercialization.[48]

Hydrogen faces a number of significant barriers to any near-term, widespread use. Lack of infrastructure, cost of renewable production, cost of fuel cells, and storage and delivery methods are main challenges. However, there are a number of groups that are working to address these barriers and hydrogen has potential as part of a future clean energy portfolio solution for Hawai`i, and Kaua`i.

[48] Department of Energy Hydrogen Program (November 2008). *Hydrogen Fuel Cells Fact Sheets.* Retrieved in July 2009 from http://www1.eere.energy.gov/hydrogenandfuelcells/pdfs/doe_h2_fuelcell_factsheet.pdf.