Biofuels Study

Final Report to the Legislature

In Accordance with

Act 203, Session Laws of Hawaii, 2011

STATE OF HAWAII

Department of Business,

Economic Development & Tourism

December, 2012

EXECUTIVE SUMMARY

In 2011, the Hawaii State Legislature and Governor Abercrombie enacted Act 203, which directed the Hawaii State Department of Business, Economic Development and Tourism (DBEDT) to prepare a biofuels report to the Legislature. This report, in response to Act 203, includes background information on fuel use; information on fifteen specific topics identified by the Legislature; a summary of the conditions and policies necessary to expand biofuel production in the state; and recommendations.

Hawaii's energy systems are highly dependent on liquid fuels, more so than in any other state. Petroleum is used for electricity production; ground, air, and marine transportation; military activities; and other needs. Each year, Hawaii uses between 1.7 and 2.2 billion gallons of liquid petroleum fuels (fuel oil, gasoline, diesel, jet fuel, bunker fuels, and others). With Hawaii's aggressive efforts to reduce petroleum use in the electricity and ground transportation sectors, it is projected that the growth in energy needs in these sectors will be met by increased energy efficiency and non-petroleum energy sources, including solar, wind, geothermal, bioenergy, ocean energy, and hydropower. Even with these initiatives, the need for liquid fuels for aviation, freight transport, and dispatchable power generation will remain; liquid fuels will continue to be an important part of Hawaii's energy mix.

Today, these liquid fuels are largely produced from petroleum. However, near-complete reliance on petroleum-based fuels causes concern about price (due to price volatility, discussed later), energy security (due to potential embargoes or shipping disruptions), environmental impacts (such as oil spills or greenhouse gas emissions), and balance of trade (particularly in areas like Hawaii, with no petroleum reserves). Therefore non-petroleum energy sources, particularly renewable sources, are receiving increased attention locally as well as globally.

Hawaii's liquid fuel needs may be met by a combination of petroleum-based and renewable fuels (i.e. biofuels) made from organic (biogenetic) materials such as plants. Biofuels are produced worldwide, including some production in Hawaii. According to local sources, major barriers to local production include price and investment risk; feedstock availability; and lack of long-term leases for large tracts of contiguous land areas.

If biofuels were always required to be priced competitively with their petroleum-based counterparts, the volatility in oil prices would result in the same price volatility being felt in the biofuels market and by biofuels purchasers. Such price volatility could create uncertainty in revenue projections for the biofuel projects, and discourage investment in the industry.

Volatility in 2002-2011 oil prices – and variability in forecasts – are illustrated in Figure 1. The 2005 forecast, as one example, showed long term oil prices peaking at $35 per barrel and retreating to below $30 per barrel. The actual 2011 price, however, was 339% higher than had been anticipated in the 2005 forecast. Petroleum price volatility is one of the reasons for Hawaii's push for non-petroleum energy alternatives.

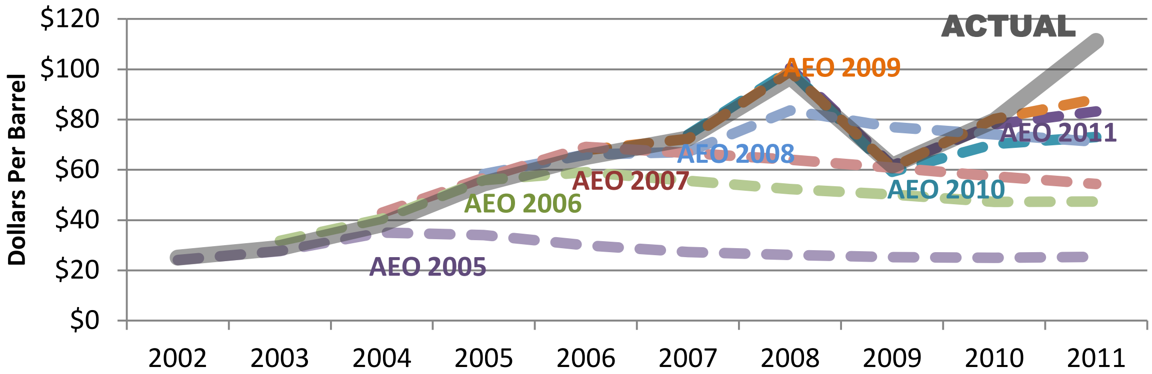

Figure 1 – Annual Average Oil Prices Compared to Oil Price Forecasts, U.S. Dollars per Barrel. [1]

Finding ways to de-link significant portions of biofuel facility revenue from oil prices could help biofuel projects to be developed. Project developers have indicated that, in addition to reliable and cost-effective feedstocks and technologies, they need long term contracts, indexed to non-petroleum price indices, with delayed start dates for product delivery.[2] These types of contracts are particularly important for first generation facilities.

To the extent that biofuel projects could be developed, and biofuel prices could be de-linked from oil prices, the impacts of oil price volatility on Hawaii's energy users could also be lessened.

In Hawaii, liquid fuels are in roughly equal demand for the electricity, ground transportation, and aviation sectors. Different conditions and policies apply to each sector, and were evaluated accordingly.

Biorefineries produce a variety of products, including a variety of biofuels. Enabling one or more of the products (such as fuel for electricity generation and/or fuel for the Department of Defense) to be supplied under long-term contracts at known prices has been identified by the industry as extremely important for success, and should be viewed as contributing to, rather than competing with, the success of other biofuel products.

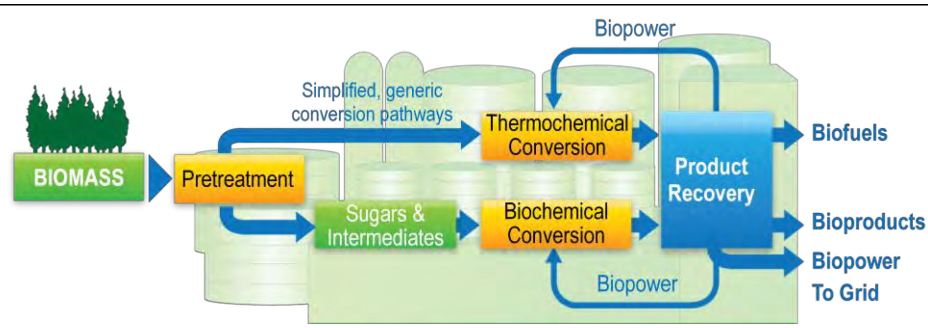

Figure 2 - Biorefineries Produce a Variety of Fuels and Co-Products.

[1] U.S. Energy Information Administration, *Annual Energy Outlook*, annual, 2005-2012.

[2] "Delayed start date for delivery" means that a biofuel developer can enter into a contract with a customer prior to construction of the biofuel production facility. Under this type of contract the customer will expect to receive fuel after the facility has been constructed. The biofuel request for proposals issued by Hawaiian Electric Company stipulated that biofuel suppliers will have up to five years to begin delivering fuel.

Electricity Sector

It is recommended that initial policies support limited production of biofuels for use in the electricity sector because electric utility sector contracts provide the type of structure needed to stimulate local biofuels production. A second reason is that fixed-price fuel contracts could provide fuel diversification and a measure of energy price stabilization for Hawaii's electricity consumers.

Regarding the type of structure needed to stimulate the biofuel industry, the electricity sector could provide long-term fixed price contracts for relatively large quantities of fuel. With long-term contracts in hand, financing costs and risks can be reduced in a manner that otherwise might not be possible. Utility contracts could also be structured to accommodate delayed start dates for fuel delivery. Also, Hawaii's electric utilities use a variety of fuels, so could use simpler fuels (for example, straight vegetable oil or pyrolysis oils) as well as more refined fuels (for example, biodiesel or green diesel).

Long-term contracts for liquid fuels for utility use could be beneficial for Hawaii's electricity consumers, who are currently faced with energy prices tied to oil price swings. Locally-produced biofuels, if less directly tied to the price of oil, could reduce the exposure of Hawaii's electricity consumers to swings in oil prices. The development of a portfolio approach to energy sources (biomass, geothermal, hydropower, ocean, solar, and wind energy) has already been put into place in the form of the renewable portfolio standard.[3] Taking a portfolio approach to liquid fuel supplies, as well, would also be prudent. Biodiesel has been successfully used in the electricity sector in Hawaii for over 8 years.

Once the biofuels industry is seeded in Hawaii,[4] biofuels should be transitioned from the generation sector to higher-value uses such as transportation fuels.

Marine and Ground Transportation Fuels

In the marine and ground transportation sectors, consistency in policy is recommended. Hawaii has favorable highway tax rates, an ethanol blending mandate, an ethanol facility tax incentive, and an alternative fuel standard that sets a target of 20% of highway fuel demand to be supplied by alternative fuels by the year 2020. If revisions are made to one or more of these laws, consistency in policy direction should be maintained. Modifications may be justified to reflect technological advancements or to reflect an expansion in the biofuels available to help Hawaii meet its fuel diversification and economic development goals.

Aviation Fuels

Jet fuel production could also provide an opportunity for Hawaii fuel producers, particularly in the areas of development and demonstration of feedstocks and conversion technologies. Care should be taken to ensure that policies enacted to encourage biofuels for other sectors also recognize the value of bio-based jet fuel. Any proposed fuel production mandates or environmental credits should be evaluated in advance to ensure that no unintended barriers or disincentives to jet fuel production are created.

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[3] Hawaii's Renewable Portfolio Standard requires that by 2015, 15% of Hawaii's electricity must be generated from renewable resources; this increases to 25% by 2020 and 40% by 2030.
[4] Act 289 of 2000 established an objective of 40 million gallons per year of in-state production capacity.

Fuels for the Department of Defense

The Department of Defense also uses a variety of fuels, including jet fuel, and could potentially enter into long-term contracts for locally-produced fuels. Hawaii has also served, and could continue to serve, as a suitable location for research, development, and demonstration of feedstock and fuel production. Where possible, State support and awareness of these initiatives is recommended.

System Synergies

The investments made in the various steps in the supply chain, i.e. planting, harvesting, processing, transport, initial conversion, upgrading, by-product sales, fuel delivery, and storage, could be directed towards a variety of fuels – including jet fuel – and could expand, accelerate, or transform as market conditions permit.

Besides providing fuels for local use, a biofuels industry can also provide economic benefits through the availability and development of co-products (including glycerin, aquaculture feed, animal feed, enzymes, fertilizers, or specialty oils) which could support Hawaii-made products and agriculture. Understanding the potential for co-products is recommended; for some projects, co-products such as nutraceuticals, specialty oils, and animal feeds may provide revenue streams greater than that provided by the fuels.

There is also potential to support and increase activity in innovation, research, development, and demonstration of tropical agriculture and biochemical conversion technologies.

Potential

A biofuels industry of between 100 and 300 million gallons per year beyond 2023, representing about 10% of liquid fuel demand, appears to be both significant and achievable, given the right conditions, continued high or increasing oil prices, and clear and consistent public policy. Construction, manufacturing, and agricultural sector jobs would be supported. Although it is difficult to predict how a biofuel and related products industry might develop in Hawaii, employment potential from an industry using 137,000 acres[5] could create about 2000 jobs and generate revenues of $500 million to $1 billion.

Conditions and policies necessary for biofuel production and use in Hawaii to displace a significant amount of petroleum-based liquid fuel

To support biofuel production and use in Hawaii, conditions must include:

1. Investor confidence.
2. Feedstock availability.
3. Technological maturity (of fuel production, fuel delivery, and fuel use).
4. Legal and regulatory clarity and consistency.
5. A balance of long-term cost competitiveness and fuel portfolio risk management deemed by regulators to be in the public interest.

[5] Estimate of lands in Hawaii potentially usable for biofuel production; see topic area 3 in the body of this report.

Policies should:

1. Allow long-term and delayed start dates in biofuel contracts, including those for electricity generation and military fuel purchases.
2. In regulated markets, require or encourage a portfolio approach to liquid fuels.
3. Develop and allow alternatives to reliance on price forecasts from the U.S. Energy Information Administration's *Annual Energy Outlook*[6] when approving contracts for electricity or fuel.
4. Allow contiguous areas of public lands to be leased together when economies of scale are needed and appropriate.

Is any specific biofuel mandate necessary in order for biofuel production and use in Hawaii to displace a significant amount of petroleum-based liquid fuel?

Although additional fuel mandates are not currently necessary, support of biofuels for electricity generation could provide the foundation for the development of a local biofuels industry which could also serve other sectors, such as ground and marine transportation and aviation.

Should the ethanol fuel requirement in section 486J-10, Hawaii Revised Statutes, be maintained, modified, or repealed?

The requirement should be maintained or, if modified, such modification should be as consistent as possible with previous policy, since legal clarity and consistency are important to investors, land owners, and project developers evaluating the possible establishment of projects in Hawaii.

Maintaining the requirement provides the highest level of consistency in policy but does not currently recognize or count the use of non-ethanol fuels (such as biogasoline or biodiesel) that are or might be produced in Hawaii.

Modifying the requirement, such as by allowing gasoline distributors to count other biofuels (for example, biodiesel, renewable diesel, or renewable gasoline) towards their required biofuel volumes, would be consistent with the policy direction of the State and could be considered.

Repeal is not recommended, as it would be counterproductive to ongoing efforts to diversify Hawaii's energy sources, attract investment, and develop local fuel production capacity.

[6] U.S. Energy Information Administration, "Energy Price Volatility and Forecast Uncertainty," October 2009, accessed October, 2012. http://www.eia.gov/forecasts/steo/special/pdf/2009_sp_05.pdf

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LEGISLATIVE HISTORY

Due to concerns about global petroleum supplies, petroleum price volatility, and environmental impacts, biofuels have been receiving an increasing amount of attention internationally, nationally, and locally. Government policies, sizable investments,[7] and substantial technological advancements have occurred in the past decade. The International Energy Agency projects that by 2050, biofuels will supply 27% of global transport fuel.

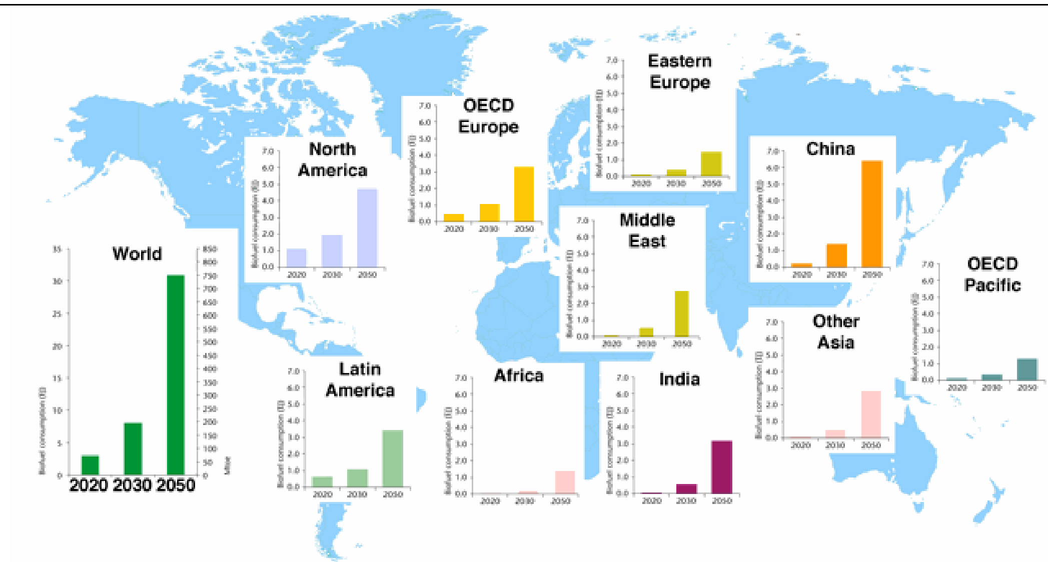

Figure 3 - Global Map of Projected Biofuel Consumption in the Years 2020, 2030 and 2050 [8]

Interest and activity is occurring in Hawaii as well, with several projects and policies under development. In mid 2011, the Hawaii State legislature passed Senate Bill 146. This was signed into law by Governor Abercrombie as Act 203, Session Laws of Hawaii 2011 (Act 203).

Act 203 directs the Hawaii State Department of Business, Economic Development and Tourism (DBEDT) to conduct a study and issue a report on "the conditions and policies necessary to expand biofuel production in the State to displace a significant amount of petroleum-based liquid fuel." The full text of Act 203 is in Appendix 1.

To fulfill the requirements of Act 203, DBEDT consulted with local biofuel producers, project developers, refinery representatives and other fuel distributors, researchers, landowners, and end users from airlines, fleets, utilities, and the military. Several fuel groups were briefed on Act 203, including the Green Initiative for Fuels Transition Pacific (GIFTPAC) group led by the Department of Defense (DoD) Pacific Command (PACOM); the Hawaii Energy Policy Forum (HEPF); the Hawaii Clean Energy Initiative (HCEI); participants in the Asia Pacific Clean Energy Summit and Expo; and others. Input was requested

[7] Over $83 billion. http://www.iea.org/media/etp/etp2012_tech_overview_05_biofuels.pdf
[8] International Energy Agency, http://www.iea.org/publications/freepublications/publication/Biofuels_foldout.pdf, 2011.

from these working groups and they were invited to share the request for information with others who might be interested in the study.

To foster additional public and stakeholder involvement, requests for input were distributed and collected via a variety of methods and events, including an on-line form.

An interim report to the Legislature was submitted at the end of 2011. It reported on tasks completed in 2011, the plan for 2012, and a report of industry and research progress prior to December of 2011. The interim report is available at http://hawaii.gov/dbedt/main/about/annual/2011-reports/2011-biofuels-interim.pdf.

Contributors to, and reviewers of, this final report are greatly appreciated.

INFORMATION REQUESTED BY ACT 203

This section provides information on specific topics identified in Act 203: (1) projected demand for liquid fuels; (2) types of feedstock that could be used; (3) availability of feedstock within Hawaii; (4) availability of feedstock outside Hawaii; (5) biofuel production within Hawaii; (6) biofuel production outside Hawaii; (7) costs for biofuel produced in Hawaii; (8) costs for biofuel produced outside Hawaii; (9) status of the technology; (10) ASTM specifications; (11) realistic timeline of production within the State; (12) benefits to the State's economy; (13) comparative emissions; (14) comparative logistics of handling and usage; and (15) comparative stability of supply and costs.

Fuel types considered in this report

The fuels identified by Act 203, and included in this report, are:

1. Ethanol
2. Cellulosic ethanol
3. Fatty-acid-methyl-ester (FAME) biodiesel
4. Synthetic or bio-based:
   Diesel fuel
   Gasoline
   Jet fuel
5. Any other type of biofuel deemed relevant to the study:
   Pyrolysis Oils
   Hydrogen (from biomass sources)

Definition of near-, mid- and long-term

For the purposes of Act 203,

"Near-term" means within three years.

"Mid-term" means from three to ten years.

"Long-term" means longer than ten years.

Specific Topics

Section 3 of Act 203 required information on fifteen (15) topics. Each topic is numbered and ordered as listed in the Act.

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(1) The State's projected demand for liquid fuels

Act 203 required “the State's projected demand in the near-term, mid term, and long-term for the biofuel's petroleum based counterparts.” Each biofuel has a petroleum based counterpart, and equipment that uses liquid fuels may use petroleum- or bio-based fuels interchangeably or in blends.

Table 1 - Projected Demand for Liquid and Gaseous Fuels in Hawaii*

Markets	**Liquid Fuels**	**Demand* (million gallons per year)**		
		Near Term (2013-2015)	**Mid Term (2016-2023)**	**Long Term (2024-2030)**
ELECTRICITY PRODUCTION	Low Sulfur Fuel Oil, Diesel, Biofuels	470-520	370-480	300-370
GROUND TRANSPORTATION	Gasoline, Diesel, Biofuels	490-530	380-480	310-380
COMMERCIAL AVIATION	Jet Fuel, Biojet	500-520	520-590	590-650
MARINE TRANSPORTATION	Bunker C, Diesel, Biofuels	100-250	100-250	100-250
MILITARY USE	Various	140-150	150-170	170-190
OTHER USES	Methane, Propane	60-70	60-70	60-70
TOTAL (Rounded)		**1840-1950**	**1700-1900**	**1600-1900**

* The table summarizes estimates presented in the sections below. Demand may be satisfied with petroleum-based or non-petroleum based liquid fuels. Some demand may be met by other forms of stored energy. Significant amounts of energy efficiency and renewable resources are not shown here. For gaseous fuels, quantities are equivalent diesel gallons based on energy content.

Biofuels may be used to augment or replace fossil-based fuels for ground transportation; electricity generation; air travel; marine transportation; military uses; or other, such as heating, cooking, or on-site equipment. Each use is discussed separately below. The table above summarizes the information presented by sector below.

FOR ELECTRICITY PRODUCTION

HISTORY

As shown in Figure 4, utility electricity sales in Hawaii have been decreasing slightly, from 10.58 terawatt-hours in 2006 to 9.96 terawatt-hours in 2011.

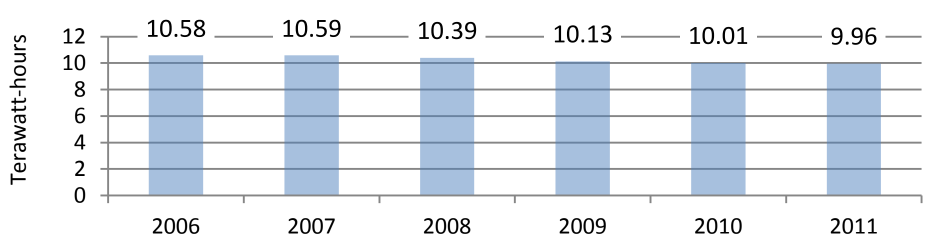

Figure 4 – Utility Electricity Sales by Year, 2006-2011 [9]

[9] DBEDT, Monthly Energy Trends

However, expenditures for fuel do not show the same gentle downward slope. The utilities' expenditures for fuel are shown in Figure 5. In the past 6 years, fuel oil costs have ranged from $500 million to $1 billion per year, with diesel fuel costs adding another $200-$300 million per year.

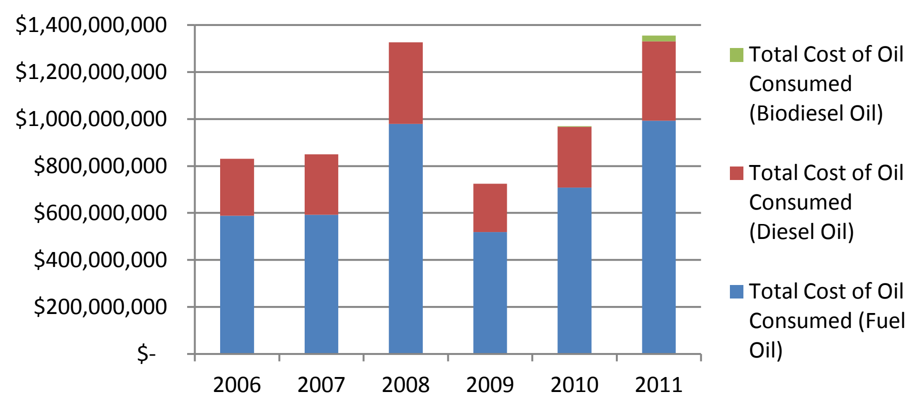

Figure 5 – Utility Fuel Expenditures by Year, 2006-2011 [10]

The large fluctuation in fuel expenditures is due to the large fluctuation in oil prices. Fuel oil prices paid by Hawaii's electric utilities are shown in Figure 6. [11]

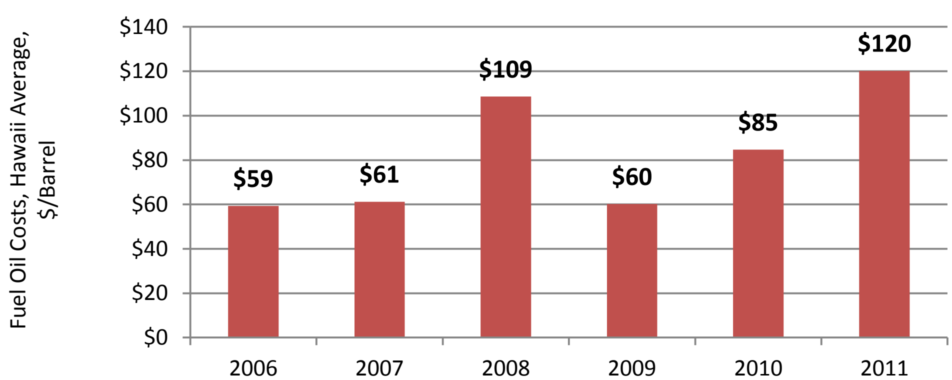

Figure 6 – Utility Fuel Oil Costs per Barrel, 2006-2011 [12]

PROJECTIONS

The electricity sector is projected to achieve a significant reduction in the use of petroleum fuels as efficiency measures and other sources of energy are brought on

[10] DBEDT, Monthly Energy Trends
[11] Note: Hawaii's oil prices change with the price of Brent Crude rather than the price of West Texas Intermediate.
[12] DBEDT, Monthly Energy Trends

line and other forms of energy storage are developed. Due to existing contracts and requirements for system stability and cost containment, however, it is highly likely that the demand for at least 300 million gallons per year will remain through 2030. One projection of liquid fuel demand for electricity production in Hawaii is shown in Figure 7.

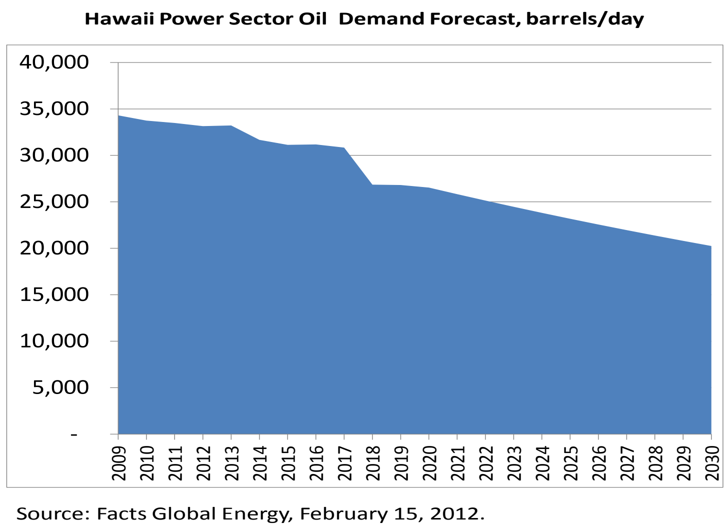

Figure 7 - Projection of Liquid Fuel Demand for Electricity Production [13]

Near Term (2013-2015): 506 MGY down to 490 MGY
(33,000 - 32,000 barrels per day).

Mid Term (2016-2023): 490 MGY down to 370 MGY
(32,000 - 24,000 barrels per day).

Long term (beyond 2023): 320 MGY
(21,000 barrels per day) by 2030.

FOR GROUND TRANSPORTATION

HISTORY

Hawaii's historical gasoline and diesel demand are shown in Figure 8. Demand for fuel from gasoline-powered vehicles has generally been between 400 and 500 million gallons per year. Demand from diesel engine vehicles has been about 10% of the gasoline demand, although the share of diesel demand has gradually been increasing (see Figure 11).

[13] "Facts versus Myths: Dispelling Common Misinformation About Hawaii's Energy and Power Situation," Facts Global Energy, 2012.

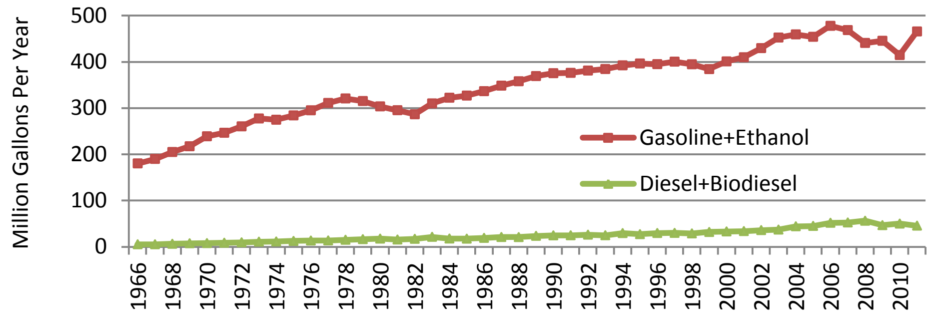

Figure 8 – Statewide Demand for On-Highway Fuels in Hawaii, 1966-2011[14]

Recent on-highway gasoline, ethanol, diesel, and biodiesel fuel demand is shown in Figure 9. A 10% displacement of gasoline has been provided by ethanol fuel blending since 2006.

The demand over the past 6 years has been about 400 million gallons per year for gasoline; 40 million gallons per year for ethanol; 50 million gallons per year for diesel; and 1 million gallons per year for biodiesel. On-highway demand for propane (also known as liquefied petroleum gases, or LPG), has been below 60,000 gallons per year and has been declining; due to the small amount, it is not shown on the graph.

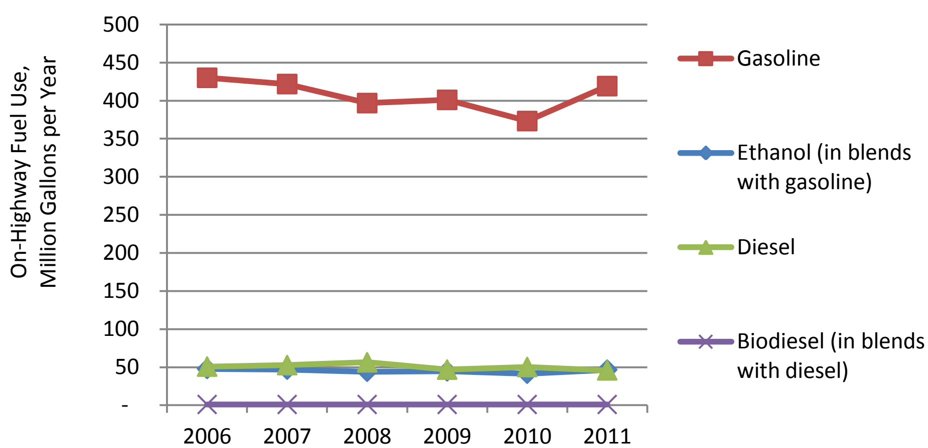

Figure 9 - Hawaii's Ground Transportation Fuel Demand, 2006-2011 [15]

[14] State of Hawaii, Department of Taxation (DOTAX), monthly "Liquid Fuel Tax Base and Collections" reports.
[15] State of Hawaii, Department of Business, Economic Development & Tourism (DBEDT), records.

The total number of registered vehicles in Hawaii is shown in Figure 10. The number has declined slightly over the six-year period, from 1,037,079 in 2006 to 1,032,481 in 2011.

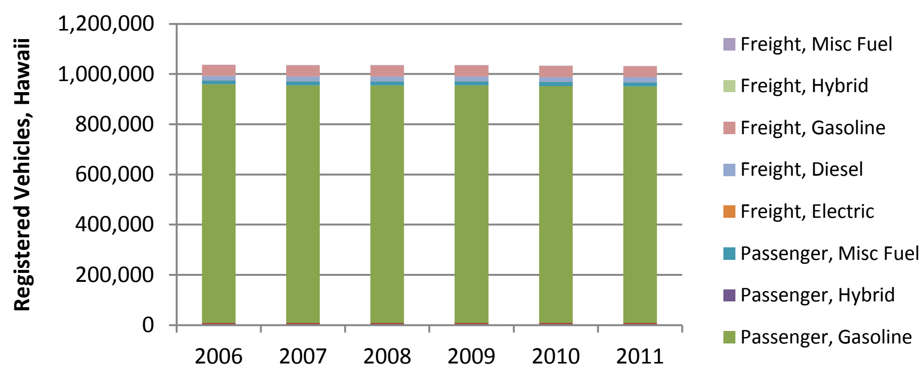

Figure 10 - Registered Vehicles in Hawaii, 2006-2011 [16]

Although gasoline still provides the vast majority of on-highway fuels in Hawaii, diesel fuel has gradually been increasing in importance, as shown in Figure 11. In Europe and Asia, diesel engines are widely used in passenger vehicles; with new diesel-fueled light duty vehicles now available in the United States, it is possible that diesel's increasing market share of passenger vehicles may be observed in Hawaii as well.

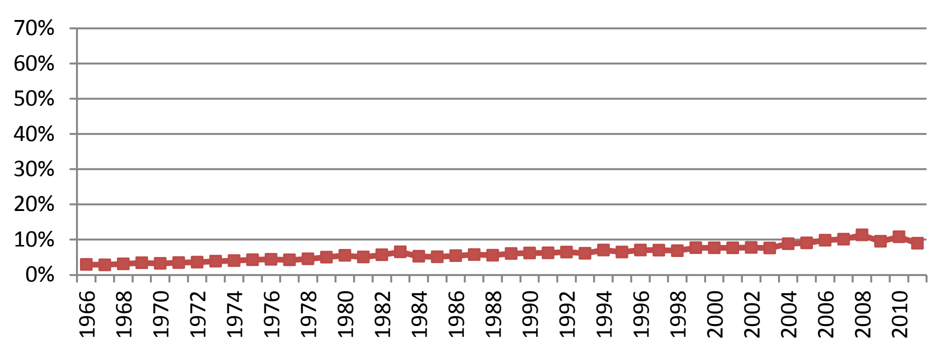

Figure 11 – Diesel Fuel as a Percent of Total on-Highway Fuels in Hawaii, 1966-2011 [17]

[16] DBEDT, Monthly Energy Trends.
[17] Calculated from DOTAX, monthly "Liquid Fuel Tax Base and Collections" reports.

PROJECTIONS

There are several factors at the local, state, and federal level that affect ground transportation fuel demand. The most significant are the fuel type and fuel economy of vehicles available from manufacturers; population; economic activity; transportation alternatives; and land use.

The Energy Information Administration's projection of transportation energy use in the U.S. (Figure 12) shows overall demand remaining relatively constant.

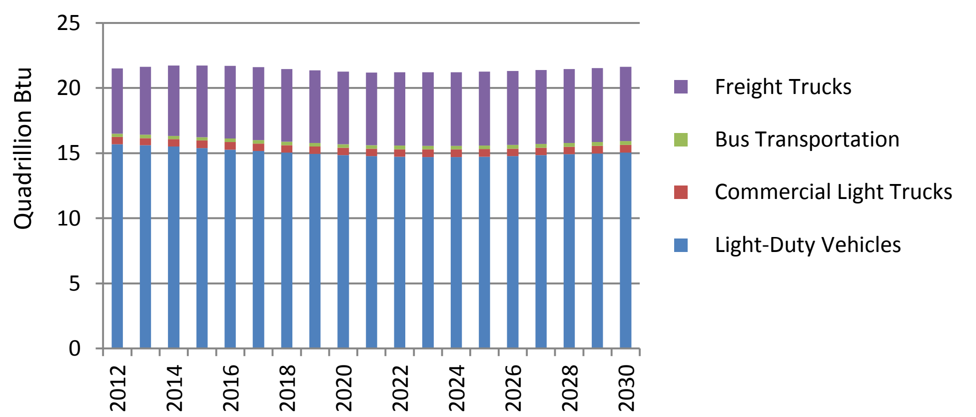

Figure 12 – Projected Demand for Ground Transportation Energy in the U.S., 2012-2030 [18]

This is consistent with other sources, such as the 2012 Outlook report by ExxonMobil, which projects personal transportation (i.e. gasoline) demand to stay flat but freight (i.e. diesel) demand to increase:

> "One of the most profound shifts in energy usage through 2040 will come from the transportation sector. The proliferation of hybrid and other advanced vehicles – along with improvements to conventional-vehicle efficiency – will result in flattening demand for personal transportation, even as the number of personal vehicles in the world doubles. In contrast, demand for fuel for commercial transportation – trucks, airplanes, trains and ships – will continue to rise sharply."[19]

As shown in Figure 13, the overall U.S. demand for liquid fuels commonly used in the ground transportation sector is also projected to stay relatively constant, with a slight reduction in gasoline and increase in diesel.

[18] U.S. Energy Information Administration, Annual Energy Outlook 2012,
[19] ExxonMobil, *2012 The Outlook for Energy: A View to 2040*, http://www.exxonmobil.com/Corporate/files/news_pub_eo.pdf

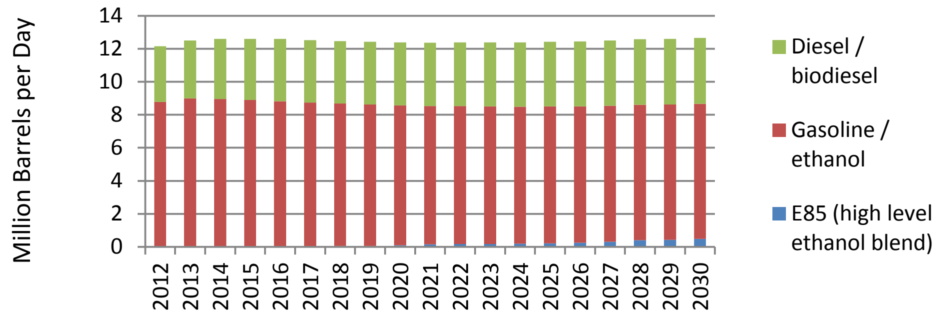

Figure 13 – Projected Demand for Selected Liquid Fuels in the U.S., 2012-2030 [20]

In Hawaii, the Hawaii Clean Energy Initiative (HCEI) is seeking a 385 million gallon per year (mgpy) reduction from the estimated transportation demand[21] of 550 mgpy by 2030. Reductions are through vehicle efficiency improvements, reduced vehicle miles of travel (VMT), and alternate fuels (including electricity, biofuels, and hydrogen). The 2008-2010 Scenario Analysis[22] indicated 235 mgpy reduced via vehicle efficiency improvements, reduced vehicle miles of travel, and electric vehicles, with 150 mgpy provided by biofuels, for a total liquid fuel demand in 2030 of 315 mgpy.

To get from the 2011 ground transportation liquid fuel demand of 512 mgpy (with ethanol and biodiesel supplying about 46 mgpy) to 315 mgpy of liquid (both petroleum- and biofuel-based) fuels in 2030, using a straight line projection, would require an average annual reduction in liquid fuel demand of 2.9%. The results of applying this rate are shown on the right side of Table 2.

Table 2 - Ground Transportation Fuel Demand Estimates, Hawaii, 2013-2030, in Millions of Gallons Per Year (mgpy)

	Baseline Ground Transportation Energy Demand (mgpy)*		**Maximum Allowable Liquid Fuel Demand to Meet HCEI Targets (mgpy)**			
Year	Gasoline Equivalent Gallons	Diesel Equivalent Gallons	Personal Transportation (spark ignition fuels**)	Freight / Transit (compression ignition fuels***)	Total Liquid (petroleum+ bio) Fuels	% reduction per year
2013	470	53	470	53	523	-2.9%
2015	469	56	443	50	493	-2.9%
2017	468	59	417	47	464	-2.9%
2023	465	66	349	40	388	-2.9%
2030	462	75	283	32	315	-2.9%

* Before efficiency, VMT reduction, electricity for vehicles.
** Gasoline, ethanol, green gasoline.
*** Diesel, biodiesel, green diesel.

[20] U.S. Energy Information Administration, Annual Energy Outlook 2012.
[21] Demand estimates were developed in 2008.
[22] Booz Allen Hamilton for the National Renewable Energy Laboratory, *Hawaii Clean Energy Initiative Scenario Analysis – Quantitative Estimates Used to Facilitate Working Group Discussions (2008-2010)*. March 2012.

FOR COMMERCIAL AVIATION

HISTORY

In 2011, commercial aviation in Hawaii consumed about 406 million gallons of jet fuel, consistent with the historical average of roughly 400 - 600 million gallons per year.

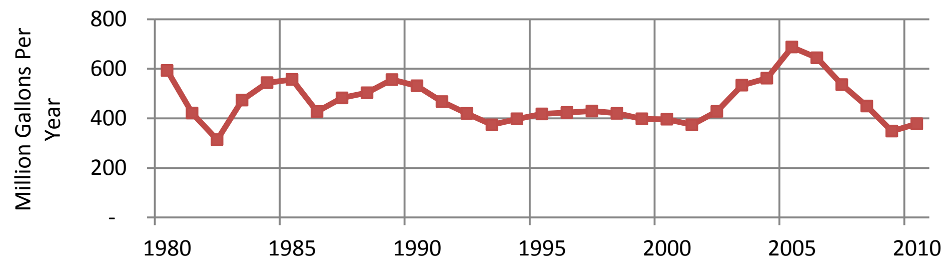

Figure 14 - Historical Jet Fuel Demand in Hawaii, 1980-2011 [23]

PROJECTIONS

Projected demand from commercial airlines in 2012 at all major airports in Hawaii (HNL, OGG, KOA, ITO, LIH) is about 495 million gallons.[24] Demand for jet fuel in Hawaii has recently increased at a moderate rate of approximately 1 to 2 percent per year[25]. The projections below are based on a 1.5 percent increase per year.

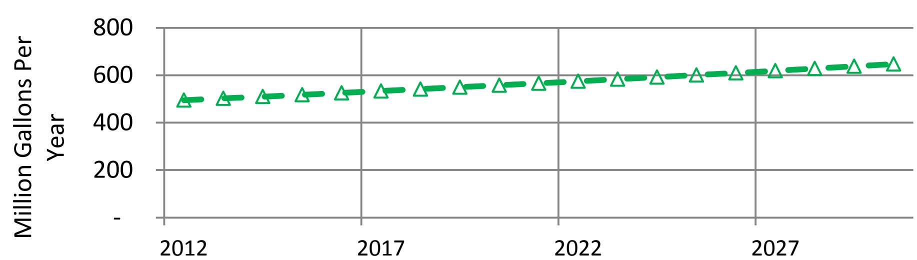

Figure 15 - Estimated Jet Fuel Demand in Hawaii, 2012-2030 [26]

Near Term (2013-2015): 502 MGY to 518 MGY

Mid Term (2016-2023): 525 MGY to 592 MGY

Long term (beyond 2023): 647 MGY by 2030.

[23] Source: Energy Information Administration, State Energy Data System.
[24] ASIGR (Aircraft Service International Group R), Jason Maga, August 27, 2012.
[25] Ibid.
[26] Using an annual average rate of increase of 1.5% per year.

FOR MARINE TRANSPORTATION

The fuels used for marine transportation are primarily bunker fuels and diesel. Quantities are highly variable. Fuel demand from international long line fishing vessels varies with international prices; cruise ship activity is also relevant. For the purposes of this report, demand was projected to remain between 100 and 250 million gallons per year in the near, mid and long term.

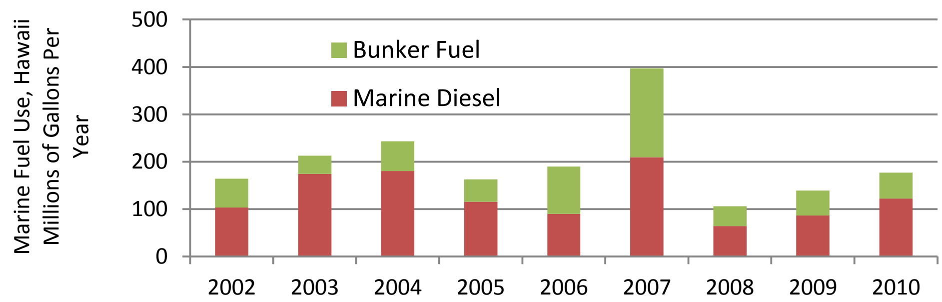

Figure 16 - Marine Fuel Use, Hawaii, 2002-2010 [27]

FOR MILITARY USE

Department of Defense demand for jet fuel (JP-5 and JP-8) and diesel fuel (F76, marine diesel, and DS2, commercial diesel) can be expected to continue a moderate annual increase[28]. A 1.5 percent per year increase has been used for the following estimated combined jet and diesel fuel demand. It should be noted that volatile or increasing fuel prices would be expected to have an impact on demand levels.

Near Term (2013-2015): 145 MGY (95 MGY jet, 50 MGY diesel), up to 150 MGY

Mid Term (2016-2023): 152 MGY to 169 MGY

Long term (beyond 2023): 187 MGY by 2030.

FOR OTHER USES

Petroleum liquids provide feedstock for the production of synthetic natural gas and propane. HawaiiGas converts naphtha from the neighboring Tesoro refinery into synthetic natural gas (SNG), which is distributed as a utility gas on the island of Oahu through approximately 1,000 miles of gas pipeline. The company also purchases propane from both Tesoro and Chevron and supplements local production by importing propane in large tankers. The propane tankers offload via pipelines located at the Nawiliwili, Kahului and Hilo harbors directly into HawaiiGas bulk storage

[27] U.S. Energy Information Administration, http://www.eia.gov/beta/state/seds; Department of Taxation, records.
[28] Joelle Simonpietri, U.S. Pacific Command / HNEI, Aug. 31, 2012.

facilities. Propane is sold on all islands as a utility and nonutility gas and is transported inter-island by two propane barges.

The SNG and propane are used predominantly for cooking, drying, water heating, forklifts and outdoor lighting.

The demand for SNG and propane is expected to fluctuate and is closely tied to the strength of the economy, the pace of new residential and commercial construction and the price of gas energy versus competing alternatives such as electricity and diesel.

(2) Types of feedstock that could be used

The materials (feedstocks) that could be used for biofuel production, shown in Figure 17, include sugars (from plants such as sugarcane or sweet sorghum); starch (such as from corn or cassava); fiber (from grasses, trees, husks, stalks, fibers from oilseeds, and from waste materials such as paper, sawdust, or other organic materials); and oil (such as jatropha, kukui, microalgae, soybean, peanut, sunflower, oil palm, or waste cooking oil).

The graphic uses colors to indicate the commercial status of the pathways in Hawaii or elsewhere. Intermediate products (sugar, starch, oil, etc.) can be converted, through different technologies (hydrolysis, gasification, pyrolysis, combustion, transesterification, fermentation, and other upgrading or synthesis processes), into final bioenergy products.

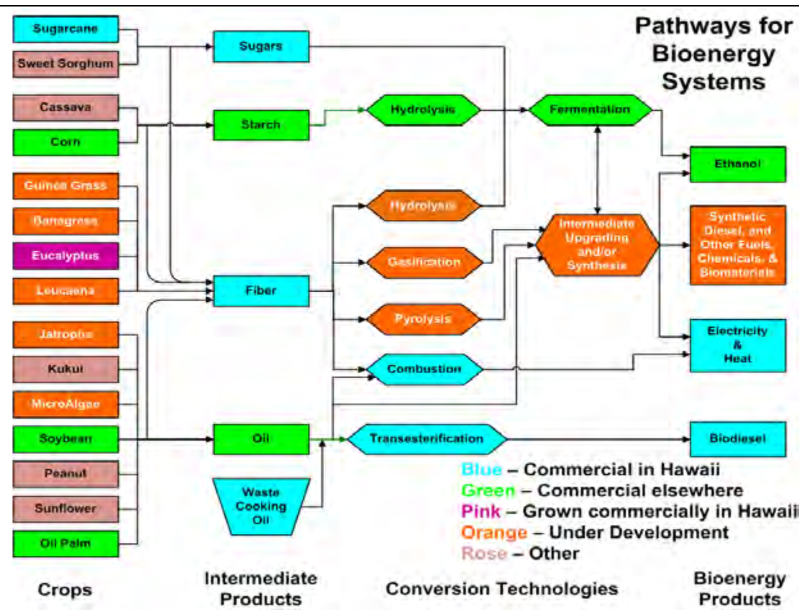

Figure 17 - Pathways for Bioenergy Systems [29]

[29] Source: Dr. Scott Turn, Hawaii Natural Energy Institute, 2012.

Most plants produce some combination of sugar, starch, fiber, oil, and other substances (for example, protein) not shown in Figure 17. Some of these other substances may be used for non-energy co-products. Co-products are discussed further in other sections of this report.

(3) Availability of feedstock within Hawaii

Feedstock may either be existing (such as by-products from other processes, or wastes) or potential (from new sources, most likely crops); see Figure 17. Several assessments have been conducted, and additional work is ongoing to better understand what lands, crops, and inputs (sunshine, water, construction) are reasonable to assume for different types of projects.

One recent assessment, completed in 2011, evaluated Hawaii lands on the basis of annual rainfall, solar insolation (i.e. energy available from sunshine), slope, zoning, and contiguous land area, all of which are important criteria for crops such as algae. The result of an analysis requiring parcels to contain not less than one thousand contiguous acres is provided in Table 3; over 76,000 acres are available with the combined attributes of less than or equal to 5% slope, insolation greater than 400 calories per square centimeter per day, and rainfall of less than 40 inches per year. A similar analysis requiring 50 contiguous acres resulted in an increase of over 50%, to about 117,000 acres. If slopes of up to 20% are permissible, the 1000 acre case increases to 398,000 acres and the 50 acre case increases to 488,000 acres.

Table 3 - Summary of Land Areas Potentially Suitable for Production of Crops Such as Algae; Minimum Contiguous Area 1,000 Acres, 2011 Study. [30]

Analysis	**Base Case**	**Base Case**	**Base Case**	**Base Case**	**Sensitivity Analysis 1**
Solar Insolation (cal/cm^2/day)	≥ 400	≥ 400	≥ 400	≥ 400	≥ 400
Rainfall	< 40 in/yr	< 40 in/yr	< 40 in/yr	< 40 in/yr	< 60 in/yr
Slope	≤ 20%	≤ 5%	≤ 5%	≤ 2%	≤ 5%
Proximity to Power Plant	-	-	10 km	-	-
Kauai	19,697	5,833	0	1,439	8,567
Oahu	49,281	15,649	11,846	1,643	19,173
Molokai	67,911	5,560	5,512	0	5,560
Lanai	22,457	7,182	7,182	0	7,182
Maui	103,415	19,965	19,720	0	19,965
Hawaii	135,711	21,794	13,334	0	24,284
Total	**398,472**	**75,983**	**57,594**	**3,082**	**84,730**

Previous studies are also available. In 2009, the *Bioenergy Master Plan* project started with former plantation lands, and took into account that many of the acres shown on maps may not be suitable for farming (too rocky, steep, or already in use). The acreage results are shown in Table 4.

[30] Hawaii Natural Energy Institute, *Analysis of Land Suitable for Algae Production, State of Hawaii*, 2011.

Table 4 - Former Plantation Lands
*Potentially Usable for Bioenergy Production (Acres), 2009 study.** [31]

Island	Public**	Private	Total
Hawaii Island	8,618	27,299	35,917
Kauai	10,766	22,149	32,915
Maui	1,109	42,371	43,480
Molokai	-	2,102	2,102
Oahu	-	22,259	22,259
Statewide	20,493	116,180	**136,673**

* Not including contiguous landholdings under 1000 acres and where sugarcane, vegetable, fruit, seed crops, or coffee are currently being cultivated
**Although not counted here since they were not former plantation lands, there are additional State lands that are potentially usable for biofuel production.

Ranges of fuel production potential are shown in Table 5. Since actual production per acre depends on many factors – crops selected, parts of the plant utilized (is the whole plant being directed to fuel production or are other parts of the plants being directed to co-products?), inputs (irrigation water, fertilizer, CO_2) – the range of fuel production potential per acre is quite broad. Achieving the highest production potential on all of the acres is considered unlikely.

Table 5 - Annual Biofuel Potential from 140,000 Acres

Potential Acres for Bioenergy	140,000	acres
Fuel Gallons (petroleum equivalent) per acre	300 - 2000	gallons/acre

Summary tables from the *Biofuels Assessment* project, completed prior to the studies discussed above, are presented below. This should be considered a high level estimate of maximum theoretical potential, unconstrained by considerations of cost, current technologies, or minimum contiguous acreage requirements.

Table 9-3. Hawai'i Agricultural Lands by Island (acres)

	Hawaii	Maui	Molokai	Kauai	Oahu	Lanai	Total
Nonprime Rainfed Lands	652,836	90,386	38,492	20,468	12,319	6,575	814,501
Prime Irrigated Lands	97,679	65,893	11,126	53,020	55,919	16,741	300,378
Total	750,515	156,279	49,618	73,488	68,238	23,316	1,114,879

Table 1-6. Maximum Theoretical Hawai'i Biofuel Production Potential

Fuel	Bio-oil	Ethanol	Green Gasoline	Green Diesel	Green Jet Fuel
Unit	LSFO equiv. million gal/yr	million gal/yr	equivalent million gal/yr	equivalent million gal/yr	equivalent million gal/yr
Energy Crops (fiber)	707	1,202	786	722	751
Cellulosic Wastes	56	95	62	57	59
Total	763	1,297	848	779	810

Figure 18 - Maximum theoretical land and biofuel production potential [32]

[31] Hawaii Natural Energy Institute, *Hawaii Bioenergy Master Plan*, prepared for the State of Hawaii, Department of Business, Economic Development & Tourism, 2009.
[32] Black & Veatch, *Biofuels Assessment,* prepared for the State of Hawaii, Department of Business, Economic Development & Tourism, 2009.

Table 6 - Annual Biofuel Potential from 300,000 Acres

Potential Acres for Bioenergy (prime irrigated lands)	300,000	acres
Fuel Gallons (petroleum equivalent) per acre	300 - 2000	gallons/acre

Figure 19 shows a graphical comparison of 2009 fuel use to the fuel production potential described above.

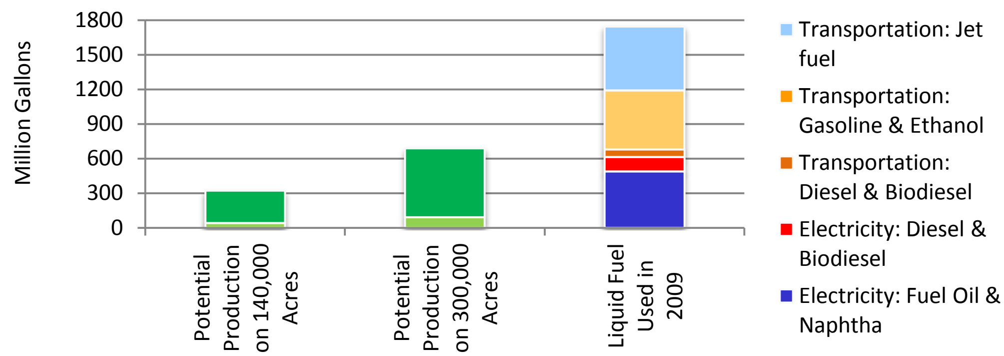

Figure 19 - Comparison of Range of Potential Biofuel Production in Hawaii

A variety of other feedstock trials, assessments, and analyses have been completed over the years, including sources for sugar (primarily sugarcane and sweet sorghum), fiber (primarily leucaena, eucalyptus, and varieties of grasses including napiergrass, banagrass and sugarcane), and oils (primarily algae, jatropha, oil palm, kukui, sunflower, safflower, camelina).

Estimates of potential feedstock availability in Hawaii depend on the number of acres, types of crops, inputs such as fertilizer and CO2, irrigation, weather, and many other site- and crop- specific factors. Assuming 136,000 acres; biomass productivities ranging from 10 to 20 tons per acre per year, and a gradual phase in between 2015 and 2023, results are as follows:

Near Term (2013-2015): 190,000 – 380,000 tons per year

Mid Term (2016-2023): 940,000 – 1,880,000 tons per year

Long term (beyond 2023): 1,370,000 – 2,740,000 tons per year

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(4) Availability of feedstock outside Hawaii

The plants and organic matter feedstock for biofuels – sugars, starches, fibers, and oils – are available worldwide and sold as commodities.

Large quantities of domestic (U.S.) materials are potentially available. A study by the U.S. Department of Energy in 2005[33] concluded that a billion ton annual supply for the bioenergy and bioproducts industry in the U.S. was technically feasible. An update to the study, completed in 2011, included an estimate of resources available in the 48 contiguous states and included an estimate of farm gate prices, with $60 per dry ton selected as a realistic, reasonable price for discussion purposes.

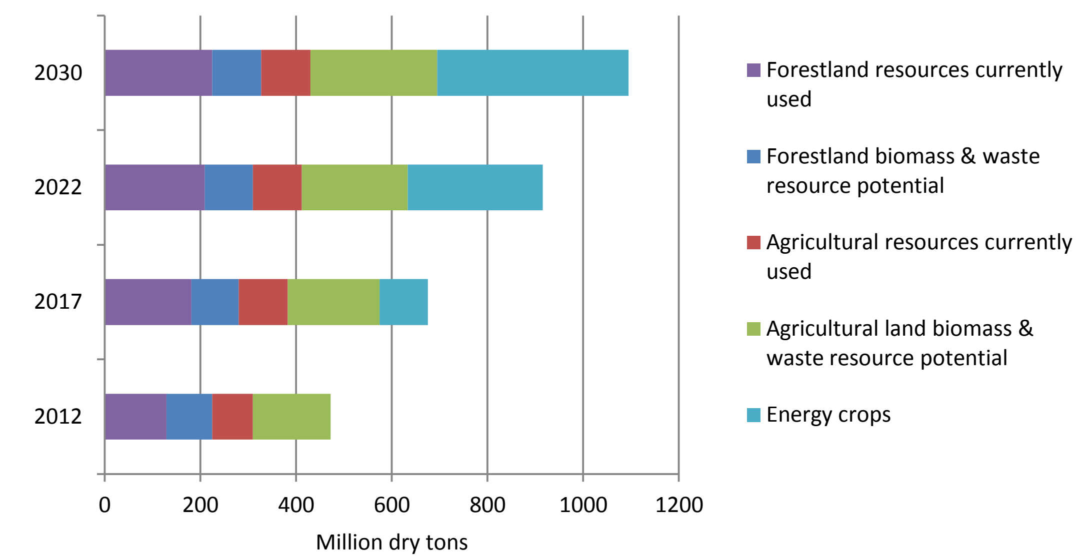

Figure 20 - Summary of currently used and potential resources at $60 per dry ton or less identified under baseline assumptions [34]

If feedstock were to be delivered to Hawaii, costs of collecting, transport, storage, and maintaining freshness of the raw materials prior to conversion would need to be determined on a case-by-case basis; minimum / maximum feasible shipment size and logistics of offloading in Hawaii harbors would also need to be considered. Figure 21, from a study prepared for the State of Hawaii's Department of Transportation, shows logistical considerations from the point of view of Hawaii's harbor facilities.

[33] Oak Ridge National Laboratory, *Biomass as Feedstock for a Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion Ton Annual Supply*, 2005.
[34] Oak Ridge National Laboratory, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, 2011.

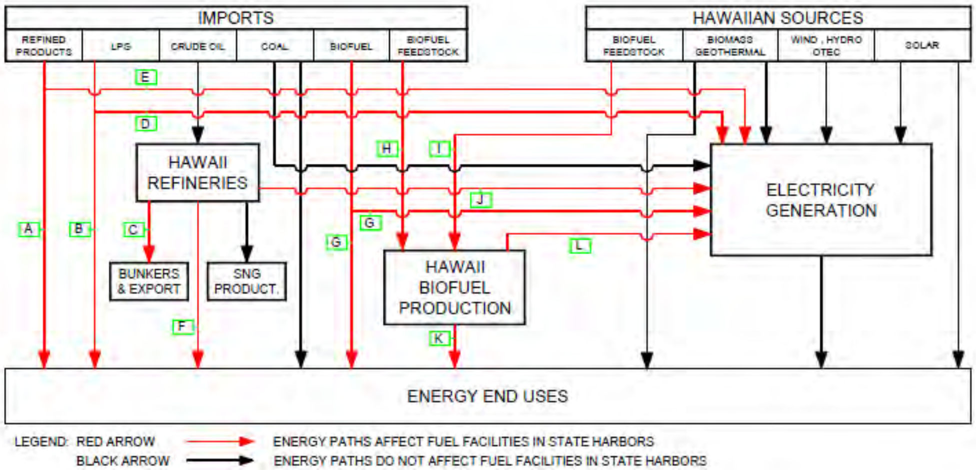

Figure 21 – Energy System Scenario Using Petroleum and Biofuels [35]

Expectations for domestic feedstock availability (not currently used) [36] outside of Hawaii are as follows:

Near Term (2013-2015):	343 million tons
Mid Term (2016-2023):	494-706 million tons
Long term (beyond 2023):	706-870 million tons

(5) Biofuel production within Hawaii

Several biofuel production facilities are operating, recently completed, under construction, and planned in Hawaii. At maturity, the biofuels industry in Hawaii is expected to have multiple inputs and a variety of output products.

Table 7 provides information on several active projects for which public information was available. Other projects, not yet publicly announced, or still in conceptual or planning stages, may also be under development.

Information on projects under development is subject to change.

[35] Marc M. Siah & Associates, *Statewide Fuel Facility Development Plan*, prepared for the Hawaii State Department of Transportation, 2009.

[36] Oak Ridge National Laboratory, *U.S. Billion-Ton Update: Biomass Supply for a Bioenergy and Bioproducts Industry*, 2011.

Table 7 - Biofuel Facilities in Hawaii

Facility	Input (feedstocks)	Output (products)	Production Capacity
Aina Koa Pono	• Cellulosic Materials: 1. Use invasive species cleared from the land; then 2. Grow energy crops. Sweet sorghum and non-seeding grasses are being considered.	Renewable: • Diesel • Gasoline Biochar soil amendment	24 million gallons per year (mgpy) (planned)
Big Island Biodiesel	• Waste cooking oil • Grease trap waste • Vegetable oils	• Biodiesel • Glycerin • Animal Feed	5.5 mgpy
Cellana	• Algae	Algae oil, animal feed	1.26 mgpy (planned)
Hawaii BioEnergy, LLC Renewable Fuels Project	• Cellulosic Materials: 1. Eucalyptus 2. Energy Grasses • Other	• Low Sulfur Fuel Oil • Renewable Jet Fuel • Renewable Gasoline • Feeds (animal, aquaculture)* • Fertilizers* • Electricity* * depends on feedstock	Fuel oil replacement: 10 million gallons per year Others: confidential (planned)
HawaiiGas Renewable Natural Gas (RNG) Plant	• Animal and plant fats and oils	Renewable: • Methane • Hydrogen • Propane	1 million gallons per year (built)
Phycal	• Algae	• Fuel oil replacement (pyrolysis oil) • Renewable Jet fuel • Renewable Diesel	100,000+ gallons per year pilot, followed by 3 mgpy demonstration (planned)
UOP Honeywell Integrated Biorefinery	• Cellulosic Materials: 1. Woody materials 2. Agricultural residues • Algae	Renewable: • Gasoline • Diesel • Jet fuel	62,000 gallons per year, pilot facility (under construction); 50 mgpy facility (potential)

AINA KOA PONO

Aina Koa Pono (AKP), a local start-up company, signed a contract to provide biofuel to Keahole Power Plant from a planned processing plant in Ka`u, on the Island of Hawaii. The company announced plans to first use invasive species cleared from the land and then to grow energy crops on 12,000 acres of farmland in Ka`u that have lain fallow for 14 years. Biofuel crops could include sweet sorghum and eucalyptus. The planned capacity is 24 million gallons per year of renewable diesel. It has been estimated that the project would create over 200 jobs in the community, including agricultural workers, facility maintenance and operation personnel, management, professional and administrative positions. The contract is subject to PUC approval.

BIG ISLAND BIODIESEL

The developer of the Big Island Biodiesel facility, Pacific Biodiesel, produces up to 1.75 million gallons of biodiesel each year in Hawaii. The main feedstock for this commercial production is waste grease and cooking oil. With the opening of their new plant on Hawaii Island, the company has the capacity to produce 5.5 million gallons per year, with an expanded feedstock intake to include waste agriculture residues as well as biofuel crops.

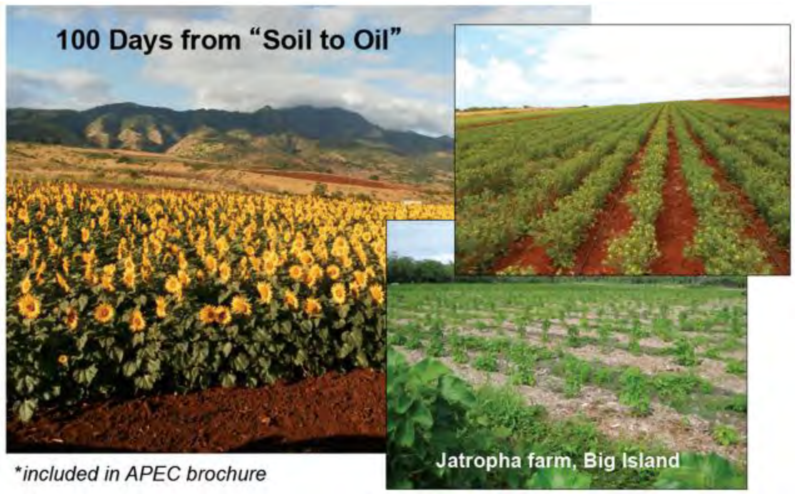

Figure 22 – Pacific Biodiesel’s Biofuel Crop Project with the U.S. Army Corps of Engineers [37]

Pacific Biodiesel signed a three-year contract, with renewal options, to supply at least 250,000 gallons of locally produced biodiesel to the 8 MW Honolulu International Airport Emergency Power Facility to be operated by Hawaiian Electric.

Pacific Biodiesel is also building a 40 ton per day crushing facility on the Big Island, to process “safflower, sunflower, camelina, soybean, jatropha, and kukui nut, with future plans to ... handle other feedstock such as palm oil kernels,”[38] performing tests of biochar as soil amendment, and working with communities on community-based agriculture projects.

CELLANA

Cellana is a developer of algae-based products with a business model of owning and operating biorefineries. Cellana’s patented ALDUO™ system couples photobioreactors with open ponds to enable low-cost, continuous production of diverse strains of microalgae. Since 2009, Cellana has operated its Kona Demonstration Facility, a 6-acre, state-of-the-art production and research facility at the Natural Energy Laboratory of Hawaii Authority (NELHA) on the Island of Hawaii.

Figure 23 - Cellana's Kona Demonstration Facility

[37] From presentation by Pacific Biodiesel at the Asia Pacific Clean Energy Summit and Expo, 2012.
[38] *Pacific Biodiesel Newsletter*, November 2012.

Cellana is a leading member of three U.S. Dept. of Energy algae consortia and a U.S. Dept. of Agriculture grant emphasizing sustainable approaches to producing biofuels and other valuable algae-based feedstocks for downstream products. Cellana's three areas of emphasis are biofuels, nutraceuticals, and animal health and nutrition.

GENERAL ATOMICS

General Atomics and its partners (including Kuenhle AgroSystems, Hawaii BioEnergy, the Hawaii Agriculture Research Center, and Ceres) participated in the Defense Advanced Research Projects Agency Algae Bio-fuel Program which had, as its objective, the development of pathways to commercial production of JP-8 (jet fuel) for less than $3 per gallon. The Phase 1 (2009-2010) target was the production of triglyceride oil from algae for less than $2 per gallon, development of dynamic cost models, and the actual production of oil and JP-8 samples of 100 liters. This facility is shown in Figure 24.

Figure 24 - General Atomics Algae-to-Jet project on Kauai, Phase 1, 2010

Figure 25 - General Atomics Algae-to-Jet Project on Kauai, Phase 2, 2011

The Phase 2 (2010-2011) scale-up, shown in Figure 25, had as its target the production of 4000 liters of JP-8, with a target cost of triglyceride oil below $1 per gallon. Oil yields of 2000 gallons per acre per year were demonstrated.[39]

HAWAII BIOENERGY, LLC

Hawaii BioEnergy, LLC entered into a 20-year contract with Hawaiian Electric Company to supply 10 million gallons per year of locally grown and processed biofuel for power generation at Hawaiian Electric's Kahe Generating Station. Crops would be grown on Kauai and, depending on the feedstocks used, co-products could include feeds (animal and aquaculture) and the production of power. The project could produce transportation fuels as well. The contract with Hawaiian Electric Company is subject to PUC approval.

HAWAIIGAS

The HawaiiGas Renewable Natural Gas (RNG) Plant is able to process up to 1 million gallons of renewable liquid feedstock.

Feedstocks include animal and plant fats and oils now sourced within Hawaii. The feedstock is thermally cracked or heated to temperatures exceeding 1,000 degrees Fahrenheit and combined with hydrogen and steam. The mixture is then passed through a catalyst to drive the desired chemical reaction.

Products include renewable natural gas (CH_4), renewable hydrogen (H_2) and renewable propane (C_3H_8) that are chemically equivalent to their fossil fuel derived counterparts.

The renewable products can be used as a fuel gas to produce the Company's SNG or blended into the SNG and distributed to the existing customer base through the existing utility pipeline.

Figure 26 - HawaiiGas Renewable Natural Gas (RNG) Plant

KUEHNLE AGROSYSTEMS

Kuehnle AgroSystems, Inc. (KAS) successfully demonstrated production of algae biomass (used subsequently for biofuels) in their algae plant run solely off industrial effluent CO2 and non-potable water. Under a site-use agreement in effect with Chevron Hawaii and with partial funding from the Office of Naval Research and the Hawaii Renewable Energy

[39] General Atomics, DARPA-funded Kauai algae facility, Congressional Briefings, Washington, D.C. (March 2012).

Development Venture, KAS connected the algae plant with piping, treatment and handling of emissions GHG (>95% CO_2) produced at the refinery's hydrogen generation plant adjacent to the algae plant.

The biomass was used to seed massive production ponds on Kauai operated by General Atomics and Hawaii BioEnergy, as well as to demonstrate KAS's own production of biojet in collaboration with Inventure Chemical and Energia Technologies.

Figure 27 - Kuehnle AgroSystems Facility at the Chevron Refinery on Oahu

PHYCAL

Phycal is developing an algae-to-fuel project on approximately 30 acres in Wahiawa. Supported by funding from the U.S. Department of Energy and industry partners, the project has completed its Environmental Assessment and construction is expected to begin in 2013.

Phycal entered into a contract to supply algae-derived biofuel to Hawaiian Electric for testing at the Kahe Generating Station on Oahu. The agreement calls for delivery of 100,000 to 150,000 gallons of algae-based biofuel at a fixed price not tied to the price of fossil fuels. The contract is subject to PUC approval.

UOP HONEYWELL

UOP Honeywell began construction in 2011 on a biofuels demonstration unit, backed by a $25 million US DOE award. The Honeywell UOP Integrated Biorefinery, located adjacent to the Tesoro refinery in Kapolei, will convert forest and agricultural residues, other cellulosic biomass, and algae into renewable gasoline, diesel and jet fuel and will be used to demonstrate viability of the technology, produce fuels for testing, and evaluate the environmental footprint of the fuels and technology. The project is scheduled to begin initial production in 2012 and to be fully operational by 2014. UOP is partnering with a number of local stakeholders.

Figure 28 - UOP/Honeywell's Integrated Biorefinery at the Tesoro Refinery on Oahu

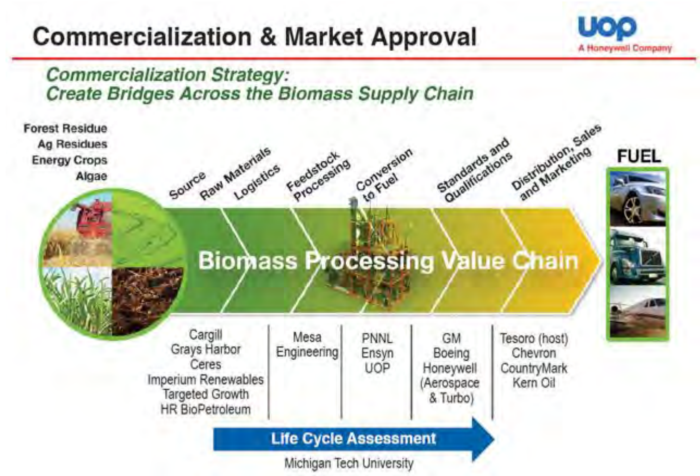

Figure 29 – UOP Project Partners Span the Biomass Value Chain [40]

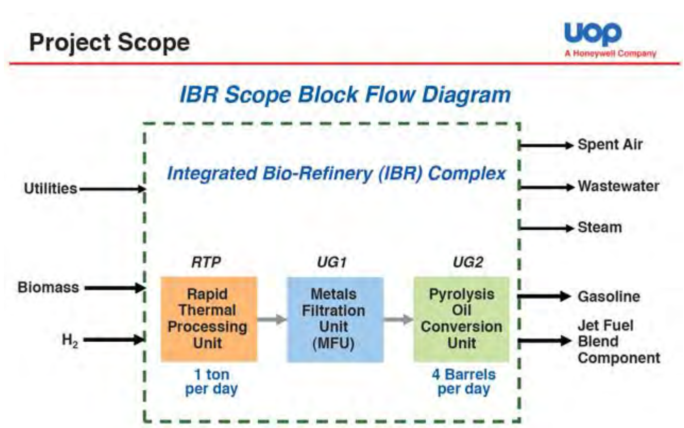

Figure 30 – Block Diagram of UOP's Hawaii Project

[40] Slides from presentation by Mike Lunda, UOP, at the Asia-Pacific Clean Energy Summit and Expo, Honolulu, 2012.

Expectations for biofuel production in Hawaii are as follows:

Near Term (2013-2015):	Existing Hawaii facilities increase production from 1 to 5 million gallons per year.
Mid Term (2016-2023):	New facilities are constructed to produce a variety of fuels, under long-term contracts with HECO and possibly the Department of Defense. The facilities also produce transportation fuels for sale into retail markets. Biofuel production volumes reach between 30 and 100 million gallons per year. Co-products support local aquaculture and agricultural activities. Hawaii's cattle and dairy industries are supported; aquaculture, poultry, and piggery operations are also supported (see topic 12, benefits to the state's economy). Research, development and demonstration of feedstock, conversion technologies, and co-products accelerate.
Long term (beyond 2023):	Fuels and co-products are competitively priced over the long term, providing a level of price and market stability for local purchasers and associated agricultural businesses. The primary fuel produced is jet fuel, although a variety of products continue to be produced at several facilities. Conditions and policies permitting, biofuel production volumes reach between 100 million and 300 million gallons per year.

The Hawaii projects described above are a part of several national and international efforts to develop integrated biorefineries. Several U.S. based integrated biorefinery projects (including the UOP project and others with Hawaii connections) are shown in Figure 31. Advanced biofuels are discussed later in the next section.

Figure 31 - Integrated Biorefinery Projects in the U.S. [41]

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(6) Biofuel production outside Hawaii

The biofuels in greatest commercial production outside of Hawaii are ethanol and biodiesel. Hawaii currently imports ethanol for use in the transportation sector and biodiesel for use in electricity generation.

Fuel-grade ethanol is produced in the U.S. and internationally. On the US mainland, most of the ethanol is produced from corn; in Brazil, sugarcane is used. As of mid-2012, ethanol imported into Hawaii to meet the ethanol blending mandate of Section 4486J-10, Hawaii Revised Statutes, comes from domestic sources, and typically has cost less than the gasoline it replaced.[42]

Although Hawaiian Electric Company (HECO) imports 3 to 7 million gallons of biodiesel per year for the 110-MW Campbell Industrial Park Generating Station, the stated preference of HECO is to source the biofuels locally when such fuels are available.

It is anticipated that domestic and international production of biofuels, particularly for the transportation sector, will continue and will expand to meet national and international demand.

[41] U.S. Department of Energy, http://www1.eere.energy.gov/biomass/integrated_biorefineries.html, last accessed October 23, 2012.
[42] DBEDT, records.

The Advanced Biofuel Market Report 2011[43] identified 240 advanced biofuel companies in the United States and Canada producing over 400 million gallons of low-carbon fuels in 2011. The majority of this production, at approximately 350 million gallons, was non-soy biodiesel.[44] This level of production is significantly below the installed capacity. It is estimated that the facilities could, if running at full capacity, produce as much as 2.1 billion gallons.[45]

Abroad, at least 25 foreign companies have the potential to export advanced biofuel to the US domestic market, and were producing 791 million gallons of advanced fuel in 2011. Two of the largest companies, Neste Oil and Argent Energy, have registered facilities under the RFS2.[46]

As stated by Shelby Neal of the National Biodiesel Board, it is expected that "biodiesel production will follow the RFS2 mandates pretty closely."

The Federal Renewable Fuel Standard (RFS2) requires 36 billion gallons of renewable fuel to be blended into the nation's fuel supply by 2022.[47]

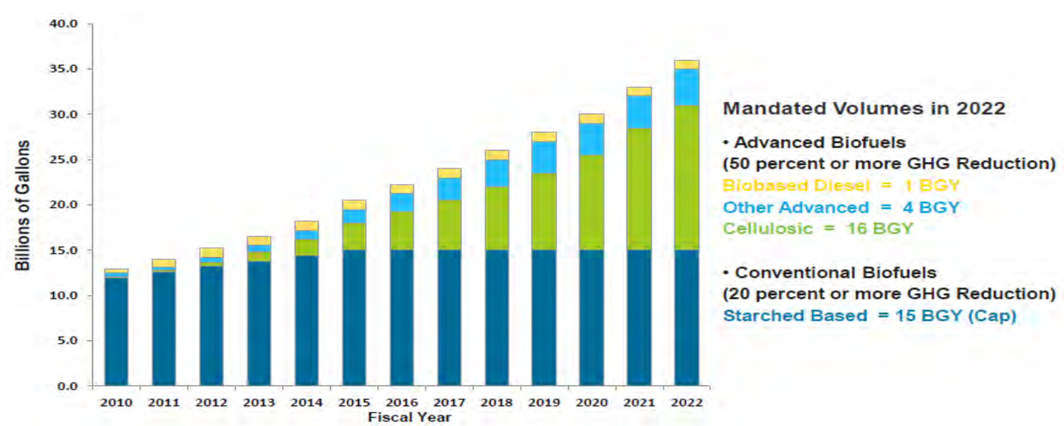

Figure 32 - Renewable Fuel Standard 2 [48]

Under the RFS2, advanced biofuel or low-carbon fuel is defined as any fuel with a carbon intensity at least 50 percent lower than the fuel it replaces. Significant reductions in carbon intensity have been made through cogeneration using renewable biomass, reusing or finding value-added commercial markets for byproducts, sourcing locally to reduce

[43] Advanced Biofuel Market Report 2011: Meeting the California LCFS, Mary Solecki, and Bob Epstein, Environmental Entrepreneurs (E2), and David Richey, Goldman School of Public Policy, August 22, 2011.
[44] Soybean Oil and Biodiesel Usage Projections and Balance Sheet, Wisner, Robert, updated 18 Feb 2011. <http://www.extension.iastate.edu/agdm/crops/outlook/soybeanbalancesheet.pdf>. Values cited are for the ''High'' case.
[45] Neal, Shelby, National Biodiesel Board. Email correspondence with Mary Solecki, E2, June 21, 2011.
[46] Advanced Biofuel Market Report 2011.
[47] U.S. Environmental Protection Agency, http://www.epa.gov/otaq/fuels/renewablefuels/index.htm, 2012.
[48] U.S. Department of Energy, http://www.usbiomassboard.gov/pdfs/reed_march2012_tac.pdf, 2012.

transportation impacts, and choosing non-food feedstocks or byproducts residual to food production.[49]

There are several cellulosic biofuels projects under development; five, with a combined total output of 21 million gallons per year, are projected by the U.S. Energy Information Administration (USEIA) to begin production in 2012 or 2013.[50] The USEIA also projects that the trend of increasing importance of biomass in the U.S. liquid fuels supply will continue.

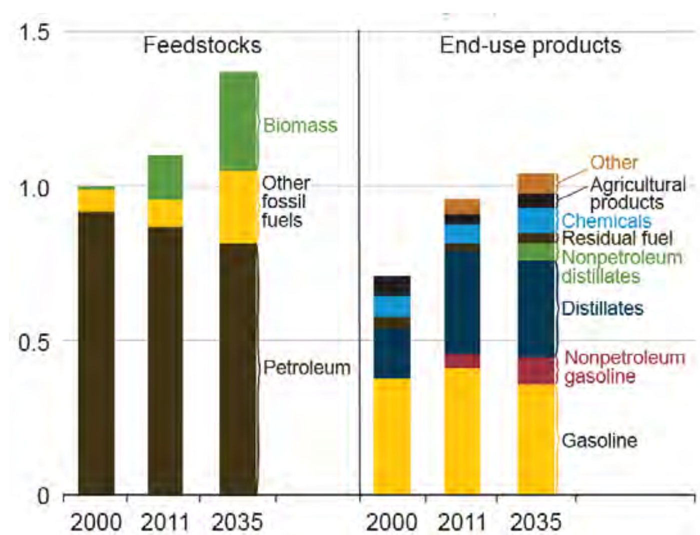

Figure 33 – Projected Liquid Fuels Industry in the U.S., Billions of Tons [51]

(7) Costs for biofuel produced in Hawaii

Biofuel costs are dependent on a variety of factors including costs of feedstock and other inputs; conversion facility costs and financing; production, distribution, and marketing; and by-product or co-product value. In topic area (8), Figure 37 provides a graphic of component prices from an international study.

Hawaii's costs and opportunities are unique. Potential co-products (electricity, methane, animal and aquatic feeds, fertilizers, specialty chemicals) are often more expensive in Hawaii, due to Hawaii's remote location and small market size. This provides a potential opportunity for biofuel production facilities to receive additional revenues from co-products to the extent that local markets exist and those local businesses are appropriately sized and are motivated to utilize local sources. This is discussed further in topic area 12.

[49] Advanced Biofuel Market Report 2011: Meeting the California LCFS, Mary Solecki, and Bob Epstein, Environmental Entrepreneurs (E2), and David Richey, Goldman School of Public Policy, August 22, 2011.
[50] U.S. Energy Information Administration, Office of Energy Analysis, Sept. 18, 2012.
[51] U.S. Energy Information Administration, *Annual Energy outlook 2012*, Fig. 42, http://www.eia.gov/forecasts/aeo/pdf/0383(2012).pdf

Biofuel has been produced in Hawaii for several years by Pacific Biodiesel using waste grease, fats and tallow that would otherwise go into a landfill. The company, which opened its first facility in 1986, was recognized as one of the first commercially viable biodiesel plants in the US. Pricing for Hawaii biodiesel on Maui, where the initial facility was located (Figure 34), has been lower and more stable than for petroleum-based diesel, particularly during petroleum price excursions.

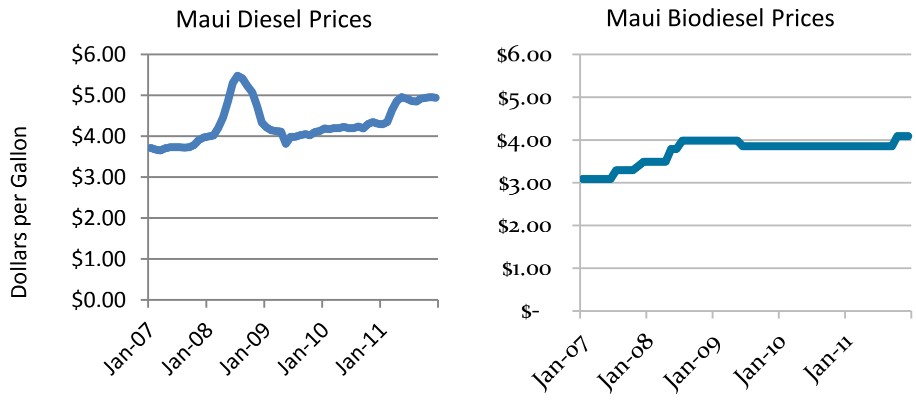

Figure 34 - Pacific Biodiesel Price History, Maui, 2007-2012 [52]

Waste feedstocks, although limited, are often low cost and may have lower startup risks than would be found with purpose-grown energy crops. Once the waste streams have been fully subscribed, however, expansion of production requires additional feedstocks: new waste or by-product streams from other sources, or purpose-grown crops with biofuel as a main product or co-product.

The value of co-products, primarily animal feed, electricity, specialty chemicals, and enzymes, has emerged as a key factor in biofuels' cost competitiveness.

Although specific cost and price projections are proprietary, there are several biofuel projects under development in Hawaii.

Some of the projects under development, including those in response to HECO's Request for Proposals (for long term biofuel contracts), include the production of other transportation fuels and additives.

Biofuel prices are dependent on fuel costs, as well as the prices and availability of competing fuels (this is discussed more under topic area 15); market demand; taxes; and incentives.

[52] Maui diesel prices: DBEDT Monthly Energy Trends report; Maui biodiesel prices: presentation by Pacific Biodiesel at the Asia Pacific Clean Energy Summit & Expo, 2012.

Project developers have indicated that, in addition to reliable and cost-effective feedstocks and technologies, they need long term contracts with delayed start dates for product delivery. Although desirable for all producers, these types of contracts are particularly important for first generation facilities which already face first mover risks.

Long term contracts can reduce the month-to-month risk that, if oil prices decline, lower-cost petroleum fuels will eliminate demand for price-stable (or non petroleum indexed) biofuels.

Cost expectations for biofuel produced in Hawaii are the following:

Near Term (2013-2015):	Existing Hawaii facilities continue to produce limited quantities, competitively priced with diesel.
Mid Term (2016-2023):	New facilities are constructed to produce a variety of fuels under long-term contracts with HECO and possibly the Department of Defense, specifically not tied to the price of petroleum. The facilities also produce some transportation fuel which are priced competitively with their petroleum-based counterparts.
Long term (beyond 2023):	Fuels and co-products are competitively priced over the long term, providing a level of price and market stability for local purchasers and associated agricultural businesses. The primary fuel produced is jet fuel, although a variety of products continue to be produced at several facilities.

(8) Costs for biofuel produced outside Hawaii

Since 2010, 3 to 7 million gallons per year of biodiesel has been imported from the Mainland for use in electric utility power production in Hawaii.

Compared to fossil-based liquid fuel quantities, the amount of biodiesel used in Hawaii for the generation of electricity is relatively small (less than 2%), as shown in Figure 35.

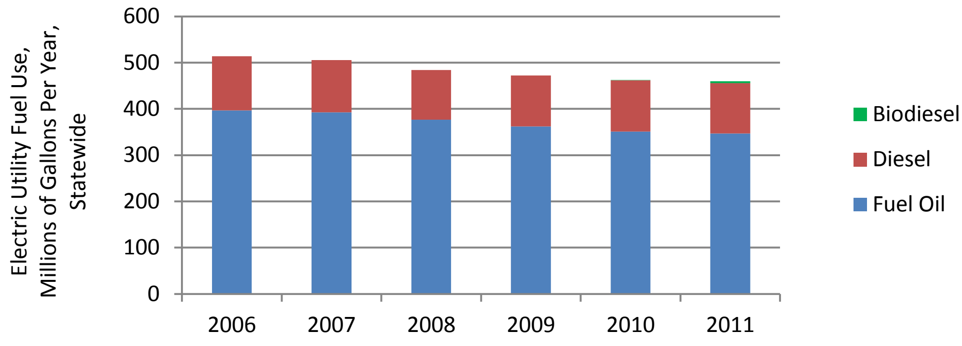

Figure 35 - Beginning in 2010, Imported Biodiesel Was Used for Utility Electricity Generation

Since biodiesel fuel imports for electricity production began in 2010, the relative cost per gallon of the imported biodiesel fuel has been significantly higher than for the fossil-based fuels used for electricity generation in Hawaii.

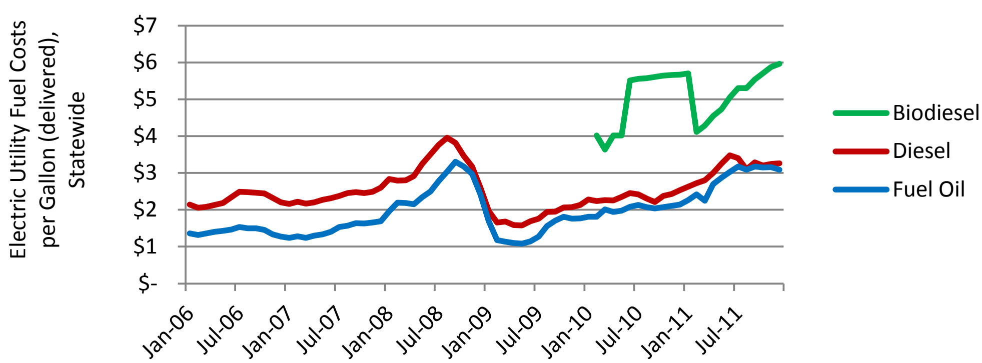

Figure 36 - Electric Utility Fuel Costs per Gallon

Biofuel producers may price the biofuel portion of their output more competitively with other fuels as economies of scale are reached and competition in the area increases, especially if the projects are able to receive significant revenues from co-products.

A report (*Biofuel Costs, Technologies and Economics in APEC Economies*) by the Asia-Pacific Economic Cooperation (APEC) Energy Working Group's Biofuels Task Force presented first-generation biofuel (ethanol and biodiesel) production costs in the U.S., Brazil, and Indonesia/Malaysia. Subsidies, to the extent possible, were removed from the calculation. The results, provided in Figure 37, illustrate the value of co-products as well as the importance of feedstock costs.

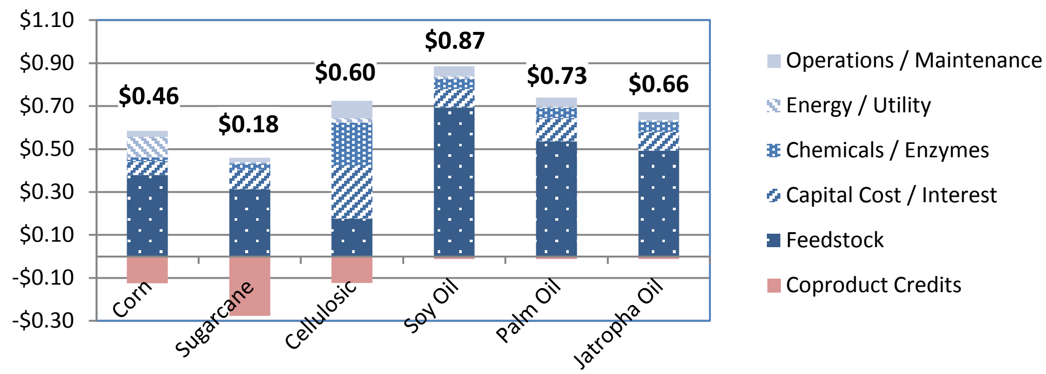

Figure 37 - Biofuels Production Cost Comparison Summary, Dollars per Liter [53]

Research, development, and demonstrations are continuing in each of the key areas, both nationally and internationally.

Recent U.S. Department of Energy production cost projections and targets indicate an expectation that, with continued attention and support, the cost of drop-in replacement gasoline, diesel, and jet fuels – "Pyrolysis to HC (hydrocarbon) Fuels," Figure 38 – will be below $3 per gallon by 2017.

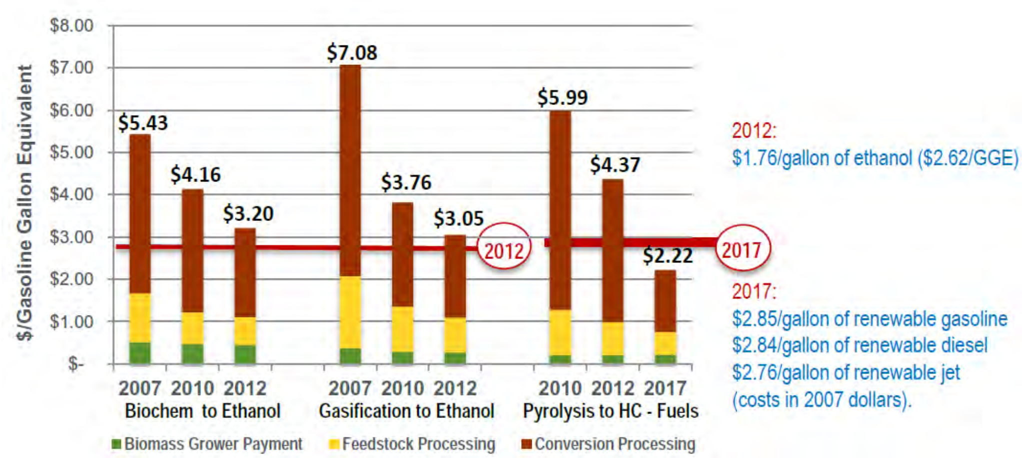

Figure 38 - Cost Projections and Targets for Ethanol and Drop-in Fuels [54]

[53] BBI Biofuels, *Biofuel Costs, Technologies and Economics in APEC Economies*, prepared for APEC Energy Working Group, 2010.
[54] http://www.usbiomassboard.gov/pdfs/reed_march2012_tac.pdf

(9) Status of the technology

A variety of technologies for fuel production are in widespread commercial use and others have reached near commercial maturity, partially in response to Federal requirements and partly in response to international concerns about global oil supplies, prices, and control.

As mentioned previously, some technologies have been in commercial use in Hawaii or internationally; others are still under development.

Fully Commercial

Ethanol via fermentation and biodiesel via transesterification are in commercial production and use across the world.

ETHANOL from starch or sugar

Ethanol is most often used as a biofuel additive for gasoline. In 2011, worldwide ethanol fuel production reached 22.36 billion U.S. liquid gallons, with the United States as the top producer, accounting for 62.2% of global production, followed by Brazil.[55] Between 2005 and 2010, the percent of U.S. gasoline containing ethanol increased from 30% to over 80%; today, almost all U.S. gasoline contains some quantity of ethanol.[56]

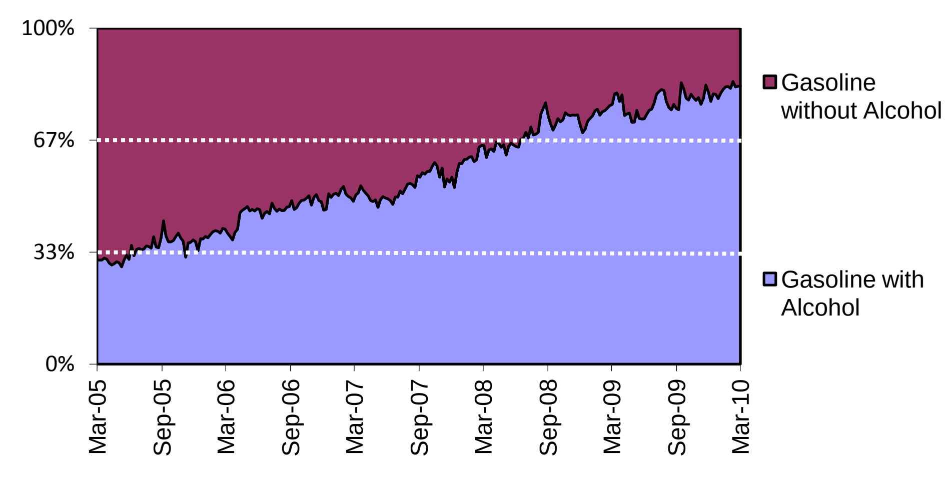

Figure 39 – Ethanol Blending in US Gasoline has Increased Steadily Since 2005 [57]

[55] "Accelerating Industry Innovation - 2012 Ethanol Industry Outlook", pp. 3, 8, 10 22 and 23, Renewable Fuels Association, March 6, 2012.
[56] U.S. Energy Information Administration, http://www.eia.gov/todayinenergy/detail.cfm?id=3070, 9/30/2011.
[57] Source: U.S. Department of Energy, Energy Information Administration, psw11.xls

Another use of ethanol fuel is in higher level blends, known as E85 (85% ethanol / 15% gasoline), which can be used in E85 flex fuel vehicles. There are several million E85 vehicles in use in the U.S., including those operating on standard gasoline in areas where E85 stations are not available. All of the E85 technologies (fuel production, distribution, and vehicles capable of using the fuels) are fully commercialized.

BIODIESEL from vegetable oil

Biodiesel is most often used as an additive to diesel fuel. Similar to ethanol, biodiesel fuel production, distribution, and vehicles are fully commercial.

The U.S. biodiesel industry produced more than 1 billion gallons of fuel in 2011.[58] This exceeded the 800 million gallon target required under the Renewable Fuel Standard (RFS).

Biodiesel use in power generation is also fully commercial. Biodiesel is used in Hawaiian Electric Company's 110 MW combustion turbine at Campbell Industrial Park and is used in Maui Electric Company's generators during startup to reduce emissions.

Technologies Under Demonstration

Several fuel production technologies are under demonstration, in Hawaii and elsewhere. Hawaii projects under construction are described under topic (5), fuel production in Hawaii.

Other projects are under development to meet the biofuel needs of Hawaii's electric utilities and of the U.S. military.

Drop-in fuels require no changes to fuel infrastructure or vehicle/aircraft/fleet technology, because they are chemically similar to traditional petroleum fuels. Drop-in fuels are the target for aviation, DOD and many ground transportation applications, as these fuels can be used in existing infrastructure and equipment, eliminating costly upgrades.

Drop-in jet fuel/green jet fuel has been developed under a grant from the U.S. Defense Advanced Research Projects Agency (DARPA) by UOP and other partners. The process converts a wide range of sustainable feedstocks like algae or camelina into a drop-in renewable jet fuel. A number of test, demonstration, commercial and military flights have been conducted using drop-in replacement fuels at a 50 percent blend, requiring no changes to fleet technology or fuel infrastructure.

This 50 percent blended fuel is being demonstrated at scale during the summer of 2012 by the US Navy. Hawaii plays host to the world's largest international maritime exercise every two years — the Rim of the Pacific Exercise (RIMPAC). The Pentagon announced in December, 2011, the largest government purchase of biofuel in history

[58] National Biodiesel Board, Production Statistics, http://www.biodiesel.org/production/production-statistics.

— 450,000 gallons for $12 million, which included substantial shipping and tracking costs, due to the demonstration aspects of the project — to fuel RIMPAC ships and aircraft in a large-scale test of the cleaner-burning alternative to petroleum. Navy Secretary Ray Mabus said during a news conference that the biofuel would be used during RIMPAC for what's been dubbed the "Great Green Fleet" aircraft carrier strike group. "We're going to have the entire strike group, aircraft and ships, sailing on a 50/50 blend of biofuel and diesel for the ships, biofuel and (aviation) gas for the aircraft," Mabus said.

Defense Logistics Agency (DLA) purchased the biofuel made from a blend of non-food waste (used cooking oil) from the Louisiana-based Dynamic Fuels, LLC, a joint-venture of Tyson Foods, Inc., and Syntroleum Corporation, as well as algae derived fuel, produced by Solazyme. The contract involves supplying the Navy with 100,000 gallons of jet fuel (Hydro-treated Renewable JP- 5 or HRJ-5) and 350,000 gallons of marine distillate fuel (diesel) (Hydro-Treated Renewable F-76 or HRD-76). The fuel will be used as part of the Navy's efforts to develop a "Green Strike Group" composed of vessels and ships powered by biofuel.

In preparation for this demonstration, the Navy recently completed testing of all aircraft, including F/A-18 and all six blue Angels and the V-22 Osprey, and has successfully tested the RCB-X (Riverine Command Boat), training patrol craft, Self Defense Test Ship, and conducted full-scale gas turbine engine testing.

Other technologies under demonstration are cellulosic ethanol production, which is of interest due to the abundance and low cost of cellulosic (grass and wood fiber) material which could be used to produce ethanol.[59]

Hydrogen can be produced from all bio feedstocks using anaerobic digestion or reforming. For example biogas from anaerobic digestion can be reformed into hydrogen.

Integration with Existing Refineries

The processing of biofuel feedstocks by existing petroleum refineries could offer system efficiencies, economies of scale, and a breadth and depth of technical know-how that would support the stability and development of the United States fuels industry. The U.S. Department of Energy is supporting partnerships between the petroleum and bio-oil industries to identify ways to integrate bio-oils into refineries.

[59] "Industrial Biotechnology Is Revolutionizing the Production of Ethanol Transportation Fuel," Biotechnology Industry Organization, 2007.

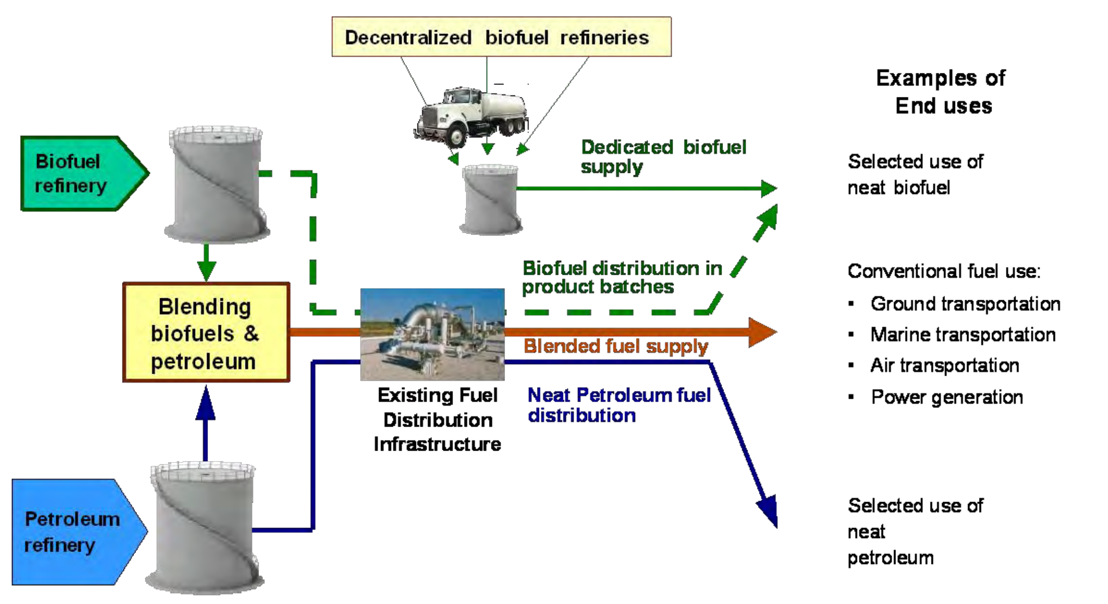

Figure 40 - Integrated Bio / Petroleum Fuel Distribution System

(10) ASTM specifications

The international standards body, ASTM International (formerly the American Society for Testing and Materials), establishes specifications, test methods, guides, and practices used and referenced by industries and governments around the world. [60] Relevant biofuel-related specifications include:

ASTM D975 – Standard Specification for Diesel Fuel Oils
Allows up to 5% biodiesel in petroleum-based diesel.

ASTM D1655 – Standard Specification for Aviation Turbine Fuels (Jet A-1)
International standard for commercial aviation.

ASTM D4054 – Standard Specification for Fuel Qualification Process for Jet Fuel.

ASTM D4806 – Standard Specification for Denatured Fuel Ethanol for Blending with Gasolines for Use as Automotive Spark-Ignition Engine Fuel.

ASTM D4814 – Standard Specification for Spark-Ignition Motor Fuel
Allows up to 10% ethanol in petroleum-based gasoline.

ASTM D5798 – Standard Specification for Ethanol Fuel Blends for Flexible-Fuel Automotive Spark-Ignition Engines.

ASTM D6751 – Standard Specification for B100, 100 percent Biodiesel Fuel.
ASTM has recently designated two D6751 levels, with 2-B for fuels meeting

[60] ASTM International website, http://www.astm.org/.

the specifications of D6751, and 1-B for premium biodiesel exceeding two standards of the D6751 specification.

ASTM D7467 – Standard Specification for B6 to B20 (up to 20% biodiesel).

ASTM D7544 – Standard Specification for Pyrolysis Liquid Biofuel.

ASTM D7566 – Standard Specification for finished, semi-synthetic fuel.

Although there are other standards bodies active in the area of biofuels, the standards established by ASTM have been recognized as internationally relevant. In 2008, the governments of the United States, Brazil, and the European Union created a joint task force to consider biofuel (ethanol and biodiesel) standards. Thousands of pages of technical documents produced by ASTM International, the Associação Brasileira de Normas Técnicas, and the Comité Europeén de Normalisation were reviewed. The standards were found to share much common ground: nine of the sixteen ethanol specifications were "in alignment;" six biodiesel specifications were compatible.[61]

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(11) Realistic timeline of production within the State

Biodiesel is currently in commercial production in Hawaii by Pacific Biodiesel, using recycled waste oils and grease. To expand biodiesel production, work is under way to grow crops specifically for the production of biofuel and animal feed. Initial results with military-funded crop trials on Oahu were successful; projects to develop animal feed co-products are gaining interest from aquaculture and livestock producers.

In 2010, Hawaiian Electric Company (HECO) issued a RFP for long term biofuel contracts to supply up to 210 MGY of locally produced biofuel from local feedstock to fuel power generation stations starting as early as July 2014. Ten proposals were submitted, and four contracts were negotiated (with Pacific Biodiesel, Hawaii BioEnergy, Aina Koa Pono, and Phycal). The contracts are and will be subject to approval by the Public Utilities Commission.

Hawaii's actions have received national attention. As noted in the "Advanced Biofuels Market Report 2011":

> "Hawaii serves as a worthwhile case study in market creation through off-take agreements. In order to meet strong state mandates for renewable electricity (40 percent by 2030), Hawaiian Electric (HECO) issued a request for proposals (RFP) to supply up to 210 million gallons of sustainably produced, renewable biofuel per year to fuel power generation stations starting as early as July 2014. This resulted in ten proposals to create new, locally sourced biofuels (Hawaii produces nearly all of its electricity from liquid petroleum derivatives). HECO and the Hawaiian Public Utilities Commission are currently vetting proposals. Once approved,

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[61] *White Paper on Internationally Compatible Biofuels Standards*, http://www.nist.gov/public_affairs/releases/biofuels.cfm

entrepreneurs can use this market guarantee to secure project financing, and to access needed resources to scale-up biofuel production.

As a small island chain, Hawaii wants to reduce risk factors of its energy supply by producing fuels locally. As a result, all proposals have been tied to a landowner, assuring access to needed land. Stimulated by strong state policy, HECO is serving as a market creator with its unique off-take agreements, and therefore develops milestones for each project to ensure success. These milestones include proof of financing, start-up instruction, test quantities, land access, lifecycle assessments, and more."

Contracts currently under consideration by the PUC for biofuels supply to HECO, if approved, must begin to deliver product no later than 5 years after contract approval but could theoretically start as early as July 2014.

(12) Benefits to the State's economy

Hawaii's major economic sectors are dependent on readily available and reasonably priced fuels. Diversification of fuel supplies can help to reduce the negative impacts of petroleum price volatility.

Energy expenditures are a significant part of Hawaii's economy. As shown in Figure 41, raw energy costs as a percent of gross state product have about doubled since the 1990s.

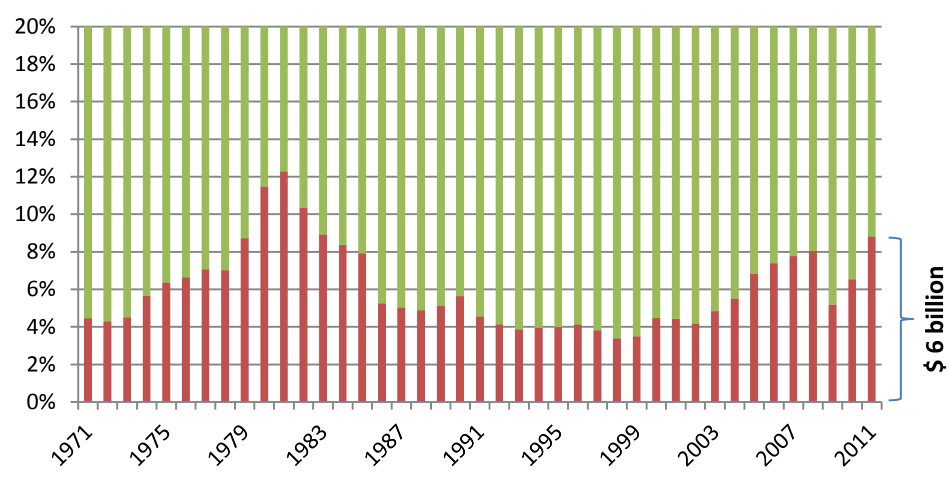

Figure 41 - Energy Costs as Percent of Gross State Product [62]

Keeping more of these funds in Hawaii — to create local jobs, invest in local infrastructure and assets, revitalize agriculture, reduce dependence on imported food and feed, and attract funding for research and development — could strengthen and diversify Hawaii's economy.

[62] State of Hawaii, Department of Business, Economic Development & Tourism, 2012.

Also, local energy, food, and feed production could help to maintain availability, reliability, and price stability of food and energy through natural disasters, economic disruption, or wartime and help to sustain emergency and critical operations for longer durations before resupplies are needed.

Job retention and creation

Industry input to the State Energy Office indicates the number of ongoing jobs created or retained, should the proposed biofuel projects come to fruition, would be over 500.

Construction

Industry input to the State Energy Office from biofuel project developers indicate construction spending of over $560 million for targeted projects in Hawaii, which would generate an estimated 2400 construction-related jobs.[63]

Strengthen Hawaii's Agricultural Sectors

There is great interest in the potential of locally produced animal feed to benefit the aquaculture, as well as cattle and dairy industries in Hawaii.

Currently, animal feeds are imported to the state, significantly increasing the cost of producing beef and milk. The cattle industry in Hawaii has declined to only one third of its former size; 50,000 head of cattle are exported each year. One estimate[64] is that 130,000 tons of feed could finish these cattle in-state. A 5.5 million gallon per year biodiesel facility using local oilseeds with 30% oil content (20,625 tons of crop oil per year), could generate an additional 68,750 tons of animal meal each year. With two such plants, running on crop oils, sufficient animal feed could be generated to finish all the cattle in Hawaii, and spur growth of this industry in the state.

Fuels and fertilizers are a significant cost in farming operations, and they both rise with fossil fuel prices. Several farmers have found that producing their own biofuel and fertilizer, along with their cash crops, reduces the effects of oil price instability on their farming operations.

Trials are underway to also test the use of biofuel crops as rotational crops, for soil restoration, in carbon sequestration, and for use on marginal lands. These projects are an ideal fit with Hawaii's strong performance in agricultural research and development.

[63] State of Hawaii, Department of Business, Economic Development, and Tourism, 2012.
[64] Bob King, Pacific Biodiesel, Sept. 1, 2012.

Other Co-products

There is also potential for other types of high value co-products, including glycerin, fertilizer, nutraceuticals and specialty oils.

Fuel price stability and security of supply

Locally-produced biofuels offer an opportunity to reduce the impacts of volatile petroleum prices, as well as energy security issues. This is discussed in more depth under topic 15.

Research and Innovation

Several of Hawaii's research entities – including the University of Hawaii's Hawaii Natural Energy Institute and the College of Tropical Agriculture and Human Resources; Hawaii Pacific University's Oceanic Institute; and the Hawaii Agricultural Research Center – along with public and private organizations, have, individually and in partnerships, conducted a variety of projects to develop crops, crop management techniques, harvesting equipment, processing technologies, co-product optimization, and a wide variety of in-depth analyses on topics ranging from invasiveness of crops to legal and regulatory issues preventing access to land, economic and business modeling, water resources, animal feed quality, pollution assessments, and many others.

With year-round growing conditions, a variety of climate types, and a wealth of crop, environmental, and business specialists, as well as engaged and active fuel users, refiners, and utilities, Hawaii provides an excellent set of conditions for a variety of research and innovation activities.

(13) Comparative emissions

Tests conducted by HECO confirm lower emissions for biodiesel and straight vegetable oil compared to diesel and low sulfur fuel oil. In HECO's Kahe Unit 3 Co-firing Demonstration Project, crude palm oil was used at blends of 0% to 100% with low sulfur fuel oil at Hawaiian Electric's Kahe Power Plant in Unit 3. The results of this project showed a 26-29% reduction of nitrogen oxides and a 67-94% reduction of sulfur dioxide along with other emissions.[65]

Tests of biodiesel blends used in diesel generator sets have produced lower carbon monoxide (CO), sulfur dioxide (SO_2), and particulate emissions, but can result in higher emissions of oxides of nitrogen (NOx).[66]

[65] Hawaii Electric Company, Cecily Barnes, Oct. 3, 2011.
[66] Kauai Island Utility Cooperative, Brad Rockwell, Dec. 19, 2011.

Drop-in biojet fuel can offer a 65 to 80% reduction in greenhouse gas emissions relative to petroleum-based fuels, and drop-in green diesel can lower emissions by up to 80% compared to petroleum diesel.[67]

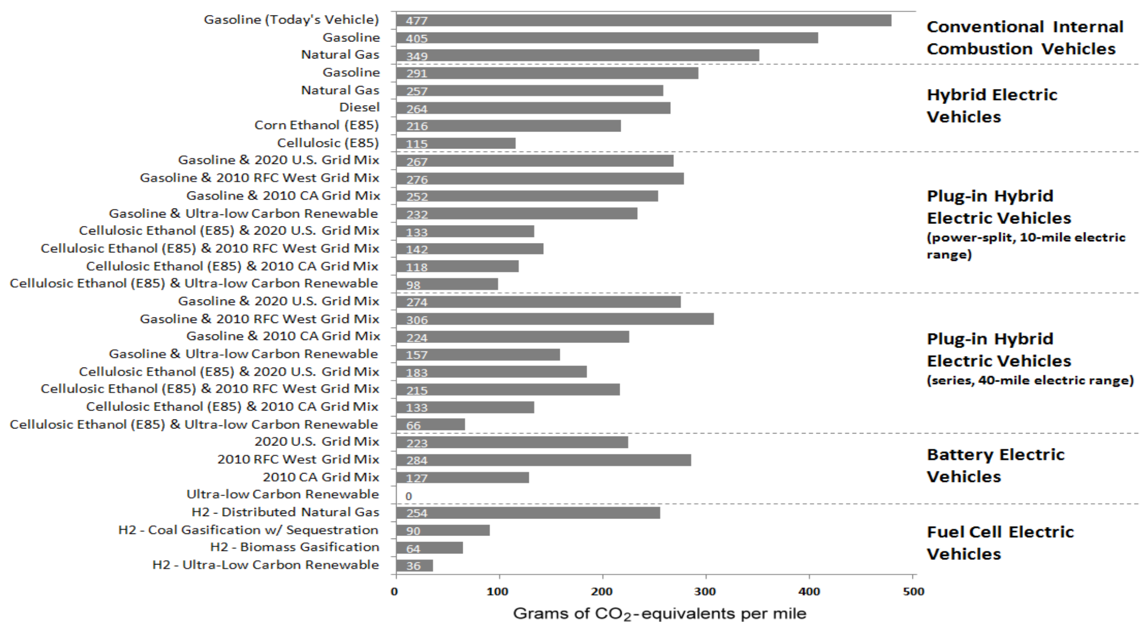

Figure 42 - Well-to-Wheel Emissions of Carbon Dioxide [68]

(14) Comparative logistics of handling and usage

Gasoline, diesel, jet fuel, low sulfur fuel oil, naphtha, and bunker fuels are either produced on Oahu from crude oil shipped in to the refineries at Campbell Industrial Park or shipped in to Oahu as refined products. From Oahu, refined products are shipped to the neighbor islands on fuel barges. A fuel distribution diagram for Hawaii is provided in Figure 43.

Biodiesel is currently produced in Hawaii and transported via tanker truck to fueling stations across Oahu. It is also produced and sold on Maui and the Island of Hawaii.

Ethanol is imported from the continental US to Oahu, delivered to and blended with gasoline at terminals on Oahu, Maui and the island of Hawaii, then distributed and sold through normal gasoline retail channels.

[67] UOP Honeywell, http://www.uop.com/processing-solutions/biofuels/.
[68] Oak Ridge National Laboratory, *Transportation Energy Data Book, Edition 31*, 2012.

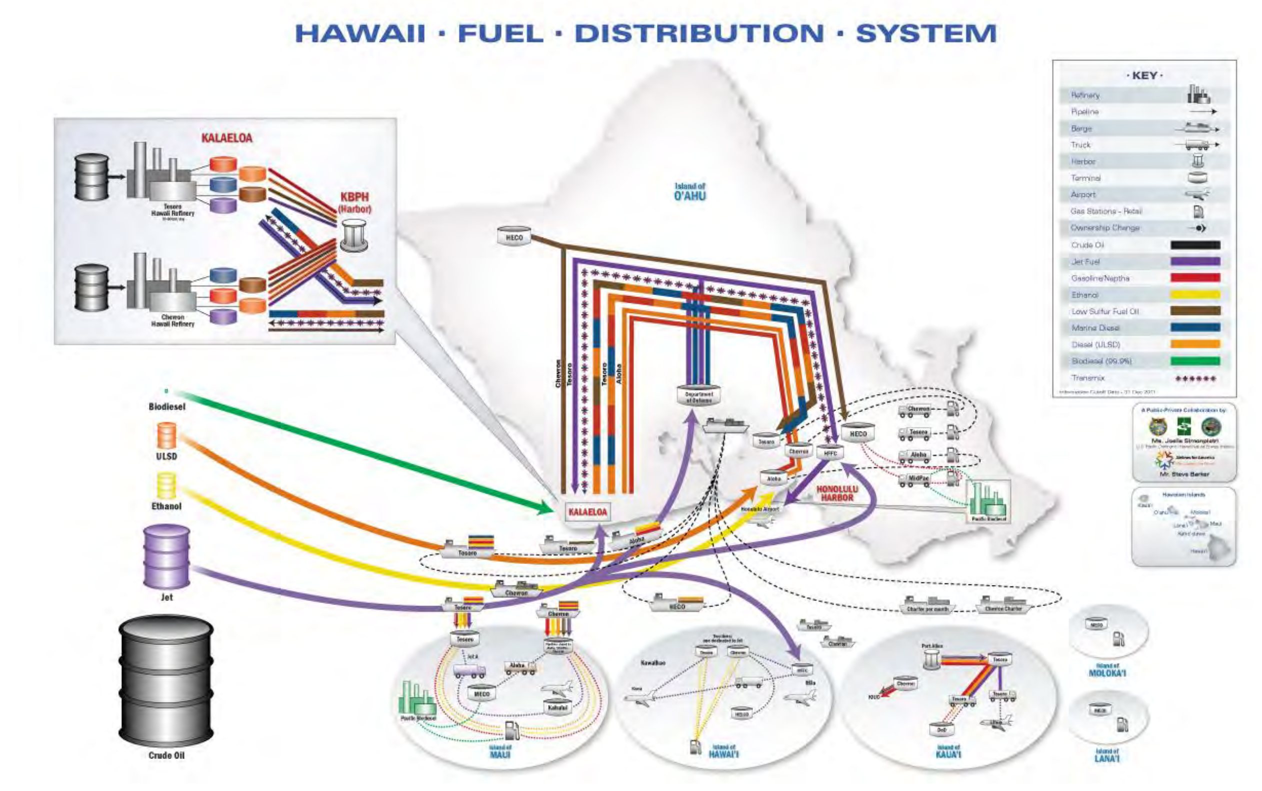

Figure 43 - Hawaii Fuel Distribution System [69]

In a previous legislative session, a bill[70] to mandate that all the diesel fuel sold in the State of Hawaii contain five per cent (5%) biodiesel was under discussion. Members from US Pacific Command (PACOM), Airlines for America (formerly known as the Air Transport Association) and Defense Logistics Agency Energy (DLA Energy) voiced concern, in both formal and informal meetings, on the great risk that exists with cross-fuel contamination within the multi-product fuel pipeline delivery system that is utilized by the refiners in Oahu. DLA Energy stated support for the principles of clean energy and the use of incentives to encourage the local production of renewable fuels but voiced concern about the potential for cross-contamination of fuel products if mandated biodiesel blends were to be transported through the same multi-product fuel pipeline delivery system used to transfer Jet fuel and diesel products to Joint Base Pearl Harbor Hickam and the Honolulu International Airport.

The practice of multi-product fuel pipeline delivery system is efficient, practical, and environmentally sound. Quality assurance procedures for handling interfaces between products, together with laboratory testing requirements, are utilized for quality assurance. The bio-component in biodiesel (Fatty Acid Methyl Ester, or FAME) is a surface-active material that can adhere to the inner wall of fuel pipelines, fuel tank walls, vehicles, and distribution manifold points as biodiesel is pumped through them. The FAME can then be

[69] Source: Ms. Joelle Simonpietri, U.S. Pacific Command / HNEI, and Mr. Steve Barker, Airlines for America, 2012.
[70] 2011: SB146 HD1; SB146 HD2.
http://www.capitol.hawaii.gov/Archives/measure_indiv_Archives.aspx?billtype=SB&billnumber=146&year=2011

picked up from these areas when another fuel, such as jet fuel, is pumped through the same multi-product distribution points. FAME can then contaminate the jet fuel by impacting the fuel's thermal stability that leads to carbon-based deposits (coking) and impacting the freezing point of the fuel resulting in gelling. These conditions result in engine operability problems and possible engine flameout.

There was concern stated that introduction of biodiesel into the multiproduct system and interisland barge systems could result in significant quality problems for the aviation and marine sectors. The current jet fuel specification limits FAME to 5 parts per million. Contamination of over 30 parts per million could disrupt air operations and potentially close Hawaiian airports. Birmingham airport was closed temporarily and Heathrow International narrowly avoided a similar fate due to FAME cross contamination. In response to these and other incidents, the international aviation industry enacted strict measures to protect the jet fuel supply. The International Aviation Transport Association, the European Institute, the Joint Inspection Group (JIG) as well as the US Department of Defense have published revised procedures and guidance for the shipping and handling of jet fuel to prevent and mitigate FAME cross contamination.

For marine traffic infrequent exposure to small quantities of biodiesel may be acceptable in the warm Hawaiian waters but if the ship sails into cold climates the bio component can solidify and clog filters. Biodiesel is highly hydrophilic (absorbs moisture) and retains water, providing a medium for the promotion of microbial growth. This growth causes fuel system corrosion, and accelerated plugging of fuel filters and coalescing oil/water separators. Given that the great majority of Navy ships stationed at and supporting Joint Base Pearl Harbor Hickam have seawater-compensated ballast fuel tanks, the contamination of FAME in the diesel fuel would seriously degrade the performance of those combatant and support ships. In response the International Standards Organization and the US Department of Defense have published revised quality standards for marine fuel aimed at minimizing FAME cross contamination.

Biofuel production in Hawaii is an important step in the roadmap to greater energy security, economic stability and achieving the 70% goal of clean energy by 2030. If biodiesel is mandated, intensive controls must be put in place to protect both the aviation and marine sectors. The transportation of biodiesel must be entirely and completely segregated from all the multi-product pipeline and distribution delivery systems that are dedicated to jet fuel and marine diesel products to avoid cross-contamination and to ensure a safe and reliable fuel delivery system.[71]

Concerns over cross-contamination limit the number of avenues open for distribution and sale of some biofuels. Drop-in biofuels, when fully certified and accepted by all users, would avoid these issues.

[71] United States Department of Defense, Defense Logistics Agency (DLA) Energy, Jan. 11, 2012.

(15) Comparative stability of supply and costs

Petroleum prices have historically been volatile. As shown in Figure 44, over the past 10 years oil prices have increased from under $25 per barrel to over $100 per barrel.

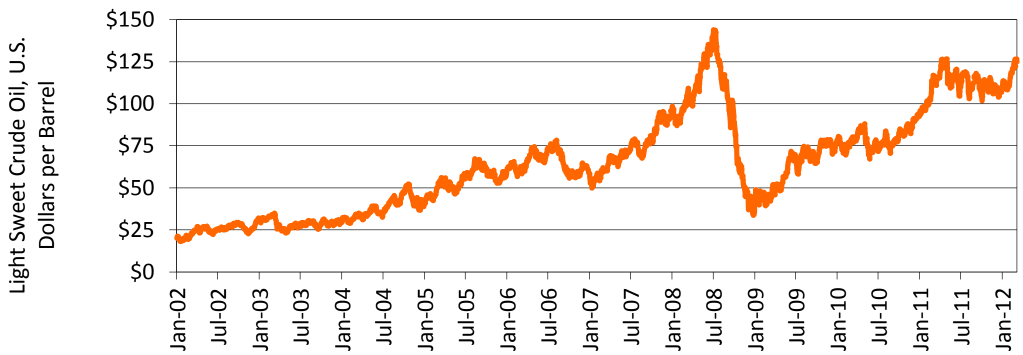

Figure 44 - Crude Oil Spot Prices (Brent), 2002-2012

Volatility in petroleum prices is expected to continue, and prices are difficult to predict. Each year, the U.S. Department of Energy publishes an *Annual Energy Outlook* which is often used as a reference for making decisions about investments or policies that will be affected by fuel prices over the projection period. As shown below, however, the projections vary significantly from year to year.

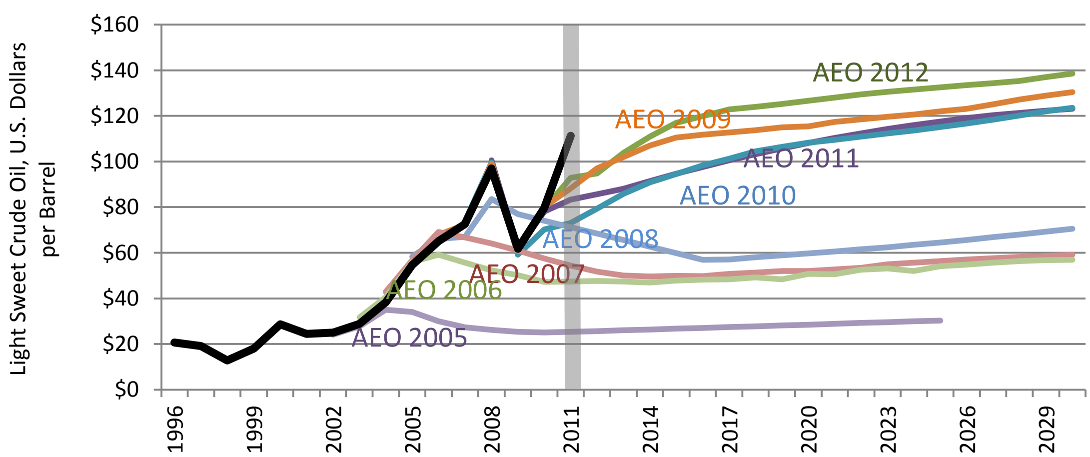

Figure 45 - Crude Oil Reference Case Price from the Annual Energy Outlook (AEO) -[72]

Given the significance of fuel costs to Hawaii's economy (see GDP chart), and difficulty in

[72] U.S. Energy Information Administration, *Annual Energy Outlook*, annual, 2005-2012.

projecting future costs, a portfolio approach to fuel supplies makes sense for the health of Hawaii's economy.

UTILITY CONTRACTS

Approximately one third of all petroleum imported to Hawaii is consumed in electricity production. In order to meet the State's Renewable Portfolio Standard for 40 percent renewable energy by 2030, Hawaii's electric utilities are including biofuels as part of their renewable energy plans.

The biofuel projects developed in response to Hawaiian Electric Company's Request for Proposals (see topic area 5) have proposed prices that are not tied to the price of oil. Such an approach would contribute to price stability of the Hawaiian Electric Companies' fuel portfolios.

The strategic plan of the Kauai Island Utility Cooperative (KIUC) calls for 50% of KIUC's electricity to come from renewable sources by 2023. Currently, 11 percent of KIUC's energy is derived from renewable resources, with the remainder of their power generated from diesel and naphtha.

USDA / USDOE / USDOD

In August of 2011, the Secretaries of Agriculture, Energy and the Navy announced an intention to invest up to $510 million during the next three years in partnership with the private sector to produce advanced drop-in biofuel to power military and commercial transportation[73] under the authority of the Defense Production Act (DPA), Title III. The objective of the Memorandum of Understanding (MOU) is the construction or retrofitting of multiple domestic commercial or pre-commercial scale advanced drop-in biofuel plants and refineries to support the Navy's goal of deploying a "Green Strike Group" by the end of 2012 and "Great Green Fleet" by 2016 fueled in part with a 50/50 blend of drop-in biofuel (hydrotreated renewable jet fuel). The slide below summarizes benefits of creating a national biomass economy.

[73] Lane, Jim; "Solazyme, Dynamic Fuels score big US Navy Aviation Fuel Contracts," *Biofuels Digest*, December 6, 2011.

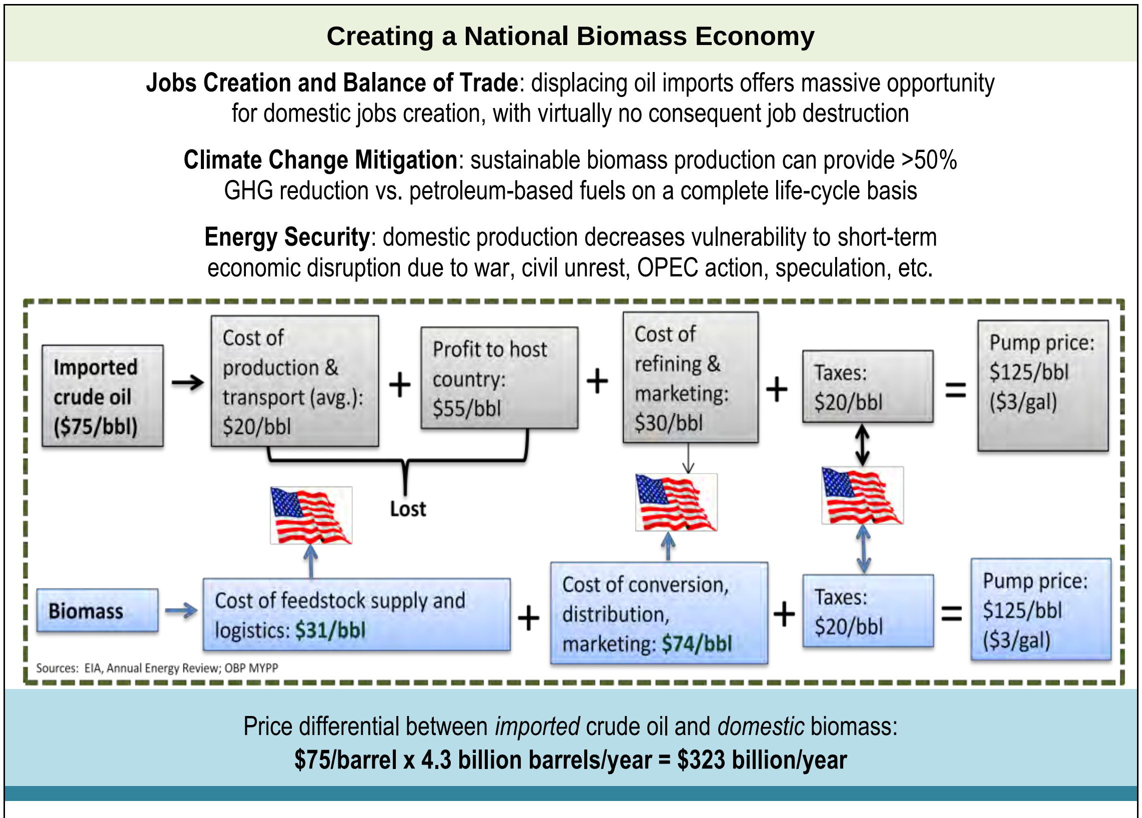

Figure 46 - Benefits of Creating a National Biomass Economy [74]

Summary

The topics surveyed in this section – fuel demand, feedstocks, technologies, logistics, emissions, and benefits – indicate that the development of a significant biofuel production capability in Hawaii is feasible and could meet a portion of Hawaii's projected fuel demand while providing a measure of energy security, economic diversification, and price stability.

Government policies can play a role in the success of the industry. Studies suggest that the combination of market forces and public policies have put the advanced biofuel industry in the United States on a path to produce significant amounts of low-carbon fuels in the next few years.[75] These reports find that investment, not technology, is the biggest market barrier and that regulatory certainty is needed to ensure market stability.[76]

The conditions and policies necessary for success are discussed in the recommendations section of this report.

[74] Reed, Valerie; Office of Biomass Programs, United States Department of Energy; "*Advanced Biofuels and the RFS*," presentation at *Advanced Biofuels and the RFS Workshop*, June 13, 2012.
[75] Advanced Biofuel Market Report 2011: Meeting the California LCFS, Mary Solecki, and Bob Epstein, Environmental Entrepreneurs (E2), and David Richey, Goldman School of Public Policy, August 22, 2011.
[76] Ibid.

RECOMMENDATIONS

Support for a biofuel industry in Hawaii is recommended for reasons of energy security, reduction in energy price volatility, and economic diversification. Biofuels grown and produced in Hawaii, with associated co-products (such as food, feeds, fertilizers, nutraceuticals or specialty oils), could retain some of the billions of dollars spent in Hawaii annually on imported fuel, feed, and other products. Local production capability would also provide a measure of energy and food security in the event of supply disruptions or shipping blockades. Finally, innovative solutions in the areas of crop optimization, fuel processing technologies, and co-product development could strengthen Hawaii's growing reputation as a successful location for research, development, demonstration, and commercialization.

Government support, whether through mandates, regulations, taxes, grants, fees, subsidies, or other measures, can be important to the establishment and long-term viability of a biofuels industry, potentially accelerating or decelerating interest and investment.

To compile current information for consideration when crafting Hawaii policies related to biofuels, the Hawaii State Legislature, in Act 203 of 2011, required the Energy Resources Coordinator (i.e. the Director of DBEDT) to report on conditions and policies necessary for biofuels production and use in Hawaii to displace a significant amount of petroleum based liquid fuel. To fulfill the requirements of Act 203, DBEDT consulted with local biofuel producers, project developers, refinery representatives and other fuel distributors, researchers, landowners, and end users from airlines, fleets, utilities, and the military. A summary of the input received is provided below.

Conditions and policies necessary for biofuel production and use in Hawaii to displace a significant amount of petroleum-based liquid fuel

To support biofuel production and use in Hawaii, conditions must include:

1. Investor confidence.
2. Feedstock availability.
3. Technological maturity (of fuel production, fuel delivery, and fuel use).
4. Legal and regulatory clarity and consistency.
5. A balance of long-term cost competitiveness and fuel portfolio risk management deemed by regulators to be in the public interest.

Policies should:

1. Allow long-term, and delayed initial delivery, biofuel contracts.

2. Require or encourage a portfolio approach to liquid fuels in regulated markets.
3. Develop and allow alternatives to reliance on price forecasts from the U.S. Energy Information Administration when approving contracts for electricity or fuel.
4. Allow contiguous areas of public lands to be leased together when economies of scale are needed and appropriate.

Initial policies should support limited production of biofuels for use in the electricity sector because electric utility sector contracts provide the type of structure needed to stimulate local biofuels production. A second reason is that fixed-price fuel contracts could provide fuel diversification and a measure of energy price stabilization for Hawaii's electricity consumers.

Liquid fuels for electricity production

Biofuels that can be used for electricity production include biodiesel, renewable diesel, pyrolysis oils, and straight vegetable oil, used as additives to or replacements for petroleum diesel, fuel oil, and naphtha. These fuels would be purchased by an electric utility, for use in its own generators, or by an independent power producer who sells electricity to a utility.

Hawaii's electric utilities are regulated by the Public Utilities Commission. Regulation includes the review and approval of fuel supply contracts as well as power purchase agreements. The Hawaiian Electric companies have stated a preference for locally-produced biofuels in requests for proposals, and have negotiated fuel supply contracts for biofuels. The contracts are subject to approval by the Public Utilities Commission (PUC).[77]

Hawaii state law specifies non-price factors that the PUC must consider in carrying out its general duties:

> The public utilities commission shall consider the need to reduce the State's reliance on fossil fuels through energy efficiency and increased renewable energy generation in exercising its authority and duties under this chapter. In making determinations of the reasonableness of the costs of utility system capital improvements and operations, the commission shall explicitly consider, quantitatively or qualitatively, the effect of the State's reliance on fossil fuels on price volatility, export of funds for fuel imports, fuel supply reliability risk, and greenhouse gas emissions. The commission may determine that short-term costs or direct costs that are higher than alternatives relying more heavily on fossil fuels are reasonable, considering the impacts resulting from the use of fossil fuels. [78]

In meeting the Renewable Portfolio Standards, with limited exceptions, the PUC has the following authority:

[77] The Public Utilities Commission, in current dockets dealing with biofuels contracts, including Docket No. 2012-0185 (AKP) and Docket No. 2011-0369 (HBE), is considering several issues, including fuel price, unit dispatch, and externalities.
[78] Hawaii Revised Statutes, 269-6(b).

> The public utilities commission may establish standards for each utility that prescribe what portion of the renewable portfolio standards shall be met by specific types of renewable energy resources;[79]

The law also requires that the production or purchase of electricity be "cost effective," with the PUC to determine what is "just and reasonable." The following sections of the law define "cost effective" and what constitutes "just and reasonable:"

> "Cost-effective" means the ability to produce or purchase electric energy or firm capacity, or both, from renewable energy resources at or below avoided costs or as the commission otherwise determines to be just and reasonable consistent with the methodology set by the public utilities commission in accordance with Section 269-27.2.[80]
>
> The commission's determination of the just and reasonable rate shall be accomplished by establishing a methodology that removes or significantly reduces any linkage between the price of fossil fuels and the rate for the nonfossil fuel generated electricity to potentially enable utility customers to share in the benefits of fuel cost savings resulting from the use of nonfossil fuel generated electricity. As the commission deems appropriate, the just and reasonable rate for nonfossil fuel generated electricity supplied to the public utility by the producer may include mechanisms for reasonable and appropriate incremental adjustments, such as adjustments linked to consumer price indices for inflation or other acceptable adjustment mechanisms. [81]

Given the uncertainties of price and other concerns associated with high levels of dependence on petroleum-based liquid fuels, and the potential benefits associated with the establishment of in-state biofuel production capability, it could be considered reasonable to take a portfolio approach to liquid fuel supplies.

Conditions and policies (whether laws, regulations, or incentives) supportive of long-term contracts for biofuels, with delayed start dates for delivery, could enable and stimulate local fuel production, especially in the initial phase of the industry.

Although it has been common for price forecasts from the U.S. Energy Information Administration's (EIA) *Annual Energy Outlook* to be used by regulators and policymakers for planning purposes, the forecasts can vary significantly from year to year, so relying on the reference case to determine the future cost-effectiveness of energy sources may eliminate projects that, in retrospect, would have been in the public's interest.

Also, oil price forecasts are simply forecasts, not contracted prices.

[79] Hawaii Revised Statutes, 269-92(b)
[80] Hawaii Revised Statutes, 269-91
[81] Hawaii Revised Statutes, 269-27.2(c)

Since petroleum prices are highly variable and future prices are unknown, a portfolio approach to liquid fuel supplies is prudent. Fixed-price, long term fuel contracts could provide diversification and energy price stabilization for Hawaii's electricity consumers, and could provide the type of structure needed to establish a successful biofuels industry.

Once the biofuels industry is seeded in Hawaii, biofuels should be transitioned from the generation sector to higher-value uses such as transportation fuels.

Recommendations on mandates

Act 203 required the following:

> "The energy resources coordinator's report shall include recommendations, taking into account the federal Renewable Fuel Standards II, as amended, on the following:
>
> (1) Whether any specific biofuel mandate is necessary in order for biofuel production and use in Hawaii to displace a significant amount of petroleum-based liquid fuel; and
>
> (2) Whether the ethanol fuel requirement in section 486J-10, Hawaii Revised Statutes, should be maintained, modified, or repealed.
>
> The coordinator shall include the rationale for all recommendations made in the report."

The Department's comments on the two specific items are provided below.

Is any specific biofuel mandate necessary in order for biofuel production and use in Hawaii to displace a significant amount of petroleum-based liquid fuel?

No, a specific biofuels mandate is not necessary at this time.

However, a local biofuel industry could be enabled and supported through other policy measures, such as initiatives in the utility and military sectors, building on work already under way.

An integrated biorefinery industry in Hawaii may benefit from – and may initially need – the participation of one or more fuel market (electricity, military, and transportation sector) customers in order to be successful.

The fuels market is complex. The purchasing methods, contracting timeframe, and required fuel delivery dates for electric utilities, military users, and transportation fuel providers are significantly different from one another.

Each sector is discussed below.

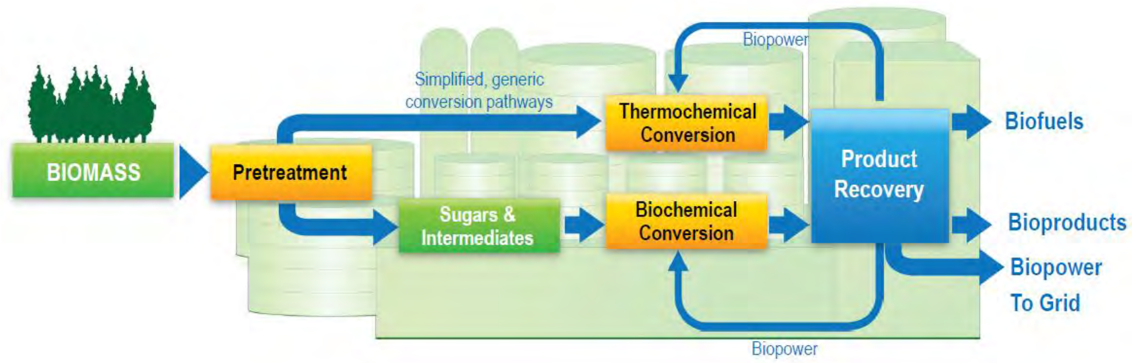

Figure 47 –Biorefineries Need Markets for Several Products [82]

ELECTRICITY SECTOR

A mandate for biofuel use in the electricity sector is not necessary. The combination of three elements: 1. Hawaii's Renewable Portfolio Standard, requiring 40% of Hawaii's electricity to be provided by renewable resources by 2030; 2. the operational realities of the need for electric utilities to have dispatchable power available, and 3. the significant quantity of preexisting utility generation equipment that could use biofuels to produce such dispatchable power; provide a combination of elements that appear to be sufficient to create demand for biofuels in the electric utility sector.

The potential missing piece is that of regulatory approval of biofuel purchase contracts. This is most appropriately developed as a policy decision, not a mandate.

As discussed previously, electric utilities are particularly well-suited to long term contracting and could serve as the "anchor tenant" for the new industry. With electric utility systems and equipment generally designed to be used for twenty years or more, long term planning and portfolio diversification are appropriate, reasonable, and (as illustrated by Hawaii's Renewable Portfolio Standard),[83] required.

An entity that purchases product for its own use may include in its specifications that the product be produced in a certain location (i.e. fuel produced in Hawaii). This is not a violation of the Commerce Clause.[84]

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[82] U.S. Department of Energy, http://www1.eere.energy.gov/biomass/pdfs/b12_reed_ap-2.pdf, 2012.
[83] Hawaii Revised Statutes, 269-91 et seq., http://www.capitol.hawaii.gov/hrscurrent/Vol05_Ch0261-0319/HRS0269/HRS_0269-0091.htm
[84] U.S. Constitution, Article I Section 8

TRANSPORTATION SECTOR

Since it is unlikely that private-sector transportation fuel purchasers will be willing to commit to a long term offtake agreement for a fixed price, sometimes mandates are seen as a means of stimulating market demand for the biofuel, creating a price premium for the biofuel, or increasing the perceived market certainty for biofuels in that area.

A State mandate for biofuel use, however, may not be sufficient to stimulate local production, since imports could satisfy the demand. Also, under Federal law, a State is not allowed to enact a requirement for locally-produced product, since to do so would have the "the purpose and effect of discriminating in favor of local products."[85] and such a law would be in violation of the Commerce Clause. [86]

A transportation fuel mandate may also be complex to implement and to administer, especially if a flexible marketplace is desired. Regulated markets may be perceived as being less flexible and, thus, may be less likely to attract investment and innovation.

For the reasons stated above, a transportation sector fuel mandate beyond what is currently in place is not recommended at this time.

DEFENSE SECTOR

A State-level attempt to mandate Department of Defense (DOD) fuel use would not be appropriate. Also, within the DOD there are already several significant biofuel support and development activities under way.

With a focus on national security, the military is a natural partner in the development of energy and supply security in areas of strategic importance. Although not subject to State regulation, partnerships and State support of military biofuel initiatives could be both effective and appropriate.

Should the ethanol fuel requirement in section 486J 10, Hawaii Revised Statutes, be maintained, modified, or repealed?

The requirement should be maintained or, if modified, such modification should be as consistent as possible with previous policy, since legal clarity and consistency are important to investors, land owners, and project developers evaluating the possible establishment of projects in Hawaii.

[85] http://supreme.justia.com/cases/federal/us/468/263/
[86] U.S. Constitution, Article I Section 8

Maintaining the requirement provides the highest level of consistency in policy but does not currently recognize or count the use of non-ethanol fuels (such as biogasoline or biodiesel) that are or might be produced in Hawaii.

Modifying the requirement, such as by allowing gasoline distributors to count other biofuels (for example, biodiesel, renewable diesel, or renewable gasoline) towards their required biofuel volumes, would be consistent with the policy direction of the State and could be considered.

Repeal is not recommended, as it would be counterproductive to ongoing efforts to diversify Hawaii's energy sources, attract investment, and develop local fuel production capacity.

CONCLUSION

Liquid fuels will continue to be needed by and important to Hawaii, for dispatchable power, aviation, freight transport, and other uses.

The use of plant-based fuels (i.e. biofuels) in combination with, or in place of, petroleum-based fuels is technically feasible.

A biofuels industry of between 100 and 300 million gallons per year after 2023 could provide about 10% of Hawaii's liquid fuel demand and, in addition to fuels, could produce glycerin, nutraceuticals, animal feeds, fertilizers, enzymes, specialty oils, electricity, and other co-products which could support Hawaii-made products and agriculture and stimulate additional economic activity.

Since biorefineries may produce a variety of fuels, enabling fuel for electricity generation and/or fuel for the Department of Defense to be supplied under long-term contracts at known prices may be necessary for the establishment of a biofuels industry in Hawaii and should be viewed as contributing to, rather than competing with, the successful production of other biofuels.

Although additional fuel mandates are not currently needed, the ethanol content requirement should be maintained, since legal and regulatory clarity and consistency are important. Modifying the law, such as by allowing gasoline distributors to count other biofuels (i.e. biodiesel, renewable diesel, or renewable gasoline) towards required volumes, would be consistent with the policy direction of the State and could be considered.

Other policy measures, addressing investor confidence, feedstock availability, land and water resources, innovation, and co-product development, may also be warranted as the industry continues to develop.

APPENDIX 1:
Act 203, Session Laws of Hawaii, 2011

RELATING TO BIOFUEL.

BE IT ENACTED BY THE LEGISLATURE OF THE STATE OF HAWAII:

SECTION 1. The legislature finds that the State needs to expand the use of biofuels as a viable source of energy in order to reduce dependence on fossil fuels and imported oil. The use of biofuels is consistent with the State's goals relating to renewable energy and sustainability. The legislature further finds that imposing a statutory requirement to utilize biofuels as energy may be premature at this time in view of the lack of research and development in the industry, the nascent nature of the industry, and the uncertain availability of biomass crops in Hawaii to produce liquid or gaseous fuel.

The purpose of this Act is to direct the energy resources coordinator to conduct a study and issue a preliminary and a final report on the conditions and policies necessary to expand biofuel production in the State to displace a significant amount of petroleum-based liquid fuel.

SECTION 2. The energy resources coordinator shall conduct a study and issue a report on the potential for biofuel production in Hawaii to displace a significant amount of petroleum-based liquid fuel. In compiling its report, the coordinator shall consult with producers, including local biofuel producers and local refineries; researchers; landowners; distributors; and end users, including airlines, fleets, utilities, and the military, on the conditions and policies necessary for biofuel production and use in Hawaii to displace a significant amount of petroleum-based liquid fuel.

The report shall include information on the following types of biofuel:

(1) Ethanol;
(2) Cellulosic ethanol;
(3) Fatty-acid-methyl-ester biodiesel;
(4) Synthetic or bio-based:
  (A) Diesel fuel;
  (B) Gasoline; and
  (C) Jet fuel; and
(5) Any other type of biofuel the coordinator deems relevant to the study.

SECTION 3. (a) For each type of biofuel listed in section 2 of this Act, the energy resources coordinator's report pursuant to section 2 of this Act shall include the following information:

(1) The State's projected demand in the near-term, mid-term, and long-term for the biofuel's petroleum-based counterparts;

(2) Types of feedstock that could be used;
(3) Availability of feedstock within the State in the near-term, mid-term, and long-term;
(4) Availability of feedstock out-of-state in the near-term, mid-term, and long-term;
(5) Production within the State in the near-term, mid-term, and long-term;
(6) Production out-of-state in the near-term, mid-term, and long-term;
(7) Costs in the near-term, mid-term, and long-term for biofuel product produced within the State;
(8) Costs in the near-term, mid-term, and long-term for biofuel product produced out-of-state;
(9) Status of the technology;
(10) ASTM specifications;
(11) Realistic timeline of production within the State;
(12) Benefits to the State's economy;
(13) Emissions compared to other comparable biofuels and to its petroleum-based counterpart;
(14) Logistics of handling and usage compared to other comparable biofuels and to its petroleum-based counterpart; and
(15) Stability of supply and costs compared to other biofuels and to its petroleum-based counterpart.

For the purposes of this Act:

"Long-term" means longer than ten years.

"Mid-term" means from three to ten years.

"Near-term" means within three years.

(b) The energy resources coordinator's report shall include recommendations, taking into account the federal Renewable Fuel Standards II, as amended, on the following:

(1) Whether any specific biofuel mandate is necessary in order for biofuel production and use in Hawaii to displace a significant amount of petroleum-based liquid fuel; and
(2) Whether the ethanol fuel requirement in section 486J-10, Hawaii Revised Statutes, should be maintained, modified, or repealed.

The coordinator shall include the rationale for all recommendations made in the report.

(c) The energy resources coordinator shall issue a preliminary report of findings and recommendations to the legislature no later than twenty days prior to the convening of the regular session of 2012 and a final report of findings and recommendations to the legislature no later than twenty days prior to the convening of the regular session of 2013; provided that the preliminary and final reports may be included in the energy resources coordinator's respective annual reports to the governor and legislature, pursuant to section 196-4(11), Hawaii Revised Statutes.

SECTION 4. This Act shall take effect upon its approval.

Approved as Act 203 on 7/8/2011 (Gov. Msg. No. 1307).