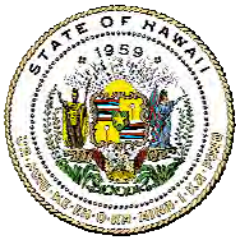
REPORT TO THE TWENTY-FIFTH LEGISLATURE
STATE OF HAWAII

IN RESPONSE TO
ACT 253, SESSION LAWS OF HAWAII 2007



HAWAII BIOENERGY MASTER PLAN

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM

DECEMBER, 2009

REPORT TO THE TWENTY-FIFTH LEGISLATURE
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HAWAII BIOENERGY MASTER PLAN
PROJECT REPORT

DEPARTMENT OF BUSINESS, ECONOMIC DEVELOPMENT & TOURISM

DECEMBER, 2009

This report has been cataloged as follows:

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Department of Business,
Economic Development & Tourism

FOREWORD

The Bioenergy Master Plan project is just the beginning of a statewide effort to understand the current and future potential of energy from – and for – Hawaii's agricultural sector.

This is an important area, with great potential and implications for both energy and food security.

We are working to develop a common vision and understanding of the opportunities while acknowledging the legal, environmental, and business realities that need to be addressed at every step along the way.

The information provided in the Bioenergy Master Plan Project report by the Hawaii Natural Energy Institute (HNEI) will be a helpful reference document for project investors, consultants, landowners, researchers, and others interested in bioenergy projects and industry development. As stated in HNEI's Executive Summary, the enabling legislation stated as its primary intent "develop a Hawaii renewable biofuels program." Thus, although the document includes information on the many private sector activities taking place, the emphasis is on government actions.

This FOREWORD is intended to set the stage by providing a summary of the context and vision for the major steps and opportunities for Hawaii.

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The Road to

Locally Produced Food & Fuel

Fuel Distributors

- Blend biomass-based fuels with petroleum-based fuels.
- Ensure that fuels meet all Federal, State, industry, and manufacturer specifications.
- Communicate that fungible biomass-based fuels have the same properties and handling as their petroleum-based counterparts, and can be blended, transported, stored, and used in the same equipment.

Fuel Users

- Land and Marine: Use biomass based fuels alone or in blends with petroleum based fuels.
- Utility: Use biodiesels, bio-oil, and other biomass-based fuels as dispatchable power in support of other renewable energy sources; capture or provide CO_2 to algae producers.
- Aviation: Complete testing, demonstration, and certification for use in civilian and military aircraft.

Processing Facilities

- Small, distributed local facilities convert sugars, oils, and/or fiber to fuels (ethanol, biodiesel); co-products (feeds, fertilizers, electricity, etc.); and/or bio-oil (for refinement at central facility).
- Centralized Hawaii facility converts bio-oil to refined fuels – biomass-based diesel, jet fuel, gasoline.

Small Farms

- Identify opportunities to increase revenues or reduce costs via electricity, feed, fertilizer, by-products, or bioenergy / bio-oil feedstock production and application.
- Participate in crop trials and co-product testing when appropriate.

Large Farms

- Evaluate long-term business plans that include production of food, feed, energy, fuels, and co-products.
- Determine cost-effective scale(s) of production.
- Monitor changes in petroleum supplies and prices, fuel production technologies, crop yields, production and harvesting costs; and market(s) for product(s).
- When feasible, obtain financing; develop project(s); modify as necessary to capture new opportunities.

Seed Farmers / Ranchers / Other Producers

- Work with potential feed producers to evaluate and test suitability of co-products for local livestock and aquatic use.
- Identify opportunities to increase land utilization through co-production or intercropping.

Conduct Research & Demonstrations; Provide Information & Support

- Crops: Conduct crop trials to determine Hawaii yields; hybrids suited to various Hawaii conditions, i.e. grasses (cane, sorghum); oilseeds; tree nuts; algae; trees (eucalyptus; seedless leucaena; timber); other crops, especially those with food or feed potential
- Water: Research & demonstrate use of non-potable sources; demonstrate low-loss irrigation techniques; provide information to farmers.
- Land: Provide soil type, slope, rainfall, solar insolation, temperature, and other relevant information in GIS format and downloadable maps; research potential use of lava lands.
- Harvesting: Develop and demonstrate technologies appropriate for Hawaii.
- Processing and Fuel Production: Reduce technical risk through private- and government-funded research; develop co-product utilization technologies and markets.
- Information: Establish Hawaii bioenergy website; provide information on projects, funding, incentives.
- Coordination: Facilitate introductions and discussions between investors, project developers, landowners, funding agencies, researchers, consultants, technical experts, and public and private organizations; provide capability for public input and community outreach.
- Sustainability: Provide scientific data on crop, processing, and resource utilization and best practices.
- Analysis: Develop agricultural/bioenergy decision model, with current agricultural entities and various processing facility, biorefinery, and by-product scenarios included.
- Policy: support existing Hawaii biofuel and agricultural operations.

Support Agricultural Sector

- Land: Protect good agricultural land and provide long term leases and reasonable lease rents for farmers.
- Water: Maintain aging irrigation systems and plan and develop new systems. Ensure access to reliable, consistent and affordable water for agriculture.
- Energy: Address rising transportation, fertilizer, fuel, electricity, feed and other input costs through use of local resources.
- Labor: Develop programs to ensure agricultural labor availability and agricultural worker housing.
- Revenue and financing: Increase revenue (electricity sales; value from co-products); develop long term contracts to offset market volatility concerns.

THE ROAD TO LOCALLY PRODUCED FOOD & FUEL

STEP 1: ENSURE FEEDSTOCK WILL BE AVAILABLE

Work with existing industry.

It is important the current agricultural producers are involved in the discussions, development, and determination of the potential value of energy projects. Bioenergy could be an expansion of agricultural opportunities and should be viewed as such.

The question originally asked by this project was, "What should be Hawaii's bioenergy plan?" However, the comments received during this project suggest that it would be better to ask:

> **"What can be done to encourage viable agricultural businesses in Hawaii – and what are the roles of electricity, fuels, and co-products in Hawaii's agricultural sector?"**

since it recognizes a broader, longer term, and more cooperative view. The question above is the one that should guide future work in this area.

The ability to produce biofuels in Hawaii requires a healthy agricultural sector. Without the ability to grow the feedstock, a bioenergy industry is not possible.

1.a. Conduct Research & Demonstrations; Provide Information & Support

An integrated approach – seeking ways for energy and fuels production to support Hawaii's existing and future agriculture – would ideally provide support for the overall sector, including development of non-potable water resources; continued crop research; the replacement of fossil-based fuels and fertilizers with local sources; attraction of investment; maintenance of local interest and agricultural expertise; and the support, information, coordination, and analysis needed for the inclusion of energy in Hawaii's agricultural sector.

1.b. Support the Agricultural Sector

Support of agriculture in general makes sense as a component of Hawaii's energy policy, and vice versa, since a viable agricultural sector can enhance Hawaii's energy security, and energy projects can help rural economies.

The local production of energy and fuels should be developed with the intent to strengthen these efforts and support current agricultural producers. Diversified agriculture and the production of fresh food products for local consumption provide local economic benefits, food security, and economic diversification for Hawaii.

According to the Hawaii Department of Agriculture's White Paper, *Food Self-Sufficiency in Hawaii*, requirements for a viable agricultural industry include:

- Land: Protect good agricultural land and provide long term leases and reasonable lease rents for farmers.
- Water: Maintain aging irrigation systems and plan and develop new systems. Ensure access to reliable, consistent and affordable water for agriculture.
- Energy: Address rising transportation, fertilizer, fuel, electricity, feed and other input costs.
- Labor: Develop programs to ensure agricultural labor availability and agricultural worker housing.
- Research: Support ongoing research to improve production, processing, and post-harvest handling; increase efficiency and yield; decrease inputs; and manage diseases and pests.

1.c. Help Farmers to Generate Revenue from Energy Sales

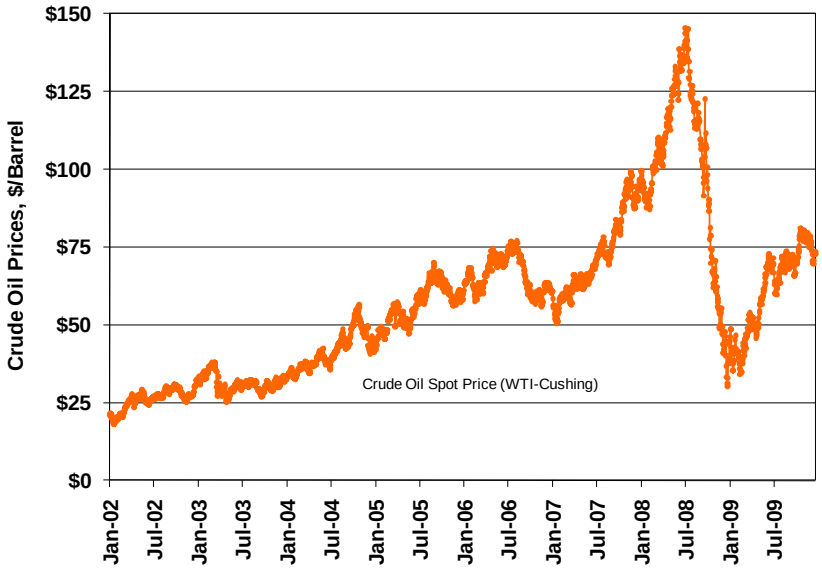
The potential synergies between agricultural production and energy are significant. For over 100 years, Hawaii's agricultural sector has not only used fuel and electricity to support agricultural production, transport, and marketing, but has also provided electricity to Hawaii's power grids.

Using on-island sources for electricity production - for example, geothermal, wind, biomass, solar, or ocean energy - reduces the need for imported fuels, and can keep energy dollars circulating in the local economy.

In mid 2008, when oil prices reached $147 per barrel (see Figure 1), Hawaii's electricity prices rose the fastest in the nation, since we are the state most dependent on oil for our electricity.

Since wind, solar, and many other renewable energy sources require no fuel, the bulk of the cost of the electricity from those sources could be repayment of capital,

Figure 1 - Oil Price Volatility



with no fuel cost. This could help to keep electricity costs more steady and predictable than electricity costs which are completely based on the price of oil.

This could benefit all of Hawaii's electricity customers, including residential customers, agricultural producers, small businesses, non-profits, and government agencies.

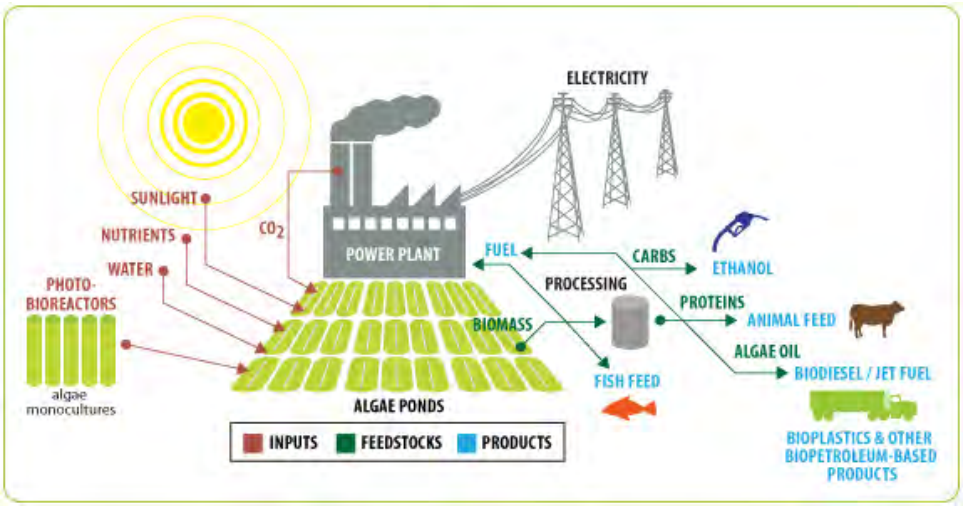
Requiring local utilities to obtain a portion of their electricity from agricultural producers could provide the agricultural producers with an additional revenue stream, thus helping to keep farm incomes positive.

If electricity is generated from biofuels which are affected by or influenced by the price of oil, a hybrid cost structure would be needed to reduce the price volatility to the electricity consumer while, at the same time, preserving the viability of the biofuel producer. This linkage can be reduced over time, as the agricultural sector gradually becomes less oil dependent and more energy self-sufficient.

STEP 2: DEVELOP CROPS, CO-PRODUCTS, AND PROCESSING FACILITIES

Hawaii's unique attributes – a year-round growing season, good solar insolation, high annual crop productivity, high demand for liquid fuels, high electricity prices – have attracted the attention of several investors, project developers, and Federal agencies interested in energy security, economic development, agricultural opportunities, and sustainability.

Figure 2 - Example of Algae Facility Concept
Source: HR Biopetroleum, via Biofuels Assessment by Black & Veatch



There are several bioenergy related projects taking place in Hawaii. There are projects to commercially produce biofuel from waste materials and locally grown oils; demonstrations of the production of algae for oils, biodiesel, diesel, and/or jet fuel; crop

trials of grasses, trees, and oilseeds; farmers' test plantings of energy crops (including jatropha, oil palm, and nitrogen fixing trees); projects to demonstrate advanced gasification and pyrolysis processes to produce fungible fuels that have the same properties and handling as their petroleum-based counterparts (i.e. can be blended, transported, stored, and used in the same equipment); projects to produce electricity from various biomass sources; and projects to develop and test co-products such as animal and fish feed.

2.a. Crops and processing facilities

These Hawaii projects have great potential, and it is expected that several may be built out at a commercial scale in a matter of months or years.

In some cases, the most economically viable feedstock(s) and crop(s) may be determined by the value and market for co-products and the appropriate scale and location of the processing facility. Therefore, the farmer(s), processing facility developer(s), and co-product customer(s) need to communicate and possibly work together in research, feasibility analysis, and project development.

Assistance should be provided as appropriate to ensure that accurate and timely information is available to the farmers, project developers, potential customers, regulatory agencies, public, and decision-makers interested in the potential and progress of the projects.

2.b. Co-Products

Under current conditions, the production of energy from Hawaii crops will most likely rely on the production of co-products to generate additional revenue streams, reduce risks from price and market volatility, and reduce by-product disposal costs.

Developing and supporting markets for these co-products can improve the commercial viability of bioenergy projects. In early stages, these co-products could even be the primary revenue source as technologies or feedstocks are phased in over time.

There are some projects that may take longer to realize their full potential or to obtain the financing needed. The need for energy is a long term issue, and is expected to grow in importance as worldwide demand and competition for petroleum continues to increase. The current price of petroleum– and perceived technical or financial risks – may not necessarily be the same as the need, opportunity, or risk profile two, five, or twenty years from now.

To ensure that Hawaii's agricultural sector is healthy and thriving when the full potential of crops, fuel production technologies, and co products are ready to join Hawaii's agricultural product mix at a commercial scale, support must be provided now to Hawaii's current agricultural businesses, whatever their end products.

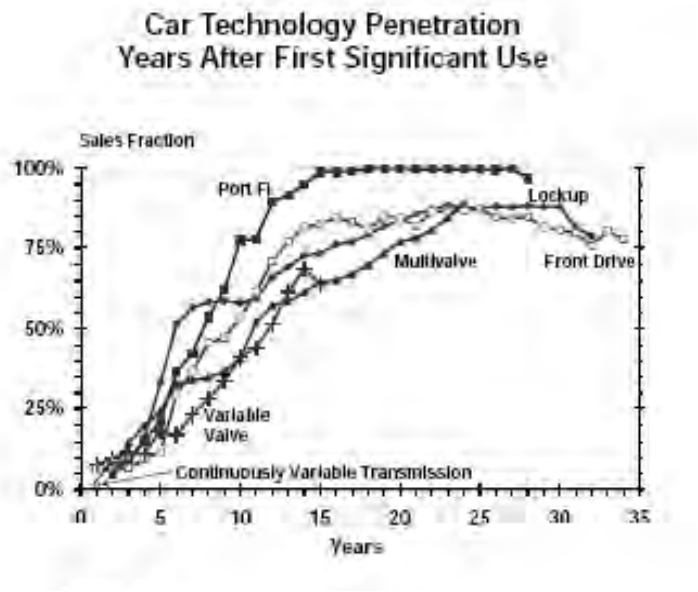
Even if the current agricultural producers are not producing fuels, they may be important customers for the co-products (for example, fuel, feed, or fertilizer) or be able to provide inputs to future bioenergy production processes.

STEP 3: WORK WITH FUEL DISTRIBUTORS AND FUEL USERS

About two-thirds of Hawaii's liquid fuels are used for transportation. Fuel distributors are faced with decisions regarding what types of fuels to plan for and to what extent their investments will be utilized as fuels and vehicles change over the years.

Although liquid fuel use in transportation could be reduced, it's not expected to be eliminated any time soon. Improved efficiency of vehicle engines and hybrid powertrains are expected to reduce fuel demand per mile of travel, and mass transit systems offer transportation alternatives to congested highways and parking shortages, but overall highway travel is generally expected to continue to increase with population and economic growth.

3.a. Liquid fuels for vehicles



Although electric vehicles are expected to be an important part of Hawaii's energy future, liquid fuels will still be needed for vehicles for at least the next 30 years.

Personal transportation could eventually be electric powered, with the batteries charged at night, possibly using off-peak renewable electricity that might otherwise be curtailed.

However, electric vehicles are not yet widely available; neither are charging locations or battery swap stations. Vehicle technologies have taken at least 15 years from initial introduction through availability in all new vehicles[1]. After that, it takes a while for the old vehicles to be retired – most likely, another 10-15 years – for a total of 25-30 years, at the least, for old technology to be completely replaced by new technology.

Therefore, it is reasonable to expect that liquid fuels (gasoline, diesel, ethanol and biodiesel) for internal combustion engines will be needed for vehicles for the next 30 years, if not longer.

[1] US EPA, *Light-Duty Automotive Technology and Fuel Economy Trends*, http://www.epa.gov/otaq/fetrends.htm

3.b. Liquid fuels for aviation

Jet airplanes are also expected to continue to need liquid fuels for the foreseeable future. About one-third of Hawaii's petroleum imports are to provide fuel for jets. Blends of bio-based jet fuel and petroleum jet fuel are being developed and undergoing test flights.

Energy security concerns and petroleum price volatility are expected to result in a continuing high level of interest in the development of bio-based jet fuels.

3.c. Liquid fuels for electricity production

The Hawaii Clean Energy Initiative's (HCEI) goal of 70% clean energy by 2030 includes energy efficiency and conservation; a gradual increase of electric vehicles for personal transportation; more wind, solar, geothermal, ocean, and other renewable energy sources; a smarter grid; self-regulation of energy demand by smarter buildings; and energy storage.

The energy efficiency and displacement objectives are aggressive: to reduce energy use by 30% below the baseline, through energy conservation, efficiency, and grid upgrades. The use of energy efficiency, conservation and displacement technologies (including solar water heating, daylighting, sea water air conditioning, and better insulation), are intended to reduce demand so that eventually electricity will only need to be produced and purchased for those end uses (refrigerators, elevators, computers, air conditioning, etc.) and times when there is no direct substitute for grid power.

Hawaii's Renewable Portfolio Standard requires that, by 2030, 40% of the electricity shall be generated from renewable resources. Some of the least cost (i.e. wind) and ubiquitous (solar) renewable energy resources are only available intermittently, since they only produce power when the wind is blowing or the sun is shining.

To ensure good power quality and dependable energy services, dispatchable energy is used by the electric utility company to fill in the gaps to ensure that electricity is available to utility customers when it is needed, particularly if the solar or wind resources are not available or the electricity demand exceeds supply.

Dispatchable energy

Dispatchable energy can be brought on line when needed. It's stored energy that can be turned on – and off – quickly, to keep the electrical grid stable.

Liquid and gaseous fuels are often used in dispatchable energy systems, particularly diesel engine generators and combustion turbines. The fuels contain energy stored in chemical form.

Liquid fuels: the most common form of energy storage

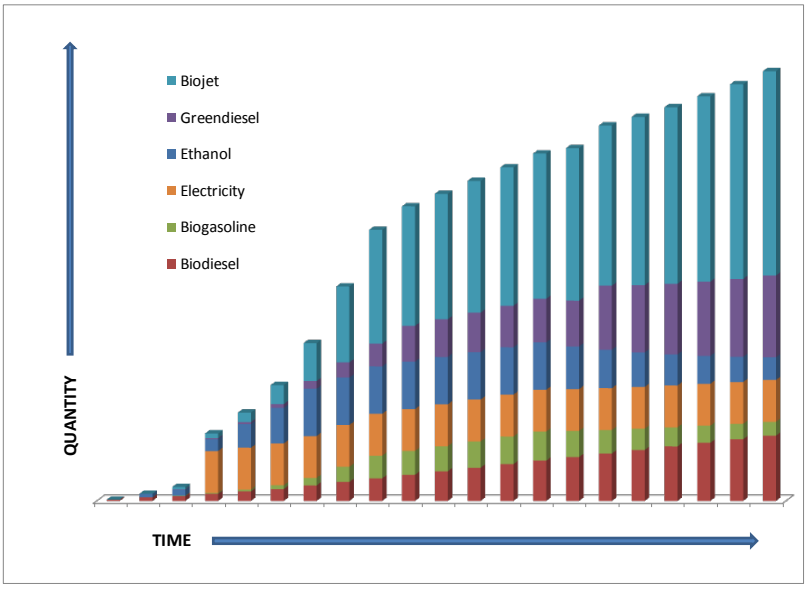
Because liquid fuels are easily transported and stored, they're reliable and convenient from a systems point of view. Liquid fuels provide dispatchable power to fill in the gaps when intermittent renewable resources are not available or when electricity demand is high. They can be used along with batteries, smart grid technologies, and pumped hydro systems to enable more intermittent renewable energy to be accepted onto the grid.

POSSIBLE BIOENERGY SCENARIOS

A wide variety of crops, conversion technologies, and end uses are in various stages of maturity. Some are fully mature and have been proven in many locations. In some cases, the technology has been proven, but the costs are not competitive with the current cost of oil; in others, the technologies are extremely promising but not yet fully proven at a commercial scale. Additional information on technologies is provided in Appendix 2.4.

EXAMPLES OF BIOENERGY FEEDSTOCKS, TECHNOLOGIES, AND CO-PRODUCTS				
	CURRENT			DEVELOPING
FEEDSTOCK:	plant oils	sugar	biomass	cellulose, oils, algae
CONVERSION TECHNOLOGY:	transesterification	biological	combustion; gasification	thermochemical
FUEL PRODUCED:	biodiesel	ethanol	electricity	drop in replacements for gasoline, diesel, jet fuel
CO-PRODUCTS:	feeds; fertilizers; biomass; glycerin	electricity	wood	feeds; fertilizers; biomass; electricity; hydrogen

Figure 3 - Possible Bioenergy Scenario: Early fuel production supports later development



THE BIOENERGY MASTER PLAN PROJECT

The Final Report on the Bioenergy Master Plan project, by the Hawaii Natural Energy Institute, fulfills the requirements of the legislation and will be a helpful reference document for project investors, consultants, landowners, researchers, and others interested in bioenergy projects and industry development.

The 96-page report summarizes the detailed information contained in the hundreds of pages of issue papers, provided as appendices.

The disc contains both the report and the appendices. Both the report and appendices are also available on-line, at http://hawaii.gov/dbedt .

The report is the result of significant effort on the part of the Hawaii Natural Energy Institute; knowledgeable experts who took the lead in researching, evaluating, inviting, and incorporating stakeholder input in each of the primary areas of evaluation; and support from the Hawaii State Legislature and the U.S. Department of Energy.

Thanks to all whose efforts contributed to this product and whose continuing efforts are even now developing the projects and establishing the basis for success in this extremely important area. Mahalo nui loa!

HOUSE OF REPRESENTATIVES
TWENTY-FOURTH LEGISLATURE, 2007
STATE OF HAWAII

H.B. NO. 1003 H.D. 3 S.D. 2 C.D. 1

Act 253

(excerpt)

PART III

SECTION 4. (a) The department of business, economic development, and tourism shall develop and prepare a bioenergy master plan in consultation with representatives of the relevant stakeholders. The primary objective of the bioenergy master plan shall develop a Hawaii renewable biofuels program to manage the State's transition to energy self-sufficiency based in part on biofuels for power generation and transportation. The bioenergy master plan shall address the following outcomes:

(1) Strategic partnerships for the research, development, testing, and deployment of renewable biofuels technologies and production of biomass crops;

(2) Evaluation of Hawaii's potential to rely on biofuels as a significant renewable energy resource;

(3) Biofuels demonstration projects, including infrastructure for production, storage, and transportation of biofuels;

(4) Promotion of Hawaii's renewable biofuels resources to potential partners and investors for development in Hawaii as well as for export purposes; and

(5) A plan or roadmap to implement commercially viable biofuels development.

(b) The bioenergy master plan shall address the following issues:

(1) Specific objectives and timelines;

(2) Water resources;0

(3) Land resources;

(4) Distribution infrastructure for both marine and land;

(5) Labor resources and issues;

(6) Technology to develop bioenergy feedstock and biofuels;

(7) Permitting;

(8) Financial incentives and barriers and other funding;

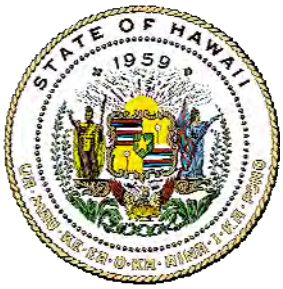
(9) Business partnering;

(10) Policy requirements necessary for implementation of the master plan; and

(11) Identification and analysis of the impacts of transitioning to a bioenergy economy while considering applicable environmental concerns.

Hawaii Bioenergy Master Plan

Volume I



Prepared for

State of Hawaii
Department of Business, Economic Development and Tourism

By

University of Hawaii
Hawaii Natural Energy Institute
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Executive Summary

This Bioenergy Master Plan report was developed in accordance with Act 253, Session Laws of Hawaii (SLH) 2007, which called for a bioenergy master plan to "set the course for the coordination and implementation of policies and procedures to develop a bioenergy industry in Hawaii." The State Department of Business, Economic Development and Tourism (DBEDT), tasked with preparation of the plan, contracted with the University of Hawaii's Hawaii Natural Energy Institute (HNEI) in mid-2008 to achieve the specifications of the legislation.

Importantly, Act 253 Part III states: "**The primary objective of the bioenergy master plan shall [be to] develop a Hawaii renewable biofuels program to manage the State's transition to energy self-sufficiency based in part on biofuels for power generation and transportation**." Thus, the objectives of the legislation - bioenergy industry and bioenergy program development - were overarching considerations in the examination of the specified issues and outcomes. These issues and outcomes were therefore studied in the context of the primary value chain components necessary for a successful bioenergy industry – feedstock production and logistics, conversion, distribution, and end use. Further, the recommendations that comprise the Roadmap are presented to be carried out programmatically, by and through a Hawaii Renewable Biofuels Program.

The report is organized in three volumes as follows:

Volume I includes four parts, reflecting the approach necessary to meet the legislated objectives and guidelines:

- Part 1 – "Overview" provides an overview including Hawaii's energy situation and the role of biofuels in Hawaii's energy mix, background of events leading to Act 253, and the approach to this project. A detailed discussion of the approach is provided to enable the reader to understand the context of this effort.

- Part 2 – "Perspectives on the Bioenergy Industry" provides the executive summaries and recommendations from nine Issue Reports: water and land resources, distribution infrastructure, labor resources, technology, permitting, financial incentives, business partnering, economic impacts, and environmental impacts.

- Part 3 – "Potential and Actions" addresses the five outcomes, further described below, prescribed by Act 253 including "Recommendations for a Hawaii Bioenergy Master Plan".

- Part 4 – "Conclusion" provides closing comments and observations.

Volume II includes the full text of nine separate Issue Reports prepared to meet the requirements of Act 253. To foster stakeholder involvement in the preparation of this report, several stakeholder events were held and a website was established to disseminate information, and to receive input from stakeholders during the project. Input from the breakout session discussions at the April 2009 stakeholder meeting is incorporated in the Issue Reports.

Volume III includes stakeholder review comments on the draft plan and team responses.

The five outcomes that comprise Volume (Vol) I Part 3 are as follows:

OUTCOME I – Does Hawaii Have The Potential To Rely On Biofuels As A Significant Renewable Energy Resource?

Act 253 recognizes the need for commitment of resources in its requirement that the master plan address an "evaluation of Hawaii's potential to rely on biofuels as a significant renewable energy resource". This report responds to this outcome in Section 3.1 (Vol I). For this project, a biofuels production scenario based on 20% displacement of 2007 Hawaii fuel consumption and projected additional bioenergy use was used to define "significant." The analysis indicates that Hawaii does have the potential to meet the production scenario goals.

OUTCOME II – Recommendations for a Hawaii Bioenergy Master Plan

Recommendations for development of a bioenergy industry, from the Issue Reports, are summarized in Section 3.2.1 (Vol I). The recommendations are diverse, reflecting the Legislature's understanding of the far reaching impacts and needs of a bioenergy industry – land and water resources, distribution infrastructure, labor, production and conversion technologies, permitting, financial incentives, business partnering, and economic and environmental impacts.

The industry Roadmap, Section 3.2.2 (Vol I), presented in the table below, identifies priority actions for a Renewable Biofuels Program in alignment with four primary areas of industry concern – availability and use of resources, value chain interdependencies, industry impacts, and program level coordination. These actions are recommended for implementation in the initial three years of the program. The majority of the recommended near-term actions should be continued at least through the mid-term (4 – 9 years) to be responsive to advancements in crop and conversion technologies and changing market conditions. Longer-term (10 – 20 years) actions are those that should be continued as an on-going practice or capability to support the evolution of the industry. These are summarized as follows.

Roadmap Action Item	Near Term			Mid-Term			Long Term		
	2010	2011	2012	2013	2015	2018	2020	2025	2030
Program Level Coordination									
1. Establish a Renewable Biofuels Program: DBEDT shall establish a bioenergy program (Program) to manage the state's transition toward energy self sufficiency based in part on bioenergy for electricity and transportation. The bioenergy program shall receive $1.5 million dollars per year to establish three staff positions using up to $340,000 and the balance shall be used to fund assessments and co-fund demonstration projects as identified in the bioenergy master plan. Assessment and demonstration projects shall be prioritized by bioenergy technical advisory group and stakeholder input. Program personnel shall schedule regular outreach meetings to exchange information with communities on all islands where bioenergy development is proposed. In its first year, the Program shall develop an appropriate tax credit based on green house gas reductions resulting from the displacement of fossil fuels by bioenergy products that accrues to Hawaii bioenergy feedstock producers and bioenergy conversion facilities. Activities of the bioenergy program shall be reported to the legislature annually in December.									
2. Establish Bioenergy Technical Advisory Group that includes one representative each from DBEDT, the Department of Land and Natural Resources (DLNR), the Department of Agriculture (DOA), the Department of Hawaiian Home Lands (DHHL), the Department of Health (DOH), and 18 other members representing the bioenergy industry (3), refiners (2), agricultural producers (4), environmental concerns (3), utilities (3), the Office of Hawaiian Affairs (1), and bioenergy research (2). The advisory group will provide advisory support to the Renewable Biofuels Program.									
3. Involve specific communities through all steps of the process.									
4. Establish Community-Based Bioenergy Working Group.									
5. Maintain an up-to-date list of State and Federal incentives, and provide guidance to prospective bioenergy value-chain business owners on how to apply for incentives (grants, loans, tax credits, etc.).									
6. Synergize the bioenergy master plan with the Hawaii Clean Energy Initiative goals.									
7. Encourage close collaborations among scientists, researchers, policy makers, extension agents, and farmers as a comprehensive link of information dissemination in order to provide the context for informed decision-making.									
8. Establish an independent fact-finding and policy discussion forum, based in science, technology assessment and land use analysis to support programmatic and policy decisions.									

Roadmap Action Item	Near Term			Mid-Term			Long Term		
	2010	2011	2012	2013	2015	2018	2020	2025	2030
9. Provide research, education, and outreach on the role of biofuels.									
10. Act swiftly to capture funding made available through federal programs, especially related to economic stimulus.									
11. Work to promote new workflow processes within State and County permitting agencies as well as efficient interagency cooperation.									
12. Develop and maintain a bioenergy partner database similar to the Bioenergy Partner Catalog in this report.									
13. Facilitate partnerships through a matchmaker. The State can significantly encourage necessary bioenergy partnerships through the creation of a position or program that facilitates such partnerships…and acting as an industry advocate and government liaison.									
14. Position Hawaii's bioenergy strategy in the context of vital State interests such as energy security and greenhouse gas emissions reduction targets.									
15. Clarify whether the State should only attempt to attract those parts of the industry where wages are above manual labor level.									
Availability and Use of Resources									
1. Develop and prepare a single, clear, consistent policy on use and lease of State lands for agriculture, grazing, forestry, and bioenergy feedstock production, in consultation with relevant stakeholders and to promulgate policies of energy and food security. The plan shall include components describing favorable lease terms for bioenergy demonstration projects. Report of this policy shall be submitted to the Legislature by December 2011.									
2. Implement land policy developed in December 2011.									
3. Provide a tax credit of __% of investment to support the refurbishment and continued maintenance of irrigation systems supplying water to agricultural lands of importance to the State of Hawaii that are used for food or bioenergy feedstock production, employ appropriate conservation agriculture practices, and are committed to production agriculture or bioenergy feedstock production for 25 years.									
4. Study the potential effect of bioenergy crop production on drinking water resources. Assess influence of new groundwater resources for biofuel production on aquifer recharge and estimated aquifer sustainable yields.									
5. Conduct a systematic study for cost/benefit analyses of potential reuse of treated water for bioenergy crops.									
6. Increase sustainable water supplies (traditional and non-traditional) for agriculture including bioenergy and biomass crops.									

Roadmap Action Item	Near Term			Mid-Term			Long Term		
	2010	2011	2012	2013	2015	2018	2020	2025	2030
7. Assess the potential for sustainable use of resources for bioenergy crops and other agriculture including ranch lands. Prioritize the use of resources for production of food and fuel.									
8. Encourage appropriate conservation agriculture practices to help reduce water consumption, use of pesticides and fertilizers, and pollution.									
9. Maintain land currently used for agriculture and forestry, and additionally, increase land available for bioenergy use sufficient to support biofuel production.									
10. Conduct research on Hawaii-specific crops and Hawaii-specific crop incentives.									
11. Develop cropping systems that integrate bioenergy crops with current crops for efficient utilization of resources such as land, water, time, and labor.									
12. Develop a decision support system to match biological characteristics of crops to physical characteristics of soil and to environmental and ecological acceptance.									
13. Test water-harvesting technologies in Hawaii to minimize water runoff and maximize water storage.									
Value Chain Interdependencies									
1. Provide a __% tax credit for investments made to convert existing infrastructure to be compatible with bioenergy products or for construction of new infrastructure components for transporting and distributing bioenergy products derived from bioenergy feedstocks that are produced in Hawaii. The credit will be available in the first year that 50% of the total product volume of the infrastructure component is a bioenergy product.									
2. Provide funding for a full-time, tenure track, faculty position in the College of Tropical Agriculture and Human Resources (CTAHR) at the University of Hawaii at Manoa to conduct research and demonstration of appropriate bioenergy feedstock harvesting technologies suitable for Hawaii's conditions.									
3. Fund a continued bioenergy technology assessment activity that can provide updated information on the status of bioenergy conversion pathways and estimates of energy return on investment (EROI) for bioenergy value chain components.									
4. Provide support to industry for preliminary feasibility studies of selected energy crop conversion alternatives to identify the most promising technology pathways and the resource requirements for those pathways.									
5. Develop funding mechanisms to leverage federal and private funds and support demonstration projects.									

Roadmap Action Item	Near Term			Mid-Term			Long Term		
	2010	2011	2012	2013	2015	2018	2020	2025	2030
6. Establish a bioenergy/biofuel development fund to support research, and technology development and demonstration.									
7. Reconcile investors' concern for exit strategies with biofuels incentives.									
8. Provide incentives for early implementation of bioenergy production.									
9. Implement a purchase program, (targeted at slightly below market rates to avoid competing with private industry) for surplus crops, with restrictions on annual volumes and the duration of the program.									
10. Develop policy to provide benefit streams to bioenergy projects that result in increased State energy resiliency, reduced greenhouse gas emissions, and benefits to rural communities in Hawaii.									
11. Test biofuels under development or in a pre-commercial stage for compatibility with existing petroleum equipment and distribution assets.									
Industry Impacts									
1. Develop a methodology for evaluation of bioenergy projects based on the principles of life cycle assessment (including energy inputs vs. energy outputs and greenhouse gas balances) in consultation with relevant stakeholders.									
2. Establish policy and process whereby State agencies will require life cycle assessments for bioenergy development proposals that seek to use State lands or State funds.									
3. Develop a certification program for biofuels to safeguard Hawaii's unique native eco-systems and culture, and support sustainable biofuels development.									
4. Assess the impacts of rising world oil prices and increasing local production of bioenergy on the two refineries.									
5. Continue assessment of economic impacts of bioenergy production as industry develops and data become available.									
6. Encourage use of existing infrastructure to minimize potential environmental impacts from the development of new infrastructure.									

From the action items in the preceding table, the following items are prioritized for immediate near term action.

1. Establish a Bioenergy Program

To carry out the priority issue area recommendations, a Bioenergy Program must be adequately staffed and funded. The State Department of Business, Economic Development and Tourism (DBEDT) is the most likely location for the program, consistent with the statutory role of the State's Energy Resources Coordinator (ERC).

Program resources should include sufficient personnel and dedicated financial resources commensurate with this industry's vital importance to the economic and energy future of the state. Program staffing of three professionals with bioenergy technical and/or policy experience is recommended. The program term should be no less than 10 years to ensure continuity of industry development, with annual dedicated funding for personnel and program activities. Determination of additional resources to assure the viability of the industry value chain is subject to the assessments recommended as priority actions.

Program activities will include:

- Assessment, research and demonstration projects which will be prioritized by a bioenergy technical advisory group and stakeholder input.
- Community involvement and education and outreach, including conduct of regular outreach meetings to exchange information with communities on all islands where bioenergy development is proposed.
- Support of partnerships including maintenance of partner database.
- Policy and planning activities, in coordination with the bioenergy technical advisory group and stakeholders, including but not limited to the planning and policy requirement items listed in the priority issue area recommendations above.
- In its first year, development of an appropriate tax credit based on green house gas reduction resulting from the displacement of fossil fuels by bioenergy products that accrues to Hawaii bioenergy feedstock producers and bioenergy conversion facilities.
- Industry coordination activities including but not limited to such items listed in the priority issue area recommendations above.
- Annual reports to the legislature.

Responsible party: DBEDT
Implementation date: 2010 - 2020
Funding: $1.5 million annually including $340,000 for 3 full-time equivalent positions

2. **Establish a bioenergy technical advisory group**

A bioenergy technical advisory group should be established and facilitated by DBEDT. The advisory group should include one representative each from DBEDT, the Department of Land and Natural Resources (DLNR), the Department of Agriculture (DOA), the Department of Hawaiian Home Lands (DHHL), the Department of Health (DOH), and 18 other members representing the bioenergy industry (3), refiners (2), agricultural producers (4), environmental

concerns (3), utilities (3), the Office of Hawaiian Affairs (1) and bioenergy research (2). The advisory group will provide advisory support to the Renewable Biofuels Program.

Responsible party: DBEDT
Implementation date: 2010 - 2020

3. Develop clear and consistent policy for use of State lands

A single, clear, consistent policy on use and lease of State lands for agriculture, grazing, forestry, and bioenergy feedstock production, in consultation with relevant stakeholders and to promulgate policies of energy and food security should be developed. The policy should include components describing favorable lease terms for bioenergy demonstration projects and lease application and process requirements.

Responsible parties: DBEDT, DLNR, DOA, DHHL
Report date: Due to the Legislature by December 2011.
Policy implementation: 2012

4. Develop methodology for evaluation of bioenergy projects

A methodology for evaluation of bioenergy projects based on the principles of life cycle assessment (including energy return on investment) should be developed in consultation with relevant stakeholders.

Responsible party: DBEDT
Report date: Due to the Legislature by December 2011.

5. Require Life Cycle Analysis for use of State lands or funding support

Establish policy and process whereby State agencies will require life cycle assessments for bioenergy development proposals that seek to use State lands or State funds.

Responsible party: DBEDT
Policy implementation: 2012

6. Provide a tax credit for irrigation systems

The State should provide a tax credit of __% of investment to support the refurbishment and continued maintenance of irrigation systems supplying water to agricultural lands of importance to the State of Hawaii that are used for food or bioenergy feedstock production, employ appropriate conservation agriculture practices, and are committed to production agriculture or bioenergy feedstock production for 25 years. The tax credit may be used over the 25 year period of performance.

Responsible party: Legislature/Administration
Tax credit implementation: 2012

7. Provide a tax credit for infrastructure systems

Provide a __% tax credit for investments made to convert existing infrastructure to be compatible with bioenergy products or for construction of new infrastructure components for

transporting and distributing bioenergy products derived from bioenergy feedstocks that are produced in Hawaii. The credit will be available in the first year that 50% of the total product volume of the infrastructure component is a bioenergy product.

Responsible party: Legislature/Administration
Tax credit implementation: 2012

8. Appropriate funds for a research position
The State shall provide funding for a full-time, tenure track, faculty position in the College of Tropical Agriculture and Human Resources (CTAHR) at the University of Hawaii at Manoa to conduct research and demonstration of appropriate bioenergy feedstock harvesting technologies suitable for Hawaii's conditions.

Responsible party: University of Hawaii - CTAHR
Faculty Hire: 2011

OUTCOME III – Strategic Partnerships for the Research, Development, Testing, and Deployment of Renewable Biofuel Technologies and Production of Biomass Crops

Section 3.3 (Vol I), Strategic Partnerships, identifies partnering arrangements that have arisen from participants identifying a common goal or information gap. Future partnerships to enhance biofuels development can be expected to form among public, private, and nonprofit organizations that leverage funds and or expertise from all parties. In keeping with the value chain approach, partnerships including land owners, biomass (agriculture or forestry) producers, technology providers, bioproduct distributors, major end-users, and investors can be envisioned. Depending on the purpose, partnerships may form vertically across the value chain or horizontally to address needs identified in one industry segment. County, state, and federal entities can be envisioned as participants in the roles of land owners, investors for the public good, and as research providers.

Several entities are already in place to help facilitate strategic partnering at points along the value chain. The Hawaii Clean Energy Initiative, the Hawaii Renewable Energy Development Venture, the Hawaii State Energy Office, University of Hawaii, Hawaii Agriculture Research Center, private companies, and other research institutions all can contribute to partnership building due to their involvement in activities related to bioenergy research, development, testing, and deployment. Coordination between these groups is important and should be fostered.

OUTCOME IV - Biofuels Demonstration Projects

Section 3.4 (Vol I) summarizes demonstration projects that were identified largely from stakeholder input. Candidate projects fell in the categories of feedstock production, conversion technology verification, and transportation/end use demonstration.

Projects designed to demonstrate crop performance/feedstock production included:

- field plantings of a variety of energy crop candidates in key climatic zones on different islands to determine plant response to varied environmental and management factors;
- farmer operated/managed feedstock demonstrations to provide realistic evaluation of production costs and resulting yields;
- feedstock production coupled with technology demonstration to include harvesting and supply logistics.

Projects designed to verify conversion technologies include:

- oil crop production, harvesting, and oil extraction from the crop product with multiple uses for the oil such as biodiesel production via transesterification, hydrotreating for renewable diesel, direct firing, or production of biogases;
- pyrolysis of biomass to produce a bio-oil that can be transported and converted in one of the petroleum refineries for production of fuel substitutes or in direct fired power generation applications;
- gasification or reforming of biomass to produce a syngas for direct use or the production of renewable electricity or biofuels that may include renewable diesel or other synthesis products;
- controlled storage of biofuels with monitoring of product quality over time to assess product life, and testing to determine potential impacts of quality deterioration on end use.

Demonstration projects related to transportation applications included:

- private cars and/or fleet vehicles such as buses converted to operate on biofuels;
- larger marine vessel conversion to renewable diesel (e.g. State of County owned or operated)

<u>OUTCOME V – Promotion of Hawaii's Renewable Biofuels Resources to Potential Partners and Investors for Development in Hawaii as Well as for Export Purposes</u>

Section 3.5 (Vol I), identified several activities that could promote Hawaii's renewable biofuels resources. These included legislative actions that reduce the regulatory burden and create financial incentives for project development, maintenance of the Hawaii Bioenergy Master Plan website, continued and active engagement by master plan participants in conferences and workshops that provide opportunities for establishing contacts, and keeping the State energy office staff engaged and informed about the bioenergy landscape.

The comprehensive approach required by Act 253, SLH 2007 has pointed to the requirement for a framework to enable government and stakeholders to work together to address the needs of the industry. During this effort, information gaps precluded project team recommendations on specific feedstocks, conversion technologies, or bioenergy products. For example, the economic impacts analysis was limited to data on sugar cane. Additional assessments are necessary to more fully address the adequacy of Hawaii's water and land resources for bioenergy crops. Life cycle analyses of the various bioenergy value chains that can be

considered for Hawaii -- including feedstock production options and impacts, energy requirements, emissions, land use changes, water use requirements, wastes, logistics, conversion technology alternatives, distribution, and end use – are not currently available.

This bioenergy master plan therefore points to a path for government and industry action needed to enable informed policy development, appropriate programmatic actions, response to stakeholder concerns, and decisions concerning feedstocks, conversion technologies, and products. It recognizes the need for government and stakeholders to continually monitor the industry and reset the priorities as technologies and opportunities evolve.

Reliable information will reduce the risk of unintended consequences for policy makers or business risk for investment partners. Information needs are represented in part by the following questions that have been raised during the course of this project:

- What feedstocks have the highest yields on non-prime agriculture land under various climatic conditions and management practices?
- Can energy crops be grown sustainably and economically?
- To what degree should agricultural land be dedicated to biofuel crops?
- What biofuel products make the most sense for Hawaii's future needs?
- Are the conversion technologies for these biofuels commercially available?
- How do we reduce the economic and technology risks inherent with new technologies?
- What will be the cost to modify Hawaii's distribution infrastructure to accommodate the various biofuel options?
- What are the appropriate incentives to encourage the production of energy feedstocks?

The development of a bioenergy industry as a component of a more secure and stable energy future for Hawaii will take the sustained support and commitment by industry, government, and the community. The industry is characterized by complexity and change. For Hawaii, there are additional challenges that relate to the need for low cost and reliable feedstock supplies. Hawaii is a unique place that may require unique solutions. With the wide range of issues, stakeholders, value chain components, changing market conditions, continuing technology innovations, and environmental incentives and disincentives, industry planning cannot and should not be a finite nor close-ended task.