Hawaii Bioenergy Master Plan
A Conversation with Hawaii’s Agricultural Sector

Agricultural Leadership Foundation of Hawaii
September 5, 2008
Hawaii Convention Center

Welcome
   Hawaii Department of Agriculture
   Hawaii Department of Business, Economic Development & Tourism

Hawaii Bioenergy Overview
   Maria Tome, DBEDT, Hawaii Bioenergy Master Plan
   Scott Turn, HNEI/UH, Bioenergy Systems Overview

Bioenergy Crop Production (illustrative research)
   Bill Cowern: Oil Palm
   Robert Osgood: Banagrass
   Michael Poteet, HARC: Jatropha
   James Brewbaker, UH: Tree Crops
   James Carpenter, UH: Guinea Grass

Group Discussion

Bioenergy Markets
   Karl Stahlkopf, Hawaiian Electric Company
   Paul Zorner, Hawaii BioEnergy LLC
   Brian Collins, Pacific Biodiesel

Group Discussion

BioEnergy Incentives
   Tim O'Connell, USDA/Rural Development

Concluding Discussion
Hawaiʻi's Agricultural Lands
Food and Fuel

Sandra Lee Kunimoto
Chairperson
Department of Agriculture
Sept 5, 2008
http://hawaii.gov/hdoa
Food and Fuel

- Goal: 70% clean energy by 2030.
- Wind, solar, geothermal, biomass, hydro, etc.
- Must think about the Farming piece not just the Industrial piece
Agriculture in Hawai`i

- 2006 Farmgate value $582 million (Total sales $2.4 billion)
- 5,500 Farms
- Median Farm Size - 5 acres
- 1,300,000 acres farmland (incl. pasture & rangeland)
  - 109,000 acres harvested cropland
- Agriculture related jobs – 23,200
Transition from plantation crops to diversified ag.
Increasing costs

- Energy
  - Transportation
  - Fertilizer
  - Fuel
  - Electricity
- Labor
- Food Safety
- Land
- Water
- Infrastructure
- Invasive Species

But price is not keeping pace with rising costs.
  - Competing Domestic & Foreign Imports
Important Agricultural Lands (IAL)

- Article XI, Sec 3. (1978) - Constitutional Mandate for IAL
- Act 183 (2005) - Process to designate IAL
- Act 233 (2008) - Incentives which trigger IAL process
Hawaii’s Energy; Biofuels Assessment Project; and Bioenergy Master Plan

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State of Hawaii
Department of Business, Economic Development & Tourism
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www.hawaii.gov/dbedt/info/energy
U.S. Electricity Generation by Source, 2006

- Coal: 50%
- Natural Gas: 20%
- Nuclear: 19%
- Petroleum: 2%
- Hydroelectric Conventional: 7%
- Other Renewables: 2%

http://www.eia.doe.gov/cneaf/electricity/epa/generation_state.xls
Fossil Fuel Costs per Million Btu

Dollars Per Million Btu, Nov. 2007

- Coal (US average): $1.78
- Natural Gas (US average): $7.11
- Petroleum Liquids (US average): $13.14
- Fossil fuel, US average 69% Coal, 28% Natural Gas, 3% Petrol. Liquids: $3.09
- Diesel fuel @ $3/gallon: $21.63

69% Coal
28% Natural Gas
3% Petrol. Liquids

Fossil fuel, US average 69% Coal
28% Natural Gas
3% Petrol. Liquids
Hawaii Electricity Generation by Source, 2006

- Oil (Petroleum) 78%
- Coal 13%
- Other Renewables 5%
- Natural Gas 0%
- Hydroelectric Conventional 1%

http://www.eia.doe.gov/cneaf/electricity/epa/generation_state.xls
State Energy Policy

§226-18, Hawaii Revised Statutes

Planning for the State's facility systems with regard to energy shall be directed toward the achievement of the following objectives, giving due consideration to all:

1) Dependable, efficient, and economical statewide energy systems capable of supporting the needs of the people;

2) Increased energy self-sufficiency where the ratio of indigenous to imported energy use is increased;

3) Greater energy security in the face of threats to Hawaii's energy supplies and systems; and

4) Reduction, avoidance, or sequestration of greenhouse gas emissions from energy supply and use.
Hawaii’s Renewable Energy Objectives*

- **Renewable Portfolio Standard** for Electricity Production
  - 10% by December 31, 2010
  - 15% by December 31, 2015
  - 20% by December 31, 2020

- **Revise Energy Cost Adjustment Clause**

- **Alternative Fuel Standard** for vehicle fuels
  - 10% by December 31, 2010
  - 15% by December 31, 2015
  - 20% by December 31, 2020

- **Ethanol Content Requirement**
  Most gasoline in Hawaii contains 10% ethanol

* In statute. The Hawaii Clean Energy Initiative will be discussed next.
Hawaii needs to transition to an economy powered by clean energy, instead of imported oil...

In 2007 Hawaii's energy portfolio included 8% renewable energy, a proportion which is set to increase to approximately 20% under current plans.

...but doing so will require a transformation of regulatory, financial, and institutional systems.
What is the First Step?

Step 1: Reduce energy waste

Efficiency is the lowest cost energy resource.
Step 2: Renewables

Hawaii has abundant renewable energy resources.
Bioenergy

SUGAR CANE / GRASSES

WOOD

SOLID WASTE

OIL SEEDS

ALGAE
Hawaii Petroleum Consumption by Sector, 2005

- Transportation - Air: 31%
- Transportation - Ground: 22%
- Transportation - Water: 8%
- Electric Utility: 25%
- Electric Non-Utility: 8%
- Other Sectors: 6%

Transportation: 61.7%
Electricity: 32.7%
Other: 5.6%

Source: State of Hawaii, Department of Business, Economic Development, and Tourism
In-State Use of Transportation Fuels*

- Gasoline: 64.0%
- Aviation fuel: 28.8%
- Diesel (hwy use): 6.8%
- Other fuel: 0.4%

*Does not include off-highway use of fuel, such as for marine transportation, or fuels not subject to in-state tax, such as jet fuel for international travel. Source: Department of Taxation, Fiscal Year 2007: http://www.hawaii.gov/tax/a5_3txcolrpt.htm
Hawaii’s Actual and Projected* Ground Transportation Fuel Demand, 1983-2008

Hawaii’s Gasoline Now Contains 10% Ethanol
10% ethanol • 90% gasoline
Blending economics: ethanol is cheaper than gasoline
About two-thirds of U.S. Gasoline Now Contains Ethanol
Biodiesel

• Produced locally (Maui & Oahu) from used cooking oil

• Can also be produced from oilseed crops

• For use in diesel engines

• Available at retail stations on Oahu and Maui
Retail Biodiesel Fueling locations

Oahu:
- B99: 76 station on Nimitz, by Carls Junior
- B20: 76 station at Niu Valley 7-11
- B20: 76 station on King Street near Piikoi

Maui:
- B99: Pacific Biodiesel pump in Kahului, Hobron Lane
- B20: Paia Chevron
Electric, Hybrid, and Fuel Cell Vehicles

- **Neighborhood Electric Vehicles**
- **Fuel Cell Car**
- **Plug-in Hybrid**
- **Hybrid electric-fuel cell bus for Hickam Air Force Base**
Energy for Tomorrow

Electricity
- Energy Efficiency First
- Customer-Sited Generation
- Combined Heat and Power
- Development of Renewable Energy Resources
  - Solar
  - Wind
  - Biomass
  - Geothermal
  - Hydropower
  - Ocean (OTE/Wave)
- Energy Storage
- Smart Grids
- Changes in Electricity Regulation

Transportation Fuels
- Land Use
- Transportation System Design
- More Efficient Vehicles
- Vehicles Capable of Using Non-petroleum Energy Sources
- Local Production of Alternative Fuels
  - Biofuels
    - Ethanol
    - Biodiesel
    - Biojet
  - Electricity from renewable sources, off-peak
  - Hydrogen
Biofuels Assessment

A 2-year project to conduct a statewide multi-fuel biofuels production assessment of:

• potential feedstocks and technologies;
• the economics of the various renewable fuels pathways; and
• the potential for ethanol, biodiesel, and renewable hydrogen production to contribute to Hawaii’s near-, mid-, and long-term energy needs

Scheduled for completion in July, 2009
Bioenergy Master Plan

DBEDT 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.
The bioenergy master plan shall address the following issues:

1. Specific objectives and timelines;
2. Water resources;
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.
Your help is needed.

Survey:

• hawaii.gov/dbedt/info/energy/renewable/bioenergy/
• In which areas do you have expertise?
  Please select up to 3 topics.
• What specific information / resource would be helpful?
• Please provide details: name, phone number, email; document link; actual document(s)
• hawaii.gov/dbedt/info/energy/renewable/bioenergy/

Input:

• Send via email: bioenergy@dbedt.hawaii.gov
• Or mail to: PO Box 2359, Honolulu, HI 96804
• By: September 15, 2008
  additional information is welcome at any time
Additional information

50,000,000 barrels per year
1,300,000 resident population
38.46 barrels per resident per year
42 gallons per barrel
1615 gallons per resident per year
365 days per year
4.4 gallons per resident per day
Bioenergy Systems Overview

Scott Turn
Associate Researcher
Hawaii Natural Energy Institute
University of Hawaii

Hawaii Bioenergy Master Plan
September 5, 2008
## Summary of Hawaii Biomass Resources by County circa 2002

<table>
<thead>
<tr>
<th>Resource</th>
<th>Hawaii</th>
<th>Maui</th>
<th>Kauai</th>
<th>Honolulu</th>
<th>State</th>
</tr>
</thead>
<tbody>
<tr>
<td>Animal Manure, Mg/yr*</td>
<td>189</td>
<td>246</td>
<td>85</td>
<td>9,185</td>
<td>10,646</td>
</tr>
<tr>
<td>Bagasse Fiber, Mg/yr*</td>
<td>0</td>
<td>249,433</td>
<td>68,027</td>
<td>0</td>
<td>317,460</td>
</tr>
<tr>
<td>Cane Trash Fiber, Mg/yr*</td>
<td>0</td>
<td>124,263</td>
<td>33,560</td>
<td>0</td>
<td>157,823</td>
</tr>
<tr>
<td>Pineapple Field Trash, Mg/yr*</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>43,311</td>
</tr>
<tr>
<td>Mac Nut Shell, Mg/yr*</td>
<td>16,871</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>16,871</td>
</tr>
<tr>
<td>Municipal Solid Waste, Mg/yr*</td>
<td>64,886</td>
<td>61,038</td>
<td>32,552</td>
<td>418,104</td>
<td>576,580</td>
</tr>
<tr>
<td>Landfill Waste in Place, 10^6 Mg</td>
<td>3.1</td>
<td>2.2</td>
<td>1.3</td>
<td>7.7</td>
<td>14.4</td>
</tr>
<tr>
<td>Wastewater Influent, 10^6 gal/day</td>
<td>7.4</td>
<td>16</td>
<td>4.4</td>
<td>99</td>
<td>127</td>
</tr>
<tr>
<td>Fats/Oil/Grease, Mg/yr*</td>
<td>841</td>
<td>1,678</td>
<td>739</td>
<td>9,232</td>
<td>12,490</td>
</tr>
<tr>
<td>Sawmill residues, Mg/yr*</td>
<td>27,617</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>27,617</td>
</tr>
</tbody>
</table>

* dry basis
Implementation issues

• Most public studies to date on potential bioenergy production systems are conducted given a set of assumptions

• Assessment must be site/location specific
  – Water availability and costs for crop production
  – Land availability for biomass production (e.g. private/public decision making)
  – Land use priorities
  – Impacts on environmental quality
  – Economic impacts
  – Cost of production for conversion technologies that are currently in development

• Additional work needed to guide government policy and/or specific bioenergy production ventures
Pathways for Bioenergy Systems

Crops
- Sugarcane
- Sweet Sorghum
- Cassava
- Corn
- Guinea Grass
- Banaggrass
- Eucalyptus
- Leucaena
- Jatropha
- Kukui
- MicroAlgae
- Soybean
- Peanut
- Sunflower
- Oil Palm

Intermediate Products
- Sugars
- Starch
- Fiber
- Oil
- Waste Cooking Oil

Conversion Technologies
- Hydrolysis
- Fermentation
- Hydrolysis
- Gasification
- Pyrolysis
- Combustion

Bioenergy Products
- Ethanol
- Other Fuels, Chemicals, & Biomaterials
- Electricity & Heat
- Biodiesel

Colors:
- Blue – Commercial in Hawaii
- Green – Commercial elsewhere
- Pink – Grown commercially in Hawaii
- Orange – Under Development
Banagrass

Bio-energy Symposium
Sept. 5, 2008

Robert Osgood
Sugarcane at Gay and Robinson
## Contributors

- Nick Dudley  HARC
- Lee Jakeway  HARC/ HC&S
- Bob Joy and staff  PMC, Moloka`i
- Charly Kinoshita  HNEI/CTAHR
- Robert Osgood  HARC
- Tom Tew  HARC
- Scott Turn  HNEI/CTAHR
- K. K. Wu  HARC
Organizations

- HARC
- DBEDT
- HNEI
- USDA, PMC Moloka`i
- UH, CTAHR
- NREL
Banagrass

- Cultivar of *Pennisetum purpureum*, a tropical grass species native to Africa
- Used for forage, biomass and orchard windbreaks
History

- Banagrass was introduced to Hawaii from Australia by the Hawaiian Sugar Planters’ Association through normal plant introduction protocol in the mid 1970’s.

- On release from quarantine in Hawaii after one year at Beltsville MD and one year on Moloka`i, banagrass was planted at the sugarcane breeding station at Maunawili, Oahu.
Biomass Attributes Noticed

In the 1980’s and 90’s:

- Vigorous growth and upright stature of banagrass were noted at Maunawili.
- It was increased and compared to sugarcane in HSPA biomass trials.
Biomass Trials

- In 1982 to 1984: First planted in “Energy Cane” trials in Ewa and Kunia on Oahu
- In 1986: included in the HSPA “Biomass to Energy” trial on Moloka`i*
- In 1988: propagated and planted in 5 standard HSPA replicated trials in comparison with sugarcane.

* Sponsored by DBEDT
Replicated Trial

- HSPA compared banagrass and sugarcane in 5 locations at sugar plantations on four islands (Wu and Tew 1989 HSPA internal report).
- Average plant crop yields (annualized) across all sites for banagrass were about equal to sugarcane yields at 18.5 tons of dry matter per acre per year.
- Ratoon yields were substantially higher at 42 tons dry matter per acre per year, about double that of sugarcane at the same locations.
HSPA “Biomass to Energy” Project*

USDA Plant Materials Center on Moloka‘i
A plant crop and 6 ratoons of banagrass were harvested from April 1987 to January 1991.
Dry matter yields ranged from 11.55 tons per acre per year in the winter/spring grown plant crop to 31.32 t/ac/yr in a spring/summer-grown 4th ratoon.
Summer grown ratoons of banagrass were about twice as productive as winter-grown ratoons
Seed produced from this planting were used to establish 11.4 acres of banagrass in a scale-up planting for mechanical harvest

Funded by DBEDT
**Banagrass Yield on Moloka`i**

<table>
<thead>
<tr>
<th>Harvest Number</th>
<th>Crop Days</th>
<th>Dry Matter*</th>
<th>Season</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>217</td>
<td>11.55</td>
<td>winter/spring</td>
</tr>
<tr>
<td>2</td>
<td>212</td>
<td>27.21</td>
<td>summer/fall</td>
</tr>
<tr>
<td>3</td>
<td>188</td>
<td>18.81</td>
<td>winter/spring</td>
</tr>
<tr>
<td>4</td>
<td>289</td>
<td>20.35</td>
<td>fall/winter</td>
</tr>
<tr>
<td>5</td>
<td>176</td>
<td>31.32</td>
<td>spring/sum</td>
</tr>
<tr>
<td>6</td>
<td>223</td>
<td>14.51</td>
<td>winter/spring</td>
</tr>
<tr>
<td>7</td>
<td>280</td>
<td>15.13</td>
<td>fall/winter</td>
</tr>
</tbody>
</table>

*Ton/Acre/Year
Scale-up Banaggrass Planting, Moloka`i*PMC

- 0.73 ton of seed per acre was used to plant the 11.4 acre scale-up
- The plant crop dry matter yield was 26.1 t/ac/yr based on hand harvest of 12 replications.
- The ratoon yield was 30.1 t/ac/yr
- The average yield for the plant and ratoon combined was 28 tons/ac.
- 7 months harvest for plant and 8 months for the ratoon

*Osgood and Dudley 1996
Moloka`i Banagrass Harvest
Moloka`i Banagrass Harvest
Direct Loading into Truck
# Mechanical Harvest Data

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Harvester productivity (Ac/Hr)</td>
<td>0.65</td>
</tr>
<tr>
<td>Average particle length (in)</td>
<td>11.3</td>
</tr>
<tr>
<td>Bulk density (lb/cu foot)</td>
<td>7 to 8</td>
</tr>
<tr>
<td>Actual Dry matter yield (ton/ac)</td>
<td>16.7</td>
</tr>
<tr>
<td>Annualized Dry matter yield (ton/ac)</td>
<td>26</td>
</tr>
<tr>
<td>Recovery (%)</td>
<td>73</td>
</tr>
<tr>
<td>Biomass harvest rate (T/Hr)</td>
<td>27</td>
</tr>
</tbody>
</table>

*Osgood, Dudley and Jakeway, 1996  
**Determined from residue recovery (4.5 Tons)
Banagrass Characteristics

Positive

- High yield of biomass dry matter
- Rapid growth, fast close in, early harvest at 7 to eight months
- Low weed control cost, especially in ratoons
- Upright habit for harvest efficiency
- At least 7 ratoon crops before replanting,
- Planting and harvest with “off the shelf” sugarcane equipment
Banagrass Characteristics

Negative

- Poor germination of vegetative seed pieces and poor stands. Can be overcome by planting extra seed.
- Some weed potential especially in wet environments.
- Grown exclusively for cellulose. No useful soluble fraction as with sugarcane.
- High ash content may be problem in energy conversion. May require milling before conversion.
- No current research or breeding program making production risky.
Conclusions

- Banagrass is a highly productive biomass crop yielding more dry matter per acre-month than sugarcane in ratoons.
- At least 7 ratoons possible
- Ratoons often produce twice the biomass as the planted crop but this depends on the month harvested
- Field compaction will limit yield
- Summer-grown crops are significantly more productive than winter-grown crops
- Use depends on cellulose conversion technology
Concluding Remarks

- Bio-energy projects require large blocks of land
- Significant costs for growing, maintaining, harvest and transport.
- Industrial infrastructure requiring a long term outlook
- Integrated field and industrial operations
- High risk
- Guaranteed market for energy produced
- C4 grass biomass crops such as banagrass and sugarcane require large amounts of water and nutrient to achieve high yield.
Banaggrass Plant Crop at 7 Months from Planting
Jatropha curcas

Michael Poteet, Asst. Agronomist
Hawaii Agriculture Research Center
September 5, 2008
HI Bioenergy Master Plan Workshop
Background

• Native to Central America/Mexico
• Used traditionally as medicine, lamp oil, soap
• Spread by Portuguese explorers
• Commercialized in Cape Verde in 1800’s
• Toxic when ingested (non-toxic varieties?)
• Life-span over 40 years
• Seeds contain 30-40% oil content
• 1 of over 170 species in Jatropha genus
Worldwide development

- Gaining in popularity throughout tropical/subtropical world
  - India
  - China
  - SE Asia
  - Africa
  - Central & South America
Commercialized production?

- Many vendors and agents are pushing commercial jatropha ventures around the world
- India & China have seen rapid expansion – expected to be millions of acres in the two countries by 2010 – government investment
- Philippines, African nations, Thailand, Myanmar, Indonesia, and others claim to have large acreage already under cultivation
‘Western’ contributions...

• Dr. Becker at University of Hohenheim in Germany - >10 years of dedicated R&D
• D1 Oils (UK), now a subsidiary of BP, has development projects in three continents
• Co-products, toxicities, breeding/selection, mechanization, etc.
Jatropha in Hawaii

• Documented in Hawaii by Bishop Museum as early as 1910
• Believed to be brought in by Asian and Portuguese immigrants for medicinal use
• Currently naturalized on parts of Big Island (from old worker camps)
• Sometimes found in people’s yards and in random overgrowth
R&D in Hawaii

• Need for determination of site suitability across the State
  – Leeward sites (w/ supplemental irrigation)
  – Upland sites (<3,000 elevation)
  – Windward sites (what is threshold for overwatering?)
  – Soils – sands, loams, lava soils, steep slopes, water-logged (heavy clays)
  – Detrimental wind effects

• Origins of seed, co-product isolation, methods to attain automation, selection of heavy yielders

• Water use
Field determinations

- Spacing
- Establishment
- Irrigation rates & frequency
- Induction of flowering
- Well-suited origins
- Uniform structure
- Oil contents x mgmt
- Potential for mechanization
Establishment – direct seeding?

- Transplanting throughout rest of world
- With drip irrigation, ability in Hawaii to direct seed
  - Fresh seed of high quality can give over 80% germ rate
  - Potential to adapt row planting equipment in future
Harvesting?

- Low labor cost around world provides environment for hand harvesting
- One worker can collect over 200 lbs of fruit in one day (8 hrs)
  - Not from soil surface
  - Imagine coffee harvesting

- Options for Hawaii:
  - Collect from ground after fruit drop
  - Remove from trees when mature
  - Biomass + fruit harvest
  - Shake trees
  - Collect from trees and ground in one pass

- This is THE critical roadblock to production in Hawaii
Moving forward...

• Co-product development
• Refining yield predictions
  – From a window of 150-350 gpa at maturity to a consistent 300+ gpa production scheme
• Increasing uniformity in structure and yields of individual trees across large plantings
• Providing high-quality planting materials
• Engineering new equipment
• Incentivizing production
More information

• Visit http://tpss.hawaii.edu/biofuel/
• Contact me @ mpoteet@harc-hspa.com or (808) 292-9724
• Data on:
  – Early yields
  – Water use
  – Mgmt strategies
  – Fertilization
  – Seed availability
LEUCAENA
Versatile Multipurpose Trees
J. L. Brewbaker, College of Tropical Agriculture, University of Hawaii

1. Genus of 22 Species, Legume family
2. Latin America (Texas to Peru)
3. Multipurpose Tree:
   Worldwide as Fuelwood
   Forage Crop
   Green Manure
   Paper
4. Major species = L. leucocephala
DOGS are NOT WOLVES (but they’re related)
LEUCAENAS are NOT KOA HAOLES (but they’re related)
SUBSPECIES

• DOGS AND WOLVES ARE:
  SUBSPECIES of *Canis lupus*

• LEUCAENA AND KOA HAOLE ARE:
  SUBSPECIES of *Leucaena leucocephala*

HISTORICALLY:
Dogs & wolves were considered separate species
Leucaena & koa haole were also
L. diversifolia at Kamuela, 3000 ft  
KX5 seedless hybrid at Waimanalo
Hawaii’s Leucaena as Forage in Australia; 350,000 acres (with Buffelgrass)
4-year old Stand of K636 Maui Sugar Waste-Water
LEUCAENA BIOENERGY
Molokai Study

• Yield: 13 t/A per year, dry matter
• 4-year old trees
• 4000 trees/acre
• Harvest one acre/day
• In-field Chipper
• 12 million kWhr annual
Leucaena KX3 Hybrid

12 year old tree; 44cm dia
Leucaena-based Furniture
KX2, Highland Hybrid, 2 year regrowth (Waimanalo)
Opportunities for Bioenergy Crop Production: Guinea Grass

Dr. James R. Carpenter
Assoc. Researcher & Department Chairman
Dept. of HNFAS, CTAHR
Univ. of Hawaii at Manoa, Honolulu

Hawaii Bioenergy Master Plan
A Conversation with Hawaii’s Agricultural Sector
Hawaii Convention Center, HNL
Key Strategic Opportunities

• Abundant biomass production in tropics (high solar radiation and year round production – water is key)
• Large land tracts potentially available (Large decrease in sugar and pineapple production)
• Diversity of Marketing Options (flexibility & challenges). New Feedstock Processing Alternatives
• Guinea – Abundant tropical grass, high yields, varied nutrient content, grows well in HI at low elevations.
• Opportunity to adapt new/existing technologies of biomass conversion → high energy feedstocks
• Synergism (Bioenergy and Biofuels) – New Crops
Figure 1. Simulated tops weight/ha (stover+grain) at maturity for maize planted on the first day of each month at Ewa, Oahu, under rainfed conditions.
Figure 2. Simulated tops weight/ha (stover+grain) at maturity for maize planted on the first day of each month at Ewa, Oahu, under irrigated conditions.
Guinea Grass
(Panicum maximum Jacq)

• Ubiquitous throughout the tropical and subtropical regions.
• Originally came from Africa.
• 15 cultivars (FAO web site) that vary considerably in plant physiological & growth charac.
• A myriad of common names which is a reflection of its presence through-out the world.
• The most frequently cited, particularly in Hawaii, is Common Guinea.
Guinea Grass (*Panicum Maximum, Jacq*)

- GG is the dominant species on former sugarcane lands.
- It is tolerant of grazing, provides good quantity and quality forage.
- It is an ideal forage plant as it grows well on a wide variety of soils.
- It responds very quickly to fertilizer and watering.
- It grows from sea level up to 1,200m. GG is considered as a suitable plant to stop soil erosion on slopes (it has dense root mats) while providing valuable forage.
- Its resistance to drought also means it builds up a dangerous mass of plant material so when fires occur, the blaze is fiercer and native plants which have not built up fire-tolerance are wiped out.
- It is considered a dangerous exotic weed that suppresses or displaces local plants. The seeds are dispersed by birds.
- It can survive long dry spells and quick-moving fires which does not harm the underground roots.
- As GG can survive fires, it dominates the ground after a fire.
Distribution, Adaptation, & Uses:

- Guinea grass is reported to tolerate annual precipitation of 6.4 to 42.9 in (mean of 40 cases = 18.5), annual temperature of 54.0 to 82.1°F (mean of 40 cases = 74.1), and pH of (3.5) range 4.3 to 8.4 (mean of 33 cases = 5.9).
- It is commonly found in moist soils, tolerates shady to open canopies, and worldwide occurs on roadsides and riverbanks from 0 to 7704 ft elevation.
- Guinea is found well north and south of the subtropics as well. It generally ranges from 16.3°N to 28.7°S although more recent sightings have expanded this range.
- In Hawai‘i, naturalized and common from 0-2789 ft, a weed of sugarcane fields, roadsides, and river banks. It does not tolerate waterlogged, clayey soils in high rainfall regions & is commonly found in moist soils - tolerates shady to open canopies.
- In fact Guineagrass has been considered a major pest, and treated like a weed in the pineapple/sugarcane lands for years – therefore historically little-no research has been conducted with GG in HI.
Plant Establishment & Fertilization:

- Full seed-bed preparation is generally required for Guineagrass establishment but because of its good seed production reseeding is not required once established.
- Sowing depth should not be more than 0.6 in, should sow in the spring or early summer so that forage is established before the extreme heat of summer at the rate of 3-6 kg/ha (2.2-4.4 lb for ‘Hamil’, 7.7-9.9 lb for ‘Common’).
- Average number of seeds per lb is 793,651 with different cultivars varying (467,120 for ‘Hamil’; 997,732 for Common) and they do not require any special treatment except ageing.
- Guineagrass normally seeds profusely.
- It should be controlled in the seedling stage, as it is very difficult to remove later when the grass is well established and it reaches maturity where seed production occurs.
Growth Patterns, Yields & Soil Requirements

- Stand density, plant maturity, soil moisture, and soil fertility are all factors positively correlated to yield.
- Although yields are most affected by rainfall amount and distribution many other factors interact with soil moisture to affect plant growth, including soil texture and fertility, management, and cultivars.
- Guineagrass regrows quickly, even in short grazing rotations, and can produce equal amounts of forage whether harvested bi-monthly or biannually in a semi-arid climate (22.8 in rainfall/year).
- In African range, Guinea grass was able to increase (sandy soils) or maintain (alluvial soils) its propagation of total DM yield after 6 yr of being clipped whenever it flowered.
Growth Patterns, Yields & Soil Requirements

• Green matter yields of 38.8 tons/acre per year have been obtained from unfertilized stands; on well manured or fertilized stands, 55.8–67.0 tons/acre green fodder has been obtained per annum.

• Guineagrass will grow on a large range of soils, but produces poor stands on infertile types. It is well adapted to sloping, cleared land in low to moderate rainfall areas (31.5 to 70.9 inches in well-drained soils) and it will tolerate acid conditions if drainage is good.

• Guineagrass requires medium to high soil fertility, and prolonged grazing or harvesting without replacing soil nutrients but it normally results in stand declines.

• Forage yield and nutritive value is also generally higher in grass-legume mixtures than pure, unfertilized grass swards.
Factors Influencing Forage Quality

Environment
- Light intensity (solar radiation)
- Day length
- Water (precipitation)
- Temperature
- Topography
- Soil (fertility, moisture)

Plant Response
- Vegetative growth (yield)
- Maturity, plant death
- Development
- Dormancy

Plant Composition
- Reserves
- Non-structural carbohydrates
- Protein fractions
- Cell wall (NDF)
- Lignification
- Secondary factors affecting user

Value as Feedstock (Animal or Bioenergy Crop)
- Nutritive value (balance)
- Availability/access
- Forage/Grazing Management
- Quantity of forage (availability)
- Intake and digestibility/passage
- Harvesting and storage

$$$ Returns to Producer
Grass Nutritional Value

- CHEMICAL COMPOSITION OF FORAGES, PARTICULARLY GUINEA GRASS (*Panicum maximum*) VARY WIDELY DEPENDING ON:
  - Geographical location (soil type, elevation)
  - Weather (temperature, solar radiation, rainfall)
  - Soil pH and fertility
  - Pasture/forage management techniques

- TROPICAL GRASSES MATURE RAPIDLY AND NUTRITIVE VALUE DELINES WITH:
  - Lower soluble carbohydrate and protein contents; Higher fiber and lignin levels
Nutrient Analysis of Various Tropical Biomass Grasses [Data on Dry Matter (DM) Basis]

Source of data - Combination of Dr. James R. Carpenter research samples and Dept of HNFAS data base.

<table>
<thead>
<tr>
<th>Grass</th>
<th>Dry</th>
<th>Crude</th>
<th>Ash</th>
<th>NDF</th>
<th>Cellulose</th>
<th>Lignin</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Matter</td>
<td>Protein</td>
<td>(Inorganic)</td>
<td>Cell Wall</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guinea Fresh</td>
<td>38</td>
<td>41</td>
<td>26</td>
<td>14</td>
<td>14</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td>33.9</td>
<td>12.1</td>
<td>11.7</td>
<td>69.3</td>
<td>32.1</td>
<td>5.9</td>
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<tr>
<td></td>
<td>15.5</td>
<td>2.3</td>
<td>7</td>
<td>56.4</td>
<td>24.5</td>
<td>3.5</td>
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<td></td>
<td>75.1</td>
<td>21.7</td>
<td>16.6</td>
<td>81.9</td>
<td>38.5</td>
<td>9.9</td>
</tr>
</tbody>
</table>

College of Tropical Agriculture and Human Resources
University of Hawai‘i at Mānoa
Mineral Analysis of Various Tropical Biomass Grasses *(Data on Dry Matter (DM) Basis)*

Source of data - Combination of Dr. James R. Carpenter research samples and Dept of HNFAS data base.

<table>
<thead>
<tr>
<th>Grass</th>
<th>Dry Matter, %</th>
<th>Ash, % (Inorganic)</th>
<th>Calcium, %</th>
<th>Phosphorus, %</th>
<th>Potassium, %</th>
<th>Silicon, ppm</th>
<th>Aluminum, ppm</th>
<th>Iron, ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guinea</td>
<td>Fresh</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>38</td>
<td>26</td>
<td>42</td>
<td>43</td>
<td>43</td>
<td>5</td>
<td>13</td>
<td>39</td>
</tr>
<tr>
<td>Mean</td>
<td>33.9</td>
<td>11.7</td>
<td>0.53</td>
<td>0.29</td>
<td>1.94</td>
<td>3.01</td>
<td>174</td>
<td>124</td>
</tr>
<tr>
<td>Min</td>
<td>15.5</td>
<td>7</td>
<td>0.15</td>
<td>0.1</td>
<td>0.4</td>
<td>2.74</td>
<td>24</td>
<td>10</td>
</tr>
<tr>
<td>Max</td>
<td>75.1</td>
<td>16.6</td>
<td>1.35</td>
<td>0.82</td>
<td>5.02</td>
<td>3.33</td>
<td>580</td>
<td>510</td>
</tr>
</tbody>
</table>
Methods: *Experimental Design (Kauai, Big Island)*

- Split-plot complete block (3 ea) with a factorial plot, randomized (3x3x2x2) arrangement four treatment factors: lime, nitrogen, legume seeding, and grazing
- Whole plot treatments include:
  - 3 levels of lime (CaCO3) application at 0, 4.5 and 11.2 t/ha,
  - 3 levels of nitrogen fertilizer (urea; 46% N) at 0, 182, and 365 kg/ha,
  - 2 seeding rates of perennial peanut (*Arachis* spp.) at 0, and 14 kg/ha.
  - Grazing level; ungrazed (UG) or moderately grazed (G) is a split plot treatment.
Preliminary Conclusions

- Many ranchers are now leasing or purchasing former sugarcane lands on the islands of Kauai, Maui and Hawaii. Most of these lands, once abandoned, developed into open grasslands where GG is now the dominant species.

- The soils on these former sugar lands tend to be strongly acidic and deficient in important plant nutrients like N, P, K, and Ca, and thus, limit the productivity of desirable grasses and legumes.

- Results to date show that GG production responded rapidly to N fertilizer added at moderate quantities. Doubling the addition of urea more than doubled guinea grass production in the Hawaii Island pasture, but did not increase grass production on Kauai.

- This suggests that N fertilizers not only increase forage production and productivity, but also improve pasture by boosting guinea grass production and reducing weeds in weedy pastures.
Preliminary Conclusions (Cont’d)

• In the short term, lime showed no effect on grass production indicating that guinea grass is well adapted to acid soils low in extractable Ca & P.

• Although they noted no significant improvement in forage quality, cattle grazing pressure on treated plots was heavier relative to the untreated plots indicating improved palatability.

• Climatic differences between the two study sites had a dramatic effect on forage productivity (dry weight accumulation (lb) per day). The low elevation pastures in a warmer climate on Kauai showed high productivity at the highest N level producing on average 170 lb guinea grass (DW) per day compared with 75 lb DW per day at the Big Island site.

• The higher average temperature at the Kauai site translates into more solar radiation and is likely the major contributor to the high grass productivity.
Overall Conclusions & Implications

• It's quite clear that several crops can be grown quite successfully in Hawaii and we are just beginning to understand the keys to GG production/utilization. We have limited knowledge of the economics or commercial production of many of these crops.

• Are we convinced that using Hawaii’s forage grasses and acreage for bio-energy is good use of these resources. Are there more efficient sources of carbon for bio-fuel/energy than grasses, and are there more efficient systems than pasture / rangelands that can produce far greater amounts of potential energy per acre.

• Are there more efficient locations (mainland) that can produce bio-energy far less expensively than here. Bio-energy production in Hawaii will always be extremely limited in quantity and quality.

• Will the value of the bioenergy extracted from the land be greater than the cost to produce it? (labor, fertilizer, equipment, fuel, irrigation, distilling, production, storage, shipping, marketing, etc.)
Overall Conclusions & Implications

• Can we produce enough carbon to meet the demand. In the long run, we will always, like our food, be importing energy sources from somewhere and they will always be cheaper than what can be produced here.

• Use of large tracks of land for bioenergy crops will greatly reduced our capacity to produce food in the islands (the byproduct from this process will not make up for the thousands of animal units lost by harvesting fresh guinea grass for bi-fuel production).

• Is importing food items into the state more costly than importing fuel/energy into the state. Unit for unit on a per capita basis, does food cost more for Hawaii consumers than the energy consumed here.

• Therefore should the state be placing more effort on land/water use for increasing agricultural food production rather than focusing on energy.
References:

- FAO web site
- Kabaija E. and O.B. Smith Effect of season, fertilizer application and age of regrowth on mineral content of guinea grass (Panicum maximum, Schum) and Giant Star grass (Cynodon nlemfuensis, Chedda) (web site)
QUESTIONS ??
Biofuels Energy Future

Briefing for the
2008 Hawaii Agriculture Conference

Karl E. Stahlkopf
Senior Vice President and Chief Technology Officer
Hawaiian Electric Company, Inc.

September 5, 2008
Leading the Way with New Technologies

- Renewable Energy Solutions
- Customer Energy Conservation and Load Control
- Biofuels
- Distributed Generation
- Advanced Metering Infrastructure
Recent initiatives
- PUC: Competitive bidding for new generation (2006)

Recent laws
  - 20% net electric sales by 2020
- Hawaii Global Warming Solutions Act of 2007
  - Limits 2020 GHG emissions to 1990 levels

Volatility of oil prices and gas prices

Increased customer interest in energy choices (PV)

Demand reduction

Proposed Renewable Energy Infrastructure Program
The Benefits of Biofuels

Electrical generation with biofuel will:

- Reduce dependence on imported fossil fuels
- Help meet Hawaii's renewable energy goals using existing generation assets with locally produced renewable biofuel
- Reduce greenhouse-gas emissions via a renewable closed loop carbon system
- Provide significant reductions of hydrocarbon, sulfur, toxic compounds, and particulate matter emissions compared to burning petroleum fuels
Three Areas of HECO Strategic Focus

1. Greening of Utility Assets
2. Expansion of Renewable Energy
3. Providing New Customer Options and Choices with Emerging Energy Efficiency, Demand Response, and Renewable Technologies
Greening of Utility Assets
Bioenergy Vision for the Future

- Actively pursue biofuels for:
  - Peaking units
  - Steam units
  - Diesel units
  - DG units
- Ensure procurement of biofuels that are certified as compliant with the HECO-NRDC sustainable biofuel procurement policy
- Develop:
  - Local supply of plant and algae feedstocks
  - Local algal oil and biodiesel production facilities
- Seek to direct power plant CO2 to algal oil production facilities
Testing Biofuels at HECO

HECO Steam Units
- Co-fire testing of biofuels at LSFO-fired HECO steam boiler
- 2008 – develop test plan and seek approvals
- 2009 – procure equipment, conduct tests (~30 days) at various blends

HECO DG Units
- Hawthorne to conduct biodiesel emissions testing of DG unit in San Diego in 4Q 2008
- Same unit as HECO substation DGs
MECO Generating Units

- Tested biodiesel in reciprocating engine and CT units at Maalaea
- Units able to burn B99 biodiesel without exceeding any air permit limits
- July 2008 – MECO issued RFP to procure 1 million gallons of biodiesel for further operational testing of large units at Maalaea
Implementing Biofuels

New Unit at Campbell Industrial Park

• 110 MW peaking combustion turbine
• 100% biodiesel commitment
• Seeking PUC approval of fuel supply contract
• Power plant construction underway
• Commercial operation scheduled for 2009
Maui Biodiesel Production Plant

- BlueEarth Biofuels plant
- Planned for MECO Maalaea land designated for renewable energy development
- Off-take by MECO to displace current diesel oil
- Fuel contract, financing, and land lease agreement negotiations continue
- Commercial operation targeted for 2011
Biofuel Crop R&D

- Providing funding to Hawaii Agriculture Research Center (HARC)
  - Identify biofuel crops
  - Evaluate production yields
  - Assess infrastructure and other requirements

- HARC subcontracting with UH Manoa and UH Hilo
  - Moringa oleifera and jatropha
  - Kukui on Molokai
  - Jatropha on Oahu
  - Hybrid oil palm on Big Island
Forging New Frontiers in Renewable Energy

- In June 2008, announced agreement among HR BioPetroleum, Alexander & Baldwin, and HECO to pursue algal oil production plant on Maui

- Potentially one of the first commercial algae biofuel farms in the world
Algae to Biofuels at Maalaea

- Target: Produce 6,000 to 10,000 gallons of biodiesel per acre per year
- Initially 200+ acres, expanding to 1,000 acres
- New business relationship:
  - Utility offers stack gas and water from nearby MECO Maalaea plant
  - Utility uses biofuel
Security of Supply
Potential Local Feedstocks in Out-Years

Long-term biodiesel feedstock requirements to be increasingly met by local growers and crops once a viable market opportunity for those crops exists.

Potential Local Growers
- Hawaiian Commercial & Sugar
- Maui Land & Pineapple
- Castle & Cooke-Dole Foods
- Kamehameha Schools
- Grove Farm Company
- Gay & Robinson
- Agricultural Co-operatives
- Hilo nonprofit company – produce and sell jatropha seedlings

<table>
<thead>
<tr>
<th>Indigenous Oil Crops</th>
<th>Gallons per Acre</th>
<th>Feedstock Potential Gallons/Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palm Oil</td>
<td>581</td>
<td>80,991,400</td>
</tr>
<tr>
<td>Kukui</td>
<td>225</td>
<td>31,365,000</td>
</tr>
<tr>
<td>Macadamia Nut</td>
<td>219</td>
<td>30,528,600</td>
</tr>
<tr>
<td>Jatropha</td>
<td>185</td>
<td>25,789,000</td>
</tr>
<tr>
<td>Caster Bean</td>
<td>138</td>
<td>19,237,200</td>
</tr>
<tr>
<td>Peanut</td>
<td>103</td>
<td>14,358,200</td>
</tr>
<tr>
<td>Sunflower</td>
<td>93</td>
<td>12,964,200</td>
</tr>
<tr>
<td>Sahflower</td>
<td>76</td>
<td>10,594,400</td>
</tr>
<tr>
<td>Sesame</td>
<td>68</td>
<td>9,479,200</td>
</tr>
<tr>
<td>Soybean</td>
<td>44</td>
<td>6,133,600</td>
</tr>
</tbody>
</table>

*139,400 Estimated HI acres available for feedstock crops

Source: Hawaii Biofuels Summit Briefing Book, 8/8/06
Meeting the Challenges

- Successful testing of biofuels in all HECO generating units
- Procuring secure supply of sustainable, certified feedstocks
- Developing commercially viable local production of feedstock for biofuels
- Identifying acreage for local plant and algae farms
- Permitting for biofuel and algae production facilities
- Research and development of algal oil products
Collaborate for Hawaii’s Biofuels Energy Future

WORKING TOGETHER, WE CAN SWITCH FROM IMPORTED OIL TO HOME-GROWN BIOFUELS.

We owe it to ourselves, our children and grandchildren to make renewable, agricultural energy a major part of Hawai‘i’s future.

HOW DO WE POWER OUR FUTURE?

BY EMBRACING HAWAII’S RICH AGRICULTURAL HERITAGE.

HERE’S WHAT WE CAN ACHIEVE TOGETHER.

Hawaii has the potential to achieve 100 megawatts of added electricity from clean, renewable sources in the next 5 to 10 years.

RENEWABLE ENERGY SOURCES

- 100 MW Wind Energy
- 85 MW Pumped Storage Hydro
- 50 MW ETHANOL IN NEW PLANT
- 83 MW ETHANOL OR BIO-DIESEL IN EXISTING PLANTS
- 85 MW Solar Energy
- 40 MW Garbage-to-Energy
- 30 MW Geothermal
- 25 MW Biomass
- 7 MW Landfill Gas
- Future Potential: Ocean Thermal Energy Conversion (OTEC), Wave Power, Hydropower
- 500 MW Total Clean, Renewable, LOCAL energy

DO WE HAVE BIOFUEL PLANTS IN HAWAII NOW?

On Maui, Pacific Bioenergy already produces clean burning fuel from recycled restaurant cooking oil. It’s used in HECO’s generators and HELE’s and NEXO’s diesel truck fleets.

Six ethanol producing plants have been proposed for the islands of Oahu, Maui, Kauai and the Big Island. Three of Hawaii’s Highest Landowners – Maui Land & Pine, Kamehameha Schools and Grove Farm on Kauai – just formed Hawaii Bioenergy, a partnership to research the best crops and technology to make biofuels here.

By starting now and staying the course, home-grown biofuels can be an economic source of clean, local, renewable energy for generations to come.

IS HECO COMMITTED TO “GREENING” ITS PLANTS WITH ETHERAL?

Absolutely! Several companies recently expressed an interest in supplying ethanol for HECO’s proposed Campbell Industrial Park power plant. HECO is investigating biofuels for existing generators on Oahu and the neighbor islands.

WHAT YOU CAN DO TO HELP.

Achieving a renewable future requires the cooperation and support of everyone – land owners, businesses, government units and communities. To learn more, visit www.hawaiief.com.
Biofuels Energy Future

Briefing for the 2008 Hawaii Agriculture Conference

Karl E. Stahlkopf
Senior Vice President and Chief Technology Officer
Hawaiian Electric Company, Inc.

September 5, 2008
Agriculture as the Foundation for a New Green Economy
Paul S. Zorner, Ph.D.
President and CEO
Hawai`i BioEnergy

September 5, 2008
Honolulu, HI
A Coalition to Support the Economic, Environmental and Community Integrity of Hawai`i through Improved Energy Security and Contributions to a Green Economy

HAWAI`I BioEnergy

Maui Land and Pineapple, Inc.
Khosla Ventures
Ohana Holdings
Finistere Partners

Kamehameha Schools
Grove Farms
BioEnergy Markets: My Message Today

- In a green economy
  - market size and market values are directly related to specific feedstocks and agronomic production methods
- Decades of agricultural and engineering research make possible today agricultural and crop processing productivity never before possible.
  - Diversity is key. Ethanol and power are starter products. True productivity lies in energy, food and biomaterials produced in an integrated biorefinery from a range of feedstocks
  - These productivity increases will allow profitable agricultural operations at a scale much smaller than possible previously
- Lots of room for improvement but its time to implement the advances we have.
  - Integration and technology consolidation is the key to help resolve the energy, food and supply chain issues being faced by communities across the globe
Hawai`i is Dependent on Oil

- US oil consumption is more than 20mbd
- Of all US states, Hawaii is the most dependent on and vulnerable to oil imports
- 95% of energy consumption in HI is from imported fossil fuels

Economic Impact:

- Hawaii imported 17m barrels of oil in the first half of 2008 to feed our power and transport sectors
- In doing so, we sent more that $1.7 billion out of HI – that’s more than $6,500 leaving our state every minute ($9.4 million per day)
Amplified American Ethanol Mandates

• 2007 – Senate passes a 36 billion gallon ethanol mandate by 2022
  – 7x current US volumes
  – 3x current global production

• Also sets a national ethanol quality standard to address CO² mitigation
  – Pooled ethanol use required to emit 20% less CO² emissions compared to gasoline
    • Current corn ethanol provides minimal CO² mitigation relative to gasoline*
    • Cellulosic and sugar cane based ethanol reduce CO² emissions relative to gasoline by over 80%

Sugarcane and Sorghum Ethanol have Greater Sustainability Profiles than do other Sources of Ethanol

Net Energy Value
(total energy out/petrocarbon energy necessary to produce the product)

Corn ethanol = 1.3 (petrocarbon equal to gasoline)

Brazilian ethanol = 8 (80% reduction in petrocarbon relative to gasoline)

Advanced cane agronomic practices = 14 (95% reduction in petrocarbon relative to gasoline)
Vision: Integrated Biorefinery

Integrating new technologies, new processes and novel feedstocks to produce from the smallest possible footprint a range of high value products for the Hawai`i market

**Feedstock**
- Cane
- Sorghum
- Process Waste
- Advanced Agronomic Practices

**Process**
- Fermentation to ethanol
- Fermentation to other
- Gasification
- Ligno-Cellulose Hydrolysis
- Ligno-cellulose Separation
- Algae
- Anaerobic digestion

**Product**
- Ethanol
- Power
- Biodiesel
- Jet Fuel
- Advanced Fuels
- Chemical Intermediates
- Biomaterials
- Animal Feed
Consolidating Technology Improves Economics of EtOH production from Sugarcane

... and remarkably increases land productivity

“Back of the Envelope” Calculations

- 25 million gallon target
- Assume 42 tons cane/acre
- EtOH and power only facility
- Hi-Fiber cane varieties

<table>
<thead>
<tr>
<th>Case</th>
<th>EtOH (gal/acre)</th>
<th>Land Required (acres)</th>
<th>Fiber (tons/acre)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base</td>
<td>916</td>
<td>27,000</td>
<td>6.3</td>
</tr>
<tr>
<td>Hi-Fiber</td>
<td>1290</td>
<td>19,200</td>
<td>12.5</td>
</tr>
</tbody>
</table>
Biomass Composition

Cellulose (Glucose) 38-50%

Hemicellulose (Other biomass sugars, esp. the pentose D-xylose) 23-32%

Lignin 15-25%

Other (Extractives, protein, ash, etc.) 5-20%
Cellulose Ethers
$3000-5000/ton
Example of value added applications from bagasse

- Food, Packaging, Coloring Agents
- Cosmetics and consumer Products
- Pharmaceuticals
- Adhesives, Ceramics
- Oil Production
In a green economy good marketing will extend to a life cycle analysis of the entire production process.

Product diversity is key in communities where scale is limiting. It remarkably impacts on economics. “Energy” products need to be produced in concert with other aspects of the supply chain.
Biodiesel Feedstock in Hawaii: Moving Forward Sustainably
Benefits of Biodiesel

- Cleaner emissions
- Renewable resource
- Local economic benefits
- Waste stream reduction/reuse
- Energy security
- Supports agricultural industry
  - “Crops not Condos”
• Currently processing 1.5 million gals of used cooking oil from 3 islands
• Biodiesel sold at 7 retail pumps on Oahu and Maui
• Product demand is greater than supply
• Used cooking oil excellent but finite source
Intelligent Growth

- Community Based Biodiesel
  - Biodiesel is grown, produced and sold in the same community
  - Production capacity is scaled to match local feedstock availability
  - Fuel is distributed locally for transport and agricultural use
Intelligent Growth

• Benefits
  – Economic and environmental benefits of biodiesel are maximized
  – Economic resilience and production flexibility are increased
  – Superior local energy security
Small Plant Technology Advances

- Grease trap waste to biodiesel
- Glycerin refinement
- Methanol recapture
- Waterless process
Potential Crops

- Numerous Varieties:
  - Jatropha
  - Kukui
  - Coconut
  - Castor
  - Peanut
  - Moringa
  - Sunflower
  - Palm...
Potential Crops

- Properties to consider
  - Oil yield per acre
  - Water requirements
  - Input requirements
  - Byproduct applications
  - Harvesting techniques
Potential Crops

• More information is required
  – Economic returns
  – Cost of inputs
  – Scalability of operations
  – Infrastructure and equipment requirements
  – Effects on food sustainability
  – Environmental impacts
Native plants prove costly, difficult for highway landscape

By Melissa Tanji, Staff Writer

- Double the cost of conventional Bermuda grass
- Weeds are taking over the native grass areas
- Landscapers discovered that the grasses cannot be grown by seeds but only by plugs.
Land Availability and Political Support

• Feedstock production incentives can aid development and reduce land cost issues

• Act 90
  – Biofuel production qualifies for direct leases of public lands

• Act 145
  – Biofuels production allowable on ag. zoned land

• Act 209
  – Biofuels production included in ag. loan program
New Industries in Hawaii

• Feedstock Crushing Facilities
  – Individual businesses
  – Co-Op models
  – Co-location with processing facilities
New Industries in Hawaii

- Byproduct Uses
  - Animal feed
  - Aquaculture
  - Biomass
Thank You
Energy Programs at USDA

Tim O'Connell
Assistant to the State Director/
Rural Energy Coordinator

USDA/Rural Development
Committed to the future of rural communities.
Rural Development

Over 40 grant, direct loan, and guaranteed loan programs to finance housing, businesses, and infrastructure in rural areas.

Program Areas:
- Rural Housing Programs
- Rural Utility Programs
- Rural Business and Cooperative Programs

http://www.rurdev.usda.gov

Committed to the future of rural communities.
“Old” Energy Programs

• Section 9006: Provide guaranteed loans and/or grants to farmers, ranchers and rural small businesses for renewable energy systems and/or energy efficiency projects.

• Section 9008: Biomass Research and Development—partnership between USDA and DOE
“New” Energy Programs

• Section 9003: Biorefinery Assistance
• Section 9004: Repowering Assistance
• Section 9005: Bioenergy Program for Advanced Biofuels
• Section 9007: Rural Energy for America Program (REAP): Replaces Section 9006
• Section 9008: Biomass Research and Development
• Section 9009: Rural Energy Self-Sufficiency
• Section 9011: Biomass Crop Assistance Program

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Section 9007

Rural Energy for America

- **Enhancements from previous program:**
  - More technologies available (now includes small hydro and wave energy)
  - Increases loan guarantees from $10M to $25M
  - Establishes an energy audit grant program
  - Allows grants for feasibility studies
  - Increases combined guaranteed loan/grant combination from 50% to 75% of project costs (subject to statutory $ limits)
Section 9008: Biomass Research and Development

- Continuation of previous Section 9008:
  - Reduces research topic areas from 4 to 3
    - Feedstocks,
    - Biofuels and Biobased Products Development,
    - Biofuels Development Analysis
Section 9003
Biorefinery Assistance

• Grants covering up to 30% of the cost of developing and building demonstration-scale biorefineries for producing "advanced biofuels," which essentially includes all fuels that are not produced from corn kernel starch.

• Loan guarantees of up to $250 million for building commercial-scale biorefineries to produce advanced biofuels.
Summary

• An opportunity to provide comments and suggestions on how [USDA] is to implement Sections 9003, 9004, 9005, 9007, 9009, 9011, 9012, and 9013.

• Federal grant funding is available—NOFA’s coming out in the next couple of months.

• However, to get funding, one must submit an application.
Contact Information

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