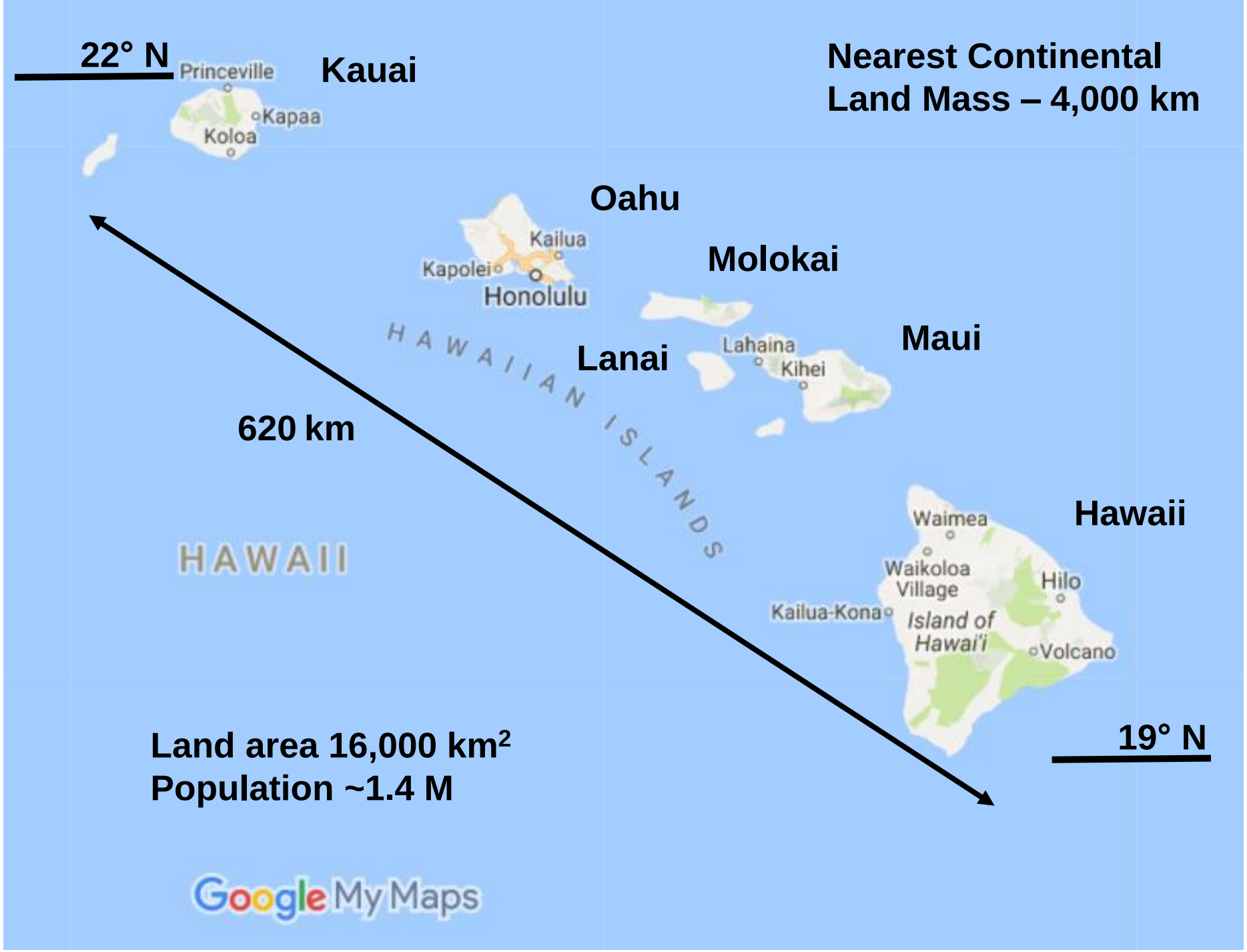
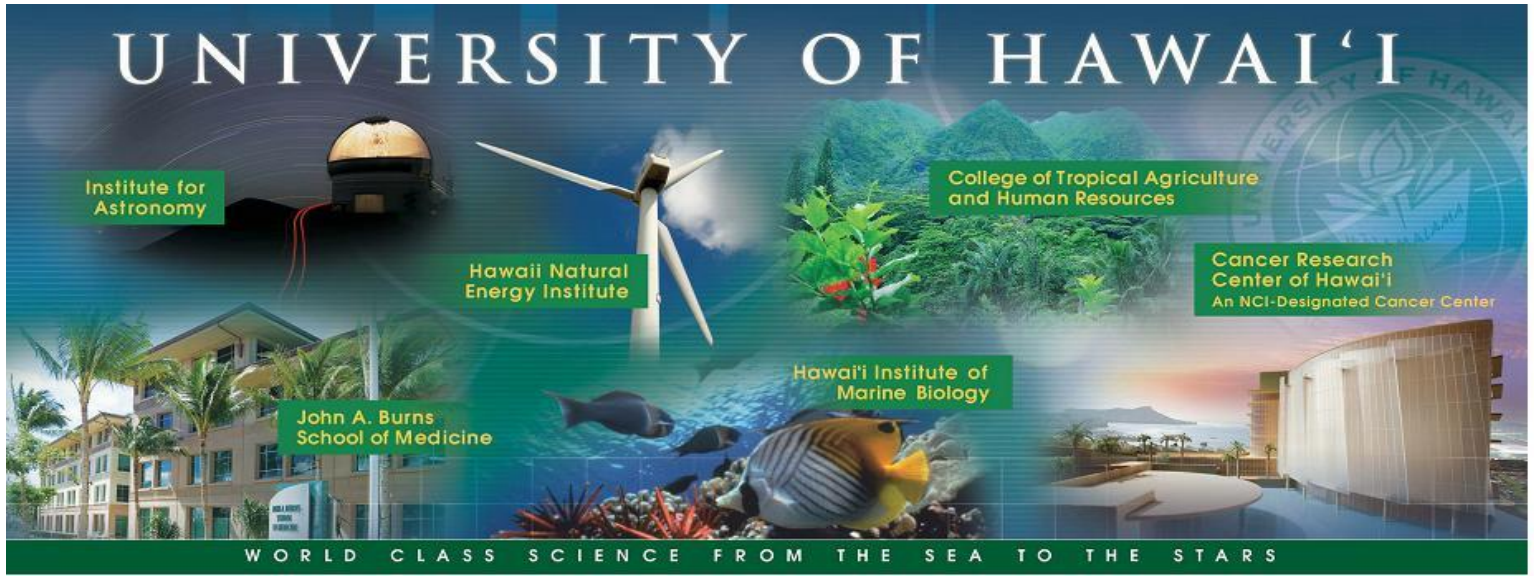
Overview of Bioenergy Development in Hawaii

Coconut Island – photo courtesy of NASA

Scott Turn
March 19, 2018
Hawaii Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa

2nd APEC Workshop on Guidelines Toward High Biodiesel Blend Diesel (eg B20) Honolulu, HI


22° N
Princeville
Kauai
Kapaa
Koloa
Nearest Continental
Land Mass – 4,000 km
Oahu
Kailua
Kapolei
Honolulu
Molokai
Lanai
Lahaina
Kihei
Maui
HAWAIIAN ISLANDS
620 km
HAWAII
Waimea
Hawaii
Waikoloa
Village
Hilo
Kailua-Kona
Island of
Hawai'i
Volcano
19° N
Land area 16,000 km²
Population ~1.4 M
Google My Maps



- Established in 1907
- 3 universities & 7 community colleges
- Over 53,000 students
- Manoa is the largest and main research campus
  - 14,000 undergraduate students
  - 6,000 graduate students
  - State and tuition funding ~ $350MM

UNIVERSITY of HAWAI'I
MĀNOA

Hawaii Natural Energy Institute

Organized Research Unit in the School of Ocean and Earth Science and Technology, University of Hawaii at Manoa

Alternative Fuels: Biomass, Biofuels, Hydrogen, Methane Hydrates

Electrochemical Power Systems

Fuels Cells, Batteries

Renewable Power Generation

Ocean Energy

Photovoltaics

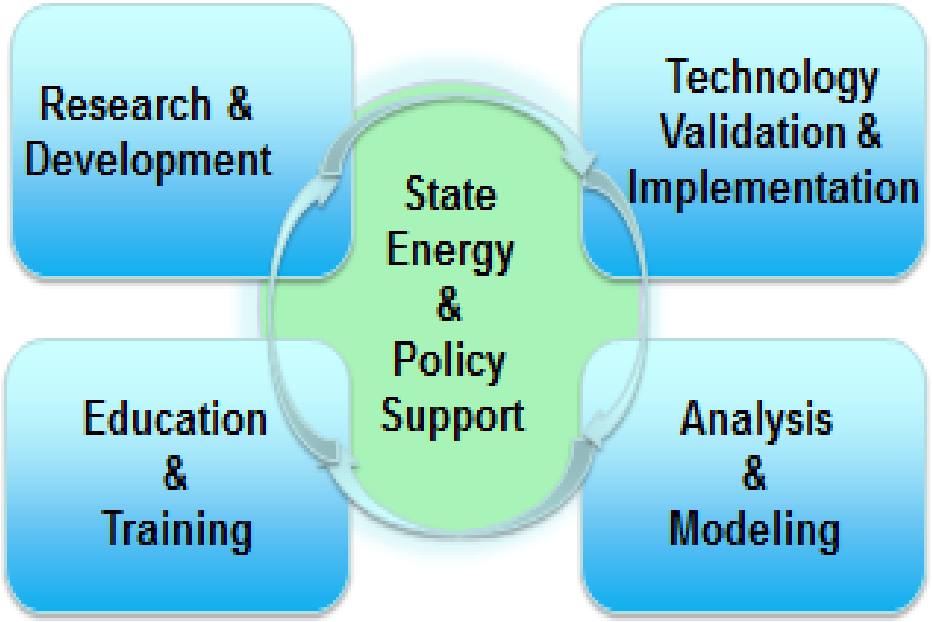
Energy Efficiency

Building Technology

Sea Water Air Conditioning

Grid Systems Integration

- Grid modeling and analysis
- Smart grid development
- Grid-scale storage



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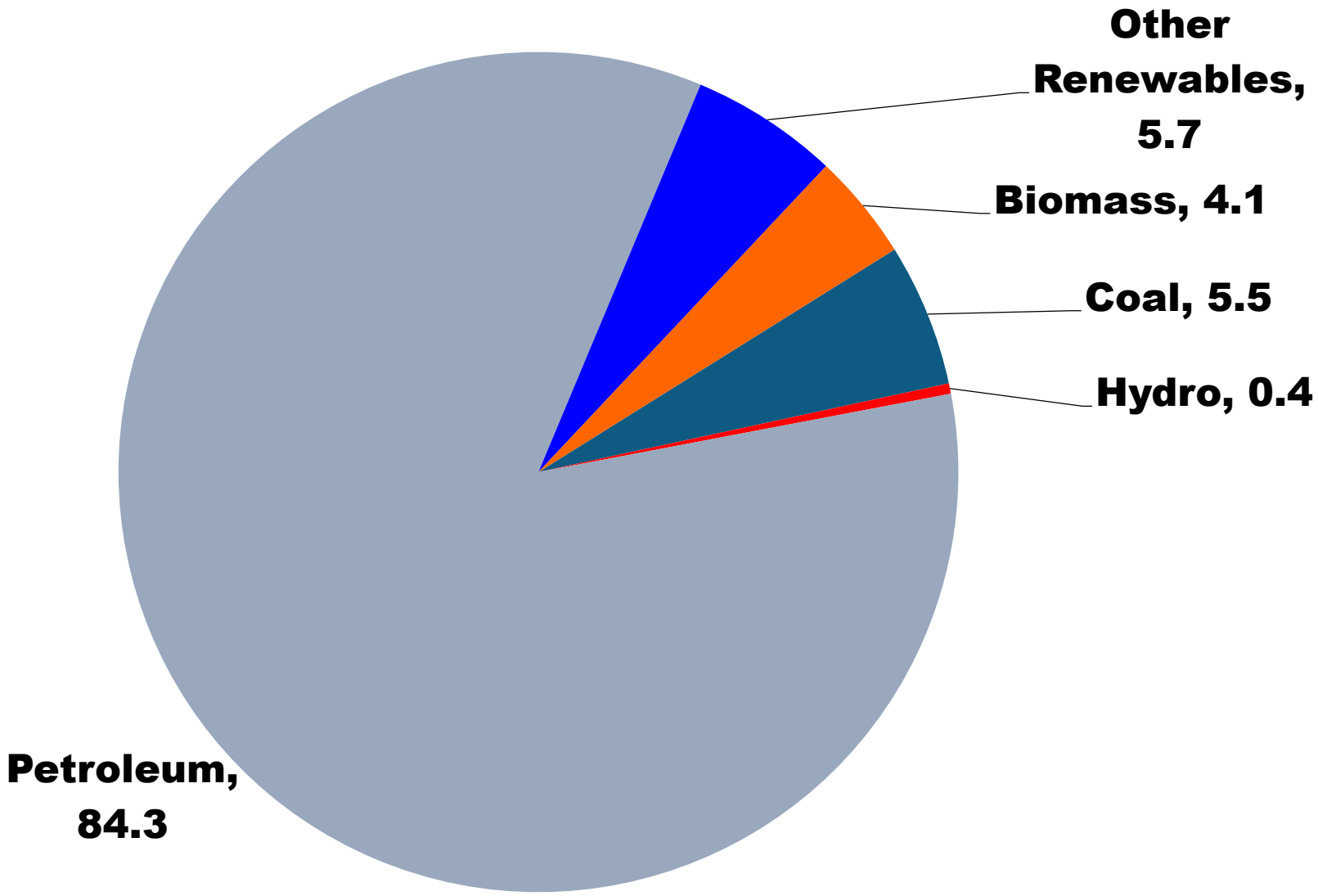
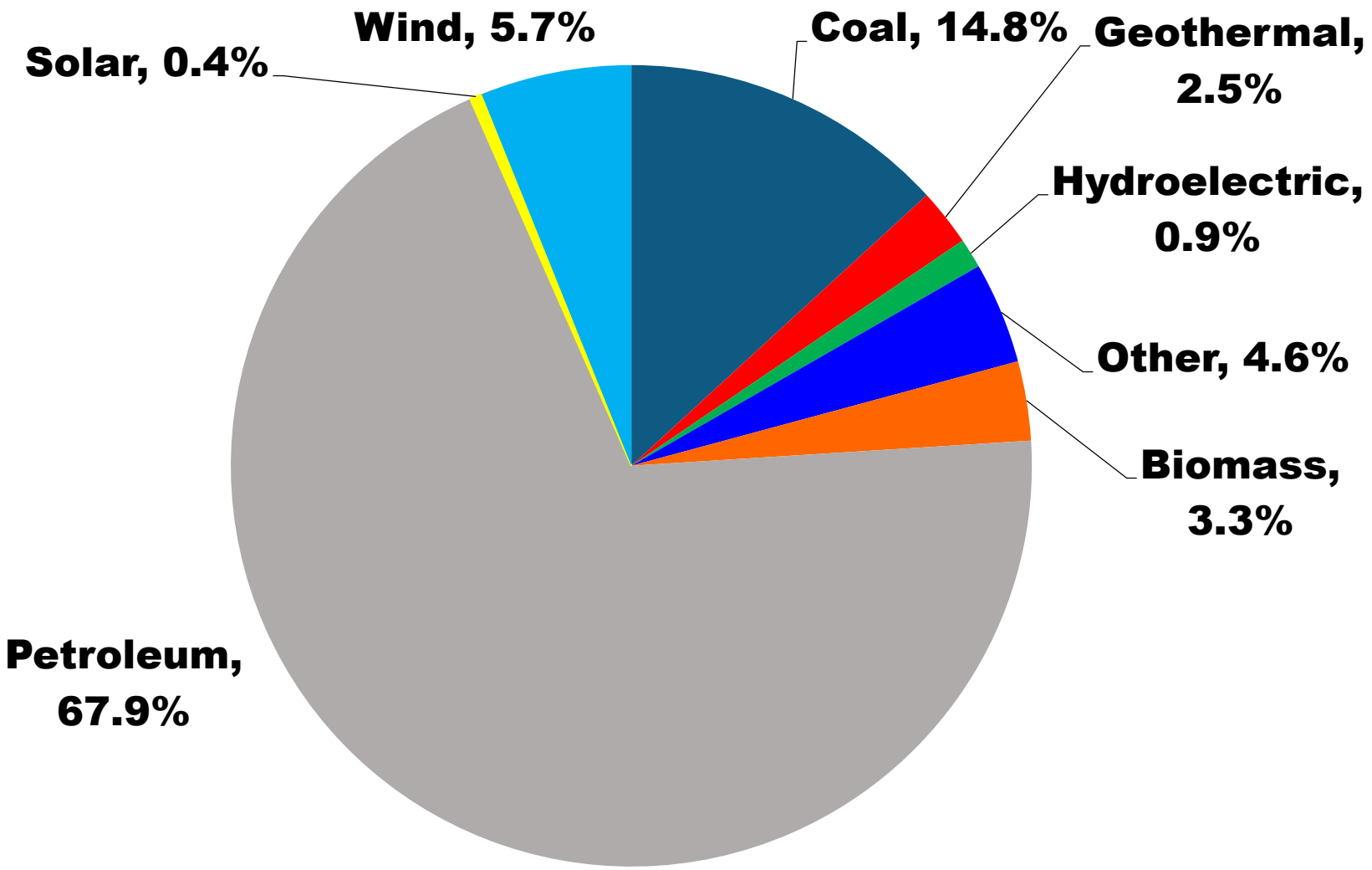
Primary Energy Sources in Hawaii, 2015

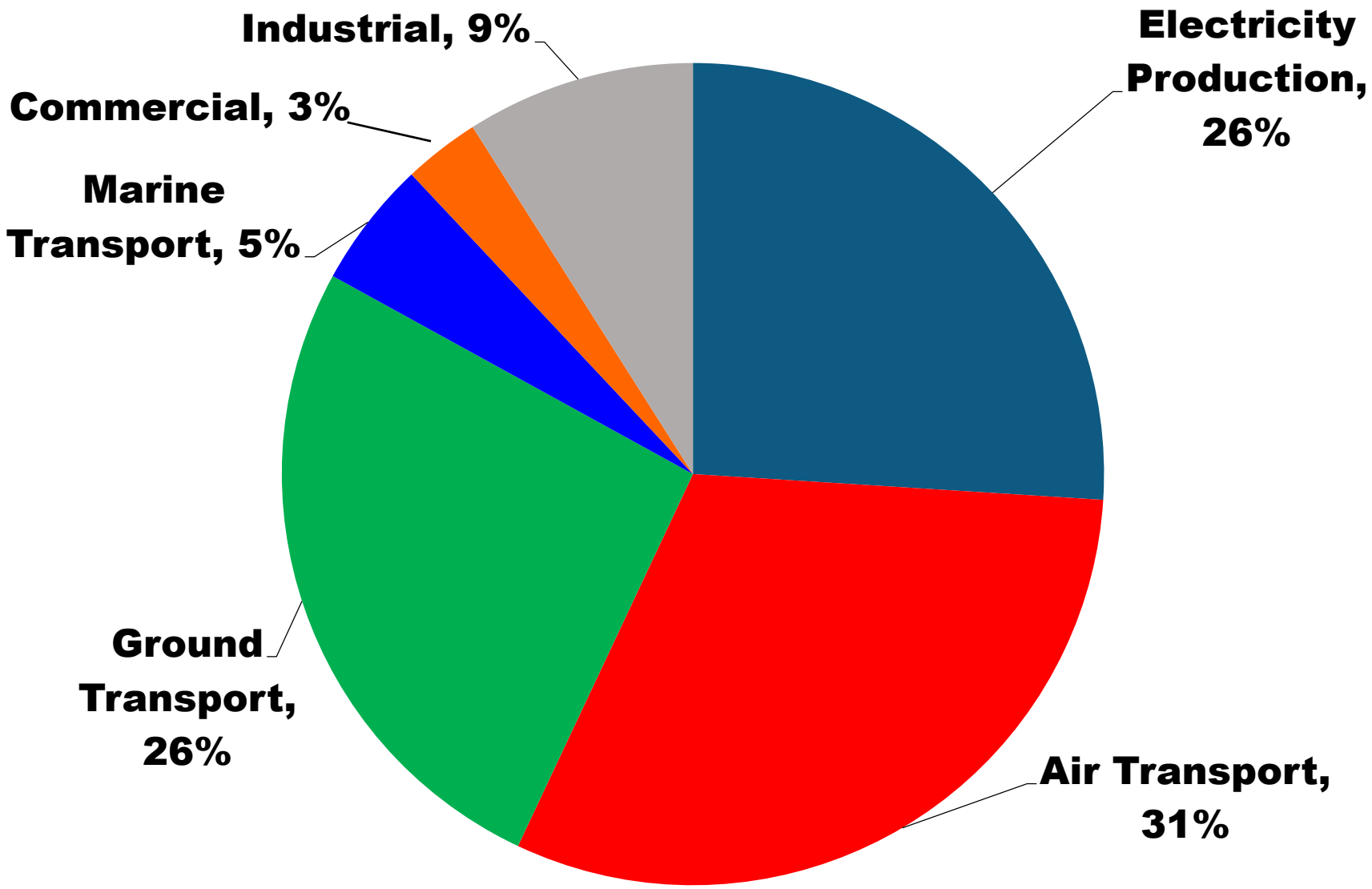


Electric Power Primary Energy Sources in Hawaii, 2014



Residential electricity rates range from $0.26 to $0.34/kWh and average monthly use is 484 kWh

Petroleum Use in Hawaii, 2016



Major Goals of Hawaii Energy Strategy

- Reduce Hawaii's dependence on oil
- Protect the environment
- Reduce the negative impacts related to using imported fuels
- Enhance renewable energy use and energy efficiency
- Improve the security, reliability, and resilience of Hawaii's energy systems

Selected Legislation Enacted in Support of Hawaii Energy Strategy

- Act 199 (1994): Requires that 85% of gasoline for use in motor vehicles contain 10% EtOH by volume (repealed 12/31/15)
- Act 240 (2006): Mandates biodiesel preference of $0.05 per gallon in State procurement laws
- Act 253 (2007): Mandates development of a Hawaii State Bioenergy Master Plan
- Federal Energy Independence and Security Act (2007) requires 36 billion gallons of biofuels by 2022 w/ special consideration for advanced biofuels
- Act 202 (2016) Five year, renewable fuels production tax credit (equal to $0.31/gal or 0.08/liter for biodiesel) for five years

Hawaii Renewable Portfolio Standards for Electricity (HRS 269-92, 2015)

- 10% of net electricity sales by 2010
- 15% of net electricity sales by 2015
- 30% of net electricity sales by 2020
- 40% of net electricity sales by 2030
- 70% of net electricity sales by 2040
- 100% of net electricity sales by 2045


Kauai Coffee Wainiha Hydro (4 MW)
Waiawa (Waimea) Hydro (500 kW)
Waimea Mauka KAA Hydro (1 MW)
Waimea Research Center PV (250 kW)
Gay & Robinson Olokele Hydro (1.3 MW)
Port Allen (McBryde) Solar (6 MW)
Kauai Coffee Kalaheo Hydro (1 MW)
MP2 Kaneshiro Solar (300 kW)
Green Energy Hydro (125 kW)
Green Energy Biomass-to-Energy Facility (6.7 MW)
Kapaa Solar (1 MW)
Anahola (KRS1) Solar (12 MW)
Waiahi (Lihue) Hydro - Upper (500 kW)
Waiahi (Lihue) Hydro - Lower (800 kW)
Wilcox Memorial Hospital Solar (500 kW)
Kauai Algae Farm (Mircoalgae Research)
Koloa (KRS2) Solar (12 MW)
EE Waianae Solar (27.6 MW)
Hawaii FIT Forty (570 kW)
Hawaii FIT Two (597 kW)
PVT Bioconversion Feedstock Facility (Feedstock)
HECO Campbell Industrial Park Generating Station (110 MW)
Kapolei Sustainable Energy Park (1.1 MW)
HPOWER (88 MW)
Hawaii Air National Guard (HCATT) Demonstration Waste-to-Energy System (Demonstration)
Kalaeloa Solar Power II (5 MW)
Kalaeloa Renewable Energy Park (5 MW)
Waihonu North and South Solar (6.5 MW)
Waianae PV-2 Solar (500 kW)
Kawailoa Wind (69 MW)
Kahuku Wind (30 MW)
Dole Plantation Solar (500 kW)
Hawaii American Water PV (250 kW)
Pacific Biodiesel Honolulu Plant (1 MGY)
HNL Dispatchable Generation Project (10 MW)
Pearl City Peninsula PV (1.23 MW)
Kaheawa Wind Power I (30 MW)
Kaheawa Wind Power II (21 MW)
Wailoa Ditch Hydro (Paia) (900 kW)
Makila Hydro (500 kW)
Kuia Solar (2.87 MW)
HC&S Co-Generation Facility (16 MW)
Wailoa Ditch Hydro (Hamakua) (400 kW)
Auwahi Wind (21 MW)
La Ola Solar (1.2 MW)
South Maui Renewable Resources Solar (2.87 MW)
North Kohala Microgrid (100 kW)
Wailuku River Hydro (11 MW)
Hawi Wind (10.56 MW)
Hamakua Springs Country Farms Hydro (75 kW)
Hoowaiwai Farms Hydro (90 kW)
Waiau Hydro (1.15 MW)
Puueo Hydro (2.5 MW)
Ainako Hydro (7 kW)
Hawaii Pure Plant Oil (Feedstock Demonstration)
Puna Geothermal Venture (38 MW)
Big Island Biodiesel (5 MGY)
Waikoloa Water Community Wind (100 kW)
OTEC Pilot Project (100 kW)
Cellana Algae Kona Demonstration Facility (Demonstration)
Cyanotech Solar (500 kW)
Hawaii County DWS System - Kahaluu Shaft, Kaloko Tank 2, Waimea WWTP (132 kW total)
Pakini Nui Wind (20.5 MW)
65
RENEWABLE PROJECTS
SURROUNDED BY OCEAN WITH YEAR-ROUND TROPICAL SUNLIGHT, STEADY TRADE WINDS AND A VOLCANO, THE HAWAIIAN ARCHIPELAGO IS BLESSED WITH RICH NATURAL ENERGY RESOURCES THAT MAKE IT IDEAL FOR ACHIEVING ENERGY INDEPENDENCE. THESE 65 PROJECTS HAVE THE CAPACITY TO GENERATE AN ESTIMATED 156,085,667 KWH PER MONTH, WHICH IS ENOUGH TO POWER APPROXIMATELY 314,689 HAWAII HOMES FOR THE NEXT 20 YEARS.
6 BIOFUEL
3 BIOMASS
1 GEOTHERMAL
19 HYDROELECTRIC
2 OCEAN
22 SOLAR
3 WASTE-TO-ENERGY
9 WIND
For more renewable energy projects, both operational and under development, visit https://energy.ehawaii.gov/epd/public/energy-projects-map.html.

Global Algae Innovations' Research Facility on Kauai

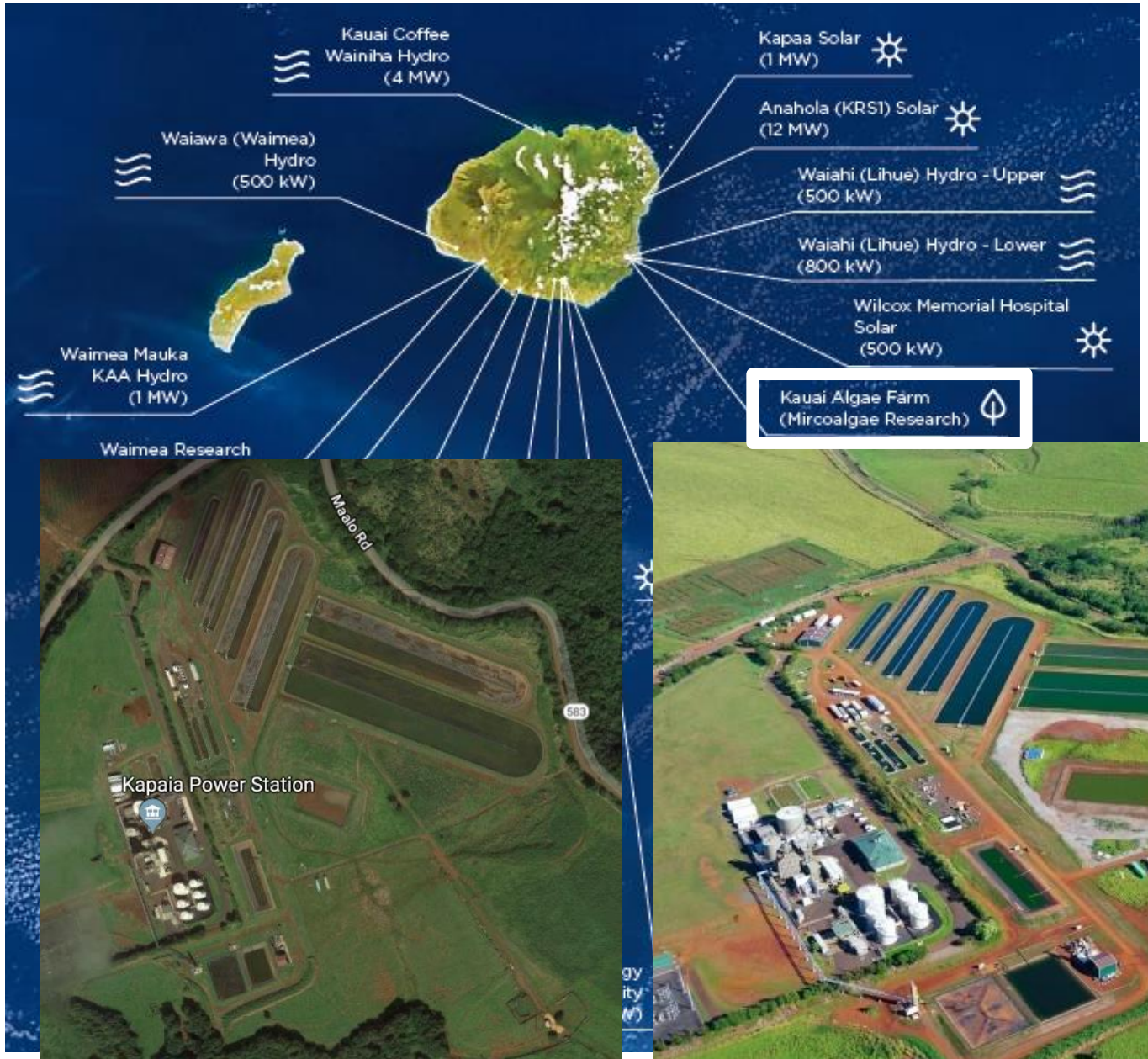
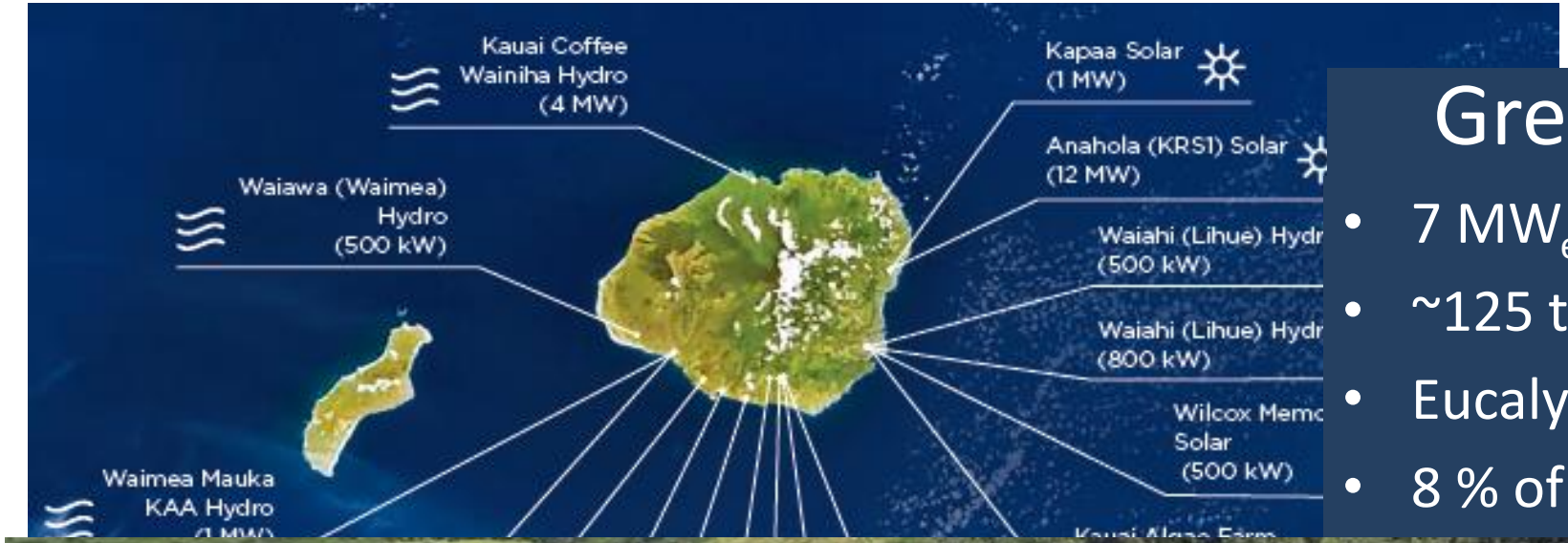


Image by Google Maps

Photo credit Global Algae Innovations, Inc., http://www.globalgae.com/



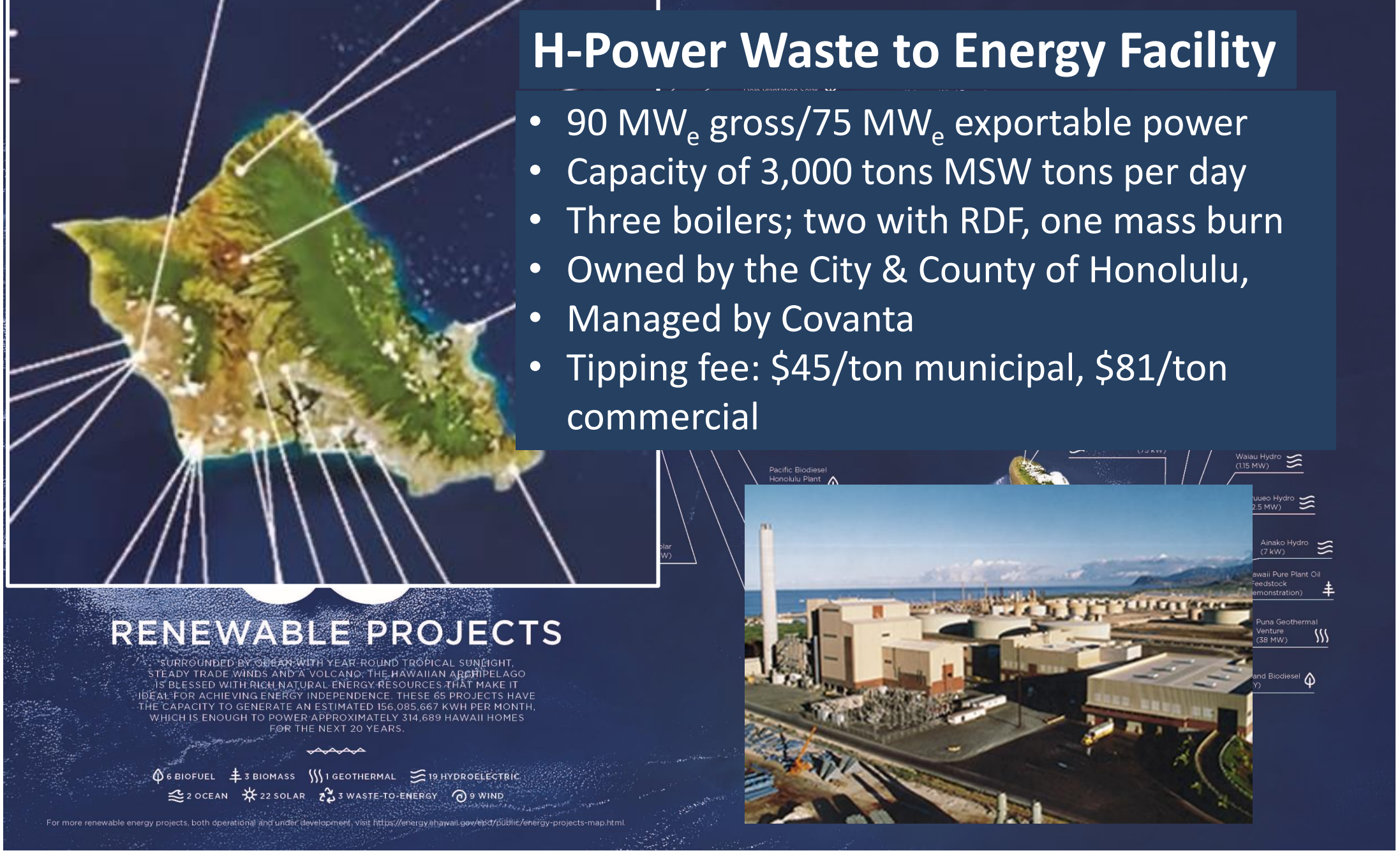
Green Energy Team

- 7 MW_e wood fired power plant
- ~125 tonne wood per day
- Eucalyptus and albizia
- 8 % of Kauai electricity demand

Photo credit Kauai Island Utility Cooperative, http://website.kiuc.coop/content/biomass

H-Power Waste to Energy Facility

- 90 MW_e gross/75 MW_e exportable power
- Capacity of 3,000 tons MSW tons per day
- Three boilers; two with RDF, one mass burn
- Owned by the City & County of Honolulu,
- Managed by Covanta
- Tipping fee: $45/ton municipal, $81/ton commercial



http://swana.org/portals/0/awards/2014/Waste%20to%20Energy/Honolulu%20_Waste-to-Energy.pdf

PVT Land Company

- **Construction & demolition landfill**
- **1,775 tons C&D waste per day**
- **~50% of intake converted to feedstock**
- **Feedstock: wood, plastic, cloth, paper, and other organics**
- **Tipping fee $50 per ton**

Biodiesel Power Plants

- **110 MW combustion turbine power plant at Campbell Industrial Park**
- **8 MW internal combustion engine for emergency power at Daniel K. Inouye International Airport, Honolulu**
- **50 MW dual fueled power plant at Schofield Barracks (in construction)**
- **Several others in the State use biodiesel for start up/shut down**

Hawaiian Commercial & Sugar

- 15,000 ha sugar plantation
- 40 MW_e total generating capacity
- Biomass and hydro
- 12 MW_e power export

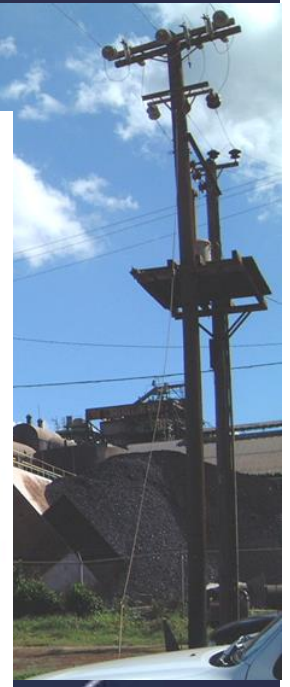
Hawaiian Commercial & Sugar

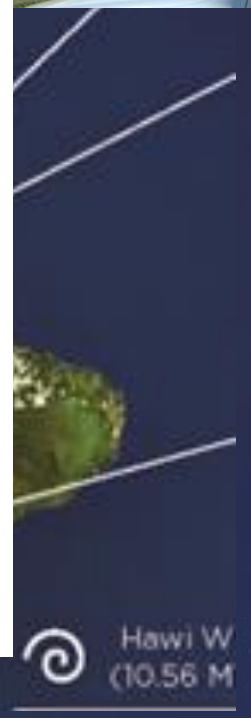
- 15,0
- 40 M
- Bio
- 12 M

Hawaii's Last Sugar Mill is Closing – The End of an Era on Maui

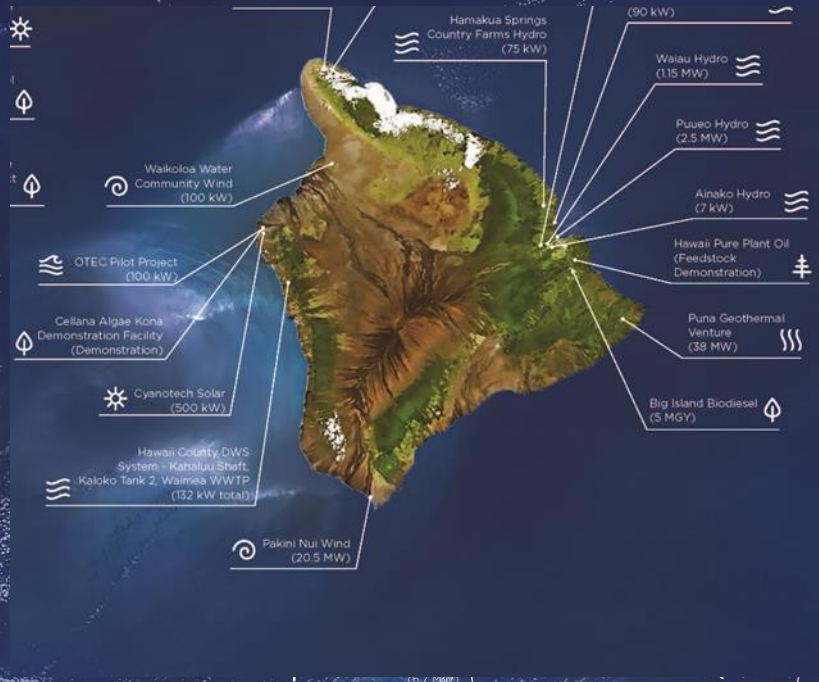
By Susan Fox | December 28, 2016 | 2 Comments | Share

As 2016 comes to an end, it brings forth the end of an era for not only Maui but the entire state of Hawaii. In January of this year, Hawaii's last sugarcane company, HC&S, announced that they will begin their final harvest and cease operations at the end of the year.





For more renewable energy projects, both operational and under development, visit https://energy.ehawaii.gov/epd/public/energy-



Cellana

- **Algae products development company**
- **6 acres (2.5 ha) facility**
- **High value products, fish feed, oil**

Land Use in Hawaii

- Total land are in Hawaii – 4.1 M acres (1.6 M ha)

- Urban and Rural land use districts - 0.2 M acres (81 k ha)
- Conservation land use district – 1.97 M acres (800 k ha)
- Agricultural land use district – 1.93 M acres (800 k ha)

- Area in farms – 1.13 M acres (460 k ha)
- Total cropland – 175,000 acres (71 k ha)
- Harvested cropland – 99,000 acres (40 k ha)

Source: 2016 Hawaii State Data Book, Dept. of Bus. Econ. Dev. & Tourism
http://hawaii.gov/dbedt/info/economic/databook/db2016/

Research and the Bioenergy Industry Value Chain

Feedstock Production	Feedstock Logistics	Conversion	Distribution	End Use





Agriculture ---- Industry ---- Investors ---- Government ---- Community

Resource Assessment of Bioenergy/Biofuel Feedstock Supply/Availability

Development of Conversion Technologies and Process Assessment Tools for Tropical Bioenergy/Biofuel Feedstocks

Integration of Bioenergy/Biofuel Products With Existing Petroleum Infrastructure & End Use

Life Cycle Assessment of Bioenergy/Biofuel Production System

Biomass-Bioenergy-Biofuel Activities

- Resource assessment/Planning
- Conversion technology and process assessment
- Integration of bioproducts with existing infrastructure
- Life cycle assessment of bioenergy systems

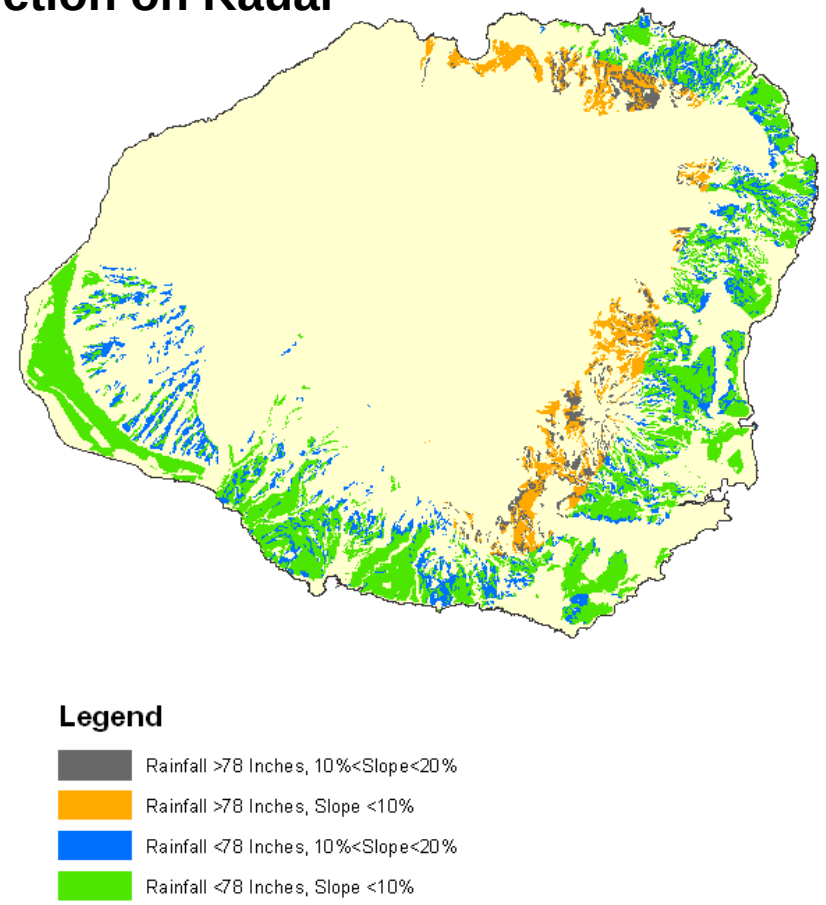
Biomass-Bioenergy-Biofuel Activities

- **Resource assessment/Planning**
- **Conversion technology and process assessment**
- **Integration of bioproducts with existing infrastructure**
- **Life cycle assessment of bioenergy systems**

Resource Assessment/Planning

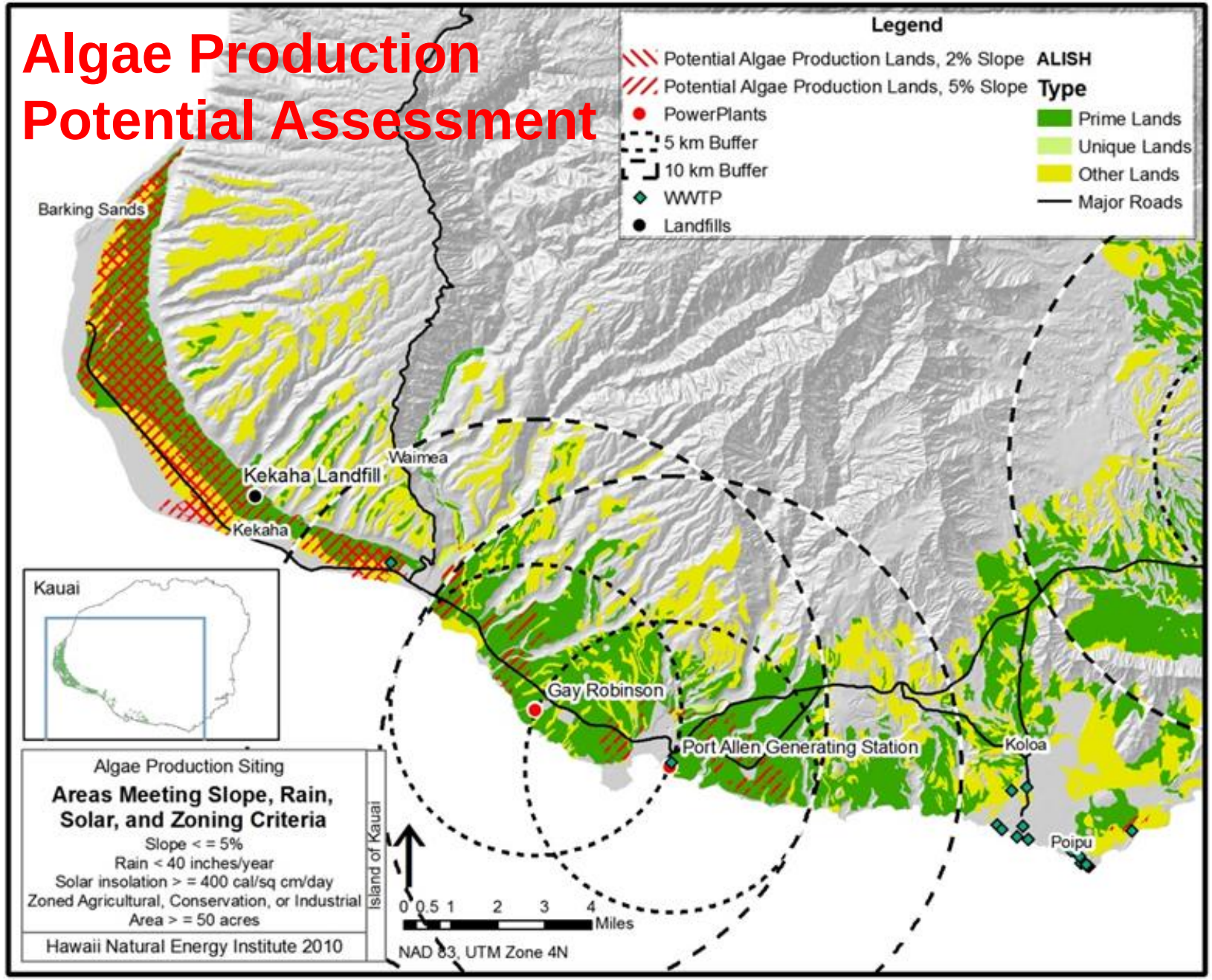
- Hawaii Bioenergy Master Plan
  - Assessment of land, water, labor, infrastructure, technology, permitting, financial incentives, policy requirements, economic and environmental impacts
- GIS-based analysis of bioenergy production potential
  - soil type, water access, rainfall, slope, insolation, land use zoning, community

Potential Areas for Sugar or Banagrass Production on Kauai



Keffer, V.I., S.Q. Turn, C.M. Kinoshita, and D.E. Evans. 2009. Ethanol technical potentials in Hawaii based on sugarcane, banagrass, *Eucalyptus*, and *Leucaena*. *Biomass and Bioenergy*. 33 pp. 247-254.

Algae Production Potential Assessment



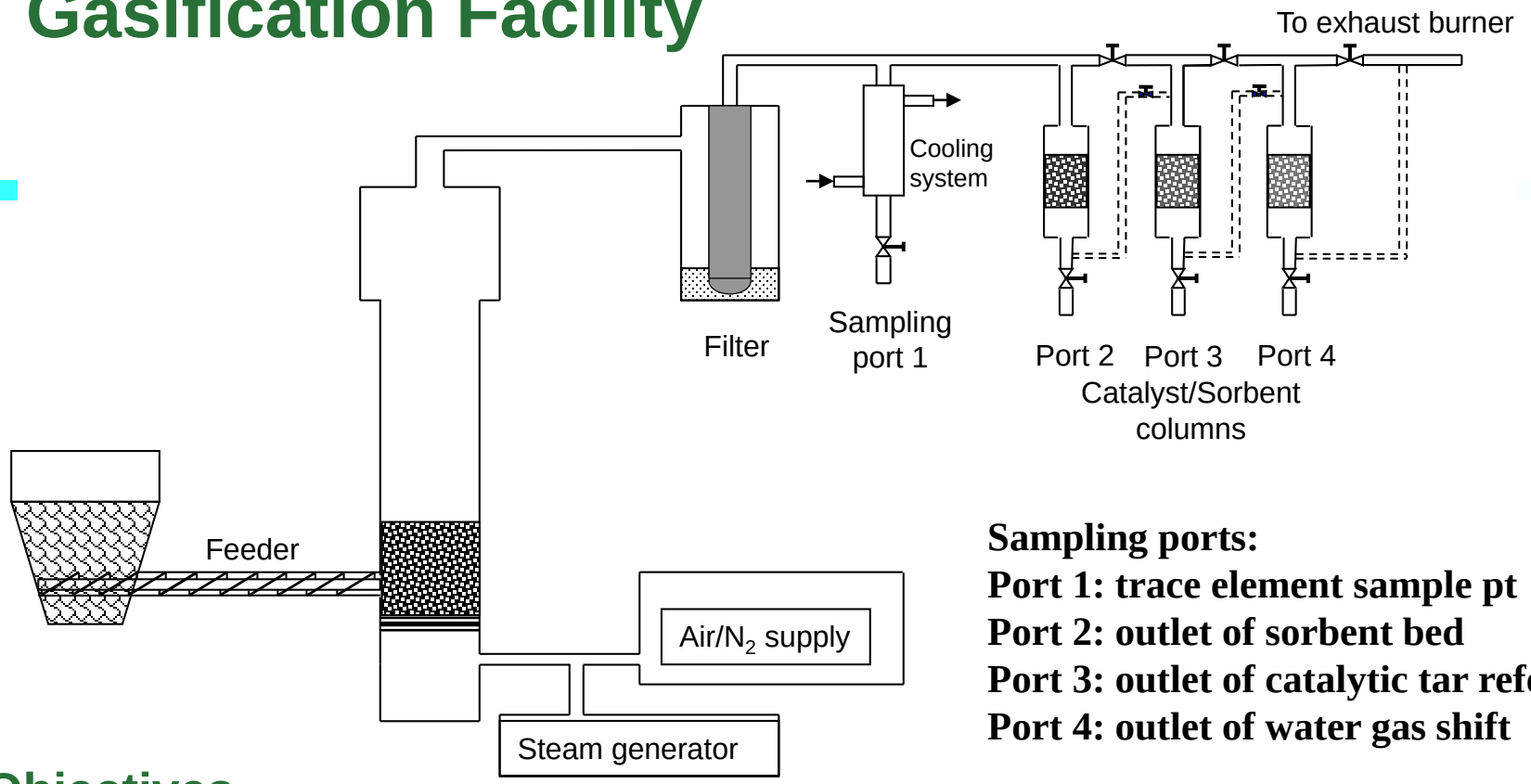
Biomass-Bioenergy-Biofuel Activities

- Resource assessment/Planning
- Conversion technology and process assessment
- Integration of bioproducts with existing infrastructure
- Life cycle assessment of bioenergy systems

Conversion Technology Activities

- Pretreatment of biomass materials to improve fuel properties
- Syngas production from biomass for higher valued products (fuels, chemicals, hydrogen)
- Plasma reforming of methane, dodecane, F76, and algal HRD76
- Pyrolysis and torrefaction of biomass materials
- Improved charcoal production techniques

Gasification Facility



Sampling ports:
Port 1: trace element sample pt
Port 2: outlet of sorbent bed
Port 3: outlet of catalytic tar reformer
Port 4: outlet of water gas shift

Objectives

- Develop analytical methods to measure contaminants in product gas
- Characterize tropical biomass feedstocks for gas production and contaminant levels
- Evaluate contaminant removal and control strategies
- Investigate biomass derived syngas conversion to liquid fuels

Cui, H., S.Q. Turn, V. Keffer, D. Evans, T. Tran, and M. Foley. 2010. Contaminant estimates and removal in product gas from biomass steam gasification. *Energy & Fuels*. 24 pp. 1222-1233.

Biomass-Bioenergy-Biofuel Activities

- Resource assessment/Planning
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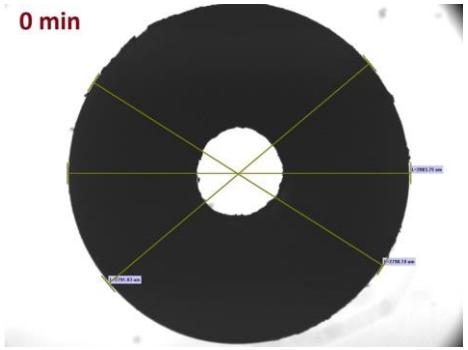
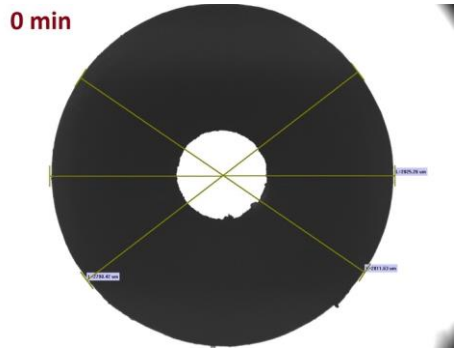
Swelling of Nitrile Rubber: Neat Fuels & Aromatics Mixtures

F-76



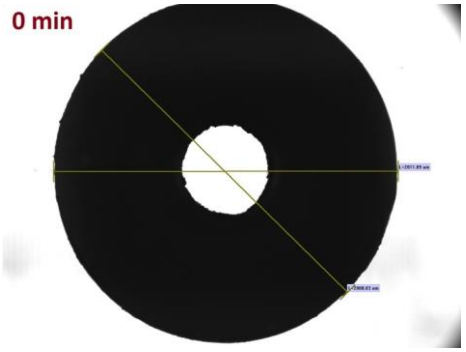
μ: 7.15%

HRD-76



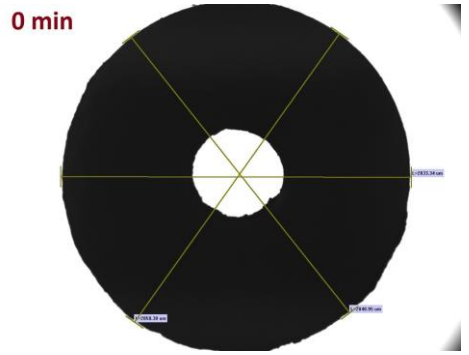
-0.29%

CHCD-76



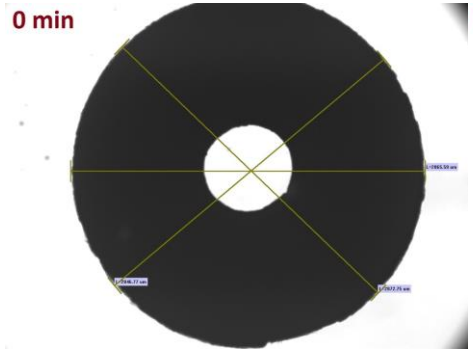
1.17%

SIP-76



-1.37%

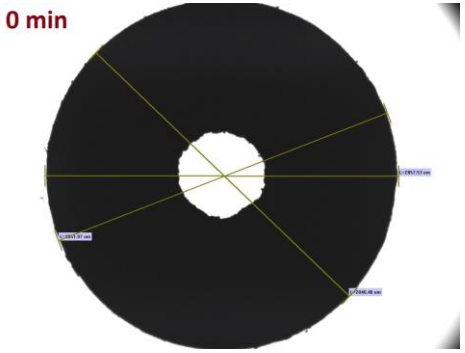
Aromatic 100



μ: 67.45%

t: ~85min

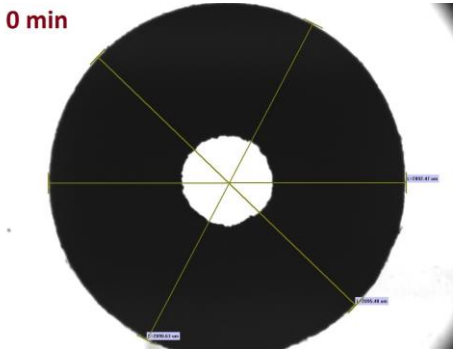
Aromatic 150



67.47%

~85min

Aromatic 200



151.18%

~150min

$$\mu = \left[\left(\frac{d_i}{d_0}\right)^3 - 1\right] \times 100\%$$

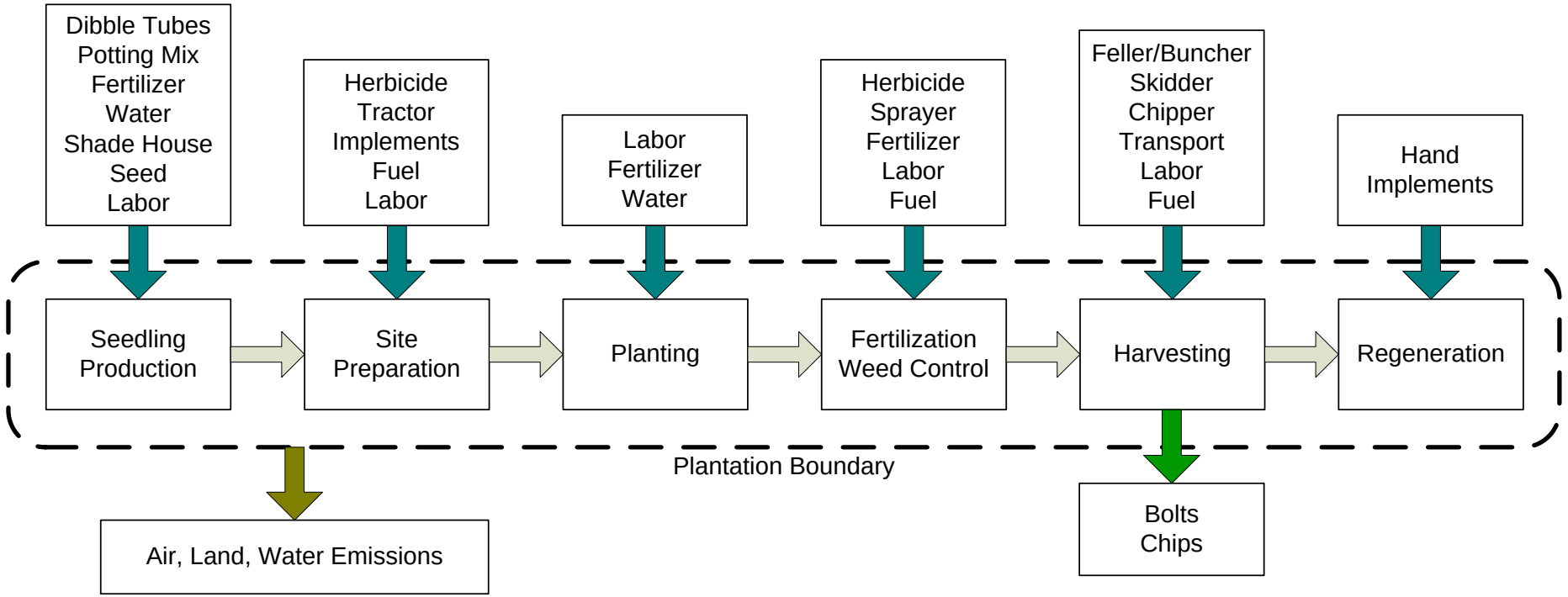
μ is the volume swell (%) and d_i and d_0 are the diameter of the O-ring in time i and 0.

t is the time when O-ring volume no longer changes

Biomass-Bioenergy-Biofuel Activities

- Resource assessment/Planning
- Conversion technology and process assessment
- Integration of bioproducts with existing infrastructure
- Life cycle assessment of bioenergy systems

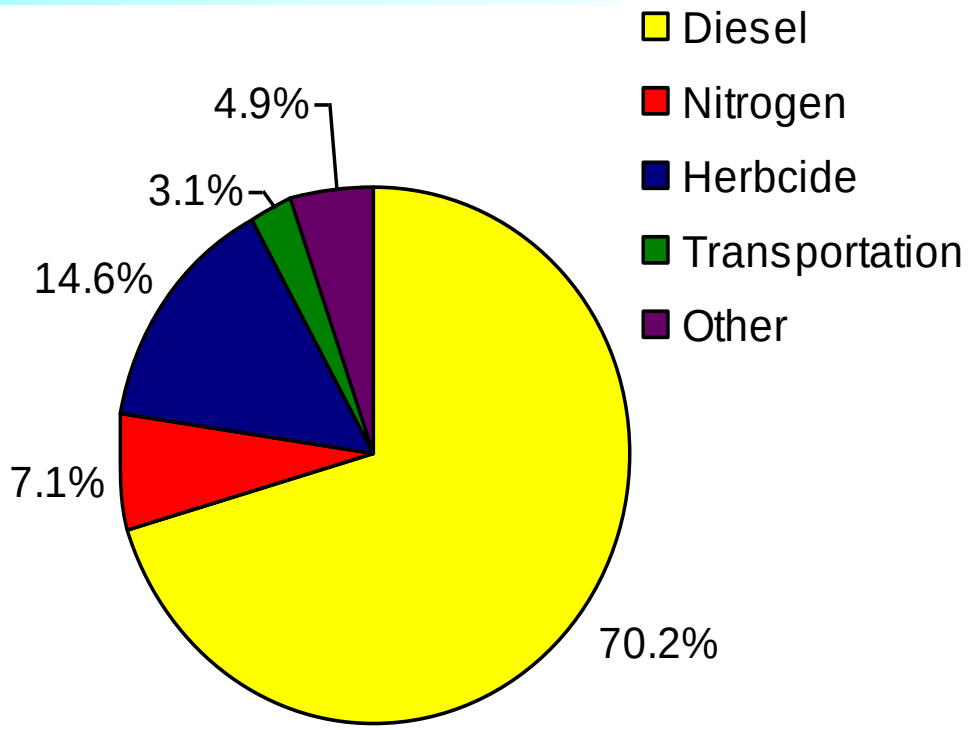
Net energy analysis of Eucalyptus production



Net energy analysis of Eucalyptus production

Energy Contributors

1. Diesel
   - 70.2%
2. Herbicide
   - 14.6%
3. N-Fertilizer
   - 7.1%



Energy Out/In Ratio

40.6

Fossil Energy Input

51,160 MJ / ha

Questions?