Renewable Energy Opportunities

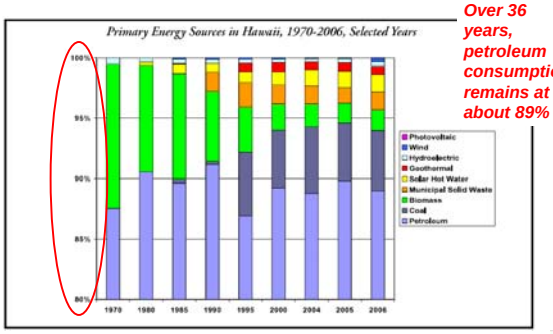
March 30, 2008

Department of Business, Economic Development & Tourism

Contents

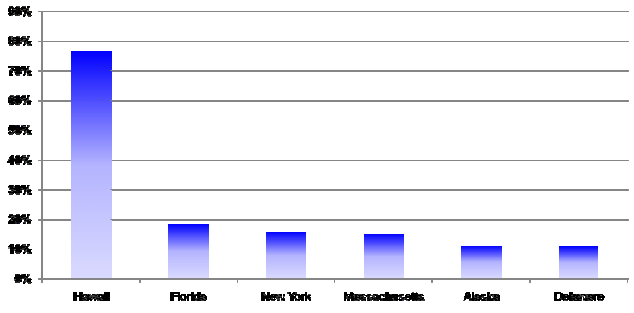
- Hawaii's Energy Picture
- Hawaii's Energy Future: 70% Clean Energy by 2030
- A Key Role: Efficiency
- New Technologies and Systems

Hawaii's Dependence on Fossil Fuels



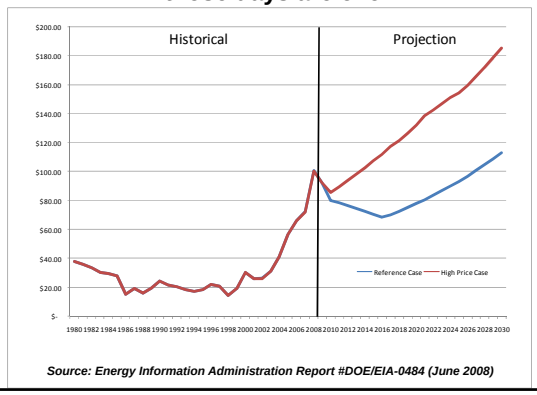
Over 36 years, petroleum consumption remains at about 89%

Hawaii is the most petroleum dependent state



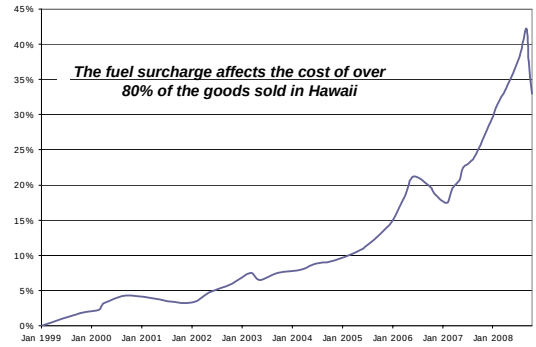
Petroleum dependence for electricity – top six states

Hawaii's energy system was based on $20/barrel oil: those days are over



Source: Energy Information Administration Report #DOE/EIA-0484 (June 2008)

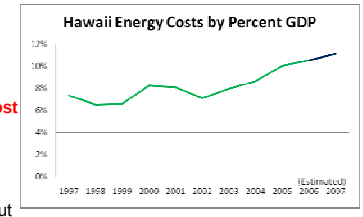
High energy costs multiply throughout the economy



5

Economic impact of dependence on expensive energy

- Household fuels and utilities **costs rose 36.4 percent**, year-over-year, in the Honolulu CPI during 2Q'08
- Mainland energy costs are 4% of a state's Gross Domestic Product; in Hawaii, it approaches 11%, **almost 3 times as much**
- Between 2007 and 2008, State Government **consumption** of electricity has **decreased 1.17%**, but **expenditures** have **increased 19.55%**

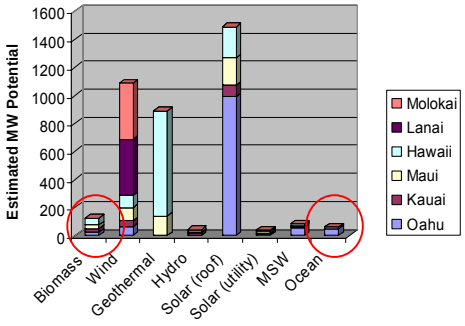


6

Energy Security is One Priority

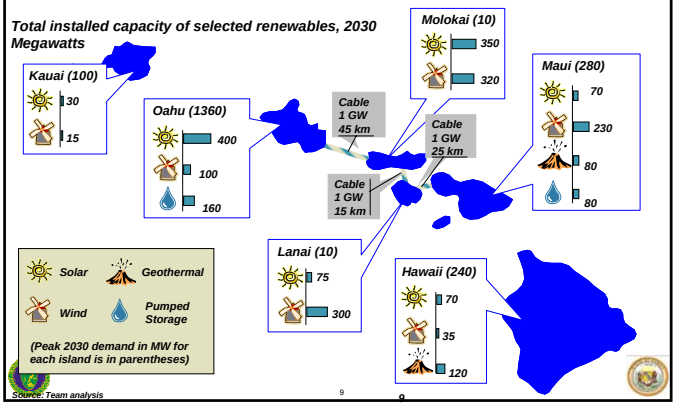
Hawaii typically has a *14-21 day supply* of oil

Hawaii's Renewable Resources
Estimated @ 150% of Current Installed Capacity



Hawaii's Wealth of Renewables

Total installed capacity of selected renewables, 2030
Megawatts



Source: Team analysis

Contents

- Hawaii's Energy Picture
- Hawaii's Energy Future: 70% Clean Energy by 2030
- A Key Role: Efficiency
- New Technologies and Systems

The Hawaii Clean Energy Initiative was launched on January 28, 2008 with the signing of a Memorandum of Understanding between the State of Hawaii and the U.S. Department of Energy

"…the Department of Energy will help Hawaii lead America in utilizing clean, renewable energy technologies."

Governor Lingle

"Hawaii's success will serve as an integrated model and demonstration test bed for the United States and other island communities globally..."

Assistant Secretary Karsner

Hawaii Clean Energy Initiative

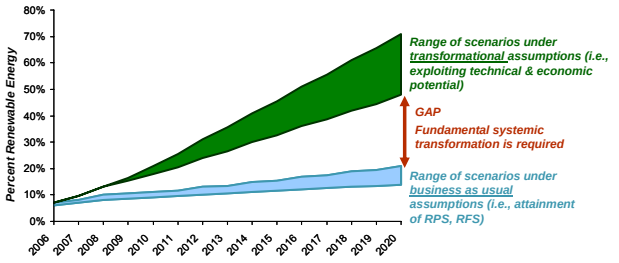
National Partnership to Accelerate *System* Transformation

The goals are:

- *Achieve a **70% clean energy economy** for Hawaii within a generation*
- *Increase Hawaii's **security***
- *Capture **economic benefits** of clean energy for all levels of society*
- *Foster and demonstrate **innovation***
- *Build the **workforce** of the future*
- *Serve as a **model** for the US and the world*

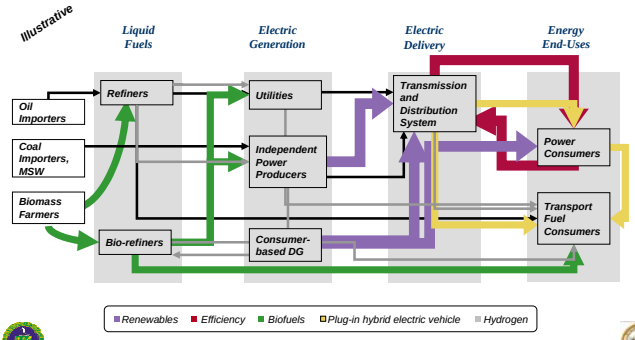
Hawaii's transition to an economy powered by clean energy, instead of imported foreign oil

In 2004, Hawaii's RPS included 6% renewables, which would increase only incrementally



…will require a substantive transformation of regulatory, financial, and institutional systems

The Hawaii Energy Ecosystem provides a level of complexity in systemic transformation that is instructive to larger systems



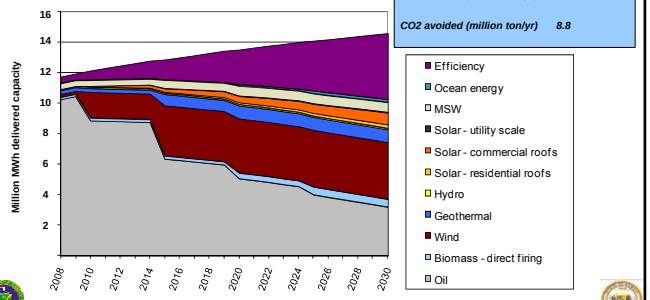
HCEI Scenarios: Analytical Path Toward 70% Clean Energy End-State

- First cut at order of magnitude requirements and impacts
- Evaluated sensitivity to several factors
- No absolutes defined in this evaluation
- Most work on electricity, some on transportation, little on jet fuel
- **Based on *current commercially viable technologies*; potential game changers like OTEC and algae to energy are not considered**
- **All scenarios are presented *without imported biofuels*; all scenarios can hit the goals with imported biofuels**
- Follow-up economic and cost/benefit impacts, refinements in progress.

Scenario 8 Electricity

Hawaii could reach 70% clean energy in the electricity sector and reduce oil imports by 20 MM bbl/year by 2030

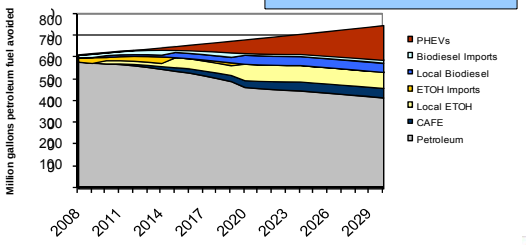
Summary of 2030 Electricity Results	
Clean energy achieved	70%
Oil reduction (million bbl/yr)	17.3
CO2 avoided (million ton/yr)	8.8



Scenario 8 Transportation

High PHEV penetration, local biodiesel and ethanol production

Summary of 2030 Transportation Results	
Clean energy achieved	63%
Oil reduction (million bbl/yr)	9.9
CO2 avoided (million ton/yr)	4.2



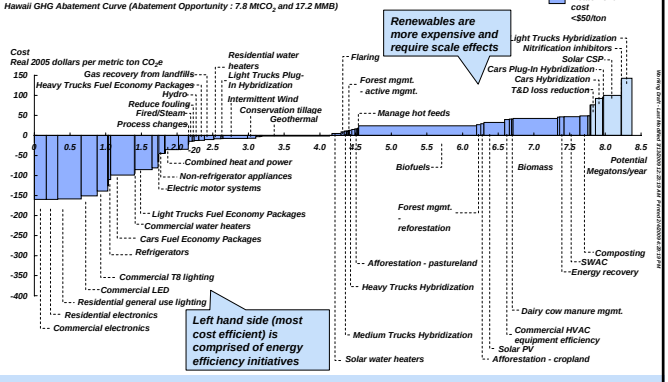
Contents

- Hawaii's Energy Picture
- Hawaii's Energy Future: 70% Clean Energy by 2030
- A Key Role: Efficiency
- New Technologies and Systems

Energy efficiency (EE) initiatives are most economical and could drive down overall cost of energy in Hawai'i

ANALYSIS BASED ON $60/BBL OIL

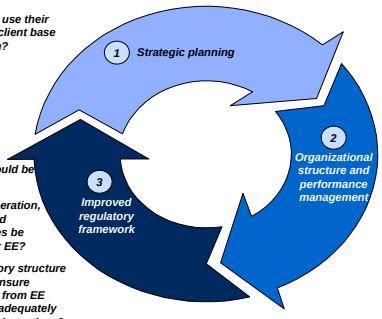
Hawaii GHG Abatement Curve (Abatement Opportunity : 7.8 MtCO$_2$ and 17.2 MMB)



Source: Team analysis

As the energy efficiency landscape evolves, the State of Hawai'i and energy utilities will need to build out three core aspects of its efficiency program

- *Where to play?*
- *How to play?*
- *How can utilities use their capabilities and client base to drive adoption?*



- *How should the EE programs be managed and measured?*
- *What is the most effective organizational structure?*
- *How should incentives within EE and between EE and other divisions be aligned?*
- *How can effectiveness be ensured as the organization grows?*

- *What targets should be set?*
- *How should generation, transmission, and efficiency utilities be compensated for EE?*
- *How can regulatory structure be designed to ensure loss of rate base from EE programming is adequately compensated by incentives?*

SOURCE:McKinsey analysis

Negawatt - the cheapest watt of energy is the one never used.

- Fastest-growing U.S. energy source (~2.5-3.5%/yr)
- Energy efficiency has tremendous potential to reduce greenhouse gas emissions
- The U.S. Department of Energy estimates that increasing energy efficiency throughout the economy could cut national energy use by 10% or more in 2010 and about 20% in 2020
- A comprehensive set of policies for advancing energy efficiency could lower national energy use by 18 percent in 2010 and 33 percent in 2020.
- These policies, along with policies to advance renewable energy, could dramatically lower U.S. carbon dioxide emissions while saving consumers and business $500 billion net during 2000-2020.
- Policy Approaches to Advancing Energy Efficiency
  - Framework – Priorities, benchmarks, mandates
  - Resources – Fees, funding, financing mechanisms for projects
  - Green Buildings (72% of electricity consumption) – Codes, standards, energy use labeling

Contents

- Hawaii's Energy Picture
- Hawaii's Energy Future: 70% Clean Energy by 2030
- A Key Role: Efficiency
- New Technologies and Systems

Hawaii National Marine Renewable Energy Test Center Program Objectives

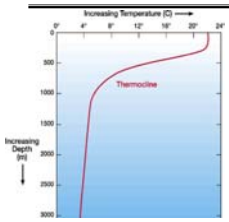
- **Objectives:**
  - Facilitate development & implementation of commercial wave energy systems for use in Hawaii and elsewhere
  - Target – one or more of these system to supply energy to grid at >50% availability within 5 years
  - Move Ocean Thermal Energy Conversion (OTEC) to pre-commercialization and conduct long-term testing

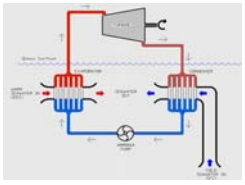
Hawaii Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa

Hawaii National Marine Renewable Energy Test Center Current Test Sites

Hawaii Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa

Ocean Thermal Energy Conversion





Using the temperature difference between: DEEP OCEAN WATER ~5°C And SHALLOW OCEAN WATER ~25°C

Closed -cycle

1. *Warm ocean surface seawater boils a refrigerant liquid at high pressure (130 psi).*
2. *Refrigerant vapor spins a turbine-generator, becomes low pressure (80 psi).*
3. *Cold deep ocean seawater condenses refrigerant to a liquid again.*
4. *Cycle continues -- similar to steam turbine but lower temperature.*

Hawaii Natural Energy Institute
School of Ocean and Earth Science and Technology
University of Hawaii at Manoa

Makai Ocean Engineering

OTEC Challenges:

- Technical challenges
  - Large diameter and long pipelines
  - Low cost, efficient heat exchangers
  - Large, stable platform and mooring design
  - Dynamic power cable to shore
- Cost Challenge:
  - Low cost must be achieved with new materials, better engineering, innovative designs, while taking advantage of economy of scale and current offshore technology.

School of Ocean and Earth Science and Technology
University of Hawaii at Manoa

Makai Ocean Engineering

Hawaii Center for Advanced Transportation Technologies

HCATT

- Develop and demonstrate zero emission and low emission transportation technologies.
- Establish infrastructure to support zero emission vehicle operations.
- Create business opportunities to attract vehicle technology companies to Hawaii.
- Facilitate growth of transportation technology industry in Hawaii.
- Secure new funding sources to expand scope of operations in Hawaii.

Hawaii Center for Advanced Transportation Technologies
531 Cooke Street, Honolulu, HI 96813
Thomas L. Quinn 808-594-0100 tquinn@htdc.org www.htdc.org/hcatt

Electric, Hybrid, and Fuel Cell Vehicles

Neighborhood Electric Vehicles

Fuel Cell Bus

Plug-in Hybrid

Hybrid electric-fuel cell bus for Hickam Air Force Base

Phycal: Algae to energy

Land

Nutrients

Waste paper

Water-
Brine & Fresh

CO_2

Sunlight

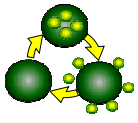
Algal Oil

Methane Gas

Phycal: Strategic Energy Products

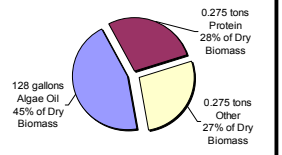
Phycal Hawaii R&D

- Objective: Grow algae for energy products
  - Algal lipids (oil), methane, hydrogen
- Major innovation: Non-destructive extraction
  - Extract lipid from cell without dewatering or killing algae
  - Recycle algae to ponds
  - Reduced dewatering, nutrient, CO_2 costs
  - Higher lipid and biomass growth rates
- Inputs: CO_2 from flue gas, wastewater, wastepaper
- Pilot plant in Q1, 2010
- Production by late 2012



"Refocusing" Agriculture: The base for a sustainable, economic and secure Hawaii ("back-of-the-envelope" estimates)

One metric ton of algae



Cane as an Algae "Feedstock"

- ***1.0 acre cane at 50 tons per acre***
  - ***1025 gallons ethanol ($2480)***
  - ***5500 kwh of power ($979)***
  - ***Revenue total = $3459***
- ***50 tons of cane/acre produces 15.2 tons CO2/acre on processing***

15.2 tons CO2 produces 5 tons of algae

- ***5 tons of algae/acre***
  - ***640 gallons of oil ($4/gallon)***
  - ***1.3 tons of protein ($700/MT)***
  - ***1.3 tons of biomass (=4.3 tons whole cane = 573 kwh or power = $84)***
  - ***Revenue total = $3554***
- ***5 tons algae require 0.07 acres of algae ponds***
  - ***(7% reduction in land available for cane)***

Increasing Land Productivity through Innovation and Integration ("per **acre** back of the envelope estimates")

Current Sugar Focus	Current Energy Focus	Future Energy Focus with advanced crop varieties and advanced processing	Future Energy Focus with advanced crop varieties and advanced processing integrated with algae
• 7-8 tons sugar • 5000 kwh power • 1x CO_2	• 1025 gallons ethanol • 5500 kwh power • 1.5x CO_2	• 2500 gallons ethanol • 9,000 kwh power • 2.5x CO_2	• 2500 gallons ethanol (or other advanced fuels) • 10,000 kwh power • 1000 gallons oil • 2 tons protein • 0.1x CO_2
	• revenue $3460 • land "footprint" = X per gallon fuel		***•revenue >$10,000 •land footprint = 1/3X per gallon fuel***

We Invite Your Attention and Partnership

Working as partners, we achieve together what none of us could do alone

"Our performance will be measured by the successful transition of the energy systems globally to clean and secure sources with stable costs, healthy and strong economies and environmental sustainability."

DBEDT
STATE OF HAWAII