

Hawaii Island: An Ideal Location to Demonstrate NH3 Applications

h₂technologies

Guy Toyama
H2 Technologies, Inc.

Hawai'i has no indigenous sources of Fossil Fuels: Coal, Oil or Natural Gas



Coal



Natural Gas



Oil

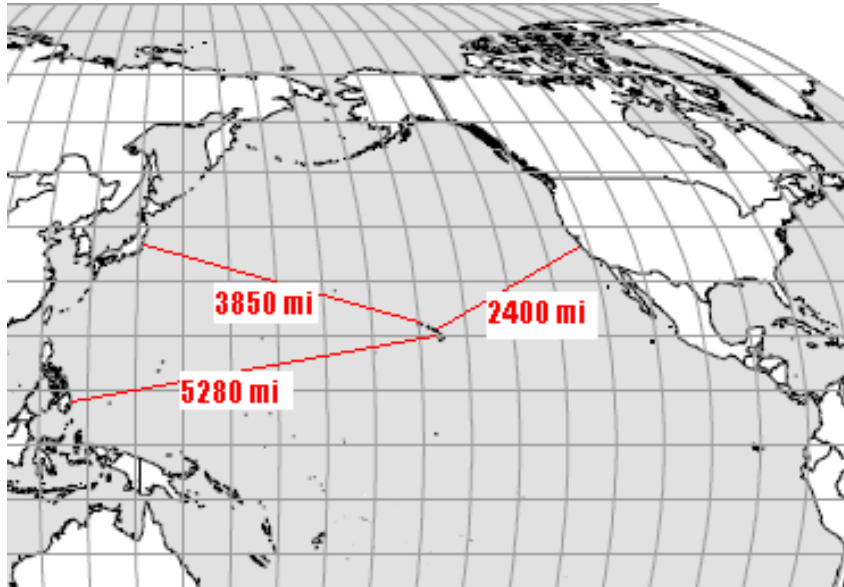
Unique Hawaii

State of Hawaii

Remote & Isolated

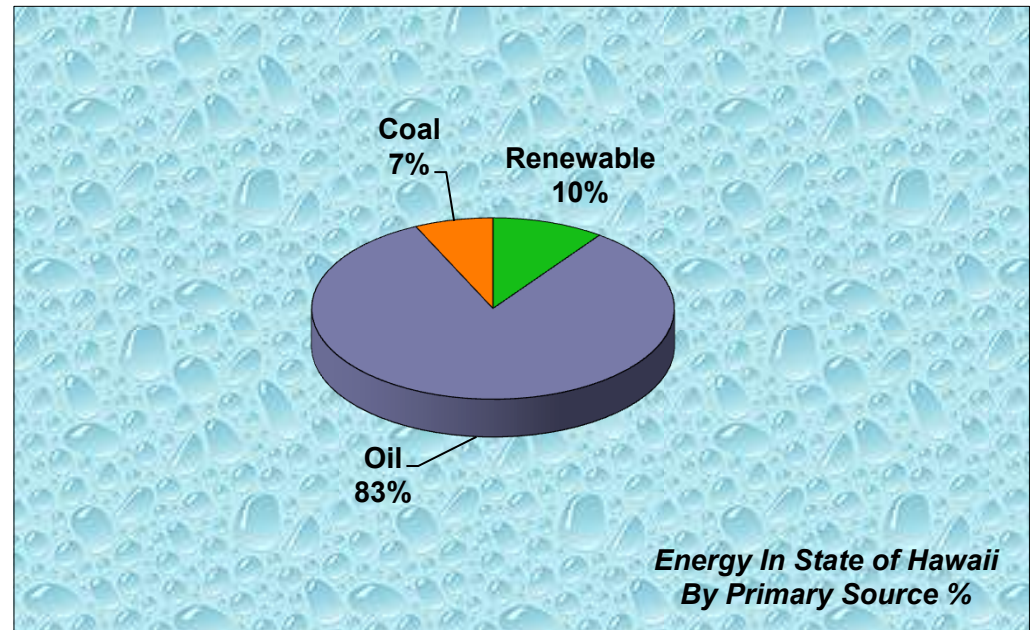
Isolated

- 2400 miles to nearest major landmass
- No Electricity grid



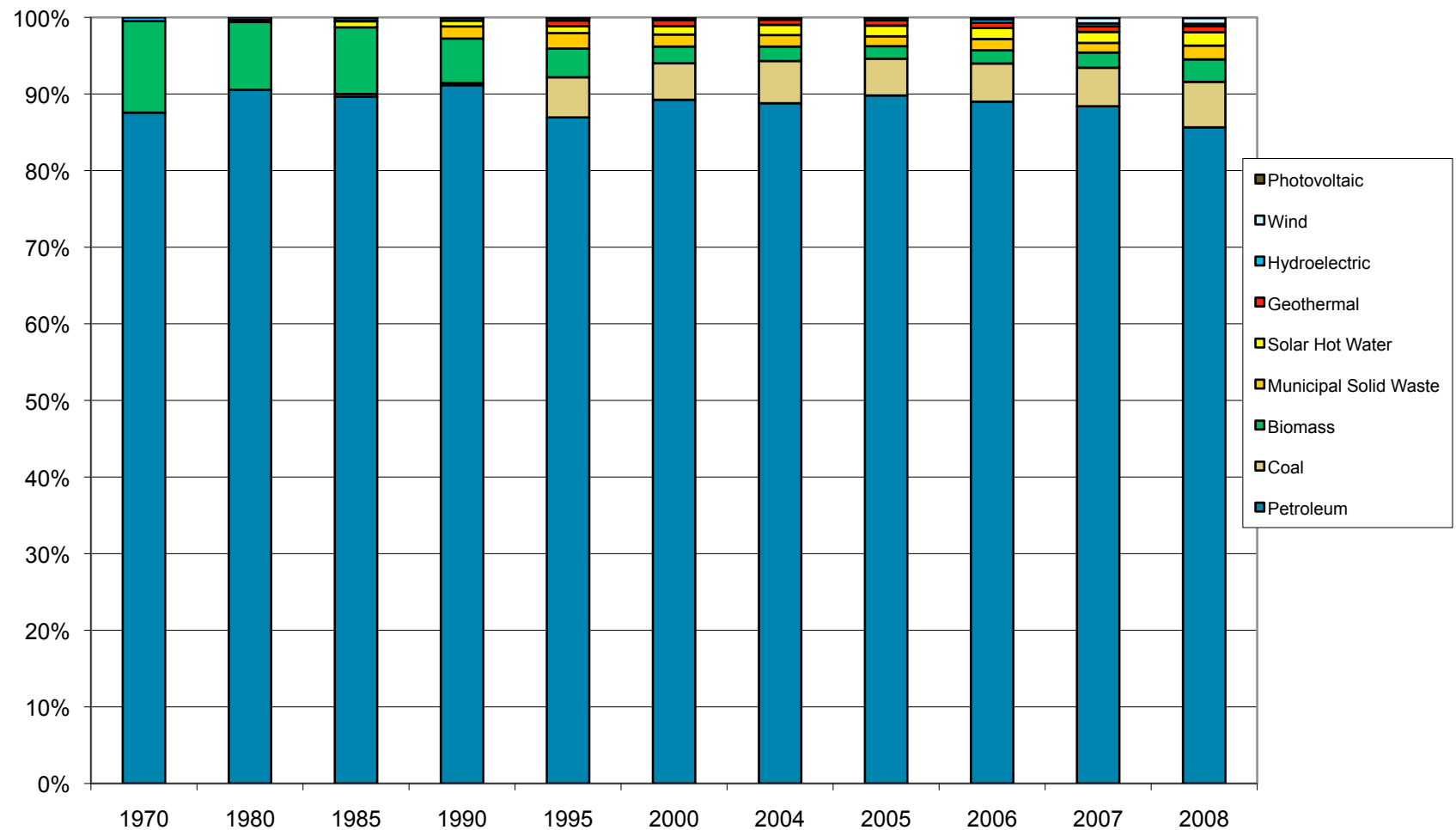
Dependant

- Hawaii imports 90% of its energy
 - ~ Coal 7%
 - ~ Petroleum 83%
- Indigenous sources - 10%

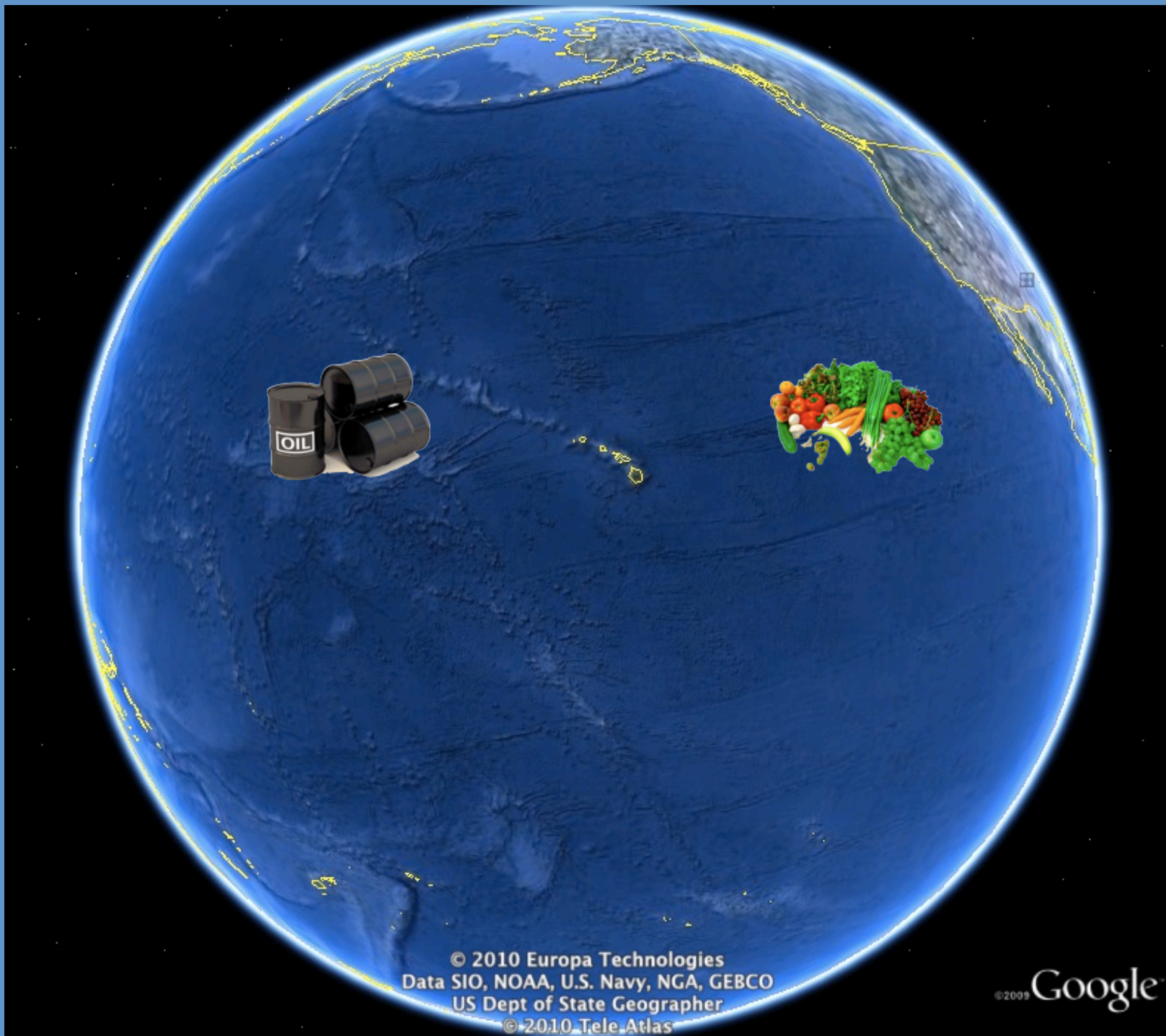


Hawaii's Historic Dependence on Fossil Fuels

Primary Energy Sources in Hawaii, 1970-2008



Over 36 years, petroleum consumption remains above 85%



© 2010 Europa Technologies
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
US Dept of State Geographer
© 2010 Tele Atlas

© 2009 Google

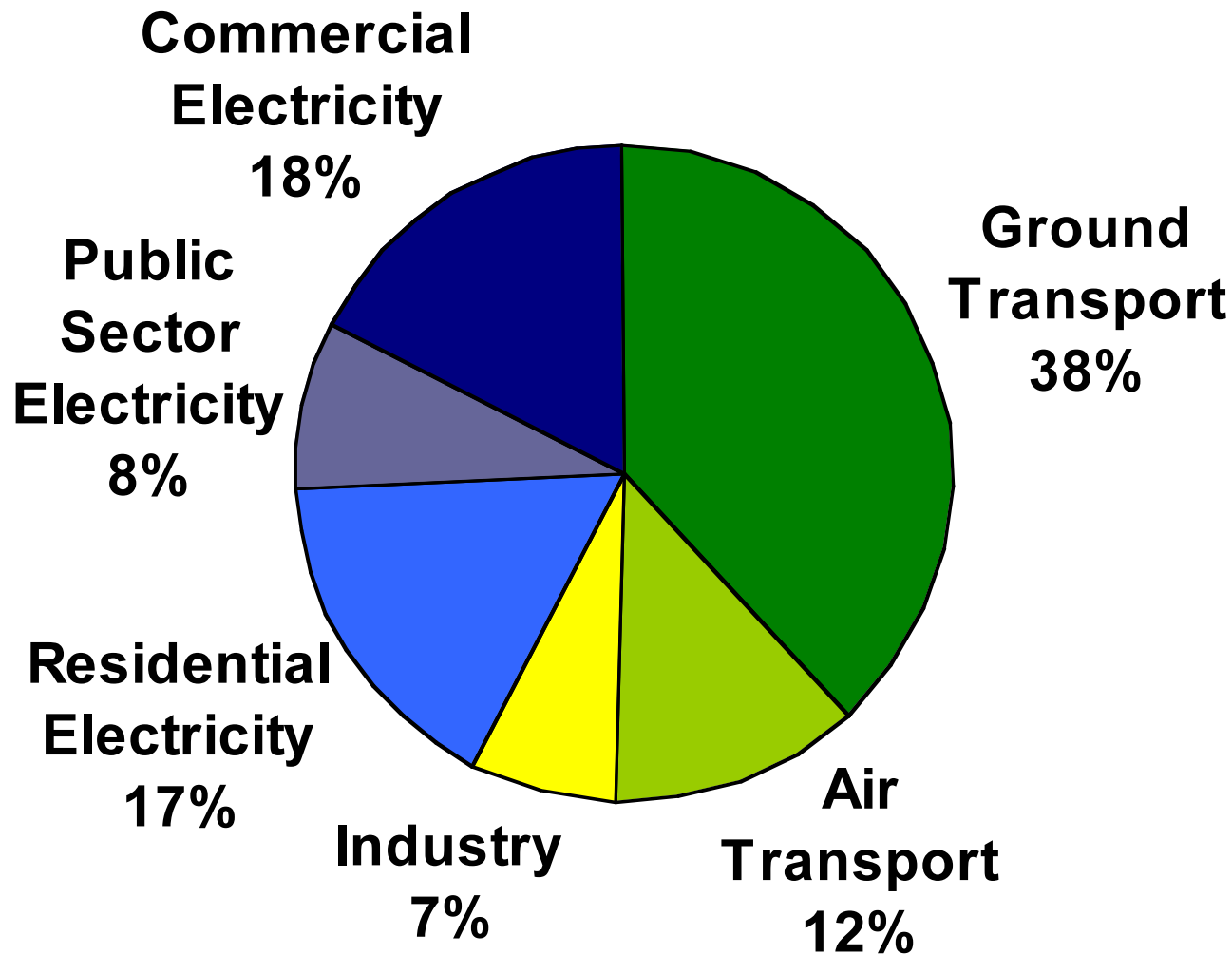
Economic Cost for Hawai'i Island



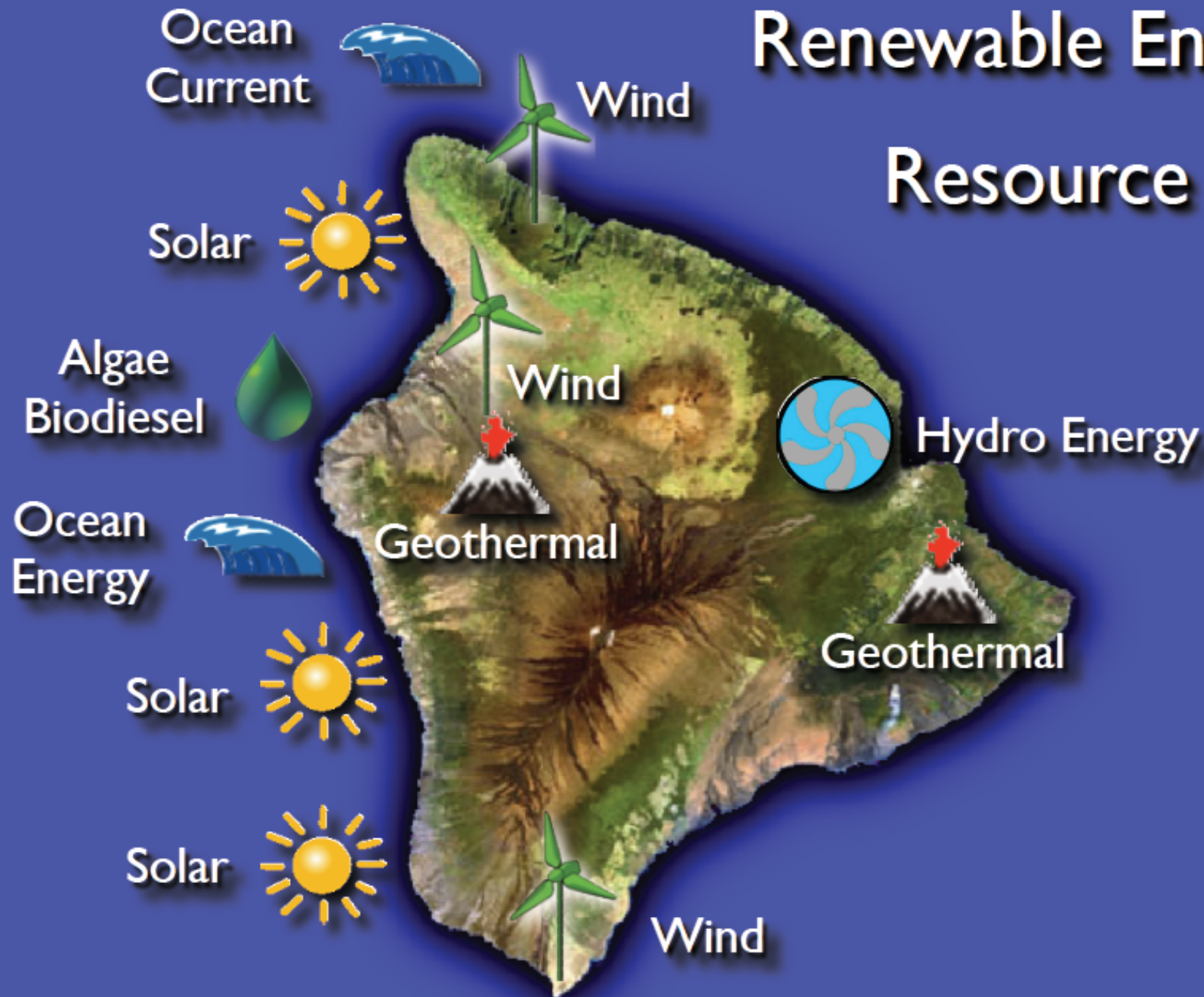
2010 Estimate

Based on 80 million gallons of gasoline at \$3.10 per gallon, 20 million gallons of diesel at \$3.50 per gallon, 1,200 million kWh of electricity at \$0.327 (residential) and \$0.300 (other), 30 million gallons of aviation fuel at \$1.90 per gallon, and liquid petroleum gas sales of \$5 million.

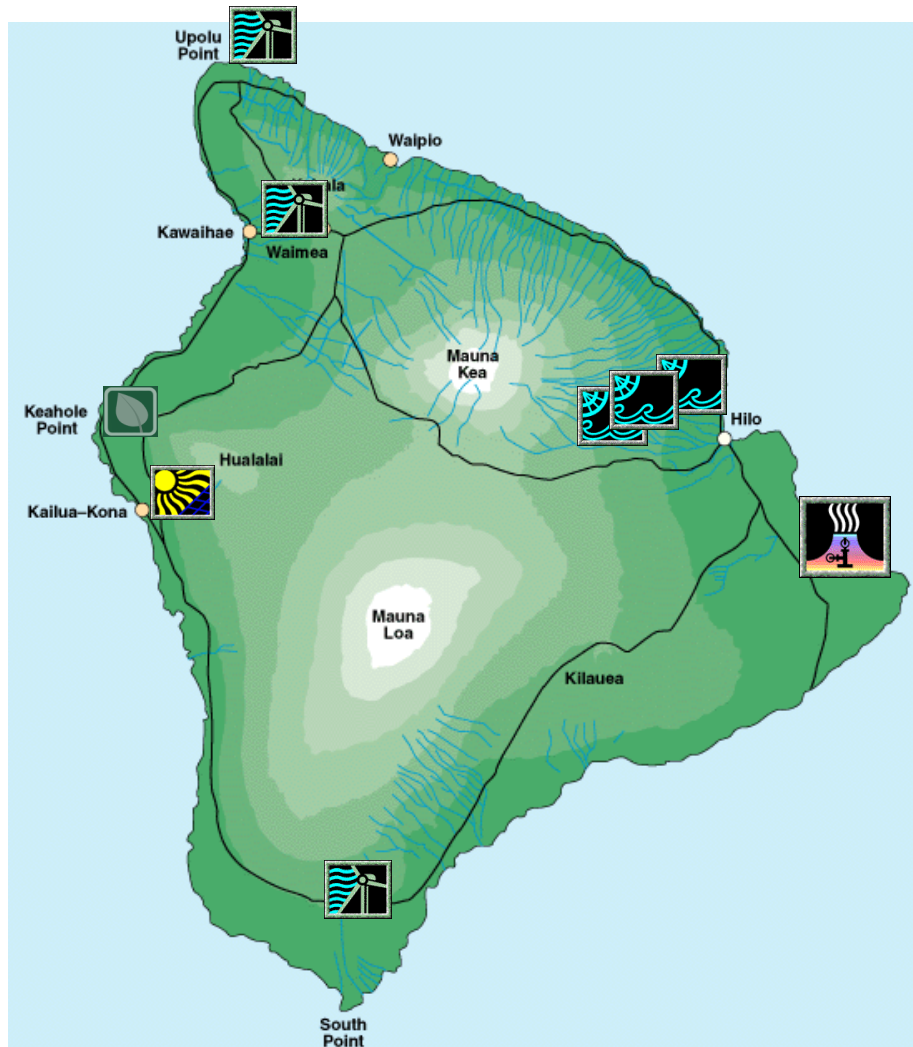
How is primary energy being used on the Island?



Renewable Energy Resource Map

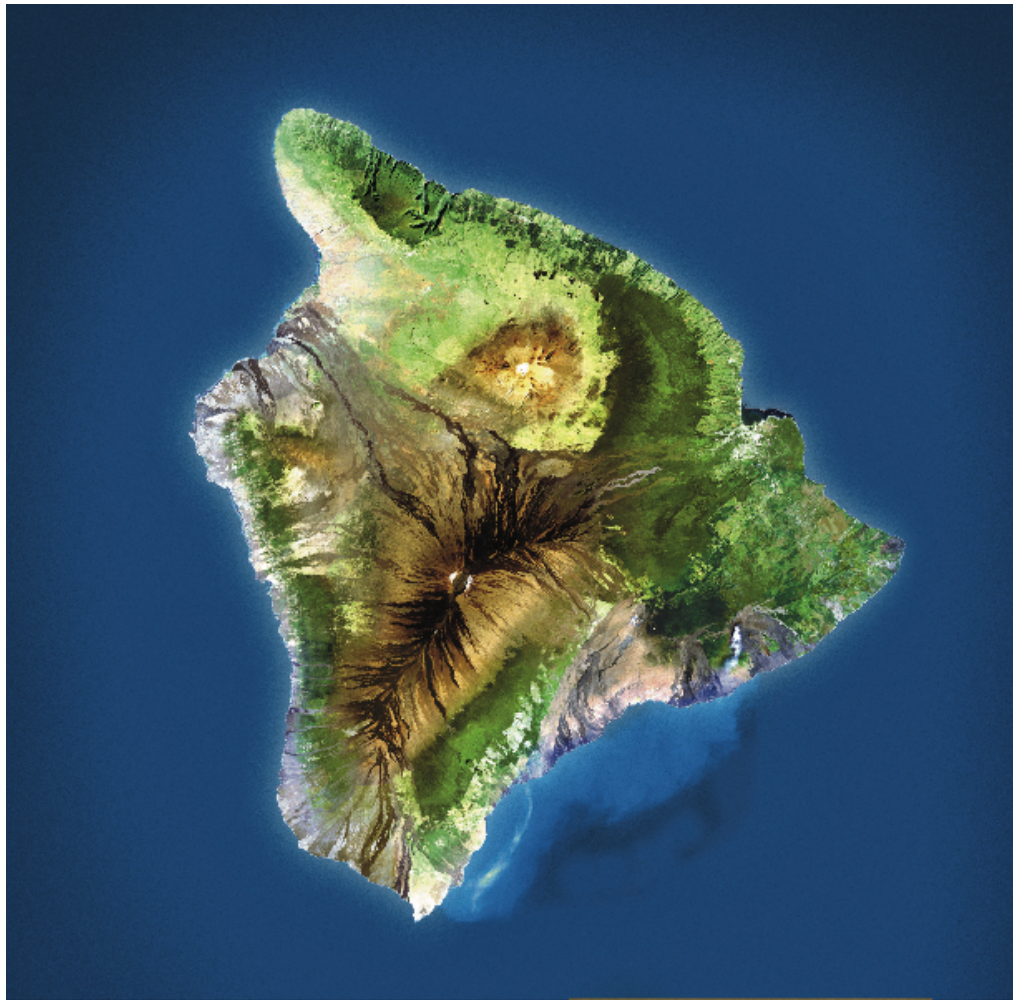


Hawaii – Existing Renewable



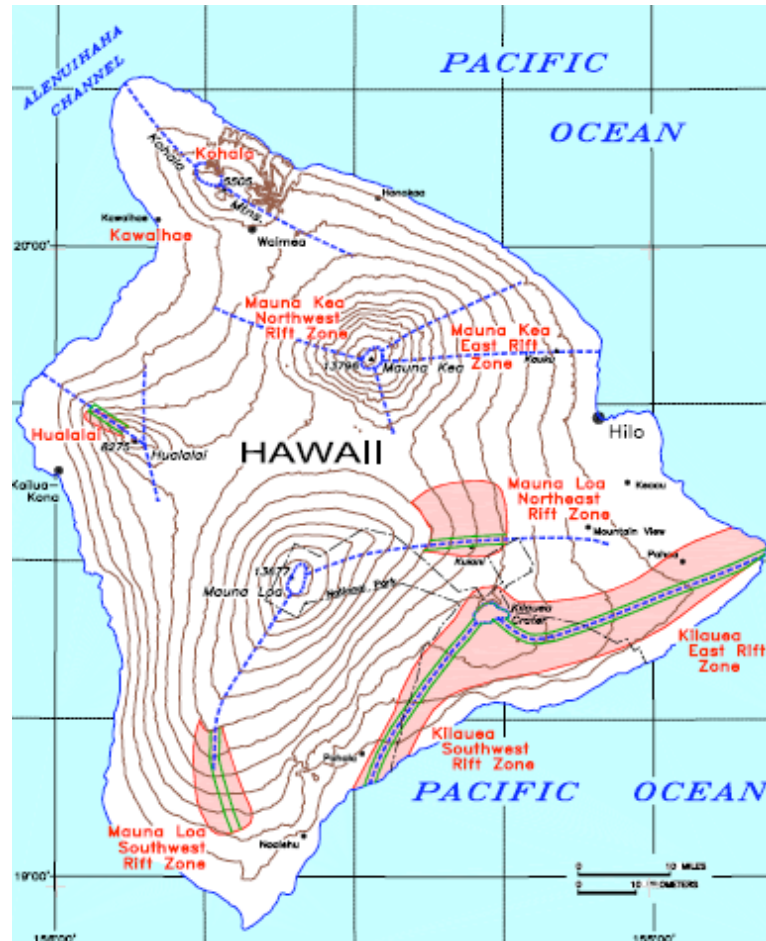
- 269 MW capacity
- 203 MW peak demand
- 70 MW off-peak baseload
- **Puna Geothermal – 38 MW**
- Sopogy (CSP) – 500kw - NELHA
- SolFocus (CPV) – TBD - NELHA
- **Hawi – 10.5 Wind – Upolu Point**
- **Pakini Nui – 20.5 MW Wind – S Point**
- Lalamilo Wind – 1.2 MW – Waimea
- Puueo Hydro – 3.25 MW – Wailuku
- Waiau Hydro – 1.1 MW – Wailuku
- **Wailuku River Hydro – 12.1 MW**
- Cellana – Biofuel TBD – NELHA
- Small Hydro – 300 KW – Various
- Distributed Solar Thermal – 13GWh
- Distributed PV – 7.5 MW+

The Island of Hawai'i



- Large land mass
- Low Population Density
- Large area of high quality wind
- 800+MW of Geothermal potential
- Ample hydro-electric potential
- **Tourism economy**
- **We go to bed early!**

Areas of Available Geothermal Energy=438MW



LEGEND

- High-temperature resource area
- Assessment area for MW capacities
- Rift-zone axis
- Inferred caldera boundary

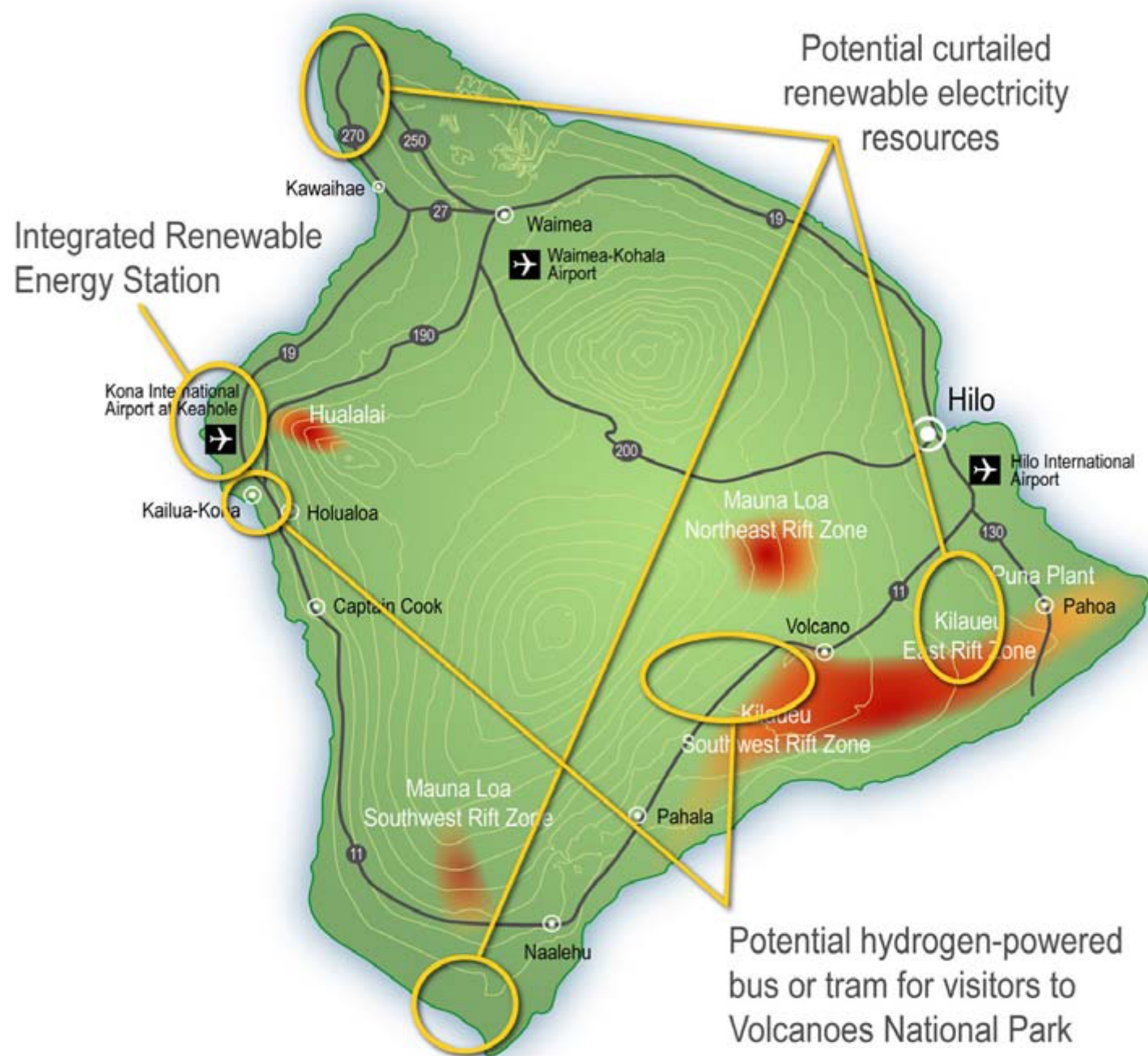
**Geothermal + Wind + Hydro
[off-peak hours]**

=

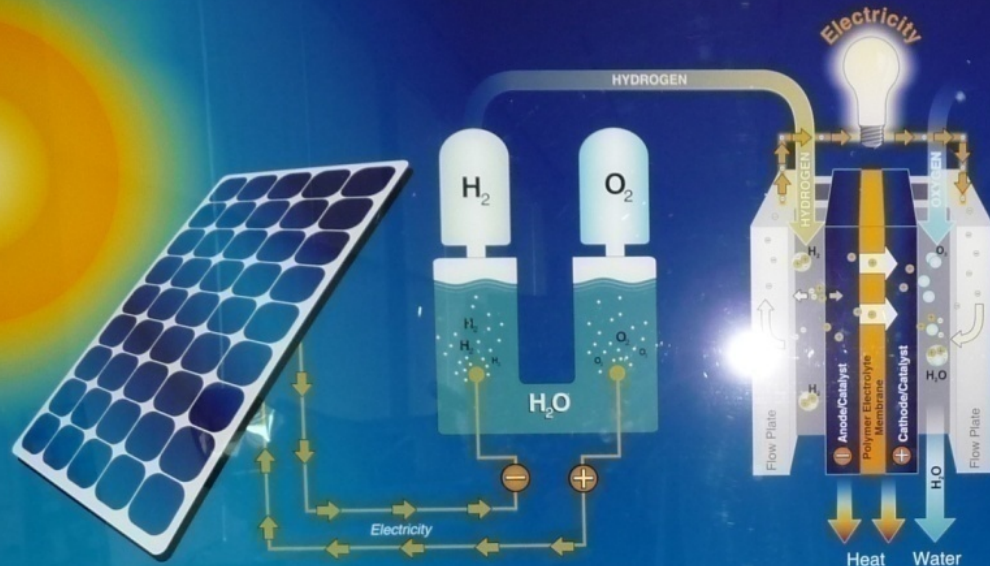
Curtailment = Waste



Curtailment = Fuel



Hydrogen Fuel from Sunshine & Water



Photovoltaic (Solar Cell) Systems

Electricity from photovoltaic modules can be used to power electrolyzers to make hydrogen.

Electrolyzer

Electrolyzers split water molecules into hydrogen and oxygen. The hydrogen can then be used as fuel.

Fuel Cell

Hydrogen can be used in *fuel cells* to generate electricity for businesses, homes, vehicles, or the utility company.



The Fuel H2FCV 8-400 made by Proton Fuel Cell Company



H₂ Fuel

Hydrogen can be used as a liquid fuel for cars, trucks, buses and other vehicles. It even powers the space shuttle!

Why Hydrogen?

Hydrogen, if made in the islands from renewable resources, could help Hawai'i become energy self-sufficient.

Of all the 50 States, Hawai'i is the most dependent on oil. Essentially all of the fuels used for transportation and most of the fuel used for electricity are based on petroleum. Because Hawai'i has no fossil fuel resources, all of this oil must be imported, making the islands very vulnerable.

Petroleum to Hawai'i



The Sun

The Sun, approximately 93 million miles away from the Earth, radiates energy in many forms, including visible light, infrared, ultraviolet, and x-rays. Solar energy is used directly to heat water and energize photovoltaic cells, as well as for other purposes. Indirectly, the sun's energy also is the source of other forms of renewable energy, including wind, biomass, hydropower, and ocean temperature differences.

Photovoltaic Module

When a photovoltaic module ("panel") is exposed to light, the energy in the light causes electrons to move. Electricity results when these electrons travel along a wire. Electrical devices and household appliances can be powered by photovoltaics. On the island of Hawai'i, thousands of buildings generate their own electricity with photovoltaic systems.

Electrolyzer

Using an electrolyzer, water can be split into its basic elements, hydrogen and oxygen. The process of electrolysis makes hydrogen gas by passing an electric current through water. Hydrogen collects at the negatively charged cathode, and oxygen collects at the positive anode. Renewable sources of energy (like solar, wind, and geothermal) can be used to generate the electricity needed for electrolysis. Hydrogen produced with electrolysis is more expensive than other fuels. Technology is currently being developed to bring costs down.

Hydrogen

Hydrogen is the simplest and most abundant element in the universe. An atom of hydrogen has only one proton and one electron. Hydrogen is naturally plentiful on Earth, but it is always combined with other elements. Combined with oxygen, it makes water (H₂O). Combined with carbon, it makes compounds such as methane, coal, and petroleum. To use it as a fuel, it must first be separated from water, methane, or another resource. Hydrogen is considered an energy carrier – a way to store and move energy – rather than an energy source.

Fuel Cell

A fuel cell is a device that uses hydrogen (or hydrogen-rich fuel) and oxygen to generate electricity. A single fuel cell consists of an electrolyte sandwiched between two thin electrodes (an anode and a cathode). In one common type of fuel cell, as hydrogen flows into the cell, a catalyst helps separate the hydrogen gas into electrons and protons. The protons pass through a membrane and combine with oxygen and electrons on the other side, producing water. The electrons, which cannot pass through the membrane, flow through an external circuit. This movement of electrons is electricity. If pure hydrogen is used, fuel cells emit only heat and water. Fuel cells are being developed to power vehicles, buildings, and even laptop computers.

H₂ Vehicles

Vehicles such as mopeds, cars, and buses that incorporate fuel cells – or hydrogen-powered internal combustion engines – are under development. They are being tested in fleet demonstration programs with vehicle manufacturers. NASA has used hydrogen in the space program for many years. Hydrogen fuel lifts the space shuttle into orbit; fuel cells power the shuttle's electrical system and provide drinkable water.



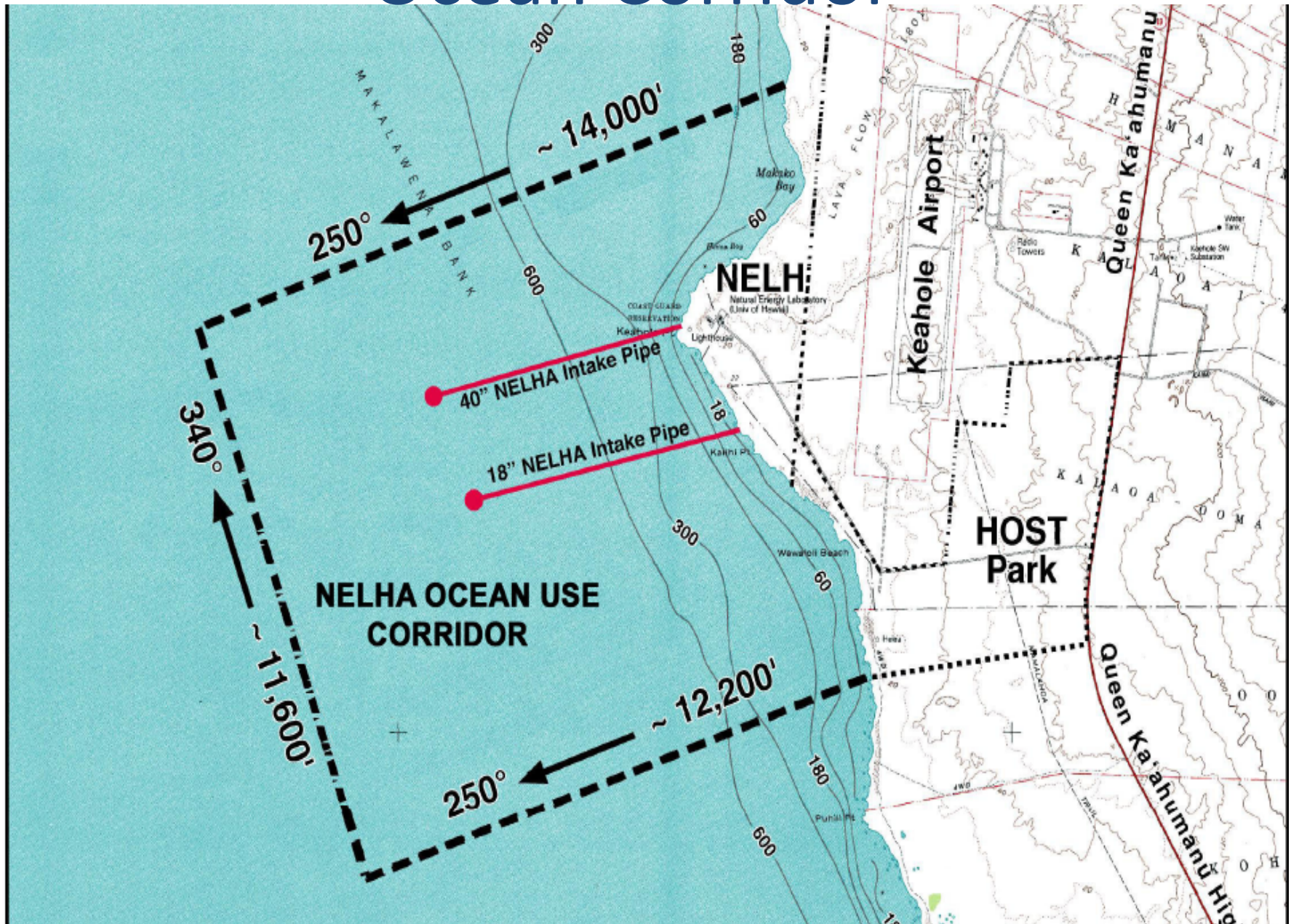
South West 1 Perspective



BioEnergy Hawaii, L.L.C.

Waste-to-Energy Facility
Kona, Hawaii

Ocean Corridor



OTEC: Baseload Power for NH₃ Production

- Floating Plant Ships
- Large Scale for Commercial Production
- 100+ MW capacity
- Electrical Source for NH₃ Production

Where can I buy a hydrogen vehicle??

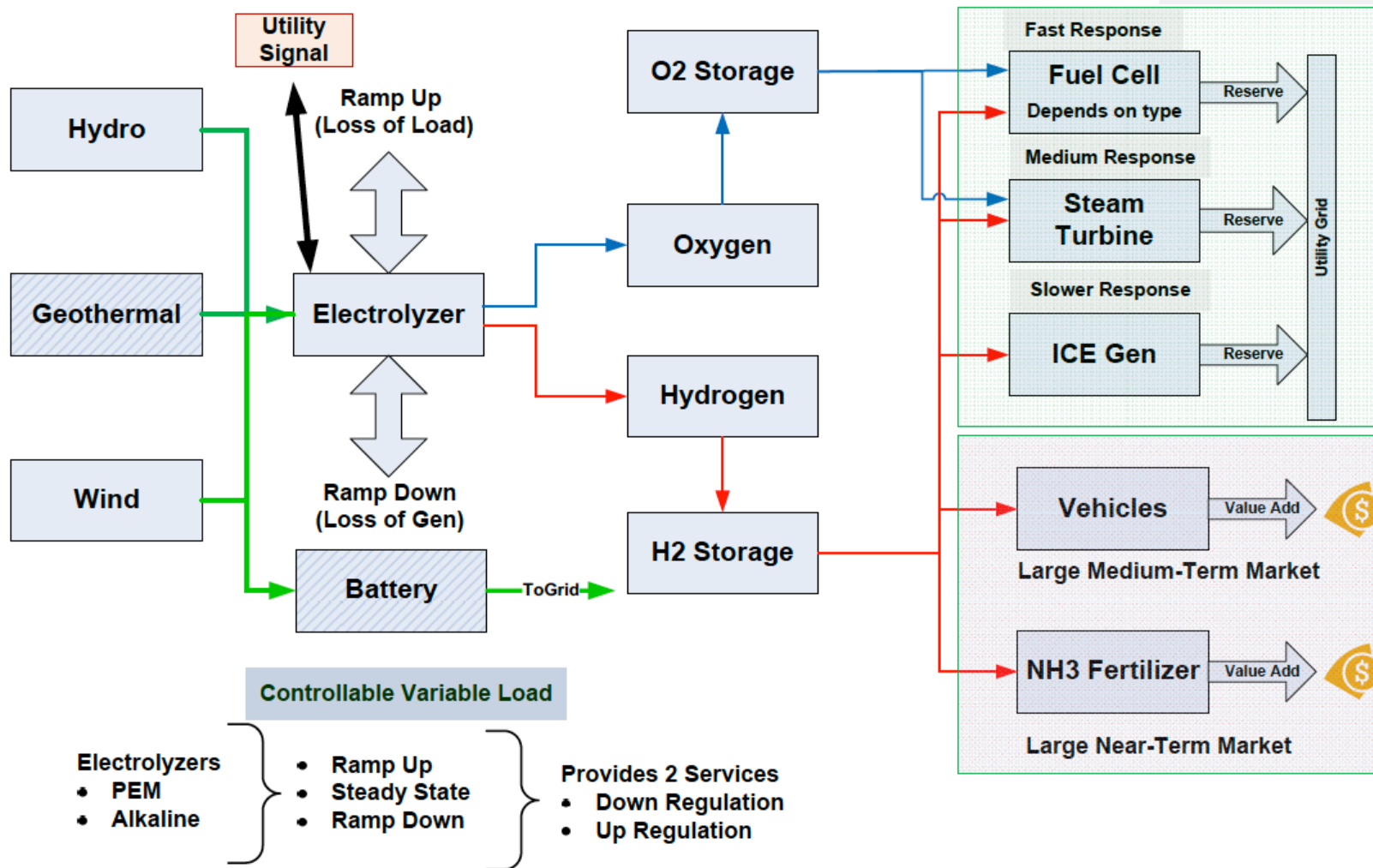


Plowing the way to the Hydrogen Economy in Hawaii



Electrolyzers, Fuel Cells & Hydrogen A New Value-Added Grid Services Methodology

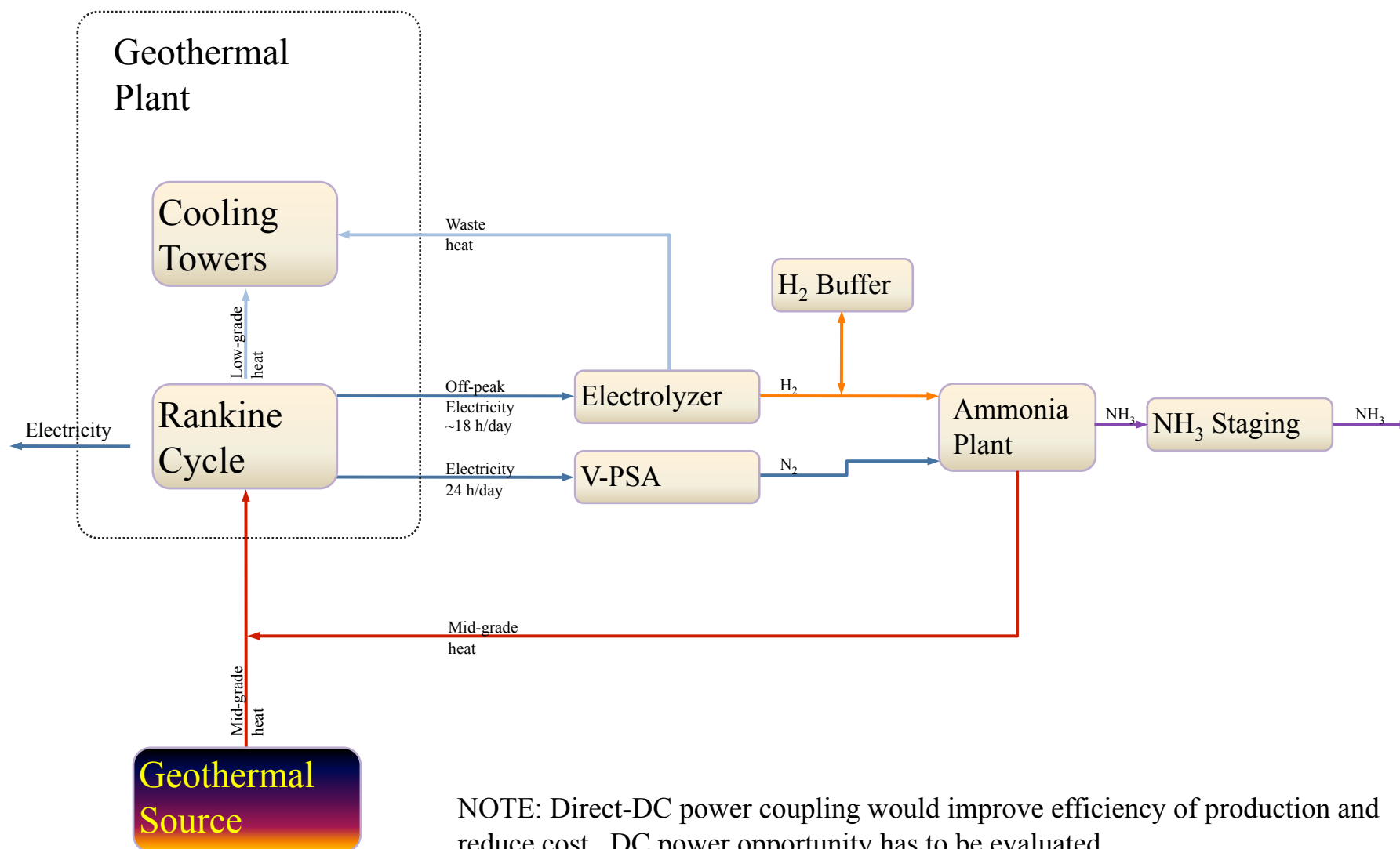
Different Characteristics
lead to different Services



Value Proposition – Change Operating Rules

- **FROM:** Wind up = Reserve up
- **TO:** Reduce Reserve requirement by throttling electrolyzer up and down
- **PLUS:** Electrolyzer producing valuable products while providing grid regulating ancillary services = potentially more value than just H2?

Ammonia Production



Immediate Demand for Ammonia in Hawaii

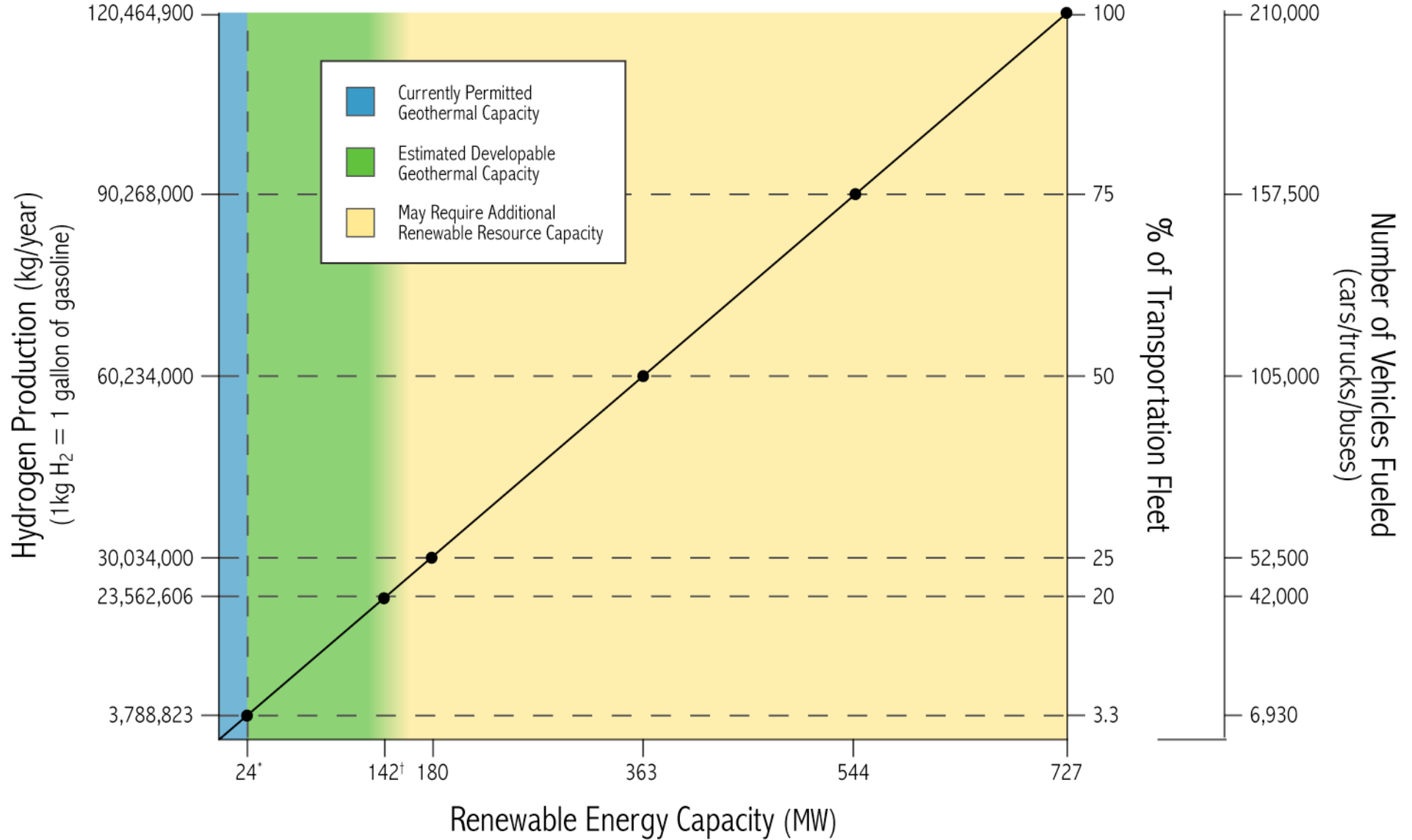
HC&S 6.8 T/D of Urea



3.8 T/D of NH₃

Analyst est. to be 9-10 T/D of NH₃

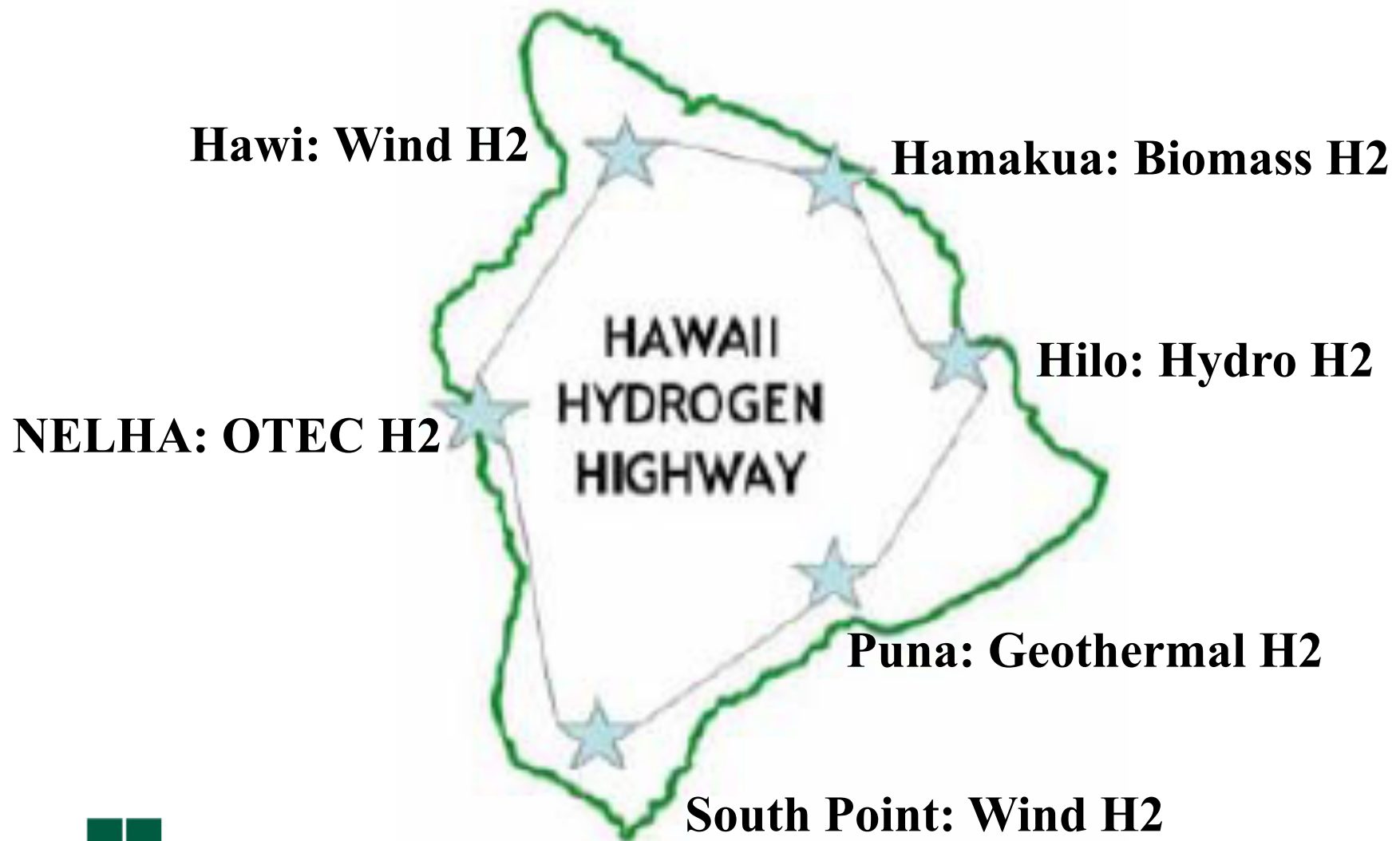
Hydrogen Production Potential on the Big Island



* 24 MW of 60 MW currently permitted geothermal capacity is utilized for H₂ production

† 142 MW of total 180 MW developable capacity is utilized for H₂ production

Hydrogen Infrastructure – Renewable H2



Ford Shuttle Van

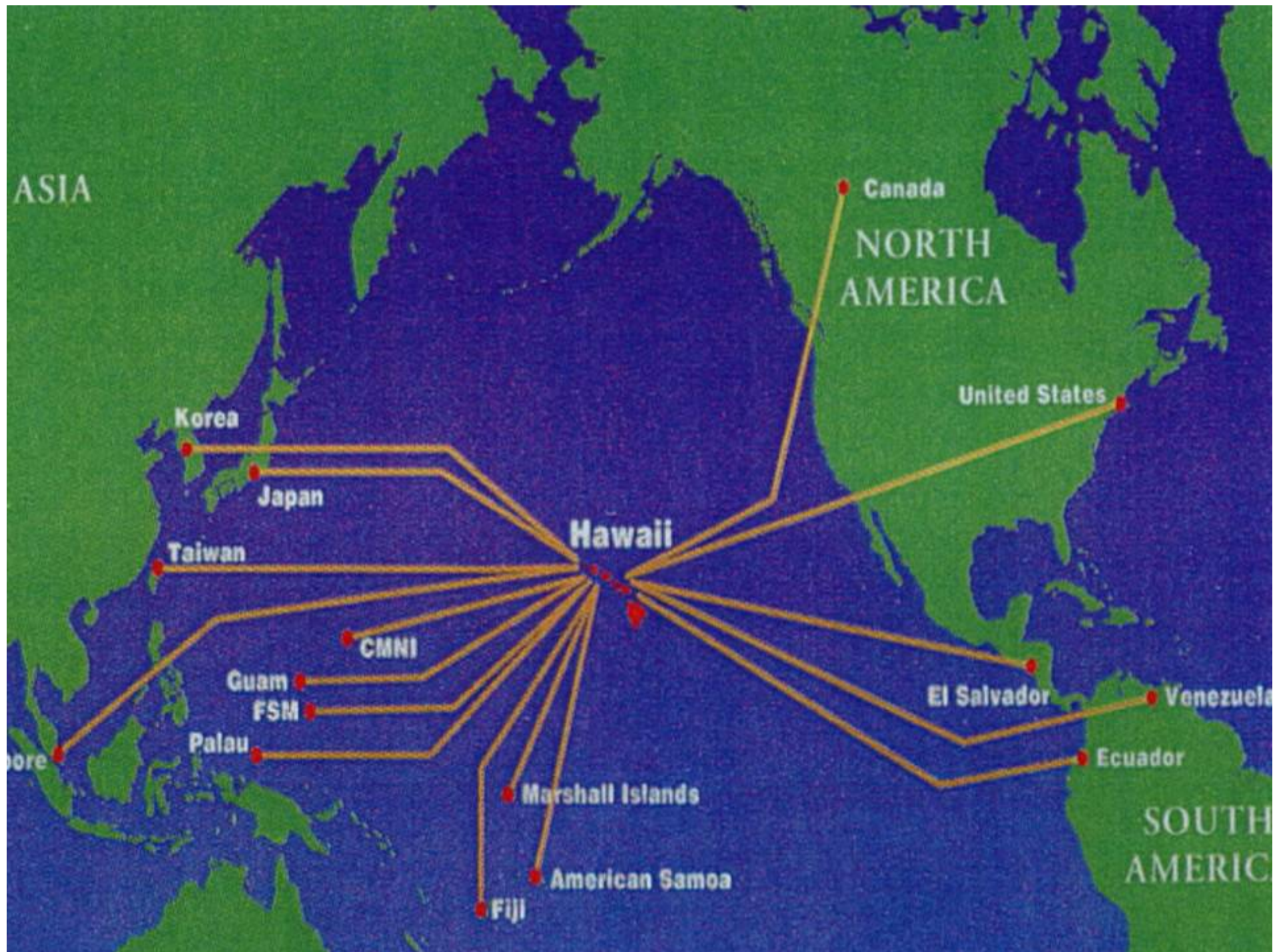


- Engine 225 hp
- 12 passengers + driver
- Compressed hydrogen – 5,000 psi
- Range – 150 miles

Hydrogen Infrastructure and Vehicles coming soon.



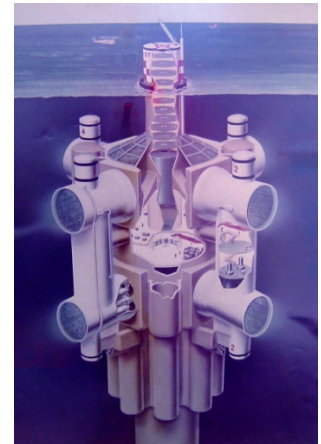




SUMMARY

Hawai'i Island, a Living Laboratory

- Millions of visitors from all over the world
- Perfect stage for branding & demonstrating the triple uses of NH_3 for fertilizer, transportation fuel and energy carrier
- Perfect stage to prove the safety of NH_3
- LET'S WORK TOGETHER! We need to:
 - a. Demonstrate running a vehicle
 - b. Run a generator or fuel cell
 - c. Use NH_3 as a fertilizer at a farm



Support from Government, Industry and Economic Dev Boards

William P. Kenoi
Mayor



County of Hawai'i
Office of the Mayor

25 Aspinwall Street, Suite 2603 • Hilo, Hawai'i 96720 • (808) 961-8211 • Fax: (808) 961-6553
KONA: 75-5722 Hanalei Place, Suite 102 • Kailua-Kona, Hawai'i 96740
(808) 327-3602 • Fax: (808) 326-5663

William T. Takaha
Managing Director

Walter K.M. Lau
Deputy Managing Director

July 6, 2010

H2 Technologies, Inc.
Guy Toyama
73-4347 Malie Place
Kailua-Kona, HI 96740

Dear Guy:

The growing opportunities on the Island of Hawai'i for food and energy production in our County and state are very exciting for our future.

Your work with ammonia in these areas using available stranded off-peak energy -- whether from geothermal in Puna, wind in Hilo or hydro in Hakalau -- promises to meet multiple alternative energy needs and goals such as storing excess electricity, using it for transportation fuel or as fertilizer for local farmers.

Ammonia has the capacity to become an important component of a clean energy future on our Island of Hawai'i, and our County Department of Research and Development is committed to sharing a portion of the expense with your non-profit arm, the Friends of NELHA, to conduct further research into use of ammonia in food and energy production applications.

I heartily endorse your project as a positive development in our progress toward food and energy sustainability in our island County and state, and I would encourage the Hawai'i Technology Development Venture to review your project favorably and grant its approval.

Aloha,

Billy Kenoi
MAYOR

County of Hawai'i is an Equal Opportunity Provider and Employer.

PUNA GEOTHERMAL VENTURE



July 11, 2010

H2 Technologies, Inc.
Guy Toyama
73-4347 Malie Place
Kailua-Kona, HI 96740

Dear Guy,

Your potential project to make hydrogen and ammonia using renewable energy is very interesting. The potential to store curtailed geothermal power during the off-peak hours to be used in loads by converting it back into electricity would potentially be very helpful to Puna Geothermal to help the power utility by making the already firm geothermal power even more 'dispatchable'.

Subject to negotiating a formal and mutually acceptable agreement, PGV supports your project hope that you will receive a favorable decision from Hawaii Technology Development Venture look forward to hearing more of how we can partner up and work towards commercializing the technology after your project is complete.

Sincerely,

Michael L. Kaleikini
Plant Manager
Puna Geothermal Venture

Post Office Box 30 • 14-3860 Kapoho-Pāhoo Road

Pāhoo, Hawai'i 96778

Tel: (808) 965-6233 • Fax: (808) 965-7254

PunaGeothermalVenture.com

an ORBIT company

SENT VIA EMAIL

July 6, 2010

Guy Toyama
H2 Technologies, Inc.
73-4347 Malie Place
Kailua-Kona, HI 96740

Aloha Guy!

Thank you for the opportunity to write a letter of support. The idea of making ammonia, using renewable energy, serves multiple goals. It can store excess electricity, it can be used as a transportation fuel and it can be used as a fertilizer for the agriculture industry in Hawai'i. The ability to store curtailed wind, hydro and geothermal power during the off-peak hours, is of extreme importance for Hawai'i, as we aim for achieving energy and food security. Ammonia is a solution for both.

We support your project and hope that you will receive a favorable decision from Hawai'i Technology Development Venture. We also look forward to hearing more of how we can partner and assist you with your goal to commercialize the technology once your project is complete.

Sincerely,

Mark McGuffie
Managing Director



ENTERPRISE
HONOLULU
THE BUSINESS CLIMATE OF PARADISE

735 Bishop Street, Suite 412, Honolulu, Hawaii 96813 • 808-521-3611
Fax: 808-536-2281 • www.enterprisehonolulu.com

Potentially Large Customer



HFuel Trolleys!



**See you at the 8th NH3 Fuel
Conference in 2011!**

