Supporting a Hawaii Hydrogen Economy

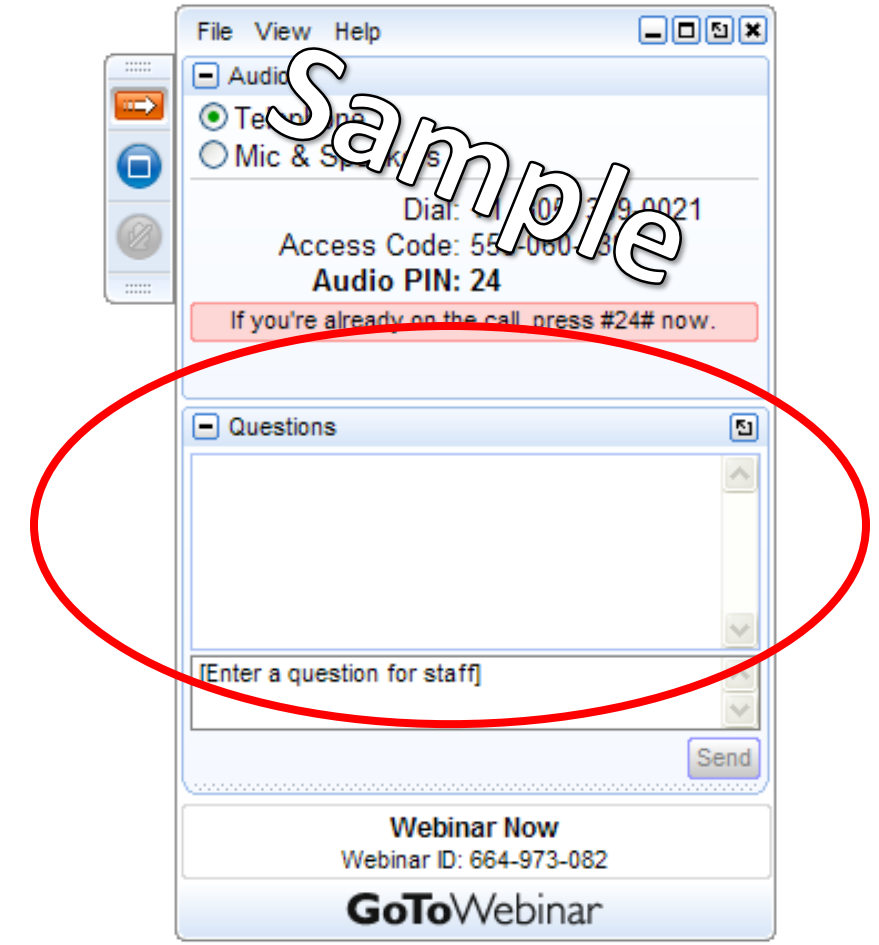
U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Pete Devlin

U.S. Department of Energy
Fuel Cell Technologies Office

Question and Answer

- Please type your question into the question box



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Supporting a Hawaii Hydrogen Economy

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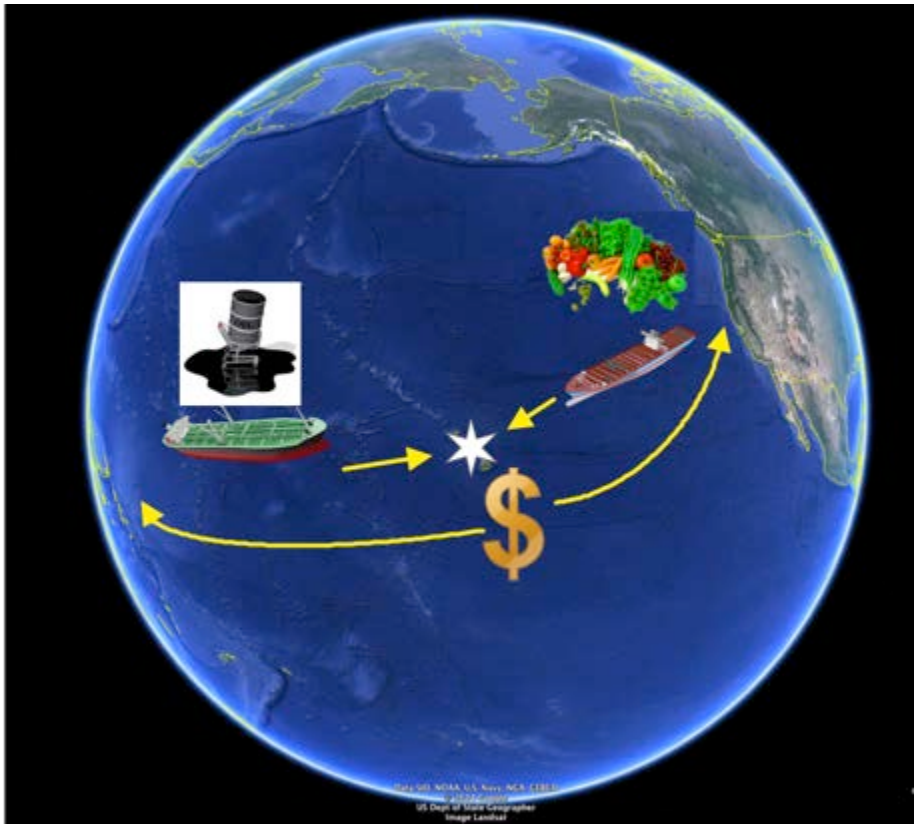
CHALLENGES

Hawaii is Most Petroleum-Dependent State in US

Import 90% of Energy
$11Billion leaves Hawaii economy*



Highest/Most Volatile Electricity Rates in US

* Based on $4B x 2.75 economic multiplier

Fundamental Challenges

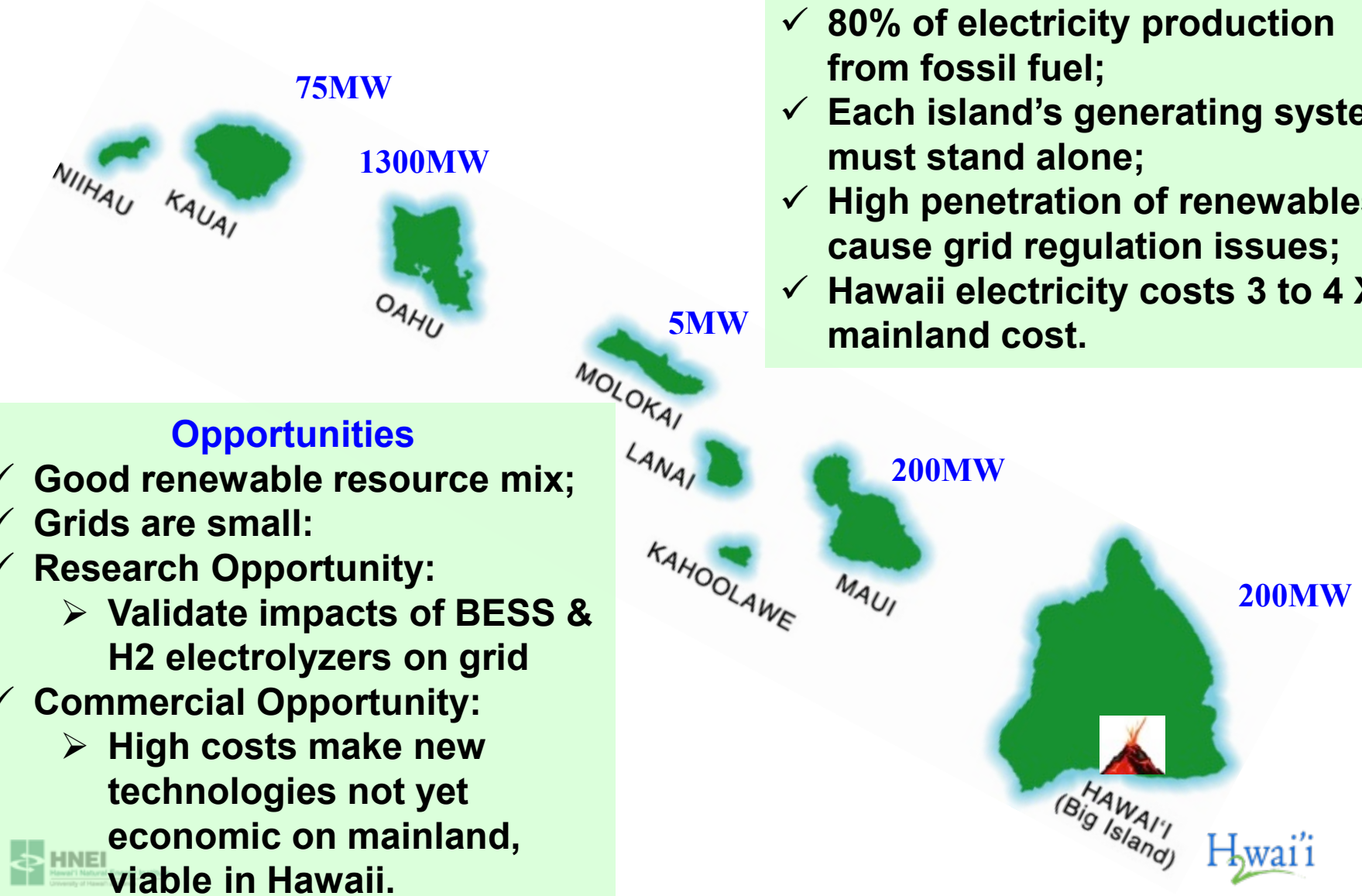
Over dependence on imported oil threatens:

- **Economy:**
  - **Electricity $.34-$.42/kWh, Gasoline $4.50+/gallon;**
  - **Syngas Residential $5.60/therm. Commercial $4.62/therm**
- **Environment;**
- **Security; and**
- **Quality of Life of its residents.**

Solutions

- ✓ **Reduce Hawaii's dependence on imported oil for electricity and ground transportation @ prices that provide more stable and lower energy costs;**
  - ➢ **Aggressively reduce our energy use;**
  - ➢ **Add as much renewable energy as possible, as soon as possible.**

Challenge: No Transmission Interconnection Between Islands



Challenges

- ✓ 80% of electricity production from fossil fuel;
- ✓ Each island's generating system must stand alone;
- ✓ High penetration of renewables cause grid regulation issues;
- ✓ Hawaii electricity costs 3 to 4 X mainland cost.

Opportunities

- ✓ Good renewable resource mix;
- ✓ Grids are small:
- ✓ Research Opportunity:
  - ➢ Validate impacts of BESS & H2 electrolyzers on grid
- ✓ Commercial Opportunity:
  - ➢ High costs make new technologies not yet economic on mainland, viable in Hawaii.

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Building Blocks for a Hydrogen Economy

1. Policies & Plans
2. Resources
3. Political Will
4. Strategic Projects
5. Community Support
6. Strategic Partners

We are addressing all 6 of these!

POLICIES & PLANS

It is Hawaii State Policy to Establish a Hawaii Hydrogen Economy

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Hawaii Renewable Hydrogen Program (HRS 196-10)

Objective is to transition state to a renewable hydrogen economy by:

- **Conducting strategic R&D, testing & deployment of renewable hydrogen technologies;**
- **Conducting engineering & economic evaluations & near-term project opportunities;**
- **Conducting electric grid reliability & security projects to increase penetration of renewable energy on Big Island;**
- **Conducting hydrogen demonstration projects including infrastructure, storage, refueling hydrogen vehicles;**
- **Promoting Hawaii renewable hydrogen resources to potential partners & investors.**

Hawaii Clean Energy Initiative (HCEI)

Most Aggressive Clean Energy Goals in the United States

40% RENEWABLE
+ 30% EFFICIENCY
= 70% CLEAN ENERGY

Hydrogen for transportation and grid support could make an important contribution to meeting HCEI goals.

Hawaii's sun, wind, land, & sea resources can provide limitless amounts of hydrogen – forever!

Strong Support from US DOE

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Hawaii Hydrogen Initiative (H2I)

- ✓ **An innovative partnership among 20 agencies, companies, and universities;**
- ✓ **Seeks to develop hydrogen infrastructure in Hawaii that supports Hawaii's transformation to a clean energy economy;**
- ✓ **Supports the deployment of fuel cell vehicles in Hawaii.**

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Resources

Hydrogen Investment Capital Special Fund (HRS 211F-5.7)

- ✓**Objectives:**
  - Provide seed capital and venture capital for private and federal projects for research, development, & testing;
  - Implement the Hawaii Renewable Hydrogen Program;
  - Any other purpose deemed necessary to carry out the purposes of the Hawaii Renewable Hydrogen Program.
- ✓**Sources of Funds**
  - Appropriations made by the legislature;
  - Contributions from public or private partners;
  - All interest earned on or accrued to moneys deposited in the special fund.

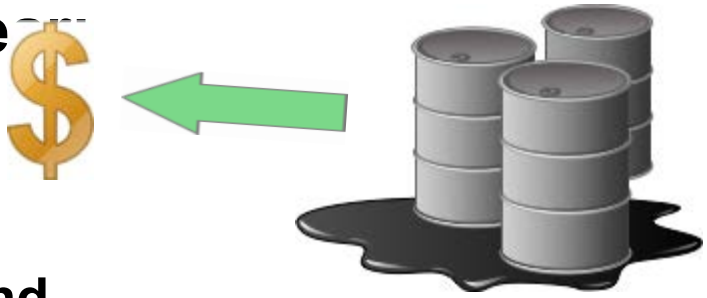
Fund Status

- ✓ Originally funded at $10 million;
- ✓ $8.7 actually provided;
- ✓ Originally managed by a VC:
  - ➢ Seed Funding – good ideas;
  - ➢ Cost Share for Federal Projects;
  - ➢ VC Investments up to $1 million.

- ✓ All initial funds dispersed;
- ✓ The special fund vehicle remains in place;
- ✓ Vehicle to accept additional funds;
- ✓ Now managed by the Hawaii Strategic Development Corporation, an agency of the State of Hawaii

Barrel Tax (HRS 243-3.5)

- ✓ Enacted in 2010
- ✓ $1.05 per barrel of oil excluding air transportation;
- ✓ Generates ~$30 million per year
- ✓ 60% goes to General Fund;
- ✓ 40% goes to:
  - ➢ Oil Spill emergency clean-up fund
  - ➢ State energy office
  - ➢ State Department of Agriculture
  - ➢ Energy Systems Development Special Fund (HNEI)
- ✓ Hydrogen projects have received funding from HNEI allocation;
- ✓ Potential source for Hydrogen Fund replenishment.



Need to make a compelling case

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Political Will

This is a key for early demonstration projects

Hydrogen Program Needs to be Cost Effective

- **Program needs to be seen as providing cost effective solutions/benefits:**
  - **What problems can hydrogen fix?**
  - **Is it affordable?**
- **Competing for scarce resources:**
  - **Long term vs. short term;**
  - **Do we fund hydrogen or air conditioners for schools? The kids are suffering today!**
- **Need success stories;**
  - **Technology validated;**
  - **Affordable.**
- **Need champions.**

Must Keep Community Informed

- ✓ Need to justify investment of taxpayer dollars to the taxpayer;
- ✓ Public needs to see an immediate benefit to them:
  - ➢ Public transportation vs. perception of supporting "rich man's toys";
  - ➢ Leverage public infrastructure for private transportation for early adopters.
- ✓ Workforce development for the new jobs created;
- ✓ First Responder training. Helps address safety concerns;
- ✓ Legal and insurance industries need to be educated;
- ✓ Active public outreach campaign

Community: First Responder Training

- Utilized PNNL training program;
- Trained 300 first responders from Oahu and Big Island;
- Classroom & field work covering hydrogen and electrical;
- Live fire with “Burn Prop”;
- Enthusiastic reception by fire departments and civil defense;
- Sets groundwork for operational phase.

Effective public outreach & promotes community acceptance.

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PROJECTS

Projects Need to be Strategic

Need to demonstrate the economic viability and benefits of the technology. Will not get investment until the numbers work out relative to other options.

Strategic Focus for Hawaii

- ✓ Demonstrate cost effective infrastructure to produce, distribute, and dispense hydrogen;
- ✓ Focus on fleet vehicles starting with public transportation & county trucks;
  - ➢ 30 kg per day per bus;
  - ➢ Public gets the benefit of their tax dollars being used to support their personal transportation needs;
- ✓ Industry will take care of the vehicles;
- ✓ Support early heavy users of hydrogen to quickly develop a hydrogen market;
- ✓ Private industry will take over when they see they can make money.

11 Hawaii H2 Projects

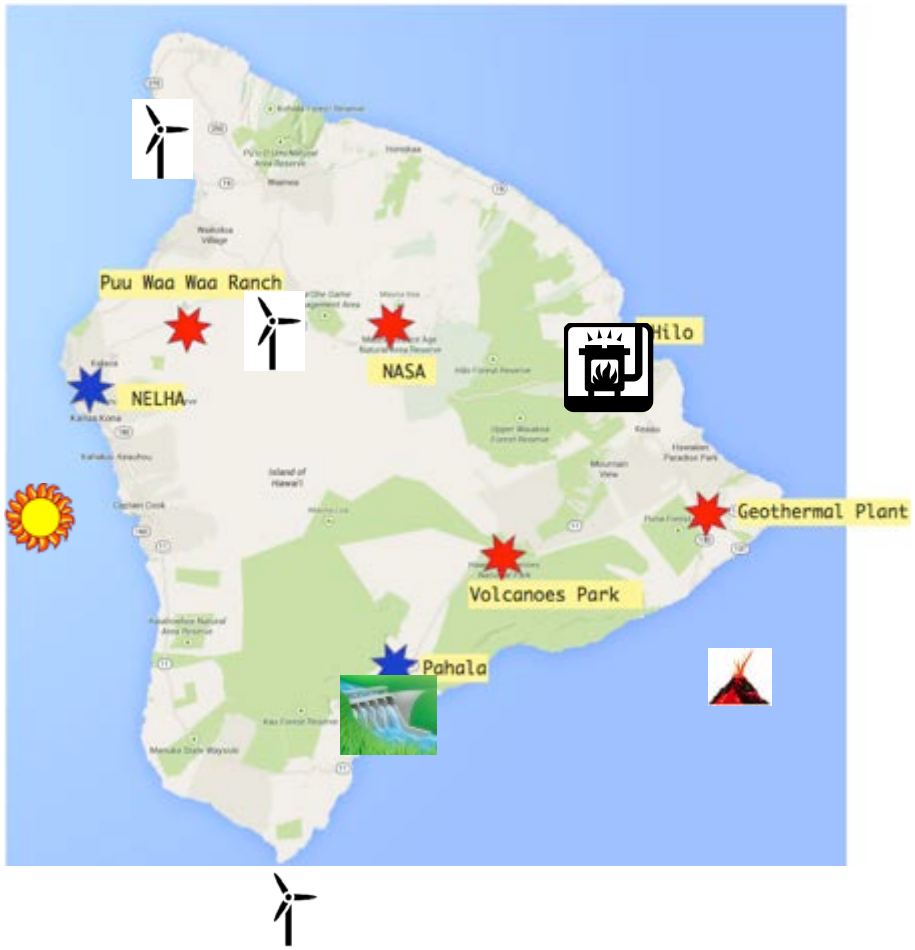
Island of Hawaii

- ✓ Hydrogen Energy Systems for Grid Management;
- ✓ Hawaii Volcanoes National Park FCEV Shuttle Bus;
- ✓ Pu'u Wa'awa'a Ranch Hydrogen Micro-Grid;
- ✓ Mars Habitat Fuel Cell System;
- ✓ Island of Hawaii Hydrogen Highway;

Oahu

- ✓ HNEI Hawaii Sustainable Energy Research Facility (HiSERF);
- ✓ DoD/GM Equinox FCEV Deployment;
- ✓ Maritime Fuel Cell Generator Project;
- ✓ Marine Corps Base Hawaii Dual Pressure "Fast-Fill" H2 Fueling Station;
- ✓ GSA Hydrogen Fueling Station;
- ✓ Hawaii Center for Advanced Transportation Technologies.

Island of Hawaii Projects



Hydrogen Energy Systems for Grid Management

- ✓ Demonstrate the use of electrolyzers to mitigate the impacts of intermittent renewable energy by regulating grid frequency;
- ✓ Characterize performance/durability of commercially available electrolyzers under dynamic load conditions;
- ✓ Supply hydrogen to shuttle buses operated by County of Hawaii Mass Transit Agency, and Hawaii Volcanoes National Park;
- ✓ Conduct performance/cost analysis to identify benefits of integrated system including grid Ancillary Services & off-grid revenue streams; and
- ✓ Evaluate effect on reducing overall hydrogen costs offset by value-added revenue streams.
- ✓ First step in developing hydrogen infrastructure.

Grid Management Project: Central Site Production/Distributed Dispensing

H2-fueled shuttle buses

1 Bus

Hydrogen Dispensing under Grid Management Program

2 Buses

Hydrogen Dispensing under Hawaii Power Park Program

Geothermal Powered Hydrogen Production.
Electricity is PGV cost-share to project.

Hawaii Volcanoes National Park
FCEV Shuttle Buses

Assembled in Hawaii

Performance Testing

- **Operation of fuel cells in high-sulfur air environment;**
- **Performance of vehicles in navigating steep and rapid changes in elevation and road grades.**

Pu'u Wa'awa'a Ranch Hydrogen Micro-Grid

- ✓ **PWW Ranch entirely off grid;**
- ✓ **Renewable energy demonstration site;**
- ✓ **85 kW PV array main power source;**
- ✓ **Energy storage systems include hydrogen production & storage;**
- ✓ **Hydrogen pipeline distribution system supplying fuel cells.**

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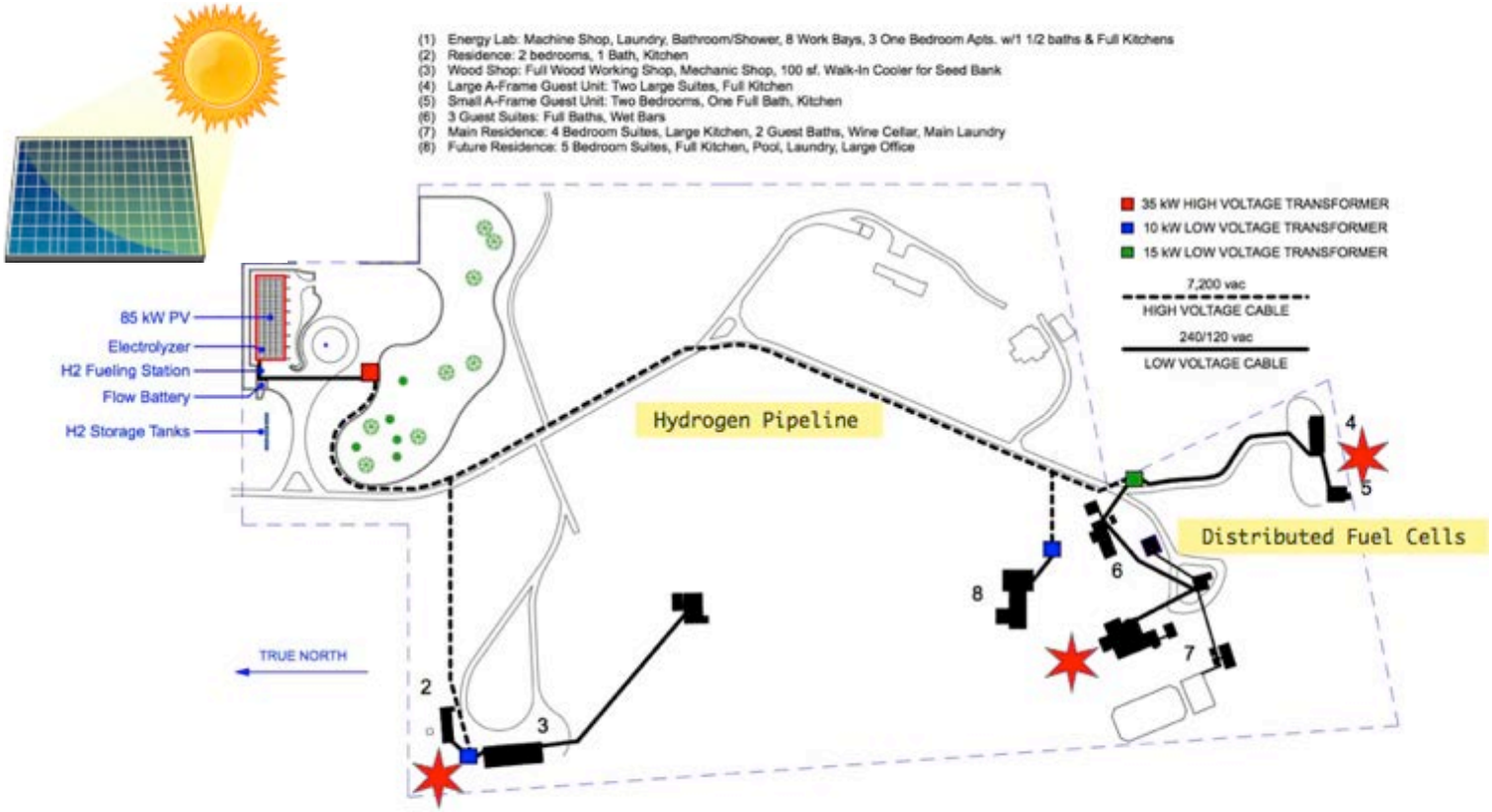
PWW Hydrogen Micro-Grid



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Mars Habitat Fuel Cell System

Control System HMI

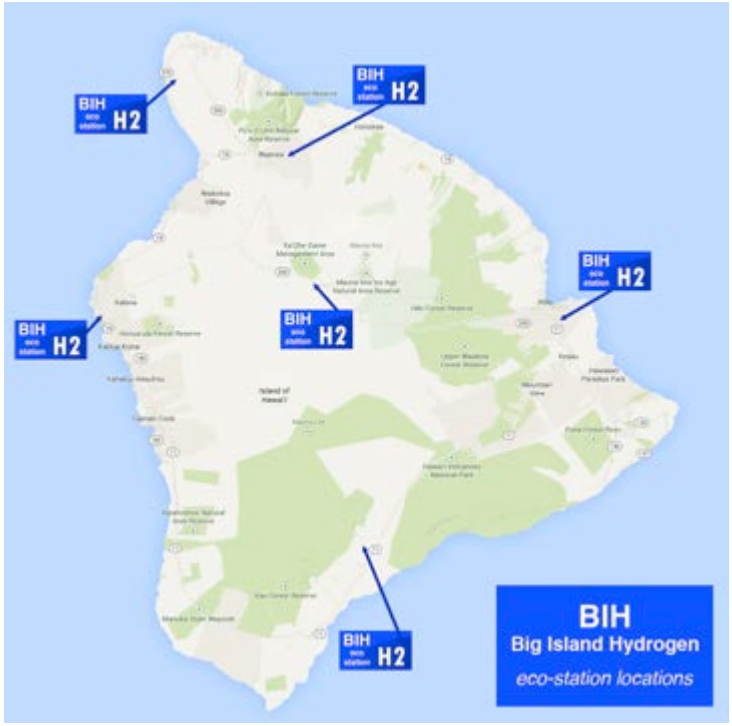
Habitat

Fuel Cell & H2

- ✓ **Powered by:**
  - ➢ **10 kW PV system;**
  - ➢ **10 kW/20 kWhs Lithium Iron Phosphate Batteries;**
  - ➢ **4 kW ReliOn T2000 H2 Fuel Cell**
- ✓ **PV & Battery system provide power under normal operations;**
- ✓ **FC supports battery if battery runs down;**
- ✓ **In 4 months of ops, FC has kept batteries above 15% SOC**

Island of Hawaii Hydrogen Highway

Big Island Hydrogen "Eco-Stations"



- Eco-Stations combine Hydrogen, Biofuels, Electric Charging, and a café & mart offering local fruits, snacks, and gourmet coffee;
- Inside are educational videos about the Big Island, sustainability, & renewable energy.

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Oahu Projects

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HNEI Hawaii Sustainable Energy Research Facility (HiSERF)

Mission: Establish strategic partnerships with government agencies and businesses to develop fuel cells, batteries, and energy storage technologies for commercial and military applications.

Capabilities

- Hydrogen fuel cell and battery testing.
- Fuel cells testing range: 5 W – 5 kW.
- Suite of electrical testing capabilities for long-term dynamic and steady state testing with single fuel cells and stacks as well as single batteries and packs.
- Several gas analysis systems .

HiSERF Office of Naval Research Projects

Objective: Develop fuel cell and energy storage systems for range of applications and operating environments.

- ✓ Supporting fuel cell bus deployment in regions with poor air quality (HAVO) by characterizing performance with impure air and developing air filtration methods.
- ✓ Developed hybrid battery/ fuel cell system for unmanned aerial vehicles (UAVs) to improve mission capabilities.
- ✓ Analyzing battery energy storage systems to maximize renewable energy penetration in the electrical grid.

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HiSERF Department of Energy Projects

Objective: Identify critical airborne and hydrogen contaminants that affect fuel cell performance and lifetime.

- ✓ Assisted in developing hydrogen purity standard SAE J2719 for fuel cell vehicles (e.g. 0.2 ppm CO limit in hydrogen).
- ✓ Screened more than 260 potential airborne contaminants and identified 7 critical airborne contaminants that decrease performance.
- ✓ Using information to develop air filtration specifications and mitigation strategies to maximize lifetime and performance of fuel cells operated in contaminated air.



DoD/GM Equinox FCEV Deployment

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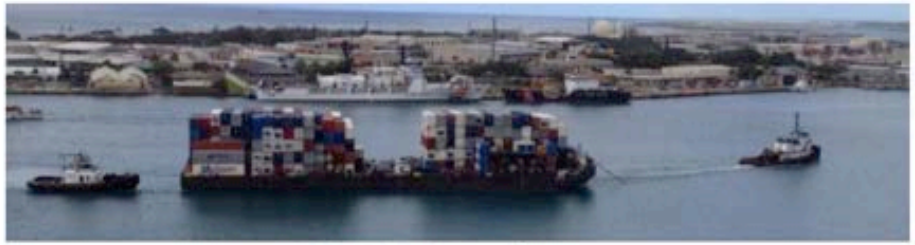
DoD/GM Equinox FCEV Deployment

- ✓ GM selected Hawaii as a location to roll out its FCEV fleet (H2I)
- ✓ 15 GM Equinox FC vehicles leased by DoD and deployed among the Air Force, Navy, and Army
- ✓ Hydrogen fueling infrastructure deployed at 3 bases
  - ➢ Hickam Air Force Base:
    - 65 kg/d electrolysis system, 700 bar fueling
    - Powered by wind (50 kw) & PV (180 kw)
  - ➢ Schofield Army Base:
    - 65 kg/d electrolysis system, 700 bar "Fast Fill"
  - ➢ Marine Corps Base Hawaii:
    - 12 kg/d electrolysis system, 700 bar "Fast Fill" fueling
    - Grid powered
    - Hydrogen transport trailer to augment hydrogen supply

Maritime Fuel Cell Generator Project



Project Concept

PEMFC unit replaces diesel generators, saving fuel cost and emissions.

Project Scope

Design, build, and deploy a containerized fuel cell system to supply portable power for refrigerated containers ("reefers").

- 100 kW (net) PEMFC and H_2 storage inside a 20-foot container.
- 6-month deployment on land and over the ocean.
- Strategic set of project partners, encompassing both the H_2-fuel cell and maritime communities.

Overall Project Objectives

Reduce overall energy consumption and criteria pollutants by taking advantage of fuel cell technology's load following capability.

- ✓ **Lower the technology risk** of future port fuel cell deployments by providing performance data of H_2-PEMFC technology in this environment.
- ✓ **Lower the investment risk** by providing a validated business case assessment for this and future potential projects.
- ✓ **Enable easier permitting and acceptance** of H_2-FC technology in maritime applications by assisting USCG and ABS develop hydrogen and fuel cell codes and standards.
- ✓ **Act as a stepping stone** for more widespread shipboard fuel cell APU deployments.
- ✓ **Reduce port emissions** with this and future deployments.

Marine Corps Base Hawaii Dual Pressure "Fast-Fill" H2 Fueling Station

- Basis of design for public stations;
- 700/350 bar dual pressure "Fast Fill";
- Supports GM Equinox deployment project;
- Containerized system by Powertech;
- 700 bar fast fill required significant electrical upgrades;
- Several codes & standards issues identified for containerized systems;
- HNEI developed data acquisition system.

MCBH H2 Transport Trailer to Augment Hydrogen Supply

MCBH Hydrogen Fueling Station
Fueling GM Equinox FCEV

Fill it up with some of that high test 700 bar H2!!

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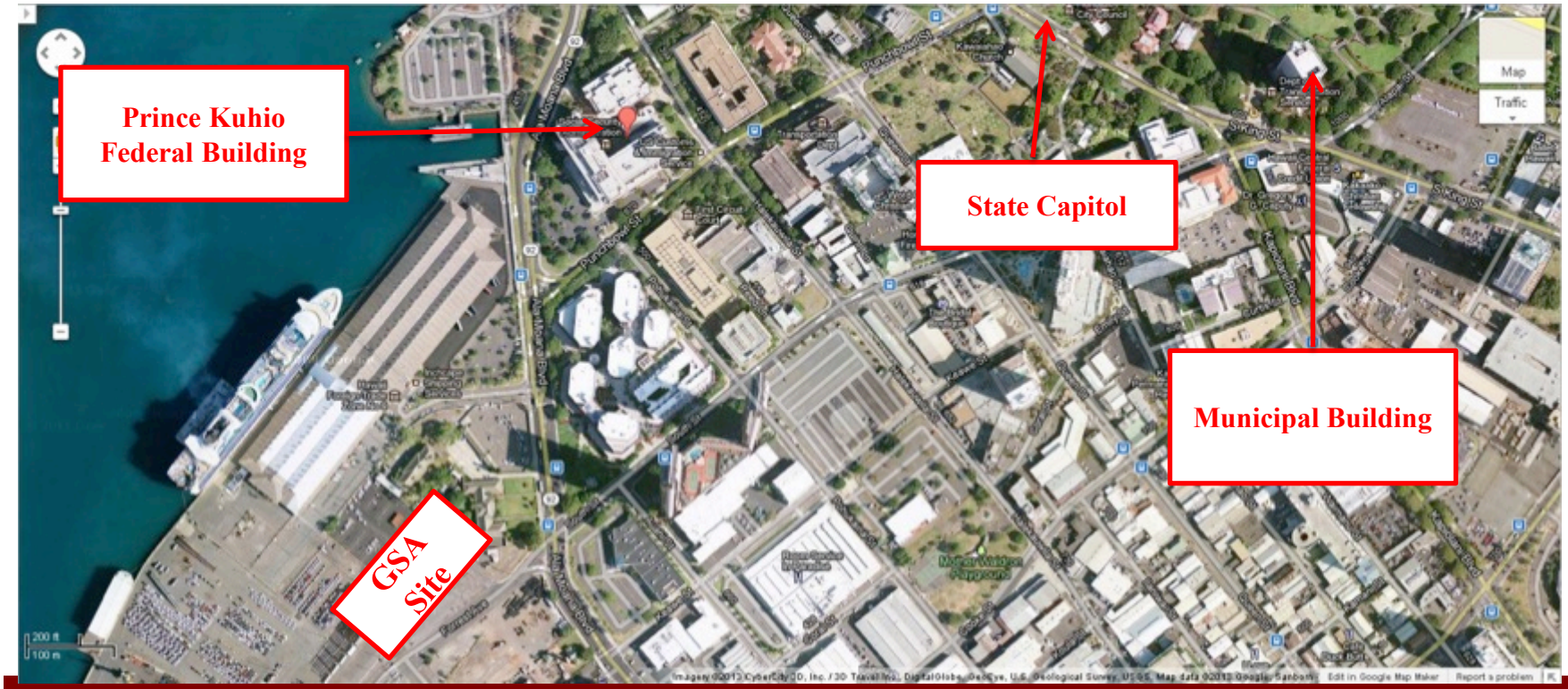
GSA H2 Station



Potential for H_2 Fueling

- Lack of H2 fueling stations major barrier for acceptance of FCEVs;
- 1.4 acres federal government-owned property;
- GSA fleet of 150 vehicles in close proximity;
- Municipal bus station in close proximity;
- Close access to high-traffic roadways.

Hawaii Center for Advanced Transportation Technologies

- **Currently in Transition from H2 R&D to Military Ops supporting FCEV Demos**
- **Expected Station Operational Start: February 2015**

Fuel Cell Electric Vehicle Demonstrations include:

- **Four (4) 20 Passenger Shuttle Buses (High Visibility into Waikiki)**
- **20 Ton Dump Truck**
- **Fed Ex Delivery Truck with 10 kw/h Secure Power On Demand (SPOD) capability**
- **F22 Weapon Loader**
- **C-17 Tow Tug**

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Summary

- ✓ Hawaii is 90% dependent on imported fossil fuels which is killing our economy: this is our "PAIN" point & driver!
- ✓ State policy is to transition to a hydrogen economy;
- ✓ Hydrogen Investment Capital Special Fund available to leverage federal funding;
- ✓ There are 11 strategic projects and activities underway that support the transition to a hydrogen economy;
- ✓ Hawaii needs continued strong federal financial support;
- ✓ Hawaii is a living laboratory for hydrogen R&D&D.
- ✓ We are making progress on the building blocks for transitioning to a hydrogen economy:

Policies & Plans	Resources
Political Will	Strategic Projects
Community Support	Strategic Partners

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Mahalo

(Thank You)

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