

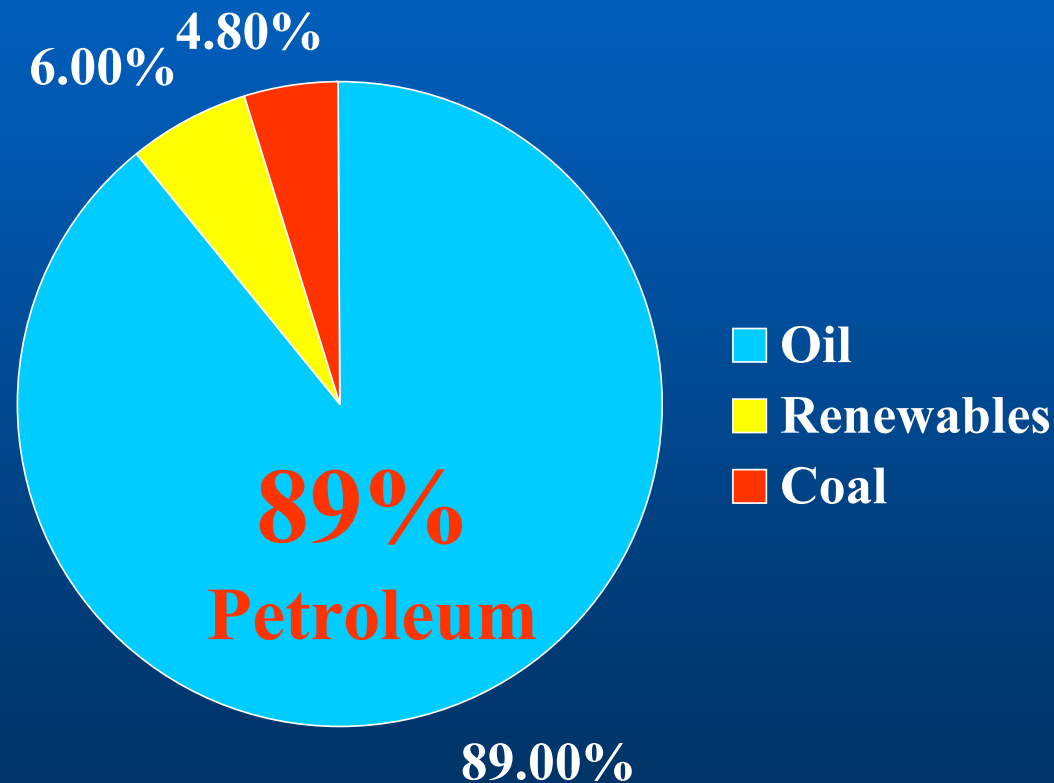


Assessment and Implementation of Renewable Hydrogen into the Hawaii Energy Economy

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Hawaii's Energy Consumption



Increasing 2.8% per year Vs World 1%

Hawaii Primary Energy Sources

Fossil

Crude Oil

Coal



● Renewables

– Hydro

– Wind

– Biomass

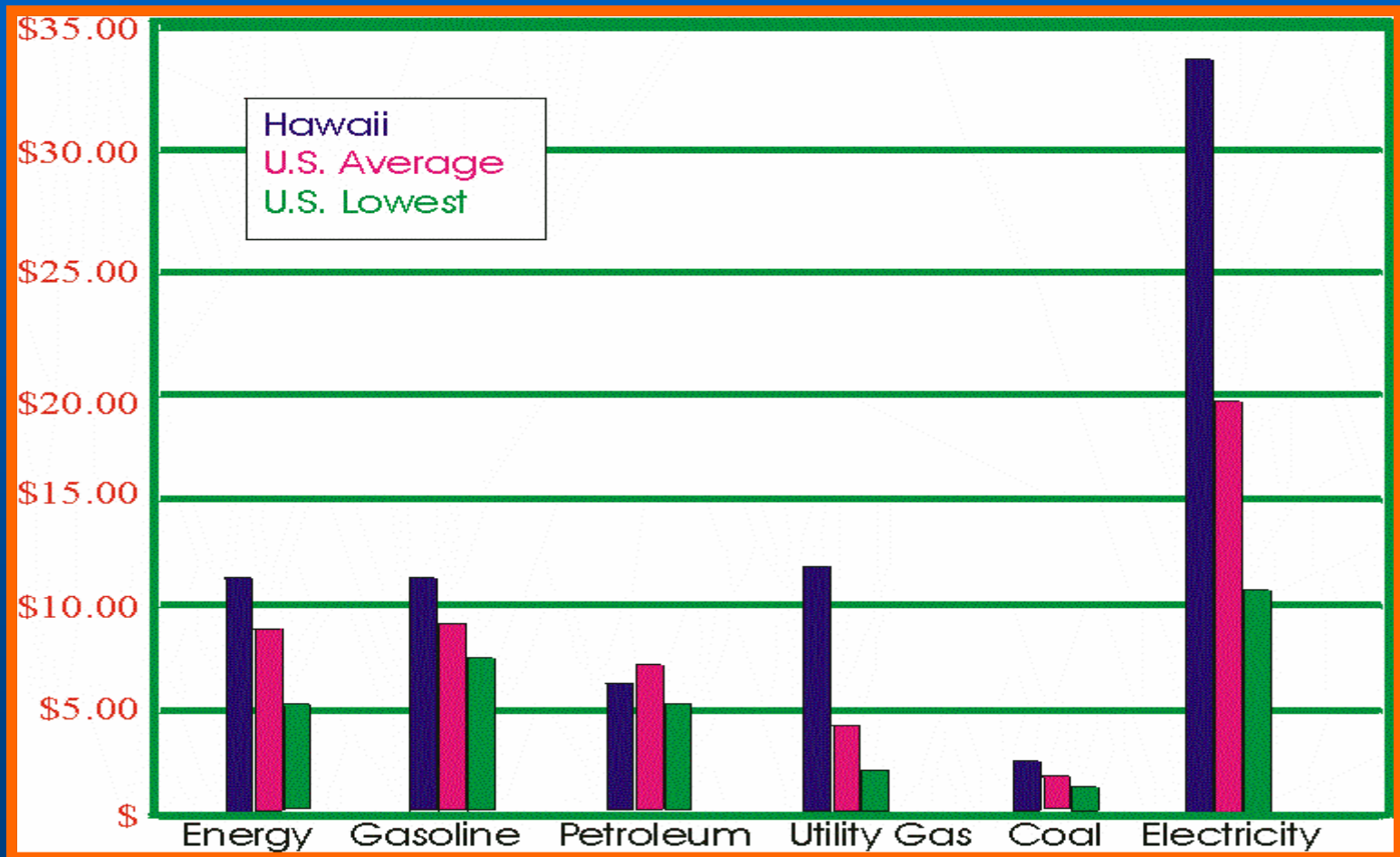
– Geothermal

– Sunlight

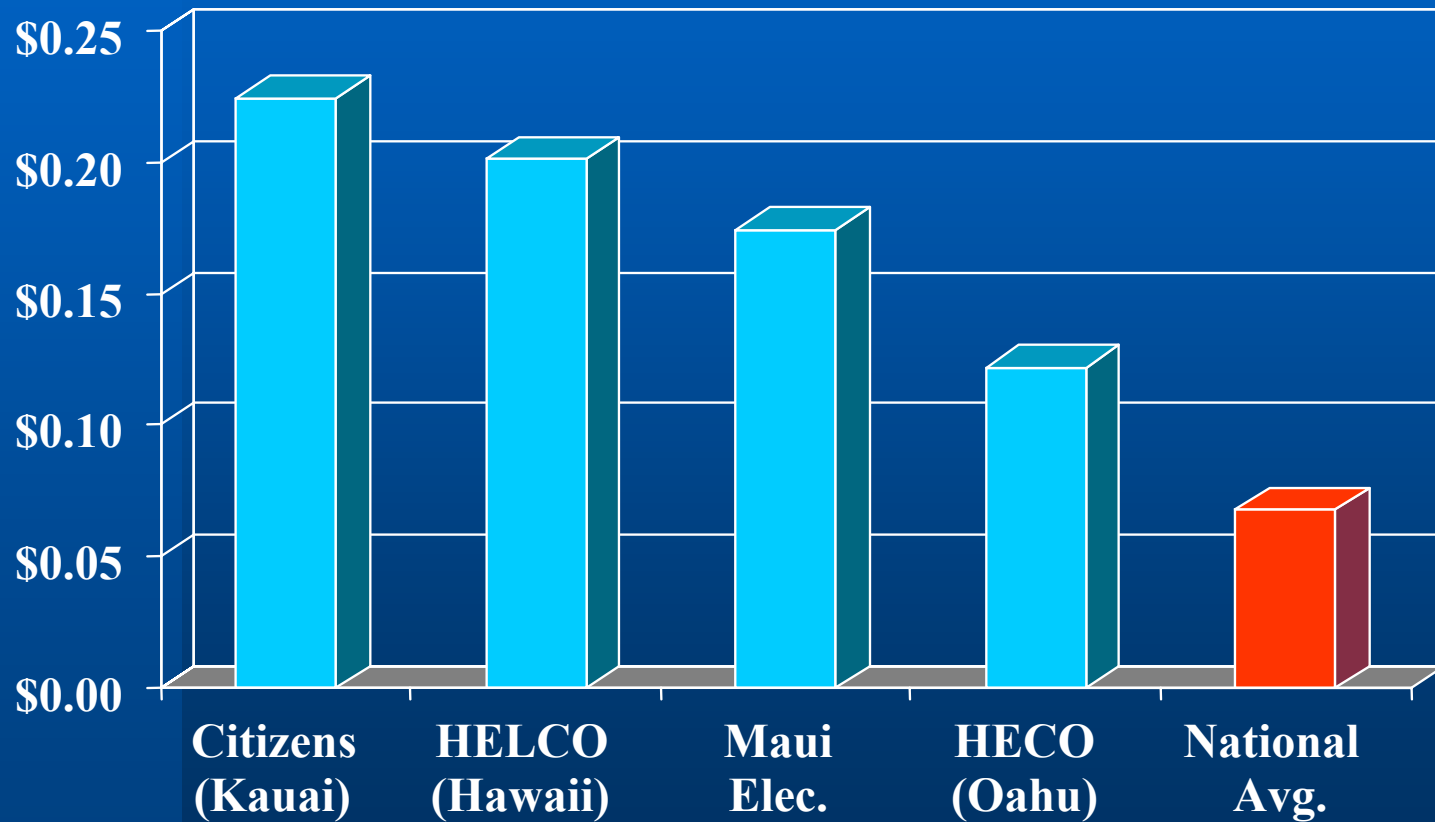
– Landfill Gas

– Municipal Solid Waste

Hawaii's Energy Prices

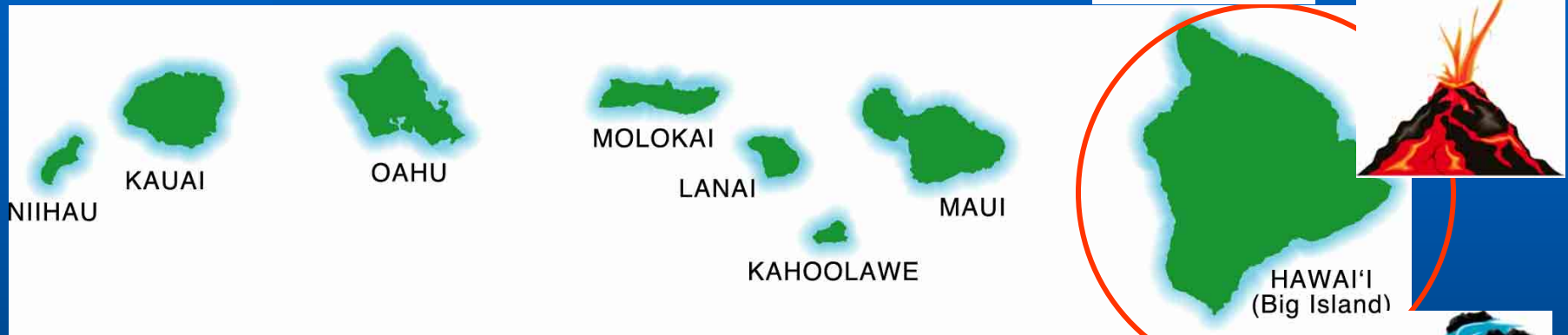


Electricity Prices



Price of Electricity (\$/kWh), 2000

Big Island Energy Picture



- Existing solar, wind, hydroelectric and geothermal generation
- Significant biomass and ocean thermal resources
- 70+ MW developed or permitted

Big Island Energy Picture

- **Small isolated grid (171 MW peak demand in 2000)**
- **High average energy cost (\$0.21/kWh, \$2.00 per gallon gasoline)**
- **Unique transmission and demand characteristics**
 - Early evening peak strains transmission system
 - Lower night demand requires curtailment of RE sources
 - Cost-effective RE is available off-peak for conversion into hydrogen and application in DG systems
- **Major energy users have installed DER systems**

Examples of Installed DER



- ◆ Orchid at Mauna Lani -- Propane cogen with heat recovery and absorption chillers

- Mauna Lani Hotel PV -- 3 projects, 0.5 MW



Examples of Installed DER



- ◆ Parker Ranch – wind / PV hybrid for water pumping
- ◆ Kahua Ranch -- village power system installed with funds from the Government of Japan

- Ho'owaiwai farms – run-of-river hydro



Hawaii H₂ Opportunity

Why Hydrogen?

- Diversify energy supplies
- Maximize the use of indigenous renewable resources
 - Hydrogen as storage medium for electricity
 - Transportation fuels
- Develop a hydrogen high tech industry

H₂ Feasibility Study

Objectives:

- **Assess the feasibility of incorporating hydrogen into the state's energy economy**
- **Analyze the benefits of incorporating large-scale hydrogen use into the state's energy economy**
- **Calculate and compare the life-cycle costs of various hydrogen & base case energy pathways**
- **Develop a strategy to incorporate hydrogen into Hawaii's energy economy**
- **Define specific next-steps or actions to implement strategy**

Recommendations for Action (2001-2006)

1. *Hold a stakeholder workshop to review Hawaii hydrogen plan.*
2. **Perform comprehensive evaluation/market study for the production of hydrogen (Hawaii, Oahu)**
3. **Conduct engineering assessments of biomass & wind energy pathways for hydrogen for Maui and Kauai**
4. *Initiate pilot projects to install multi-megawatt electrolyzer to produce hydrogen from indigenous resources on the Big Island*
5. **Re-examine current environmental and energy policy options to promote hydrogen energy**
6. *Initiate pilot projects that include distribution of hydrogen produced on Hawaii to other islands*
7. *Consider creation of a public/private sector partnership for economic development of hydrogen infrastructure*

Gateway Project : Location NELHA

- Created by the Hawaii State Legislature in 1990 to administer the 322 acre Natural Energy Laboratory of Hawaii (NELHA) and 548-acre Hawaii Ocean Science & Technology (HOST) Park properties located at Keahole Point on the Island of Hawaii.
- A unique complement of natural and logistical resources gives NELHA an advantage over other locations for development and deployment of renewable energy resources.
 - Warm surface seawater
 - Cold deep seawater
 - High solar insolation
 - Adjacent to international airport



Phase I: Center for Distributed Energy Resources

The Gateway Project provides the foundation for a premier national institute dedicated to the development, testing, and deployment of distributed energy generation technologies.

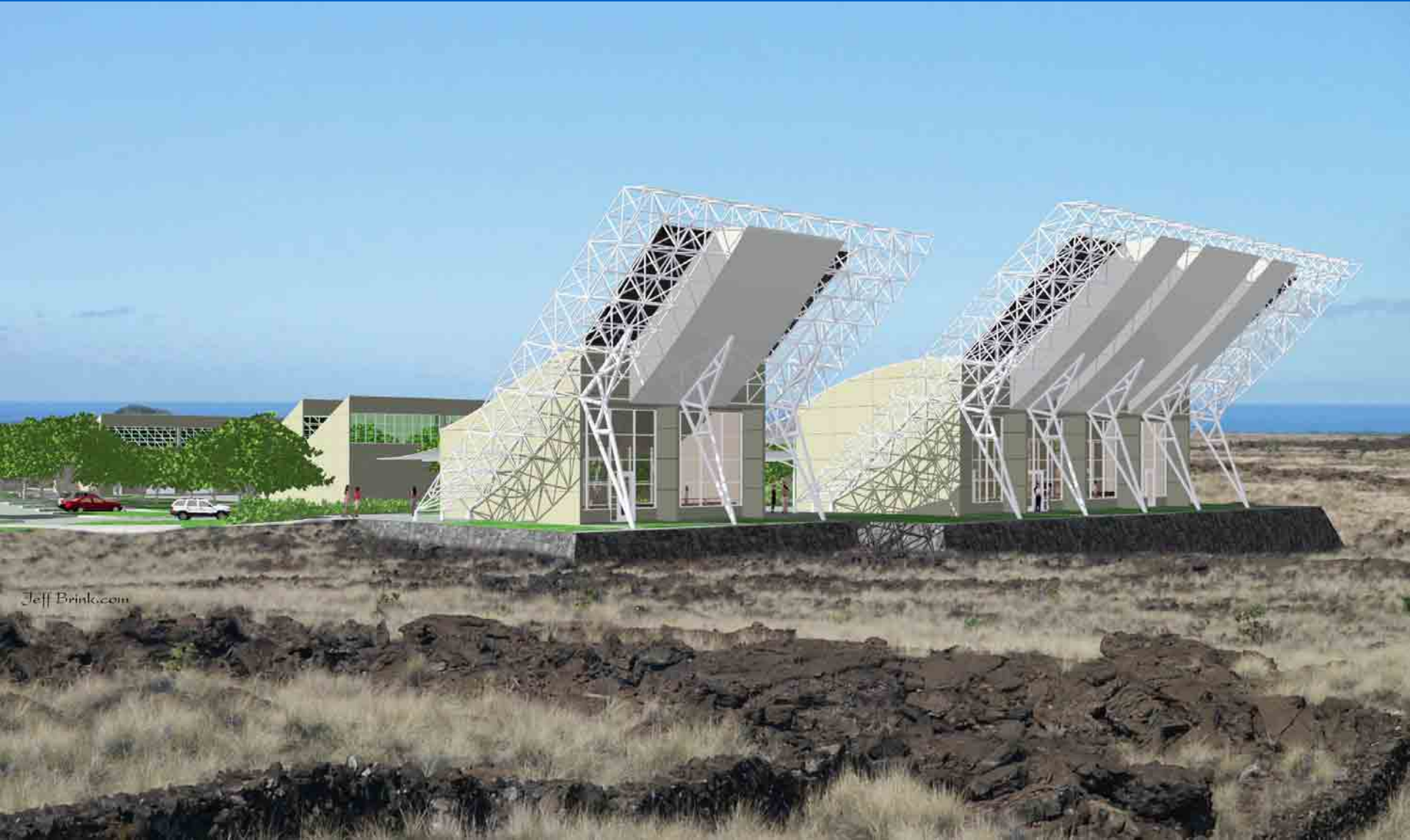
- Construction grant to be used to design and build a state-of-the-art facility and infrastructure.
- Center will serve as incubator for companies focused on renewable/distributed energy generation and hydrogen.
- Development of industry partnerships through co-sponsored R, D & D is a key program element.
- National partners will advance market penetration overseas (to bridge U.S. technology with Asia-Pacific needs)



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Partnerships Strengthen the Gateway Center

Active collaboration of government, research, and industry will enable:

- Appropriate programmatic guidance
- Mechanisms for sustained funding
- Best available technical assistance
- Community, government, and industry outreach
- Opportunities for collateral joint projects
- Achievement of partners' objectives



UTC Fuel Cells

A United Technologies Company



Stuart

the hydrogen fuel company
www.stuartenergy.com

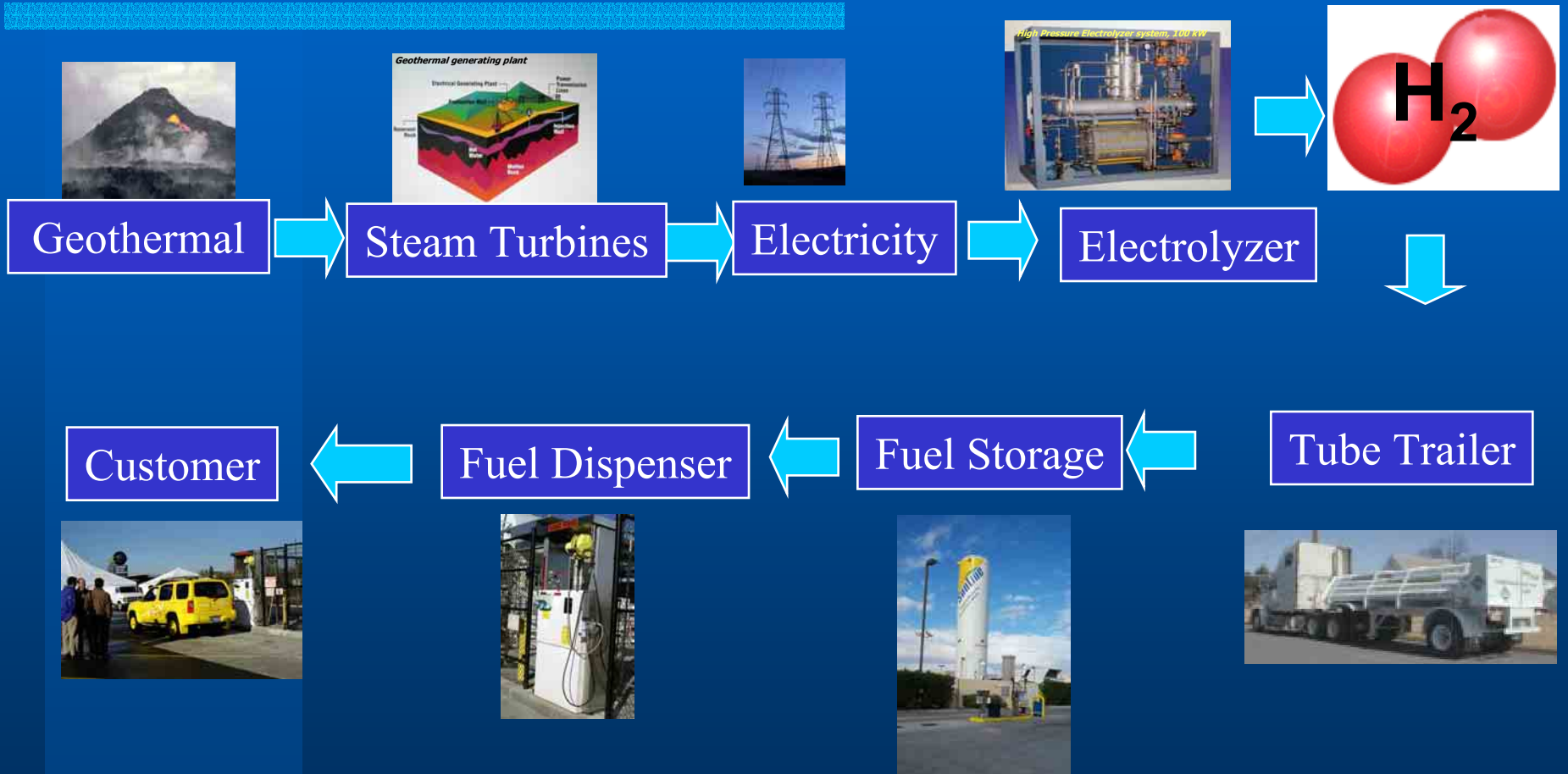
THE GAS COMPANY
Citizens Energy Services



Hawaiian Electric Company, Inc.



MW Scale Renewable Hydrogen



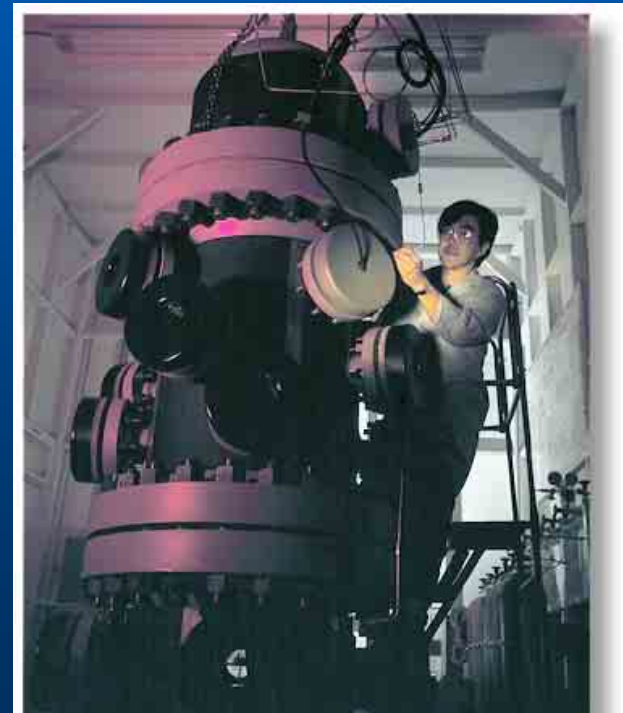
Hawaii Energy & Environmental Technology

“HEET” Initiative

DOD-funded partnership with Naval Research Laboratory

Focus areas:

- **Methane hydrates—vast marine-based reserves of hydrogen-rich fuel**
- **Fuel cell systems—testing and development of fuel cell systems for commercial and military applications**
- **Biofuels processing**



HNEI/HECO Fuel Cell Test Center



- Development of state-of-the-art fuel cell test station in Hawaii in partnership with UTC Fuel Cells & HECO
- Downtown Honolulu
- Construction complete fall 02



Hawaiian Electric Company, Inc.



UTC Fuel Cells

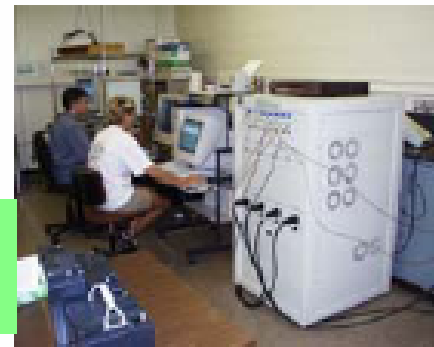
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Electrochemical Power Systems Laboratory

Integrated experimental analysis with simulation/modeling greatly enhances our R&D capabilities



Advanced Battery Testing & Fundamental Property Characterization

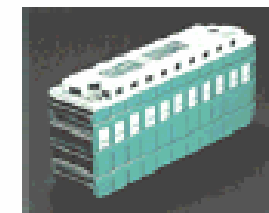
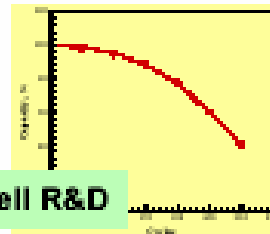
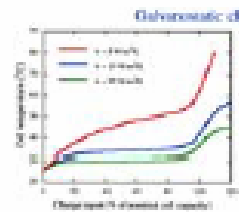


Rapid Charging Algorithm

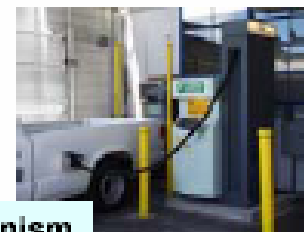
Battery Simulation & Modeling



Solid Oxide Fuel Cell R&D



Degradation Mechanism



Cycle Life Prediction

Hawaii's Policies Can Facilitate Renewable Hydrogen

2001 legislation promotes the use of distributed energy resources.

- **Act 272 – Sets Electric Utilities Renewable Energy Goals**
 - Electric utilities to set a renewable portfolio standard goal of 7% of net electricity sales by 12/31/03, 8% by 12/31/05, and 9% by 12/31/10.
 - Provides “net energy metering” for eligible customer-generators up to 0.5% of the electric utility’s system peak demand.
- **Act 283 – Provides Seed Funding**
 - Establishes a public/private partnership to support & promote hydrogen use in Hawaii.
 - Appropriates \$200,000 to the Dept. of Business, Economic Development & Tourism for a workshop, policy study and assessments, and projects.
- **Act 221 – Establishes 4% Tax Credit**
 - Provides a 4% tax credit for technology infrastructure renovation costs including backup and emergency power systems.
 - Expands the definition of a “qualified high technology business” (QHTB) to include “non-fossil fuel energy related technology.”

Conclusions

- **The Big Island of Hawaii is the ideal location for a U.S focus on renewable hydrogen and fuel cells**
- **The Gateway Project at NELHA will provide a unique location for developing hydrogen infrastructure on the Big Island**
- **Hawaii supported projects are underway with partnerships already formed from energy interests both inside and outside of Hawaii**
 - ➔ **Hydrogen Power Park (DOE)**
 - ➔ **HEET (DOD)**
 - ➔ **Research Center of Excellence (HNEI)**
 - ➔ **Fuel Cell Test Center HNEI/HECO/UT Fuel Cells)**
 - ➔ **Others**
- **Projects are strengthened by Hawaii's supportive state energy policies and the collaborative partnerships involved.**