Hawaii Hydrogen Center for Development and Deployment of Distributed Energy Systems

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TV8

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Overview

Project comprised of 4 stand-alone tasks coordinated under one project.

Timeline

- Start - October 2004
- Finish - December 2008
- 95% Complete

Budget

- Total project funding
  - DOE $4.1 million
  - Cost share $1.2 million
- Funding received in FY04
  - $3.1 million
- Funding received in FY05
  - $1 million

Cost Share Partners

- ClearFuels Technology
- GE Global Research Center
- Hawaii Department of Business, Economic Development, and Tourism
- HELCO/HECO
- The Gas Company
- AirGas
- New Mexico Tech
- Hawaiian Commercial & Sugar Co.
- Center for a Sustainable Future
- PICHTR
- Sandia National Laboratory
- Sentech

Future Partners

- Puna Geothermal Venture
- Volcanoes National Park
- HCATT
- E-Nova Power Systems

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Barriers

Task 1: Hawaii Hydrogen Power Park - Completed

- B, C, E, H, I: Technology Validation
- G, H: Hydrogen safety

Task 2: Hydrogen Fuel Quality Assessment – Completed 2007

- A, C: Fuel Cells – Durability and Performance

Task 3: Renewable Hydrogen Production: Biomass – 90% Completed

- S: Biomass Gasification – Feedstock Cost
- T: Biomass Gasification – Cost and Efficiency

Task 4: Big Island Energy Road Mapping - Completed

- B, C, D, H, I: Technology Validation

Objectives

Task 1: Hawaii Hydrogen Power Park: (Ewan)

- Develop integrated renewable hydrogen system (electrolyzer, hydrogen storage, and fuel cell) to characterize component & system performance
- Develop & validate control protocols
- Collect performance and cost data
- Conduct outreach to local authorities and the general public

Task 3: Renewable Hydrogen Production: Biomass: (Turn)

- Evaluate H_2 yield potential of Pearson Technologies' gasification process
- Characterize technologies for tar reforming and H_2 purification

Task 4: Big Island Energy Road Mapping: (Rocheleau, Surles)

- Develop strategic energy roadmap to identify economically viable technologies to transform the Big Island energy infrastructure.
- Develop and validate baseline models for electricity and transportation.
- Identify scenarios to facilitate acceptance of emerging new energy systems including hydrogen.

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Approach

Task 1: Hawaii Hydrogen Power Park

- Leverage existing renewable infrastructure at Kahua Ranch to establish integrated PV-wind-electrolysis and fuel cell test bed.
- Collaborate with SNL modeling group for economic and engineering analysis
- Use internet to leverage Power Park infrastructure for education & outreach

Task 3: Renewable Hydrogen Production: Biomass

- Leverage investment by ClearFuels LLC in biomass gasification to assess direct hydrogen production feasibility using Pearson Technologies pilot plant in Aberdeen, Mississippi
- Develop skid-mounted, producer-gas clean-up test bed to include tar reforming and hydrogen purification

Task 4: Big Island Energy Road Mapping

- Collaborate with GE Global GRC and island utilities to develop integrated energy model for Big Island
- Work with stakeholder groups to identify scenarios for evaluation, demonstration and deployment of DER technologies

Technical Accomplishments/Progress/Results

Task 1: Hawaii Hydrogen Power Park

HFCTF Component Evaluation

- Load-following, pressurized PEM electrolyzer (175 psi) from EH Inc. tested.
- Worked with EH to upgrade electrolyzer stack and refine system design by providing test data and equipment failure reports.
- Electrolyzer efficiency increased from 36% to 50.2% (HHV)

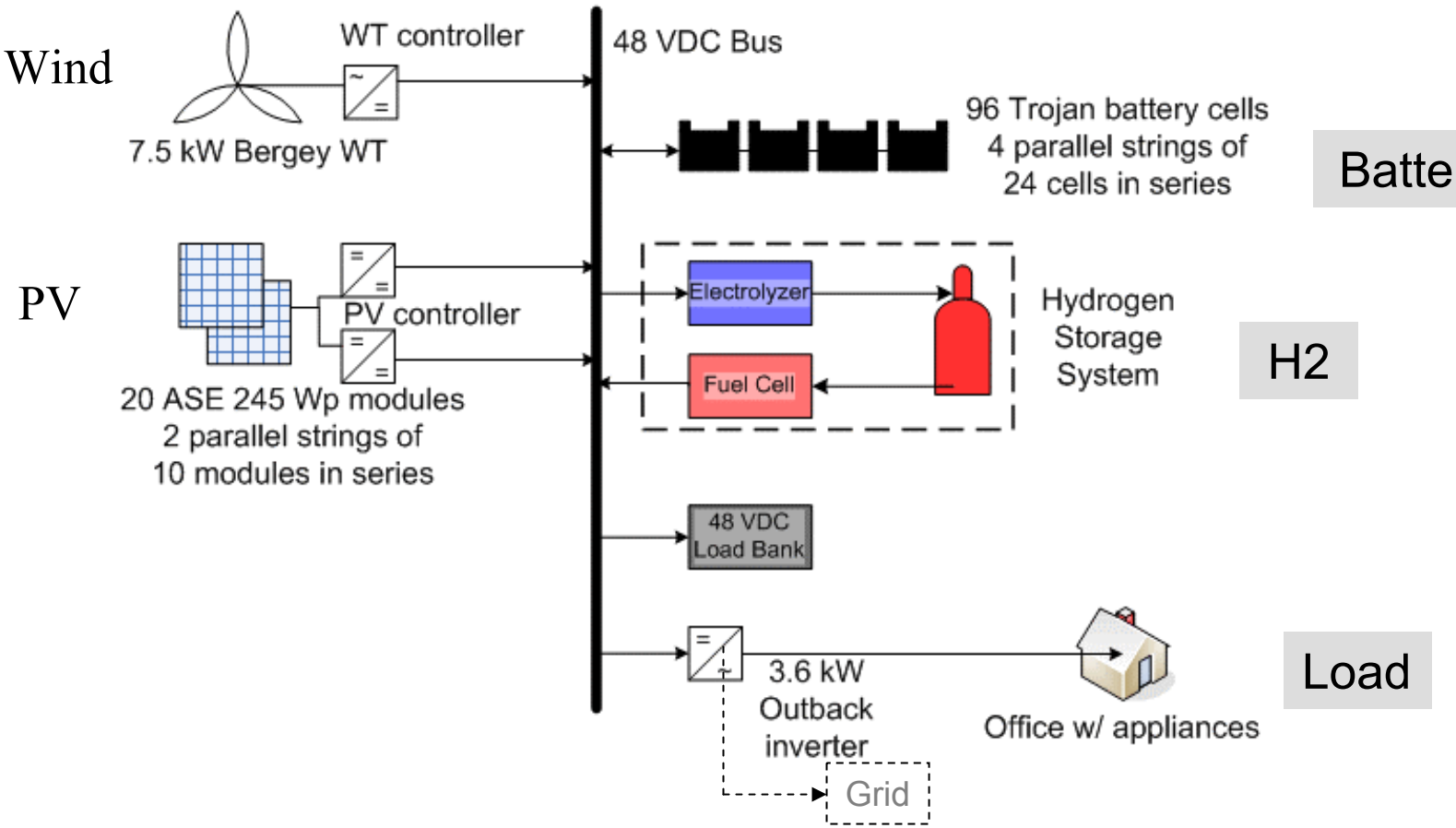
Kahua Ranch: PV-Wind-Hydrogen-Fuel Cell Test Bed

- All equipment installed and commissioned.
- Safety review completed. Ranch personnel safety brief.
- Extensive testing to ensure “fail-safe” operation.
- Over 60 days of operational data collected and analyzed.
- System operated remotely over the internet.

Public Outreach

- Daily slide presentation presented to public at the Hawaii Gateway Energy Center by the Friends of NELHA.

Kahua Ranch Power Park System



- **Eliminated diesel generator**
- **Component & system testing**
- **Education and outreach**

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Hydrogen System Components

Excess RE
Hydrogen Production

$2H_2O \rightarrow 2H_2 + O_2$

Electrolyzer Eh!
2 kW, 48 VDC, 0.2 Nm³/h, 12 bar

O_2

Water

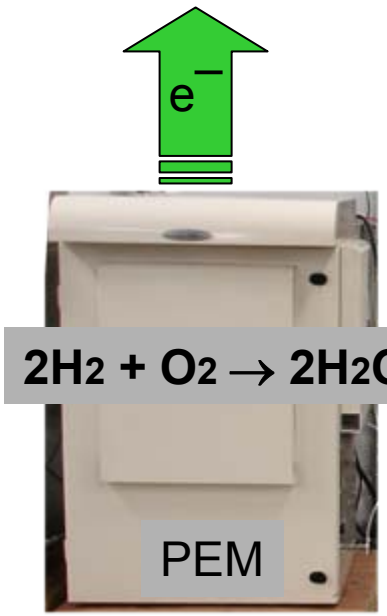
Deionized Water Tank

H_2

Hydrogen Storage
9 bottles, 50 liters, 12 bar (175psi)
452 g of hydrogen or 5.4 Nm3
or 17.8 kWh (HHV)

H_2

Deficit of RE
Electricity Production



$2H_2 + O_2 \rightarrow 2H_2O$

Fuel Cell Plug Power
5 kW, 48 VDC, 4 Nm³/h, 2 bar

Air

Water

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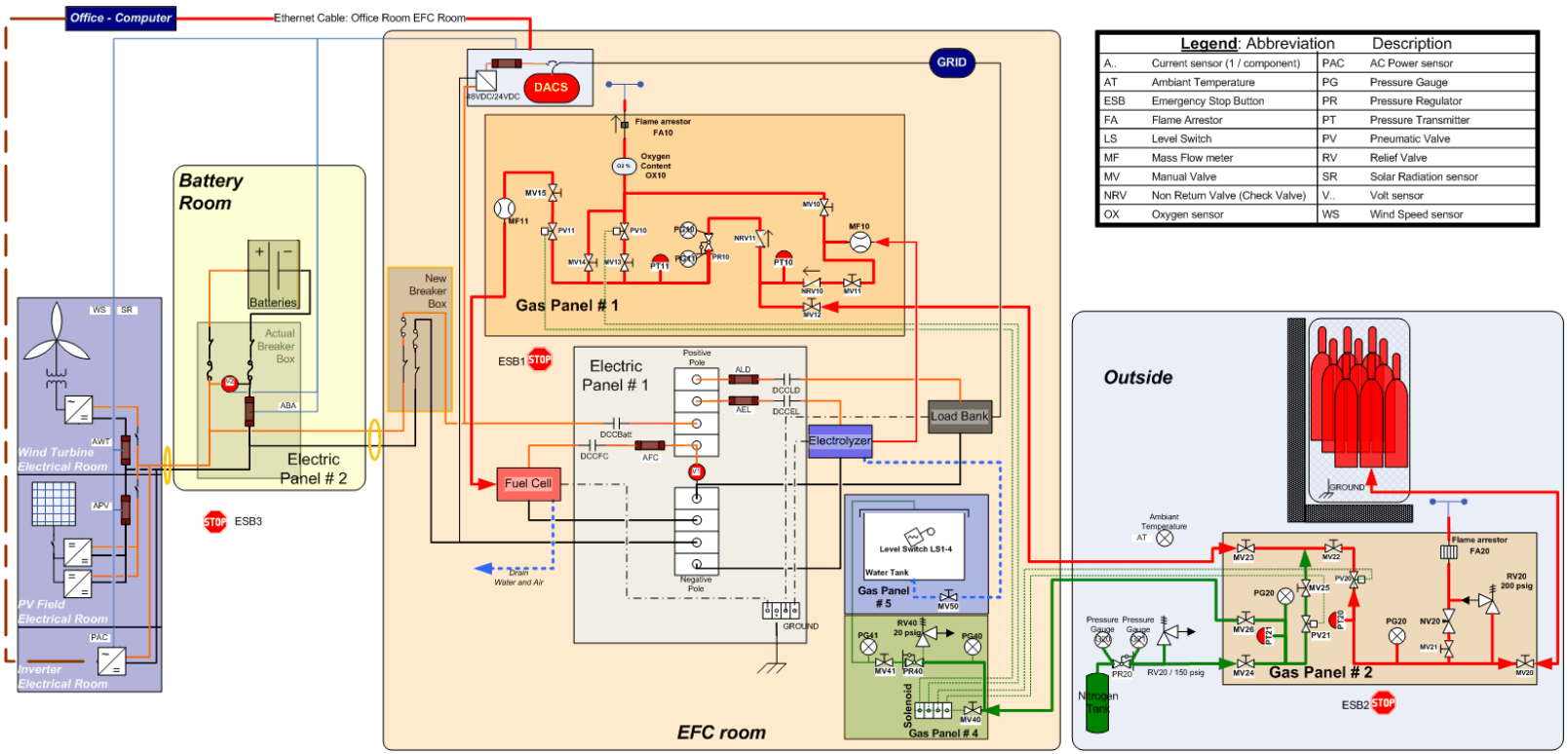
Interface/Control System

- ✓ **Designed for fail-safe operation**
- ✓ **Optimizes the energy management in the system.**
- ✓ **Visible and controllable over internet.**



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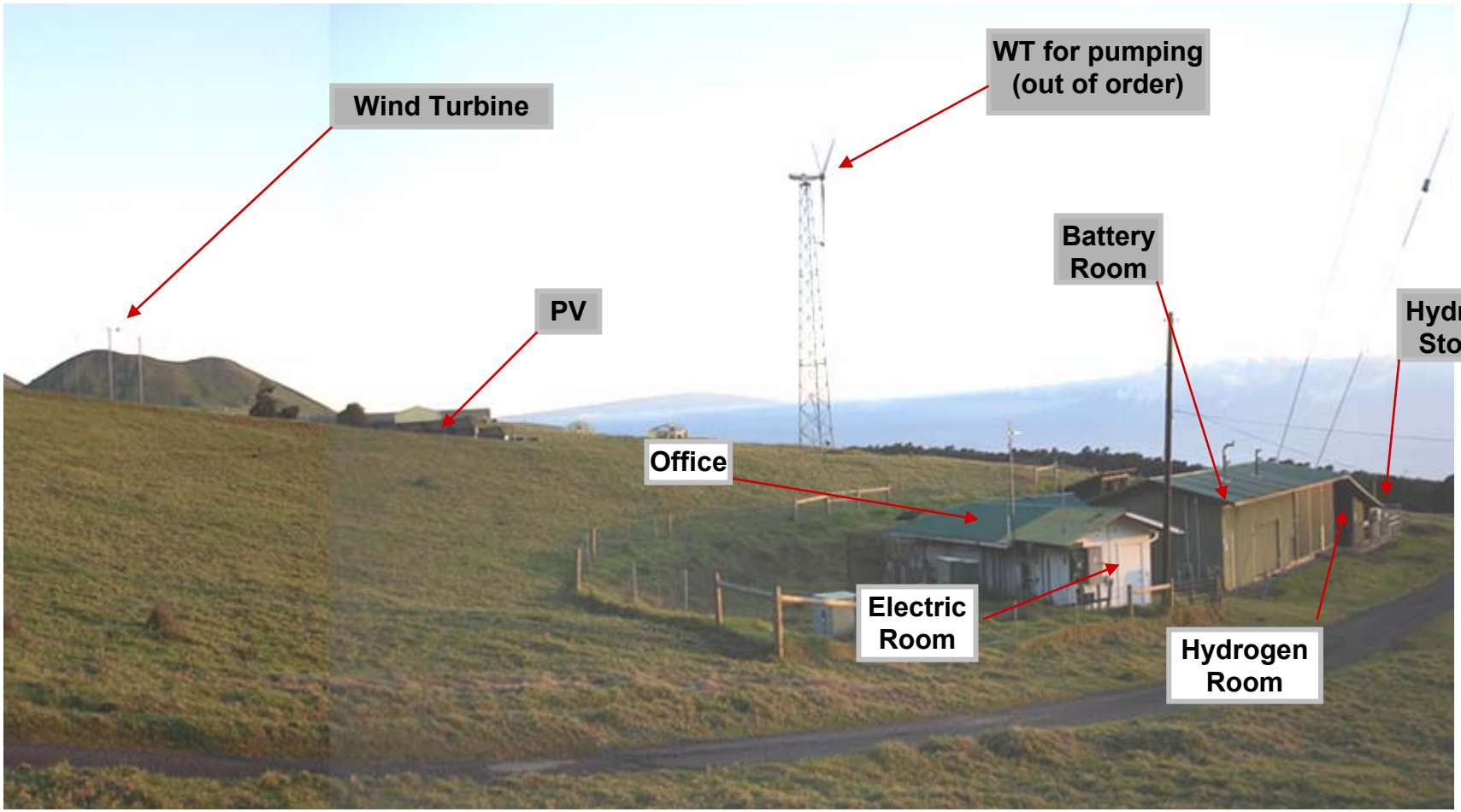
Kahua Ranch Layout



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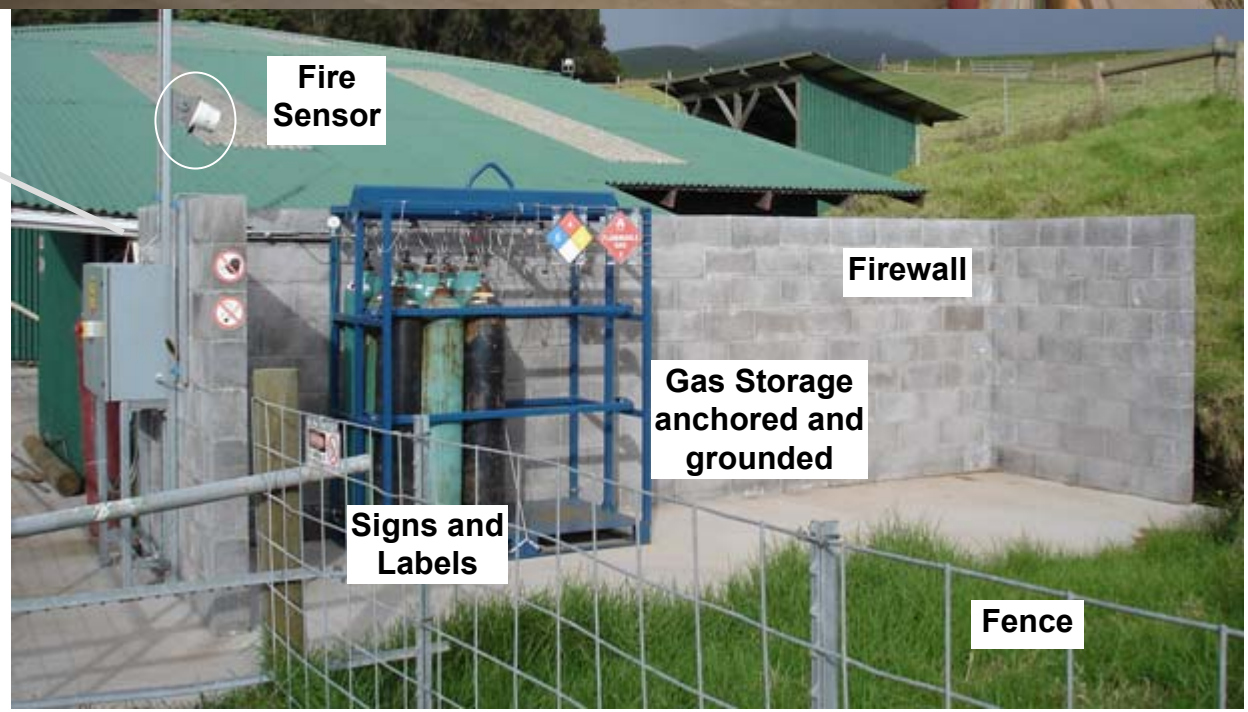
Installation at Kahua Ranch



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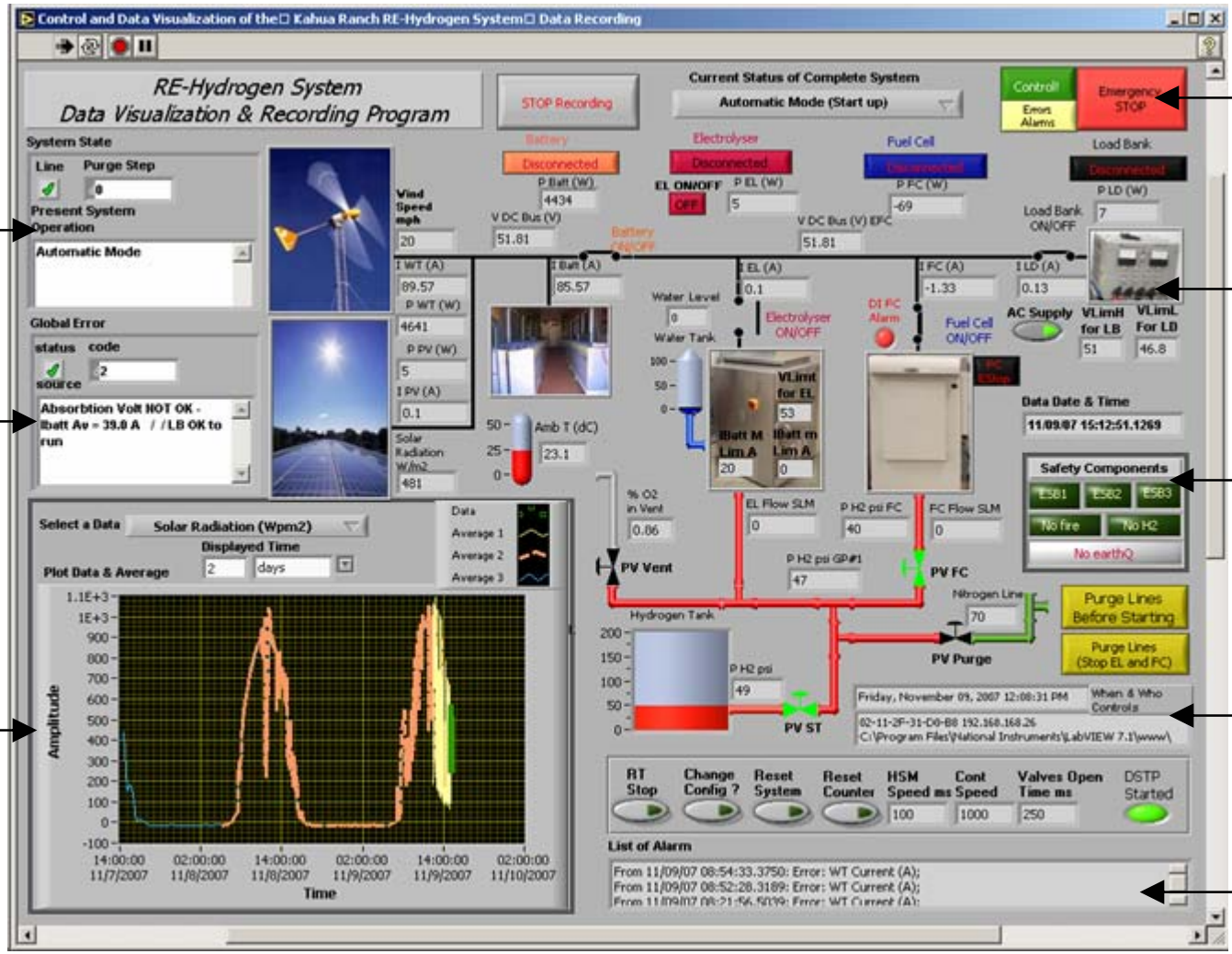
Data Visualization and Remote Control



Operation Mode

Component Control Information

Data History

Control Buttons

Real Time Data

Safety Component Status

Remote Control Information

List of alarms

Visible on the project web site
(Available on Request)

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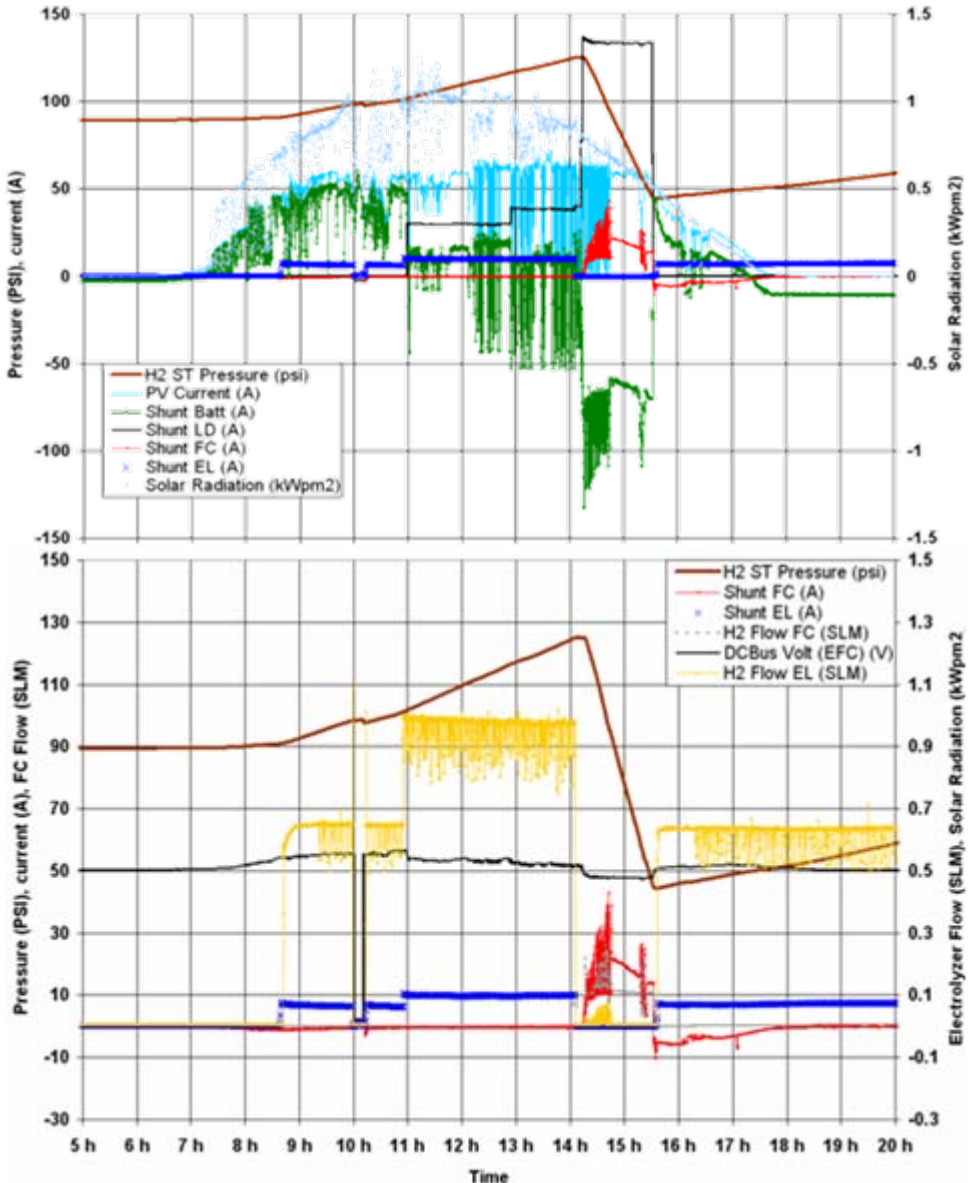
Kahua Ranch - Experimental Results

Automatic mode



First conclusions

Eh! electrolyzer (adapted design)

- Short warm up period (5 min)
- Delivers hydrogen in only 3 min
- 50.2% efficient (HHV)

Plug Power FC unit

- Adapted FC low bus mode to Kahua Ranch DACS
- 34.3% efficient (HHV)

Hydrogen Storage System Efficiency

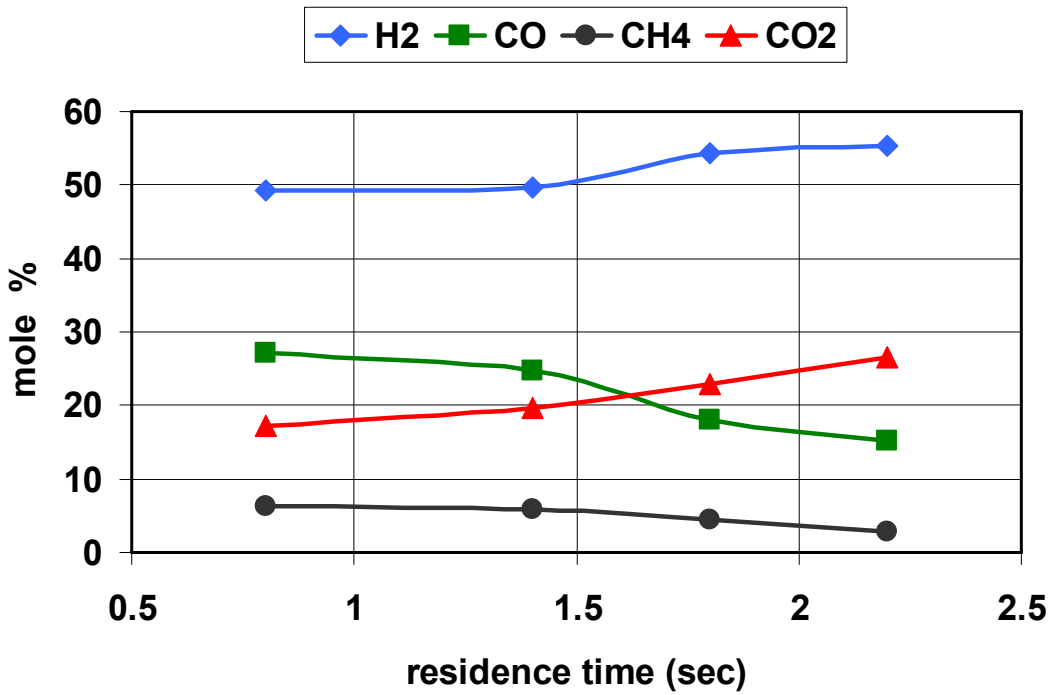
- Over 68 days of operation overall average system efficiency of between 12% and 17%* (HHV)
- Areas for efficiency improvement:
  - ✓Lower losses
  - ✓Decrease FC power (oversized)
  - ✓Co-Generation: Heat + Electricity

* With new EH stack

Technical Accomplishments/Progress/Results

Task 3: Renewable Hydrogen Production: Biomass

- Parametric tests conducted at Pearson Technologies' 5 ton/day pilot plant at Aberdeen, MS
- Hydrogen yields up to ~180 lb/ton biomass (90 kg/tonne) without gas upgrading demonstrated
- Clearfuels building 50 ton/day plant at G&R on Kauai (F)
- HNEI to have access to slipstream for testing of gas clean up and conditioning and hydrogen technologies (F)
- Kauai facility to serve as anchor site for biomass/biofuels RD&D



Product gas yield as function of residence time showing hydrogen concentration up to 55%

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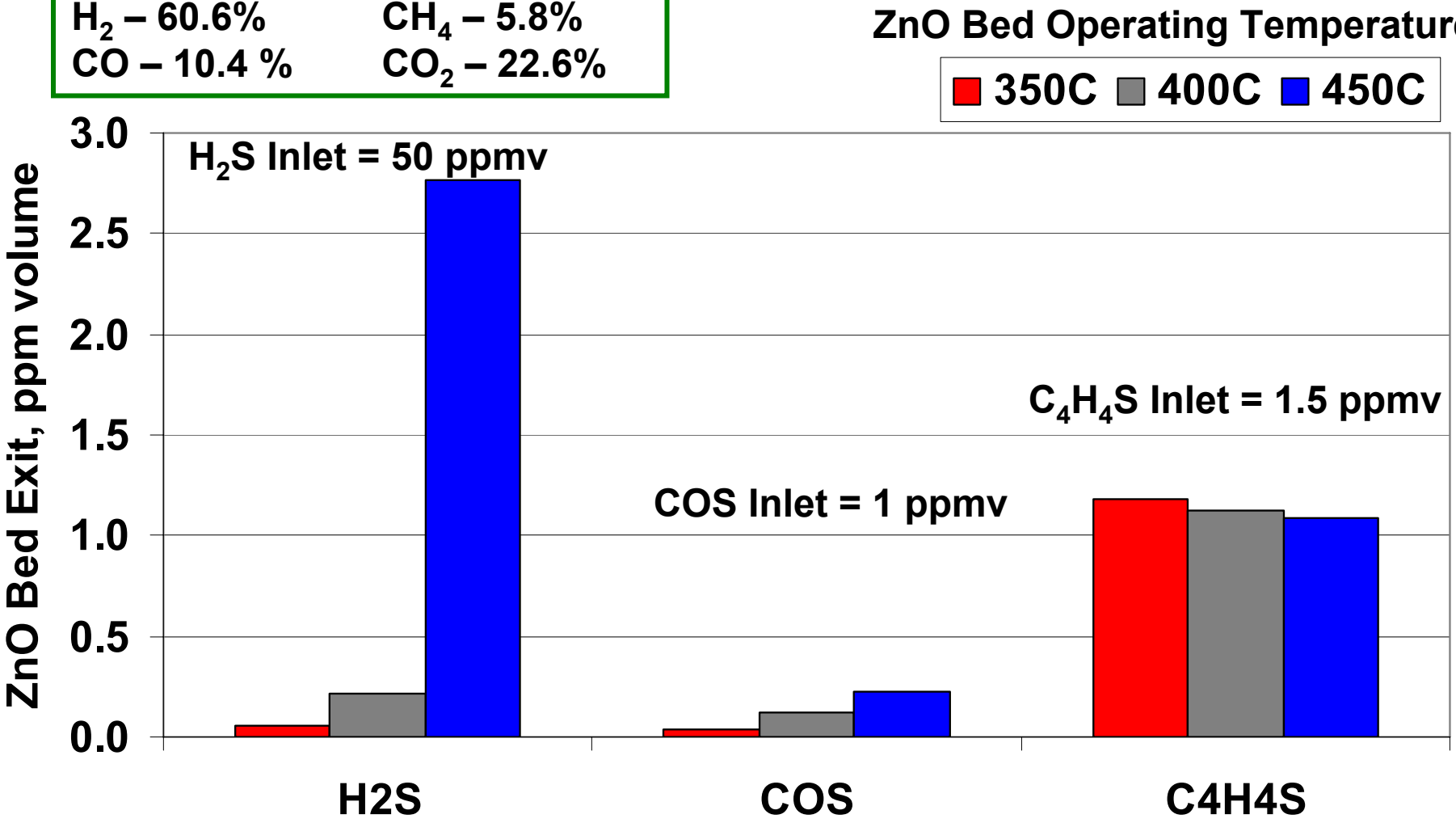
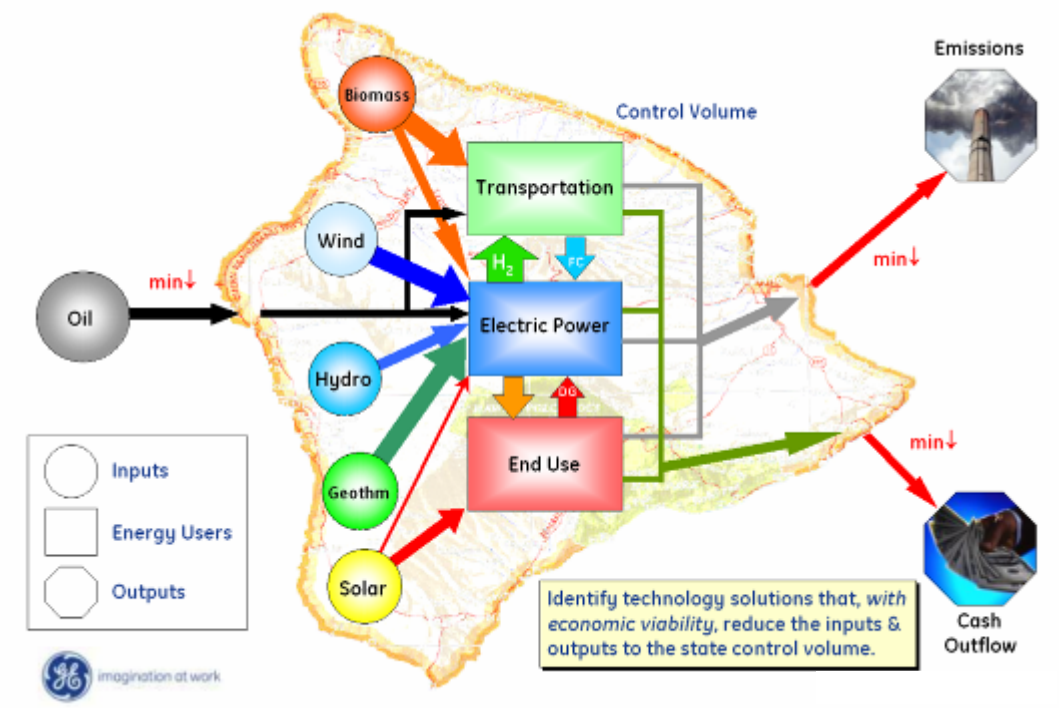
H_2 from Biomass Gasification: Sulfur contaminant speciation and removal

Dry Producer Gas Composition
H_2 – 60.6% CH_4 – 5.8%
CO – 10.4 % CO_2 – 22.6%



Technical Accomplishments/Progress/Results

Task 4: Big Island Energy Road Map



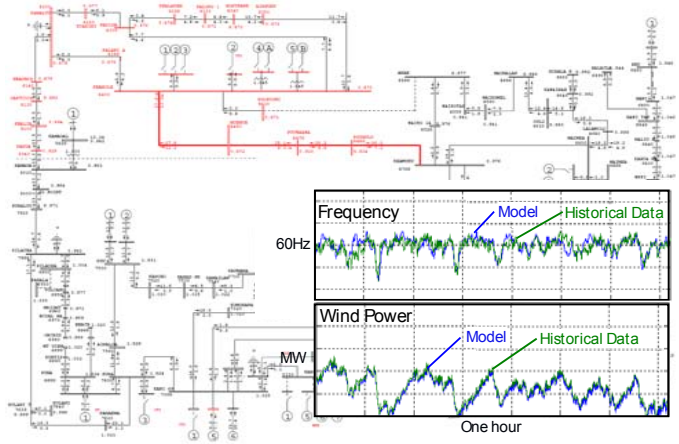
- Developed and validated baseline models for electricity (dispatch & stability) and transportation
- Identified & evaluated scenarios for deployment of new energy systems

US DOE | Hawaii Natural Energy Institute | State of Hawaii | GE Global Research GE Energy | Sentech | Hawaii Electric Light Company

Electricity Model Validation

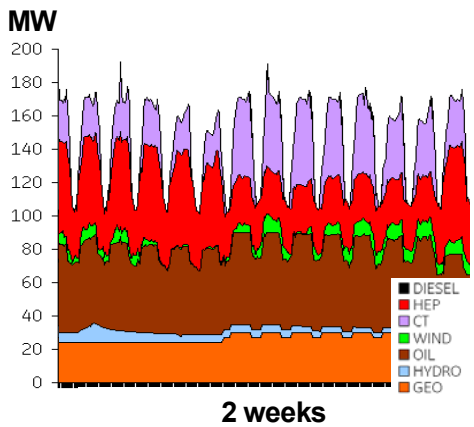
Transient Performance (GE PSLF™)

- Full network model, incorporating generator governors and AGC
- Transient stability simulation
- Long-term dynamic simulation
- **Major dynamic fluctuations accurately characterized by model**



Production Cost (GE MAPS™)

- Representation of dispatch and unit commitment rules
- Hour-by-hour simulation of grid operations for a full year
- **Annual unit dispatch from model within 1% of actual grid operations**



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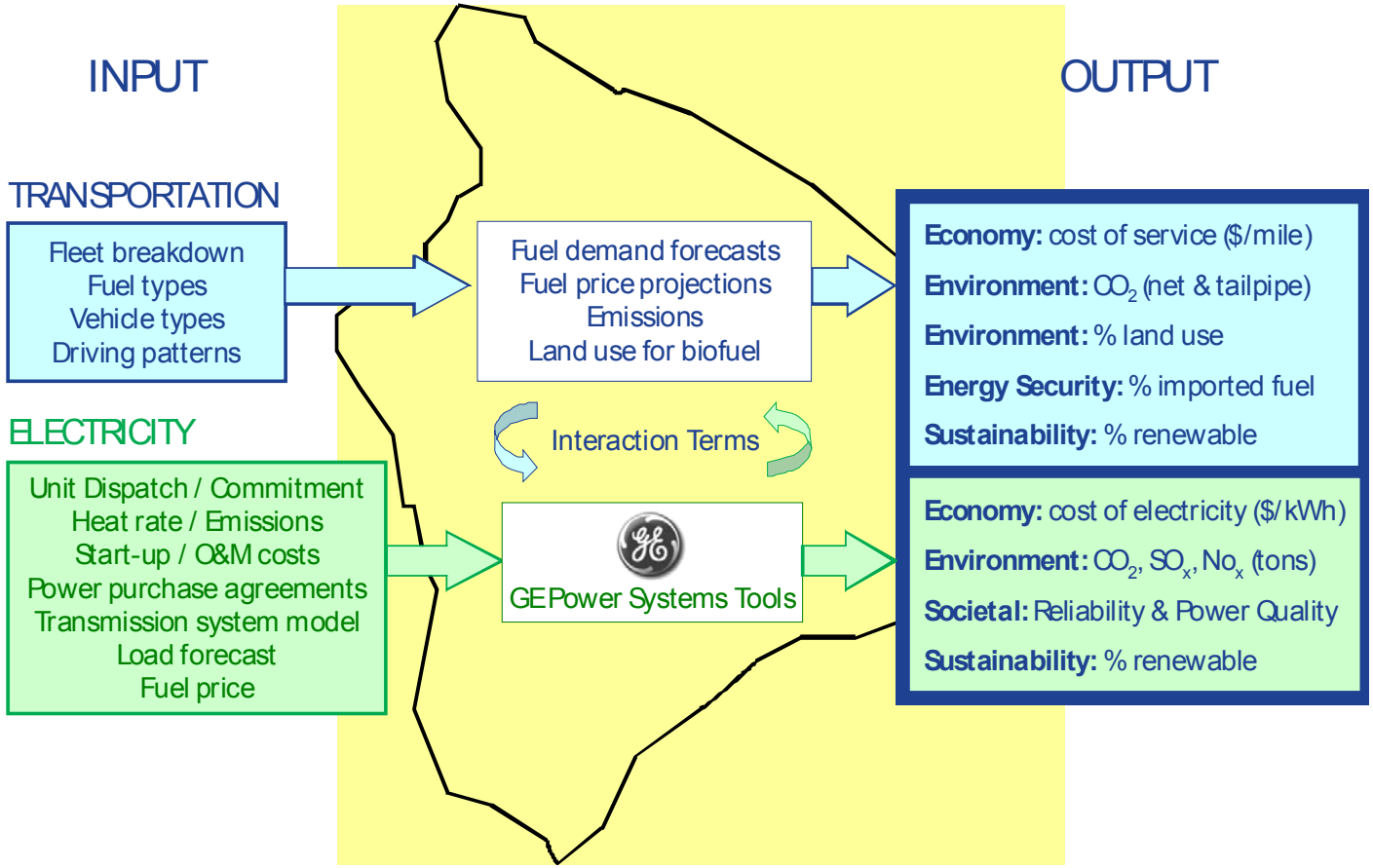
Transportation and Electricity Systems Models Developed



Future scenarios may include H2 use, high wind penetration, economic dispatch etc.

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Future Work

- **Task #1: Hydrogen Power Park**
  - Use Kahua Ranch for education & outreach. HNEI teamed with Bishop Museum for DOE education proposal (pending).
  - Expand internet bandwidth to allow public viewing of system operation.
  - Install hydrogen fueling infrastructure at Hawaii Volcanoes National Park (HAVO) to support up to 5 hydrogen hybrid shuttle buses as continuation of SEP Power Park project.
- **Task #2: Hydrogen Fuel Quality Assessment**
  - Work continuing under separate agreement with NREL.
- **Task #3: Renewable Hydrogen Production: Biomass**
  - Work continuing under separate agreement with DOE
- **Task #4: Big Island Road Mapping**
  - Work continuing under separate agreement with DOE.
  - Roadmapping/analysis underway for other major islands.

HAVO Renewable H2 Fueling Station

- ✓ Power Park to provide hydrogen infrastructure to support hydrogen shuttle bus program at Volcanoes National Park (HAVO)
- ✓ Over 2 million park visitors annually. Hawaii's biggest tourist attraction.
- ✓ Supports NPS "**Climate Friendly Parks**" program to reduce carbon footprint.
- ✓ HAVO has facilities & team of tour guides for public outreach:
  - ➢ Visitor Center theater and interpretation center
  - ➢ Park Ranger interpreters on shuttle buses will incorporate hydrogen outreach into presentations.

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HAVO Program Details

- Hydrogen Fueling Infrastructure funded by USDOE with cost share from State of Hawaii via H2 Capital Investment Fund
- Total funding for infrastructure approx $ 2.4 million
- Up to five (5) battery-dominant Hydrogen Plug-in Hybrid Electric Vehicles. First 2 vehicles approved.
- Geothermal power from **Puna Geothermal Ventures** over **HELCO** grid to HAVO.
- Hydrogen production up to15 kg/day depending on final vehicle design
- **DOD Kilauea Military Camp** proposed as site for fueling infrastructure
- **Hawaii Center for Advanced Transportation Technologies**– proposed partner for vehicle conversions. Leverages Hickam Air Force hydrogen programs

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Leveraging the HAVO Project

- Positions HAVO and HNEI as NPS system-wide resource to demo zero emission transportation solutions.
- First step towards **Hawaii Hydrogen Highway** on Big Island
- Kolohala/HNEI team selected to manage $8.7 million H2 capital investment fund

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