

Hawaii Hydrogen Center for Development and Deployment of Distributed Energy Systems

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May 17, 2007

TVP 12

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Overview

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

Timeline

- Start - October 2004
- Finish - December 2007
- 85% 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

Barriers

- See next slide

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

Other Partners

- Sandia National Laboratory
- Sentech



Barriers

Task 1: Hawaii Hydrogen Power Park

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

Task 2: Hydrogen Fuel Quality Assessment

- A, C: Fuel Cells – Durability and Performance

Task 3: Renewable Hydrogen Production: Biomass

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

Task 4: Big Island Energy Roadmapping

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



Objectives

Task 1: Hawaii Hydrogen Power Park

Develop and operate a test bed to validate and characterize hydrogen technologies in a real-world setting

- Integrate a renewable energy source with an electrolyzer, hydrogen storage, and fuel cell to power a building
- Collect performance and cost data
- Conduct outreach to local authorities and the general public

Task 2: Hydrogen Fuel Quality Assessment

Characterize the effect of trace level fuel contaminants on the performance and durability of PEM fuel cells

Task 3: Renewable Hydrogen Production: Biomass

Investigate critical steps for hydrogen production from biomass

- Evaluate H₂ yield potential of Pearson Technologies' gasification process
- Develop skid-mounted test system for tar reforming and H₂ purification

Task 4: Big Island Energy Roadmapping

- Complete a comprehensive assessment of the Big Island's electricity and transportation infrastructure
- Assess integration of DER technologies (including hydrogen) to facilitate greater use of Hawaii's indigenous renewable energy resources



Approach

Task 1: Hawaii Hydrogen Power Park

- Evaluate component performance: Stuart electrolyzer, high pressure hydrogen storage system, and 5 kW Plug Power fuel cell
- Establish integrated PV-wind-electrolysis and fuel cell test bed at Kahua Ranch on the Big Island
- Provide data to SNL modeling group for economic and engineering analysis

Task 2: Hydrogen Fuel Quality Assessment

- Work with North American Fuel Quality Team (DOE) and USFCC to identify contaminants and contaminant levels of interest.
- Use non-proprietary MEAs to allow post-test analysis



Approach

Task 3: Renewable Hydrogen Production: Biomass

- Leverage ClearFuels LLC investment in biomass gasification to assess direct hydrogen production feasibility
- Conduct parametric gasification tests 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 Roadmapping

- Work with GE Global Research Center to develop integrated transportation, electricity model for Big Island
- Work with stakeholder groups to identify scenarios for testing, evaluation, demonstration and deployment of DER technologies



Technical Accomplishments/Progress/Results

Task 1: Hawaii Hydrogen Power Park

HFCTF Component Evaluation

- All system components received, assembled and tested as a complete system
- LabVIEW interface for remote operation developed and tested
- Load-following, pressurized PEM electrolyzer (175 psi maximum) received from EH Inc. and tested – working with EH to upgrade

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

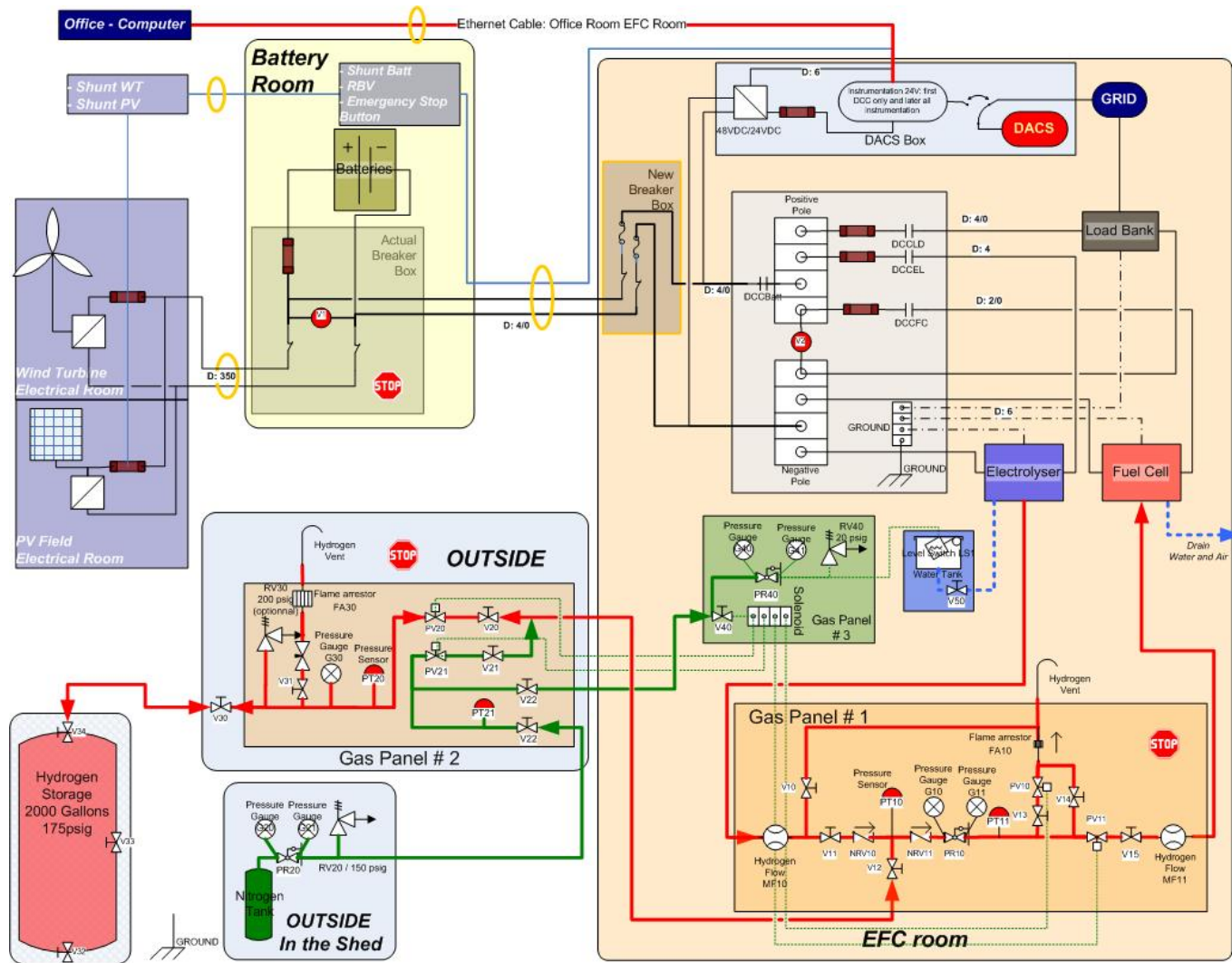
- Infrastructure installed – concrete slabs, firewalls, wiring and conduit
- 10 kW Bergey wind turbine being modified to produce 48 VDC output
- 10 kW PV array reconfigured to produce 48 VDC output
- 48 V Industrial lead acid battery system reconditioned as PV-wind energy absorber
- System currently being installed

Public Outreach

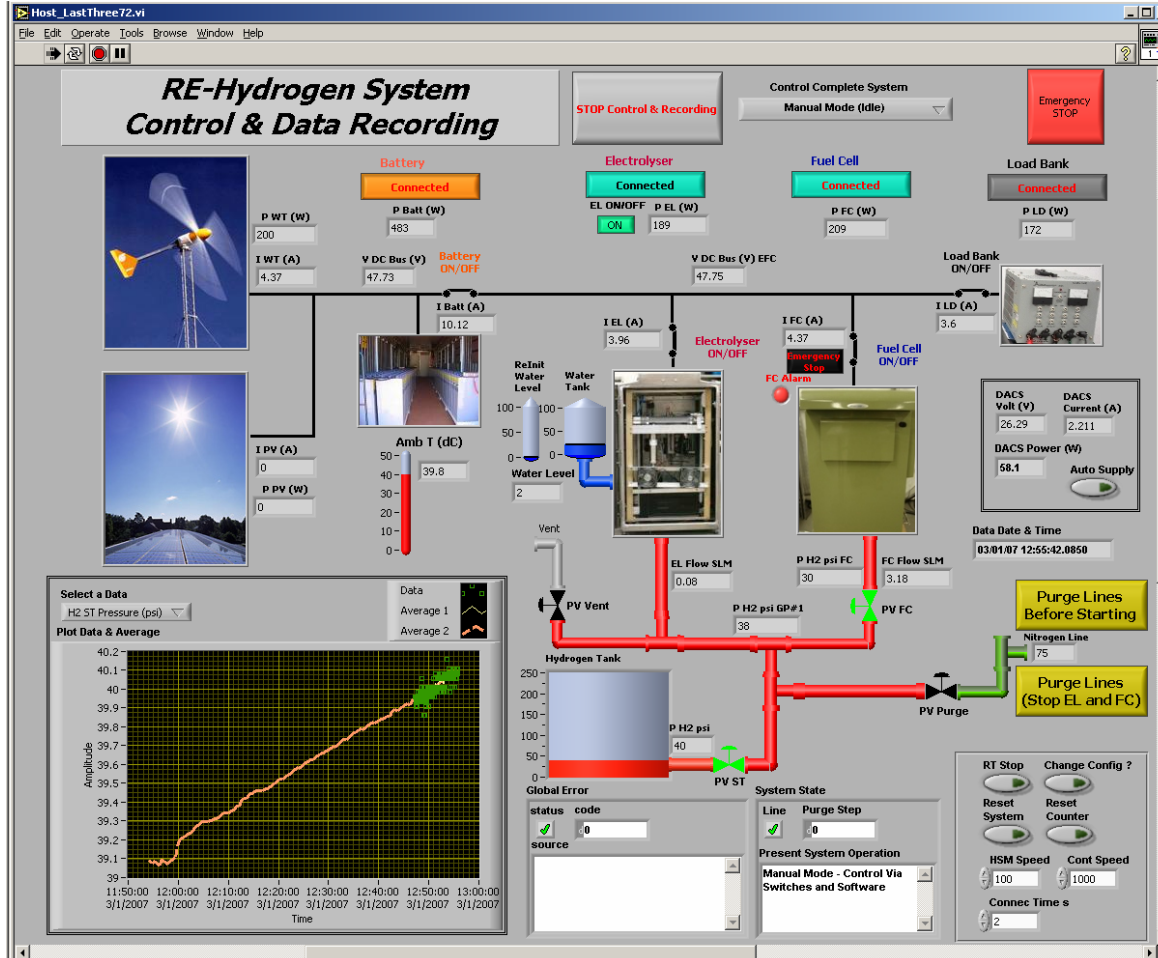
- Daily public outreach being provided at the Hawaii Gateway Energy Center



Schematic of Kahua Ranch Installation



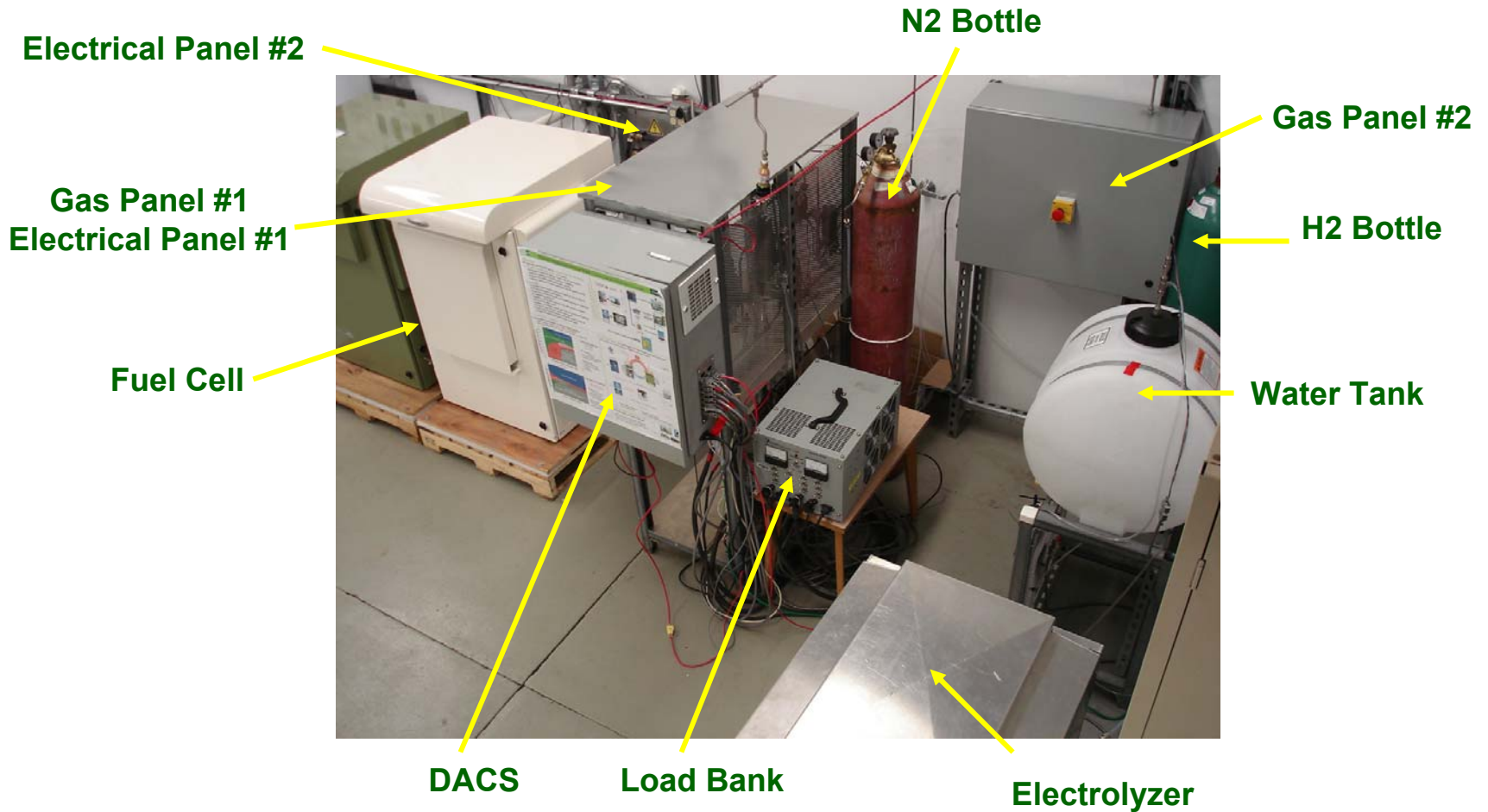
LabVIEW Interface for Control of PV-Wind Hydrogen System



- **DACS in charge of safe component operation, data visualization and acquisition**
- **DACS starts up and shuts down the electrolyzer**

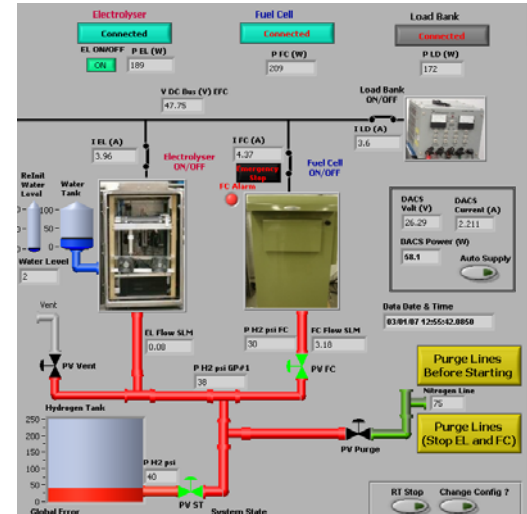
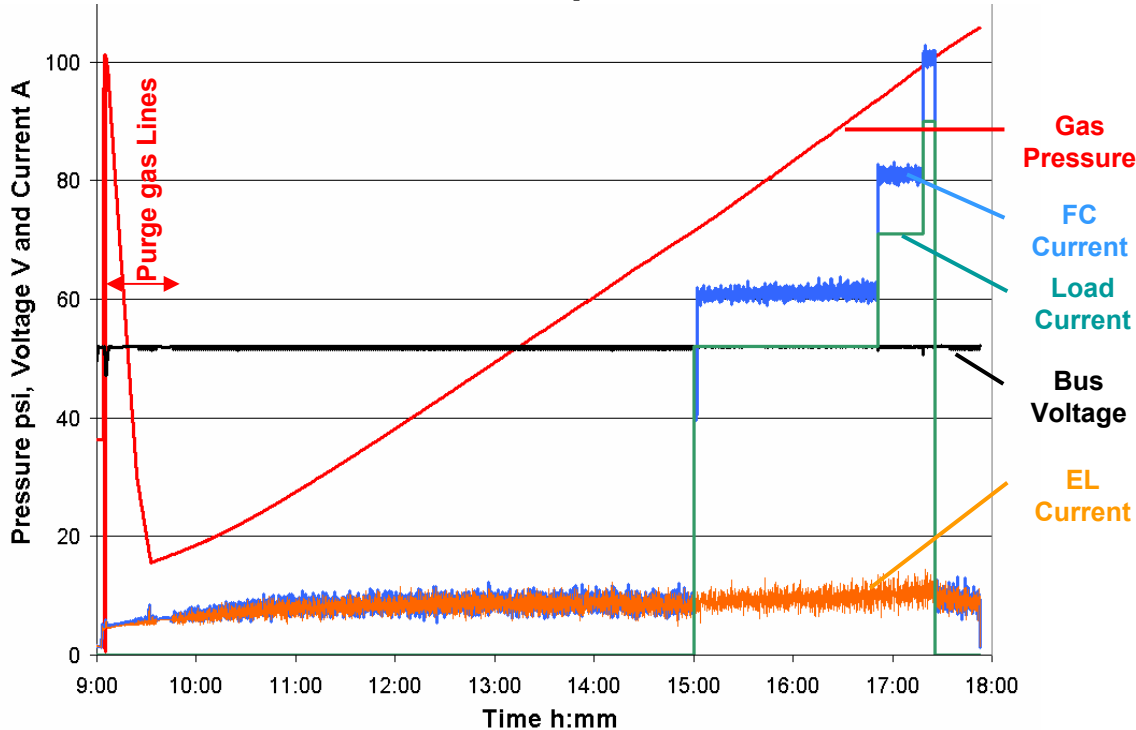


Component Testing at Hawaii Fuel Cell Test Facility



Validation of Components & Control System

- All elements were built, tested, and tuned at HNEI's Hawaii Fuel Cell Test Facility
- Graph shows performance of electrolyzer and gas storage using fuel cell as a 48VDC power source



- Voltage stable even when load varies
- Current noise due to electrolyzer (to be modified)



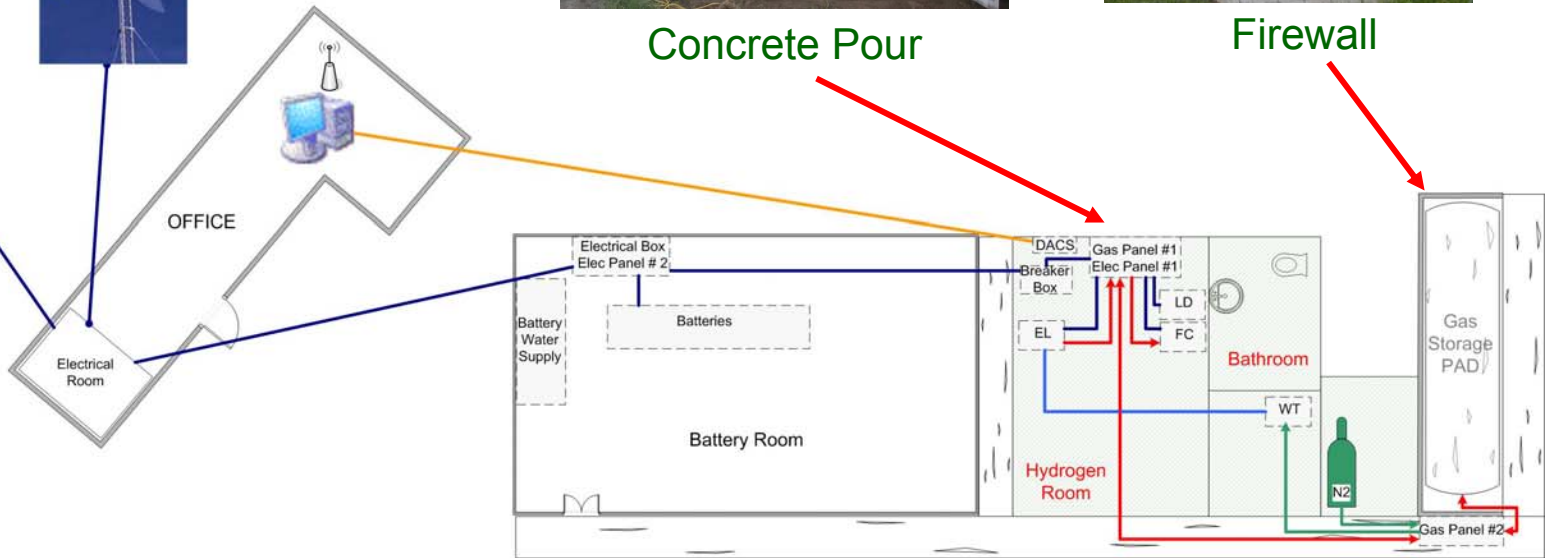
Kahua Ranch Infrastructure



Concrete Pour



Firewall



Hawaii Gateway Energy Center (HGEC)



**H2 Fueling Station Site
(Planned)**



HNEI Space



Seminar & Office Space



PV Array



New Lab Building



Public Outreach

- Leverage “Friends of NELHA” at Gateway Visitor Center
- Provide daily program with information on emerging research of alternative sustainable energy.
 - K-12 students
 - Residents
 - Tourists from around the globe
- Hydrogen an important component of outreach program



Future Plans



- \$1.6 million (50/50 DOE/State) secured for hydrogen fueling station at HGEC
- Hawaiian Electric Company request submitted to PUC to supply renewable energy at a special rate
- Supporting infrastructure for hydrogen fueling station at HGEC being designed
- Teamed with Volcanoes National Park to support hydrogen fuel cell plug-in hybrid shuttle buses
- Teamed with venture capital partners to develop a Hawaii Hydrogen Highway (H3) on the Big Island



Technical Accomplishments/Progress/Results

Task 2: Hydrogen Fuel Quality Assessment



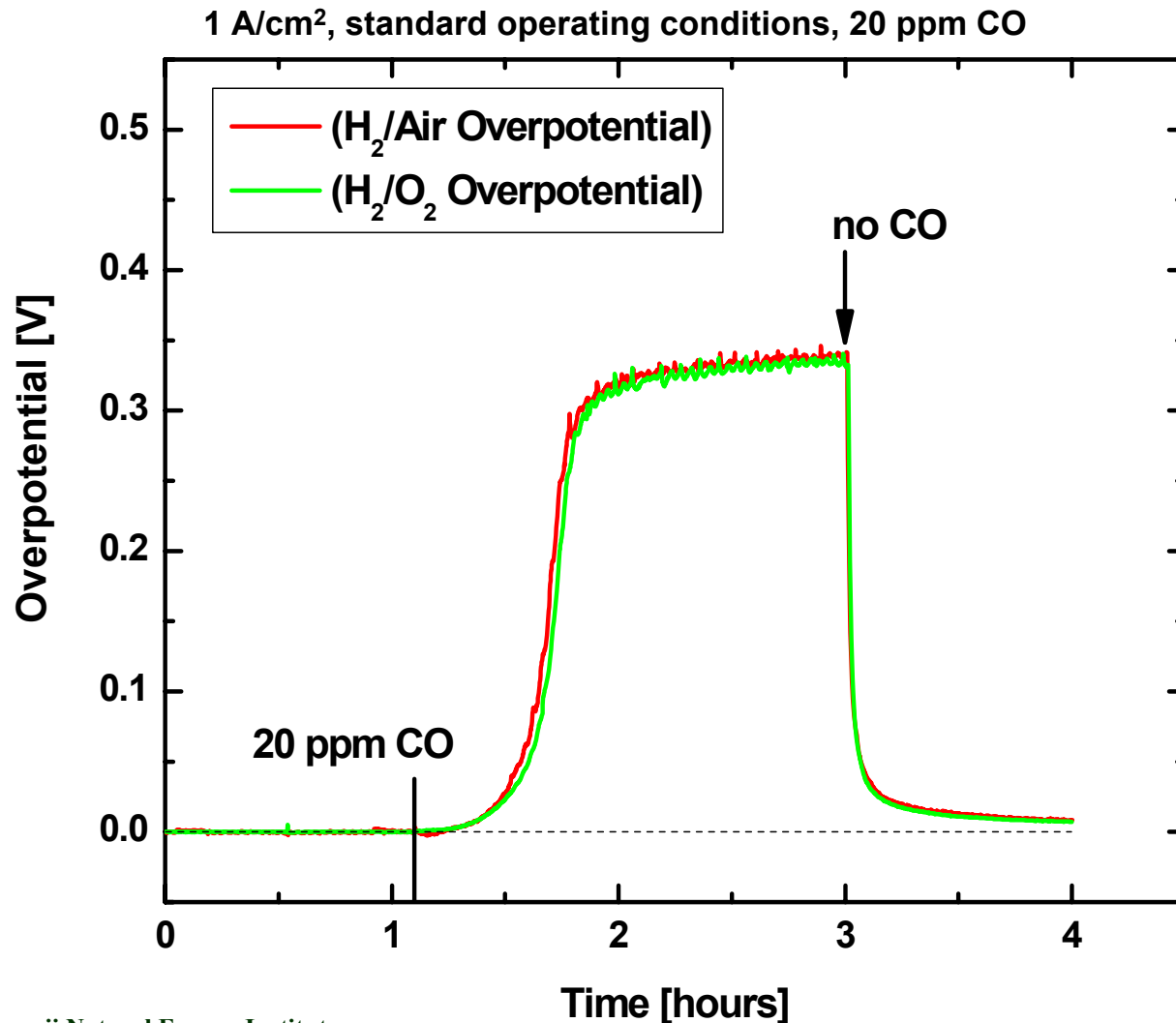
•Photo of Fuel Cell Test Facility showing various fuel cell test stands

Hawaii Fuel Cell Test Facility

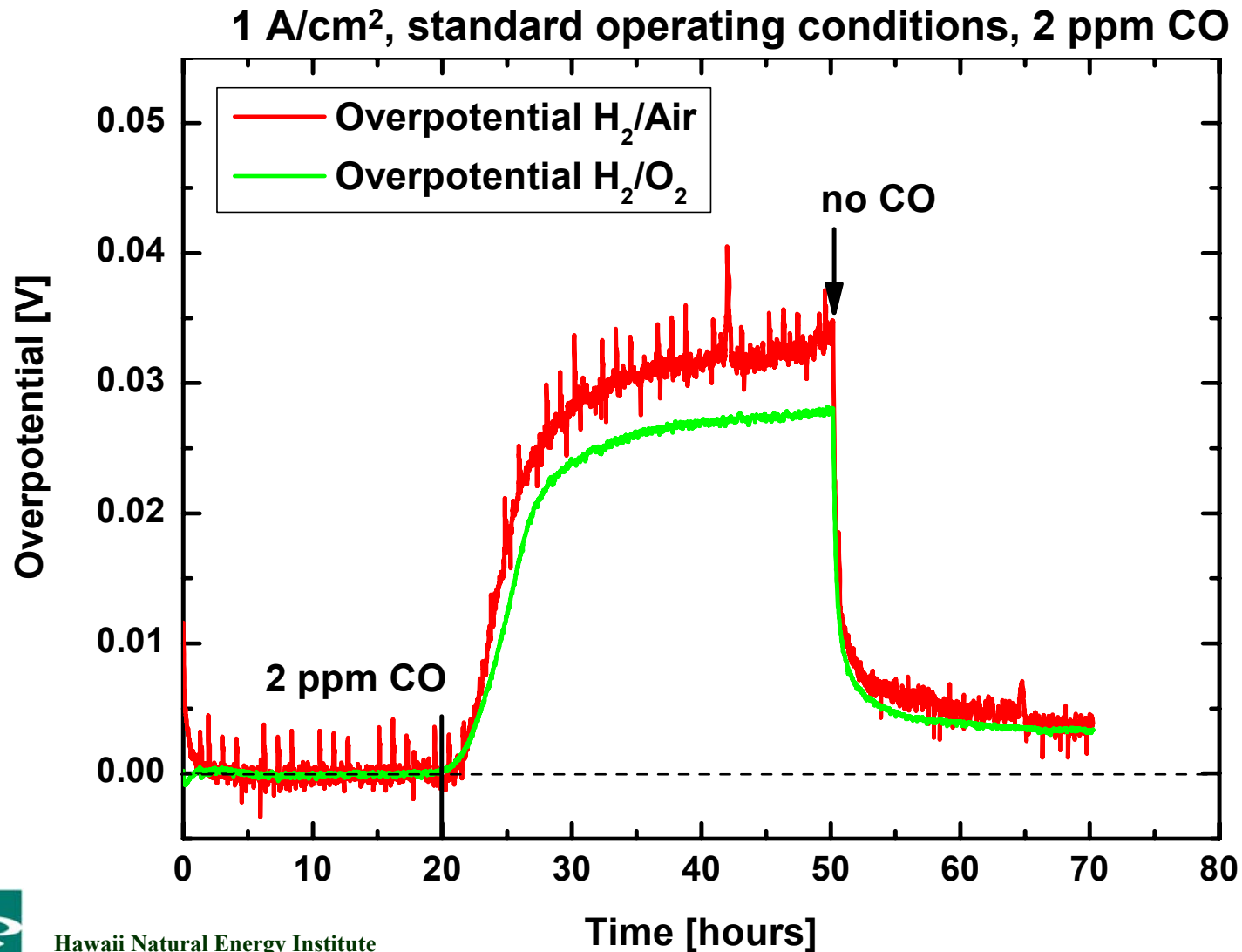
- Developed in partnership with the fuel cell industry and Hawaiian Electric Co. with funding from the Office of Naval Research
- Automated operation with remote data access (24/7) and on-site H₂ generation
- Includes world's fastest dynamic test station for hardware-in-loop testing
- Cell hardware provided by UTC Power, Ballard Power Systems, GM and HNEI
- ONR effort includes characterization of effect of air impurities on performance of polymer fuel cells
- DOE (this) effort focused on fuel contaminant effects



Comparison of the Effect of 20 ppm CO in Hydrogen with Air and Oxygen on Cathode



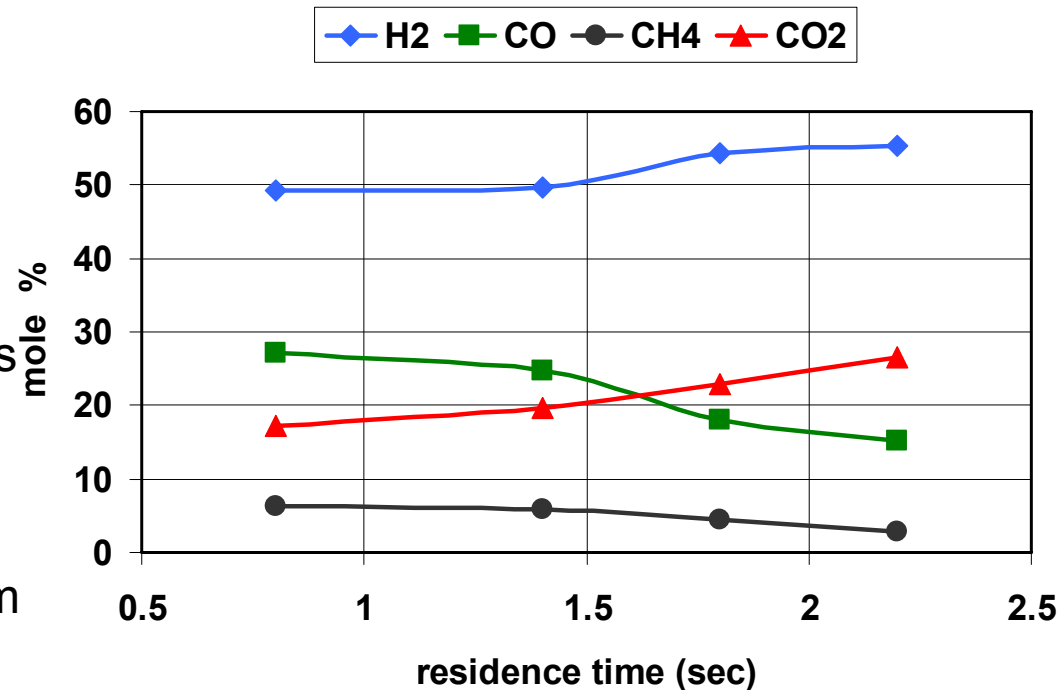
Comparison of the Effect of 2 ppm CO in Hydrogen with Air and Oxygen on Cathode



Technical Accomplishments/Progress/Results

Task 3: Renewable Hydrogen Production: Biomass

- Collaborating with ClearFuels LLC, a licensee of Pearson Technologies
- 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
- HNEI to have access to slipstream for testing of gas clean up and conditioning and hydrogen technologies
- 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%

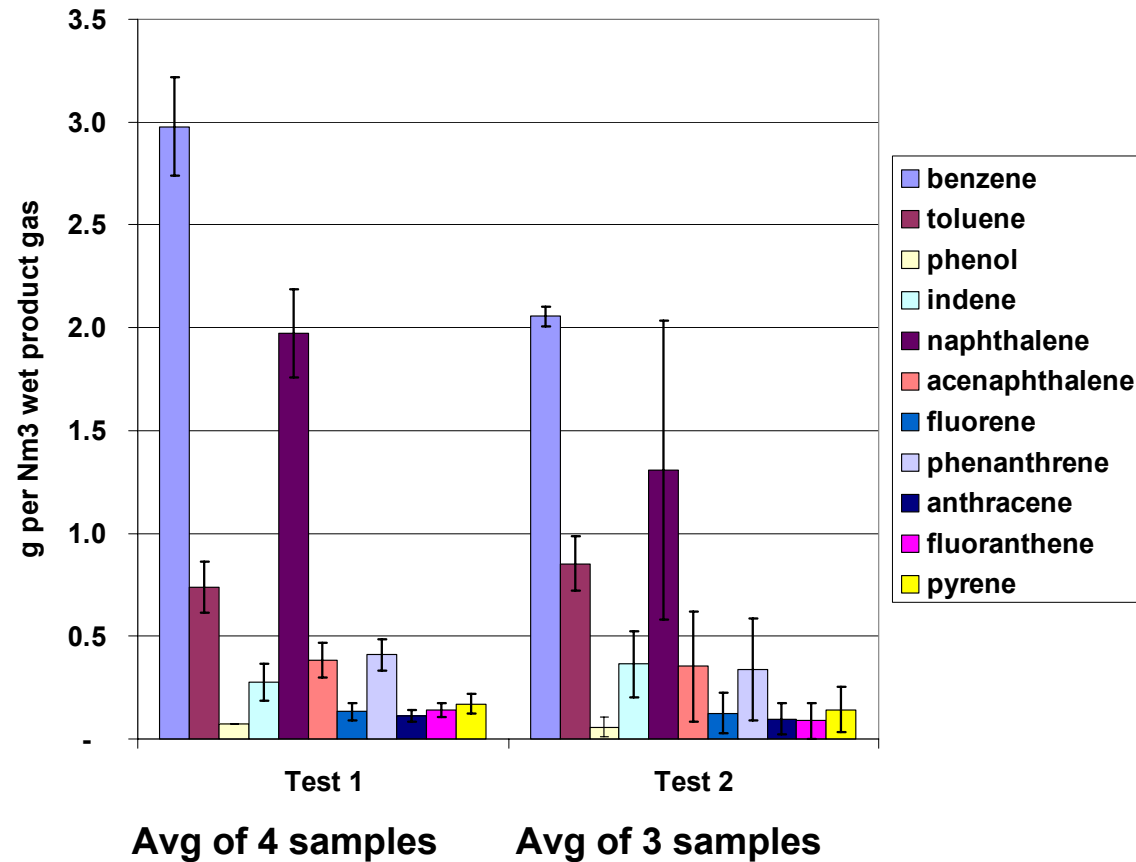


Producer Gas Purification

Characterization of Tar Species in Biomass Product Gas

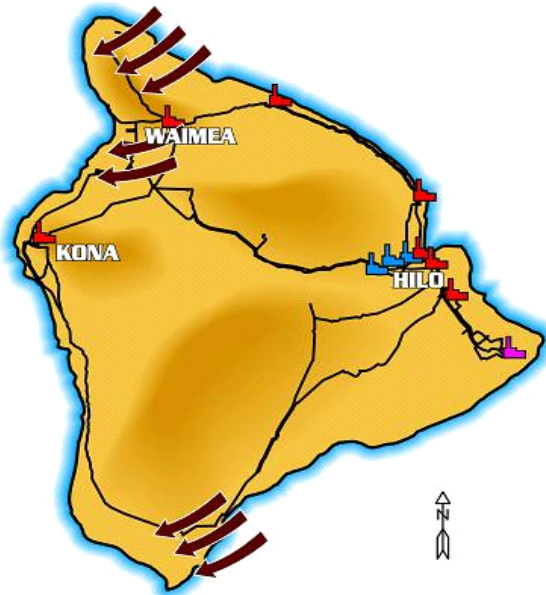
- **Gasifier conditions**
 - Equiv. Ratio = 0.26
 - Steam to Biomass Ratio = 0.3
 - Gasifier Temperature = 800°C
- **Total tar concentrations in wet gas**
 - Test 1 = 8.1 ± 0.8 g/Nm³
 - Test 2 = 7.6 ± 1.3 g/Nm³
- **Unidentified compounds as % of total**
 - Test 1 = 10%
 - Test 2 = 14%
- **Future work - GC/MS validation**
- **Initial purification tests conducted; release of data pending**

Results of Tar analysis using GC/FID



Technical Accomplishments/Progress/Results

Task 4: Big Island Energy Roadmapping



- Objective – fully describe electricity and transportation energy flow on the Big Island
- Conducted in partnership with GE Global Research Center, Hawaiian Electric Co., Hawaii Electric Light Co., and Sentech
- Process includes:
 - Model development
 - Data collection
 - System model validation
 - Stakeholder survey
 - Scenario analysis (July 07)
- Establishes valid & defensible criteria for maximum use of renewable energy resources on the island
- Evaluates strategies for integration of emerging technologies, e.g., H₂ & storage



Electricity System Modeling Approach

Time Scales for System Planning and Operation Processes

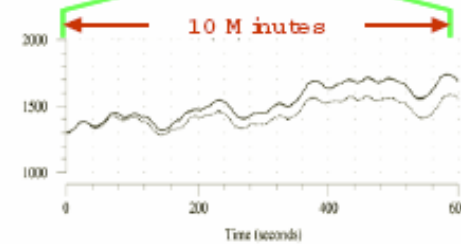
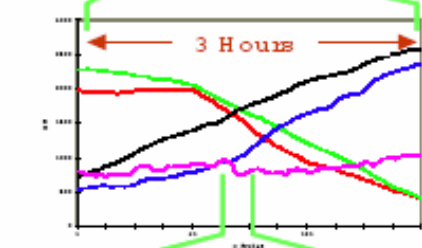
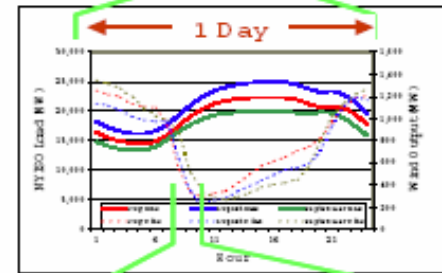
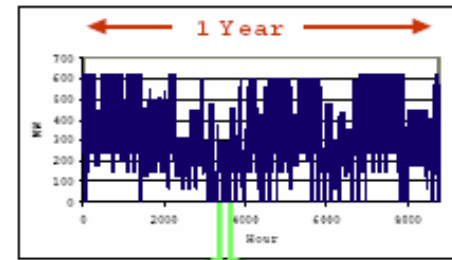
Slower (Years)
Time Frame
Faster (seconds)

Long-Term Resource and Capacity Planning
Capacity Value

Unit-Commitment
Day-Ahead Scheduling
Multi-Day Forecasting

Load-Following (5-minute dispatch)
Hour-Ahead Forecasting

Frequency and Tie-Line Regulation (AGC)



Future Work

Task 1: Hawaii Hydrogen Power Park

- Complete testing & analysis (SNL) of integrated PV-wind-hydrogen-FC system at Kahua Ranch on the Big Island
- Restart SEP-funded Power Park and provide hydrogen fuel to Volcanoes National Park vehicles (under proposal)

Task 2: Hydrogen Fuel Quality Assessment

- Complete short- and long-term characterization of contaminant effects

Task 3: Renewable Hydrogen Production: Biomass

- Complete clean-up unit and test at HNEI gasifier facility
- Transport unit to Kauai to evaluate 45 Mg/day gasifier
- Characterize fate of trace contaminants in gasifier process

Task 4: Big Island Energy Roadmapping

- Hold a decision-making conference in Hawaii regarding initial project efforts

