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

• 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

- Fuel Cell
- Gas Panel #1
- Electrical Panel #1
- Electrical Panel #2
- N2 Bottle
- Gas Panel #2
- H2 Bottle
- Water Tank
- DACS
- Load Bank
- Electrolyzer
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)
Hawaii Gateway Energy Center (HGEC)

- H2 Fueling Station Site (Planned)
- Seminar & Office Space
- New Lab Building
- PV Array
- HNEI Space

Hawaii Natural Energy Institute  
www.hnei.hawaii.edu
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

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

1 A/cm², standard operating conditions, 20 ppm CO

- (H₂/Air Overpotential)
- (H₂/O₂ Overpotential)

Overpotential [V] vs Time [hours]

20 ppm CO

no CO
Comparison of the Effect of 2 ppm CO in Hydrogen with Air and Oxygen on Cathode

1 A/cm², standard operating conditions, 2 ppm CO

- Overpotential H₂/Air
- Overpotential H₂/O₂

Time [hours]

Overpotential [V]

- 2 ppm CO
- no CO
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

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<th>Test 1 Uncertainty</th>
<th>Test 2 Average</th>
<th>Test 2 Uncertainty</th>
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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 & defendable criteria for maximum use of renewable energy resources on the island
- Evaluates strategies for integration of emerging technologies, e.g., $\text{H}_2$ & storage
Electricity System Modeling Approach

Time Scales for System Planning and Operation Processes

- 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)

Slide courtesy GEGRC
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