U.S. Department of Energy
Energy Efficiency and Renewable Energy

DOE Hydrogen Program
Technology Validation Sub-Program

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Objectives

Validate integrated hydrogen and fuel cell technologies for transportation, infrastructure, and electric generation in a systems context under real-world operating conditions.

1. By 2009, 250+ mile range, 2000 hour fuel-cell durability (vehicle), $3.00/gge hydrogen (untaxed)
2. By 2008, 30,000 hour fuel-cell durability (stationary), 32% efficiency, $1,250/kW
3. By 2010, biomass/wind or geothermal electrolyzer-to-hydrogen system to produce hydrogen for $3.30/gge at the plant gate

Budget

Task		DOE		Cost Shares
		EW&D	Interior	
1	Fleet & Infrastructure	$297,000	$8,911,781	$8,870,781
2	Power Parks	$680,000		$680,000
3	Natural Gas to H2 Refueling Stations	$1,622,751		$1,119,751
4	Energy Station	$660,000		$622,500
5	Renewable	$415,000		$100,000
1-5	Earmarks	$13,924,403		~$7,860,500
6	Analyses	$495,000	$515,000	$0

Earmark Projects

Hawaii Energy Center	$2,982,300	Develop fuel cell test center
Chattanooga *	$2,485,250	Develop, build and test solid oxide fuel cell coproduction system
Washoe County *	$1,962,155	Develop, build & test geothermal/ electrolyzer refueling station
Regional Infrastructure in PA	$2,943,232	Develop materials and sensors for pipelines and storage systems
Research & Educ. at U. of So Carolina	$2,158,370	Develop advanced production, storage, & fuel cell MEA systems
Locomotive fuel cell *	$600,000 ($1,862,155)	Develop, build & test underground H2 mine loader
NEXT Energy *	$793,096	Build and test refueling station

* Pertinent to Technology Validation activities.

Earmark Projects Continued

New York State Hi-Way Initiative	($1,962,155)	Build and test wind hydrogen coproduction facility, build and test refueling station
Florida Hydrogen Partnership	($1,962,155)	TBD
Hawaii Power Park	($490,539)	Build and test power parks
Univ. of Alabama Birmingham	$963,372 (2003)	Test stationary and vehicle hydrogen systems
UNLV	$963,372 (2003)	Build and test photovoltaic refueling station

Barriers

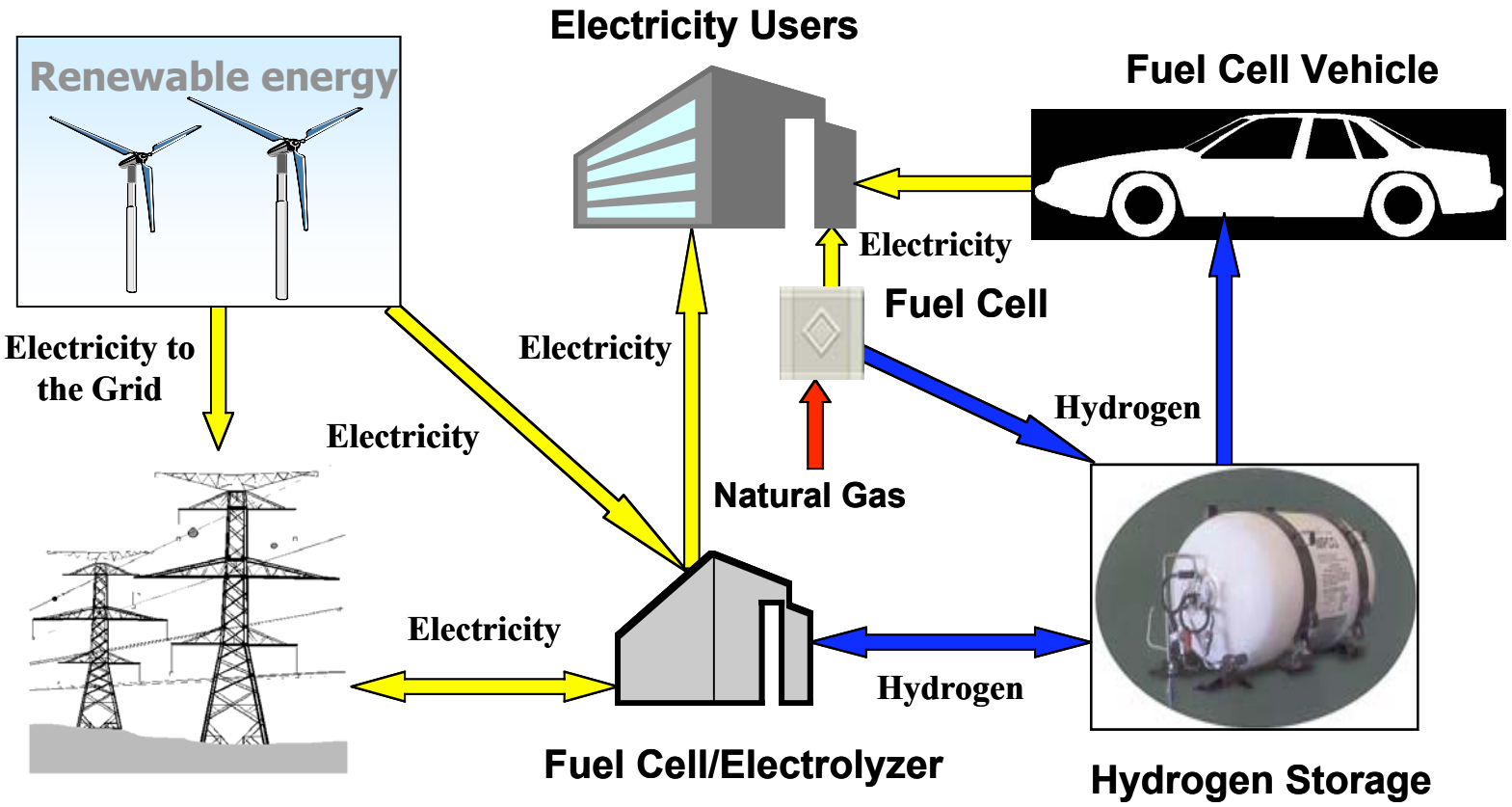
A	Vehicles	• statistical data for vehicles that are operated under controlled, real-world conditions (i.e., fuel economy, cold start efficiency, stack degradation, system durability) • vehicle drivability, operation and maintenance
B	Storage	• driving range • cost • composite tank operating cycle life and failure
C	Hydrogen Refueling Infrastructure	• capital costs to build and install • footprints • system availability
D	Hydrogen and Electricity Coproduction	• statistical data on cost and durability of hydrogen fuel cells and reformer systems • development of safety procedures • codes & standards development • availability, operation and maintenance experience
E	Maintenance & Training Facilities	• limited certified procedures • limited trained personnel • lack of data on operation and maintenance costs

Barriers Continued

F	Codes & Standards	• statistical data for codes and standards development • need development of safety procedures (i.e., HAZOP and FMEA) • global standards need to be established
G	Hydrogen from Renewable Resources	• durability, cost and efficiency for integrated renewable electrolysis systems • biomass feed system, catalyst lifetimes
H	Centralized Hydrogen Production from Fossil Resources	• durability, efficiency and cost of high temperature electrolysis systems
I	Hydrogen from Nuclear Power	• statistical data on reaction rates, non-equilibrium reactions, and material properties for systems • cost and operation of integrated systems • durability, efficiency and cost of high temperature electrolysis systems

Approach

- Hydrogen/Electric Economy



Project Safety

- Identification of safety vulnerability techniques used in the analysis of the design and operation of equipment, e.g. hazard and operability study (HAZOP), failure mode and effects analysis (FMEA), others
- Identification of management of change (MOC) process used for the project, briefly describing procedures for changes in chemicals, technology, equipment, and operations
- Any safety-related lessons learned from the project
- Other safety-related insights benefiting the project and/or of potential application to other projects

Tasks

Task 1	Vehicle Field Evaluations
Task 2	Hydrogen Infrastructure
Task 3	Natural Gas-to-Hydrogen Refueling Stations
Task 4	Co-Production of Hydrogen and Electricity
Task 5	Renewable Hydrogen Production Systems
Task 6	Technical Analyses

Task 1 – Vehicle Field Evaluations (Objective 1)

Description

- Support CaFCP vehicle and bus demonstration
- Support Controlled Fleet demonstrations (collect vehicle operating experience from different geographic regions)
- Identify maintenance, safety and refueling requirements
- Design, build and test hydrogen locomotive and front-end loader vehicles

Accomplishments

- Develop data collection plan in collaboration with FTA for fuel cell buses
- Issued Solicitation, responses received and evaluated, and selections made in 2Q 2004
- Completed construction and initial testing of hydrogen locomotive in underground mines

Technology Validation Strategy

- To conduct learning demonstrations that emphasize co-developing hydrogen infrastructure in parallel with hydrogen fuel cell-powered vehicles to **allow a commercialization decision by 2015**.
  - Test, demonstrate, and validate optimum system solutions
  - Refocus Hydrogen R&D Program as appropriate

Controlled H2 Fleet & Infrastructure Solicitation: General Information

- Five year project 2004 – 2009
- Government/industry cost shared co-operative agreement
- $150M –$240M Government share subject to the appropriations process
  - $190M announced
- Data from project to help refocus R&D projects
- 2 Generations of vehicles
- Cold climates to be included by 2nd generation
- Codes, Standards and Education integral to the success of the project
- Stationary facilities that co-produce electricity and hydrogen are encouraged

SOLICITATION FOR SUBMISSION OF FINANCIAL ASSISTANCE APPLICATIONS

OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY

SOLICITATION NUMBER
DE-PS36-03GO93010

CONTROLLED HYDROGEN FLEET AND INFRASTRUCTURE DEMONSTRATION AND VALIDATION PROJECT

Controlled Fleet Performance Targets

(From solicitation RFP, Appendix C)

- 2008 Performance Targets
  - FC Stack Durability: 2000 hours
  - Vehicle Range: 250+ miles
  - H2 cost at station: $3.00/kg

To verify progress toward 2015 targets

- 2015 Performance Targets
  - FC Stack Durability: 5000 hours
  - Vehicle Range: 300+ miles
  - H2 cost at station: $1.50/kg

Subject of subsequent projects to validate 2015 targets

Successful Teams Announced

- Ford Motor Co./BP
- FC: Ballard
- Stations in
  - Detroit, MI
  - Orlando, FL
  - Sacramento, CA

- General Motors/Shell
- FC: GM
- Stations in
  - Washington, DC/Fort Belvoir, VA
  - Detroit, MI
  - New York, NY
  - Los Angeles, CA

- DaimlerChrysler/BP
- FC: Ballard
- Stations in
  - Los Angeles, CA
  - Detroit, MI
  - Sacramento, CA

- Texaco Energy Systems/Hyundai
- FC: UTC Fuel Cells
- Stations in
  - Southern CA
  - Northern CA

- Air Products, Conoco-Phillips, Toyota, Honda, Nissan, BMW
- FC: UTC, others
- Stations in
  - Northern CA
  - Southern CA
  - Las Vegas, NV

Task 2 – Hydrogen Infrastructure (Objectives 2 & 3)

Description

- Design and construct early refueling facilities on integrated renewable/ fossil systems
- Document permitting requirements, lessons learned and safety plans
- Collect and disseminate operating data from different geographic regions

Accomplishments

- Completed 2 power park system designs and initiated equipment purchases. Third power park design in process (to be completed 6/30/04).
- Regenerative back-up power system installed at a casino and business plan developed for telecommunication industry
- Back-up power system with alkaline fuel cell installed and tested at a university (business plan in place to produce 50 units per month)

Task 3 – Natural Gas-to-H_2 Refueling Stations (Objective 1)

By 2006, validate $3.00/gge

Description

- Build and operate natural gas-to-hydrogen refueling station to collect data on reformer performance and reliability
- Validate the cost of H_2 produced including station operation and maintenance
- Disseminate data from refueling sites to verify component performance

Accomplishments

- Phase 2 subsystem development in progress on natural gas to hydrogen refueling station; verified $3.00/gge
- Completed approval process for hydrogen refueling system installation @ LAX
- Integrated advanced compressor and reformer with existing transit company hydrogen production system @ Palm Desert, CA
- Initiated feasibility/system design of advanced fluid compressor

Task 4 – Co-Production of H_2 & Electricity (Objective 2)

By 2005, validate 8¢/kWh and $3.60/gge

Description

- Collect data on reformer and fuel cell performance, reliability and cost
- Identify the operation and maintenance requirements for the Energy Station (Las Vegas)
- Determine the economics for a large co-production refueling station

Accomplishments

- Preliminary tests completed, verified $3.60 gge and 8¢/kWh electricity production (2003)
- Initiated validation of reformer (2004)
- Completed Phase 1 modifications of 30% hydrogen/70% natural gas trucks and bus with low exhaust emissions
- Completed Phase 1 of high-temperature fuel-cell coproduction system study (documented station design for $1.50/gallon gasoline equivalent hydrogen and 7¢/kWh electricity production by 2010)

Task 5 – Renewable H_2 Production Systems (Objective 3)

Description

- Validate integrated systems and their ability to deliver hydrogen
- Collect data to verify component performance

Accomplishments

- Initiated biomass pyrolysis system tests
- Awarded wind-hydrogen system cooperative agreement with Office of Science

Task 6 – Technical Analyses

Description

- Analyze early infrastructure deployment options
- Analyze advanced Power Parks for production of hydrogen and electricity

Accomplishments

- Early hydrogen infrastructure analysis in process
- Power Park validation analysis in process

Future Work

Task 1	Award cooperative agreements, operate vehicles, and install and operate infrastructure
	Complete hydrogen loader and locomotive test programs at 3 underground mines
	Support FTA on California Fuel Cell Partnership Bus Program assessment
Task 2	Complete the installation and operation of 3 power park projects and 2 back-up power projects
Task 3	Complete validation of 2 natural gas to hydrogen refueling stations
	Complete installation and operation of 3 advanced compressor and storage systems

Future Work Continued

Task 4	Complete validation of Energy Station in Las Vegas (2005), testing of ten 30% hydrogen/70% natural gas light-duty vehicles and one bus, and make decision on high-temperature coproduction facility
Task 5	Complete biomass pyrolysis system tests (2004)
Task 6	Identify early infrastructure scenarios and define market applicability of power park concept

Future Work – Earmarks

Task 1	Complete Locomotive and Underground Loader Vehicles Project
	Refueling Stations: NEXT Energy, Detroit, MI; Washoe County Transit, Reno, NV; New York State HI-Way Initiative; Florida Hydrogen Partnership; Photovoltaic Refueling Station NV
Task 2	Hawaii Power Park
Task 4	Chattanooga, TN Coproduction Facility
Test Centers:	Hawaii Energy Center
	University of Alabama, Birmingham

The Players

- Task 1. Vehicle Field Evaluations
  - Controlled fleet and infrastructure demonstration and validation project
  - California Fuel Cell Partnership (NREL)
- Task 2. Hydrogen Infrastructure
  - Power parks (Hawaii, Pinnacle West and DTE)
  - Back-up power plants (Apollo, Proton)
- Task 3. Natural Gas to Hydrogen Refueling Stations
  - Refueling stations (GTI and Air Products & Chemicals, Inc. [APCI])
  - Advanced compressors and storage (Praxair – LAX, APCI, SunLine and Hydradix @ SunLine)

The Players Continued

- Task 4. Coproduction of Hydrogen and Electricity
  - Las Vegas energy station (APCI, Plug Power, Collier Technologies)
  - High temperature fuel cell (APCI)
- Task 5. Renewable
  - Biomass reactor (Clark-Atlanta University)
- Task 6. Analyses
  - Infrastructure analysis (NREL)
  - Power park analysis (SNL)