Hydrogen Generation from Electrolysis

Proton Energy Systems
Air Products and Chemicals
University of California, Irvine

Presented at the 2004 DOE Hydrogen, Fuel Cells & Infrastructure Technologies Program Review
Philadelphia, PA

May 26, 2004

Hydrogen Generation from Electrolysis

Objectives

Determine Pathway to Optimum Electrolysis-Based H_2 Fueling through Conceptual System Design and Component/System Development

1. Develop the Requirements for the Fueling System
2. Optimize Fueling System Designs Through Systems Analyses
3. Conduct Research and Development to improve component performance, cost, and/or durability

Supports DOE Multi-Year Research, Development, and Demonstration Plan Objective “By 2010, verify renewable integrated hydrogen production with water electrolysis at a hydrogen cost of $2.50/kg (electrolyzer capital cost of $300/kWe for 250 kg/day at 5,000 psi with 73% system efficiency). By 2010 verify large-scale central electrolysis at $2.00/kg hydrogen at the plant gate

Hydrogen Generation from Electrolysis

Background

The total price for Hydrogen Fuel is determined by:

1. Capital Costs
2. Operating Cost (electricity and water)
3. Service, Maintenance,and Replacement Costs
4. (Emissions may be a Future Consideration)

The total price will be minimized by:

1. Low Capital Costs – Eliminate Components, Optimize the Integrated System, High Volume Manufacturing
2. Low Operating Cost – High Efficiency
3. Low Service, Maintenance,and Replacement Costs – Long Equipment Durability and High Reliability
4. (Zero Emissions or Reduced Emissions)

Hydrogen Generation from Electrolysis

Budget

Contract Value:	$3.79M over 3 years
Total Funding :	$1.9M DOE Share plus $1.9M Contactor Share

Contract Start Anticipated in May 2004

Hydrogen Generation from Electrolysis
DOE Technical Barriers and Targets

- DOE Technical Barriers for Hydrogen Generation by Water Electrolysis
  - Q. Cost
  - R. System Efficiency
  - S. Grid Electricity Emissions
  - T. Renewable Integration

- DOE Technical Target for 250 kg/day Hydrogen Generation by Water Electrolysis in 2010
  - $2.50/kg
  - 73% (LHV) System Efficiency

Reference the DOE Multi-Year Research, Development, and Demonstration Plan, Section 3.1.4.2.4 Hydrogen Generation by Water Electrolysis Barriers

Hydrogen Generation from Electrolysis

Approach

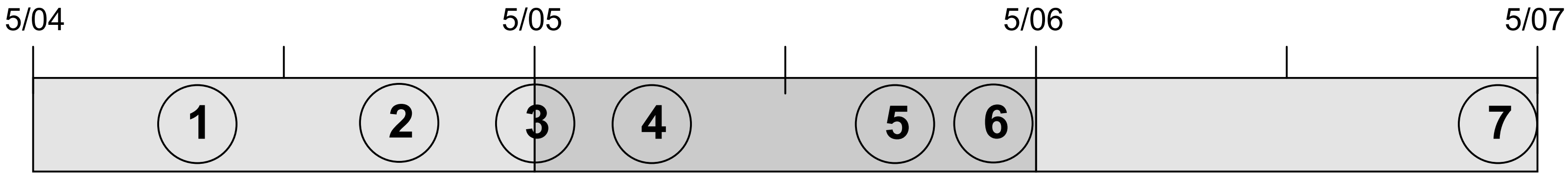
1. Establish the Fueling Station Requirements:
   - Hydrogen Production Requirements
   - Hydrogen Storage Requirements and Vehicle Fueling Requirements (including pressure requirements)
   - Price of Hydrogen Fuel to the end-user
   - Emissions Requirements

2. Conceptual Systems Analyses/Designs:
   - Component and Subsystem Cost and Performance Models
   - Analytical System Optimization

3. Component and Subsystem Development:
   - Cell Stack
   - Mechanical and/or Electrochemical Compression Technology
   - Power Management and Distribution
   - Hydrogen Drying/Purification
   - Hydrogen Storage and Dispensing

Hydrogen Generation from Electrolysis

Project Timeline



1. Fueling System Requirements
2. Initial Experimental Data to Support Models
3. Component and Subsystem Analytical Models
4. Optimum System Design(s) Identified
5. Preliminary Component Development Test Results
6. System Designs Revised
7. Component and Subsystem Development Completed

Contract Start Anticipated in May 2004

Hydrogen Generation from Electrolysis

Interactions and Collaborations

- Proton Energy Systems is Prime Contractor
- Air Products and Chemicals is Partner for Design, High Pressure BOP Analysis and Development, and Safety.
- University of California, Irvine is Partner for Wind Resource Analysis and Integration.
- Northern Power Systems may Support Integration, Maintenance, and Servicing

Hydrogen Generation from Electrolysis

<u>Program Status</u>

Contract Start Anticipated in May 2004

Hydrogen Generation from Electrolysis

Safety Slide

Potential Safety Hazards	Safety Precautions
Hydrogen Leaks	•Proper component selection: Components rated for hydrogen service, pressure and temperature. •Leak testing of the fueling system after onsite integration. •Combustible gas sensors to sense hydrogen leak and shutdown system on high LFL.
Storage of 430 bar Compressed H_2	•ASME approved storage tanks for hydrogen storage. •Approved pressure relief devices for the storage tanks.
Explosion Protection	• Eliminate the likelihood of an explosive gas atmosphere occurring around the source of ignition by diluting any hydrogen release to a concentration below LFL, or •Protect against ignition source by using explosion proof components.
Dispensing H_2 Fuel into Vehicles	•Follow Fueling procedures established by CaFCP and SAE

Follow appropriate Codes and Standards (NFPA 50A, NFPA 52, NFPA 70, ASME, NFPA 496)