

Renewable Hydrogen Fueling Station System

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

UNLV Research Foundation
(Janice Wiedemann, Project Manager) to
Robert Boehm, University of Nevada Las Vegas
Tom Maloney, Proton Energy Systems

May 26, 2004

This presentation does not contain any proprietary or confidential information

Objectives

As a first step in the development of a hydrogen utilization network, we will install and analyze performance of a hydrogen fueling system powered by the sun's energy.

1. Develop the requirements for the fueling system
2. Survey potential sites and note favorable/unfavorable characteristics of each.
3. Select the site, devise the site plan and support the site permitting process
4. Design the fueling system layout
5. Install the fueling station in Las Vegas
6. Monitor operation of the fueling system and characterize performance

Budget

Total Funding (currently in first year) :
\$963k DOE Share plus
\$688k Contractor Cost Share

Technical Barriers and Targets

Project addresses the generation of electricity, the electrolysis of water, and the separation of oxygen and hydrogen, the efficiency aspects of the compression of the hydrogen, and examining possible applications of the oxygen produced.

- Feedstock and Water Issues. Distributed hydrogen production relies on local availability of resources, which may pose limitations in certain areas. Technologies and strategies for water clean up are needed to avoid intolerable impurities in reformer steam. Feedstock-flexible reformers are needed to mitigate and/or take advantage of price fluctuations and to address location-specific feedstock supply issues.
- Education: the project impacts the educational program through the use of student research assistants (both undergraduate and graduate). In addition, many project elements will be incorporated into energy-related classes at UNLV.

Technical Barriers and Targets (cont.)

- 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 2 kg/day Hydrogen Generation by Water Electrolysis in 2010
 - \$3.80/kg
 - 70% (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 and Technical Targets

Technical Barriers and Targets

First year barriers are more societal, less technical

- Acquiring permits from agencies that may have not previously approved hydrogen fueling stations.
- Tune corporate attitudes to the acceptance of hydrogen applications. Use facility as a possible model.
- Set up a facility to allow future expansion of work and to accommodate vehicle integration.
- Publicize this facility and its function.

Approach

1. Identify Suitable Site and Owner/Operator. Beyond the concern for installing an electrolysis system during the first year, a major objective is to find an owner/operator who:
 - Can facilitate future years' research work
 - Provide cost share in the development and use of hydrogen-fueled vehicles
 - Has the ability to install and operate a high-pressure electrolysis system
2. Install a PEM Electrolysis-Based Hydrogen Fueling Station to:
 - Generate hydrogen from water using PEM electrolysis
 - Compress the hydrogen and store it at ~6,000 psig
 - Establish 5,000 psig hydrogen vehicle fueling capability
 - Utilize solar energy resources as the power source
3. Analyze Performance of the Fueling System
4. Educate a variety of constituencies

Approach, Cont.

5. Work closely with consulting engineers, city and county inspection agencies, and advocacy groups to bring knowledge of what a hydrogen future might bring.
6. Related to item 1 is to educate a variety of constituencies in the utilization of hydrogen. This includes
 - Consulting engineering firms
 - Local government key individuals
 - University education through individual students being employed to work on this project and formal classes
7. Generally publicize benefits of hydrogen technology to the local community
8. Demonstrate that hydrogen can be generated with the renewable energy form so prevalent in the southwest: solar energy

Renewable Hydrogen Fueling Station System

Project 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 H₂

- 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.

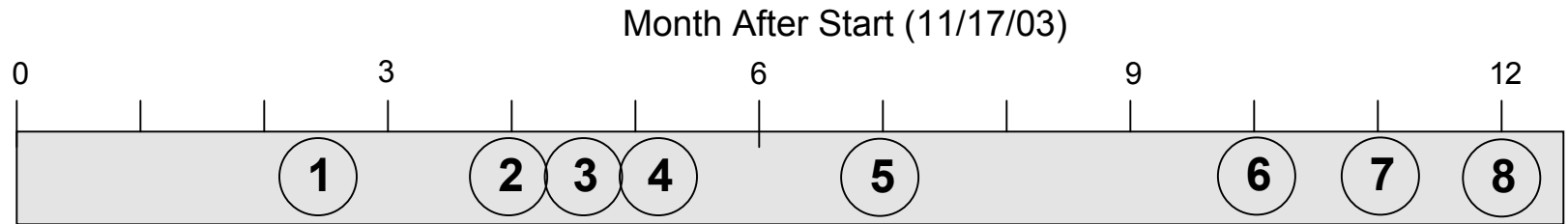
Dispensing H₂ Fuel into Vehicles

- Follow Fueling procedures established by CaFCP and SAE

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

Renewable Hydrogen Fueling Station System

Project Timeline



1. Candidate Sites Screened and Site Selected
2. NEPA Document Submitted and Approved for Site Permitting
3. Site Plan/Design Prepared
4. System Requirements Defined
5. System Design Completed
6. Site Prepared and Permitted
7. Fabrication and In-house Check-out Tests Completed
8. Fueling Station Commissioned at Site

Technical Accomplishments and Progress

- Screened 9 potential sites for location of a refueling station. Preferred one adjacent to CNG refueling capabilities.
- Selected one with significant buy-in and support of management for the location. Met all requirements.
- Completed contractual arrangements. Good partnership assured.
- Completed site design, including analysis of PV output.
- Initiated inspection approval process. Secured commitment of assistance from one other refueling station operator (City of Las Vegas).

Renewable Hydrogen Fueling Station System

Major Equipment



Air Products Series 100E

Compression, Storage, Dispensing Module

~9'x4'x6

Nominal Fill Pressure: 350 barg (~5,000 psig)

3 Bank Cascade H₂ Storage



Proton's HOGEN 40 RE

PEM Electrolyzer

~3' x 3' x 4' (without enclosure)

2.2 kg H₂/day

6-8 kW nominal input power; ~1 liter/hr H₂O

Renewable Hydrogen Fueling Station System

Preliminary Site Plan



PV Panels

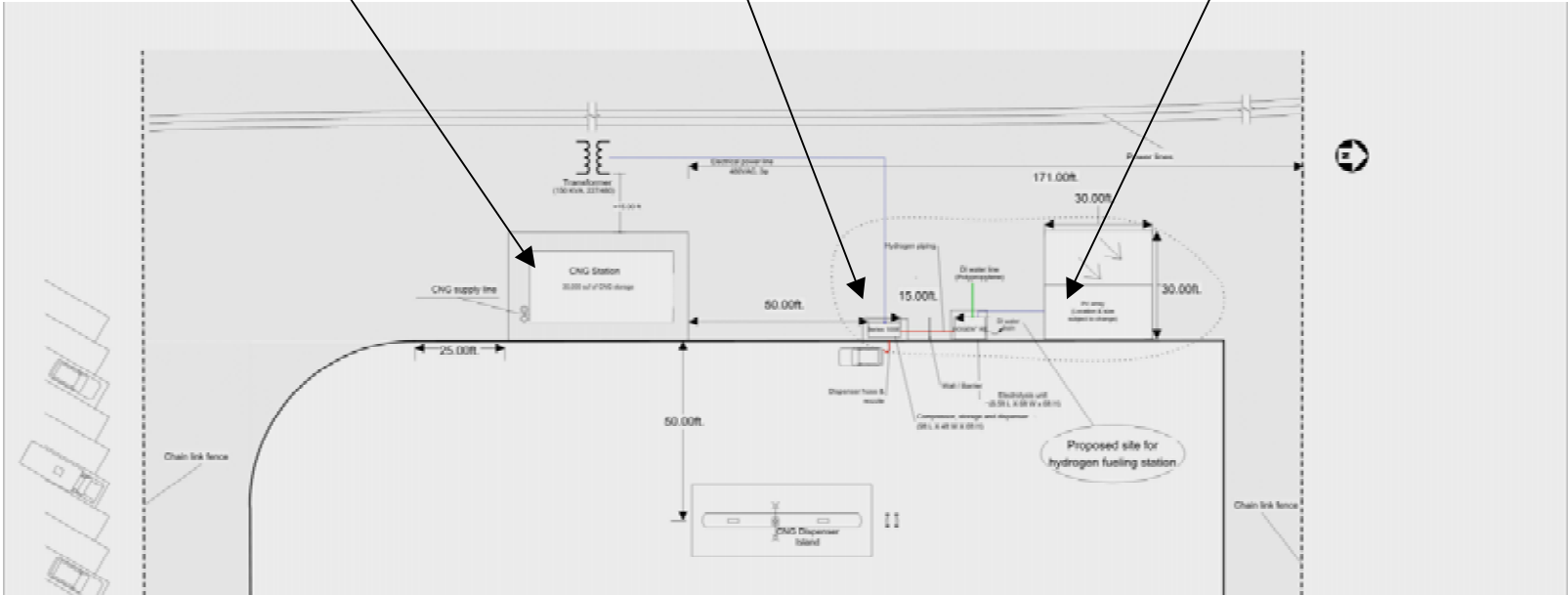
(Existing CNG Station)



H₂ Compression,
Storage, Dispensing
Module



PEM
Electrolyzer



Renewable Hydrogen Fueling Station System

Preliminary Site Plan

**H₂ Compression, Storage,
Dispensing Module**



**PEM
Electrolyzer**



CNG Station

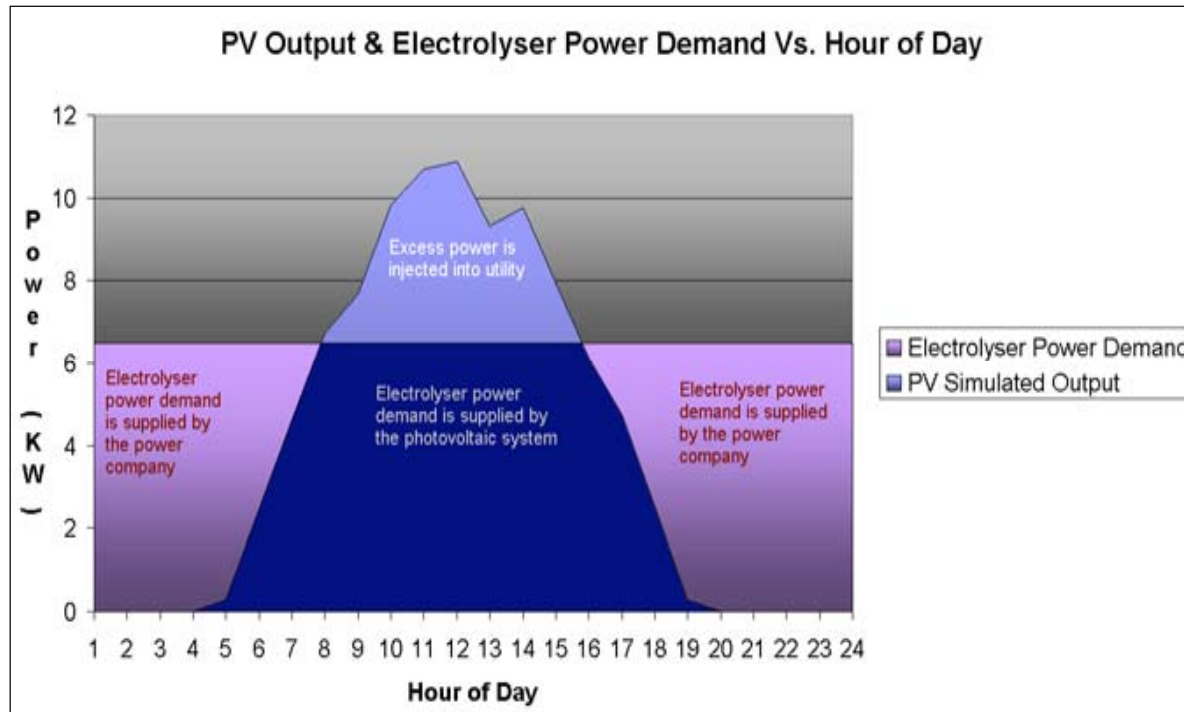


PV Panels



PV Output Compared to Demand

Illustrative example



Shown is how PV output will compare to demand if the latter is constant over a 24 hour period. Actually, the demand will generally be less and it will be controlled to coincide with PV output. Net metering is in effect in Nevada, so any excess power can be returned to utility at same value as power purchases. Specific data is TMY2 archive for Las Vegas on July 15.

Interaction and Collaborations

- UNLV CER: R. Boehm, technical direction; Y. Baghzouz, PV system design.
- Proton Energy: T. Maloney and A. Khan, electrolyzer design, evaluation.
- Air Products: H₂ Compression, Storage, Dispensing
- LVVWD: Doug Keene, incorporation of refueling station into the facility and planning utilization approaches.
- UNLVRF: Tom Williams and Janice Wiedemann, administrative and financial project management.

Future Work

- Use the LVVWD site as a research facility.
- Install a high pressure electrolyzer.
- Perform fundamental work on high pressure electrolysis.
- Develop hydrogen fueled vehicles for the LVVWD. This will be both hydrogen ICE work as well as fuel cell vehicles. Make this technology available to the general public.
- Begin work in concert with a developer of tandem solar cells for direct hydrogen production.
- Select a location for another refueling station.