RESEARCH AND DEVELOPMENT OF A PEM FUEL CELL, HYDROGEN REFORMER, AND VEHICLE REFUELING FACILITY

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Abstract

Air Products and Chemicals, Inc. has teamed with Plug Power Inc., of Latham, NY, and the City of Las Vegas, Nevada, to develop, design, procure, install, and operate an on-site hydrogen generation system, an alternative vehicle refueling station, and a stationary hydrogen fuel cell power plant, to be located in Las Vegas, Nevada.

This proposed facility will become the benchmark for validating new natural gas based hydrogen production systems, PEM fuel cell power generation systems, and numerous new technologies for the safe and reliable delivery of hydrogen as a fuel to vehicles. Most importantly, this facility will serve as a commercial demonstration of hydrogen as a safe and clean energy alternative.

Significant progress was achieved in the current year in all aspects of the project development including the H_2 generator, fuel station, and stationary fuel cell. The following sections report on this progress and the future plans and milestones in the next year.

Project Overview

A team of three organizations, Air Products and Chemicals Inc., Plug Power Inc., and the City of Las Vegas, has come together to develop, design, procure, install, and operate an alternative vehicle refueling station, and a stationary hydrogen fuel cell power plant, to be located in Las Vegas, Nevada. The objective of this project is to advance the technology and validate the commercial viability of an alternative refueling station for dispensing H_2/CNG blends and pure H_2 to vehicles, and which includes a stationary fuel cell. This co-production of hydrogen fuel and electric power is referred to, as an "Energy Station." Air Products is the prime contractor to DOE for this technology validation project. Figure 1 is a block diagram of the proposed refueling facility. This refueling station will include onsite hydrogen generation equipment supplied by Air Products and a stationary fuel cell powered electric generator, to be supplied by Plug Power under a subcontract to Air Products. The City of Las Vegas (CLV) is also a team member, providing the site location and the operating and maintenance staffing for the refueling station. The DOE cooperative agreement covers a five-year nominal period for development, design, installation, startup, and up to 4 years operation of the refueling station.

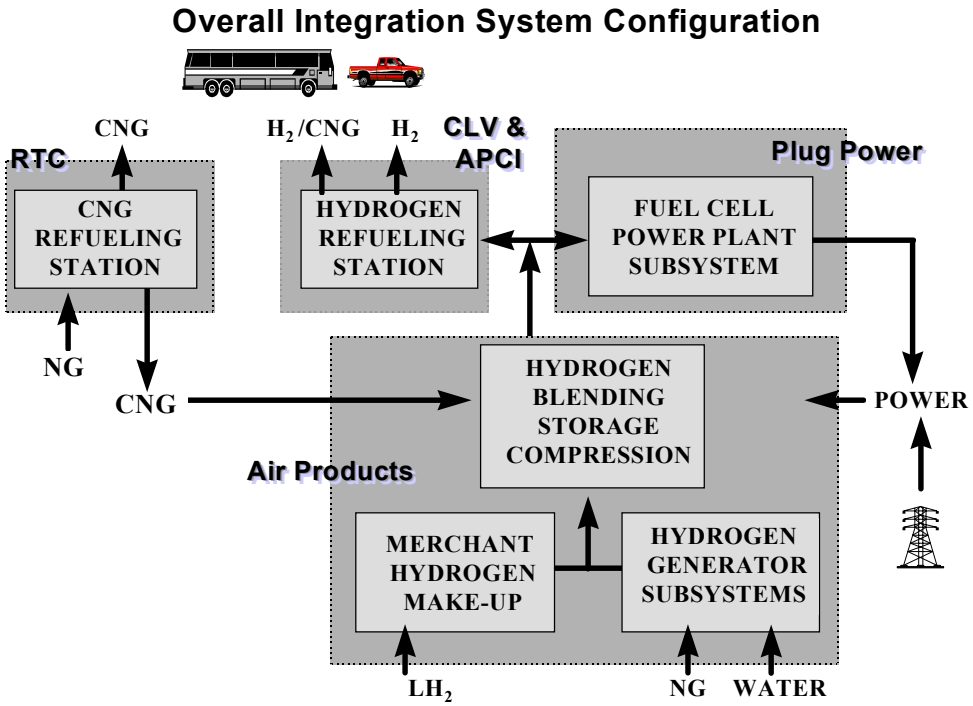

Figure 1

In Phase 1 a standard merchant liquid hydrogen supply system (liquid hydrogen storage tank and vaporizers) will be installed to satisfy initial demand of hydrogen at the refueling station. A blending system will be installed that will mix hydrogen with compressed natural gas (CNG) in a pre-determined blend to be dispensed to the alternative fuel vehicles. The station will also be able to dispense pure hydrogen to vehicles. The hydrogen compression, storage, blending and

dispensing systems will be installed nominally in July 2001 to make the station operational to meet initial refueling requirements. It is expected that there will initially be two Light Duty Vehicles (LDVs) and one para-transit bus fueled with the CNG/H_2 blend. There will also be one H_2 Hybrid Electric bus (operating at low pressure with metal hydride storage) fueled with the pure hydrogen.

CLV will be receiving six new CNG fueled buses in July 2001. Upon successful testing/operation of the first CNG/H_2-fueled para-transit bus, CLV will proceed to convert their six new buses, beginning in August 2001, to CNG/H_2-blended fuel operation. They expect to have all six buses converted over a six-month period, nominally one bus per month through January 2002. H_2 demand growth is expected to continue as additional buses and light duty vehicles are converted to the alternative fuels over the remaining three years of the demonstration project.

To meet this increasing demand, natural gas-based onsite hydrogen generation equipment will be installed and operated at the refueling station in the second phase of the project. In addition, a Fuel Cell Power Plant, that will use hydrogen feed to generate electric power for the refueling station will be completed for installation at the refueling station. The fuel cell will be operated to balance the hydrogen demand on the hydrogen generator for vehicle refueling. For system reliability, the onsite hydrogen generation system will continue to be backed up or supplemented by the liquid hydrogen supply system.

Should the alternative vehicle refueling demonstration station prove to be successful, it is anticipated that vehicle fleets would continue to grow. Plans are included in the project to expand hydrogen generation capacity early in 2002 to meet this additional demand and improve station reliability.

Process Description of the Facility

The overall integrated system configuration and the general areas of responsibility of each member are illustrated in Figure 1. The following section is a general description of the scope of the facility to be installed.

A hydrogen supply system with capacity to meet the nominal projected hydrogen requirements and provides additional capacity to allow growth of the station to serve fleets of commercial vehicles in the future. This hydrogen supply system will consist of natural gas-based hydrogen generation subsystem and a liquid hydrogen make-up backup supply subsystem.

A compressed natural gas (CNG) system that will be installed at the proposed CLV site as part of a separate program would be used to supply the CNG. Tie-ins for the CNG supply would be made on the outlet of the CLV fueling station storage tubes and routed to the hydrogen/CNG blend fuel station that will be designed and constructed by Air Products. This system includes hydrogen compression, storage and blending subsystems that will supply the H_2-and CNG/H_2, blended fuels to the metering and dispensing units.

A Fuel Cell Power Plant being supplied by Plug Power will help to test, and demonstrate the technical and economic viability of integrating baseload fuel cell power generation with on-site hydrogen production for vehicle refueling. The fuel cell power plant will be connected to the fuel station, and to the local power grid.

Project Objectives

The technical objectives of the project include the following:

1. Resolve design issues and demonstrate small, on-site H_2 production for fuel cells and H_2 fuel stations
2. Design, construct, and operate a multipurpose refueling station
3. Dispense CNG, H_2/CNG blends, and pure H_2 to up to 27 vehicles
4. Design, construct, and operate a 50kW fuel cell on pure H_2
5. Evaluate operability, reliability, and economic feasibility, of integrated power generation and vehicle refueling designs
6. Maintain safety as a top priority in the refueling station and fuel cell design and operation
7. Obtain adequate operational data on fuel station to provide basis of future commercial fueling station designs. Develop appropriate "standard" designs for commercial applications
8. Expand the current facility to serve as the first commercial facility when sufficient hydrogen demand develops. Ultimately serve as a link in a national H_2 corridor.

Project Status

Significant progress was made in the development of this project in the current year as described below:

H_2 Generator

We completed construction of a fully integrated auto thermal (ATR)-based prototype H_2 generator, and successfully tested it at the Air Products laboratories in Allentown, PA to demonstrate technical viability of the technology. Several operational issues around heat and waste gas management were resolved as part of meeting this major milestone.

We completed an internally-funded study on the competitiveness of various reformer technologies, and concluded that steam methane reformer (SMR) technology was more economical than ATR technology at this size range (50-100kW), to generate pure H_2. An SMR technology vendor was identified and procurement was initiated for the next generation unit at a nominal 100 kW size.

Fuel Station

Air Products has completed the fuel station design, and various equipment components such as the compressor, storage tubes, blender, and dispenser have been fabricated.

Process and design hazards and operability (HAZOP) reviews have been completed for the prototype H_2 generator, fuel station and fuel cell.

Electrical supply design for the project site has been completed by the City of Las Vegas for the project site at the CLV West Service Center.

Fuel Cell

Plug Power recommended a change in the fuel cell design basis from the originally proposed automotive system that was being developed under a separate DOE initiative, to one based on their commercial residential fuel cell system and stack design to minimize technical, schedule, field support and cost risk. This recommendation was approved, and the design of the 50 kW Fuel Cell System has been completed.

Testing of the various parts of the system has been completed, including: air and hydrogen humidification components, mass flow meters, blower, inverter/power conditioner, motor controls, and the stack voltage monitoring card. The 50 kW fuel cell stack system comprised of eight 7.5 kW stack modules was also tested in parallel/series configuration. The fuel cell is now in the final assembly process.

Nevada Power approved the grid interface including the design of interconnection of the fuel cell with the grid at the project site.

Future Work and Milestones

The planned work and milestones for the upcoming year are as follows:

H_2 Generator

We plan to install and operate the prototype ATR H_2 generator at the Las Vegas facility in August 2001. The next generation SMR H_2 generator 100 kW (3000 SCFH H_2) will be constructed and tested at the vendor's facility in Summer 2001. This unit will be installed in Las Vegas by January 2002.

Opportunities to integrate and test a metal hydride "thermal" compressor will be evaluated with the scale-up SMR H_2 generator. This system is intended to take advantage of the waste heat from the reformer to compress the H_2 for the fuel station.

Comprehensive system testing and analysis will be completed in the summer of 2002.

Fuel Station

The multi purpose fuel station is expected to be operational in July 2001 starting with a fuel source of delivered liquid hydrogen.
The fuel station will be tied-in to on-site sources of H_2 with future installations of the prototype ATR (Aug 2001), and later the SMR H_2 generator (January 2002).

Fuel Cell

The fully assembled 50kW Fuel Cell System will undergo operational testing at Plug Power's facilities in Latham, NY in May 2001. The unit will be shipped to Las Vegas in June for installation and start up in July 2001.

Performance data will be monitored and recorded daily during operations at Las Vegas. The fuel cell unit will be upgraded as required to increase its reliability, availability and performance in the field.

Shown below is a photo of the assembled 50kW fuel cell power plant.

Figure 2
Plug Power Fuel Cell Power Plant

Leadership-Cooperative Efforts

Venki Raman gave technical presentations on Hydrogen Fuel Infrastructure at the following conferences:

1. Energy Frontiers International, Marcos Island, FL, February 1-2, 2000
2. 11th Annual NHA Conference, Tyson's Corner, VA, March 1-2, 2000

3. IQPC Fuel Cells 2000 Conference, Palm Springs, CA, May 24-25, 2000
4. Florida's Hydrogen Summit, Tallahassee, FL, October 24-25, 2000

Outreach efforts have been made to auto participants of the California Fuel Cell Partnership with a view to promote the Las Vegas site as a link in a California-Nevada H_2 corridor.

Acknowledgments

The invaluable contributions made by the following individuals in achieving the progress reported here is gratefully acknowledged:

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