VI.C.3 NextEnergy Center Microgrid and Hydrogen Fueling Facility*

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Project End Date: July 13, 2008
(3 years of operation)

*Congressionally directed project

Objectives

- To support the DOE "Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project" in the greater Detroit area.
- To integrate, within a core urban environment, critical hydrogen infrastructure components and systems for multi-use operations.
- To optimize integrated, system-based solutions to advance hydrogen infrastructure for vehicular and stationary distributed power generation use.
- To provide a flexible "test" platform to advance the development and validation of commercial-type on-site generation technologies.
- Beyond delivery of the physical facilities, NextEnergy Center will contribute to:
  - Advancement of hydrogen-related codes and standards within a core urban center.
  - Site safety studies and plans.
  - Use by industry and government as a learning, validation and demonstration platform.
  - Use by institutions as a teaching and research site.
  - Public education and outreach center for the demonstration and understanding of hydrogen and related alternative energy technologies.
  - Potential for dedicated vehicles (fleet demos) and public transit opportunities.
  - An economic development site for companies and government entities interested in co-locatation opportunities.

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section (3.5.4.2) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(C) Hydrogen Refueling Infrastructure

(E) Codes and Standards

Contribution to Achievement of DOE Technology Validation Milestones

The NextEnergy Hydrogen Station will contribute to achieving the DOE technology validation milestone from Appendix B of the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 13: Total of eight stations and four maintenance facilities constructed using advanced sensor systems and operating procedures.** The NextEnergy station is being constructed to comply with the most recent published codes and standards. As a result, the Vehicle Fueling Station will employ a gas and flame detection system and the most recent requirements for the dispenser. Future phases will employ a sophisticated SCADA system that will use the most recent innovations in sensors and actuators integrated into a complete hydrogen monitoring and control system. NextEnergy's operating procedures will be state-of-the-art and will be developed within the frame work of an integrated management system that is being created to be ISO 9000 and ISO 14001 compliant.

Accomplishments

The NextEnergy Hydrogen Station is currently under construction.

- Completed Phase 1 of the project in June 2005 which supplied gaseous hydrogen to the NextEnergy Microgird.

Introduction

In October 2002, NextEnergy was organized as an independent Michigan 501(c)(3) non-profit corporation. Shortly thereafter, the Michigan Economic Development Corporation provided a $30 million seed grant to NextEnergy to build its facility, energy infrastructure, and associated programs. Subsequently, NextEnergy was approached by partners in industry (predominantly automotive OEMs) with interest in utilizing a hydrogen fueling station at the site to serve their needs for hydrogen-related demonstration and validation. This opportunity resulted in a DOE administrated award that envisioned a site capable of generating, storing and distributing hydrogen for vehicle fueling, distributed generation assets and use in R&D applications.

Through interactions with alternative fuel technology developers the original design has evolved to accommodate the ability to install and test a wider array of alternative fuel technologies. NextEnergy is currently developing projects with many of these proponents to utilize its physical assets to demonstrate the performance of technologies ranging from fuel cell vehicles to large, stationary fuel cell distributed generators to reformers utilizing higher energy density liquid fuels for ultra pure hydrogen generation.

Approach

The NextEnergy Center Microgrid and Hydrogen Fueling Facility construction is divided into five phases. Phase 1 was completed in June 2005 and provides gaseous hydrogen to the NextEnergy Microgrid. The NextEnergy Microgrid consists of eight test bays that are supported by interconnections for both fuel delivery and power generation. It is interconnected to the local electric utility grid and can operate in a grid connected mode, a grid parallel mode and an islanded mode. The test bays are designed to accommodate the demonstration and testing of pre-commercial distributed generation technologies.

Phase 2 focuses on the vehicle fueling portion of the facility. In January 2006 the contract to construct this portion of the facility was awarded. Phase 2 is scheduled for completion in July 2006 in co-operation with DaimlerChrysler and the BP America Production Company.

Phases 3 and 4 include the build-out of the ground storage, associated electrical and mechanical control and protection systems, the ability to store and deliver liquid feedstock, the development of five test bays that will accommodate alternative energy equipment for testing and demonstration and the delivery of one methanol-to-hydrogen reformer. Phase 3 is scheduled for completion in December 2006 and Phase 4 in March 2007.

Phase 5 includes the delivery of the next generation of methanol-to-hydrogen reformer scheduled for installation in March 2008.

Results

The build-out of the Hydrogen Station has provided many insights into the development of this type of station. A detailed description of the Project Schedule Status is given in Table 1. In addition, we have experienced the following “lessons learned” so far during the construction phase.

Safety Reviews

Due to the need to continue to operate Phase 1 while the Phase 2 work was proceeding, a significant effort was dedicated to the analysis of the design and construction methods from both a functional perspective (failure mode effects analysis) and a hazard operability perspective (hazard identification analysis). All of the major proponents of the project participated in this exercise and each utilized their own methodology to uniquely analyze the work. These unique analyses were then synthesized into a composite strategy that was scrutinized by a team from the DOE Hydrogen Safety Review Panel and ultimately implemented to govern how the work was performed. The outcome of this review will provide an excellent basis for Phases 3 through 5 and should provide important “lessons learned” for implementing hydrogen facilities in urban settings that cannot be taken out of service during construction.

Gas and Flame Detection System

Subsequent to the granting of the DOE award but prior to the submission of the detailed Phase 2 design for permitting, the National Fire Protection Association (NFPA) Code 52 was modified to include the requirement for a hydrogen gas and flame detection system. This requirement was addressed by all of the major proponents including Air Products and Chemicals Inc., the station equipment supplier. This scrutiny has resulted in a system that incorporates the latest detection equipment and meets the letter of the code. It will provide an excellent test of how a system designed to fulfill this requirement under NFPA 52 will perform under real world conditions.

Vehicle Fuel Cell Hydrogen Purity

The ability to economically supply high purity hydrogen was to be addressed in Phase 2. The original design called for the use of a new in-line filter design that would have allowed industrial grade hydrogen (i.e. 99.95% pure with less than 10 ppm CO and 5 ppm H_2O)

T**ABLE 1.** Project Schedule Status

Task Schedule

Task Number	Project Milestones	Task Completion Date				Progress Notes
		Original Planned	Revised Planned	Actual	Percent Complete	
1	Preliminary Design for Phases 1 – 5 & Phase 1 Detailed Design & Construction	04/29/05	08/19/05	06/21/05	100%	Complete
2	Phase 2 Detailed Design	07/29/05	12/22/05	12/02/05	100%	Complete: Delayed due to DOE funding approval & commercial negotiations with Cost Share partners
3	Phase 2 Equipment Procurement & Construction	12/02/05	07/28/06		95%	On-Track: Delay due to safety review of modified H2 supply method.
4	Phase 2 Commissioning & Site Acceptance Testing	12/30/05	07/28/06		95%	On-Track: Completion delayed per #3 above.
5	Phase 3 Detailed Design	10/28/05	08/15/06		20%	Start date 06/01/06: Delay due to Phase 2 Safety Review Process
6	Phase 3 Equipment Procurement & Construction	05/12/06	01/15/07		0%	On-Track
7	Phase 3 Commissioning & Site Acceptance Testing	06/02/06	02/15/07		0%	On-Track
8	Phase 4 Detailed Design	01/27/06	08/15/06		20%	Start date 06/01/06
9	Phase 4 Equipment Procurement & Construction	09/01/06	03/15/07		0%	On-Track
10	Phase 4 Commissioning & Site Acceptance Testing	10/02/06	03/31/07		0%	On-Track
11	Phase 5 Detailed Design	12/22/06	11/30/07		0%	On-Track
12	Phase 5 Equipment Procurement & Construction	08/31/07	03/14/08		0%	On-Track
13	Phase 5 Commissioning & Site Acceptance Testing	10/01/07	03/31/08		0%	On-Track

to be supplied to the site and then purified to deliver hydrogen that would meet the new SAE J2719 Hydrogen Purity Specification Guideline.

The U.S. industrial gas supplier infrastructure cannot easily accommodate economically delivering small quantities of high purity hydrogen in gaseous form. At an integrated demonstration site like NextEnergy, our hydrogen usage profile tends toward needing a lot of mass at lower pressure and industrial grade purity punctuated by the need for much smaller amounts of mass at much higher pressures and purity for fuel cell vehicle applications. This suggests that a lower cost, in-line filter could be a very useful piece of equipment for the industry.

NextEnergy sourced a U.S. manufacturer of such a filter and incorporated it into the Phase 2 design. The preliminary economic analysis showed that a simple payback of less than six months would be easily achievable when compared to the cost of purchasing the higher purity hydrogen from conventional sources.

Unfortunately, the filter design-build firm could not meet the flow requirements for the vehicle fueling station compressor so this component could not be incorporated into the Phase 2 design. However, NextEnergy is still fully committed to this design concept and will attempt to incorporate the filter into a future phase of this project.

Since this revelation, NextEnergy has spent considerable time sourcing gaseous hydrogen where the vendor repeatedly delivers gas of acceptable purity. Most industrial gas suppliers (IGSs) use a “drop & swap” delivery strategy. This strategy allows the IGS to deliver a fully charged tube trailer to the client and to pick-up the empty unit at the same time. The empty unit is then brought to any number of IGS sites for filling for the next delivery. The returning tube trailer

is not purged so any residual hydrogen is commingled with the new hydrogen. The new hydrogen can vary in purity depending on the source (i.e. IGS location). This results in a composition that is unique and cannot be guaranteed. This strategy does not usually present a problem. However, when the client needs a guaranteed supply of high purity hydrogen the "drop & swap" arrangement is not acceptable. This need has caused two national IGSs to decline to service the NextEnergy account. Their recommended solution was to serve our low-mass, high-purity load with 12 packs. These units are much more controlled in terms purity (i.e. filling procedure) and repeatability.

NextEnergy has found one supplier that can consistently supply acceptable purity hydrogen in bulk. This IGS relies on tube trailers to transport the hydrogen to their clients within a region and then off load the hydrogen from the tube trailer to ASME-based ground storage. This strategy works because the tube trailers are always filled from the same liquid source so the "residual" gas purity is not a factor. In NextEnergy's specific case, this IGS utilizes two tube trailers to service their Michigan clients.

Conclusions and Future Directions

NextEnergy will continue to build-out the Hydrogen Station according to the Table 1 schedule.

NextEnergy will develop a revised set of project control documents that reflect the "lessons learned" from the Phase 2 Safety Reviews. NextEnergy will complement the project control documents with a complete integrated management system that complies with ISO 9000 and 14001 and includes an emergency response plan, a safety management system and a complete set of facility operating procedures and facility maintenance procedures. This work is outside of the scope of the current DOE award.

NextEnergy will monitor the performance of the gas and flame detection system with particular attention focused on the system's reliability with respect to false alarms.

NextEnergy will pursue the development of the in-line purifier that we were unable to incorporate in Phase 2 due to flow constraints.

NextEnergy is working with several other industry parties to develop a 700 barg (10,000 psig) gaseous storage and vehicle dispensing demonstration project. Details are being developed now and the outcome may mean a re-design of the hydrogen storage system and the installation of a 700 barg vehicle dispenser and compressor.

The ability to accommodate 700 barg storage, compression and dispensing, to provide liquid feedstock fueling and to accept and distribute generated electrical power is outside of the scope of the current DOE award and will not be funded by this award. However, NextEnergy believes that it is important to integrate these future capabilities into the design to make this facility as versatile as possible for future demonstrations. Therefore, the interfaces to these future sub-systems will be considered in the Phase 3 and 4 designs.

FY 2006 Publications/Presentations

NextEnergy has referred to the Microgrid and Hydrogen Fueling Facility in several overview-type presentations to a variety of audiences including:

- Authorities Having Jurisdiction.
- Federal and State government departments.
- National labs such as Oak Ridge National Lab and the National Renewable Energy Lab.
- National organizations such as the Society of Automotive Engineers, the Institute of Electrical and Electronic Engineers and National Association of State Fire Marshals.
- Several educational institutions.
- Delegations from foreign governments and organizations such as Singapore and the Japanese Automotive Research Institute.
- Companies that are interested in working with NextEnergy on future alternative energy development projects.

NextEnergy has used the specific design parameters of the facility in presentations to the State of New Mexico and the State of Oklahoma in an attempt to develop joint projects with them.

NextEnergy has developed an emergency first responders presentation that utilizes some of the Center's features. NextEnergy has delivered this presentation throughout the State of Michigan.