XII.8 H-E-B Grocery Total Power Solution for Fuel Cell-Powered Material Handling Equipment

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Subcontractors:
- Airgas Southwest, San Antonio, TX
- Airgas Merchant Gases, Bozrah, CT
- Parkway Systems, San Antonio, TX

Project Start Date: September 1, 2009
Project End Date: August 30, 2011

Objectives

Validate DOE market transformation activities by demonstrating:

- Fuel cell-powered forklifts operating in a high-usage, highly transient mobility application.
- An on-site natural gas-based hydrogen generation and refueling station as a precursor to future distributed automotive fuel cell refilling stations.

Relevance to the American Recovery and Reinvestment Act (ARRA) of 2009 Goals:

- Stimulate use of emerging technologies – additional investment by H-E-B is anticipated, without ARRA funding.
- Develop jobs and job skills (manufacturing, product development, repair and maintenance) in clean energy growth industries.
- Develop product and performance improvements to make fuel cells and hydrogen refueling equipment commercially viable.

Technical Barriers Addressed

- Reliability of technology (fuel cell systems and hydrogen generation, storage, and compression equipment) used in a highly demanding materials handling application and environment.
- Durability of fuel cell systems and hydrogen generation, storage, and compression equipment.
- Quantification of costs associated with operation and maintenance of all equipment.
- Proper safety planning and safe operation of all equipment.
- Safe hydrogen use indoors, in high-throughput, high-density distribution center.
- Obtaining necessary permitting for motive fuel cell power units and hydrogen generation and refueling equipment, requiring collaboration of authorities having jurisdiction (AHJs), the industrial truck fleet manager, the environmental health and safety (EHS) coordinator, and the industrial truck equipment provider.
- Obtaining insurance coverage for the use of all equipment.
- Availability of hydrogen generated on-site from a steam methane reformer.

Technical Targets and Milestones

- Install 14 proton exchange membrane (PEM) fuel cells in Class II forklift trucks and operate for two years in produce and dry goods grocery distribution centers.
- Generate hydrogen on-site from natural gas to support forklift truck fleet and maintain 100% availability of hydrogen at the pump through combination of hydrogen generator and hydrogen tube trailer backup.

Accomplishments

- Built a permanent PowerTap hydrogen refueling station and introduced 14 PowerEdge systems into 24/7 service at a grocery distribution center owned and operated by a nationally recognized industry leader.
- Generated 11,002 kg of hydrogen on site through July 2011.
- Maintained >99% hydrogen availability at the pump for forklift refueling.
- Logged 21,899 operating hours on 14 PowerEdge fuel cell power units through July 2011.
- Demonstrated 10% productivity gain associated with fuel cells vs. lead acid batteries.

- Redesigned the next generation PowerEdge system for greater performance and reliability.
- Obtained field data that has been fundamental in next-generation PowerEdge fuel cell system and PowerTap hydrogen refueling equipment designs.
- Provided extensive data on PowerTap and PowerEdge performance to the National Renewable Energy Laboratory.

Introduction

H. E. Butt Grocery Company, Inc. (H-E-B) is a privately-held supermarket chain with 310 stores throughout Texas and northern Mexico. The company agreed to convert a portion of its lift truck fleet to fuel cell power to verify the value proposition and environmental benefits associated with the technology. H-E-B management believes that fuel cell forklifts can help alleviate several issues in its distribution centers, including truck operator downtime associated with battery changing, truck and battery maintenance costs, and reduction of grid electricity usage. It is also interested in other uses of hydrogen produced on site in the future, such as for auxiliary power units used in tractor-trailers in its fleet.

Currently, the H-E-B distribution center operates a total of approximately 300 Class II reach trucks and 700 Class III pallet jacks over two work shifts, for a total of 20 hours per day. There are three temperature zones in the facility, ranging from dry goods at ambient temperature, to refrigerated goods at 34°F (1°C), to freezer goods at -13°F (-25°C). The PowerEdge units provided are powering Class II fork lift trucks that were designed for use with 1,000 Ah lead acid batteries, and are capable of operation in both the ambient and refrigerated goods temperature zones of the San Antonio facility. Data collected from this initial installation will enable H-E-B to make economic decisions on expanding the fleet of PowerEdge and PowerTap units in the company.

Approach

In order to verify compatibility of the PowerEdge fuel cell power units with H-E-B's forklift fleet, information was gathered regarding truck make and model and usage profile within H-E-B's grocery and produce distribution centers. Power monitoring of the trucks was undertaken in order to confirm that the duty cycle was achievable with the PowerEdge product, and to determine the number of units that could be supported by a PowerTap system producing 50 kg/day of hydrogen. We determined that 14 PowerEdge systems could be supported by the PowerTap production capacity, which is how that number of forklifts was chosen for repowering.

A site-specific installation plan was prepared that detailed where all hydrogen generation, compression, storage, and dispensing equipment would be placed. As the site plan was being developed, the PowerTap and PowerEdge equipment was manufactured and delivered to the H-E-B facility, where it was installed in accordance with required codes and standards. Upon final sign-off from both the local AHJ and the insurance carrier, the forklift fleet was deployed for operation in the grocery and perishable sections of the distribution center alongside forklifts operating with standard lead-acid batteries. Side-by-side operation allows H-E-B to assess the value associated with the PowerEdge and PowerTap products compared with conventional battery technology.

Results

As presented in Table 1 below, the build of all 14 PowerEdge systems and the PowerTap hydrogen refueling equipment was complete as of October 30, 2009. In parallel, Nuvera application engineers, working with H-E-B facility engineers, created site-specific service and installation plans. Nuvera and H-E-B's EHS coordinator also developed a comprehensive safety plan, which was reviewed by a DOE-appointed safety panel over the last 6 months.

TABLE 1. Work Breakdown Schedule

Task #	Project Milestones	Milestone Completion Date			
		Original Planned	Revised Planned	Actual	Percent Complete
1	Build	10/30/09		10/30/09	100%
2	Site Plan	10/30/09		10/30/09	100%
3	Deployment	11/30/09	2/28/10	2/28/10	100%
	Go/No-Go: 2 PowerEdges Productivity Trial; certify passing of FAT; permitting and approvals	11/30/09	12/30/09	12/30/09	100%
4	Confirm Value Proposition	5/31/11	5/31/11		100%
5	Final Testing	8/31/11	8/31/11		0%
6	Project Management & Reporting	8/31/11	8/31/11		96%

FAT – factory acceptance test

A total of 60 H-E-B forklift operators received hydrogen and fuel cell training. Based on the agreed site plan, Nuvera identified and provided basic training to two local fuel cell service personnel, who work for an H-E-B wholly-owned subsidiary, Parkway Systems. The role of the Parkway service provider is to keep the PowerEdge systems operational by providing a fast response to diagnosing system faults and repairing the units. This type

of service includes scheduled preventive maintenance, basic troubleshooting, and the repair or replacement of non-safety critical items. Nuvera's Customer Care group provides spare parts, training, data analysis, and more complex field support, including troubleshooting and repairs of safety-critical items (high pressure, high voltage). Nuvera also trained and qualified three Airgas personnel (two from Airgas Southwest, the local service provider, and one from Airgas Bozrah, responsible for 24-hour hydrogen system monitoring) for Tier 1 service of the PowerTap hydrogen generator and the PowerTap hydrogen station (compression, storage, dispensing).

During this process, all relevant codes and standards were identified, and working with the AHJ and the H-E-B insurance carrier, all permits were obtained for site construction, installation, and operation.

The deployment process began upon establishing the final site plan and was completed on February 28, 2010.

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In May 2010, H-E-B conducted an analysis to determine whether any productivity benefits were realized in association with the fuel cell forklift conversion. H-E-B concluded that the fleet was 10% more productive than it was running on lead acid batteries, a combination of the elimination of the battery changing task and the improved performance of the trucks. The equipment maintenance supervisor also noted a marked decrease in motor controller failures on lift trucks running on fuel cells, a consequence of the elimination of voltage sag associated with batteries. As part of the project conclusion, H-E-B is quantifying the value proposition benefits.

PowerEdge Fuel Cell Systems

Over the first three months of operation, H-E-B reported an increase in productivity of 10% for the PowerEdge systems compared to forklifts running on batteries.

As part of the ongoing program, Nuvera provides data to the National Renewable Energy Laboratory using jointly-agreed data templates. Information collected during the course of daily operations includes the following:

- Power pack fault code indication
- Service notifications
- Operating status
- Fuel cell run time
- Fuel cell power
- Total kWh energy produced
- Total kWh energy consumed

The full fleet of 14 fuel cell-powered trucks was operational until July 2010, when hot weather combined with several other factors caused reliability of the systems to suffer and to negatively impact operations. Since these issues were disruptive to H-E-B's operations, Nuvera scaled back the number of units in service. We identified the root causes of the problems and determined the required corrective actions. The solutions were implemented on four operational PowerEdge fuel cell units in early October, 2010. The solutions were validated, and Nuvera implemented them on the remaining 10 PowerEdge units and introduced them back into service in December 2010.

PowerTap Hydrogen Generation and Refueling Systems

Figure 1 shows the amount of hydrogen provided at the site from the PowerTap system and from the back-up tube trailer. The percent of hydrogen supplied by PowerTap is also indicated. Note that reduced usage from July through November reflects reduced fuel cell fleet size.

Conclusions and Future Directions

- Our next generation PowerEdge system design will address performance and reliability issues that have surfaced in this demanding application. Specifically, our new product for the reach truck application will:
  - Replace the 'ultrabattery' with a lithium ion battery, which our analysis indicates will improve battery life to be on par with the remainder of the system (>20,000 hours).
  - Incorporate an 'auto-on' feature to turn the PowerEdge unit on in the event that the truck is being used but the operator has neglected to also start the fuel cell system.
  - Incorporate a fuel cell stack with approximately twice the power rating at end of life (10 kW) as the current system.
  - Incorporate more robust power circuits.
  - Improve controls to extend stack life.
- Similarly, the next generation PowerTap design will incorporate improvements required for satisfactory operation in a demanding materials handling application, including the following:
  - A solution to avoid water pump damage associated with superheated steam.
  - A controls upgrade to avoid reformate compressor wear.
  - A higher capacity desulfurizing system to avoid sulfur breakthrough.
- H-E-B has determined that fuel cells are their preferred motive power source for reach trucks. They have already set aside the budget required for expanding the fleet by purchasing 28 additional PowerEdge units, pending a demonstration of acceptable performance of our next generation higher power system. The increased fleet size will required the addition of two PowerTap systems.

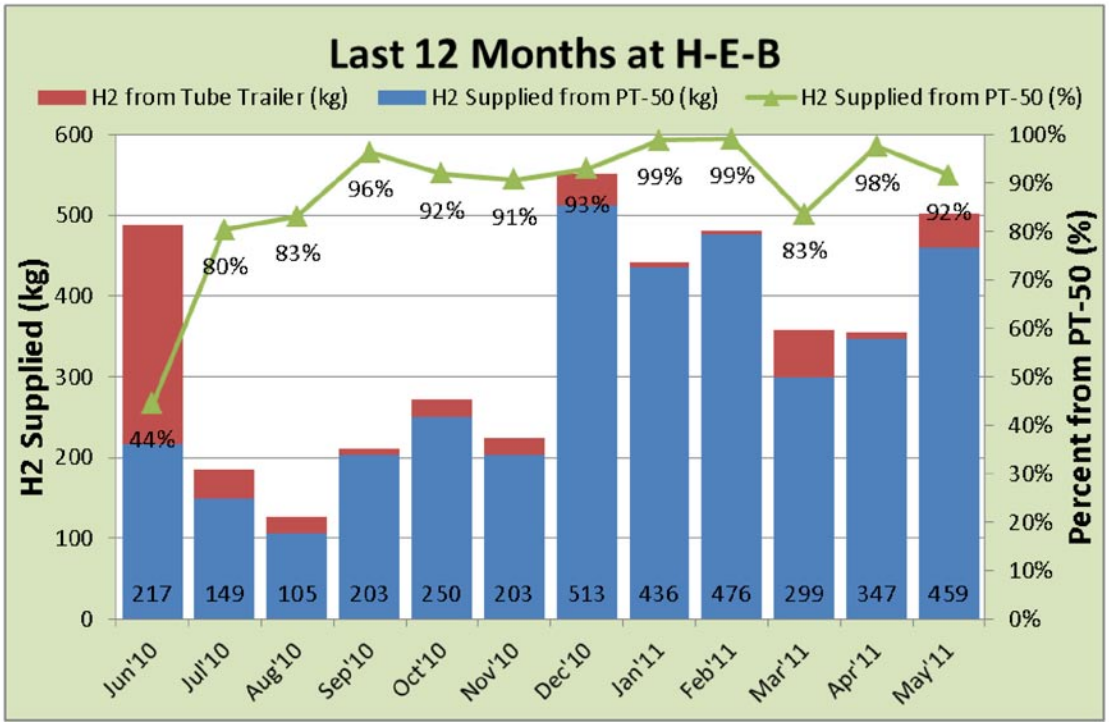

FIGURE 1. PowerTap PT-50 Usage and Reliability at H-E-B, June 2010 through May 2011

FY 2011 Publications/Presentations

1. Gus Block, *H-E-B Grocery Total Power SolutionTM for Fuel Cell Powered Material Handling Equipment,* 2011 U.S. Department of Energy Hydrogen Program and Vehicle Technologies Program Annual Merit Review and Peer Evaluation Meeting, Washington, D.C., May 13, 2011.