VII.10 Hydrogen and Fuel Cell Analysis: Lessons Learned from Stationary Power Generation

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Contract Number: DE-FG36-07GO17107

Project Start Date: October 1, 2007
Project End Date: September 30, 2009

Objectives

Three main project objectives include:

- quantifying and critical analyzing lessons learned from stationary power programs,
- demonstrating best practices, and
- recommending research, development and demonstration (RD&D) strategy related to stationary fuel cells.

Sub-objectives include:

- consideration of environmental and safety concerns,
- education of key stakeholders, and
- delineating early market applications and transformation.

Technical Barriers

This project primarily addresses the following technical barriers from the Systems Analysis section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Future Market Behavior

Contribution to Achievement of DOE Systems Analysis Milestones

This project will contribute to achievement of the following DOE milestones from various sections of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

3.2.6 Task 1: Delivery Infrastructure Analysis

- Milestone 2: Identify cost-effective options for hydrogen delivery infrastructure to support the introduction and long-term use of hydrogen for transportation and stationary power. (4Q, 2007)

4.7 Task 1: Perform Studies and Analysis

- Milestone 4: Complete a “lessons learned” study of the development of other infrastructures which apply to hydrogen fuel and vehicles. (4Q, 2008)

3.4.6 Task 8: Stationary and Other Early Market Fuel Cells

- Milestone 67: Determine whether to continue stationary fuel cell system R&D based on progress towards meeting targets. (4Q, 2011)

3.7.4 Task 4: Domestic Standards

- Milestone 21: Completion of necessary codes and standards needed for the early commercialization and market entry of hydrogen energy technologies. (4Q, 2012)

Accomplishments

- Compilation and data collection related to projects and programs.
- Distribution of online survey and hosting of Stationary & Portable Fuel Cell Market Transformation and Applications Workshop.
- Analysis of lessons learned, draft best practices and strategy recommendations.

Introduction

This study is considering opportunities for hydrogen in stationary applications in order to make recommendations related to RD&D strategies that incorporate lessons learned and best practices from relevant national and international stationary power efforts. The study will identify the different challenges and opportunities for producing and using hydrogen as an energy carrier. By identifying the lessons learned from prior stationary power programs, including the most significant obstacles, how these obstacles have been approached, outcomes of the programs, and how this information can be used by the Hydrogen, Fuel Cells & Infrastructure Technologies Program to overcome barriers and achieve milestones related to the implementation of fuel cell technologies for distributed stationary power.

Approach

The approach consists of compilation and classification of programs, establishment of contacts, program data collection, including questionnaires, workshops, and site visits. Finally, lessons learned and best practices are being analyzed to develop strategy recommendations. The information collected is currently being incorporated into the analysis leading toward lessons learned and best practices for stationary fuel cell research and development, as well as early market penetration and market transformation. The lessons learned from the programs are being used in order to establish best practices and provide recommendations for a hydrogen strategy that addresses opportunities for hydrogen in stationary power generation systems. As required, this strategy will analyze all hydrogen pathways and a combination of distributed power generating stations, and provide an overview of stationary power markets, benefits of hydrogen-based stationary power systems, and competitive and technological challenges.

Results

To date, nearly 100 respondents have participated in the survey. By acquiring the fuel cell customer/end-user opinion on the current status of the stationary fuel cell market, we have gained knowledge pertaining to what steps need to be taken to make recommendation on how to bring more customers into the fuel cell market.

One of the initial questions asked was to provide information on how many years had elapsed between initial planning and implementation of their fuel cell project. It is important to evaluate this duration of time as to better understand how much time was spent for risk analysis, budget management, cost-benefit analysis, and verifying that their site met applicable codes and standards. Of the respondents who were able to answer the question with confidence, 59.4% of the respondents stated the time between initial planning and implementation was 2 years or less. This shows quick action was taken to get a large majority of the projects operational and that few obstacles stood between initial planning and actual implementation. Also, 69.0% of the projects became operational between the years of 2005 and 2008, which shows there has been a large push for fuel cell implementation in recent years. This push is most likely due to factors including support for alternative energy solutions, rising energy costs, and environmental reasons. The duration of time in which the fuel cell was in operation is also a critical statistic for this study since initial planning incorporates a significant portion of initial costs.

Figure 1 shows the largest percentage of the respondent's fuel cells are still in operation, which indicates a correlation to a trend of increasing life expectancy of fuel cells. Although the 24.14% of projects with less than one year of operation seems to point to the contrary of the earlier statement, further analysis of the data shows that most of these projects had less than a one year lifespan because the purpose of those projects was for proof of concept and demonstration. Since proof of concepts and demonstrations rarely last longer than one year, it is apparent why 24.14% of the respondents had a project whose lifespan of less than one year.

Another important category of questions asked the respondents to discuss the types of application implemented in their program, which type of fuel cell was installed, and what type of fuel was used in the program. Not surprisingly, the vast majority of fuel cell projects were fueled by hydrogen and natural gas, 51.5% and 24.2%, respectively, with other fuel sources being JP-8 (kerosene-based jet fuel), LPG (liquefied petroleum gas), and methanol. This supports the opinions of many fuel cell advocates, which suggest hydrogen could be the future for both stationary and transportation alternative energy power applications.

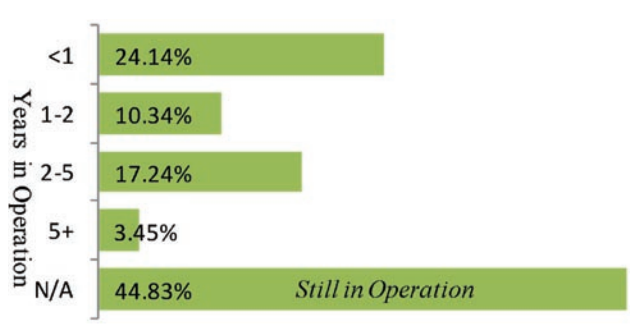

FIGURE 1. Responses to Question 5, "If the fuel cell is no longer operational, how many years did it operate?"

The popular types of applications used by the pool of respondents were backup power, material handling equipment, and grid independent power. From the data shown in Figure 2, backup power shows to be the typical application used in the respondents' programs.

Intriguingly, of those types of applications shown in Figure 2, 37.0% were grid connected systems, which encourages optimism for future fuel cell projects that wish to take advantage of grid connected systems and the opportunities they provide for backup power and reliability.

As shown in Figure 3, the range of answers was wide when the respondents were asked to describe the cost-effectiveness of the program in terms of investment vs. market success/failure. Successful programs highlighted the fact that their fuel cells operated excellently without constant maintenance, high initial costs were subsidized (by the government), ability to promote "green" behavior, and the repeatability of demonstrations. Whereas reasons for unsuccessful programs included success in proving technology but total investment did not lead to proving the cost effectiveness of the fuel cell solution, high initial investment, and varying regional energy prices. Programs which were in need of constant power for primary power applications discovered problems pertaining to constant fuel cell durability along with significant delays in acquiring spare parts for failed components.

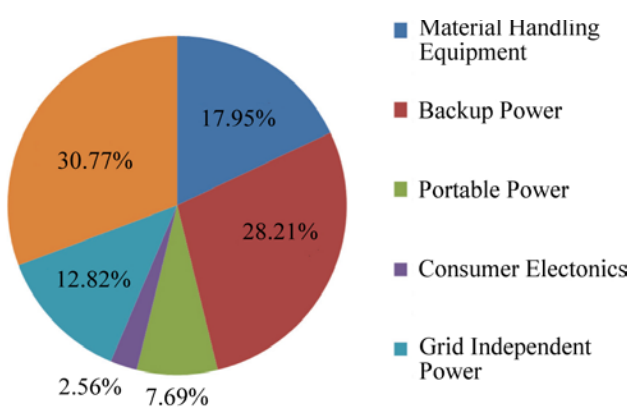

FIGURE 2. Responses to Question 7, "What type of application was implemented in your program?"

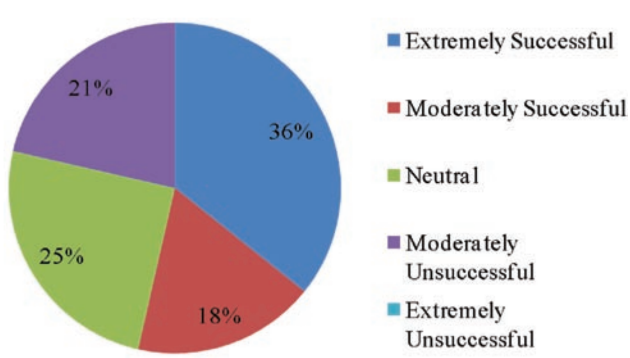

FIGURE 3. Responses to Question 21, "How would you describe the cost-effectiveness of the program (investment vs. market success/failure)?"

In addition, feedback gathered through site visits and a workshop are being incorporated into the results. A wide variety of lessons learned, best practices, and suggestions for early market development strategies, as well as opinions on what actions should be taken regarding policies for promotion of technical RD&D were compiled.

Conclusions and Future Directions

Research continues on the ***preliminary conclusions***:

- The role and use of hydrogen fuel cells in stationary applications can be significant in portable applications, niche markets, distributed generation or co-generation.
- Market penetration is the ultimate goal of the energy related industries, but early markets must be strategically aligned with balancing near-term and long-term objectives.
- Focus on demonstrating that cost, durability, and reliability can be met for early markets (with incentives, if necessary).
- Consider opportunities and trade-offs for stationary applications in conjunction with the other application sectors, e.g., providing fuel for transportation applications.
- Take a systems perspective – components should address multiple systems.

A related response was also provided for Request for Information DE-PS36-09GO3900.

Special Recognitions & Awards/Patents Issued

1. "Stationary & Portable Fuel Cell Market Transformation and Applications Workshop", Held at *National Hydrogen Association Annual Conference and Expo*, Columbia, April 2, 2009.

FY 2009 Publications/Presentations

1. Cottrell, C.A., Thomas, M., and Grasman, S.E., "Best Practices for Stationary and Portable Fuel Cell Markets", *World Congress of Young Scientists on Hydrogen Energy Systems*, Turin, October 2009.

2. Cottrell, C.A., and Grasman, S.E., "A Preliminary Study on Lessons Learned from Stationary and Portable Fuel Cell Applications", *Proceedings of the IIE Research Conference and Exhibition*, Miami, May 2009.

3. Grasman, S.E., "Hydrogen and Fuel Cell Analysis: Lessons Learned from Stationary Power Generation", *US Fuel Cell Council Member Meeting*, March 2009.

4. Grasman, S.E., "Hydrogen and Fuel Cell Analysis: Lessons Learned from Stationary Power Generation", *US Fuel Cell Council Webinar*, November 2008.

5. Grasman, S.E., "Transitional Hydrogen Supply Chain Modeling", *INFORMS National Meeting*, Washington, DC, October 2008 [invited].