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

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Objectives

Two main project objectives include:

- a synopsis/critical analysis of lessons learned from stationary power programs, and
- best practices and strategy recommendations for stationary fuel cells.

Sub-objectives include:

- consideration of environmental and safety concerns, and
- education of key stakeholders.

Technical Barriers

This project addresses the following technical barriers from the Systems Analysis section (4.5) 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)

3.4.6 Task 8: Stationary and Other Early Market Fuel Cells

- **Milestone 67:** Determine whether to continue stationary fuel cell system research and development (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)

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)

Accomplishments

- compilation and data collection related to projects and programs, including over 2,500 projects, state, national, international and multinational programs, as well as over 1,000 fuel cell developers, and
- draft lessons learned and best practices.

Theses related primarily to determination of future stationary fuel cell systems R&D directions.

Introduction

This study is considering opportunities for hydrogen in stationary applications in order to make recommendations related to research, development and demonstration strategies that incorporate lessons learned and best practices from relevant national and international stationary power efforts, as well as cost and environmental modeling of pathways. The study will analyze the different strategies utilized in power generation systems and will identify the different challenges and opportunities for producing and using hydrogen as an energy carrier.

The motivation for this project is to identify 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. In order to understand how to prepare the future for this technology, this study will conduct a thorough investigation of past alternative stationary power projects throughout the world in order for an assessment of the opportunities for and interactions of joint stationary and transportation hydrogen sectors to be completed.

Approach

The lessons learned from the programs will be 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.

The approach consists of compilation and classification of programs, establishment of contacts, program data collection, including questionnaires and site visits. Finally, lessons learned and best practices will be analyzed to develop strategy recommendations.

Results

Results are presented corresponding to project tasks.

- **Task 1.0: Compilation and Classification of Programs**
  A listing of past and existing programs is currently being developed and classified. The main focus is on 5 kW to 200 kW systems, primarily proton exchange membrane fuel cells, but also with more general technology. The current technology status, i.e., what is currently installed, and applications, e.g., telecommunications, backup power, and larger applications, are being delineated in order to identify lessons learned. The current focus is on stationary power generation, but the interrelationship with the transportation sector should also be understood and will be addressed later.
  - **Subtask 1.1: Compilation of Programs**
    A substantial list of programs has been identified based on DOE-funded projects, as well as some international programs. This list will continue to be expanded, but provides a basis for program data collection. A significant amount of academic literature, press releases, program announcements, and other related documentation continues to be archived.
  - **Subtask 1.2: Classification of Programs**
    The programs are being classified in order to develop the combination of surveys and site visits required to ascertain complete lessons learned. Initial classification is related to size, type, and location of project, relevant dates, funding sources, and available documentation. This classification is ongoing.
  - **Subtask 1.3: Establishment of Contacts**
    The contact list is being updated along with compilation and classification of the programs. Some of these contacts will be used for program data collection, while others will be used for project review. These contacts constitute the target audience for the Missouri S&T sponsored workshop and advisory committee.
- **Task 2.0: Program Data Collection**
  A questionnaire has been developed as a means of collecting data related to compilation/classification of projects and establishment of contacts. The questionnaire will also be used to establish a preliminary list of lessons learned and best practices.
  - **Subtask 2.1: Questionnaires**
    The questionnaire consists of two main components. The first part solicits program information in order to validate the compilation and classification performed in Task 1 (and to make any necessary modifications). The second part specifically solicits information related to technology status at the time of introduction, strategies used for the introduction of the stationary power technology, consumer behavior and attitudes, as well as industry participation or lack thereof, impact of infrastructure availability, including environmental benefits/impacts, cost-effectiveness of the program (investment vs. market success/failure), description of challenges/solutions, major achievements

of the project/program or justification for lack of success, and financial status and competitiveness of industry. Respondents are also provided the opportunity to provide additional unsolicited input. The questionnaire is being finalized and prior to dissemination.

- **Subtask 2.2: Site Visit Plan**
  Concepts for site visits are in the preliminary stage.
- **Subtask 2.3: Site Visits**

Conclusions and Future Directions

To date, the project has focused on gathering information necessary for developing lessons learned and best practices. The next steps consist of complete analysis of lessons learned and best practices for stationary fuel cell R&D. It is anticipated recommendations will be provided related to early market penetration and market transformation.

Preliminary conclusions include:

- 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.

The remaining tasks are planned for the upcoming year. Of note is a planned workshop and sponsored session at the 2009 National Hydrogen Association Annual Hydrogen Conference.

- **Re-evaluation of Task 1.0**: Compilation and Classification of Programs and Task 2.0 Program Data Collection
- **Task 3.0: Analysis of Lessons Learned and Best Practices**
  - **Subtask 3.1: Data Preparation**
  - **Subtask 3.2: Lessons Learned**
  - **Subtask 3.3: Best Practices**
- **Task 4.0: Pathways Analysis**
  This task continues as part of ongoing research. The scope of this task needs to be finalized.
  - **Subtask 4.1: Supply Network Modeling**
  - **Subtask 4.2: Demand Growth Modeling**
  - **Subtask 4.3: Scenario Analysis**
- **Task 5.0: Strategy Recommendation**

FY 2008 Publications/Presentations

1. Dogan, F., Grasman, S.E., and Sheffield, J.W., "Fuel Cell and Hydrogen Transportation Test Bed Development at the Missouri University of Science and Technology", Global Conference on Global Warming, Istanbul, July 2008.

2. Grasman, S.E., Faulin, J., and Lera, F., "Public-Private Partnerships for Technology Growth in the Public Sector", IEEE International Engineering Management Conference, Estoril, Portugal June 28 – 30, 2008.

3. Grasman, S.E., and Martin, K., "Strategies for Stationary Power Generation", NHA Annual Hydrogen Conference 2008, Sacramento, California, March 30 – April 4, 2008.