IV.E.5 Analysis of Storage Needs for Early Motive Fuel Cell Markets

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Fiscal Year (FY) 2011 Objectives

- Identify needs for onboard energy storage in key early motive markets.
- Target early motive markets such as material handling equipment (MHE), ground support equipment (GSE), public transit, and unmanned vehicles.
- Identify gaps of current hydrogen storage technologies to the onboard energy storage needs.

Technical Barriers

This project addresses the technical barrier of a lack of knowledge of energy storage performance needs for early fuel cell motive markets.

Technical Targets

This project is investigating gaps of current hydrogen storage technologies against the needs of onboard energy storage in early motive markets. Insights gained from this investigation will be used to focus research and development (R&D) efforts in hydrogen storage technologies that can accelerate market adoption.

FY 2011 Accomplishments

- Organized and completed two workshops held in conjunction with the Fuel Cells and Hydrogen Energy Association conference and ProMat2011 expo.
- Summarized top needs for MHE and public transit onboard energy storage based on workshop breakout groups.
- Participated in "Utilizing Hydrogen Power as an Alternative Energy Source" and non-motive stakeholder workshop.
- Implemented Kano Method into questionnaire development and analysis to classify solution-independent customer needs.
- Completed and transmitted electronic questionnaire to key stakeholders and end-users in key early motive markets.
- Collaborated with Sandia National Laboratories (lead for similar activity with non-motive applications) and Pacific Northwest National Laboratory (lead for technology readiness assessment of hydrogen storage technologies).

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Introduction

The market adoption of non-motive fuel cell systems can be accelerated by improving storage system technologies. Effective improvements in hydrogen storage systems will result in extended product run times, increased productivity, decreased installation and operating costs, improved delivery methods, improved volumetric capacity, and facilitation of siting and permitting processes. These improvements can be achieved through focused R&D efforts based upon an in-depth understanding of storage requirements in key early markets. As fuel cell systems penetrate these early markets, increased manufacturing volumes, learning-by-doing, and technology advancements will result in cost reductions and performance improvements. Additional market opportunities will open up for fuel cell systems as they become established in key early markets. Early motive fuel cell markets with hydrogen storage can be categorized in three segments:

- **Material Handling and Ground Equipment.** This market includes traditional forklifts and pallet jacks for material handling in warehouses and manufacturing facilities, as well as other ground equipment used in airports, mining operations, and grounds keeping/maintenance operations.
- **Public Transit.** This market includes transit services (urban routes, commuter and para-transit) and shuttle services (airport, campus and large events).
- **Niche Motive Markets.** These markets include applications for unmanned air vehicles, heavy-duty trucks, and other military motive applications.

Approach

NREL is identifying storage R&D needs for fuel cell systems for these early markets by obtaining information from the broad set of contacts. NREL is leveraging: 1) understanding of early motive market applications through data analysis in NREL's Hydrogen Secure Data Center, 2) expertise in hydrogen storage, and 3) existing industry contacts.

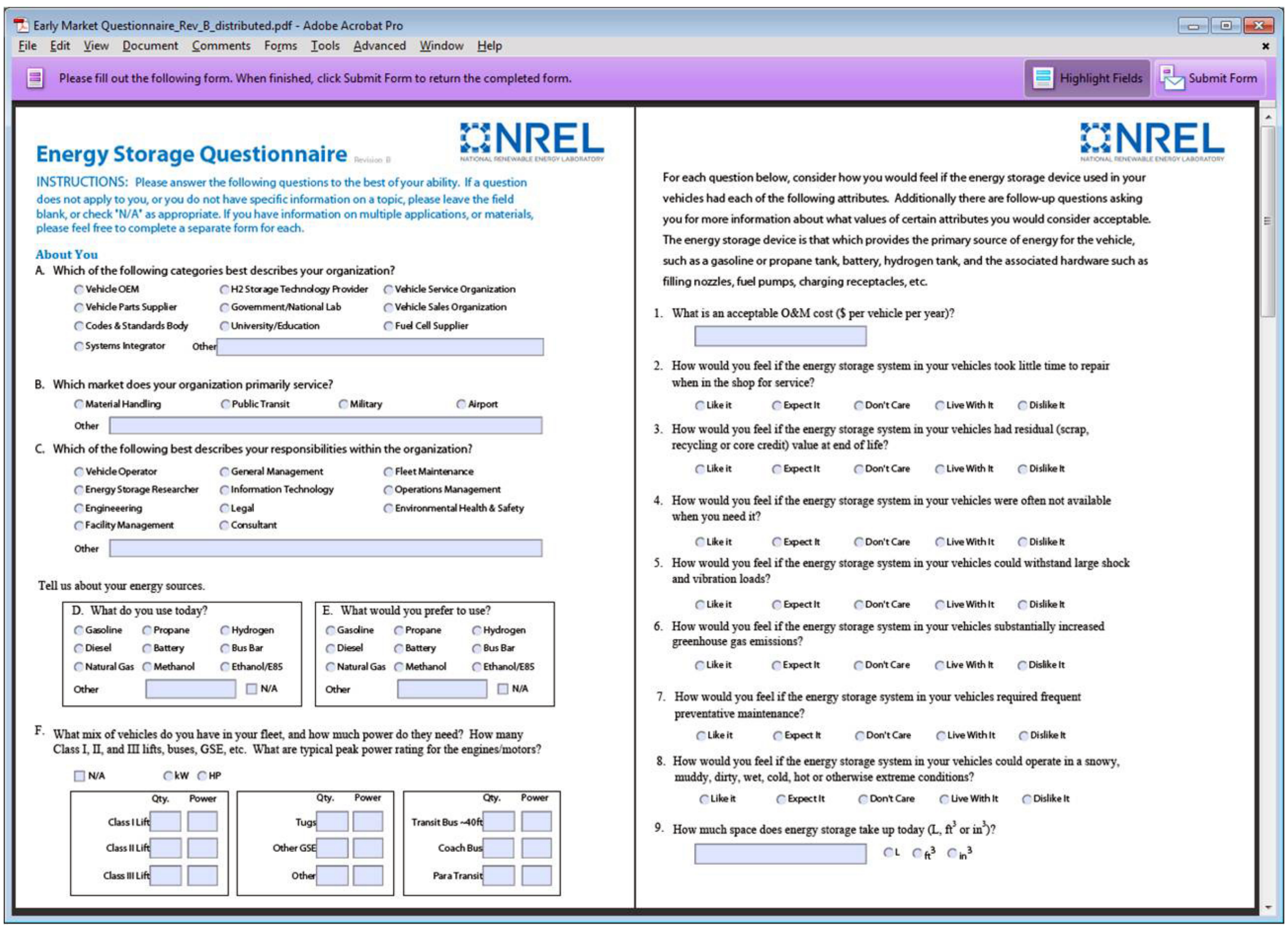
NREL used workshops for gathering and prioritizing hydrogen storage needs, dialog within and across applications, along with conducting interviews with individual companies. NREL is also using an electronic questionnaire designed to categorize the user's needs for onboard energy storage. The questionnaire is based on the Kano Method and identifies important performance metrics and the corresponding quantitative performance levels without specifying a storage technology. Response from the workshops and questionnaires are the basis for the analysis to detail performance gaps of existing hydrogen storage technologies.

Results

The majority of work completed to date has been focused on the information gathering and analysis preparation. Figure 1 is a snap shot of the first two pages of the electronic questionnaire. The questions are asked in positive and negative pairs along with a third question to gather the quantitative data. Topics covered in the questionnaire include run time, refueling, weight, volume, operation lifetime, operation conditions (e.g. temperature, shock and vibration, and environment), safety (procedural controls), cost (e.g. operation, fuel, maintenance, and end of life), preventative maintenance, availability, emissions, reliability, time for maintenance, operator training and expertise, and warranty. To date, 34 people have submitted their responses.

NREL also used workshops held in conjunction with market relevant conference(s) and expo(s) to capitalize on end user attendance. The workshops focused on breakout sessions with two questions:

1. What are the key performance needs for your application?
2. How could advanced onboard energy storage technology improve the performance of your vehicles or operation?


Early Market Questionnaire_Rev_B_distributed.pdf - Adobe Acrobat Pro

File Edit View Document Comments Forms Tools Advanced Window Help

Please fill out the following form. When finished, click Submit Form to return the completed form.

Highlight Fields Submit Form

Energy Storage Questionnaire Revision B

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INSTRUCTIONS: Please answer the following questions to the best of your ability. If a question does not apply to you, or you do not have specific information on a topic, please leave the field blank, or check 'N/A' as appropriate. If you have information on multiple applications, or materials, please feel free to complete a separate form for each.

About You

A. Which of the following categories best describes your organization?

Vehicle OEM / H2 Storage Technology Provider / Vehicle Service Organization
Vehicle Parts Supplier / Government/National Lab / Vehicle Sales Organization
Codes & Standards Body / University/Education / Fuel Cell Supplier
Systems Integrator / Other

B. Which market does your organization primarily service?

Material Handling / Public Transit / Military / Airport
Other

C. Which of the following best describes your responsibilities within the organization?

Vehicle Operator / General Management / Fleet Maintenance
Energy Storage Researcher / Information Technology / Operations Management
Engineeering / Legal / Environmental Health & Safety
Facility Management / Consultant
Other

Tell us about your energy sources.

D. What do you use today?
Gasoline / Propane / Hydrogen
Diesel / Battery / Bus Bar
Natural Gas / Methanol / Ethanol/E85
Other / N/A

E. What would you prefer to use?
Gasoline / Propane / Hydrogen
Diesel / Battery / Bus Bar
Natural Gas / Methanol / Ethanol/E85
Other / N/A

F. What mix of vehicles do you have in your fleet, and how much power do they need? How many Class I, II, and III lifts, buses, GSE, etc. What are typical peak power rating for the engines/motors?

N/A kW HP

	Qty.	Power		Qty.	Power		Qty.	Power
Class I Lift			Tugs			Transit Bus ~40ft		
Class II Lift			Other GSE			Coach Bus		
Class III Lift			Other			Para Transit		

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For each question below, consider how you would feel if the energy storage device used in your vehicles had each of the following attributes. Additionally there are follow-up questions asking you for more information about what values of certain attributes you would consider acceptable. The energy storage device is that which provides the primary source of energy for the vehicle, such as a gasoline or propane tank, battery, hydrogen tank, and the associated hardware such as filling nozzles, fuel pumps, charging receptacles, etc.

1. What is an acceptable O&M cost ($ per vehicle per year)?
2. How would you feel if the energy storage system in your vehicles took little time to repair when in the shop for service?
   Like it / Expect It / Don't Care / Live With It / Dislike It
3. How would you feel if the energy storage system in your vehicles had residual (scrap, recycling or core credit) value at end of life?
   Like it / Expect It / Don't Care / Live With It / Dislike It
4. How would you feel if the energy storage system in your vehicles were often not available when you need it?
   Like it / Expect It / Don't Care / Live With It / Dislike It
5. How would you feel if the energy storage system in your vehicles could withstand large shock and vibration loads?
   Like it / Expect It / Don't Care / Live With It / Dislike It
6. How would you feel if the energy storage system in your vehicles substantially increased greenhouse gas emissions?
   Like it / Expect It / Don't Care / Live With It / Dislike It
7. How would you feel if the energy storage system in your vehicles required frequent preventative maintenance?
   Like it / Expect It / Don't Care / Live With It / Dislike It
8. How would you feel if the energy storage system in your vehicles could operate in a snowy, muddy, dirty, wet, cold, hot or otherwise extreme conditions?
   Like it / Expect It / Don't Care / Live With It / Dislike It
9. How much space does energy storage take up today (L, ft^3 or in^3)?
   L / ft^3 / in^3

FIGURE 1. Pages 1 and 2 of Electronic Questionnaire

A summary of the top performance needs in MHE as discussed in the workshops are:

- Robust tanks capable of high cycling (fill frequency) over 10 years.
- Certified field support with low maintenance requirements (e.g. 2-3 maintenance hours per 500 operation hours) and cost.
- Onboard storage capacity limits should be about one shift (5 to 8 hours).
- Onboard energy storage should be easy to use with fast and convenient filling.
- Flexible storage designs to fit within existing or custom products.
- Simple, low-cost options to compete with incumbent technologies.

A summary of the top performance needs in public transit as discussed in the workshop are:

- Low cost of storage through consistent tank system designed for low weight.
- Low storage system weight.
- Operation period should match that of the bus (e.g., 12 years/500,000 miles or ~5,000 tank cycles) with a daily operation range of between 200 and 250 miles.

We completed an early set of draft results. Figure 2 includes results for storage capacity, fill rate, operation lifetime, and preventative maintenance. At the time of this figure creation, most of the responses were from the MHE application. (The response analysis in the final report will be broken down by application and the other performance categories.) The four metrics in Figure 2 are all important to the responders and the corresponding bar charts breakdown the expected performance level. For instance, storage capacity is an important metric and most of the responders say that 8-10 hours is the necessary capacity level.

Conclusions and Future Direction

The analysis preparation and workshops have created a foundation for identifying the onboard energy storage needs and the following gap analysis task. So far, the performance needs are application specific and focus around robustness, simplicity, runtime, weight, and cost.

Planned future work includes:

- Continue questionnaire response and information gathering.
- Continue analyzing response and workshop data and summarizing important performance metrics and the corresponding performance levels.

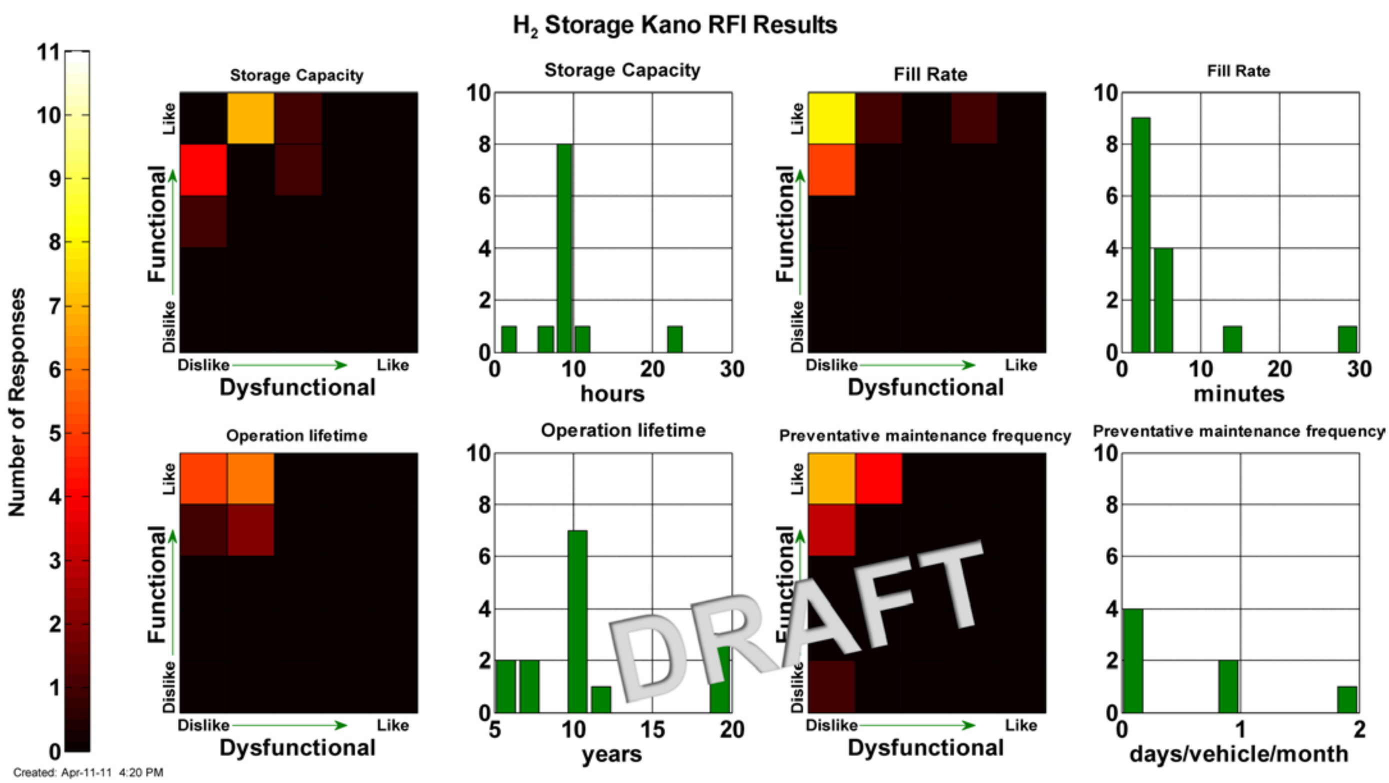

FIGURE 2. Draft Results of Important Performance Metrics using Kano Method

- Summarize capabilities of current hydrogen storage technologies.
- Gap analysis of current hydrogen storage technologies to the early motive fuel cell markets' onboard energy storage needs.
- Complete final report.

FY 2011 Publications/Presentations

1. Kurtz, J.; Ainscough, C.; Simpson, L. "Analysis of Storage Needs for Early Motive Fuel Cell Markets," Presented at DOE's Annual Merit Review, May 13, 2011.