XI.2 Hydrogen Infrastructure Market Readiness Analysis

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- IDC Energy Insights, Framingham, MA
- Energetics, Columbia, MD

Project Start Date: October 2010
Project End Date: September 2011

Fiscal Year (FY) 2011 Objectives

- Collect stakeholder input on key issues pertaining to hydrogen infrastructure market readiness, with a focus on cost reduction opportunities.
- Identify quantitative and qualitative cost reduction opportunities associated with economies of scale, volume production, learning, standardization, streamlining station design and permitting processes, technology research and development, and other any other relevant factors.
- Communicate cost reduction opportunity findings in a cohesive final report.

Technical Barriers

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

(A) Future Market Behavior

(C) Inconsistent Data, Assumptions, and Guidelines

(B) Stove-Piped, Siloed Analytical Capability

Contribution to Achievement of DOE Systems Analysis Milestones

This project will contribute to achieving the following DOE milestone from the System Analysis and System Integration sections of the Fuel Cell Technologies Program Multi-Year Research, Development and Demonstration Plan:

- Milestone 8 (System Analysis): Complete analysis and studies of resource/feedstock, production/delivery, and existing infrastructure for technology readiness. (4Q, 2014)

Accomplishments

- Convened a 1.5-day Market Readiness Workshop with more than 60 expert participants to discuss and prioritize technology market readiness and cost reduction opportunities.
- Collected feedback from panel discussions and breakout groups during the Market Readiness Workshop.
- Designed and distributed an Excel-based cost calculator that calculates the cost of hydrogen based on stakeholder responses to detailed cost questions about four general types of hydrogen stations: state-of-the-art, early commercial, larger stations, and more stations.
- Participated in meetings and supported the analysis process associated with the infrastructure rollout planning being undertaken by the California Fuel Cell Partnership (CaFCP).
- Integrated findings and feedback from all project activities into a final report.
- Initiated discussions about follow-up activities to better understand subtopics associated with hydrogen infrastructure market readiness.

Introduction

The cost of hydrogen infrastructure components required to support early markets for hydrogen fuel cell electric vehicles (FCEVs) is a significant barrier because of high investment risks and technology uncertainty. Past studies of the hydrogen transition have highlighted the importance of competitive early infrastructure costs to market transformation [1,2]. Cost and performance of infrastructure technologies have improved in recent years, especially with growth in emerging markets such as forklifts and telecommunications. An update on current status is necessary to inform the investment community and to improve the realism of scenario transition models.

Approach

This project examines cost reduction opportunities for hydrogen stations through three distinct activities: 1) conducting an expert workshop to discuss and prioritize opportunities, 2) distributing a cost calculator that enables stakeholders to provide quantitative feedback, and

3) coordinating with efforts at the CaFCP to integrate recent developments. These activities are summarized in the following.

The Hydrogen Infrastructure Market Readiness Workshop was held on February 16–17, 2011 in conjunction with the annual Fuel Cell and Hydrogen Energy Association conference. More than 60 attendees participated in two panel sessions during the afternoon of February 16; group discussions and breakout sessions were held all day on February 17. Each breakout group, with assistance from Energetics facilitators, used a voting system to prioritize opportunities. The mix of breakout group participants was predetermined to include diverse stakeholder perspectives in each group (see Figure 1). Breakout groups focused on the following key questions:

- What are the biggest opportunities to reduce the costs of hydrogen fueling stations over the next 2–5 years?
- What can we do to achieve the high-priority cost reduction opportunities?
- Who needs to do what when? What kind of help is needed? Is information sharing or coordination needed?

The Hydrogen Station Cost Calculator was distributed to a select group of experts to collect feedback on costs for stations designed to support early FCEV markets, as well as stations supporting expanding markets. The calculator was designed to enable experts to provide multiple levels of detail on cost and performance, and provides direct feedback on the implied cost of hydrogen ($/kg) using the Hydrogen Analysis (H2A) discounted cash flow financial framework [3]. A Beta version of the calculator was distributed for review, and revisions were made based on suggestions for improvement before the final version was distributed. IDC Energy Insights distributed the calculator through a clean room mechanism, ensuring the anonymity of all responses and delivering only aggregate results to NREL staff. The third project activity, coordination with the CaFCP, has occurred by attending planning meetings and providing California-specific infrastructure cost estimates based on NREL cost models.

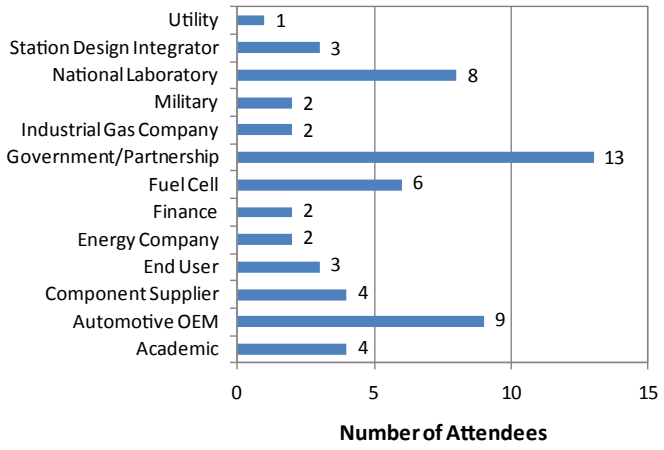

FIGURE 1. Distribution of Workshop Attendees by Stakeholder Group

Results

To date, complete results are available from the first activity only; feedback from the calculator is still being collected and the CaFCP is still being engaged. Figure 2 shows aggregate results of the Market Readiness Workshop cost reduction opportunity prioritization process; the number of opportunities in each category is shown on the vertical axis, and the number of points received though the prioritization process is indicated on the horizontal axis. Color coding indicates categories of a similar type. Two points were allocated to each opportunity identified during the panel sessions, and one point for each opportunity raised in the breakout groups. Additional points were added based on the voting process, with each breakout group attendee allocating three points in two prioritization sessions. With the choice of categorization shown in Figure 2, streamlining the station permitting process is a high-priority cost reduction opportunity. Other types of categorization, especially around station design (green boxes), would highlight other priorities. Examples of specific hydrogen station cost reduction opportunities are:

System Station Costs (Design, Performance Requirements)

- Eliminate station design/installation requirements with ultraconservative requirements.
- Increase the number of station components and equipment that have achieved third-party certification for use in hydrogen service.
- Target processes and components that cause station reliability problems (O-rings, infrared nozzles, etc.).
- Encourage modular station designs that harmonize requirements for small, medium, and large stations, and enable modular station expansion.
- Provide awards for networks of stations using the same (or a similar) design, rather than one-off projects.
- Harmonize and standardize dispensing equipment specifications.
- Increase the number of suppliers of hydrogen station components and systems.

Component Level Costs

- Reduce capital equipment costs, especially for high-pressure equipment.
- Reduce hydrogen storage costs (e.g., enable use of 14,000 psi storage; composite tanks).
- Reduce compressor capital, and operations and maintenance costs.

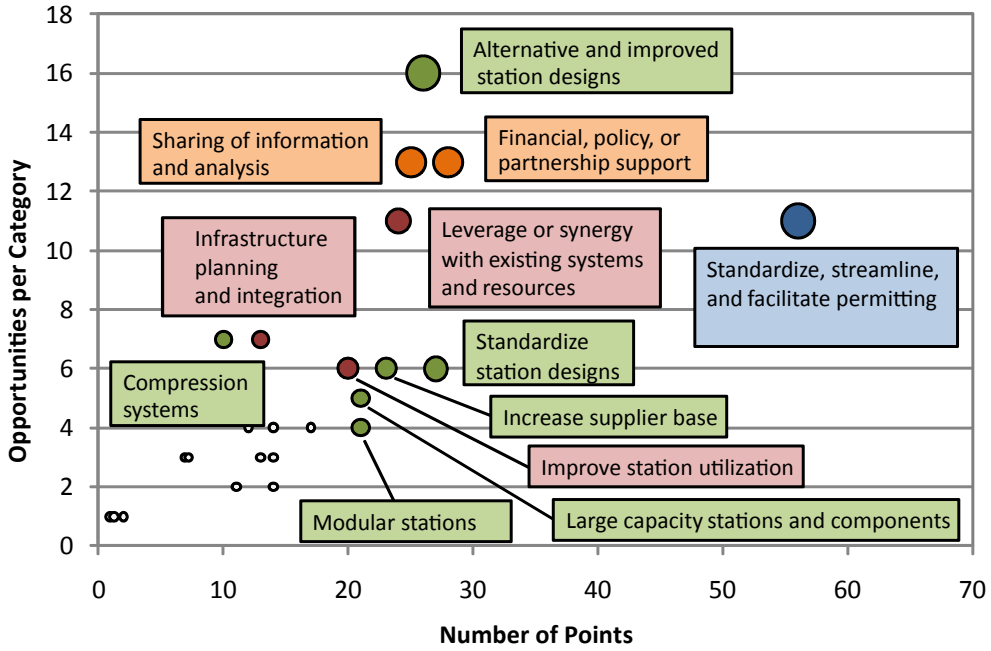

FIGURE 2. Summary of cost reduction opportunities collected from workshop breakout groups (vertical axis) and points allocated through voting process (horizontal axis).

Reduce Dispensing Costs

- Reduce planning and permitting costs (siting, cost of compliance).
- Institute a "type approval" approach for hydrogen stations to simplify and streamline the permitting process.
- Develop a model or models for a streamlined, uniform permitting process (written for permitting officials).
- Develop targeted, "plain language" information products and forums to educate fire marshals, permitting officials, municipal officials, the public, and the insurance industry about hydrogen stations.

Economies of Scale and Learning by Doing

- Modular approaches and standardized manufacturing can lead to as much as 50% cost reduction.
- More uniform permitting processes could reduce station costs by 20%–30%.
- Cut equipment operations and maintenance costs by 75% by using validated components.

Collaborative Actions

- Detailed station deployment plan – include automotive original equipment manufacturers, focused markets, potentially contractual, with a 5–10 year outlook.
- Early market hydrogen users group – webinar series, conferences, briefings to be posted on website, codes and standards database, Annual Merit Review meeting-like exchange of information across industries.

Research and Development

- Design modular expansion stations.
- Design a targeted DOE program on large-scale compression.

Conclusions and Future Directions

NREL researchers have identified numerous diverse opportunities to further reduce the cost of hydrogen stations that are designed to serve early FCEV markets. These opportunities must be pursued through a variety of means, including technical design, codes and standards, and policy mechanisms. Station design and streamlining the permitting process appear to be two general categories that include multiple high-priority cost reduction opportunities. This project ends in FY 2011, but plans are to provide improved characterizations of distinct cost reduction opportunities through follow-up stakeholder workshops. All results and feedback will be compiled in a final report.

Special Recognitions

1. 2011 Department of Energy Hydrogen and Fuel Cells Program R&D Award, Dr. Marc Melaina, National Renewable Energy Laboratory, Infrastructure Analysis and Program Model Development.

References

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