U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

CROSS-CUTTING HYDROGEN STATION INFRASTRUCTURE REVIEW REPORT

June 10th, 2016

U.S. Department of Energy
Fuel Cell Technologies Office
Annual Merit Review

NOTICE

Objective

The Department of Energy (DOE)'s Fuel Cell Technologies Office (FCTO) hosted a cross-cutting review to evaluate FCTO's activities related to hydrogen station infrastructure. This report summarizes the review session presentations, discussions, and feedback gathered.

Summary of Presentations

The review started with four background presentations. First, Dr. Sunita Satyapal provided high-level framing on behalf of FCTO, including information on the early market for fuel cell electric vehicles (FCEVs) as it compared to the early market for gasoline, current issues with hydrogen station infrastructure, and a high-level view of FCTO's strategy and overall activities.

Andrew Martinez from the California Air Quality Board (CARB) updated the participants on California's current funding for hydrogen stations, station development challenges and key issues, and needs the state of California has identified. The issues include new station performance, equipment reliability, and other equipment issues, such as from the compressor, cooling system, or point of sale. California's acknowledged needs include in-line, real-time detecting of contaminants in the hydrogen fuel stream, determining how to build infrastructure at scale, and how to increase financial investment. Furthermore, in the long term the cost of hydrogen to the station operator and at the pump remains the primary concern for viability. CARB is looking at the supply chain of hydrogen production in California, in order to identify opportunities to reduce cost while also increasing renewable hydrogen production.

Bob Oesterreich from Air Liquide provided an overview of their current plans to build twelve hydrogen fueling stations in the Northeast states and the challenges they are facing. Air Liquide is focused on New Jersey, the New York City area, and Boston for station locations, and they are using a hub and spoke approach for supply of hydrogen. Construction in the Boston area will start this summer, using the same station model as is being used in California. Air Liquide is facing a different set of challenges from California, since they are further behind in developing stations. These barriers and challenges include leasing/renting, codes and regulation differences between municipalities and states, and a lack of grant funding to support hydrogen infrastructure. Air Liquide would like to see DOE helping to fast-track outdated regulations on hydrogen handling, as well as helping to establish and set guidelines for implementing weights and measures standards similar to in California for hydrogen sales. Air Liquide is also interested in continued support for advanced mobile fueling equipment needed to seed new markets and geographies, and easing site acquisition efforts with land grants.

Erika Gupta presented last, to frame and set-up the break out group discussions, outlining the barriers to hydrogen station infrastructure deployment FCTO has identified, and the activities FCTO is funding to address these barriers. For a complete list of the barriers and activities covered, please see the Appendix.

Summary of Discussions: High-Level Takeaways

In the four break-out groups, there were five high-level suggestions made to FCTO and DOE. These are summarized here. The rest of the feedback acquired from the break-out groups is included in the section summarizing all reviewer feedback.

1. In weighing priorities for activities addressing the barriers to hydrogen station deployment, it is important to think both near and long-term, as well as east and west coast. These time scales and geographies present different barriers and challenges, but it is important to fund activities across this spectrum.

2. It is worth spending time understanding and explaining the value of hydrogen, to create a market pull for hydrogen as an energy that is beyond the vehicles. If DOE and other stakeholders can effectively explain the potential of hydrogen to the public, this will create a demand for a clean hydrogen energy.

3. FCTO should fund projects at a station and/or system-level, instead of funding component-focused projects (i.e., on a chiller, or a compressor). It would be helpful to design and demonstrate optimized systems and

stations. Similarly, it would be useful to build and test larger stations, planning for increased demand in the future.

4. FCTO should increase intergovernmental collaboration, to involve other federal agencies in supporting hydrogen and fuel cell outreach and training, and codes and standards efforts.

5. It is critical that DOE continues to work on ensuring that National Laboratory projects are being connected back to industry, and continue to disseminate results and information.

Summary of Reviewer Feedback

Reviewers consisted of several stakeholder groups, including automakers, hydrogen suppliers, other federal agency employees, fuel cell manufacturers, consultants, state agencies, and National Laboratory scientists. Feedback was received anonymously, and the trends are reported here.

Every reviewer stated that FCTO's cross-cutting hydrogen fueling station activities are effective in addressing barriers tied to hydrogen station deployment.

Reviewers from all stakeholder groups identified the following **key barriers** to successfully deploying hydrogen fueling station infrastructure (order is not a ranking):

1. Station cost
2. Station reliability, station performance, and station availability
3. Outreach and education needs, particularly around the value of hydrogen
4. Updating codes and standards, particularly decreasing setback distances
5. Lack of manufacturing economies of scale, and need to certify components
6. A current lack of intergovernmental collaboration

Reviewers also identified **key activities** addressing these barriers that FCTO should continue to fund. These included projects working to lower station cost, improve station reliability and performance, update codes and standards, and to gather real-world data from stations. The specific feedback was to continue projects in the below areas; those that were presented at the AMR[1] are listed for reference:

- Projects to address meter inaccuracies
  TV037; PD newly awarded to IVYS
- Codes and Standards R&D, particularly on setback distances and liquid hydrogen
  SCS002, SCS005, SCS010, SCS011, SCS022, SCS026
- Projects to develop contaminant detection for hydrogen quality
  TV019, SCS007
- Station data gathering/analysis
  TV017, TV024, TV038
- Delivery and Dispensing R&D
  PD101, PD088, PD133, PD100, PD108, PD126
- Projects to decrease station footprint
  PD107, SCS001

[1] https://www.hydrogen.energy.gov/annual_review16_proceedings.html

There were no common trends in reviewers' opinions on which activities FCTO should stop funding.

Both in the discussions and review forms received, a majority of reviewers were united in their views on two high-level suggestions mentioned above:

1. The DOE should work more with other agencies on hydrogen activities, particularly outreach and training, as well as efforts to update codes and standards. Reviewers indicated that they think DOE is the only agency "carrying the water" for hydrogen and fuel cells currently, and that the industry would benefit from increased involvement from the Department of Transportation, the National Highway Transportation Safety Administration, and the Department of Commerce.

2. FCTO should aim to fund hydrogen station projects at a systems level, instead of focusing on lowering costs component-by-component. Some reviewers indicated that they think it may be possible to achieve easier and simpler cost reductions by looking to increase efficiencies at a systems level for a station.

Next Steps

FCTO will use the above feedback received to inform a Request for Information that allows more stakeholders to weigh in on funding priorities related to hydrogen fueling station infrastructure.

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Appendix

Summary of FCTO Current/Funded Activities

This is a list of projects the FCTO is funding to address the near to mid-term barriers to Hydrogen Refueling Station Deployment, and where appropriate, the AMR presentation number.

Key:

I. **Category**
   a. **Barrier**
      i. FCTO activity (AMR number)

I. Station Performance

a. Inaccuracy in hydrogen dispensing

i. H_2 meter benchmark testing (TV037)
ii. R&D to improve dispenser and meter accuracy (PD, newly awarded to IVYS)

b. Unreliability of station equipment

i. Hydrogen station data collection and analysis: maintenance data collection, and time between failures (TV025)
ii. Hydrogen component validation: required maintenance of components (TV019)
iii. Hydrogen Compressor R&D (PD108/SWRI and PD126/GTI)
iv. Barrier coatings for seals to extend life (PD, SBIR to GVD)
v. 700 bar Hydrogen Dispenser Hose Reliability Improvement (PD100)
vi. Station Component Reliability Testing (SCS002): TPRDs, etc.
vii. Hydrogen compatibility of materials (SCS005, SCS026): component materials compatibility testing

c. Station availability to the customer is less than 80%

i. Station Operational Status System (SOSS) Implementation (TV027): cell phone app for station status

d. Lack of real world data to inform the codes and standards

i. Hydrogen behavior efforts (SCS010): liquid hydrogen release laboratory, model development
ii. Quantitative Risk Assessment (SCS011): HyRAM
iii. Hydrogen compatibility of materials (SCS005, SCS026): component materials compatibility testing
iv. Codes & Standards committee support (SCS001, SCS022): NFPA 2/55 task group
v. Hydrogen station data collection and analysis (TV017): considerable station operational data
vi. CSULA H2 Station (TV024): station operation data
vii. HITRF (TV038, NREL): collecting station data

II. Station Cost:

a. High cost of station equipment

i. Small 'box' stations (TV033, Brentwood Case Study)
ii. Low cost station storage (PD088/SCCV and PD110/Wiretough, 875 bar)
iii. Consolidation Scheme testing and verification (PD133, H2FIRST)
iv. Manufacturing Competitiveness Analysis (MN017)

b. Immature supply chain and lack of international standardization

i. Develop US hose supplier (PD101/Nanosonic)
ii. Component Support (SCS002)
iii. Codes & Standards committee support (SCS001)
iv. Manufacturing Competitiveness Analysis (MN017, MN012)
v. Online Fuel Cell and Hydrogen Component Supply Chain Database (MN013): Virginia Clean Cities at James Madison
vi. Integrated Regional Technical Exchange Centers for Supply Chain Growth and Component Standardization (MN012): OFCC

III. Station Financing:

a. Lack of investor familiarity with HRS

i. H2FAST tool developed to enable investors to evaluate station economics
ii. Investor Fora – inform potential investors in monetary and non-monetary value propositions (MT ongoing activity)

b. High risk profile for station investment and limited opportunities for profitability

i. Demonstrate fueling stations in fleet applications, such as LDV vans (MT017)
ii. H2FAST tool has risk analysis capability for station investment analysis
iii. Develop business cases with alternatives to typical refueling station costs and revenues. (SA052)

c. Long return on investment (ROI) timeframe

i. H2FAST tool enables investors to evaluate ROI over various timeframes

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IV. Training and Outreach Needs:

a. Regional variability in the permitting requirements

i. Lessons learned from Brentwood (TV033): worked through permitting process
ii. Regional AHJ outreach and training (SCS001)
iii. Development of permitting guides and video resources (SCS001)
iv. H2Tools.org (SCS019)

b. Lack of AHJ familiarity with relevant codes and standards

i. Development of permitting guides and video resources (SCS001)
ii. H2Tools.org (SCS019)

c. First responders lack adequate training to respond to hydrogen related incidents

i. In-person classroom and hands-on training for first responders (SCS019)

ii. Online first responder training (SCS019): current activity to transfer hosting of this resource to the national fire academy
iii. HyRESPONSE multi-lateral collaboration (SCS019)
iv. H2Tools.org (SCS019)

d. Lack of education on and comfort with hydrogen refueling
i. CSULA H2 Station (TV): consistent educational outreach activities
ii. H2Tools.org (SCS019)
iii. Collaborating with Clean Cities Initiative to provide information regarding H2 infrastructure, training and FCEVs to the public.
iv. Monthly webinars, newsletters, social media outreach from FCTO

e. Lack of trained workforce for stations (maintenance and construction)
i. HyStep (TV026, H2FIRST): assist with station testing
ii. H2VETS will link military and veterans with experience to be matched with required skillsets
iii. Employment study to identify skillsets and workforce requirement gaps (SA035)

V. Fuel Quality Needs:

a. Fuel quality does not consistently meet specifications
i. Hydrogen component validation (TV019): contamination in hydrogen components

b. Fuel quality analysis is expensive

c. Lack of available in-line technology for fuel quality detection
i. Hydrogen component validation (TV019): identifying key components for contamination
ii. Fuel Quality Efforts (SCS007): effects of contaminant species
iii. In-Line Fuel Quality Analyzer (SCS007): development of analyzer for fuel quality assurance

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VI. Station Utilization & Footprint:

a. Facing low utilization of stations in the near-term market and low market demand
b. Station footprint limits the availability of viable sites
i. Hydrogen Fueling Station Pre-Cooling Analysis (PD107)
ii. Codes & Standards committee support (SCS001): NFPA 2/55 task group

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VII. Station Network Expansion:

a. Lengthy process to commission new stations
i. Development of the Hydrogen Station Equipment Performance (HyStEP) Device, assist with station testing (TV026)
b. Lack of coordination between automakers and fuel providers for market expansion
i. H_2USA Activities
ii. Validation of SunHydro Station (TV020): cooperation of stations and automakers

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