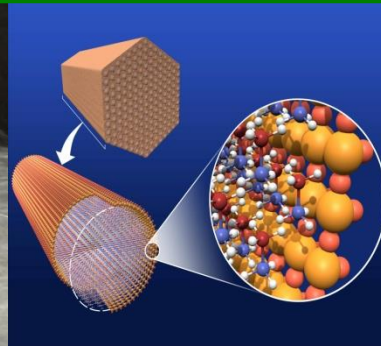




U.S. DEPARTMENT OF
ENERGY



FCTO Cross-Cutting Hydrogen Station Activities

- Overview -

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On behalf of FCTO Infrastructure Team

2016 Annual Merit Review and Peer Evaluation Meeting

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FCTO works across technology readiness levels to support HRS infrastructure.

Barriers to HRS deployment fall into these **categories**:

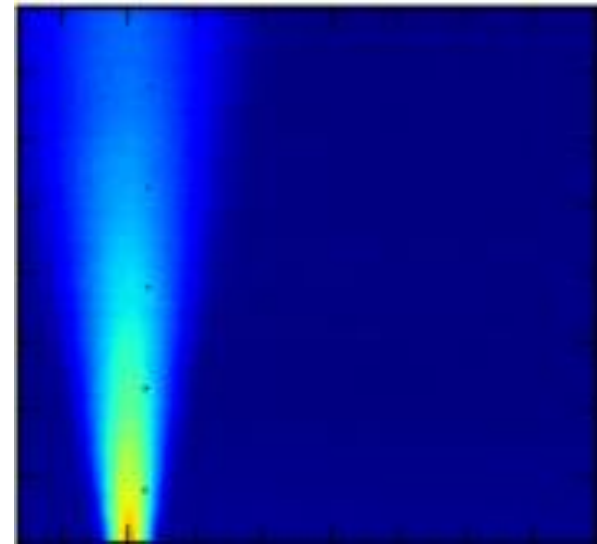
- **Station Performance**
- **Station Cost**
- **Station Financing**
- **Training and Outreach Needs**
- **Fuel Quality**
- **Station Utilization**
- **Station Footprint**
- **Station Network Expansion**



Barriers span a wide range of areas associated with stations

- **Station Performance:**

1. Inaccuracy in hydrogen dispensing
2. Unreliability of station equipment (Station availability to the customer is less than 80%).
3. Lack of real world data to inform the codes and standards



Station performance barriers are focused on equipment issues and lack of data.

- **Station Cost:**

1. High cost of station equipment
2. Immature supply chain and lack of international standardization

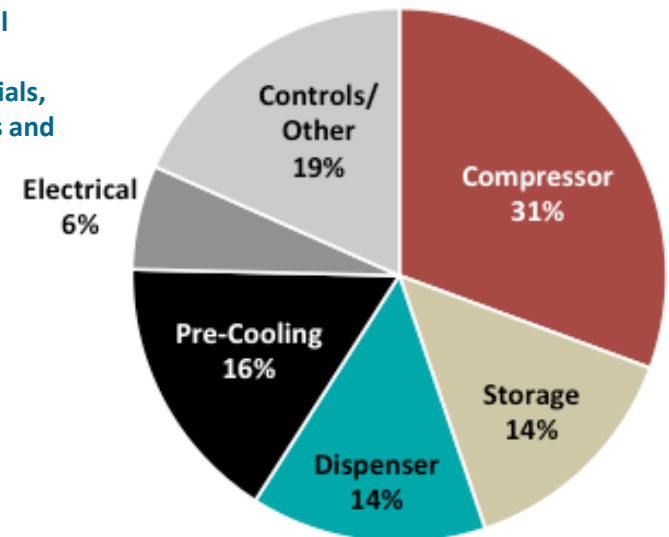


Reference Station Design Report

- ✓ Analyzed 120 station permutations and selected four high-priority, near-term station concepts based on economics, technical feasibility, and market need
- ✓ Produced spatial layouts, bills of materials, and piping & instrumentation diagrams and detailed cost estimates

Profile	Site Type	Delivery	Capacity (kg/day)	Consecutive Fills	Hoses	Station Contribution to Hydrogen Cost (\$/kg)	Capital Cost (2009\$)
High Use Commuter	Gas station or greenfield	Gaseous	300	6	1	\$6.03	\$1,251,270
High Use Commuter	Greenfield	Liquid	300	5	2	\$7.46	\$1,486,557
Low Use Commuter	Gas station or greenfield	Gaseous	200	3	1	\$5.83	\$1,207,663
Intermittent	Gas station or greenfield	Gaseous	100	2	1	\$13.28	\$954,799

700-bar Gaseous Refueling Station



Equipment cost at stations remains high, requiring R&D and supply chain development

- **Station Financing:**

1. Lack of investor familiarity with HRS
2. High risk profile for station investment and limited opportunities for profitability
3. Long return on investment timeframe

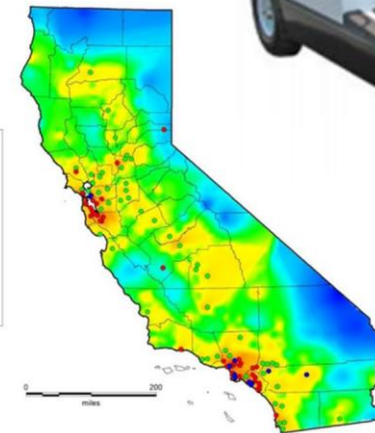
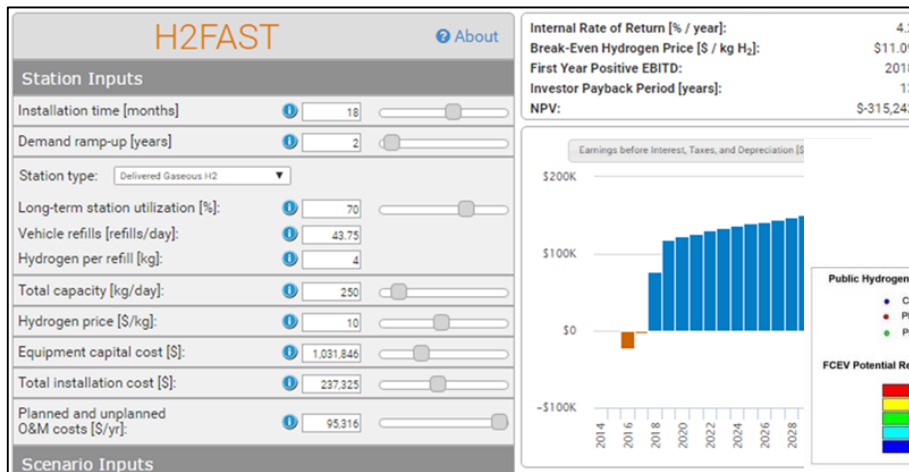


FIGURE 2. Thermal map of ranked locations with proposed coverage network as a complement to current and planned stations

Station financing must be made more realistic for wide-spread deployment.

- **Training and Outreach Needs:**

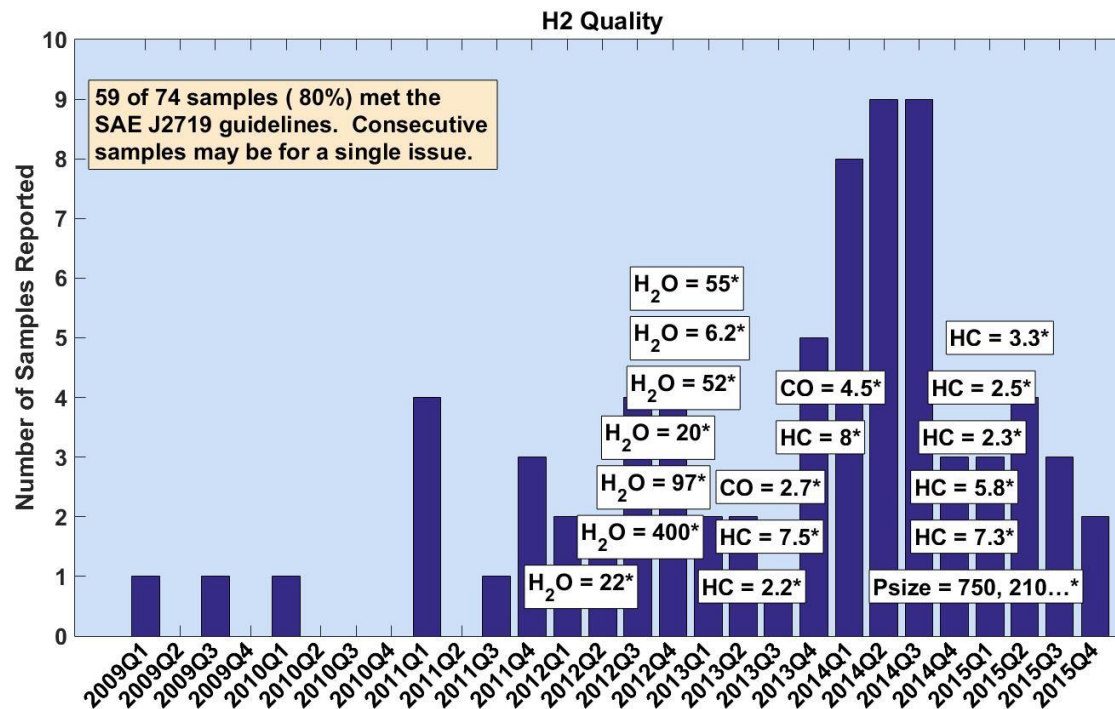
1. Regional variability in the permitting requirements
2. Lack of AHJ familiarity with relevant codes and standards
3. First responders lack adequate training to respond to hydrogen related incidents
4. Lack of education on and comfort with hydrogen refueling
5. Lack of trained workforce for stations (maintenance and construction)




Training & Outreach is critically important for numerous stakeholders.

- Fuel Quality Needs:**

1. Fuel quality does not consistently meet specifications
2. Fuel quality analysis is expensive
3. Lack of available in-line technology for fuel quality detection



 NREL cdp_infr_25
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*Values are in micromole/mole, except for particulate size (Psize) in micrometer. Only values that exceed SAE J2719 guideline are shown in text. Left edge of text box aligns with date

Hydrogen fuel quality must be guaranteed as market develops

- **Station Utilization**

1. Facing low utilization of stations in the near-term market and low market demand

- **Station Footprint**

1. Station footprint limits the availability of viable sites

- **Station Network Expansion:**

1. Lengthy process to commission new stations
2. Lack of coordination between automakers and fuel providers for market expansion

Barriers remain to station utilization and expanding station coverage

Barriers to HRS deployment fall into these **categories**:

- **Station Performance**
- **Station Cost**
- **Station Financing**
- **Training and Outreach Needs**
- **Fuel Quality**
- **Station Utilization**
- **Station Footprint**
- **Station Network Expansion**



Barriers span a wide range of areas associated with stations

1. Inaccuracy in hydrogen dispensing

- a. Meter benchmark testing (TV037)
- b. R&D to improve dispenser and meter accuracy (PD, newly awarded to IVYS)

2. Unreliability of station equipment

- a. Station data collection & analysis: maintenance data collection, & time between failures (TV025)
- b. Hydrogen component validation: required maintenance of components (TV019)
- c. Hydrogen Compressor R&D (PD108/SWRI and PD126/GTI)
- d. Barrier coatings for seals to extend life (PD, SBIR to GVD)
- e. 700 bar Hydrogen Dispenser Hose Reliability Improvement (PD100)
- f. Station Component Reliability Testing (SCS002): TPRDs, etc.
- g. H₂ compatibility of materials (SCS005, SCS026): component materials compatibility testing

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

- a. Station Operational Status System (SOSS) Implementation (TV027): cell phone app

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

- a. Hydrogen behavior efforts (SCS010): liquid hydrogen release laboratory, model development
- b. Quantitative Risk Assessment (SCS011): HyRAM
- c. H₂ compatibility of materials (SCS005, SCS026): component materials compatibility testing
- d. Codes & Standards committee support (SCS001, SCS022): NFPA 2/55 task group
- e. Hydrogen station data collection and analysis (TV017): considerable station operational data
- f. CSULA H₂ Station (TV024): station operation data
- g. HITRF (TV038, NREL): collecting station data

1. High cost of station equipment

- a. Small 'box' stations (TV033, Brentwood Case Study)
- b. Low cost station storage (PD088/SCCV; PD110/Wiretough, 875 bar)
- c. Consolidation Scheme testing and verification (PD133, H2FIRST)

2. Immature supply chain and lack of international standardization

- a. Develop US hose supplier (PD101/Nanosonic)
- b. Component Support (SCS002)
- c. Codes & Standards committee support (SCS001)
- d. Manufacturing Competitiveness Analysis (MN017, MN012)
- e. Online Fuel Cell and Hydrogen Component Supply Chain Database (MN013):
Virginia Clean Cities at James Madison
- f. Integrated Regional Technical Exchange Centers for Supply Chain Growth and
Component Standardization (MN012)

1. Lack of investor familiarity with HRS

- a. H2FAST tool developed to enable investors to evaluate station economics
- b. Investor Fora – inform potential investors in monetary and non-monetary value propositions

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

- a. Demonstrate fueling stations in fleet applications, such as LDV vans (MT017)
- b. Develop business cases with alternatives to typical refueling station costs and revenues. (SA052)

3. Long return on investment timeframe

- a. H2FAST Tool will enable investors to evaluate return on investment over various timeframes

1. Regional variability in the permitting requirements + Lack of AHJ familiarity with relevant codes and standards

- a. Lessons learned from Brentwood (TV033): worked through permitting process
- b. Regional Authorities Having Jurisdiction (AHJ) outreach and training (SCS001)
- c. Development of permitting guides and video resources (SCS001)
- d. H2Tools.org - safety information and resources (SCS019)

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

- a. In-person classroom and hands-on training for first responders (SCS019)
- b. Online first responder training - transferring hosting of this to the national fire academy (SCS019)
- c. HyRESPONSE multi-lateral collaboration (SCS019)
- d. H2Tools.org (SCS019)

3. Lack of education on and comfort with hydrogen refueling

- a. CSULA H2 Station (TV): consistent educational outreach activities
- b. Collaborating with Clean Cities Initiative to provide information and training to the public
- c. Monthly webinars, newsletters, social media outreach from FCTO

4. Lack of trained workforce for stations (maintenance and construction)

- a. HySTeP (TV026, H2FIRST): assist with station testing
- b. H2VETS will link military and veterans with experience to be matched with required skillsets
- c. Employment study to identify skillsets and workforce requirement gaps (SA035)

1. Fuel quality does not consistently meet specifications

1. Hydrogen component validation (TV019): contamination in hydrogen components

2. Fuel quality analysis is expensive

3. Lack of available in-line technology for fuel quality detection

1. Hydrogen component validation (TV019): identifying key components for contamination
2. Fuel Quality Efforts (SCS007): effects of contaminant species
3. In-Line Fuel Quality Analyzer (SCS007): development of analyzer for fuel quality assurance

Station Utilization, Footprint, & Network Expansion

- 1. Facing low utilization of stations in the near-term market and low market demand**
- 2. Station footprint limits the availability of viable sites**
 1. Hydrogen Fueling Station Pre-Cooling Analysis (PD107)
 2. Codes & Standards committee support (SCS001): NFPA 2/55 task group
- 3. Lengthy process to commission new stations**
 1. Development of the Hydrogen Station Equipment Performance (HyStEP) Device (TV026)
- 4. Lack of coordination between automakers and fuel providers for market expansion**
 1. H2USA Activities
 2. Validation of SunHydro Station (TV020): cooperation of stations and automakers

1. Are barriers to hydrogen station deployment adequately being addressed through FCTO's cross-cutting activities, with all important issues and challenges identified?
2. Are there additional barriers to widespread hydrogen station deployment that the presented activities are not addressing?
3. Start: For the barriers presented, please identify gaps in activities that are not currently funded and identify with which barriers they are associated.
4. Stop: Please identify activities (or barriers being addressed) that are not adding significant value and describe why.
5. Continue: Please identify activities that have significant value and should be continued.
6. Are there additional stakeholders that should be engaged?
7. Please provide any additional feedback you have on the cross-cutting hydrogen fueling station activities.

We are eager to get your feedback!

There will be four break-out groups for discussion

Thank you!

Questions?