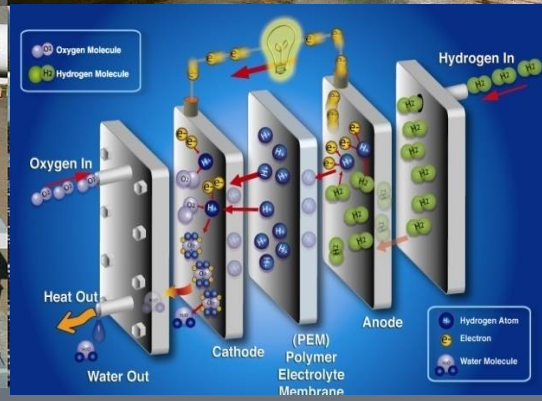
Fuel Cell Technologies Office

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



Hydrogen Contaminant Detection Workshop

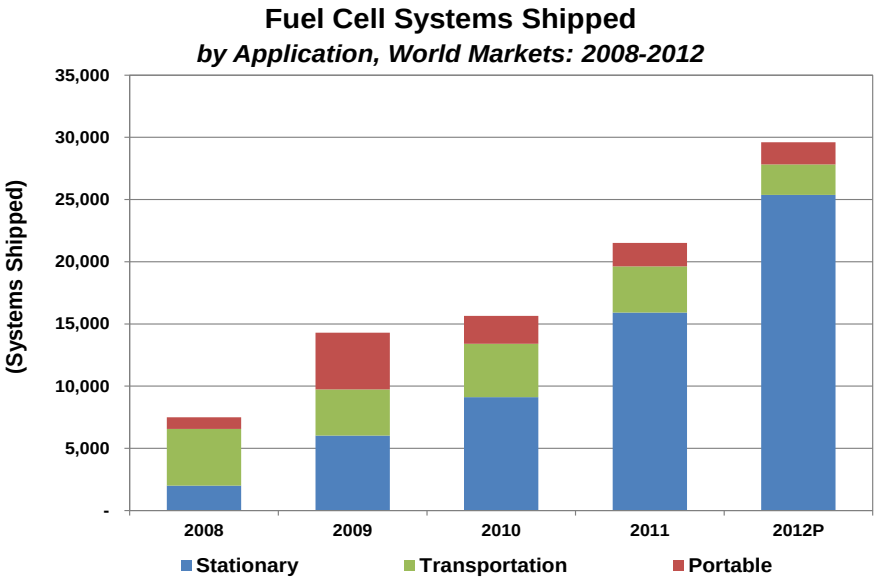
Troy, Michigan

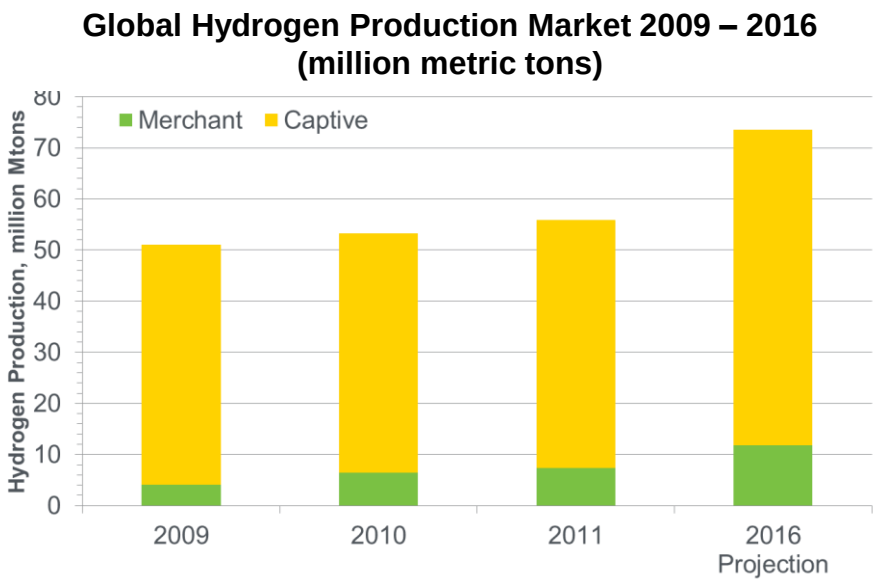
6/12/2014

Will James

Program Manager
Safety, Codes and Standards Program
Fuel Cell Technologies Office
U.S. Department of Energy

Fuel Cell Market Overview





Market Growth

Fuel cell markets continue to grow

- **48% increase in global MWs shipped**
- **62% increase in North American systems shipped in the last year**

The Market Potential

Independent analyses show global markets could mature over the next 10–20 years, with potential for revenues of:

- **$14 – $31 billion/year for stationary power**
- **$11 billion/year for portable power**
- **$18 – $97 billion/year for transportation**

The global hydrogen market is also robust with over 55 Mtons produced in 2011 and over 70 Mtons projected in 2016, a > 30% increase.

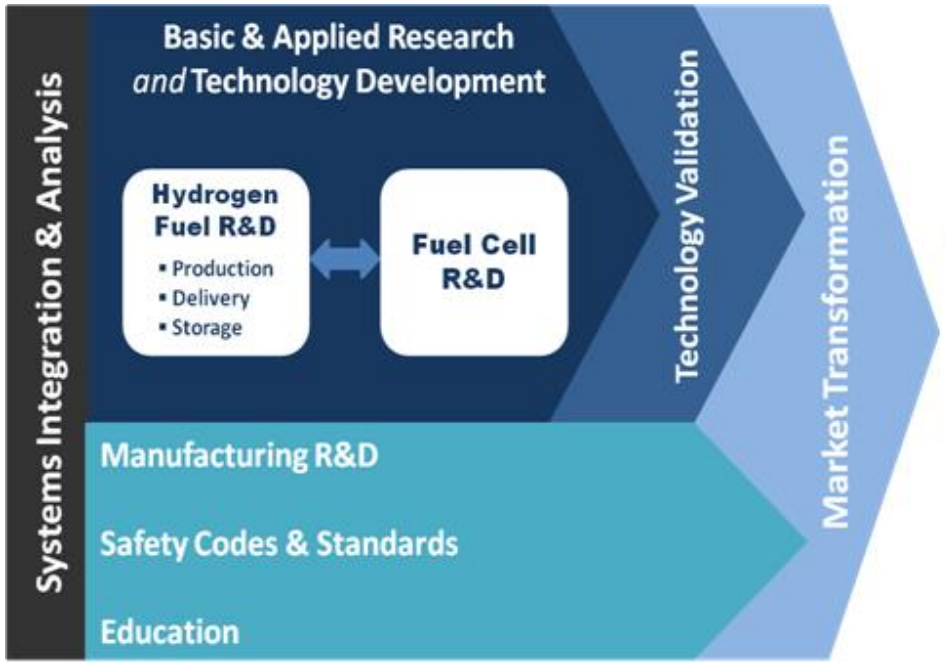
Several automakers have announced commercial FCEVs in the 2015-2017 timeframe.

For further details and sources see: *DOE Hydrogen and Fuel Cells Program Plan,* http://www.hydrogen.energy.gov/pdfs/program_plan2011.pdf; FuelCells 2000, Fuel Cell Today, Navigant Research, Markets & Markets

Fuel Cell Technologies Office Overview

Mission: Enable widespread commercialization of a portfolio of hydrogen and fuel cell technologies through applied research, technology development and demonstration, and diverse efforts to overcome institutional and market challenges.

Key Goals : Develop hydrogen and fuel cell technologies for early markets (stationary power, lift trucks, portable power), mid-term markets (CHP, APUs, fleets and buses), and long-term markets (light duty vehicles).



More than 200 projects currently funded at companies, national labs, and universities/institutes

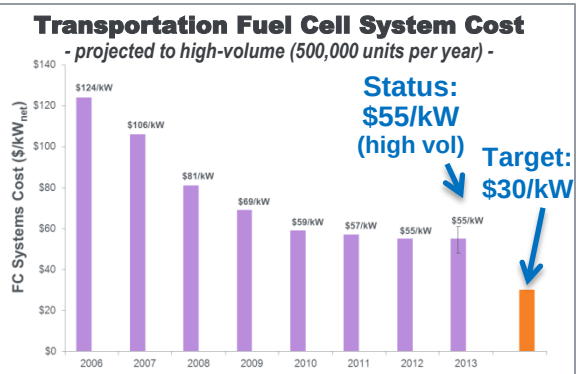
Key Targets for Automotive Applications

- **$40/kW by 2020 (ultimate target: $30/kW)**
- **5000 hour durability (150,000 miles)**
- **60% efficiency**
- **> 300 mile driving range**

DOE R&D

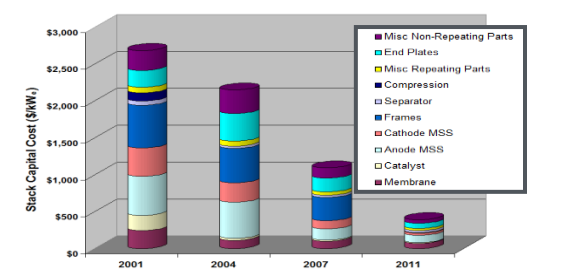
- *Reduces cost and improves performance*

Examples of progress:



→ *Reduced cost of fuel cells 50% since 2006*

→ *2020 target $40/kW, ultimate target $30/kW*



→ *Reduced cost of electrolyzer stacks 60% since 2007*

DOE Demonstrations & Technology Validation

- *Validate advanced technologies under real-world conditions*
- *Feedback guides R&D*

Demonstrated >180 FCEVs, 25 stations, 3.6 million miles traveled

Examples—validated:

- *59% efficiency*
- *254 mile range (independently validated 430-mile range)*
- *75,000-mi durability*

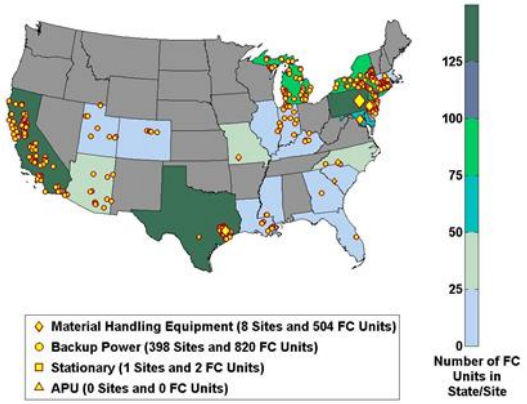
Demonstrated **world's first tri-gen** station (250 kW on biogas, 100 kg/d)

Program also includes enabling activities such as codes & standards, analysis, and education.

Deployments

- *DOE Recovery Act and Market Transformation Projects*
- *Government Early Adoption (DoD, FAA, California, etc.)*
- *Tax Credits: 1603, 48C*

Recovery Act & Market Transformation Deployments

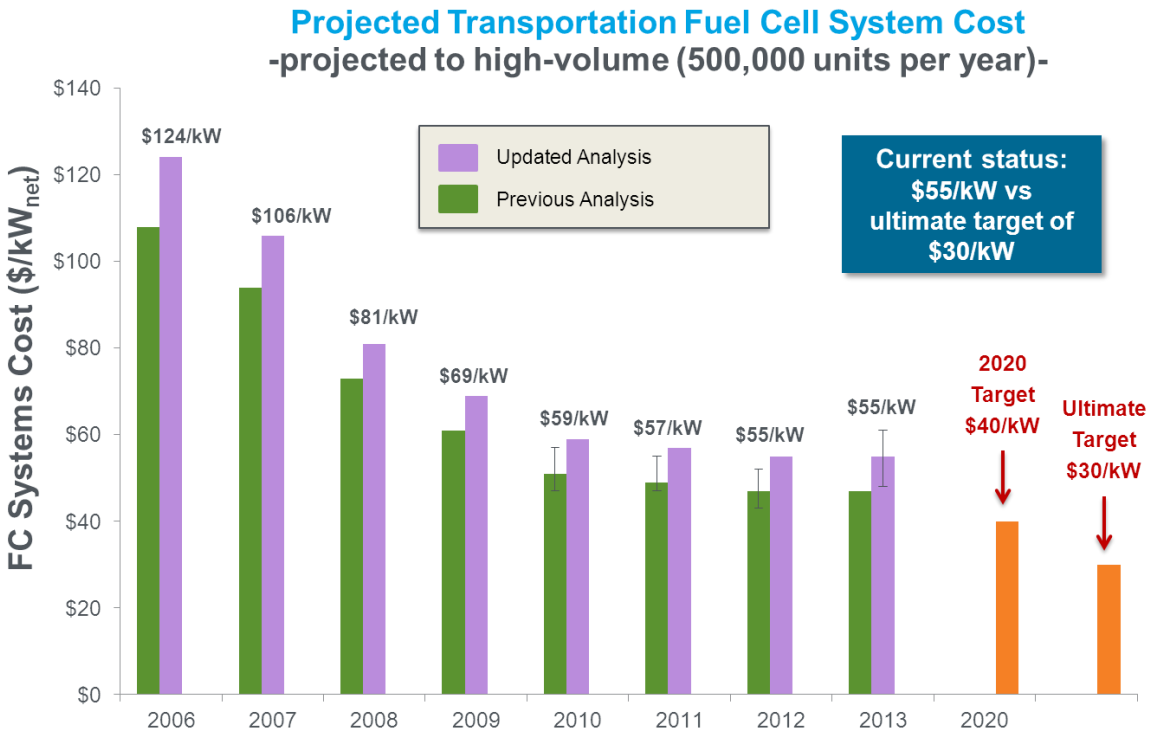


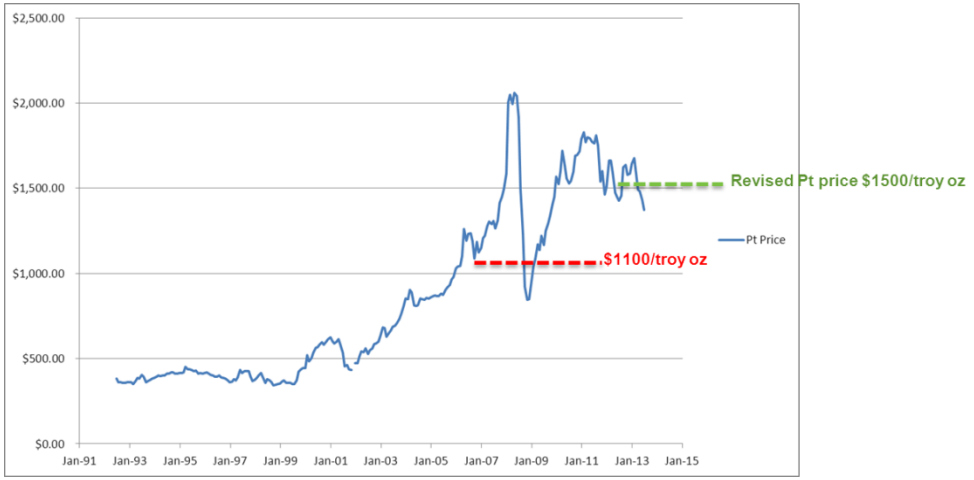
Nearly 1,600 fuel cells deployed

Fuel Cell Cost Reduction

Projected high-volume cost of fuel cells has been reduced to $55/kW (2013)*

- ***More than 30% reduction since 2008***
- ***More than 50% reduction since 2006***





Based on projection to high-volume manufacturing (500,000 units/year). *The projected cost status is based on an analysis of state-of-the-art components that have been developed and demonstrated through the DOE Program at the laboratory scale. Additional efforts would be needed for integration of components into a complete automotive system that meets durability requirements in real-world conditions.*

Co-Launched Public-Private Partnership

H_2USA

Mission: To promote the commercial introduction and widespread adoption of FCEVs across America through creation of a public-private partnership to overcome the hurdle of establishing hydrogen infrastructure.

Current partners include (additional in process):

U.S. DEPARTMENT OF ENERGY
Fuel Cell & Hydrogen Energy Association
GlobalAutomakers
GM
DAIMLER
HYDROGENICS Advanced Hydrogen Solutions
HONDA The Power of Dreams
EDTA Electric Drive Transportation Association
NISSAN
HYUNDAI
ITM POWER Energy Storage | Clean Fuel
Mercedes-Benz
OAK RIDGE National Laboratory
AGA American Gas Association
California Fuel Cell Partnership
DRIVING FOR THE FUTURE
SCRA
Sandia National Laboratories
PROTON THE LEADER IN ON SITE GAS GENERATION.
Pacific Northwest National Laboratory
NREL National Renewable Energy Laboratory
AIR LIQUIDE
arc:HYDROGEN
plug power
NUVERA Making hydrogen make sense.
Massachusetts Hydrogen Coalition
TOYOTA
Argonne NATIONAL LABORATORY

Early Market Challenges

Photo Credits Top: NREL, Middle: NREL, Bottom: Hexagon Lincoln

Being addressed by H2 USA

- **Station Cost Reduction**
  - Specification, design, and deployment
  - Fueling resources & delivery
  - Station and dispensing technology improvement
  - State and local regulations
- **Station Locations**
  - Identify and prioritize markets
  - Regulatory barriers (zoning)
  - Station rollout timing
- **Investment and Finance**
  - Private sector financing
  - Government support
- **Market Support and Acceleration**
  - Product launch and timeline
  - Codes and standards (non-vehicle related)
  - Public education

Co-Launched Public-Private Partnership

H_2 USA

Mission:
To promote the commercial introduction and widespread adoption of FCEVs across America through creation of a public private partnership to overcome the hurdle of establishing hydrogen infrastructure.

Key Activities

- Situational assessment and analysis
- Forming a strategy to coordinate vehicle and infrastructure rollout by:
  - Identifying potential investments and funding opportunities
  - Developing an action plan to identify and address key barriers
  - Conducting a rigorous evaluation of potential infrastructure deployment, including promising locations and timeframes
- Identifying synergies and opportunities to leverage other alternative fueling infrastructure – such as natural gas – to enable cost reductions and economies of scale
- Identifying actions to incentivize early adopters for deploying infrastructure and FCEVs
- Evaluating the business cases required for national commercialization of vehicle and hydrogen infrastructure technologies
- Supporting participation in programs for the deployment of advanced technology vehicles, such as the National Community Deployment Challenge

H2FIRST Project

Established by the Department of Energy's Fuel Cell Technologies Office, the Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST) project team, in collaboration with industry partners, will draw on existing and emerging core capabilities at the national labs and aim to reduce the cost and time of new fueling station construction and improve the stations' availability and reliability in support of H2 USA.

Project Teams:

- Station Qualification
- Dispenser Components Research
- Fuel Quality Sensor
- Station Component RD&D
- Reference Station Design

The proposed work scope includes

and provides support for H_2 USA

System Performance
Station benchmarks and targets
Test methods and devices for metering, quality and capacity
Siting and footprint

Component Reliability
Low-utilization effects (e.g. start/stop, idle, etc.)
High-utilization effects (e.g. failure modes, maint. planning)

System Integration
Fueling protocols and CSD engineering cost trade-offs
Dynamic effects of fueling (e.g. back-to-back cycles, pre-cooling) Parts-reduction and component configuration strategies

Component Innovation
Reliability, accuracy, and durability improvements
Novel concepts in compression, storage and dispensing

Materials
Temperature and pressure effects on material performance
System and component reliability and cost reduction
Material performance under aging conditions

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Maximize Impact by Leveraging

Broad role of the DOE labs:

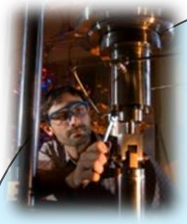
- Perform high-impact R&D to make H_2 fueling technologies affordable and convenient
- Assist in breaking down barriers to H_2 fueling technology deployment

DOE and State Agency Support

Broad role of the private sector :

- Develop and commercialize affordable and convenient H_2 technologies
- Implement successful business models for $H_2$and FC systems

National Labs



- Provide objective, scientifically sound assessments and coordination
- Develop R&D plans
- Provide capabilities and perform research that cannot be accessed elsewhere

H2FIRST

Advanced station technology
Enhanced customer experience

Private Sector

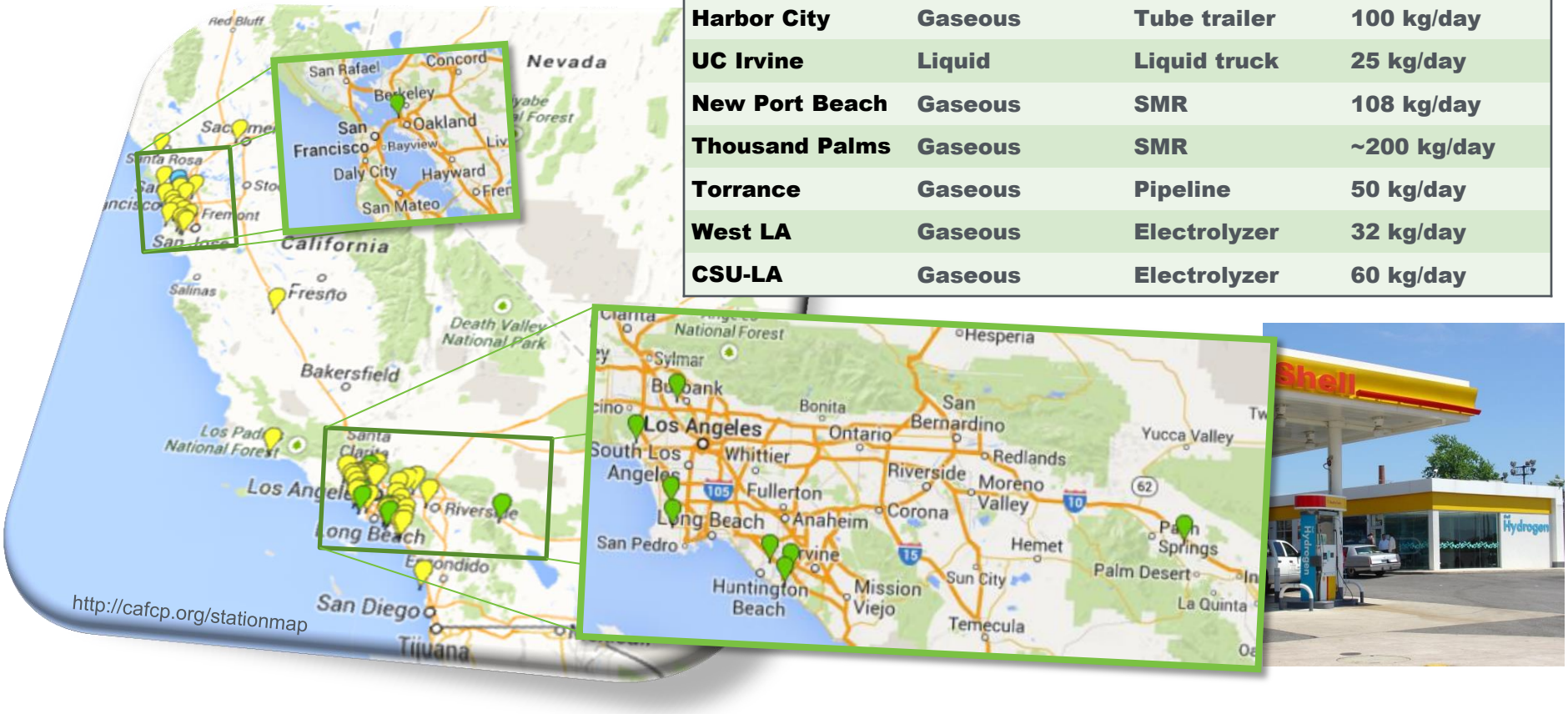
- Inform H2FIRST activities from a market perspective
- Contribute people, equipment, time, money to achieve H2FIRST objectives
- Implement results from H2FIRST into technology development

Market Growth

Infrastructure Status

- 10 stations open and operating in CA
- 46 stations in development
  - On May 1st CEC announced it will invest $46.6 million for H_2 refueling stations in CA adding 13 new locations in Northern CA and 15 in Southern CA

Station	Type	Source	Capacity
Burbank	**Gaseous**	**SMR**	**108 kg/day**
Emmeryville/ AC transit	**Gaseous & Liquid**	**Electrolyzer & Liquid truck**	**60 kg/day**
Fountain Valley	**Gaseous**	**SOFC – biogas conversion**	**100 kg/day**
Harbor City	**Gaseous**	**Tube trailer**	**100 kg/day**
UC Irvine	**Liquid**	**Liquid truck**	**25 kg/day**
New Port Beach	**Gaseous**	**SMR**	**108 kg/day**
Thousand Palms	**Gaseous**	**SMR**	**~200 kg/day**
Torrance	**Gaseous**	**Pipeline**	**50 kg/day**
West LA	**Gaseous**	**Electrolyzer**	**32 kg/day**
CSU-LA	**Gaseous**	**Electrolyzer**	**60 kg/day**



H_2 and Fuel Cell Initiatives at the State Level

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Several states—including California, Connecticut, Hawaii, Ohio, New York, and South Carolina—have major hydrogen and fuel cell programs underway

8 states sign MoU to put 3.3M zero emission vehicles on roads by 2025

States include California, Connecticut, Massachusetts, Maryland, New York, Oregon, Rhode Island, & Vermont

- **Represents a new vehicle market penetration of ~15%**

California

FCEVs and Fuel Cell Buses

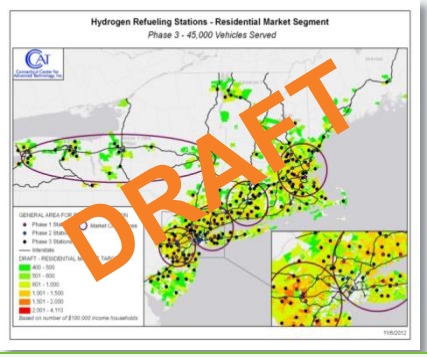
- **> 560 vehicles** in operation since 1999 — ~230 currently operating
- **> 6 million miles** driven
- **> 1 million passengers** on fuel cell buses

H_2 Station Investment

- **$51.5M invested** *(CARB and CEC)*
- **~$13M invested** by SCAQMD
- **~$46.6M for 28 stations and 1 mobile refueler** (CEC PON 13-607)
- **$20M planned annually** thru 2023 for at least 100 stations (AB8)

Northeast (e.g. MA, NY, CT)

Preliminary Plans: ***3 phase plan modelled by CCAT for the development of hydrogen infrastructure and deployment of fuel cell electric vehicles (FCEVs) in the north eastern coastal metro centers.***



Hawaii

Agreement signed by 12 stakeholders—including GM, utilities, hydrogen providers, DOD, DOE—to establish hydrogen as a major part of the solution to Hawaii's energy challenges.

- **15 GM FCEVs currently in demonstrations with military**
- **Renewable hydrogen (from geothermal and wind energy) will be used for buses**
- **Goals include a public access nascent refueling infrastructure on Oahu by 2020 to support initial deployments of government and industry FCEV fleets**

Future Plans - Summary

Continue to promote and strengthen R&D activities

- Hydrogen, fuel cells, safety, manufacturing, etc.
- Cost, performance, durability need to be addressed

Conduct strategic, selective demonstrations of innovative technologies

- Industry cost share and potential to accelerate market transformation

Continue to conduct key analyses to guide RD&D and path forward and increase communication & outreach

- Life cycle cost; economic & environmental analyses, etc.
- Engage House and Senate H2 and Fuel Cells Caucus

Leverage activities to maximize impact

- State and global partnerships
- H2USA: Public-Private partnership to enable widespread commercialization of hydrogen vehicles in the United States

Collaboration is Critical

To meet fuel needs and reduce emissions, sustained and effective collaboration among key stakeholders is critical.

"It is literally true that you can succeed best and quickest by helping others to succeed."

- Napoleon Hill, American Author 1883-1970

Thank You

Charles.James@ee.doe.gov

hydrogenandfuelcells.energy.gov

HCD Workshop Objective

- Gather input from stakeholders on requirements, technologies and R&D gaps associated with detection of contamination at hydrogen fueling stations
- Input will help identify current state-of-the-art detection technologies for the near-term and R&D advancements needed for low-cost, accurate, and robust detectors for the long-term
- Three Breakout Sessions
  - Technical and Performance Requirements (Scott McWhorter, SRNL)
  - Near-Term Solutions to Meet Deployment Requirements (Danny Terlip, NREL)
  - Long-Term R&D Areas to Address Technical Gaps (Terry Johnson, SNL)
- Will provide feedback to the group through a published report of the findings
- What we are NOT aiming for?
  - Not looking to change the Fuel Quality Specifications, SAE J2719 or ISO 14687-2
  - Not mandating or requiring contamination detection at the HRS

Preliminary RFI Feedback

- What is the maximum allowable cost for an HCD solution to be economical?
  - High capitol cost seems reasonable ($10k to $20k) with no maintenance or low cost (< $250) with replacement and calibration considerations
- Where do HCDs need to be positioned with respect to station components?
  - A positioned in close proximity to the fuel dispenser (close to the delivery nozzle) to sample through a reliable connection. Note that sources of contamination may be diverse
  - Around the storage bank was mentioned
  - Flexibility for different parts of the station or upstream supply chain
- For each contaminant, what is the minimum sensitivity a device would need to have in order to provide a useful response to the contaminant (for near-term deployment)?
  - Sensitivity for each critical contaminant should be 1/10 of the max value
  - Limit should be better than within an order of magnitude of allowable limits defined in SAE J2719
  - Sensitivity of 500 ppm or better