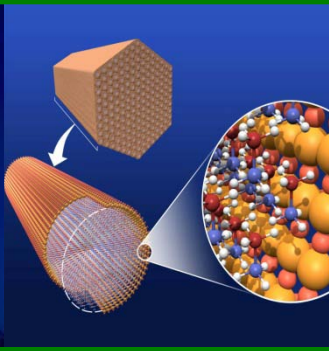
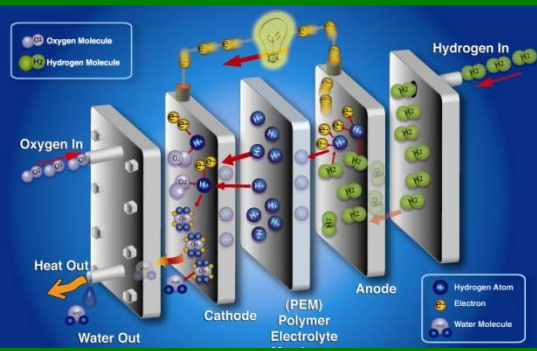




U.S. DEPARTMENT OF
ENERGY



Technology Validation

John Garbak

*2010 Annual Merit Review and Peer Evaluation Meeting
(8 June 2010)*

Goal: Validate complete systems of integrated hydrogen and fuel cell technologies for transportation, infrastructure and electricity generation applications under real-world operating conditions

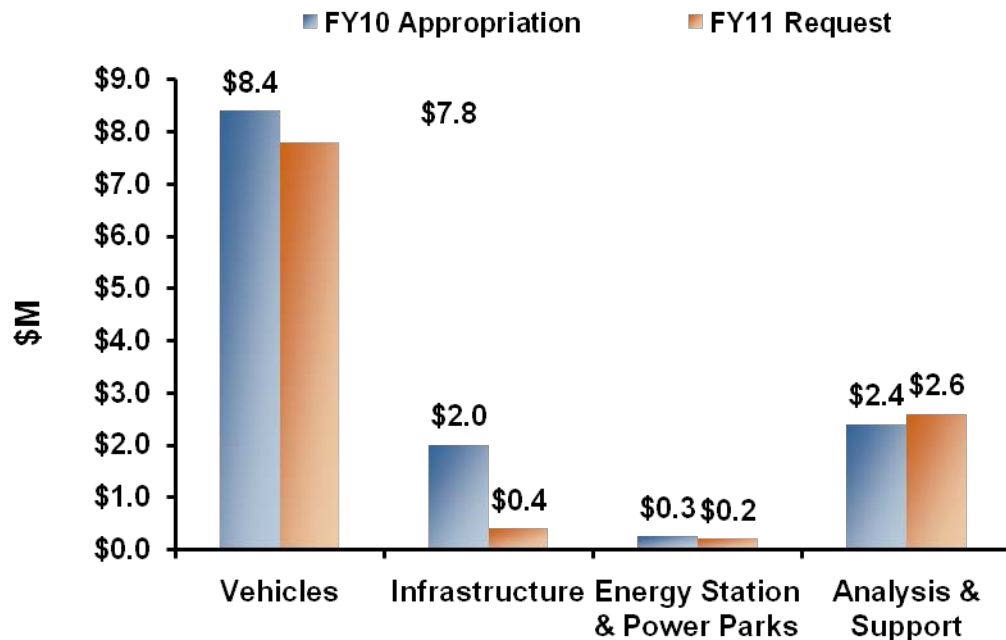
Objectives:

- Validate hydrogen and fuel cell technologies in parallel
- Identify current status of the technology
 - Assess progress toward technology readiness
 - Provide feedback to H₂ Research and Development

Key Targets

Performance Measure	2009	2015
Fuel Cell Stack Durability	2000 hours	5000 hours
Vehicle Range	250+ miles	300+ miles
Hydrogen Cost at Station	\$3/gge	\$2-3/gge

FY 2011 Request = \$11.0 M
FY 2010 Appropriation = \$13.1 M



EMPHASIS

- Final report from two learning demonstration teams to be completed
- Advanced fuel cell vehicles being introduced and data collection to continue in final two projects
- Collect operational and maintenance data at Combined Heat and Power site at Orange County Sanitation District in Fountain Valley, CA
- Continue data collection of fuel cell buses

Through data collection during the Learning Demonstration many challenges have been met

- **Lack of fuel cell vehicle performance and durability data**
 - Learning Demo and FC Bus evaluation have generated significant quantities of fuel cell vehicle data that have been analyzed and published
- **Lack of refueling infrastructure performance and availability data**
 - Tech Val projects have analyzed many aspects of H2 refueling infrastructure, including refueling rates, safety, maintenance, production efficiency, and availability
- **Assess fuel cell start-up and operation in 3 different climatic conditions and ability to start fuel cells in cold climates**
 - FCVs have demonstrated acceptable cold start performance and hot start durability
- **Evaluation of filling vehicles at 700 bar**
 - Over 5,500 fueling events performed at 700 bar, with an average fill rate of 0.63 kg/min
- **Need to address fuel cell vehicle and infrastructure interface issues**
 - Communication fills (vehicle talks to station during fill) have been evaluated, and on average communication fills are 30% faster than non-communication fills



- **Fuel cell durability**
 - 2,500 hours projected (nearly 75K miles)
- **Over 2.5 million miles traveled**
- **Over 106K total vehicle hours driven**
- **Fuel cell efficiency 53-59%**
- **Over 150,000 kg of hydrogen produced or dispensed**
- **144 fuel cell vehicles and 23 hydrogen fueling stations have reported data to the project**
 - There are 17 vehicles and 15 fueling stations active in the project

Summary – Key Performance Metrics

Vehicle Performance Metrics	Gen 1 Vehicle	Gen 2 Vehicle	2009 Target
<i>Fuel Cell Stack Durability</i>			2000 hours
Max Team Projected Hours to 10% Voltage Degradation	1807 hours	2521 hours	
Average Fuel Cell Durability Projection	821 hours	1062 hours	
Max Hours of Operation by a Single FC Stack to Date	2375 hours	1261 hours	
<i>Driving Range</i>	103-190 miles	196-254 miles	250 miles
<i>Fuel Economy (Window Sticker)</i>	42 – 57 mi/kg	43 – 58 mi/kg	no target
<i>Fuel Cell Efficiency at ¼ Power</i>	51 - 58%	53 - 59%	60%
<i>Fuel Cell Efficiency at Full Power</i>	30 - 54%	42 - 53%	50%

Infrastructure Performance Metrics			2009 Target
<i>H₂ Cost at Station (early market)*</i>	On-site natural gas reformation \$7.70 - \$10.30	On-site Electrolysis \$10.00 - \$12.90	\$3/gge
<i>Average H₂ Fueling Rate</i>	0.77 kg/min		1.0 kg/min

* DOE independent panels concluded at 500 replicate stations/year:
 Distributed natural gas reformation at 1500 kg/day: \$2.75-\$3.50/kg (2006)
 Distributed electrolysis at 1500kg/day: \$4.90-\$5.70 (2009)

2010 Progress & Accomplishments

NREL has collected data for DOE and FTA on 9 FCBs in service at 5 sites:

**AC Transit
SunLine
CTTRANSIT
VTA
Columbia, SC**

Traveled:

~ 395,000 miles

Dispensed:

80,304 kg H₂

NREL Hydrogen Bus Evaluations for DOE and FTA																			
Site/Location	State	Eval. Funding	2009				2010				2011				2012				
			1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4	
AC Transit/ SF Bay Area	CA	DOE Technology Validation					CA ZEB Advanced Demo												
SunLine/ Thousand Palms	CA		FCB																
SunLine/ Thousand Palms	CA		Advanced FCB Project																
CTTRANSIT/ Hartford	CT		FCB Demo																
City of Burbank/ Burbank	CA		Burbank FCB																
AC Transit/ Oakland	CA	FTA National Fuel Cell Bus Program	Accel. Test																
SunLine/ Thousand Palms	CA		American FCB Demo																
CTTRANSIT/ Hartford	CT		Nutmeg Hybrid FCB Demo																
USC, CMRTA/ Columbia UT/ Austin	SC, TX		Hybrid FCB																
Logan Airport / Boston	MA		MA H2 FCB Demo																
Albany / NY	NY		Light-wt FCB																
TBD / NY	NY		NYPA H2 Powered FCB																
SFMTA / San Francisco	CA		FC APU Hybrid																

Demonstration sites color coded by geographic area:

- Northern California
- New England
- Southeast
- Southern California
- New York
- South



Fuel economy results: 39% to 141% better than diesel and CNG buses

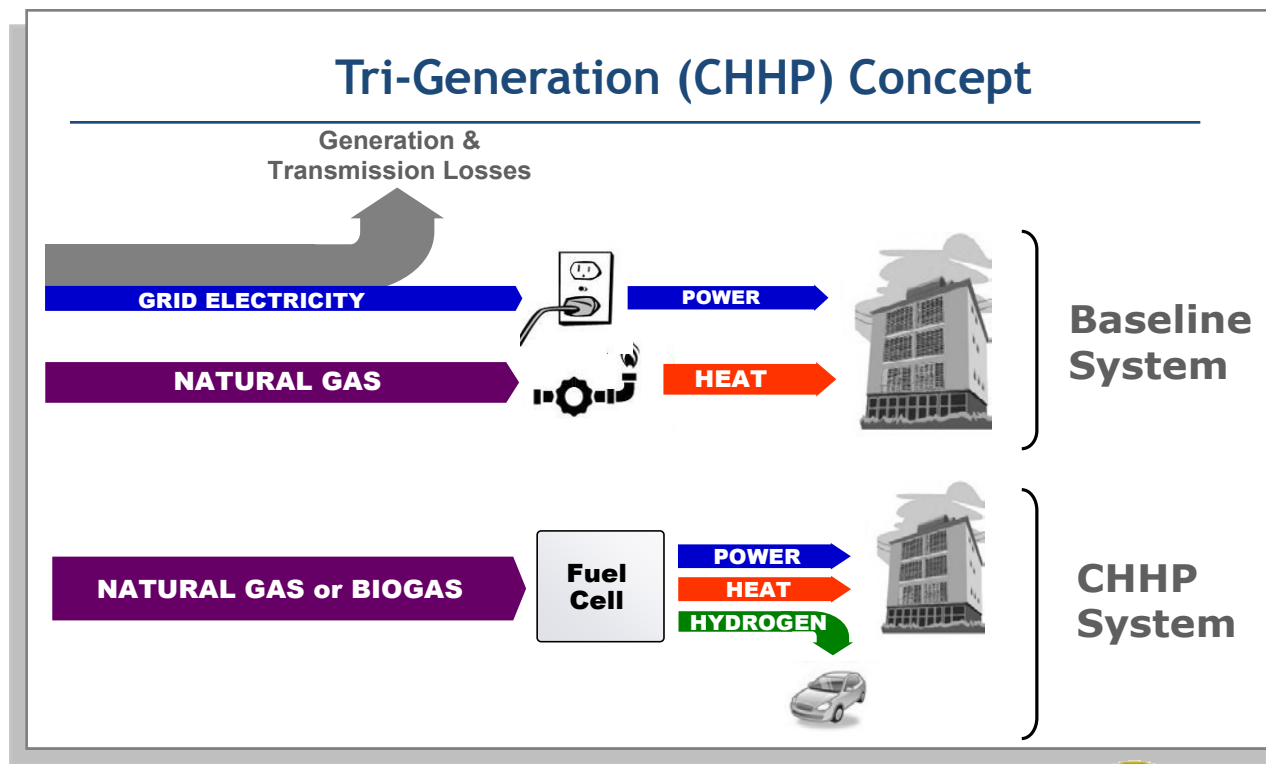
www.nrel.gov/hydrogen/proj_tech_validation.html

Estimate of data collection/evaluation - schedule subject to change based on progress of each project

2010 Progress & Accomplishments

We are participating in a project to demonstrate a combined heat, hydrogen, and power (CHHP) system using biogas.

- System has been designed, fabricated and shop-tested
- Improvements in design have led to higher H₂-recovery (from 75% to >85%)
- On-site operation and data-collection planned for FY10 – FY11



Combined heat, hydrogen, and power systems can:

- *Produce clean power and fuel for multiple applications*
- *Provide a potential approach to establishing an initial fueling infrastructure*

Public-Sector Partners:



South Coast Air Quality Management District



California Air Resources Board



Fuel Cell Energy & Air Products

- **Continue data collection of the advanced fuel cell vehicles in the Learning Demonstration**
- **Begin to collect data from the Fountain Valley Energy Station**
- **Continue data collection of fuel cell buses, stationary fuel cell and fork lifts**

- This is a review, not a conference
- Presentations will begin precisely at the scheduled times
- Talks will be **20 minutes** and **Q&A 10 minutes**
- Reviewers have priority for questions over the general audience
- Reviewers should be seated in front of the room for convenient access by the microphone attendants during the Q&A
- Please mute all cell phones, BlackBerries, etc.

- Deadline for final review form submittal is **June 18th**
- ORISE personnel are available on-site for assistance. A reviewer lab is set-up in room 8216 and will be open Tuesday –Thursday from 7:30 AM to 6:00 PM and Friday 7:30 AM to 3:00 PM.
- Reviewer feedback session – **Thursday, at 1:30pm, (after lunch) in the room of the last session.**

Technology Validation

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