NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Parallel Session 5 – Early Markets 2

Next Steps for the FCEV Learning Demonstration Project

Keith Wipke, Sam Sprik, Jennifer Kurtz, Todd Ramsden, Chris Ainscough, Genevieve Saur

February 16, 2011

Fuel Cell & Hydrogen Energy Conference
Washington, DC

NREL/PR-5600-50842

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Outline

- Project Goals
- Vehicle and H_2 Station Deployment Status
- Critical Performance Compared to Targets
- Highlights of Latest Vehicle and Infrastructure Analysis Results and Progress
- Learning Demo Next Steps
- Highlights of Partner Activities
- Summary

Fuel Cell Electric Vehicle Learning Demo Project Objectives, Relevance, and Targets

- Objectives
  - Validate H_2 FC Vehicles and Infrastructure in Parallel
  - Identify Current Status and Evolution of the Technology
- Relevance
  - Objectively Assess Progress Toward Technology Readiness
  - Provide Feedback to H_2 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

Note: Project extended 2 years through 2011

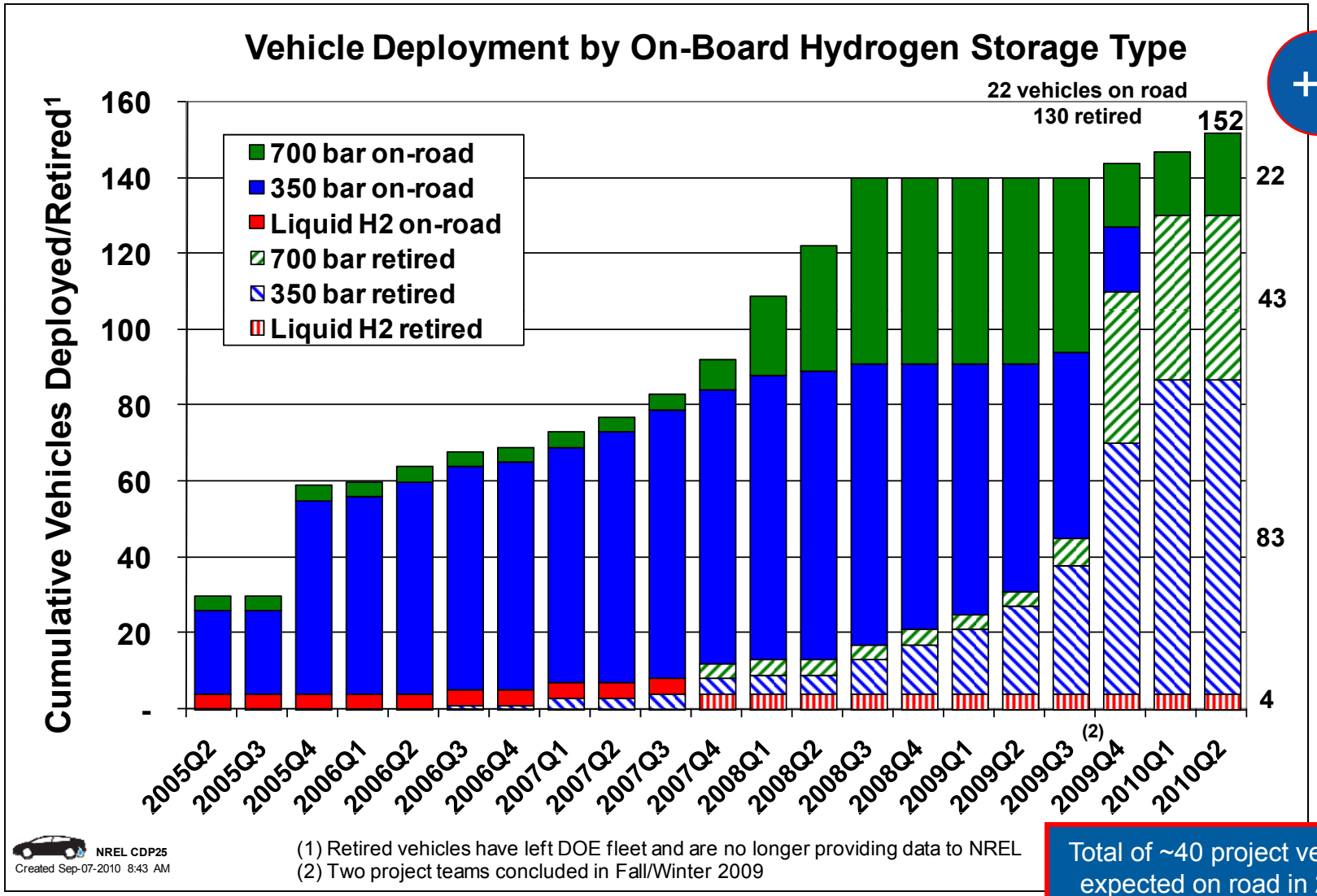
Burbank, CA station. **Photo: NREL**

Two Teams Concluded Their Projects in 2009, Three are Continuing through 2011

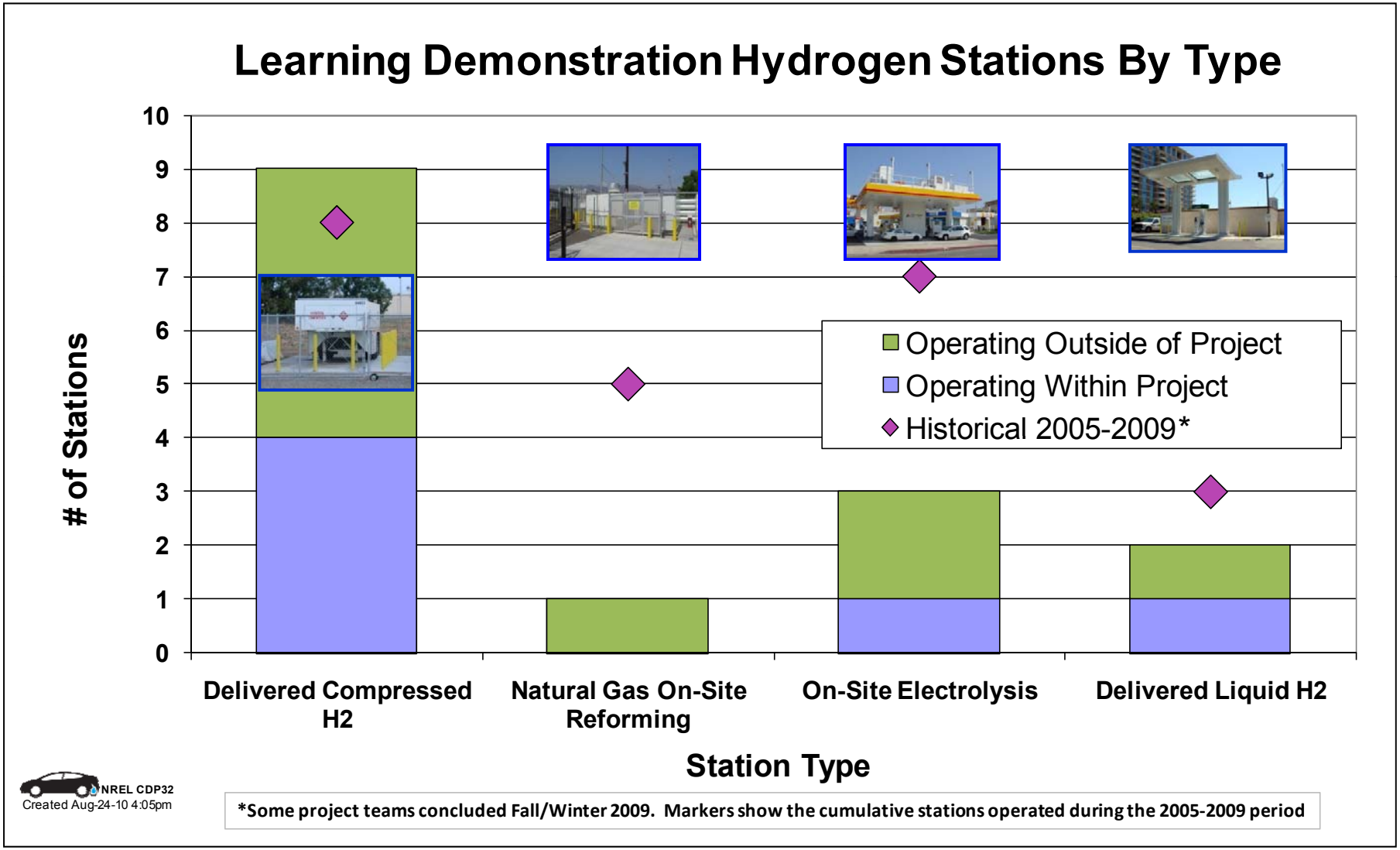
Ford/BP and Chevron/Hyundai-Kia Concluded in 2009

Daimler, GM, and Air Products Continue to Demonstrate Vehicles/Stations within Project through 2011

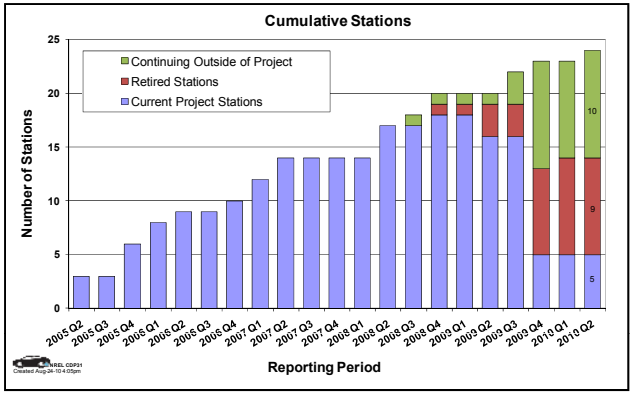
Vehicle Status: All 350 bar Vehicles Retired, Only 700 bar Vehicles Continuing

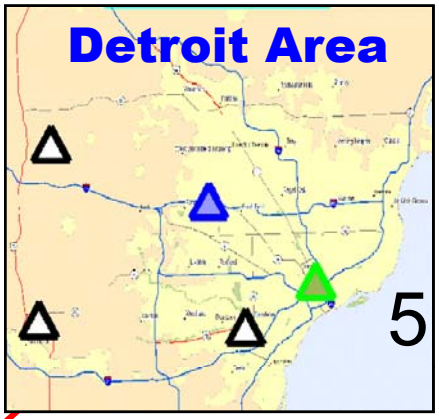


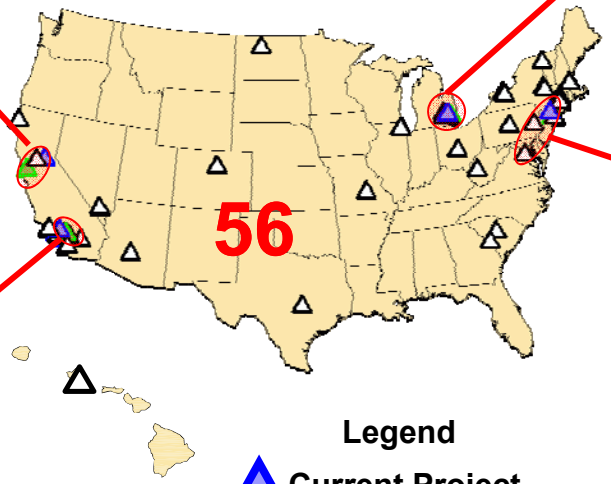
Fueling Station Status: Stations that Continue to Operate are Mostly Delivered Compressed Hydrogen



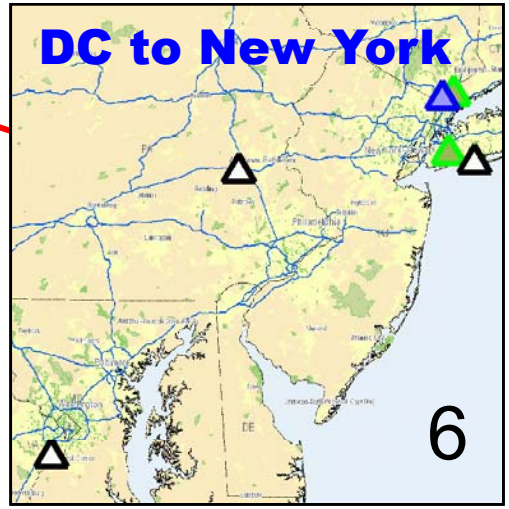
Out of 24 Project Stations, 15 Are Still Operational (2/3 outside of DOE project)







Los Angeles Area



Legend
- Current Project
- Continuing Outside
- Other

Feb-3-2011

Project Achieved Both Technical Goals; Outside Analysis Used for Cost Evaluation

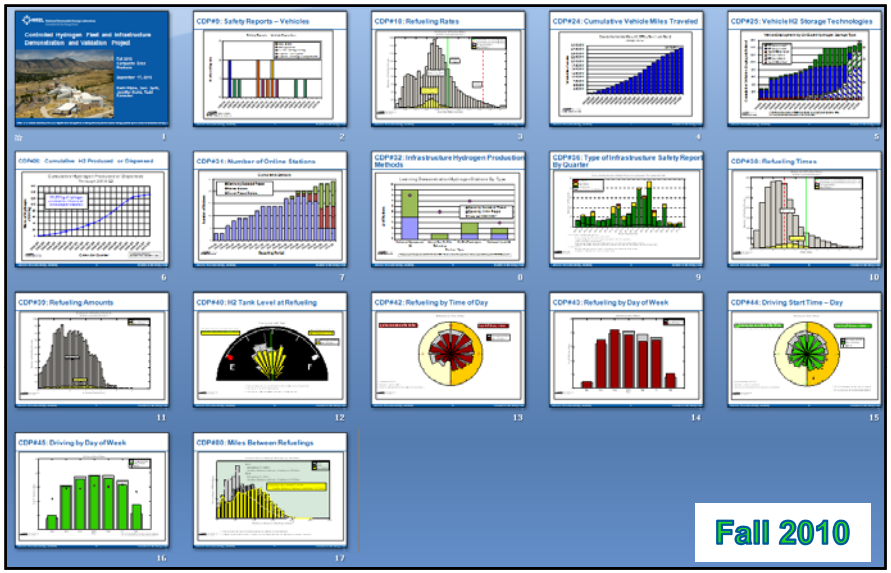
Vehicle Performance Metrics	Gen 1 Vehicle	Gen 2 Vehicle	2009 Target
Fuel Cell Stack Durability			**2000 hours**
Max Team Projected Hours to 10% Voltage Degradation	**1807 hours**	**2521 hours**	
Average Fuel Cell Durability Projection	821 hours	1062 hours	
Max Hours of Operation by a Single FC Stack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

Infrastructure Performance Metrics			2009 Target
H_2 Cost at Station (early market)	On-site natural gas reformation **$7.70 - $10.30**	On-site Electrolysis **$10.00 - $12.90**	**$3/gge**
Average H_2 Fueling Rate	0.77 kg/min		1.0 kg/min

Outside of this project, 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)

Outside review panel

What are the Most Recent Project Results? Differences Between Spring & Fall 2010 CDPs



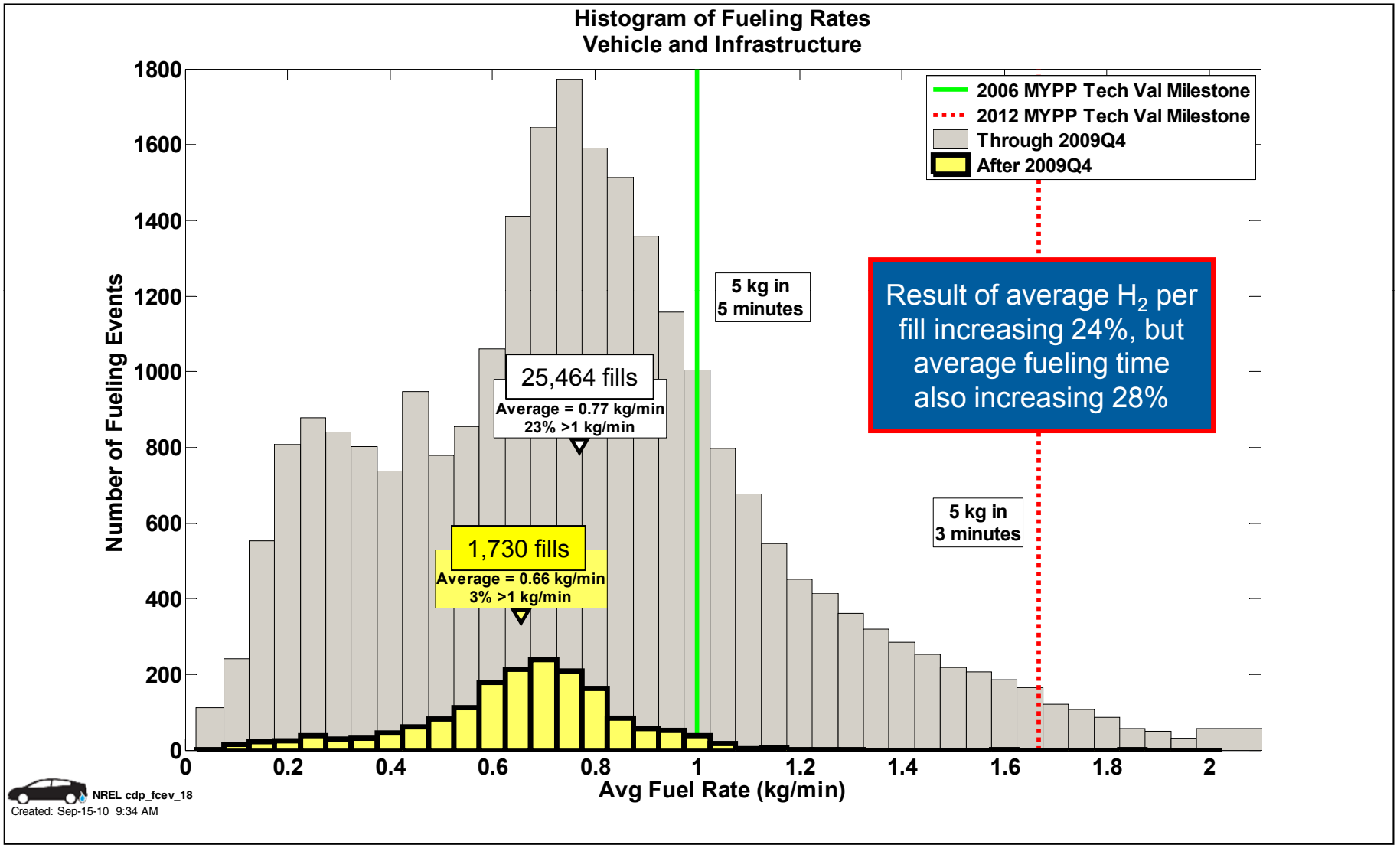
80 Spring 2010 Results

- Most comprehensive set we ever published
- Includes durability, range, fuel economy, etc.
- Covers data from all 4 Learning Demo teams + CHIP project over 5 year period
- Majority of these will now stay static, serving as a historical record of Gen 1 & Gen 2 comparisons.

16 Fall 2010 Results

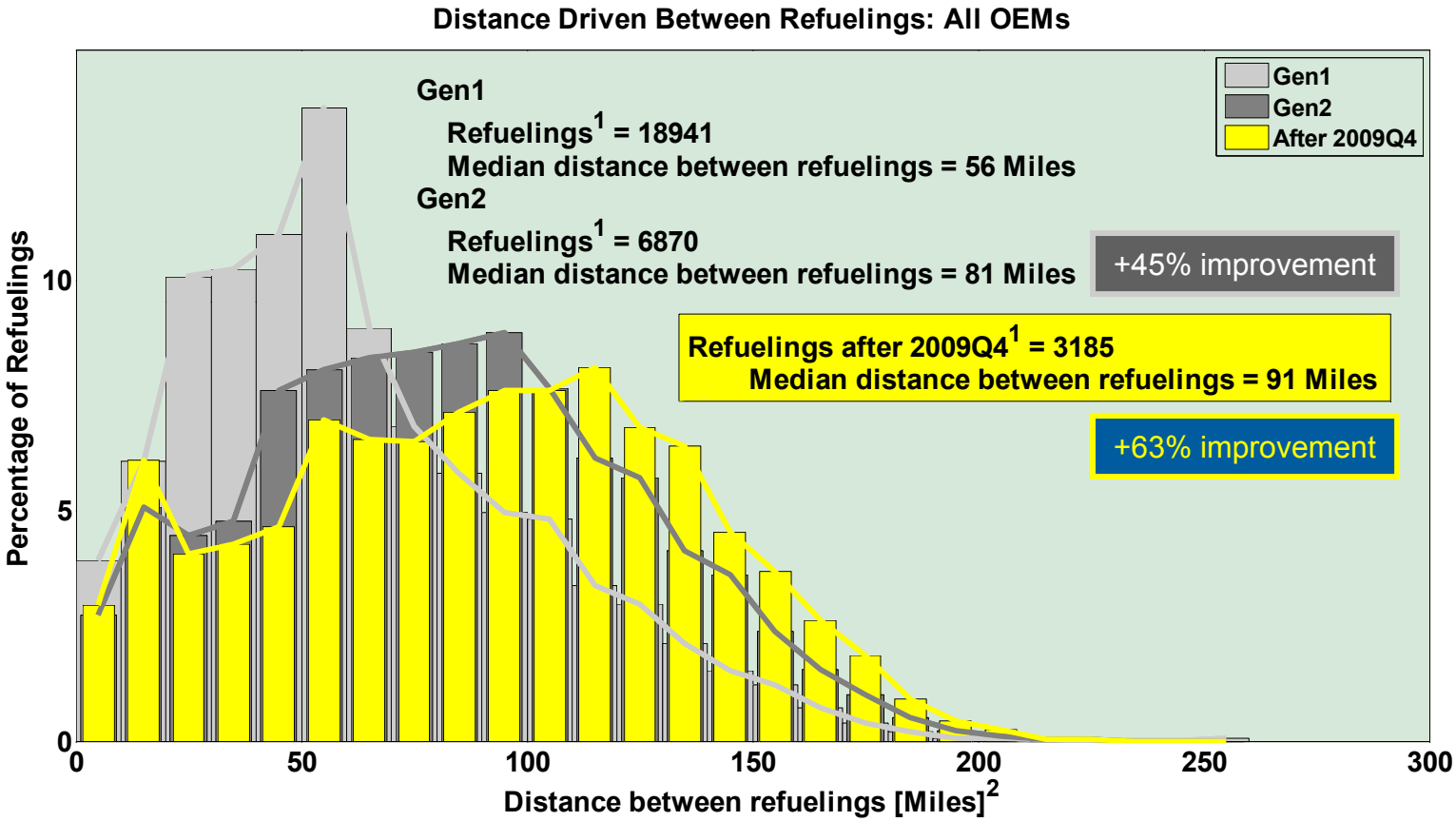
- No “new” CDPs, but we updated 16 previously published CDPs with data from last 6 months
- Results on most recent durability, range, fuel economy, not yet possible to publish until more data accumulated (in 2011)
- Covers data from 2 Learning Demo OEMs + CHIP project
- Emphasized changes observed in last 6 months through use of gray (old) and colors (new)

Changes in Refueling Rate Trends: Average Refueling Rate Decreased 14%



Fall 2010

Real-World Driving Range Between Refuelings Continues to Improve as Demonstration Progresses



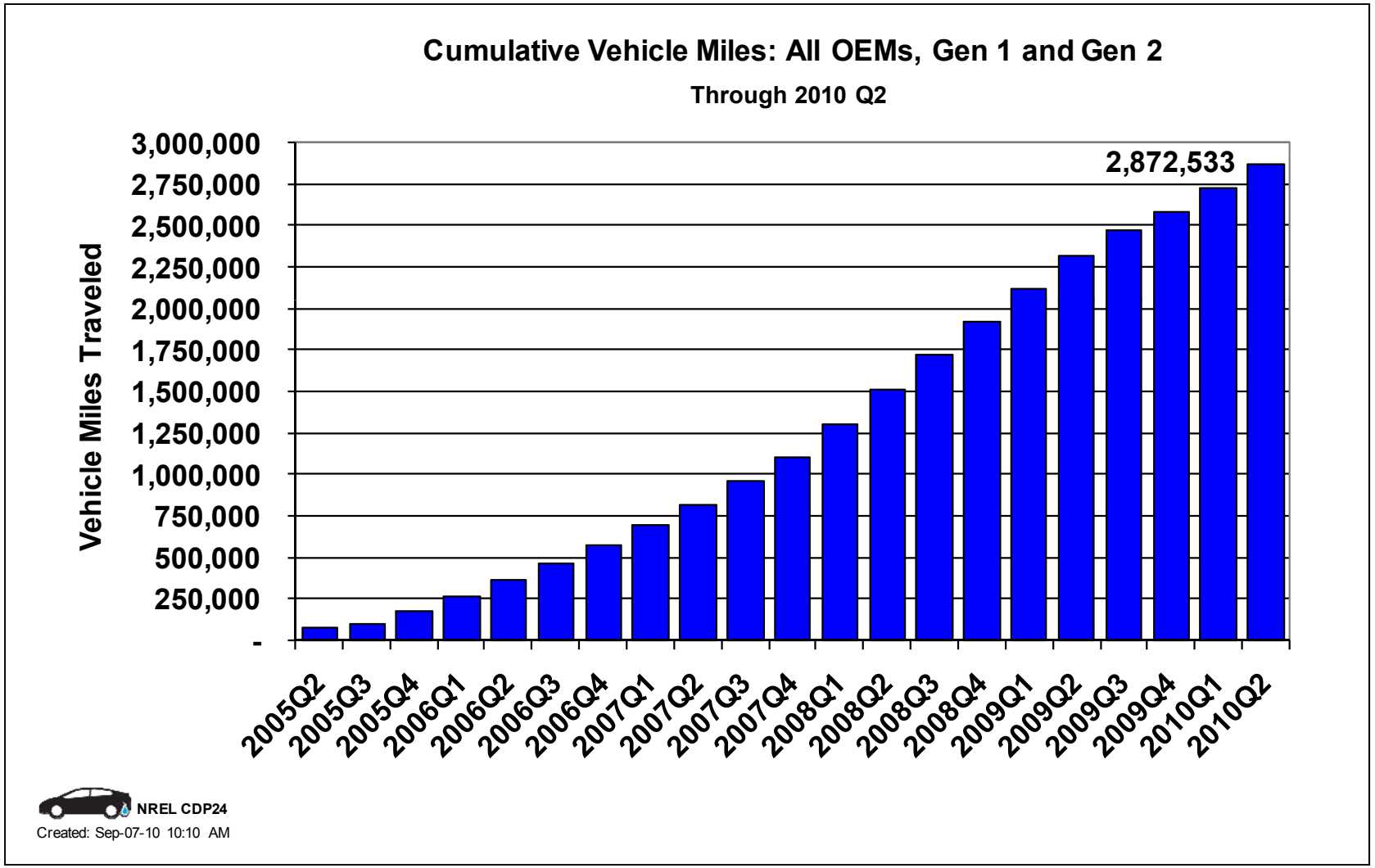
1. Some refueling events are not detected/reported due to data noise or incompleteness.
2. Distance driven between refuelings is indicative of driver behavior and does not represent the full range of the vehicle.

"window-sticker" range from adjusted dyno tests is 196-254 miles

NREL cdp_fcev_80
Created: Sep-07-10 9:16 AM

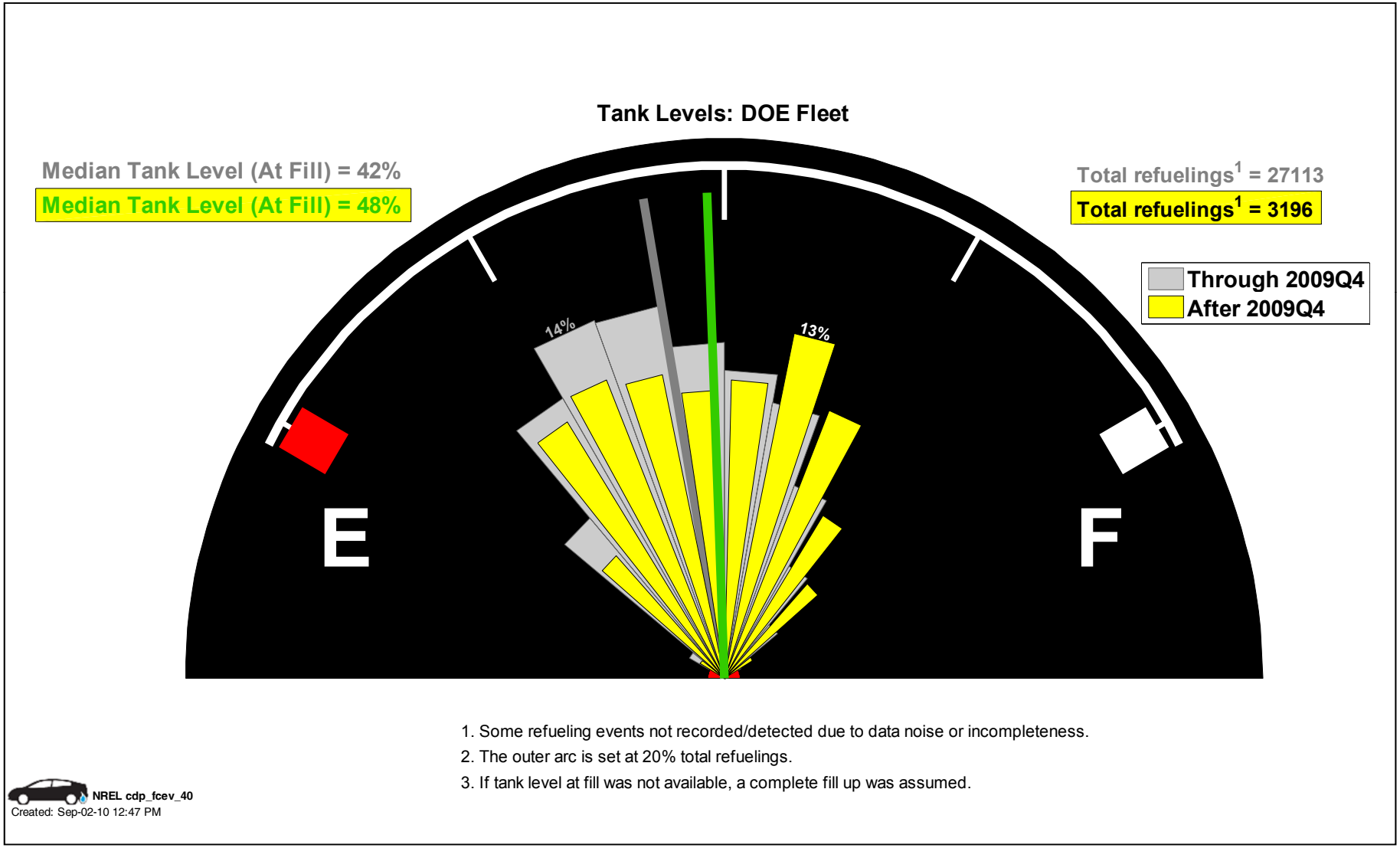
Fall 2010

Rate of Mileage Accumulation Has Decreased in the Last Year, But Vehicles Still Added 550,000 Miles



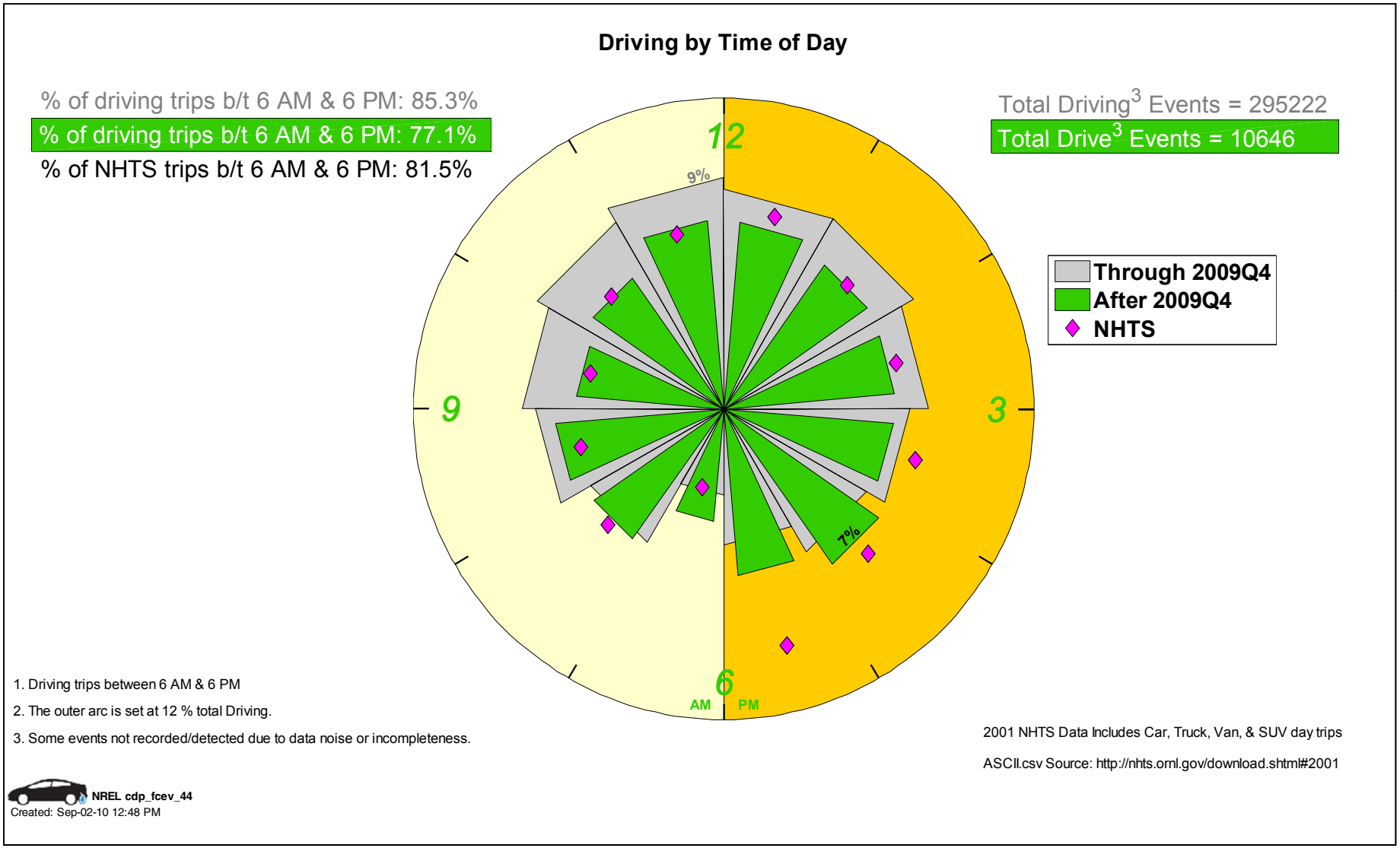
Fall 2010

Based on Limited Number of Fuelings in Last 6 Months, Higher Level of Tank at Refueling Observed



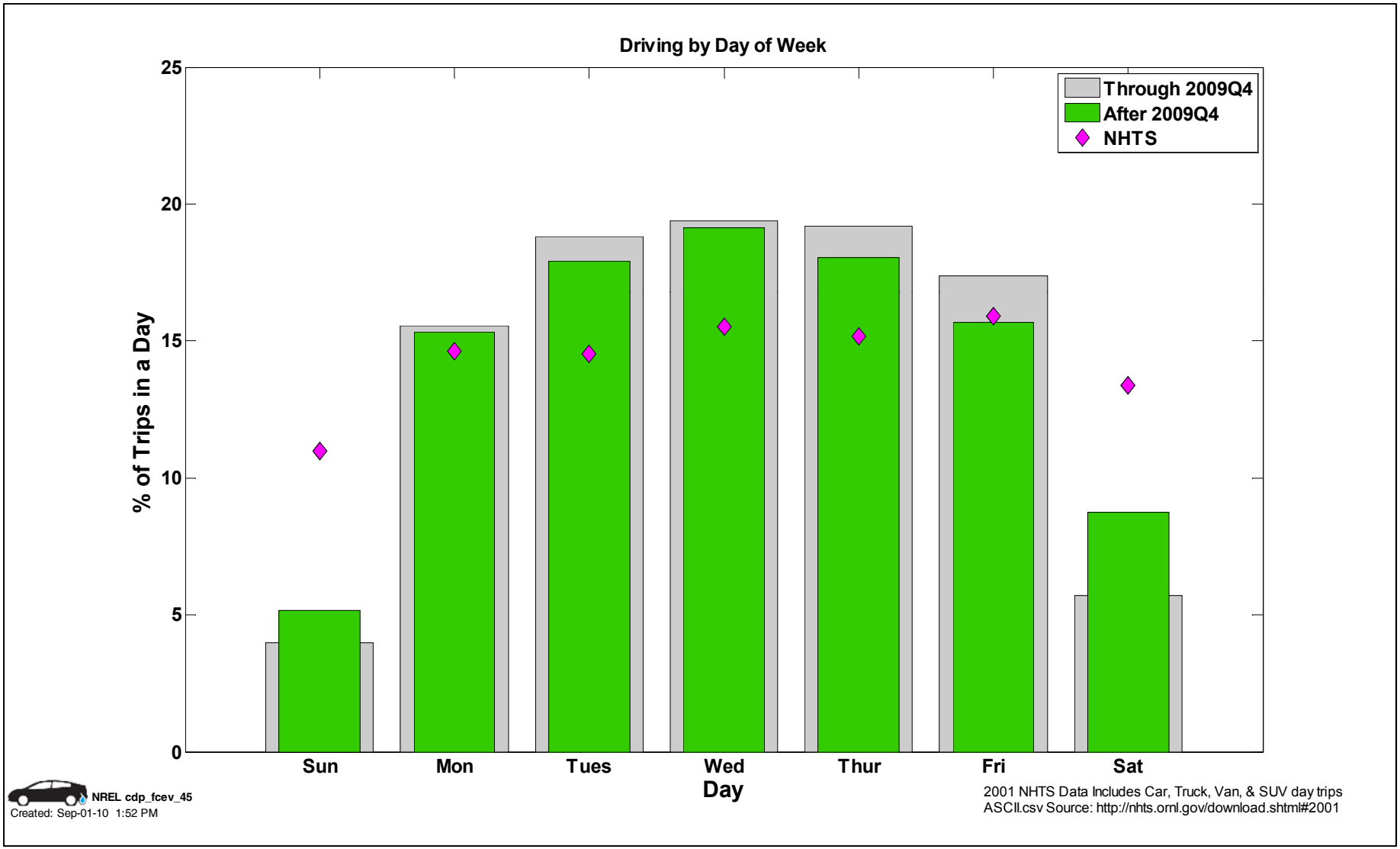
Fall 2010

Driving Behavior (Timing) in Last 6 Months Much More Similar to National Average



Fall 2010

More Weekend Driving Observed in Last Six Months – Still Much Less than National Avg.



Fall 2010

Learning Demo Next Steps

NREL
NATIONAL RENEWABLE ENERGY LABORATORY

- Currently analyzing July – December 2010 data
- Spring 2011 CDPs published in March, presented at DOE AMR in May
- Publish one or two more Learning Demo CDP sets after that
- Begin receiving fueling data from Burbank station and others

- Partners scheduled to provide data through September 2011
- Participating in many other demonstration and pre-commercial activities outside of this project

Update on Continuing Partner Activities
GM – LOU for Hawaii Hydrogen Initiative

GM

The New York Times

December 8, 2010, *2:11 pm*

G.M. Has Hydrogen Hopes for Hawaii

By JIM MOTAVALLI

Steve Fecht for General Motors The General Motors Fuel Cell vehicle on the coast of Oahu. The ideal early market for hydrogen fuel-cell cars is small, self-contained, facing exorbitant fossil fuel prices and has an abundant supply of renewable energy on tap, according to Charles Freese, executive director of General Motors' fuel-cell activities.

Iceland, which fits that description, had actually announced its intentions to be the world's first hydrogen energy economy, but access to fuel-cell cars proved to be a crippling barrier. The Hawaiian island of Oahu, with a population of one million, may be over that hurdle.

On Wednesday, G.M. announced the Hawaii Hydrogen Initiative (or H2I in marketing speak) in Honolulu. It's a new partnership with, among others, Aloha Petroleum (which operates filling

General Motors LLC	Charles Freese Executive Director Fuel Cell Activities	GM
The Gas Company LLC	[illegible] President and Chief Executive Officer	HAWAIIGAS
The State of Hawaii	Theodore A. Peck Administrator State Energy Office	
PACOM	George Kailiwai III Director, Resources and Assessment	
The U.S. Department of Energy	Steven G. Chalk Chief Operating Officer and Acting Deputy Assistant Secretary for Renewable Energy	
National Renewable Energy Laboratory, managed and operated by Alliance for Sustainable Energy, LLC	Dan Arvizu Laboratory Director and Alliance President	NREL
University of Hawaii	Richard Rocheleau Director Hawaii Natural Energy Institute	

4

The County of Hawaii	Randy Kurohara Director Department of Research and Development	
University of California at Irvine	Scott Samuelsen Director National Fuel Cell Research Center	
FuelCell Energy	Christopher Bentley Executive Vice President	
The Louis Berger Group	Keith Eastin Vice President Strategic Initiatives	
Aloha Petroleum	Richard Parry Chief Executive Officer	

Update on Continuing Partner Activities
Daimler – F-CELL World Drive

DAIMLER

Mercedes-Benz F-CELL World Drive: Around the world in 125 days - Mercedes-Benz takes off on the first circumnavigation of the world with fuel cell-powered electric vehicles

Detroit, Jan 10, 2011

Text | Photos (2)

- select action - Go

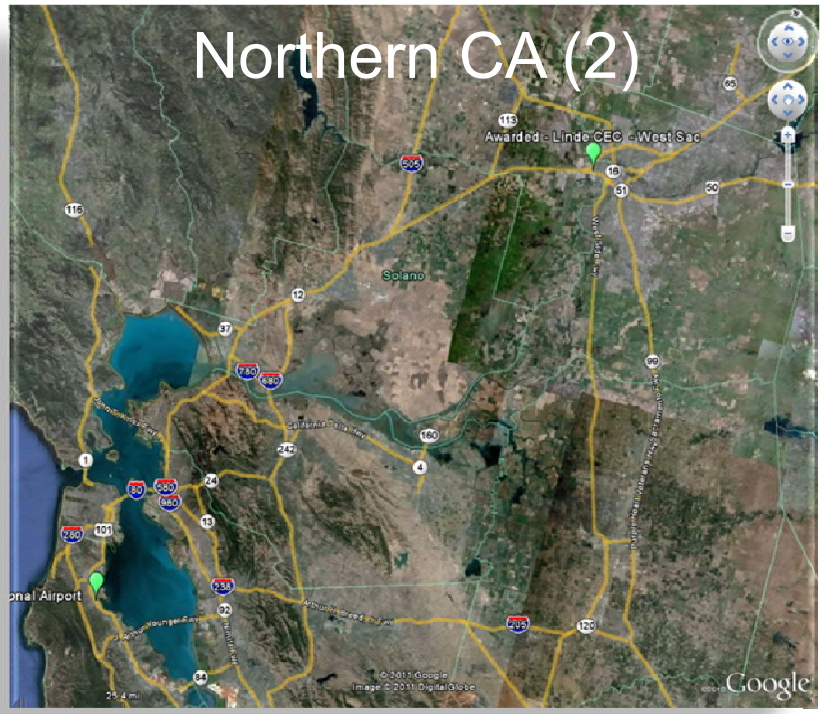
Detroit – At the end of January Mercedes-Benz will give the starter's signal for what until now is an unparalleled long-distance journey – the F-CELL World Drive. This is what the automotive manufacturer from Stuttgart announced at the North American Auto Show in Detroit. Mercedes-Benz will circumnavigate the world with the first series-produced fuel cell vehicle, the B-Class F-CELL. The aim of the F-CELL World Drive is to demonstrate the efficiency and suitability for everyday use of fuel cell technology, and at the same time campaign for the development of a global hydrogen filling station network.

To demonstrate the technical maturity of the B-Class F-CELL - which currently already enables local emission-free driving in everyday use as well as on long distances - the inventor of the automobile will be setting off on the F-CELL World Drive in the B-Class F-CELL on January 30. The journey will last 125 days, driving through four continents and the widest variety of climate zones as well as an equally diverse mixture of routes, ranging from asphalt streets to unpaved roads."With this unique circumnavigation of the world we are emphasizing the high level of technical maturity of our electric vehicles with fuel cell. Such an undertaking would not be possible, using purely battery-powered electric vehicles.", explains Dr. Thomas Weber, Member of the Board of Management of Daimler AG responsible for Group Research and Development Mercedes-Benz Cars.

Update on Continuing Partner Activities
Air Products – 8 Stations through CEC in CA

AIR PRODUCTS (CHIP)

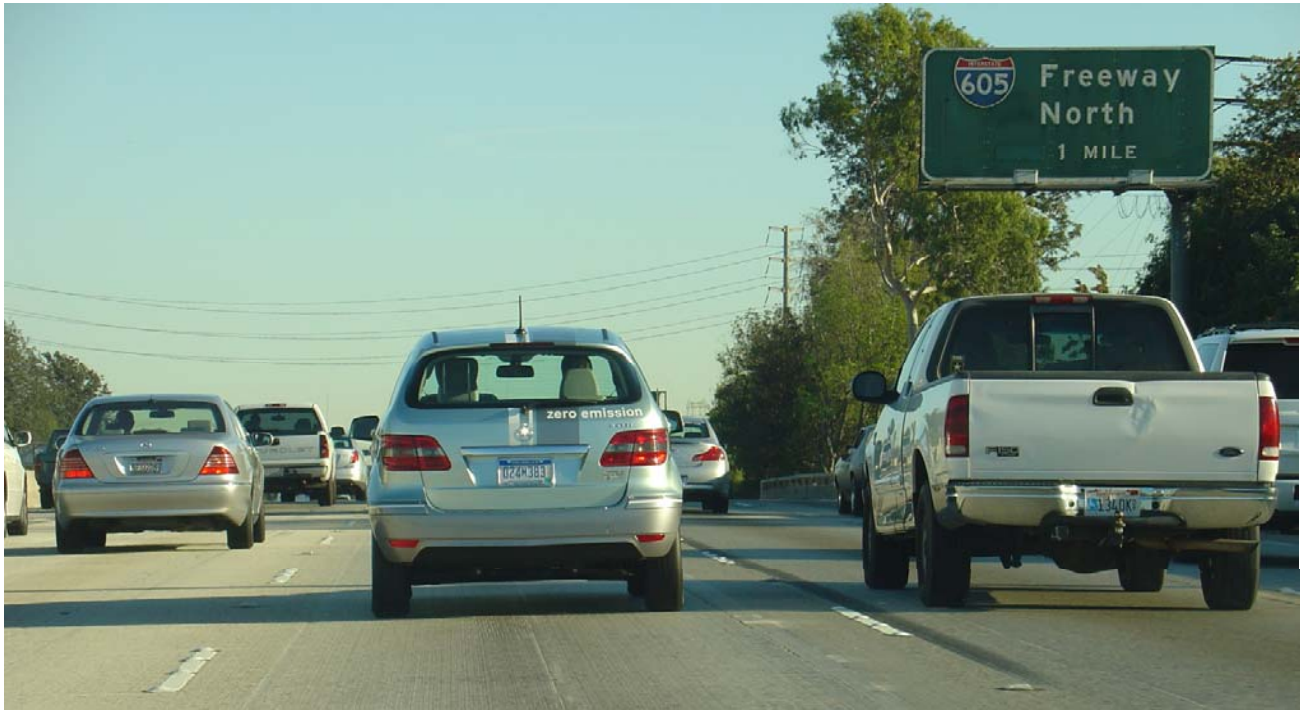
- 11 H_2 station awards announced by CEC in Oct.
  - 8 new stations, 3 upgrades
  - Air Products planning 8 stations: 7 new, 1 upgrade – all in Southern CA
  - Linde planning 3 stations: 1 new, 2 upgrades



Summary

- Project has completed ~6 years of validation
- Vehicle operation: 114,000 hours, 2.87 million miles, 436,000 trips
- H_2 station operation: 134,000 kg produced or dispensed, 27,000 fuelings
- DOE Key Technical Targets Met: FC Durability and Range
- Data reporting and analysis continues through remainder of this year
- New CA fueling stations planned for inclusion in future NREL infrastructure analysis as they come online and provide data

Questions and Discussion



Project Contact: Keith Wipke, National Renewable Energy Lab
303.275.4451 keith.wipke@nrel.gov

All public Learning Demo papers and presentations are available online at http://www.nrel.gov/hydrogen/proj_tech_validation.html