U.S. DEPARTMENT OF ENERGY

Results from the Vehicle/Infrastructure Learning Demonstration Project

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2006 DOE Hydrogen Program
Merit Review and Peer Evaluation Meeting

May 18, 2006

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Project Objectives and Targets

- **Objectives**
  - ➔ Validate H_2 FC Vehicles and Infrastructure in Parallel
  - ➔ Identify Current Status of Technology and its Evolution
  - ➔ Re-Focus H_2 Research and Development
  - ➔ Support Technology Readiness Milestone by 2015

Hydrogen refueling station, Chino, CA Photo: NREL

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

* To verify progress toward 2015 targets
** Subsequent projects to validate 2015 targets

Teams are Fielding Four Main Types of Vehicles

Validation also includes FCV Sprinter vans

Representative Hydrogen Refueling Infrastructure Supporting Vehicles

DTE/BP Power Park, Southfield, MI

LAX refueling station

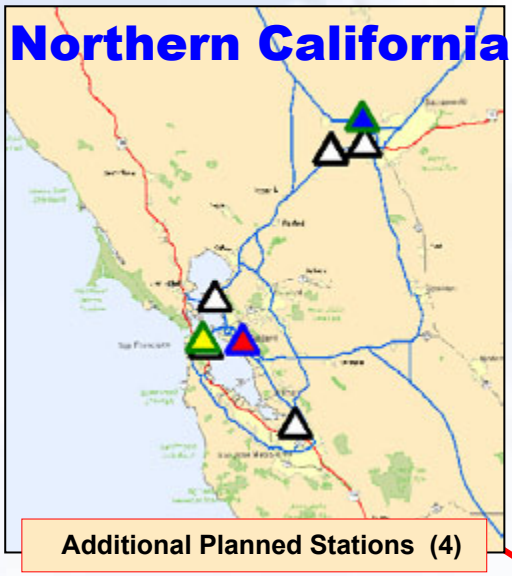
Hydrogen and gasoline station, WA DC

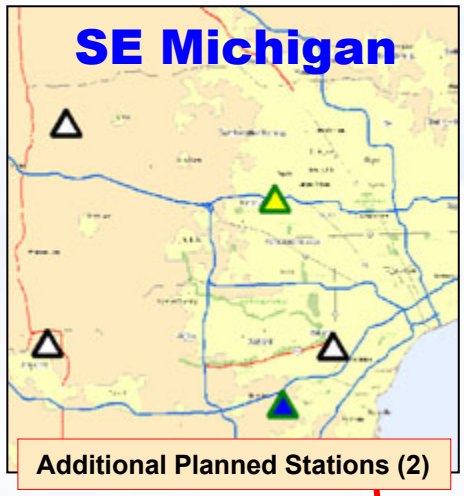
Photo:Shell Hydrogen

Chino, CA

Photo: H2CarsBiz

Refueling Stations from All Four Teams Test Vehicle/Infrastructure Performance in Various Climates





Legend
- Chevron & Hyundai/Kia
- DaimlerChrysler & BP
- Ford & BP
- General Motors & Shell
- Other

Project Produces Results for Both the Public and the Industry Project Teams

Raw Data, Reports

Hydrogen Secure Data Center (HSDC)

- Located at NREL: Strictly Controlled Access
- Detailed Analyses, Data Products, Internal Reports

Composite Data Products

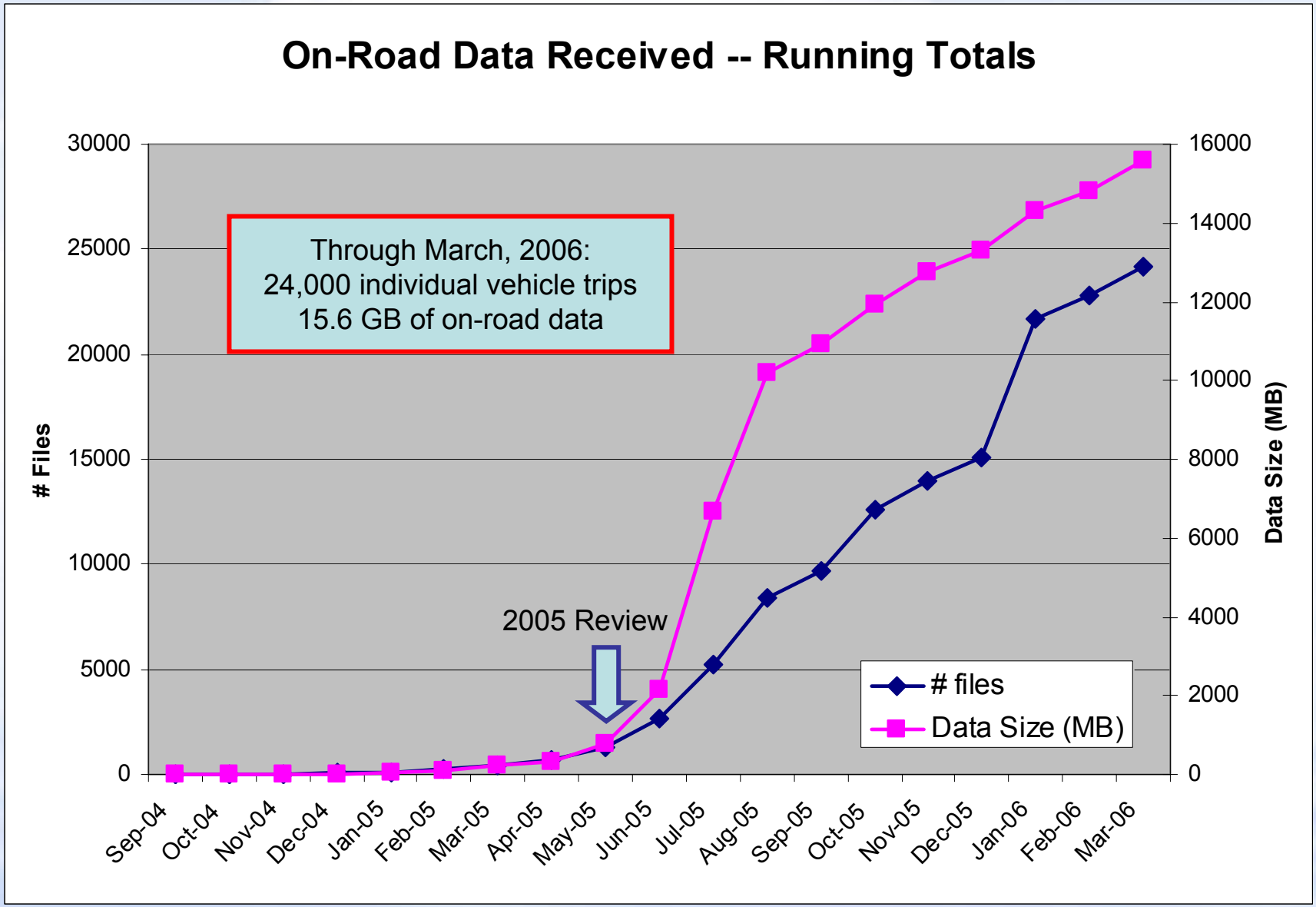
- Pre-agreed upon aggregate data results for public
- No confidential information

Detailed Data Products

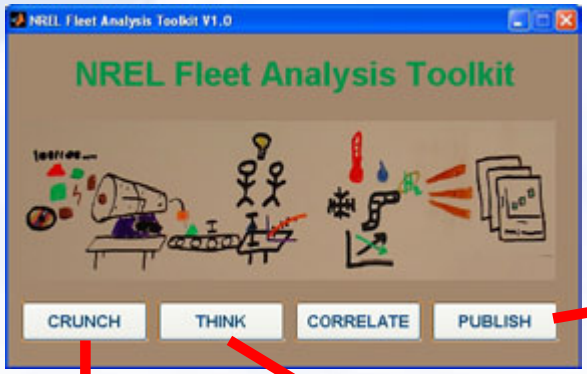
- Only shared with company which originated the data

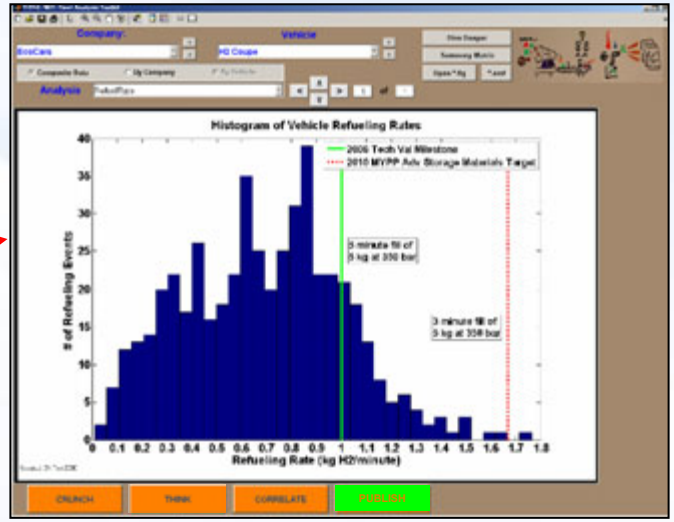
Project Now Well Underway: 1st Year of Data Analyzed

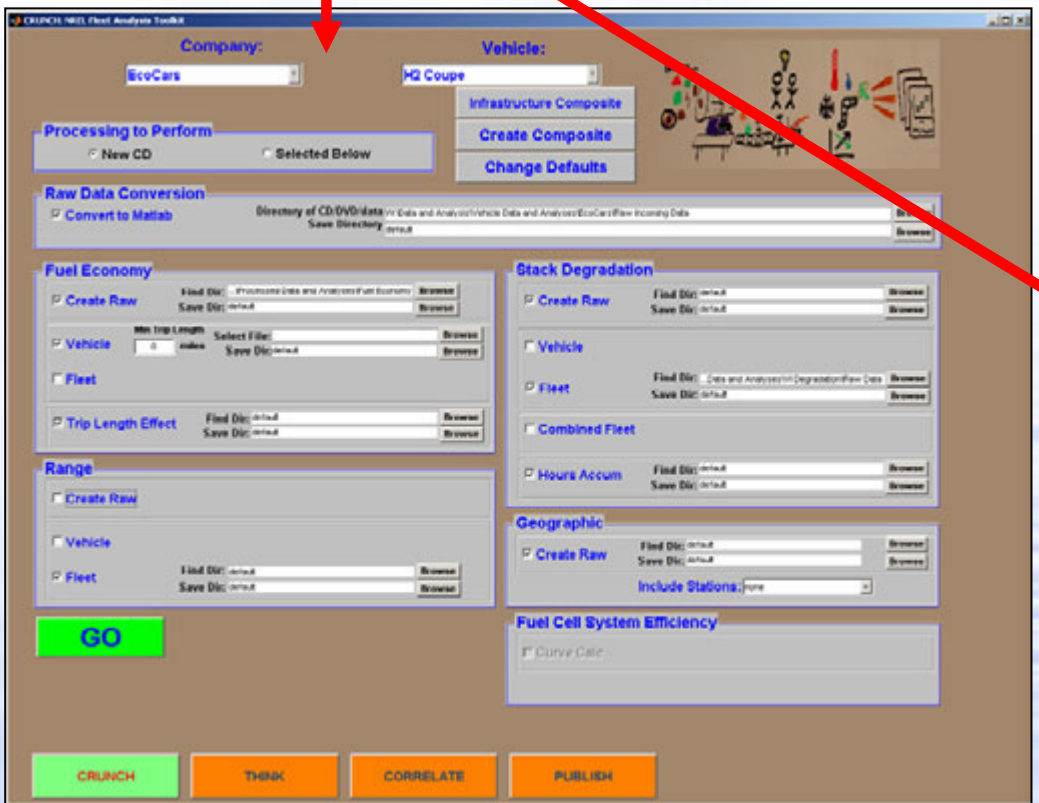
Current Status of Data Reporting to the Hydrogen Secure Data Center at NREL

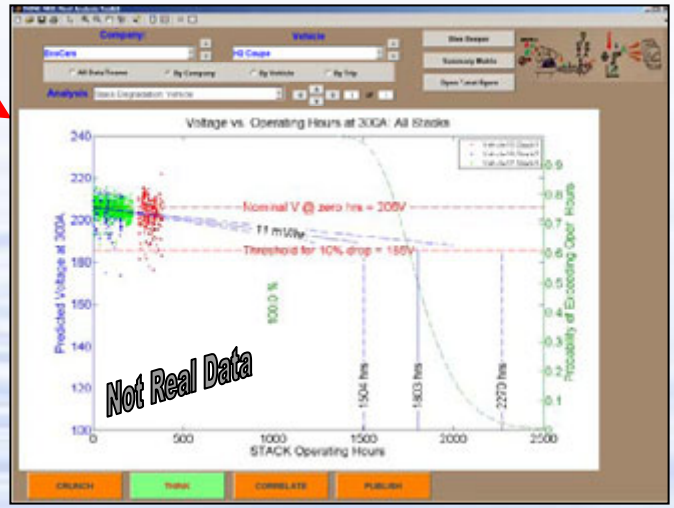


New Fleet Analysis Toolkit (FAT) Helps Automate the Analysis









First 16 of 26 Composite Data Products Published Earlier This Year

A. Critical Program Metrics:

1. Fuel Cell Durability, Actual vs. DOE Targets, All OEM's
2. Vehicle Ranges, Actual vs. DOE Targets, All OEM's
3. H2 Production Cost. Actuals/Projections vs. DOE Targets

B. Composite Performance Tracking:

Vehicles

4. Reliability (FC System & Powertrain, MTBF)
5. Start Times vs. DOE Target
6. Fuel Economy: Dyno, On-Road
7. Normalized Vehicle Fuel Economy
8. Fuel Cell System Efficiency
9. Safety Incidents - Vehicle Operation
10. Weight % Hydrogen
11. Energy Density of Hydrogen Storage
12. Vehicle Hydrogen Tank Cycle Life

Hydrogen Infrastructure

13. H2 Production Efficiency vs. Process
14. Combined Heat and Power (CHP) Efficiencies
15. H2 Production Cost vs. Process
16. H2 Purity vs. Production Process
17. Hydrogen Impurities - Range for Production Process A
18. Histogram: Refueling Rate
19. Average Maintenance Hours - Scheduled and Unscheduled
20. Safety Incidents - Infrastructure

Highlighted CDPs Have Been Completed

C. High Level Program Progress:

Vehicles

21. Range of Actual Ambient Temperatures During Vehicle Operation – All Vehicle Teams
22. Histogram: # Vehicles vs. Operating Hours to Date
23. Histogram: # Vehicles vs. Miles Traveled to Date
24. Cumulative Vehicle Miles Traveled - All Teams
25. Progression of Low to High Pressure On-board H2 Storage

Hydrogen Infrastructure

26. Cumulative Hydrogen Production – All Teams

Composite Data Products are Main Output to Public and Hydrogen Community

Dynamometer Testing Completed to Evaluate Fuel Economy Under Controlled Conditions

- One vehicle per team per geographic region
- 11 vehicles tested using SAE J2572

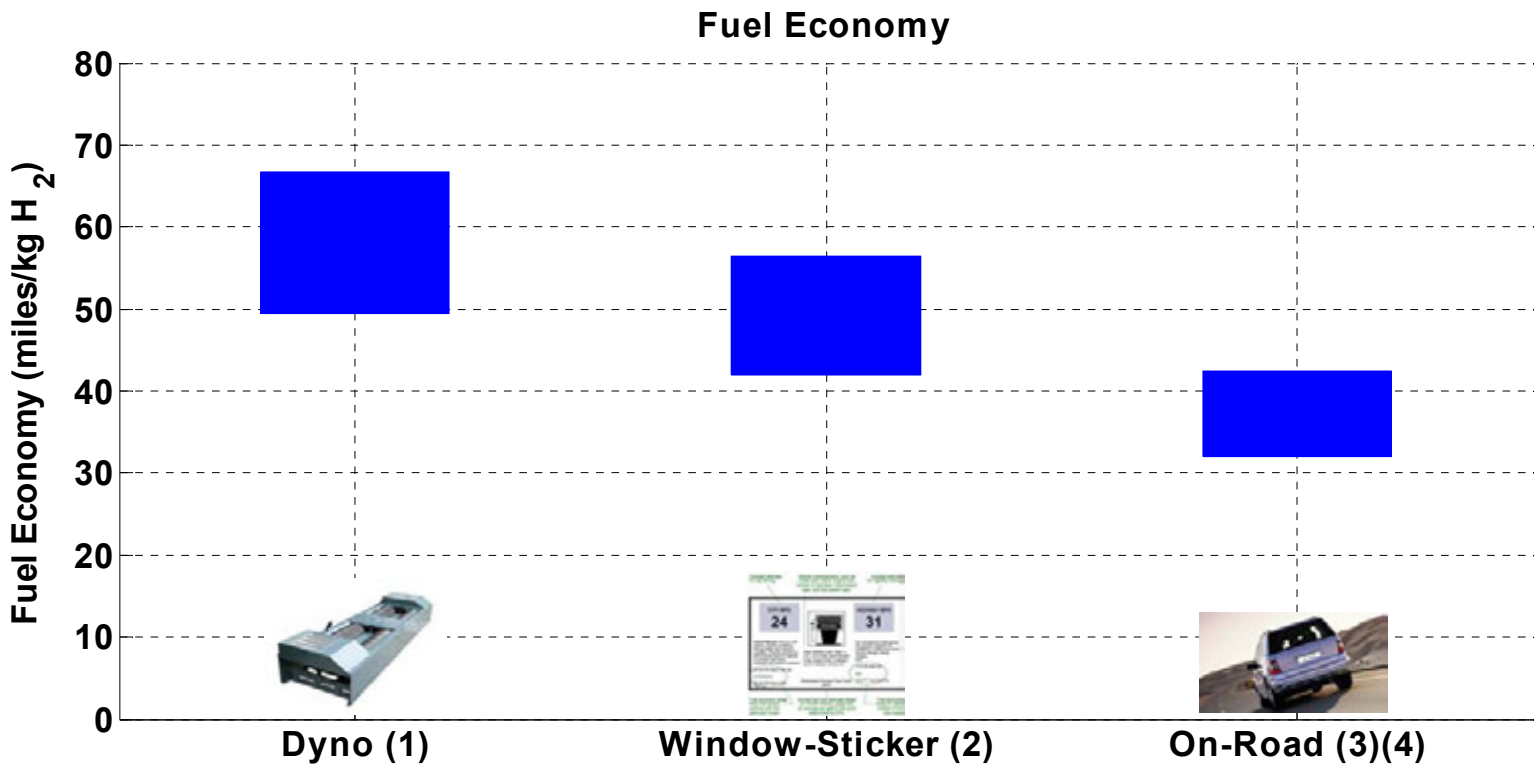
Chevron/Hyundai-KIA

DaimlerChrysler/BP

GM/Shell

Ford/BP

Dynamometer and On-Road Fuel Economy



(1) One data point for each make/model. Combined City/Hwy fuel economy per DRAFT SAEJ2572.

(2) Adjusted combined City/Hwy fuel economy (0.78 x Hwy, 0.9 x City).

(3) Excludes trips < 1 mile. One data point for on-road fleet average of each make/model.

(4) Calculated from on-road fuel cell stack current or mass flow readings.

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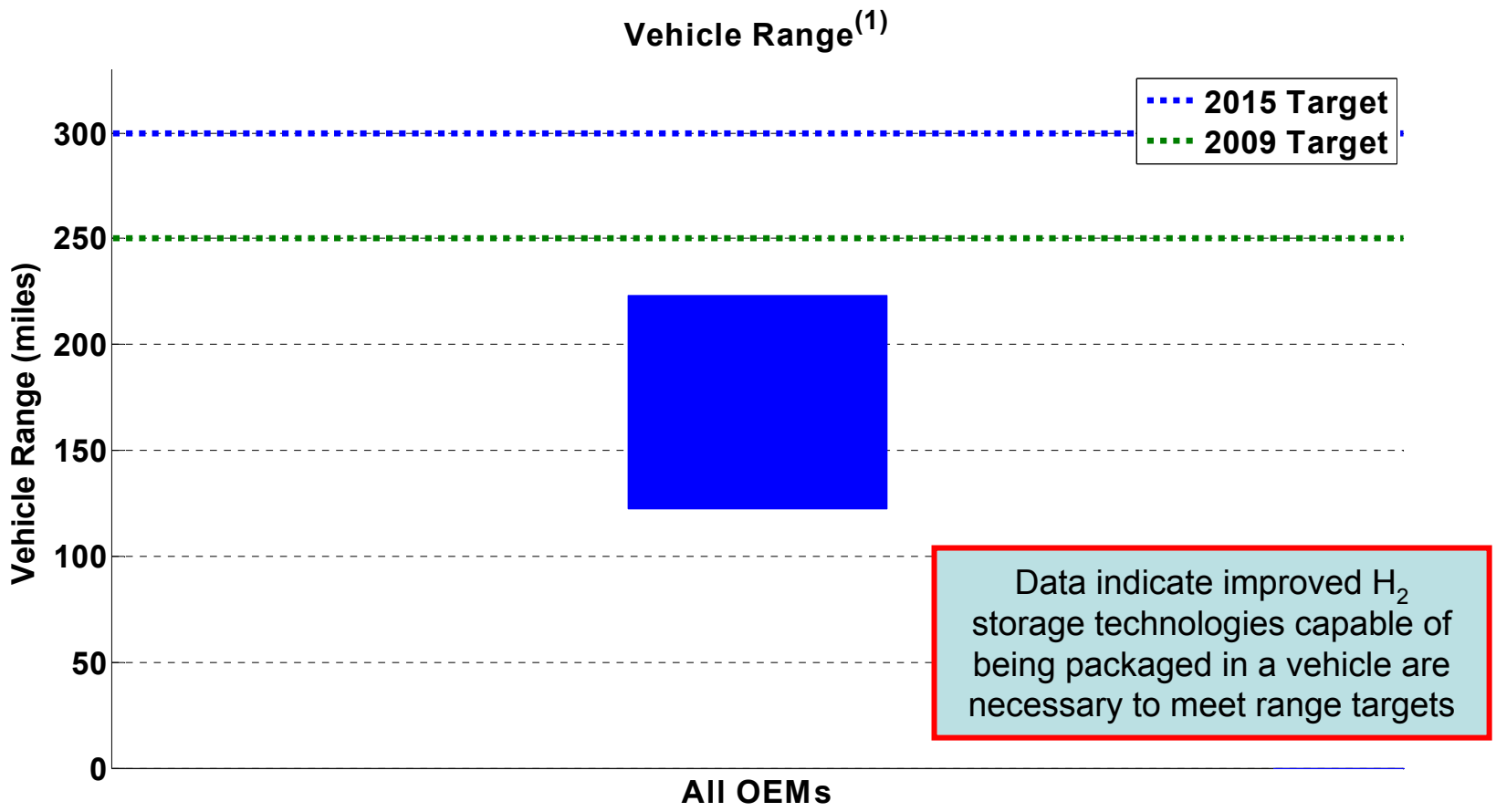
Vehicle Range Based on Dyno Results and Usable H_2 Fuel Stored On-Board



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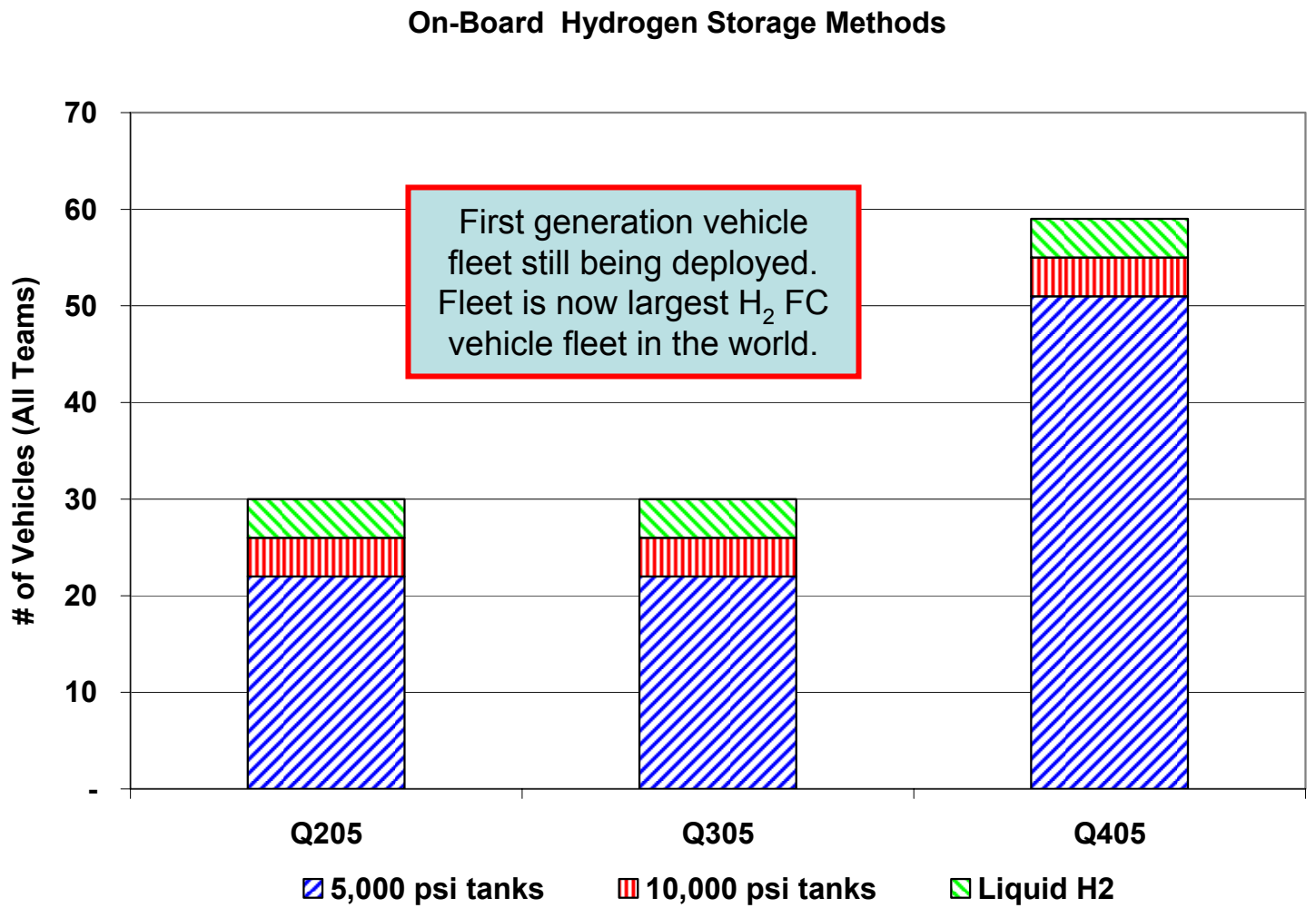
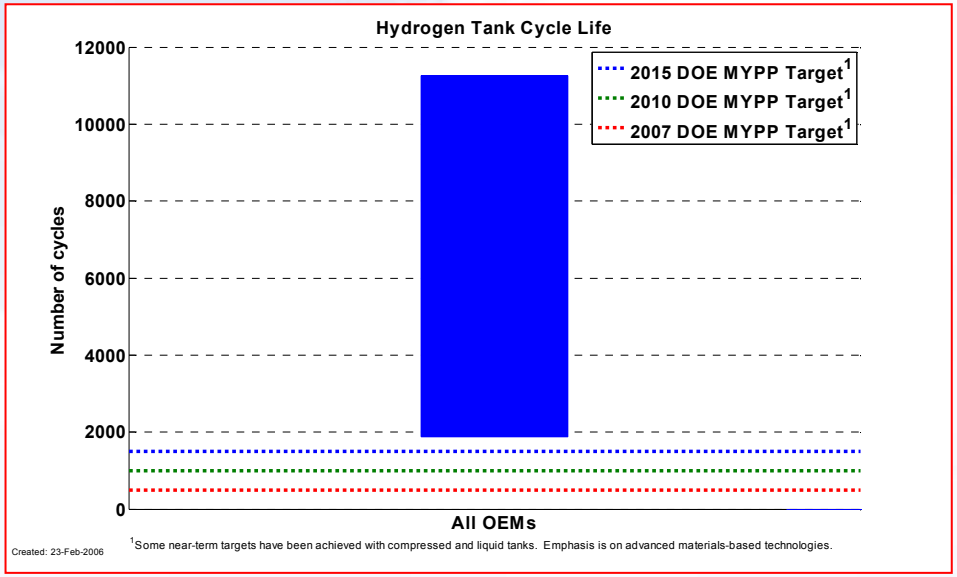
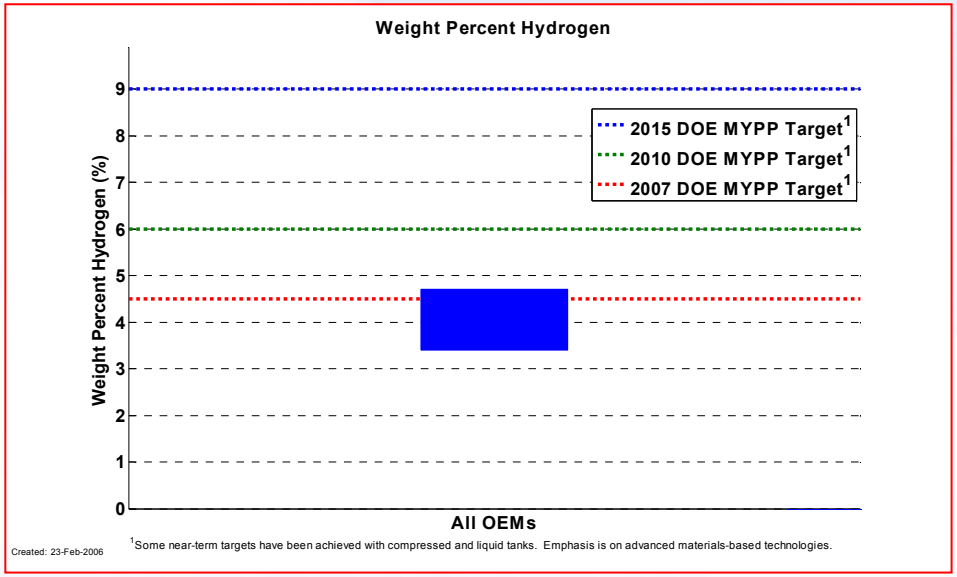
(1) Calculated from combined City/Hwy fuel economy (dyno test) per DRAFT SAE J2572 and usable fuel on board.

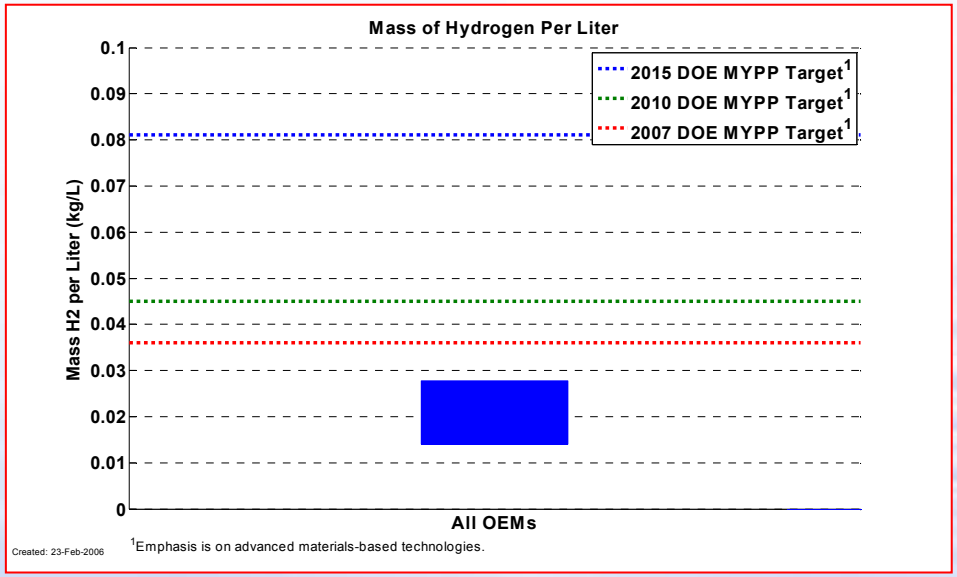
Vehicle H_2 Storage Technologies Include 350 bar, 700 bar, and Liquid H_2



Technical Status of On-Board H_2 Storage Technologies Being Validated

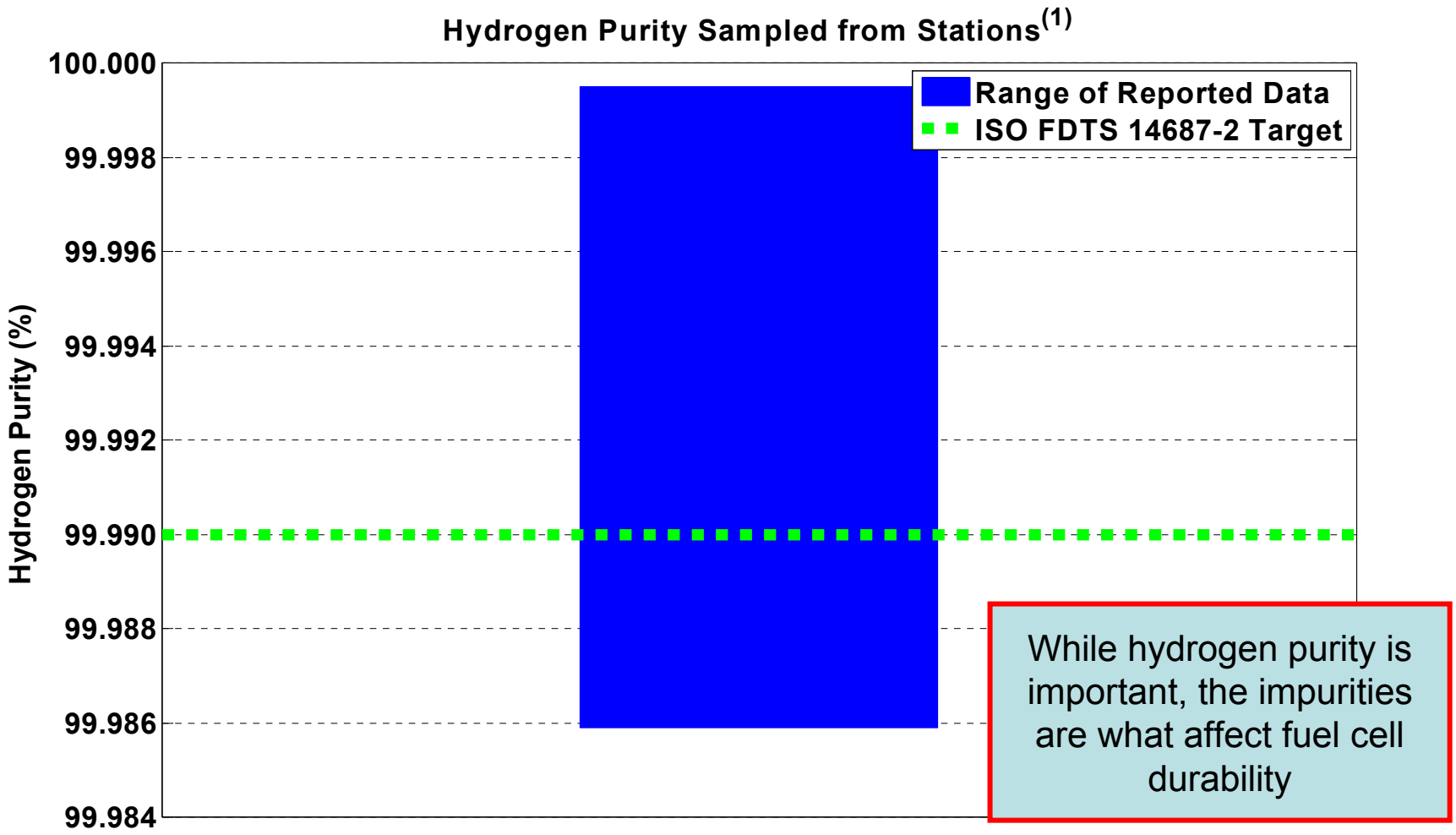






Compressed and liquid H_2 tanks meet durability and short term weight %, but don't meet long-term weight % or volumetric capacity targets for vehicles

Hydrogen Purity Sampled from Stations Meets Target Majority of the Time



(1) Includes sampling from both electrolysis and reforming

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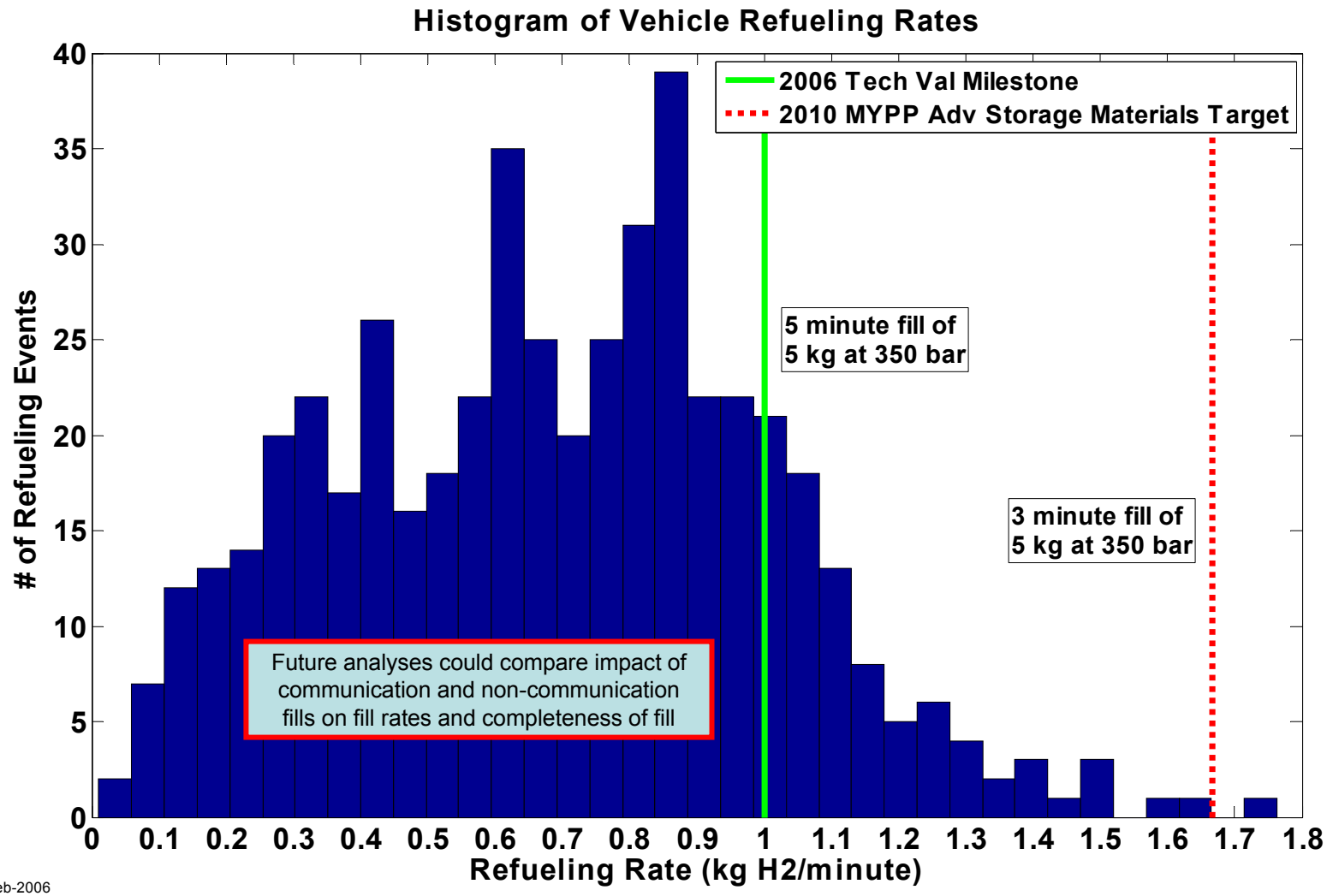
Actual Vehicle Refueling Rates: Measured by Stations or by Vehicles



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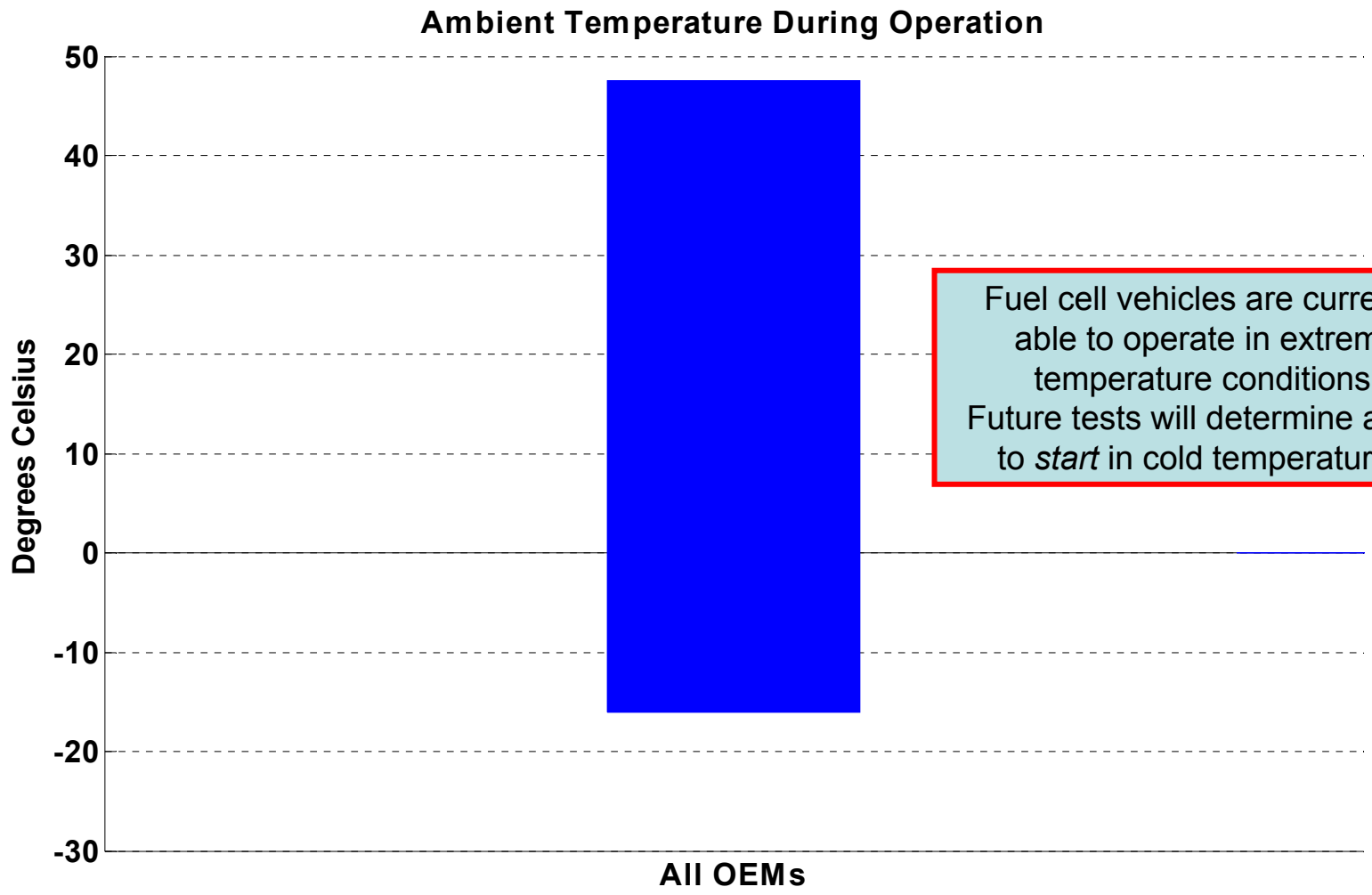
Range of Ambient Temperature During Vehicle Operation



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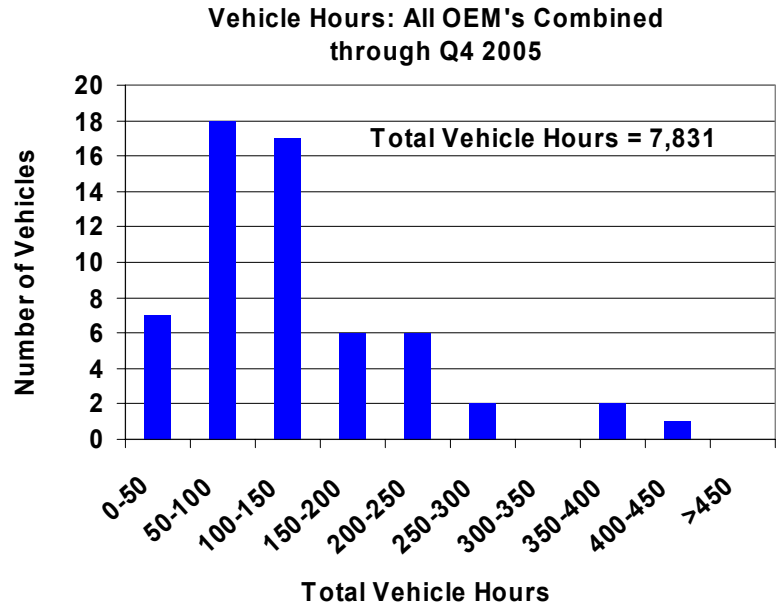
Vehicle Operating Hours and Miles Traveled Distribution



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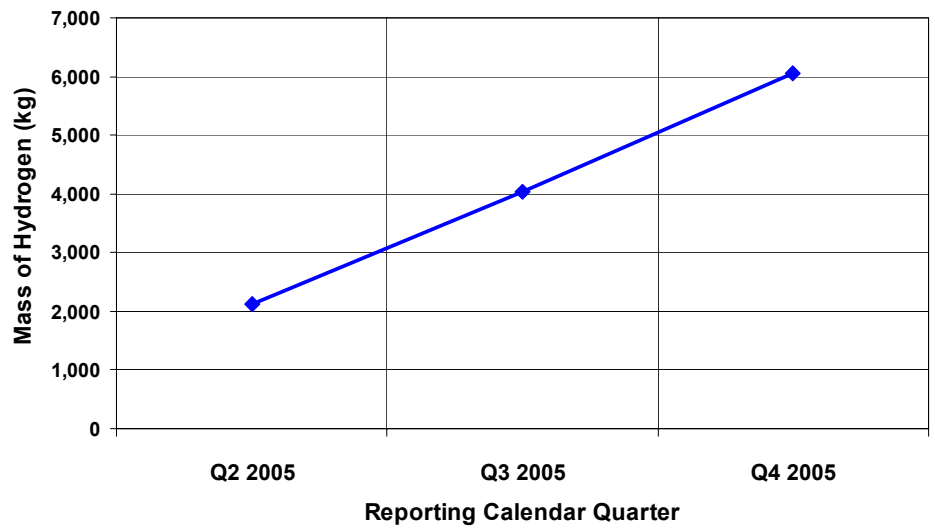
Fleet is young, but vehicle usage is increasing and initial fleets are approaching full Gen 1 vehicle deployment

Large amount of hydrogen used includes both vehicle refueling and on-site electricity production



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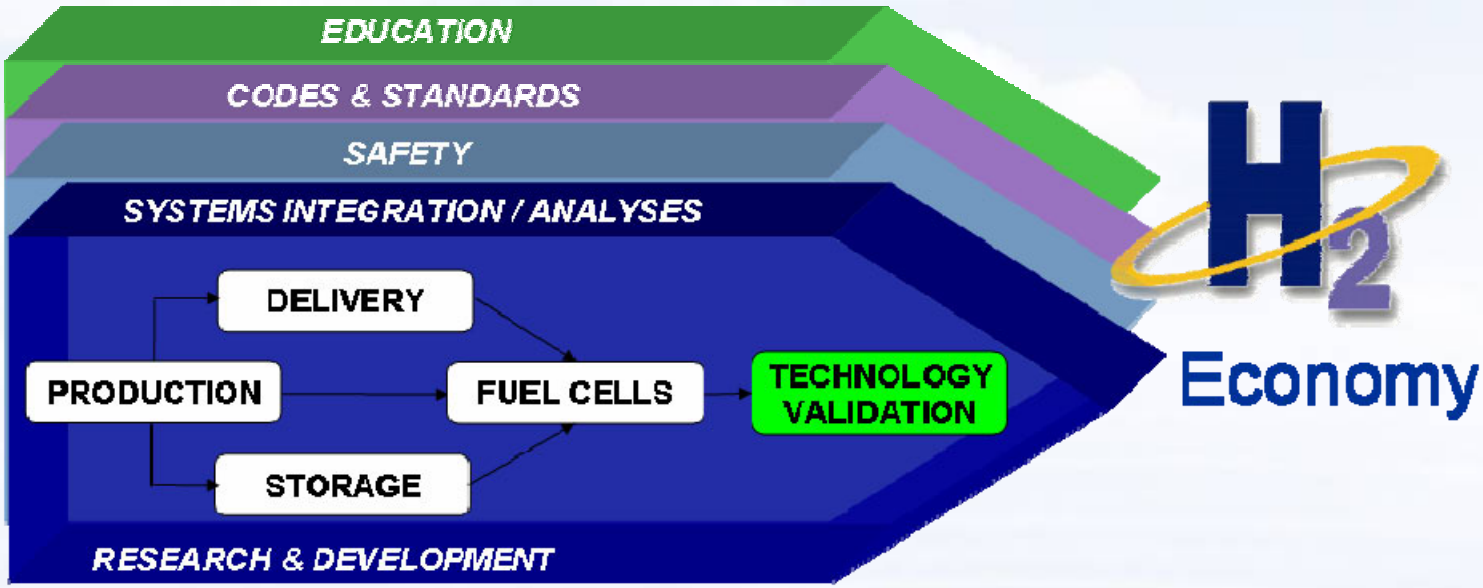
Summary

- First year of the 5-year project completed
  - ➔59 vehicles now in fleet operation
  - ➔Several new refueling stations opened
  - ➔No major safety problems encountered
- Project has identified current technical status relative to program targets
  - ➔Will track improvements from 2nd generation stacks/vehicles introduced mid-way through project
- Future public results will include:
  - ➔FC durability, reliability, efficiency, and start-up times
  - ➔H_2 production cost, efficiency, and maintenance

Questions and Discussion



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http://www.nrel.gov/hydrogen/proj_tech_validation.html