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Innovation for Our Energy Future
A national laboratory of the U.S. Department of Energy
Office of Energy Efficiency & Renewable Energy

Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

Spring 2008
Composite Data Products
Final Version: February 29, 2008

Keith Wipke, Sam Sprik, Jennifer Kurtz

Technical Report
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Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project

Spring 2008 Composite Data Products Final Version: February 29, 2008

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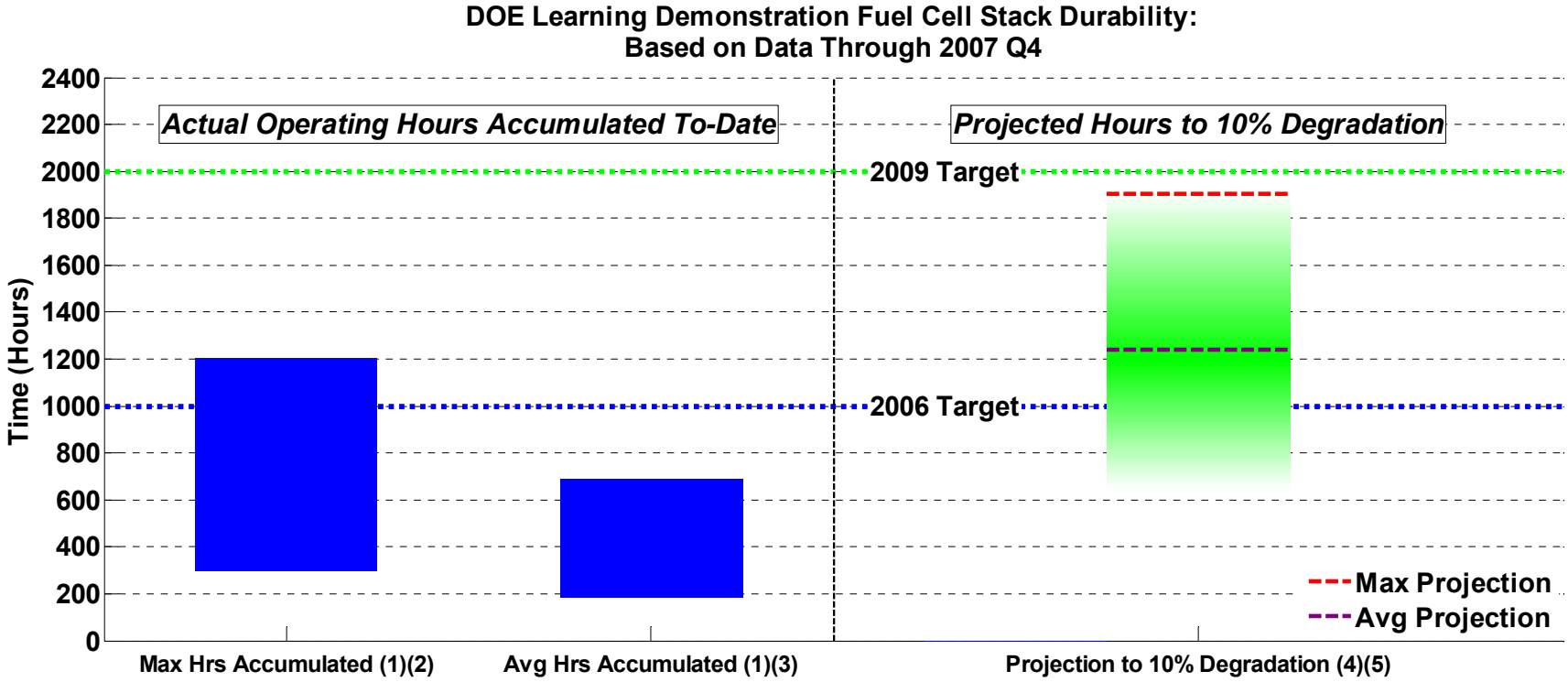
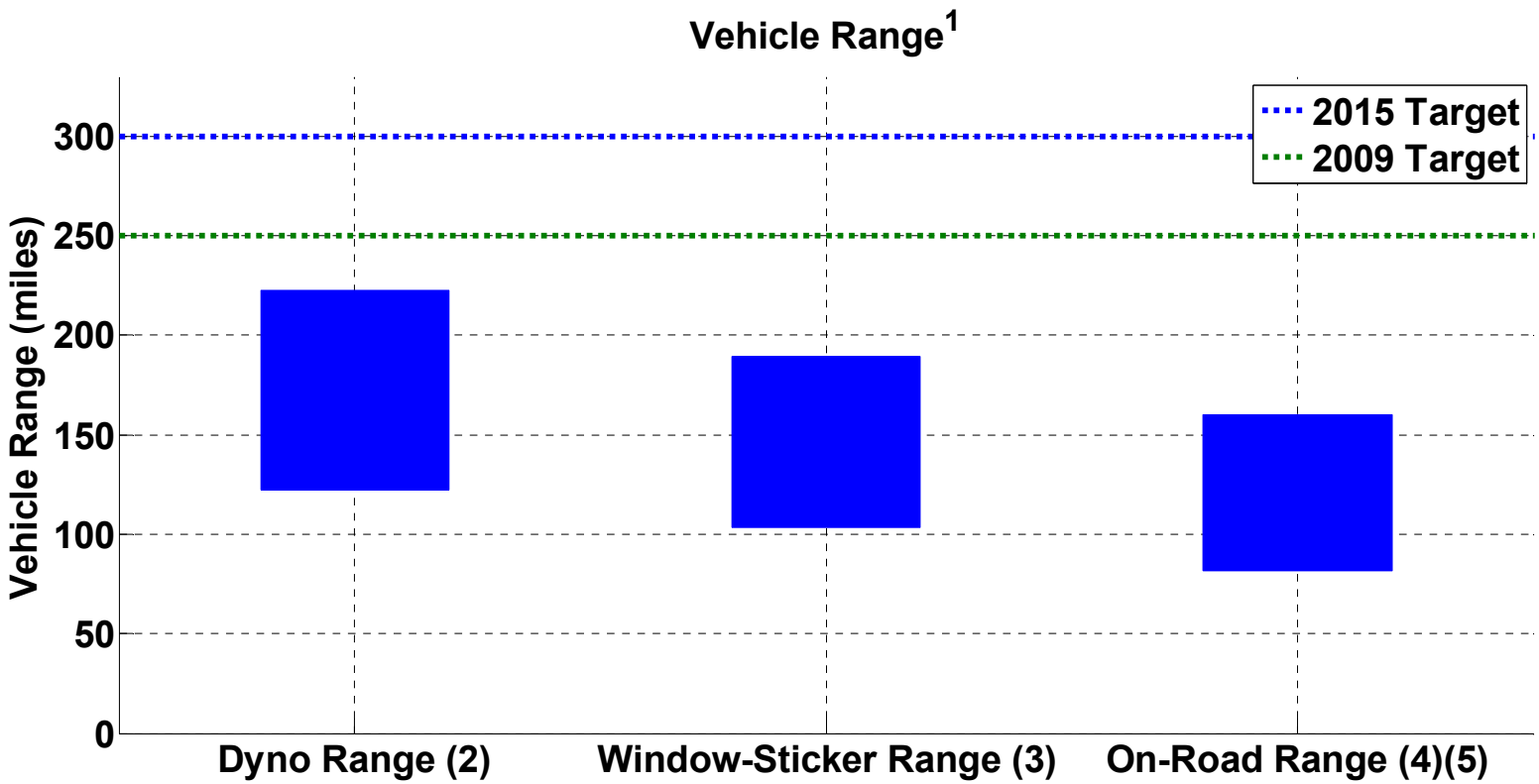
CDP#1: Hours Accumulated and Projected Hours to 10% Stack Voltage Degradation



(1) Range bars created using one data point for each OEM.
(2) Range (highest and lowest) of the maximum operating hours accumulated to-date of any OEM's individual stack in "real-world" operation.
(3) Range (highest and lowest) of the average operating hours accumulated to-date of all stacks in each OEM's fleet.
(4) Projection using on-road data -- degradation calculated at high stack current. This criterion is used for assessing progress against DOE targets, may differ from OEM's end-of-life criterion, and does not address "catastrophic" failure modes, such as membrane failure.
(5) Using one nominal projection per OEM: "Max Projection" = highest nominal projection, "Avg Projection" = average nominal projection. The shaded green bar represents an engineering judgment of the uncertainty due to data and methodology limitations. Projections will change as additional data are accumulated.

Created: Feb-26-08 11:46 AM

CDP#2: Vehicle Range



(1) Range is based on fuel economy and usable hydrogen on-board the vehicle. One data point for each make/model.
(2) Fuel economy from unadjusted combined City/Hwy per DRAFT SAE J2572.
(3) Fuel economy from EPA Adjusted combined City/Hwy (0.78 x Hwy, 0.9 x City).
(4) Excludes trips < 1 mile. One data point for on-road fleet average of each make/model.
(5) Fuel economy calculated from on-road fuel cell stack current or mass flow readings.

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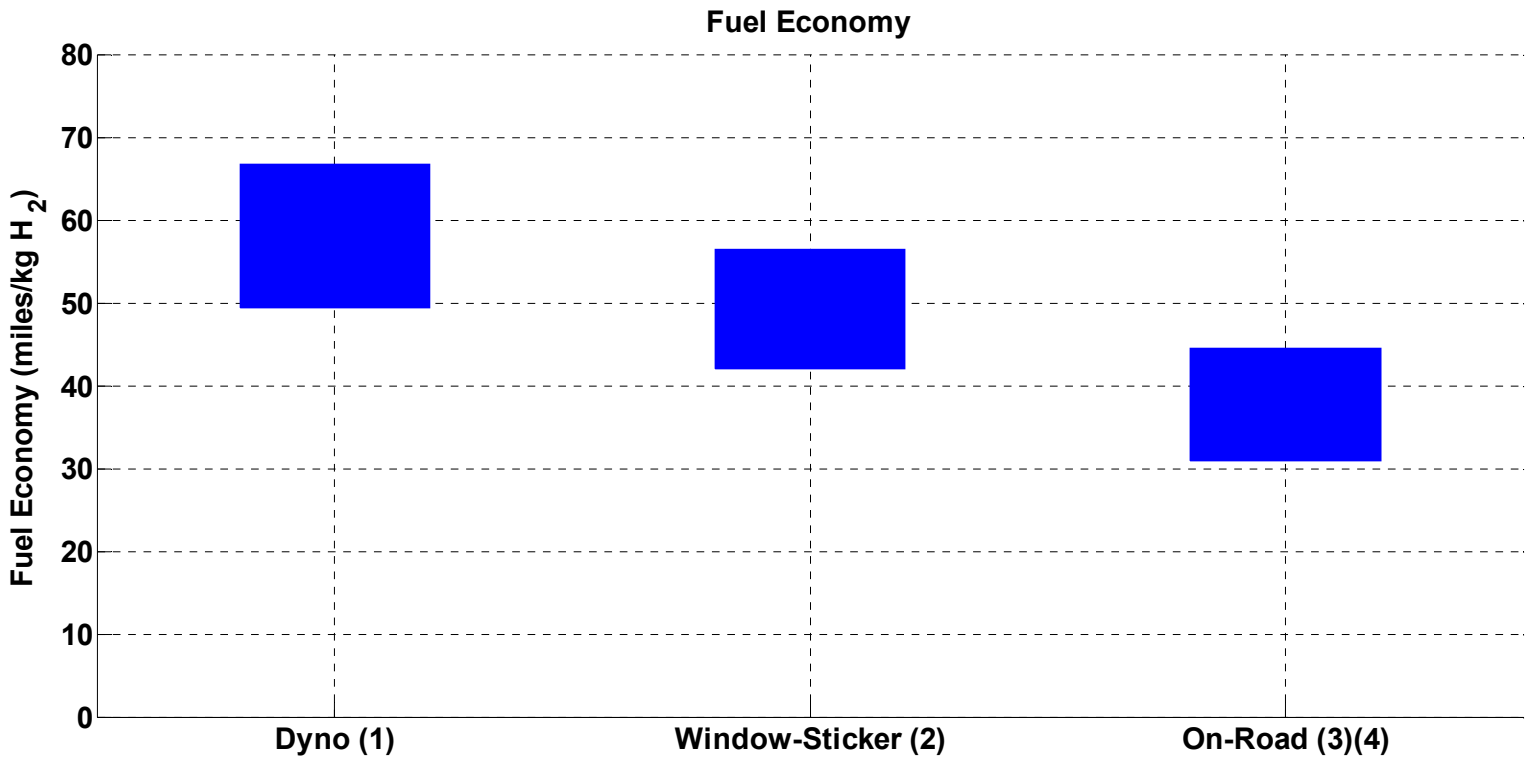
CDP#6: Fuel Economy



(1) One data point for each make/model. Combined City/Hwy fuel economy per DRAFT SAE J2572.

(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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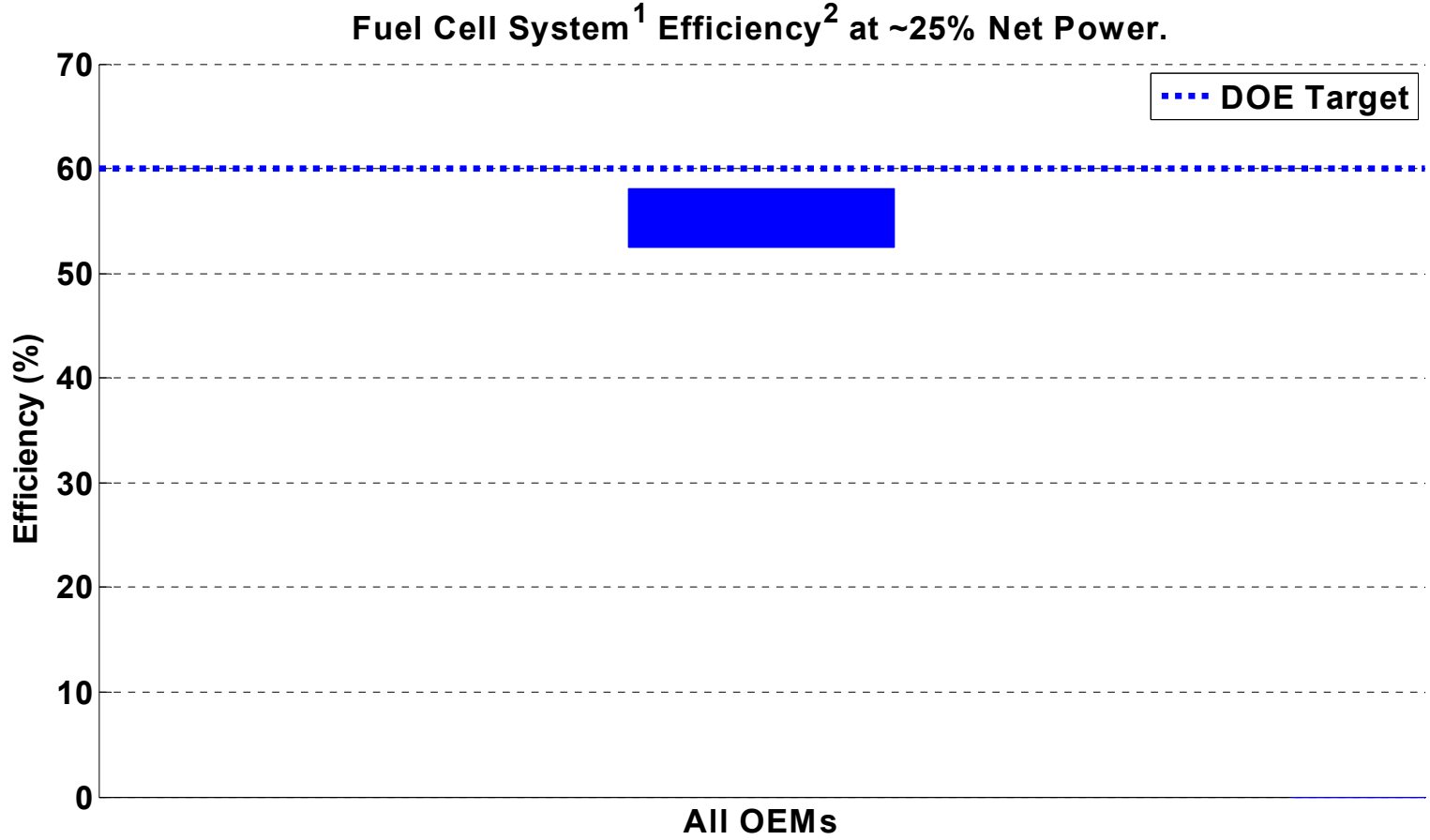
CDP#8: FC System Efficiency

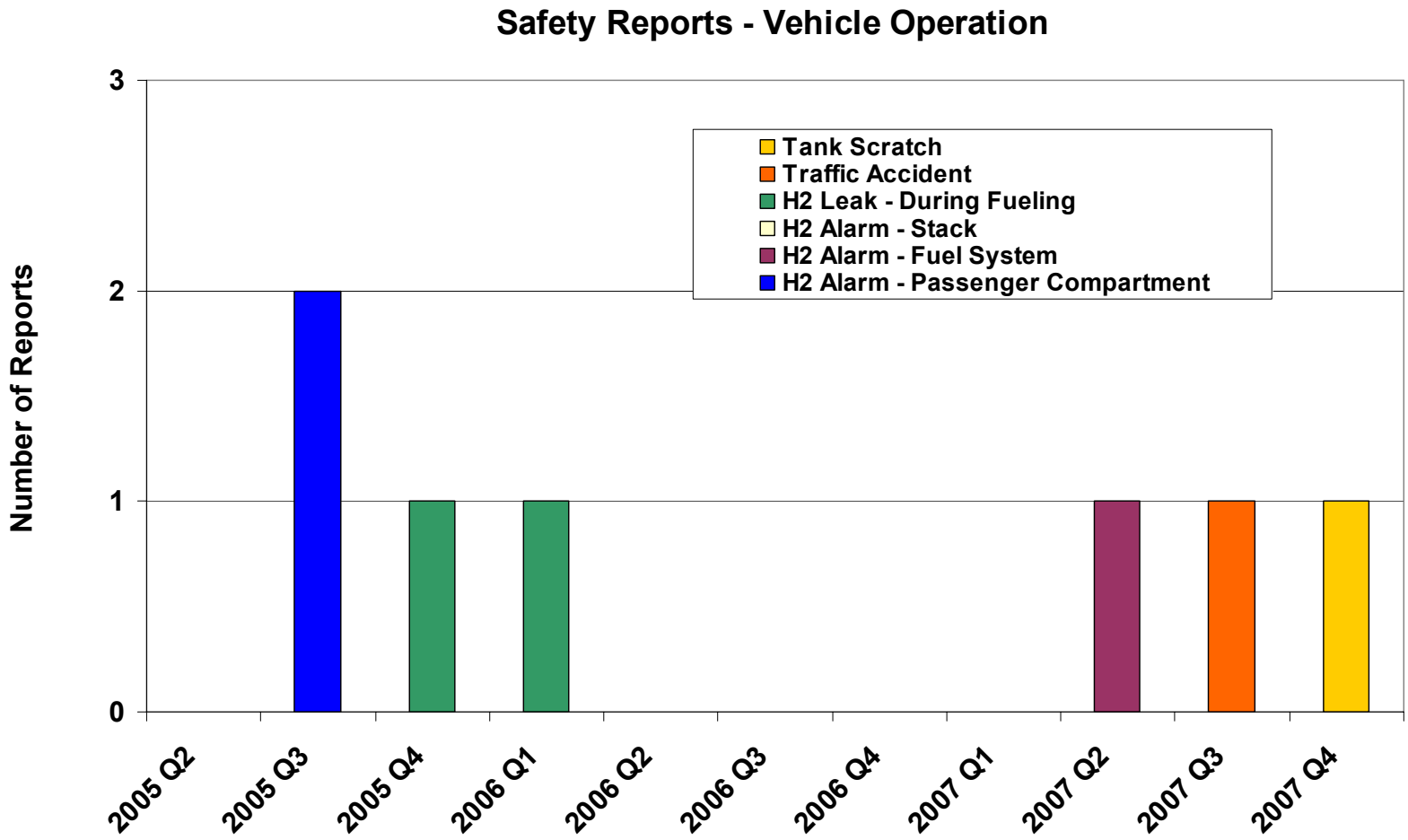


[1] Gross stack power minus fuel cell system auxiliaries, per DRAFT SAEJ2615.

[2] Ratio of DC output energy to the lower heating value of the input fuel (hydrogen). Excludes power electronics and electric drive.

Created: Aug-29-06 4:09 PM

CDP#9: Safety Reports – Vehicles



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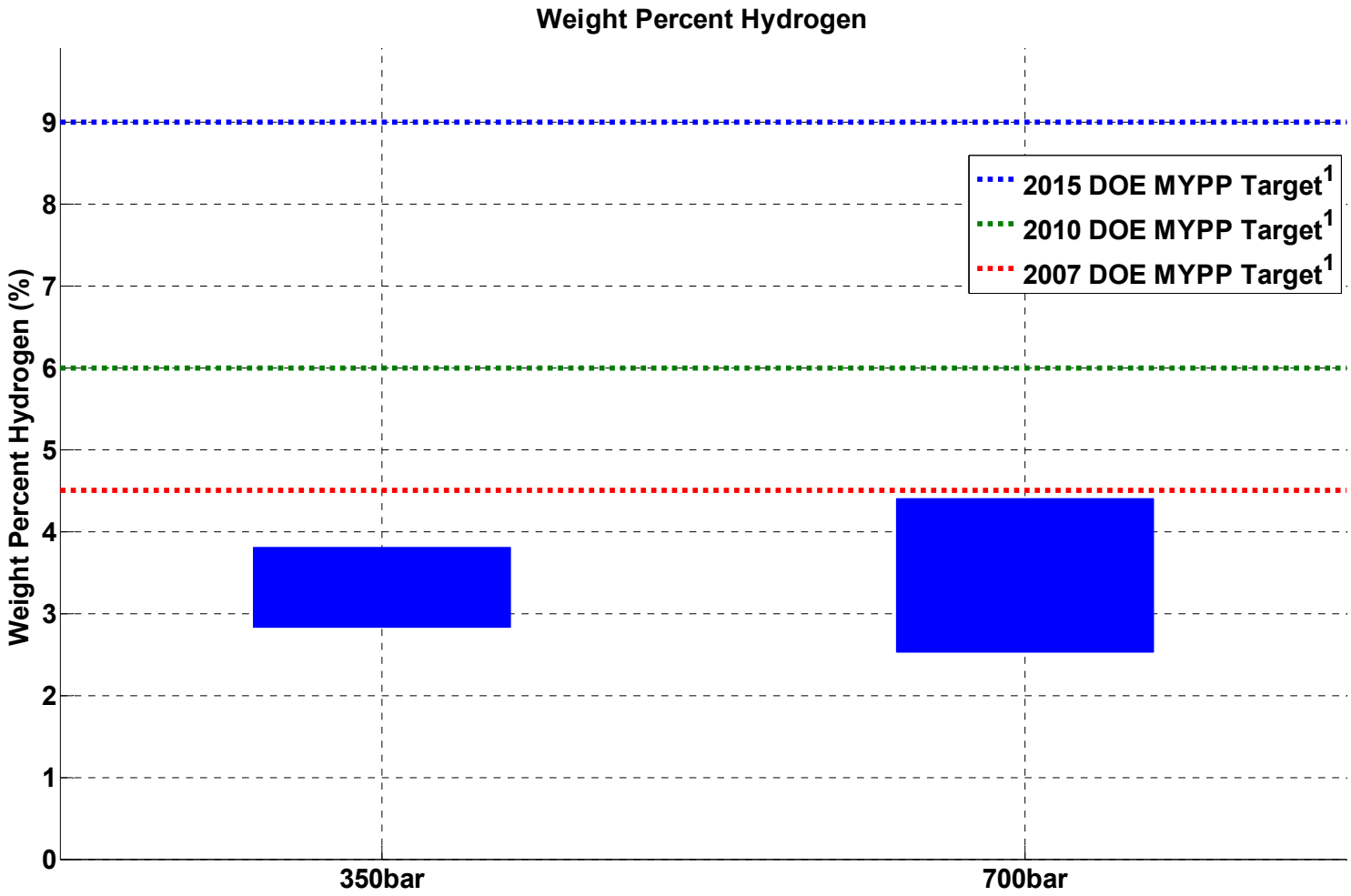
CDP#10: Storage Weight % Hydrogen



[1]Targets are set for advanced materials-based hydrogen storage technologies.

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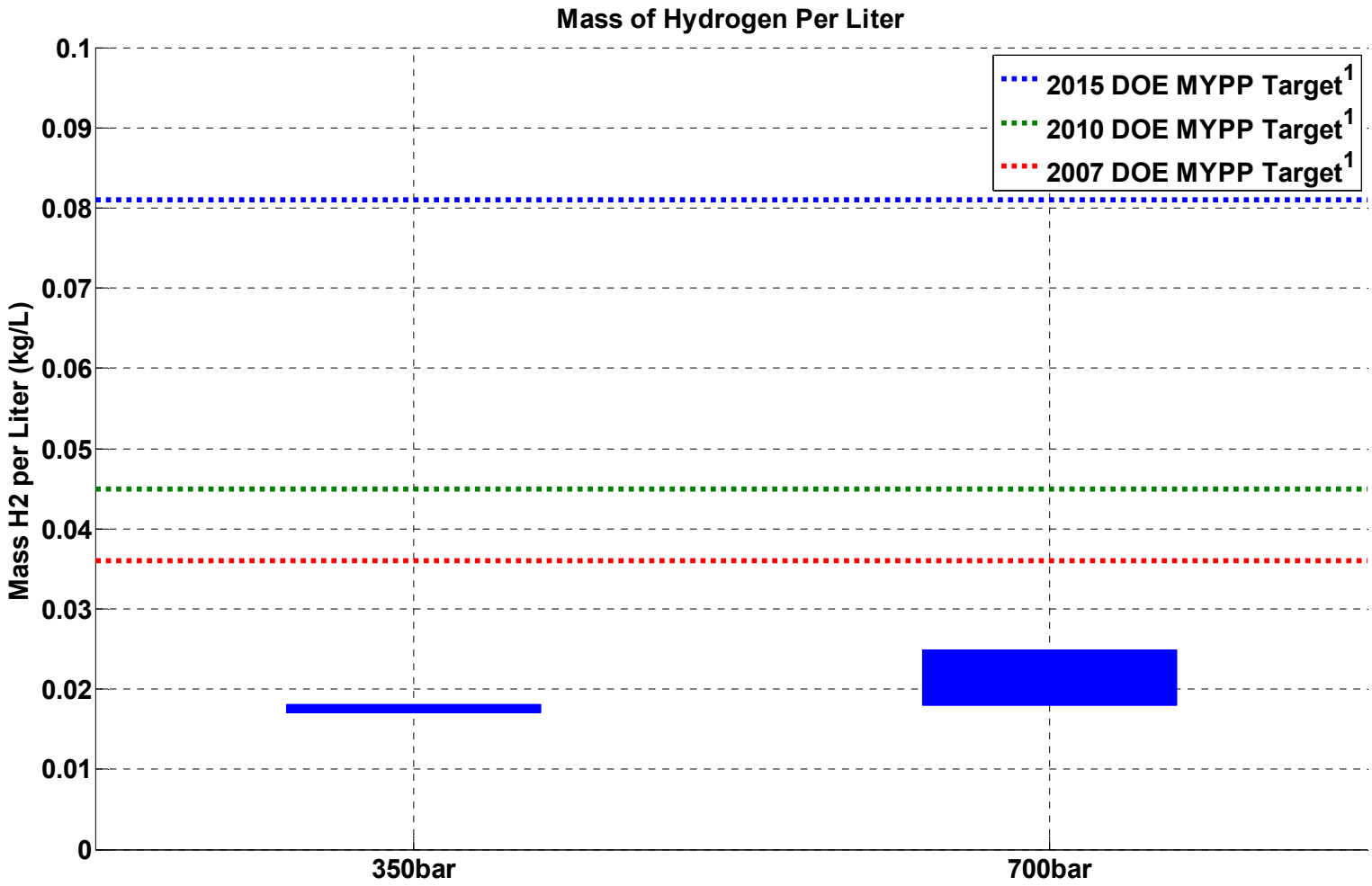
CDP#11: Volumetric Capacity of H2 Storage



[1]Targets are set for advanced materials-based hydrogen storage technologies.

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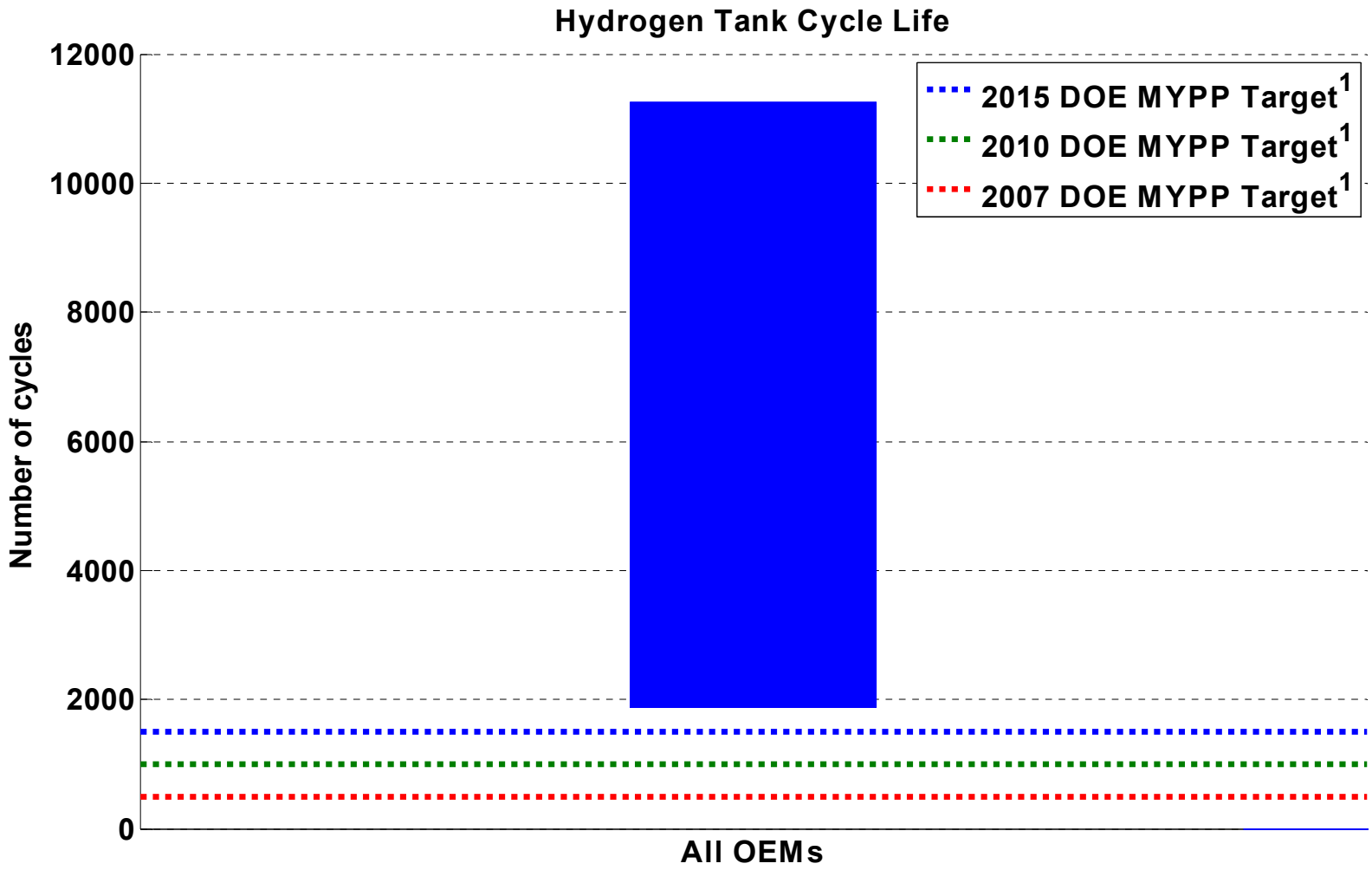
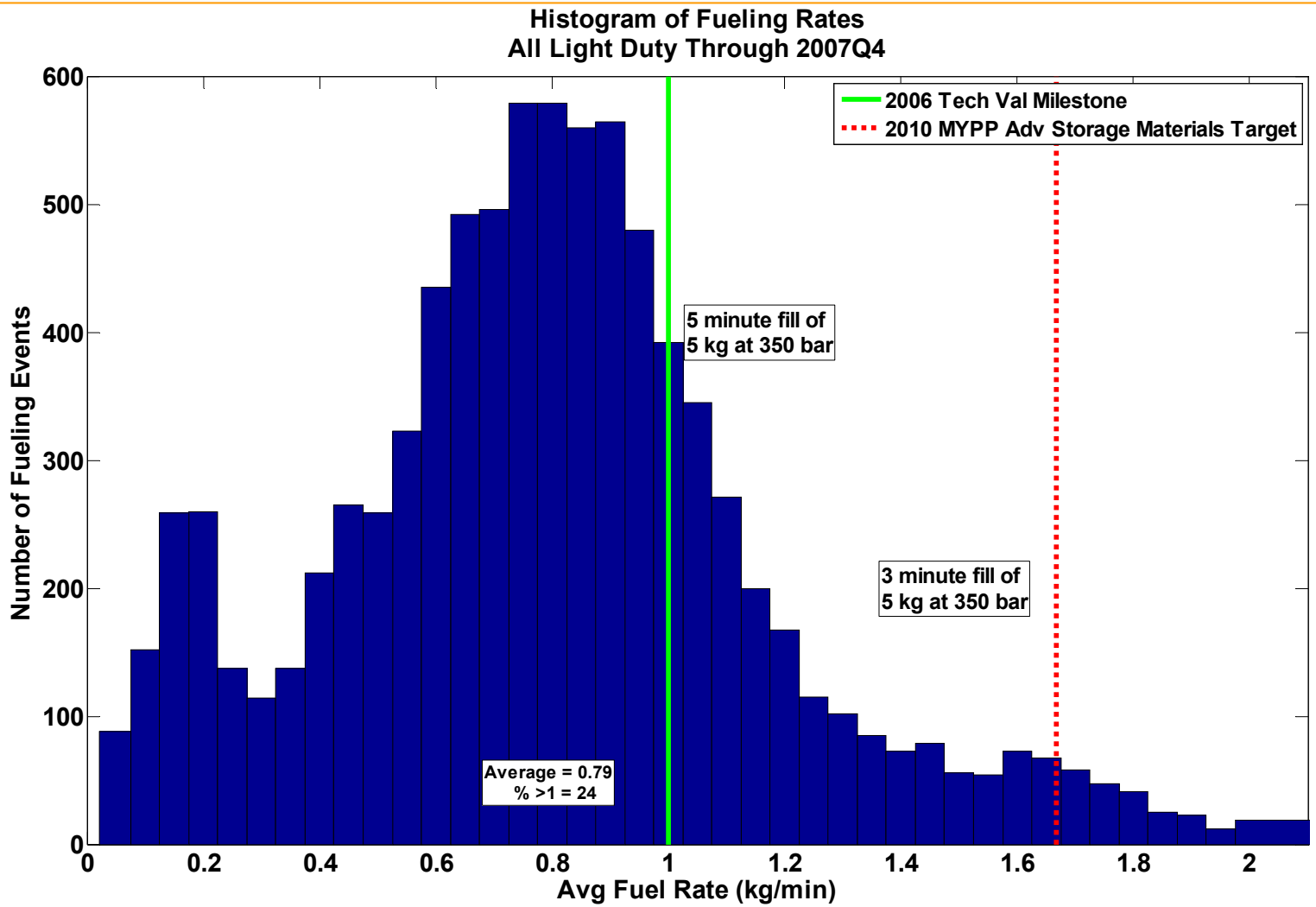
CDP#12: Vehicle Hydrogen Tank Cycle Life



Created: 23-Feb-2006

[1]Some near-term targets have been achieved with compressed and liquid tanks. Emphasis is on advanced materials-based technologies.

CDP#18: Refueling Rates



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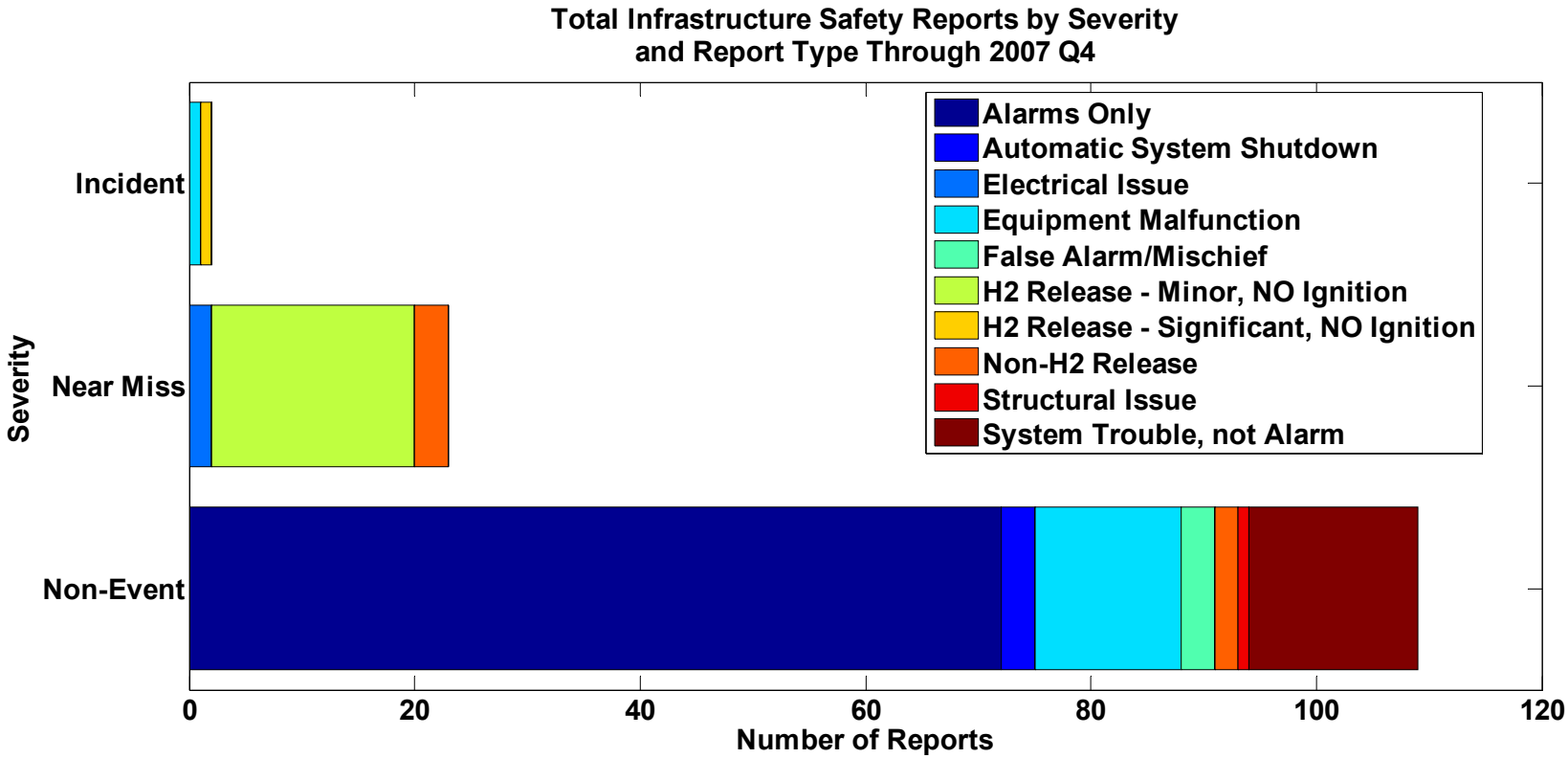
CDP#20: Safety Reports – Infrastructure



An INCIDENT is an event that results in:

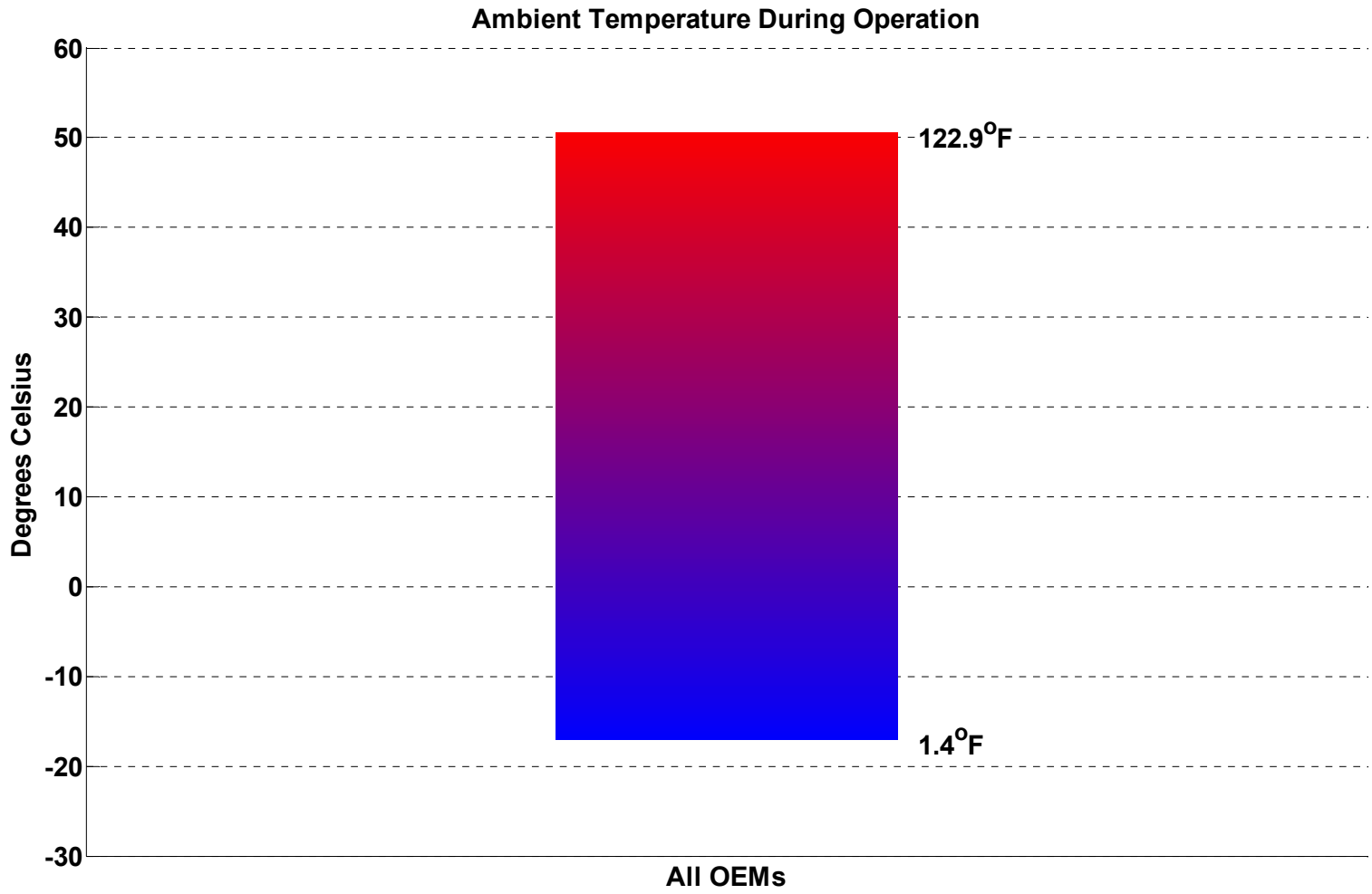
- a lost time accident and/or injury to personnel
- damage/unplanned downtime for project equipment, facilities or property
- impact to the public or environment
- any hydrogen release that unintentionally ignites or is sufficient to sustain a flame if ignited
- release of any volatile, hydrogen containing compound (other than the hydrocarbons used as common fuels)

A NEAR-MISS is:

- an event that under slightly different circumstances could have become an incident
- unplanned H2 release insufficient to sustain a flame

Created: Feb-15-08 1:24 PM

CDP#21: Range of Ambient Temperature During Vehicle Operation



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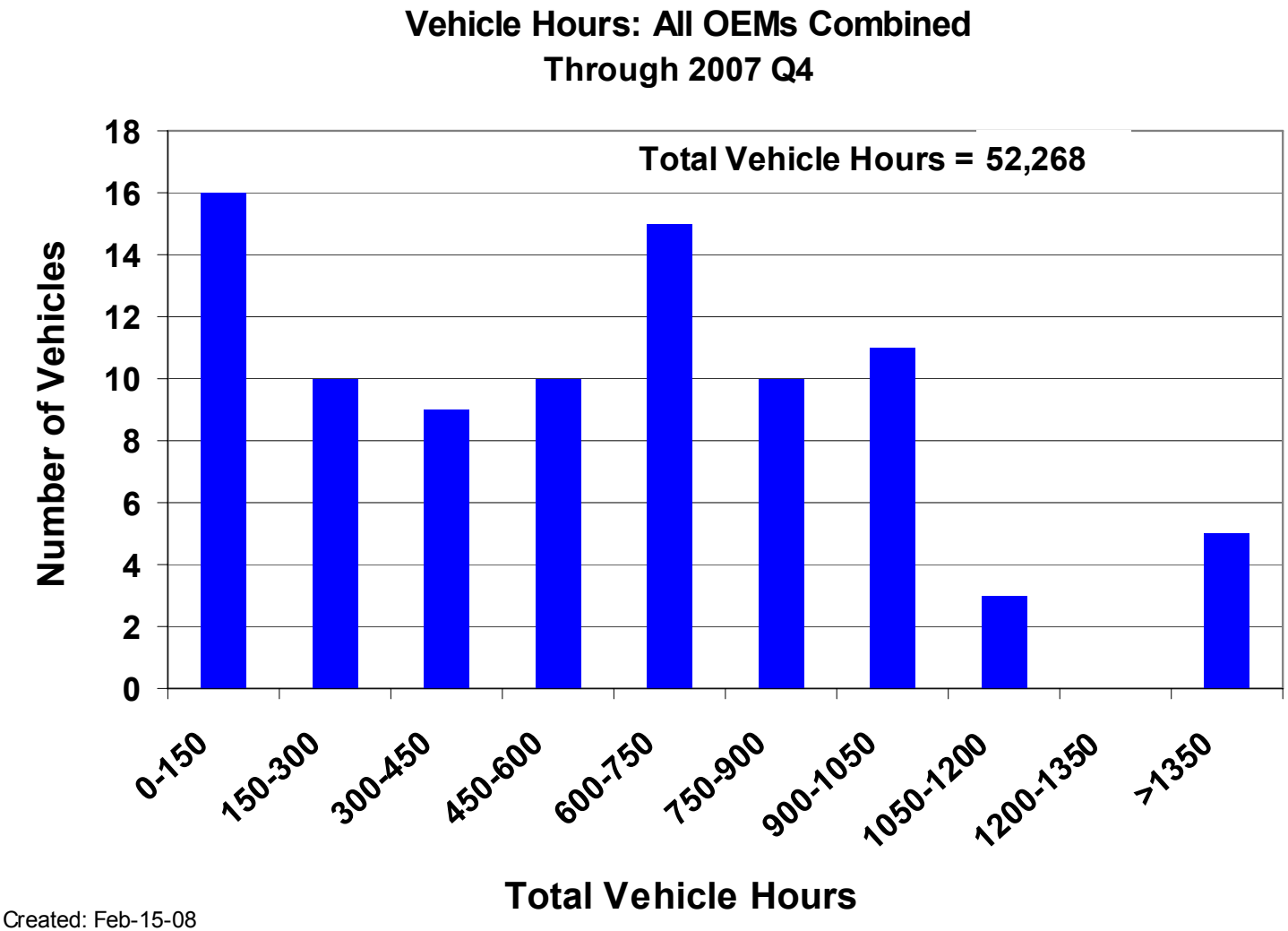
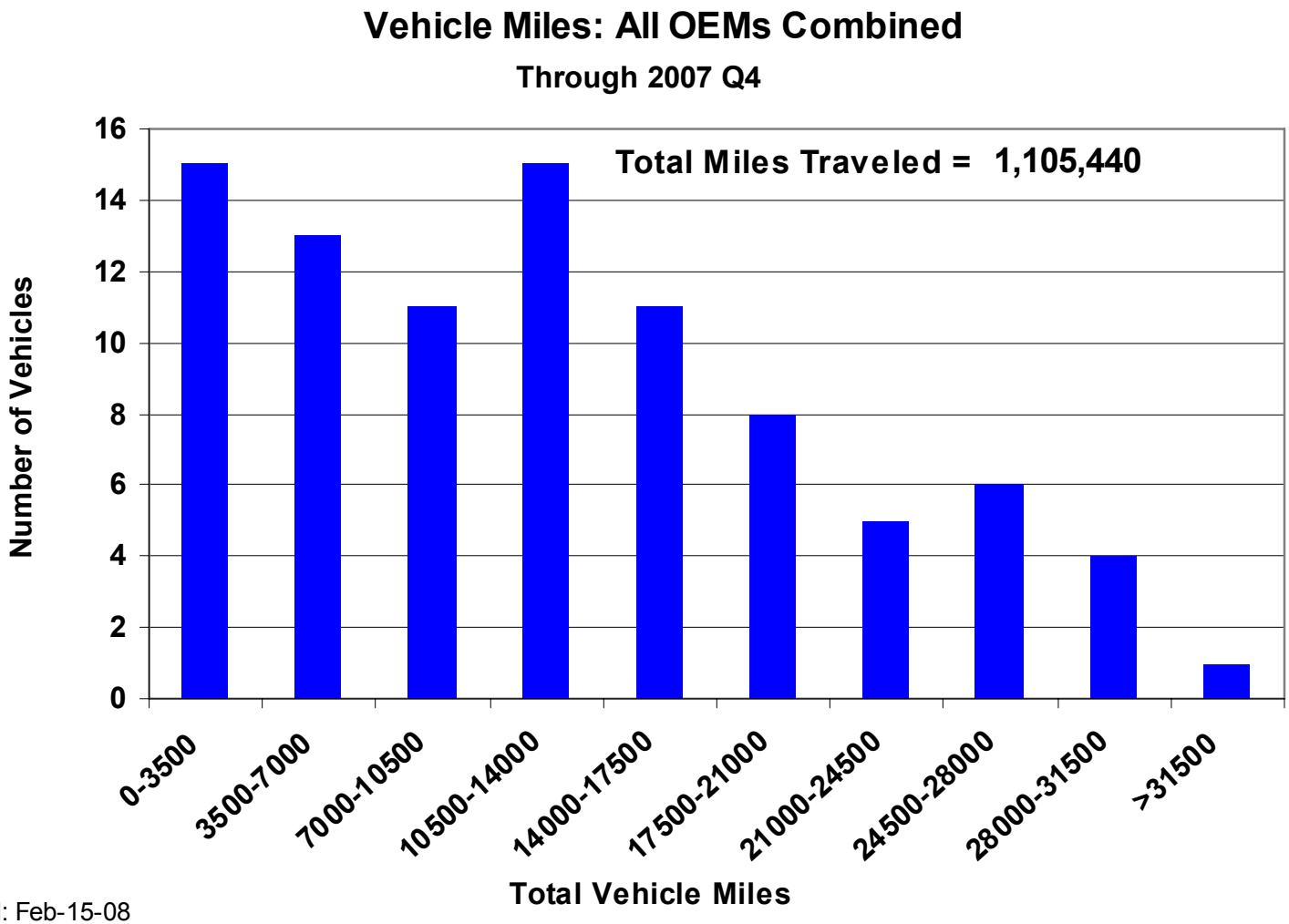
CDP#22: Vehicle Operating Hours



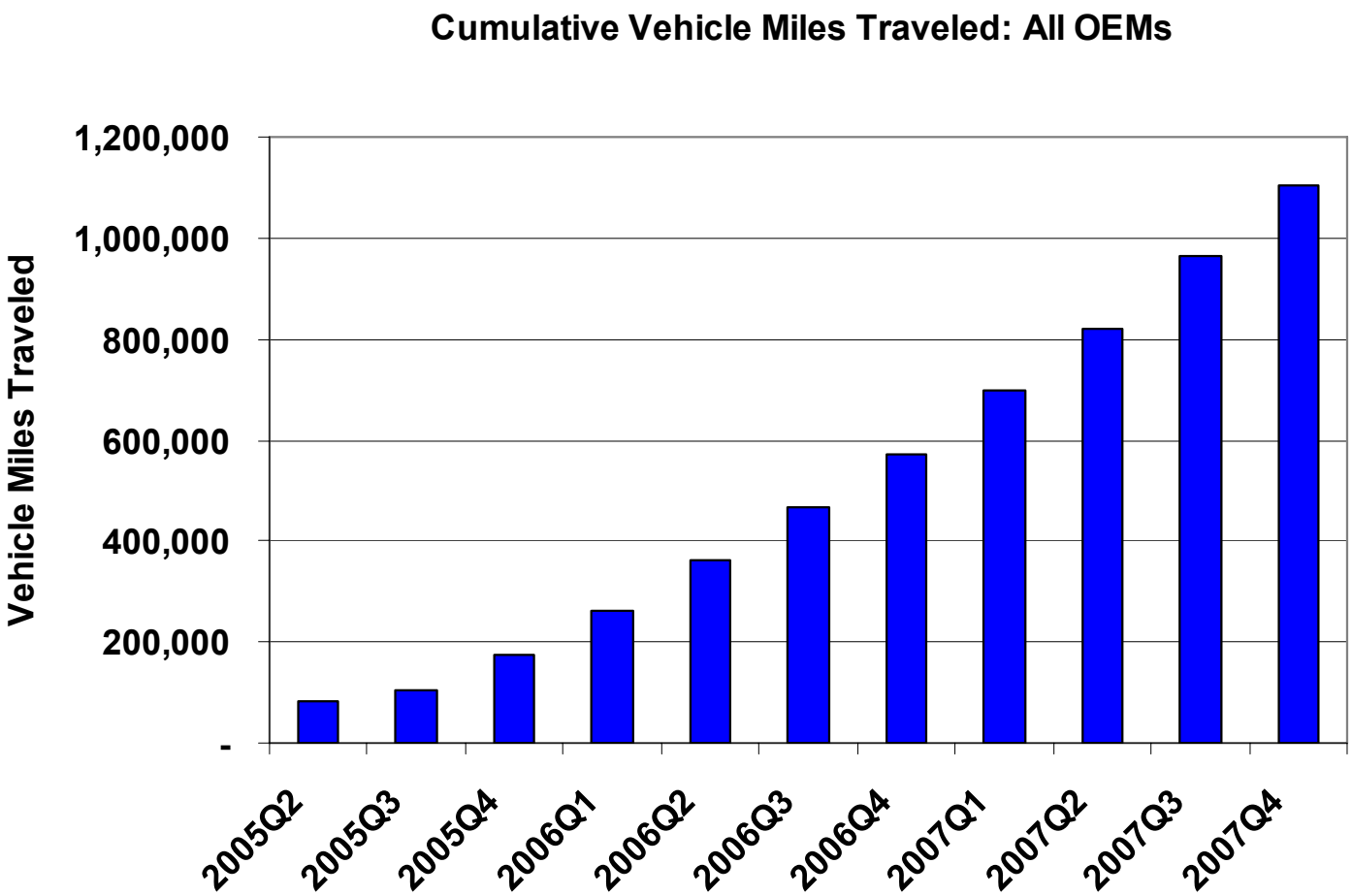
Created: Feb-15-08

CDP#23: Vehicles vs. Miles Traveled



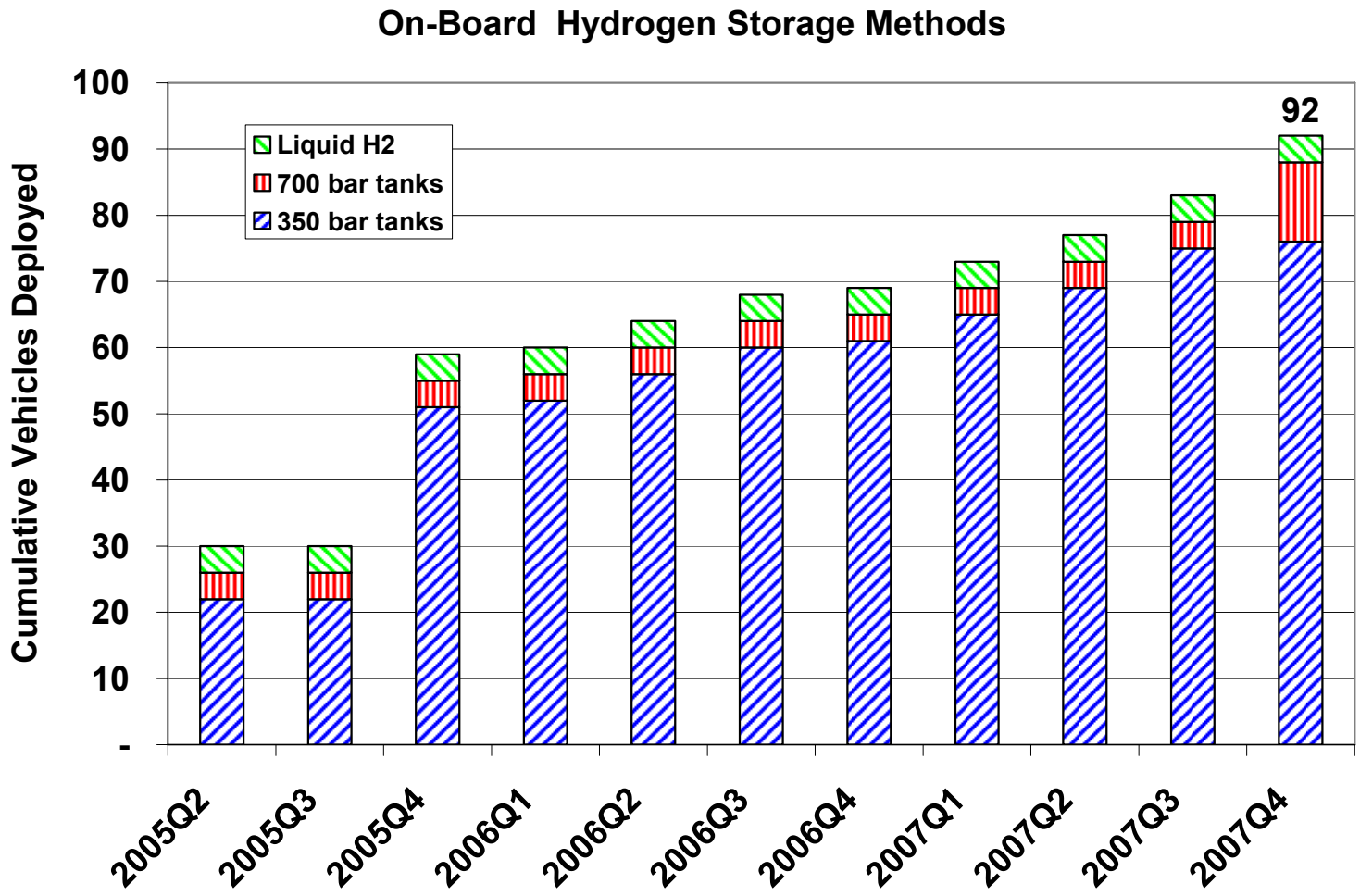
Created: Feb-15-08

CDP#24: Cumulative Vehicle Miles Traveled

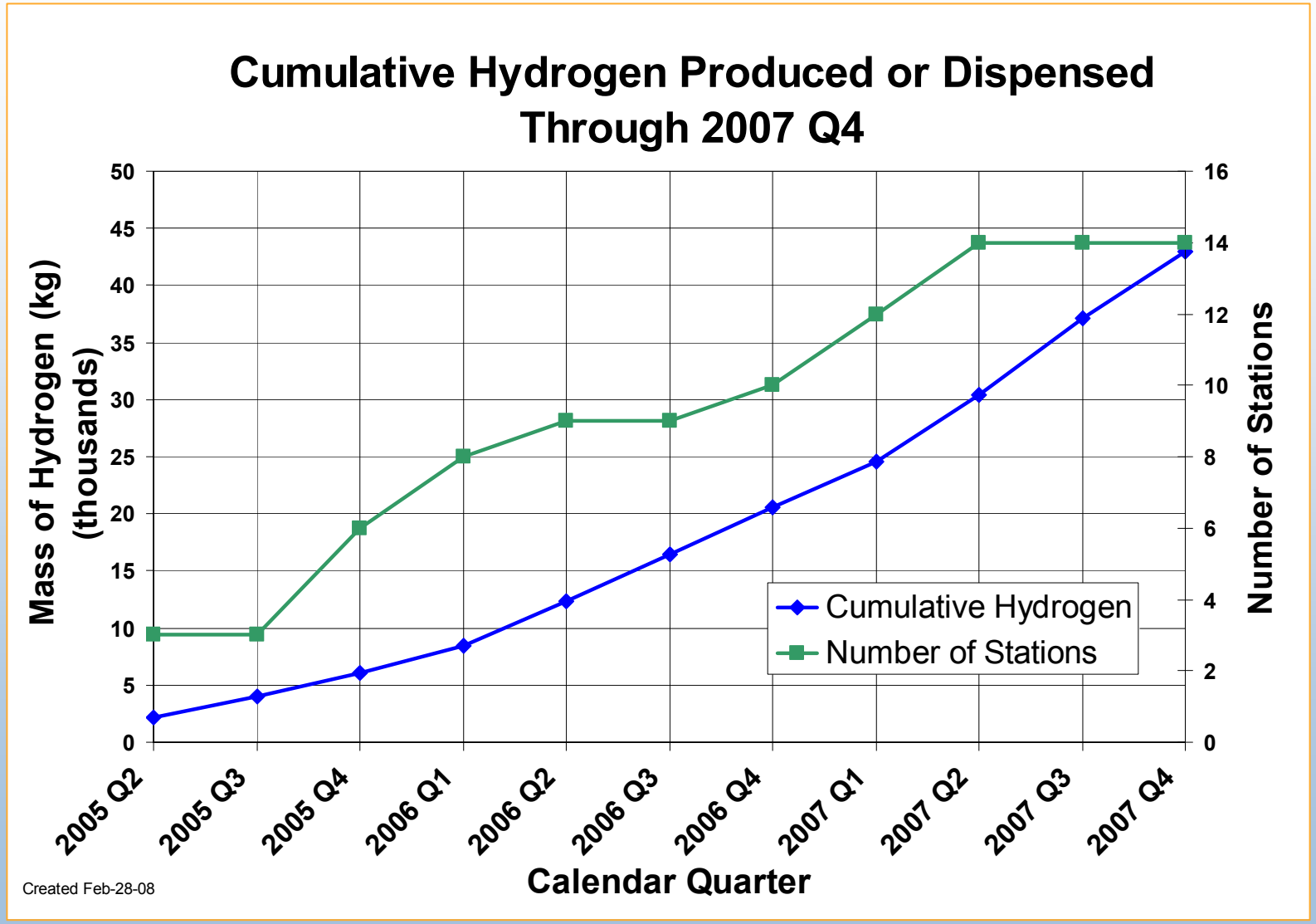


Created: Feb-15-08

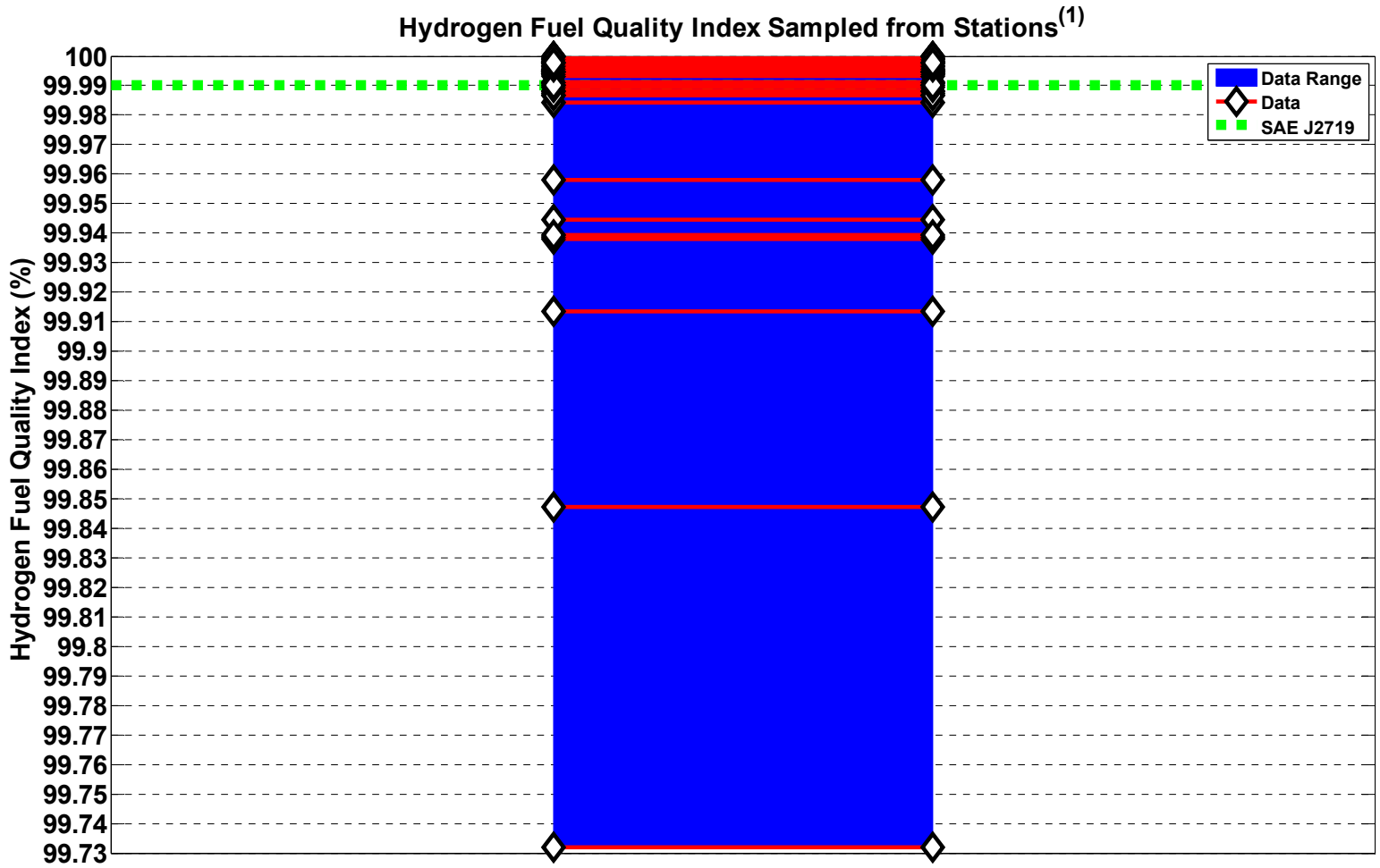
CDP#25: Vehicle H2 Storage Technologies



CDP#26: Cumulative H2 Produced or Dispensed



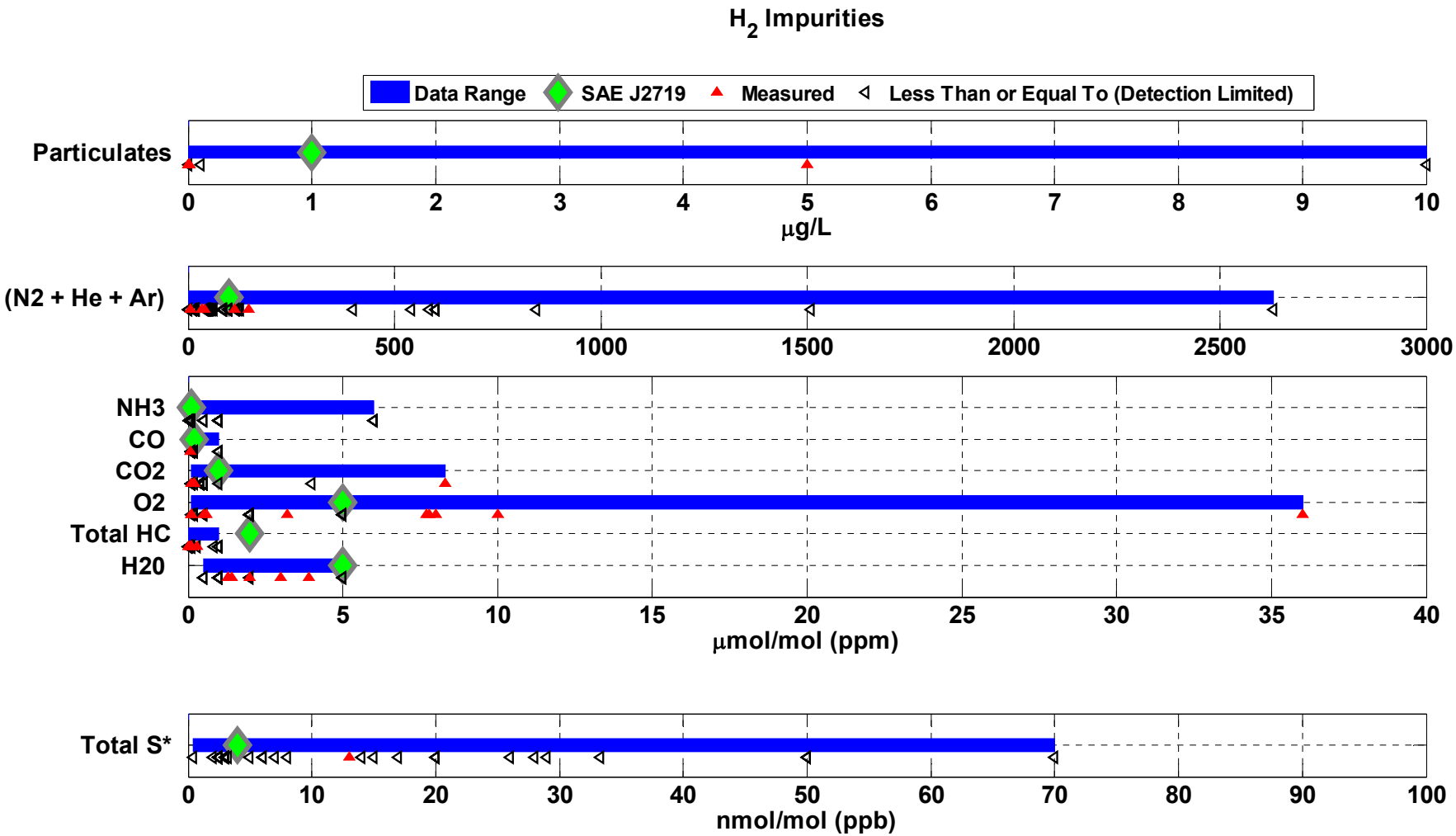
CDP#27: Hydrogen Purity Scatter Plot



(1) Includes sampling from both electrolysis and reforming

Created: Feb-15-08 2:10 PM

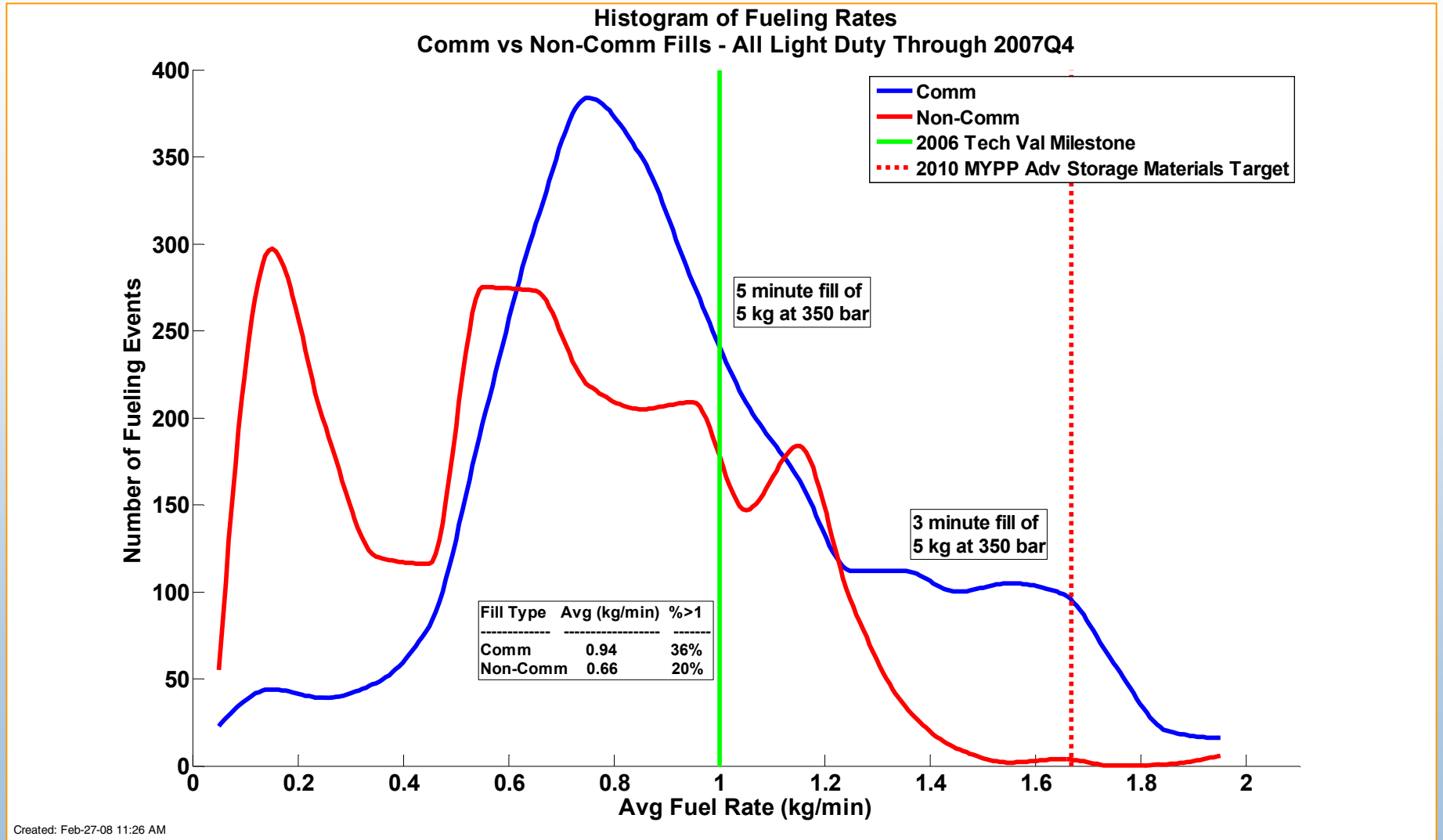
CDP #28: Hydrogen Impurities Scatter Plot



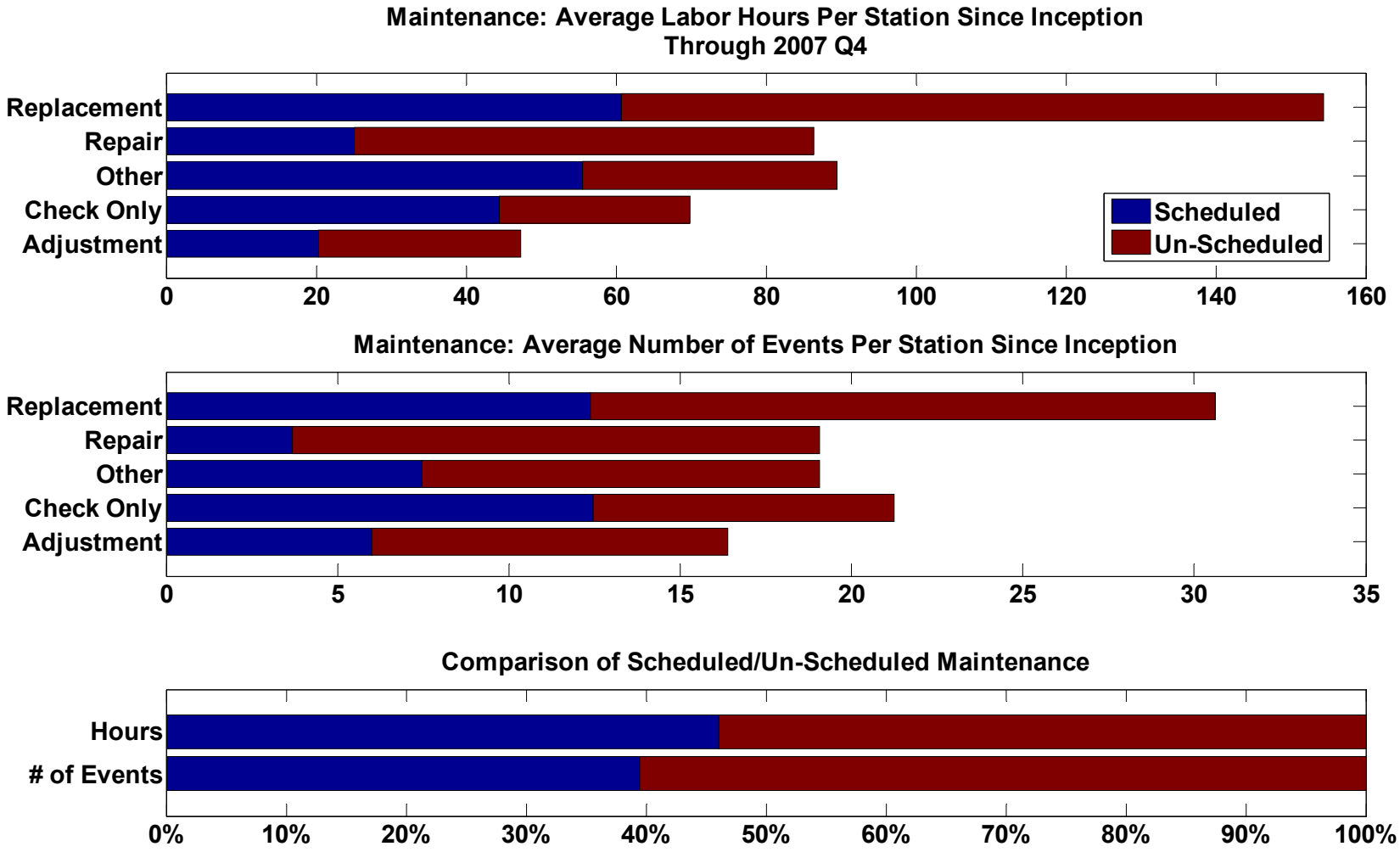
Created: Feb-15-08 2:10 PM

*Calculated from SO2, COS, H2S, CS2, and Methyl Mercaptan (CH3SH).

CDP#29: Fueling Rates – Communication and Non-Communication Fills



CDP#30: Infrastructure Maintenance



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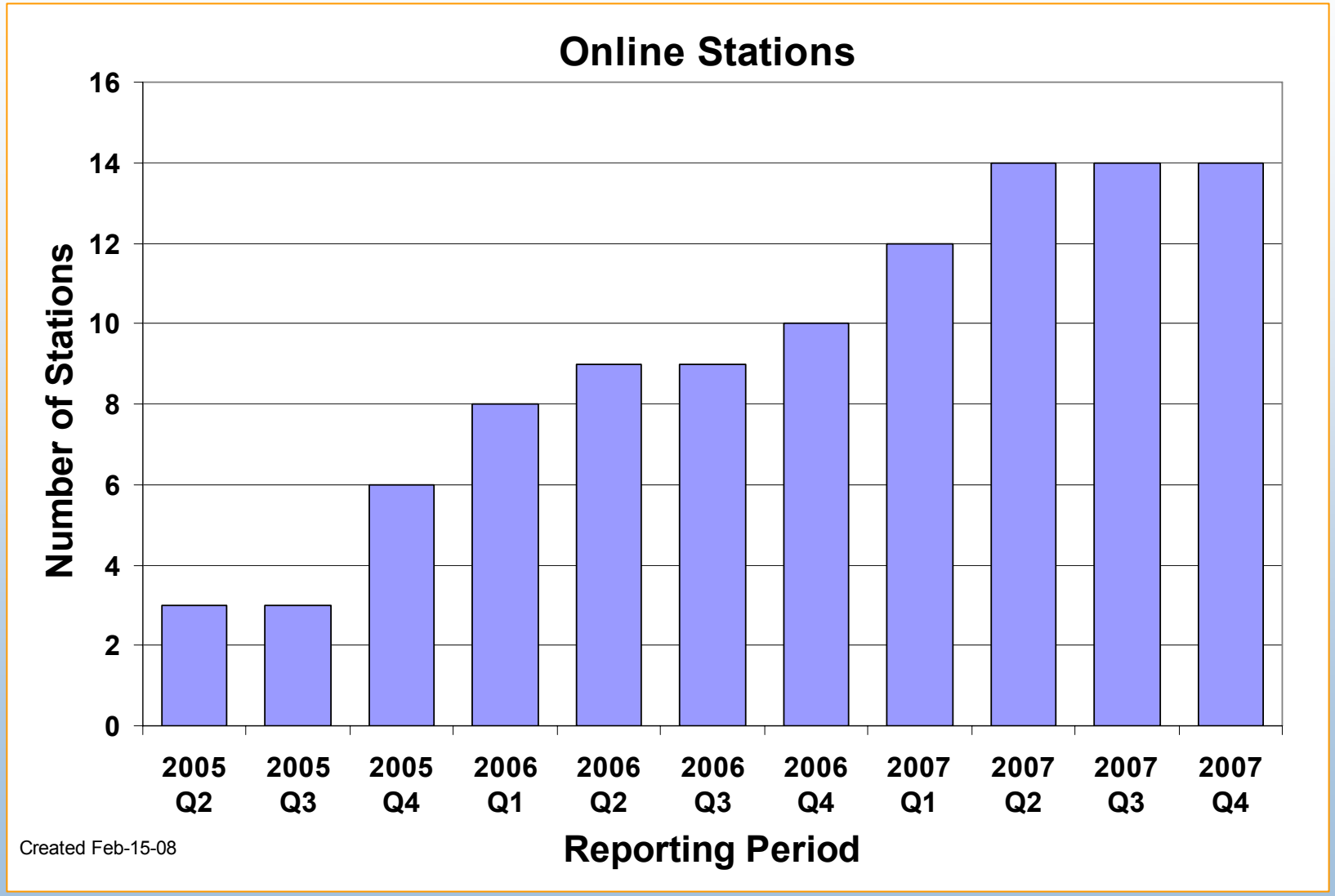
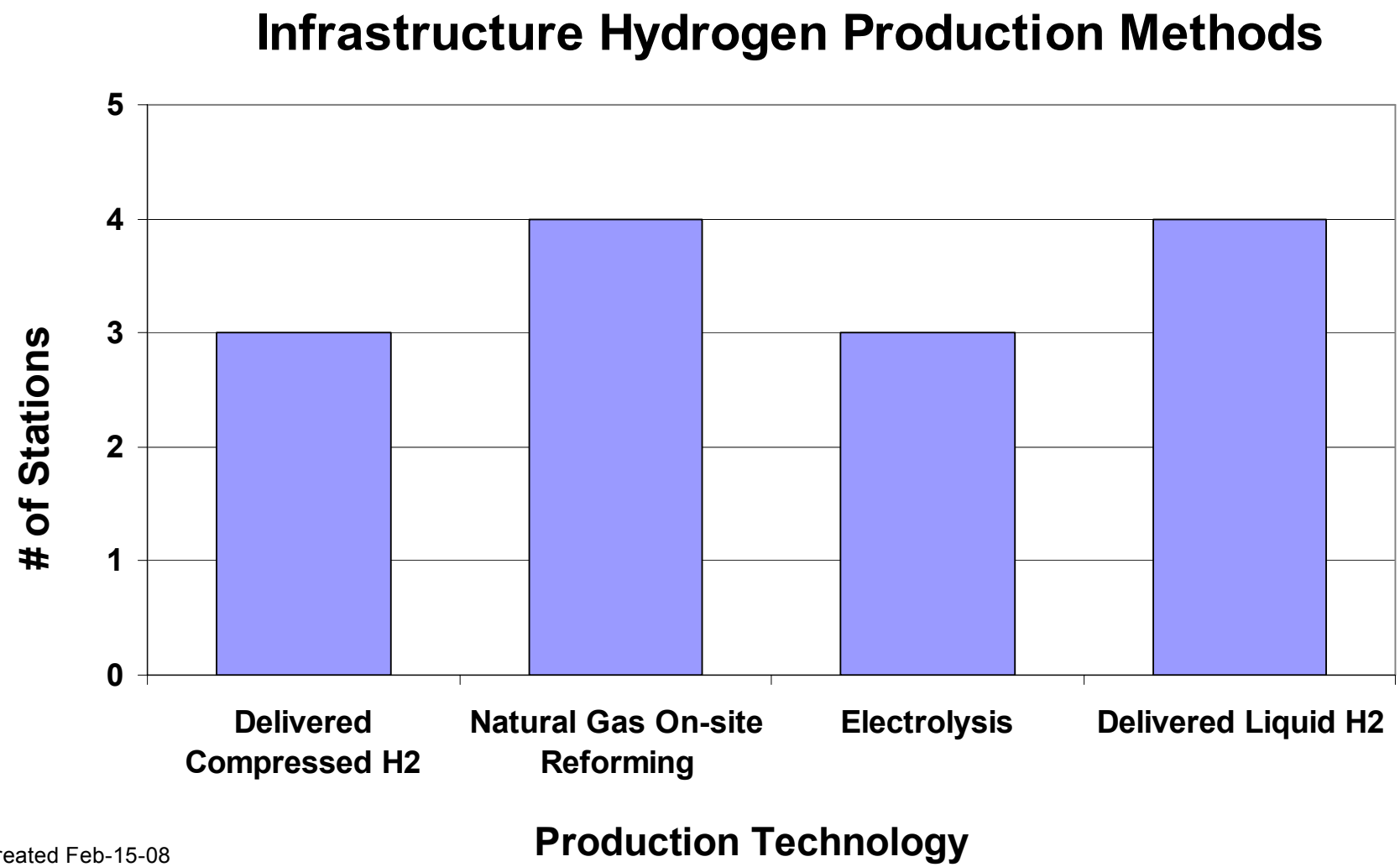
CDP#31: Number of Reporting Stations

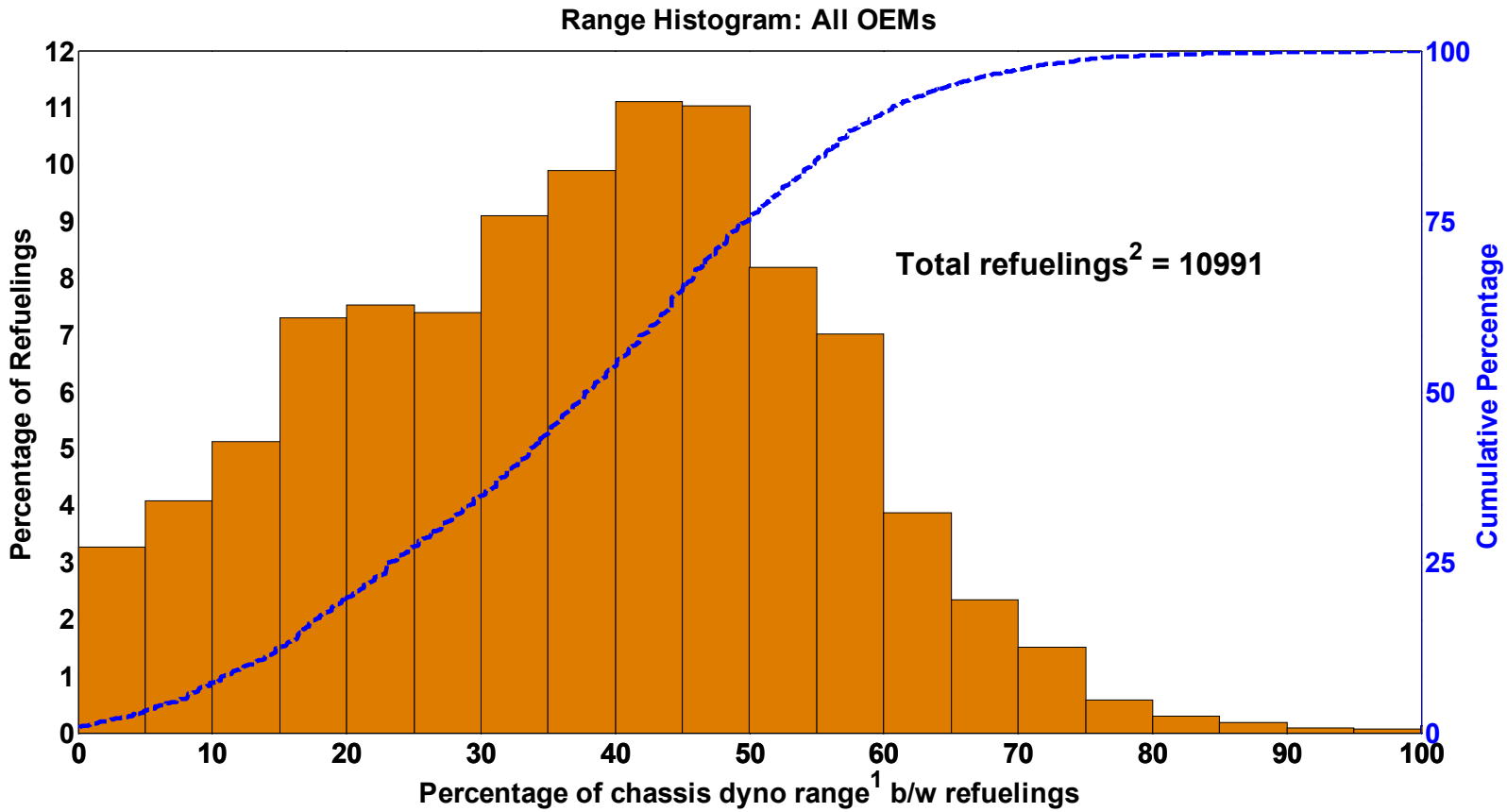


CDP#32: Infrastructure Hydrogen Production Methods



Created Feb-15-08

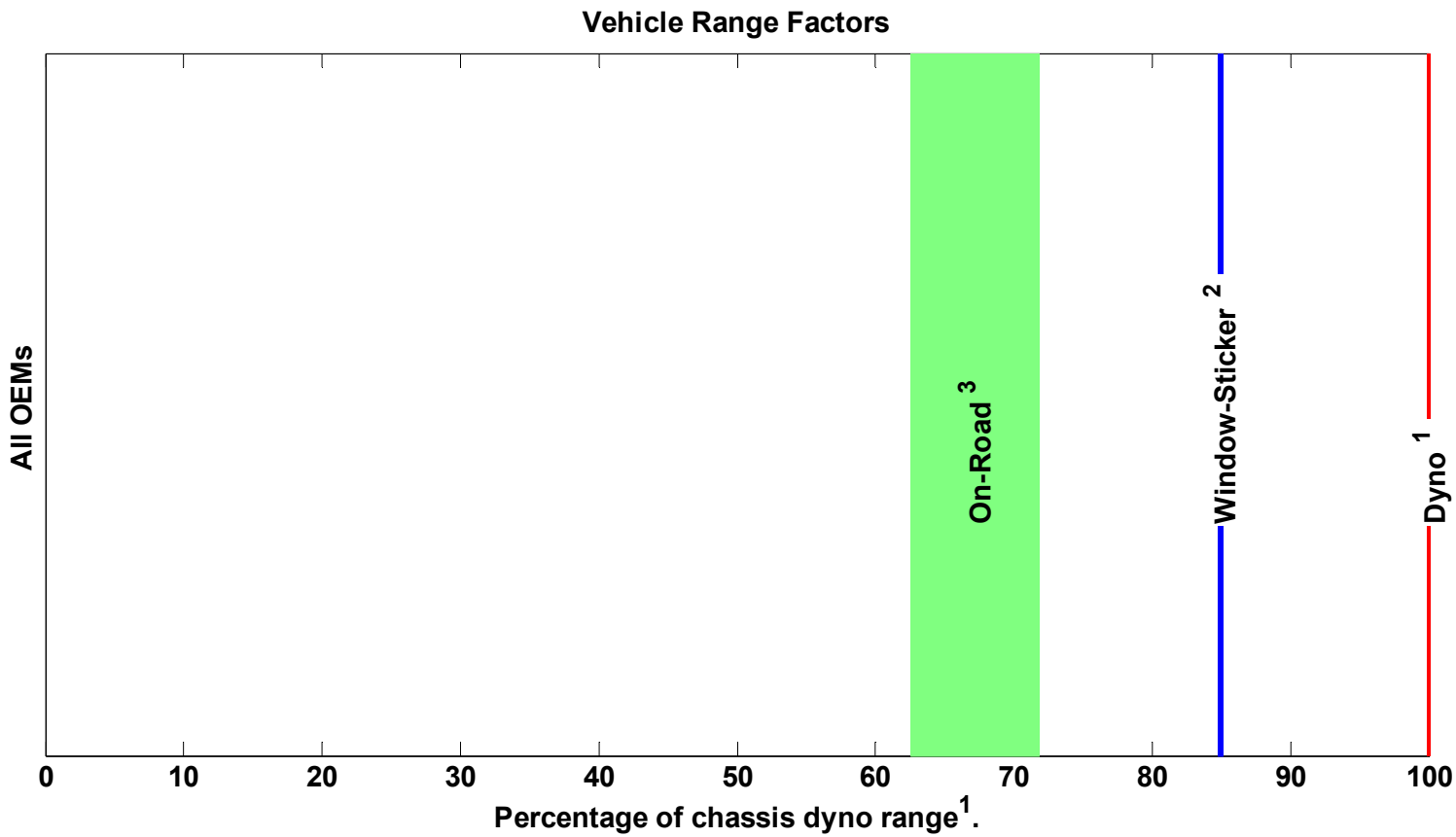
CDP#33: Percentage of Theoretical Range Traveled Between Refuelings



1. Range calculated using the combined City/Hwy fuel economy from dyno testing (not EPA adjusted) and usable fuel on board.
2. Some refueling events are not detected/reported due to data noise or incompleteness.

Created: Feb-15-08 9:20 AM

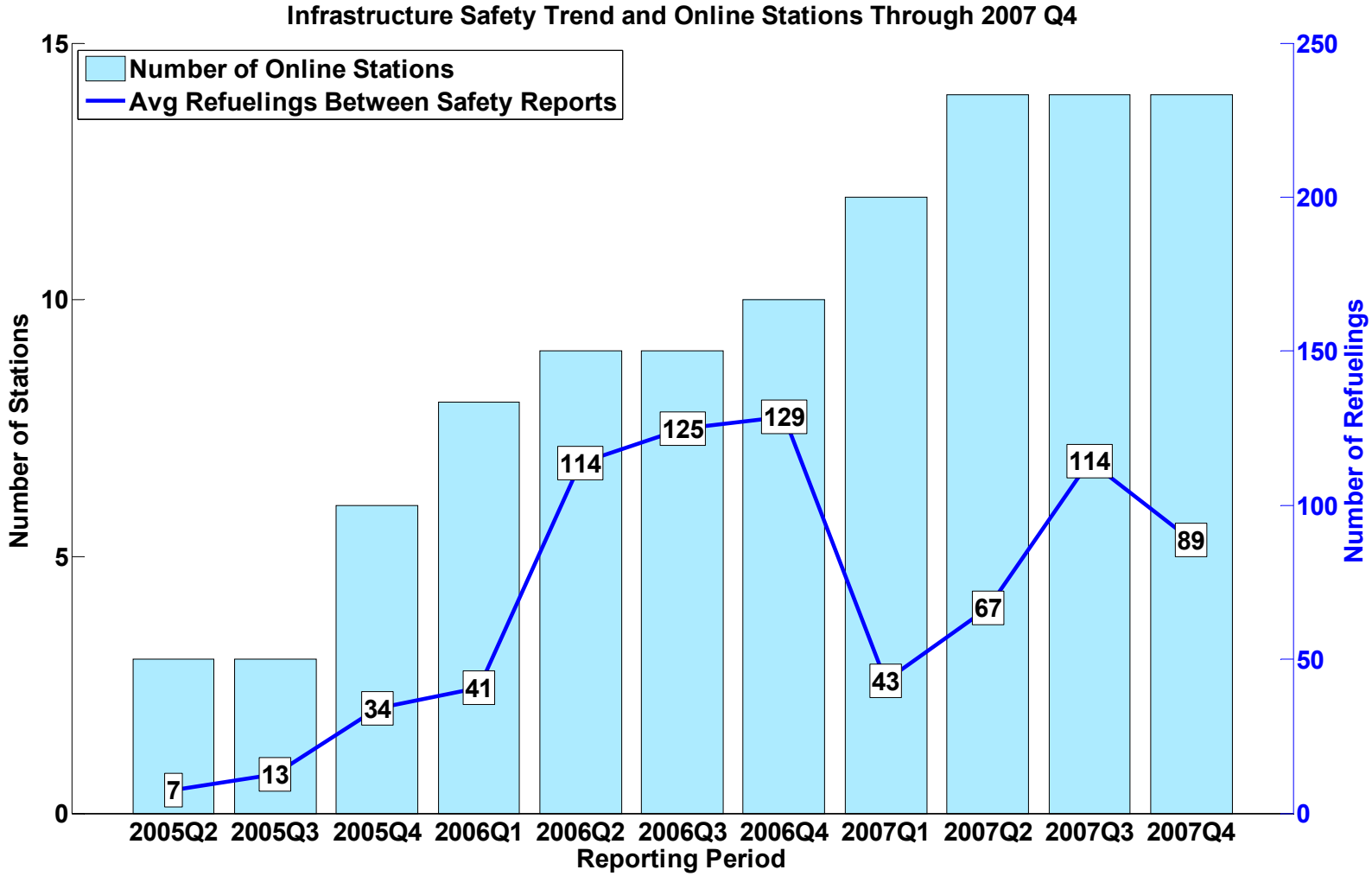
CDP#34: Effective Vehicle Range



1. Calculated using the combined City/Hwy fuel economy from dyno testing (non-adjusted) and usable fuel on board.
2. Applying window-sticker correction factors for fuel economy: 0.78 x Hwy and 0.9 x City.
3. Using fuel economy from on-road data (excluding trips > 1 mile, consistent with other data products).

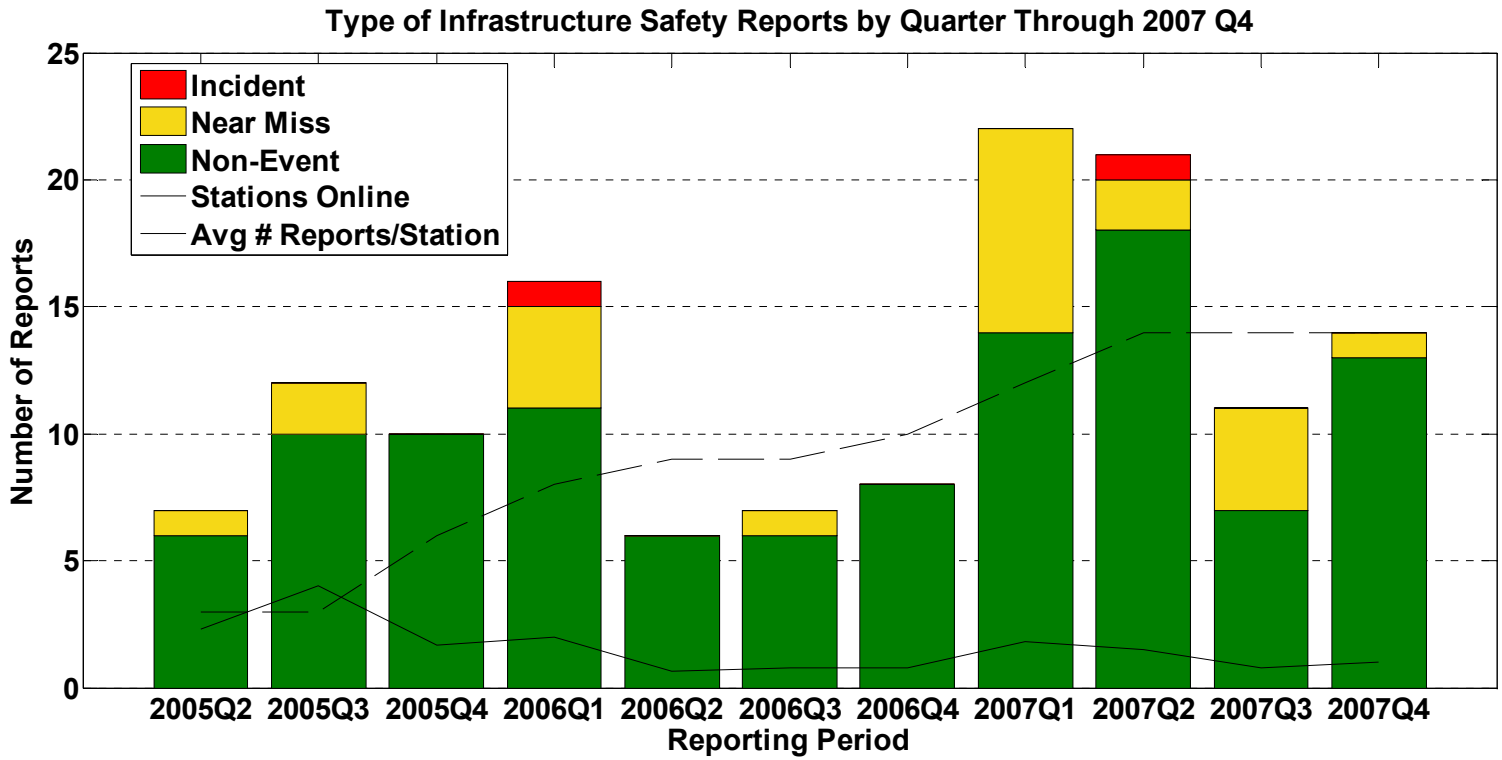
Created: Feb-15-08 9:20 AM

CDP#35: Average Refuelings Between Infrastructure Safety Reports



Created: Feb-15-08 1:24 PM

CDP#36: Type of Infrastructure Safety Report By Quarter



An INCIDENT is an event that results in:

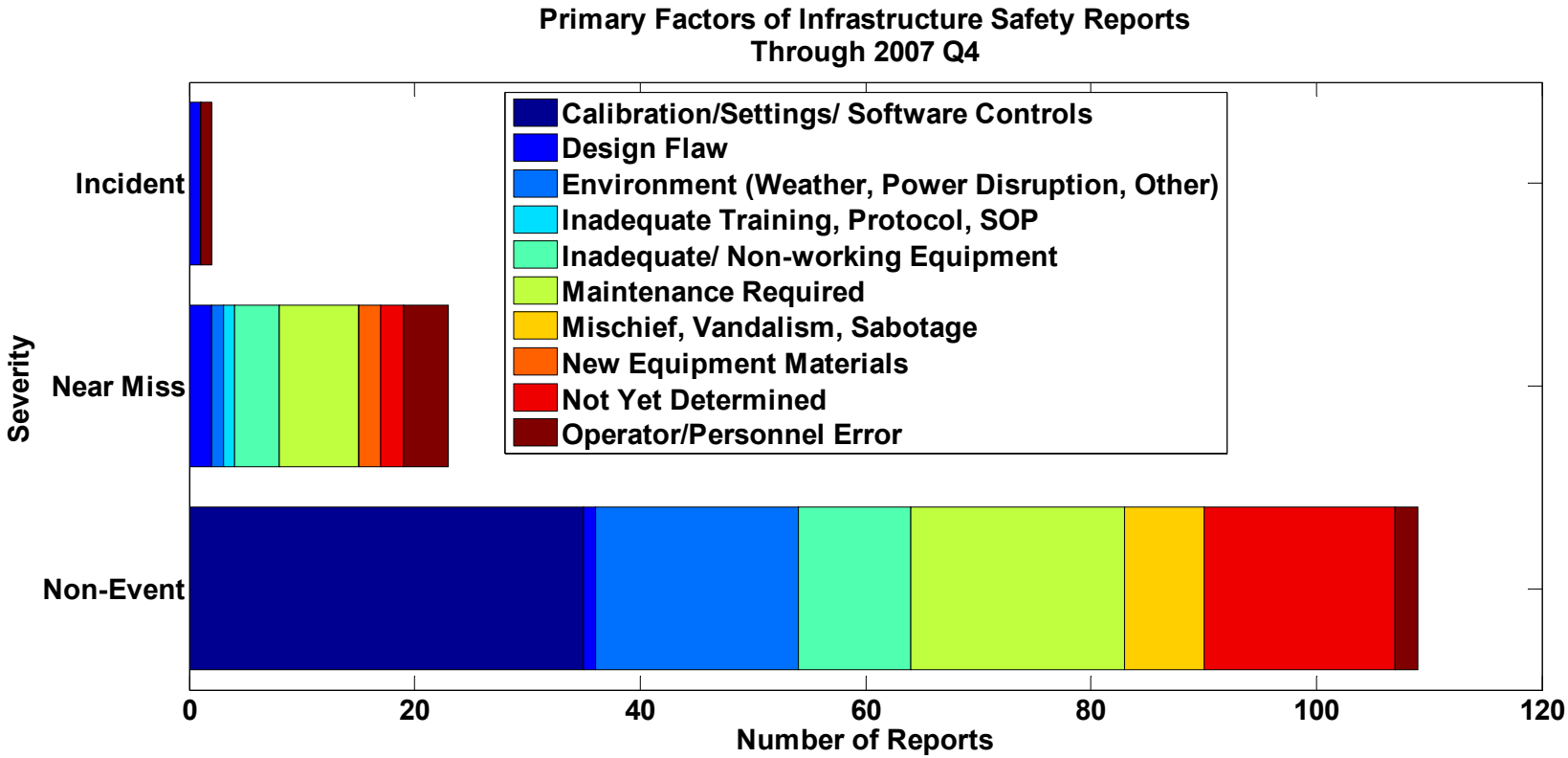
- a lost time accident and/or injury to personnel
- damage/unplanned downtime for project equipment, facilities or property
- impact to the public or environment
- any hydrogen release that unintentionally ignites or is sufficient to sustain a flame if ignited
- release of any volatile, hydrogen containing compound (other than the hydrocarbons used as common fuels)

A NEAR-MISS is:

- an event that under slightly different circumstances could have become an incident
- unplanned H2 release insufficient to sustain a flame

Created: Feb-15-08 1:24 PM

CDP#37: Primary Factors of Infrastructure Safety Reports



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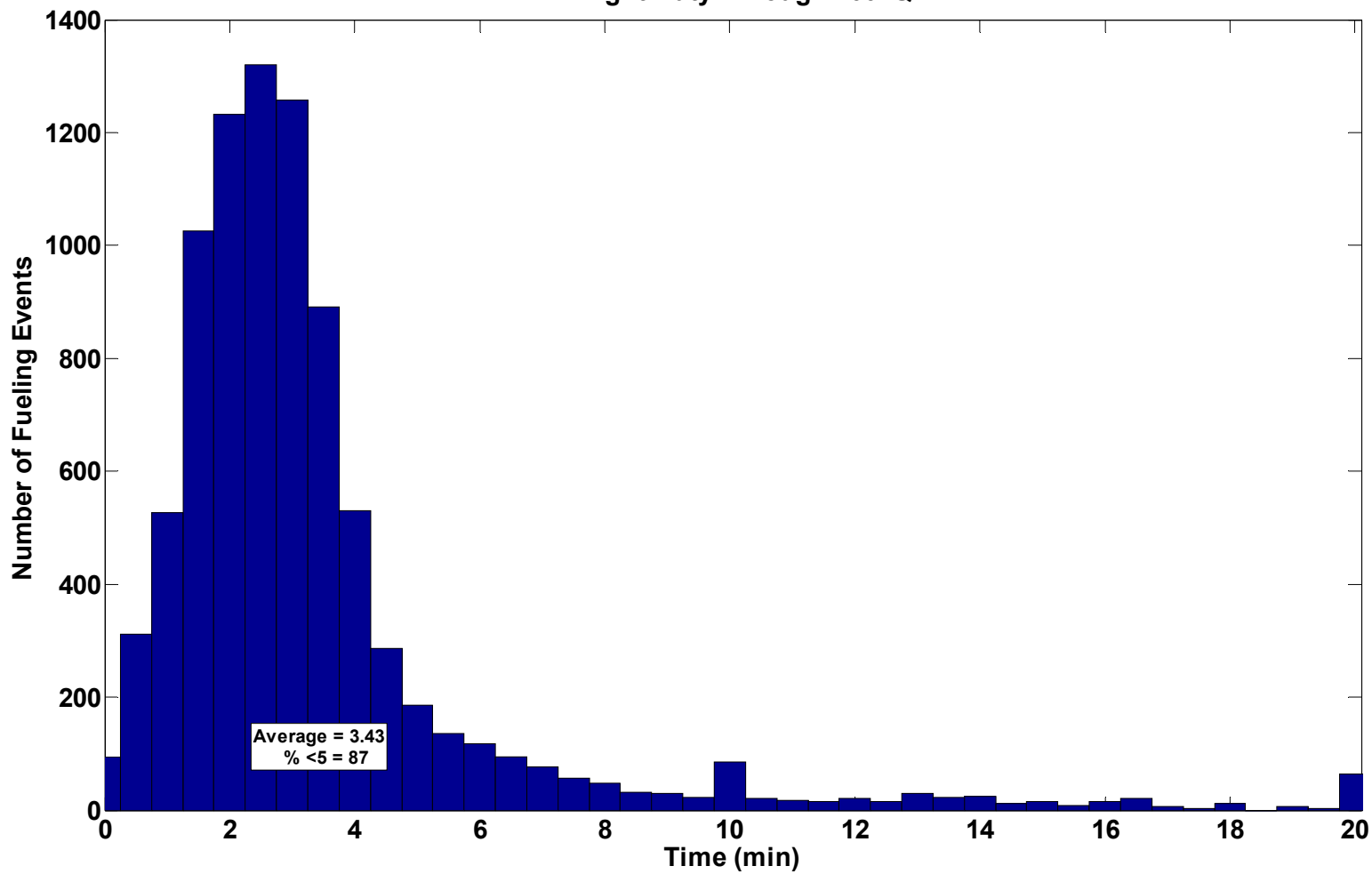
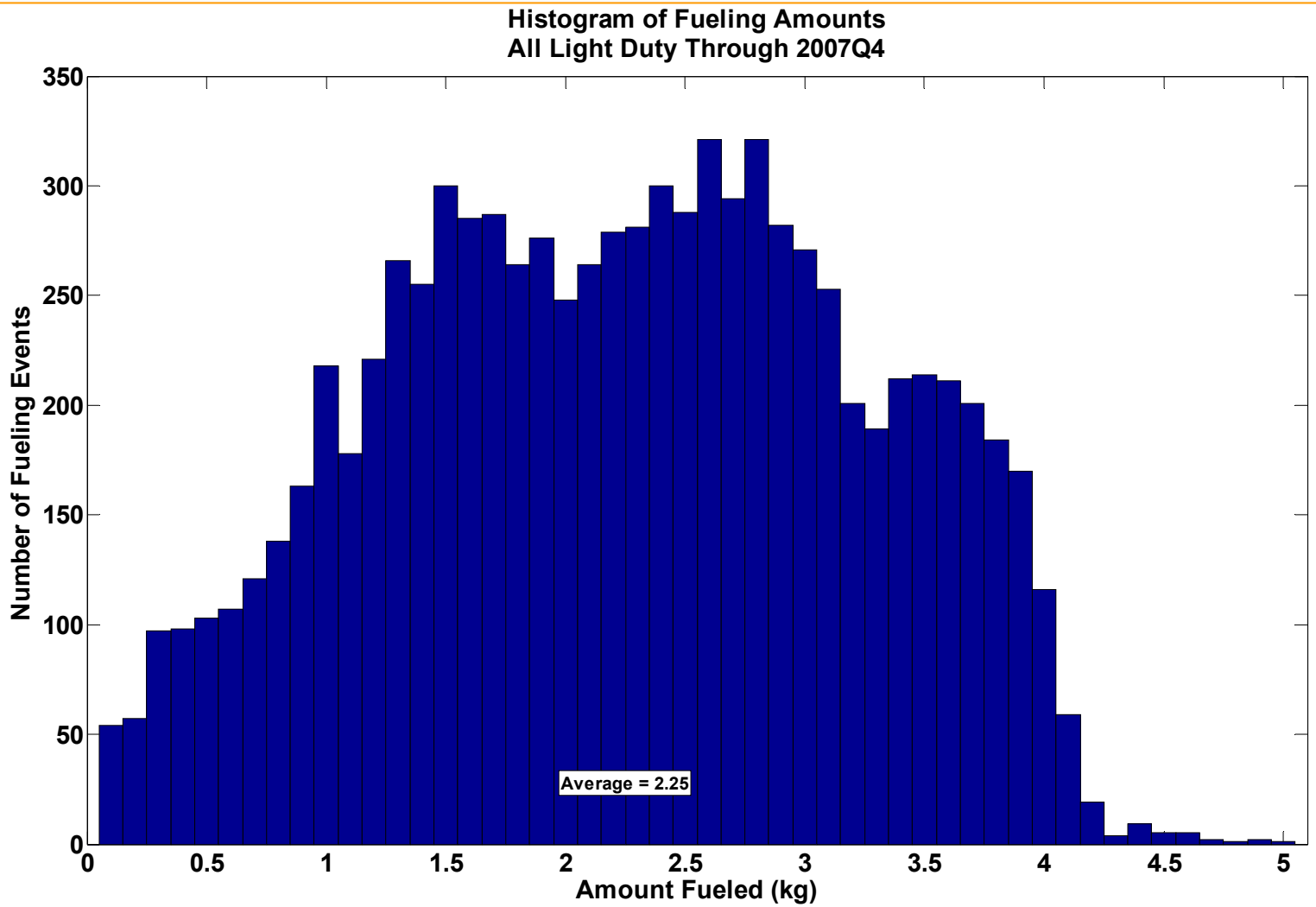
- unplanned H2 release insufficient to sustain a flame

Created: Feb-15-08 1:24 PM

CDP#38: Refueling Times

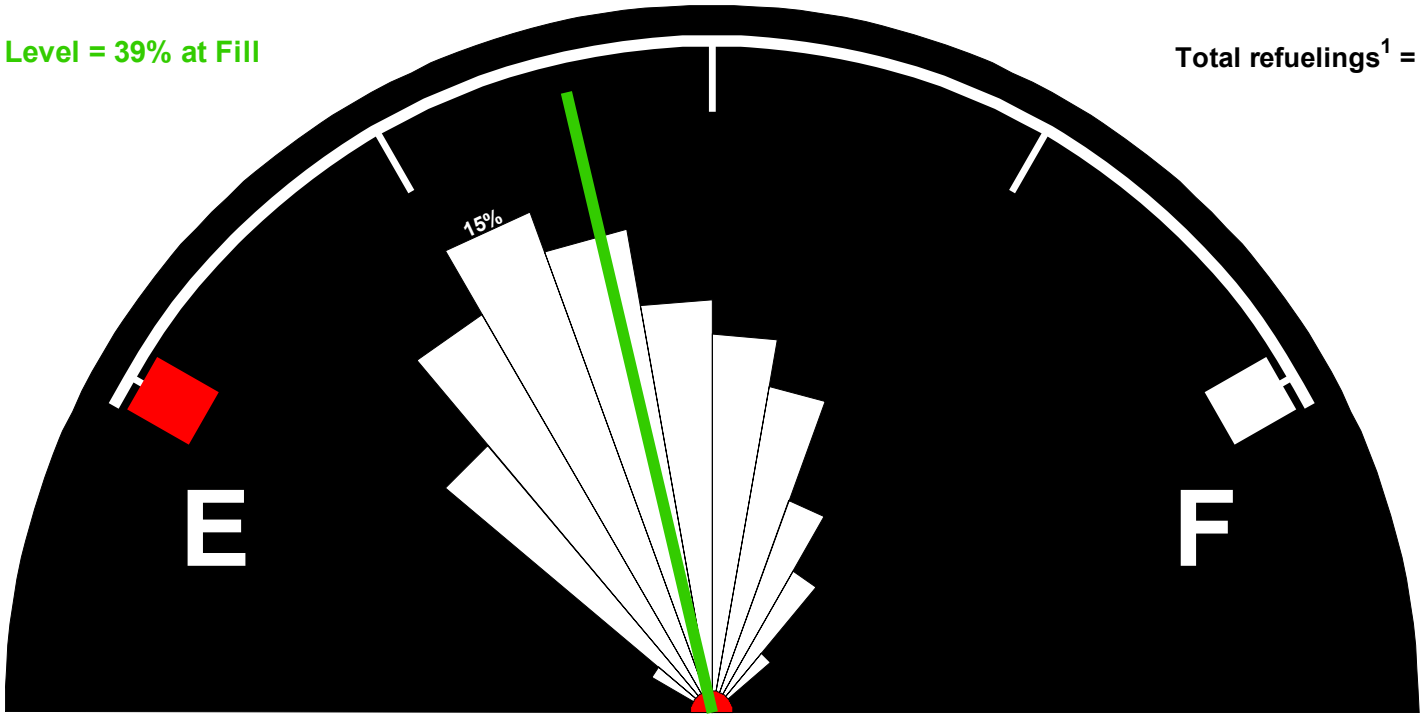


CDP#39: Refueling Amounts



Created: Feb-15-08 1:44 PM

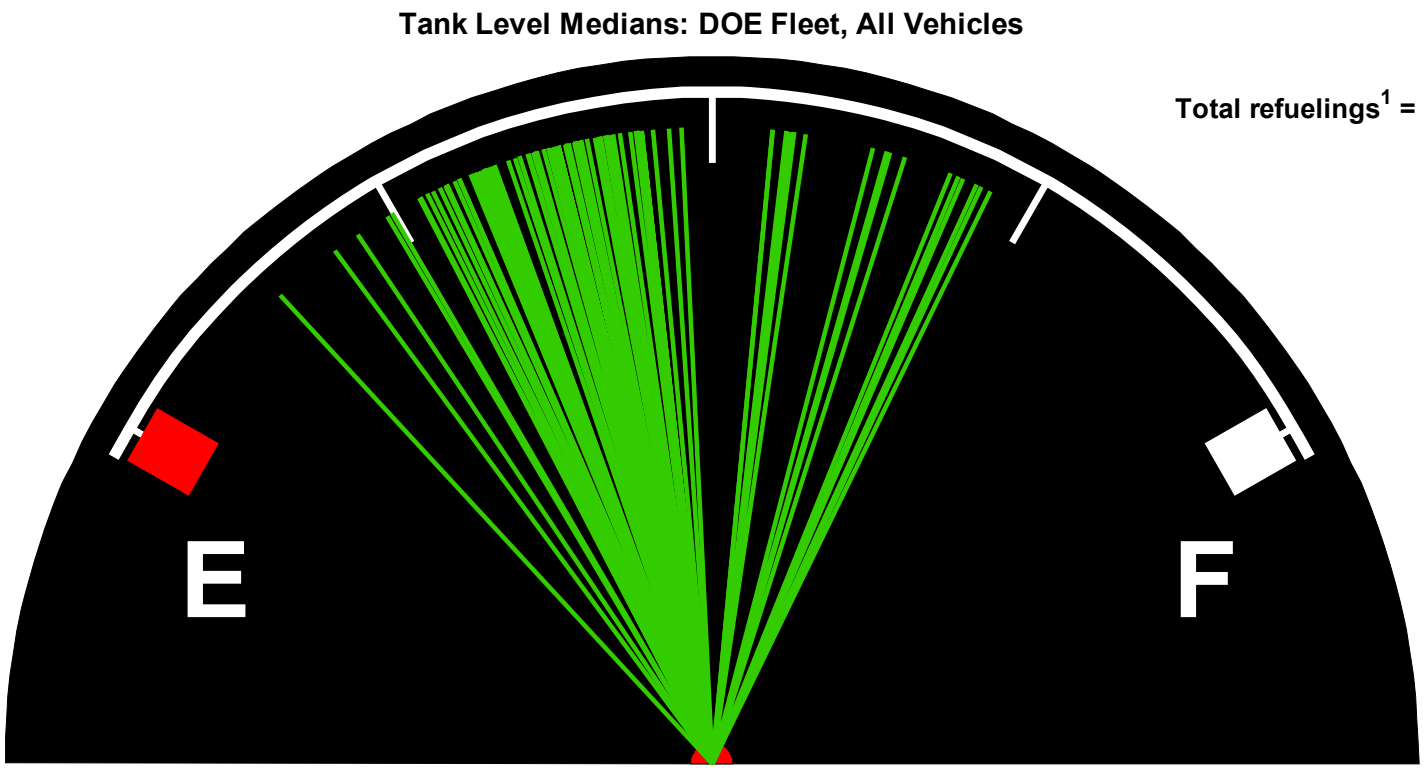
CDP#40: H2 Tank Level at Refueling



1. Some refueling events not recorded/detected due to data noise or incompleteness.
2. The outer arc is set at 20% total refuelings.
3. If tank level at fill was not available, a complete fill up was assumed.

Created: Feb-27-08 10:51 AM

CDP#41: Refueling Tank Levels - Medians



1. Some refueling events not recorded/detected due to data noise or incompleteness.
2. If tank level at fill was not available, a complete fill up was assumed.

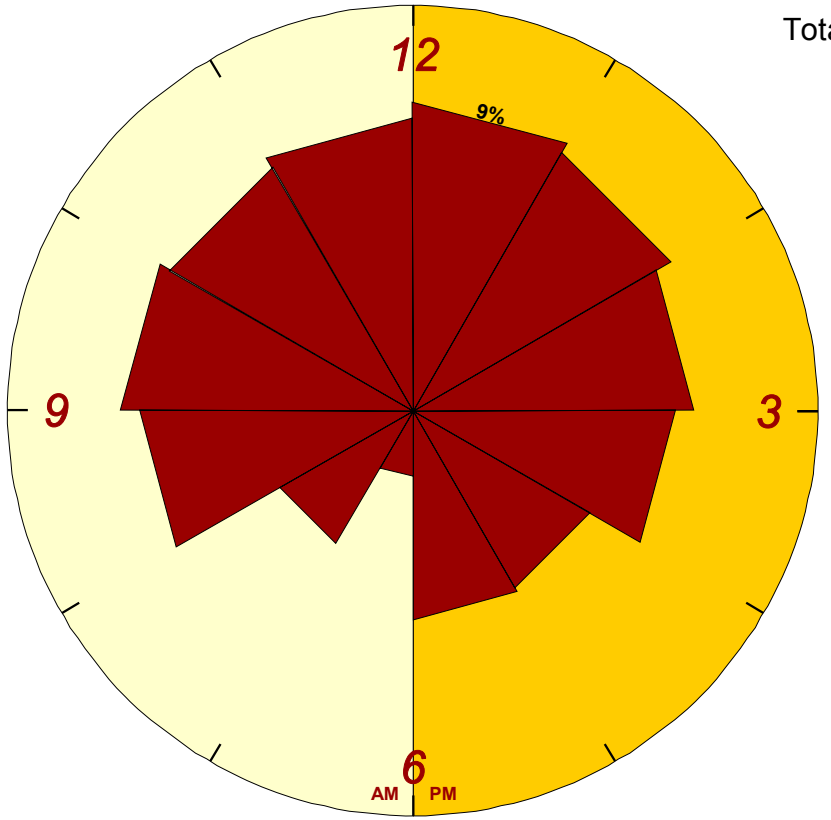
Created: Feb-27-08 10:51 AM

CDP#42: Refueling by Time of Day

Refueling by Time of Day: DOE Fleet

% of fills b/t 6 AM & 6 PM: 86.5%

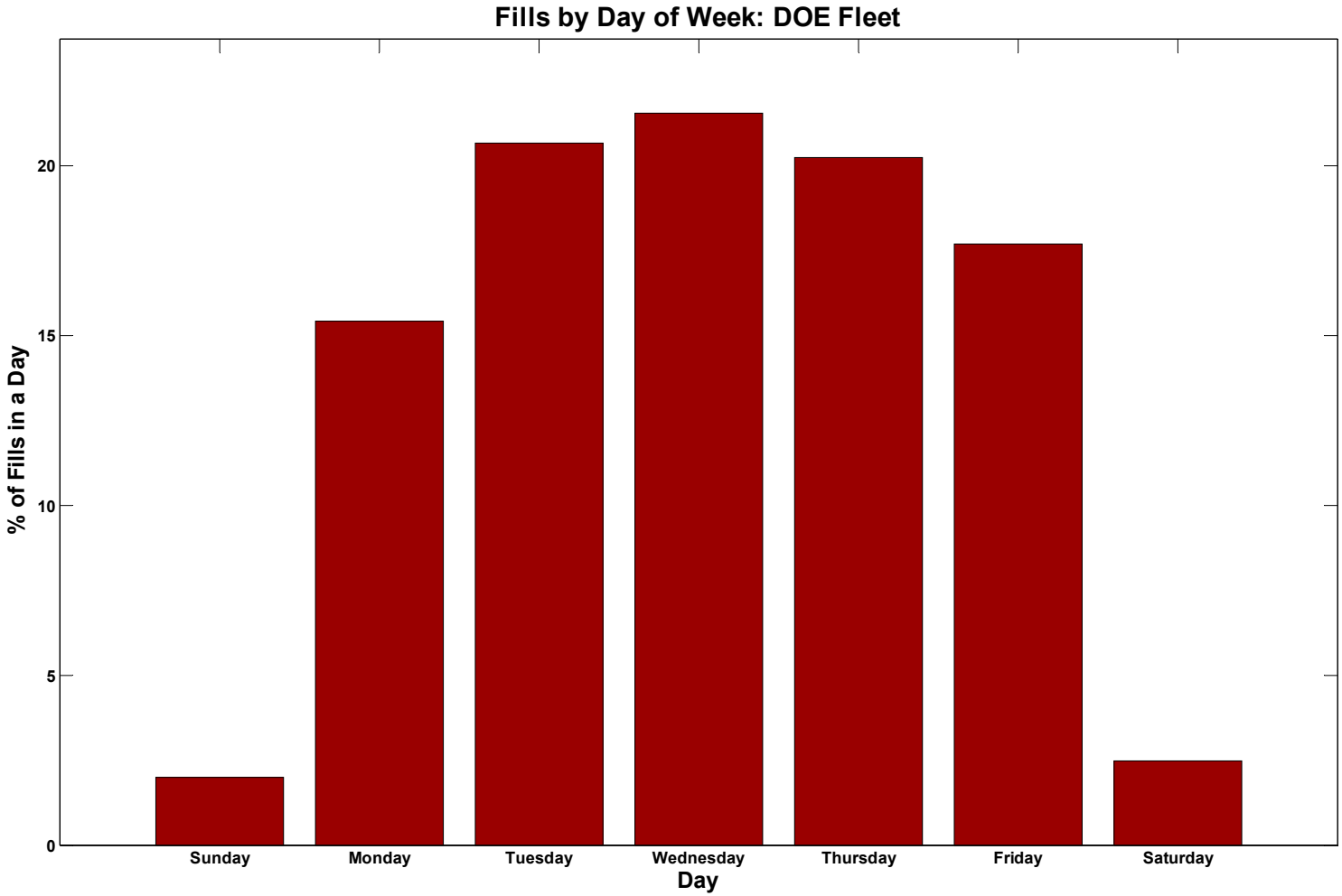
Total Fill[3] Events = 11356



1. Fills between 6 AM & 6 PM
2. The outer arc is set at 12 % total Fill.
3. Some events not recorded/detected due to data noise or incompleteness.

Created: Feb-27-08 10:51 AM

CDP#43: Refueling by Day of Week



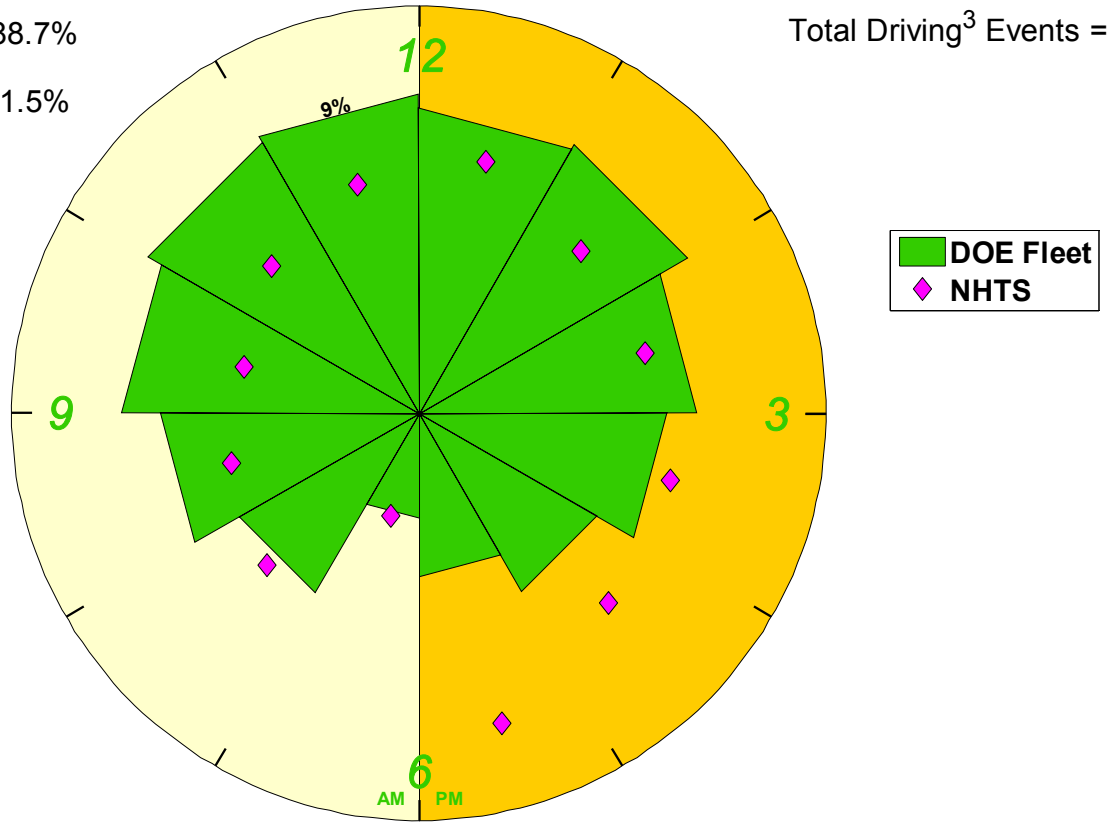
Created: Feb-27-08 10:51 AM

CDP#44: Driving Start Time – Day

Driving Start Time - Day: DOE Fleet

% of driving trips b/t 6 AM & 6 PM: 88.7%

% of NHTS trips b/t 6 AM & 6 PM: 81.5%



Total Driving[3] Events = 139968

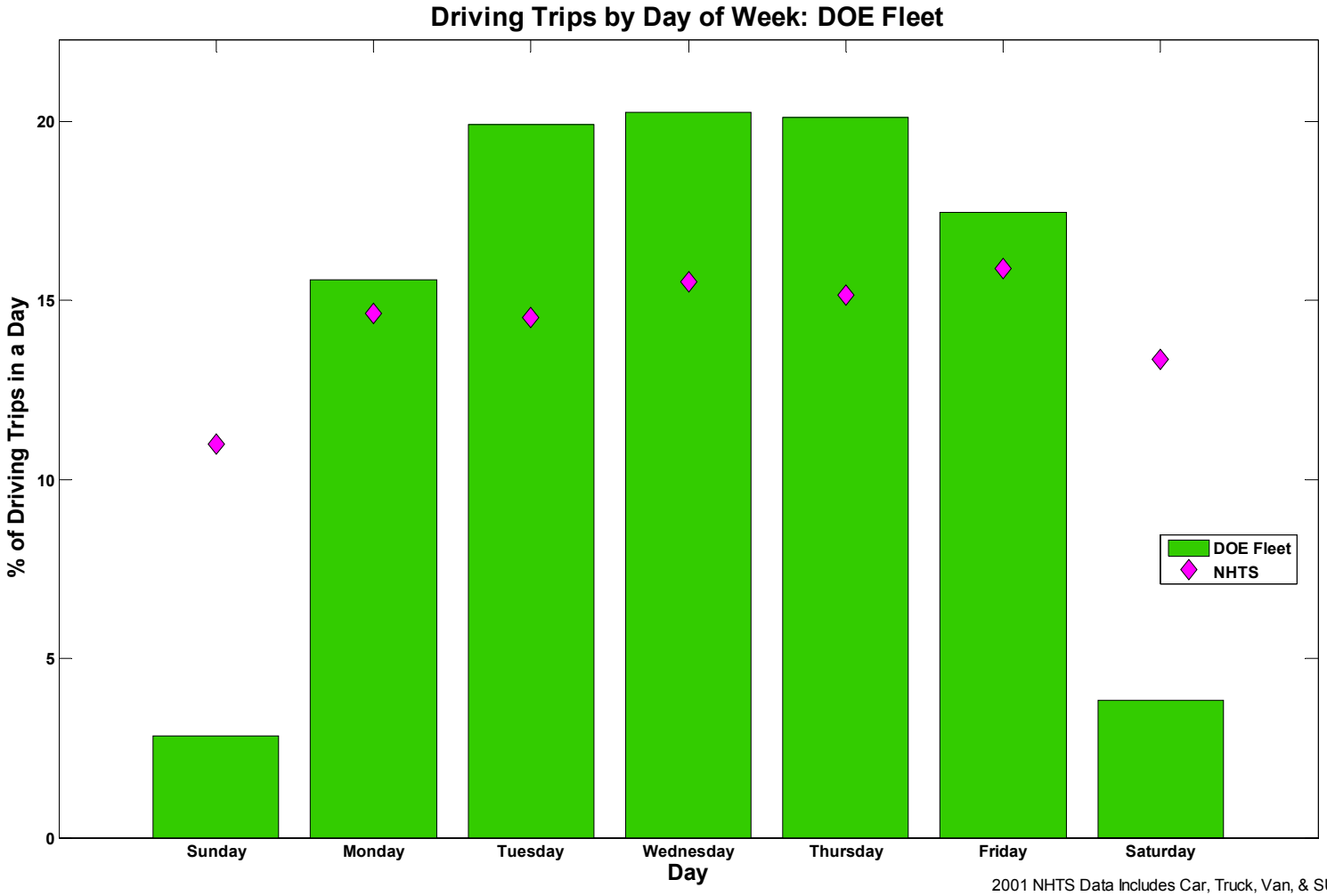
1. Driving trips between 6 AM & 6 PM
2. The outer arc is set at 12 % total Driving.
3. Some events not recorded/detected due to data noise or incompleteness.

2001 NHTS Data Includes Car, Truck, Van, & SUV day trips

ASCII.csv Source: http://nhts.ornl.gov/download.shtml#2001

Created: Feb-27-08 10:51 AM

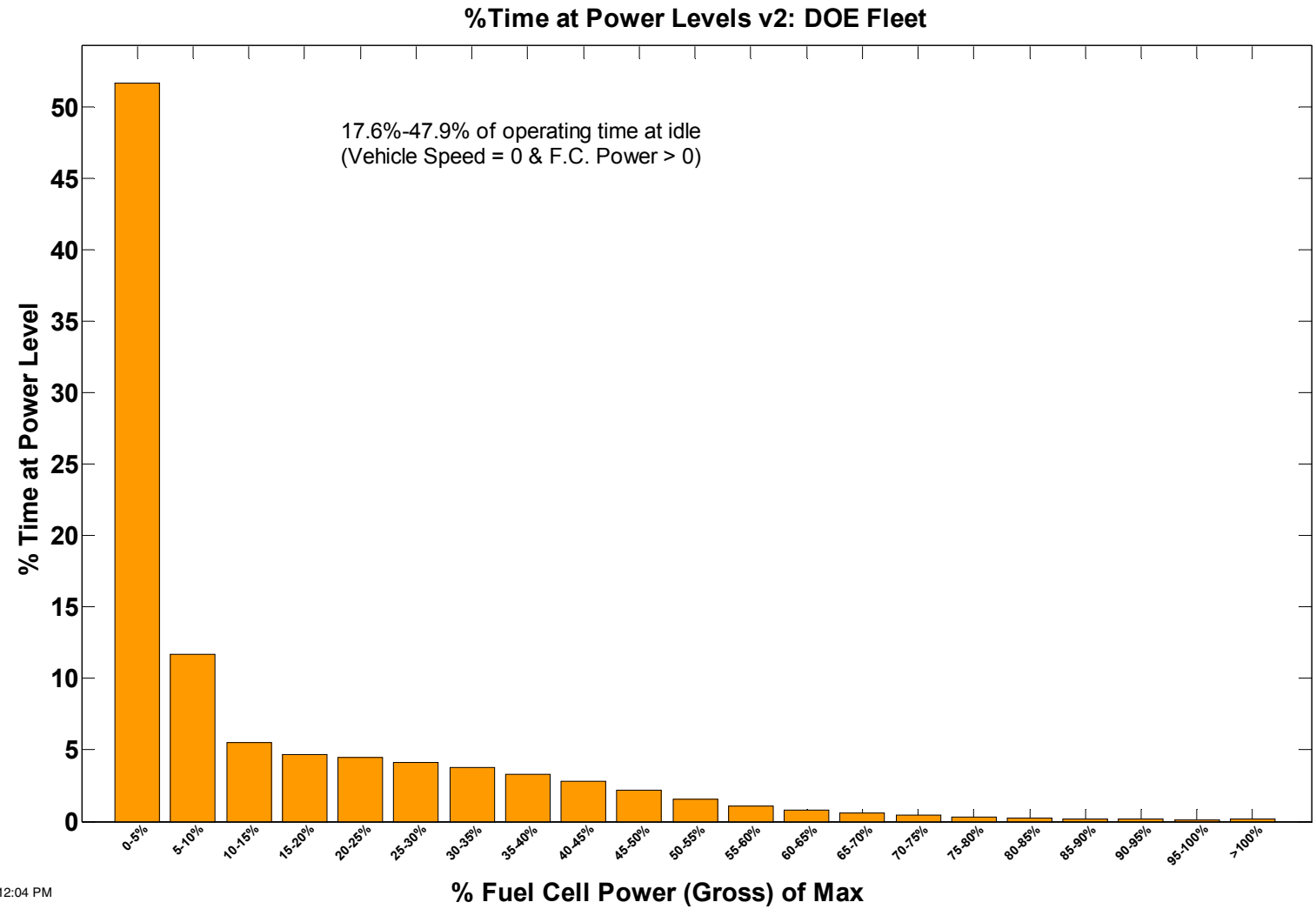
CDP#45: Driving by Day of Week



2001 NHTS Data Includes Car, Truck, Van, & SUV day trips
ASCII.csv Source: http://nhts.ornl.gov/download.shtml#2001

Created: Feb-27-08 10:51 AM

CDP#46: Fuel Cell System Operating Power



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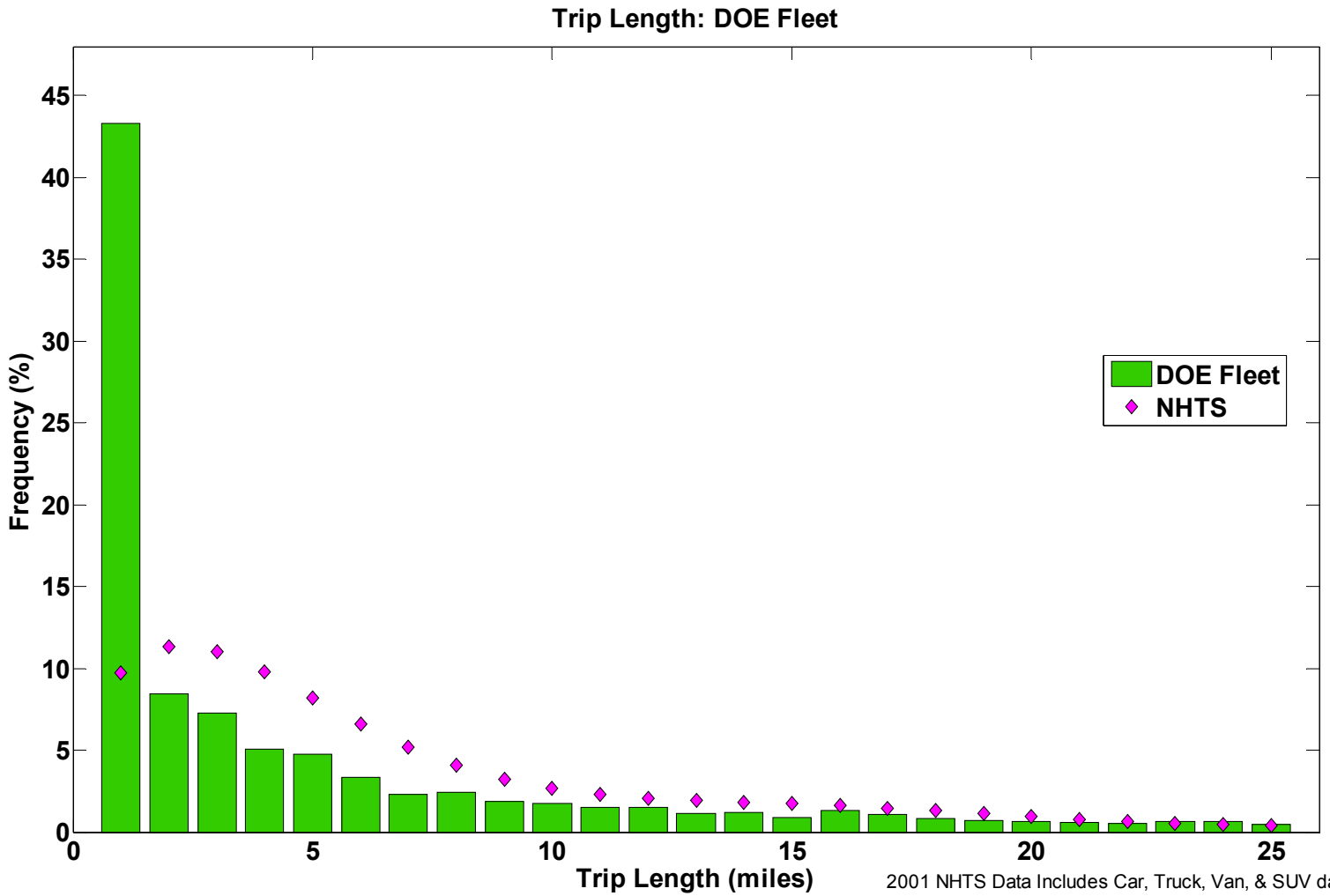
CDP#47: Trip Length



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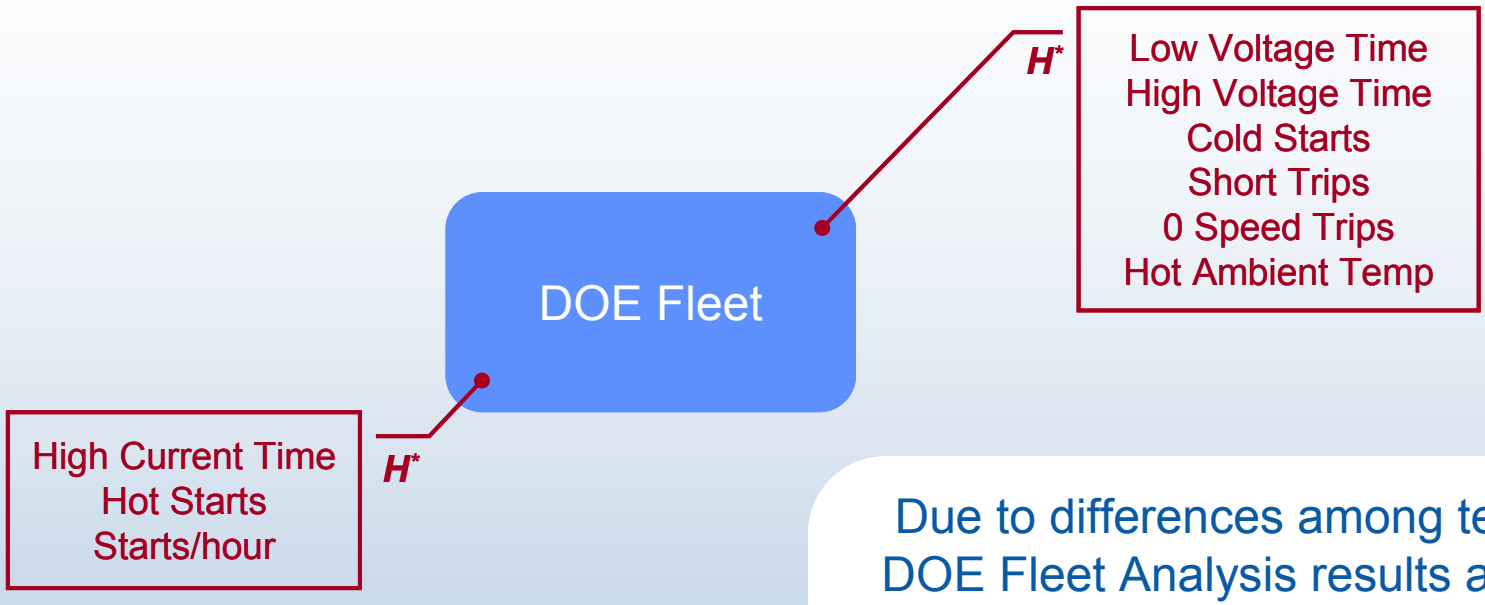
2001 NHTS Data Includes Car, Truck, Van, & SUV day trips
ASCII.csv Source: http://nhts.ornl.gov/download.shtml#2001

CDP#48: Primary Factors Affecting Learning Demo Fleet Fuel Cell Degradation



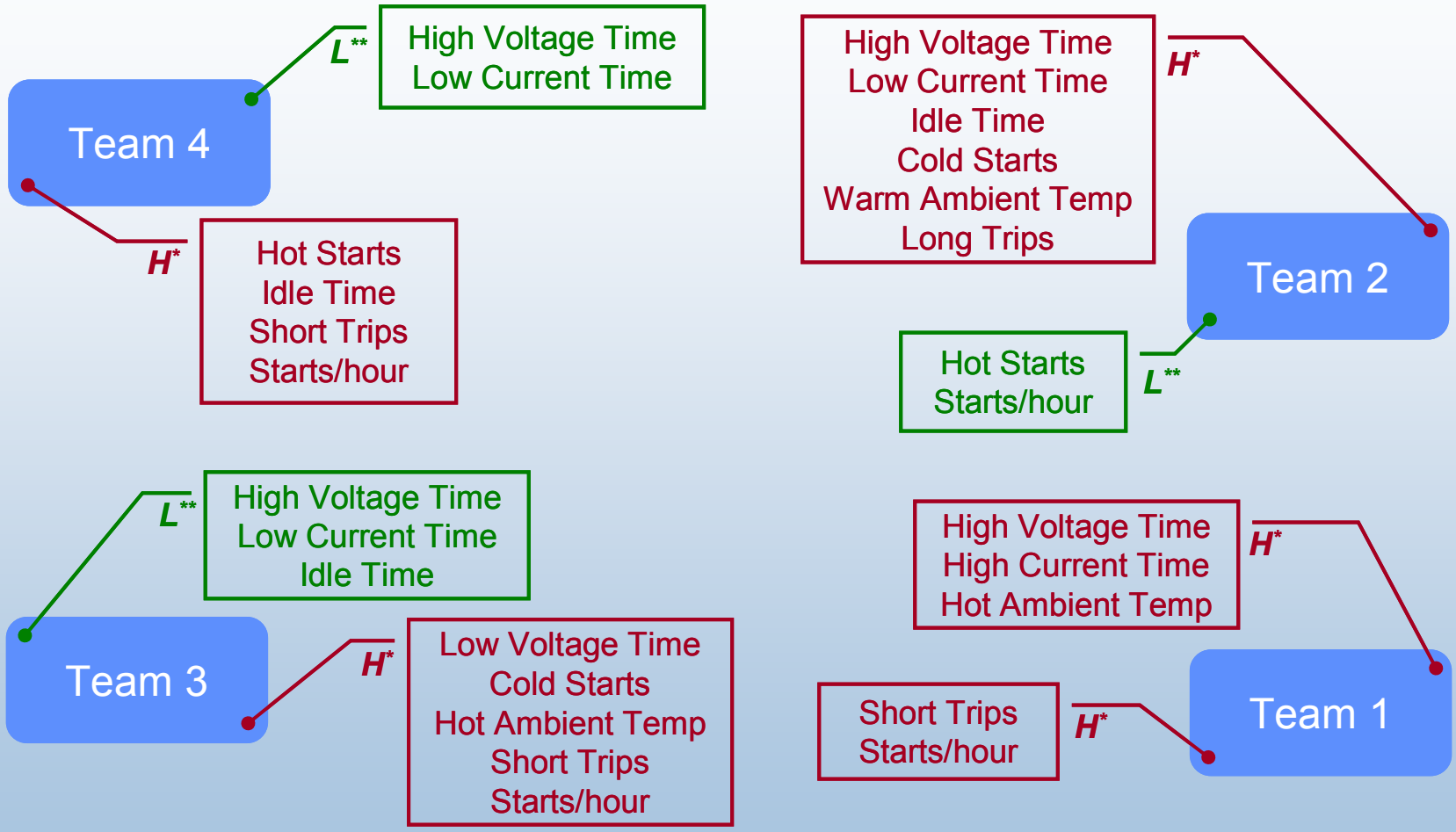
Due to differences among teams, the DOE Fleet Analysis results are spread out and concrete conclusions are difficult to draw.

Individual team analyses (CDP#49) focused on patterns within a fleet.

1) On-going fuel cell degradation study using Partial Least Squares (PLS) regression model for combined Learning Demonstration Fleet.
2) DOE Fleet model has a low percentage of explained decay rate variance.

H*: Factor group associated with high decay rate fuel cell stacks
L**: Factor group associated with low decay rate fuel cell stacks

CDP#49: Primary Factors Affecting Learning Demo Team Fuel Cell Degradation



1) On-going fuel cell degradation study using Partial Least Squares (PLS) regression model for each team.
2) Teams' PLS models have a high percentage of explained decay rate variance, but the models are not robust and results are scattered.

H*: Factor group associated with high decay rate fuel cell stacks
L**: Factor group associated with low decay rate fuel cell stacks

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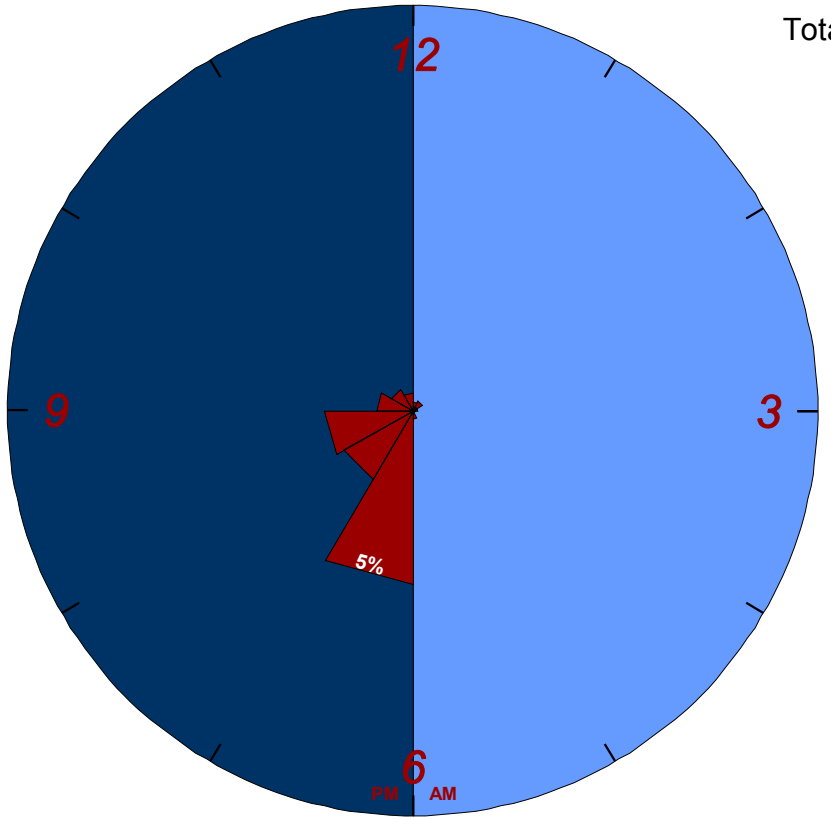
CDP#50: Refueling by Time of Night

Refueling by Time of Night: DOE Fleet

% of fills b/t 6 PM & 6 AM: 13.5%

Total Fill[3] Events = 11356



1. Fills between 6 PM & 6 AM
2. The outer arc is set at 12 % total Fill.
3. Some events not recorded/detected due to data noise or incompleteness.

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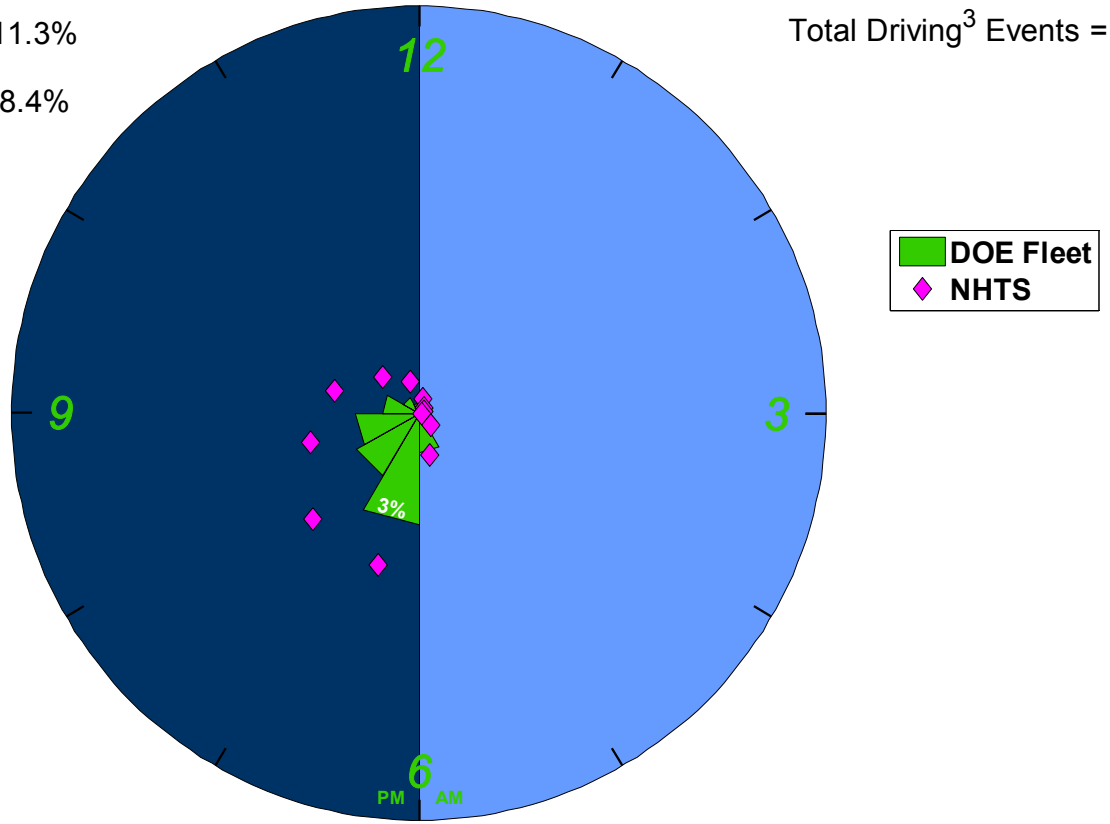
CDP#51: Driving Start Time – Night

Driving Start Time - Night: DOE Fleet

% of driving trips b/t 6 PM & 6 AM: 11.3%

% of NHTS trips b/t 6 PM & 6 AM: 18.4%

Total Driving[3] Events = 139968



1. Driving trips between 6 PM & 6 AM
2. The outer arc is set at 12 % total Driving.
3. Some events not recorded/detected due to data noise or incompleteness.

2001 NHTS Data Includes Car, Truck, Van, & SUV day trips

ASCII.csv Source: http://nhts.ornl.gov/download.shtml#2001

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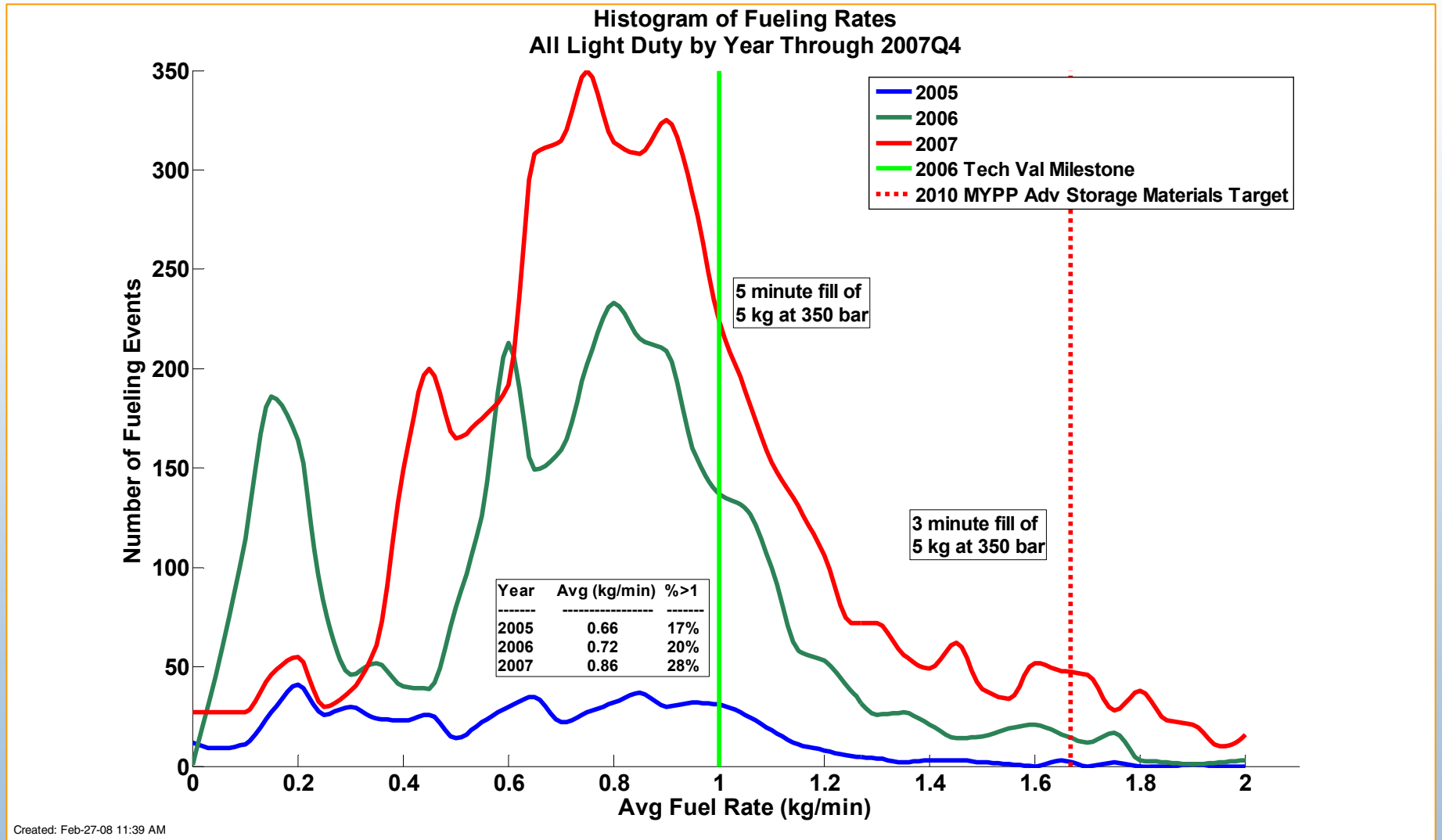
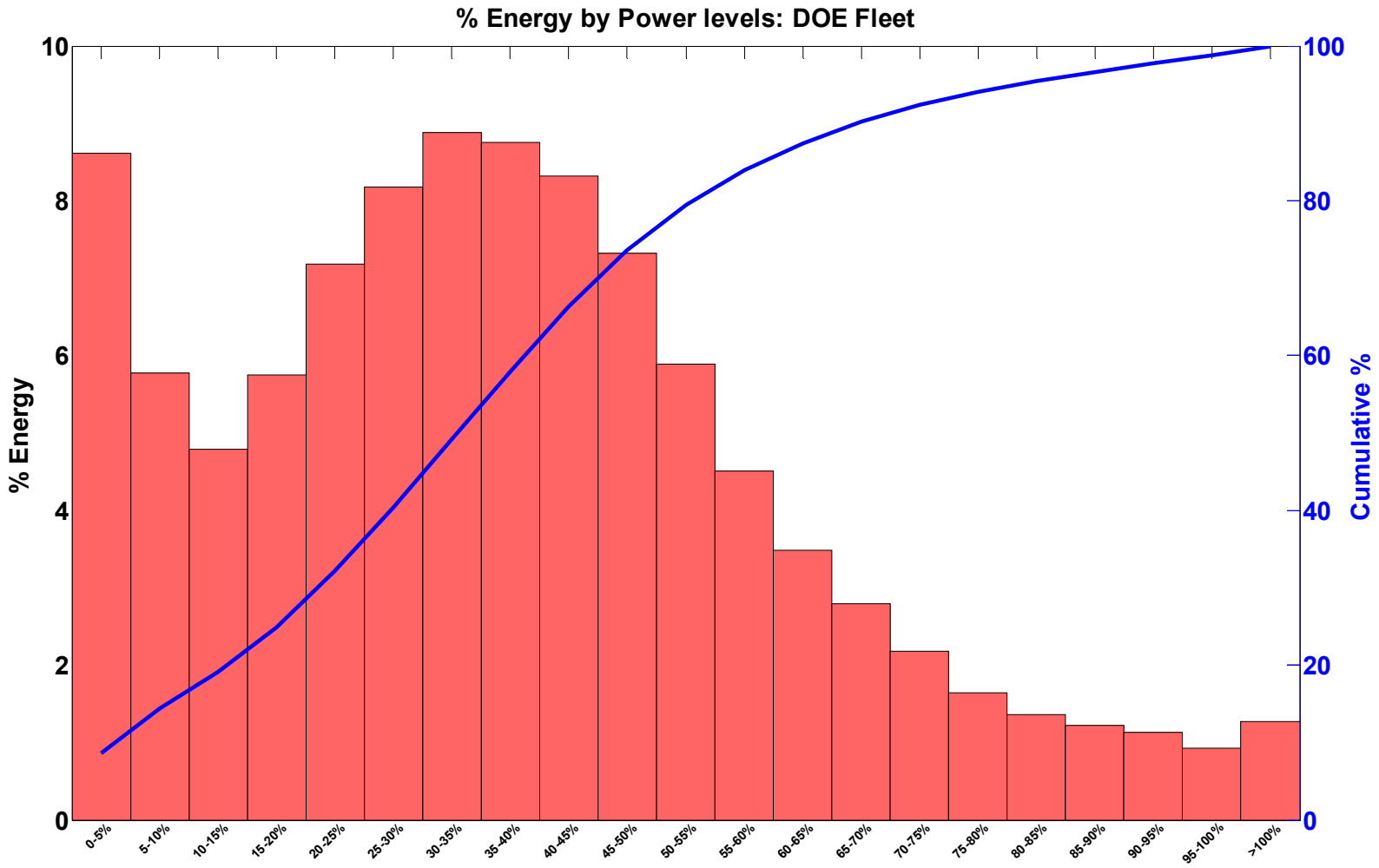
CDP#52: Refueling Data by Year



CDP#53: Fuel Cell System Energy within Power Levels



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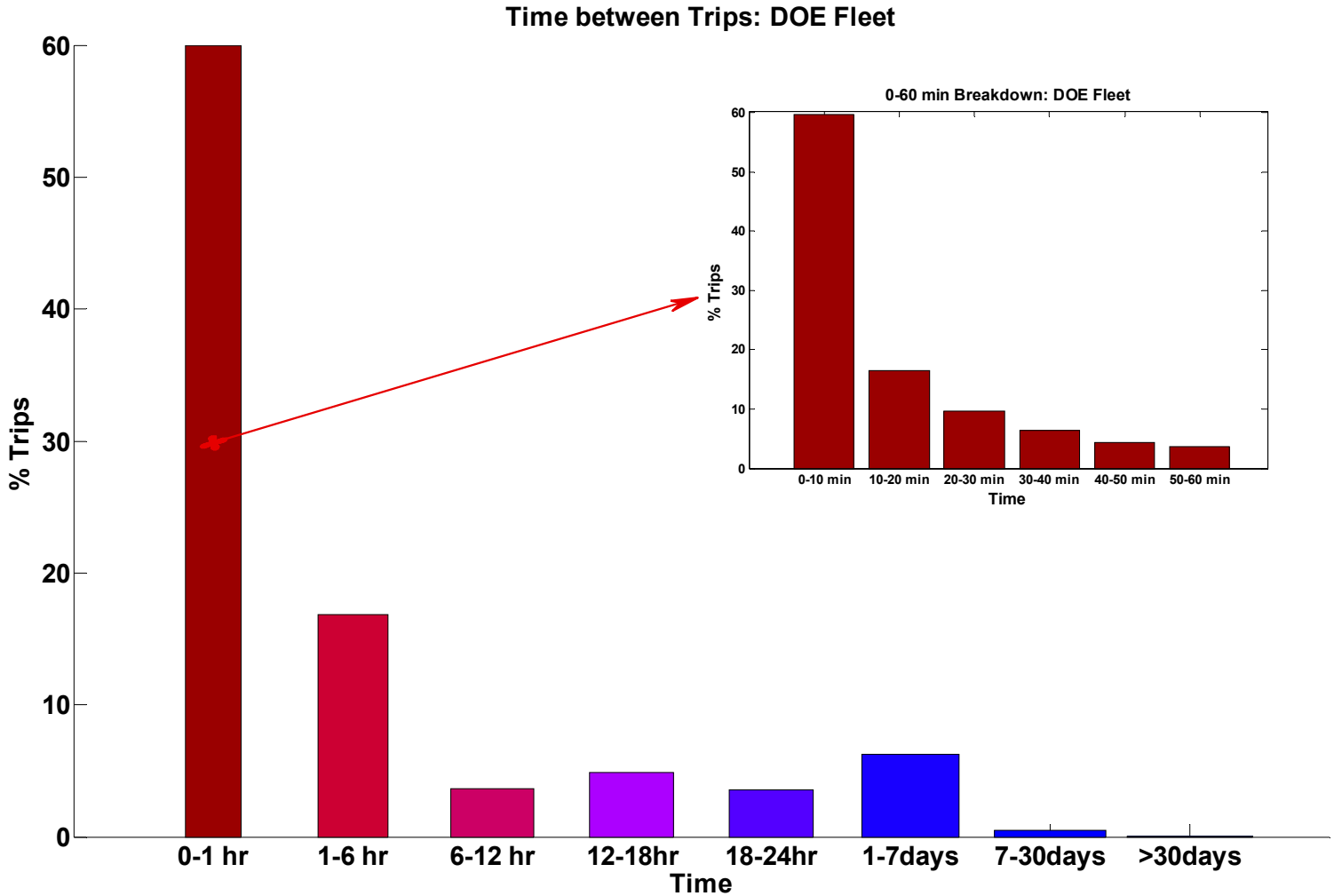
CDP#54: Time Between Trips



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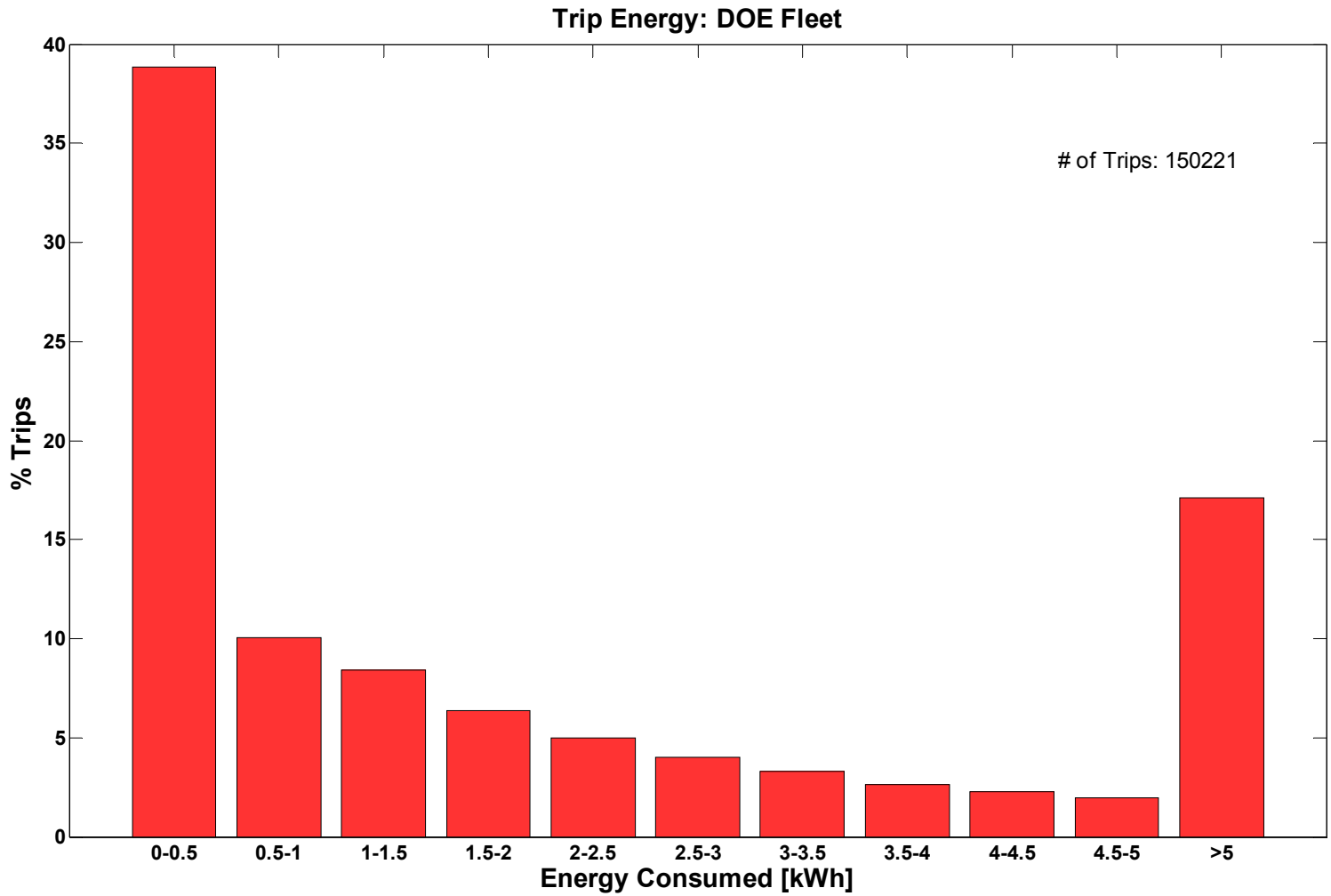
CDP#55: Fuel Cell System Energy



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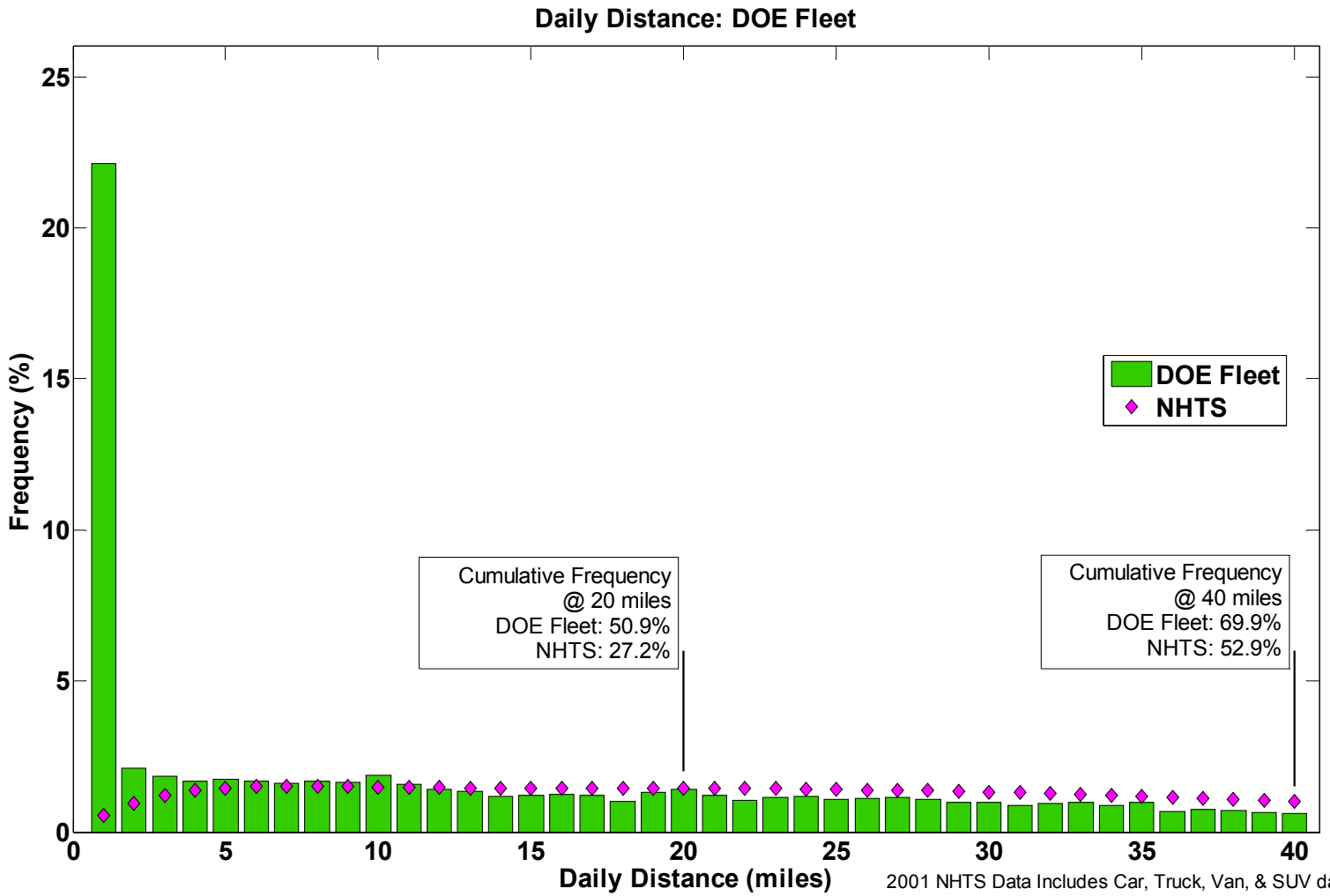
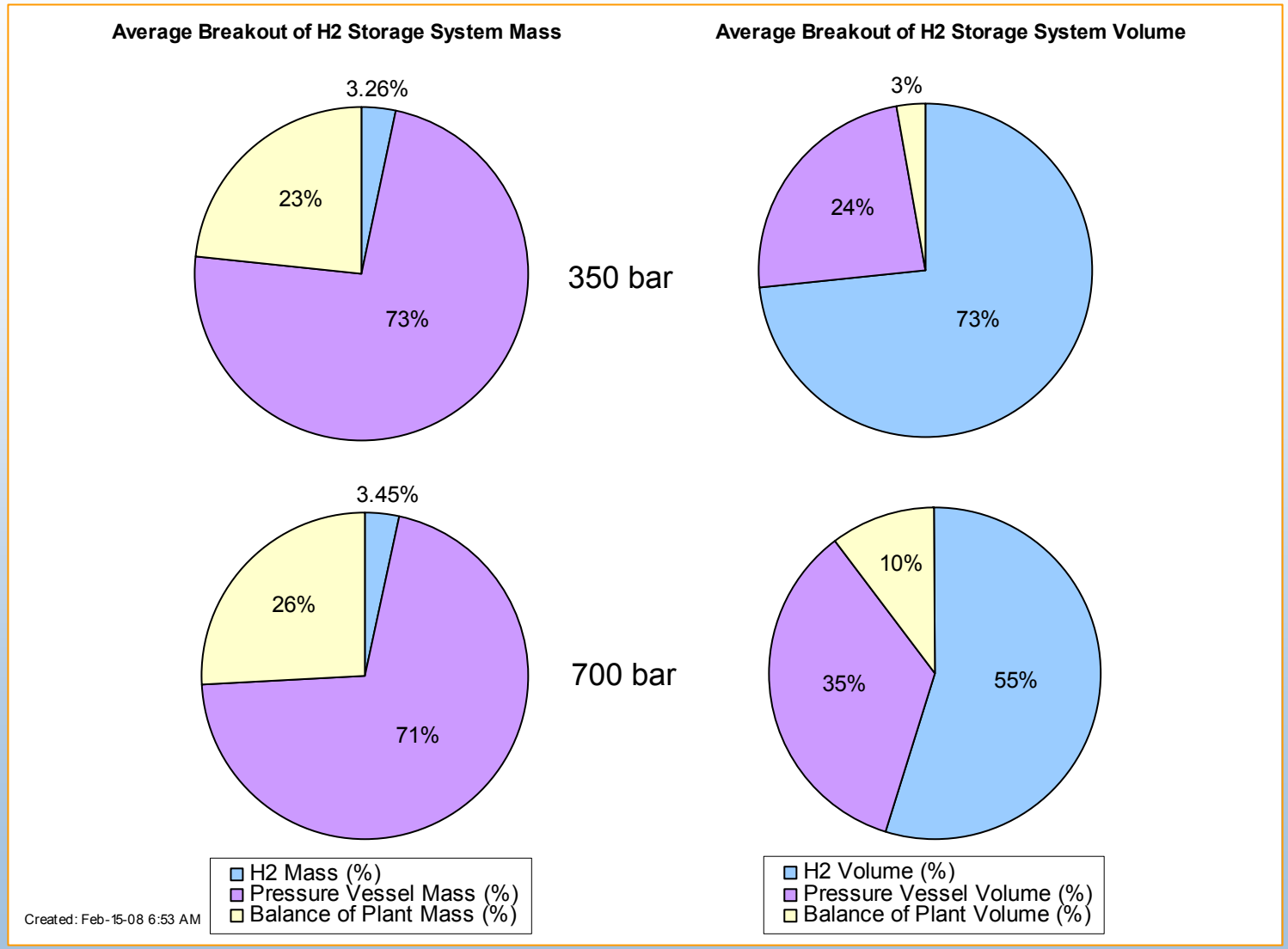
CDP#56: Daily Driving Distance



CDP#57: H2 Storage System Mass and Volume Breakdown



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