



Technical Report
NREL/TP-5600-54020
January 2012

National FCEV Learning Demonstration

Winter 2011

Composite Data Products

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

NOTICE

This report was prepared as an account of work sponsored by an agency of the United States government. Neither the United States government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States government or any agency thereof.

Available electronically at <http://www.osti.gov/bridge>
Available for a processing fee to U.S. Department of Energy
and its contractors, in paper, from:
U.S. Department of Energy
Office of Scientific and Technical Information
P.O. Box 62
Oak Ridge, TN 37831-0062
phone: 865.576.8401
fax: 865.576.5728
email: <mailto:reports@adonis.osti.gov>

Available for sale to the public, in paper, from:
U.S. Department of Commerce
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
phone: 800.553.6847
fax: 703.605.6900
email: orders@ntis.fedworld.gov
online ordering: <http://www.ntis.gov/help/ordermethods.aspx>

Cover Photos: (left to right) PIX 16416, PIX 17423, PIX 16560, PIX 17613, PIX 17436, PIX 17721



Printed on paper containing at least 50% wastepaper, including 10% post consumer waste.

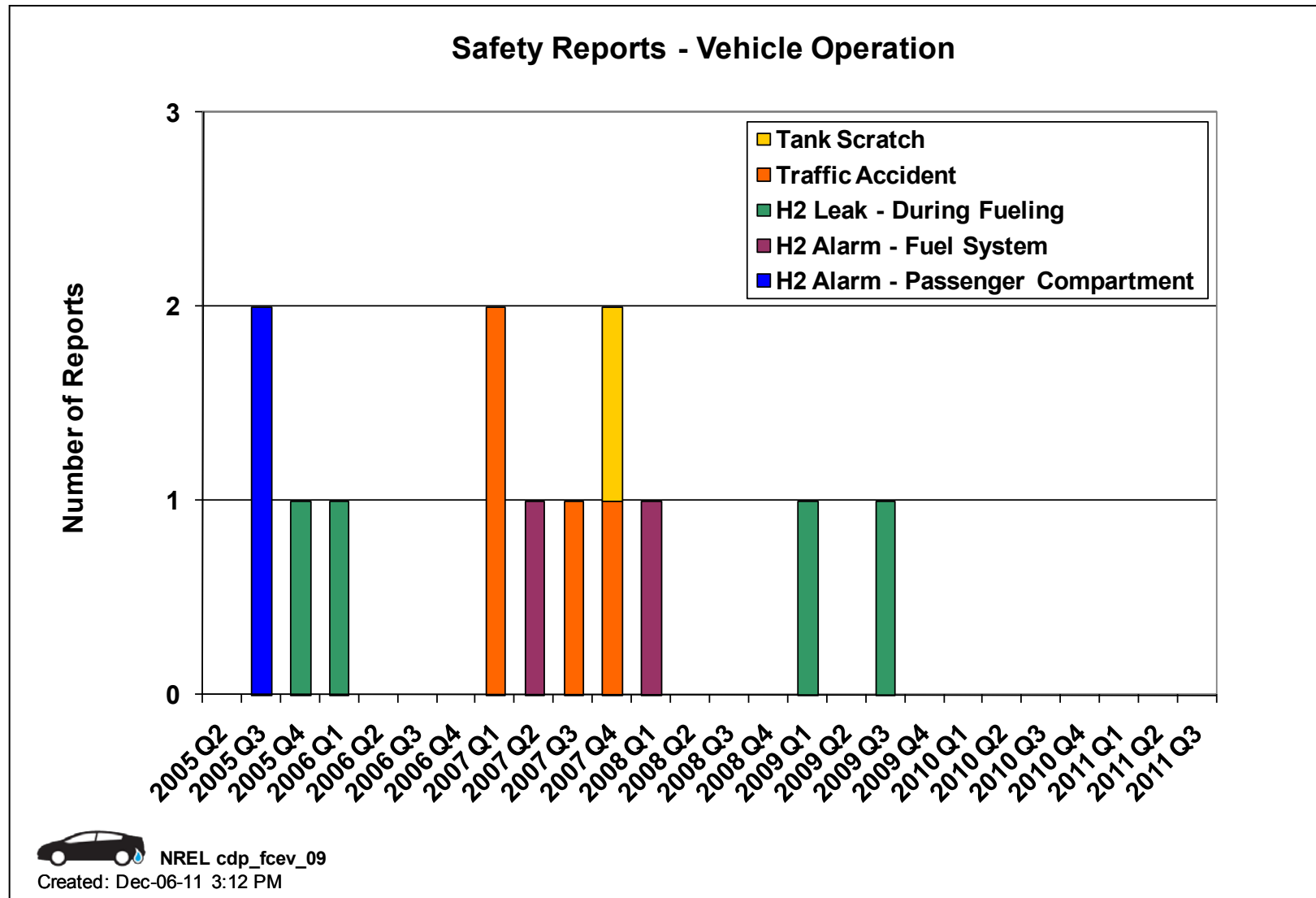
Winter 2011 Composite Data Products: National FCEV Learning Demonstration



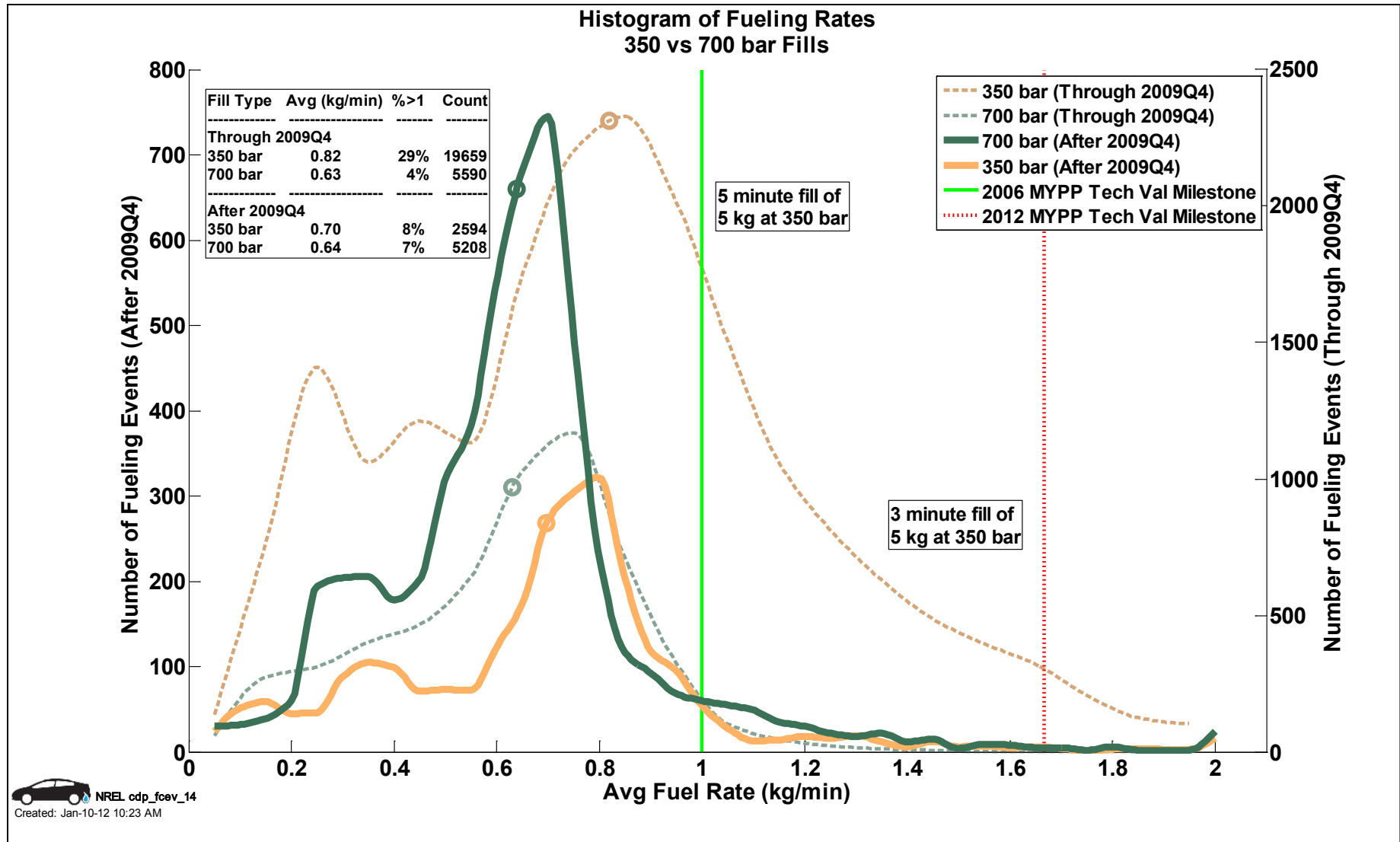
January 18, 2012

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

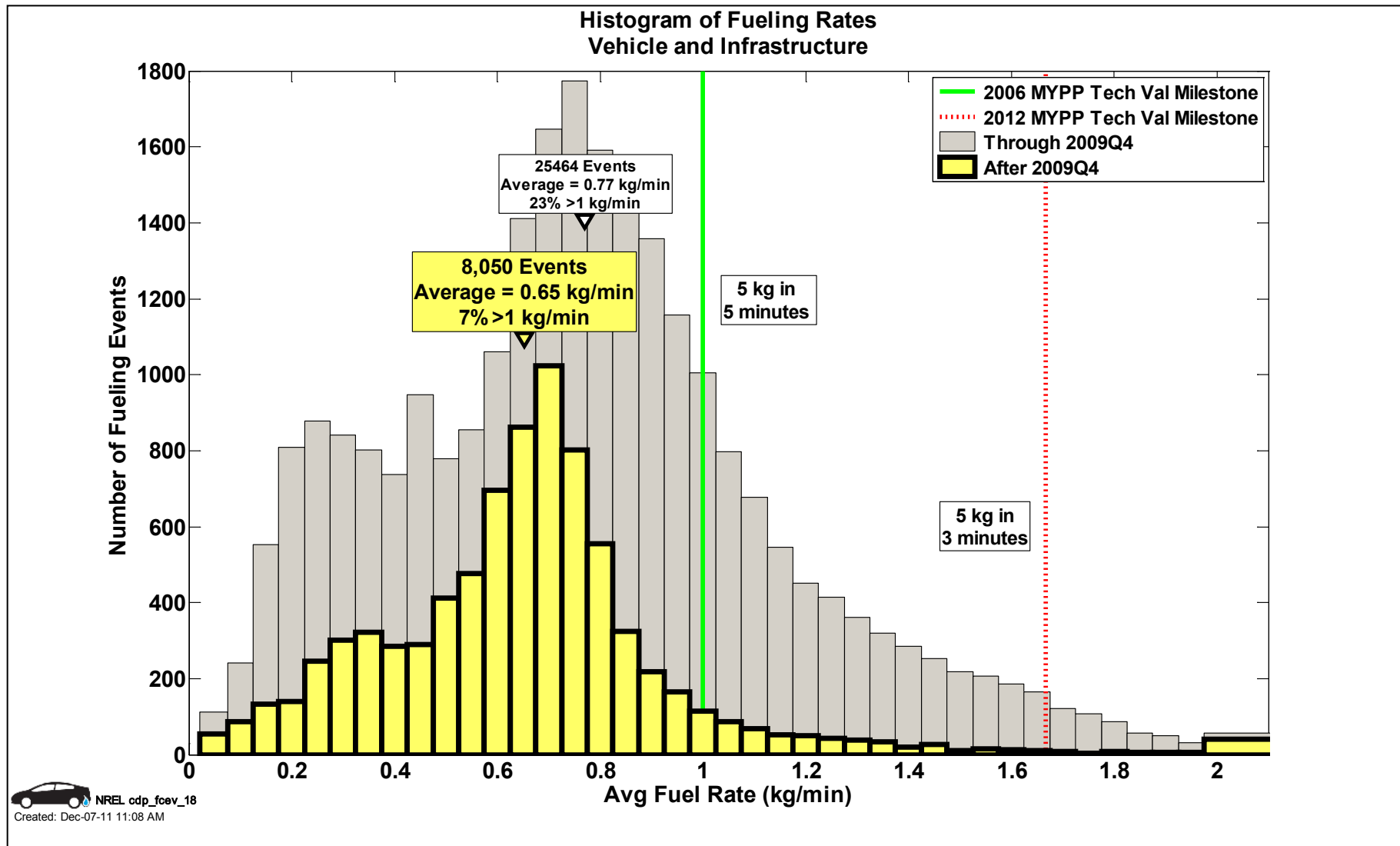
CDP#9: Safety Reports – Vehicles



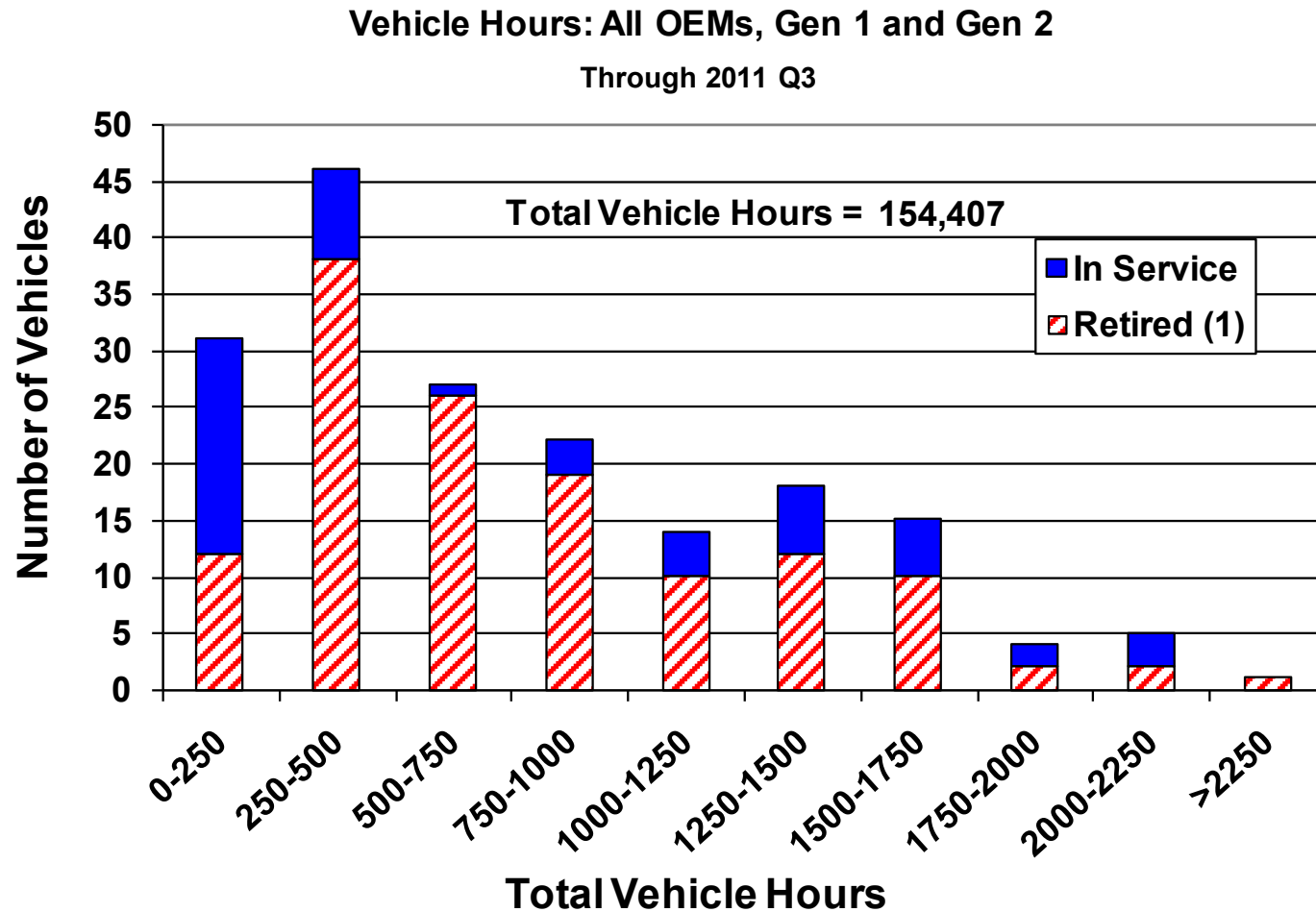
CDP#14: Fueling Rates by Fill Pressure



CDP#18: Refueling Rates



CDP#22: Vehicle Operating Hours

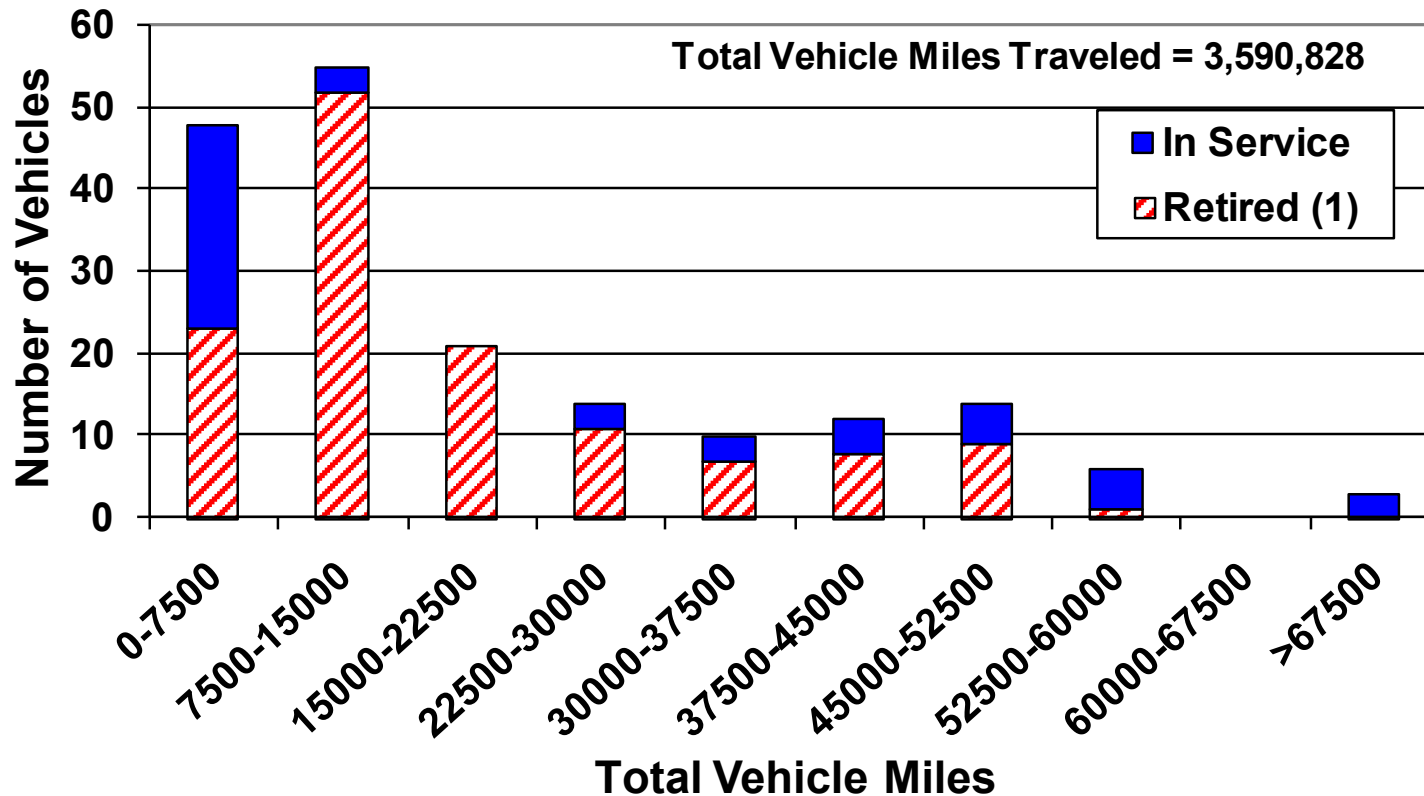


NREL cdp_fcav_22
Created: Dec-13-11 04:15 PM

(1) Retired vehicles have left DOE fleet and are no longer providing data to NREL
Some project teams concluded in Fall/Winter 2009

CDP#23: Vehicles vs. Miles Traveled

Vehicle Miles: All OEMs, Gen 1 and 2
Through 2011 Q3

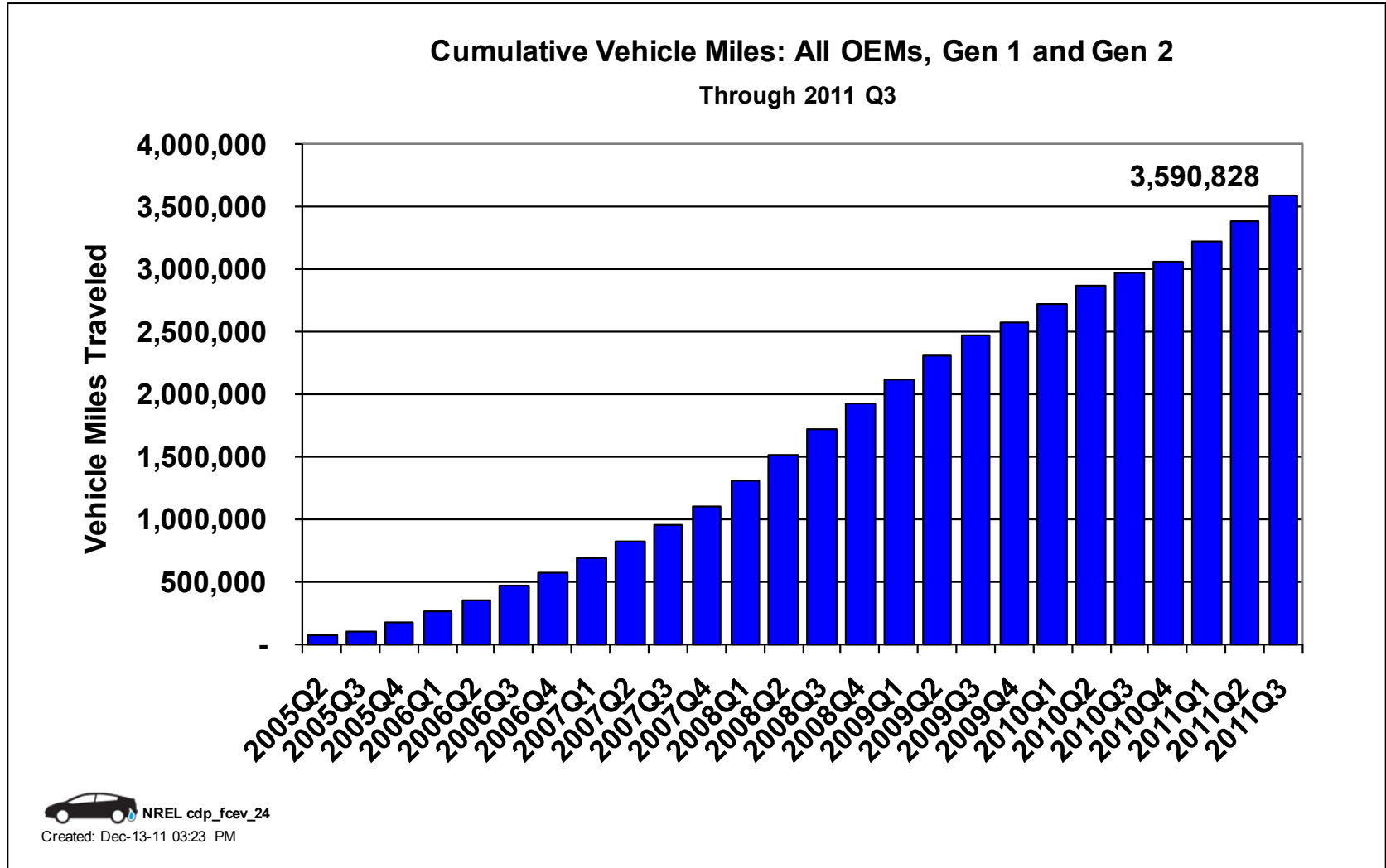


NREL cdp_fcev_23

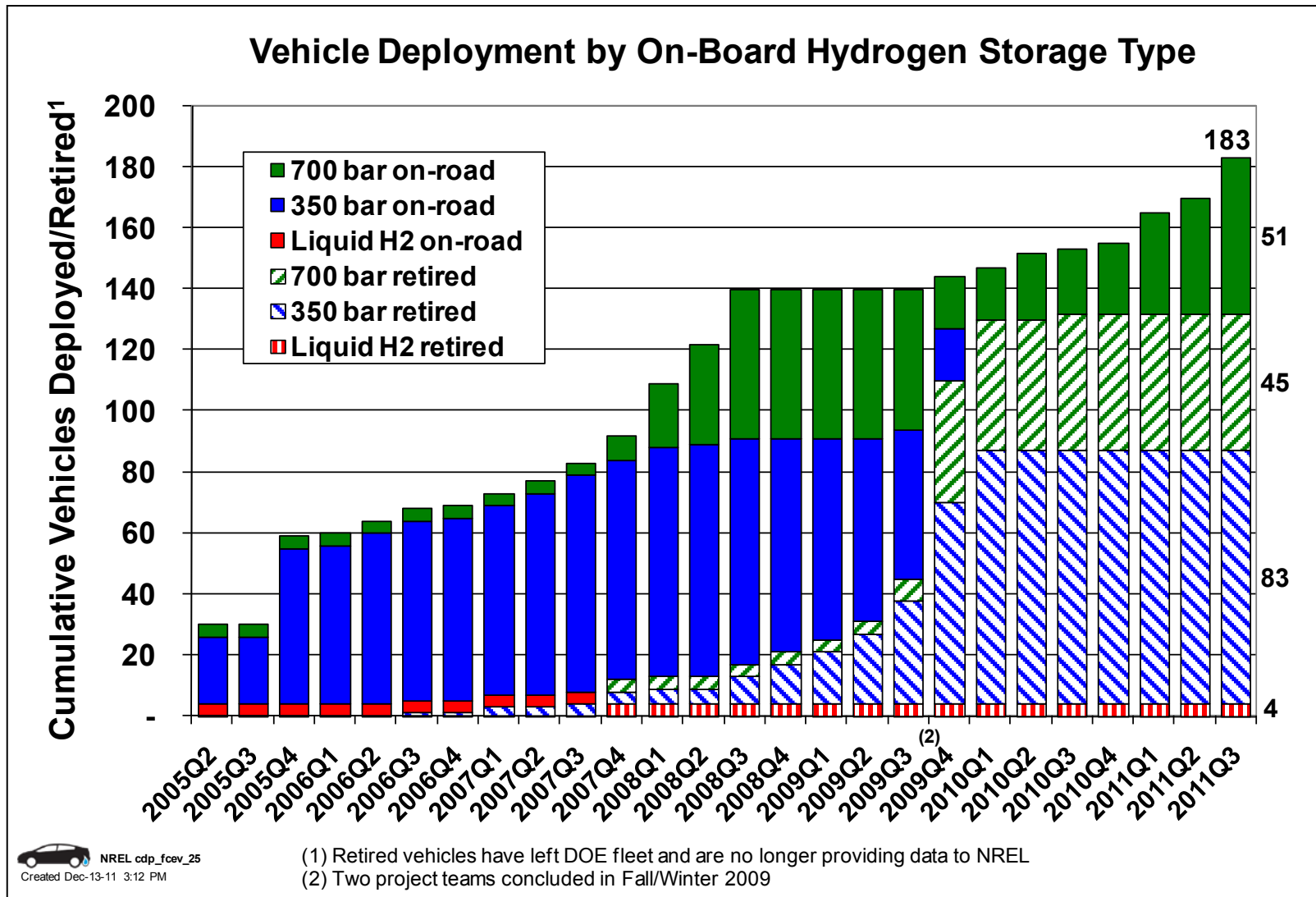
Created: Dec-13-11 03:23 PM

(1) Retired vehicles have left DOE fleet and are no longer providing data to NREL
Some project teams concluded in Fall/Winter 2009

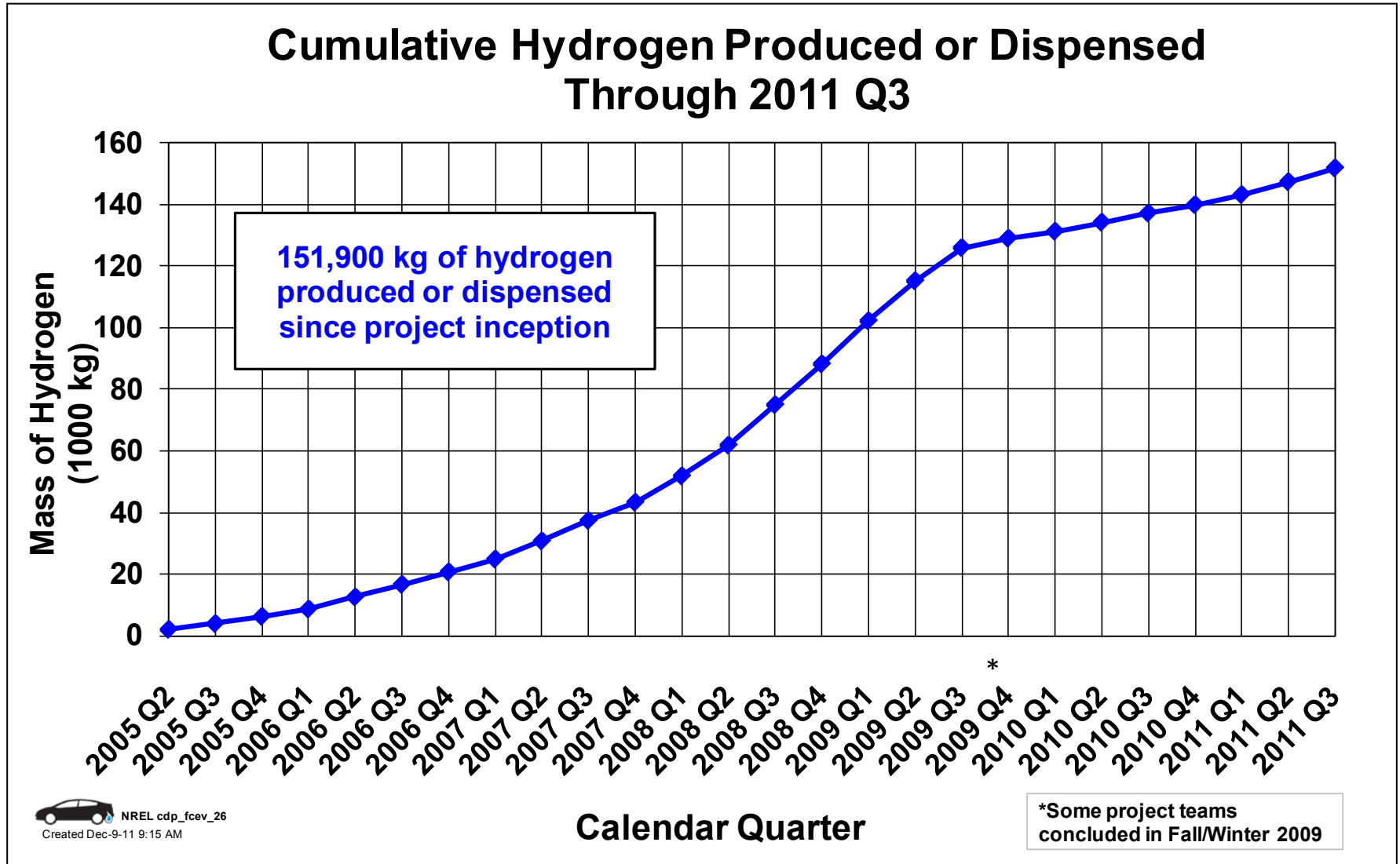
CDP#24: Cumulative Vehicle Miles Traveled



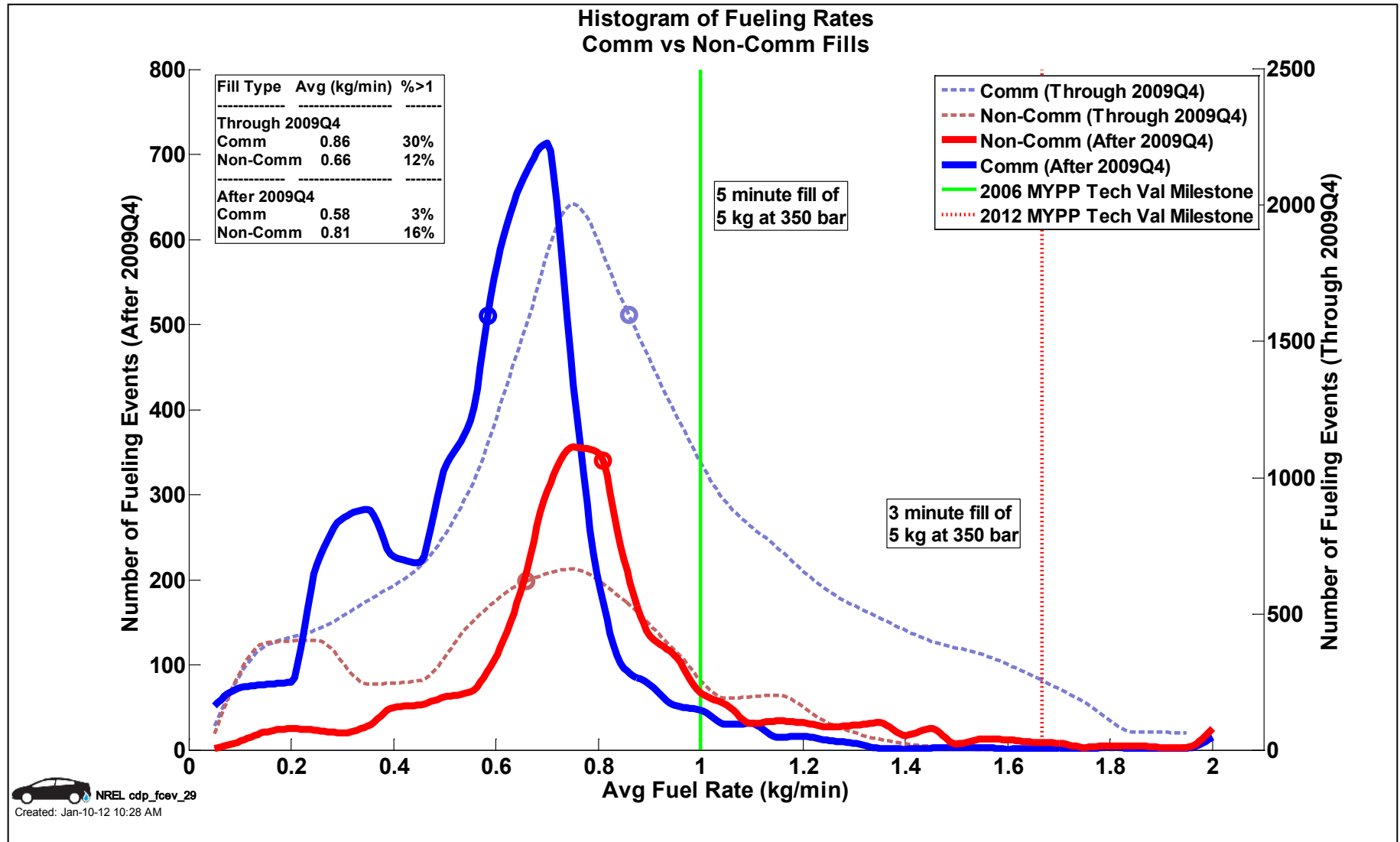
CDP#25: Vehicle H2 Storage Technologies



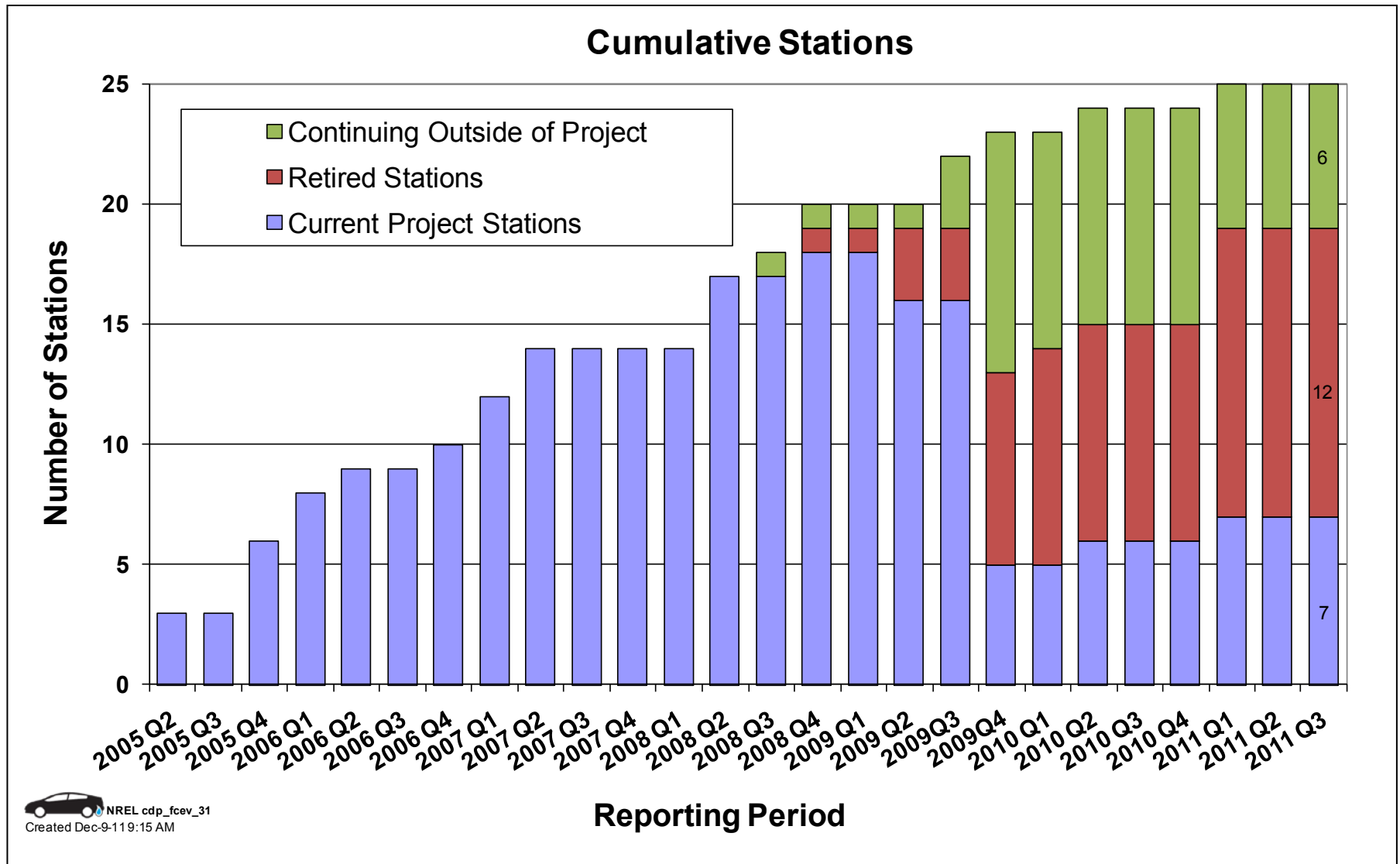
CDP#26: Cumulative H2 Produced or Dispensed



CDP#29: Fueling Rates by Communication Type

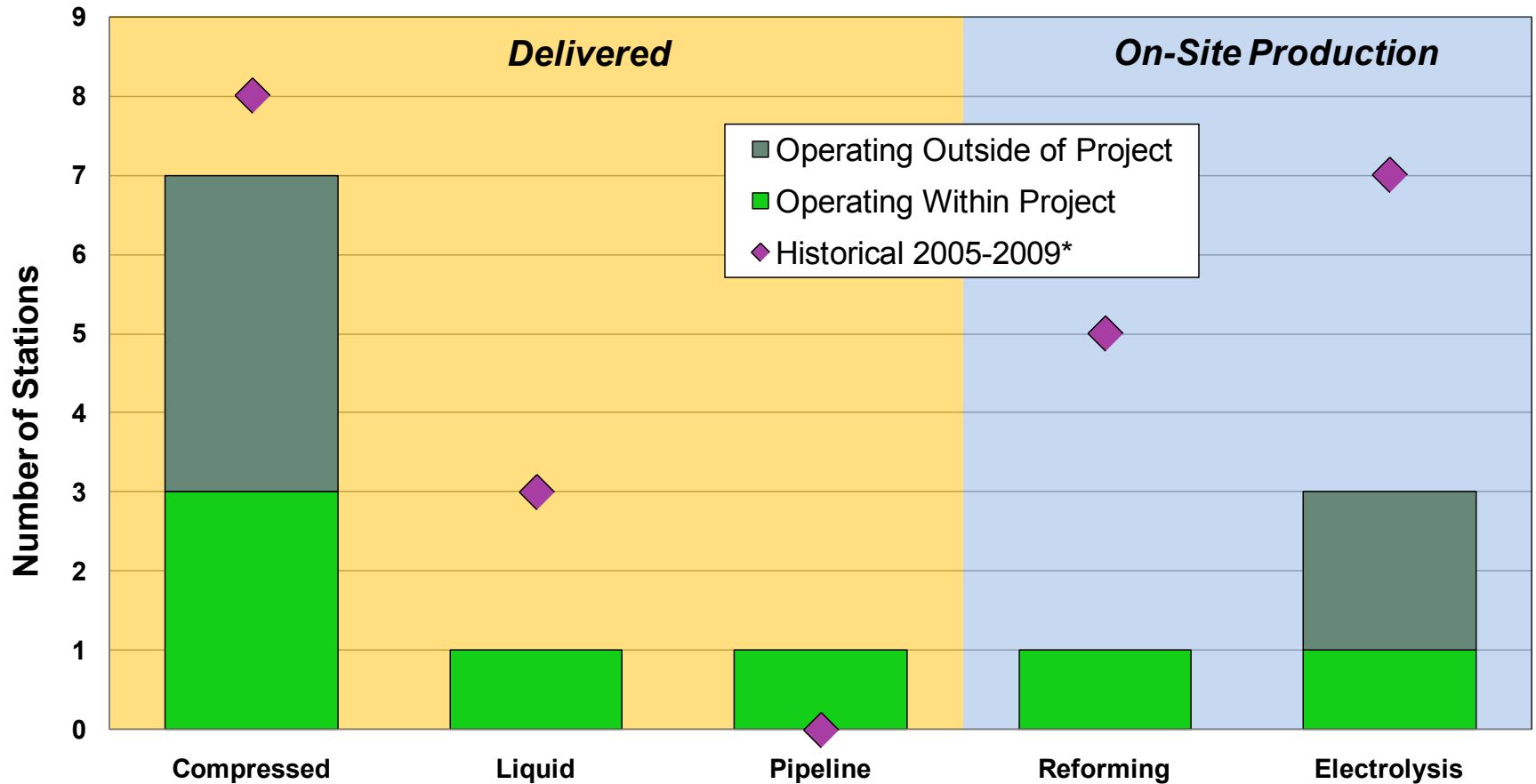


CDP#31: Number of Online Stations

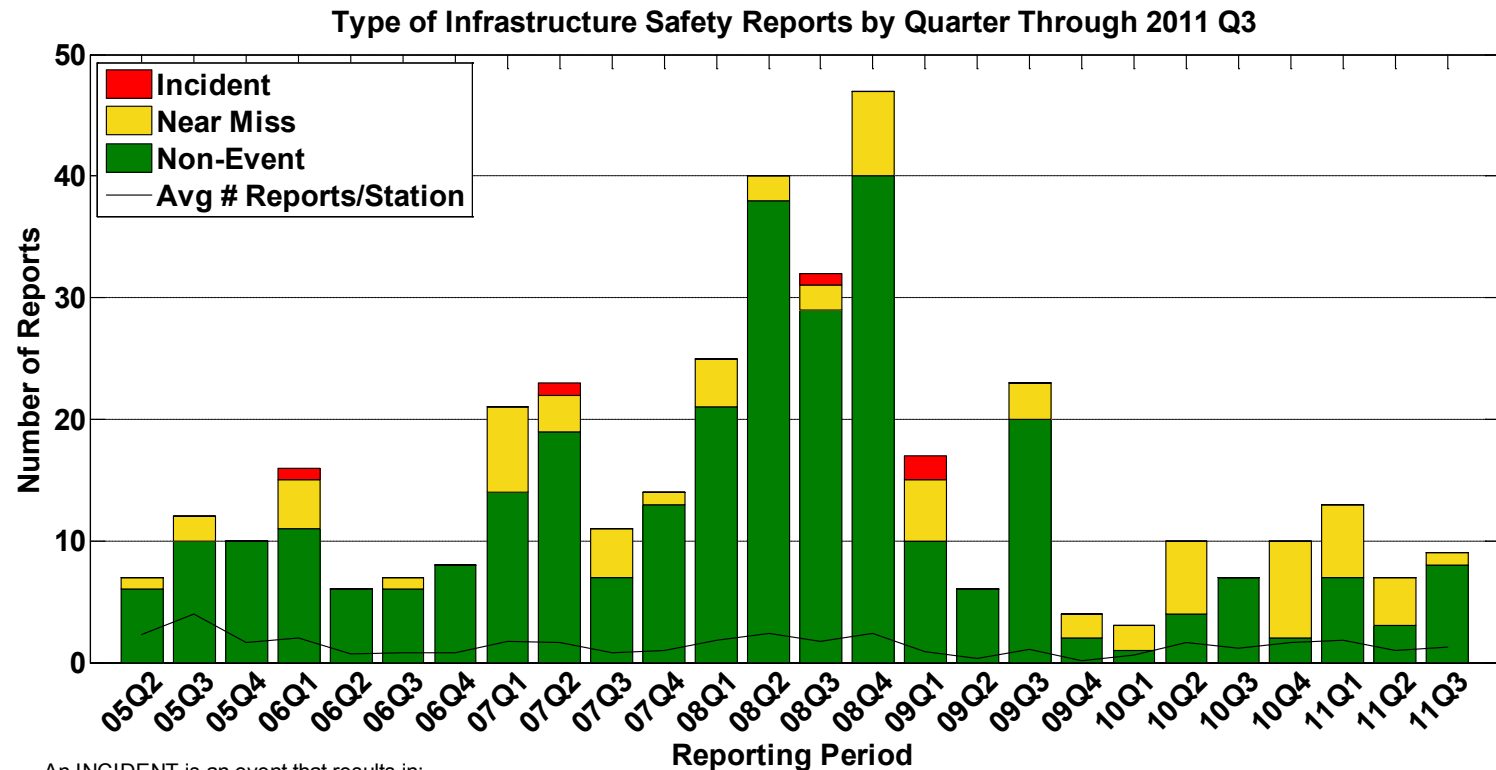


CDP#32: Infrastructure Hydrogen Production Methods

Learning Demonstration Hydrogen Stations by Type



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:

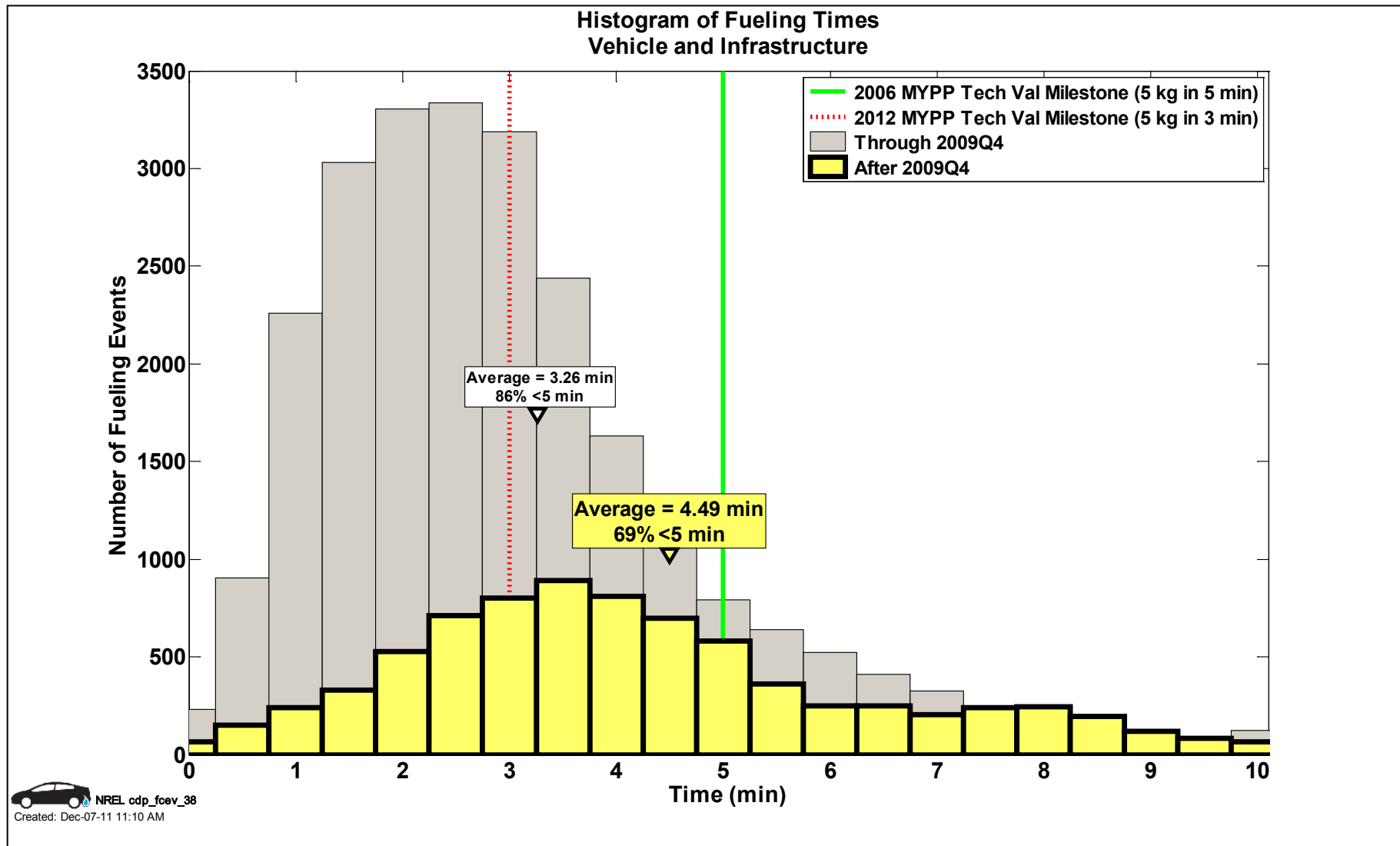
- an event that under slightly different circumstances could have become an incident
- unplanned H2 release insufficient to sustain a flame



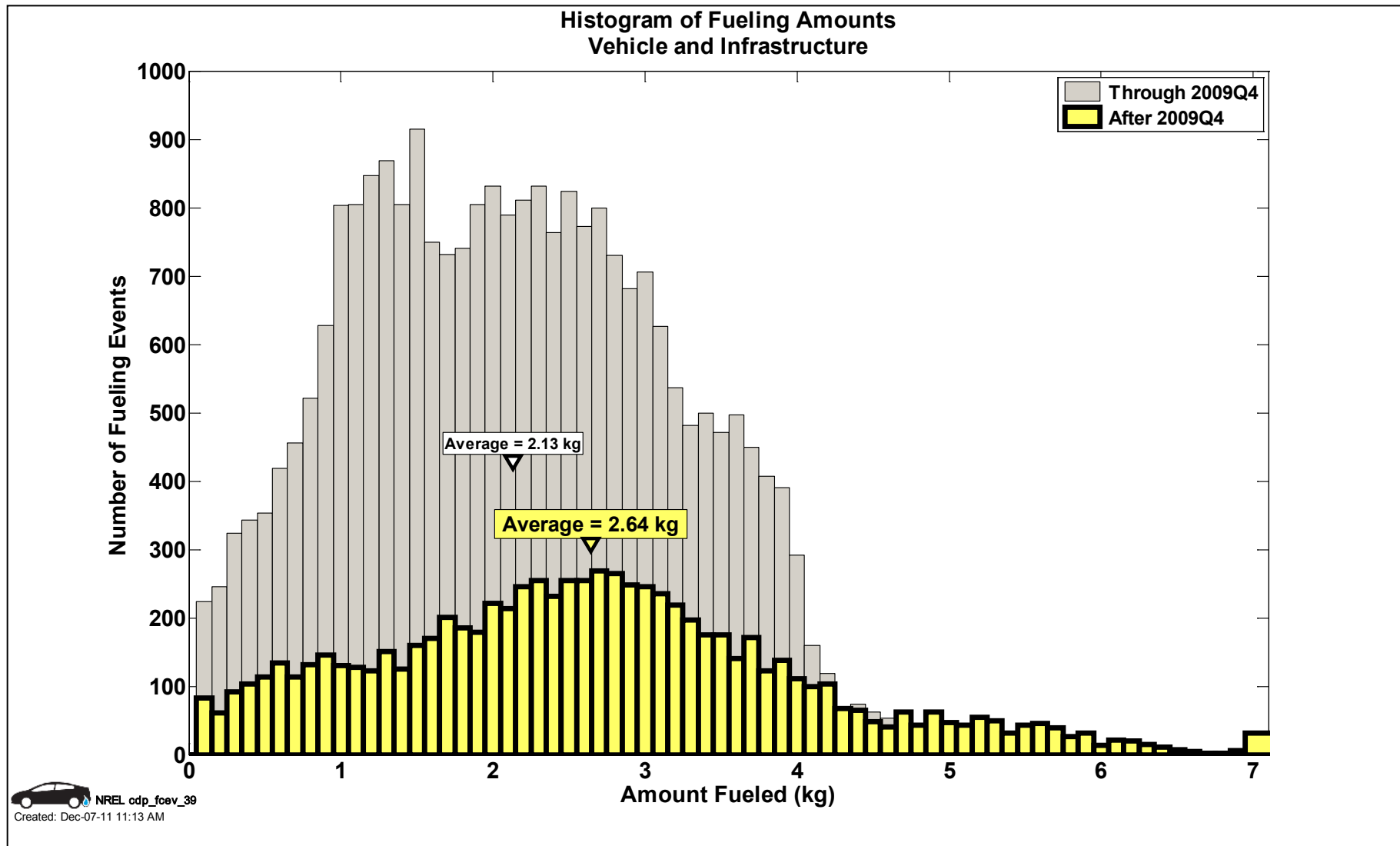
NREL cdp_fcev_36

Created: Dec-15-11 3:36 PM

CDP#38: Refueling Times



CDP#39: Refueling Amounts



CDP#40: H2 Tank Level at Refueling

Tank Levels: DOE Fleet

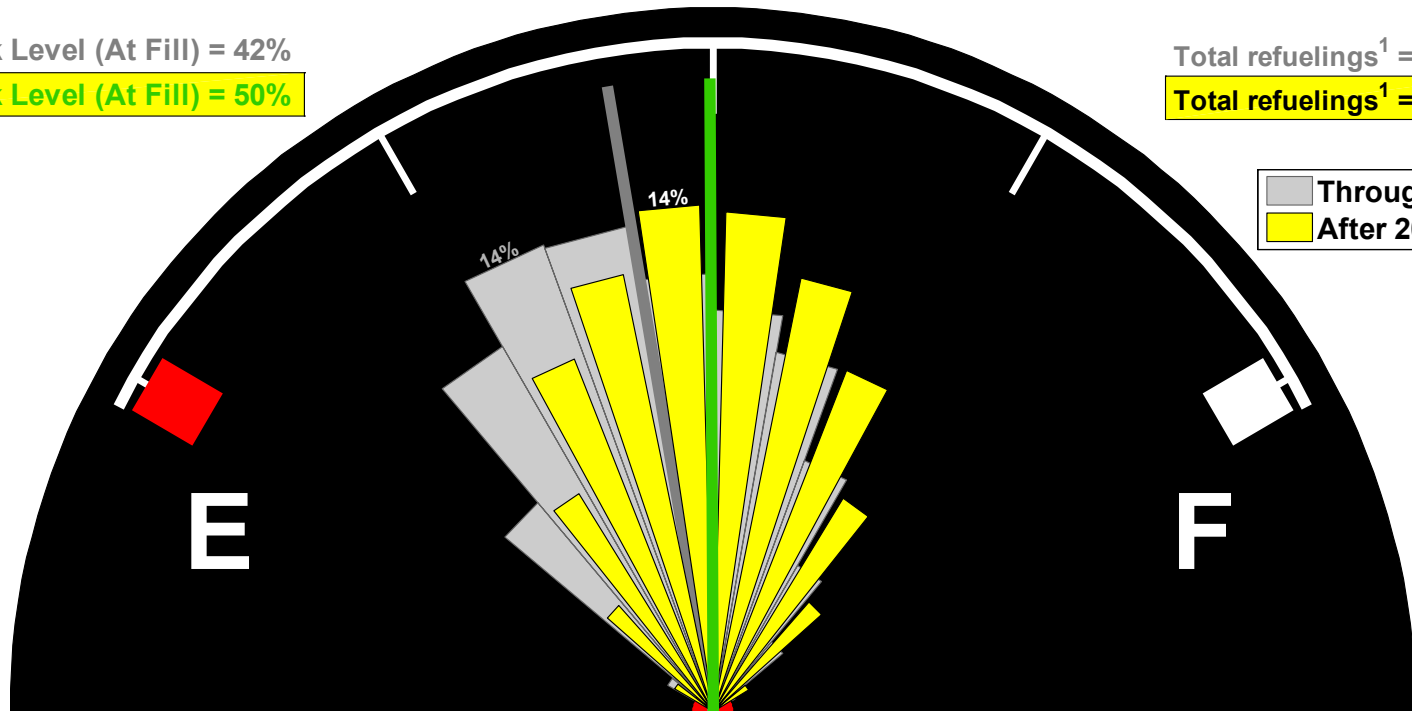
Median Tank Level (At Fill) = 42%

Median Tank Level (At Fill) = 50%

Total refuelings¹ = 27113

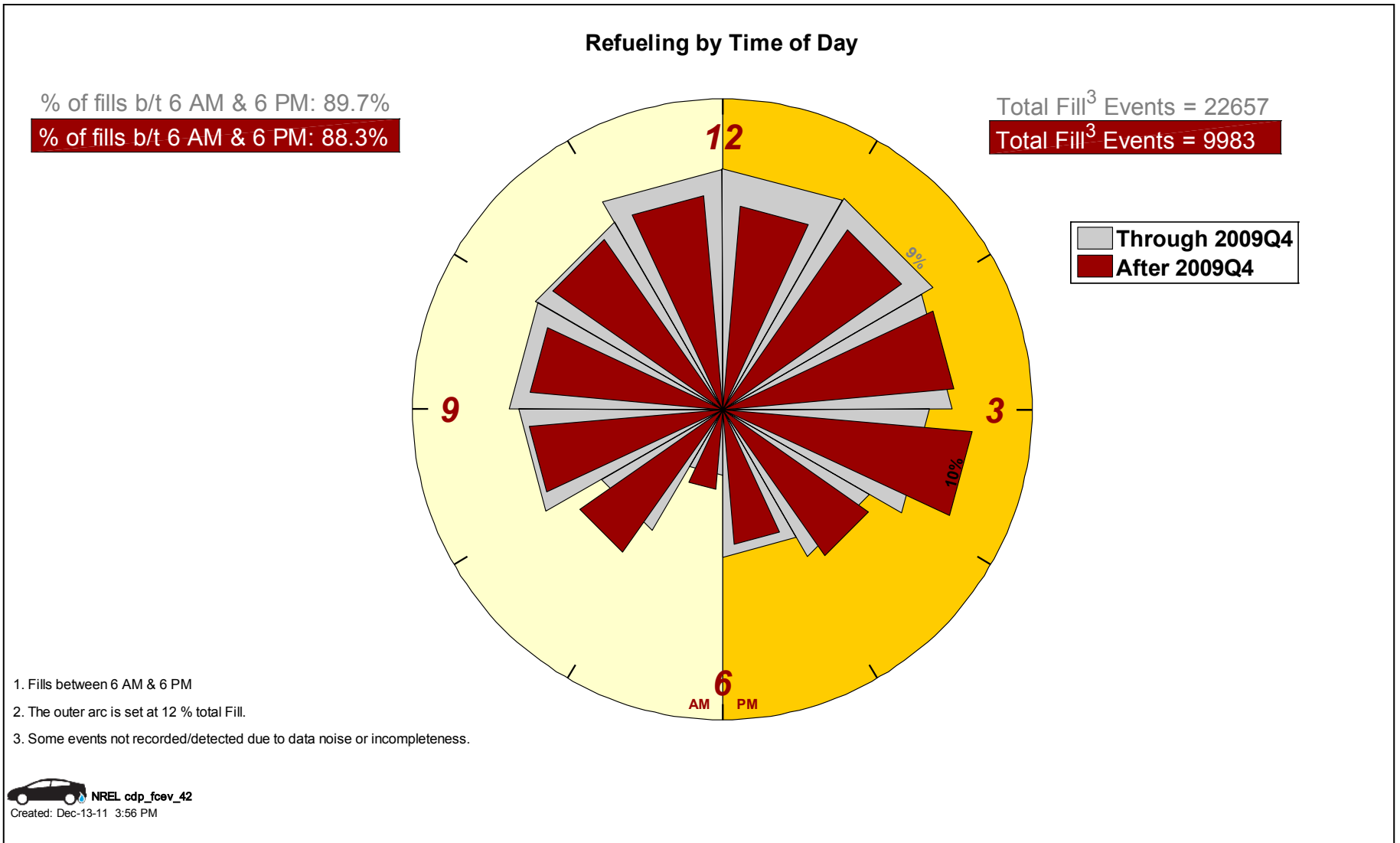
Total refuelings¹ = 9,965

Through 2009Q4
After 2009Q4

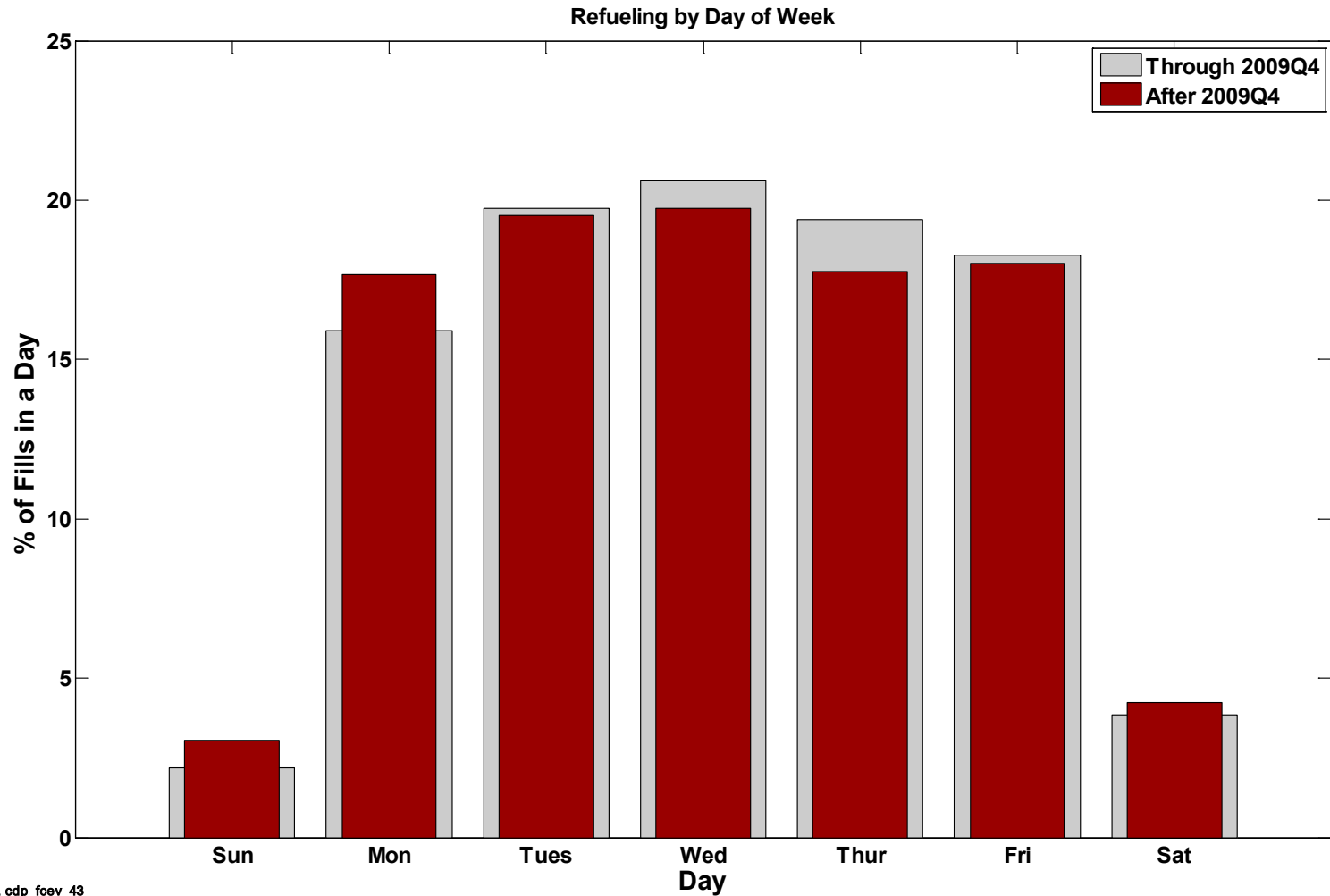


1. Some refueling events not recorded/detected due to data noise or incompleteness.
2. The outer arc is set at 20% total refuelings.
3. If tank level at fill was not available, a complete fill up was assumed.

CDP#42: Refueling by Time of Day



CDP#43: Refueling by Day of Week



NREL cdp_fcov_43
Created: Dec-13-11 3:56 PM

CDP#44: Driving Start Time – Day

Driving by Time of Day

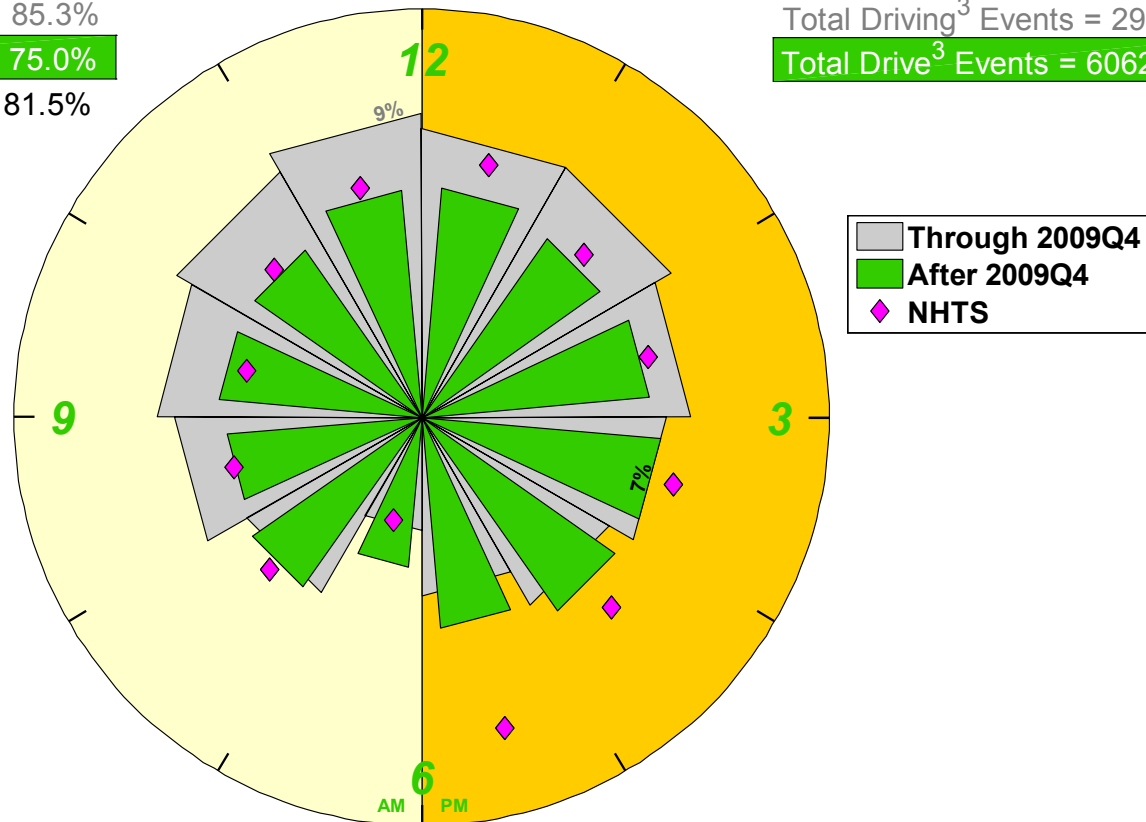
% of driving trips b/t 6 AM & 6 PM: 85.3%

% of driving trips b/t 6 AM & 6 PM: 75.0%

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

Total Driving³ Events = 295222

Total Drive³ Events = 60623

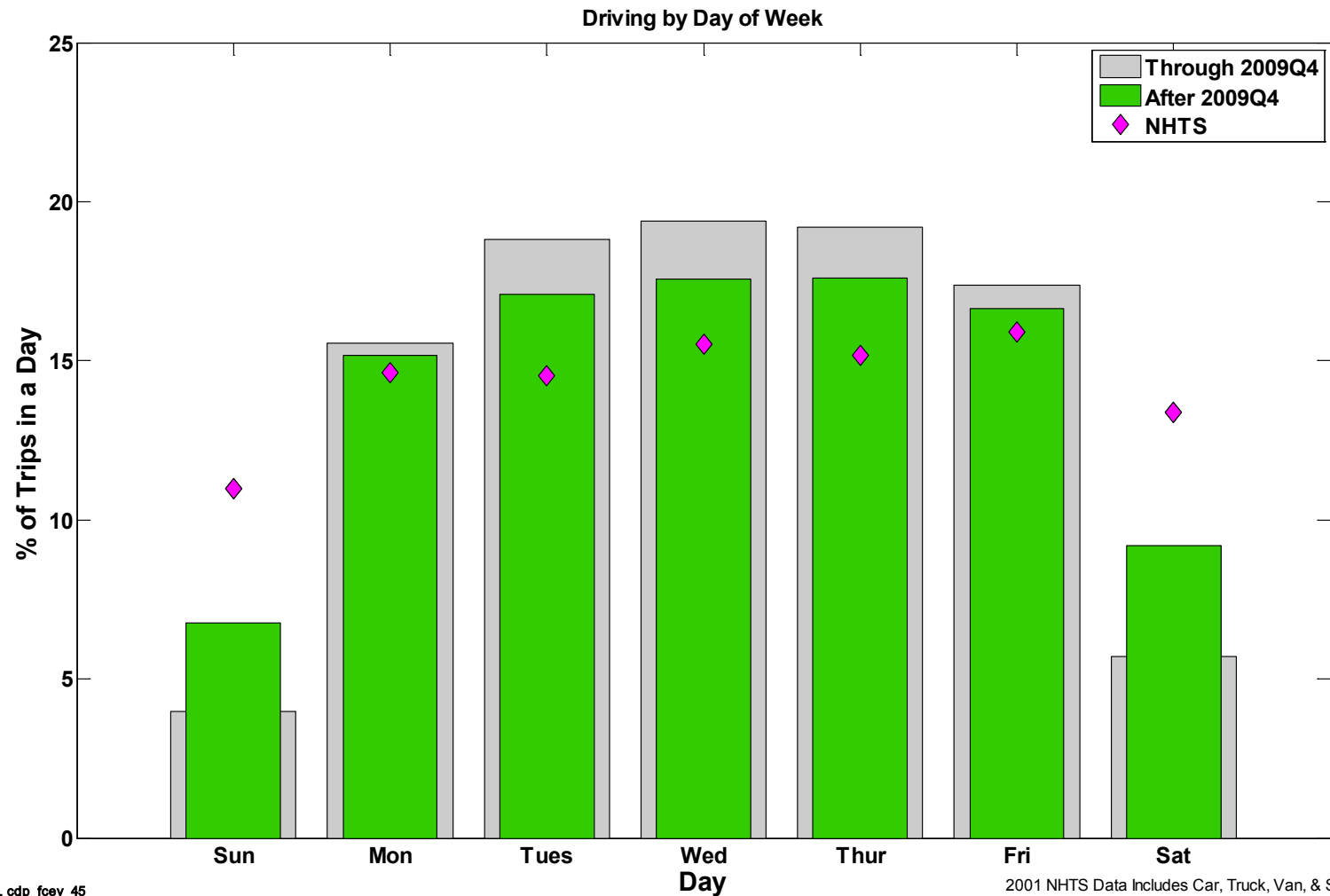


1. Driving trips between 6 AM & 6 PM

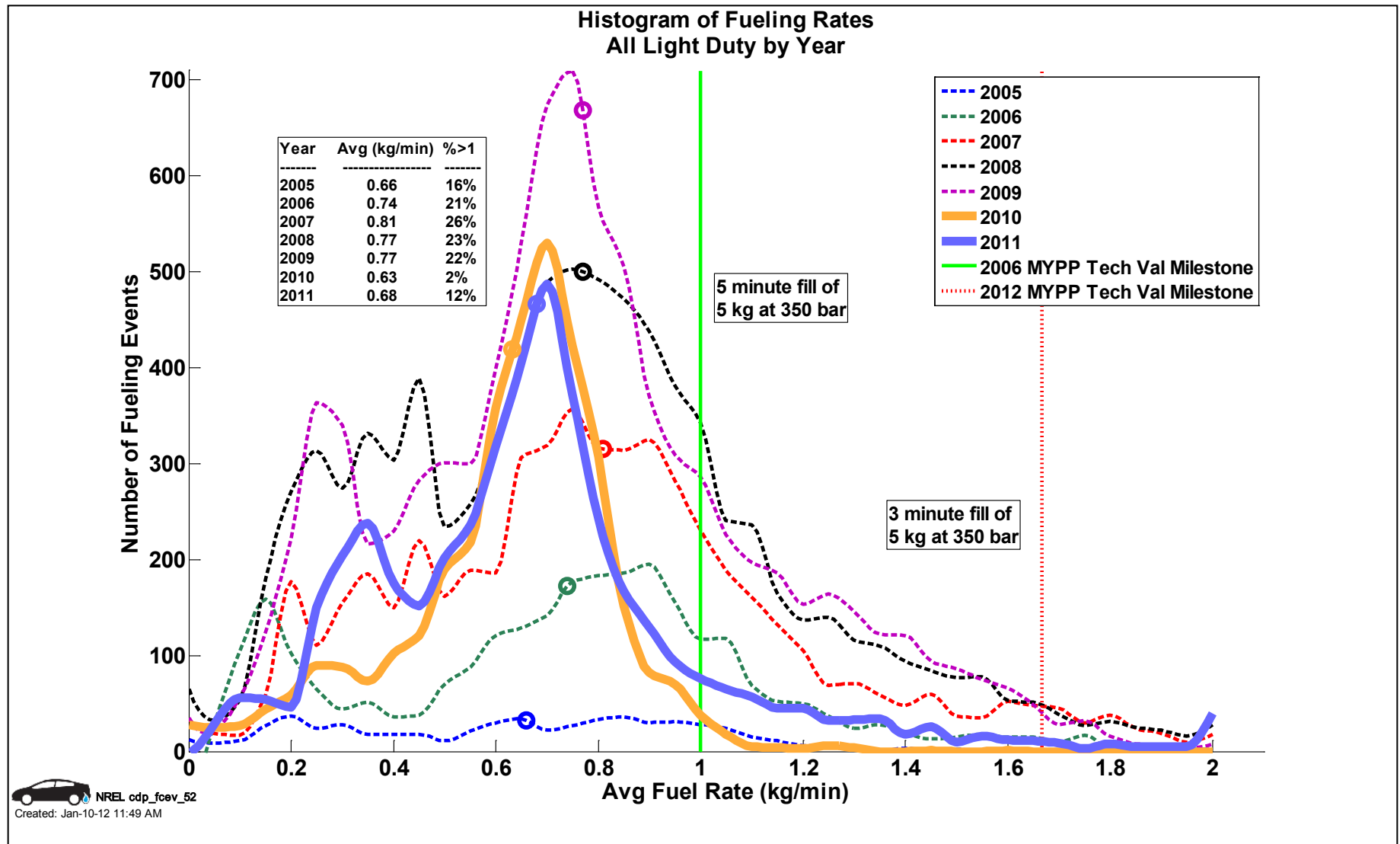
2. The outer arc is set at 12 % total Driving.

3. Some events not recorded/detected due to data noise or incompleteness.

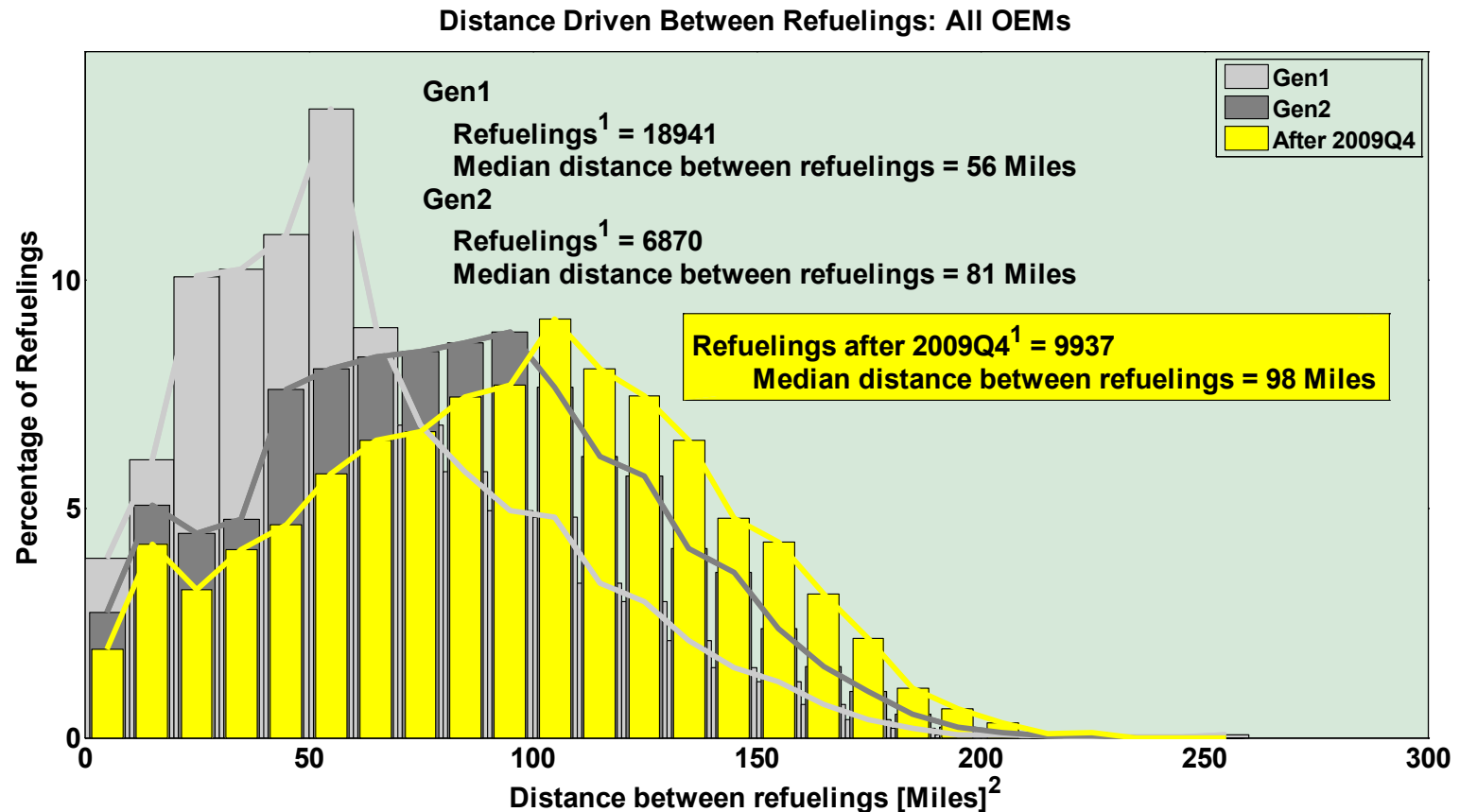
CDP#45: Driving by Day of Week



CDP#52: Fueling Rates by Year

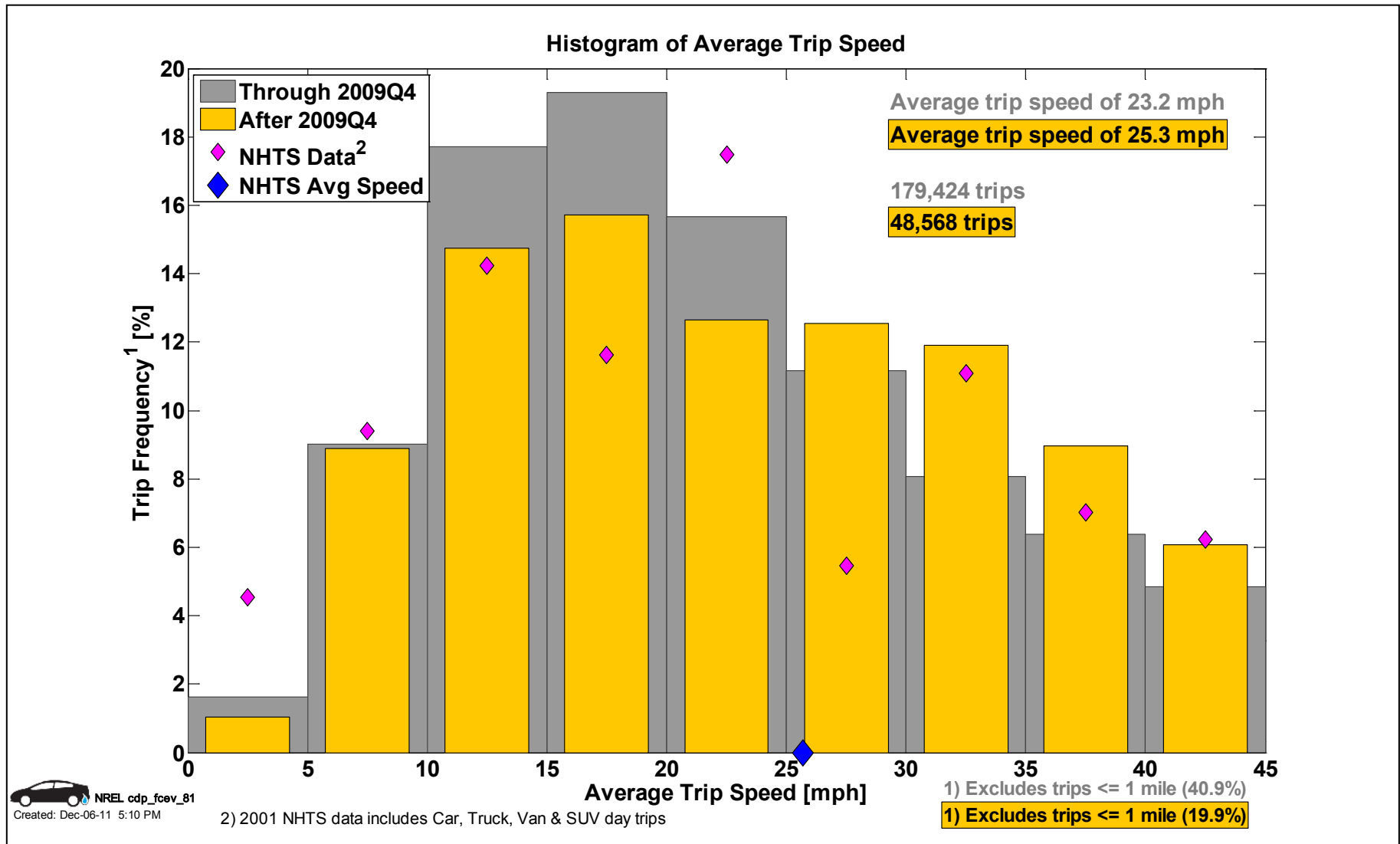


CDP#80: Miles Between Refuelings

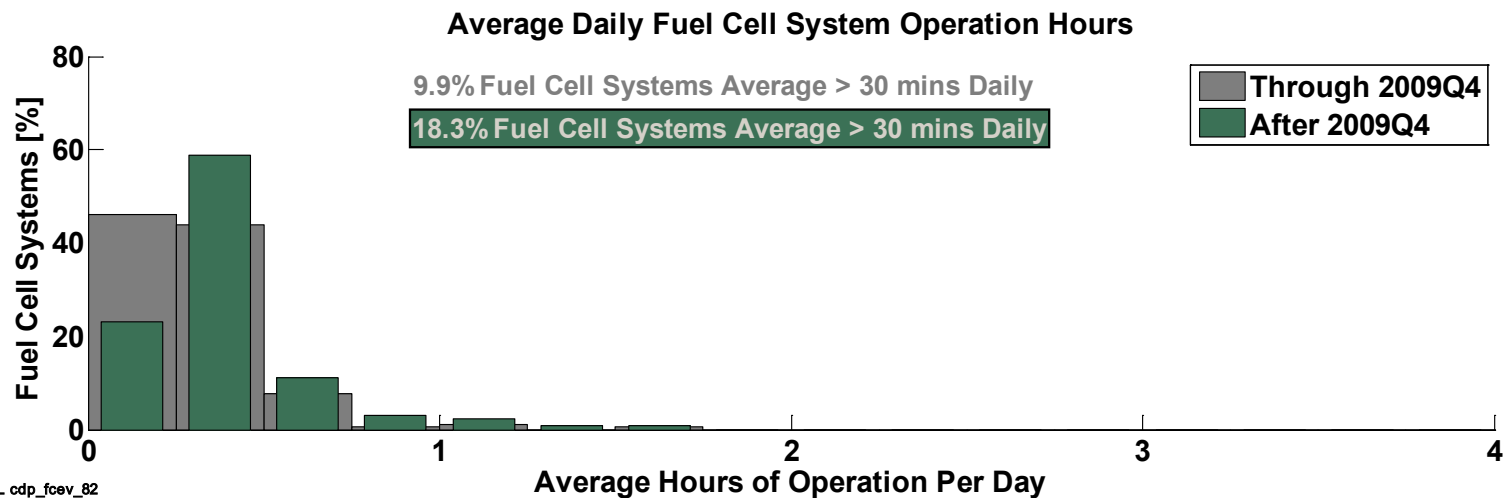
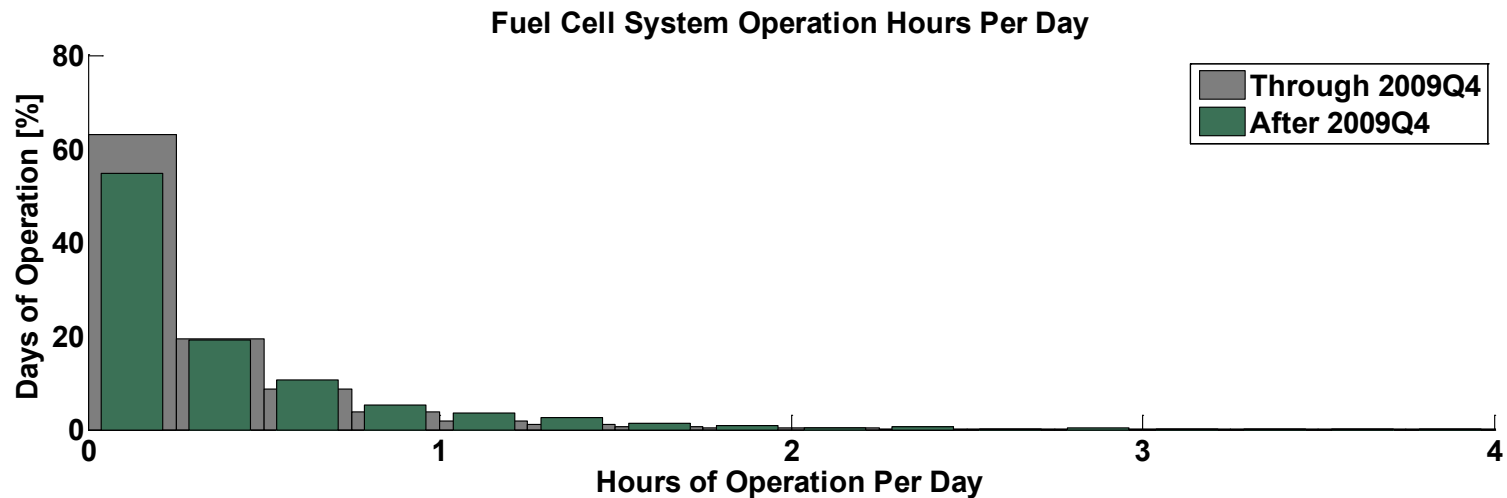


1. Some refueling events are not detected/reported due to data noise or incompleteness.
2. Distance driven between refuelings is indicative of driver behavior and does not represent the full range of the vehicle.

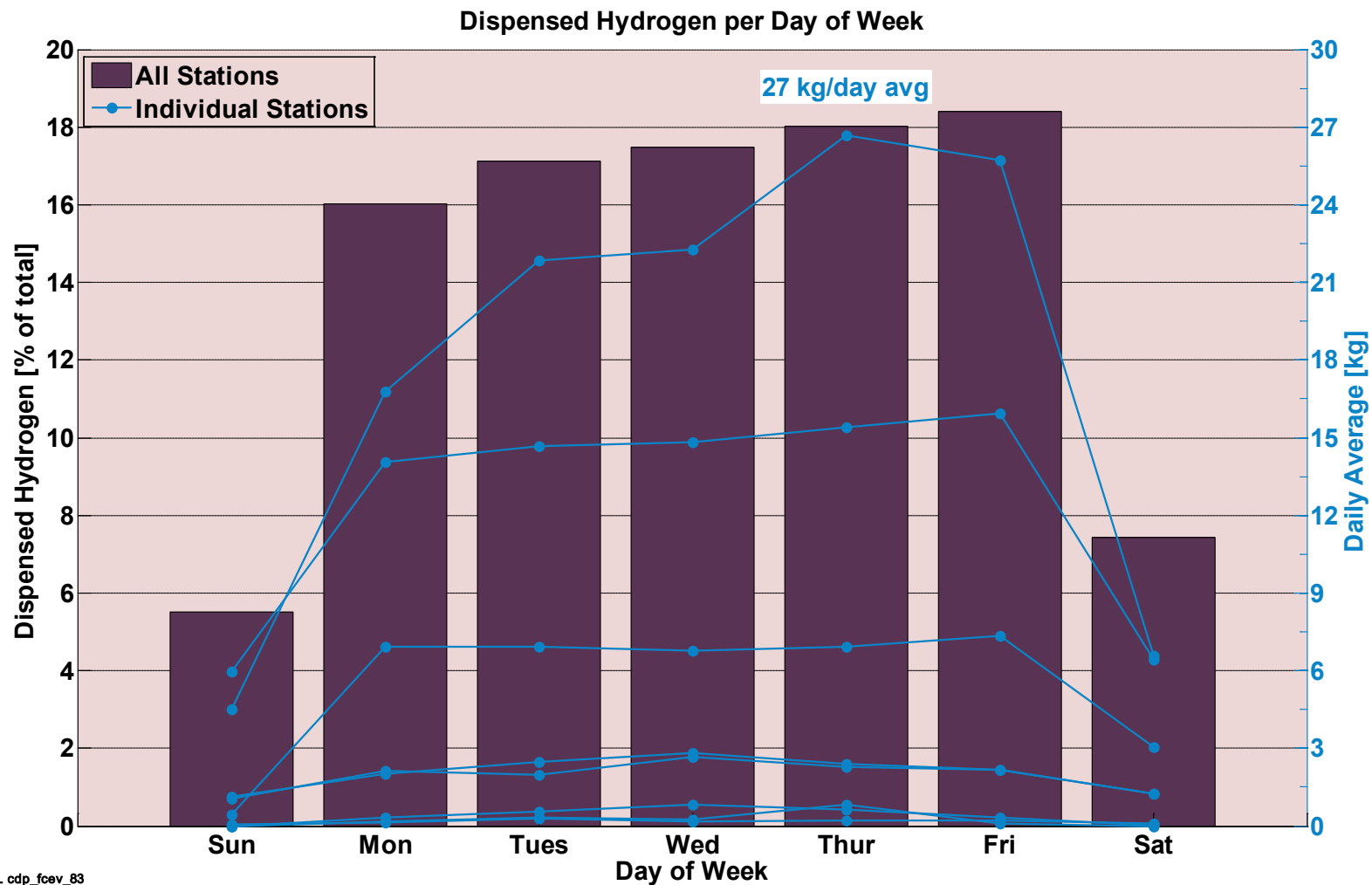
CDP#81: Average Trip Speed



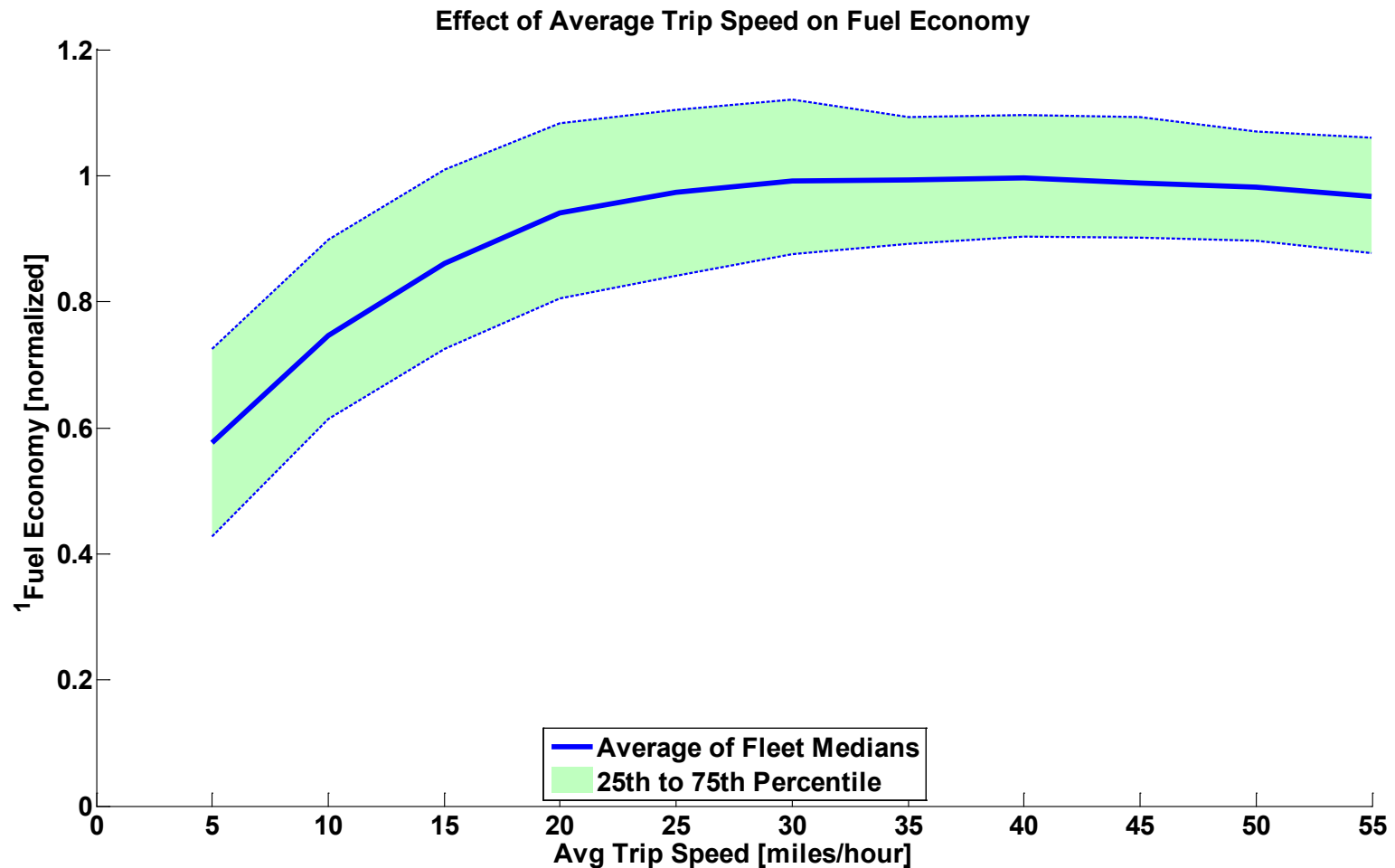
CDP#82: Daily FC Operation Hours in Automotive Application



CDP#83: Hydrogen Dispensed by Day of Week

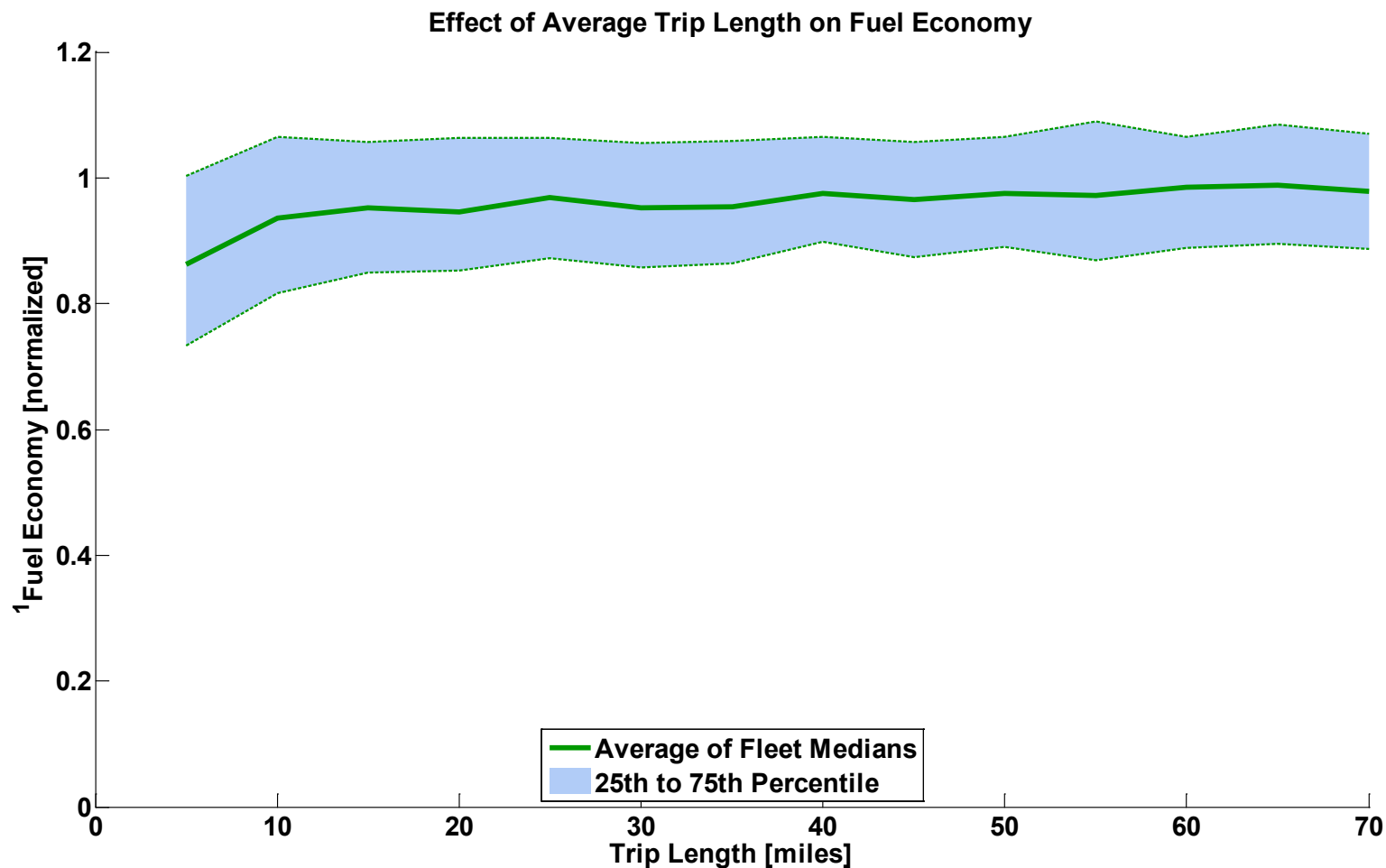


CDP#84: Effect of Average Trip Speed on Fuel Economy



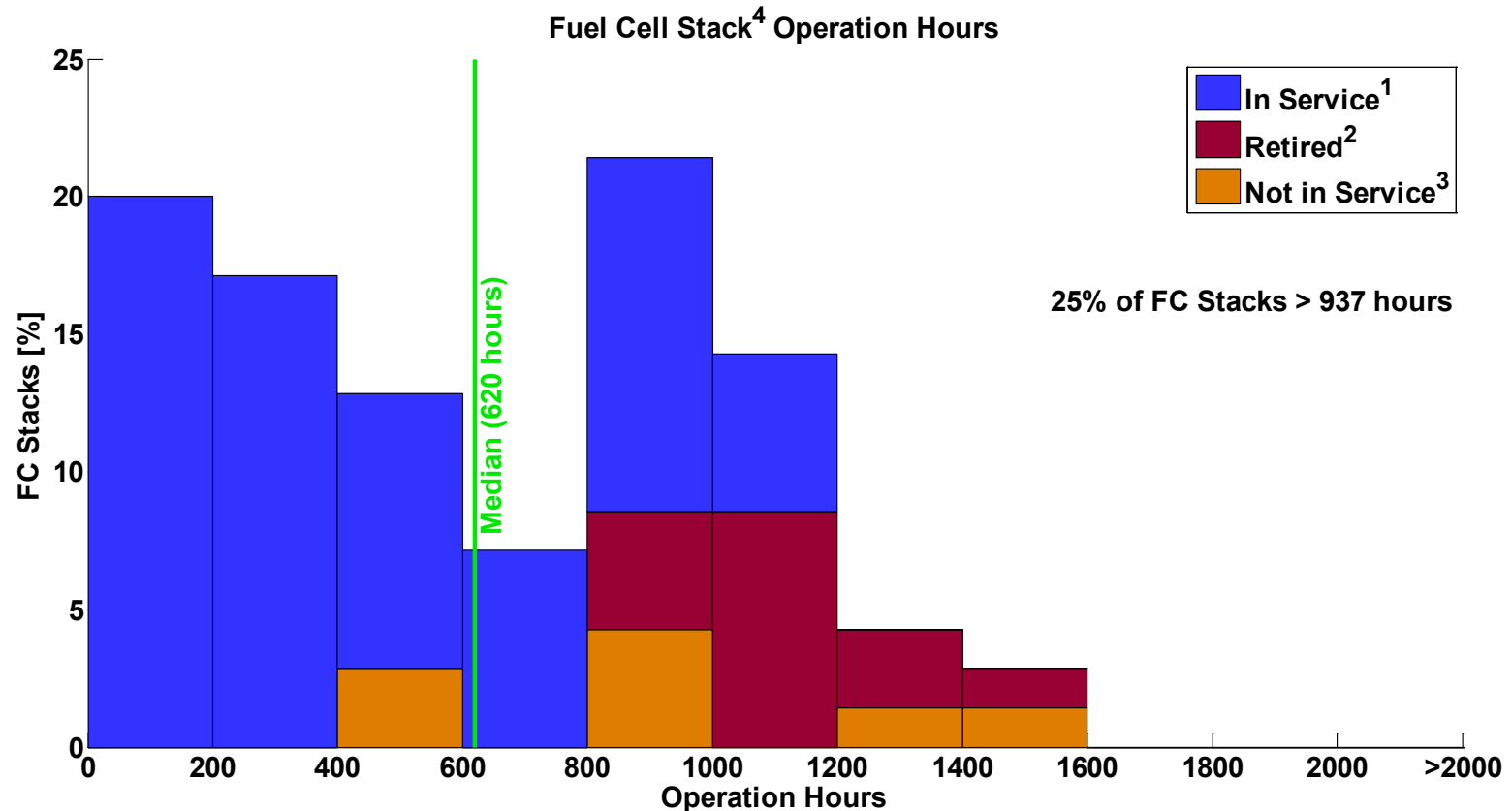
(1) Data after 2009Q4. The data has been normalized to the max of the median curve for each fleet.
Data binned every 5 mph for calculating median and percentiles.

CDP#85: Effect of Trip Length on Fuel Economy



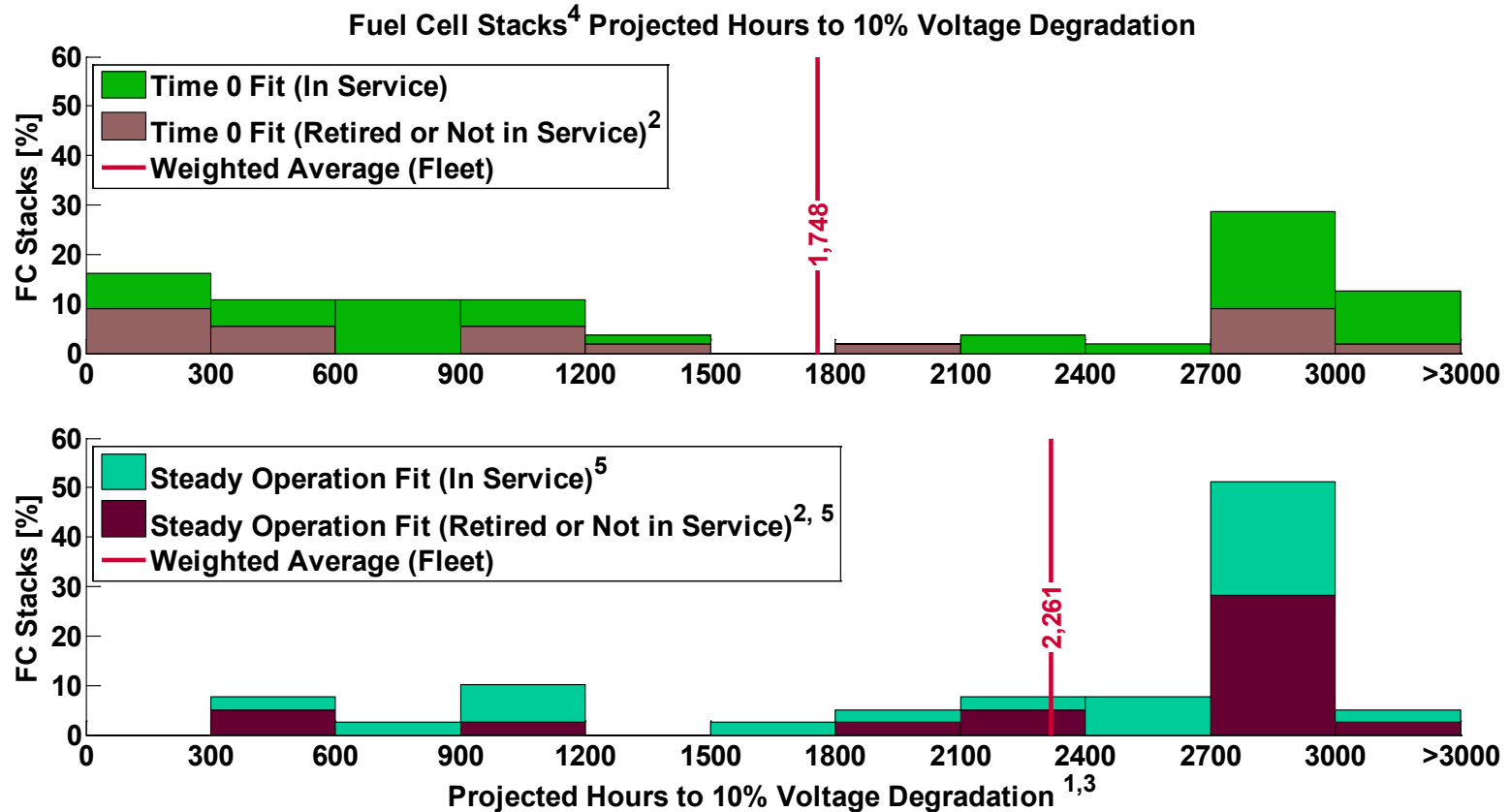
(1) Data after 2009Q4. The data has been normalized to the max of the median curve for each fleet.
Data binned every 5 miles for calculating median and percentiles.

CDP#86: Fuel Cell Stack Operation Hours



- 1) Stacks that are in service and accumulating operation hours.
- 2) Stacks retired due to low-performance or catastrophic failure.
- 3) Indicates stacks that are no longer accumulating hours either a) temporarily or b) have been retired for non- stack performance related issues or c) removed from DOE program.
- 4) Only includes systems operating after 2009Q4.

CDP#87: Fuel Cell Stacks Projected Hours to 10% Voltage Degradation with Two Fits



1) Projection using field data, calculated at high stack current, from operation hour 0 or a steady operation period.

Projected hours may differ from an OEM's end-of-life criterion and does not address "catastrophic" failure modes.

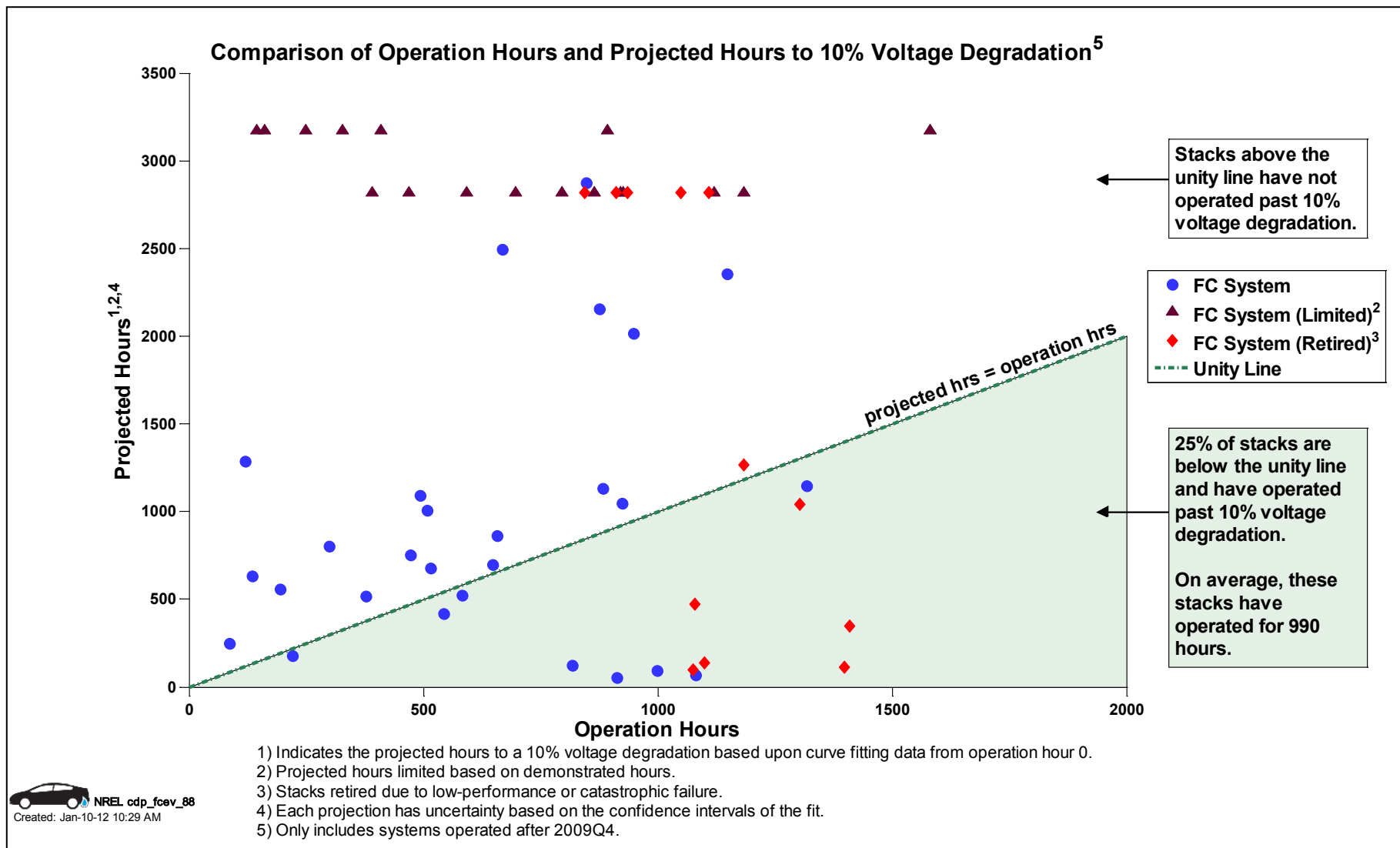
2) Indicates stacks that are no longer accumulating hours either a) temporarily or b) have been retired for non-stack performance related issues or c) removed from DOE program.

3) Projected hours limited based on demonstrated hours.

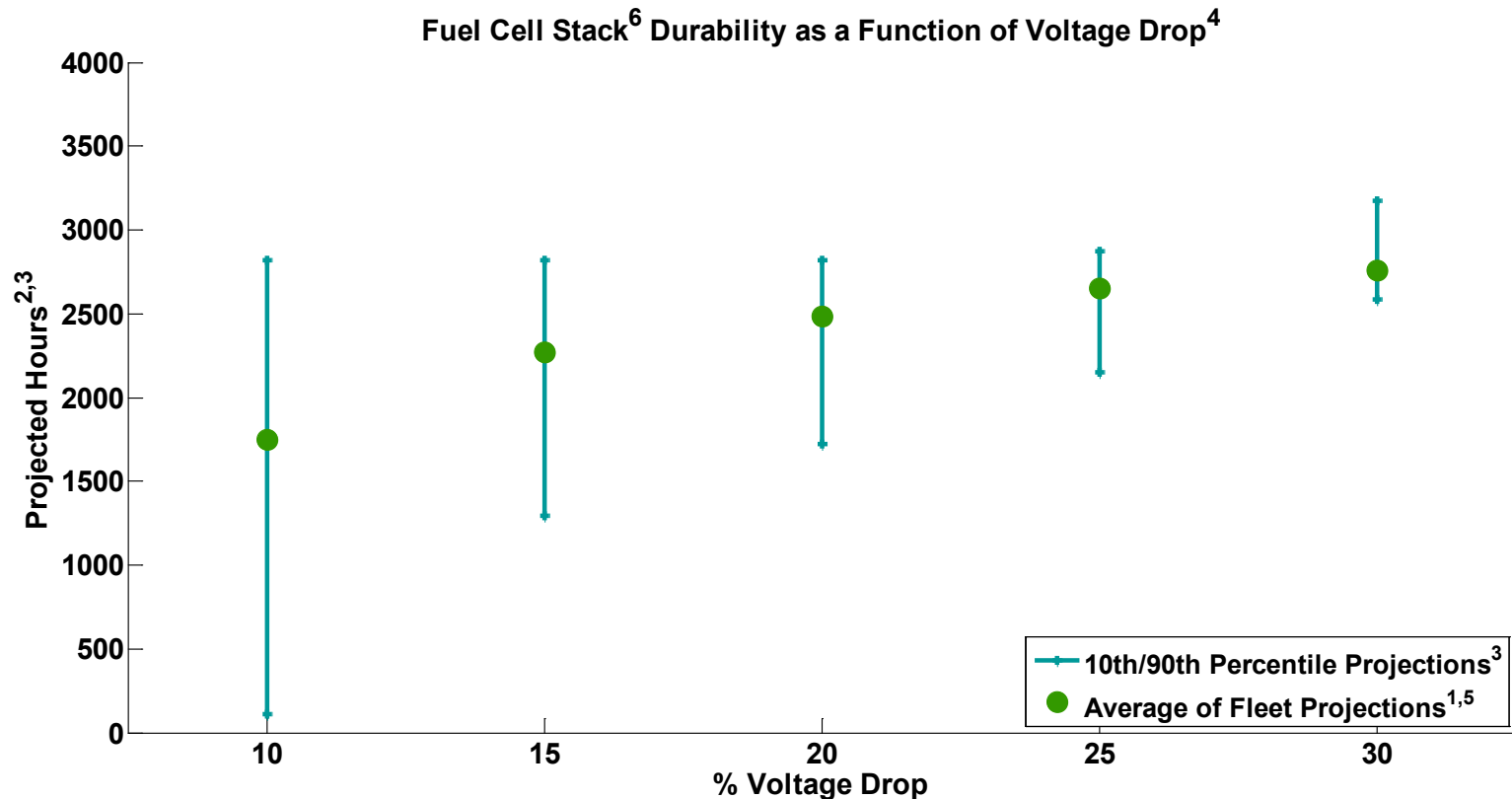
4) Only includes systems operating after 2009Q4.

5) Not all stacks have a steady operation fit which is calculated from data after 200 hr break-in period. The steady operation starting hour is an approximation of the period after initial break-in where degradation levels to a more steady rate.

CDP#88: Comparison of Fuel Cell Operation Hours and Projected Hours to 10% Voltage Degradation

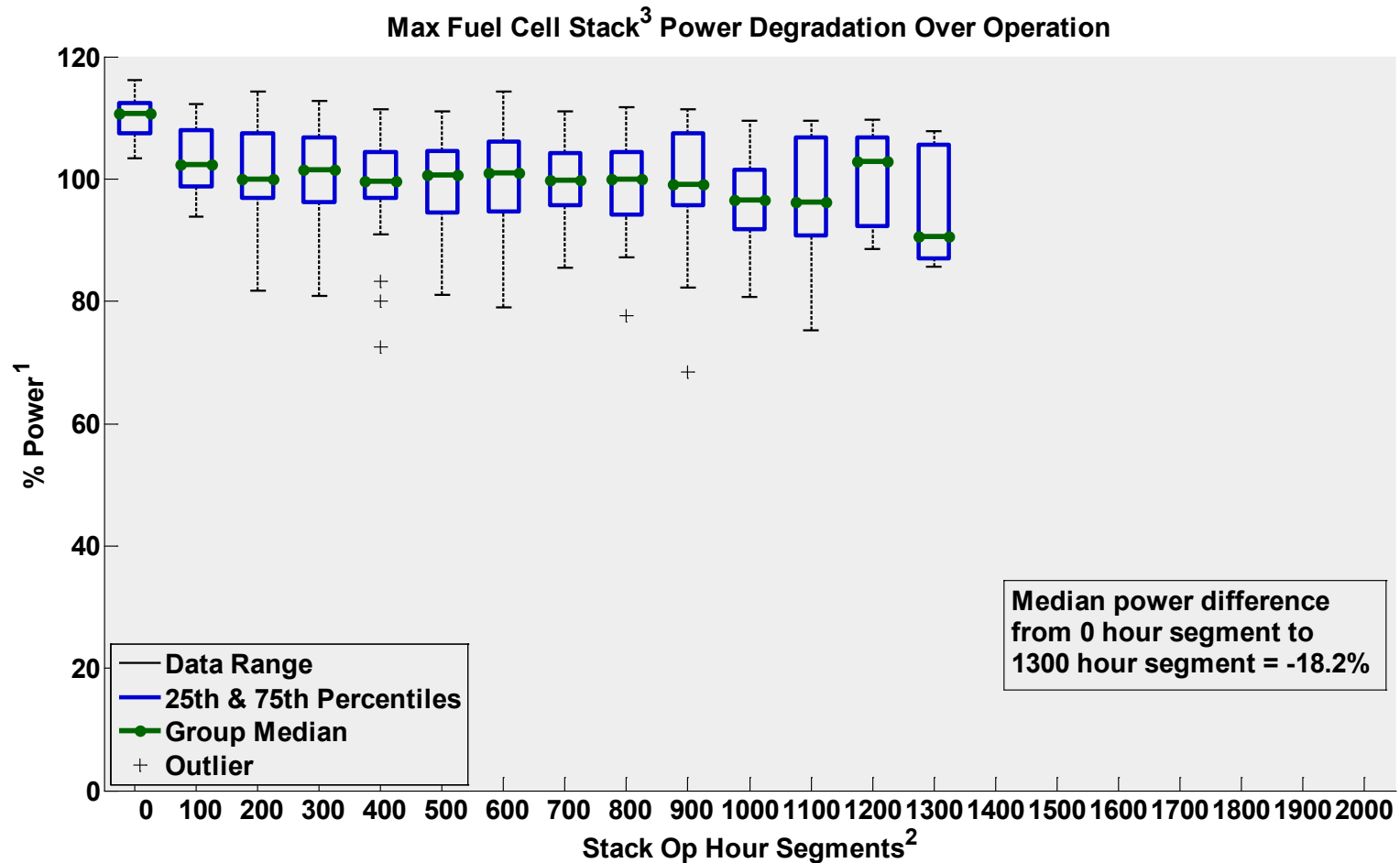


CDP#89: Fuel Cell Stack Durability as a Function of Voltage Drop



- 1) 10% Voltage degradation is a DOE metric for assessing fuel cell performance not an indication of an OEM's end-of-life criteria.
- 2) Projections using field data and calculated at high stack current.
- 3) 10th and 90th percentiles spans the range of stack projection. The included stacks satisfy a minimum number of operation hours and weighting factor.
- 4) The projected hours vary based on the percentage of voltage degradation, but the projected hours do not imply that all stacks will (or do) operate to these voltage degradation levels.
- 5) Each fleet has one voltage projection value that is the weighted average of the fleet's fuel cell stack projections.
- 6) Only includes systems operated after 2009Q4.

CDP#90: Max Fuel Cell Stack Power Degradation Over Operation

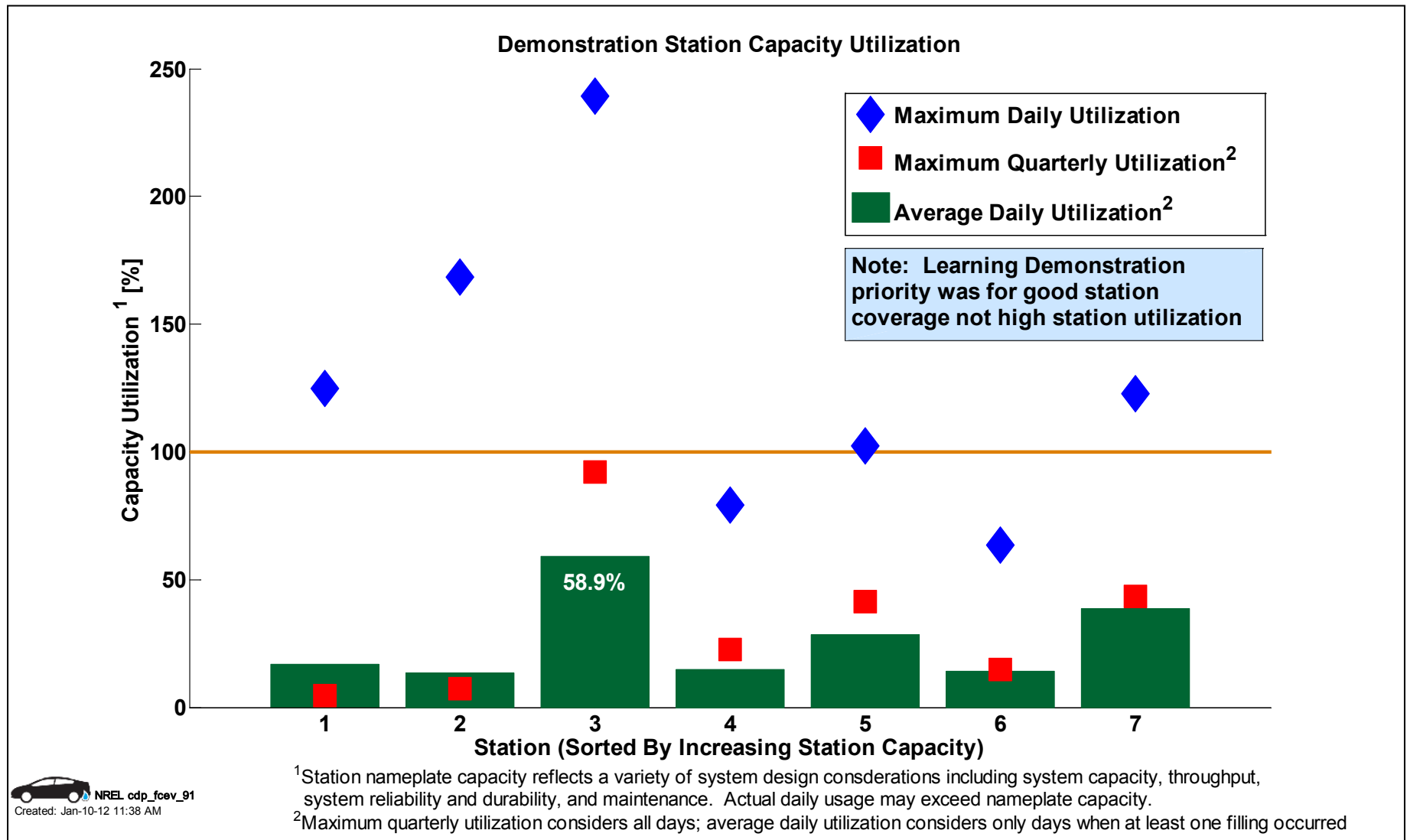


1) Normalized by fleet median value at 200 hours.

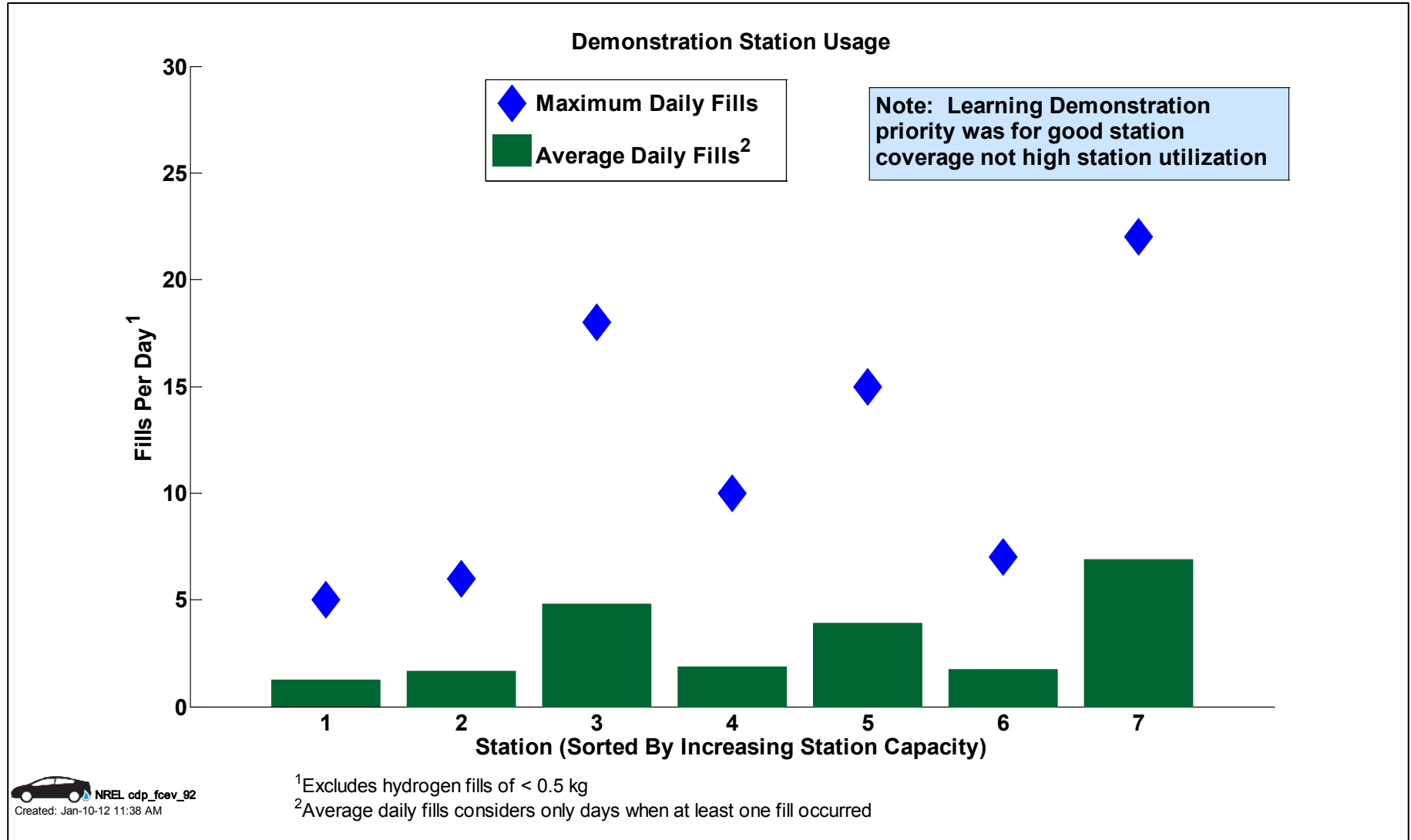
2) Each segment point is median FC power (+50 hrs). Box not drawn if fewer than 3 points in segment.

3) Only includes systems operated after 2009Q4.

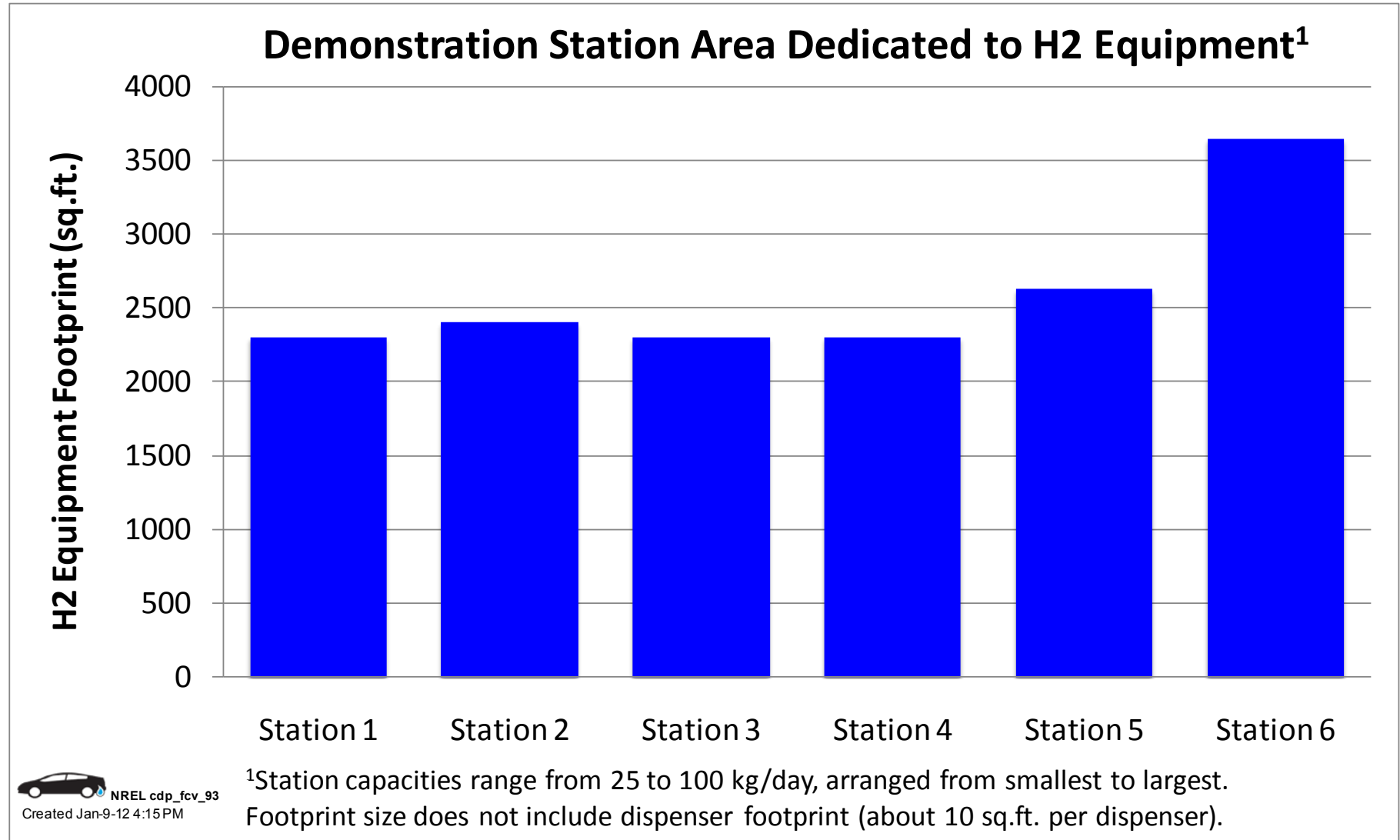
CDP#91: Station Capacity Utilization



CDP#92: Station Usage (fills per day)

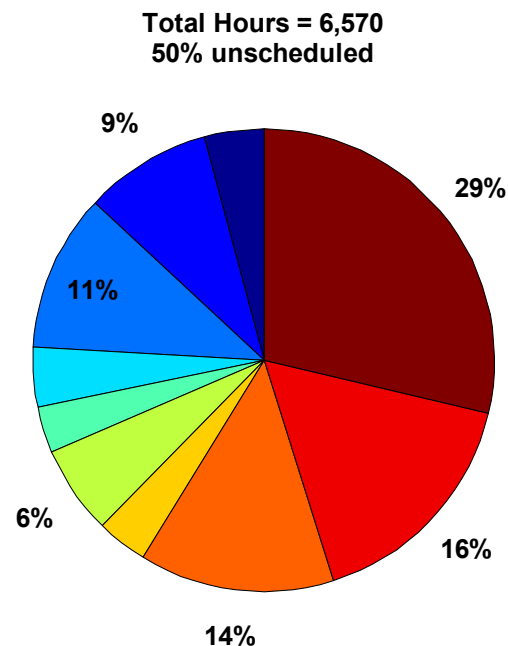
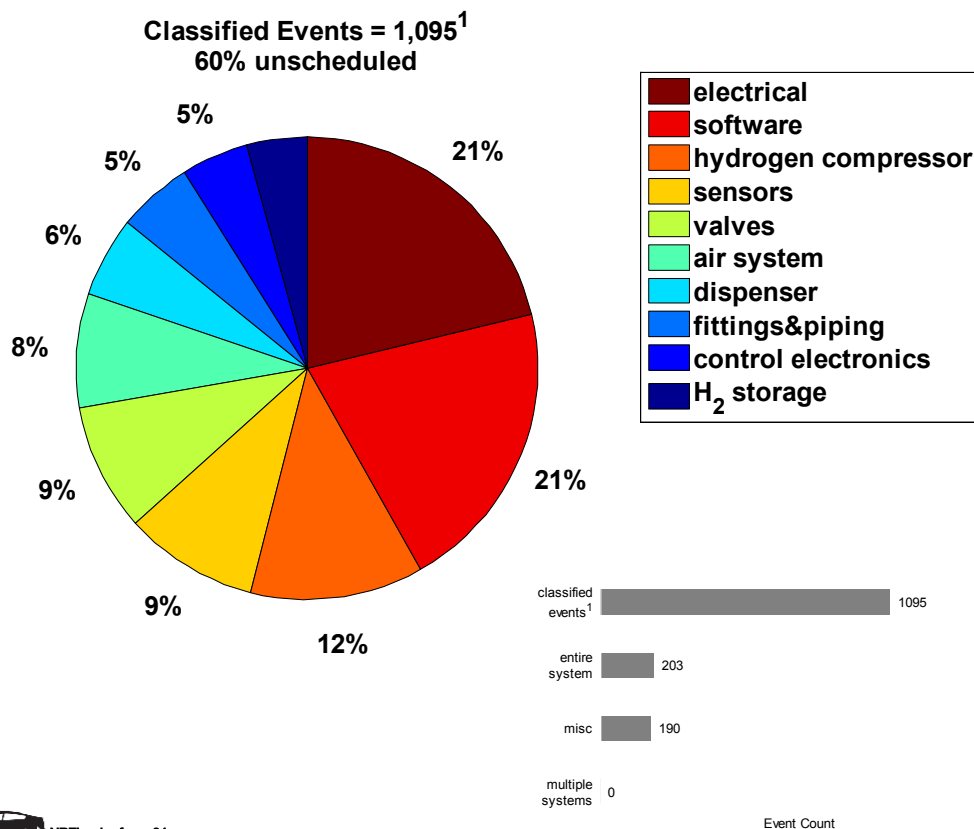


CDP#93: Hydrogen Equipment Footprint



CDP#94 Infrastructure Maintenance by Category

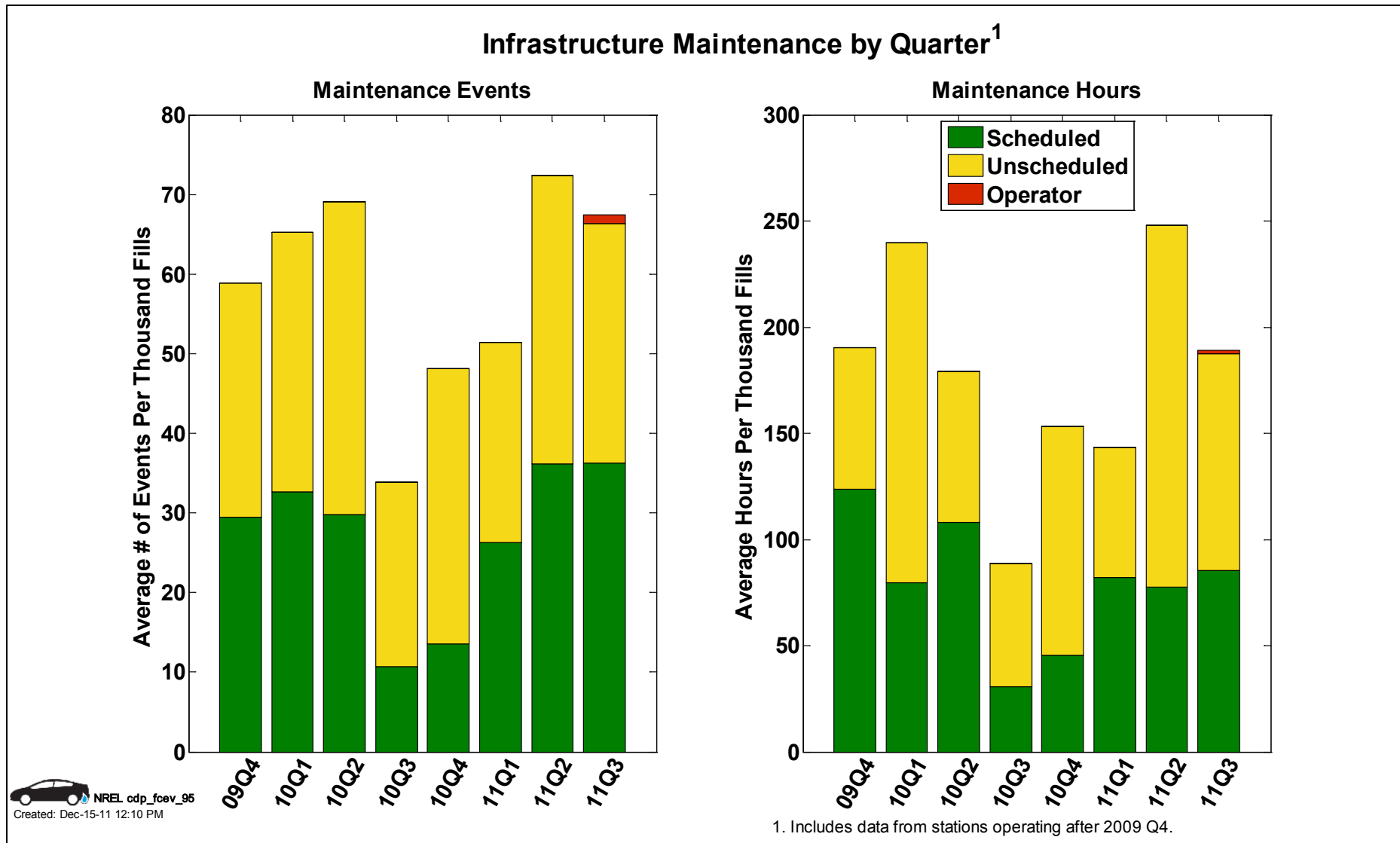
Infrastructure Maintenance By Equipment Type²



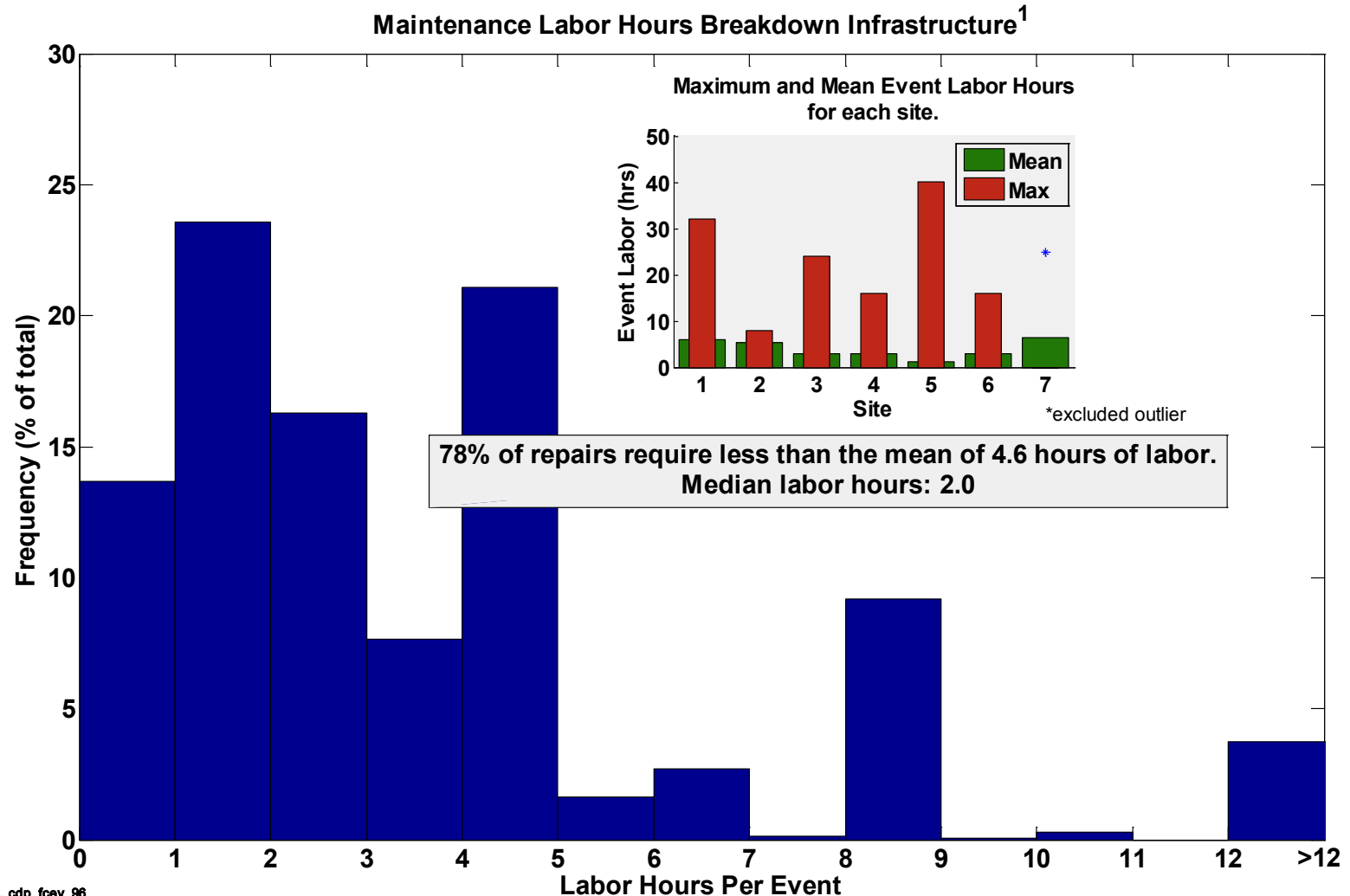
MISC includes the following failure modes: purifier, nitrogen system, feedwater system, seal, safety, reformer, electrolyzer, thermal management, other

2. Includes data from stations operating after 2009 Q4. For legacy results refer to CDP #63.

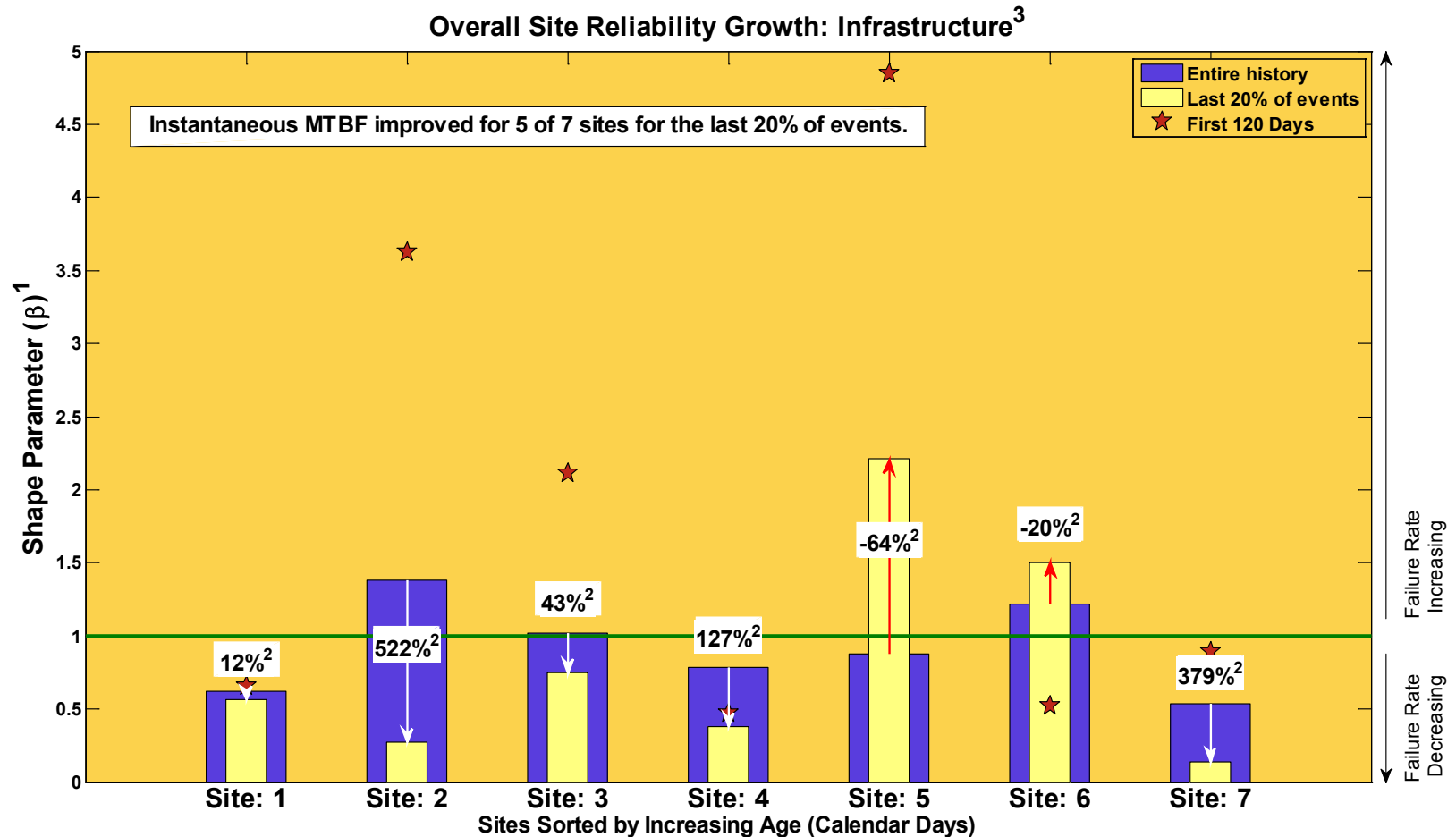
CDP#95 Infrastructure Maintenance By Quarter



CDP#96 Infrastructure Maintenance Labor Hours



CDP#97 Infrastructure Reliability Growth

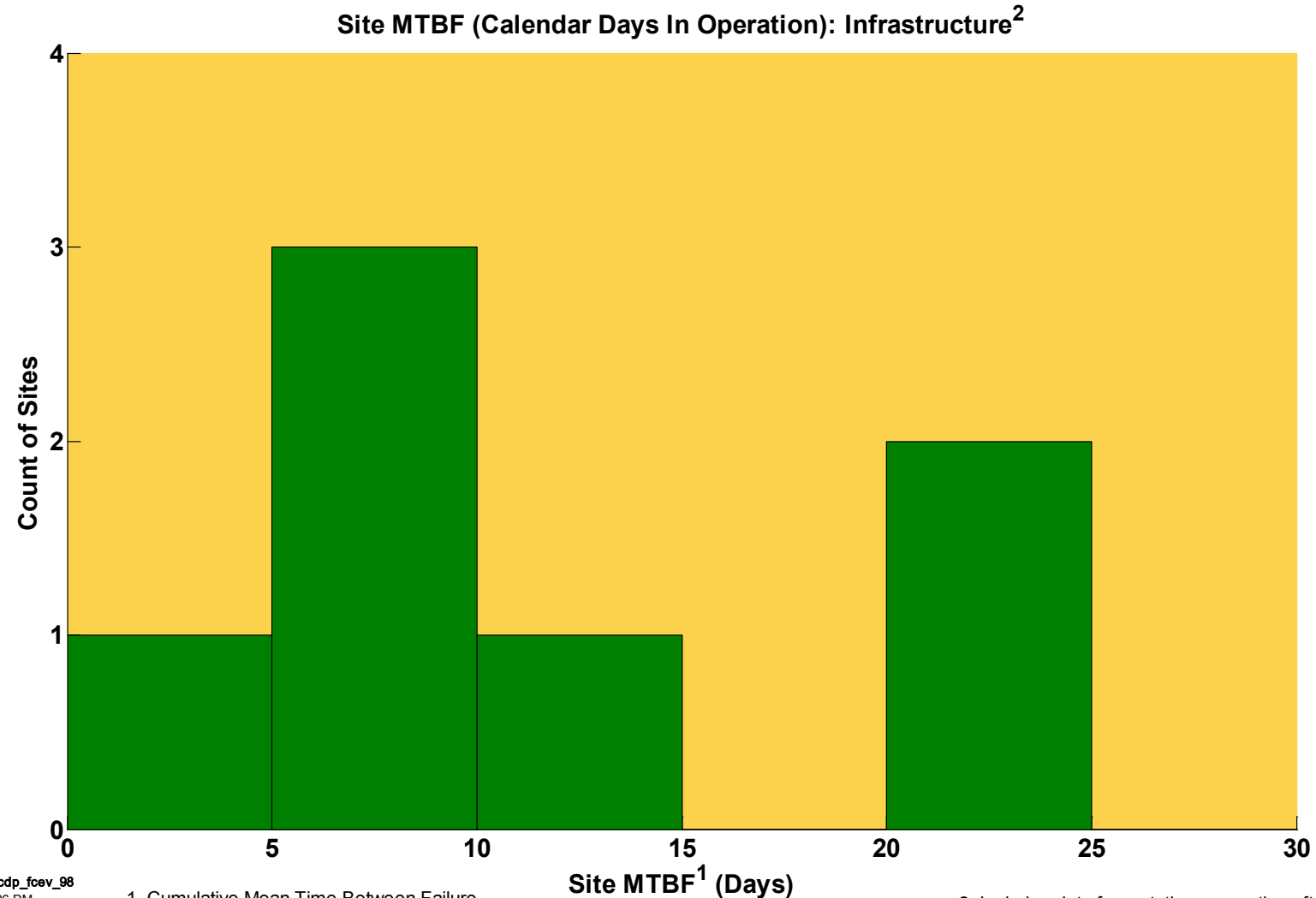


1. IEC 61164:2004(E), Reliability Growth - Statistical Test and Evaluation Methods, IEC. 2004.

2. % change in instantaneous MTBF

3. Includes data from stations operating after 2009 Q4.

CDP#98 Infrastructure MTBF (based on Calendar Days of Operation)



CDP#99 Infrastructure Mean Time between Scheduled Maintenance

