



Technical Report
NREL/TP-5600-54020
January 2012

National FCEV Learning Demonstration

Winter 2011

Composite Data Products

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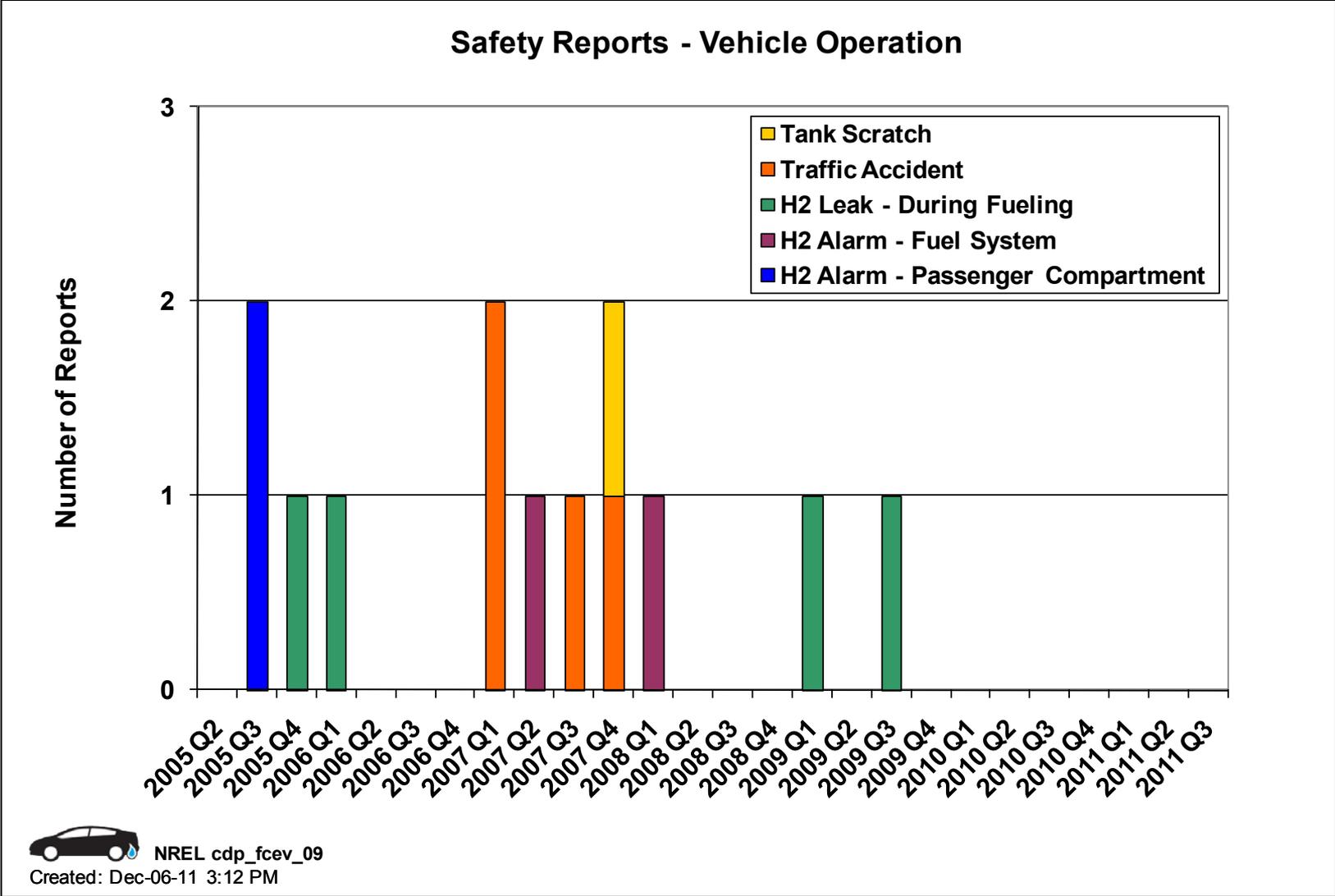
Winter 2011 Composite Data Products: National FCEV Learning Demonstration



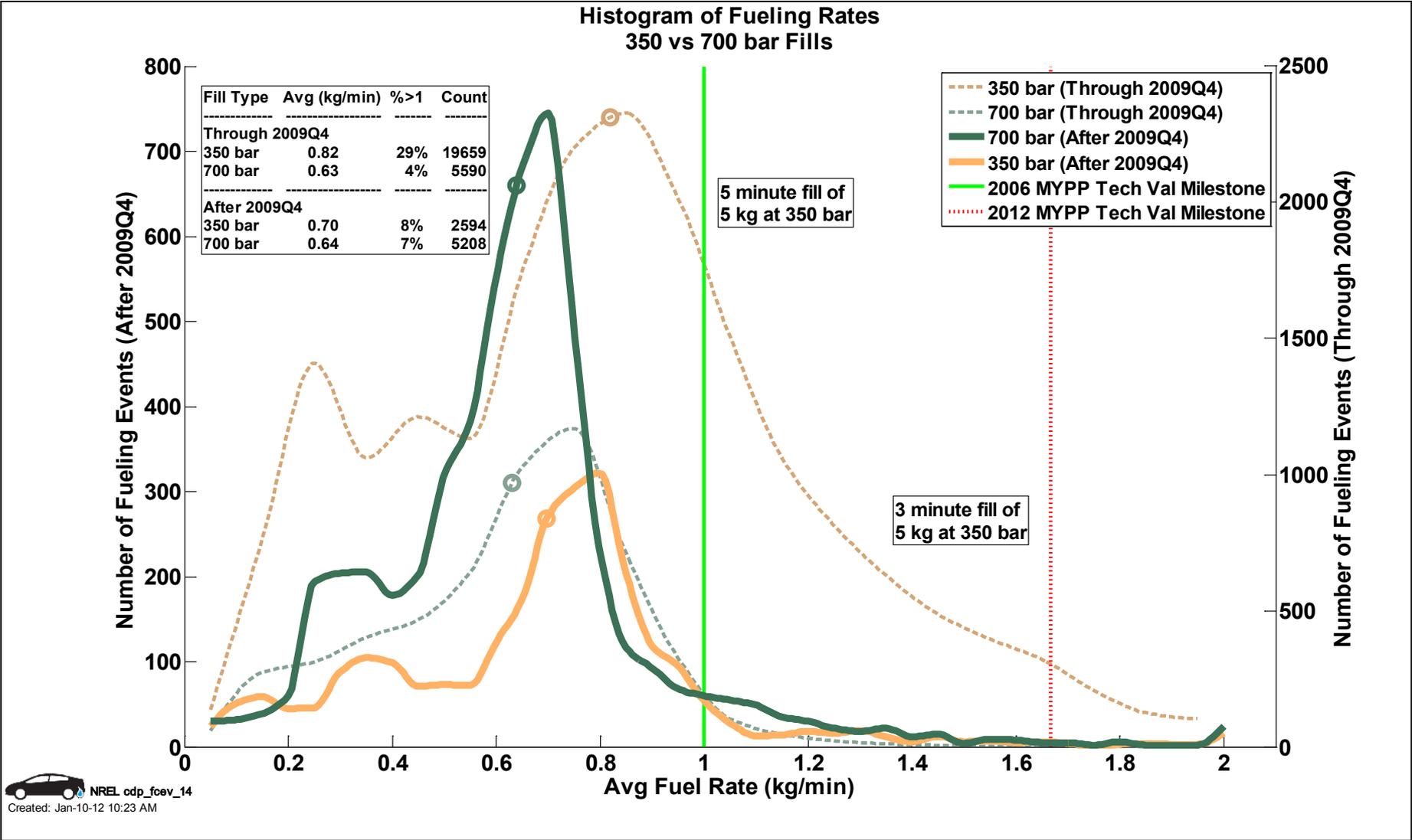
January 18, 2012

Keith Wipke, Sam Sprik,
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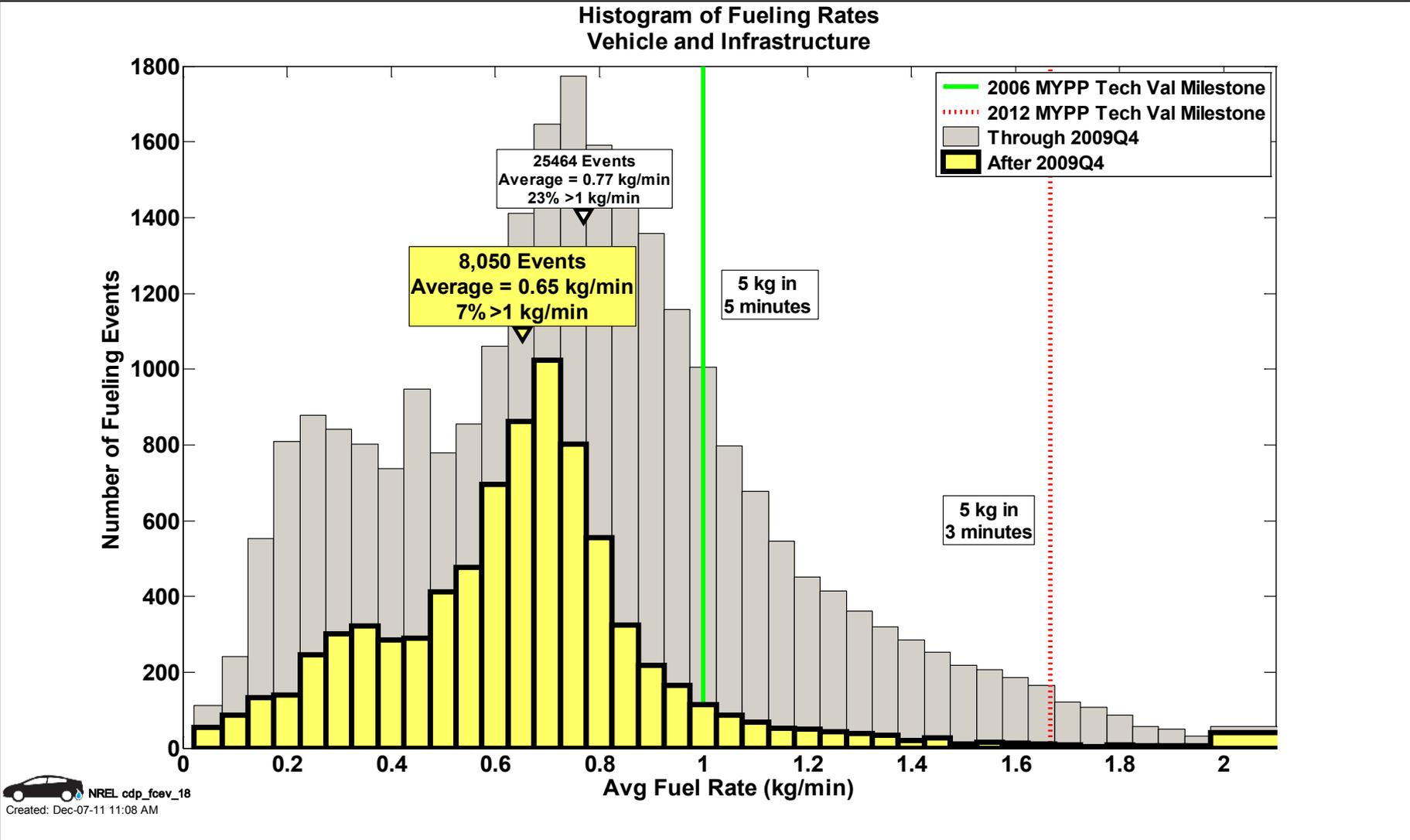
CDP#9: Safety Reports – Vehicles



CDP#14: Fueling Rates by Fill Pressure

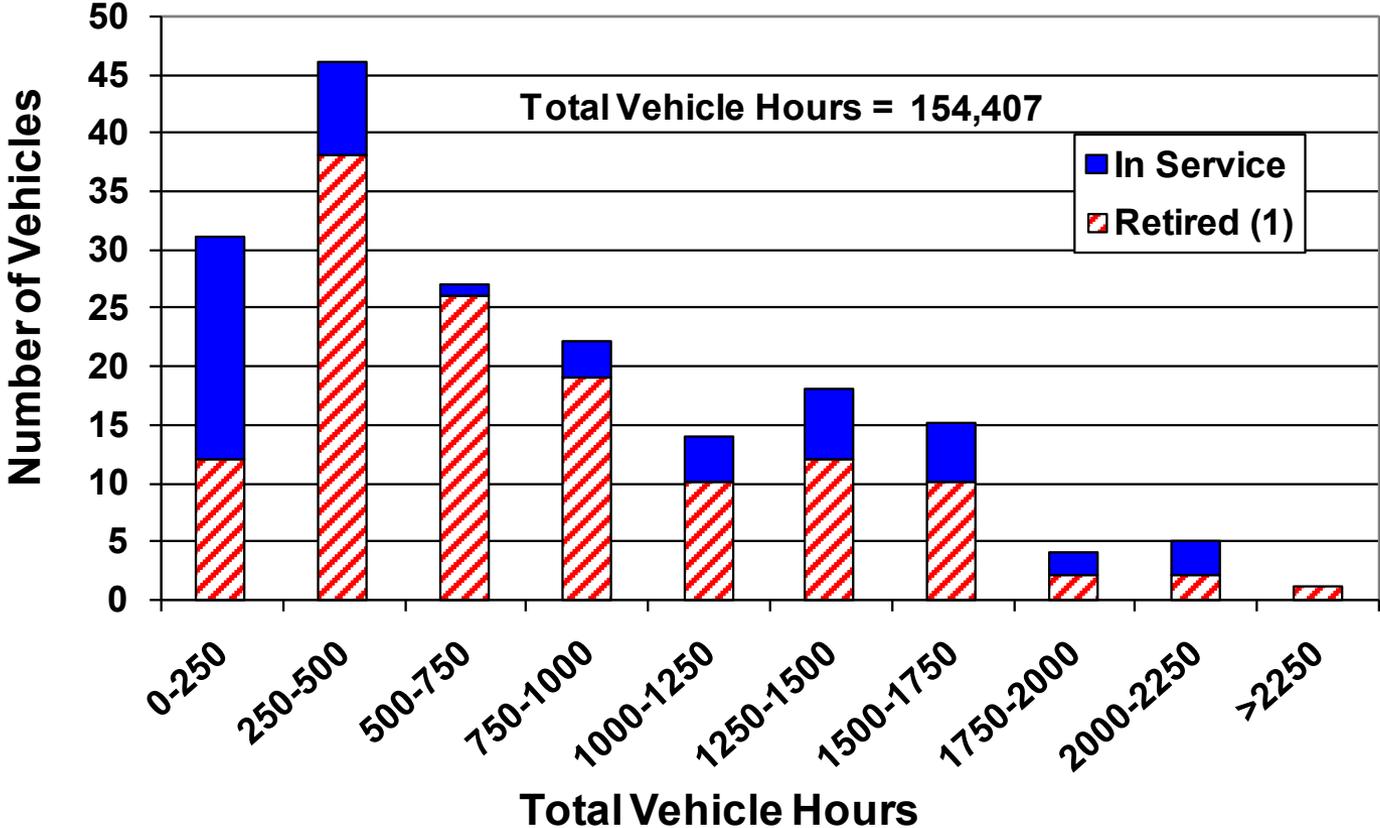


CDP#18: Refueling Rates



CDP#22: Vehicle Operating Hours

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



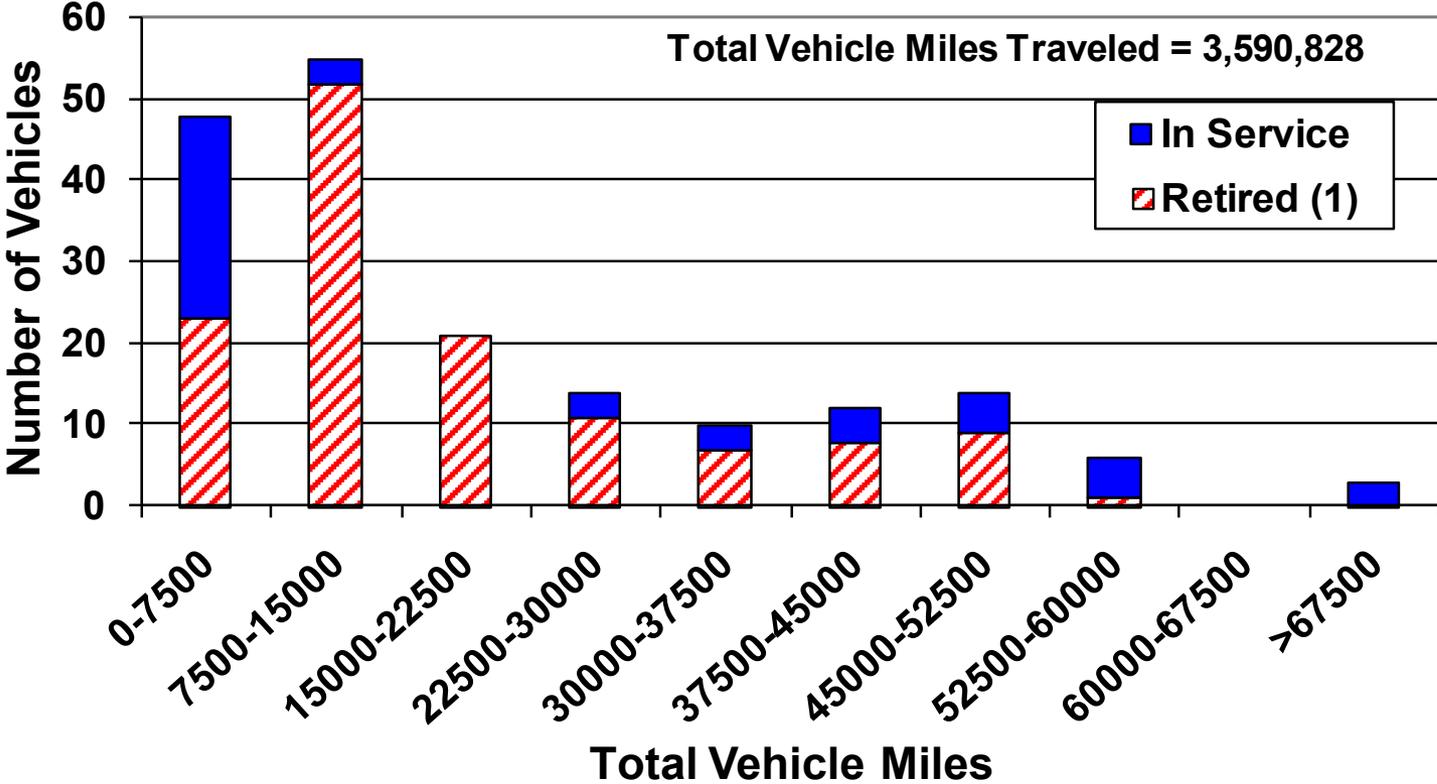
NREL cdp_fcvev_22

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

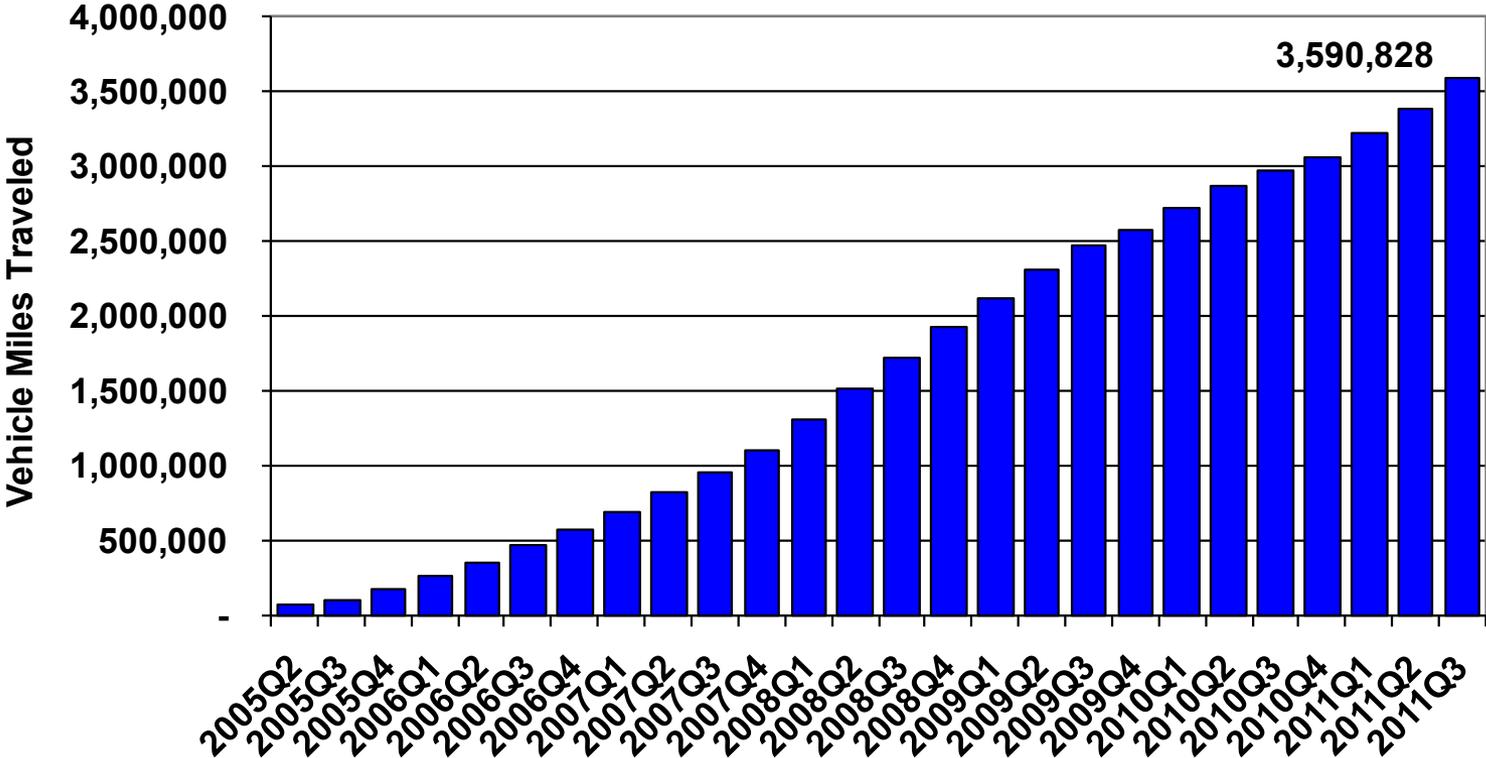
Vehicle Miles: All OEMs, Gen 1 and 2
Through 2011 Q3



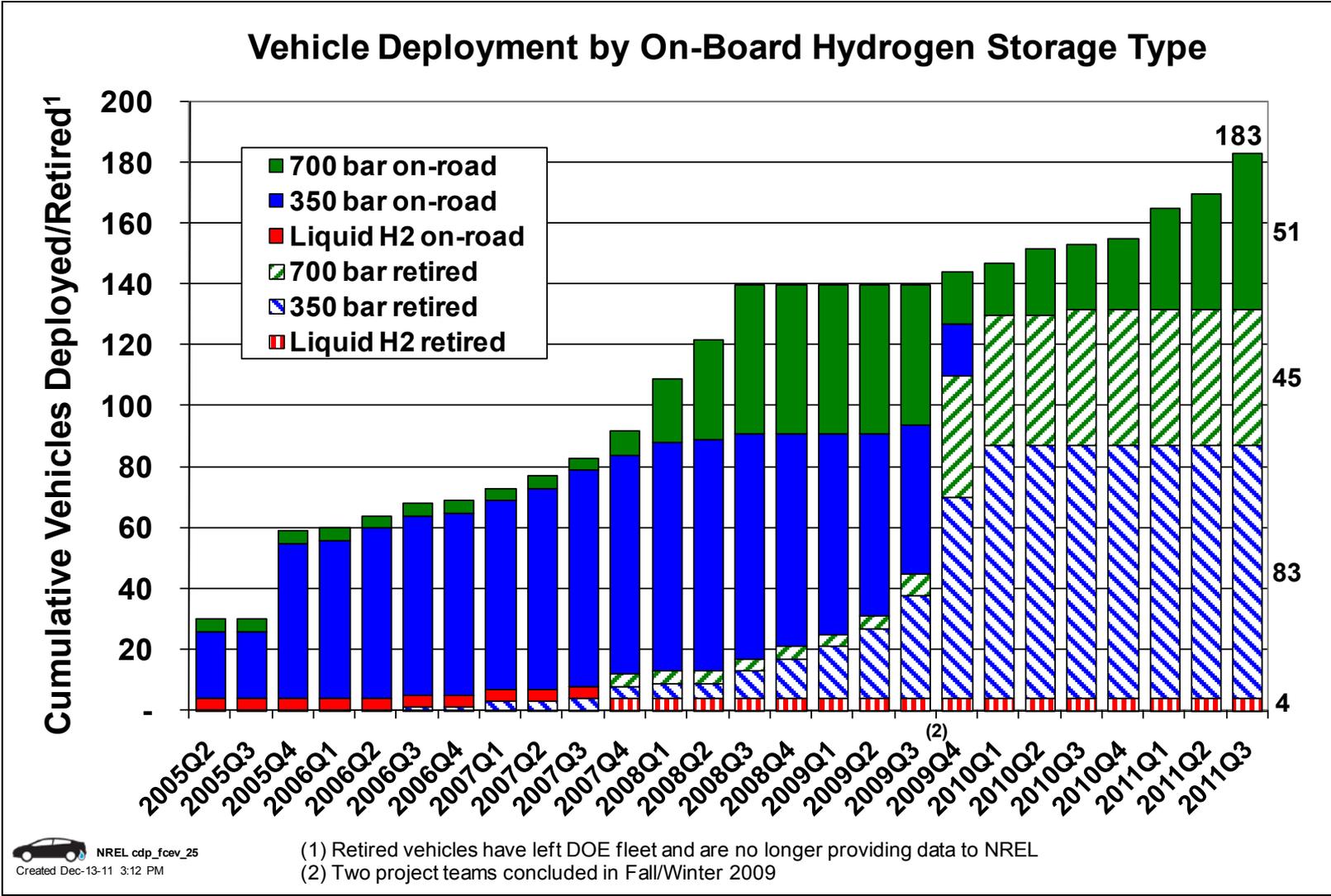
(1) Retired vehicles have left DOE fleet and are no longer providing data to NREL
Some project teams concluded in Fall/Winter 2009

CDP#24: Cumulative Vehicle Miles Traveled

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

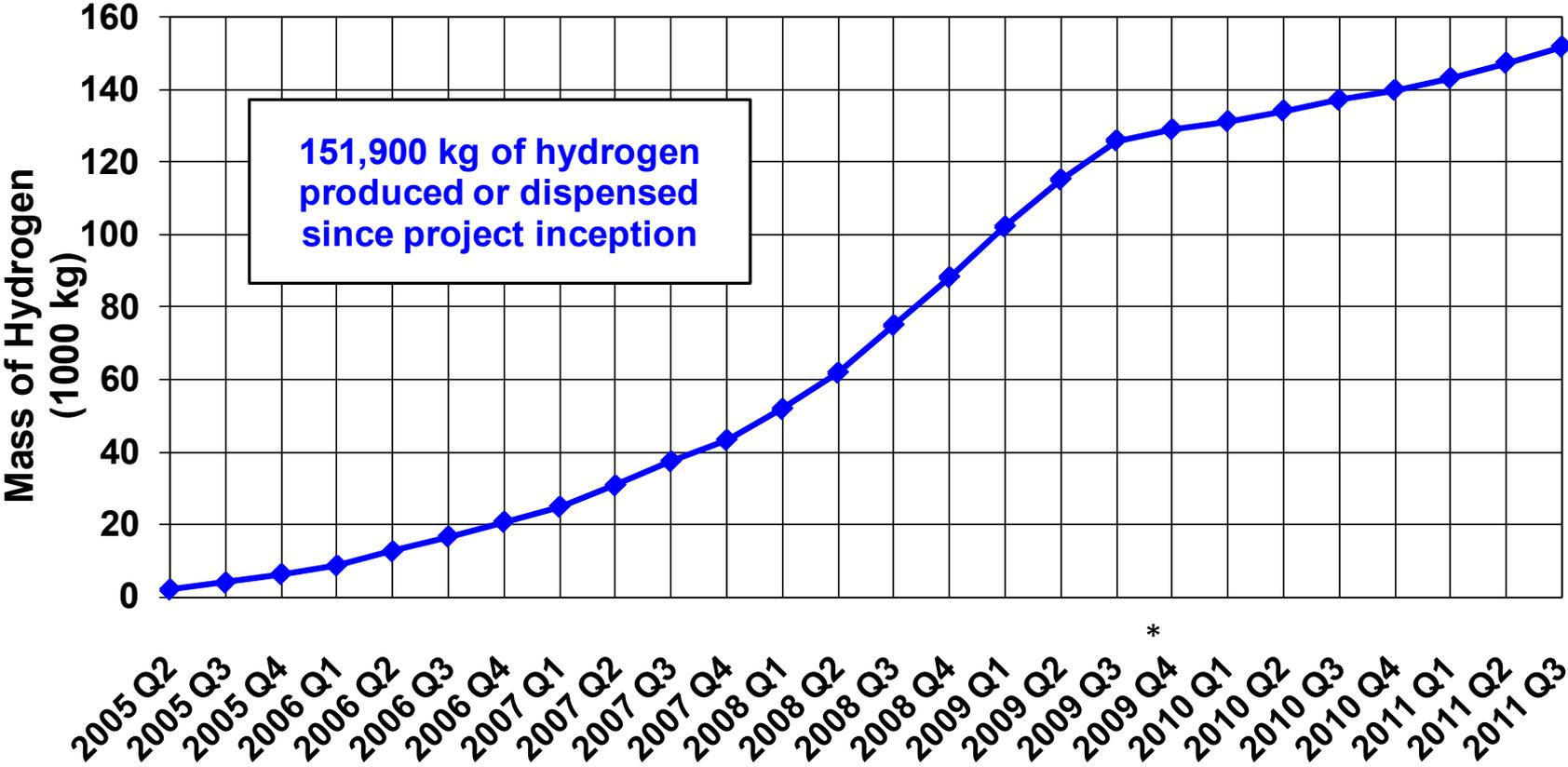


CDP#25: Vehicle H2 Storage Technologies

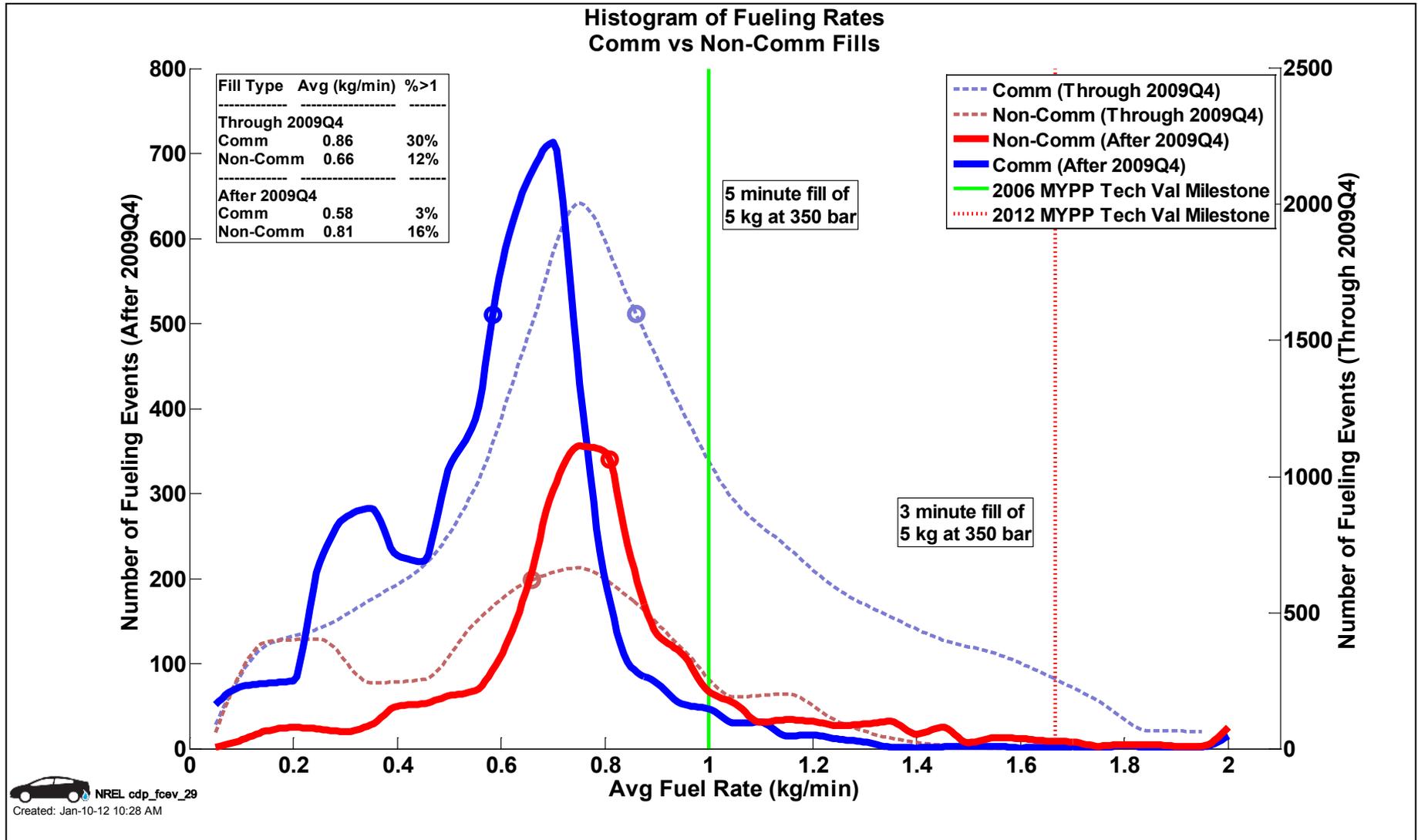


CDP#26: Cumulative H2 Produced or Dispensed

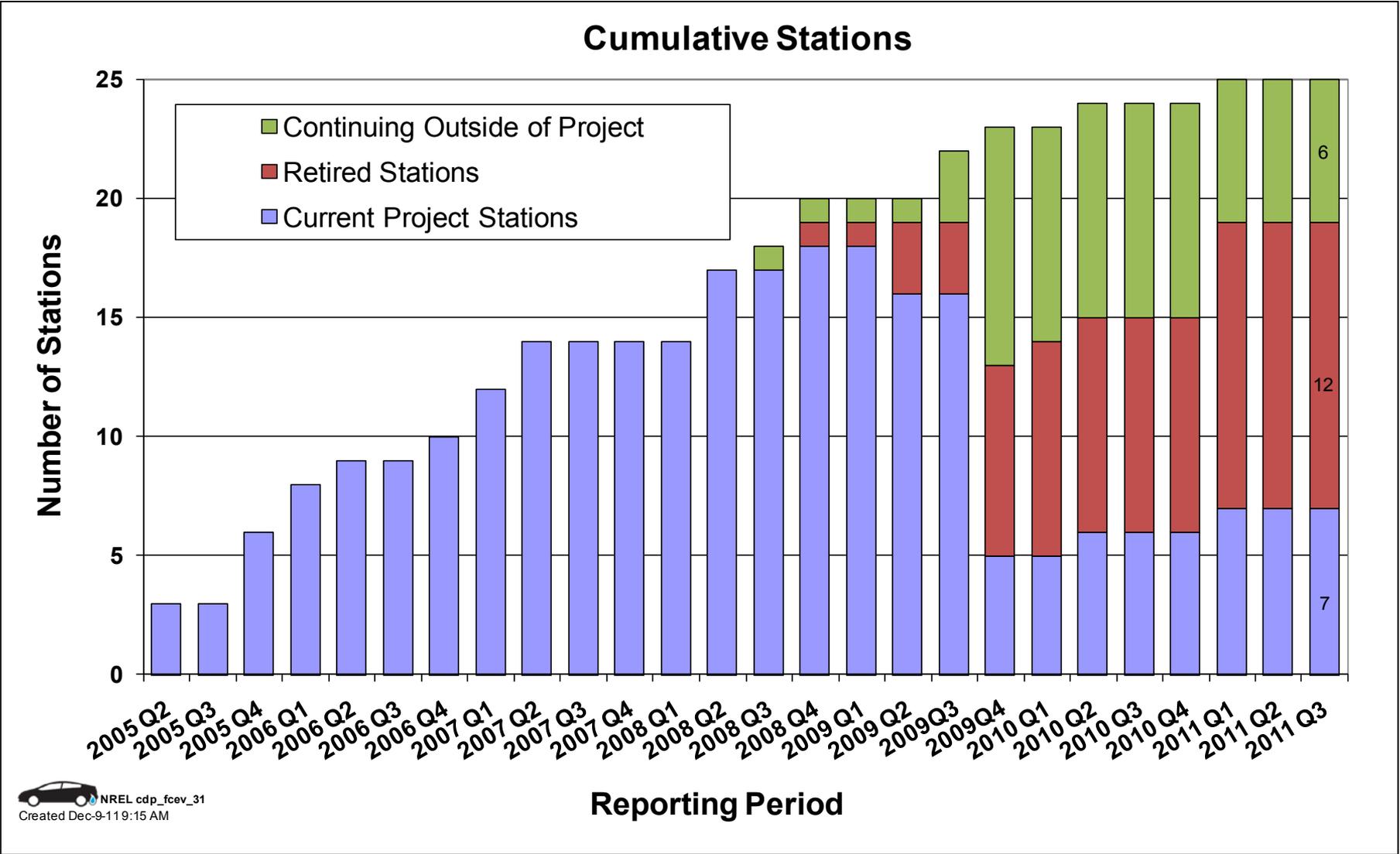
Cumulative Hydrogen Produced or Dispensed Through 2011 Q3



CDP#29: Fueling Rates by Communication Type

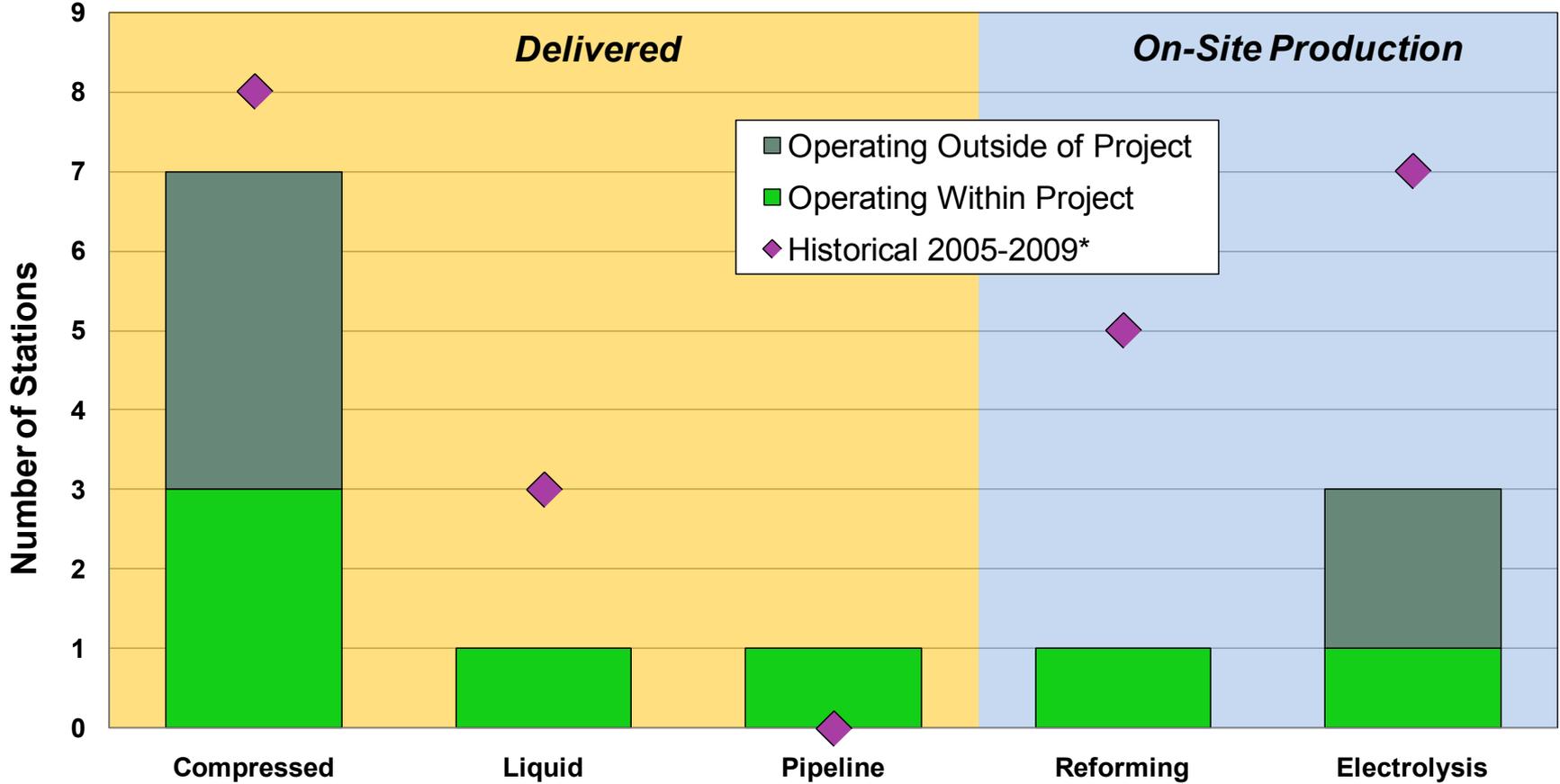


CDP#31: Number of Online Stations



CDP#32: Infrastructure Hydrogen Production Methods

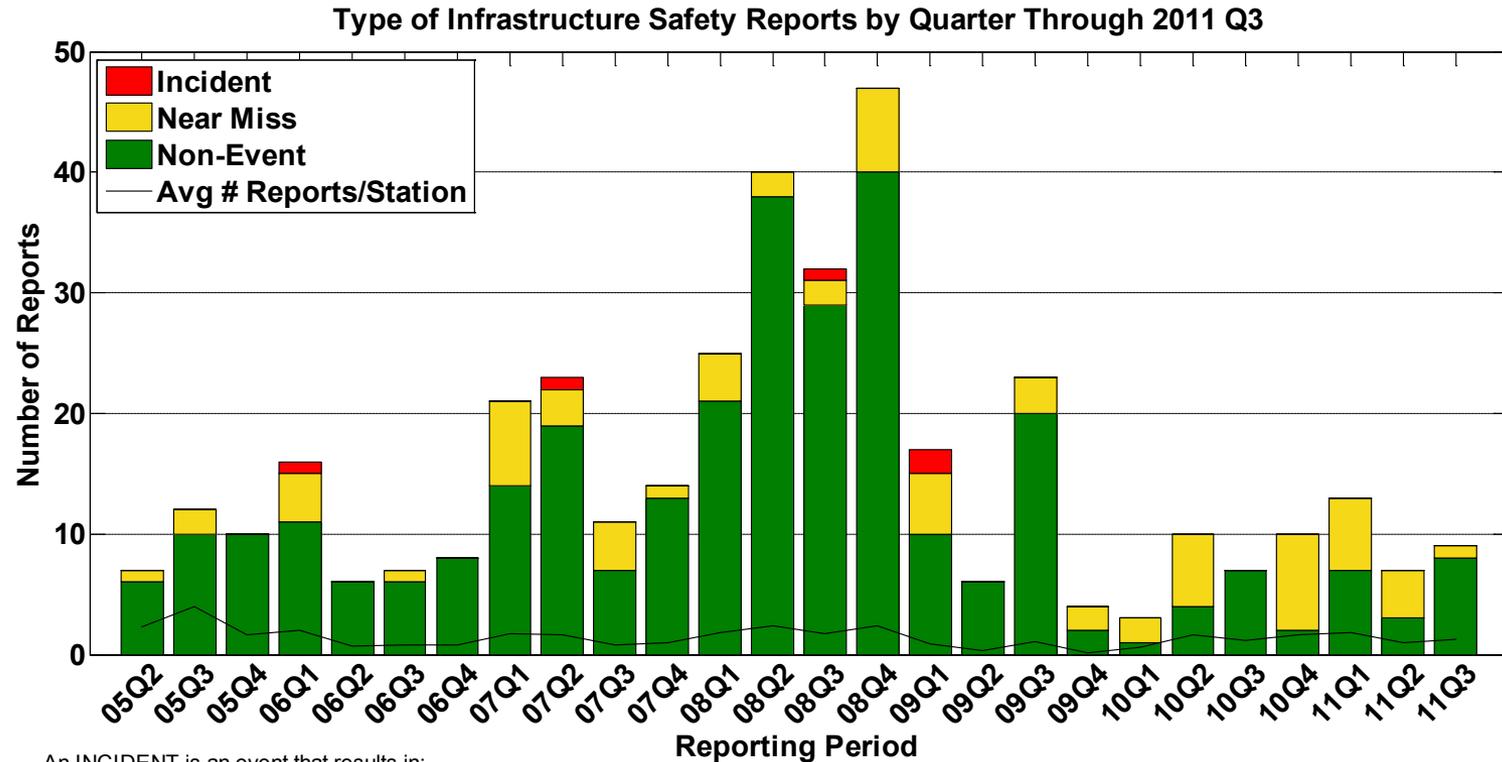
Learning Demonstration Hydrogen Stations by Type



 NREL cdp_fcav_32
Created Dec-9-11 9:15 AM

*Some project teams concluded Fall/Winter 2009. Markers show the cumulative stations operated during the 2005-2009 period

CDP#36: Type of Infrastructure Safety Report By Quarter



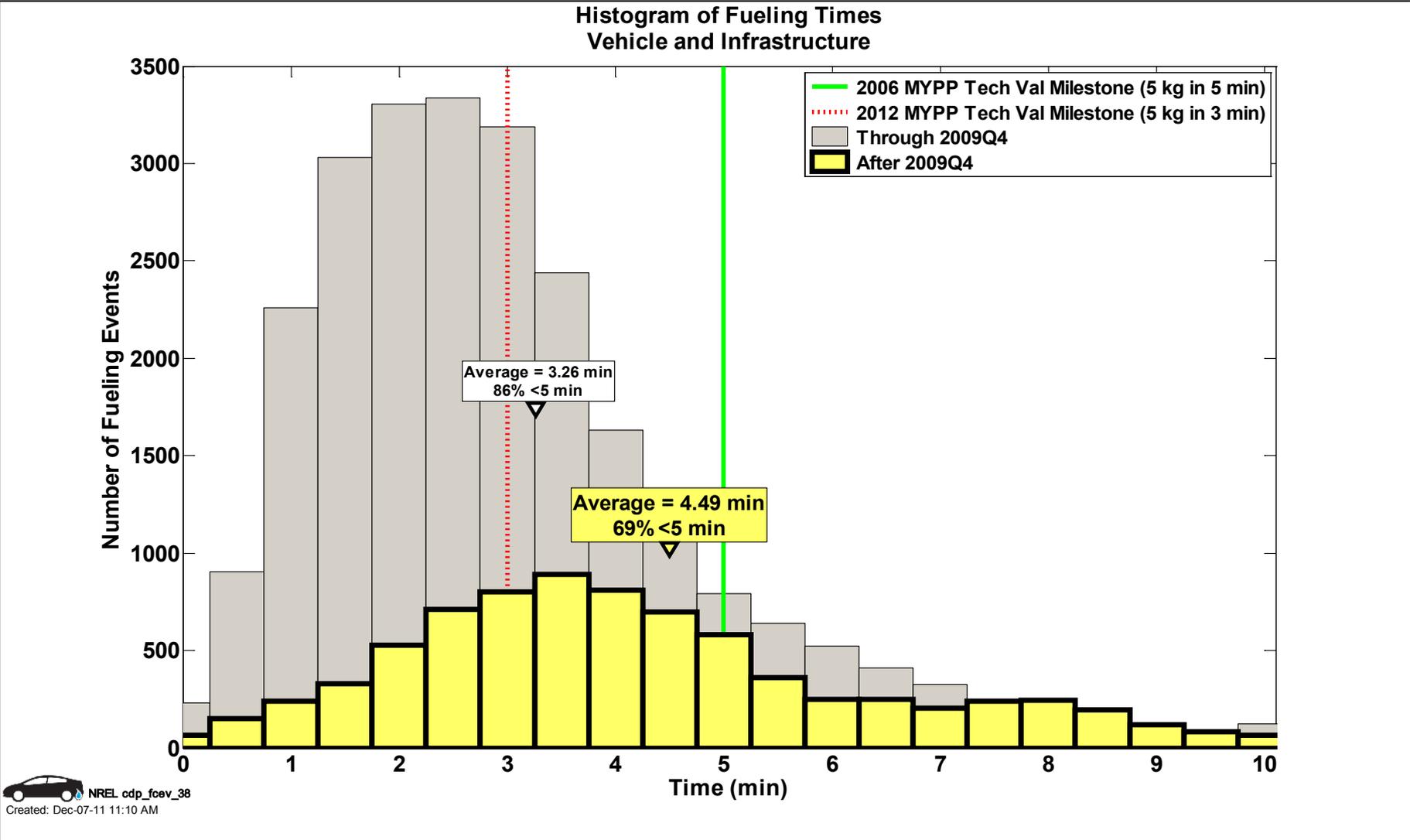
An INCIDENT is an event that results in:

- 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)

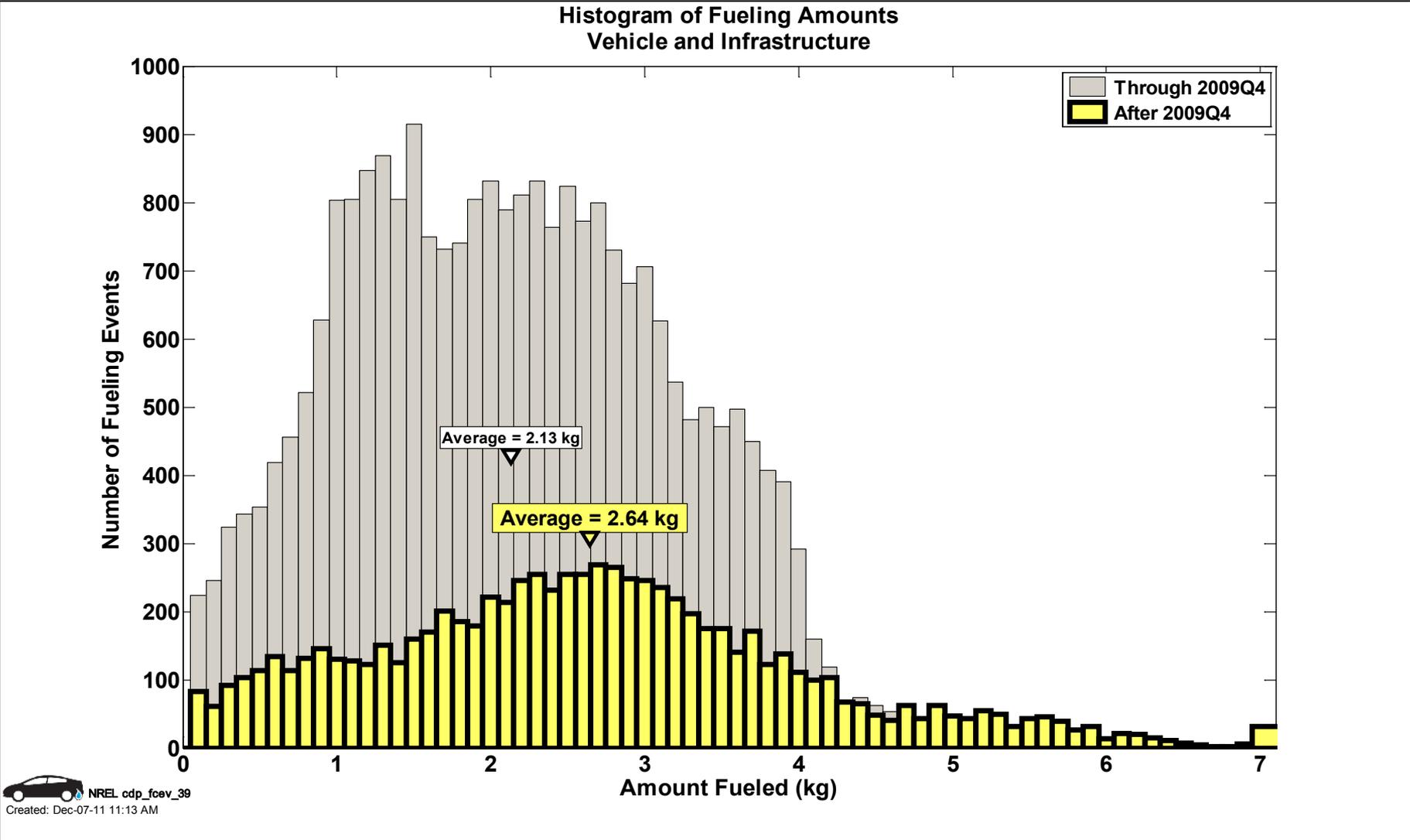
A NEAR-MISS is:

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

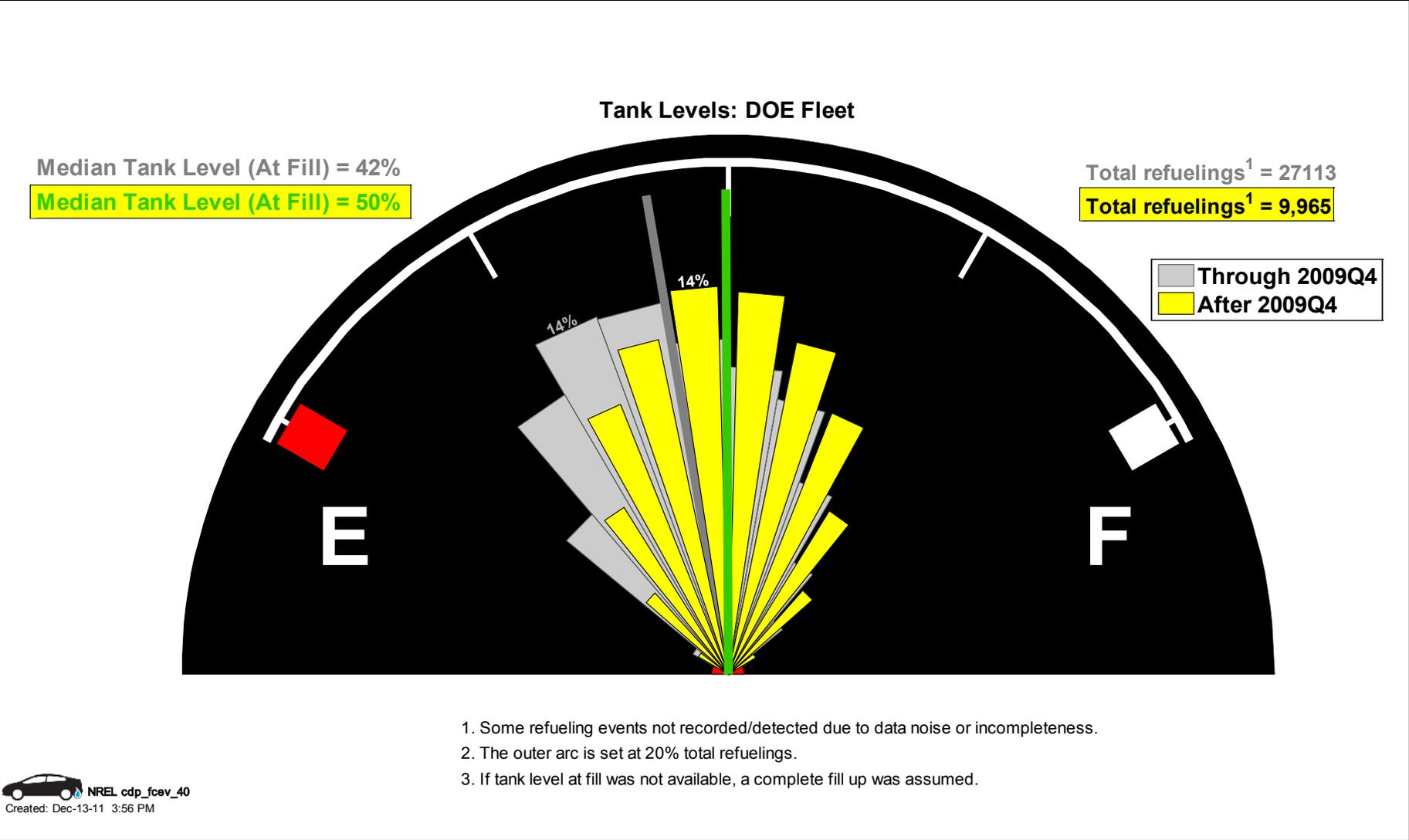
CDP#38: Refueling Times



CDP#39: Refueling Amounts



CDP#40: H2 Tank Level at Refueling



CDP#42: Refueling by Time of Day

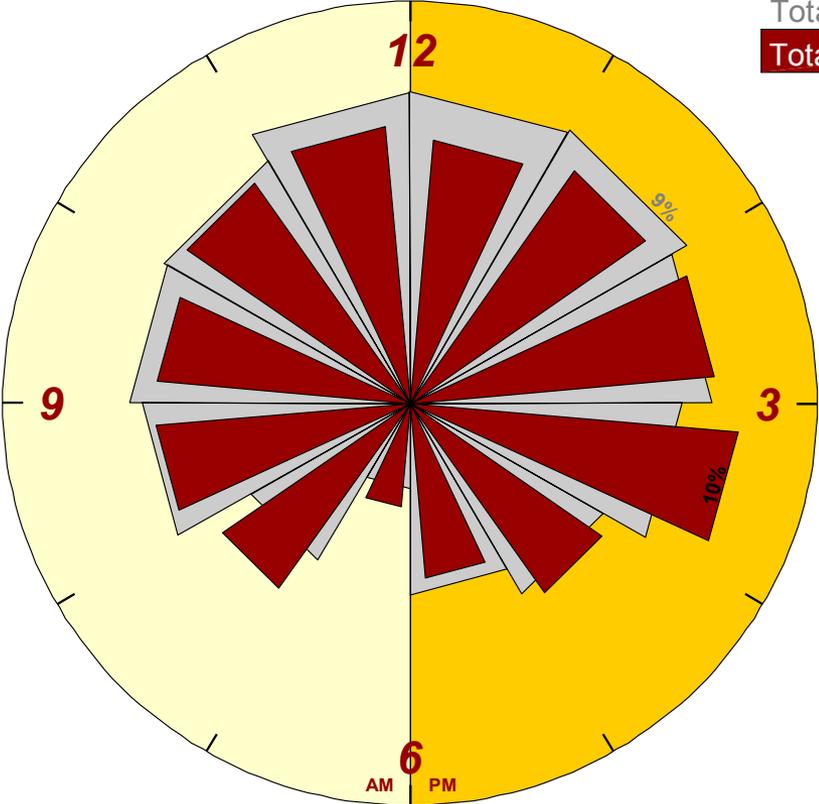
Refueling by Time of Day

% of fills b/t 6 AM & 6 PM: 89.7%

% of fills b/t 6 AM & 6 PM: 88.3%

Total Fill³ Events = 22657

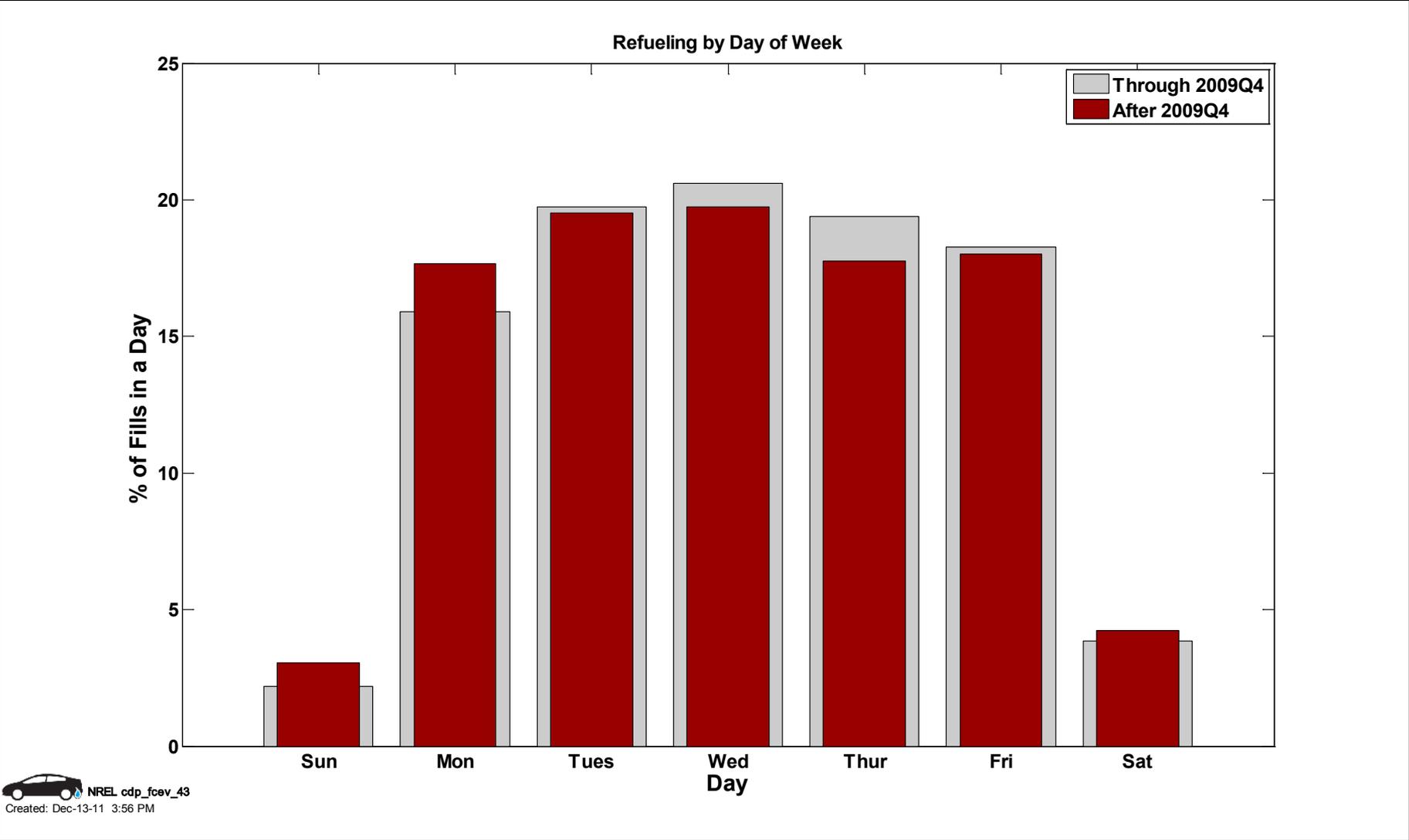
Total Fill³ Events = 9983



Through 2009Q4
After 2009Q4

- 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.

CDP#43: Refueling by Day of Week



CDP#44: Driving Start Time – Day

Driving by Time of Day

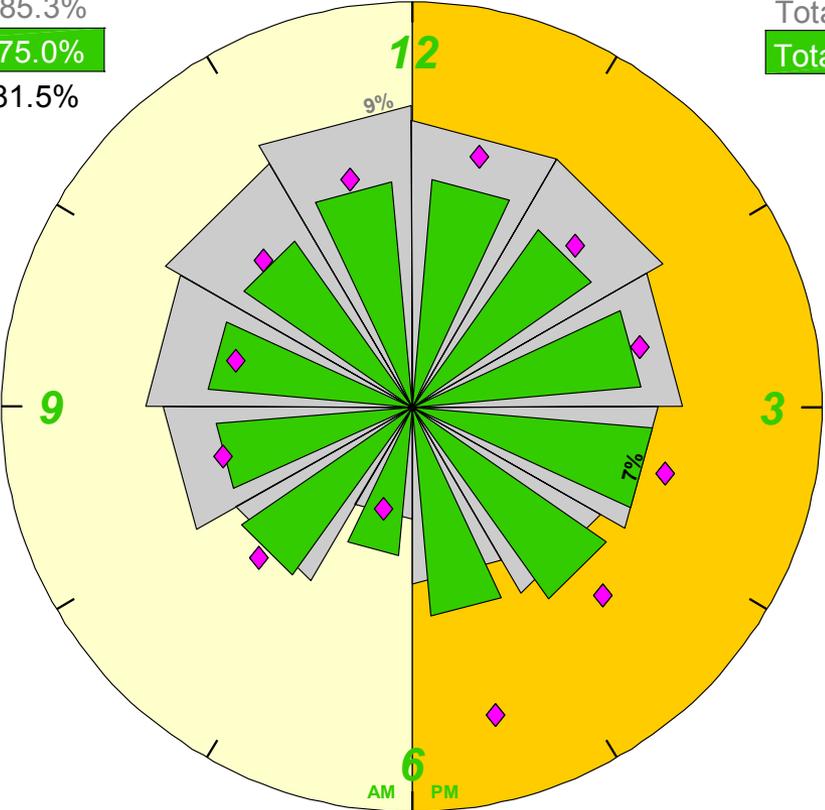
% of driving trips b/t 6 AM & 6 PM: 85.3%

% 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

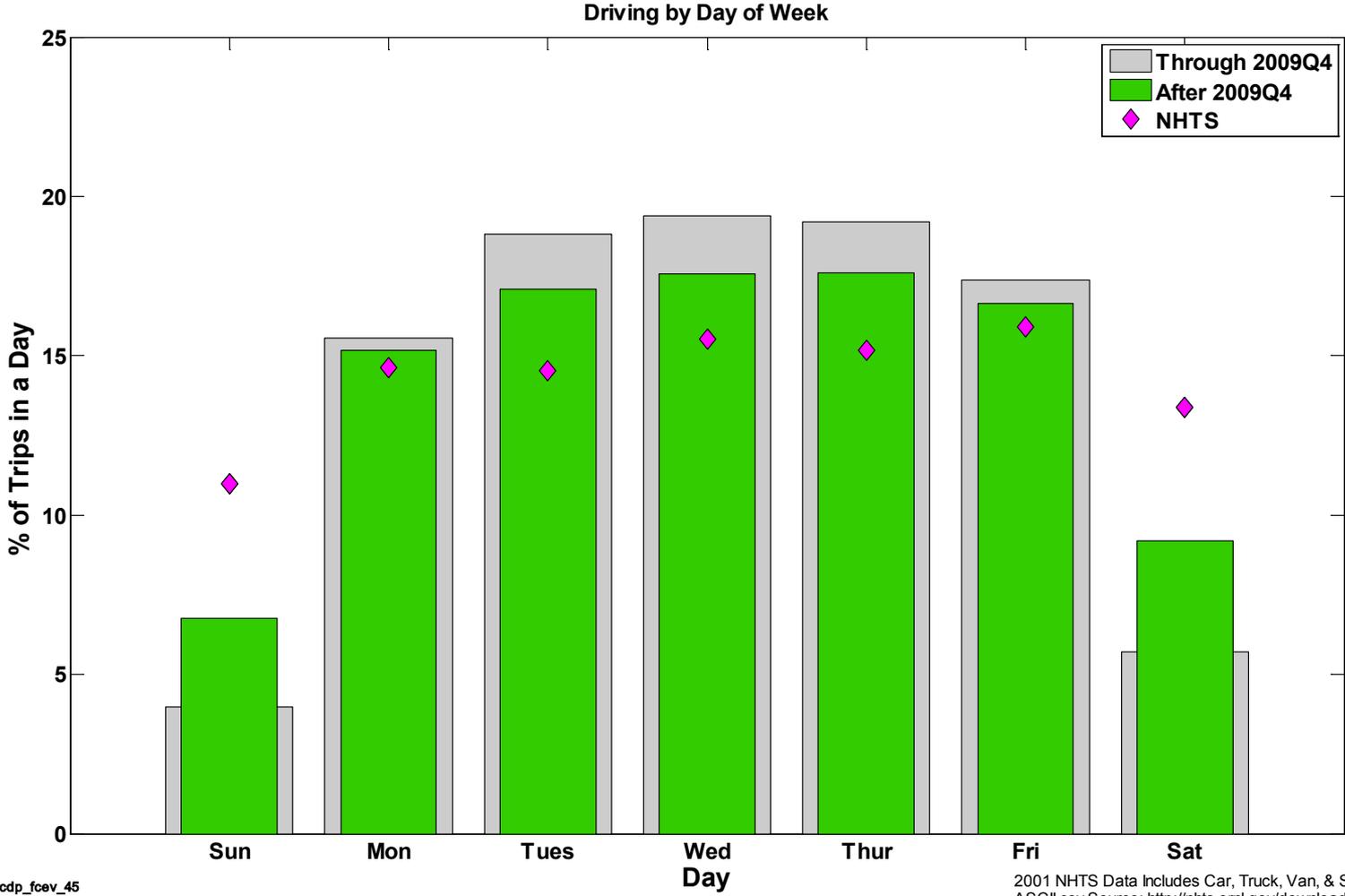


Through 2009Q4
 After 2009Q4
 NHTS

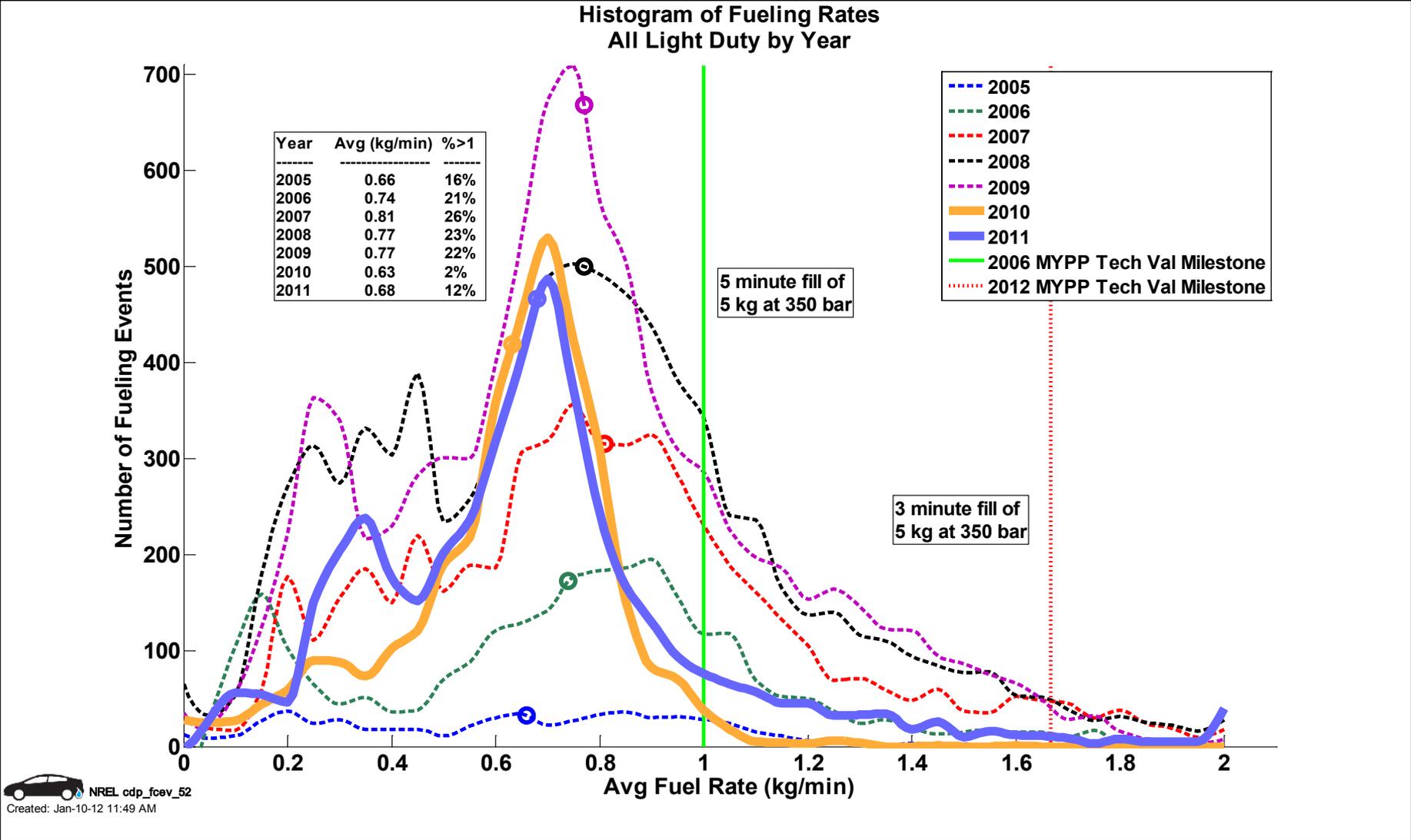
1. Driving trips between 6 AM & 6 PM
2. The outer arc is set at 12 % total Driving.
3. Some events not recorded/detected due to data noise or incompleteness.

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

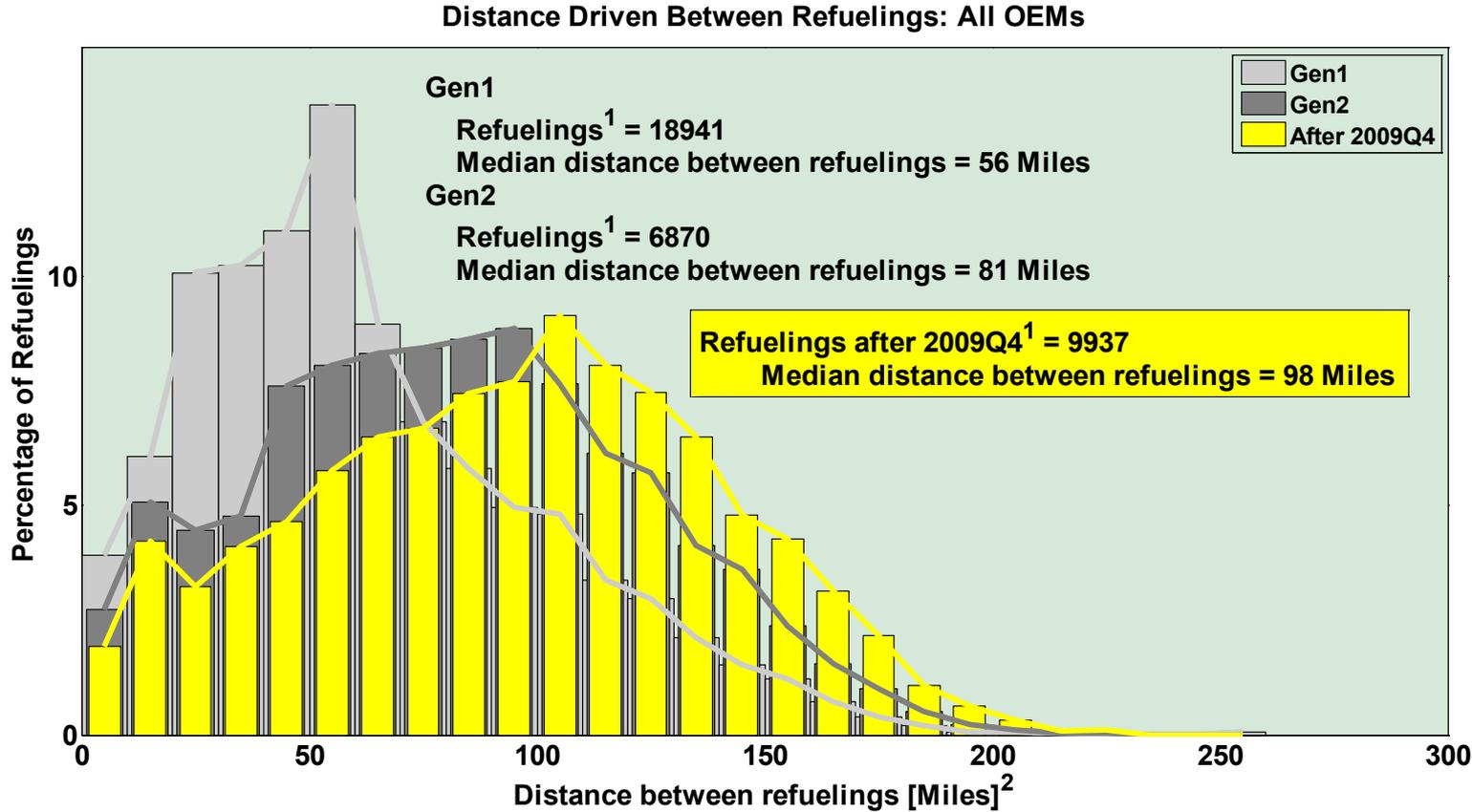
CDP#45: Driving by Day of Week



CDP#52: Fueling Rates by Year

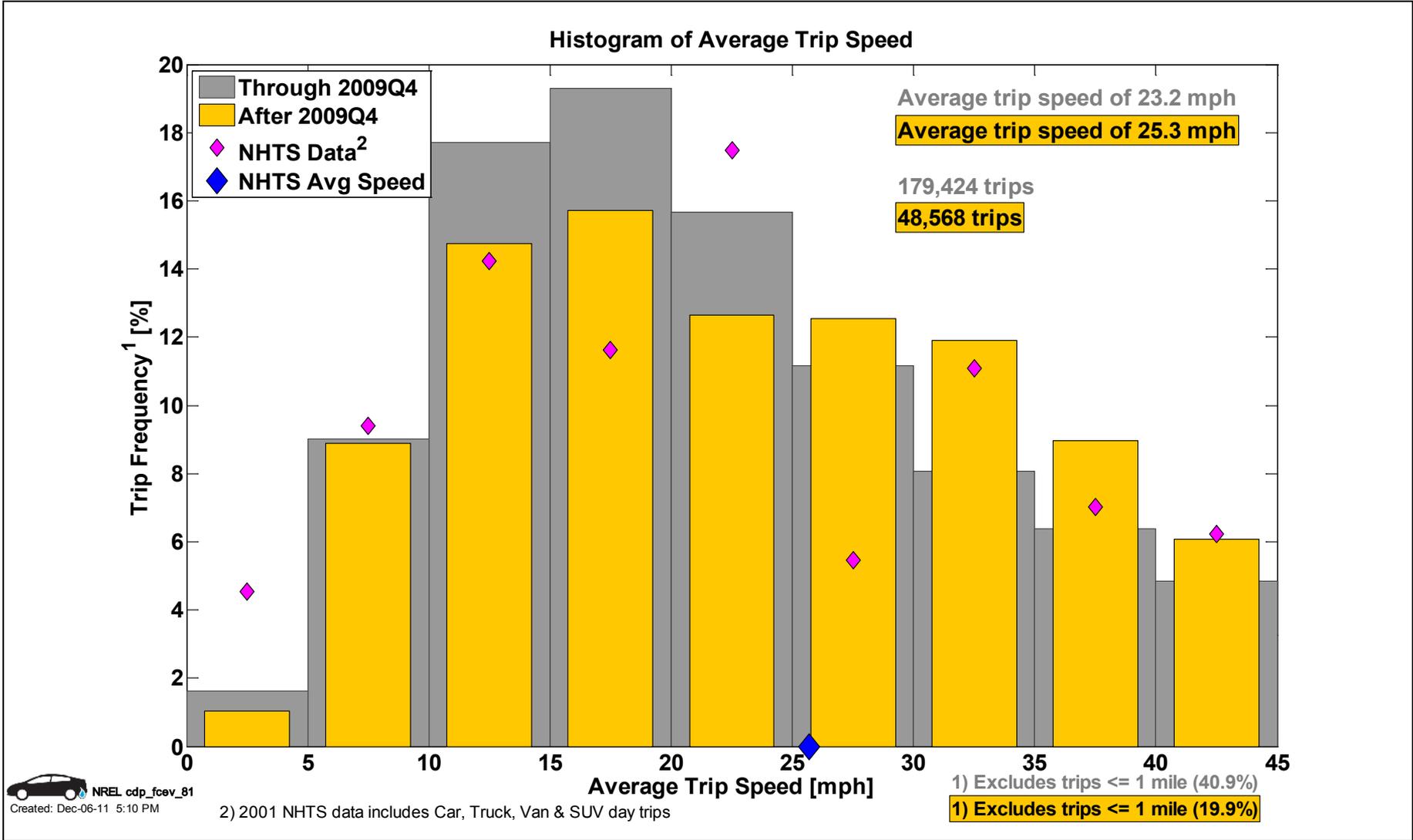


CDP#80: Miles Between Refuelings

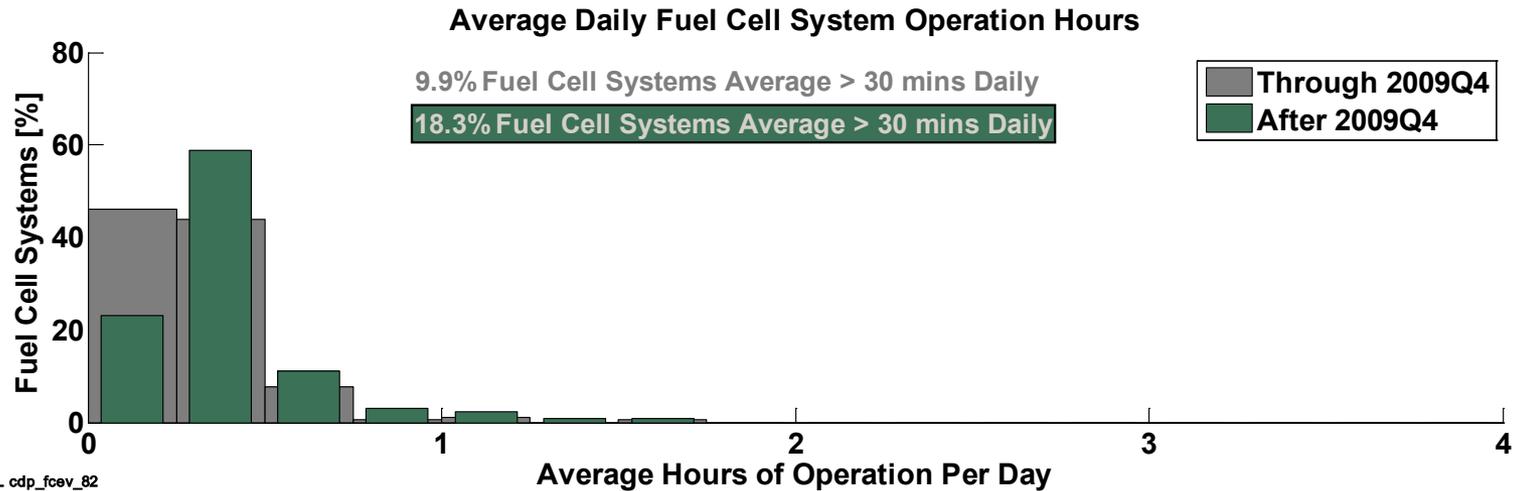
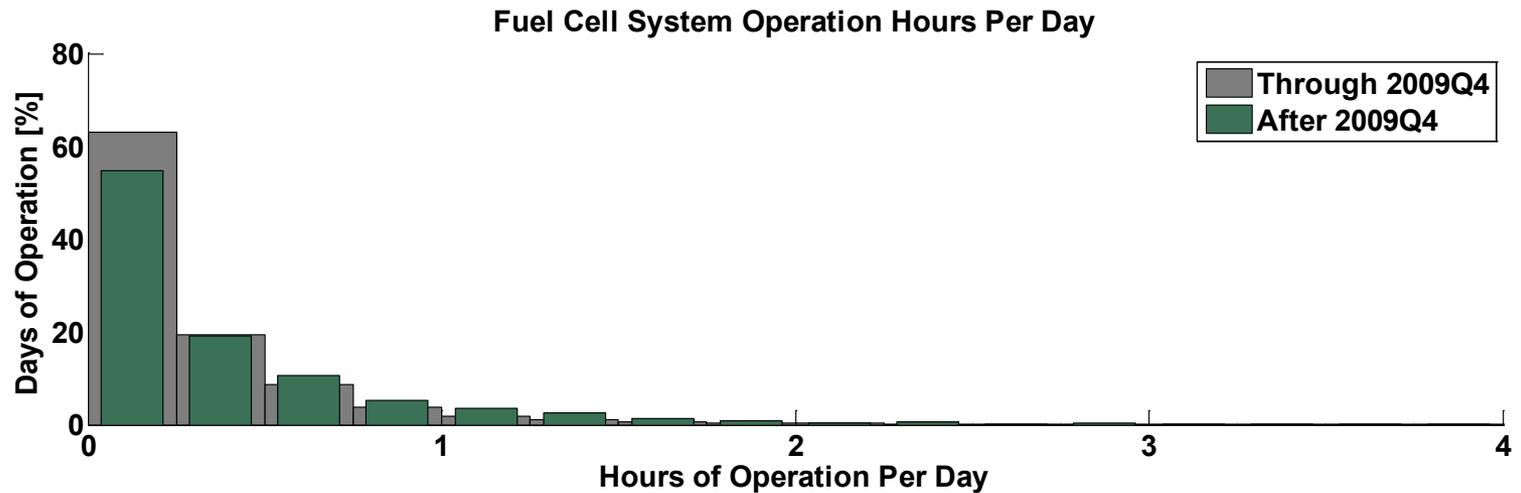


1. Some refueling events are not detected/reported due to data noise or incompleteness.
 2. Distance driven between refuelings is indicative of driver behavior and does not represent the full range of the vehicle.

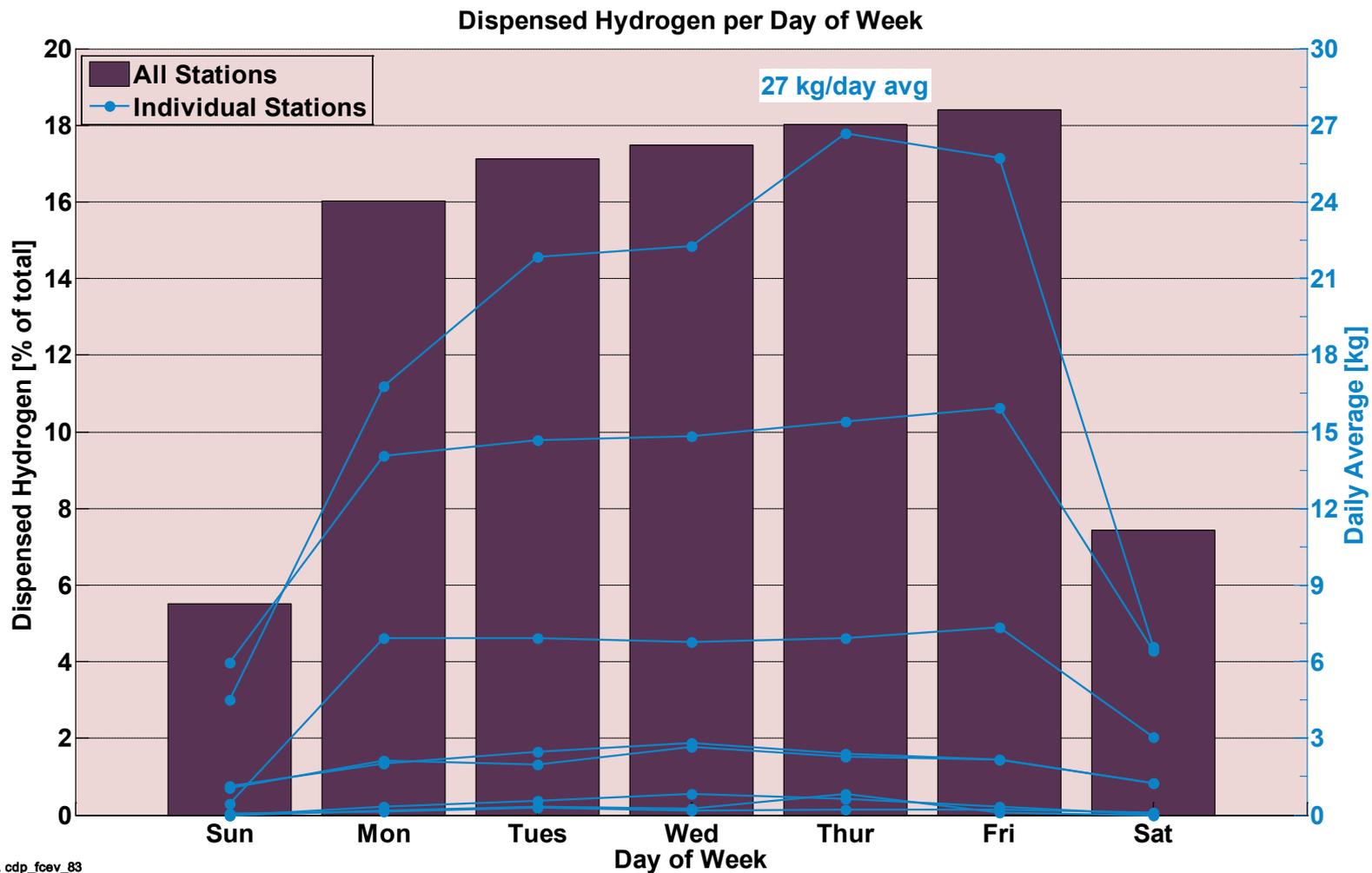
CDP#81: Average Trip Speed



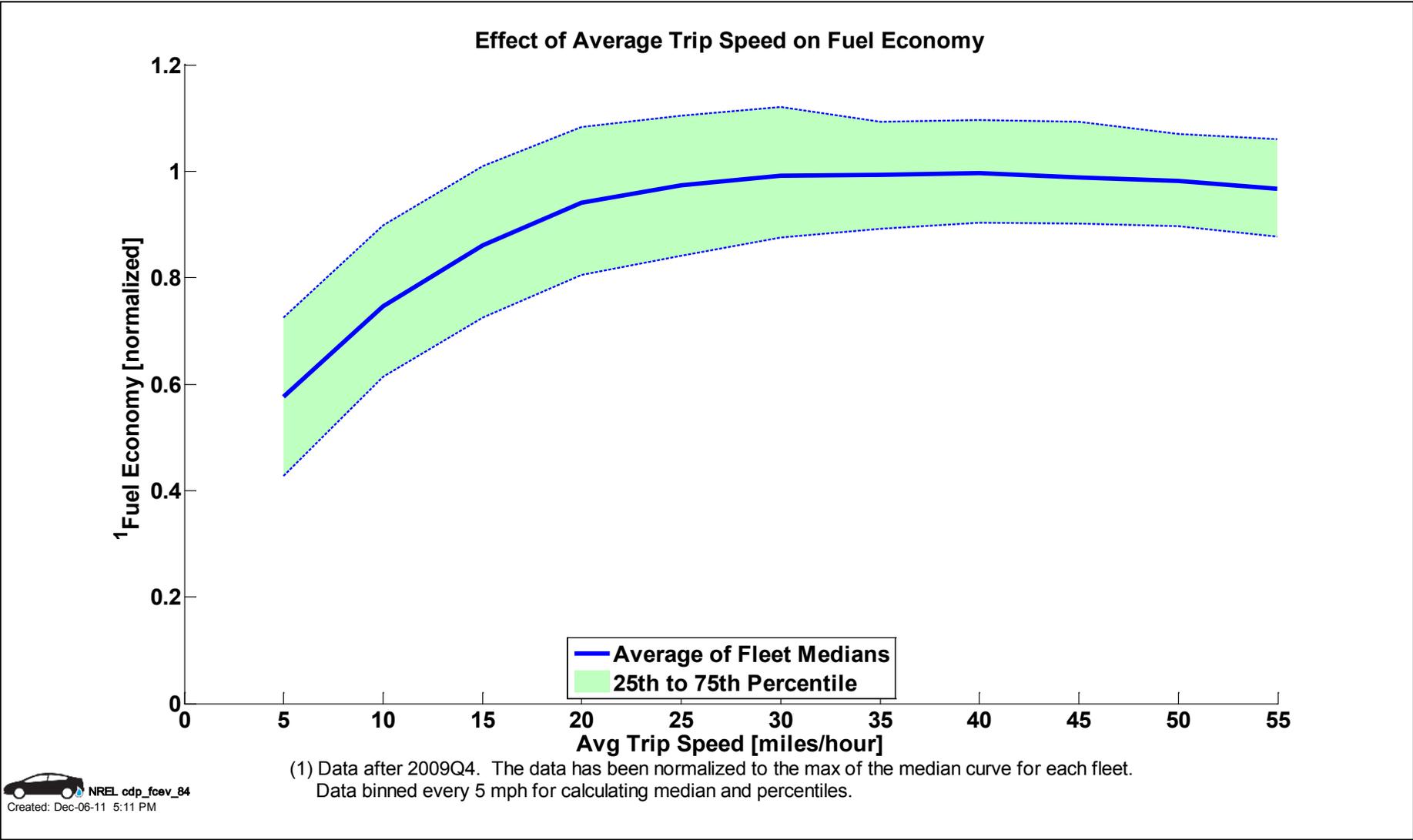
CDP#82: Daily FC Operation Hours in Automotive Application



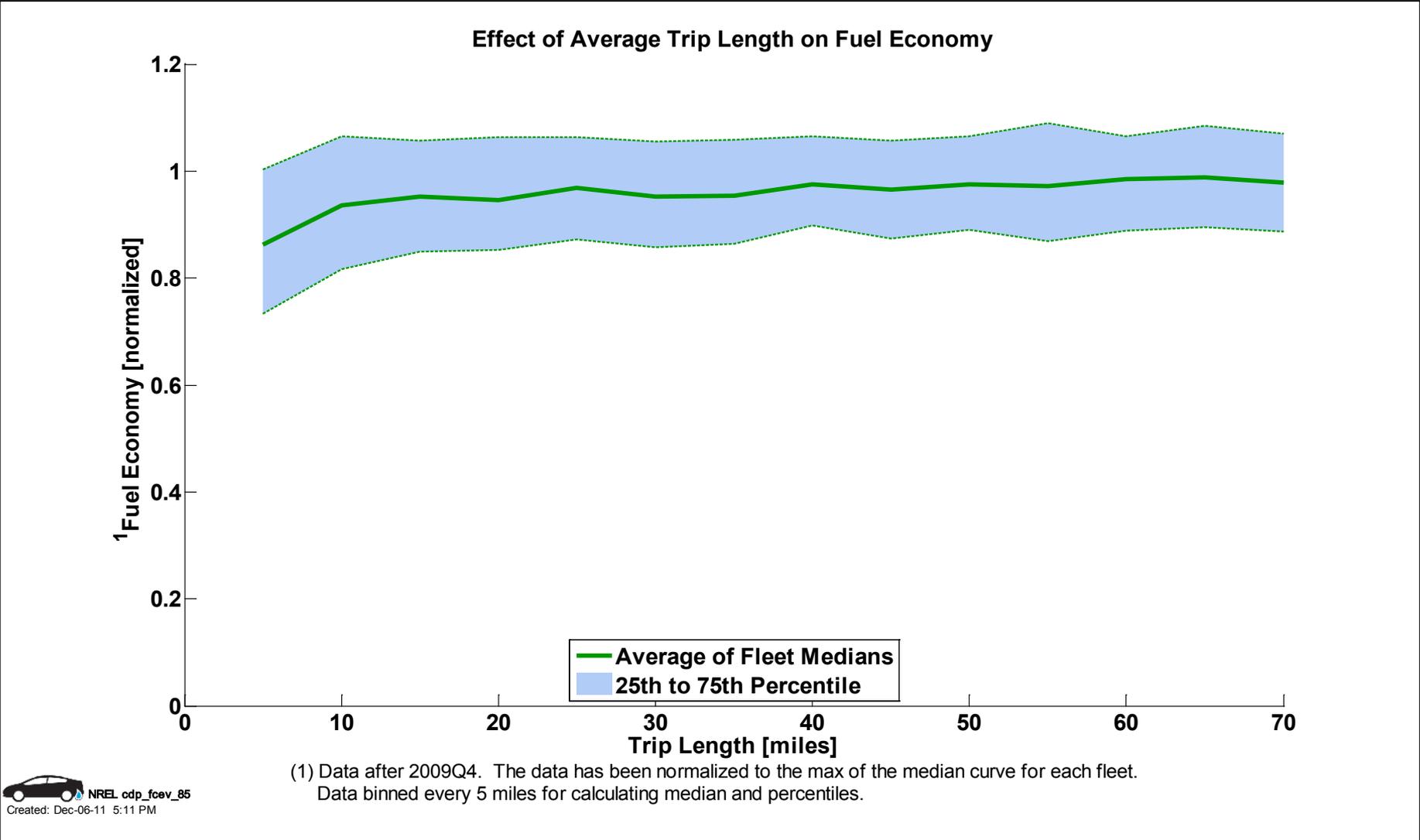
CDP#83: Hydrogen Dispensed by Day of Week



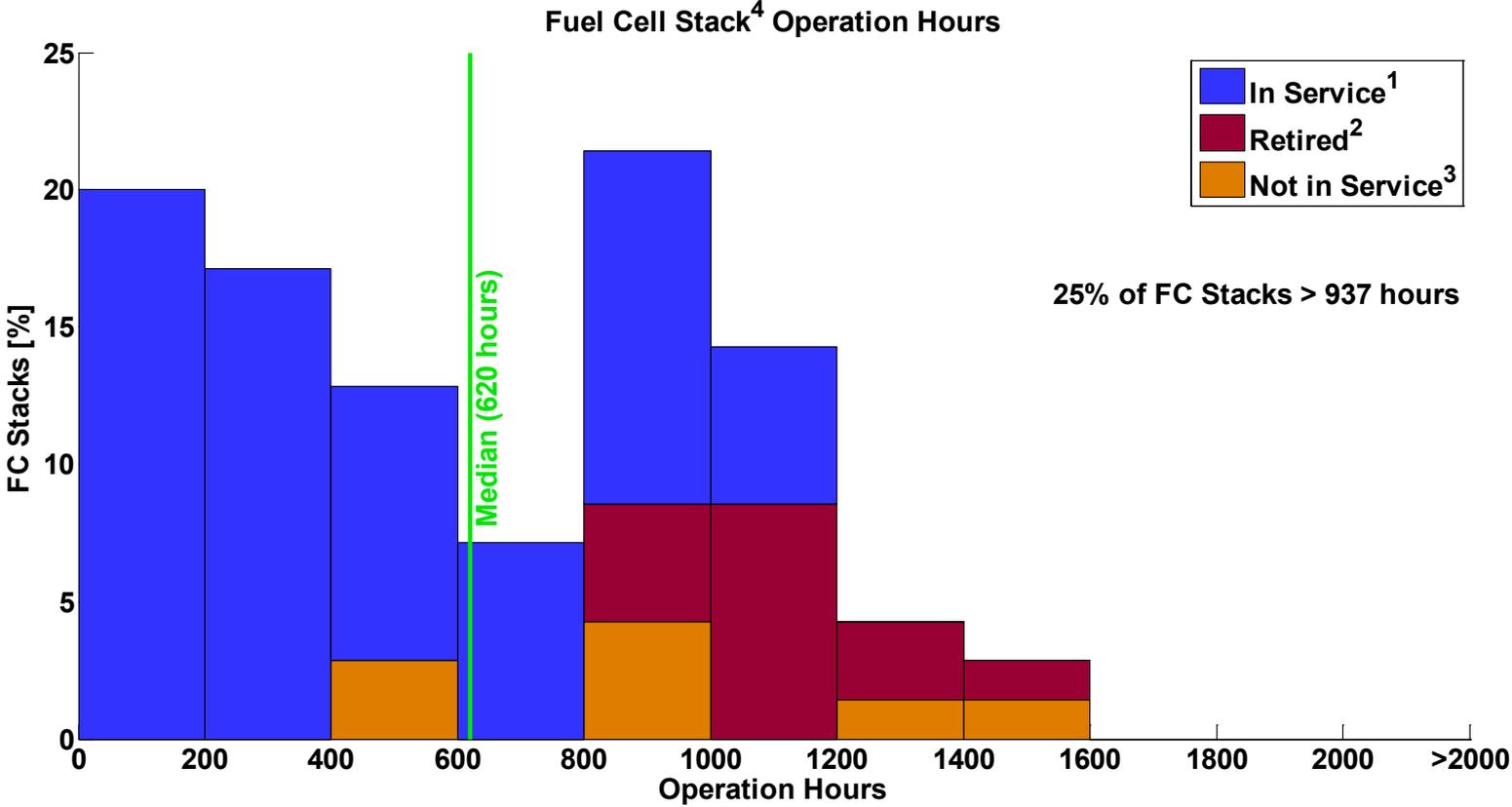
CDP#84: Effect of Average Trip Speed on Fuel Economy



CDP#85: Effect of Trip Length on Fuel Economy

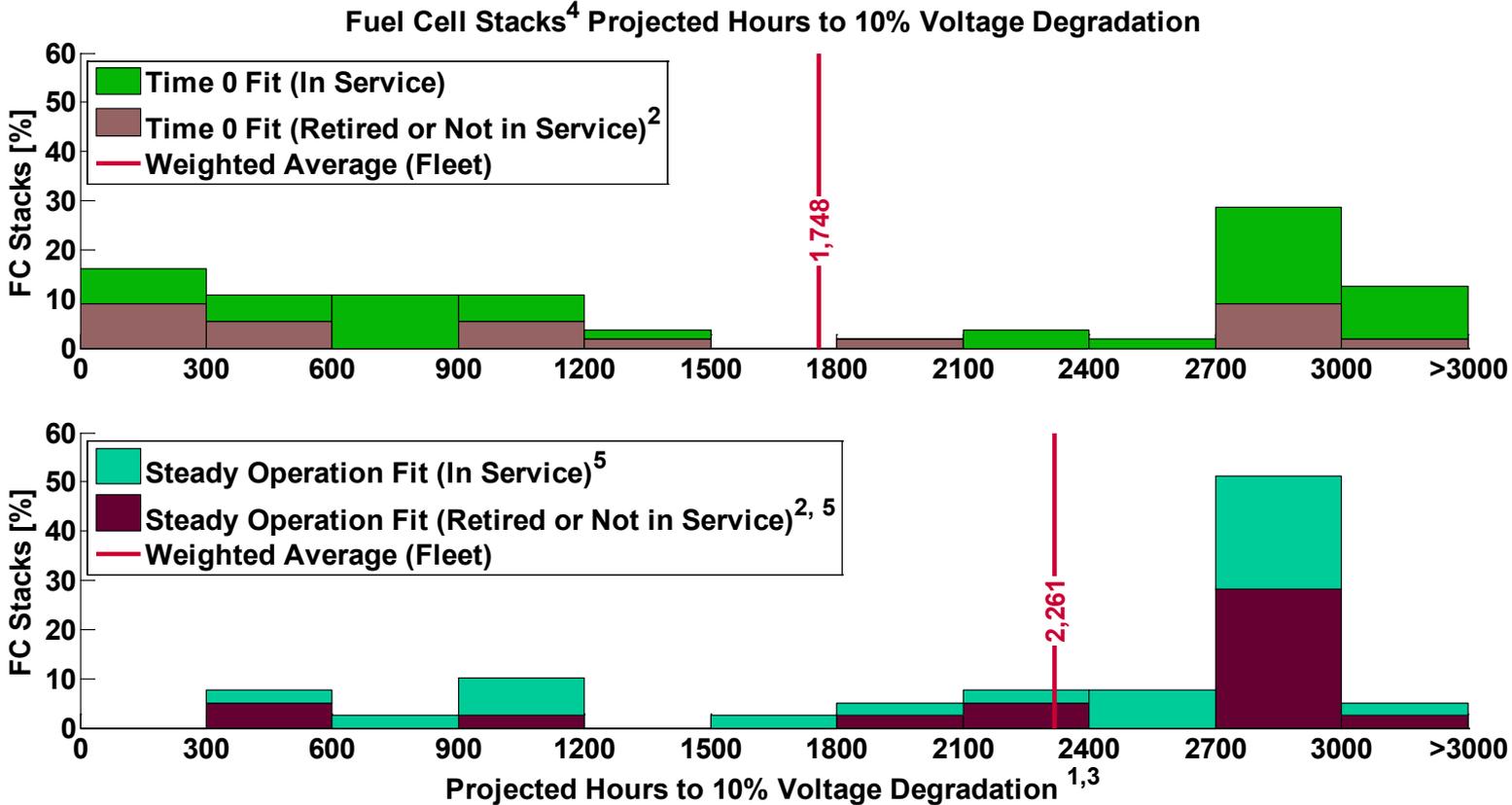


CDP#86: Fuel Cell Stack Operation Hours



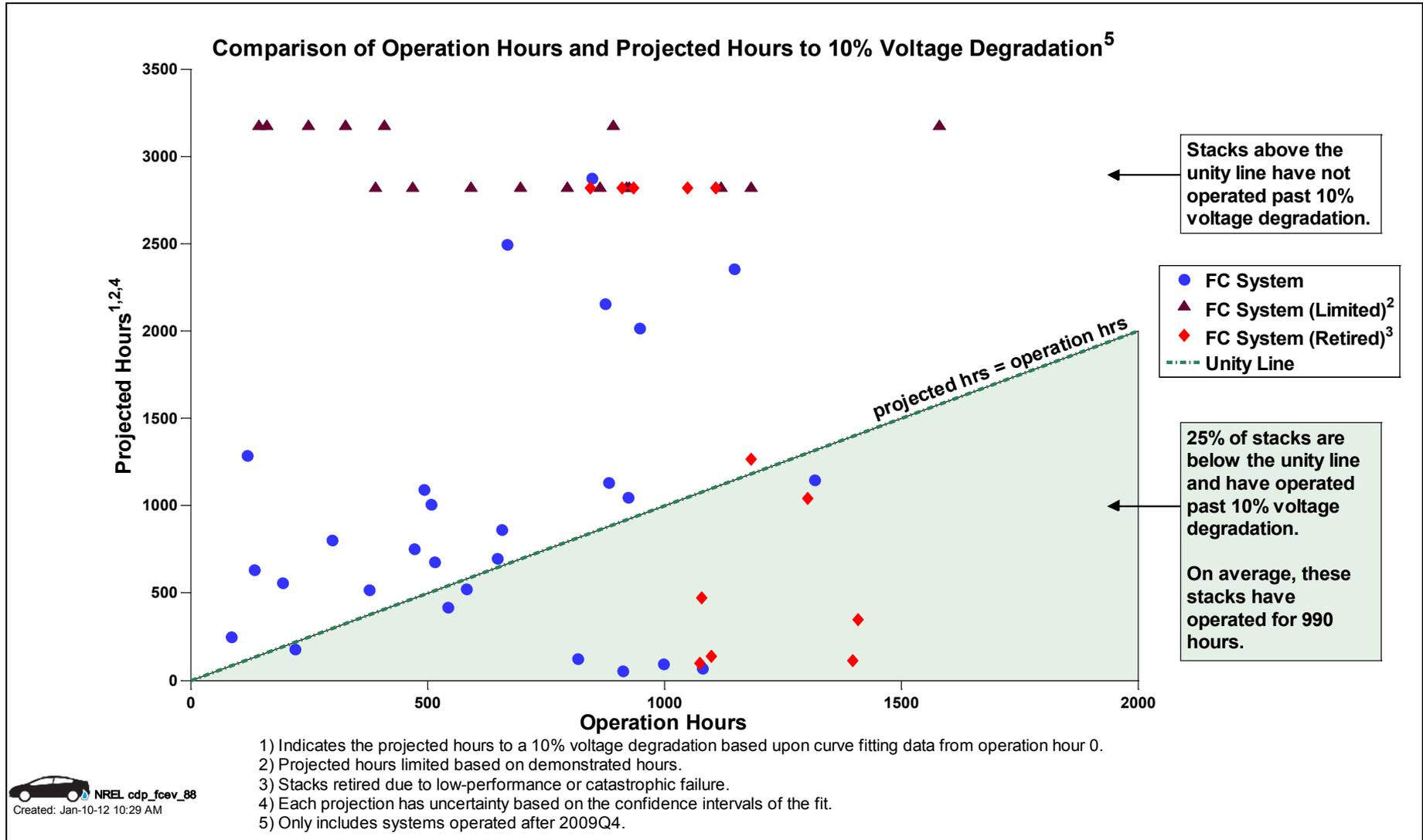
- 1) Stacks that are in service and accumulating operation hours.
- 2) Stacks retired due to low-performance or catastrophic failure.
- 3) Indicates stacks that are no longer accumulating hours either a) temporarily or b) have been retired for non-stack performance related issues or c) removed from DOE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

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

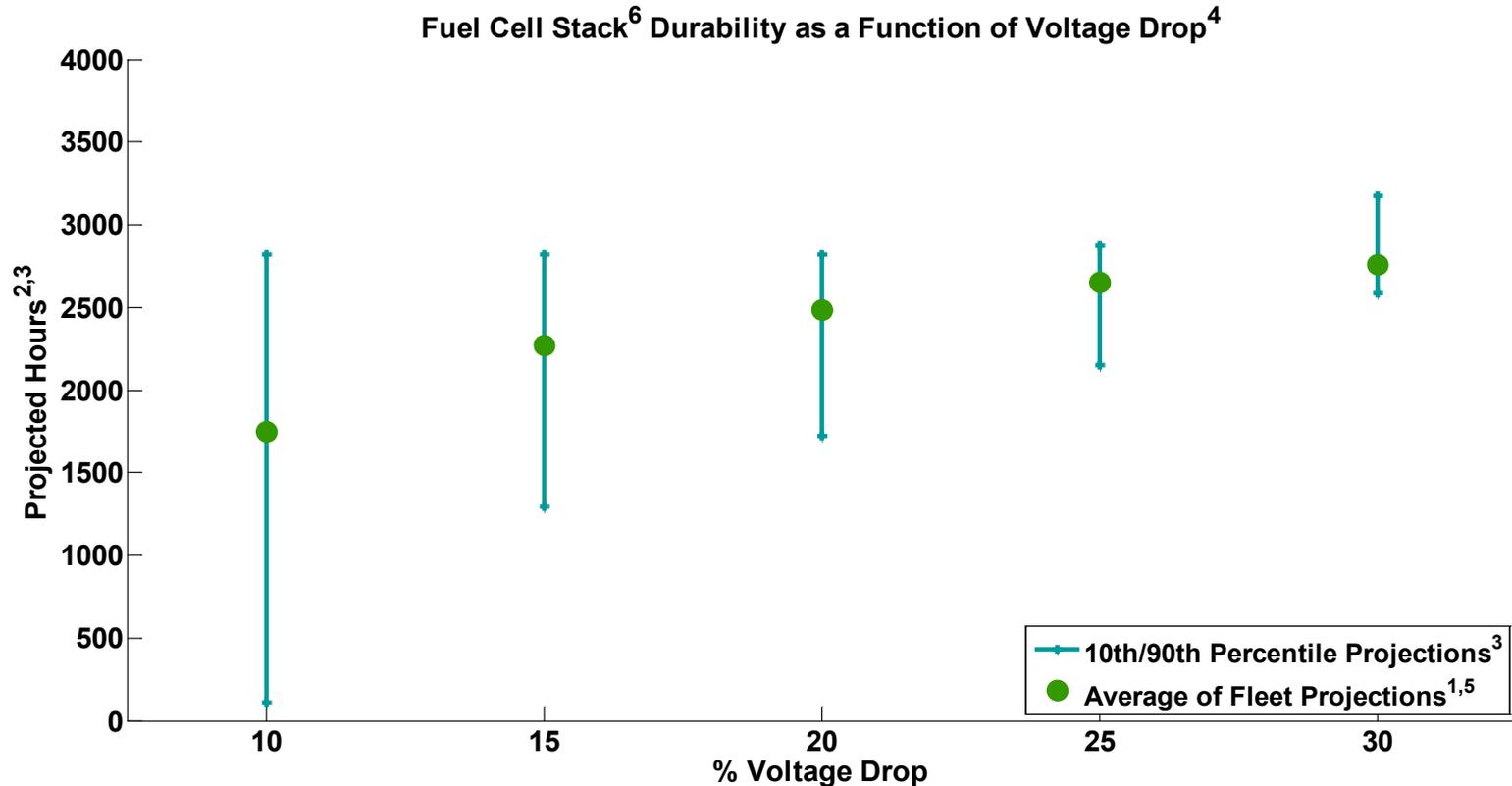


1) Projection using field data, calculated at high stack current, from operation hour 0 or a steady operation period. Projected hours may differ from an OEM's end-of-life criterion and does not address "catastrophic" failure modes.
 2) Indicates stacks that are no longer accumulating hours either a) 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

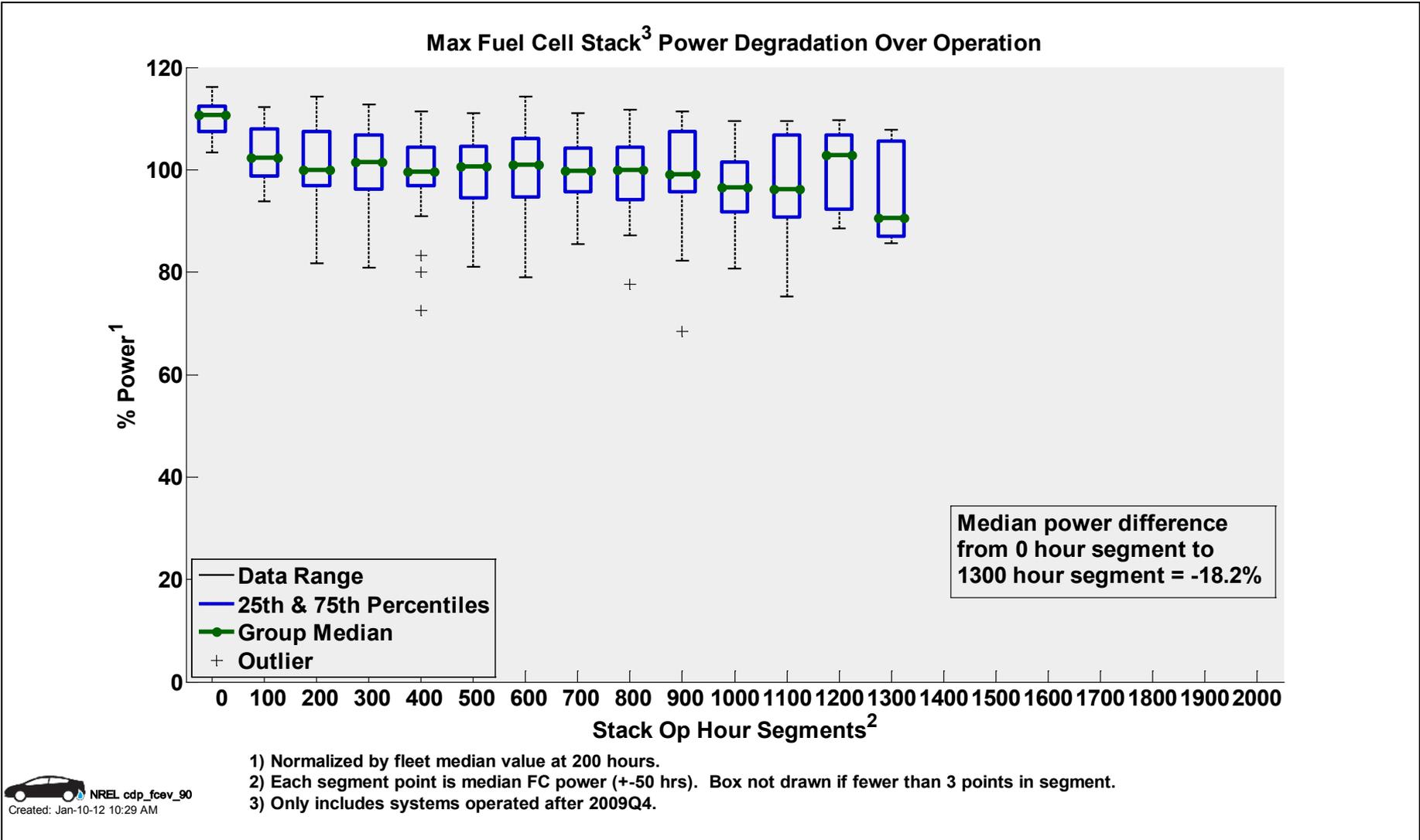


CDP#89: Fuel Cell Stack Durability as a Function of Voltage Drop

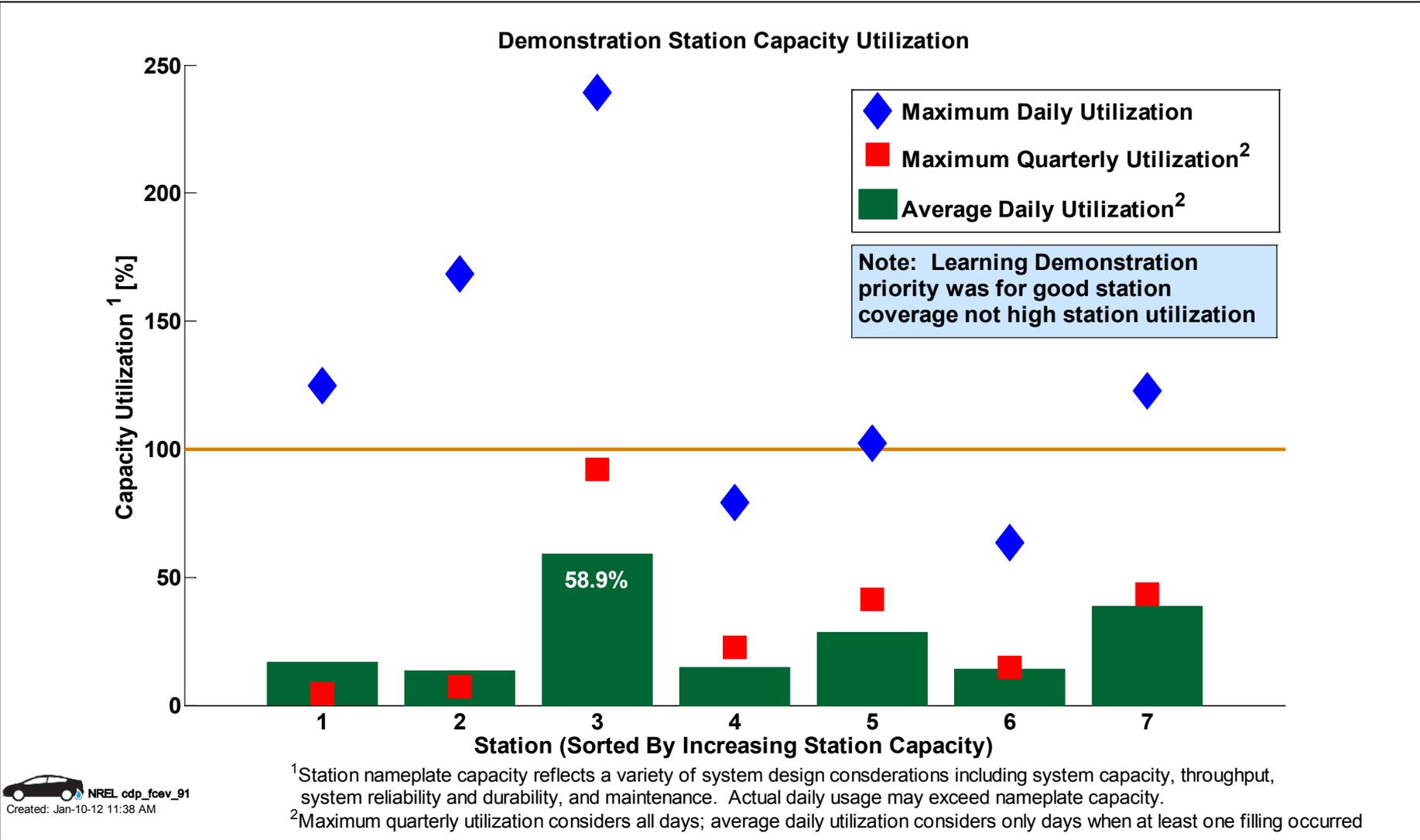


- 1) 10% Voltage degradation is a DOE metric for assessing fuel cell performance not an indication of an OEM's end-of-life criteria.
- 2) Projections using field data and calculated at high stack current.
- 3) 10th and 90th percentiles spans the range of stack projection. The included stacks satisfy 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.

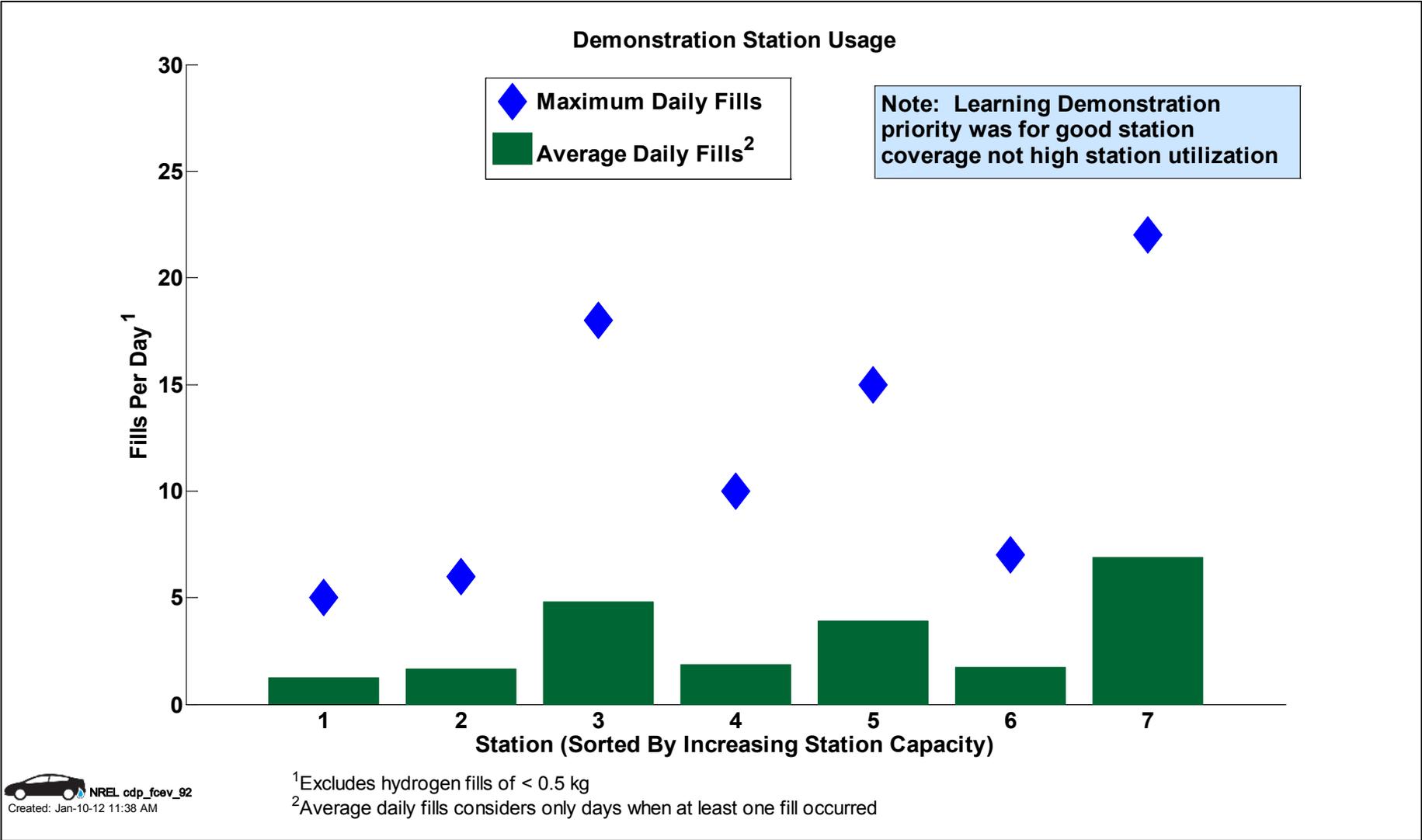
CDP#90: Max Fuel Cell Stack Power Degradation Over Operation



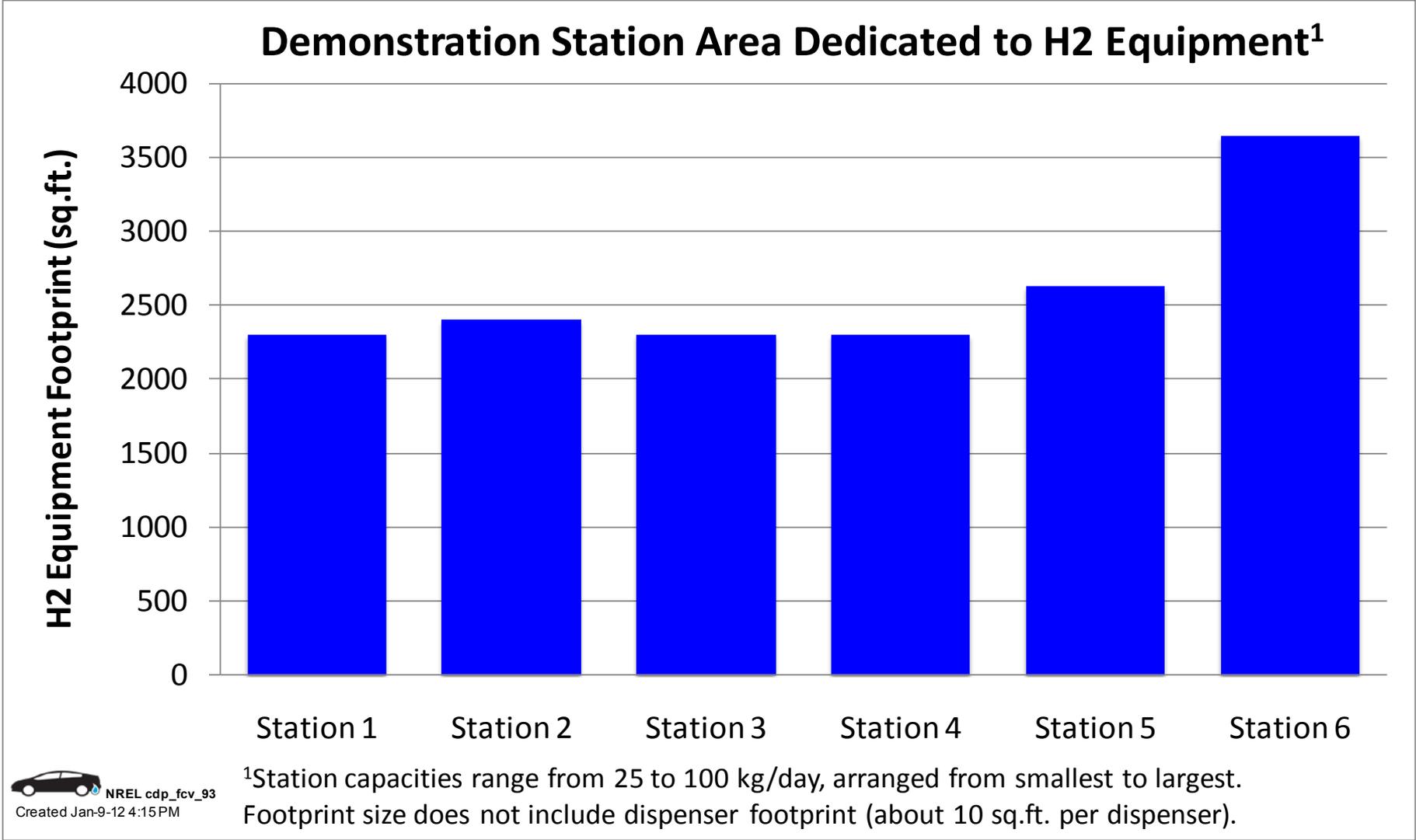
CDP#91: Station Capacity Utilization



CDP#92: Station Usage (fills per day)

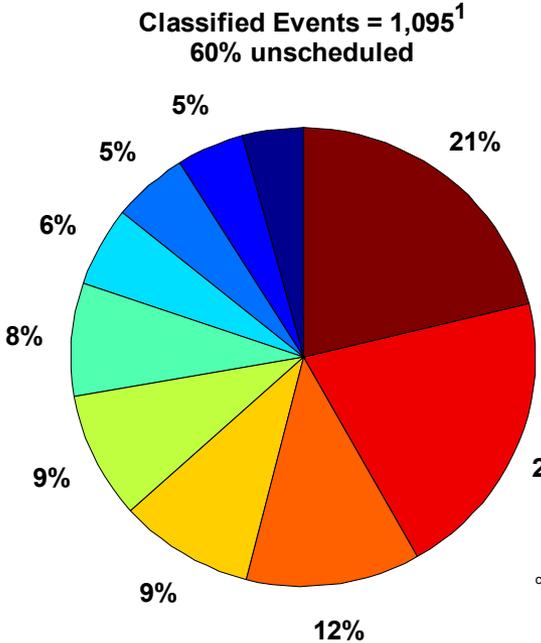


CDP#93: Hydrogen Equipment Footprint

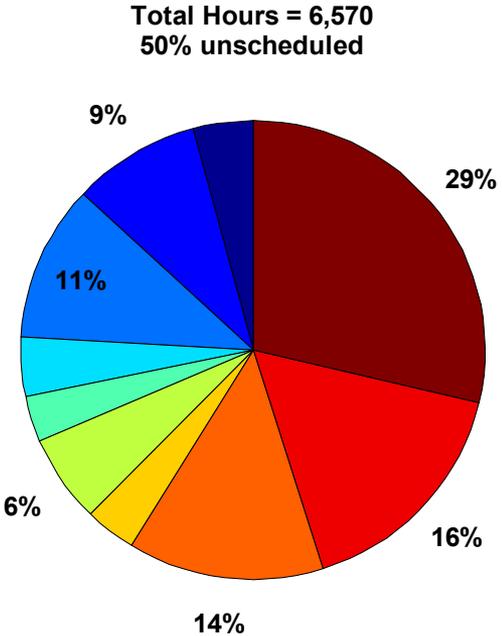
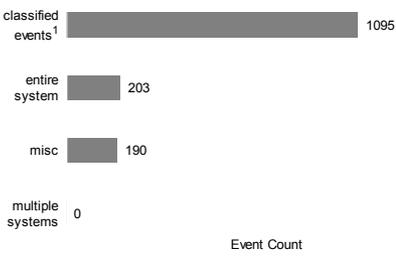


CDP#94 Infrastructure Maintenance by Category

Infrastructure Maintenance By Equipment Type²



- electrical
- software
- hydrogen compressor
- sensors
- valves
- air system
- dispenser
- fittings&piping
- control electronics
- H₂ storage

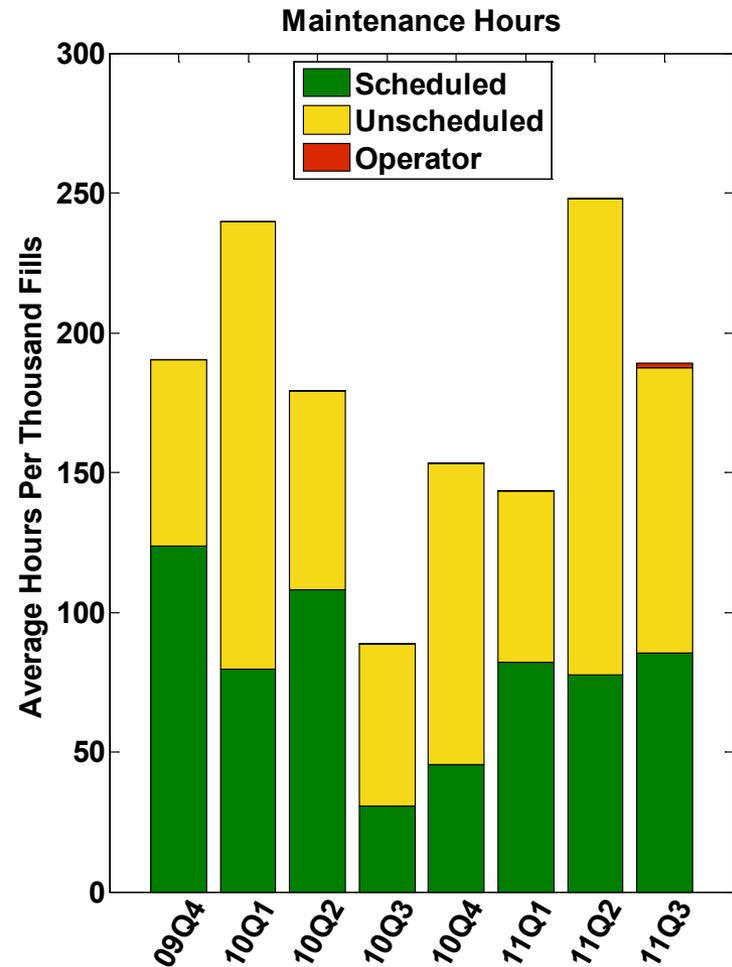
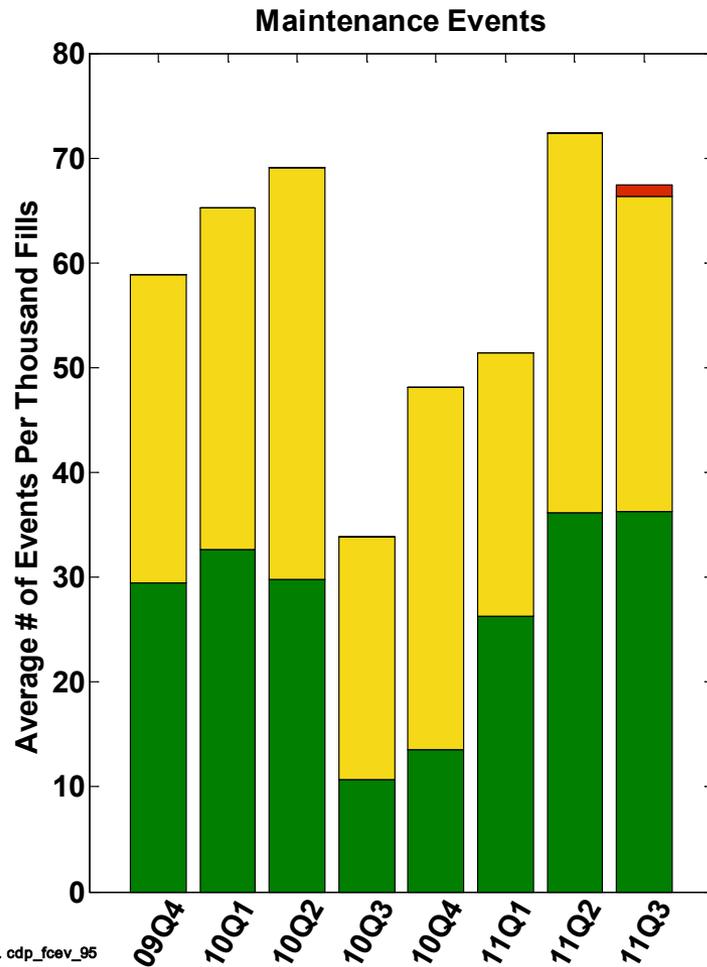


MISC includes the following failure modes: purifier, nitrogen system, feedwater system, seal, safety, reformer, electrolyzer, thermal management, other

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

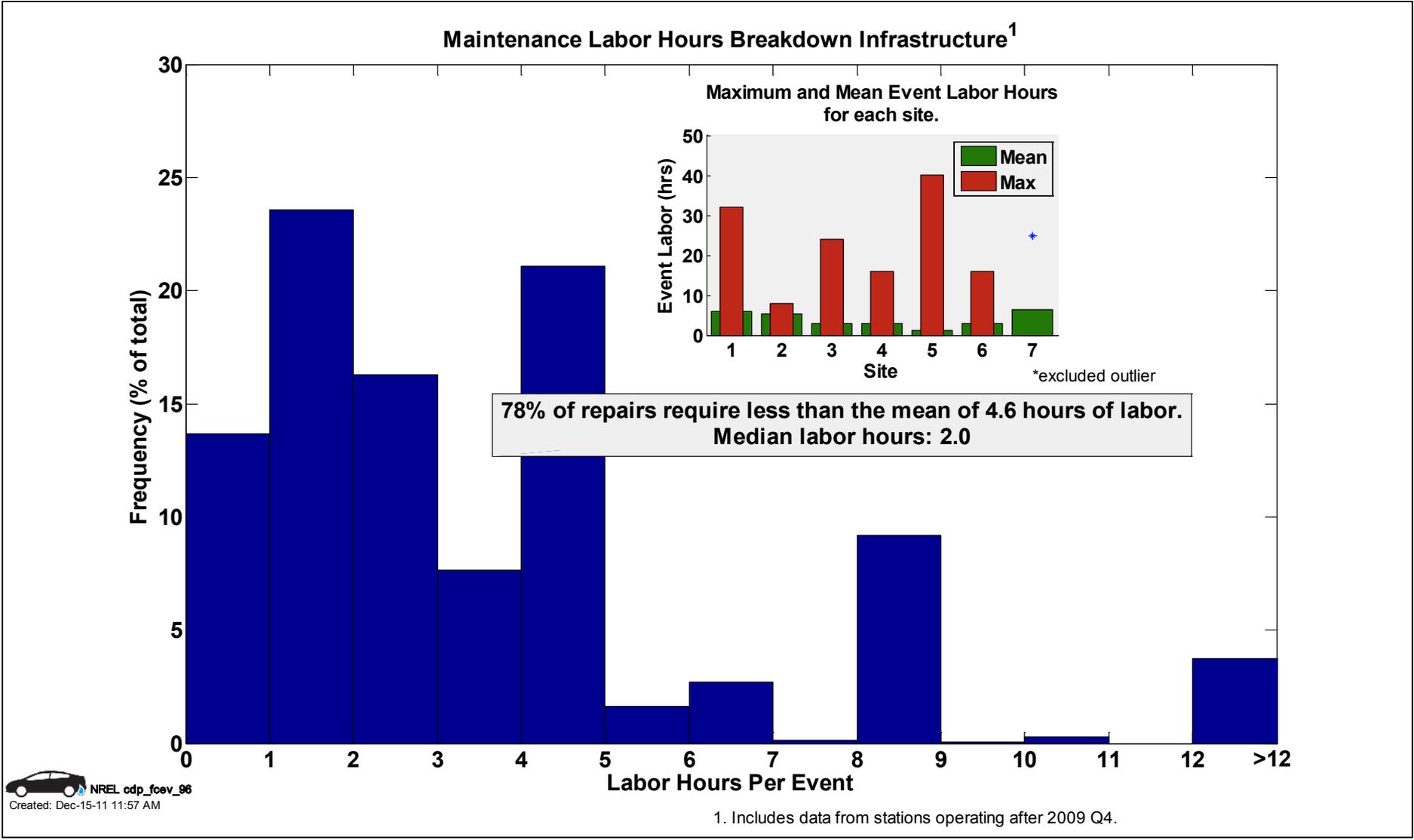
CDP#95 Infrastructure Maintenance By Quarter

Infrastructure Maintenance by Quarter¹



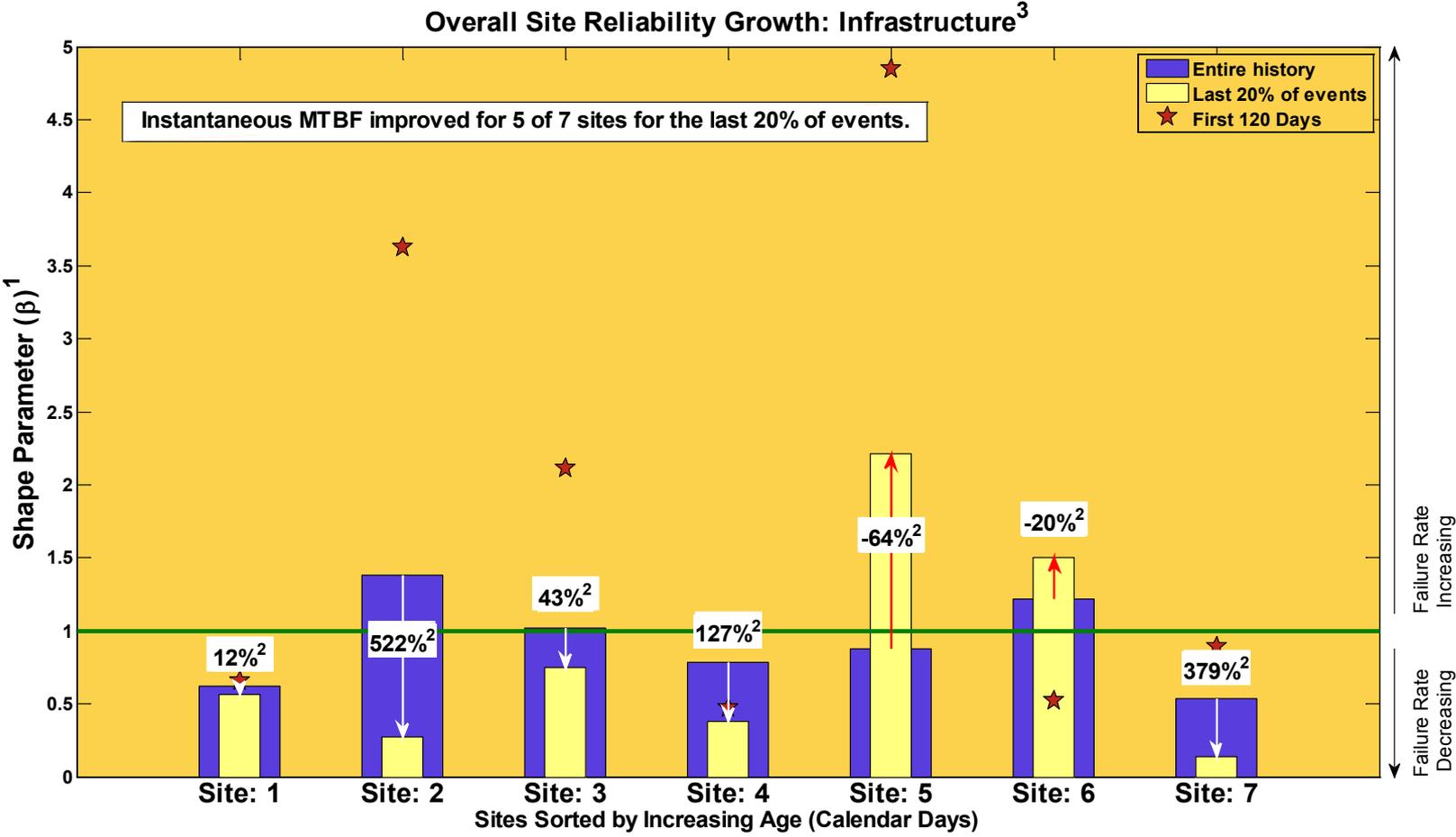
1. Includes data from stations operating after 2009 Q4.

CDP#96 Infrastructure Maintenance Labor Hours



1. Includes data from stations operating after 2009 Q4.

CDP#97 Infrastructure Reliability Growth

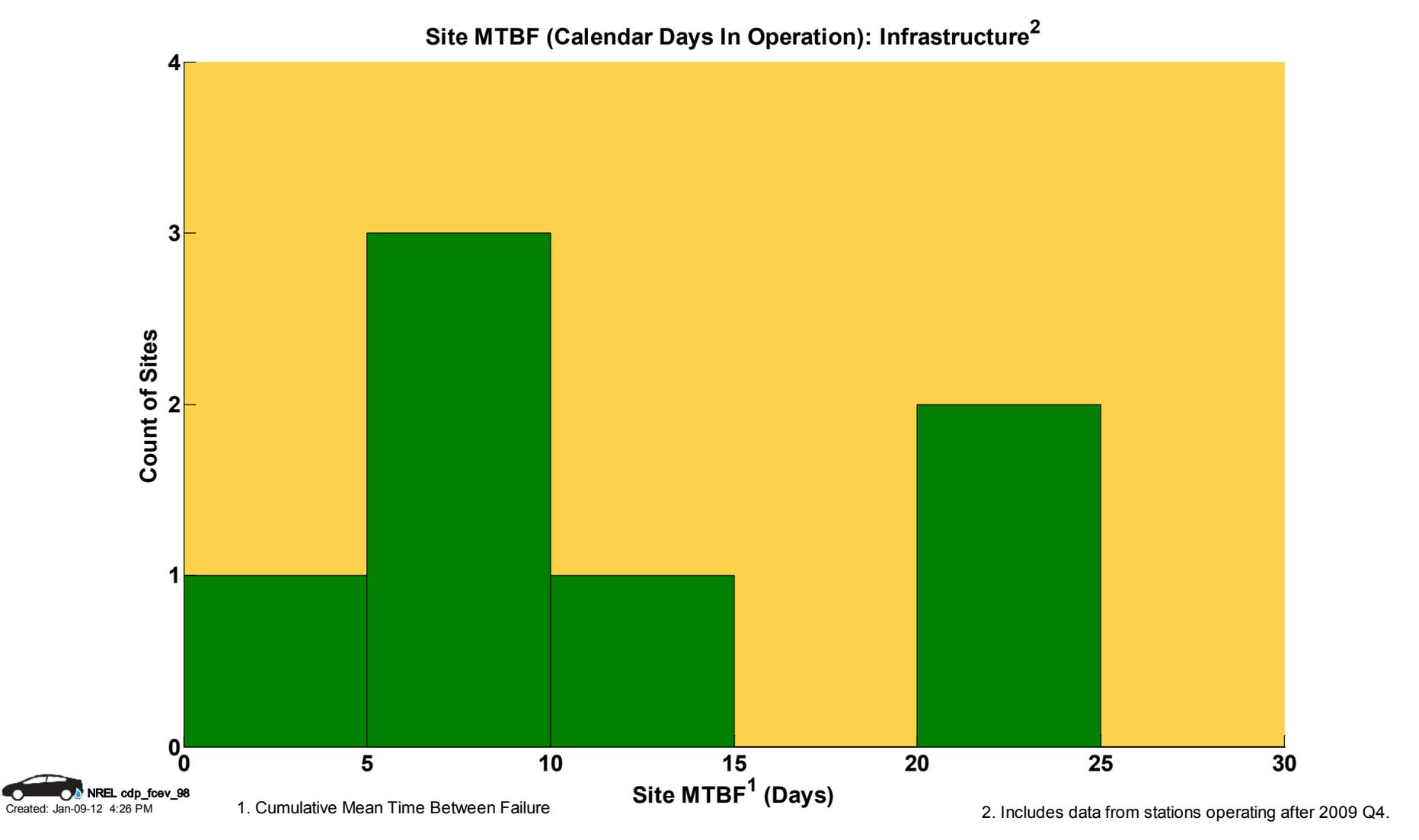


1. IEC 61164:2004(E), Reliability Growth - Statistical Test and Evaluation Methods, IEC. 2004.

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

