NREL
NATIONAL RENEWABLE ENERGY LABORATORY

Technical Report
NREL/TP-5600-56782
October 2012

ARRA Material Handling Equipment Composite Data Products

Data through Quarter 2 of 2012

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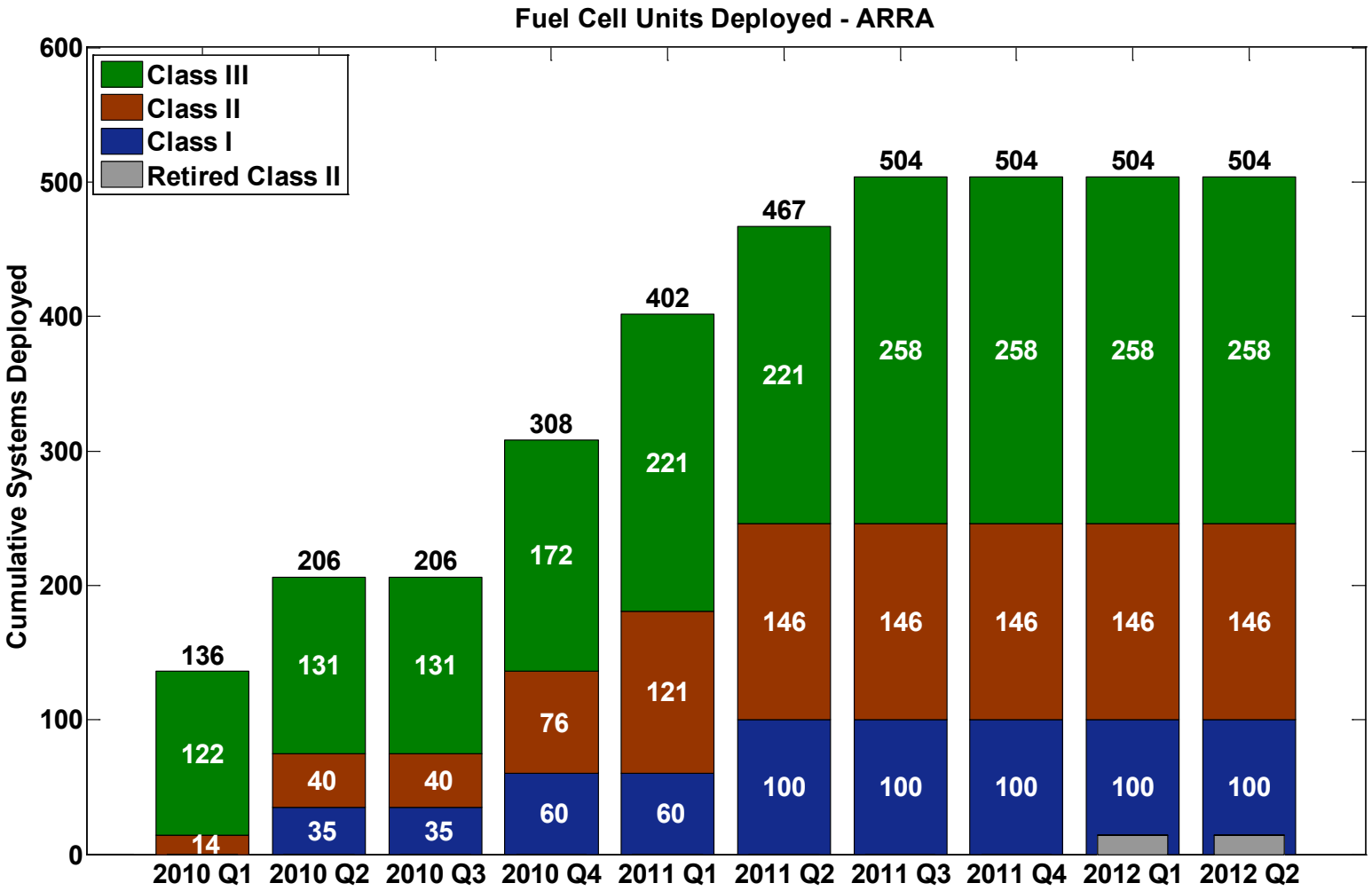
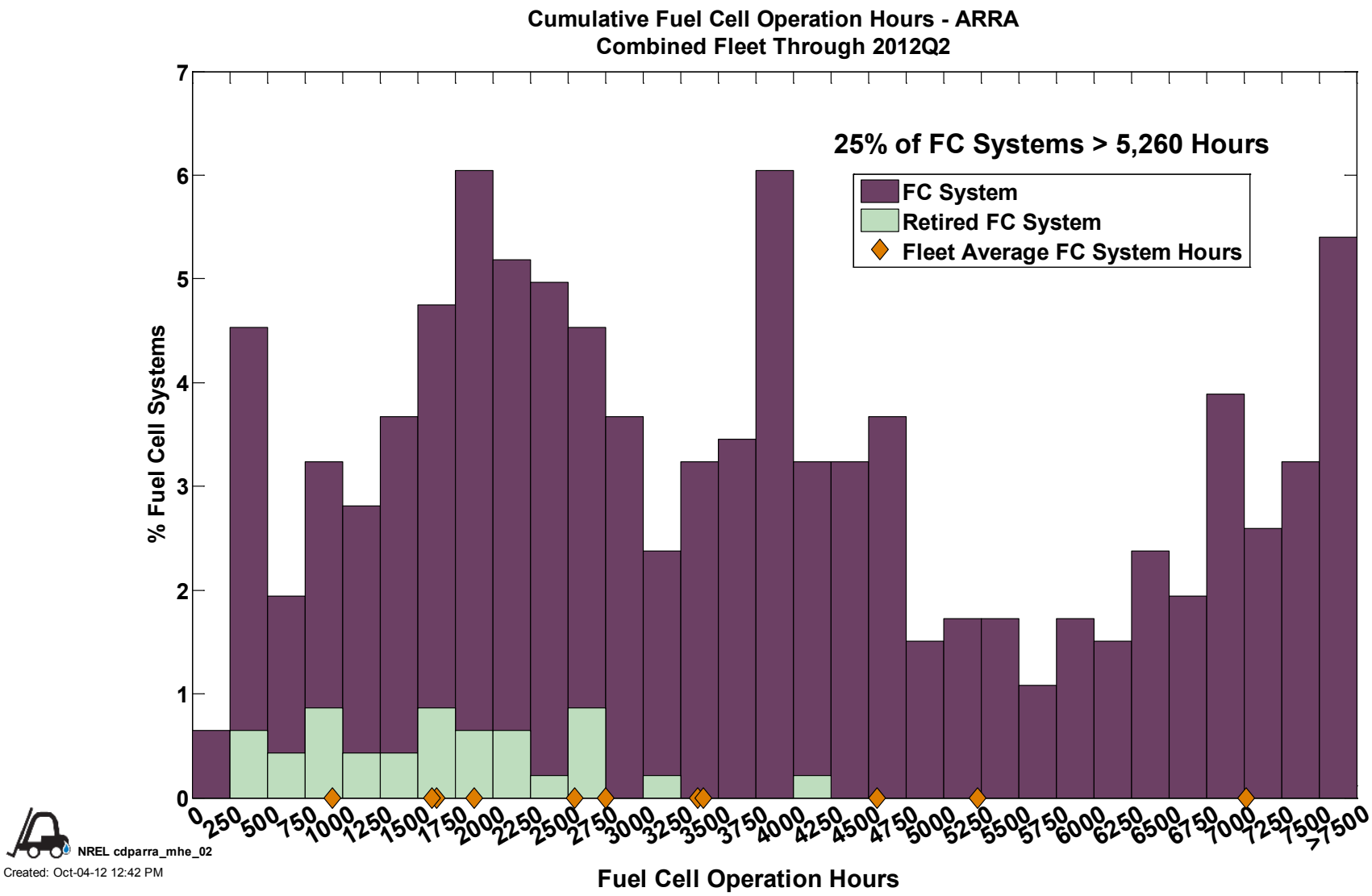
CDPARRA-MHE-01
Fuel Cell MHE Systems Deployed

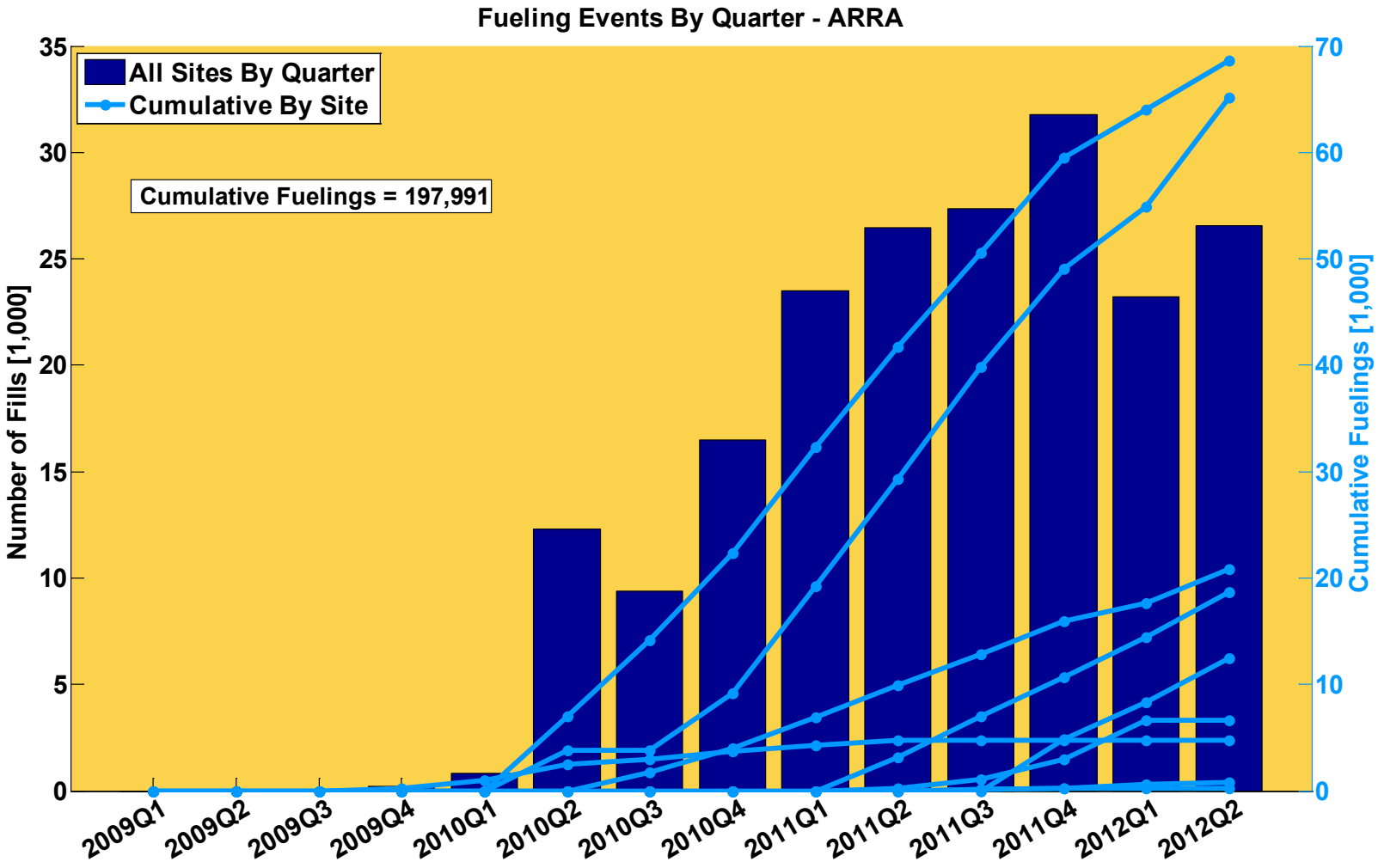


NREL cdparra_mhe_01
Created: Oct-04-12 12:31 PM

CDPARRA-MHE-02
Fuel Cell System Operation Hours



CDPARRA-MHE-03
Fueling Events by Quarter



NREL cdparra_mhe_03
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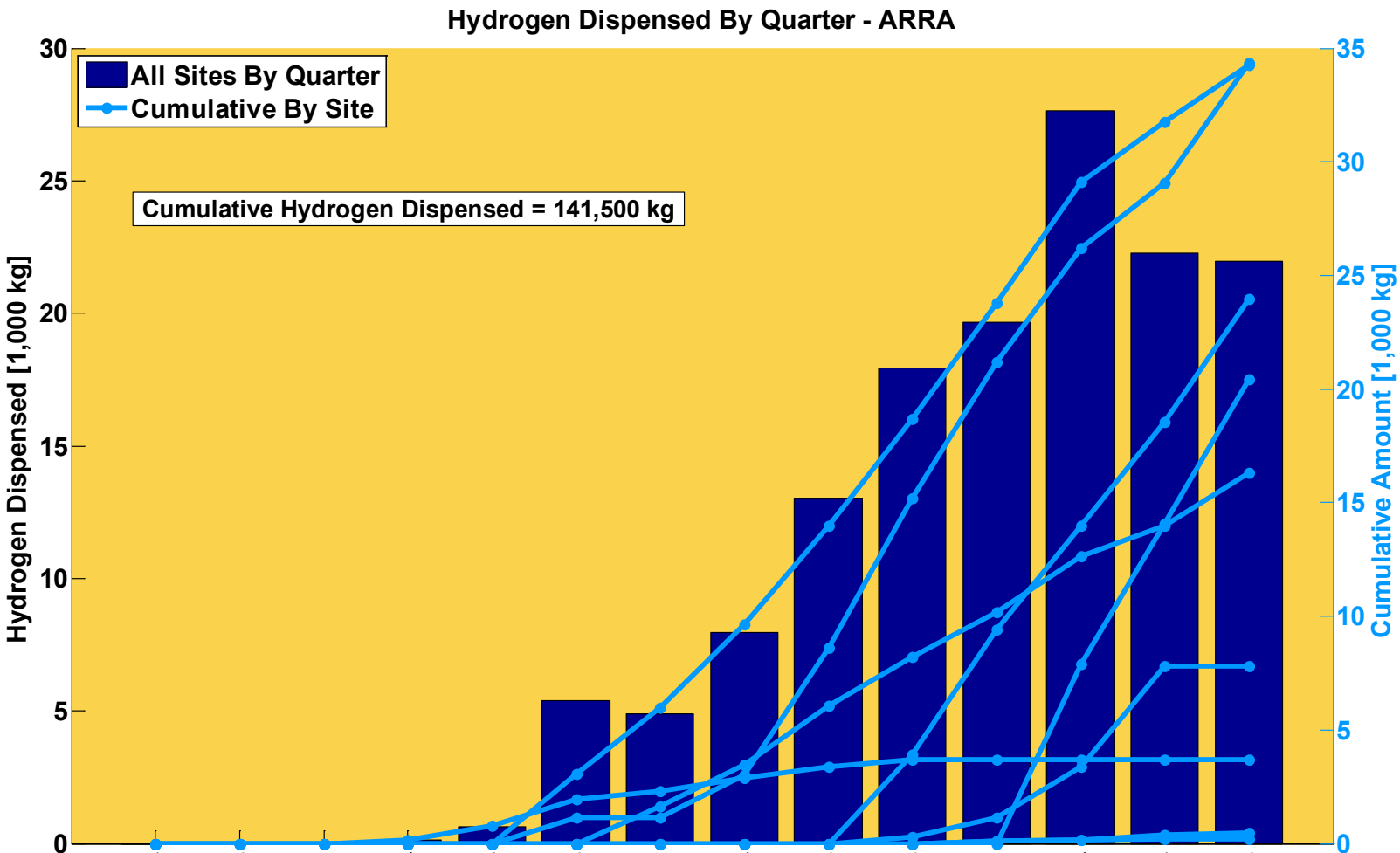
CDPARRA-MHE-04
Hydrogen Dispensed by Quarter



NREL cdparra_mhe_04
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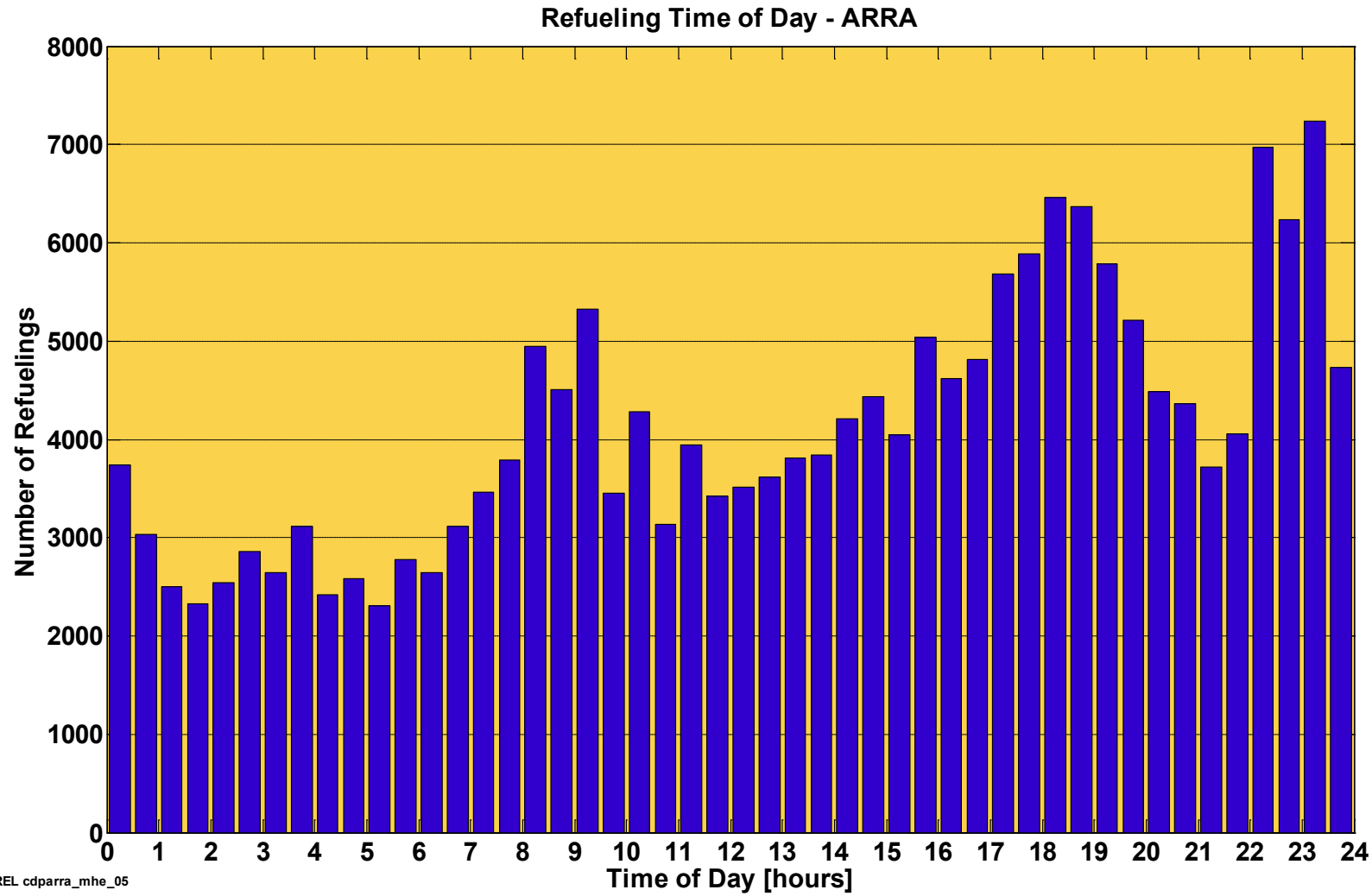
CDPARRA-MHE-05
Refueling Time of Day



NREL cdparra_mhe_05
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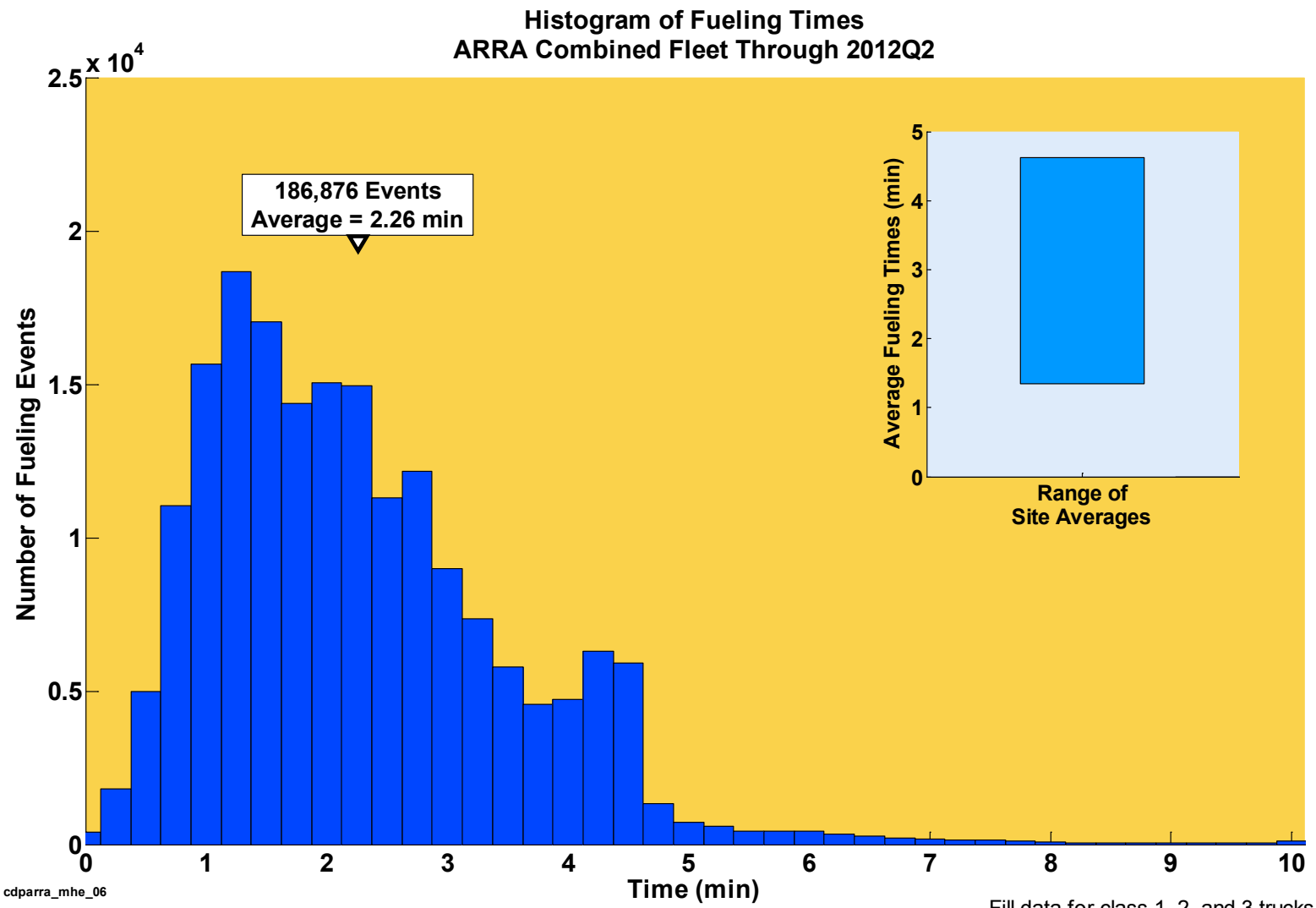
CDPARRA-MHE-06
Histogram of Fueling Times



NREL cdparra_mhe_06
Created: Oct-04-12 1:57 PM

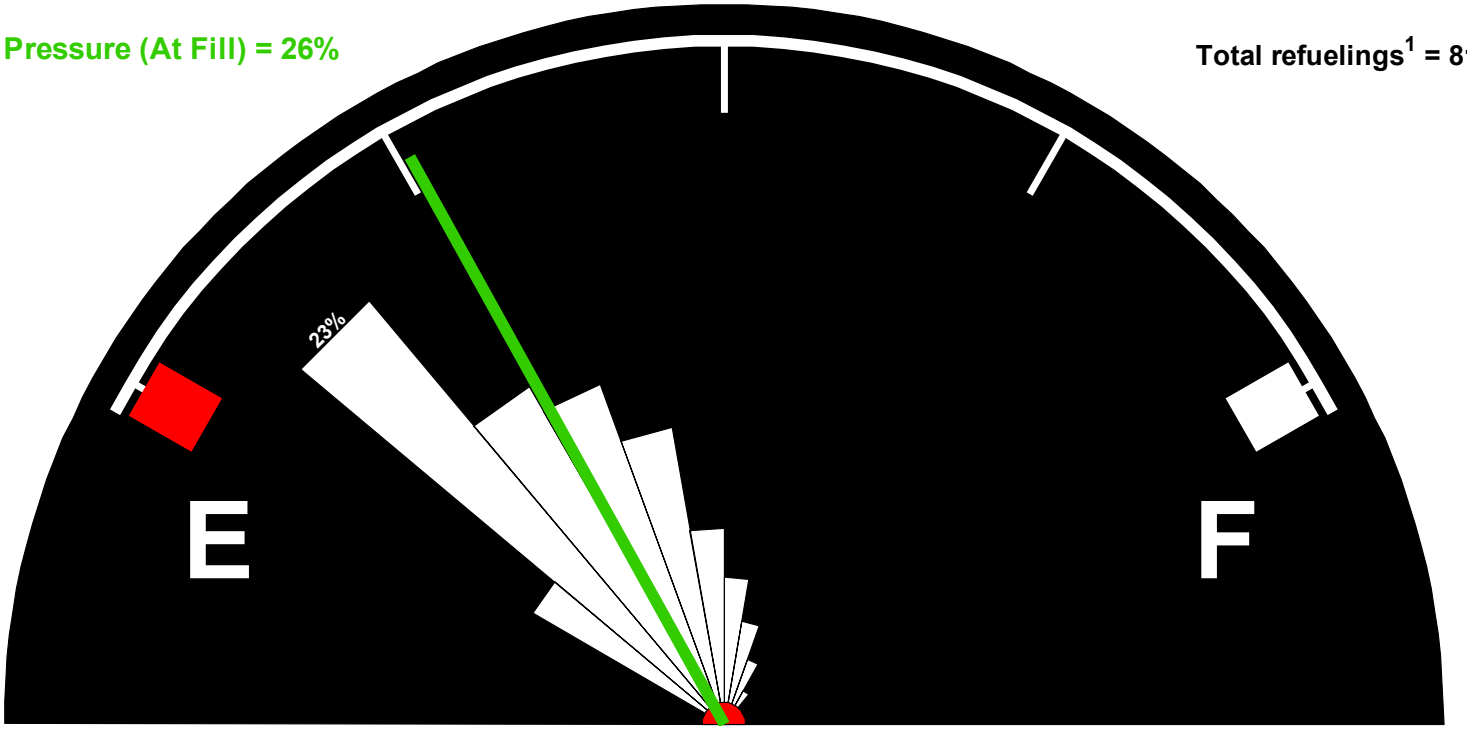
Fill data for class 1, 2, and 3 trucks

CDPARRA-MHE-07
Tank Pressure Level at Fueling

Tank Pressure At Fill: ARRA

Median Tank Pressure (At Fill) = 26%

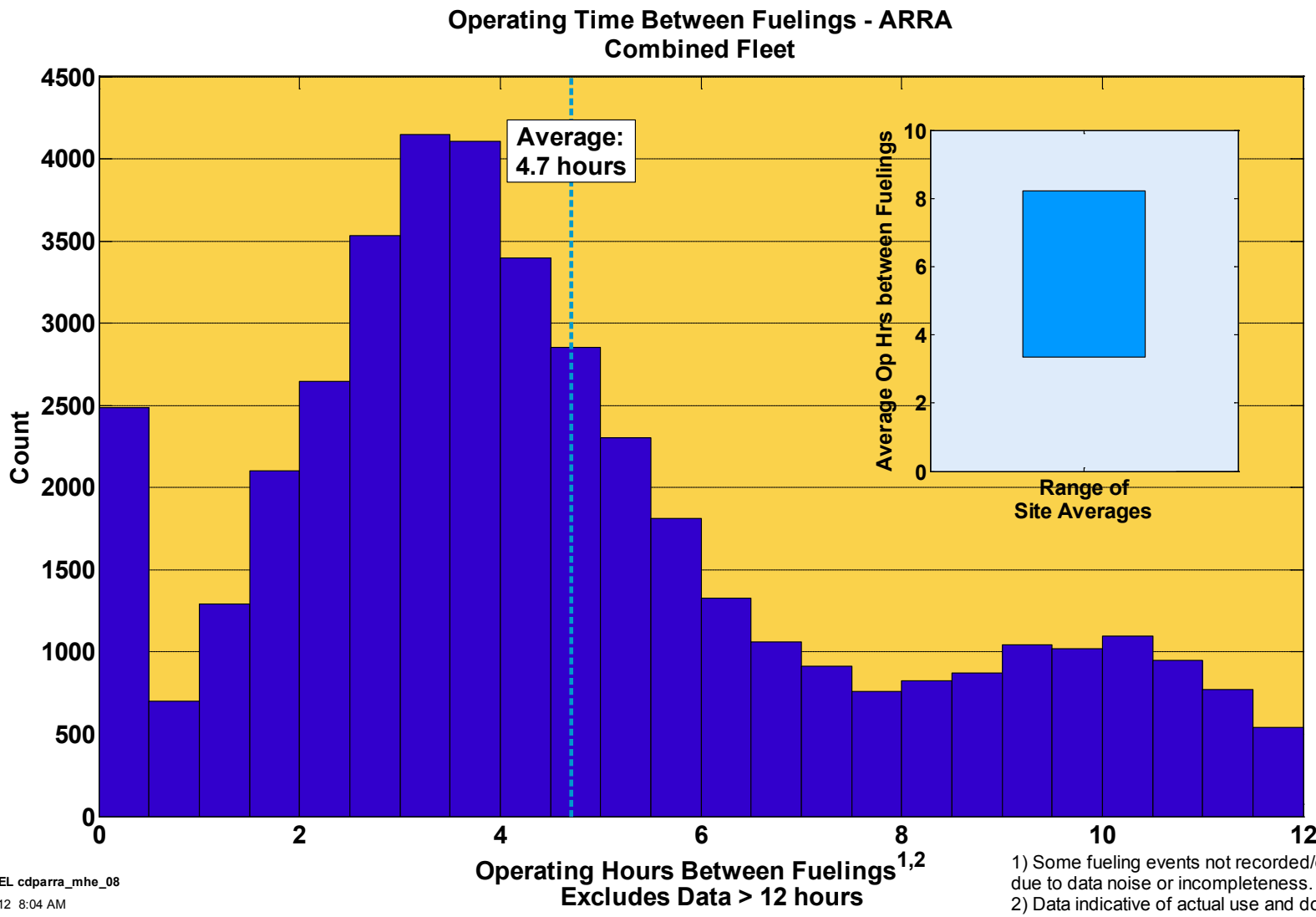
Total refuelings[1] = 81,892



1. Some refueling events not recorded/detected due to data noise or incompleteness.
2. The outer arc is set at 30% total refuelings.
3. Full Pressure is either 3600 psi or 5000 psi.

NREL cdparra_mhe_07
Created: Sep-20-12 3:05 PM

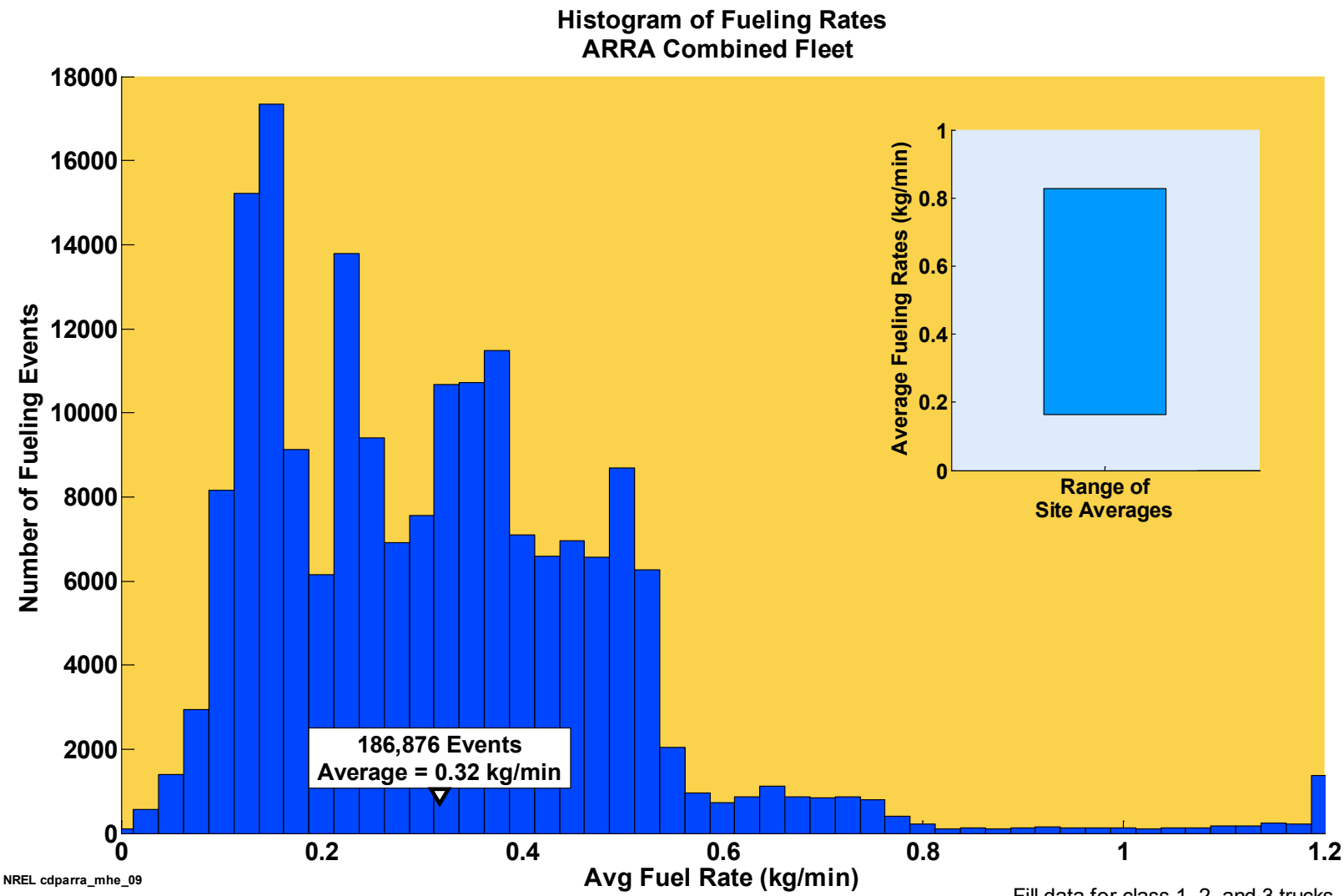
CDPARRA-MHE-08
Operation Time between Fueling



NREL cdparra_mhe_08
Created: Oct-05-12 8:04 AM

1) Some fueling events not recorded/detected due to data noise or incompleteness.
2) Data indicative of actual use and does not represent the max capability of the systems.

CDPARRA-MHE-09
Histogram of Fueling Rates



NREL cdparra_mhe_09
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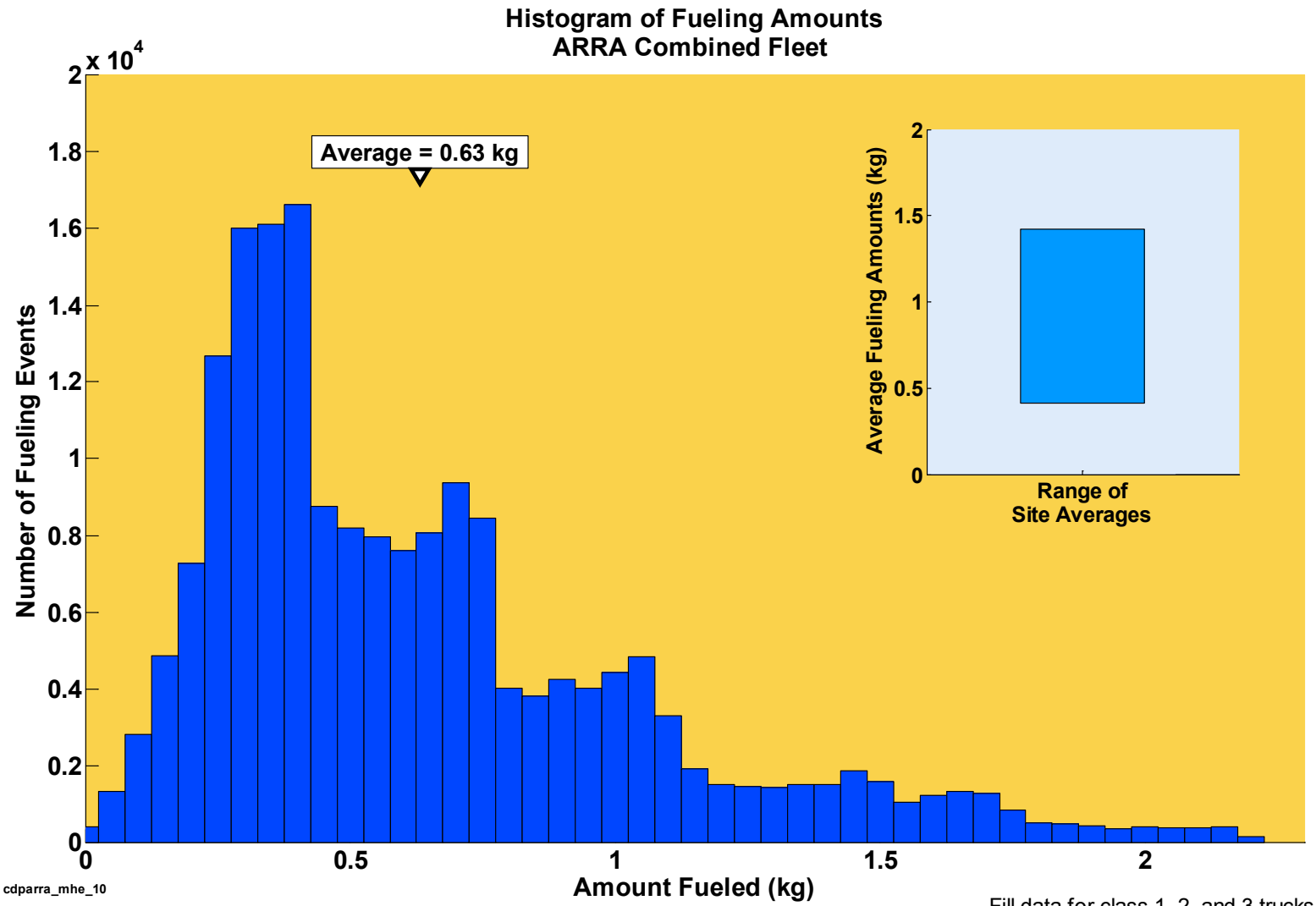
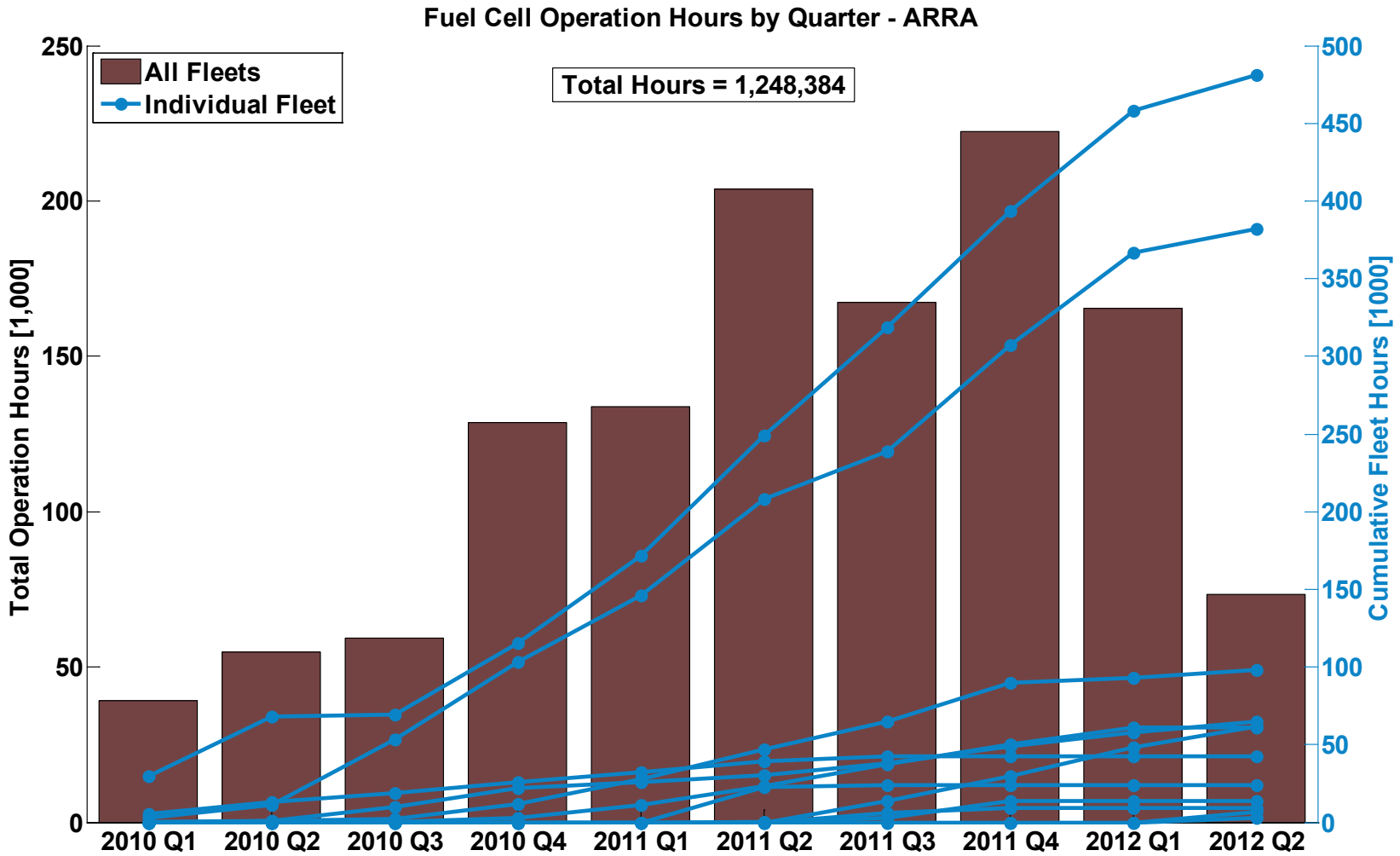
Fill data for class 1, 2, and 3 trucks

CDPARRA-MHE-10
Histogram of Fueling Amounts



Fill data for class 1, 2, and 3 trucks

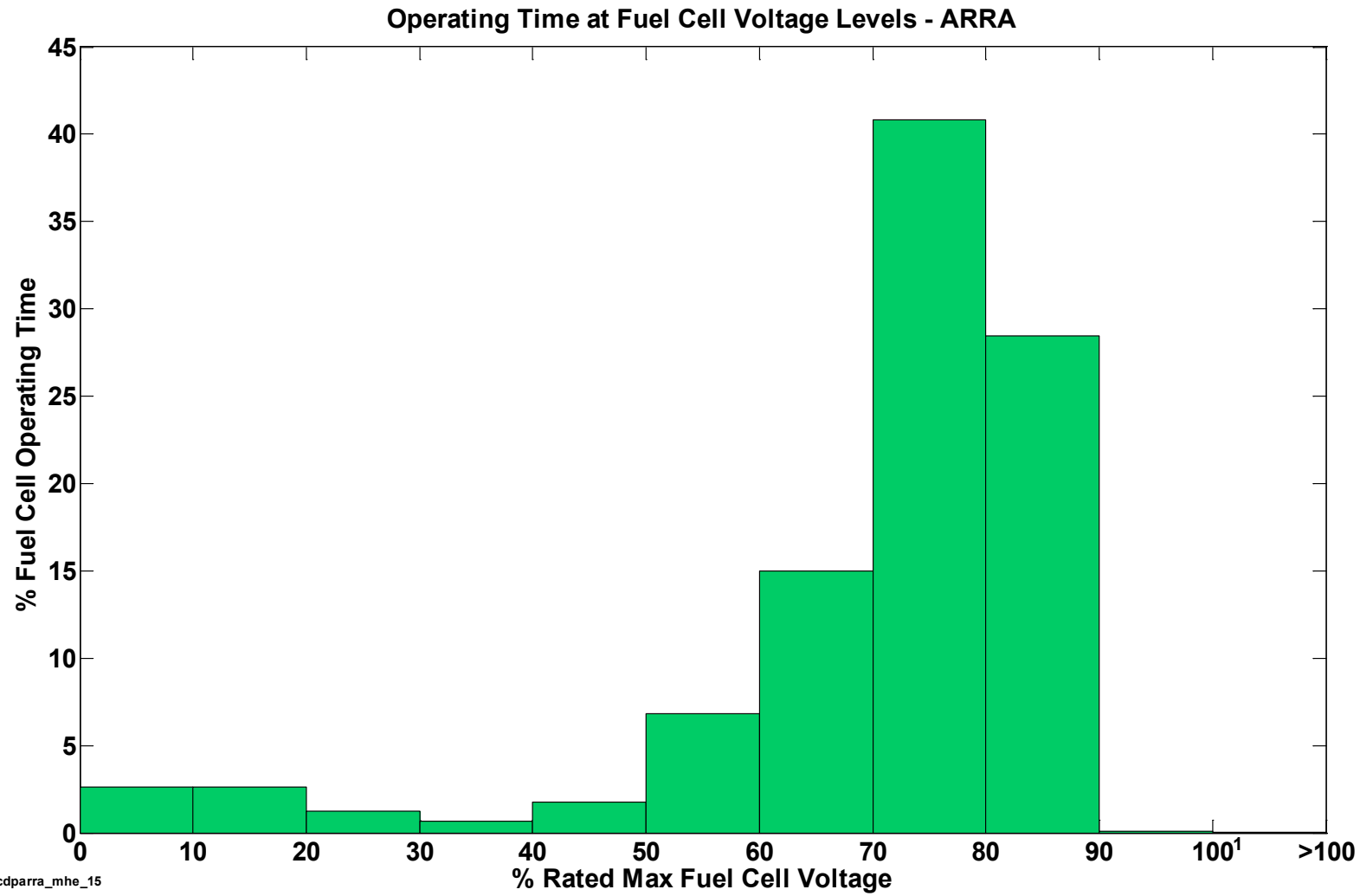
CDPARRA-MHE-11
Fuel Cell Operation Hours by Quarter



NREL cdparra_mhe_11

Created: Sep-21-12 9:11 AM

CDPARRA-MHE-15
Operating Time at Fuel Cell Voltage Levels

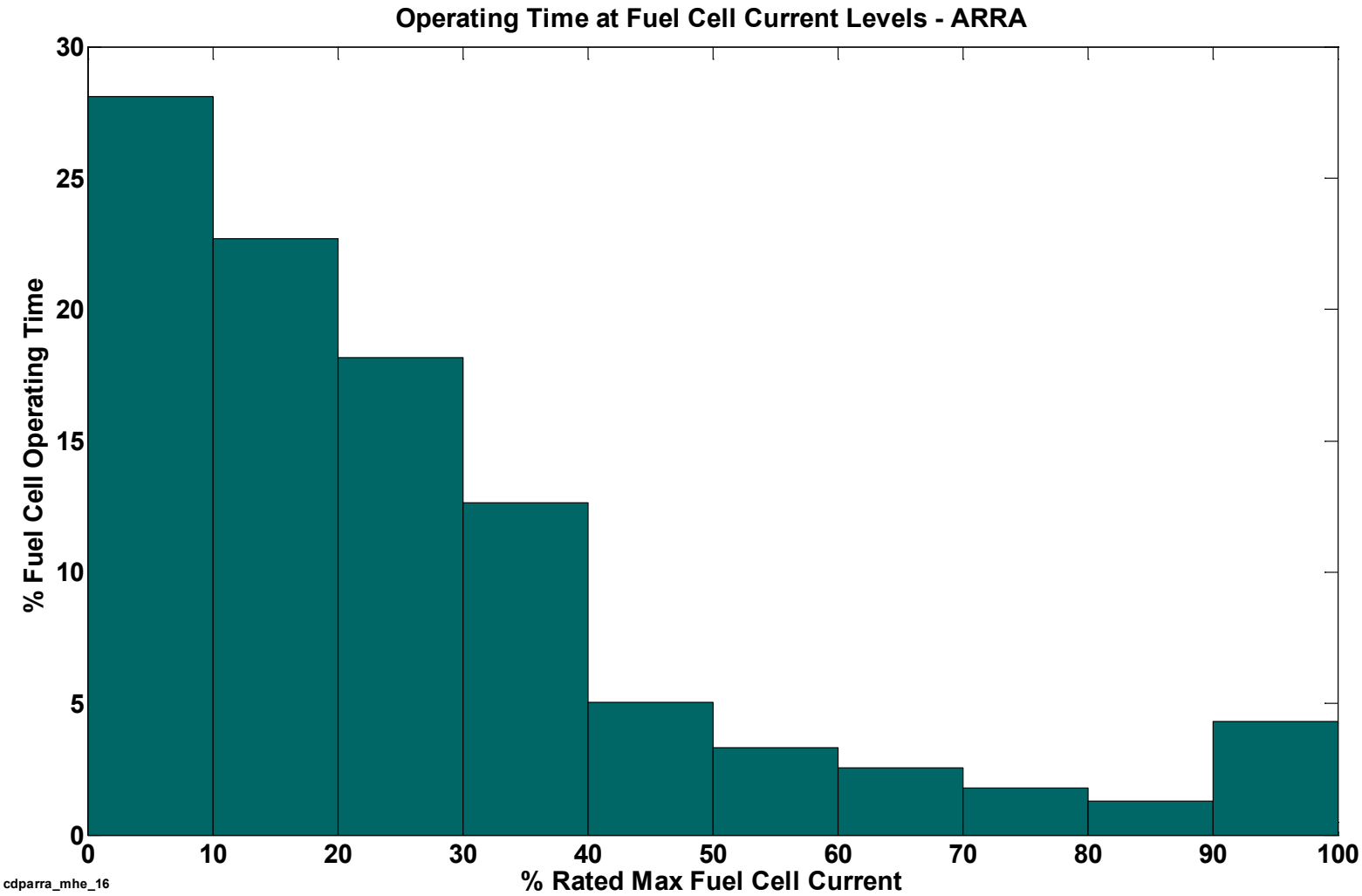


NREL cdparra_mhe_15

Created: Sep-21-12 9:12 AM

1) 100% max fuel cell voltage is approximately open-circuit voltage

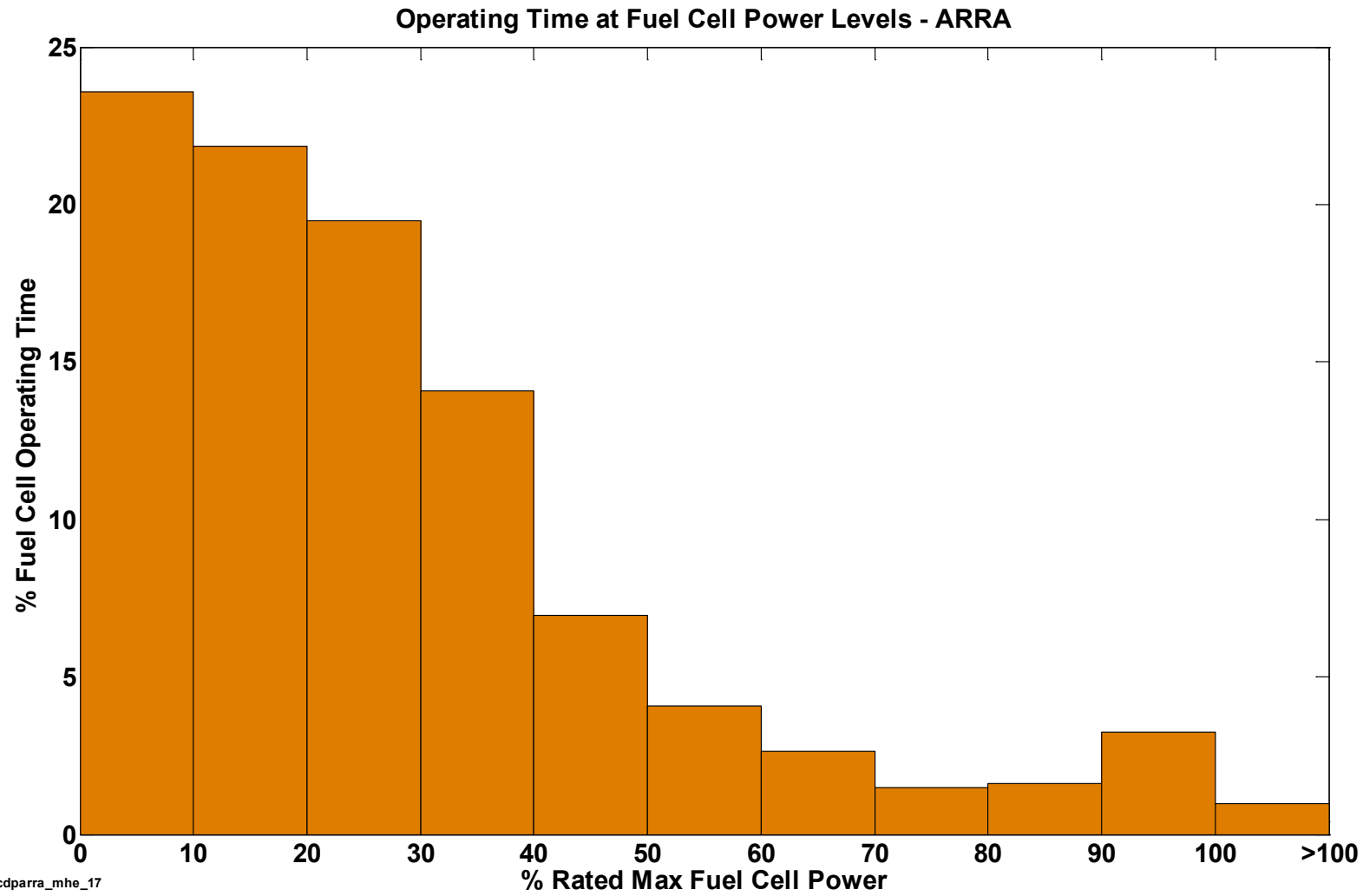
CDPARRA-MHE-16
Operating Time at Fuel Cell Current Levels



NREL cdparra_mhe_16

Created: Sep-21-12 9:12 AM

CDPARRA-MHE-17
Operating Time at Fuel Cell Power Levels



NREL cdparra_mhe_17

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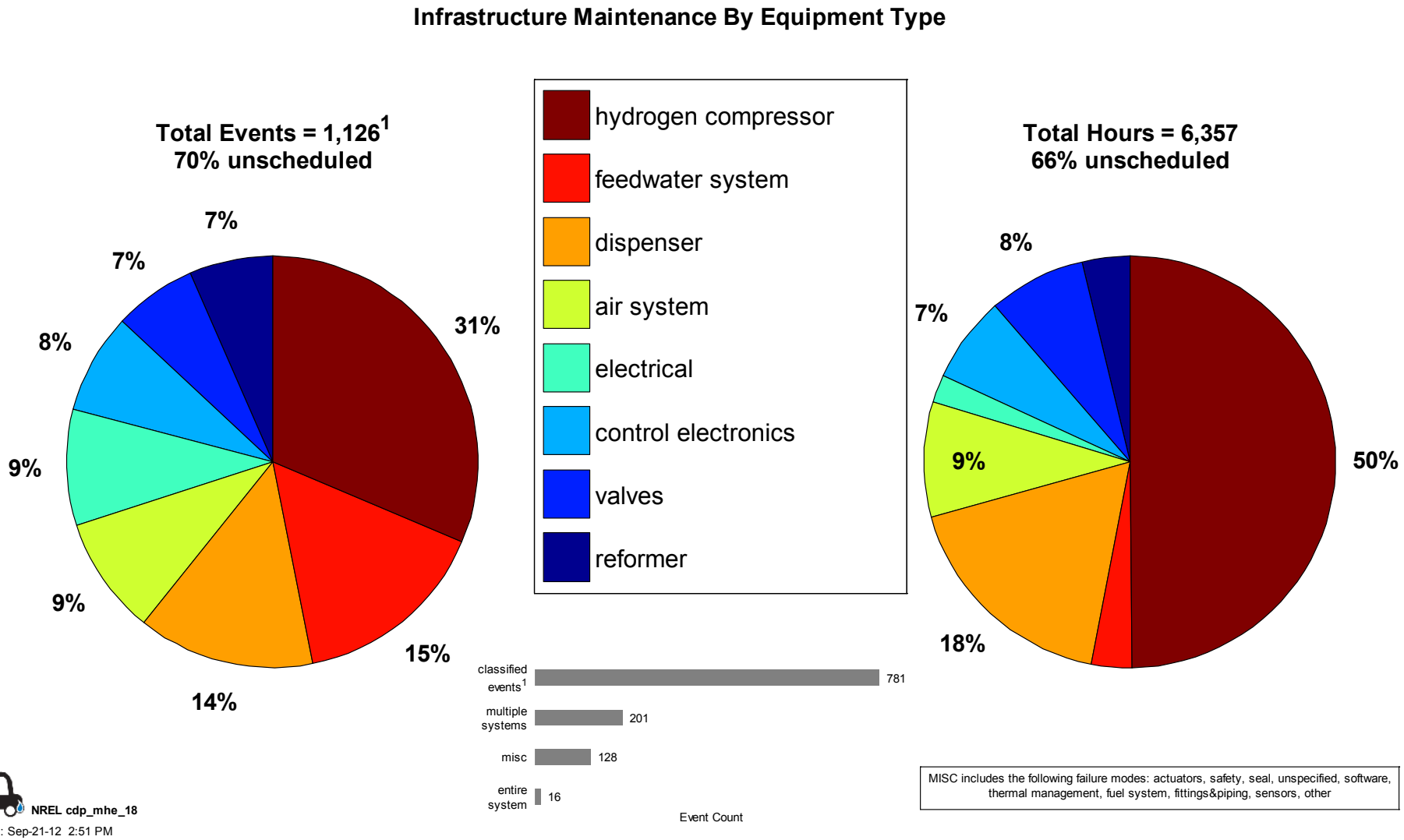
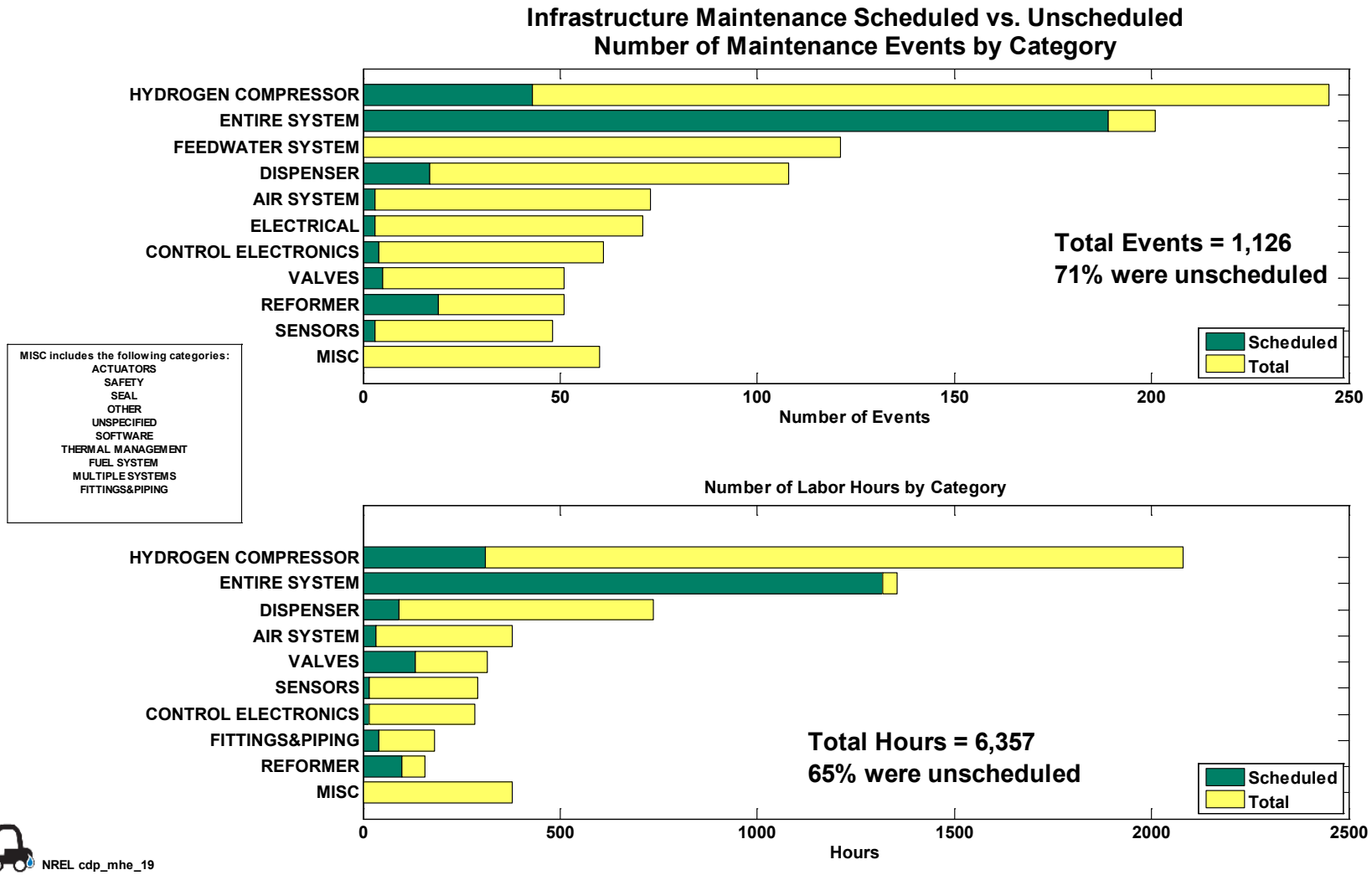
CDP-MHE-18
Infrastructure Maintenance by Category



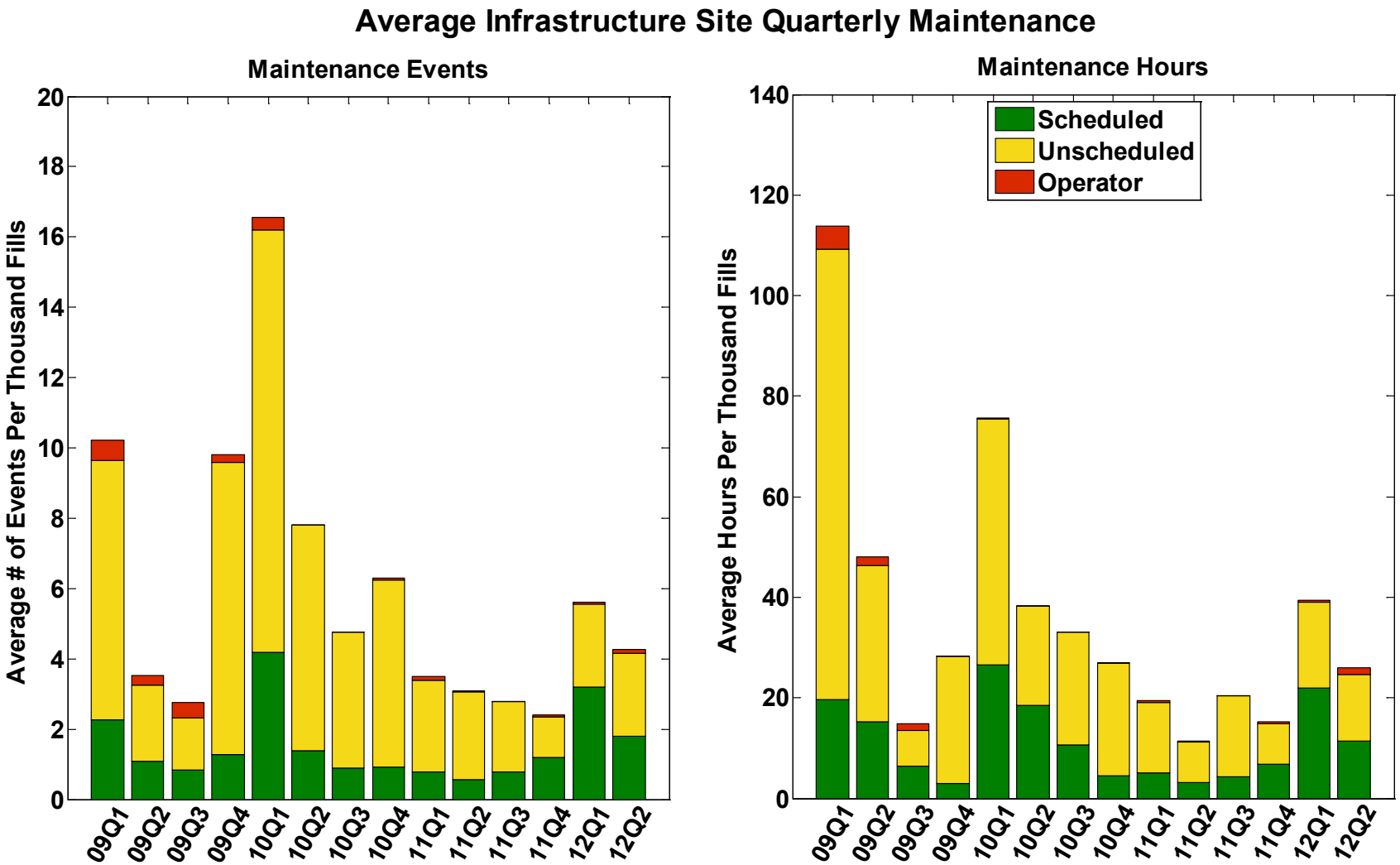
CDP-MHE-19
Infrastructure Scheduled & Unscheduled Maintenance by Category



NREL cdp_mhe_19

Created: Sep-21-12 2:52 PM

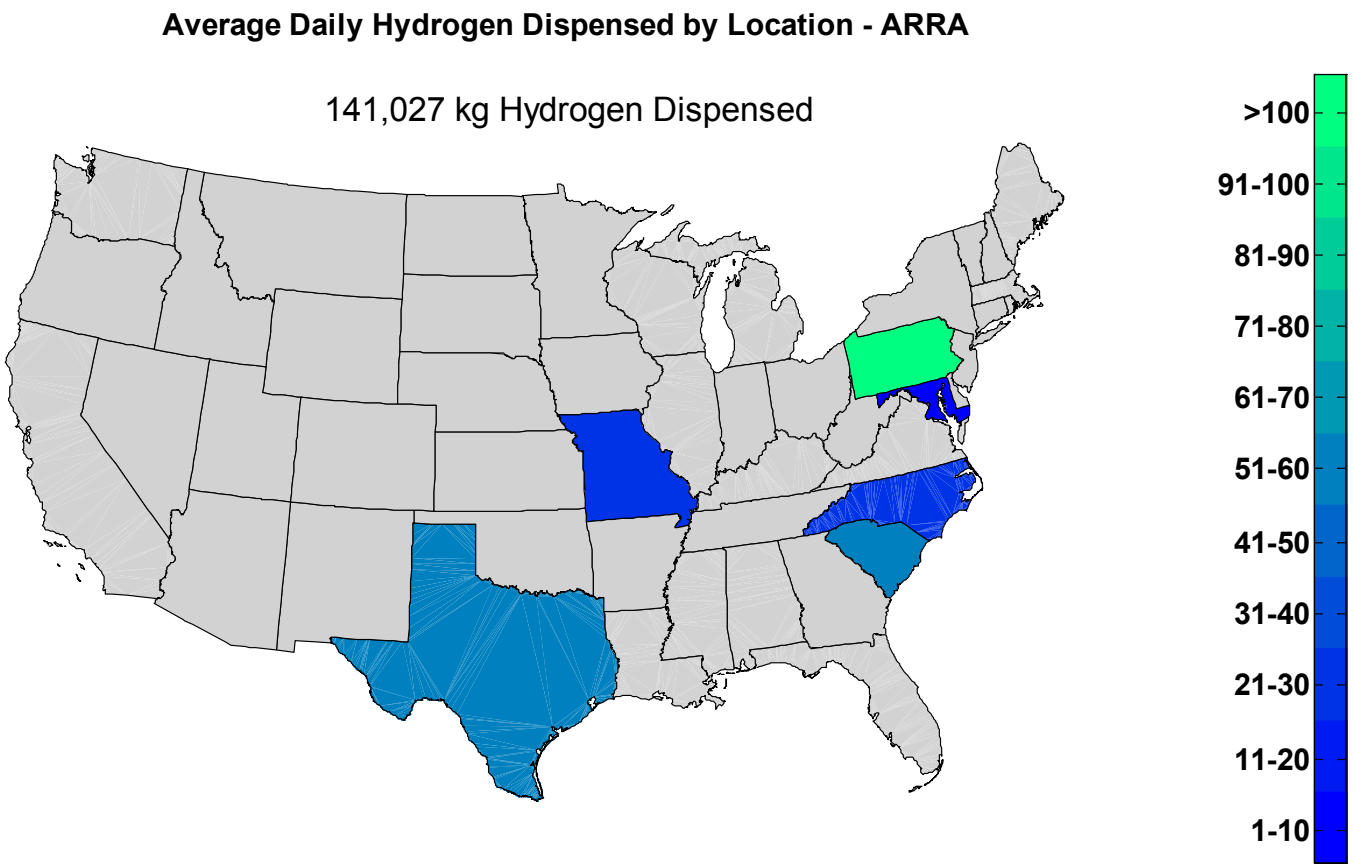
CDP-MHE-20
Infrastructure Maintenance by Quarter



NREL cdp_mhe_20

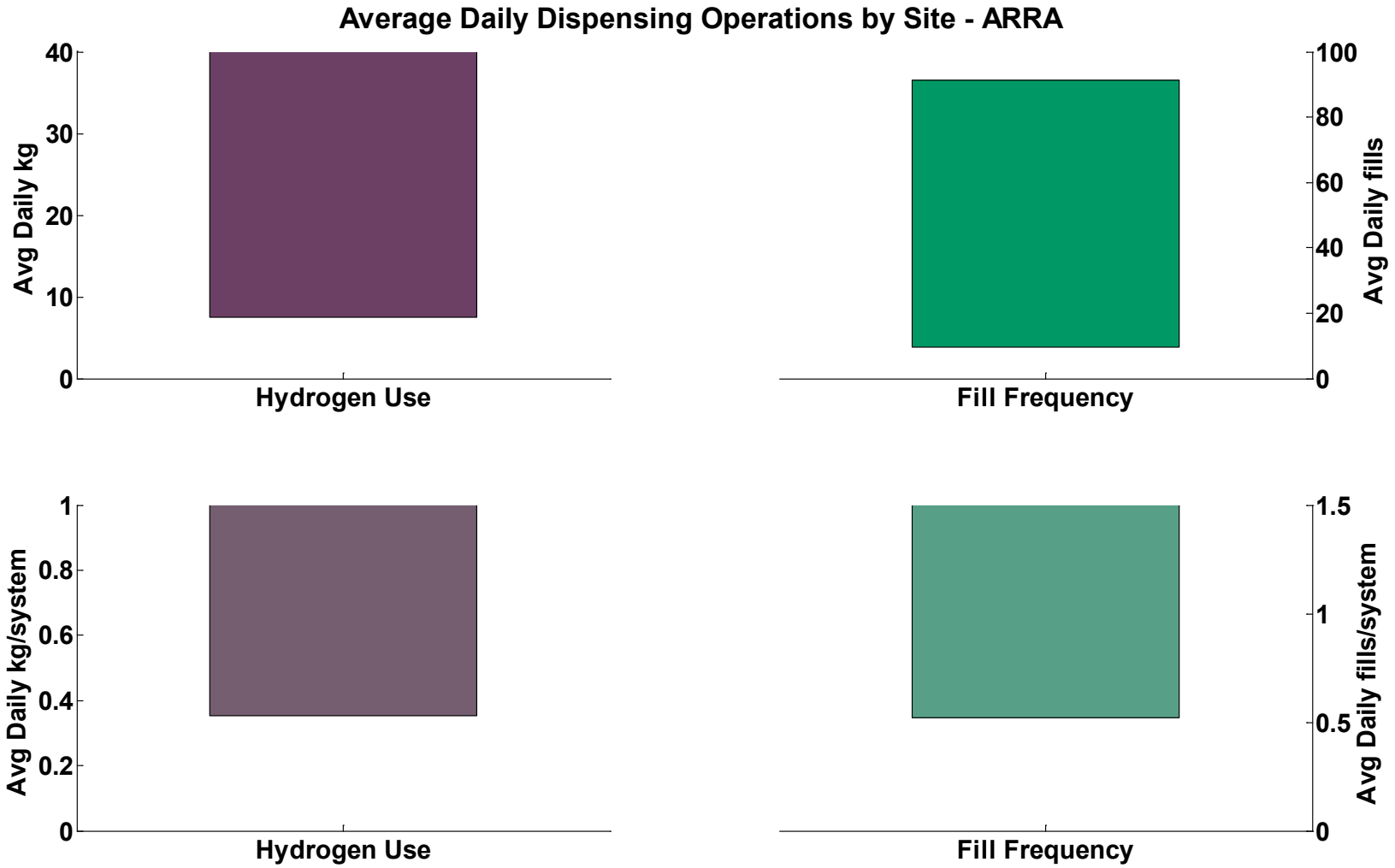
Created: Sep-21-12 2:52 PM

CDPARRA-MHE-21
Average Daily Hydrogen Dispensed by Location



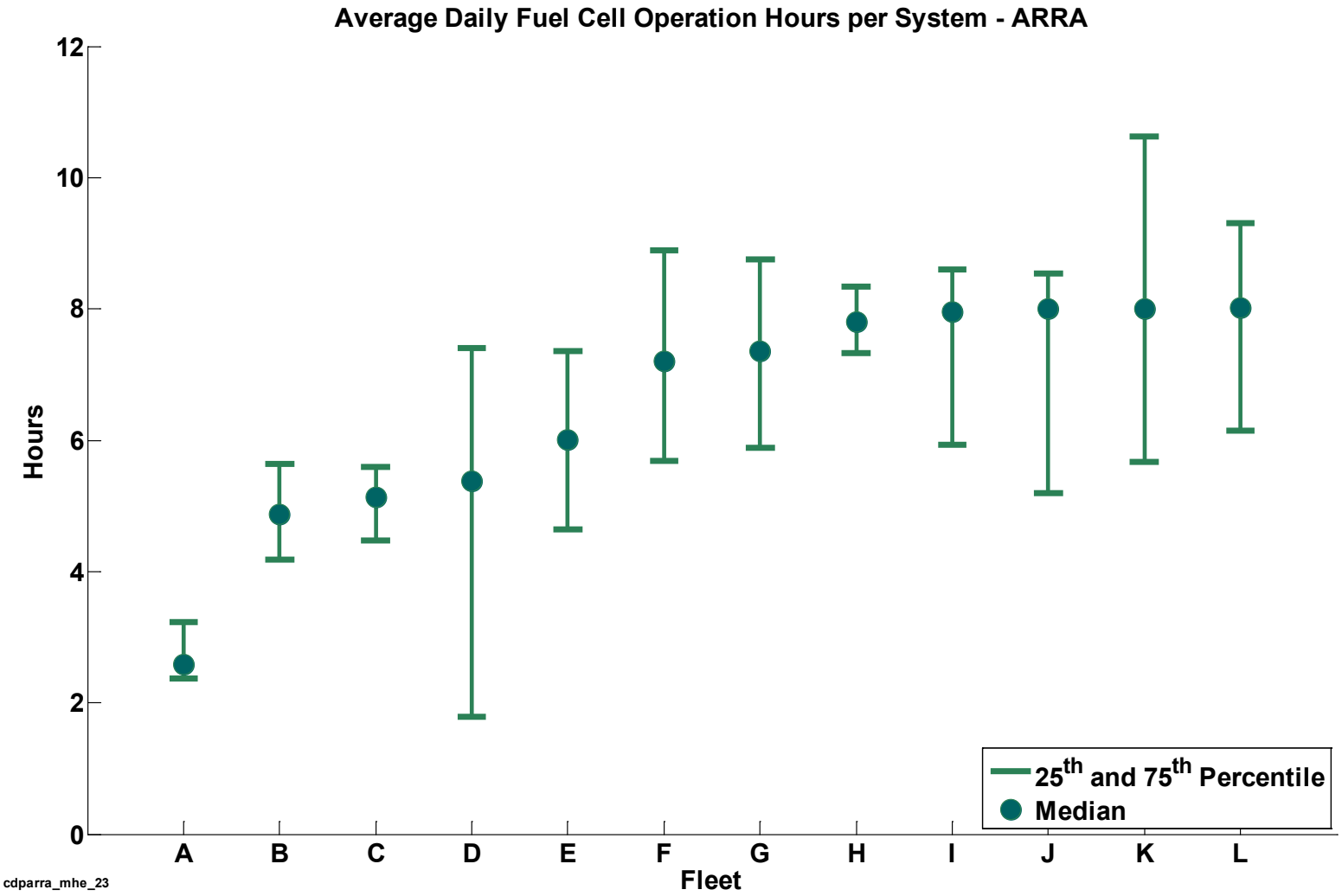
NREL cdparra_mhe_21
Created: Oct-04-12 12:14 PM

CDPARRA-MHE-22
Average Daily Dispensing Operations by Site



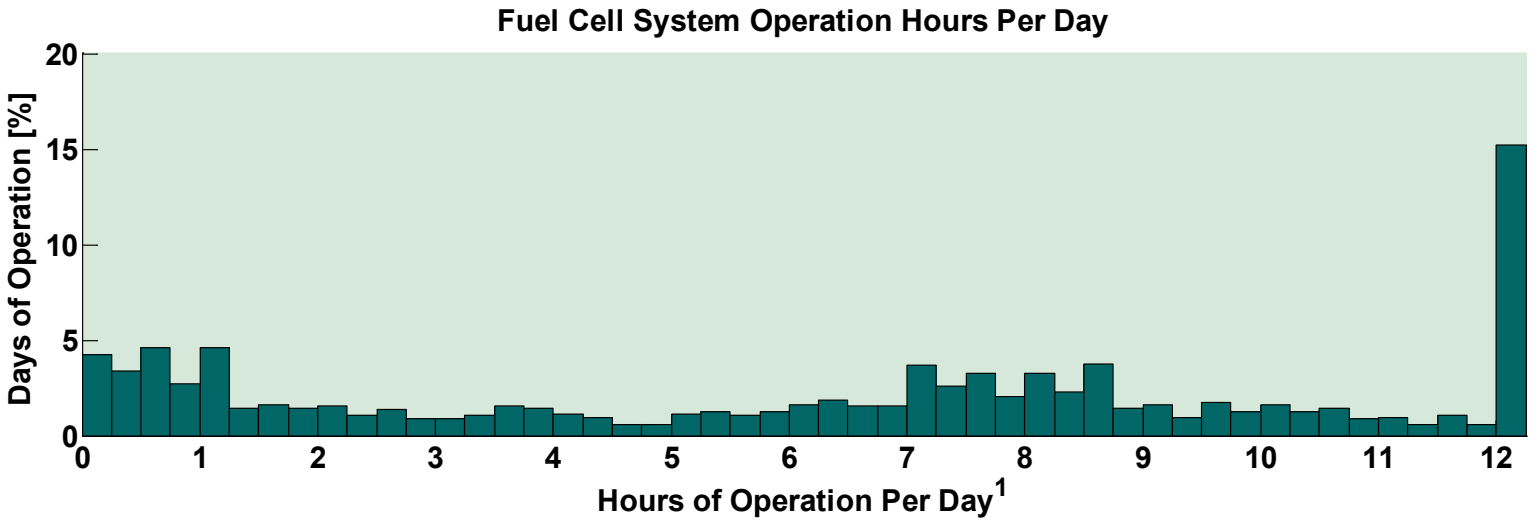
Shaded areas represent the min and max site average hydrogen use and fill frequency

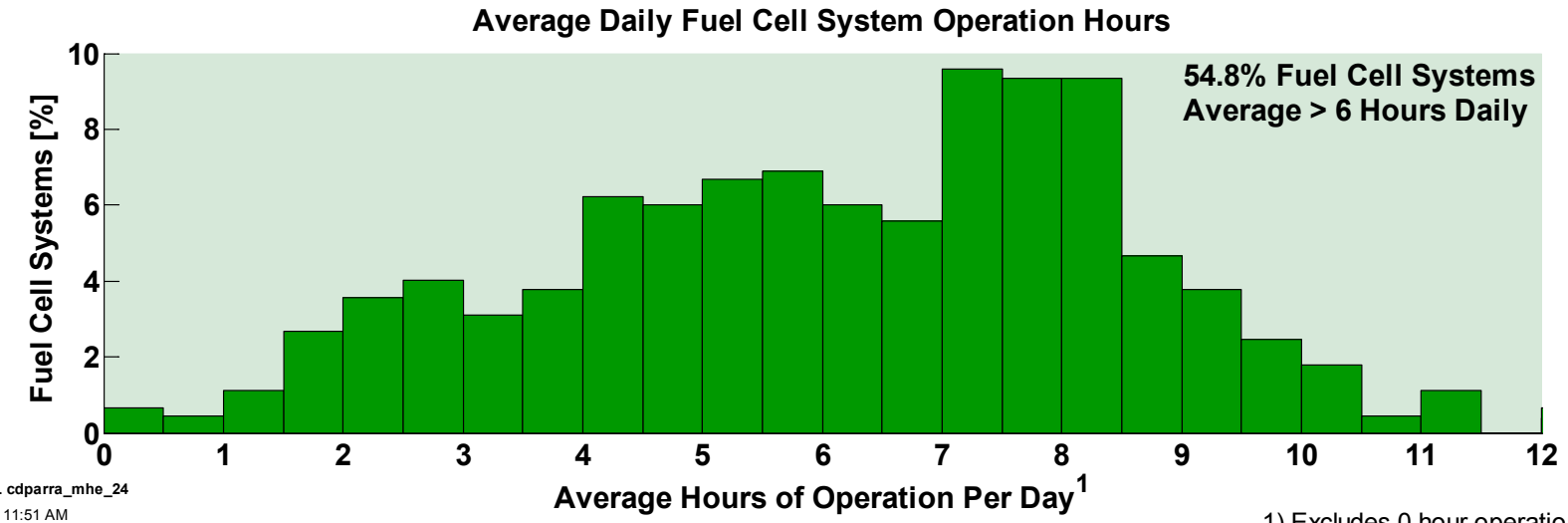
CDPARRA-MHE-23
Average Daily Fuel Cell Operation Hours per Fleet



NREL cdparra_mhe_23
Created: Oct-05-12 12:07 PM

CDPARRA-MHE-24
Average Daily Fuel Cell Operation Hours per System





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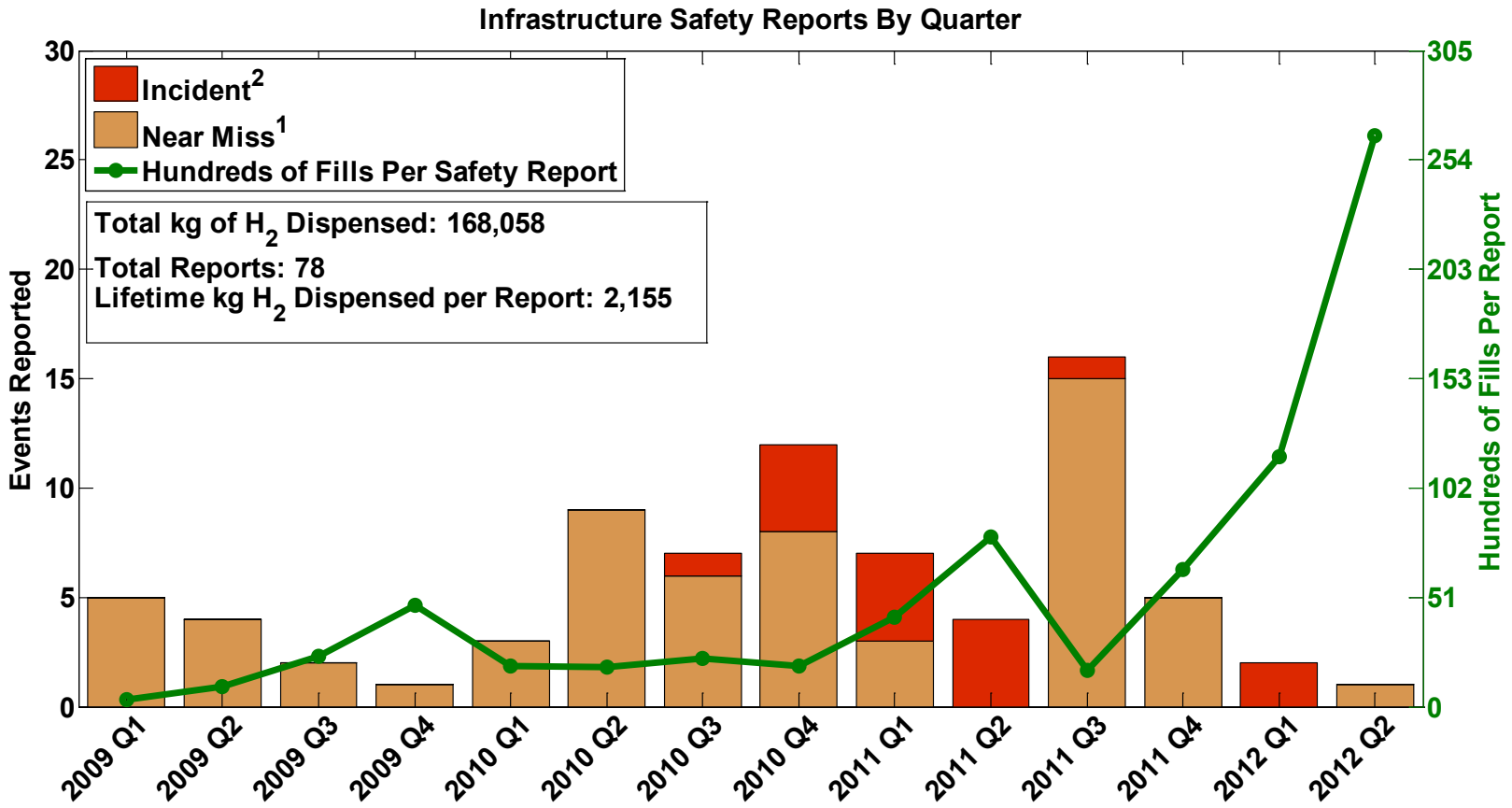
Created: Oct-05-12 11:51 AM

1) Excludes 0 hour operation days

CDP-MHE-25
Infrastructure Safety Reports by Quarter

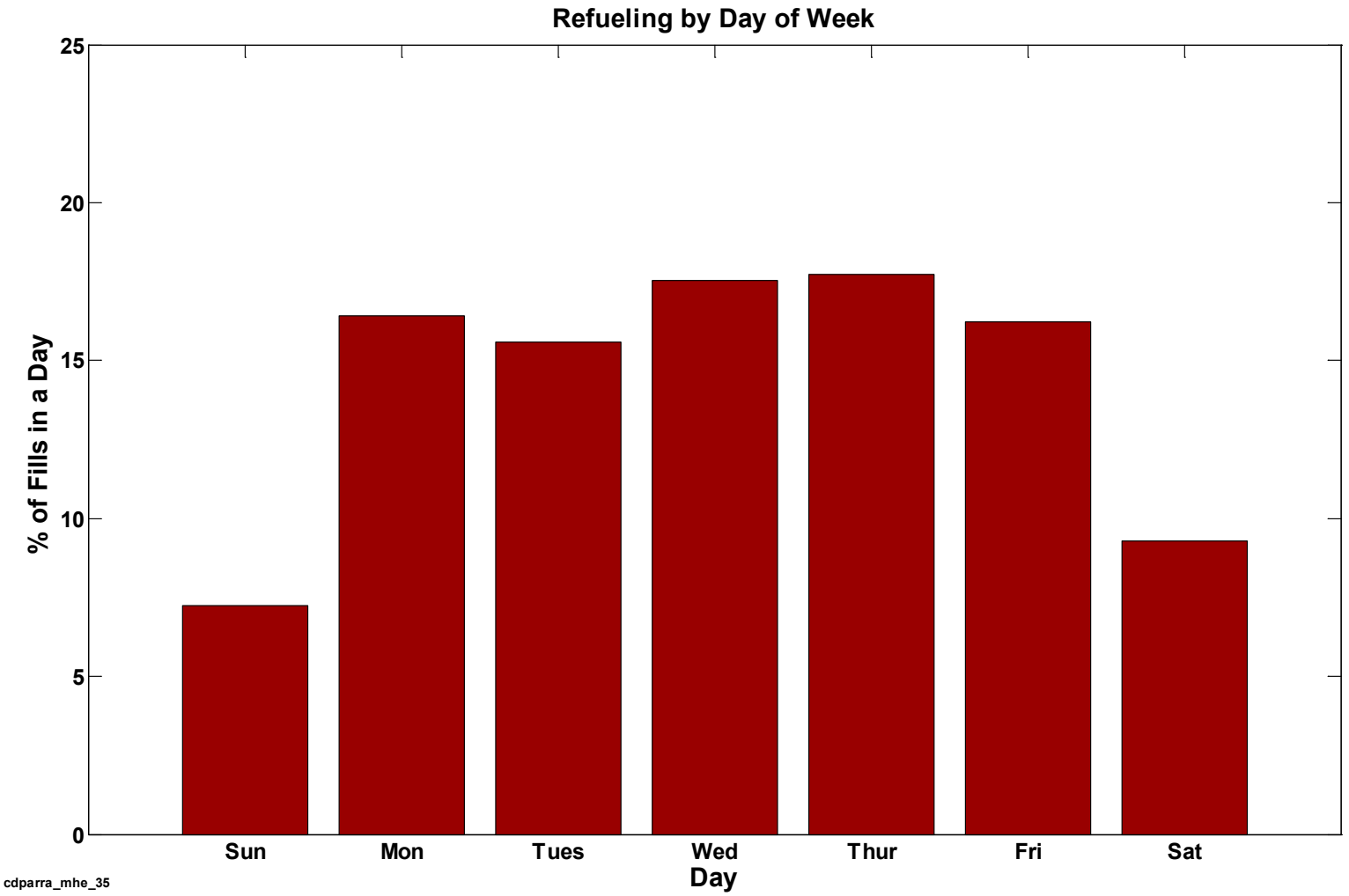


1) Near Miss is an event that under slightly different circumstances could have become an incident
-unplanned H2 release insufficient to sustain a flame

2) 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 uses as common fuels)

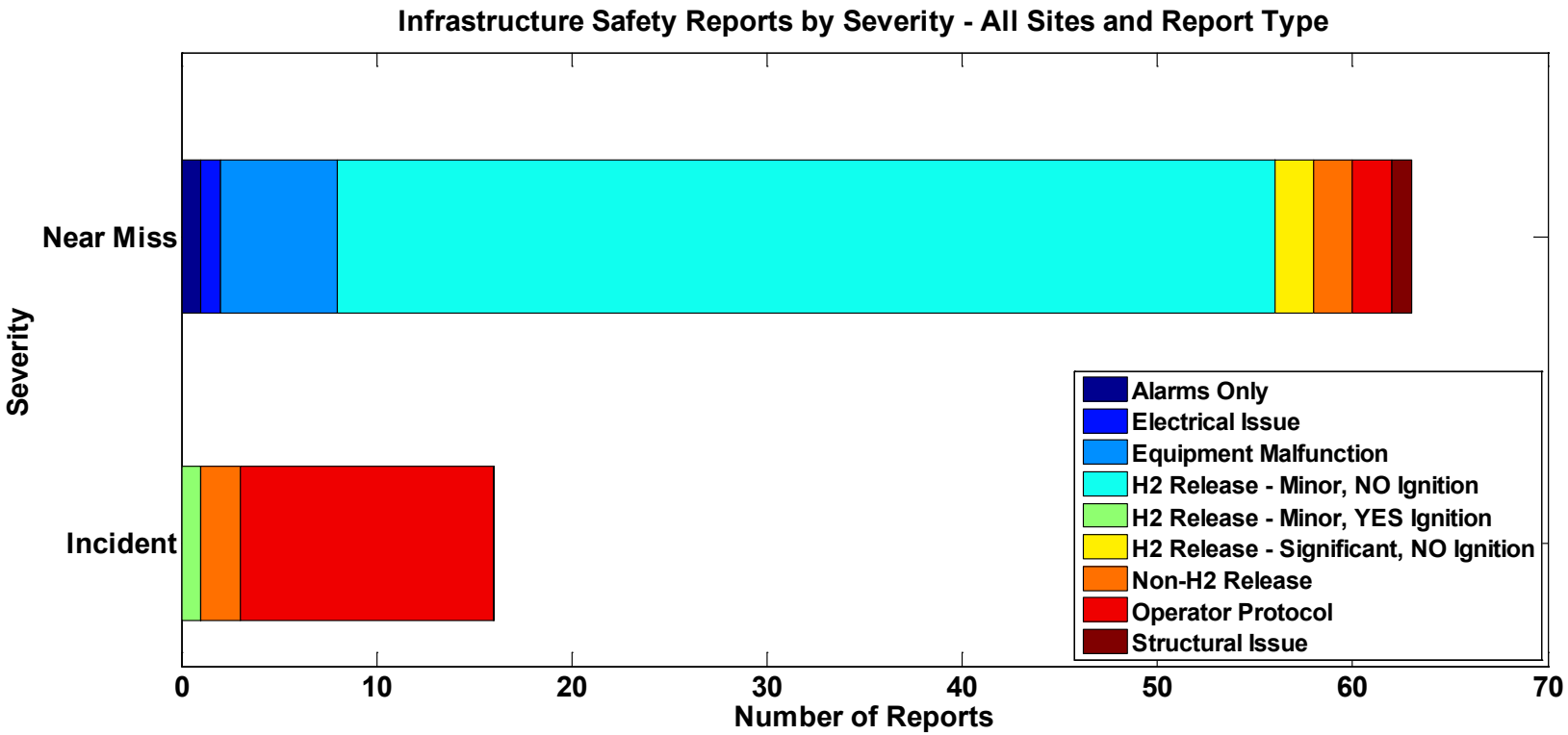
NREL cdp_mhe_25
Created: Oct-04-12 12:11 PM

CDPARRA-MHE-35
Refuel Events by Day of Week



NREL cdparra_mhe_35
Created: Sep-20-12 3:42 PM

CDP-MHE-41
Infrastructure Safety Categories

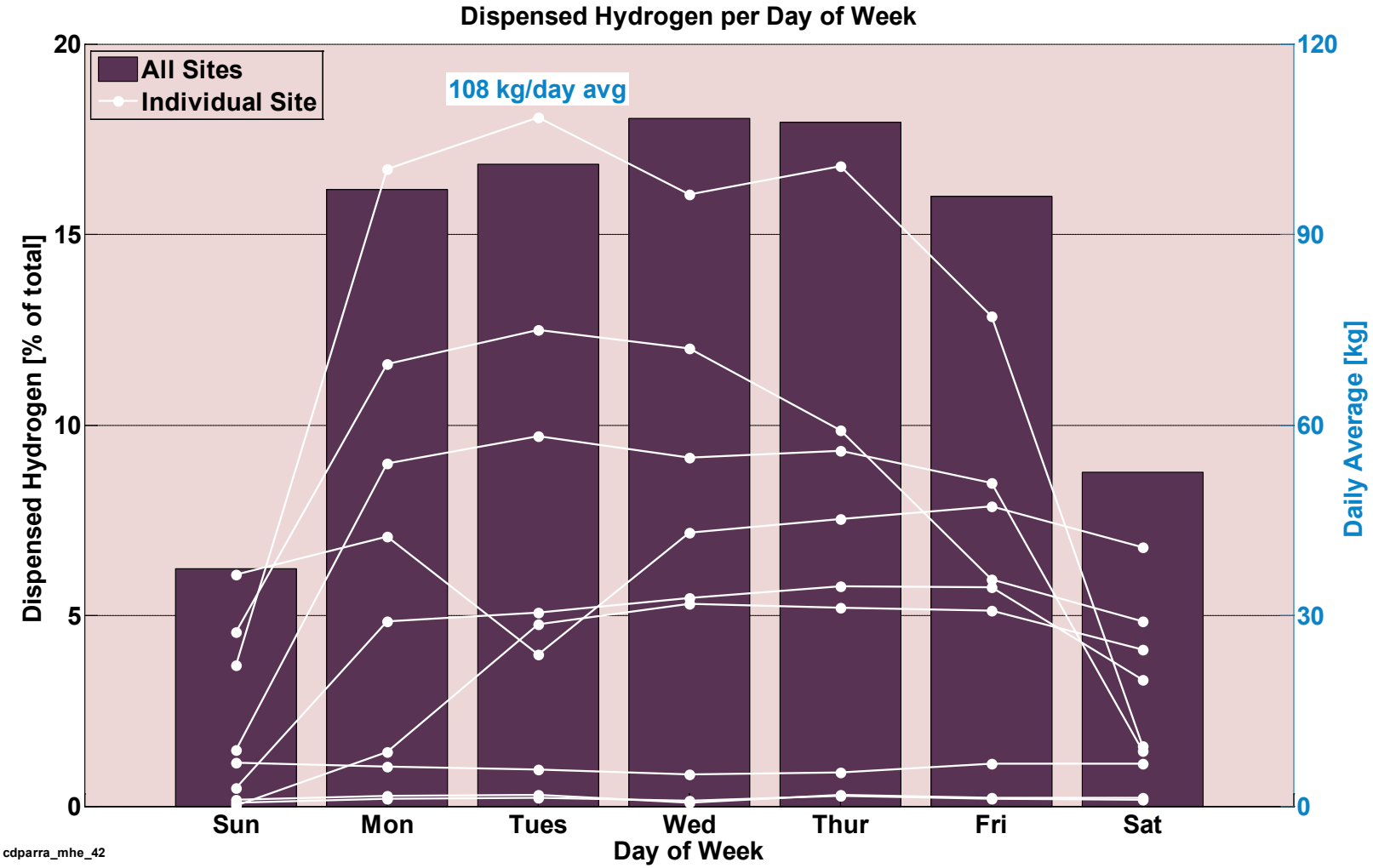


An INCIDENT is an event that results in:
- a lost time accident and/or injury to personnel
- damage/unplanned downtime for project equipment, facilities or property
- impact to the public or environment
- any hydrogen release that unintentionally ignites or is sufficient to sustain a flame if ignited
- 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_mhe_41
Created: Oct-05-12 12:03 PM

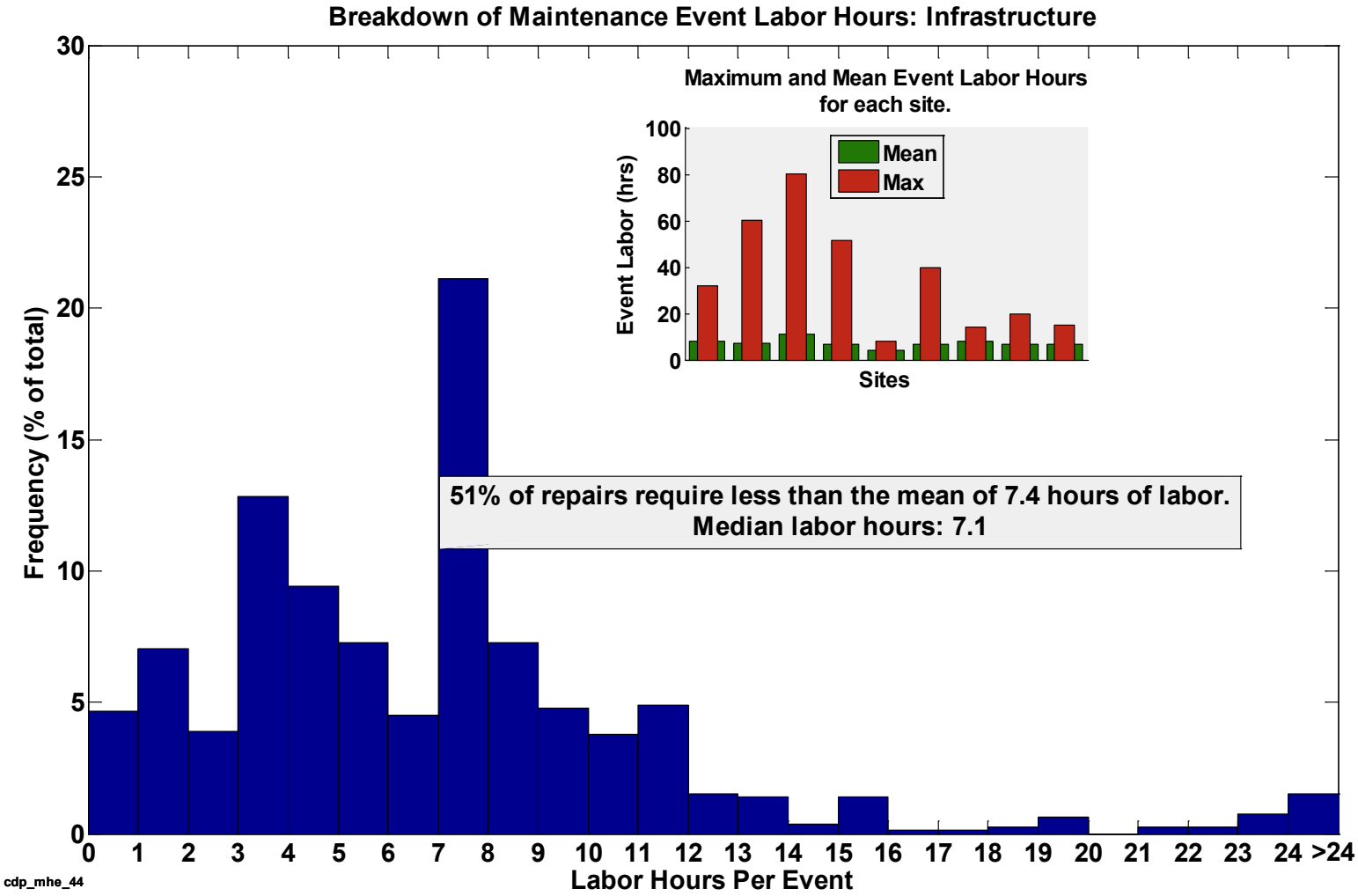
CDPARRA-MHE-42
Amount of Hydrogen Dispensed by Day of Week



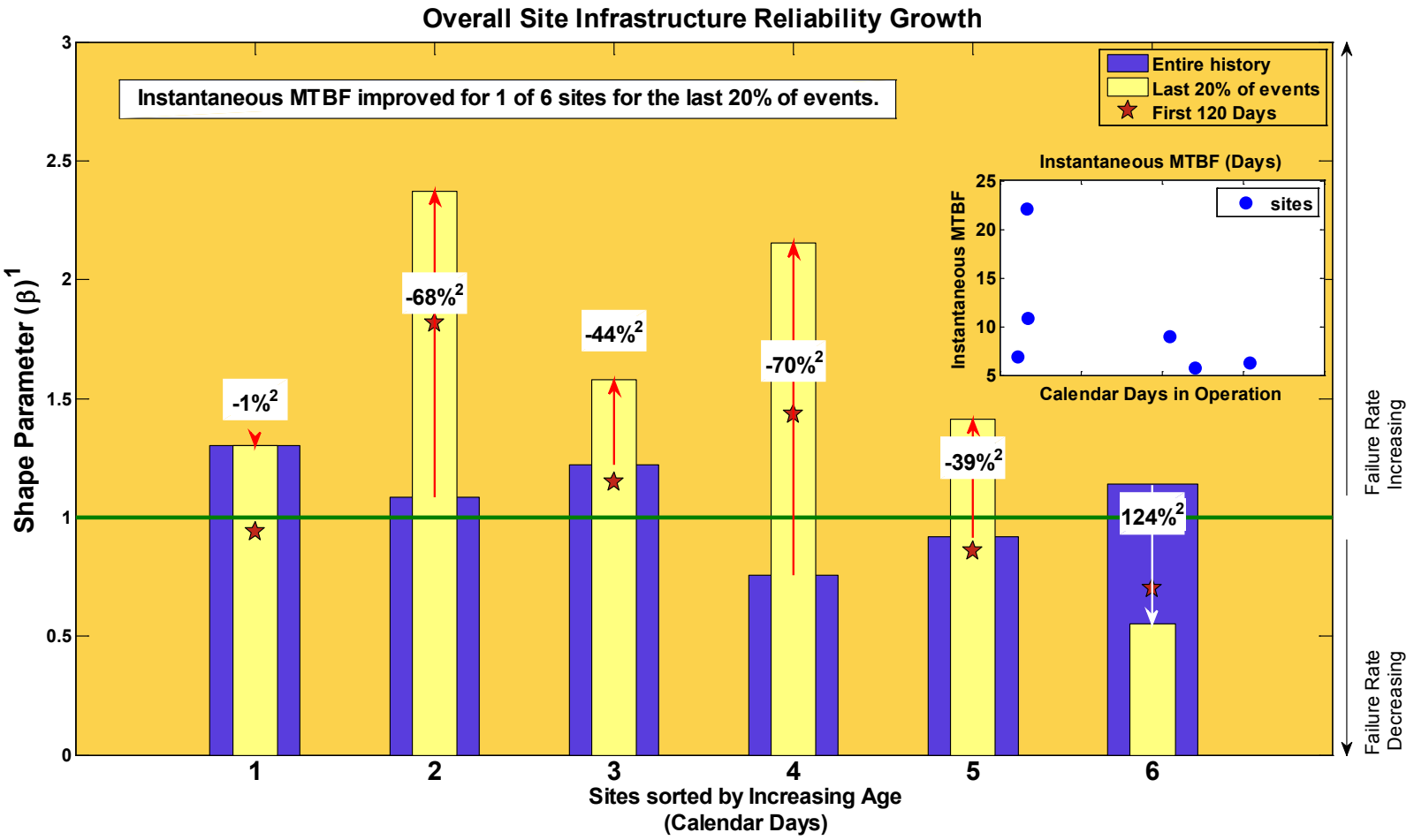
NREL cdparra_mhe_42

Created: Oct-04-12 12:19 PM

CDP-MHE-44
Infrastructure Maintenance Labor Hours



CDP-MHE-45
Infrastructure Reliability Growth

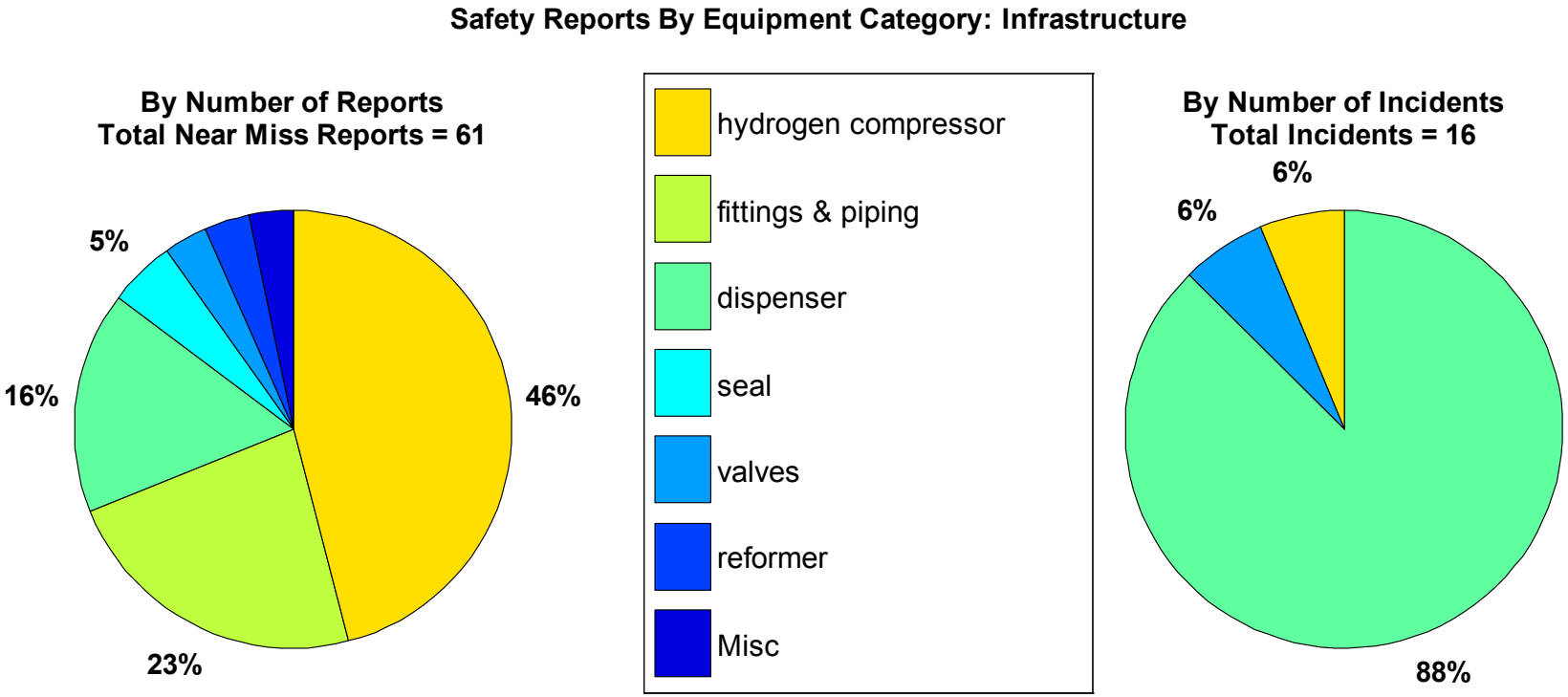


1. IEC 61164:2004(E)., Reliability Growth - Statistical Test and Evaluation Methods, IEC. 2004.

2.% change in instantaneous MTBF

NREL cdp_mhe_45
Created: Sep-21-12 3:04 PM

CDP-MHE-46
Infrastructure Equipment Category of Safety Events



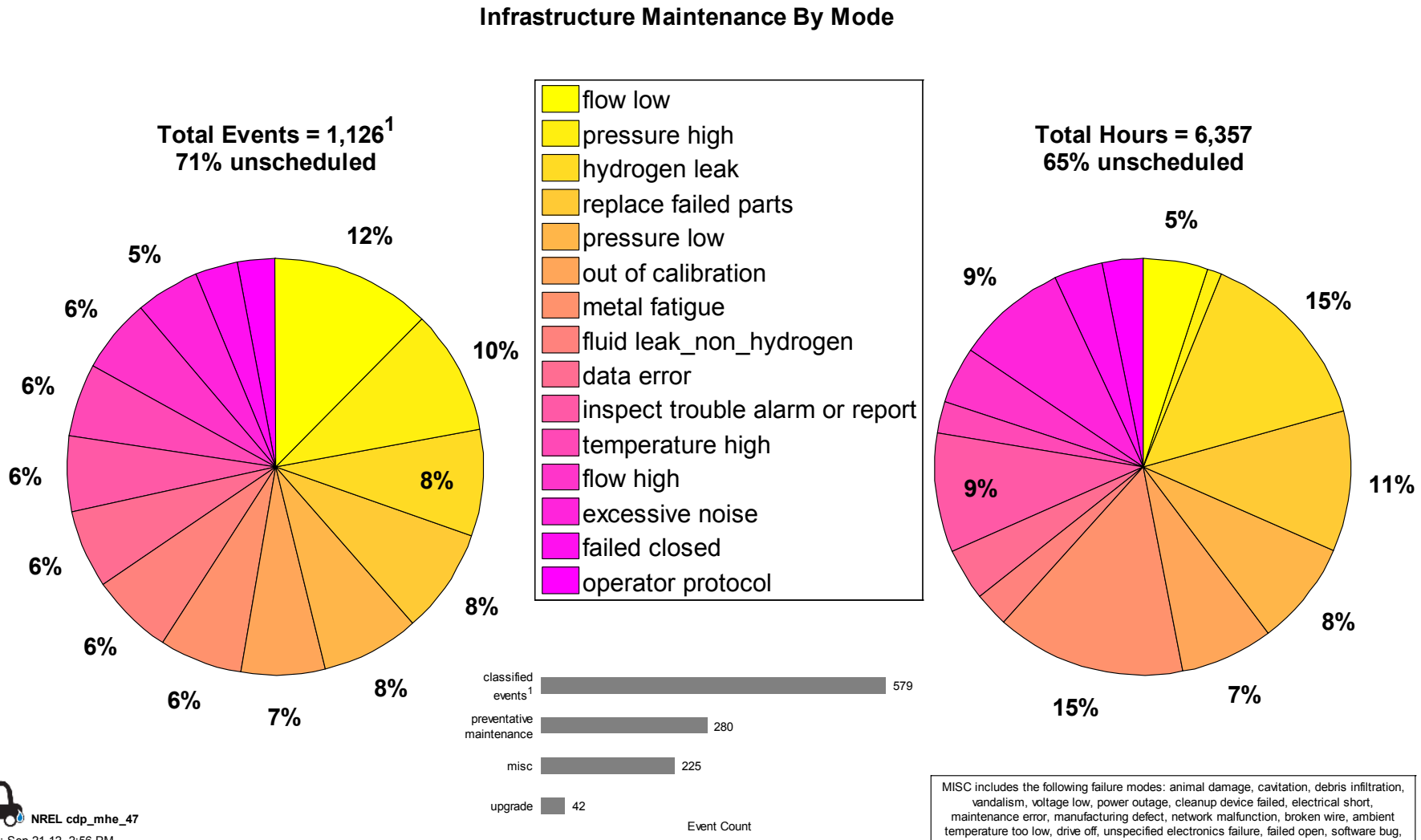
MISC includes the following categories:
FUEL SYSTEM
OTHER

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)

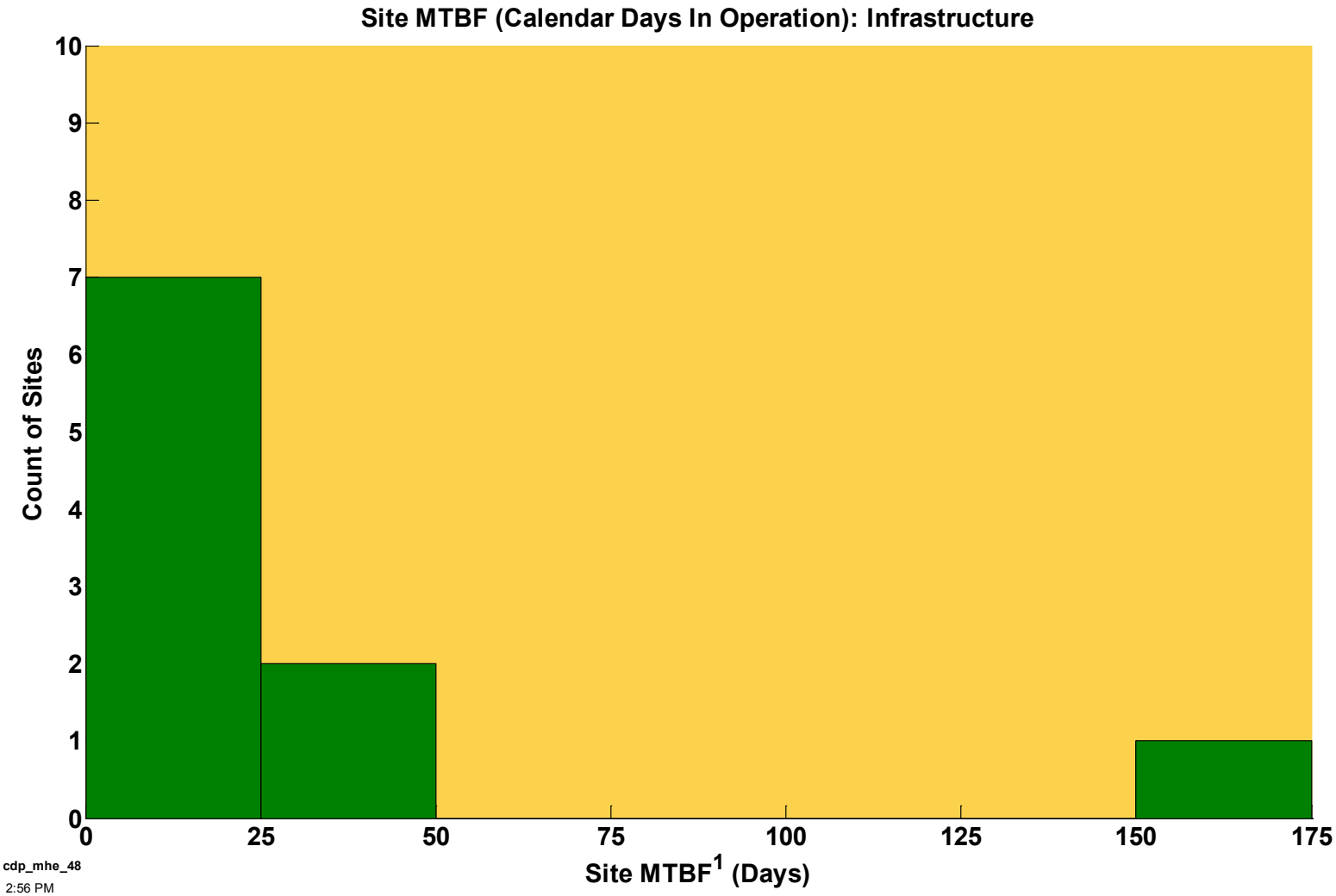
A NEAR-MISS is:
- an event that under slightly different circumstances could have become an incident
- unplanned H2 release insufficient to sustain a flame

NREL cdp_mhe_46
Created: Sep-21-12 2:55 PM

CDP-MHE-47
Infrastructure Maintenance by Mode

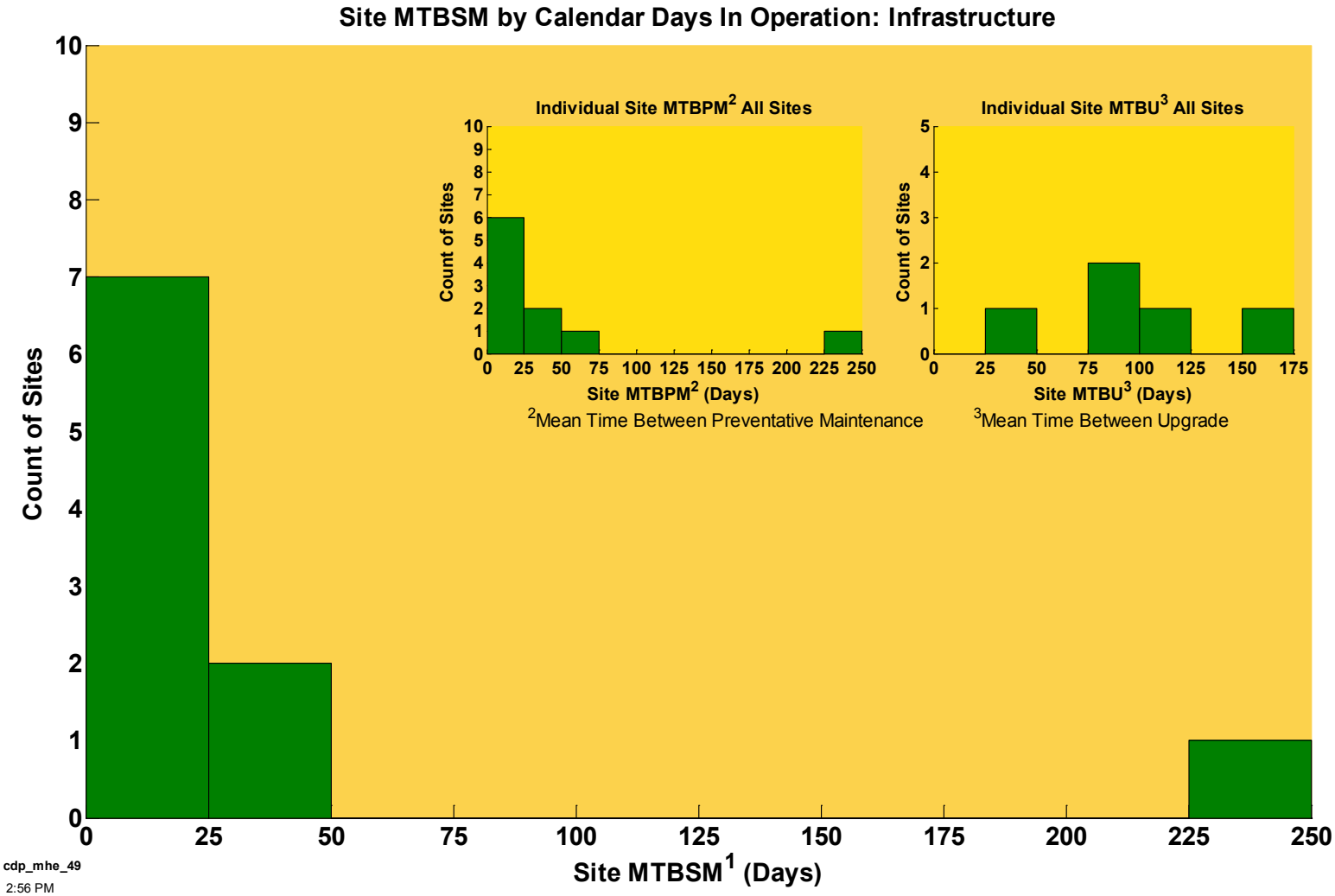


CDP-MHE-48
Infrastructure Mean Time Between Failures



1. Cumulative Mean Time Between Failure

CDP-MHE-49
Infrastructure Mean Time Between Scheduled Maintenance



[2]Mean Time Between Preventative Maintenance

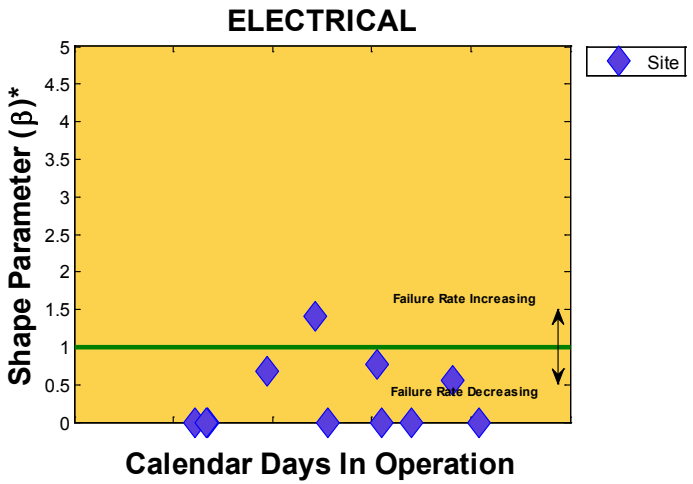
[3]Mean Time Between Upgrade

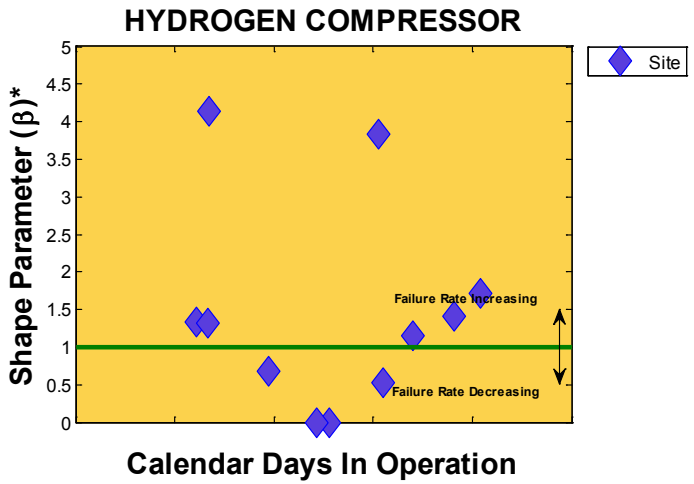
NREL cdp_mhe_49

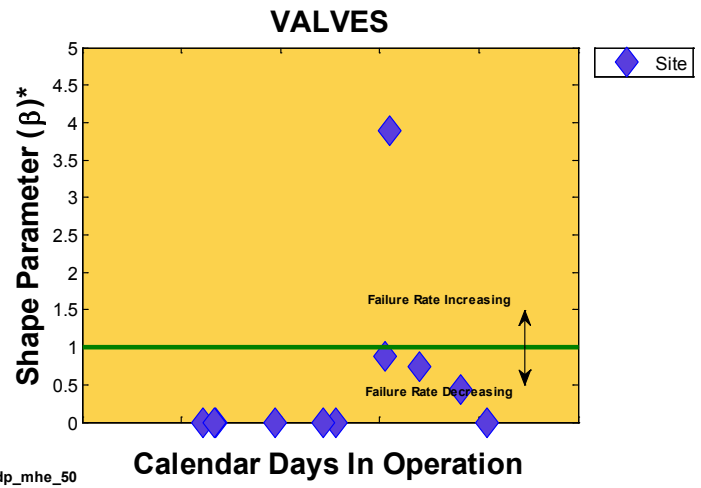
Created: Sep-21-12 2:56 PM

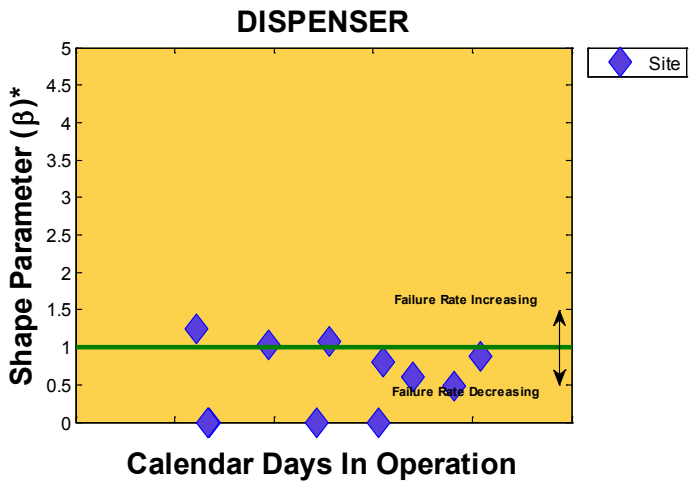
1. Cumulative Mean Time Between Scheduled Maintenance. Includes Preventative and Upgrades

CDP-MHE-50
Infrastructure Reliability Growth by Category







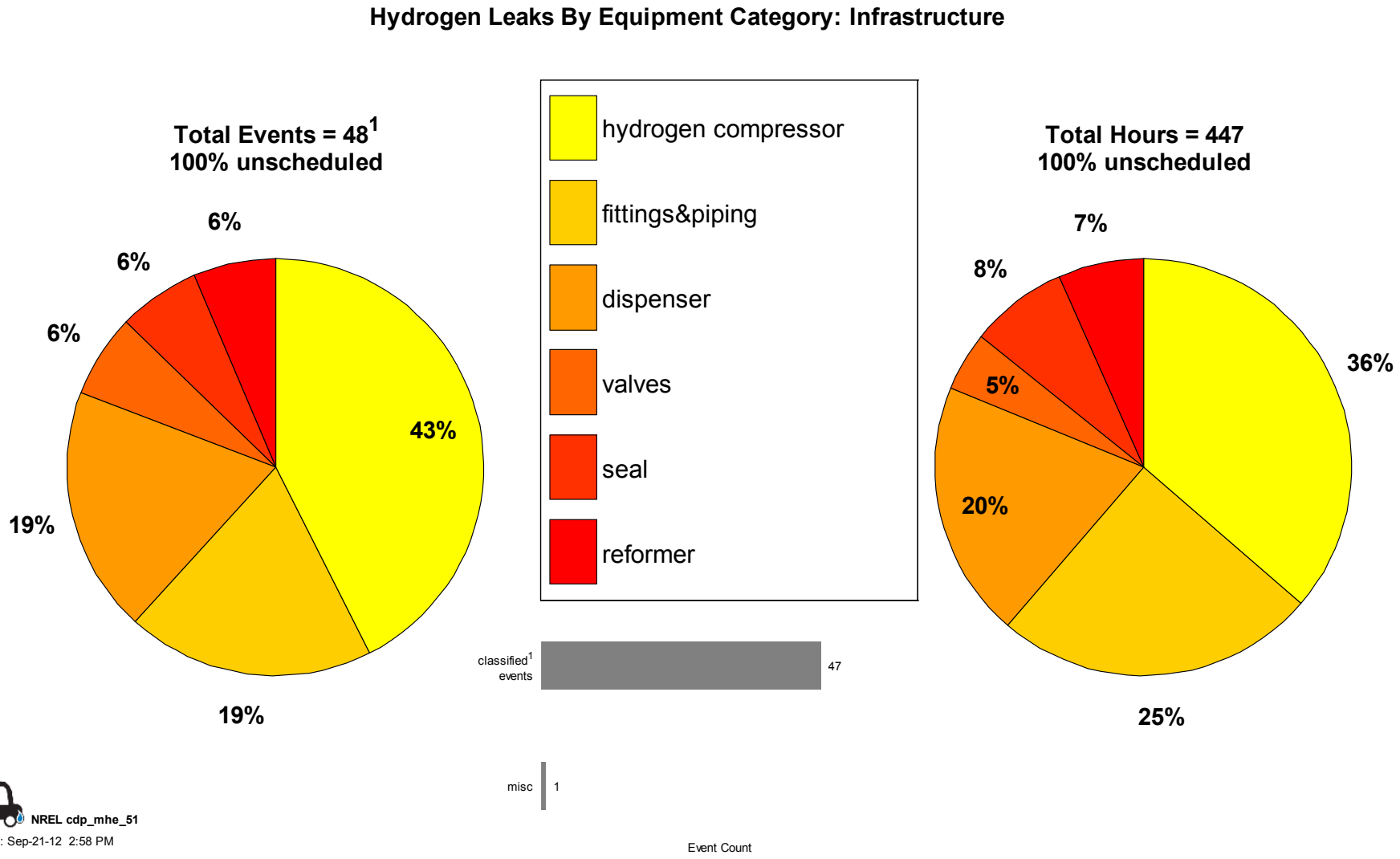


NREL cdp_mhe_50
Created: Sep-21-12 2:57 PM

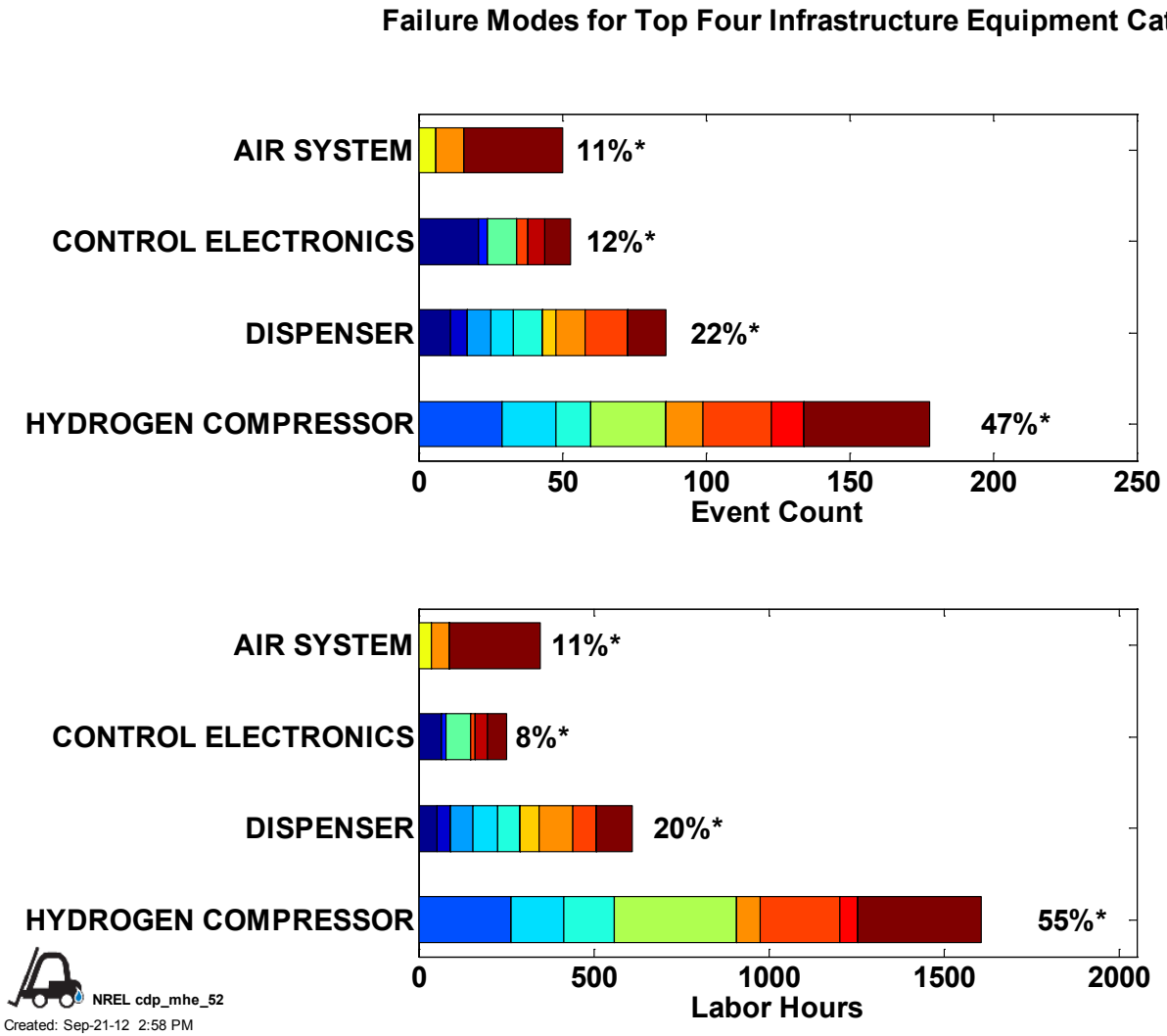
These represent the top four equipment failure categories from all combined data.

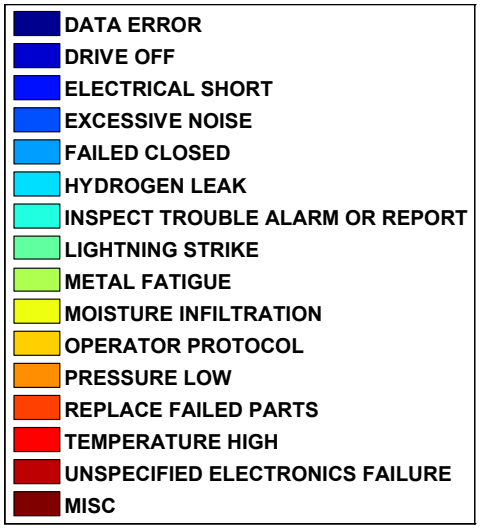
*IEC 61164 β

CDP-MHE-51
Infrastructure Hydrogen Leaks by Equipment Type



CDP-MHE-52
Infrastructure Failures by Mode

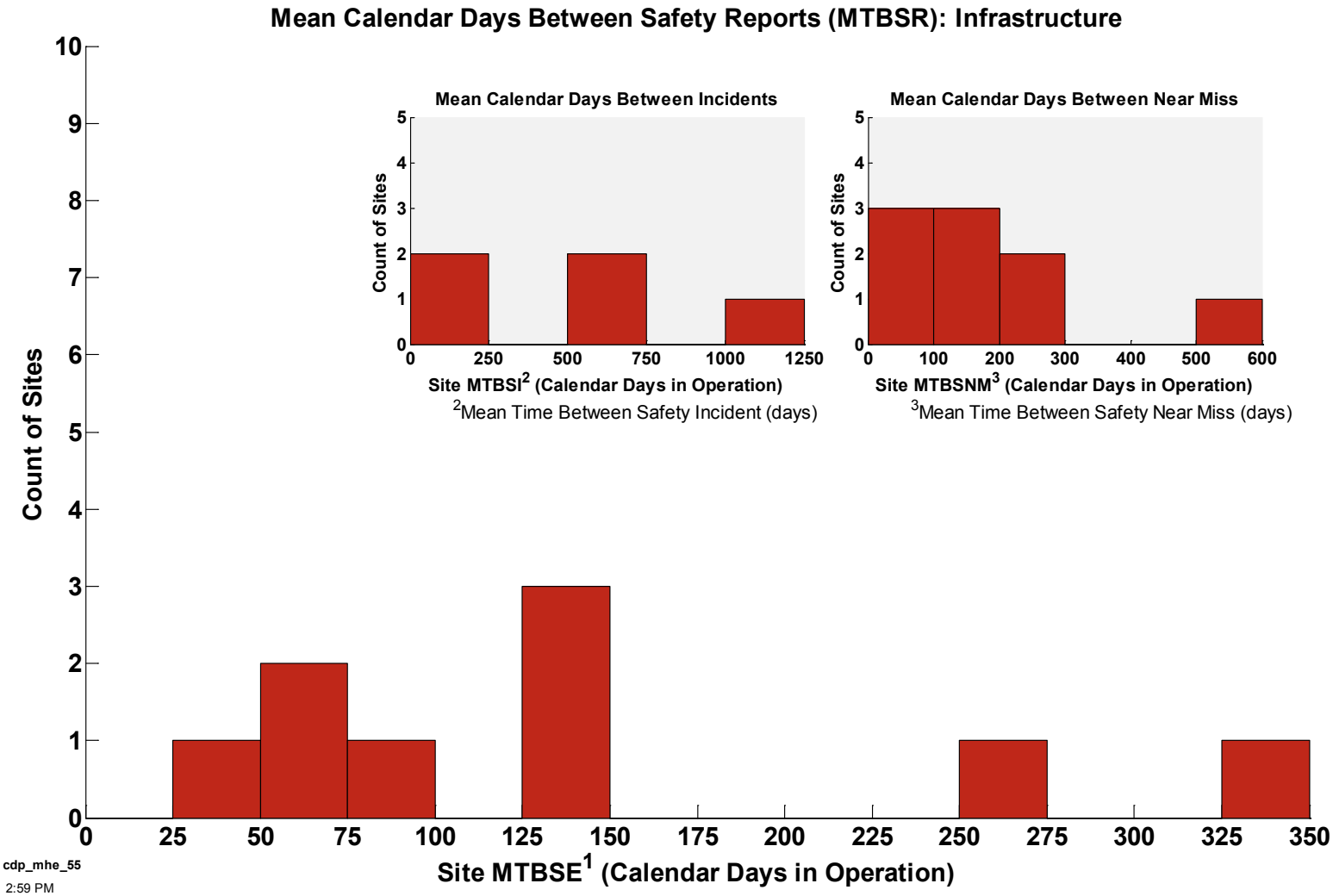




MISC includes the following failure modes: ambient temperature too low, broken wire, cavitation, debris infiltration, failed closed, flow high, flow low, fluid leak_non_hydrogen, inspect trouble alarm or report, maintenance error, manufacturing defect, metal fatigue, moisture infiltration, network malfunction, operator protocol, other, pressure high, software bug, vandalism, voltage low, other

*** Percentage of total events or hours, reference CDP 66.**

CDP-MHE-55
Infrastructure Mean Time Between Safety Events

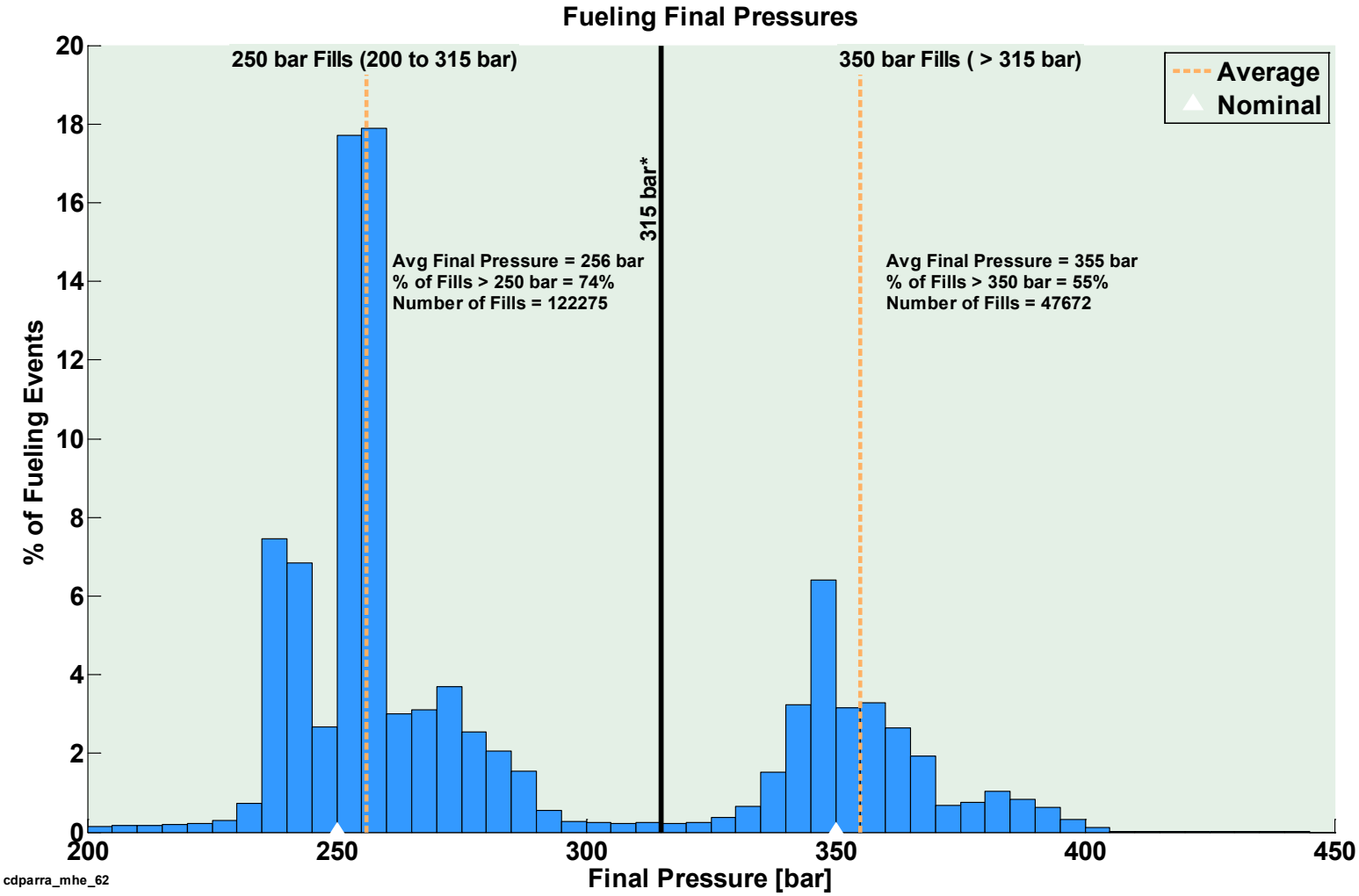


NREL cdp_mhe_55

Created: Sep-21-12 2:59 PM

1. Cumulative Mean Time Between Safety Report (days)

CDPARRA-MHE-62
Final Pressure of Hydrogen Fills

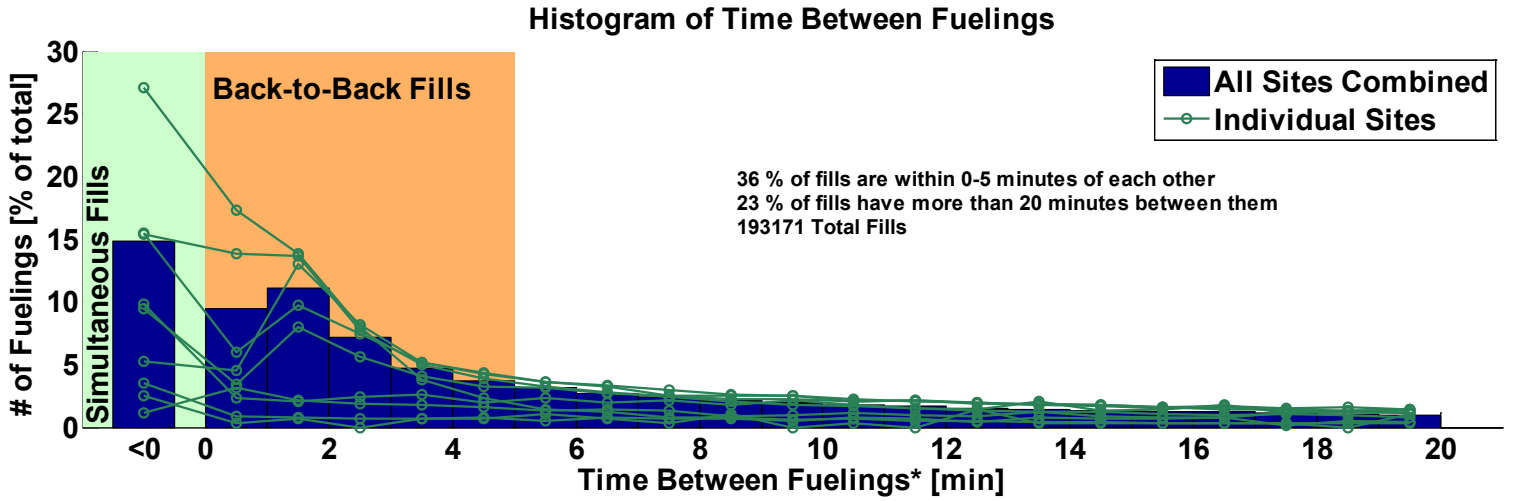


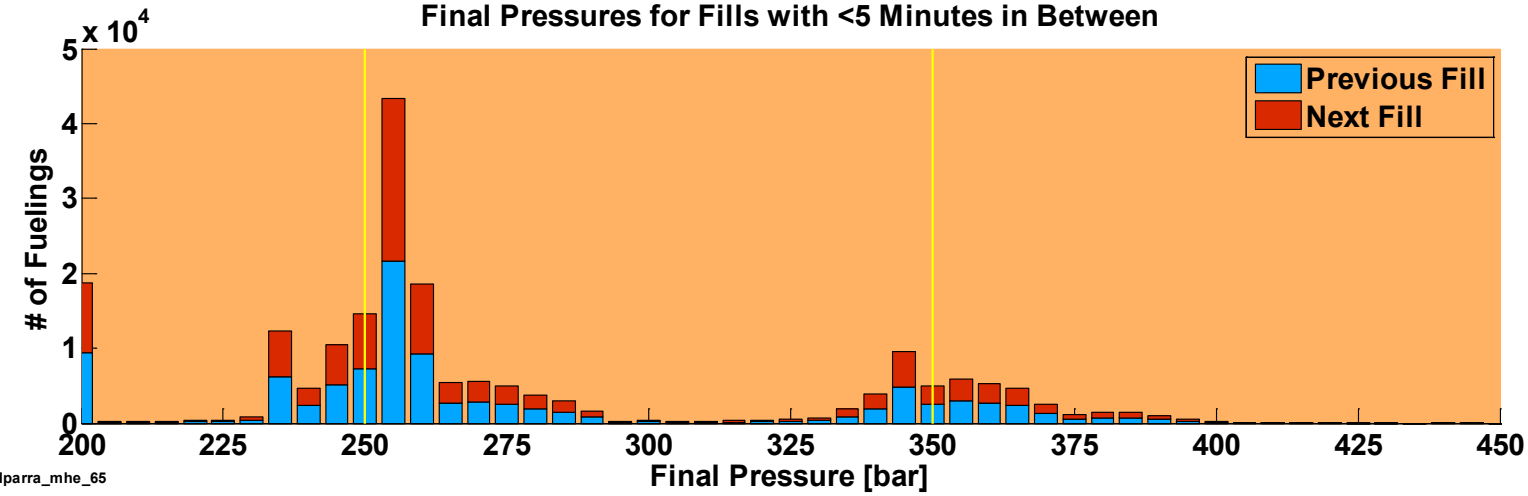
NREL cdparra_mhe_62

Created: Oct-05-12 1:41 PM

*The line at 315 bar separates 250 bar fills from 350 bar fills. It is slightly over the allowable 125% of nominal pressure (312.5 bar) from SAE J2601.

CDPARRA-MHE-65
Details of Back-to-Back Fills





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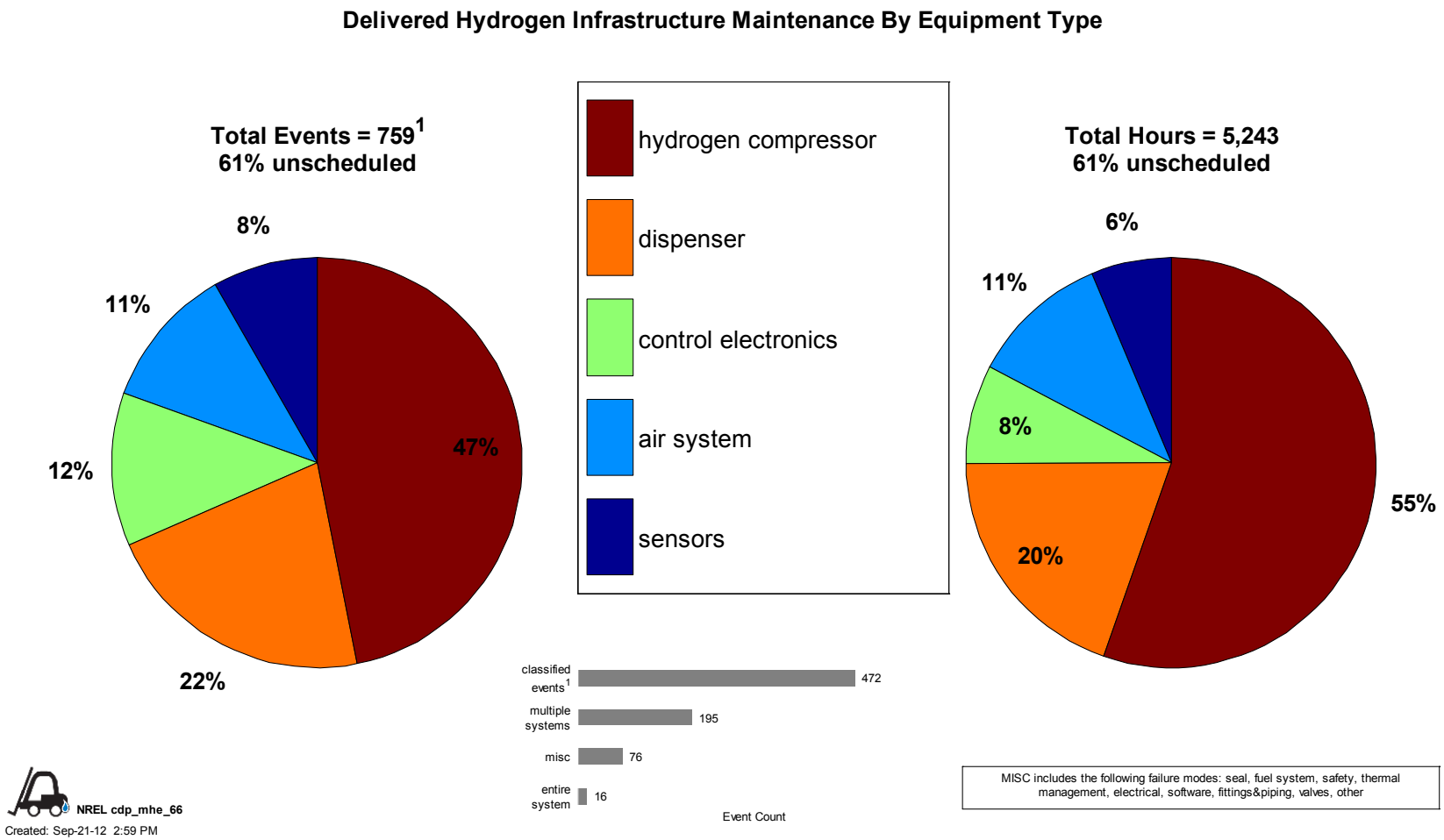
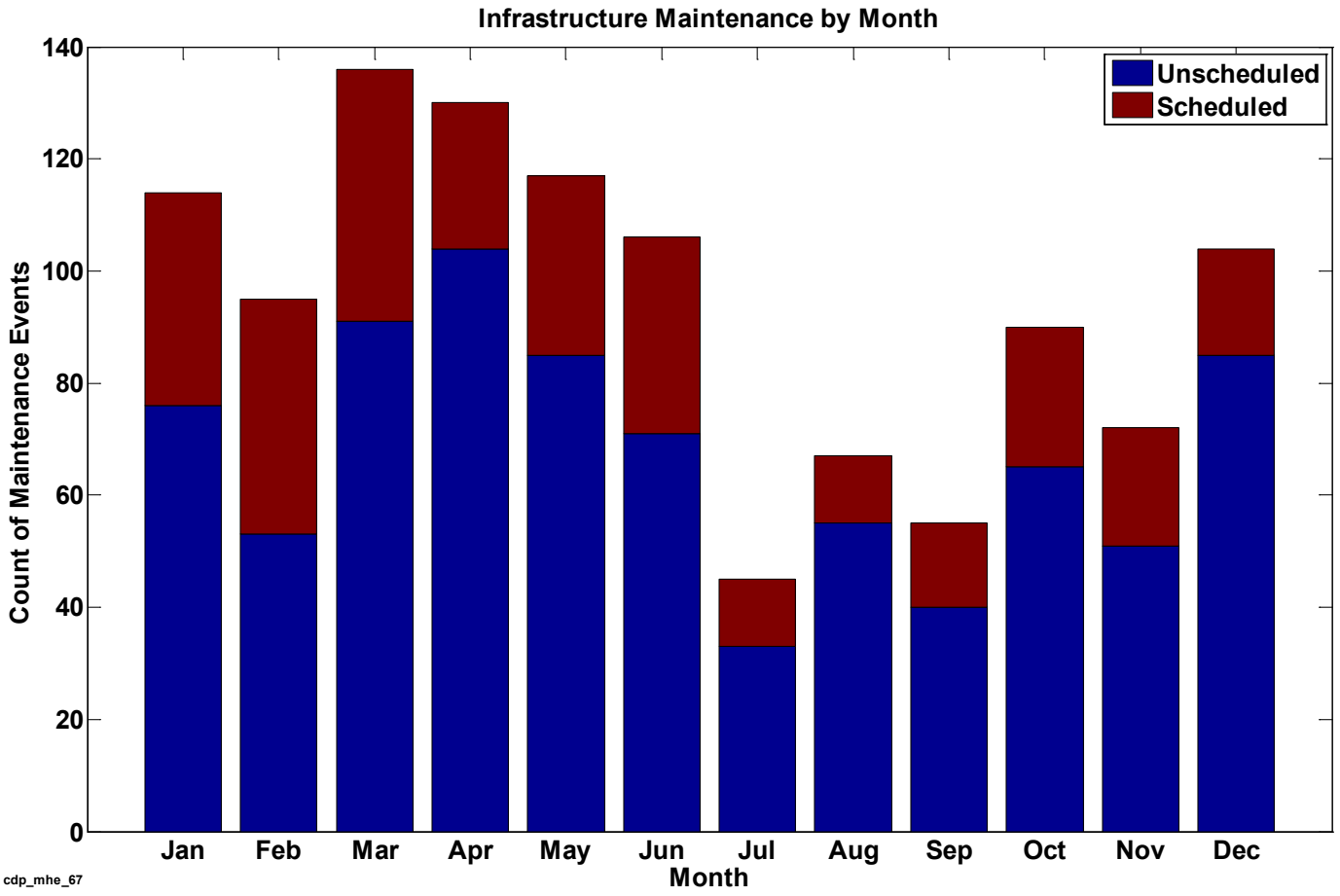
*Time is from end of fill to start of next fill.

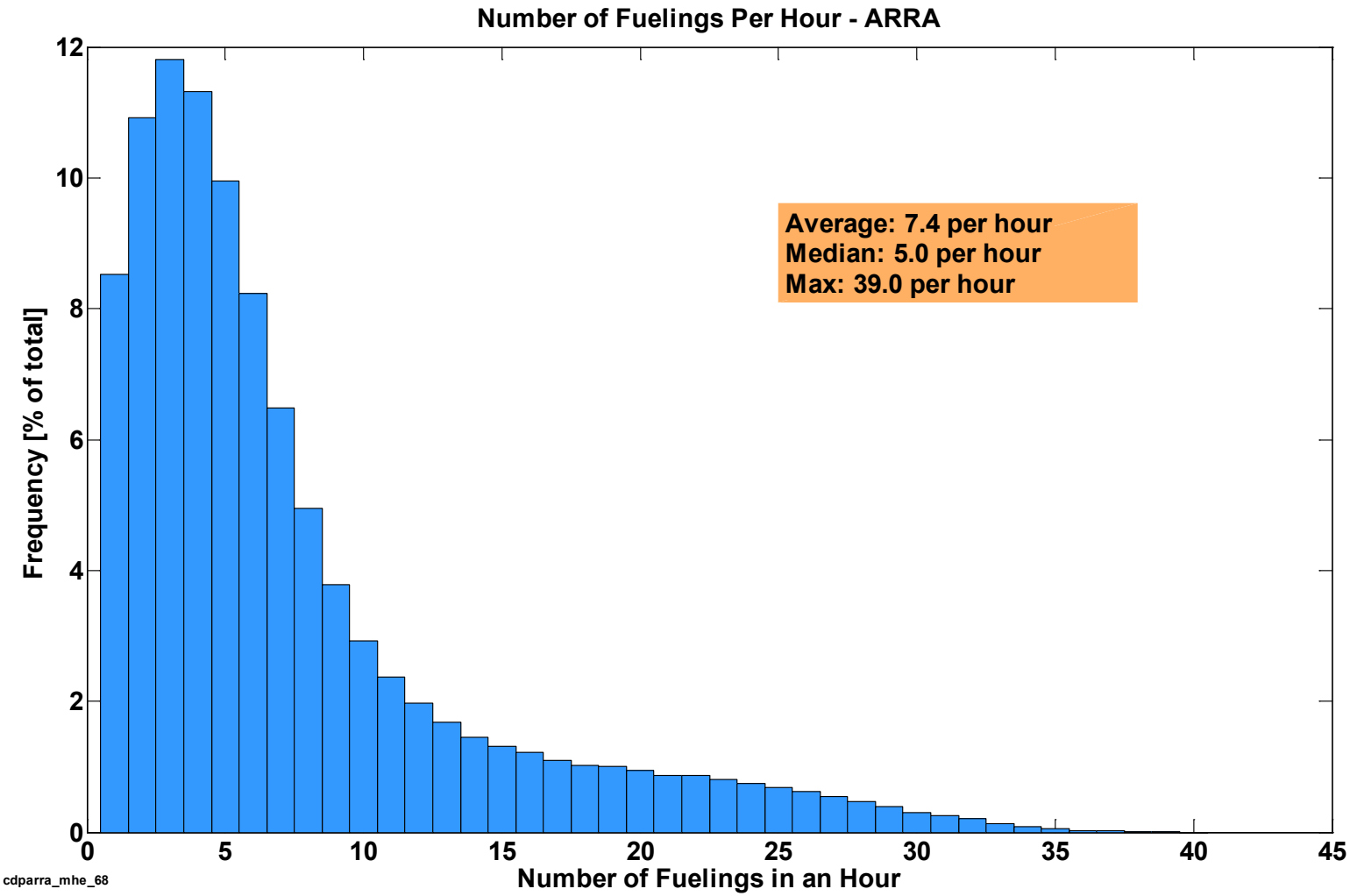
CDP-MHE-66
Infrastructure Maintenance for Delivered Hydrogen



CDP-MHE-67
Infrastructure Maintenance by Month



CDPARRA-MHE-68
Fill Counts per Hours



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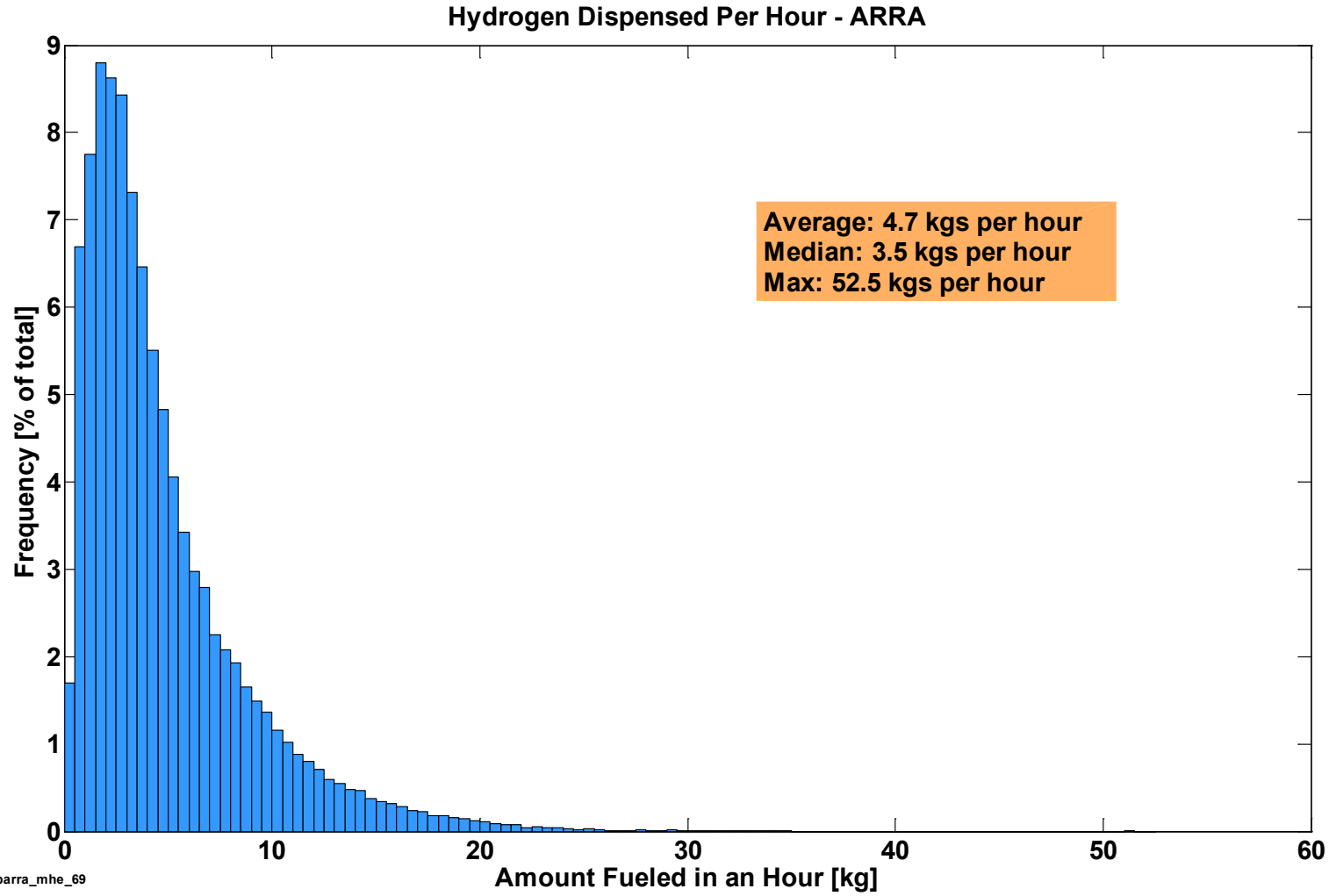
CDPARRA-MHE-69
Fill Amount per Hour



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