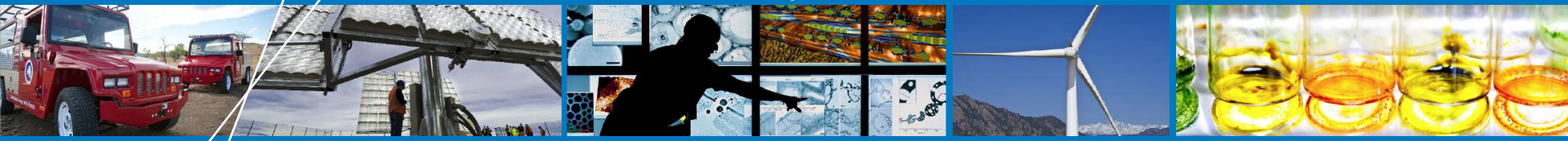
NREL
NATIONAL RENEWABLE ENERGY LABORATORY

ARRA MHE Composite Data Products for Data Through 2011 Q4

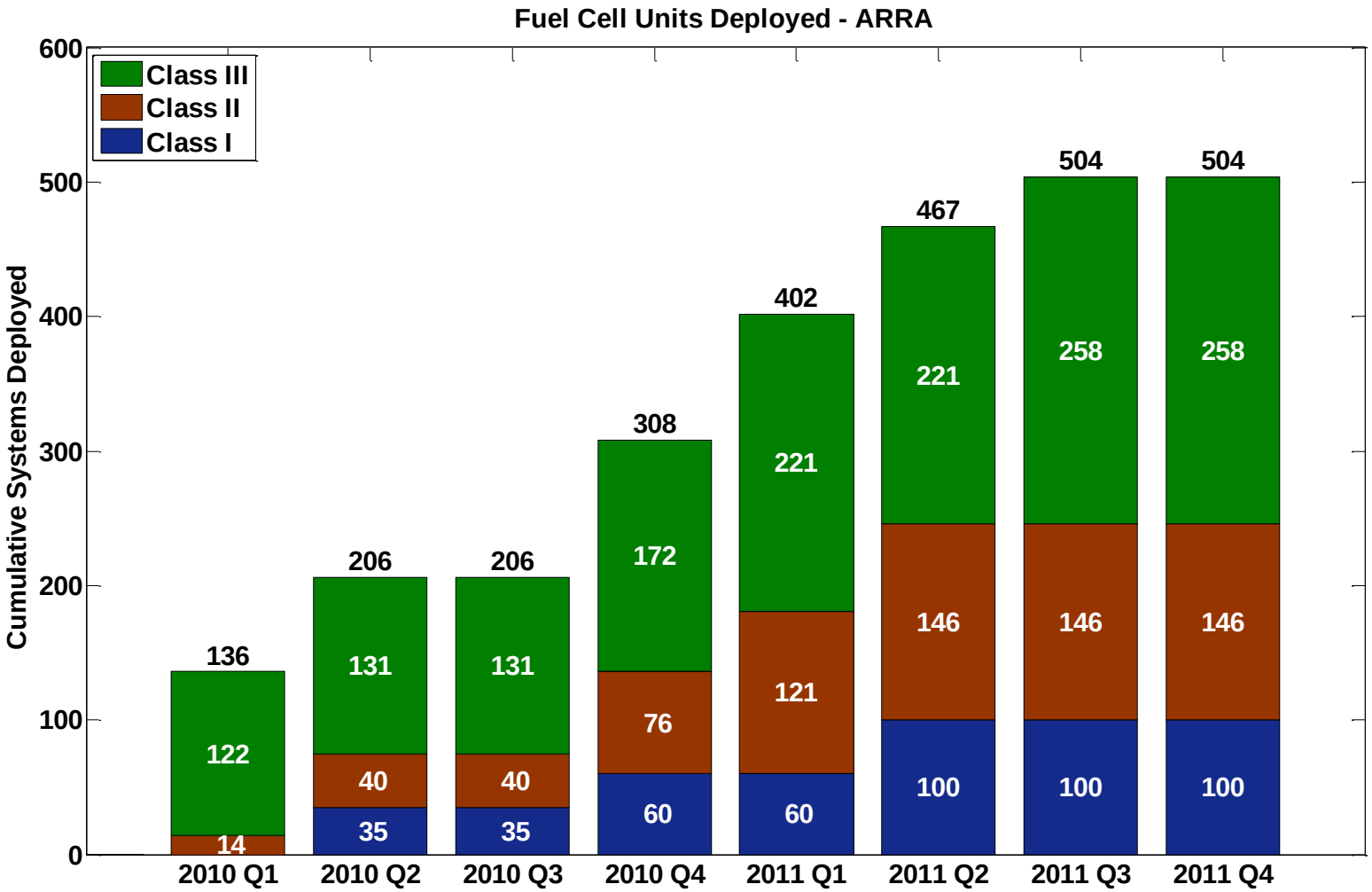


Jennifer Kurtz, Keith Wipke, Sam Sprik, Todd Ramsden, Chris Ainscough, Genevieve Saur

April 04, 2012

NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

CDPARRA-MHE-01
Fuel Cell MHE Systems Deployed



NREL cdparra_mhe_01

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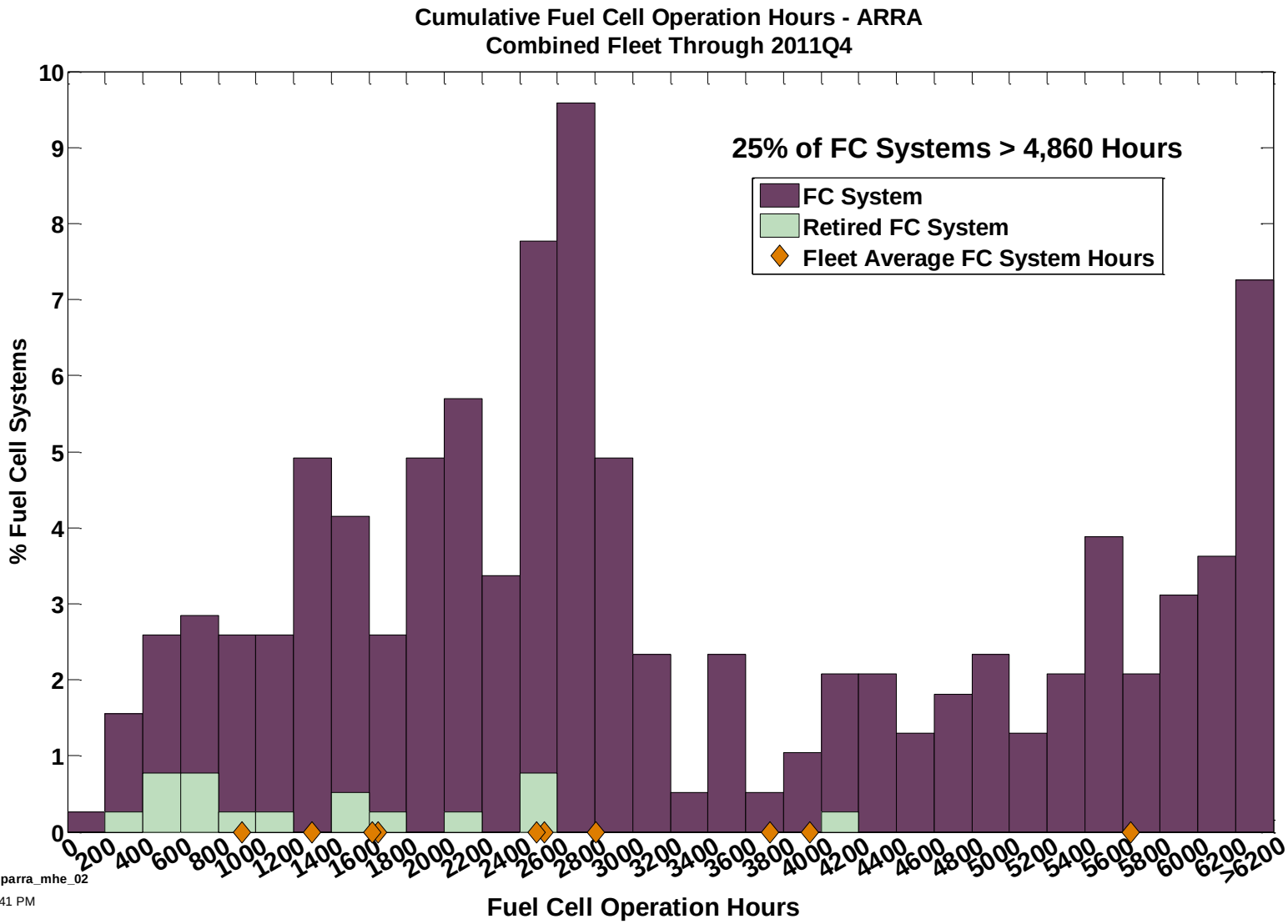
CDPARRA-MHE-02
Fuel Cell System Operation Hours



NREL cdparra_mhe_02

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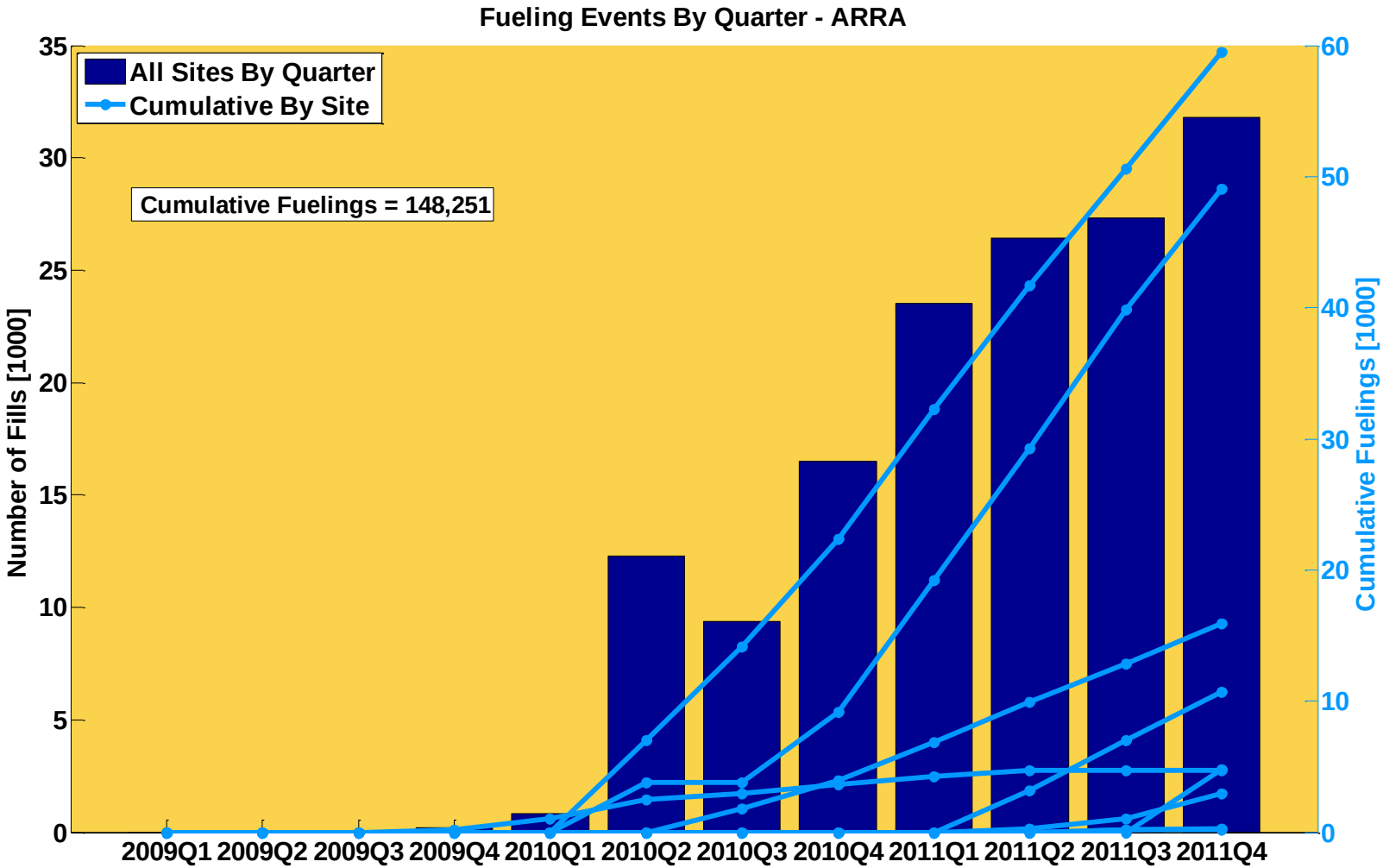
CDPARRA-MHE-03
Fueling Events by Quarter



NREL cdparra_mhe_03

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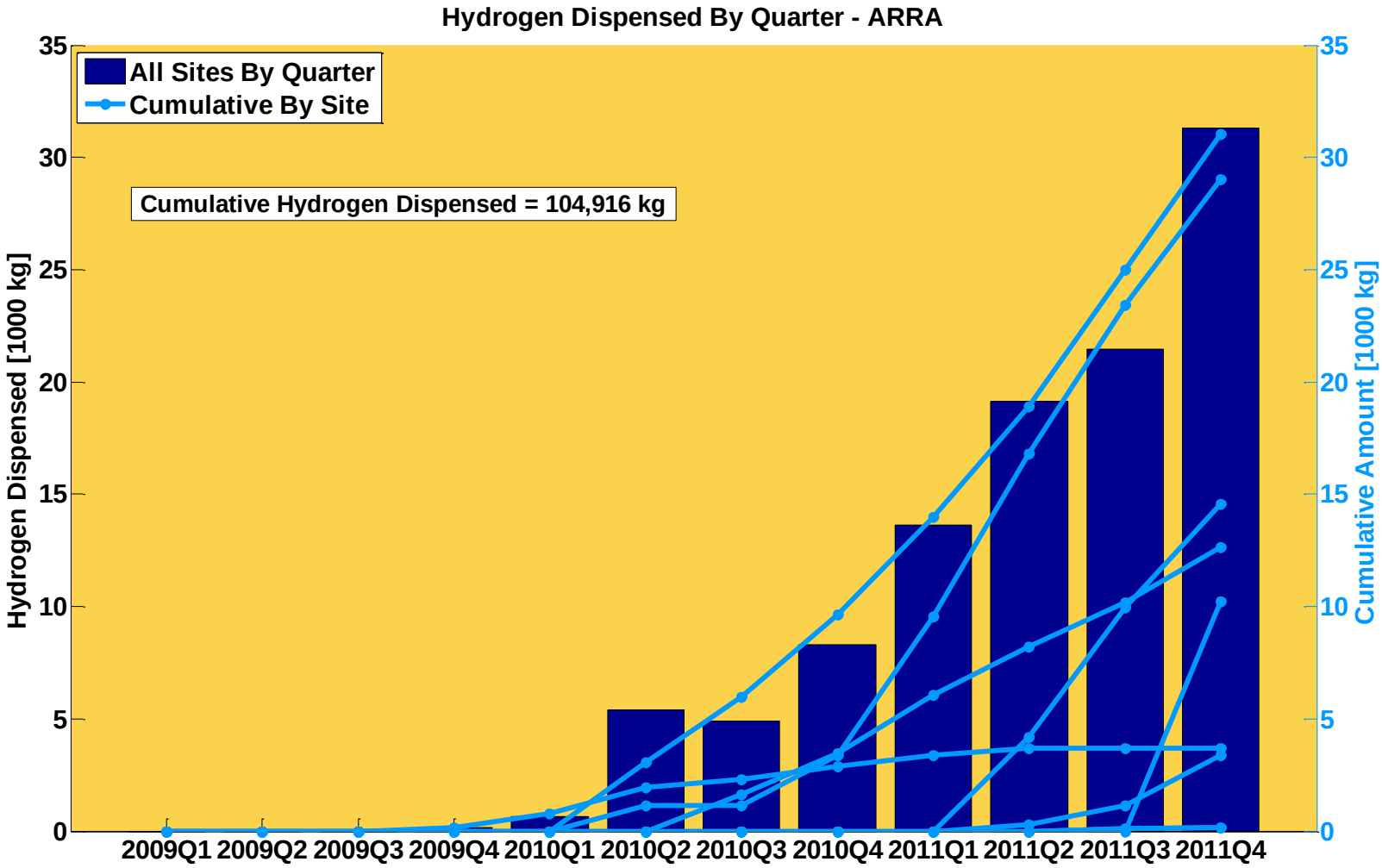
CDPARRA-MHE-04
Hydrogen Dispensed by Quarter



NREL cdparra_mhe_04
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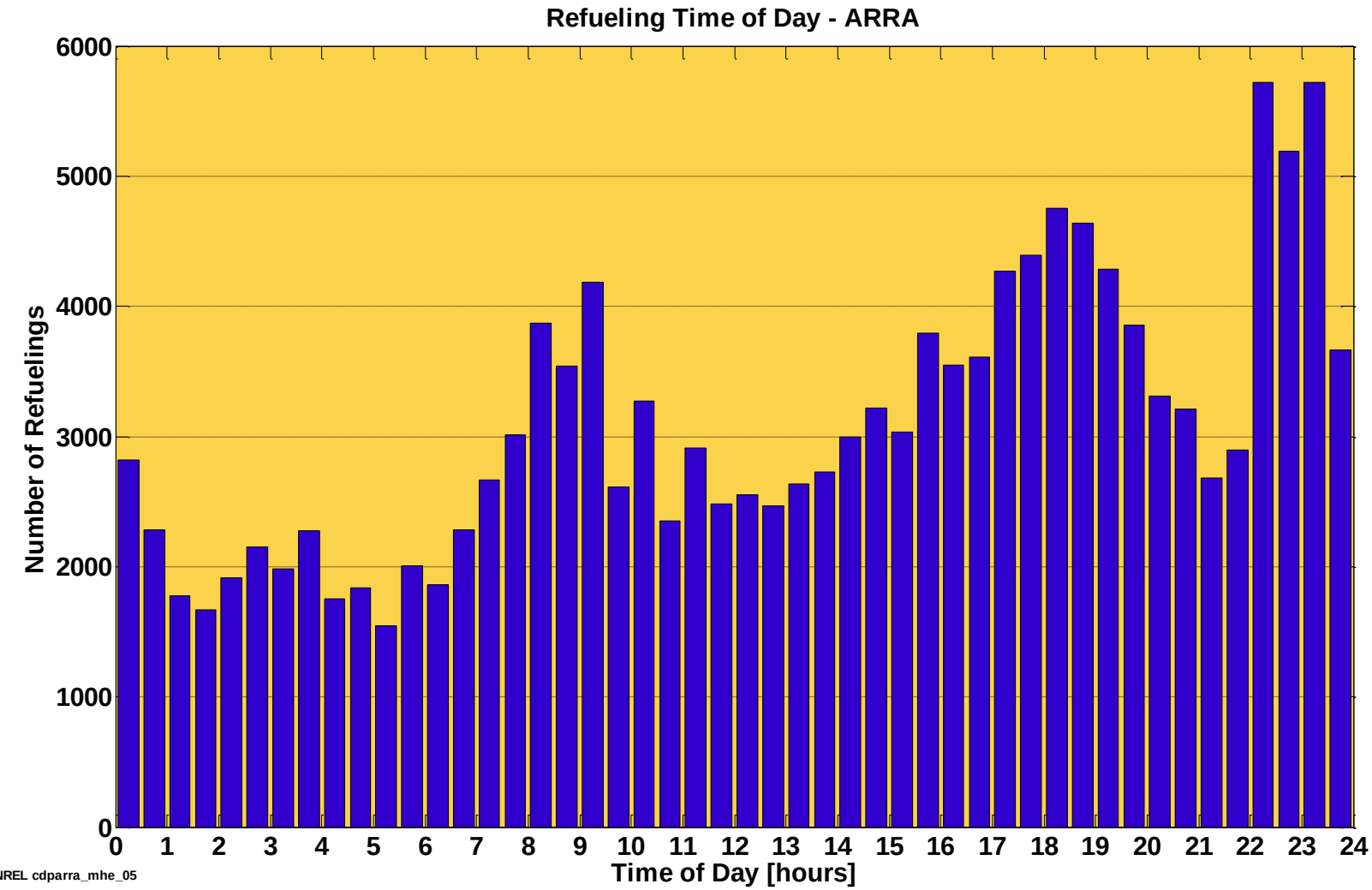
CDPARRA-MHE-05
Refueling Time of Day



NREL cdparra_mhe_05

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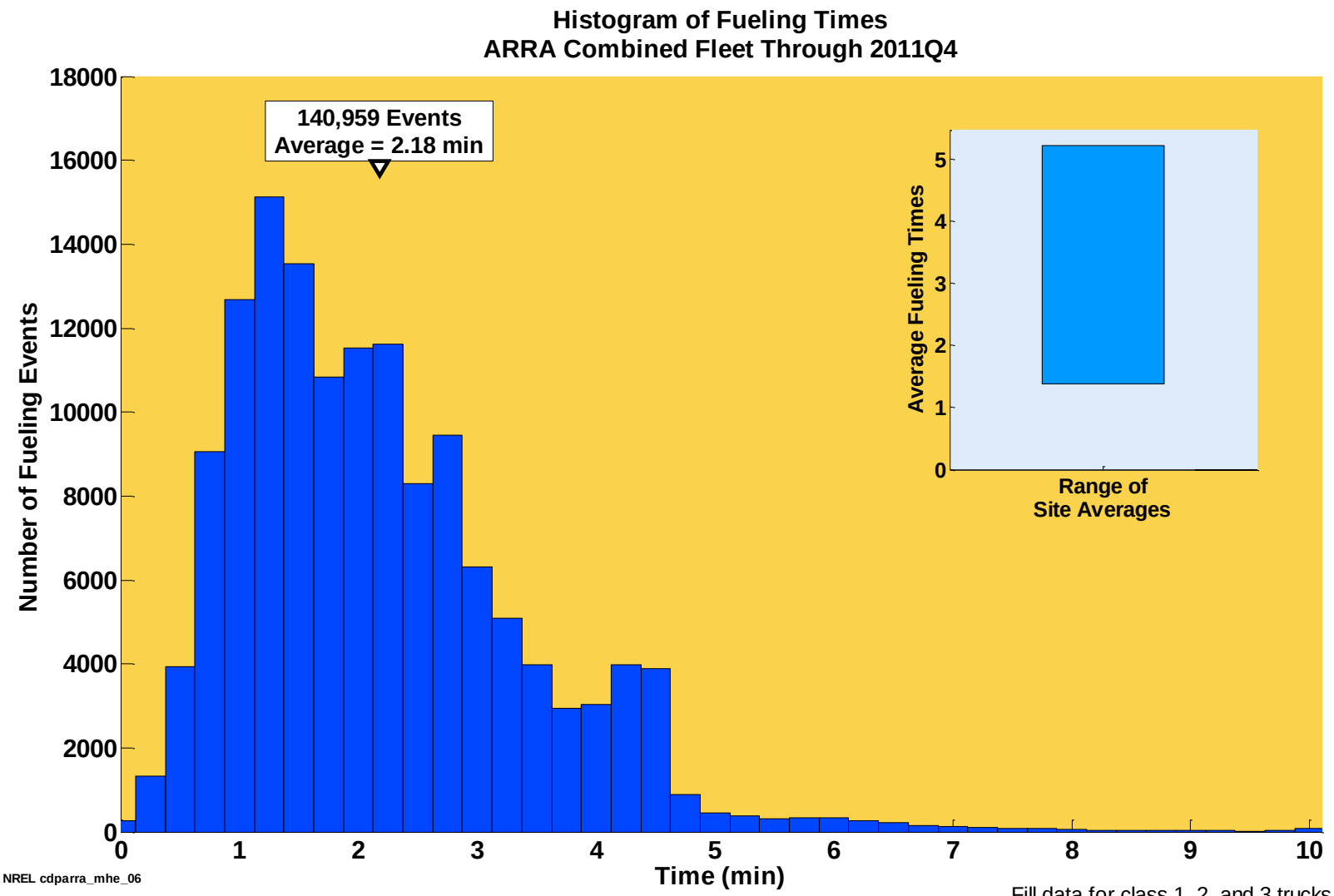
CDPARRA-MHE-06
Histogram of Fueling Times



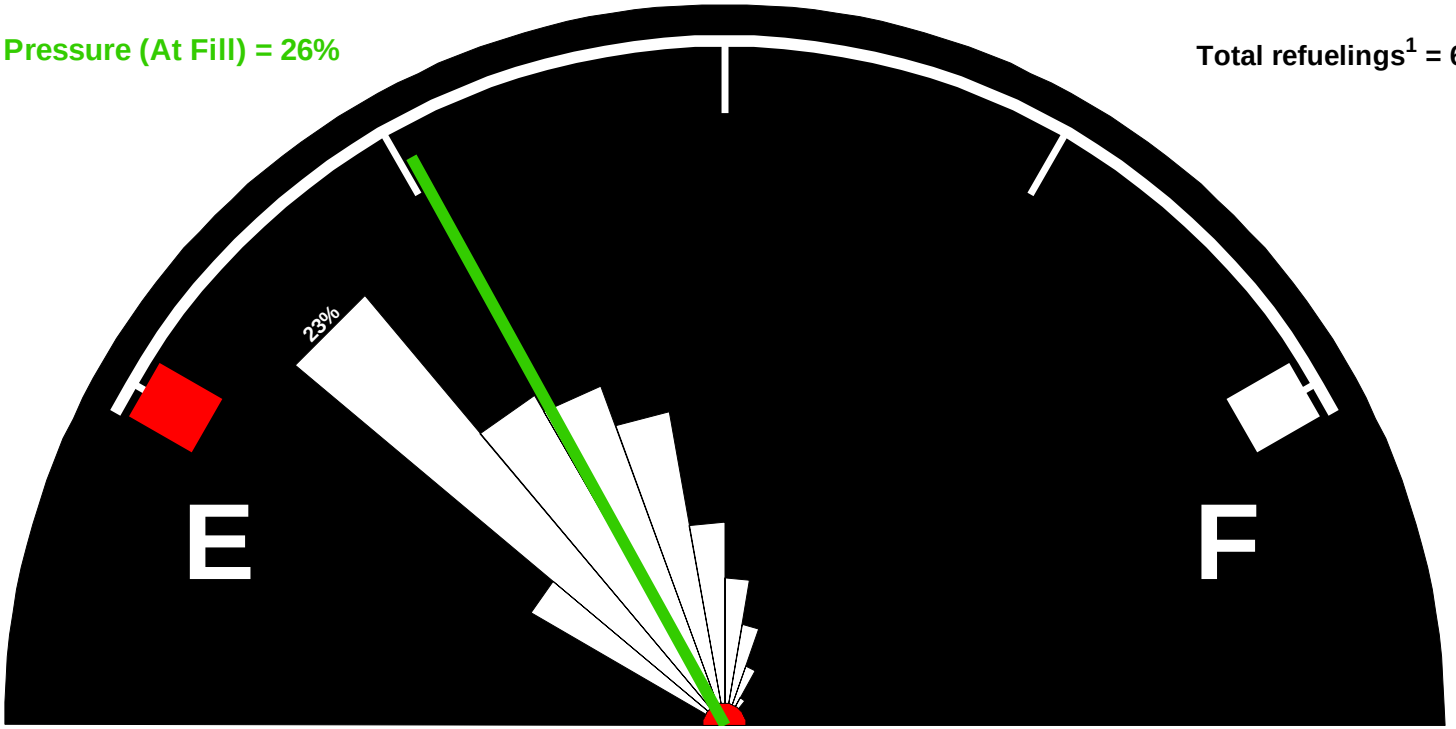
Fill data for class 1, 2, and 3 trucks

CDPARRA-MHE-07
Tank Pressure Level at Fueling

Tank Pressure At Fill: ARRA

Median Tank Pressure (At Fill) = 26%

Total refuelings[1] = 62,062



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

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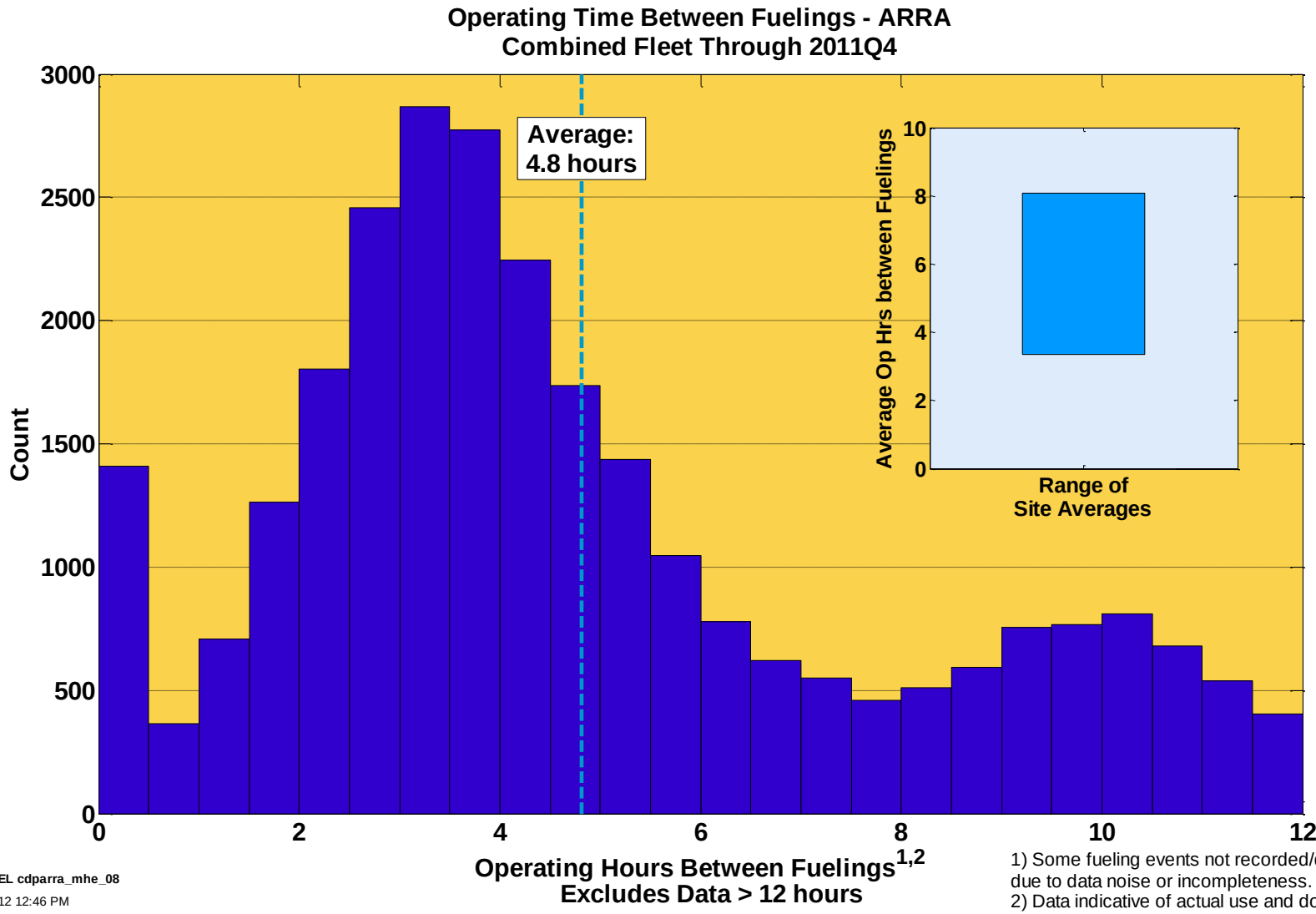
CDPARRA-MHE-08
Operation Time between Fueling

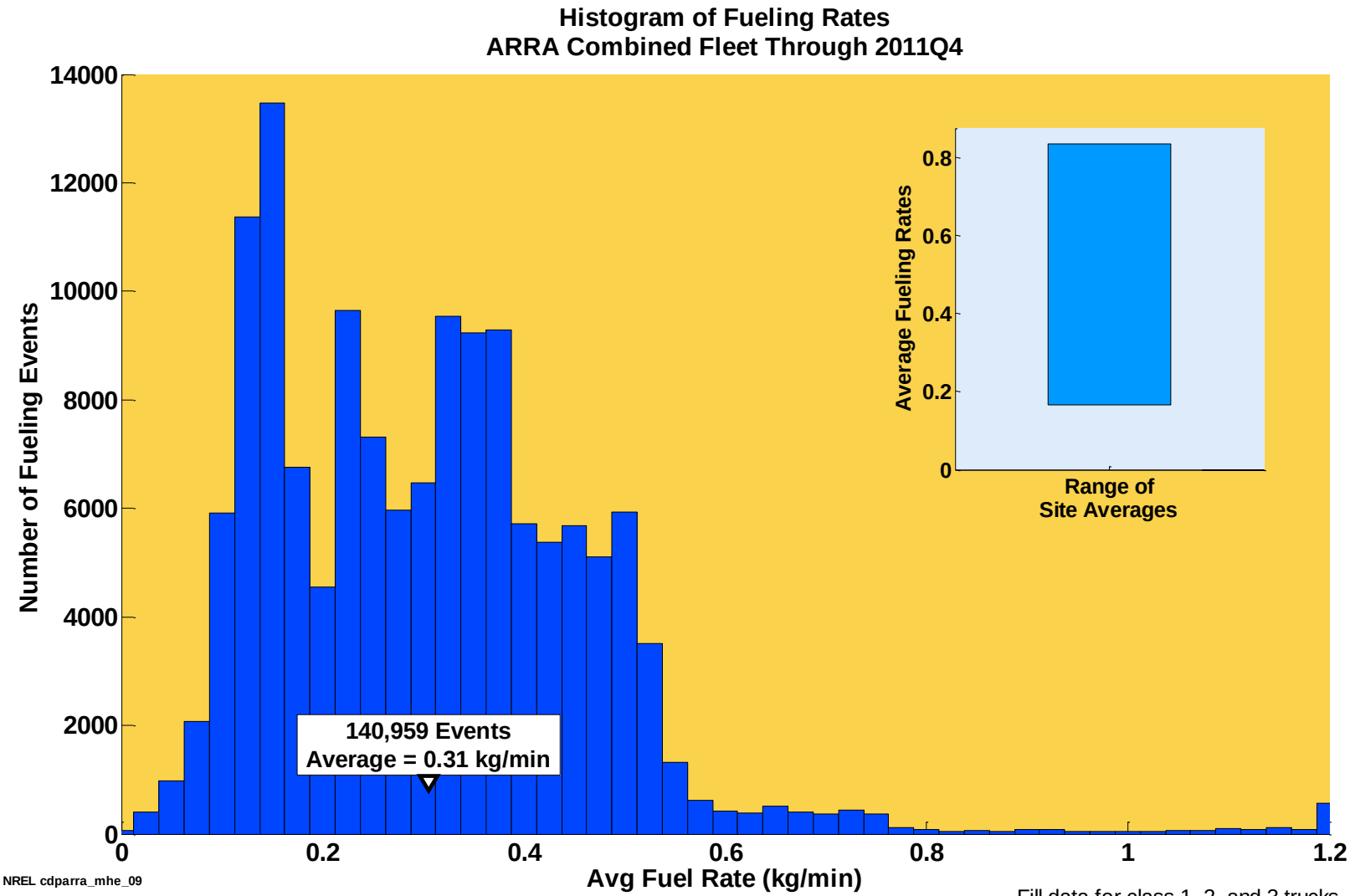


NREL cdparra_mhe_08

Created: Mar-15-12 12:46 PM

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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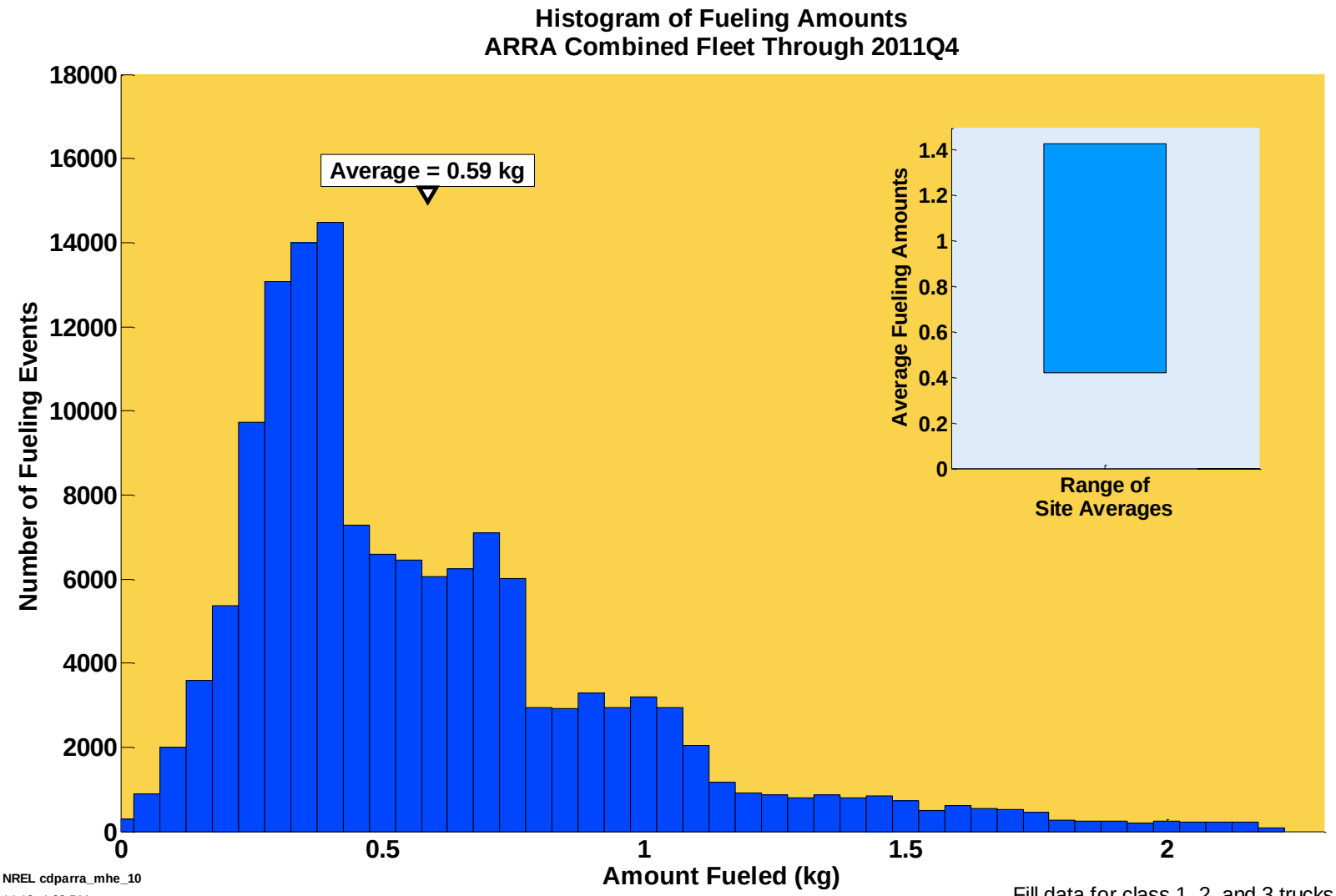
Fill data for class 1, 2, and 3 trucks

CDPARRA-MHE-10
Histogram of Fueling Amounts



NREL cdparra_mhe_10
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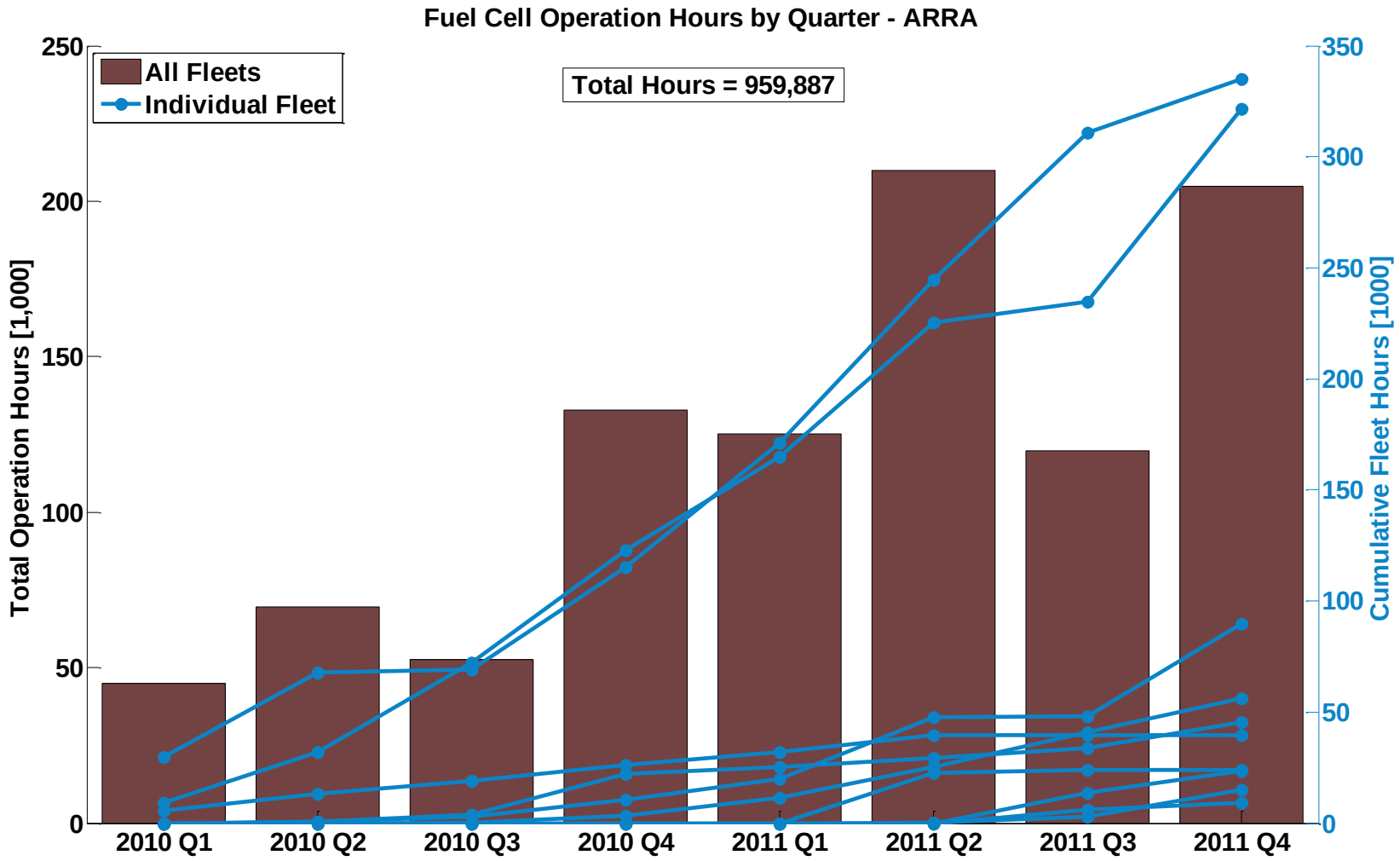
Fill data for class 1, 2, and 3 trucks

CDPARRA-MHE-11
Fuel Cell Operation Hours by Quarter



NREL cdparra_mhe_11
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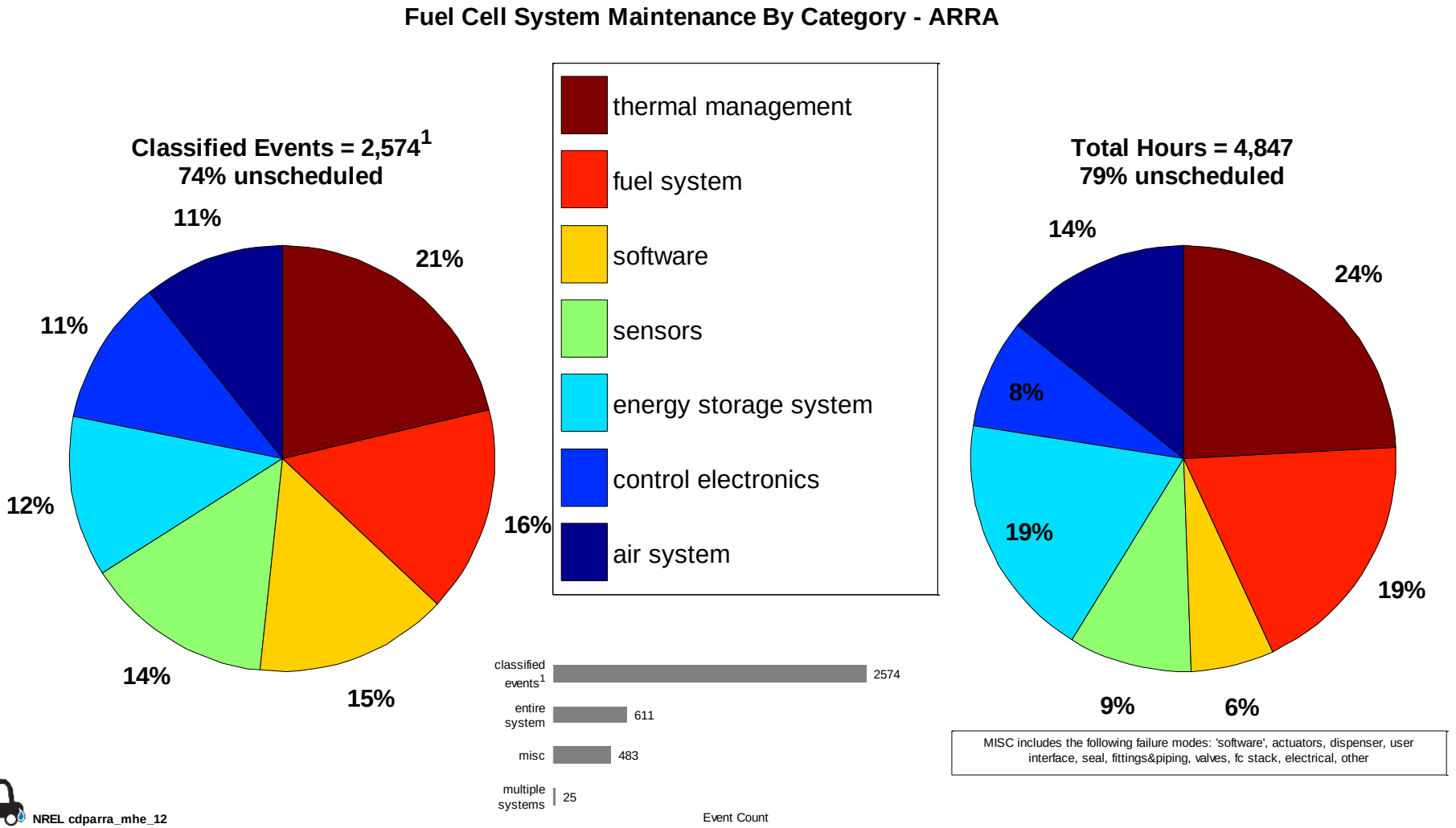
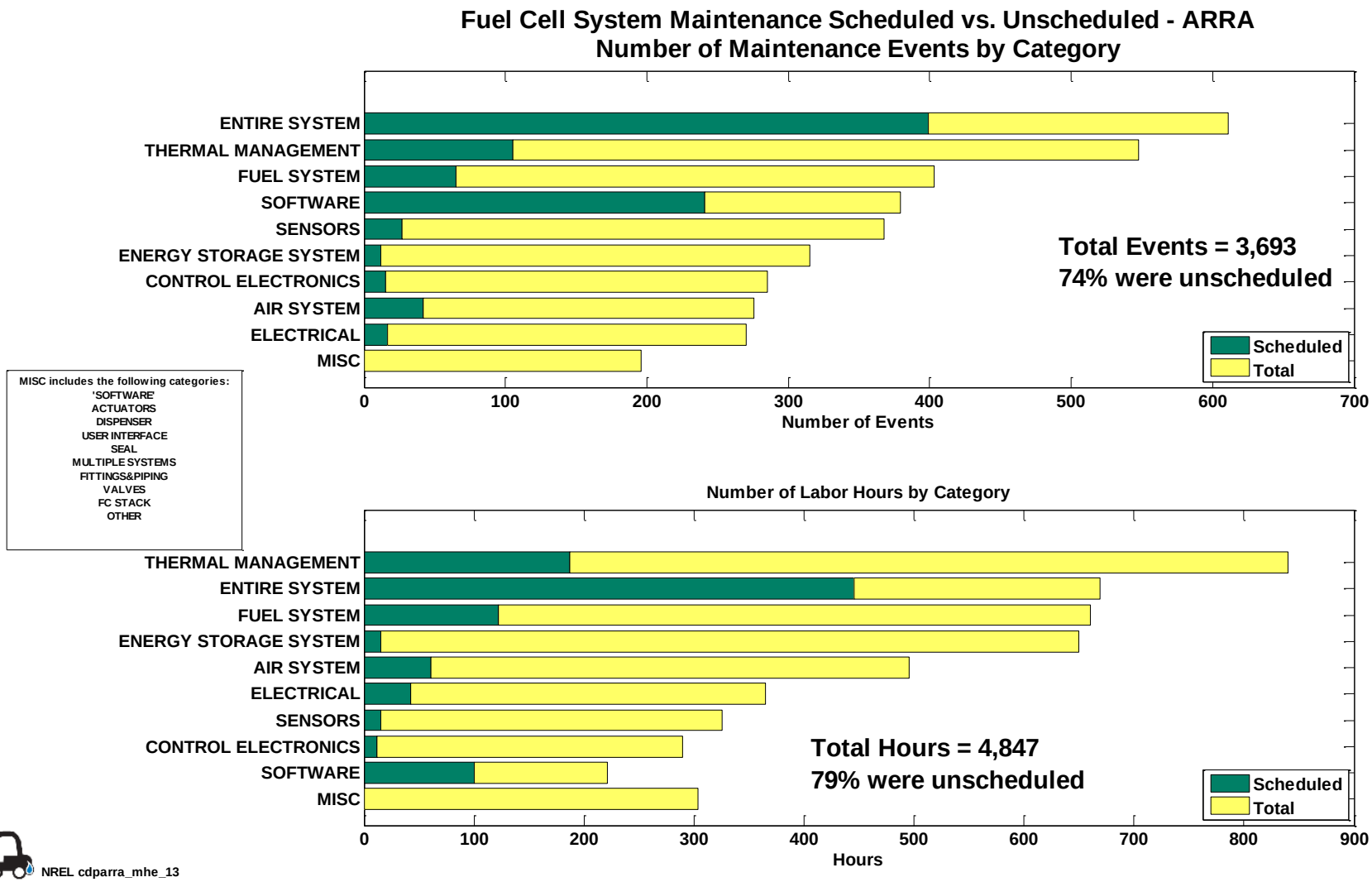
CDPARRA-MHE-12

Fuel Cell System Maintenance by Category



CDPARRA-MHE-13

Fuel Cell System Scheduled and Unscheduled Maintenance by Category



NREL cdparra_mhe_13

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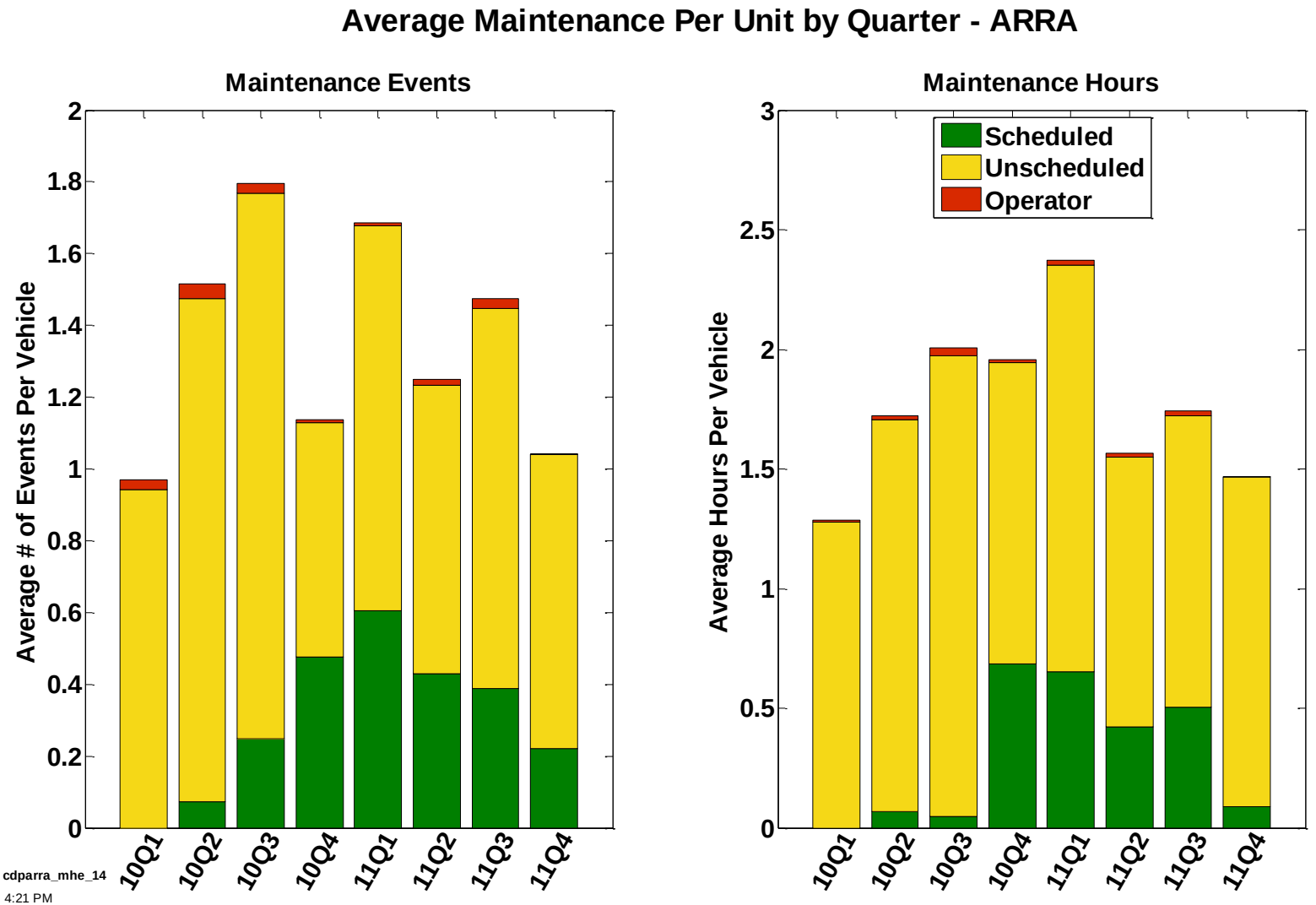
CDPARRA-MHE-14

Average Fuel Cell System Maintenance by Quarter



NREL cdparra_mhe_14

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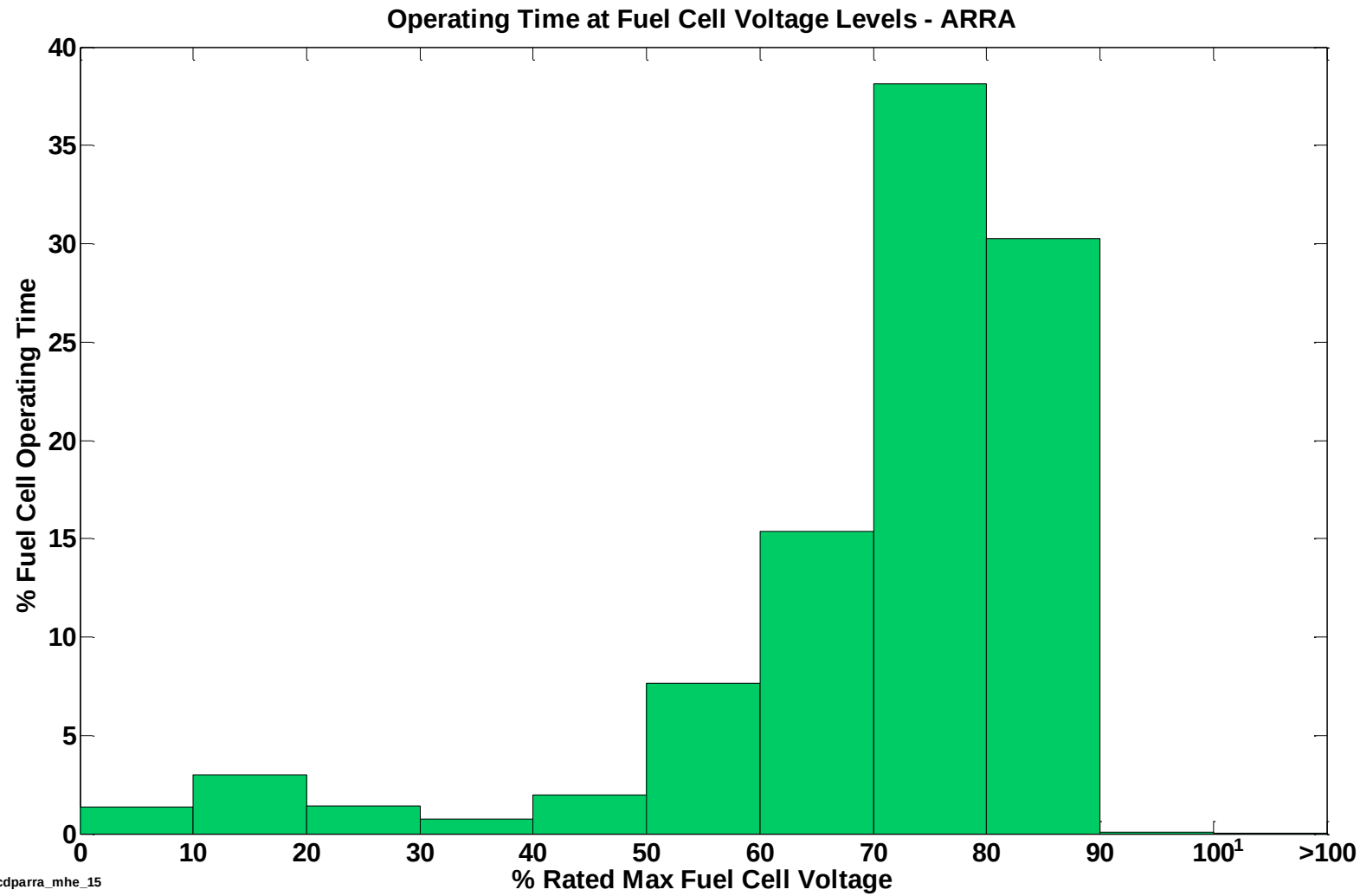
CDPARRA-MHE-15
Operating Time at Fuel Cell Voltage Levels

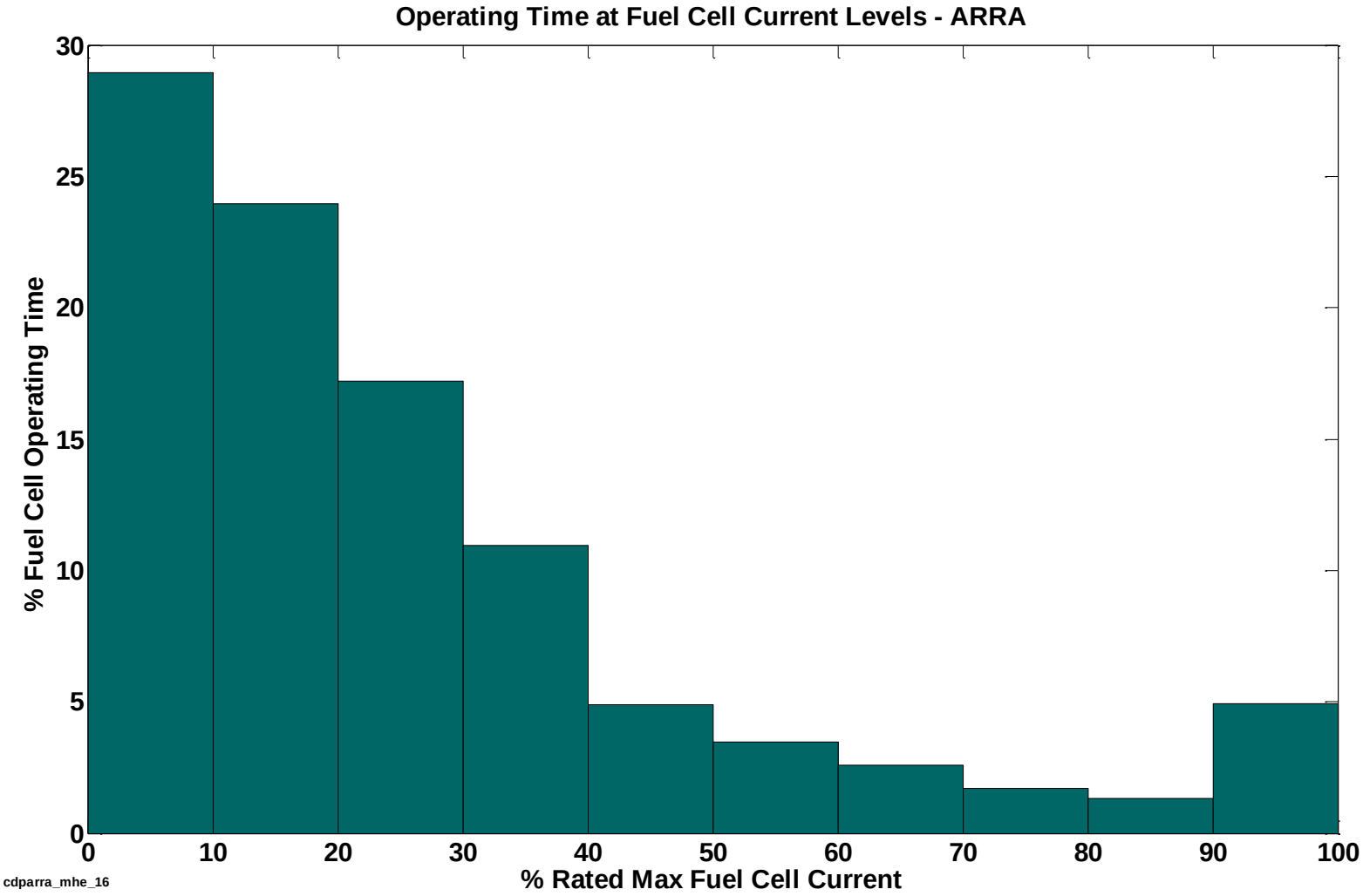


NREL cdparra_mhe_15

Created: Mar-09-12 11:09 AM

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

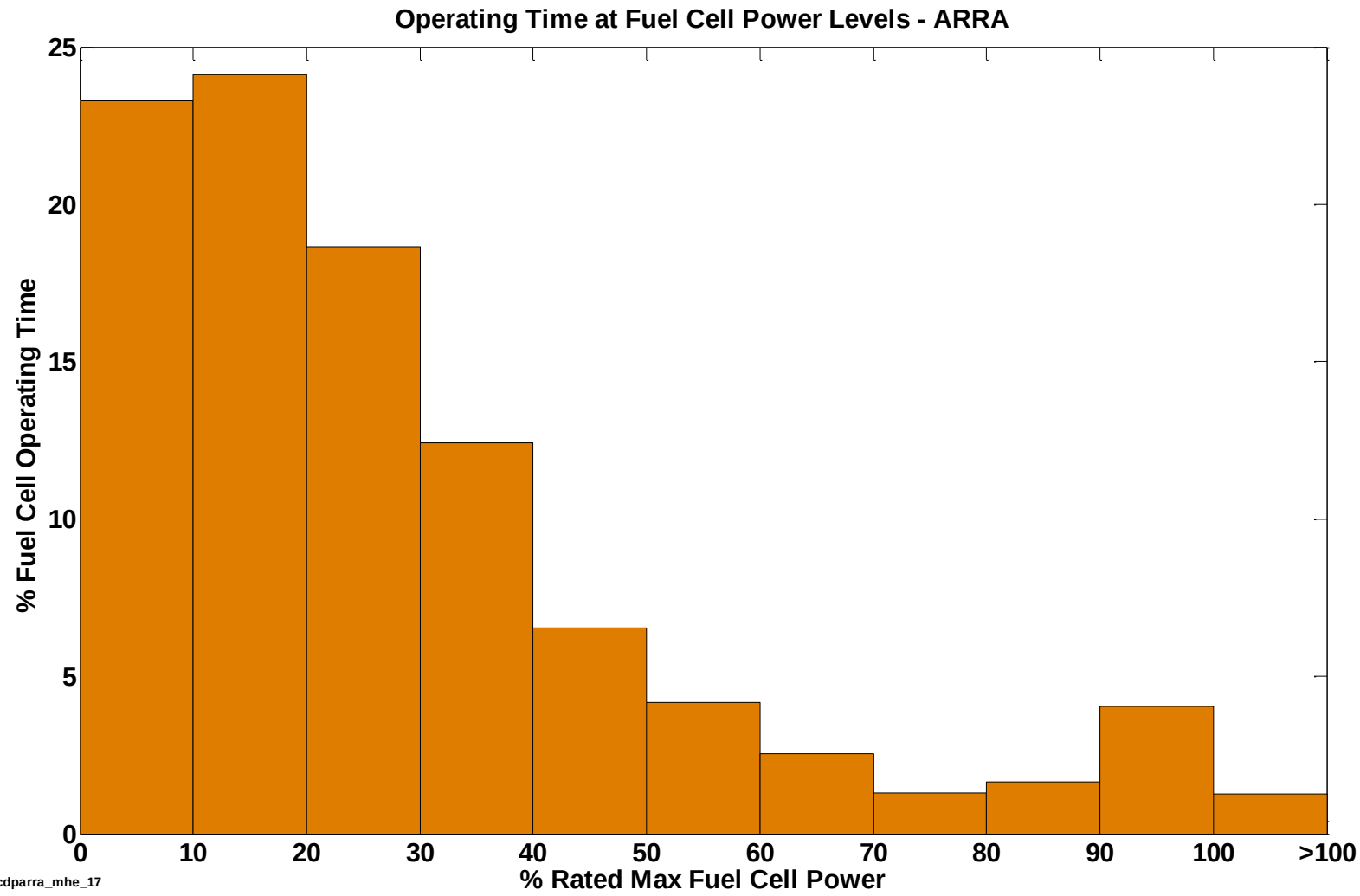
CDPARRA-MHE-16
Operating Time at Fuel Cell Current Levels



NREL cdparra_mhe_16

Created: Mar-09-12 11:09 AM

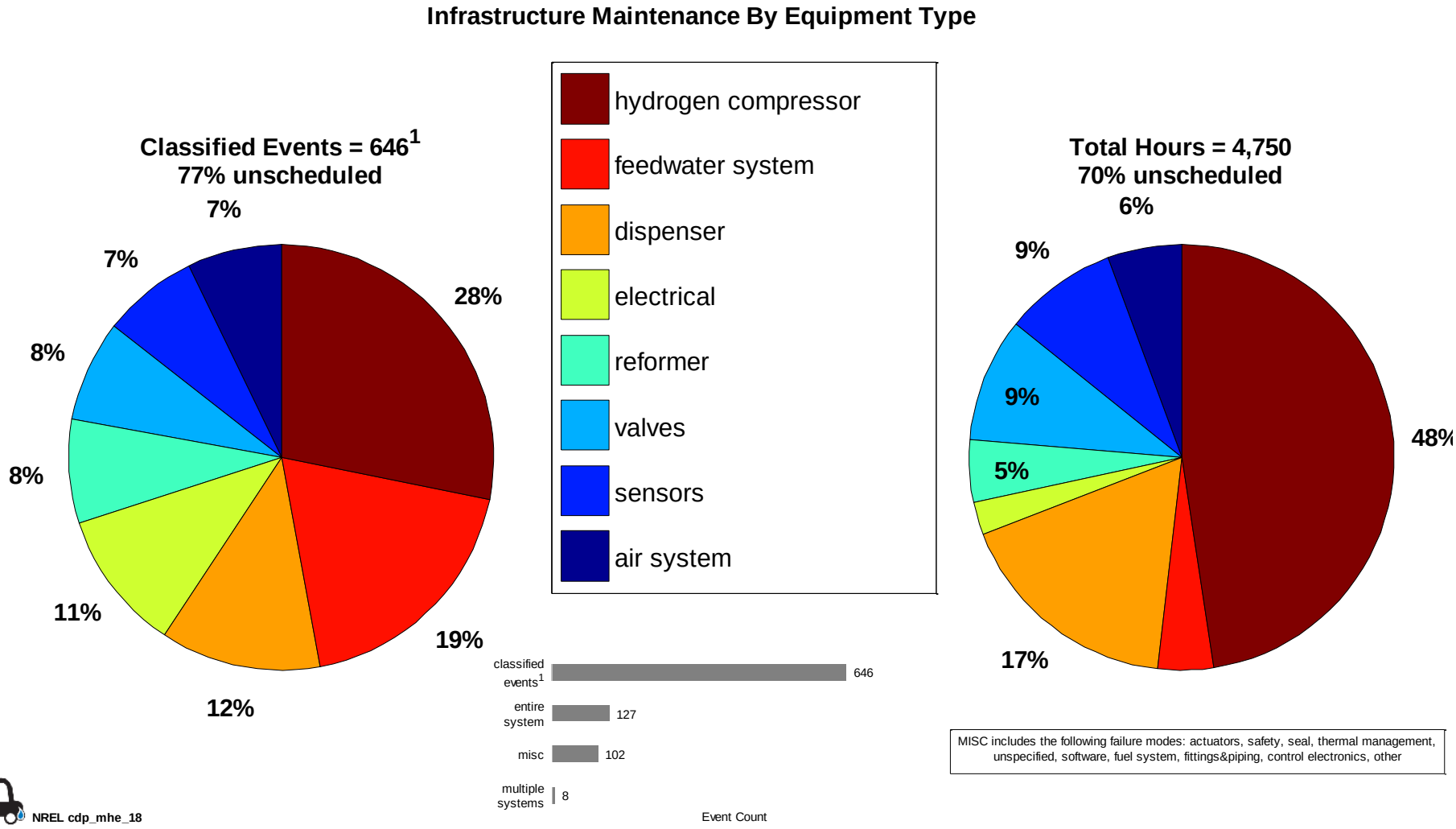
CDPARRA-MHE-17
Operating Time at Fuel Cell Power Levels



NREL cdparra_mhe_17

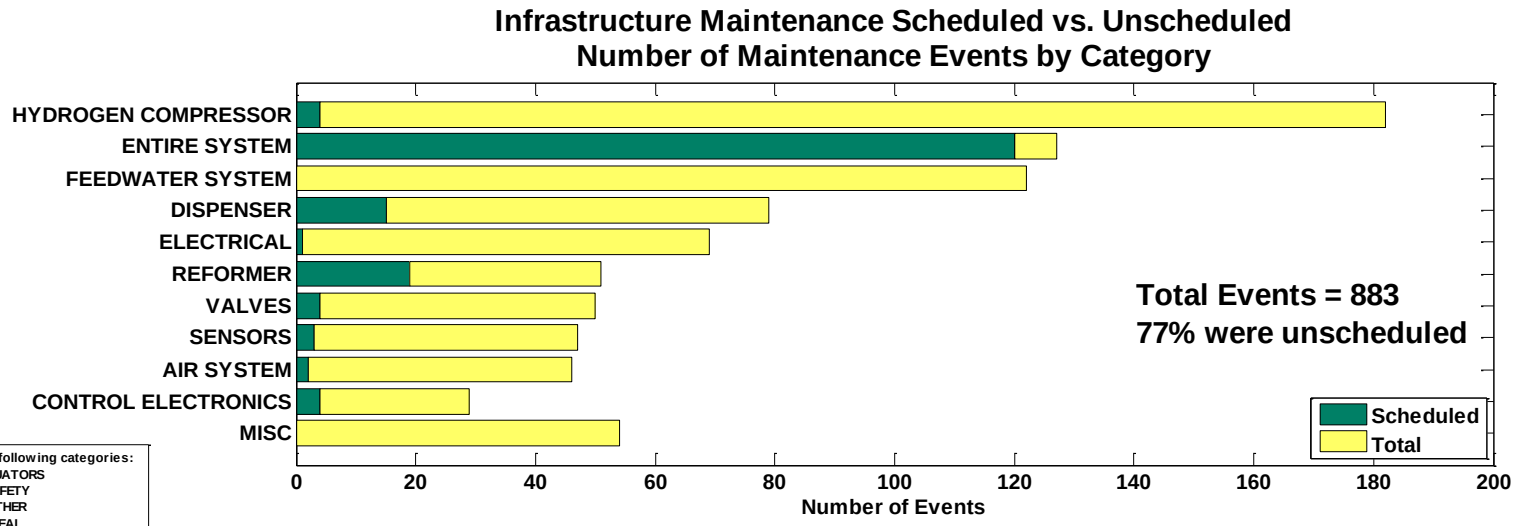
Created: Mar-09-12 11:10 AM

CDP-MHE-18
Infrastructure Maintenance by Category

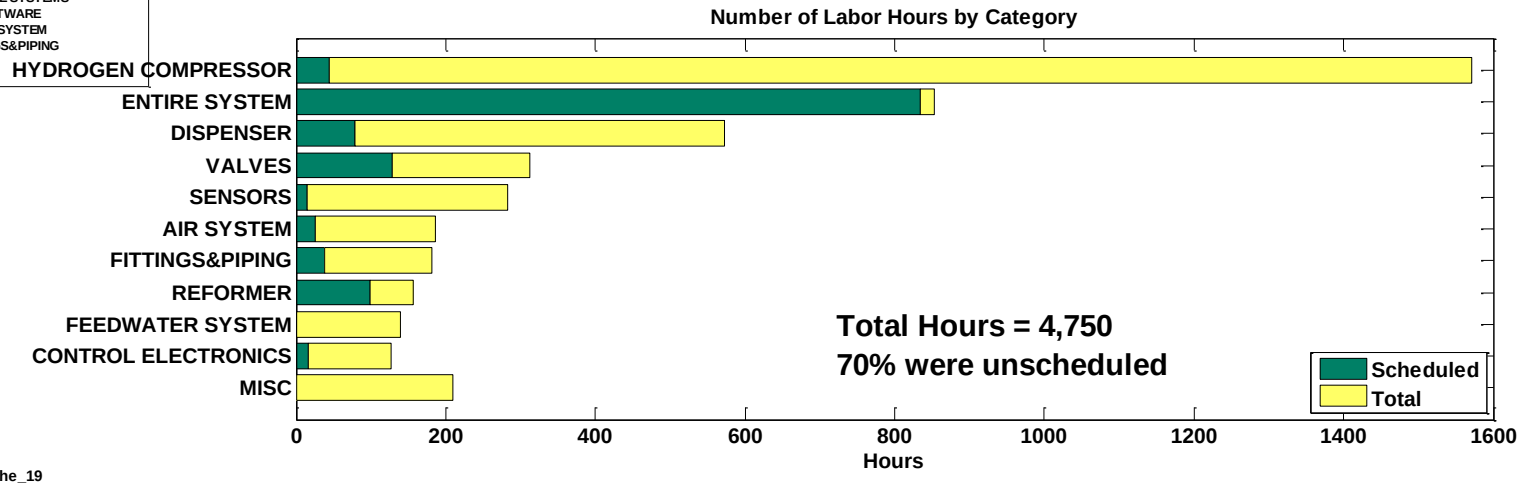


CDP-MHE-19

Infrastructure Scheduled & Unscheduled Maintenance by Category



MISC includes the following categories:
ACTUATORS
SAFETY
OTHER
SEAL
THERMAL MANAGEMENT
UNSPECIFIED
MULTIPLE SYSTEMS
SOFTWARE
FUEL SYSTEM
FITTINGS&PIPING



NREL cdp_mhe_19

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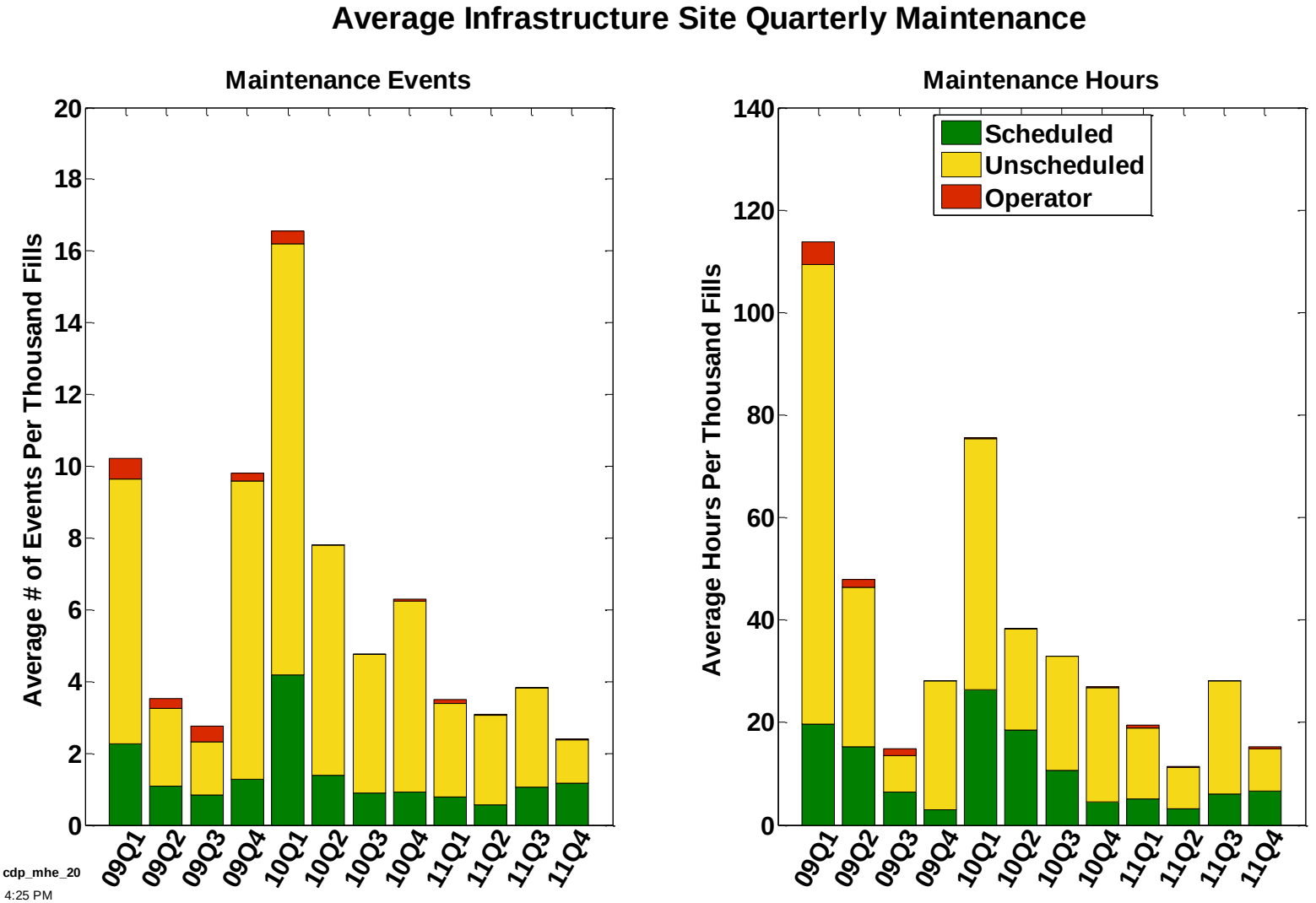
CDP-MHE-20
Infrastructure Maintenance by Quarter



NREL cdp_mhe_20
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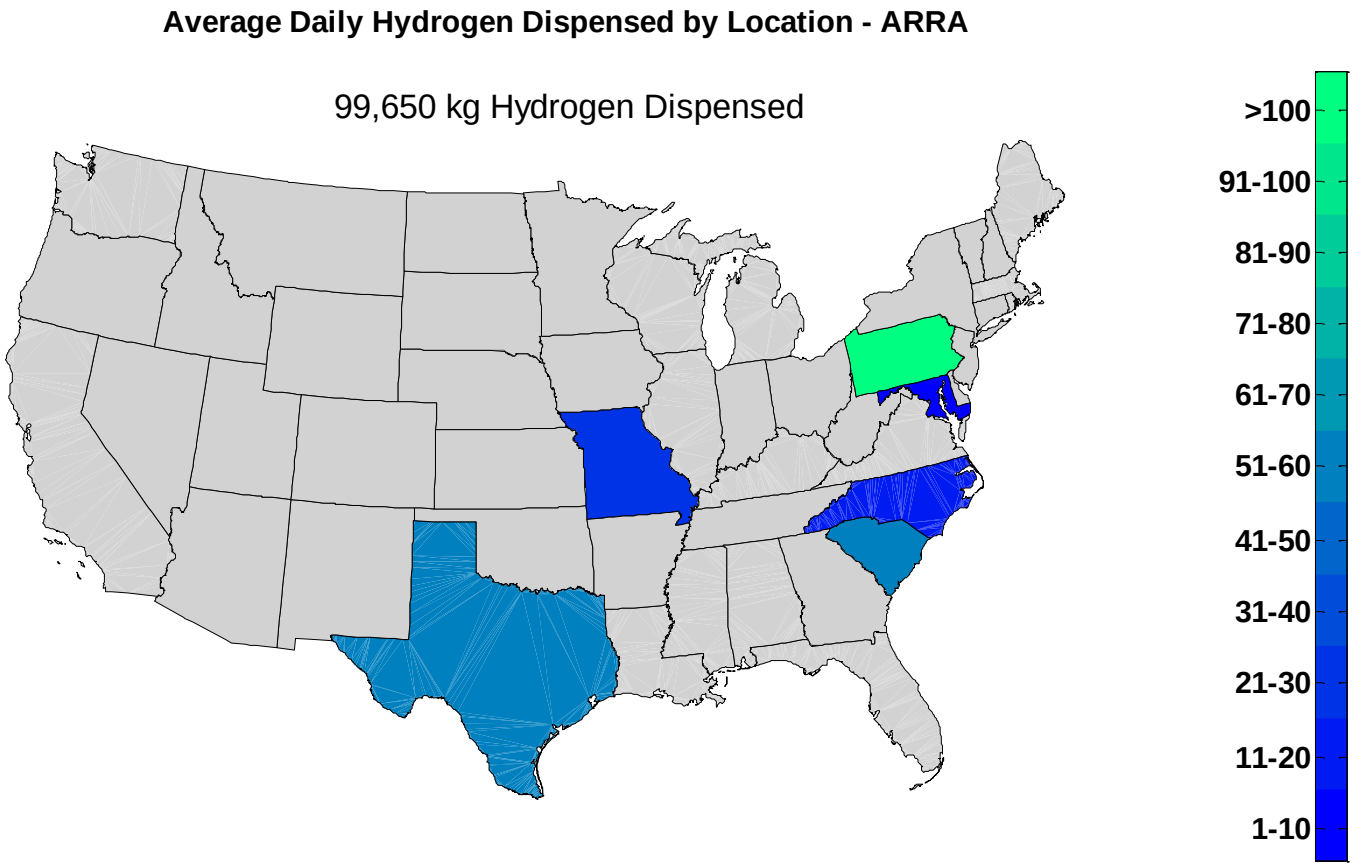
CDPARRA-MHE-21

Average Daily Hydrogen Dispensed by Location



NREL cdparra_mhe_21
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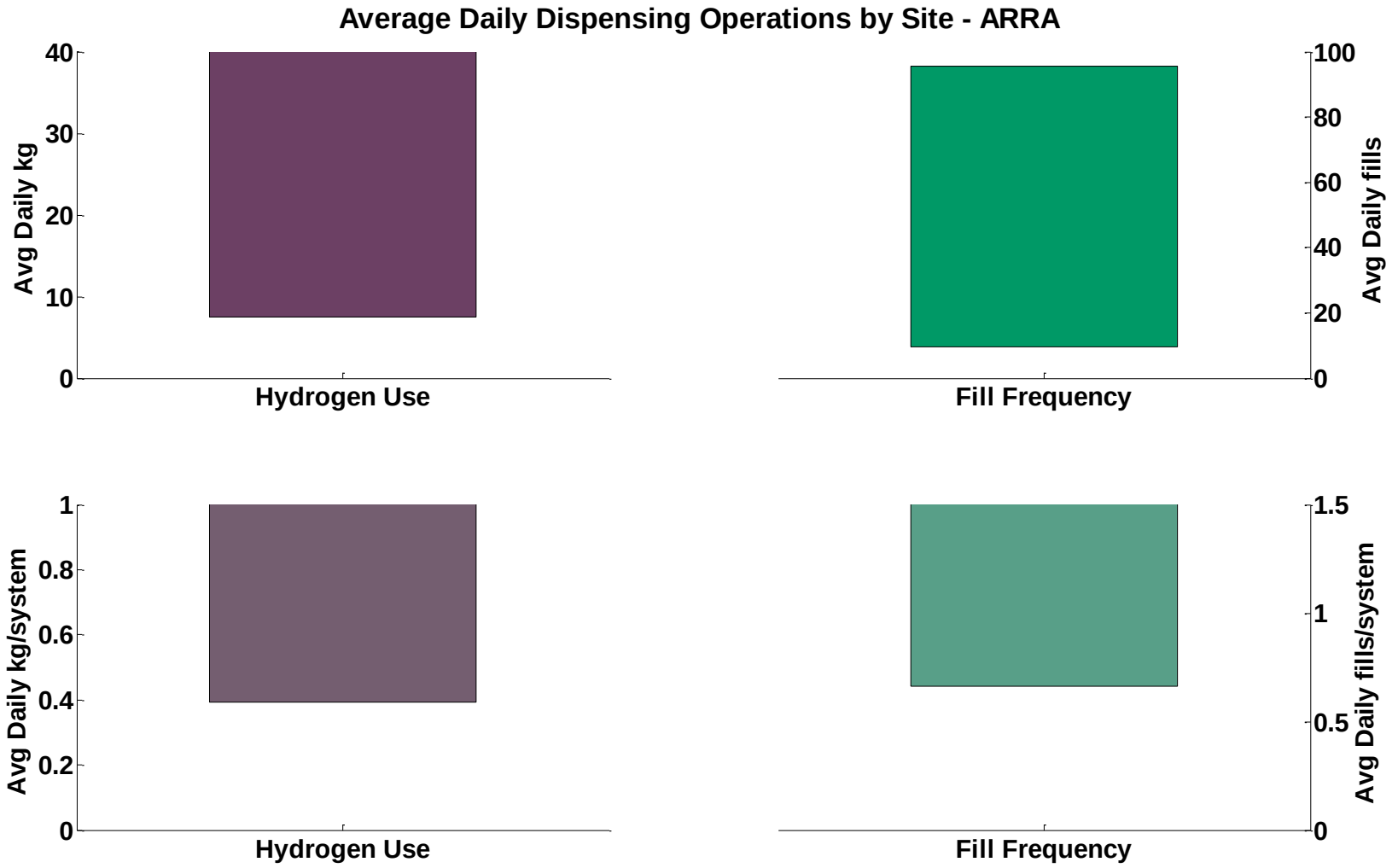
CDPARRA-MHE-22
Average Daily Dispensing Operations by Site



NREL cdparra_mhe_22

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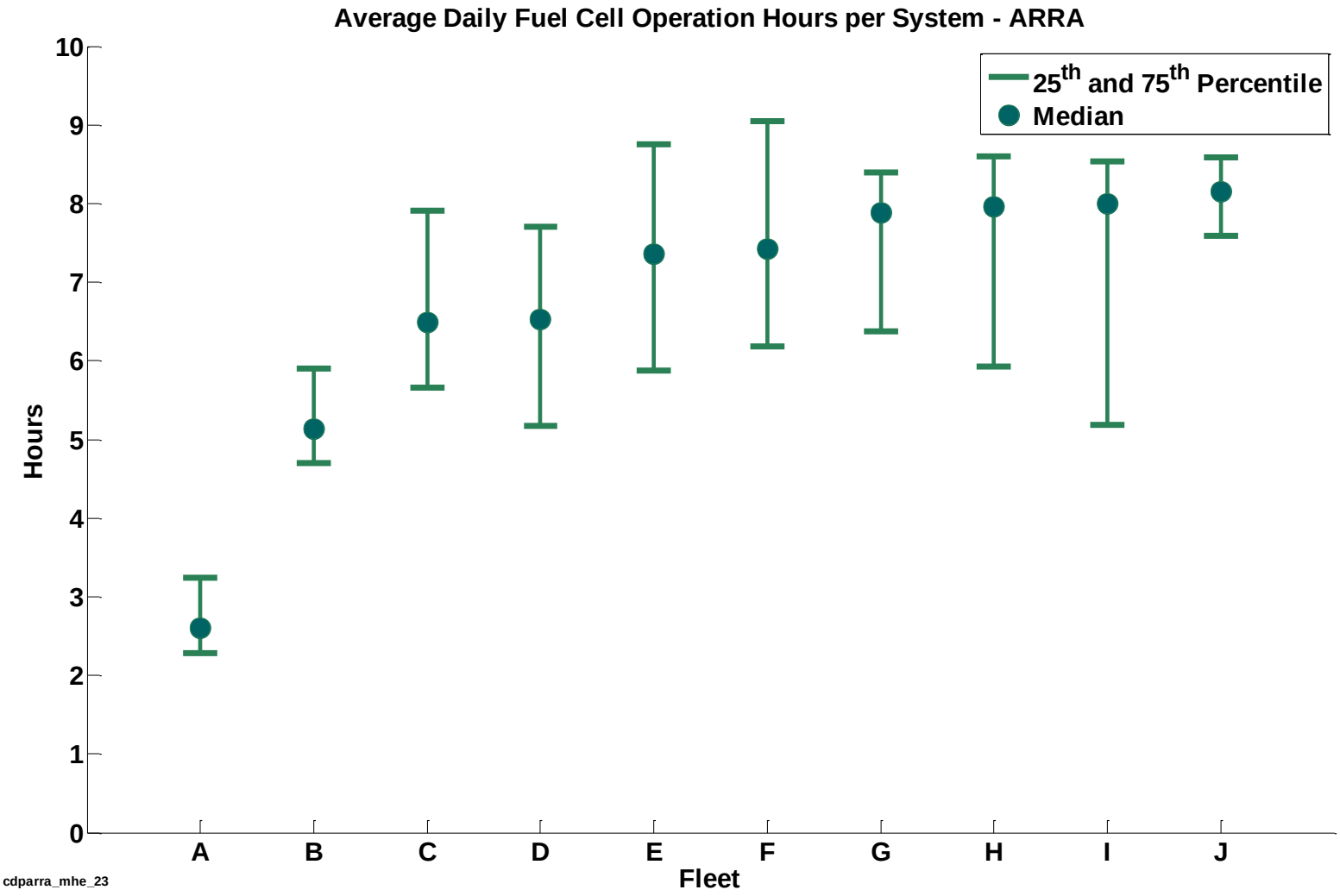
Shaded areas represent the min and max site average hydrogen use and fill frequency

CDPARRA-MHE-23

Average Daily Fuel Cell Operation Hours per Fleet



NREL cdparra_mhe_23

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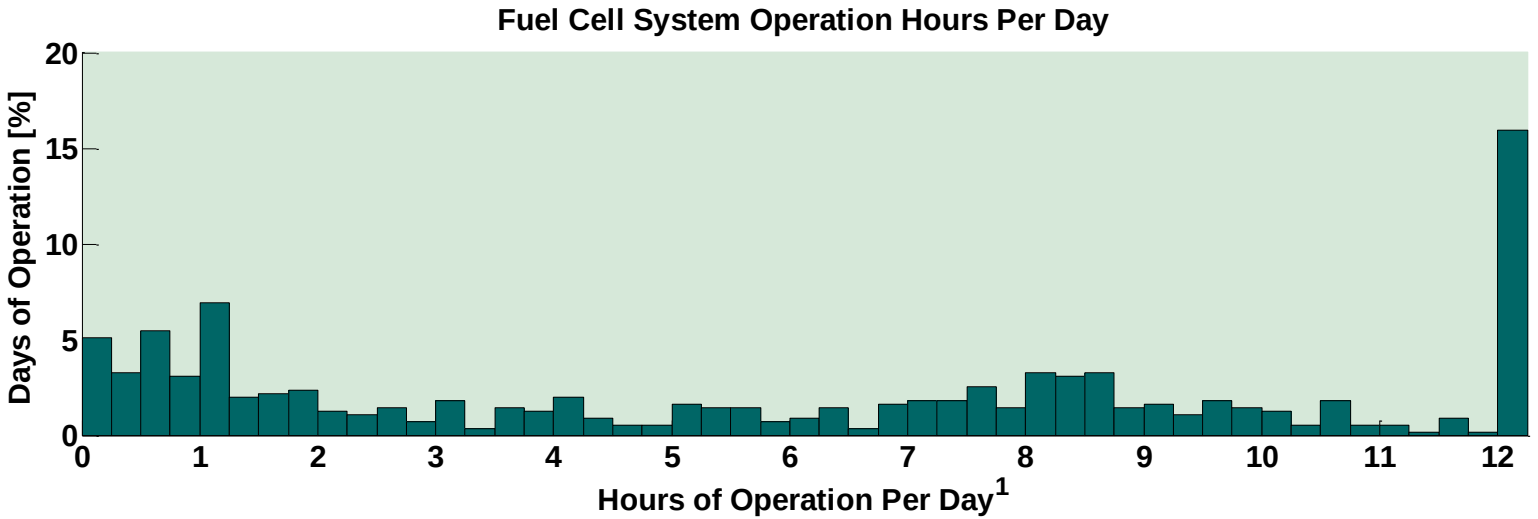
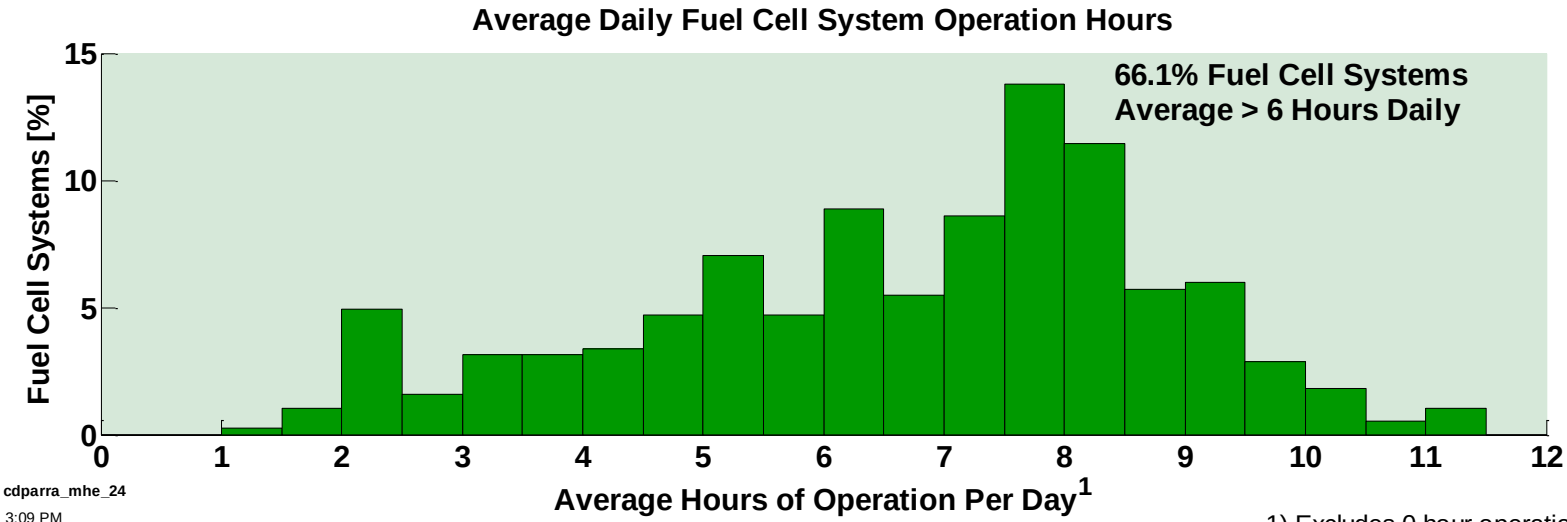
CDPARRA-MHE-24

Average Daily Fuel Cell Operation Hours per System



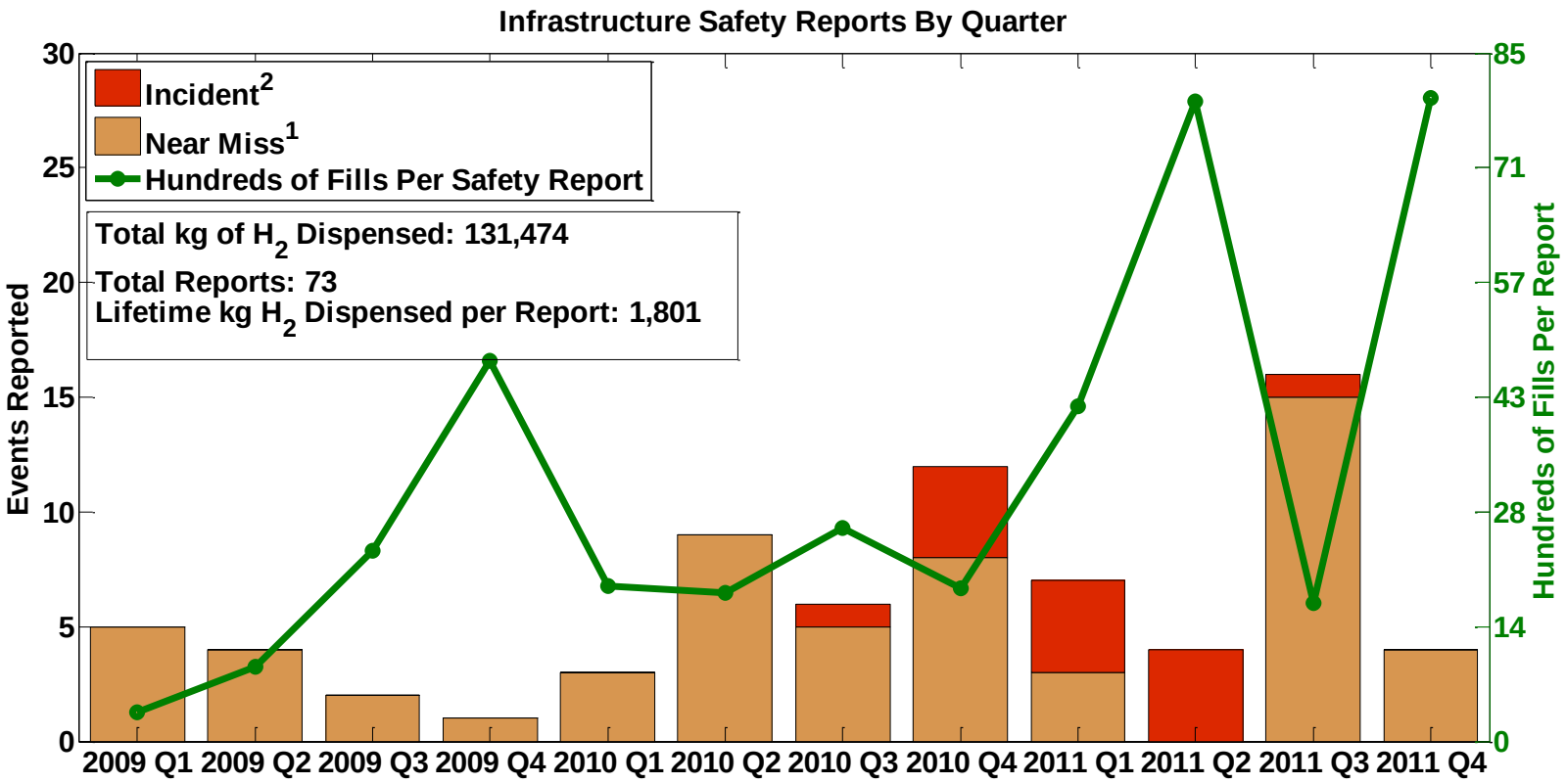


NREL cdparra_mhe_24

Created: Mar-28-12 3:09 PM

1) Excludes 0 hour operation days

CDP-MHE-25
Infrastructure Safety Reports by Quarter



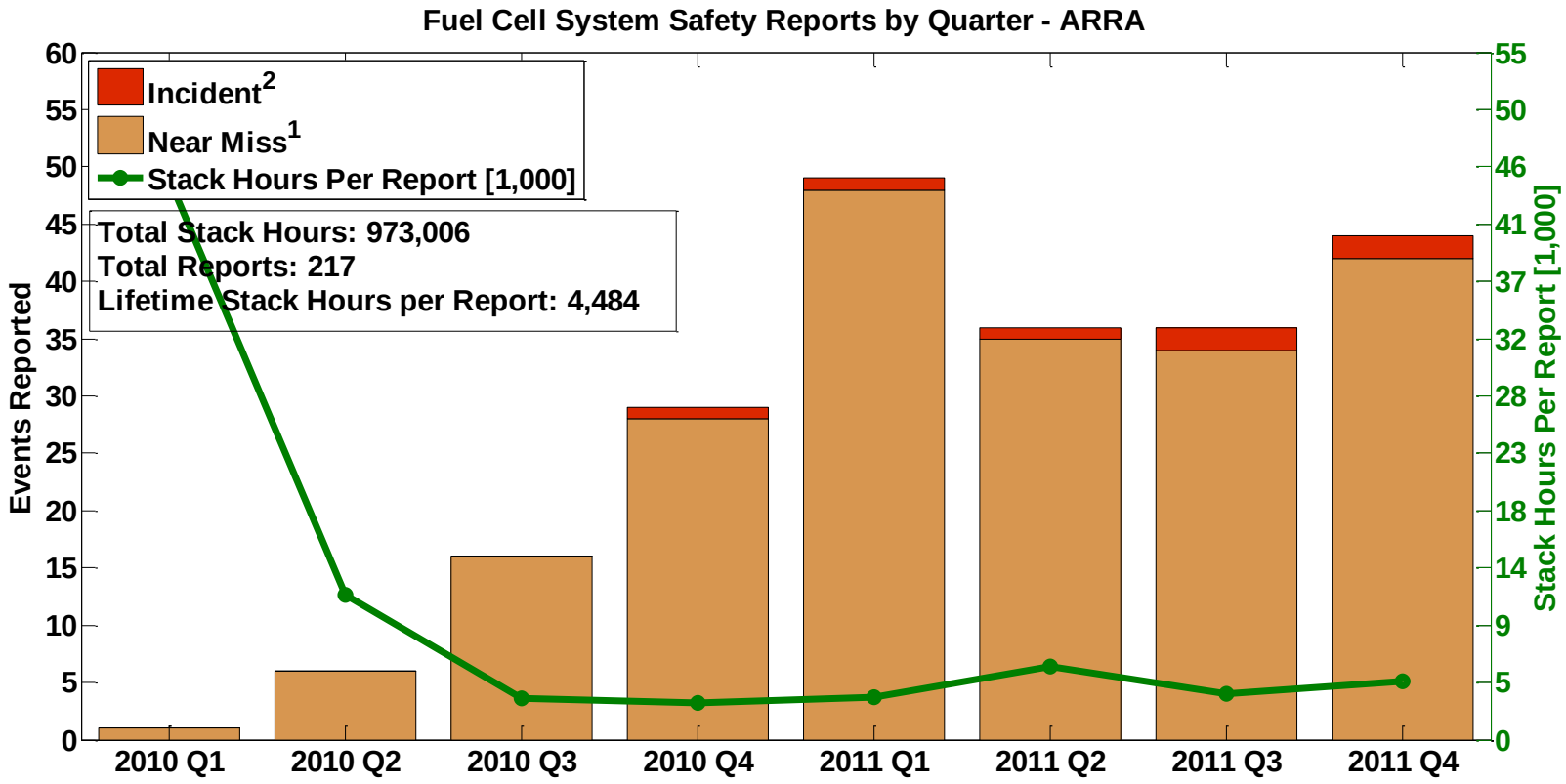
1) Near Miss is an event that under slightly different circumstances could have become an incident
   -unplanned H2 release insufficient to sustain a flame

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: Mar-14-12 4:37 PM

CDPARRA-MHE-26

Fuel Cell System Safety Reports by Quarter

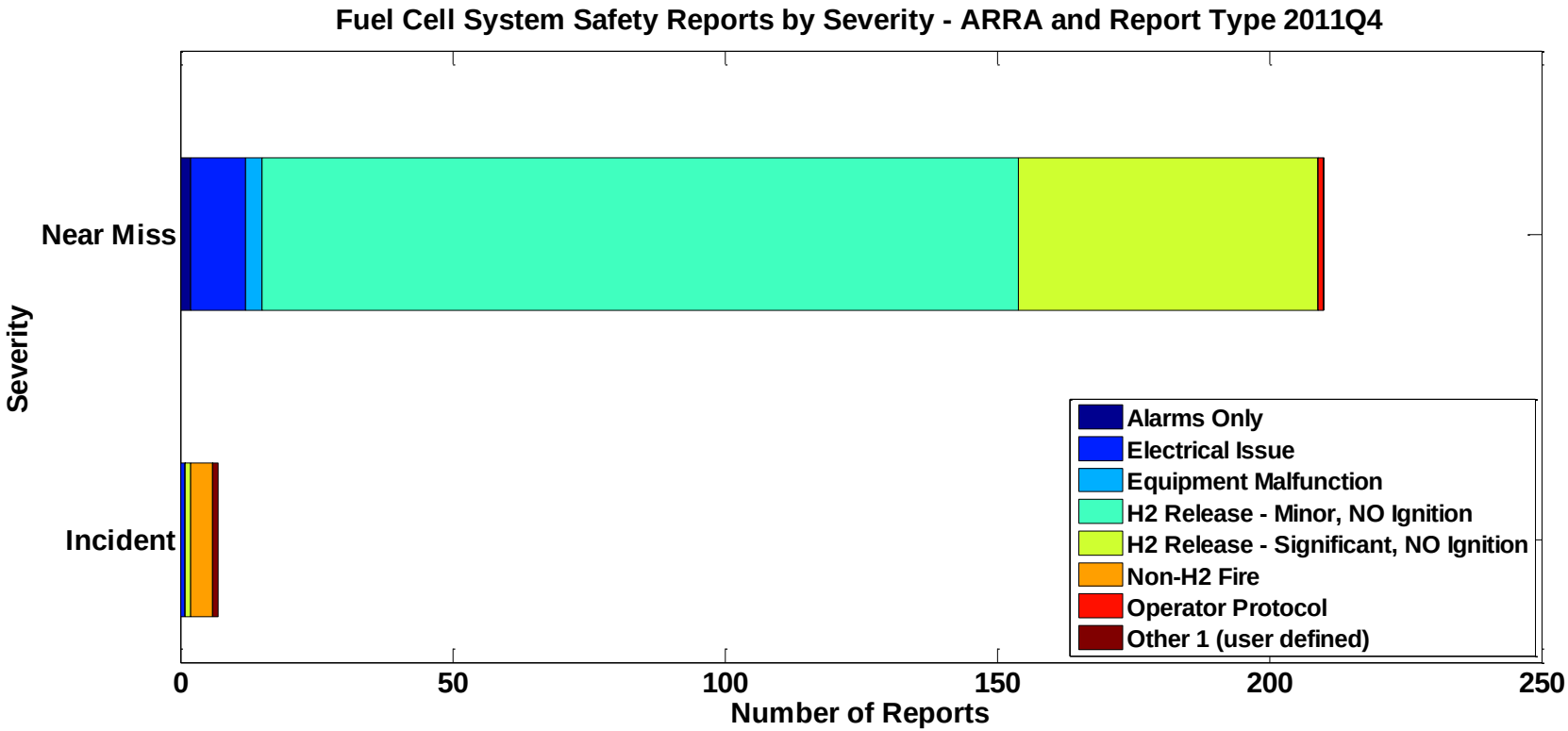


1) Near Miss is an event that under slightly different circumstances could have become an incident
   -unplanned H2 release insufficient to sustain a flame

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 cdparra_mhe_26
Created: Mar-26-12 4:21 PM

CDPARRA-MHE-27
Fuel Cell System Safety Reports by Severity and Type



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 cdparra_mhe_27

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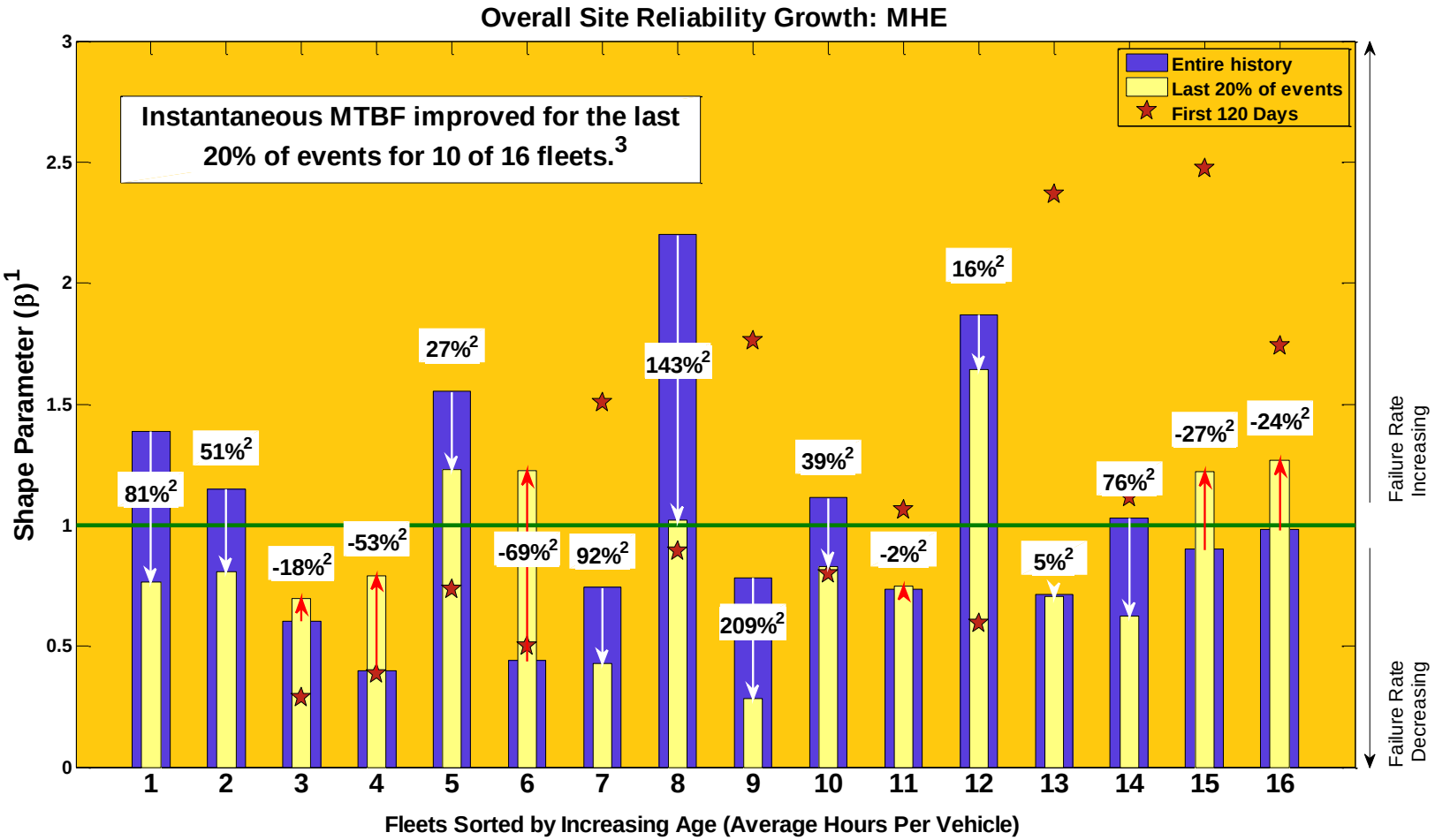
CDP-MHE-28

Fuel Cell System Reliability Growth by Site for Quarter



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

2.% change in instantaneous MTBF

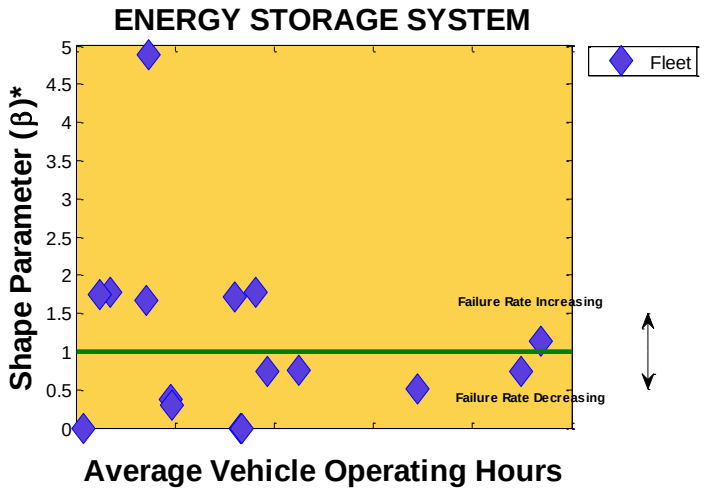
3. Some sites are no longer active. Final results are shown for those sites.

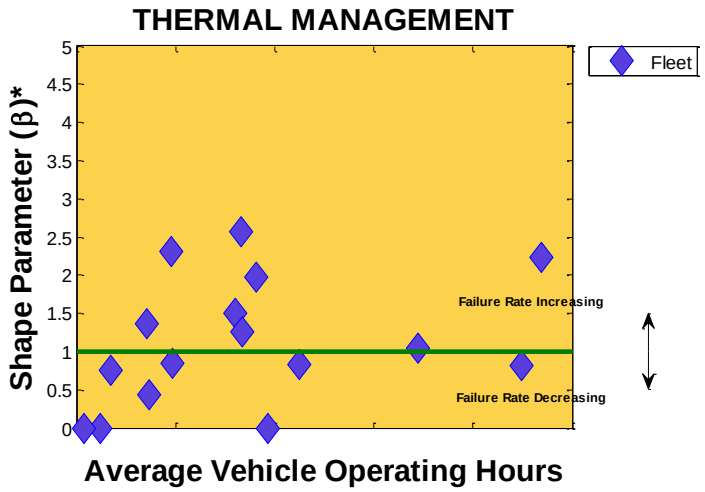
NREL cdp_mhe_28

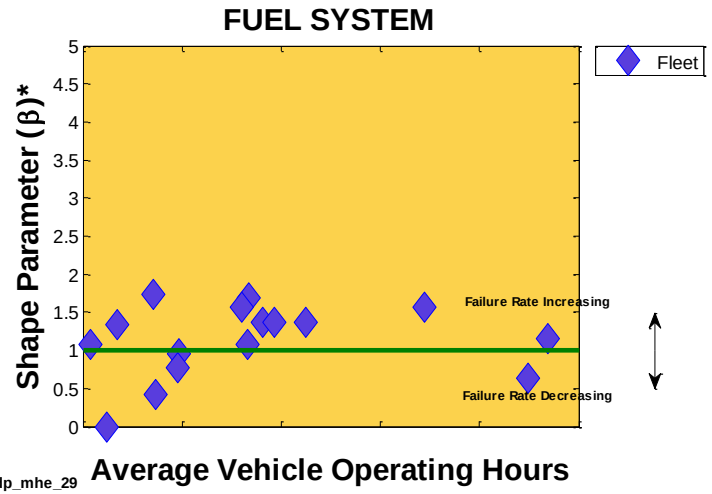
Created: Mar-27-12 8:59 AM

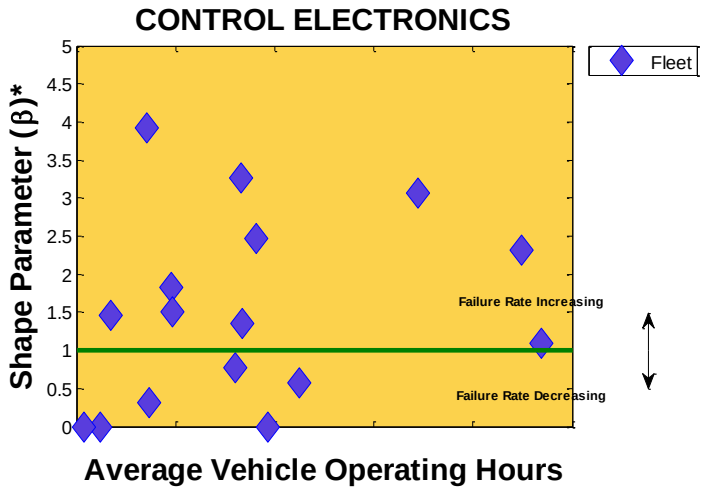
CDP-MHE-29

Fuel Cell System Reliability Growth by Top 4 Categories









NREL cdp_mhe_29
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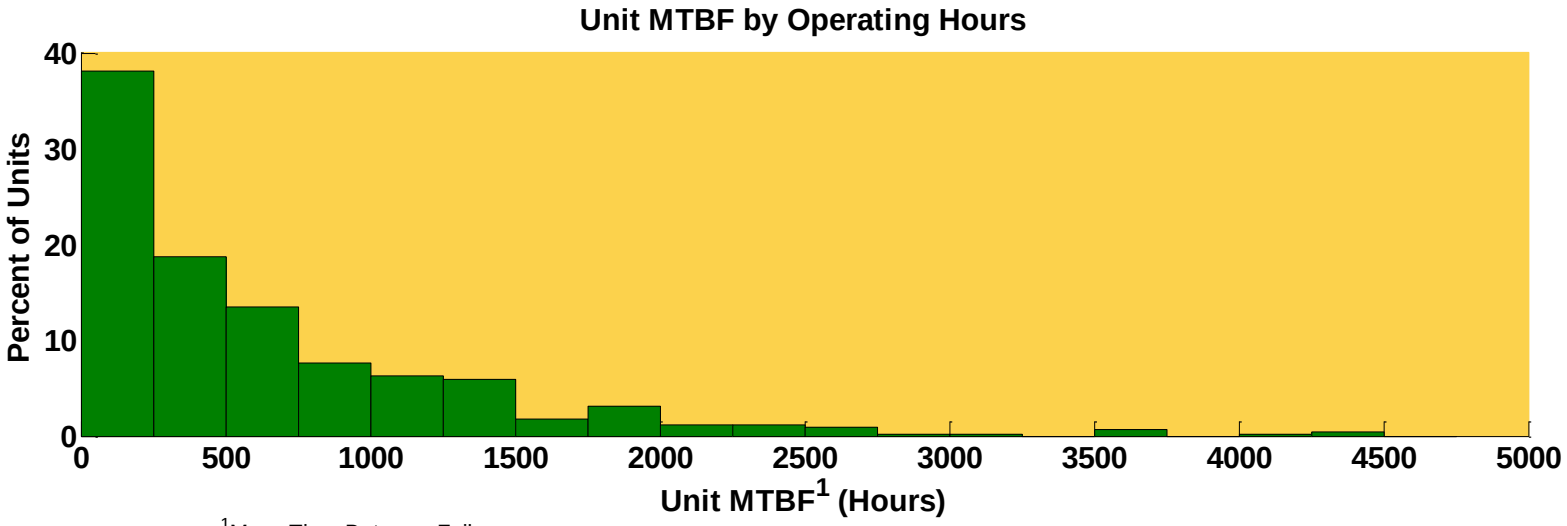
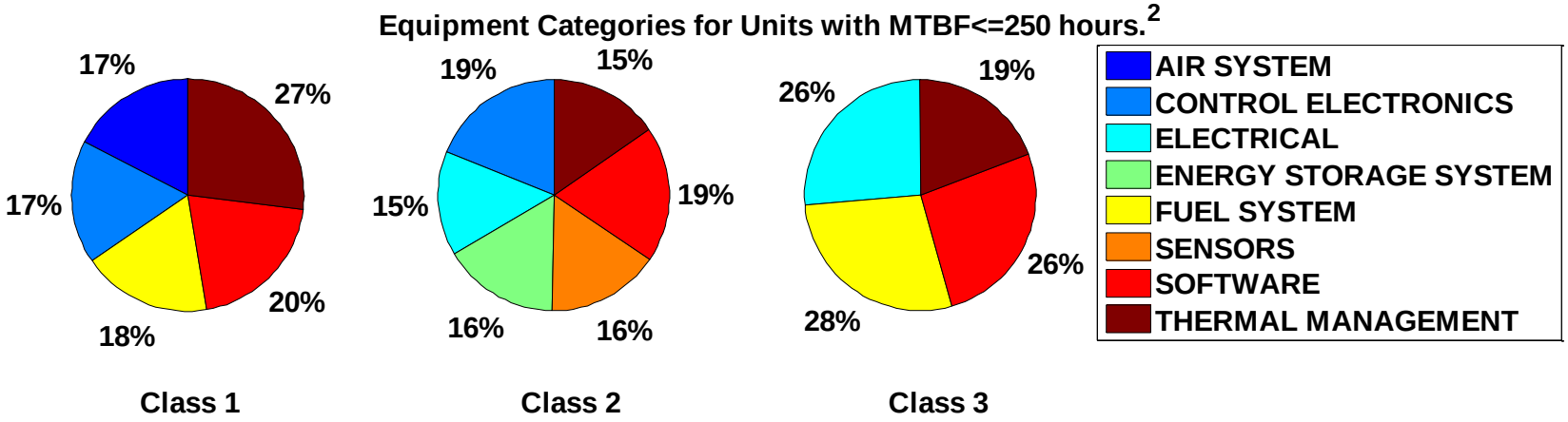
These represent the top four equipment failure categories from all combined data.

*IEC 61164 β

CDP-MHE-30
Fuel Cell System Mean Time Between Failure



[1]Mean Time Between Failure

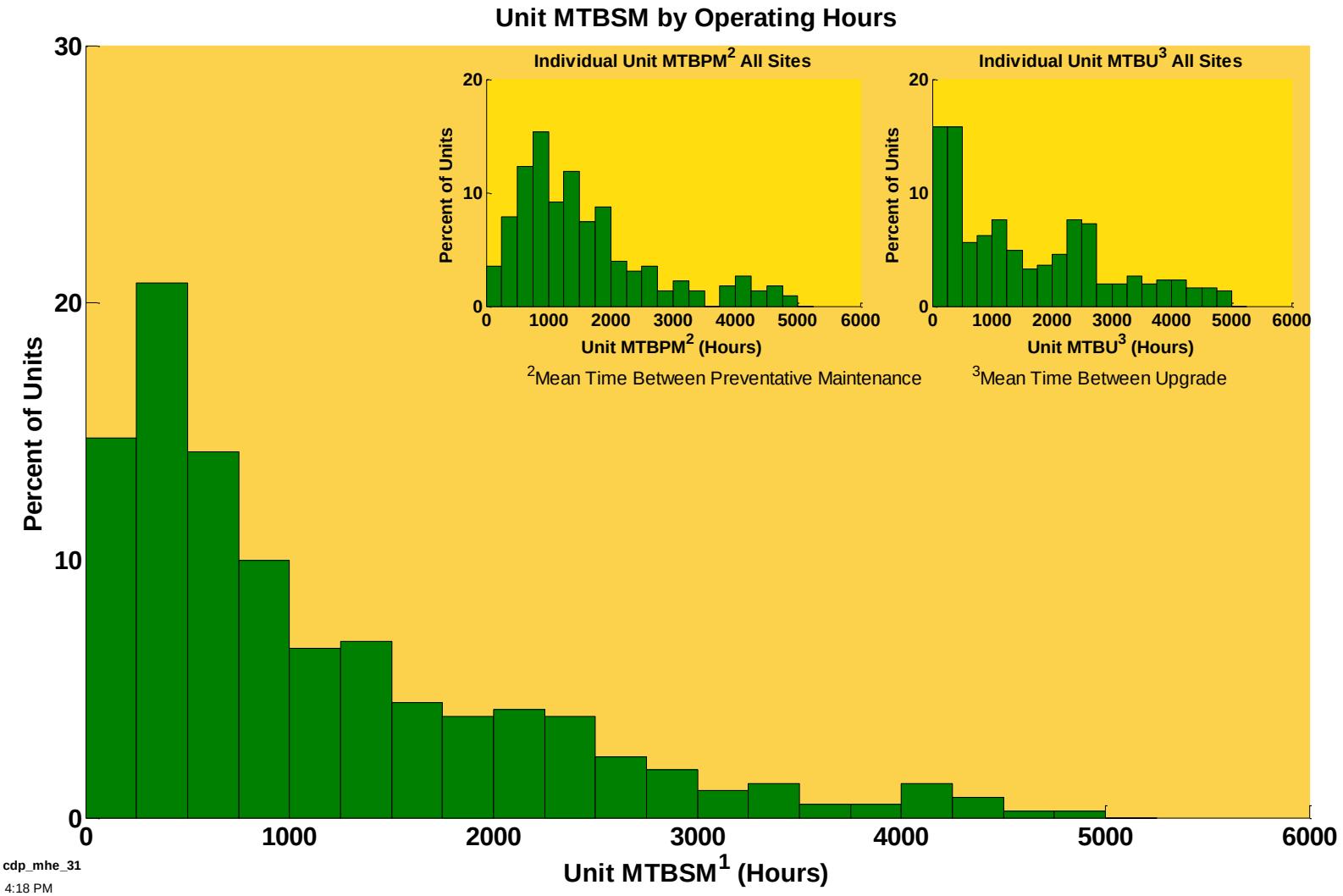


NREL cdp_mhe_30
Created: Mar-26-12 4:17 PM

[2] Categories representing <10% of the total are not shown

CDP-MHE-31

Fuel Cell System Mean Time Between Scheduled Maintenance



[2]Mean Time Between Preventative Maintenance

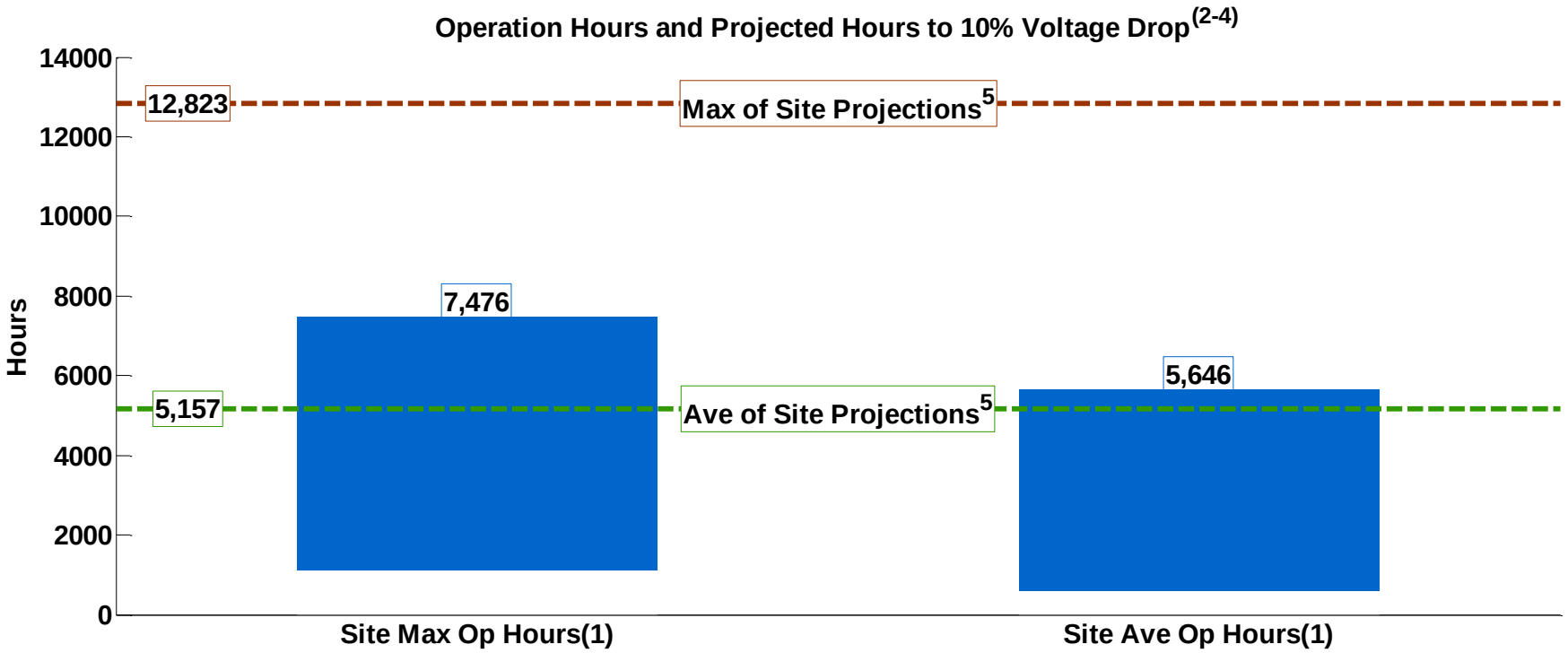
[3]Mean Time Between Upgrade

NREL cdp_mhe_31

Created: Mar-26-12 4:18 PM

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

CDP-MHE-32
Site Operation Hours and Voltage Durability



(1) Range bars created using one data point for each fleet. Some stacks have accumulated hours beyond 10% voltage degradation.
(2) 10% voltage drop level is a DOE metric for assessing fuel cell performance.
(3) Projections using field data and calculated at a high stack current.
(4) 10% voltage drop is NOT an indication of an OEM's end-of-life criteria and projections do not address catastrophic stack failure.
(5) Each site has one voltage projection value that is the weighted average of the site's fuel cell stack projections.

NREL cdp_mhe_32
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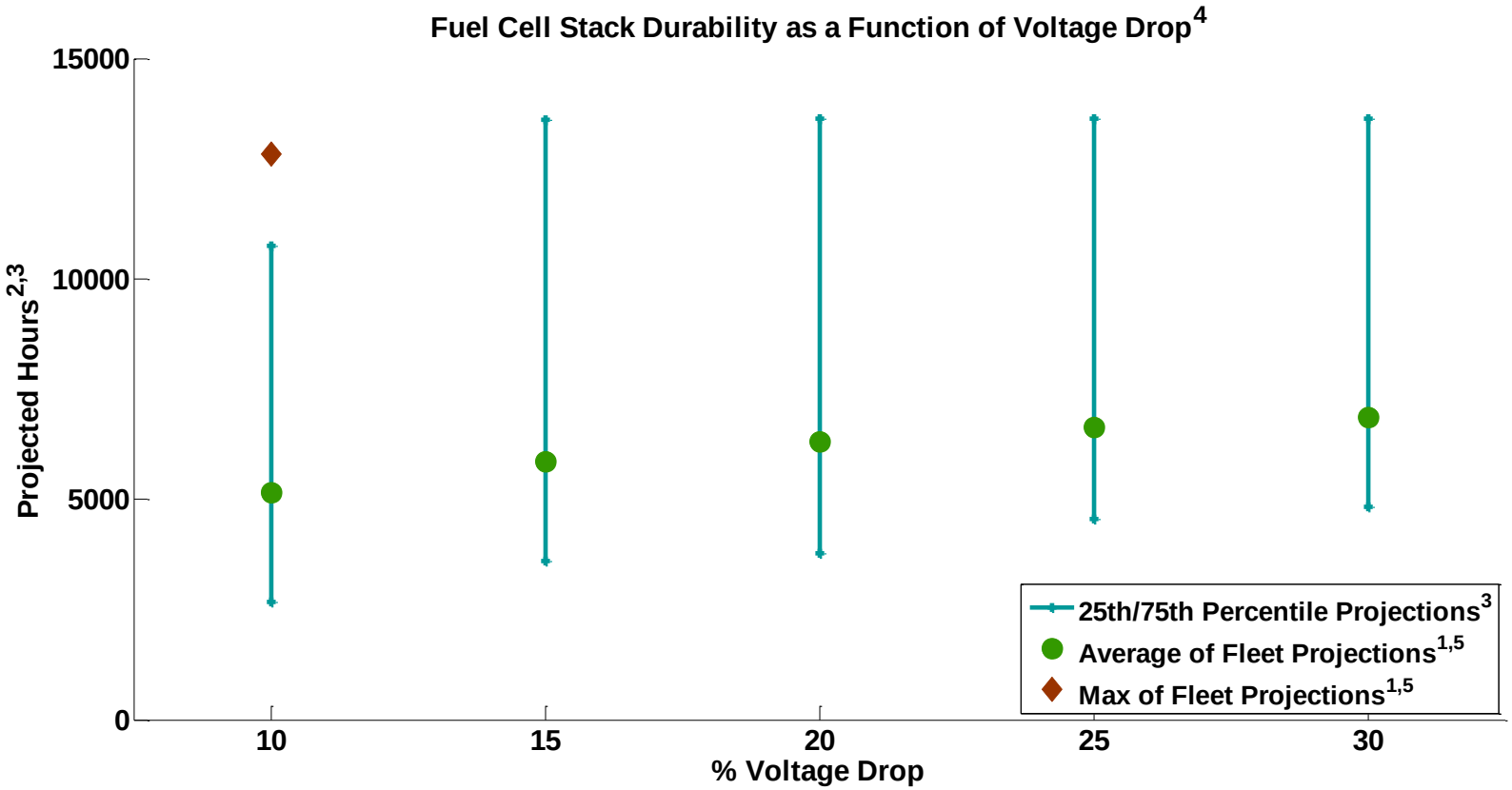
CDP-MHE-33

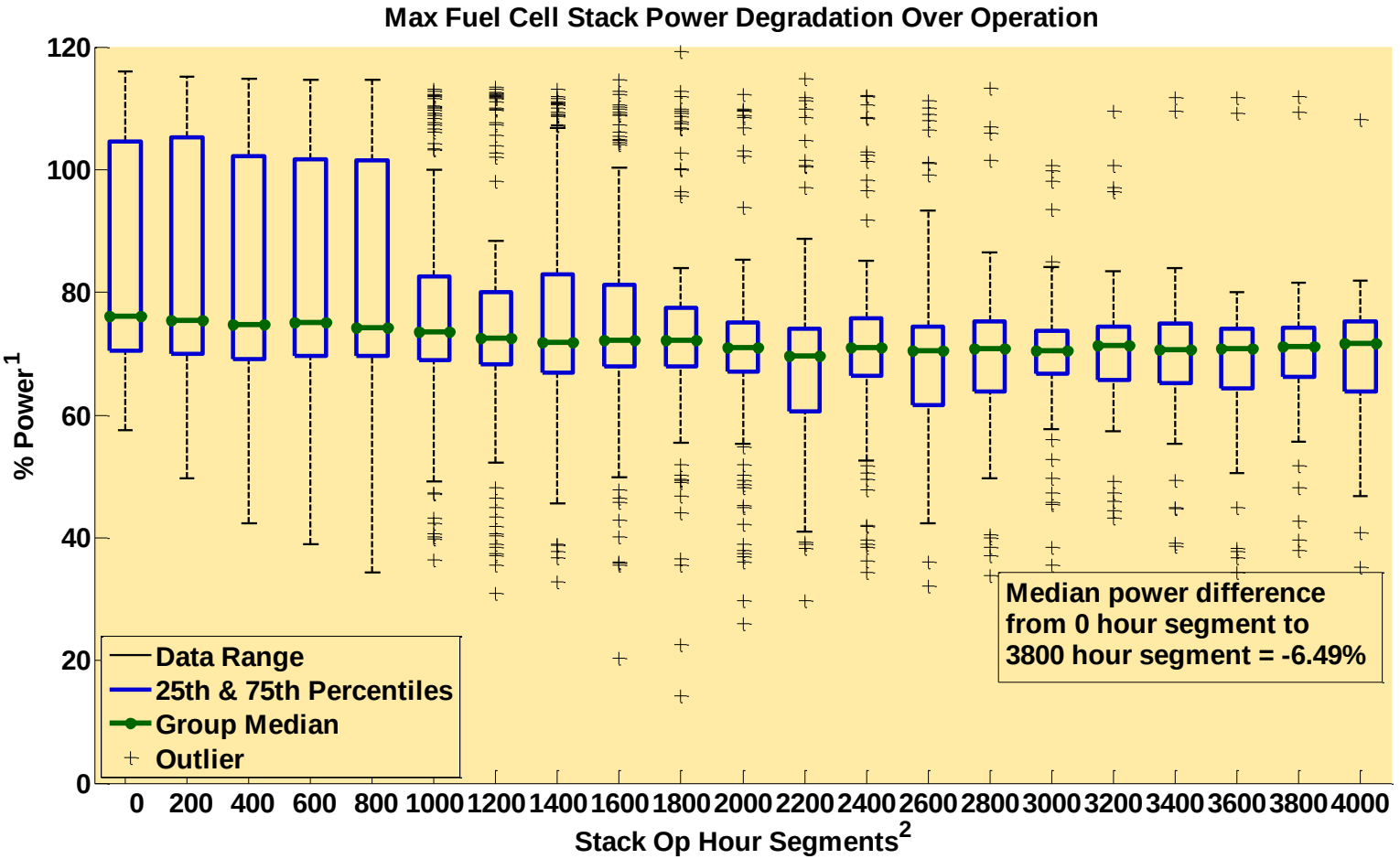
Fuel Cell Stack Voltage Durability as a Function of Voltage Drop Levels



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) 25th and 75th 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 site has one voltage projection value that is the weighted average of the site's fuel cell stack projections.

NREL cdp_mhe_33
Created: Mar-28-12 3:33 PM

CDP-MHE-34
Fuel Cell Stack Power Degradation over Time



NREL cdp_mhe_34
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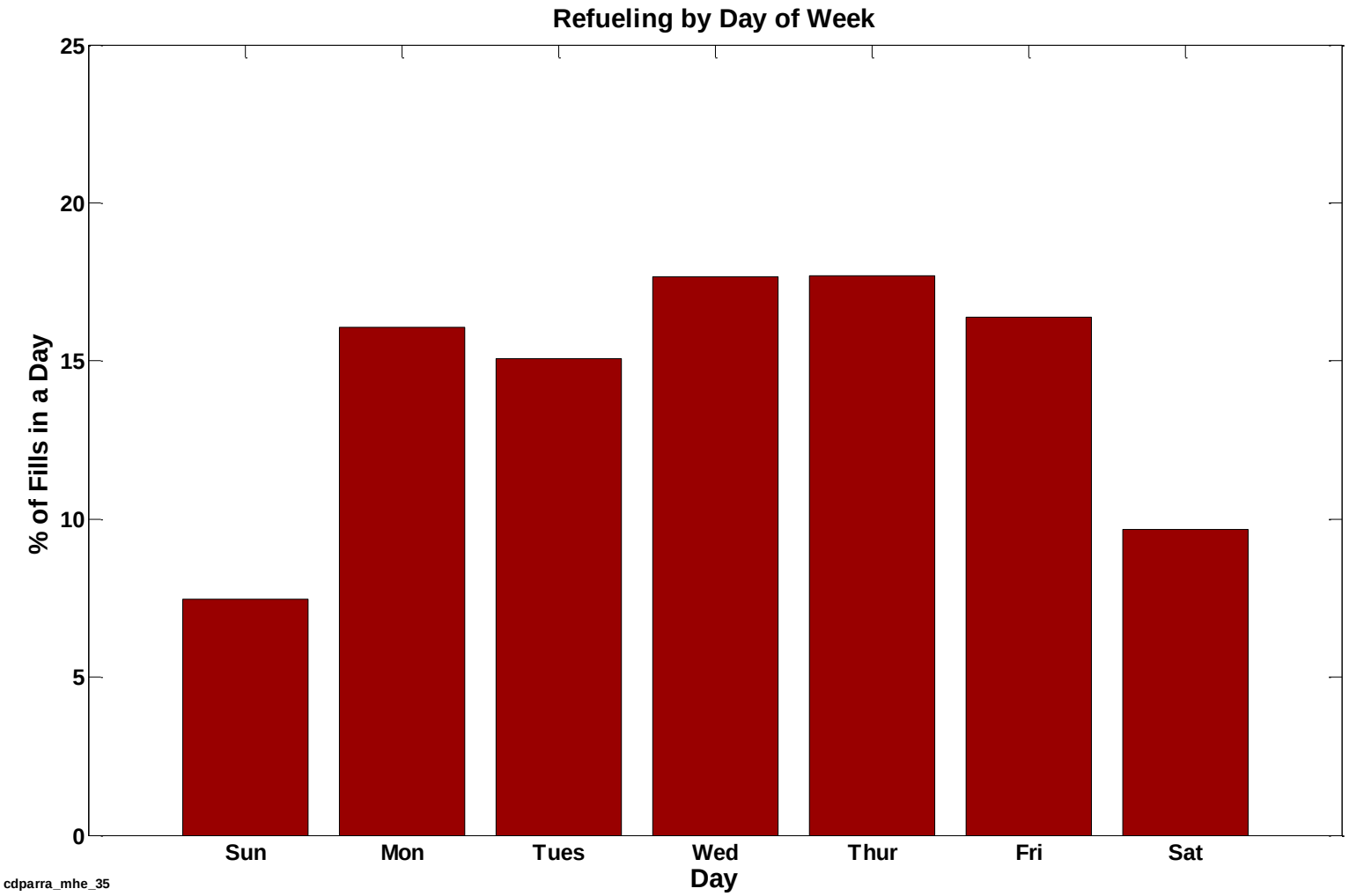
1) Normalized by fleet maximum power.
2) Each segment point is median FC power (+-100 hrs). Box not drawn if fewer than 3 points in segment.

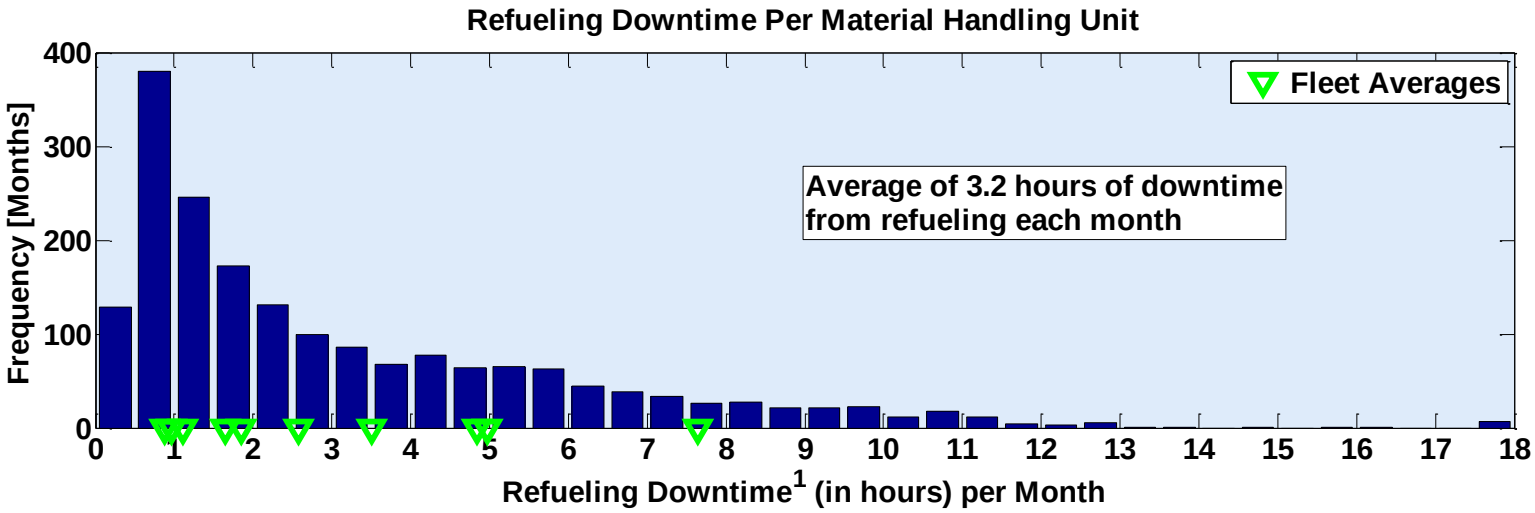
CDPARRA-MHE-35
Refuel Events by Day of Week



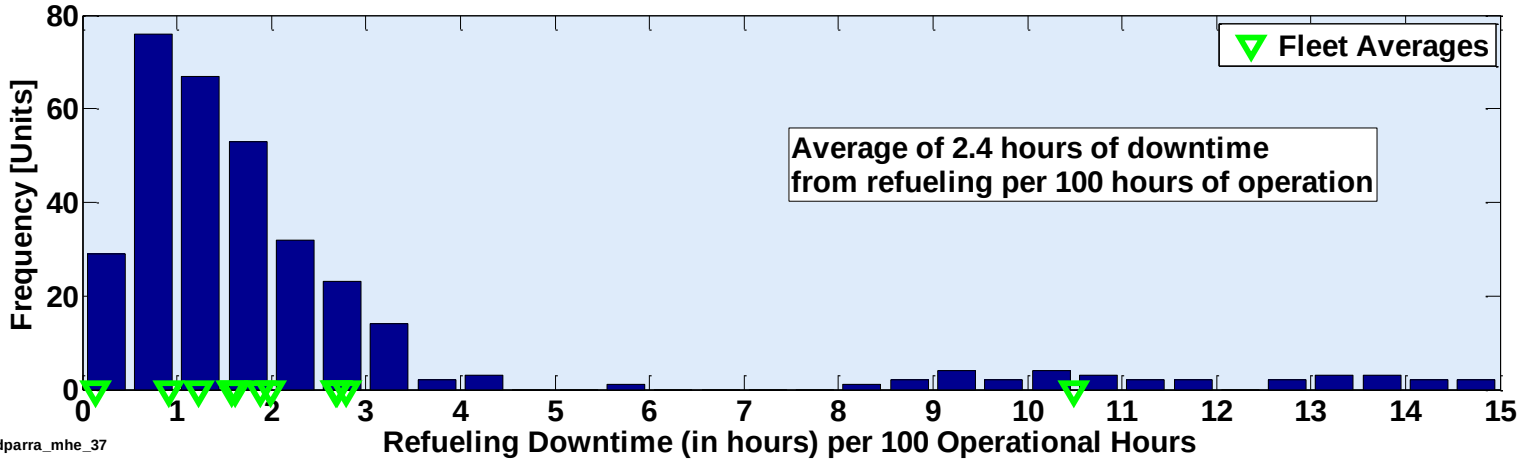
NREL cdparra_mhe_35

Created: Mar-09-12 5:36 PM

CDPARRA-MHE-37
Fuel Cell System Downtime



[1] Refueling downtime represents total refueling time from "drive-up" to "drive-away" not only hydrogen gas dispensing time



NREL cdparra_mhe_37

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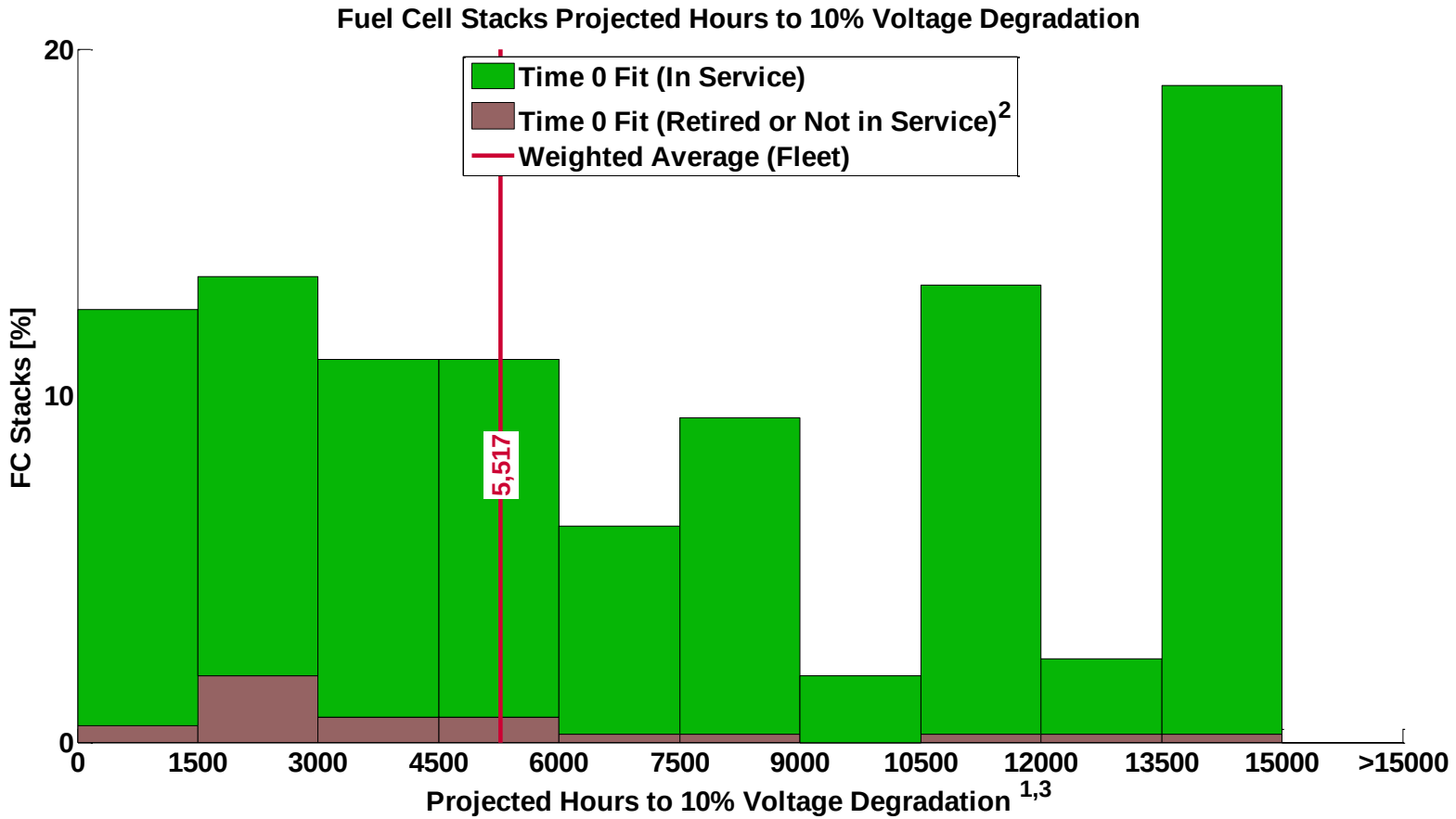
Note: Some refueling events not recorded/included due to data noise or incompleteness

CDP-MHE-38
Histogram of Fuel Cell Stack Voltage Degradation



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

NREL cdp_mhe_38
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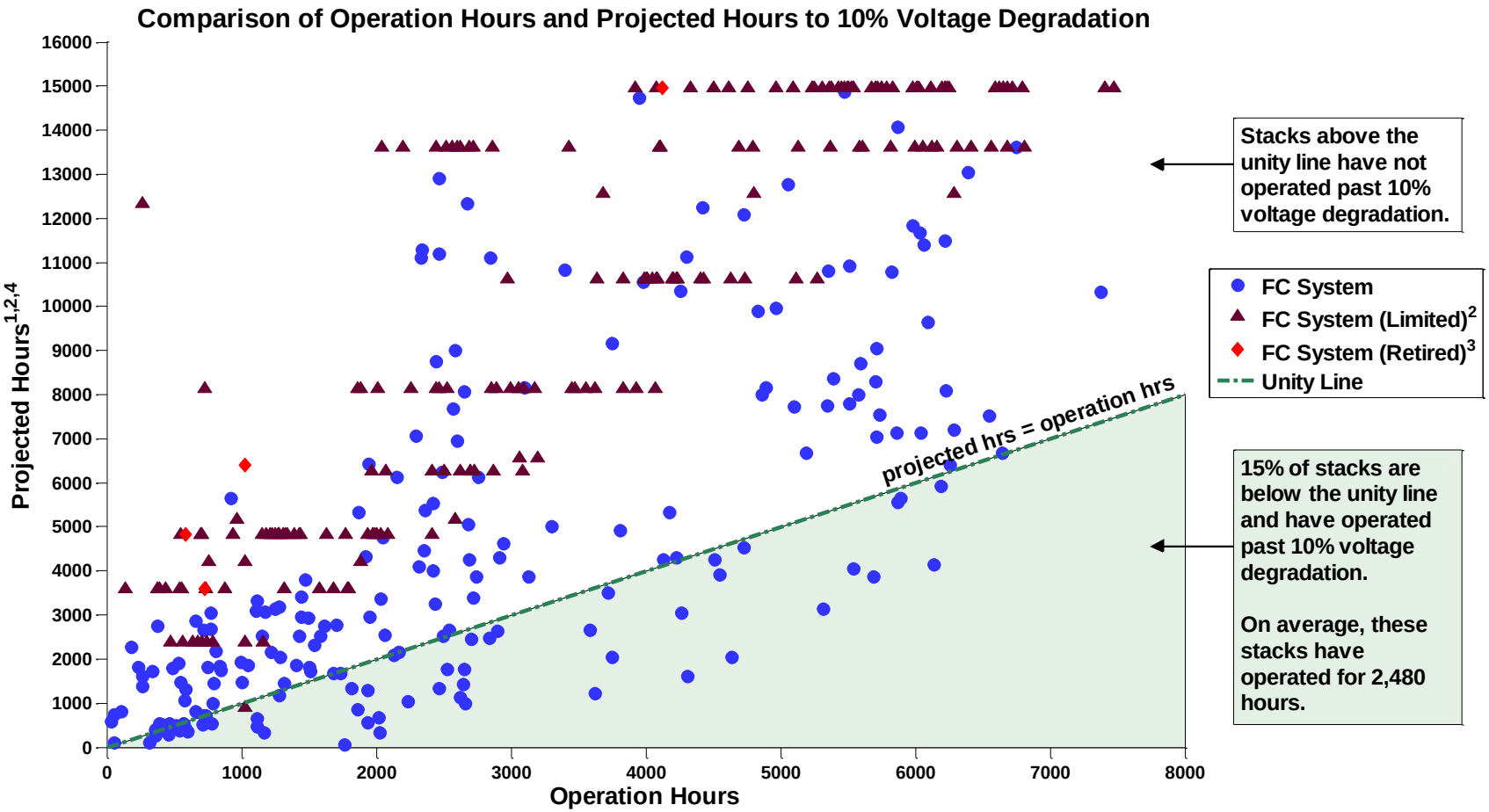
CDP-MHE-39

Comparison of Operation Hours and Projected Hours to 10% Voltage Degradation



1) Indicates the projected hours to a 10% voltage degradation based upon curve fitting data from operation hour 0.
2) Projected hours limited based on demonstrated hours.
3) Stacks retired due to low-performance or catastrophic failure.
4) Each projection has uncertainty based on the confidence intervals of the fit.

NREL cdp_mhe_39
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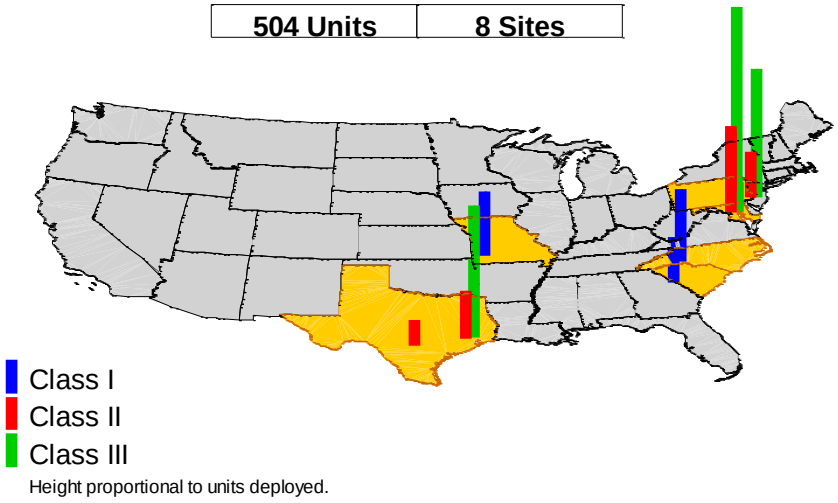
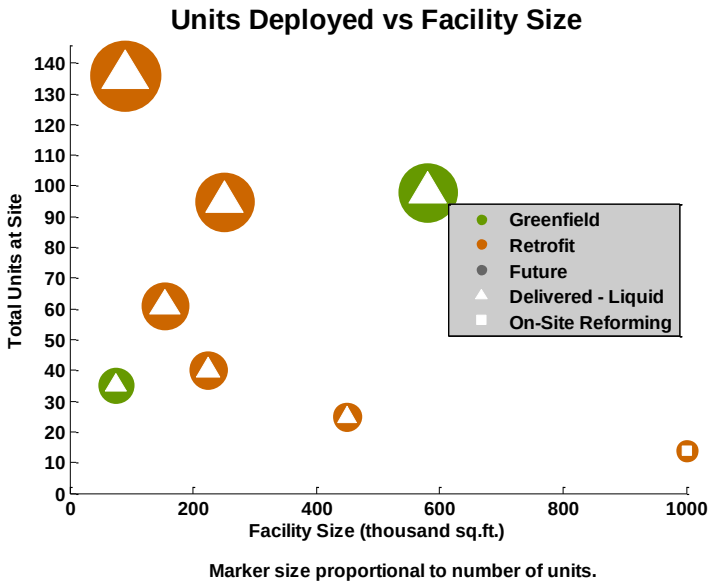
CDPARRA-MHE-40
Site Summary

MHE Deployment - ARRA





Forklift Units (I,II,III)	0,26,72	0,14,0	35,0,0	25,0,0	45,14,2	0,36,100	40,0,0	0,25,70
Operation								
Shifts per Day	2	2	3	1-2	3	2	2	3
Hours per Shift	8-10	9.5	8	10	8	8-10	8	8
Days per Week	6	N/A	N/A	7	7	6	6	6

NREL cdparra_mhe_40
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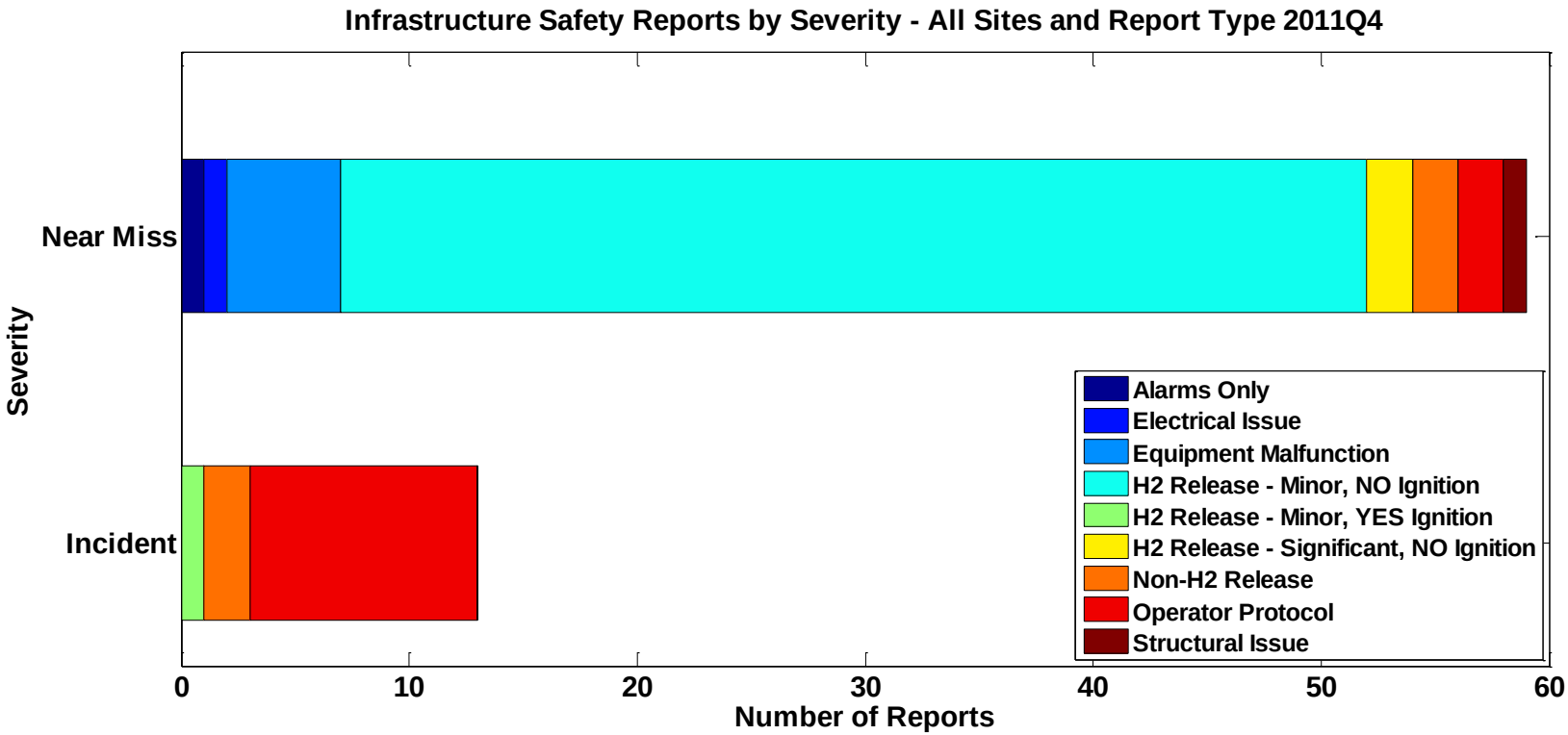
CDP-MHE-41
Infrastructure Safety Categories



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

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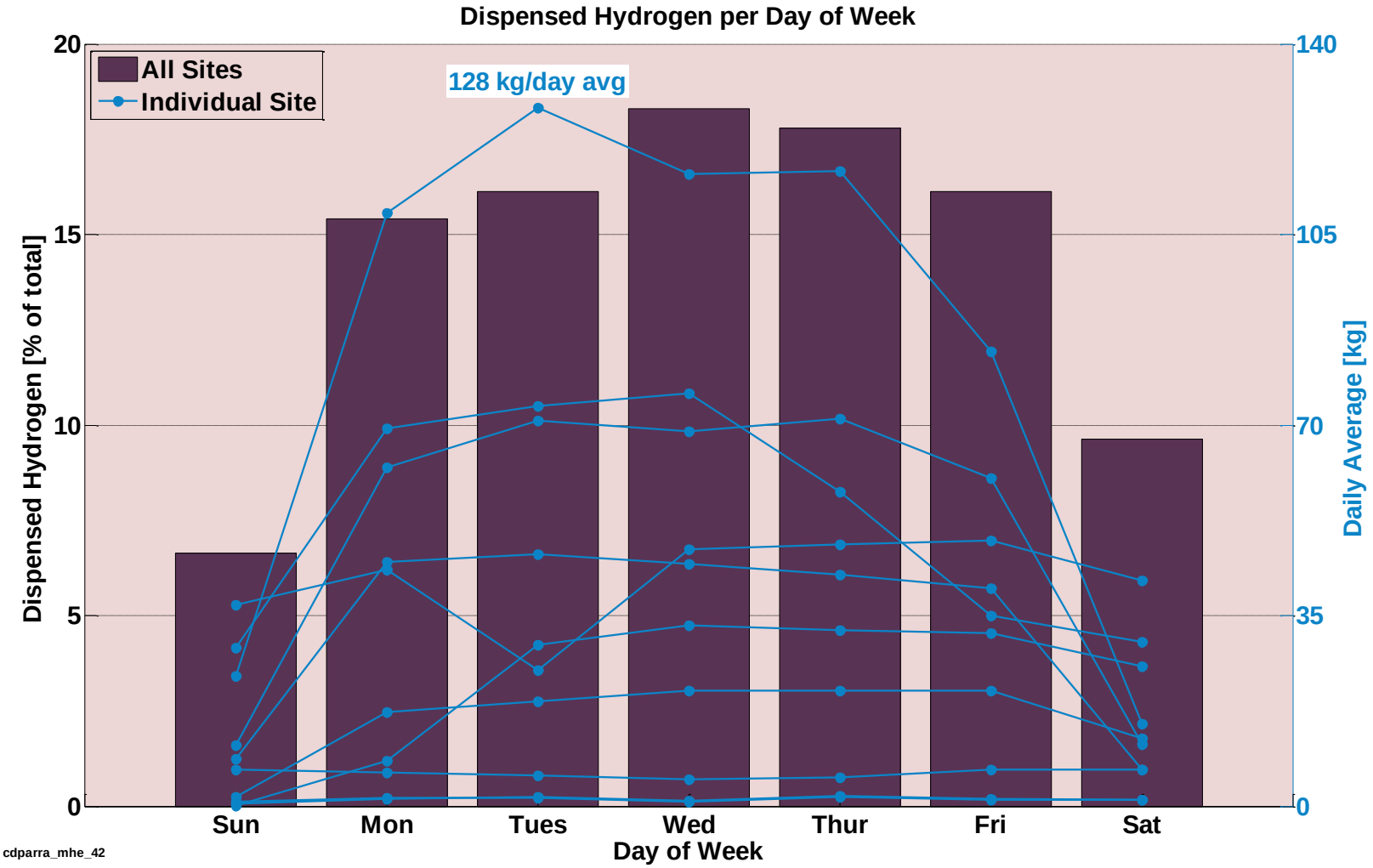
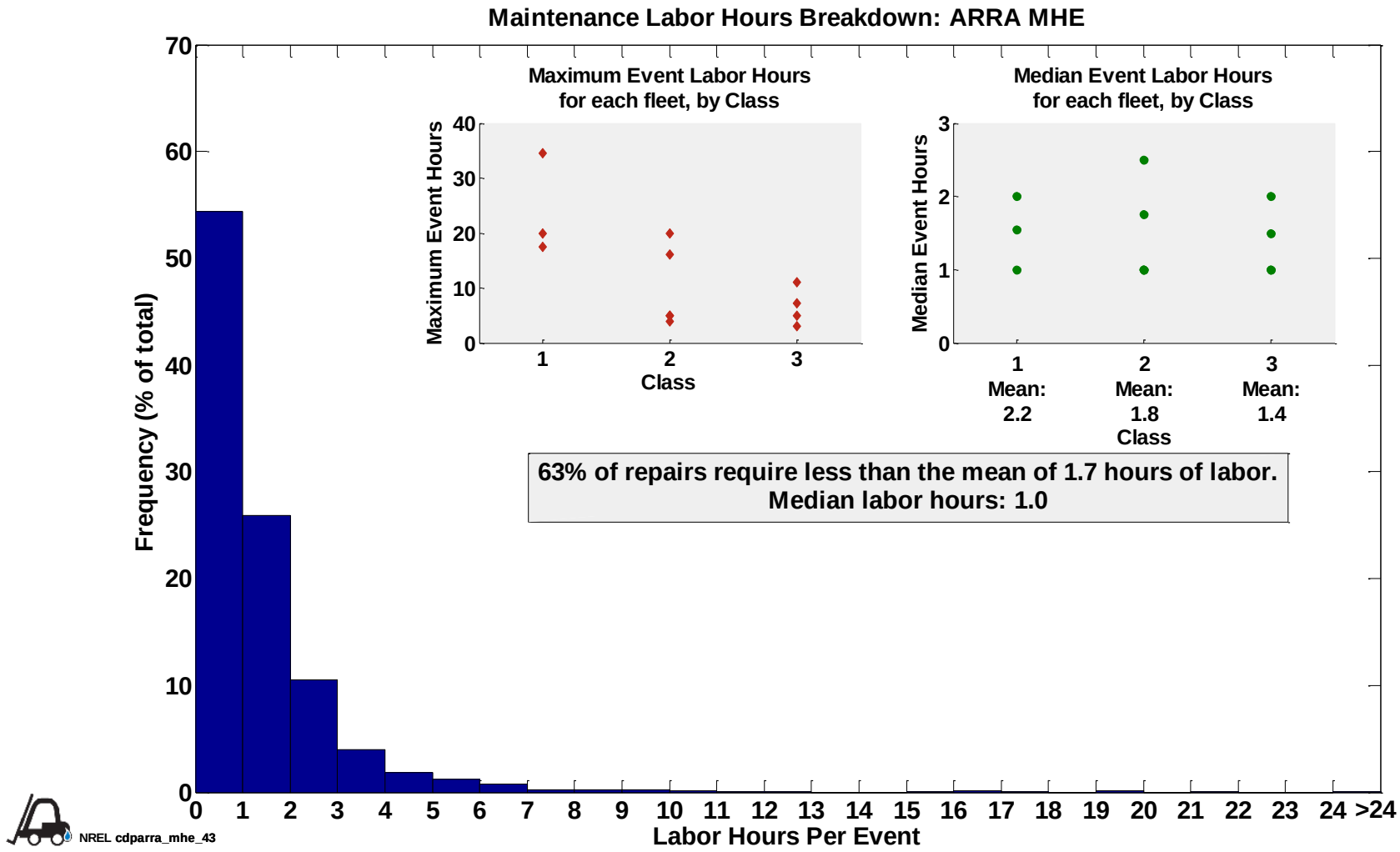
CDPARRA-MHE-42
Amount of Hydrogen Dispensed by Day of Week



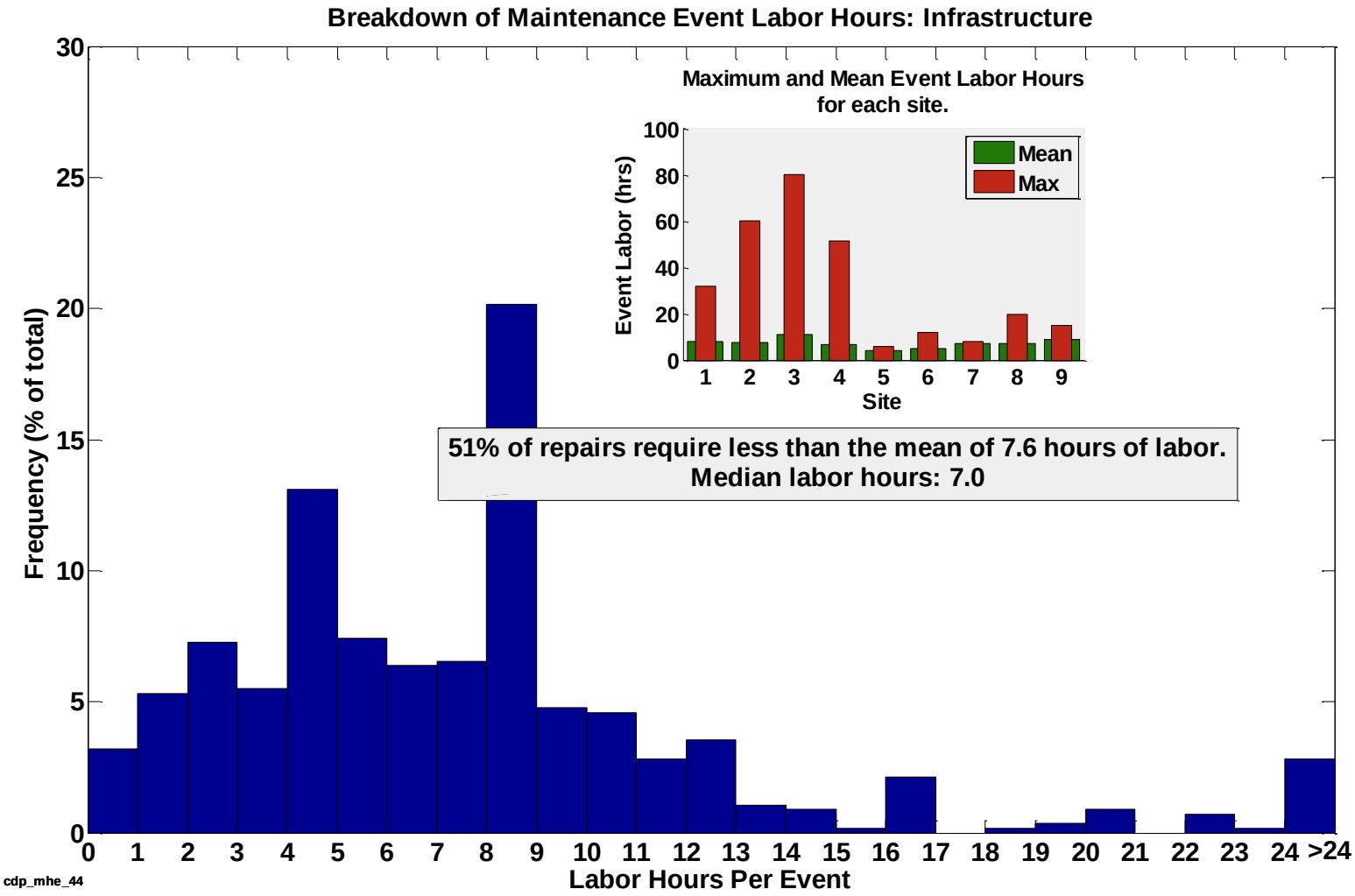
NREL cdparra_mhe_42

Created: Mar-09-12 5:41 PM

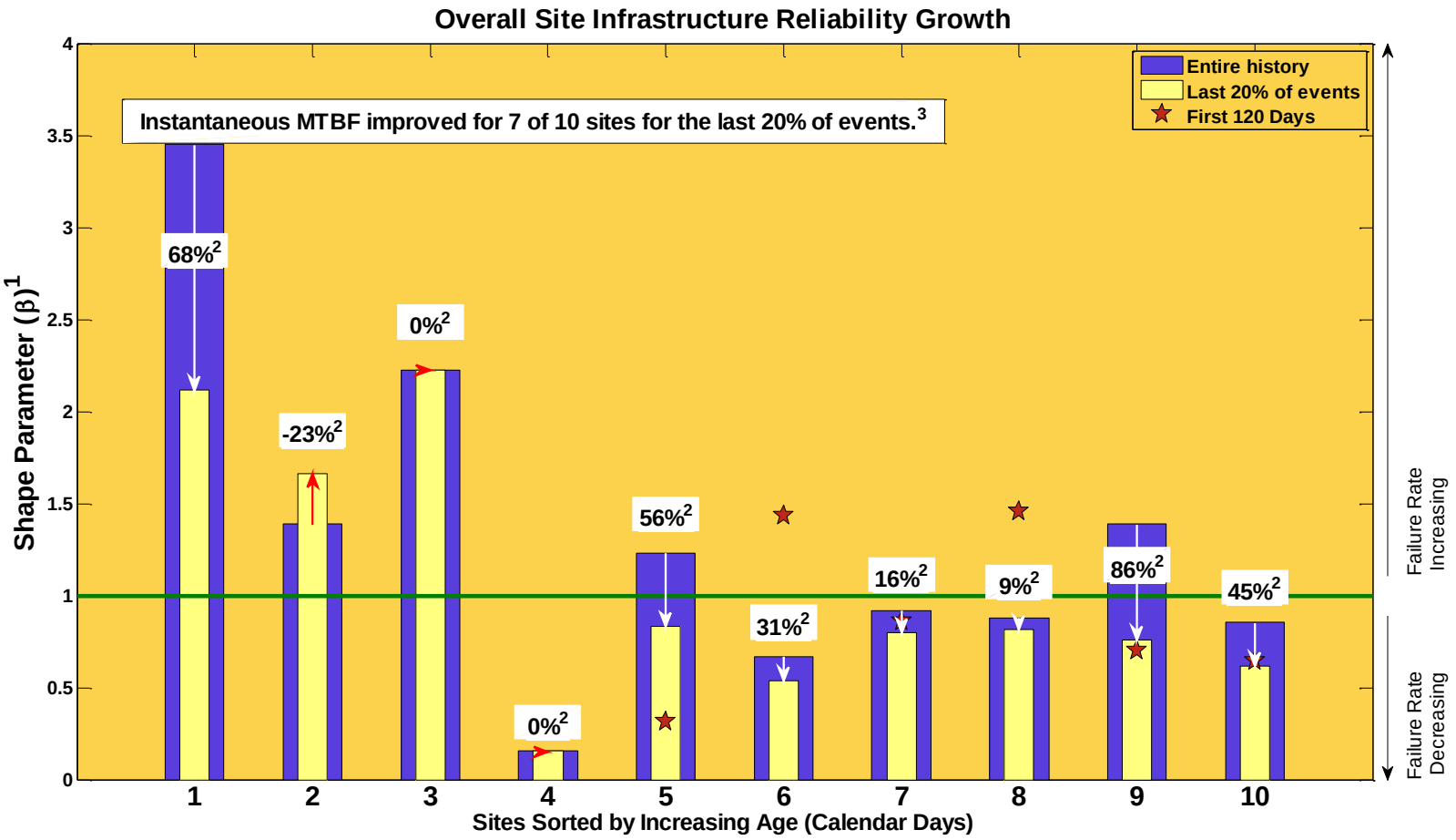
CDPARRA-MHE-43
MHE Maintenance Labor Hours



CDP-MHE-44
Infrastructure Maintenance Labor Hours



CDP-MHE-45
Infrastructure Reliability Growth



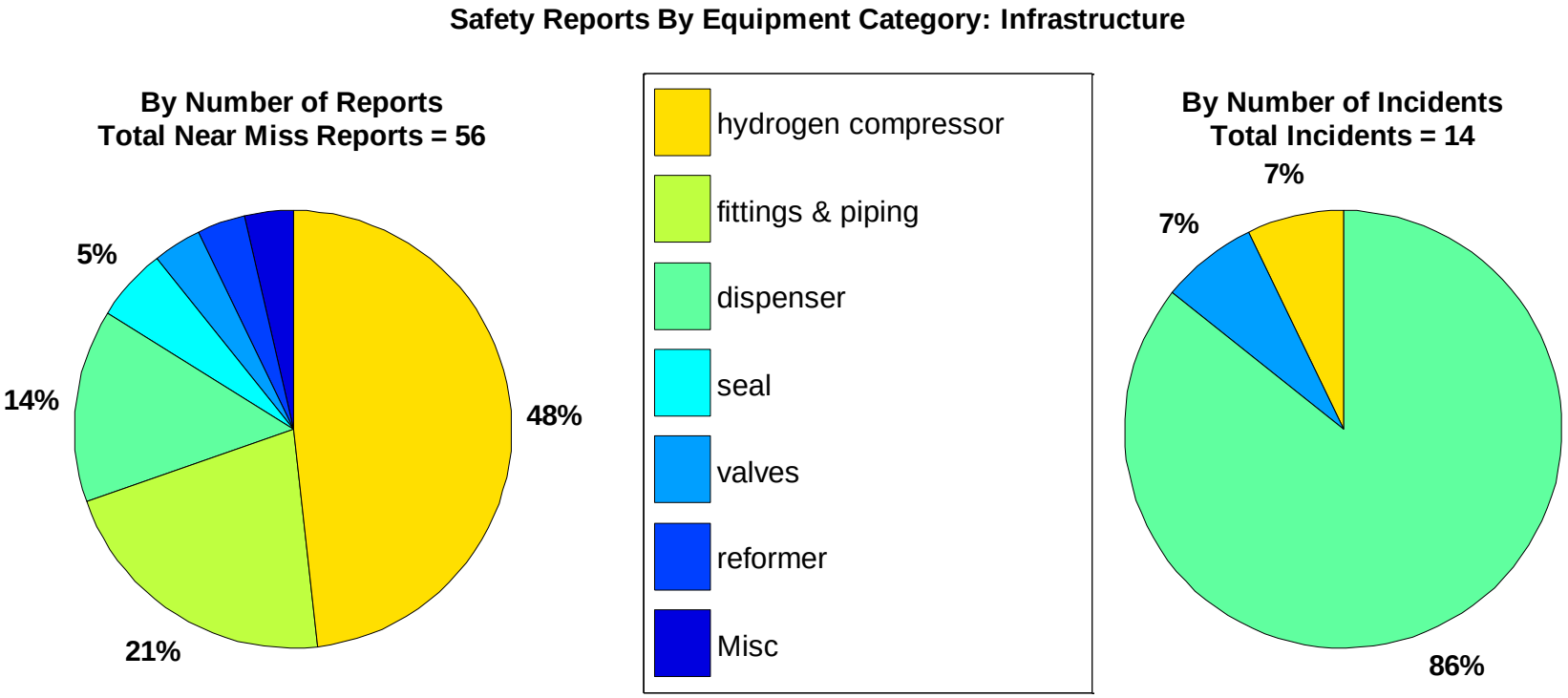
1. IEC 61164:2004(E)., Reliability Growth - Statistical Test and Evaluation Methods, IEC. 2004.

2.% change in instantaneous MTBF

3. Some sites are no longer active. Final results are shown for those sites.

NREL cdp_mhe_45
Created: Mar-13-12 5:50 PM

CDP-MHE-46
Infrastructure Equipment Category of Safety Events



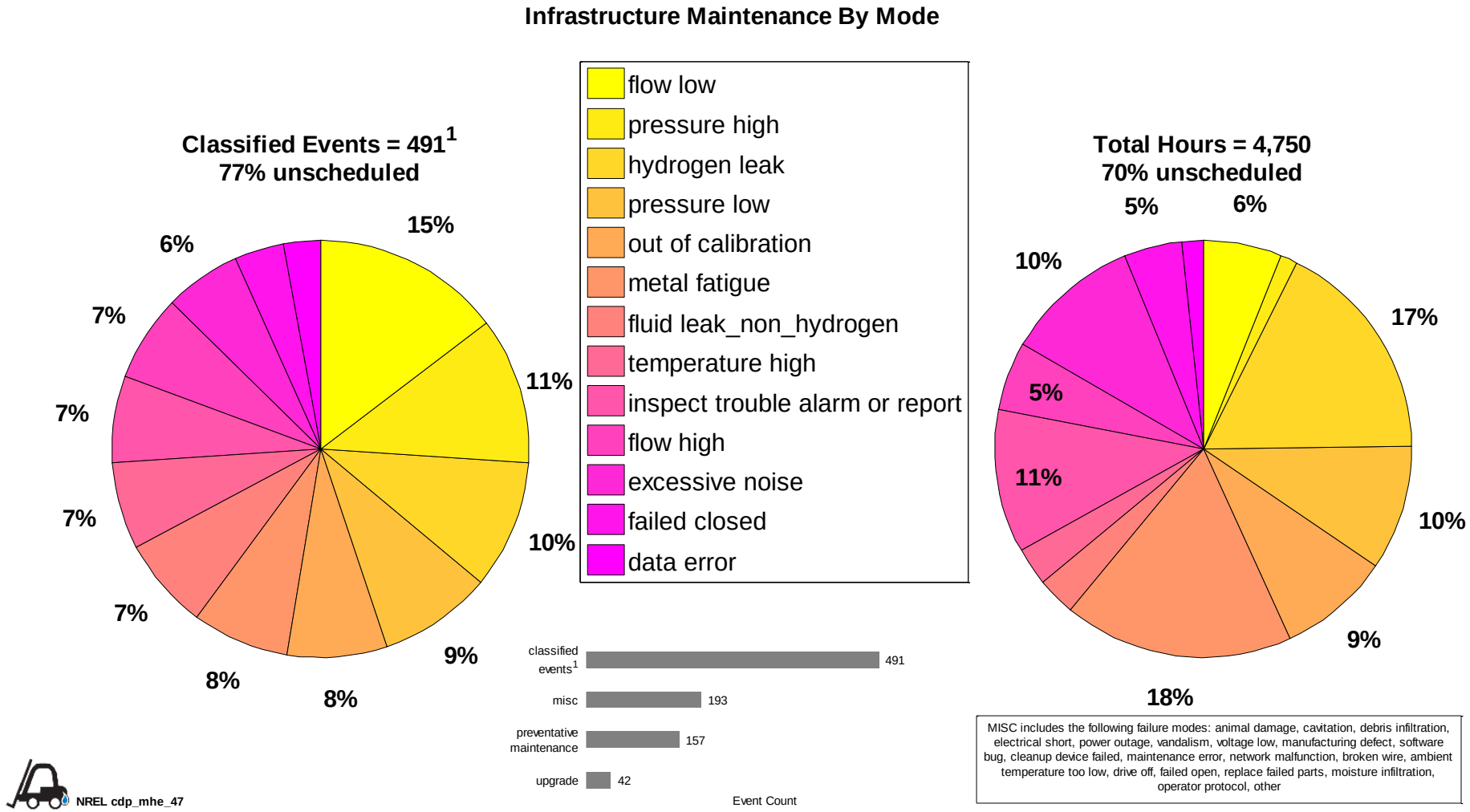
MISC includes the following categories:
FUEL SYSTEM
OTHER

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: Mar-14-12 2:38 PM

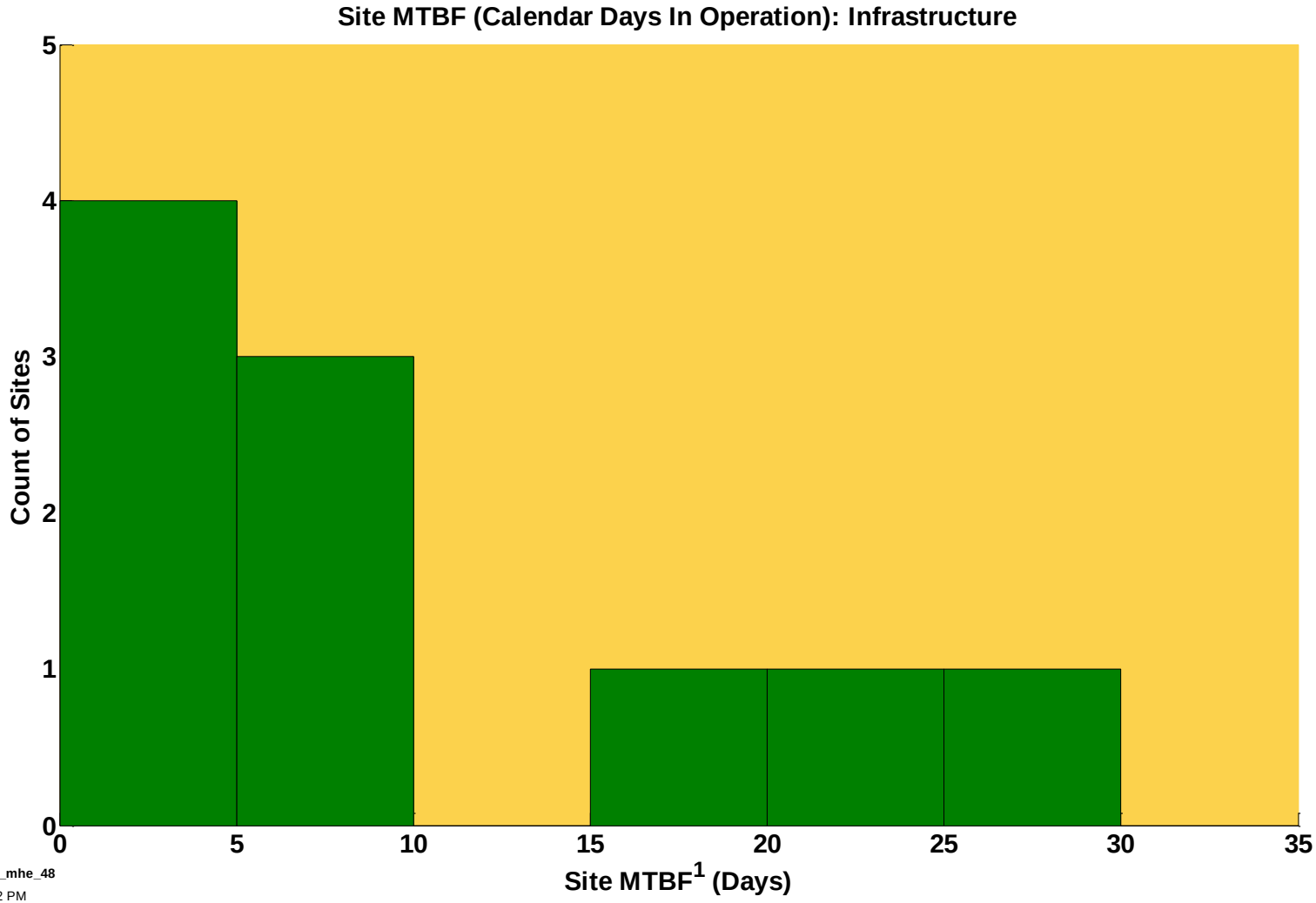
CDP-MHE-47
Infrastructure Maintenance by Mode



NREL cdp_mhe_47

Created: Mar-09-12 2:04 PM

CDP-MHE-48
Infrastructure Mean Time Between Failures

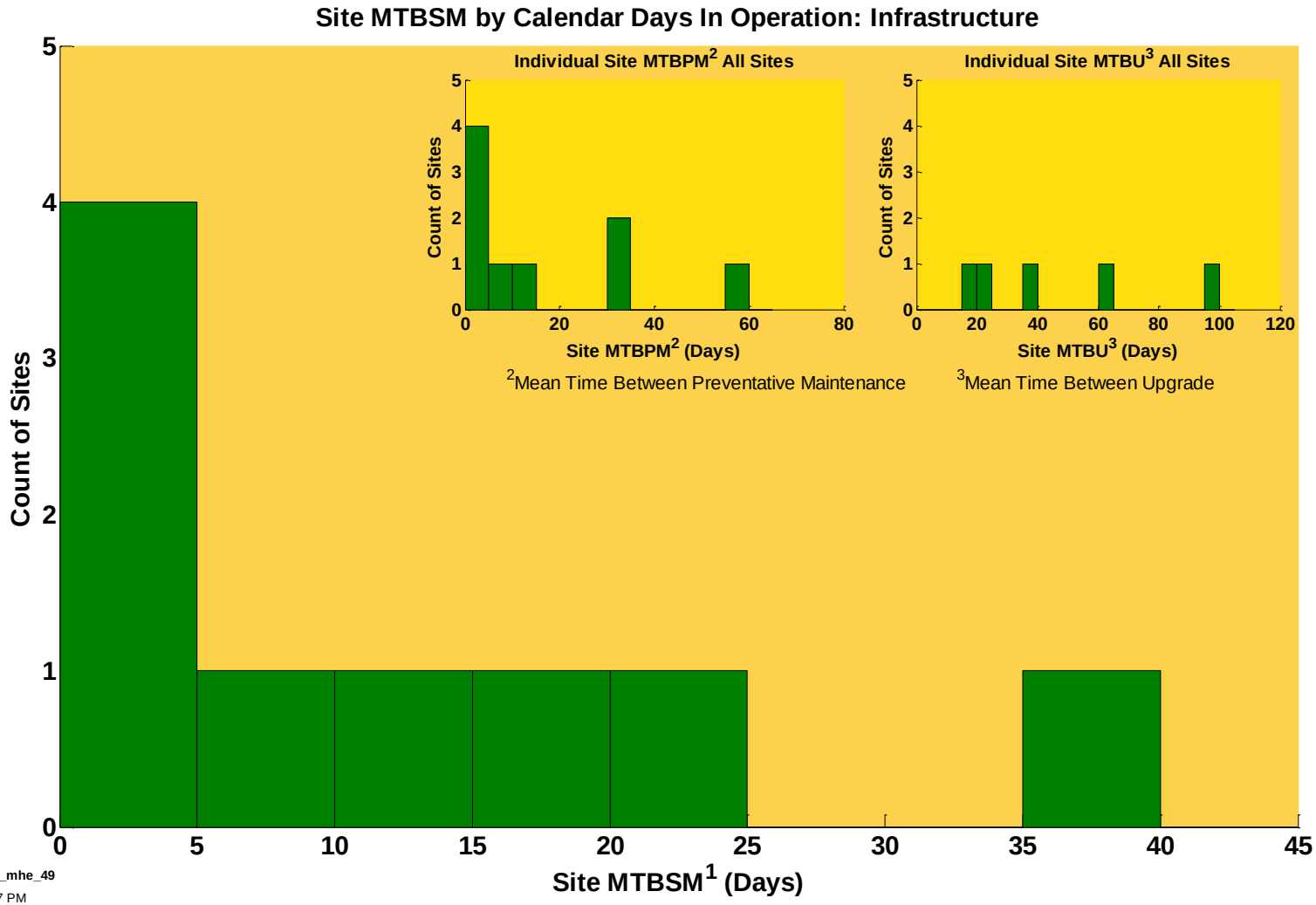


NREL cdp_mhe_48
Created: Mar-28-12 5:02 PM

1. Cumulative Mean Time Between Failure

CDP-MHE-49

Infrastructure Mean Time Between Scheduled Maintenance

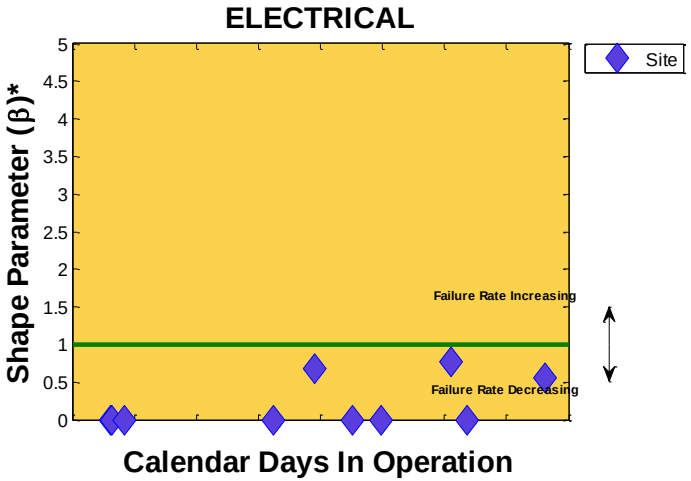


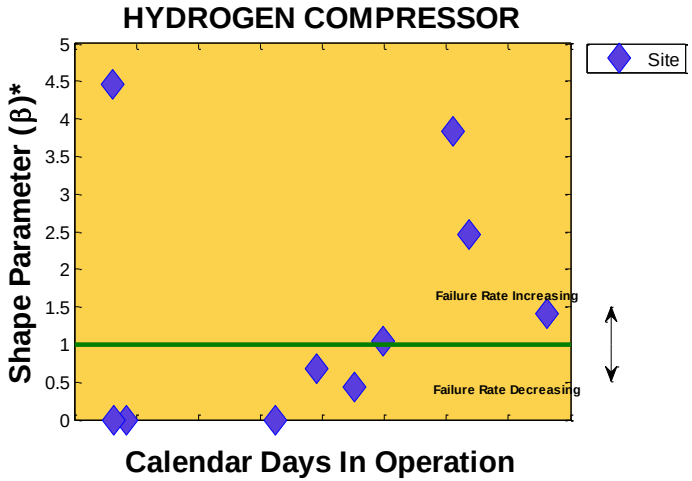
NREL cdp_mhe_49

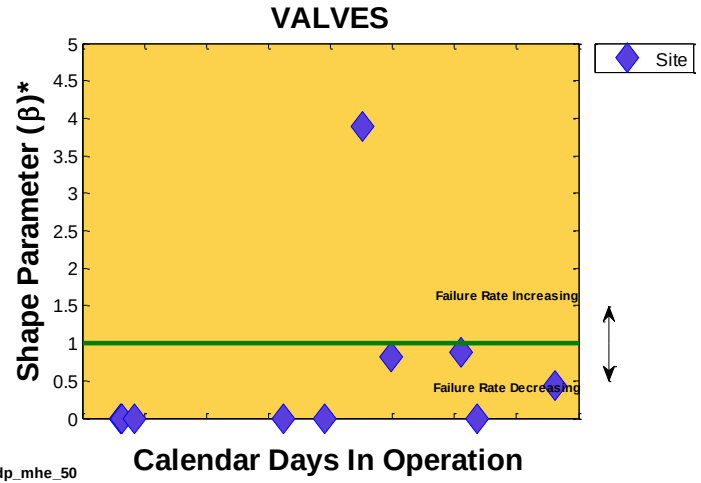
Created: Mar-28-12 4:57 PM

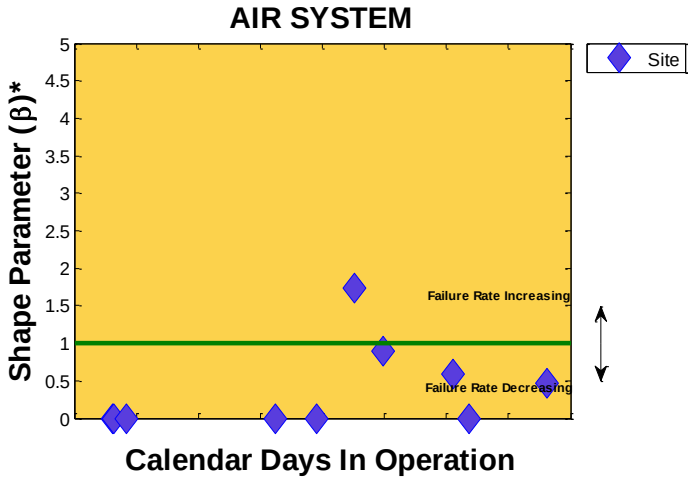
1. Cumulative Mean Time Between Scheduled Maintenance. Includes Preventative and Upgrades

CDP-MHE-50
Infrastructure Reliability Growth by Category







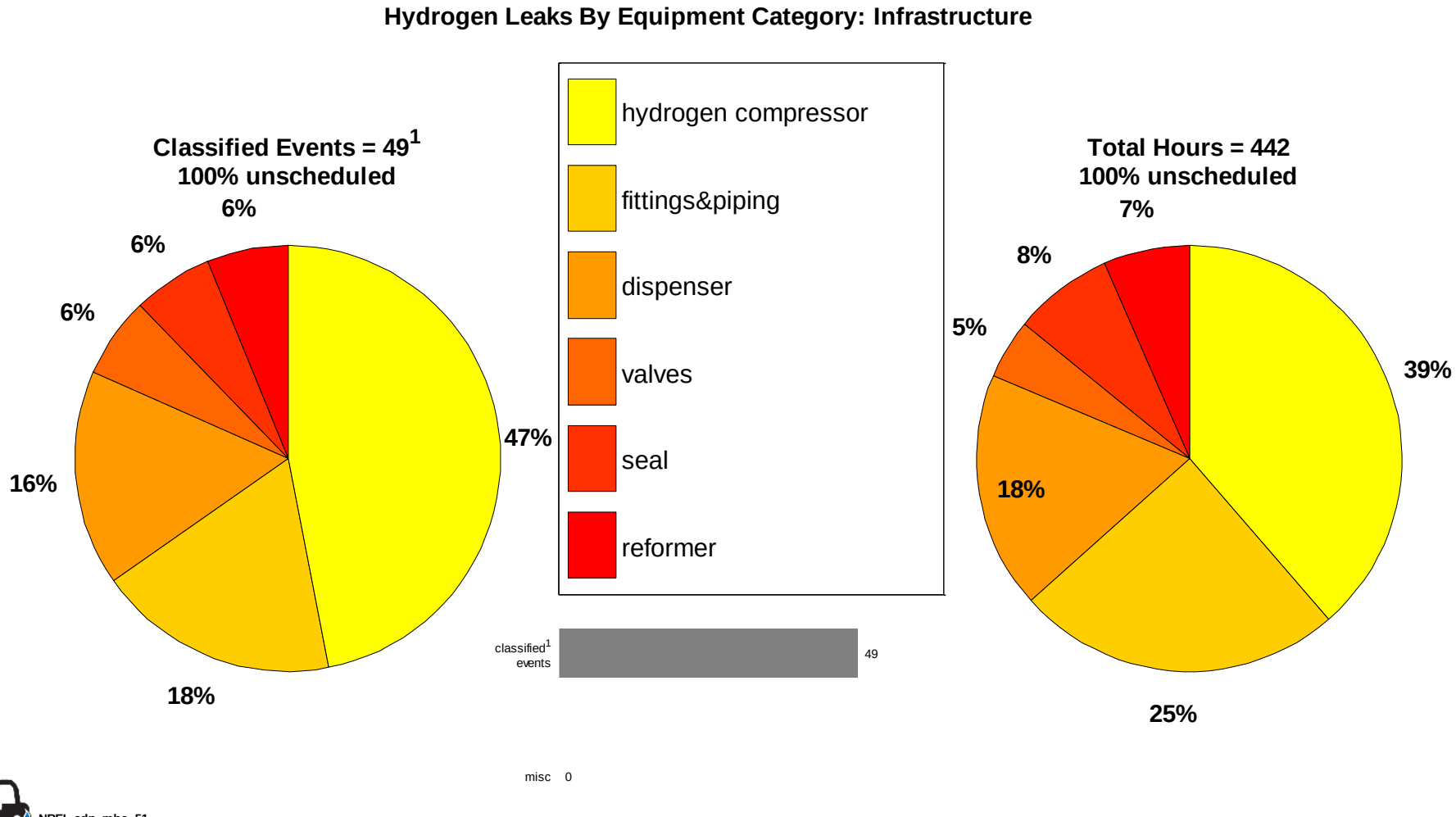


NREL cdp_mhe_50
Created: Mar-12-12 6:23 PM

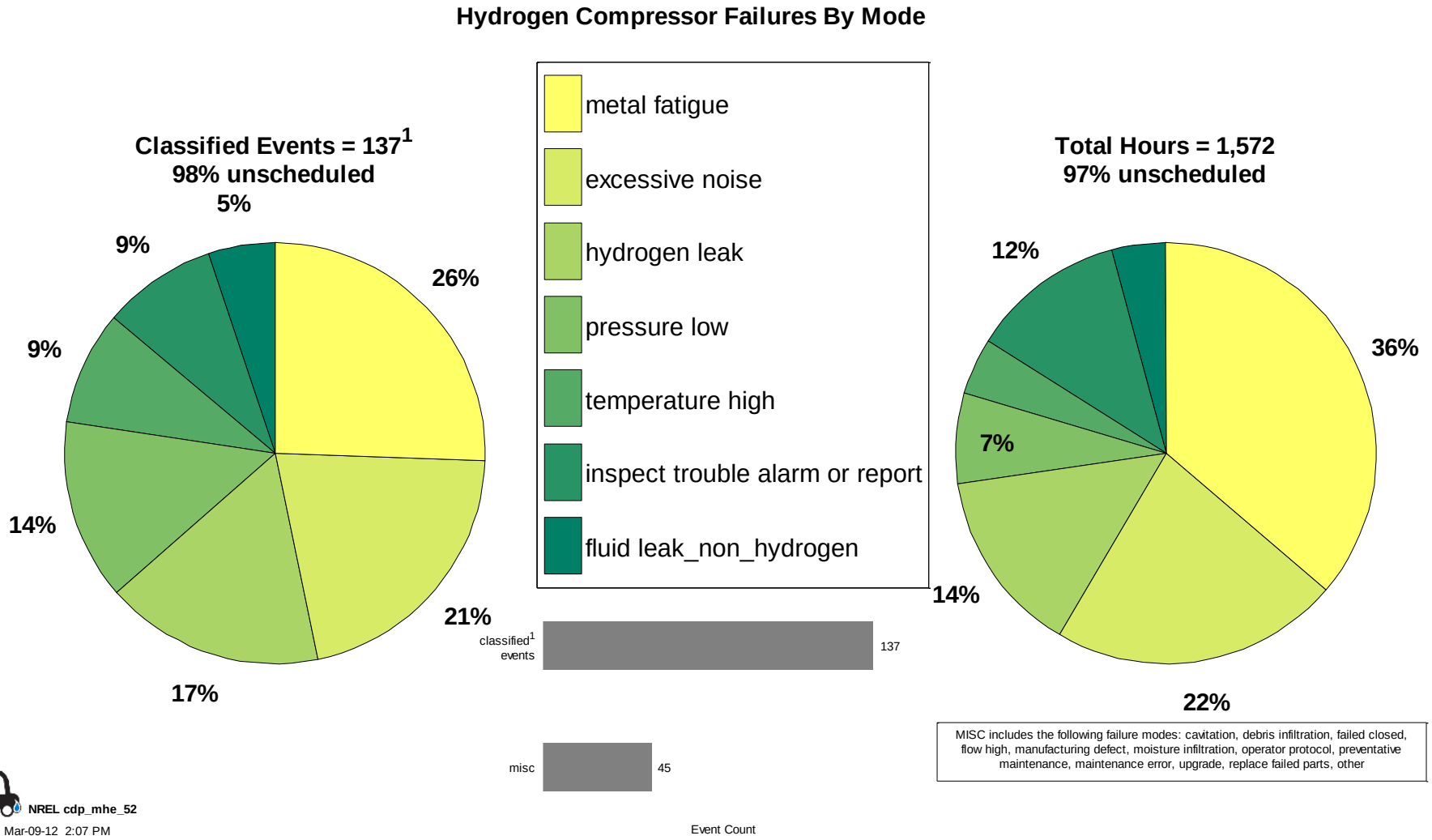
These represent the top four equipment failure categories from all combined data.

*IEC 61164 β

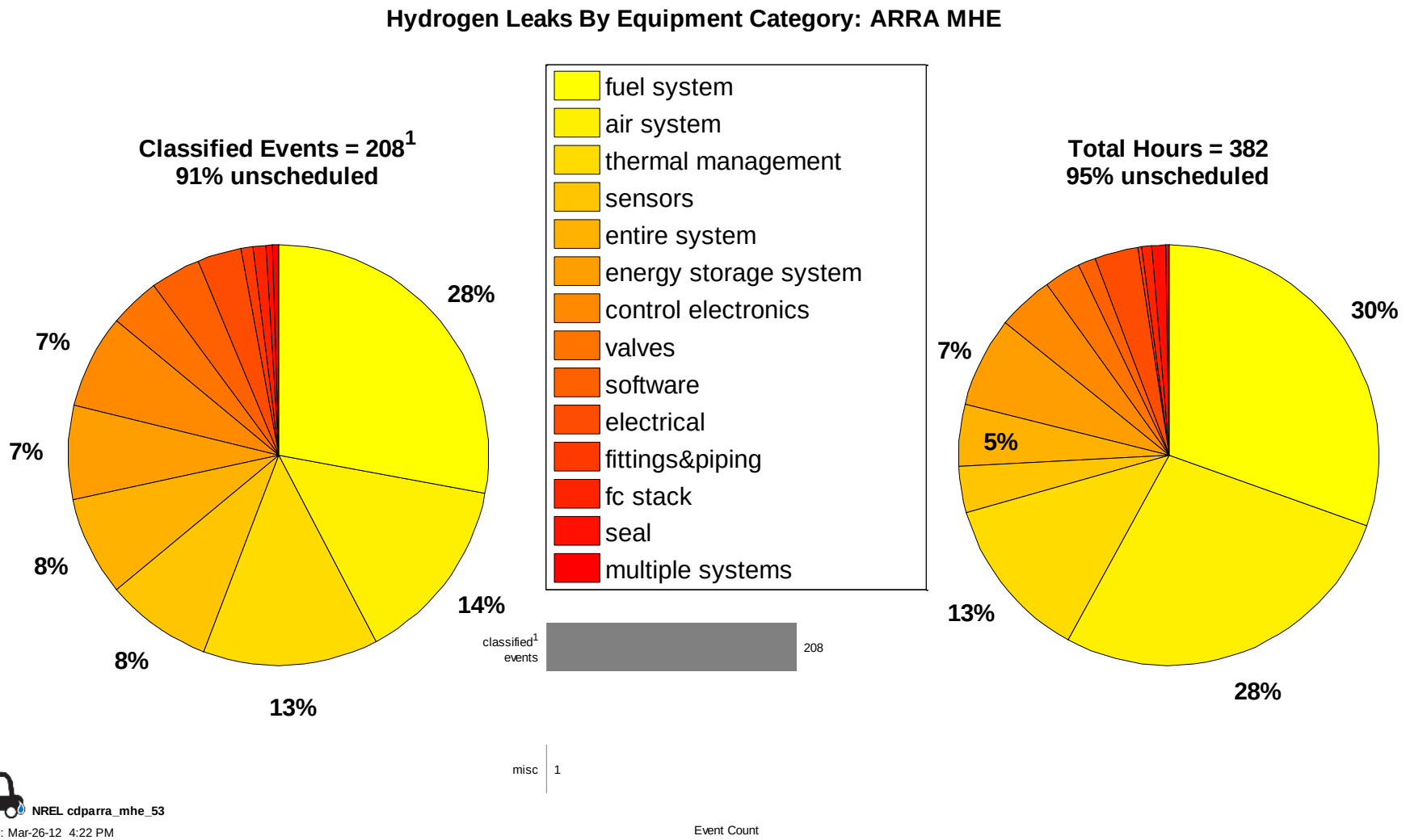
CDP-MHE-51
Infrastructure Hydrogen Leaks by Equipment Type



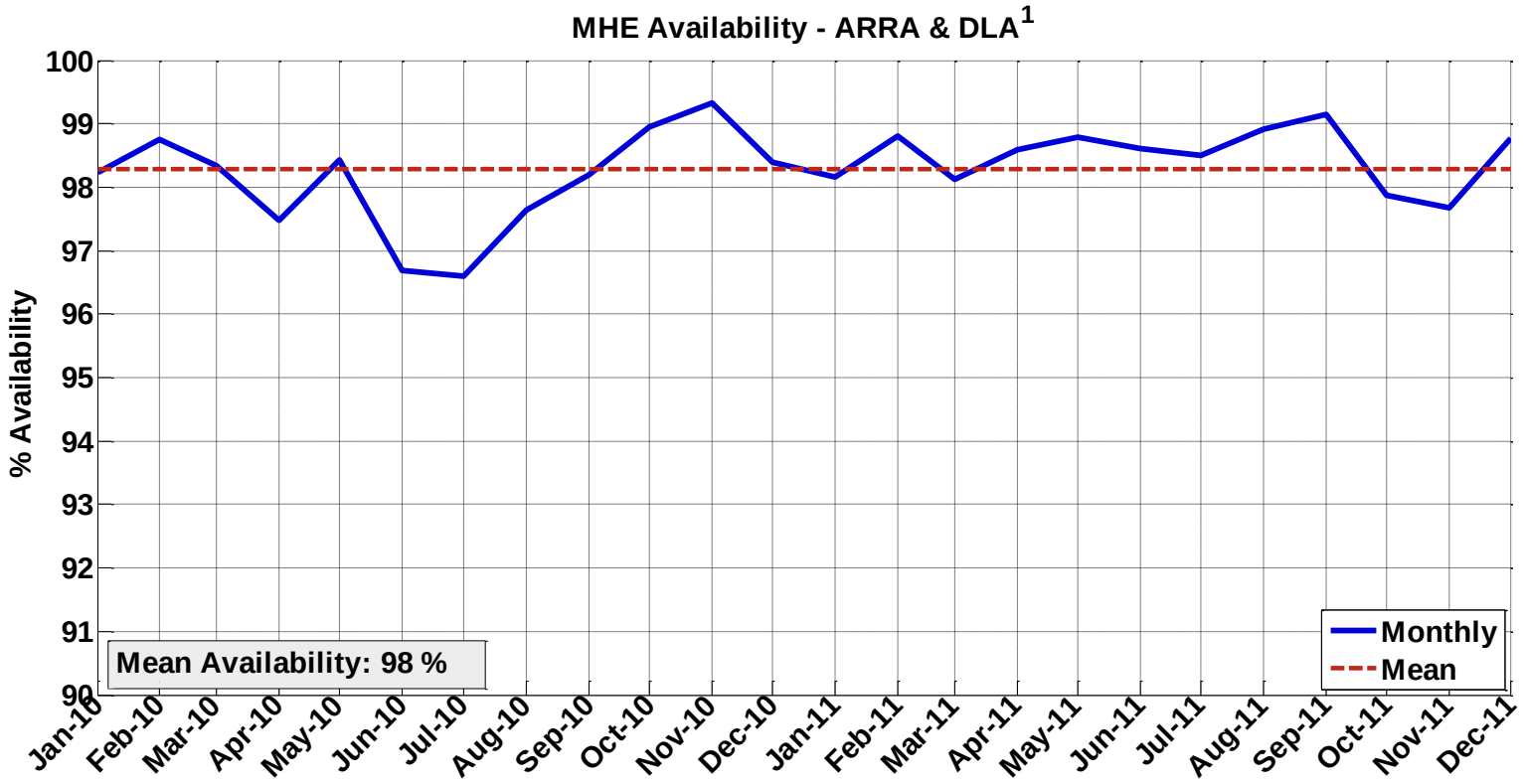
CDP-MHE-52
Infrastructure Compressor Failures by Mode



CDPARRA-MHE-53
MHE Hydrogen Leaks by Equipment Type



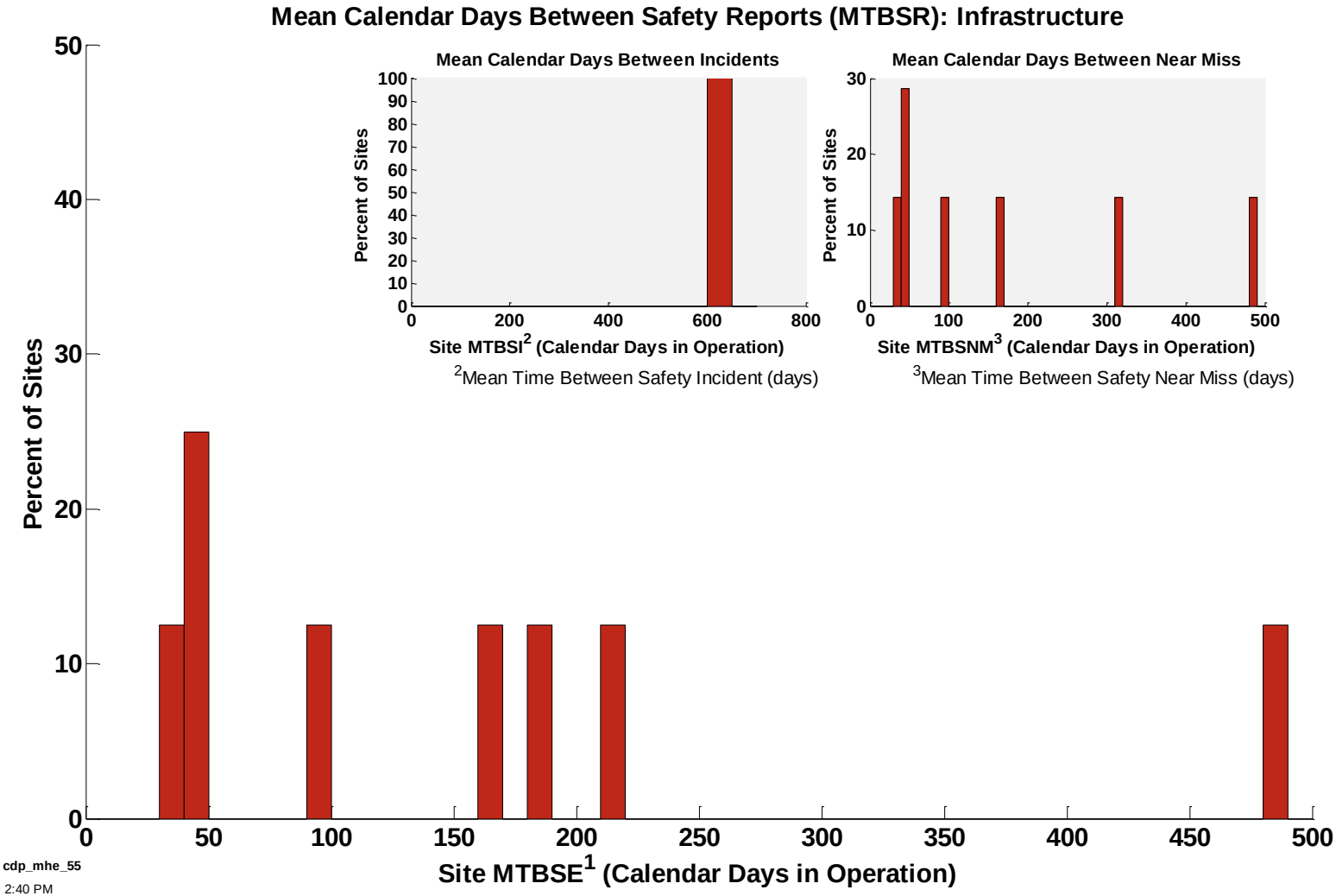
CDP-MHE-54
MHE Availability



1. Availability is calculated as follows:
   Availability starts at 100% for each vehicle on each calendar day.
   If the vehicle has a maintenance record on a given day, unavailable hours are subtracted from availability.
   The number of unavailable hours is calculated according to the following schedule:
   - A. Unavailable hours = 21 hours if maintenance hours is blank or > 6 hours.
   - B. Unavailable hours = if maintenance hours are between 4 and 6 hours.
   - C. Unavailable hours = the actual maintenance hours if it is less than 4 hours.
   - D. If maintenance hours are > 21 , the rules A-C above are applied recursively to any remainder above 21 hours.

NREL cdp_mhe_54
Created: Mar-26-12 4:19 PM

CDP-MHE-55
Infrastructure Mean Time Between Safety Events



[2]Mean Time Between Safety Incident (days)

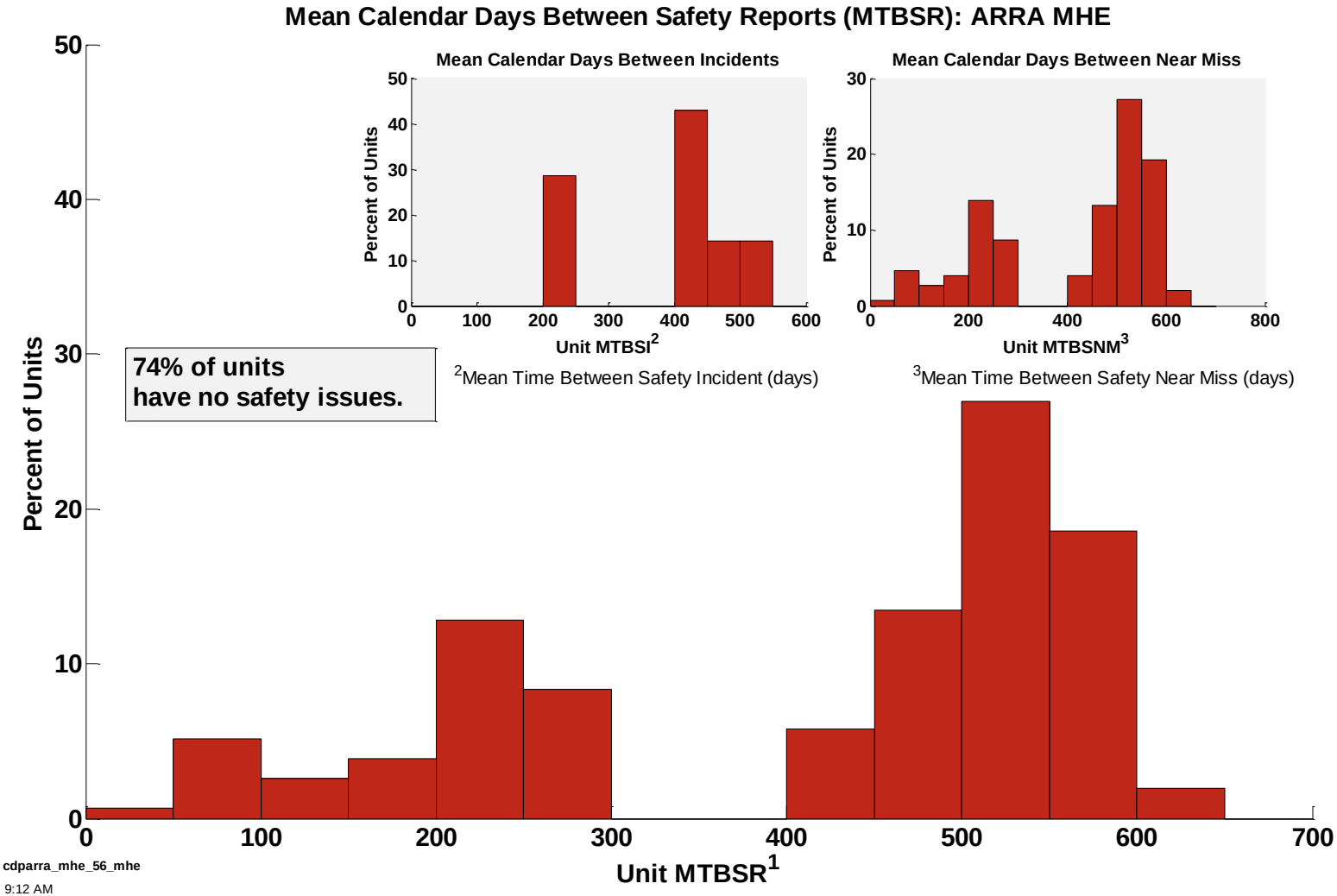
[3]Mean Time Between Safety Near Miss (days)

NREL cdp_mhe_55

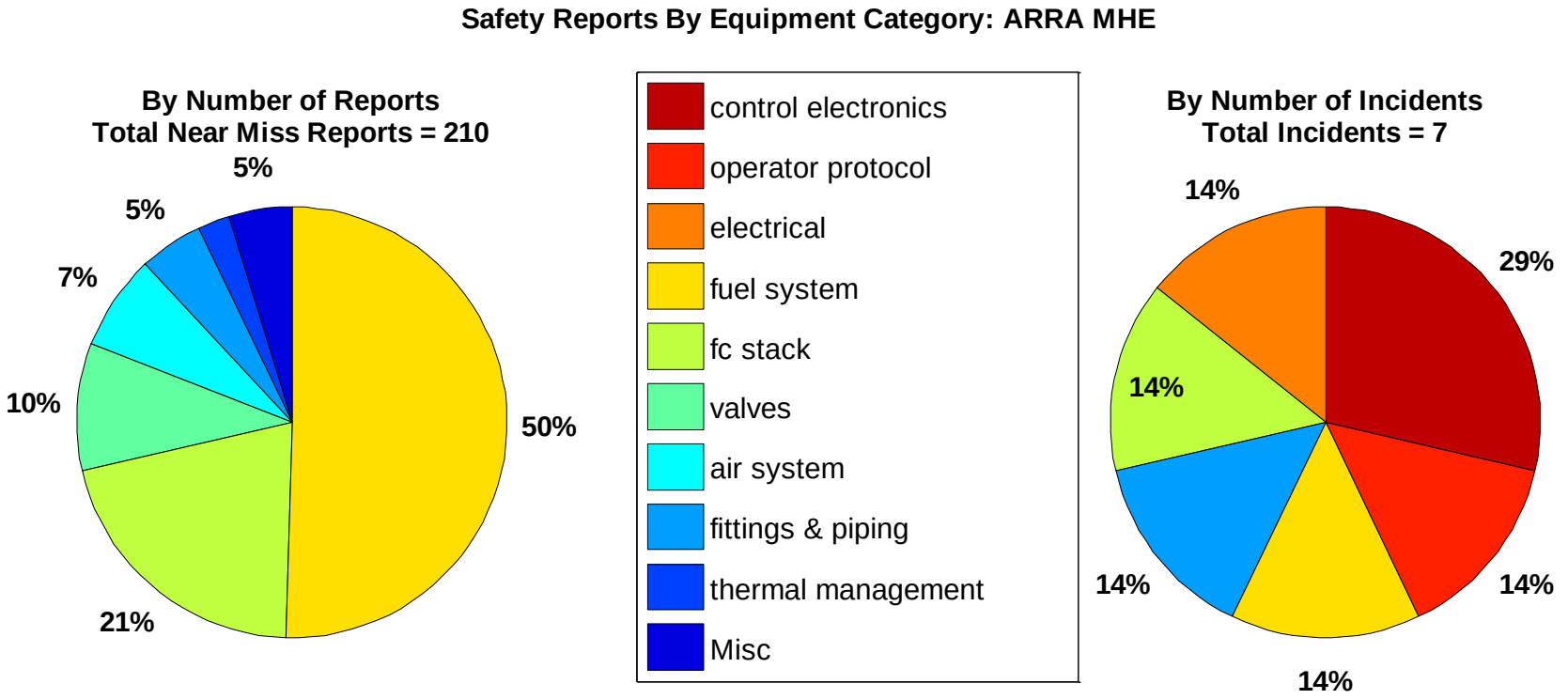
Created: Mar-14-12 2:40 PM

1. Cumulative Mean Time Between Safety Report (days)

CDPARRA-MHE-56
MHE Mean Time Between Safety Events



CDPARRA-MHE-57
MHE Equipment Category of Safety Events



MISC includes the following categories:
SOFTWARE
ELECTRICAL
REFORMER
SENSORS
SEAL
OTHER

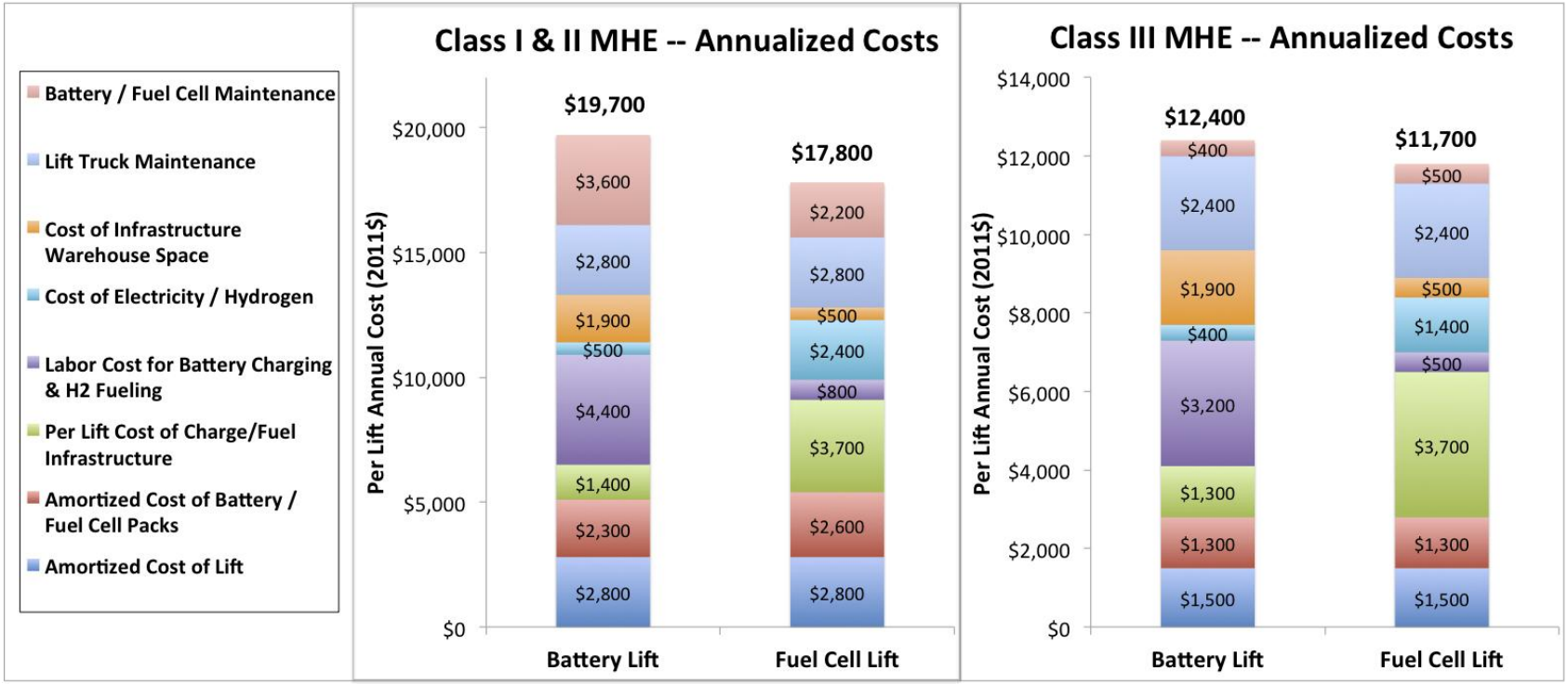
NREL cdparra_mhe_57
Created: Mar-26-12 4:23 PM

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-MHE-58
MHE Total Cost of Ownership

Total Cost of Ownership for Class I, II & III Forklifts[1]



(1) Total cost represents the annualized cost of ownership of Class I, II, and III forklifts on a net present value basis, accounting for capital, operating, and maintenance costs of forklifts, power packs, and infrastructure (labor costs for maintenance and for charging or fueling are included, but labor costs of forklift material handling operations are excluded). Costs are calculated assuming that the material handling operations are ongoing, with equipment replacements made as necessary. Capital, operating, and maintenance costs are assumed to remain constant in real-dollar terms, and capital purchases are discounted using a discount rate representing the time value of money. Fuel cell system costs reflect the current fuel cell tax credit of $3,000/kW or 30% of purchase price. Analysis does not consider the potential productivity increases resulting from the constant power output of fuel cell systems, which may be significant. Costs of ownership of Class II forklifts are expected to be similar for Class I forklifts, though the cost of the lift itself is expected to be higher.

Costs are based on information provided by deployment host partners (end-users) based on a questionnaire developed by NREL, supplemented with data provided by project partners, and are reflective of the material handling operations of these deployments. Where appropriate, fuel cell deployment data were used in place of end-user questionnaire data; in particular, data from CDPs 1, 6, 8, 14, and 22 were used. Cost assessment will be further refined as additional data are available.

NREL cdp_mhe_58
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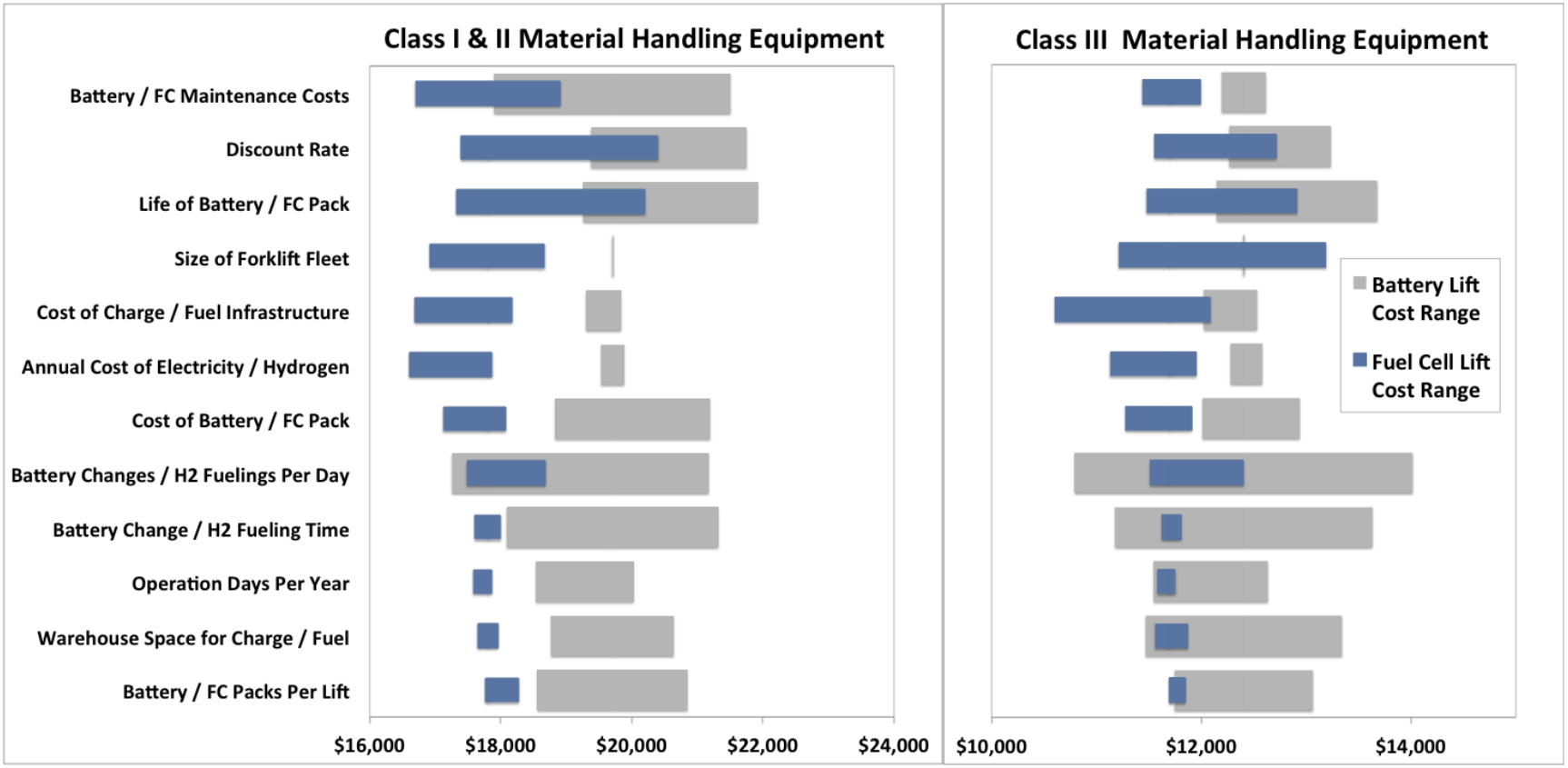
CDP-MHE-59
MHE Total Cost of Ownership - Sensitivity

Total Cost of Ownership Sensitivity Analysis[1]



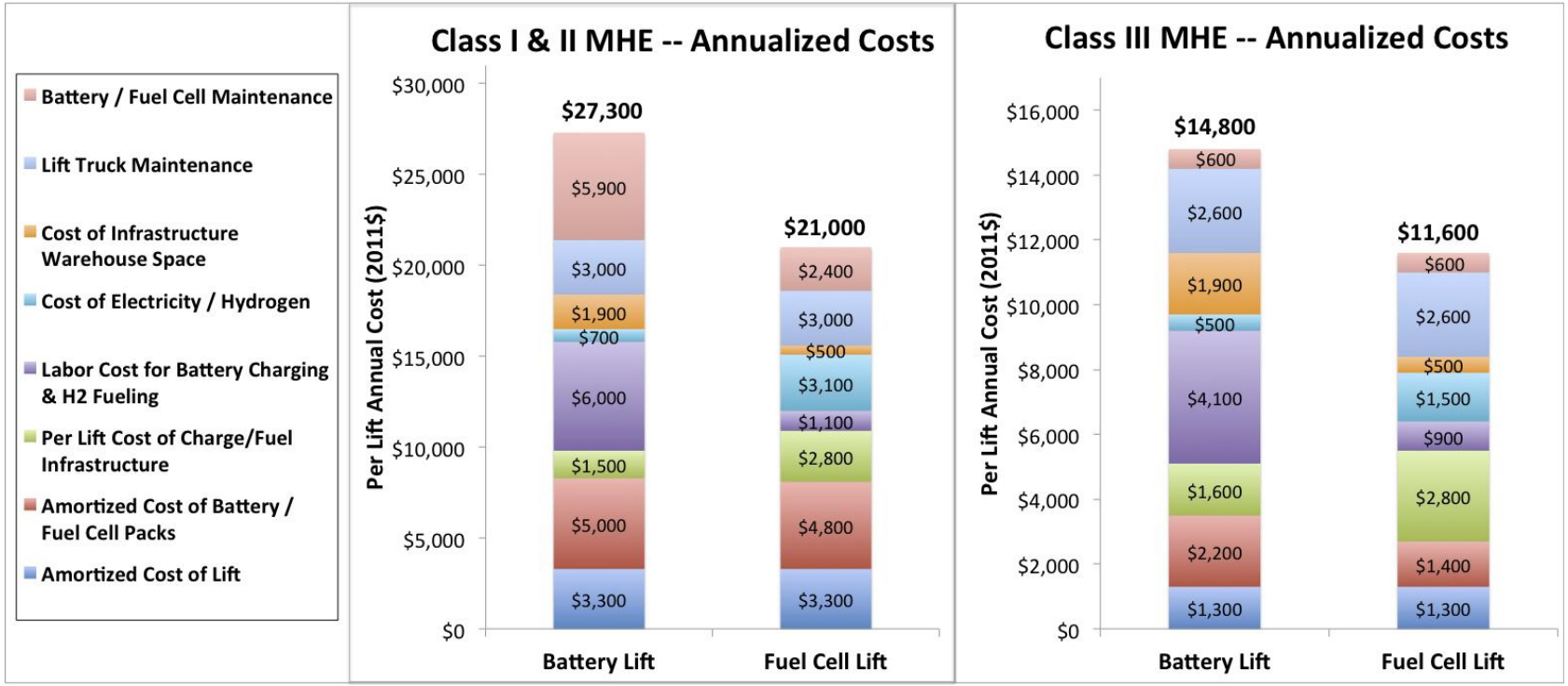
(1) Total cost represents the annualized cost of ownership of Class I, II, and III forklifts on a net present value basis. Fuel cell system costs reflect the current fuel cell tax credit of $3,000/kW or 30% of purchase price. Costs are based on information provided by deployment host partners based on a questionnaire developed by NREL, supplemented with additional data provided by project partners, and are reflective of the material handling operations of these deployments. Where appropriate, fuel cell deployment data were used in place of end-user questionnaire data; in particular, data from CDPs 1, 6, 8, 14, and 22 were used.

Sensitivity analysis shows the ranges in annual per lift cost of ownership resulting from varying key parameters affecting battery and fuel cell forklift cost.

NREL cdp_mhe_59
Created: Mar-29-12 4:43 PM

CDP-MHE-60
MHE Intensive Deployment Total Cost of Ownership

Intensive Deployment Scenario: Projected Total Cost of Ownership[1]

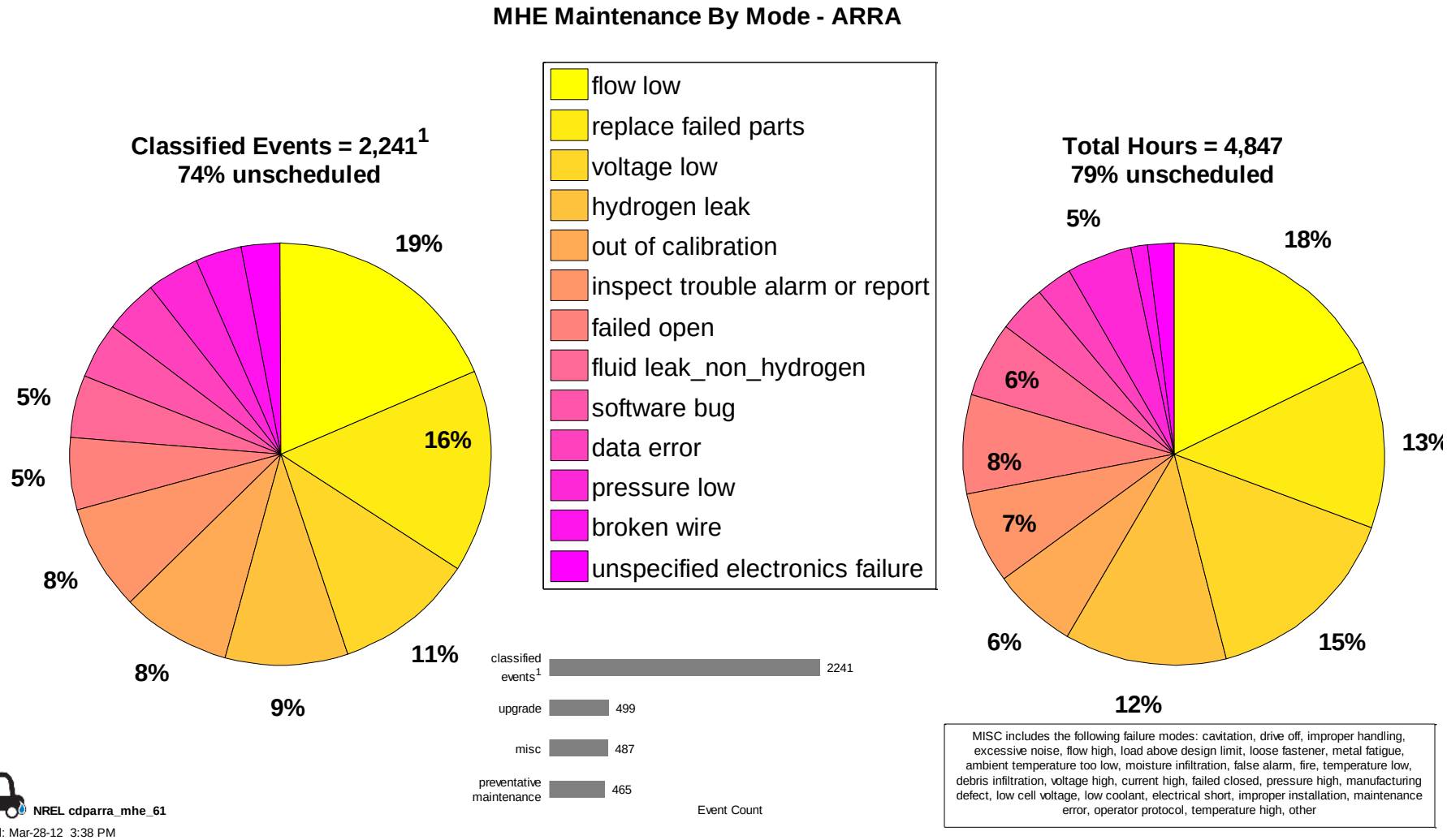


(1) Total cost reflects the projected annualized cost of ownership on a per lift basis for an intensive material handling operation: 100 lifts deployed 3 shifts per day, with 350 days per year of operations (3,000 hours of lift operation per year). Total cost represents the annualized cost of ownership of Class I, II, and III forklifts on a net present value basis, accounting for capital, operating, and maintenance costs of forklifts, power packs, and infrastructure (labor costs for maintenance and for charging or fueling are included, but labor costs of forklift material handling operations are excluded). Costs are calculated assuming that the material handling operations are ongoing, with equipment replacements made as necessary. Capital, operating, and maintenance costs are assumed to remain constant in real-dollar terms, and capital purchases are discounted using a discount rate representing the time value of money. Fuel cell system costs reflect the current fuel cell tax credit of $3,000/kW or 30% of purchase price. Analysis does not consider the potential productivity increases resulting from the constant power output of fuel cell systems, which may be significant. Costs of ownership of Class II forklifts are expected to be higher than shown, due to higher costs for the lift itself.

Costs are based on information provided by deployment host partners (end-users) based on a questionnaire developed by NREL, supplemented with data provided by project partners, and are reflective of the material handling operations of these deployments. Where appropriate, fuel cell deployment data were used in place of end-user questionnaire data; in particular, data from CDPs 1, 6, 8, 14, and 22 were used. Cost assessment will be further refined as additional data are available.

NREL cdp_mhe_60
Created: Mar-29-12 4:28 PM

CDPARRA-MHE-61
MHE Maintenance Event by Mode



NREL cdparra_mhe_61

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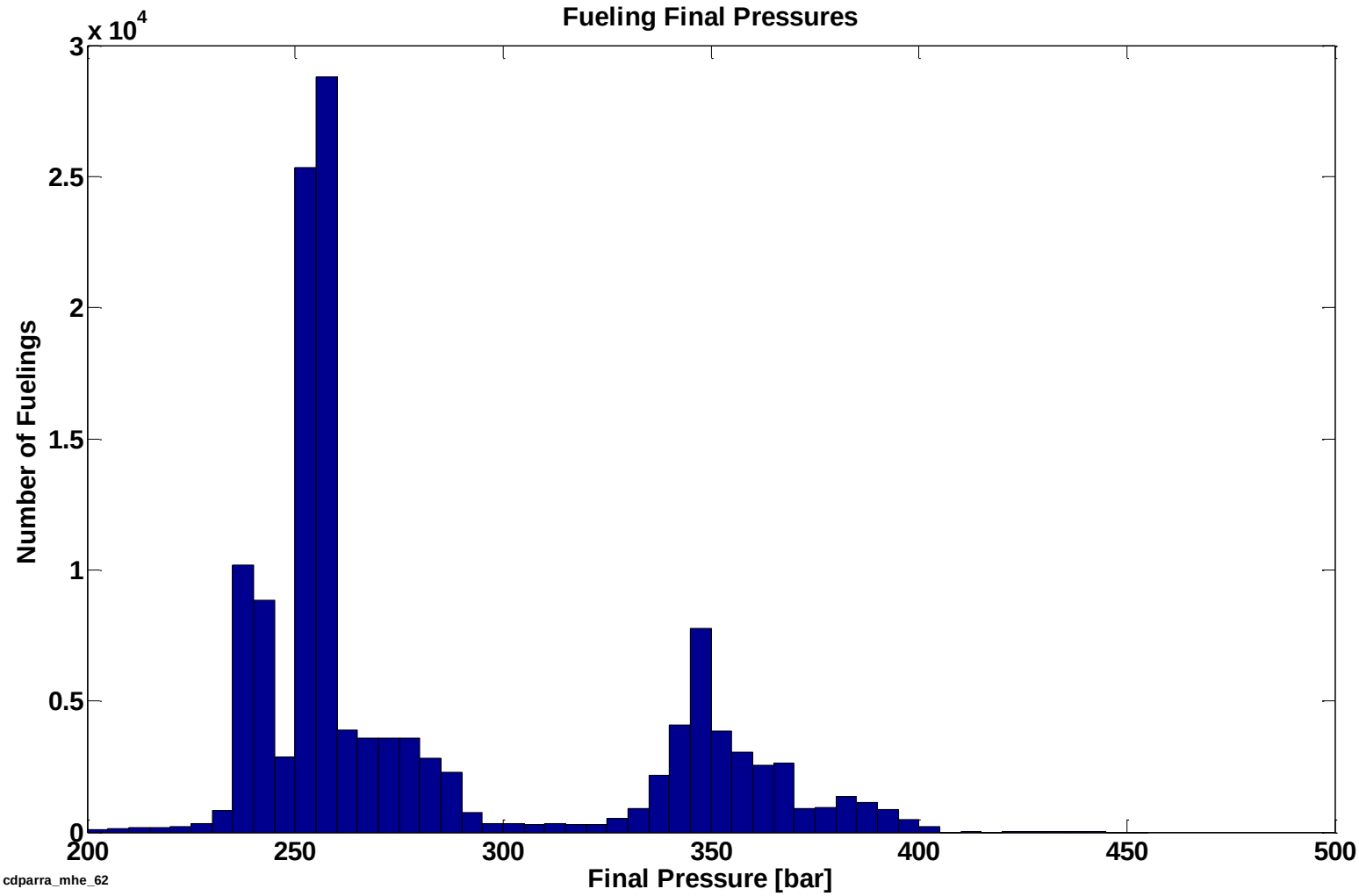
CDPARRA-MHE-62
Final Pressure of Hydrogen Fills



NREL cdparra_mhe_62

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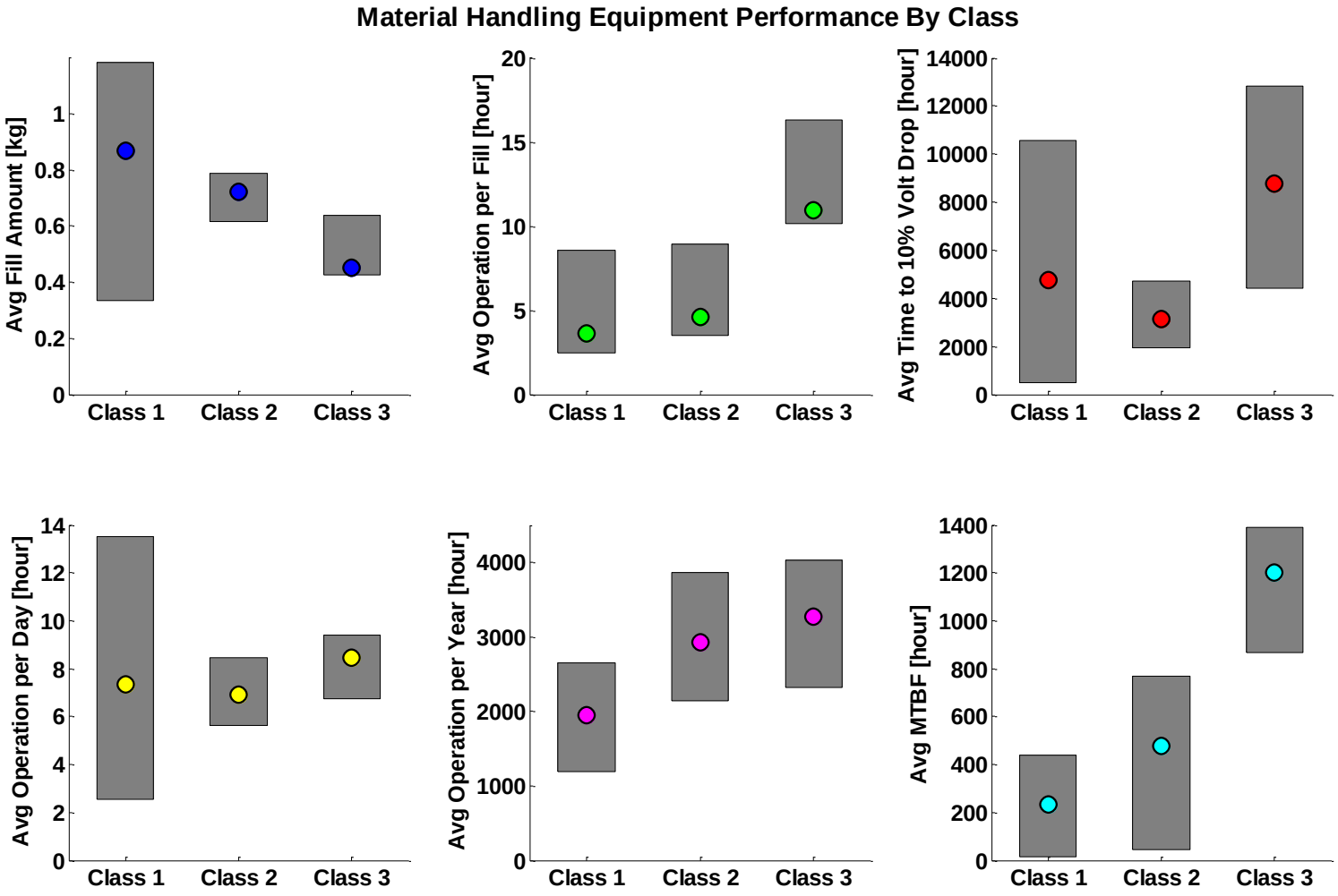
CDPARRA-MHE-63
Key Performance Areas by Classification



NREL cdp_mhe_63

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CDPARRA-MHE-64a
General & Capital Cost Inputs for Class I/II MHE

General & Capital Cost Inputs for Class I/II MHE

Key Parameters for General And Capital Costs[1]		Class I/II MHE	
		Battery	Fuel Cell
General	Discount Rate for Capital Purchases	1.5%	1.5%
	Operation Days Per Year	340	340
	Operation Hours Per Year	2,400	2,400
	Average Shifts Per Day	2.25	2.25
	Size of Combined Class I, II, & III Fleet	97	58
	Cost of Hydrogen ($/kg)	–	$8/kg
Lift Truck Capital	Capital Cost of Bare Lift	$25,000	$25,000
	Average Life of Lift (years)	10	10
Battery & Fuel Cell Capital	Cost of Battery / Fuel Cell System	$4,800	$33,000
	Federal Tax Credits Available	–	$9,800
	Battery / Fuel Cell Systems Per Lift	2	1
	Life of Battery / Fuel Cell System (yrs.)	4.4	10

[1]Inputs for cost of ownership results in CDP-MHE-58

NREL cdp_mhe_64a
Created: Mar-29-12 4:43 PM

CDPARRA-MHE-64b
General & Capital Cost Inputs for Class I/II MHE

Infrastructure & Operation Costs for Class I/II MHE

Key Parameters for Infrastructure and Operations & Maintenance Costs[1]		Class I/II MHE	
		Battery	Fuel Cell
Battery & Hydrogen Infrastructure	Capital Cost of Battery Charger	$2,800	–
	Average Life of Charger (years)	7.5	–
	Average Number of Chargers Per Lift	1.1	–
	Infrastructure Capital + Service ($/mo.)	$75 per lift	$17,000
Labor Cost for Battery Changes & H2 Fueling	Battery Change / H2 Fill Time (min.)	10.5	3.0
	Lift Travel + Queue Time (min.)	3.8	3.3
	Battery Changes / H2 Fills Per Day	2.25	1.0
	Operator Loaded Labor Rate ($/hr.)	$24	$24
Warehouse Space Cost	Indoor Space for Infrastructure (ft^2)	5,100 ft^2	500 ft^2
	Outdoor Space for Infrastructure (ft^2)	–	2,500 ft^2
	Indoor Warehouse Space Cost ($/$ft^2$)	$3/$ft^2$	$3/$ft^2$
	Outdoor Land Space Cost ($/$ft^2$)	–	$0.34/$ft^2$
Maintenance	Monthly Lift Truck Maintenance	$230	$230
	Monthly Battery / FC Maintenance	$150	$180

[1]Inputs for cost of ownership results in CDP-MHE-58

NREL cdp_mhe_64b
Created: Mar-29-12 4:43 PM

CDPARRA-MHE-64c
General & Capital Cost Inputs for Class III MHE

General & Capital Cost Inputs for Class III MHE

Key Parameters for General And Capital Costs[1]		Class III MHE	
		Battery	Fuel Cell
General	Discount Rate for Capital Purchases	1.5%	1.5%
	Operation Days Per Year	340	340
	Operation Hours Per Year	3,000	3,000
	Average Shifts Per Day	2	2
	Size of Combined Class I, II, & III Fleet	97	58
	Cost of Hydrogen ($/kg)	–	$8/kg
Lift Truck Capital	Capital Cost of Bare Lift	$7,800	$7,800
	Average Life of Lift (years)	5.7	5.7
Battery & Fuel Cell Capital	Cost of Battery / Fuel Cell System	$2,800	$15,000
	Federal Tax Credits Available	–	$4,600
	Battery / Fuel Cell Systems Per Lift	2	1
	Life of Battery / Fuel Cell System (yrs.)	4.5	9

[1]Inputs for cost of ownership results in CDP-MHE-58

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CDPARRA-MHE-64d
General & Capital Cost Inputs for Class III MHE

Infrastructure & Operation Costs for Class III MHE

Key Parameters for Infrastructure and Operations & Maintenance Costs[1]		Class III MHE	
		Battery	Fuel Cell
Battery & Hydrogen Infrastructure	Capital Cost of Battery Charger	$1,600	–
	Average Life of Charger (years)	5	–
	Average Number of Chargers Per Lift	1.1	–
	Infrastructure Capital + Service ($/mo.)	$75 per lift	$17,000
Labor Cost for Battery Changes & H2 Fueling	Battery Change / H2 Fill Time (min.)	9	1.6
	Lift Travel + Queue Time (min.)	2.8	2.8
	Battery Changes / H2 Fills Per Day	2	0.8
	Operator Loaded Labor Rate ($/hr.)	$24	$24
Warehouse Space Cost	Indoor Space for Infrastructure (ft^2)	5,100 ft^2	500 ft^2
	Outdoor Space for Infrastructure (ft^2)	–	2,500 ft^2
	Indoor Warehouse Space Cost ($/$ft^2$)	$3/$ft^2$	$3/$ft^2$
	Outdoor Land Space Cost ($/$ft^2$)	–	$0.34/$ft^2$
Maintenance	Monthly Lift Truck Maintenance	$200	$200
	Monthly Battery / FC Maintenance	$18	$45

[1]Inputs for cost of ownership results in CDP-MHE-58

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