



**Technical Report**  
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# State-of-the-art Fuel Cell Voltage Durability Status

## 2013 Composite Data Products

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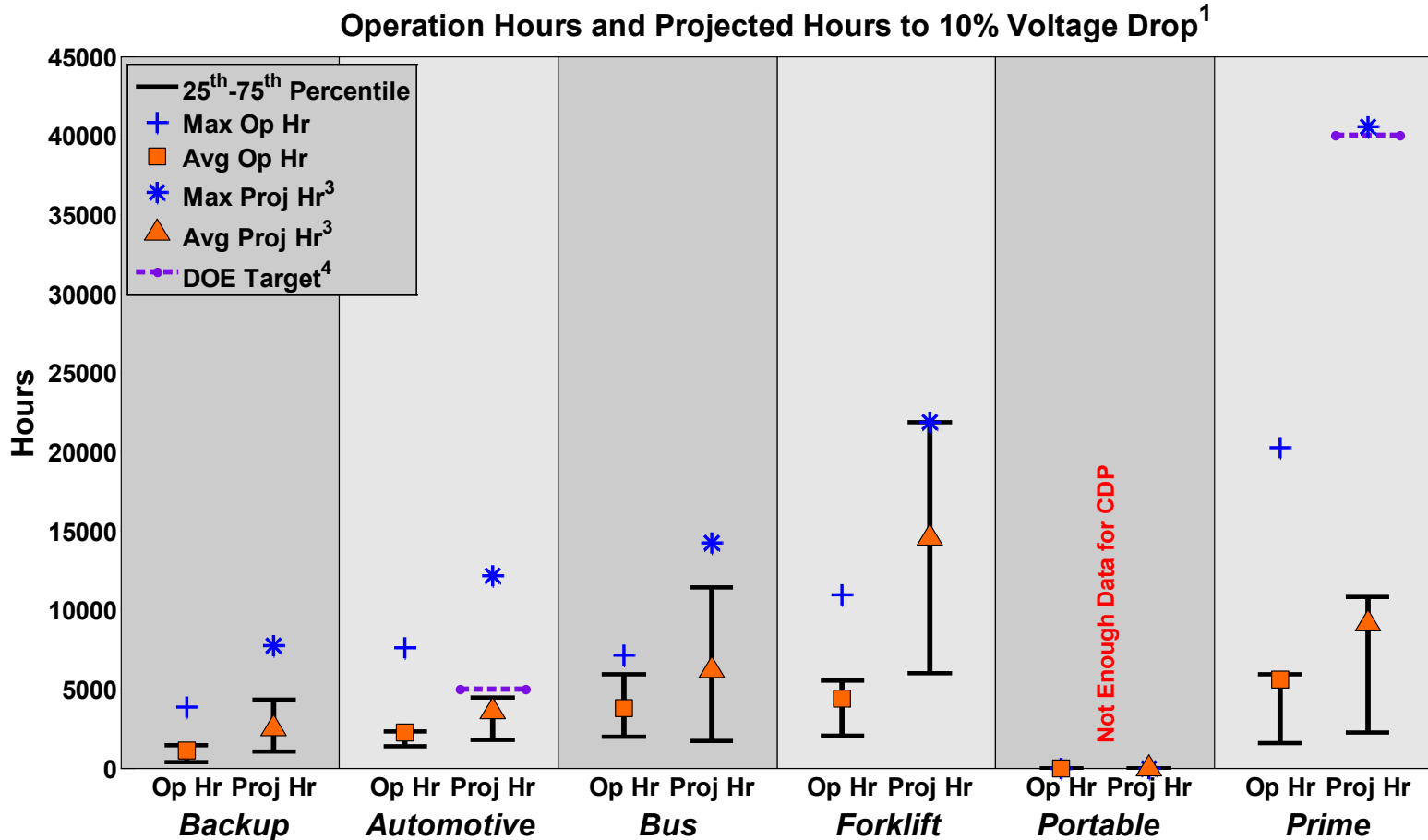
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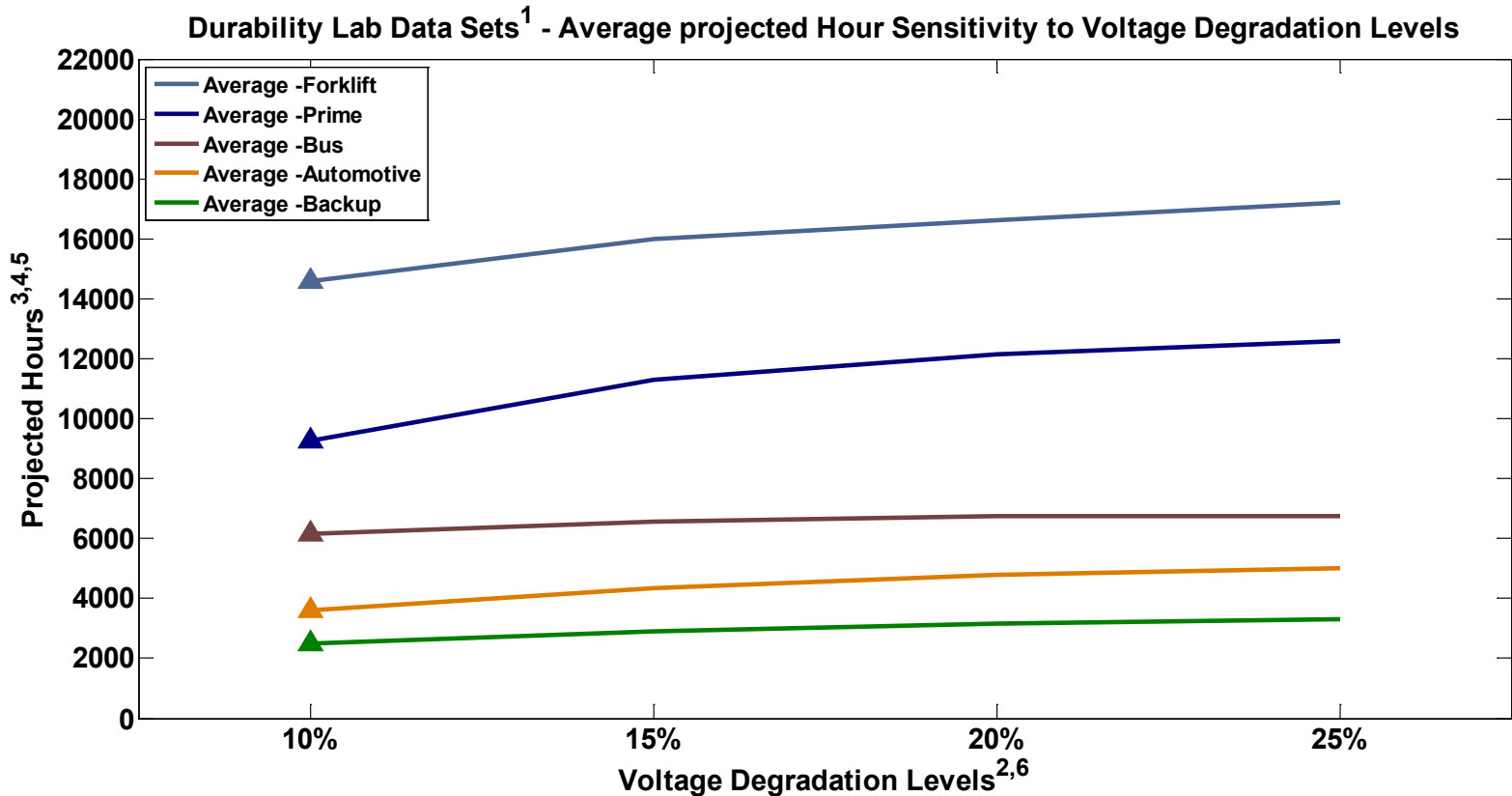
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# CDP#1: Lab Data Hours Accumulated and Projected Hours to 10% Stack Voltage Degradation



(1) At least 15 U.S. and international fuel cell developers supplied data. Analysis is updated periodically.  
 (2) PEMFC, DMFC & SOFC data from lab tested, full active area short stacks and systems with full stacks. Data generated from constant load, transient load, and accelerated testing between 2004 and early 2012.  
 (3) The DOE 10% voltage degradation metric is used for assessing voltage degradation; it may not be the same as end-of-life criteria and does not address catastrophic failure modes.  
 (4) DOE targets are for real-world applications; refer to Hydrogen, Fuel Cells, & Infrastructure Technologies Program Plan.

# CDP#2: Durability Lab Data Projection Sensitivity to Voltage Degradation Levels



- (1) PEM & SOFC data from lab tested, full active area short stacks and systems with full stacks. Data generated from constant load, transient load, and accelerated testing between 2004 and 2012.
- (2) 10% Voltage degradation is a DOE metric for assessing fuel cell performance.
- (3) Curves generated using the average of each application at various voltage degradation levels.
- (4) The projection curves display the sensitivity to percentage of voltage degradation, but the projections do not imply that all stacks will (or do) operate at these voltage degradation levels.
- (5) Projections may be limited by demonstrated operation hours to minimize extrapolations.
- (6) The voltage degradation levels are not an indication of an OEM's end-of-life criteria and do not address catastrophic stack failures such as membrane failure.

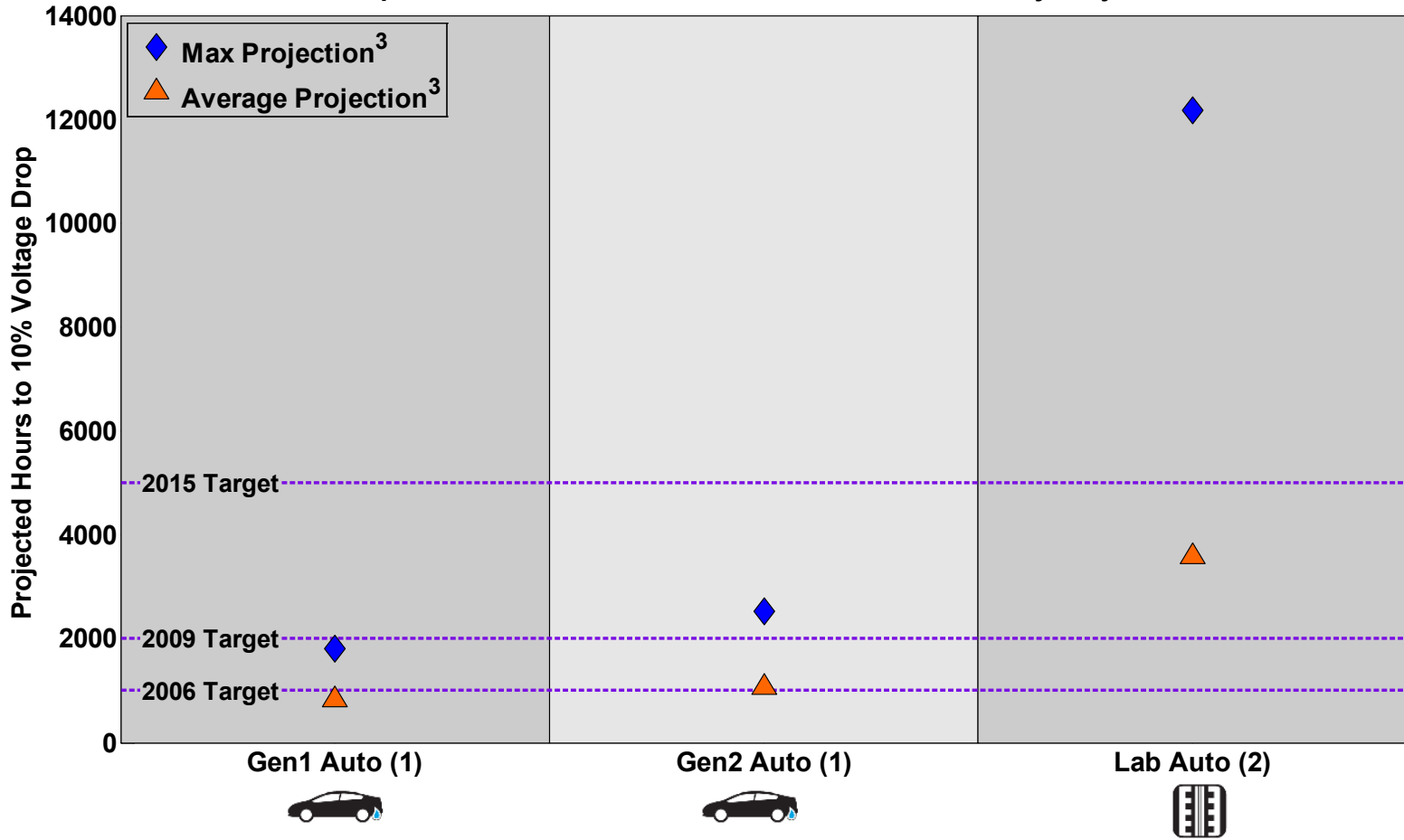


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# CDP#3: Field and Lab Durability Projection Comparison CDP for Automotive Category

Comparison of Fuel Cell Vehicle Field and Lab Durability Projections



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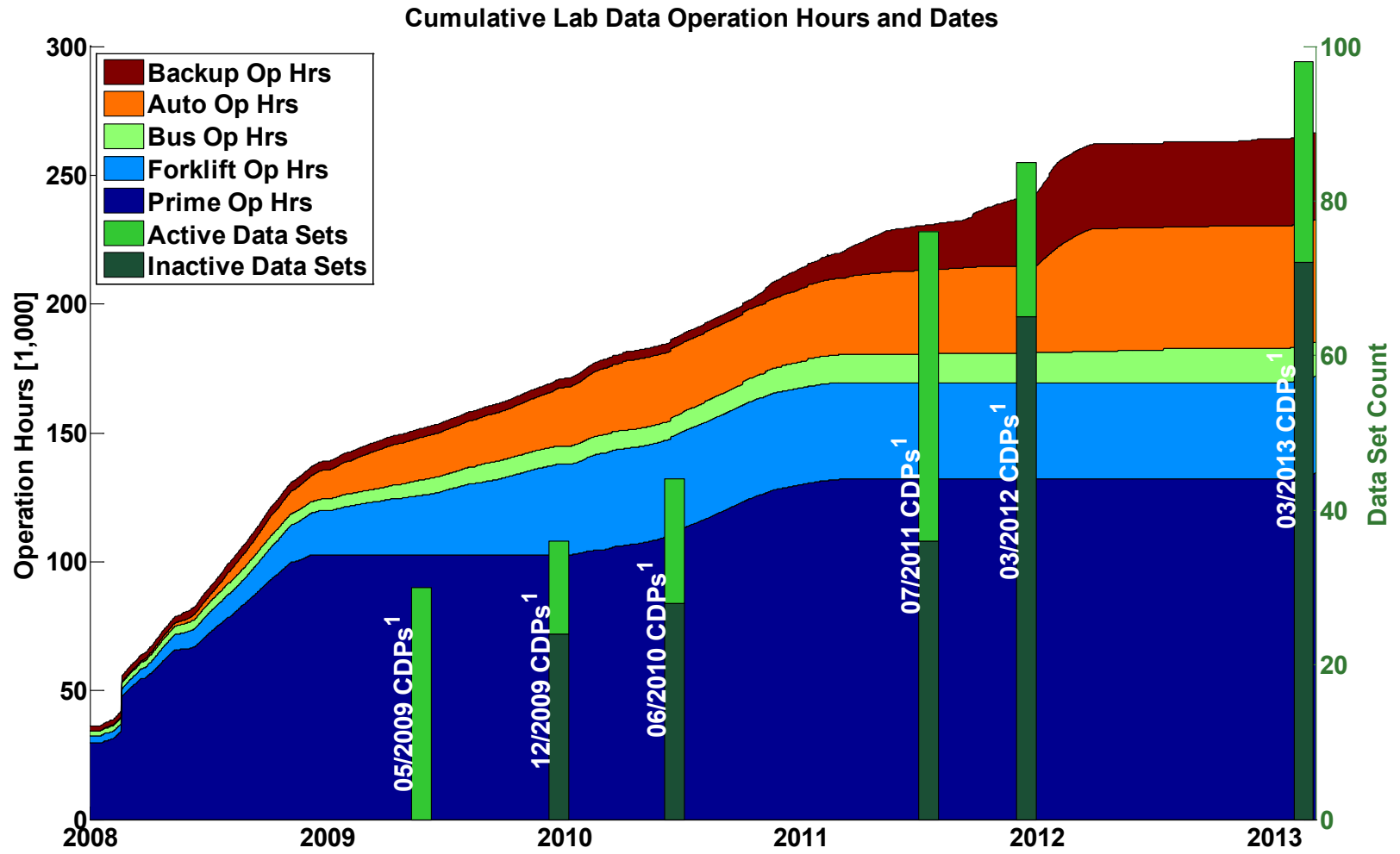
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(1) Gen1 and Gen2 Data from DOE's Learning Demonstration (2005 - 2010)

(2) Lab data providers may not be the same as participants in DOE's Learning Demonstration. 50% of data are full active area short stacks.

(3) The DOE 10% voltage degradation metric is used for assessing voltage degradation; it may not be the same as end-of-life criteria and does not address catastrophic failure modes.

# CDP#4: Cumulative Operation Hours by Application and Number of Data Sets

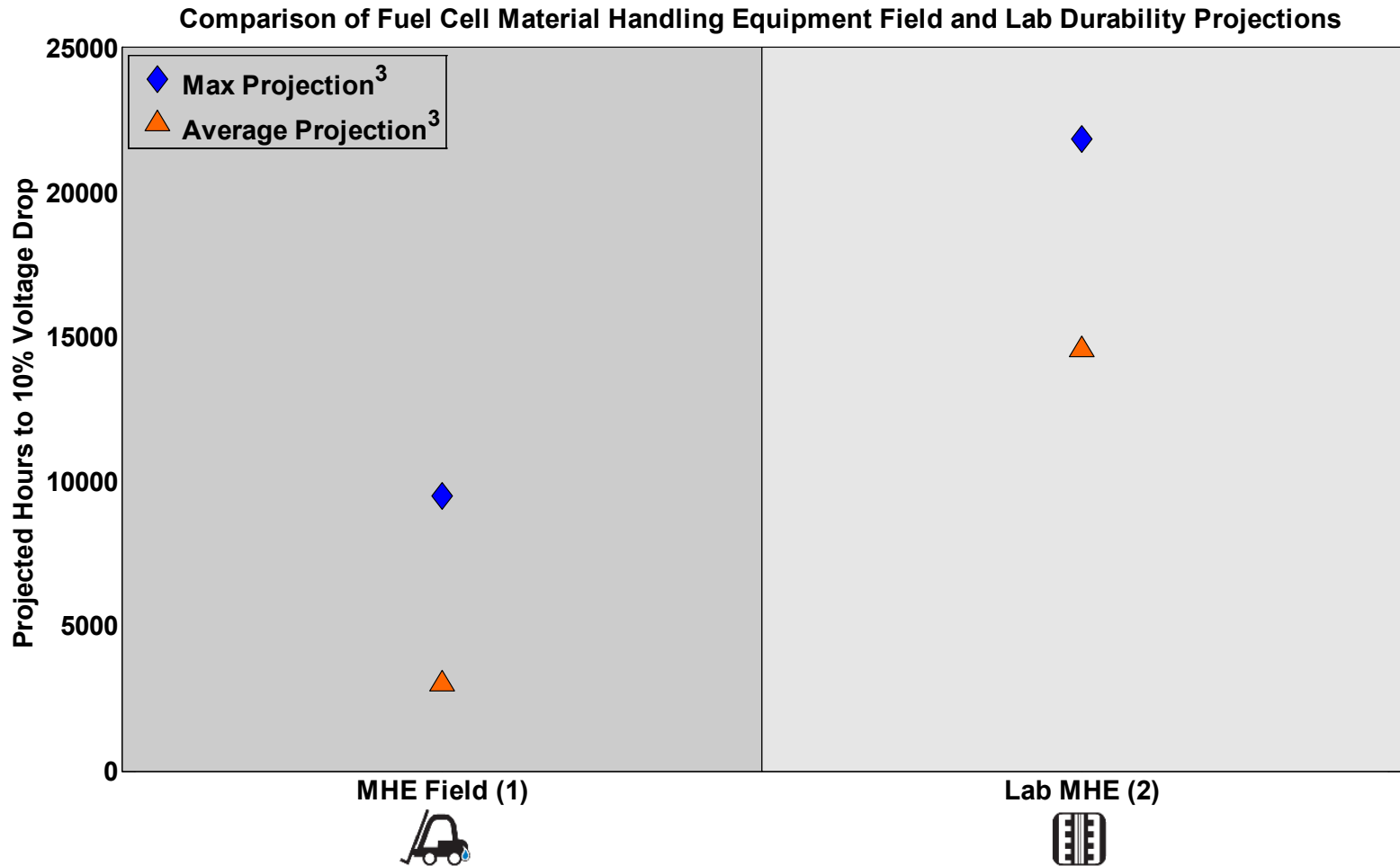


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1) Data set count at publication of a CDP set - where a data set represents a short stack, full stack, or system test data.

# CDP#5: Field and Lab Durability Projection Comparison CDP for MHE Category



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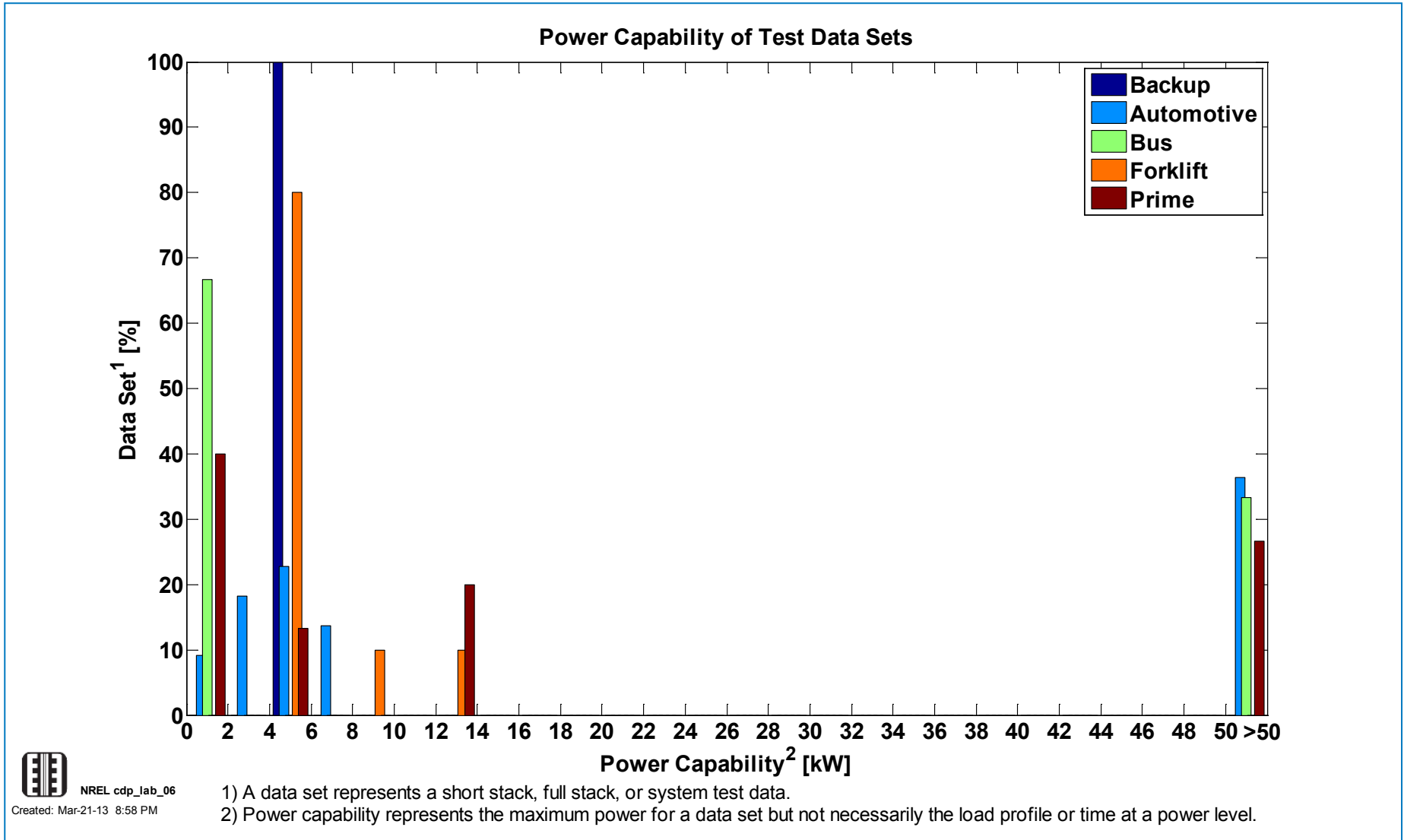
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(1) MHE Data from DOE's Early Market Demonstration (2009 - )

(2) Lab data providers may not be the same as participants in DOE's Field Demonstration. 67% of data are full active area short stacks.

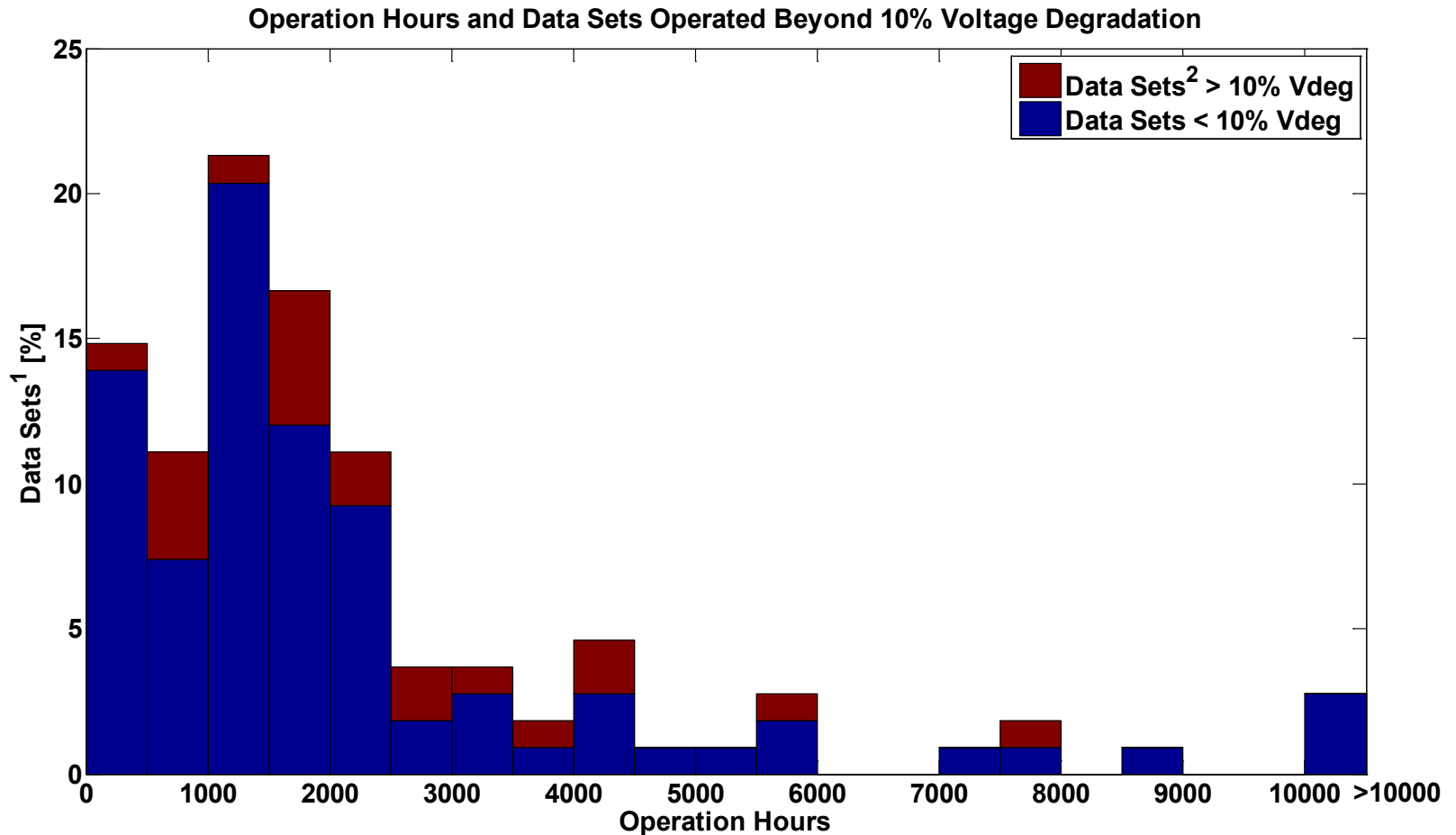
(3) The DOE 10% voltage degradation metric is used for assessing voltage degradation; it may not be the same as end-of-life criteria and does not address catastrophic failure modes.

# CDP#6: Data Set Power Capability





# CDP#7: Data Set Operation Hours and the Percentage of Data Sets That Have Passed 10% Voltage Degradation



1) A data set represents a short stack, full stack, or system test data.

2) The DOE 10% voltage degradation metric is used for assessing voltage degradation; it may not be the same as end-of-life criteria and does not address catastrophic failure modes.

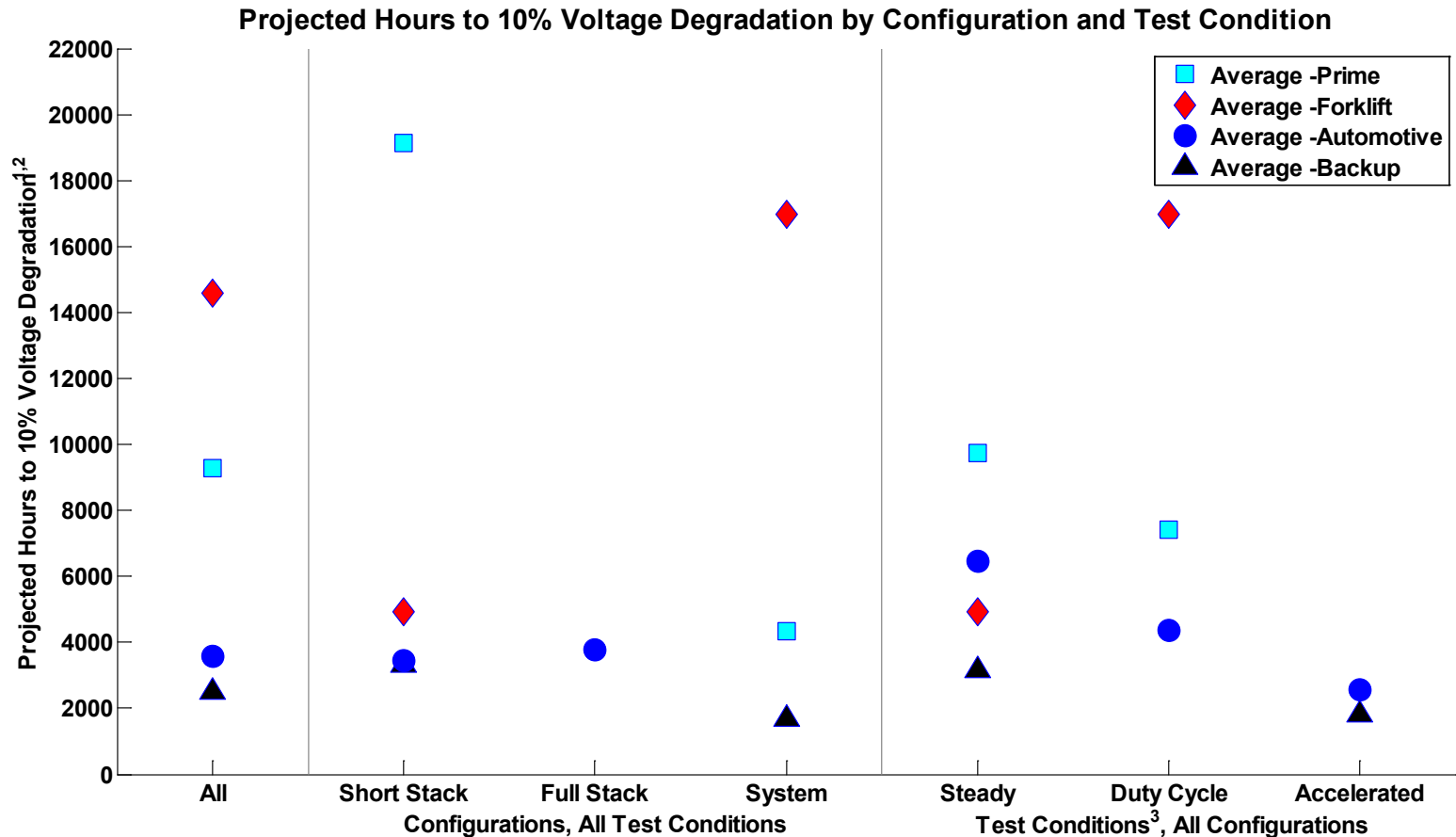
Some data sets have operated beyond 10% voltage degradation because they are able to satisfy the operating requirements at a higher percentage of voltage degradation or the test is designed to operate until a failure.



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# CDP#8: Voltage Degradation by Configuration and Test Condition



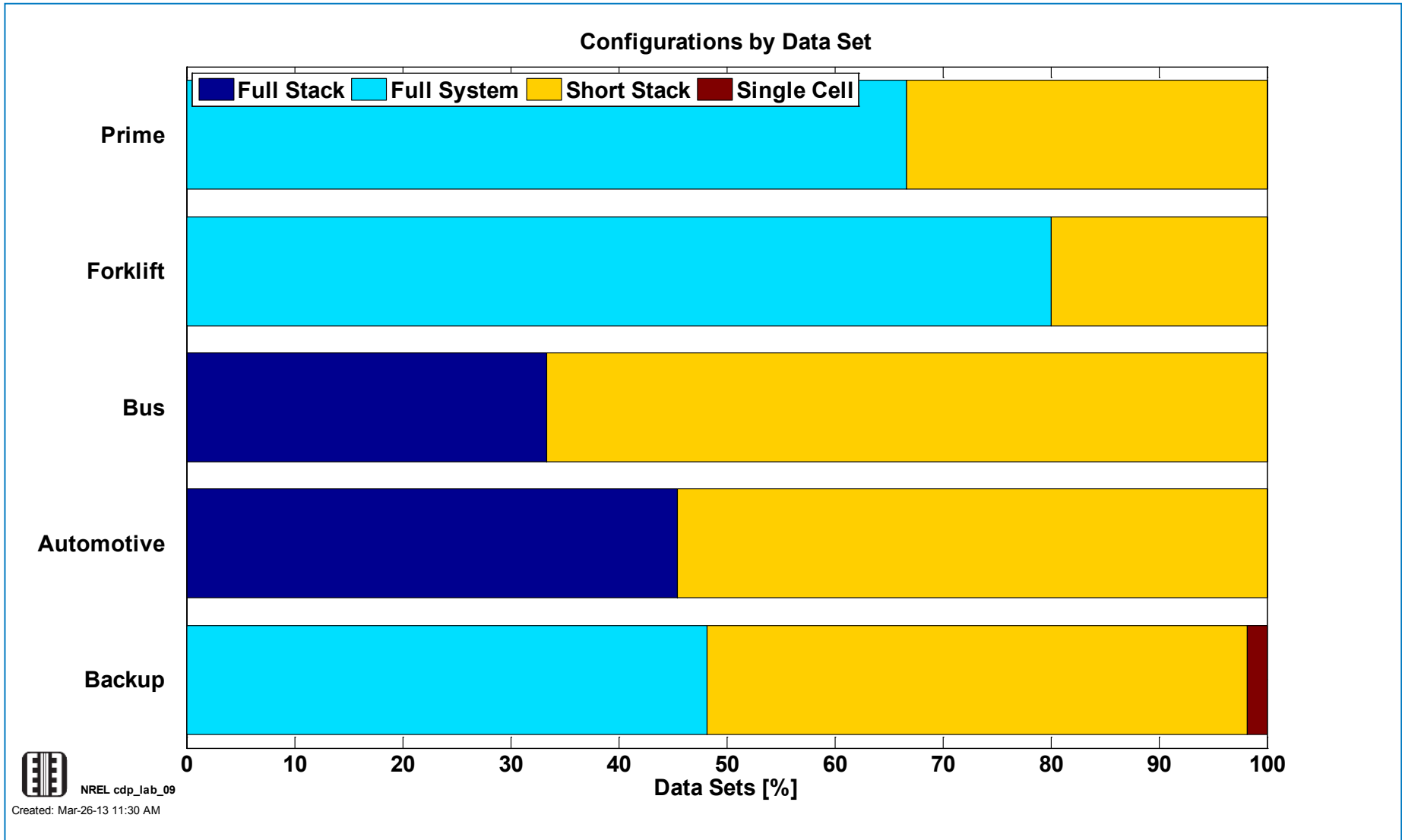
- 1) The DOE 10% voltage degradation metric is used for assessing voltage degradation; it may not be the same as end-of-life criteria and does not address catastrophic failure modes.
- 2) Not all applications have data sets in each configuration or test condition group.
- 3) Steady - little or no change to load profile  
 Duty Cycle - load profile mimics real-world operating conditions  
 Accelerated - test profile is more aggressive than real-world operating conditions



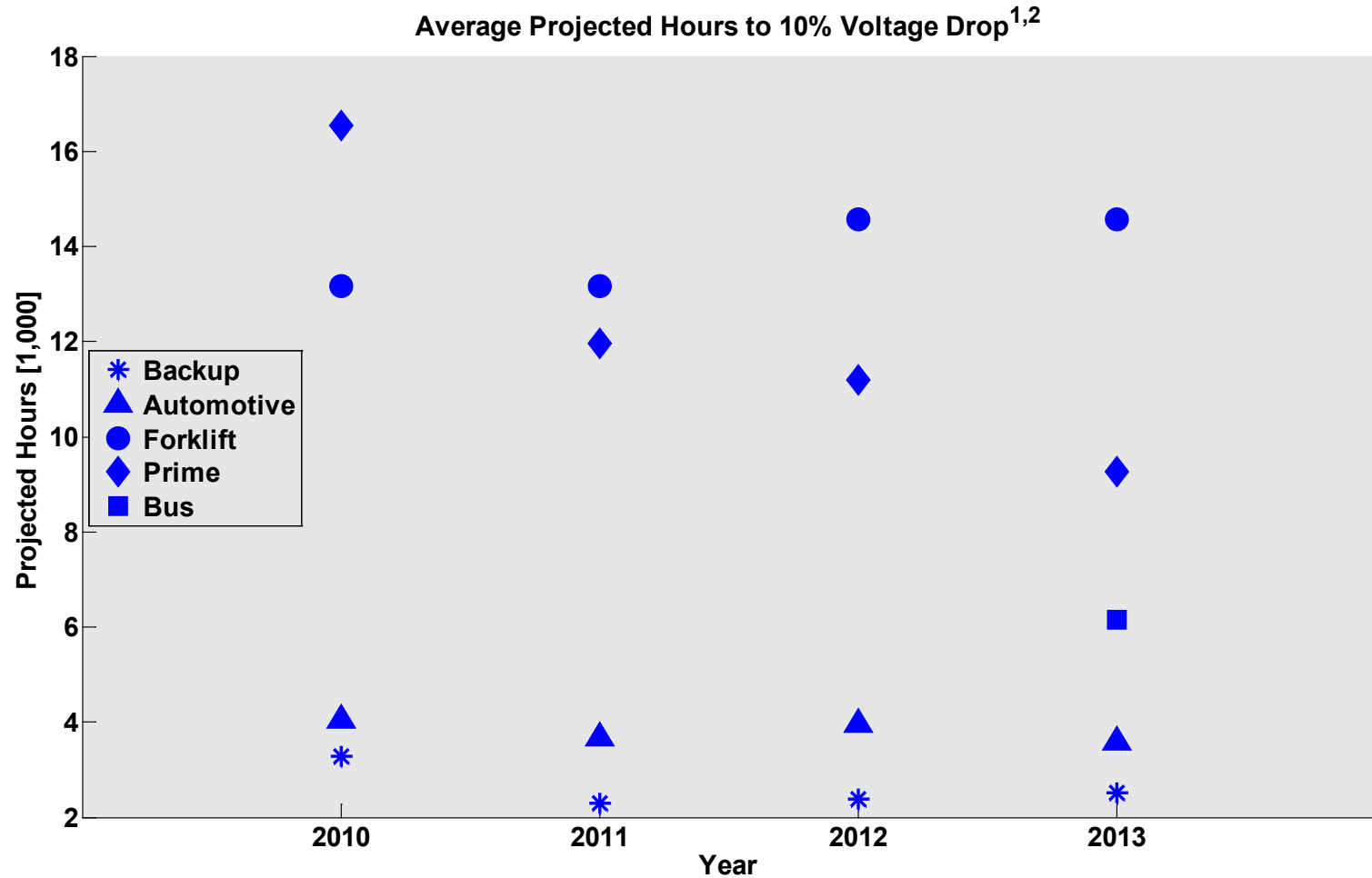
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# CDP#9: Data Set Configuration



# CDP#10: Average Projected Voltage Degradation by Year



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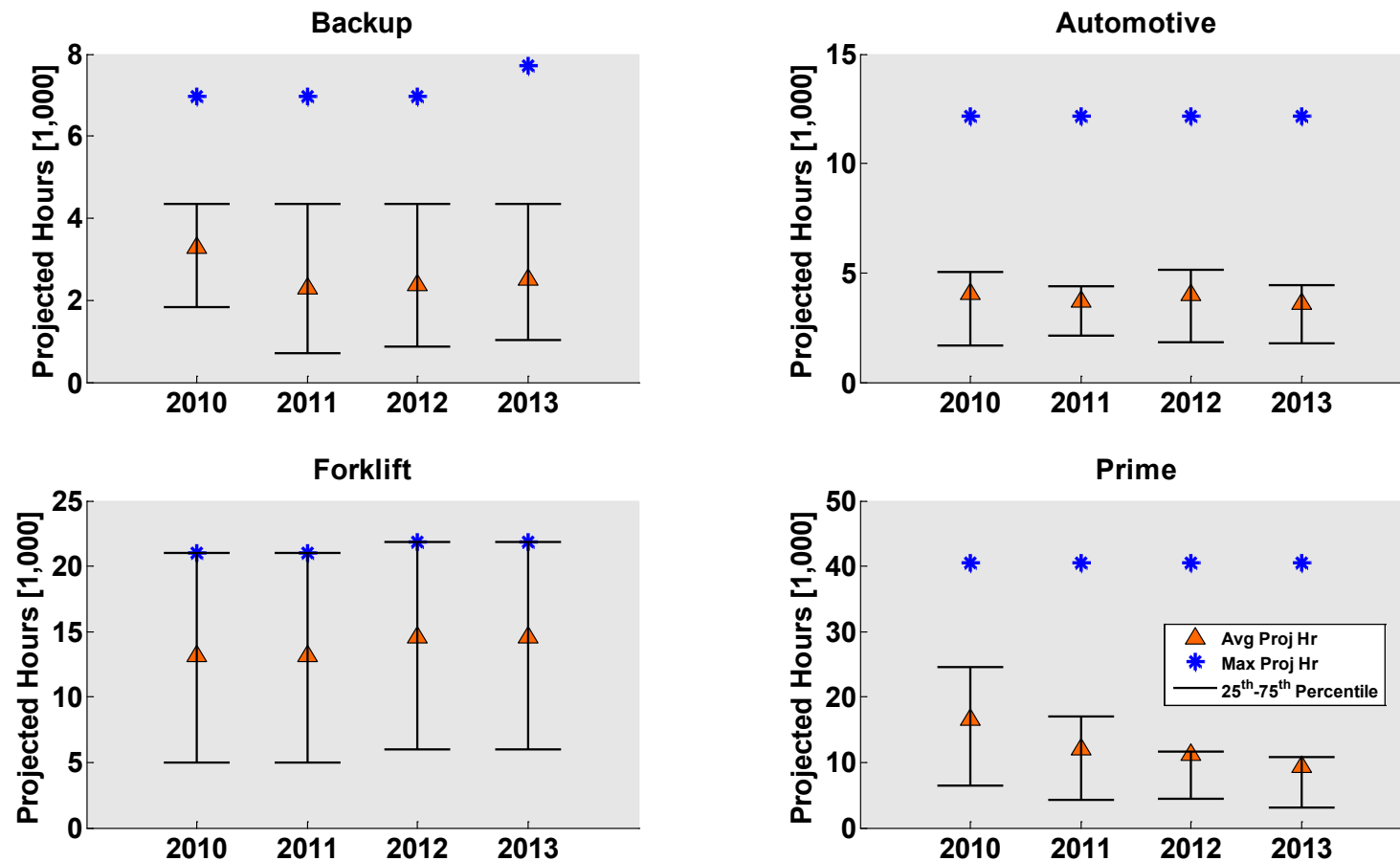
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(1) The DOE 10% voltage degradation metric is used for assessing voltage degradation; it may not be the same as end-of-life criteria and does not address catastrophic failure modes.

(2) At least 13 fuel cell developers supplied data, including international. Analysis is updated periodically.

# CDP#11: Voltage Degradation by Year

## Projected Hours to 10% Voltage Drop<sup>1,2</sup>



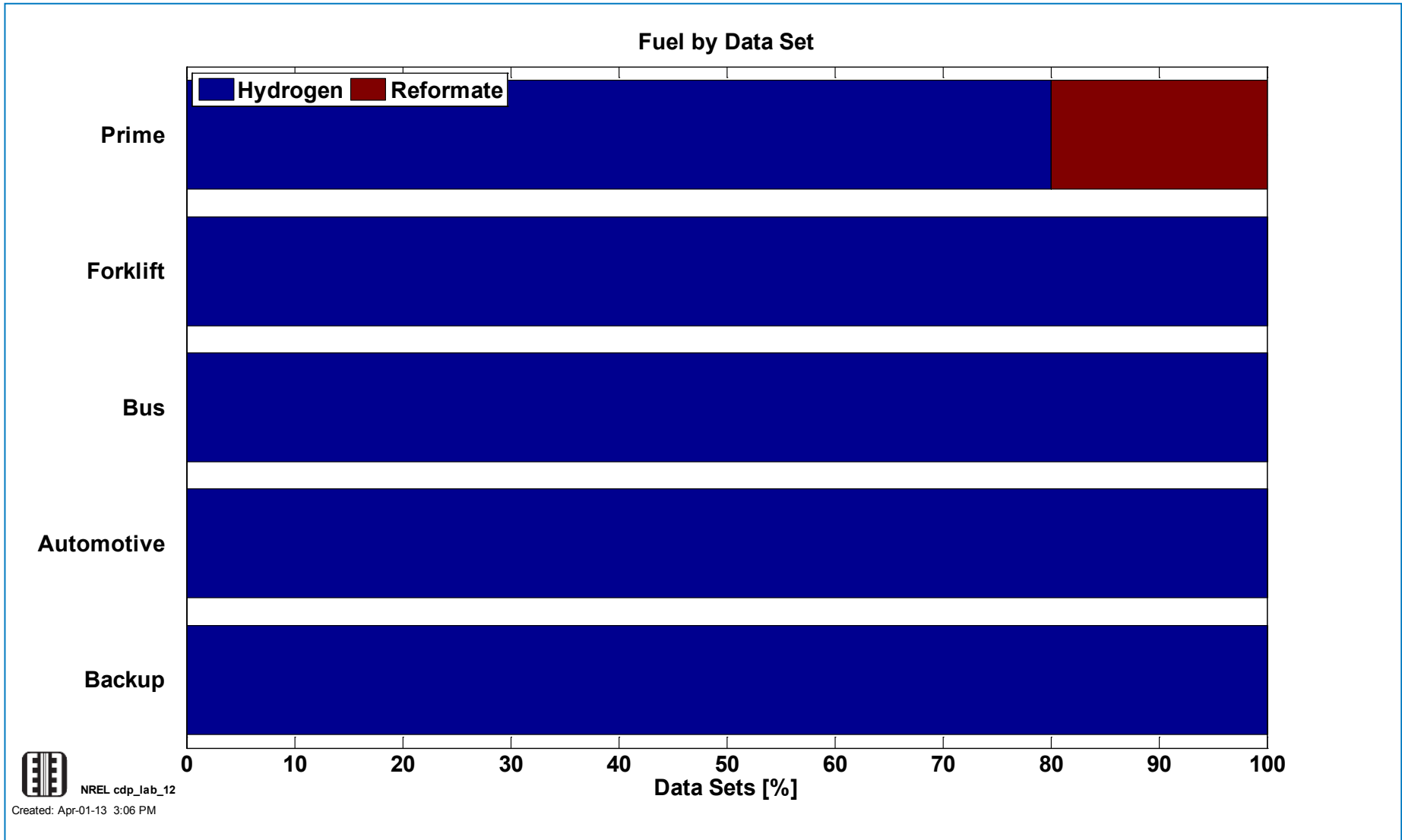
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(1) The DOE 10% voltage degradation metric is used for assessing voltage degradation; it may not be the same as end-of-life criteria and does not address catastrophic failure modes.

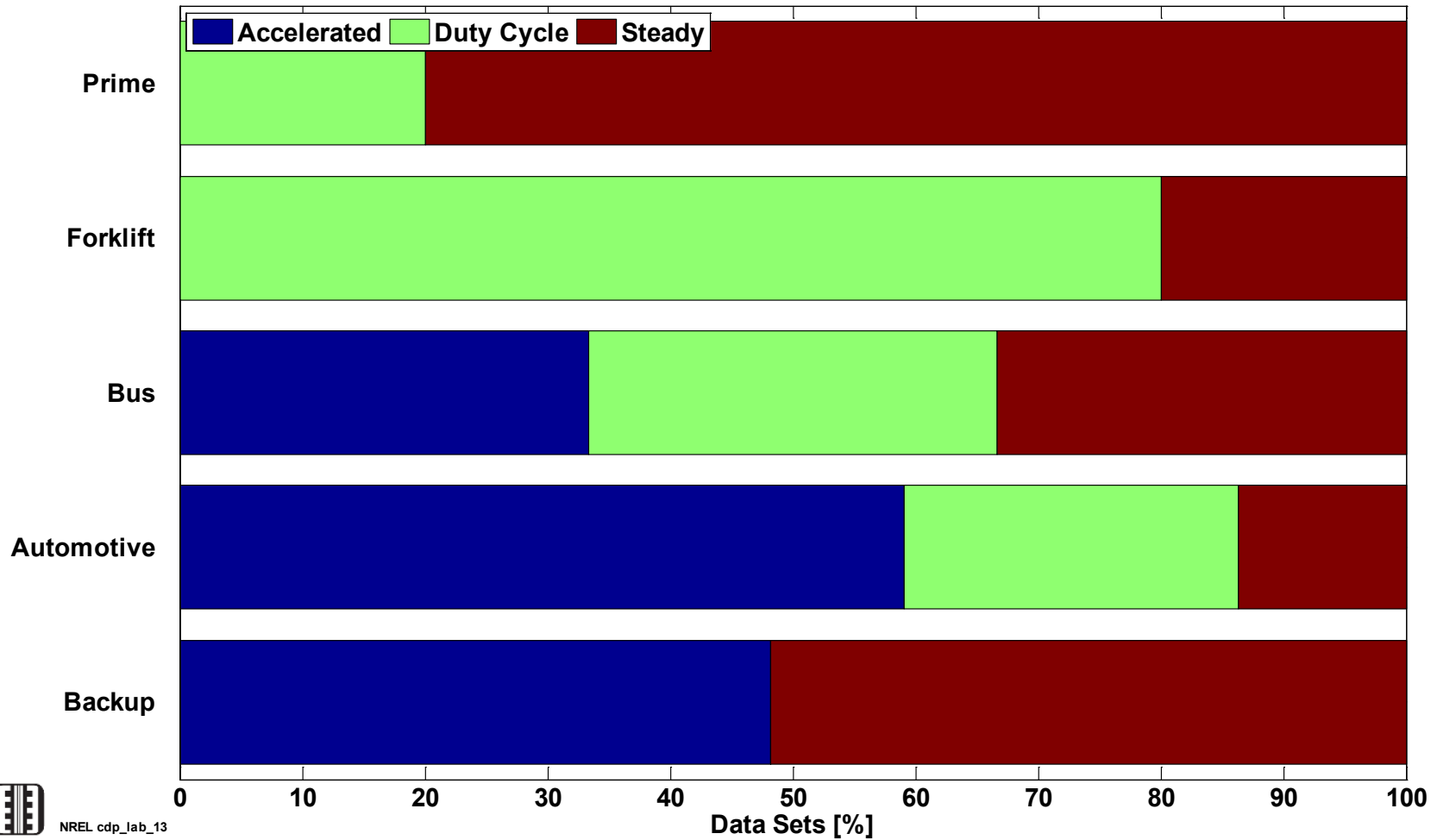
(2) At least 13 fuel cell developers supplied data, including international. Analysis is updated periodically.

# CDP#12: Data Set Fuel



# CDP#13: Data Set Test Conditions

Test Conditions by Data Set

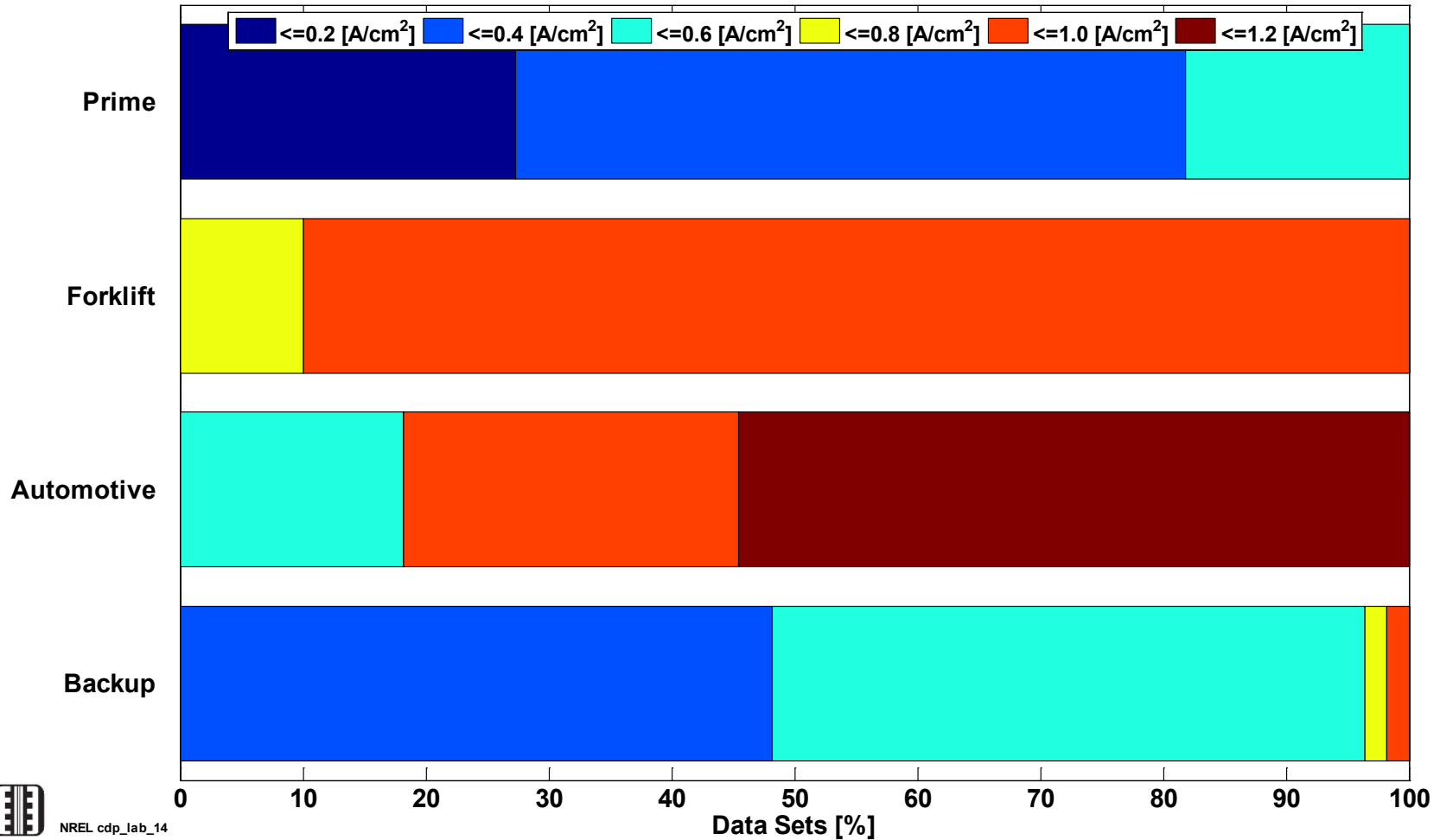


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# CDP#14: Current Density Points

Current Density Point by Data Set<sup>1</sup>



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1) Current density referenced are the points at which the voltage degradation is analyzed in CDP Lab 01