CDP-LAB-01: Lab Data Hours Accumulated and Projected Hours to 10% Stack Voltage Degradation

Operation Hours and Projected Hours to 10% Voltage Drop

- 25th - 75th Percentile
- Max Op Hr
- Avg Op Hr
- Max Proj Hr
- Avg Proj Hr
- DOE Target

Not Enough Data for CDP Operation Hours and Projected Hours to 10% Voltage Drop
CDP-LAB-01: Lab Data Projected Hours to 10% Stack Voltage Degradation – Simplified

- 25th - 75th Percentile
- Avg. Projected Hours
- DOE Target
- Interim DOE Target

Hours (1,000s)

Backup Power  Automotive  Bus  Forklift  Prime Power
CDP-LAB-02: Durability Lab Data Projection Sensitivity to Voltage Degradation Levels

Durability Lab Data Sets

- Average - Forklift
- Average - Prime
- Average - Bus
- Average - Automotive
- Average - Backup

Projected Hours

Voltage Degradation Levels

NREL cc

NATIONAL RENEWABLE ENERGY LABORATORY
CDP-LAB-03: Field and Lab Durability Projection Comparison
CDP for Automotive Category

Comparison of Fuel Cell Operation Hours and Durability

- Max Op Hours
- Max Fleet Ave Durability
- Ave Fleet Ave Durability

Comparison of Fuel Cell Operation Hours and Durability

Max Op Hours
Max Fleet Ave Durability
Ave Fleet Ave Durability

DOE MYRD&D 2020 Durability Target

CDP-LAB-04: Cumulative Operation Hours by Application and Number of Data Sets

Cumulative Lab Data Operation Hours and Dates

- Backup Op Hrs
- Auto Op Hrs
- Bus Op Hrs
- Forklift Op Hrs
- Prime Op Hrs
- Active Data Sets
- Inactive Data Sets

Operation Hours [1,000]

Data Set Count

Operational Hours over years with specific dates and counts for different data sets.
CDP-LAB-06: Data Set Power Capability

Power Capability of Test Data Sets

- Backup
- Automotive
- Bus
- Forklift
- Prime

Data Set 1 [%]

Power Capability [kW]

NREL CC
CPD-LAB-07: Data Set Operation Hours and the Percentage of Data Sets That Have Passed 10% Voltage Degradation

Operation Hours and Data Sets Operated Beyond 10% Voltage Degradation

- **Data Sets > 10% Vdeg**
- **Data Sets < 10% Vdeg**

Data Sets 1 (%)

Operation Hours

NREL cc
CDP-LAB-08: Voltage Degradation by Configuration and Test Condition

Projected Hours to 10% Voltage Degradation by Configuration and Test Condition

- Average - Prime
- Average - Forklift
- Average - Automotive
- Average - Backup

Configuration and Test Conditions:
- All
- Short Stack
- Full Stack
- System
- Steady Duty Cycle
- Accelerated

Projected Hours to 10% Voltage Degradation:
- 0
- 2000
- 4000
- 6000
- 8000
- 10000
- 12000
- 14000
- 16000
- 18000
- 20000
- 22000
CDP-LAB-09: Data Set Configuration

Configurations by Data Set

- **Prime**
  - Full Stack: 30%
  - Full System: 40%
  - Short Stack: 10%
  - Single Cell: 20%

- **Forklift**
  - Full Stack: 30%
  - Full System: 40%
  - Short Stack: 20%
  - Single Cell: 10%

- **Bus**
  - Full Stack: 30%
  - Full System: 20%
  - Short Stack: 30%
  - Single Cell: 20%

- **Automotive**
  - Full Stack: 30%
  - Full System: 20%
  - Short Stack: 30%
  - Single Cell: 20%

- **Backup**
  - Full Stack: 30%
  - Full System: 20%
  - Short Stack: 30%
  - Single Cell: 10%
CDP-LAB-12: Data Set Fuel

Fuel by Data Set

Prime
- Hydrogen: 70%
- Reformate: 30%

Forklift
- 100%

Bus
- 100%

Automotive
- 100%

Backup
- 100%
CDP-LAB-13: Data Set Test Conditions

Test Conditions by Data Set

Prime
- Accelerated: 10%
- Durability: 20%
- Duty Cycle: 30%
- Steady: 40%

Forklift
- Accelerated: 0%
- Durability: 90%
- Duty Cycle: 10%
- Steady: 0%

Bus
- Accelerated: 30%
- Durability: 20%
- Duty Cycle: 40%
- Steady: 10%

Automotive
- Accelerated: 40%
- Durability: 20%
- Duty Cycle: 20%
- Steady: 20%

Backup
- Accelerated: 30%
- Durability: 10%
- Duty Cycle: 60%
- Steady: 10%
# CDP-LAB-14: Current Density Points

<table>
<thead>
<tr>
<th>Current Density Point</th>
<th>Data Sets [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;=0.2 [A/cm^2]</td>
<td>Prime</td>
</tr>
<tr>
<td>&lt;=0.4 [A/cm^2]</td>
<td></td>
</tr>
<tr>
<td>&lt;=0.6 [A/cm^2]</td>
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<tr>
<td>&lt;=0.8 [A/cm^2]</td>
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<td></td>
</tr>
<tr>
<td>&lt;=1.2 [A/cm^2]</td>
<td></td>
</tr>
<tr>
<td>&gt;1.2 [A/cm^2]</td>
<td>Forklift</td>
</tr>
<tr>
<td>&lt;=0.2 [A/cm^2]</td>
<td>Automotive</td>
</tr>
<tr>
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<td>&lt;=1.2 [A/cm^2]</td>
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</tr>
<tr>
<td>&gt;1.2 [A/cm^2]</td>
<td>Backup</td>
</tr>
</tbody>
</table>

![Current Density Point by Data Set](image-url)
Average Projected Hours to 10% Voltage Drop

Year

Projected Hours (1,000)

Backup
Automotive
Forklift
Prime
Bus

CDP-LAB-17: Voltage Degradation by Year

- **Backup**
  - Projected Hours (1,000)
  - Years: 2010 to 2016

- **Automotive**
  - Projected Hours (1,000)
  - Years: 2010 to 2016

- **Forklift**
  - Projected Hours (1,000)
  - Years: 2010 to 2016

- **Prime**
  - Projected Hours (1,000)
  - Years: 2010 to 2016

- **Avg Proj Hr**
- **Max Proj Hr**
- **25 th - 75 th Percentile**
CDP-LAB-18: Electrolyzer Operation Hours and Voltage Degradation

Electrolyzer Operation Hours and Projected Hours to 10% Voltage Drop

- **25th - 75th Percentile**
- Max Op Hr
- Avg Op Hr
- Max Proj Hr
- Avg Proj Hr

**Renewable Energy Storage**