Impacts of Mileage Accumulation and Fast Charging on EV Range and Energy Usage - Part 3 -

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Inception

• What is the source of data on BEV durability?

- Accelerated cell testing
- Accelerated module testing
- Accelerated pack testing
- Public Data Aggregators
- OEM Evaluations
- 3rd Party ISO Accredited Lab Testing
- BEV Lifecycle Performance Map?
Inception

• Who wants to know?
  • Federal/National Regulators
  • International Working Groups
    • United Nations Economic Commission for Europe
      Electric Vehicles and the Environment working group
Project Overview

• Answer the questions:
  • How does mileage accumulation and vehicle aging affect useable battery energy (UBE), full recharge energy (FRE) and energy consumption (ECdc) of a 2015 model year BEV?
  • How does fast charging (DCFC) affect UBE, FRE and ECdc of the same vehicle model?
Project Overview

• Peripheral Questions:
  • Is durability an issue with BEVs?
  • Does cold climate affect durability?
Test Plan Overview

- Mileage accumulate 2 identical model BEVs over prescribed routes through all 4 seasons of the year
- Conduct chassis dynamometer testing (SAE J1634 method) every 15,000 km interval up to odometer readings of 105,000 km
- Report findings of mileage accumulation and in-lab testing at appropriate intervals
### On-Road Route

#### 2017-12-18

<table>
<thead>
<tr>
<th>Time</th>
<th>BEV1</th>
<th>BEV2</th>
</tr>
</thead>
<tbody>
<tr>
<td>8am</td>
<td>DCFC</td>
<td>ACL2</td>
</tr>
<tr>
<td>10am</td>
<td>DCFC</td>
<td>ACL2</td>
</tr>
<tr>
<td>12pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4pm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6pm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

#### Average Distance [km/year], Average Speed [km/h], Idle Time [%]

<table>
<thead>
<tr>
<th>Description</th>
<th>Ave. Dist. [km/year]</th>
<th>Ave. Speed [km/h]</th>
<th>Idle Time [%]</th>
</tr>
</thead>
<tbody>
<tr>
<td>CVUS (2014)</td>
<td>15,894</td>
<td>40.9</td>
<td>22.0</td>
</tr>
<tr>
<td>BEV1</td>
<td>23,274</td>
<td>46.6</td>
<td>19.2</td>
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<tr>
<td>BEV2</td>
<td>23,970</td>
<td>46.5</td>
<td>19.5</td>
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</tbody>
</table>
In-Lab Testing Matrix

- Ambient Temperature (°C)
  - 35
  - 25
  - -7
  - 3
  - 3*
  - 2
  - 2*

- Test Sequence
  - US06 MCT
  - SC03 SCT
  - NYCC SCT

* Rounds 1 and 8 only
# In-Lab Testing Matrix

<table>
<thead>
<tr>
<th>SAE J1634 US06 MCT</th>
<th>LA4</th>
<th>HWFCT</th>
<th>LA4</th>
<th>US06</th>
<th>55mph SS</th>
<th>US06</th>
<th>LA4</th>
<th>HWFCT</th>
<th>LA4</th>
<th>55mph SS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>15s</td>
<td>10min</td>
<td>10min</td>
<td>0-30min</td>
<td>0-30min</td>
<td>10min</td>
<td>15s</td>
<td>10min</td>
<td>0-30min</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>SC03 SCT</th>
<th>SC03</th>
<th>SC03</th>
<th>SC03</th>
<th>SC03</th>
<th>55mph SS</th>
<th>SC03</th>
<th>SC03</th>
<th>SC03</th>
<th>SC03</th>
<th>55mph SS</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>1 min</td>
<td>10min</td>
<td>1 min</td>
<td>0-30min</td>
<td>0-30min</td>
<td>1 min</td>
<td>10min</td>
<td>1 min</td>
<td>0-30min</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>NYCC SCT</th>
<th>NYCC</th>
<th>NYCC</th>
<th>NYCC</th>
<th>NYCC</th>
<th>55mph SS</th>
<th>NYCC</th>
<th>NYCC</th>
<th>NYCC</th>
<th>NYCC</th>
<th>55mph SS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0min</td>
<td>10min</td>
<td>0min</td>
<td>0-30min</td>
<td>0-30min</td>
<td>0min</td>
<td>10min</td>
<td>0min</td>
<td>0-30min</td>
<td></td>
</tr>
</tbody>
</table>
Instrumentation

FleetCarma a GEOTAB company, 2018

HIOKI E.E. Corp. 2018

Graphtec Corp., 2018

OMEGA Engineering Inc., 2018
Instrumentation

- DRIVE UNIT
- Electric Heater
- High-Voltage Junction Box
- BATTERY
- Compressor
- Accessories
- 12V Battery
- 200V Grid Supply

- Amp Probe
- Voltage Tap
Results – On-Road Temperatures

- BEV1 Drive
- BEV2 Drive
- BEV1 Charge
- BEV2 Charge
- Ambient, Drive
Results – ECdc (DC Wh/km)
Results – Energy Metrics

Battery Energy vs. Accumulated Mileage [25°C]
Results – Ranges

Range vs. Accumulated Mileage [25°C]

- BEV1 LA4
- BEV1 NYCC
- BEV1 HWFCT
- BEV1 CSC
- BEV1 US06
- BEV2 LA4
- BEV2 NYCC
- BEV2 HWFCT
- BEV2 CSC
- BEV2 US06

Percentages:
- 20%
- 18%
- 24%
- 15%
- 17%
Modelling Comparison

![Graph showing capacity fade comparison]
Regulatory Perspective

- When a BEV’s performance (range) degrades over time, its ability to displace conventional fueled mileages decreases.
- There are no current regulations to maintain the range of a BEV over its life.
- The United Nations Ecomonic Commission for Europe (UN ECE) is exploring this subject.
- Model or test or both?
Next Steps

• This is the 3rd update on this study. At this time, two more rounds of in-lab testing and 21,000km of mileage accumulation remain to be completed

• The results are available and have been provided to organizations, such as the JRC, UNECE and other Government bodies to further their battery models, thermal models and regulatory investigations
Electric Vehicle Fleet Evaluation

Project Description

- Assessing the performance of an electric taxi fleet through collection and analysis of battery usage data and operational parameters during charging and driving events.

Milestones

- This year’s work consists of the analysis of the suitability of electric vehicles for use in a taxi fleet, taking into account driving routes, vehicle driving range, potential battery degradation, and costs.
- A proposal for electric taxi infrastructure demonstration has been submitted to EVID by Hydro Ottawa, with partners including: TC, NRCan, ECCC, vehicle manufacturers, charger manufacturers, electricity distributors, taxi companies, road-side assistance providers, and battery technology developers.

Next Steps

- Complete analysis and report on the expected suitability of electric vehicles in a taxi fleet.
- Results of this year’s work will be essential for guiding the 2019 deployment of an electric taxi fleet of up to 25 vehicles (if funded).