In-Use Performance Results of Medium Duty Electric Vehicles

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National Renewable Energy Laboratory
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Background

- The U.S. Department of Energy (DOE) and the American Recovery and Reinvestment Act (ARRA) is helping to deploy MD and HD vehicles and EVSEs:
  - **Smith Electric Vehicles - Newton (500 vehicles)**
  - Navistar - eStar (up to 950 vehicles)
  - South Coast Air Quality Management District / EPRI – Utility bucket trucks and shuttle buses (~350 vehicles)
  - Cascade Sierra Solutions - sleeper cab trucks equipped with various anti-idle reduction devices and using electrified truckstops (50 sites and 5000 trucks)

- The DOE Vehicle Technologies Program funded NREL to collect and analyze this data
  - Goal is to monitor and report out on vehicle performance and energy utilization of deployed vehicles
  - Similar to light duty efforts by the INL AVTA programs
  - Provide useful data for additional R&D
Background

Data collection and analysis plan:

• ~30 channels of 1hz data collected and stored at NREL (~300GB/month)

• Quarterly reports published on basic usage statistics

Quarterly and cumulative summary results are available on the NREL and DOE website:
http://www.nrel.gov/vehiclesandfuels/fleetttest/
Smith Electric Vehicles - Info

- 500 Newtons being deployed in U.S.
  - Manufactured in Kansas City, MO
  - $32 Million ARRA award
  - 100 mile electric range required (cycle dependent)
  - Deployment plans included 20 launch partners including:
    - Frito-Lay
    - Coca Cola (NY)
    - Kansas City Power and Light (MO)
    - AT&T (MO)
    - Staples (CA, OH)
    - PG&E (CA)

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curb Weight</td>
<td>9,700-10,200 pounds</td>
</tr>
<tr>
<td>Length</td>
<td>268-368 inches</td>
</tr>
<tr>
<td>Width</td>
<td>87 inches</td>
</tr>
<tr>
<td>Height</td>
<td>94-99 inches</td>
</tr>
<tr>
<td>Peak Motor Power</td>
<td>134 kW</td>
</tr>
<tr>
<td>Electric Range</td>
<td>Up to 150 miles</td>
</tr>
<tr>
<td>Seating</td>
<td>3</td>
</tr>
<tr>
<td>Payload</td>
<td>12,324-16,200 pounds</td>
</tr>
<tr>
<td>Electric Top Speed</td>
<td>50 mph</td>
</tr>
<tr>
<td>Battery Capacity</td>
<td>80 or 120 kWh</td>
</tr>
<tr>
<td>Battery Voltage</td>
<td>~350 V nominal</td>
</tr>
<tr>
<td>Charging Standards</td>
<td>J1772 or 3-phase</td>
</tr>
<tr>
<td>Transmission</td>
<td>Single Speed Reduction</td>
</tr>
<tr>
<td>Gear</td>
<td></td>
</tr>
<tr>
<td>Drag Coefficient</td>
<td>~0.5</td>
</tr>
<tr>
<td>Wheel Base</td>
<td>153 - 220 in.</td>
</tr>
</tbody>
</table>
Smith Electric Vehicles – Data Collected

- First quarterly report covered Oct 2011-Dec 2011 (published)
- Next will cover January-March 2012 (published in July)
- Cumulative report will be published (July)

- Cumulative results to Date:
  - Reporting period: 10/1/2011 to 3/31/2012
  - Number of vehicles reporting: 151
  - Number of vehicle days driven: 6,352
  - Number of miles recorded: 199,625 miles
  - Number of operating cities: 75
Smith Electric Vehicles – Route Info

Average Number of Stops (Per Day | Per Mile): 68.4 | 2.7
Average Brake (Regen) Events (per mile): 12.3
Average Maximum Acceleration (g): 0.4
Average Daily Maximum Driving Speed (mph): 47.2
Average Daily Driving Speed (mph): 20.3
City | Highway Distance (miles): 155,531.5 | 44,094.8
City | Highway Distance %: 79.1 | 22.4
Smith Electric Vehicles – When Used

- Driving and charging patterns reflect typical commercial use.
- ‘when charging’ is defined as time of day when plugged in.
### Smith Electric Vehicles – Overall Charging

<table>
<thead>
<tr>
<th>Metric</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Average Fleet Charging Events (per month)</td>
<td>2,475.2</td>
</tr>
<tr>
<td>Average Fleet Charge Energy (per month)</td>
<td>72,886.5 kWh</td>
</tr>
<tr>
<td>Average Vehicle Charging Frequency (per day)</td>
<td>2.3</td>
</tr>
<tr>
<td>Average Per Vehicle Charge Energy (per day)</td>
<td>67.7 kWh</td>
</tr>
<tr>
<td>Average Energy Delivered (per charge)</td>
<td>29.6 kWh</td>
</tr>
<tr>
<td>Average Duration of Charge Event</td>
<td>7.5 hr</td>
</tr>
<tr>
<td>Average Distance Between Charges</td>
<td>13.3 miles</td>
</tr>
</tbody>
</table>
Smith Electric Vehicles – Overall Energy Use

Overall DC Electrical Energy Discharged: 1,732.7 Wh/mi

Driving DC Electrical Energy Consumption: 1,594.3 Wh/mi

Total Number of Charges: 14,851.0

Total Charge Energy Delivered: 437,318.7 kWh

Overall Gasoline Equivalent Fuel Economy: 19.4 mpge (based on EPA method of 33.7 kWh/gal)
Average daily distance driven: 31 miles
Route specific average range (w/idle): 46.2 miles
Route specific average range (only moving): 50.2 miles
Smith Electric Vehicles – Distance and Idle

- Looking into ‘key on’ time:
  
  Will affect overall efficiency - (increases the Wh/mi and decreases overall range)
Smith Electric Vehicles – Efficiency vs Drive Cycle

Effect of Daily Driving Aggressiveness on Fuel Economy

- ‘Fuel Economy’ varies based on drive cycle
- Average driving style observed is somewhere between CARB HHDDT cycle and HTUF 6 Cycle
- Significant daily operations in more ‘urban routes’ approaching NY Composite Cycle
Smith Electric Vehicles – Avg Daily Energy Use

Includes ‘idle’: ~1.7 kWh/mi avg
Smith Electric Vehicles – Avg Daily Energy Use
Smith: Fuel Cost Comparison to Diesel

- What if compared to conventional vehicle?
- Modeled a diesel package delivery van and ran it on all the daily routes recorded for Smith vehicles

### Conventional Vehicle Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Test Weight (lbs)</td>
<td>15,020</td>
</tr>
<tr>
<td>CD</td>
<td>0.7</td>
</tr>
<tr>
<td>FA (m²)</td>
<td>7.8</td>
</tr>
<tr>
<td>RR</td>
<td>0.008</td>
</tr>
<tr>
<td>Engine Power (kW)</td>
<td>149</td>
</tr>
</tbody>
</table>

### Conventional Vehicle (Empty/Average/GVWR)

<table>
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<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Curb Weight (lbs)</td>
<td>11,020</td>
</tr>
<tr>
<td>Payload Weight (lbs)</td>
<td>0/2,998/11,978</td>
</tr>
<tr>
<td>Total Weight (lbs)</td>
<td>11,020/14,019/22,998</td>
</tr>
</tbody>
</table>
Assumes $0.11 per kWh, $3.50 per gal diesel
Next Steps

• Repeat process with additional data every quarter for Smith
  • Expect usage to change as vehicles are further implemented into service and adjusted based on performance

• Repeat process for Navistar eStar, AQMD shuttle buses and bucket trucks, and Cascade Sierra

• Continue to add additional analysis to explore:
  • Demand charge implications at commercial sites (smart charging / V2B / V2G)
  • Battery degradation vs drive/duty cycle, secondary use
  • Effects of environment on range

• Present and publish data on all projects into 2014
Thanks!

Acknowledgement:
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For More Information:
www.afdc.energy.gov

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