Medium-Duty Plug-in Electric Delivery Truck Fleet Evaluation

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NREL Field Data, Testing, and Analysis Tools

Data from field evaluations helps populate FleetDNA database

DOE fleet tools (DRIVE, FASTSim, AFleet, etc.) used to analyze and investigate impacts – data used to validate and improve tools

Published information and data used by fleets, industry, DOE and other research programs, and other agencies

Collect Lab and Field Data
Capture, Store and Analyze
Laboratory Testing
Explore & Optimize
Communicate & Inform

Identify Barriers, New R&D Opportunities, Validate Efforts

Data from field evaluations help populate FleetDNA database.
DOE fleet tools (DRIVE, FASTSim, AFleet, etc.) are used to analyze and investigate impacts — data used to validate and improve tools.
Published information and data used by fleets, industry, DOE and other research programs, and other agencies.

Partnership with Fleets and Technology Providers = Relevant Results & Optimized Solutions for Real World Applications

Photos: Dennis Schroeder / NREL
Frito-Lay North America

- 269 Electric Delivery Trucks
- 208 CNG trucks
- Member of the National Clean Fleet Partnership (NCFP) since 2011
  - The NCFP provides fleets with resources, expertise, and support to incorporate alternative fuels and fuel-saving measures into their operations.

“At Frito-Lay, our goal is to be the most fuel-efficient fleet in the country.”
- Mike O’Connell, Director, Frito-Lay Fleet Capability

http://www.fritolay.com/purpose/fleet-sustainability
Smith Newton Electric Delivery Vehicle

- **Project Objective:** Evaluate and compare real world, in-use performance of Smith Electric delivery vehicles to conventional diesels.

- **Smith Newton Specifications**
  - Class 6 vehicles
  - 80-kWh LiFePO$_4$ battery
  - Motor power: 150 kW (peak) | 80 kW (continuous)
  - Top Speed: 80 kph (50 mph)
  - Charging standard: J1772

Photo: Robert Prohaska / NREL
Data Collection

• Electric Vehicles
  o Data collected via onboard telematics as part of American Recovery and Reinvestment Act grant funding requirements

• Diesel Vehicles
  o Data loggers with GPS installed to collect SAE J1708/OBD CAN messages

Photos: Adam Ragatz / NREL
• Facility located Northeast of Tacoma, WA
• Sample route traces show EVs (red) and diesels (blue) cover the same region
• Drivers service customer accounts by filling orders and stocking store shelves
• Warehouse and distribution center
• Services Tacoma, WA area
• Onsite charging with 10 chargers
### Driving Kinematics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Electric Vehicles</th>
<th>Diesel Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Daily Distance</td>
<td>52.3 [km]</td>
<td>61.52 [km]</td>
</tr>
<tr>
<td>Average Speed</td>
<td>34.6 [km/hr]</td>
<td>40.5 [km/hr]</td>
</tr>
</tbody>
</table>

#### Daily Distance vs. Average Speed

- **Diesel Day**
- **Diesel Veh Avg**
- **EV Day**
- **EV Veh Avg**

![Graph showing daily distance vs. average speed for electric and diesel vehicles](image-url)
Driving Kinematics

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Electric Vehicles</th>
<th>Diesel Vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Kinetic Intensity</td>
<td>0.44 [1/km]</td>
<td>0.34 [1/km]</td>
</tr>
<tr>
<td>Average Speed</td>
<td>34.6 [km/hr]</td>
<td>40.5 [km/hr]</td>
</tr>
</tbody>
</table>

**Kinetic Intensity vs. Average Speed**

- **Diesel Day**
- **Diesel Veh Avg**
- **EV Day**
- **EV Veh Avg**
- **HHDDT Transient**
- **HHDDT Composite**
- **HHDDT Cruise**

HHDDT: Heavy Heavy-Duty Diesel Truck
# Drive Cycle Statistics

<table>
<thead>
<tr>
<th>Daily Averages</th>
<th>Diesels</th>
<th>σ</th>
<th>EVs</th>
<th>σ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Driving Time (hours)</td>
<td>1.51</td>
<td>0.31</td>
<td>1.54</td>
<td>0.45</td>
</tr>
<tr>
<td>Average Total Distance (km)</td>
<td>61.52</td>
<td>20.54</td>
<td>52.31</td>
<td>16.74</td>
</tr>
<tr>
<td>Average Speed (km/h)</td>
<td>40.52</td>
<td>11.01</td>
<td>34.57</td>
<td>6.80</td>
</tr>
<tr>
<td>Average Fuel Consumed (L)</td>
<td>18.82</td>
<td>5.98</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Average Energy Consumed (kWh)</td>
<td>187.24(a)</td>
<td>N/A</td>
<td>45.66</td>
<td>13.12</td>
</tr>
<tr>
<td>Energy Consumed per km (kWh/km)</td>
<td>3.07(a)</td>
<td>0.25</td>
<td>0.87</td>
<td>0.12</td>
</tr>
<tr>
<td>Average Fuel Economy (km/L\textsubscript{de})</td>
<td>3.24</td>
<td>0.25</td>
<td>10.24(b)</td>
<td>1.21</td>
</tr>
<tr>
<td>Avg. Fuel Consumption (L\textsubscript{de}/100 km)</td>
<td>30.84</td>
<td>2.54</td>
<td>9.77(b)</td>
<td>1.39</td>
</tr>
<tr>
<td>Average Number of Stops /day</td>
<td>44.25</td>
<td>13.74</td>
<td>43.28</td>
<td>14.47</td>
</tr>
<tr>
<td>Average Number of Stops/km</td>
<td>0.72</td>
<td>0.67</td>
<td>0.83</td>
<td>0.86</td>
</tr>
<tr>
<td>Average Kinetic Intensity (1 / km)</td>
<td>0.34</td>
<td>0.23</td>
<td>0.44</td>
<td>0.14</td>
</tr>
</tbody>
</table>

- **9.9477 kWh/L of diesel fuel [37.656 kWh / gallon of diesel fuel]**
- **Assumes 90% charger/inverter net efficiency**

- EVs and diesels are operated very similarly EVs are driven slightly less distance on average
- EVs demonstrated over 3 times the average fuel economy
Fuel and Energy Consumption

- EVs consume less than 1/3 the equivalent energy as the diesels

\[ 9.9477 \text{ kWh/L of diesel fuel} \] [37.656 kWh / gallon of diesel fuel]
Daily Energy Consumption

- Energy consumption (and savings) directly proportional to distance traveled

\[ y = 2.8323x + 12.991 \]
\[ R^2 = 0.9559 \]

- Opportunity for additional savings by deploying EVs to longer routes

\[ y = 0.7297x + 7.4968 \]
\[ R^2 = 0.8659 \]
EV Cost Savings – Energy Only

Potential Savings for each EV Deployed

- Avg. -25%: 10,243 km
- Avg. +25%: 17,075 km
- Average: 13,660 km

2013 Avg. Fuel ($3.92/Gal)
2014 Avg. Fuel ($3.83/Gal)
2015 Avg. Fuel ($2.71/Gal)

*Savings based on $0.102/kWh electricity cost

- Cost savings based on energy efficiency only using Federal Way, WA average electricity cost of $0.102/kWh.
• EVs demonstrated over 3x improvement of diesel equivalent fuel economy over conventional diesels in Frito-Lay’s Federal Way, WA fleet

• Overall energy consumption is highly dependent on drive cycle dynamics, operation, and environment

• Peak demand charging and infrastructure requirements are a key aspect to a successful deployment

For more information:
http://www.nrel.gov/transportation/fleettest_electric_frito.html

Project Partners:
• Frito Lay N.A.
• Smith Electric Vehicles
• Chateau Energy Solutions
• U.S. Department of Energy
Thank You

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http://www.nrel.gov/transportation/fleettest.html
Appendix
## Smith EV Newton Vehicle Cost

<table>
<thead>
<tr>
<th></th>
<th>Conventional</th>
<th>Incremental</th>
<th>NY Voucher</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smith Newton 80 kWh</td>
<td>$151,442</td>
<td>$86,791</td>
<td>$60,000</td>
</tr>
<tr>
<td></td>
<td>$64,651</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>


[http://www.cmap.illinois.gov/documents/10180/316900/Change_Requests_082114.pdf/31d5a4c7-a419-4c97-8a0e-7e7547fe5e18](http://www.cmap.illinois.gov/documents/10180/316900/Change_Requests_082114.pdf/31d5a4c7-a419-4c97-8a0e-7e7547fe5e18)
1: Plug in at end of shift | 2: Unplug to load truck
3: Plug in after loading | 4: 100% SOC, Charging stopped
Thank You

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http://www.nrel.gov/transportation/fleettest.html