Analysis and Scenarios of Low-Carbon Options for Heavy Duty Trucks

Christopher Yang
Marshall Miller, Lew Fulton, Dominique Meroux
STEPS Board of Advisors Meeting
August 18, 2015

NextSTEPS (Sustainable Transportation Energy Pathways)
Project Overview – Low Carbon Options for Trucks

- STEPS3 Project
- Phase I – Summer 2015-Winter 2016
- Conduct lit review, data search, develop simple prototype model
- Focus on long-haul trucking in this phase
The trucking sector has historically been poorly represented in long-term models that are used to characterize energy use and emissions and analyze technology adoption scenarios of low-carbon futures.

- Many of these energy and scenario models only deal with highly aggregated categories: heavy-duty and medium-duty trucks.
- These simplifications ignore differences in average driving distances, ownership models and other key variables that drive truck purchase decisions.

The goal of this research is to improve our understanding of the potential role of alternative truck technologies and fuels to reduce emissions in the heavy- and medium-duty truck sectors.
Our project

• This project focuses on 3 key areas:
• **Truck cost and fuel consumption model** - Improving cost and performance projections for trucks of different types and drivetrain technologies
• **Truck decision framework** - Developing a truck choice model that incorporates financial and other relevant factors that influence the purchase of conventional and alternative/advanced technologies
• **Develop scenarios and fleet modeling of long-term truck futures** – utilize a stock turnover model in conjunction with vehicle choice model to model fleet characteristics, cost, fuel consumption, and emissions
Key Research Questions

• What factors do truck owners/operators consider when making decisions to purchase trucks and how do they influence the purchase of alternative fueled and advanced trucks?
• What are reasonable adoption rates for alternative truck technologies in the near-term and how does this influence how we achieve a low-carbon, low emissions fleet to meet longer-term air quality and greenhouse gas goals for transportation?
• What sorts of policy levers and incentives can help bring about these changes to a sustainable truck fleet?
<table>
<thead>
<tr>
<th>Truck Type</th>
<th>Description or example</th>
<th>Average Mileage/year</th>
<th>Relative fleet size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long haul</td>
<td>Class 8 long distance travel</td>
<td>Very high ~100,000</td>
<td>Medium</td>
</tr>
<tr>
<td>Short haul</td>
<td>Class 7, 8 regional travel</td>
<td>High ~50,000</td>
<td>Low</td>
</tr>
<tr>
<td>Heavy-duty vocational</td>
<td>Refuse truck</td>
<td>Medium 20,000 – 30,000</td>
<td>Medium</td>
</tr>
<tr>
<td>Medium-duty vocational</td>
<td>Trash compactors, bucket trucks</td>
<td>Medium 20,000 – 30,000</td>
<td>Medium</td>
</tr>
<tr>
<td>Medium-duty urban</td>
<td>Delivery trucks (UPS, FedEx)</td>
<td>Medium 20,000 – 30,000</td>
<td>High</td>
</tr>
<tr>
<td>Buses</td>
<td>Transit buses, shuttles, coaches</td>
<td>Medium ~30,000</td>
<td>Medium</td>
</tr>
<tr>
<td>Heavy-duty vans and pickup trucks</td>
<td>Class 2B and 3 &gt; 8,500 lbs. GVWR</td>
<td>Medium 20,000 – 30,000</td>
<td>Very high</td>
</tr>
</tbody>
</table>
Truck Decision Framework

- Based upon existing vehicle choice models (LDV):
  - Utility of decision-makers is dependent on direct costs as well as a number of other factors related to the technology, perceptions, and fuel infrastructure

- Nested Multinomial Logit Model
  - Used in many vehicle choice approaches based on work by Greene
    - LAVE-TRANS (Greene, Park, and Liu) used in the NRC study for LDVs
    - MA3T (Lin and Greene) for LDVs
    - CVCM – (EIA) LDV module for the NEMS model
  - Nests represent groupings of similar technologies that consumers consider close substitutes

```
Trucks
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Liquid ICE Nest</td>
</tr>
<tr>
<td>Diesel</td>
</tr>
<tr>
<td>Diesel Hybrid</td>
</tr>
<tr>
<td>NG ICE Nest</td>
</tr>
<tr>
<td>CNG</td>
</tr>
<tr>
<td>LNG</td>
</tr>
<tr>
<td>Electric Nest</td>
</tr>
<tr>
<td>BEV</td>
</tr>
<tr>
<td>H2 Nest</td>
</tr>
<tr>
<td>FCV</td>
</tr>
</tbody>
</table>
```
Choice Model Factors

NMNL Choice Model

**Decision-maker attributes**
- Fleet size
- Annual driving distance
- Expected payback period
- Risk tolerance
- Fueling characteristics

**Technology attributes**
- Vehicle capital cost
- Fuel type
- Fuel economy
- Vehicle range
- Maintenance cost
- Vehicle technology “risk”

**External attributes**
- Subsidies and incentives
- Regulations
- Fuel cost
- Fuel station availability
- Fuel carbon intensity
Research Progress

• In progress:
  – Collecting cost projections for truck technologies
  – Reviewing literature on major factors for truck purchases
  – Developing decision model based on existing vehicle choice models

• Challenges:
  – Quantitative data is limited on factors influencing truck purchases
  – Data is mostly non-existent for advanced technology trucks
  – Calibrating the model