Sustainable Transportation Energy Pathways (STEPS)

Truck Technology Transitions with a Decision Choice Model

STEPS Symposium
December 10, 2015

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www.steps.ucdavis.edu
Work Status / Research Team

• Work in progress

• Research team
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  – Dominique Meroux
  – Marshall Miller
  – Chris Yang
Outline

• Project Outline
• Preliminary findings
• Decision choice model framework
• Decision choice model parameters/inputs
• Preliminary results
• Next steps
Project Outline

• Understand critical elements of transition to alternative fuels and technologies in MD and HD trucks to reduce GHGs and criteria pollutants through 2050 (Present work – CA, future add US)

• Develop decision choice model which utilizes important purchase decision factors for different truck fleet categories

• Incorporate choice model into ARB Vision model to project truck stock, fuel use, emissions

• Questions:
  – Which factors influence truck purchase decisions?
  – How do reasonable technology adoption rates influence achieving emissions goals?
  – How does infrastructure development influence truck purchases?
  – What policy levers and incentives best help achieve emissions goals?
Preliminary Findings

• Increase payback period, VMT => increase NG, BEV truck sales (vehicles with lower fuel/operating costs will benefit)

• Generalized truck costs converge over time (increased volume sales, green PR, carbon tax, lower risk, incentives all work to reduce spread in costs)

• Fleet purchase factors such as risk, green PR, fuel availability have large uncertainty
  – Major thrust for 2016

• Need more detailed data for specific truck fleet categories to better understand the potential for BEV and FC trucks.
  – Major thrust for 2016
• 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
  – Nests represent groupings of similar technologies that consumers consider close substitutes
Decision Choice Model Parameters

• Capital Cost
• Operating costs (fuel use, maintenance)
• Green PR (Environmental perception)
• Uncertainty (Risk)
• Incentives/Subsidies
• Vehicle Range
• Refueling Time
• Station Availability
• Carbon Tax
Truck Fleet Categories

- Fleet categories can strongly affect decision factors
- HD: Long haul, short haul, drayage (port)
  - Range, station availability
- Fleet size (large, medium, owner operator)
  - Risk
  - Payback period
- Private, For hire
- Challenge to understand how each fleet category makes purchase decisions
Decision Choice Model Inputs

• Determine weighting of decision factors (How important are factors for various fleet categories?)
  – Interviews with fleet operators and other experts
  – Surveys for fleets operators

• Example inputs (PoLB, PoLA drayage)
  – 2008 regulation: drayage trucks must meet 2007 engine standards
  – Incentives for retrofit diesel engines, LNG trucks
  – Owner operators only considered retrofits (risk, capital cost too high)
  – Some fleets purchased LNG trucks
    • Incentives
    • Fuel cost low
    • Could deal with reliability problems
    • Environmental perception: benefit with Lowes, Target, and other customers
## Truck and Fuel Technology Inputs

<table>
<thead>
<tr>
<th>Truck Segment</th>
<th>Long haul</th>
<th>Short haul</th>
<th>Port/drayage trucks</th>
<th>Heavy duty vocational</th>
<th>Medium-duty vocational</th>
<th>Medium-duty urban</th>
<th>Buses</th>
<th>Heavy-duty vans and pickup trucks</th>
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</thead>
<tbody>
<tr>
<td>Truck Class</td>
<td>Class 8</td>
<td>Class 7, 8</td>
<td>Class 7, 8</td>
<td>Class 6-8</td>
<td>Class 3-5</td>
<td>Class 3-5</td>
<td>Class 6-7</td>
<td>Class 2B and 3 &gt; 8,500 lbs. GVWR</td>
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<tr>
<td>Vehicle Examples</td>
<td>Tractor Trailer</td>
<td>Tractor Trailer</td>
<td>Tractor Trailer</td>
<td>Refuse truck</td>
<td>Trash compactors, bucket trucks</td>
<td>Delivery trucks</td>
<td>Transit buses, shuttles, coaches</td>
<td>Pickups and Vans</td>
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<tr>
<td>Avg Annual VMT</td>
<td>68,805</td>
<td>20,237</td>
<td>45,594</td>
<td>13,416</td>
<td>5,170</td>
<td>13,150</td>
<td>12,042</td>
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<tr>
<td>Avg Daily VMT</td>
<td>220</td>
<td>65</td>
<td>146</td>
<td>43</td>
<td>17</td>
<td>40</td>
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<tr>
<td>Fleet size</td>
<td>112,319</td>
<td>376,946</td>
<td>19,528</td>
<td>41,366</td>
<td>22,274</td>
<td>166,553</td>
<td>752,938</td>
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<tr>
<td>Avg Age</td>
<td>6.8</td>
<td>27.9</td>
<td>5.0</td>
<td>27.3</td>
<td>29.6</td>
<td>29.7</td>
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<tr>
<td>Avg MPG</td>
<td>5.8</td>
<td>7.1</td>
<td>5.5</td>
<td>4.6</td>
<td>8.0</td>
<td>12.6</td>
<td>14.2</td>
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<tr>
<td>Annual Fuel Consumption</td>
<td>1342.7</td>
<td>1077.1</td>
<td>163.0</td>
<td>120.6</td>
<td>14.4</td>
<td>174.3</td>
<td>637.9</td>
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<tr>
<td>% Fuel Consumption</td>
<td>38%</td>
<td>31%</td>
<td>5%</td>
<td>3%</td>
<td>0%</td>
<td>5%</td>
<td>18%</td>
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### Vehicle Technology Commercialization

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<thead>
<tr>
<th>Energy Type</th>
<th>CNG/LNG</th>
<th>Hydrogen</th>
<th>Electricity</th>
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<tbody>
<tr>
<td>Commercial/Early Market</td>
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### Vehicle Range / Energy Storage Considerations

<table>
<thead>
<tr>
<th>CNG/LNG</th>
<th>Hydrogen</th>
<th>Electricity</th>
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</thead>
<tbody>
<tr>
<td>Favorable</td>
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### Infrastructure Deployment

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<tr>
<th>Refueling Considerations</th>
<th>Truck Stops</th>
<th>Truck Stops / Central location</th>
<th>Near Port</th>
<th>Central Fleet Refueling</th>
<th>Central Fleet Refueling</th>
<th>Central Fleet Refueling</th>
<th>Central Fleet Refueling</th>
<th>Conventional Fueling Stations</th>
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<tbody>
<tr>
<td>Hydrogen</td>
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<td>Early Market/Demonstration</td>
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<td>Electricity</td>
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Generalized Costs – Subsidy (2015, 2030, 2050)

Generalized Costs by Truck Technology

- Subsidy & Incentives
- Green PR
- Carbon Taxes
- Uncertainty
- Refueling Inconvenience
- Maintenance
- Fuel Cost
- Capital Cost
- Net Generalized Cost

Total (Net) Generalized Cost

- Diesel
- Dsl HEV
- CNG
- LNG
- Electricity
- Hydrogen

2011

2030

2050
Next Steps

- Conduct interviews and surveys with fleets to better understand model parameters
- Expand truck types to include fleet categories where useful (fleet size, private vs for hire, VMT, other segments?)
- Include more detailed data for each truck fleet category (stock, VMT, fuel economy, performance needs, choice factors, etc.)
- Create scenarios based on fleet purchase decisions for transitions to a low emissions truck sector
  - Understand critical factors and time periods for achieving emissions goals
  - Explore policy levers to achieve goals
Thank You