Truck Emission Reduction Strategies
Presentation overview

• Baseline emissions
• Emission reduction strategies
• Policy issues
Zero-Emission Technology Strategy

- Two-pronged approach
  - An aggressive program to bring more clean fuel / hybrid trucks into service represents the best near-term strategy
  - A regional freight corridor program represents an opportunity to commercialize zero-emission technologies and build incentives into an existing program (e.g., the RTP)
Current goods movement emissions

### NOx Emissions

- **Heavy Duty Trucks**: 75%
- **Ocean Going Vessels**: 14%
- **Harbor Craft**: 2%
- **Freight Trains**: 5%
- **Cargo Handling Equipment**: 4%

### PM2.5 Emissions

- **Heavy Duty Trucks**: 58%
- **Ocean Going Vessels**: 33%
- **Harbor Craft**: 2%
- **Freight Trains**: 4%
- **Cargo Handling Equipment**: 3%
Heavy duty trucks – baseline NOx emissions in the SCAG Region (tpd)

- Year: 2010, 2023, 2035
- Categories: HHD, MHD, LHD
- Units: tons per day (tpd)
Heavy duty trucks – baseline PM2.5

<table>
<thead>
<tr>
<th>Year</th>
<th>HHD</th>
<th>MHD</th>
<th>LHD</th>
<th>PM2.5 Emissions in SCAG Region (tpd)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>13</td>
<td>12</td>
<td>1</td>
<td>13</td>
</tr>
<tr>
<td>2023</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>8</td>
</tr>
<tr>
<td>2035</td>
<td>5</td>
<td>4</td>
<td>1</td>
<td>10</td>
</tr>
</tbody>
</table>
Heavy duty trucks – baseline GHGs

GHG Emissions in SCAG Region (x10^3 tpd)

- 2010
  - LHD
  - MHD
  - HHD

- 2023
  - LHD
  - MHD
  - HHD

- 2035
  - LHD
  - MHD
  - HHD

Year
Near-term: Impact of ARB’s In-Use Truck & Bus Rule

• By 2023, nearly all HDVs will be model year 2010 or newer

• Accelerating turnover will produce no significant emissions benefits

• So … further emission reductions must come from introduction of advanced technology HDVs
Truck advanced technology options

- Advanced natural gas engines
- Hybrid technologies
- Plug-in hybrid technologies
- Battery electric technologies
Natural gas engines

• Available today for most applications

• Emissions reductions per truck
  
<table>
<thead>
<tr>
<th>NOx</th>
<th>PM</th>
<th>GHGs</th>
<th>NOx</th>
<th>PM</th>
<th>GHGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>20-30%</td>
<td>0%</td>
<td>21-38%</td>
<td>35-50%</td>
<td>10-30%</td>
<td>20-37%</td>
</tr>
</tbody>
</table>

• Incremental cost per truck
  – Class 3: $15-20K
  – Class 8: $35-45K

• Fueling infrastructure needed
Hybrid technologies

- Available today for most single-unit trucks
- Limited availability for Class 8; more in next few years
- Emissions reductions per truck

<table>
<thead>
<tr>
<th>Class 3 Gasoline</th>
<th>Class 8b Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>NOx</strong></td>
<td></td>
</tr>
<tr>
<td>11-21%</td>
<td>31-41%</td>
</tr>
<tr>
<td><strong>PM</strong></td>
<td></td>
</tr>
<tr>
<td>21-31%</td>
<td>4-24%</td>
</tr>
<tr>
<td><strong>GHGs</strong></td>
<td></td>
</tr>
<tr>
<td>20-35%</td>
<td>5-20%</td>
</tr>
</tbody>
</table>

- Incremental costs per truck
  - Class 3: $10-15K; potential to decrease 50% by 2035
  - Class 8: $55-60K; potential to decrease 50% by 2035
Plug-in hybrid technologies

• Demonstration stage
• Emissions reductions per truck
  – Class 3: $20-30K; potential to decrease 50% by 2035
  – Class 8: $70-100K; potential to decrease 50% by 2035
• Incremental costs per truck
  – Class 3: $20-30K; potential to decrease 50% by 2035
  – Class 8: $70-100K; potential to decrease 50% by 2035
• Charging infrastructure needed
• Could potentially use wayside power

<table>
<thead>
<tr>
<th>Class 3 Gasoline</th>
<th>Class 8b Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>NOx</td>
<td>NOx</td>
</tr>
<tr>
<td>68-78%</td>
<td>28-58%</td>
</tr>
<tr>
<td>PM</td>
<td>PM</td>
</tr>
<tr>
<td>43-58%</td>
<td>9-33%</td>
</tr>
<tr>
<td>GHGs</td>
<td>GHGs</td>
</tr>
<tr>
<td>42-52%</td>
<td>10-25%</td>
</tr>
</tbody>
</table>
Battery electric technologies

• Demonstration stage
• Emissions reductions per truck
  - Class 3: $30-50K; potential to decrease 50% by 2035
  - Class 8: $100-135K; potential to decrease 50% by 2035
• Incremental costs per truck
  - Class 3: $30-50K; potential to decrease 50% by 2035
  - Class 8: $100-135K; potential to decrease 50% by 2035
• Charging infrastructure needed
• Could potentially use wayside power
Emission reduction (per HHDV)

![Graph showing emission reduction per HHDV for NOx, PM2.5, and GHGs for different vehicle types (NGV, Hybrid, PHEV, BEV).]
Deployment scenarios

- Assume technology deployed in first year available for each weight class
- Assume cost is incremental purchase price of vehicle
### Deployment scenario - 2023

- **Example:** if 20% of new vehicle purchases are advanced technology
- **Results for 2023:**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Assumed first year of commercial availability</th>
<th>Baseline (tpd)</th>
<th>NOx Reduction (tpd)</th>
<th>% of Baseline</th>
<th>PM2.5 Reduction (tpd)</th>
<th>% of Baseline</th>
<th>Capital Cost (Millions)</th>
<th>Vehicles</th>
<th>Infrastr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>2012</td>
<td></td>
<td>4.8</td>
<td>6%</td>
<td>0.09</td>
<td>3%</td>
<td>$1,433</td>
<td>$131</td>
<td></td>
</tr>
<tr>
<td>Hybrid Electric</td>
<td>2012-14</td>
<td>76.2</td>
<td>4.2</td>
<td>6%</td>
<td>0.07</td>
<td>3%</td>
<td>$1,432</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>Plug-In Hybrid</td>
<td>2016-20</td>
<td></td>
<td>3.9</td>
<td>5%</td>
<td>0.08</td>
<td>3%</td>
<td>$989</td>
<td>$138</td>
<td></td>
</tr>
<tr>
<td>Battery Electric</td>
<td>2017-23</td>
<td></td>
<td>3.6</td>
<td>5%</td>
<td>0.09</td>
<td>4%</td>
<td>$882</td>
<td>$234</td>
<td></td>
</tr>
</tbody>
</table>
### Deployment scenario - 2035

- **Example:** if 20% of new vehicle purchases are advanced technology
- **Results for 2035:**

<table>
<thead>
<tr>
<th>Technology</th>
<th>Assumed first year of commercial availability</th>
<th>NOx Baseline (tpd)</th>
<th>NOx Reduction (tpd)</th>
<th>NOx % of Baseline</th>
<th>PM2.5 Baseline (tpd)</th>
<th>PM2.5 Reduction (tpd)</th>
<th>PM2.5 % of Baseline</th>
<th>Capital Cost (Millions)</th>
<th>Vehicles</th>
<th>Infrastr.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural Gas</td>
<td>2012</td>
<td>6.4</td>
<td>8%</td>
<td></td>
<td>0.10</td>
<td>4%</td>
<td></td>
<td>$1,956</td>
<td>$177</td>
<td></td>
</tr>
<tr>
<td>Hybrid Electric</td>
<td>2012-14</td>
<td>5.9</td>
<td>8%</td>
<td></td>
<td>0.09</td>
<td>3%</td>
<td></td>
<td>$1,591</td>
<td>$0</td>
<td></td>
</tr>
<tr>
<td>Plug-In Hybrid</td>
<td>2016-20</td>
<td>8.3</td>
<td>11%</td>
<td></td>
<td>0.16</td>
<td>6%</td>
<td></td>
<td>$1,910</td>
<td>$199</td>
<td></td>
</tr>
<tr>
<td>Battery Electric</td>
<td>2017-23</td>
<td>14.9</td>
<td>20%</td>
<td></td>
<td>0.39</td>
<td>15%</td>
<td></td>
<td>$2,126</td>
<td>$359</td>
<td></td>
</tr>
</tbody>
</table>
Deployment scenario – 100% of new purchases are advanced technology

<table>
<thead>
<tr>
<th>Year</th>
<th>Technology</th>
<th>NOx</th>
<th>PM2.5</th>
<th>GHGs</th>
</tr>
</thead>
<tbody>
<tr>
<td>2023</td>
<td>NGV</td>
<td>$7,165 / $653</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hybrid</td>
<td>$7,161 / $--</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHEV</td>
<td>$4,944 / $688</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BEV</td>
<td>$4,410 / $1,172</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2035</td>
<td>NGV</td>
<td>$9,778 / $883</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hybrid</td>
<td>$7,957 / $---</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>PHEV</td>
<td>$9,551 / $993</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>BEV</td>
<td>$10,629 / $1,794</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Potential mechanisms to accelerate clean truck deployment

• New emission standards
  – Outside control of SCAG and regional partners

• Vehicle purchase subsidies
  – Buy down incremental cost; like Carl Moyer

• Access control
  – Highway segments and/or major terminals (e.g., ports)
  – Need to couple with vehicle incentives

• Clean truck technology infrastructure
  – Wayside power
  – Charging / fueling infrastructure
Operational & maintenance strategies

• Maximize use of on-dock rail
  – Actively pursued by ports
• Expand use of near-dock rail
  – SCIG and ICTF expansion
• Railroad grade separation
  – Safety and mobility benefits
• Railroad capacity expansion
  – Minimize train delay/idling
Operational & maintenance strategies cont.

- Truck idle reduction
  - Expand enforcement of ARB rule
  - Use permits for new/expanded warehouses
- New truck I&M program
  - Concern about SCR systems
- System management
  - Bottleneck relief
  - Incident management for trucks
Truck strategies – Policy implications

• Freight corridor with access restrictions and/or wayside power:
  – Could potentially accelerate low/zero emission truck deployment
  – Will affect only a portion of regional truck VMT

• Significant **regional** HDV emission reductions will require vehicle purchase incentives

• Investments in clean truck infrastructure should maximize flexibility to avoid stranded capital