Heavy-Duty Diesel Vehicle Emissions in Greater Vancouver

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Objectives

- Overall objective was to evaluate cost-effectiveness and emission reduction potential of options for fleet HDDVs.
- Focus of this paper is the emission analysis that was integral to the broader study:
  - Characterize government and large privately owned fleets.
  - Estimate emission factors for each class of vehicle in the HDDV fleets.
  - Calculate “baseline” emissions of criteria air pollutants, greenhouse gases and air toxics to 2025.
  - Estimate annual average PM2.5 concentrations contributed by HDDVs near major roads and in the region.
Fleet Characterization Data Sources

- Data set included commercial vehicles:
  - With GVW of 8,500 lb or more.
  - Normally operated in Lower Fraser Valley according to owners registration.
  - Vehicle model year, GVW, body style, territory code, fleet code, and other data.
- Survey data from government and some primate fleet managers – fleet code (voluntary), km/yr, Litre fuel/100km, BHP, rebuild year, and other.
**Emission Estimation Method**

\[
\text{No. of vehicles by age in each vehicle classification} \times \text{Annual VkmT} \times \text{Emission factor for each pollutant} = \text{Annual emission}
\]

- MOBILE6.2C (adapted by Environment Canada)
- Emission factors for criteria and toxic pollutants.
- Local data for input assumptions – fuel quality, climate, etc.
- Default EPA data for VkmT.
- GHG factors for vehicle and life-cycle determined using GHGenius model.
Distribution of Fleet Size

- 1 veh: 4.2%
- 2-5 veh: 15.9%
- 6-10 veh: 13.8%
- 11-25 veh: 18.1%
- 26-50 veh: 16.6%
- 51-100 veh: 12.5%
- 101-200 veh: 7.4%
- 201-500 veh: 4.7%
- 501-1000 veh: 6.9%

12,138 fleet vehicles
Vehicle Age Distribution - all Onroad

![Vehicle Age Distribution Chart](chart.png)
Vehicle Class Distribution – All Onroad

32,521 vehicles
NOx Emission Forecast

NOx (tonnes/yr)

<table>
<thead>
<tr>
<th>Year</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>14,000</td>
</tr>
<tr>
<td>2005</td>
<td>12,000</td>
</tr>
<tr>
<td>2010</td>
<td>8,000</td>
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<tr>
<td>2015</td>
<td>4,000</td>
</tr>
<tr>
<td>2020</td>
<td>2,000</td>
</tr>
<tr>
<td>2025</td>
<td>1,000</td>
</tr>
</tbody>
</table>
Exhaust PM2.5 Emission Forecast

- 2000: 450 tonnes/yr
- 2005: 250 tonnes/yr
- 2010: 150 tonnes/yr
- 2015: 50 tonnes/yr
- 2020: 30 tonnes/yr
- 2025: 20 tonnes/yr
NOx Emissions by Vehicle Class

Percent of NOx Emissions

- HDDV 2b & 3
- HDDV 4,5,6 & 7
- HDDV 8a & 8b
- Transit Bus
- Other Buses

Years:
- 2000
- 2010
- 2020
PM2.5 Emissions by Vehicle Class

- HDDV 2b & 3
- HDDV 4,5,6 & 7
- HDDV 8a & 8b
- Transit Bus
- Other Buses

Years: 2000, 2010, 2020

Percent of PM2.5 Exhaust Emissions

Emissions breakdown for different vehicle classes over different years.
Estimation of Avg PM2.5 Near Roads

\[ C_Z (\text{Link L}) = \frac{E_i}{L} \times F_D \]

\( C_Z \) = Zone annual average PM2.5 concentration (\( \mu g/m^3 \))
\( E_i \) = Annual average emission rate on link L (g/s)
\( F_D \) = Dispersion Factor for zone Z (\( \mu g/m^3 \))/(g/s-km)
\( L \) = Link Length (km)

Zones: 5-20 m; 20-100 m; 100-500 m; and >500 m
Dispersion Correlation from CALINE3

\[ y = 277.88x^{-0.5778} \]

\[ R^2 = 0.9915 \]

ZONE 1 = 73
ZONE 2 = 49
ZONE 3 = 19

Dispersion Coefficient (\( \mu g/m^3/(g/s-km) \))

Distance from road edge (m)
Traffic input from EMME/2 Model

- Upper estimates of dispersion factors used to offset for effects from nearby links not included explicitly in the simplified method.
- Peak AM traffic volume for 2000 from EMME/2 transportation model, scaled to annual average traffic.
- Traffic volume for 8,000, 2-directional road links for all of LFV.
- Two emission cases:
  - Emission factors used for the 2000 emission inventory, net of reduction from the AirCare OnRoad Program (ACOR).
  - Updated emission factors developed in this study.
## Estimated Exhaust PM2.5 from HDDV

<table>
<thead>
<tr>
<th></th>
<th>Predicted Annual Average PM$_{2.5}$ Concentration ($\mu$g/m$^3$)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>GVRD Emission Factors with ACOR</td>
<td>Updated Emission Factors &amp; no ACOR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Zone 1 &lt;20 m</td>
<td>Zone 2 20-100 m</td>
<td>Zone 1 &lt;20 m</td>
</tr>
<tr>
<td><strong>Transit Buses</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>1.70</td>
<td>1.14</td>
<td>1.32</td>
</tr>
<tr>
<td>98$^{th}$ Percentile</td>
<td>0.40</td>
<td>0.27</td>
<td>0.31</td>
</tr>
<tr>
<td>95$^{th}$ Percentile</td>
<td>0.24</td>
<td>0.16</td>
<td>0.19</td>
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<tr>
<td><strong>Trucks</strong></td>
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</tr>
<tr>
<td>Maximum</td>
<td>15.32</td>
<td>10.28</td>
<td>26.94</td>
</tr>
<tr>
<td>98$^{th}$ Percentile</td>
<td>0.60</td>
<td>0.40</td>
<td>1.05</td>
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<tr>
<td>95$^{th}$ Percentile</td>
<td>0.30</td>
<td>0.20</td>
<td>0.51</td>
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<tr>
<td><strong>All HDDV</strong></td>
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</tr>
<tr>
<td>Maximum</td>
<td>15.32</td>
<td>10.28</td>
<td>26.94</td>
</tr>
<tr>
<td>98$^{th}$ Percentile</td>
<td>0.78</td>
<td>0.53</td>
<td>1.09</td>
</tr>
<tr>
<td>95$^{th}$ Percentile</td>
<td>0.49</td>
<td>0.33</td>
<td>0.61</td>
</tr>
</tbody>
</table>
Annual Avg Exhaust PM2.5 – Zone 1
Annual Avg Exhaust PM2.5 – Zones 1-3
Conclusions

- The three largest onroad HDDV categories are Class 8a+b (29.9%), Class 2b (22.7%) and Class 3 (19.6%), totalling 72.2% of HDDVs.
- 12,138 vehicles, or 37% of HDDVs are part of a vehicle fleet.
- Emissions of criteria pollutants forecast to decrease by 60% to 90% between 2000 and 2020.
- Air toxic emissions, excluding diesel particulate matter and ammonia, are forecast to decrease 57% by 2020.
- GHGs are forecast to increase by 35% by 2020.
Conclusions

- 196 kilometers of road have predicted annual PM2.5 concentrations from HDDVs above 1 µg/m³ beyond 20 m of the edge of the road - an increase of 300 in a million lifetime risk (70 yrs) of cancer.
- This is 5% of the 4,266 km included in the EMME/2 model of LFV traffic network.
- These and other results can be used to guide monitoring and assessment of effects of PM from HDDVs.
Project Funding Partners

- Greater Vancouver Regional District
- Fraser Valley Regional District
- BC Ministry of Water, Land and Air Protection
- Environment Canada
- Greater Vancouver Transportation Authority
- Clean Air Research Fund
- Clean Energy