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School Buses, Air Pollution & Children's Health


Presented to Clean Air Hamilton
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Clean Air Partnership

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Report: School Buses, Air Pollution & Children's Health

- **Project Manager:** Kim Perrotta, Environmental Health Manager, OPHA
- **Background:** Ralph Torrie, Torrie Smith Associates
- **Funding:**
 - The Laidlaw Foundation
 - Walter & Duncan Gordon Foundation
 - Environment Canada
- **In-kind Support:**
 - Toronto Public Health
 - Peel Health Services
 - York Region Health Services
 - Waterloo Region Public Health



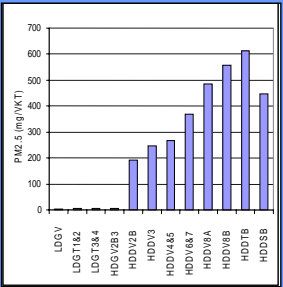
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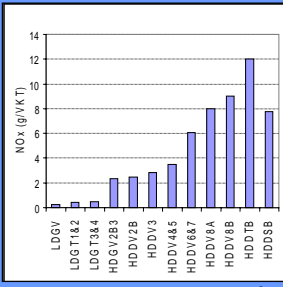


Why Focus on School Buses? High Emitters of PM & NO_x

(Waterloo Centre for Atmospheric Science, 2005)



Vehicle Type	PM _{2.5} (mg/VKT)
LDGV	~10
LDGTT1&2	~10
LDGTT3&4	~10
HDSV2B3	~150
HDDV2B	~250
HDDV3	~300
HDDV4&5	~350
HDDV6&7	~450
HDDV6A	~550
HDDV6B	~600
HDDTB	~650
HDDSB	~450




Vehicle Type	NO _x (g/VKT)
LDGV	~0.5
LDGTT1&2	~0.5
LDGTT3&4	~0.5
HDG1/2B3	~2.5
HDGV3	~3.5
HDGV4&5	~4.5
HDDV6&7	~6.5
HDDV6A	~8.5
HDDV6B	~9.5
HDDTB	~12.5
HDDSB	~8.5

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Notice how high the PM and NO_x emissions are for the school buses (HDDSB) and transit buses (HDDTB) relative to gasoline-fuelled cars and light-duty trucks.....

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 **Why Focus on School Buses?**
Elevated Levels On-Board
(New Brunswick Lung Association, 2005)

Average Concentrations: Walking to School, On-Board School Bus, Ambient Air
No Idling, uncongested roads & relatively good air quality

	PM _{2.5} ($\mu\text{g}/\text{m}^3$)	PM _{1.0} (particles/cc)	Black Carbon ($\mu\text{g}/\text{m}^3$)	PAHs (ng/m^3)
Walking	9.7	4,000	0.2	265
School Bus	32.1	11,000	0.7	775
Ambient Air	5.0			


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Notice that the average concentrations on-board school buses are several times higher than levels along walking routes and in the ambient air.


The New Brunswick study actually provides the most conservative results because it has relatively good air quality (half the PM_{2.5} that we have in some Ontario cities), the study was done on uncongested roads where air levels would be quite low, and the buses were not allowed to idle.

The Black Carbon is an indicator of diesel particulate matter....

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 **What is Diesel Particulate Matter?**


- 80-95% fine particulate matter
- 1-20% ultra-fine particles
- Includes hydrocarbons such as PAHs
- Deep into lungs & into bloodstream




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DPM is particularly nasty because of the small size of the particles and their ability to carry toxic hydrocarbons into the body.

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 **Acute Health Impacts: PM_{2.5} & DPM**

- Aggravate asthma
- Increase respiratory infections
- Reduce lung function
- Aggravate allergies
- Increase school absences
- Increase emergency room visits, hospital admissions & premature deaths




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 **Chronic Health Impacts – PM_{2.5} & DPM**

- Increase risk of heart disease
- Increase risk of lung diseases including lung cancer
- Possibly increase risk of developing asthma



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 **Air Pollution & Children**

- **Acute effects** with short-term exposures
 - increase in asthma symptoms
 - Increase in hospital admissions
 - Increase in respiratory infections
- **Chronic effects** with long-term exposures
 - Reduced rate of lung function growth which predisposes to chronic lung & heart disease
 - Possible increase in cases of asthma
- **800,000 Ontario children** use school buses
- Small increase in health risk can result in significant # of health impacts

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 **Ontario's Current Fleet of School Buses**

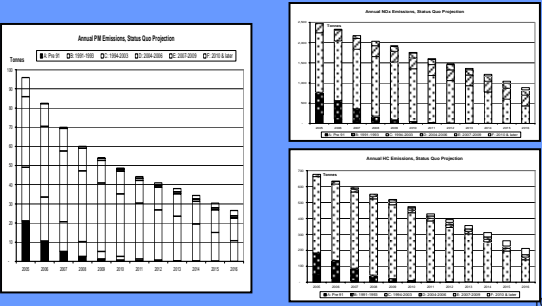
- 15,000 school buses; mostly diesel
- 3400 tonnes smog-forming air pollutants
- **30% buses** - pre-1994 (12-21 years)
 - Emit **10-25** kg of PM/year each
- **70% buses** - 1994-2006 (0-11 years)
 - Emit about **4** kg of PM/year each
- **2007 Model Year Buses**
 - Will emit about **0.4** kg of PM/year each

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Note the difference in PM emissions from the different model years....this is why we are targeting pre-1994 for retirement and aiming for 2007 emission standards.

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 **Emissions – Different Model Years, 2006- 2016**
PM, NOx & HC (Torrie, 2005)




The figure consists of three stacked bar charts showing annual emissions from 2006 to 2016. The top chart is for PM (Tonnes), the middle for NOx (Tonnes), and the bottom for HC (Tonnes). Each bar represents a model year cohort: Pre-1994 (black), 1994-2003 (white), 2004-2006 (hatched), 2007-2009 (dotted), and 2010-2016 (solid grey). The PM chart shows a significant contribution from the Pre-1994 cohort, which decreases over time. The NOx and HC charts show a more uniform distribution across cohorts, with the 1994-2003 cohort being particularly prominent.

These graphs illustrate the PM, NOx and HC emissions from Ontario's fleet of school buses by model year cohorts over the next 10 years.

Notice two things:


The pre-1994 school buses dominate PM emissions for the next few years even though there are relatively few of them; and
The 1994-2003 cohort dominates in all three categories over the next 10 years.

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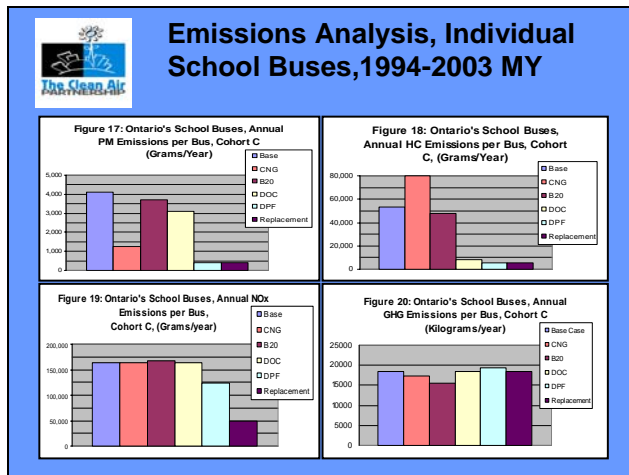
Emission Reduction Options

- Maintenance & Operation Practices
- Retrofitting – DOCs, DPFs, & Engine Filters
- Replacing – new Diesel, CNG & HEV
- Fuel Switching - Biodiesel



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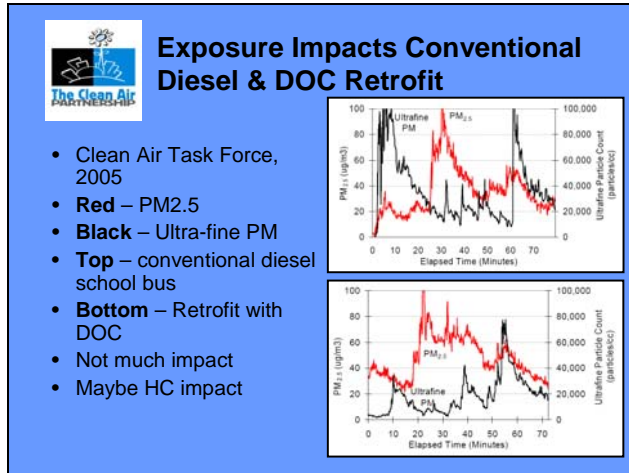


Notice:

How well diesel particulate filters (DPF) reduce PM and HC and potentially NOx;
 How well new 2007 school buses reduced PM, HC and NOx;
 That while CNG reduces PM, it increases HC;
 That Biodiesel (B20) provides modest air pollutant reductions and fairly substantial GHG reductions.

Ideally, have B20 and DPF but that scenario is very costly at present.

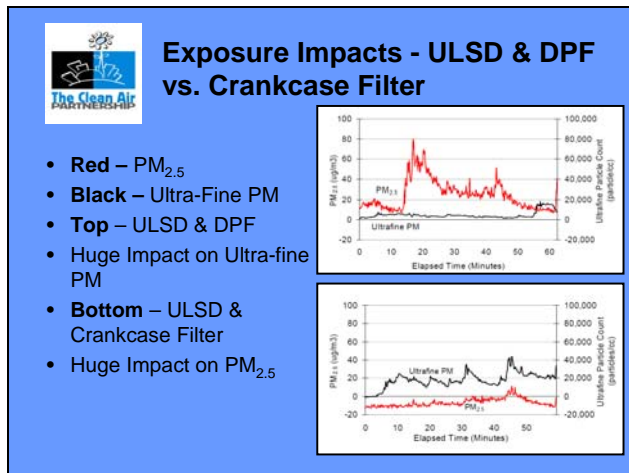
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Notice how high PM_{2.5} levels can be; peaking at 100 ug/m³.

Notice that Diesel Oxidation Catalyst (DOC) does not appear to have a huge impact on concentrations, although it may be reducing the toxicity by removing hydrocarbons (HC).

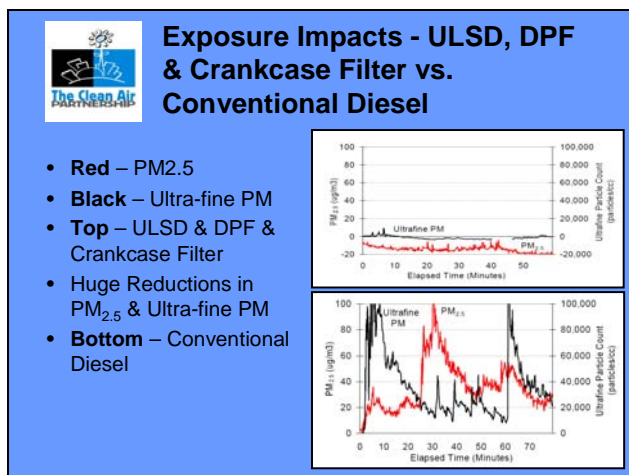
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Notice that the DPF significantly reduces ultra-fine particles; it also reduced black carbon and PAHs.

Notice that the Crankcase Filter significantly reduces PM_{2.5}.

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Notice that the DPF and Engine Crankcase Filter together reduce air levels on-board school buses below ambient air levels.


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 **OPHA Recommendations –
Healthy School Bus Program**

- **Ministry of Environment**
- Multi-year Program
- \$10-20 million/yr
- Replacement of older buses & retrofitting of newer buses
- **Environment Canada**
- Multi-year Fund
- \$10-20 million/yr



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 **What can be done at a Local Level?**

- Support **OPHA Recommendations**
- Develop **Idling Policies & Factsheets**
 - Emphasize doors closed when engines on
 - Start buses after children are on-board
- Develop **Healthy School Bus Plans**
 - Describe fleet (age, size and routes)
 - Assess replacement/retrofit options with and without supplementary funds
 - Give priority to retirement pre-1994 buses
 - Give priority to crankcase filters (\$400/bus)
 - Assign routes with awareness of bus age

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 **OPHA School Bus Report**
www.opha.on.ca/resources/schoolbus.pdf

