Diesel Health Impacts & Recent Comparisons to Other Fuels

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The Natural Resources Defense Council is a national, non-profit organization of scientists, lawyers and environmental specialists dedicated to protecting public health and the environment.

Founded in 1970, NRDC has more than 500,000 members nationwide, served from offices in New York, Washington, Los Angeles and San Francisco.

General Health Effects of Diesel Exhaust

- General Acute Exposure Effects: Nausea, eye irritation, increased blood pressure, headache, light-headedness, loss of appetite, poor coordination & difficulty concentrating.[1]
- Diesel Particulates (**PM**) and Nitrogen Oxides (**NOx**) are responsible for a wide array of health problems.
- Typical Diesel exhaust contains up to 40 different air **toxics**, including arsenic, dioxins, formaldehyde, lead and mercury compounds.
- Listed as a Toxic Air Contaminant (TAC) by the Cal. Air Resources Board in 1998.

[1] Agency for Toxic Substances and Disease Registry, http://www.atsdr.cdc.gov/tfacts75.html

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Diesel Exhaust Particulates

- Diesel exhaust is a major source of fine particles, which can lodge deep in the lungs, carrying other air toxics with them.
- Numerous studies have shown that fine particulates:[1]
  - Impair lung function
  - Aggravate respiratory problems: Bronchitis, emphysema, asthma
  - Are associated with premature mortality.
- Generally, health risks from fine PM exposure in most large cities translates to a 20% increase in risk of developing lung cancer for a nonsmoker. This is analogous to living with a smoker.[2]

[1] Pope et. al., J. Am. Medical Assoc., 287:1132-1142, 2002.
[2] Hood., Environmental Health Perspectives, 110:A456, 2002.

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Particulate Related Mortality

- Many studies tie fine PM to increased hospital admissions for respiratory diseases, chronic obstructive lung disease (COPD), pneumonia, and heart disease, including elevated risk of acute myocardial infarction (heart attack).[1]

- An NRDC study of 239 U.S. cities estimated an annual death toll of 50,000 due to fine particulate pollution.

- U.S. EPA estimates that 8,300 premature deaths will be avoided annually by 2030, due to the 2007 On-Road Heavy-duty Diesel Engine & Fuel Standards.[2]

[1] Peters et. al., Circulation, 103:2810-2815, 2001.
[2] Tables VII-19 & 22, Regulatory Impact Analysis Document

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Carcinogenic Effects

- The State of California classified Diesel exhaust as a known lung carcinogen in 1990. Numerous other agencies – U.S. & International – consider diesel exhaust likely to be carcinogenic.
- Scores of studies have shown that long-term exposure to diesel exhaust is associated with significantly increased risk of lung cancer.[1]
- Many other types of cancer have been linked to occupational exposure to diesel exhaust, including bus & truck drivers, garage workers, railway & dock workers and others.[2]

[1] CARB & OEHHA, Report to the ARB on the Proposed Identification of Diesel Exhaust as a TAC, Executive Summary as approved by the SRP on April 22, 1998, ES-20.
[2] Boffetta et. al., Cancer causes Control 12:365-374, 2001.

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Cancer Risk Statistics

- Government regulators estimate that diesel exhaust is responsible for 125,000 cancers nationwide, based on lifetime exposure. (STAPPA/ALAPCO, 2000)
- Studies in California reveal that more than 70% of cancer risk from air pollution comes from diesel exhaust alone. (SCAQMD, MATES II, 2000)
- A recent analysis of U.S. EPA inventory data shows even higher percentages of cancer risk from diesel exhaust: 78-90% of the total risk from HAPs in the U.S. (ED, based on NATA, 2001)

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Diesel & Asthma

- According to numerous studies, diesel exhaust is associated with asthma, which is rapidly on the rise in this country.
  - Asthma has risen by 160 percent in children under age four since 1980, and the severity of the disease among children has also increased.[1]
  - > 5% of Americans suffer from asthma
  - Almost 5 million children are affected
  - Asthma leads to ~ 5,000 deaths each year
- The frequency & severity of asthma attacks may be increased by diesel exhaust, which acts as a respiratory irritant, triggering responses in susceptible people.

[1] Mannino DM, et al. "Surveillance for asthma – United States, 1960-1995." Morbidity and Mortality Weekly Reports CDC Surveillance Summaries 47, 1998.

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Diesel & Asthma Continued

- New research indicates that diesel exhaust may actually cause allergies and asthma, rather than simply aggravating pre-existing conditions.[1]

- Diesel particles can worsen reactions to common allergens such as pollen.[2]

- Studies have shown that the proximity of a child's school or home to major roads is linked to asthma, and decreased lung function, and the severity of children's asthmatic symptoms increases with proximity to truck traffic.[3]

[1] Diaz-Sanchez et al., J Allergy Clin Immunol 104, 1999:1183-1188.

[2] Pandya et. al., Environ Health Perspectives 110(Suppl 1):103-112, 2002.

[3] McConnell et al., Environ Health Perspect 107, 1999: 1-9.

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Health Effects of NOx

NOx causes a wide variety of health & environmental impacts because of the many compounds & derivatives in the family of nitrogen oxides, including:

Nitrogen dioxide, Nitric acid, Nitrous oxide, Nitrates, & Nitric oxide.

- These compounds can react to form other toxic chemicals.
- NOx causes respiratory problems; A recent Southern California study showed that exposure can lead to significant decreases in lung function growth among children.[1]
- It is known to cause birth defects.

[1] Gauderman et.al., Am. J. Resp. and Crit. Care Med., 162:1384-1390, 2000

Adverse Environmental Impacts of NOx

- It forms ozone smog, which can trigger serious respiratory problems.
- It Contributes to many other environmental problems including:
  - Acid rain,
  - Nutrient overloading leading to water quality problems,
  - Haze, and
  - Global warming.

Diesel Exhaust: An Enormous Source to Contend With

- Though diesels only account for 2% of on-road vehicles in California, they contribute to 30% of NOx and 65% of particulates from the on-road sector. (CARB, 2002)
- While new diesels are much cleaner, older dirtier diesels remain in use for decades, especially in off-road applications.
- For example, 16 large ocean-going ships typically release more smog-forming gases than 1 million cars.

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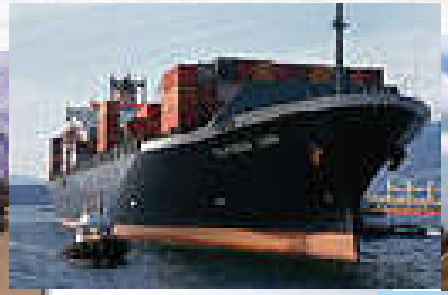
The Dirtiest Diesel Sources

Off-road equipment & vehicles are the dirtiest source of diesel exhaust, followed closely by stationary generators.



In California,
Heavy-duty Trucks, Construction & Farm Equipment, Marine Vessels and Locomotives, together account for over 85% diesel PM emissions

California Diesel Risk Reduction Plan, ARB, 2000

Heavy-duty Diesel Emission Testing & Research

Transit Buses:

- California Transit Bus Studies:
  - BP Arco
  - CARB
  - SF Muni
- N.Y.S. Dept. of Environmental Conservation

Other Heavy-duty Vehicles:

Research in U.S. & Abroad

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California Transit Bus Studies

Test Buses: 40’ Newflyer Buses, supplied by LAMTA

- Detroit Diesel w/ “market diesel” & ox. cat. (BD)
- “ w/ Low S diesel & PM trap (DPF)
- Compressed Natural Gas, uncontrolled (CNG)
- “ w/ox. cat.

Pollutants Tested:

- Criteria: PM, NOx, CO + HCs
- Toxics (ex. Benzene); Carbonyls (ex. Formaldehyde)
- Semivolatiles, PAHs, and Nitro-PAHs
- Mutagenicity

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CA Studies, Emissions from Highest to Lowest:

Pollutant:	*CARB Study*	*ARCO Study*
NOx	BD ~ DPF > CNG	DPF > CNG
PM	BD >> CNG > DPF	DPF = CNG
THC/NMHC	CNG >> BD > DPF	CNG >> DPF
CO	CNG > BD > DPF	CNG >> DPF
Benzene	CNG > BD > DPF[1]	CNG > DPF
Aldehydes	CNG > DPF[2]	CNG >> DPF
PAH Species	BD > CNG > DPF[3]	DPF ~ CNG
Nitro-PAHs		DPF ~ CNG
Mutagenicity	CNG >> BD ~ DPF[4]	
NO2/NOx	DPF >> BD ~ CNG	
CO2	DPF ~ BD ~ CNG	

[1] For combined BTEX (Benzene, Toluene, Ethylbenzene & Xylene)

[2] Baseline Diesel Samples were invalidated

[3] Excluding naphthalene, due to contamination of sampling media

[4] This test appears to have had problems

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Comparison of Recent Transit Bus Study Emission Data, CBD Test Cycle

	NOx (g/mile)			PM (g/mile)		
	BD	**DPF**	**CNG**	**BD**	**DPF**	**CNG**
CARB Study	30	31	19	0.12	0.01	0.04
BP-ARCO Study	40	35	16	0.66	0.01	0.01
NYC Study	26	27	24	0.22	0.04	0.02

BD = Baseline Diesel
DPF = Diesel with DPF

CNG = Compressed Natural Gas, no controls

M. Lev-On et. al., SAE 2002, Presented as Test - Tunnel Background & C. LeTavec et.al SAE World Congress, March 4-7, 2002); Chatterjee et. al., Society of Automotive Engineers 2002-01-0430; WMATA Alternative Fuels Workshop, July 6, 2000: NYCT Clean Fuel Bus Programs.

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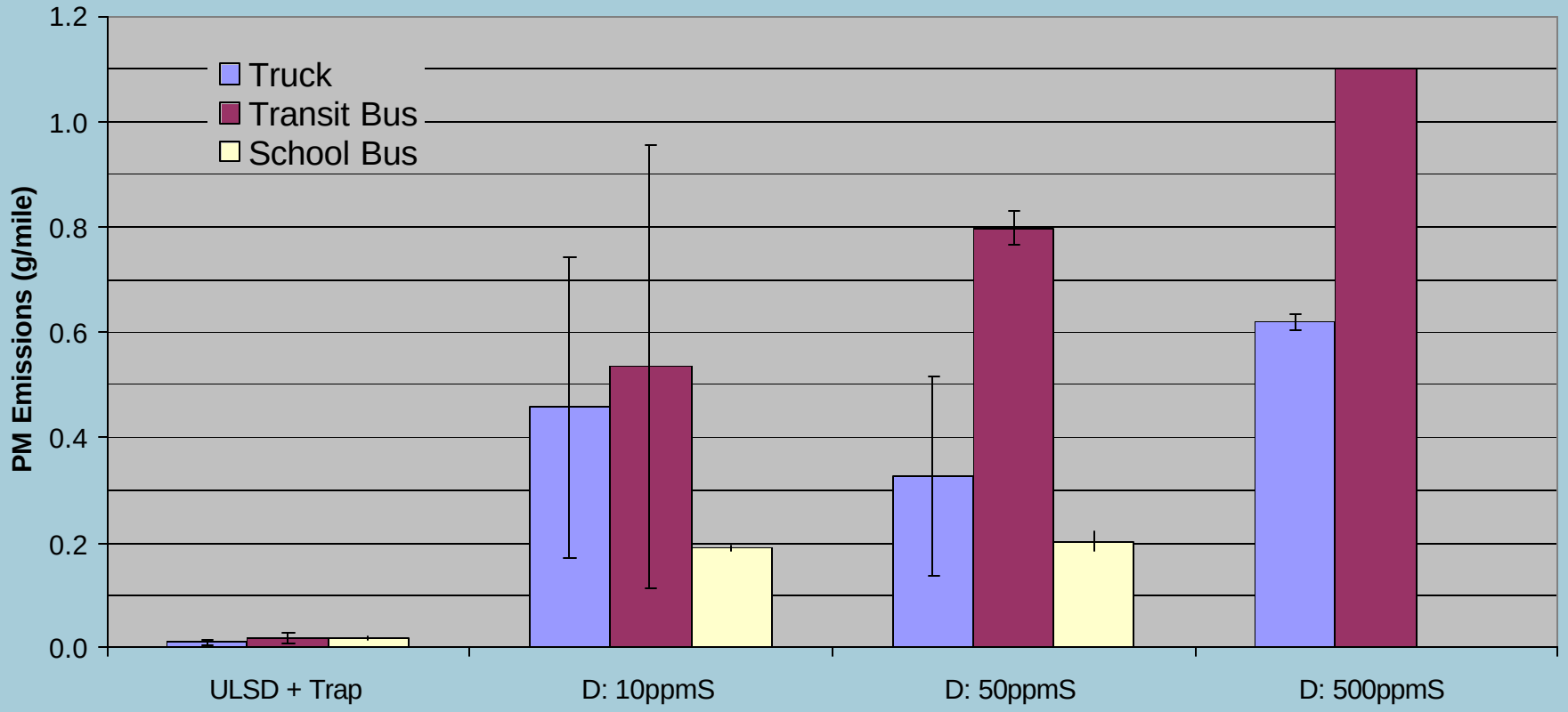
Heavy-Duty Vehicle PM Emissions, Various Grades of Diesel Fuel



1) T. Beer et. al., "Comparison of Transport Fuels," Final Report to the Australian Greenhouse Office, 2001.
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3) Chatterjee et. al. SAE 2001.
4) Clark et. al., Diesel & CNG Transit Buses, 1999
5) Clark et.al. JAWMA; 52: 89-94. 2002.
6) Gragg K. MTC 2001.
7) Lanni et al. SAE. 2001-01-0511.
8) LeTavec et al. Average Vehicle Test Results (School Buses, CSHVR Driving Cycle)
9) Lev-On M et al. SAE. 2002-01-0432.
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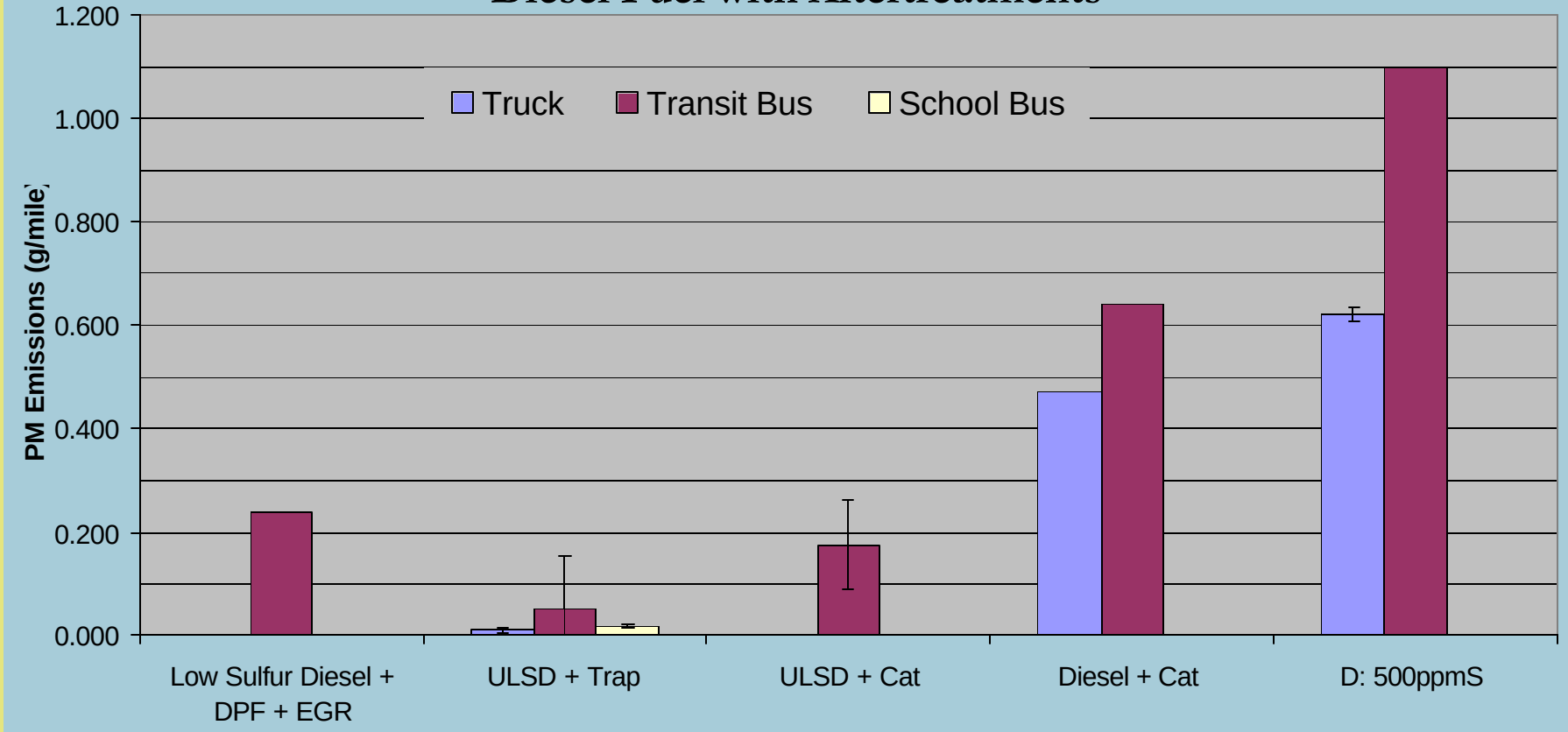
Heavy-Duty Vehicle PM Emissions, Diesel Fuel with Aftertreatments



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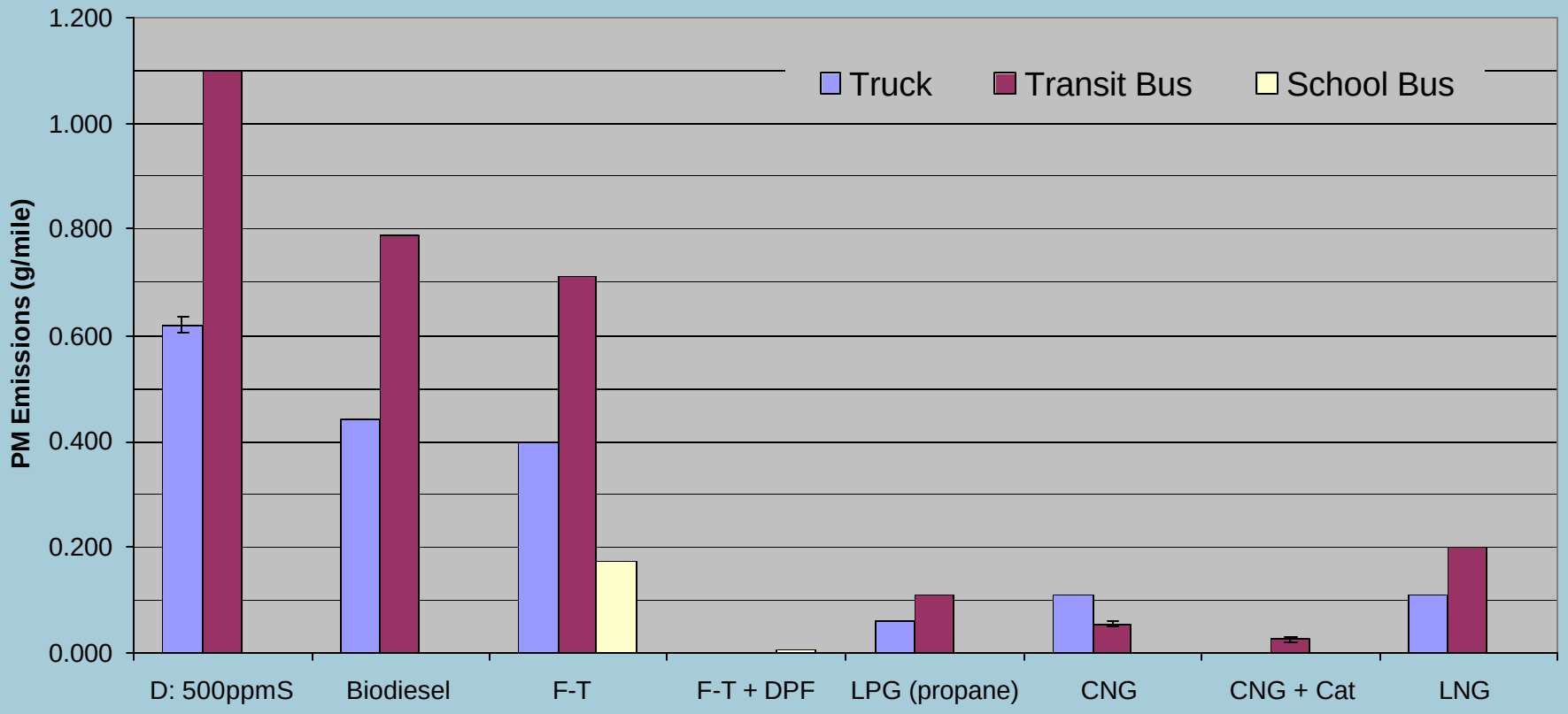
Heavy-Duty Vehicle PM Emissions, Alternative Fuels



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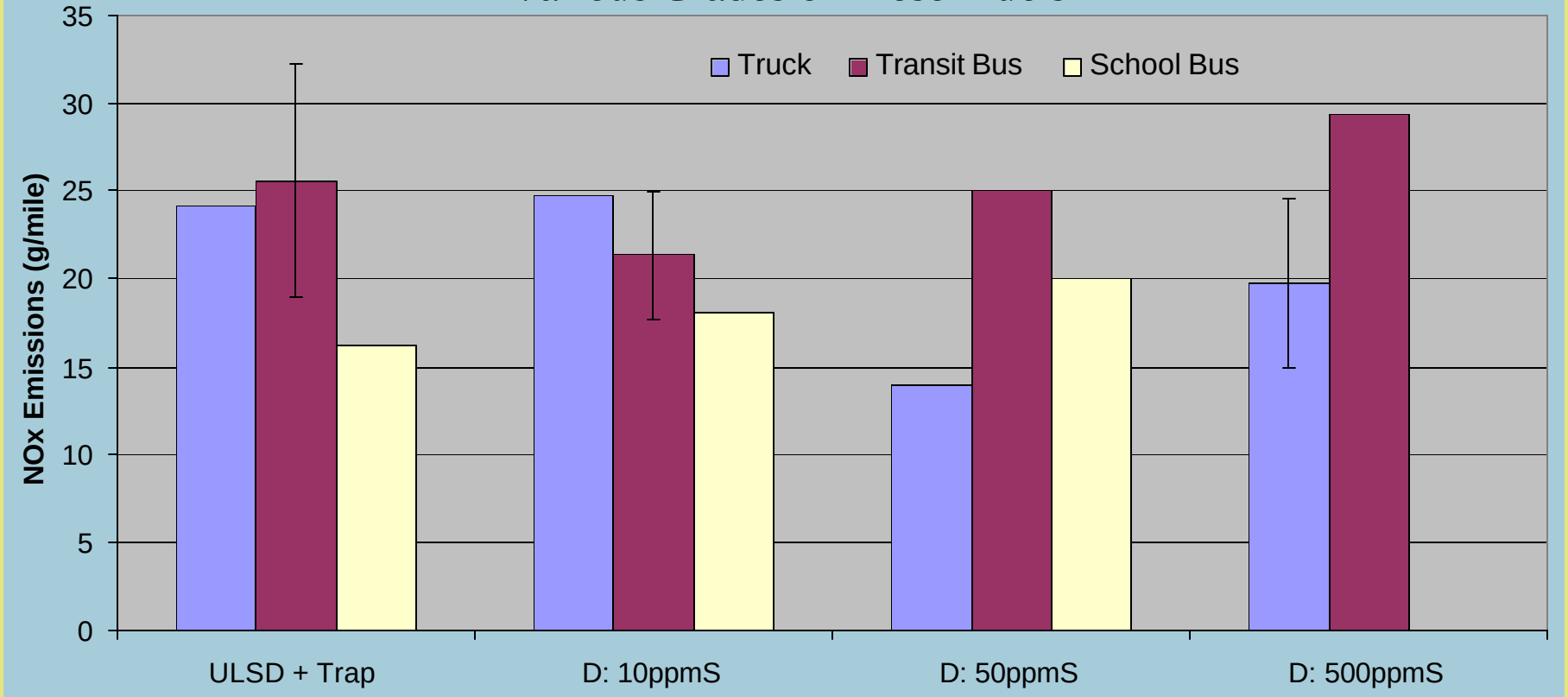

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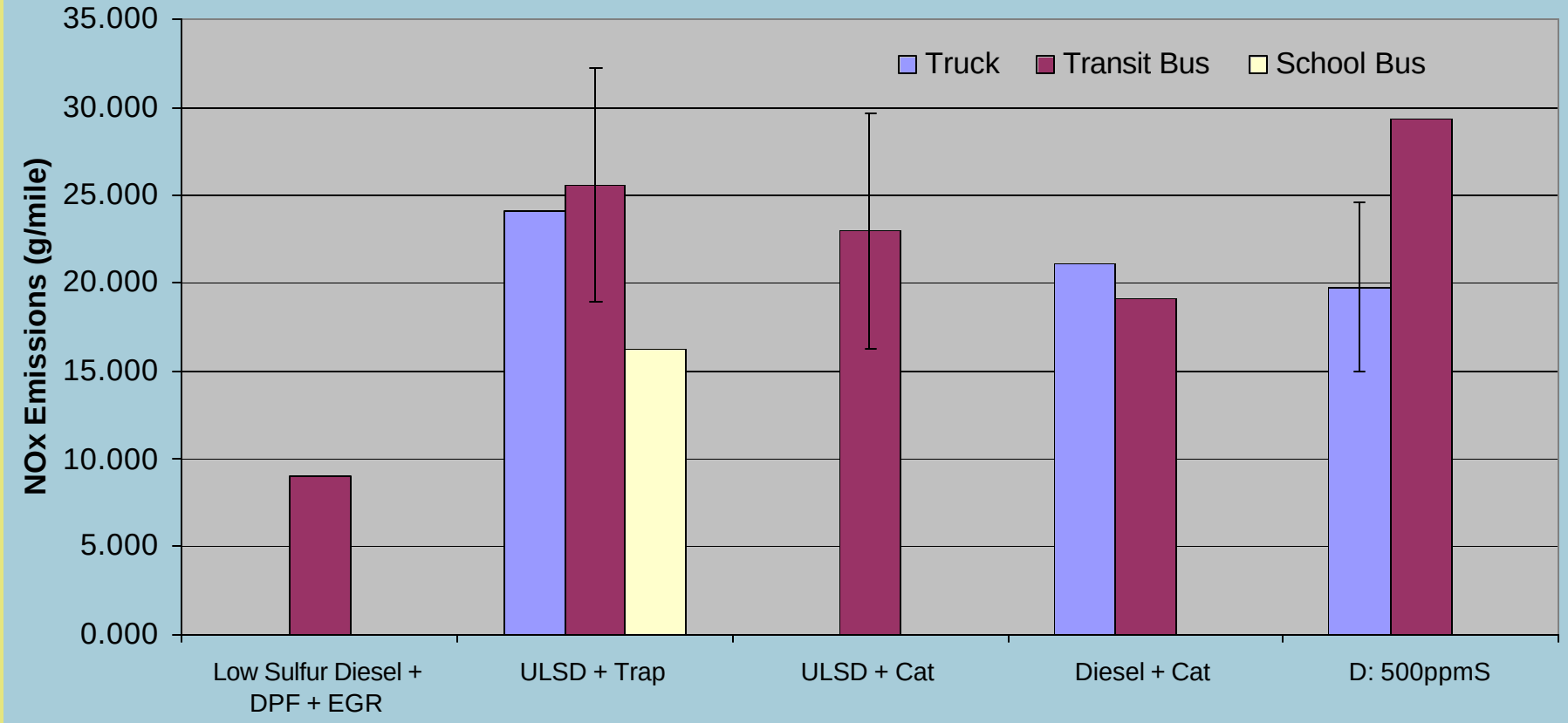

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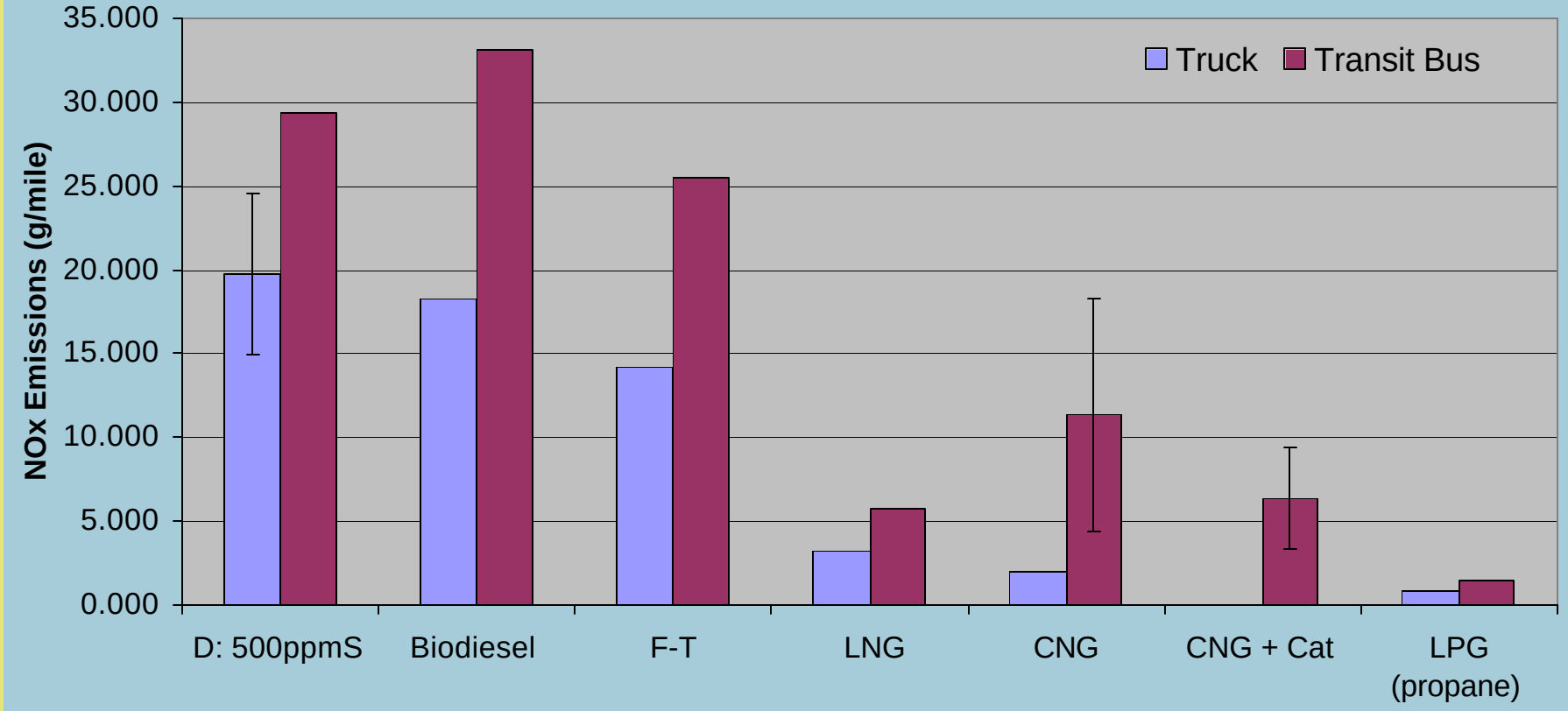

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Conclusions

- Despite the large estimated reductions in diesel PM, ARB predicts that over 250 excess cancer cases per million residents in California will still be attributable to diesel PM in 2020.

- Children and other sensitive populations need special protection from the adverse health effects caused by diesel exhaust.

- Since exposure cannot be prevented, the sources themselves – diesel engines – must be cleaned up.

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Final Conclusions

- The advances in diesel technology making new vehicles much cleaner are very positive. However, the NO_2 & NOx increases from new technology still must be addressed.

- If diesel vehicles and equipment cannot meet current or future emissions standards, which are designed to protect public health, those engines must be phased out.

- For older vehicles and equipment that will remain in use for many decades, here in the U.S. and abroad, the diesel industry must rise to the challenge of developing clean-up technology.

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