STUDY OF CNG AND DIESEL TRANSIT BUS EMISSIONS

April 22, 2004

Air Resources Board
California Environmental Protection Agency

Presentation Outline

- Project goals
- Description of emissions testing
- Highlights from study results
- Final remarks

Project Status

- Testing : 2001 - 2002
- Results reported at various venues:
  - publications
  - technical presentations
- Information in website:
  - http://www.arb.ca.gov/research/cng-diesel/cng-diesel.htm

Acknowledgements

- ARB multi-division effort:
  - Research Division
  - Stationary Source Division
  - Mobile Source Control Division
  - Monitoring and Laboratory Division
- Collaborators:
  - University of California, Davis
  - University of Connecticut
  - Clean Air Vehicle Technology Center
  - South Coast AQMD (co-funding)
  - The Gas Company (co-funding)
  - CA Natural Gas Vehicle Coalition
  - BP (fuel donation)
  - Los Angeles County Metropolitan Transit Authority

PROJECT GOALS

- Compare “clean” technology options for HD transit buses
- Fill research data gaps:
  - Evaluation of fuel and after-treatment
  - Assessment of driving cycle effects
  - Measure exhaust components of toxic risk significance
  - Investigation of ultrafine (<0.1μm) particle tailpipe emissions

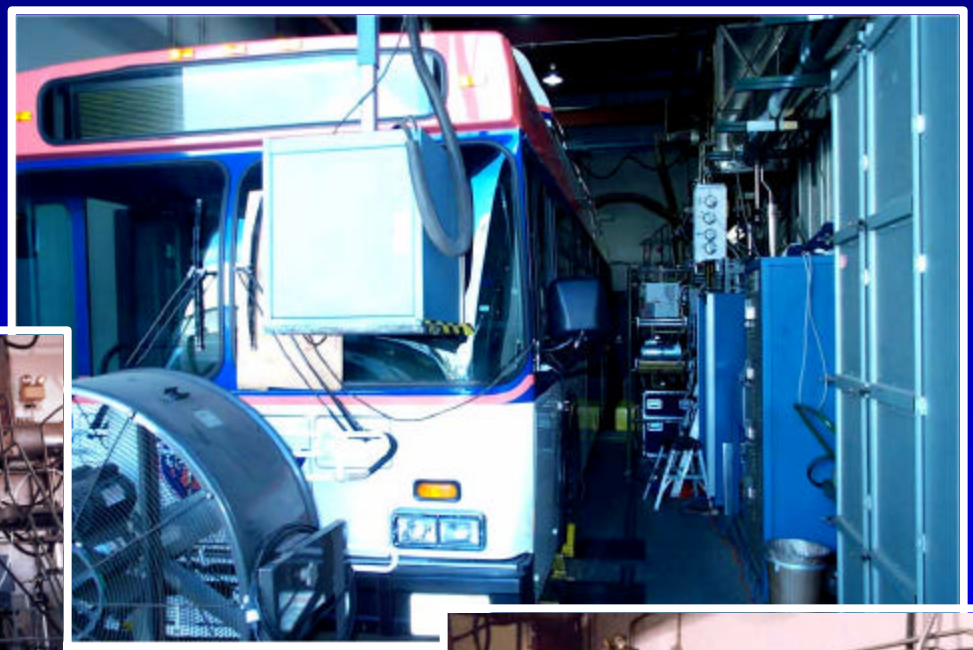
Three Test Buses*

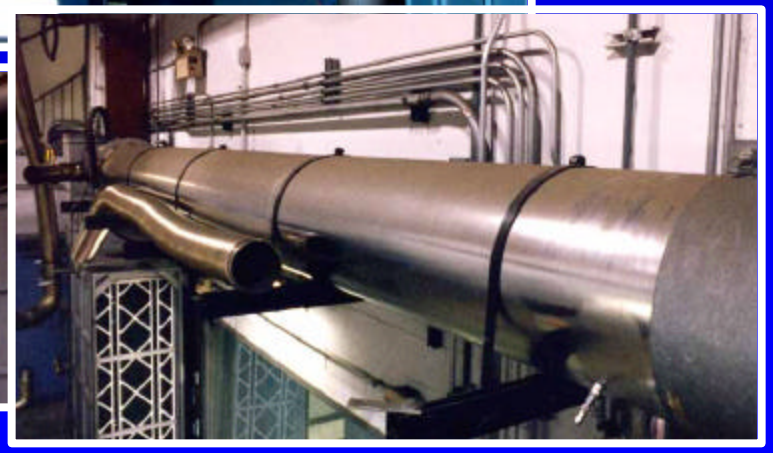
	Model Year	Engine Make	After-treatment	Fuel
Diesel	1998	DDC-S50	DOC CB-DPF	ULSD
CNG-1	2000	DDC-S50G	none OC	CNG
CNG-2	2001	Cummins-Westport C-Gas Plus	OC	CNG

***All 40 passenger, New Flyer chassis from So.Cal. public fleets tested "as-is"**

Test Facility

CARB Heavy- duty Emissions Testing Laboratory
Los Angeles





After-treatment for Transit Buses

DIESEL TRAP

Catalyst-based DPF (CRT™ by JMI)

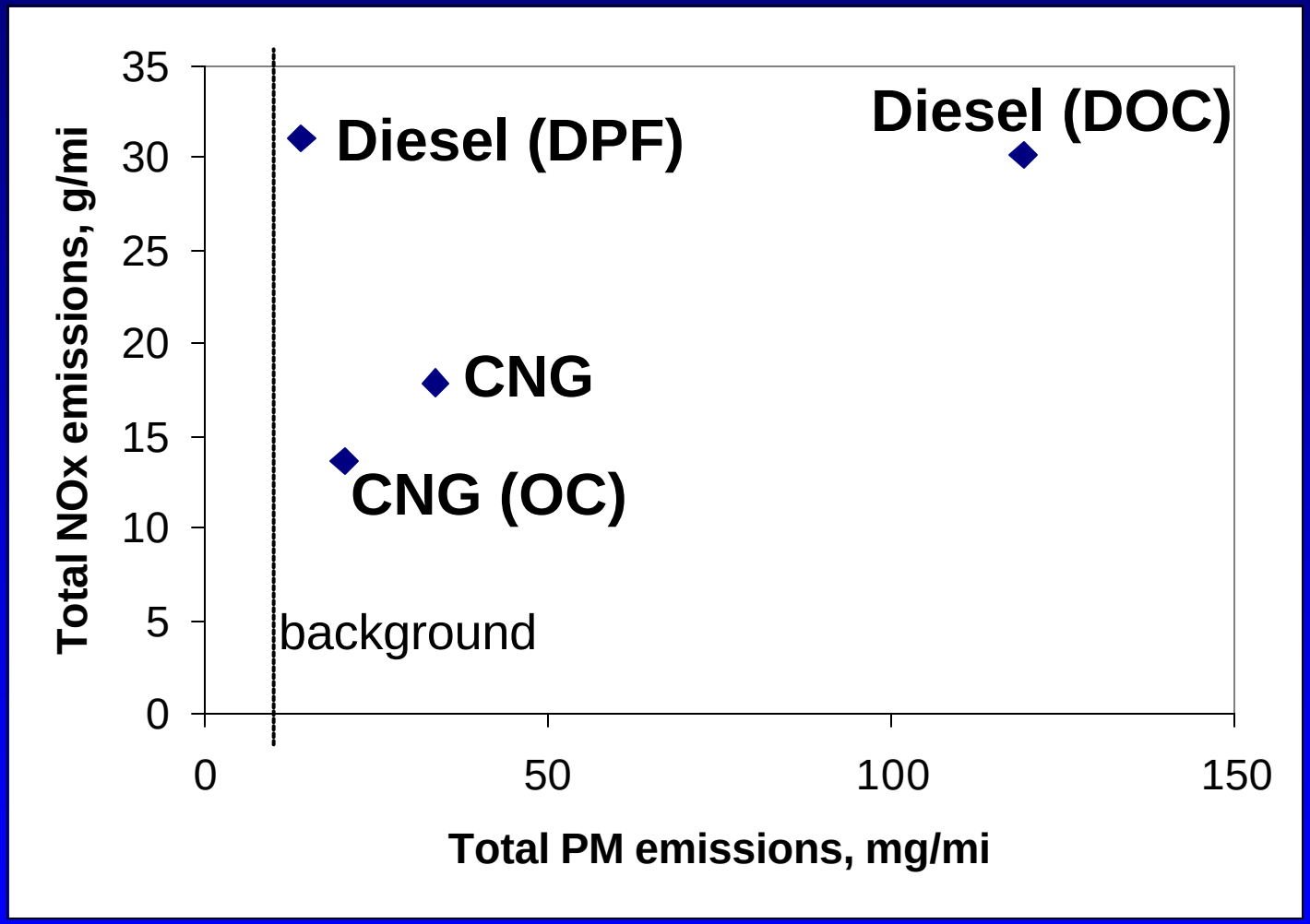
CNG

Oxidation Catalyst

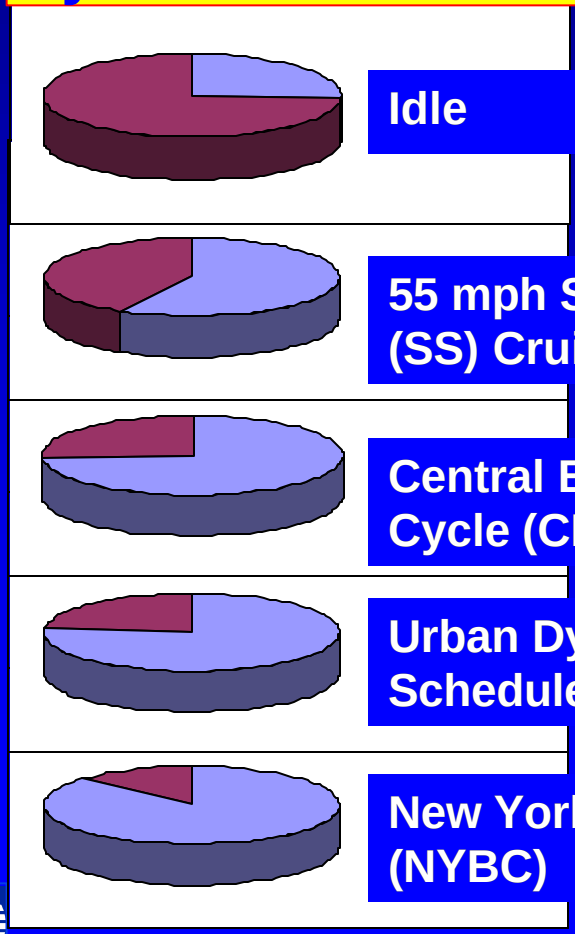
Experimental Approach

- Focus on criteria emissions and other pollutants of toxic significance
- Gaseous emissions:
  - NO_X, NO_2, CO, CO_2,
  - Total Hydrocarbons, CH_4/NMHC, and VOCs
- Particulate matter emissions:
  - Total PM, metals, and elemental and organic carbon
  - Ultrafine particle number and size
- Phase distribution (PM / volatile / semi-volatile) of:
  - Mutagenicity via bioassay (modified Ames Assay)
  - Polycyclic aromatic hydrocarbons

NO_X and PM Emissions (CBD)

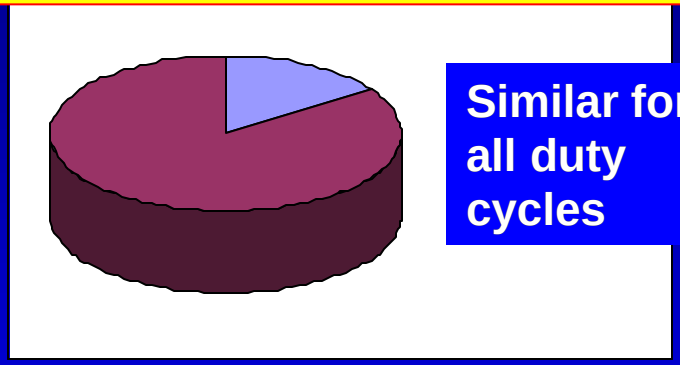


Diesel PM composition depends on duty cycle



Increasing cycle aggressiveness

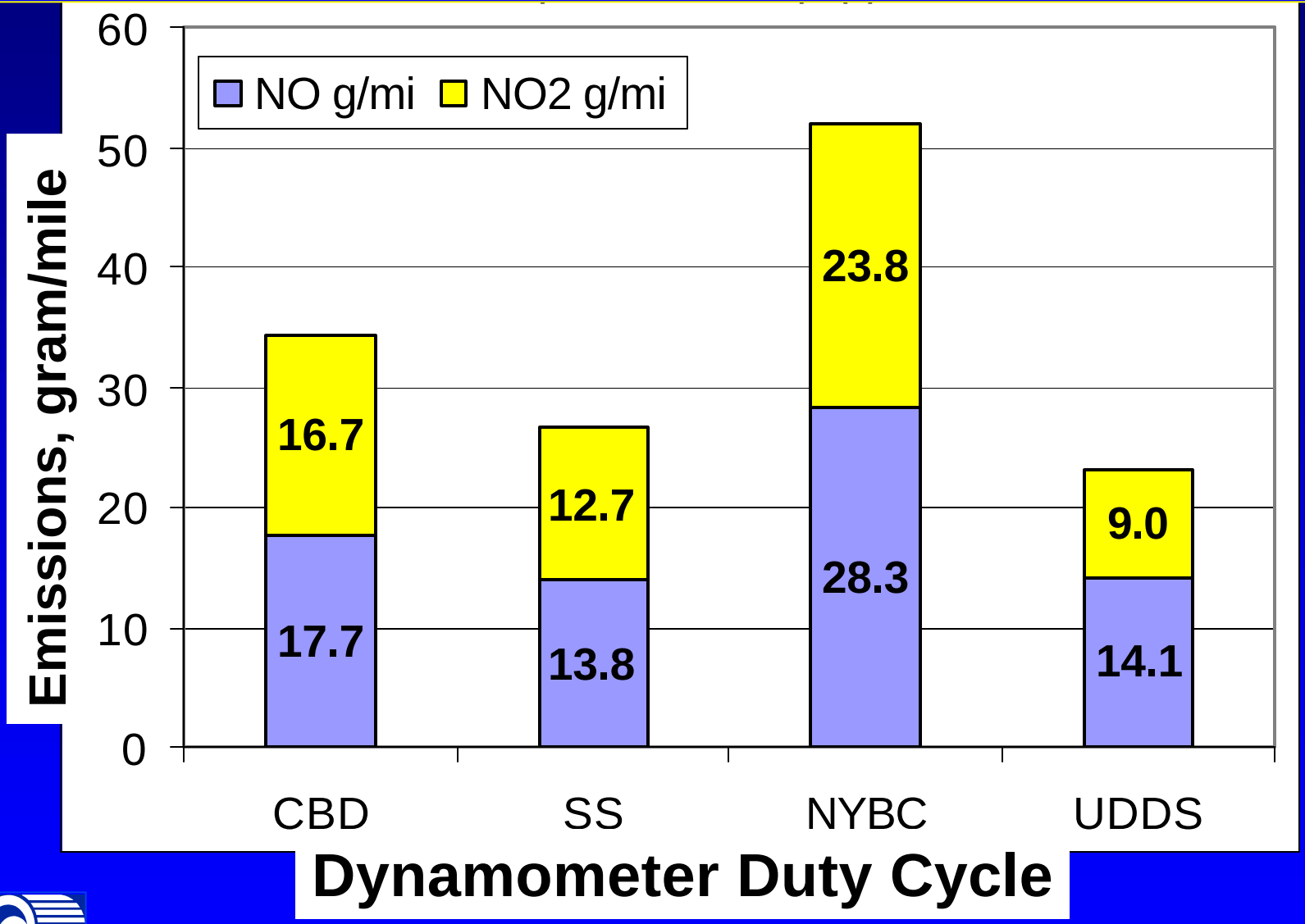
Diesel trap PM and CNG PM composition less dependent on duty cycle



Elemental Carbon

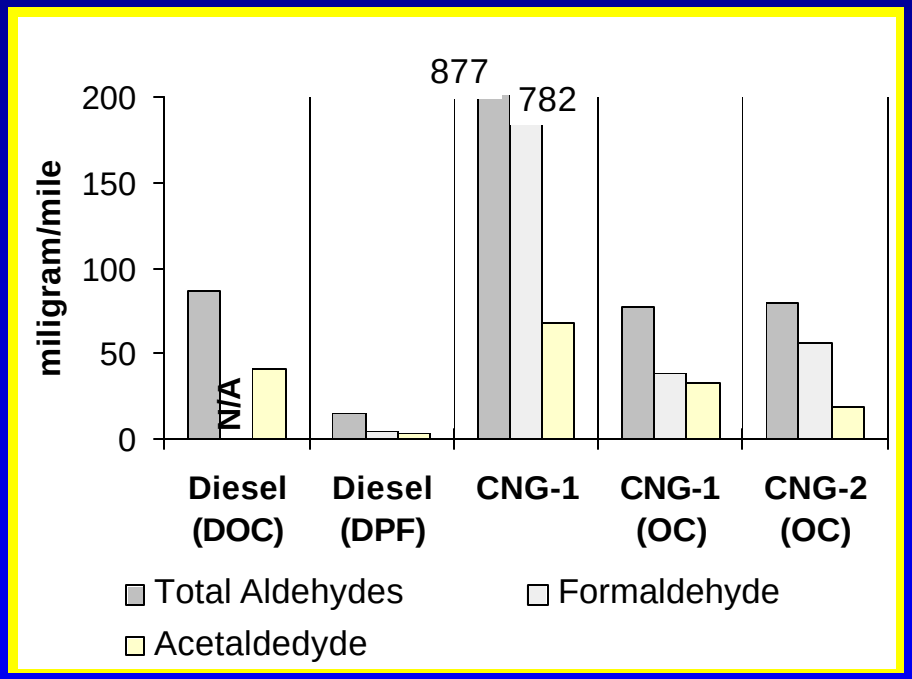
Organic Carbon

NO & NO_2 Emissions from Trap-equipped Diesel

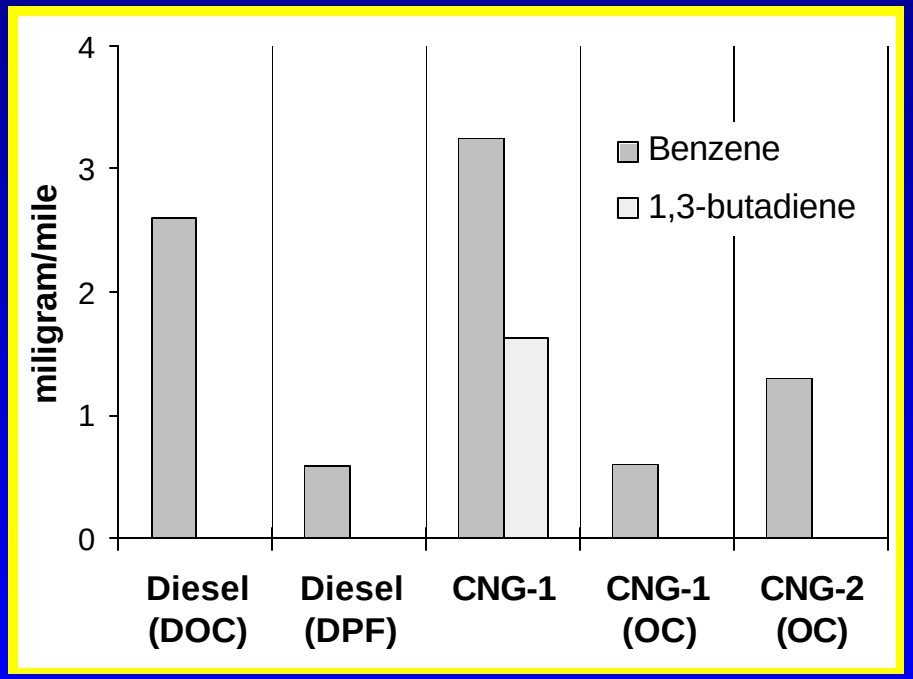


Non-regulated Emissions (CBD)

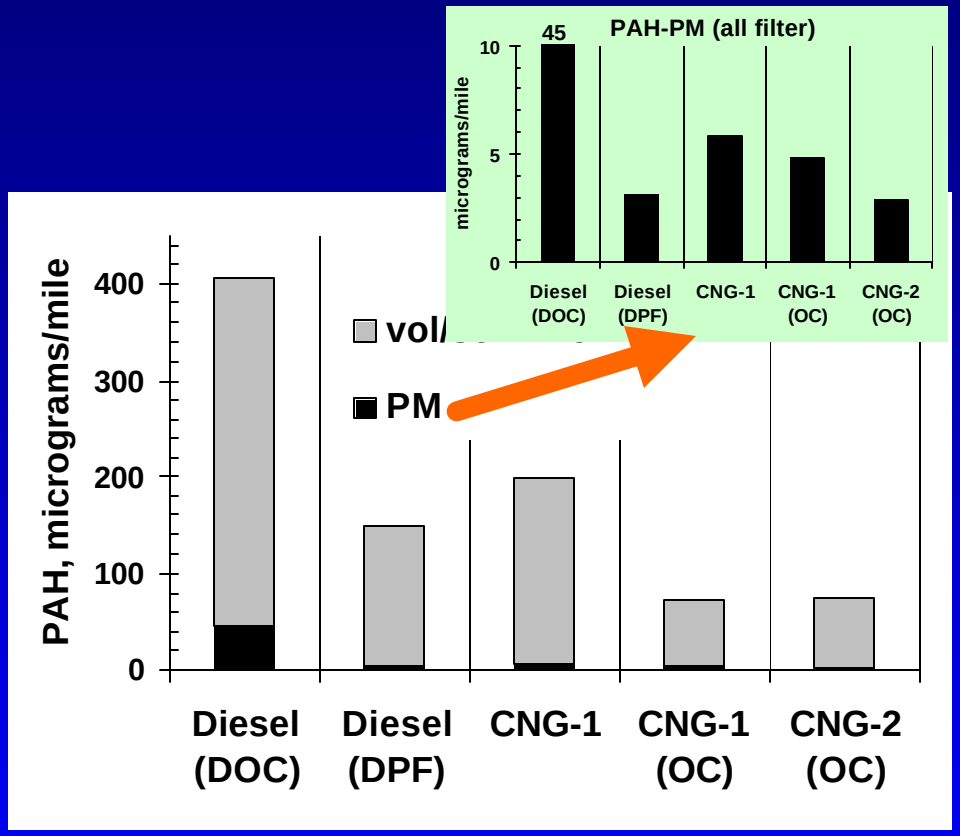
Carbonyls



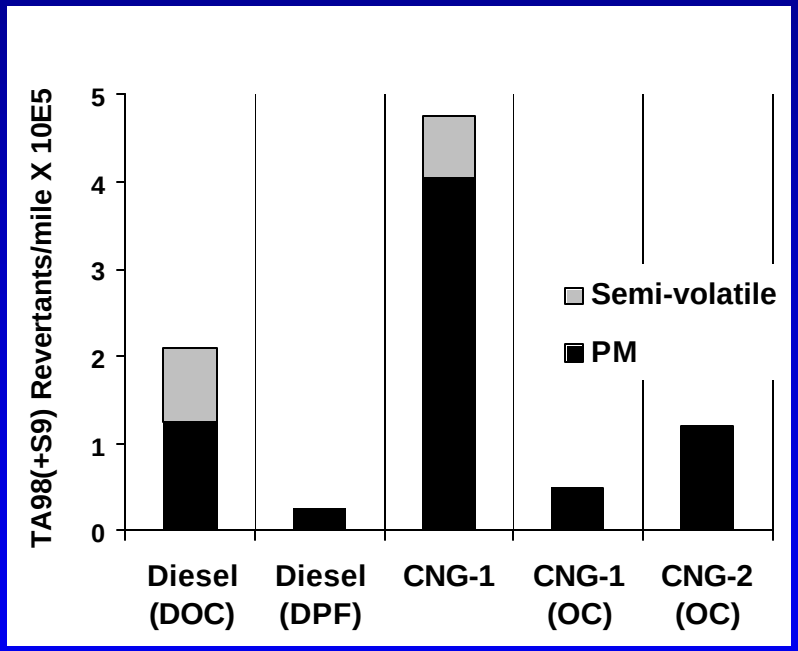
VOCs



Non-regulated Emissions (CBD) – cont'd



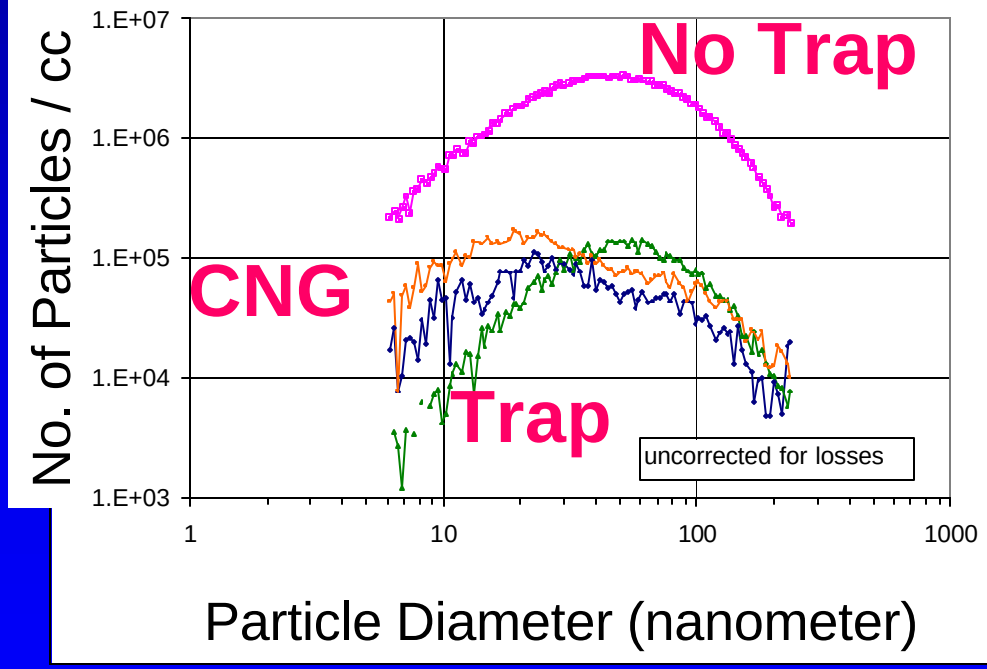
Polycyclic Aromatic Hydrocarbons



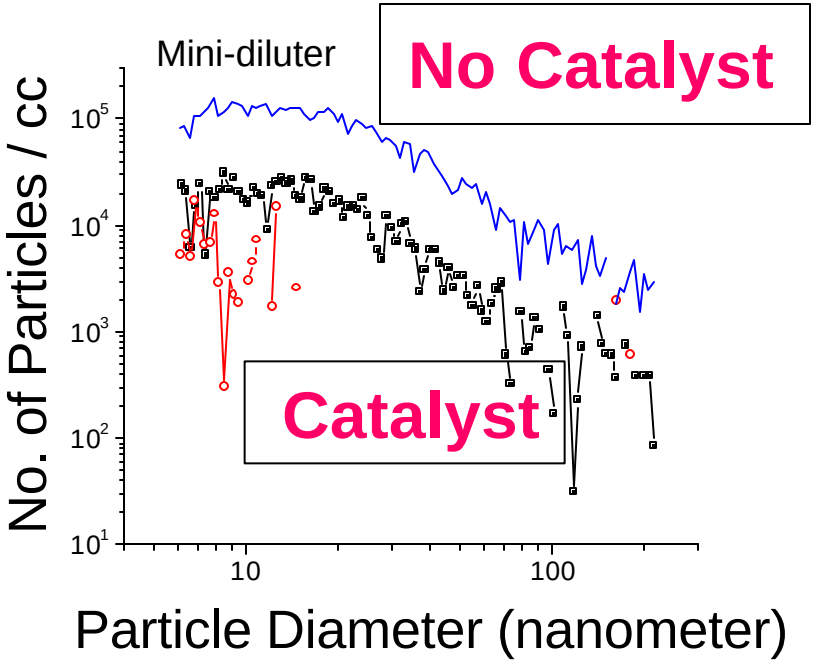
Mutagenecity

Ultrafine Particle Size Distribution

Trap Diesel and CNG Comparison



Oxidation Catalyst for CNG



Final Remarks

- "Clean" alternatives can benefit from additional control and improvement
- Diesel trap changes PM composition, reduces toxic emissions, but emits high NO_2
- CNG emits lower NO_X, but higher formaldehyde. Catalyst reduces formaldehyde
- Lubricating oil most likely plays a key role in PM toxicity
- When comparing results, difficulty arises because diesel PM is a TAC whereas CNG PM has no such designation
- ***Durability, deterioration, and maintenance were not evaluated***