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Impacts of Changing Particulate Emission Profiles Session

Comparison of Emissions from Diesel and CNG Buses with After-treatment

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Project Background

- CARB has reported benefits offered by diesel transit bus with a trap and low-sulfur fuel relative to benefits offered by CNG transit bus without after-treatment

- This presentation focuses on comparison of same diesel bus relative to CNG bus outfitted with OEM catalyst

An "apples-to-apples" comparison of "state of the art" technology based on speciated emission profiles

	Diesel Bus (Diesel_Trap)	CNG Bus (CNG_OxiCat)
engine	1998 DDC Series 50	2001 Cummins Westport C Gas Plus
fuel	BP/ARCO's ECD-1 (15 ppm sulfur)	(pipeline) CNG meeting CARB spec's
after-treatment	JMI's CRT™	OEM Catalyst
Chassis	New Flyer 40 passenger	New Flyer 40 passenger

Scope of Presentation

- **Chassis dynamometer testing at CARB's Heavy-Duty Emissions Laboratory in Los Angeles**
- **Central Business District Cycle (particle sizing under steady state)**
- **Exhaust Emission Profile Speciation:**
  - **Criteria gases and PM**
  - **Unregulated gases, toxic hydrocarbons, and mutagen emissions**
- ***Other info. available: Steady Steady results, additional assay results, metals and carbon emissions, and ultrafine particle size characterization (to be reported by CARB in future publications)***

After-treatment for both diesel bus (i.e. trap) and CNG bus (i.e. catalyst) results in significant reduction of emissions relative to uncontrolled levels.

References: SAE Tech. Paper 2003-01-1900

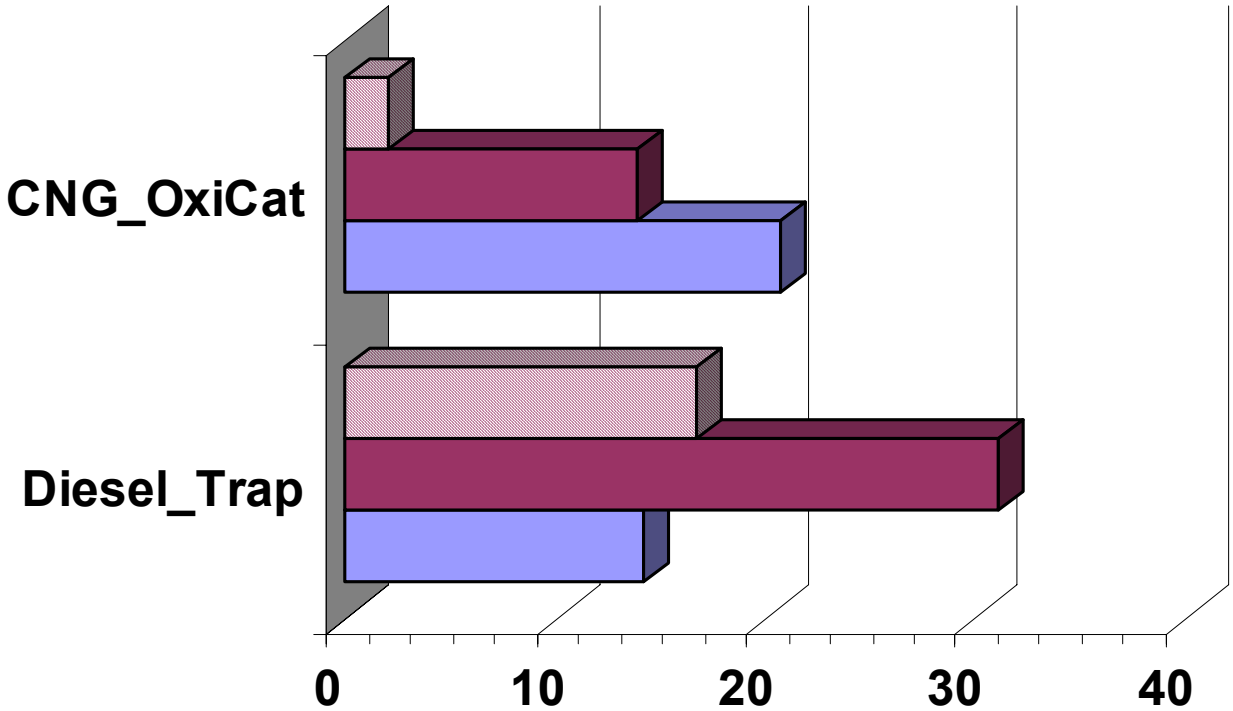
Environ. Sci. Technol. 2002, Vol. 36, No. 23, pp.5041-5050

AAAR Conference, Oct. 2002, Charlotte

6th ETH Nanoparticle Conference, Aug. 2002, Zurich

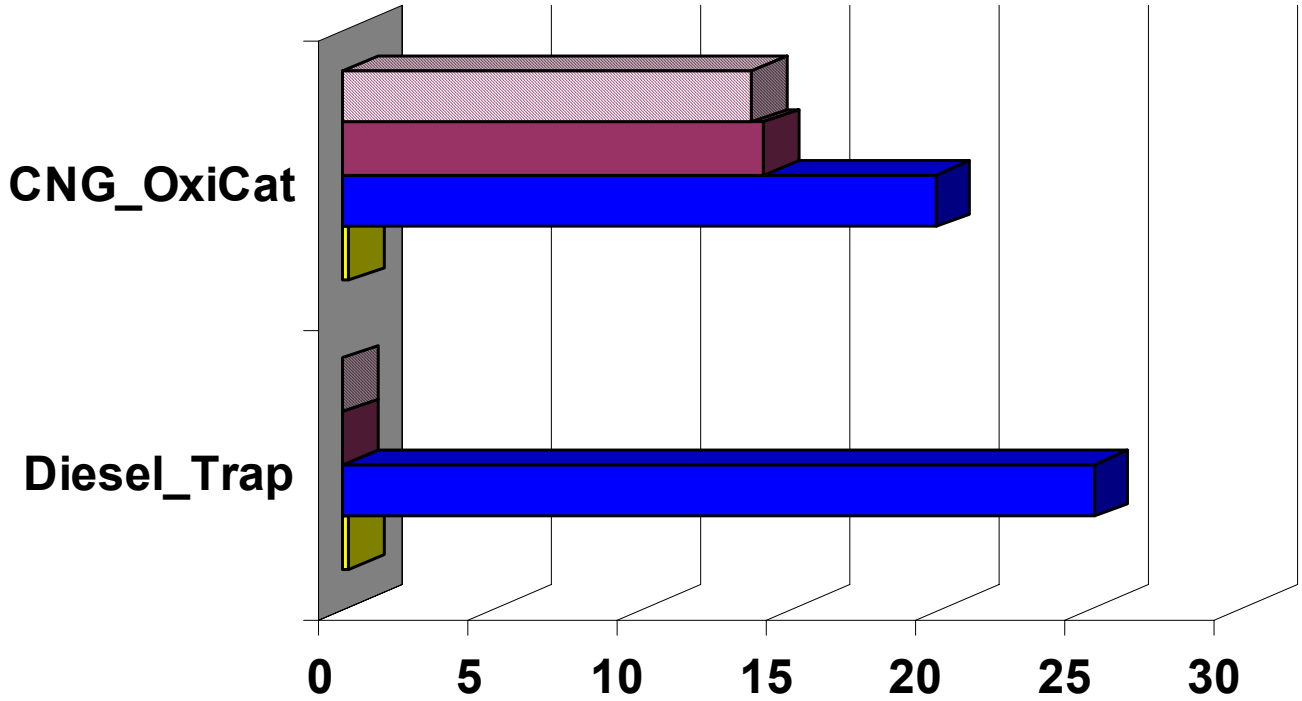
SAE Tech. Paper 2002-01-1722

Average PM and NOx Emissions - CBD



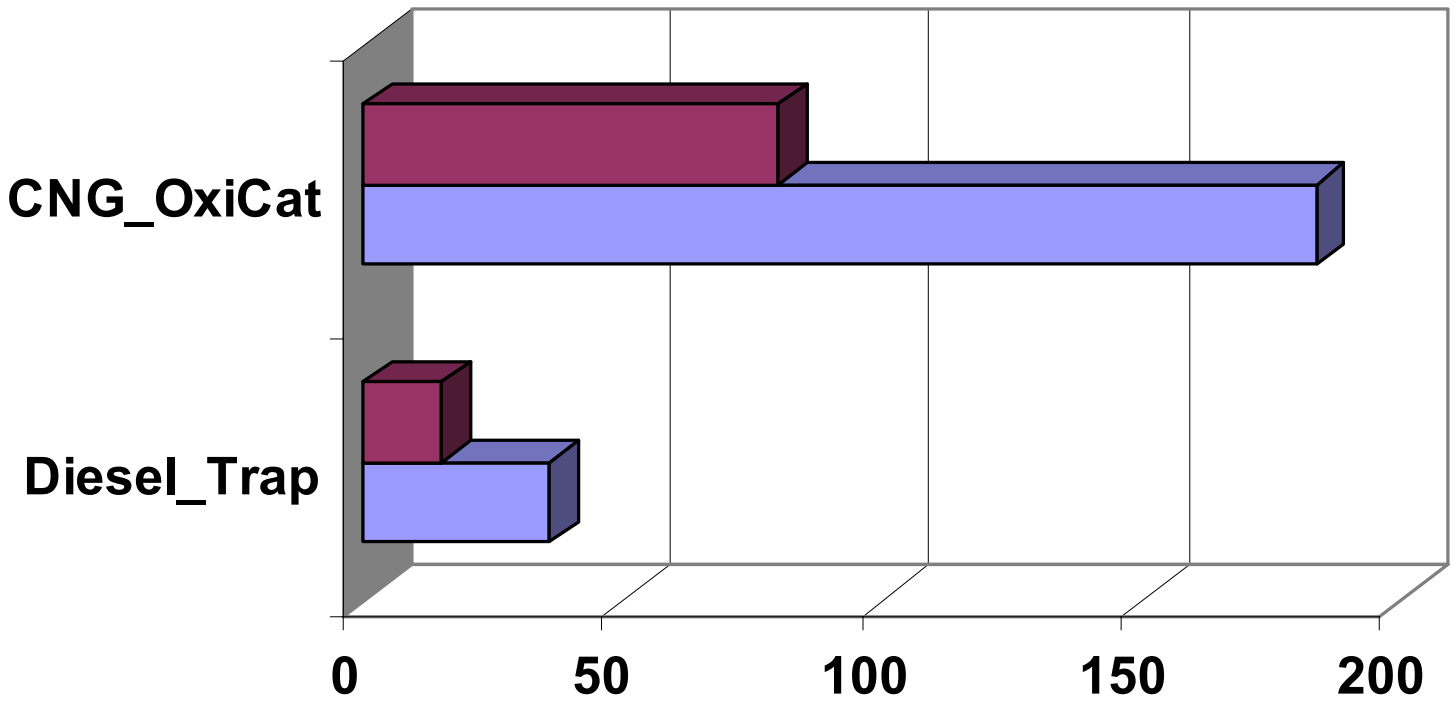
	Diesel_Trap	CNG_OxiCat
NO2, g/mi	16.7	2.1
NOx, g/mi	31.1	13.9
PM, mg/mi	14.2	20.7

Average HC, CO2, and CO Emissions - CBD



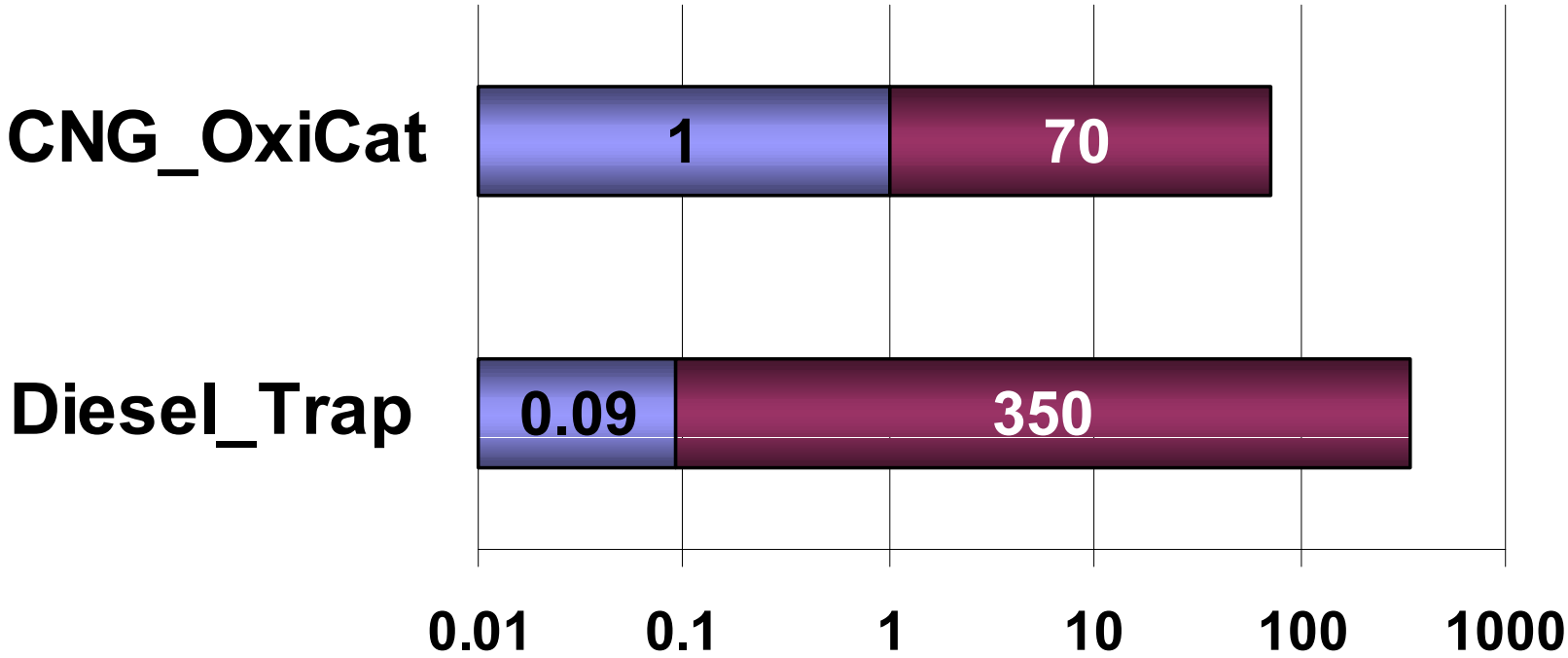
	Diesel_Trap	CNG_OxiCat
CH4 (GC), g/mi	non-detect	13.7
THC (FID), g/mi	non-detect	14.1
CO2/100, g/mi	25.13	19.87
CO, g/mi	0.2	0.2

Average NMOG Emissions - CBD



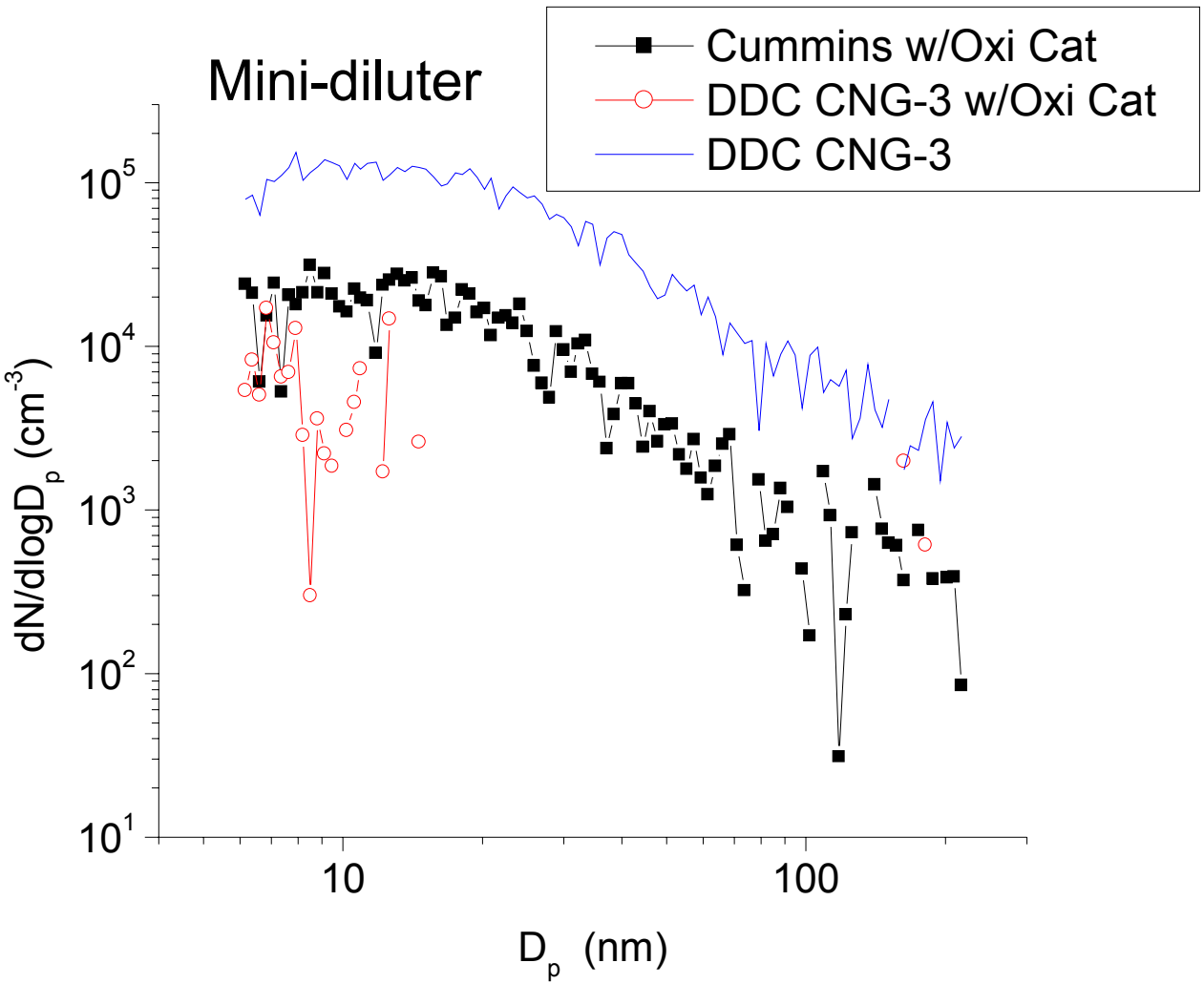
	Diesel_Trap	CNG_OxiCat
Carbonyls, mg/mi	15	80.1
NMHC, mg/mi	36	184

Average PAH Emissions - CBD

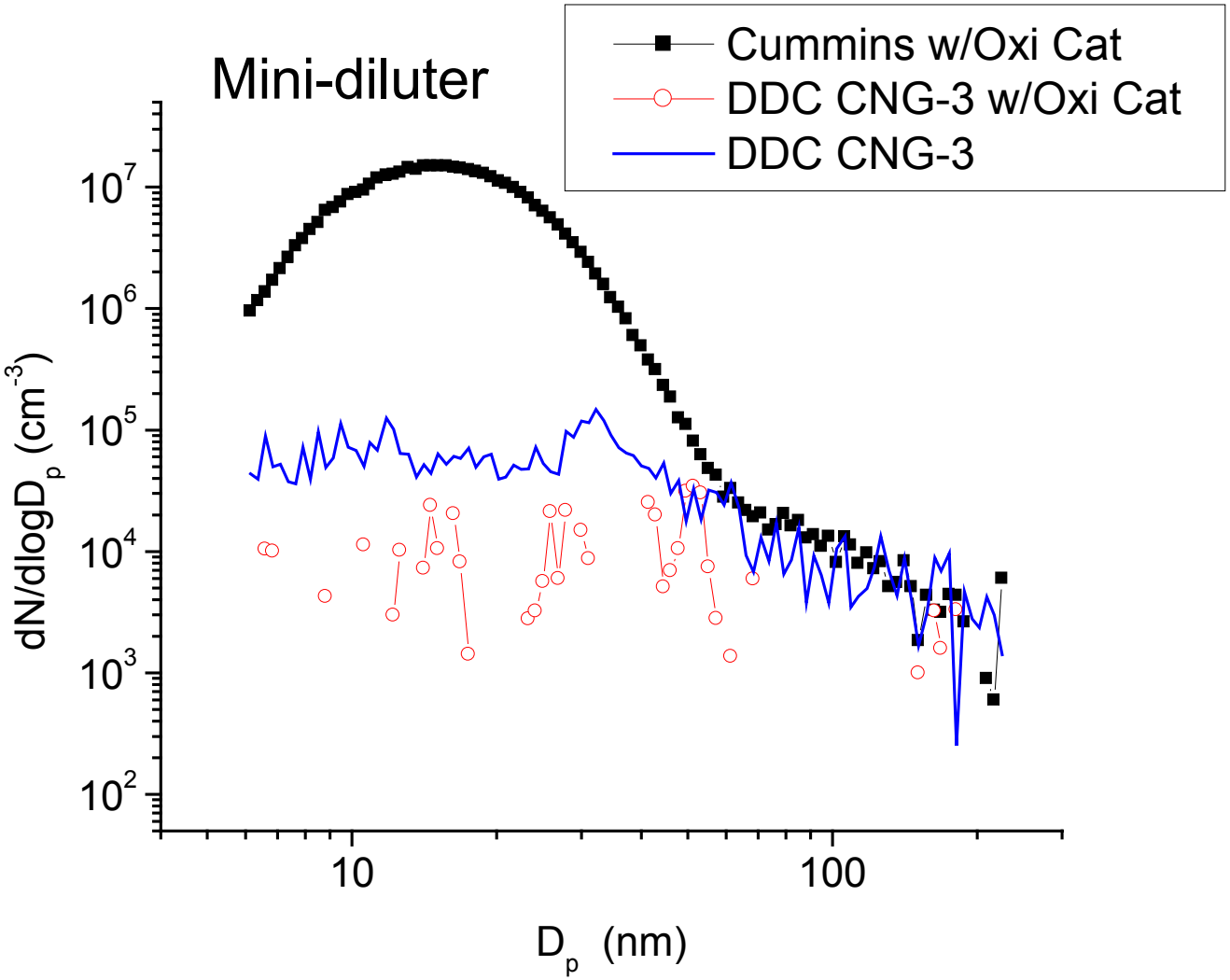


	Diesel_Trap	CNG_OxiCat
Light PAHs, (ug/mi)	350	70
Heavy PAHs, (ug/mi)	0.09	1

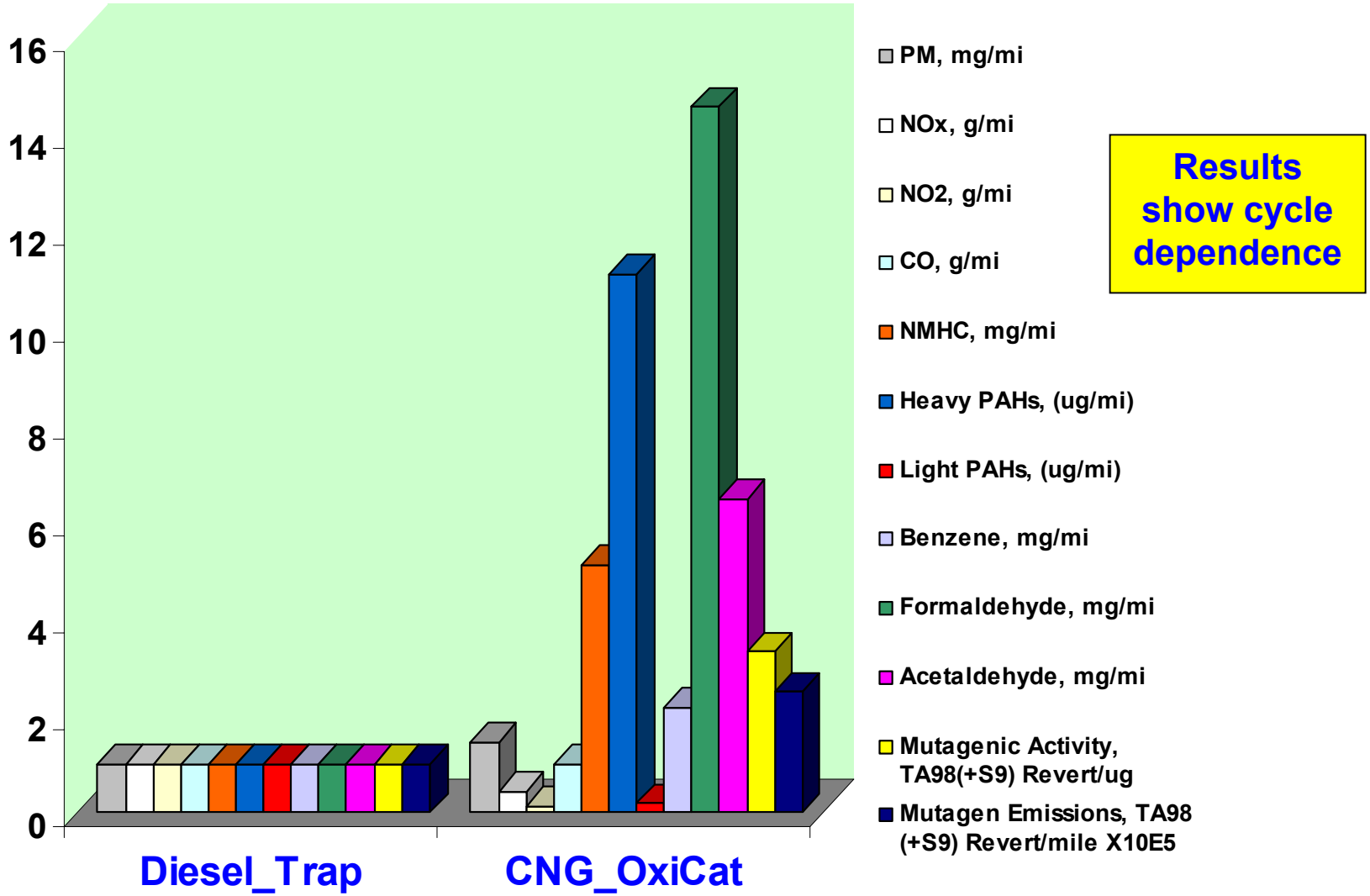
CNG Buses: Steady-State Cruise (55 mph)



CNG Buses: Idle



Relative Tailpipe Average Emission of Species of Toxic Significance - CBD



Summary of CBD Results

- CNG_OxiCat and Diesel_Trap total PM emissions are similar and CO emissions are the same.
- CNG_OxiCat offers potential reductions for NOx, NO2, CO2, and PAH emissions.
- Diesel_Trap offers potential reductions for HC, carbonyls, benzene, and mutagen emissions.

http://www.arb.ca.gov/research/cng-diesel/cng-diesel.htm

Final Remarks

- CNG catalysts reduce ultrafine particle numbers for some operating conditions.
- Results show duty cycle dependence.
- Results support dual fuel path regulations for California.
- Results are “snap-shot” of two buses only.
- As technology evolves, emission profiles will change.
- After-treatment durability, deterioration, and vehicle maintenance effects were not investigated.
- Dilution tunnel background concentrations are important factors. Tunnel blank is not constant or negligible.

Further Research Needs

- How to use results to determine toxicity equivalency?
- CNG PM is not a Toxic Air Contaminant (TAC) while Diesel PM is a TAC. This includes after-treatment.
- Results must be confirmed. Concurrent studies by: BP/ARCO, USDOE, International, MTC, others?