CNG Emissions Research

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California Air Resources Board

Research Division

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Purpose

- Characterize emissions from CNG powered engines:
  - Criteria pollutants
  - Greenhouse gases
  - Chemical speciation
  - Toxic species, and toxicity assays
- Light duty and heavy duty
  - Understand the effect of new emission control technologies (oxidation catalyst, TWC, etc.)
- Put results into context of diesel and other light duty combustion technologies
- Develop data and understanding that feed into inventories and inform decision makers

Light Duty – Current Work

Characterizing Physicochemical and Toxicological Properties

NO.	Fuel	Technology
Veh1a	**Gasoline**	**PFI**
Veh1b	**E-85**	**PFI**
Veh2	**CNG**	**PFI**
Veh3a	**Gasoline**	**GDI**
Veh3b	**Gasoline**	**GDI +GPF**
Veh4	Gasoline (high-emitter)	PFI
Veh5	Diesel	DI
Veh6	Biodiesel	DI
Optional		
Veh7	Hybrid	PFI

Completed

On-going

Light Duty – PM Filters

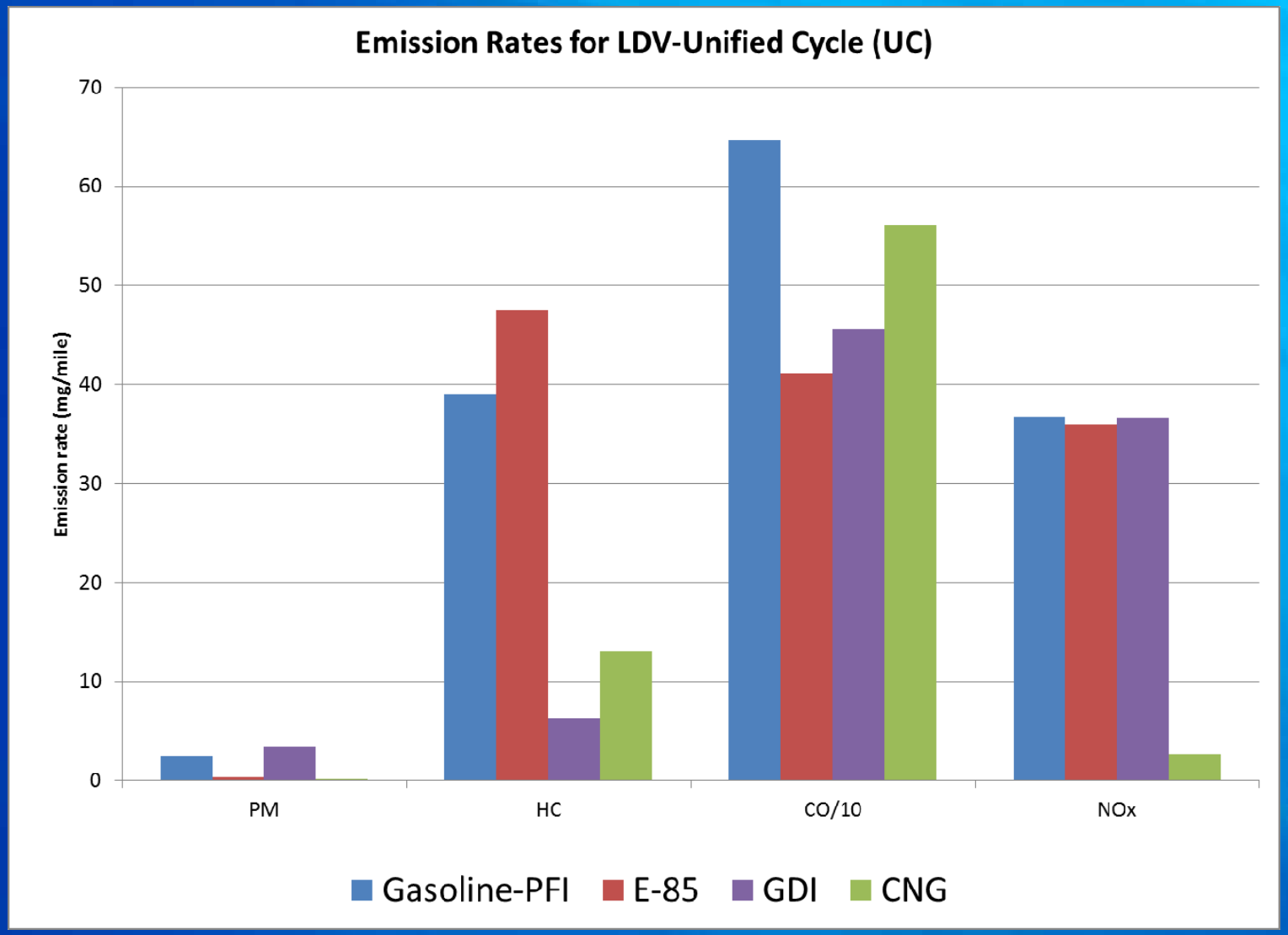
Gasoline

GDI

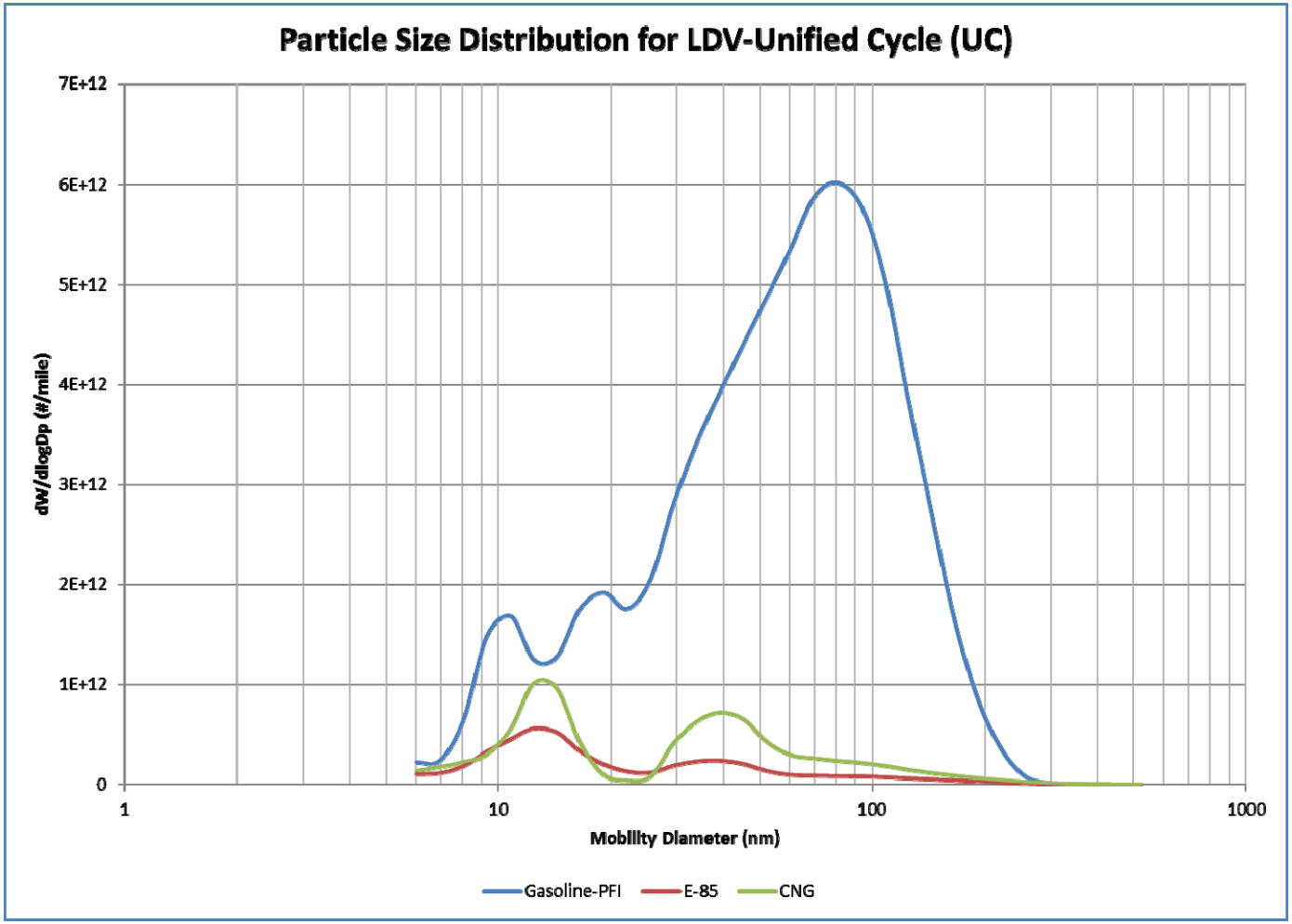
E-85

CNG

Light Duty

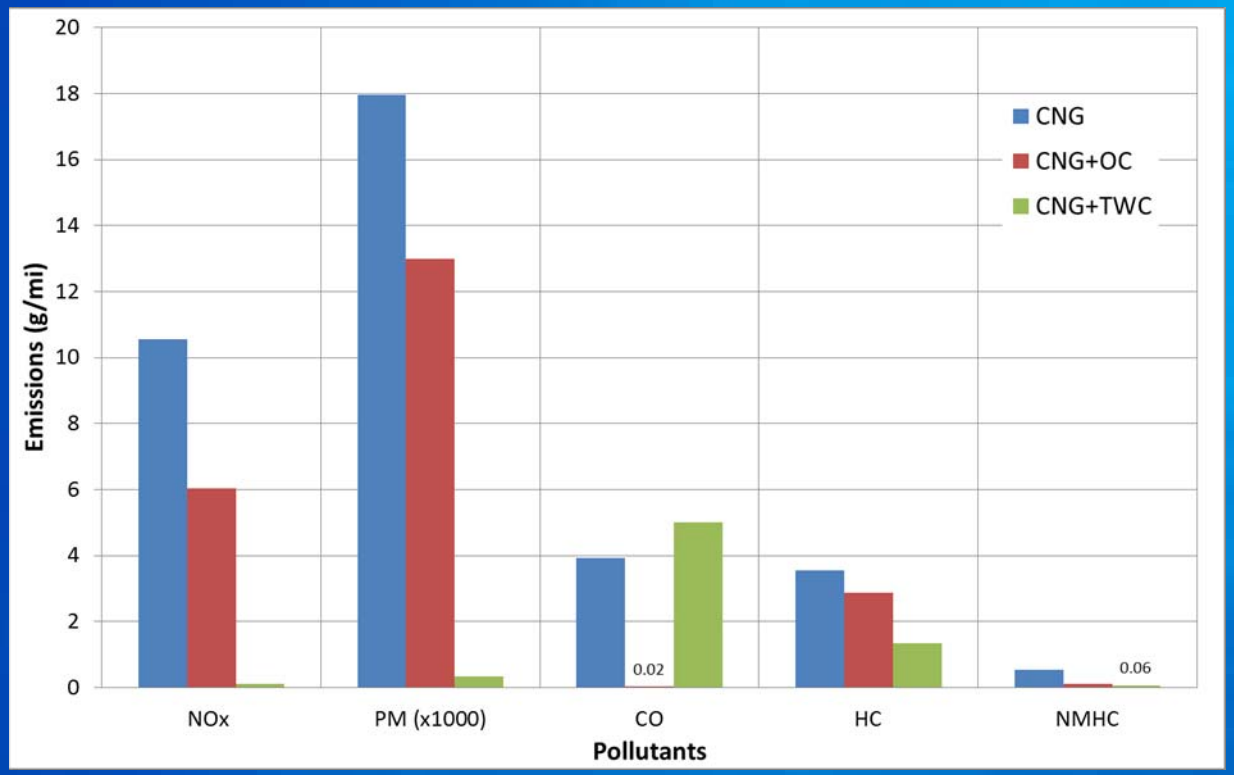

Emission Rates for LDV-Unified Cycle (UC)
Emission rate (mg/mile)
70
60
50
40
30
20
10
0
PM
HC
CO/10
NOx
Gasoline-PFI
E-85
GDI
CNG

Light Duty


Particle Size Distribution for LDV-Unified Cycle (UC)
7E+12
6E+12
5E+12
4E+12
3E+12
2E+12
1E+12
0
dN/dlogDp (#/mile)
1
10
100
1000
Mobility Diameter (nm)
Gasoline-PFI
E-85
CNG

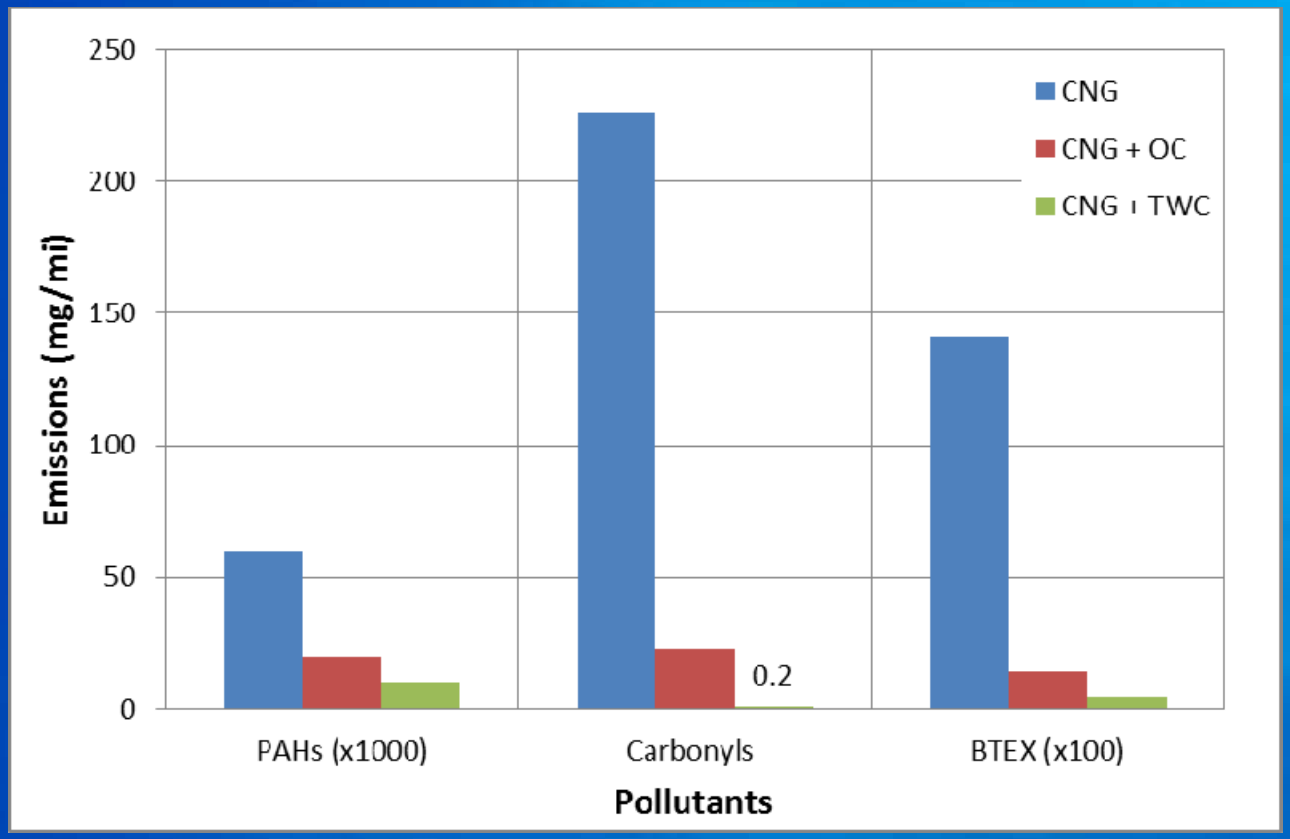
CNG Busses

- Uncontrolled lean burn CNG – 2000
- Lean burn CNG with Oxidation Catalyst – 2001
- Stoichiometric with Three-way Catalyst - 2010



CNG Busses

Non criteria pollutants



Toxicological Assays

Assays:

Many exist. It would be beneficial if the community agreed on a set that in aggregate could provide an indication of toxicity and allows for relative comparisons.

Type	Name	Toxicological Effect Measured
Chemical Assays	DTT	Oxidative activity
	DTT+DTPA	Oxidative activity attrib.to metals
Cellular in vitro Assays	Macrophage ROS	Oxidative Activity
	Inflammatory and Oxidative markers mRNA	Inflammatory and oxidative activity
Genotoxicity Assays	Ames Bioassay	Mutagenicity
	Comet Assay	DNA damage

Toxicological Assays

Study:	Chemical Assays		Cellular in vitro Assays		Genotoxicity Assays	
	DTT	DTT + DTPA	Macrophage ROS	Inflammatory and Oxidative Markers mRNA	Ames bioassay (mutagenicity)	Comet Assay
Phase I					x	
Phase II HD	x		x	x[1]	x	x[1]
WVU CNG	x	x	x	x[1]	x	*not enough sample*
Biodiesel				x	x	x
Phase II LDV	x	x	x	x	x	x
2010 HD Diesel	Planned for January 2012					
Small Eng./other	*Possible future testing not yet planned*					

[1] If enough sample is available

Study	Year done	Technologies Tested
Phase 1	2000-2001	Transit buses: CNG with and without OC, Diesel w/ DPF
Phase II	2007	HD Diesel with DPF and SCR retrofits
WVU CNG	2010	2010 compliant Stoic CNG w/TWC
Biodiesel	2009-2011	2000, 2006 and 2007 model year HD diesel tested on a large matrix of bio and renewable diesel
Phase II LDV	2011-2012	LDVs: gasoline, E85, CNG, GDI, GDI+GPF, high emitter, diesel, biodiesel
2010 HD Diesel	2012	2010 compliant HD Diesel with DPF and SCR
Small Engines	TBD	Motorcycles, leaf blowers, lawn mowers, generators, etc
Other	TBD	Ships, off road, construction and ag.

Results from CNG will be ready in 2012

What is next ?

Open research questions for CNG

- Issues of ammonia from 2010 compliant CNG
- Evaporative emissions
- Total greenhouse gas emissions (CH_4, N_2O, CO_2)
- Others??

Questions?

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