Relative toxicity of old and new technology heavy- and light-duty mobile source PM

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Health Effects Institute
Workshop on Effects on Fuel Composition on PM
Chicago, Illinois.
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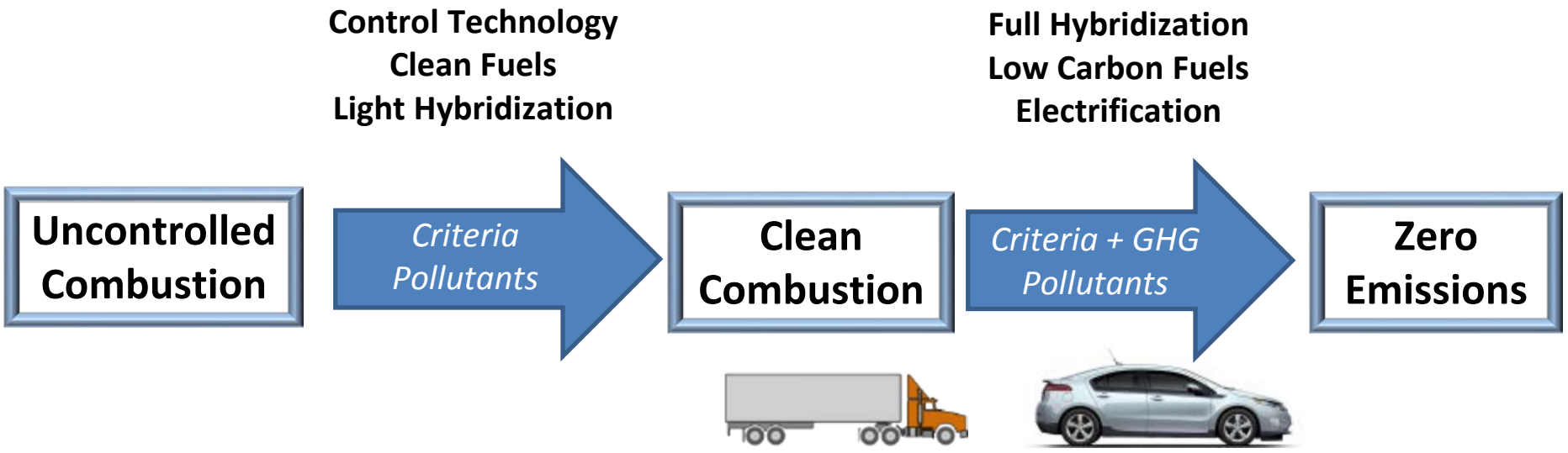
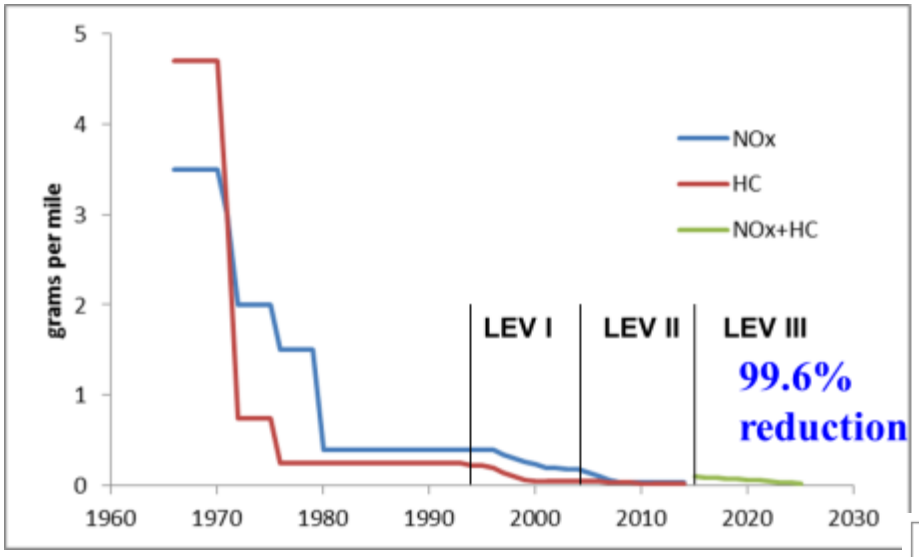
The Path to Zero Emissions

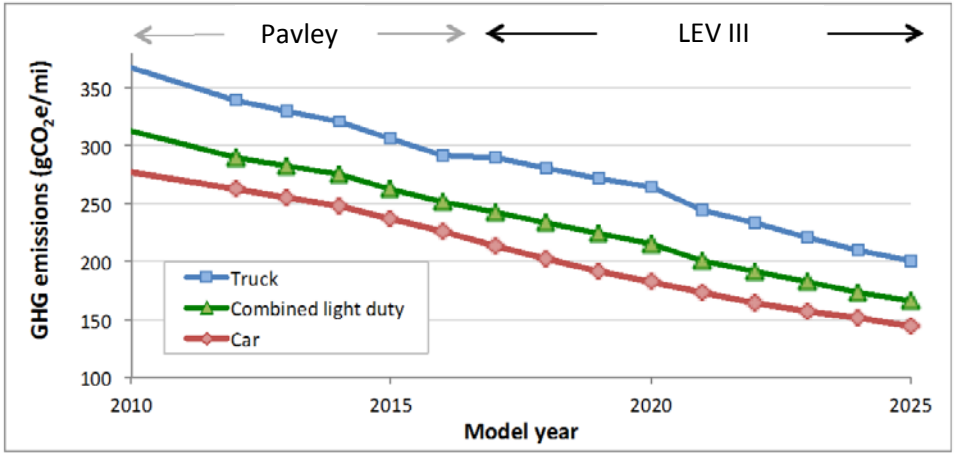


Light Duty Vehicles



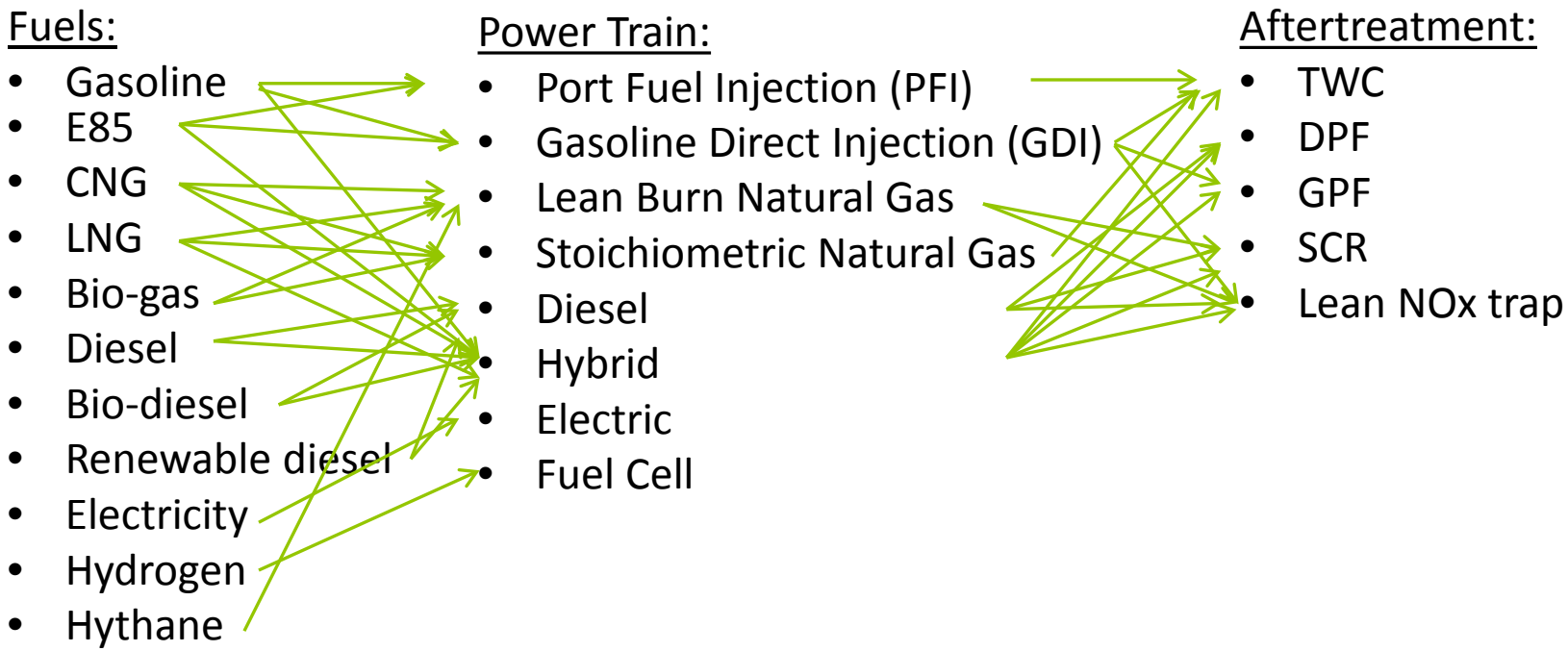
Drastic reductions in criteria pollutants achieved and ahead of us.

Need for significant reductions in greenhouse gas emissions moving forward.

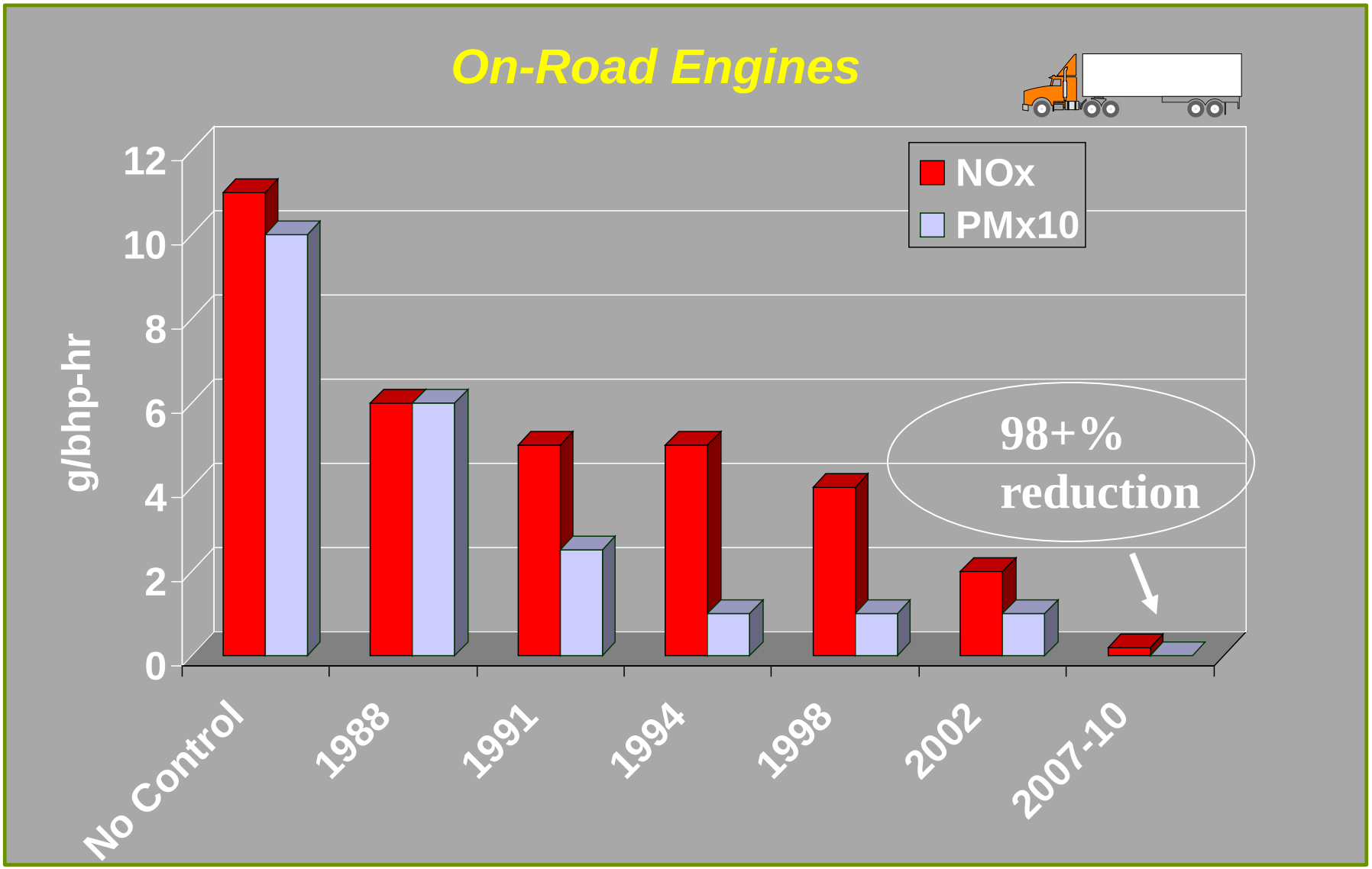


Light Duty Vehicle Technology

The need for reduction in exhaust emissions has led to an ever larger suite of technologies and fuels currently in use



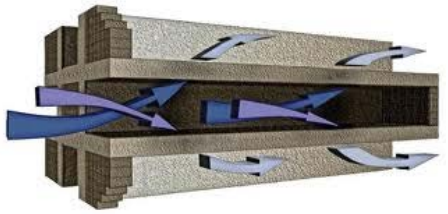
Heavy Duty Vehicles



Heavy Duty Vehicles

2007 – <u>PM standard lowered 90%</u>

Diesel needs DPF



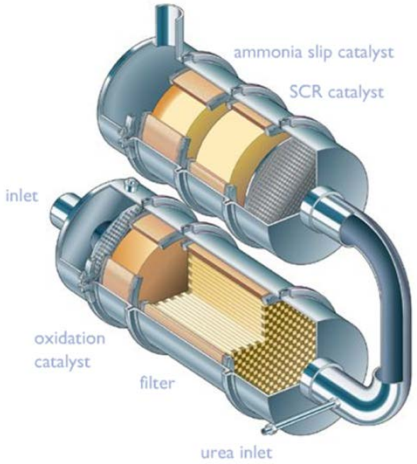
2010 – <u>NOx Standard Lowered 90%</u>

Diesel needs DPF and SCR

Natural Gas:

Lean Burn with SCR

Stoichiometric with TWC



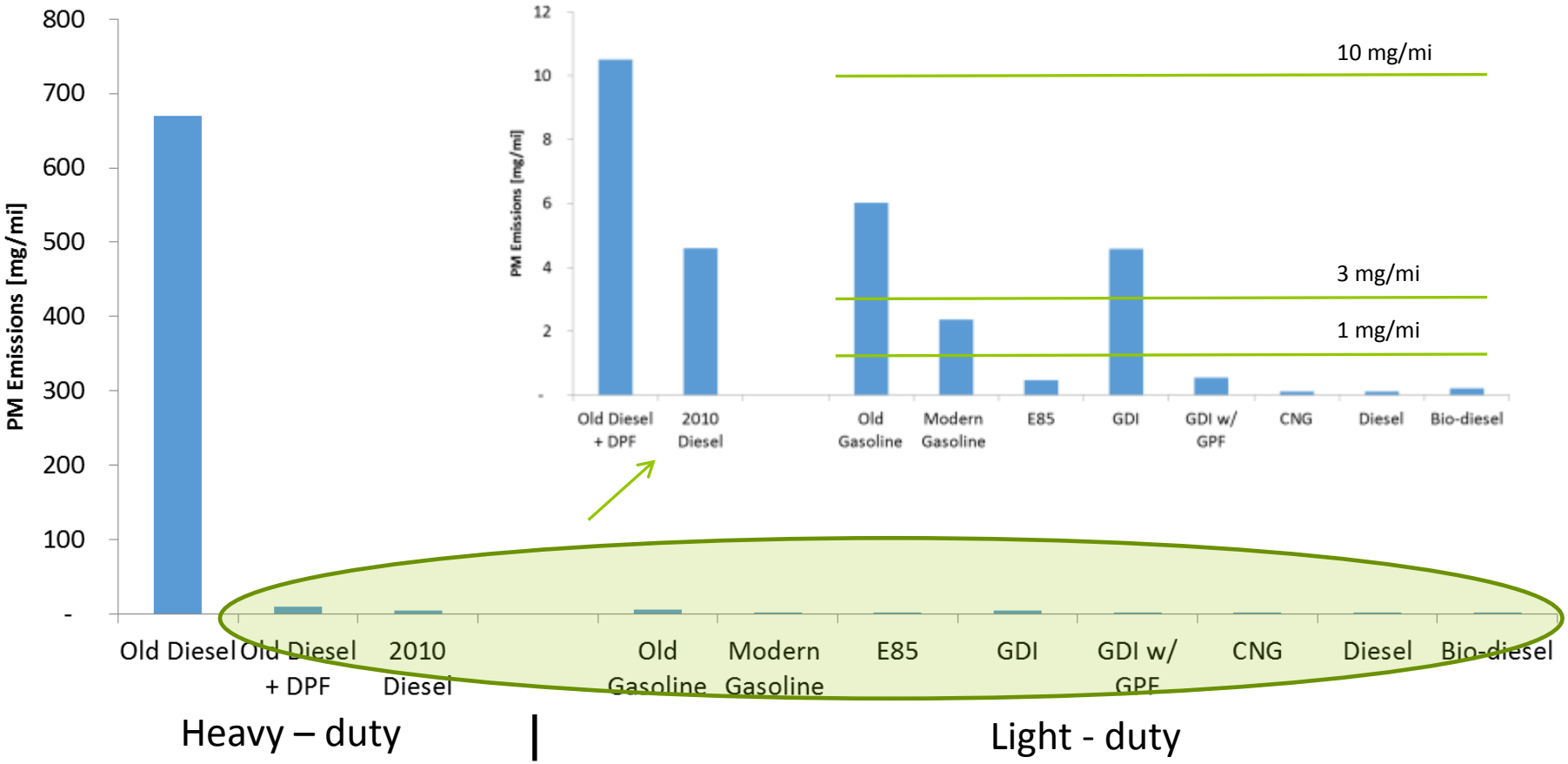
Exploring Relative Emissions

Test Matrix

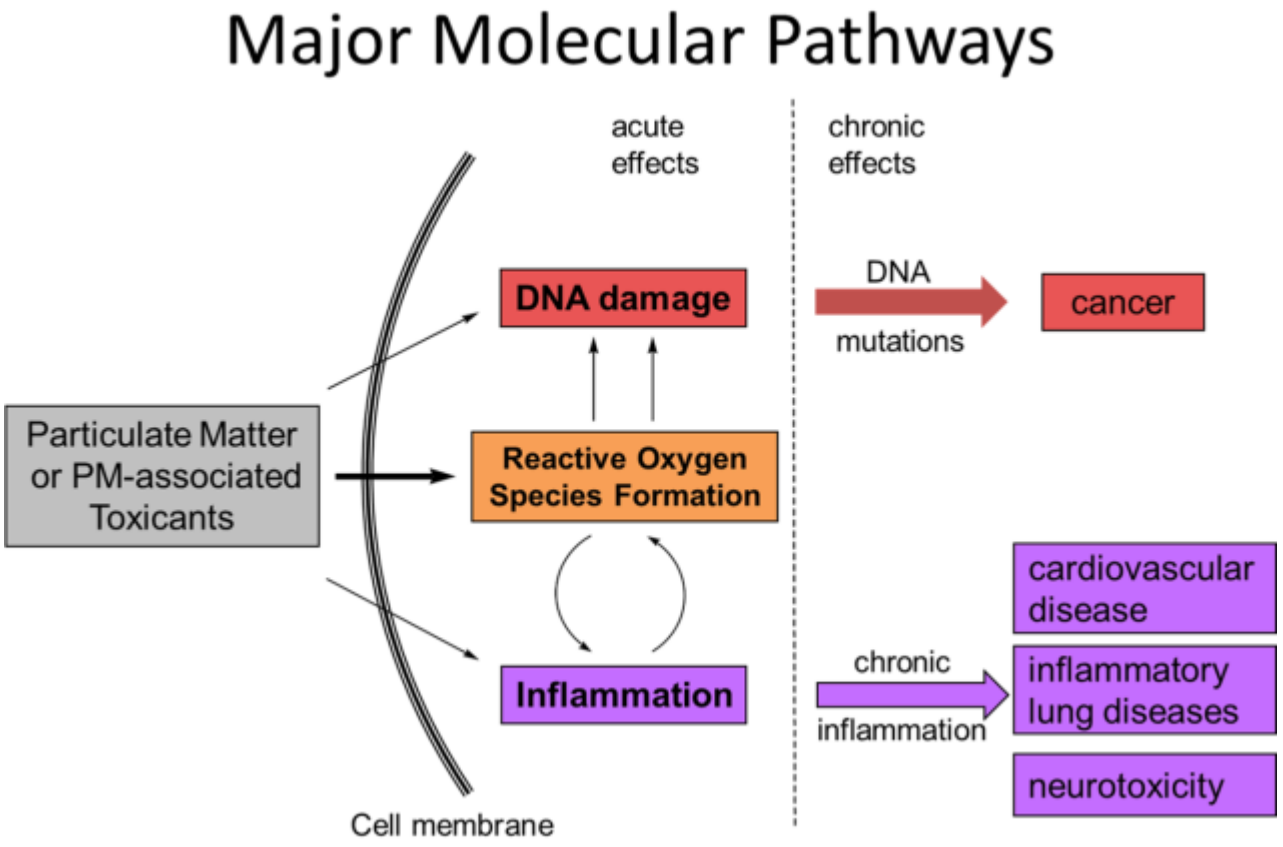
		Vehicle	Make	Model Year	Mileage
Heavy Duty		Old Diesel	Cummins, 11L	1998	374,000
		Old Diesel + DPF	Cummins, 11L	1998	374,000
		2010 Diesel	Volvo, 13L	2012	68,000
Light Duty		Old	Mercedes 420SEL	1988	240,000
		Modern Gasoline	Chevy Impala	2008	35,000
		E85	Chevy Impala	2008	35,000
		GDI	Volkwagen Jetta	2010	10,000
		GDI + GPF	Volkwagen Jetta	2010	10,000
		CNG	Honda Civic	2007	15,000
		Diesel w/ DPF	Chevy Silverado	2012	10,000
		Bio-diesel w/ DPF	Chevy Silverado	2012	10,000

Measured on chassis dynamometer

Relative PM Emissions



Common Screening Method for Toxicity



In vitro assay panels

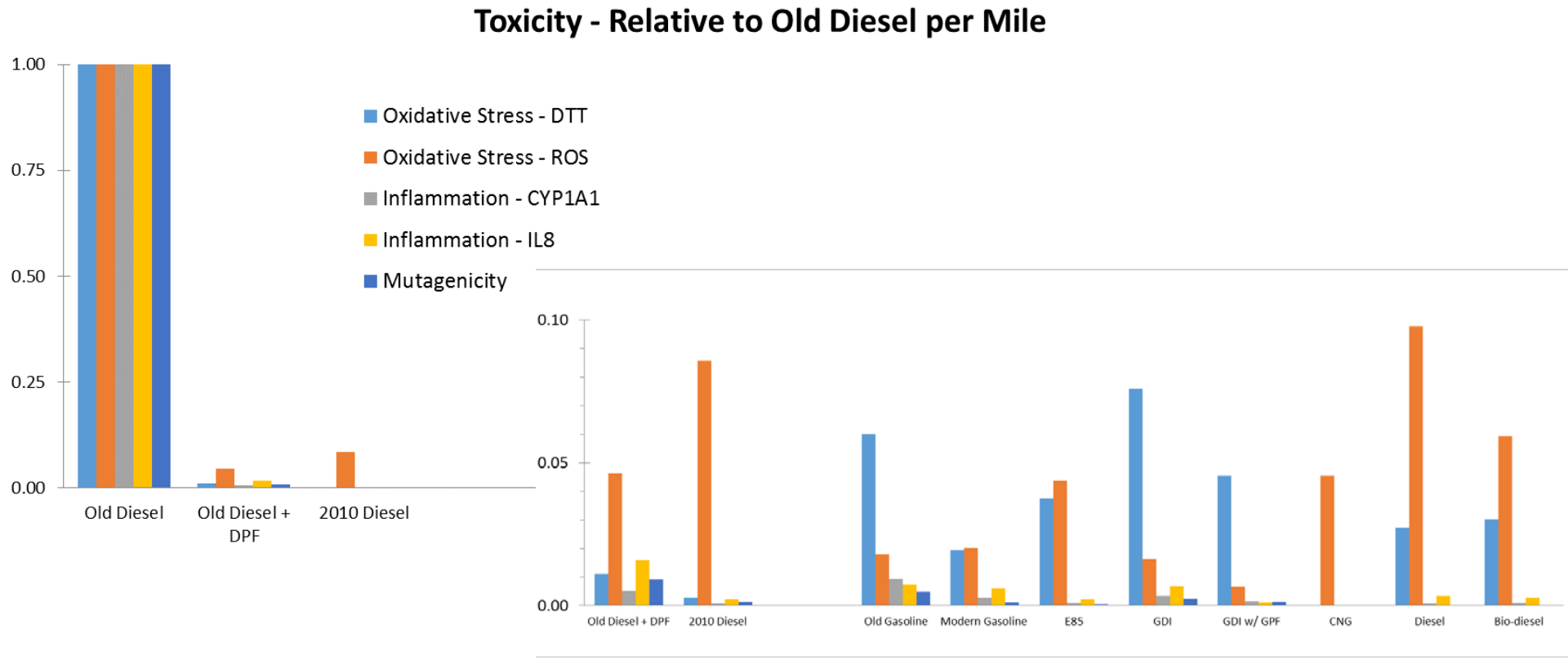
A panel of *in vitro* assays was proposed based on the biological pathways associated with the to toxicological effects of engine PM exposure in recent literature.

Table 1 Biological categories and assays for investigating engine PM toxicity

Biological Pathway	Subcategories	Biomarkers	Assays
Oxidative Stress	Direct ROS formation from PM components	Rate of disappearance of reduced DTT	Dithiolthreitol (***DTT***)[a] oxidation
	ROS production by the cell in response to PM sample exposure	Fluorescent molecular probes which react with cellular ROS	Cellular ROS measurement assay (***cROS***)
	Increased cellular production of oxidative stress related proteins in response to PM sample exposure	Cellular gene expression of HO-1	Cellular gene expression assays using mRNA (RT-PCR) or protein levels (ELISA) for markers of oxidative stress (***HO-1***), inflammation (***IL-8, COX-2***) and AhR activation (***CYP1A1***)[b]
Inflammation	Increased cellular production of inflammatory marker related proteins in response to PM sample exposure	Cellular gene expression of IL-8 and COX-2	
Genotoxicity	Ability of PM sample to cause cellular mutations (mutagenicity)	Number of bacterial revertants due to mutagenesis	***AMES*** mutagenicity bioassays
	Ability of PM sample exposure to cause physical DNA damage	Measurement of cellular DNA fragmentation. (chromosomal aberration)	***COMET*** assay

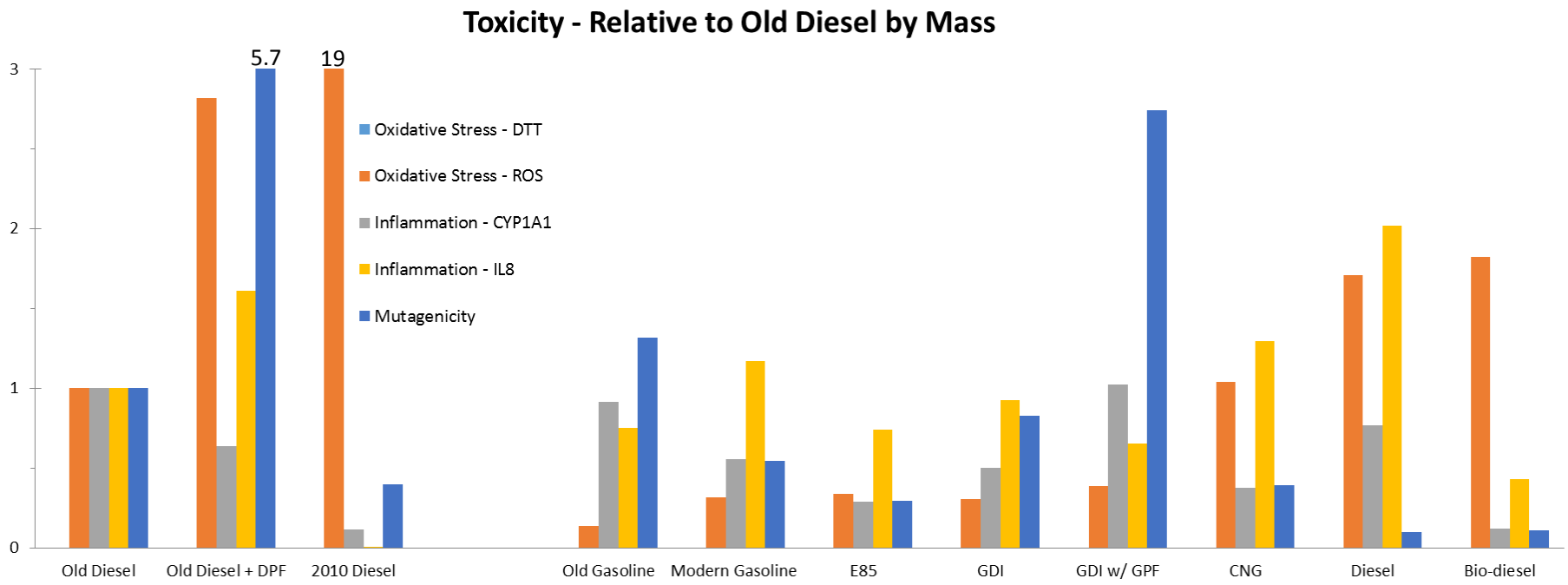
[a] Italicized and bold text refer to specific assays performed in this study
[b] AhR activation by PAHs have been shown to promote inflammatory pathways as well as the metabolism of PM components to more toxic species which cause oxidative stress

Relative Toxicity per Mile



DTT assays for heavy and light duty performed at different laboratories, inter-comparability studies are lacking

Relative Toxicity by Mass



Diesel PM is Carcinogenic

International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 213

12 June 2012

IARC: DIESEL ENGINE EXHAUST CARCINOGENIC

Lyon, France, June 12, 2012 -- After a week-long meeting of international experts, the International Agency for Research on Cancer (IARC), which is part of the World Health Organization (WHO), today classified diesel engine exhaust as **carcinogenic to humans (Group 1)**, based on sufficient evidence that exposure is associated with an increased risk for lung cancer.

All PM is Carcinogenic

International Agency for Research on Cancer

World Health Organization

PRESS RELEASE
N° 221

17 October 2013

IARC: Outdoor air pollution a leading environmental cause of cancer deaths

Lyon/Geneva, 17 October 2013 – The specialized cancer agency of the World Health Organization, the International Agency for Research on Cancer (IARC), announced today that it has classified outdoor air pollution as *carcinogenic to humans* (Group 1). [1]

After thoroughly reviewing the latest available scientific literature, the world's leading experts convened by the IARC Monographs Programme concluded that there is *sufficient evidence* that exposure to outdoor air pollution causes lung cancer (Group 1). They also noted a positive association with an increased risk of bladder cancer.

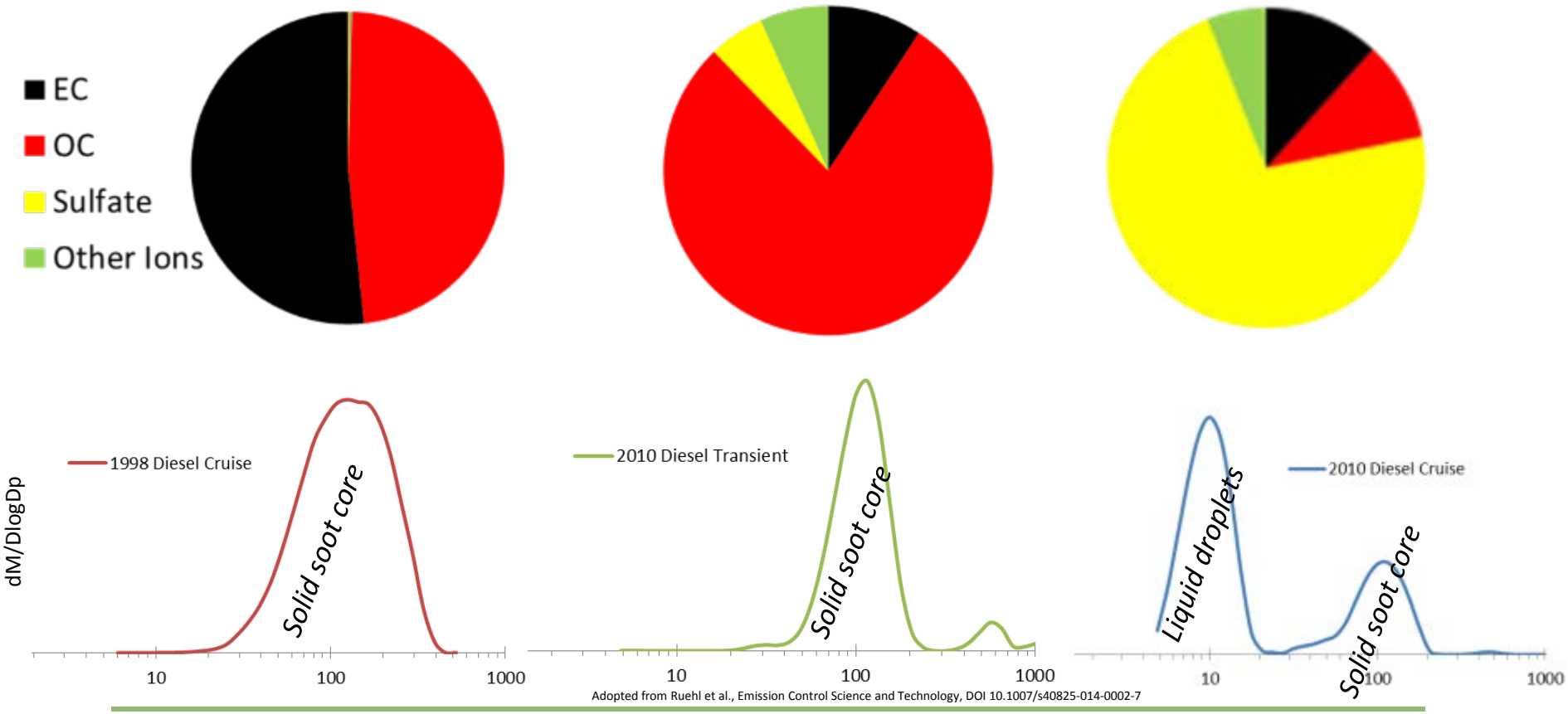
Particulate matter, a major component of outdoor air pollution, was evaluated separately and was also classified as *carcinogenic to humans* (Group 1).

BACKUP SLIDES

Heavy Duty PM Chemical Composition

Measured on chassis dynamometer

Bulk PM Chemical Composition



Adopted from Ruehl et al., Emission Control Science and Technology, DOI 10.1007/s40825-014-0002-7

Light duty PM chemical composition