

---

# Recent Developments Related to the Health Effects of Diesel Exhaust (DE): Implications for Hydraulic Fracturing and Oil & Gas Development

---

Christopher M. Long, Sc.D., DABT  
Peter A. Valberg, Ph.D.  
Gradient

November 12, 2013

# Agenda

- Introduction
  - DE at oil & gas development sites
  - Background on DE composition
  - Key terminology: NTDE vs. TDE
- June 2012 DE re-assessment by IARC (International Agency for Research on Cancer)
- Emergence of New Technology Diesel Exhaust (NTDE)
  - Emissions characterization
  - Toxicological testing
- Additional issues to follow

# DE at Oil & Gas Development Sites

- Numerous sources
  - Trucks, compressors, pumps, generators, drill rigs, *etc.*
  - 2012 estimate of 700 million gallons of diesel fuel burned domestically at HF sites
- Source of public and regulator concerns
  - Direct DE impacts
    - 2012 US GAO report highlights DE as source of air quality impacts at oil & gas sites
  - Indirect DE impacts
    - Contributor to ozone formation

## Examples of DE Claims by Public Interest Groups

**ANOTHER FRACKING PROBLEM**

**DIESEL EXHAUST**  
a known **carcinogen**

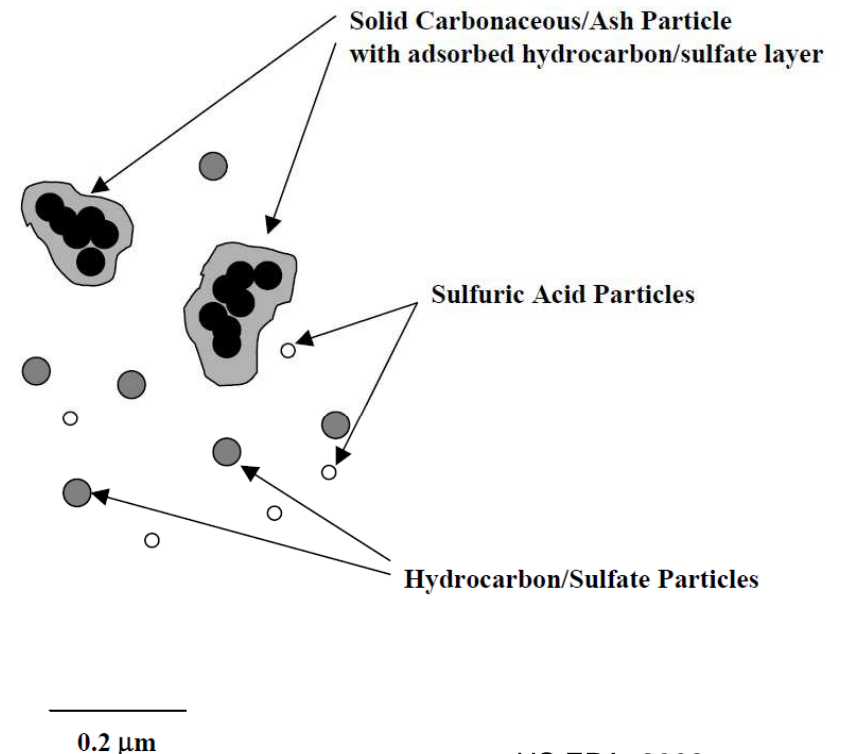
**Diesel engines power:**

- Well construction
- Fracking process
- Pumping frack fluid
- Compressing gas
- 6,790 trucks/well

**NEW YORKERS AGAINST FRACKING**

# Diesel Exhaust (DE) Constituents

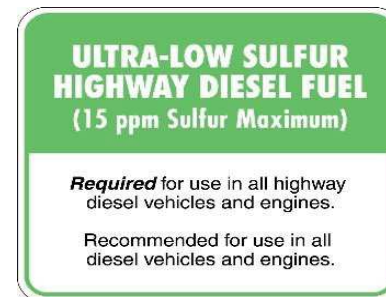
- Complex mixture consisting of:
  - $\text{CO}_2$  and  $\text{H}_2\text{O}$
  - Diesel exhaust particulates (DEP)
  - Nitrogen oxides ( $\text{NO}_x$ )
  - Sulfur dioxide ( $\text{SO}_2$ )
  - Hydrocarbons
  - Air toxics
    - Formaldehyde
    - Acetaldehyde
    - 1,3-Butadiene
    - Acrolein
    - Benzene
    - Polycyclic Aromatic Hydrocarbons (PAHs)
- Elemental carbon often used as DEP surrogate



US EPA, 2002

# Key Terminology

- Traditional Diesel Exhaust (TDE)
  - Pre-1988 diesel engine technology in place prior to US EPA diesel particulate matter (PM) standards
  - Can have high emissions
- New Technology Diesel Exhaust (NTDE)
  - Post-2006 “clean diesel” engine technology that includes multi-component after-treatment systems
  - Significant emissions reductions for PM, air toxics, NOx (post-2010)



+



# 2012 IARC Re-assessment

International Agency for Research on Cancer



- June 2012 meeting in Lyon, France
  - Update to 1988 assessment
  - Panel also re-evaluated gasoline engine exhaust (and some nitroarene species)
- DE upgraded from a Group 2A probable human carcinogen to a Group 1 known human carcinogen
  - Driven by new epi findings indicating lung cancer risk for TDE-exposed worker cohorts (non-metal miners, truckers)
  - Classification makes no distinction between TDE and NTDE
- No change in gasoline engine exhaust classification of Group 2B possible human carcinogen

# Statements in the Media Regarding DE as a Group 1 Carcinogen

*Diesel exhaust fumes 'definitely' cause cancer – should we be worried?*

*Diesel exhaust fumes cause cancer, WHO says*

IARC Cancer Classifications		
Group 1	Carcinogenic to humans	112 agents
Group 2A	Probably carcinogenic to humans	66 agents
Group 2B	Possibly carcinogenic to humans	285 agents
Group 3	Not classifiable as to its carcinogenicity to humans	505 agents
Group 4	Probably not carcinogenic to humans	1 agent

**Diesel exhaust fumes are 'major cancer risk' and as deadly as asbestos and mustard gas, says World Health Organisation**

# NIOSH-NCI Diesel Exhaust in Miners Study (DEMS)



- Major study- ~20 years to conduct, >12,000 workers, >275,000 person-years of follow-up, ~200 lung cancers, 7 journal publications, >400 statistical comparisons
- Study reported some of strongest evidence to date linking elevated DE exposures with lung cancer risk, including evidence of exposure-response trends
  - 3- to 7-fold elevations in risks for heavily-exposed workers
- Some important study limitations
  - Uncertainty in the exposure assessment; calls for re-analysis
  - Specific to older diesel engine technologies
- Can results be extrapolated to other DE-exposed populations differing in exposure levels and DE sources?

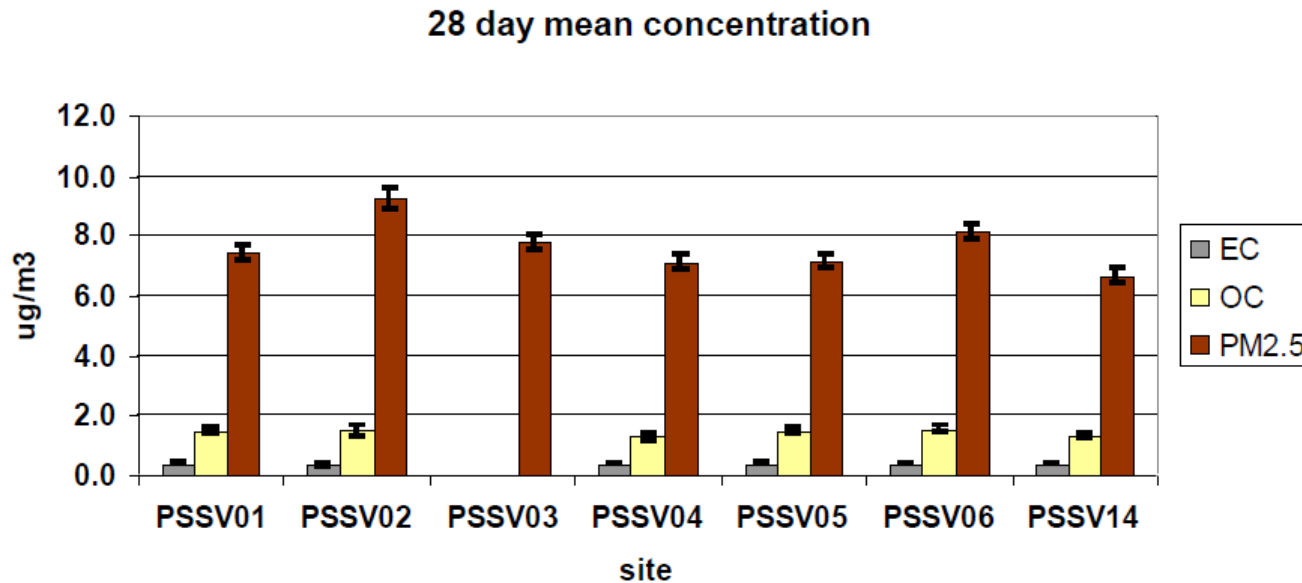


# Large Uncertainty of DEMS Findings to DE at Oil & Gas Development Sites

Exposed Population	Average Elemental Carbon (EC) Exposure Conc. ( $\mu\text{g}/\text{m}^3$ )
DEMS Underground Mine Production Workers	Estimated historical exposures of up to $600 \mu\text{g}/\text{m}^3$
DEMS Surface Mine Workers	Estimated historical exposures of up to $11 \mu\text{g}/\text{m}^3$
Fracking Site Workers	???
Residents Nearby to Fracking Sites	???

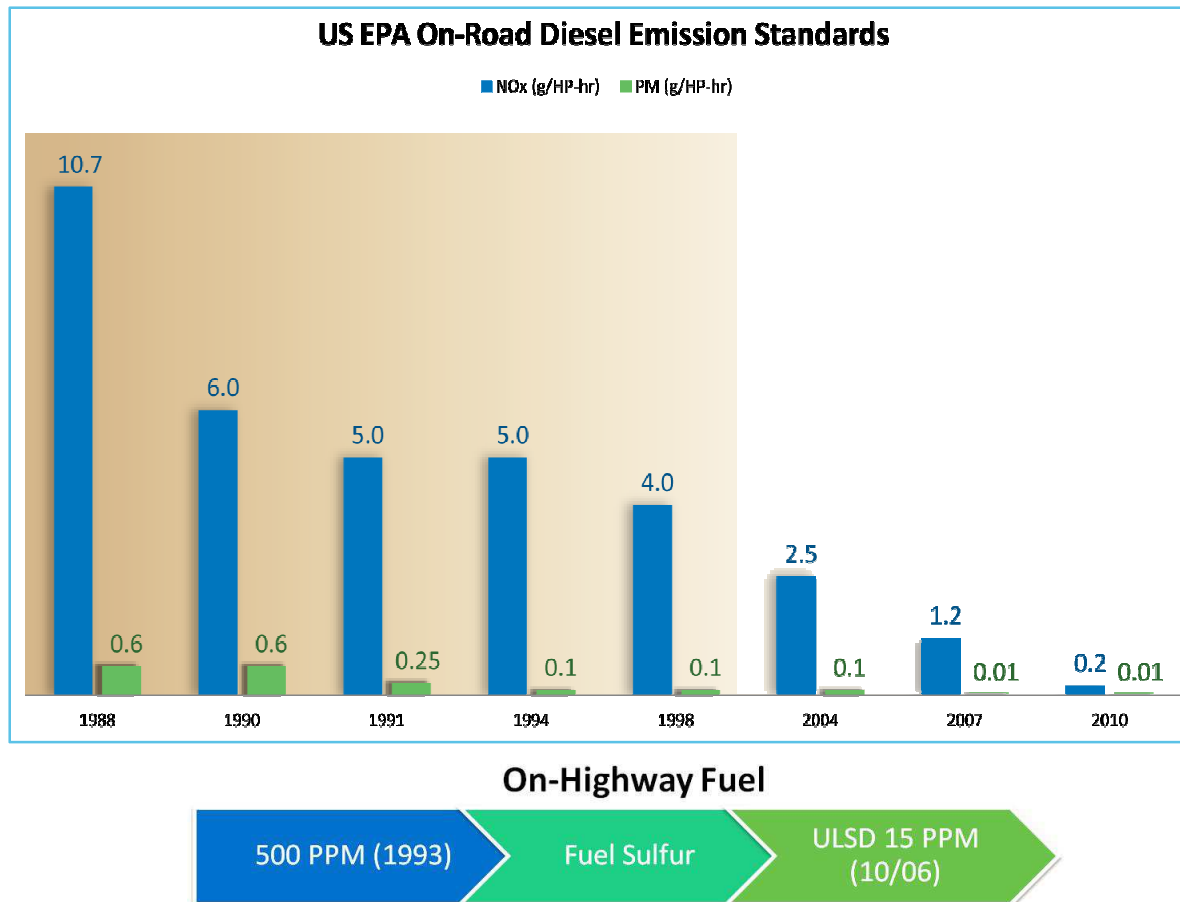
# Preliminary Evidence of Minor DE-Related Air Quality Impacts in Barnett Shale Region (DRI, 2010)

- Short-term air sampling study at multiple locations in Shale Creek Community (TX)
  - Large diesel-powered compressor station
  - Several production wells in surrounding area

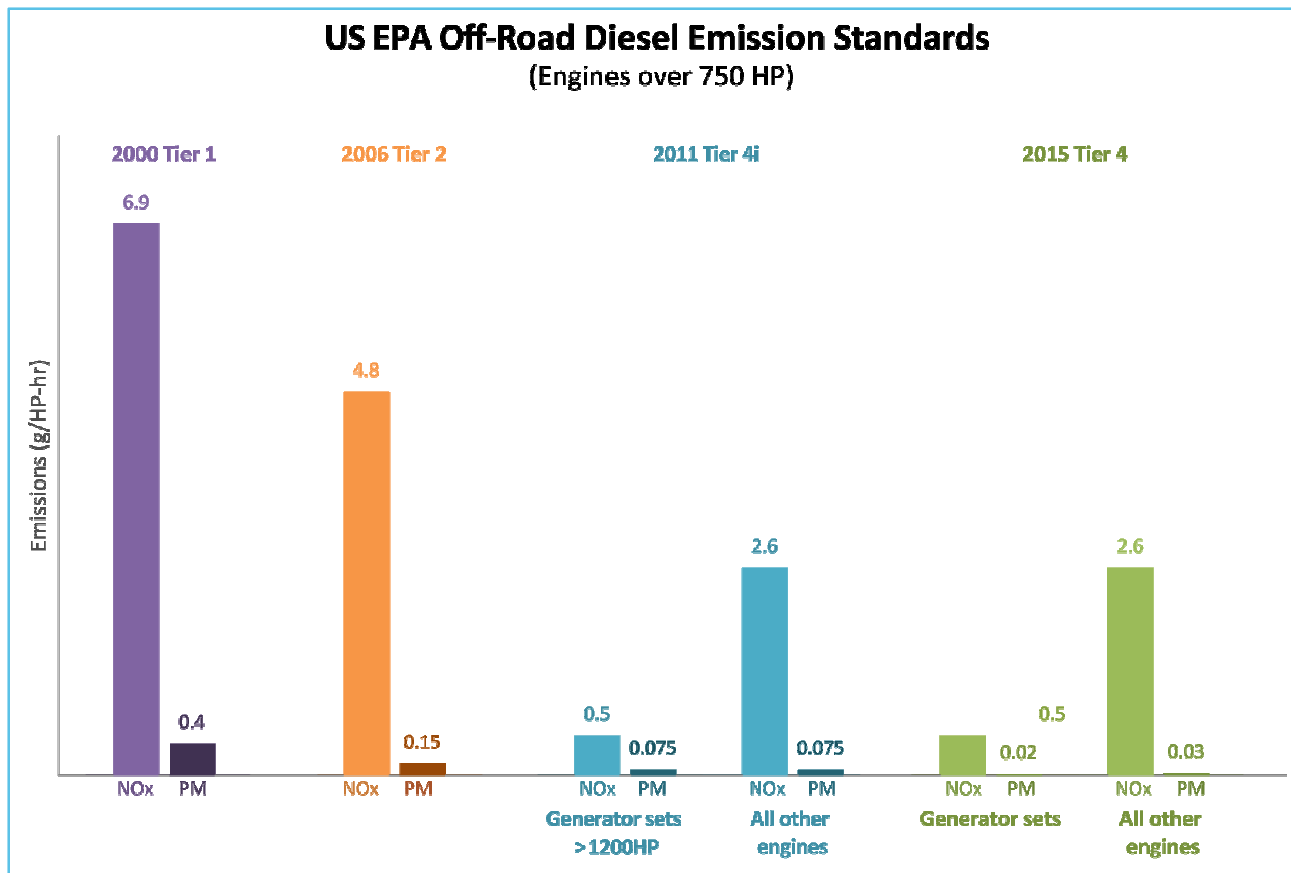


# Large Uncertainty of DEMS Findings to DE at Oil & Gas Development Sites (cont.)

- Major changes to DE with evolution of diesel emissions standards and engine technology



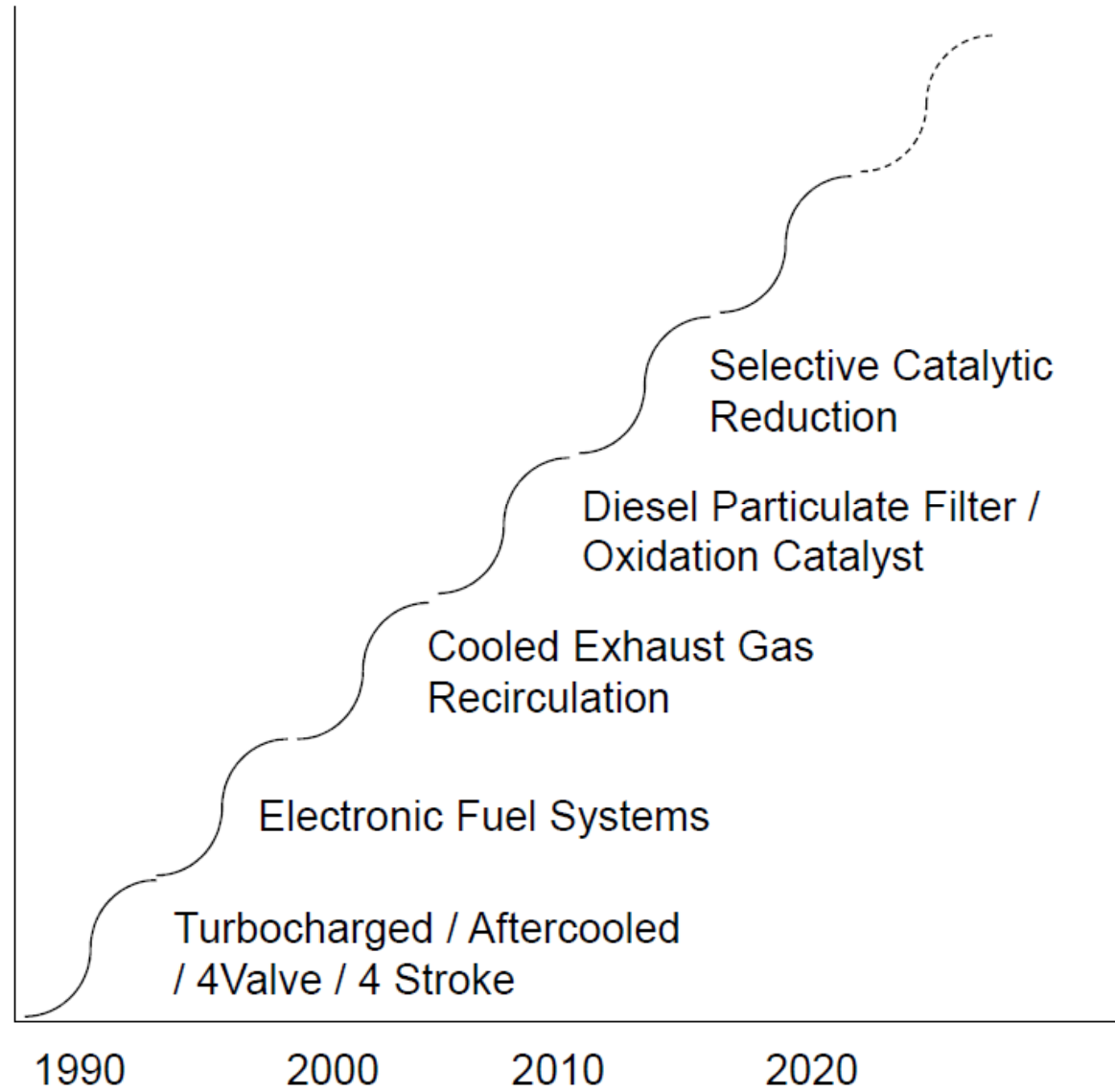
# Large Uncertainty of DEMS Findings to DE at Oil & Gas Development Sites (cont.)



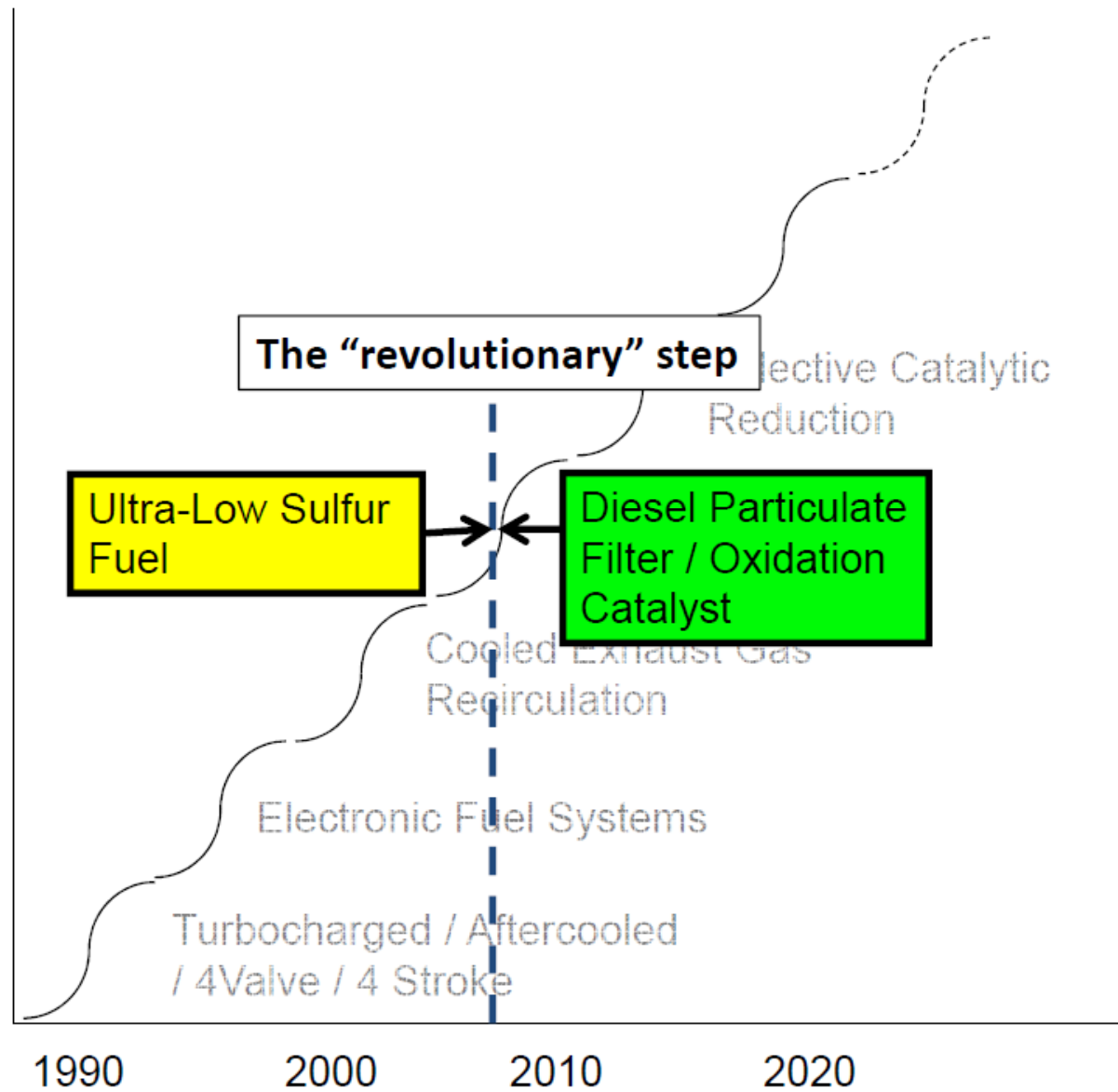
## Off-Highway Fuel



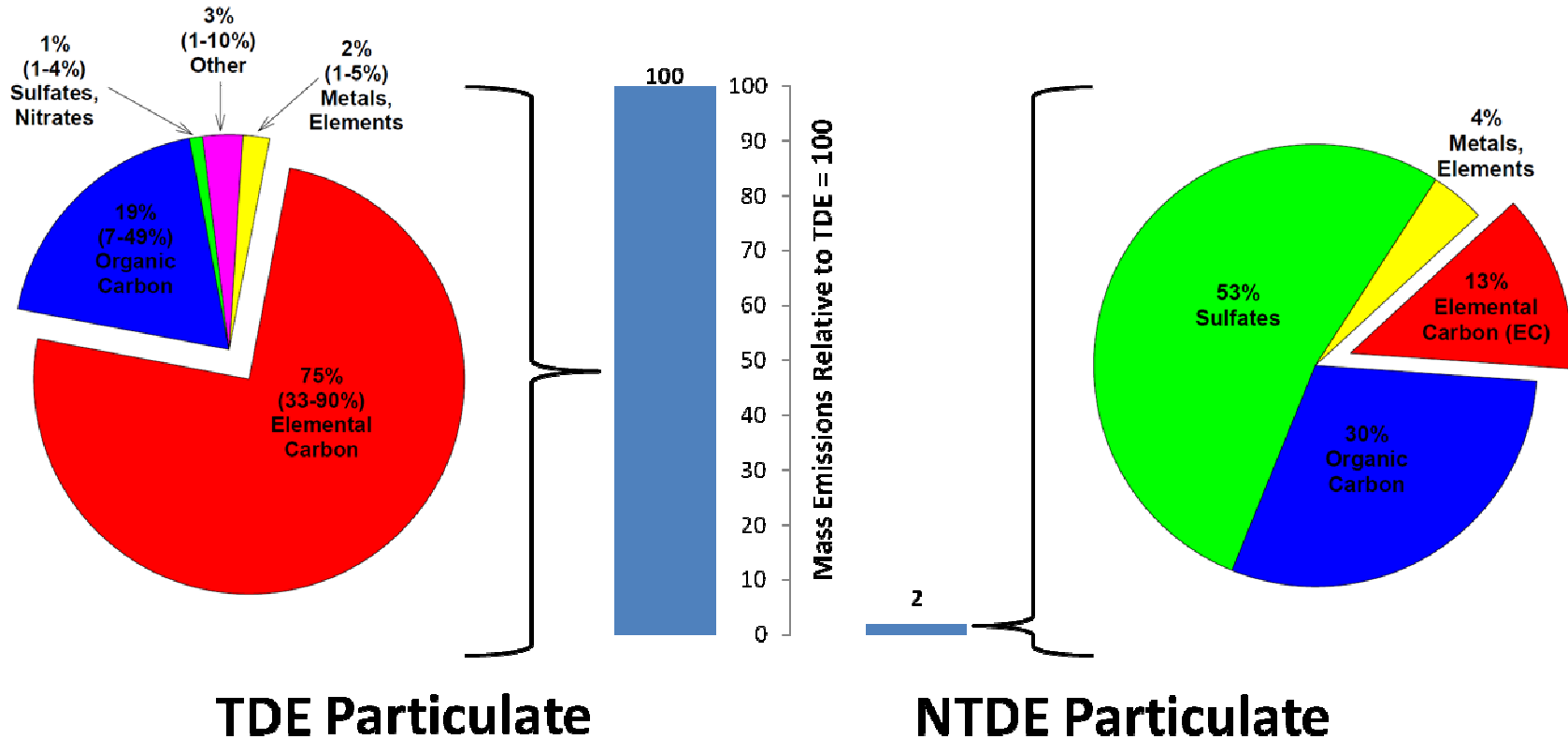
# Evolution of Diesel Engine Technology



# Emergence of NTDE

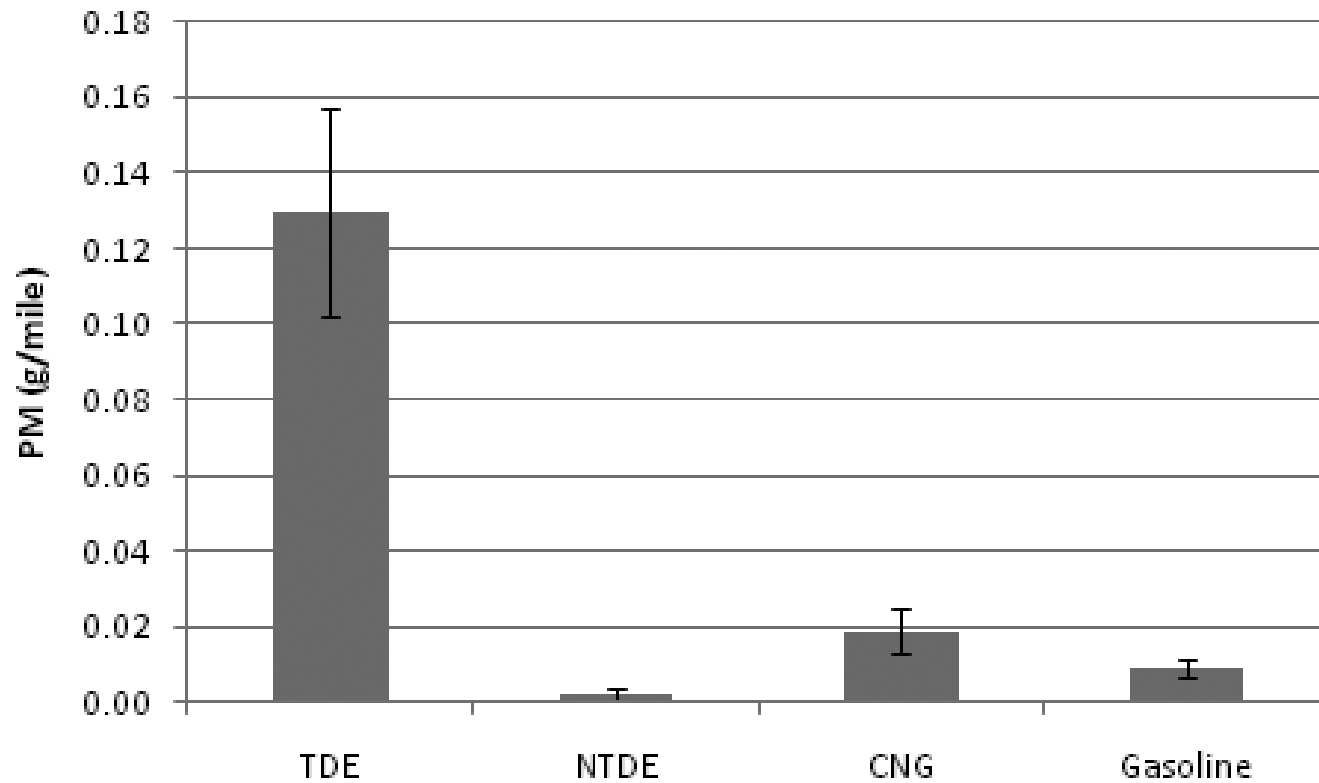


# Reduced and Changed PM Emissions



From Hesterberg, Long, *et al.* (2012)

# How Does NTDE Compare to Other Engine Exhaust Types?



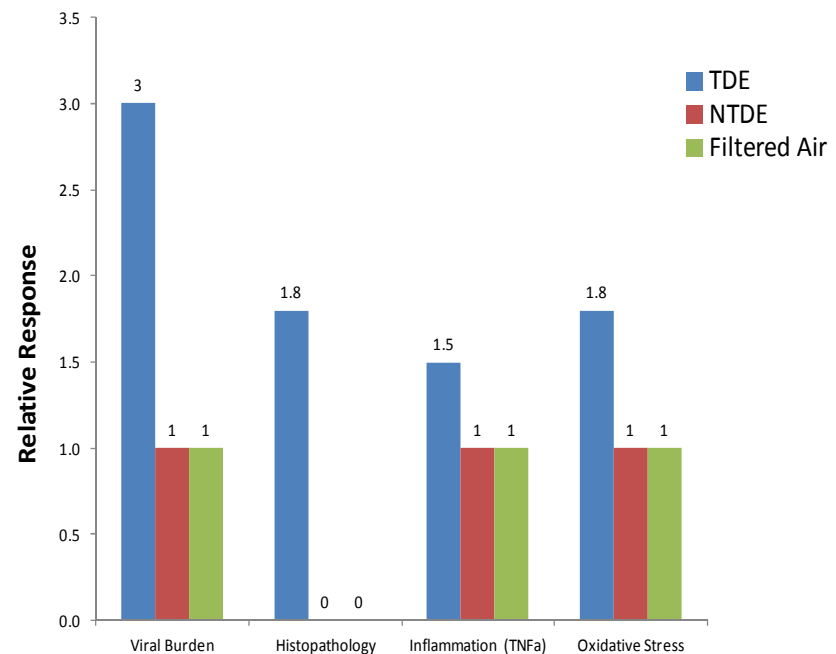
From Hesterberg, Long, *et al.* (2011)



# Does NTDE Have Reduced Toxicity?

- No epi studies of NTDE-exposed worker cohorts
- But, preliminary animal data support reduced toxicity- *e.g.*, McDonald *et al.* (2004)
- As does one human clinical study of biomarkers of cardiovascular health- *e.g.*, Lucking *et al.* (2011)
- But is it carcinogenic?

McDonald *et al.* (2004) mouse acute toxicity findings



# Advanced Collaborative Emissions Study (ACES)



- \$20 million study initiated in 2006
- Includes large chronic rat carcinogenicity bioassay
  - Inhalation exposures 16 hr/day, 5 days/wk for 24-30 months
  - 3 dilutions of NTDE + clean air controls
- Exposures now complete, final report expected early 2014
- Preliminary findings available for small number of rats sacrificed for 24-month interim evaluation
  - No treatment-related lung lesions in low or mid dose groups
  - Some minimal to mild lung lesions in high dose group, but none that resemble typical preneoplastic lesions

# Closing Thoughts

Many developing issues to closely follow, including:

- Release of full IARC report
  - What, if anything, will it do to distinguish NTDE from TDE?
- Final ACES carcinogenicity report for NTDE
  - Will the 24-month preliminary findings hold up?
- Health Effects Institute (HEI) Diesel Epidemiology Project
  - 10/24/13 workshop postponed due to government shutdown
- NIOSH to investigate health risks at drilling sites; specifically mention impacts of co-exposures to diesel emissions and silica

# Closing Thoughts (cont.)

## Implications for oil & gas development:

- Given its Group 1 status, DE likely to be closely scrutinized at oil & gas development sites
- Need for exposure assessment studies that measure/model DE exposure levels
  - Distinguish between TDE and NTDE
  - Distinguish DE constituents from other site-related and background emissions
  - On-site vs. community exposure levels
- Complex nature of DE health risk assessments for oil & gas development sites
  - Not all DE is the same



**Any Questions?**

**[clong@gradientcorp.com](mailto:clong@gradientcorp.com)**