

The Toxicity of Diesel Exhaust

**Dan Greenbaum, President
Health Effects Institute**

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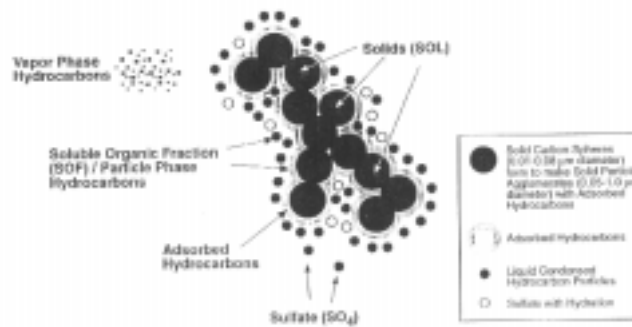
The Diesel Challenge

- The Opportunity:
 - high efficiency
 - lower emissions of some pollutants
- The Challenge:
 - higher emissions of some key pollutants
 - questions about cancer and other health effects

Assessing the Toxicity of Diesel Exhaust

- Diesel and Ambient Air Pollution
 - Particulate Matter (PM)
 - Nitrogen Oxides (NOx)
- Diesel and Lung Cancer Risk
 - Animal and Human Studies
 - Risk Assessment
- Diesel and Non-Cancer Risk

At The Core

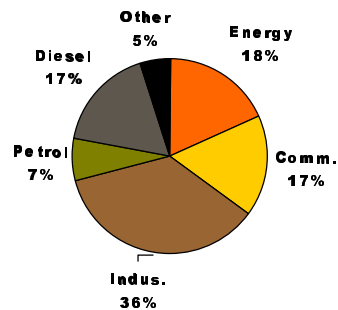


Diesel and PM

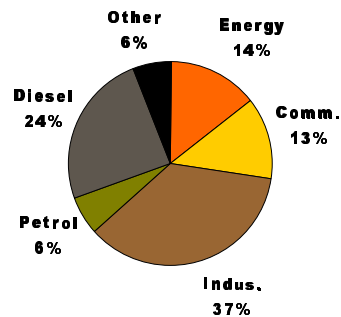
- PM a Major Focus of Science/Regulation
- Diesel contributes in two primary ways:
 - Direct emission of PM
 - in particular, ultra fines
 - Emission of precursors to secondary PM
 - in particular NOx to Nitrates

How Much of PM is Diesel?

PM10 (UK Data, 1999)



PM2.5 (UK Data, 1999)



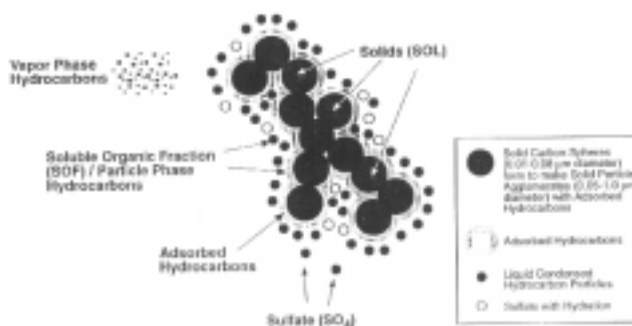
Diesel and Ultrafine PM

- Ultrafines of particular interest
 - | More likely to penetrate to deep lung; may be more responsible for PM effects
 - | German study: asthmatics have greater breathing difficulty on high-ultrafine days (Peters, 1997)
- Newer diesels may have higher ultrafines
 - | HEI Bagley Study (1996) 30-60 fold increase despite 80% PM mass decrease
 - | Others finding same/different results

Diesel and NOx

- NOx important as a precursor to Ozone, Secondary PM
- Diesel an important contributor to NOx
- NOx and PM
 - | interrelated in diesel emissions control
 - | have been and continue to be the focus of most diesel control requirements

Diesel and Lung Cancer - I



Diesel and Lung Cancer - II

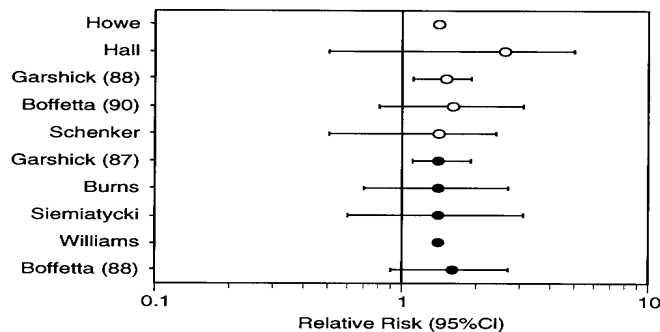
- Chemicals on Diesel PM (e.g. PAHs) cause gene mutation (Ames Test)
 - May not be "bioavailable" in body
- Diesel causes lung tumors in rats, not in other animals
 - Tumors likely due to lung overload
 - Not likely to be relevant to humans at street level

Diesel and Lung Cancer - III

- Over 30 studies of workers exposed to diesel exhaust
- Relatively consistent association of diesel exposure with 20%-40% increase in lung cancer
 - also in studies which attempt to control for smoking

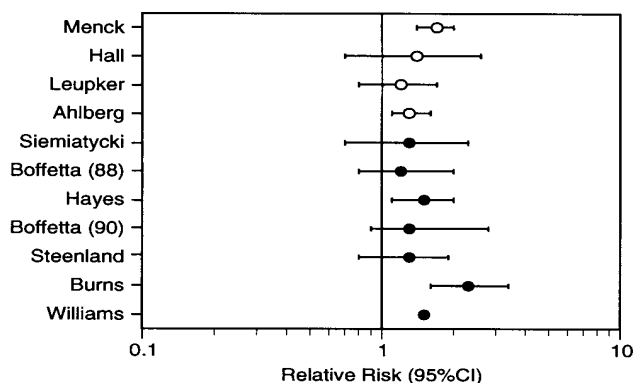
Studies in Railroad Workers

HEI, 1995



Studies in Truckers

HEI, 1995



Diesel and Lung Cancer- IV

- | Consistent association suggests a hazard; some have attributed causality

- | Association is considered "weak" in epidemiology terms
 - relative risks are small - less than 2.0
 - few of the studies controlled for all possible confounders
 - no concurrent exposure measurements
 - only two (Garshick, Steenland) with detailed measurements

Diesel Risk Assessment - I

■ International, National, State Agencies

- IARC (WHO,1989)
- International Programme on Chemical Safety (WHO,1996)
- U.S. EPA (Draft, 1998)
- California OEHHA (1998)
- National Institute for Environmental Health Science/NTP (1999)

- ### ■ All have made the hazard identification of diesel as a “probable” or comparable human carcinogen

Diesel Risk Assessment - II

- ### ■ While most agencies have identified diesel’s “hazard”

- ### ■few have made quantitative estimates of risk

- ### ■ It is a challenge to make quantitative estimates:

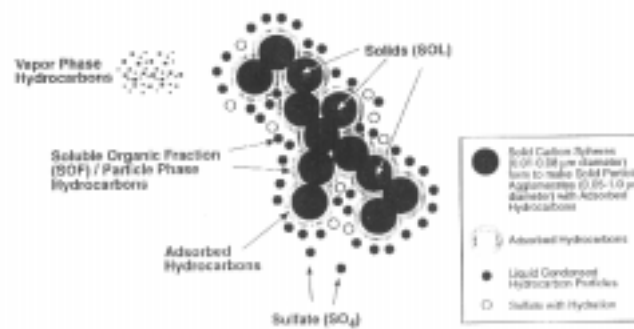
- | few studies large enough and well enough done
- | few with detailed exposure information

Diesel Risk Assessment - III

- HEI Diesel Epidemiology Panel (June 1999)
 - Reviewed two best epi studies
 - Concluded:
 - Garshick has significant limitations for estimating quantitative risk
 - Steenland may be useful; additional work to reconstruct past exposures



Diesel and Lung Cancer

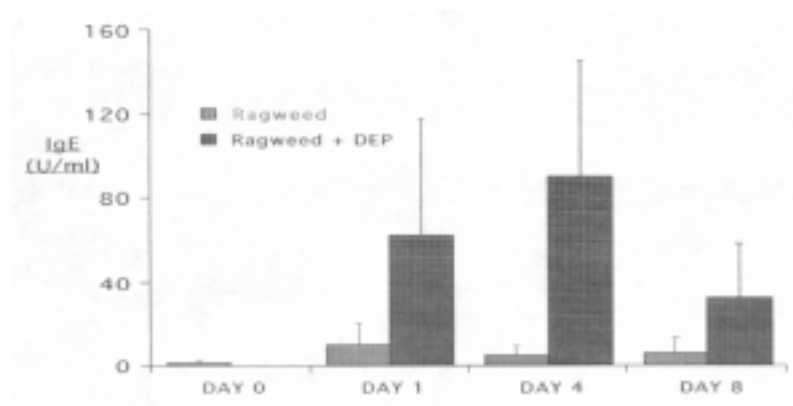


Diesel and Non-Cancer Effects

- Most attention focussed on cancer
- Some emerging data on diesel and
 - | allergy
 - | childhood illness (Europe)
- Does exposure to diesel exacerbate allergic response?
 - | Still very early, some results of note

Diesel and Allergy

- Does diesel exacerbate allergic response in humans? (High dose experiments by Diaz-Sanchez, 1999)
- Limited data base available



Summary: The Toxicity of Diesel Exhaust

- Diesel a Contributor to PM, NO_x (though not sole contributor)
 - ultrafines an important question
- Most review bodies consider diesel a “probable” human carcinogen
 - still questions about mechanism, how potent
- Science on other effects (e.g. allergy) emerging but in early stages

The Implications

- Progress to date in reducing diesel emissions
 - challenge: older vehicles continue on road
- Broadly-held continued interest in reducing emissions from diesel
- Key issues will be
 - extent and timing of reduction of PM, NO_x, PAHs and other organic compounds
 - techniques for replacing/upgrading older vehicles