

The Global Impacts of Heavy Duty Vehicle Emissions

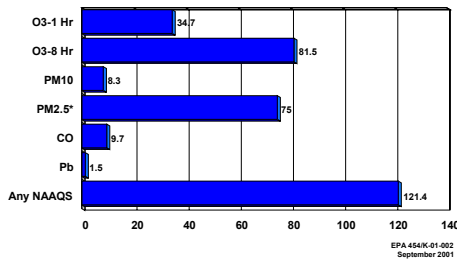


Clean Heavy Duty Vehicles:
Setting the Direction For
Advanced Technologies &
Fuels

Summary

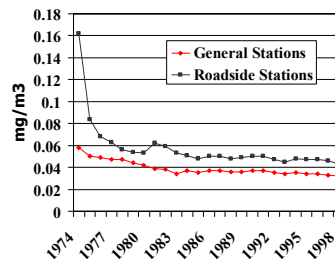
- Impacts of Heavy Duty Sector
 - Conventional Pollutants Especially PM and NOx
 - Energy Consumption and Associated Greenhouse Gases
- What is Being Done To Address The Concerns
- Remaining Challenges

Number of People Living in Areas Exceeding Air Quality Standards in 2000 in the US

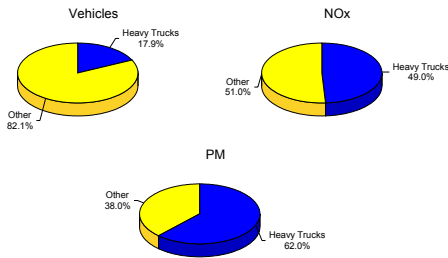


*= this number Will Likely Increase
 •As more PM2.5 Data Become Available

Suspended Particulate Matter Air Quality Trends in Japan



The Role of Trucks in Japan



PM Health Effects

- High levels of PM (e.g. $500 \mu/m^3$) known to cause premature death
 - e.g. London 1952
- Recent studies in US, Europe, Asia, South America have found association of PM with premature death at much lower levels
 - no evidence of a "threshold" (safe level)

PM - The Epidemiology Studies

A Number of Epidemiology Studies

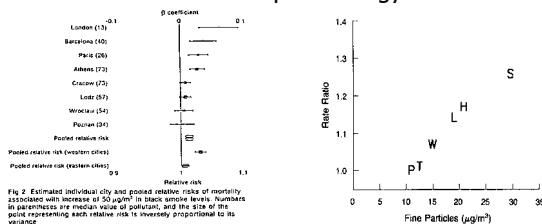


Fig. 3. Estimated individual city and pooled relative risks of mortality associated with increase of $50 \mu g/m^3$ in black smoke levels. Numbers in parentheses are the number of subjects, and the size of the point representing each relative risk is inversely proportional to its variance.

Europe Studies

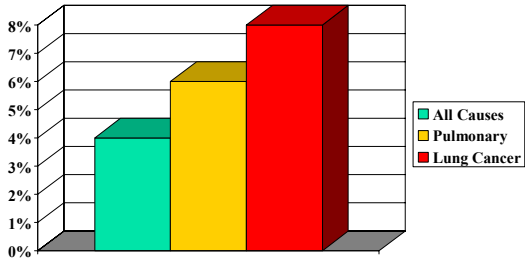
Harvard 6 Cities Study

PM10 Study in Europe

(Lancet Medical Journal – September 2, 2000)

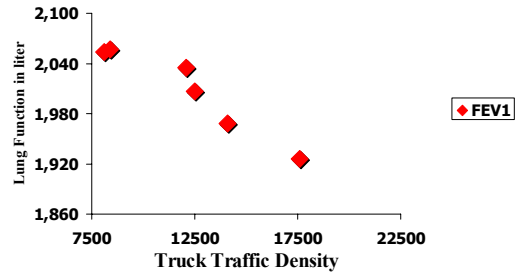
- ~6% of all deaths from PM10
- ~40,000 deaths per year in Austria, France, Switzerland; 2 times traffic fatalities
- Motor Vehicles Responsible For ~50%
- People in Cities Die ~18 Months Earlier Than They Otherwise Would
- Over 300,000 cases of chronic bronchitis; 500,000 asthma attacks; 16 million lost person days of activity
- Health Costs From Traffic Pollution ~1.7% of total GDP

Increased Risk of Premature Mortality Due To $10\mu\text{g}/\text{m}^3$ $\text{PM}_{2.5}$

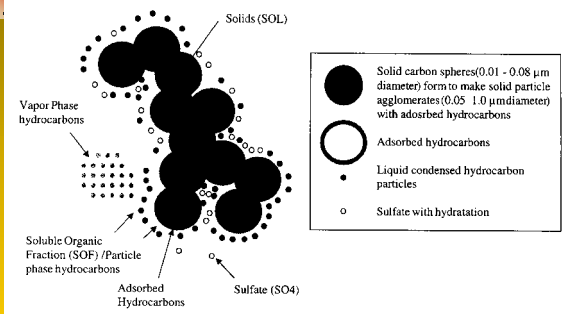


JAMA, March 2002

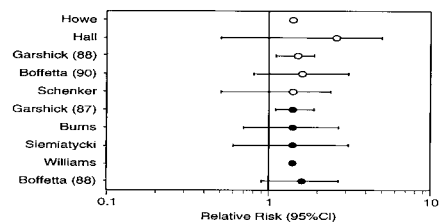
Brunekreef, Epidemiology 1997; 8: 298-303



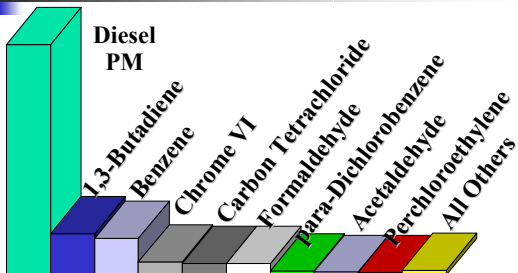
Diesel Particulate Matter



Cancer Studies in Railroad Workers HEI, 1995

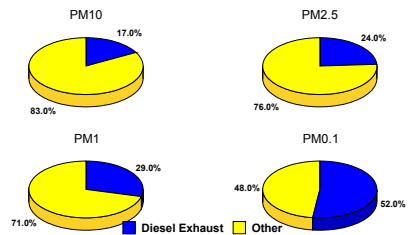


Relative Cancer Risks



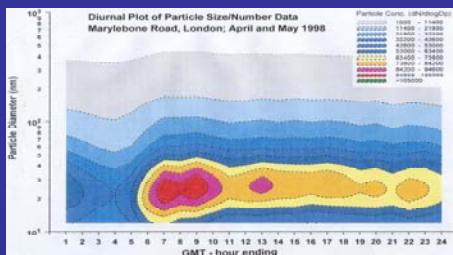
Based on ARB monitoring data 1995 - 1997

PM Emissions in the UK - 1996



"Source Apportionment of Airborne Particulate Matter in the United Kingdom"

Vehicles Are A Major Source of Ultrafine Particles

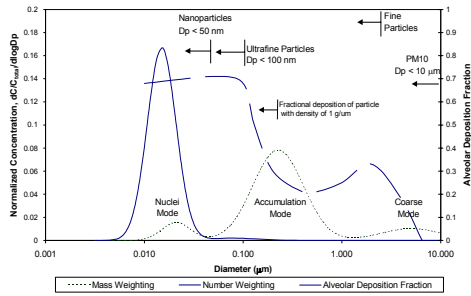


Concern Over Ultrafine PM Reinforced

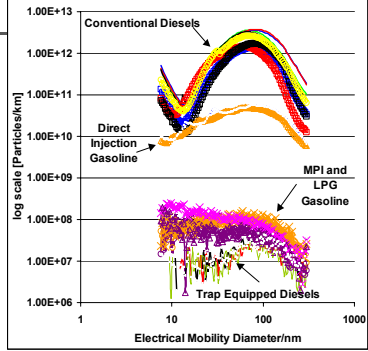
- Daily Mortality in Erfurt Germany
 - Health Effects of Ultrafine & Fine PM Comparable
 - Effects of Ultrafines Depend on Number and Surface Area
 - Since 91/92 PM Mass Has Declined
 - Since 91/92 very small particles (.01-.03) increased

HEI Research Report 98, November 2000

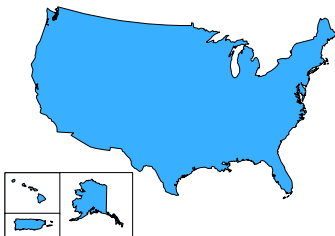
Typical engine exhaust mass and number weighted size distributions shown with alveolar deposition



Comparison of Particle Emissions from SMPS.7: All Vehicles and Fuels - 50kph



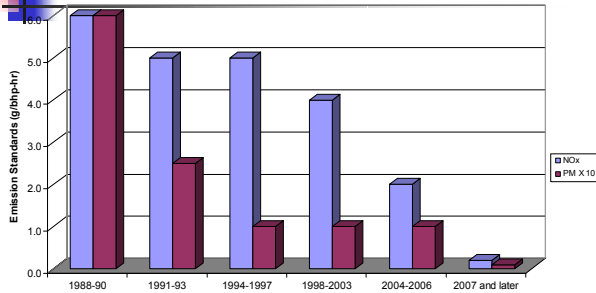
United States



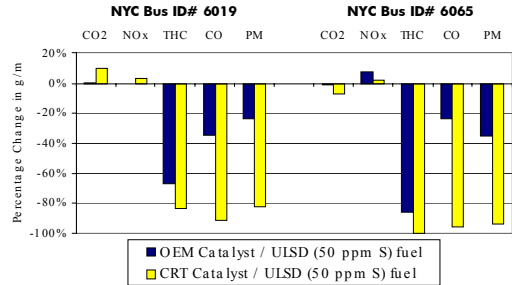
Bins for Tier 2/LEV2 (g/mile)

Bin #	NOx	NMOG	CO	HCHO	PM
11	.9	.28	7.3	.032	0.12
10	.6	.156/.230	4.2/6.4	.018/.027	0.08
9	.3	.090/.180	4.2	.018	0.06
8	.2	.125/.156	4.2	.018	0.02
7	.15	.09	4.2	.018	0.02
6	.10	.09	4.2	.018	0.01
5	.07	.09	4.2	.018	0.01
4	.04	.07	2.1	.011	0.01
3	.03(.07)	.055	2.1	.011	0.01
2	.02	.01	2.1	.004	0.01
1	0	0	0	0	0

United States and California On-road Truck Engine Standards, Beginning with the 1988 Model Year



New York City Retrofit Experience



California Diesel Risk Reduction Program

- Require PM Filters on All New & Most Existing Diesels (On & Off Road)
- Aiming for 90% Reduction in Total PM Emissions From 1.25 Million Engines
- Full Implementation By 2010
 - PM Traps
 - Low Sulfur Fuel
 - In Use Emission Testing
 - Alternative Fuels

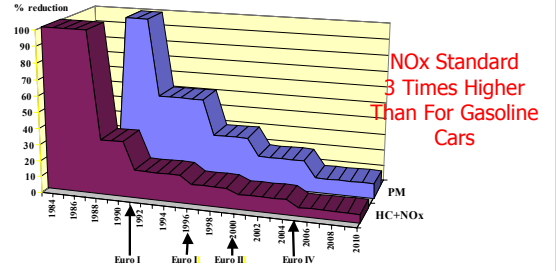
Rest of the US

- EPA's Target is Commitment For 100,000 Retrofits
- ~71,000 To Date
 - New York
 - Seattle
 - Texas
 - Others

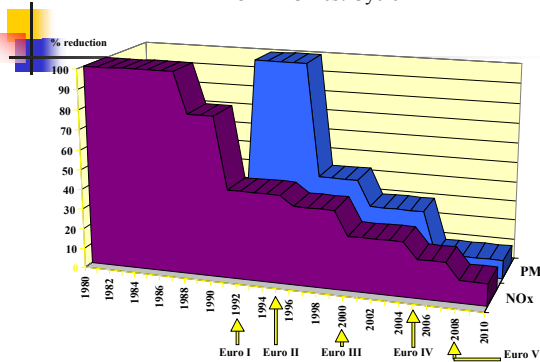
Europe



Emissions From Diesel Cars In Europe

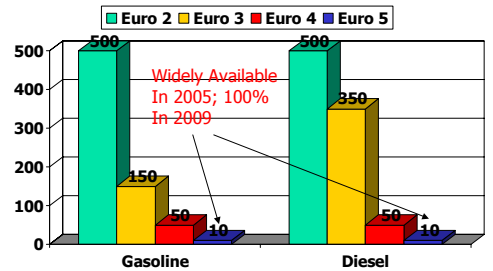


Heavy-duty Vehicles Emission Reduction In Europe On ETC Test Cycle

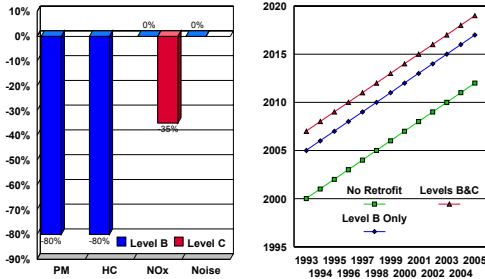


Euro 5 Technology Review

European Fuel Sulfur Levels (PPM)



Swedish Retrofit Program All Trucks Above 3.5 Tons

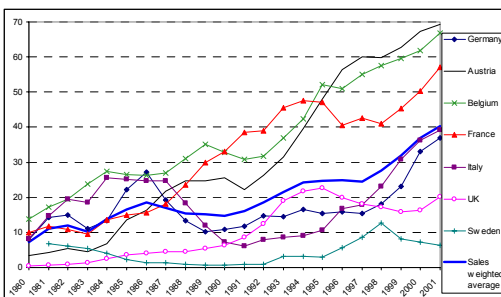


Very Low Sulfur Fuel Dominates The Market

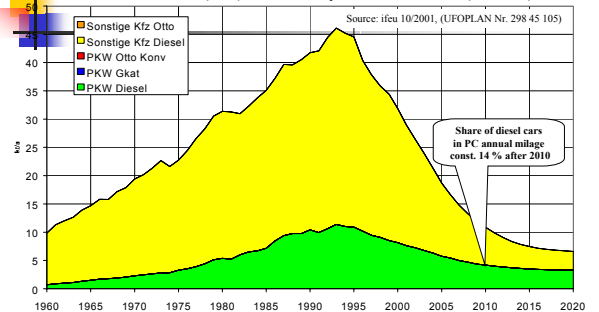
Conclusions From Auto-Oil II

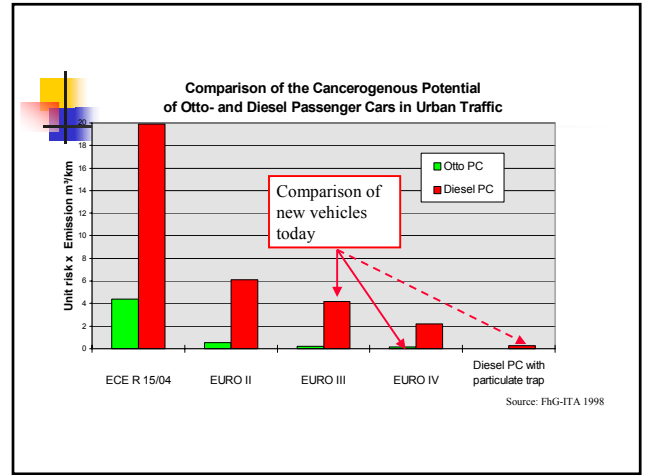
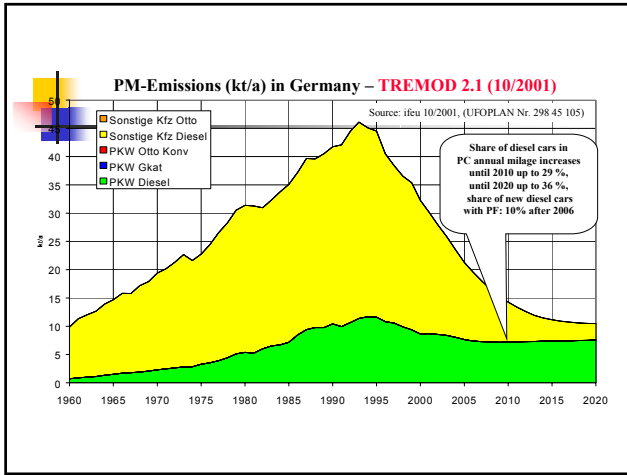
- Emissions From Road Traffic Will Likely Be Reduced by 80% From 1995 Levels by 2020
- Remaining Problems Will Require Further Actions To Address
 - PM From Diesel Vehicles
 - High Levels of Localized NO₂
 - Ozone

Penetration of Diesel Cars in Europe (% of New Sales)



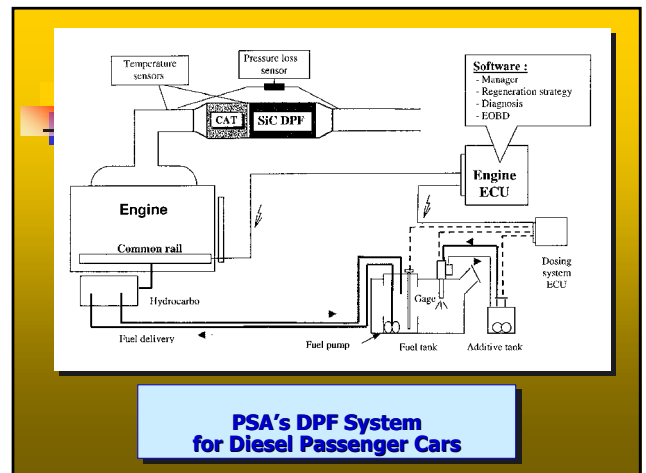
PM-Emissions (kt/a) in Germany – TREMOD 2.0 (08/2000)

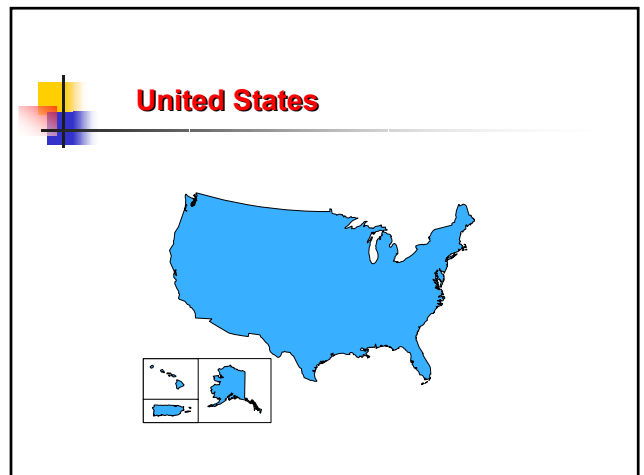
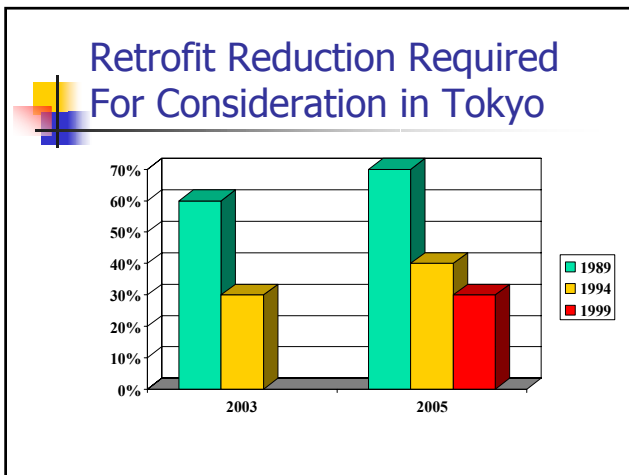
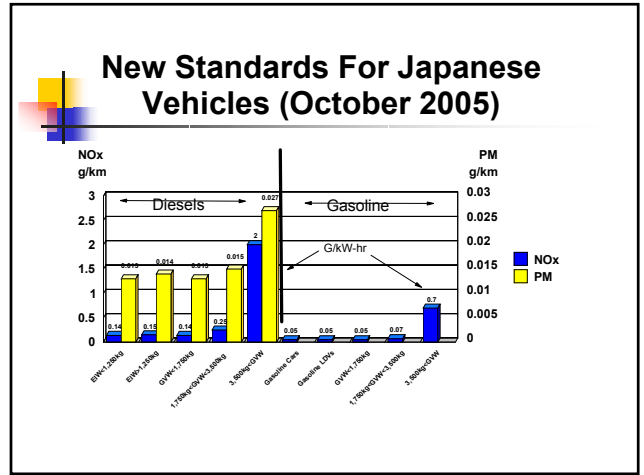
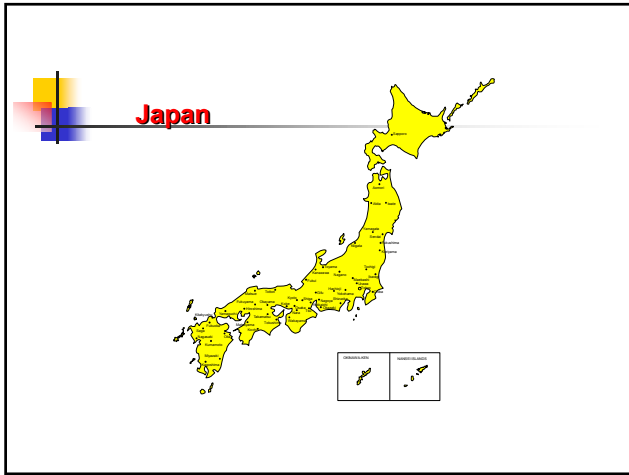




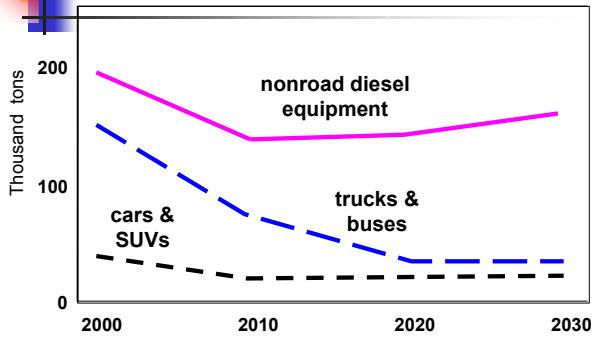
Letter To Commission From France & Germany (29/1/2003)

- In Spite of Progress, Significant Problems From NOx and PM Emissions
- PM number in range 0.01-2.5 μM Remains High; Vehicles Major Source
- Diesel Registrations Have Doubled
- PM Filters Could Reduce By 99%; Current Standards Can Largely Be Met Without Filters
- US Standards 80% Lower Than Euro IV
- Request Tighter Standards Proposal by Mid 2004





Mobile Source PM



2WD tractor
130 hp



combine
300 hp



4WD tractor
250 hp



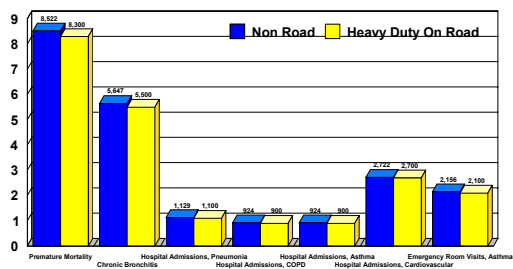
square
baler
60 hp



square
bale
wagon
150 hp

Potential Benefits of Non Road Rule (PM Only)

Avoided Incidences Per Year
Thousands




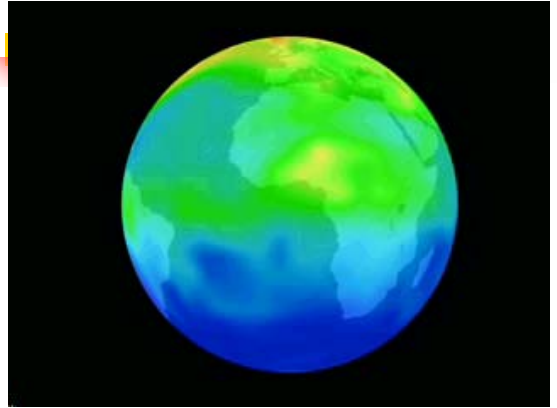
Stringent Non-Road Diesel Standards Under Development In The US

- Fuel
 - 15 PPM in 2008/2010?
 - Includes Locomotive & Recreational Marine?
- Engine Standards
 - PM=0.01, phased in 2009-2010?
 - NOx=0.3, phased in 2011-2012?



Conclusions

- PM Remains A Major Concern
- Special Concerns With Diesel PM
 - Small Size
 - Toxicity
- Stringent New Diesel Standards and Low Sulfur Fuel Standards Spreading
- PM Filters Seen As Key To Control
- Europe Considering Additional Step
- Non Road & Retrofit – Unfinished Agenda



Thank You for Your Attention !