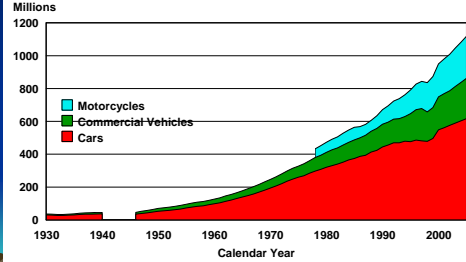


Introduction of Cleaner Diesel Engines and Retrofits of Older Engines: Progress and Impact on Air Quality

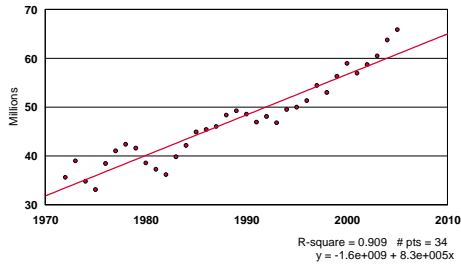


HEI Annual Meeting
 April 2007
 Michael P. Walsh
 International Consultant,
 Board Chairman ICCT

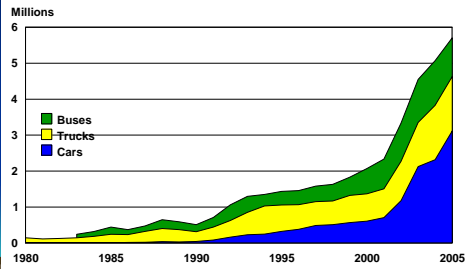
World Motor Vehicle Population



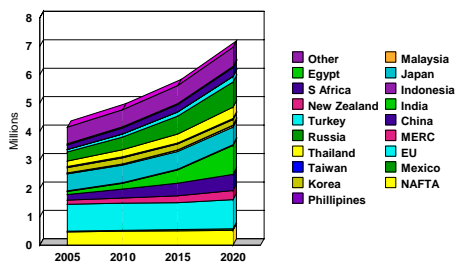
Annual Production of Cars, Trucks and Buses



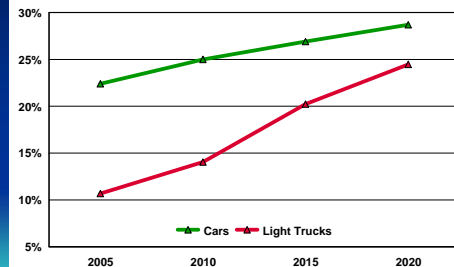
Production of Cars, Trucks and Buses in China



Heavy Duty Diesel Truck Sales Forecast



Global Light Duty Diesel Penetration Rates (%)



Perception Modern Diesel



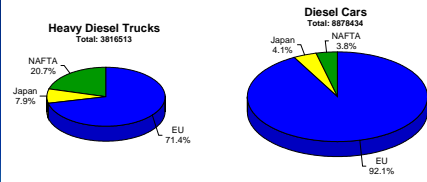
7

Now That Clean Diesel Vehicle Technology is Available

- Challenge #1: Get Advanced Technologies Introduced Rapidly For **New** Vehicles Around the World
- Challenge #2: Clean Up the Existing "Legacy" Fleet
- Availability of Ultra Low Sulfur Diesel is Critical Step

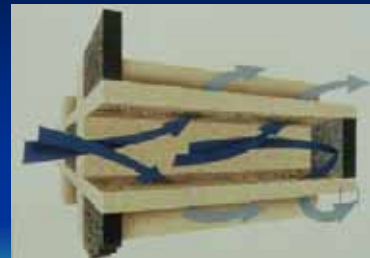
8

Global Vehicle Sales in 2005 Categorized by Emissions Path



9

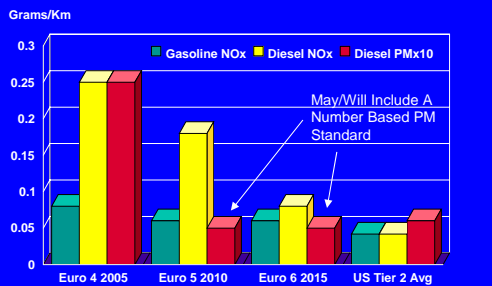
The Most Critical Technology For A "Civilized" Diesel



Catalyzed Diesel Particulate Filters (CDPFs)
can eliminate >90% of soot particles
can eliminate >90% of Ultrafine Particles

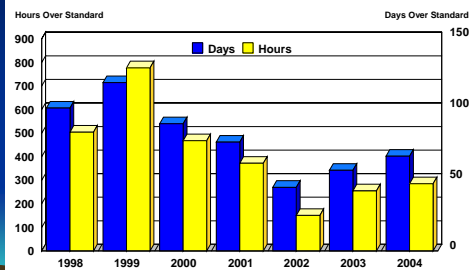
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EU and US Light Duty Gasoline and Diesel Vehicle Standards

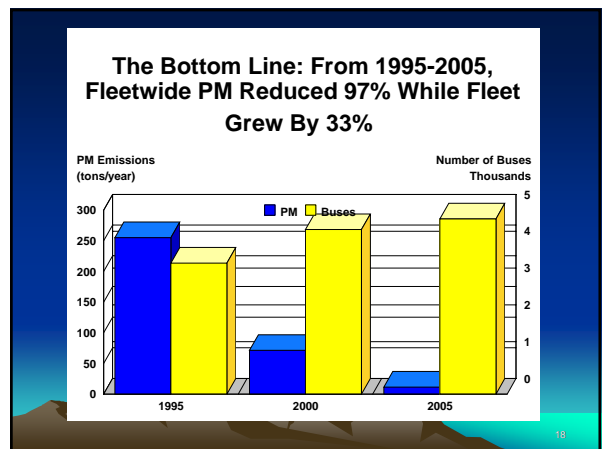
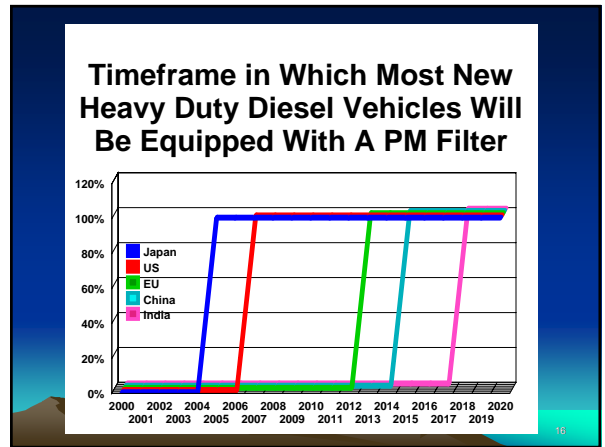
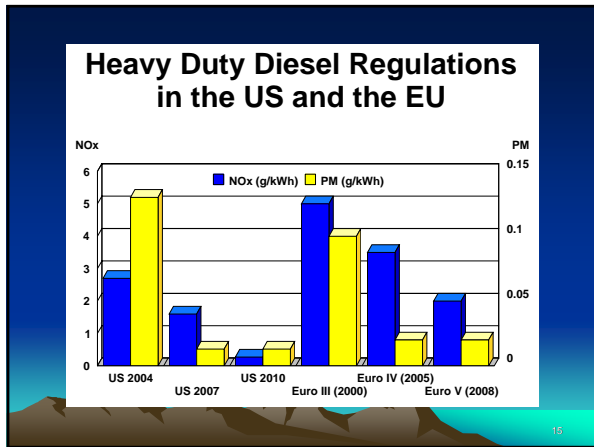
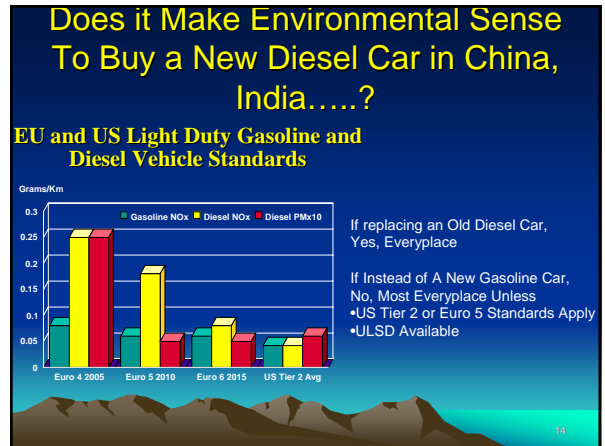
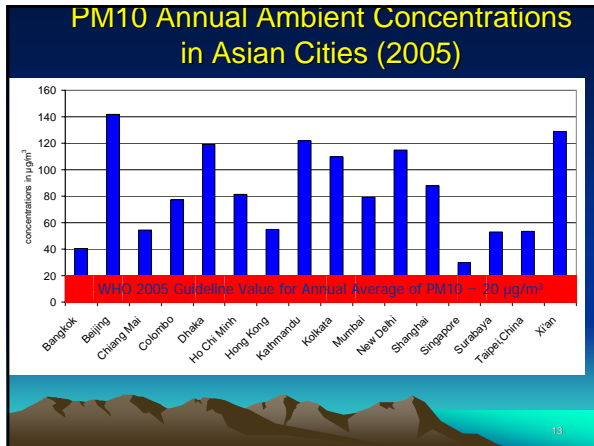


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Ozone Air Quality Trends in Beijing



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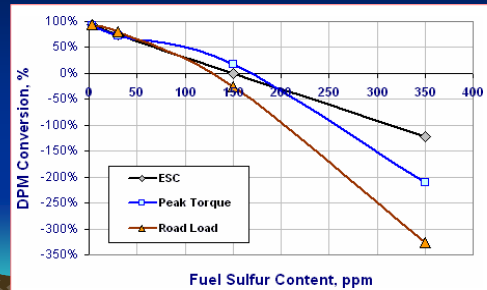


Mexico City US EPA with WRI and its Center for Sustainable Transport

- 20 buses; operated for 10 months
- At 2255 meters above sea level !!!!
- Ultra low sulfur diesel fuel for all
 - 1991s got Diesel Oxidation Catalysts
 - 2001s got Diesel Particulate Filters
- 20-30% PM reduction with DOCs
- ~90% PM reduction with DPFs

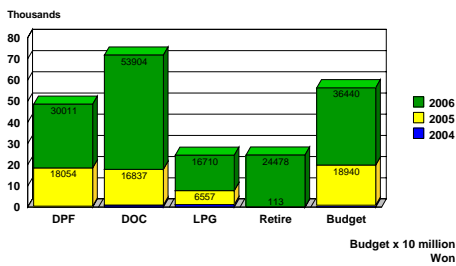
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Sensitivity to Sulfur With Catalyzed Soot Filters



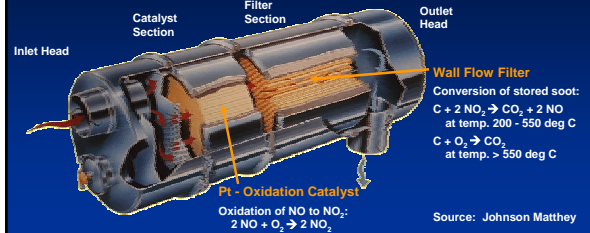
20

Control Measures for In Use Diesels in Korea



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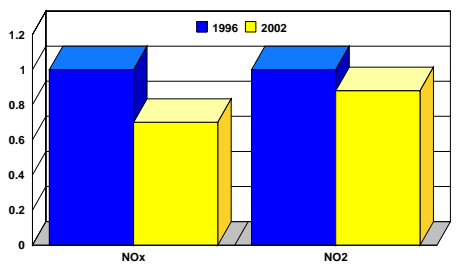
Emission Reduction Technology EGR + Particulate Reduction with DPF



- Advantages**
- High PM conversion rates
- Challenges**
- Regeneration: min. 250°C exhaust gas temperature
 - Low sulfur fuel required to avoid too frequent maintenance due to ash accumulation

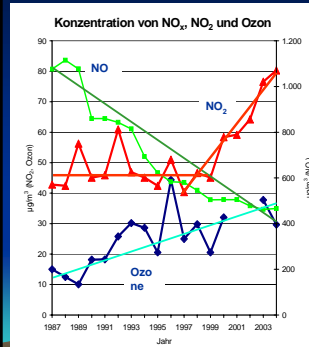
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NO₂ in London Not Declining As Fast As NO_x



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Higher NO₂ – Shares in Exhaust Gas



- Measurements at the Autobahn A 4 measurement values NO- and NO₂- between the lanes (yearly average)
- NO- reduction about 60 %
 - Ozone : increase by a factor of 2 - 3; from 1999 increase of about 20 %
 - NO₂ no change until 1998
 - from 1998 to 2004 twofold increase

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Addressing NO2 in Retrofit Applications

- California Air Resources Board
 - As of January 1, 2007, no more than a 30% increase over the baseline;
 - as of January 1, 2009, no more than a 20% increase over the baseline

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Conclusions

- Technology Now Exists to Make “Civilized” Diesels – Low PM & NOx and, of course, low CO2
- Diesels Cars Are Much Cleaner Than In The Past But Most Outside US & Japan Still Emit Much Higher PM and NOx Than Comparable Gasoline Cars
- It will be Some Years Before Most **New** Diesel Cars Outside the US & Japan Are Equipped with PM Filters
- PM and Ozone are the Most Serious Air Pollution Problems in Most Major Cities Worldwide and Will Be Difficult to Solve Until All Diesels (Light & Heavy) Are “Clean” Diesels Emitting Much Lower PM and NOx
- Until at Least Euro 6 Standards Are Introduced, Gasoline Fueled Cars Are Much Better Environmental Choice For Urban Air Pollution

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Conclusions (2)

- New Heavy Duty Diesels are Much Cleaner than Older Trucks and Could Be Much Much Cleaner
- ULSD Fuels Required For “Clean” Diesels
- If ULSD is Available, PM Filter Retrofits Are A Viable Option
- Retrofit Efforts Are Widespread Around the World
- Concerns Regarding NO2 Emissions

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