

Worldwide Evolution of Diesel Emissions Standards

3rd Aaqius & Aaiqus Paris Forum

September 28, 2004

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International Consultant



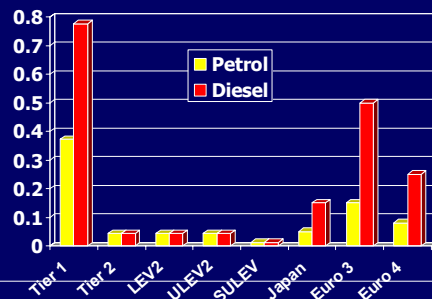
Environmental Drivers

- No serious debate regarding diesel PM control
 - Only question is when PM number will be controlled
- No serious debate regarding NOx control
 - Ozone
 - Secondary PM
 - Acidification/Eutrophication
- Some debate regarding greenhouse impacts
 - CO2 very good
 - Black carbon negative

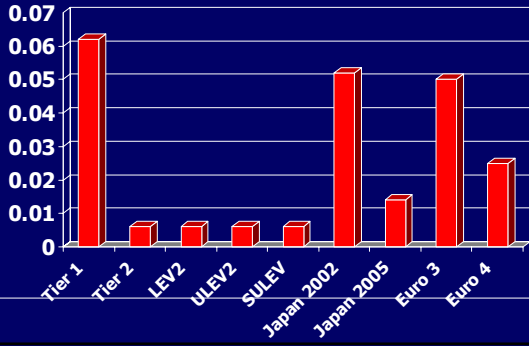
Status of New Vehicle Controls

- US largely finished for a while at least
 - Cars, Trucks, most off road done
 - Locomotive & Marine Still To come
- EU major push next 2-3 years
 - Car, truck proposals due 2005
 - Tax incentives
 - Non road likely tightened
- Japan will also go to next steps
- Developing countries following EU/US with significant lag

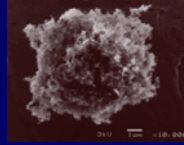
Light Duty Vehicle NOx Standards (g/km)



Light Duty Vehicle PM Standards (g/km)



Concerns Continue To Be Raised Regarding Impact of Soot On Climate

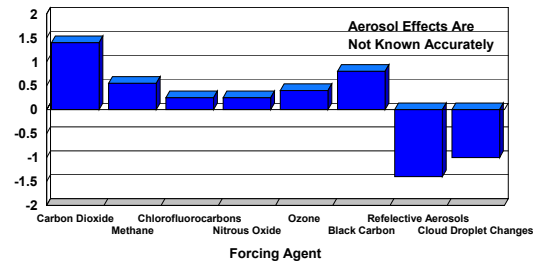


- Soot Deposited On Snow Reduces Its Ability To Reflect Sunlight
- Soot May be Twice as Effective as Carbon Dioxide in Forcing Global Warming

James Hansen and Larissa Nazarenko

Climate Forcings

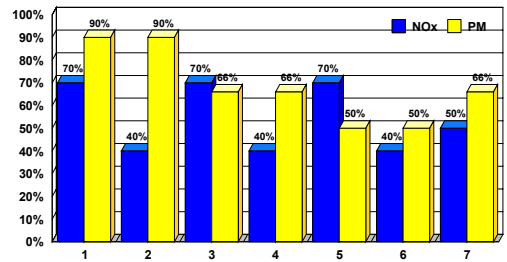
Watts Per Square Meter



Source: Hansen, Scientific American, March 2004

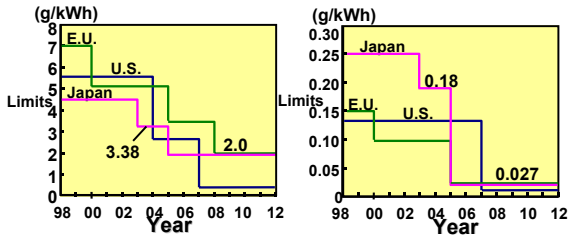
Euro 5 Scenarios Proposed By Commission For Diesel Cars

% Reduction From Euro 4



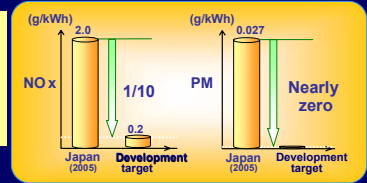
International Emission Regulations: - Heavy-duty vehicles (GVW>3.5t) -

● Nitrogen oxides (NOx) ● Particulate matter (PM)

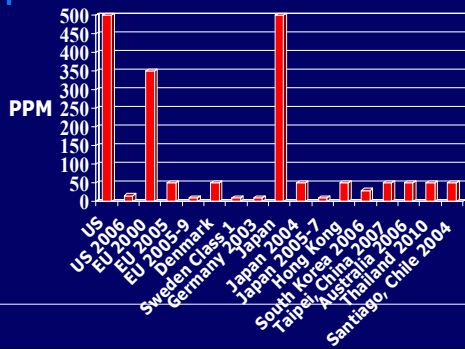


Environmental performance target for next-generation EFVs in Japan 2010 Target

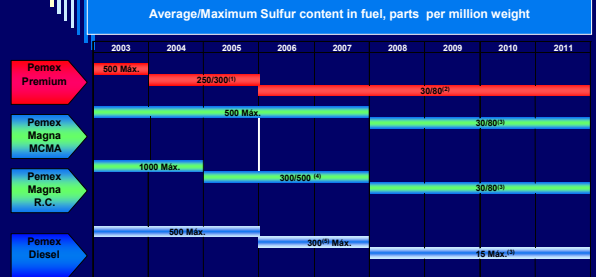
Fuel-efficiency target:
To maintain present level
of diesel vehicles
Exhaust emissions target:
NOx: 1/10 of 2005 target
PM: Nearly zero



Ultra Low Sulfur Diesel Fuel Is Spreading



ULSF introduction agreement: SEMARNAT-SENER-PEMEX REFINACION



Notes:
(1) January, 2004
(2) January, 2006
(3) September 2008
(4) January, 2005
(5) January, 2006

Lubricating Oil Specifications Change For Aftertreatment Compatibility

- ❑ Reduce ash to enable extended maintenance intervals on the diesel particulate filter
- ❑ Maintain other properties at current levels for backward compatibility
- ❑ Cost impact expected to be negligible



2WD tractor
130 hp



combine
300 hp



4WD tractor
250 hp



square
baler
60 hp



square
bale
wagon
150 hp

US Final Engine Standards Program

hp	500 ppm NR fuel					15 ppm NR fuel						
	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
<25	Tier 1											
25-75	PM (reduction w/oxidation catalysts or engine-based control)											
75-175	PM: 100% NOx											
175-750	PM: 100% NOx: 50%											

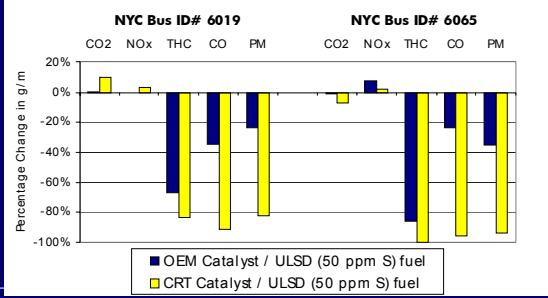
Percentages indicate portion of sales required to meet advanced emission control technology standards

For Engines >750 HP, EPA Will Require PM Filters But NOx Controls For Some Categories Still Under Review

Existing Vehicles Receiving Great Attention Worldwide

- ❑ Major retrofit programs underway in US (including California), Europe, Japan
- ❑ Retrofit demonstrations in Mexico City and Bangkok
- ❑ Increasing attention to diesel I/M with loaded tests
- ❑ Some developing countries limiting vehicle lifetimes

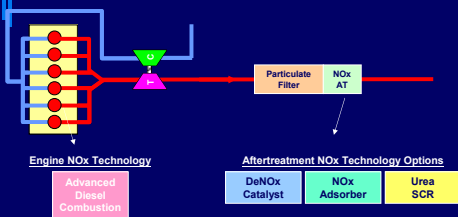
New York City Retrofit Experience



Technologies Are Advancing Rapidly

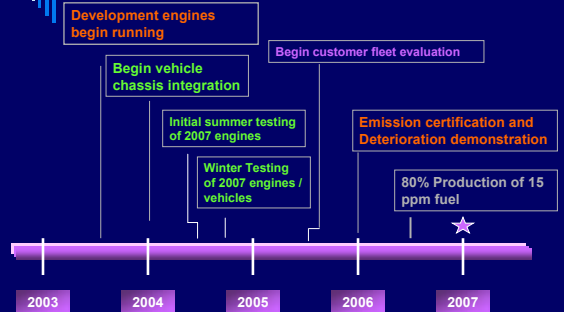
- PM Filters Are A Reality For Both Light and Heavy Duty Vehicles
- Major Efforts on NOx Controls Underway
 - Combustion Improvements
 - EGR
 - SCR
 - DeNox Catalysts
 - NOx Adsorbers
 - Different Solutions May Apply to Different Markets/Vehicles

NOx Reduction Options



- Engine-Out NOx Measures Reduce Size / Cost of Aftertreatment
- Aftertreatment Options Need to be Evaluated for Maturity and Cost
- Combination of Engine Out and Aftertreatment may Provide Best NOx Reduction Value Path

The Path Toward 2007



The Challenge for On-Highway Trucks

Ultra Low Sulfur Diesel Fuel

Particulate Reduction with the use of Particulate Filters

Manufacturer Run In-Use Emission Testing

On-Board Diagnostics

New Lubricating Oils Compatible with Aftertreatment



Closed Crankcase

NOx Reduction with Increased EGR rates

Additional Maintenance Requirements

Anti - Idling Requirements ??

The Testing Program

- Assess in-use exhaust emissions using portable emission measurement systems for NTE compliance.
- Applicable to 2007 and late model-year engines.
- Testing to be conducted on:
 - on in-use vehicles,
 - under real-world driving conditions,
 - within useful life of engine
- Emissions to be measured are: NOx, HC, CO, and PM
- Testing to be conducted and paid for by manufacturers
- Pilot testing for 2005-2006 model years
- Nonroad program modeled after on-highway

One Manufacturers (DDC) Global Technology Perspective

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Japan		EGR		EGR & DPF				EGR & SCR+DPF			
USA		EGR		EGR & DPF				EGR & SCR+DPF			
Europe			SCR		SCR			EGR & SCR+DPF			

Conclusions

- Diesel PM & NOx Remain Major Concerns
 - PM₁₀ & PM_{2.5} & Ultrafines
 - Ozone
 - NO₂
- Special Concerns With Diesel PM
 - Small Size
 - Toxicity
- Stringent New Diesel Standards and Low Sulfur Fuel Requirements Spreading
- PM Filters Seen As Key To Control; Different NOx Controls
- Europe and Japan Considering Additional New Vehicle and Engine Standards
- Non Road & Retrofit – Unfinished Agenda