

# Worldwide Evolution of Diesel Emissions Standards

3<sup>rd</sup> Aaqius & Aaiqus Paris Forum

September 28, 2004

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International Consultant



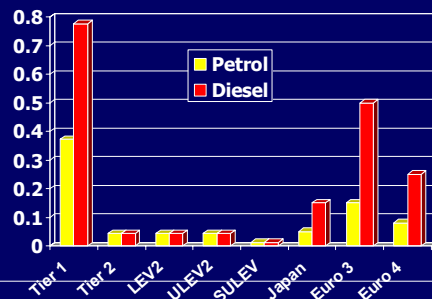
## Environmental Drivers

- 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

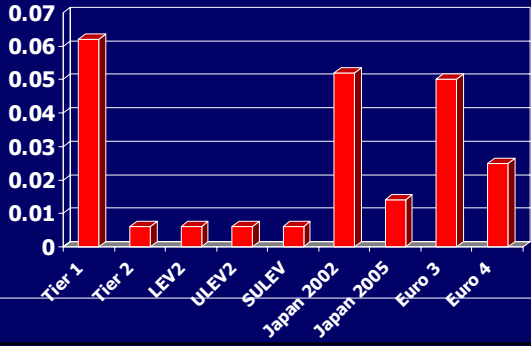
## Status of New Vehicle Controls

- 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

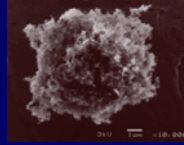
## Light Duty Vehicle NOx Standards (g/km)



## Light Duty Vehicle PM Standards (g/km)



## Concerns Continue To Be Raised Regarding Impact of Soot On Climate

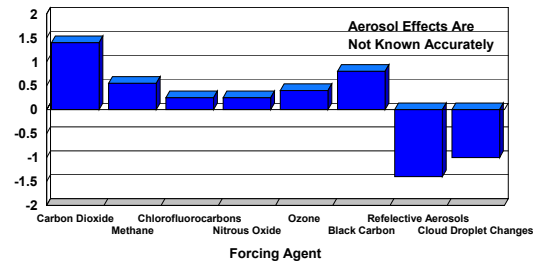


- Soot Deposited On Snow Reduces Its Ability To Reflect Sunlight
- Soot May be Twice as Effective as Carbon Dioxide in Forcing Global Warming

James Hansen and Larissa Nazarenko

## Climate Forcings

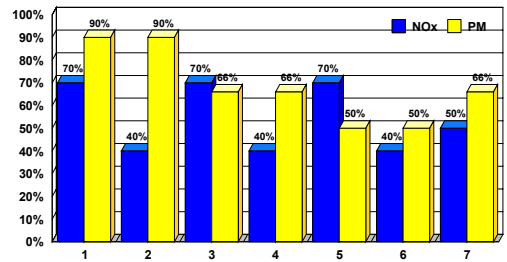
Watts Per Square Meter



Source: Hansen, Scientific American, March 2004

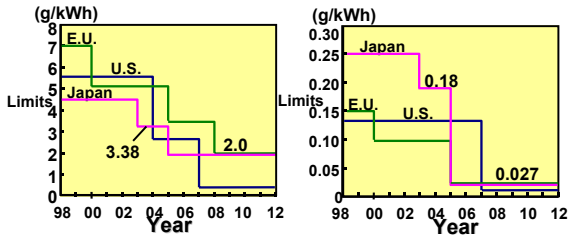
## Euro 5 Scenarios Proposed By Commission For Diesel Cars

% Reduction From Euro 4



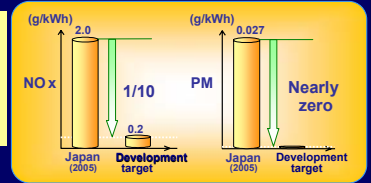
## International Emission Regulations: - Heavy-duty vehicles (GVW>3.5t) -

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

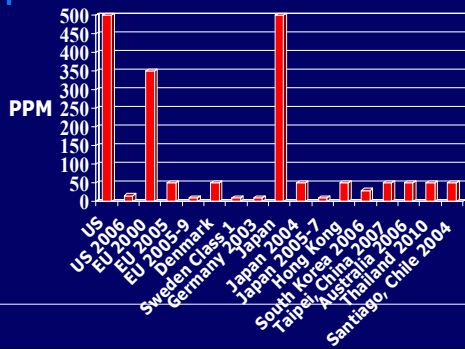


## Environmental performance target for next-generation EFVs in Japan 2010 Target

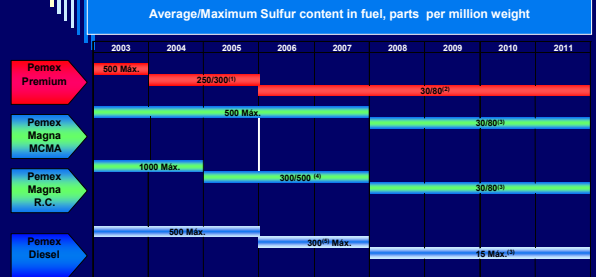
Fuel-efficiency target:  
To maintain present level  
of diesel vehicles  
Exhaust emissions target:  
NOx: 1/10 of 2005 target  
PM: Nearly zero



## 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	existing Tier 2				existing Tier 3				PM: 100%	NOx: 50%	50%	100%	
175-750							PM: 100%	NOx: 50%	50%	50%	100%		

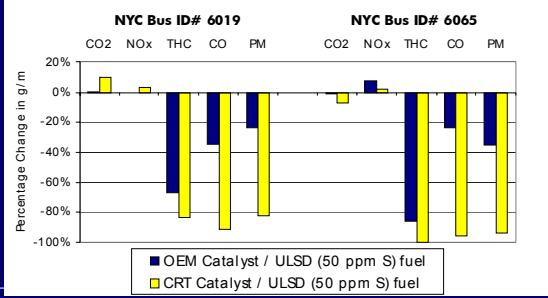
Percentages indicate portion of sales required to meet advanced emission control technology standards

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

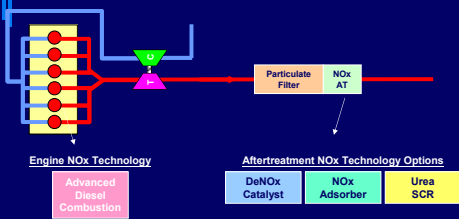
## New York City Retrofit Experience



## Technologies Are Advancing Rapidly

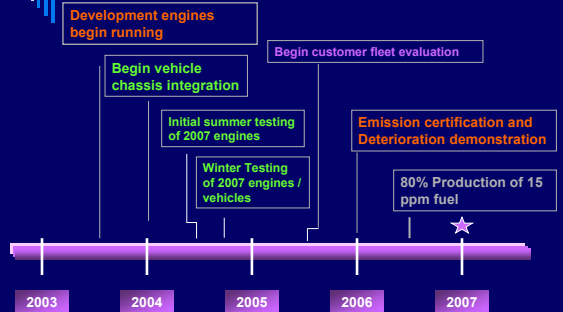
- PM Filters Are A Reality For Both Light and Heavy Duty Vehicles
- Major Efforts on NOx Controls Underway
  - Combustion Improvements
  - EGR
  - SCR
  - DeNox Catalysts
  - NOx Adsorbers
  - Different Solutions May Apply to Different Markets/Vehicles

## 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 & adv. NSC			
Europe				SCR			SCR			EGR & SCR+DPF	

## Conclusions

- Diesel PM & NOx Remain Major Concerns
  - PM<sub>10</sub> & PM<sub>2.5</sub> & Ultrafines
  - Ozone
  - NO<sub>2</sub>
- 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