

# Diesel Engines Emission Reduction: California's Clean Air Strategy

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California Air Resources Board



# Diesels are an Important Part of the World's Economy



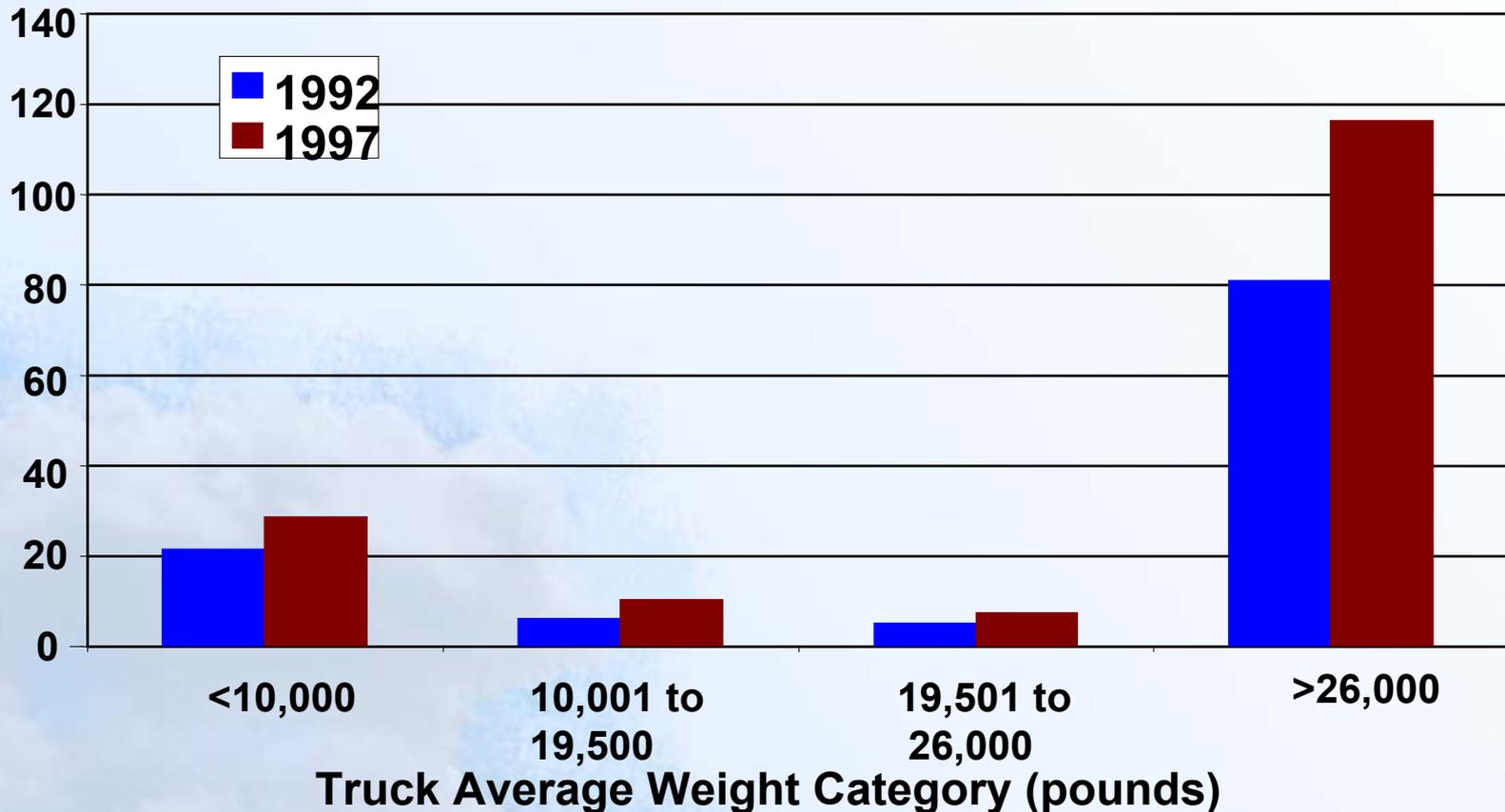
**Land and sea  
transport**

**Electrical power**

**Farming, industrial,  
and construction  
activities**

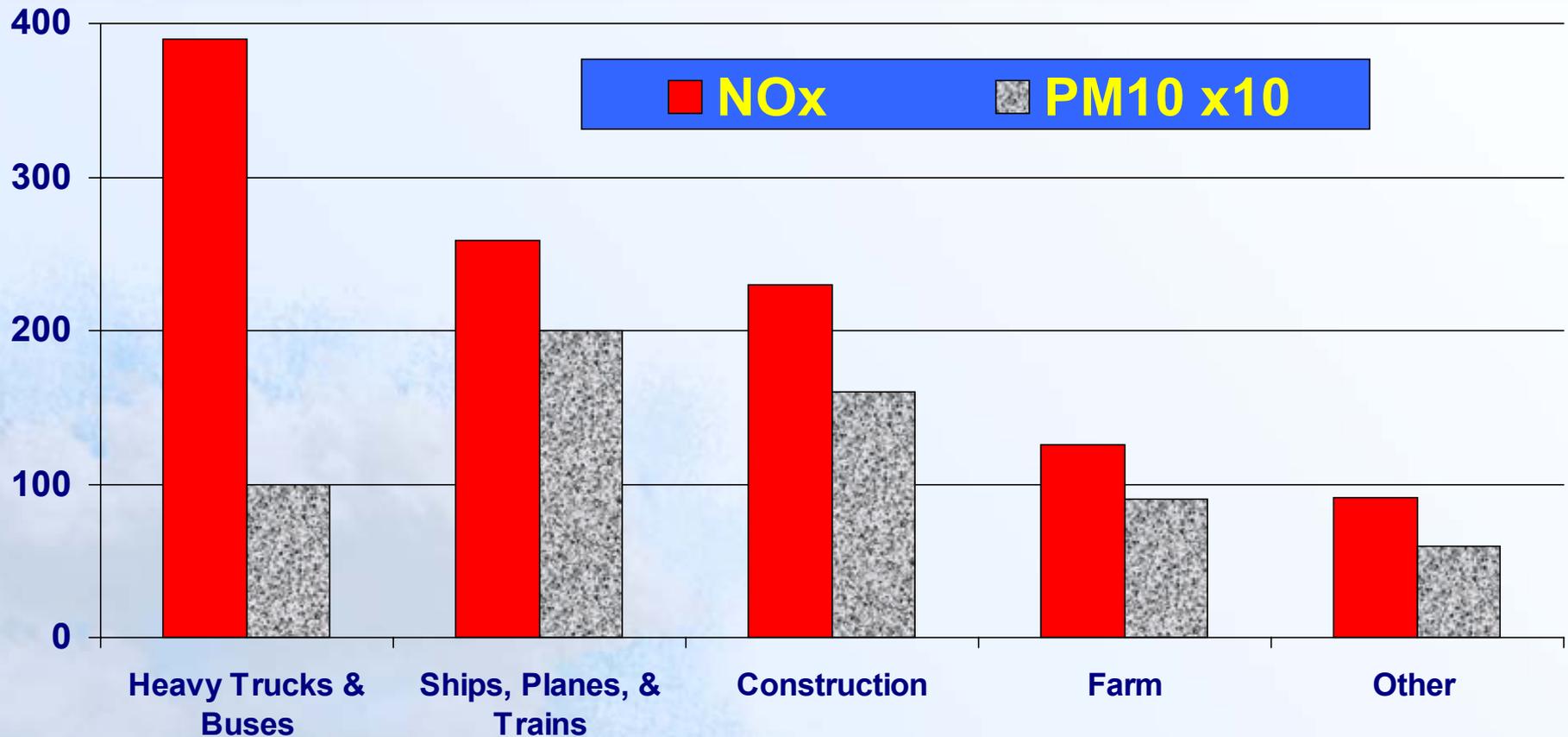
# Diesel Truck VMT is Growing in the U.S.

Annual VMT (billions)

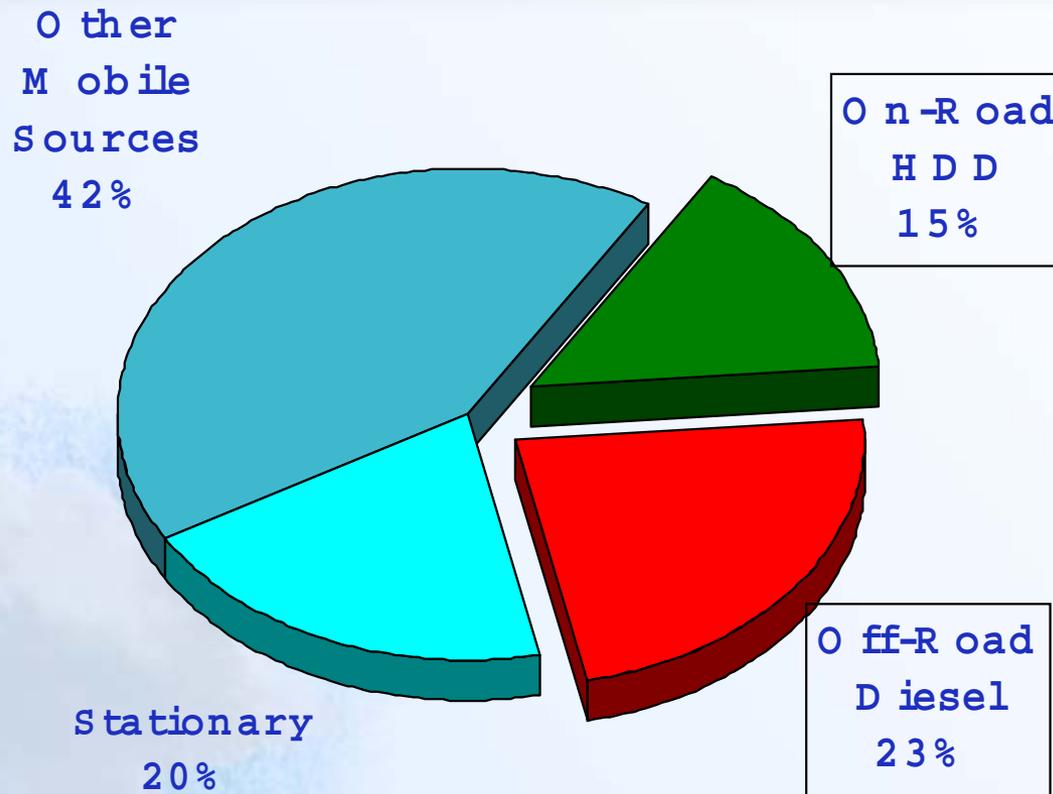


Source: U.S. Department of Commerce

# Diesel NOx and PM Emissions in 2010



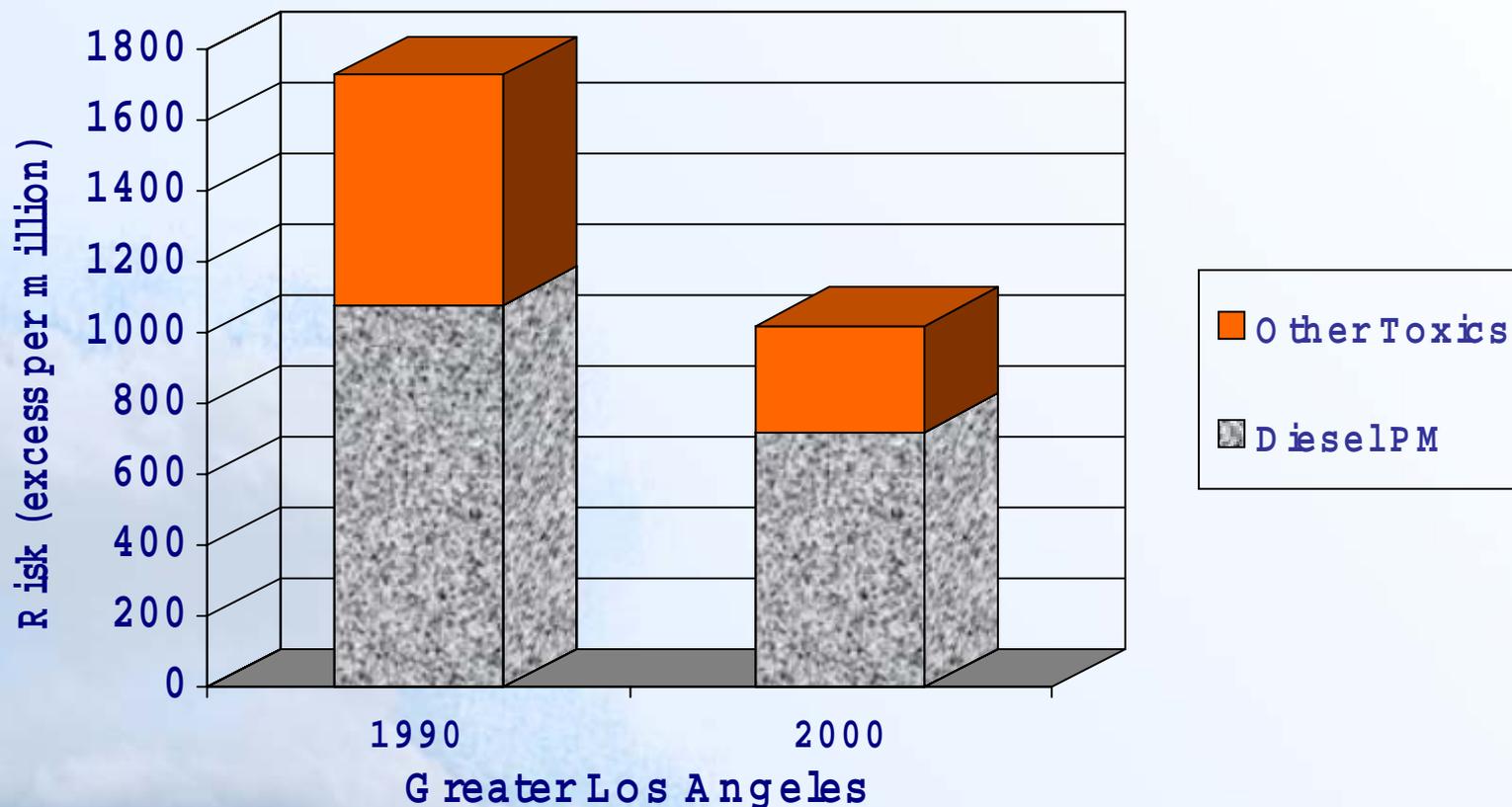
# Diesel is a Major Source of NO<sub>x</sub> in California



California in 2000

Source: EMFAC2000

# Diesel is a Majority of Air Toxic Risk in Los Angeles



# Yearly Deaths Attributable to Particulate Matter

<b>Europe</b>	<b>40,600*</b> due to PM10 <i>(About 6% of all natural deaths in Austria, France, and Switzerland)</i>
<b>Nationwide</b>	<b>~70,000**</b> due to PM2.5 <i>(About 3% of all natural deaths)</i>
<b>California</b>	<b>1,380- 4,250***</b> due to <u>Diesel</u> PM2.5 <i>(1.3% of all natural deaths in 1999)</i>

\* Kunzli, 2000 \*\*Schwartz, 2000 \*\*\*Krewski, 2000 and DHS records

# Cancer Effects of Diesel

**Increased lung cancer incidence supported by 30+ population studies**

**WHO, U.S. EPA, NIOSH, and HEI acknowledge the cancer potential in humans**

**ARB identified diesel exhaust PM as TAC**

**Unit Risk Range: 130 - 2,400 per million**

# Diesels and Visibility Reduction



**Black carbon absorbs light efficiently**

**Diesels largest source of black carbon**

**10-75% of light extinction in urban areas**

# Air Resources Board's Clean Air Plan: Strategies for a Healthy Future



**Plan for reducing  
criteria and toxic  
pollutants from  
every source**

**Focus on at-risk  
communities**

**Board Hearing  
December 2001**

**Clean Air Plan**

# Reducing Emissions from Diesels

## New Engines (Stationary and Mobile)

Engine modifications

Post-combustion clean-up

Alternatives to Diesel

## Fuels

Cleaner diesel

Alternatives

## Current fleet

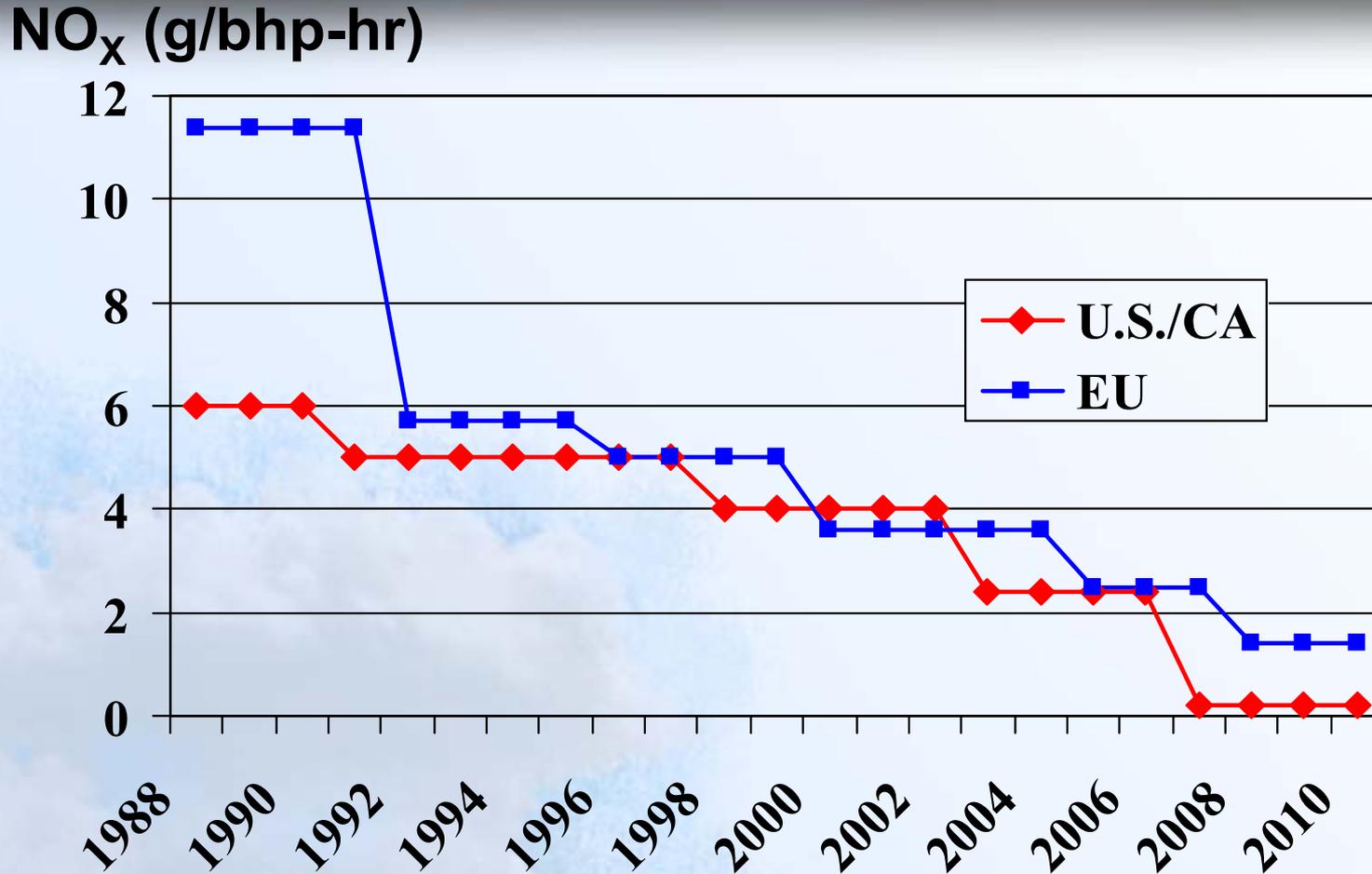
Proper maintenance

Retrofit



**Clean Air Plan**

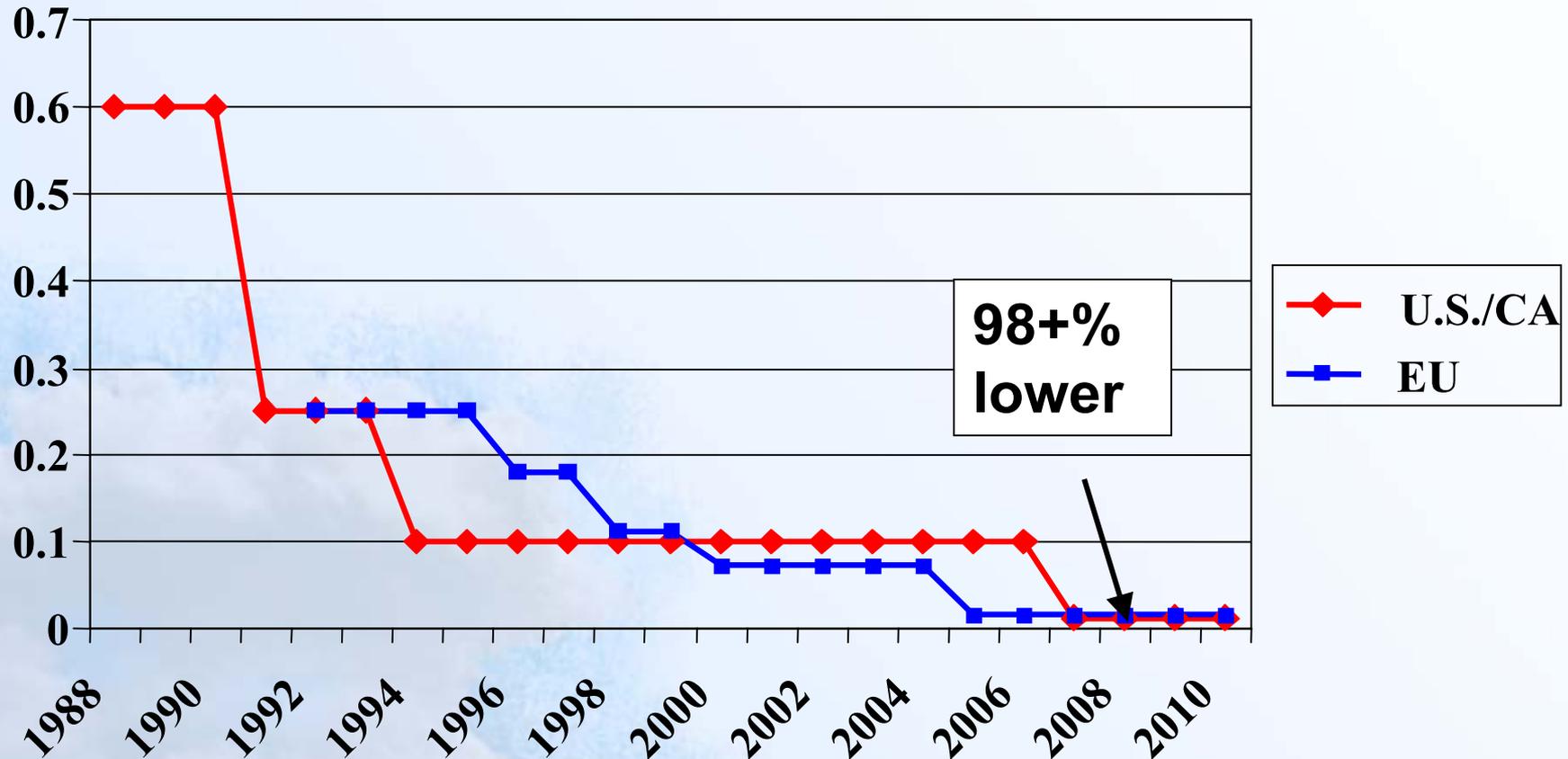
# NO<sub>x</sub> Emission Standards for New On-road Engines



Source: DieselNet. *Emissions Standards: European Union, 2001.*

# PM Emissions Standards for New On-road Engines

PM (g/bhp-hr)



Source: DieselNet. Emissions Standards: European Union, 2001.

# Transit Bus Rule

## **Two compliance paths**

**Alternative fuel**

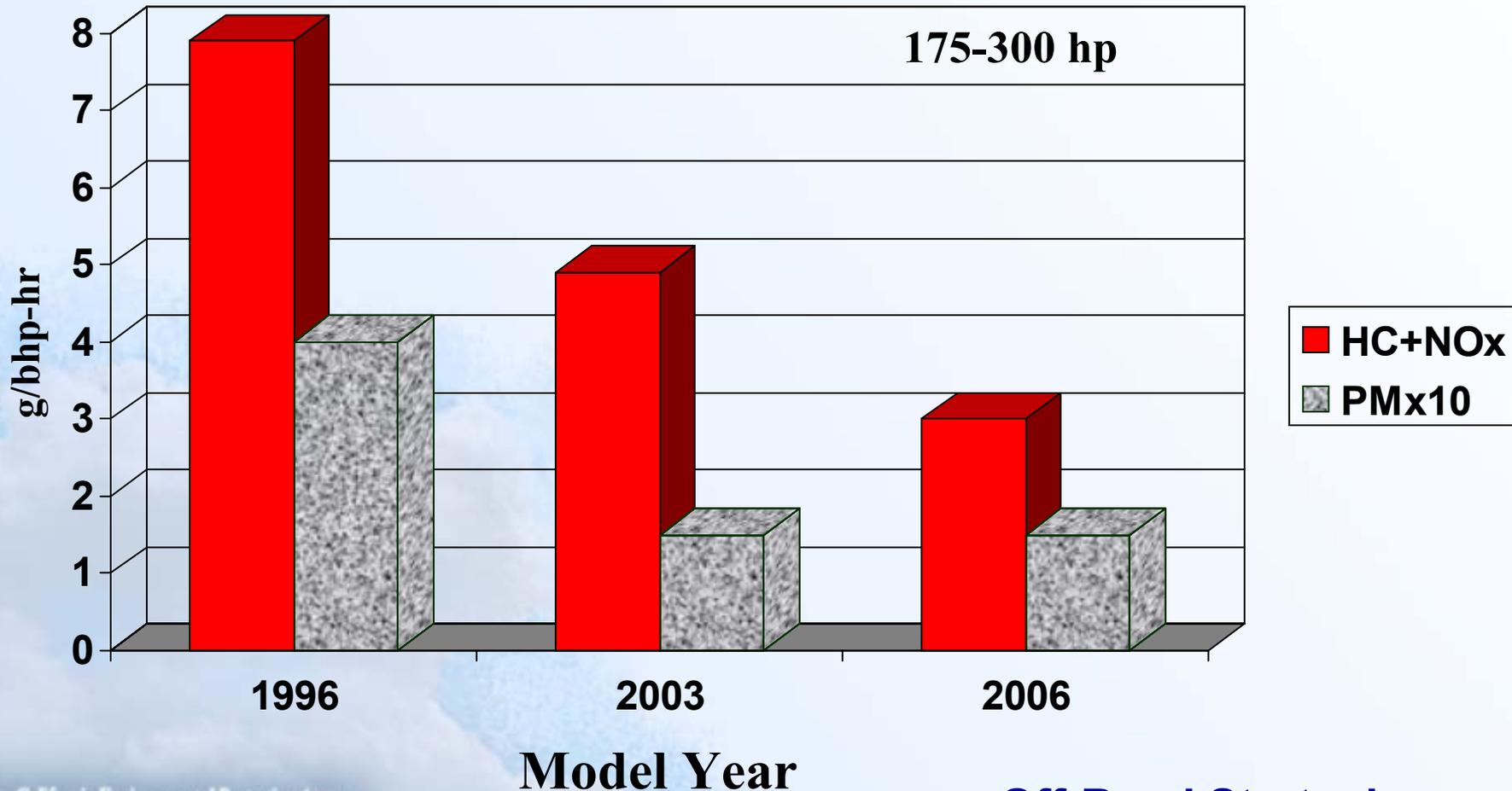
**Diesel fuel**

**Both paths provide an accelerated  
timeframe relative to HDDV rules**

**Both paths will achieve zero/near-zero  
emission technology**

**Near-term benefits differ**

# Emission Standards for New Off-road Engines



# Technologies to Meet Future Emission Standards

**NO<sub>x</sub>**

**Exhaust gas recirculation (EGR) - 2002/4**

**Combustion improvement**

**After-treatment (2007)**

**PM**

**Filter**

**Ultra-Low Sulfur Fuel**

**15 ppm (2006)**

# New and In-use Measures - On- and Off-Road



**On-Board Diagnostics  
continuous monitoring  
of performance and  
emission controls**

**In-use inspection and  
maintenance program**

**Reduce Idling**

**Possible Measures**

# Retrofit Measures

**85% reduction in PM emissions**

**Expect about 85% reduction in ROG emissions**

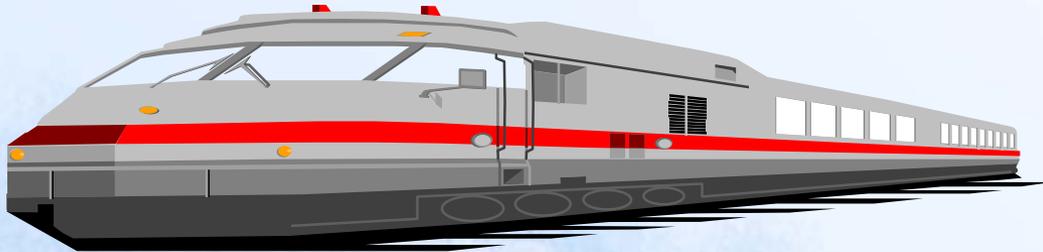
**Applicable to 90% of in-use fleet**

**Retrofits for NOx reductions will also be considered**

# Federal Measures



**More stringent standards for aircraft, locomotives and marine vessels**



**Require the use of cleaner fuel**



**Reduce Idling Time for ships and trains**

**Retrofit program**

**Possible Measures**

# Diesel Fuel Improvements



**Lower Sulfur**

**Reduces PM**

**Less engine wear**

**Current Limit**

**350 ppm on-road**

**3500 ppm off-road**

**CA 150 ppm**

**2006 Limit**

**US 15 ppm on-road**

**CA 15 ppm on-and off-road**

**Diesel Fuel**

# Alternative Fuels

## Natural Gas

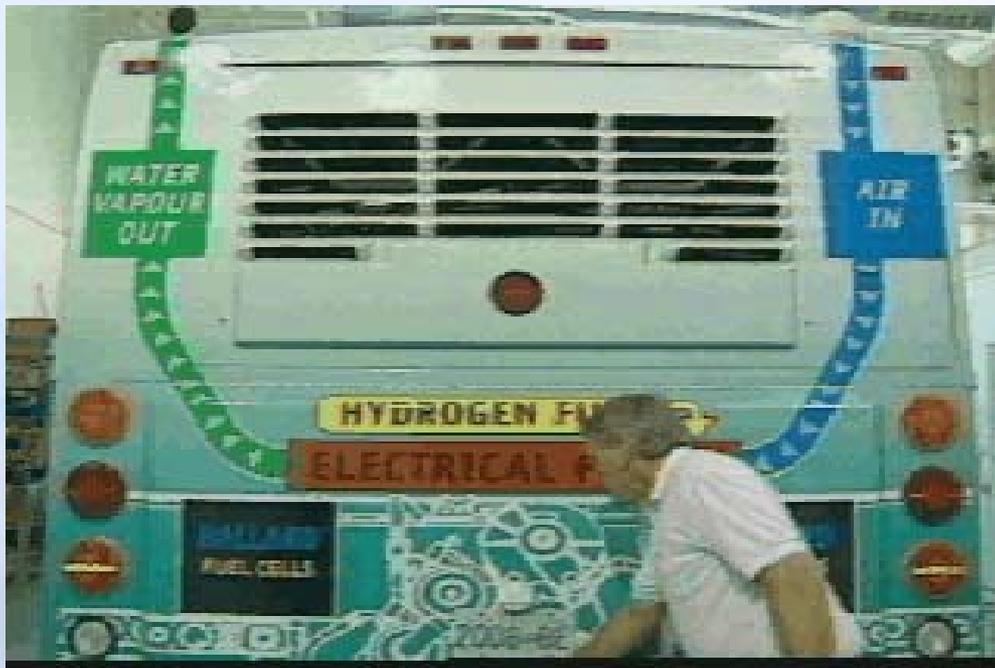
Lower NO<sub>x</sub> and PM

Nanoparticle formation being investigated

## Methanol and Ethanol

Poor durability and frequent overhauls

# Fuel Cells



**Ultimate replacement for diesel engines**

**Zero Emissions**

**High efficiency**

**Cost reduction needed**

**Initial transit buses in 2003**

**Near-term promise as truck APU**

**Future Technologies**

# Progress Means Regulations and Monitoring



**Environmental regulations result in reduced emissions**

**Equal focus on off-road engines and fuels needed**

**Monitoring of in-use emission performance must continue**

**For more information about California's Clean Air Plan, please check our website at:**

**[www.arb.ca.gov/planning/caplan/present.htm](http://www.arb.ca.gov/planning/caplan/present.htm)**

**For a comprehensive analysis of ARB's position as it related to diesel engine emission reductions, please see:**

**“Volume 51 of the Journal of Air and Waste Management Association, June 2001”**

**Critical Review, Diesel Engines: Environmental Impact and Control, by Dr. Alan C. Lloyd and Thomas A. Cackette.**