Motor Vehicle Pollution Control – A 2003 Update

Michael P. Walsh

Drivers For Motor Vehicle Pollution Controls & Regional Status

- Vehicle & Fuels Emissions Regulation
  - Health Effects
  - Environmental Effects
  - Air Quality
- Vehicle Population Growth
  - Population Growth
  - Urbanization
  - Economic Growth
- World Tour
  - OECD Countries
  - Selected Developing Countries

What pollutants are of concern?

- Greenhouse Gases: CO2, methane
- Haze
- Ozone (ROG + NOx)
- Particles (PM10/PM2.5)
  - NOx, SOx, ROG, ammonia
- Carbon monoxide (CO)
- Toxics
  - Diesel particles
  - Benzene
  - Chromium
  - Asbestos

Health Impacts of Air Pollution

Health Effects

- Different Pollutants have Different Effects
  - Carbon Monoxide - circulatory system, heart
  - Ozone - respiratory system, lung
  - Nitrogen Dioxide - respiratory system
  - PM - lung, potential effects on heart
  - Diesel, Air Toxics - cancer, respiratory effects
- There are potential effects of the Mixture
- Some Populations more sensitive than others
  - elderly
  - people with heart and lung disease

Increased Risk of Premature Mortality Due To 10 µg/m³ PM$_{2.5}$
California Air Quality vs. Growth
Percent Change 1980 to 1999
Greater Los Angeles Area

Reduction of Ozone
in Los Angeles

PM Trends in Los Angeles

Growth Areas and Emissions

Percent Change in Air Quality
Across The US
Over 90% of Californians Breathe Unhealthy Air at Times

Days Over Applicable State Standard, 1999 Monitoring Data

Ozone
PM10

0-5 Days  6-50 Days  50-100 Days  >100 Days

Number of People Living in Areas Exceeding NAAQS in 2000

<table>
<thead>
<tr>
<th>NAAQS</th>
<th>General Stations</th>
<th>Roadside Stations</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SO2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PM10</td>
<td>0.12</td>
<td>0.14</td>
</tr>
<tr>
<td>PM2.5</td>
<td>0.13</td>
<td>0.14</td>
</tr>
<tr>
<td>CO</td>
<td>0.08</td>
<td>0.11</td>
</tr>
<tr>
<td>0.00</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>0.00</td>
<td>0.02</td>
<td>0.03</td>
</tr>
<tr>
<td>0.00</td>
<td>0.02</td>
<td>0.03</td>
</tr>
</tbody>
</table>

Suspended Particulate Matter Air Quality Trends in Japan
Nitrogen Dioxide Air Quality Trends in Japan

Nitrogen Oxide Air Quality Trends in Beijing

Air Quality Readings

Calendar Year
**Greenhouse Gas Effect**

- Some of the infrared radiation passes through the atmosphere.
- Some infrared radiation is absorbed and re-emitted in all directions by GHG.
- The effect is to warm Earth.

**Global Warming Concerns**

- IPCC - 1995
  - "the balance of evidence suggests a discernible human influence"
- IPCC - 2000
  - "there has been a discernible human influence on global climate"

**Recent and Projected World Transportation Fuel Demand**

- **Source:** EIA/DOE (2001)

**Global Trends In Motor Vehicle (Cars, Trucks & Buses)Production**

- **Linear Regression:**
  - $y = -1.86e+009 + 9.6e+005x$
  - $R^2 = 0.941$, $\text{MSE} = 0.041$, $F = 53.4$, $p = 0.000$
Global Population Trends and Forecast

Projected Population Growth 1998-2050

Shifting Distribution of World's Population

Share of population living in urbanized areas is increasing

Developing world urbanization

Urban population densities are falling

More Urban Sprawl = More Dependence On Motor Vehicles
There has been enormous growth in personal travel
Total and per capita passenger-kilometers traveled – 1950-1997

<table>
<thead>
<tr>
<th>Region</th>
<th>Total (billions)</th>
<th>Per Capita (AAGR*, %/yr)</th>
<th>Total (billions)</th>
<th>Per Capita (AAGR*, %/yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Industrialized</td>
<td>2,628</td>
<td>3.8</td>
<td>14,951</td>
<td>4.4</td>
</tr>
<tr>
<td>Regions</td>
<td>717</td>
<td>6.4</td>
<td>12,068</td>
<td>4.2</td>
</tr>
<tr>
<td>World</td>
<td>2,340</td>
<td>4.6</td>
<td>62,049</td>
<td>5.4</td>
</tr>
<tr>
<td>United States</td>
<td>1,706</td>
<td>2.9</td>
<td>11,205</td>
<td>2.5</td>
</tr>
<tr>
<td>Western Europe</td>
<td>542</td>
<td>5.1</td>
<td>18,031</td>
<td>4.4</td>
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<tr>
<td>Former Soviet</td>
<td>127</td>
<td>5.0</td>
<td>4,589</td>
<td>3.6</td>
</tr>
<tr>
<td>Other</td>
<td>125</td>
<td>5.3</td>
<td>4,082</td>
<td>3.1</td>
</tr>
</tbody>
</table>

*Average Annual Growth Rate, 1950 to 1997.

Note: Data not available for selected years.


This growth is projected to continue for the next several decades

Recent and projected world transportation fuel demand (million barrels per day, oil equivalent)

<table>
<thead>
<tr>
<th>Fuel</th>
<th>Industrialized Countries</th>
<th>Other Countries</th>
<th>Growth*</th>
<th>Growth*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1990</td>
<td>1999</td>
<td>2020*</td>
<td>1990</td>
</tr>
<tr>
<td>Gasoline</td>
<td>11.2</td>
<td>13.1</td>
<td>17.3</td>
<td>2.0</td>
</tr>
<tr>
<td>Diesel fuel</td>
<td>5.2</td>
<td>6.6</td>
<td>9.5</td>
<td>1.7</td>
</tr>
<tr>
<td>Jet fuel</td>
<td>2.5</td>
<td>3.0</td>
<td>5.6</td>
<td>2.8%</td>
</tr>
<tr>
<td>Bunker fuel</td>
<td>1.2</td>
<td>1.2</td>
<td>1.3</td>
<td>0.8%</td>
</tr>
<tr>
<td>Other</td>
<td>0.5</td>
<td>0.9</td>
<td>1.5</td>
<td>2.2%</td>
</tr>
<tr>
<td>Total</td>
<td>20.9</td>
<td>20.0</td>
<td>28.5</td>
<td>1.9%</td>
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</tbody>
</table>

* Indicates estimate.


Notes: “Industrialized Countries” include North America, Western Europe, Japan, and Australasia.

Road freight is growing everywhere

<table>
<thead>
<tr>
<th>Country</th>
<th>1970</th>
<th>Early 1990s</th>
</tr>
</thead>
<tbody>
<tr>
<td>United States</td>
<td>500</td>
<td>1,000</td>
</tr>
<tr>
<td>Russia</td>
<td>300</td>
<td>600</td>
</tr>
<tr>
<td>China</td>
<td>100</td>
<td>200</td>
</tr>
<tr>
<td>Japan</td>
<td>150</td>
<td>300</td>
</tr>
<tr>
<td>Mexico</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Brazil</td>
<td>200</td>
<td>400</td>
</tr>
</tbody>
</table>


New Vehicle Sales Forecast


Note: Data not available for selected years.
**New Vehicle Sales Forecast (Including Motorcycles)**

**New Vehicle Sales Forecast (Excluding Motorcycles)**

**Recent and Projected World Transportation Fuel Demand**

A Gradual Shift Toward Diesel is Underway

**Europe**

- Issues:
  - Diesel PM/NOx
  - HDD Technology Review
  - Next Steps?
  - Climate Change

**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
European Fuel Sulfur Levels (PPM)

- Euro 2: 500 PPM
- Euro 3: 150 PPM
- Euro 4: 50 PPM
- Euro 5: 10 PPM

Widely Available in 2005; 100% in 2009

Yearly Car Tax in Denmark

- 24 Different Car Classes Based On Kilometers Per Liter of Fuel
- Diesel Taxed More Than Gasoline
- Annual Increase with Inflation Plus 1.5% Per Year

Emissions From Gasoline Cars In Europe

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

European Agreement (g CO₂/km)

- Some 120 g/km Cars in 2000
- Target Range of 165-170 g/km in 2003
- Review Feasibility of 120 g/km for Average car by 2012 in 2003

Fuel Consumption: Diesel Vs. Gasoline Mercedes E320

- Fuel Economy
- Fuel Consumption Over 100,000 Miles

Saves 1000 Gallons

Source: Dr. Rudolf W. Thom
January 2003, SIAT 2003
ACEA’s CO2 Reduction

Vehicle Weight: 800 kg (Aluminum)
Engine: Turbocharged, Intercooled Direct-Injection Diesel
High Pressure Unit Injector
1.2 liters, 3 cylinders, 100 kg wt
Power: 45 kW/4000 rpm
Torque: 148 Nm/2000 rpm
Fuel Economy: 2.99 liters/100 km

However....

Diesel Particulate Matter

Cancer Studies in Railroad Workers HEI, 1995

PM Emissions in the UK - 1996

*Source Attribution of Airborne Particulate Matter in the United Kingdom*
Comparison of PM10, PM2.5, and Ultrafine PM

- PM10 (10 \(\mu\)m)
- PM2.5 (2.5 \(\mu\)m)
- Ultrafine PM (0.1 \(\mu\)m)

Human Hair (60 \(\mu\)m diameter)

Relative size of particles

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

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

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

A PM Solution Exists!

PSA’s DPF System for Diesel Passenger Cars
Emissions From Diesel Cars In Europe

European Auto Standards

Gasoline Light Duty Truck Standards in EU

Diesel Light Duty Truck Standards in EU

Comparison of NOx Emission Type Approval Data from Current Passenger Car Types

In Germany, Diesels Actually 7 times More NOx Than Otto
NOx-Emissionen (kt/a) in Deutschland – TREMOD 2.1 (10/2001)

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

PM-Emissions (kt/a) in Germany – TREMOD 2.1 (10/2001)

Light Duty Vehicle PM Standards (g/km)

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

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

**Proposal of UBA for EURO 5 Limits for PC and LDT**

<table>
<thead>
<tr>
<th>Vehicle category</th>
<th>Reference weight</th>
<th>CO (g/km)</th>
<th>HC (g/km)</th>
<th>NOx (g/km)</th>
<th>PM (g/km)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Category</td>
<td>Class</td>
<td>petrol</td>
<td>petrol</td>
<td>petrol</td>
<td>GDI</td>
</tr>
<tr>
<td>01.04.2008</td>
<td>PC</td>
<td>—</td>
<td>alle</td>
<td>1.0</td>
<td>0.05</td>
</tr>
<tr>
<td>01.04.2008</td>
<td>LDT</td>
<td>I</td>
<td>0.1</td>
<td>1.0</td>
<td>0.05</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>III</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Future Directions in Europe**

- Assure Filters or Traps Be Used Across the Board
- EEV Standards with Tax Incentives
- Tighter Standard(s)
- PM Standards – Current Standard Not Tight Enough
- Ultra Fine PM
- Toxic Emissions
- Diesel NOx Tightened To Gasoline NOx Standards
- recent agreement on sulfur enables diesel NOx technology to accomplish this
- Maybe Even Tighter Gasoline Vehicle Standards

**United States**

**Issues:**
- Diesel Trucks/Low Sulfur
- Fuel Economy – LDD Threat To Tier 2

**Opportunities:**
- Offroad Diesel
- Light-duty diesel
- Retrofits

**New Car Emissions Standards in the US**
Vehicle Miles Traveled Grew Rapidly

US Tier 2 Standards

Key Motor Vehicle Regulations In California

California's Goal: “Zero” Emissions

Bins for Tier 2/LEV2 (g/mile)
Zero Emission Vehicle Regulation

Goal: Zero Emission Vehicles in California
- Advance Pure ZEV technology research, development and deployment
- Support development through volume production of Advanced Technology PZEVs
- Achieve air quality improvement through increased AT PZEVs & implementation of PZEV deployment

ZEV Regulation 2003
- April Board Hearing
- Two Path Compliance System
- Maximize near term technology
- Continue pressure on pure zero emission vehicles
- Address litigation

Overview of Regulation

Alternative Compliance Path
Market share of 250 type III ZEVs (fuel cell vehicles) placed between 2001 and 2008
Remaining gold obligation may be met with silver

<table>
<thead>
<tr>
<th>Staged Growth</th>
<th>Phase</th>
<th>Vehicles Required</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2001 - 2008</td>
<td>250</td>
</tr>
<tr>
<td></td>
<td>2009 - 2011</td>
<td>2,500</td>
</tr>
<tr>
<td></td>
<td>2012 - 2014</td>
<td>25,000</td>
</tr>
<tr>
<td></td>
<td>2015 - 2017</td>
<td>50,000</td>
</tr>
<tr>
<td></td>
<td>2018 - 2020</td>
<td>89,000</td>
</tr>
<tr>
<td></td>
<td>Cumulative Total</td>
<td>166,750</td>
</tr>
</tbody>
</table>

Hybrid Electric Vehicles
Important for development of zero emission vehicles
- ZEV enabling technology:
  - electric drive train
  - batteries
  - power management

Number of Vehicles--AT PZEVs
Hybrid Vehicle Commercialization

- Toyota Prius: Small car 2000
- Honda Civic: Small car 2002
- Ford Escape: Small SUV 2003
- Dodge Durango: Large SUV 2003
- GM Sierra: Large Pickup 2004
- GM: Medium SUV 2004
- Toyota Minivan: ?

California’s Family of Clean Cars

- PZEVs
  - Super Ultra Low Emissions
  - Zero Evaporative Emissions
  - 150,000 mile emissions durability
- AT PZEVs
  - Hybrid Electric Vehicles
  - Compressed Natural Gas Vehicles
  - Hydrogen Internal Combustion Engine Vehicles
- ZEVs
  - Battery Electric Vehicle
  - Fuel Cell Vehicles

1999 California GHG Emissions (in CO₂ Equivalents)

- Carbon Dioxide: 84%
- Methane: 9%
- HFCs: 3%

Sources: 1997 Global Climate Change, DOE; Draft Greenhouse Gas Inventory Update, California Energy Commission, 2001

Transportation is California’s Largest Source of CO₂

- Commercial: 4%
- Electricity generation: 16%
- Residential: 13%
- Transportation: 58%

California Fossil Fuel CO₂ Emission Sources, 1999

Potential Climate Change Impacts

- Agriculture
- Coastlines
- Ecosystems
- Forests
- Health
- Infectious and Tropical Diseases
- Precipitation Patterns and Extremes
- Sea Level Rise
- Species and Natural Areas

Source: Anne Grambsch, 1998

Hotter Days Lead to Higher Emissions and More Smog

- 10 warmest years of the last century all occurred within the last 15 years.

Source: California Environmental Protection Agency
AB 1493: General Requirements

By January 1, 2005 Board to adopt regulations that achieve maximum feasible and cost-effective reduction of greenhouse gas emissions from motor vehicles

- Regulations may not take effect prior to January 1, 2006
- Regulations apply only to 2009 and later model years

In Developing Regulations ...

Consider:

- technical feasibility
- impact on state economy
- Provide compliance flexibility
- Conduct public workshops
  - communities with significant exposure to air contaminants, including communities with minority or low-income populations
- Grant credit for early reductions

Regulations Shall Not Require ...

- Fees or taxes on vehicle, fuel or VMT
- Ban on sale of any vehicle category
- Reduction in vehicle weight
- Limitation on or reduction of speed limit
- Limitation on or reduction of VMT

Milestones

- Detailed technical work
- Initial workshop (GHG inventory) December 2002
- Symposium on vehicle technology March 2003
- Additional workshops Various
- Board update November 2003
- Draft staff proposal
  - Release staff draft May 2004
  - Workshop June 2004
  - Final staff proposal July 2004
  - Board adoption September 2004
- Report to Legislature/Governor January 2005

Health Impacts of Diesel in California

<table>
<thead>
<tr>
<th>Impacts Of Diesel PM 2.5</th>
<th>Annual</th>
</tr>
</thead>
<tbody>
<tr>
<td>Deaths</td>
<td>2,900</td>
</tr>
<tr>
<td>Chronic Bronchitis</td>
<td>2,590</td>
</tr>
<tr>
<td>Hospital Admissions</td>
<td>2,790</td>
</tr>
<tr>
<td>Lower Lung Symptoms</td>
<td>95,400</td>
</tr>
<tr>
<td>Loss of Days Work</td>
<td>621,000</td>
</tr>
</tbody>
</table>

Emission Challenges: Light-duty Diesel

- NOx and PM
  - PM Std. = 0.01 gpm - Peugeot @0.0005
  - NOx Std. = 0.05 gpm - Toyota @ 0.05
- U506 standard: Challenge for NOx
- Emission control technology same as for heavy diesels
- Climate change
  - If black carbon higher than gasoline, diminishes CO2 benefit

\(^1\) Prototype
Emission Performance
Light-duty Diesels

<table>
<thead>
<tr>
<th>Model</th>
<th>NOx g/mile</th>
<th>PM g/mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>CA VW 1.9 l Jetta</td>
<td>0.7</td>
<td>0.053</td>
</tr>
<tr>
<td>US Mercedes 3.0 l E300</td>
<td>0.8</td>
<td>0.08</td>
</tr>
<tr>
<td>EU Peugeot 607 3</td>
<td>0.6</td>
<td>0.0005</td>
</tr>
<tr>
<td>Toyota Avensis Prototype</td>
<td>0.05</td>
<td>0.006</td>
</tr>
</tbody>
</table>

Policy Considerations: Light-duty Diesels
- If light-duty diesels met LEV2 emissions, consider them clean (for now)
- Compliance by 2007 likely
- No need for standards relaxation
- Can play a role in reducing climate change emissions
- Mix of technologies likely
- G-ICE, G-HEV, Diesel

Diesel Engine Technology (Pickups and SUVs)
Cummins working with DOE to develop diesel engine for pickups and SUV’s (6000-8500 lbs. GVW)
- Target Tier 2 Bin 5 and LEV II LEV
  - HC 0.09 g/mi/NOx 0.07 g/mi/PM 0.01 g/mi demonstrated Tier 2 Bin 8
  - Requires low sulfur fuel (2006)
- Claim a 29% reduction in CO₂ emissions
- Combined city/hwy

National Pressure Building To Address Fuel Economy

Current Nonroad and Highway Standards:
- Tier 3 Nonroad
  - 6.0 g/hp-hr NOx
  - 0.15 g/hp-hr PM
- Tier 2 Nonroad
  - 4.8 g/hp-hr NOx
  - 0.15 g/hp-hr PM
- Each incremental step has followed the pattern of transferring technology from highway.
**Differences between Highway and Nonroad Markets**

<table>
<thead>
<tr>
<th></th>
<th>Highway Diesel</th>
<th>Nonroad Diesel</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total US Sales (units)</td>
<td>~800,000</td>
<td>~800,000</td>
</tr>
<tr>
<td>Power Range</td>
<td>250 - 600 hp</td>
<td>3 - 3,000+ hp</td>
</tr>
<tr>
<td># of Engine Manufacturers</td>
<td>~ 10</td>
<td>~ 60</td>
</tr>
<tr>
<td># of Vehicle/Equipment Manufacturers</td>
<td>&lt;16</td>
<td>&gt;800</td>
</tr>
<tr>
<td># of Engine Families</td>
<td>107</td>
<td>650</td>
</tr>
<tr>
<td># of Vehicle/Equipment Models</td>
<td>&lt;200 (trucks)</td>
<td>&gt; 6,000 (anything you can think of)</td>
</tr>
<tr>
<td>Volume of “identical” products</td>
<td>- 100,000 LH duty</td>
<td>- 10,000 HH duty</td>
</tr>
</tbody>
</table>

Far Greater Scope than 2007 Highway Rule

- Fuel sulfur reduction 10 times what was achieved in 2007 highway rule.
- nonroad, marine, and locomotive fuel regulated nationwide for first time ever.
- Alaska included.
- In use control: Adding transient test, cold start test, not-to-exceed program.
- Regulating all engines from smallest to largest.
- Despite larger scope, 10-year timing for program implementation (promulgation to end of phase-in) would be same as for 2007 rule and highway Tier 2 rule.
- Overall, this is a very cost-effective program, consistent with 2007 highway program.

**Engine Standards – 2 Step Fuel Program**

- Inventories: significant
- Machine population: large (and growing)
- Personal exposures: very important due to where used and how designed

**Small Engine Impacts**

- 2WD tractor 130 hp
- 4WD tractor 250 hp
- square baler 60 hp
- square bale wagon 150 hp

PM

- Small engine impacts: significant
- Machine population: large and growing
- Personal exposures: very important due to where used and how designed
Relative Cancer Risks in Los Angeles

Based on ARB monitoring data 1995 - 1997

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 By End of 2001
- ~71,000 To Date
  - New York
  - Seattle
  - Texas
  - Others

Other Retrofit Efforts

- On & Off Road in Sweden
- London
- German Cities
- Switzerland
- Hong Kong
- Tokyo
- Other

Key US Air Regulatory Schedules

<table>
<thead>
<tr>
<th>Mobile Source Program</th>
<th>PM Standards (Fine Particles)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2003 Non-road diesel proposed</td>
<td>2003 States recommend nonattainment designations</td>
</tr>
<tr>
<td>2004 Other non-road categories</td>
<td>2004 EPA makes nonattainment designations</td>
</tr>
<tr>
<td>2005-09</td>
<td>2005-09 Non-att NOx “Rule NAQOS review*</td>
</tr>
<tr>
<td>2004-07 States develop/submit SIP's</td>
<td>2004-08 EPA approves SIP's</td>
</tr>
<tr>
<td>2007-08</td>
<td>2007-08 Alteration deadlines vary</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Air toxics/Stationary Source Program</th>
</tr>
</thead>
<tbody>
<tr>
<td>2004 Complete update MACT standards</td>
</tr>
<tr>
<td>2006-12 Residual risk standards</td>
</tr>
<tr>
<td>2004-10 Area source standards</td>
</tr>
<tr>
<td>2004-14 Community assessment based risk reduction programs</td>
</tr>
</tbody>
</table>

*Dates subject to ongoing legal discussions

Japan

Issues:
- Advanced Technologies
- Retrofit

Opportunities:
- Retrofit

Kyoto
Air Quality in Tokyo (1)

Historical Success & Today’s Issue

Successful reduction in 7-80’s

SO₂  CO  Stationary Sources
Factories  Power plants  etc.

Main issue today

NO₂  SPM  O₃

Vehicle Emissions

Historical Success & Today’s Issue

SO₂  CO  Stationary Sources
Factories  Power plants  etc.

Main issue today

NO₂  SPM  O₃

Vehicle Emissions

Major Causes of Air Pollution Today

Vehicle Emissions

67% of NOₓ
Planes, Vessels 5%
Factories 14%
Home, Office 14%
Cargo vehicles 49%
Passenger cars 18%

82% of SPM
Planes, Vessels 2%
Factories 13%
Home, Office 4%
Road dust 46%
Vehicle emissions 36%

Say No! to Dirty Diesel Campaign

Policy making by raising proposals
open to the public

Five Proposals

- Do not buy, ride and sell diesel passenger car
- Substitute low emission vehicle
- Install emission reduction devices
- Correct supportive taxation to diesel vehicles
- Tighten emission regulation and call for technical innovation for it

Open Discussion on Website

830 opinions in 70 days, More than 13,000 access

Diesel Vehicle Issue

High Impact by Diesel Vehicles

- 70% of NOₓ (among vehicle emissions)
- Almost 100% of vehicle caused SPM
- Only 23% of total travel mileage

Heavy reliance on Diesel Vehicles

650 thousand vehicle in Tokyo & it’s increasing
**Finalized Programs** Starts October 2003

New Ordinance on Environmental Preservation

Diesel vehicles fail to meet new TMG standard to be banned from operating in Metropolitan area

-- Replace with low-emission vehicle
-- Buy latest vehicle which meet the standard
-- Install PM reduction devices

**Introduction of Low Emission Vehicles**

-- Business owners with more than 200 vehicles are required to introduce LEV at least 5% of total #

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**Finalized Programs (Major program)**

**Environmental management plan**

Business owners are required to submit management plan for more environmental friendly vehicle operation

**Environmental information Disclosure**

Car dealers are required to explain the environmental information on new vehicles to the buyers

**Stop idling**

Drivers are required to stop idling when they stop or park. Parking lot owners are required to post the notes etc.

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**Reduction of Sulfur in Diesel Fuel in Japan**

<table>
<thead>
<tr>
<th>Year</th>
<th>Sulfur Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>~1992</td>
<td>5000 ppm</td>
</tr>
<tr>
<td>1993</td>
<td>2000 ppm</td>
</tr>
<tr>
<td>1997</td>
<td>500 ppm</td>
</tr>
<tr>
<td>2003/4</td>
<td>50 ppm</td>
</tr>
<tr>
<td>2005/7</td>
<td>10-15 ppm</td>
</tr>
</tbody>
</table>

---

**Retrofit Reduction Required For Consideration in Tokyo**

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**PM and NOx Reduction System “DPNR”**

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**New Japanese Fuel Economy Regulations**

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Future Directions in Japan

- Tokyo Government & Courts Pushing For Faster Action on PM
- Shift from NOx to PM Priority Control
- 2007 Diesel Standards Brought Forward; With New Heavy Duty Transient Test
- Low Sulfur Fuel (< 50 PPM) By 2003; Near Zero by 2005/7
- Aggressive Retrofit Program In Tokyo and ...

New Vehicle Standards In Asia

<table>
<thead>
<tr>
<th>Year</th>
<th>Country</th>
<th>Standards</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>Bangladesh</td>
<td>Euro 1</td>
</tr>
<tr>
<td>1996</td>
<td>Cambodia</td>
<td>Euro 1</td>
</tr>
<tr>
<td>1997</td>
<td>Hong Kong</td>
<td>Euro 1</td>
</tr>
<tr>
<td>1998</td>
<td>India</td>
<td>Euro 1</td>
</tr>
<tr>
<td>1999</td>
<td>Indonesia</td>
<td>Euro 1</td>
</tr>
<tr>
<td>2000</td>
<td>Malaysia</td>
<td>Euro 1</td>
</tr>
<tr>
<td>2001</td>
<td>Nepal</td>
<td>Euro 1</td>
</tr>
<tr>
<td>2002</td>
<td>Philippines</td>
<td>Euro 1</td>
</tr>
<tr>
<td>2003</td>
<td>PRC</td>
<td>Euro 1</td>
</tr>
<tr>
<td>2004</td>
<td>Singapore</td>
<td>Euro 1</td>
</tr>
<tr>
<td>2005</td>
<td>Sri Lanka</td>
<td>Euro 1</td>
</tr>
<tr>
<td>2006</td>
<td>Taipei China</td>
<td>US Tier 1</td>
</tr>
<tr>
<td>2007</td>
<td>Thailand</td>
<td>Euro 1</td>
</tr>
</tbody>
</table>

Motorcycle Registrations Around The World

Source: N.V. Iyer Derived From Honda
New Vehicle Standards In Asia

Motorcycle Standards

<table>
<thead>
<tr>
<th>Year</th>
<th>CO</th>
<th>HC</th>
<th>Smoke</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Bangladesh: None

Cambodia: 4.50% 10,000 ppm

Hong Kong: None

India:
- 2000: 2 2 (proposed)
- 2005: 1.5 1.5 (proposed)
- 2007: 5 3 (proposed)

Indonesia:
- 2001: 12 10 (proposed)
- 2007: 5 3

Malaysia: None

Nepal:
- 2000: 2 2

Philippines:
- 1999: 6.00%
- 2003: 4.50%

PRC:
- 1993: E CE 40.01

Singapore: None

Sri Lanka: None

Taipei:
- 2004: 7 2 Cold Test
- 2004: 7 1 Cold Test

Thailand:
- 2001: 4.5 3 15% (2T only)

Viet Nam:
- 1998: E CE 40.01

Diesel Fuel Sulfur Levels in Selected Countries (2000)

Sulfur Maxima by Fuel Type

Sulfur Maxima by Fuel Type

Conclusion: Costs

- Costs ranged from 2.8 to 3.2 c/g inclusive in 2005, 4.04 c/g in 2008, 4.7 c/g in 2010 except for EUROS 5.2 c/g
- Diesel costs were roughly twice gasoline costs.
- Costs are well within acceptable parameters by US and European standards.
- Ability to pay is a policy issue.
- Benefits may include emissions, fleet maintenance, fuel harmonization, ability to export

Road Map for Indian Vehicular Emission Norms

New Vehicles (except 2 & 3 wheelers)

Entire Country

- Bharat Stage II emission norms
  - From 1.4.2005
- Euro III equivalent emission norms
  - From 1.4.2010

For Cities of Delhi / NCR, Mumbai, Kolkata, Chennai, Bangalore, Hyderabad, Ahmedabad, Pune, Surat, Kanpur & Agra

- Bharat State II emission norms
  - Delhi, Mumbai, Kolkata & Chennai
  - Bangalore, Hyderabad & Ahmedabad, Pune Surat, Kanpur & Agra
  - From 1.4.2003.

Cont...
Road Map for Indian Vehicular Emission Norms (cont’d)

- Euro III equivalent emission norms for all private vehicles, city public service vehicles and city commercial vehicles.
  From 1.4.2005

- Euro IV equivalent emission norms for all private vehicles, city public service vehicles and city commercial vehicles
  From 1.4.2010.

Road Map for Indian Vehicular Emission Norms for New Vehicles (New 2 & 3 Wheelers)

Emission norms for 2/3 wheelers to be the same in the entire country

- Bharat Stage II norms
  From 1.4.2005

- Bharat Stage III norms
  Preferably from 1.4.2008 but not later than 1.4.2010 in any case.

Average NOx and PM Emissions - CBD

South America

Argentina Pushing For EU/US Equivalent Requirements: Brazil Considering Next Steps

Emissão de CO - Veículos Novos

Emissão de HC - Veículos Novos
CONCLUSIONS:

- It is necessary to include additional future phases to “ULEV” and “ZEV” levels, already adopted in USA, to establish the technological challenges to be planned and pursued;
- Since Diesel LDVs present NOx emission potential always higher than Otto cycle vehicles, this alternative alternative will represent a negative environmental impact;
- The evolution of diesel fuel specifications might be accelerated to implement phase 5, if the introduction of diesel LDVs in Brazil would be done;
- It is necessary and URGENT that PROCONVE includes modern tools and procedures to the IM Program to reduce new forms of tampering and better evaluate the modern vehicles through OBD systems, the remote sensing evaluation and dissemination of a databank of vehicle specs for inspection purposes;
- It is necessary to update the technology and test procedures for “flexible-fuel” vehicle type approval and its evaluation;
- The adopted limits for motorcycles are much higher than the LDV’s and appropriated technology exists to bring them to compatible levels, in Brazil.

Dakar Resolution Opens Opportunity For Lead Free Fuel

Sales of Leaded Gasoline
End of 2001

Low Sulfur Diesel Fuel Is Also Spreading

Current and Future Technologies

Clean Diesel Fuels

- Zero (<1 ppm) and near-zero (1-15 ppm) sulfur fuel
- CNG/diesel bi-fuel
- Dimethyl ether and dimethyl carbonate
- Diesohol (diesel fuel/alcohol blends)
Durability Requirements Are Increasing (km)

Heavy Duty NOx Standards Around The World (g/kW-hr)

Heavy Duty PM Standards Around The World (g/kW-hr)

Annual Emission Related Vehicle Tax in Germany (in €/100 ccm per year)

Economic Instruments to Reduce Emissions from the Transport Sector
## Two Major Classes of Anthropogenic Aerosols

<table>
<thead>
<tr>
<th>Sulfates</th>
<th>Black Carbon (BC)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in reflected solar radiation at TOA is same as reduction at surface.</td>
<td>Absorbs solar radiation in atmosphere and blocks radiation reaching surface. Also absorbs upward reflected solar radiation from surface and clouds.</td>
</tr>
</tbody>
</table>

∇ ∇

Surface and atmosphere cool. Atmosphere is heated. Surface is cooled.