Mitigating The Environmental and Health Effects of Motor Vehicles and Fuels

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Moscow, Russia

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

World Motor Vehicle Population

Growth Will Likely Continue

...and even more significant freight transport growth: 2.4% /year
Share of Worldwide CO2 Emissions From The Combustion Of Fuel, By Sector

- Production of Energy: 41%
- Commercial and other: 6%
- Manufacturing and Construction: 19%
- Transport: 26%
- Residential: 8%

Source: IEA 2000a.

Recent and Projected World Transportation Fuel Demand

Transportation is the Fastest Growing CO2 Emissions Source

Products of Combustion

- Lead
- Hydrocarbons
- Carbon Monoxide
- Oxides of Nitrogen
- Carbon Dioxide
- Particulates
- Other pollutants
- Water Vapor

Ambient Air
Real Fuel

Engine/Emission Technology
What pollutants are of concern?

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

Health Impacts of Air Pollution

- Premature Deaths
- Cancer
- Developmental Effects
- Hospitalization
- Asthma Attacks and Bronchitis
Health Effects

- Different Pollutants have Different Effects
  - Carbon Monoxide - circulatory system, heart
  - Ozone - respiratory system, lung
  - 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

Health Effects From Emissions Beyond Dispute

- WHO Concludes ~ 800,000 Premature Deaths Each Year From Urban PM; Diesels One Major Source
- Numerous Studies in Europe & US Consistently Link PM With Premature Deaths, Hospital Admissions, Asthma Attacks, Etc.
- No Evidence of a Threshold
- Ozone Also A Serious Health Concern

Increased Risk of Premature Mortality Due To $10 \mu g/m^3$ PM$_{2.5}$

- All Causes
- Pulmonary
- Lung Cancer

PM10 Study in Europe

- ~6% of all deaths from PM10
- ~40,000 deaths per year in Austria, France, Switzerland; 2 times traffic fatalities
- Motor Vehicles Responsible For ~50%
- People in Cities Die ~18 Months Earlier Than They Otherwise Would
- Over 300,000 cases of chronic bronchitis; 300,000 asthma attacks; 16 million lost person days of activity
- Health Costs From Traffic Pollution ~1.7% of total GDP
Integrated Air Quality Management Framework

- Ambient Concentration
- Dispersion Modeling
- Meteorology
- Emissions
- Distribution & Activity
- Exposure
- Damage Assessment
- Dose-Response

- Establish objectives, identify data gaps, studies and pilots
- Identify, analyze and select management options
- Develop strategies & implement action plan
- Institute monitoring and enforcement

Issues
- Technical
- Economic
- Institutional
- Legal
- Policy
- Social
- Stakeholder Involvement

Options
- Fuels & Vehicle Technology
- Traffic Management
- Standards
- Economic Incentives and Disincentives

Integrating Science & Policy: How to Evaluate a Emissions Control Strategy?

Select Pollution Reduction Strategy

- Model Changes in ambient air concentrations of pollutants
- Model Changes in human exposure
- Model Value of Health Benefits

Emission Management

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Elements of a Comprehensive Vehicle Pollution Control Strategy

- Clean Vehicle Technology
- Appropriate Maintenance
- Transportation & Land Use Planning
- Clean Fuels

Tremendous Success With Technology-based Air Pollution Standards

Over 95% reduction over the past 40 decades of standards
Emissions From Diesel Cars In Europe

Gasoline Car Regulations

Euro I 500 ppm
Euro II 500 ppm
Euro III 150 ppm
Euro IV 50 ppm

Japan '00 100 ppm
Japan '05 10 ppm
CA SULEV 30 ppm

EU Emissions Standards For Heavy-duty Vehicles on ETC

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

Nitrogen oxides (NOx)  Particulate matter (PM)

Low-sulfur diesel needed to meet 2005 regulations
Meaningful Emission Control Reductions Requires a Systems Approach

- Advanced Engine Designs
- Advanced Emission Controls
- Low Emissions
- High Quality Fuel and Lubricants

Close Linkage Between Vehicle Emissions Standards and Fuel Sulfur Levels

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European Fuel Sulfur Levels (PPM)

- Gasoline
  - Euro 2: 500 PPM
  - Euro 3: 50 PPM
  - Euro 4: 50 PPM
  - Euro 5: 50 PPM

- Diesel
  - Euro 2: 50 PPM
  - Euro 3: 50 PPM
  - Euro 4: 50 PPM
  - Euro 5: 50 PPM

Sulfur Effects

- Precious Metal
- Zeolite or refractory oxide support
- Sulfur Poisoning
- Sulfate poisoning
- Transition Metal
- Sulfate make
- Sulfur inhibition
- O3

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Fuel Parameters
Important For Emissions

- Gasoline
  - Sulfur
  - Vapor Pressure
  - Benzene
  - Oxygenates
  - Additives
  - Other

- Diesel
  - Sulfur
  - Volatility
  - Aromatic Hydrocarbons
  - Additives
  - Other

Lead Free Gasoline Worldwide
2004

Ultra Low Sulfur Diesel Fuel Is Spreading

Euro 5/6 Developments

- Germany, France, Denmark Alwesen Pushing Hard For traps
- Standards Process Could Be Very Slow
  - DG XI Wants Part of CAFE Process – 2005 Proposals
  - 10 Accession Countries
  - New Constitution
  - New Parliament
  - New Commission
  - Likely 2-3 Years
- There Will Very Likely Be Tight Euro 5/6

- Looking For Incentives Approach in the Interim
  - German Environment Ministry Pushing Tax Incentives
  - Arguably Illegal But EU in Tough Spot
- UBA Jawboning Effectively
Euro 5 Scenarios Proposed By Commission For Diesel Cars

Percent Reduction From Euro 4

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

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

What To Do About Existing Vehicles?
Diesel Particulate Filter

Diesel Oxidation Catalyst

Flow through monolith with catalytic coating

- CO
- Aldehydes
- HC
- PAH
- SO$_2$
- NO$_x$

- CO$_2$
- CO$_2$ + H$_2$O
- CO$_2$ + H$_2$O
- CO$_2$ + H$_2$O

- Metals
- Soot

- So2/H$_2$O
- NO$_x$

Swedish Retrofit Program
All Trucks Above 3.5 Tons

Very Low Sulfur Fuel Dominates The Market

New York City Retrofit Experience

NYC Bus ID# 6019
NYC Bus ID# 6065

- CO$_2$
- NO$_x$
- THC
- CO
- PM

- PM
- HC
- NO$_x$
- Noise

Percentage Change in g/m
Durability & Reliability

Average Grocery Truck Emissions, CSBVR(1&2)

Inspection/Maintenance Considerations

- Program Type
- Effectiveness
  - Enforcement
  - Test types
  - Network design
  - Frequency
  - Quality of repairs
- Cost
  - Economies of scale
  - Sophistication
  - Capital
  - Operations
- Economic Impact
  - Ability to pay for repairs
  - Waivers
  - Scrappage
  - Alternatives
- Institutional Support
  - Audits
  - Oversight
  - Training

Enforcement

- Most critical factor to the success of I/M
  - Without good enforcement, program inherently weak!
  - Critical to getting emission reduction benefits
- Enforcement mechanisms are required to:
  - Insure all subject vehicles get tested
  - Insure tests are honest and fair
  - Insure failed vehicles are properly repaired
  - Insure failed vehicles are honestly retested
  - Prevent adjustment after retest

Enforcement Features

- Getting cars tested:
  - Registration denial
  - Windshield sticker
  - Computer list checking
  - Penalties
- Ensuring honest tests:
  - Automated systems
  - No money exchange
  - Covert audits
  - Penalties
- Insure repairs work:
  - Technician training
  - Transient testing
  - Standards for HC, CO and NOx
- Prevent readjustment:
  - Remote sensing
  - Penalties
Network Type

- Centralized
  - High throughput test
  - Only lanes run by government or contractor
- Decentralized
  - Repair shops licensed to conduct test and perform repairs
- Features
  - Best approach
  - Most cost effective
  - Cheapest to manage
  - Lowest fraud problems
  - Best quality control
- Features
  - Requires extensive quality assurance
  - Big fraud problem
  - Low quality control
  - Expensive due to loss of economies of scale

Institutional Support

- Government agencies must:
  - Set standards and establish procedures
  - Manage program and collect data
  - Conduct audits and enforce requirements
  - Insure vehicle owners participate in program
  - Train or certify training of inspectors and auditors
  - Train or certify training of repair technicians

The Current Situation In Russia

- High Vehicle Population Growth, especially in Cities
- Poor Vehicle Maintenance
- Insufficient Development of Road Network
- Poor Road Conditions
- Ineffective Traffic Engineering

Emissions Technology Structure of Russian Motor Vehicle Fleet

Source: Donchenko
European Tax Incentives Schemes To Encourage Low Sulfur Fuels

- National Tax incentives for 50ppm sulphur fuels
- National Tax incentives for 50ppm & 10ppm sulphur fuels (and or availability)

### Diesel (2000)
- 3.9Ec/l

### Petrol (2001)
- 0.3Ec/l (50ppm)
- 5.7Ec/l (10ppm)

### Diesel (2001)
- 2.5Ec/l (50ppm)
- 3.1Ec/l (10ppm)

### Petrol (2002)
- 1.5EC/l (10ppm)

### Diesel (2002)
- 2.4 Ec/l (1999)

### Petrol (2000), Diesel (2001)
- 4.5Ec/l (50ppm)
- 0.76Ec/l (50ppm)

### Petrol/Diesel (2001)
- 2 Ec/l
- 4 Ec/l

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