Motor Vehicle Pollution Control: Lessons Learned Over The Past Fifty Years

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Overview

• Great Progress Has Occurred
• Serious Problems Remain
• Some Lessons Learned
  – Comprehensive Strategy
  – Sulfur in Fuels
  – MMT
  – Diesels and SUVs
• Comments on China Program
• Conclusions

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

The Global Market for New Motorcycles and Mopeds

R-square = 0.951   # pts = 53
y = -1.8e+009 + 9.28e+005x

Source: Honda Facts & Figures
One Result: Serious Health Concerns

- WHO Concludes ~ 800,000 Premature Deaths Each Year From Urban PM; Most in Asia
- Numerous Studies in Europe & US Consistently Link PM With Premature Deaths, Hospital Admissions, Asthma Attacks, Etc.
- No Evidence of a Threshold
- PAPA Project Indicates Similar Effects in Asia
- Ozone, NO₂, Various Toxics Also Serious Health Concerns

Problem Could Get Much Worse Due To High Growth Especially In Asia

...and even more significant freight transport growth: 2.4% /year
Lesson 1: Solving the Motor Vehicle Pollution Problem Requires A Comprehensive Approach

Elements of a Comprehensive Vehicle Pollution Control Strategy

Los Angeles 1955: The Start of the Story
Air Not Breathable and no solutions.

Good Programs Can Improve Air Quality: California Trends
(1-hour Peak Indicator)

California PM10 Air Quality Trend
(Maximum Annual Average of Quarters)
Positive Actions Are Spreading Around The World

Lead Free Gasoline Worldwide

2004

The Three-way Catalytic Converter Is Going On Over 90% Of All New Gasoline Cars Produced This Year Worldwide

Layered washcoat architectures and support materials with high thermal stability
Integrated HC adsorption functions
Mounting materials with improved durability
High cell density ceramic or metallic substrates
Insulation schemes for heat management

Lesson 2: Clean Vehicles and Clean Fuels Should Be Treated As A System

Gasoline Car and Fuel Regulations

EPA g/kW-hr

EURO g/kW-hr

Combined

Diesel 50/10 ppm

10/03

10/05

500 ppm

50 ppm

100 ppm

50 ppm

Euro I

Euro II

Euro III

Euro IV

Euro IV/V

Caterpillar, Cummins, Detroit Diesel, Mack Trucks/Volvo

15 months

10/02

10/05

10/08

Japan '00

Japan '05/07

CA SULEV/Tier 2

EURO I

EURO II

EURO III

EURO IV

EURO V

500 ppm

500 ppm

150 ppm

50 ppm

10 ppm

10 ppm

30 ppm

Diesel 15 ppm

15 months
HD Diesel NOx and PM Emissions Regulations

Costs & Benefits of Clean Fuels and Vehicles

NOx g/kWh
PM g/kWh

Japan’03
US’04
EURO4’05
EURO5’08
EURO4’05

Tier 4 nonroad
Heavy-duty highway
Tier 2 Light-duty highway

$ Billion Annually in 2030

Increase in In-Use Vehicle Emissions in Bangkok Due To Sulfur in Fuel (Gasoline)

Increase in In-Use Vehicle Emissions in Bangkok Due To Sulfur in Fuel (Diesel)
The Hong Kong Retrofit Experience

- Introduce Ultra Low Sulfur Diesel Fuel (<50 PPM)
- Retrofit in-use vehicles with emission reduction devices
  - About 89% of the eligible pre-Euro light diesel vehicles fitted with particulate traps or catalysts
  - Nearly 60% of the pre-Euro heavy diesel vehicles fitted with oxidation catalysts

Other Benefits from Sulfur Control

- Sulfur reduction reduces SO2 emissions.
  - Less sulfate formation in the atmosphere (about 1/3 of SO2 reacts to sulfate)
  - Reduced acid rain.
- Sulfur reduction reduces engine wear.
  - Reduction from 2500 ppm to 500 ppm reduces engine wear 10 - 20%; about 33% if starting out at 5000 ppm.
  - Greater engine wear with infrequent oil change.
- Retrofit Opportunities

Metropolitan Tokyo in-Use Diesel Program

- Measurement results indicate that Diesel PM levels have been significantly reduced.
  (By the Research Institute for Environmental Protection)

Tokyo Retrofit Program Began With Low Sulfur Fuels (<50 ppm)
Air Quality Needs Driving World to Ultra-Low Sulfur Diesel

Lesson 3: Be Very Cautious Regarding The Use of Metallic Fuel Additives

- Organo-metallic additives such as MMT are a cheap way to increase octane.
- Experience with these additives shows that they can cause:
  - Health problems
  - Technical problems
- Precautionary Principle Says Don’t Use Until and Unless Proven To Be Safe

Implications of Recent Health Studies

"The finding that manganese transport out of the brain occurs via the slow process of diffusion, rather than via carrier-mediated transport, is important: it suggests that no mechanism exists to protect the brain from accumulating manganese. This finding has important implications for neurotoxicity resulting from chronic manganese exposure."

Potential Impact of MMT

- Californian Civic 600 cpsi catalyst - 49,000 miles
- Canadian Civic 600 cpsi catalyst - 49,000 miles
ICCT Conclusions Regarding MMT

Consistent with the precautionary principle, the ICCT recommends that countries delay any use of MMT in gasoline at this time, pending the outcome of ongoing health-based studies and further review of the vehicle impacts.

Copies of the ICCT Report Available at http://www.cleantransportcouncil.org/index.php

Lesson 4: Vehicles Which Do the Same Job Should Meet Identical Requirements

Light Duty Vehicle NOx Standards (g/km)

SUVs Should Have Same Requirements As Cars

Tier 2 Standards

Diesels Should Have The Same Requirements As Gasoline Fueled Vehicles

European Auto Standards
Lesson 5: Ignore Transportation and Land Use Planning At Your Peril

US Air Quality: Ozone and PM$_{2.5}$ Present Significant Challenges

Applying The Lessons To China

Chinese Vehicle Population Growth Has Been Exploding (million)
Most Vehicles Are in Cities

Modal Splits in Shanghai, 1986-2000

Shift From Walking & Bicycling to Cars & Motorized Transit

Vehicle Growth in Beijing is Exploding
Pollution Shifting From Coal Based To Vehicle Based

Weekly Average Concentration of PM$_{2.5}$ in Beijing: 1999-2003

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<th>Date</th>
<th>PM$_{2.5}$ Concentration (µg/m$^3$)</th>
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</table>

Figure 4

Emission Control for On-road Light-duty Vehicles in China

Emission Control for On-road Heavy-duty Diesel Engines
Diesel Fuel Sulfur Requirements

Gasoline and Diesel Reformulation Costs in China

Experience with MMT
China: Blocked catalytic converter

China Fuel Consumption Standards – MT Cars

- Phase I will be effective in July 2005
- Phase II will be effective in July 2008

Source: Dr. Yamaguchi

Source: Schindler, VW
China Must Break The Vicious Circle

Conclusions

- Great Progress is Occurring Around the World in Reducing Vehicle Emissions
- Success Requires A Comprehensive Approach
- Serious Problems Remain & More Must Be Done
- Several Lessons Can Guide Future Progress

Conclusions (2)

Lessons Learned
- Adopt A Comprehensive Strategy
- Treat Vehicles and Fuels as A System
  - Unleaded Gasoline Key To Clean Spark Ignition Vehicles
  - Near Zero Sulfur Fuels Key To Future Progress
- Very Clean Spark Ignition Cars
- Very Clean Cars, Trucks & Buses
- Possible Retrosfits
- Avoid Metallic Additives Such as MMT Until Proven Safe
- Vehicles Doing Same Job Should Meet The Same Emissions Requirements
  - Cars & SUVs
  - Diesel & Gasoline
- Transportation & Land Use Planning Are Critical

Conclusions (3)

Lessons For China
- Move Rapidly To Near Zero Sulfur Fuels
- Concurrently Leapfrog To “State of the Art” Emissions Standards
- Ban MMT Until Proven Safe
- Build On Vehicle Fuel Economy Program
- Expand Transportation and Land Use Planning
- Expand Public Transportation (BRT) Systems