

The Need For and Benefits of Eliminating Lead From Gasoline

Pretoria, South Africa
January 27, 2002

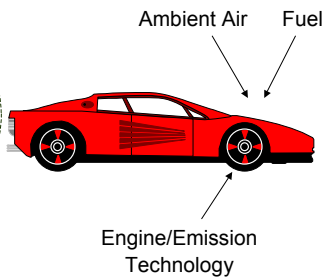


Outline

- The Problem of Motor Vehicle Pollution
- Lead in Gasoline
 - Why Lead Was Added
 - Why A Consensus To Eliminate It
 - International Experience
- Beyond Lead

Combustion Emissions

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



Other Emissions

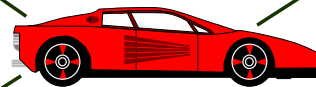
Refueling Losses
displaced vapors

Evaporative Emissions
diurnal, running losses, hot soak

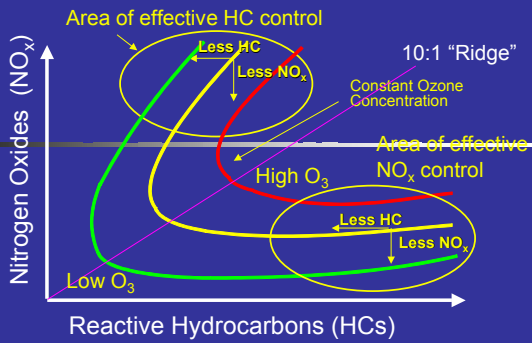
■ Other Emissions

- brake linings, tire wear, fluid leaks

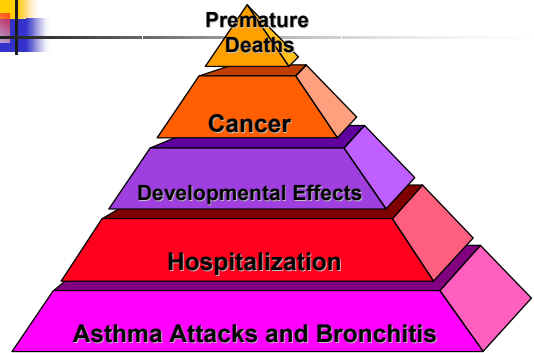
Crankcase Losses
due to "blow-by"



Ozone Isopleth Plot (EKMA Diagram)



Health Impacts of Air Pollution

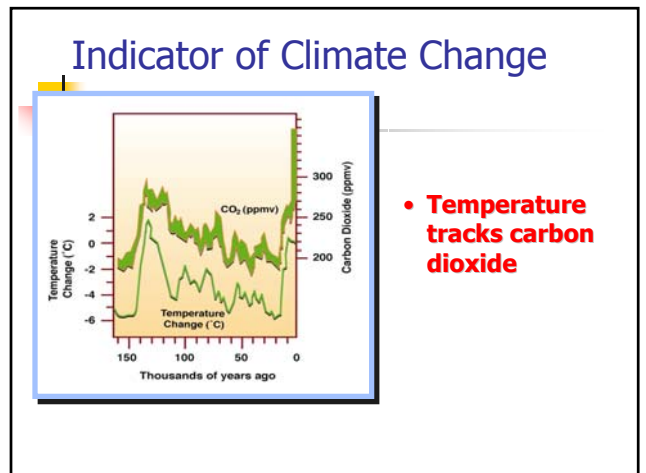
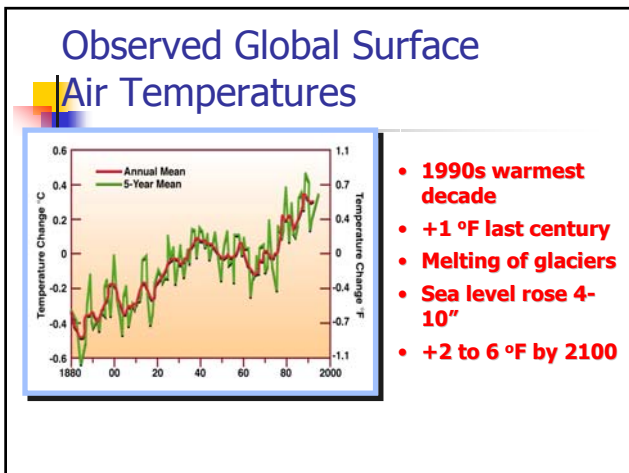
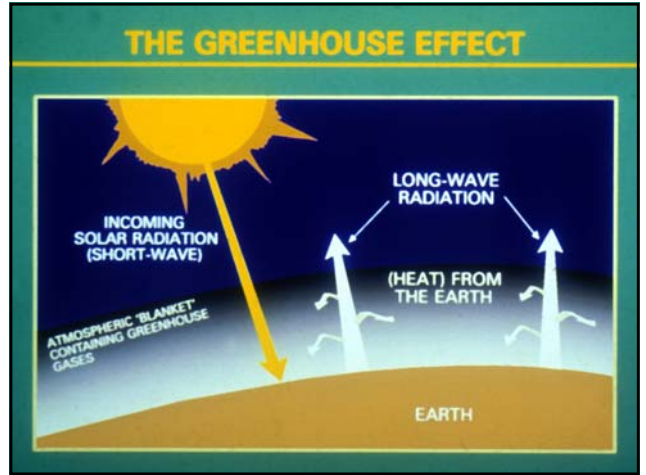


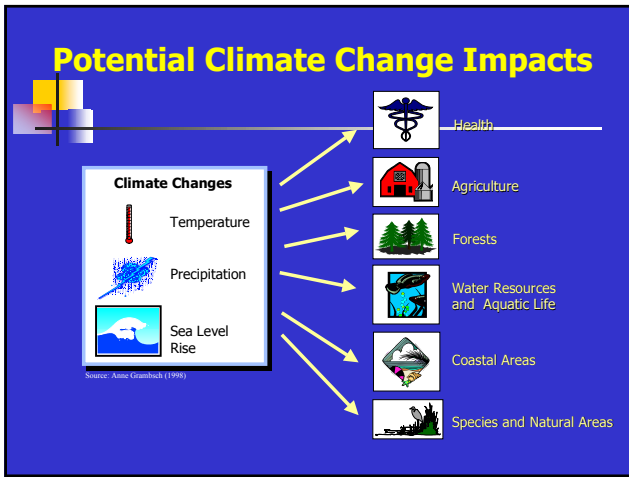
Health Effects

- 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

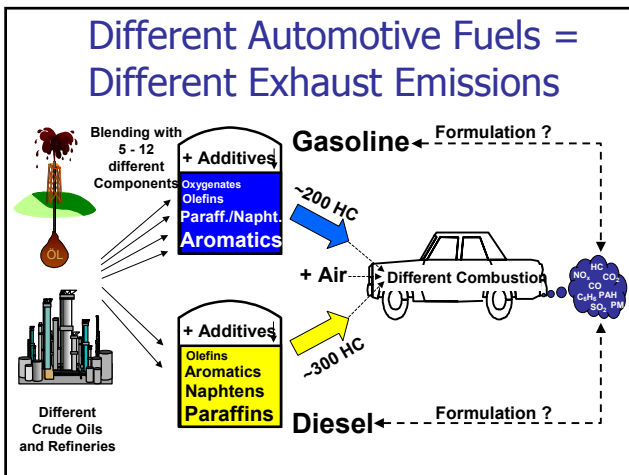
Special Population Exposures

- Average Annual Levels Can Be Misleading
- In Urban Areas, there are *Hot Spots*:
 - Street canyons, roadsides, urban centers
 - Exposure levels for PM, diesel, CO, air toxics can be 2 to 10 times higher than average
 - Exposure levels for Ozone will be somewhat lower (NO_x "scavenges" the ozone)
- In these settings, vehicle contribution will be higher





With All Of These Problems, Why Are We Worried About Lead in Gasoline?



Why Are Fuels Important?

- Fuel Constituents **Directly** Affect Emissions/Air Quality/Health
- Fuel Changes Can **Immediately** Impact on Emissions From All Existing Vehicles
- Fuel Composition Can **Enable/Disable** Pollution Control Technology

Why Was Lead Added To Gasoline

- Low Cost Octane Enhancer
- Higher Octane Allowed Better Engines
 - More Efficient
 - Higher Power Output

We Have Learned However

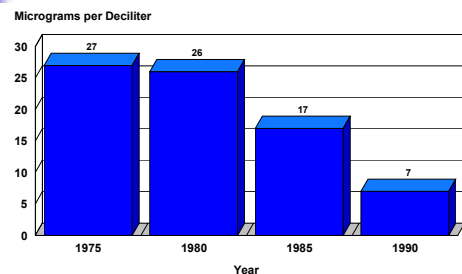
Lead In Gasoline Has Negative Side Effects

- High Ambient Lead Levels
- Serious Health Risks
- Precludes The Use of Catalytic Converters To Reduce Other Hazardous Vehicle Pollutants (CO, HC, NOx & Toxics)
- Higher Vehicle Maintenance Costs

Why Do We Care About Leaded Gasoline?

- Concerns About Lead
 - Impairs development of brain function in children & lowers IQ
 - Causes cardiovascular diseases in adults
 - No safe level of exposure
- Concerns About Leaded Gasoline
 - Largest source of exposure in most urban areas
 - Effective dispersion to all environmental media
 - Long-term exposure by accumulation
 - Increasing problem due to high traffic growth

Blood Lead Levels Considered Elevated

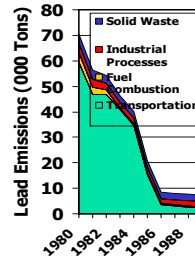


Is Any Lead Acceptable From A Health Standpoint?

Children Are Especially Susceptible To Adverse Health Effects

- increased likelihood of exposure,
- increased absorption, and
- increased susceptibility of the brain.

Trend in Lead Emissions and Air Quality in the US



- 87% Decrease in Average Ambient Lead Levels in 189 Urban Sites Over This Same Period
- Median Blood Lead Level Declined From 9.2 to 2.8 micrograms/dL

The Experience Of Egypt - Health Effects Study

- Heart Attacks - 6,500 to 11,600
- Strokes - 800 to 1,400
- Premature Deaths (Adults) - 6,300 to 11,100
- Infant Deaths - ~820
- Average IQ Loss in Children - 4.25 Points

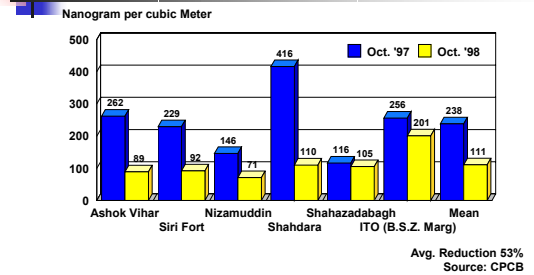
The Experience of Egypt The Role of Gasoline

- Peak Ambient Levels ~ 10 micrograms/m³
- ~ 2/3rds from Gasoline; 1/3 Smelters

The Experience of Egypt Results of Action

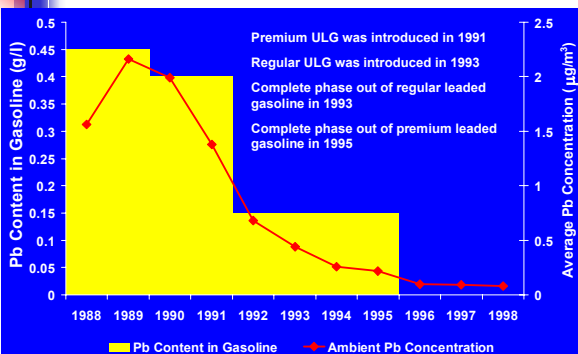
- Refinery Modifications
 - Process Changes
 - 15% Oxygenates
- Within 6 Months
 - 85% Unleaded Nationally
 - 100% Unleaded in Cairo

Ambient Particulate Lead in Delhi Pre and Post Unleaded Petrol

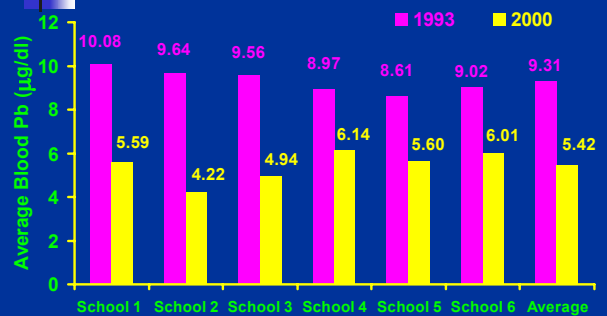


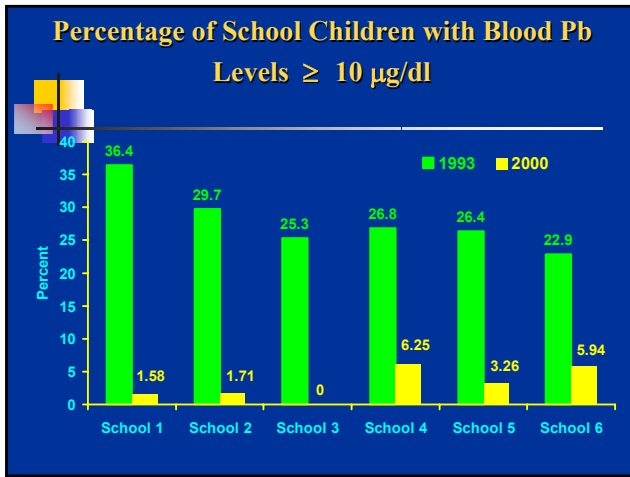
Lead Phase Out Started in September 1998

Ambient Pb Concentrations in Bangkok and Pb in Gasoline from 1988 - 1998



Comparison of Average Blood Pb Levels in Children at 6 Schools in Bangkok between 1993 and 2000





The Magnitude of Health Impacts

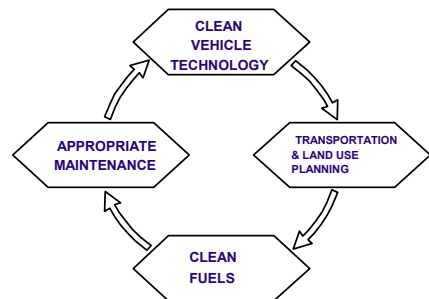
- Losses of 4 or more IQ points in 30,000-70,000 Children in Bangkok
- More than 800 Infants and 10,000 Adult Deaths Annually in Cairo
- More than 150 Premature Deaths Annually in Jakarta

The Cost of Health Impacts

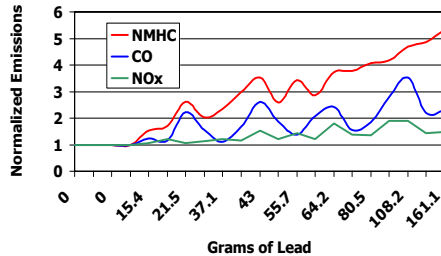
- Reduced Productivity and Lifetime earnings
- Increased Medical Costs
- Compensatory Education Costs
- Premature Deaths of Infants and Adults

An Estimated \$17 Billion for each 1 $\mu\text{g}/\text{m}^3$ Increase in Ambient Airborne Lead in the US

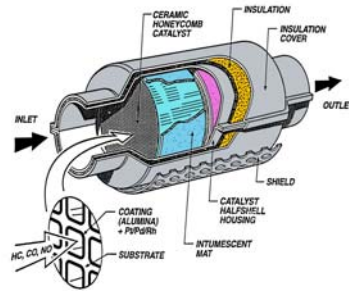
ELEMENTS OF A COMPREHENSIVE VEHICLE POLLUTION CONTROL STRATEGY



Impact of Lead on Catalyst Performance



The Three-way Catalytic Converter: A Familiar Technology Re-Engineered for High Performance in Close-coupled and Underfloor Applications



- 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

Unleaded Gasoline: Gateway To The Future

- Direct Health Benefits
- Technology Enabling
- Modern Vehicle Technology
 - Low "Conventional" Emissions
 - Low Greenhouse Gas Emissions
 - Retrofit Technologies
- Modern Gasoline Technology
 - Low Benzene
 - Low Sulfur
 - Low Volatility

Lead Free Fuel Can Be Used in Older Vehicles

- Valve Recession Problem Has Not Materialized
- Need Sustained High Speed, High Load Operation
- Lead Substitutes Exist if Needed
- No Other Impediments Identified

Refinery Modifications Available To Replace Lead In Gasoline

- Increase Reformer Severity to Raise Reformate Octane
- Increase Production/Use of High Octane Blend stocks
 - Reformate
 - FCC Gasoline
 - Alkylate
 - Isomerate
 - Oxygenates

Quality Tradeoffs For Key Gasoline Blendstocks

	High Octane	Low RVP	Low Olefins	Low Benzene	Low Aromatics
Butanes	Yes	No	Yes	Yes	Yes
Alkylate	Yes	Yes	Yes	Yes	Yes
Isopentane	Yes	No	Yes	Yes	Yes
C6 Isomerate	No	Yes	Yes	Yes	Yes
Lt FCC Naptha	Yes	No	No	No	Yes
HV FCC Naptha	No	Yes	Varies	Yes	No
Reformate	Yes	Yes	Yes	No	No
MTBE	Yes	No	Yes	Yes	Yes

Don't Replace One Harmful Substance With Another



California Civic 600
cpsi catalyst - 49,000
miles

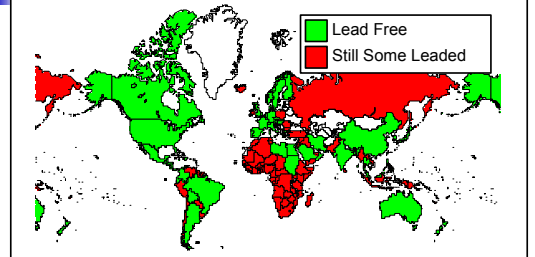
No MMT



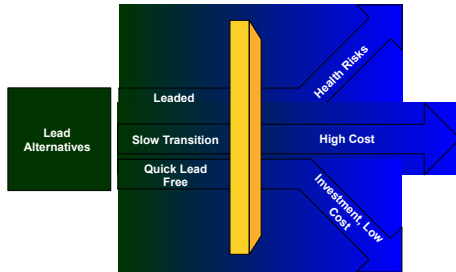
Canadian Civic 600
cpsi catalyst - 49,000
miles

With MMT

Sales of Lead Free Gasoline By End of 2002



Issue: Fast Track or Slow Track



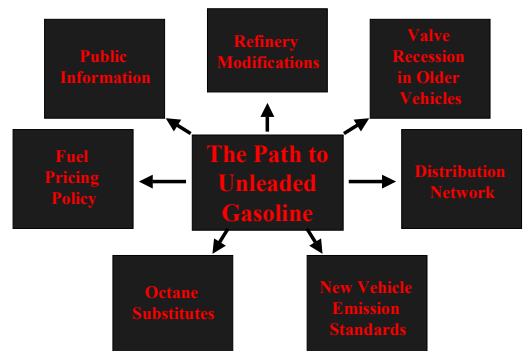
Problems With A Slow Transition

- Risks of Contamination
 - Deliberate
 - Accidental
- Expense of Dual Distribution System
 - Delivery
 - Pumps & Storage
 - Vehicles
- Administrative

Cost Effectiveness and Policy Implications

- Phasing out Lead from Gasoline is Highly Cost-effective (In the US, the Benefits Outweighed Costs more than 10 Times)
- Benefits Justify Rapid Phase-out - Faster than Car Fleet Replacement

Issues to be Addressed in Phasing-Out Leaded Gasoline





Policy Options For Lead Free

- Command and Control
- Vehicle Market Driven
- Fuel Pricing
- Combination



Eliminating Lead Is Only The Beginning Toward Clean Fuels

- | | |
|------------|----------|
| ■ Gasoline | ■ Diesel |
| ■ Lead | ■ Sulfur |
| ■ Sulfur | ■ Sulfur |
| ■ RVP | ■ Sulfur |
| ■ Benzene | ■ Other |



Worldwide Consensus

Leaded Gasoline Should Be Eliminated

- Alternatives Are Widely Available
- Health Concerns No Longer Debatable
- Catalysts Are Best Solution To CO, HC, NOx Problems and Only Work With Lead Free Gasoline
- Modern Engines Designed For Lead Free Fuel



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