The Need For and Potential Benefits of Advanced Technology Vehicles in China

Workshop On Advanced Technology Vehicles
April 24-25, 2003
Beijing, PRC

Outline:
Vehicle Trends & Forecasts
Associated Problems
Air Pollution
Global Warming
Oil Imports
Advanced Technologies Could Help Solve These Problems

Motor Vehicle Production in China

China Vehicle Population Has Grown Rapidly

Forecast: 4 to 7 times More Cars By 2020

2002: Domestic Made Vehicles Over 3 million
2003: Already Growing Rapidly
Motorcycle Annual Production and Sales

Recent Developments in China’s Vehicle Industry Indicate Substantial Future Growth

- FAW – VW; $1 Billion Venture with Toyota
- DMC – recent link with Honda; $1 Billion Venture with Nissan; Peugeot JV
- SAIC – joint venture with VW & GM; Already Largest Car Sales in China; GM-Daewoo JV

The Vehicle Population Is Forecast To Grow Rapidly

Air Pollution Problem is Already Severe

A Median Estimate is 120 million Vehicles & 200 Million Motorcycles by 2030 – Tsinghua University
What pollutants are of concern?

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

BEIJING: O3 Concentration in 1997-1999

<table>
<thead>
<tr>
<th>Year</th>
<th>Number of non-attainment days</th>
<th>Number of non-attainment hours</th>
<th>Max. Hourly concentration (µg/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td>71</td>
<td>434</td>
<td>346</td>
</tr>
<tr>
<td>1998</td>
<td>101</td>
<td>504</td>
<td>384</td>
</tr>
<tr>
<td>1999</td>
<td>119</td>
<td>777</td>
<td></td>
</tr>
</tbody>
</table>

BEIJING: PM₂.₅ Mass Concentration Levels 1999-2000

BEIJING: NOx Concentration In 1998

2# and 3# monitoring stations are near to the arteries, and 6# monitoring station is far away from the arteries.
### China: Urban NOx Problems

<table>
<thead>
<tr>
<th>Year</th>
<th>No. Of Cities</th>
<th>Non-attainment cities</th>
<th>Non-attainment for Class II standard</th>
<th>Non-attainment for Class III standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>1995</td>
<td>88</td>
<td>32 36.4</td>
<td>3 3.4</td>
<td>0 0</td>
</tr>
<tr>
<td>1996</td>
<td>88</td>
<td>27 30.7</td>
<td>25 28.4</td>
<td>2 2.3</td>
</tr>
<tr>
<td>1997</td>
<td>94</td>
<td>32 34.1</td>
<td>29 30.9</td>
<td>3 3.2</td>
</tr>
<tr>
<td>1998</td>
<td>96</td>
<td>32 33.3</td>
<td>29 30.2</td>
<td>3 3.1</td>
</tr>
</tbody>
</table>

#### Motor Vehicle Pollution in Urban Areas
- Motor vehicles contribute nearly 50% of NOx emissions in metropolitan cities
- About 1/3 of Major Cities Exceed ambient NOx NAAQS;
- CO concentration generally higher than national standard in traffic areas;
- Photochemical pollution emerging in big cities;
- Vehicles becoming a main source of air pollution in urban areas.
Health Impacts of Air Pollution

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

Global Warming

- Fastest carbon growth globally
- 2nd largest after U.S. in Energy: Production, Consumption

Carbon Dioxide Emissions From the Road Transport Sector

Fuel Consumption Trends in China

Source: EIA
Growing Dependence on Imported Oil

By 2020, China will import 80% of its oil demand. Source: IEA

Current and Projected Road Transport Oil Demand in China

Road transport oil demand will be 57% of the total in 2020, and 87% in 2030, making it the principal source of oil demand and oil imports at that time. - Tsinghua University

Oil Use in China

Source: Tsinghua University
Efforts in China To Address Urban Air Pollution

- Initial Clean Air Strategy Developed
- Complete Lead Phase Out by 2000
- European Emissions Standards Introduced For Cars & Trucks
- Individual Cities Supplementing National Actions
- I/M Pilot Being Developed in Shanghai
- Alternative Fuels For Buses & Taxis
- Catalyst Retrofits in Beijing

Control Measures on Motor Vehicle Pollution

Emission Standards For New Vehicles

<table>
<thead>
<tr>
<th>Time Category</th>
<th>Before 2000</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
</tr>
</thead>
<tbody>
<tr>
<td>PC</td>
<td>EURO I</td>
<td>EURO II</td>
<td>EURO III</td>
<td>EURO IV</td>
<td>EURO V</td>
<td>EURO VI</td>
<td></td>
</tr>
<tr>
<td>LDV &amp; LDT</td>
<td>EURO I</td>
<td>EURO II</td>
<td>EURO III</td>
<td>EURO IV</td>
<td>EURO V</td>
<td>EURO VI</td>
<td></td>
</tr>
<tr>
<td>HHDV</td>
<td>None</td>
<td>EURO I</td>
<td>EURO II</td>
<td>EURO III</td>
<td>EURO IV</td>
<td>EURO V</td>
<td></td>
</tr>
<tr>
<td>Motorcycle</td>
<td>EURO 40</td>
<td>EURO I</td>
<td>EURO II</td>
<td>EURO III</td>
<td>EURO IV</td>
<td>EURO V</td>
<td></td>
</tr>
</tbody>
</table>

Beijing, Shanghai Introduced Euro 2 in 2003

Overview of Fuel Quality

Specifications for Gasoline

<table>
<thead>
<tr>
<th>ITEM</th>
<th>LIMITS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lead (g/L, max.)</td>
<td>0.35, (0.45)</td>
</tr>
<tr>
<td>Sulfur (% Mass, max.)</td>
<td>0.15</td>
</tr>
<tr>
<td>Manganese (g/L, max.)</td>
<td>0.18</td>
</tr>
<tr>
<td>Phosphorus (g/L, max.)</td>
<td>0.0013</td>
</tr>
<tr>
<td>HGON, Min.</td>
<td>90, 93, 97</td>
</tr>
<tr>
<td>HGON=MC3+MC2, Min.</td>
<td>85, 89, 92</td>
</tr>
<tr>
<td>Aromatics HC (vol. %, max.)</td>
<td>40</td>
</tr>
<tr>
<td>Nitro (vol. %, max.)</td>
<td>35</td>
</tr>
<tr>
<td>Benzene (vol. %, max.)</td>
<td>2.5</td>
</tr>
<tr>
<td>Vapor pressure</td>
<td>Winter (Dec.- Feb.), kPa max.</td>
</tr>
<tr>
<td></td>
<td>Summer (Mar.- Aug.), kPa max.</td>
</tr>
<tr>
<td>Oxygen (vol. %, max.)</td>
<td>2.7</td>
</tr>
</tbody>
</table>

Note: 1) Implemented from Jan. 1, 2000

Specifications for Light Diesel in China

<table>
<thead>
<tr>
<th>ITEM</th>
<th>LIMITS 1)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Code of Standard</td>
<td>GB 252-94</td>
</tr>
<tr>
<td>Cetane Number, min</td>
<td>45 (40)</td>
</tr>
<tr>
<td>Sulfur, %(m/m), max</td>
<td>0.2 (0.5, 1.0)</td>
</tr>
<tr>
<td>Flash point POC, ℃, min</td>
<td>65 (45)</td>
</tr>
<tr>
<td>Ash, wt%, max</td>
<td>0.01 (0.02)</td>
</tr>
<tr>
<td>Acid, mgKOH/100ml, max</td>
<td>5 (10)</td>
</tr>
<tr>
<td>Oxidation stability, mg/100ml, max</td>
<td>2.0</td>
</tr>
<tr>
<td>Density@20 ℃, kg/m3</td>
<td>—</td>
</tr>
<tr>
<td>CCR 10%, wt %, max</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Note: 1) Limits in ( ) are for basic qualified diesel; 2) GB 252-2000 went into effect on Jan. 1, 2002.
Motor Vehicle Emissions Trends in China With Current Program

China Addressing Emissions & Energy Consumption But More is Needed
- 10th 5-Year Plan
  - Hybrid Vehicles Ready For Production
  - Prototype Fuel Cell Vehicle
  - Parity With EU Emissions Standards by 2010
- Beijing "Green" Olympics
- Shanghai World Expo
- SETC Developing Fuel Economy Program

Advanced Technologies Could Help Address These Problems
- Substantially Reduce Conventional Urban Pollutants
- Reduce Oil Consumption Through High Efficiency
- Major Challenges:
  - Cost
  - Vehicle Availability

Advanced Technology Alternatives
- Hybrid Vehicles
  - Available in Short Term
  - Very Low Pollution
  - Very Good Fuel Economy
  - Low Noise
  - Urban Buses & Trucks
    - Very Good in Stop&Go
    - Lowers Pollution Exposure
- Fuel Cell Vehicles
  - Longer Term
  - Near Zero or Zero Pollution
  - 2 X Fuel Economy or More
  - Low Noise
  - Significant Challenges Remain
    - Cost
    - Infrastructure
Next Steps

- Near Zero Sulfur Fuels
- Euro 4/5 Emissions Standards
- Fuel Efficiency Standards For Light Duty Vehicles
- Emphasize Hybrids For Special Events
  - Olympics
  - World Expo
- MOST Investment
- Offer Incentives To Offset Higher Price
- Special Concessions
  - Manufacturers
  - Fleet Managers

Conclusions

- High Vehicle Growth Is Leading To Rapid Increases in Vehicle Emissions
- Air Quality Already Degrading
- Initial Pollution Control Effort Reflects A Good Start
  - Unleaded Gasoline
  - Euro 1/Euro 2 Standards For New Vehicles
  - In Use Vehicle Controls

Conclusions (2)

- Most Vehicle Pollutants Will Continue To Go Up Without Additional Controls
- Goal Should Be State of the Art Controls by About 2010
- Much Cleaner Fuels Will Be Required
- Fuel Consumption/CO2 Must Also Be Addressed
- Hybrids Could Help Substantially in Short Term
- Fuel Cells Could Play Important Long Term Role if Challenges Can Be Overcome