International Experience in Reducing Greenhouse Gases From The Transportation Sector

The Haagen-Smit Symposium
Fourth Annual Meeting
April 5 to 8, 2004
UCLA Lake Arrowhead Conference Center

Outline
- Reasons For Reducing Greenhouse Gases
- Policy Tools
- Actions Underway in Various Countries
- Available and Emerging Technologies
- Conclusions

Share of worldwide CO2 emissions from the combustion of fuel, by sector

Recent and Projected World Transportation Fuel Demand

Transportation is the Fastest Growing CO2 Emissions Source
Vehicle Climate Change Emission Sources

Approaches To Improving Fuel Efficiency Around The World

- Tax Policy
- Regulation
  - Fuel Economy
  - CO2 Emissions
- Voluntary Agreements
- Joint Government/Industry Research

United States

New Vehicle Fuel Economy Improved Rapidly Until mid 1980s
CAFE Program Was A Major Success

- Fuel Efficiency of New Cars Doubled
- Immense Savings in Oil Import Costs
- Carbon Dioxide Reduced Significantly
- Advanced Technology & Materials Stimulated
- Saves 55 Billion Gal/Year; 800 Billion To Date
- About $70 Billion/Year; $400 Billion Cumulatively
- ~ 100 MMTCE Reduced Per Year
- Electronics Revolution Advanced

European Approach To High Efficiency

- High Fuel Prices
- “Voluntary” Agreement With Industry
- Tax Incentives

Fuel Prices in Selected Countries (2002$/Gal)
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)

Average specific CO₂ emissions:
Relative to 1995 value

Climate Forcings

Aerosol Effects Are Not Known Accurately

Source: Hansen, Scientific American, March 2004
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

New Japanese Fuel Economy Regulations

- Fuel Economy Improvements Adopted In Japan (km/liter)
  - Gasoline
  - Diesel

Source: Japan Ministry of Transport
Disseminating 10 million LEVs for practical use by the year 2010. Included are:

- CNG, Electric, and Hybrid Vehicles
- Vehicles meeting the 2010 fuel economy standard and 2000 LEV guideline.

Developing “Next-Generation LEVs” including:

- FC Vehicles (50,000 FCVs targeted by 2010!)
- Super clean diesel, advanced hybrid system and DME engine for heavy-duty vehicles

Policy measures will be taken to achieve the targets.

Next Generation EFVs to be Developed by 2010 and to be Disseminated by 2020 (Supported by MLIT, 2002)

### Technical Targets
- Halved Fuel Consumption
- 1/2 CO₂ Reduction
- Nearly Zero Emissions

### Vehicle Types
- Hybrid PCs
- FC PCs
- LD Hybrid Vehicles
- LD CNG Vehicles

### Major Driving Forces for Chinese Vehicle FC Standards
- Energy Security
- Industry Consolidation
- Alignment of vehicle regulation system with WTO
- Increase Competitiveness of China’s auto industry
- Stimulate Transfer of better technologies from JVs’ foreign partners

China
Main Features of Chinese Vehicle Fuel Consumption Standards

- M1 (EU classification) vehicles, including passenger cars, SUVs and MPVs with less than 9 seats
- Two different sets of standards for:
  - Passenger cars with manual transmission
  - Passenger cars with AT, SUVs, and MPVs with 3+ rows

Main Features of Chinese Vehicle Fuel Consumption Standards (Continued)

- Weight-based standards, 16 weight classes
- New European Driving Cycle (NEDC)
- Liters/100 km, thus, they are fuel consumption standards
- Maximum fuel consumption level to be met by each vehicles within a class, not an average value for the class

Chinese Vehicles Are Small, Concerns Regarding An Upward Trend

<table>
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<th>curb wt (kg)</th>
<th>Capacity (cc)</th>
<th>Rated Engine Power (kw)</th>
<th>Transmission</th>
<th>Fuel Consumption (L/100km)</th>
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<td>1187</td>
<td>1650</td>
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<td>Japan</td>
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<td>1999</td>
<td>111.2</td>
<td>64% AT(44 A5)</td>
<td>22% MT(55 M6)</td>
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</tbody>
</table>

Chinese Government’s Economic and Energy Targets in 2020

- GDP to be quadrupled from 2000 to 2020
- GDP per capita to exceed $10K by 2020
- Constrain energy consumption To Only Double from 2000 to 2020
- Maintain oil imports below 55%
- Three principal policies to achieve these goals
  - Population control
  - Environmental protection
  - Energy conservation
Fuel Consumption Standards – MT Cars
Phase I will be effective in July 2005
Phase II will be effective in July 2008

Fuel Consumption Standards – AT Cars, SUVs, and 3+ Rows Passenger Vehicles

China vs. Japan – Loose for Light-Weight But Stringent for Heavy-Weight Classes

China vs. U.S. – Loose for Light Models But Stringent for Heavy Models (SUVs)
Chinese Standards Are Stringent for SUVs

Oil Saving Potential of the Standards

Other Programs Are Underway or Under Development
- Australia
- Taiwan
- South Korea
- Canada

Summary and Conclusions
- Many Technologies to reduce mobile source GHG emissions available today
- Some already in use or in product plans
- Others under development and available soon
- Vehicle performance and function unaffected or improved
- Significant cost-effective climate change emission reductions possible
- Many Countries Are Making Substantial Progress But Sustained Efforts Are Needed To Reduce Emissions In Absolute Terms
Engine Technologies with Potential to Improve Vehicle Fuel Economy

- 5, 4 or 3 valves per cylinder
- variable valve timing
- idle stop/start
- cylinder deactivation
- variable compression ratio
- variable displacement
- advanced IC engines (diesel, DI gas)

Additional Technologies with Potential to Improve Vehicle Fuel Economy

- Transmissions
  - lockup 6/5/4 speed
  - automatically shifted manuals
  - CVTs
- Advanced Powertrains
  - integrated starter alternatives
  - hybrids
  - fuel cells

Technologies That Reduce Methane or Nitrous Oxide

- Relatively high global warming potential compared to carbon dioxide
- Catalyst modifications have been demonstrated that reduce methane emissions
- Nitrous oxide emissions may also be reduced through catalyst modifications

Technologies That Reduce HFC Emissions

- Better materials and fittings can reduce leakage
- Alternative refrigerants with lower global warming potential
  - R152a, CO₂
- Variable displacement compressors reduce system energy requirements, leading to lower CO₂ emissions
Hybrid Electric Drive

Honda Civic
25% CO₂ reduction compared to non-hybrid model

Toyota Prius
29% CO₂ reduction compared to comparable conventional vehicle

Coming: 2004 Ford Escape, 2005 Lexus SUV, and others

Fuel Cell Vehicles

Promising technology
Significant cost, manufacturing and performance challenges
Volume production expected 2010 or later

Fuel Cell Vehicles - Today

41 cars

Over 122,000 miles

5,000+ riders/drivers

The Greenhouse Effect

Some of the infrared radiation passes through the atmosphere and causes it to become warmer. The effect of this is to raise the Earth’s surface and lower atmospheric temperature.

SUN

Infrared radiation

Atmosphere

Earth

Infrared radiation

Absorbed in the atmosphere
Climate Change: IPCC Consensus

- More data, less uncertainty
  - Climate is changing
  - Most of the warming is due to human activity
- Greater confidence in climate modeling
- Severe predictions for next 100 years
  - Surface temperature rises 2.5°F to 10.4°F
  - Sea level rises of 4 to 35 inches

U.S. Transportation Oil Demand

Five Government Strategies to Reach Sustainable Vehicle Goals

- Technology R&D
- Market Incentives
- Infrastructure Investment
- Public Education
- Regulation

The US Program To Improve Vehicle Fuel Efficiency

- Corporate Average Fuel Economy (CAFE)
- Standards For New Cars & Light Trucks
- Labels on New Vehicles
- Gas Guzzler Taxes
- Partnership For A New Generation of Vehicles (PNGV)/FreedomCar
- Tax Incentives
PNGV Replaced By FreedomCar

- Longer Term Goals
- Support Fundamental R&D
- All Light Duty Vehicles
- Special Focus On Fuel Cells/Hybrids
- No Specific Targets/Commitments

Diesel Engines

Diesel engines can provide substantial CO₂ reductions compared to their gasoline counterparts.

Diesels face a significant challenge in meeting NOx emission requirements; Black carbon concerns