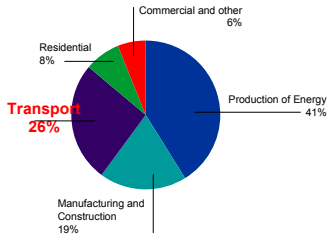
International Experience in Reducing Greenhouse Gases From The Transportation Sector

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

Outline

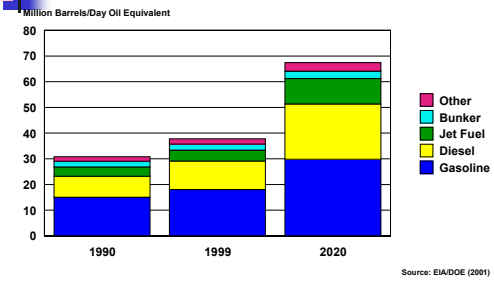
- Reasons For Reducing Greenhouse Gases
- Policy Tools
- Actions Underway in Various Countries
- Available and Emerging Technologies
- Conclusions

Share of worldwide C02 emissions from the combustion of fuel, by sector



Source: IEA 2000a.

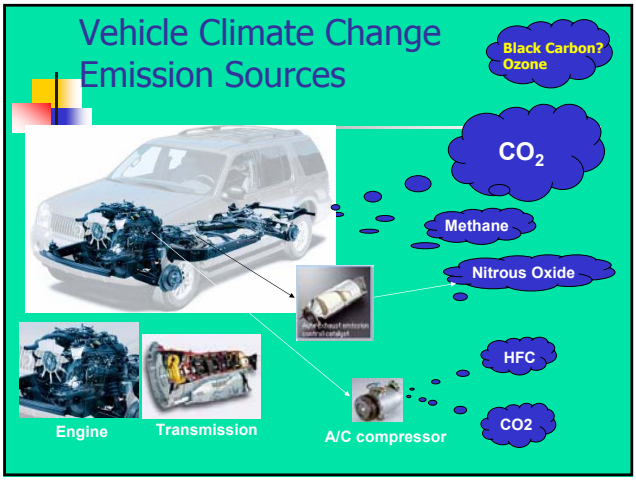
Recent and Projected World Transportation Fuel Demand



Source: EIA/DOE (2001)

Transportation is the Fastest Growing CO_2 Emissions Source

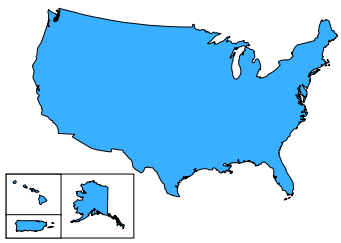
Vehicle Climate Change Emission Sources



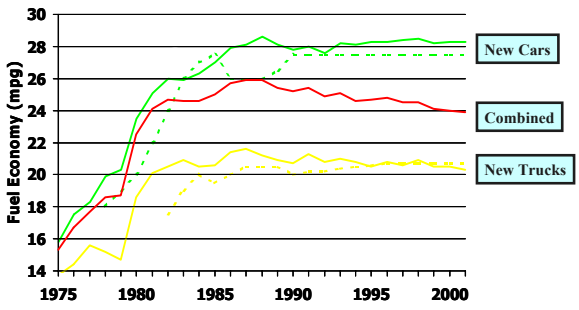
Approaches To Improving Fuel Efficiency Around The World

- 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

Regulation

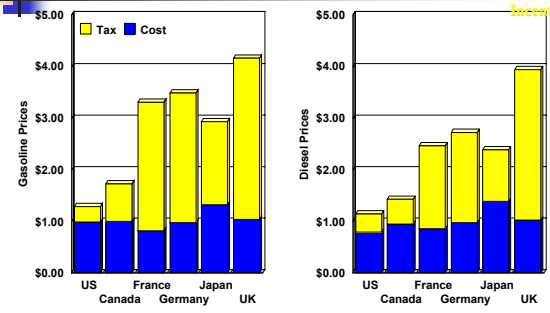
Europe

European Approach To High Efficiency

- High Fuel Prices
- "Voluntary" Agreement With Industry
- Tax Incentives

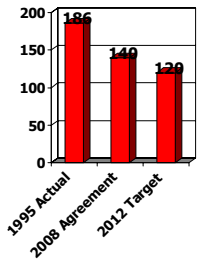
Fuel Prices in Selected Countries (2002$/Gal)

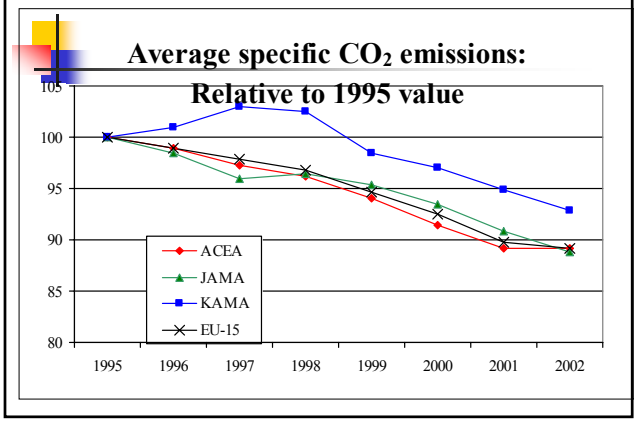
Market Incentives:



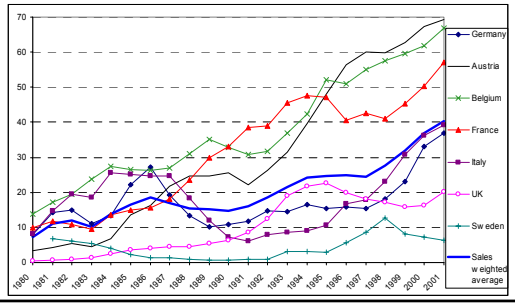
European Agreement (g CO_2/km)

- 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

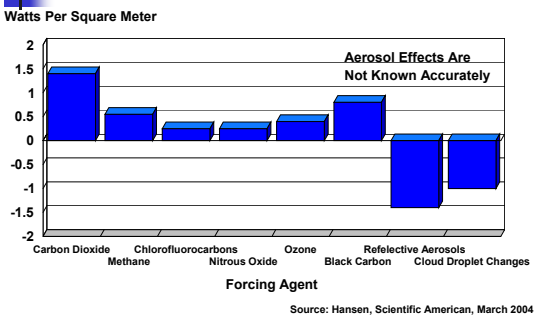




Penetration of Diesel Cars in Europe (% of New Sales)

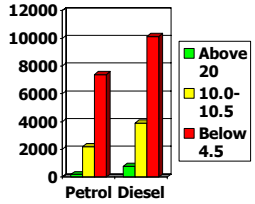


Climate Forcings

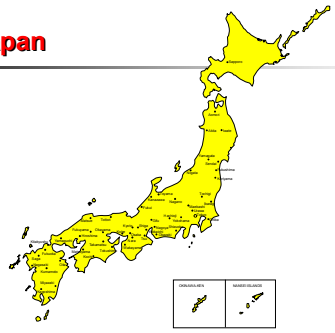


Yearly Car Tax in Denmark

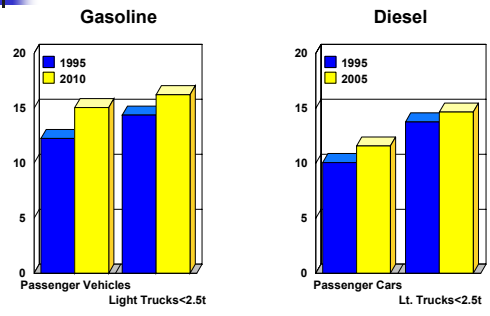
- 24 Different Car Classes Based On Kilometers Per Liter of Fuel
- Diesel Taxed More Than Gasoline
- Annual Increase with Inflation Plus 1.5% Per Year



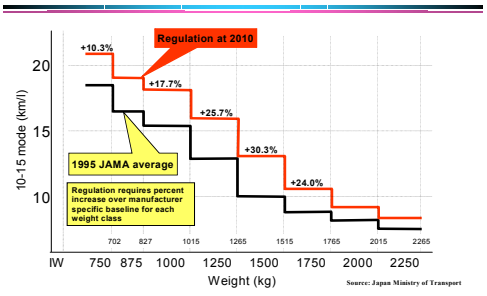
Japan



Fuel Economy Improvements Adopted In Japan (km/liter)



New Japanese Fuel Economy Regulations



"The Action Plan for Developing and Disseminating Low Emission Vehicles"
~ MLIT, METI and MOE in July, 2001 ~

☆ Disseminating 10 million LEVs for practical use by the year 2010. Included are:
- a) CNG, Electric, and Hybrid Vehicles
- b) Vehicles meeting the 2010 fuel economy standard and 2000 LEV guideline.

☆ Developing "Next-Generation LEVs" including:
- a) FC Vehicles (50,000 FCVs targeted by 2010!)
- b) 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)

Passenger Cars & Light-Duty Vehicles

Technical Targets

*Halved Fuel Consump.
1/2 CO_2 Reduction
*Nearly Zero Emissions

Vehicle Types

*Hybrid PCs *FC PCs
*LD Hybrid Vehicles
*LD CNG Vehicles

China

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

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

	curb wt (kg)	Capacity (cc)	Rated Engine Power (kw)	Transmission	Fuel Consumption (L/100km)
China	1187	1650	72.6	23% AT(A4 A3) 76% MT(M4 M5) 1% CVT	9.1
USA	1472	2900	145	70% AT(A4 A5) 30% MT(M5 M6)	9.7
Germany	1349	1898	97	61% AT(A4 A5) 38% MT(M5 M6) 1% CVT	8.5
Japan	1329	1999	111.2	64% AT(A4 A5) 22% MT(M5 M6) 14% CVT	7.85

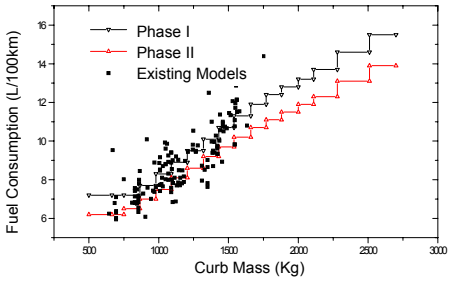
Chinese Government's Economic and Energy Targets in 2020

- 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

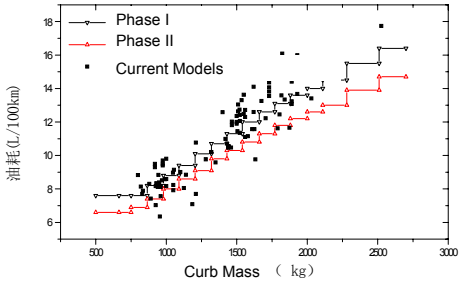
Fuel Consumption Standards – MT Cars

Phase I will be effective in July 2005

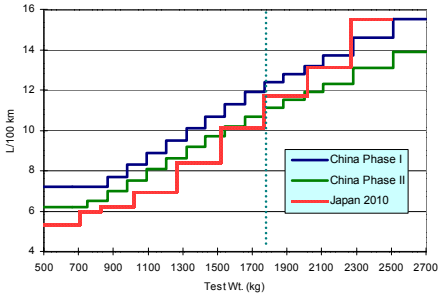
Phase II will be effective in July 2008



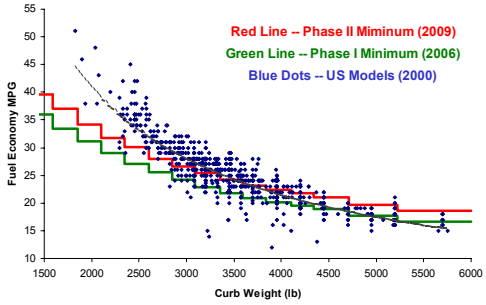
Fuel Consumption Standards – AT Cars, SUVs, and 3+ Rows Passenger Vehicles



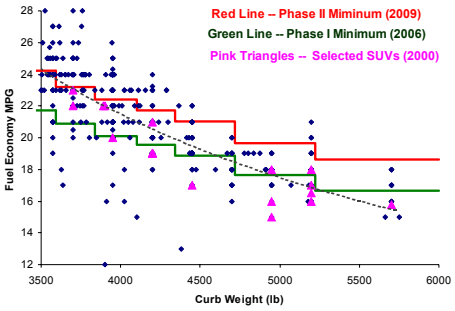
China vs. Japan – Loose for Light-Weight But Stringent for Heavy-Weight Classes



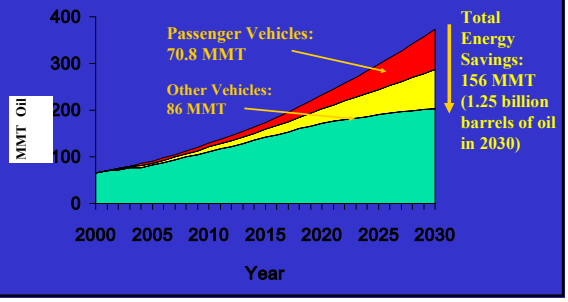
China vs. U.S. – Loose for Light Models But Stringent for Heavy Models (SUVs)



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 potent
  - R152a, CO_2
- Variable displacement compressors reduce system energy requirements, leading to lower CO_2 emissions

Hybrid Electric Drive

Honda Civic
25% CO_2 reduction compared to non-hybrid model

Toyota Prius
29% CO_2 reduction compared to comparable conventional vehicle

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

Fuel Cell Vehicle

Promising technology

Significant cost, manufacturing and performance challenges

Volume production expected 2010 or later

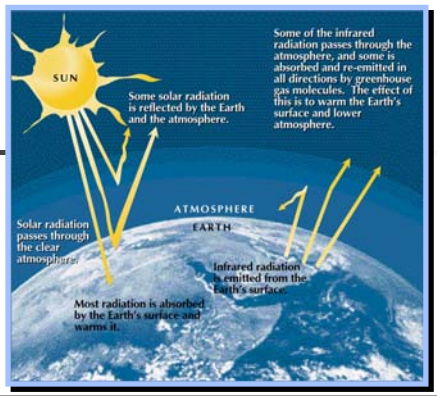
Fuel Cell Vehicles - Today

41 cars

Over 122,000 miles

5,000+ riders/drivers

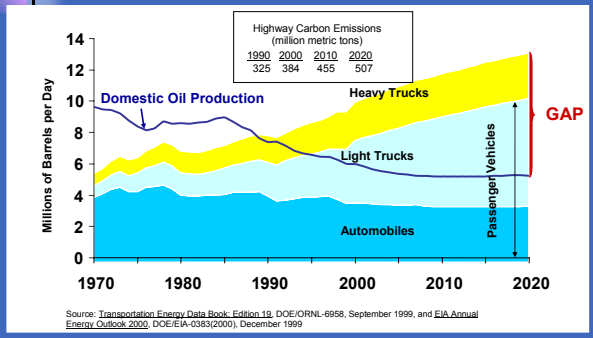
The Greenhouse Effect



Climate Change: IPCC Consensus

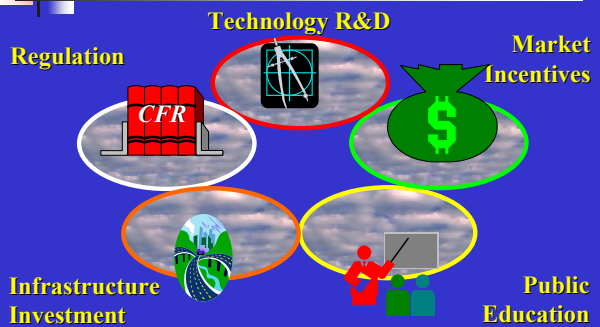
- More data, less uncertainty
  - Climate is changing
  - Most of the warming is due to human activity
- Greater confidence in climate modeling
- Severe predictions for next 100 years
  - surface temperature rises 2.5°F to 10.4°F
  - sea level rises of 4 to 35 inches

U.S. Transportation Oil Demand



Source: Transportation Energy Data Book: Edition 19, DOE/ORNL-6958, September 1999, and EIA Annual Energy Outlook 2000, DOE/EIA-0383(2000), December 1999

Five Government Strategies to Reach Sustainable Vehicle Goals



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

Regulation

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 CO_2 reductions compared to their gasoline counterparts.

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