

The Path to Near-Zero Vehicle Emissions: Applying California's Experience To China

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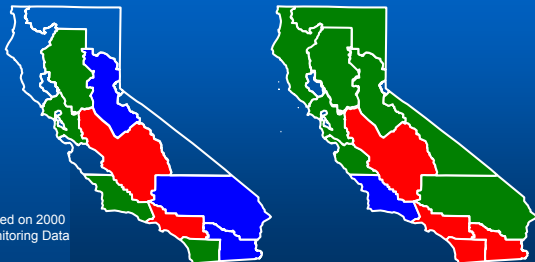
Overview

- California
 - Air Quality and Emission Reduction Strategy
 - Status of the Zero Emission Vehicle (ZEV) Regulation
 - The California Fuel Cell Partnership
 - Reducing Climate Change Emissions from Vehicles
- China
 - Rapid Vehicle Growth
 - Environmental & Energy Impacts
 - The Path Forward- Applying California's Experience

Air Pollution is Widespread

Days Over State
Ozone Standard

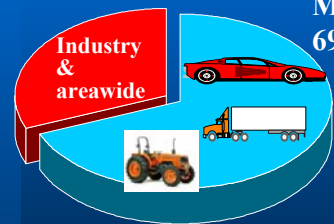
Days Over State
PM10 Standard



Based on 2000
Monitoring Data

0-5 Days 6-50 Days 50-100 Days >100 Days

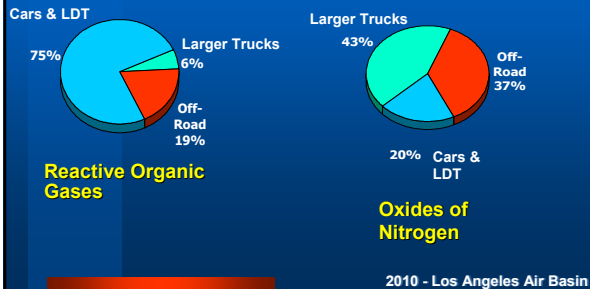
Motor Vehicles are Dominant Emission Source



Mobile -
69%

Industry
&
areawide

Many Vehicle Sources are Major Emitters



The Challenge

- 22 million cars in California
- Average age of passenger cars is 10 years
- Average daily mileage of 35 miles
- California VMT continues to grow ~2% per year

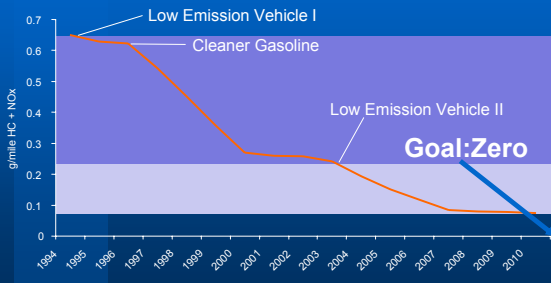
The Low-Emission Vehicle/Zero Emission Vehicle Solution

- Analysis in 1990 showed that conventional technology would not be sufficient
- Some part of the fleet had to emit near “zero” levels
- LEV/ZEV program adopted

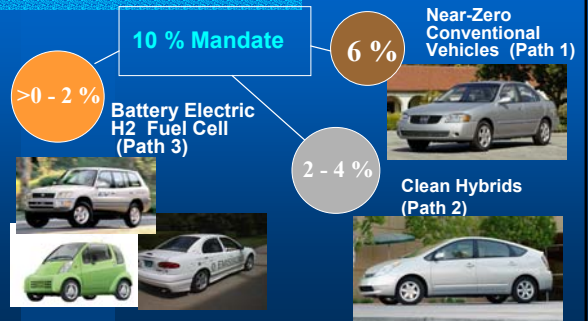
What Has Happened Since 1990?

- Batteries fell short
 - performance
 - cost
- Conventional technology over-achieved (matched battery vehicle charging emissions)
- New near-zero emission technologies introduced
 - hybrids
 - gaseous fuels

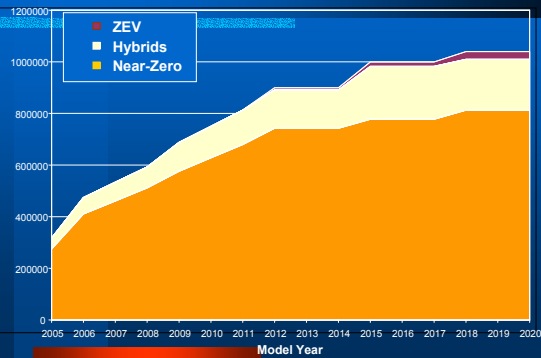
Evolution of ARB Auto Controls Implementation: 1994 - 2010



ZEV Regulation Restructured in 2003 for More Flexibility



Vehicle Production Scenario (example)



Path 1: Near-Zero Emission Conventional Vehicles

- Near zero exhaust emissions
- Zero evaporative emissions
- 15 year/150,000 mile warranty
- On-board diagnostics
- 140,000 sales in 2003
- 200,000 sales in 2004



Path 2: Hybrid Electric Vehicles

- Three models now available
- More models coming
- ~ 20,000 sales expected in 2005



Lexus 400 H Hybrid
(coming soon)

Toyota Prius Hybrid



Honda Civic Hybrid

Hybrid Electric Vehicles

“ZEV enabling” technology:

- electric drive train
- batteries
- power management



Incentives for Near-Zero Emission Hybrid Electric Vehicles

- Extra regulatory incentives (credits) encourage “strong” hybridization
- Incentives based on:
 - system voltage
 - power output of the electric motor
- Short term incentives for 42-volt systems

Path 3: Battery Electric and Fuel Cell Vehicles

- Full size battery electric
- Neighborhood electric
- Fuel cell

Full-Sized Battery Electric Vehicles



- Over 2,500 sold or leased
- Cost and range issues shifts focus:
 - smaller vehicles
 - fuel cells

Neighborhood Electric Vehicles

25 mph top speed
limited range
2-4 passengers



Over 8,000 sold or leased in response to ZEV regulation



Fuel Cell Vehicles

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



Hydrogen Fuel Cell Benefits

- No direct smog-forming or greenhouse gas emissions
- Potential for extremely low lifecycle ("well to wheel") emissions
- Better fuel economy, greater efficiency
- Quiet and smooth operation

Transition to Fuel Cells

- Prototype fuel cell vehicles now being demonstrated
- California Fuel Cell Partnership

California Fuel Cell Partnership



- Promotes fuel cell vehicle commercialization
- Infrastructure
- Safety
- Public Education



Fuel Infrastructure



- Liquid H₂ storage
- Delivers gaseous hydrogen at two pressures:
 - 3600 psi & 5000 psi
- Fill time ≤ 4 minutes

2400+ fueling events



Fuel Cell Vehicles - Today



41 cars

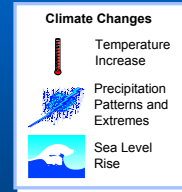
Over 122,000 miles

5,000+ riders/drivers

Global Climate Change is a Major Challenge

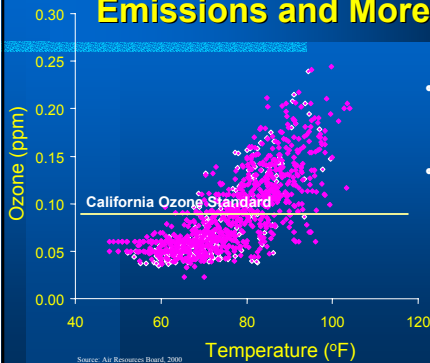
- May be an opportunity for hybrid vehicles
- Technology mix will depend on fuel cell progress

Climate Change is a Major Concern for California



Source: Anne Grambsch, 1998

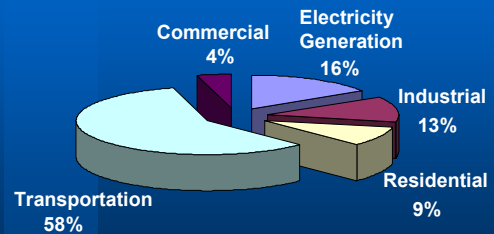
Hotter Days Lead to Higher Emissions and More Smog



- Los Angeles Ozone Levels (1995-1998)
- 10 warmest years of the last century all occurred within the last 15 years.

Source: Air Resources Board, 2000

Transportation is California's Largest Source of CO₂



Climate Change Legislation in California

- Achieve maximum feasible and cost-effective reduction of greenhouse gas emissions from cars and light trucks
- 2009 and later model years

Climate Change Regulation

- Regulations will provide flexibility, not mandate specific technology
- Hybrid vehicles will compete with other emerging technologies
- Hybrid's role will depend on developments in conventional and fuel cell technology - but increased sales seems certain

Long-Term Vision

- The ultimate goal remains - zero-emission technology
- Must be energy-efficient; reduced climate impact
- California is taking the necessary steps now

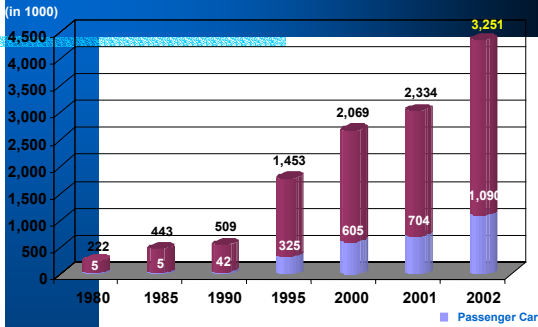


Where Do We Stand in China?

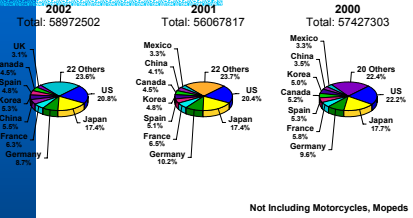


Outline:
Vehicle Trends & Forecasts
Associated Problems
Air Pollution
Global Warming
Oil Imports
Advanced Technologies Could Help Solve These Problems

Vehicle Production in China 1980 - 2002

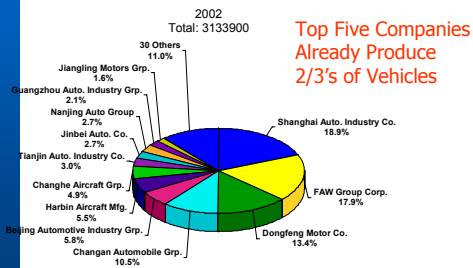


Vehicle Production By Country



China Is Now 5th Largest Producer in the World

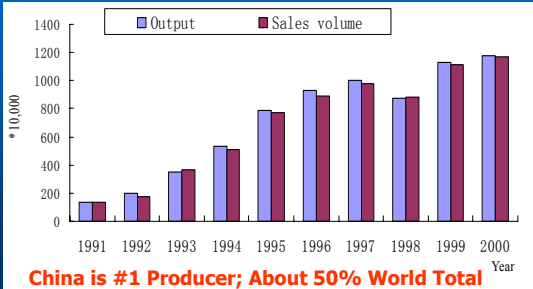
Motor Vehicle Production By Manufacturer



Recent Investments in China's Vehicle Industry Indicate Substantial Future Growth

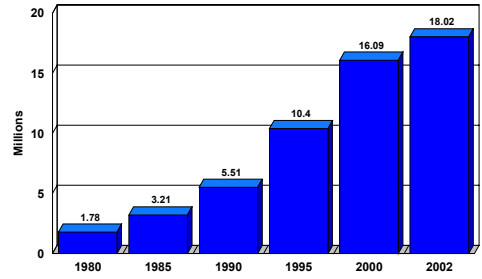
- FAW – VW; \$1 Billion Venture with Toyota
- DMC – recent link with Honda;
 - \$1 Billion Venture with Nissan; Peugeot JV
- SAIC – joint venture with VW & GM;
 - Already Largest Car Sales in China; GM-Daewoo JV
- Chang'an Automotive Group - Ford Increased Investment By \$1.5 Billion

Motorcycle Annual Production and Sales



China is #1 Producer; About 50% World Total

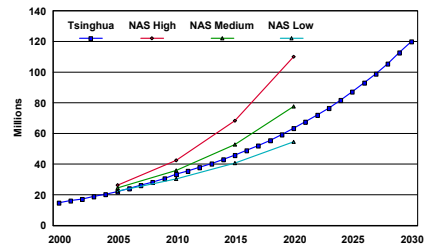
China's Vehicle Population (Cars, Trucks & Buses)



Vehicle Growth in Beijing is Exploding

- Growth in the Number of Cars in Beijing
 - ▶ From 0 to 1 million - 48 years
 - ▶ From 1 to 2 million - 6.5 years
 - ▶ From 2 to 3 million - est 3 years
- Relative Growth Rates
 - ▶ Average Annual Growth in Vehicles ~20%/year
 - ▶ Average Annual Growth in Road Network ~3.5%/year

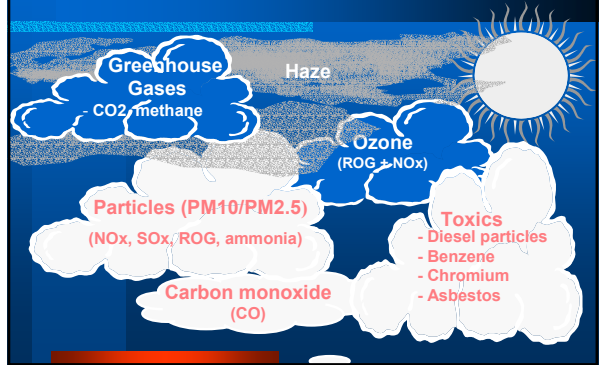
Recent Forecasts of Chinese Vehicle Population



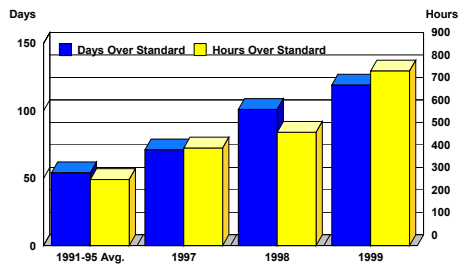
Tsinghua Also Predicts About 200 Million MC By 2030

Air Pollution Problem is Already Severe

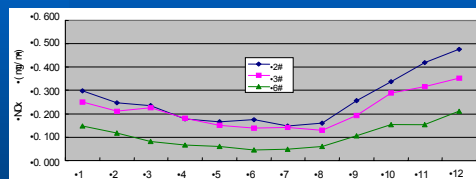
What pollutants are of concern?



Ozone Trends in Beijing



BEIJING: NO_x 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

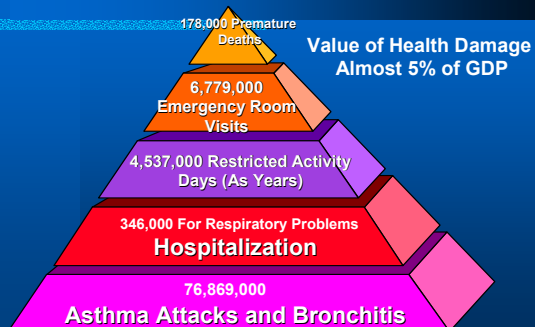
NOx Concentration in Chinese cities

year	No. Of cities	Non-attainment cities		Non-attainment for Class II standard		Non-attainment for Class III standard		Non-attainment cities for Class III
		number	rate (%)	number	rate (%)	number	rate (%)	
1995	88	32	36.4	3	3.4	0	0	
1996	88	27	30.7	25	28.4	2	2.3	Beijing, Guangzhou
1997	94	32	34.1	29	30.9	3	3.2	Beijing, Guangzhou, Shanghai
1998	96	32	33.3	29	30.2	3	3.1	Beijing, Guangzhou, Shanghai

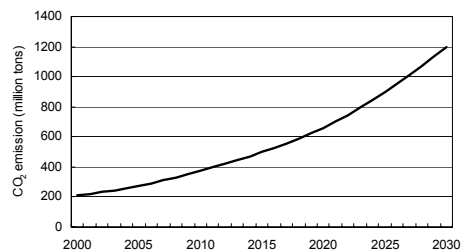
Motor Vehicle Pollution in Urban Areas

- 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.

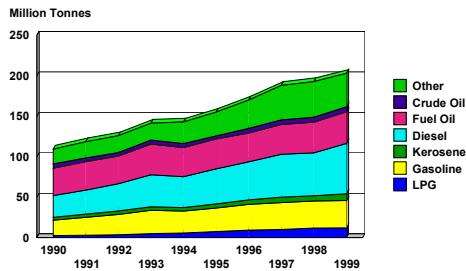
Health Impacts of Air Pollution in China



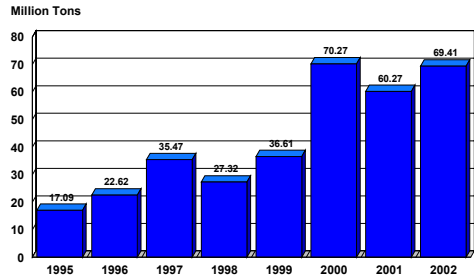
Carbon Dioxide Emissions From the Road Transport Sector Are Skyrocketing



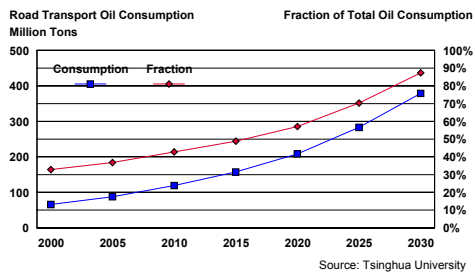
Fuel Consumption Trends in China



Oil Imports Have Grown Rapidly in China



Current and Projected Road Transport Oil Demand in China



Road transport oil demand will be over 50% of the total by 2020, and almost 90% by 2030, making it the principal source of oil demand and oil imports at that time.

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
 - ▶ Tax Incentives For Euro 2 Vehicles
- Individual Cities Supplementing National Actions
 - ▶ I/M Pilot Being Developed in Shanghai
 - ▶ Alternative Fuels For Buses & Taxis
 - ▶ Catalyst Retrofits in Beijing

Fuel Quality Improvements

- Eliminated Very Low Octane Fuels
- Eliminated Lead Additives But
 - MTBE
 - MMT
- Gasoline Aromatics Limited To 40%
- Gasoline Olefins Limited to 35%
- Sulfur Levels Reduced But Still High

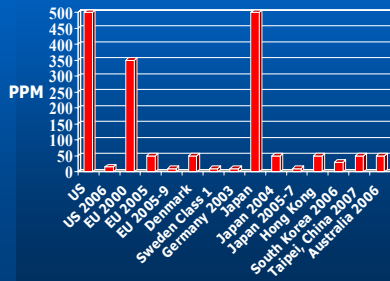
Pollution Control Measures on Motor Vehicles

Emission Standards For New Vehicles

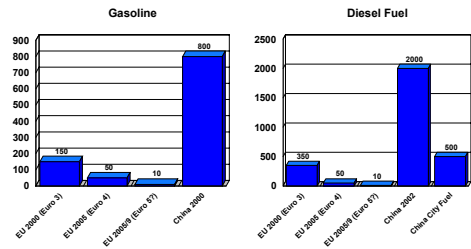
Time Category	Before 2000	2000	2001	2002	2003	2004	2005
PC	ECE 1503	EURO I	←	←	←	EURO II	←
LDV&LDT	ECE 1503	←	EURO I	←	←	←	EURO II
HDDV	None	←	EURO I	←	←	EURO II	←
Motorcycle	ECE R40	←	EURO I	←	←	←	EURO II

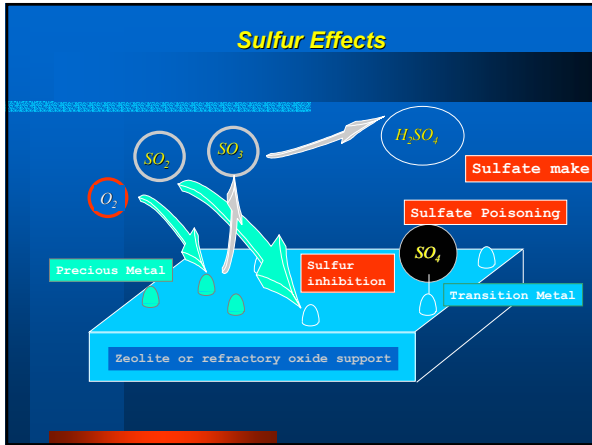
Beijing, Shanghai Introduced Euro 2 in 2003

Ultra Low Sulfur Diesel Fuel Is Necessary For Continued Progress



Maximum Sulfur Levels in Chinese & EU Fuels (PPM)





Summary of Influence of Fuel Sulfur on Gasoline and Diesel Exhaust Emission Control Devices

<ul style="list-style-type: none"> ● Control Technology – TWC – Oxidation Catalyst – Lean NOx Catalyst – SCR with Urea – Catalytic Filters – NOx Adsorbers – Hybrid With TWC 	<ul style="list-style-type: none"> ● Sulfur Effects – Sulfur Inhibition – Sulfur Inhibition, Sulfation – Sulfur Inhibition, Sulfation – Sulfur Inhibition, Sulfation – Sulfur Inhibition, Sulfation – Extreme Sulfur Inhibition – Sulfur Inhibition
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China Addressing Emissions & Energy Consumption But Not Yet On The Path To Zero Emissions

- 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
- New Fuel Economy Program

Advanced Technologies Could Play A Critical Role

- 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 Potential
 - 2 X Fuel Economy or More
 - Low Noise
 - Significant Challenges Remain
 - Cost
 - Infrastructure

Next Steps in China

- **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**
- **Oil Imports Soaring**
- **Initial Pollution Control Effort Reflects A Good Start**
- **New Fuel Economy Program A Big Step Forward**

Conclusions (2)

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