

Climate Change and the Transportation Sector

Challenges and Mitigation Options

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Administration Commitments

June 11, 2001 and February 14, 2002

Administration Position



White House photo

■ *Short-term commitment:*

Reduce emissions/GDP by 18% by 2012.

■ *Long-term commitment:*

"I reaffirm America's commitment to the United Nations Framework Convention and its central goal, to stabilize atmospheric greenhouse gas concentrations at a level that will prevent dangerous human interference with the climate."

—President George W. Bush

Implications

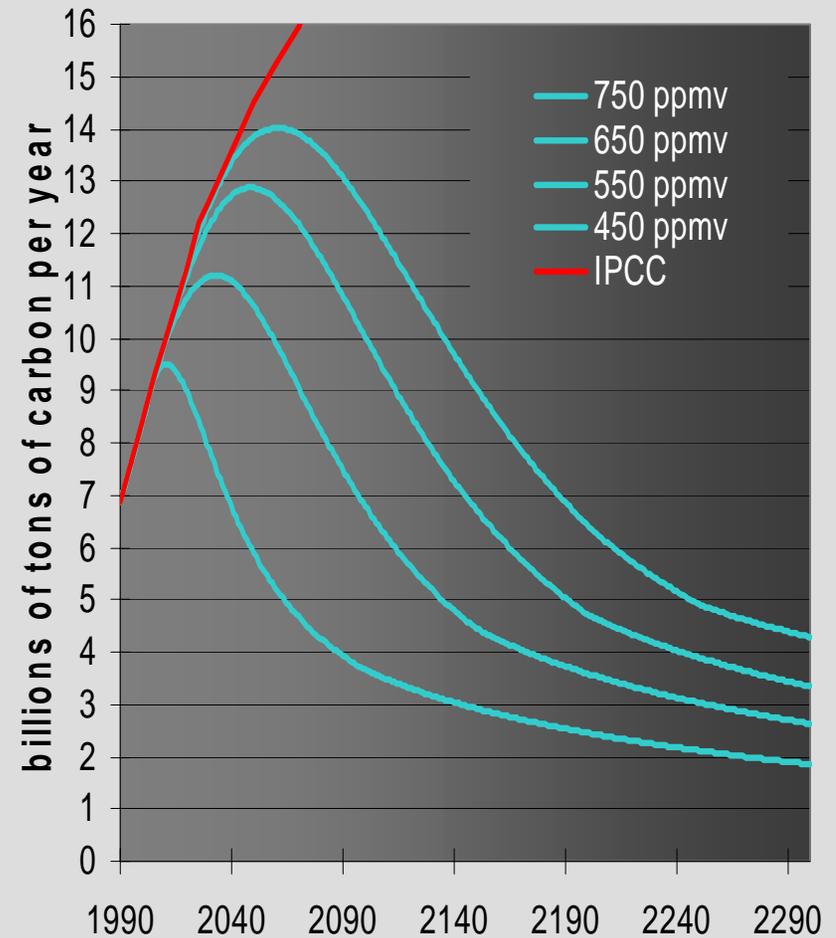
Deployment of Best Available Technologies and Practices Across the US

Requires Tremendous Breakthroughs in the Cost and Performance of a Portfolio of Technologies:

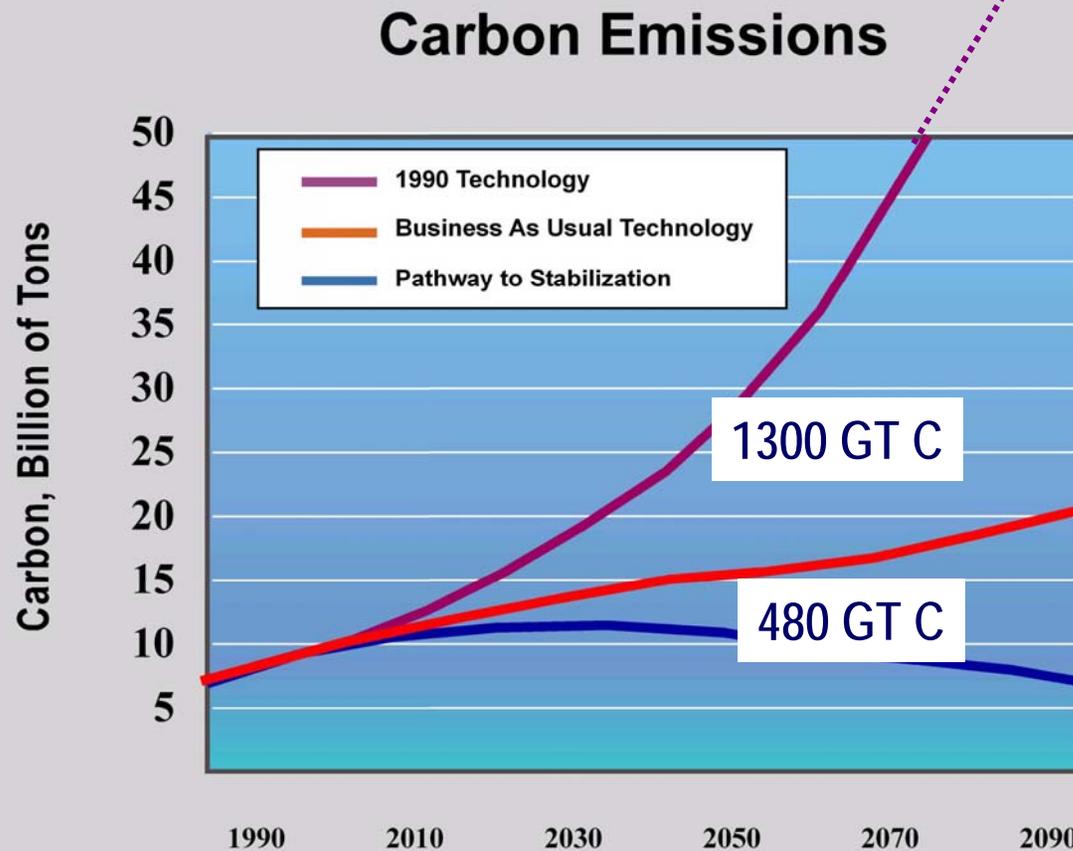
- Advanced Coal
- Sequestration
- Advanced Gas
- Hydrogen
- Energy Efficiency
- Nuclear
- Renewables

Managing Carbon Concentrations

- ▶ Stabilizing concentrations is not the same as stabilizing emissions
- ▶ Addressing the climate change challenge requires a portfolio of responses, including:
 - emissions mitigation,
 - technology development,
 - climate adaptation, and
 - resolving scientific uncertainty



Commitment to Stabilization Requires Closing TWO "Technology Gaps"



"Business-As-Usual"
Technology Gap

"Stabilization"
Technology Gap

A gigaton is...

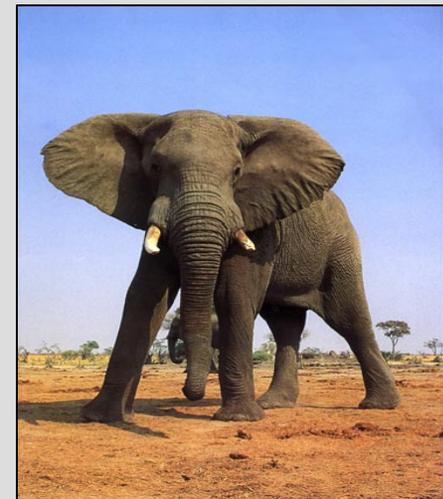
The combined weight of 77% of the earth's population assuming everyone weighed as much as Aaron Gibson (#78), an offensive tackle for the Chicago Bears



2740 Empire State Buildings
or 77 Empire State Buildings
made out of solid lead



142,857,142 African elephants
That's enough elephants stacked
on top of each other to reach from
Earth to the moon and halfway back



A gigaton of emissions reduction per year ...

Technology	1 Gigaton Carbon / year (1 billion tons C / year)	Major Issues
Coal Plants with Sequestration	700 1GW plants all CO ₂ sequestered	Economic Viability, Regulatory Approval, Social Acceptance
Geologic Sequestration	3500 Sleipners, at 1 Mt(CO ₂)/year ¹	Technical, Social, & Economic Viability
Nuclear	1500 1GW plants	Economic & Social Viability, Proliferation Concerns
Efficiency	2 billion cars at 60 mpg instead of 30 mpg ¹	Point of Diminishing Return is Reached Unless Lifestyle Change
Wind	150 x current ¹	Geographic Limitations, Storage
Solar PV	2000 x current ¹	Geographic Limitations, Storage
Biomass fuels from plantations	200x10 ⁶ ha ¹	Land-Use Changes and Biotech Concerns
Storage in new forest	500x10 ⁶ ha ¹	Land-Use Changes

Roughly seven times the fossil fired capacity built in the USA since 1980

More than three times number of nuclear power plants currently on the planet

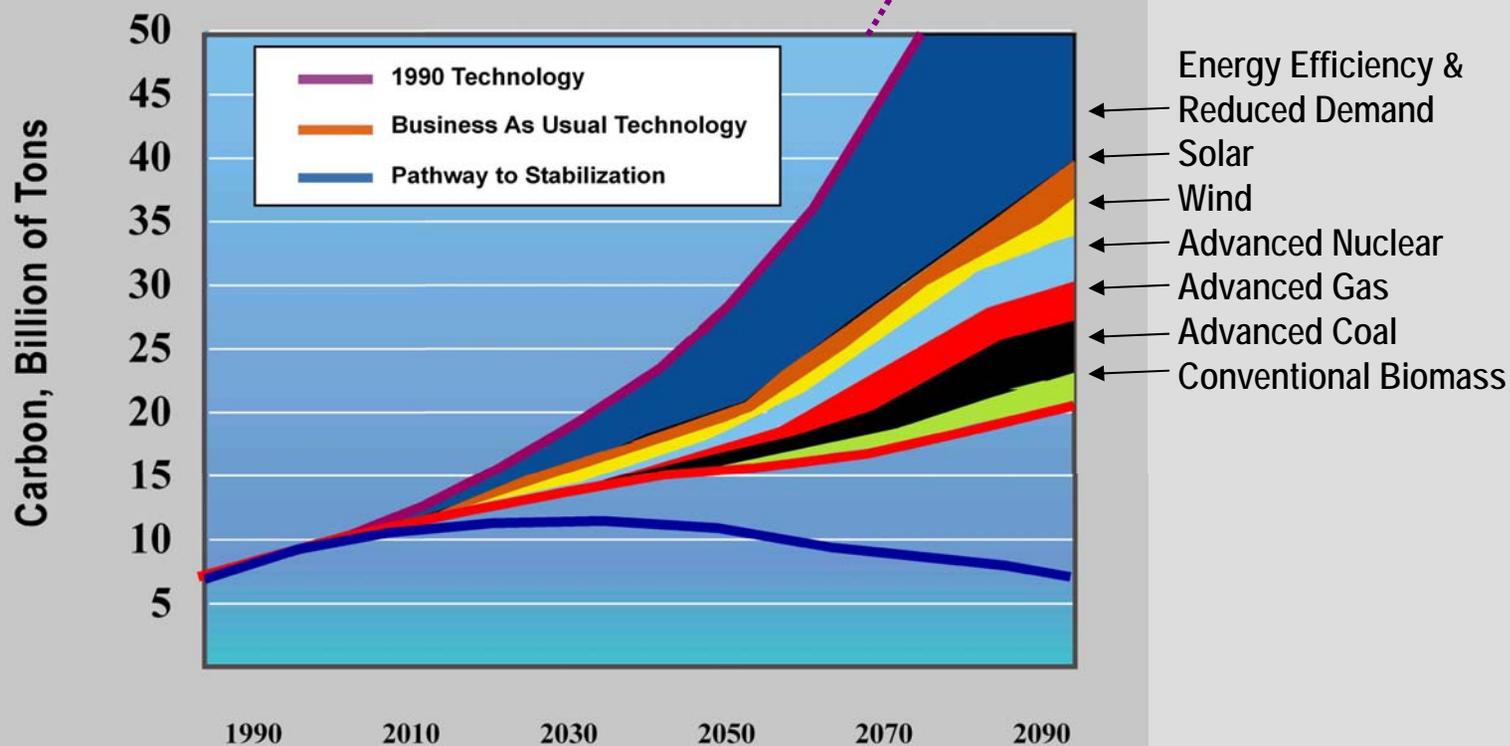
Three times the number of cars that currently exist on the planet

Nearly six times the acreages devoted to corn production in entire USA

Business-As-Usual Gap

Extraordinary Improvement is Built in to BAU

Carbon Emissions

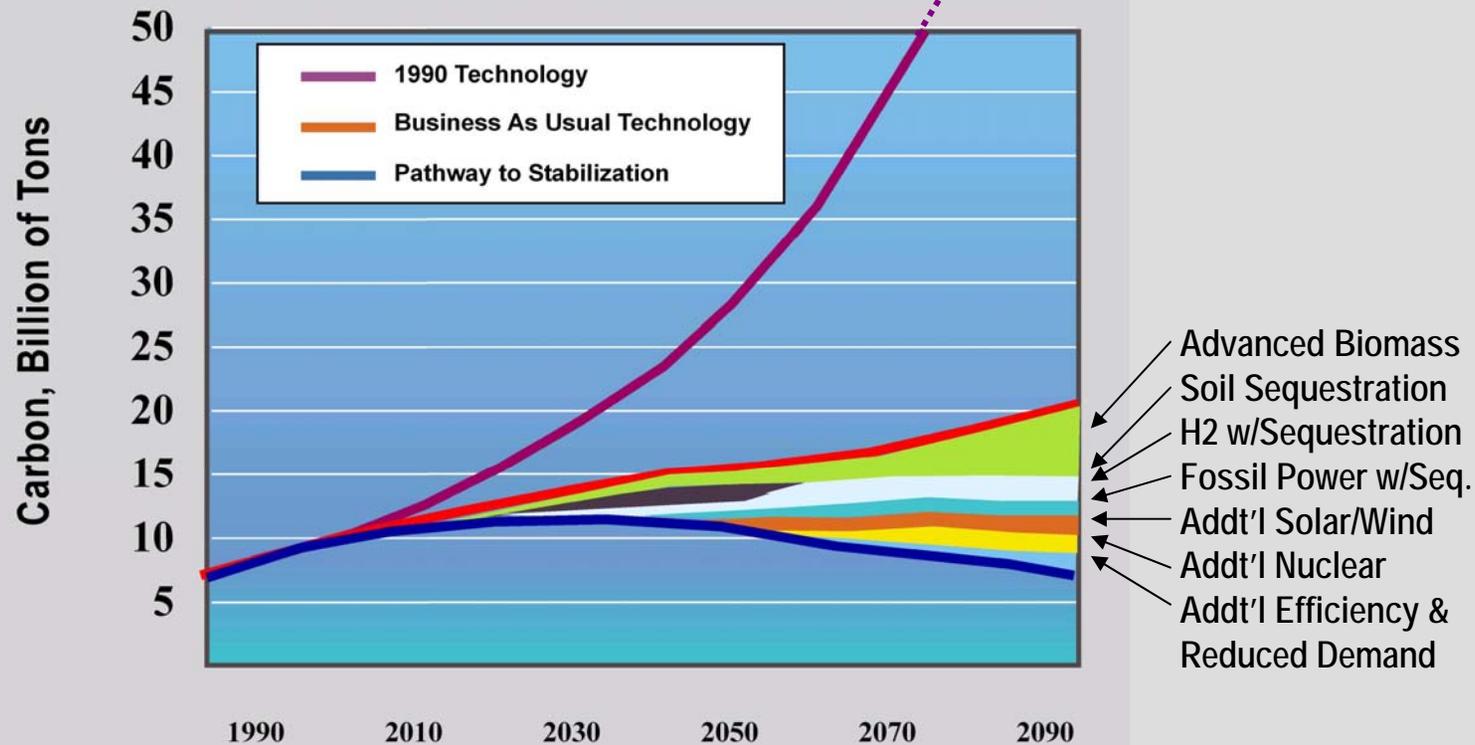


"Business-As-Usual"
Technology Gap

Stabilization Gap

Tremendous Additional Technological Advance Required

Carbon Emissions

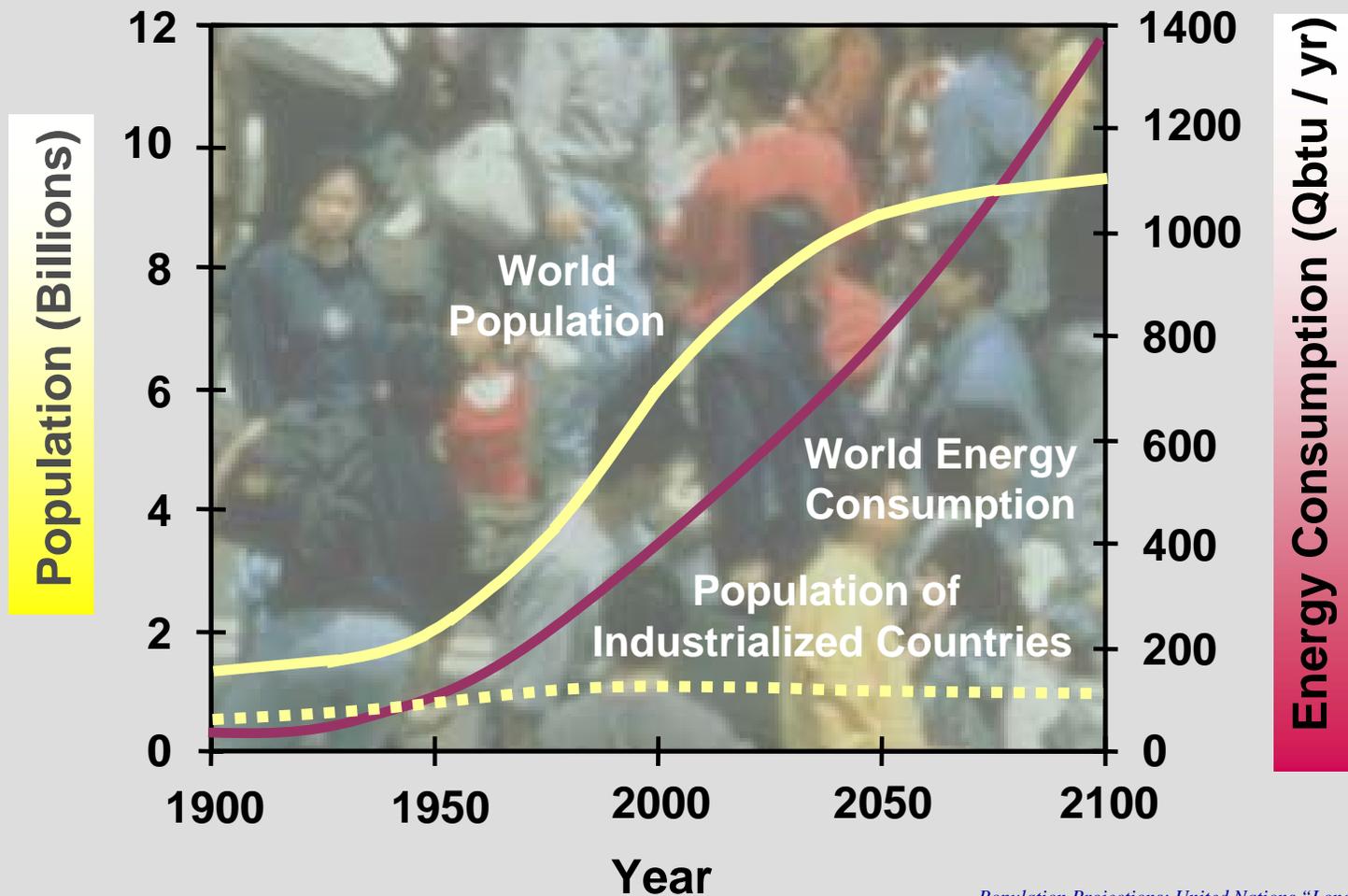


“Stabilization”
Technology Gap

Take Home Points

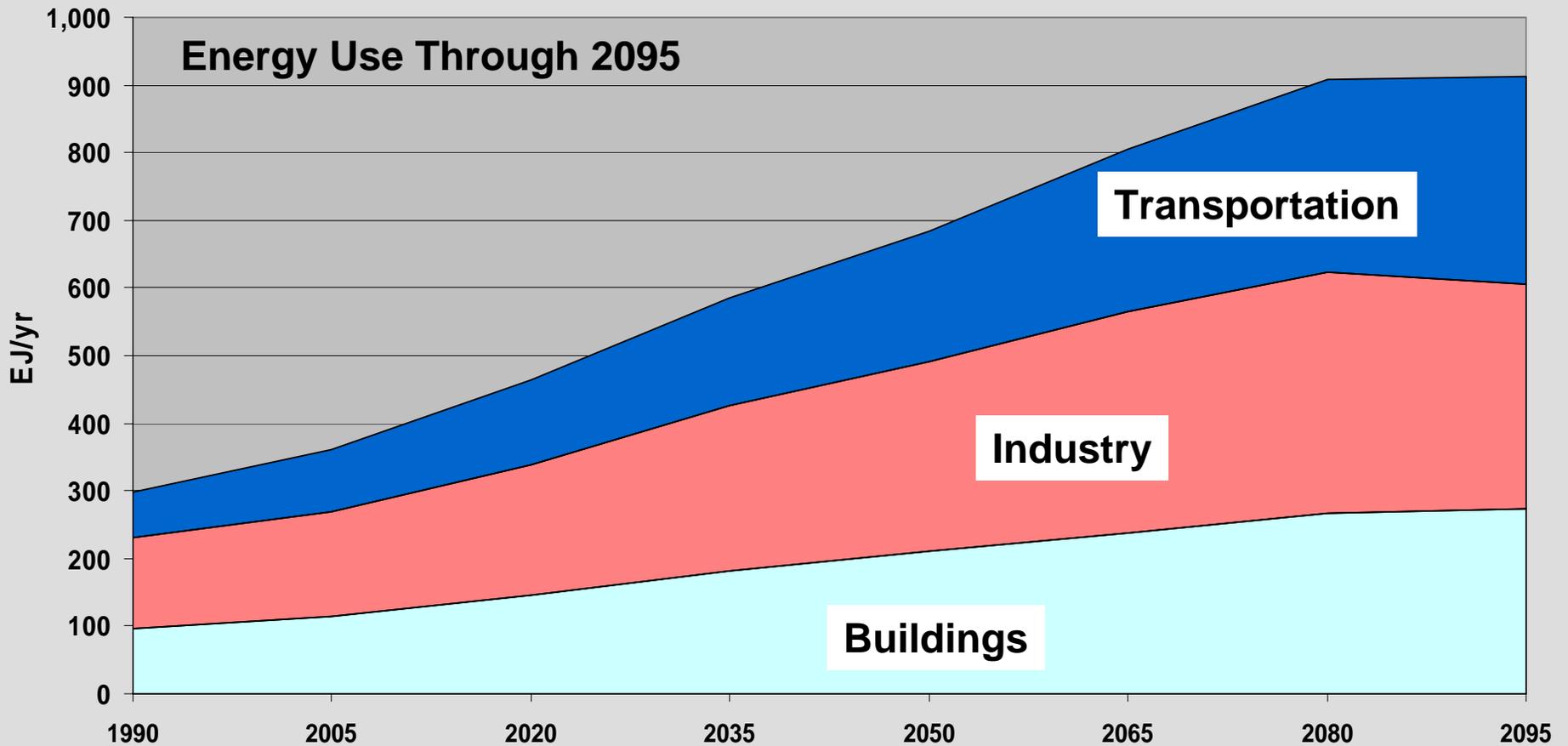
- ▶ **Addressing climate change will take continued progress on traditional energy R&D and carbon management R&D**
- ▶ **Key Carbon Management Technologies that have to be ready to be deployed by 2020 include:**
 - Commercial Biomass
 - Soil Carbon Sequestration
 - Geologic Carbon Sequestration
 - Advanced Gasification
 - Fuel Cells and Hydrogen Systems
- ▶ **Recognition of scale and scope is critical**
 - Century scale problem
 - A gigaton of carbon is a lot!
 - International scope and implications
- ▶ **R&D programs need to be designed to lay the ground work for massive deployment.** Near term field demonstrations need to be designed with this in mind.

Population and Economic Growth will Increase Demands for Energy Services



Population Projections: United Nations "Long-Range World
Population Projections: Based on the 1998 Revision"
Energy Projections: "Global Energy Perspectives" ITASA / WEC

Transportation Sector Demands over 1/3 of Projected Energy Use



The US transportation system is the world's largest

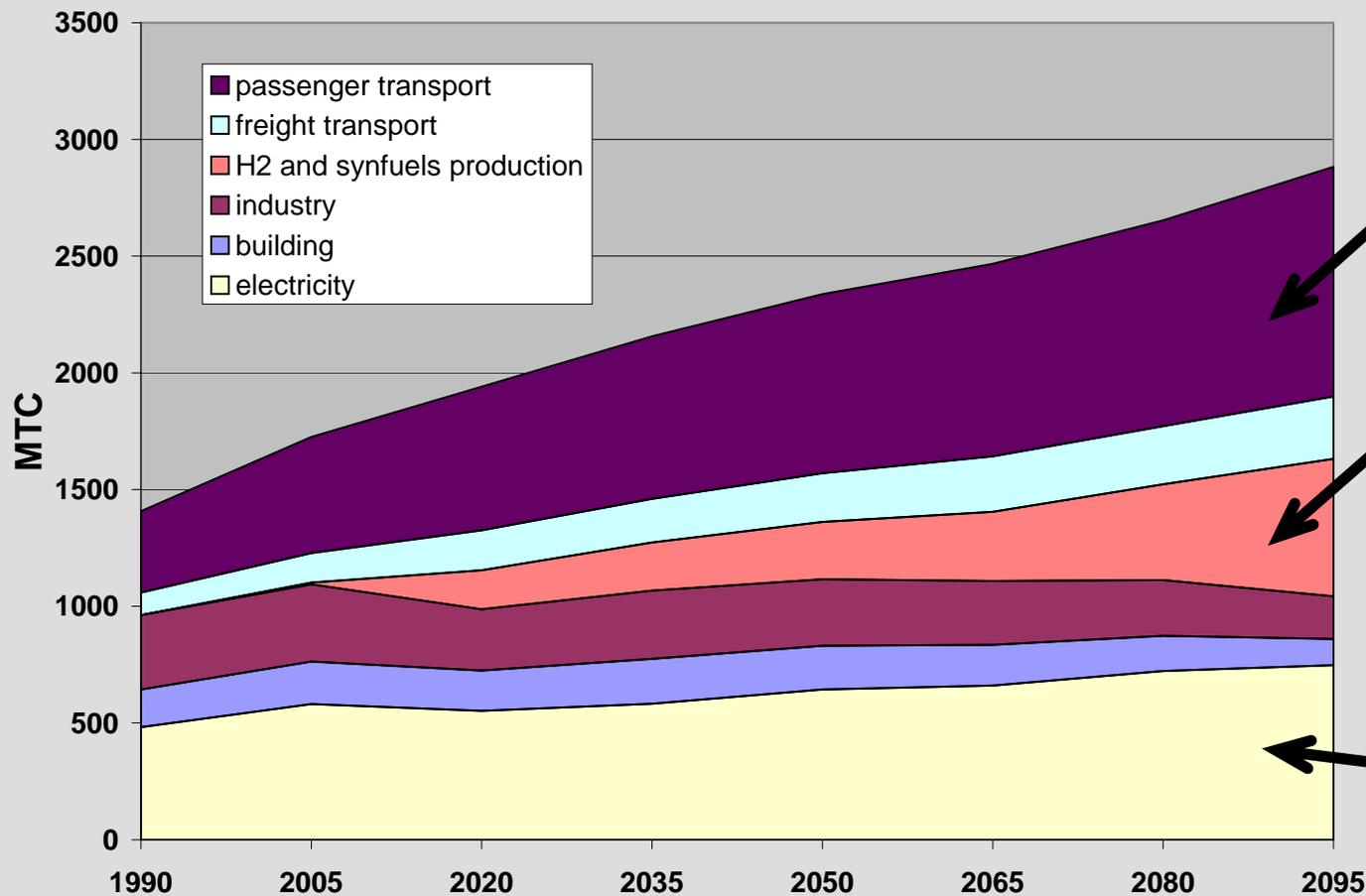
- ▶ Current global fleet is over 600 million vehicles and growing; projected to reach 3.5 billion by 2050
 - Worldwide production (2000) ~ 58 million vehicles
 - US production (2000) ~ 13 million vehicles
 - **Fastest growth expected in emerging markets**
- ▶ An economic engine
 - Transportation-related goods and services accounted for more than 10% of US GDP in 2000
 - US auto industry investment in R&D highest of any other manufacturing industry
 - Tremendous investment in infrastructure, manufacturing facilities and labor skills
- ▶ Most projections show significant increase in energy demands

Parameters of the Business as Usual Baseline

- ▶ US (and global) population and GDP/capita are assumed to increase over the course of this century
 - US population increases to ~450 million and GDP/capita increases 1-2% per year; these yield increased demand for energy (including transportation) services
- ▶ No explicit climate policy imposed
- ▶ Technological improvements in fuel efficiency are assumed

BAU: US CO₂ Emissions

Passenger Vehicle CO₂ Emissions Major Area of Growth



The lack of a viable non-petroleum based transport technology in the base case results in this growth in CO₂ emissions

Building and Industry energy use continue to electrify so not much growth in CO₂ emissions

Non and Low CO₂ Emitting Electric Generation Technologies Assumed to Make Great Strides in Baseline

Two Scenarios: Emissions Reductions from Diesel Deployment

▶ 50% Diesel Penetration (50% Diesel):

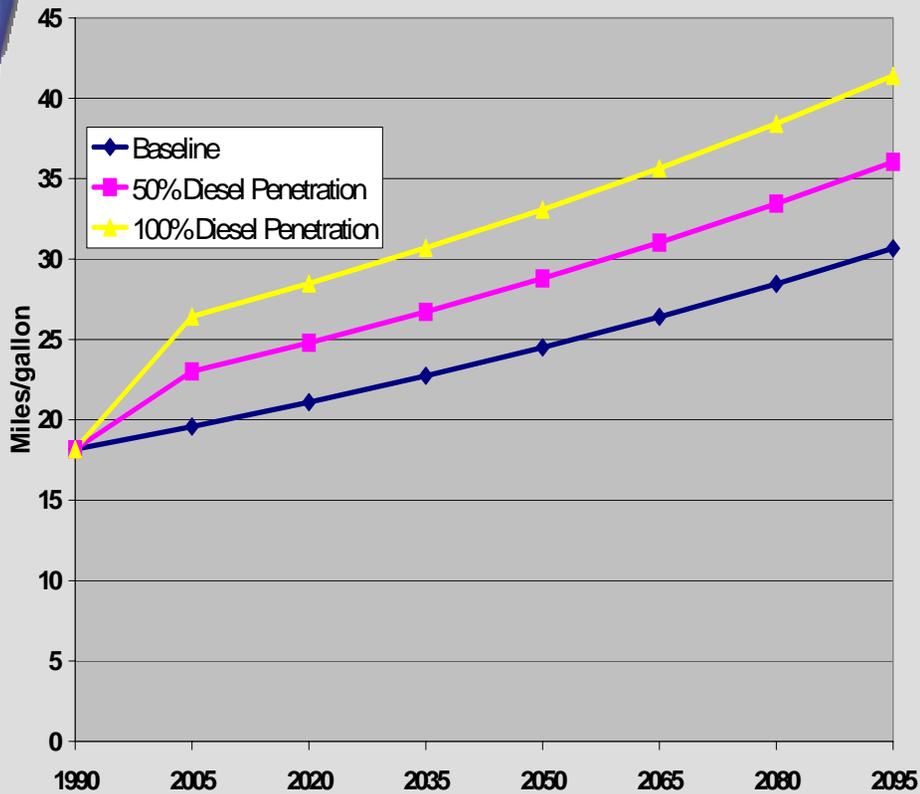
- Assume that diesel engines obtain and hold 50% of the market for passenger transportation services
- Diesels maintain their current dominance in freight transport
- All other socio-economic and demographic assumptions of the base case are kept constant

▶ 100% Diesel Penetration (100% Diesel):

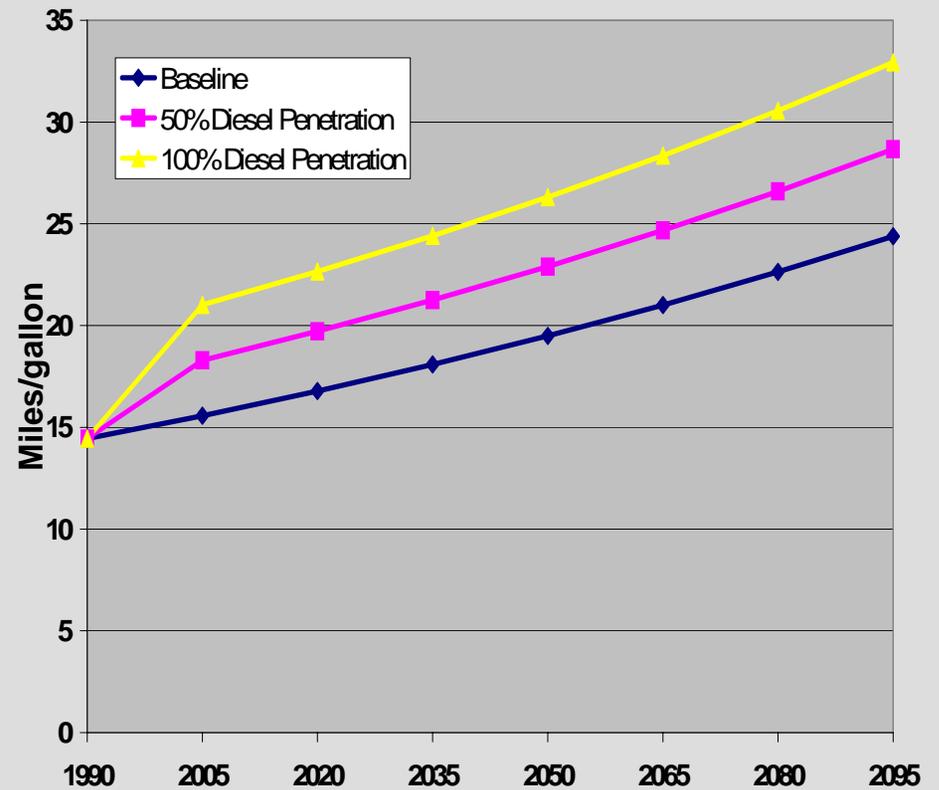
- Diesel engines obtain and hold 100% of the market for passenger transportation services
- All other parameters same as 50% Diesel case

Assumed Passenger Auto and Light Truck Fuel Efficiencies

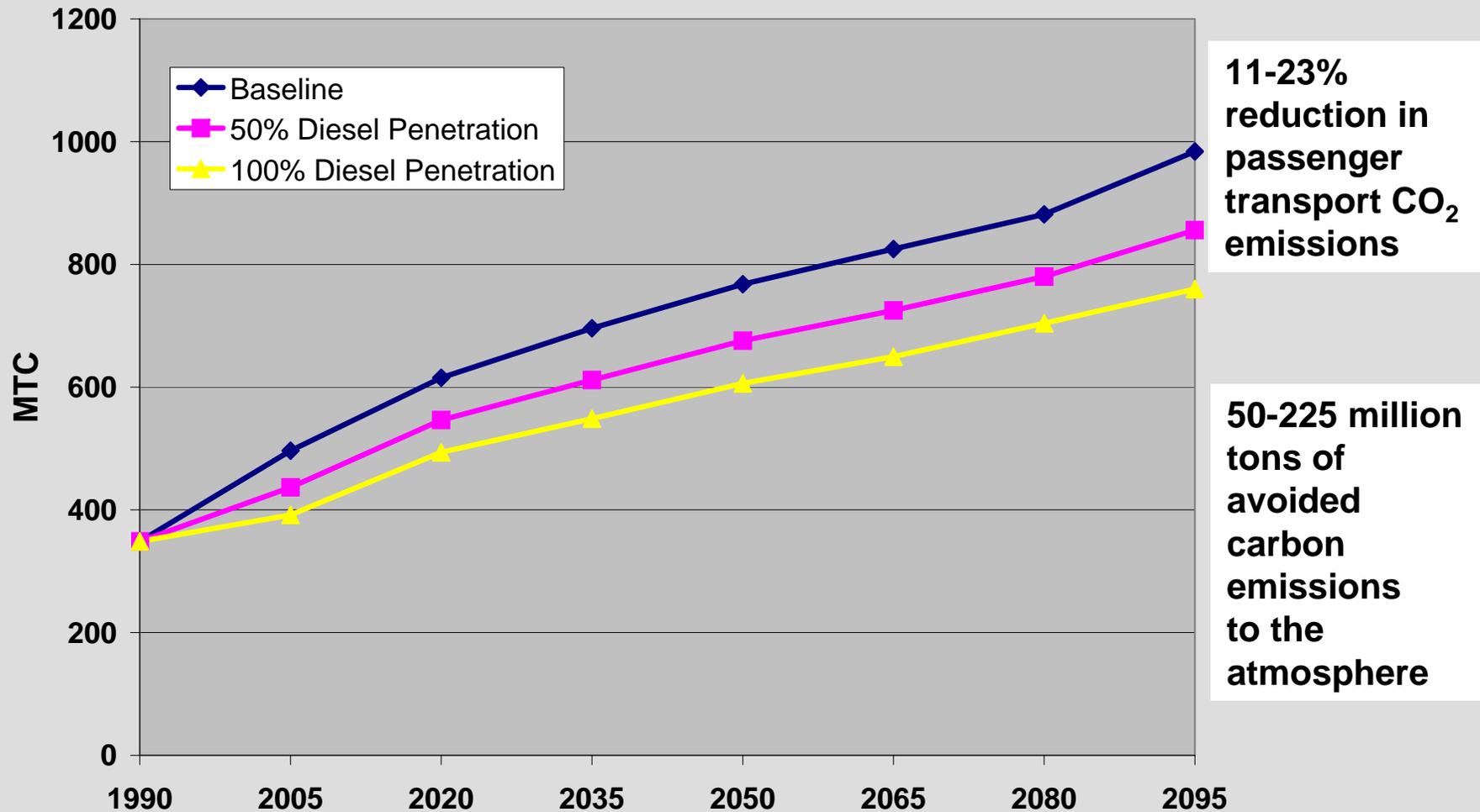
Automobiles



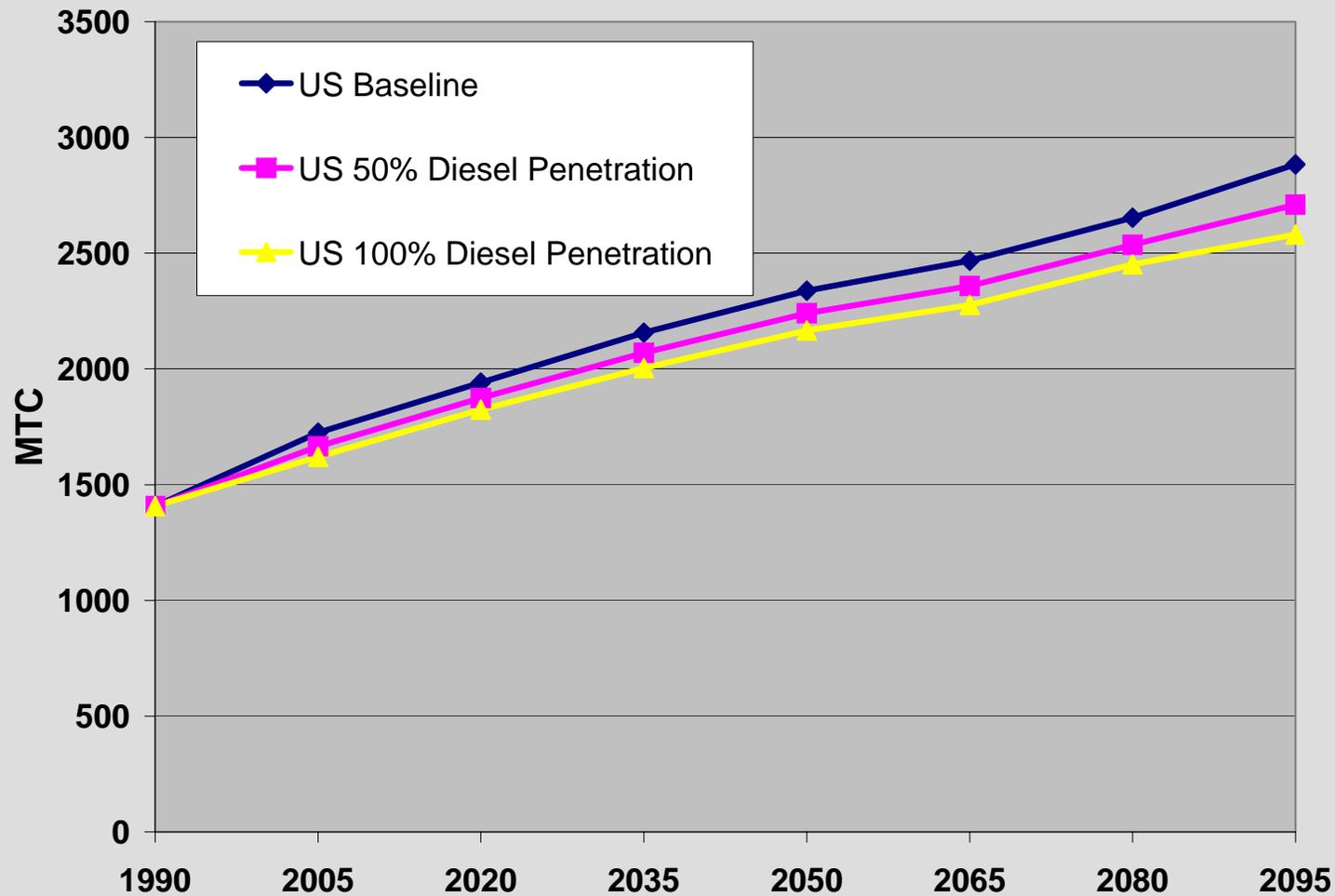
Light Trucks



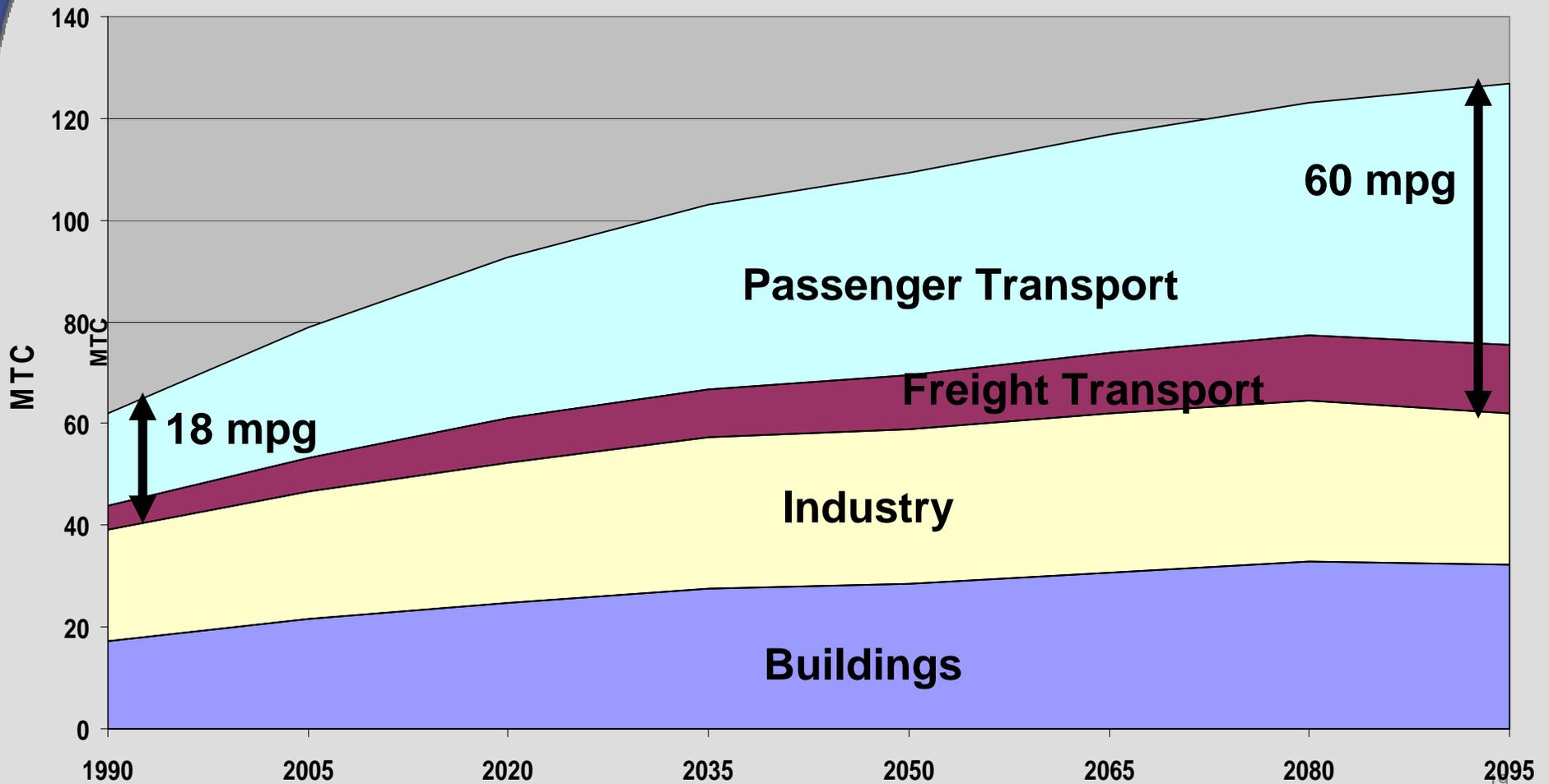
US Passenger CO₂ Emissions (Autos and Light Trucks)



Deployment of Diesel Technology can Reduce Total US CO₂ Emissions



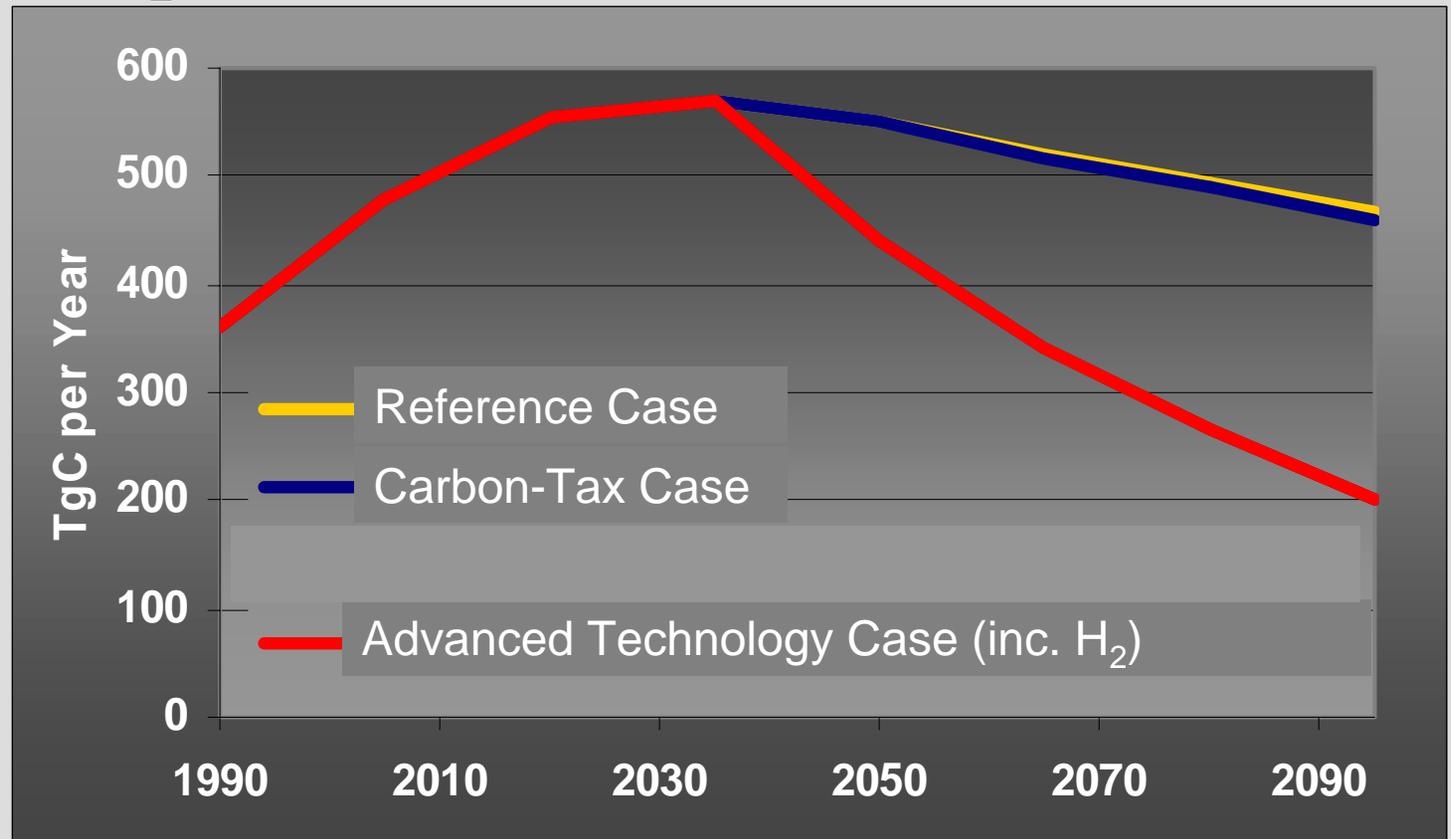
But even with Significant Fuel Economy Improvements, US Transport Emissions Triple in the 21st Century



Hydrogen is another option for lowering CO₂ emissions from transportation

US CO₂ emissions from the transportation sector

Carbon taxes have little impact on demand for transportation fuels; only new technology can impact transportation emissions.



Hydrogen systems for transportation raise many issues

H2 sources

Fuel Input

CH₄

Coal

Oil

Biomass

Electricity

Adv.

Biotechnology

Storage and Transport

Production

Central station with transport

- truck
- pipeline

Production at the point of distribution

- CO₂ transport

Infrastructure

Cost

COST ... competition with H2

Competing Technologies

Conventional ICE

Hybrids

Diesels

Non-H Fuel On-board Reforming

Bio-fuels

Environment, Health, & Safety

Byproducts

Trace element recycling

Local Fog

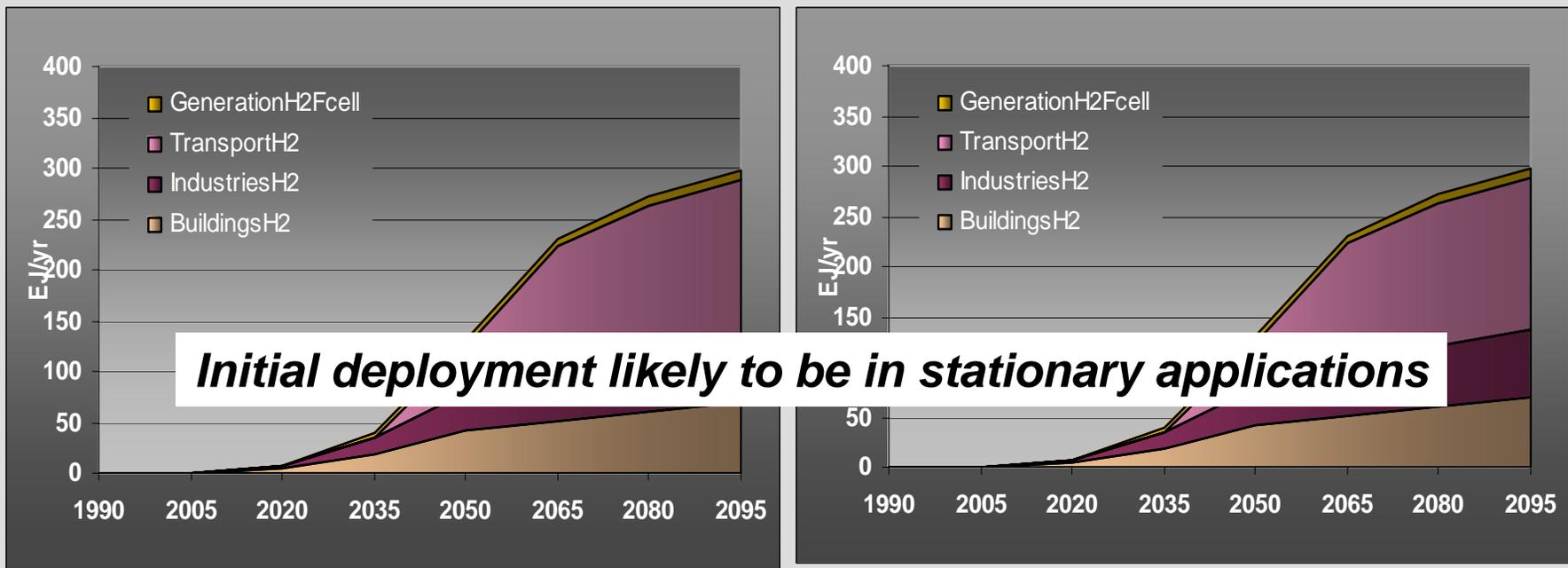
Losses and local atmospheric impacts

What don't we know?

Even with rapid technology improvement, significant market penetration is likely decades away

Advanced Technology
No climate policy

Advanced Technology
CO₂ Stabilization

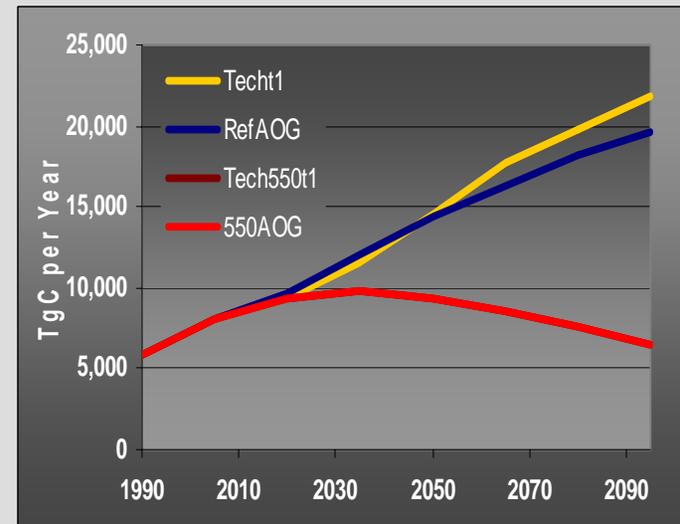
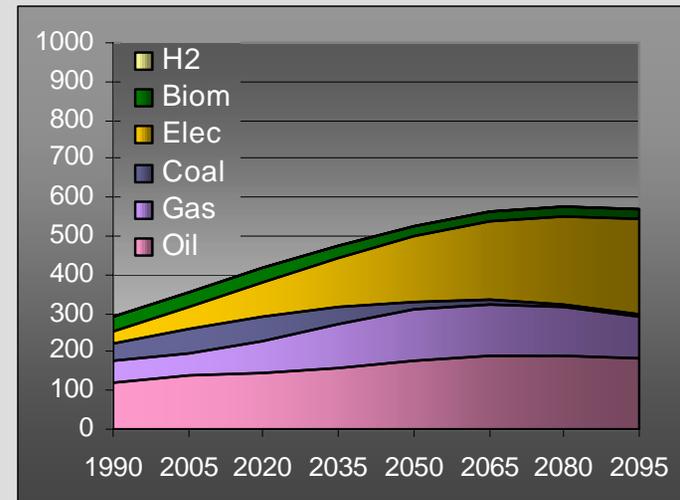


H₂ Production—Exajoules/year

Hydrogen deployment must be evaluated in the context of the integrated system

Climate policy will not necessarily make the hydrogen market.
It's about technology.

Successful hydrogen technology development may not necessarily solve the climate problem.
What is the source of the hydrogen?



In the long term, the question of which system(s) may prevail remains

- Fossil fuels → H_2 +Carbon Capture & Sequestration → H_2 pipeline → Local H_2 storage → H_2 fuel cell vehicle.
- Fossil fuels → Natural gas pipeline → Local H_2 production+Carbon Capture & Sequestration → Local H_2 storage → H_2 fuel cell vehicle.
- Commercial biomass → Refinery → Conventional (including diesel) vehicles.
- Wind → H_2 → fuel cell vehicle.
- Fossil fuels → Electricity + Carbon Capture & Sequestration → Electric vehicle.

And if the end game is hydrogen, what does the technology transition path look like?

Closing Thoughts

- ▶ Reducing carbon emissions from the transportation sector is dependent on advanced technology
- ▶ We will need a portfolio of technology options, globally deployable; energy technologies that could be major components of the global energy system by 2050 are minor players today
- ▶ Significant diesel penetration could yield important emissions reductions and provide a step forward in the transition to a lower carbon-emitting transportation system
- ▶ Hydrogen has the potential in the long term to help address climate change and energy security simultaneously, depending on how it is produced, but it must be able to compete in the market

