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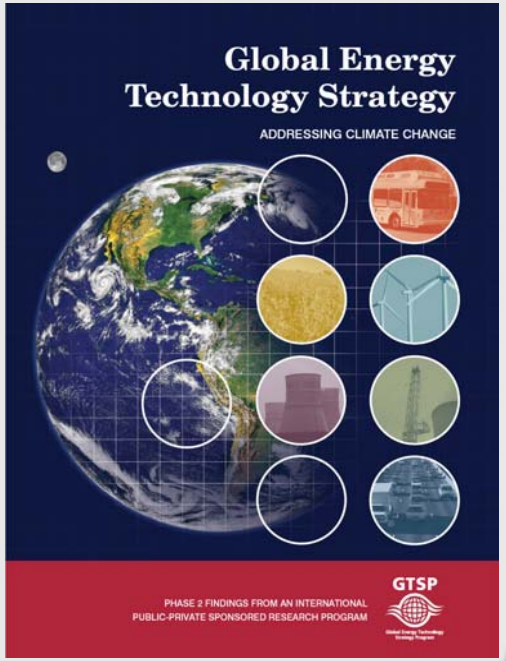
The Role of End-use Energy Technology in Addressing Climate Change



Energy Security, Innovation & Sustainability Initiative

Progressive Dialogue II: Discover Demand Drivers for Sustainable Energy Solutions—Users

Jae Edmonds

March 6-7, 2008

Battelle

JGCRI Joint Global Change Research Institute | UNIVERSITY OF MARYLAND

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Acknowledgements

- Thanks to the Council on Competitiveness.
- Thanks to the sponsors of the Global Energy Technology Strategy Program (GTSP) as well as the DOE Office of Energy Efficiency and Renewable Energy for research support.

GTSP Sponsors – Phases 1,2, & 3

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A Note on Units
CO2 Versus C

- 1 ton C = 44/12 tons of CO_2
  = $3^2/_3$ tons of CO_2
  = ~4 tons of CO_2

- \$1/ton CO_2= \$$3^2/_3$ tons of C
  = ~\$4 tons of C

Both appear in the literature.

This presentation used tons of carbon.

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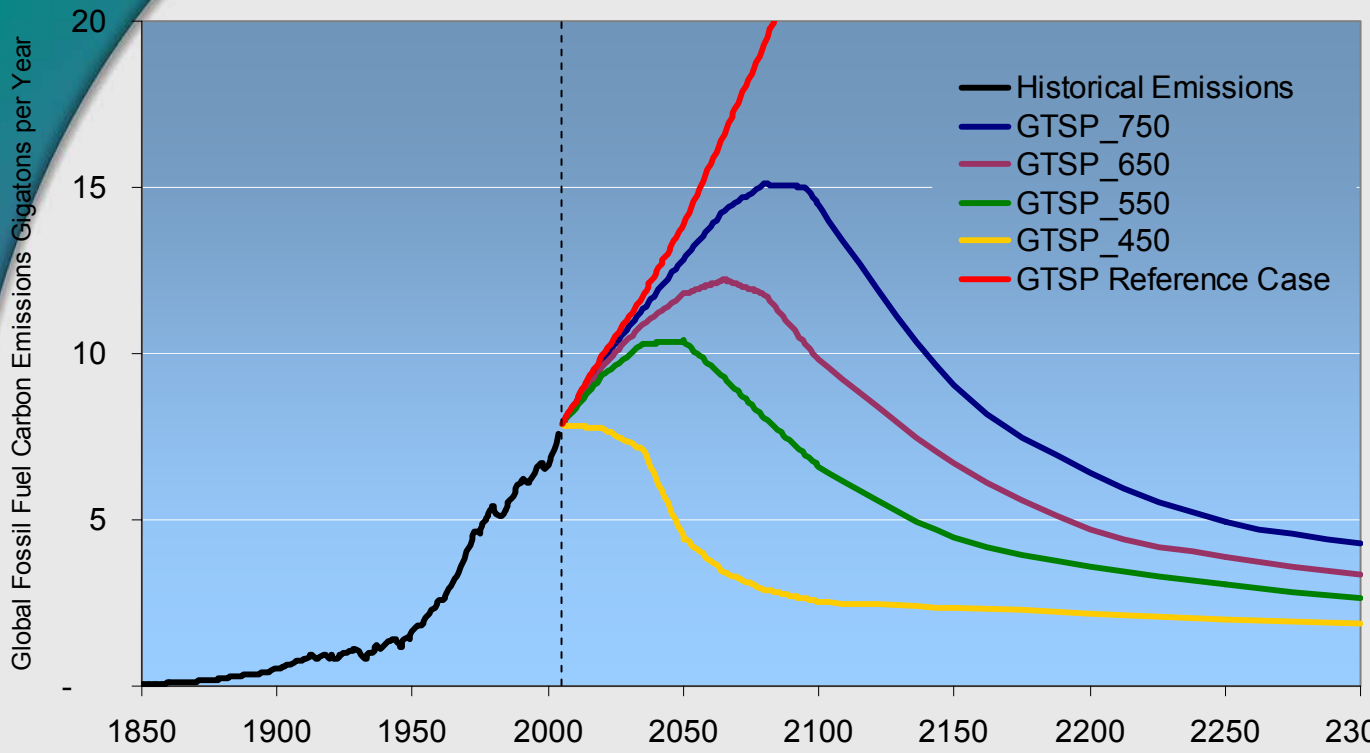
Summary

- Climate is a long-term public goods problem, with implications for actions today.
- Stabilizing the concentration of CO_2 means fundamental change to the global energy system.
- End-use energy technologies will play an important role in addressing climate change along with other technologies, such as CO_2 capture and storage, Biotechnology, Hydrogen systems, Nuclear energy, and Wind and solar, though none is a “silver bullet.”
- Emissions mitigation occurs both through improved end-use energy efficiency and through fuel substitutions.
- Improving end-use energy technologies will not stabilize climate in the absence of a value on carbon and other GHG emissions.
- Improving end-use energy technology will help make climate stabilization more affordable. It is potentially worth Trillions of dollars.

Climate change is a long-term strategic problem with implications for today



Fossil Fuel Carbon Emissions

Historic & 2005 to 2100

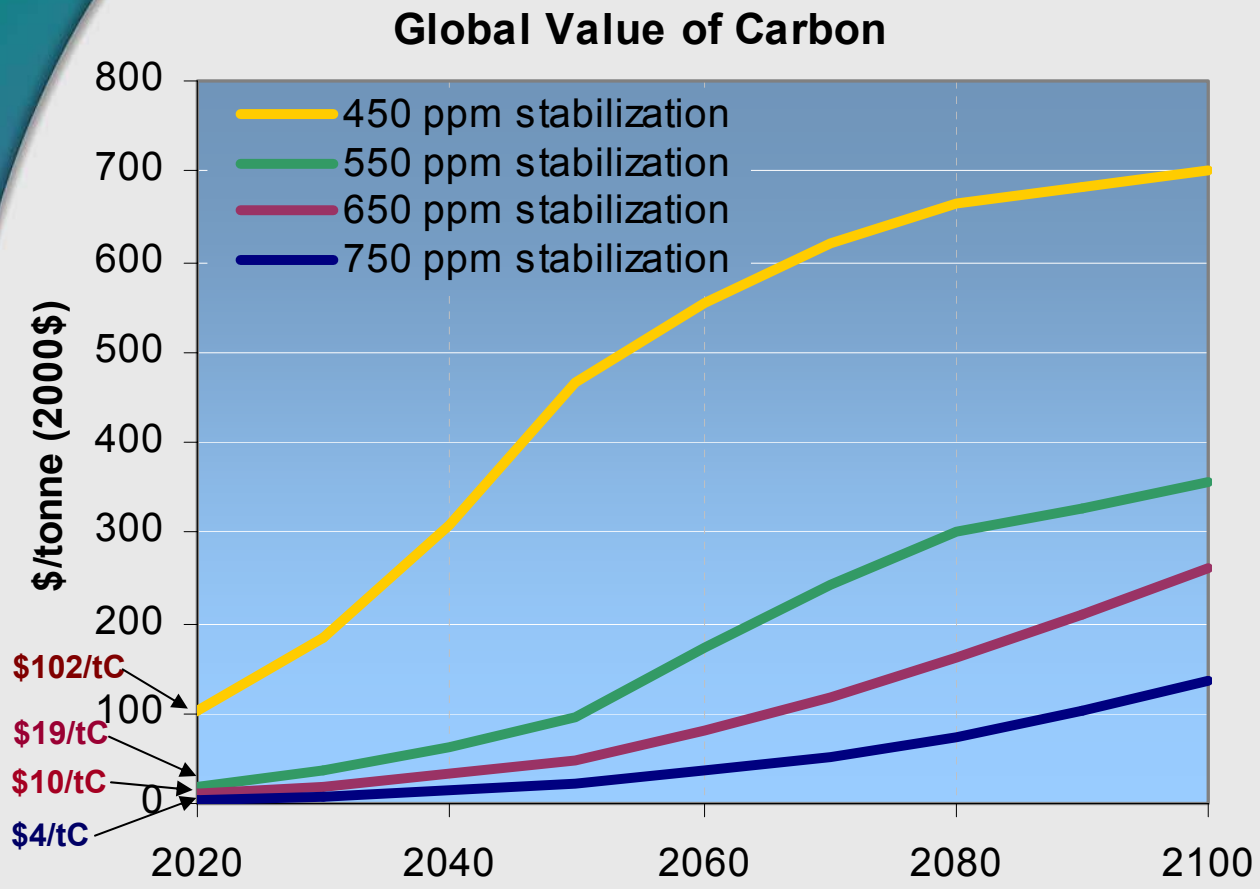
1750-2005	**300 GtC**
GTSP Ref	**1430 GtC**
750 ppm	**1200 GtC**
650 ppm	**1040 GtC**
550 ppm	**862 GtC**
450 ppm	**480 GtC**

- Stabilization of greenhouse gas **concentrations** is the goal of the Framework Convention on Climate Change.
- Stabilizing CO_2 **concentrations** at any level means that **global**, CO_2 emissions must peak and then decline forever.

Stabilization requires that greenhouse gases have a price—implicit or explicit.

- **Climate is a Public Good**
- You cannot solve a **public** goods problem with better **private** decisions alone.
  - Public goods problems require public intervention.
  - Markets are needed to communicate the public interest to private decision makers.
- A price of carbon should reflect the social value of carbon.

A global commitment to stabilizing CO_2 concentrations requires a carbon price that escalates over time



- Price of carbon should start low and rise steadily to minimize society's costs.
- Eventually all nations and economic sectors need to be covered as the atmosphere is indifferent as to the source of CO_2 emissions.
- The response to this escalating price of carbon will vary across economic sectors and regions.

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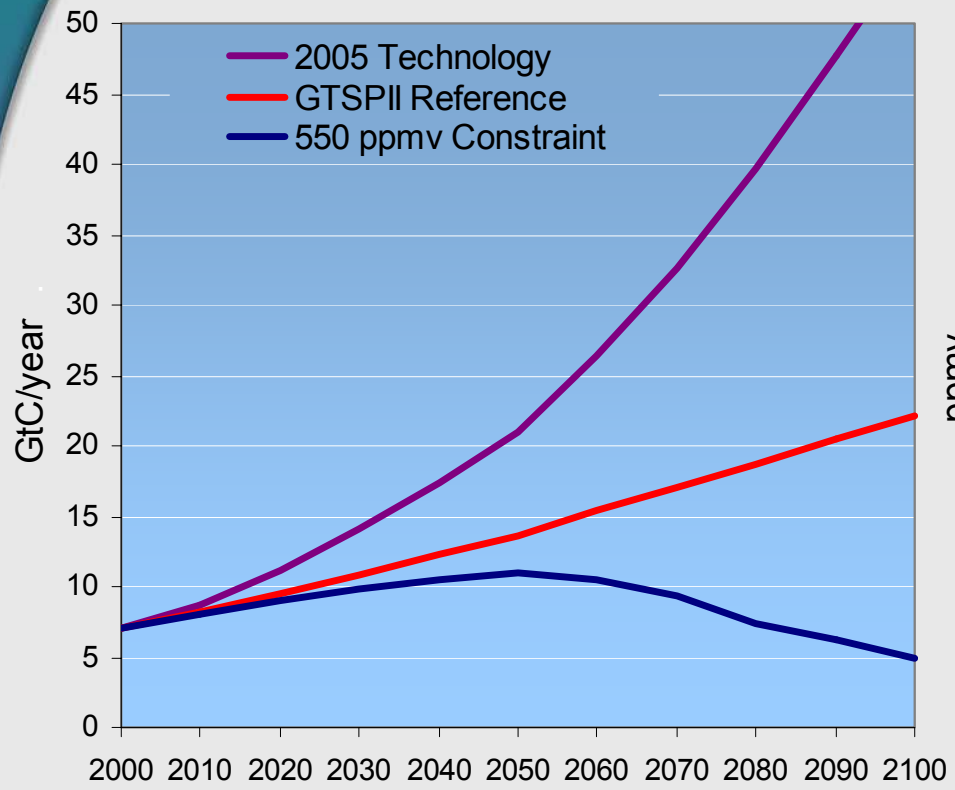
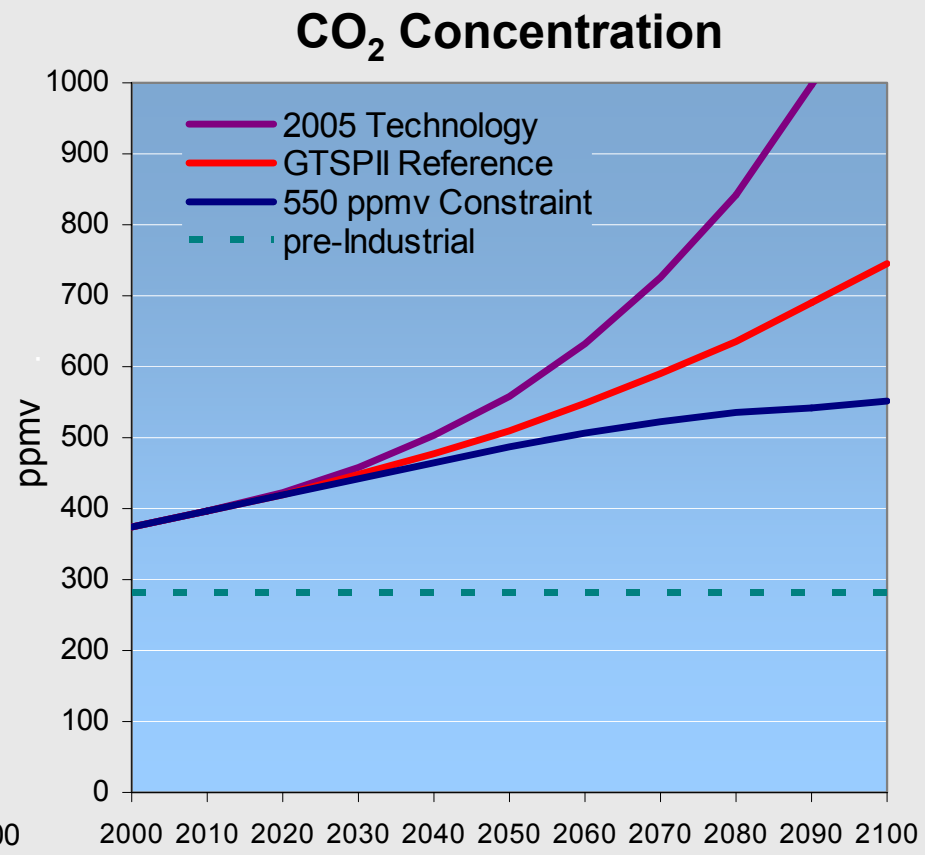
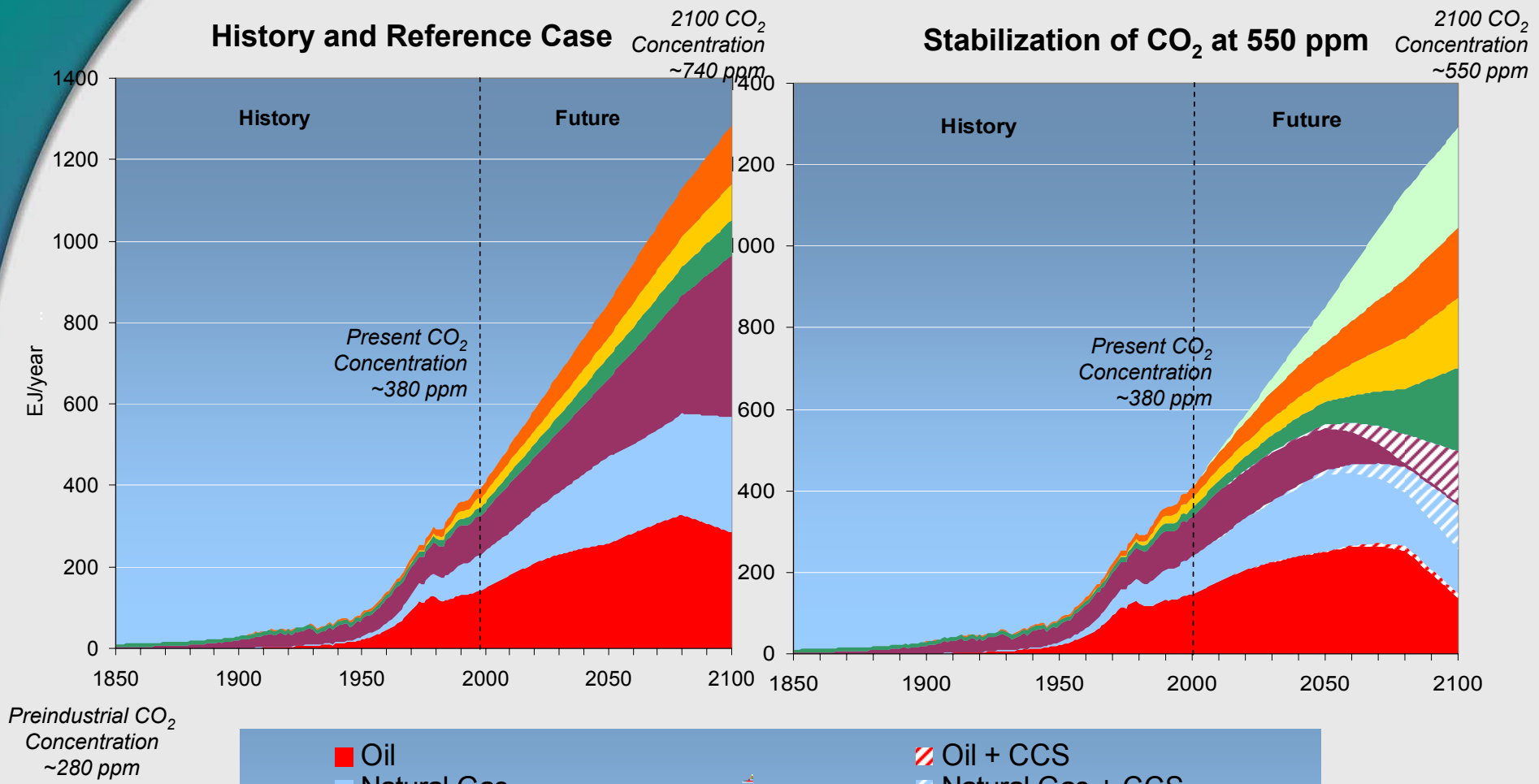
End Use Energy Technology Is Part of a Larger Global Energy System

Future projections of energy use and CO_2 emissions assume significant technological progress in their no-climate-policy, business-as-usual cases



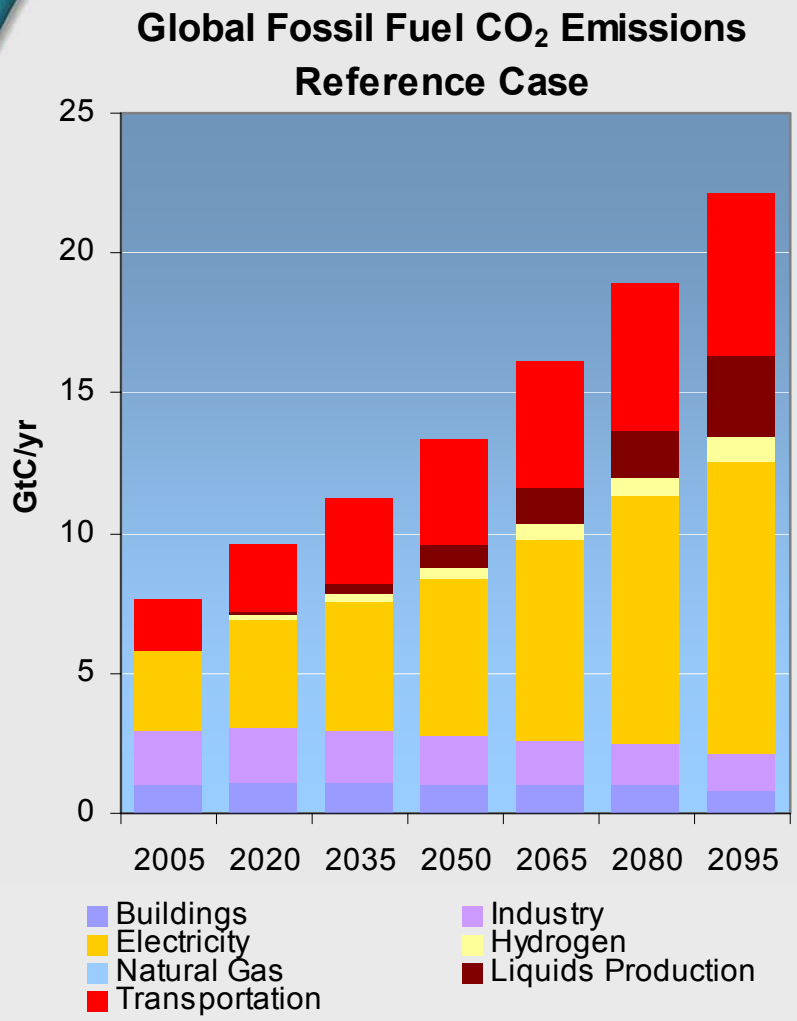


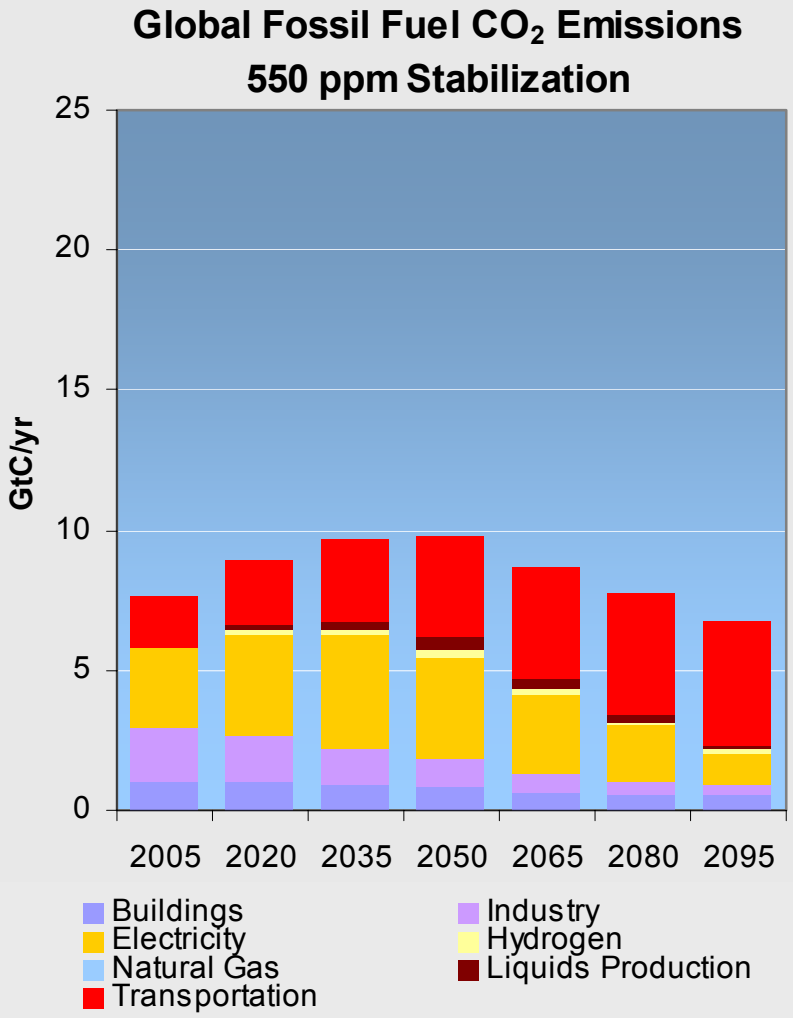
Stabilizing CO_2 concentrations means fundamental change to the global energy system



The response to this escalating price of carbon will vary across economic sectors and regions.

Stabilization changes the sources of fossil CO_2 emissions. Utility emissions drop to virtually zero. Transportation emissions dominate.

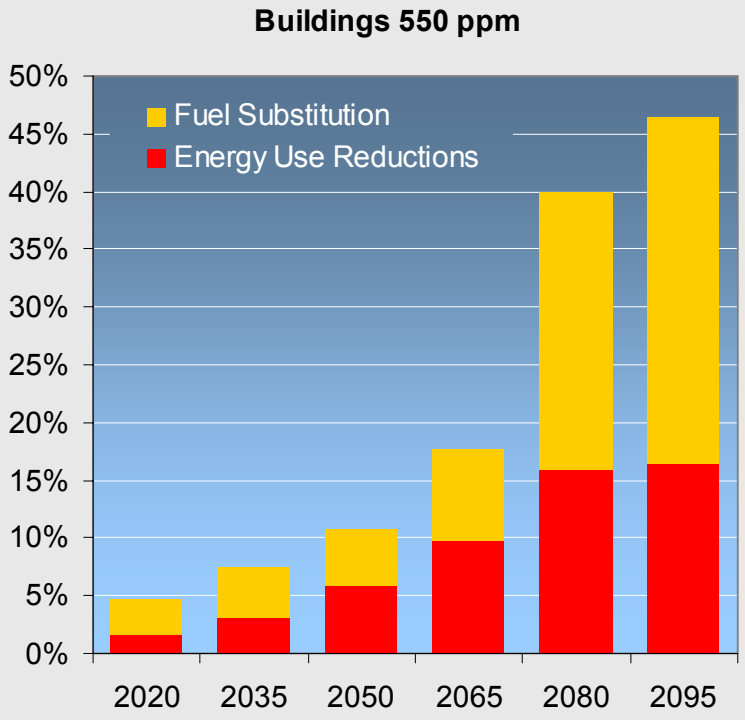


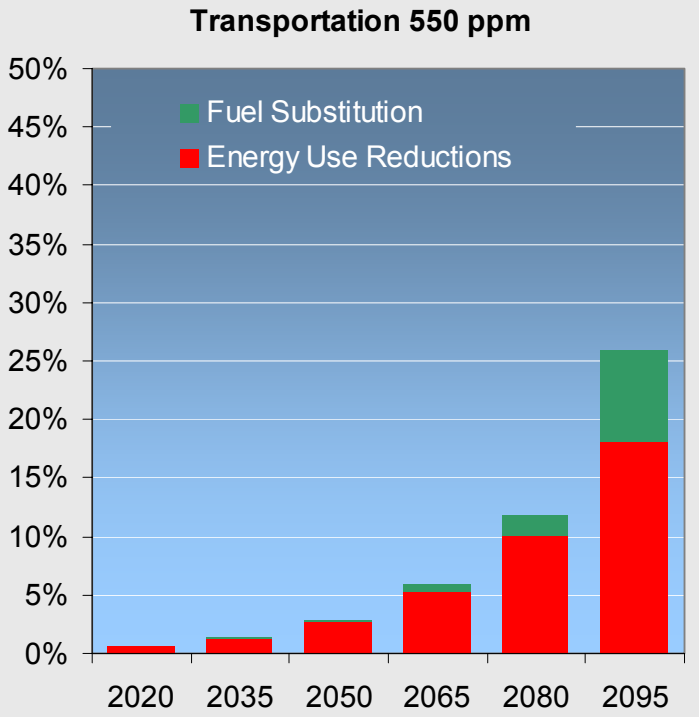


End-use Energy Technologies

- **Three sectors**
  - Buildings
  - Industry
  - Transportation

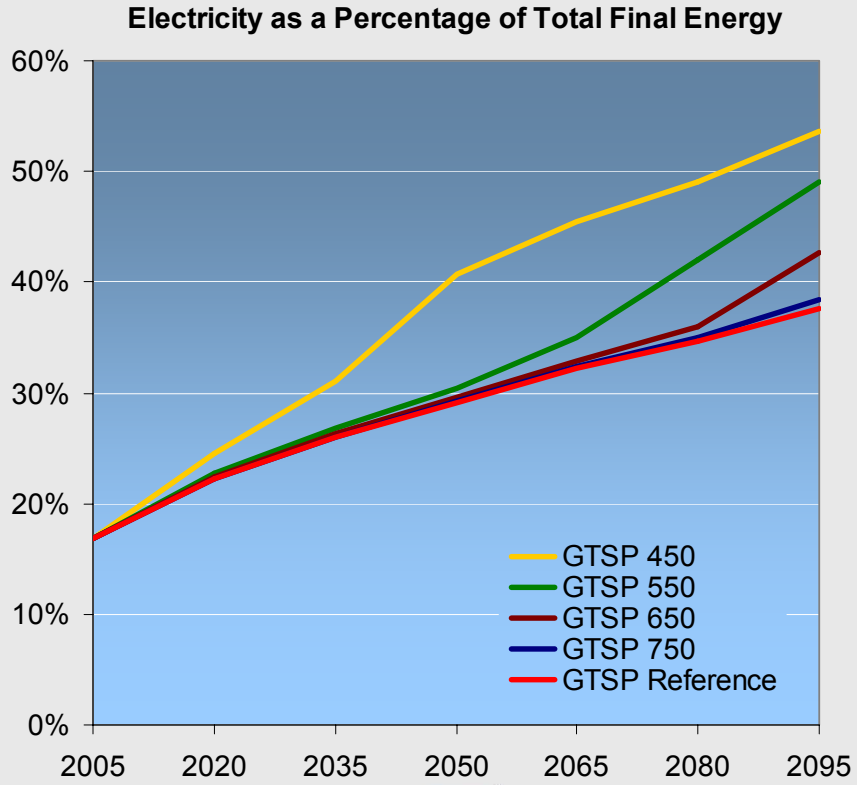
- **Emissions reductions come from two sources**
  - Energy efficiency improvements
  - Fuel substitution

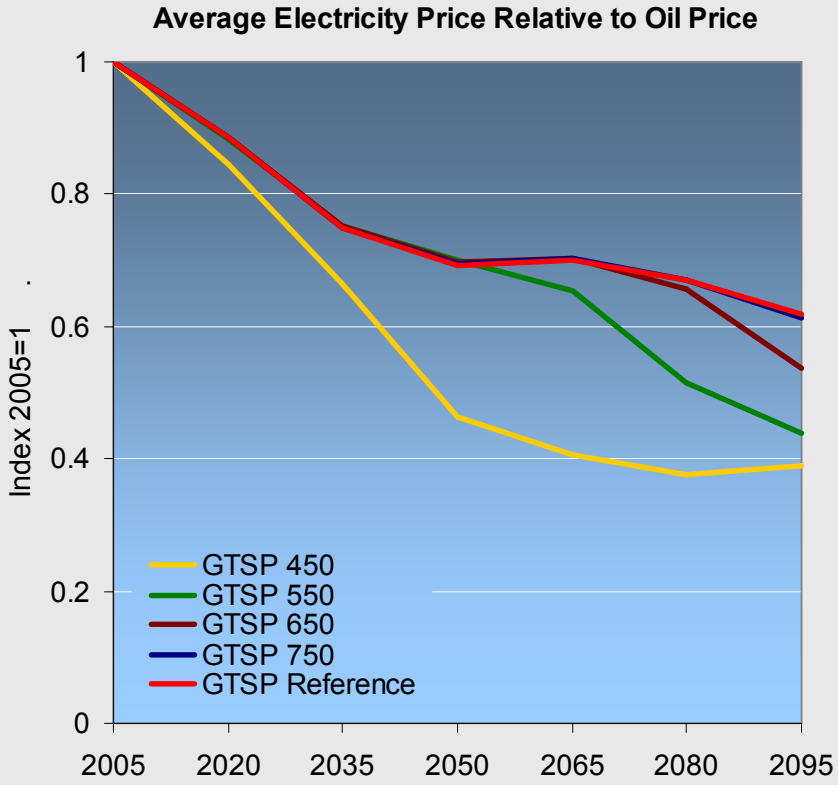




Electrification

- The world is electrifying.
- Emissions mitigation increases the relative role of electricity.
- Electricity prices fall relative to fossil fuel prices.





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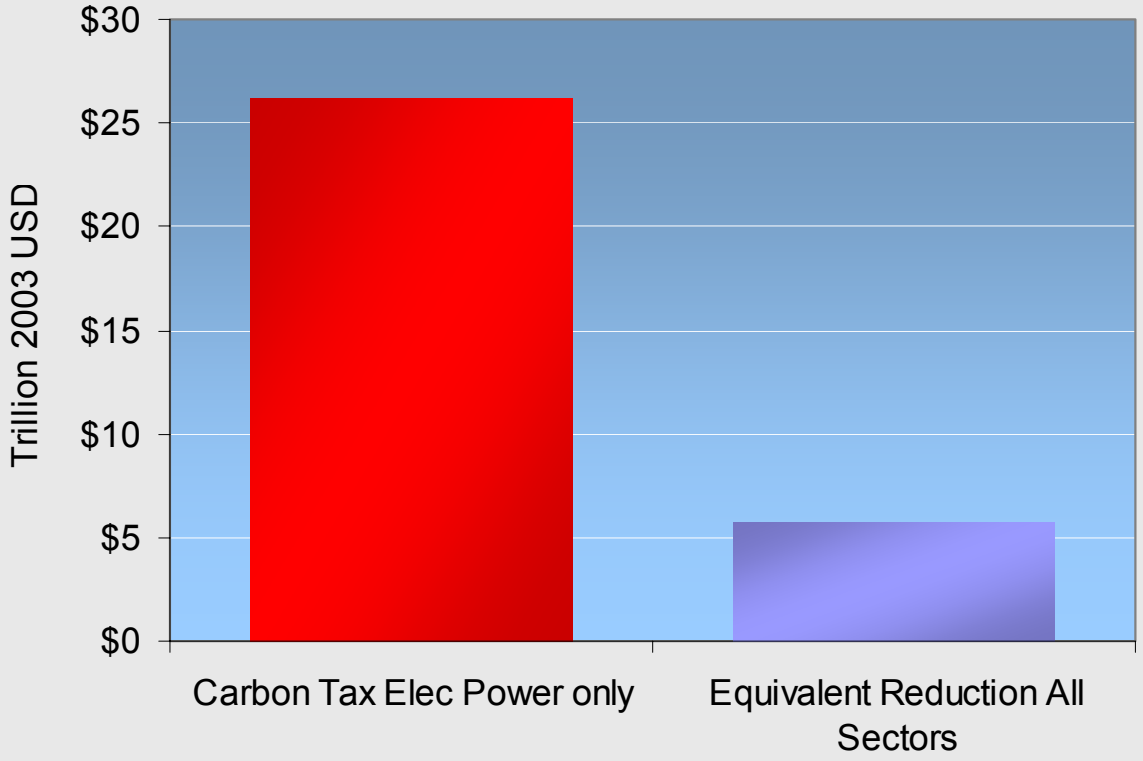
All the Carbon Counts

The economic cost of taxing power generation emissions only



Shortcut to papers & presentations\2005 morita Special Issue--Electrification paper\EPRI_Electricty_Sector_Targeted_Tax2

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The Value of End-use Energy Technology Improvement

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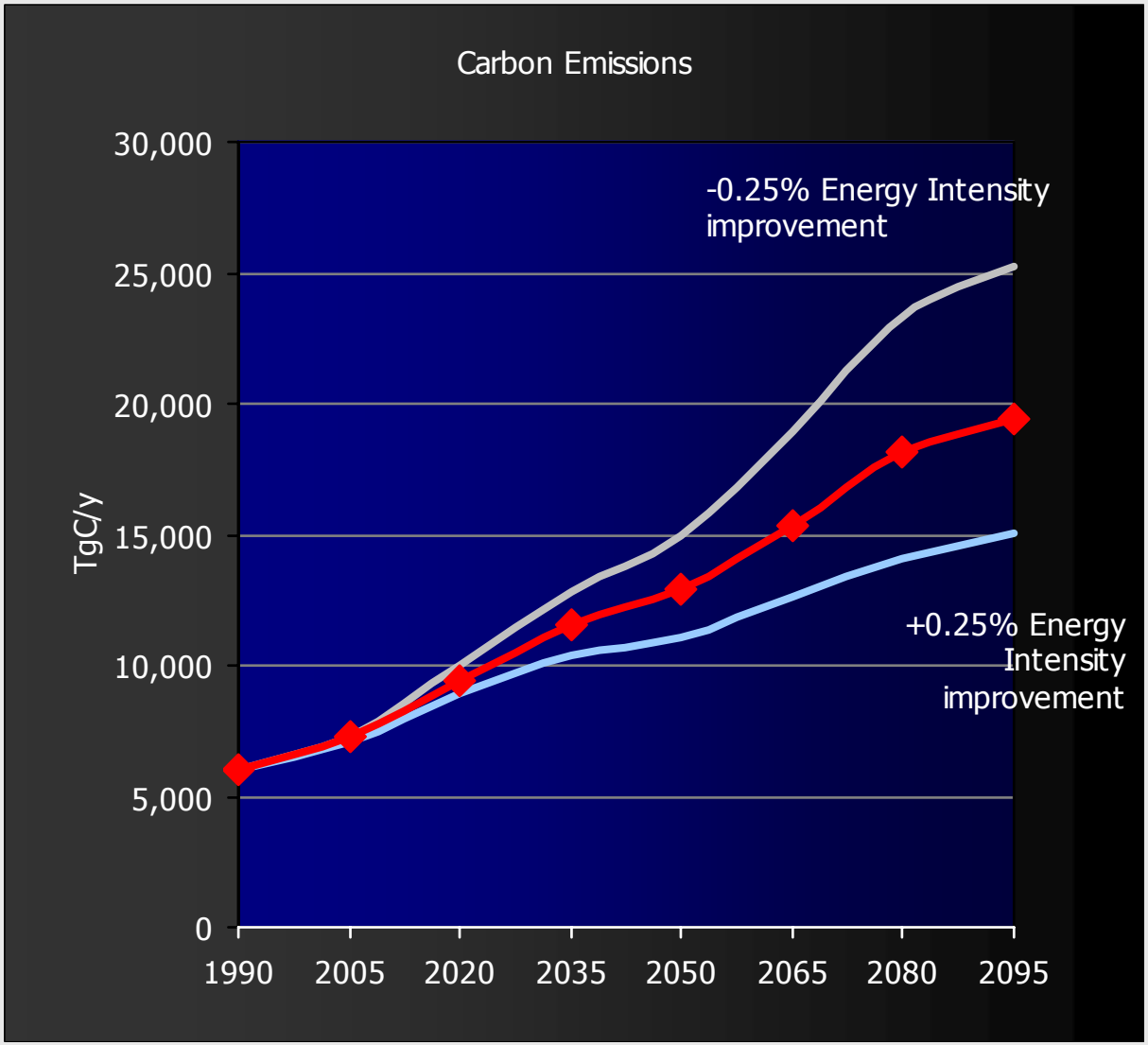
Energy Intensity



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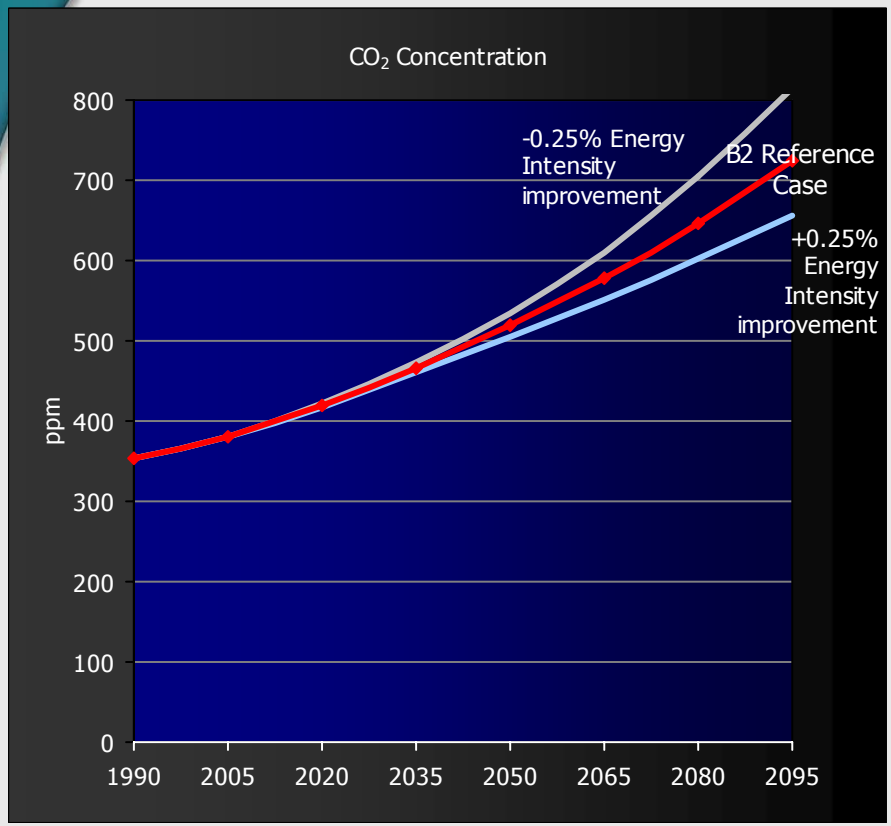
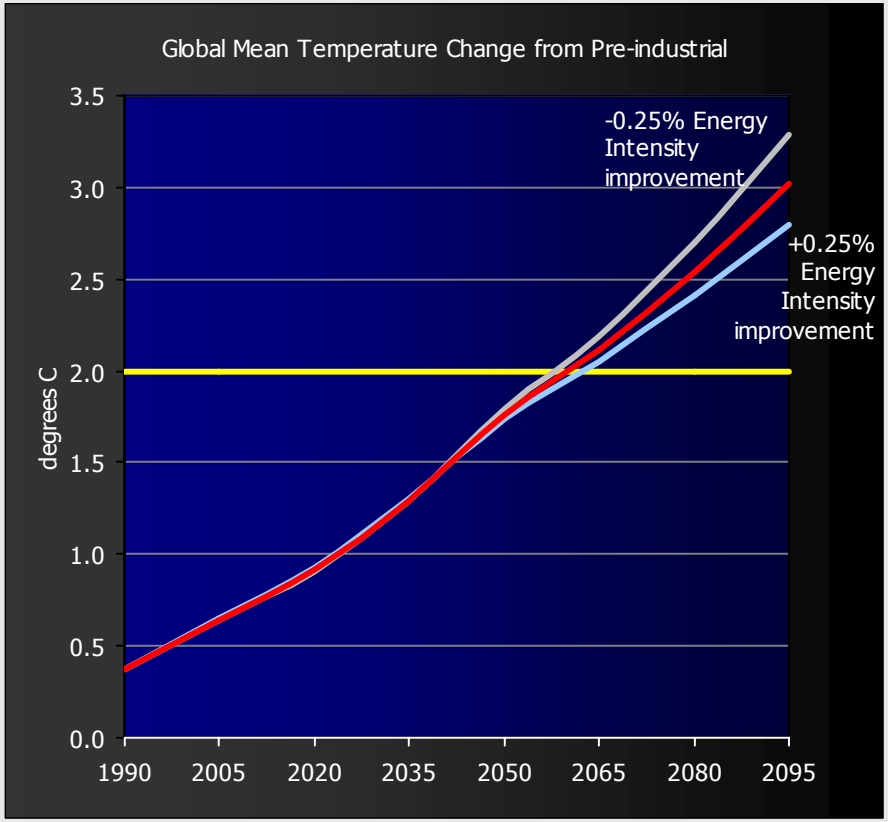
Energy Intensity

Technology Alone Doesn't Stabilize Climate





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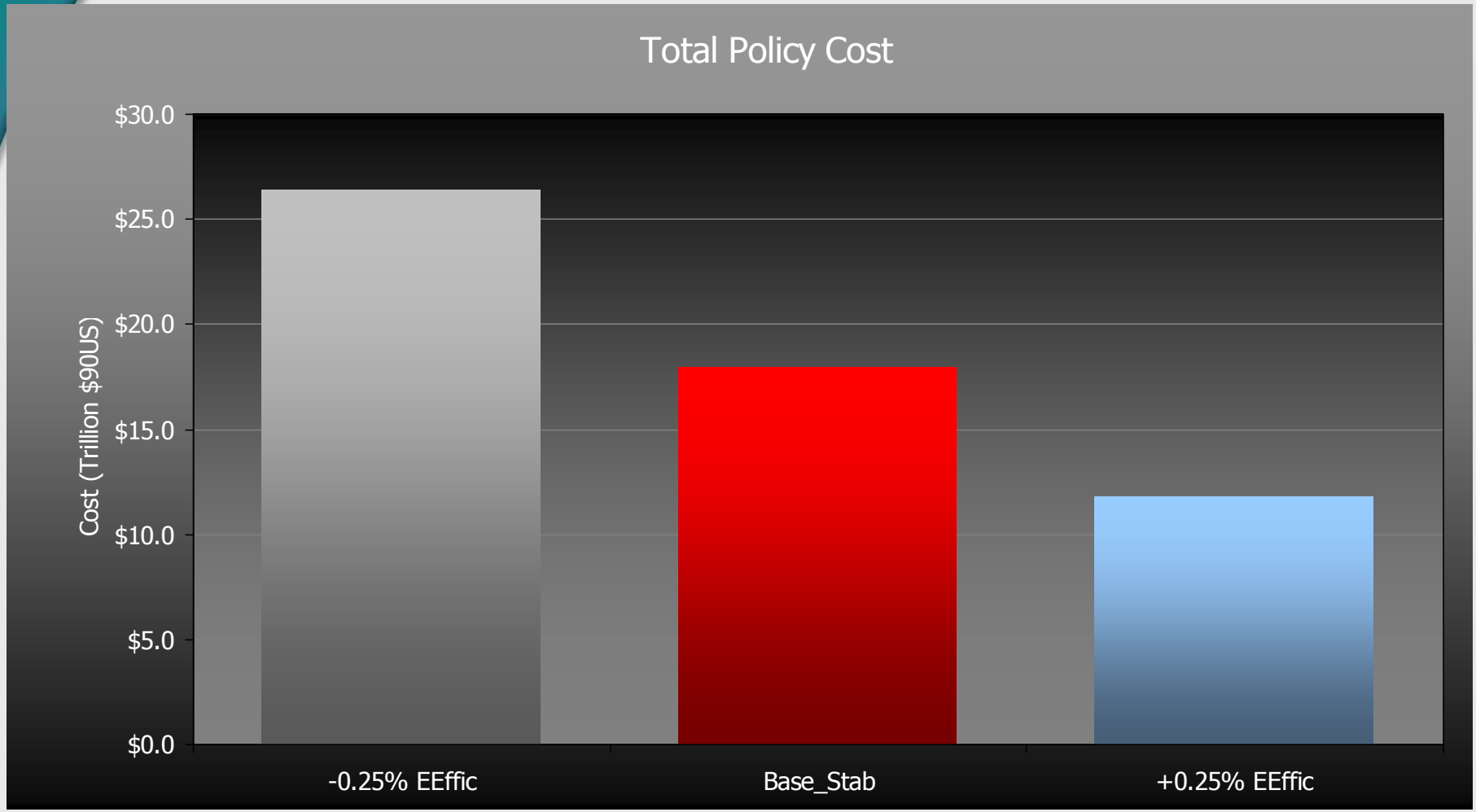
Energy Intensity and Climate Stabilization



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DOE/EERE Advanced Technologies and US Emissions Mitigation

Technology Scenarios

Two scenarios were constructed.

- Reference Case

  Continued technological advance in all end-use sectors. Advances chosen to be at a level that is “likely to occur” with existing policies.

- Advanced Case

  Further technological advances are assumed. Research goals for advanced end-use technologies are met allowing cost effective production and deployment.

In both cases, technology choices was determined by economic competition (using a logit choice model).

Technology Scenarios

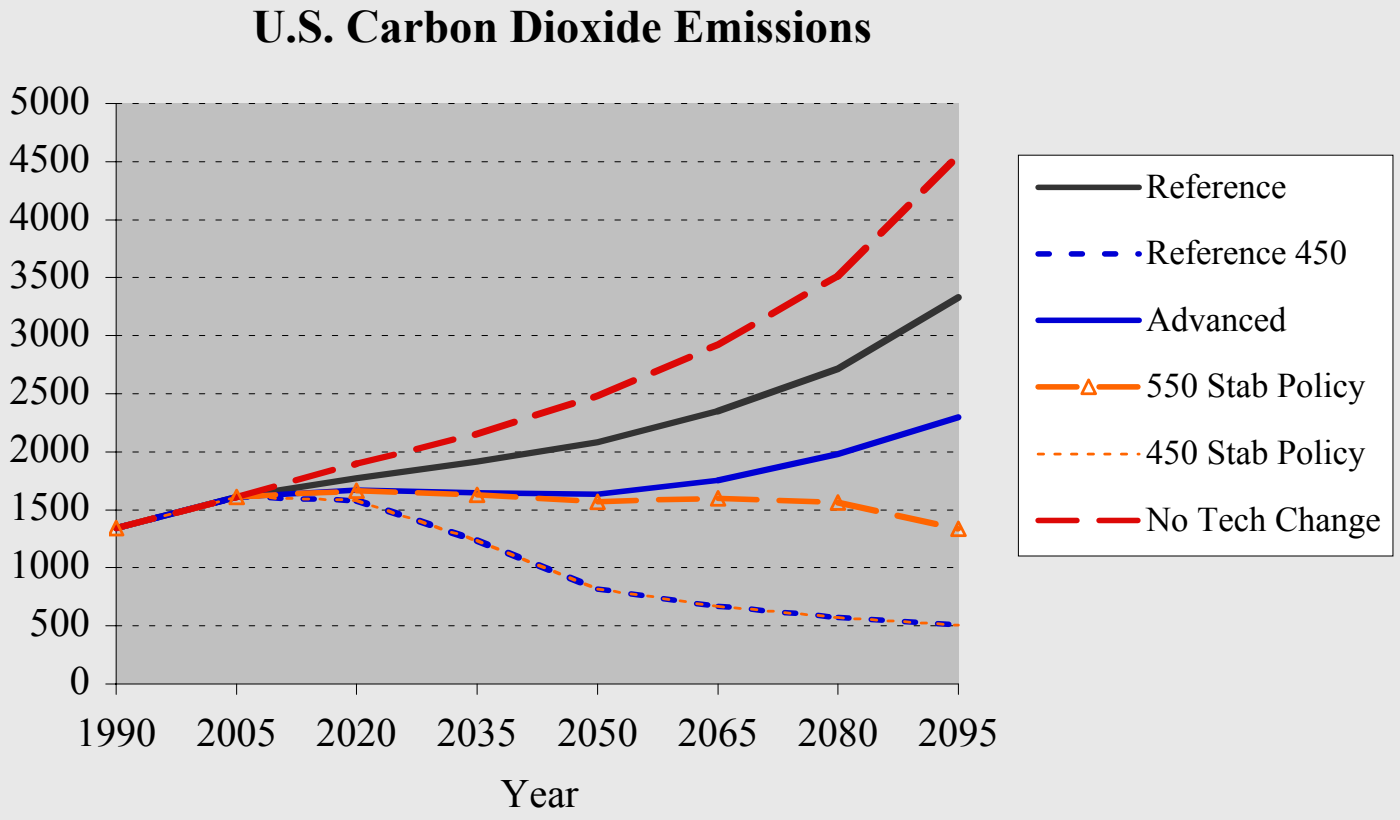
The cost and efficiency of the stock of each end-use technology is specified as a scenario parameter in each year for the reference and advanced cases. For example:

		Reference	Advanced	
Solid State Lighting	2050	122	152	Lumens/W
Solid State Lighting	2095	127	186	Lumens/W
Hybrid Electric Cars	2050	35	58	mpg
Hybrid Electric Cars	2100	39	75	mpg
Industrial Processes	2050	1.05	1.14	-
Industrial Processes	2100	1.09	1.31	-

This provides a "what if" analysis of the impact of these technologies.

Development and demonstration was not modeled.

Carbon Dioxide Emissions

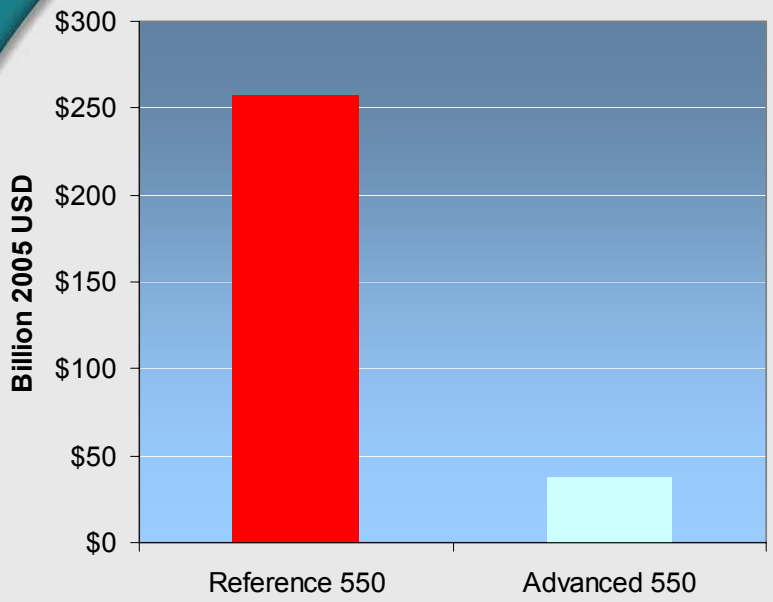


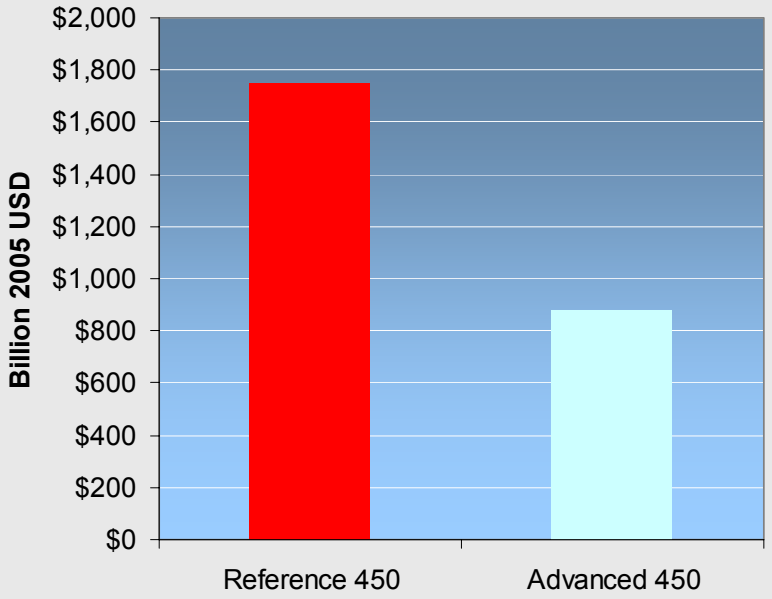
– Without the technological advances embodied in reference case end-use technologies, U.S carbon emissions would be 30% larger by the end of the century.

– Emissions under the advanced scenario increase slowly.

– Even with these advances in end-use efficiency, however, carbon emissions do not fall and atmospheric CO_2 concentration would continue to increase.

Potential Value of End-Use Technology Development





The figures show the total U.S. discounted climate policy cost with reference technology and the case with improved end-use energy efficiency.

The deployment of advanced energy efficiency technologies lowers the cost of achieving a climate policy by 50-85% as compared to the reference case.

The relative value of efficiency is somewhat smaller for more stringent targets. For more stringent targets, emissions reductions are required earlier – which gives efficiency less time to deploy (although the effect of past efficiency policies is still present).

The absolute value is still much larger, however, given the overall higher costs of tighter targets.

*Cost defined as total discounted U.S. carbon payments.

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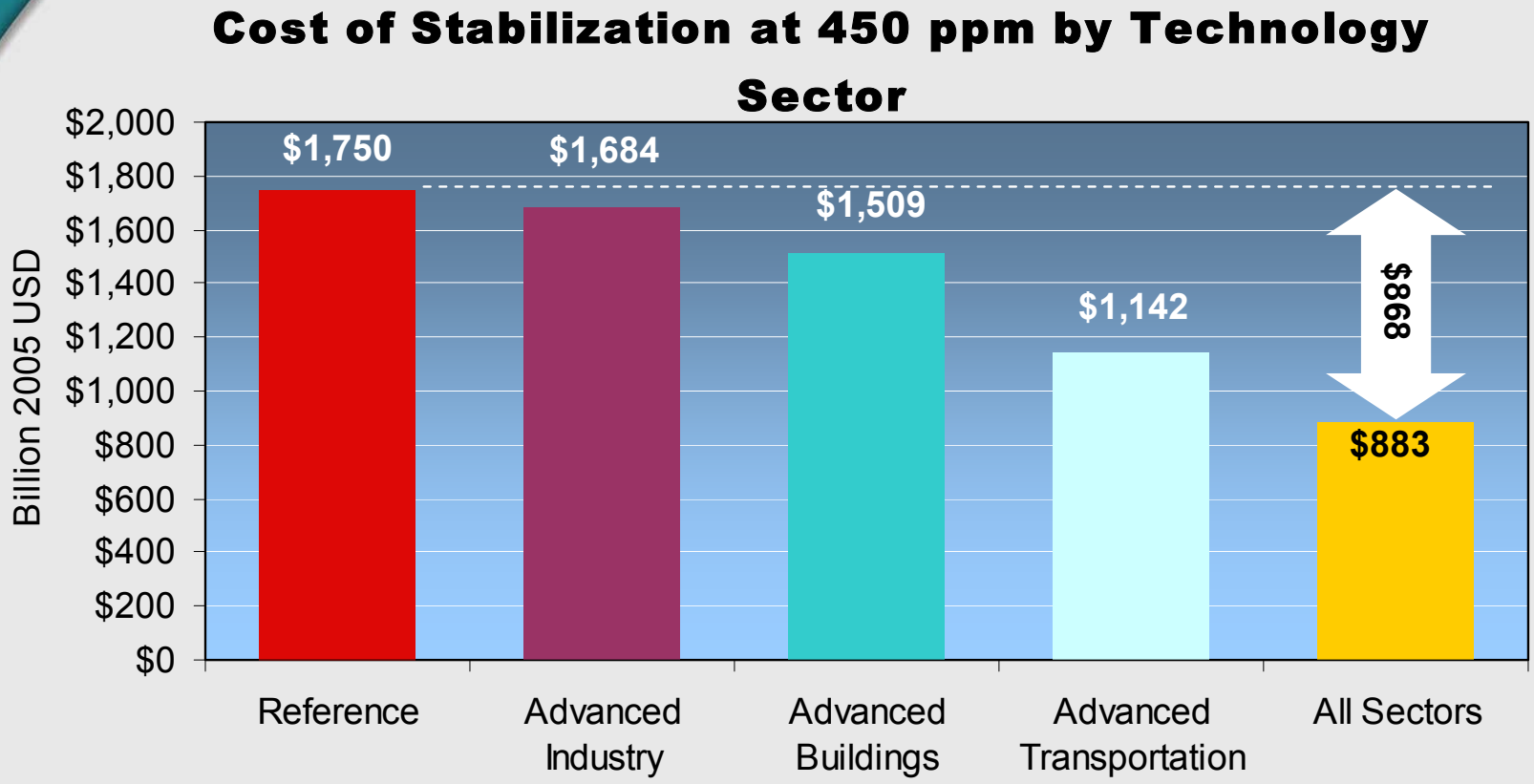
Stabilization Cost by Technology Case and by Sector



– Efficiency improvements in transportation provide the largest value.
– Industry the least (in part due to declining share of US energy consumption).
– At low carbon prices some options are substitutes -- at high carbon prices all efficiency options contribute to policy cost savings.

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One Final Thought

Technology in the Near, Mid, and Long Term

- **The challenge of scale grows exponentially over the century**
- **The role of technology is to help manage the cost of stabilizing greenhouse gas concentrations.**
  - Emissions mitigation starts with the existing suite of technologies.
  - Improving the existing suite of technologies will help to lower the cost of stabilization.
  - In the long term that suite of improving technology options can be augmented by new technology options, some of which do not yet have names. Those technologies will emerge out of near-term investments in basic and applied science across a broad range of research domains.

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Summary

- Climate is a long-term public goods problem, with implications for actions today.
- Stabilizing the concentration of CO_2 means fundamental change to the global energy system.
- End-use energy technologies will play an important role in addressing climate change along with CO_2 capture and storage, Biotechnology, Hydrogen systems, Nuclear energy, and Wind and solar, though none is a “silver bullet.”
- Emissions mitigation will occur both through improved end-use energy efficiency and through fuel substitutions.
- Improving end-use energy technologies will not stabilize climate in the absence of a value on carbon and other GHG emissions.
- Improving end-use energy technology will help make climate stabilization more affordable.

More Information Is Available in the GTSP Report

Hard Copies of the Report are Available upon request

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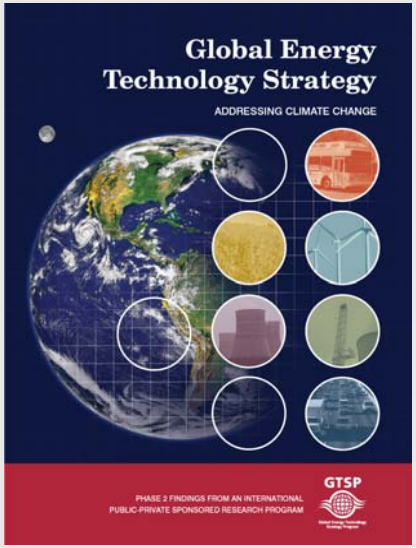
Summarizing Ten Years of Technology Research



And on the Web

http://www.pnl.gov/gtsp

or

http://gtsp.battelle.org

Technology Scenarios: Residential Building Assumptions

	Historical		Reference		Advanced	
Residential Equipment	**1990**	**2005**	**2050**	**2095**	**2050**	**2095**
Shell efficiency (indexed to 2005)	1.03	1.00	0.81	0.63	0.76	0.47
Heating: energy out/energy in						
Gas furnace	0.70	0.82	0.88	0.91	0.88	0.91
Gas heat pump	na	1.30	na	na	1.67	1.90
Electric furnace	0.98	0.98	0.99	0.99	0.99	0.99
Electric heatpump	1.61	2.14	2.49	2.58	2.82	3.02
Fuel oil furnace	0.76	0.82	0.85	0.87	0.85	0.87
Wood furnace	0.52	0.58	0.66	0.68	0.66	0.68
Cooling: energy out/energy in						
Air Conditioning	2.16	2.81	3.76	3.90	4.18	4.47
Water heating: energy out/energy in						
Gas water heater	0.52	0.56	0.80	0.91	0.80	0.91
Gas hp water heater	na	na	na	na	1.53	1.91
Electric resistance water heater	0.84	0.88	0.95	0.96	0.95	0.96
Electric heatpump water heater	na	na	na	na	2.39	2.51
Fuel oil water heater	0.51	0.55	0.56	0.58	0.56	0.58
Lighting: lumens per watt						
Incandescent lighting	15	15	17	18	17	18
Fluorescent lighting	65	75	100	107	100	107
Solid-state lighting	na	na	122	127	152	186
Appliances and other: indexed to 2005						
Gas appliances	0.96	1.00	1.66	1.72	1.66	1.72
Electric appliances	0.70	1.00	1.42	1.47	1.58	1.80
Gas other	0.99	1.00	1.12	1.25	1.12	1.25
Electric other	1.04	1.00	0.98	1.01	1.42	1.47
Fuel oil other	0.99	1.00	1.05	1.09	1.05	1.09

Transportation Technology Assumptions

	Historical		Reference		Advanced	
	1990	2005	2050	2095	2050	2095
Passenger LDV						
ICE Automobile	20.3	22.8	27.1	30.8	38.7	50.7
HEV Automobile	na	29.5	35.1	39.9	58.3	76.4
ICE Light Truck	16.1	18.1	24.4	30.4	30.8	40.3
HEV Light Truck	na	23.0	30.9	38.5	39.0	51.1
Freight Trucking						
Diesel Truck	6.1	5.9	7.0	7.8	9.9	12.4