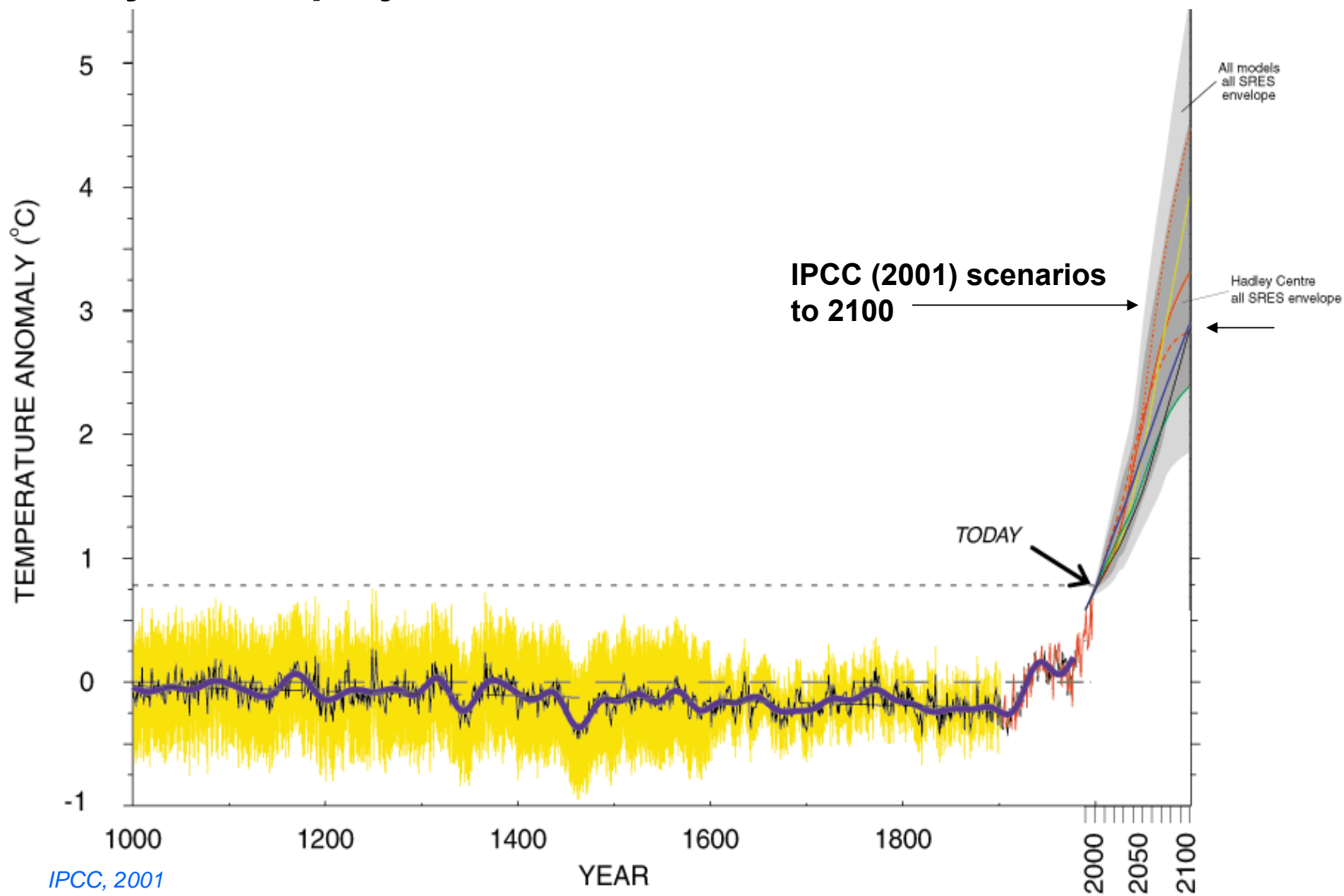


Getting Ahead of the Curve ...
How big is the challenge?

Rosina Bierbaum, Dean and Professor
Corporate Strategies that Address Climate Change
November 10, 2006

1000 years of Earth temperature history...and 100 years of projection



The choices

Facing growing climate-change dangers, we have 3 options:

- Mitigation, which means measures to reduce the pace & magnitude of the changes in global climate being caused by human activities.
- Adaptation, which means measures to reduce the adverse impacts on human well-being resulting from the changes in climate that do occur.
- Suffering the adverse impacts that are not avoided by either mitigation or adaptation.

The choices

Mitigation and adaptation are both essential.

- Human-caused climate change is already occurring.
- Adaptation is already occurring.
- But adaptation becomes costlier and less effective as the magnitude of climate changes grows.
- The greater the amount of mitigation that can be achieved at affordable cost, the smaller the burdens placed on adaptation and the smaller the suffering.

How much mitigation is needed?

(How hard to we need to pull on the levers we've got?)

- The UN Framework Convention on Climate Change of 1992 is “the law of the land” in 188 countries (including the United States).
- It calls for
“stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system”.
- But there was no formal consensus in 1992 as to what constitutes “dangerous anthropogenic interference” or what level of GHG concentrations will produce it.

How much mitigation is needed? (continued)

There's still no consensus, but evidence suggests current level of anthropogenic interference may be dangerous.

- Global average surface temperature (T_{avg}) is $\sim 0.8^{\circ}\text{C}$ above the pre-industrial value.
- The world is already experiencing rising incidence of floods, droughts, wildfires, heat waves, coral bleaching, summer melting of sea ice & permafrost, shrinkage of mountain glaciers, accelerating loss of Greenland and Antarctic ice, drying out of rainforests, and intensification of storms.
- T_{avg} would rise another 0.6°C even if GHG concentrations were stabilized today.

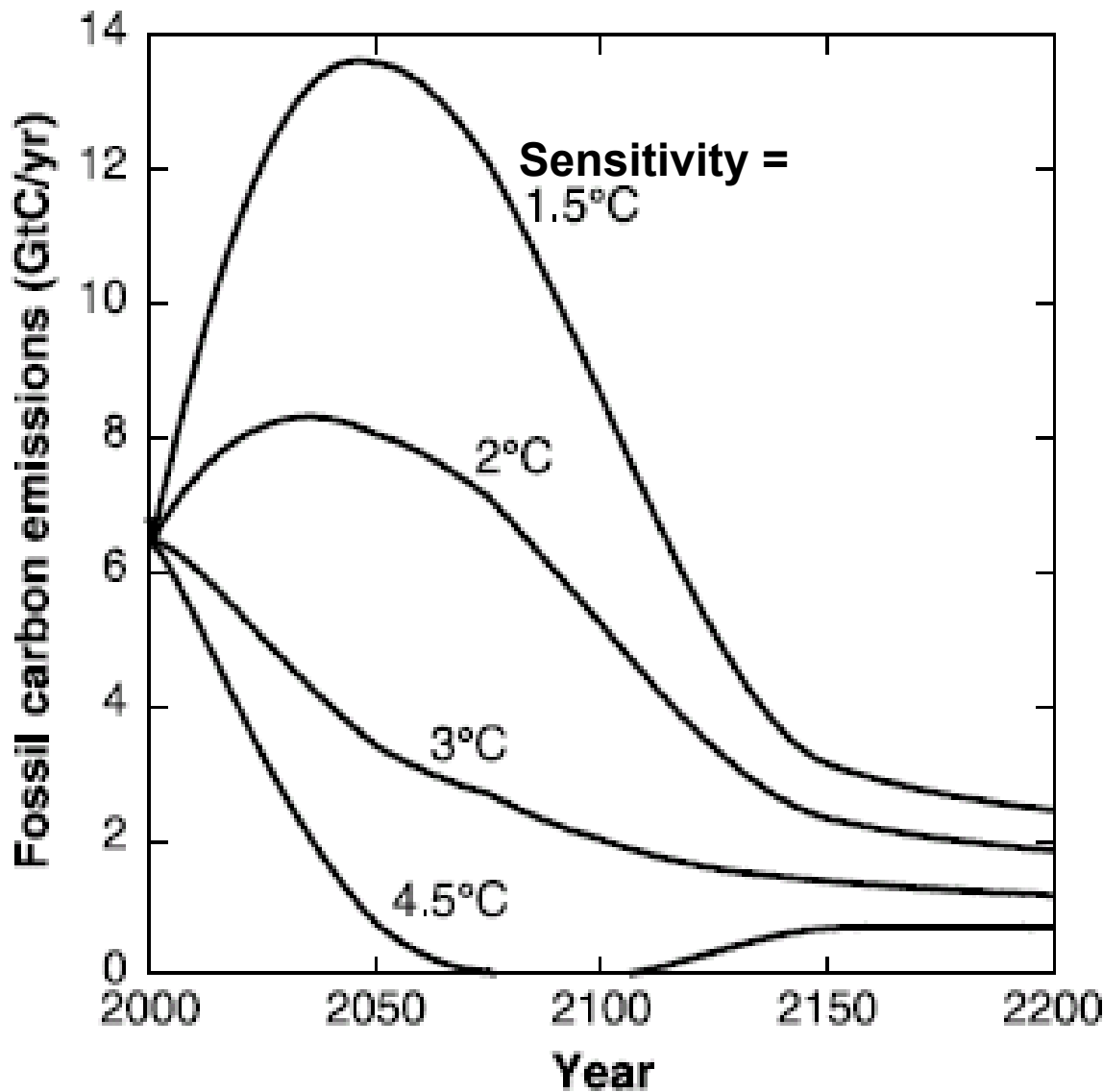
How much mitigation? (continued)

- Under continuation of “business as usual” (BAU) global-average surface temperature above its pre-industrial value (ΔT_{avg}) is likely to reach almost 2°C by 2050 and $\sim 3^{\circ}\text{C}$ by 2100 (possibly much more).
- The best current science indicates that...
 - $\Delta T_{\text{avg}} \sim 1.5^{\circ}\text{C}$ could mean the end of coral reefs & the extinction of polar bears;
 - $\Delta T_{\text{avg}} \sim 2^{\circ}\text{C}$ could mean catastrophic melting of Greenland & Antarctic ice, producing rates of sea-level rise that might reach 3-4 meters per century;
 - $\Delta T_{\text{avg}} \sim 2.5^{\circ}\text{C}$ is likely to sharply reduce crop yields worldwide.

Suitable CO₂ target?

- Thus stopping at 2x pre-industrial CO₂ (550 ppmv, corresponding to ~3°C), once thought a reason-able target by many) may not be good enough.
- Many analysts & groups now conclude that prudence requires aiming not to exceed 2°C (450 ppmv) which many analysts think is VERY tough.

Dependence on climate sensitivity of emissions trajectory for stabilization at CO_2 concentration corresponding to $\Delta T_{avg} = 2^\circ C$

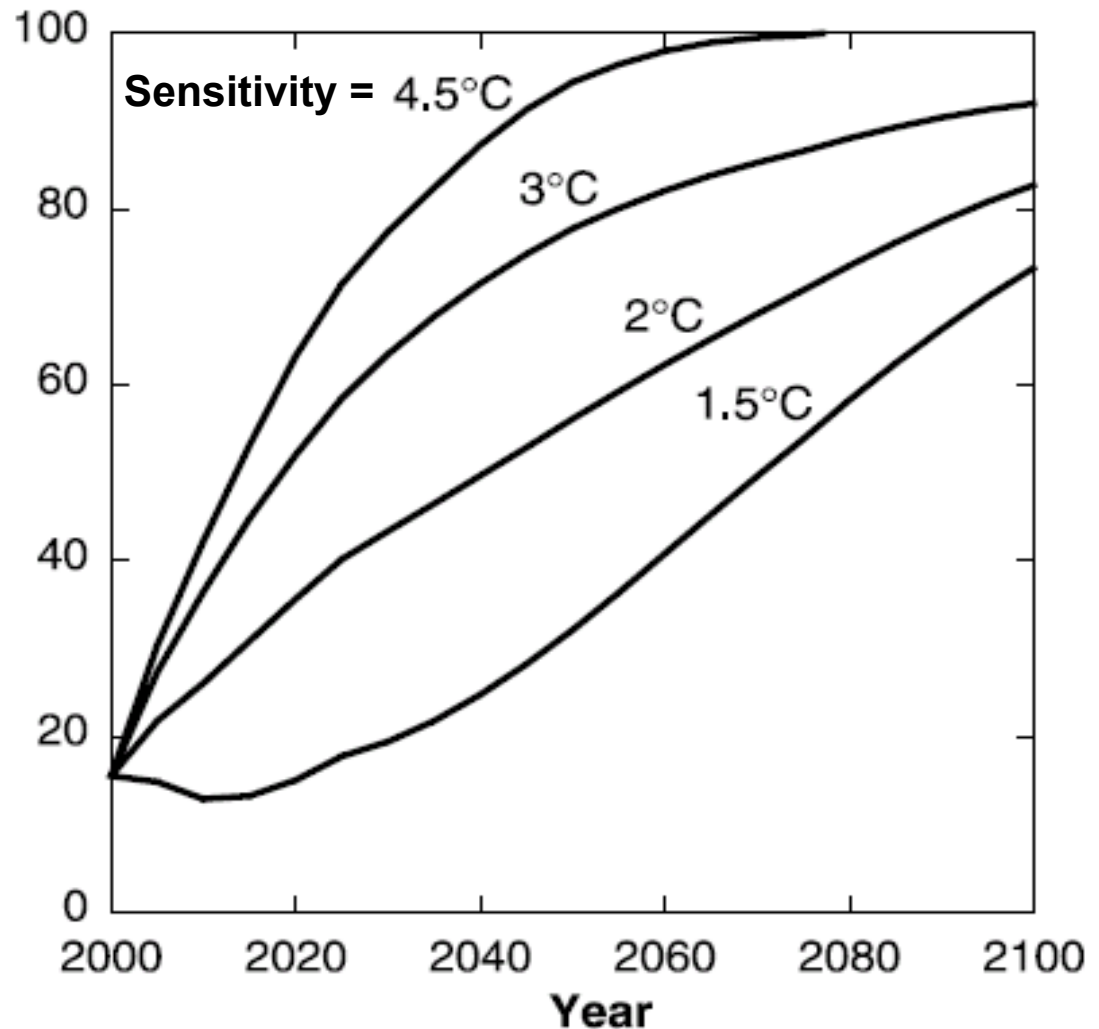


From Caldeira, Jain,
and Hoffert,
SCIENCE, 28 March
2003

Analogous results for the case of stabilization to avoid exceeding $\Delta T_{avg} = 2^{\circ}C$

(and showing effect of different climate sensitivities)

Fraction of total energy supply that must be C-free, versus time, for stabilization at CO_2 concentration corresponding to $\Delta T_{avg} = 2^{\circ}C$



From Caldeira, Jain,
and Hoffert,
SCIENCE, 28 March
2003

Policy for getting there: what's happened so far?

- The Kyoto Protocol
 - a landmark as a negotiated global commitment to move forward to address the problem
 - but limited in time frame, magnitude of required reductions, and participation
- The EU carbon trading system
 - implemented starting in January 2005, embracing 12,000 installations accounting for almost half of EU carbon emissions
 - C trading price reached \$100/tC, but has recently fallen after emergence of a glut of cheap reduction options
- Non-federal jurisdictions in the United States
 - USA has not ratified Kyoto; federal climate policy consists only of research, incentives, and modest "voluntary" targets.
 - But US Senate endorsed mandatory GHG restraints in 6/05;
 - 28 states have climate-action plans, 21 have renewable portfolio standards, 328 cities have embraced Kyoto targets;
 - and many major corporations are acting on their own.

Policy options for promoting mitigation

Measures to affect choices among available technologies

- analysis of and education about the options
- correction of perverse incentives
- lowering bureaucratic barriers
- financing for targeted options
- performance & portfolio standards
- subsidies for targeted options
- emission cap & trade programs
- taxes on carbon or energy

These are listed in order of increasing intrusiveness & political difficulty. But combinations that don't include one of the last two are almost certain to be insufficient.

Measures to improve mix of available technologies

- improving capabilities for RD&D
- encouraging RD&D with tax policy & other policies
- funding the conduct of RD&D
- promoting niche & pre-commercial deployment
- international transfer of resulting technologies

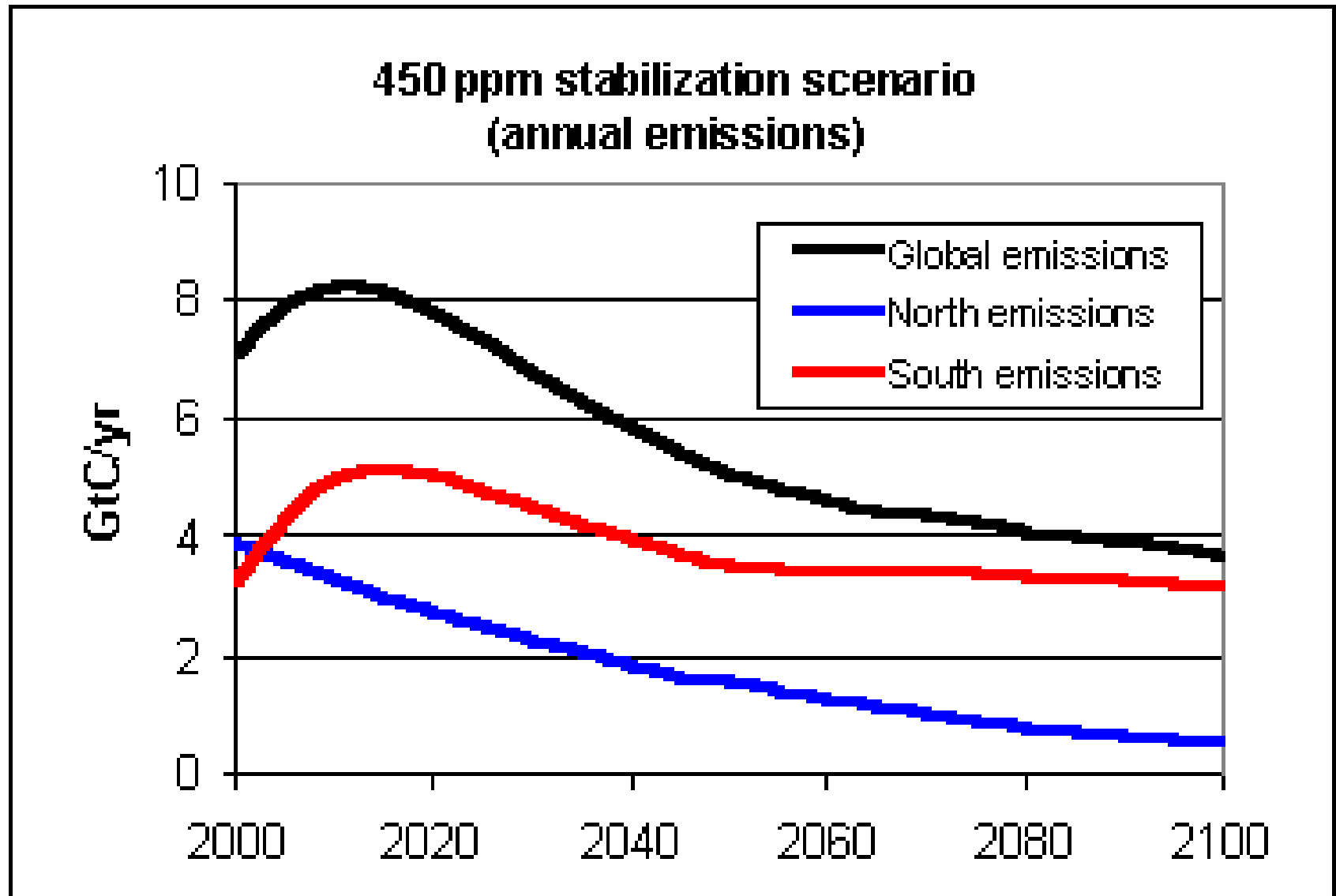
Policy for getting there: what more is needed?

- A mandatory, economy-wide, market-based approach to greenhouse-gas reductions - emissions tax or tradable permits -- in the United States beginning no later than 2010.
- China, India, Brazil, Mexico, other major developing-country emitters to join a global framework of this type no later than 2015.

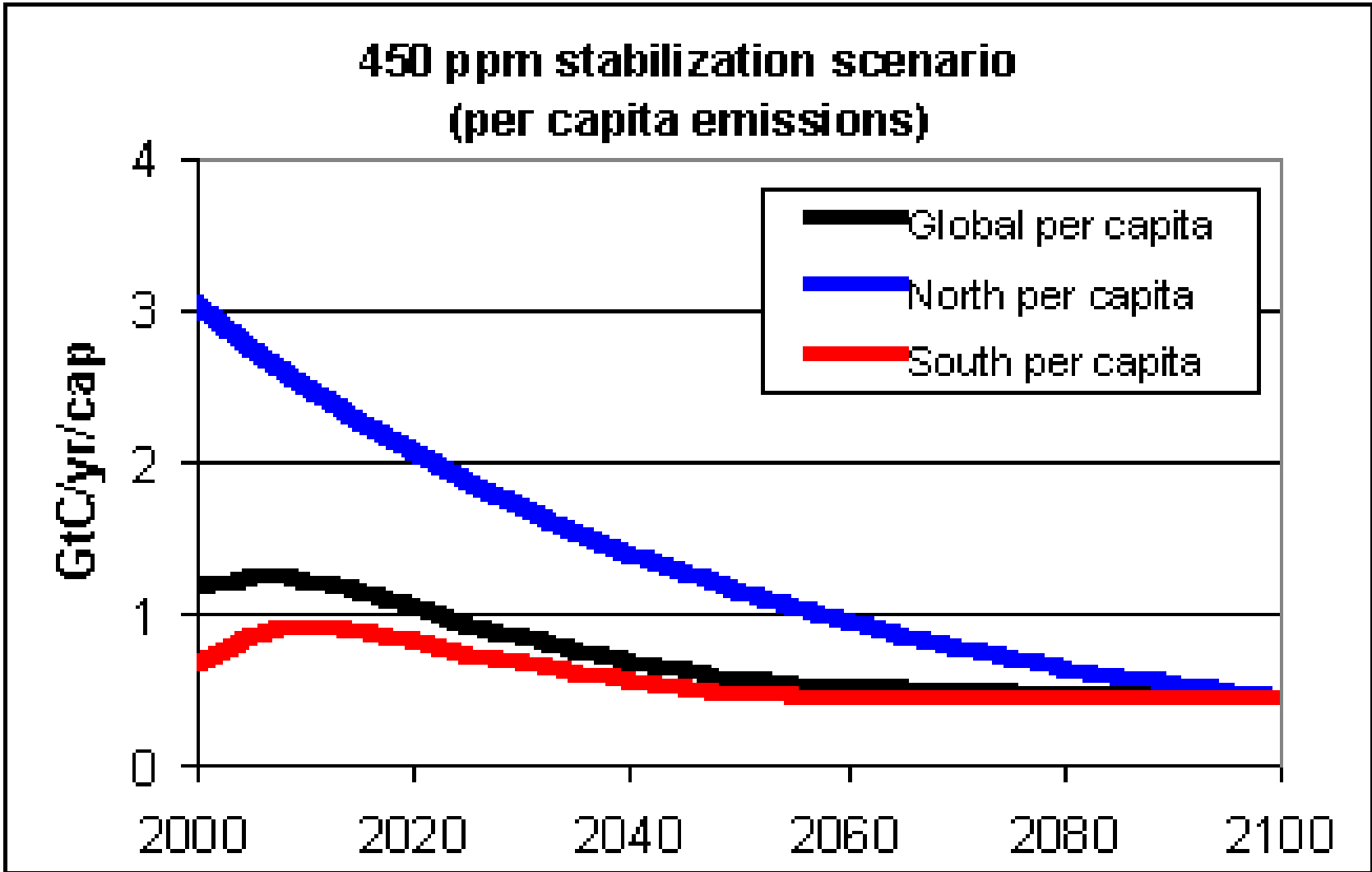
Equivalent worldwide price on carbon emissions (value of permits) will likely need to be ~\$100/tC by 2020 if intolerable increases from deployment of non-CO₂-capturing coal power plants are to be avoided.

Targets and permit allocations in a global system will need to reflect equity / development-rights concerns.

Straw-man disaggregation of 450 ppmv CO₂ stabilization trajectory (corresponding to $\Delta T_{avg} = 2.0^{\circ}\text{C}$ for mid-range sensitivity)



Per capita emissions trajectories for the same case



State of the Union 2006

Keeping America competitive requires affordable energy. And here we have a serious problem: **America is addicted to oil**, which is often imported from unstable parts of the world.

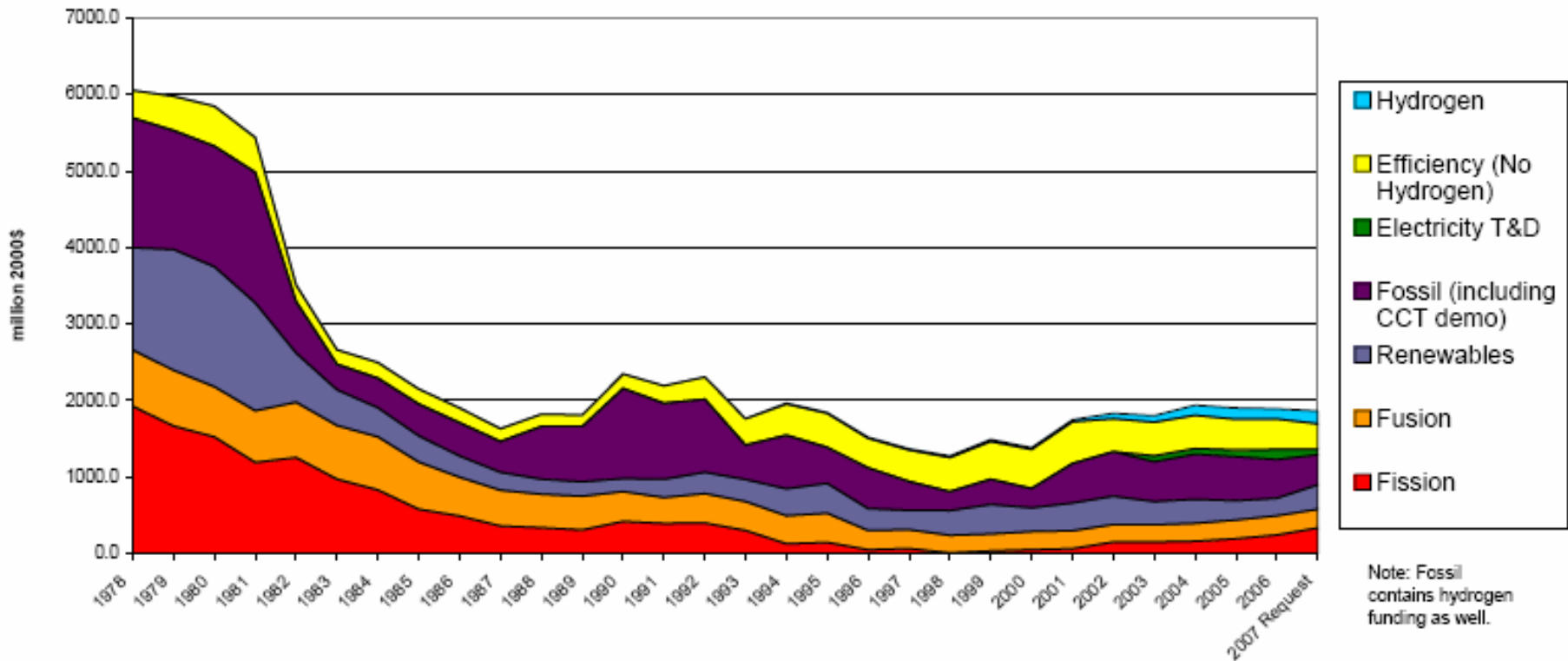
So tonight I announce the Advanced Energy Initiative -- To change how we power our homes and offices, we will invest more in **zero-emission coal-fired plants**; revolutionary solar and wind technologies; and clean, safe nuclear energy.

We must also **change how we power our automobiles**. We will increase our research in better batteries for hybrid and electric cars and in pollution-free cars that run on hydrogen. We will also fund additional research in cutting-edge methods of producing ethanol, not just from corn but from wood chips and stalks or switch grass. Our goal is to make this new kind of ethanol practical and competitive within six years.

Breakthroughs on this and other new technologies will help us reach another great goal: **to replace more than 75 percent of our oil imports from the Middle East by 2025**.

Separating out Hydrogen Reduces Efficiency

U.S. DOE Energy RD&D
1978-FY2007 Admin. Request



Change from FY06 to FY07: Administration Request in Broad Categories (million 2000\$)

| <u>Category</u> | FY06 | FY07 Request | % change |
|-------------------------|-------|--------------|----------|
| Renewable energy | 228.2 | 319.4 | +40% |
| Fission | 241.9 | 331.7 | +37% |
| Efficiency | 533.6 | 500.2 | -6% |
| Fusion | 253.2 | 247.7 | -2% |
| Non-hydrogen efficiency | 398.0 | 333.2 | -16% |
| Fossil | 505.6 | 391.7 | -23% |
| Electricity T&D | 130.4 | 70.9 | -46% |

Changes in the House of Representatives

Energy and Commerce:

John Dingell of Michigan (*outgoing: Joe Barton of Texas*)

Agenda is to free the U.S. from "dependence on foreign oil & create a cleaner environment with initiatives for energy-efficient technologies & domestic alternatives such as biofuels."

- a Nat'l Energy Security Commission
- a New Manhattan [Project] Center for High Efficiency Vehicles

Resources:

Nick Rahall of W.Va. (*outgoing: Richard Pombo of California*)

The committee is expected to address climate change in greater detail...

Science:

Bart Gordon of Tenn. (*outgoing: Sherwood Boehlert of N.Y.*)

Gordon has introduced legislation to address the concerns raised in the "Rising Above the Gathering Storm" report; includes plans to create an ARPA-E focused on cutting edge energy research)

Changes in the US Senate

Energy and Natural Resources:

Jeff Bingaman of New Mexico (*outgoing: Pete Domenici of New Mexico*)

Bingaman is expected to push a bipartisan plan requiring the government to reduce its petroleum consumption by 20% in 5 years and 40% in 2020. It would also set goals that 10% of gas stations offer alternative fuels by 2015 and that 25 % of new vehicles sold in the U.S. by 2010 be equipped with flexible fuel technology.

May conduct oversight hearings on the FTC, centering on the way the Commission is addressing allegations of gasoline price gouging.

Environment and Public Works:

Barbara Boxer of California (*outgoing: James Inhofe of Oklahoma.*)

Boxer has supported tough mandatory curbs of industrial carbon dioxide emissions.
Return of scientists to testify on science?

Changing Landscape

- **Sense of the Senate Resolution**
 - (to be followed by real legislation?)
- **Pressure coming from**
 - Cities
 - States
 - Drumbeat of science
 - New voices: Evangelicals
 - Mainstream corporate America
 - International
 - The election?

