



Stanford University

Global Climate & Energy Project

November 29-30, 2007

Introduction to GCEP and Scope of Workshop

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GCEP Fission Energy Workshop



The Need for Technology

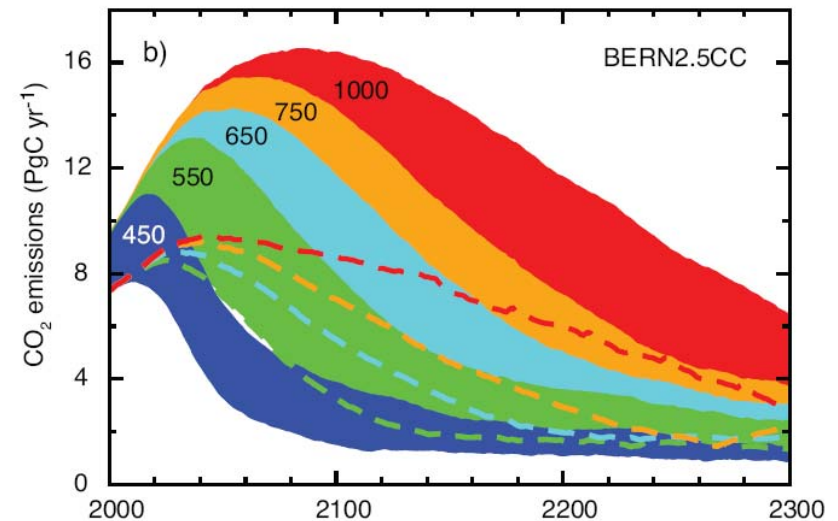
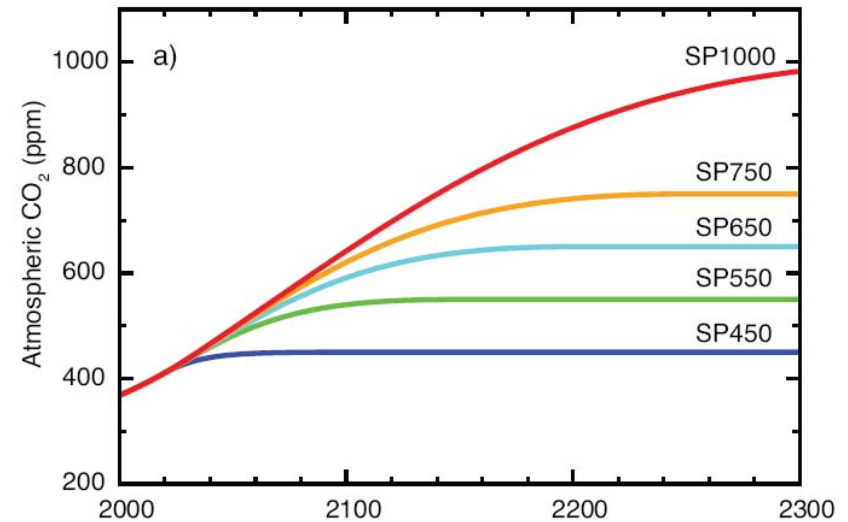


Concentrations of CO₂ will rise above current values (380 ppm), even under the most optimistic scenarios.

Stabilization will require that emissions peak and then decline. Peak timing depends on the stabilized concentration.

Improvements in efficiency, introduction of renewables, nuclear power, CCS, ... all help.

New technology options will be needed for the really deep reductions.



Source: IPCC 2007



Stabilizing Atmospheric CO₂



Stabilization Level (ppm)	Global Mean Temp Increase (°C)	Year Global CO ₂ Needs to peak	Year CO ₂ Emissions Return to 2000 Levels	Reduction in 2050 CO ₂ Emissions Compared to 2000
445-490	2.0-2.4	2000-2015	2000-2030	-85 to -50
490-535	2.4-2.8	2000-2020	2000-2040	-60 to -30
535-590	2.8-3.2	2010-2030	2020-2060	-30 to +5
590-710	3.2-4.0	2020-2060	2050-2100	+10 to +60
710-855	4.0-4.9	2050-2080		+25 to +85
855-1130	4.9-6.1	2060-2090		+90 to +140

Source: IPCC 2007, Working Group III



The Oceans in a High CO₂ World



The oceans have taken up ~400 Gt of fossil fuel CO₂. Global surface oceans now remove 20-25 Mt CO₂/day.

Decline in pH (0.1 since industrial revolution) affects bicarbonate, carbonate ion concentrations, rates of fixation of CaCO₃ by assorted critters in the trophic chain, potential for feedbacks with temperature change.

Source: Oceanography Vol.17, No.3, Sept. 2004

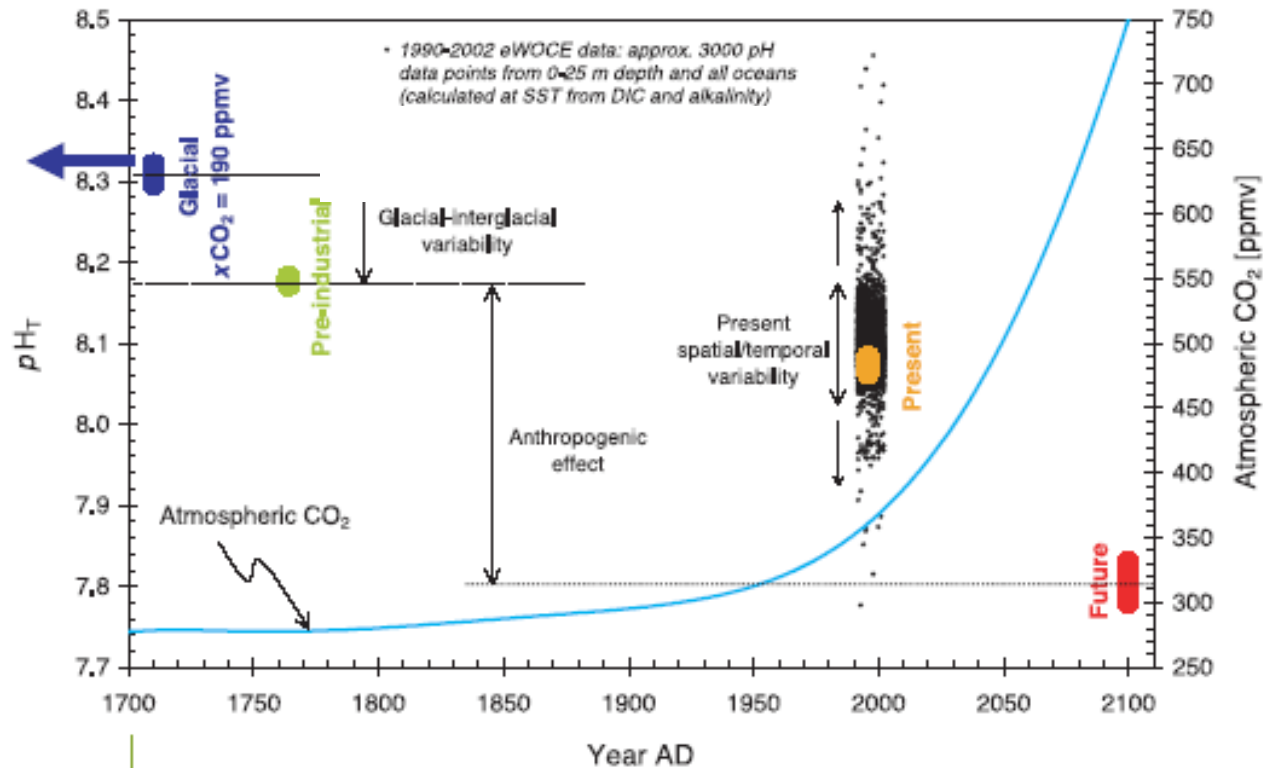


Figure 2. Present (1990-2002) surface seawater pH_T values from all oceans (3000 data points from the upper 25 m, pH_T were calculated from measured dissolved inorganic carbon and alkalinity). The majority of the data fall into a rather narrow pH range of 8.1 ± 0.1. Also shown



The Global Climate and Energy Project



Goals

- Fundamental and pre-commercial research
- Novel technology options for energy conversion and utilization
- Impact in the 10-50 year timeframe

Strategy

- Step-out research: revisit the fundamentals and explore new approaches
- High risk / high reward

Budget

- \$225M commitment

Participants

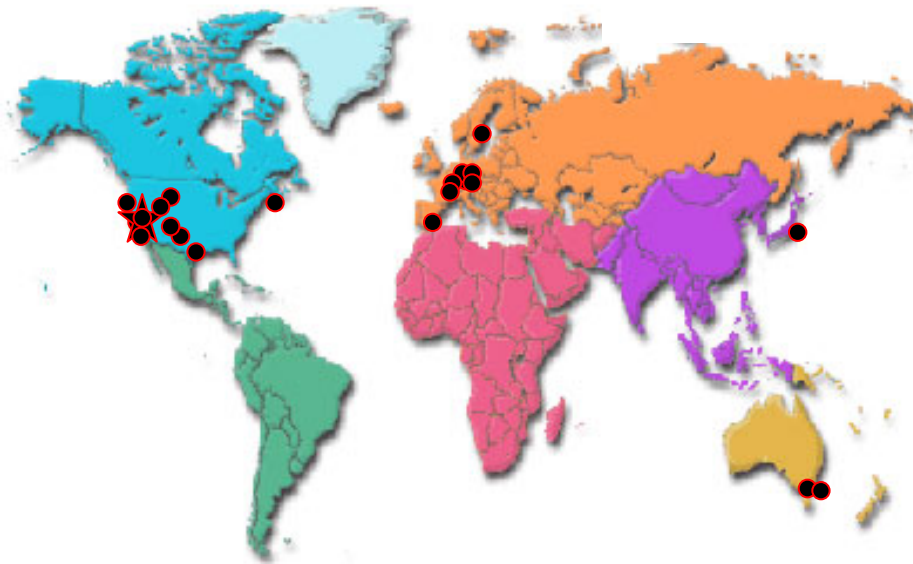
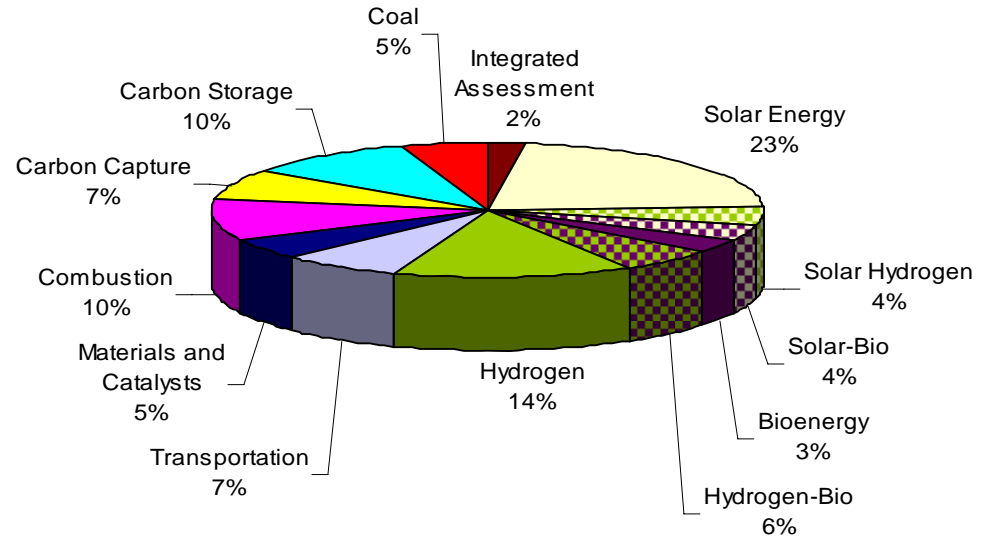
- Industrial sponsors
- Academic institutions - Stanford and an increasing number of other universities worldwide



Project Status



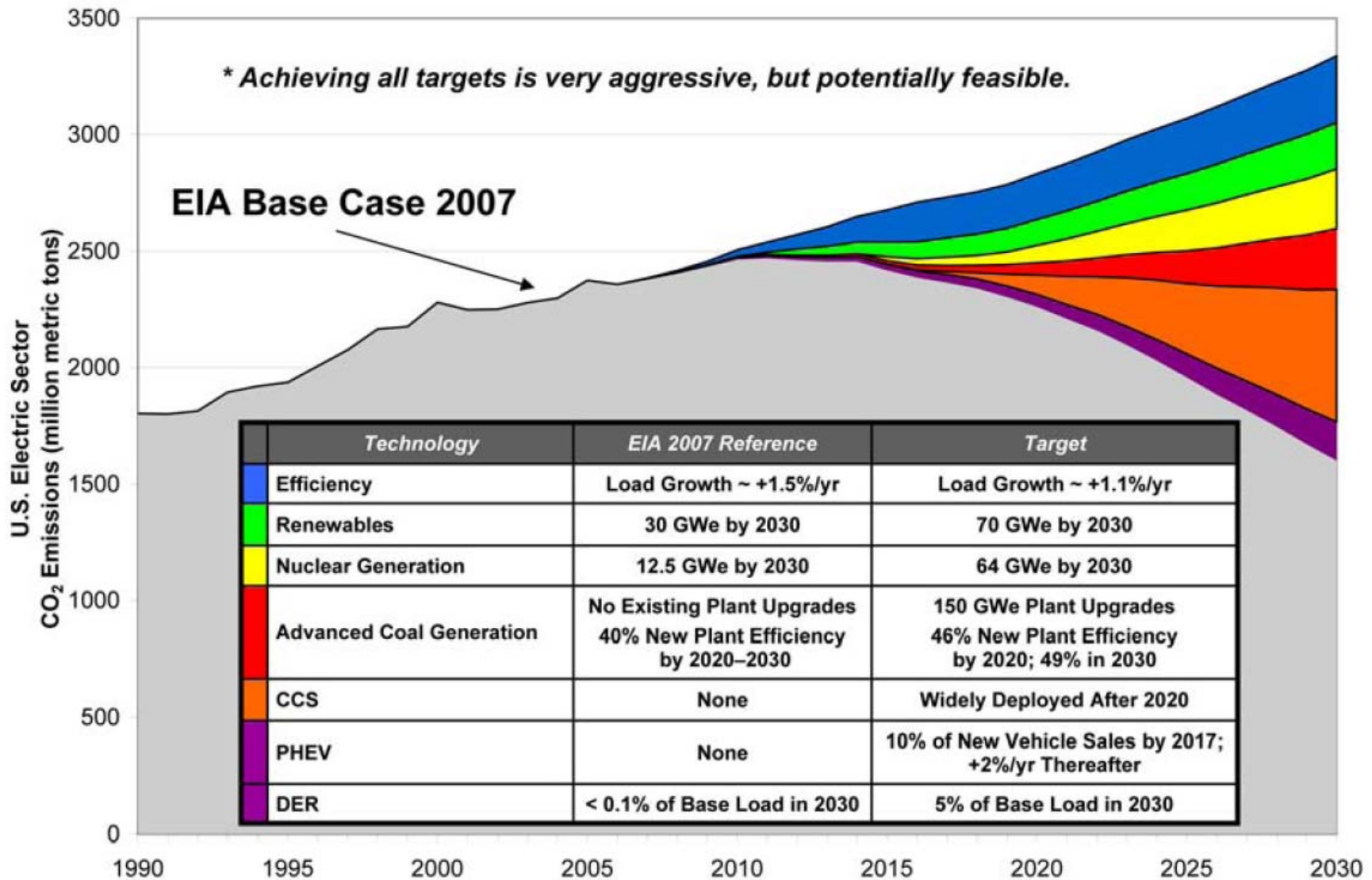
- \$72.1M committed
- 47 3-year projects
- 69 investigators
- 20 institutions



Participating Institutions



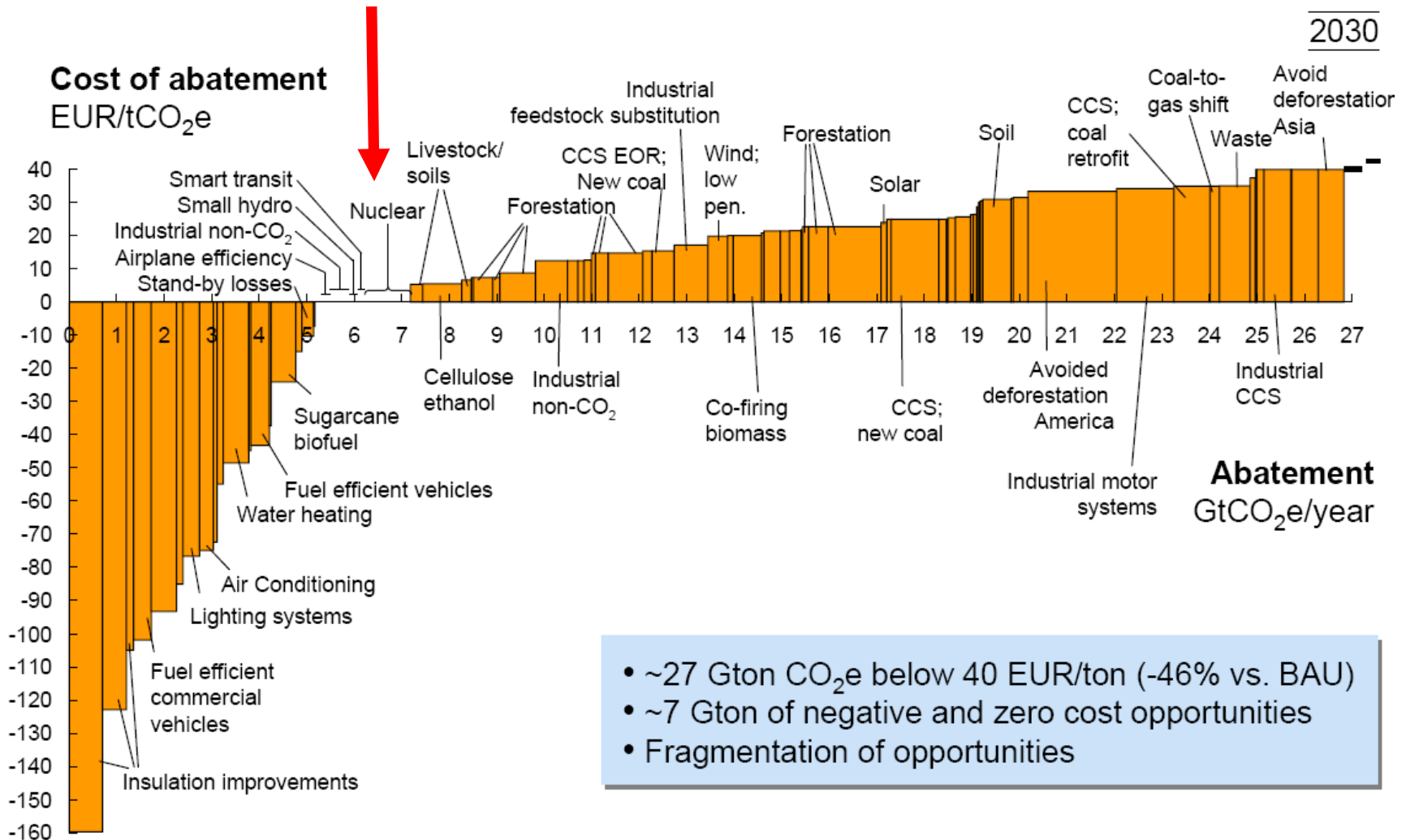
How do we change this? One transition pathway (EPRI)



Source: EPRI, The Power to Reduce CO₂ Emissions, 2007



Supply Curve for CO₂ Emission Reductions





Questions for the Workshop



- What alternative approaches have the potential to increase the efficiency, safety, security, and sustainability of fission energy ?
- What scientific breakthroughs are still required to overcome scientific and technical barriers to the deployment of fission power at the necessary scale ?
- What are the opportunities for fundamental research for overcoming these barriers ?
- How can GCEP, with its objectives and its relatively modest research project budgets, create additional options that would have a significant impact ?



Workshop Topics



Day 1

- Opportunities and Challenges for Fission Energy
- Design Innovation in Reactor Technology
- Advanced Materials for Nuclear Fission – Challenges and Research Needs

Day 2

- Closing the Fuel Cycle
- Waste Management



Thank You!



Mujid Kazimi, Pavel Hejzlar, and CANES

- for all the useful discussions and your help with the organization of this meeting at MIT

Paolo Bosshard

- for the technical organization of the workshop

Carolyn Carrington

- for organizing everything else

Our Sponsors (ExxonMobil, GE, Schlumberger, Toyota)

- for making this project possible

Our Speakers

- for sharing your time, expertise, and opinions with us

The Energy Community

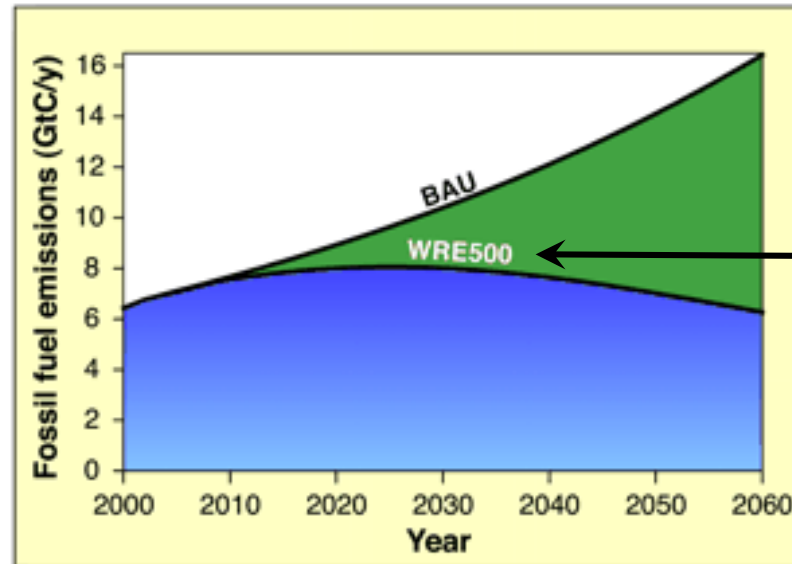
- for taking time to participate in our discussions



How Can the Atmospheric Carbon Concentration Be Stabilized?



Carbon Emission Rate



~ 2x pre-industrial concentration

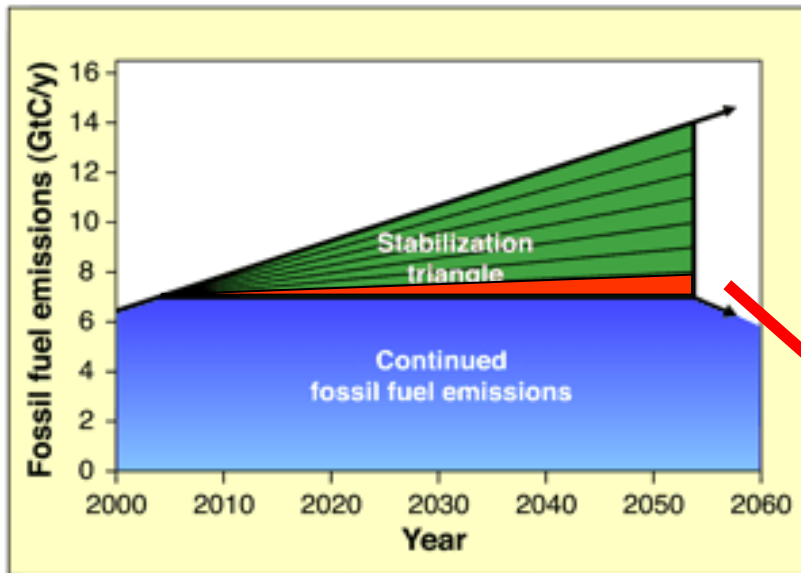
	2000 (380 ppm)	2050 (550 ppm)
Resources		
Fossil	11 TW	12 TW
Carbon-free	3 TW	15 TW



What Can Be Done with Existing Technologies?



The analysis by Pacala and Socolow : the *emission stabilization wedges*



Science vol. 305, Aug. 2004

Wedges corresponding to 7 strategies for reducing carbon emissions by 1 billion tons per year (1GtC/yr)

Existing Technologies

- Energy savings
- Higher efficiency
- Carbon sequestration
- Renewables
- Nuclear

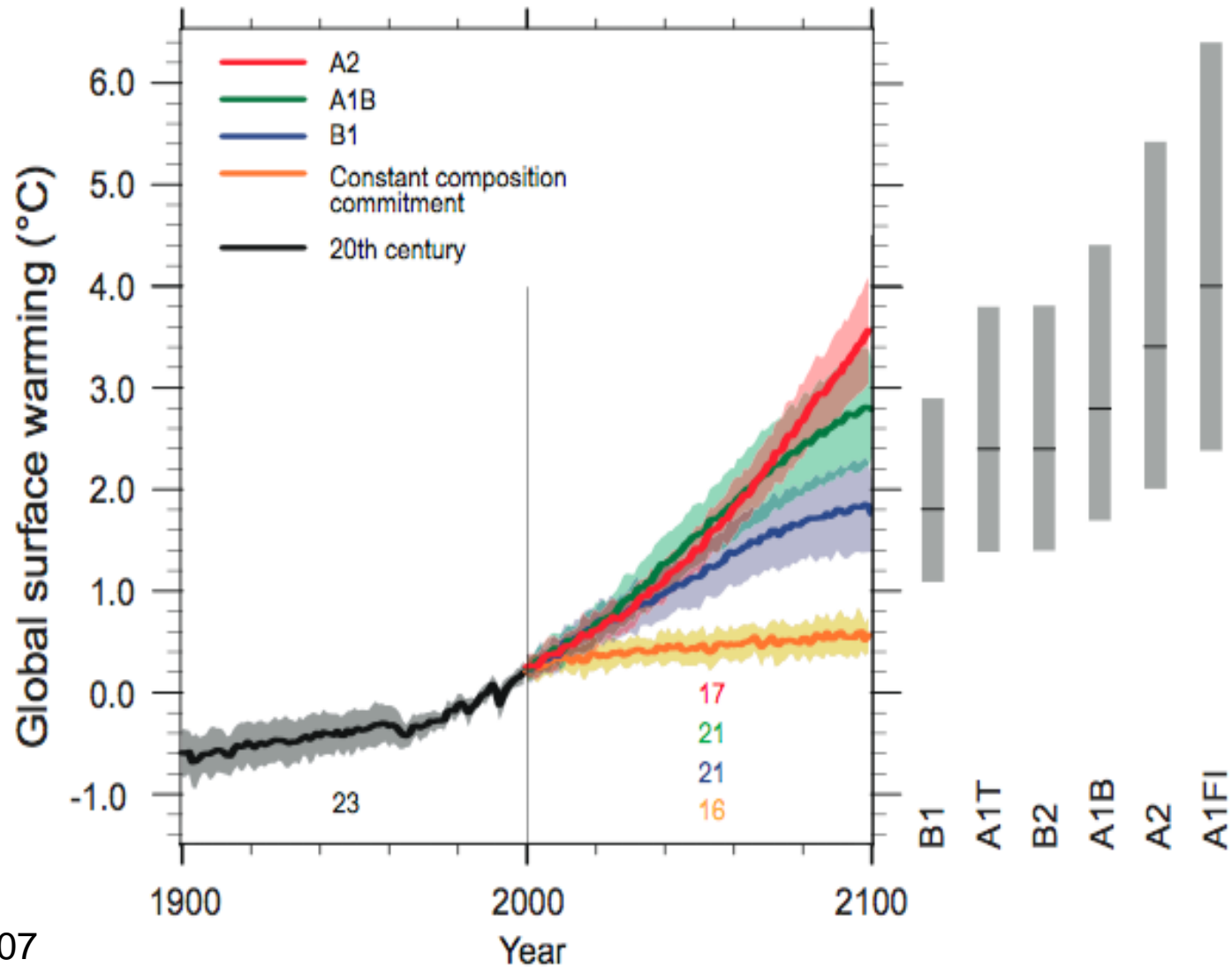
Nuclear:

Triple today's nuclear power output displacing coal

- Can this goal be achieved with existing technologies?
- Is this target sufficiently aggressive?¹³



Predicted Global Average Temperature



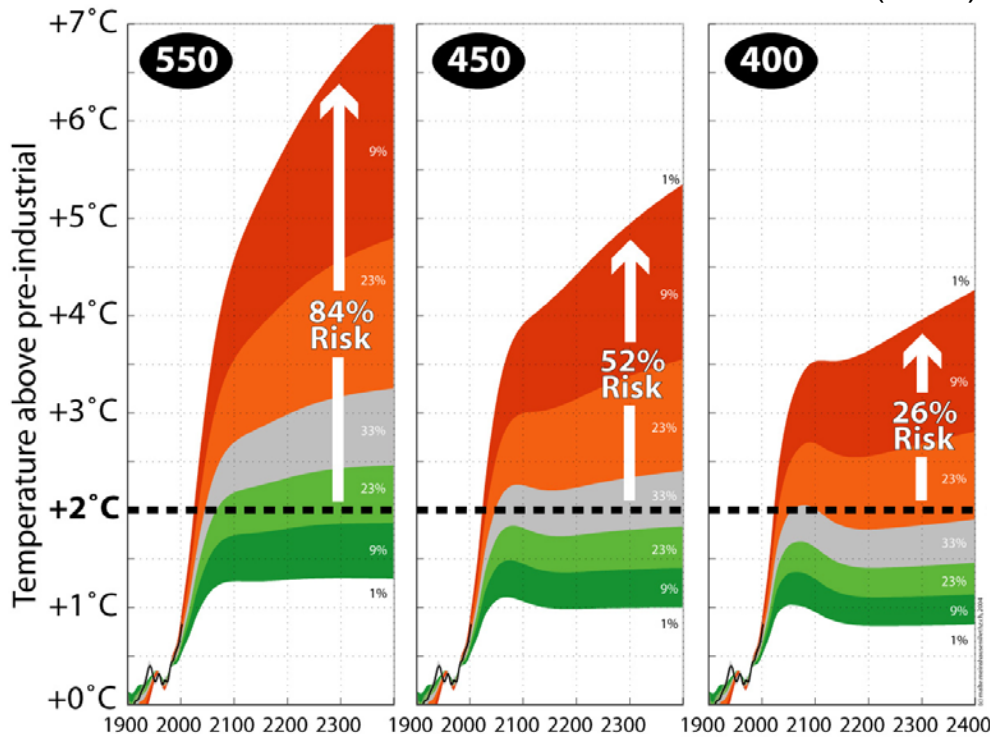
Source: IPCC, 2007



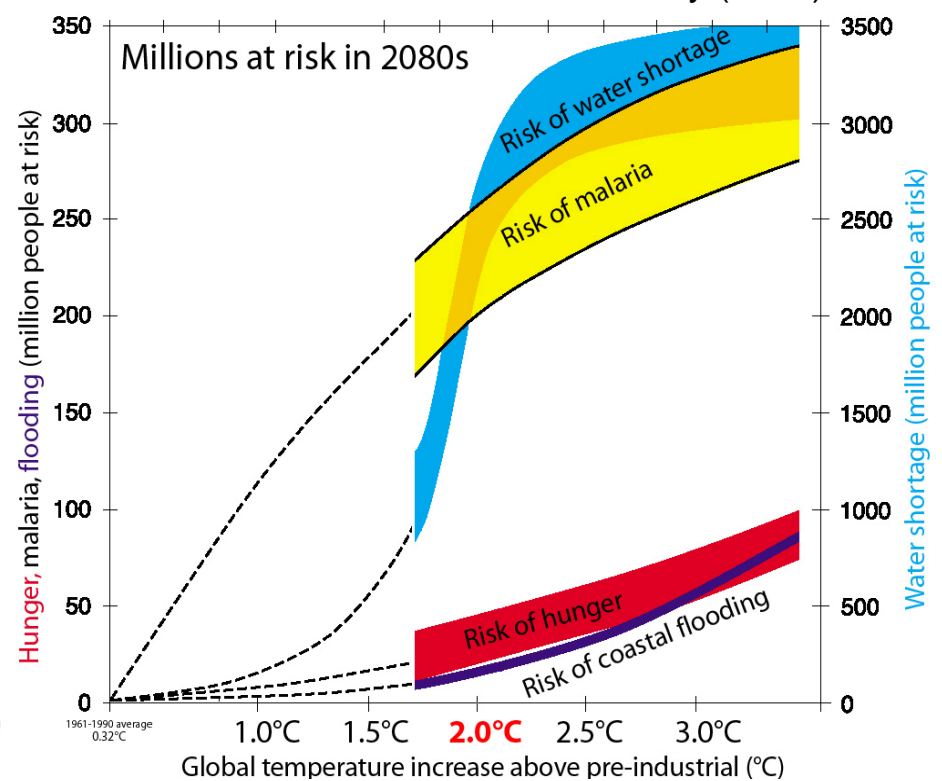
Risks Associated with Global Temperature Rises of Over 2°C



Source: Meinshausen (2004)



Source: Parry (2001)



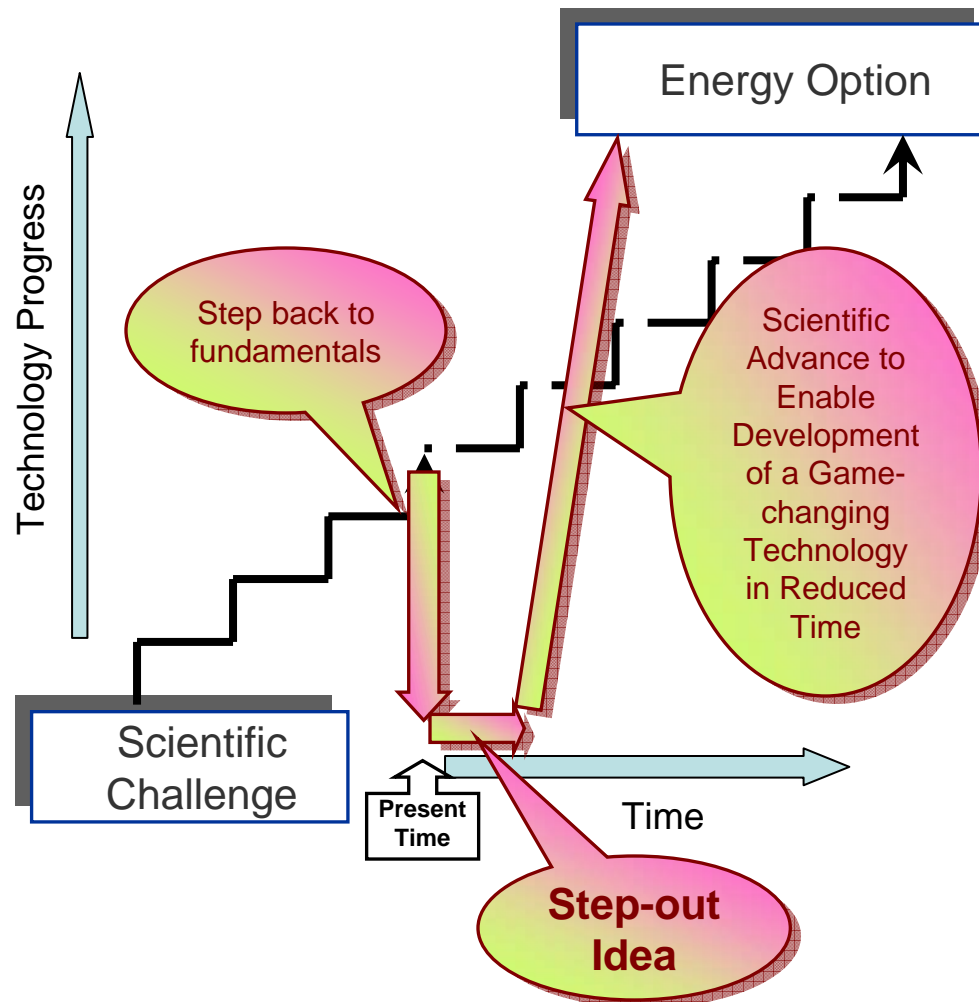
Novel step-out technologies are necessary to stabilize CO₂ concentration below 500ppm by mid-century



GCEP Strategies



Pathway to Technical Breakthroughs



Research Portfolio

Existing Project Areas

- *Advanced combustion*
- *Advanced coal*
- *Carbon capture and separation*
- *CO₂ sequestration*
- *Hydrogen production, storage, utilization*
- *Advanced transportation*
- *Renewable energies (solar, biomass)*
- *Advanced materials (separation membranes, catalysts, ...)*

Areas Undergoing Assessment

- *Nuclear technologies (fission and fusion)*
- *Electric energy distribution and infrastructure*

Future Research Areas

- *Geo-engineering*