Global Climate Change and the Technology Challenge

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McIlvaine Company Hot Topic Hour: "Greenhouse Gas Strategies for Coal-fired Plant Operators"

The views expressed in this presentation are those of the author and do not necessarily reflect the views or policies of the U.S. Environmental Protection Agency.

Office of Research and Development
National Risk Management Research Laboratory

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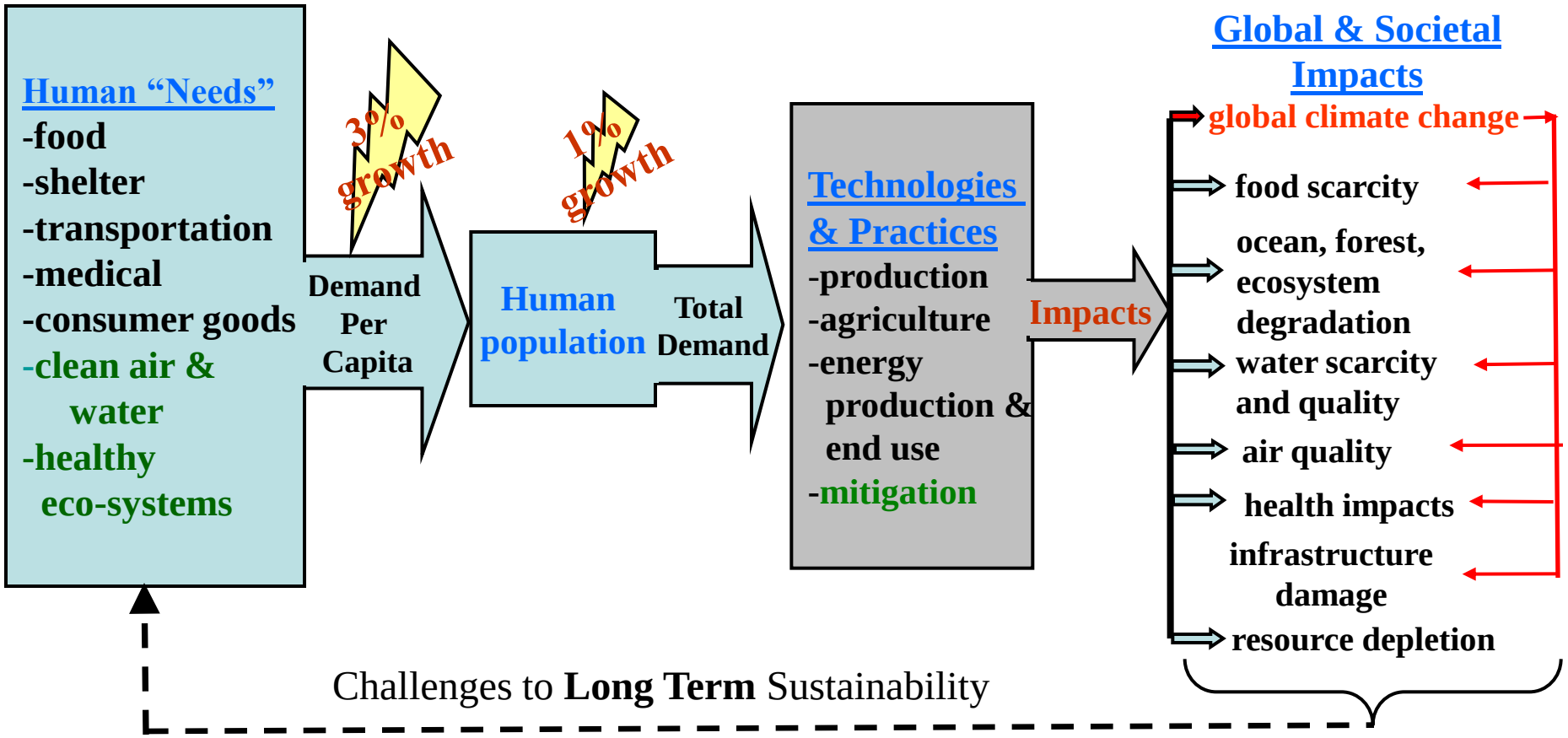
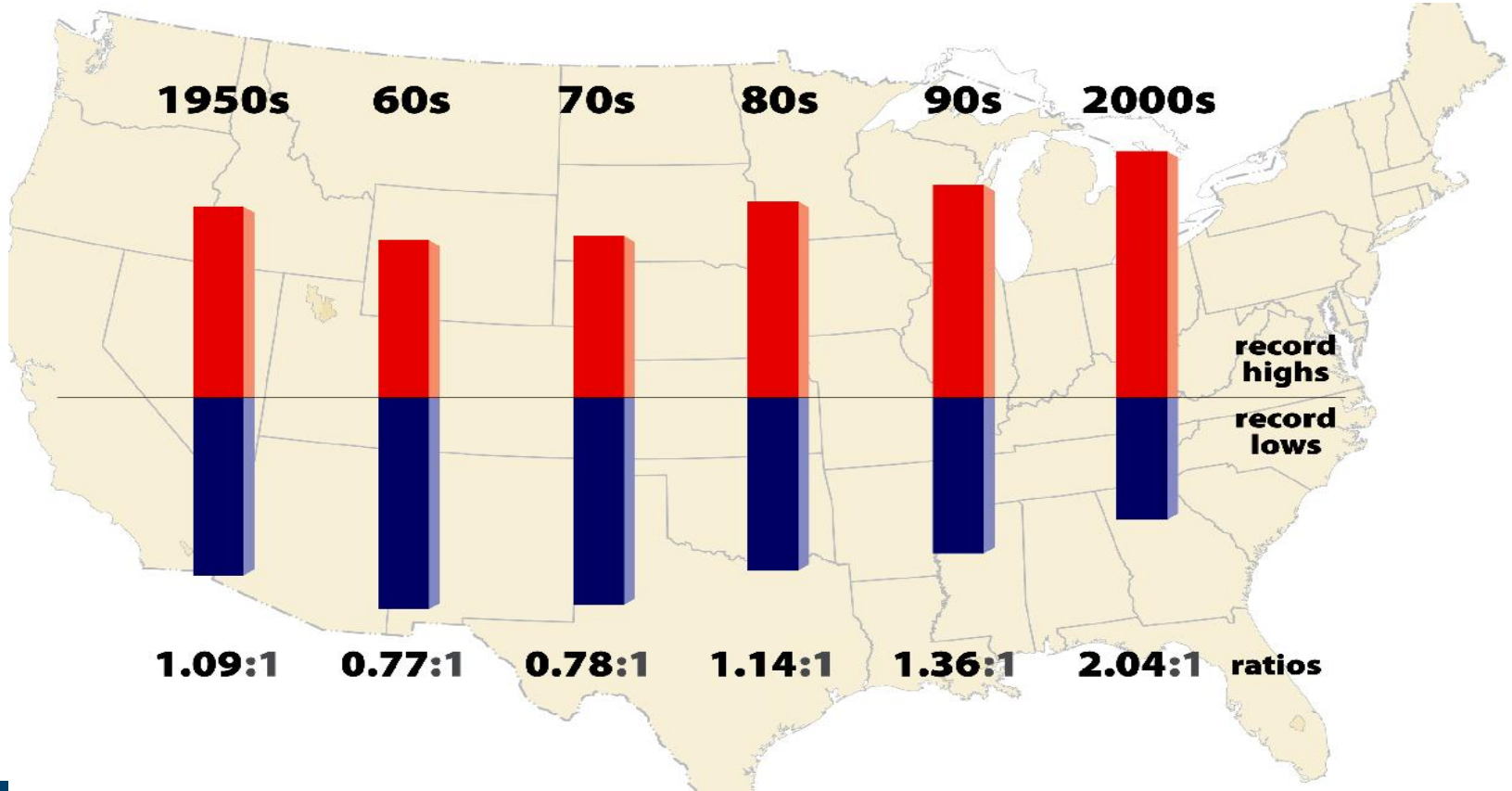
Relationship of Climate Change to Sustainability and the Role of Technology



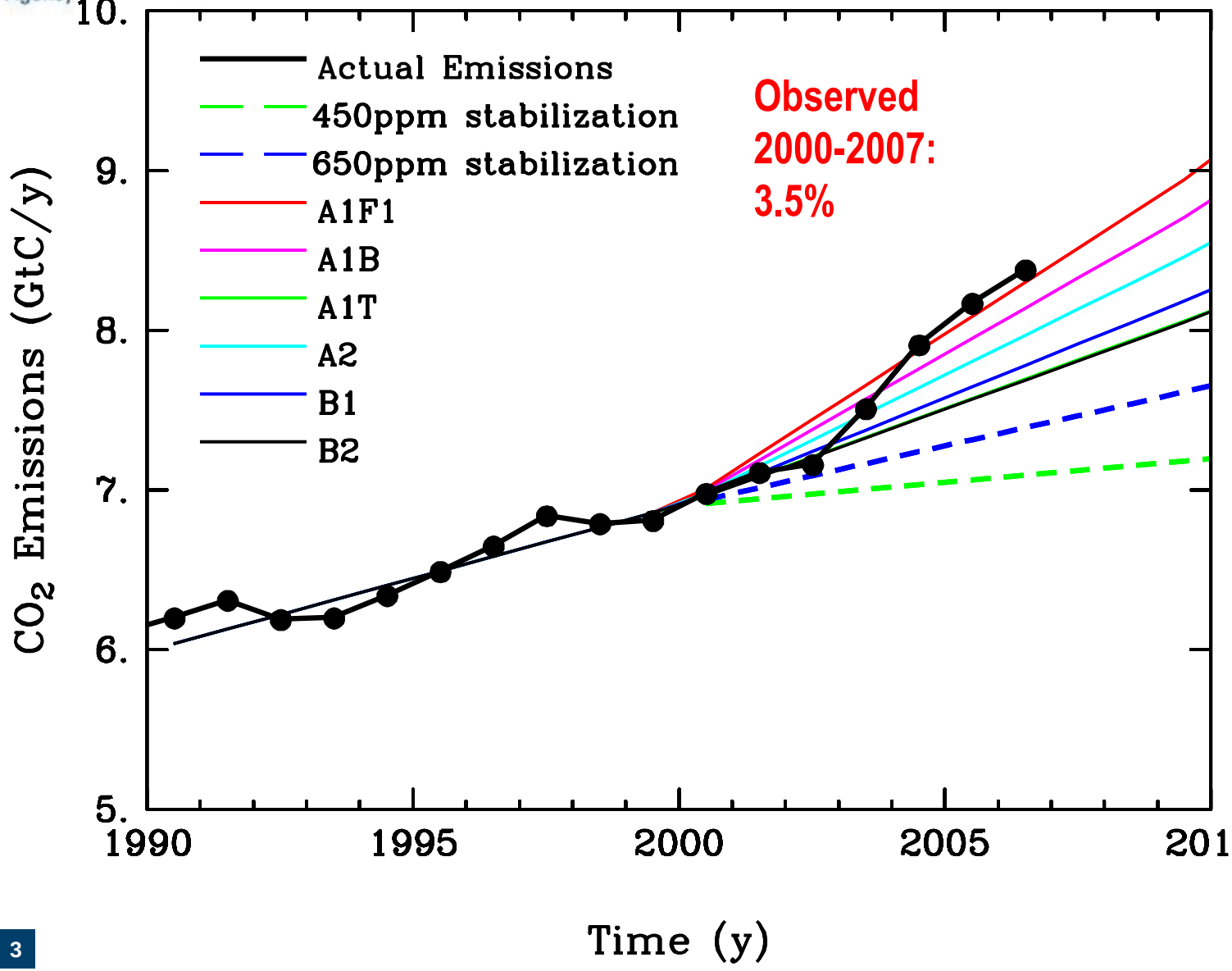
UCAR Study (November 2009), *US Warming Continues:*

Major changes in the *ratio of record daily highs to record daily lows* over the last six decades (through September 2009) for 1800 weather stations



University Corp. for Atmospheric Research:
http://www.ucar.edu/news/releases/2009/maxmin.jsp

Trajectory of Global Fossil Fuel Emissions



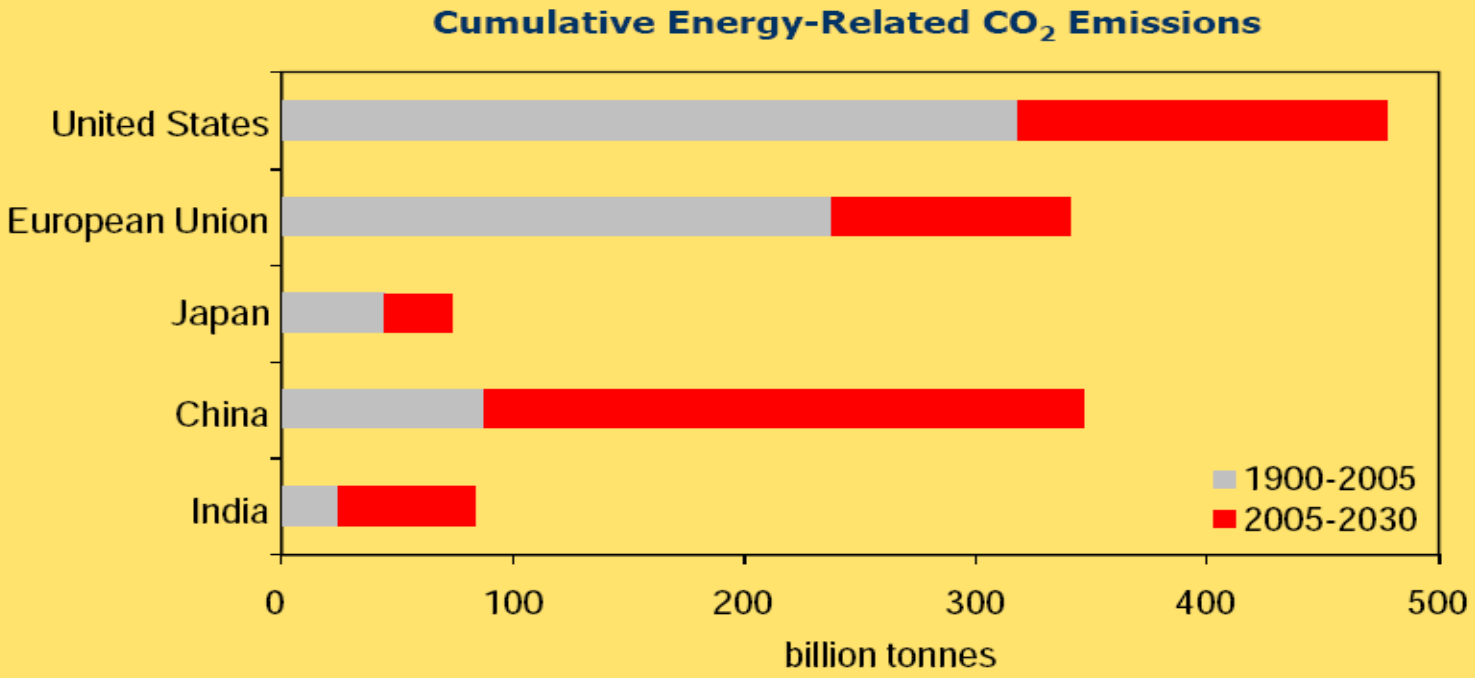
IPCC SRES (2000) growth rates in % y^{-1} for 2000-2010:

A1B: 2.42
A1FI: 2.71
A1T: 1.63
A2: 2.13
B1: 1.79
B2: 1.61

Raupach et al. 2007, PNAS

EPA United States Environmental Protection Agency

China & India in Global CO_2 Emissions WEO2007 Reference Scenario



Around 60% of the global increase in emissions in 2005-2030 comes from China & India

US vs. World CO_2 Emission Reductions: Base Case & 3 Aggressive Mitigation Cases:

Base Case

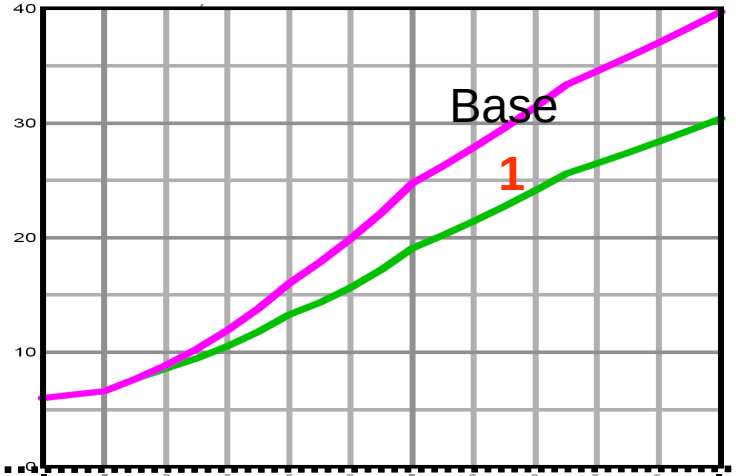
1) US only

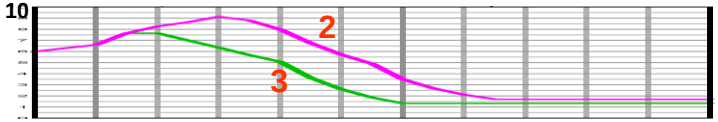
2) All developed countries + developing countries> ***delayed*** 15 yrs.

3) World, all countries

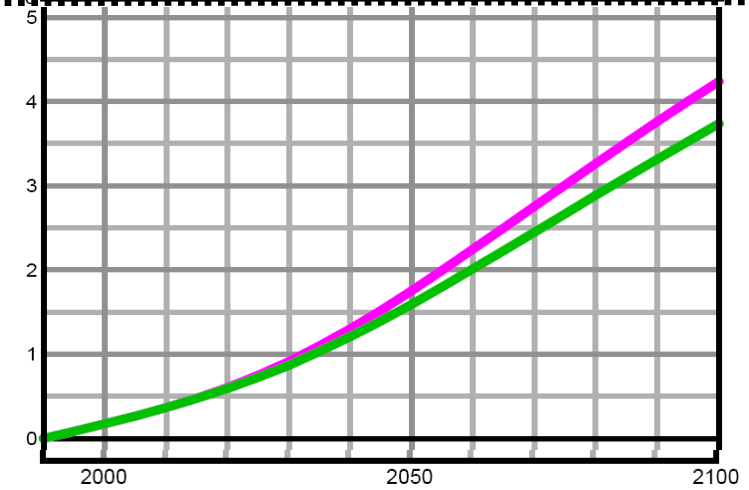
CO_2 Emissions

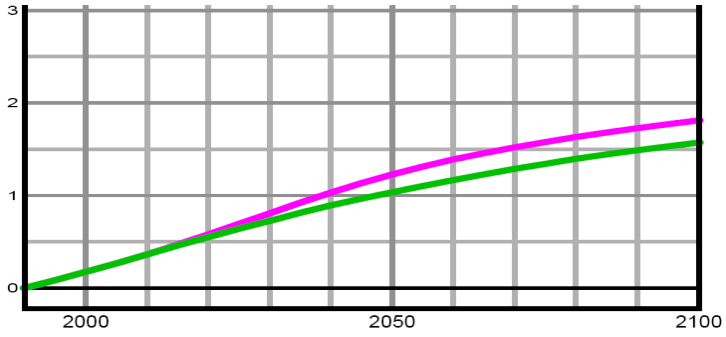
Gt C per Year





Warming from 1990, C degree





Assumed aggressive mitigation: 2005 to 2012:capped; 2005 to 2020:-17%,2005to2030:-34%;2005 to 2050:-83%

In June 2008 IEA Released the 2008 version of Energy Technology Perspectives

- Mandate by G-8 Leaders and Energy Ministers
- in 2006 their *ACT* scenario (2050 =2005 emissions) still yielded ~3.1 C warming
- In light of IPCC (2007), they analyzed new *Blue* scenario to limit warming to ~ 2.4 C; this requires 2050 emissions to be 1/2 of 2005 values (1.5% annual reduction for 45+ years)
- They concluded:

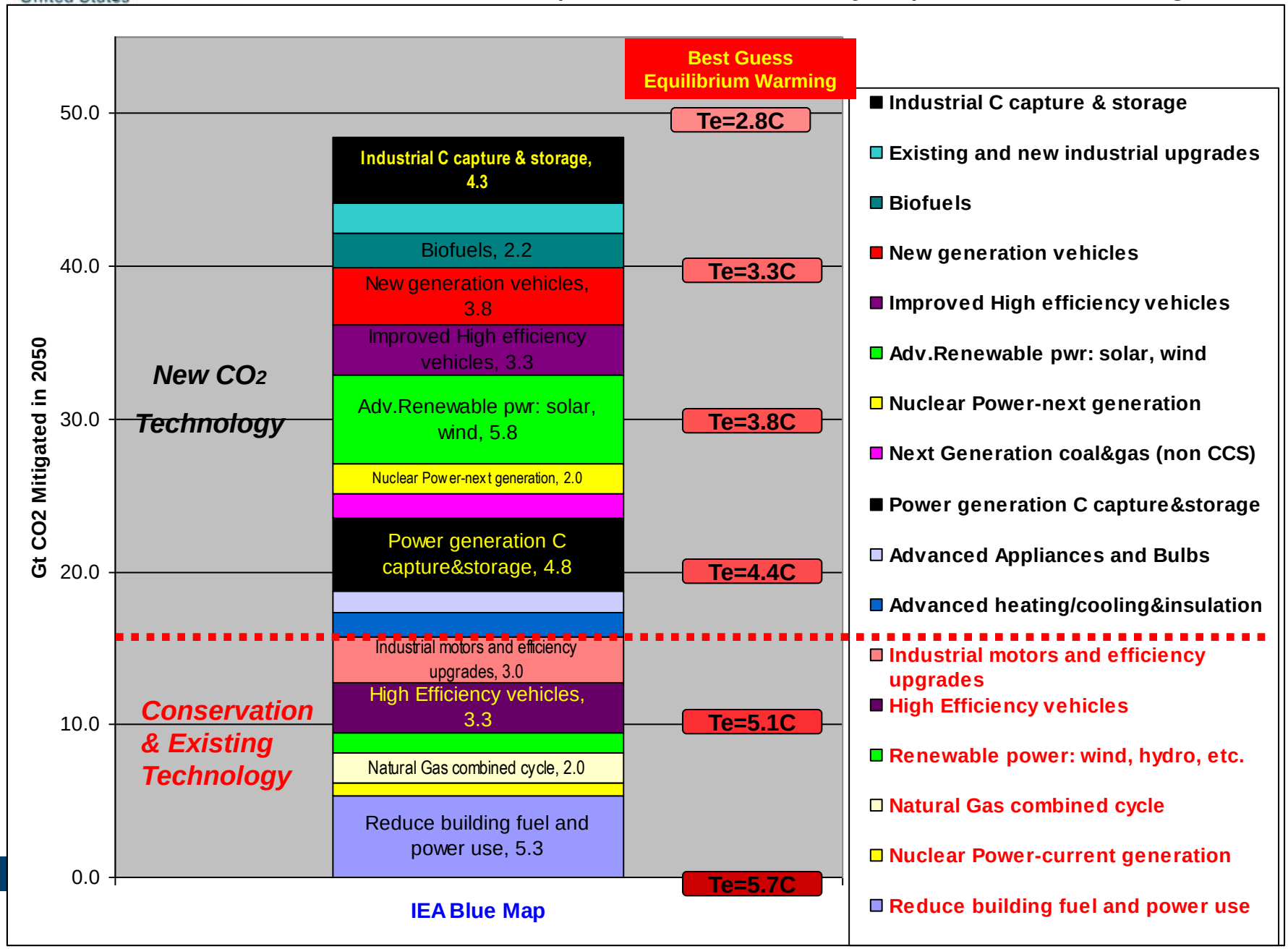
  "We are facing serious challenges in energy sector"

  "The situation is getting worse"

  "A global revolution is needed in ways that energy is supplied and used"

  "The Blue scenarios require urgent implementation of unprecedented and far reaching new policies in the energy sector"

Energy Technology Categories-existing & new: their potential to mitigate global Gt CO_2 in 2050 and impact on next century equilibrium warming, Teq



Power Generation Sector-Key Technologies

Impact in 2050, Gt CO_2 per IEA

Technology	Blue 2050 Impact	Current State of the Art	Issues	Technology R,D&D Needs
Solar-Photovoltaic and Concentrating (renewable)	**2.5**	First generation commercial, but very high costs	Costs unacceptably high, solar resource intermittent and variable	**High:** Breakthroughs needed to develop & demo cells with higher efficiency, & lower capital costs & commercialize affordable storage technology
Wind Power (renewable)	**2.1**	Commercial (on-shore)	Costs very dependent on strength of wind source, large turbines visually obtrusive, intermittent power source	**Medium**, higher efficiencies, off-shore demonstrations. Affordable storage technology
Fuel Switching coal to gas	**1.8**	Commercial (w/o CCS)	Key issue is availability and affordability of natural gas	**High**, higher efficiencies with new materials desirable. CCS demos.
Nuclear Power-next generation	**1.8**	Developmental, Generation III+ and IV: e.g. Pebble Bed Modular Reactor and Supercritical Water Cooled Reactor	Deployment targeted by 2030 with a focus on lower cost, minimal waste, enhanced safety and resistance to proliferation	**High**, Demonstrations of key technologies with complimentary research on important issues

Power Generation Sector-Key Technologies
Impact in 2050, *Gt CO2 per IEA, Cont'd*

Technology	Blue 2050 Impact	Current State of the Art	Issues	Technology R,D&D Needs
Pre-combustion **Coal IGCC with CO_2 Capture and Storage**	**1.6**	*IGCC*: early commercialization, *Underground storage (US)*: early development.	*IGCC*:High capital costs, complexity and potential reliability concerns; *US*: Cost, safety, efficacy and permanency	**High**, *IGCC*: Demos on a variety of coals, hot gas cleanup research; *US*: major program with long term demos evaluating large number of geological formations to evaluate environmental impact, efficacy, cost and safety
Combustion **Pulverized Coal/O_2 with CO_2 Capture and Storage**	**1.6**	Developmental, Underground storage (US): early development.	Although O_2 combustion facilitates CO2 rich stream; O2 production yields major plant derating; *US*: Cost, safety and permanency	**High**, large pilot followed by full scale demos needed, low cost O_2 production needed, *US* requires major program
Post-Combustion **Pulverized Coal with CO_2 Capture and Storage**	**1.6**	CO2 scrubbing with MEA near commercial for refinery applications, Underground storage (US): early development.	*US*: Cost, safety and efficacy issues, CO_2 scrubbing energy intensive: yielding power output derating & high costs, US: Cost, safety and permanency	**High,** *US* requires major program (see write-up above); affordable CO_2 removal technologies need to be developed and demonstrated, US requires major program

On Feb 3, President Obama Called for an Interagency Task Force to Plan a Major CCS Initiative

By August 2010, the Task Force shall develop a plan to overcome barriers to widespread, cost-effective deployment of CCS within 10 years:

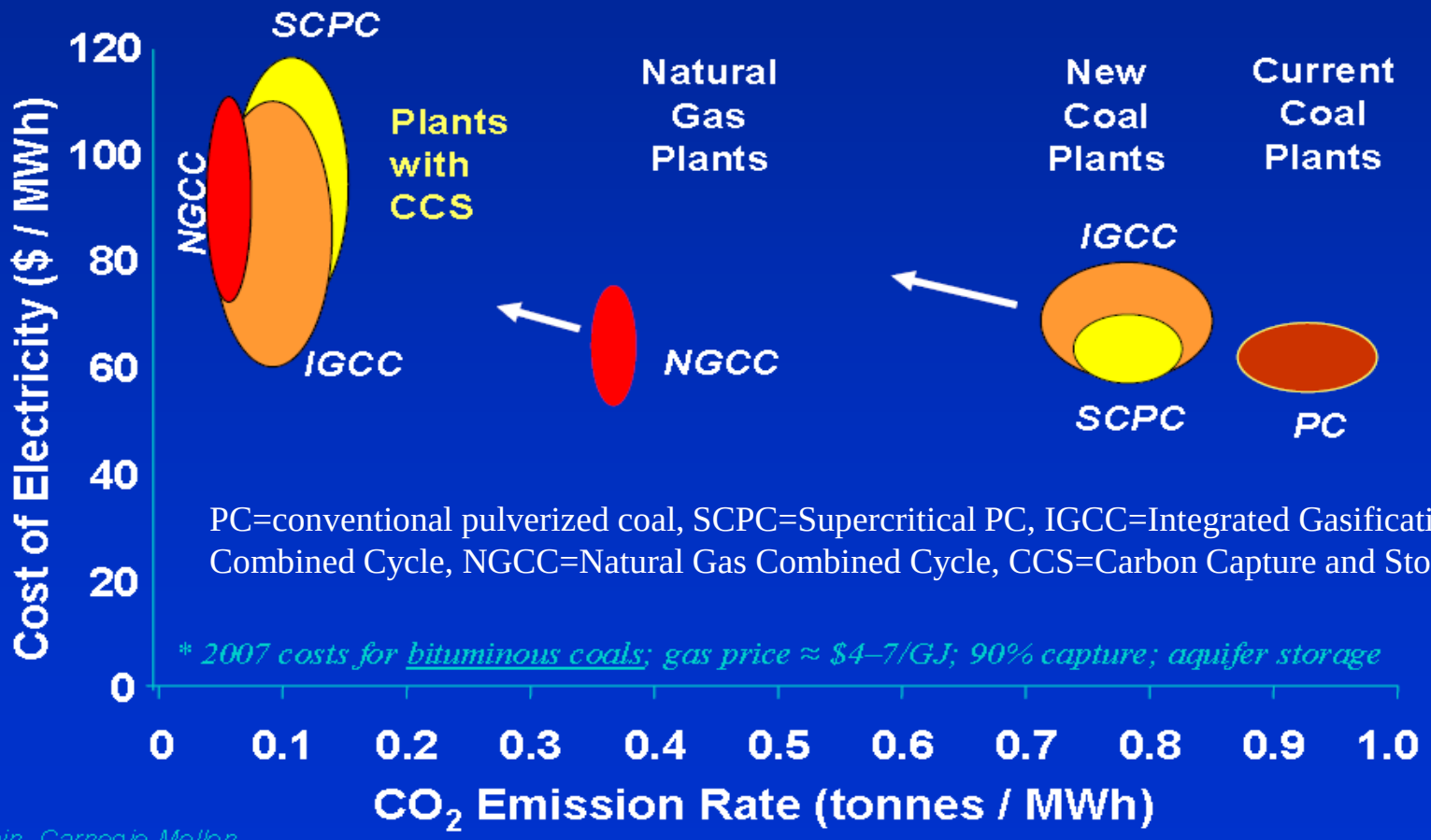
- *Bring 5 to 10 commercial demonstration projects online by 2016.*
- *The plan will explore incentives for commercial CCS adoption and address financial, economic, technological, legal, institutional, social barriers to deployment*
- *The Task Force should consider how best to coordinate existing administrative authorities and programs, including those that encourage international collaboration*
- *The Co Chairs (DOE and EPA) shall report progress periodically to the President through the Chair of the CEQ*

CCS Projected to Play Key Role; However Formidable Challenges

- Capture technologies in various stages of development; energy penalty 20 to 30%
- Retrofit with CCS difficult; challenging requirements include: space, water & proximity to sequestration sites
- Post combustion/gasification technology, closest to commercial, can not be readily retrofitted
- Saline aquifer sequestration sites limited by need to avoid seismic risk & to be in proximity to plant
- Underground sequestration unproven at required scale; long term stability, safety, environmental and legal issues unresolved

Coal versus Natural Gas:

Cost & CO_2 Mitigation Comparison for Various Options



PC=conventional pulverized coal, SCPC=Supercritical PC, IGCC=Integrated Gasification Combined Cycle, NGCC=Natural Gas Combined Cycle, CCS=Carbon Capture and Storage

E.S. Rubin, Carnegie Mellon

Additional **annual** capacity needed in power generation sector for ACT and Blue Scenarios (Relative to Baseline, 2005 to 2050)

Source: IEA Energy Technology Perspectives, 2008