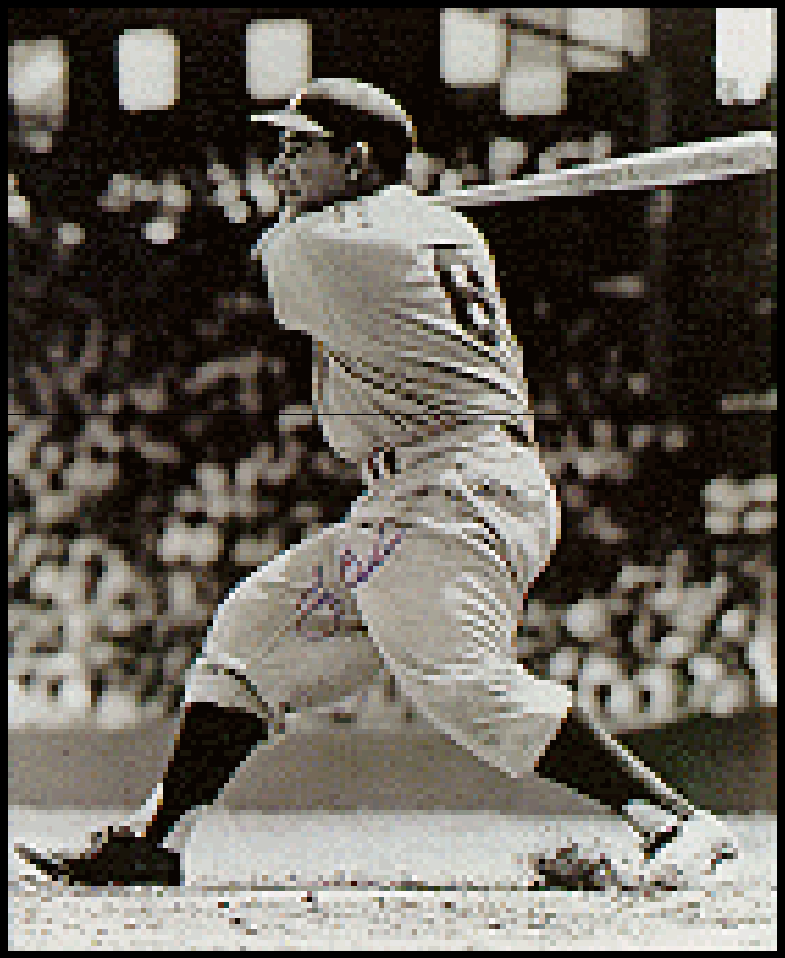
Meeting the Energy and Climate Challenge

Whittington Lecture

Georgetown Public Policy Institute

29 March 2010

I will make two predictions:



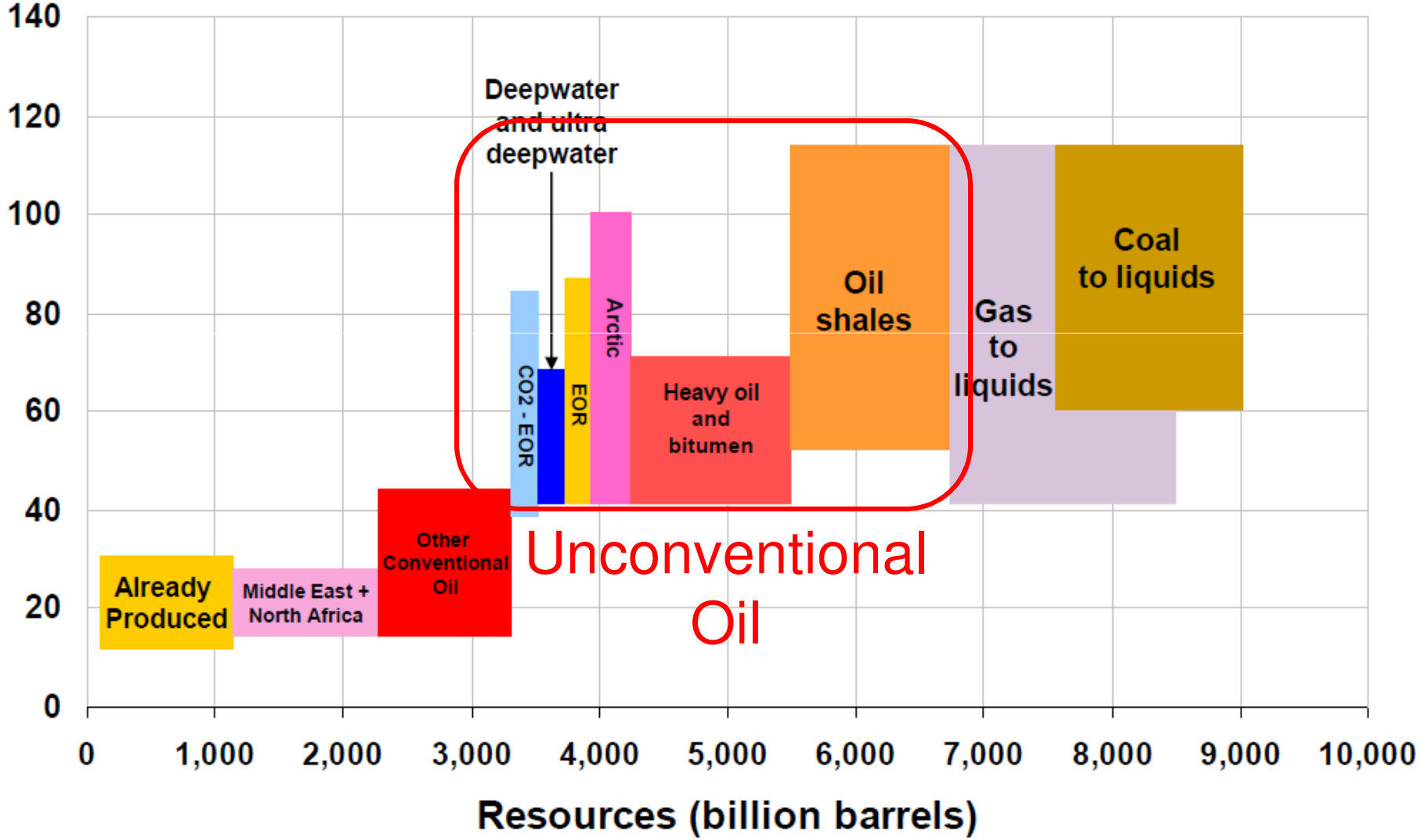
"Predictions are hard to make, especially about the future."

1. The price of oil will be higher in the coming decades.

2. We ***will*** live in a carbon constrained world.

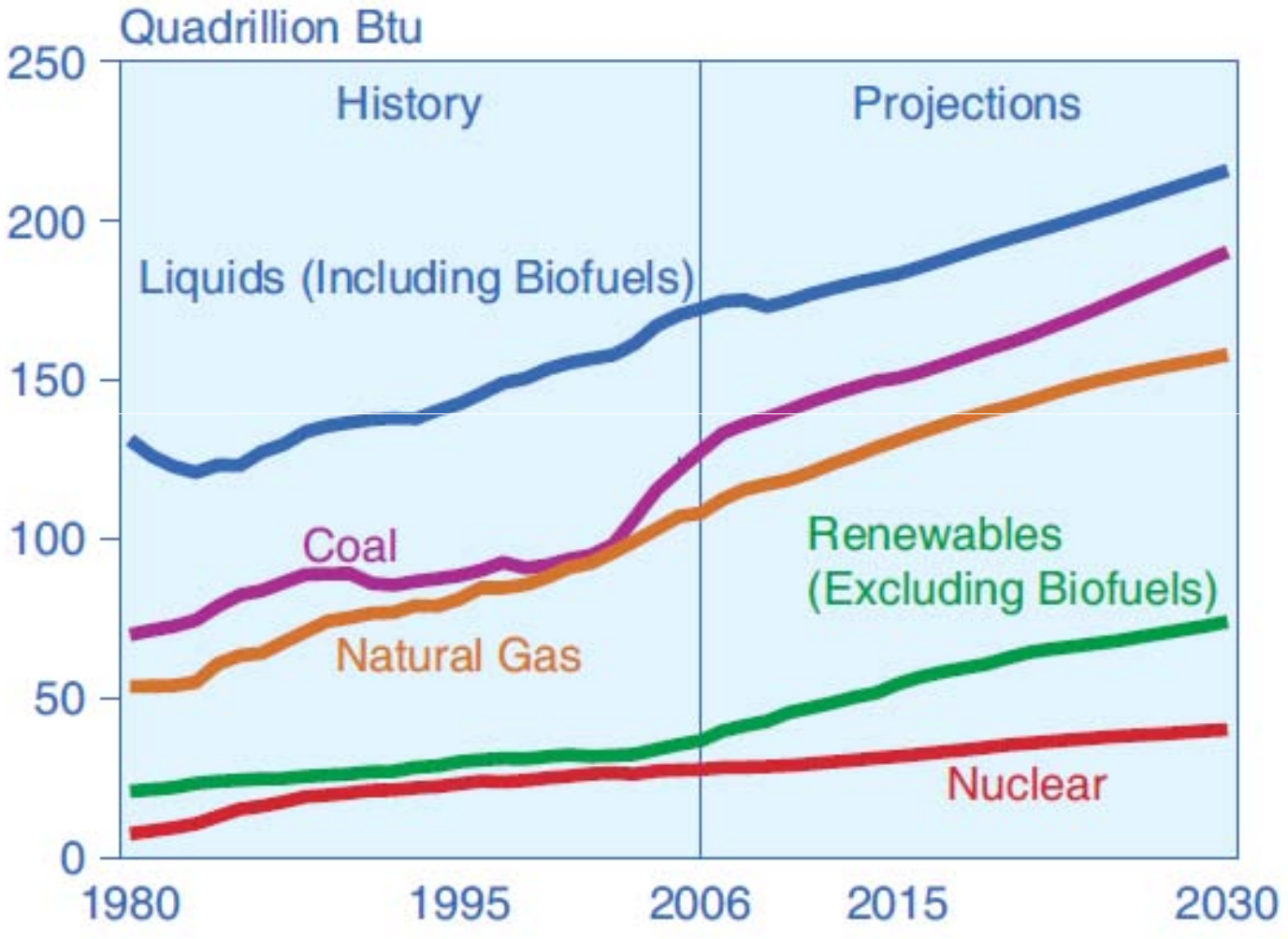
"Breakeven" Price of Oil (Dollars/Barrel)

Conventional oil is 30% of world oil reserves. Production costs of unconventional oil are much higher.



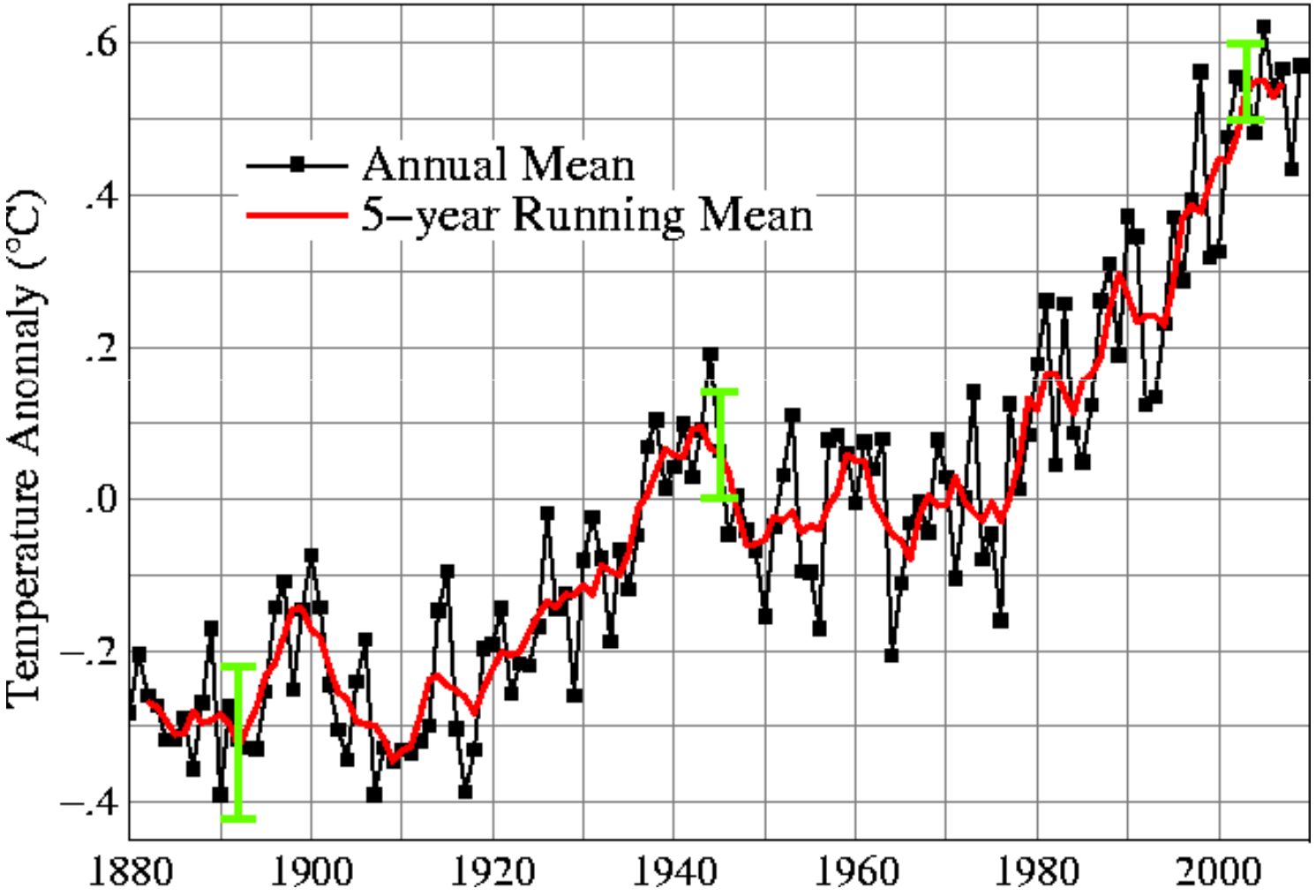
Source: International Energy Agency

Energy Use: 1980 - Present and Projections to 2030



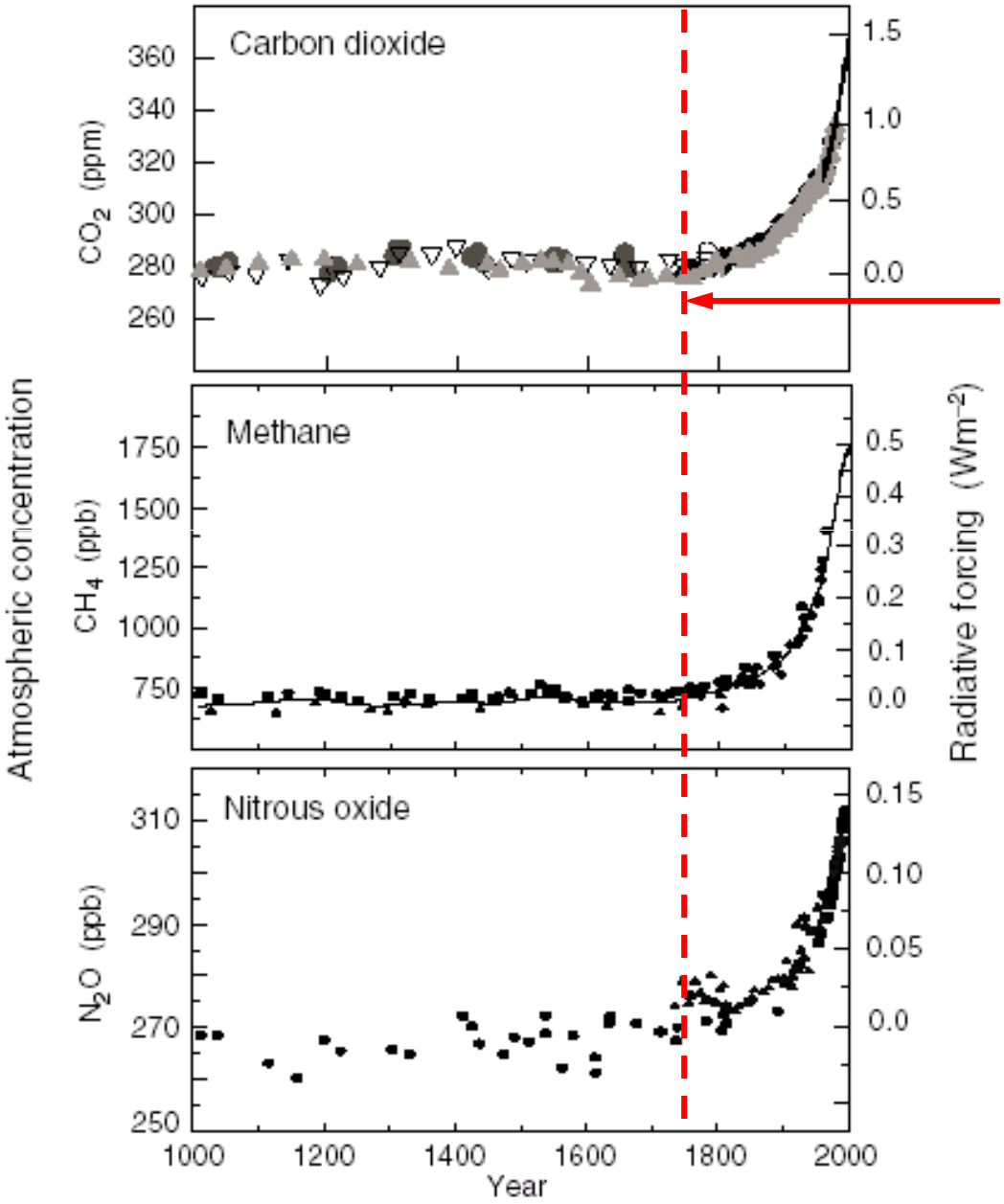
Source: EIA *International Energy Outlook 2009*

Climate Change is real: the temperature record from 1880 – 2007



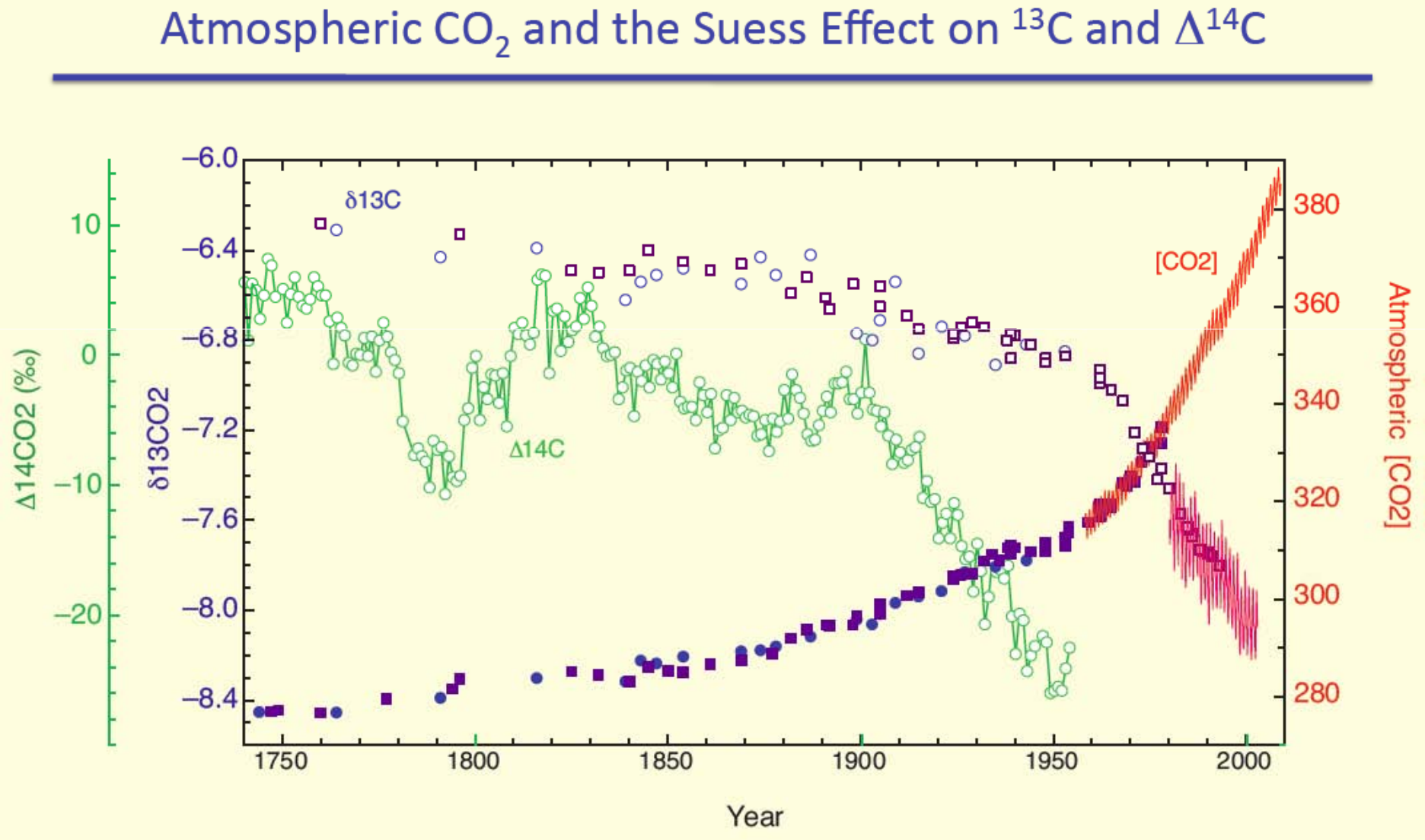
Source NASA: http://data.giss.nasa.gov/gistemp/graphs/

Concentration of Greenhouse gases

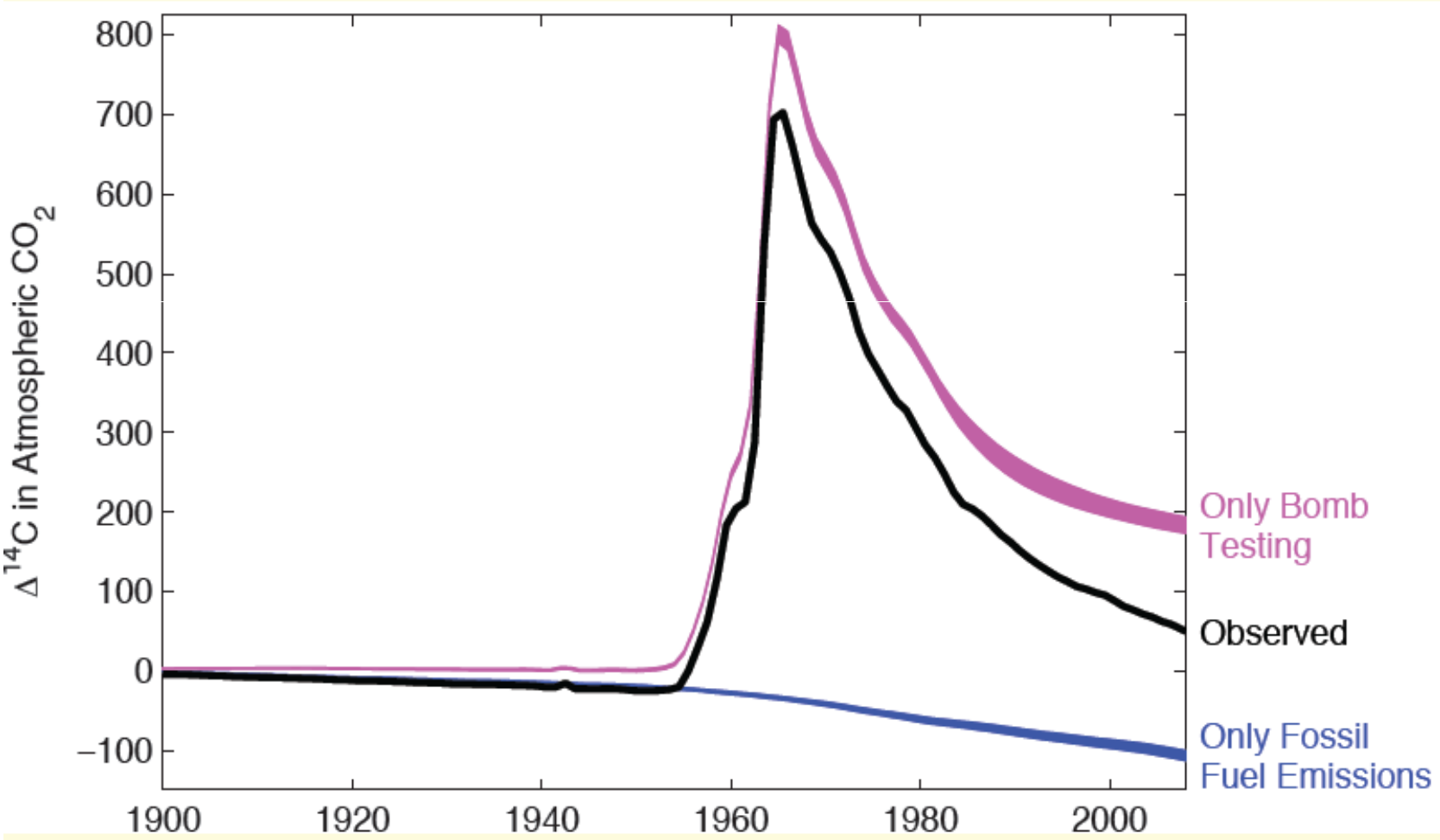


The beginning of the Industrial Revolution

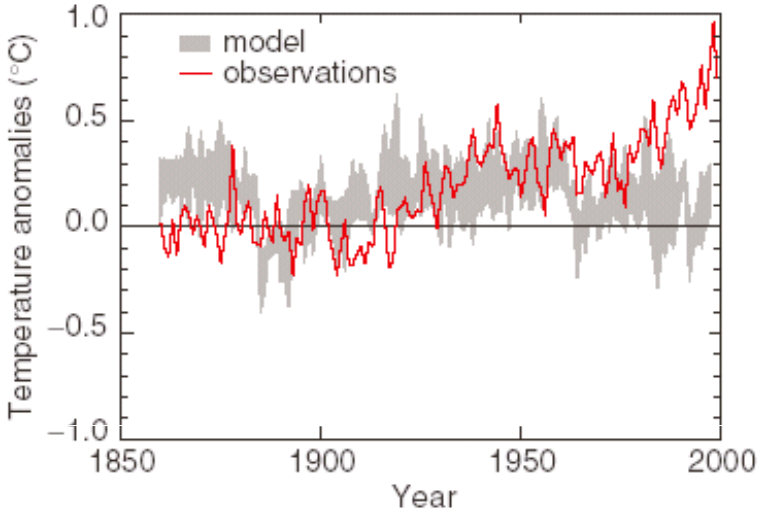
^{14}C is produced through cosmic-ray bombardment. It is incorporated into plants and animals and decays with a 5,730 year half-life. Fossilized organic material is depleted of ^{14}C.



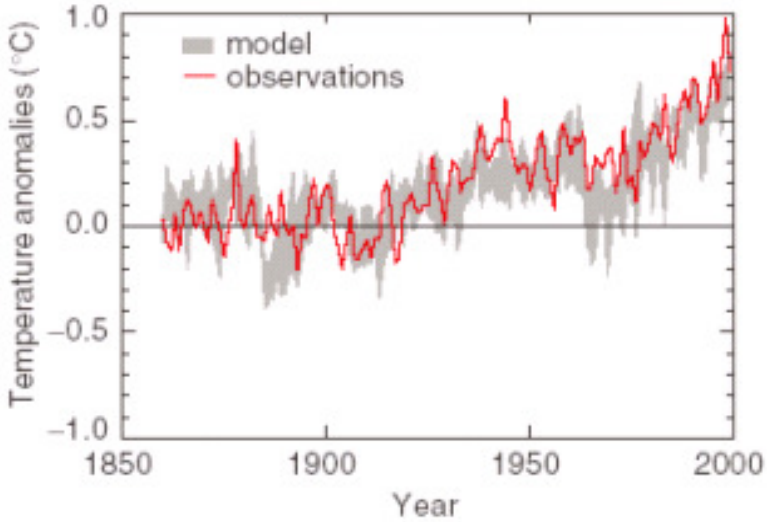
Atmospheric nuclear testing added huge amounts of ^{14}C into the atmosphere. The observed ratio of ^{14}C / ^{12}C is declining a rate consistent with increased burning of fossil fuel.



Temperature rise due to human emission of greenhouse gases



Climate change due to natural causes (solar variations, volcanoes, etc.)

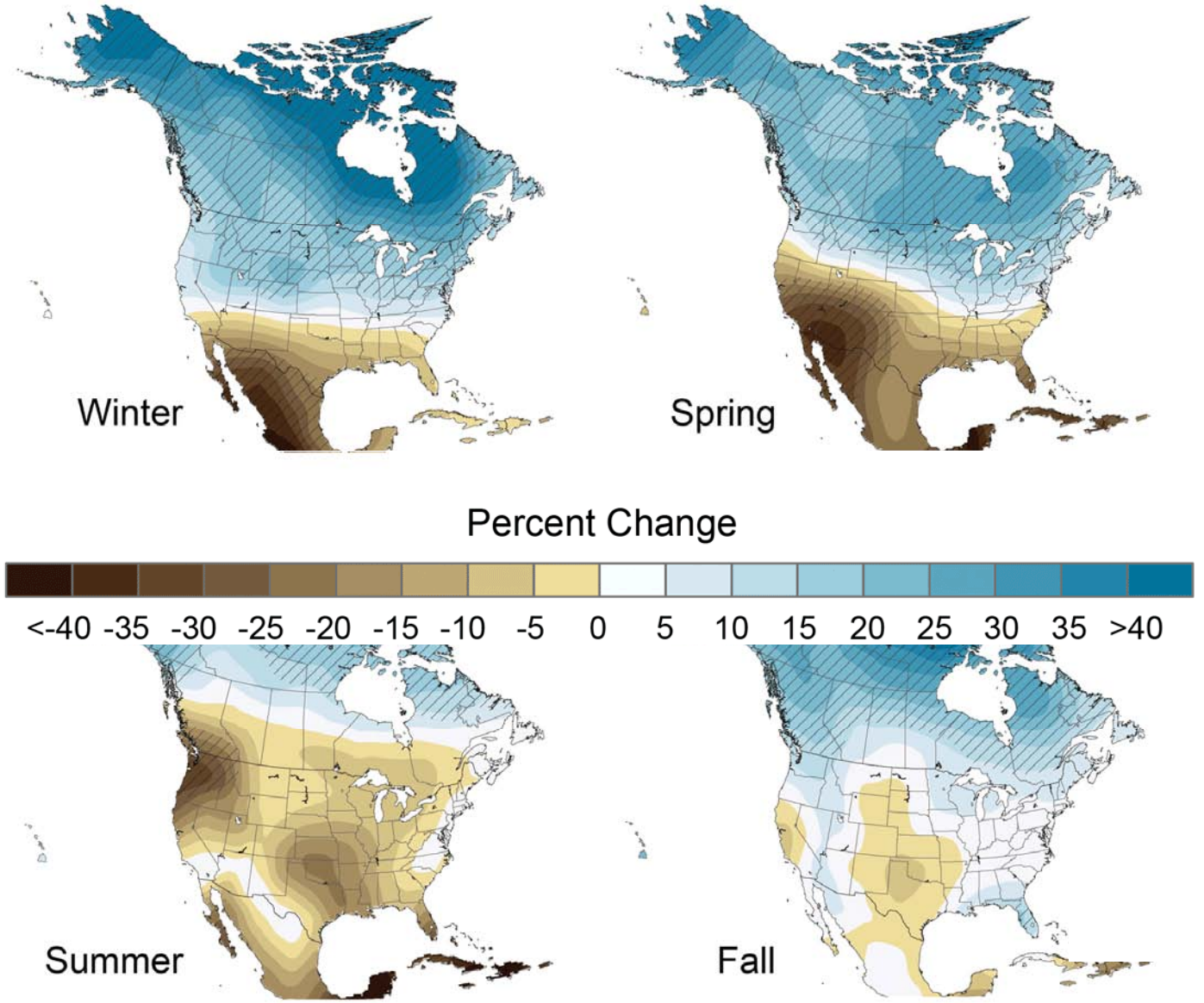


Climate change due to natural causes *and* human generated greenhouse gases

Potential effects of climate change:

- Water Shortages
- Property losses and population displacement from sea-level rise
- Increased damage from storms, floods, wildfires
- Reduced productivity of farms, forests, & fisheries
- Increased species extinction
- Spread of disease (malaria, cholera, dengue fever, …)

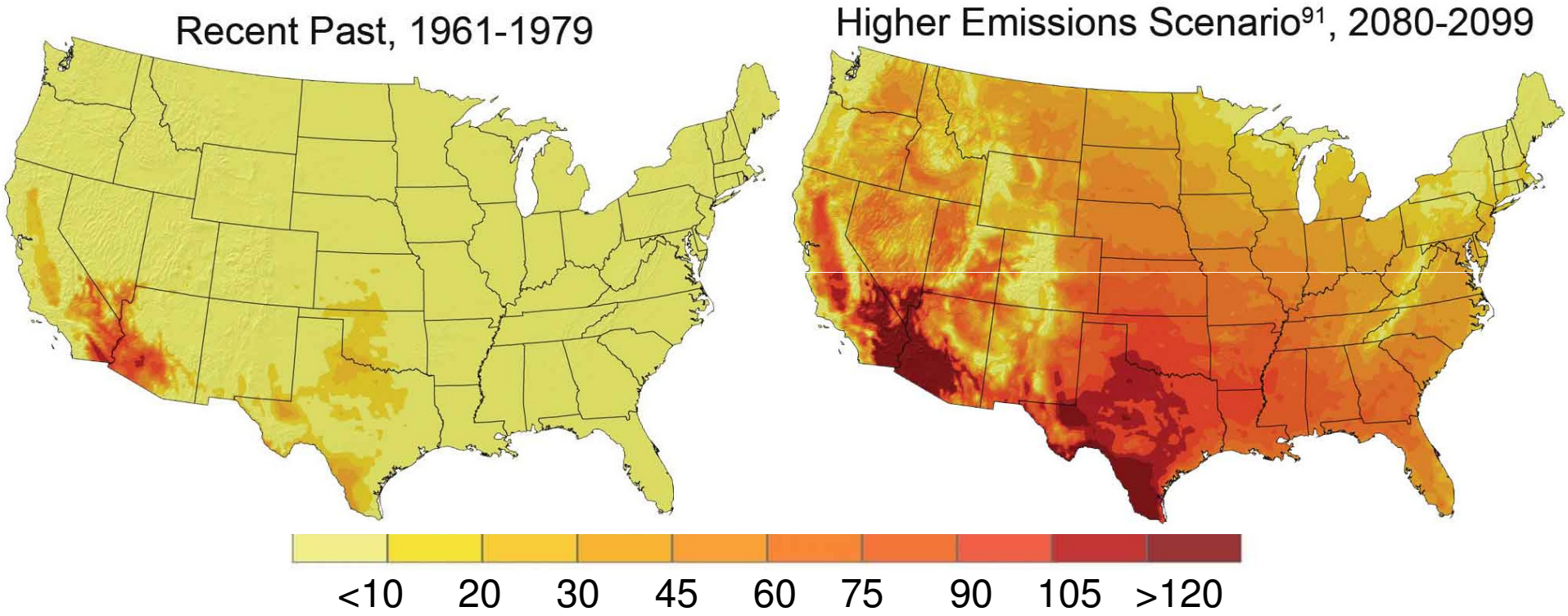
Change in Precipitation by 2080-90s (Higher emissions scenario)
Bread Basket states projected to have 10 -25% less summer rain



Source: NOAA U.S. Global Change Research Program

If we fail to act, climate change could have potentially devastating effects

Days above 100º F



Much of the U.S. would go from 0 - 10 days above 100º F to 45 to 70 days per year above 100º F

Source: NOAA U.S. Global Change Research Program

Great Plains Climate Projections

- Decreasing soil moisture and water availability due to rising temperatures and water depletion.
- Rising temperatures lead to higher evaporation rate and more frequent and sustained drought.
- Drought will stress aquifers.
- Pests will spread northward, encouraged by milder winters and earlier springs.

Source: *United States Global Change Research Program*

The permafrost is beginning to thaw

(Carbon that could be released may double the amount currently in the atmosphere)

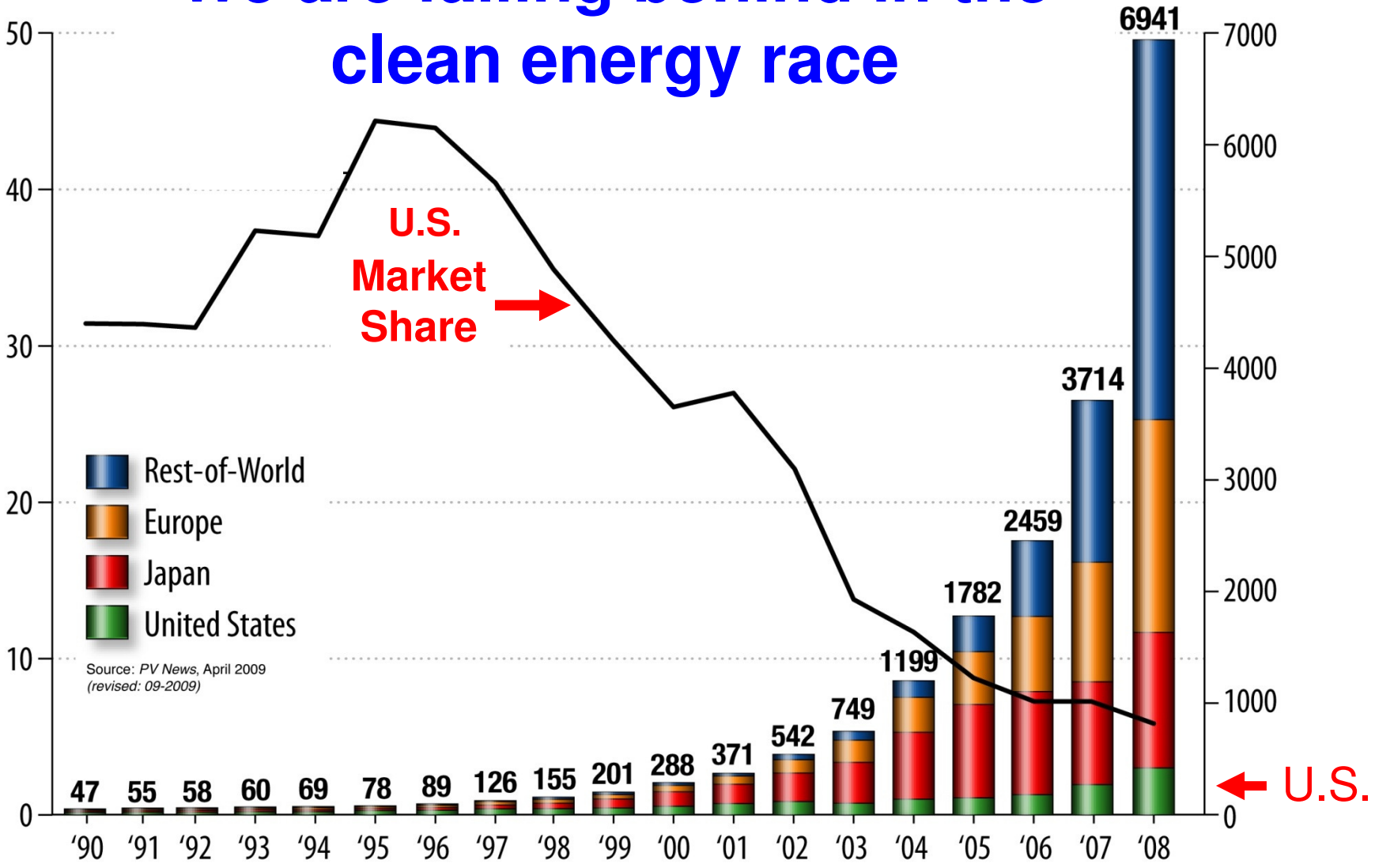
Zimov et al., 2006. Science. 312:1612-1613

In order to avoid the chance that we pass "tipping points", climate scientists are calling for more aggressive action.

Is there reason for hope?

We will need a new industrial revolution to mitigate climate change and to decrease our dependency on foreign oil. The United States has the opportunity to be the innovation leader.

We are falling behind in the clean energy race



Worldwide shipments of Solar Photovoltaics – in Megawatts

China is spending ~$9 billion a month on clean energy

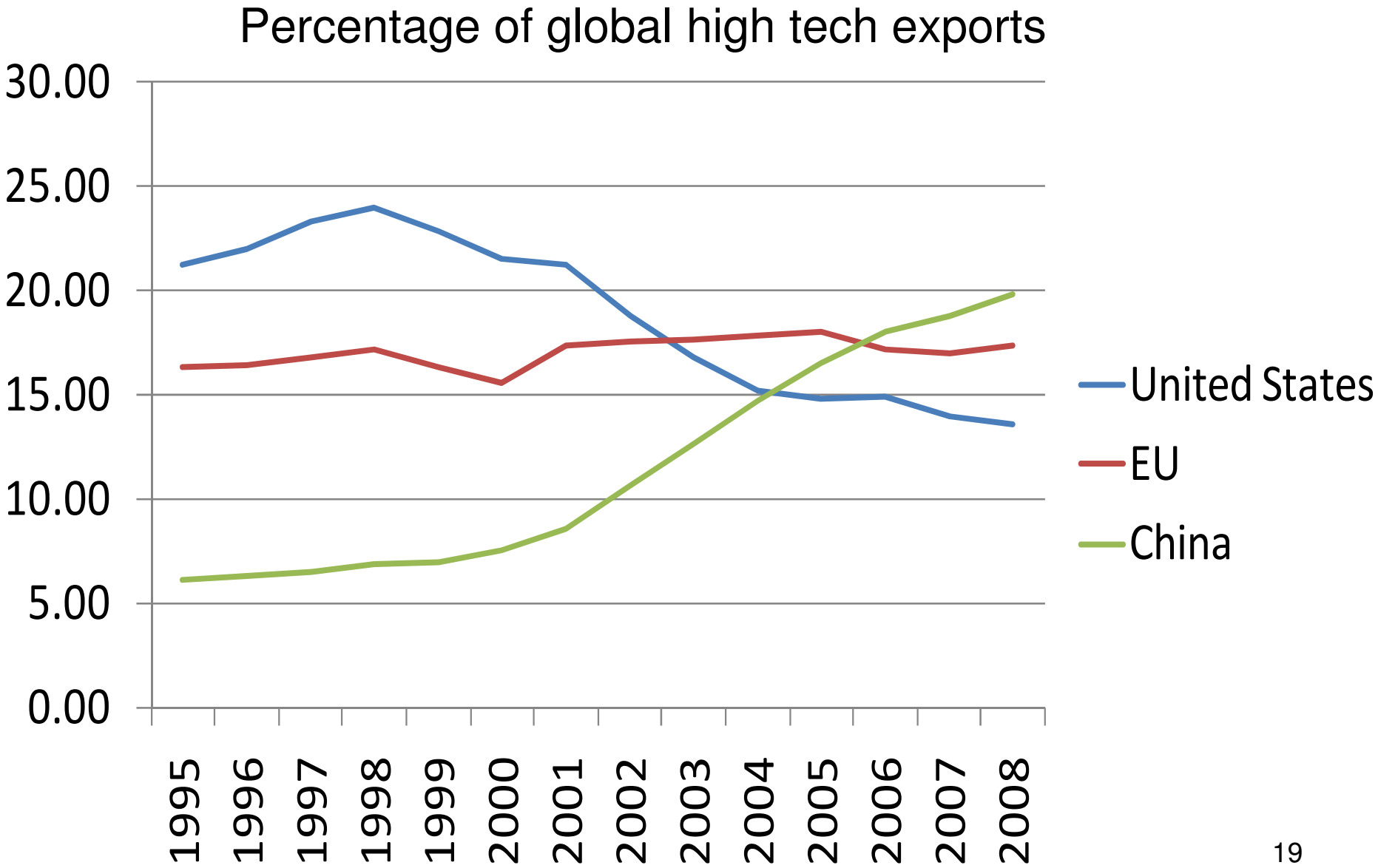
China's Goal: generate 10% of its electricity from renewable sources by 2010 and 15% by 2020.

11th Five Year Plan: reduce energy intensity by 20% by 2010

Wind target:
100 GW by 2020

State Grid: $44 B by 2012 and $88 B by 2020 in UHV transmission lines

China's high-tech manufacturing is rising



In the near term, government investment is critical

The Recovery Act is making an **$80 B** down payment on a clean energy economy

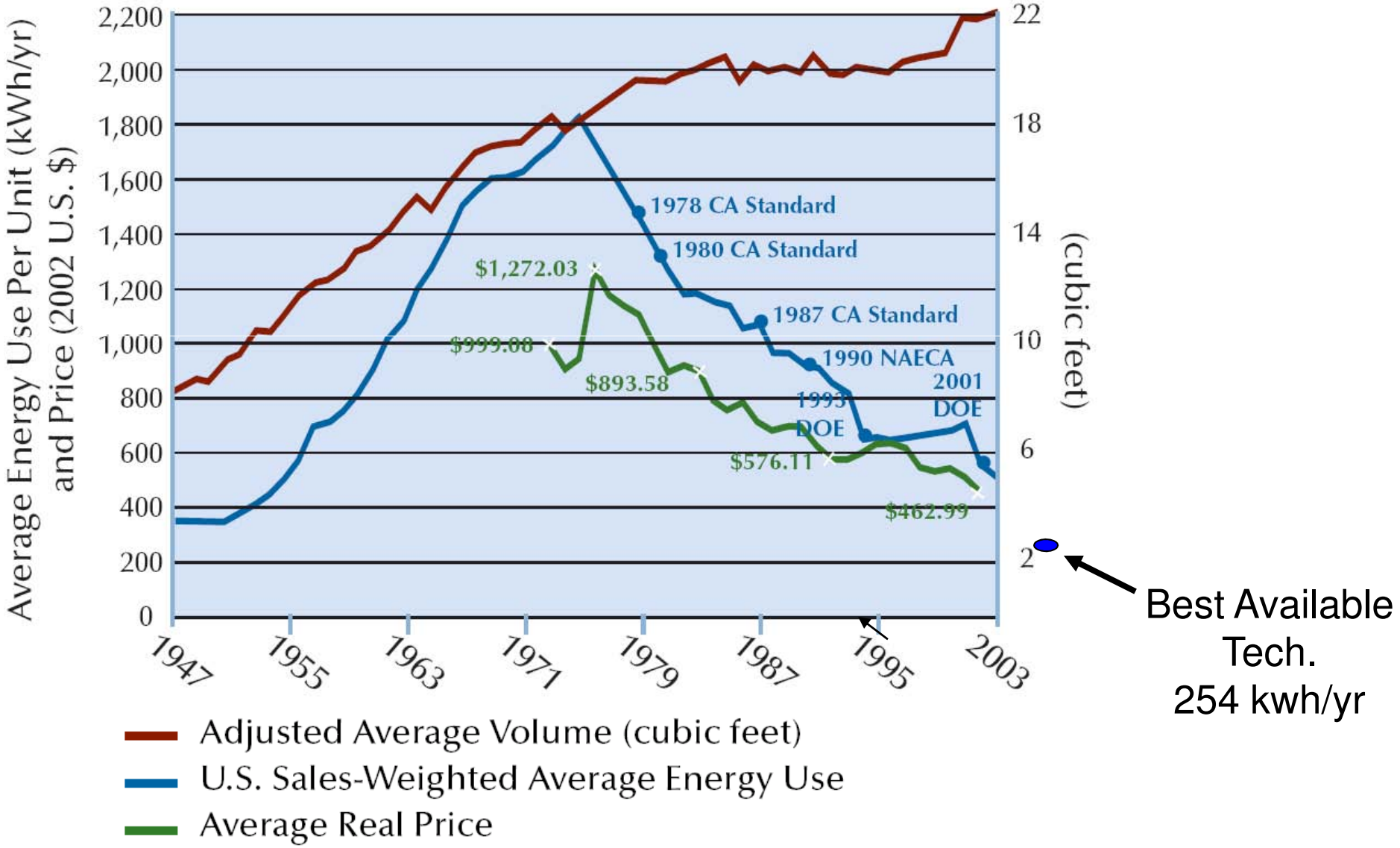
Creating jobs immediately

Investing in our energy infrastructure to provide lasting value

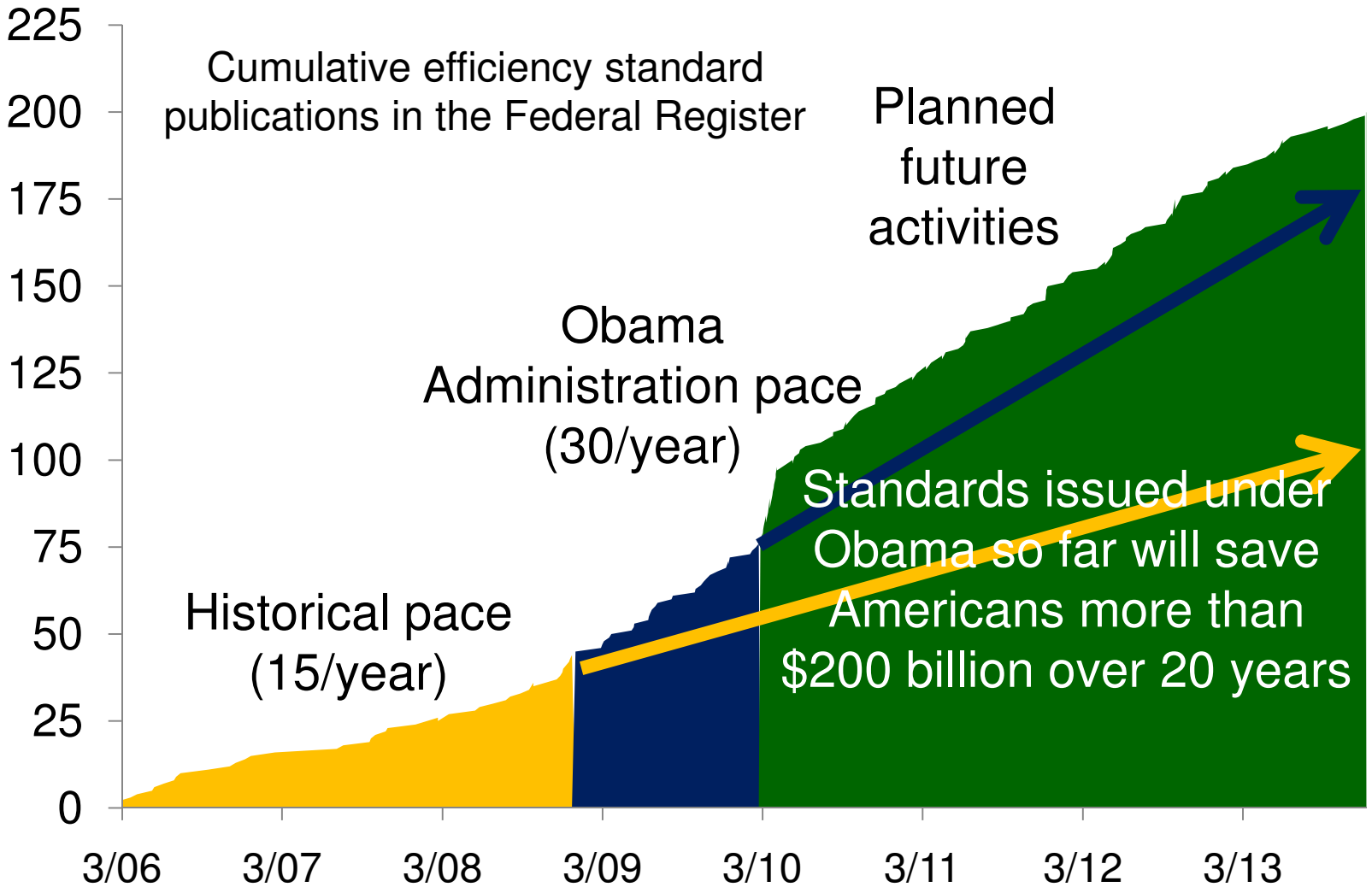
The momentum started by the Recovery act needs to be continued.

For the next few decades, energy efficiency and conservation will remain the most effective mitigation tools

Refrigerator energy savings (3%) is greater than ***all*** of US renewable energy generation



We are accelerating appliance standards – and toughening & enforcing them



The Administration has started a "Recovery through Retrofit" initiative to overcome barriers

Access to Information:

- **Develop Energy Performance Label for Homes (DOE)**
- **Develop a National Home Energy Performance Measure (DOE)**

Access to Financing:

- **Support Municipal Finance Programs (DOE)**
- **Improve Energy Efficiency Mortgages (HUD)**
- **Expand State Revolving Loan Funds (DOE)**

Access to Skilled Workforce:

- **Establish National Workforce Certification and Training Standards (DOE/DOL/SBA)**

Building a home retrofit industry in America

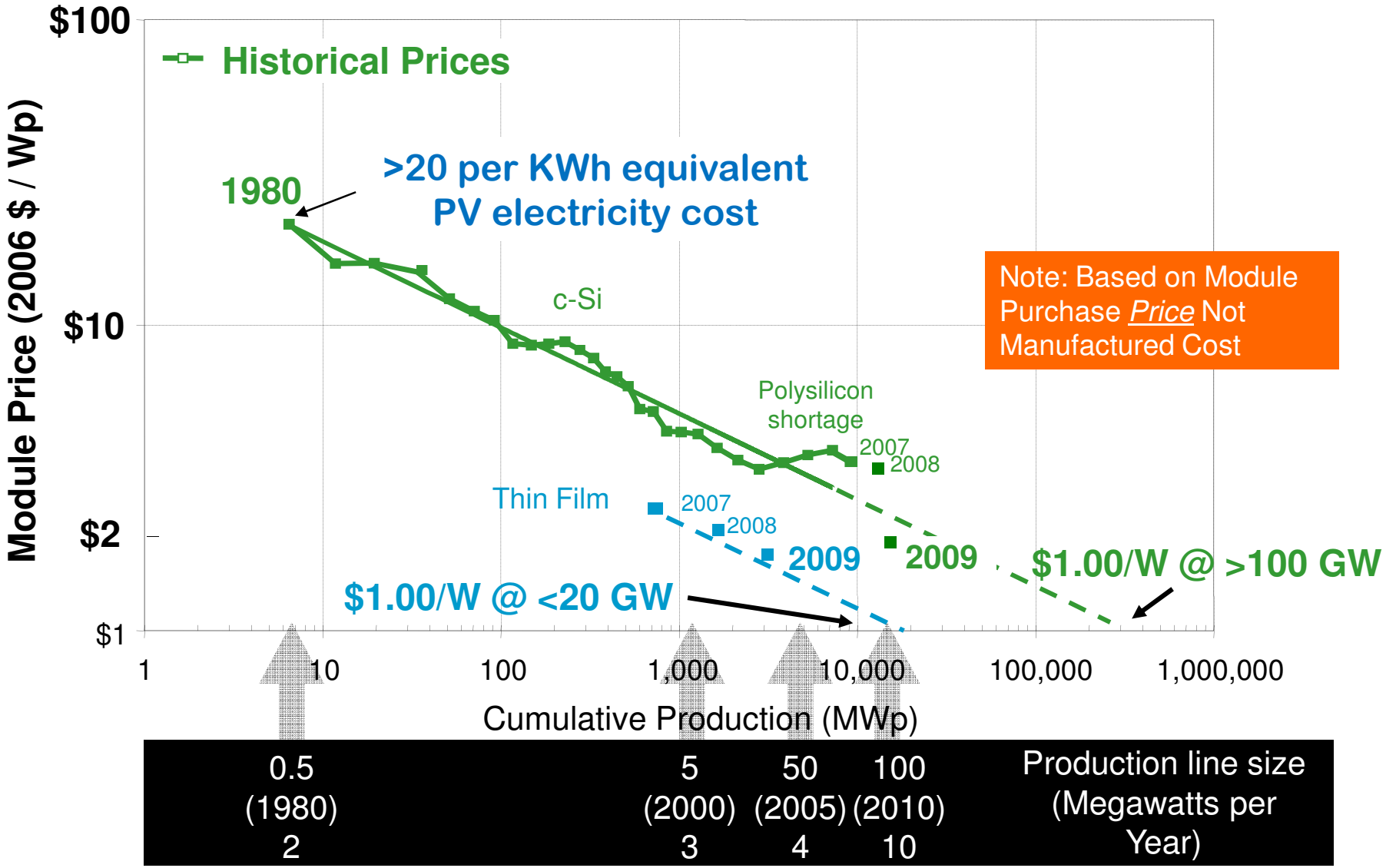
Retrofit Ramp-up – a $400 million initiative to fund building retrofit programs that reach ***whole neighborhoods***

Home Star – Would provide rebates directly to homeowners to create jobs and save energy

We are open to all ideas on how to make energy/money savings a social norm.

We are developing technologies
that will have a significant impact

Learning Curves: crystalline silicon and thin-film technology



Source: Adapted from National Renewable Energy Laboratory

The US, China, Russia, Australia, and India have ¾ of the world's known coal reserves.

The US is investing $4 billion in CCS, matched by ~$7 billion of private sector money.

We are supporting $8 billion in loan guarantees.

We are working towards reducing costs to allow commercial deployment in 8 – 10 years

Small Modular Reactors (300 MW or less)

Artists rendering of one possible design.

Benefits:

- Can be “mass-produced” in a factory, and transported by ship, truck, or rail.
- Replacements for moderate sized power plants with no need to upgrade existing transmission system.
- Investment costs of one conventional large nuclear reactor is between 7 to 9 Billion dollars. This amount of financial commitment would be a significant fraction of many power producer’s assets or market capitalization.

President’s budget request includes $39 million for a new program for small modular reactors.

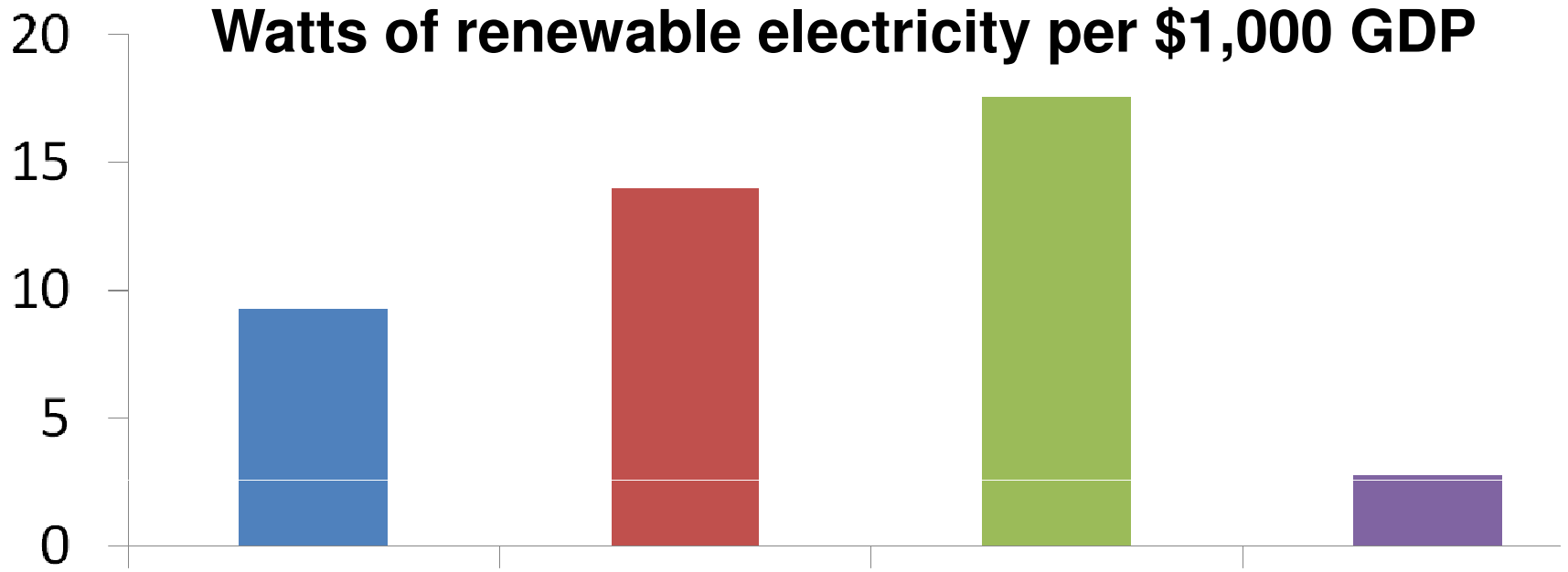
To achieve our clean energy goals, we need rapid, large-scale deployment of technology.

Technology deployment requires investment.

Investment flows toward opportunities for profit.

Market opportunities are structured by policy.

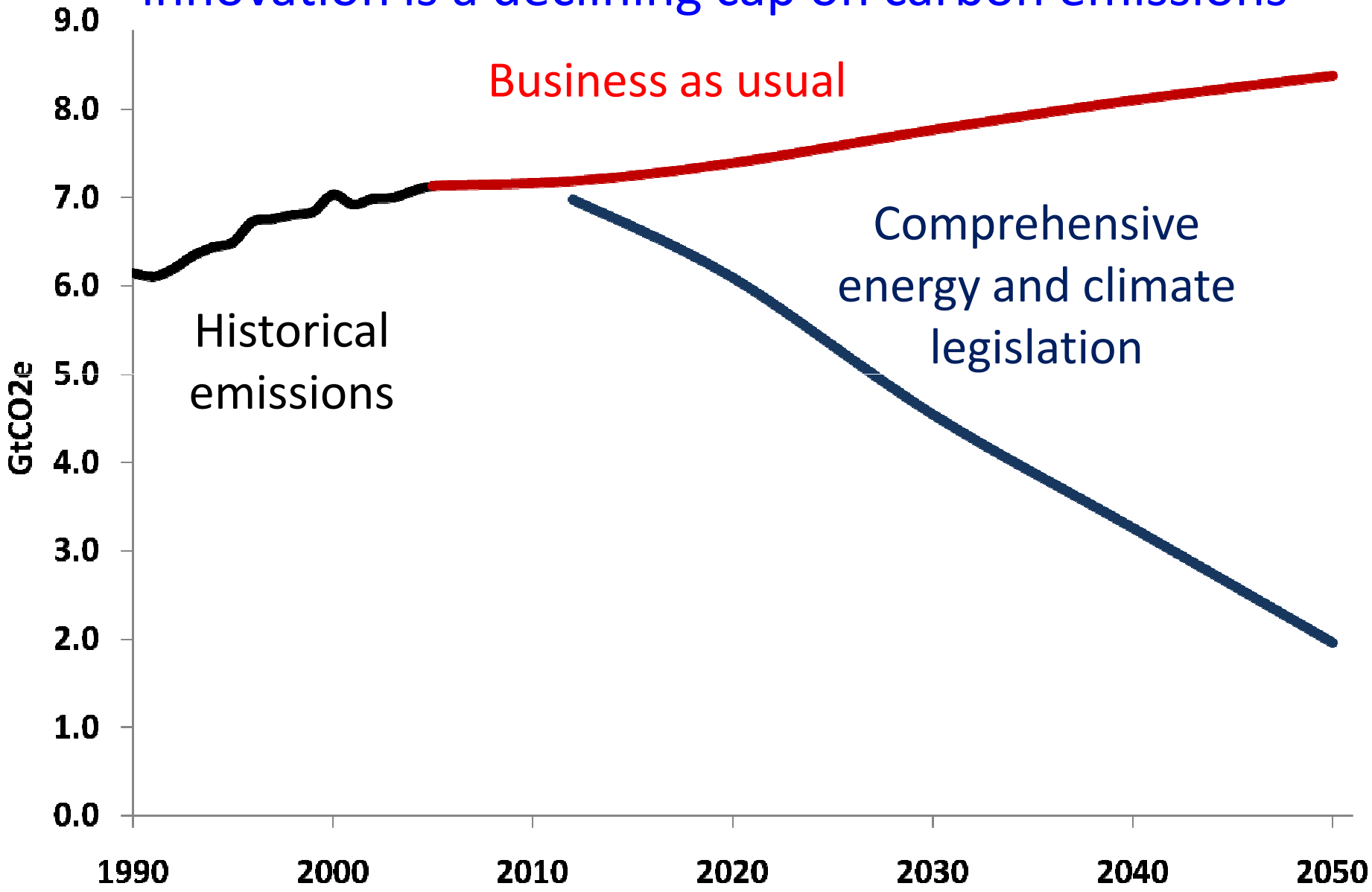
Strong policies drive clean energy investment



	Germany	Spain	China	United States
Policies include:	Carbon cap	Carbon cap	Renewable electricity standard	?
	Green Bank	National efficiency target	Feed-in tariffs	
	Renewable electricity standard	Feed-in tariffs	Tax incentives	

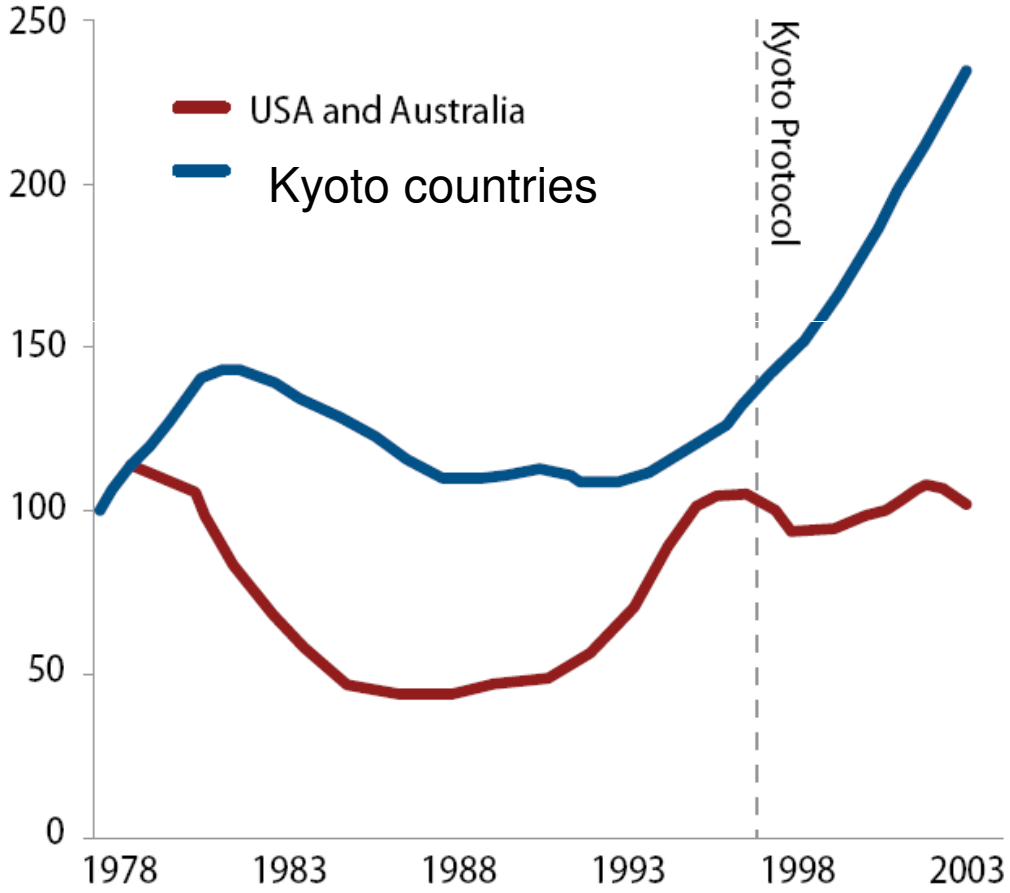
Source: REN 21; IMF, Center for American Progress

The most important policy that will stimulate innovation is a declining cap on carbon emissions



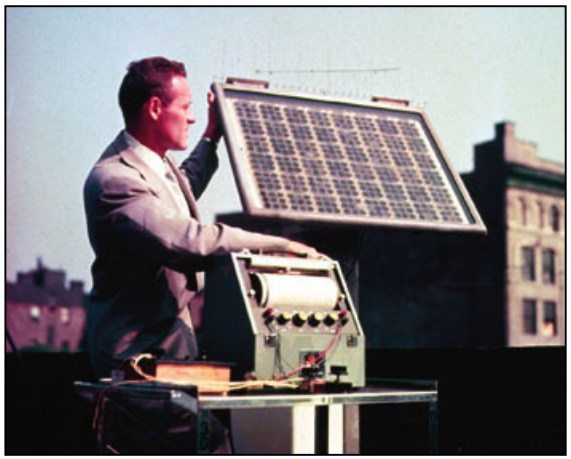
Market clarity sparks innovation

"Green" patents in Kyoto Protocol countries compared to US and Australia (did not ratify Kyoto)



Source: CERNA Research Program on Technology Transfer and Climate Change

The U.S. innovation machine is the greatest in the world. We can lead the world in the transition to sustainable energy



Bell Labs solar cell - 1954

First transistor

Pentium CPU

Ted Maiman and the first laser - 1961

NAVSTAR GPS satellite

Scientists have come to the service of our country in times of National need.

Los Alamos

MIT's Radiation Laboratory (Now Lincoln Labs)

Metallurgical Laboratory, Univ. of Chicago

Energy Innovation Hubs

Large, multi-disciplinary, highly-collaborative teams of scientists and engineers working toward a high priority goal:

Fuels from sunlight

Energy efficient buildings

Computer simulation of nuclear reactor designs

Batteries and energy storage (proposed FY2011)

U.S. DEPARTMENT OF ENERGY

Earthrise from Apollo 8 (December 24, 1968)

"We came all this way to explore the moon and the most important thing is that we discovered the Earth.“

Bill Anders, Apollo 8 Astronaut

“If you don't know where you're going, you might not get there.”

“When you come to a fork in the road, take it.”