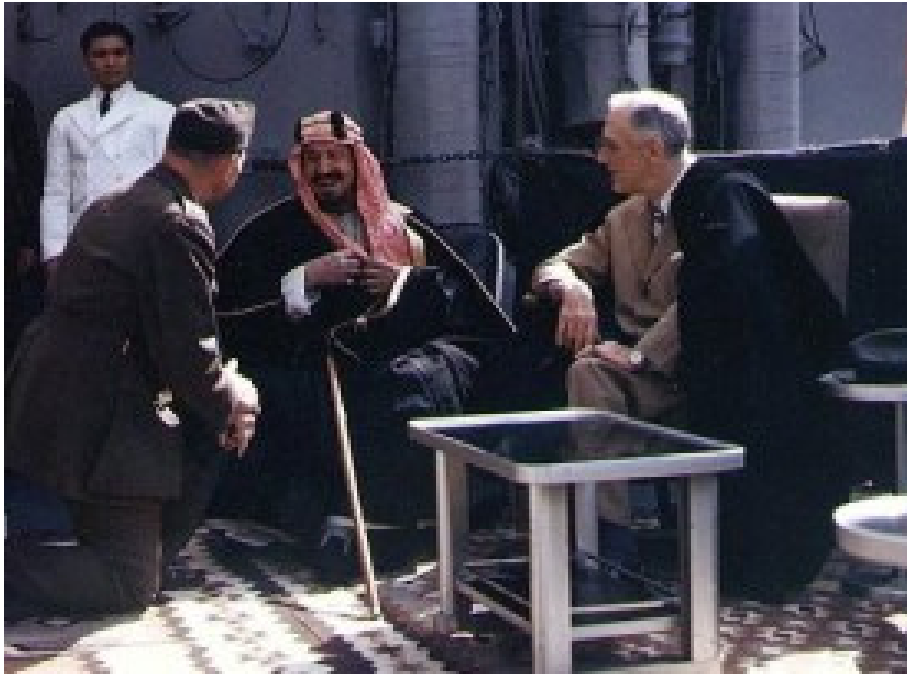


# Solving the Energy and Climate Challenge Together

Secretary Steven Chu  
International Energy Forum  
Riyadh, Saudi Arabia  
22 February 2010

# King Faisal Prize Winners, 1993





Saudi King Abdul Aziz Al Saud and President Franklin Delano Roosevelt on the USS Quincy 65 years ago

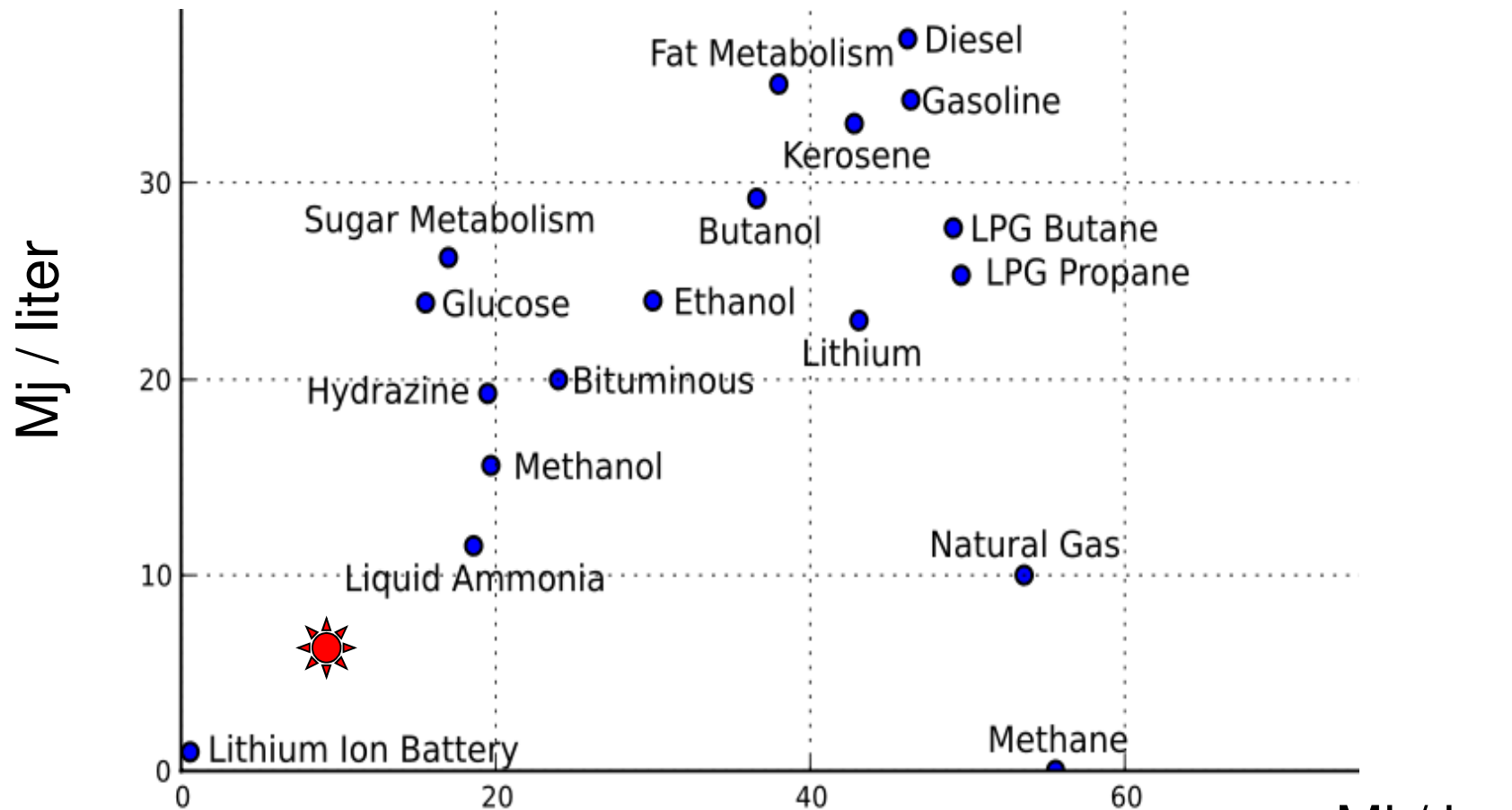
The United States of America and Saudi Arabia have a long and deep relationship

We are adding a new dimension to our relationship – as we move to meet shared energy and climate challenges

# The Energy and Climate Challenge

- (1) The global economy needs energy resources.
- (2) Our long-term economic prosperity is tied to the sustainable use of energy.
- (3) There are risks of adverse climate change for both our countries.
- (4) We don't have the luxury of focusing only on the short run or the long run; we must address both.

# Energy densities of chemical fuels and the best commercial battery



Body Fat

38 MJ/kg

35 MJ/liter

Kerosene, jet fuel

43 MJ/kg

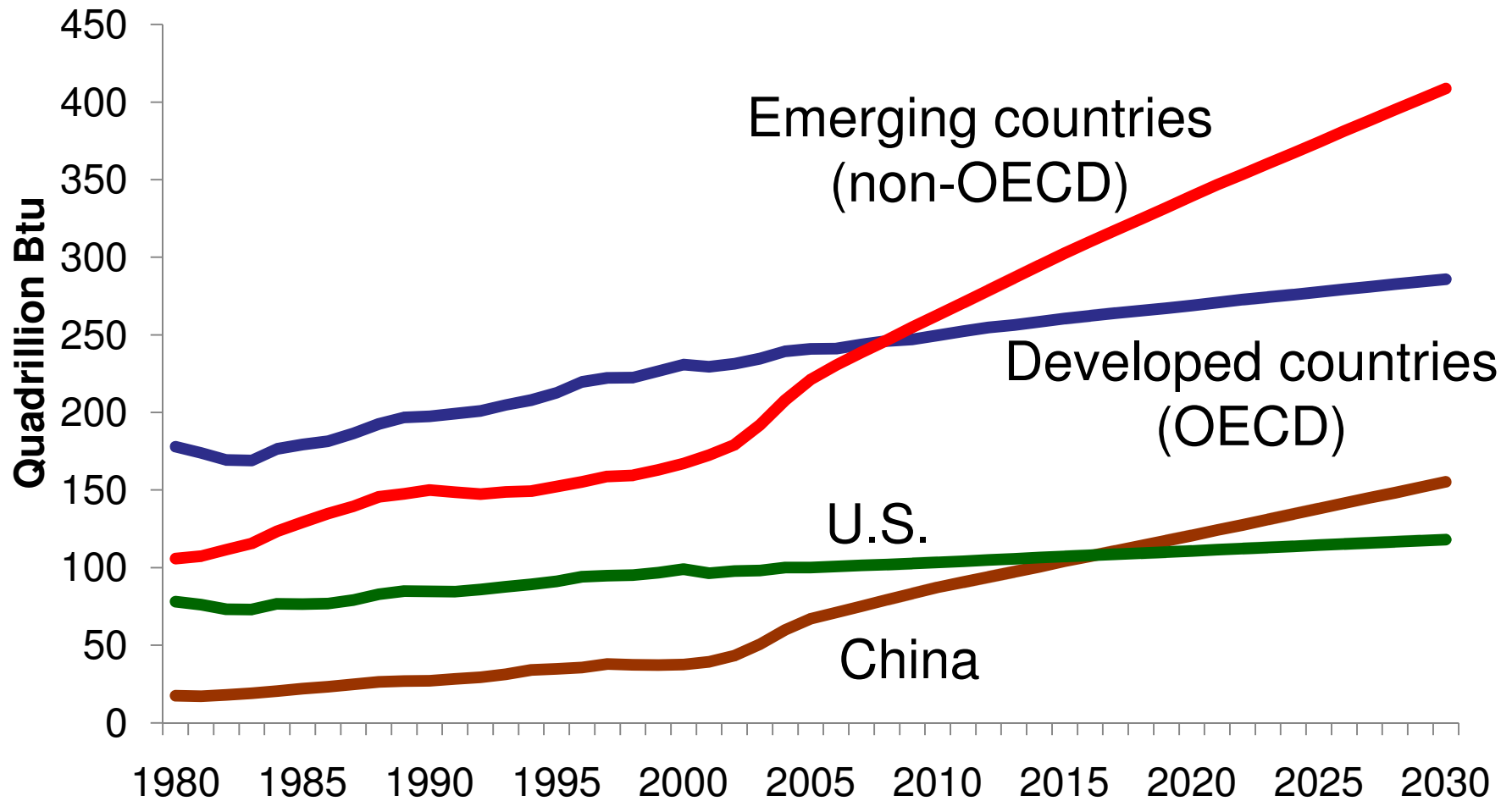
32 MJ/liter

Lithium ion battery

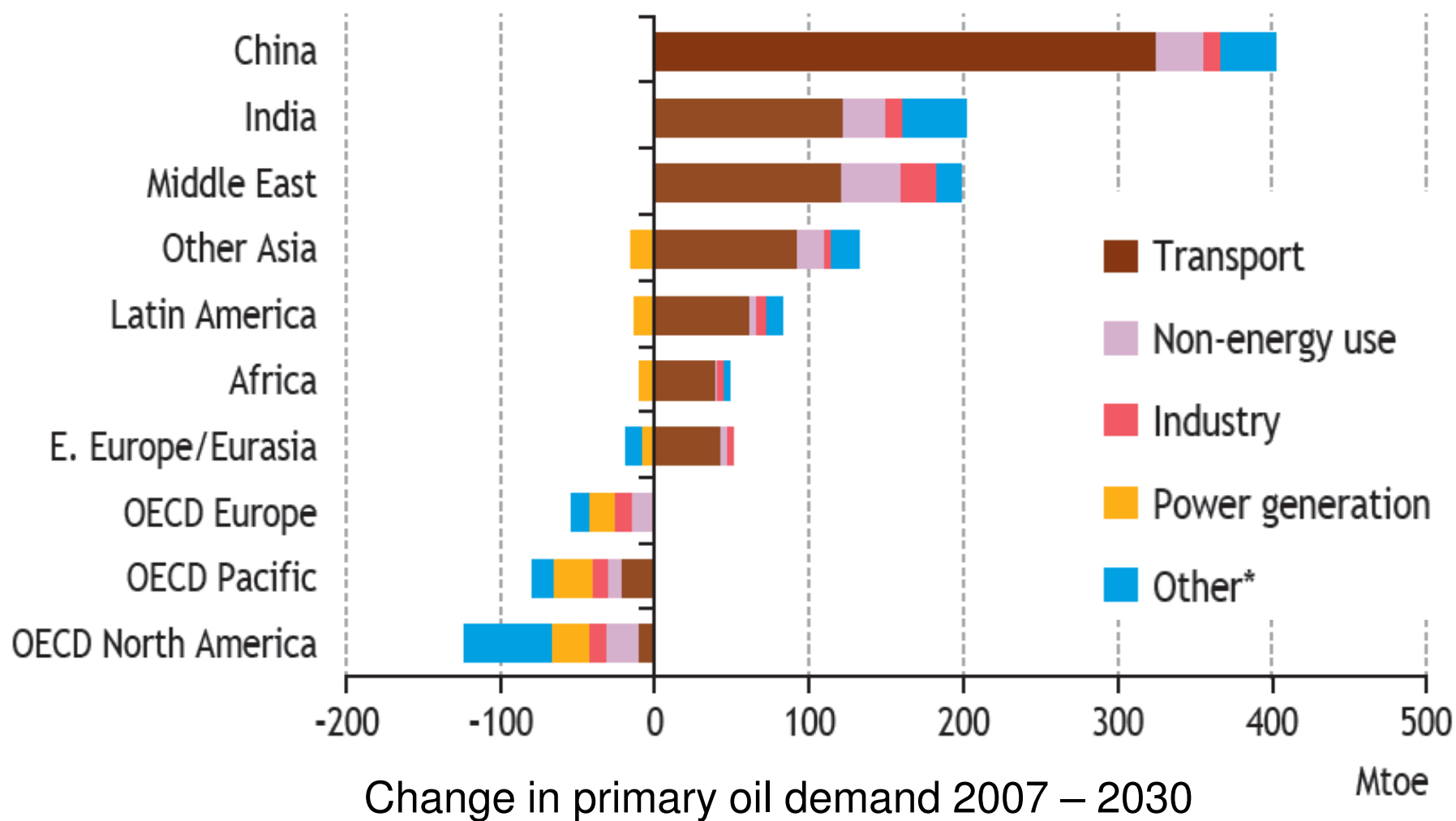
0.54 MJ/kg

0.9 MJ/liter

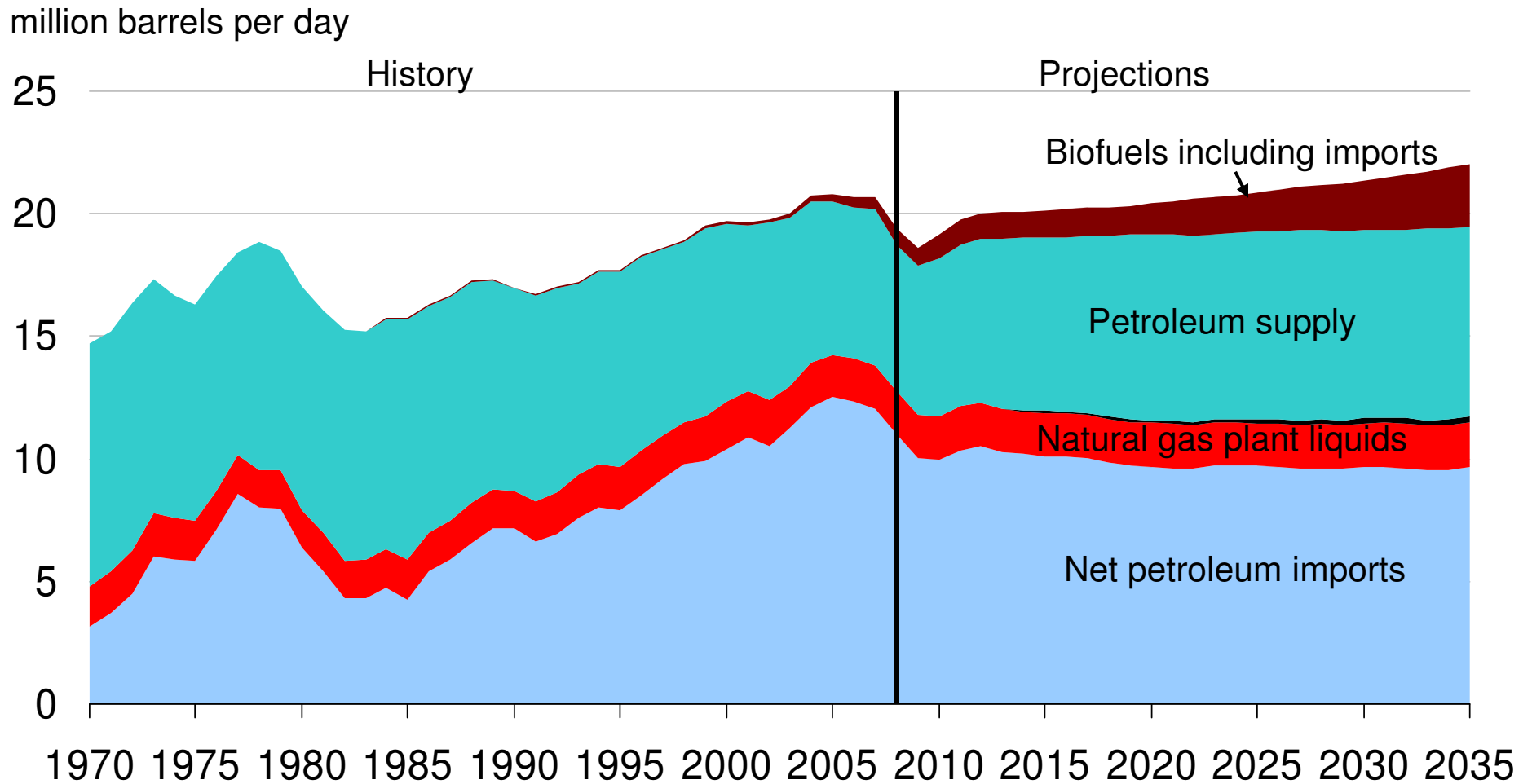
# Energy demand from emerging countries is increasing dramatically



## Huge growth in oil demand is projected from the developing world

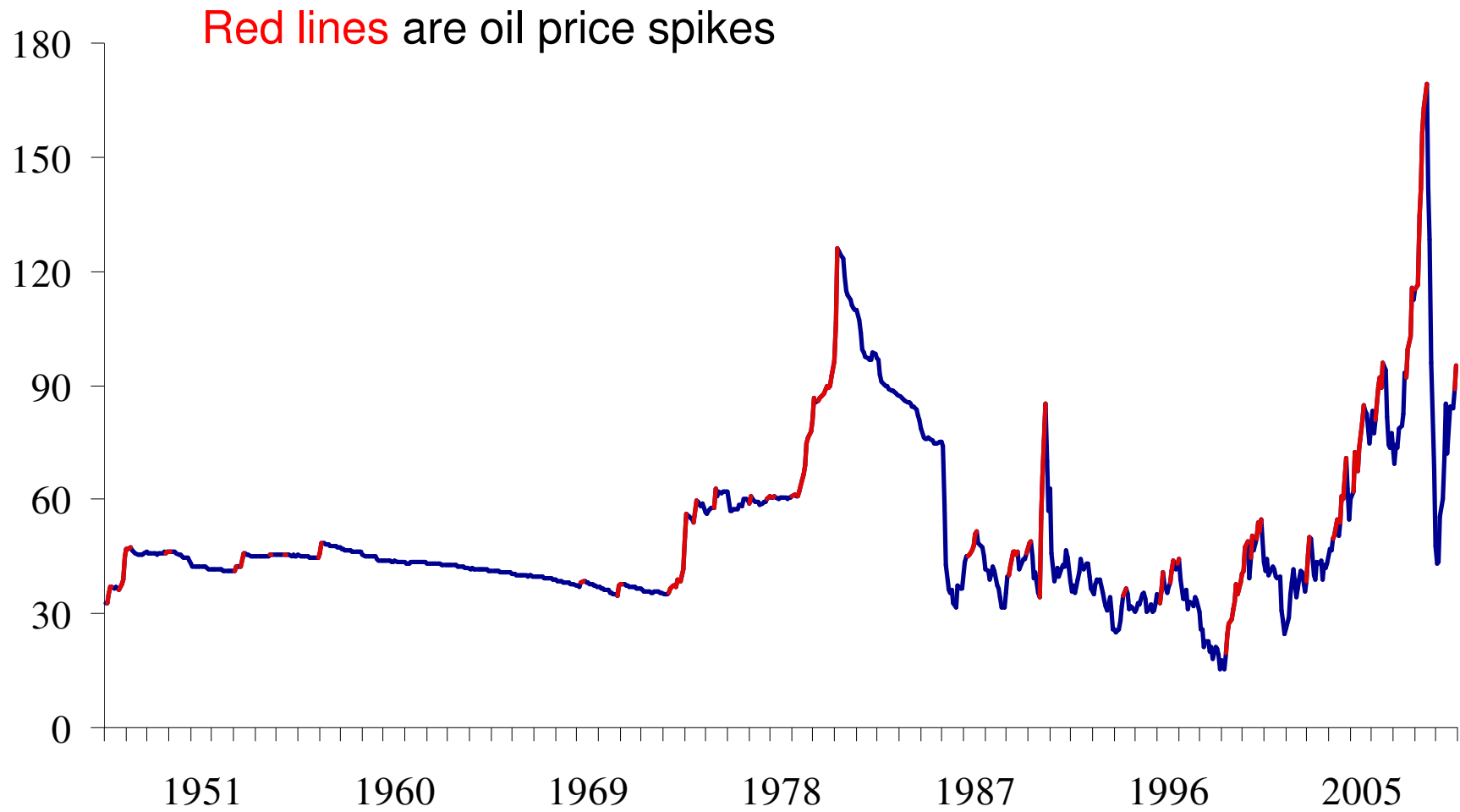


# Energy Information Administration Outlook 2010: Biofuels meet most of the growth in U.S. liquid fuels supply





# Global economic health is affected by the price of oil



Real Oil Price Index, 1982=100

# Oil prices relate to many uncertain factors



# The International Energy Forum can serve the interests of both producers and consumers

Fosters informal dialogue



Promotes exchanges among technical experts policymakers, and businesspeople

Focuses on transparency

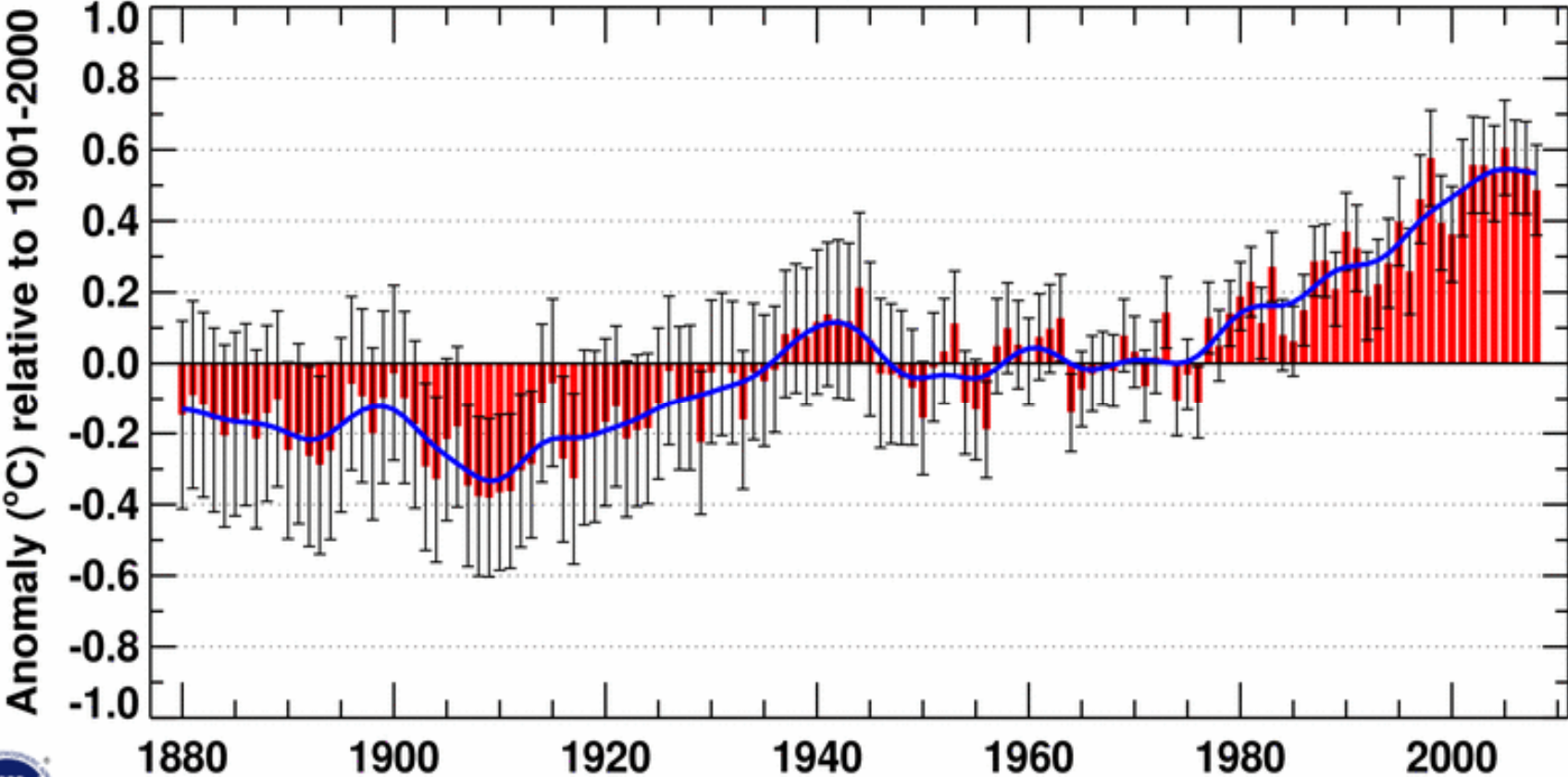


We greatly value the Joint Oil Data Initiative

We also need a new dimension to  
our shared energy future.

Why?

# Climate Change is real: the temperature record from 1880 – 2008.



NCDC/NESDIS/NOAA

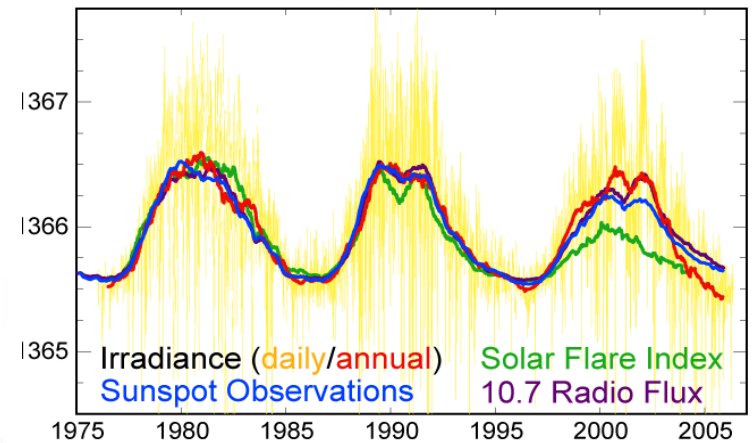
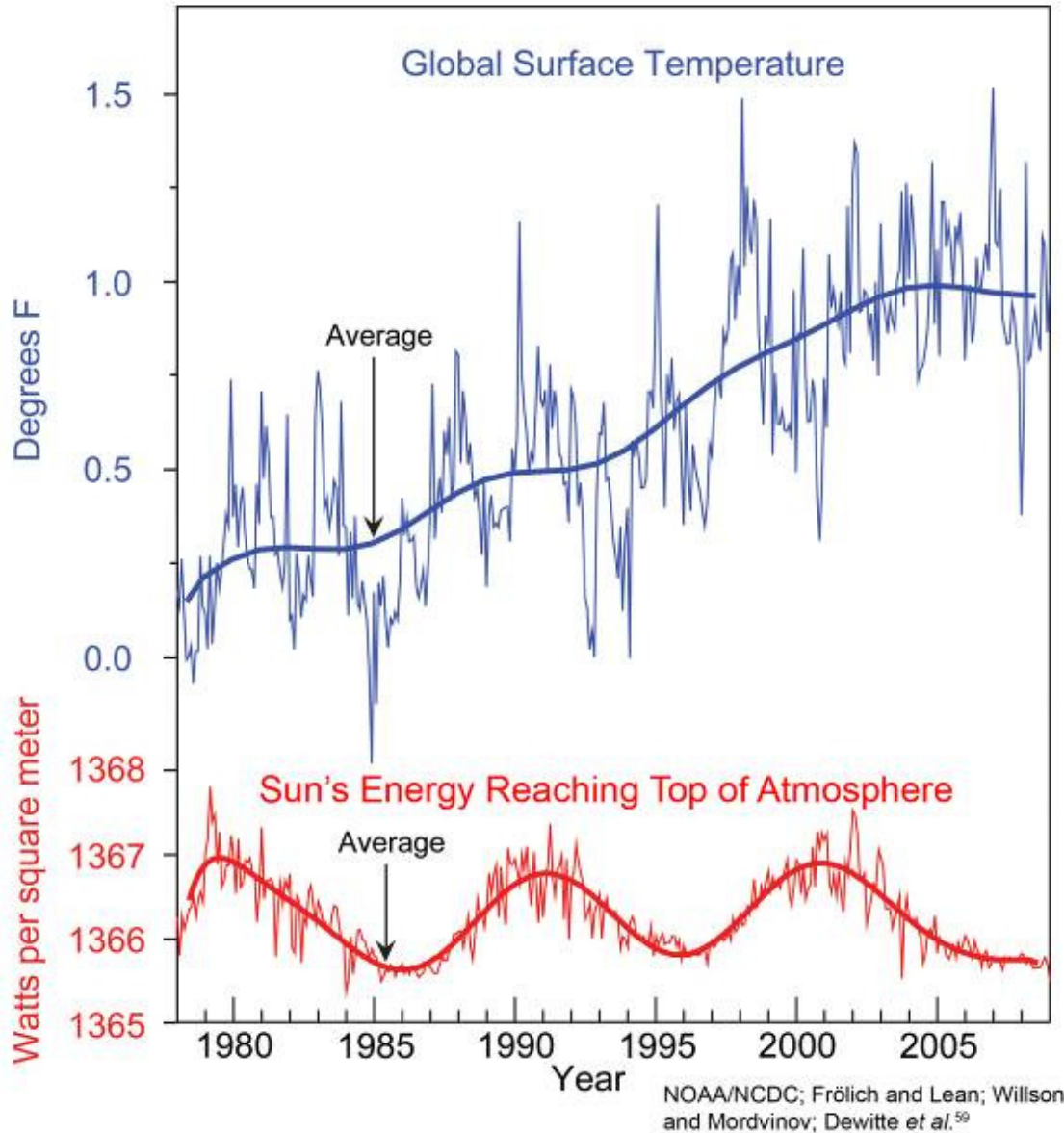
Can the rise in temperature be due to an increase in solar energy reaching Earth?

What about **Sun Spots**?

**Sunspots (blue)**

**Solar flares (green)**

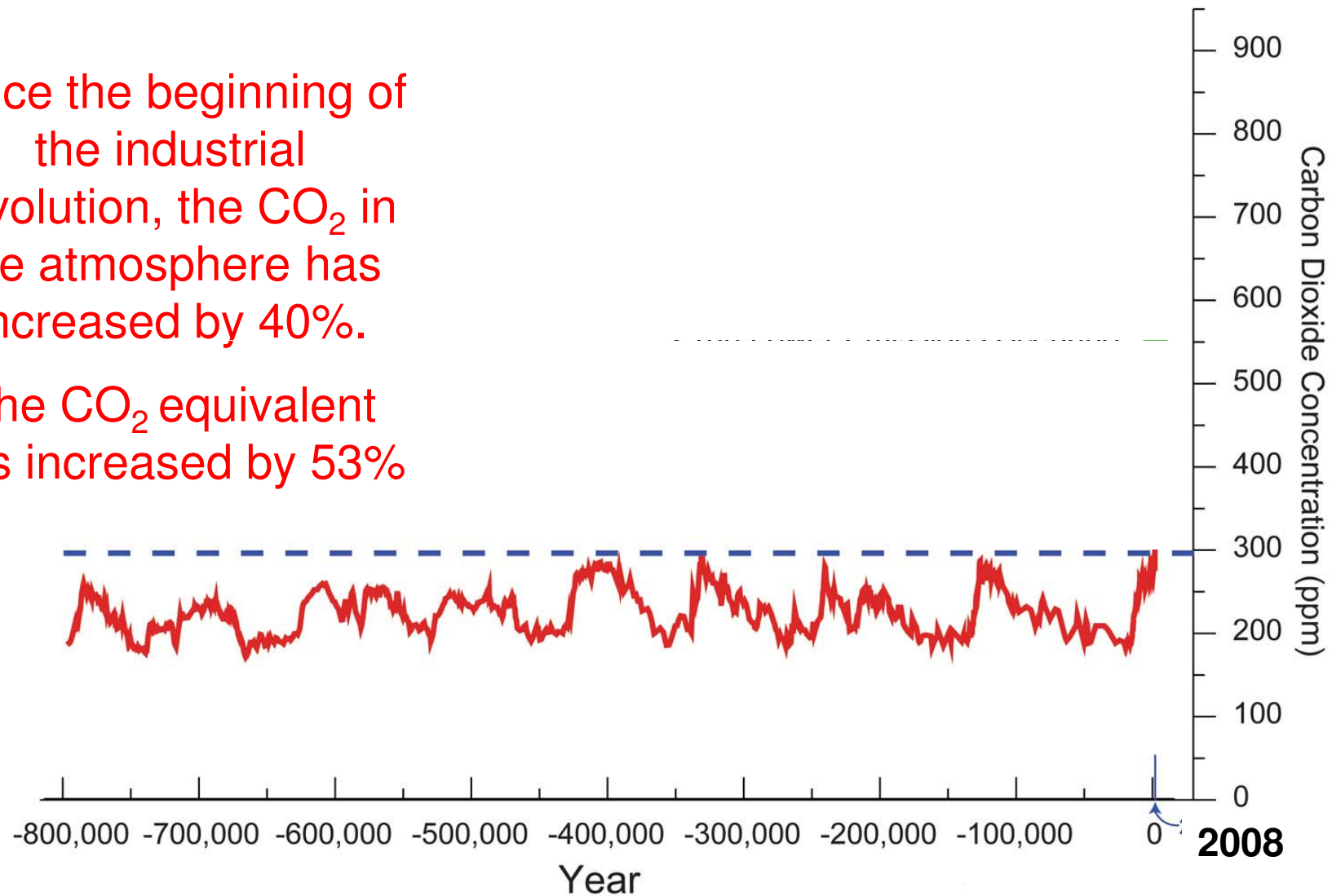
**Radio emissions (purple)**



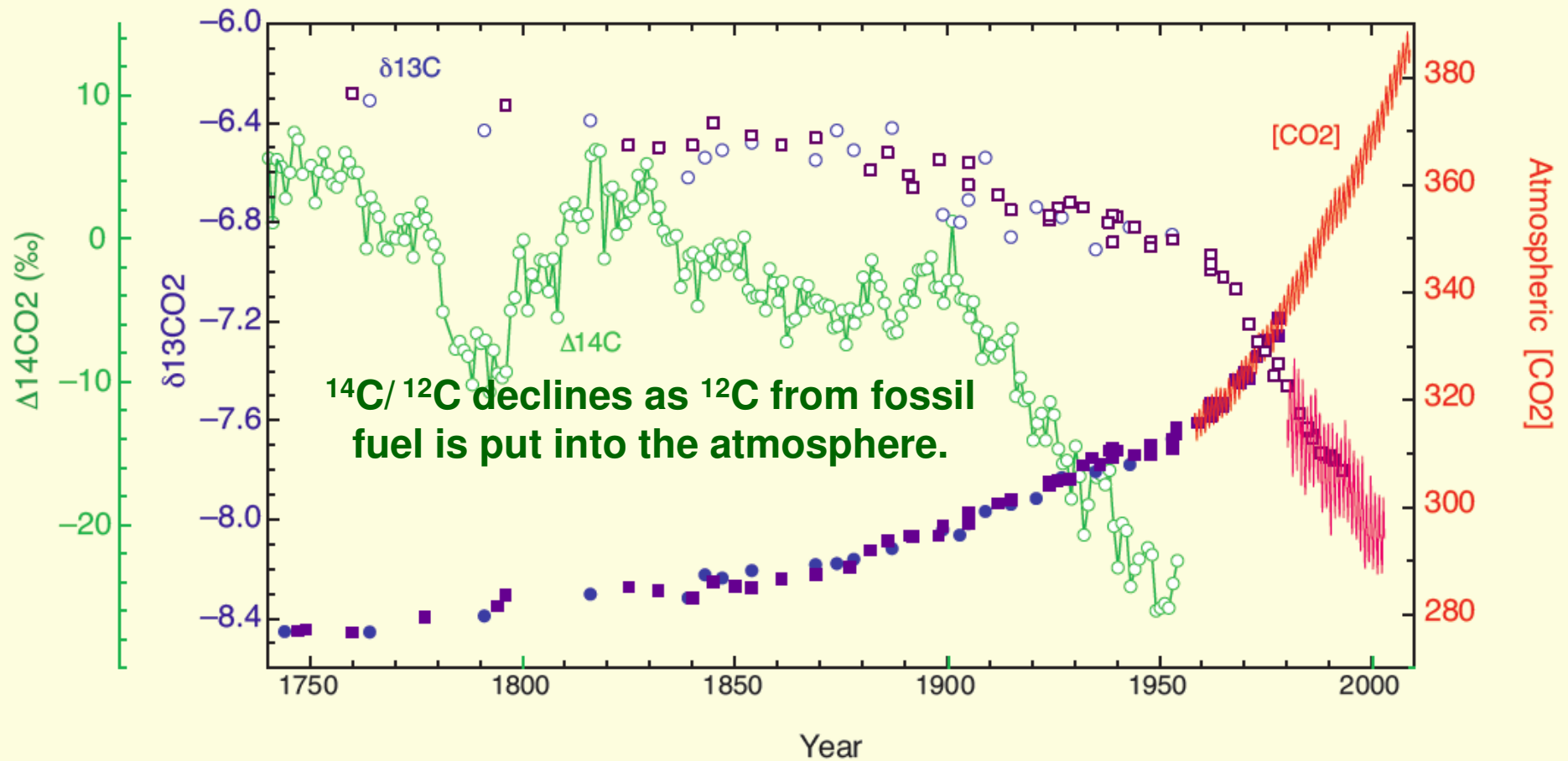
# Carbon Dioxide Concentration during the past 800,000 years

Since the beginning of the industrial revolution, the CO<sub>2</sub> in the atmosphere has increased by 40%.

The CO<sub>2</sub> equivalent has increased by 53%



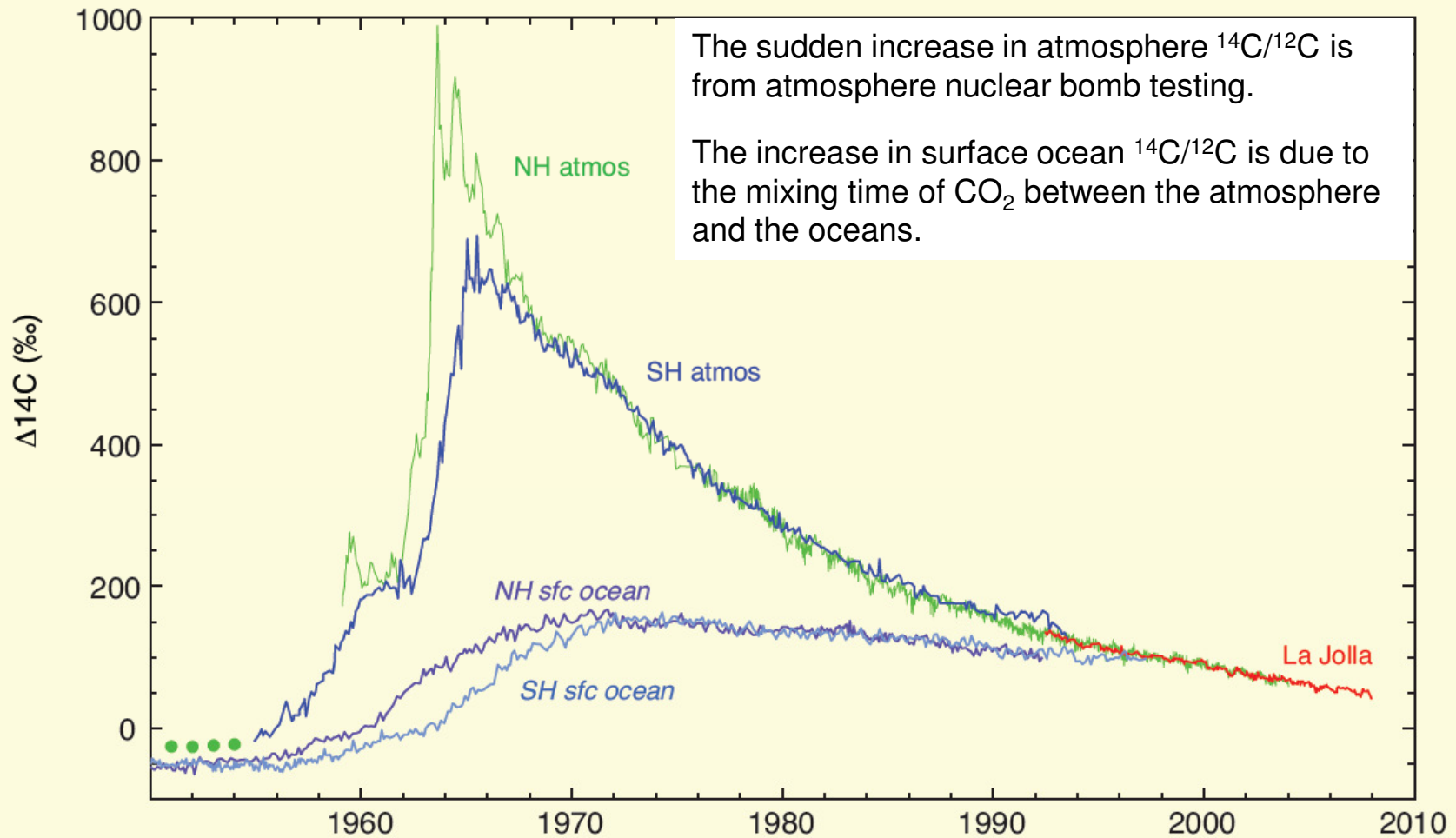
## Atmospheric CO<sub>2</sub> and the Suess Effect on <sup>13</sup>C and Δ<sup>14</sup>C



<sup>14</sup>C, produced through cosmic-ray bombardment, is incorporated into plants and animals. The half-life of <sup>14</sup>C is 5,730 years. Organic material buried for millions of years no longer contains <sup>14</sup>C.



# Post 1950 Atmosphere and Surface Ocean $\Delta^{14}\text{C}$ History



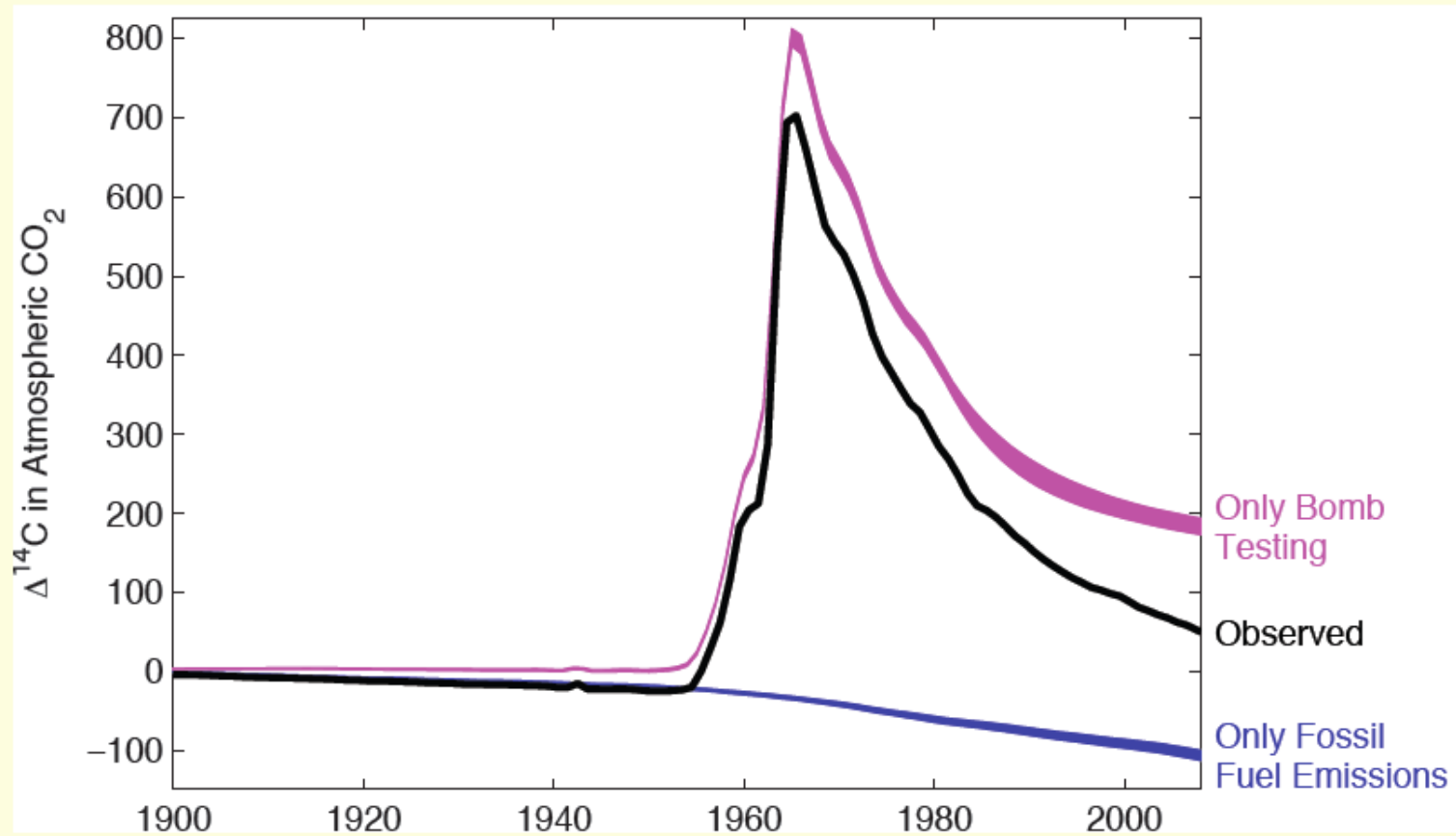
Atmosphere

Subtropical Surface Ocean

- Germany/Austria [Levin, assorted]
- Wellington NZ [Manning *et al.*, ]
- La Jolla (CA) [Graven *et al.*, *in prep*]
- NH annual [Stuiver and Quay, 1981]

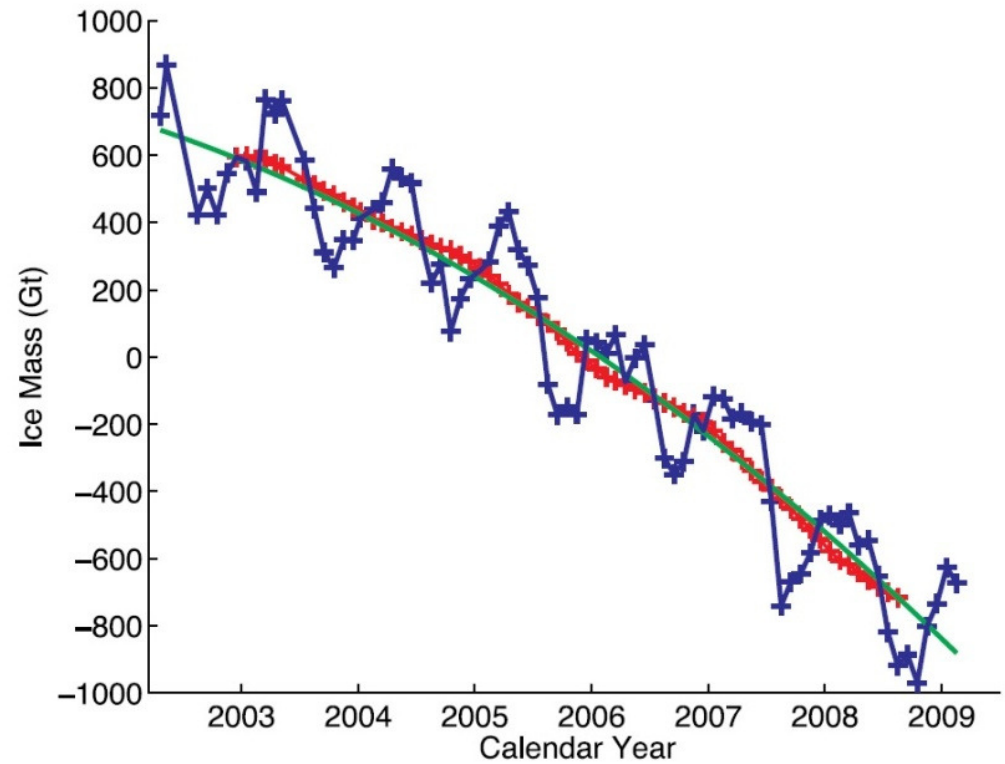
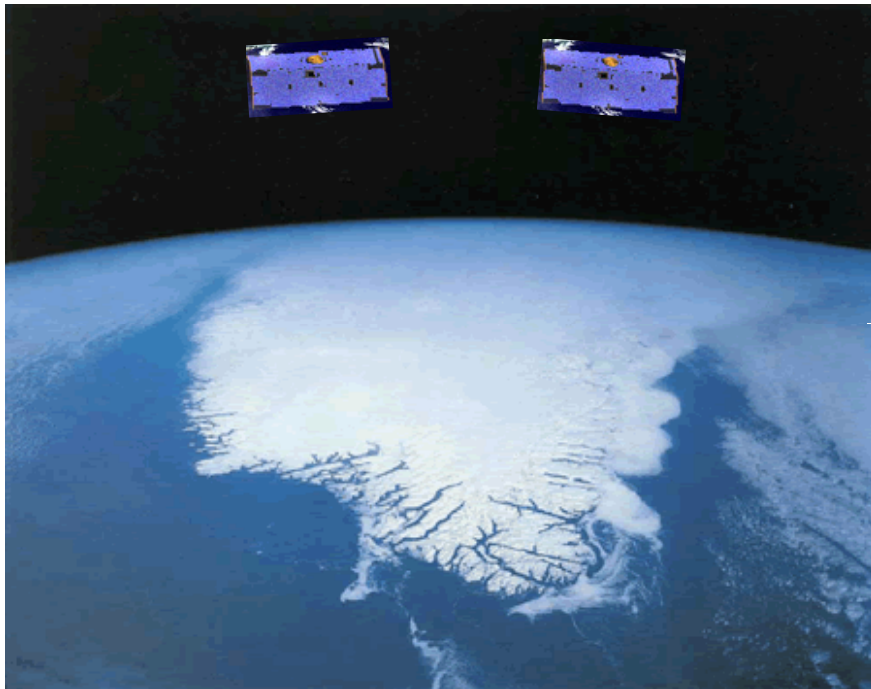
- North Pacific gyre [Guilderson *et al.*, *in prep*]
- South Pacific gyre [Guilderson *et al.*, 2000]

# $\Delta^{14}\text{C}$ of the Atmosphere: With and Without Fossil Fuel Emissions



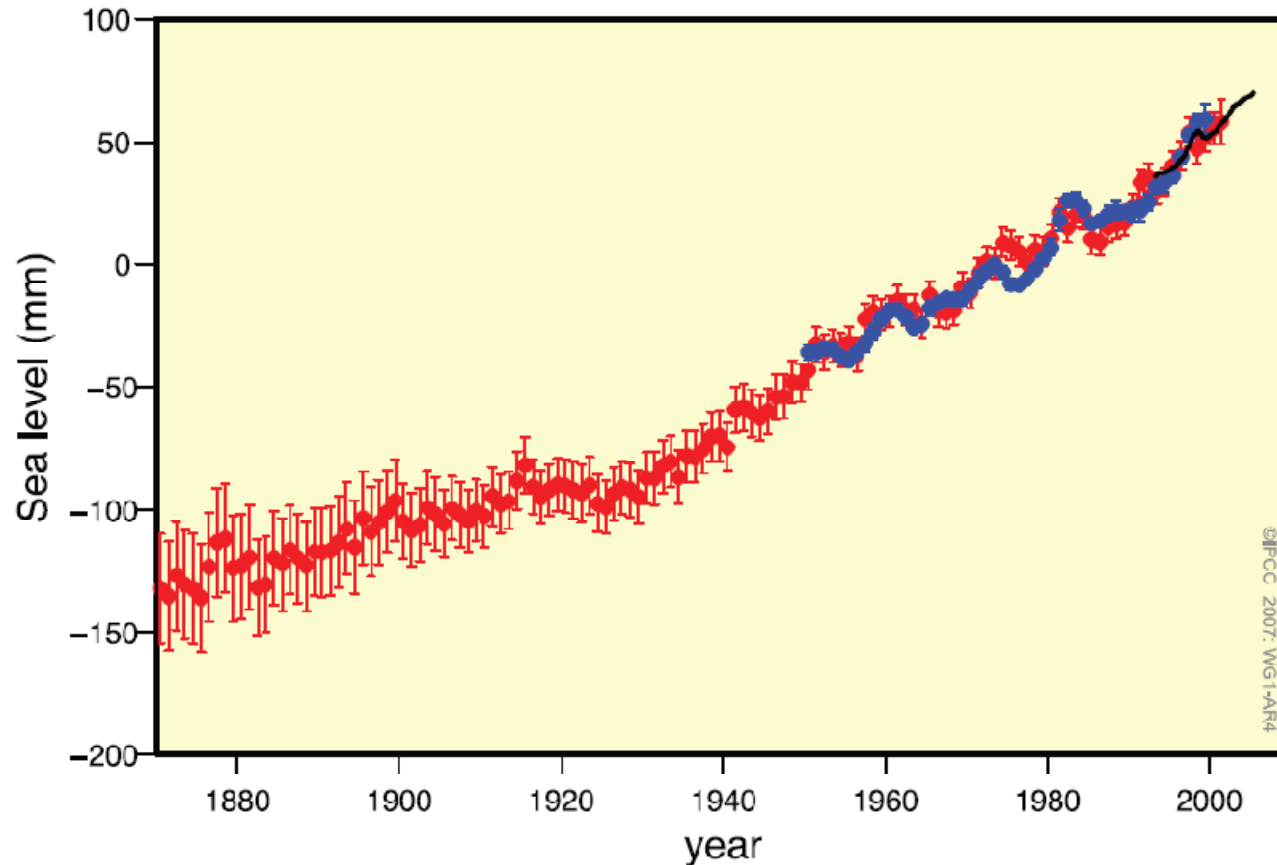
# Greenland Ice Mass Loss – 2002 to 2009

Ice mass loss from the Greenland and Antarctic ice sheets measured by **GRACE** (Gravity Recovery and Climate Experiment) mission.



I. Velicogna, *GEOPHYSICAL RESEARCH LETTERS*, VOL. 36, L19503, doi:10.1029/2009GL040222, 2009

# Global Sea Level: 2007 IPCC Technical Summary



Past 2000 years: 0.0 - .02 mm/year

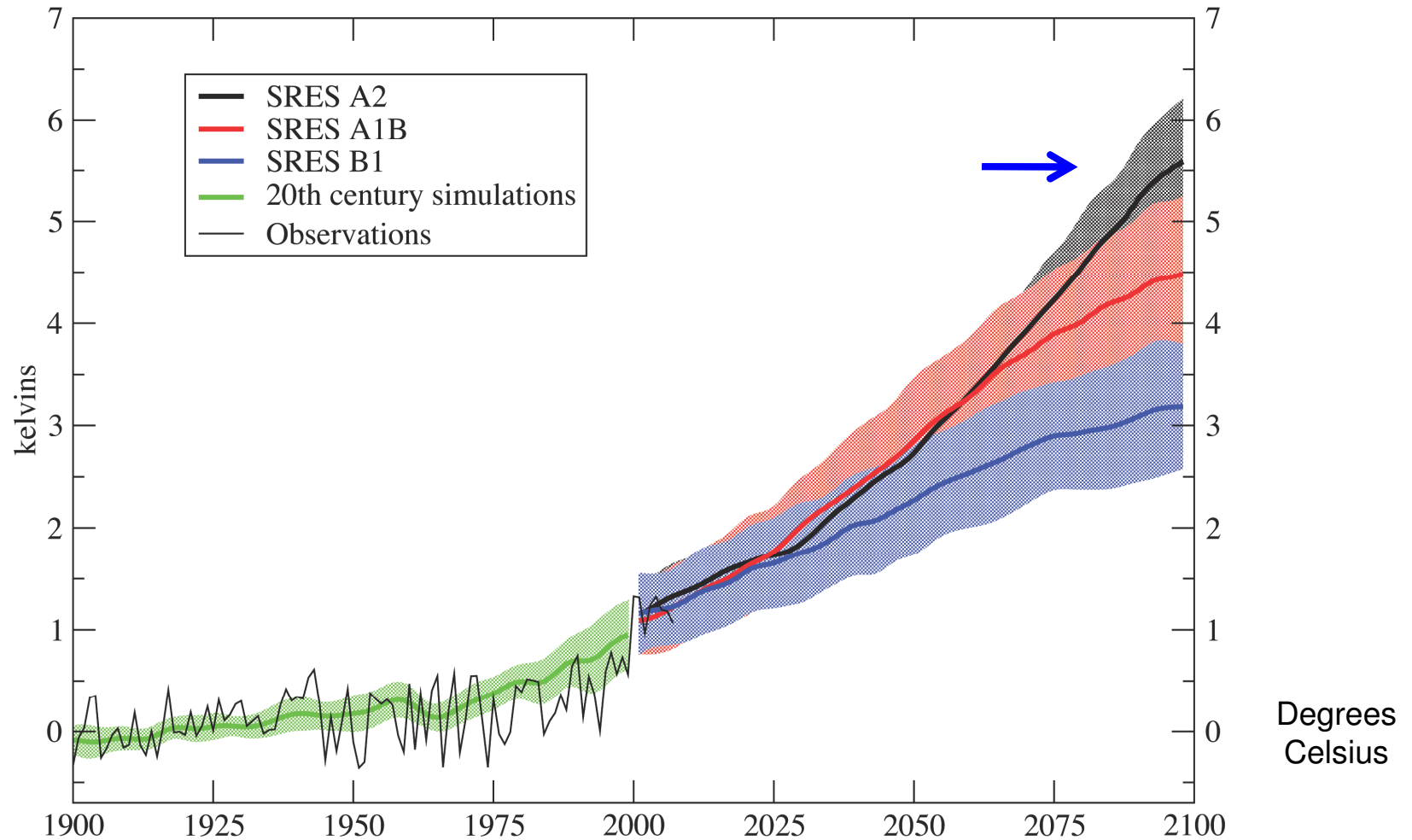
1870 – 1890: 0.6 mm/year

1990 – 2008: 3.0mm/year

(including recent satellite data)

If the world follows a “Business-as-usual” path, what do climate models predict will happen?

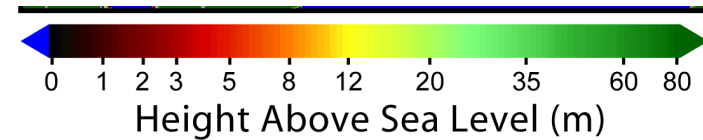
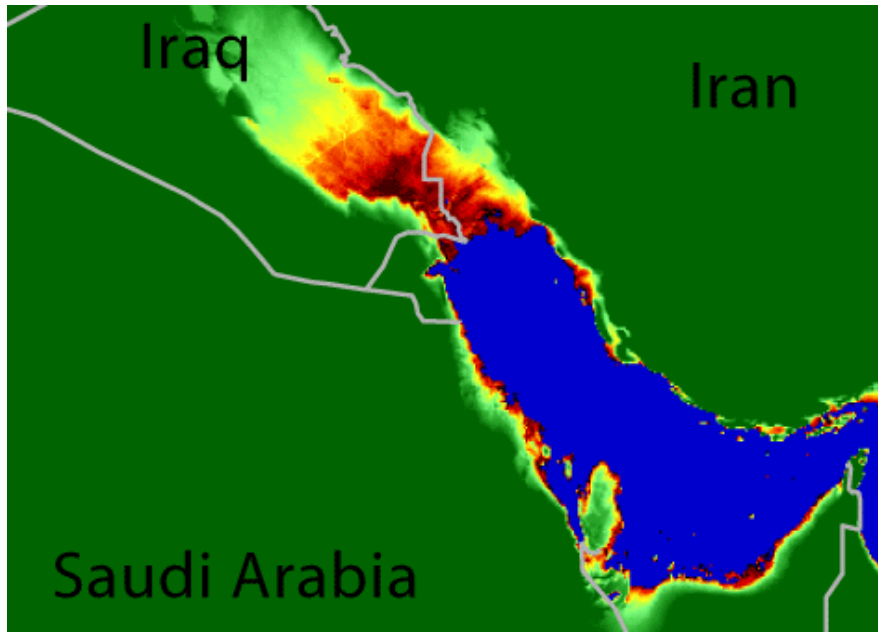
# No emission reductions: 5 – 6 degree Centigrade temperature increase in Saudi Arabia



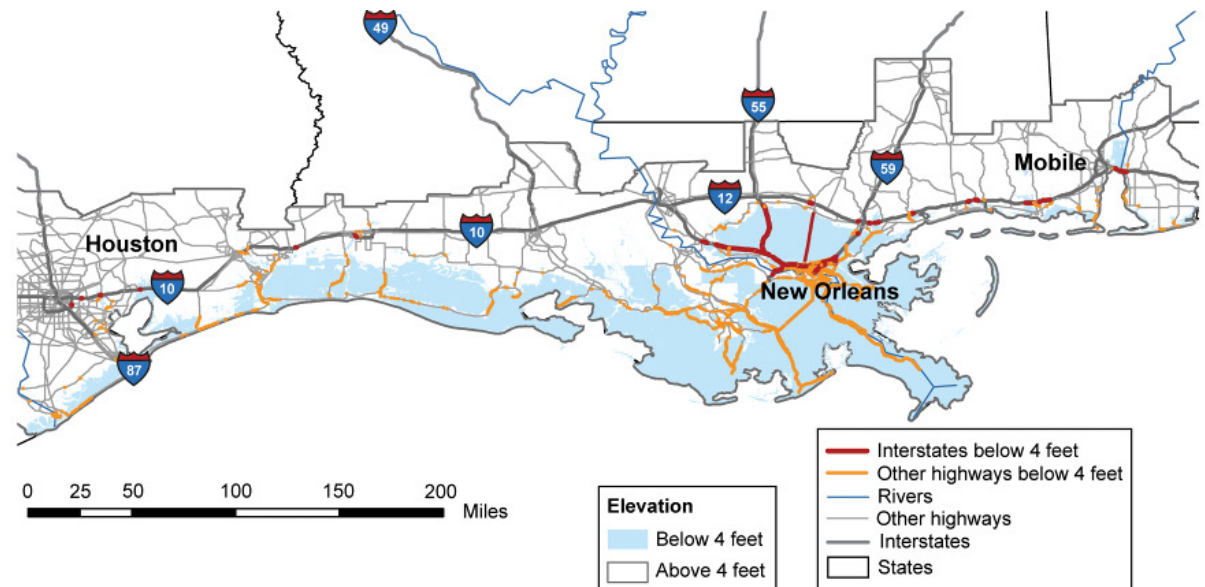
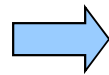
Surface air temperature change relative to 1900-1909 average

Saudi Arabia and surroundings

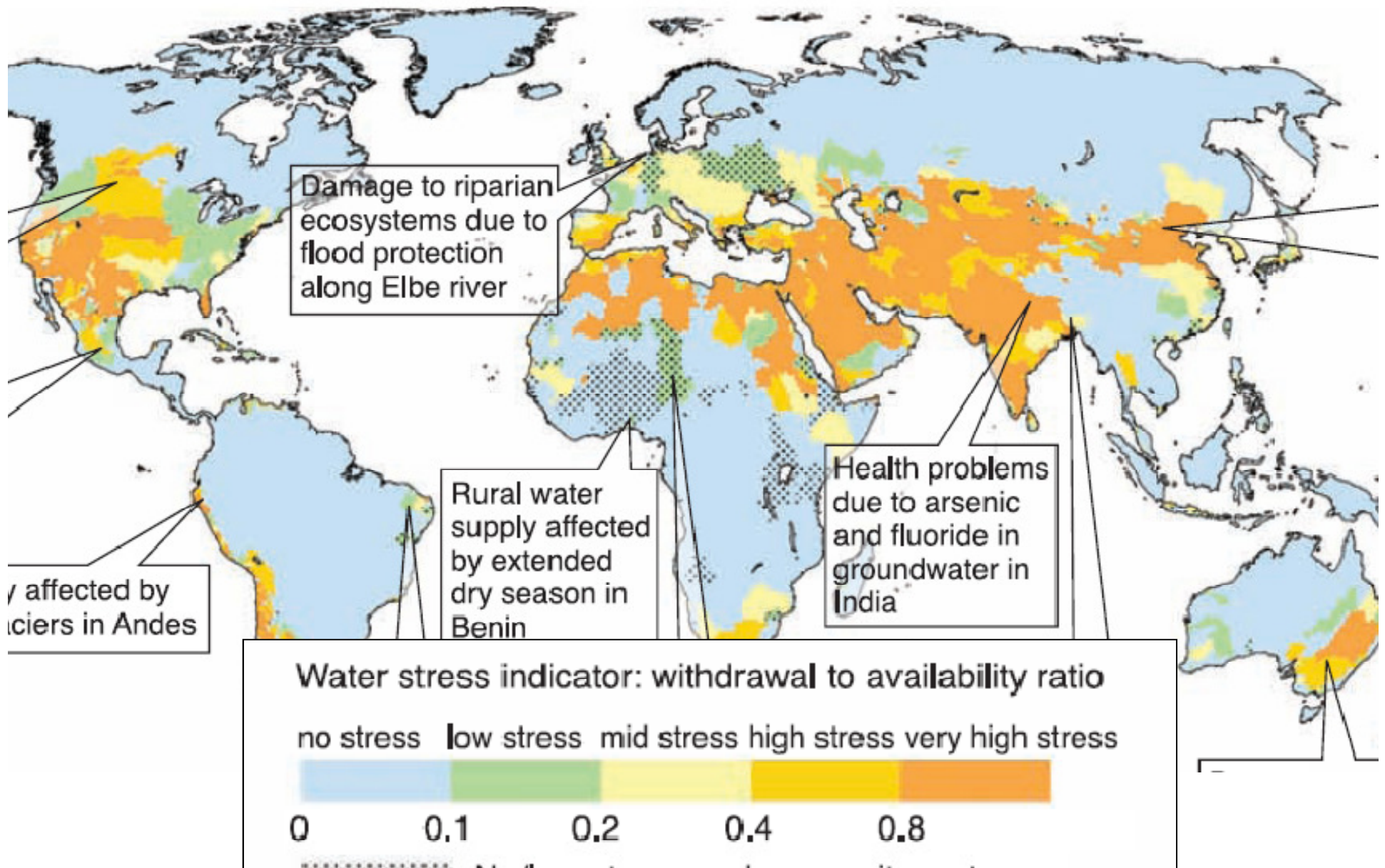
# Coastal areas at risk from sea-level rise



Areas in blue below 4 feet -- includes significant U.S. refining infrastructure

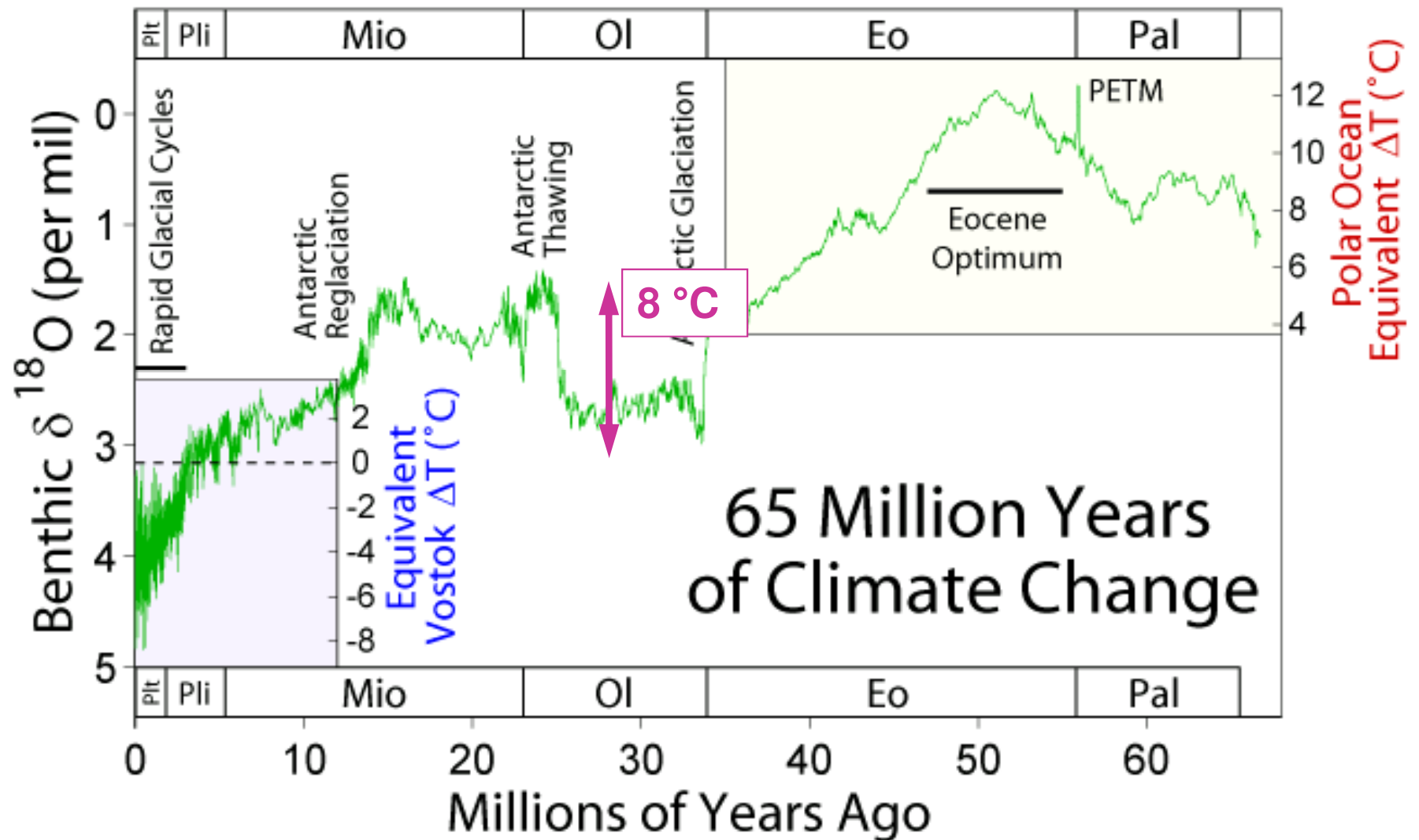


# Predicted water stress areas around the world





The world was warmer place 50 million years ago.



The world is on an unsustainable energy path.

Both of our countries know we need to diversify our energy mix.

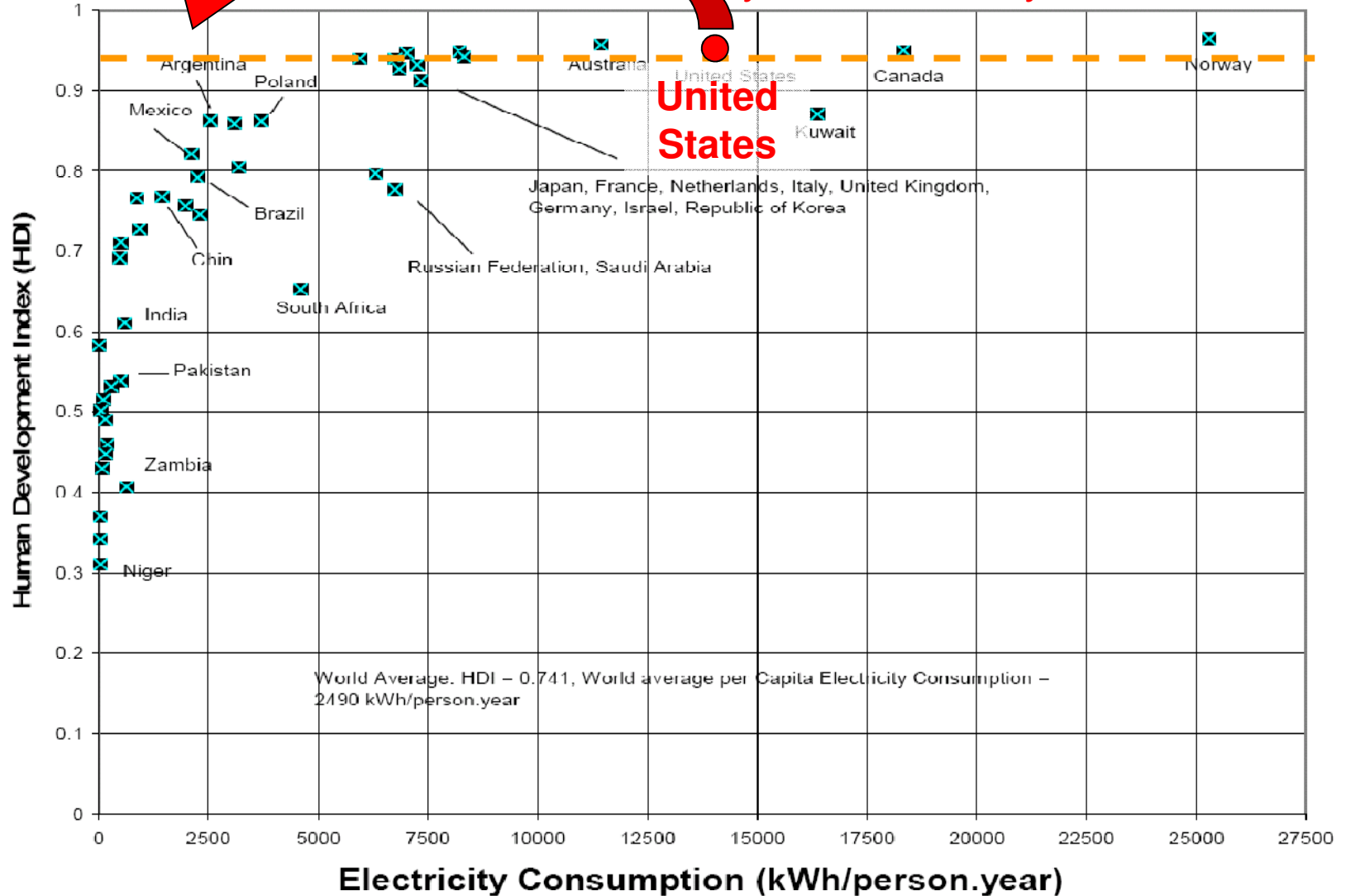
We must work together to find new solutions that benefit us all.

The first Industrial Revolution taught us that wealth creation through technology is not a zero-sum game.

There is no law of physics that says prosperity is proportional to carbon emissions.

# Human Development Index (GDP/capita, education level, health care, etc.) vs. Electricity Use

U.S. must reduce carbon emissions by at least 80% by 2050





# U.S. DEPARTMENT OF **ENERGY**

The Department of Energy is a  
***science-based*** agency

We have funded the work of more than  
100 Nobel Prize winners – more than any  
other organization in the world

President Obama's American Recovery and Reinvestment Act  
is making an **\$80 billion** down payment on a clean energy  
economy – with an **\$8 billion investment in innovation**

## We must work together

“It was innovation in Muslim communities that developed the order of algebra; our magnetic compass and tools of navigation; our mastery of pens and printing; our understanding of how disease spreads and how it can be healed.”



President Obama, Cairo, 4 June 2009



To inspire a new age of scientific achievement

Investing in human capital is critical for prosperity

We look forward to student exchanges and scientific cooperation

We must work together



مدينة الملك عبد العزيز  
للعلوم و التقنية KACST



U.S. DEPARTMENT OF  
**ENERGY**

Today, we are reaffirming the government-to-government science and technology agreement signed in 2008 between the U.S. and Saudi Arabia.

Priority areas include science and technology entrepreneurship, materials science, water purification, agriculture and biotechnology.

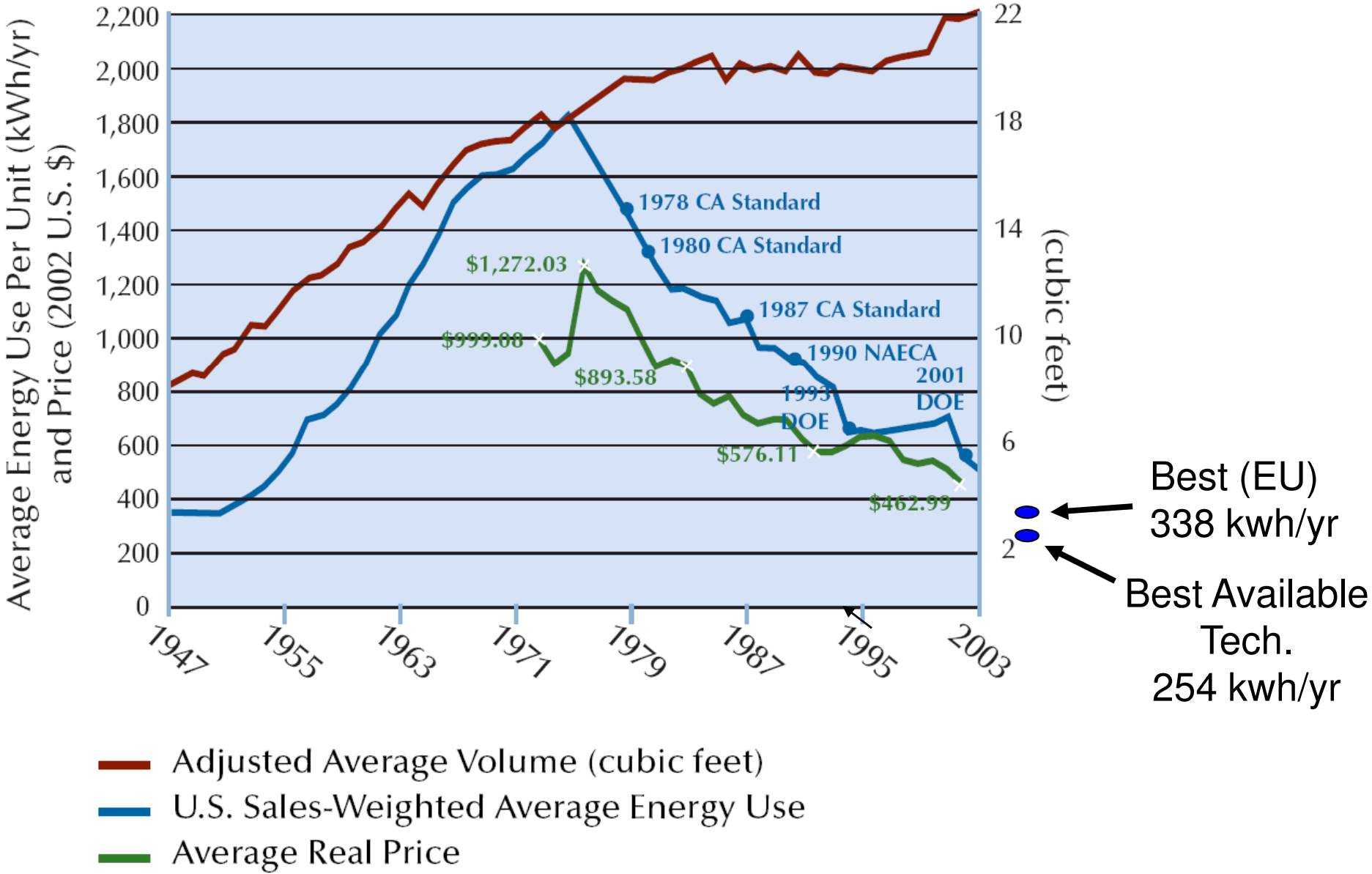
In the next few decades, energy efficiency and conservation will be the most effective tools.

“I strongly believe that a core feature of any energy strategy must be policies to promote increased energy efficiency and conservation.”

Minister Ali Al-Naimi

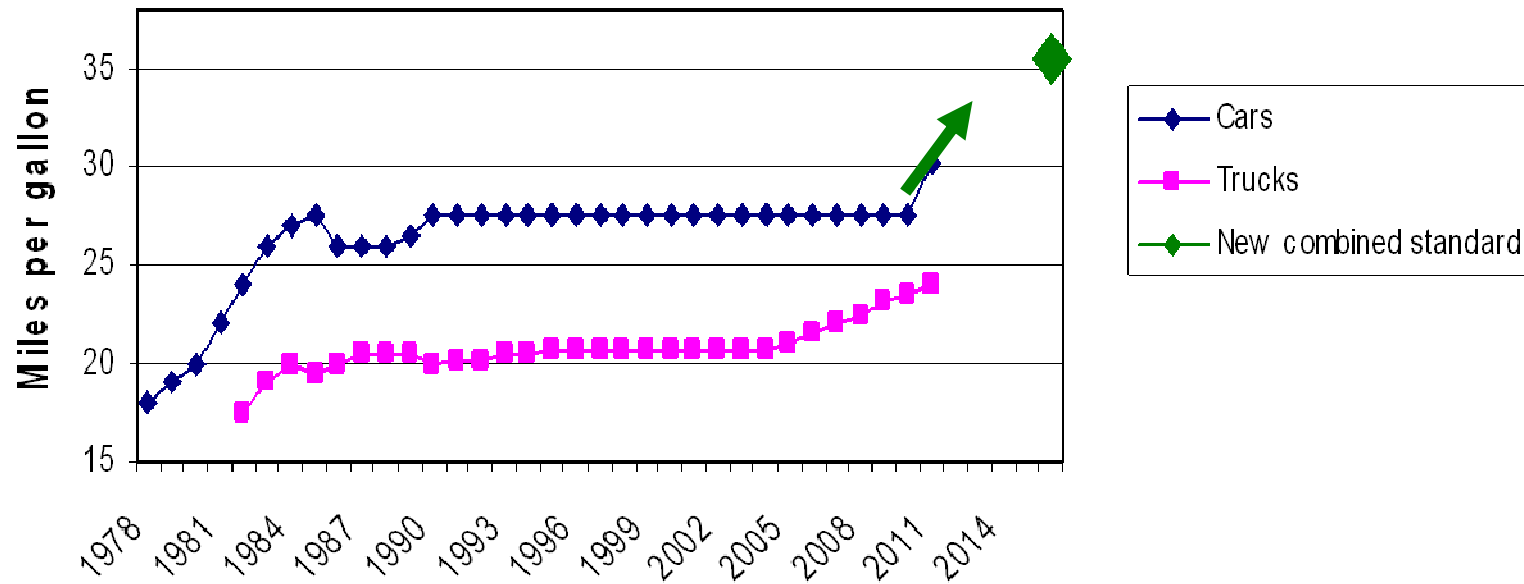


# Energy savings is greater than *all* of US solar and wind energy generation



President Obama announced a new U.S. automobile and light truck fuel standard -- **35.5 mpg by 2016**

## U.S. Fuel Economy Standards



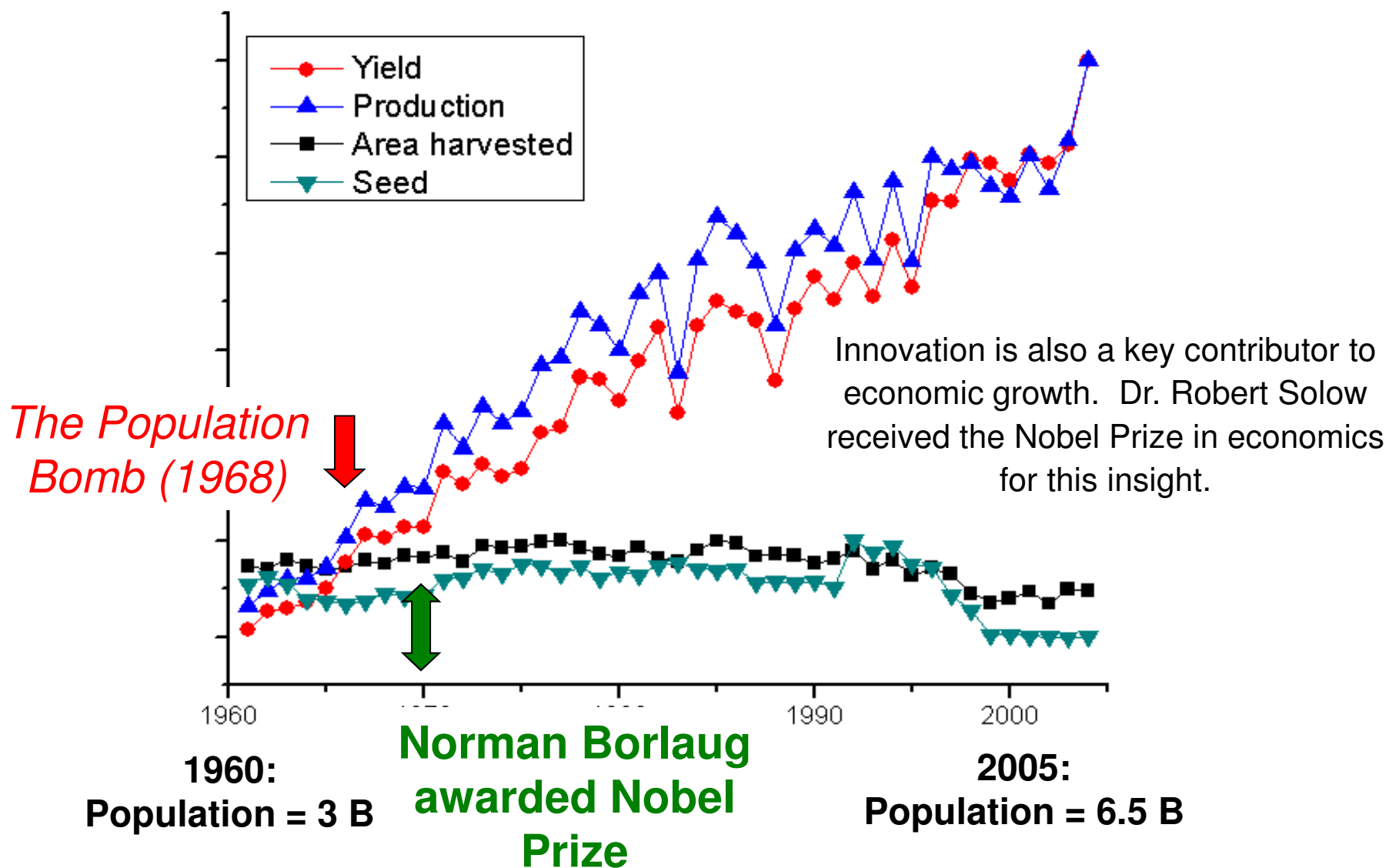
We're investing in advanced combustion engines

\$186 million in R&D to raise the fuel economy of trucks and light-duty engines

Science and Technology has given us solutions in the past.

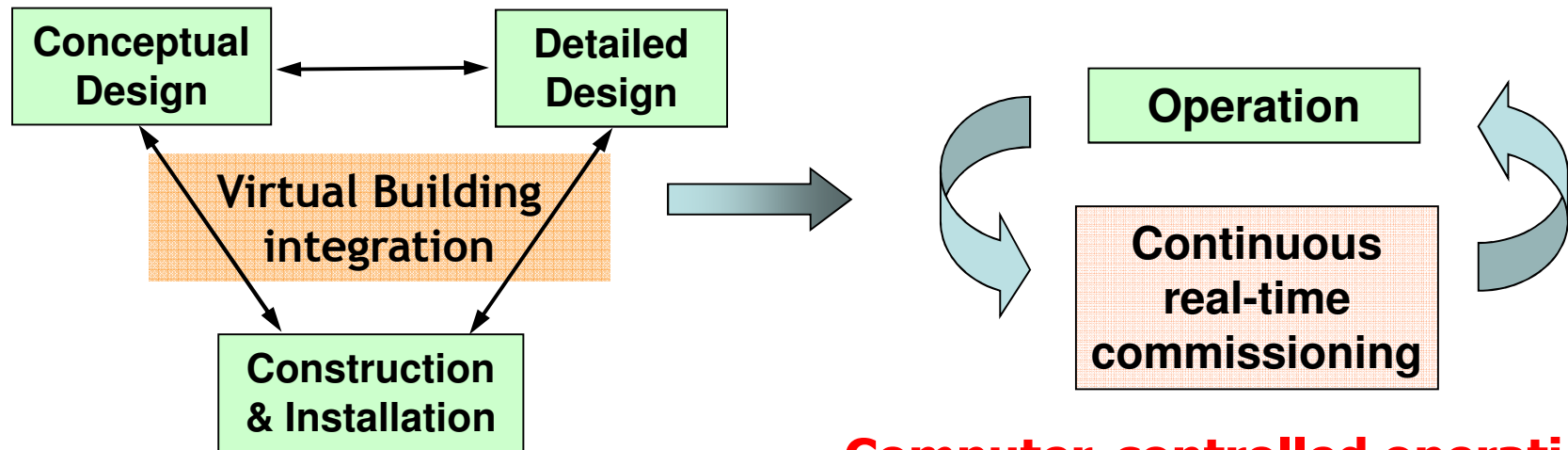
With the right government policies, it will come to our aid in the future.

# World Production of Grain (1961 – 2004)



Source: Food and Agriculture Organization (FAO), United Nations

# Buildings consume 40% of energy in U.S.: A new way of designing and constructing buildings.



**Computer-aided design tools  
with Embedded Energy Analysis**

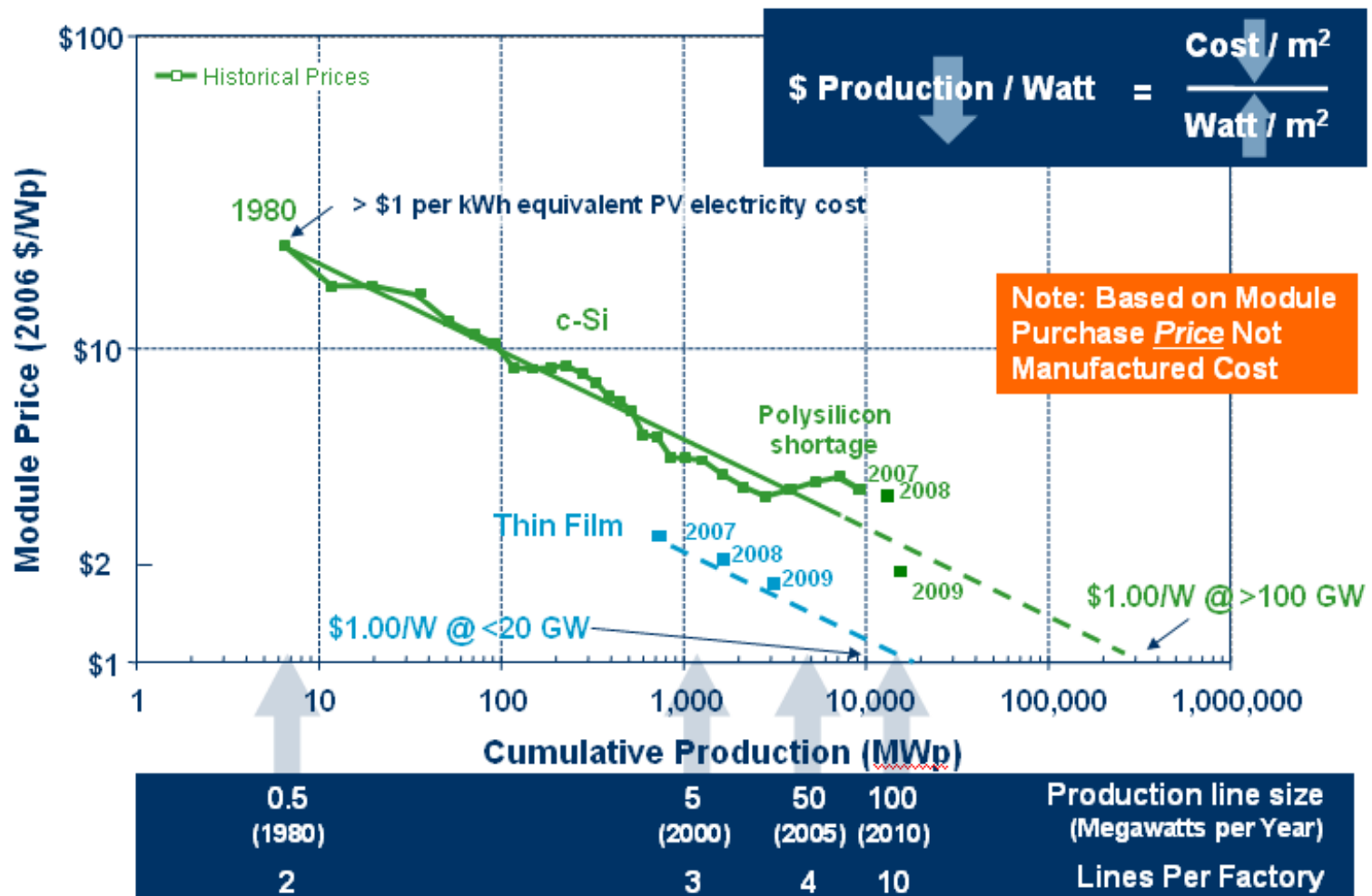
**Computer-controlled operation  
with Sensors and Controls for  
Real-Time Optimization**



- Oxygen sensor
- Air pressure sensor
- Air temperature sensor
- Engine temp. sensor
- Throttle position sensor
- Knock sensor

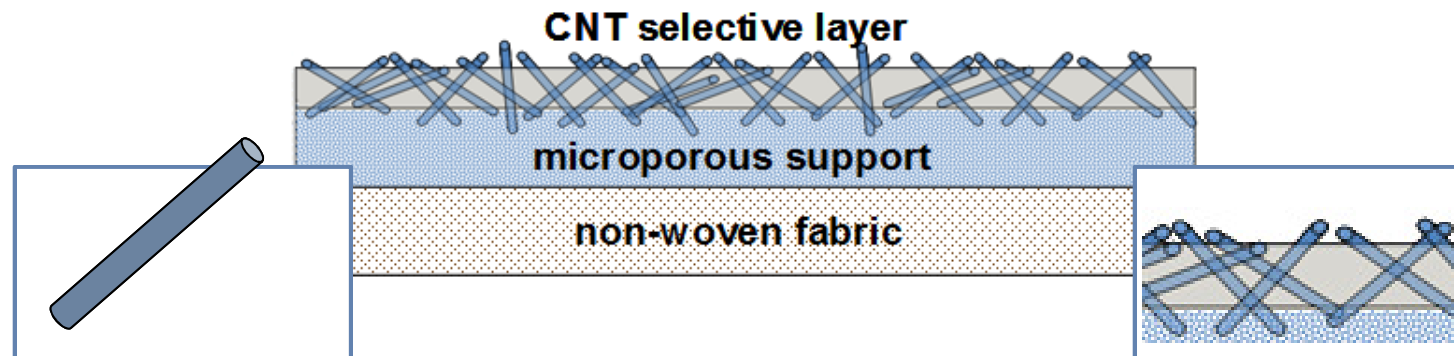
“Saudi Arabia aspires to export as much solar energy in the future as it exports oil now.”

Minister Ali Al-Naimi



# Carbon Nanotube Breakthrough

nanOasis



## ULTRA-HIGHLY PERMEABLE SMALL DIAMETER CARBON NANOTUBE

- Frictionless, Atomically Precise Pore
- **Enhanced Flux** 1,000-10,000X vs. Conventional Pores

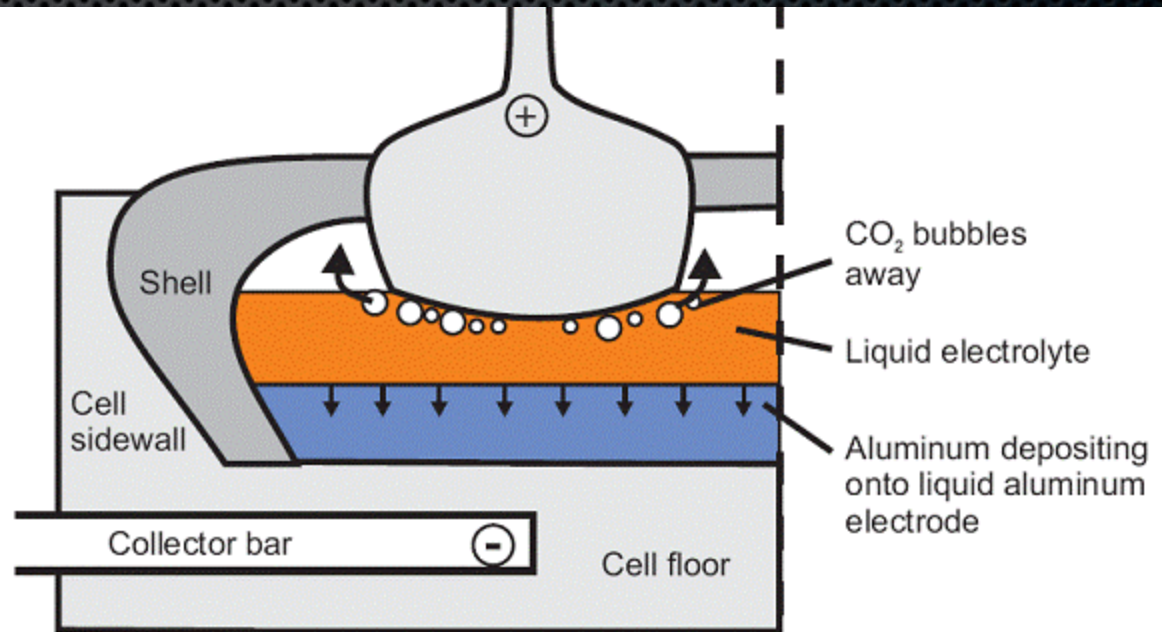
## LOW COST MEMBRANE ARCHITECTURE

- SuperFlux™
- 10X Higher Membrane Permeability vs. Today's State of the Art

**Water Passes More Freely Through the Membrane  
Requiring 30-50% Less Energy**



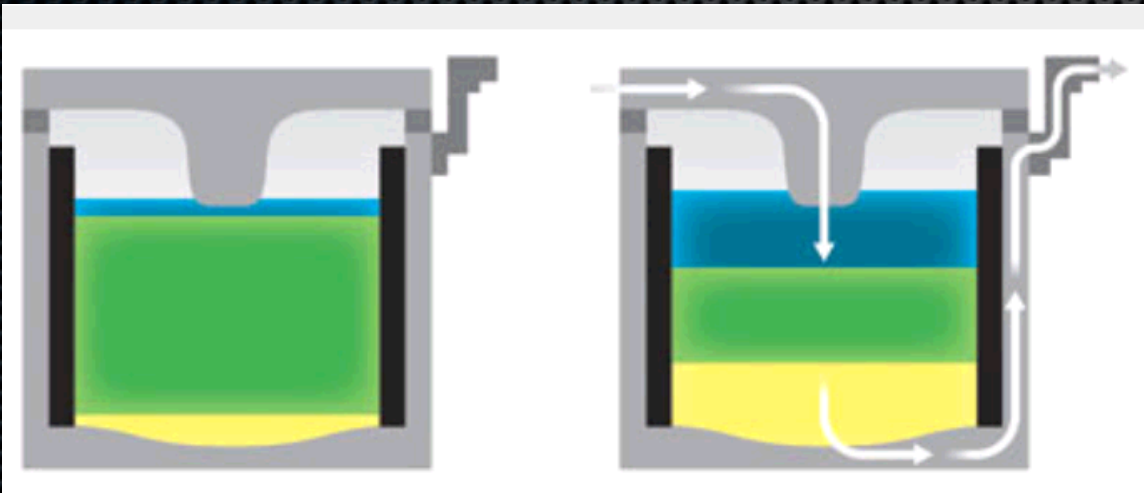
Aluminum refining  
requires millions of  
watts of power





## Battery Charging mode

Electricity is used to convert dissolved metal salts (green) into magnesium (Mg) and antimony (Sb) metal ions.

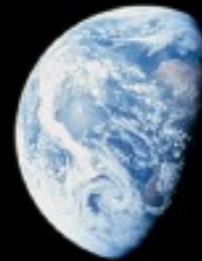


## Discharge mode

Mg (blue) and Sb (yellow) ions return to dissolved salts.



## 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