Energy Innovation that Can Make a Difference

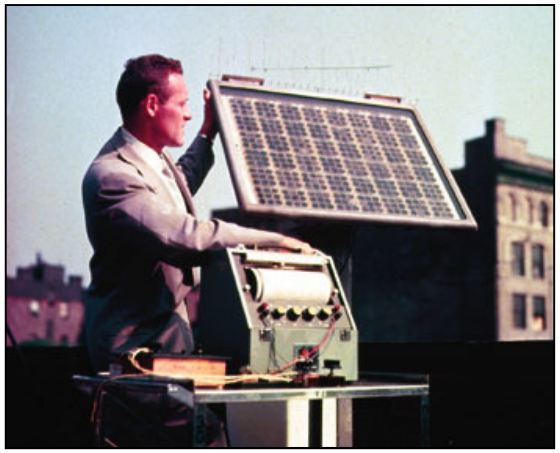
Secretary Steven Chu

Emirates Palace Hotel

Abu Dhabi, United Arab Emirates

24 February 2010

Innovation can change the world

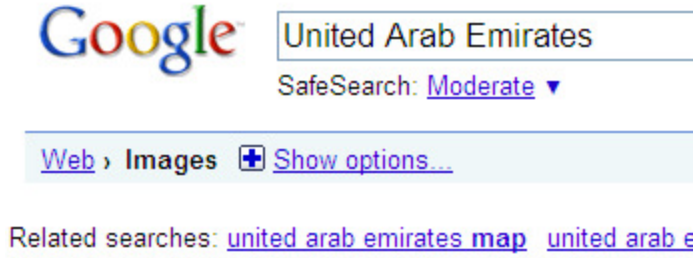


Bell Labs solar cell - 1954

First transistor

Pentium CPU

Ted Maiman and the first laser - 1961



The Internet

The Energy and Climate Challenge

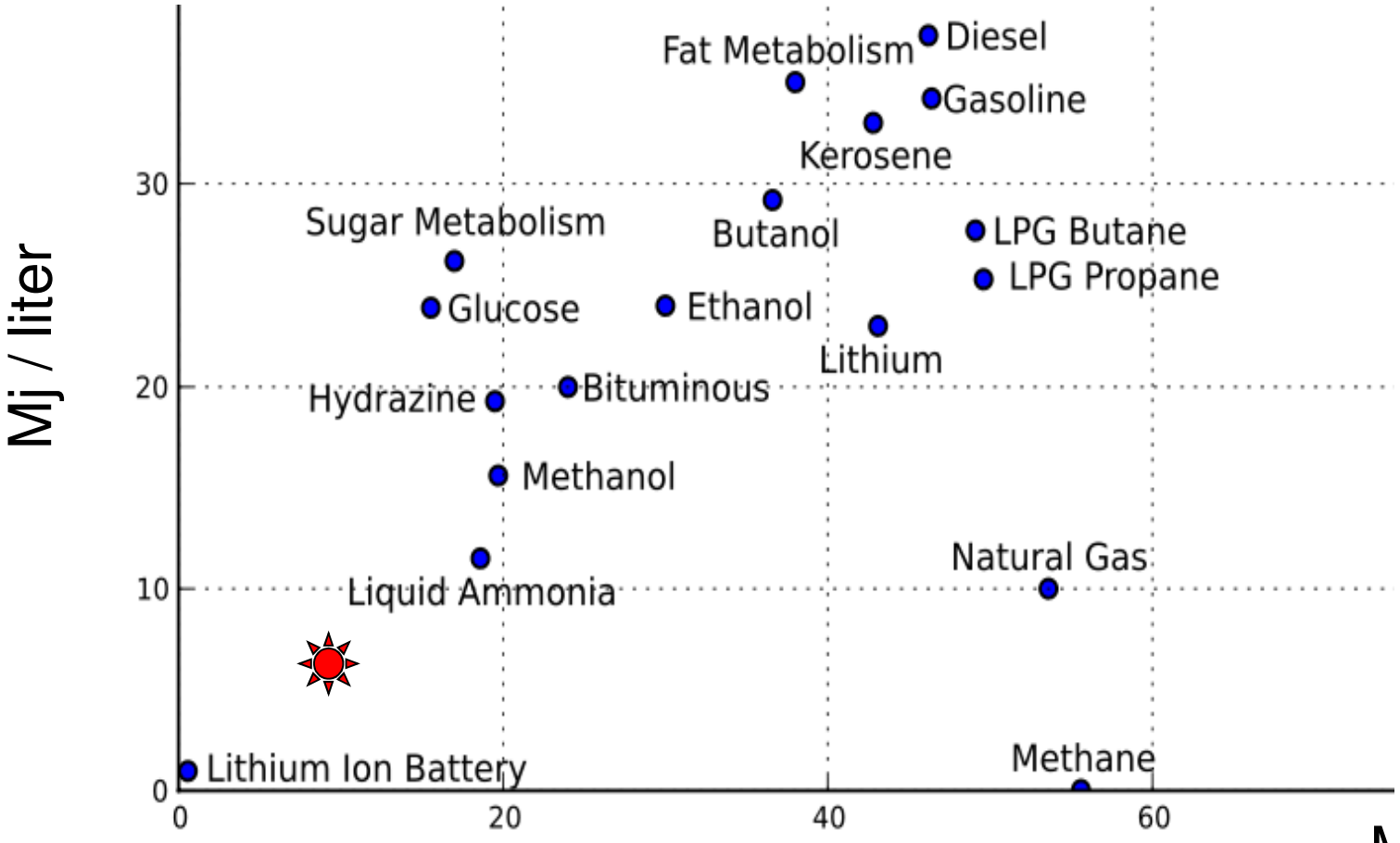
(1) The global economy needs energy resources.

(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

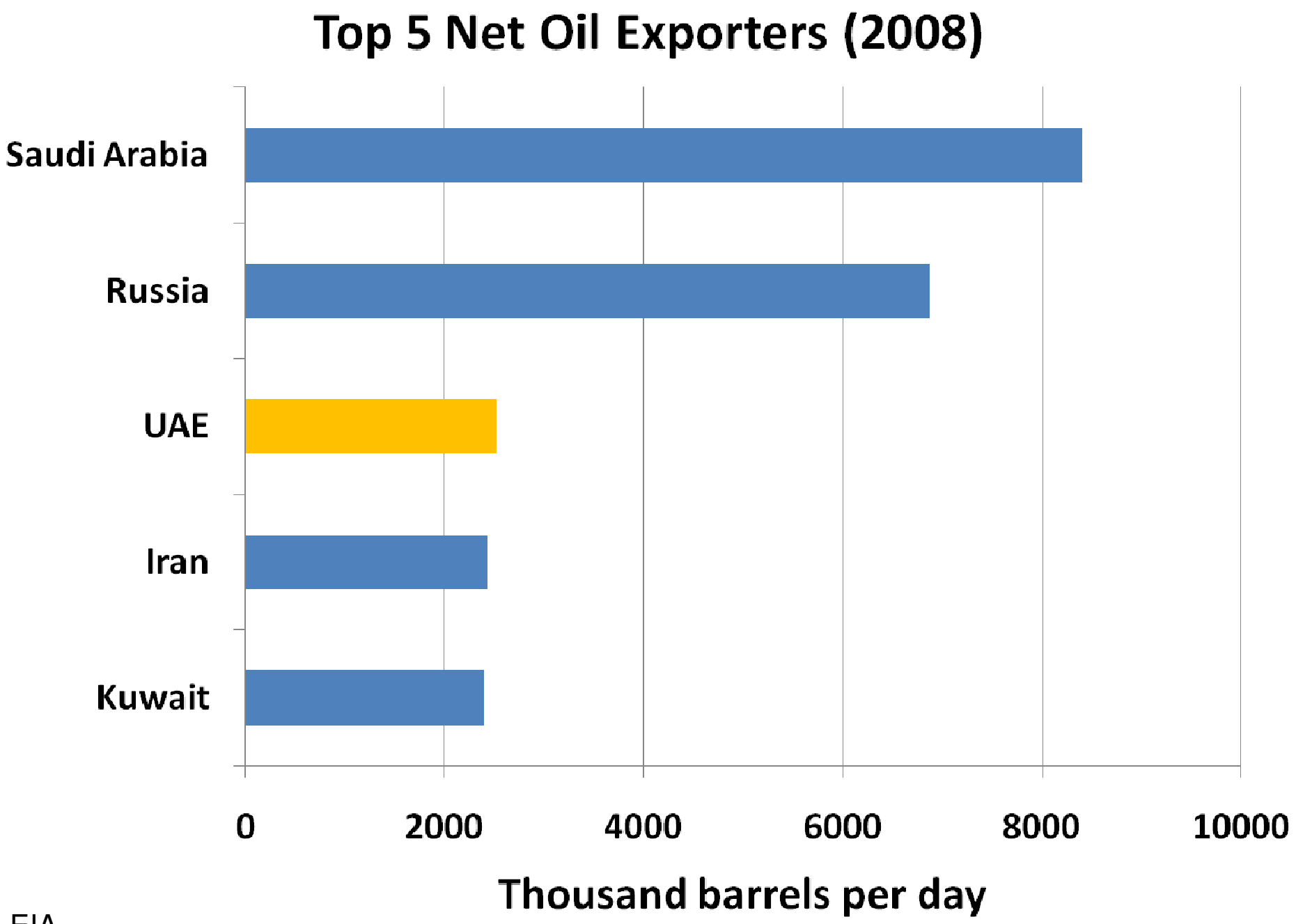
Question: What does a Boeing 777 have in common with a Bar-tailed Godwit?

Boeing 777

Bar-tailed Godwit

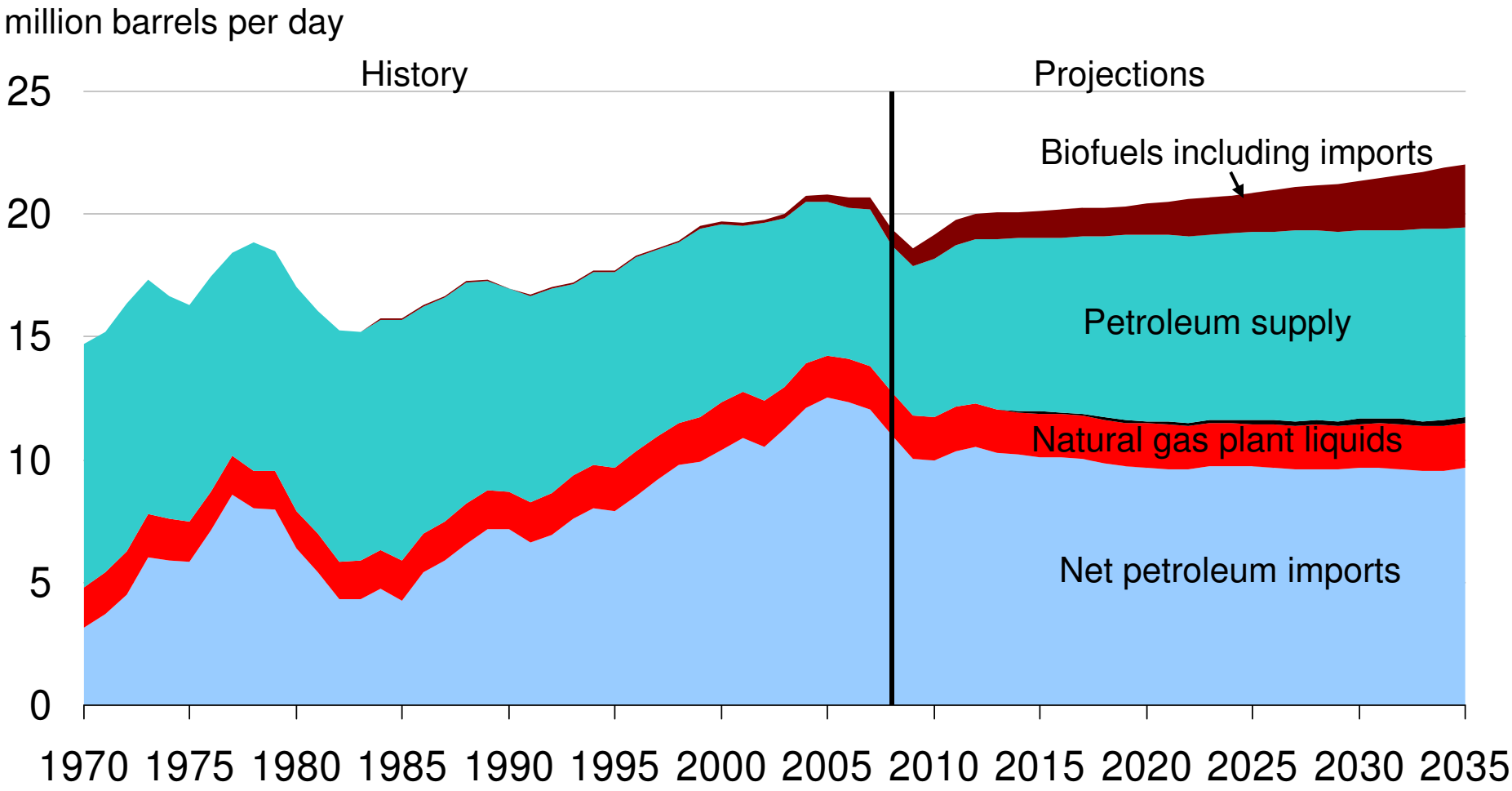
Answer: Both can fly non-stop 11,000 km.

At take-off, the fuel weighs ~ 50% of their total weight.


Top 5 Net Oil Exporters (2008)
Saudi Arabia
Russia
UAE
Iran
Kuwait
0
2000
4000
6000
8000
10000
Thousand barrels per day

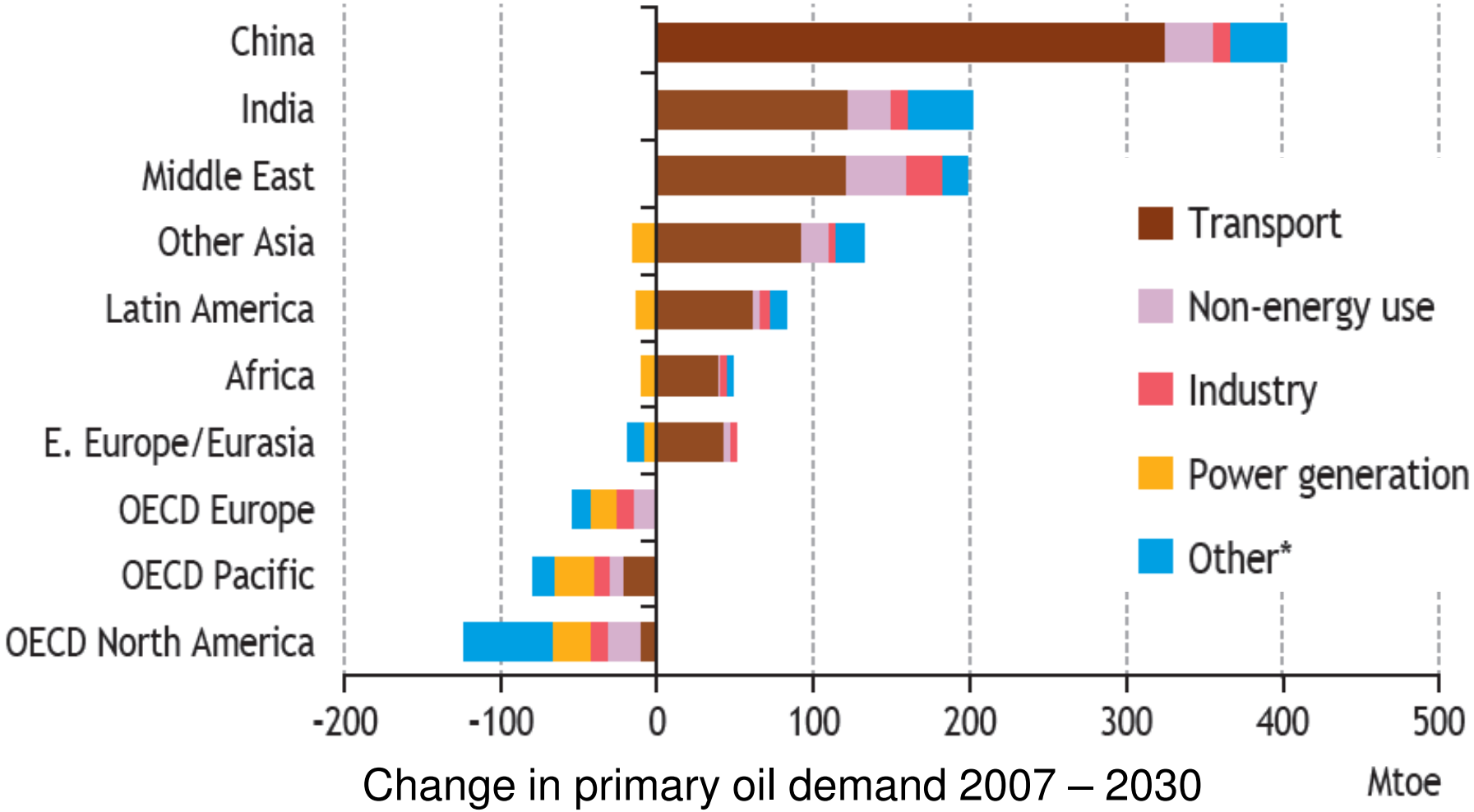
EIA

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



Source: *Annual Energy Outlook 2010*

Huge growth in oil demand is projected from the developing world

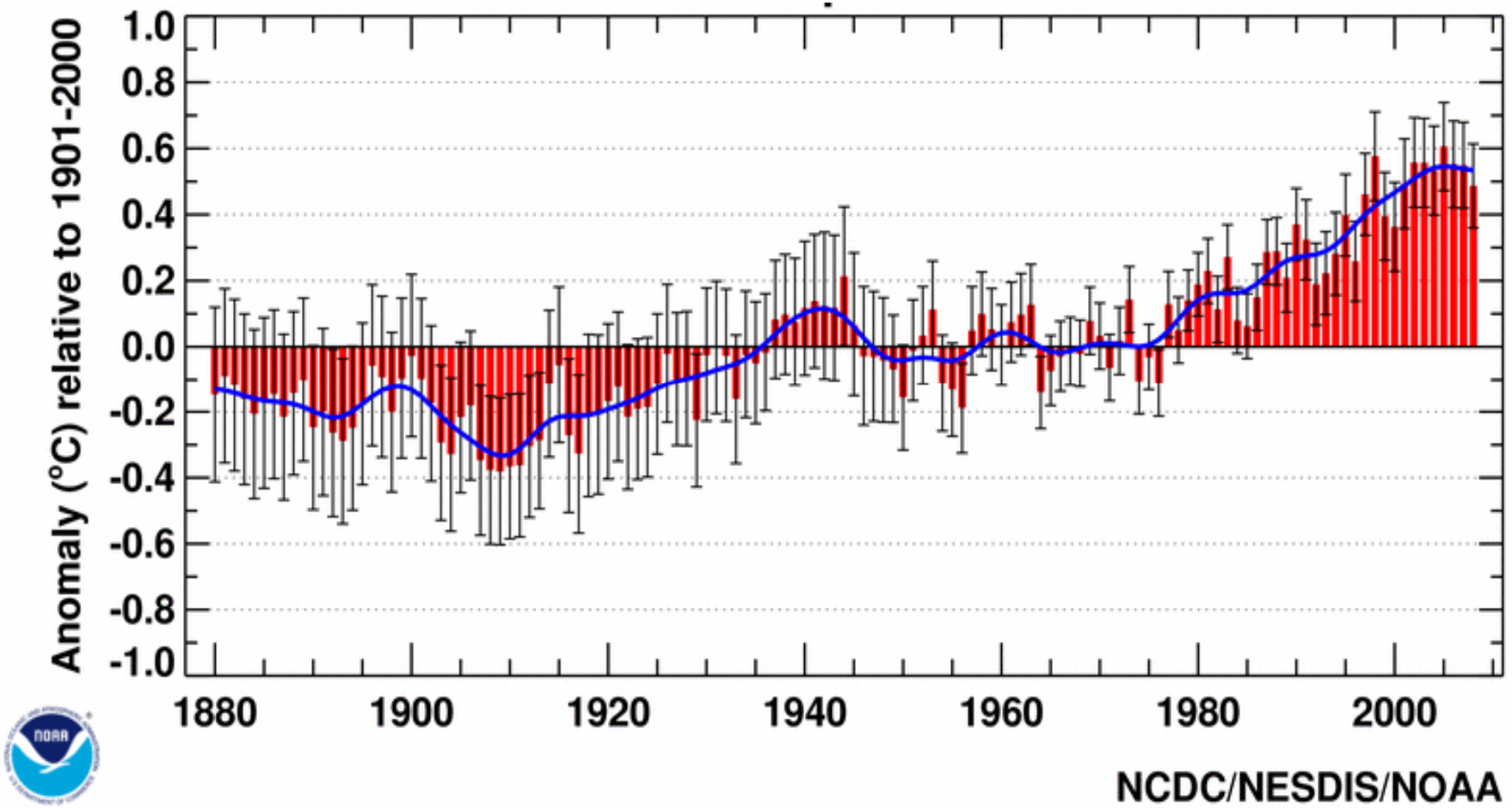


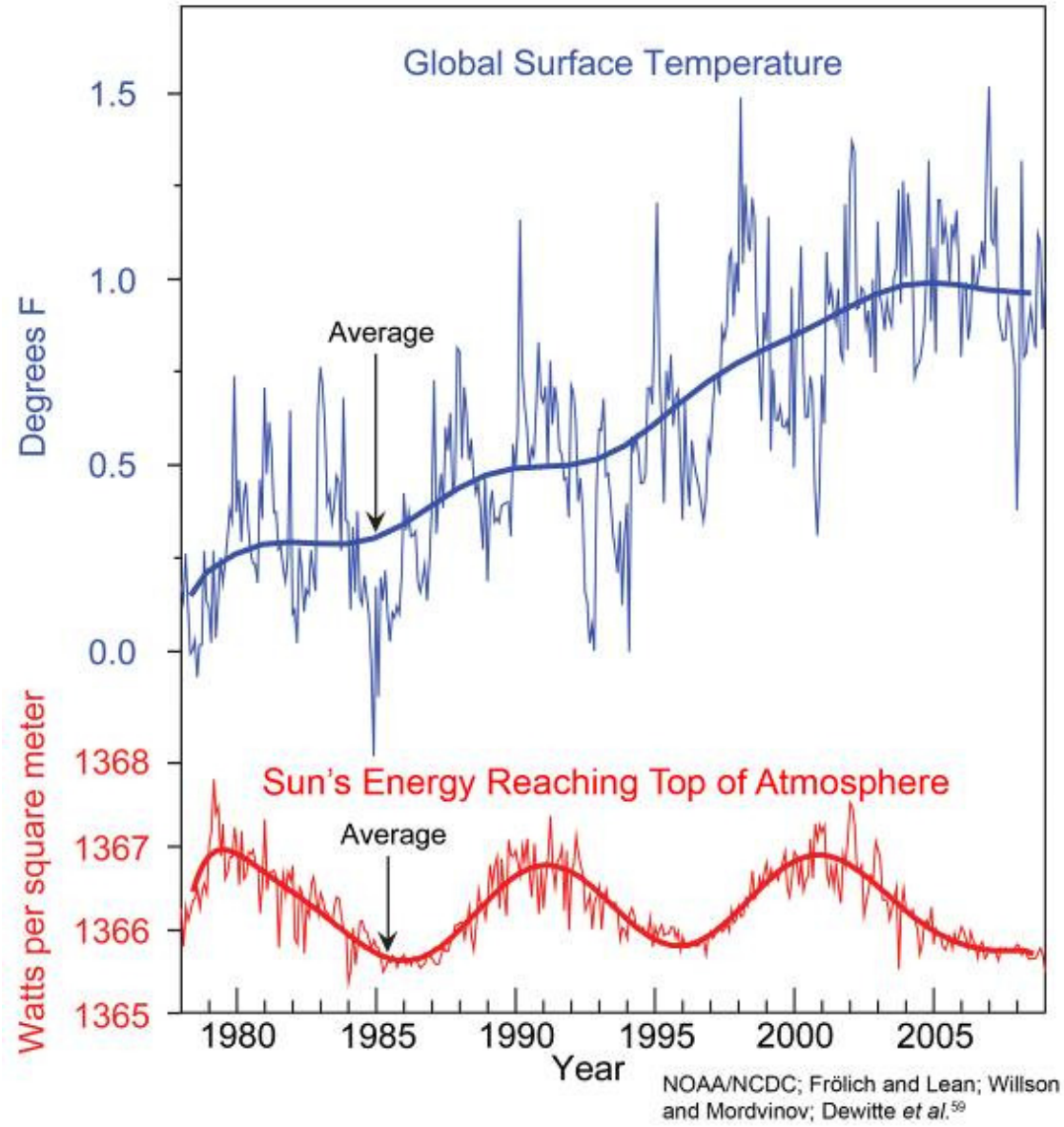
IEA: World Energy Outlook 2009

We also need energy innovation to ensure our future prosperity.

Why?

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

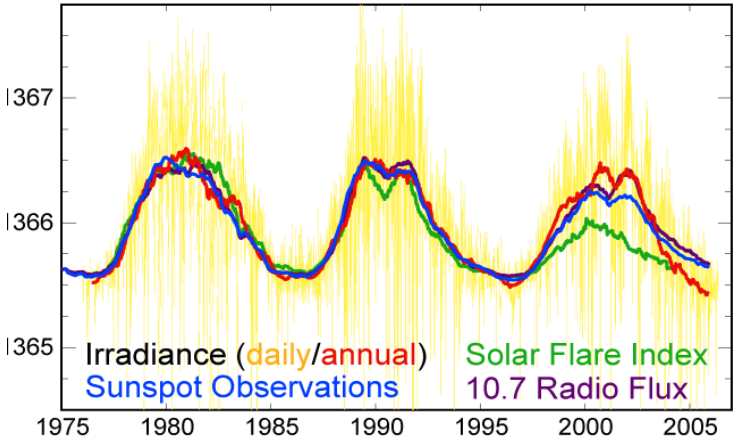




Can the rise in temperature be due to an increase in solar energy reaching Earth?

What about **Sun Spots?**

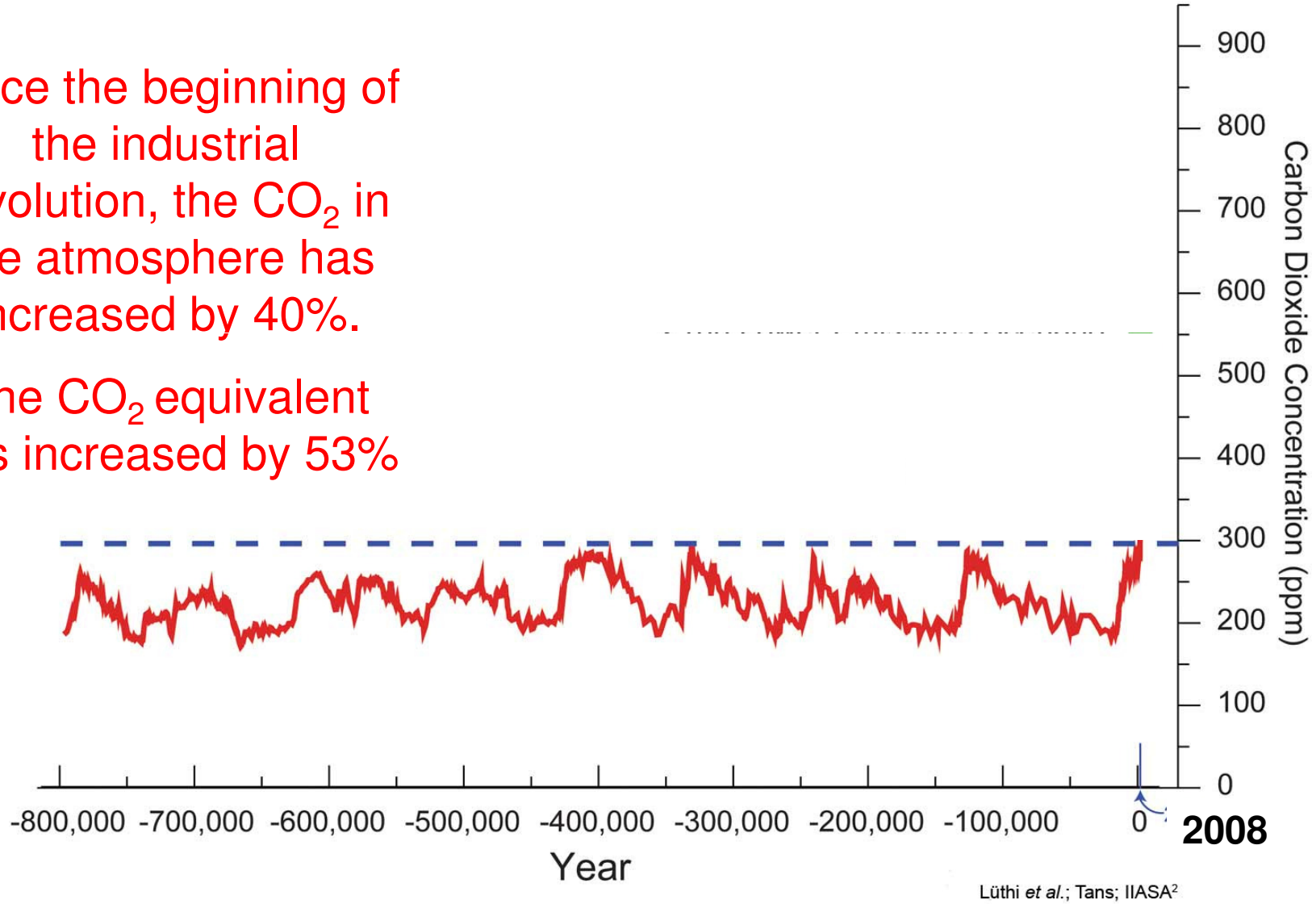
Sunspots (blue)
Solar flares (green)
Radio emissions (purple)



Carbon Dioxide Concentration during the past 800,000 years

Since the beginning of the industrial revolution, the CO_2 in the atmosphere has increased by 40%.

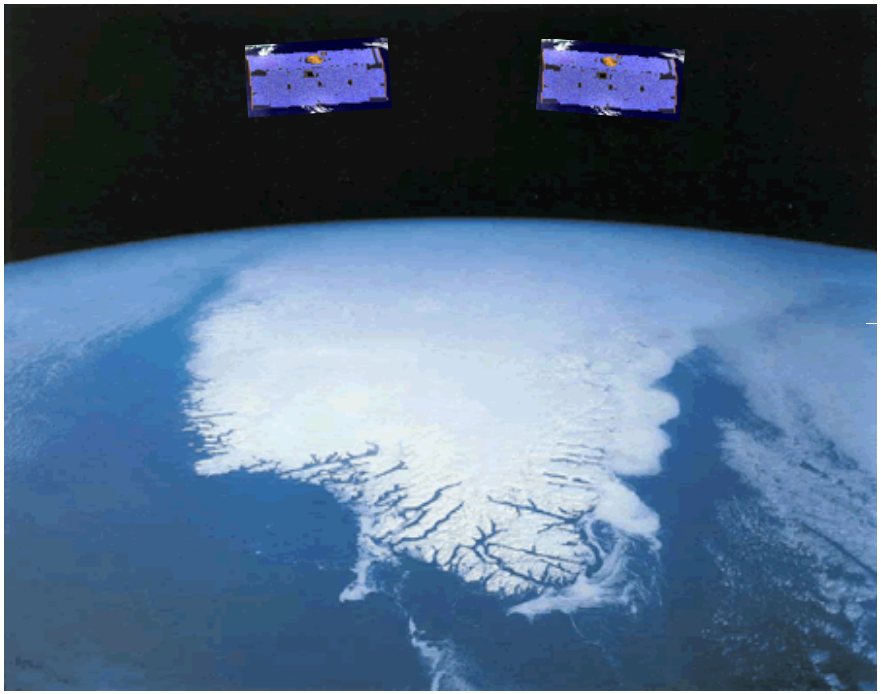
The CO_2 equivalent has increased by 53%

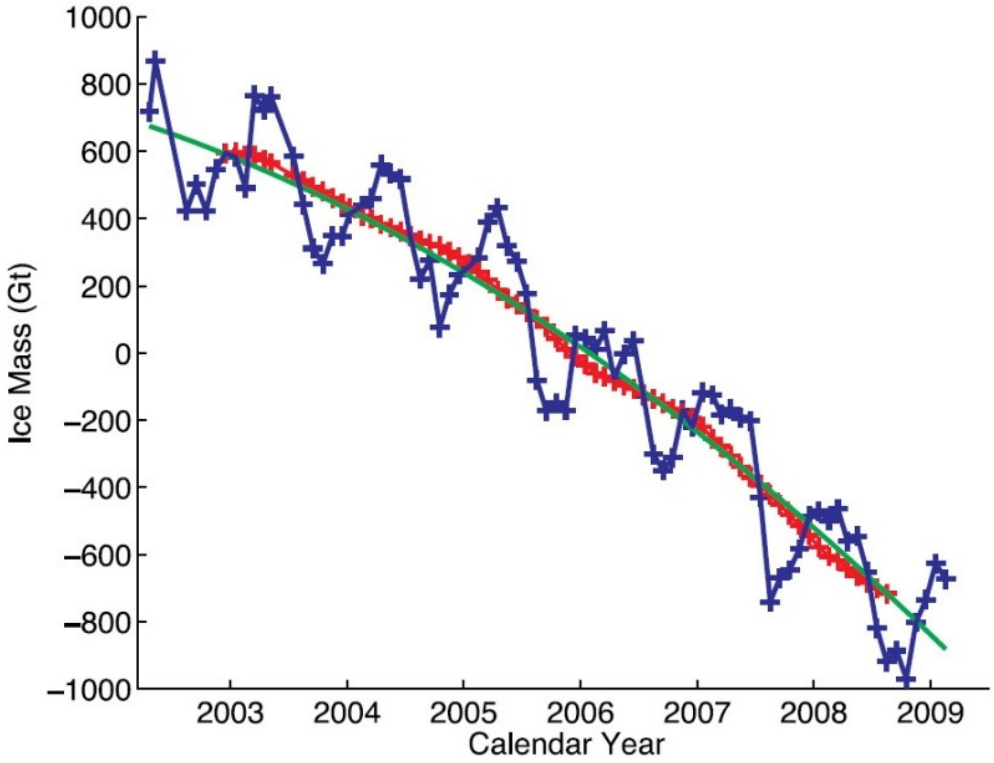


Lüthi *et al.*; Tans; IIASA[2]

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.

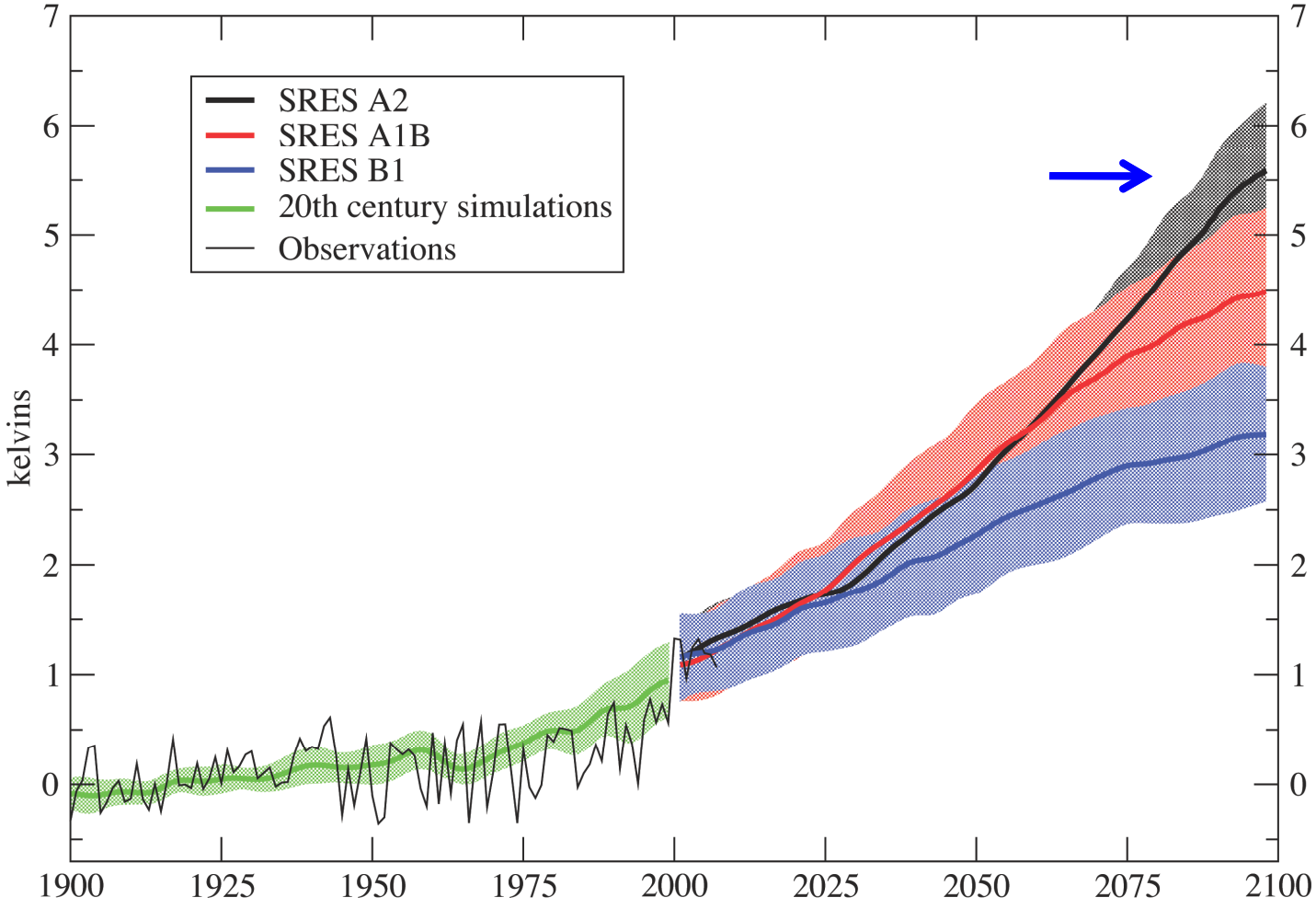




I. Velicogna, GEOPHYSICAL RESEARCH LETTERS, VOL. 36, L19503, doi:10.1029/2009GL040222, 2009

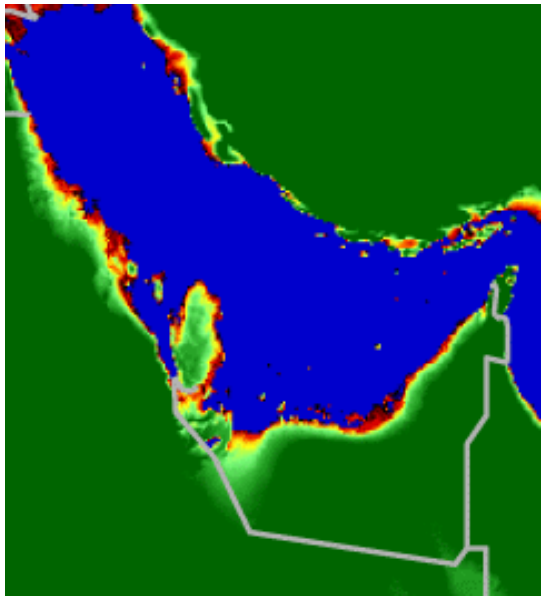
If the world follows a “Business-as-usual” path, what do climate models predict will happen?

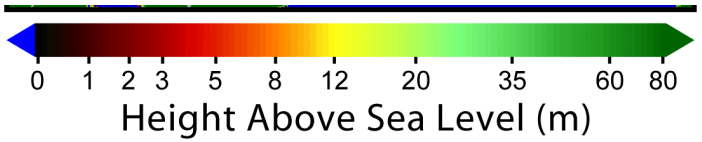
No emission reductions:
5 - 6 degree temperature increase in Middle East



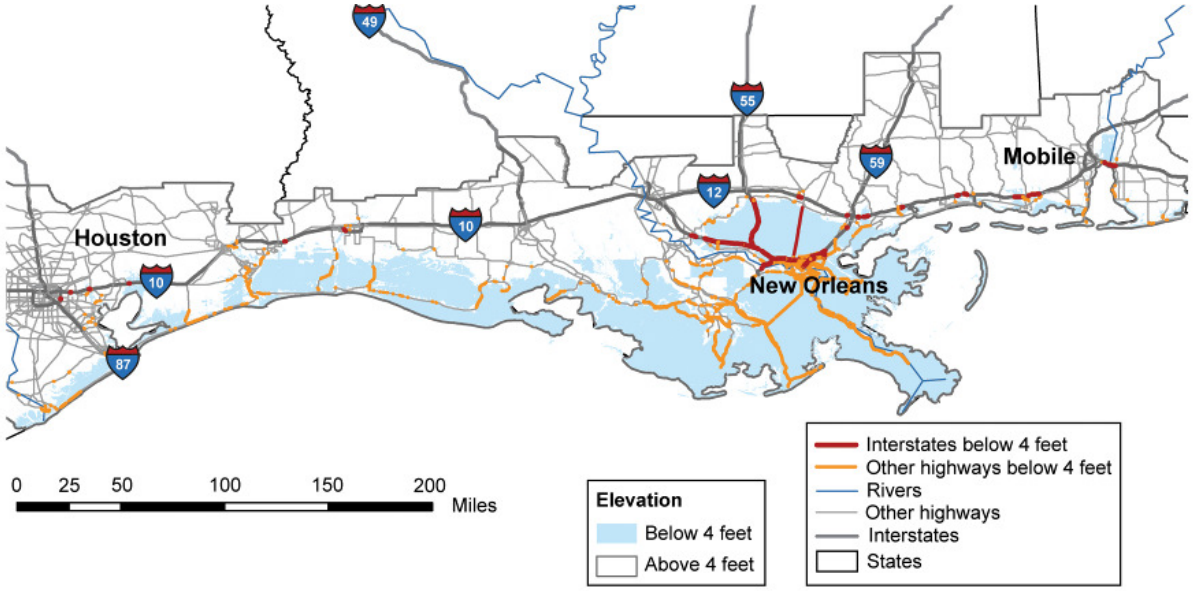
Surface air temperature change relative to 1900-1909 average

Coastal areas at risk from sea-level rise

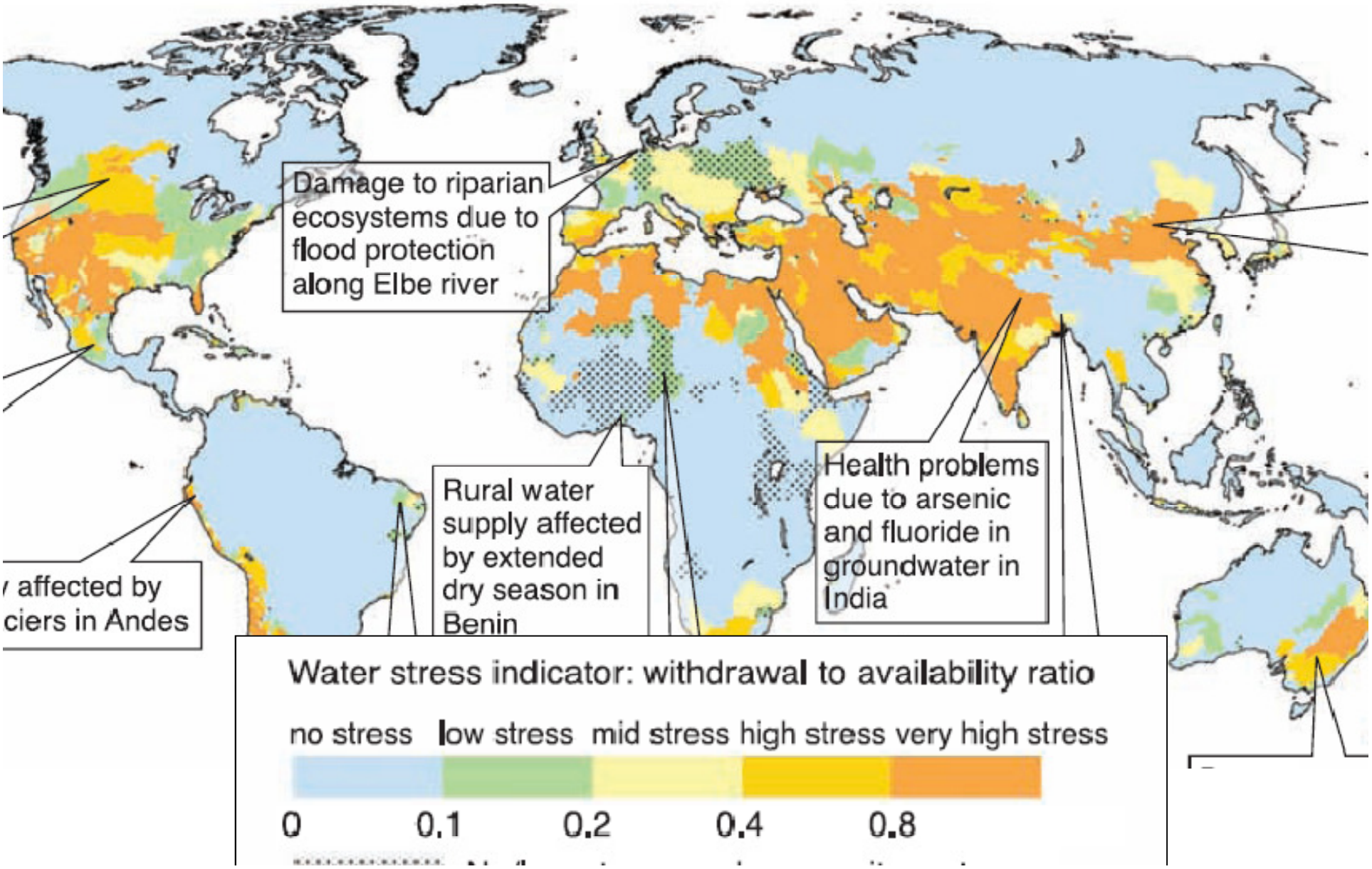




Areas in blue below 4 feet -- includes significant U.S. refining infrastructure



Predicted water stress areas around the world



The world is on an unsustainable energy path.

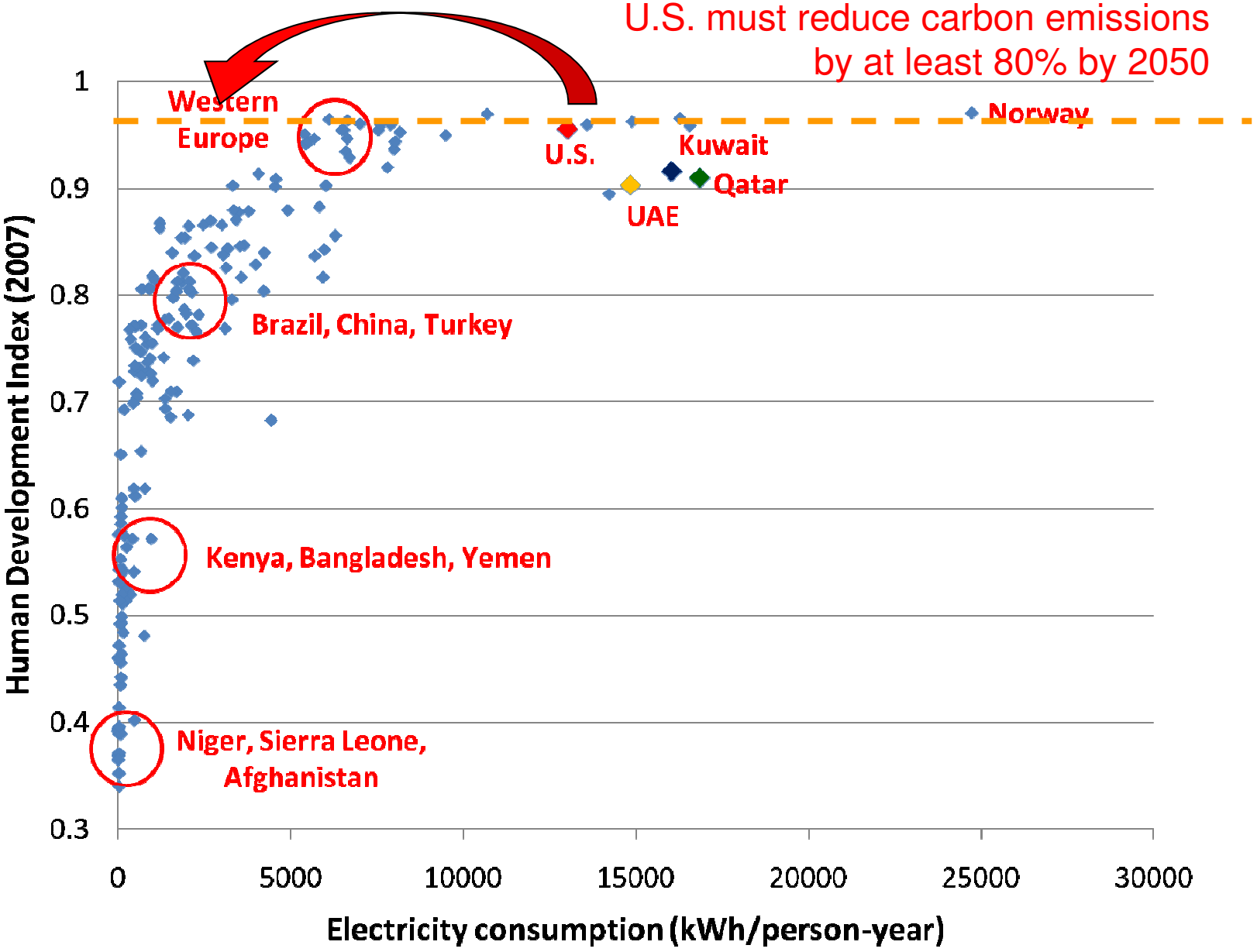
Both of our countries know we need to diversify our energy mix

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. 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 should 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

MASDAR
ABU DHABI FUTURE ENERGY COMPANY

MASDAR INSTITUTE
OF SCIENCE AND TECHNOLOGY

معهد مصدر
للعلوم والتكنولوجيا

U.S. DEPARTMENT OF
ENERGY

Masdar is thinking big

Masdar City is exemplary in its use of clean energy technologies

It will house the Masdar Institute of Science and Technology and International Renewable Energy Agency

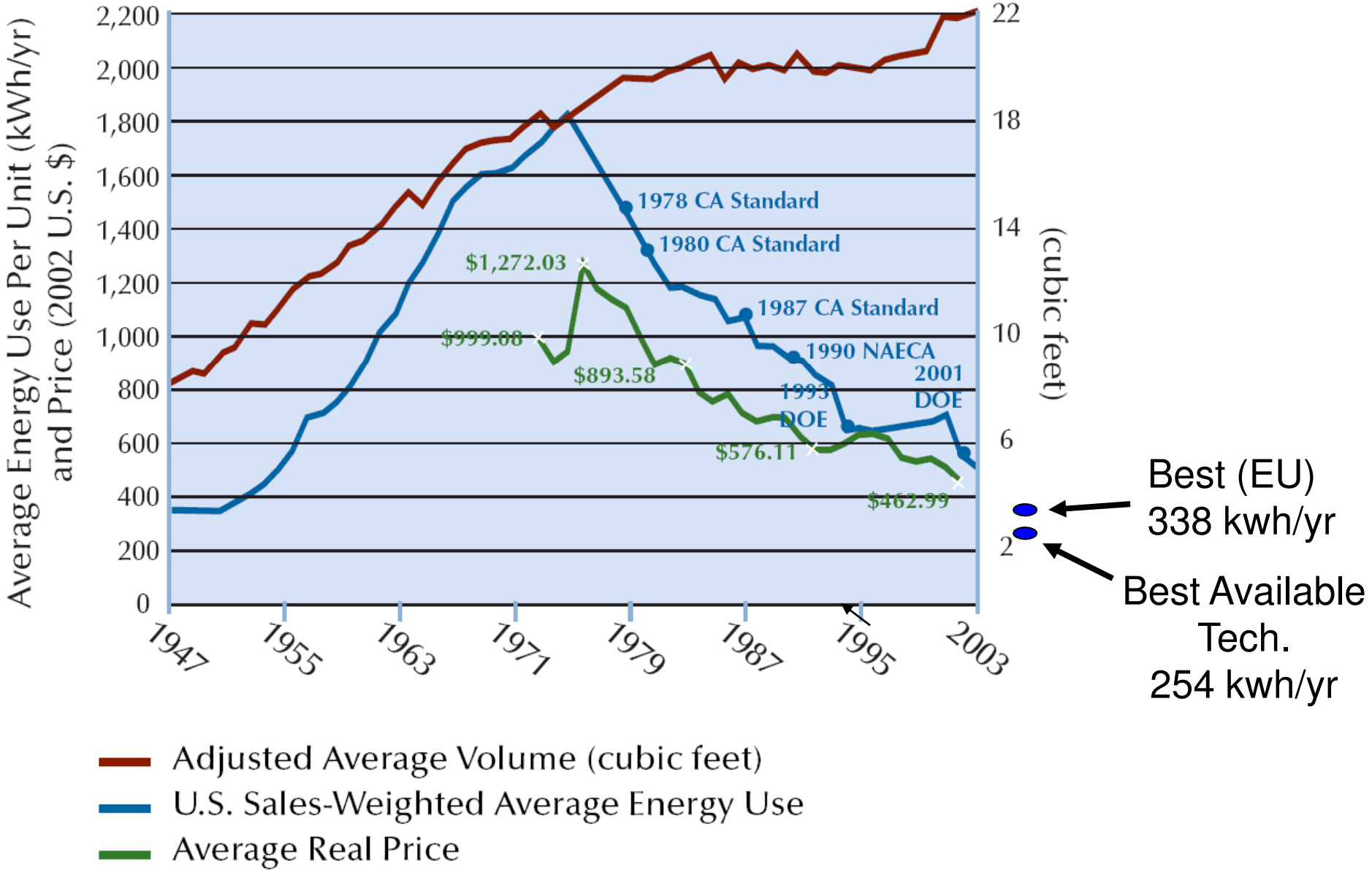
Masdar has launched two clean energy investment funds and is developing a world-class CCS network

Masdar City and the Department of Energy can collaborate in the development and testing of innovative technologies.

To achieve our energy and climate goals, we need to:

- Use energy more wisely

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



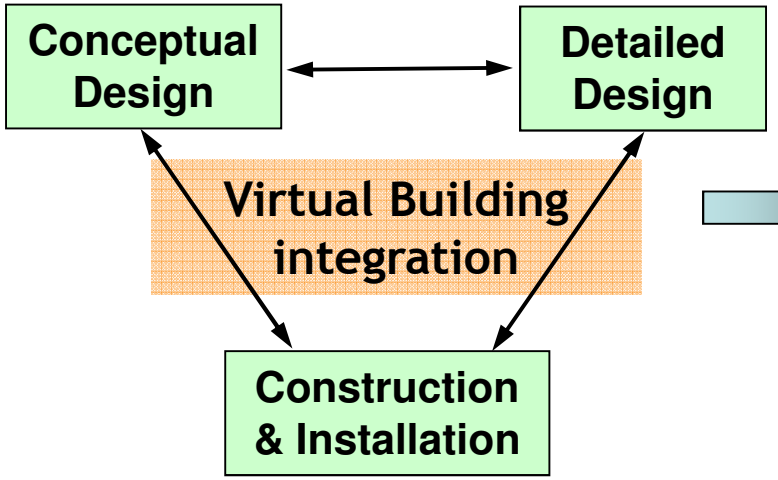
New York Times Building

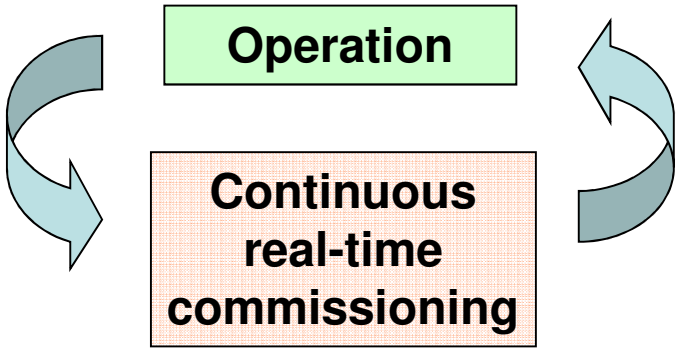
- Active shading
- Dimmable lighting
- New products developed to meet specs

Federal Building San Francisco

- Natural convection cooling (chimney effect)
- Exposed concrete provides thermal inertia

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

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

Computer-aided design and operation will lead to enhanced comfort, energy savings ***and*** cost savings.

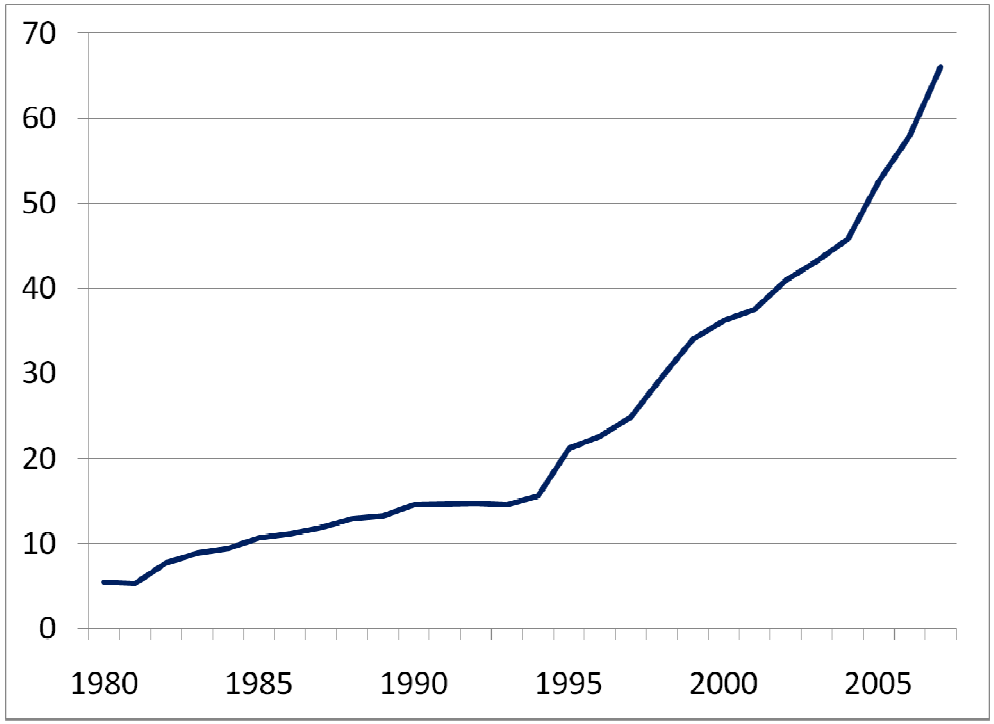
Energy Efficiency ⇔ Money Saved

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

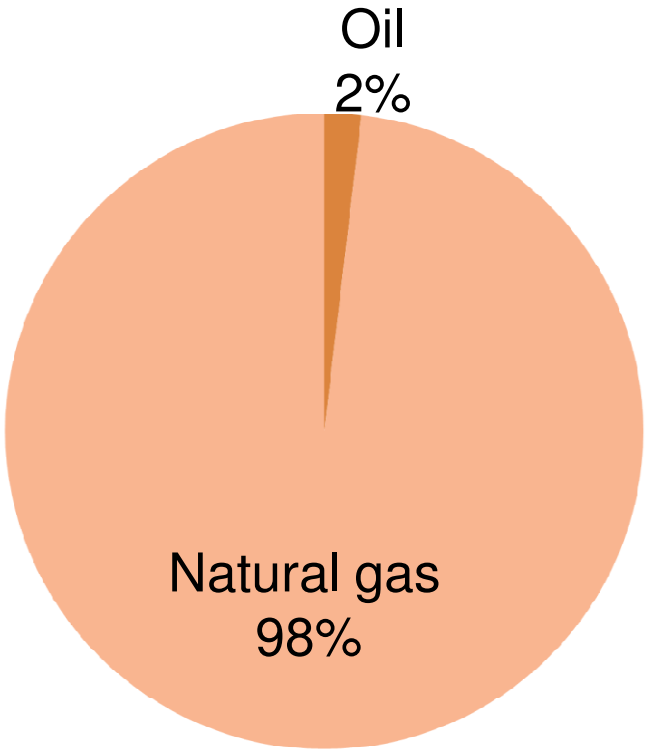
To achieve our energy and climate goals, we need to:

- Use energy more wisely
- Develop and deploy renewables and other low carbon technologies

UAE's electricity use is soaring



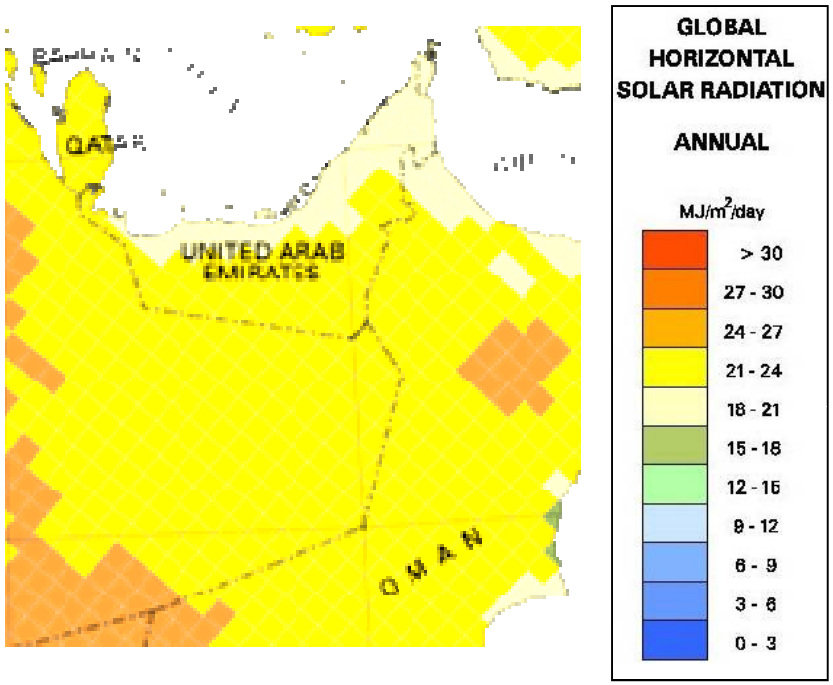
UAE's electricity consumption
(billion kilowatt hours)



Electricity generation sources

EIA

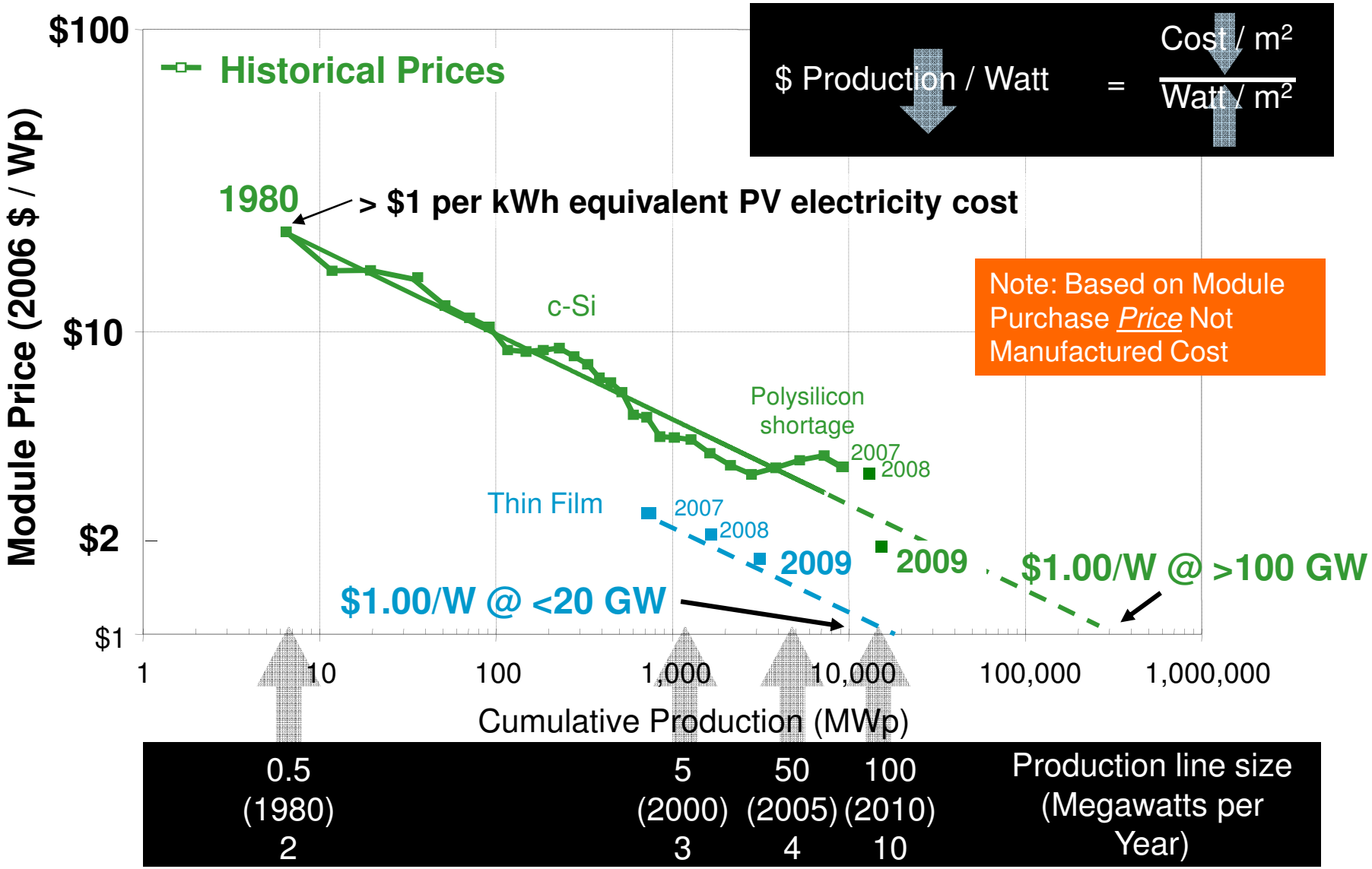
UAE has tremendous solar resources



Masdar is leading the way

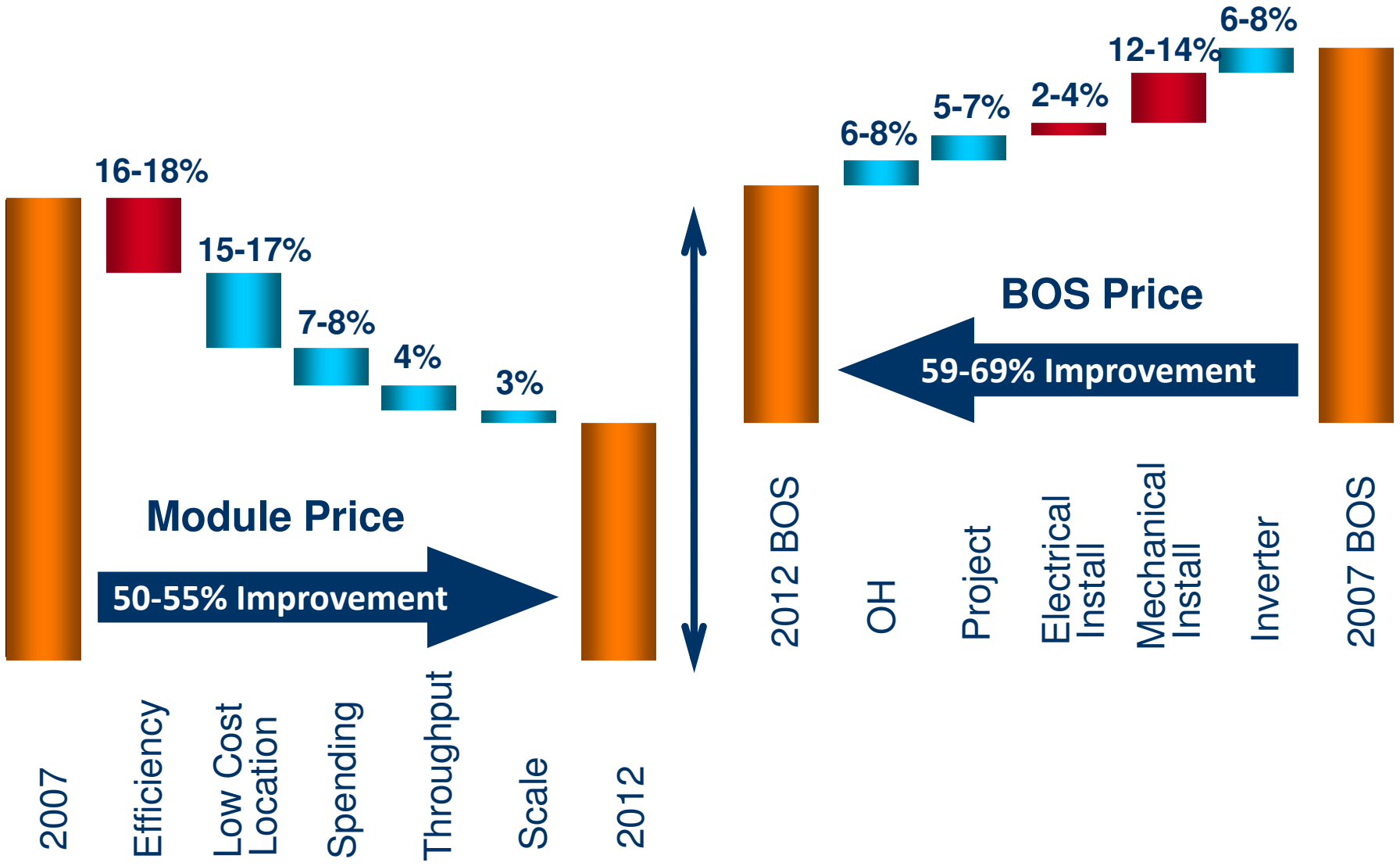
MASDAR مصدر
ABU DHABI FUTURE ENERGY COMPANY شركة أبوظبي لطاقة المستقبل

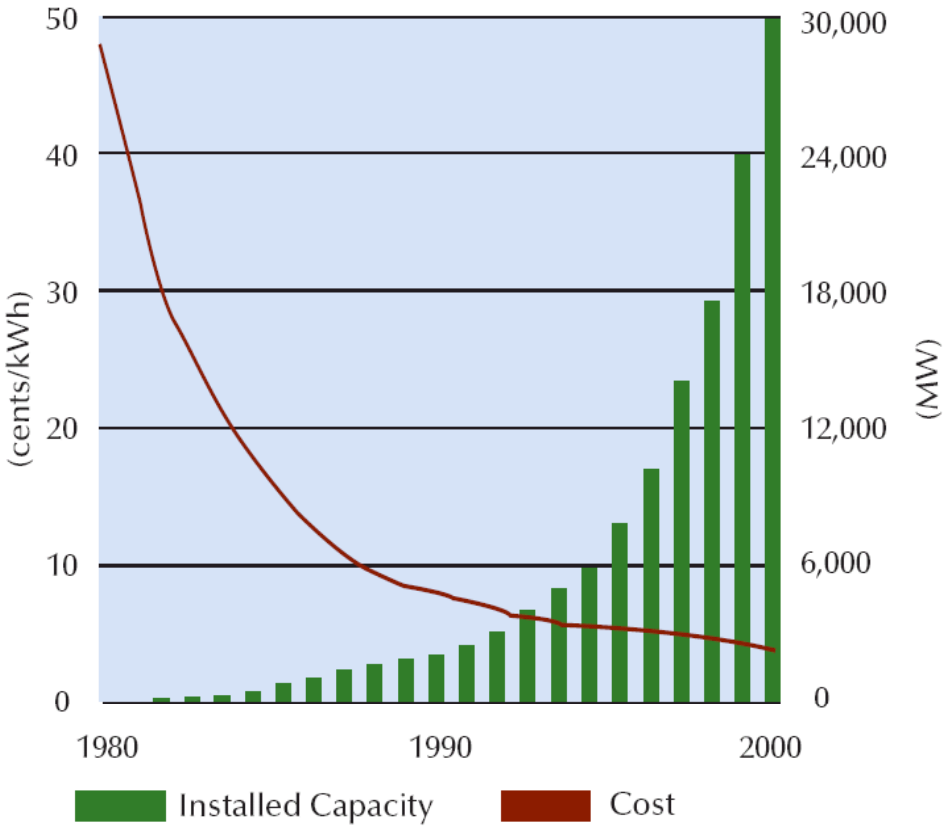
Separate cSi and Thin Film Learning Curves



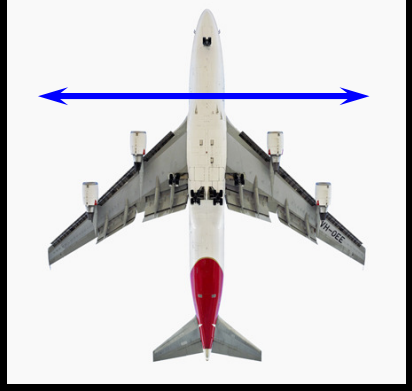
Source: Adapted from National Renewable Energy Laboratory

Balance of System costs must also be reduced





747- 400
64.5 m



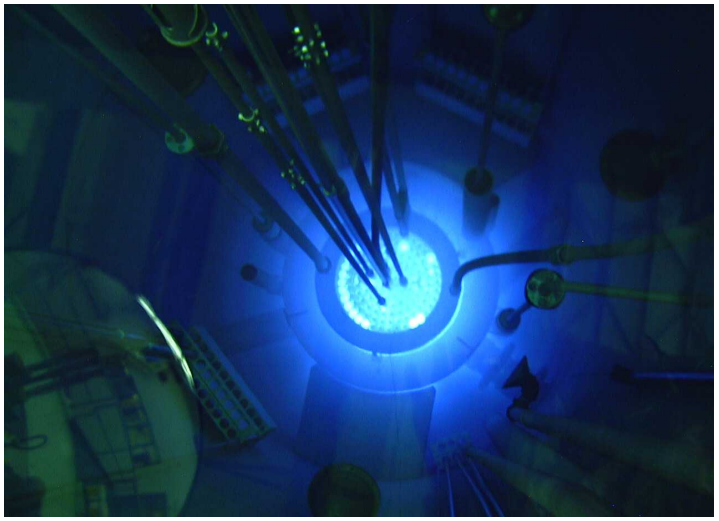
As turbines increase in size and move offshore, long term reliability will become more important:

$25 million blade testing facility

$45 million drive train testing facility

Nuclear Fission provides carbon-free base-load power

President Obama recently approved a loan guarantee for the first new U.S. nuclear reactor in decades



We must address used fuel and nuclear waste issues

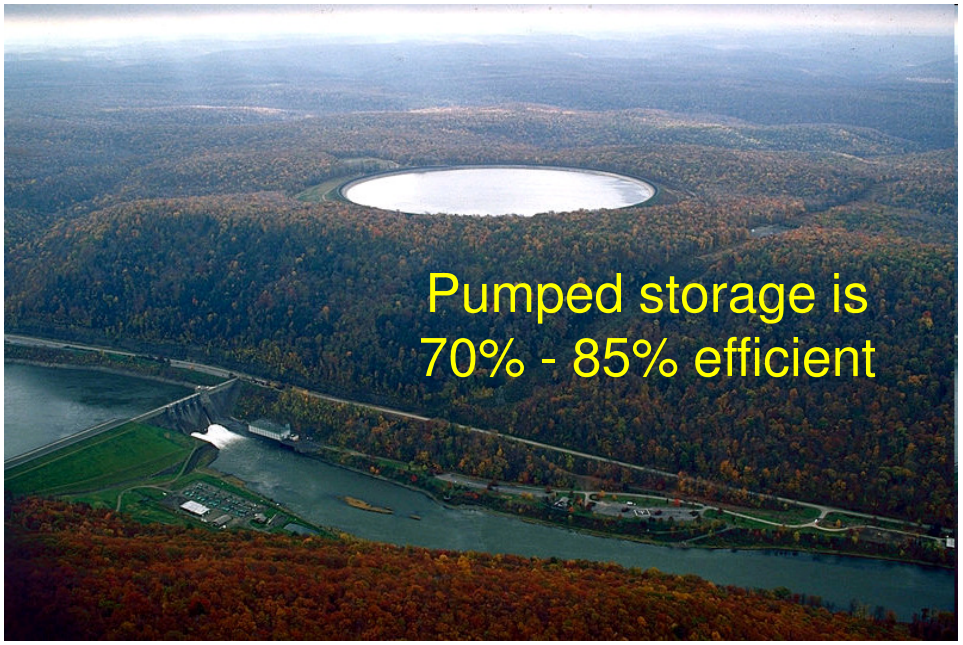
We must assure nuclear power does not lead to nuclear proliferation

This will require international cooperation and strengthening the Non-Proliferation Treaty

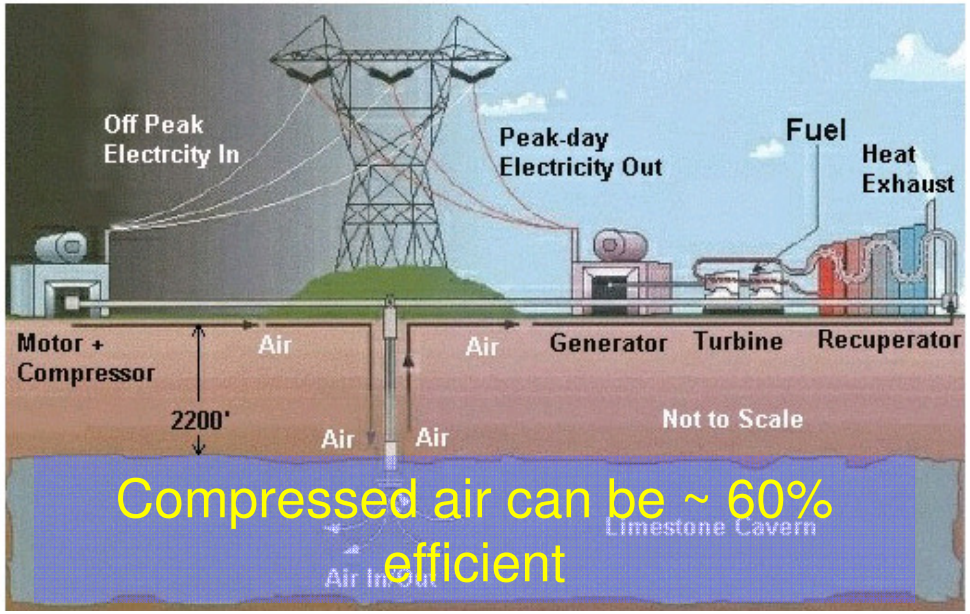
The U.S. – U.A.E. 123 Agreement reflects U.A.E.'s strong commitment to nonproliferation

To achieve our energy and climate goals, we need to:

- Use energy more wisely
- Develop and deploy renewables and other low carbon technologies
- Improve energy storage



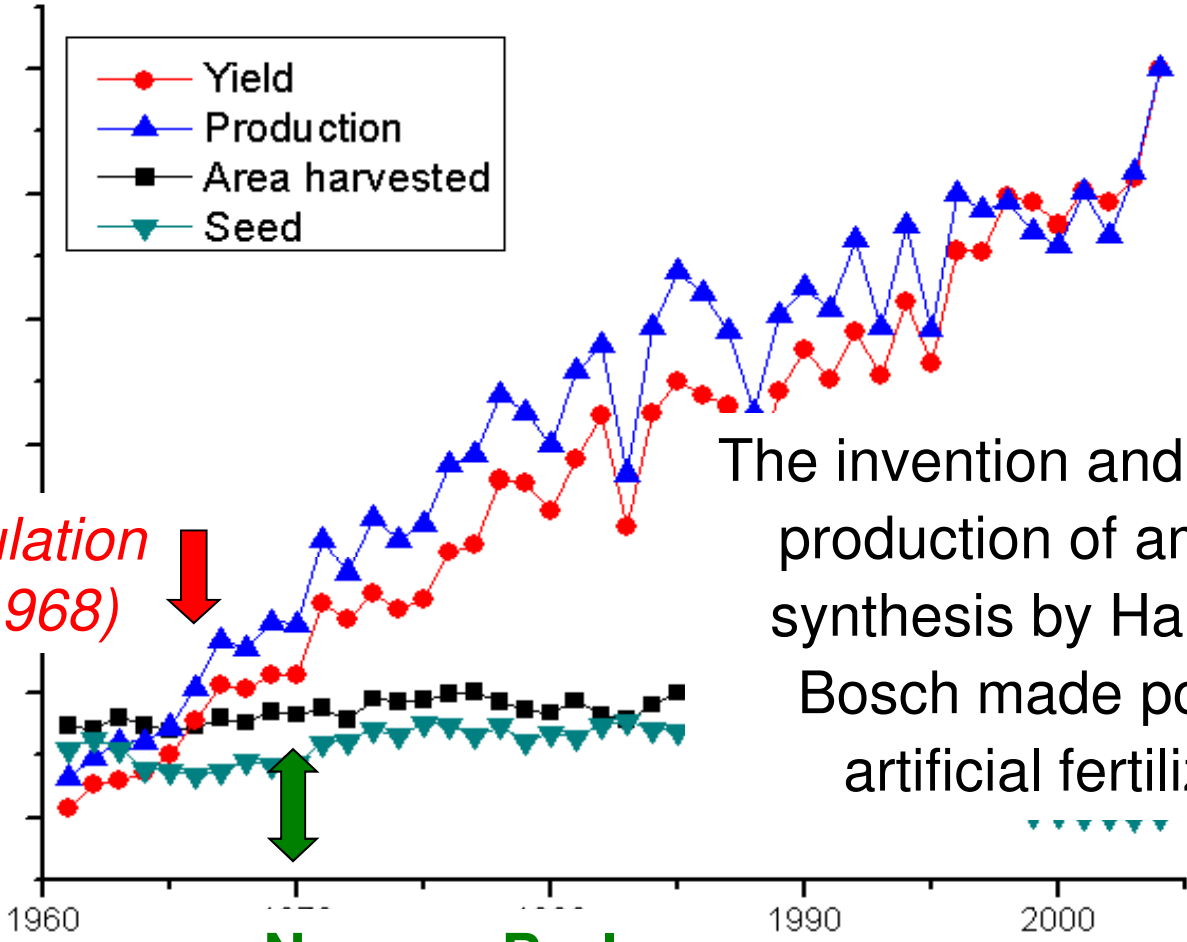
As wind and solar energy sources become a greater part of our electricity supply, we will need large scale energy storage and a smart grid to respond to variable generation.



To achieve our energy and climate goals,
we need to:

Aggressively pursue
transformative technologies and
truly out-of-the-box ideas

World Production of Grain (1961 – 2004)



The Population Bomb (1968)

The invention and industrial production of ammonia synthesis by Haber and Bosch made possible artificial fertilizers.

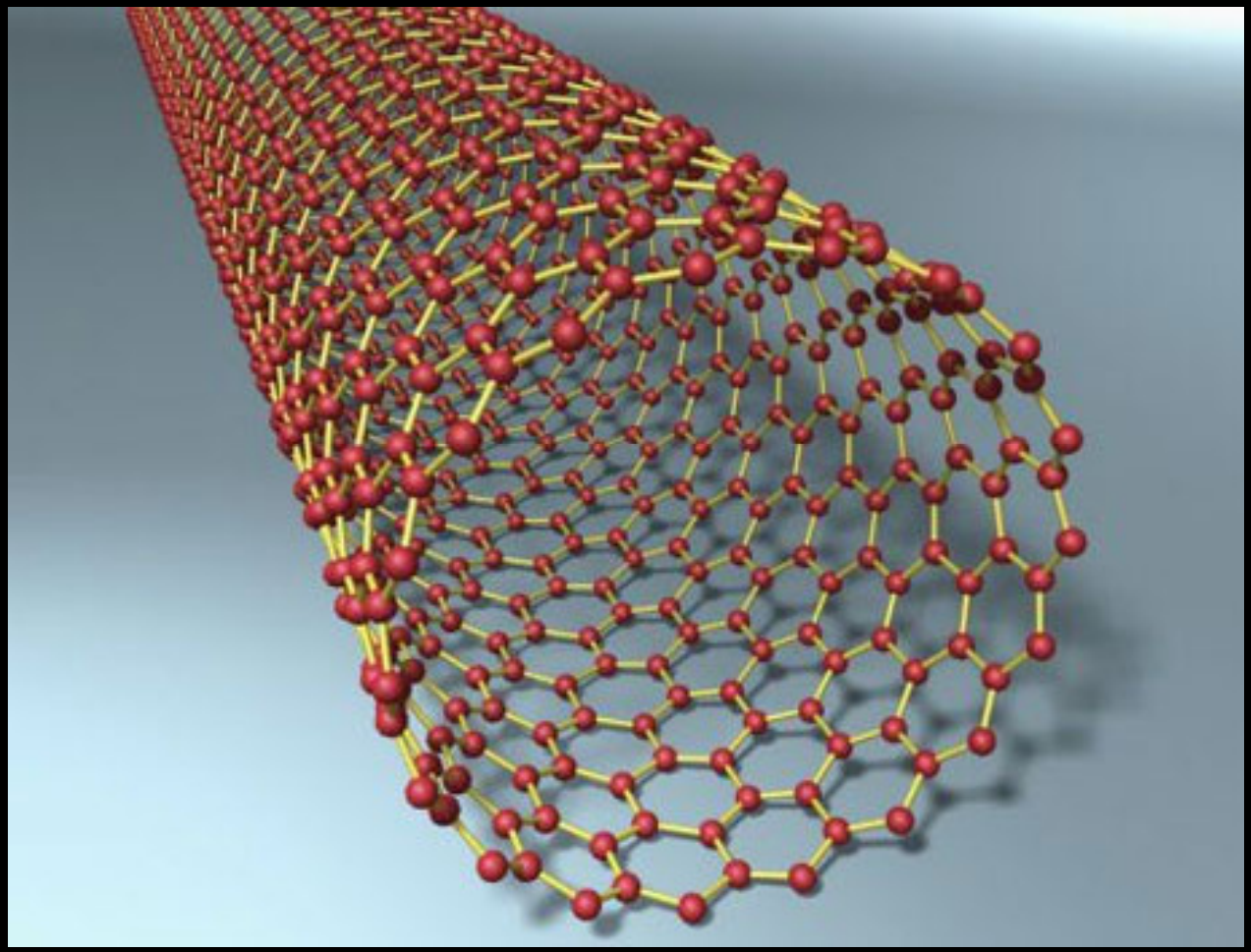
1960: Population = 3 B

Norman Borlaug awarded Nobel Prize

2005: Population = 6.5 B

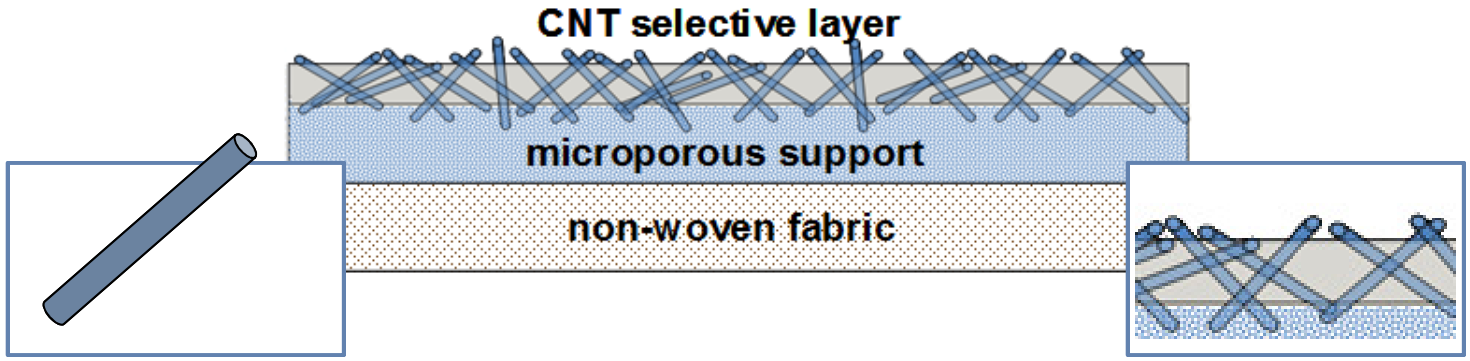
Source: Food and Agriculture Organization (FAO), United Nations

Carbon Nanotube



Carbon Nanotube Breakthrough

nanOasis



ULTRA-HIGHLY PERMEABLE SMALL DIAMETER CARBON NANOTUBE

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

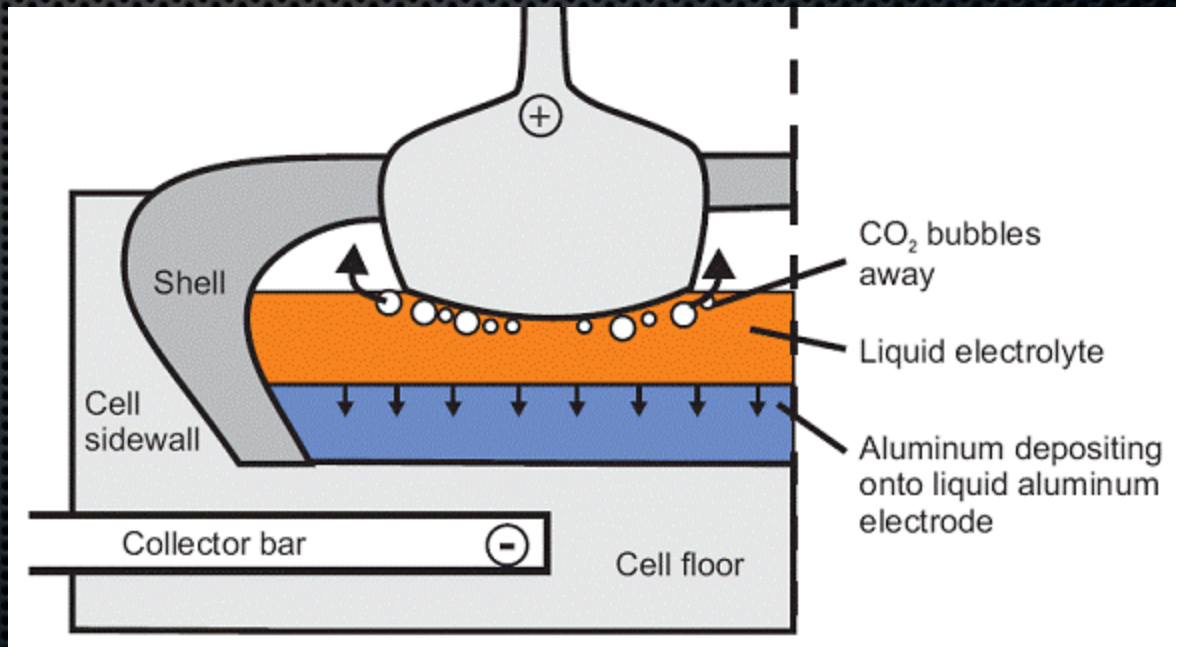
LOW COST MEMBRANE ARCHITECTURE

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

Water Passes More Freely Through the Membrane

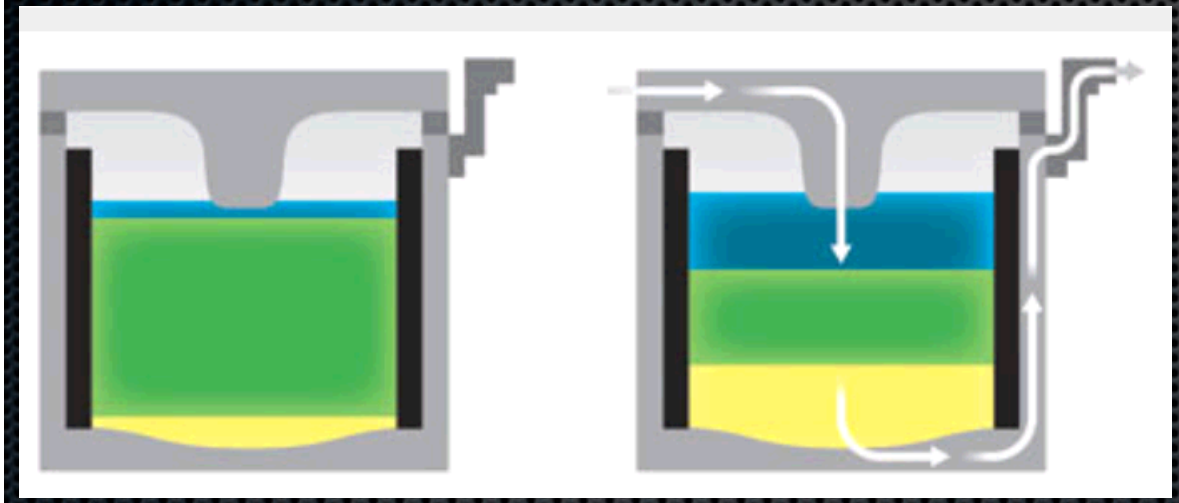
Requiring 30-50% Less Energy

Aluminum refining requires millions of watts of power



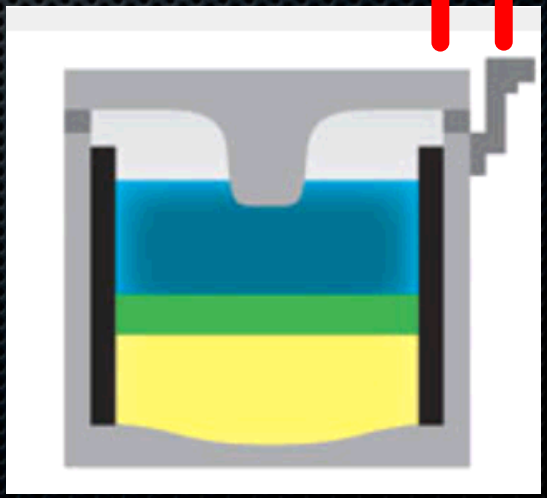
Battery Charging mode

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

Martin Luther King (1967) :

“….We are now faced with the fact, my friends, that tomorrow is today. We are confronted with the fierce urgency of now. In this unfolding conundrum of life and history, there is such a thing as being too late.”