STANFORD UNIVERSITY
GLOBAL CLIMATE & ENERGY PROJECT

The Global Energy Challenge

Roel Snieder

Photo: USFWS/Susanne Miller

The Global Climate and Energy Project

GCEP

ExxonMobil

GE

Schlumberger

TOYOTA

GCEP

Mission

- Research on low-GHG emission energy conversions
- Focus on fundamental and pre-commercial research
- Applications in the 10-50 years timeframe

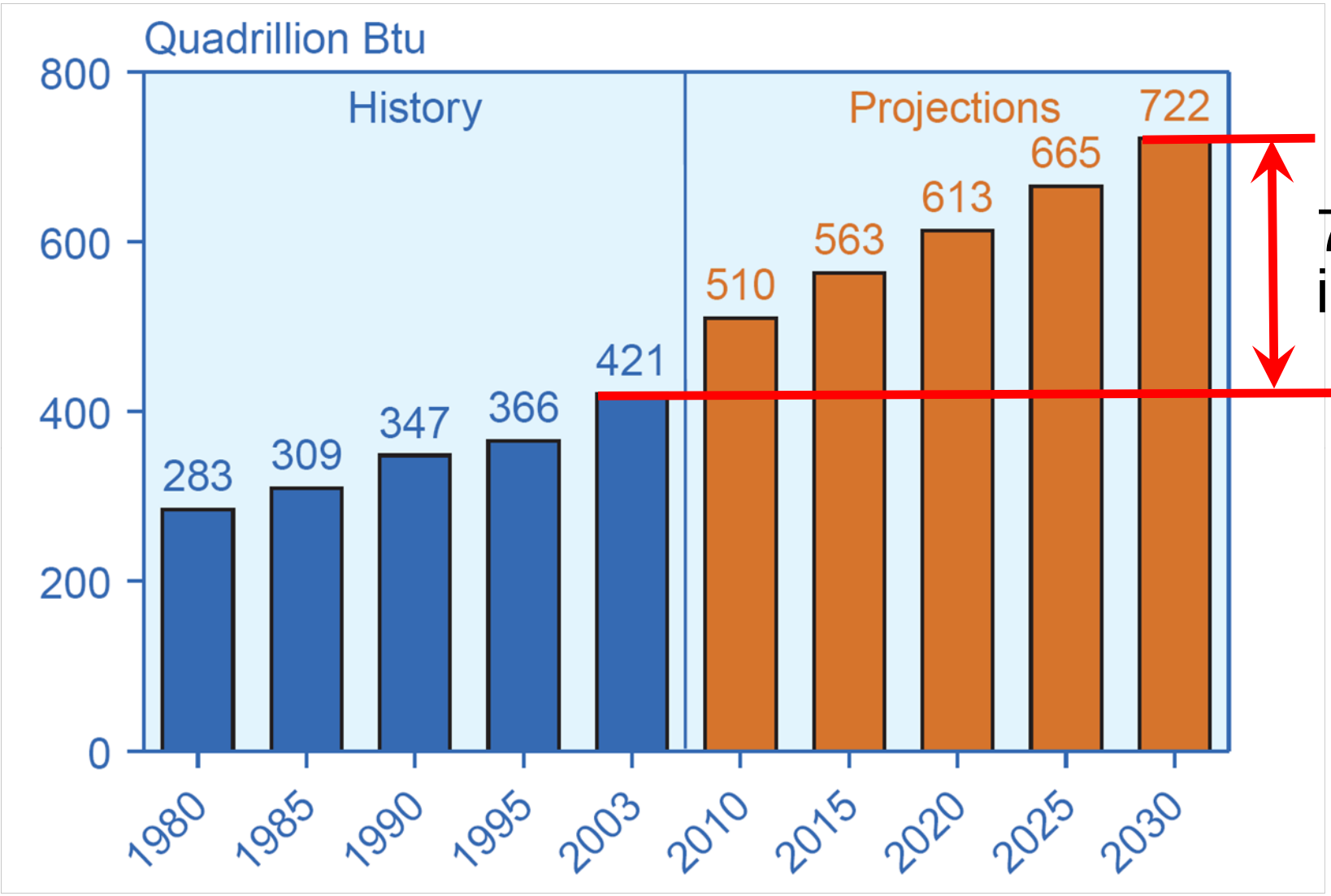
Strategy

- Research projects with potential for significant impact on GHG emissions
- Look for potential breakthroughs for new conversion options
- High risk / high reward
- Work at Stanford and at other institutions around the world

Schedule and Budget

- 10 years (2003 – 2013+)
- $225 M

Total global energy demand



(International Energy Outlook 2006)

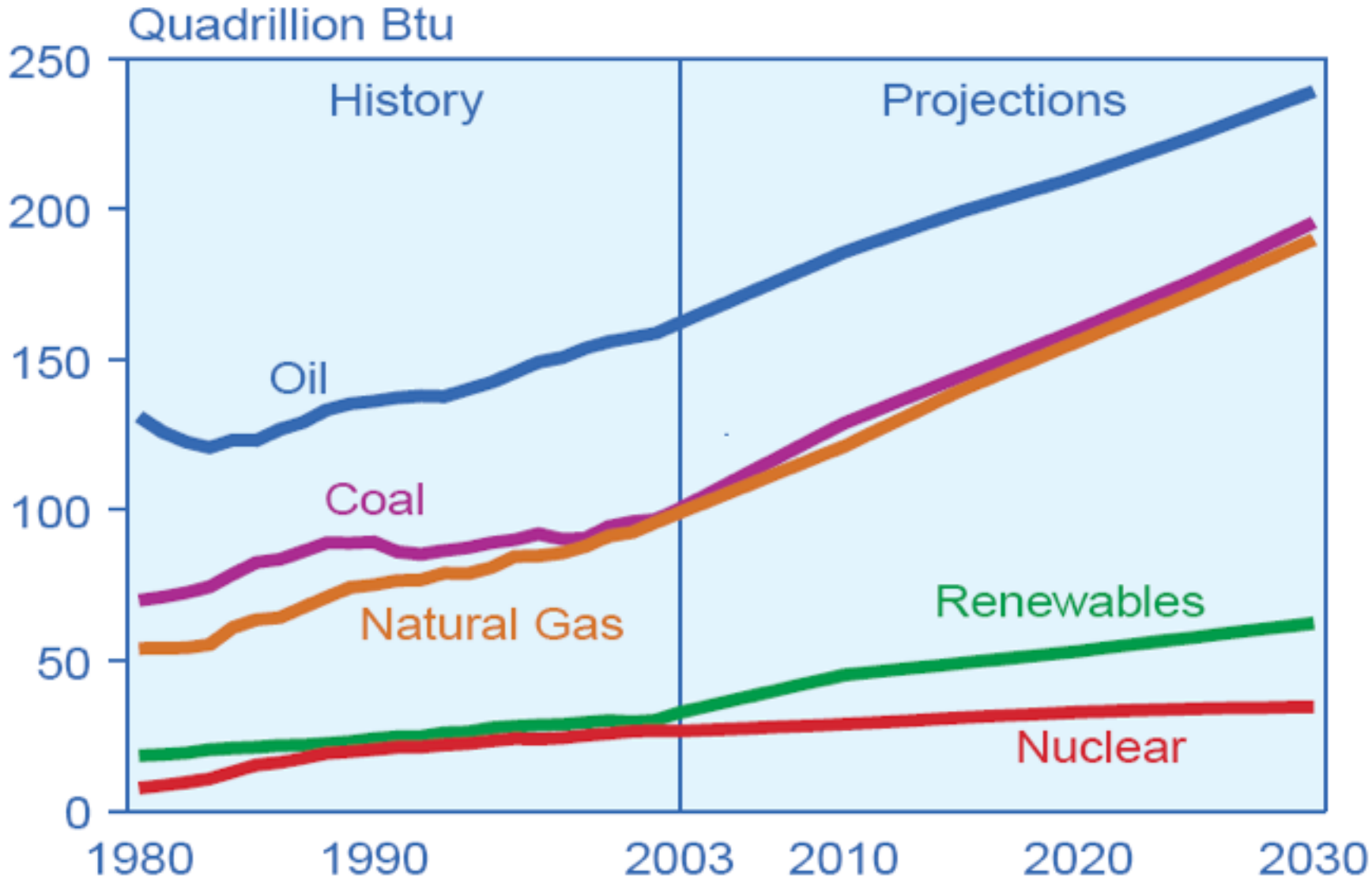
Developing countries

… and our energy use

Our energy-dependence (1)

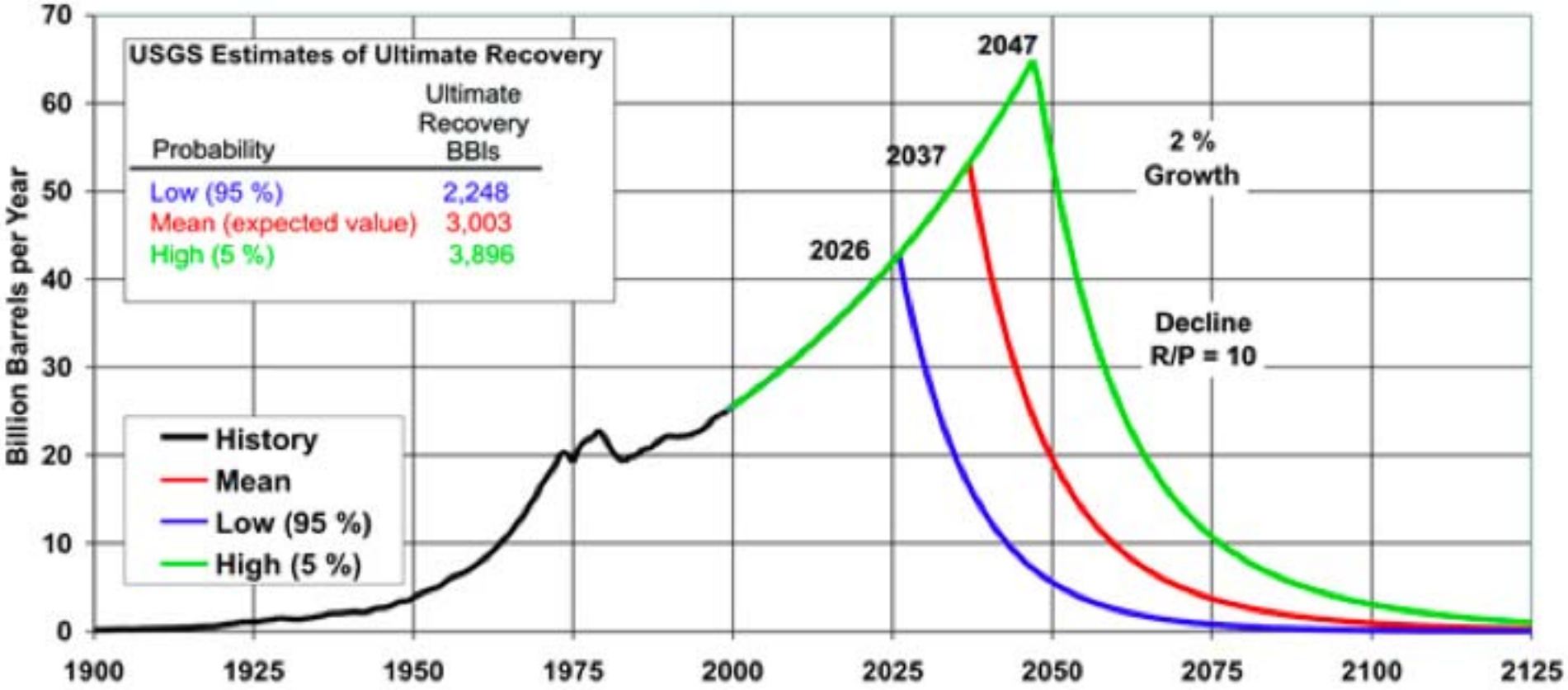
Our energy-dependence (2)

Energy use by type



(International Energy Outlook 2006)

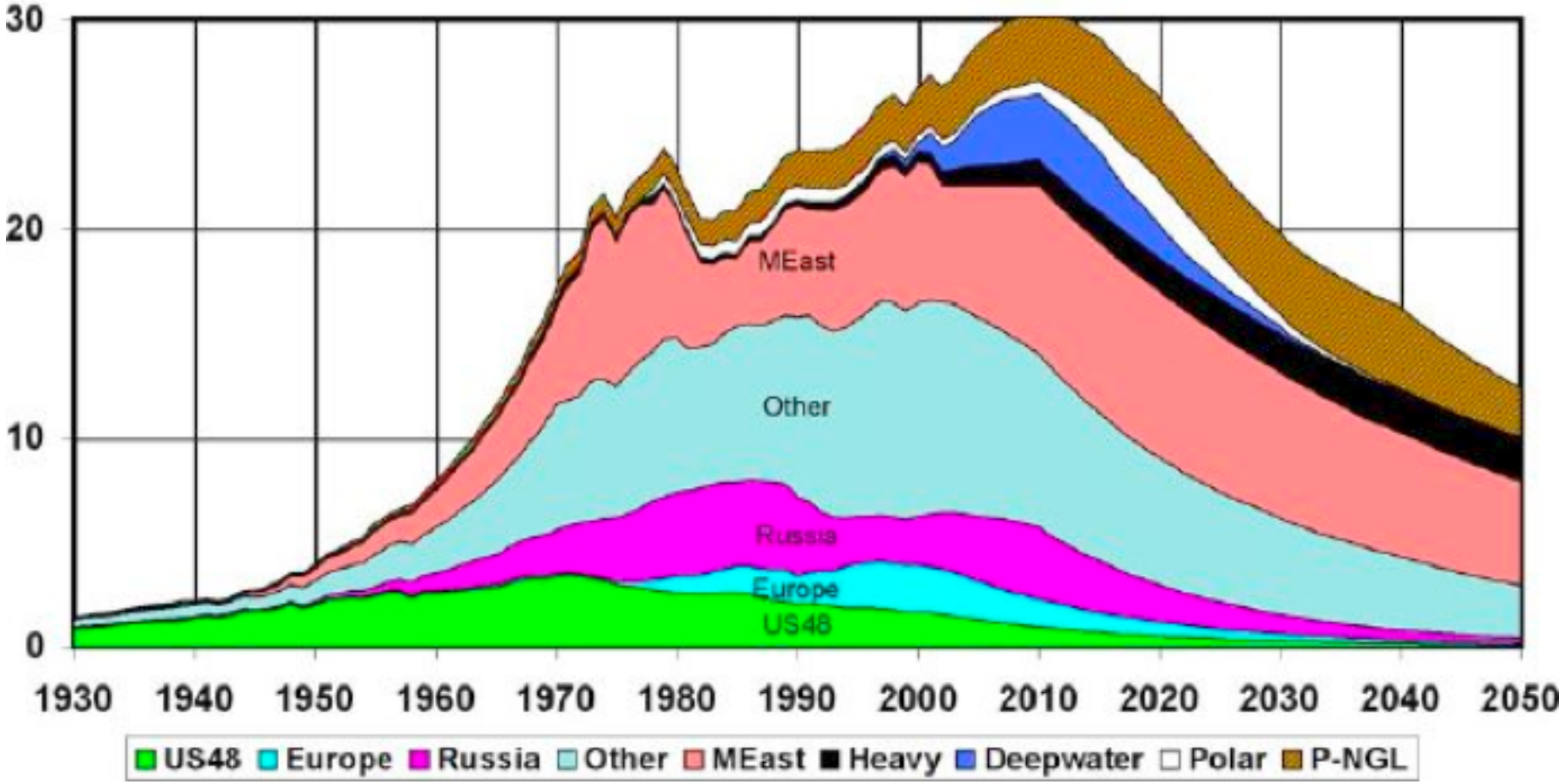
Peak oil



N.B. based on USGS estimates, these are among the most optimistic

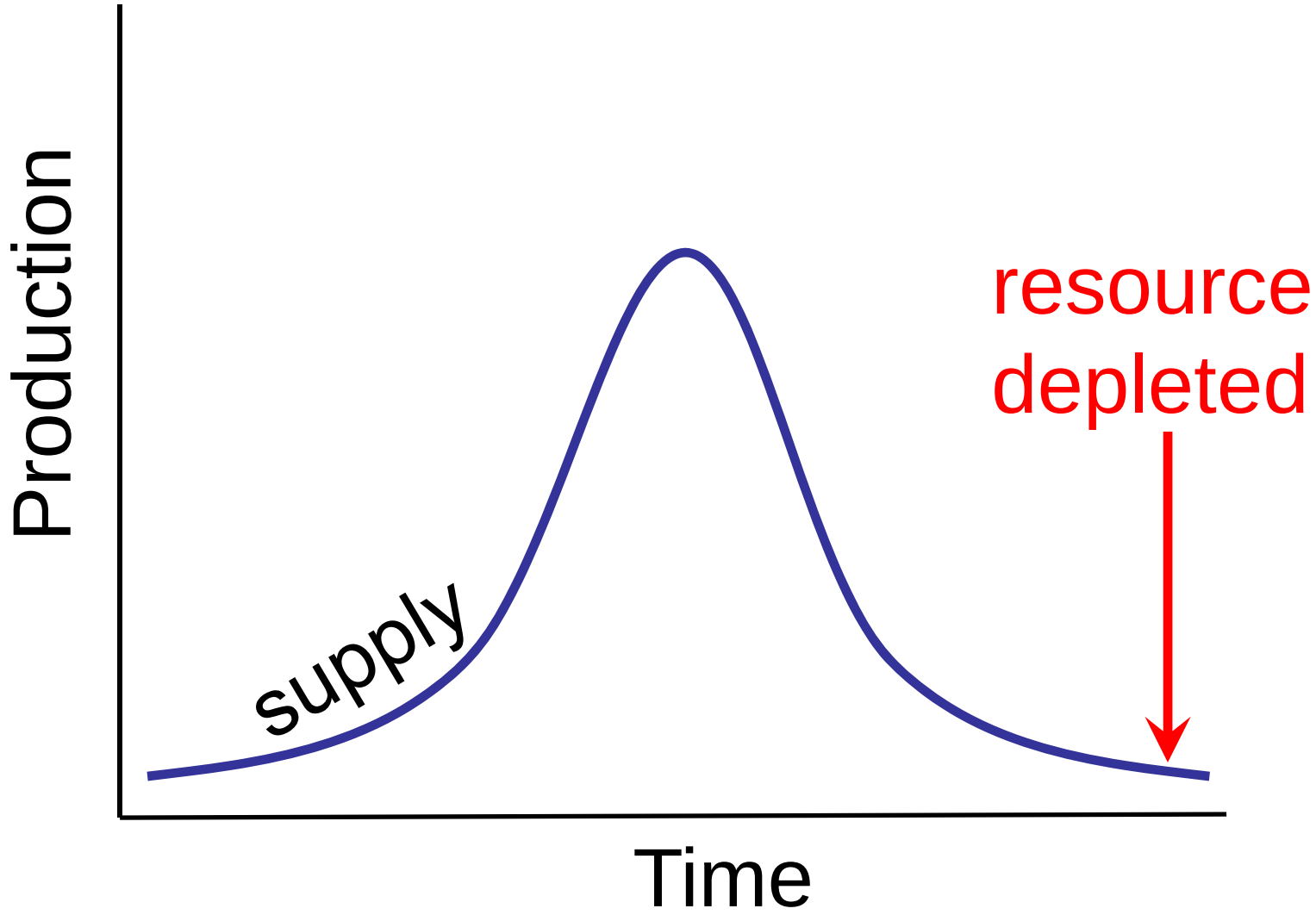
(Energy Information administration)

Peak oil (again)

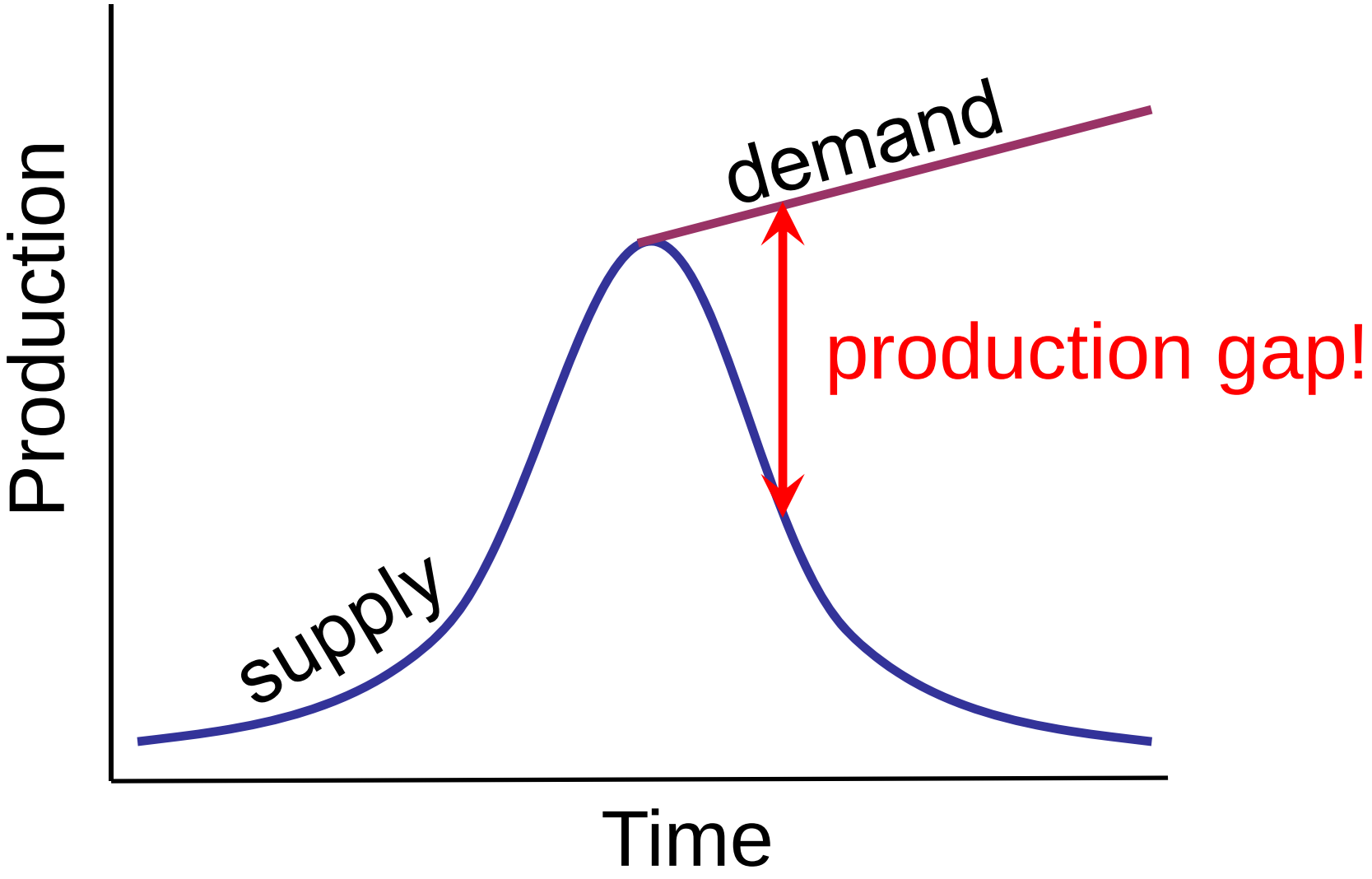


http://info.energyscenariosireland.com/Overview

Declining production (1)



Declining production (2)



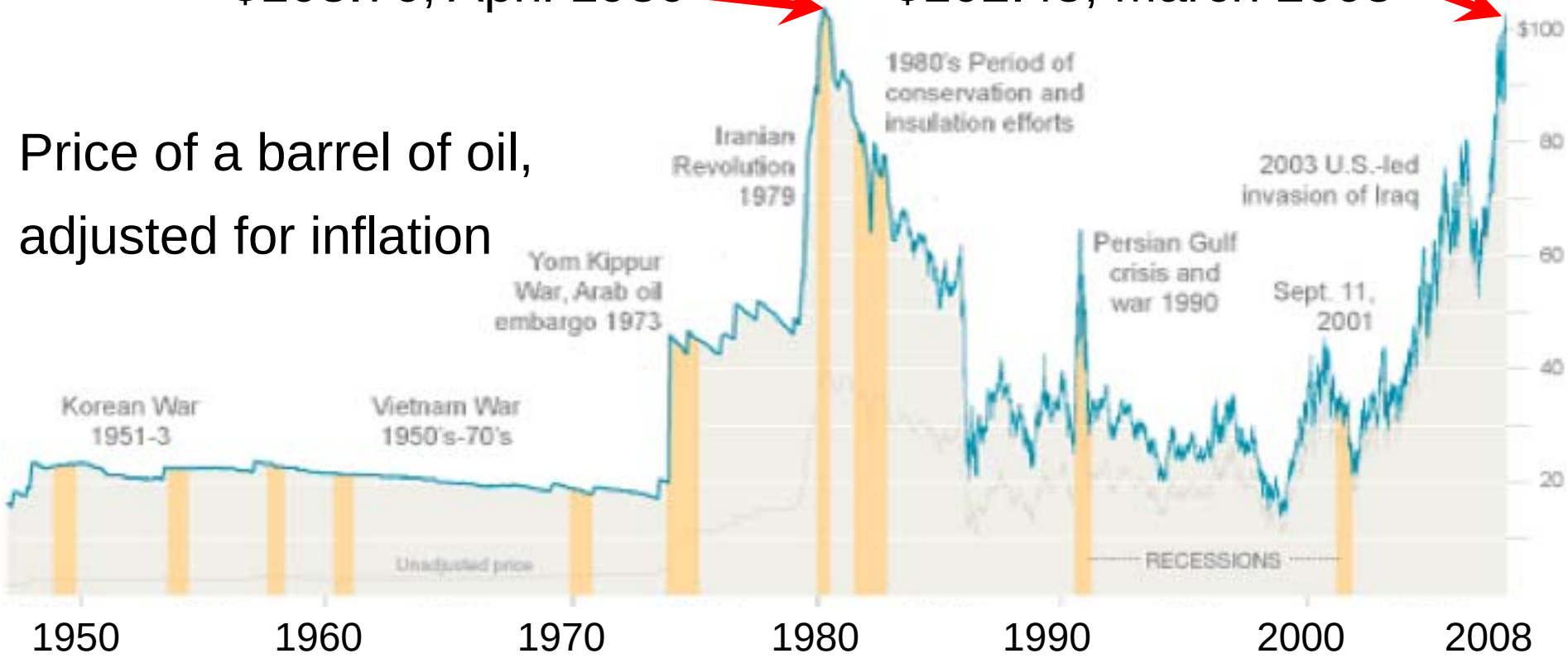
Oil Tops Inflation-Adjusted Record Set in 1980

(NYT, March 4, 2008)

$103.76, April 1980

$102.45, March 2008

Price of a barrel of oil, adjusted for inflation



(Source: Federal Reserve Energy Information Administration)

John Hess, CEO of Hess Corp.

"We've moved from a supply-led market to a demand-led one. In the past, the world has relied on OPEC's spare capacity, which in 1985 was 10 million barrels per day. Today that number is about 2.5 million barrels a day. We no longer have a safety margin to ensure price stability in the face of supply interruptions and demand spikes. Right now it's hard to see any relief in sight. Then there's demand. About 50 percent of oil demand is for transportation, and auto ownership in the developing countries is growing swiftly, especially in India and China. ….. Put those two things together - limited supply and increasing demand - and you get high oil prices."

(Newsweek, March 15, 2008, http://www.newsweek.com/id/123482)

New find in GOM
(Jack No. 2 test well)

- up to 3-15 billion barrels of oil
- US consumption 20 million barrels/day
- 5 months - 2 years
- reservoir is 8 km under sea level

A Quest for Energy in the Globe's Remote Places

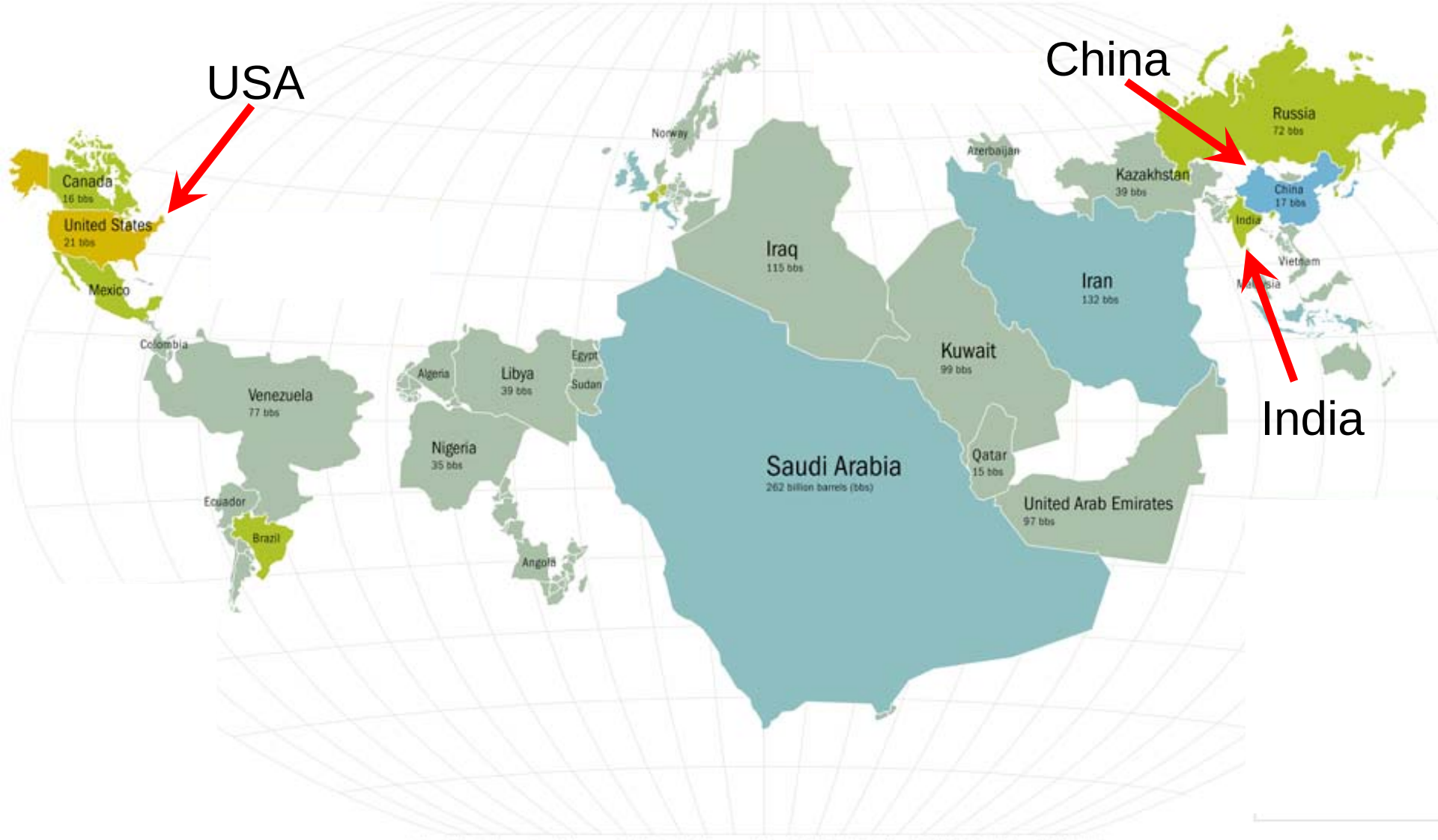
(New York Times, October 9, 2007)

A natural gas cargo ship passing Melkoya Island, across the bay from Hammerfest, Norway.

Oil-Rich Nations Use More Energy, Cutting Exports

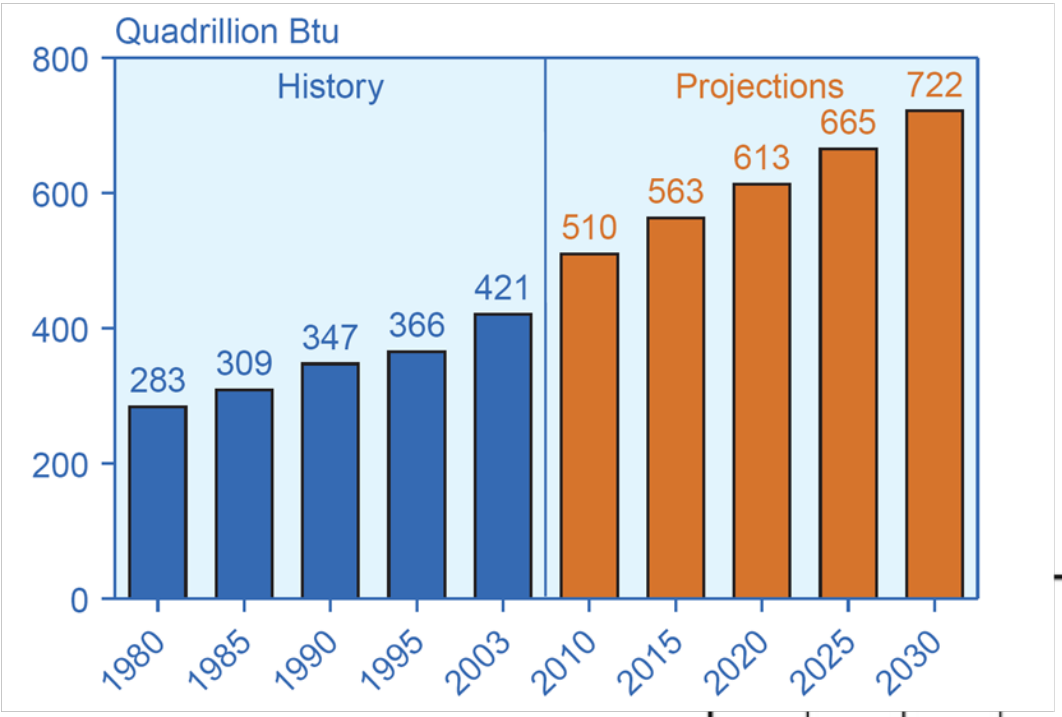
(New York Times, December 9, 2007)

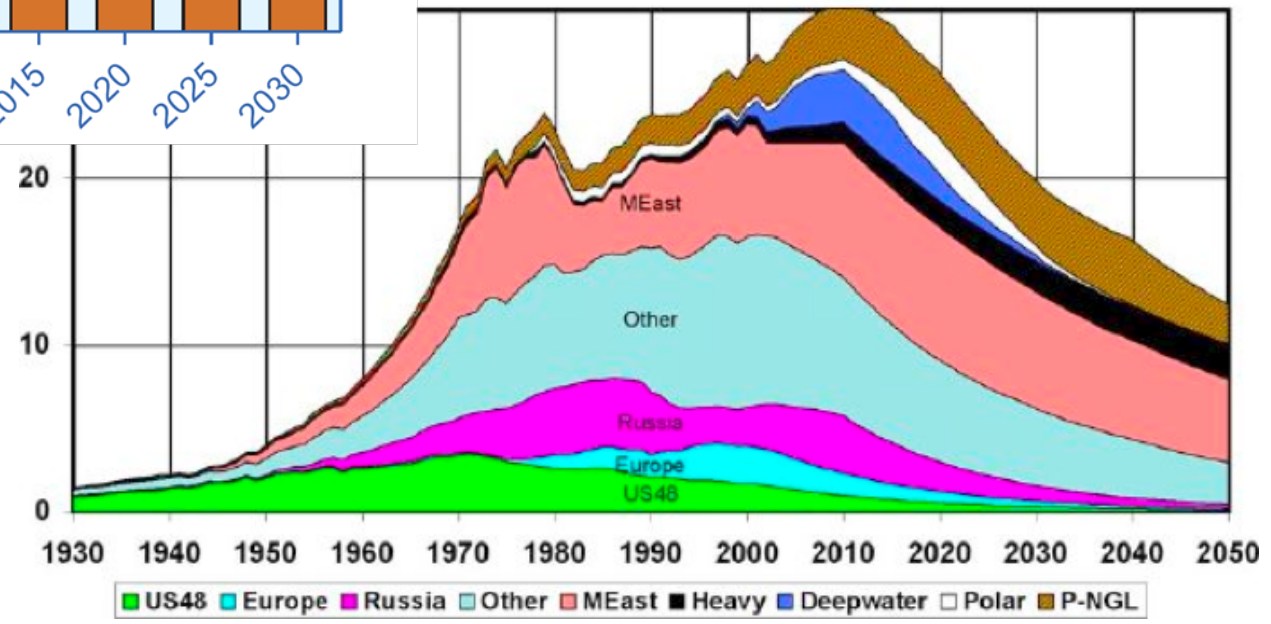
Who has the oil?



(http://www.energybulletin.net/37329.html)

What is the plan?





A New, Global Oil Quandary: Costly Fuel Means Costly Calories

(NYT, January 19, 2008)

Rising prices for cooking oil are forcing residents of Asia's largest slum, in Mumbai, India, to ration every drop. Bakeries in the United States are fretting over higher shortening costs.

Carbohydrates and biofuel

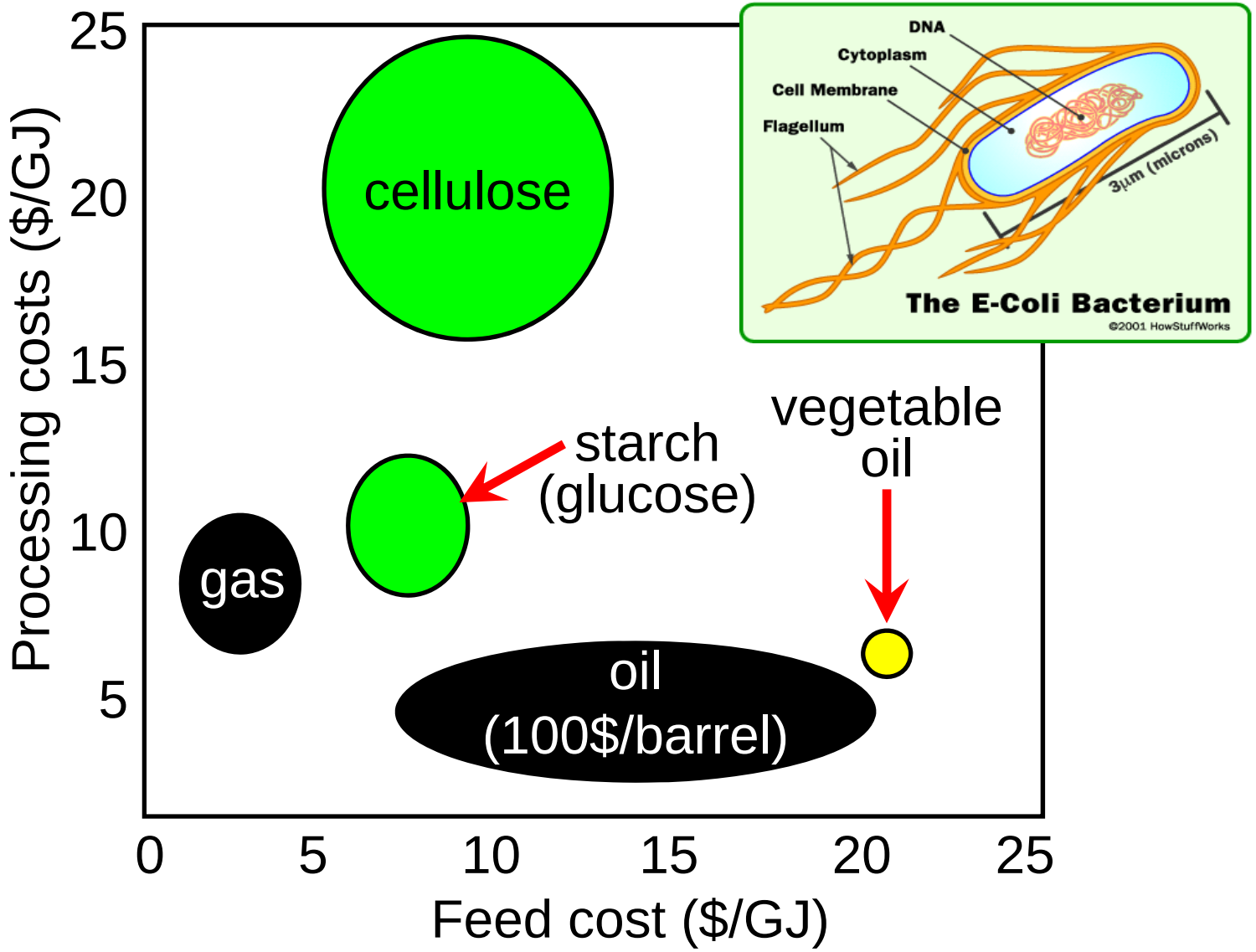
glucose

cellulose

Do we feed humans or cars?

Is it a good idea to compete with our machines for calories?

Research: biofuel from cellulose



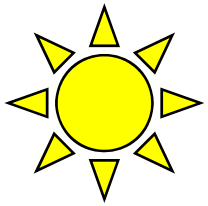
http://gcep.stanford.edu/research/biomass.html

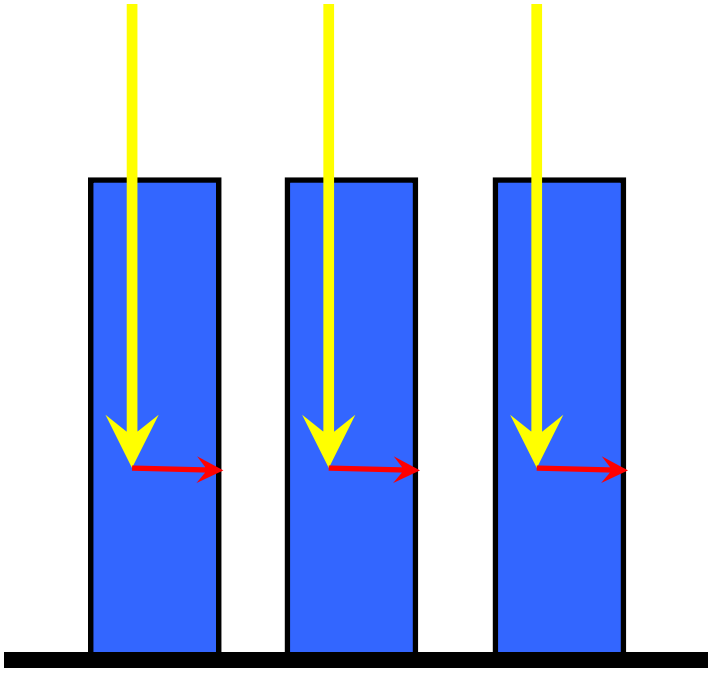
(Figure adapted from Lange, J.P., Biofuels, Bioproducts and Biorefining, 1: 39-48, 2007)

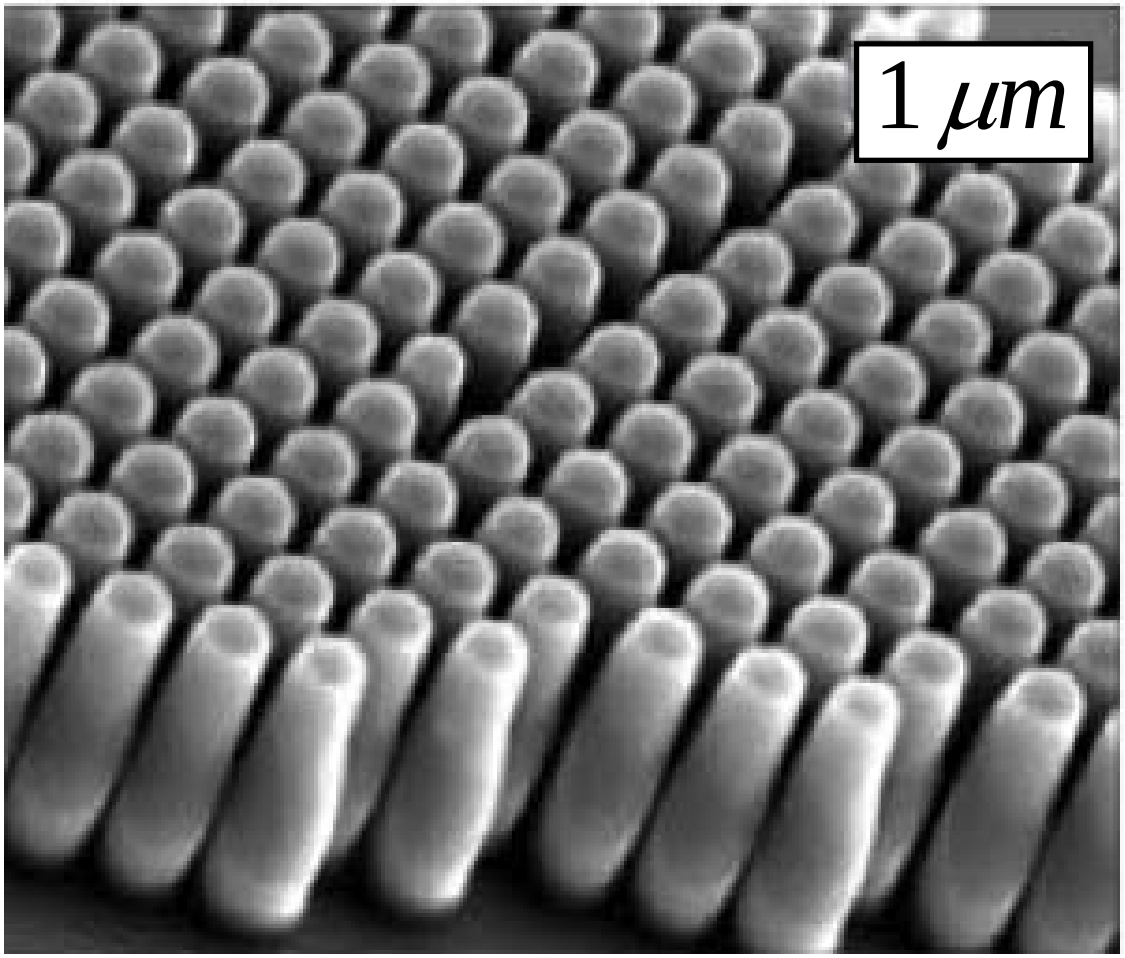
First solar 2 MW array

Ft. Carson, CO

Research: efficient solar cells

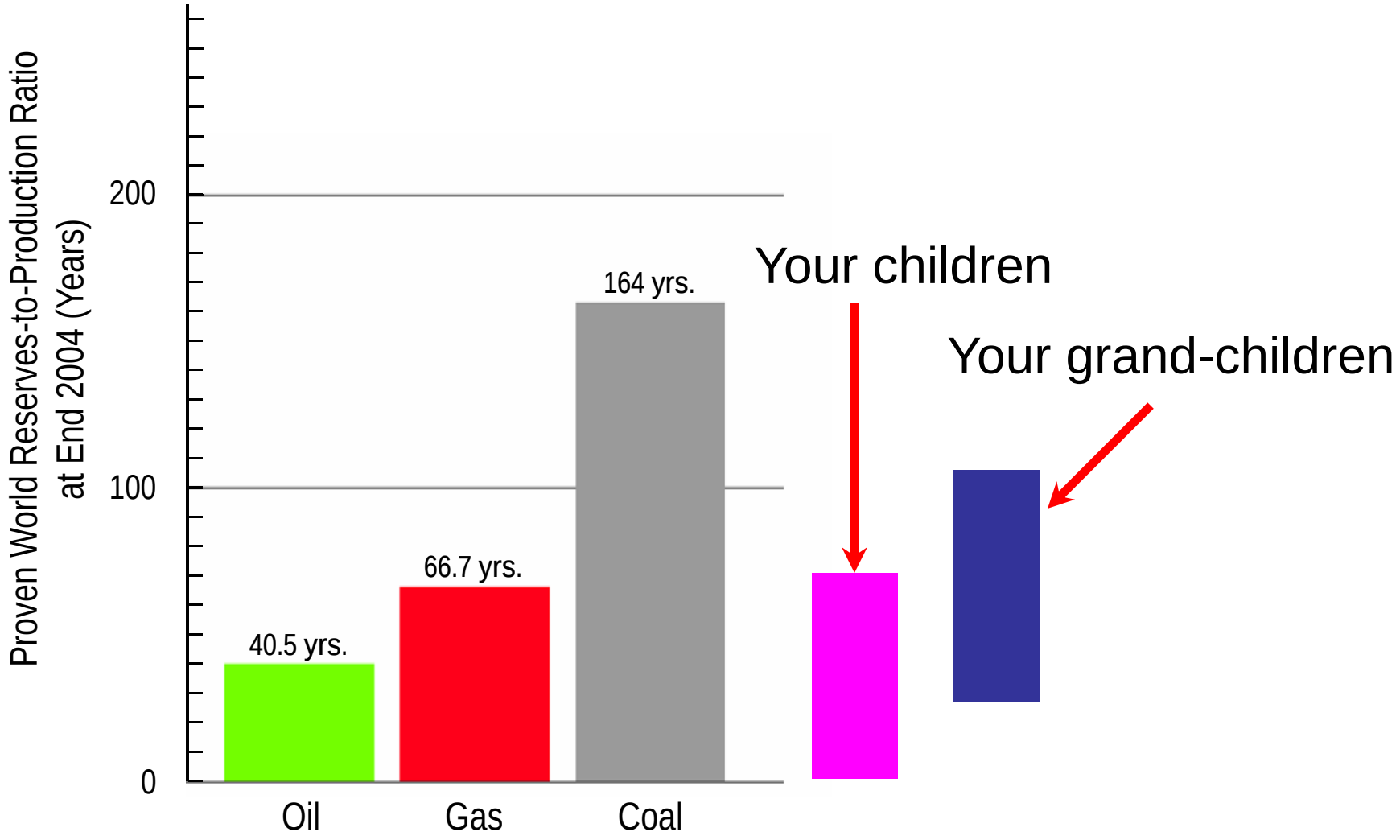






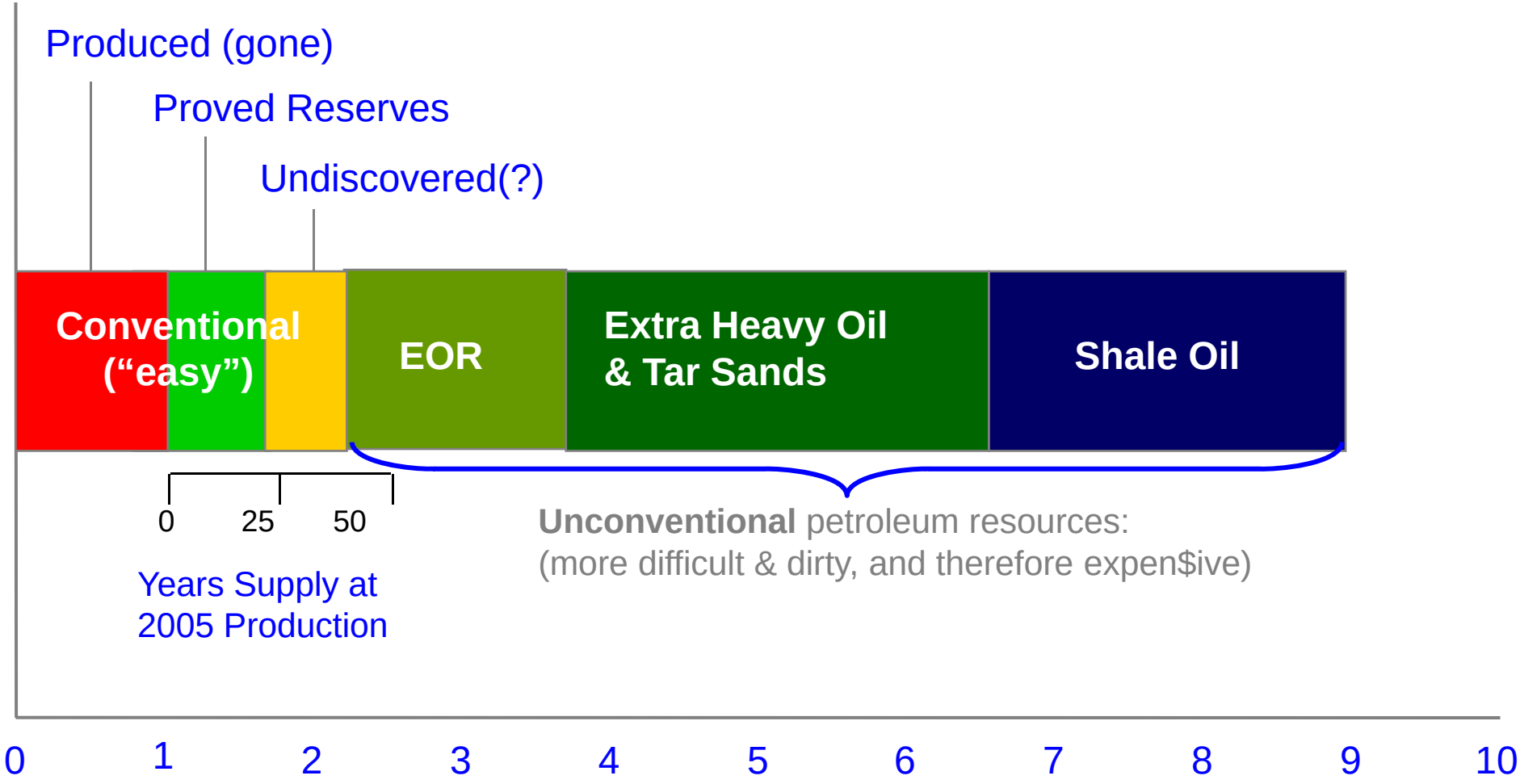
http://gcep.stanford.edu/research/solar.html

Fossil fuel reserves



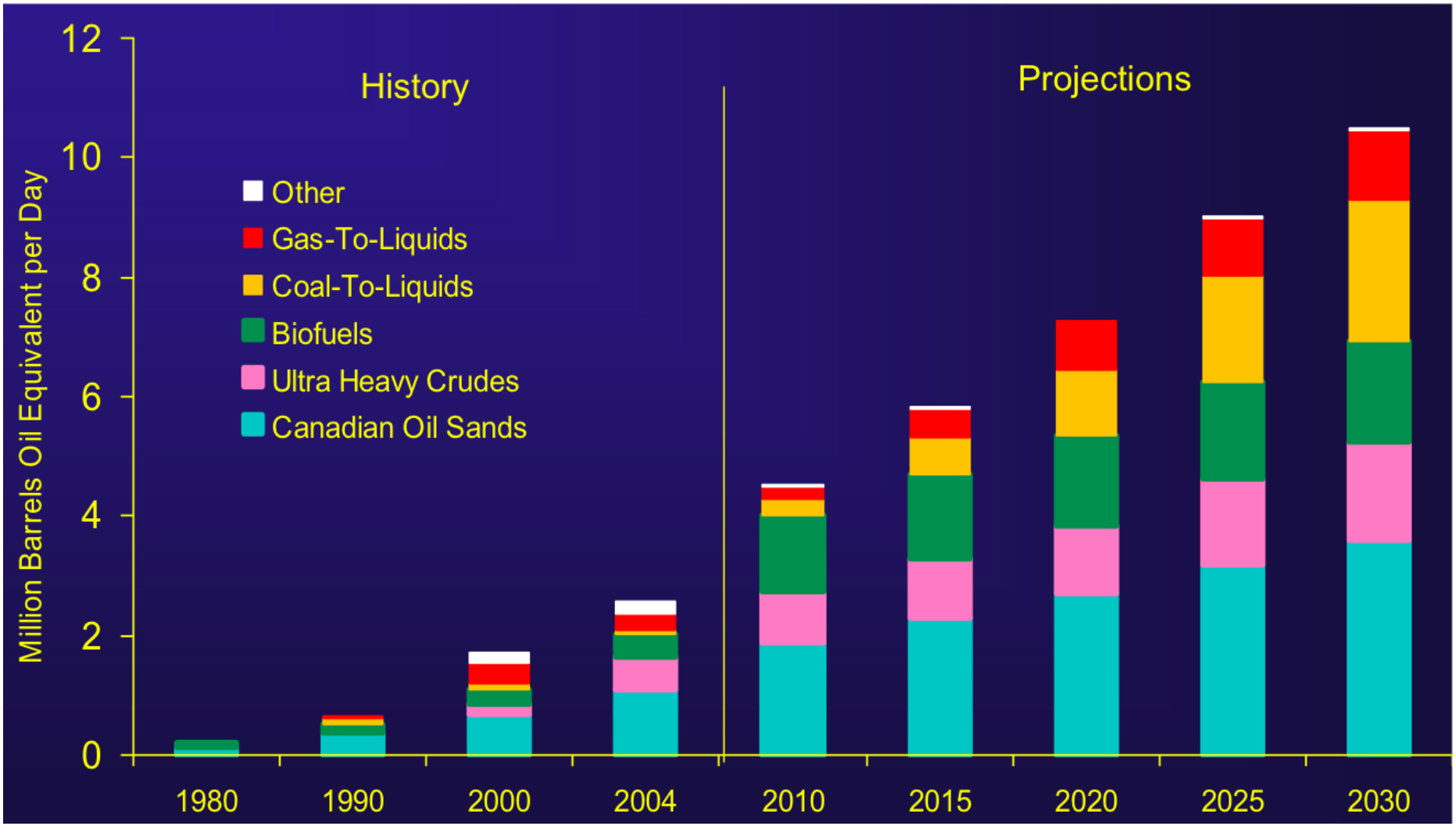
BP Statistical Review of World Energy 2005

Non-convenional reserves (excluding gas and coal)



(Courtesy of Joe Stefani)

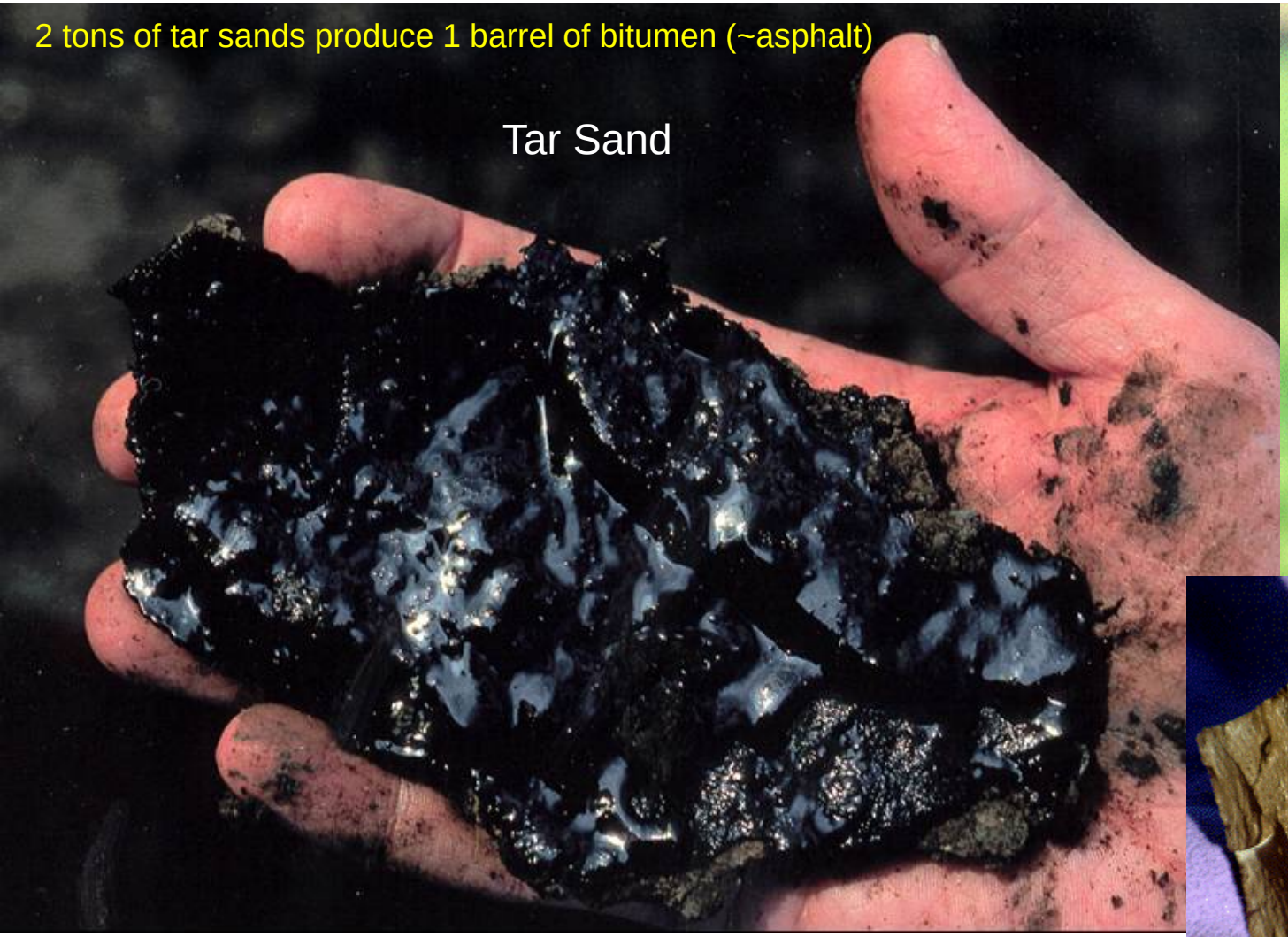
World's unconventional production

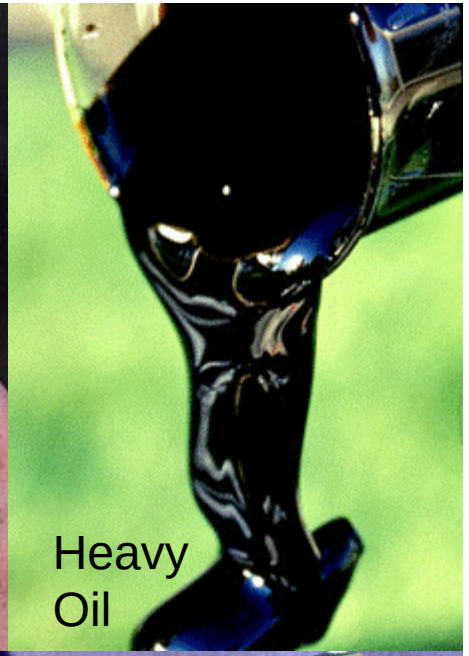


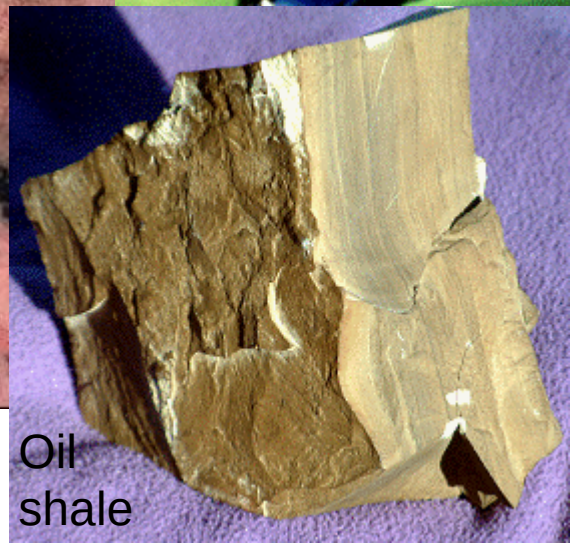
N.B. World's annual oil consumption 2006 is 85 million barrels/day

Source: Energy Information Administration, 2007

Non-conventional oil

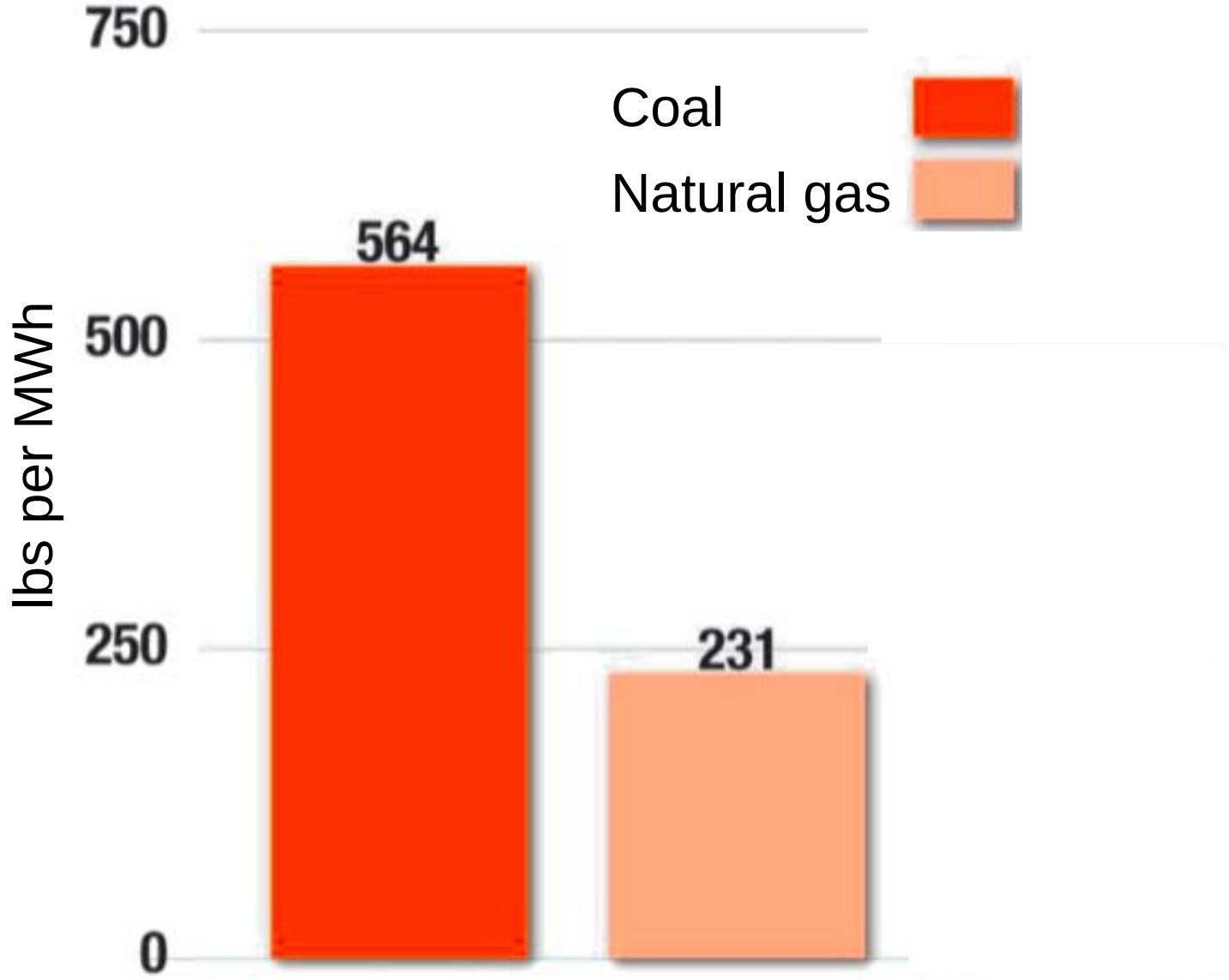






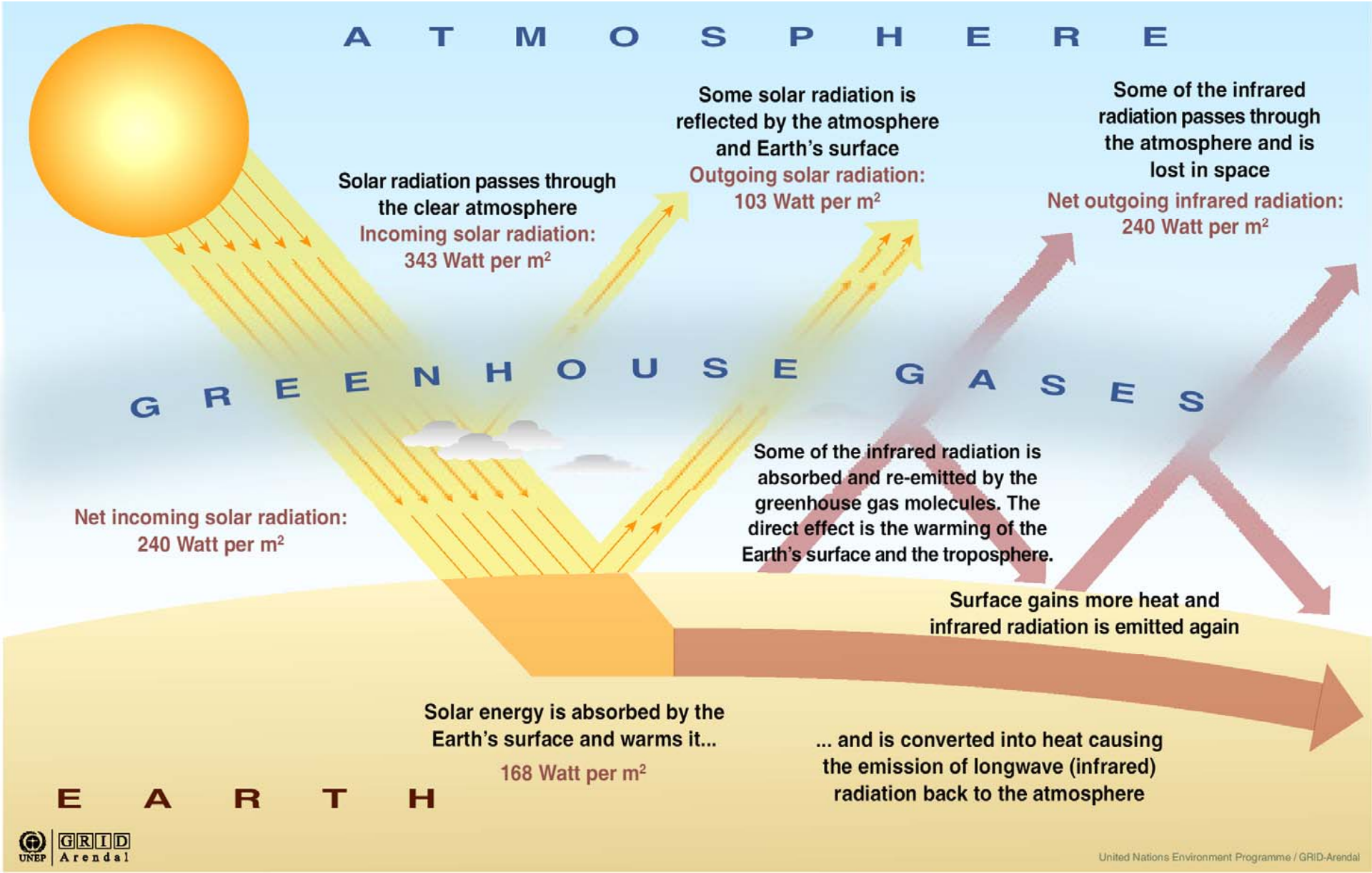
from National Geographic, June 2004

CO_2 emissions vs fuel type



NREL technical report NREL/TP-840-400665

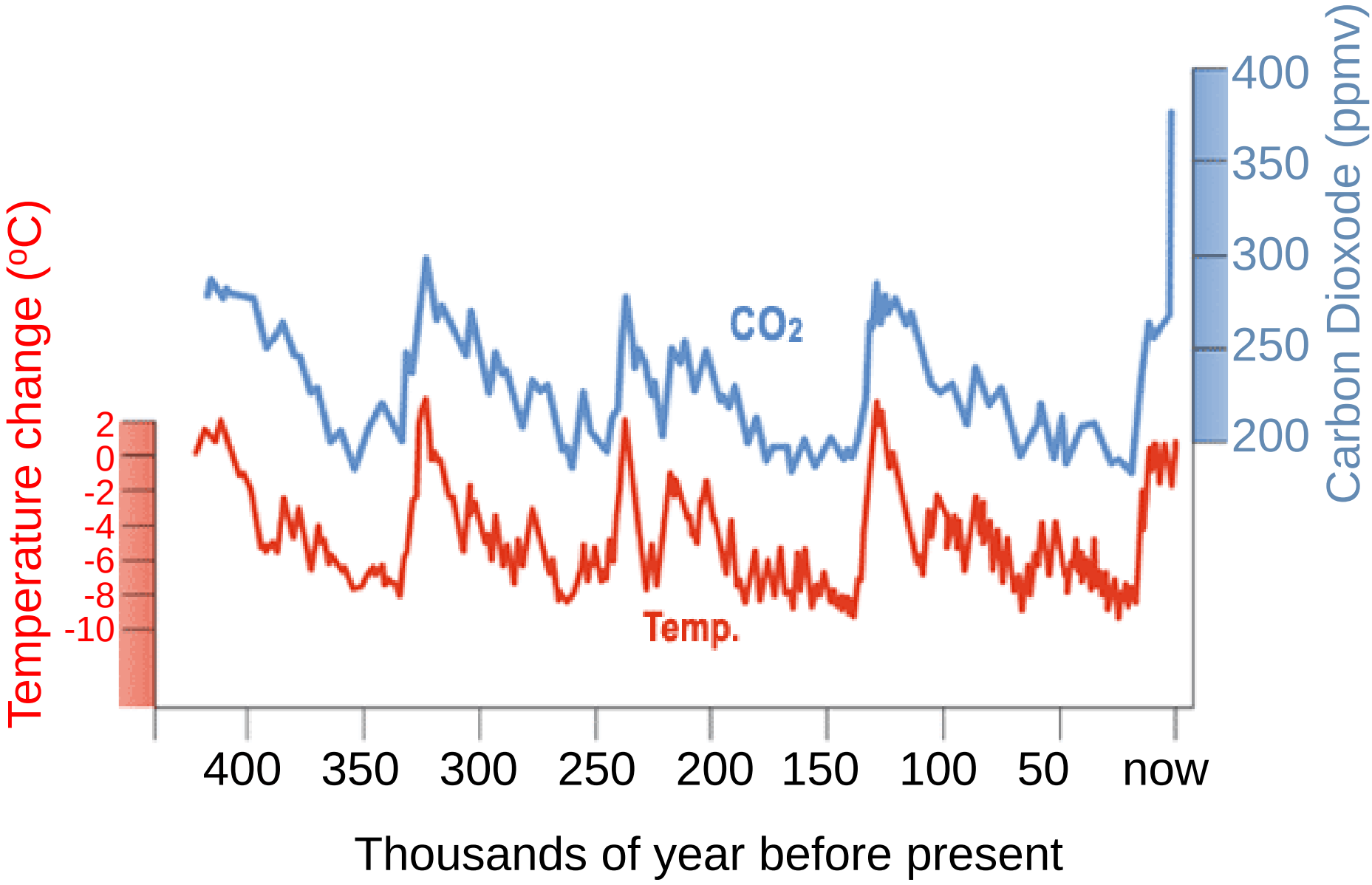
The Greenhouse Effect



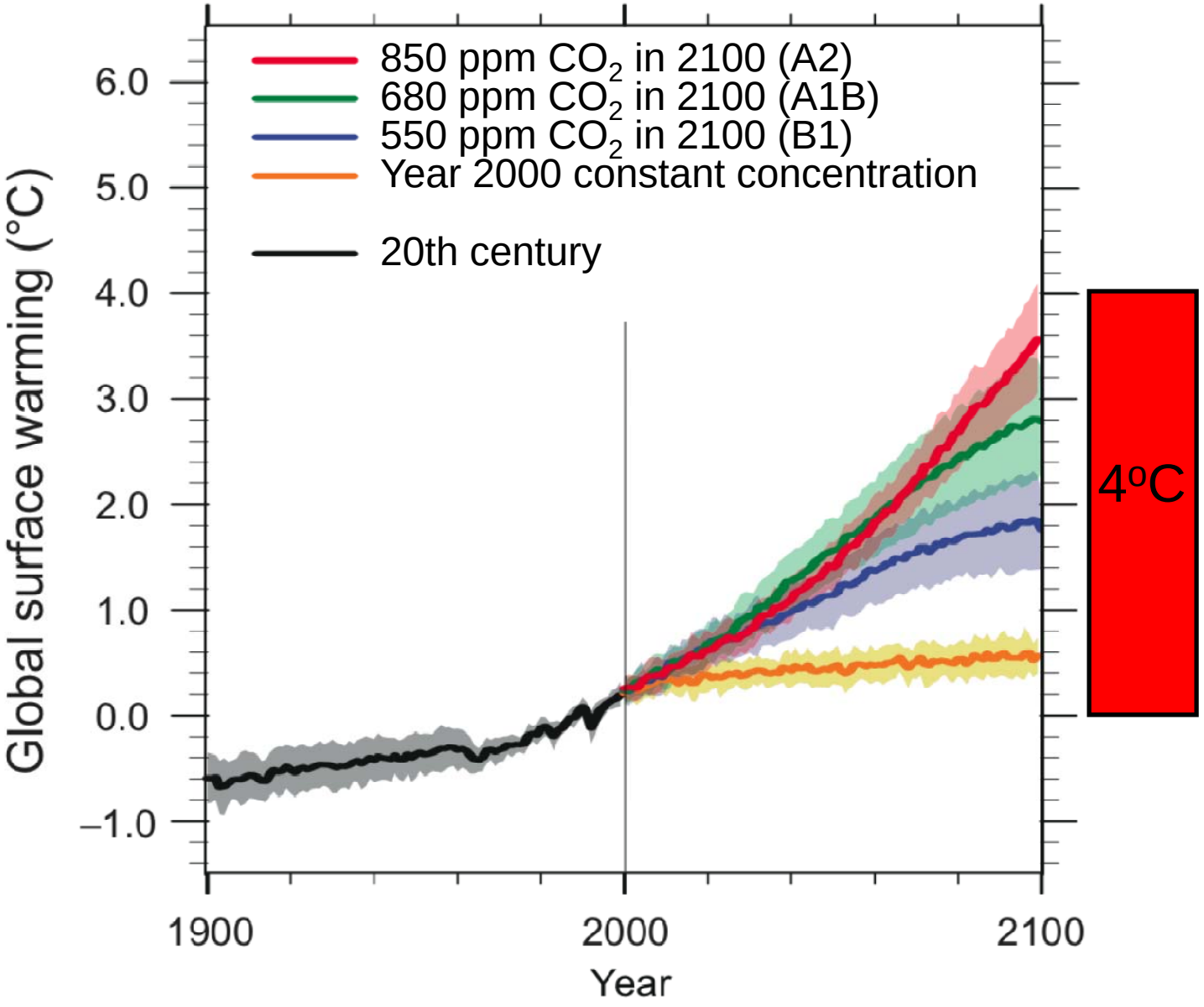
UNEP GRID Arendal

United Nations Environment Programme / GRID-Arendal

Temperature and CO_2 records

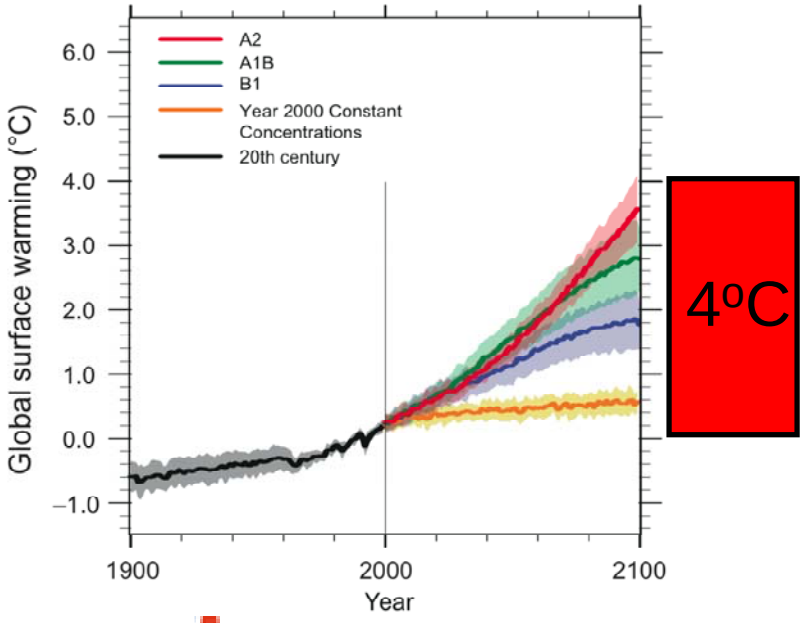


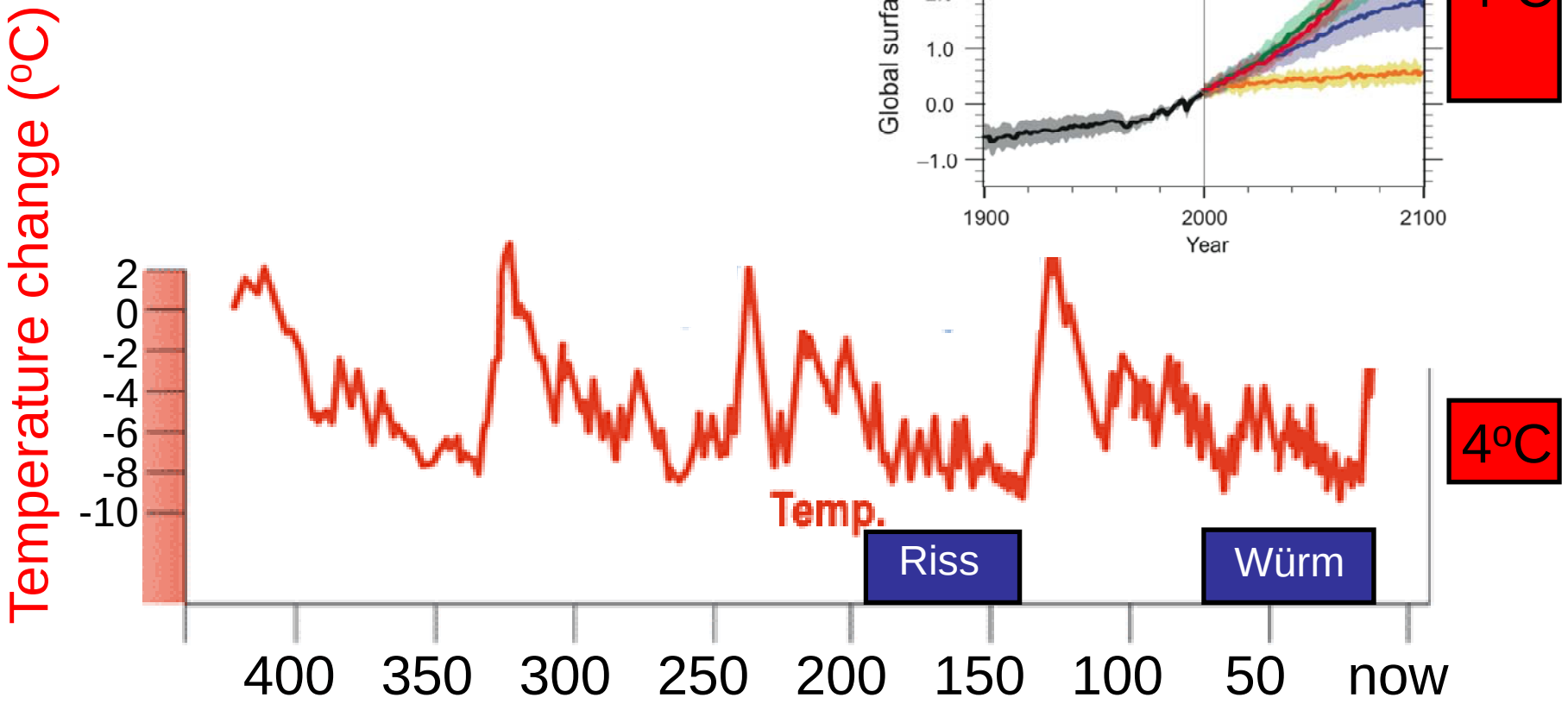
IPCC 4th Report



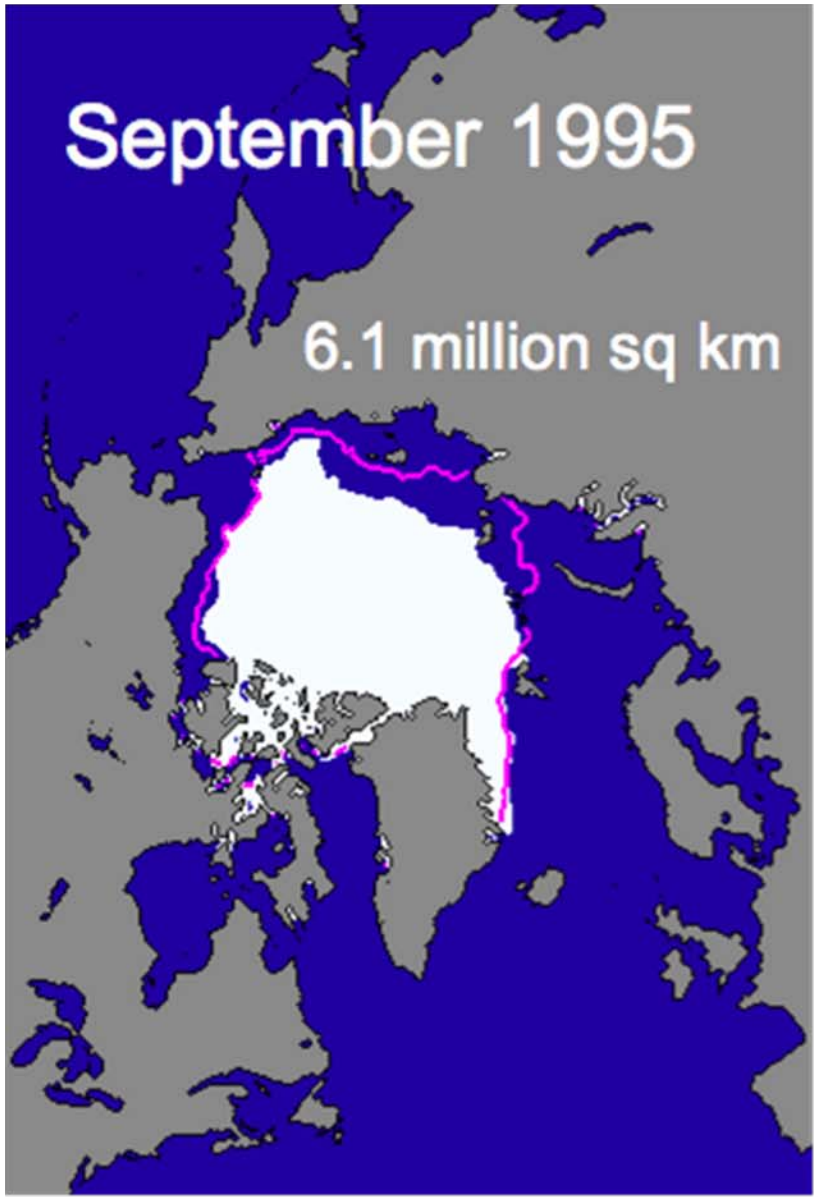
http://www.ipcc.ch/SPM2feb07.pdf

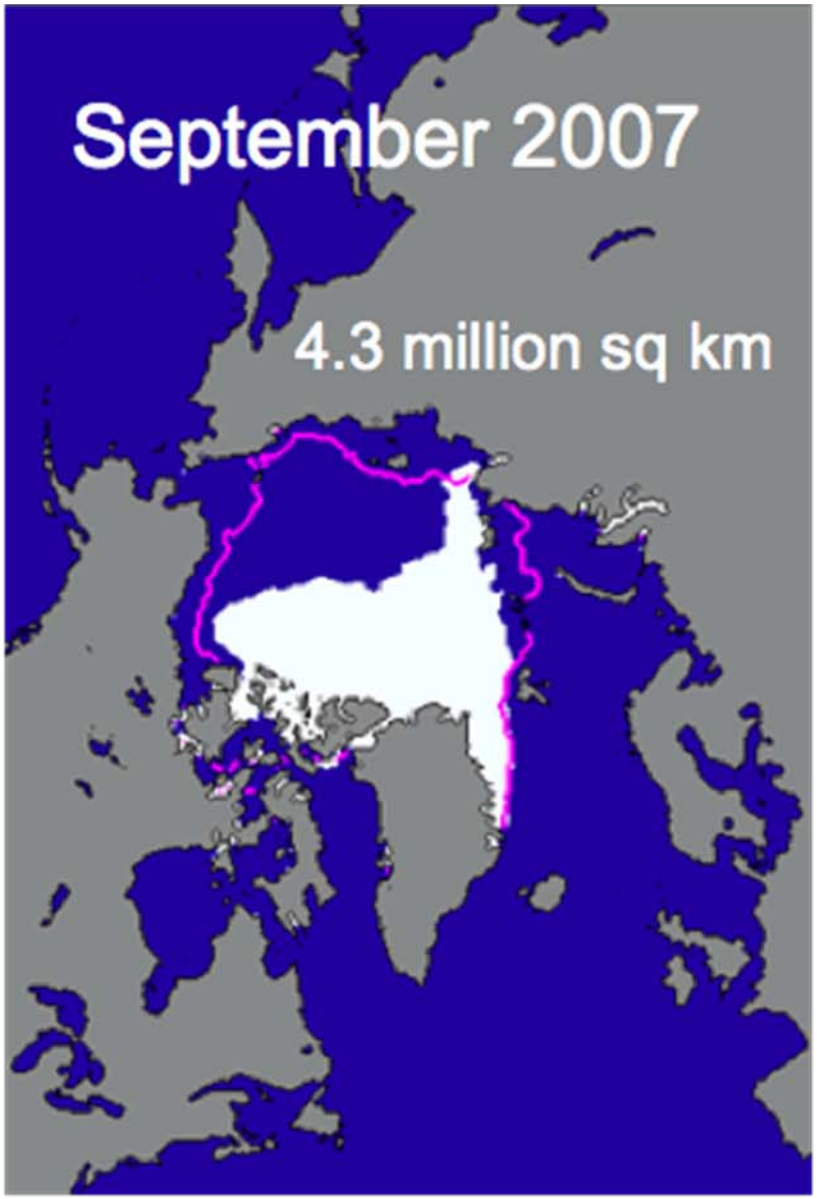
What is 4ºC difference?





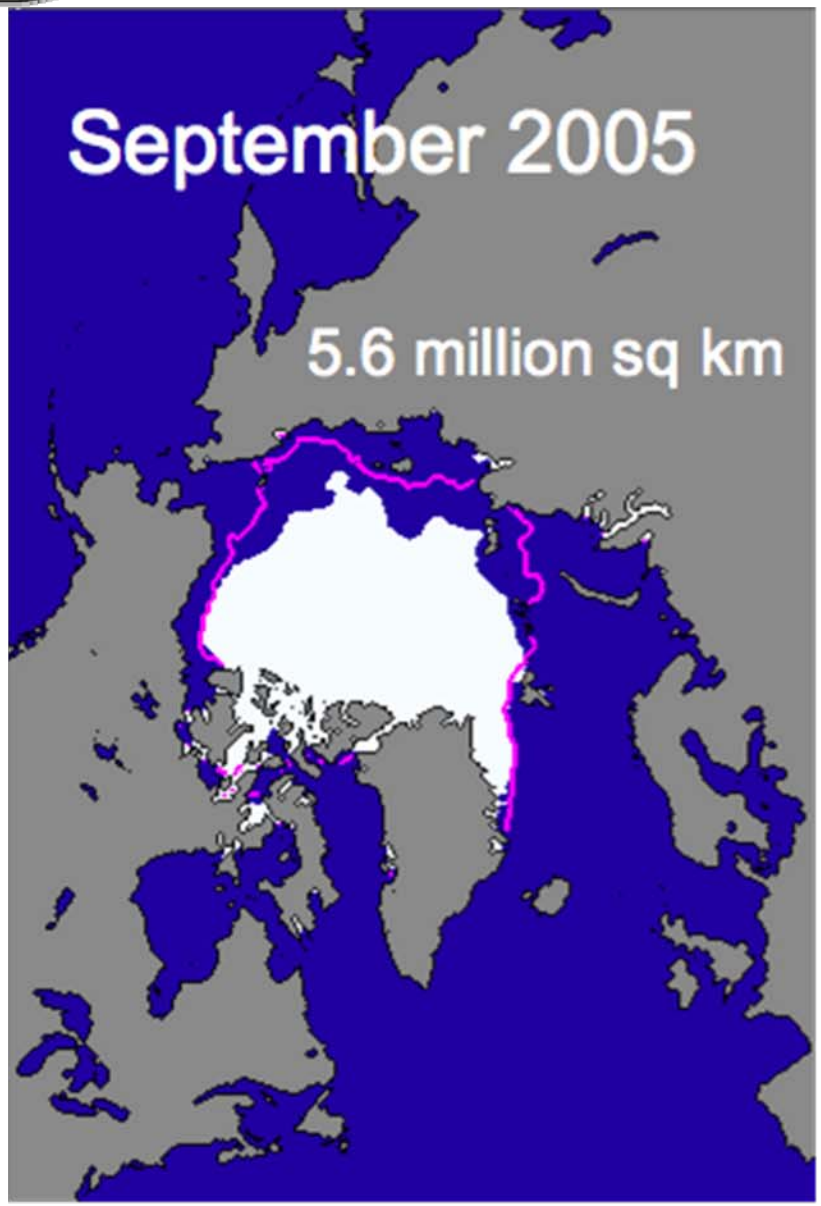
Arctic sea ice 1995-2007

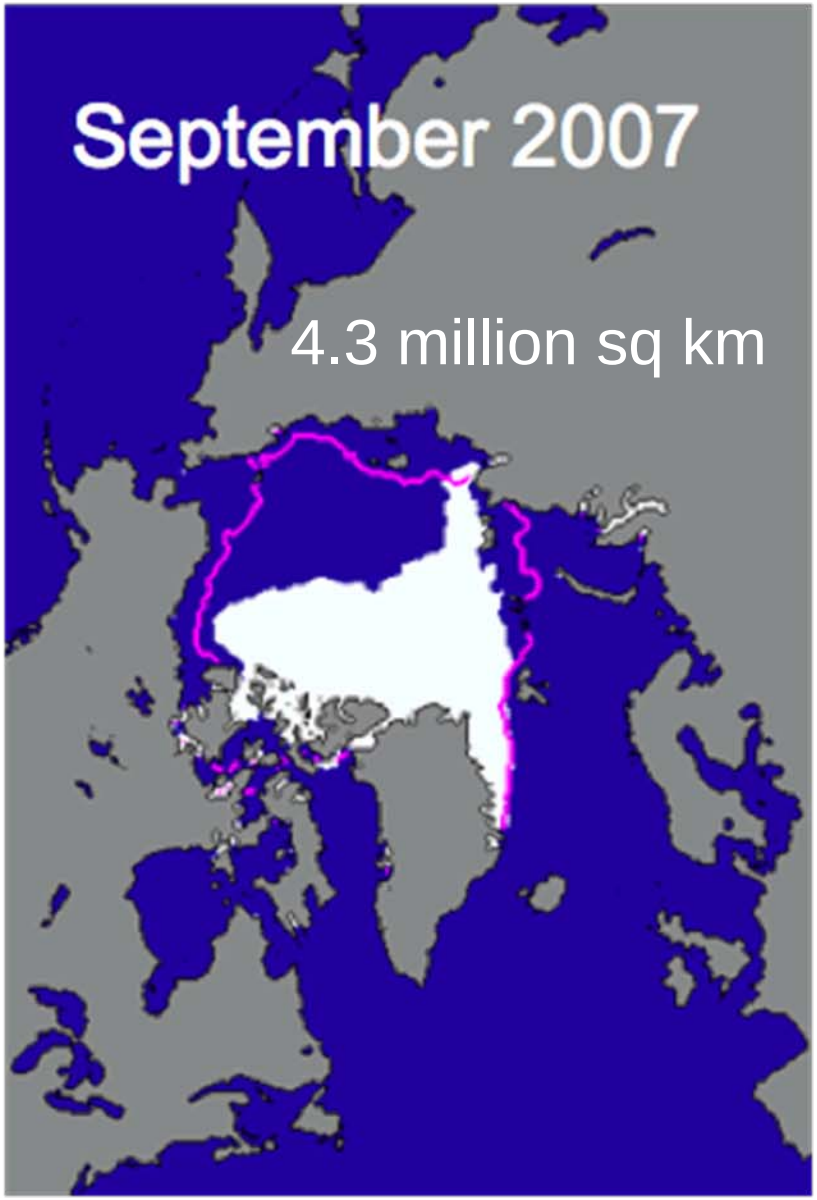




(National Snow and Ice Data Center, Boulder)

Arctic sea ice 2005-2007

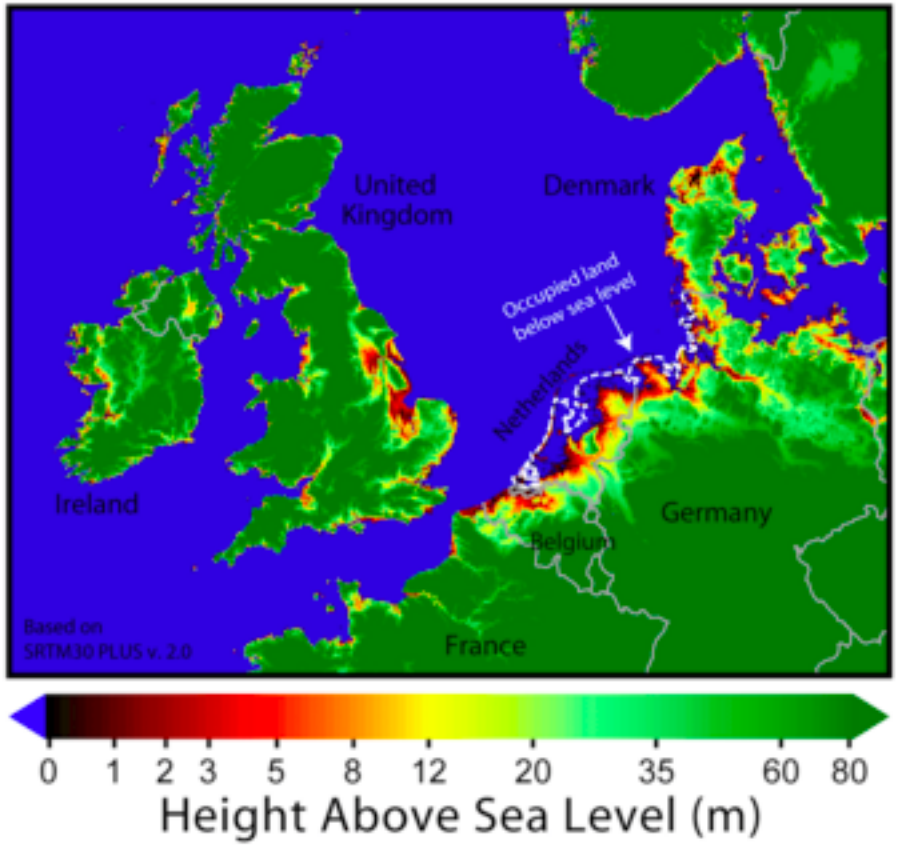


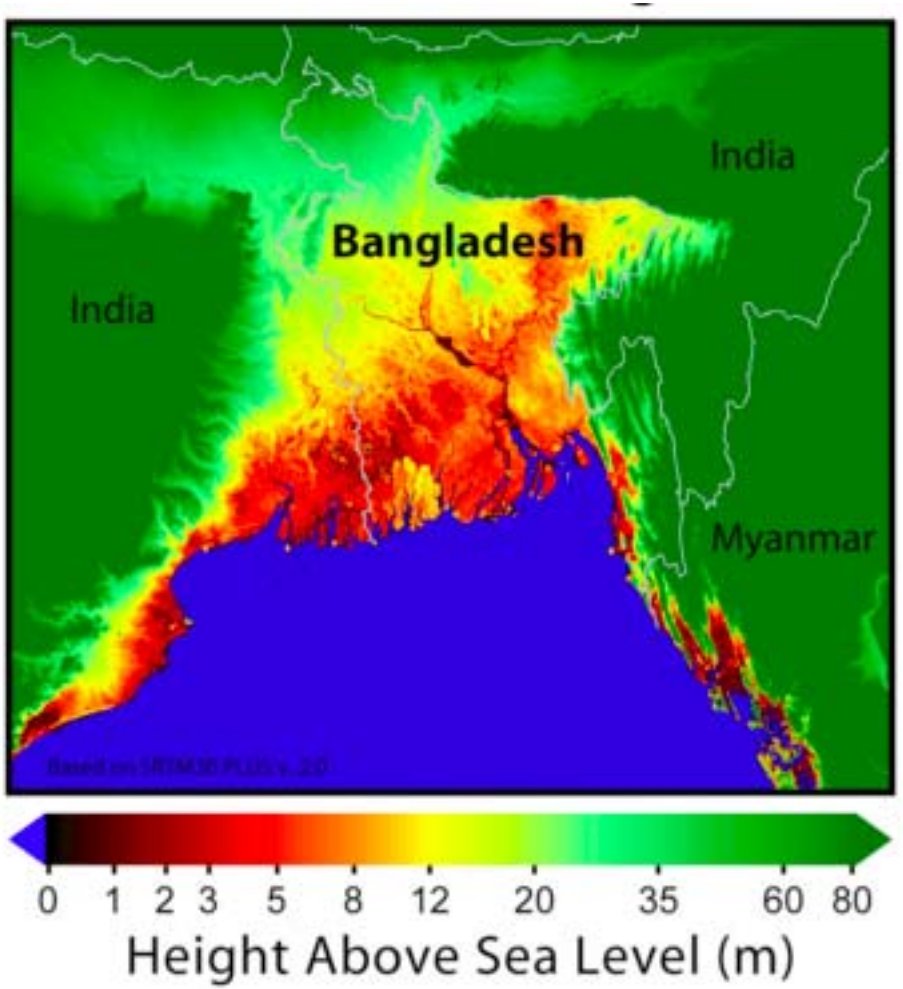


(National Snow and Ice Data Center, Boulder)

Sea-level rise in Florida

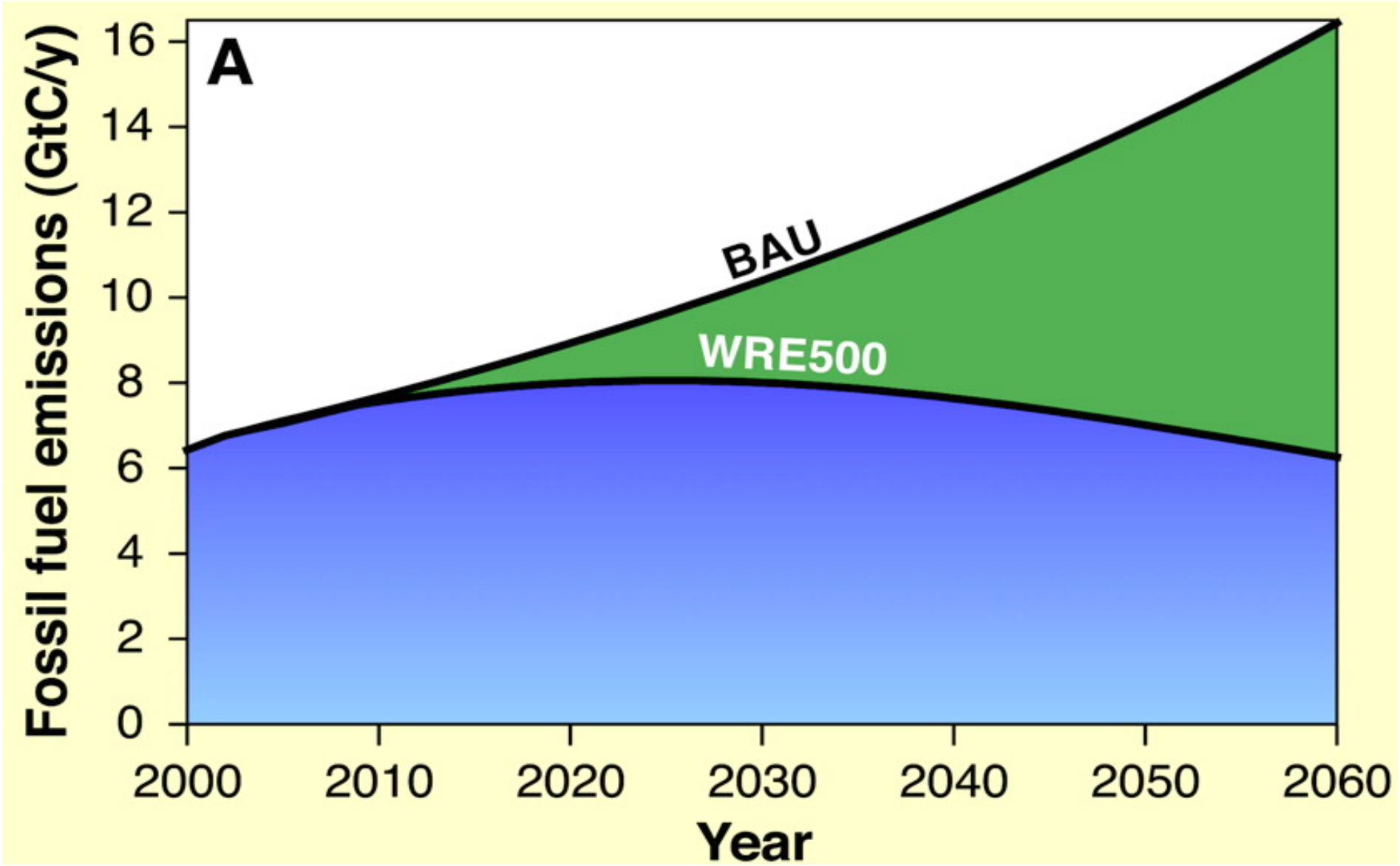
…. and in other parts of the world





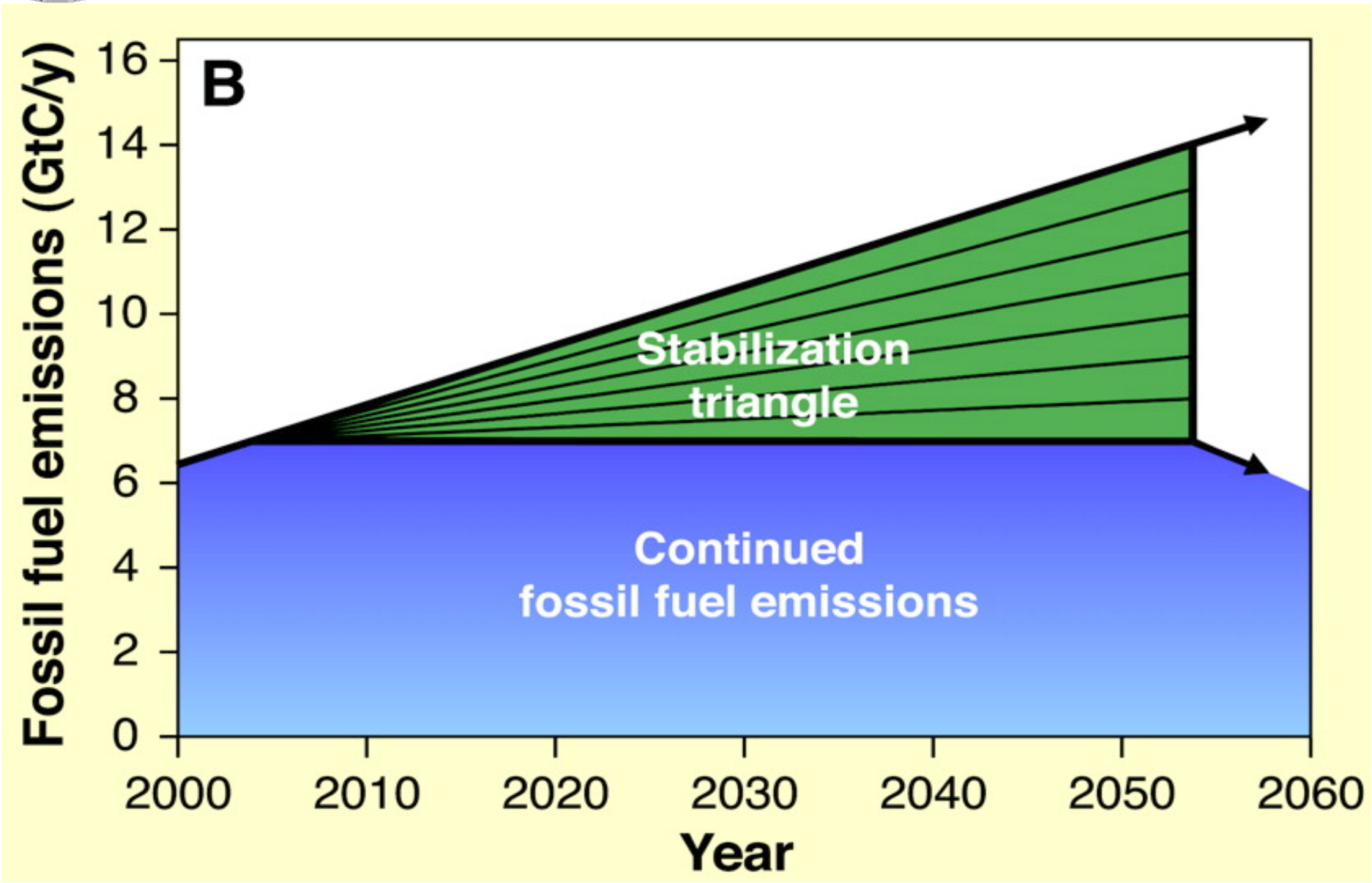
http://www.globalwarmingart.com/wiki/Sea_Level_Rise_Maps_Gallery

Curbing CO_2 emissions



(Pascala and Socolow, Science, 305, 968-971, 2004)

The 7 wedges



(Pascala and Socolow, Science, 305, 968-971, 2004)

Choose 7 out of 15 wedges distributed over:

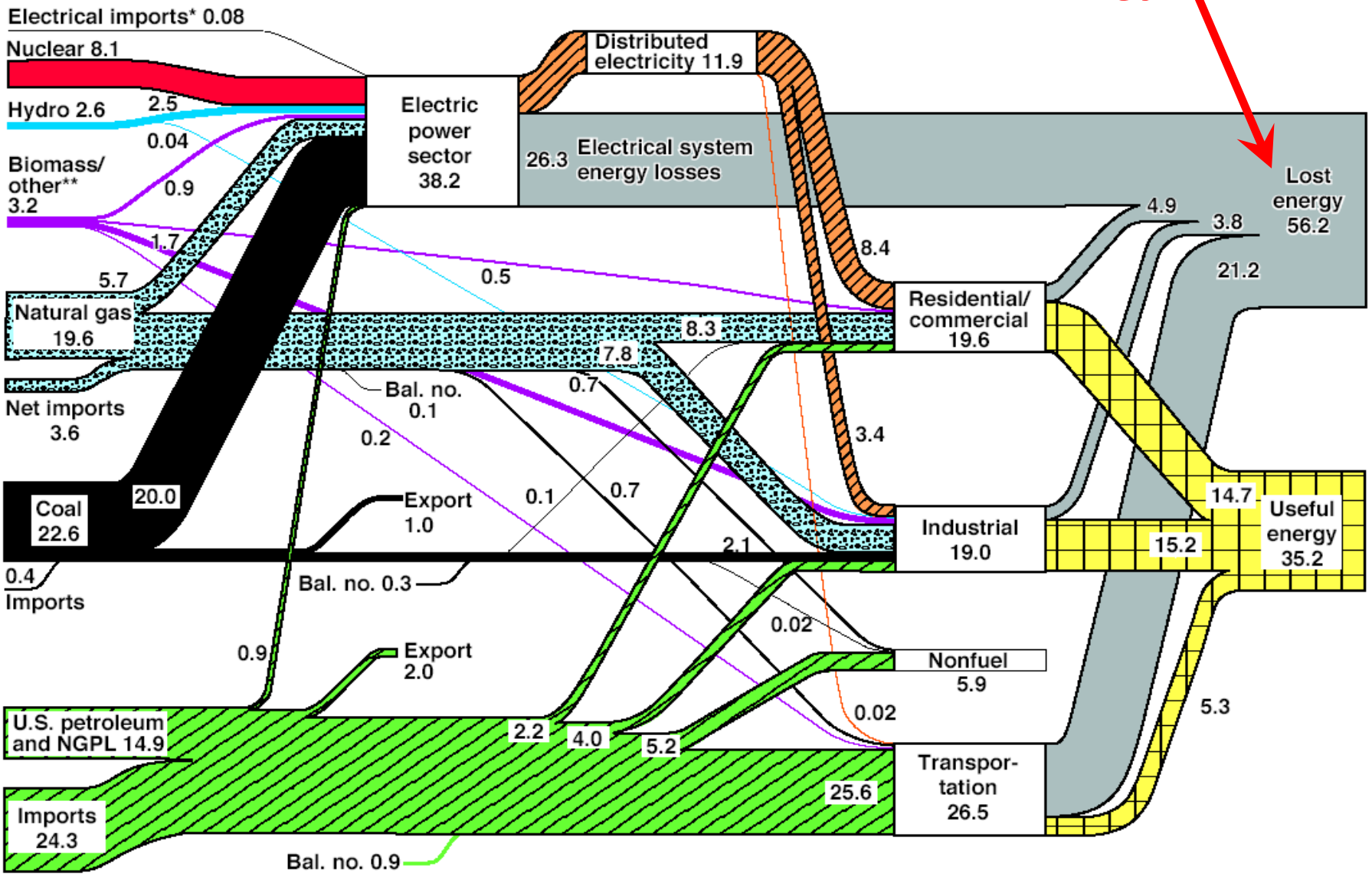
- energy efficiency and conservation
- nuclear energy
- renewable energy and fuels
- more efficient forest and land use
- injecting CO_2 in the subsurface

One wedge is …..

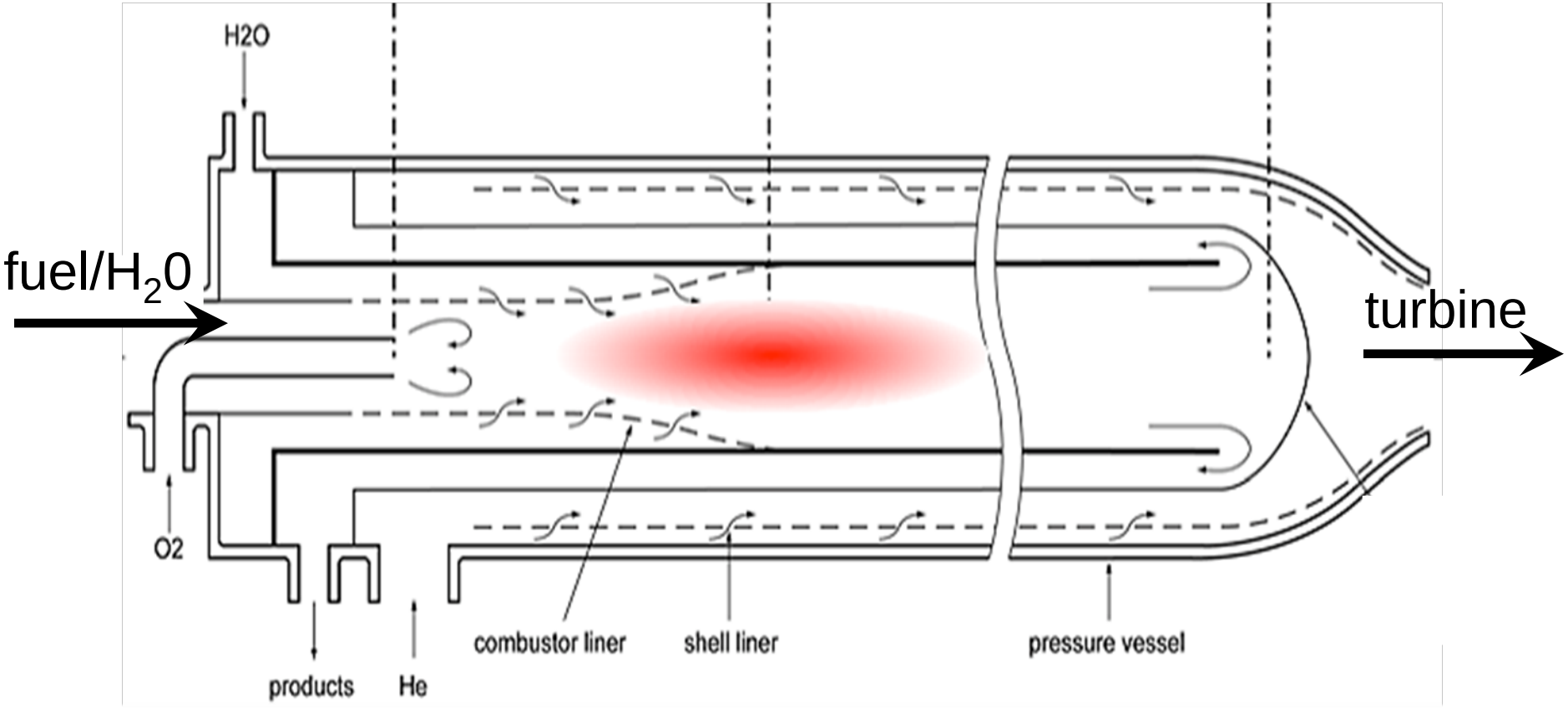
- generate electricity at 60% efficiency
- wind turbines: 3% of the USA surface
- photovoltaics: 700 X today's use
- nuclear power: double (build 500)
- inject 3 Giga-ton of CO_2 per year

Energy efficiency

Lost energy = 60%!

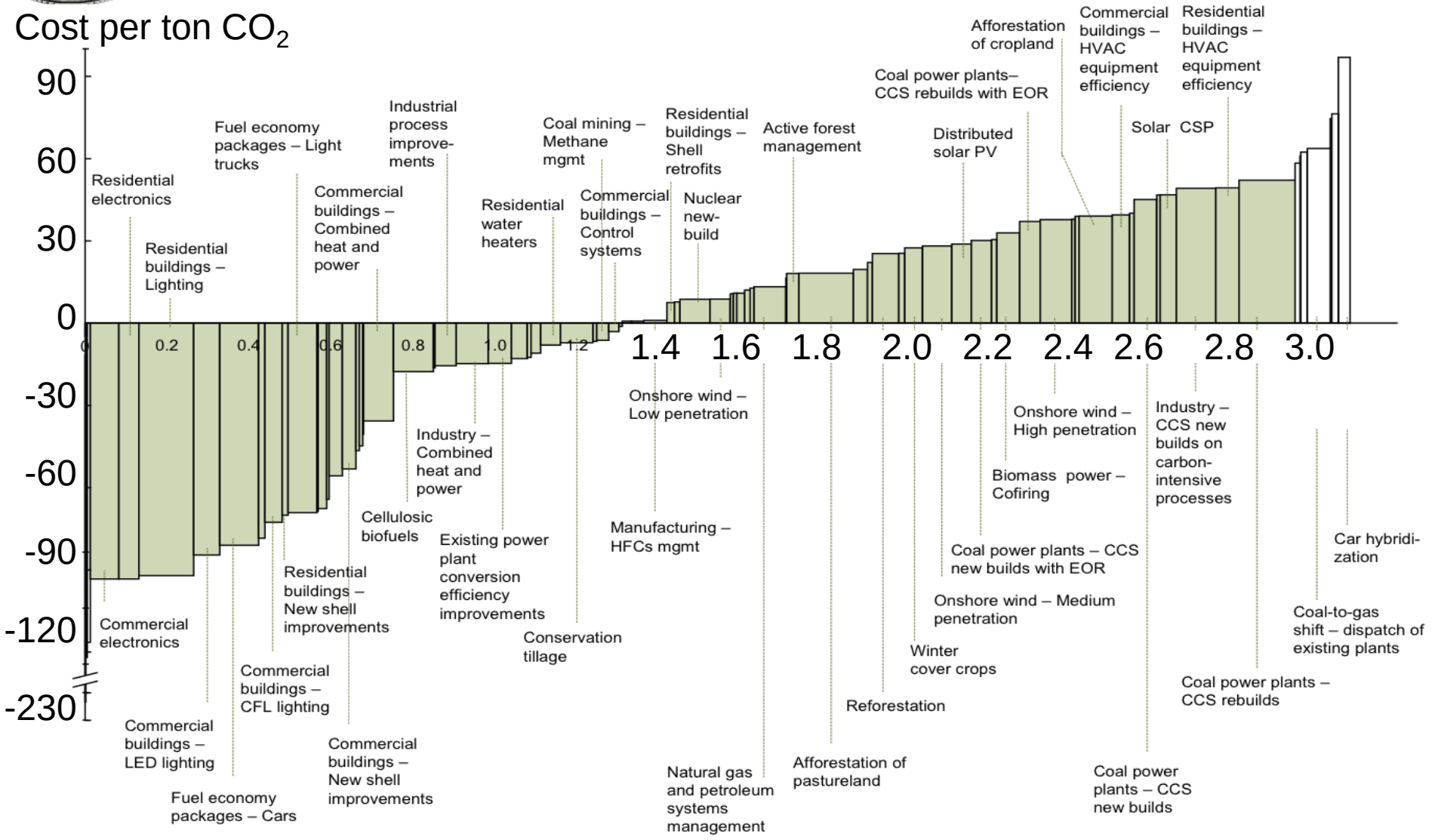


Research: high-temperature combustion



http://gcep.stanford.edu/research/combustion.html

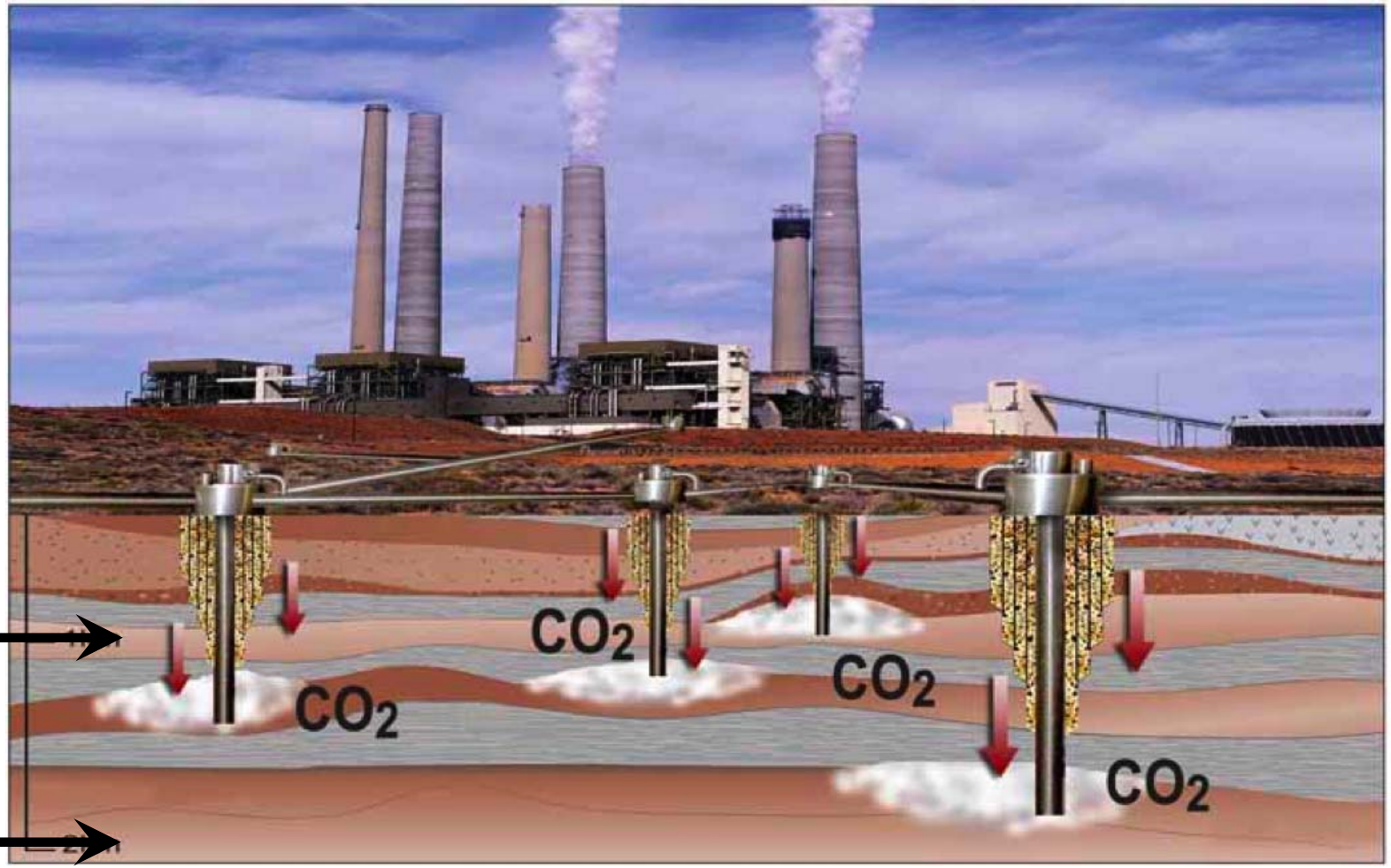
Efficiency can pay off



Current USA emissions: 7 Gigatons CO_2/year

Source: McKinsey analysis, http://mckinsey.com/clientservice/ccsi/greenhousegas.asp

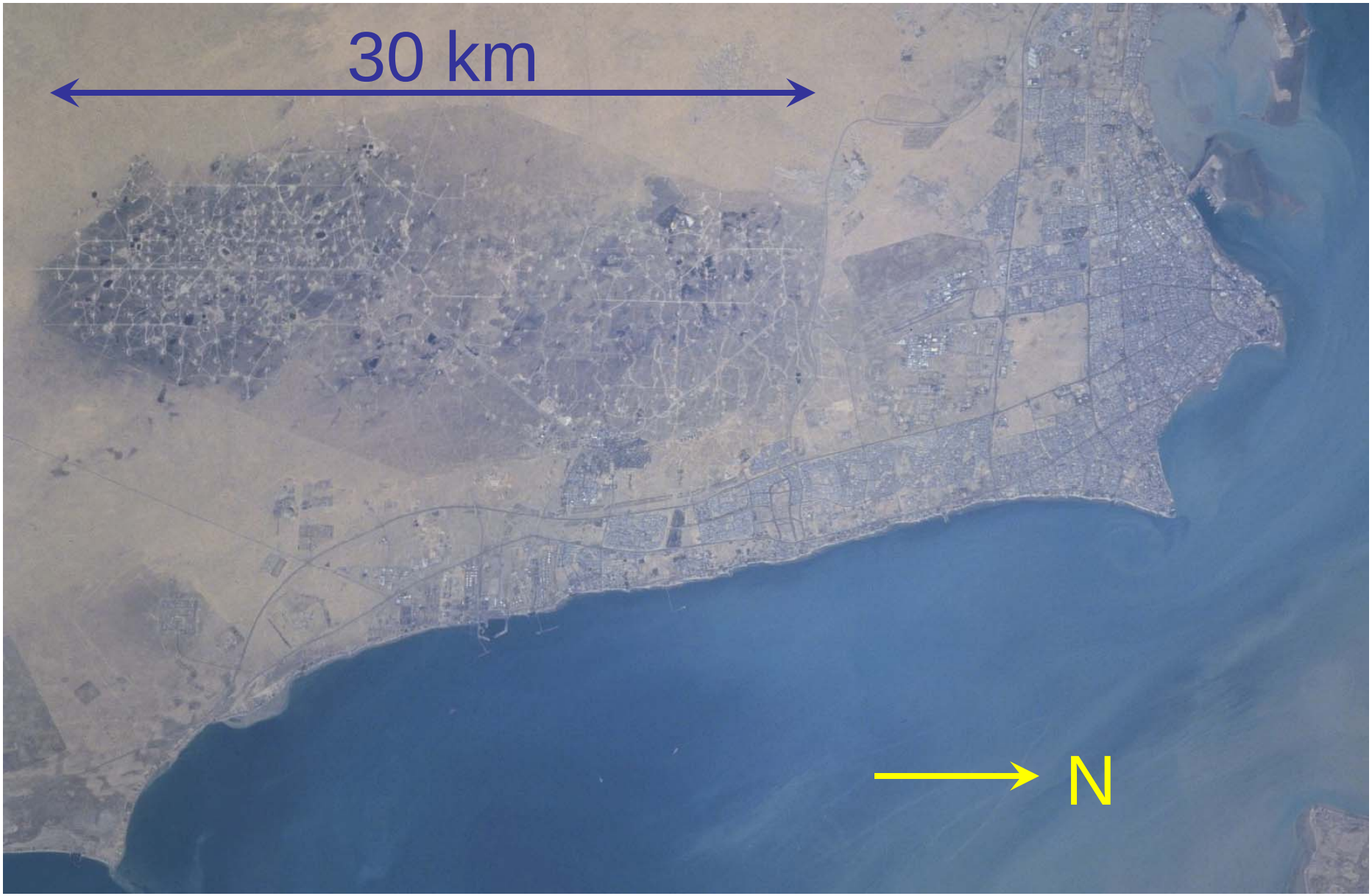
How much CO_2 to sequester?



- one wedge is 3 $GtCO_2$/year
- world oil production is 4 Gt/year

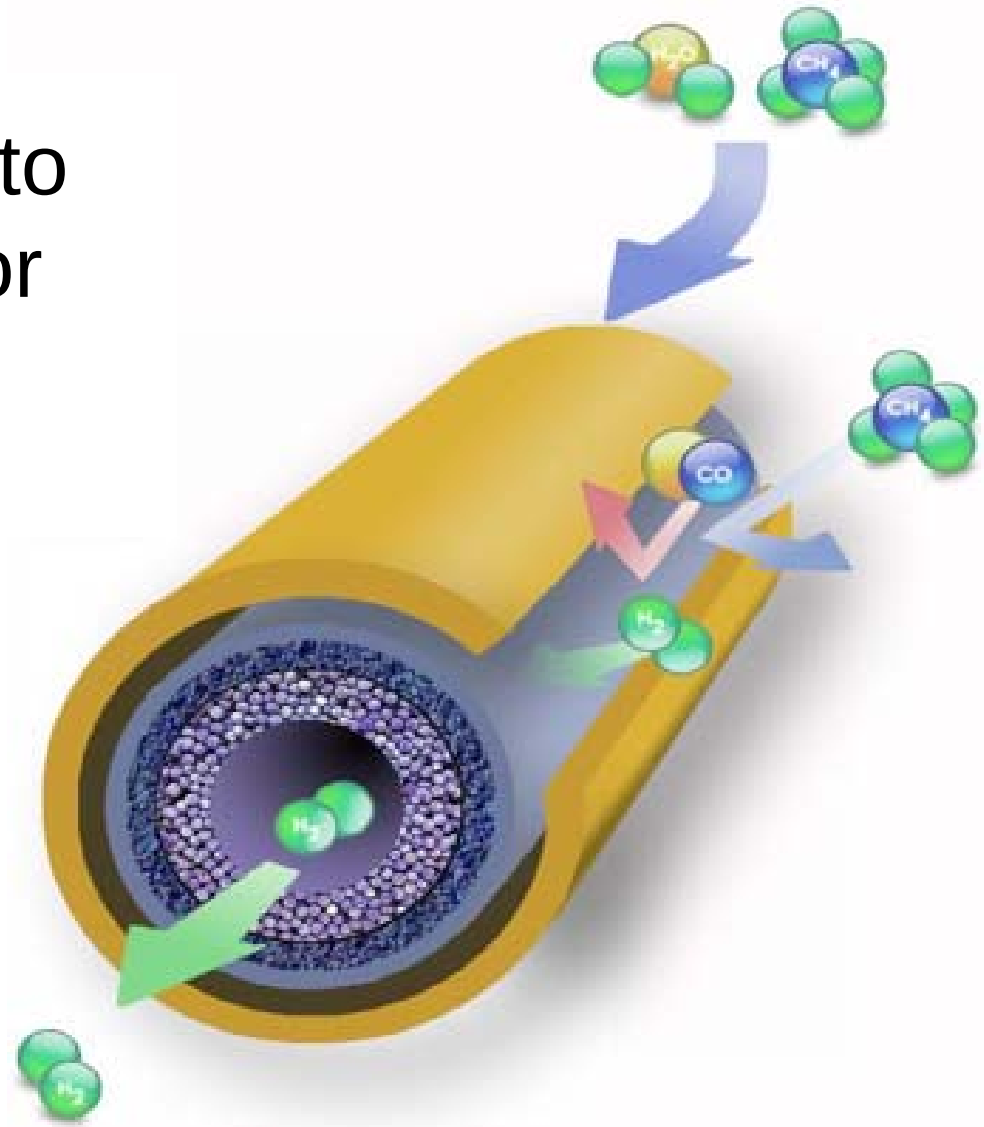

X 3500 !

Kuwait from space



Research: gas separation

Develop membranes to separate H_2 or CO_2 for carbon-free hydrogen production.



http://gcep.stanford.edu/research/co2capture.html

What can I do as educator?

"I think we have the responsibility to insist that education is more than learning job skills, that it is also the bedrock of a democracy. I think we must be very careful that in the race to become wealthier, more prestigious, and to be ranked Number One, we don't lose sight of the real purpose of education, which is to make people free - to give them the grounding they need to think for themselves and participate as intelligent members of a free society."

Myers, T.M., A student is not an input, NYT, March 26, 2001

How much CO_2 is produced by burning the coal in one railroad car?

Conservation requires education

From the thirteen myths ….

- Today's energy crisis is a hype
- The public is well informed about energy
- The hydrogen economy is a solution
- Efficiency improvements have reached their potential
- Climate policy will bankrupt the US economy
- World-wide power systems are optimal

(Energy and American society - thirteen myths, eds. B.K. Sovacool and M.A. Brown)

1. Initiate the development of a comprehensive plan to achieve climate neutrality as soon as possible.
2. Initiate two or more of the following tangible actions to reduce greenhouse gases while the more comprehensive plan is being developed….
3. Make the action plan, inventory, and periodic progress reports publicly available ……

http://www.presidentsclimatecommitment.org/

What can I do as consumer?

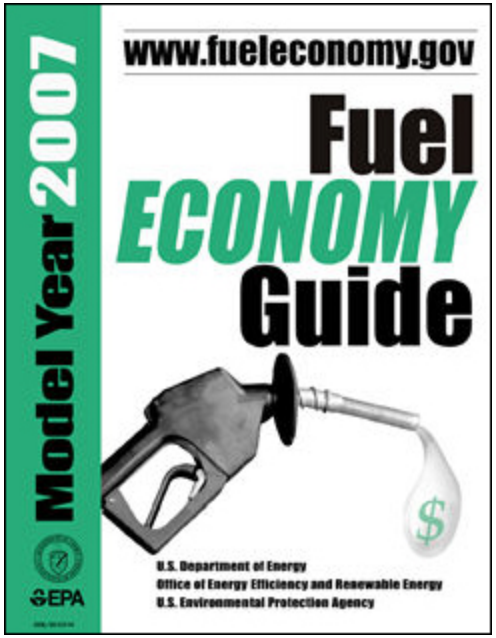
LIGHT OUTPUT EQUIVALENCY

To determine which ENERGY STAR qualified light bulbs will provide the same amount of light as your current incandescent light bulbs, consult the following chart:

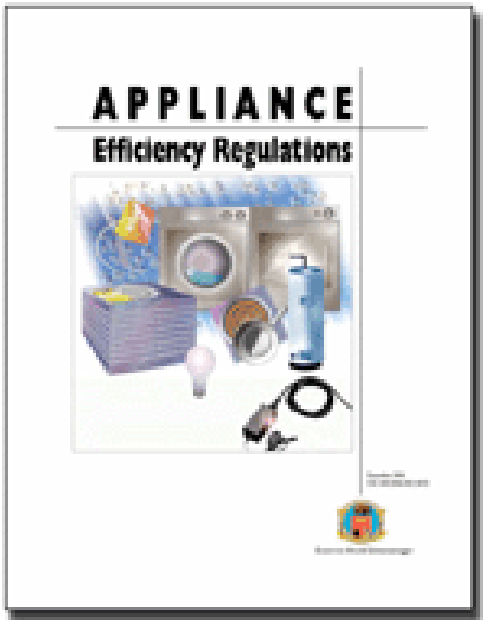
INCANDESCENT LIGHT BULBS	MINIMUM LIGHT OUTPUT	COMPACT FLUORESCENT ENERGY STAR QUALIFIED LIGHT BULBS
WATTS	LUMENS	WATTS
40	450	9-13
60	800	13-15
75	1,100	18-25
100	1,600	23-30
150	2,600	30-52

LEARN MORE AT energystar.gov

Lighting



Transportation



Appliances

Oil needed to produce bottled water

(http://www.armchairenvironmentalist.com/blog/index.php?paged=2)

Kirsch Center
DeAnza Community College

Energy saving: $65,000/year

Plug-in vehicles

Consider the life-cycle

Consider the life-cycle

What can I do as student?

- become a professional
- seek out new opportunities
- push for energy conservation

Seek projects

http://community.uui.asu.edu/features/solar.asp

What can I do in business?

- Seek opportunities in sustainable business (for ideas: http://www.sustainablebusiness.com)
- Create an energy plan and save.
- Imagine what is possible when energy prices rise.

http://www.danchiras.com

What can I do as citizen?

- Ask: what is our energy plan?
- Start a discussion in your community.
- Demand that the United States becomes a world-leader in responsible use of energy.

“That which we are, we shall teach, not voluntarily but involuntarily.” [Emerson]

What if we had the courage to dream …..

and raise fuel standards for cars by 25% to European levels,

generate 20% of electricity by wind (as Denmark does),

generate another 20% of electricity from sunlight,

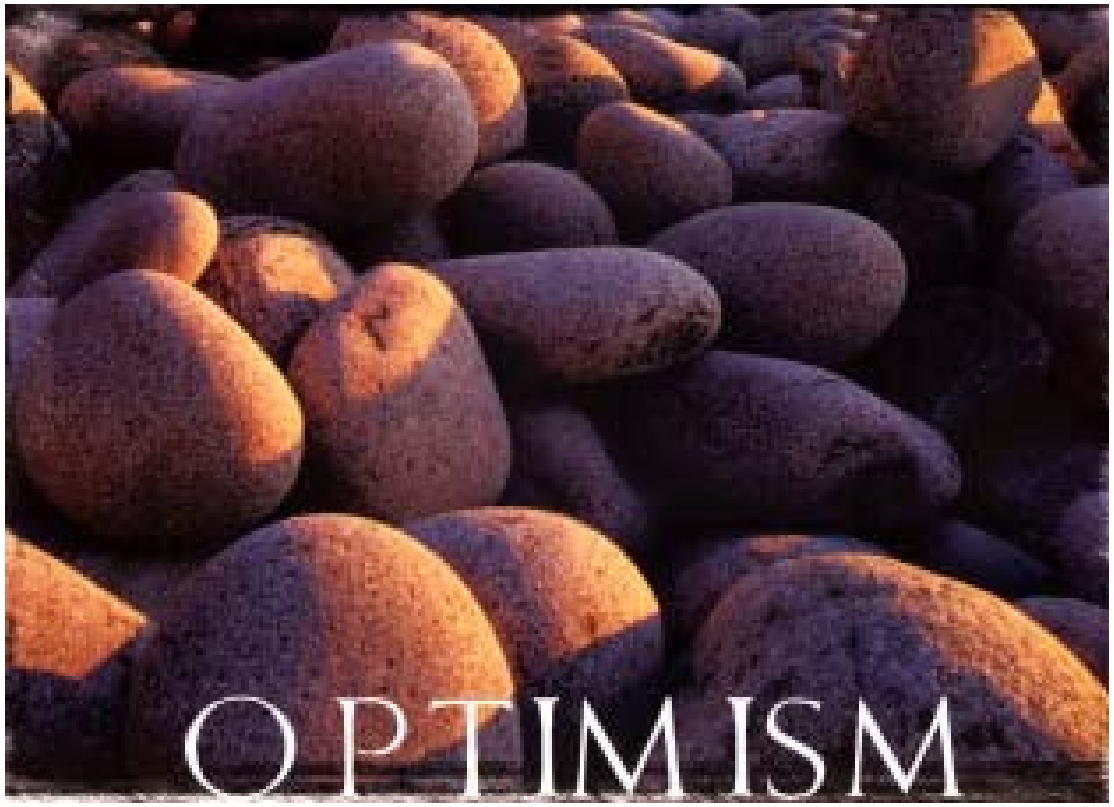
and conserve 20% by increased efficiency.

This can be done if we want it to happen!

"To have sustainable economic growth 10 years from now, both consumers and producers need to start acting now."

John Hess, CEO of Hess Corporation in Newsweek, 3/15/2008
http://www.newsweek.com/id/123482

Questions/comments?



"The difference between stumbling blocks and stepping stones is how you use them."

Send feedback to Roel Snieder: email rsnieder@mines.edu

Presentation: http://www.mines.edu/~rsnieder/Global_Energy.html