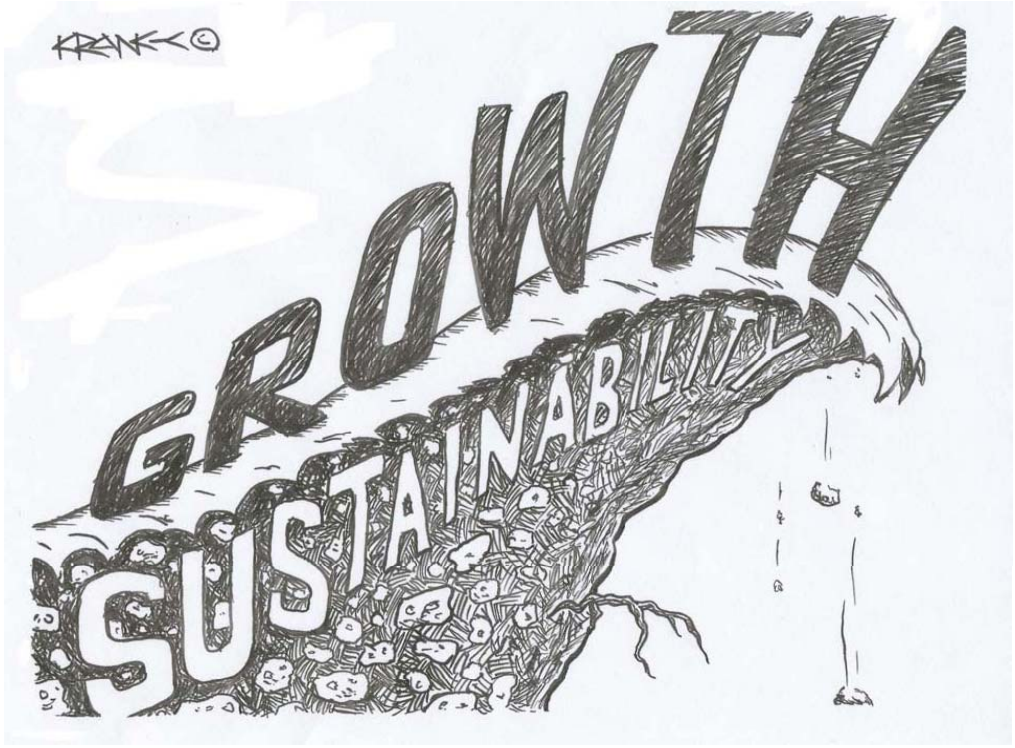
SUSTAINABLE DEVELOPMENT & ENERGY OPTIONS

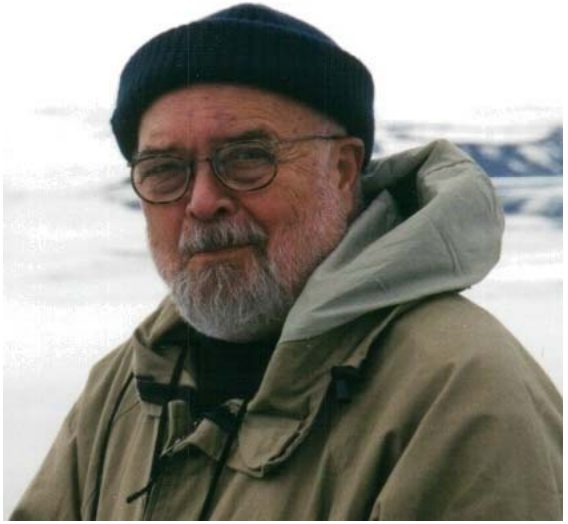
Dean E. Abrahamson ©



Cartoon used with permission

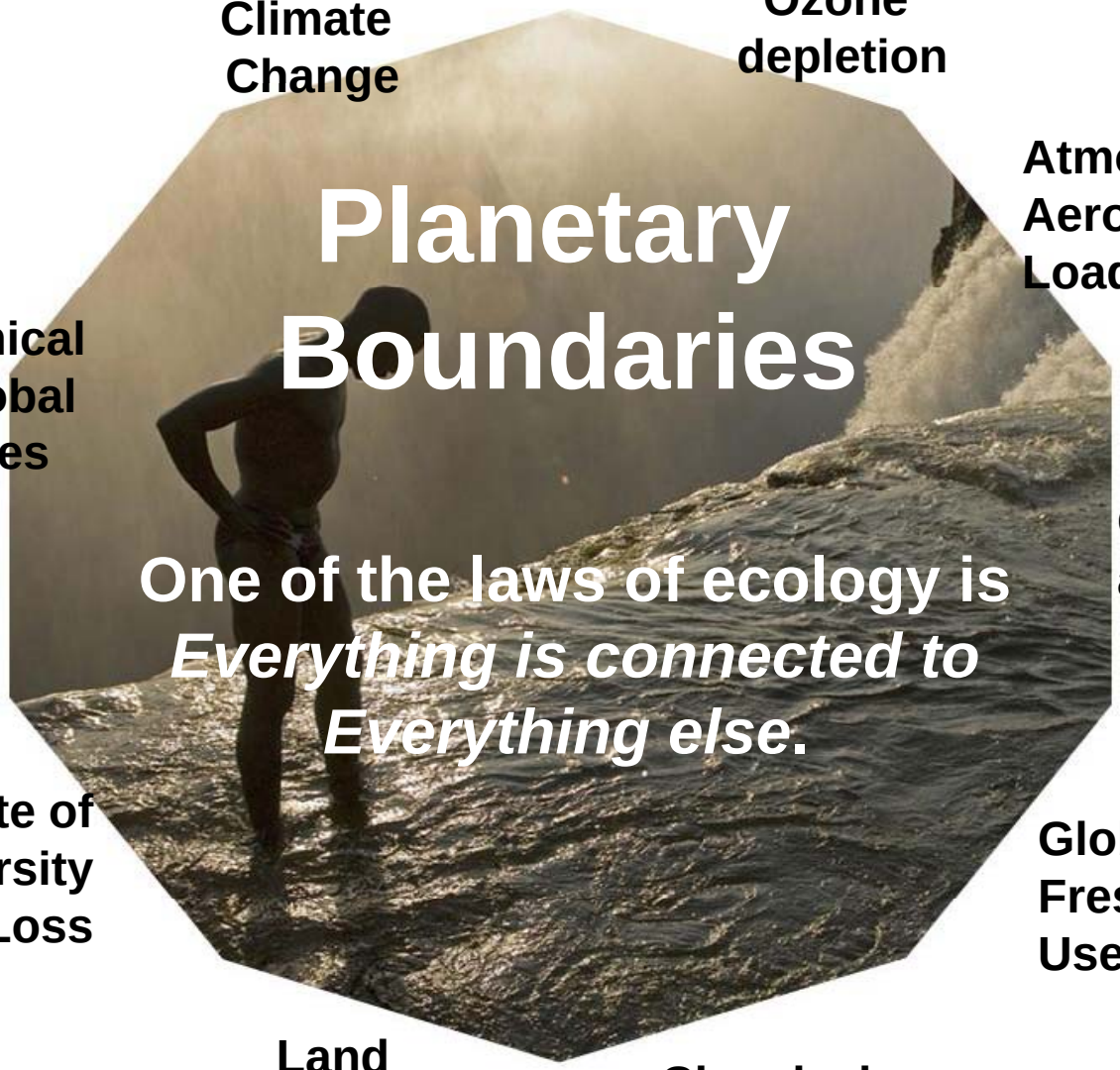
The Speaker

My name is Dean Abrahamson; I retired as professor of energy & environmental policy from the University of Minnesota in 1998. My first professional job, after physics graduate school, was as a reactor physicist. I then spent a few years as senior research scientist at Honeywell before going to medical school. My first tenured appointment was in the Univ of Minnesota School of Medicine. One thing led to another, along the way I read some biology and economics, and I ended up at what is now the Humphrey Institute of Public Affairs where I focused on energy policy and for about ten years worked on climatic change & wrote a couple of books. I've taught energy policy since the early 1970s. I've been a Trustee of the NRDC since 1972.



OUTLINE

- The context: Growth v. sustainable development
- Major issues: Middle-East oil, nuclear power, global warming
- Current energy supply
- Energy options
  - Reduce demand for energy
  - Increase energy supply
    - Solar, windpower & other renewables
    - Natural gas
    - Oil
    - Coal
    - Nuclear power
- Global warming & climatic change
- Summary



Planetary Boundaries

Climate Change

Ozone depletion

Atmospheric Aerosol Loading

Biogeochemical loading: Global N & P Cycles

Ocean acidification

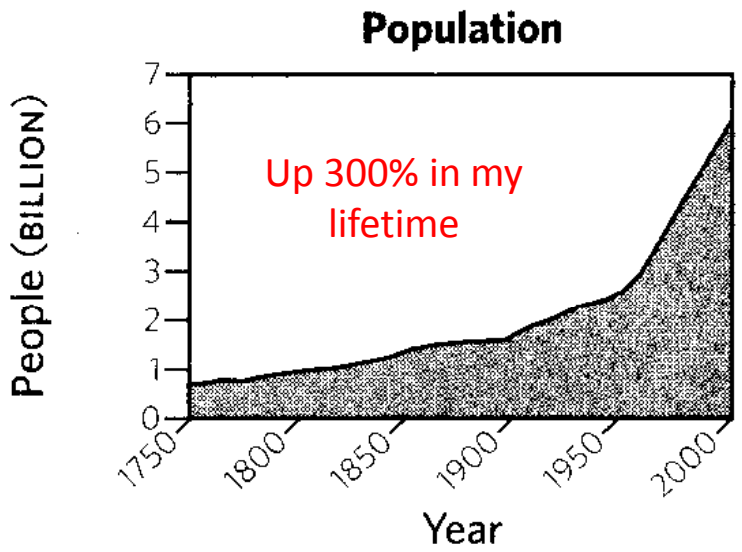
One of the laws of ecology is *Everything is connected to Everything else*.

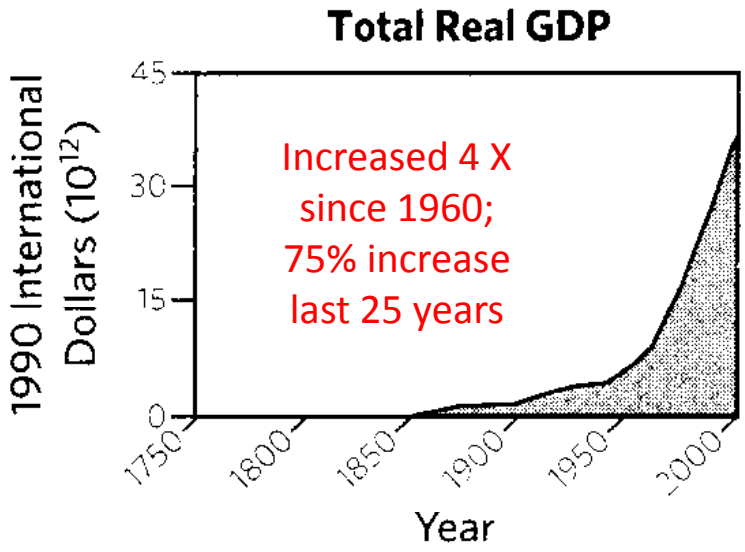
Rate of Biodiversity Loss

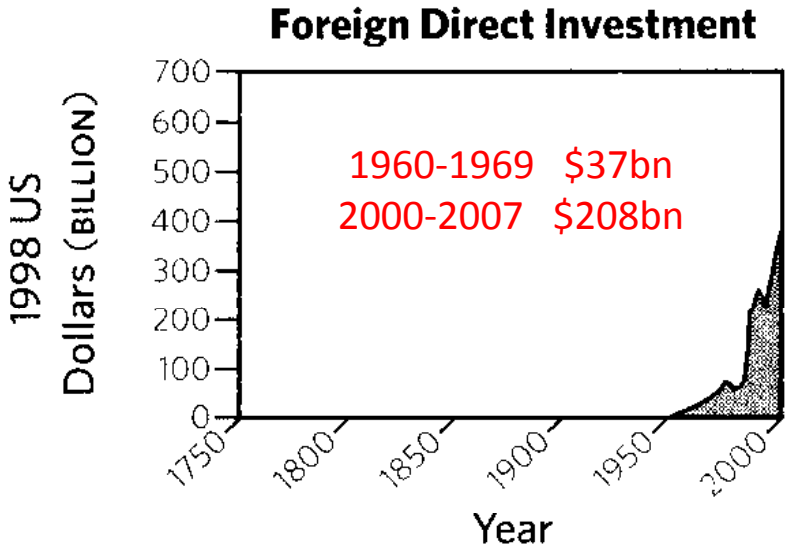
Global Freshwater Use

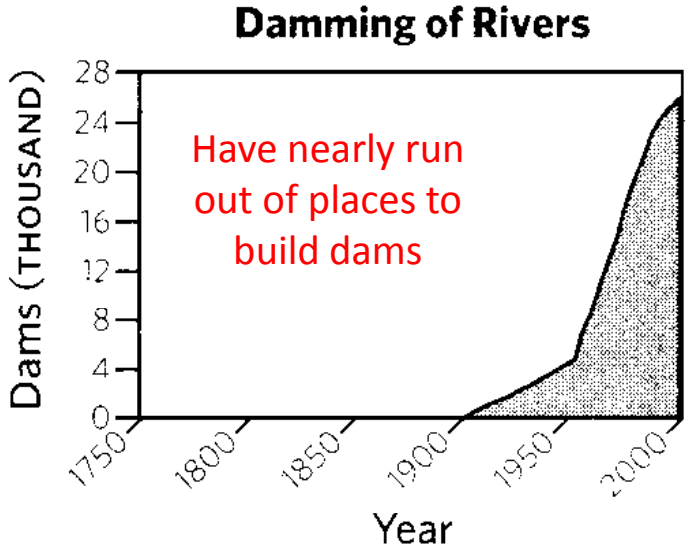
Land System Change

Chemical Pollution

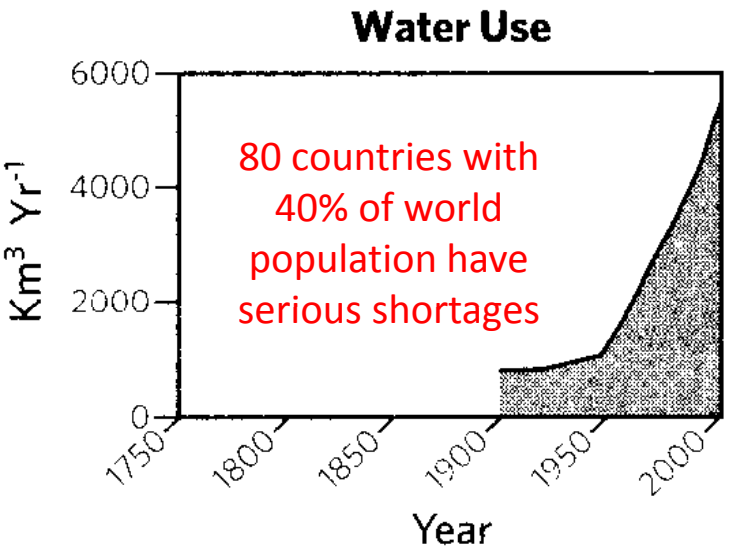


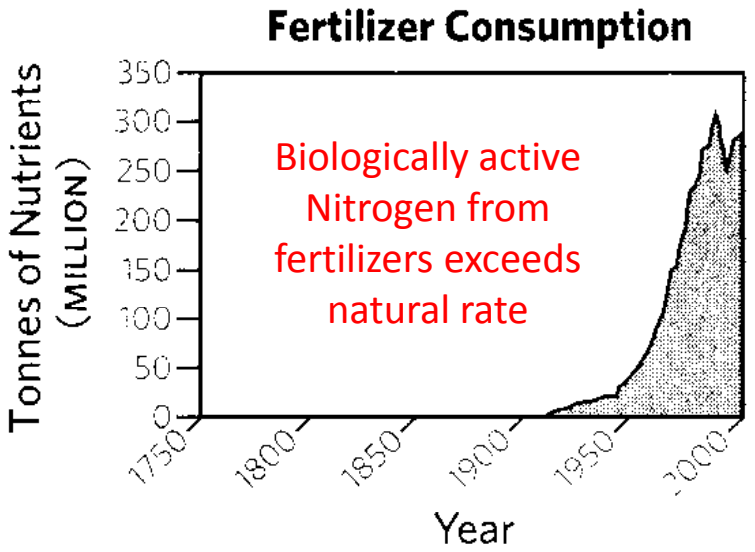


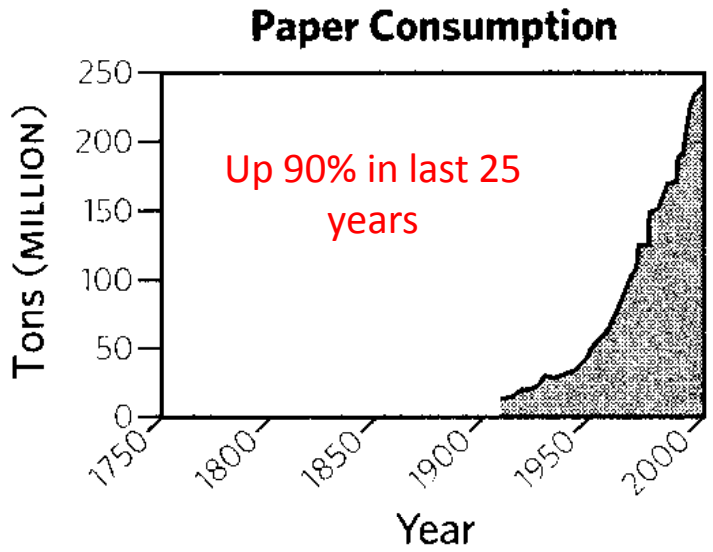


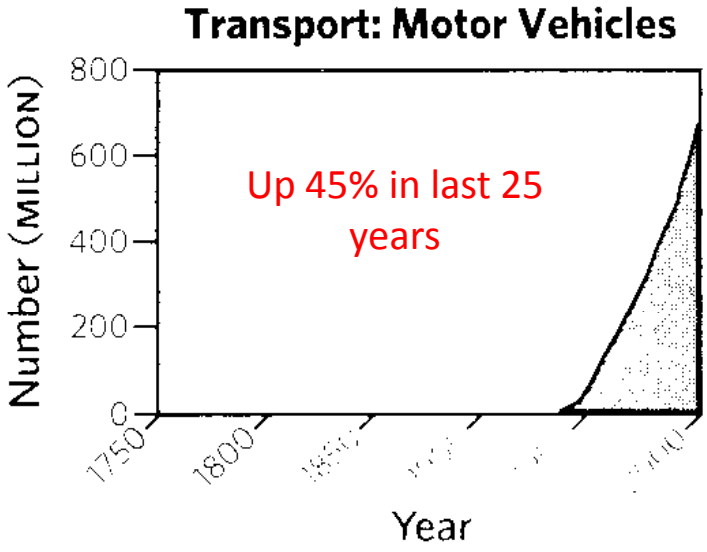


J.G. Speth (2004) *Red Sky at Morning: America and the crisis of the global environment*, Yale Univ. Press









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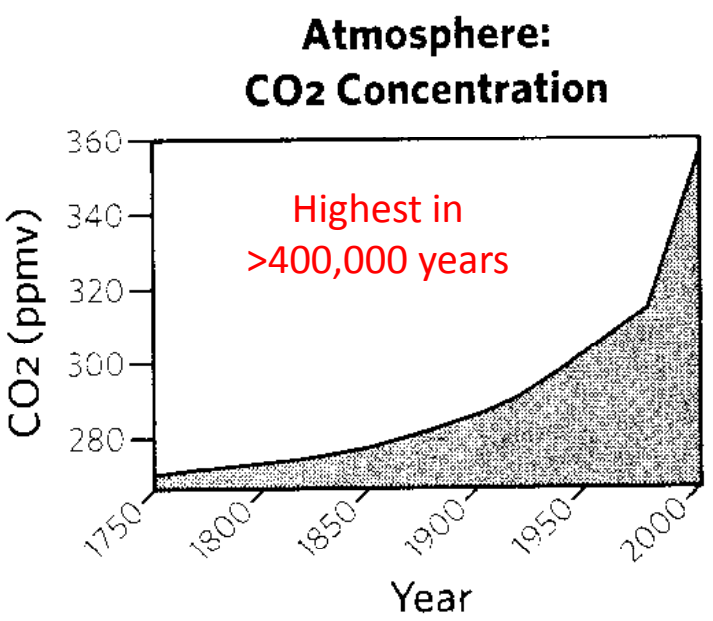

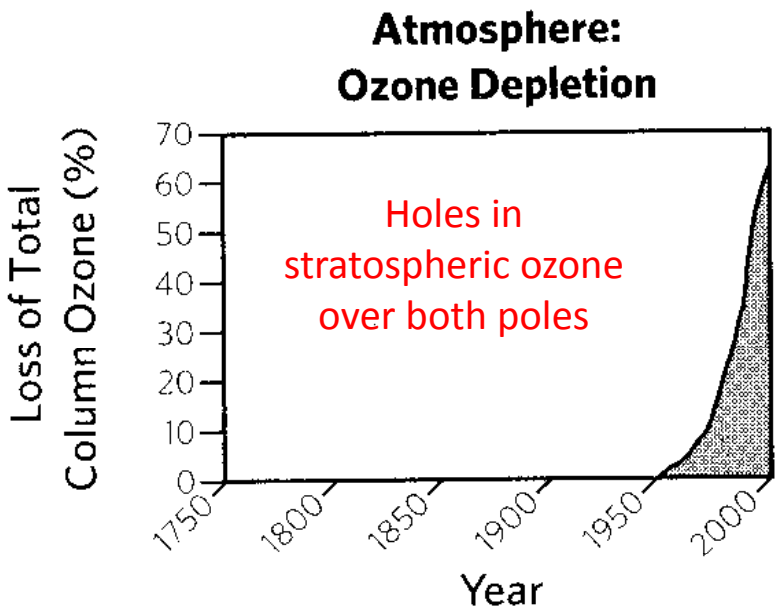

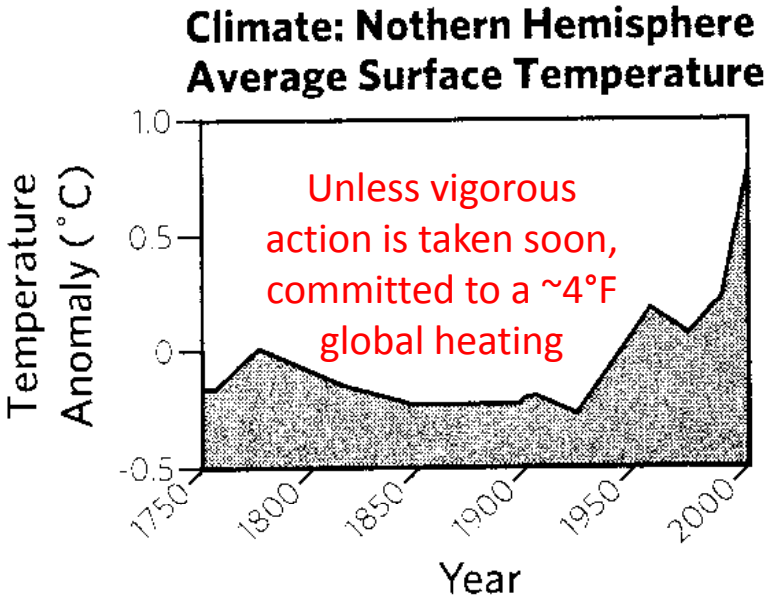

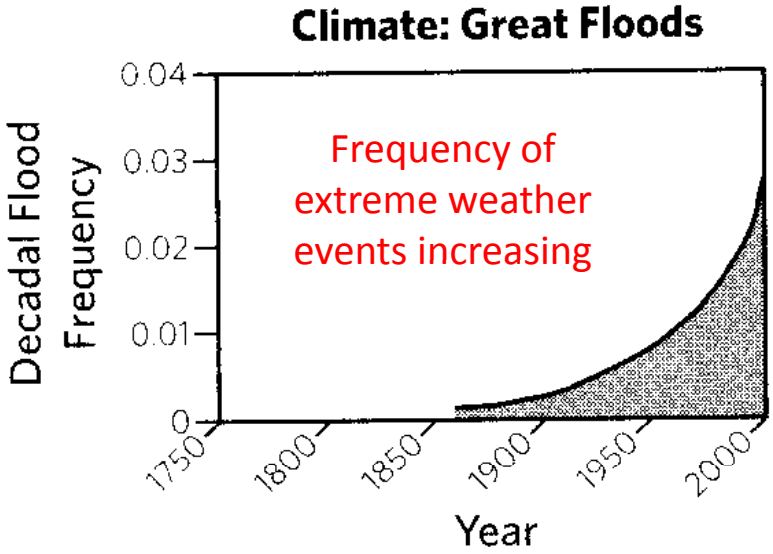

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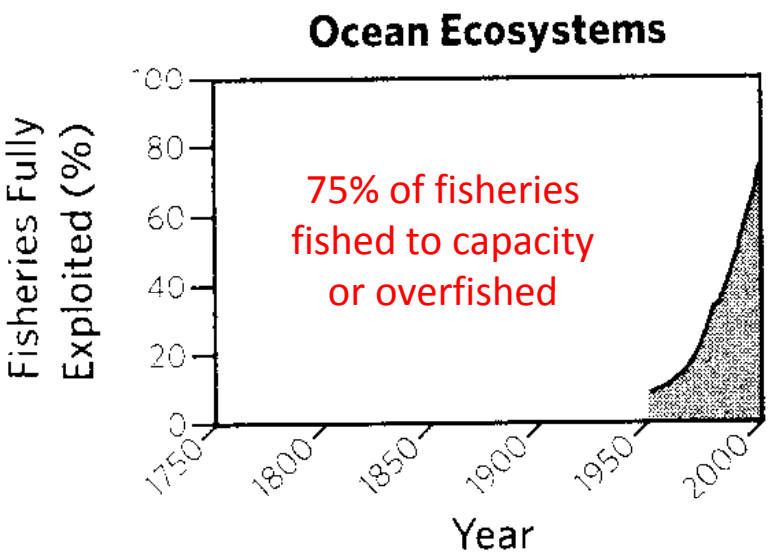
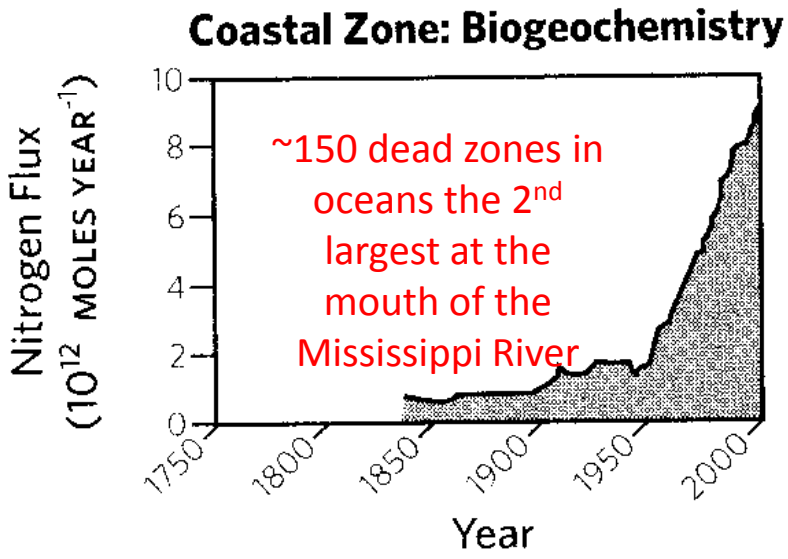
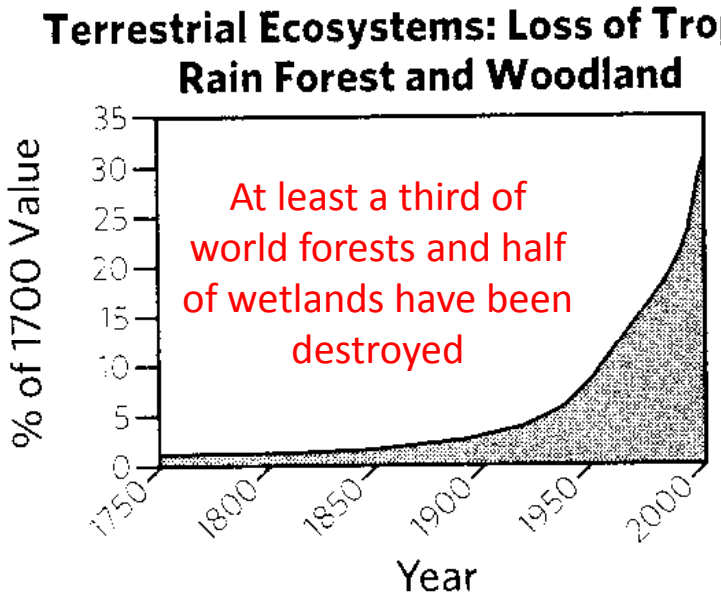
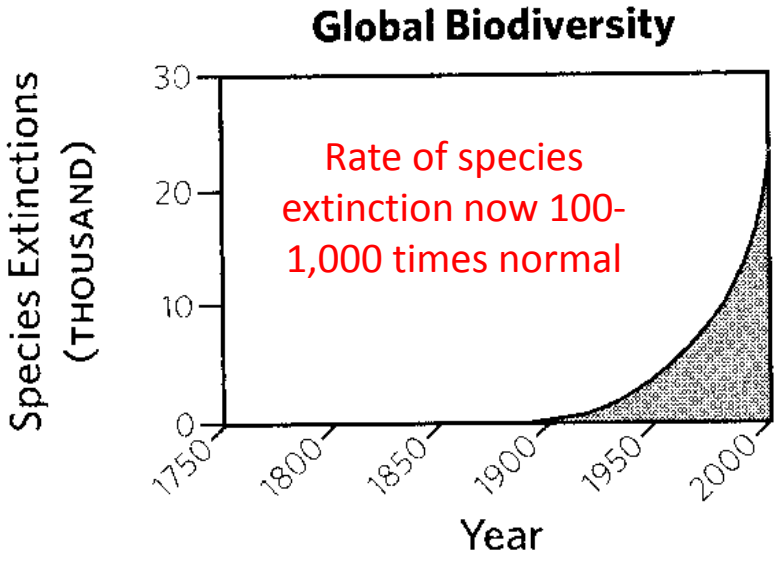








J.G. Speth (2004) *Red Sky at Morning: America and the crisis of the global environment*, Yale Univ. Press

Business-as-usual is not sustainable

Major changes are necessary, not the least with our energy system

AMONG THE MAJOR ENERGY-RELATED SUSTAINABILITY ISSUES

Increasing scarcity of conventional oil and increasing dependence on oil from the Middle East. This is resulting in:

- Massive military spending and wars
- Use of non-conventional oil, primarily Tar Sands which are the dirtiest of all fuels.
- Conversion of food to fuels

There is a new, and major, push to build new nuclear power plants even though

- New nuclear power is the most expensive non-carbon energy option

and

- There are massive external costs.
  - Waste isolation
  - Accidents
  - Risk of proliferation of nuclear weapons

The need to greatly reduce carbon dioxide pollution to limit climatic change. [And similar reductions in the other major greenhouse gases.]

This requires reducing fossil fuel (coal, oil, natural gas) consumption by 60-80% by mid-century and shifting to energy sources that have little or no net emissions of carbon dioxide (CO_2) if we are to avoid catastrophic climatic chang.

CURRENT ENERGY SUPPLY

Primary & Secondary Energy

- *Primary energy* is as found in nature
  - Solar
  - Geothermal
  - Tidal
  - Hydrocarbons (Natural gas, Oil, Coal, Oil shale, Tar sands . . .)
  - Uranium and thorium (Fission fuels)

- *Secondary energy, or energy carrier*, is the form delivered to the user
  - Electricity
  - Hydrogen
  - Petroleum & natural gas products
  - Heat

Solar Energy

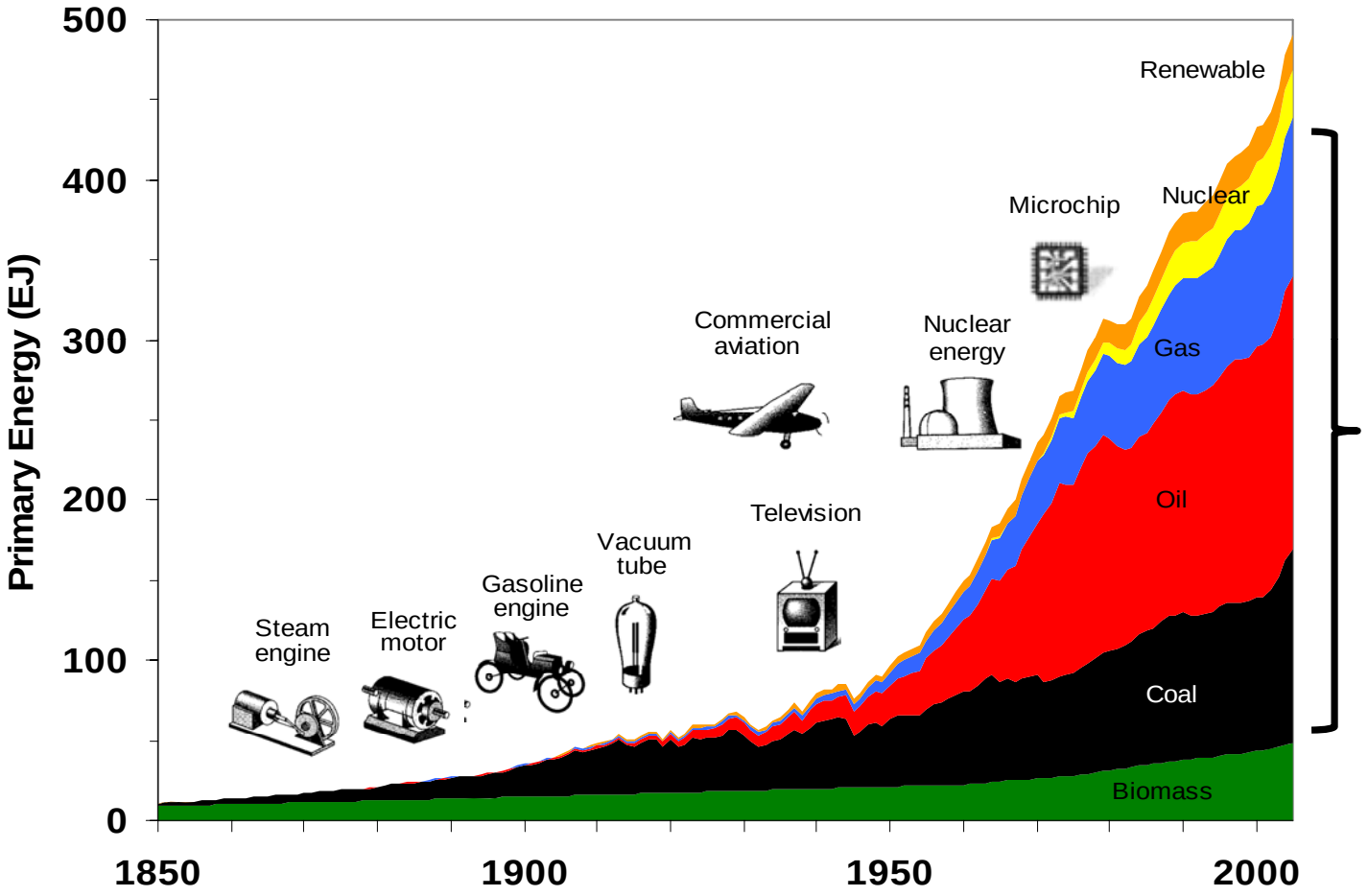
Solar energy usually refers to all systems driven by the flux of solar energy

- Hydropower
- Wind
- Photovoltaics
- Direct heating
- Biofuels

Renewable Energy Supply

- Solar
- Geothermal
- Tidal

Fossil Fuels: >80% Global Primary Energy

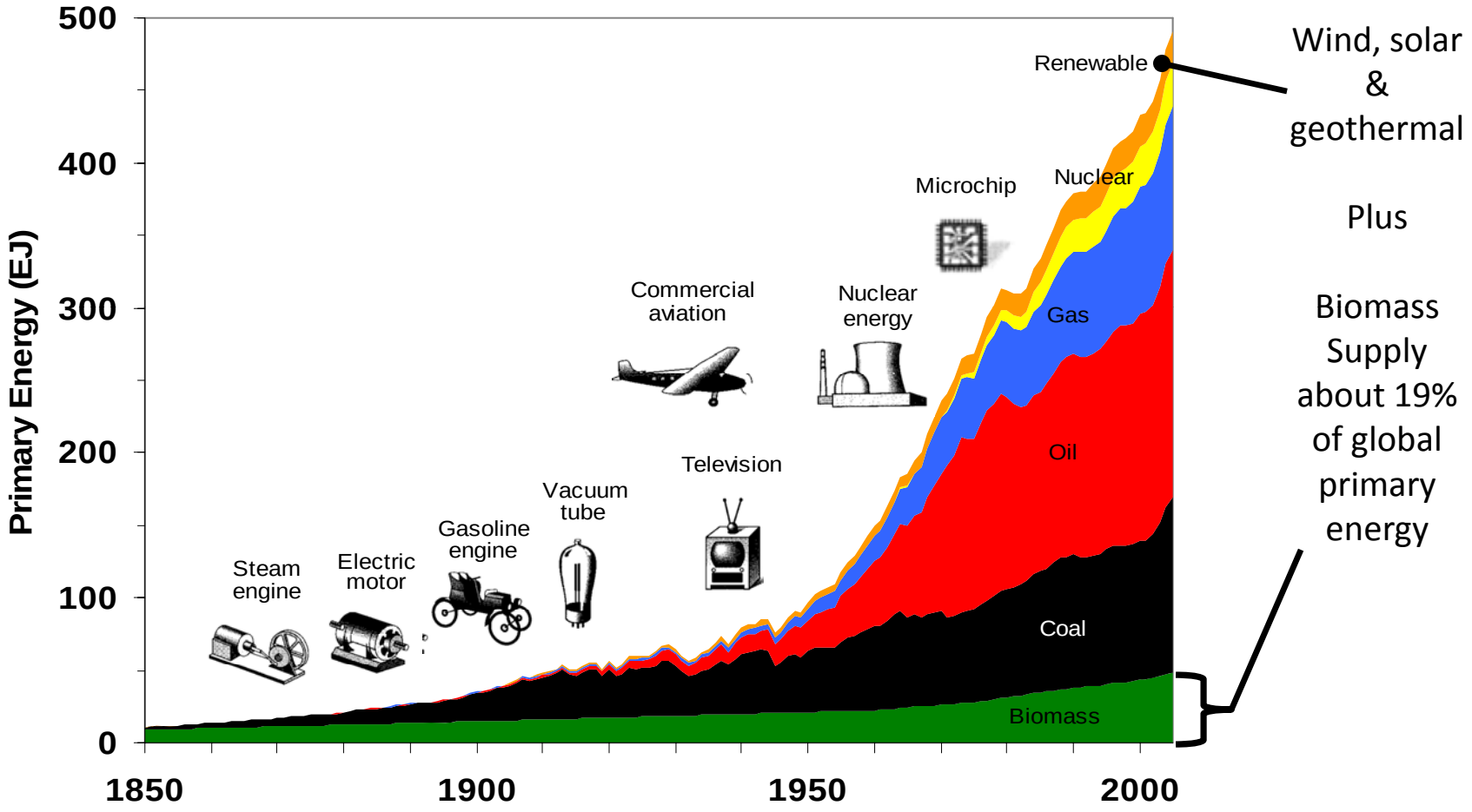


Fossil Fuels >80% of primary energy

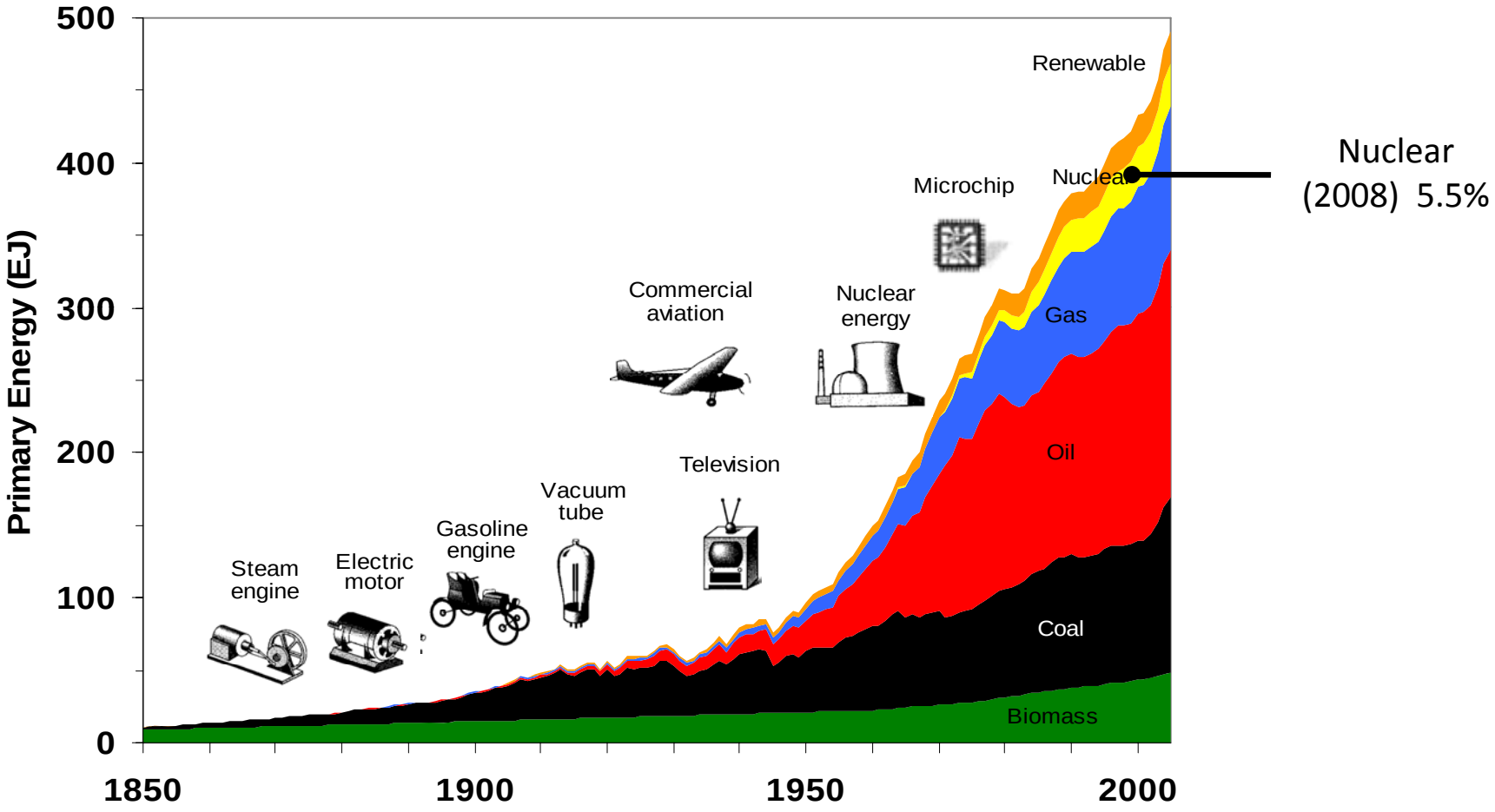
and

~80% of greenhouse gases

Renewables: ~19% Primary Energy



Nuclear 5½ % Primary Energy



Energy Options

1. **REDUCE CONSUMPTION** by means that reduce energy use without decreasing energy services, i.e., increase the efficiency with which primary energy is converted to energy services, or by changing our consumption patterns.
2. **INCREASE SUPPLY**
    - Renewables
    - Natural Gas
    - Coal
    - Oil
    - Nuclear Power

REDUCING ENERGY USE WITH NO LOSS OF ENERGY SERVICES

The Total Cost of Increasing Efficiency

A 2010 analysis by David B. Goldstein, one of the recognized world experts in energy efficiency, concluded that

Now approaching $10,000

Today nuclear power would average ~~$5,000~~ or more per kilowatt. By comparison, efficiency improvements typically cost about $300 per kilowatt, and that includes the entire cost, not just the construction costs.

David B. Goldstein (2010) *Invisible Energy*, Bay Tree Publishing, CA, p. 158

An Example

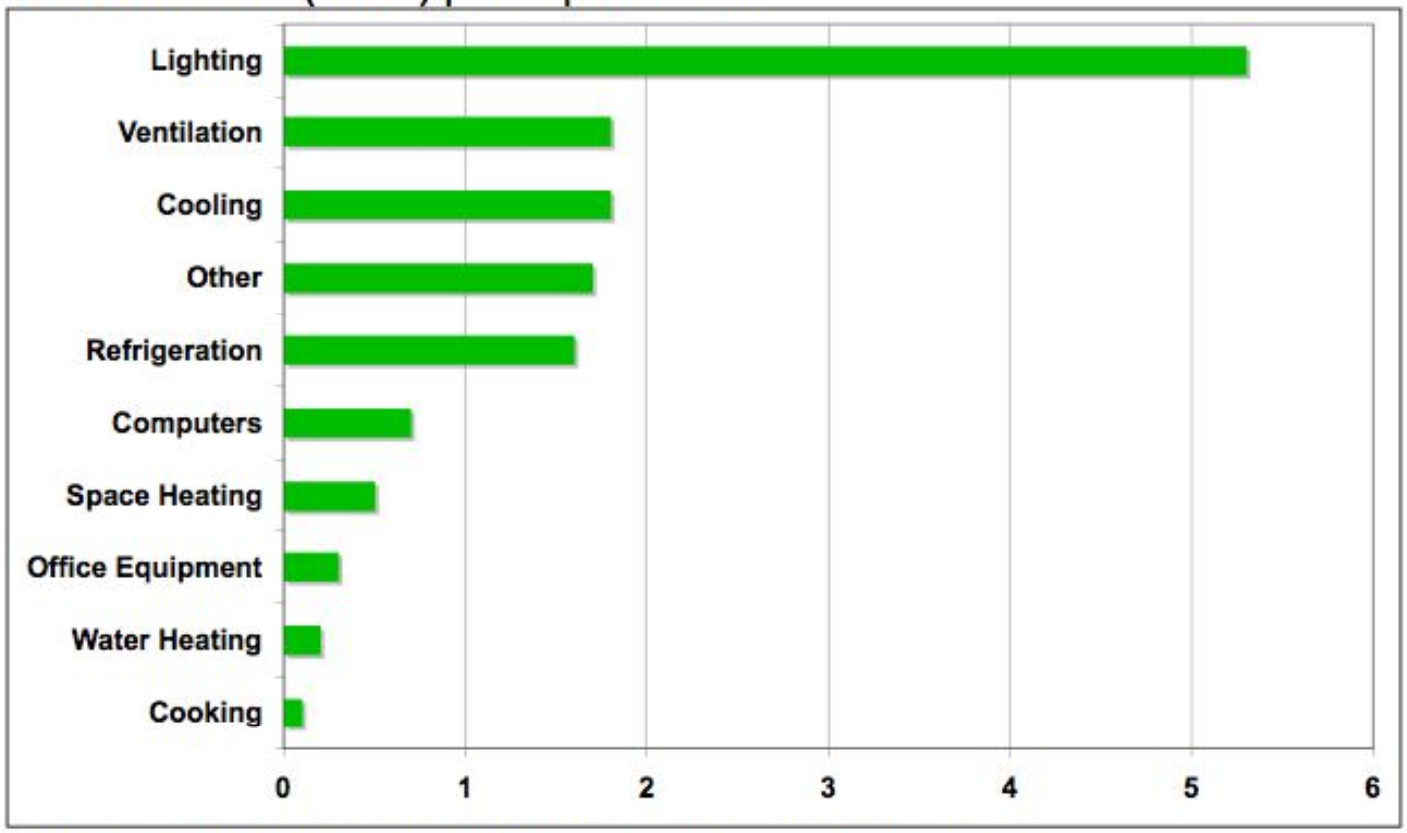
Buildings

Buildings Use 25-40% of Energy Demand

Buildings are one of the largest end users of energy;
the building sector accounts for 25-40% of the
final energy demand in
OECD countries.

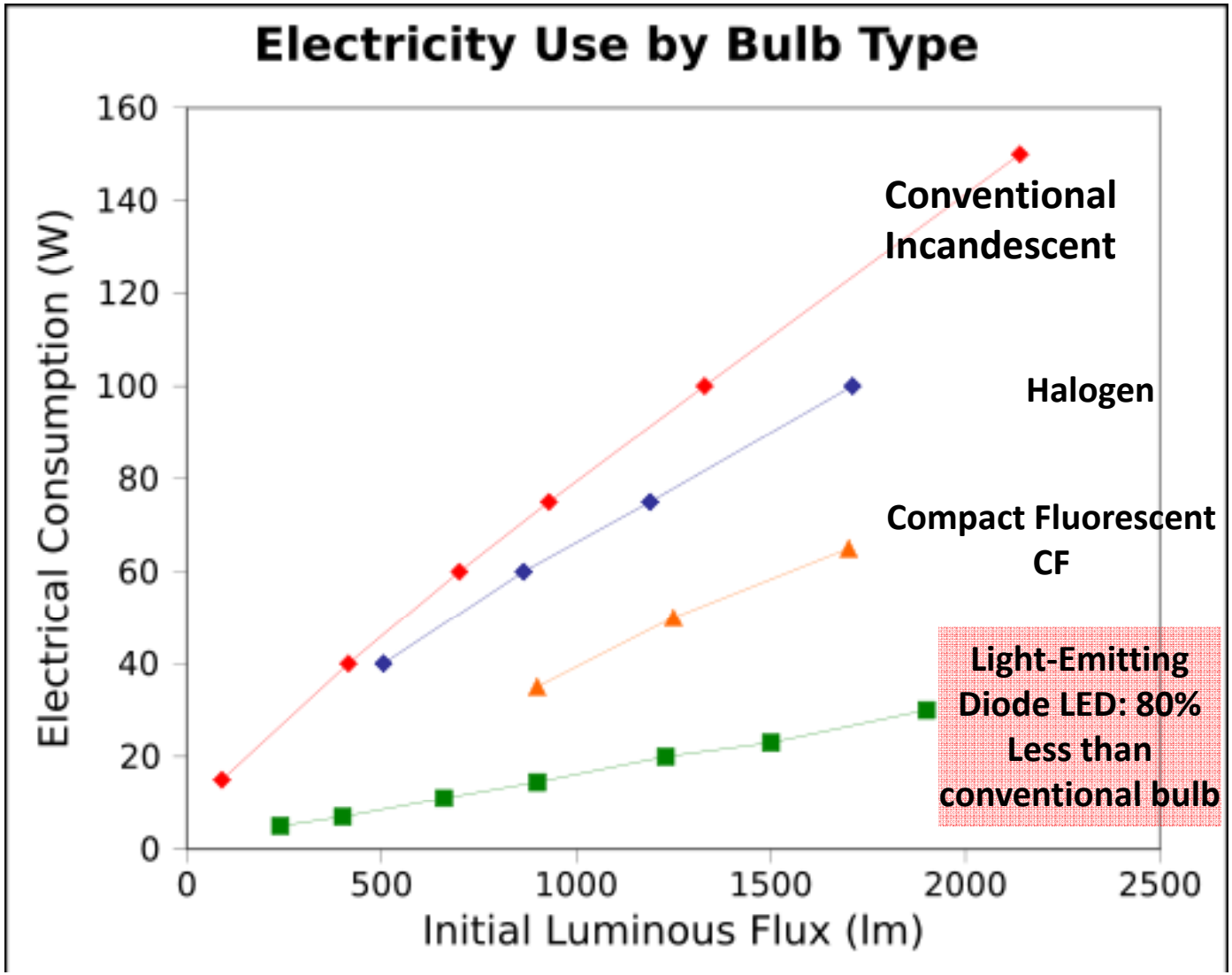
Lighting Consumes Most Energy

Kilowatt-hours (KWH) per Square Foot



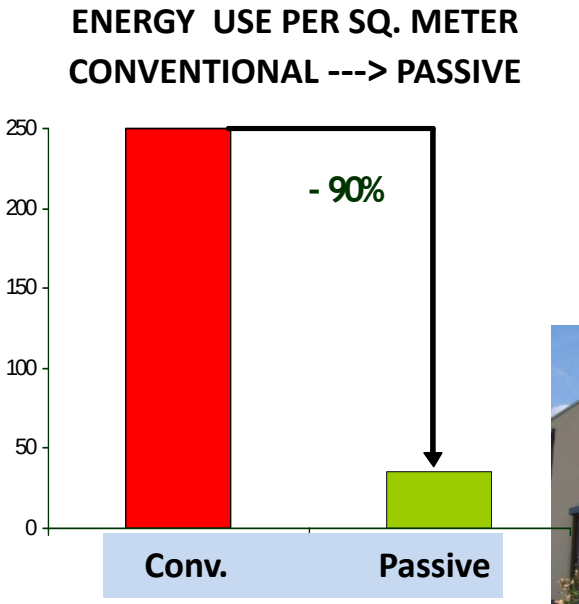
Source Energy Information Administration and Green Econometrics research

According to the EIA. in commercial buildings, lighting fixtures consume the most electric energy, three times the energy consumption of air conditioning.


Electricity Use by Bulb Type
Electrical Consumption (W)
160
140
120
100
80
60
40
20
0
0
500
1000
1500
2000
2500
Initial Luminous Flux (lm)
Conventional Incandescent
Halogen
Compact Fluorescent CF
Light-Emitting Diode LED: 80% Less than conventional bulb


Open
PIZZA
OPEN
OPEN
OPEN

Passive Buildings



Before reconstruction

Reconstruction according to the passive house principle

over 150 kWh/(m²-year)

-90%

15 kWh/(m²-year)

Source: Jan Barta, Center for Passive Buildings, www.pasivnidomy.cz, EEBW2006

Remember that almost none of us care about energy, we care about energy services—heating, cooling, lighting, transportation . . . There is a huge potential to reduce energy use with no loss of energy services while at the same time saving money for those of us who must pay the energy bill.

INCREASE ENERGY SUPPLY

Energy Resources

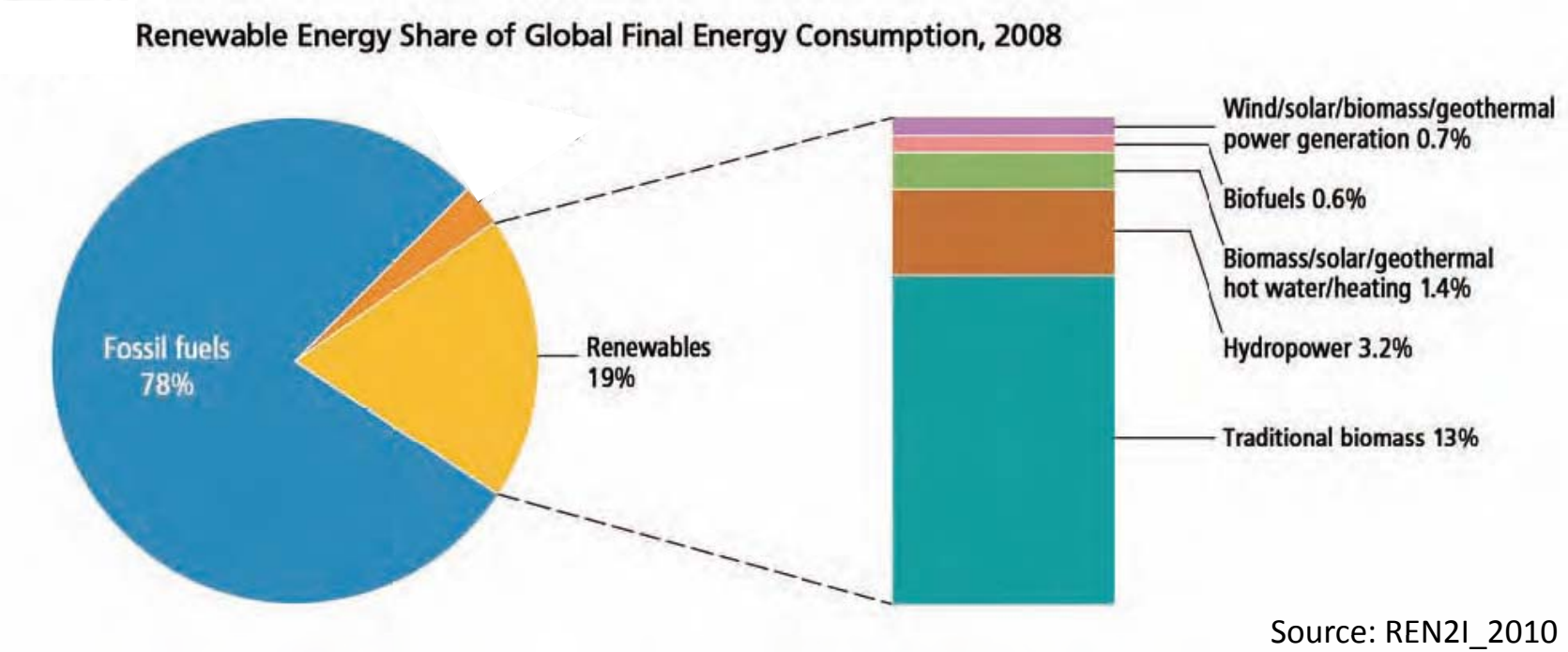
TW = 10^{12} Watts = 1 Trillion Watts

Present global commercial energy use = 15 TW-yr/yr

RENEWABLES: ENERGY FLOWS	
Solar	Huge: 173,000 x 10^{12} Watt (TW)
Geothermal	Small: ~40 TW
Tidal	Tiny: ~4 TW
MINERAL ENERGY RESOURCE	
Coal, Tar Sand, Oil Shale	Huge
Natural Gas	Large: Global production peak in a couple of decades
Conventional Oil	Global production now peaking
NUCLEAR FUEL RESOURCE	
Uranium	No scarcity foreseen

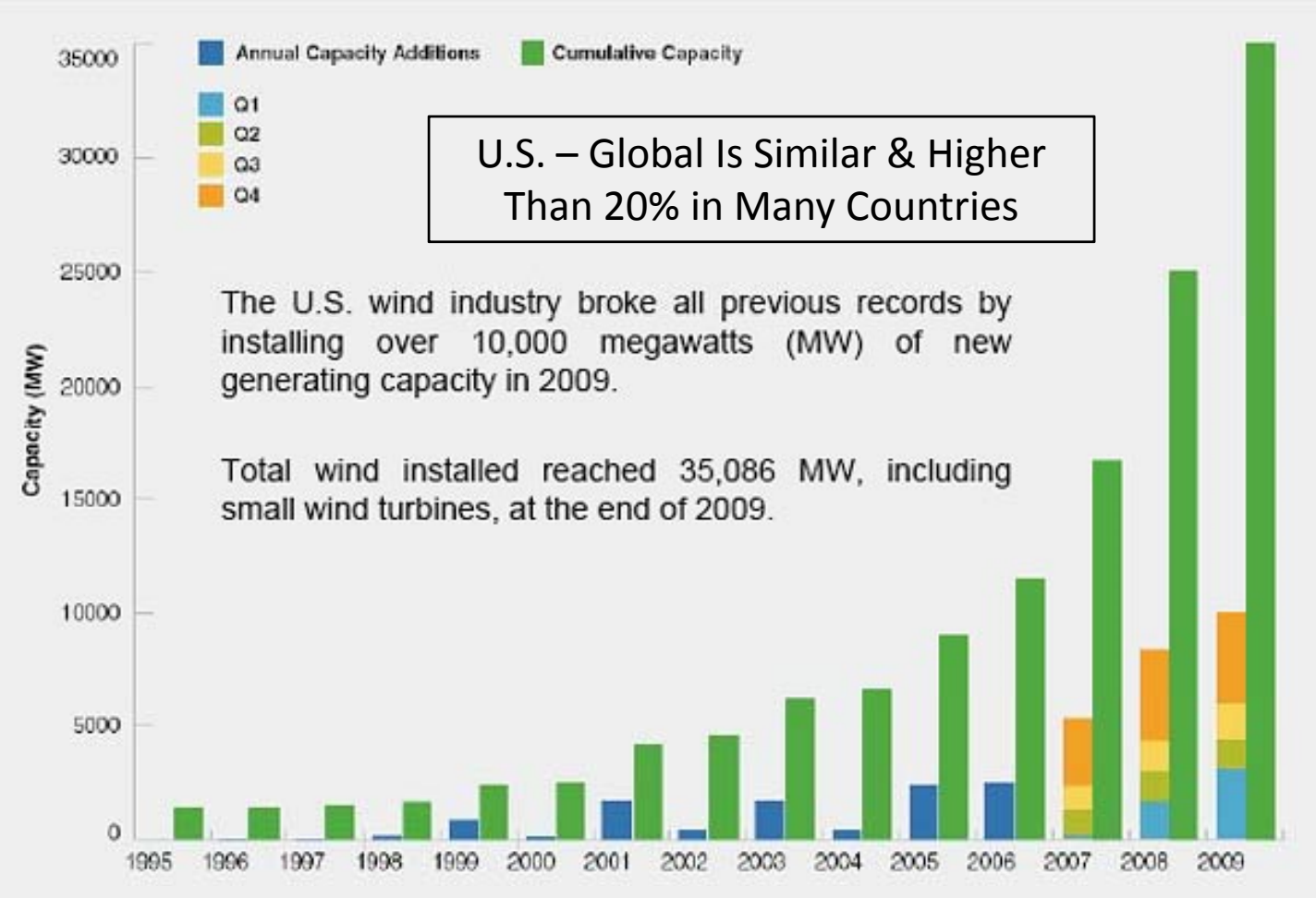
RENEWABLES

Renewables ~19% Global Final Energy Consumption In 2008 – and Growing Rapidly

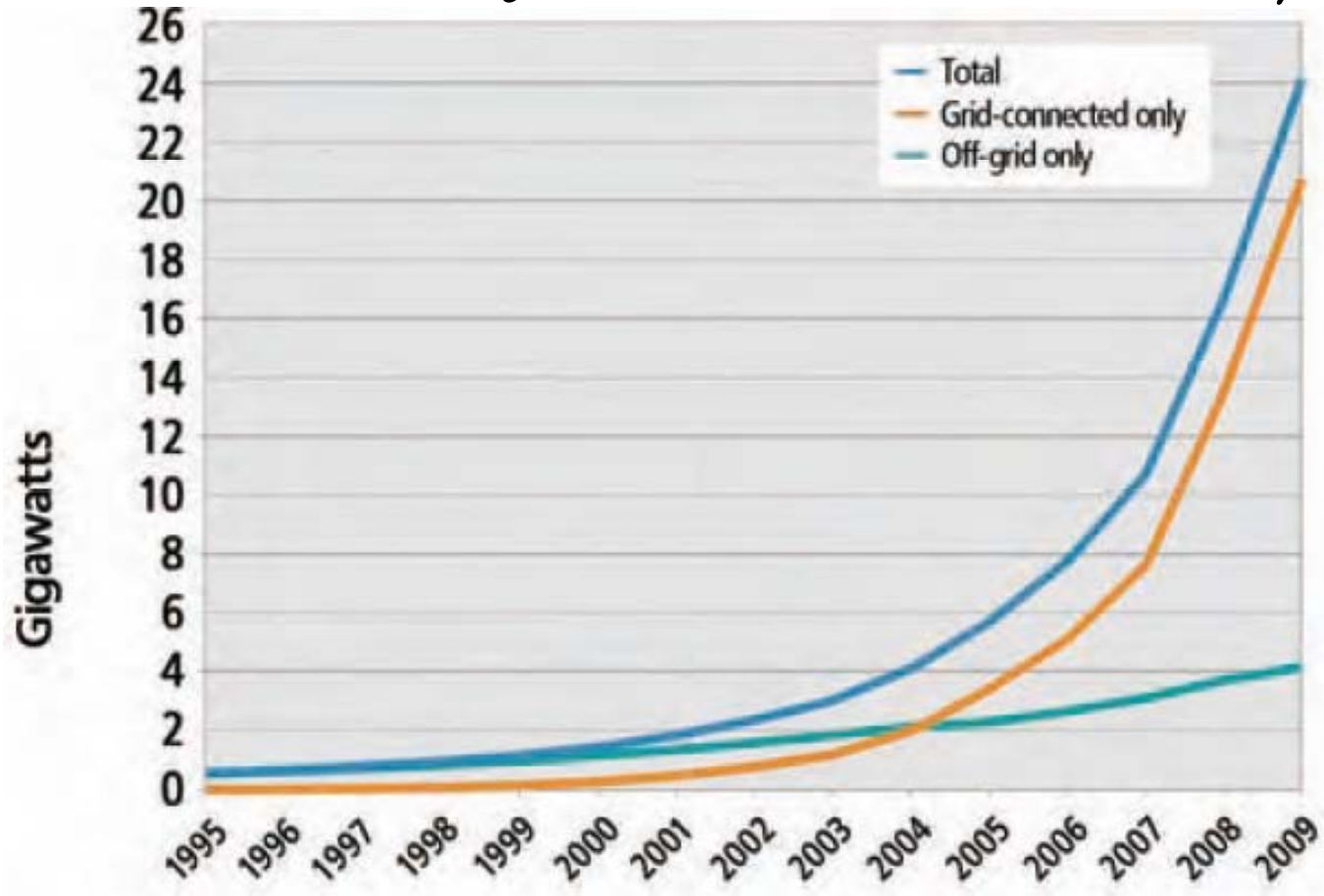


Source: REN2I_2010

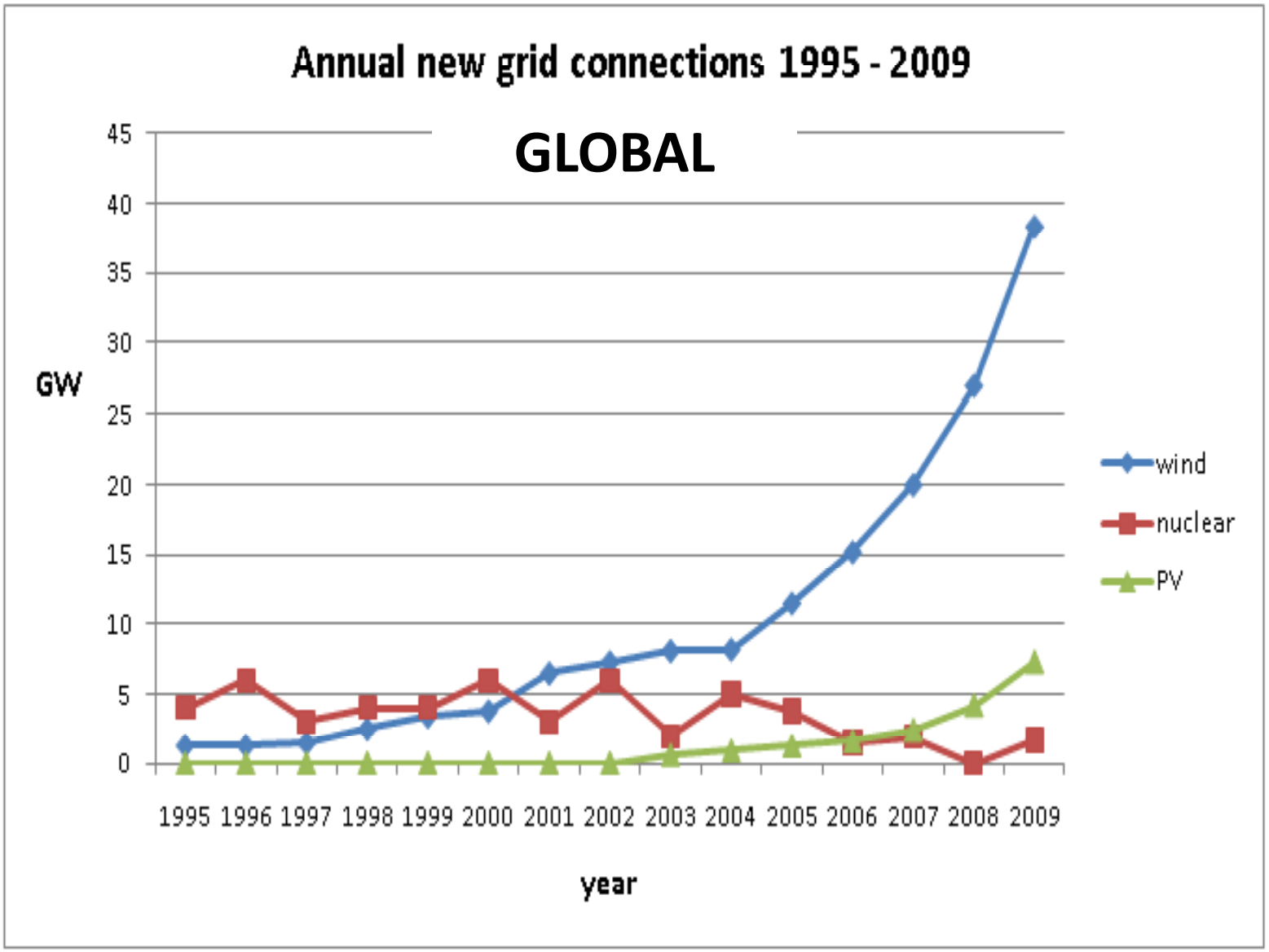
Windpower Growing at More than 20%/year



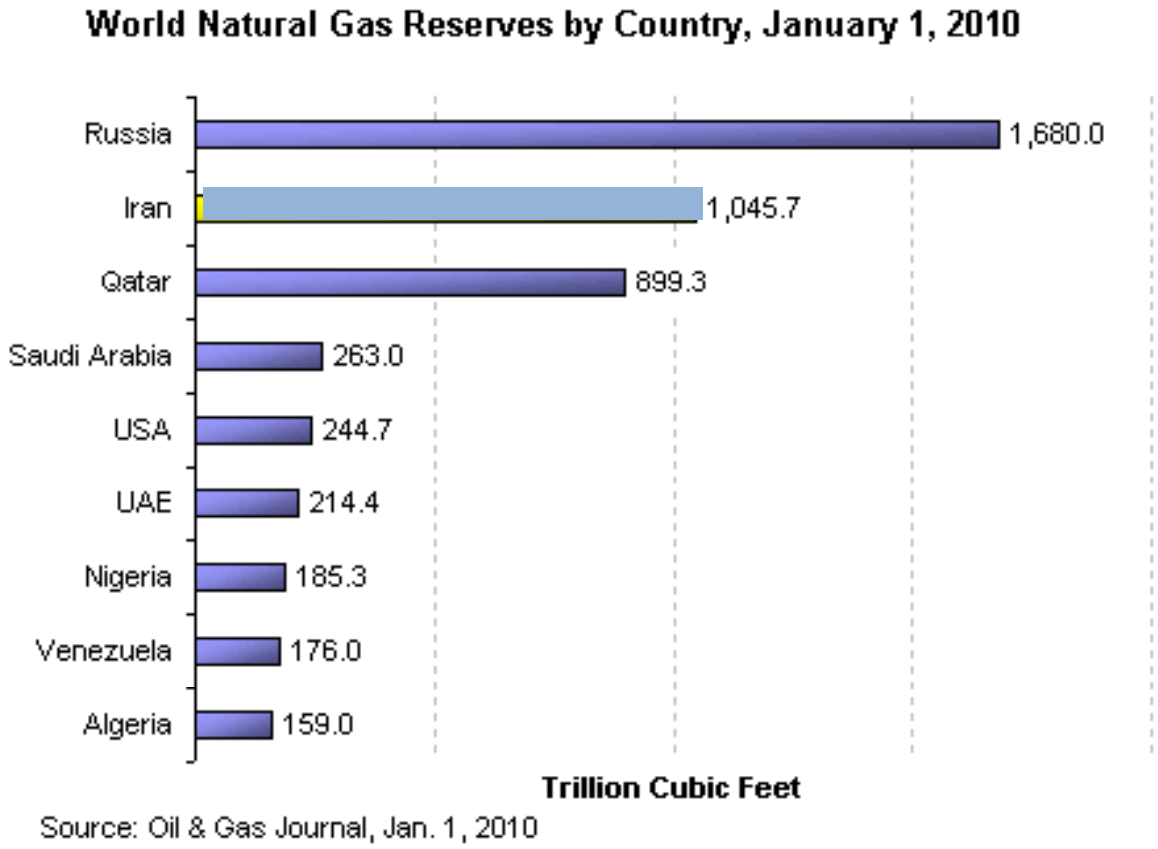
Solar PV Growing at More than 20%/year



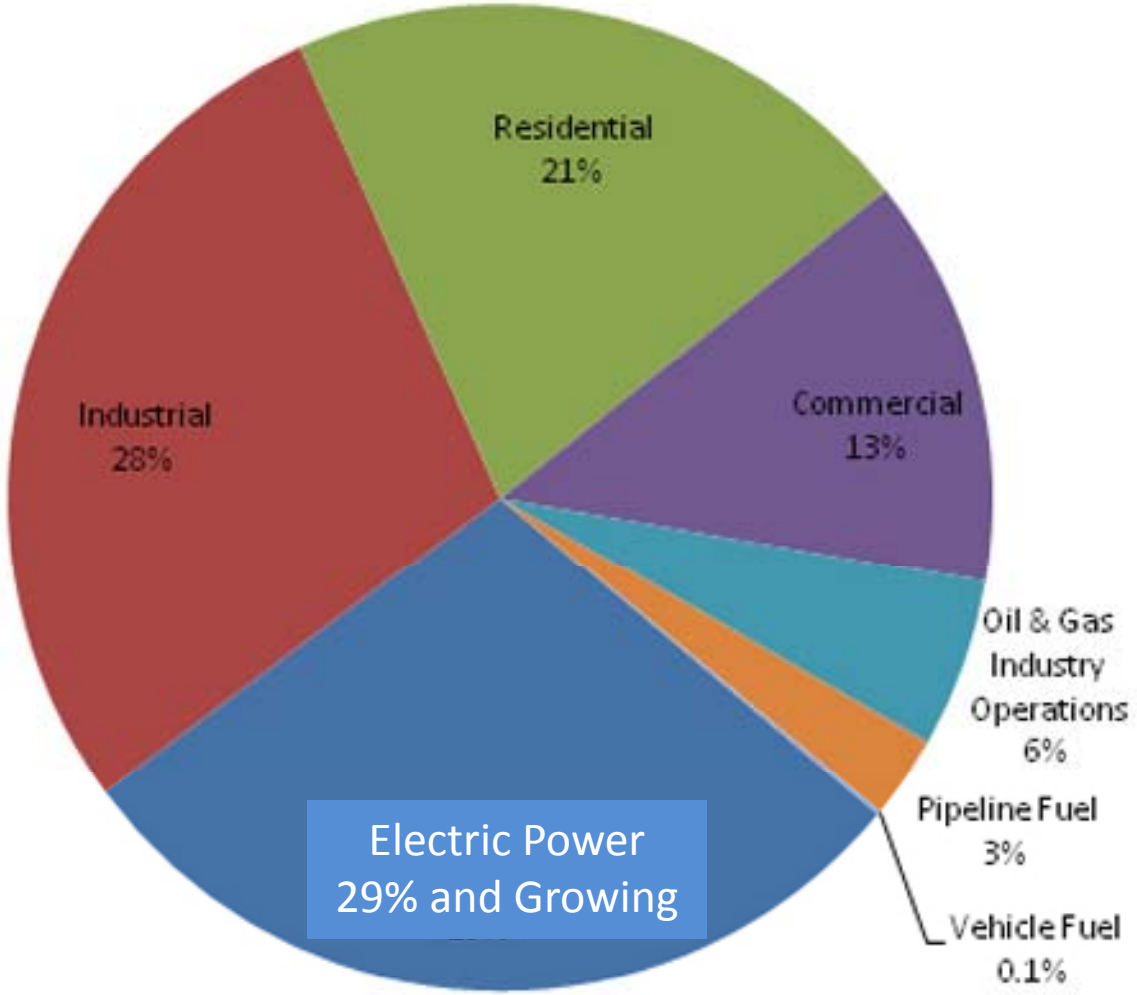
http://www.ren21.net/globalstatusreport/REN21_GSR_2010_full.pdf


Annual new grid connections 1995 - 2009
GLOBAL
GW
45
40
35
30
25
20
15
10
5
0
1995 1996 1997 1998 1999 2000 2001 2002 2003 2004 2005 2006 2007 2008 2009
year
wind
nuclear
PV

NATURAL GAS


World Natural Gas Reserves by Country, January 1, 2010
Russia
1,680.0
Iran
1,045.7
Qatar
899.3
Saudi Arabia
263.0
USA
244.7
UAE
214.4
Nigeria
185.3
Venezuela
176.0
Algeria
159.0
Trillion Cubic Feet
Source: Oil & Gas Journal, Jan. 1, 2010

U.S. Natural Gas Use



Natural Gas Pollution is Smaller than from Oil or Coal, but Not Zero

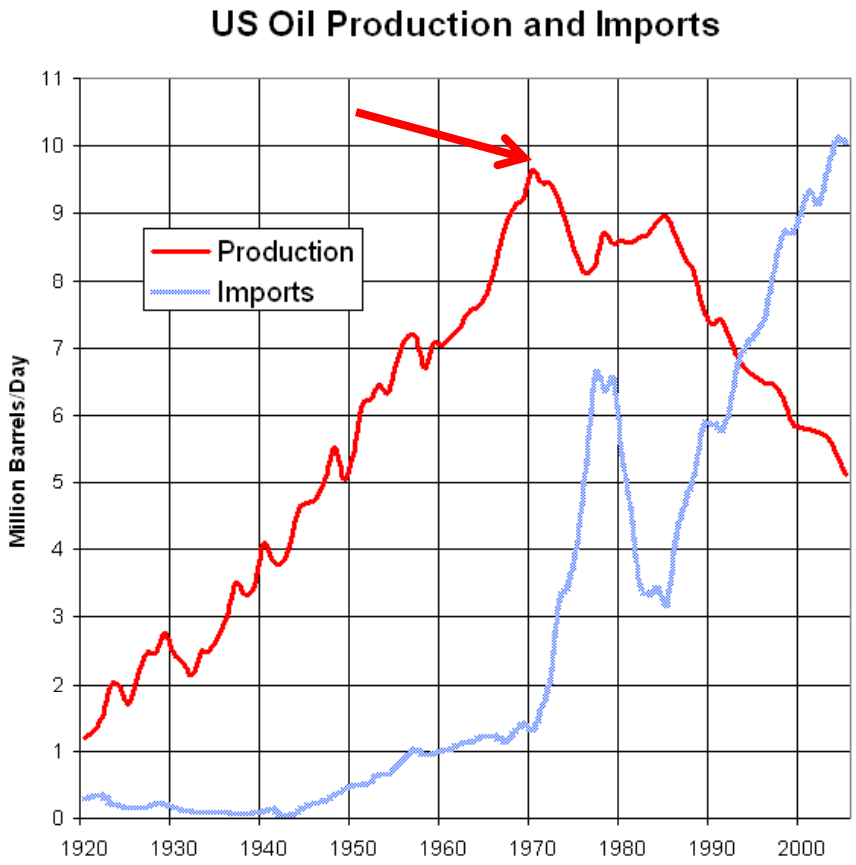
- Less than half as much greenhouse gas pollution as coal or and about 1/3rd as much as from tar sands oil
- No toxic heavy metals
- Relatively low, but far from zero, land-use impact
- Production of non-conventional natural gas from shale deposits raises serious environmental issues.

OIL

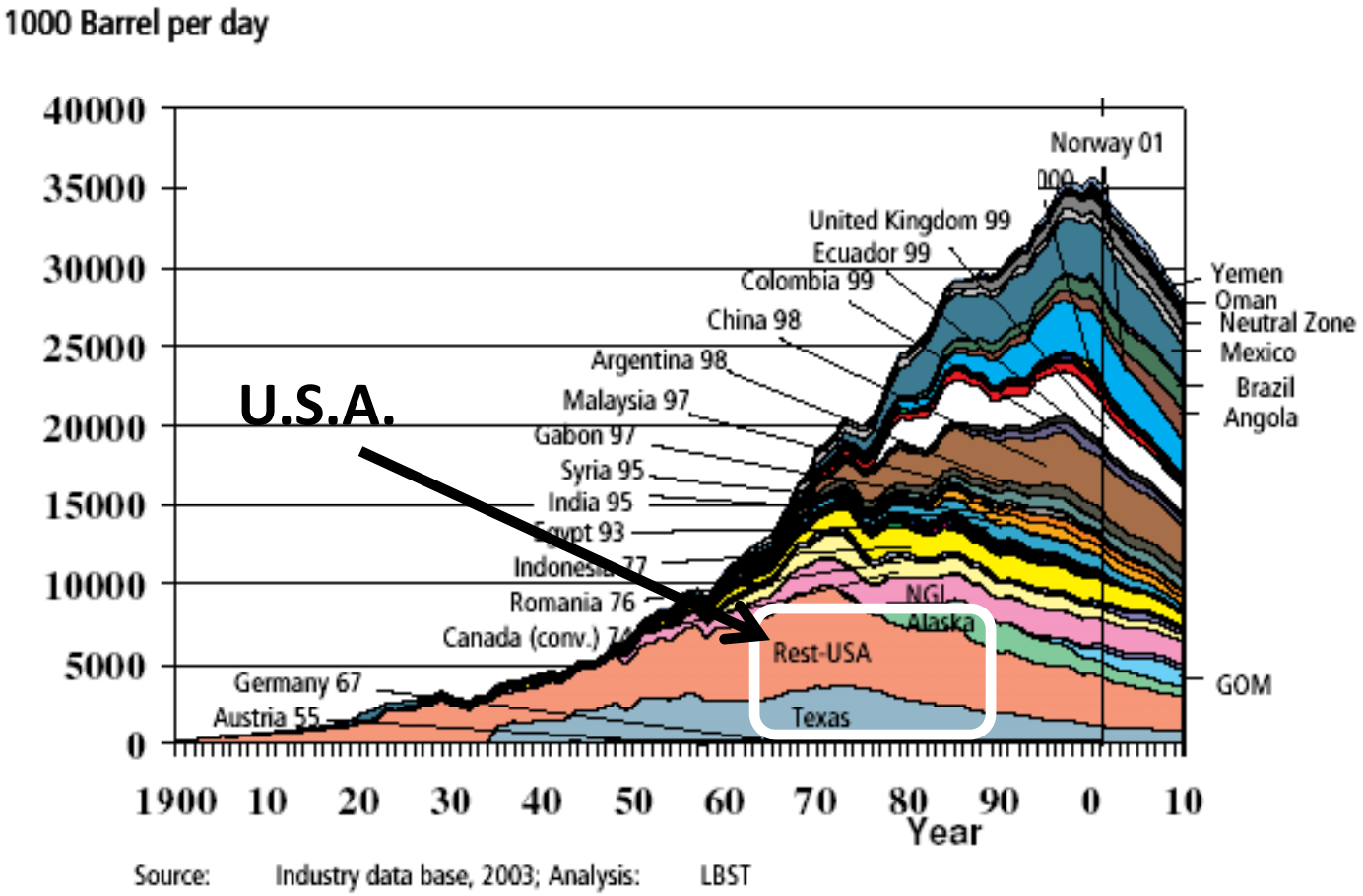
36% of global energy
>40% of U.S. energy

The U.S. has about **2%** of global oil reserves and consumes about **23%** of the world's oil production.

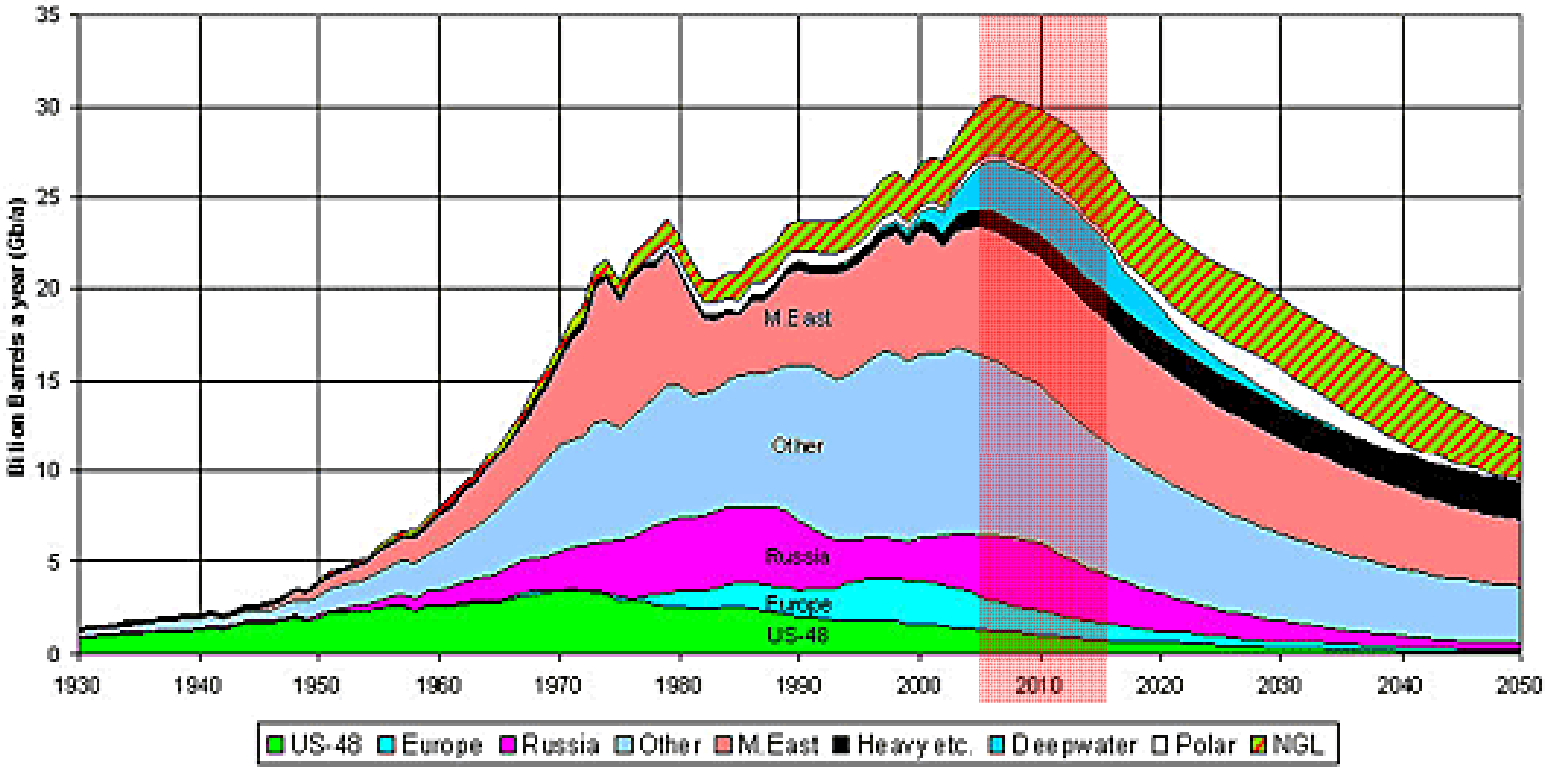
U.S. Oil Production Peaked in December 1970



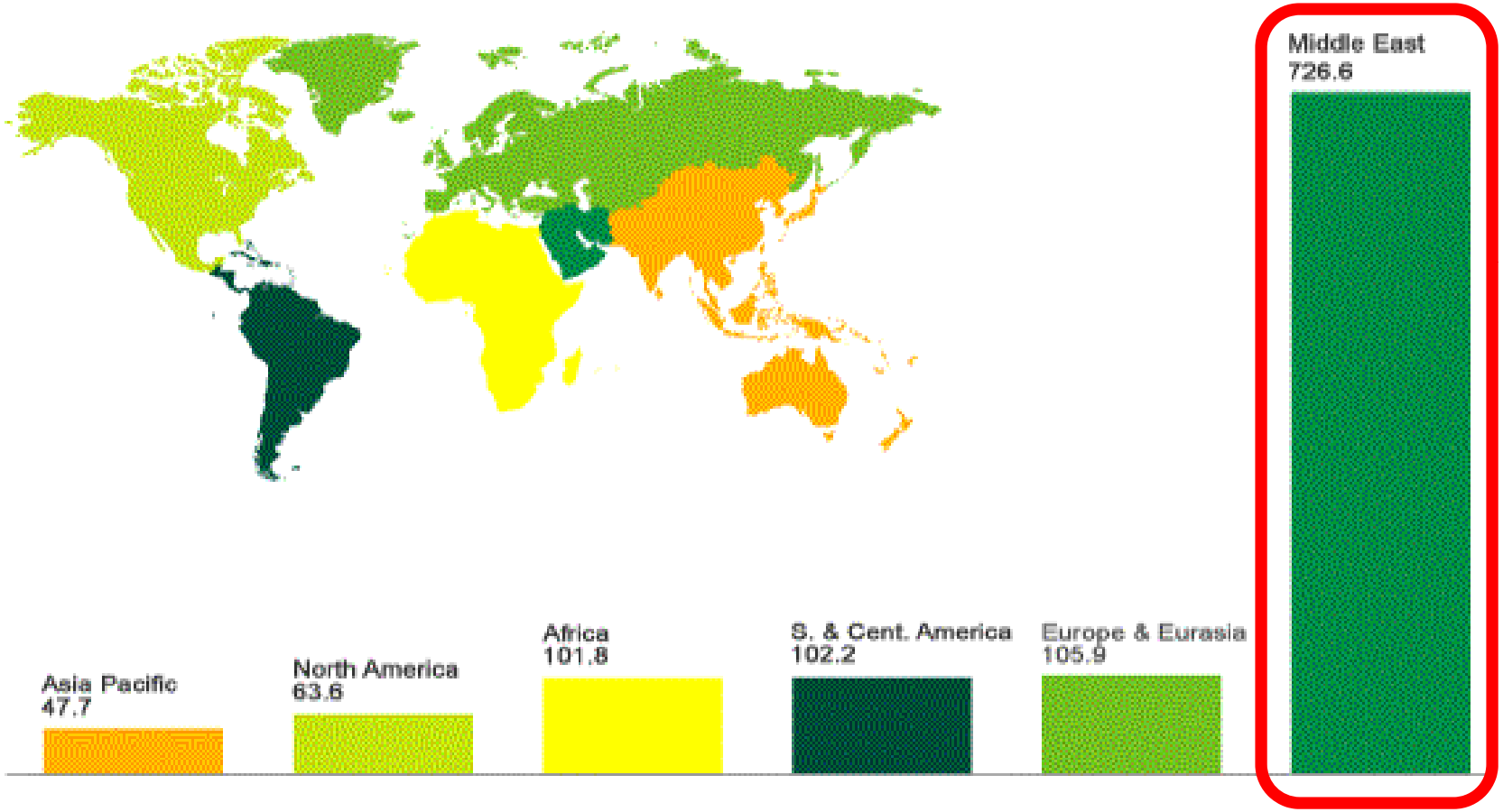
Conventional Oil Production Has Peaked in Most Non-OPEC Countries



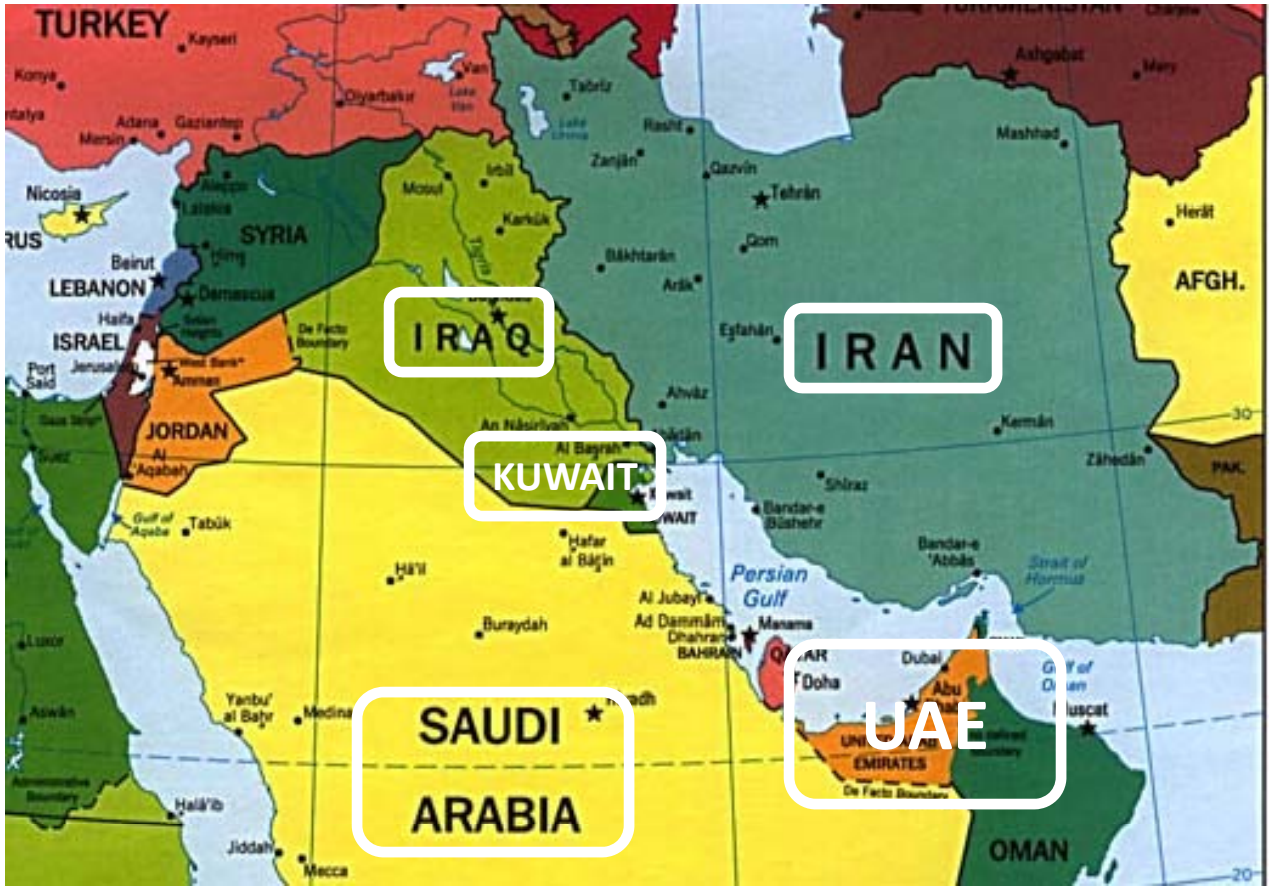
Global Conventional Oil Production Has Peaked or Will Soon Peak. We'll Know in A Couple of Years



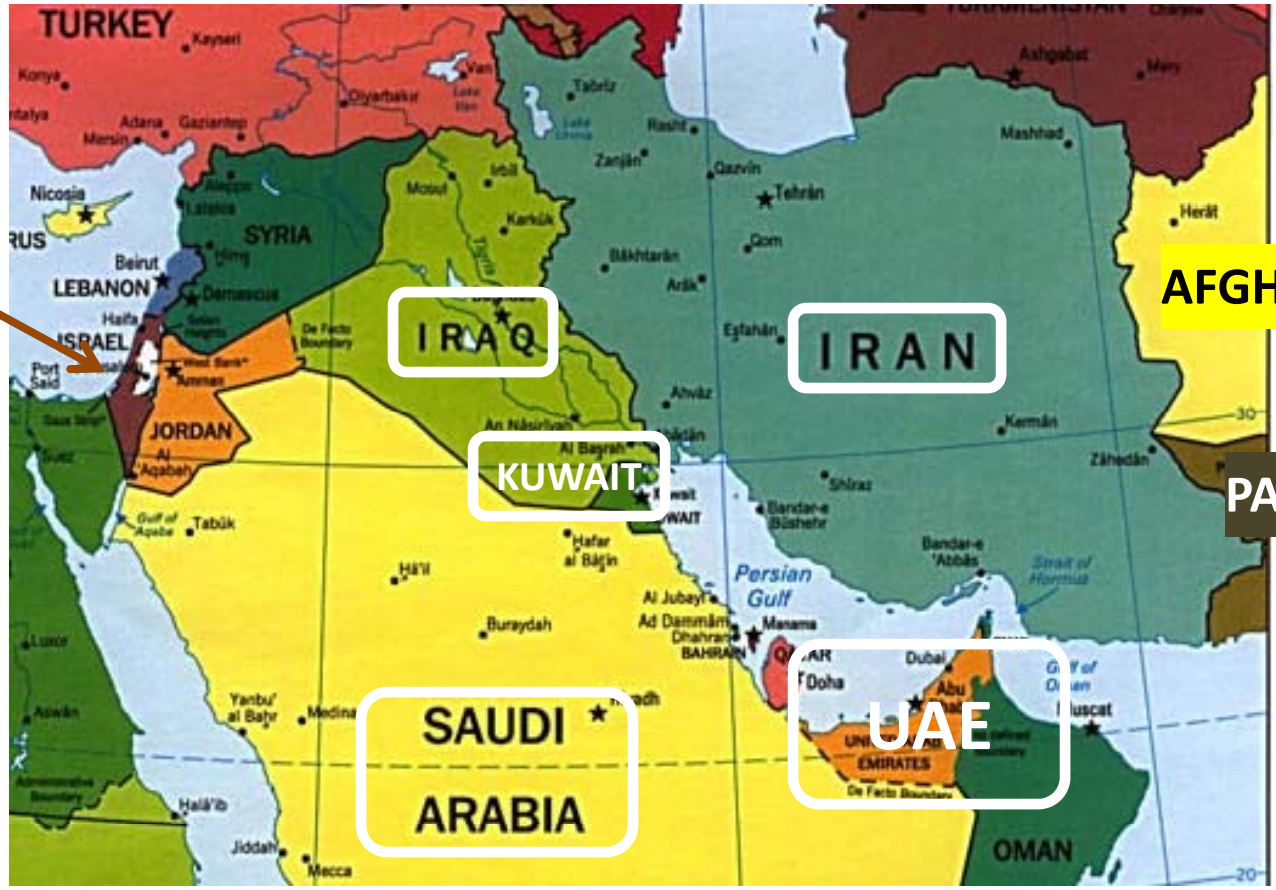
60+% of the Remaining Conventional Oil Is in the Middle East Primarily in Five Countries



THE MIDDLE-EAST OIL "SWING COUNTRIES"



NEIGHBORS THAT ARE MUCH IN THE NEWS



ISRAEL

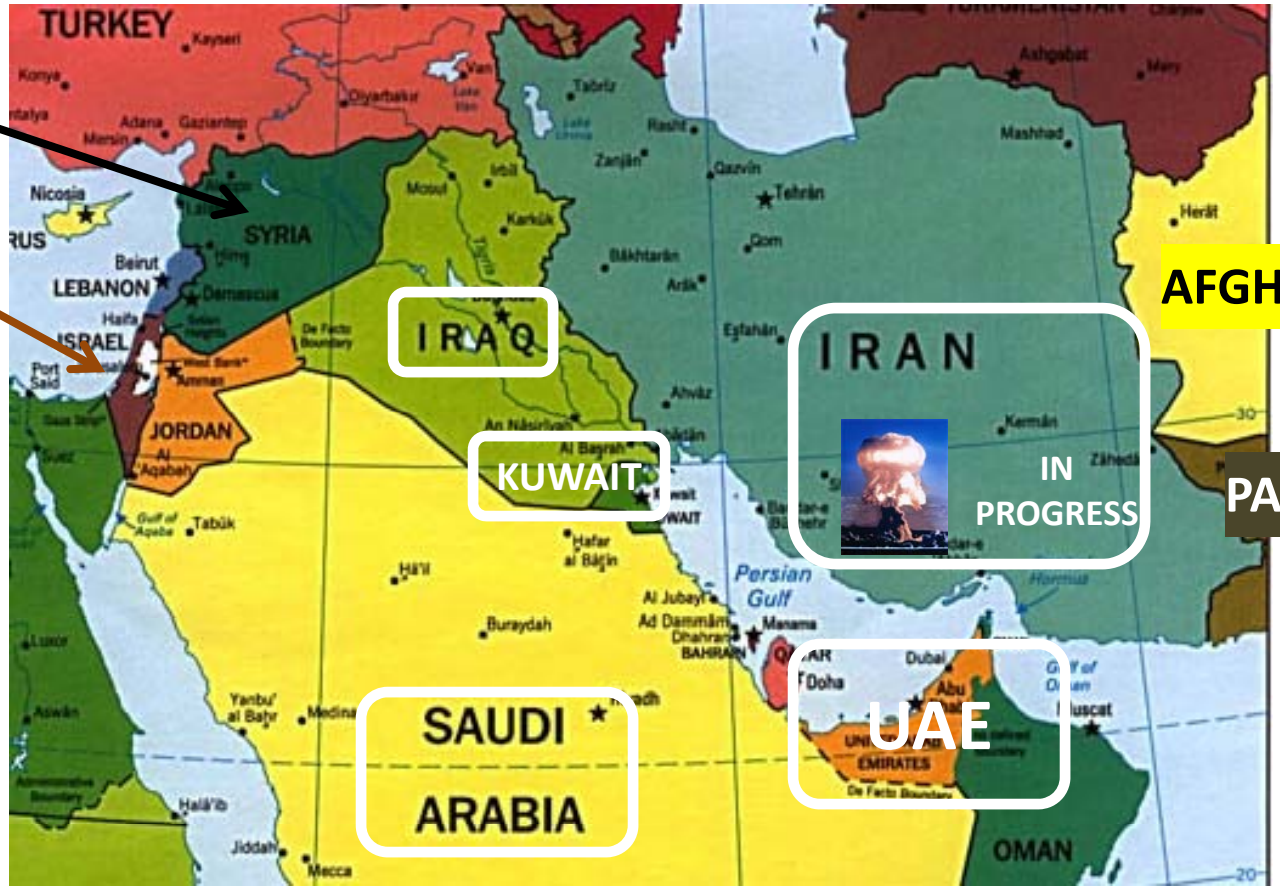
AFGHANISTAN

PAKISTAN

NUCLEAR WEAPONS IN THE REGION

SYRIA
Nuclear
Intentions
Unclear

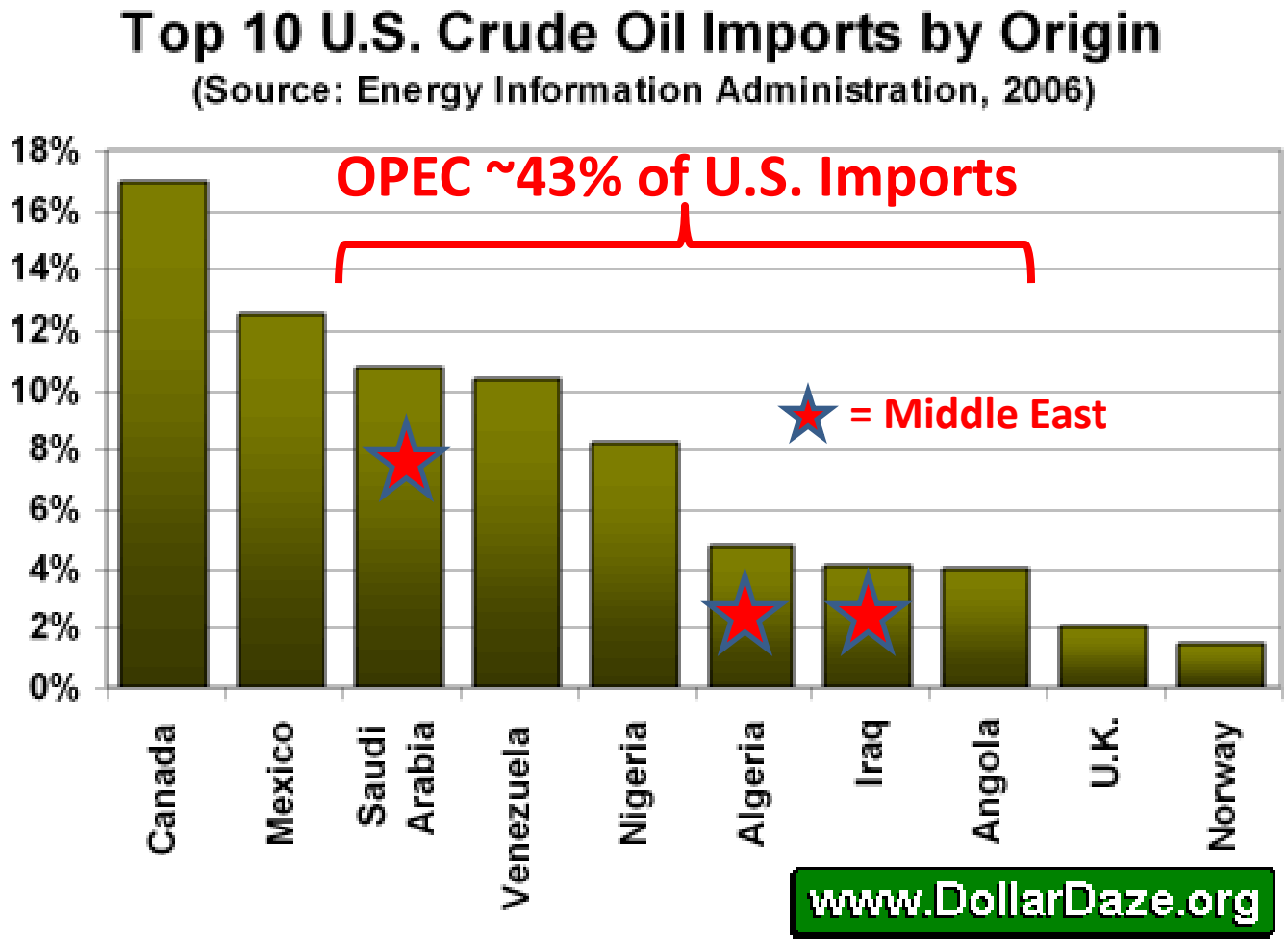
ISRAEL



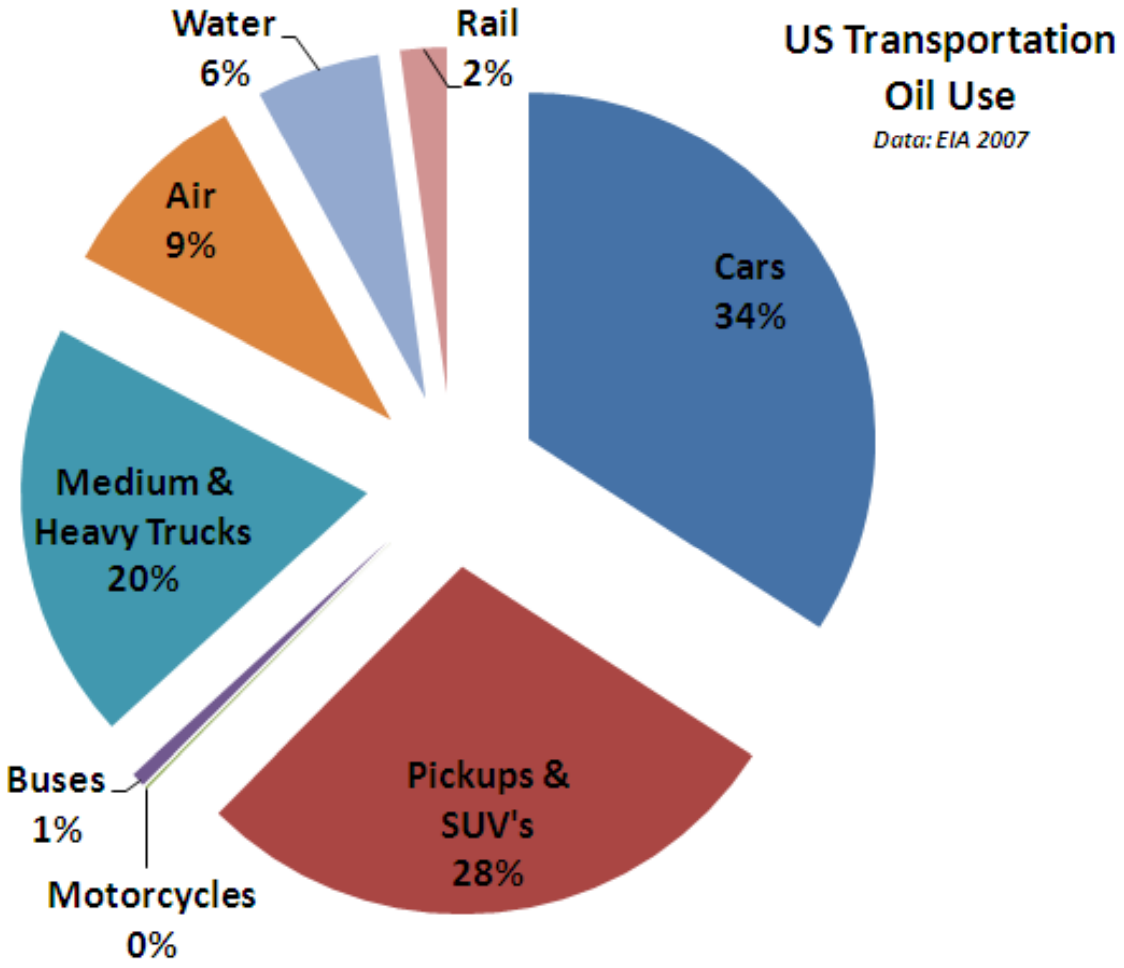
AFGHANISTAN

PAKISTAN

U.S. IMPORTS: 60+% OF OIL CONSUMPTION



U.S. Oil Use


US Transportation Oil Use
Data: EIA 2007
Water 6%
Rail 2%
Air 9%
Cars 34%
Medium & Heavy Trucks 20%
Buses 1%
Motorcycles 0%
Pickups & SUV's 28%

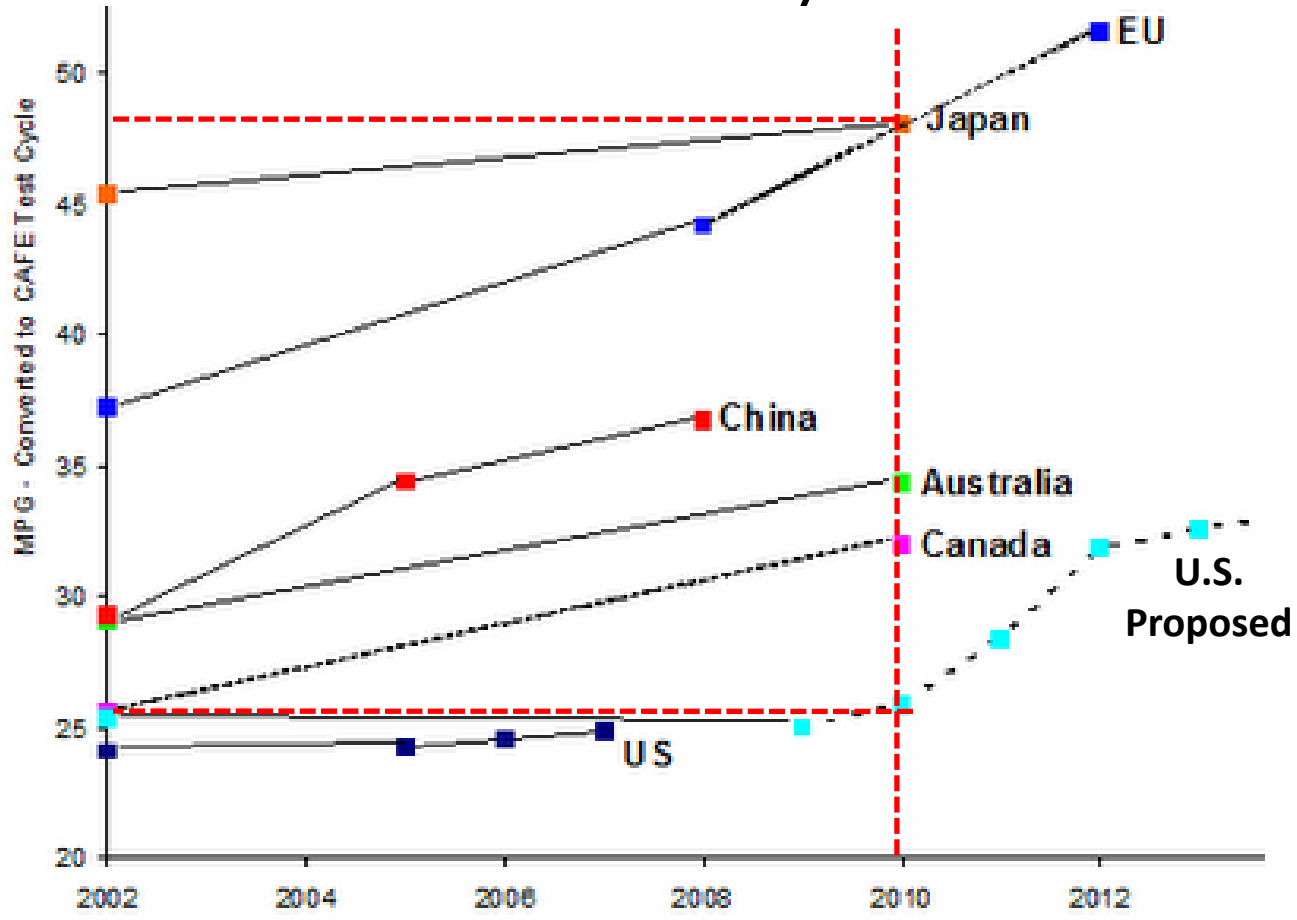
For the record, the U.S. military is the largest single consumer of oil in the world,
burning 16.8 million gallons
per day.

Lehrer (2010), p. 81

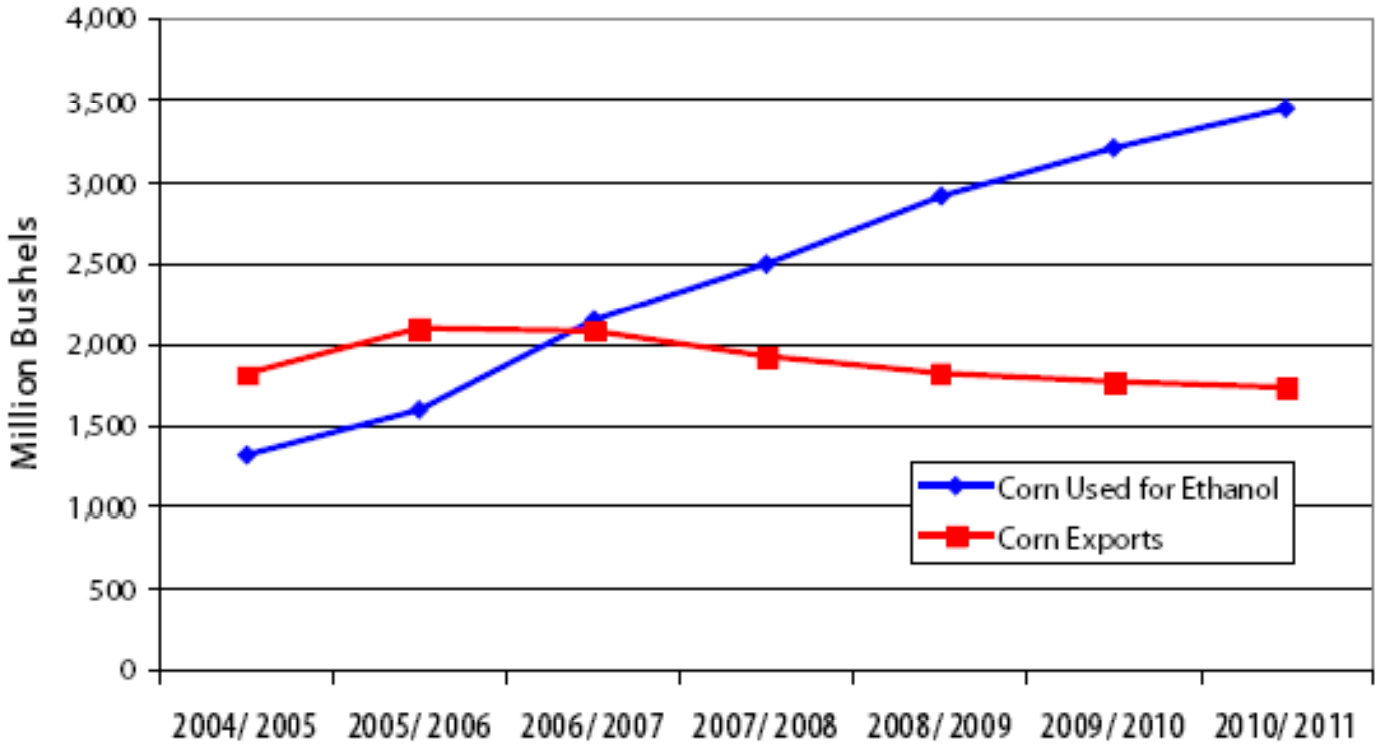
Major Components of U.S. Oil Policy

- Token auto efficiency standards
- Mandate conversion of corn to ethanol
- Increase imports of Alberta Tar Sands non-conventional oil
- Make war to protect access to Middle East oil

U.S. Auto "Efficiency" About half that of the E.U. and Japan



Nearly 30% of U.S. Corn Goes to Ethanol Production



Source: Data from FAPRI July 2006 Baseline Update for U.S. Agricultural Markets

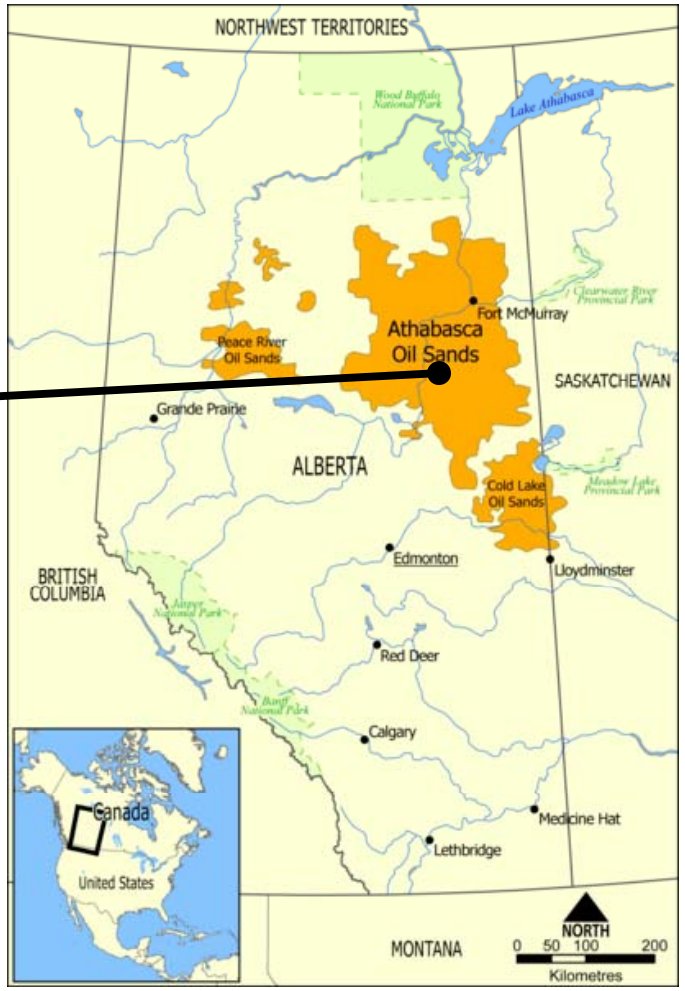
Corn → Ethanol → SUV
Feed a Person for a Year or Fill Up an SUV?

"While politicians and Big Agriculture insist on casting the need for ethanol in terms of national security, the larger issue is a moral one: are we going to use our precious farmland to grow food, or use it to make motor fuel?"

http://www.alternet.org/environment/48790

CANADIAN TAR SANDS

By far the largest North American oil resource is Canadian tar sands.

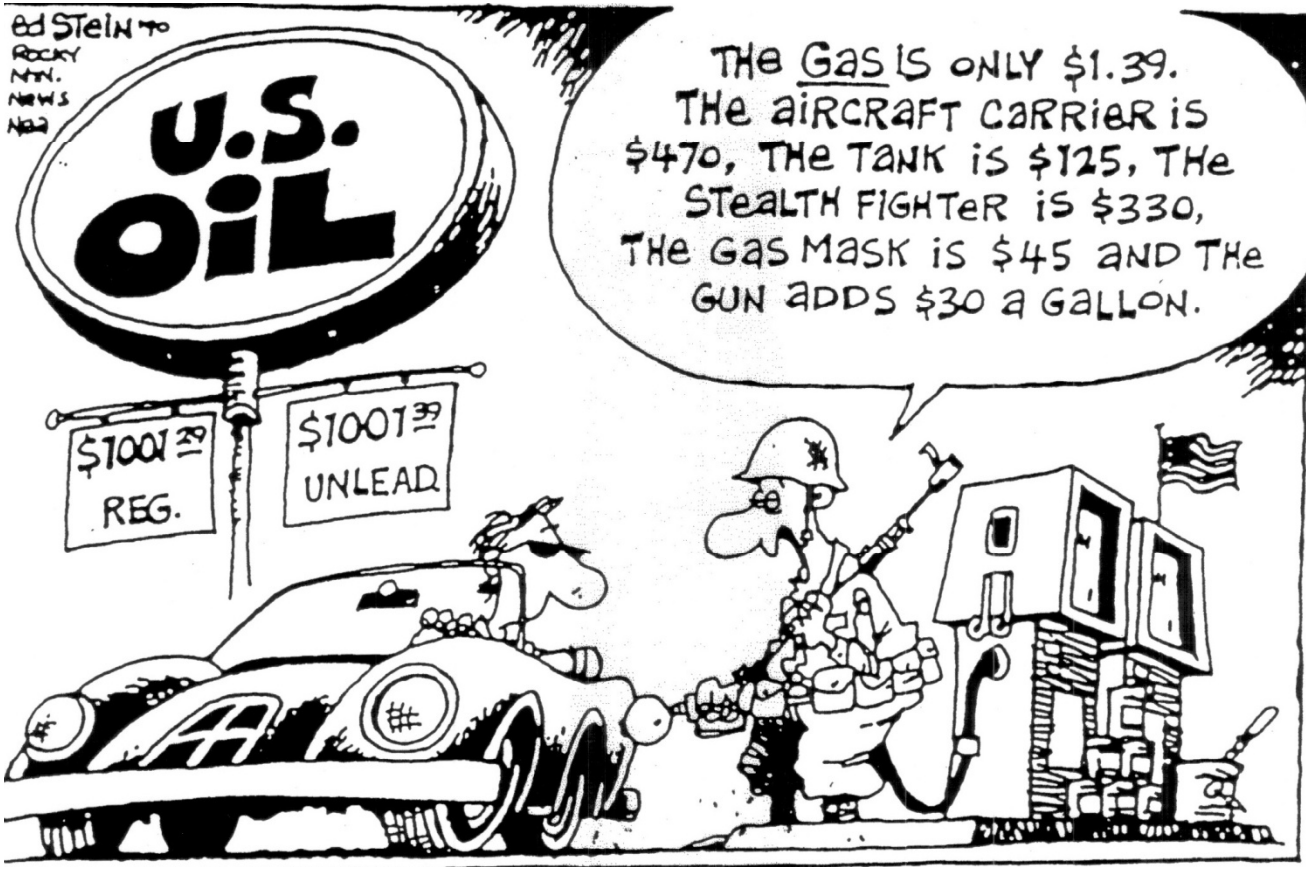


The Alberta tar sands system is the world's largest industrial program

The Alberta tar sands program has been called the most destructive program on earth.

- Non-conventional oil from tar sands produce more greenhouse gas pollution than any other fuel used in the U.S.
- Massive land use disturbance.
- Massive water use and water pollution
- Major impact on native culture

Primary U.S. Middle East Oil Policy



The True Cost of Oil

- ✓ Crude oil now costs ~$70/Bbl (per barrel) $1.67/gallon [1 Barrel Oil = 42 gallons]
- ✓ The cost of gasoline at the pump, in the U.S., is about $3/gal
- ✓ Military cost protecting access to Middle East oil; estimated at $7.41/gal
- ✓ Total economic costs are estimated at $480/bbl ~$11/gal)
- ✓ Plus direct subsidies
- ✓ Plus environmental cost
- ✓ Plus health costs
- ✓ And more

http://www.energyandcapital.com/articles/oil-gas-crude/461

U.S Direct Federal Tax Subsidies to Oil Companies

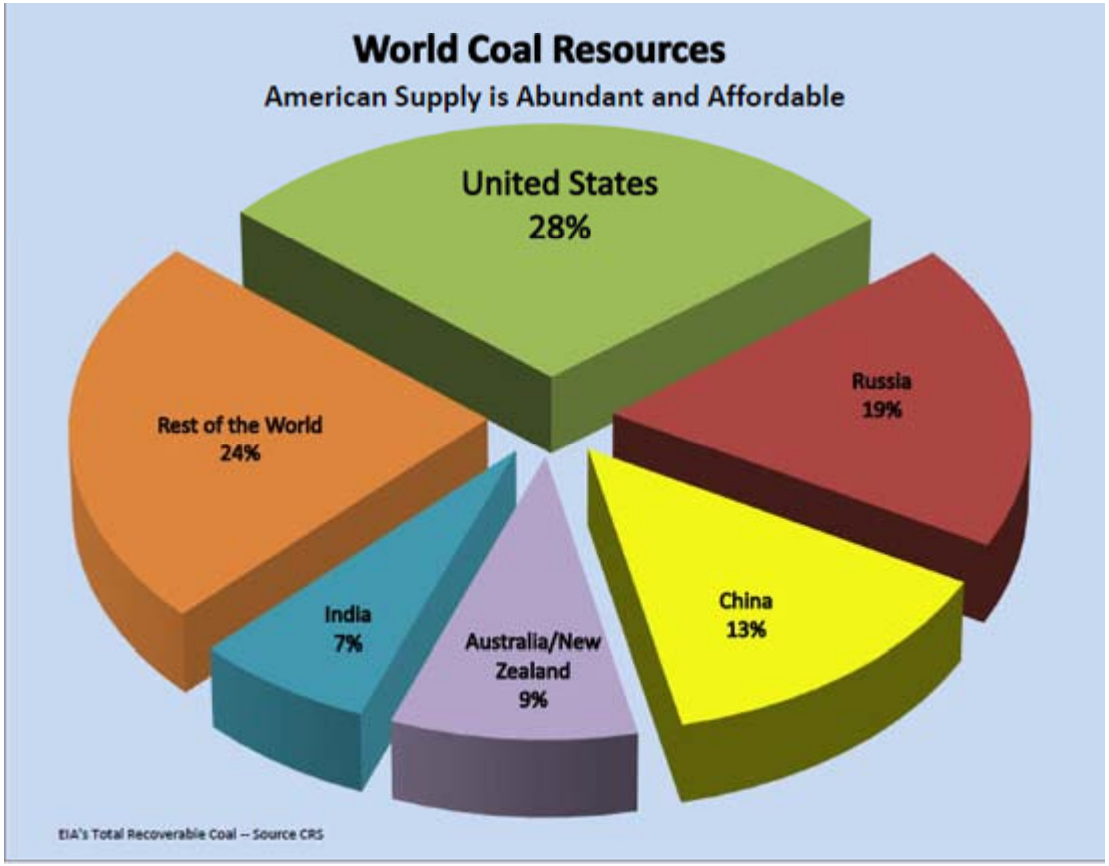
Federal tax breaks that directly benefit oil companies include: the Percentage Depletion Allowance (a subsidy of $784 million to $1 billion per year), the Nonconventional Fuel Production Credit ($769 to $900 million), immediate expensing of exploration and development costs ($200 to $255 million), the Enhanced Oil Recovery Credit ($26.3 to $100 million), foreign tax credits ($1.11 to $3.4 billion), foreign income deferrals ($183 to $318 million), and accelerated depreciation allowances ($1.0 to $4.5 billion)

http://www.progress.org/2003/energy22.htm

And, there are problems like the BP oil blowout in the Gulf of Mexico – the greatest single environmental disaster in U.S. history

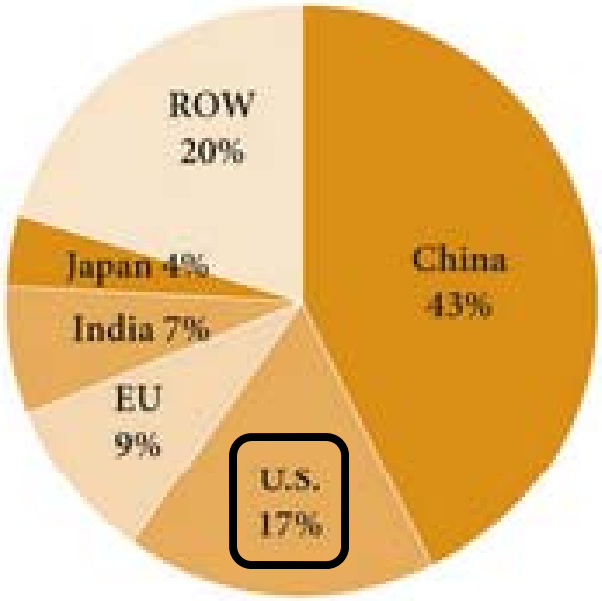
COAL

The U.S. Has the World's Largest Coal Resource



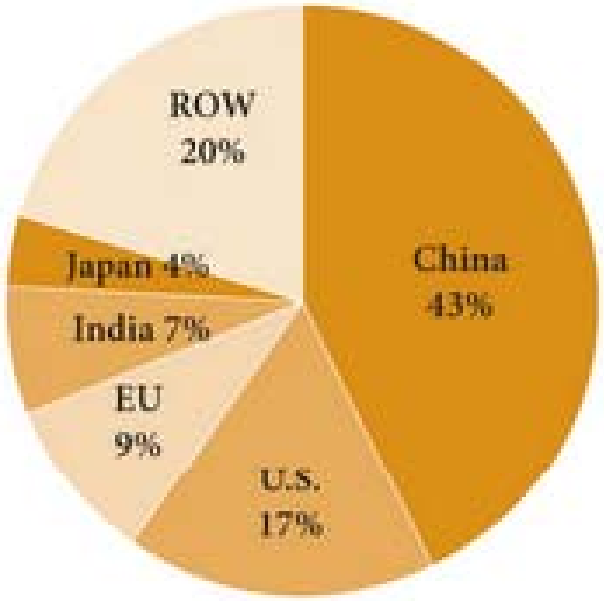
The U.S. Consumes Nearly 20% of Global Coal Production

COAL CONSUMPTION

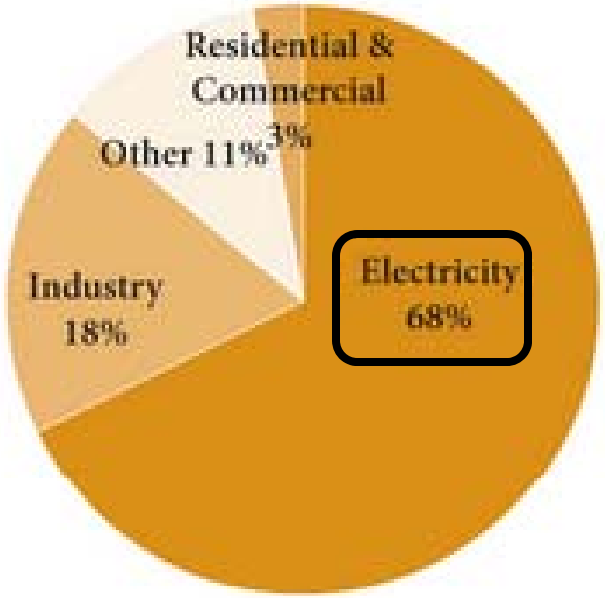


Coal is Used to Produce about 70% of Global Electricity

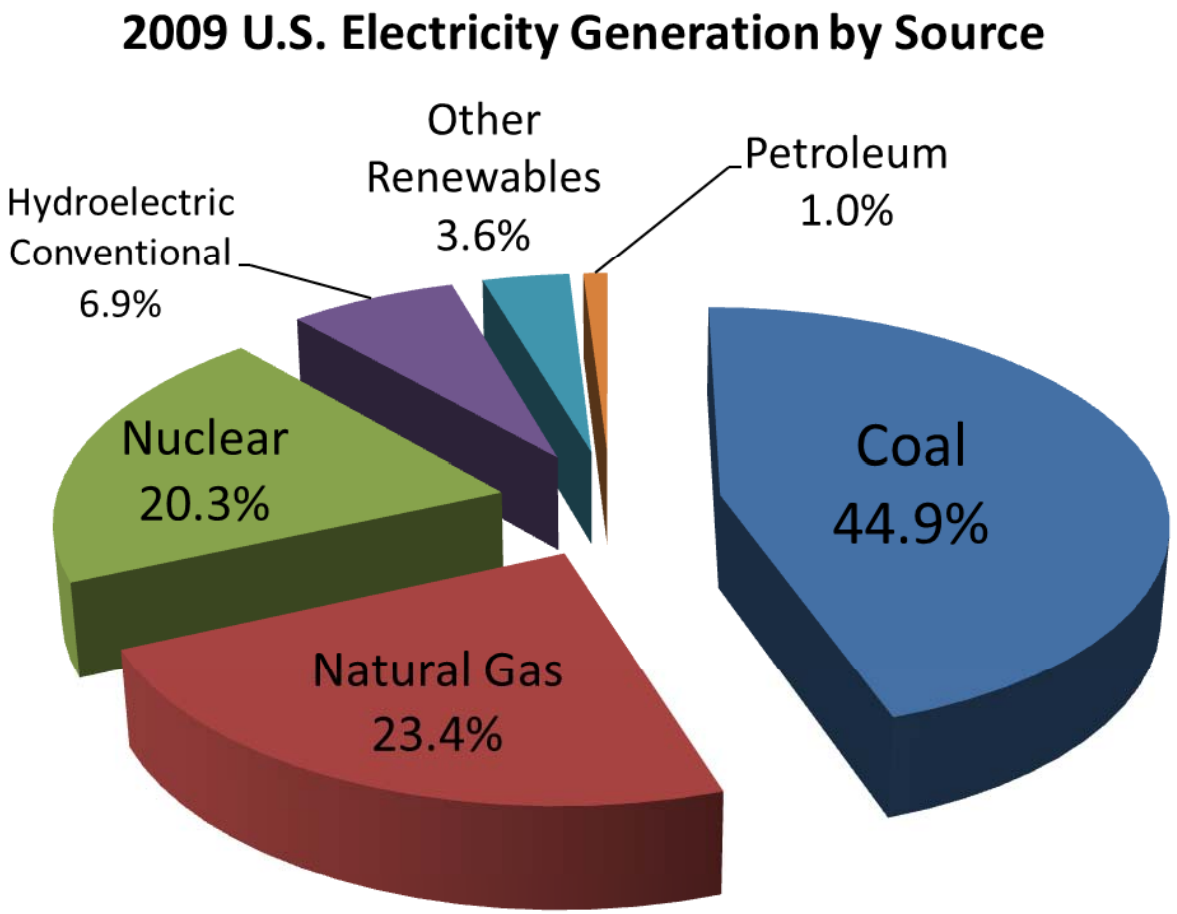
COAL CONSUMPTION



COAL USE



Coal Produces 45% of U.S. Electricity

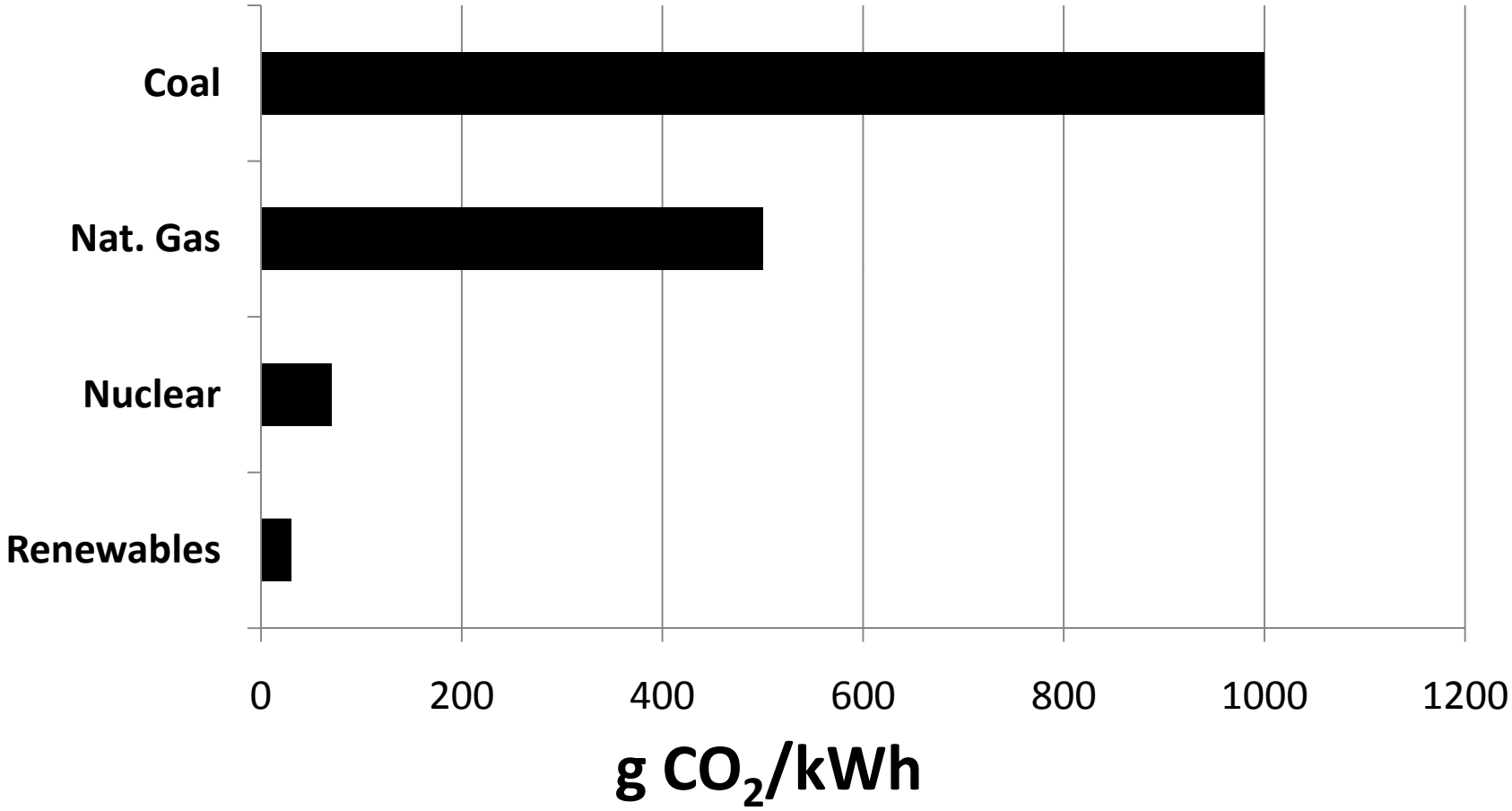


Coal Comes From Strip Mines in e.g., Wyoming

Coal is Extracted by Mountain Top Removal Throughout Appalachia

Coal is Hauled by Unit Trains
100-120 Cars/train: 10,000 to 15,000 tons coal/train
A large power plant uses 1-3 trains of coal per day

CO_2 From Electricity Production



COAL SUMMARY

- Huge Resource
- Very High Greenhouse Gas Pollution
- Very High pollution from toxic heavy metals, e.g., mercury
- Very High small particle pollution (Particulates cause the most important health effects from air pollution)
- Very High Land-Use Impacts Including Mountain Top Removal

EXPANDING NUCLEAR POWER

A NUCLEAR POWER REACTOR PRODUCES

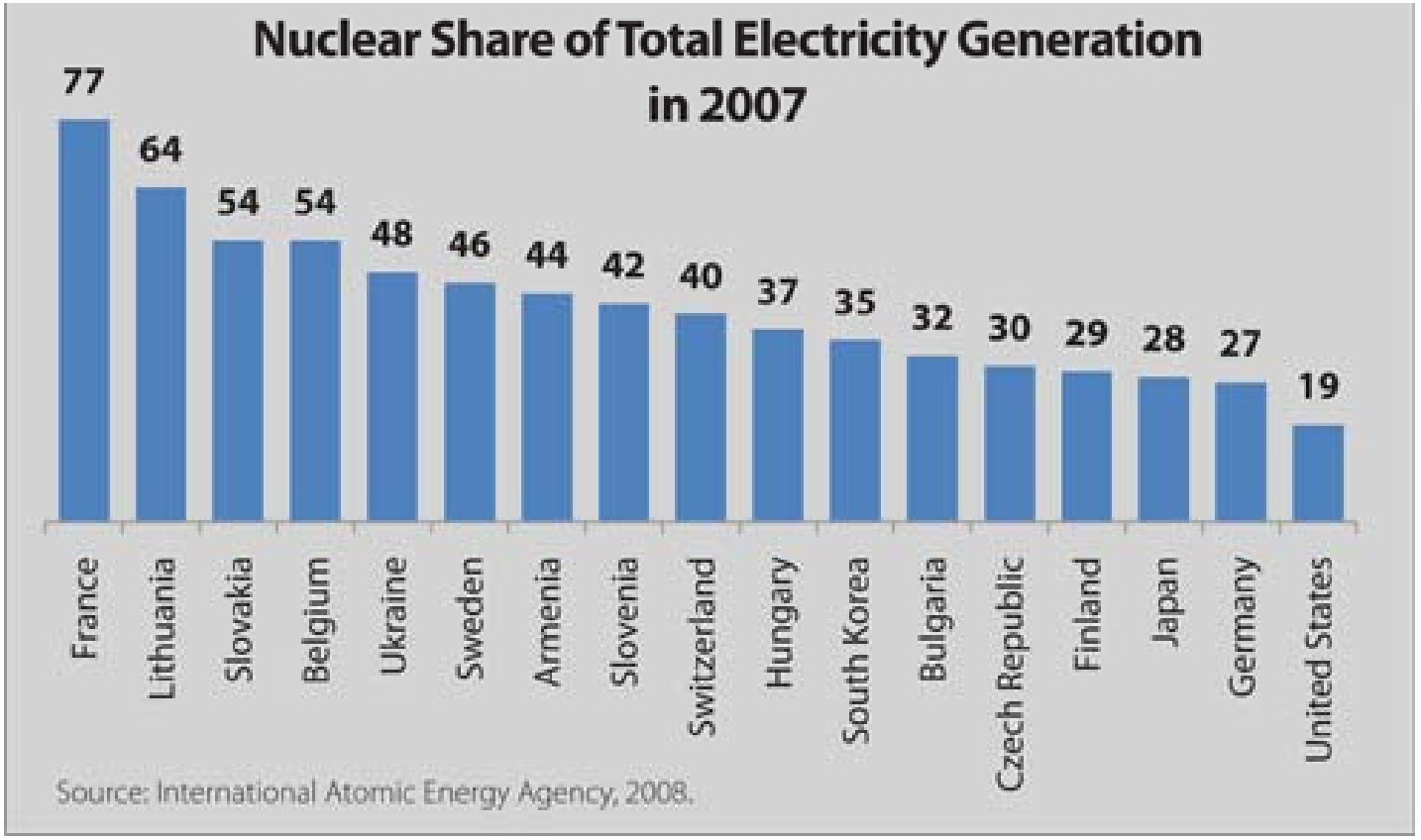
- Electricity

- Waste heat

- Radioactive waste

- Plutonium

NUCLEAR PRODUCES ABOUT 5½ % OF GLOBAL PRIMARY ENERGY AND ABOUT 14% OF ELECTRICITY



It had been recognized from the dawn of the atomic age that nuclear power brings with it three imperatives

I

The ***safeguards*** problem.

To safeguard potential nuclear explosives, both uranium-235 and the plutonium created as an inevitable by-product of the fission process.

II

T*he **safety** problem.*

To prevent accidents that could release radioactivity beyond the plant boundaries.

III

*The **waste** problem*.

To isolate the radioactive wastes from the biosphere for at least 200,000 years.

FORECASTS FOR NEW NUCLEAR POWER

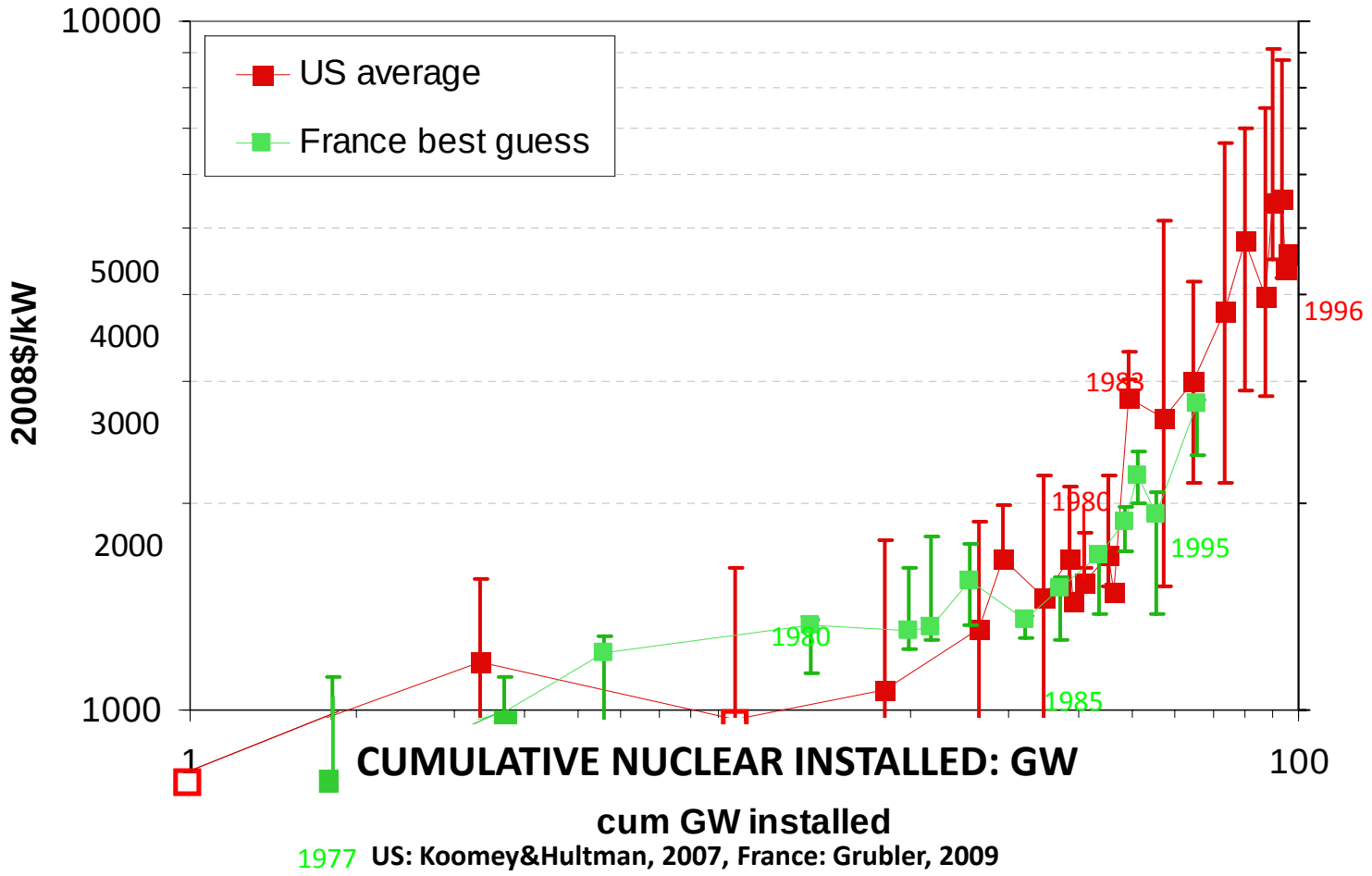
- There are about as many forecasts for future nuclear power as there are forecasters.

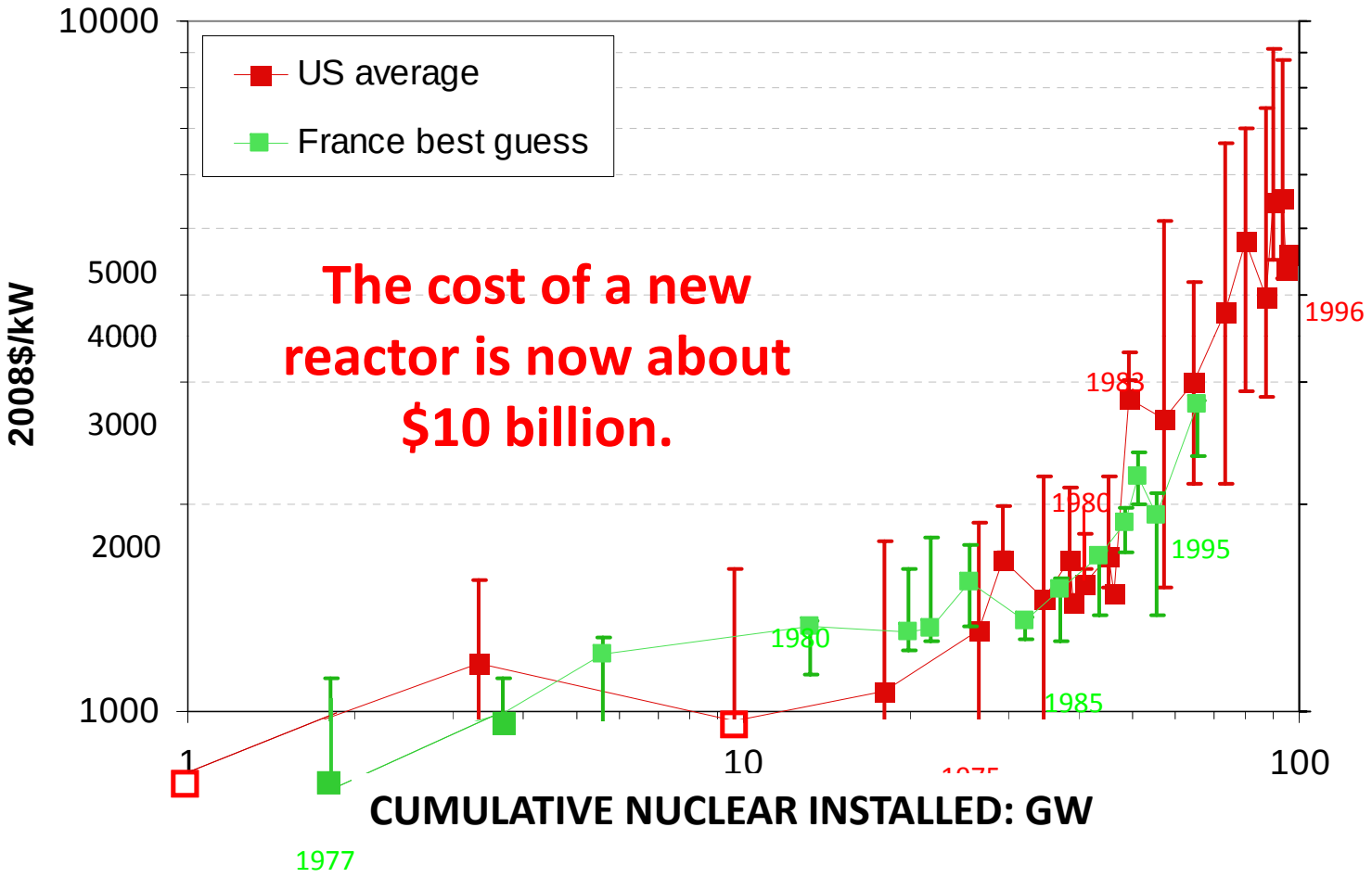
- Forecasts range from no nuclear power by mid-century to thousands of plants.

NUCLEAR POWER COSTS

- As with oil, it is very difficult to establish the total cost of nuclear power. This is so because the largest costs have been ***externalized***, that is, removed from the market place by government action.
- ***External costs*** are not paid by the firm involved with the activity, e.g., electricity utility or by the user of the electricity, but are paid by society at large.
- The ***internalized cost*** of new plants is increasing steadily. (Internalized costs are those that appear on the books of the firm conducting the activity.)

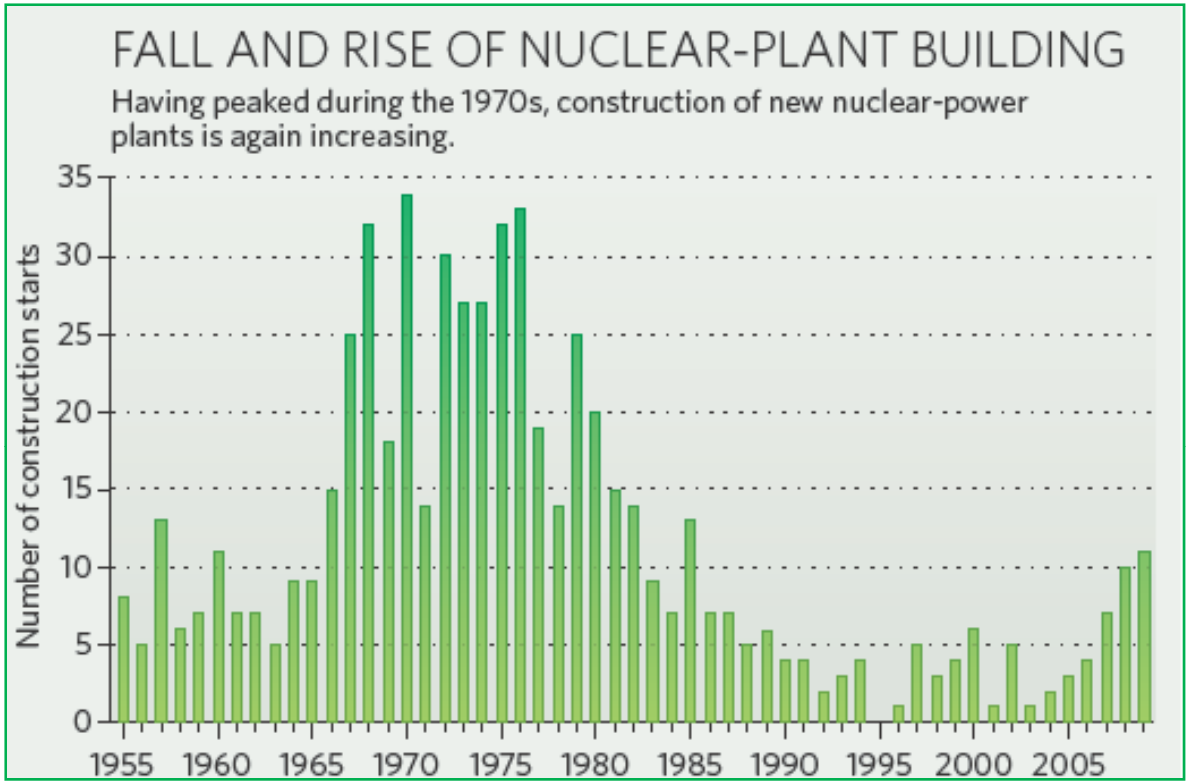
Nuclear Reactor Investment Costs Have Shown Negative "Economies of Scale"





US: Koomey&Hultman, 2007, France: Grubler, 2009

New Nuclear Power



Western Democracies

Only a few of the new reactors are in countries that choose nuclear capacity through free market processes. Some of these countries may be using civilian nuclear power as a cover for a nuclear weapons program.

http://www.nature.com/news/2010/100623/full/465990a.html

http://www.world-nuclear.org/info/inf17.html

New U.S. Nuclear Power

- Following recent U.S. legislation which authorized massive federal subsidies, there were 18 applications for 27 new nuclear power plants from U.S. utilities & merchant power companies.
- In no case has a builder made a firm decision to go forward.
- The number is dwindling month by month
- Most recently, in October 2010, Consolidated Energy cancelled the proposed $10 billion Calvert Cliffs #3 unit in Maryland. [This caused waves throughout the global nuclear industry as it may mean no new U.S. reactors in the foreseeable future] http://nuclear-news.net/2010/10/12/no-saving-prospects-for-nuclear-industry-on-the-cliff-edge/

NUKESPEAK

The history of nuclear development has been profoundly shaped by the manipulation of information... and the use of information-management techniques. For example:

- **Accidents** are now referred to as **incidents** or **operational problems**
- Reactor licensing applications used to include **Hazard Analyses.** These morphed into **Safety Analyses**
- **Explosions** have been called **Prompt Disassembly Events**
- So it goes. There are Nukespeak dictionaries

http://www.amazon.com/s/ref=nb_sb_noss?url=search-alias%3Dus-stripbooks-tree&field-keywords=nukespeak&x=0&y=0

NUCLEAR POWER
EXTERNAL COSTS

WASTE ISOLATION

The highly radioactive nuclear waste must be kept out of the biosphere for on order 200,000 years.

Nuclear power is the only energy technology where the waste is so dangerous that the government has to assume responsibility for disposal of the waste.

LIABILITY FOR MAJOR ACCIDENTS

Nuclear power is the only energy technology where the government has to assume the liability for catastrophic accidents.

The U.S. mechanism is the *Price-Anderson Nuclear Industries Indemnity Act*.

http://en.wikipedia.org/wiki/Price-Anderson_Nuclear_Industries_Indemnity_Act

REGULATORY AND SECURITY

Nuclear power is unique among energy supply options in that it requires large regulatory costs and large security costs at individual plants.

SAFEGUARDS

Nuclear Power is the only existing energy technology that requires an international safeguards regime to prevent countries from making nuclear weapons using "civilian" nuclear fuel cycle facilities and materials

Nuclear Terrorism Now Judged to be "Single Biggest Threat"

President Obama 11 April 2010: "The central focus of this nuclear summit is the fact that the single biggest threat to U.S. security—both short term, medium term and long term—would be the possibility of a terrorist organization obtaining a nuclear weapon."
http://www.president-obama.org/obama-officials-stress-nuclear-threat-u-s-strength

New York Times reported: The Obama administration's classified review of nuclear weapons policy will for the first time make thwarting nuclear-armed terrorists a central aim of American strategic nuclear planning

http://nuclear-news.net/2010/01/13/obama-recognising-nuclear-terrorism-as-the-greatest-risk

There is a very, very thin line between a civilian nuclear power system and a military weapons system.

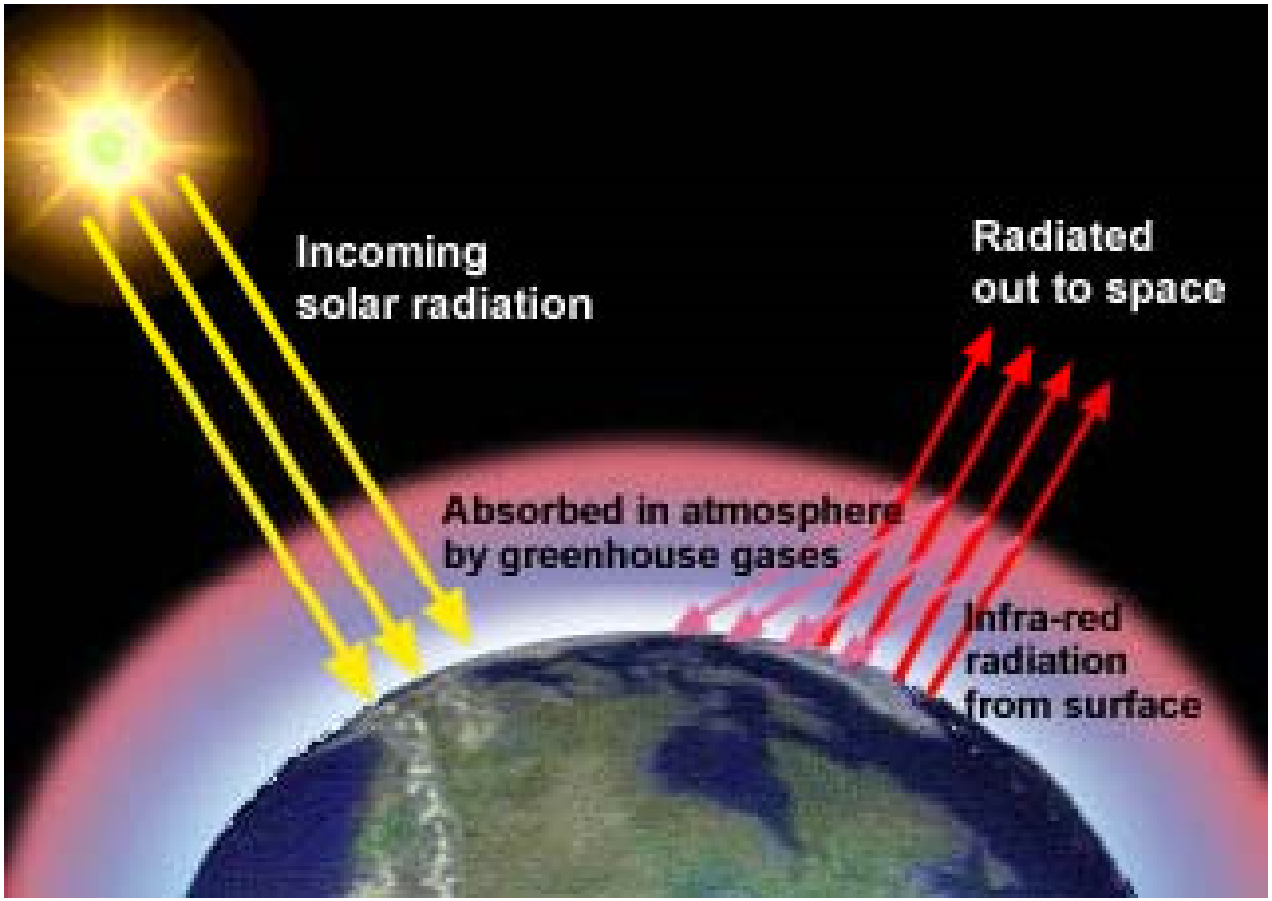
A Curious Thing

It has always seemed curious that so-called "small-government" conservatives are among the most vigorous advocates for nuclear power, although **nuclear power absolutely requires governmental control**.

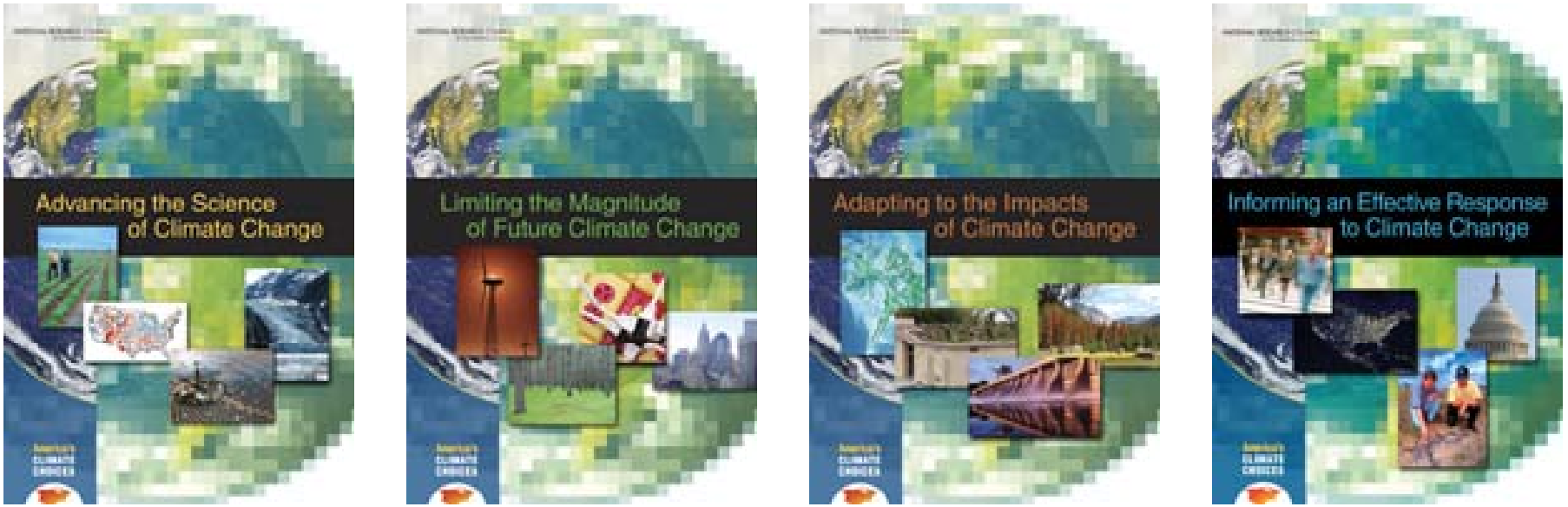
It began as, and continues to be, a technology of the State.

Climatic Change

GLOBAL GREENHOUSE WARMING



U.S. National Academy of Sciences Underscores Needed Climatic Change Actions May 2010



U.S. National Academy of Sciences
http://americasclimatechoices.org/

U.S. National Academy of Sciences Underscores Needed Climatic Change Actions May 2010

"Climate change is occurring, is caused largely by human activities, and poses significant risks for — and in many cases is already affecting — a broad range of human and natural systems."

"Substantially reducing greenhouse gas emissions will require prompt and sustained efforts to promote major technological and behavioral changes."

"The U.S. should act now to reduce greenhouse gas emissions and develop a national strategy to adapt to the inevitable impacts of climate change."

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http://americasclimatechoices.org/

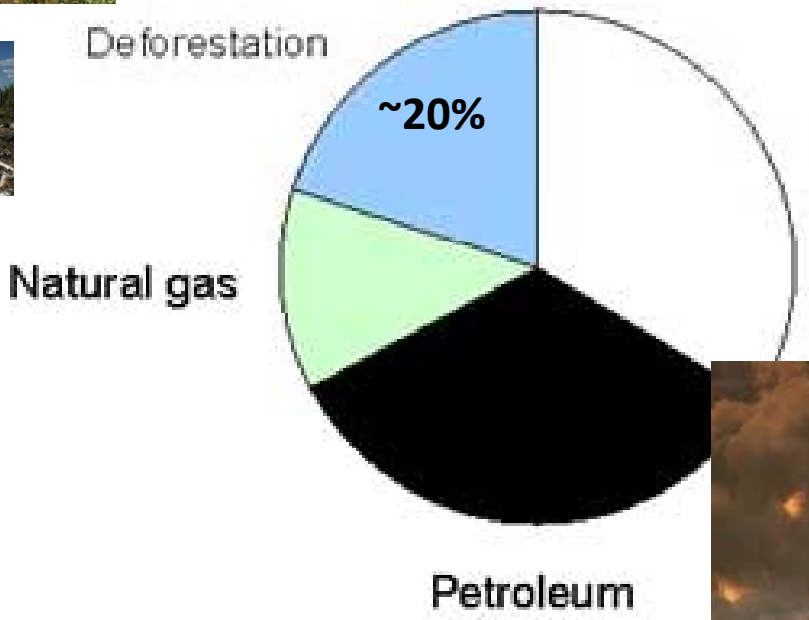
The Main Greenhouse Gases

CO_2 is the big one, three times as much global heating as methane & N_2O together

Greenhouse gases	Chemical formula	Human Activity Sources
Carbon-dioxide	CO_2	Fossil fuel combustion Land use conversion Cement production
Methane	CH_4	Fossil fuels Rice paddies Waste dumps Livestock
Nitrous oxide	N_2O	Fertilizer industrial processes combustion
CFC-12	CCl_2F_2	Liquid coolants. Foams
HCFC-22	$CHClF_2$	Liquid coolants
Perfluoromethane	CF_4	Production of aluminium
Sulphur hexa-fluoride	SF_6	Dielectric fluid

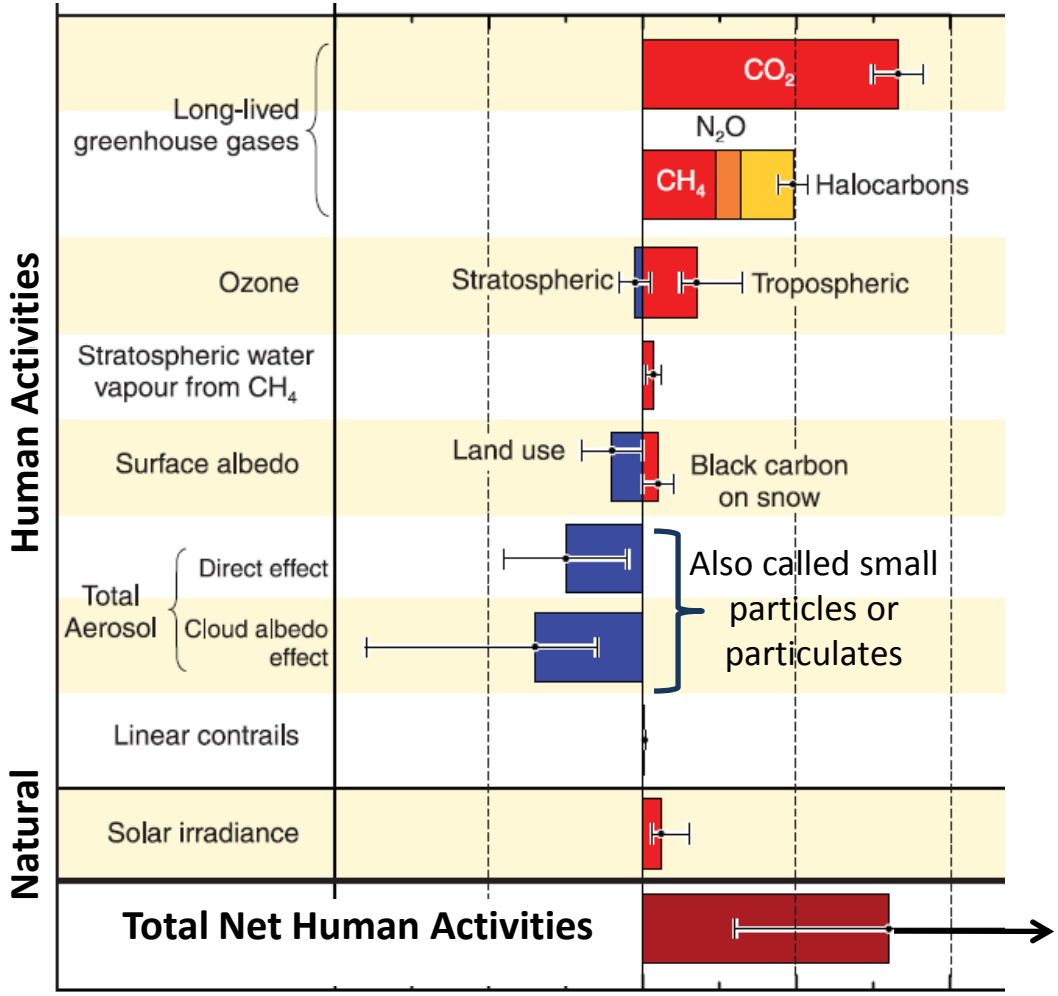
A group of industrial chemicals that together produce about the same global heating as does methane

Fossil Fuels Produce ~80% of Carbon Dioxide Pollution



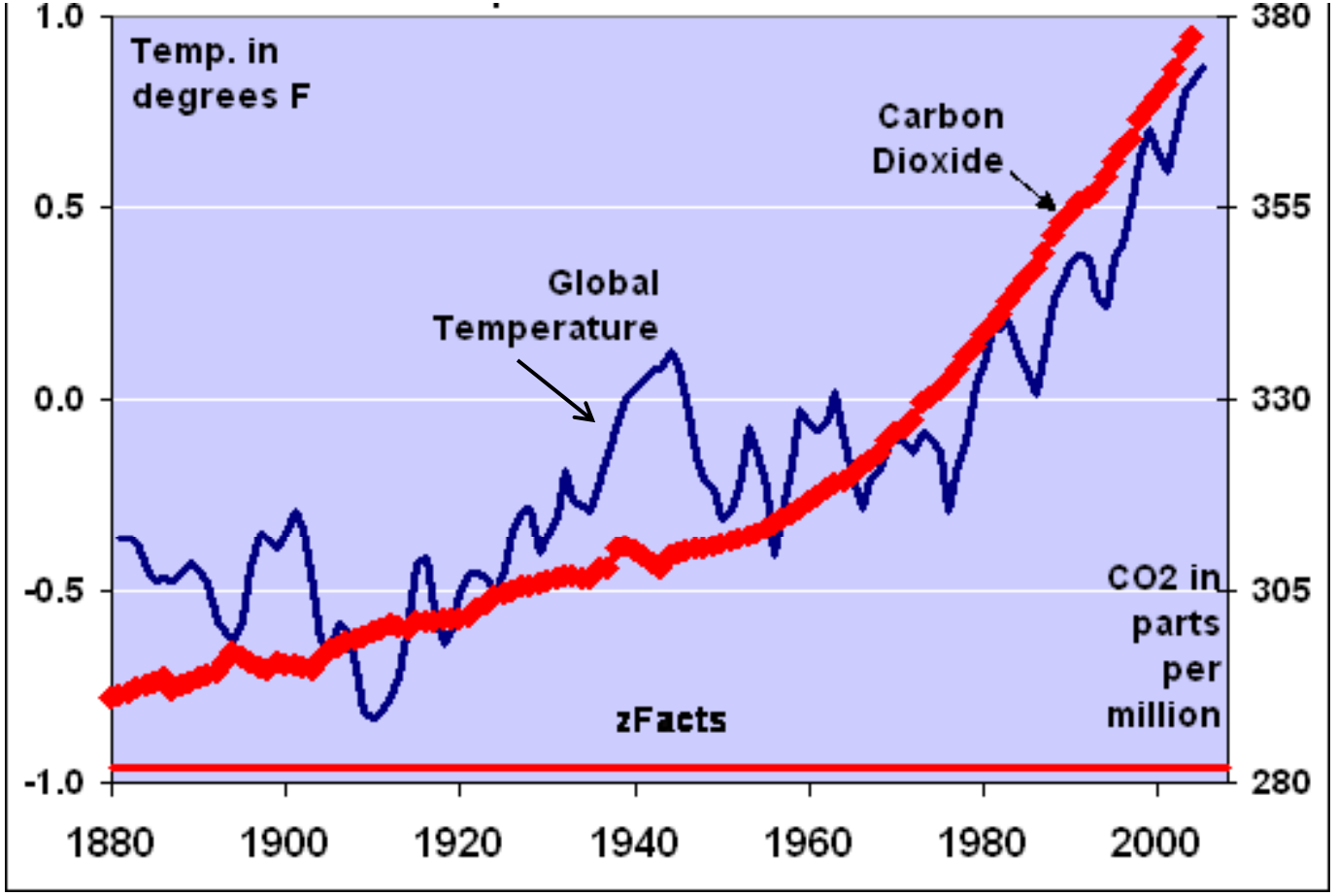
The 3rd largest anthropogenic source is cement production about 4% of CO_2 pollution

Carbon Dioxide (CO_2) Causes Over Half of Global Warming



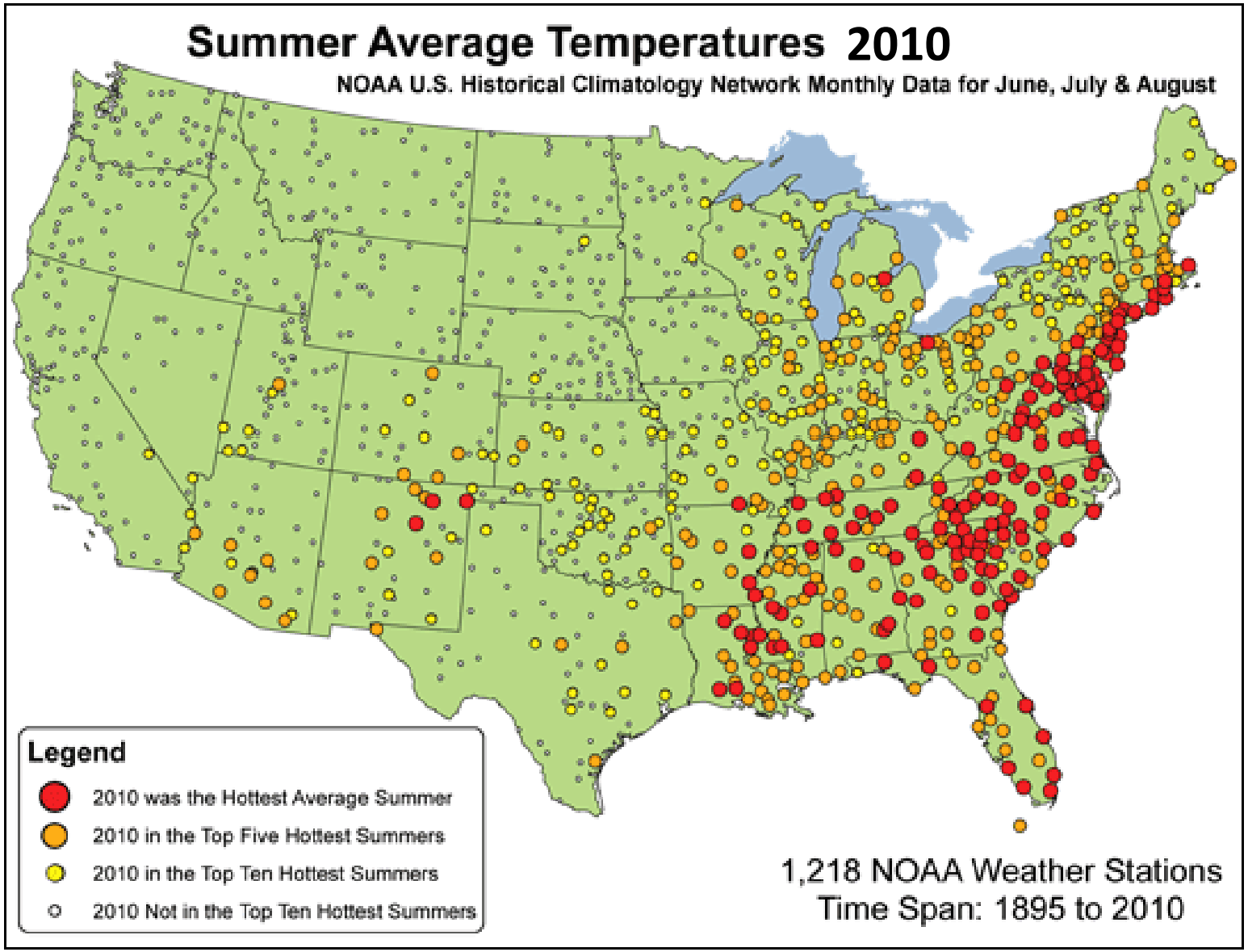
1.6+ Watts per meter^2 of earth surface

Global Temperature & Atmospheric Carbon Dioxide



Global annual average surface temperature increased by 0.74 ± 0.18 °C (1.33 ± 0.32 °F) during the 20th century

Of 1,218 weather stations in the contiguous United States, with data going back to 1895, 153 locations recorded their hottest summer on record in 2010 and nearly one in three stations recorded average temperatures among their five hottest on record.


Summer Average Temperatures 2010
NOAA U.S. Historical Climatology Network Monthly Data for June, July & August
Legend
2010 was the Hottest Average Summer
2010 in the Top Five Hottest Summers
2010 in the Top Ten Hottest Summers
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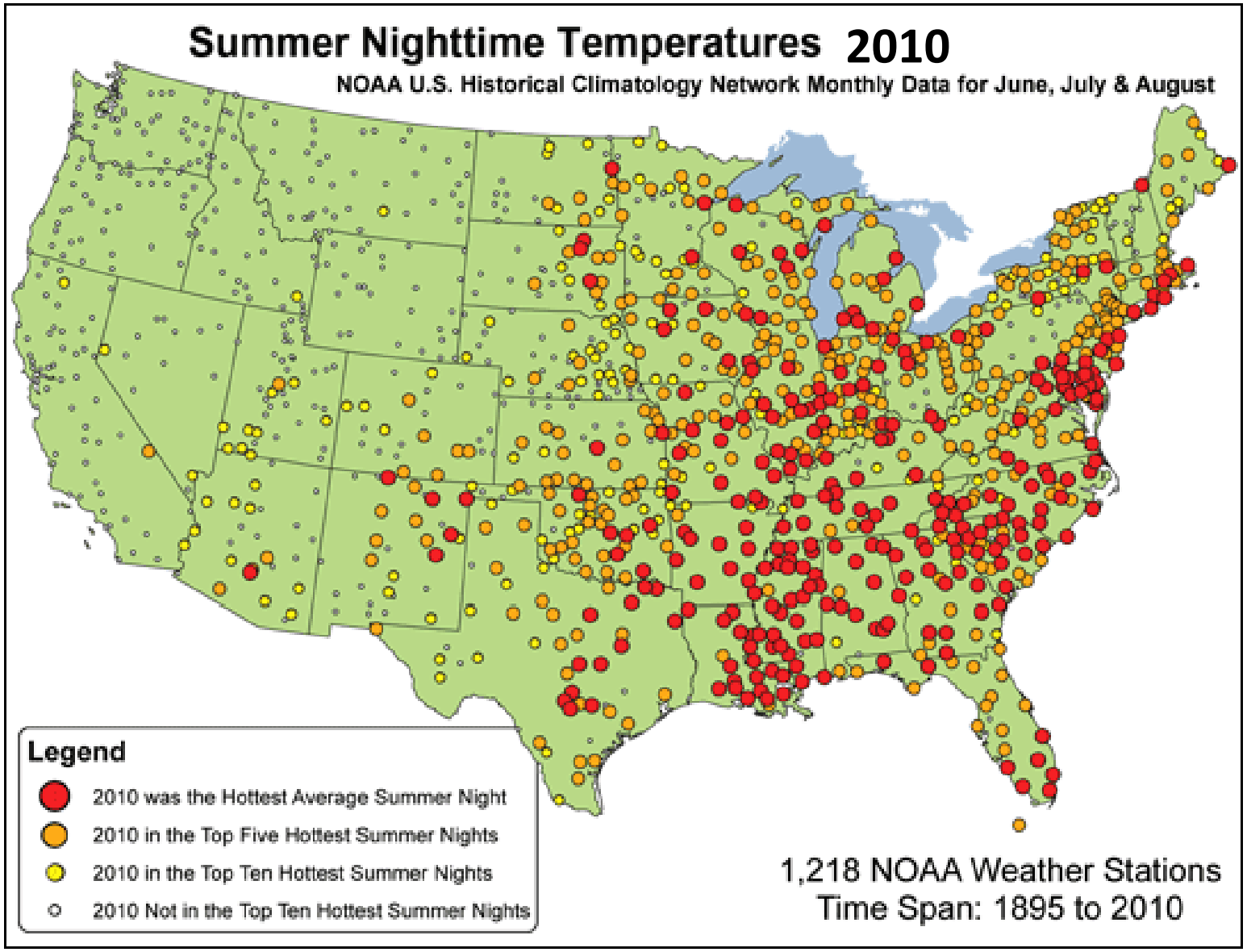
Time Span: 1895 to 2010


Summer Nighttime Temperatures 2010
NOAA U.S. Historical Climatology Network Monthly Data for June, July & August
Legend
2010 was the Hottest Average Summer Night
2010 in the Top Five Hottest Summer Nights
2010 in the Top Ten Hottest Summer Nights
2010 Not in the Top Ten Hottest Summer Nights
1,218 NOAA Weather Stations
Time Span: 1895 to 2010

See the Following for A Sample of What Global Warming of About 1.3 °F Looks Like

http://www.youtube.com/watch?v=pG41xDxrzI8

How Much Warming is Legally (By International Treaty) Considered to Be Dangerous?

The United Nations Framework Convention on Climate Change (UNFCCC), been ratified by 187 nations, commits signatories' governments to reduce atmospheric concentrations of greenhouse gases with the goal of

"preventing dangerous anthropogenic [human activity] interference with Earth's climate system."

At the 2009 Copenhagen meeting of the parties to the UNFCCC it was agreed that this will require keeping greenhouse warming **to less than 2°C (3.8°F).**

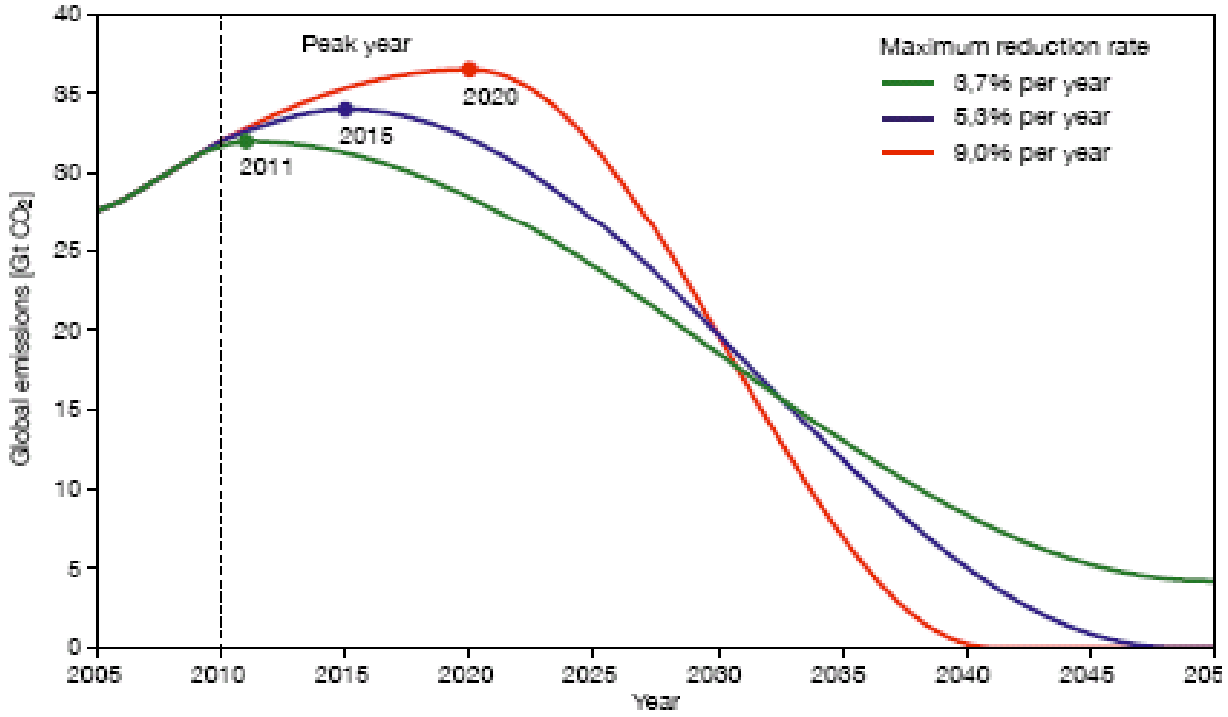
To Avoid Devastating Climatic Change

It is likely that keeping global warming to less than 2°C (3.8°F) requires reducing the concentration of atmospheric carbon dioxide to about **350 parts-per-million (ppm)**

This requires reducing carbon emissions from human activities by **60% to 80% by mid-century.** [The later we start, the more emissions must be reduced.]

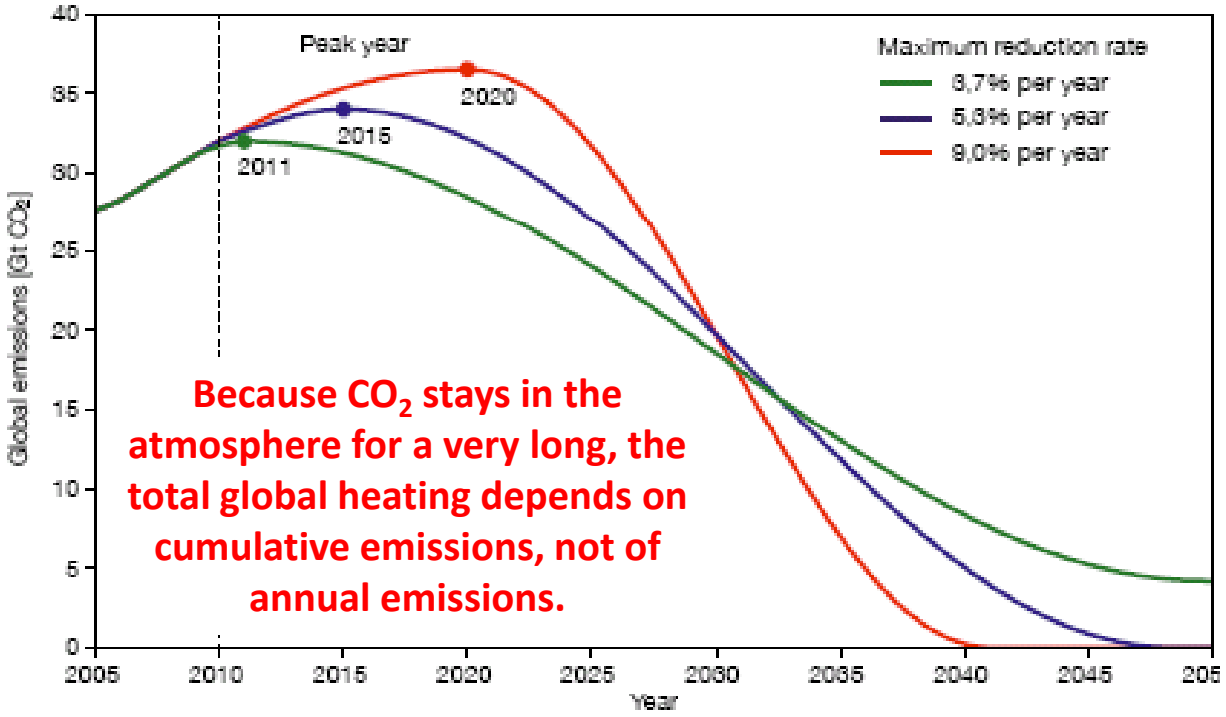
This means shifting to energy sources and systems that result in essentially zero carbon dioxide emissions.

Global Emission Pathways to An Average Annual Global Warming of 2°C



Source: (WBGU 2009)

Global Emission Pathways to An Average Annual Global Warming of 2°C



Because CO_2 stays in the atmosphere for a very long, the total global heating depends on cumulative emissions, not of annual emissions.

The Powerful U.S. Coal Lobby and Reactionary "Conservatives" Continue to Block Attempts to Limit Carbon Emissions in the U.S.

See the excellent report, "As the World Burns", in the 11 October 2010 issue of The New Yorker.

http://www.newyorker.com/reporting/2010/10/11/101011fa_fact_lizza

European countries and China have imposed carbon taxes or the equivalent

The Choices

OPTION / ISSUE	INCREASE EFFICIENCY	RENEWABLES	COAL & OTHER SOLID HYDROCARBONS	NUCLEAR
Resource Base	Limited only by imagination & thermodynamics	Huge	Very large	Very large
Public & Occupational Safety	None	Minor issues except large dam failure	Major air pollution and coal miner health and safety	Major issues
Waste	None	Minor issues	Huge issues	Huge issues
Climate	None	Essentially zero	Huge issues	Small but not zero
Weapons Proliferation	None	None	None	Huge issues
Availability	Always	Solar & wind are intermittant	High capacity factor	High capacity factor in old plants but prone to unscheduled outages
Employment	Many professional & relatively unskilled	Many professional & relatively unskilled	Many coal mining jobs in a few states	Only highly-trained professional jobs
Regulation needed	None	Local land-use	National & international absolutely necessary [Climate]	National & International absolutely necessary [Weapons proliferation, safety, waste]
Capital Cost	Very low	High	High	Very High
Operating Cost	Zero	Low	High	Lower than coal Higher than natural gas
External Costs	Virtually none	Very low	Huge	Huge
System Requirements	Fits any system	Distributed & centralized systems	Highly centralized	Absolutely requires large, highly centralized systems
Political Implications	None	Largely local	Political Power highly concentrated	Political power very highly concentrated

John Holdren Summarized

Holdren is Now President Obama's Science Advisor

Of all environmental problems, the most threatening and in many respects the most intractable is global climate change.

The only other external energy cost that might match the devastating impact of global climate change is the risk of causing or aggravating large-scale military conflict. One such threat is the potential for conflict over access to petroleum resources.

Another threat is the link between nuclear energy and the spread of nuclear weapons. The issue is hardly less complex and controversial than the link between carbon dioxide and climate; many analysts, including me, think it is threatening indeed.

The decision to pay the monetary costs of solar energy, if it is made, will represent the ultimate internalization of the environmental costs of the options that solar energy would displace.

John P. Holdren, "Energy in Transition," Scientific American (September 1990)

Components of U.S. Energy Policy

- Mandate conversion of corn to ethanol
- Increase imports of Alberta Tar Sands oil
- Make war to protect access to Middle East oil
- Token support for conservation and efficiency
- Insipid federal support for R&D on sustainable energy
- Much talk, but little meaningful action on climatic change
- Failure to set a price on greenhouse gas pollution
- Huge subsidies for nuclear power being offered, but even with these, the price and risks have been too high for utilities to swallow.

The Overreaching Goal of U.S. Energy Policy

Keep energy prices as low as possible,
mollify every conventional energy lobby
and damn-the-consequences!

Energy Is the Ultimate Resource

and

The Ultimate Pollutant

We Must **All** Do Much More Than Business-As-Usual With It's Very Slow Incremental Change

APPROPRIATE POLICIES ARE SUGGESTED IN

James Gustave Speth (2008) *The Bridge at the Edge of the World: Capitalism, the Environment, and Crossing from Crisis to Sustainability*, Yale University Press

David B. Goldstein (2009) *Invisible Energy: Strategies to Rescue the Economy and Save the Planet*, Bay Tree Press