Global Warming

TIME (2006)

VICIOUS CYCLES

The debate over whether Earth is warming up is over. Now we're learning that climate disruptions feed off one another in accelerating spirals of destruction. Scientists fear we may be approaching the point of no return

TIME graphic by Joe Lertola; reported by Missy Adams

THE GREENHOUSE EFFECT

Without the **greenhouse effect**, life on Earth would not be possible. Energy from the sun is absorbed by the planet and radiated back out as heat. Atmospheric gases like **carbon dioxide** trap that heat and keep it from leaking into space. That's what keeps us warm at night.

But as humans pour ever increasing amounts of greenhouse gases into the atmosphere, more of the sun's **heat gets trapped**, and the planet gets a fever

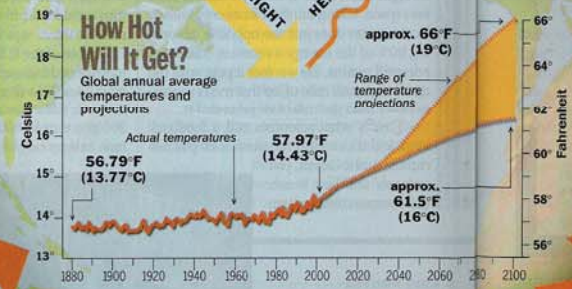
SUNLIGHT

HEAT

Greenhouse gases

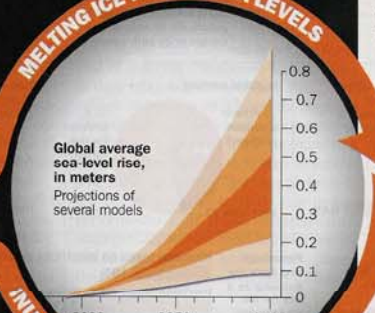
How Hot Will It Get?

Global annual average temperatures and projections



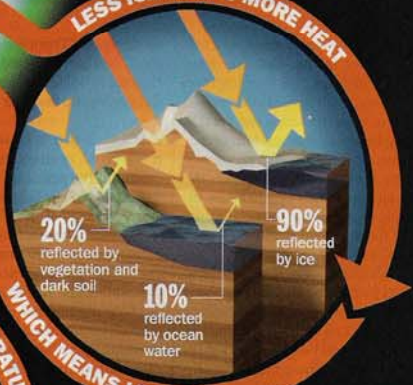
WASHING ASHORE The ice at the North Pole is floating, so as it melts, the sea level won't change much. But the massive ice sheets over Antarctica and Greenland are another story. If both melted completely, sea levels could rise nearly 220 ft. (72 m). That's a worst-case scenario. But the melting is accelerating, and sea levels are projected to rise gradually, threatening low-lying communities

MELTING ICE RAISES SEA LEVELS



INUNDATING LOW COASTAL AREAS

LESS ICE MEANS MORE HEAT

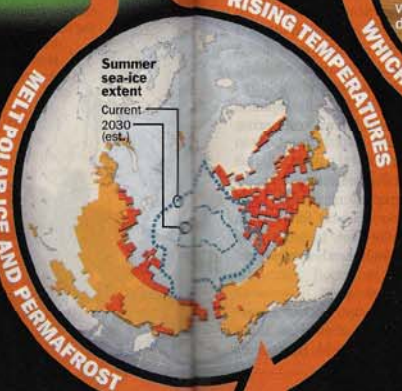


WHICH MEANS LESS ICE

SPEEDING UP Ice reflects nearly all the sun's energy that hits it. As the planet's ice melts, more of that energy is absorbed by Earth—which further raises the temperature. That, in turn, makes the remaining ice melt quicker

RISING TEMPERATURES

MELT POLAR ICE AND PERMAFROST



THAWING OUT The North Pole may be seasonally ice free by 2050. Melting permafrost will release vast amounts of trapped carbon into the air

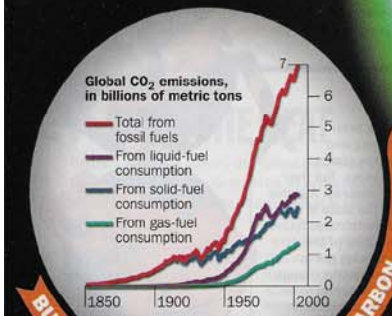
Near-surface permafrost
1980-99
2080-99 (est.)

REDUCES OXYGEN AND INCREASES DROUGHT

BURNING FORESTS

SPREADING THE PAIN Deforestation, through clear-cutting or burning, sows havoc far beyond the affected area. The fires release still more carbon into the atmosphere, fewer plants survive to convert CO_2 into oxygen, and scorched soil absorbs more heat and retains less water, increasing droughts

BURNING FOSSIL FUELS RELEASES CARBON



FUELING THE FIRE The amount of carbon dioxide in the atmosphere is climbing fast. Most of it comes from burning fuels for energy—gasoline in cars or coal for electricity, for example. The U.S., with less than 5% of the world's population, produces one-quarter of all greenhouse gases

Sources: Intergovernmental Panel on Climate Change, Third Assessment Report; NOAA; NASA; National Snow and Ice Data Center; Carbon Dioxide Information Analysis Center; National Center for Atmospheric Research; U.S. Global Change Research Program; Goddard Institute for Space Studies

cold water, so it floats on the surface. As it reaches Europe and releases its heat, the current grows denser and sinks, flowing back to the south and crossing under the northbound Gulf Stream until it reaches the tropics and starts to warm again. The cycle works splendidly, provided the water remains salty enough. But if it becomes diluted by freshwater, the salt concentration drops, and the water gets lighter, idling on top and stalling the current. Last December, researchers associated with Britain's National Oceanography Center reported that one component of the system that drives the Gulf Stream has slowed about 30% since 1957. It's the increased release of Arctic and Greenland meltwater that appears to be causing the problem, introducing a gush of freshwater that's overwhelming the natural cycle. In a global-warming world, it's unlikely that any amount of cooling that resulted from this would be sufficient to support glaciers, but it could make things awfully uncomfortable.

"The big worry is that the whole climate of Europe will change," says Adrian Luckman, senior lecturer in geography at the University of Wales, Swansea. "We in the U.K. are on the same latitude as Alaska. The reason we can live here is the Gulf Stream."

DROUGHT

AS FAST AS GLOBAL WARMING IS TRANSFORMING the oceans and the ice caps, it's having an even more immediate effect on land. People, animals and plants living in dry, mountainous regions like the western U.S. make it through summer thanks to snowpack that collects on peaks all winter and slowly melts off in warm months. Lately the early arrival of spring and the unusually blistering summers have caused the snowpack to melt too early, so that by the time it's needed, it's largely gone. Climatologist Philip Mote of the University of Washington has compared decades of snowpack levels in Washington, Oregon and California and found that they are a fraction of what they were in the 1940s, and some snowpacks have vanished entirely.

Global warming is tipping other regions of the world into drought in different ways. Higher temperatures bake moisture out of soil faster, causing dry regions that live at the margins to cross the line into full-blown crisis. Meanwhile, El Niño events—the warm pooling of Pacific waters that periodically drives worldwide climate patterns and has been occurring more frequently in global-warming years—further inhibit precipitation


GLOBAL WARMING
More and more land is being devastated by drought...
MOONSCAPE Cattle struggle across parched land in Ethiopia. The amount of the earth's surface afflicted by drought has more than doubled since the 1970s
BOBBY HAAS—NATIONAL GEOGRAPHIC IMAGE COLLECTION


GLOBAL WARMING
Polar ice caps are melting faster than ever...
AT SEA In the Canadian high Arctic, a polar bear negotiates what was once solid ice. Bears are drowning as warmer waters widen the distance from floe to floe
ARCTICNET—NCE

Our Energy Challenge

Columbia University
NYC
September 23, 2003

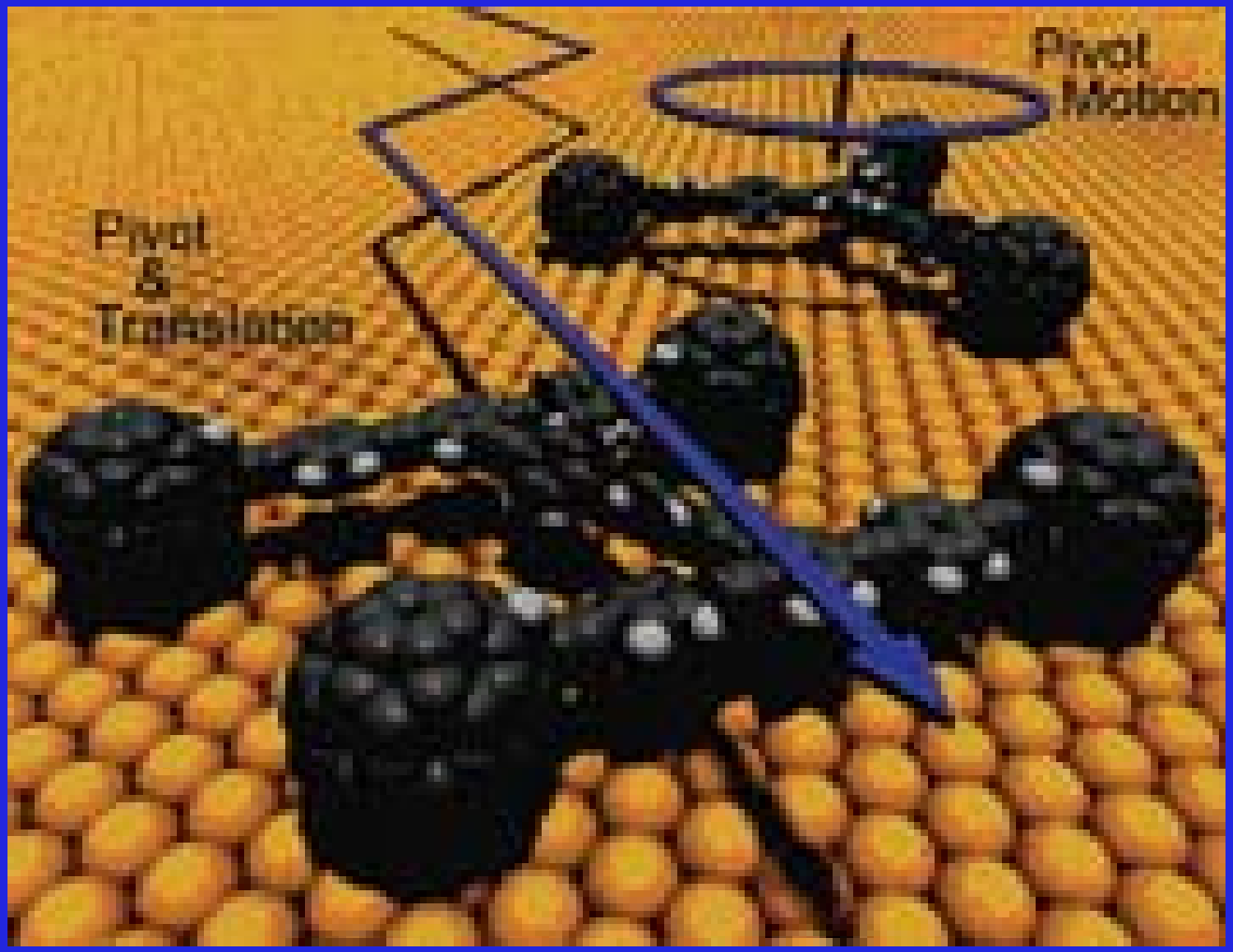
R. E. Smalley
Rice University

Richard Smalley: 1943-2005

Eminent nanotechnologist Richard Smalley has died in Houston on October 28, 2005 (at the age of 62), following a long battle with cancer.

Smalley received the 1996 Nobel Prize in Chemistry for the discovery of buckminsterfullerene molecules, or buckyballs, together with Robert Curl and Harold Kroto.

A Nanoscale Vehicle (Nanocar)



The biggest single challenge for the next few decades:

ENERGY

for 10^{10} people

- At MINIMUM we need 10 Terawatts (150 M BOE/day) from some new clean energy source by 2050
- For worldwide energy prosperity and peace we need it to be cheap.
- We simply can not do this with current technology.
- We need Boys and Girls to enter Physical Science and Engineering as they did after Sputnik.
- Inspire in them a sense of MISSION (BE A SCIENTIST SAVE THE WORLD)
- We need a bold new APOLLO PROGRAM to find the NEW ENERGY TECHNOLOGY

New Energy Research Program
(The Nickel & Dime Solution)

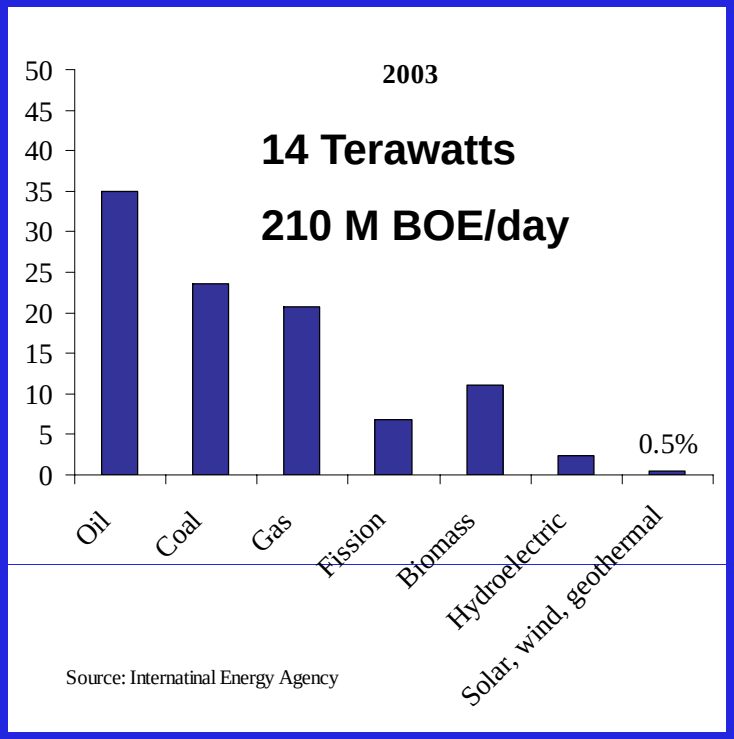
- **For FY04-FY09 collect 5 cents from every gallon of oil product**
  Invest the resultant > $10 Billion per year as additional funding in frontier energy research distributed among DOE, NSF, NIST, NASA, and DoD.
- **For the next 10 years collect 10 cents from every gallon;**
  invest the >$20 Billion per year in frontier energy research.
- **Devote a third of this money to New Energy Research Centers located adjacent to major US Research Universities.**
- **At worst this endeavor will create a cornucopia of new technologies and new industries.**
- **At best, we will solve the energy problem before 2020,**
  and thereby lay the basis for energy prosperity & peace worldwide.

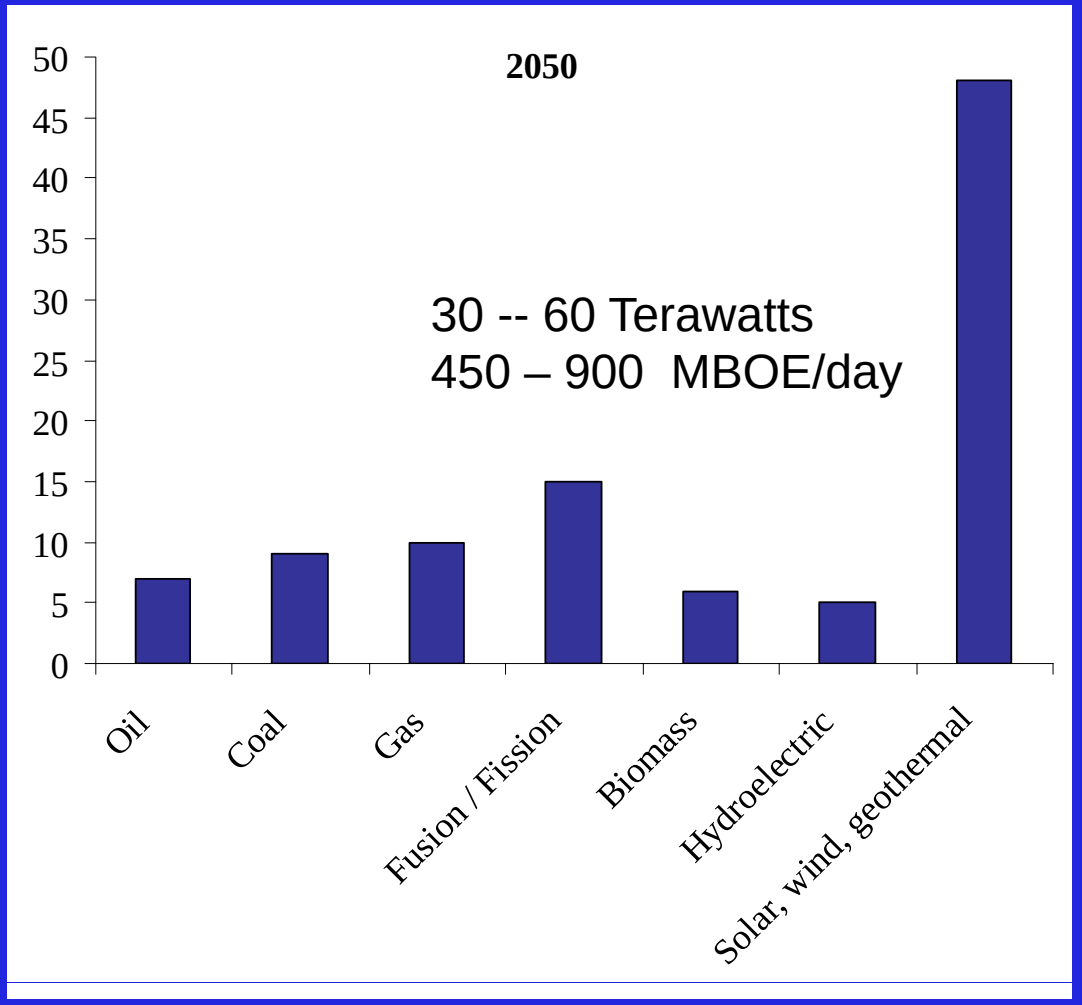
Humanity's Top Ten Problems for the next 50 years

1. **ENERGY**
2. WATER
3. FOOD
4. ENVIRONMENT
5. POVERTY
6. TERRORISM & WAR
7. DISEASE
8. EDUCATION
9. DEMOCRACY
10. POPULATION

2003	**6.5**	**Billion People**
2050	**8-10**	**Billion People**

The ENERGY REVOLUTION (The Terawatt Challenge)





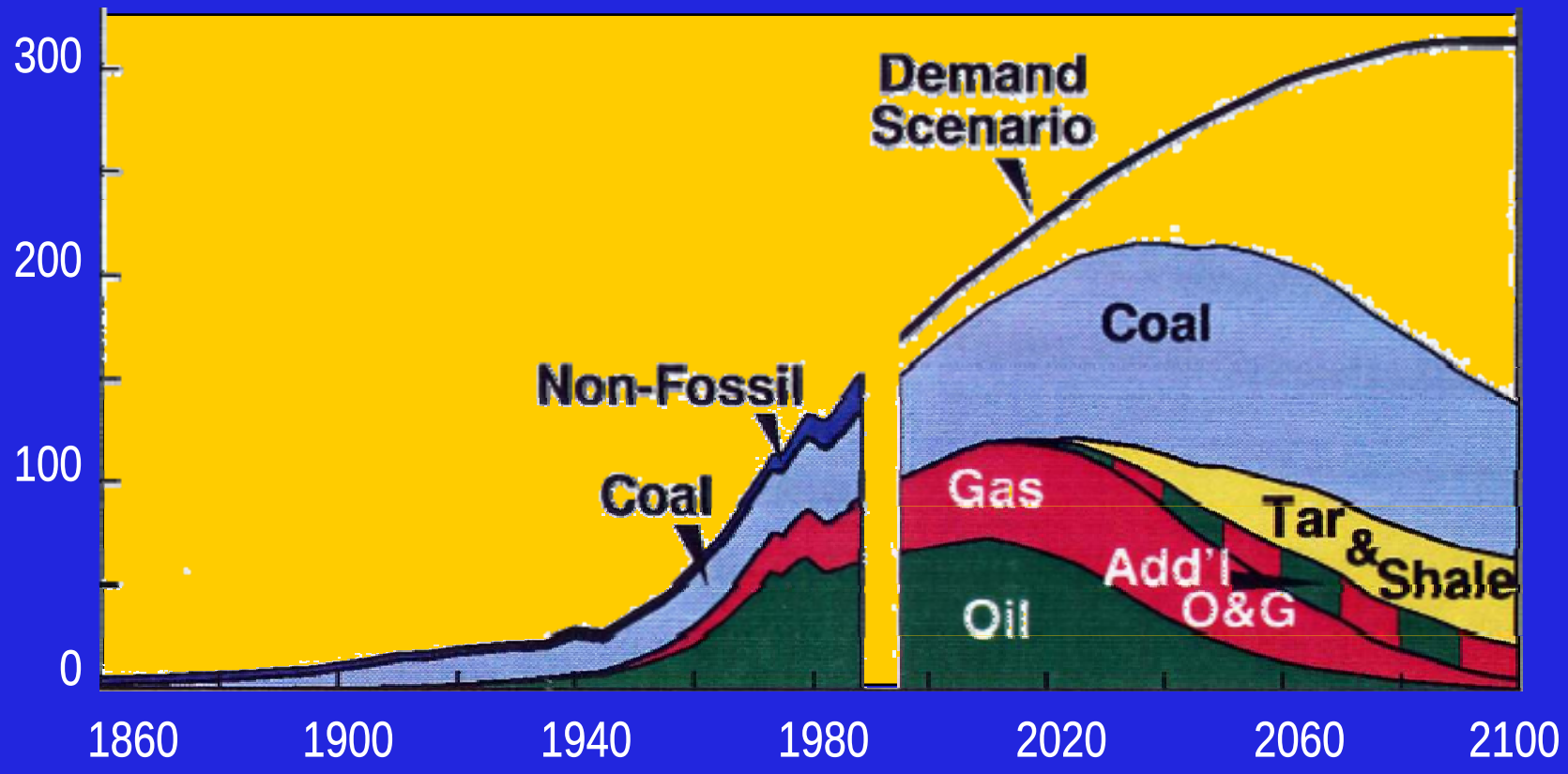
The Basis of Prosperity

20st Century = OIL

21st Century = ??

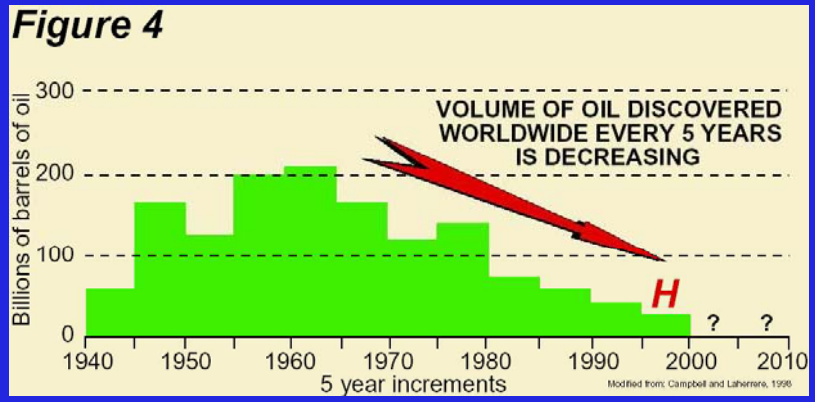
World Energy

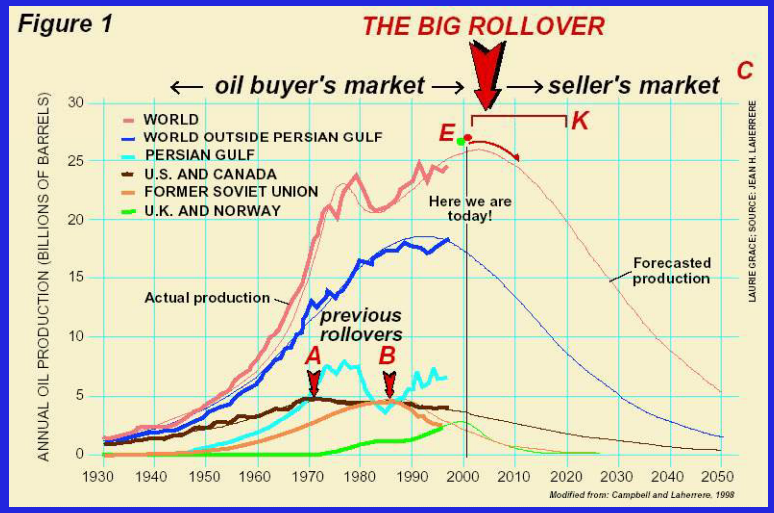
Millions of Barrels per Day (Oil Equivalent)



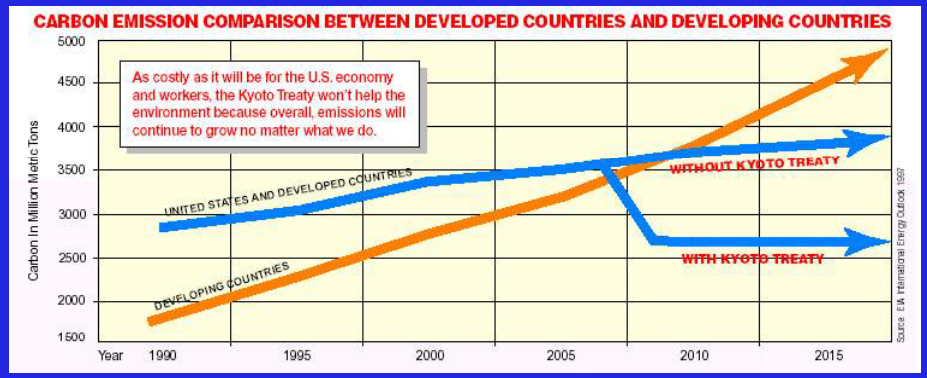
Source: John F. Bookout (President of Shell USA) ,"Two Centuries of Fossil Fuel Energy" International Geological Congress, Washington DC; July 10,1985. Episodes, vol 12, 257-262 (1989).

화석연료 에너지의 미래





CO_2 emission & Green house effect



"Are we running out of oil?" by L. B. Magoon (2000)

From "Basic Research Need for a Hydrogen Economy",
Report of DOE BES Workshop on Hydrogen Production, Storage, and Use
May 13-15, 2003 (available on the DOE BES web site)

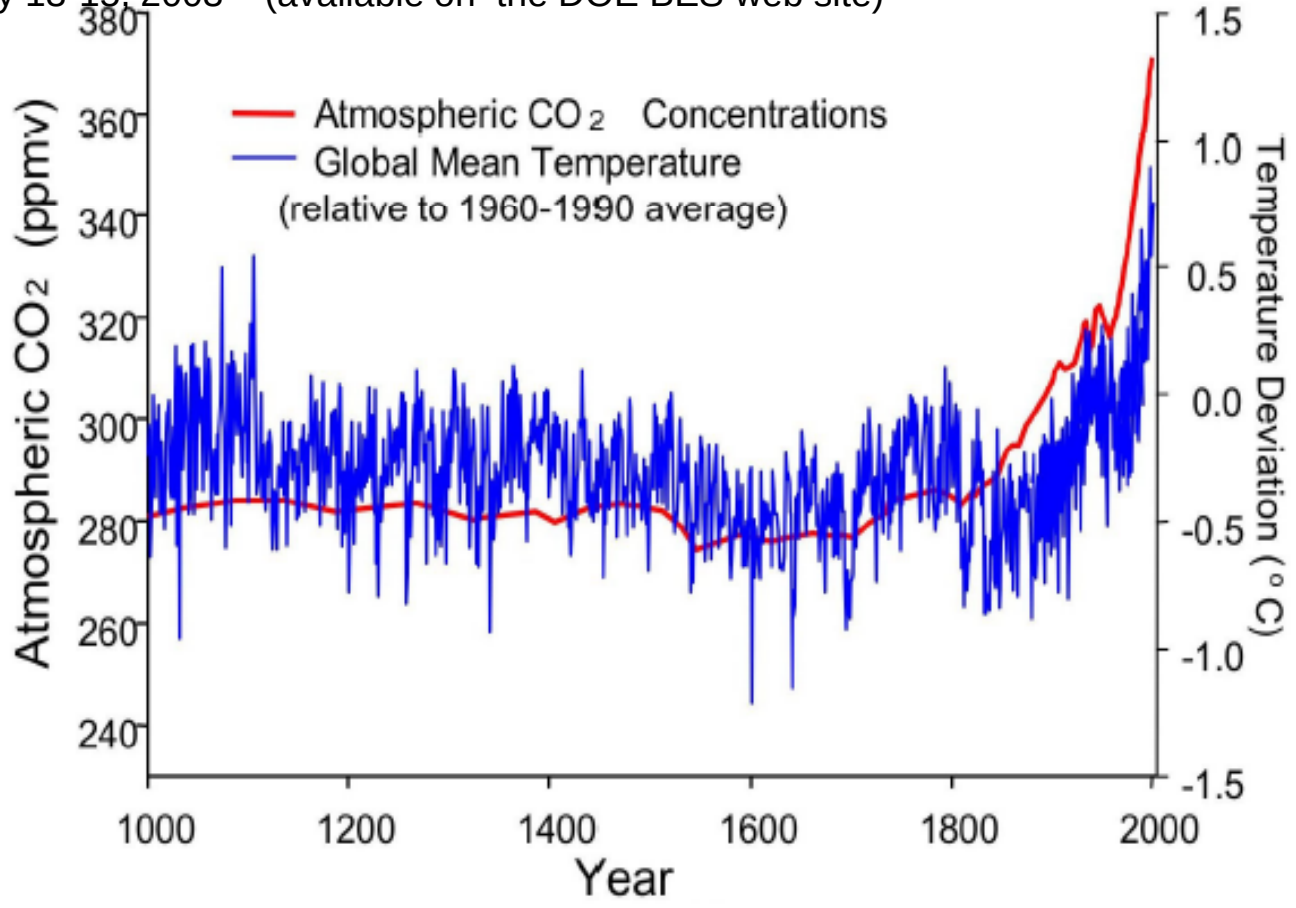


Figure 1b Increased CO_2 Emissions Causing a Rise in Atmospheric CO_2 Associated with a Rise in Global Temperature (Sources: CO_2 data from Ethridge et al. 2001, Keeling and Whorf 2002; temperature data from Jones et al. 1998, Peterson and Vose 1997)

PRIMARY ENERGY SOURCES
Alternatives to Oil

TOO LITTLE

- **Conservation / Efficiency -- not enough**
- **Hydroelectric -- not enough**
- **Biomass -- not enough**
- **Wind -- not enough**
- **Wave & Tide -- not enough**

CHEMICAL

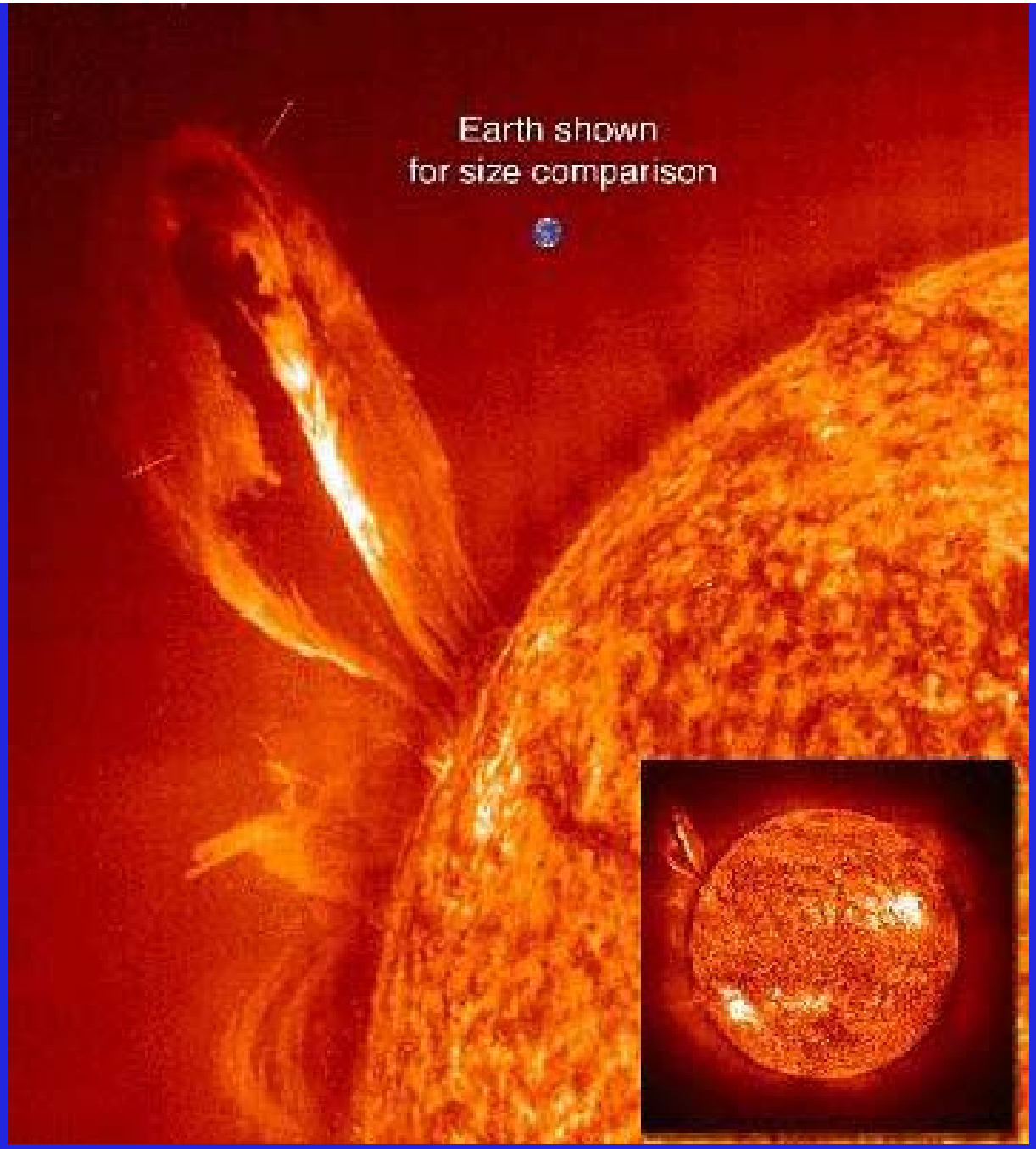
- **Natural Gas -- sequestration? cost?**
- **Clean Coal -- sequestration? cost?**

NUCLEAR

- **Nuclear Fission -- radioactive waste? terrorism? cost?**
- **Nuclear Fusion -- too difficult? cost?**
- **Geothermal HDR -- cost ? enough?**
- **Solar terrestrial -- cost ?**
- **Solar power satellites -- cost ?**
- **Lunar Solar Power -- cost ?**

165,000 TW of sunlight hit the earth every day

For 10^{10} people, minimum 10 Terawatts.



Solar Cell Land Area Requirements

6 Boxes at 3.3 TW Each = 20 TWe

One World Energy Scheme for 30-60 TW in 2050: The Distributed Store-Gen Grid

- Energy transported as electrical energy over wire, rather than by transport of mass (coal, oil, gas)
- Vast electrical power grid on continental scale interconnecting ~ 100 million asynchronous "local" storage and generation sites, entire system continually innovated by free enterprise
- "Local" = house, block, community, business, town, …
- Local storage = batteries, flywheels, hydrogen, etc.
- Local generation = reverse of local storage + local solar and geo
- Local "buy low, sell high" to electrical power grid
- Local optimization of days of storage capacity, quality of local power
- Electrical grid does not need to be very reliable
- Mass Primary Power input to grid via HV DC transmission lines from existing plants plus remote (up to 2000 mile) sources on TW scale, including vast solar farms in deserts, wind, NIMBY nuclear, clean coal, stranded gas, wave, hydro, space-based solar…"EVERYBODY PLAYS"
- Hydrogen is transportation fuel

Enabling Nanotech Revolutions

1. Photovoltaics -- drop cost by 100 fold.
2. Photocatalytic reduction of CO_2 to methanol.
3. Direct photoconversion of light + water to produce H_2.

4. Fuel cells -- drop the cost by 10-100x + low temp start + reversible

5. H_2 storage -- light weight materials for pressure tanks and LH2 vessels, and/or a new light weight, easily reversible hydrogen chemisorption system (material X).
6. Batteries, supercapacitors, flywheels -- improve by 10-100x for automotive and distributed generation applications.

7. Power cables (superconductors, or quantum conductors) with which to rewire the electrical transmission grid, and enable continental, and even worldwide electrical energy transport; and also to replace aluminum and copper wires essentially everywhere -- particularly in the windings of electric motors and generators (especially good if we can eliminate eddy current losses).

Enabling Nanotech Revolutions

8. Nanoelectronics to revolutionize computers, sensors and devices.

9. Nanoelectronics-based Robotics with AI to enable construction maintenance of solar structures in space and on the moon; and to enable nuclear reactor maintenance and fuel reprocessing.

10. Super-strong, light weight materials to drop cost to LEO, GEO, and later the moon by > 100 x, to enable huge but low cost light harvesting structures in space; and to improve efficiency of cars, planes, flywheel energy storage systems, etc.

11. Thermochemical catalysts to generate H_2 from water that work efficiently at temperatures lower than 900 C.

12. Nanotech lighting to replace incandescent and fluorescent lights

13. Nanomaterials/ coatings that will enable vastly lower the cost of deep drilling, to enable HDR (hot dry rock) geothermal heat mining.

14. CO_2 mineralization schemes that can work on a vast scale, hopefully starting from basalt and having no waste streams.

We Know We Have to Do This: Revolutionize Energy

WHAT ARE WE WAITING FOR?

- An Energy Crisis ?
- A Global Warming Disaster ?
- A New Administration ?
- An Asian Technology Boom ?

(or)

Consensus in the S&T establishment, DoD, State Dept.

and

POLITICAL LEADERSHIP

References

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