The Greening of Evangelical Christendom: How Green Should We Be?

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Meaning of Green

- Visible light of 520 – 570 nm wavelength (blue + gold) or the color of nature (chlorophyll in plants)

- Being green equates to “goodness”

- Commonly, being green is to not harm nature (natural, nontoxic, nonpolluting, renewable, sustainable, healthy, small,…)

- Green is now becoming a widely held political philosophy, especially in the Bay Area: just look at the number of Prius cars

The Bay Area is Very Green: PG&E's Electric Power Mix

And we pay for it too!

ENERGY RESOURCES	PG&E 2008 POWER MIX* (I	US
Biomass and waste	4%	
Geothermal	4%	
Small hydroelectric	4%	
Solar	<1%	0.1%
Wind	2%	
Coal	**2%**	50 %
Large Hydroelectric‡	**17%**	7 %
Natural Gas	**44%**	20 %
Nuclear	**22%**	20 %
Other	**1%**	3 % (oil)
TOTAL	**100%**	100 %

Power = energy/ time: 1 kiloJoule (kJ)/s =1 kiloWatt (kW) = 1 horsepower

We pay for energy consumed: 19 ¢/kWh radke's pg&e bill(05/15/09)

US price ranges from 5 – 10 ¢/kWh The Bay Area pays 2 – 4 times as much as US avg

Why? Price of natural gas: 3.5 ¢/kWh (from Canada)
Price of coal: 0.4-0.8 ¢/kWh

It costs a lot to be green

- How Green are You?

Answer T or F to following statements

1. Electric & hydrogen powered cars are nonpolluting
2. Global warming is causing increased numbers and intensity of hurricanes and tornadoes
3. Spent nuclear waste can not be safely stored
4. Off-shore oil & gas drilling must be prohibited
5. The energy problem can be solved by increased use of solar and wind power
6. Hetch-Hetchy dam should be dismantled
7. Use of genetically modified plants should not be pursued
8. Global warming is caused by burning of fossil fuel releasing CO_2 to the environment
9. Natural chemicals are safer than synthetic ones.
10. It is important for the US to sign the Kyoto Protocol
11. The US is the world's largest CO_2 emitting country
12. Using corn ethanol for a transportation fuel is a good idea

On what basis should Evangelical Christendom think about and act upon these questions?

What Does Scripture Say about Greenness?

Scripture does not teach about greenness per se anymore than it teaches scientific principles. Scripture's purpose is to reveal who God is and to bring saving grace to mankind through Jesus Christ. However, there are some important foundational principles:

1. God created Nature as well as man, and pronounced it "very good".
2. Mankind is given dominion over Nature to use for his/her purposes
3. Man is to steward Nature ("till and keep the garden")
   The Jewish concept of sabbath includes resting the land
4. When man fell, it appears that Nature also fell (Nature "groans in travail"). Man must work to overcome (subdue) Nature
5. There is continuing cosmic spiritual warfare that God will culminate not only redeeming mankind but also Nature ("no longer in bondage to decay")

Evangelical Christendom is often held responsible for environmental misuse because of Mandate 2. Clearly, Mandates 2 and 3 are in tension

1. We must hold mandates 2 and 3 in balance
2. We must become informed

Top 10 Global Challenges for the New Millennium

Richard E. Smalley, Nobel Laureate,
Chemistry, 1996, *MRS Bulletin*, June 2005

- 1 Energy
- 2 Water
- 3 Food
- 4 Environment
- 5 Poverty
- 6 War
- 7 Disease
- 8 Education
- 9 Democracy
- 10 Population

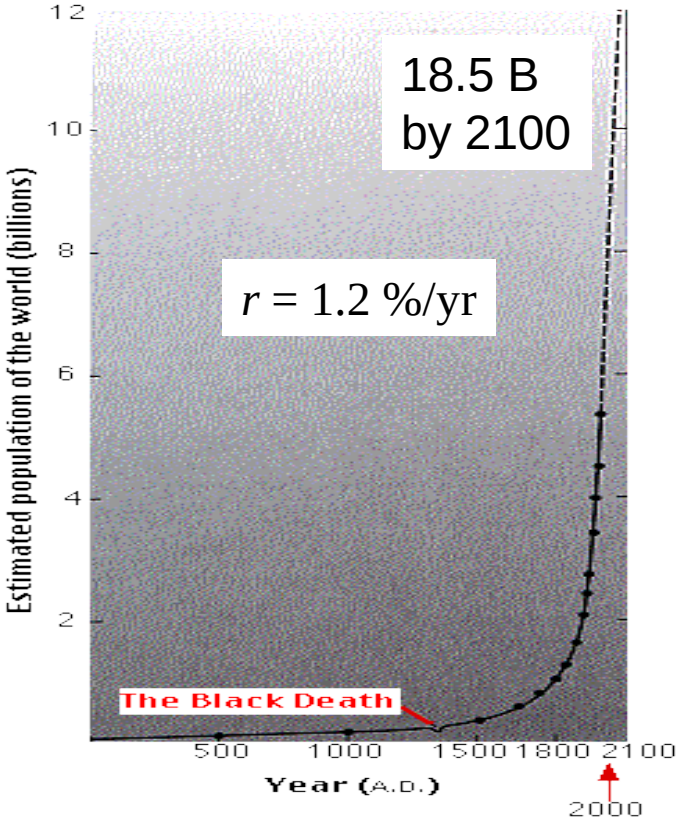
Why do you think Smalley rates energy # 1 ?

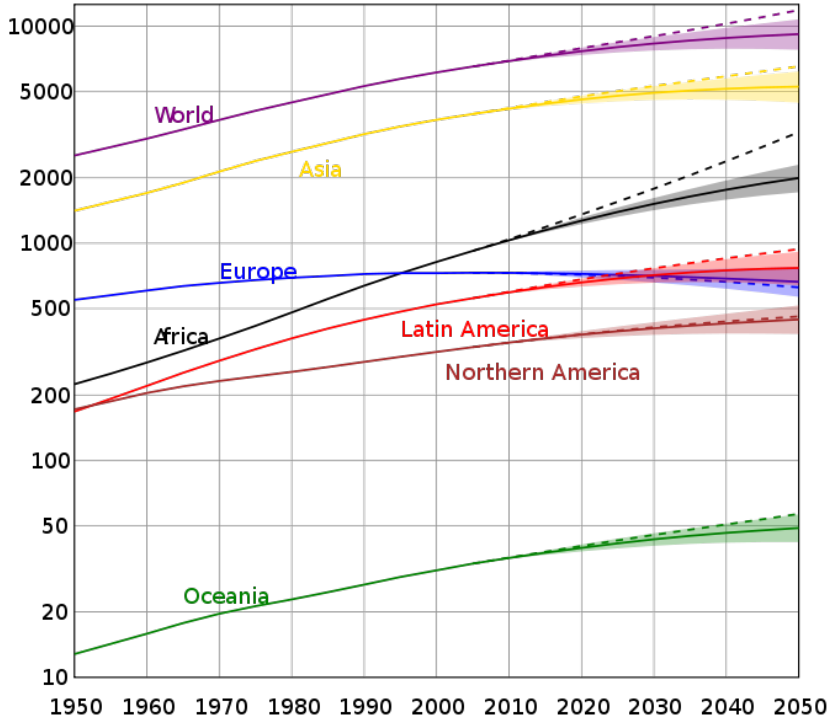
We will touch upon issues 1-4 and 10, but not in order.

World Population

Population grows in proportion to number of people

$N = N_o \, exp(\, rt\,)$ where r = net growth rate (birth - death)





85 % chance of peaking at 11 B by 2100
(Lutz, Nature 2001)

Country	*r*	*Pop*
Europe	*0.2*	*0.7 B*
US	*0.6*	*0.3 B*
China	*0.6*	*1.3 B*
India	*1.7*	*1.1 B*

No solid reasons are offered. Speculation is that a higher standard of living and feminism mean fewer children at enough decline to offset lower death rates due to better health.

The Malthusian Catastrophe

"The power of population is indefinitely greater than the power in the earth to produce subsistence of man. Population, when unchecked, increases in a geometrical ratio. Subsistence increases only in an arithmetical ratio. Once population growth outpaces agricultural production, mankind returns to a subsidence level." Malthus, 1798 Chapter 1

Thomas Malthus, 1766-1834

- Malthus predicted a catastrope in his life time.
- Many, many others have predicted catastrope throughout the ages, even in the 1950s (Roberts, 1951).

Why have they all been wrong?

Food production has outpaced population, chiefly as a result of the development and use of improved plant varieties, major increases in the use of nitrogen, potassium and phosphorus fertilizers, a doubling of the irrigated area, more effective control of insects and diseases, improved strains of livestock and poultry, and wider use of nutritionally balanced feeds.

B. Gilland / Food Policy 27 (2002) 47–63

Can our rate of food production continue to increase and keep pace with current population growth, even if we level at 11 B?

Current World Food Production (1990) (World Book Encyclopedia)

	metric tons per year
wheat	498×10^6
rice	450×10^6
corn	344×10^6
fruits and vegetables	669×10^6
total	*1,991x10⁶*

- Energy content of wheat 13 GJ/kg
- We need about 2500 cal/day of food intake = 3.82 GJ/y person

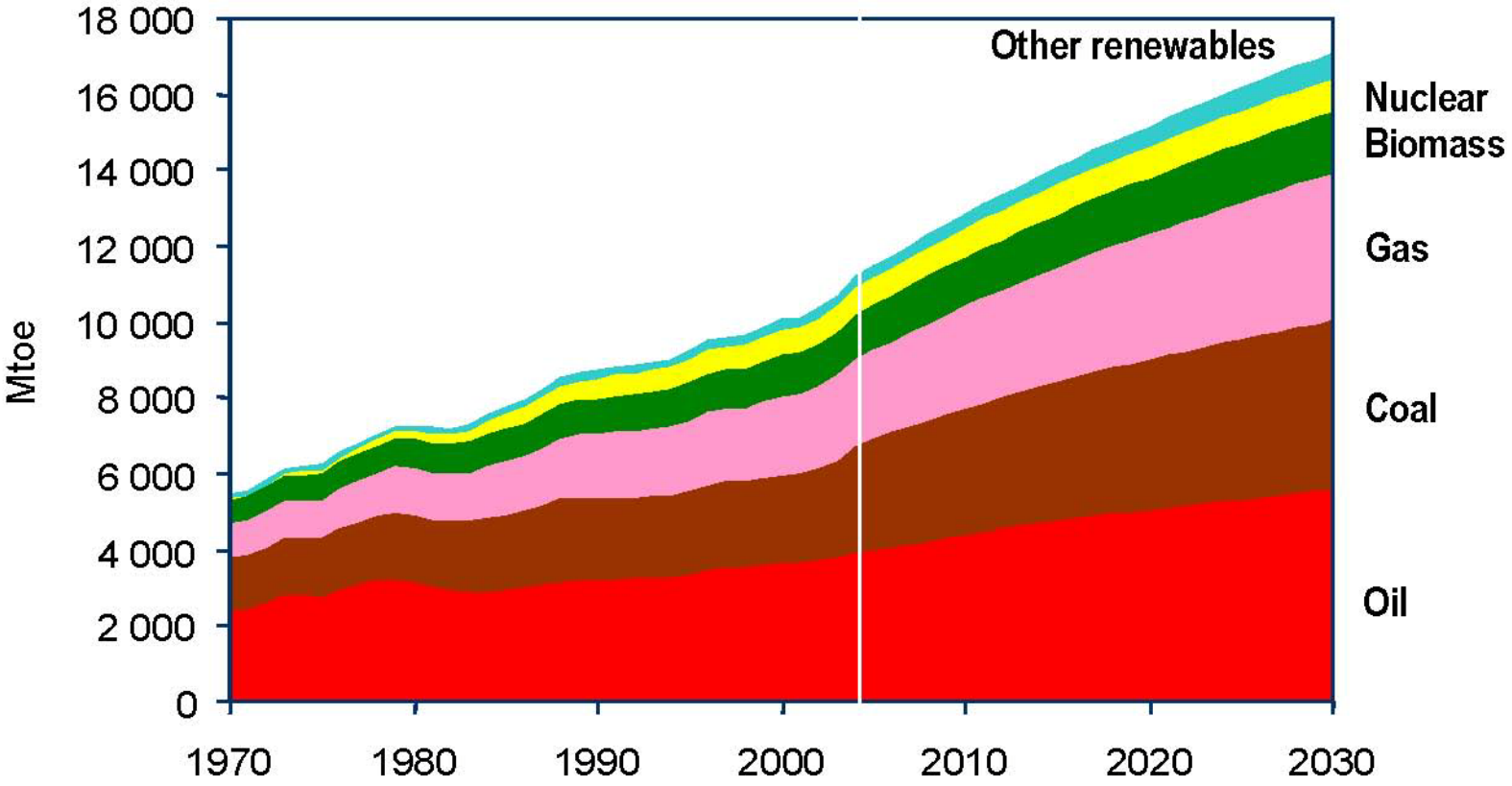
Supportable population = $(\frac{ton}{y})(\frac{energy}{ton})(\frac{person\ y}{energy\ needed})$ = 6.7 B We're there!

- To reach 11 B in population, we need to double our food production!
- If it can be done at all, we will need a major change in diet (little meat), major improvements in agricultural land area and practices, and lots of water.
- To accomplish this we need loads of energy:

The systems that produce the world's food supply are heavily dependent on fossil fuels. Vast amounts of oil and gas are used as raw materials and energy in the manufacture of fertilisers and pesticides, and as cheap and readily available energy at all stages of food production: from planting, irrigation, feeding and harvesting, through to processing, distribution and packaging. In addition, fossil fuels are essential in the construction and the repair of equipment and infrastructure needed to facilitate this industry, including farm machinery, processing facilities, storage, ships, trucks and roads. The industrial food supply system is one of the biggest consumers of fossil fuels and one of the greatest producers of greenhouse gases.

Church, Energy Bulletin 04/27/2009

Energy Needs (from IEA 2007)



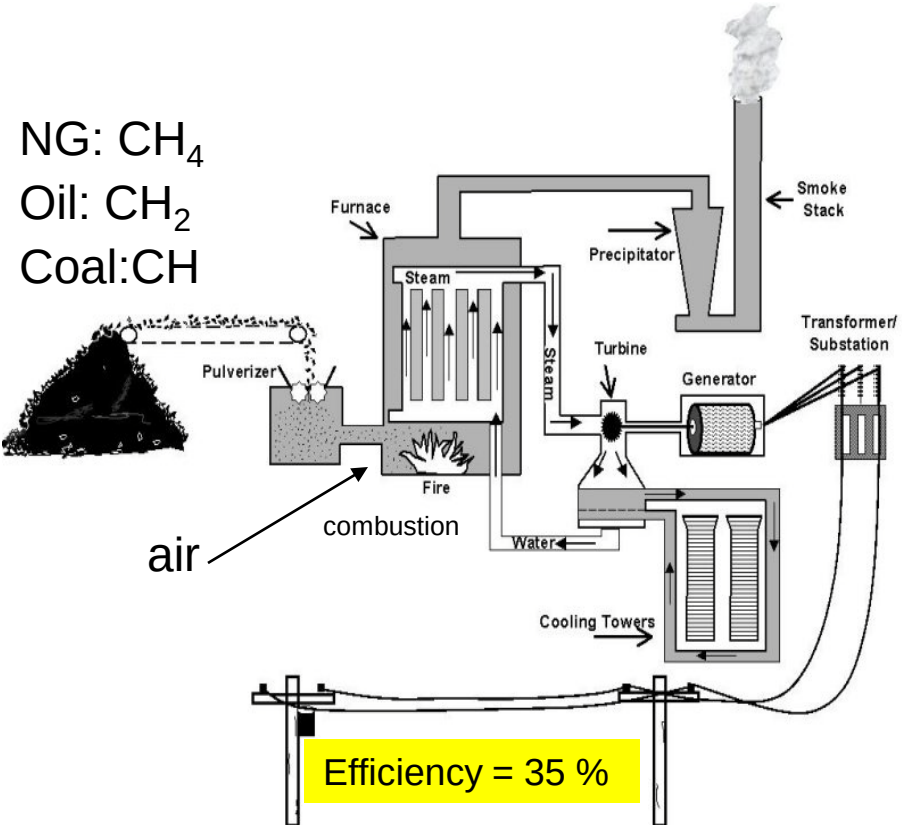
Numbers beyond 2007 are projections. World oil production peaked in 2004 and continues to fall!

Energy is primarily used for two purposes:

- Electric-power generation
- Transportation

Moss Landing Power Plant: Nat Gas Fired 2.56 GW (1 M homes)

NG: CH_4
Oil: CH_2
Coal:CH



Efficiency = 35 %

Still

From January through October 2005, the Moss Landing power plant released almost 900,000 tons of CO2, 60 tons of NOx and 4 tons of SO2 into the atmosphere.These amounts are relatively small, given the amount of power produced, and especially when compared to coal-burning facilities. Under certain conditions, the water is allowed to be released at a temperature 40°F higher than it is taken, thereby perturbing if not killing the surrounding aquatic life

Why is natural gas is preferred ?

NG: $CH_4 + 2O_2 \longrightarrow CO_2 + 2\,H_2O + 890\ kJ$

Coal: $CH + 3/2\ O_2 \longrightarrow CO_2 + 1/2\ H_2O + 518\ kJ$

Fuels more rich in H_2 are greener i.e., much less is CO_2 released

No energy-convesion process is completely green (you can't get some-thing for nothing). Coal is particularly dirty

Coal is Very UnGreen

In addition to significant CO_2, coal contains minerals (e.g., uranium, arsenic, selenium, mercury), sulfates (acid rain), and nitrogen (NOx). “More uranium is released into the environment from coal power plants each year than total ever released from nuclear power, including Chernoble,” (Wattenburg KGO). Uncombusted minerals lead to ash ponds.

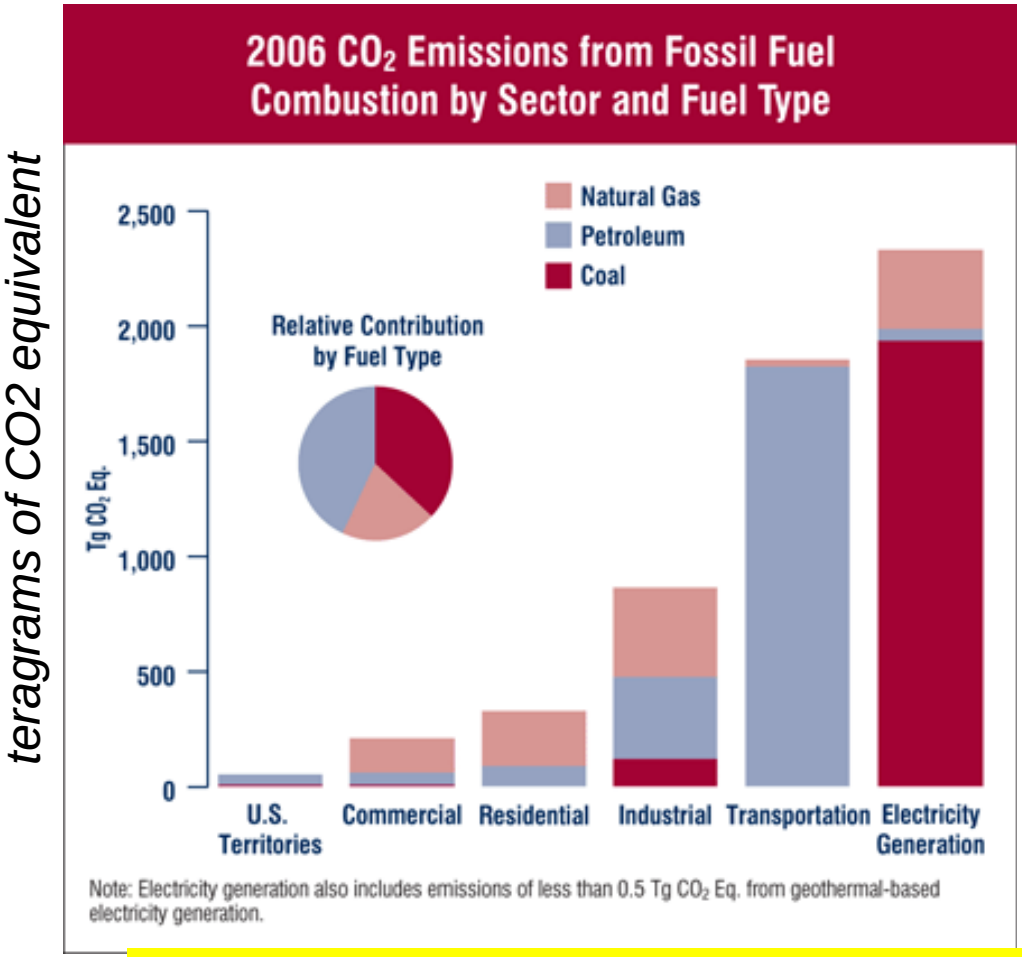
In Dec 2008, the ash-pond dam at Kingston, TN broke allowing 84 acres of waste to spill into the Tennessee river (C&EN 02-23-09)

The world has plenty of coal. China (1.3 B people) is building one GW coal-fired power plant every week! As of Dec 09, China now emits more CO_2 than does the US. In the coal-mining region of China, so much pollution is in the air that the sun never shines. India (1.1 B people) is not far behind. Neither India nor China are building clean plants (The Kyoto Protocol does not apply to China or India).

Our Cars Are Mini Power Plants

Gasoline: $CH_2 + 5/2\ O_2 \rightarrow CO_2 + H_2O + 642\ kJ\ (+SO_4 + NO_x)$

I gal of gasoline releases 19.6 lb_m CO_2



About ½ of CO_2 emitted in the US comes from automobiles and trucks.

So what's the concern about CO_2 emissions ?

Greenhouse Gases (GHG)

Certain gases in the atmosphere absorb IR radiation from the sun: CO_2, CH_4, H_20. They behave like the glass in a “green house”.

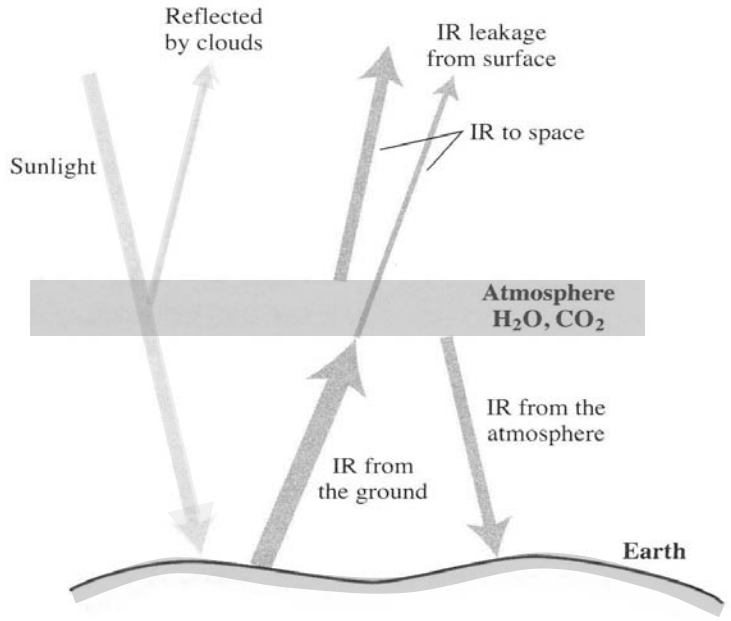


Figure 20.2. The physics of the greenhouse effect, with cloud reflection and atmospheric leakage included.

Hence, the worry is that increased greenhouse gases from burning fossil fuels increases the global temperature. Is this correct?

Global Temperature is Increasing

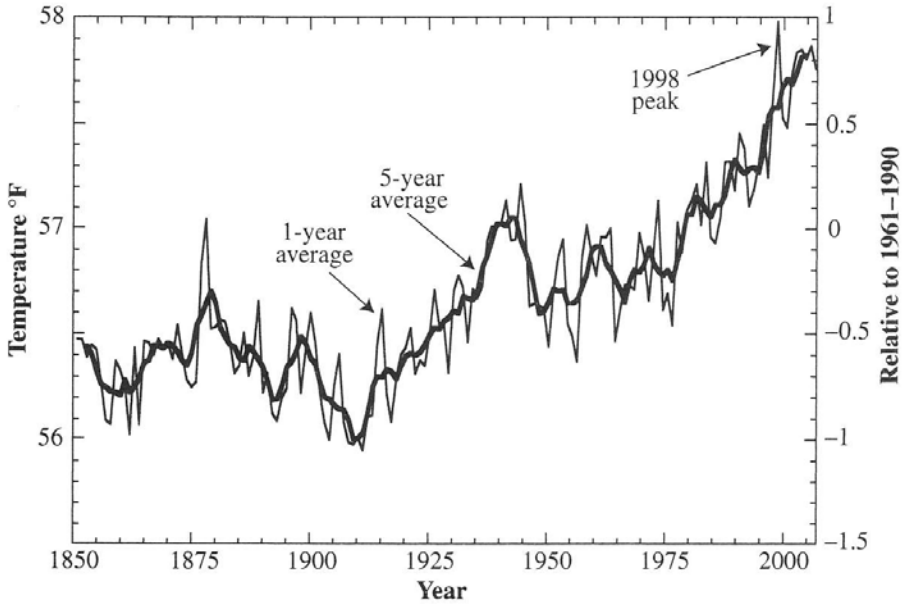
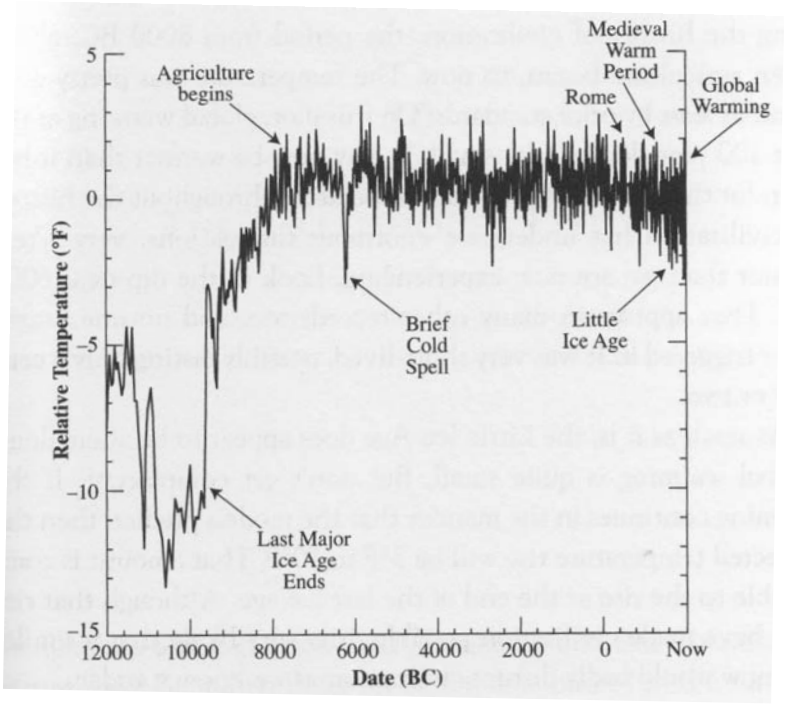


Figure 19.1. Global warming seen with thermometer measurements.



In the 1950 s there was concern about a new ice age!

When viewed over a very long time, the current temperature rise is minimal.

Nevertheless, if the current trend continues there is possibility of significant environmental changes (sea level, etc). Is CO_2 the cause of the warming?

Role of CO_2 in Global Warming

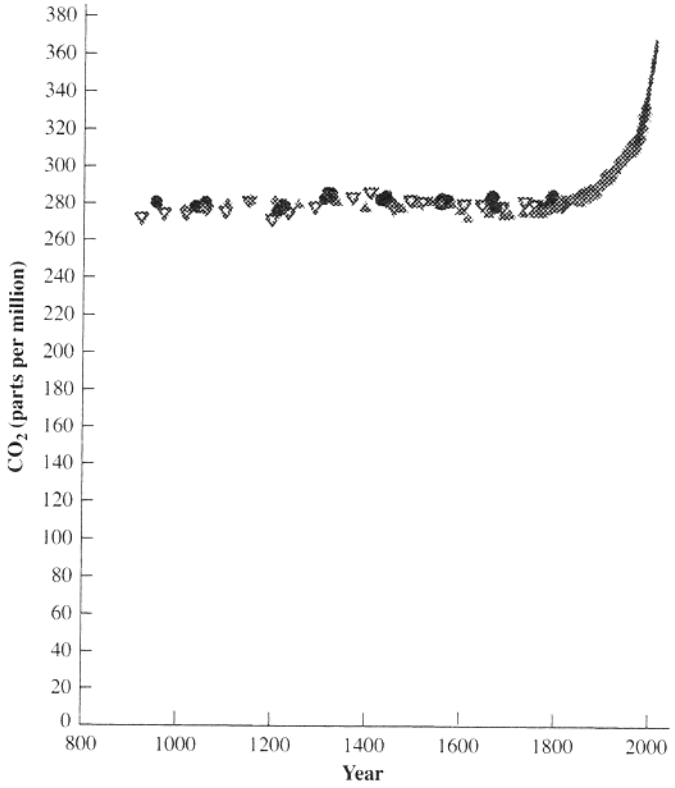
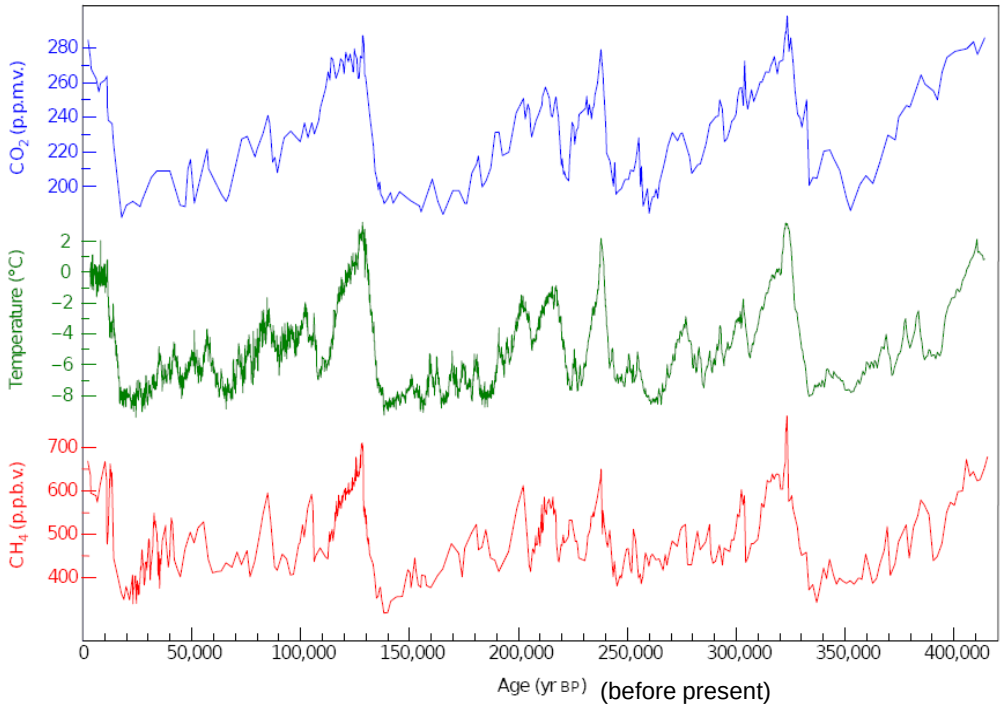


Figure 20.3. Carbon dioxide in the atmosphere over the past 1200 years. The sudden 36% rise in the recent past is due primarily to the burning of fossil fuels.

- Since 1800 the CO_2 level in the environment has risen from 280 to 360 ppm due to fossil-fuel burning. Oceans are acidifying.

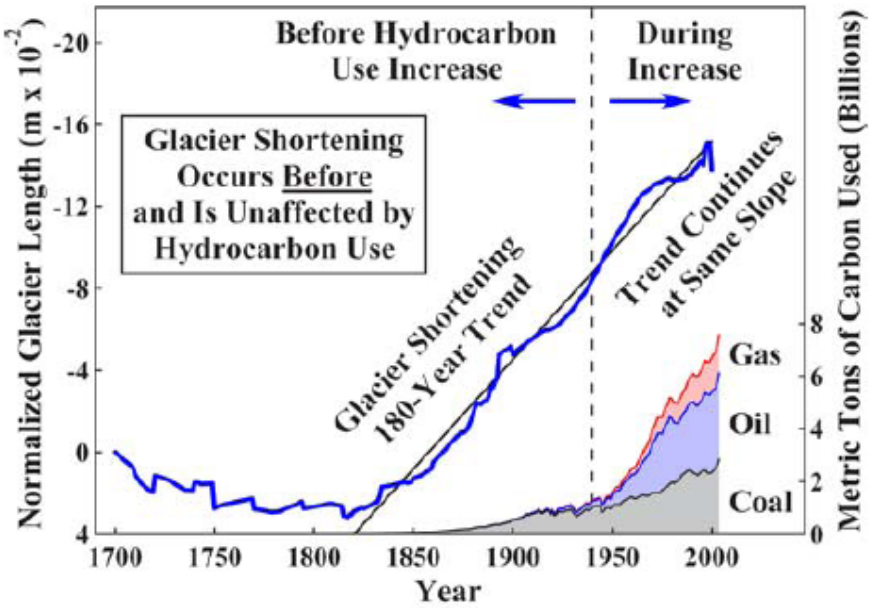
Gore in "An Inconvenient Truth"



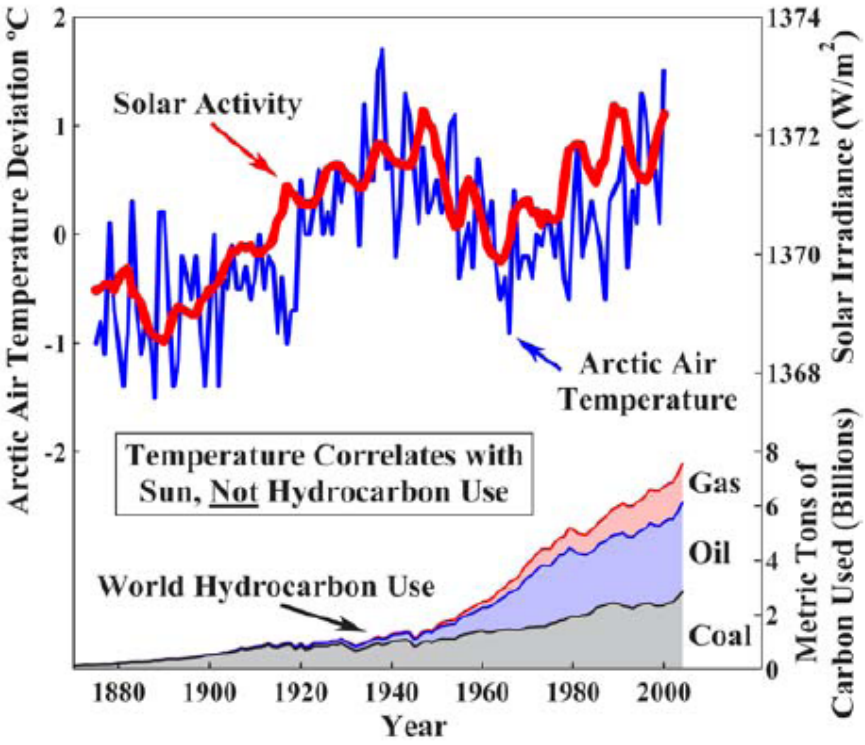
- CH_4 (from landfills) too is a greenhouse gas whose concentration is rising. Clearly, CO_2 & CH_4 correlate with global temperature.
- Importantly, there is a small time lag between temperature and CO_2 and CH_4 changes. Current view is that natural temperature changes drive the CO_2 and CH_4 changes due to ocean solubility

Correlation does not mean Causation !

More “Inconvenient Truths”



Glacier shortening is not directly correlated with fossil fuel use!



Sunspot activity correlates with temperature, but not with fossil-fuel use

National Research Council Opinion:

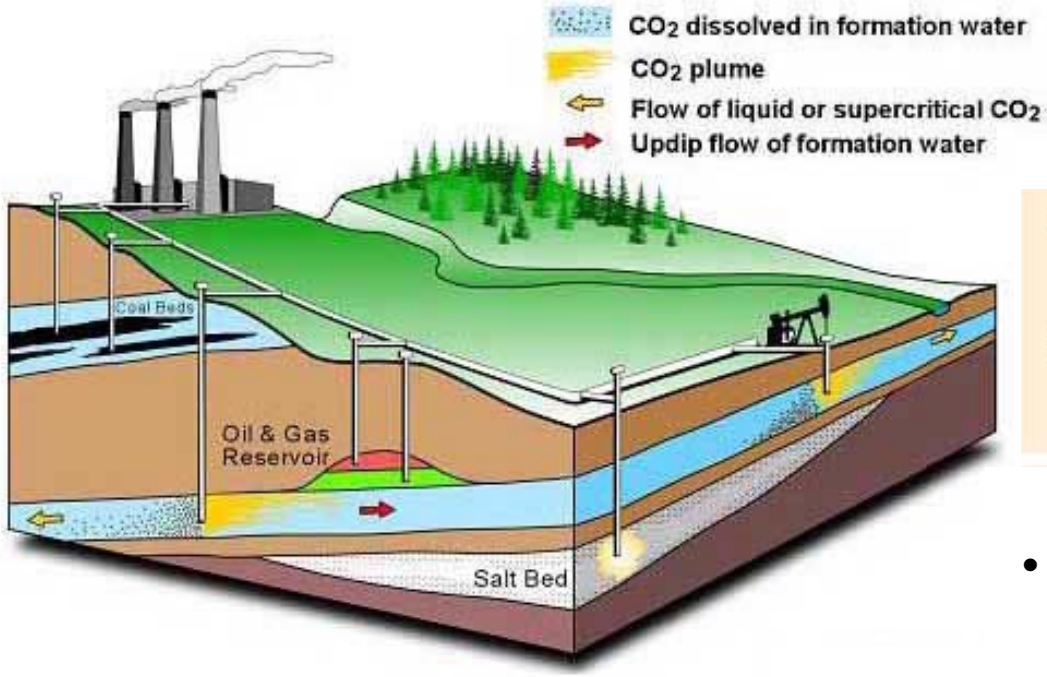
- Based on extensive global weather modeling, there is a 90 % chance that current global warming is driven by CO_2. Uncertainty is due to lack of understanding of H_2O (in clouds etc)

Greenhouse-Gas Concentrations

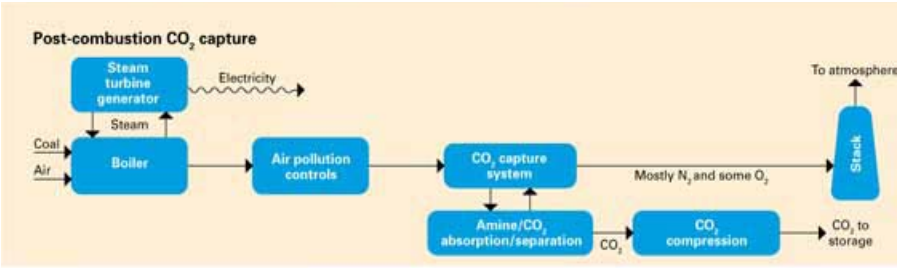
CO_2	360 ppm
CH_4	1650 ppm
H_2O	3,000 ppm @ 50 % RH & 25 °C

It seems that the least present GHG is causing global warming

CO_2 Sequestration: Put it in Underground



- Massive separation plant



- Transportation pipelines will be needed (NIMBY)

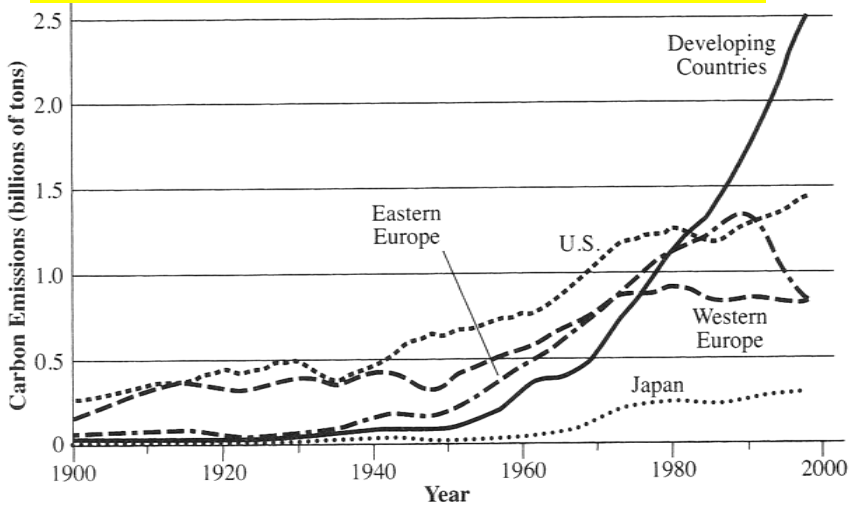
- Can we guarantee permanent storage ? Due to an earthquake on August 15, 1985, CO_2 released from Lake Manoun, Camaroon killing 1800 people. Problem is not unlike nuclear waste storage.

- Costs are large, about 2-4 times current price of electricity. While US is proceeding, it is unlikely that China and India, the major sources of global CO_2, will implement. Technology transfer is possible but high cost remains.

- Clean coal on the US scale and surely on the global scale is not likely in the near future (20 y).

“Physics for Future Presidents”: Richard Muller

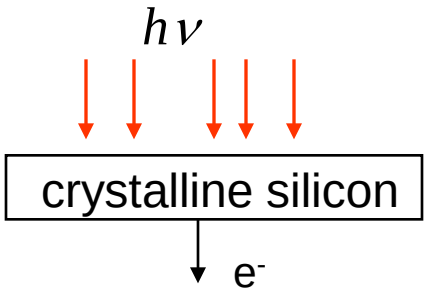
Nonsolutions to Global Warming



No to following:

- H_2 Economy: $H_2+1/2O_2 \rightarrow H_2O$ (no pollution!)
  Unfortunately, H_2 comes from carbon sources by steam reforming: $CH + H_2O \rightarrow CO + 3/2H_2$. This gives CO_2 emission. Energy density is too low (range is 15 miles). Major distribution problems.
- Fusion: too far off, if ever
- Recycling: good for minimizing waste but does not help GHG. Degradation produces CO_2.
- Electric Automobiles: energy density too low (haul around too much weight), cost to replace batteries and waste disposal, availability and cost of materials (Li), CO_2 emission remains)
- Kyoto
- Solar

Solar Power (PhotoVoltaic or PV)



Silicon comes from sand:

SiO_2 + heat ⟶ Si + O_2

It is very expensive and energy intensive to make perfectly crystalline silicon
Efficiency = 10 -15 %.

Creating vast arrays of silicon-based solar cells is like “trying to coat the desert with real high-quality diamonds,” P Alivisatos, Head LBNL

Silicon Ingot (computer chips)

- New “paint on” type materials are much cheaper but have only 5 - 8 % efficiency and are currently impractical (40 % of all ag land to meet US power demand)
- Can operate only when sun shines: i.e., no heat at night !
- There are no (desert) transmission lines (NIMBY and green says “go small”, SF Chron D.R Baker 09)
- Transmission lines can not handle varying loads. There is no Massive Electrical Storage (MES). Also need transformers (200 kV) and inverters

PV can not contribute much to our national power needs for at least 2 decades!

Home Solar Cost: 1 kW Unit
Michael Barnes, Berkeley, 2007

Installation:

Secure a permit for the project from the appropriate jurisdiction
Install aluminum mounting feet on the sloped south-facing roof of the rear cottage; waterproof with metal flashing
Install aluminum mounting rails on the feet using stainless steel hardware
Install the modules on the rails with aluminum clips and stainless steel bolts
Install the inverter and associated equipment on the exterior wall near the existing main panel
Wire the modules per manufacturer's specifications and run wiring in conduit to the DC disconnect
Wire the DC disconnect to the inverter
Wire the inverter outputs in conduit to the main panel feed
Install lockable disconnect per local utility requirements within 10' of the meter
Test and start up system
Coordinate all utility and local permit inspections
5 year complete system warranty; extended PV module performance warranty carried by manufacturer

Note: The price quoted below assumes a rebate of $2.80 from the California Energy Commission ("CEC"). In order to ensure the highest rebate Client must provide all required documents and signatures in a timely manner.

Total Cost Before Rebate, including sales tax:		**$23,787.00**
State of California Emerging Renewables Buydown Rebate:		**($6,346.28)**
Net Project Cost after Rebate:		**$17,440.72**
Federal Tax Credit if applicable:	30% / $2,000 maximum	**($2,000.00)**
State Tax Credit if applicable:	7.5%	**($1,308.05)** *
Net Project Cost after Tax Credits:		**$14,132.67**

* Note: State tax credit may cause an increase in Federal taxes. Please consult your accountant.

Client

COPY

Home Solar Power

Cost is the Issue

- Currently, $ 15/ W installed (Barnes paid $ 24/ W)
- Typical household uses electric power at 1 kW, so unit cost is $ 15,000
- Assume unit lasts 10 y

We pay $\left(\frac{\$15{,}000}{kW}\right)\left(\frac{1}{10\,y}\right) = \$1500\,/\,y$ (¢ 40-60/kWh)

We save $\left(\frac{\$0.10}{kWh}\right)(1\,kW\ unit)\left(\frac{24h}{day}\right)\left(\frac{365days}{y}\right) = \$876\,/\,y$

We lose $ 625/y

- Does not include roof costs, repair, rebates, purchase of excess power, etc. Perhaps a larger unit (3 kW = $ 45,000) with buy back may have better economics.

Larger solar units generating excess power coupled with air conditioning may make sense

Wind Power

- Much less costly than solar, ¢ 8-10/kWh

- However, wind faces many of the same problems as solar: limited places with enough wind, no power lines, intermittent generation & load leveling, unsightly, harmful to foul.

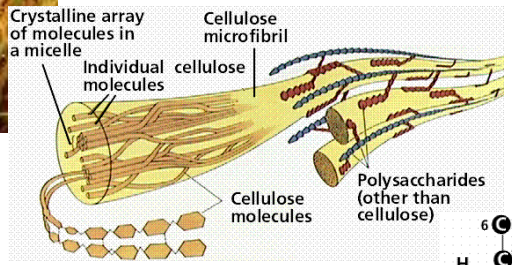
- Generally feasible, especially large units off-shore and out of sight. Perhaps, 2-5% of US needs (currently about 1 %)

Biomass: From Grass to Gasoline

Switch grass

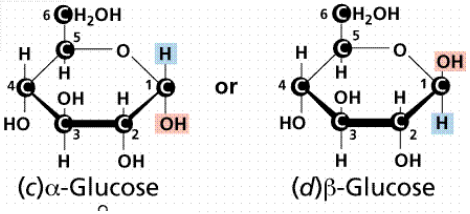
Biomass growth

Biomass preparation



CO_2 in

Cellulose depolymerization



Glucose conversion to plastics

Glucose conversion to fuel (alkanes, alcohols)

CO_2 out

Technology Needs

- Genetically modified crops that grow rapidly and require no fertilizer
- Efficient catalysts for cellulose depolymerization
- Selective catalysts for the conversion of glucose to fuels (alkanes) and chemicals

- **Biomass is CO_2 neutral**
- **Biomass can provide for 10 % of the US fuel needs**
- **Must not compete with food crops**
- **Corn ethanol is bad idea. More energy in than out. For every gal of gasoline (equiv), 1.1 gal are needed to produce**

“Physics for Future Presidents”: Richard Muller

Possible Solutions to Global Warming

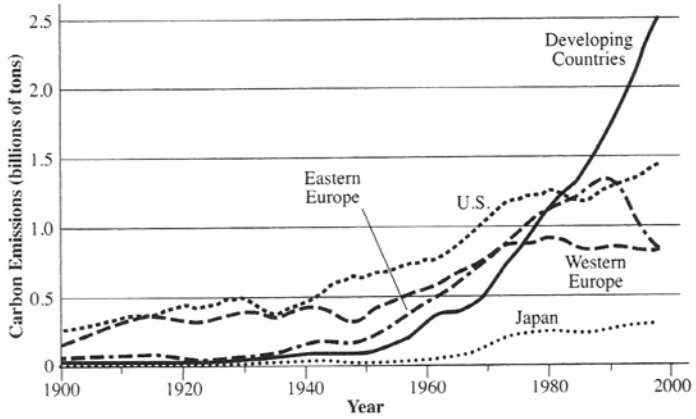


Figure 23.1. Carbon dioxide emissions in the twentieth century.

Now:

- Conserve
- Reflective roof colors and fluorescent lights
- Efficient automobiles: increased CAFE standards, lighter (smaller), hybrids (because of regenerative braking)
- Nuclear: Yes, there is the problem of waste. Its already being (safely) stored

  “If Yucca Mt were full and all radioactivity leaked out to reach ground water, the danger is 20 times less than that of natural uranium currently leaching into the Colorado River.”

  Remember, coal slag and stack gas release uranium. We need to reprocess spent fuel as France does. Nuclear can tide us over until renewable is feasible
- Wind

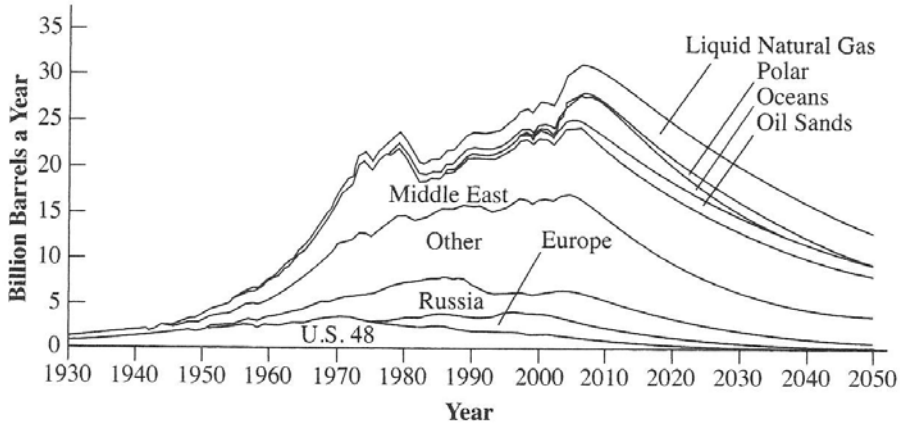
Future (> 20 y):

- Clean Coal: CCS & IGCC
- Improved Solar
- Biofuels

T Boone Pickens Plan

We are running out of oil as a transportation fuel

Large supplies of CH_4 are available but in tight rocks



The Plan:

1. Use nat gas as a fuel for trucking and public transport
2. Replace nat gas now used in electric power generation (45 % in CA) by renewable: wind and solar

Observations: 1. Pickens owns large rights to CH_4 and large wind farms in TX
2. Solar and wind can not now replace CH_4 in the amounts needed

Alternate Plan:

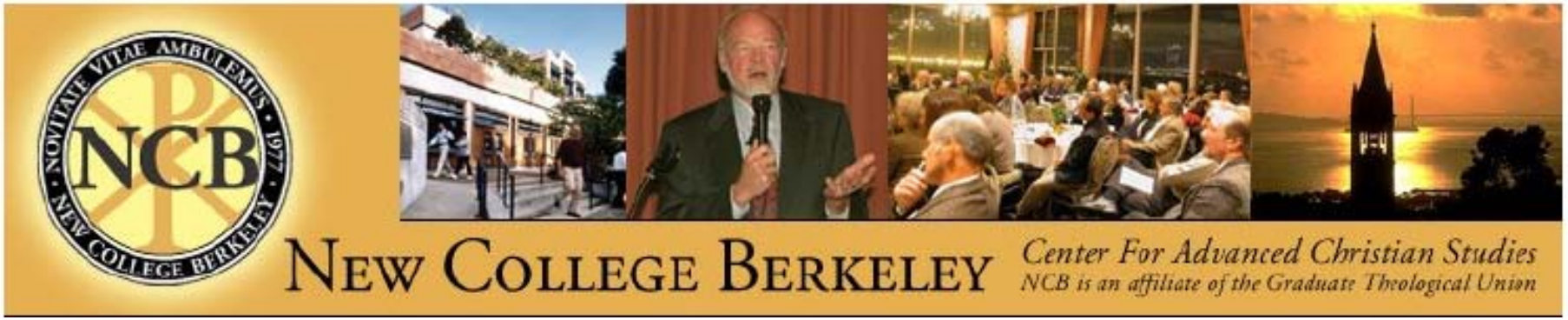
1. Invest in rail transport. Use nat gas as a fuel for trucking and public transport.
2. Replace nat gas now used in electric power generation (45 % in CA) by nuclear

A Complicated Challenge

Adequate clean energy, food, & water are a worldwide challenge. Herculean efforts in the US will not turn the tide. Science, although essential, is not going to solve the problem in the near term (20 y). How do we as individuals proceed?

1. Think globally. International cooperation is essential, especially as we deal with coal as a power source. National security is a confounding issue
2. Avoid NIMBY and emotion. We will have to build nuclear plants, transmission lines, pipelines, rail lines, water aqueducts, etc. Small is good, but not good enough.
3. Conserve, conserve, conserve… Establish a mind set to reduce consumption, even down to our driving habits and dish and teeth washing. See Gershon: “Low Carbon Diet.”
4. Encourage our leaders to get a move on. We need to establish wise policy and to proceed rather than study more. Read Professor Muller’s book.

Bottomline: It is possible to be too green. We need to be blue and gold. Mandates 2 and 3 should be held in perspective. All things should be done in decency and order.



On behalf of NCB:
Thank you for attending

Slides will be available on NCB web

NCB Fall program schedule is online at: www.newcollegeberkeley.org including

Susan Phillips, Sharon Gallagher, Bonnie Howe, Chris Corwin, Philip Yancey, and Conference on Global Scarcity.

Wait, I do have one more slide

Have You Changed Your Mind?

T or F on following statements

1. Electric & hydrogen powered cars are nonpolluting
2. Global warming is causing increased numbers and intensity of hurricanes and tornadoes
3. Spent nuclear waste can not be safely stored
4. Off-shore drilling must be prohibited
5. The energy problem can be solved by increased use of solar and wind power
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