

Lecture 36

Are there solutions to global warming?

- 1) Energy alternatives
- 2) Cutting emissions - a political issue

The Energy Issue

currently:

- global, primary energy production is 12 TW (i.e. 12×10^{12} Watts = 12 TeraWatts)
- 85% from fossil fuels = 10 TW... this is the problem, equivalent to ~ 6 Gt C/yr

need:

- to stabilize CO₂ at 550 ppm (double pre-industrial) - where impacts are perhaps manageable
- to accommodate rising population (to 10 billion) and economic progress
- 10-30 TW emission-free energy by 2050

Further info on world energy:

Hoffert et al (2002), *Science*, 298, 981-987 [www.sciencemag.org >search]

Technical solutions

- improving efficiency a few TW, safe, feasible, immediate
- carbon sequestration But how, exactly?
- renewable Safe, requires capital investment
 - wind power
 - tidal power
 - geothermal power
 - biomass power (i.e. from fast-growing plants with zero net CO₂ input because the plant growth uses CO₂)
 - solar energy promising, currently expensive
- nuclear fission a few TW; radioactive waste issue
- nuclear fusion Not yet feasible.

Energy Alternatives

Improving efficiency

- Fuel efficient cars; Mass transit
- Fuel cell hydrogen* cars - up to 70% efficient
(*assuming hydrogen is made using renewable energy, not oil/coal (which is the plan in the Bush Administration hydrogen fuel initiative))
- Conservation via building codes
- US could reduce emissions by 10-40% at a net savings (according to study by Rubin et al (1992) *Science*, 257, 261-266)
- 1975-2000, US reduction in energy intensity saved energy equivalent to 3 times total oil imports

Carbon emission sequestration

- Remove CO₂ at source with organic solvents (active area of research by energy companies in anticipation of future regulation)
- Huge challenge: a typical 500-MW coal-fired power station emits 10,500 tonnes CO₂/day.
- Recover CO₂ and store in deep ocean/underground (relatively impractical and a potential time-bomb if it were to escape)

Energy Alternatives

Renewable energy

- hydropower (close to saturation)
- solar, wind, geothermal currently <1% of global energy
- In 2001, wind provided 24 GW (i.e. 1/400 of total global energy) but is growing very rapidly (24% per year in 2001)

- 10 TW from biomass requires land area similar to ALL present agriculture
- 10 TW solar requires an area 500 km x 500 km = 250,000 km² vs. 3 km² presently.
Massive but could be done. Could be used to generate H₂. Possible leap in technology: ultra-efficient plastic solar cells.
- Wind power limited in location. But does supply 10-25% of power in Germany, Spain, Denmark. Could supply ~10% of world's power according to recent estimates.

Energy Alternatives

nuclear fission
at 10 TW, only 6-30 years of proven uranium reserves
waste disposal and security issues

nuclear fusion
no working technology at present
prospects are murky

geoengineering or climate engineering
reflect about 2% of sunlight with stratospheric particles or space mirrors
technical feasibility not well known
unintended consequences very likely

BUT: Publicly-funded energy R&D in the EU and US declined 35%, 1985-1998.
US private sector investment in energy research fell 53% over same period.

Policy

Bottom line: Global warming is a global problem and can only be solved through international cooperation.

Conference	Result
Rio de Janeiro, 1992 (http://unfccc.int/)	UN Framework Convention on Climate Change (UNFCCC) - signed by USA. Currently, a total of 188 signatories; 6 observers
Conference of the Parties (COP 3), Kyoto , 1997	Kyoto Protocol set targets for CO ₂ emissions for industrialized nations. Signed by USA but not ratified. Currently, President G.W. Bush neither supports ratification nor enforcement of CO ₂ emission reductions.
Conference of the Parties (COP 6), The Hague, 2000	Failure to agree between Europe and USA on how tough the treaty should be
Conference of the Parties (COP 9), Milan, Dec 2003	Discussed implementation issues concerning emissions reductions; discussed national progress.

The Kyoto Protocol

Targeted CO₂, CH₄, N₂O, SF₆ and some CFC substitutes

Proposed reductions in GHG emissions:
5.2% below 1990 levels for whole world within the period 2008-2012

8%	"	"	"	EU	"	"	"
7%	"	"	"	USA	"	"	"

Makes a 20-30% reduction from "business as usual" in 2008-2012

Countries joining also agreed to other measures, e.g.,:

- inventory of national sinks and emissions of GHGs
- formulate national programs to mitigate climate change

Possible mechanisms (not specified in the treaty):

- carrot & stick: fossil fuel taxes, energy conservation tax breaks
- US govt idea of emissions trading based on quotas

Kyoto developments

Bush Administration objections:

- developing countries are exempt, including India and China
- "incomplete state of scientific knowledge of the causes of, and solutions to, global climate change"
- the Kyoto Protocol "would cause serious harm to the US economy"

Other countries argue for a "precautionary principle" ("better safe than sorry") in the face of climate uncertainty, analogous to buying insurance. Critics note the security gain for the US if it were to reduce its dependence on foreign oil.

Status of emissions:

2000: EU average GHG emissions were 3.5% below 1990 levels

2000: US GHG emissions were 13% higher than in 1990 - makes Kyoto even less likely to be joined by USA

1990-2020: China global contribution to emissions expected to go from 7% to 25%

To enter into international law, Kyoto needs

- 1) to be ratified by >55 countries [done: 104 govts by 2003: EU, Japan, China,...]
- 2) that they emit at least 55% of the industrialized world's CO₂ (not yet done, requires Russia to ratify, given that USA won't)

Kyoto continued...

Dec 2003: Putin decides not to join Kyoto

Increasing energy exports to USA are thought to be a large factor (environmentalists blamed Bush Admin for influencing Putin's decision)

Yesterday: March 9, 2004: Putin tells Canadian PM he will ratify Kyoto

Prospect of EU investment in Russian energy industry may be a factor.

2004: Russia's emissions have fallen 32% since 1990 due to poor economy.

Scientists all agree, however, that the Kyoto Protocol is not enough to stop global warming (you can work this out: Fig. 16-14 in textbook). It amounts to -0.15°C GAASST decrease. Kyoto is analogous to the Montreal Protocol, which was insufficient to stop ozone depletion and had to have numerous amendments to bring ozone levels back to 1970 values by 2100.

Conclusion: Currently, global warming has no solution because it requires global cooperation, which is not happening, even with insufficient measures (Kyoto). And the largest emitter, the USA, is not engaged.