Report of the College of Engineering Committee on Globally Sustainable Development: Energy & Its Environmental Impacts

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Preamble

"Many of the most difficult and dangerous environmental problems at each of these levels of economic development --- from the damage that the very poor do to the immediate environment, and thus to themselves, to the damage that the very rich do to the global environment, and thus to everybody --- arise from the harvesting, transport, processing, and conversion of energy. In light of all this, it has become increasingly clear that energy is the core of the environmental problem; environment is the core of the energy problem; and the energy--environment intersection is the core of the sustainable development problem."

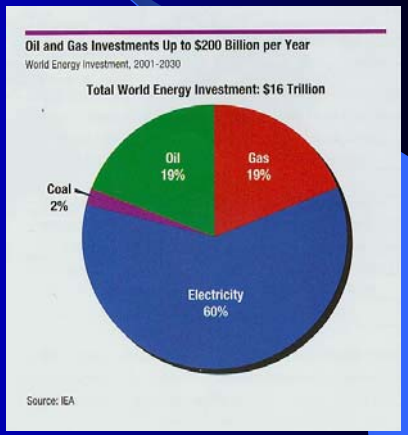
- John P. Holdren, President Woods Hole Institute, the Teresa and John Heinz Professor of Environmental Policy, and Director Science, Technology, and Public Policy Program, Harvard Kennedy School

The Problem and the Opportunity

- Energy production and utilization in stationary power production, portable power, in machinery for production and transportation, and in heating and air conditioning make modern life possible and, together with food production and the provision of shelter, remain the most basic features of social concern and of engineering responsibility.
- A planetary scale issue- global warming due to greenhouse gas emissions has elevated the needs for engineering solutions.
- Energy drives the world economy and is the origin of much global conflict.

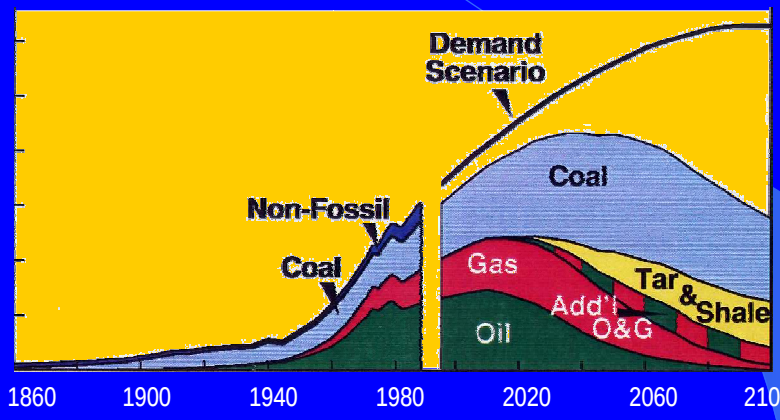
Some Economic Consequences

- World population in 2050 will be 50% greater than now
- World primary energy consumption will triple
- Investment in energy supply infrastructure in 2001-2030 will be $ 16 trillion
- This does not include capital costs for new (even conventional) end use technology



World Energy

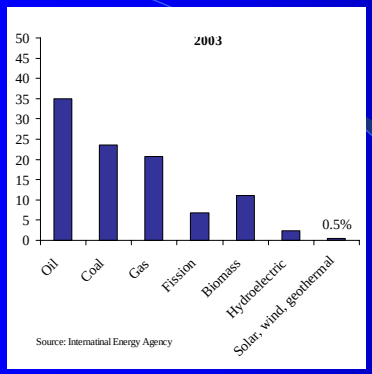
Millions of Barrels per Day (Oil Equivalent)

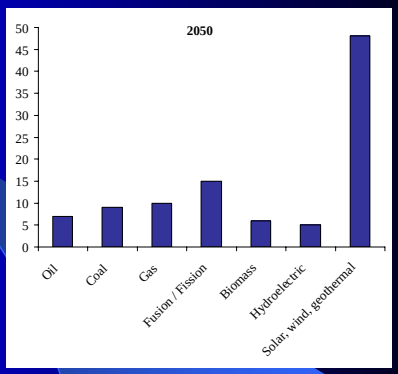


Source: John F. Bookout (President of Shell USA) ,"Two Centuries of Fossil Fuel Energy" International Geological Congress, Washington DC; July 10,1985. Episodes, vol 12, 257-262 (1989). See also update from DOE EIA, 2004

To Supply Capacity

Without increasing CO_2 by more than factor of 2





20st Century = OIL
21st Century = ??

Examples of Engineering Solutions

- Nuclear power (fission, maybe fusion later on)
- Renewable power sources, i.e., wind power, biomass, solar power
- Hydrogen-fueled fuel cells provided the hydrogen is produced without carbon emission
- Combustion with onboard sequestration

Existing Cornell Activity

- Extensive efforts in BEE, CEE, and CBE in biomass research. The extent and quality of this effort makes Cornell a national leader in biomass energy, as Cornell's designation as a Sun grant center affirms.
- Strong programs in Chemistry and in MSE in fuel cell research, including the Cornell Fuel Cell Institute (CFCI).
- Through ECE, Cornell leads PSerc, Power Systems Engineering Research Center, a 13 NSF university consortium focused on the national electrical power grid.
- Strength in gas hydrates, a massive untapped methane source, in EAS and CBE.

Existing Cornell Activity

- Strength in MAE in atmospheric turbulence.
- Strength in MAE, CBE and Physics in turbulence of particulates and aerosols.
- Strong programs in MAE and AEP in combustion, and chemical kinetics of hydrocarbons.
- DOE program (COBRA) in LPS in fusion plasma processes.
- Strength in EAS in climate modeling
- Strength in CEE and MAE in coastal, lake, and small-scale ocean physical processes, especially mixing and air/water transport processes.

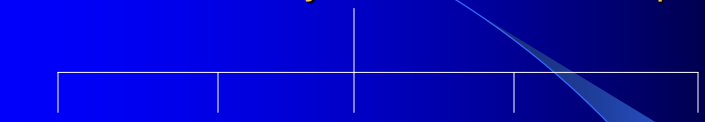
Cornell Gaps

- Energy systems engineering. A senior hire in this area is advisable, preferably someone with the perspective and vision to integrate and lead the entire energy/environment effort in the College.
- Carbon capture and sequestration. Expertise in this area is believed to be central to global warming mitigation in the near term (50 years), during which fossil fuels will continue to be the dominant primary energy sources.
- Modeling gas transfer and chemical processes between the atmosphere, land, and sea.
- Renewable energy technology. Wind power; fuel cells; photovoltaics; hydrogen generation, storage, and distribution systems; and electrical grid adaptations to distributed generation.

Recommendations

- Create an executive committee of Cornell academics, an external advisory board composed of experts from industry, government and other universities. Search for a Director of the Institute.
- Enable the Director to hire four new faculty. Each hire would have his or her tenure home in an existing department.
- Provide $1M/year over a five-year start-up period, exclusive of the costs of hiring new faculty. We envision the funds to be used as follows:
  - $600,000/year seed money for the redirection of research of existing College faculty, half provided by the Dean and half by Departments and Schools whose faculty members apply for seed monies,
  - $400,000/year for fellowships, national workshops, salary for the Director's Assistant, and miscellaneous expenses.

Center for Globally Sustainable Development



- Institute for Sustainable Energy Systems
- Institute for Sustainable Business Enterprises
- Institute for Adaptation to Global Change
- Institute for Policy and Analysis
- Institute for Legal and Regulatory Responses to Global Climate Change

Structure of the Institute for Sustainable Energy Systems

1) Energy systems
2) Prediction of system impacts of global climate change, power plant siting
3) Energy efficiency & conservation (new indoor heating and cooling technology, new lighting technology)
4) Primary energy sources (fossil, nuclear, solar, wind, biomass)
5) Energy conversion (prime movers, fuel cells, H_2 production, ethanol production)
6) Carbon sequestration
7) Energy storage & distribution (new grid technologies effectively integrating distributed energy production schemes, batteries, hydrogen fuel containment and distribution, disposal of energy waste products)