The Future of Energy:
Applying Ecological Economics to Global Issues
with Cutler Cleveland, PhD
Wednesday, March 12, 2008

Dr. Cutler Cleveland is currently a professor in the Department of Geography and Environment and the Center for Energy and Environmental Studies at Boston University. Dr. Cleveland is Editor-in-Chief of the *Encyclopedia of Energy* and the *Dictionary of Energy*, the founding Editor-in-Chief of the *Encyclopedia of Earth* and former Editor-in-Chief of the *Journal of Ecological Economics*. Dr. Cleveland is a member of the American Statistical Association's Committee on Energy Statistics, a participant in the Stanford Energy Modeling Forum, and the recipient of the Adelman-Frankel Award from the United States Association of Energy Economics for "unique and innovative contributions to the field of energy economics." Dr. Cleveland is Chairman of the Environmental Information Coalition, the governing body of the *Earth Portal*. He has won publication awards from the International Association of Energy Economics, the American Library Association, and the National Wildlife Federation and teaching awards from the University of Illinois and the Honor's Program in the College of Arts and Sciences of Boston University. Dr. Cleveland has been a consultant to numerous private and public organizations. His research employs the use of econometric models of oil supply, natural resource scarcity, and the relation between the use of energy and natural resources and economic systems and has been supported by the National Science Foundation, the National Aeronautics and Space Administration and the MacArthur Foundation

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K.C. Golden joins Dr. Cleveland as local expert and respondent. He is policy director for Climate Solutions, a research and advocacy organization pioneering practical and profitable solutions to global warming, and he serves as a governor's appointee to the Executive Board of Energy Northwest. He helped engineer Seattle's commitment to beat the goals of the Kyoto Protocol and to operate the first major zero-carbon electric utility. He has also served as assistant director of Washington's Department of Community, Trade and Economic Development and as executive director of the Northwest Energy Coalition. Mr. Golden was a Kennedy Fellow at Harvard University's John F. Kennedy School of Government, where he received a master's degree in public policy. He was recognized as one of Seattle Magazine's most influential people and its #1 Eco-Hero in 2007.

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The rapid expansion of the human population and its standard of living over the last 200 years has been driven by the exploitation of fossil fuels: i.e. coal, oil and natural gas. In the coming decades, world oil production will peak and then begin to decline, followed by natural gas and eventually coal production. Though there is considerable debate about when these peaks will occur, the precise timing doesn't really matter. A more fundamental issue is the magnitude and nature of the transition away from fossil fuels.

How much renewable energy is needed if it were to replace fossil fuels? This question has many components and is related to sustainability in three important ways, corresponding to three critical dimensions of sustainability:

Energy as a source of environmental stress (ecological sustainability)
The environmental stress is clear in the relationship between energy extraction, processing and use and environmental quality. This link is well established with **air pollution** (mercury, sulfur, nitrous oxide, etc.) and now with **climate change** due to carbon dioxide emission. Another environmental stress comes from **appropriation of the products of the biosphere.** Most renewable energy alternatives compete with other human uses of the earth such as production of food and basic ecosystem services and, since such fuels require much more land area to produce, they are likely to seriously compromise the earth's basic ecosystem services and life support systems.

Energy as a prerequisite for meeting basic human needs (social sustainability)
Energy use and economic development go hand-in hand. Nearly 1.6 billion people have no access to electricity in the world. Far more people rely on traditional biomass for cooking and heating, the combustion of which has profound human health impacts, making it a major environmental contributor to ill health. Future energy systems must supply adequate energy to relieve poverty, as well as support living standards in wealthy nations.

Energy as a principal motor of macroeconomic growth (economic sustainability)
A strong relationship exists between the quantity of energy a nation uses, the size of its economy and its standard of living. For a sustainable future, it is necessary to balance the economic benefits of increased energy use with its potential for environmental damage, to achieve social justice, and to transition to alternative energy in the long run.

Energy quality is an important concept that allows comparison of different forms of energy: It is the difference in the ability of a unit of energy to produce goods and services for people and has the following components.

Energy density: the quantity of energy contained in a form of energy per unit mass or volume.

Power density: the rate of energy production per unit of the earth's area, usually expressed in watts per square meter.

Energy surplus: the gross amount of energy extracted or delivered, minus the energy used directly and indirectly in that process. A related term is Energy return on investment (**EROI**).

Intermittency: the fraction of time that an energy source is available to society.

Spatial distribution: All natural resources show distinct geographical distributions, imposing transportation and transaction costs and, in the case of oil, risk associated with economic and national security.

Conclusion
The debate about "peak oil" aside, there are relatively abundant remaining supplies of fossil fuels. Their quality is declining, but not yet to the extent that increasing scarcity will help trigger a major energy transition like wood scarcity did in the 19th century. The costs of wind, solar and biomass have declined due to steady technical advances, but in key areas of energy quality—density, net energy, intermittency, flexibility, and so on—they remain inferior to conventional fuels. Thus, alternative energy sources are not likely to supplant fossil fuels in the short term without substantial and concerted policy intervention. The need to restrain carbon emissions may provide the political and social pressure to accelerate the transition to wind, biomass and solar, as this is one area where they clearly trump fossil fuels. Electricity from wind and solar sources may face competition from nuclear power, the sole established low-carbon power source with significant potential for expansion. If concerns about climate change drive a transition to renewable sources, it will be the first time in human history that energetic imperatives, especially the economic advantages of higher-quality fuels, were not the principal impetus.

For more information, read articles by Dr. Cleveland:
Energy Transitions Past and Future www.eoearth.org/article/Energy_transitions_past_and_future
Energy and Sustainable Development at Global Environmental Summits
www.bu.edu/cees/people/faculty/cutler/articles/Energy_at_Env_Summits.pdf