The World Energy Modeling Project

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The following is a guest post about the need for global energy systems modeling, by ASPO-USA co-founder Dick Lawrence. Mr. Lawrence has a degree in Physics from Rensselaer Polytechnic Institute. After a career at Digital Equipment and Intel he is focusing on the world energy model and starting a solar hot-water business in Massachusetts. In 1986 he read "Beyond Oil" (the original) which was his introduction to resource depletion, Hubbert's peak, and the power of computers to model the behavior of complex systems. In May 2004 he proposed a project to model global energy flow at the ASPO meeting in Berlin.

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Energy is at the foundation of every aspect of our present globalized economy. Without adequate energy, the well-being of our still-growing world population, increasingly urbanized and industrialized, faces the prospect of reduced standards of living, declining access to food and clean water supplies, and contraction of global trade and GDP.

In the next decade and beyond, decisions will be made at national-policy (and, possibly, global) levels that have consequences to large segments of the Earth's human population and to the world environment. These decisions will directly and indirectly impact energy and resource availability, human well-being, and the sustainability of the environment on which all economies ultimately depend.

Understanding the complex relationships between energy, the economy, human living standards, and national policy decisions is a difficult task. Well-informed observers often arrive at opposite conclusions, even when in possession of the same collection of facts. How can we cut through the morass of conflicting opinions and develop a better understanding of the consequences of policy decisions?

Increasingly, researchers turn to computer-based dynamic-systems modeling techniques when they are trying to understand complicated systems. 35 years ago, colleagues of Jay Forrester at MIT published the results of a study 35 years ago called Limits to Growth, which attempted to look at the global human population and its relationships to resources, food supply, pollution, and more.

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After several years of presentations and proposal refinement, a project to model world energy flow is now underway. Following our presentation at ASPO-USA's Boston conference in October 2006, we developed a Request for Proposals and distributed this to organizations and academic groups considered to have the resources and skill sets to implement such a model. After reviewing the proposals, ASPO-USA decided to merge the capabilities of two responders into a combined project team. ASPO-USA brought the two groups together in mid-May of 2007 and officially launched the project.

The two teams are:
• Millennium Institute – main model development, building on the foundation of their T21-USA model, which has substantial energy components;
• State University of New York – Environmental Science and Forestry (SUNY-ESF) – creation of the "energy core" of the model, including EROI database and feedback paths. ESF will also develop new graphical user interfaces.

The teams will develop the North America model (United States, Mexico, and Canada) over the summer of 2007, performing initial model runs in September. They will then expand the scope of the model to the global level, completing development by (approximately) mid-2008.

TARGETED RESULTS

We want the model to be capable of answering the following questions:

• Given the finite and future limited availability of fossil fuels, with growing supply-demand mismatch, what is the best use to which we can put remaining supplies of "cheap" oil and gas?

• How much of our present and near-term fossil-fuel supply should be diverted to developing sustainable / renewable energy resources in a way that minimizes negative impacts on food production, water supply, per-capita energy availability, and quality of life for residents in developed, developing and under-developed nations? What would be the consequences of delaying accelerated or "crash" programs by a decade? Two decades? (see "the Hirsch Report")

• What are the net-energy consequences for a variety of likely mixes of energy sources (i.e. a specified mix of conventional fossil fuels, biofuels, nuclear, and renewable, for example)?

• How much can biofuels (ethanol, biodiesel) be reasonably expected to contribute to energy supply without negatively impacting food supply or prices?

• To what extent do limits on water availability restrict energy development from unconventional sources (both fossil-fuel based and renewable)?

• What is the CO2 emissions impact for likely future energy scenarios? (CO2 emissions will be tracked for all scenario runs).

• What is the energy cost and "carbon footprint" of CO2 sequestration proposals? Are they realistic?

• Is a "hydrogen economy" feasible? What are the net-energy and environmental implications of different approaches to hydrogen production? What would be the consequences of a "crash program" basing most transportation uses on hydrogen and fuel cells? How would that compare with an all-electric transportation scenario?

• Can we substitute energy products based on tar sands, shale oil and coal (CTL) for conventional liquid fuels? If so, how long would these resources actually last at different growth rates?

• What is the interaction of energy supply, demand, and price – how will energy price respond to supply-demand mismatch for world supplies of oil and natural gas? What's the elasticity of demand as energy prices go into new (higher) territory?

• As wealth flows into energy-exporting nations from energy importers, standards of living and demand for products and energy rises in the exporting countries. What are the consequences for availability of energy supply, and energy costs, for importing nations?

These are, of course, preliminary questions. Over time, new questions will be put to the model. A comprehensive and well-tested model will be able to answer new questions as they arise with only minimal modifications, if any.

The model incorporates complex relationships between energy, the economy, agriculture, industry, transportation, and the environment, including tracking CO2 emissions for all scenarios. Like the groundbreaking Limits to Growth more than three decades earlier, its results are not predictions of future events, but provide insight into the consequences of economic and energy policy decisions. The model is a policy-making tool that permits investigators to better understand the impacts of regulation, financial investment and incentives, and energy policy, and to analyze the consequences of developing various future mixes of energy source.

In addition, varying estimates of fossil fuel supply may constitute different scenarios – for example, using ASPO's estimate of recoverable oil and gas, vs. those of USGS/EIA, are two scenarios we can run to explore the consequences of those supply estimates – are fossil resources in "Scenario X" sufficient to enable investment in renewable sources while simultaneously supplying the exploding energy needs of a growing global consumer society? Or does competition between investment in future energy supply and "everything else" force difficult decisions about how to ration energy and economic capital?

During a scenario run, decisions are made which influence the outcome. The results will be collected and analyzed to understand which decisions yield preferred outcomes. We intend to disseminate the results of model runs to a broad audience of academics, energy researchers, the public, companies in the energy industry, and (most importantly) to policy-makers at all levels of government.

Recent studies, like "The Hirsch Report" commissioned by U.S. DOE, and released in early 2005, warn of potentially serious consequences if we fail to respond in time to the threat of depletion of fossil fuel supplies. A model of world energy flow will permit a more detailed investigation of these scenarios and what energy policy decisions, and timing of implementation, will best reduce the impact of depletion.

Climate change is obviously a critical topic now getting enormous media and political attention. While it will not attempt to model the complex relationships between anthropogenic CO2 emissions, climate, and the human economy, the model will monitor CO2 emissions for all scenarios. The consequences of those emissions – temperature changes, regional and global weather changes, agricultural impacts – may be factored into some scenarios. In those cases the necessary data will be imported from results of dedicated climate-change models. Those impacts will then, via various feedback paths, affect other portions of the model – for example, modifying agricultural output as a consequence of changing long-term weather and rainfall patterns.

The model will account for and track flows of energy and materials based on physical laws (i.e. energy and matter cannot be created from nothing). It will access a database of EROI (energy return on energy invested) for all forms of energy – conventional, renewable, and unconventional. The model will show what is possible, given known constraints on energy availability, material resources, and financial capital.

We will develop the world energy model as an "open source" project – anyone with Internet access will be able to run the model and view the results of scenario runs.

One goal of the project is to develop a simple game-like user interface that makes the model accessible to those without experience in modeling complex systems. Others with more expertise will be able to go into the model, understand how it works ("transparency" is another goal), and develop their own scenarios. Model users from around the world will be able to communicate with each other using a web site dedicated to model discussion, modification, and operation.

There will be a presentation of the results of preliminary scenario runs at ASPO-USA conference, Houston, in October.

Public announcement of the predecessor to T21-North America was on Monday, July 16th at New America Foundation in Washington DC. TOD readers can view the presentations including my discussion of the motives for modeling world energy flow here and clicking on the embedded YouTube link.

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