A REPORT ON THE EMF 19 STUDY ON TECHNOLOGY AND GLOBAL CLIMATE CHANGE POLICIES

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Introduction

This paper reports on progress to date - and plans for the future of - the Stanford Energy Modeling Forum (EMF) EMF 19 study on "Technology and Global Climate Change Policies." The primary focus of this effort is on designing alternative sets of technology assumptions and ways to represent technological progress that can be used to study the costs of alternative global climate change policies. The working group for this study includes key government and industry technology evaluators, developers and keepers of relevant technology data bases, economists interested in technology, technological change and technology policy, and global climate policy modelers. This study includes models developed from around the world (e.g., Australia, Germany, Netherlands, Japan and the U.S.).

Objectives

Estimates of the costs of alternative global climate change policies depend strongly on assumptions about the cost and performance of current and future technologies. The technology assumptions that have been made in constructing many widely cited baseline scenarios and policy excursions made from them are not well understood. This situation leads to confusion about what technologies and technology strategies are already included in the available projections.

The primary focus of this effort is on the design of design alternative sets of technology assumptions that can be used to study the costs of various global climate change policies. Included in these technology assumptions are the concerns such as how to represent alternative greenhouse gases (other than carbon dioxide) and carbon sinks. Although this effort involves global models developed around the world (e.g., Australia, Germany, Netherlands, Japan and the United States), this year’s effort will focus on technology issues most relevant for U.S. policymakers. A more selective focus will help the group to understand the key dimensions of the problem before expanding the analysis to Asia, Europe and in key developing countries. This approach will also allow us to develop the appropriate international research support for adopting a more global perspective.

Approach

The EMF (Energy Modeling Forum) was established in 1976 to provide a structured forum within which energy experts from government, industry, universities, and other research organizations could meet to study important energy and environmental issues of common interest. The Forum seeks to: (1) harness the collective capabilities of participating experts for improving our understanding of an important energy/environment problem, (2) explain the strengths and limitations of competing analytical approaches, and (3) identify high priority directions for future research.

EMF studies emphasize the important insights for energy planning and policy that are learned from a comparison of alternative modeling approaches. These insights are far more important than precise "forecasts" based upon a single perspective or expert. This focus makes the Forum's conclusions relevant to policy makers and decision makers who are not modeling experts.

While much is learned from comparing existing energy models, EMF studies have increasingly included supporting analyses of issues less amenable to modeling. In this way, the EMF has become a forum for improving energy and environmental analysis in private and public decision making.

The heart of each EMF study is an ad hoc working group, organized to examine a single topic to which many existing models can be applied. The working group chairman and the issues to be studied are determined before the working group is formed, with the chairman helping to recruit the working group members. Individual invited to participate in a study are considered to have expertise in the topic under investigation. Also these individuals may be able to recommend other prospective participants for a study. A working group consists of 50-100 members, comprised of equal numbers of model builders and users, who are volunteers with very diverse backgrounds. Approximately 1/3 of the participants are from government, 1/3 are from academia, and 1/3 are from the private sector. These individuals represent a mix of corporate, academic and government perspectives. The goal is to form a diverse working group, composed of members familiar with models and modeling, policy issues, and with a desire to improve the application of models to policy and planning processes.

A study normally requires four to eight working group meetings and a substantial amount of interim model execution and EMF staff work. The first meeting establishes the problem structure and key parameters of the topic under review. The participants select the set of energy/environmental models to be examined in the analysis. EMF 19 is the19th major energy-environment study initiated by the EMF. It has also organized numerous Workshops and symposiums over its twenty plus year history.

Project Description

The EMF 19 Working Group will meet as a whole approximately every six months, and various study groups comprised of subsets of members of the full working group will meet on there own (frequently in concert with meetings of other related groups) in between the full working group meetings. So far three study groups have been initiated: (1) long-run economy/technology baseline scenarios, (2) characterization of current and potential future technologies, and (3) ways of modeling technological change. This should serve to maximize the participation of key technologists, developers and keepers of relevant technology data bases, economists interested in technology, technological change and technology policy, and global climate policy modelers. The major overlap in the membership in the study groups are the global modelers. The cross-fertilization between modelers and technical experts can be very productive, as has been the case in previous EMF studies.

Accomplishments

The models participating in the study so far are shown in the attached Table. All of the modeling teams listed have expressed an interest in continuing to participate in the work of the technology study group. The majority of the time at the meetings would be to develop a broad, but balanced and realistic, set of alternative assumption about the costs and performance of future technologies and how fast they will be adopted.

In many models, technologies are represented with “production functions” that specify what combinations of inputs are needed to produce particular outputs. The production function specifies the rates at which inputs can be substituted for one another in response to shifts in input prices. As new capital investment occurs and older capital is retired, the technology mix within the model will change.

Two basic types of production functions may be specified. Some models (e.g., G-Cubed, SGM, and EPPA – see box for information on models cited in the text) use smooth and continuous aggregate production functions that allow incremental input substitutions as prices change, even if the resulting input configuration does not correspond to a known technology. These models do not represent individual technologies. Such models often assume 'nested' production functions: For example, at one level, substitutions are possible between energy, capital, and labor in producing final commodities; at a second level, substitutions are possible between electricity and fuel oil in producing energy; and, at a third level, substitutions are possible between coal and natural gas in producing electricity.

In contrast, other models (e.g. Markal-Macro and NEMS) draw from a 'menu' of discrete technologies, each requiring fixed input combinations—i.e., each technology is essentially represented with its own production function. This approach is often referred to as “process analysis.” These combinations correspond to those employed in actual, or anticipated, technologies that the modeler specifies. The technology-rich Markal-Macro model specifies over 200 separate technologies. For discrete technology models, different technologies become cost effective as input prices change. Modelers then assume that these technologies are selected and used to produce outputs. A number of models use a process analysis approach within the energy sector and an aggregate production approach for the remainder of the economy (e.g., MERGE, MARKAL-Macro). When using either approach, it is important to be able to distinguish between the causes of changes in the selections the models make among the existing technologies. Sometimes the technology choice changes because of changing prices, and sometimes it changes because of new technologies becoming available.

Some models represent both individual energy supply technologies and individual energy consumption technologies, and do not represent the remainder of the economy explicitly. With these models, however, the analyst must either: (1) assume that "end-use" energy demands (such as the demand for home heating and automotive transport) do not respond to changes in the prices of those services, or (2) employ a complex statistical estimation technique (that requires some historical data on the cost of end-use energy equipment) to estimate the price responsiveness.

As of the February 2001 meeting ten preliminary model comparison scenarios were being explored:

(1) A Modeler's Reference case with each team using the "no new climate policy" assumptions it feels most comfortable with.

(2) A Standardized Reference case using the IPCC's Special Report on Emissions Scenarios B1 scenario Regional population and GDP assumptions.

(3) A 550 ppmv case run relative to the Modeler's Reference case with the atmospheric concentration of CO2 limited to 550 ppmv.

(4) A 550 ppmv case (case 3) with a 50% increase in sequestration cost assumptions.

(5) A 550 ppmv case (case 3) with a 50% decrease in sequestration cost assumptions.

(6) A +$10/ton per decade carbon tax increase case which starts with a $10/ metric ton carbon tax in 2010, which increases by $10 per decade from then on.

(7) A +$10/ton per decade case (case 6) with a 50% increase in sequestration cost assumptions.

(8) A +$10/ton per decade case (case 6) with a 50% decrease in sequestration cost assumptions.

(9) A +$25/ton per decade carbon tax increase case which starts with a $25/metric ton carbon tax in 2010, increasing by $25/metric ton per decade until 2040, and then held at the $100/metric ton level through the end of the century.

(10) A +100/metric ton carbon tax case implemented in 2010 and held at that level through the end on the century.

A number of additional scenarios will be introduced over the next couple of years, but we are working to establish 2000 as a base year for the comparisons (which will take some time and effort), and waiting to see the results of COP-6 before finalizing the scenario design for the study.

So far three study groups have been initiated: (1) long-run economy/technology baseline scenarios, (2) characterization of current and potential future technologies, and (3) ways of modeling technological change. The baseline scenarios group will build on the IPCC's Special Report on Emissions Scenarios, specializing what is in that report to the needs of the Integrated Assessment community. The technology characterization group will try to systematically catalog what is currently being assumed on technology in the models and what is included in the technology data bases that have been developed, and ultimately help provide guidance on what would be optimistic and pessimistic technology assumptions. This group has prepared a detailed modelers' questionnaire and is working with many of the modeling teams on a on-on-one basis to find out what information is needed. The technological change group will continue the EMF history of reviewing and assessing the available approaches to modeling technological change, including the modeling of induced technological change and the limited modeling of the response to various kinds of technology policies that has been produced thus far. Additional study groups will be formed as seems appropriate.

An organizational meeting for this study was held in Snowmass Colorado in August of 1999 Presentations were made by representatives of each of the groups mentioned above and it was decided to ask the modeling teams to provide information on: (1) the technologies included in the model's typical baseline scenario, (2) what technologies would be employed if no new technologies were introduced after 2000, and (3) the technologies included in the model's projection of a 550 ppm carbon dioxide in the atmosphere scenario. It was also decided to look at a very broad range of technology options – at least initially. The following categories of technologies are being addressed: (1) energy supply technologies, (2) energy demand technologies, (3) carbon sequestration technologies, (4) technologies for reducing "other" greenhouse gas emissions, (5) "sink" technologies, and (6) possibly even technologies that would help people adapt to climate change when it occurs.

A second meeting was held in March 2000 in Washington D.C. The March meeting focused on the available estimates of the costs and performances of carbon-sequestration technologies, the costs of abating other, non-carbon greenhouse gases, and the various approaches for representing technological change in the available global models. The modelers will simulate several scenarios that will help to identify the major technology options that are important in both the baseline and the constrained greenhouse-gas cases. This work will be combined with technical assessments of the costs and performances of promising technologies, based upon available databases.

The group reviewed initial results from technology scenarios in Snowmass, Colorado, in early August of 2000. Where appropriate, participants updated these technology scenarios. A fourth meeting took place at Stanford University in February 2001. At that meeting sensitivities on GDP growth and sequestration costs were examined and new scenarios considering alternative rates of increase in a global carbon tax and alternative baseline assumptions were proposed. The results for these scenarios will be reviewed at a modelers meeting at the International Institute for Applied Systems Analysis (IIASA) in Vienna in June of 2001. Future meetings beyond that period could be held in Japan, Europe, the U.S., or other parts of the world.

Future Plans

Most of 2000 and early 2001 was spent on carefully describing what the models currently do in representing technology and technological change, and what enhancements and alternative ways of representing technology might be useful. During the second half of 2001 and beyond we will move towards employing a richer set of technology/economy baselines and the use of alternative technology/technological change scenarios based, in part, on the work of the technology characterization and methods for representing technological change study groups. Currently scheduled meetings include a large workshop on modeling technological change in Washington DC on June 3-5, 2001, and a modelers meeting in conjunction with the 20th annual meeting of the International Energy Workshop (IEW) at the International Institute for Applied Systems Analysis (IIASA) on June 19-21, 2001. For more information on the EMF 19 study contact John Weyant (weyant@leland.stanford.edu) or visit the EMF Web site at: http://www.stanford.edu/group/EMF/.

Models Participating in EMF 19 Study

ABARE-GTEM	Brian Fisher/Vivek Tulpule/Darren Kennedy/ Steve Brown (ABARE)
AIM	T. Morita, M.Kainuma (NIES, Japan) Yuzuri Matsuoka (Kyoto University)
AMIGA	Don Hanson (Argonne National Laboratory)
AS/ExM	Rob Lempert (Rand Corporation)
CETA	Stephen Peck (EPRI) Thomas Teisberg (Teisberg Assoc.)
CETM	David Montgomery/ Paul Bernstein (Charles River Assoc.) Thomas Rutherford (Univ. Of Colorado)
Dynamic New Earth 21	Kenji Yamaji/Yasumasa Fujii (University of Tokyo) Keigo Akimoto (RITE)
FUND	Richard Tol (Vrije Universiteit Amsterdam)
G-Cubed	Warwick McKibben (Australian National Univ.) Peter Wilcoxen (Univ. of Texas) Robert Shackleton (Congressional Budget Office)
GRAPE	Atsushi Kurosawa (Institute for Applied Energy, Japan)
Maria-8	Shunsuke Mori (Science University of Tokyo)
MARKAL-Europe	Tom Kram (ECN, Netherlands)
MARKAL-U.S.	Phillip Tseng (U.S. Department of Energy)
MERGE 4.1	Alan Manne (Stanford University) Richard Richels (EPRI)
MiniCAM	Jae Edmonds (Pacific Northwest National Lab) Sonny Kim (Pacific Northwest National Lab) Hugh Pitcher (Pacific Northwest National Lab) Ron Sands (Pacific Northwest National Lab)
MIT-EPPA	Henry Jacoby/John Reilly (MIT) Mustafa Babiker/Ian Sue Wing (MIT)
NEMS	Andy Kydes/Susan Holte (Energy Information Administration)
SGM	Jae Edmonds (Pacific Northwest National Lab) Hugh Pitcher (Pacific Northwest National Lab) Ron Sands (Pacific Northwest National Lab)
WorldScan	Ton Manders (Netherlands Bureau for Economic Policy Analysis) Johannes Bollen (RIVM, National Institute of Public Health and the Environment, Netherlands)