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Contents

Energy/Environment Management: A Tale of Four Regions

In a major research effort during the past three years, IIASA has carried out a comparative analysis of regional energy/environment systems in four different regions. The results of this effort were discussed at a Conference at Laxenburg earlier this year and will soon be published in a volume in IIASA's *International Series*.

During the early years of IIASA, several distinct research topics were pursued within the "Ecology/Environment Project", all of which have had similar underlying objectives, concepts, and methodologies. Case studies played a central role in each of the efforts. Each had as one of its major goals the further development of a "coherent science" or process for environmental and ecological management and made an explicit effort to design it for embedding within an existing decisionmaking or policy design framework. Probably the most widely known of these studies is the one on the spruce budworm (a forest pest in North America), which has developed new methodologies for addressing pest management problems as well as suggesting possible courses of action for the decision makers involved (see also OPTIONS, Winter 1977). Another case study concentrated on the human impact on high mountain regions (Obergurgl case study, see OPTIONS Summer 1978). A third major effort in this series, concentrating on the "Energy/Environment" Systems, is described below.

In early 1975, The Ecology/Environment Project of IIASA initiated a "Research Program on Management of Regional Energy/Environment Systems". The study, designed to integrate regional energy and energy-related environmental management from a systems perspective, had four primary objectives:

1. To analyze patterns of regional energy use and to develop insights into their relationships to socio-economic patterns.
2. To compare current methods for regional energy and environmental forecasting, planning and policy design.
3. To develop new concepts and methods for energy/environment management and policy design.
4. To examine alternative energy futures and strategies for the regions and to explore their implications from various perspectives.

Continued page 2

*Prof. Wesley Foell from the University of Wisconsin, Madison, led IIASA's research on developing new concepts and methodologies for policy design and management of alternative energy/environment systems, including a multi-national comparison of such systems, at the regional level from January 1975 to August 1977.

Energy/Environment Management: A Tale of Four Regions

Continued from page 1

Several "world" or "global" energy studies have been conducted within the past few years, e.g., the Workshop on Alternative Energy Strategies (WAES), The Second Club of Rome Report, the OECD energy forecast (World Energy Outlook), and the IIASA Energy Systems Program which is still under way. These international studies play an important role in providing a broad perspective for efforts to evaluate the combined *global* effect of various national strategies and technological choices. In contrast, a regional, rather than global, perspective was employed for the IIASA Energy/Environment study because of the conviction that many of the significant social and environmental consequences of energy systems are best analyzed within the context of a *limited geographical region*. Since many of the important energy and environmental decision and policymaking institutions are at the regional or national level, a usable policy tool or analysis should address systems at that level. Of course, this must be done with an eye to global concerns, which are becoming more apparent in all regions. By choosing regions with greatly differing characteristics, the IIASA team sought to develop a better understanding of some of the relationships within an energy system. Comparative studies of differing energy systems can help formulate a more generalized understanding of systems behavior, as well as an appreciation of the generality of the techniques used to study and manage them.

Four Differing Regions

Four regions were studied, three of them in Europe, one in the United States: Austria (IIASA's host country), the Rhone-Alpes area in France, the German Democratic Republic (GDR), and the State of Wisconsin in the USA. The studies were conducted by an international core research team at IIASA in close collaboration with energy and environmental institutions in each of the regions.

A comparison of historical energy use in the four regions has revealed some large differences. Wisconsin has by far the greatest per capita energy use—three times that of Austria—whereas on a density basis the GDR has almost twice the energy use of Rhone-Alpes and three times that of Wisconsin and Austria. Although the energy density varies considerably within a region, this overall density for the region is nevertheless indicative of the concentration of energy-related activities.

The primary energy sources differ significantly: nearly 70% of Austria's energy is provided by petroleum and gas (mostly imported). The GDR relies heavily on coal (mainly domestically strip-mined), whereas the Rhone-Alpes is heavily dependent on petroleum and hydropower. Wisconsin, although having no naturally occurring fuel resources within its boundaries, has a diverse supply mix consisting mainly of petroleum, natural gas, and coal; uranium has provided a growing fraction of its energy.*

Scenarios to View the Future

The IIASA study used scenario building as a formal quantitative approach to policy analysis and the examination of energy/environment strategies. The process was one of

1) specifying given policies for the regions, within the framework of their initial conditions and constraints, and

2) evaluating the resulting development and evolution of the regions.

The policy issues were chosen on the basis of their common interest to the regions as well as for their relevance in the mid- to long-time frame (5 to 50 years). The issues were addressed by two specific paths. First, alternative "policy sets" were developed for application in each region and the resulting scenarios were investigated. Second, "sensitivity studies" were conducted to evaluate the effects of variations in only one or a few policy variables while holding the others constant.

In order to create a framework within which a scenario could be built, four overall characteristics were specified, namely: Socio-economic structure; Life-style; Technology; and Environment. Within these four general categories, a large number of assumptions about policies and/or future events were built into the scenarios. The resulting energy futures were not developed as predictions, but rather were intended to help test and compare the consequences of different policy choices. The policies and assumptions were not chosen arbitrarily, but were developed from lengthy and repeated interactions with collaborating specialists in the respective regions. Where possible, they were tested by reference to other economic or technical studies, such as the GDR long-term energy outlook and national energy assessments in France and Austria.

Methodology

The principal analytic tool used to examine the scenarios was a family of simulation models [1] originally developed in part at the University of Wisconsin and extended at IIASA to treat energy/environment systems with characteristics differing from the Wisconsin system. The models simulate a region's energy system within a framework that includes energy demand, regional supply systems, and environmental impacts. Most of the models are based on engineering process descriptions. Socio-economic development of the regions, e.g., population, settlement patterns, economic activity, etc., was modeled differently in each of the regions; the techniques ranged from extrapolating the trend of the value-added variables (Wisconsin) to use of a demand-oriented input-output model (Austria). In all cases, care was taken that the regional socio-economic development scenarios were consistent with national and/or global patterns.

Because the studies for the GDR, Rhone-Alpes and Wisconsin were conducted simultaneously and coordinated rather closely, some scenario characteristics could be specified in common to all three of the regions, e.g., stronger conservation measures, greater emphasis on renewable energy sources, etc. Although the Austrian study was conducted subsequently, the scenarios were specified in a similar manner. For all regions, the energy scenarios could be categorized as high, medium, or low cases. The policies and assumptions in the medium cases are in general a continuation of current trends (at the time the scenarios were constructed) and assume no dramatic changes in energy prices. The high scenarios result from policies leading to higher growth in energy use; they are based on the presumption of decreasing relative energy costs and few incentives for improved efficiency of energy use. The low energy scenarios are based on the presumption of higher relative energy costs and on the desirability of energy saving measures; however, they do not depict the lowest energy consumption future that could reasonably be constructed.

Low Growth Rates of Energy

In general, the major findings of these studies are not the result of any single scenario, but rather were deduced from the analysis of the entire set of senarios and sensitivity studies. The scenarios studied for all four regions indicate that future energy growth rates will be considerably lower than historical values, although the regions differ considerably. In Austria for instance, in the case of vigorous conservation measures and somewhat lower than historical economic growth, the growth rate for energy demand could drop to less than one percent per year after the year 2000 (during the sixties it averaged more than five percent).

Another important result of the study was additional insight into the oft-debated relationship between energy-consumption and economic growth. In the scenarios we have investigated the potential concurrent trends in economic activity and energy use by means of an

*However, a moratorium on new nuclear plants with the exception of those now in the planning stage has recently been imposed.

"inferred elasticity"; this elasticity expresses the ratio of percentage change in annual energy use to percentage change in economic activity (e.g., GNP). In general for all of the regions, the elasticity over the next few decades was less than one, indicating that the ratio of primary energy to GNP decreases over time. Decoupling of GNP and energy growth in part reflects the shifts of these industrialized regions toward more service-oriented societies. The shift contrasts with developing countries, which, during certain phases of industrial development, may experience energy growth rates exceeding GNP growth. This contrast may be analogous to what is known as the "demographic transition" in population dynamics (in developed countries, birth rates tend to decline and migration patterns change). This interpretation of the energy dynamics needs considerably more investigation under more diverse conditions. The current extension of our studies to developing regions of the world should shed further light on the subject.

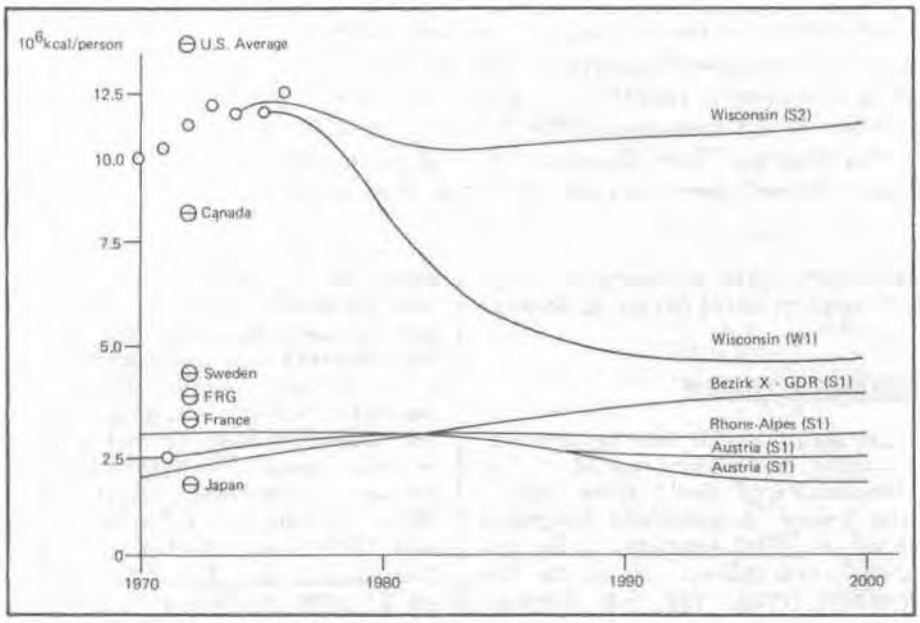

Figure 1: Personal Transporation Energy Use Per Capita:

Bezirk Z - GDR (S1):	Car ownership rises to approximately 240 cars per 1000 persons by 2025; fuel economy remains approximately constant.
Austria (S1):	Car ownership and efficiency saturates at 300 vehicles per 1000 persons and 8.9 liters/100 km, respectively.
Austria (S4):	Same as S1 except efficiency improves to 7.0 liters/100 km.
Rhone-Alpes (S1):	Ownership and efficiency do not greatly change.
Wisconsin (S2):	Fuel efficiency remains at level of 1975 cars; ownership and travel length unchanged.
Wisconsin (W1):	Introduction of U.S. Energy Policy and Conservation Act standards.

The graph also indicates levels of per capita energy use for personal transport for some other countries for reference.

Petroleum Consumption in the USA

A number of interesting features of future energy demand were examined for various economic sectors (residential, transportation, industry, commercial and service). For example, the present per capita energy consumption for personal transport is four times as high in Wisconsin as in Austria. With no significant improvement in fuel economy (Scenario S2 in Fig. 1), the Wisconsin consumption (mainly petroleum) would remain far higher than in the other regions. The U.S. Energy Policy and Conservation Act (EPCA), which requires an annual fleetwide average fuel economy for new cars sold that reaches 8.6 liters of gasoline per 100 kilometers by the year 1985, will dramatically change this situation (Scenario W1 in Fig. 1). This reduction in consumption in the transport sector could have an important impact on the oil imports of the United States. Our studies [2] indicate that a continuation of the rapidly increasing auto ownership in the GDR, and a modest extension of EPCA in the USA would result in Wisconsin per capita use for personal transport exceeding that of the GDR by only 20% in the year 2000 (Fig. 1).

Environmental Implications

The analysis of environmental consequences was one of the major objectives of regional scenario building. A wide range of environmental indicators was used to characterize the environmental implications of alternative energy policies. The choice of this set of impacts is of course a subjective one, and varying degrees of uncertainty and controversy are associated with many of the impact factors. Nevertheless a system-wide picture of these quantified impacts has provided valuable input to energy policy in the regions [3].

Aim: Improved Energy/Environment Management

The preceding paragraphs have highlighted only a few of the results of our research. The testing and development of methodological tools for the greatly differing institutional frameworks was a challenging and valuable experience for the IIASA research team [4]. But of equal importance is the significant transfer of models and analytic methodology between IIASA and the collaborating institutions in the regions. For example, in Austria, the Electric Utility Association is already making use of the IIASA/Wisconsin energy demand models for examining its electricity forecasts; the City of Vienna has employed the residential sector model to explore alternative energy conservation strategies. In the GDR, both the scenario results and some of the methods of environmental impact analysis are playing a role in energy planning at the Leipzig Institut für Energetik, the main planning arm of the Ministry of Energy. In Wisconsin the entire family of models has been incorporated into the Office of State Planning and Energy.

A Research Network

One of the most important outputs of this research has been the creation of a network of research institutions, coordinated by IIASA and providing it with encouragement in its role as catalyst and coordinator of policy-oriented research in the international scientific community. Scientists from these institutions continue to address in concert the problems addressed in the IIASA study, and work on other regions is already underway. Although we realize that there can never be a universal energy/environment model, our long range goal is generalization of the approaches into a coherent and sound process for resource management in all regions of the world.

References

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Global Modeling: Modeler Client Relationships

J. Robinson*

Ever since its foundation in 1972, IIASA has provided a forum for the small community of global modelers, which started forming itself in the early seventies. Although no actual Global Modeling research is carried out at IIASA, the obvious interaction of the Institute's own global studies in certain sectors (energy, food and agriculture) meant that it was natural for IIASA to keep a monitoring brief on the work going on elsewhere in the world, and the most satisfactory way to do this was to provide an international forum for the interchange of experience via a series of annual conferences. The latest meeting in this series, the Sixth IIASA Global Modeling Conference, which took place from October 17 to 20, concentrated on issues in global modeling rather than dealing with one or two specific models. One of the most controversial issues discussed at this meeting was the relationship between the modeler and his client, an issue not only important for global modeling, but for mathematical modeling in general. As we feel that this topic is of interest to a wider audience, OPTIONS publishes the following paper on the Modeler-Client Relationship in global modeling which reflects the author's personal account of this discussion.

Global modeling started out as client-directed, under a strong client, and shifted to become academic and client-independent. The client centeredness of the first global models is clear. The Club of Rome set the ball rolling—first they hired Hans Ozbekhan, a cybernetician, with the hope that he could assist in conceptualizing and clarifying the tangle of interrelated problems that the Club called the "global problematique". The Club remained in a directing position; when Ozbekhan's work stayed too long on too high a level of abstraction, they withdrew support; whereupon Jay Forrester appeared on the scene. Forrester is by training an engineer, and he related to the Club in a fashion typical of engineer-client relations. After ascertaining the problem focus of the intended model at a Club of Rome meeting, Forrester built a simple working prototype model—WORLD 1—for client review. WORLD 1 was enthusiastically received, and was revised and documented as WORLD 2. After approving the prototype, the Club found funding for a full-scale marketable product—WORLD 3, which was constructed by former students of Forrester under his supervision. The Club only relinquished control when the exercise had produced their desired product—as evidenced by the fact that client pressure drove the modelers to violate their scientific values by publishing the *Limits to Growth* before the technical documentation for WORLD 3 was completed.

The Modeler as Client

Later global models have become progressively less client-oriented. The Mesarovic/Pestel World Model (otherwise known as the World Integrated Model or WIM) originated under the special circumstance of having the modelers among their own clientele. This allowed the modelers to follow their proclivities with minimal external control. The result was a large detailed model with central conceptualization designed in accordance with the modelers' perception of the global system. In theory the model was user-oriented. However, for the Mesarovic/Pestel Model, "client-oriented" had a distinctly different meaning than for the three WORLD models. In the WORLD models, "client" was a specific, named entity. In the Mesarovic/Pestel work, "client" was a generic concept, and the model aspired to be adaptable to many clients—mostly policy makers. The WORLD models were custom designed. The WIM was not. In my observation the multiple-client strategy has been only partially successful. That is, a large number of agencies have been convinced to contract for use of the WIM and have reflected with interest and curiosity on its outputs, but it has not to date come to be well understood or institutionalized as a planning tool by any of its users.

Like the Mesarovic/Pestel model, later global models were based on modeler perceptions of the world and have sought clients for their work in national governments and international organizations. The UN World Model, FUJI, SARUM and the Latin American World Model have all been brought into policy analysis in one way or another. None of the modelers involved are terribly enthusiastic about the results of their work in the policy arena, and several are openly cynical. Complaints against policy makers include the following: they only listen when you tell them what they want to hear; their time horizons are too short to use long-term models; and they are not open to insights about how the world operates.

Will the Client Believe?

The policy-makers' version of these stories remains unrecorded; however, given the large number of people with solutions to the world's problems and the equally large number pointing out the difficulties with the policy-makers' solutions, it is not surprising that policy makers have not paid global modelers much heed—especially given the controversial character of many models and their typically large number of unrealistic caveats (e.g., assuming no wars or revolutions and no technological shifts). There may be a basic principle to be discovered here. For example, where the part of model structure clearly relating to client interest is dominated by a structure that does not relate to client conceptualizations, it is very difficult for the client to understand or trust the model. If this rule holds, it follows that models have to be almost custom designed to establish client rapport, and that modeler-conceived multi-client models are prone to failure.

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Get Rid of Clients?

The logical next step after multi-client modeling is "clientless" modeling, meaning not modeling without a sponsor (which, given the costs involved, is almost impossible) but modeling where neither the sponsor nor parties associated with him are involved in model conceptualization or development.

The only obvious niche for clientless modeling is pure science, where funding is procured for theoretical research and research findings are to be presented to scientific peers. Pure science, however, is an uncomfortable niche for the global modeler. First, competition is tight and funding has become extremely hard to secure. The scientific establishment appears to question whether global modeling is a science—or an exercise in ideology—and is not easily convinced of the values of further global modeling work.

Second, the traditional modes of communication in the sciences are not adequate for the presentation of global models. Scientific journal articles are a poor forum for the description of models. Model documentation is difficult and expensive to prepare, voluminous generally, and boring. Publishers are hard to find, audiences are sparse. Once published it is as likely as not that an article will merely gather dust. The only fast way for academic articles to reach a wider public is for them to be picked up and transmitted by the popular press—which may sufficiently distort an article's content that the publicity becomes more of a curse than a blessing.

Third, the academic atmosphere, with its selection pressures favoring the esoteric, the refined, the theoretically pure and the specialized, is not a particularly healthy environment for multi-disciplinary global modeling. Criticism from an academic audience does not generally help a modeler develop an overview of the real world, or assist him in figuring out what in his model is of general importance, what is unclear or incomprehensible, and what is nonsense. Rather, it tends to call his attention to abstract details, such as whether he would have done better to use some other data base, computing routine, or estimation procedure.

Ironically, the attempt to be purely scientific and client free seems to be responsible for giving global modeling something other than the basically cooperative and universal-minded spirit that is supposed to characterize pure science. With funding scarce and audiences growing deaf, global modelers are apt to make a case for their own work by overselling it and deprecating the work of others, only to be followed by others who denounce their work in turn. This situation seems to have worked itself to its logical conclusion: funding seems at least temporarily to have dried up for academic models of the world. To my knowledge no new global models have been initiated in the name of science since about 1974.

The Past and the Future

Over the course of the past decade, global modeling has moved out from under the wing of the Club of Rome and come to be sponsored both as a policy tool and as a form of academic analysis. In general, recent sponsors of global modeling have not known what they want from global models, and have not found much use for their output. Shortages of funds have constrained some modelers and eliminated others. At times competition for the limited available funds has become uncivil and characterized by overselling and slander, Public audiences seem bored with global modeling, and the scientific community remains sceptical.

If modeler-client relationships continue in the present vein, a scenario for the next decade might be:

1) Mesarovic, the Carter-Petri (the UN World Model) group and other multi-client strategy modelers will find occasional commissions by various bureaucracies, but no meaningful sponsorship.

2) The institutionalized modeling groups (SARUM and FUJI) will be funded until some bureaucratic adjustment cuts them off.

3) Two or three more books will come out documenting global models, but they will probably not sell well; and

4) Global modeling will pass away as a fad.

The above scenario, like most trend extrapolations, misses turning points; it is unlikely that global modeling will arrive at the above dead end. Three factors are operating to alter the present trend:

1) Modelers are becoming more professional.

2) Potential global model clients are getting more numerous and more sophisticated, and

3) The global situation is becoming more critical, making the need for models greater and more apparent.

Below the three factors are examined separately.

Professionalism Replacing Pioneering

The early years of global modeling were characterized by exuberance, unrealistic expectations and inexperienced management. Costs and time requirements were grossly underestimated with the consequence that model construction greatly overshadowed model testing, documentation and refinement. Much of the energy used in global modeling has gone to "starting costs" such as learning how to run interdisciplinary investigations, finding data sources, constructing software, and finding capable staff members. Modelers appear to be catching on to procedures such as budgeting for documentation and testing; and start-up costs decrease with experience. Those who continue with global modeling should be able to turn out better quality work at a lower cost than did their predecessors—although the excitement of the earlier work has died down.

Changing Clientele

Various institutions—including the World Bank and oil companies—have discovered that world models constructed to solve their specific problems can be useful, and have begun to employ modelers. The resulting models are tending to be custom-designed, as were the WORLD models. There also appears to be a tendency for national planning models to expand their treatment of the rest of the world—and to move toward greater consideration of intersectoral activities. In the USA, for example, the International Energy Evaluation System (IIES) has replaced the Project Independence Energy System (PIES); almost everywhere agricultural models are being expanded to account for increasing energy costs.

Furthermore, clients should be getting more sophisticated. Each year more people are trained in computer techniques of all sorts, and each year people with training in systems analysis gain seniority.

Changing Global Situation

Finally, the seriousness of global problems will increase over the next few decades, and with it the urgency for new integrated approaches to their management. Modeling could serve a useful role in reducing the uncertainties, and helping to derive efficient and humane strategies for its management.

In sum, global modeling is an evolving institution in a rapidly changing environment. In the past, modelers have looked increasingly to academic sponsors for support, which appears to be an evolutionary dead end—both because academia lacks funds and because it does not provide selective pressures that encourage pragmatic, interdisciplinary, holistic thinking. However, pressures are mounting, from both modelers and clients, and from changes in the global situation as well, to bring global models out of the ivory tower and into a useful role in dealing with global problems.

New Books from IIASA

Myths and Uncertainty

In the third volume of IIASA's *International Series*, C.S. Holling and his colleagues offer a new and exciting approach to environmental assessment and management. *Adaptive Environmental Assessment and Management* debunks the myths of current practice, replacing them with an approach based on a fundamental understanding of the structure and dynamics of ecosystems. In addition to providing a step-by-step account of the entire process of adaptive environmental management, the book illustrates, through case histories from Europe and North and South America, the application of this new approach in settings ranging from the Pacific salmon fishery to regional development in Venezuela. It is, in fact, a book for policy analysts in general as well as for those concerned with environmental policy alone.

The vital importance of an *adaptive*, rather than a *reactive*, approach is emphasized throughout the book—only in this way can ecological understanding be used to improve and guide program development and management. This adaptiveness is made necessary by the recognition that uncertainty is an inevitable and significant part of all environmental planning and management—it is not something that can or should be eliminated. There is uncertainty—obviously—about the effects of a proposed development on the ecosystem, but there is also—less obviously—uncertainty about the time and complete nature of the current state of the ecosystem, uncertainty that no amount of sampling or investigation can eliminate. There is uncertainty about the economic and social systems with which the ecosystem is linked, and there is uncertainty about the value system within which assessment and management is done. Even the ultimate objectives of environmental policies and programs may be uncertain.

Even though, as Holling says, man has always lived in a sea of the unknown, dealing with uncertainty through trial-and-error, the costs of error have grown so alarmingly of late that it has become common to attempt to eliminate the uncertain and the unknown, rather than to engage in "experiments" whose effects may be catastrophic and irreversible. This attempt is of course doomed to failure, and the environmental policies that emerge from it are often sterile, static, and brittle. "Maximizing the distance from an undesirable region is within the highly responsible tradition of safety engineering, of nuclear safeguards, of . . . health standards. It works well if the system is simple and known—say, the design of a bolt for an aircraft . . . . The goal is to minimize the probability of failure. For bolts, this approach has succeeded." The failure of an aircraft bolt, though unlikely, has dire consequences—how much more dire would the consequences be if an environmental policy were designed by this method, especially as such failure is infinitely more likely, since an ecosystem and the impinging economic, social, and institutional systems are hardly "simple and known".

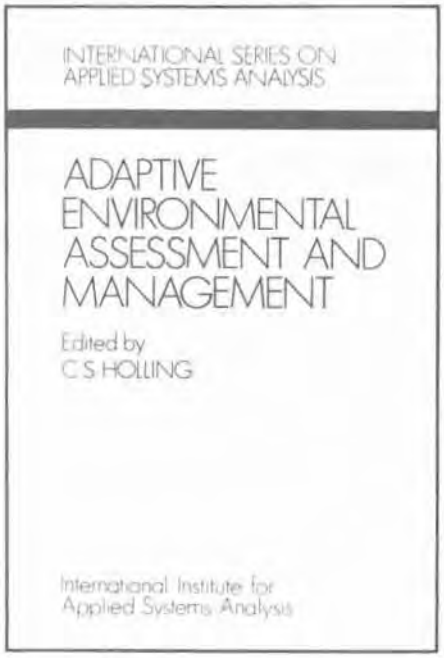
What Holling and his colleagues propose is designing *for*, rather than *against*, uncertainty. "If surprise, change, and the unexpected are reduced, systems of organisms, of people and of institutions can "forget" the existence of limits until it is too late." *Adaptive Environmental Assessment and Management* reflects this view of reality.

Part 1 of the book offers a step-by-step description of the theory and practice of adaptive environmental assessment and management, with chapters on "The Nature and Behavior of Ecological Systems", "Steps in the Process", "Orchestrating the Assessment", "Choosing a Technique", "Model Invalidation and Belief", "Evaluation of Alternative Policies", "Communication", and "An Underview". Throughout this part, the vital importance of continuing communication and interaction between scientist and manager is emphasized, and innovative methods of achieving this communication are described.

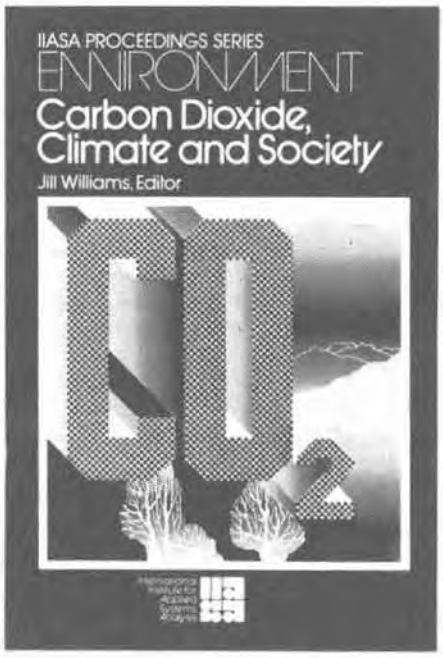
Part 2 documents the specific applied problems that figured in the development and testing of the general approach to adaptive impact assessment and management. The examples discussed include the well-known spruce-budworm/forest management problem (see OPTIONS, Winter 1977) and the Obergurgl study (land use and development in an alpine region of Austria, see OPTIONS, Summer 1978); much of the work on these two studies was performed at IIASA. The other three case studies—of Pacific salmon management, regional development in Venezuela, and a wildlife impact information system—may be new to readers of OPTIONS.

Both IIASA and UNEP, who cosponsored the work, feel that this book is a uniquely valuable contribution to the literature of ecology, and environmental management, operations research, and systems analysis. And, since it is written in a style that makes it easily understandable to managers, government officials, and others who may not have advanced scientific training, it will convey IIASA's message—that systems analysis can contribute to the solution of real problems (and has, indeed, done so)—to a new and larger audience.

Jeannette Lindsay



—*Adaptive Environmental Assessment and Management*, edited by C.S. Holling, ISBN 0-471-99632-7, can be ordered from John Wiley and Sons Ltd, Baffins Lane, Chichester, Sussex PO19 1UD, England. The price is $16.50.



—*Carbon Dioxide, Climate and Society*, edited by J. Williams, ISBN 0-08-0232 52-3, can be ordered from Pergamon Press, Headington Hill Hall, Oxford OX3 0BW, England.
The price is $30.00.

News from IIASA

CO_2 Proceedings

Most of the world's leading experts on the effects of CO_2 on the climate met in Baden near Vienna earlier this year to examine the latest evidence on this question that could affect the world's future use of fossil fuels. Readers of OPTIONS will recall our report on this Workshop, that was cosponsored by the World Meteorological Organization (WMO), the United Nations Environmental Programme (UNEP), the Scientific Committee on Problems of the Environment (SCOPE), and IIASA (see OPTIONS Spring 1978). Now the proceedings of this Workshop have been published as the first volume of the new *IIASA Proceedings Series* with Pergamon Press.

The major topic of discussion at the Workshop was how to make policy decisions when we face uncertainty about

- where the Carbon Dioxide is and how long it will stay there,
- what effects it will have on the climate,
- and, taking into account the first two points, what has to be done.

The Workshop's three Working Groups concentrated on these crucial issues. First, the question of the sources and sinks of Carbon Dioxide and the transfers of Carbon between the atmospheric, biospheric, and oceanic reservoirs was considered. Although future levels of atmospheric CO_2 concentration can only be predicted with detailed knowledge of the biogeochemical carbon cycle, the Working Group concluded that reasonable predictions can be made for a period of 20-30 years, using the existing models.

Given that the atmospheric CO_2 concentration will reach a certain level in the future, the second Working Group examined the impact of this Carbon Dioxide on climate and thus on environment, including such areas as agriculture and ice caps.

The third Working Group then considered the interaction between energy strategies and the CO_2 problem. The Groups discussion centered on the question: what are the tolerable rates of burning fossil fuel?; and derived policy statements, which reflect the importance of flexibility in determination of energy policies.

The Working Group's conclusions together with the papers presented at the conference, all included in the proceedings, not only provide a unique overview of the state-of-the-art in this field of research but also indicate the next steps to be taken by science and which strategies in tackling this problem appear to be reasonable, taking into account the present—limited—knowledge on the CO_2 problem.

External Funding Contracts

During the past few months, a number of external funding contracts have been completed. The Institute's Energy Systems Program has submitted four studies recently:

- The first, a "Systems Study on the Possibilities of Large-Scale Utilization of Solar Energy in the Federal Republic of Germany", was supported by a grant from the FRG Ministry for Research and Technology at a level of DM 481.000 over a period from August 1975 to September 1978. Four options for solar energy conversion were selected as being of specific interest in the FRG:

1. Low temperature systems for space and water heating.
2. Medium temperature systems for process heat.
3. High temperature solar-thermal systems.
4. Photo-voltaic systems for electricity production.

The analysis, which included the study of storage alternatives, performance and cost assessments and capital and energy payback estimation, indicated that the low temperature systems may offer the earliest potential, if further improvements and cost reduction are achieved. It appears that the potential of the other options remains uncertain until further developments prove successful.

- The report on the study for the Austrian National Bank of capital and currency requirements as constraints for future technological strategies for meeting energy demand has been delivered. This was supported over the period July 1975 to December 1977 at a level of AS 280.000 from the Bank's Jubilee Fund. The study, entitled "Long-Term Energy Strategies: Manpower and Capital Requirements" examined the interaction of the energy sector with the rest of the economy. It describes a methodology for approaching long term and global energy development analysis.

- "The Dynamics of Energy Systems and the Logistic Substitution Model" is the title of the final report on a DM 144.400 grant made by the Volkswagen Foundation to IIASA on "Mechanisms for Market Penetration". The work was carried out by a team under Dr. C. Marchetti between January 1976 and February 1978. The objective of the study was to explore the potential and mechanisms of logistic analysis to describe the structure and evolution of energy systems. Over 300 cases of substitution between energy sources over history were analyzed for 13 countries (as well as for the world as a whole) and the "fit" of the logistic description of substitution was found to be remarkably good. The accuracy of the approximation has provided an important check on the consistency of the modeling work of the Energy Program as a whole.

- A second study for the Volkswagen Foundation carried out by the Energy Program was also initiated in January 1976. Entitled "Procedures for the Setting of Standards", the study was supported at a level of DM 377.200 until its completion in May this year. The team under Professor Haefele was required to analyze existing procedures for standard setting. The studies identified several possible uses and limitations of the three analytical approaches investigated: policy analysis, decision theory, and game theory. Uncertainty, conflict, and institutional constraints emerged as the main areas of regulatory concern in standard setting.

IIASA's Resources and Environment Area has completed two studies for funding agencies:

- The first, a further study for the Volkswagen Foundation, on the modeling of water demands, has just been submitted. The report derives from a study of water demand analysis carried out in the last two years under the leadership of Dr. Janusz Kindler. The work constitutes a comprehensive discussion of all aspects of modeling and forecasting of water demands, a subject which is increasingly being recognized as of foremost importance to water resources management, in view of its relative underattention compared with water supply studies. The work was made possible by a grant of DM 275.000 for the period from January 1976 to May 1978.

- A contract with the Austrian National Bank on regional energy/environment interaction has been brought to a particularly satisfactory conclusion. The executive summary report on the Austrian case study by Professor Foell and his team has already been used in a number of ways. In particular, it has been incorporated in the energy concept for the City of Vienna, as a basis for the scenarios under consideration for Vienna (see also "A Tale of Four Regions" in this issue of OPTIONS). In addition, one of IIASA's collaborating institutions in the work, the Austrian State Utilities Board, has subsequently provided financial support for the purpose of implementing IIASA's computer models on their own machine. The Jubilee Fund of the Bank made available over 800.000 Austrian Schillings to support the work carried out between July 1975 and June 1978.

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