APPLYING SYSTEMS ANALYSIS IN AN INTERNATIONAL SETTING

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Howard Raiffa's legacy was an Institute that had been brought from a vague ideal to a functioning reality. In October 1972 there had been a Charter and a wish; in November 1975, there were over 60 scientists, 11 research projects, and a growing body of research results.

At the beginning of Raiffa's term there were questions about the meaning of systems analysis in an international setting, about the proper role for IIASA, and about the appropriate strategy for IIASA to pursue. By the end of those years, enough experience had been gained to enable us to formulate answers with sufficient clarity to guide the Institute in its next phase of development.

I shall first address the answers to those three questions:

- What is the meaning of "applied systems analysis" at IIASA?

- What is the proper role for IIASA?

- What strategy should IIASA follow to fulfill its role?

Then I shall explore the likely results of IIASA's efforts, and try to define what might reasonably be expected by our Member Organizations and the international community from our activities.

APPLIED SYSTEMS ANALYSIS AT IIASA

When IIASA began there was no experience with the conduct of applied systems analysis in an international, East-West, setting. Many nations had traditions of analysis of complex systems as an aid to decision makers; but these traditions were by no means identical. The stages of development differed widely in different countries, as did the meaning, the purpose, and even the name of the activity.

What in some places was called "systems analysis" was elsewhere called "policy analysis", "operations research", "cybernetics", or "qualitative planning". What in some countries was still a field of academic inquiry was in others a working tool for real decision-making agencies. And although in several nations the emphasis was on the study of complex systems to gain understanding of them, in others it was on providing analytical assistance to decision makers.

These differences existed within countries, as well; there were in many nations groups of scientists and decision makers who were skeptical about the validity and potential benefits of systems analysis.

Thus, the phrase "applied systems analysis" did not sharply define what the Institute would do or how it would go about it. Rather, it set a tone and an aspiration, which had to be given form and content through invention and experimentation.

Now, from the initial three years of experimentation some answers are beginning to appear. The first--and perhaps most important--conclusion is that there is no single model that all systems analyses at IIASA can follow. Instead, there are a number of distinct patterns, adapted to the circumstances of the system being studied and the decision problem being investigated. Let me explain.

One type of systems analysis is illustrated by the first study made by the Ecology project at IIASA. The problem was to determine and evaluate alternative policies for control of an economically significant forest pest: the spruce budworm of northern forests, particularly in New Brunswick, Canada. I want here only to point out some of its features as a systems analysis.

The left side of Figure 1 shows the problem schematically. There is a forest of trees, some of them infested by budworm, which are in turn subject to predators. Affecting this system are policies implemented by the government, logging enterprises, and land owners. These policies include decisions about spraying logging, and tree planting. The direct consequences of applying the policies to the forest system will be a temporal and spatial pattern of budworm infestation, tree growth, and harvesting. This will be translated into economic costs and benefits to individuals, enterprises, and government, and into social and recreational benefits to individuals. Now the problem that syste analysis addresses in this case is: which policies should the decision makers select to achieve the most desirable consequences

The decision maker would ordinarily rely on his trained intuition and the lessons of experience to decide upon a policy. But there are severe limitations to trial and error or intuition when systems have complex interactions over long distances in space and time.

The systems analyst can provide useful help here, because ecologists and biologists have learned enough about the spruce

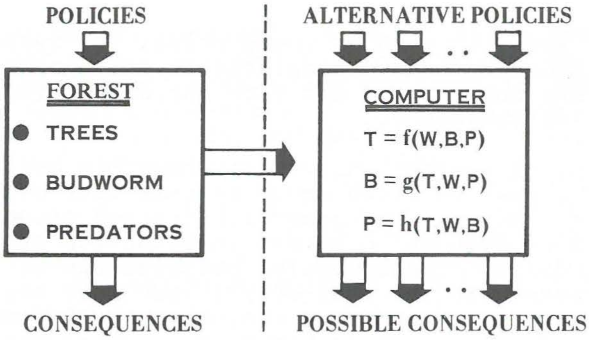

Figure 1. Systems analysis, Type I: forest pest management.

forest and the budworm to be able to predict their responses under most likely conditions. The systems analyst can use this scientific knowledge to create a mathematical and computer model that satisfactorily simulates the behavior of the forest and the budworm under a very broad range of circumstances. This then opens the possibility of testing possible policies *in the model*, rather than *in the real world*; especially since the model can trace the forest's evolution over 150 years in less than 150 minutes.

So on the right side of Figure 1 we see a mathematical-computational simulation of the forest, which the systems analyst uses to test alternative policies and determine their possible consequences. With this information, the decision maker is in a much better position to select, from the options he faces, the one that best serves his needs.

But the role of the systems analyst in this case extends beyond the development of a descriptive systems model based on biological and ecological knowledge. Most decision makers know what consequences they would like to achieve, but not which one of a large number of policies they should pursue to achieve them. The systems analyst can help by developing a prescriptive or optimizing model that, using mathematical techniques, finds the best policy to attain a specified goal or to optimize a specific criterion.

Often, furthermore, the systems analyst assists the decision maker to clarify his objectives, the relationships between them, and their priorities over time. When there are many independent decision makers, the systems analyst can help them to trace the consequences of their interacting policies. This happens, for example, when analysis displays the interaction between the logging policies of the lumber enterprise and the recreational policies of the government environmental agency.

At each step, in each of these roles, the systems analyst must be skillful in dealing consistently and honestly with uncertainty and complexity, and with the distinction between facts and value judgments.

This type of systems analysis is possible ordinarily only when decisions must be taken about systems that are physical or ecological. Science has generally learned enough about the behavior of such systems to permit construction of adequate descriptive models. Consequently, policies can be tested in the model, instead of the real world. But most significant problems facing decision makers concern systems comprising individuals and groups, whose behavior is by no means well understood. Systems of that kind generally cannot be adequately modeled as a whole, and policies therefore cannot be tested all at once in a comprehensive computer model. One approach to such complex social-technical systems is illustrated by our Global Energy Systems program.

In Figure 2, I have followed the same conventions as in the previous figure. The left side schematically portrays the problem. But in place of the relatively simple forest system of the previous example, we have here a complex interaction among technologies, economics, environment, and social attitudes. Instead of a compact geographic region in northern Canada, we have the full globe. And in place of a few decision makers, we have a very large number of independent policy makers in industry, national governments, and international enterprises and organizations.

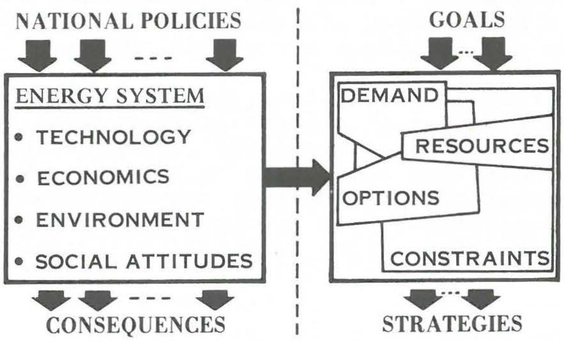

Figure 2. Systems analysis, Type II: global energy systems.

The role of IIASA systems analysis in this setting, therefore, cannot be to determine a single best policy for a single global decision maker. Instead, it is to try to provide a broader perspective against which the autonomous decision makers can make their choices. Systems analysis here must look beyond single system components, in single nations, in the short term. It must identify and improve understanding of the important interactions among energy system *components*, among the energy policies of *nations and regions*, and among energy choices in the *short, medium, and long term*. The system analyst's--and IIASA's--hope must be that, armed with this knowledge, the decision makers will choose policies that are better not only from the standpoint of their own nations, but for the globe as well.

On the right side of this figure, I have shown schematically our approach to this type of systems analysis. In place of a single comprehensive computational model--impossible, because of our lack of validated knowledge and the size and complexity of the system--there is an overlapping, interlinked series of investigations of the principal questions affecting the global energy system:

- What will be the evolving pattern of demand?
- What resources are available to satisfy it?
- Which technological options will be feasible?
- What constraints will limit selection among the options?

And instead of a quantitative evaluation of alternative policies, there is the identification of a range of strategies responsive to different possible national and international goals. Here, as in many analyses, the desired result of analysis is synthesis--the design of alternatives that satisfy specified demands by selecting from among various options those that satisfy the constraints and best serve given goals. The decision makers can then use these strategic alternatives as guides in forming their own policies.

Another approach to the analysis of complex systems that include social and economic components as well as technical ones is illustrated in our study of systems for the planning and management of regional development.

This third type of systems analysis is illustrated in Figure 3. The left side shows three examples of regional development systems: the Tennessee Valley Authority (TVA) in the United States, the Bratsk-Ilimsk Territorial Industrial Complex in the Soviet Union, and the Shinkansen project in Japan. Each is affected by policies that produce consequences, denoted by the entering and leaving arrows. Each is internally organized and managed in different ways to achieve its goals within its specific setting.

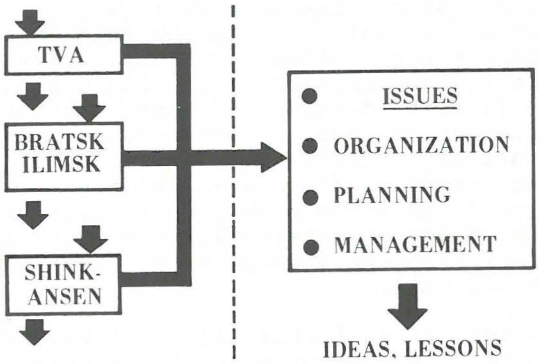

Figure 3. Systems analysis, Type III: regional development.

Although the conduct of regional development involves complex systems that defy realistic descriptive modeling on computers, it differs from the setting of global energy policy in that it is not unique; numerous regional development activities are occurring at different places simultaneously, and at different times as well. This means that the systems analyst can learn about the potential consequences of different policies by carefully examining the experience of the "natural experiments" under way around the world. Our systems analysis in this instance is intended to help decision makers concerned with regional development to select effective planning, managerial, and organizational means by studying the experience of real cases. We replace the testing of alternative policies in computer simulations of reality by their testing in reality itself. But the difficult task of systems analysis in these circumstances is to develop procedures for deriving conclusions from what, of necessity, are unstructured, uncontrolled "experiments". How can the effects of a particular organizational arrangement be separated from those of the other factors that also change from case to case?

The answers to this question are by no means clear. Our approach so far has been to try to develop conceptual or qualitative models of the processes under investigation that guide and structure our examinations, and second, to be clear about the nature of our findings. We cannot expect to be able to say that one approach or another is best, or even better, under all circumstances. Our goal at this stage must be more modest: to identify approaches that appear to have been useful and that warrant adaptation and trial in other settings.

These three types of systems analysis do not exhaust all the possibilities, but they do span the range of experience IIASA has had during its first three years. Moreover, despite their significant differences, they share a number of features, which serve to establish a common meaning for the phrase "applied systems analysis".

All three types have as their purpose the provision of aid to decision makers in making difficult decisions about complex systems. In each case, the analyst seeks, to the extent possible, to separate the determination of factual, objective information--which is the role of analysis--from the making of value judgments, which is the role of the decision maker. Although this separation is often difficult, it is always important. In each case, too, the systems analyst has a broad viewpoint that cuts across the conventional disciplinary or organizational divisions to establish boundaries of investigation appropriate to the problem. This means, in turn, that the analysis must rely upon and draw together the knowledge and approaches of many distinct disciplines.

A characteristic of modern science that has underlain the evolution of systems analysis is the development of quantitative and computational tools to deal with complexity and uncertainty. Many, but not all, systems analyses use the computer or sophisticated mathematics to organize and trace the consequences of complex system interactions, to account for uncertainty, or to search for optimal policies. But despite its reliance on the findings of science and the precise tools of mathematics and computation, systems analysis remains, like science itself, an inherently human enterprise calling for individual judgment, skill, and creativity. Like science, it is an art.

THE PROPER ROLE FOR IIASA

Against this background we can now turn to the question: what is the proper role for IIASA? The answer to that question follows from a consideration of the features that give IIASA its uniqueness. There are two of them.

First, IIASA is an international institute that is, nevertheless, non-governmental. Consequently, it can address international issues in a non-political setting. Furthermore, it is the joint creation of countries from both East and West, and can therefore bring together scientists from widely differing economic, political, and social systems to work on problems faced by all societies.

Second, IIASA is an interdisciplinary institute, that is, furthermore, applied. This means that it can bring together the findings and insights of many special scientific disciplines to solve practical problems. But it also means that methods must be found to bridge the gap between natural and social scientists. It is generally harder to develop effective communication between an American physicist and an American sociologist than between the American physicist and a physicist from the Soviet Union.

These two characteristics lead directly to the definition of the two dimensions of IIASA's proper role.

The first is that IIASA should address problems of international importance, leaving for others matters of strictly national relevance. Problems of international importance may be *global*--that is, they cross national boundaries, involve inherently more than one nation, and cannot be resolved without the joint action of more than one nation; or they may be *universal*--that is, they lie within the boundaries of single nations and can be resolved by their individual actions, but are shared by almost all nations.

Global problems include, for example, the preservation of the global environment and climate, and assurance of adequat global food and energy supplies. Universal problems comprise regional development within nations, design of national health care delivery systems, and development of automated management systems. In both cases, IIASA can play a unique role. It is the only place in the world where scientists from East and West can work together on the global issues that all nations face. And it can facilitate the exchange of experience across social, economic, and political boundaries on universal issues confronted by every country.

The second dimension of IIASA's proper role is a comprehensive approach. There are many studies that focus on one aspect or another of, for example, energy problems--studies of energy resources *or* environmental problems; of urban energy needs *or* health effects of nuclear power; of new technologies *or* methodologies for studying energy demand. In contrast, IIASA's goal is to analyze international problems such as energ in a comprehensive way, identifying and investigating the inter relationships among the pieces of the overall problem.

IIASA'S STRATEGY

These two dimensions of IIASA's role determine its dual strategy: *first*, to build a solid base of competence in those areas of science and technology that are essential components of a comprehensive approach to international problems; and *second*, to draw upon this base of competence in conducting major cross-cutting studies of both global and universal problems.

We have identified four research areas that constitute the pillars of our competence.

The first we call *Resources and Environment*; it is concerned with the Earth's natural endowment--its climate, environment, water, renewable and non-renewable resources, and ecological systems. The activities begun by our Ecology/Enviro ment, Water Resources, and Food and Agriculture projects now fall within this area.

The second is *Human Settlements and Services*; it is concerned with the Earth's human endowment--its populations, their distribution and collection in settlements, and the health, education, communication, and transportation services they need. Our Urban and Regional and Biomedical projects have come together here.

The third is *Management and Technology*; it is concerned with the man-made contributions to the global endowment--institutions, economic systems, and technologies. We have brought together in this area our work on integrated industrial systems and large organizations.

The fourth area differs from the first three by dealing with analytical processes rather than with the objects of analysis. We call it *System and Decision Sciences*, to emphasize its concern with the mathematical and computational tools that support studies of large systems and provide aid to decision-making. It embraces our formerly separate Methodology and Computer Science projects.

Cutting across these four basic areas of competence, we have established two major applied studies, one global and one universal.

Knowing that we could hope to complete our studies only in the long run, we chose as our problem of global concern the question of *the path of global development over the next century*. The dynamics of global population growth, and the parallel growth in the aspirations of all people for adequate food, clothing, and shelter, for education and health care, and for at least minimal amenities, will place severe pressures on the Earth's capacities. To meet the expanding needs of an expanding population, while husbanding the Earth's resources and preserving its environment, is likely to demand far more perceptive care and joint action by national and international decision makers than have ever been applied before. IIASA's unique position gives it the responsibility to assist, over the long run, in the analysis of these global prospects.

But we believe that in the short run IIASA cannot address this vast problem comprehensively. There have, of course, been efforts by a number of groups to build comprehensive global models; we have chosen another approach. Instead of beginning with a study of the linkages among the various sectors that comprise the global system--energy, food, water, environment, industry, and so on--we will begin with sector-by-sector studies. Our hypothesis is that we do not yet know enough about each sector at the global scale to do truly satisfactory intersectoral modeling. The first sector we are studying is energy; that investigation began in 1973 and will be completed in 1978. I have stated the nature of that study earlier. This year we are beginning our analysis of the global food sector.

The problem at the universal level is different. Here we have chosen to concentrate on issues arising in the development of regions within nations. In contrast to the situation at the global scale, sectoral studies are well advanced at a regional scale; but there has been relatively little work on the integrated consideration of these sectors. Thus, IIASA's effort is being addressed to the planning and management of integrated regional development. These problems are common to many nations, especially those that are beginning to exploit new resources.

The two aspects of IIASA's strategy come together, as is shown schematically in Figure 4, through a matrix form of organization. The columns are the four research areas, each comprising a wide range of research skills. The rows are the two cross-cutting research programs: Global Energy Systems and Integrated Regional Systems. Each program has a three- to five-man core group and an interdisciplinary team drawn from the experts in the research areas. About half of IIASA's research effort is allocated to the cross-cutting programs; the remainder constitutes studies made within individual areas or jointly between two or more areas.

	RESOURCES & ENVIRONMENT	HUMAN SETTLEMENTS & SERVICES	MANAGEMENT & TECHNOLOGY	SYSTEM & DECISION SCIENCES
GLOBAL ENERGY SYSTEMS				
UNIVERSAL REGIONAL DEVELOP-MENT				

Figure 4. IIASA's matrix organization.

The strategy I have sketched is ambitious; it would strain the resources of a major research institution. Yet IIASA's internal resources are limited. The Institute has a core staff of 70 scientists. While it occupies marvelous facilities in Schloss Laxenburg--which have been provided with the generous assistance of the Austrian government, the government of Lower Austria, and the City of Vienna--it has only a modest library and medium-sized computing facilities. Its annual budget is 110 million Austrian Schillings, or about 6 million dollars. Although significant, these resources are below those needed to fulfill IIASA's large ambitions.

For this reason, we are trying to find ways to amplify the efforts of IIASA's core through ties with the external research community. The founders of the Institute saw its true purpose in stimulating and linking collaborative research in the participating countries. But Professor Raiffa and the Council felt strongly that such an external network could only be built on the base of significant internal research; without that, there would be little reason or capacity for external scientists to collaborate with the Institute. In the last year this policy has shown results. The way in which external resources expand the Institute's capacities is shown in Figure 5.

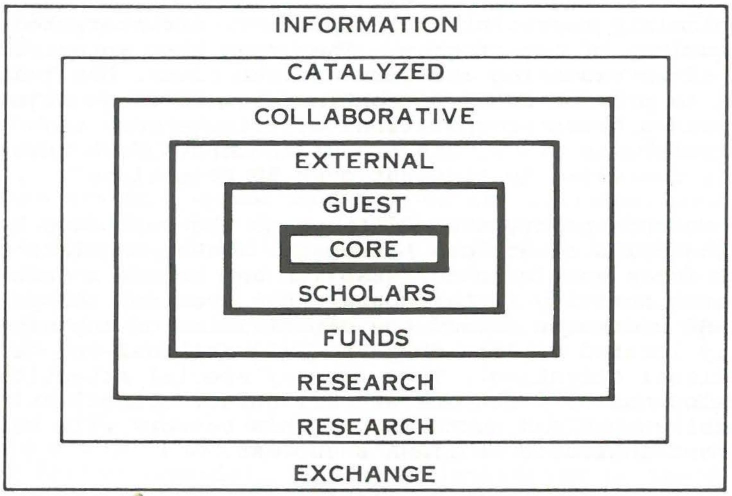

Figure 5. IIASA's external resources.

Around the central core of scholars who are supported by the contributions of the National Member Organizations (NMOs) there has been added a group of guest scholars--scientists supported by outside organizations. There will be 10 guest scholars at IIASA this year--paid directly by research institutions in France and industrial corporations such as

Shell, IBM, Arthur Andersen, Siemens--who participate with the rest of the staff in the research program approved by our Council. These guests enlarge our staff to about 80.

The next addition to the core is made possible by funds we receive from external sources--foundations, international and national agencies--in order to extend or deepen the treatment of specific portions of our research program. This year we expect to receive about 20 million Austrian Schillings--somewhat more than 1 million dollars--from such sources. They include the United Nations Environment Programme (UNEP); the Volkswagen, Ford, and Rockefeller Foundations; the Austrian Ministry of Science and Research, the Austrian National Bank, and the Ministry of Research and Technology of the Federal Republic of Germany. This is about a 20 percent increase in our total budget, and--of greater importance--almost a one-third increment in our research budget.

We value these monies for three reasons. First, they enable us to pursue important research topics more fully than we could with our internal resources. Second, they often provide a direct link with interested decision makers, which is one way of assuring the practical relevance of our work. Third, they implicitly represent an independent, disinterested review of the quality of our program. They mean that an outside agency, after examining our work and our plans, has judged it valuable to provide funds to continue toward those objectives. In many cases these organizations contribute more than the annual membership fee of one of our members. With these funds our staff increases to somewhat over 90 scientists.

Up to this point, the additions to the core have been within the halls of Schloss Laxenburg. Guest scholars and external funds enable us to establish and retain a critical mass of research activity in Laxenburg. But even so, the problems that IIASA addresses exceed the capabilities of any single, centrally located staff: they are international and demand international attention. Thus, we pay special attention to the development of a network of collaborative institutions. The establishment and nurturing of this network will be a significant indicator of IIASA's success.

One of the first of these collaborative relationships began here in Vienna, with the International Atomic Energy Agency (IAEA). We have established a joint group on the assessment of risk, with particular emphasis on the role risk estimates play in the choice of energy options. The IAEA and its member countries contribute staff to the group, as does IIASA. Its leader is at the IAEA, and the team collaborates closely with our Energy program.

We now collaborate with research organizations in almost all the countries having IIASA National Member Organizations, and this network is continually growing. A very promising developmen is the establishment in our NMO countries of research groups that will work in parallel with and serve as links to our research activities. Bulgaria, for example, is designating laboratories that will work in conjunction with our Food and Energy programs. Thus our findings can be implemented in Bulgaria through the efforts of persons and organizations who are aware of the specific situation and needs in Bulgaria. At the same time, we have obtained a channel through which our program may draw upon Bulgarian experience, needs, and reality.

An additional example will help me to illustrate how the collaborative network amplifies and extends IIASA's efforts. As part of our study of global energy systems, we are exploring the possibilities of returning to coal as a major source of energy. In our core research program, however, we have allocated less than one man-year of effort to this problem. Obviously, the ability of one man, no matter how competent, to evaluate the coal option is quite limited; you might feel justified in questioning the seriousness of our commitment. But IIASA's internal effort is only the tip of an iceberg. To amplify that effort we have created a Coal Task Force, which draws upon representatives of the coal authorities in Czechoslovakia, Poland, the Federal Republic of Germany, and the United Kingdom. We expect additional countries to join in. This Task Force meets regularly at IIASA, and its members then return to their home institutions to carry out the work that they have agreed upon. The results will be of obvious value to our Energy program, but the participating institutions expect to benefit more directly as well.

There are many other examples of our collaborative research network. Sometimes IIASA's external influence occurs through a less tight linkage than I have just described. In such cases we identify in the course of our work problems that demand deeper treatment than we with our own resources can give them, and attempt to stimulate research in national research institutions among our NMO countries.

One example of this is the matter of climatological effects of energy production. As global energy production increases, two waste products may influence the global climate. They are *heat* and *carbon dioxide*. We became interested in these potential problems early in our energy studies, but did not have the resources to explore them adequately ourselves. Instead, we approached organizations in countries having NMOs to ask for help. Two of them, the British Meteorological Office and the National Center for Atmospheric Research (NCAR) in the USA, offered us the use of their large, computer-based, global-circulation models. Another, the Nuclear Research Institute in Karlsruhe, FRG, offered us computing assistance. Interesting results for our own work have come from these efforts. But of equal importance has been the catalyzing of work at one of those centers that might not otherwise have been undertaken. Let me quote from a letter we received from the President of the NCAR:

> ...we are very appreciative of the kind of synthesis that IIASA is attempting in the area of energy systems, since it helps us to see where some of the more important practical problems lie, and where we can contribute most fruitfully. I foresee a long-term interaction between our two organizations, each working on the problems that we understand best, and with a continuing dialogue in which we exchange ideas and latest results.

This is an excellent statement of the role that we see ourselves playing in relation to many research institutions around the globe.

The last ring in the web of external resources is formed through IIASA's capacity to facilitate international exchange of information, and thereby to strengthen national research efforts and help to identify issues of global and universal importance. One example of this is our series of internationa conferences on global modeling. As I mentioned earlier, IIASA has chosen not to develop a comprehensive global model of its own. We have, however, felt it important to provide a forum through which the methodologies of the various global models can be reported, discussed, criticized, and disseminated. The have been three such conferences thus far, with the fourth to be held this fall. Each will result in a proceedings volume, which in some cases provides the most complete available documentation of the various models.

So the efforts of IIASA's small core--70 scientists--are amplified many times as they travel outward through the successive layers of our international network.

IIASA'S RESULTS

I have already described several consequences that IIASA' work has had. Of course, the nature and extent of our results are matters that every participant in this Conference will be considering. Each will ask: is IIASA worth what it costs? Can it promise results commensurate with the resources it engages?

Each of you will, of course, form his own answers to thos questions. As an aid during those deliberations, it may be helpful to have a classification of the types of results we expect to produce.

1. Findings Applicable in a Single Nation

The first and most direct result of IIASA's work will be specific findings applicable in a single nation.

- The work of the Ecology project on the management of the spruce budworm in New Brunswick is already being employed in Canada.

- The Energy project's determination that with current oil prices solar electric energy may be economically viable in Austria has led the Austrian government to investigate that possibility in more detail.

- The work our Water project is doing in conjunction with the Hungarian National Water Authority on development of the Tisza River Basin is of direct value in Hungary's current planning.

2. Findings Applicable in Many Nations

Although we are happy to have achieved such results for individual nations, we feel that IIASA's role does not consist *fundamentally* in producing single effects. Rather, we work in individual nations as part of the discipline of preparing findings that have universal value--that can be used by many nations.

Thus, the next step in our Ecology project is to extend the findings on the spruce budworm so that they become relevant to control of that and similar forest pests in other countries. In the same way, we are extending the results of our case study of solar energy in Austria to other countries in central Europe. We are looking, as well, at the general problem of integrating the naturally fluctuating electric energy supplied by solar means into existing energy systems. These studies will be of value to all nations contemplating solar electric power generation.

Similarly, our work on the Tisza basin in Hungary is part of a larger activity whose purpose is to derive findings of value to river-basin managers in many different countries, including Poland, Bulgaria, and Italy.

3. Methodologies to Aid National Decision-Making

Some of our results will be of relevance to particular decisions or groups of decisions. But one of IIASA's distinguishing features is its concentration on problems that demand and inspire the development of new techniques. At the same time we have a first-class team of methodological specialists. Consequently, we expect that a major part of IIASA's results will be new, refined, or extended methodologies. For example, the overall goal of our Ecology project has been to develop methodologies for ecological system management. In particular, one case study has focused on methods for studying the environmental consequences of alternative regional energy policies. You will hear more about this work, carried out in the USA, France, and the GDR.

4. Global Context for National Decision-Making

Sometimes the important result of our work is the global context we can provide to assist national decision makers. For example, both our global energy and our global food studies will examine the likely patterns of global supply and demand in these key resources. These studies, conducted at IIASA with the collaboration of scientists from many different countries, will, we hope, provide better information about global trends and interactions than can be constructed by national groups acting alone. Their availability should prove valuable to national decision makers and their staffs.

International decision makers are not so easily identifie as national ones. They occupy positions in international agencies and enterprises; they sit on international commission and attend international conferences; in large measure, all of us--when acting in our national capacities--are internation decision makers in this interdependent world.

5. Information for International Decision-Making

One of IIASA's central goals is to assist in internationa decision-making. An important way in which we can do so is by providing information. Because the community of decision makers is so diffuse, this information may not take the form of precise recommendations for particular persons. Rather, it may appear as a report addressed to a very wide audience. Our examination of the medium- and long-term prospects for the global energy system will include such reports among its products. They will provide a broad global perspective about the future supply of energy and the options for satisfying demand, as well as an indication of alternative strategies that might be pursued nationally and internationally. No single decision maker will be able to implement our findings; thousands of decision makers should find it useful to have them.

6. Methodologies to Aid International Decision-Making

Another type of contribution we can make to international decision-making is methodological. For example, we have received a three-year grant from UNEP to develop and dissemina methods for comparing energy options. We shall be working jointly with the IAEA and the World Health Organization (WHO) this effort.

7. Contribution to Scientific and Technological Knowledge

Although we are an applied research institution with our primary focus on preparing results of value to decision makers it is both essential and natural for us to produce results of general scientific and technological relevance. For example, our ecologists proposed early in IIASA's development that an important criterion of system performance was what they called "resilience". Intuitively, they defined the term as a system' ability to absorb and recover from unanticipated shocks. The concept quickly gathered support from other projects, especially Energy. But there was no practical quantitative definition of resilience that could be used in system evaluation. In recent months our methodologists have developed a promising approach defining resilience. Should these results gain acceptance, they will constitute a contribution to the wider scientific community as well as a practical benefit to IIASA's own research.

8. Exchange of Experience and Methods

Because IIASA is a meeting ground for scientist from many countries who come as long- or short-term staff members, visitors, and conference participants, it naturally facilitates the exchange of experience and methods. For example, the central focus of our work in the biomedical field is the development of dynamic models of national health care systems through the collaboration of individuals and groups in the Soviet Union, Great Britain, Austria, Canada, and Japan. A core group at IIASA interlinks the efforts, but more direct exchange will occur through visits to IIASA of several months or longer by scientists from each participating activity.

9. Stimulating Research Elsewhere

A crucial part of science--both basic and applied--is asking the right question. We feel that IIASA has an important function in this respect. Our international setting and interdisciplinary approach give us a view of issues and scientific developments that differs from those open to national research institutions in a single descipline. Often this leads us to identify important gaps in knowledge or application that are not so visible elsewhere. At the same time, we have neither the resources nor the inclination to pursue all these questions ourselves. Thus, we seek to stimulate research in national institutions, as we have done in the NCAR and other research groups with which we are in contact.

10. Linking Research Elsewhere

Sometimes we are able to serve better as intermediaries than as stimulators of work. An example is the work in our Human Settlements and Services area on the dynamics of urban growth and national settlement policy. This, with support from the Ford Foundation, is engaging research institutions in North America, Eastern and Western Europe, and Japan, in the coordinated gathering, structuring, and analysis of data about the dynamics of urban economic regions. This linked network of institutions would have been extremely difficult to create outside the IIASA framework. Not only does IIASA benefit, but so do the participating institutions, who obtain comparative data in comparable formats that would otherwise have been inaccessible.

Another example is our work on management and control sys- tems in the steel industry. Through the cooperation of indus- tries in Europe, North America, and Japan, scientists in the Integrated Industrial Systems project prepared a state-of-the- art survey on integrated control systems. This was followed by a major conference at which participating industries could exchange experiences and methods for industrial management. This is a case where IIASA's results are directly transferabl to decision makers in industry, and we have received favorabl reactions to the survey and the conference from many of the participating industries, including the United States Steel Corporation and the Ministry of Instruments and Automation in the Soviet Union.

I cannot leave this category of results without mentioni one effort that combines both stimulation and linkage. This is what we call the IIASA computer network project. It arose from two types of need: first, our need to gain access to computing resources in the home institutions of our scientist and in collaborating institutions; and--reciprocally--the scientists' need to retain contact with IIASA when they retur to their home institutions, and our collaborating institution desire to have access to our programs and data. IIASA's activities have triggered an international effort by teams in many of our NMO countries, coordinated not only through us but directly with one another.

11. Education in Systems Analysis

The final type of results that I want to mention concern human resources. I feel that the most important impact of IIASA's activities will be their effect on the people from many different countries who will have spent time at Laxenbur or come into some contact with the Institute.

Some of this effect will occur through educational progr We expect to organize formal courses in the near future; and we have begun an activity whose purpose is to determine, systematize, and disseminate the international state of the a of applied systems analysis. The results of this Survey proj will include a Handbook of Applied Systems Analysis and a ser of volumes on particular aspects of the subject.

12. Preparation of Systems Analysts for Advanced Careers

But I feel that the most important benefits will occur through the effects of the IIASA experience on the scientists who spend time at the Institute. What a scientist publishes in his reports can be only a small portion of what he has learned in studying a problem. This is expecially true of those who work in interdisciplinary research teams addressing real policy issues. The knowledge they gain is a form of intellectual capital that can be drawn on over and over again and that remains with them as they return to their home institutions. Thus, a result of considerable value to each NMO country is the knowledge embodied in each IIASA alumnus. Of course, what seems to us most important is that the learning experience is different from that available elsewhere; for at IIASA, each scientist has the opportunity to see problems from a broader perspective--both international and interdisciplinary--than he would have at his home institution.

So I hope that those who are concerned about IIASA's benefits will keep this categorization of results in the back of their minds. Although not yet complete, it suggests the multidimensional view we have of our objectives.

Perhaps I can summarize what I have said as follows: IIASA brings together scientists from many nations--having widely differing economic, social, and political systems--to consider the important problems facing mankind. It makes their findings available to national and international decision makers, the scientific community, and the public.

CONFERENCE PURPOSES

The IIASA Conference is an integral part of IIASA's activities. According to the Institute's Charter, signed by representatives of the 12 founding Member Organizations in October 1972:

> The Conference of the Institute is the major forum for providing broad scientific and technical advice to the Council and the Director; for encouraging the programs of the Institute and linking them with the research efforts of other national and international institutions; and for fostering understanding of the work of the Institute.

In organizing the first IIASA Conference we tried to serve all three purposes.

As you examine the Conference papers, we would like you to keep three questions in mind. They are:

- What should IIASA's future research program include?
- How can IIASA improve its linkage with other research efforts?
- Who should know about IIASA's work, and how can they be reached?

Each of these questions corresponds to one of the Conference purposes. As we plan the development of the Institute, it would be a significant help to have your responses to these questions.

I hope that the spirit of the first IIASA Conference will be the spirit that pervades IIASA--one in which persons from many nations can work together in an objective, frank, and friendly way on the problems that all of us, as residents of the same planet, share.