International Institute
for
Applied Systems Analysis

PROCEEDINGS
OF
IIASA PLANNING CONFERENCE
ON
ENERGY SYSTEMS

July 17-20, 1973

INTERNAL SUPPLEMENT

Schloss Laxenburg
2361 Laxenburg
Austria

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July 17-20, 1973 - Baden, Austria

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Introductory Remark

W. Haefele

Whereas during the first three days of the IIASA Planning Conference on Energy Systems all aspects of the production, conversion, transmission, and consumption of energy had been discussed, the last day of this meeting was devoted exclusively to discussion of the question what possible research strategies could be selected by IIASA in this field.* As these questions are of specific interest mainly for IIASA--contrary to the questions discussed during the three foregoing days of the meeting--the minutes of the last day have been separated from the Proceedings of the main part of the meeting. It is to be noted, however, that the question of IIASA research strategies was raised several times in the course of the conference, and that therefore additional comments can be found in the Proceedings.

In addition to the discussions of the last day, this volume includes comments which the participants and others delivered to the Chairman before, during, and after the meeting.

It is hoped, therefore, that together with the Proceedings of the meeting this volume gives a comprehensive view of experts from all over the world about the question what could be possible research strategies of IIASA in the field of energy systems.

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* Director Raiffa, Deputy Director Letov, and other scientific leaders of the Institute are responsible for drawing up a more final version of a research strategy for the Institute which will be subject to approval by the Council in November, 1973.

Special Discussions and Suggestions

Mr. Raiffa opened the Friday morning session by welcoming the conference to Schloss Laxenburg. After some comments about the architecture of the Schloss, he quickly surveyed the results of the two preceding conferences.

The first conference, chaired by Mr. Letov, considered what IIASA should do in the field of water resources. Even though work will begin this fall on a state of the art handbook for systems analysis, to be updated periodically, those conference participants felt that there should be another handbook on the state of the art of design and management of water systems. As the survey proceeds, attention should be paid to methodological research problems. In particular, IIASA should identify who is working on the problems and act as a catalyst for new research. Thirdly, it would be constructive of IIASA to critique recently completed studies, such as those of the Vistula, Trent, and Delaware rivers. The principal original researchers might come for these retrospective analyses to discuss what they learned from them and what might be done better. Fourthly, as IIASA builds up a corps of people knowledgeable about water problems, it could serve as a sounding board for ongoing research and perhaps offer active help with problems common to several studies.

There was agreement that it would be good to work on a concrete problem. The only question is the size of the problem. There was much discussion of this, with proposals ranging from lakes or modest size river systems to more grandiose plans. A large part of the group felt that it might be worthwhile to look at a very complicated system like the Danube but not in great detail. Rather, one would investigate what work is already being done, examine relationships among concerned institutions, and look at the geographical and institutional realities. This would be a feasibility study at the organizational rather than at the hydrological level.

Other discussion focussed on the fact that there are water topics not included under the control of a river basin. In particular there are ice flows, the melting of the ice caps, arid areas, and thermal pollution. One idea was to convene conferences on very specific aspects of the problems.

Mr. Raiffa reiterated that the projects will not be isolated but will work with each other, with research in the National Member Organizations, with universities, and with special institutions such as WMO and IAEA.

Mr. Raiffa continued by describing the conference on the Design and Management of Large Organizations, chaired jointly by Mr. Milner of the USSR and Mr. Bower of the USA. That meeting also called for a separate handbook focussing on its field, the state of the art in management. They discussed the organizational structure of IIASA and strongly recommended a matrix format, in which concrete projects would be in one dimension and methodological methods that cut across projects in the other. IIASA should have social and behavioral scientists, for example, who are not assigned to any specific project but work on all of them as methodologists. They emphasized that one must specify research areas for recruitment purposes, but one must also encourage the overlaps.

They also discussed a need to identify researchable subtopics in the management and organization field. There is a growing literature on mathematical problems related to organizational structures. One idea was to help organize the literature to identify what further research needs to be done.

They also suggested retrospective case studies taking advantage of IIASA's cross-cultural nature. Teams could compare different institutions. Also, some attention should be paid to developing a set of variables or themes so that one can make comparisons.

The desirability of looking at healthy organizations was also noted. IIASA might study or invite reports on completed studies of Electricité de France, IBM, of the Tennessee Valley Authority, or of development projects in Siberia.

Again, it was suggested to expand manpower by cooperation with other groups. An additional suggestion was for IIASA to sponsor doctoral or candidate dissertations done jointly on the same theme with IIASA acting as a coordinator. There was some feeling that additional support, e.g. from foundations, could be found for this. Some time was spent discussing liaison with, for example, the water project. Mr. Clough from Canada had outlined a zero order approach. Mr. Raiffa asked the group to try, in its discussion, to keep in mind links to the other projects.

Mr. Haefele thanked Mr. Raiffa and asked for suggestions on the scope of IIASA's work.

Mr. Weinberg opened the discussion. He noted that the long range energy problem presents an odd dilemma. We require an inexhaustible energy source. If we're realistic, our main option is fission. If we turn away from this for non-economic reasons, our only choice is solar energy. It is important for IIASA to reflect upon these options from a long-range point of view. It should ask what the consequences would be if, for example, man had to depend on solar energy. (One consequence

would be an increase by a factor of five or ten in the cost of prime energy.)

Secondly, IIASA should reflect on all of the implications of using fission; it creates technological and social commitments. For example, it requires the existence of a cadre of knowledgeable people for unprecedented times in the future, for a thousand years. Is it reasonable to assume this? Is there something we could do to ensure that such people would exist? He noted that earlier discussion had perhaps left the impression that he felt that the issue was primarily reactor siting. He amended that, adding however that this is the most important single aspect of the problem he can now think of. The issues are much broader. It would be helpful if IIASA, in collaboration with IAEA and national institutions, would reflect on what the current generation of men can do technologically and socially so as not to close options. Beyond that, IIASA could take the first steps necessary to ensure the stability of the nuclear intellectual enterprise. The siting problem has the advantage of being definite but he hoped that IIASA would consider the broad issues.

Mr. Weinberg went on to make suggestions relative to the informational activities of IIASA. He noted that a number of energy economic models have apparently been developed, for example, in England, in France, and in Japan. He suggested that IIASA devote effort to establishing an information center to keep track of work in this field. The center could range from a simple catalogue of the models to a group actively collecting computer codes and through workshops disseminating understanding of them. He added that such an approach has been effective semi-internationally with the computer codes developed for calculating reactors.

Finally, Mr. Weinberg commented that in fields lacking a strong disciplinary framework, one of the most important ways to command the situation is to have control of the instruments of information flow. "The institution that has the information is often the one that exerts great leverage upon the situation." Thus, IIASA should consider, in broad terms, its role for information flows in energy systems and should establish a center which could contain more knowledge about energy modelling than is found elsewhere. He closed by noting that a parable states that the kings in the Tigris-Euphrates culture were the descendants of the irrigation gate keepers.

Mr. Haefele noted that the question is whether other centers already exist which consider themselves the proper place for such an energy economics clearing house.

Mr. Ananichev agreed with Mr. Weinberg about specification of aspects of the problem to be treated within IIASA. He added a suggested procedure for future activity, naming four

focuses for IIASA research. First should be a study of the parameters, terminology, and units of measurement in energy problems, coupled to the collection, analysis, and assessment of currently used prognostic methods of the energy "crisis." These activities would generate a common language for assessments and judgments. Secondly, existing energy conversion systems would be analyzed with special emphasis on a) fission, b) geo-thermal and gravitational sources, c) solar and biologically based sources. Thirdly, IIASA should develop an overall survey of the development of the world's huge energy complex using existing data and the results of the first and second study. This project could include forecasts to the end of the century. Fourth would be a study of the most progressive means of preventing a possible energy crisis. Emphasis should be on the most economical ways of obtaining energy, taking into consideration that until the end of the century we will have to rely mainly on fossil fuels. In addition, these studies should cover means of accumulating and transporting energy and, generally, the most economical way of using the energy generated.

The next question is how to organize the research. Mr. Ananichev suggested three possible ways. First, an aspect of each problem--a sub-problem--could be delegated to each of the NMO's as national projects, the results of which would be distributed and discussed by IIASA. Secondly, for problems which the NMO's are reluctant to undertake because of their complexity or uncertain success, IIASA could recommend establishment of joint groups or could hold a series of seminars to probe the problems more deeply, after which some NMO might take the job of finishing the work. Thirdly, for each problem, some NMO might be chosen as a center for research. Its laboratories and staff would be open to IIASA scholars and scientists from other NMO's for research in conjunction with the IIASA program.

Mr. Ananichev then responded to the query on other international organizations. He observed that the main international organizations currently dealing with energy are United Nations groups--e.g. International Atomic Energy Agency (IAEA), World Meteorological Organisation (WMO), UN Economic Commission for Europe (ECE), and UNESCO's man and biosphere program. The UN Environment Program (UNEP) probably has funds to support activities elsewhere. The UN Department of Resources and Transportation (in New York) is also active in the energy field. There are also a number of non-governmental organizations in this field. For example, the World Power Conference is a solid and reliable source of information with which IIASA would do well to establish good relations. The World Petroleum Congress has a standing committee which IIASA should contact. The question is how to coordinate with these groups to avoid repetition. First, we should establish contacts with them and learn about their programs as we compile our own. Also, it would be fruitful to have representatives of other international orga-

nizations at IIASA meetings as a standard practice, and to authorize IIASA scientists to attend their meetings.

Mr. Haefele thanked Mr. Ananichev and asked Mr. Hutber to comment on economic modelling.

Mr. Hutber began by commenting that it is important to "keep our feet in reality." We must accept that the various national members will go their own way, have their own programs, protect their own interests. IIASA should keep track of what they are all doing. Work done in individual countries will, necessarily, be sub-optimal from the global point of view as any group has its biases. Thus IIASA should concentrate on international aspects and on the meaning, application, and interpretation of methods developed by individual countries for their own purposes.

Mr. Hutber also commented on one of the organizations mentioned by Ananichev, the ECE. He noted that both he and Mr. Ananichev are government expert representatives to this body. It has no working team, no internal work. It functions primarily as a postal box. All work is done by the members themselves on their own time. In IIASA, the members have preempted some of their resources for this type of work. Simply a vast increase in communication is not necessarily desirable. There should be connections to suitable grouping--single countries, groups of countries, and international organizations like OECD or ECE--but IIASA should not just be a post box.

Mr. Hutber also commented that he was heartened by the structure of the meeting. He felt that an international meeting where everyone contributes is a rare occurrence. He suggested that it was important that all of the participants were individually invited by virtue of their status or work, and suggested that IIASA should continue to hold such meetings in smaller fields. He concluded by stating that the future of IIASA depends upon what IIASA does. At the moment, it has the good faith of everyone, but it must demonstrate that it can make a reasonable contribution within a short time, say, within one or two years. Thus, it would be advisable not to be too ambitious at start. IIASA should strike a compromise and not be just a glorified post box, not just a place for exchange of information, but should also continue the atmosphere of the conference where one could argue in perfect freedom.

Mr. Weinberg noted that Mr. Hutber is one of the energy economy modellers. He asked him whether he would have use for a center like Mr. Weinberg had described, or whether his contacts with other modellers were already sufficient.

Mr. Hutber responded that in his country they tend to "breed their own expertise." If they feel lacking in some area, they bring someone in or do research themselves. For

example, the world energy model was done entirely internally, Mr. Weinberg asked whether Mr. Hutber was saying that each situation is unique, so that an EdF model, for example, would not be relevant to Mr. Hutber's work; this situation is very different from that in the field of reactors. More precisely, are the computer codes not switchable? Mr. Hutber replied that perhaps a clearing-house could work on the basis of switching codes, but that is not critical. The major problem is to identify favorable options in methodology, to determine what is successful. Modellers all have ideas on how variables are connected. However, it requires much work to substantiate these guesses. A workshop would be useful as a pool of these ideas. Suggestions of what might work are more useful than large computer programs.

One advantage that IIASA has over the World Energy Conference is that the discussion is freer and less formal, in part because everyone is speaking the same language. Also, at this IIASA conference, all of the delegates are experts who contribute to the science. The WEC could be a clearinghouse for programs. One could write individuals and ask for their models. These could be collated and put out in the form of papers. However, the WEC descriptions of models tend to be short and require a long lead time. Mr. Hutber concluded with the judgment that the exchange of information through WEC is not currently of great value.

Mr. Weinberg interjected two points related to his comments on the role for IIASA in information exchanges. First, he had received the impression during the conference that a large community of economic modellers was developing. Secondly, he reiterated his feeling that such a role would strengthen IIASA as a research institution. Mr. Haefele noted that clearinghouses in the energy field might already exist.

Mr. Raiffa added that IIASA has an obligation to the NMO's and the world to be a sophisticated information conduit. Just being a "post office" would not suffice; hence, much in-house work is required. IASA would have to coordinate, penetrate, and distribute research, ask the right questions, and foster bilateral contacts. For example, in the case of economic energy modelling, Mr. Raiffa said that he personally knows some of the U. S. literature and the fast pace at which it is growing. IIASA's initial recruiting includes two distinguished economists in this field, Alan Manne and Tjalling Koopmans. They will bring a survey of the state of the art in the United States and hopefully will be joined by others from elsewhere. After some in-house work on this topic there could be a large conference on the subject for an exchange of viewpoints. This is a labor-consuming approach at the beginning (even though it can be continued with just one or two people). It cannot be done for all aspects of the work. IIASA must determine critical areas. Mr. Raiffa noted that IIASA cannot do basic research

in such fields as geo-thermal and solar energy. It can serve as a sophisticated clearing-house which understands the research and follows it up. In the field of energy one could name a half dozen such projects, including economic modelling, climatology, different types of conversion. It is important to remember that other projects will have aspects related to the energy project and thus can reinforce it.

Mr. Janin said that the World Power Conference National U. S. Committee chaired by Charles F. Luce of Consolidated Edison can provide IIASA with good data. It is gathering information from different countries. With respect to IIASA as a clearing-house, Mr. Janin agreed that it would be useful to have an office with a catalogue of models, but noted that unlike some physical or technical models, economic models are often used only once because conditions change. One place where IIASA might have a role is in the philosophy and methodology of models, in the general ideas behind them rather than in their application to specific problems. For example, IIASA might look at the direction of variation against some variables as even this is still not known. IIASA could also usefully look at long-term problems since these are not being handled by those who must make day-to-day decisions. Another orientation would be to look at the level of energy consumption per capita. We assume that it is approaching an asymptotic limit, but we do not know what that limit is or when it will be reached. It might be useful to do research considering extreme prices, in other words, work like Weinberg's but in the economic field. Without the economic factors, there is no way to direct a choice.

Mr. Ananichev urged the group to be more precise in its discussion, reminding them that they should produce a well-defined initial program for IIASA. The first birthday is approaching soon; it is important to produce something. Conferences and workshops alone are not sufficient. It is important to consider what the annual results, or production, of the energy project would be. The intention of his four programs was to direct attention to reports that could be made annually showing the contribution of the Institute to the world community. Each of the four programs could produce an annual document which could be given to those to whom the Institute is accountable. The list of four is not meant to exclude other work. Prognoses, for example, require modelling work. However, one cannot divide a field like energy into areas like "weather;" the climate is tied to all human activities. Modelling should not create false independences. The IIASA program should be action oriented.

Mr. Raiffa responded that he had contradictory hopes for conference outcomes. On the one hand, he would like concrete suggestions for a research program. He had agreed with the Executive Committee and Council to set out a research strategy

by 15 October. However, he would like to avoid premature concreteness. All of the projects are linked; they must not be considered as isolated units, but in terms of their interactions. Thus, he urged additional suggestions, especially in written form, and added that the problem will be to integrate all of them into a research program. Simply accepting separate concrete suggestions from each conference would result in an unworkable program.

Mr. Ishida presented some comments for himself and Mr. Oshima (who had to leave earlier). They are included in full in this document. He suggested that IIASA undertake research in methodology and tackle the data base problem. He added that there will be several Japanese study groups in this field which might maintain contacts with IIASA. Mr. Haefele agreed that permanent and strong contacts with the NMO's is a precondition for successful work at IIASA.

Mr. Knop remarked that he had heard that a group of ten people was being considered for the energy project; a group this size could not coordinate and still do work itself. Coordination requires much time. He urged that not too much be demanded from this small group, that is, that more be asked from others. He noted that there were not many economists at the conference. Methodological problems in economic forecasting might be a good problem for IIASA. The questions of predicting when a change in technology will come and of forecasting time scales for the development of energy demand are of great interest. Already there are groups of countries working together in the field of energy prognosis. IIASA could study which existing links appear useful and how cooperation could be best organized between groups of countries. Not too much coordinating work could be required of the small team. Rather, one must choose a few specific problems of interest to the member countries.

Mr. Haefele expressed the personal hope that those who come to IIASA for short times would come as exponents of existing groups rather than as isolated, single scientists. This would create de facto interweaving of institutions.

Mr. Roberts pointed out that some of the problems and tasks discussed up to that point are already being studied by different national groups. However, most studies by individuals governments and even groups of countries tend to be short term. If IIASA wishes to study a new problem, it should place most effort in long term problems. He supported Weinberg's position about preparing for the extreme long term, adding that he knows of no one now worrying about these problems. The point is that we will influence the next thousand years; it is therefore vital to be directly concerned with these longer term problems. IIASA can enter these problems in a unique way. Long term energy problems melt into other fields, such as

social and environmental problems. This is a single problem of profound interest which IIASA could study. Mr. Raiffa commented that there seemed to be a consensus that this would be a suitable topic.

Mr. Weinberg asked Mr. Ananichev for his reaction to Mr. Robert's comments. Mr. Ananichev responded that IIASA was formed because many nations discovered that there are many problems which must be assessed and analysed internationally, on the basis of international exchange of men and ideas. It was Mr. Ananichev's understanding that the founders wanted IIASA to be an instrument of international cooperation to help the world with advice or at least with statements of what the problems are and of possible ways to solve them. Thus, IIASA certainly could direct itself to long term problems. Today many people are trying to make forecasts, yet there are more speculations than scientifically based observations. Even the scientifically-based forecasts vary greatly. It is part of the task of IIASA to make objective, independent assessments and analyses and to offer its own view of the state of affairs and of ways to solve problems. IIASA should not only arrange work, but should also have its own concepts in many programs. Otherwise, if it only served an informative role, it would have no identity and simply would be another international organization. Mr. Ananichev said that he saw IIASA as a very special international institution, which should not just exchange information but also help national institutions cooperate. In light of this, he suggested the three forms of organization.

He went on to say that he does not think that the long term problem should be the only one which IIASA should study. It should also tackle current issues, including the state of the art in systems analysis. Every group at IIASA shoud publish such a report on what systems analysis is and how it is developing. The management of large organizations and systems present definite problems which we are facing today. Mr. Roberts interjected that he did not mean to imply that IIASA should study no current problems, merely that a sizeable part of its effort should be devoted to the long term. He added that he thought that Mr. Weinberg agreed with that view.

Mr. Chernilin said that he would present both his own and the IAEA's views. He noted that IIASA exists because it is needed. IIASA is beginning with many advantages, one of which is its age, which allows for great enthusiasm. However, its youth is also a danger. He agreed with Mr. Roberts that we have no traditional approaches to these problems, and each country has its own approaches to studying them. Since many different philosophies exist, it is important that IIASA have its own. This, too, is an advantage. Thirdly, IIASA can take the outside, global view, rather than a view from within any one country. However, IIASA also faces dangers. It might try the impossible task of covering all the interesting subjects

that come up. It might try to justify each activity in a precise manner, which would lead to great loss of time. It must act immediately and get results to serve as concrete evidence of its existence.

He said he anticipated close cooperation between IAEA and IIASA. IAEA has already left a slot in its work which the Institute could enter immediately. The relationship clearly should exist both formally and informally. IIASA scientists would be welcome to come talk to any IAEA staff at any time. The IAEA has much data which IIASA could use and a large nuclear data information system. Also, four center, in the US, in the USSR, in France, and at the IAEA, are collecting measurements. IIASA is in a key position to convince people to do the work it needs. Moreover, IAEA is mainly doing short term work in the field of energy. IIASA work apparently will be at least partly in the long term. Both groups must give results to the world community. Within the UN family, there is a lack of coordination; IIASA could be useful in this field.

Mr. Haefele thanked Mr. Chernilin. He asked Mr. Lamb for advice on how the Institute might approach the important question of climate, which might prove to be the ultimate limit on energy. Mr. Lamb replied that it is clear that work on climatology must proceed primarily in special climatological institutions. There are many data to be handled. What is needed is a very few specialized institutions; there are a few which are tackling the right problems. Mathematical laboratories and meteorological services are looking at the theoretical aspects. What is required is support work on the observational side to support the theoreticians. The meeting at the University of East Anglia in Norwich, England, in May 1973 presented a strong case for collaboration on a formal and regular basis between Norwich and American units. Enough institutions exist, but they require strengthening and need to be forced into the necessary collaboration.

Mr. Kostjanoj remarked that climatology is changed by all human activities, not just by energy consumption. Climatology is interested in the release of heat and secondary products. The source of the heat is not interesting; the heat itself sets the boundary. What is important is how much energy is extracted from natural sources, e.g. wind, sun, etc. The climate is also affected by agriculture, industry, pollution. Secondly, Mr. Kostjanoj agreed with Mr. Lamb that cooperation is required. IIASA as an international institution should first cooperate with other international organizations as they have great experience and many personnel. Even if IIASA contacts national groups, is should go through international organizations. WMO, for example, has a commission on climatology and collects data everywhere. Mr. Kostjanoj also mentioned the international hydrological decade. The point is that WMO has lots of information and experts which IIASA could use.

At this point, Mr. Haefele suggested breaking for lunch. Mr. Janin thanked the direction of IIASA and especially Mr. Haefele for organizing a successful meeting. Messieurs Raiffa and Haefele thanked him and closed the meeting.

Commentary on the Speech and Discussion about Energy Systems

K. Ananichev

In the light of the above remarks, it is possible to draw certain conclusions and to formulate some proposals on ways of solving problems of energy and of the use of energy resources.

1. The problem of energy and energy resources cannot be treated in isolation from the problems of the environment, of water resources, and the condition of the atmosphere, nor from the outlook for further economic progress, and in particular, scientific and technical progress--technological development. In other words, the approach to solving problems of energy and energy resources must be programmatic and must be systematic. The interconnections between the problem of energy and problems of ecology, economics and technology against a background of developing human civilisation are intensifying. Even at the present time, it is already virtually impossible to predict solutions to any one of the problems mentioned without considering solutions to the others.

2. The problem of energy must in its turn be regarded as a collection of systemic categories. These include the energy systems mentioned above. For each of these systems we must take into account:

a) the existence, dimensions, and accessibility of the energy reserves;

b) the possibility of converting energy from these sources into some form of energy which is usable by man;

c) the possibility of accumulating and transporting energy or energy sources; and

d) ways of using energy in the most economic way possible without harmful ecological consequences.

Thus, the problem of energy can be regarded as a series of systems with a given set of programmatic indices.

3. The extent to which a given energy system can be implemented is closely linked with the accepted or achieved indices of quality, or with decisions taken in the ecological, economic, and technological spheres. Success in the above will

also be determined by the criteria of assessing energy sources enumerated above. In this connection, an important consideration is the fact that the development of one or another type of energy sources will be subjected more and more to considerations of economics, both from the viewpoint of energy consumed in converting from one type to another, and from the viewpoint of using energy in the production process and for the consumer. It is likely that energy-intensive products and productive processes will tend to decline: any product or process which uses less energy will be considered an achievement.

4. Ecological considerations will inevitably force man to produce and consume more and more "clean" energy. In such cases it will be necessary to devote particular attention to combatting so-called "thermal pollution", especially of water, but also of the atmosphere. The problem of calorification of the globe may very rapidly assume a global character and will demand a radical review of all sources of energy in use. The question of what to do with the excess heat and how to preserve the existing cold areas of our planet may be decisive in the choice of a particular energy source or system.

Ecological necessity on the one hand, and the problem of "thermal pollution" on the other, will clearly demand systematic analysis of the energy and energy resources problem in the context of the planetary system. This would take account of the natural balance of all types of energy reaching the Earth, being reflected and absorbed by it, and also of energy from the interior of the planet, from gravitational forces, and from the Earth's rotation. A special role in this balance must be played by the energy absorbed and given off by the biosphere and above all by its living substance. Here, the systematic approach will consist of determining whether the high velocity of energy conversion maintained by the biosphere, and particularly by man, can disturb the balance of the world's energy system and evoke inevitable consequences.

It is likely that an important place in such an analysis would be occupied by the first energy system (the inexhaustible sources), and mainly by geothermal energy. Establishing the extent to which the correlation between the internal heat of the Earth and solar radiation reaching our planet can be controlled could be an interesting object of research for systems analysis as applied to the problem of energy.

5. Forecasts of a solution to the energy crisis must take account of the outlook for the development of water resources. It is likely that energy considerations should include organically the complex use of water resources. Figuratively speaking, not a drop of water should be spent without obtaining energy or storing it. It is also very important to consider water resources as a medium for heat transfer.

The programmatic researching of water resources from the viewpoint of energy production should probably not be restricted to questions of building hydroelectric power stations or pumping installations. Important heat processes linked with water (evaporation, rainfall, sea and air currents, other types of interaction between water and atmosphere,) deserve close attention and programmatic, systematic research. Water, for example, transfers vast quantities of heat energy from one place to another. To understand and learn to use low-temperature heat gradients of surface and atmospheric water is an extremely interesting and promising field of study for systems analysis.

6. The solution of the energy problem will be a function of the success of scientific and technological progress. To forecast the development of energy systems without attempting to forecast technological progress would be a mistake, to say the least. There are certain areas of technology which traditionally serve the development of energetics. It is probable that forecasts of the development of these areas interdependently with other, neighbouring fields of scientific and technical progress could perform a useful service when it comes to analysing possible directions which solutions to problems of energy and energy resources could take. The establishment of such interdependence and the determination of such links also become an interesting object of research of specialists in the field of applied systems analysis.

7. It is essential to assess critically the state of man's knowledge with regard to specific energy systems or sub-systems. There is, of course, no point in studying again and again those aspects which have already been the subject of exhaustive study, let us say, in the course of the last hundred years. This would apply for example to sub-systems connected with the use of carbohydrate fuels. The less well-known systems are of greater interest: those based on the use of nuclear fuels, for example, or sub-systems using geothermal energy sources. Great selectivity must be exercised in choosing objects of more detailed programmatic research. In particular, it seems desirable to undertake such research into systems using nuclear fuels and geothermal energy indicated above.

At the same time, there are certain aspects of systems already carefully studied which should not be neglected. For example, the investigation of potential possibilities of systems using carbohydrate fuels seems important, not only from the viewpoint of the efficiency of their conversion into energy, but also with regard to a more rational use of the energy thus obtained. It seems probable that the need to husband energy resources and energy will become rather acute, if progress in the areas of atomic power stations, and in particular, of breeder reactors turns out not to be as rapid as is hoped. The systems approach to the use of energy is an extremely urgent problem in today's conditions and those projected for the future.

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* This may be an incorrect translation of the Russian word "zamykayushtchich"

Comments upon IIASA Research in Energy Systems

K. Ananichev

The whole project should consist of the following programs:

1. The study of parameters, terminology, and measures concerning energy problems; gathering, analysis, and estimation of available forecasts of energy crisis development.

2. The analysis of present energy conversion systems, with special emphasis on

   a) nuclear energy,

   b) geothermal energy and energy of gravitational origin; and

   c) energy based on biological and biochemical processes.

3. The survey-forecast of the world fuel-energy system development, with critical evaluation of utilized information and with reference to the results of the first two programs. This program should be aimed at the end of the twentieth century.

4. The study of the most progressive ways to overcome the possible energy crisis. Special emphasis should be given to the economical ways of fossil fuel utilization, energy accumulation, transportation, and consumption.

A Summary of Remarks on Economic Modelling, Demand, and Supply

E. B. Dudin

Mr. Dudin began by commenting on the objectives of modelling and the limitations of model design. Although mathematical models are necessary for planning and decision making, they are auxiliary to them. Thus, IIASA cannot have as an ultimate goal simply research into modelling.

IIASA should consider those systems and, hence, models which are complex in character. It is important to use the right verbs to describe these. However, there is much talk today about simulation of energy subsystems and there are many experts with experience in this field. IIASA should not repeat this research. Instead, it should try to tie together the work done elsewhere and use an integrated system of energy models for forecasting.

The effectiveness of models remains an open question. An important determinant of the answer is data; data will determine the validity and efficiency of any project. Thus, the IIASA research group should try to elaborate standards for data.

When one begins to build models there is a question of the appropriate time and space domains. In the case of this IIASA project, the time scale is determined by the character of energy forecasting. Hence, the upper time horizon should be the year 2000. The scope in space is determined by the international nature of IIASA. Its proper concern is global modelling and forecasting. National groups can develop national models.

Finally, economic and mathematical models represent important and very different subsystems. An international symposium sponsored by the UN Economic Commission for Europe will consider these models with respect to the field of energy. IIASA should consider the Proceedings of this symposium in planning its research program.

Comments and Recommendations Concerning the IIASA Energy Systems Project

K. Hoffman

The outline of the energy systems project prepared by Prof. Haefele was quite comprehensive and provided an excellent stimulus for the discussion of specific research topics. All of the major issues were identified and discussed during the course of the meeting. Although it is important to identify possible topics in these formative stages of the project, the further definition and evaluation of these topics will, in large, depend on the interaction of the individuals involved in the energy project and in related areas such as urban development and bio-medical studies. The project should remain flexible so that individuals can work most effectively within a unifying theme.

During the project, it appears that there may be many topical reports and progress reports prepared, but it is too early to identify any project "milestones" or opportunities for final reports.

There are several considerations that must be weighed in identifying research topics. A short list of such criteria is as follows:

a) avoid duplication with national activities;

b) topics should be of shared concern to the member nations;

c) must be within the scope of IIASA resources;

d) political acceptability; and

e) amenability to systems analysis.

Discussion of Research Topics

Several research topics were suggested during the course of the meeting. Following are some comments on these topics. They are not listed in order of priority, and it obviously is not possible to include all of these activities in the study at the same level of effort.

1. Long Term Global Effects

The emphasis here should be on the long term global implications of an asymptotic energy system. The long term climatological effects of CO_2 and particulates produced from fossil fuel combustion should be considered within the context of natural emissions of these materials. The global capability to absorb waste heat should also be studied.

2. Impact of Exploiting Solar, Wind, and Geothermal Energy on the Biosphere

Here the problem must be studied on a regional level to consider local effects and their propagation through the atmosphere.

3. Urban Energy Systems

The urban problems involving energy and its effects is common to almost all participatory nations and should be studied in coordination with the urban study group. I believe that regional energy studies must be within the scope of IIASA activity involving both this topic and the previous topic. A problem common to all participants should be identified (e.g. transportation, waste handling) for study. Problems that are unique to a small set of participatory nations should, however, be left for national studies. although individual nations may already be studying the common problems, there would still be a need for IIASA to foster interchange and development of methodologies.

This topic is also an appropriate near term topic that could balance some of the longer term topics that were proposed.

4. Risk and Reliability

Methodologies are required to handle the questions of common mode failures. This is fairly well-developed for reliability analysis of reactor systems but needs to be extended to other areas. The question of diversity in agricultural and ecological systems, as well as in energy systems, must be considered. The siting problem for large energy installations could also be considered in this context.

5. Demand Projections

The potential effect of conservation strategies, alteration of life styles, and economic growth on demands should be studies. Particular attention should be given to the interrelationships between energy demand and life styles.

6. Bio-medical Effects

It is important to consider how morbidity and mortality due to energy activities should be considered in energy system planning. If these costs, as perceived by society, are in excess of "true" costs, what are the implications? I think that we are a long way from having the capability to incorporate these factors in an objective function for optimization.

7. Data Requirements

This topic cuts across all of the possible activities of the energy project. It seems clear that IIASA should not be in the business of gathering data as this is too much of a job to undertake with limited resources. IIASA can, however, develop recommendations for definitions and terminology relating to resource availability and energy demands. This would be an important contribution to improvement in the flow of data.

8. Long Term Interfuel Substitutability

The role of the renewable or abundant resources (solar, geothermal, fission, and fusion) in the long term should be considered. The problems of substituting these energy sources in order to conserve fossil resources should be considered.

9. Embedding in Society

The question of the interrelationships between energy demands and life styles came up at several points in the discussion. However, it is not clear that any of the national programs are addressing this topic adequately. IIASA would seem to be in a good position to study this topic, but it is not apparent that the program is constituted to do so.

10. Cooperation with National Groups

The IIASA activities should not, of course, be duplicative of national activities. IIASA can, however, play a role as a central contact point for national activities. The adaptability of specific methodologies to the planning activities of market and planned economies will be an important consideration in such interchanges and could be an important research topic at IIASA.

The most recent output of national systems analysis groups could be kept in the library at IIASA and made

available to all interested scholars. Group meetings could be held periodically for more detailed discussions. Such meetings should be informal in nature and should be working periods with a minimum of formal presentations.

There are active energy systems analysis activities in the U.S. at Brookhaven, MIT, and Battelle Memorial Institute-Northwest Laboratories. With respect to the programs at Brookhaven, cooperation would be most fruitful in the area of energy systems analysis, technology assessment, energy model data base, and biomedical and environmental effects.

Some Remarks on the IIASA Study Project on Energy Systems

J. Holubiec

Generally I agree with Dr. Ananichev's and Dr. Weinberg's remarks on the study project in energy systems.

It seems to me that the determination of data resources is needed for a longer period of time than up to the year 2000.

The problems of modelling are important for all countries. Having many experiences with the use of linear programming in energy systems (USA, USSR, France, GDR, Romania, Poland), we may expect that after some time (needed, for example, for data unification) IIASA will be able to prepare one model ready to be used for IIASA's member countries.

It seems to me that the limits to growth in energy consumption (per capita) ought to be analysed. There are many quite different estimations in this field, (for example, for electrical energy from 55.000 kwh/year/capita to 150.000 kwh/year/capita).

Interaction with other IIASA study projects must be taken into consideration.

Comments at the Closing Session

R. Janin

The idea of orienting IIASA work so that the Institute will serve as a clearing-house for models dealing with energy appears worthwhile.

However, economic models--in contrast to physical models--are closely tied to the conditions for the functioning of the economic system they represent. That is, they can rarely be transposed from one country to another. Perhaps what is most important for IIASA is to extract the philosophy behind each model to indicate its genuinely novel ideas.

It would also be appropriate to undertake an analysis of the types of responses of these models to changes in exterior conditions: it does not appear certain, *a priori*, that the consequences of a given variation in an event would be felt in the same manner by all the models. Comparison of the responses to a "stimulus" could, it seems, provide a study topic in coherent systems.

But IIASA studies along these lines should be long term and should seek to deal with problems not treated elsewhere. In this respect, it would be interesting to prolong the discussions we have had during these four days and attempt to define what type of energy mankind will use after fission. We have the duty to start preparations for this very distant future by beginning the indispensable research on an international scale. IIASA can make a fundamental contribution to these studies.

Ideas and Proposals on the Research Project "Energy Systems"

H. Knop

1. The papers on this project, set forth by Prof. Haefele in November 1972 and in May 1973, deal with very interesting subjects and give a suitable starting point for our joint discussion. This attempt to analyze the present scientific situation in the field of energy systems on the basis of the available publications (in particular the western publications) is very useful and meritorious. I fully agree that it will be necessary now to work out a more detailed and definitive program on this basis and to make this project ripe in order to be able to start a serious scientific work.

In all our countries energy problems are main problems of economic policy and social strategy. They are intertwined with all fields of social life because they require a relatively great part of the annual national income. The intended as well as unintended results of energy policy and energy economics are connected with the interests of everyone.

2. The wide ranging consequences of the development of production and consumption of energy led us to adopt in our country a comprehensive view of energy problems during our work on the prognoses and long-term plans of the development of our energy economy up to the year 1990 and, in some fields, up to the year 2000. We considered it necessary to include the following problems in an energy forecast:

- the opening, mining, and manufacturing of primary energy sources
- all steps of energy transformation
- the development of energy demand in the different fields of production and consumption
- international cooperation in the field of energy supply

- the social preconditions and requirements for long range development of our energy basis and the possible and necessary steps to fulfill these requirements

- the allocation of energy production, in particular of nuclear power stations with all problems of water supply and energy transport

- the development of environmental protection

- the development of the number and qualifications of manpower working in the energy sector of our national economy

- the optimization of the necessary reserves in our entire energy system, a problem of possible risk and necessary reliability

- the determination of price relations in order to promote the process of substitution among the different energies.

(My experience as the head of the prognosis group of energy economy of our Council of Ministers are written down in a separate paper, which is at your disposal.)

In view of our experiences, I fully agree with the comprehensive approach to the systems analysis of energy systems suggested in Prof. Haefele's paper. It might be useful to discuss the question, if necessary and possible, to include also social preconditions and consequences as well as problems of manpower in the investigations.

3. The consequence of the comprehensive approach to energy problems is a very complex optimization of energy development, requiring utilization of adequate mathematical means. These means are developed in our country as a model system with central models of the entire energy economy, submodels of the different branches of obtaining and transforming energy and submodels of the different territories.

We gained much experience with most of these models during our work on the prognosis and long-term plan of our energy economy. (I am ready to inform you about this model system with a separate paper from our Institute for Energetics in Leipzig.)

4. A very complicated problem is the problem of the objective function for energy optimization. From my point of view, price is unsuitable to serve as an objective function in long-term calculations. The calculations with a synthetic price--the so-called "expenditure indicator"--in our country were not fully satisfactory. Therefore an evaluation matrix was applied in which the different evaluation criteria appeared with a certain weight having to be determined outside the matrix. The following criteria stood side by side in this matrix:

- specific energy supply per manpower
- expenditure of investment
- demand in primary energy
- specific cost of generation of electric energy and gas
- transformation efficiency between final energy and primary energy
- application efficiency
- share of energy import in the import expenses of the national economy
- the improvement of the working and living conditions
- supply guarantee.

5. Some remarks as to the time and space domains (suggested in Prof. Haefele's paper) within which the problems of demand and supply of energy shall be studied: It would be more effective to consider the current forecast and long-term planning work which is done in the different countries or groups of countries and to coordinate the choice of the forecast period with the respective national institutes.

From the aspect of the benefit for all members of the IIASA, the investigated period should not be longer than up to the year 2000. That means it will be more useful to answer the current questions of the next twenty years than to work out hypotheses about a world with energy abundance.

As far as the investigated territories are concerned I think we should act as realists. There are different groups of countries in the world with different social orders

and close economic connections among them. Most of the current energy problems (i.e. the problems of the next twenty years) are to be solved within the scope of these groups of countries and not so much between these groups. Therefore it would be most effective to do the investigations of the IIASA in these real existing economic territories.

Here we should mention that this approach also will give the best background for the necessary data basis. The situation is that most of the published data are not very reliable and the other data--in particular from countries with centralized long-term planning--which are more reliable, are not published.

6. There are many connections among the different projects. The energy systems project, for example, is closely interlinked with the water project, with the ecological project of city systems, and with the environmental project. The organization project might have a central position. Under these conditions, I regard it necessary to determine more definitively how the cooperation among the different projects shall be managed and what the different tasks of each working team shall be. This will help to make the energy project program more detailed and ripe.

7. One remark relating to the timetable suggested in the paper from November 1972: This timetable seems to be a realistic one. Now it must be divided into more definitive, detailed and shorter parts. In this connection one question: Given the present very rough program, with what purpose is the computing time for 1973 planned?

8. So far, these have been particular remarks. In conclusion I want to underline that I agree with the main direction of the project proposed by Prof. Haefele. Despite the work necessary to make this project more concrete, practicable and better timed and to answer the questions of this discussion, I think this project gives a good and useful starting point for the elaboration of a detailed research program.

Remarks

G. Kostjanoj

He called the attention of the participants to the importance of considering possible man-produced effects in climatic changes due to release of heat and other pollutants in the form of gases, particles, and so on into the atmosphere and hydrosphere. The particular question was "should such effects be included in the formation of the price of energy in order to maintain acceptable levels of pollution in the environment?"

The WMO activities in the field of measurements of meteorological parameters, solar and radiation balance observations were briefly described from the view point of possible IIASA and WMO cooperation for estimating energy (winds, tides, currents, solar energy and other related phenomena) which could be available to mankind.

The participants were also informed of the involvement of the WMO, particularly of its Commission for Atmospheric Sciences in the studies of man-made effects on the climate.

Suggested Energy Study Problems for the I.I.A.S.A.

W. B. Lewis*

1. There is no energy crisis anywhere now that money could not cure, (remembering to include provision for social costs), but if an early solution of a local problem is needed, one should forget fast breeder reactors, nuclear fusion and novel solar energy schemes for which the development time is either unpredictable or too long. There is now significant unemployment of technologists and engineers in several advanced countries, and it is their effort (as well as that of others still to be educated and trained) that would have to be harnessed to the known techniques of: fission reactors and fossil fuel burners coupled to process steam, to fuel hydrogenation, or to turbo-generating plants.

The "energy problem" is which route to choose and how to finance it. Men must be liberated from slavery to the obsolete ideas of defunct economists (to borrow from the late J.M. Keynes [1]).

It is necessary to evaluate a number of routes on a cash flow basis and to demonstrate, by computer methods, their cost characteristics [2].

2. Where industrialization is heavy, the cost that is being shunned is likely to be that needed to avoid thermal pollution [3]. This does not apply in Canada and countries with a cold climate [2]. There the problem may be one of atmospheric pollution at sub-zero (Fahrenheit) temperatures [4] [2].

3. A major problem is how to organize the provision of power in under-developed countries. This is an economic paradox well known in basic economics (e.g. J.K. Galbraith, The New Industrial State, page 45: "Most communities in the past were limited in their progress by the savings they could extract from their meagre product....The same is true of poor nations today....In the rich nations the tendency of savings and thus of capital to abundance, abundant use notwithstanding, is a matter of penetrating historical and social consequence.")

4. It is known whether the level of CO_2 in the atmosphere rises linearly with additions from combustion, nor what is the net effect on climate and local weather of a significant increase in the CO_2 level [5]. This is a very complex analytical problem requiring experimental data and computation.

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Some small but important contributions come from study of the C-14 in the atmosphere [6] [7].

5. The earth's albedo for solar radiation depends on dust and clouds in the atmosphere, and on the extent of polar ice-caps, the time of year, the latitude, the ratio of sea to land area, etc. Changes of albedo directly change the earth's energy budget. Recent satellite experiments by T.H. Vonder Haar and V.E. Suomi indicate the earth's mean albedo is about 29 to 30% instead of 35% as previously believed [8].

As discussed by Haefele quoting M.I. Lvovich [9], the evaporation and run-off of precipitated water sets limits to generated power density. Both the data and calculations deserve critical analysis. See also F.K. Hare and J.E. Hay "Anomalies in the large-scale annual water balance over northern North America" [10].

7. Energy transmission costs are important and need to be better established for prospective hydrogen pipe-lines [11] and super-conducting and high voltage D.C. transmission over long distances in all weathers.

8. M.K. Hubbert [12], Chauncey Starr [13], M.A. Adelman [14], and others have published weakly based estimates relating fuel costs to resources. These need substantiation.

9. The possibilities of hybrid fusion-fission reactors deserve much more study [15]. Note that fusion does not have to be thermo-nuclear [16].

10. Will 50 thermal kW/capita be enough for 15,000 million population [2] [17] [18] if land now arid has to be brought into cultivation [19]?

11. What balance between hydrogen and synthetic hydrocarbons is likely for secondary fuels in the long term [2]?

Notes and References

[1] (Lord) J.M. Keynes, The General Theory of Employment, Interest, and Money, page 383: "The ideas of economists ...both when they are right and when they are wrong are more powerful than is commonly understood. Indeed the world is ruled by little else. Practical men, who believe themselves to be quite exempt from any intellectual influence are usually the slaves of some defunct economist. Madmen in authority, who hear voices in the air, are distilling their frenzy from some academic scribbler of a few years back. I am sure the power of vested interests is vastly exaggerated compared with the gradual encroachment of ideas. Not indeed, immediately, but after a certain interval; for ...the ideas which ...politicians ...apply to current events are not likely to be the newest. But, soon or late, it is ideas, not vested interests, which are dangerous for good or evil." The book ends here. Macmillan & Co., London, 1936.

[2] W. Bennett Lewis, "Nuclear Energy Based Synthetic Hydrocarbon Fuels, Basic Technology and Economics" DM-140, May 1973.

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Strategy for Survival - A Club of Rome Project In The Predicament of Mankind Study

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Motivation and Historical Background

The interdependence between various problem areas besetting modern society, the presence of strong forces which cause developments in all corners of the globe to interact with each other, and the need to take these factors explicitly into account when considering the future, are beyond dispute today. However, it was only as recent as 1970 that a group of individuals, to be named the Club of Rome, decided to do something about what they called the Predicament of Mankind by starting a debate on the issue and by helping to initiate the research into the "problematique humaine". The first research effort was carried out at MIT under Professors Forrester and Meadows, whose findings are published in the widely known book, Limits to Growth.

Only half-way through that project, in Summer 1971, the authors conceived an alternative, radically different approach to the problematique based on the multilevel, hierarchical systems theory rather than on Industrial Dynamics, later termed System Dynamics. The project was initiated after it became obvious that the MIT project would be deficient in at least three aspects:

1. Its extremely high degree of aggregation, because the world was treated as a whole and not as a system of quite different political and economic regions, interacting with each other.

2. The mechanistic and deterministic character of the computer model in which all structural relationships were fixed, so that the results of the computer runs could be influenced only by the choice of the initial or intermediate conditions.

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3. Limitation of the project to the physical aspects of the world problematique without consideration of the sociological, political, and psychological conditions that are certain to undergo tremendous changes during the long time span considered by the project.

In view of the wide publicity given to the MIT-project it should be noticed that our project is not the second phase to the former; it is not supposed either to confirm or to refute the assumptions and conclusions of the former study, nor is it based in any way on the model already developed. Rather, it is an alternative approach to the consideration of the original problem raised by the problematique and left as yet unsolved. The Volkswagen Foundation has provided support for both these efforts.

Objectives and Approach

The principal objective of our project is to develop a computer-based planning and decision-making tool which can be used to analyse the "problematique" and to assess alternative policies and strategies for implementation. The project has diagnostic as well as therapeutic aims. It will be made accessable to the responsible decision-makers and in this way provide specific help to the solution of the problematique.

Among the main characteristics of the model are the following:

a) The world system is represented in terms of a number of interconnected and interacting regions (presently 10, but possibly more) such that the countries of each region are expected to be faced by similar problems, to have reached a similar state of technical and economic development, and are run by similar political and economic institutions, etc., and therefore will respond similarly to crisis-conditions of interest. This is essential for the analysis and recommendations to be relevant for the prevailing conditions in the world system.

b) The decision-making, goal-seeking processes relevant for the long-term development are shown explicitly in the regional models; the need to recognize these processes follows immediately from the regional view of the system, since the interregional

relationships are governed by such processes. This will also allow viewing the human society as an adaptive system, which it surely is.

c) The model is constructed on the basis of the multilevel hierarchical systems theory which allows full integration of the knowledge and data from any relevant field of inquiry or experience, by using stratified structures for the model. This appears to be the only way in which the "problematique" can be approached with a sufficient degree of reality, and the model can be made compatible with the present state of human understanding and credible for use in the analysis of policies.

d) The model has an interactive mode of operation for simulation and analysis. This is essential for avoiding determinism and allows the insertion of prevailing values and intangibles as perceived by the policy analyst.

State of the Project

Progress has been made in a number of directions and in particular:

1. The total framework has been developed for the implementation of the model based on a three strata structure, namely, the causal stratum, the organizational stratum, and the norm stratum.

2. A first generation model of the regionalized world economic system has been completed and verified by data over the past 20 years.

3. A dynamic model of regional population growth has been developed, and the effects of timing of various birth control programs in different regions have been analysed.

4. A model of the world energy system has been developed, giving information of the production, consumption, export, and import of energy and energy resources. The model

has been validated over a period of 20-50 years, depending on the data available.

5. A phosphorus use and food production model has been developed for the analysis of phosphorus as an essential resource for the world food production.

6. An interactive mode decision-making program has been developed and applied for the analysis of alternative policies for the solution of the energy crisis in the developed world region.

7. Foundations have been laid for a comprehensive model of the technology stratum, and a data collection effort is under way.

8. Foundations have been laid for the development of a model of the world ecological system based on the basic ecological cycles; the model will provide a basis for the assessment of pollution in real rather than abstract terms.

9. An effort is under way for research on the norm stratum which will be used as a guide for the interactive policy analysis by the planners and decision-makers.

10. The world-wide applicability of the model will have its first test in 1973 when the regional models stored in Hannover and Cleveland will be connected via a satellite communications network for the on-line interactive analysis of the energy policies of the respective regions. Five to six more regions will be included in the satellite network during the next 12 months.

Special attention is given to the advice and support for the project from the scientific community and responsible decision-makers. A meeting was held in December 1972 at the Rockefeller University on the economic model and a follow-up is scheduled for the end of July, 1973 in Reisensburg, Germany. Support is coming forth also from an international expert group on problems concerning food, energy, and mineral resources under the leadership of Professors Dennis Gabor and Umberto Colombo. Furthermore, a work-shop is being planned with the Institute of Ecology on the global modeling of the ecological system. Many other contacts are being made with professional and political leaders.

Proposal for IIASA Energy Systems Study

K. Oshima

There are several groups in Japan which are carrying on or starting systems studies of energy problems: in-government agencies, research groups under government contracts, groups in industry, and research institutions.

The interest covers the long range, the medium range, and the short range in the definition of Prof. Haefele. The "long range" is mainly for government policy, especially in relation to R&D directions, as well as scientific interests. The "medium range" is to supply information for governmental and industrial efforts in formulating policies and options for future energy. The "short range" is mostly linked directly with the strategy to cope with the present energy situation by the government or industries.

The expectation for IIASA may be classified into three categories:

1. Joint Research in Methodology

It will be very fruitful if IIASA can become a core of exchange of information and comparison of methodologies studied in different groups around the world. Our interest is to discover what kind of methodologies can be applied and to learn the experiences of other groups on the validity of such methodologies in practical application.

IIASA can work as a clearing house, but also it is most desirable that a group be set up in IIASA composed of specialists coming from different international groups to work together at least for several month to carry on such exchanges and comparisons.

2. Data Base

As noted several times during the meeting, we need many data for systems study of energy which are lacking. It is not practical to expect IIASA to try to collect such data by itself. But it would be most fruitful if IIASA could identify the data needed for system studies and through its broad international contacts ask other national and international organizations to supply such data.

3. Research Projects

IIASA should carry on research projects of energy systems. In this case, short range study might be difficult to do in such international organization because political and local national interests will inevitably be involved. However, in medium range and long range studies, international research projects in IIASA will make great contributions to this field, especially because such studies must be global. Understanding of regional problems and conditions of the world is essential and, further, a broad interdisciplinary view and input data are needed.

For such projects, I suggest that in the first phase IIASA set up a work-shop to identify the problem areas and do preparatory work to select some specific project. National groups should contribute to the workshop by communication.

In Japan, we hope to set up some ad hoc group to become a contact point between IIASA and Japanese study groups. This group will work to facilitate contacts between study groups and IIASA, avoiding any control or screening. It is expected a few researchers; perhaps two or three at the beginning, will join the IIASA research team. Other scholars -- five to seven, in the beginning -- will be commuting members, doing research in Japan and visiting IIASA occasionally.

Some Remarks on the Presentation of Prof. W. Haefele Research Planning Symposium on "Energy Systems"

F. Rabar

1. More than being excellent and impressive, the presentation was persuasive and convincing, so convincing that one is inclined to accept it as a research program without further hesitation or modification. The first feeling one has is that at last we have found the special objective of the Institute, the duty "par excellence" of those working in the impartial atmosphere of an international institute: to develop models independently of any existing institutions, to optimize objective functions of mankind as a whole (if only such a thing existed). Who should do this kind of work if not an international institute devoted to solving worldwide problems, noncommitted, and objective in every respect?

2. However, we have touched here a very important aspect of the future research strategy of the Institute. There are two different kinds of reality around us: the reality of nature--physics, the atmosphere, the hydrosphere--and the reality of institutions, nations, borders, oil companies, and vested interests. Sometimes the second type of reality is stronger and determines technical development whatever the consequences might be. When starting research we can regard the institutional framework as nonexistant; we may use a global point of view, and, in this case, the resulting model will be an exercise in logic, based on assumptions which are unrealistic from the beginning. On the other hand, if we accept all the institutional constraints, the conflicting partial interests and sometimes diverging paths of the different groups involved, we give up the idea of influencing technical development, the first duty of an international institute.

Nevertheless, the question was put many times already at the conference on water resources: "How does the work of the Institute help me?" asked the participants (e.g., Dr. Clough). It seems indispensable to come up with results immediately applicable, with solutions to problems which can be identified with the goals of some or of all the participating institutions.

3. If we want to meet both requirements: a) to accept "the message" of Prof. Haefele's paper (which was most instructive) and b) at the same time to do something profitable

also in the short run for the members of the Institute (with their "simple-minded," limited, and partial interests), we must break down the proposed project so that some building blocks result which are useful for individual members.

4. How to break down the project? We can do it in many ways:

- into regions (that was the proposal of Prof. Pestel)
- into time spans (short run, medium run, and long run, proposed by Prof. Haefele)
- into economic units
- into disciplines (sociology, ecology, etc.)
- into technologies, etc.

In any case, there is one important, basic requirement that should be met: all the building blocks (slices of the pie as Prof. Fiering called it as the Water Resources Conference) should be systems themselves. The cores of at least six or seven such subsystems are contained in the presentation of Prof. Haefele: not only can the three different time spans be handled separately (but not independently), but also the energy-water-weather aspect, the energy-ecology aspect, the energy-social risk aspect, etc.

5. Summing up the lessons drawn from the paper:

a) The Institute must deal with worldwide problems as this alone is the specific, new feature which can be added to the work of other existing institutions.

b) The work should be always of an integrating, synthesizing nature, using a global, overall point of view.

c) All such global models should be broken up into well-defined subsystems, identifiable with the field of interest with the partial objectives of the participants.

d) The conception, the basic context, the interfaces should be worked out here in the Institute by excellent professional people; the coordination must be done here.

e) The subsystems, the data collection, and some of the methodological work must be done by the institutes represented in IIASA.

f) All the results must be distributed among all of the participants.

g) It follows that the work to be done next should be proper definition of the subsystems and of their interrelationships.

Note on Raiffa's Query About IIASA and BNL Models

A. Weinberg

I would urge very carefully considering IIASA serving as a full scale clearing house for energy-economic modelling. This could range all the way from simply keeping a catalog of such activities to maintaining a library of codes and computer models. In the latter instance IIASA would become a full-fledged information center for energy-economic modelling.

There are many models for such centers in the nuclear community. Perhaps the nearest to what I have in mind are the Reactor Shielding Information Center at ORNL and the Reactor Codes Information Center at Argonne. These centers keep the actual codes and make the codes available to groups that might be interested. They sponsor "Code" workshops to which people interested in learning how to use the codes come. The centers themselves are operated by people who are expert in the field; the existence of the center greatly strengthens the internal work of the laboratory since it gives the laboratory very intimate access to the relevant data and methodology. The centers also strengthen the external work in shielding and reactor calculations by making these important methods widely available.

The main point is that IIASA Energy Project ought to make it its business to keep intimately abreast of everything going on in the world related to energy systems analysis. Our experience at ORNL with many such centers demonstrates their great usefulness both internally and externally.