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ENERGY FUTURE STUDIES

A Brief Review

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ENERGY FUTURE STUDIES

A Brief Review

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ENERGY FUTURE STUDIES - A Brief Review.

I PURPOSE

The purpose of this short report is to outline major future studies regarding energy which are underway or have recently been completed. The information provided on domestic studies covers the most important activities presently underway or recently completed which might be expected to have policy implications at the Federal level. The data on international agency activity is provided as a framework within which to place the Canadian effort. The information on activities in individual countries is given to allow a degree of comparison but provide only that data which could be readily obtained in the time available and therefore cannot be taken as either complete or representative.

II BACKGROUND

The term 'energy future studies' can refer to activities ranging from 10 year projections of the electrical needs of a utility to the overall energy policy study of a country. For this reason it was necessary to place some limits on what was considered in this review. The following general rules were adopted in deciding what constituted an energy future study. In general the study,

i) must deal with a time span out to at least 1990,
ii) should consider more than one energy source,
iii) be of a national or international scale,
iv) be expected to have major policy/political impact,
v) be organized on a project basis rather than be an ongoing activity, and,
vi) result in a report which is available.

These criteria were less rigorously applied to domestic studies where a number of provincial and/or single commodity studies are listed because they are expected to have a large impact on overall domestic policy.

In general an energy future study consists of three parts:

i) a model of the energy situation which is projected

into the future on the basis of a set of assumptions;

ii) an interpretation of the results obtained from analysing the evolution of the model and the influence of factors not in the model; and,

iii) a set of policy recommendations aimed, usually, at trying to modify the future as seen in the model projection.

However, the level of development and sophistication of each element of the study may vary considerably. Models may range from a simple projection of supply and demand, towards a complex computer program which may contain 10 to 15 thousand equations linking supply/demand, GNP, transportation costs, regional variations, world prices and a host of other variables. These computer programs are not, in themselves, energy future studies, but rather tools which allow a vast amount of complex arithmetic, bookkeeping if you like, to be done. There are an impressive number of these computer energy models presently available. Appendix A is a list of some of the major World Energy models developed in the U.S.

Perhaps the most difficult phase of energy future studies is part (ii), the interpretation of results and the integrating of these results with less quantifiable factors. An excellent example of the need to take into account factors of social and political significance not normally part of a computer model can be illustrated by the Swedish Nuclear Energy Program. The energy supply/demand computer model for Sweden could not take into account the resistance of the Swedish people to nuclear energy which ultimated resulted in the defeat of the party in power. Often key factors which represent serious constraints with respect to the development of an energy source cannot be quantified.

Finally the energy future study is expected to produce policy recommendations. Usually these recommendations come with a set of benefits and costs which are often estimated by comparing the output of the model with and without the recommended action taken. An excellent example of such an exercise involves the raising of the domestic price of crude oil. A model, fed the price rise, indicated the drop in demand resulting from an increased price but also listed the costs. Among them an increase in inflation and unemployment. (Economic indicators calculated using the CANDIDE computer model, energy values calculated using ENEMA computer model).

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The analysis of energy future studies would be considerably simpler if each study comprised one model, one interpretative study and a set of policy recommendations. Unfortunately this is rarely the case. The overall model used is often constructed using several different computer programs (individual commodity supply/demand, econometric, energy accounting, etc.). In addition, a major study incorporates and sums up studies on individual energy sources. For example projections of electrical supply/demand may be approached both by projecting national demand or by summing the results of individual projections made for each major system (i.e. Ontario Hydro plus Quebec, etc.).

III ENERGY FUTURE STUDIES : CANADA.

General

In Canada the major effort to pull together the many diverse parts of the energy situations has rested predominately with the Department of Energy Mines and Resources (EMR). Commencing with policy (An Energy Policy for Canada, 1973)[1], to the development of an energy strategy for the short and middle term (An Energy Strategy for Canada : Policies for Self-Reliance, 1975)[2], to the present program to examine the long-term future, (Long-term Energy Assessment Program) each phase of study has attempted to anticipate events further and further in the future.

A parallel effort to that of EMR has been made by the Science Council of Canada commencing in 1975 with "Canada's Energy Opportunities"[3], supported by the background study "Energy Conservation"[4]. Forthcoming studies include "Population : Technology and Resources"[5], a report on the Conserver Society, and a report on Energy R, D and D Priorities.

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1. An Energy Policy for Canada, Vol. I and II, Dept. of Energy, Mines and Resources, Ottawa, 1975.
2. An Energy Strategy for Canada : Policies for Self-Reliance, Dept. Energy, Mines and Resources, Ottawa, 1976.
3. Canada's Energy Opportunities, Science Council of Canada Report 23, 1975.
4. Energy Conservation, F.H.Knelman, Science Council of Canada, Study 33, 1975.
5. Population, Technology and Resources, Science Council of Canada, in preparation.

The National Energy Board (NEB) has tended to concentrate on a single energy sector in most of its major studies. Most recently it published 'Canadian Oil : Supply and Requirements', which, although primarily concerned with oil, does discuss long-term (to 1995) oil requirements against a background of the general domestic energy picture. Of key importance is the NEB's ruling on the MacKenzie Valley and Related Pipeline Applications. This report discusses natural gas supply/demand projections in the context of an overall Canadian energy picture.

In Ontario the Royal Commission on Electric Power Planning (The Porter Commission) is holding public hearings on the future direction of electrical development in that province. Although this is a single commodity in a single province it is included here under Energy Future Studies because its conclusions, particularly with respect to nuclear generated electrical power, may profoundly affect the expansion of nuclear power in the country's most industrialized province. A second important provincial study likely to have national impact is the legislatively required periodic review of provincial energy requriements expected in 1978 by the Alberta Energy Conservation Board. Other provincial activities affecting future energy include a B.C. Energy Commission modeled on the Porter Commission, Quebec's nearly complete legislative inquiry into energy policy and Newfoundland's just completed analysis of offshore resources.

IV MAJOR STUDIES

1. L.E.A.P.

The Long-Term Energy Assessment Program will be producing a draft report for internal use before 1 September, 1977. The report will be written by the Energy Review Group of EMR under the direction of Mr. James Gander. This report will be based upon the work of 10 committees with membership drawn from various departments of the Federal Government. The authors aim "to produce a report outlining basic goals for an energy policy to the year 2025 and suggest policies and priorities to achieve these goals".[1]

The committees responsible for supply and demand will utilize computer programs which have been developed at EMR

1. James Gander, 1977. Program Outline.

to model the Canadian energy picture. This information will be interpreted by experts in various fields with a view to identifying important factors which will influence energy development over the projected time span.

It is expected that this report will examine energy supply/demand options and locate key areas of uncertainty with respect to meeting the long-term objective of achieving sustainable self-reliance in energy. The report will make policy recommendations aimed at reducing these uncertainties.

The authors of this report have been requested to have a draft report available for the deliberations which will precede the decision on a pipeline from the western Arctic. In addition this document can be expected to affect decisions relating to AECL's advanced fuel cycle proposals, LNG transport by marine mode from the Arctic and R&D priorities in the renewable energy area.

This report is expected to be a synthesis not only of a number of primary sources of information but will probably provide a synthesis of all the more geographically or commodity restricted reports (i.e. Ontario Hydro, AECL, etc.).

2. Science Council: Energy R, D and D Priorities.

The Science Council tabled at its meeting of 17 May, 1977 a draft Council statement on energy research, development and demonstration priorities. This report, researched and drafted by E.R.Stoian of the Council's staff, attempts to provide a framework within which energy research, development and demonstration priorities can be assigned. The report is an attempt to set priorities on the basis of an evolving energy picture out to the year 2050. The main emphasis of the report is upon the setting of criteria within which priority choices can be made.

The report is expected to be made public sometime before 1 September, 1977. This report probably will not depart greatly from the recommendations on energy R, D and D which will come out of the LEAP report. From an internal Government policy point of view the impact will probably be minimal because the report accompanying the "A base review" is more specific, better documented and covers essentially the same ground. In terms of public reaction, the Science Council

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report strongly endorses the concept of demonstration projects and therefore will provide support for those wishing expanded activity in this area.

A critique of the draft report was prepared for the Secretary of MOSST as part of the briefing notes for the 17 May, 1977 meeting of the Science Council.

3. Science Council: Conserver Society.

The Science Council has in preparation a report on the Conserver Society. This report can be expected to suggest a broad range of policies aimed at reducing energy demand. Emphasis will be placed upon both material and energy savings through changes in present technological practice (fix technologies), the development of new technologies (i.e. methanol from wood), and changes in the nations' consuming habits. The report will be published as a public document in late September or early October in advance of a conference on the Conserver Society.

It is expected that this report will provide a focus for those wishing to promote alternatives to major energy developments. It will probably provide a concise summary of the counter-arguments to the "growth" philosophy.

4. National Energy Board: Northern Pipeline Report.

The National Energy Board has just tabled a report on the Northern Pipelines. The terms of reference of the NEB are such that, although the direct purpose of the report was to rule on the applications before the Board to build a pipeline for natural gas from the Western Arctic, the Board has considered alternate natural gas supplies, deliverability, and supply and demand questions extending at least twenty years into the future. In this respect at least two sections of the report qualify as energy future studies: future energy supply/demand and future natural gas supply/demand. The NEB report now tabled in the House of Commons will be background, along with the Berger report (Volume 1 and possibly Volume 2), to the expected debate in the House in August. The report will represent one of the key factors in providing a technical background for the pipeline decision.

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V ENERGY FUTURE STUDIES : INTERNATIONAL AGENCIES

General

A number of international agencies are examining the energy future either globally or with relationships to groups of nations (i.e. OECD). Briefly outlined below are five studies underway in international agencies and one recently completed study by an independent group concerned with the world energy future.

1. United Nations: Future of the World Economy.

This report and related model was produced with the idea of "maintaining the ecological balance and ensuring the survival of mankind". The emphasis has been upon developing countries and the reduction of economic disparities. The report utilizes primarily two scenarios, optimistic and pessimistic, for the years 1980, 1990, 2000. The report projects no energy shortage but only shortages in the type of energy. It projects, essentially, an infinite supply of coal energy by assuming a present world coal reserve of close to ten billion metric tons. The report notes that regardless of an optimistic or pessimistic scenario, there will be serious balance of payments problems generated by increased petroleum costs, particularly among developing countries. It suggests a problem with the international monetary system of catastrophic proportions.

2. OECD: Interfutures.

The Organization of Economic Cooperation and Development have launched a study called Interfutures. The objective is "to consider the long-term problems...of advanced industrial societies in relations with the developing countries". At the moment occasional papers are being produced and summary documents will be published. A confidential paper "Energy in Long-Term Development" is now available through government channels.

3. IIASA: The Energy System Study.

The International Institute for Advanced Systems Analysis is presently engaged in building a model of the world energy system. The approach to modeling in this study is one of understanding economic structure rather than identifying

historical inter-relationships. The system therefore is more closely tied to physical constraint rather than price and the market forces. A status report on this program is due in October, 1977. Individual task forces results are due December, 1977 and December, 1978.

4. Economic Commission for Europe.

Of the 16 committees in this organization none of them deal specifically with energy. However, a group has now been formed which draws together the energy issues of all areas. Their basic interest is in energy economy and more efficient use of energy; some preliminary reports are available. There are presently 60 projects in the 1976-81 work program which concern energy. The over riding majority of these activities are problem oriented; only a few projects consider policies as such in their entirety. The majority of in-depth enquiries concern technical problems followed by economic, methodological and environmental problems.

A lot of emphasis is placed on the joint international undertaking of studies followed by an exchange of views at meetings and seminars.

There are several projects of interest to Canada. The first is a seminar to be held in Canada in October on the impact of energy considerations on the planning and development of human settlements. The purpose is to examine long-term implications of settlement policies to the year 2000. Another project focuses on technologies related to new energy sources and examines both technologies for renewable energy and improved efficiency in using other potentially important energy sources.

5. IEA

The International Energy Agency, a nineteen member group of the OECD, is mostly concerned with ensuring adequate supplies to members and coming to political agreements with respect to allotments and rationing. The Agency's time horizon is 1990 - its structure encompasses a governing board and four standing groups:

1 - SOM - standing group on oil markets - major interest in reducing dependence on imported oil.

2 - SEQ - concerned with getting agreement on emergency measures - the percentage of fuel types to be stored in countries or cut back.

3 - SLT - standing group on long-term co-operation. Three working groups - conservation, accelerated development, nuclear. The conservation group published projected demand by fuel type and end use for years out to 1990. The SLT is now taking a firmer role in coordinating views of the three working groups.

4 - CRD - Committee for Research and Development - looks at new technologies for conservation and new supply options. Most of this completed work is available through EMR. As well some of the conservation estimate have been made public.

6. WAES: MIT Workshop on Alternative Energy Strategies.

This workshop used detailed demand analysis projected into the future and modified for improved energy efficiency, substitution and government conservation policies to develop a demand model. Demand, compared to potential supply, indicated the non-Communist world will face - perhaps as early as 1980 - an annual oil shortage which will grow by the year 2000 to 15-20 million barrels a day. The WAES report, "Energy: Global Prospects 1985-2000", is available to the public.

VI ENERGY FUTURE STUDIES: FOREIGN COUNTRIES.

To obtain an overview of activities in other countries a telex was sent through External Affairs to Science Counsellors in major capitals. Information was requested on ongoing or recently completed energy future studies within the limits set out at the beginning of this paper. Responses were received from the USA, Japan, France, Germany, UK, and Australia.

1. United Kingdom.

The UK is in the rather unique position among industrialized countries (along with Norway and the Netherlands) of being able to increasingly meet its energy needs from domestic resources. The increasing production of North Sea oil and gas is expected to make the UK a net exporter of these commodities until sometime after 1990 (the exact date is not agreed upon). The UK is therefore in a position of having some 15 to 30 years in which to develop alternate energy sources. The Department of Energy in its report, Energy Paper # 11, stressed the need to use the energy rich decade(s) to build both a sound energy and industrial position. Most favoured areas of concentration are coal, nuclear energy and technologies such as solar and wave power. Both the Department of Energy and the Royal Society recommended keeping the nuclear option open by continuing research on the fast-breader reactor. The Royal Society expressed concern that not enough emphasis was being placed on R&D in radioactive waste management. More recently a UK white paper on nuclear power and the environment was decidedly vague on nuclear energy's future. The white paper, in response to the Flower's Report questioning the British nuclear power program has backed off a commitment to a large nuclear program until the issue has been debated in public but proposes several mechanisms to strengthen radioactive waste management.

In general a number of organization in the UK have recently published reports urging greater effort in renewables (primarily solar and wave energy) and claiming up to 30% of energy needs can be met from this source.

2. Germany.

In the post oil crisis time, Germany viewed nuclear energy and coal as the main routes by which to lessen dependence on imported oil. However, a new four year program, 1977 through 1980, places greater emphasis on non-nuclear energy although nuclear R&D will still be funded much more heavily than non-nuclear research. There is evident a basic German commitment to nuclear but the ratio of nuclear to non-nuclear funding has dropped from 45.2 to 1 in 1973 to 4.3 to 1 in 1980. R&D funds are also being spent on coal liquefaction, gasification and hydrogenation. Germany has enough coal for

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200 years at the present rate of usage. Other technologies being investigated for future use include district heating. Analysis of potentially available alternate sources of energy and an estimate of the development feasible by the year 2000 indicates that hydro-electric, solar and wind, in that order, will contribute to over-all energy requirements.

3. France.

The French government has commissioned many studies on energy for the 1990 era but has published few. The Science Counsellor in France has been promised documentation relating to some of the energy future studies as well as the "Report on Energy for Seventh Plan". These have not yet been received.

4. Japan.

Japan is now dependent on imports for approximately 90% of its primary energy. With very few natural energy resources Japan has tended to concentrate its energy policy on assuring security of offshore energy supply, increasing conservation efforts, nuclear power and development of limited indigenous sources such as solar and geothermal. Japanese policy is clearly outlined in two documents "Energy Stabilization Policy for the Coming Decade - A Choice for Stable Supply", Report by the General Energy Council for the Minister of International Trade and Industry, 15 August, 1975, and "Basic Direction of General Policy". A Decision of the Ministerial Council on General Energy Policy, December 19, 1975, (both available in English).

One of the unique features of the Japanese policy is the recognition that security of energy supply in the long-term will be more costly and the cost of this "insurance" should be spread equitably within the energy sector. Simply stated: it is better to pay a higher price for a guaranteed 20 year supply than a lower price for a 5 year supply. Therefore the Japanese are willing to pay a premium for supply assurances.

The Japanese nuclear program will continue to represent an important component of their policy. Like most countries developing nuclear power they are having difficulty locating sites for power plants and are seriously concerned with reactor safety and waste disposal. Japan has reprocessing

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capabilities which can be expected to be expanded to meet the needs of a program to develop advanced fuel cycles.

5. USA

The amount of activity in energy future studies in the US is impossible to adequately summarize in the time and space available. The best short summary available is the telex received from the embassy in Washington in response to our request. The following is abstracted directly from that telex:

"The following is a list of recently completed studies which have had significant impact at policy levels of the US government:

A. 'A Time to Choose: America's Energy Future' Ford Foundation Energy Policy Project, 1973.

B. Nuclear Power Growth - 2000, US Atomic Energy Commission, 1974.

C. Project Independence Report, Federal Energy Administration, 1974.

D. A National Plan for Energy Research, Development and Demonstration: Creating Energy Choices for the Future, Energy Research and Development Admin. Annual 1975,1976.

E. Energy Perspective, Department of the Interior Annual 1975, 1976.

F. Energy Outlook, Federal Energy Administration Annual 1976, 1977.

G. Mitre Report on Nuclear Policy Issues, Ford Foundation, April, 1977.

In addition, in the private sector major studies are ongoing at several US universities and research institutes including the University of Southern California, MIT, Brookhaven National Laboratories and Stanford Research Institute. The latter has developed a "World Energy Model" which is widely used by government and industry and has produced some

controversial results (e.g. a much more optimistic estimate of future oil supplies than other models). Other studies include a national energy strategies study currently being carried out by Resources for the Future as a result of a Mellon Foundation grant. This study is an effort to identify choices for the US into the next century and the most appropriate policy tools for their implementation. It is expected to be completed in 1978.

The National Academy of Sciences Committee on Alternate Energy Systems is preparing a comprehensive study of US energy options to the year 2010 with emphasis on assessment of risk associated with each option. The report is expected in the Fall of 1977.

The above is by no means a complete survey. Much of the pertinent literature was reviewed during the hearings of the House Commerce Subcommittee on Energy held March 25-26, 1977."

6. Australia.

Australian officials were very responsive to our request providing a list of 15 different studies related to energy which are ongoing in that country. The Australian experience is interesting because the government structure and the problems faced are similar to the Canadian situation. The complete list is attached as Appendix B. A quick review of this list indicates that many agencies and organizations are similar to those in Canada. It is noted, however, that at the moment Australia does not appear to have a group working to synthesize the other activities on a project basis. Presumably the councils and committees (first three on the list) function to advise the government on a continuous basis.

VII CONCLUSIONS.

1. Within the next 24 months a number of very important decisions will be made with respect to Canada's future energy supply. Areas where decisions are pending include: i) a pipeline from the western Arctic, ii) radioactive waste management R&D, iii) recycling of CANDU fuel R&D, iv) development of Arctic LNG

capabilities, v) the pricing of domestic oil with respect to world prices.

2. All these decisions are in one way or another going to be influenced by how the middle and long-term energy future is viewed. Generally, Canadian energy future studies agree that: i) oil and gas production from conventional sources (mostly Alberta) will peak between now and 1985, ii) world oil will be in short supply after 1985 and the real price will rise, iii) Canada has a multitude of domestic energy supply options many of which will have to be exercised to meet anticipated demand, and iv) the main areas of concentration are conservation, renewables, increasing domestic oil and gas supply from frontier sources and nuclear power.

3. Computer models are extremely helpful in formulating a conceptual framework within which future energy policy may be developed, but the model, by itself, cannot constitute an energy future study. Even the largest most sophisticated energy models (Stanford's with 116,000 equations), requires that both the input and the output information be interpreted. With regards to complex computer programs which try to build in every conceivable variable the following quote is apt "the most sophisticated expression of intuition I have ever seen". Fred Bellaire on Stanford's World Energy Model.

4. Studies by international agencies generally agree that the world demand for oil will exceed supply in 10 to 15 years and that the impending shortage will drive up prices and cause both financial instability and an increase in the disparity between rich and poor nations.

5. Countries can be devided into two basic categories: those with indigenous energy supplies and those without. Those countries without supplies are concentrating in the international sphere in arranging security of supply. Countries with indigenous sources of supply are developing them while also developing programs of conservation and R, D and D on renewables (solar, wind wave, geothermal).

6. Most striking is that all countries view nuclear as a main cornerstone to long-term energy supply stability but are encountering resistance to nuclear power station construction from the public. All countries embracing the nuclear option are concerned with reactor safety and radioactive waste disposal.

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7. EMR has several staff members who are keeping abreast of the many international developments within areas covered by the term Energy Future Studies.

Government Branch
Government Projects Division
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Appendix 'A'

World Energy Models

The following list with comments is taken from notes by J.A. Coombs of EMR who attended a conference on World Energy Models held at the Harvard - M.I.T. Joint Centre in May 1977. This is only a partial listing of models available or being developed in the U.S.A.

World Energy Model - Houthakker and Kennedy

This model of about 200 endogenous variables is an outgrowth of the world oil model developed by Kennedy and operational on the Data Resources Incorporated (DRI) computer facilities. The model has the following characteristics:

energy sources:	oil, natural gas, coal, uraniu, electricity
variables:	demand, supply, input to electrical generation, net imports, prices and trade flows
regions:	United States, Canada, Latin America, Europe, Middle East and Africa, Asia and Pacific and Total World.

The model separates light water and heavy water reactors and allows for enrichment and reprocessing. The OPEC price is exogenous and must be provided while all other parameters have built in default values, although these default values can be overridden if desired.

The model outputs results in decade averages and is programmed to handle 5 decades with the last decade centred on 2025. The cost of running the model is approximately $15 per decade. Professor Houthakker believes that the model should not be used seriously beyond the year 2000. There is no documentation on the model yet but there will be within a few months. However, the world oil model, of which the world energy model is a generalization, has been well documented[1].

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[1] Jorgenson, D.W. ed. Econometric Studies of U.S. Energy Policy, North-Holland Publ. Co., 1976. A copy of this book is in our library.

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There is no oil refining sector in the model yet but one is being developed. Further work is also being done on reprocessing and enrichment of uranium. The model incorporates short and long run supply elasticities for all fossil fuels except coal. These supply elasticities were developed in conjunction with estimates made by the Modelling Research Group for the U.S. It was assumed that the price response of other countries would be the same as for the U.S. Dr. Eckbo from M.I.T. thought that the supply elasticities were estimated naively.

In all runs made to date, the U.S. is a net exporter of uranium, based strictly on the economics built into the system. Professor Houthakker found this an interesting result.

We could arrange to use this model fairly easily by making a contract with DRI in Toronto or by getting the Bank of Canada Research Department to make some runs for us since they make use of DRI regularly.

M.I.T. World Oil Project - Jacoby

This project focuses on oil but takes account of other fuels by allowing for interfuel substitution through relative price variables in the estimated demand functions. The project started about 2 years ago and the main emphasis to date has been on collecting data and estimating supply and demand functions. There is no completely packaged model at present. The data problems are severe, with differences in estimates for some variables being as high as 5 per cent, even for 1972 data.

The modelling efforts to date have several unique features. The 31 countries of the model are divided into three groups, Importers, Price-Taker Suppliers and the Cartel Core. A model has been developed for the behaviour of the Cartel Core countries by Pindyck. The representative from the Stanford Research Institute noted that this Cartel model is to be incorporated in the SRI model.

A great deal of effort has been expended to develop reasonable estimates of the supply side. For the North Sea a disaggregated pool analysis has been made, relating the probability of a discovery to pool size and discovery sequence. The statistical analysis of the exploratory process is combined with estimates of reservoir economics and estimates of potential reserves to develop detailed estimates of supply elasticities. This procedure is expensive and hence a simpler method is also being developed which it is hoped will give results not too

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different from the detailed approach. The supply side is considered such that the model can be used only for about 10 years with any reasonable assurance. Dr. Eckbo, who has done much of the work on the project, is particularly concerned with the implications of the Venezuelan and Canadian heavy oil deposits beyond the mid 1980's.

The demand side of the model has the standard breakdown of demand into residential, commercial, industrial, transportation and energy transformation. Logarithmic oil demand functions are estimated incorporating relative fuel prices, own prices and other variables such as income, industrial production, etc. Separate estimates of electrical demand feed into demand for crude oil. These demand equations are estimated for each of the 31 countries in the model, as are the supply equations.

A number of reports on various segments of the model have been written over the past year and are to be mailed to Ottawa. It is possible to obtain the computer programs and data tape from M.I.T. for a nominal fee. Dr. Eckbo felt that two days at M.I.T. would be sufficient for an economist to familiarize himself with the programs.

A North American Interregional Input-Output, Linear Programming Model - Isard and Goettle (Isard not an author)

This model combines an energy sector represented by a multi-regional linear programming model with an interindustry model of the economic system. Large energy intensive industries can be removed from the inter-industry structure and made exogenous components of regional final demand. The integrated formulation has the following advantages, according to the authors:

1) Intra-regional interfuel substitution and variable inter-regional energy trade patterns.

2) The interindustry formulation preserves the conceptual dependency of the energy sector on the larger regional economic system in which it is embedded, though accepting constraints from the LP model of the energy sector.

3) It allows for technological change and also for industrial migration in important export-based industries.

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It seems to me that the interindustry model linkage adds little since the traditional components of final demand must come from macro-economic projections of regional product either by judgment or from a multi-regional econometric model. Macro-economic variables in the energy sector equations preserve the dependency of the energy sector on the larger regional economic system, and energy intensive industries can be treated separately in final demand without the need for a full interindustry table.

The model is being developed for 9 regions in the U.S. with the capability of handling Canadian and Mexican regions as well for a complete North American regional model. The model can have numerous objective functions and is similar to a system being developed by West Germany at Julich. It is an extension of the Brookhaven Energy System Optimization Model (BESOM) and the Reference Energy System developed at Brookhaven. The energy sources include the standard ones plus uranium, crude oil from shale, geothermal and solar. The IEA are considering using one of these models on a multinational basis, without the interindustry segment, for evidence on the optimal allocation of R & D expenditures.

Professor Isard of the University of Pennsylvania is anxious to pursue the incorporation of Canadian regions into the model, and would like us to co-operate by providing the necessary data. The model would indicate the optimal interregional energy flows and would provide estimates of the economic costs of politically imposed constraints. Alternatively it could provide information on optimal energy swaps. The data available in Canada are:

a) a regional interindustry table for 1966 which includes the major fuel types.

b) a detailed energy breakdown for 1966 for 210 industries and 660 commodities by 12 fuel types in natural units and BTU's.

Hence, it appears that much of the required data is available for 1966, if that is sufficient. Updating the data to say 1974 would be a relatively large project which could not be completed for about two years. Professor Isard mentioned the possibility of his sending one of his students to collect the data, and said that he would pay us a visit when he comes to his summer cottage at Chaffey's Locks.

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Project Link - Adams

Project Link combines econometric models from 13 industrial countries, the Soviet block and an LDC block. Link produces consistent estimates of world trade by forcing the import and export projections from the country models to agree.

Consideration is being given to connecting an energy model to link but nothing has been done to date. The Link system is intended only for short term projections of a few years.

World Bank

The model work of the World Bank is concentrated on the less developed countries and was not of much interest.

Long Range Energy Development and Supplies (LORENDAS) - Soyster

LORENDAS is a huge multi-programming model developed at the Virginia Polytechnic Institute for the U.S. and Europe. The LORENDAS matrix has 4500 rows and 5600 columns, with an information density of 0.3 per cent. From the data presented at the meeting, many of the results from one series of runs are highly dubious, although the project has cost about 3/4 of a million dollars to date.

Energy Modelling Laboratory - National Bureau of Economic Research - Kresge

Two months ago the Energy Modelling Laboratory was established to assess energy models. The model assessment proceeds by steps from an overview to model verification to an in-depth model assessment. The two models selected for an intensive assessment are the Baughman-Joskow Electrical Generation Model and the Wharton energy model. According to Kresge from NBER the following types of problems have been found to date:

- documentation generally poor
- models aften cannot answer questions their builders claim they can because of their specification
- computer programming errors
- sensitivity to alternative theoretical specifications

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A view expressed by Kresge and concurred in by several present was that any model which was so large that it could not be reasonably accessed and validated should not be used.

Appendix 'B'

Australian Studies related to energy

The following list is provided by the Australian Government through the Canadian Embassy in Canberra.

1. Title: National Energy Advisory Committee

   Responsible Agency: Department of National Resources

   Terms of Reference: The function of the National Energy Advisory Committee is to advise the Minister for National Resources on matters relating to energy including -

   (a) Australia's energy reserves;

   (b) factors likely to influence

   (i) the pattern of energy supply and demand in Australia

   (ii) the future costs of energy in Australia

   (iii) the assessment and development of Australia's energy resources

   (iv) the economy of use of energy in Australia;

   (c) the balance of resources for research relating to the development of energy sources in Australia;

   (d) developments in Australia and overseas in respect of methods and technology associated with the production and distribution of energy.

   Outline: Established February 1977 to advise the Government on energy matters and assist in the formulation and development of a national energy policy for Australia. Currently examining matters relating to conservation of energy and energy research and development.

2. Title: Australian Minerals and Energy Council

   Responsible Agency: Department of National Resources

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Terms of Reference: To promote the general welfare and progressive development of the Australian mining and mineral industry, and to consult on the nation's energy needs, resources and policies.

Outline: Comprises Federal and State Ministers with responsibility for mines and energy. Met for the first time in March 1977. Replaces the former Australian Minerals Council.

3. Title: Australian Science and Technology Council

Responsible Agency: Department of the Prime Minister and Cabinet

Terms of Reference: The functions of ASTEC are to advise the Government on science and technology, including:

(a) the advancement of scientific knowledge and the development and application of science and technology in relation to the national well-being;

(b) the adequacy, effectiveness and overall balance of the national effort in science and technology in government, industry, education and other sectors of the community;

(c) the assessment of gaps and overlaps in science and technology in Australia;

(d) the identification and support of new ideas of science and technology likely to be of national importance;

(e) the practical development and application of research discoveries and the fostering of technological innovation in industry; and

(f) the means of improving efficiency in the use of resources related to science and technology.

Outline: Established as statutory body on 19 April 1977 after previous interim status. Currently inquiring into the role and status of Australian science and technology.

NB: The above Councils and Committee have only recently been established and the timing and nature of their inquiries is as yet not fully determined.

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4. Title: Ranger Uranium Environmental Inquiry

Responsible Agency: Department of Environment, Housing and Community Development (for carriage of the Inquiry)

Terms of Reference: The Commission is required to inquire:

in respect of all the environmental aspects of:

(a) the formulation of proposals;

(b) the carrying out of works and other projects;

(c) the negotiation, operation and enforcement of agreements and arrangements;

(d) the making of, or the participation in the making of, decisions and recommendations; and

(e) the incurring of expenditure,

by, or on behalf of, the Australian Government and the Australian Atomic Energy Commission and other authorities of Australia for and in relation to the development by the Australian Atomic Energy Commission in association with Ranger Uranium Mines Pty Ltd. of uranium deposits in the Northern Territory of Australia.

Outline: Established in July 1975. First Report in November 1976, second Report expected in May/June 1977.

5. Title: Australian Natural Gas Utilisation and Transport Study

Responsible Agency: The Pipeline Authority

Terms of Reference: To provide authoritative assessments of the probable demand for natural gas at all major centres, and of its probable availability and cost; and thereby to provide a comprehensive basis for considering the nature and timing of progressive pipeline developments.

Outline: The Report, presented in October 1976 also examines cases involving two alternative levels of LNG exports.

...4

6. Title: Senate Standing Committee on National Resources, Report on Solar Energy

Responsible Agency: The Senate

Terms of Reference: Concerned with all aspects of solar energy, seeking to establish whether and in what ways solar energy can be developed as an alternative energy source.

Outline: The Committee's Report was tabled on 4 May, 1977. In general it concluded that solar energy will not make a significant contribution to Australia's energy requirements before 2000.

7. Title: Royal Commission on Petroleum

Responsible Agency: Administration, Department of Administrative Services. Implementation of Recommendations, Department of National Resources, Department of Business and Consumer Affairs.

Terms of Reference: All aspects of the production by refining, and the marketing and pricing, in Australia of all types of petroleum fuels.

Outline: The Commission produced six reports, three major ones dealing with marketing of motor spirit and refining of petroleum and with liquefied petroleum gas.

8. Title: Victorian Government Green Paper on Energy

Responsible Agency: Ministry of Fuel and Power

Terms of Reference: To examine Victoria's known energy resources in the light of the State's needs during the next 30 years and to review Victoria's energy policies.

Outline: Report presented March 1977 outlines a policy of husbanding Victoria's energy resources, encouraging maximum use of brown coal and conservation of resources.

9. Title: Victorian Solar Energy Committee

Responsible Agency: Ministry of Fuel and Power

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Terms of Reference: Review all solar energy research being carried out in Australia with particular reference to Victoria and advise the Government on how to support promising research.

Outline: Established in May 1977, the Committee will report annually to the Minister for Fuel and Power.

10. Title: South Australia State Energy Committee

Responsible Agency: Premier's Department

Terms of Reference: To detail the State's energy requirements to 2000, to evaluate reserves including nuclear fuels and assess their contribution to future needs, to report on energy R&D.

Outline: Report presented May 1976 recommending, inter alia, the establishment of an energy authority and the encouragement of exploration for fuels.

11. Title: Kimberley Tidal Power

Responsible Agency: State Energy Commission of Western Australia

Terms of Reference: Provision of cost study for main dam

Outline: Report presented January 1976 suggests costs of about $2,000 per KW without storage

12. Title: Western Australia Fuel Demand 1977-1997

Responsible Agency: Western Australia State Energy Commission

Terms of Reference: Provide estimates of fuel demand based on historical data and other information

Outline: Report presented March 1977 estimates annual growth rates of 5.9% to 1987 and 4.6% to 1997

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13. Title: Task Force on Energy

Responsible Agency: Institution of Engineers

Terms of Reference: To coordinate Institution activity on energy, to prepare advice to Government and the public.

Outline: Twelve working parties established to report on a wide range of energy matters. Results to be discussed at a Conference in Canberra in July 1977.

14. Title:Energy Discussion Paper

Responsible Agency: Department of National Resources

Terms of Reference: Preparation of a discussion paper on energy

Outline: The discussion paper will be presented in October 1977 at a national conference on energy arranged by the Academy of Technological Sciences in conjunction with the Department of National Resources.

15. Title: Survey of Energy Research and Development

Responsible Agency: Department of National Resources

Terms of Reference: To ascertain the level and direction of energy R&D expenditure in Australia

Outline: The survey is to be undertaken when resources permit, by the Department of National Resources in consultation with the CSIRO.