RECOMMENDATIONS CONCERNING SUPPLY-DEMAND ANALYSIS

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Recommendations Concerning Supply-Demand Analysis

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The analysis of supply-demand interactions and of the social, economic, and technological implications of changes in demand level, induced by both supply constraints and changes in life style, is recognized as an important part of the IIASA Energy Program. A variety of analytical techniques is required to address this problem. It is probably not feasible, nor is it desirable to attempt to cover this diverse range of interactions with a single model. Rather, attention should be directed towards linking several models together based on consistent input data and the appropriate transfer of critical parameters between models. The linkages must be established initially with careful analysis and interpretation. As individual models evolve and the linkages become better defined, these may be strengthened.

A series of important questions related to supply-demand modeling were defined in a memorandum of 21 Jan. 1974 from Dr. Häfele These were:

1. What are the consequences or implications of a reduction in the primary demand for oil and gas of 5,10, and 25%? What difficulties arise and what is the sequence?

2. What are the consequences or implications of a reduction in growth of the primary energy demand from the present 4-5% to 2-3%?

3. What is the optimal partition in the above-mentioned situations between electrical and non-electrical secondary energy?

4. What comments may be made on the Rand reports?

Paricular attention was given to the tools and models that could be employed in these supply-demand analyses. These questions are discussed in the balance of this report. In addition a section is is included at the end which outlines current and planned activities of the Energy Systems Analysis Group at Brookhaven, that may be relevant to the IIASA Energy Program.

1. Consequences of reduction in demand for oil and gas : The reduction in the use of these fuels will be considered in the context of supply constraints on their availability. The immediate consequences of a reduction in supply can be handled by allocation, rationing, or through the price mechanism. There is little apportunity for interfuel substitution and the expansion of production of other fuels. This near term problem is probably of interest to IIASA only in terms of the implications it has for the longer term response involving the substitution of other fuels for those that are in short supply.

Analysis of the U.S situation indicates that a 5 to 10% shortfall of oil may be handled in the short run through conservation measures, such as reduced automobile travel and space heating, with a minimum economic impact. It would require at least a 10 year period, however, to adapt to a 25% reduction in supply. This adaptation would require both conservation and substitution of other energy forms.

An interfuel substitution model should be used as the basic analytical tool in analysis of this situation. Over the long term the substitution possibilities are heavily dependent on the availability of specific technologies such as coal liquefaction and the electric car. Since the longer term will probably involve increased reliance on nuclear power and increased electrification of the system, a model of the nuclear fuel cycle and electric sector is required. Dynamic models are needed here and the Häfele-Schikkor and Manne models are most appropriate. The technological details may be introduced in specific time frames by the use of the Hoffman L.P. model. The use of this model will allow the development of increased end use and technical detail. A dynamic version of this model is under development at Brookhaven, however, this is not felt to be a crucial feature since the limitations attributable to dynamic elements other than the nuclear fuel cycle may be treated rather simply by adding constraints to the static model. The dynamic models of the electric and nuclear sectors thus may furnish appropriate constraints on the nuclear-electric and nuclear-hydrogen supply options in the static L.P. model. The static model in turn may be used to develop a detailed view of the supply-demand configuration of the entire energy system at a given point in time.

The Nordhaus model, which is a dynamic multi-region L.P. model with more aggregation than the Hoffman static model would also be useful to the IIASA program.

Extensive demand analysis is required to address the first two questions posed. Changes in fuel prices resulting from fuel substitution may cause substitution among consuming activities. No models are proposed for energy demand analysis because it is felt that they are all too aggregated. Relatively simple analyses (which are not defined here as models) may be employed to make the specific relationships between life styles and energy demands explicit. The demands should be considered at the level of functional end use since the substitution possibilities are dependent on this classification. It would be of interest, for example, to consider the energy demands of the model population for two life styles; Dantzig's compact city and a suburban sprawl settlement.

In considering the implications of supply reductions, the reallocation that takes place across income groups must be addressed. Such reallocation can have severe social and political consequences.

The price changes resulting from fuel supply constraints and the substitution of more costly energy sources may have an impact on the economy. This implication also arises in the context of the second question and will be discussed in the following section

2. Implications of a reduction in growth rate for all energy demands: Here the economic consequences become more important. Constraints on the supply of all energy forms will force the substitution of less energy intensive technologies and activities. This question can be addressed through the use of macroeconomic models of the Houthakker-Jargenson and Wharton School type. These should, however, be coupled with an interfuel substitution model to get around the problem with input-output models of fixed coefficiants, at least in the energy sector. (Such work is underway at Brookhaven and should be completed in 6-9 months)

Again, demand analysis is important in relation to this question. The implications are dependent on the distribution of the growth reduction across demand sectors and across income groups.

3. Optimal partition between electrical and non-electrical secondary energy forms: This is a more specific aspect of the interfuel subsititution problem discussed in section 1 above. Greater definition of the components of the 10 or 20 Kw/capita energy budget is needed to determine the optimal partition. This definition must be based on functional end use, and the specific technologies assumed are important (e.g., water splitting, hydrogen aircraft, methanol fueled or electric vehicles)

The same analytical techniques discussed previously are pertinent to this question. My personal view of the trend with respect to the introduction of hydrogen or a synthetic fuel such as methanol derived from hydrogen goes as follows. The first step will involve the use of coal in those nations rich in this resource, and off-peak, nuclear-electrolysis in other nations, to produce hydrogen. The hydrogen (or methanol) would be used for peak-electric generation and other direct uses where environmental considerations dictate it (e.g. urban fleet vehicles). This step could take place within 10 years. In the next step (10-20 years) base load nuclear-electrolysis would be employed to produce these synthetic fuels. After 20 years thermo-chemical water splitting, biochemical conversion based on solar energy, or some other technology may come into the picture.

In any event increased electrification of the energy system seems inevitable, perhaps reaching the 35 to 60% level by 2000 in the U.S. The uncertainty in this range depends on the specific end use technologies that are employed, the impact of environmental groups on nuclear plant construction schedules, and the response of domestic natural gas and oil production to deregulation and price increases.

4. Rand report on energy in California: It is felt that the Rand report suffers from a lack of attention to technological details and too narrow a focus on the electric sector. In recommending geothermal energy over nuclear energy, no attention was given to the waste heat, H_2S, and subsidence problems associated with the geothermal power systems. The report also indicates that a price rise will slow the growth of electricity demands and lead to the substitution of natural gas. Nothing was said of the likely unavailability of additional quantities of gas. The Rand group downplays the economic consequences of price rises for electricity with little analysis, but does recommend a cautious approach until the initial consequences are observed.

5. Summary of Brookhaven Energy Systems Analysis activities:

a) Energy Model Data Base (EMDB).
This is an extensive data base covering 593 energy supply processes (long wall coal mining, catalytic cracking of oil, etc.) and 200 energy demand activities.

Efficiency, air and water emissions, occupational hazards, and cost are quantified for each process. This data base will be available on tape in about 2 months. A summary copy of the EMDB was left with Dr. Charpentier. The data base was designed by Brookhaven and we also gathered the efficiency data. Hittman Associates gathered the environmental data. The EMDB will be used at Brookhaven to develop coefficients for the models in use there.

b) Model Development: the linear programming optimization model is being expanded to 400 variables and coupled to a 365 sector input-output model. A dynamic L.P. model is being developed.

c) Biomedical and Environmental Assessment. A comprehensive assessment of the transport mechanism and damage functions of the major energy externalities is being performed by a group under the direction of Leonard Hamilton, M.D. This activity will provide information for energy systems analysis as well as to the AEC Division of Biomedical and Environmental Research to help guide their allocation of research funds.

d) Studies:

1. Technology Assessment to develop energy R+D plan
2. Regional studies of NYC urban region and Northeast megalopolis.

3. <u>Coal substitution strategies for the year 1985</u>: The attached preliminary report summarizes the results of this analysis. The substitution of electricity produced in coal-fired power plants with SO_2 controls for imported oil was studied. It was determined that through increased electrification and conservation, oil imports could be reduced to about $4x10^6$ bbl/day from the projected level of around $14x10^6$ bbl/day. Conservation measures account for a 10% reduction in total demand in 1985 and coal production must increase from $600x10^6$ tons/year to $1400x10^6$ tons/pear to make up the balance. The final results of this analysis will be reported in a paper at the World Energy Conference.