Staff Paper Series

REGIONAL IMPACTS OF ALTERNATIVE
ENERGY ALLOCATIONS

Wilbur R. Maki
Peter C. Knobloch

Department of Agricultural and Applied Economics

University of Minnesota
Institute of Agriculture
St. Paul, Minnesota 55101

P74-8   May 1, 1974

REGIONAL IMPACTS OF ALTERNATIVE ENERGY

ALLOCATION STRATEGIES

Wilbur R. Maki and Peter C. Knobloch
University of Minnesota

REGIONAL IMPACTS OF ALTERNATIVE ENERGY
ALLOCATION STRATEGIES

Wilbur R. Maki and Peter C. Knobloch*

In both regional planning and regional science, a growing concern is being expressed about the regional impacts and unanticipated external effects of development decisions. Studies of the regional impacts of the energy crisis and its energy shortages, however, deal only in part with the external effects of energy management decisions. Few, if any, studies identify the specific gainers and losers of particular energy allocation "rules" or strategies for dealing with energy shortages, nor are the affected groups being asked to "reveal" their preferences in advance of the rule-making and the decision-making. Lacking, also, are criteria for evaluating the usefulness of the information in terms of trade-offs between the costs of acquiring additional information and the decision costs of not having this information.

Energy Problem

In this paper we report on the development and use of an information system for state or regional energy planning which attempts to deal with both external effects and information needs. A regional economic model is included as an integral part of the information system. External impacts

of alternative energy allocation rules are simulated and criteria for evaluating these impacts are presented.

Specification of an energy information system implies basic understanding of the energy problem. For example, information on new energy supplies needed by Minnesota residents is now being sought prior to the granting of a license to build a new energy-producing facility. Also sought is information on the impacts of certain energy conservation measures which may be promoted as an alternative to the construction of new facilities.

Included in the information system for short-run, operational decisions is the response of specific energy users to changes in energy flow rates. The intermediate-range, tactical solutions to problems of energy conservation, on the other hand, involve the application of new production technologies and management practices. Information is needed on the potential adjustments in various industries which occur under conditions of energy scarcity as contrasted with conditions of energy abundance.

In the long run, the energy problem becomes one of strategies for expanding energy supplies. Information on the fiscal and ecologic impacts of new energy facilities for reducing regional supply deficits is needed, for example, in state licensing of energy production facilities. Such information must include the projection of alternative future utilization patterns in the state or region and alternative energy sources which would meet projected uses. Existence of external fiscal and ecologic effects calls for allocation strategies which minimize the social costs of these effects.

A simple input-output representation of a state or region helps identify the role of the energy system in the total economy (fig. 1). Use,

SOCIAL PREFERENCES AND VALUES

FINAL DEMANDS IN REGION

FINAL DEMANDS IN REST OF WORLD

Social-Economic Assets

Natural Resource Assets

Economic Inputs

ENERGY CONVERSION

NON-ENERGY RESOURCE CONVERSION

Materials Stock [Energy [Other]

WASTE EMISSIONS

ECONOMIC GOODS AND SERVICES

Economic Policy

Social Inputs

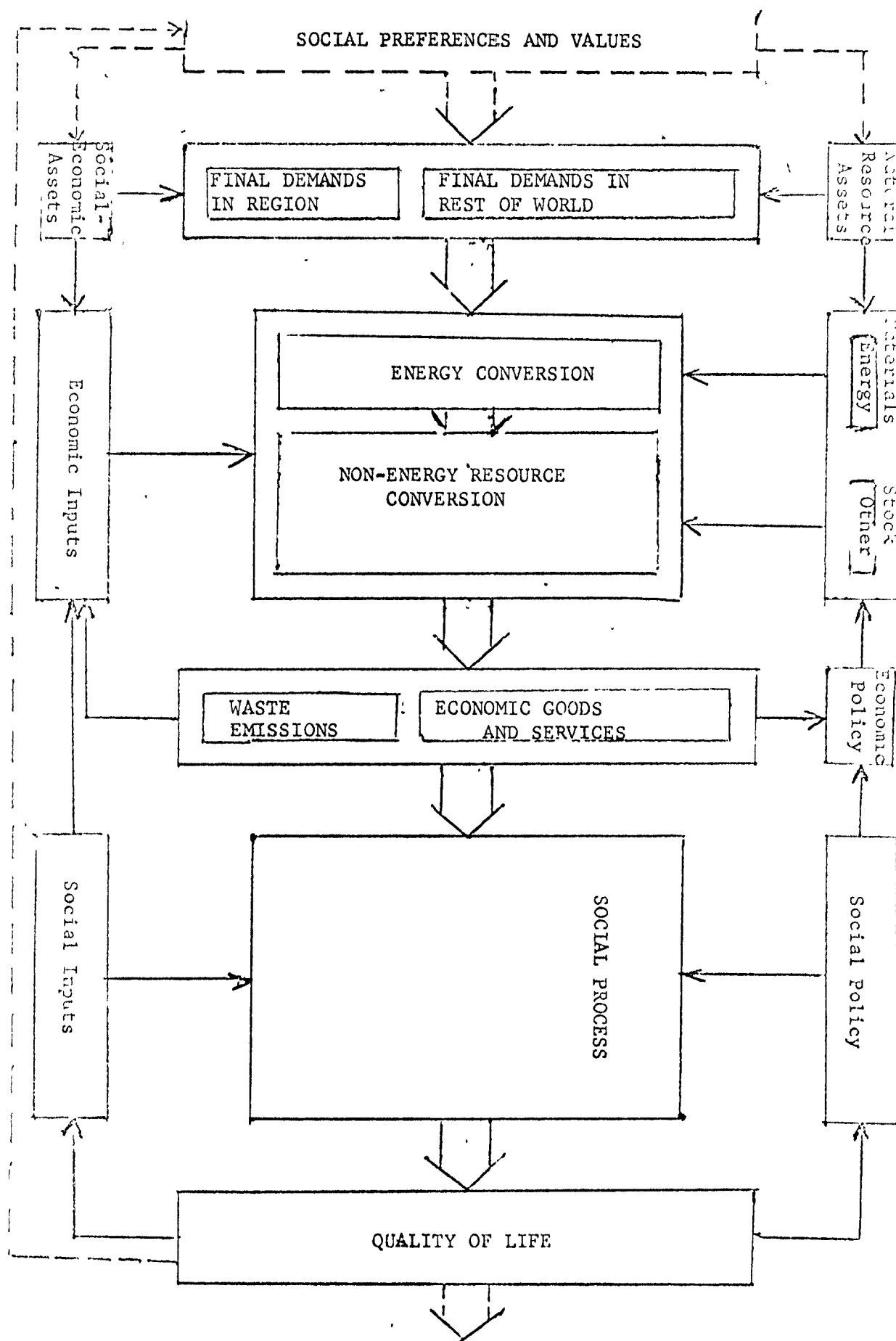SOCIAL PROCESS

Social Policy

QUALITY OF LIFE

Fig. 1. Simplified Regional Economic System Model

here, of the term _energy_ _system_ denotes a complex spatial and temporal

collection of interrelated elements through which there is a physical

flow of energy which may be generated, stored and consumed in the system.

The existence and properties of elements and the nature of the relation-

ships between them requires research with an empirical component in it.

The empirical component requires information for the "real world" to

study cause and effect of the physical flow of energy. In this illustra-

tion, the energy resource inputs are converted into energy outputs which

are used in producing economic goods and services, including energy as a

final consumption good. The economic outputs subsequently are transformed

by social processes into social outputs which are represented in the quality

of life experienced by residents in the region. Both the economic and social

processes are constrained by resource inputs and public policies.

Final demands for goods and services "drive" the regional economy.

The levels of natural resource assets and of economic and social assets

in the region set the levels of final demands (through price and other

economic changes in energy resource inputs and non-energy product outputs).

Economic policies affect the level of energy stocks, conversion technology,

and flows in the regional economy while social and environmental policies

affect the total supply of energy resources available in the region (1,20,21).

Information System

Elements of a regional energy information system, insofar as they are

now visible to us, fall into three categories of data which correspond

with the three-fold breakdown of energy management problems cited earlier.

Industry and household utilization data are needed for dealing with day-to-

day problems of local shortages in _operational_ planning. Periodic reports

of existing energy stocks and energy flows into and out of the state, or

sub-areas of the state, are needed in mounting the medium-term conserva-

tion programs in _tactical_ planning. Finally, studies of long-run trends in

energy consumption patterns and supplies of energy resources are needed in

strategic planning, particularly as it relates to the location and develop-

ment of new energy facilities.

Utilization data

Lack of current data on specific industry and household utilization

of energy poses a serious problem in the management and regulation of

energy systems. Dependence on the technical coefficients of the 1963 U.S.

input-output table, for example, or the production data reported in the

1954, 1958 and 1963 U.S. Censuses of Manufacturers, are grossly inadequate

in estimating energy utilization levels under conditions of scarcity and

uncertainty of energy supplies such as we now experience. The immediate

short-run impacts of alternative energy resource allocation proposals

cannot be determined simply from the historical data, either in terms of

energy requirements _per se_ or the unemployment and related economic impacts

of reduced energy supplies.

Because of the lack of utilization data, a Governor's Energy Study

Committee was established in Minnesota to develop and recommend a study

of the energy requirements in Minnesota on an industry-by-industry basis.

A task force of this committee prepared a survey design for which funding

is now being sought.

An industry utilization study, like the one developed in Minnesota,

provides a basis for updating the production coefficients in currently

available input-output tables. The survey design, however, must be keyed to the industry categories in the existing input-output tables for effective use of both sets of data (25).

Periodic reports on energy stocks and flows

A cross-sectional study of industry utilization of energy is outdated quickly without access to periodic reports on energy stocks and flows. A second study of the energy system has been developed, therefore, as a means of providing essential management information.

In this study, the energy information system is viewed as having two main components -- the accounting subsystem and the model network (15). The model network is the heart of the information system. It is a representation of the energy system within the selected geographical area; it shows the significant features of the real world of the decision maker. The accounting subsystem links the model network to the physical energy system: it collects pertinent historical and current information, audits for completeness and correctness, maintains the data base, provides values to the model network, and provides certain historical information directly to the decision maker.

Energy information accounting subsystem. The term energy information accounting subsystem is understood here to be concerned with providing information about energy to decision makers. The accounting function is concerned with some of the information about the state of the regional energy system and with some of the information from the environment. Internally (with reference to the region), the accounting function must be integrated with the operational document flow which describes energy sources, storage, conversion, transportation and end use. Externally,

information accounting is concerned with inter-state comparison and integrated with technological and market information about energy provision or energy utilization.

The value of the information produced by the accounting subsystem depends on the degree of correspondence between the reports describing a situation and the actual situation. For immediate decision making, the quality of the reporting must be high. Unless the accounting subsystem implementation begins with exact information rather than general diagrams or patterns, projections or trends, effective decision making is greatly diminished.

Operational decision making, which the accounting subsystem supports, should include data, for example, on:

(1) critical consumers such as hospitals in need of particular fuel deliveries, and their required deliveries;

(2) stocks of fuel already at the consumer locations, and their rates of utilization;

(3) total consumption and dealer supply of the fuel; and

(4) reporting of exceptions to spotlight consumers who are not conserving fuel.

It is important to recognize that the controlling element in attaining effective management of the local supply is the data base of the accounting subsystem. The data base is the collection of summarized information which is updated and processed to support the inquiries or reports which are the end product of an energy information system.

The main function of the data base is to provide information to study "what if..." questions. For example, the network model might be used to simulate alternate fuel allocations if a fuel supplier denies delivery to a particular agricultural co-operative. Or, a regional energy planner needs to know the energy requirements of an agricultural region if produc-

tion is to be increased by fifteen percent. Or, an area development agency

needs to know what is a "hardship" to a town if a gas station or distributor

goes out of business.

Like the regional economic model, the energy information accounting

subsystem provides for feedback of the effects of changes so that decision

(or decision impacts) can be evaluated. Thus, it is a needed supplement to

the modeling of the economic system; in fact, the later is an integral part

of the former in the total information system.

Energy information network model. The information system representa-

tion of the model network is a mathematical abstraction, but it can be

represented and thought of schematically. The physical energy network

includes the functions of source identification (production), conversion,

storage, transportation, and consumption (fig. 2). Each function is defined

as follows:

(1) Energy source, by type of energy resource, for example, coal,
which is specified by unit volume; BTU volume; and geographical
location.

(2) storage, which is represented by type of energy stored, for
example, oil; capacity in unit volume; loss factor; unit volume
stored, BTU volume stored; and geographical location;

(3) conversion, by type of energy input; unit volume input; BTU
volume input; type of energy output; unit volume output;
BTU volume output; geographical location; and capacity (in terms
of energy stored);

(4) consumption, by type of every used; unit volume used; BTU volume
used; geographical location; type of use, for example, heating;
and user class (by SIC code); and

(5) movement, by type of transport, for example pipeline; type of
energy; capacity of unit volume; BTU volume; location to and
from.

The model network shows all nodes and arcs of the physical energy

system within specified geographical boundaries; it is the portion of the
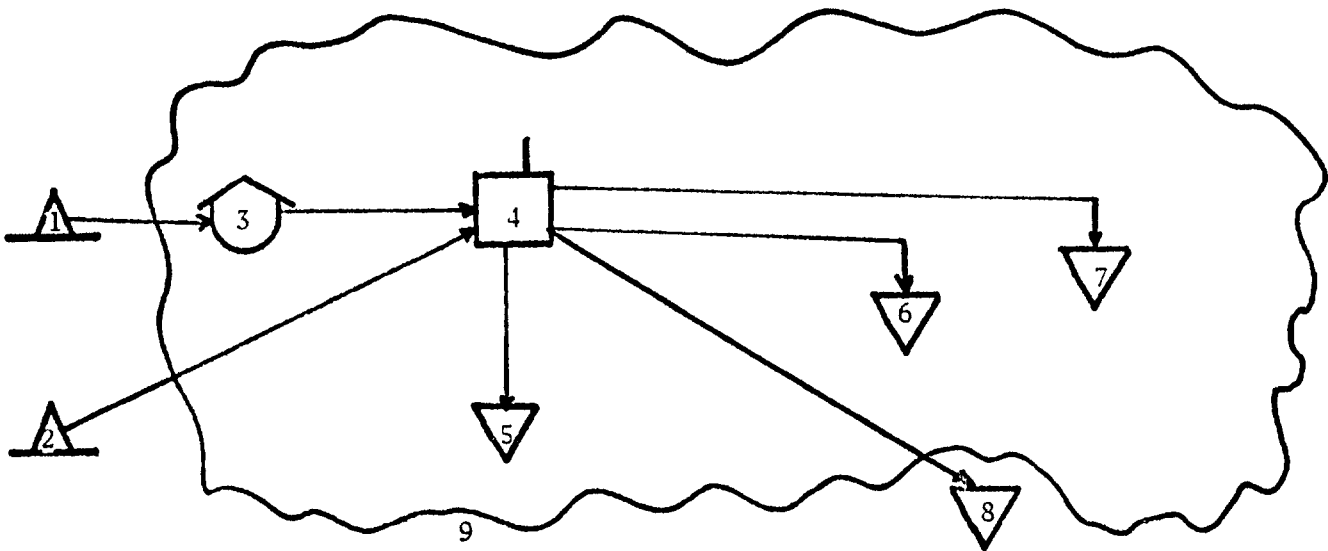
1. is a source of energy, such as coal

2. is a source of energy, such as oil

3. is storage of the coal, perhaps at

4. an electrical generation plant which

5. consumes energy in the conversion process, and distributes energy to

6. a class of users within the system

7. another class of users, and

8. a user outside the system boundaries

9. is the system boundary

Fig. 2. Simplified Energy Information Network Model (15).

information system used in predicting present and future energy require-
ments. The decision makers use the simulation capabilities of the model
network to evaluate the effects of possible changes to the energy system,
or changes in sources and uses of energy upon the rest of the network and
communities it serves before making changes to the physical energy effort.
Thus, the regional economic model is included within the total information
system.

Energy demand and facility location

While the two studies cited earlier deal with problems of energy
utilization and conservation, i.e., the operational and tactical decisions,
the study of energy demands in the context of energy facility requirements
is concerned primarily with long-run problems of expanding energy sources
to meet anticipated future energy demands. The Wisconsin Regional Energy
Model illustrates a long-run, supply-oriented approach in the modeling of
an energy information system (5,6). In this model, however, non-energy
production and utilization of energy in production and final consumption
"drives" the model. Projected energy demands depend upon projected trends
in industry value added per capita and the intensity of energy use (7).

A critical shortcoming of the trend-based regional energy models is
the lack of strategic focus in the specification of industry structure and
its internal linkages in both production and consumption. Inter-industry
linkages, under conditions of differential rates of growth in individual
industry outputs, make the use of the data based simply on historical
trends extremely questionable. Nothing short of an inter-industry, input-
output type of regional economic model (where the input-output table is one
important element of the total system) is adequate for dealing with the

problems of energy supply expansion to meet changing energy requirements (8).

An interindustry energy transactions model of the U.S. economy is being used by the Energy Research Group at the Center for Advanced Computation (CAC) at the University of Illinois at Urbana (13). Data prepared by the U.S. Department of Commerce on 363 sectors of the economy for the years 1963 and 1967 is being used in deriving the energy multiplier for a unit delivery to final consumption by a given sector. The dollar output of each sector also can be converted into employment, waste emissions, land use, and related multipliers.

Input-output models of subnational economies are being used also in impact analyses and projections for state and regional resource planning and development (16,19). These models can be adapted for use in impact studies of alternative energy allocation strategies at the state and regional levels of resource management and regulation.

Economic Model

In this study, a two-region, 81 sector, input-output model of the Minnesota economy is adapted for use in the long-range energy planning function (18). A computer programming procedure is used to simulate the state level impacts of alternative energy allocation strategies, as indicated earlier. In addition, a second two region, 81-sector computer simulation model is being developed to represent an eight-county study region focusing on Duluth-Superior metropolitan area (namely, the seven counties in the Northeast Minnesota Planning Region and Douglas County, Wisconsin). Thus, two levels of data collection and analysis are represented. The Minnesota input-output table is part of the state-level information system. The sub-state table is used to test and demonstrate on a manageable scale

the role and value of input-output analysis and related procedures in the energy planning process.

Model specifications

The state-level input-output table shows specifically the distribution of the outputs of 81 sectors in Minnesota among purchasing industry sectors in Minnesota and the rest of nation (RON). Alternatively, the input-output table shows the purchases of 81-sectors from producing sectors in Minnesota and RON. In addition, a series of so-called final demand and primary input sectors outside the 81 interacting industry sectors shows the in-state and out-state utilization of Minnesota industry outputs and in-state and out-state sources of Minnesota industry inputs of the 81 interacting industry sectors.

Two major groups of interacting industry sectors are identified, namely, five energy-producing sectors, and 76 energy-using sectors. The energy-using sectors are subdivided further into 10 essential services (including transportation), critical materials, and other energy-using industries. An identical grouping of the 81 sectors is used in the two regions, i.e., Minnesota and RON. In addition, six final demand and three primary input and import sectors are specified.

Again, the final demand sectors "drive" the two-region economy. In the final demand sectors are included purchases of industry outputs by households, government and businesses (for private capital formation) in Minnesota and RON. Interindustry sales and purchases in the RON are included in the export and import sectors for the Minnesota economy.

Data requirements of the 81 sector, two-region model include estimates (base year, e.g., 1963 or 1970) of intermediate and final demand outlays

for the 81 sector industry outputs (fig. 3). In addition, base-year data
are needed on waste emissions and facility requirements per $1 gross out-
put. Much of the needed data are provided in the existing two-region
input-output table of the Minnesota economy (18).

Projected industry output is derived, next, for specified levels of
final demand in Minnesota and RON. Alternative output levels for the energy
producing sectors are introduced into the programming procedures for the
two-region model. Alternative energy allocation strategies also are speci-
fied in the computer simulation of the two-region economy. Dollar changes
in specific industry outputs, which are associated with given changes in
final demand and energy inputs, are obtained by using the output multi-
pliers cited earlier.

Computer manipulation of the state-level two-region model yields
planning data on the 81 sectors as follows:

(1)   Output multipliers (to show the direct and indirect effects
      on output of a $1 change in a specified final demand) and
      projected outputs;

(2)   Employment multipliers (to show the direct and indirect employ-
      ment effects of a $1 change in a specified final demand) and
      projected industry employment.

(3)   Fiscal multipliers (to show the direct and indirect public and
      private fiscal effects of per $1 change in a specified final
      demand); and projected public and private income and expendi-
      tures; and

(4)   Ecologic multipliers (to show the direct and indirect ecologic
      i.e., natural resource inputs and waste emissions effects per
      $1 change in a specified final demand) and projected resource
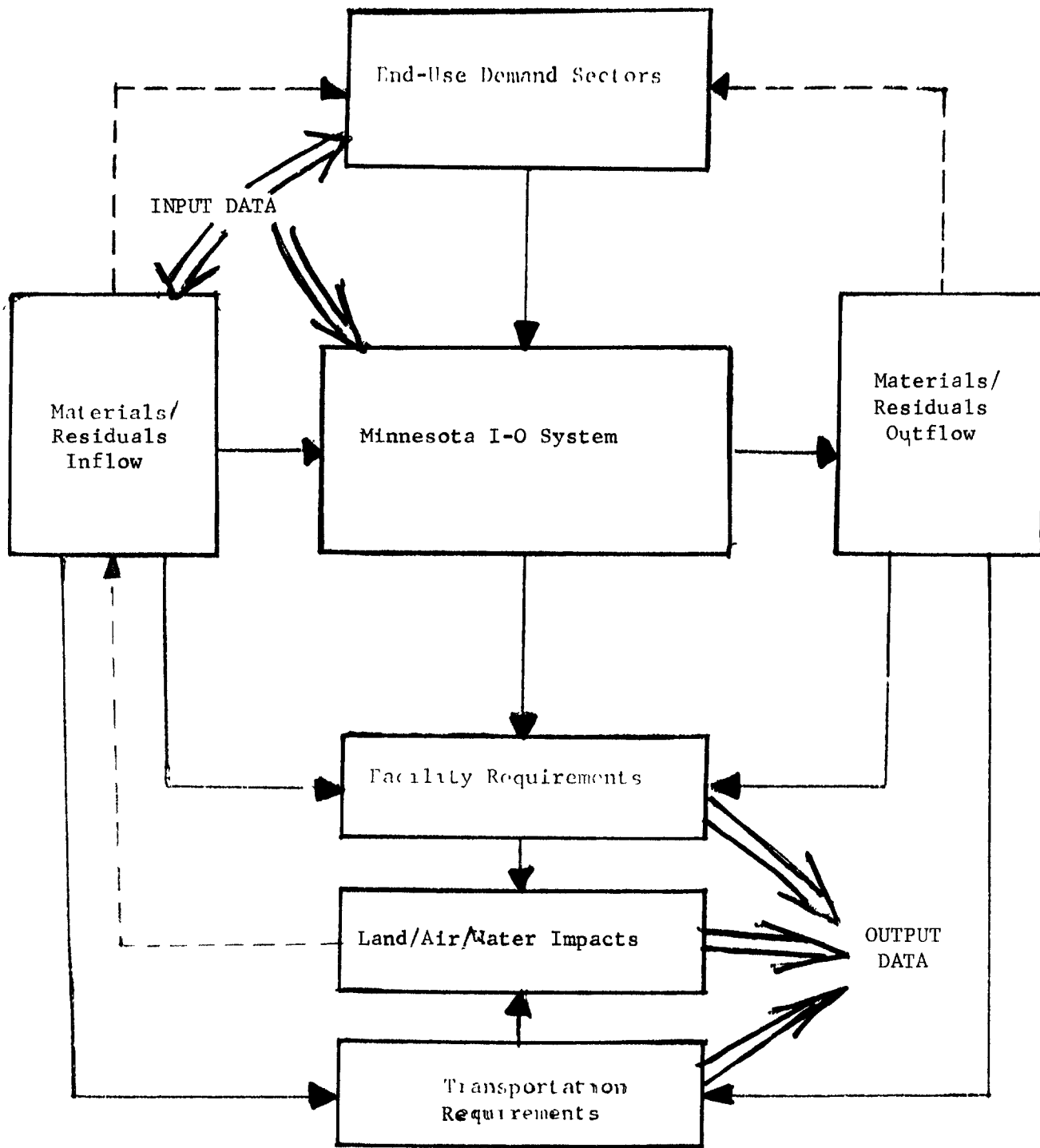
Fig. 3. Simplified Data Network for Minnesota Regional Economic Model

inputs and waste emissions.

Use of the analytical capability in long-range energy planning is demonstrated in the pilot study which focuses on the eight-county region. Regional economic implications of the energy crisis are derived by use of the eight-county version of the basic two-region, 81-sector input-output table.

Data on current and projected future energy utilization levels and energy conservation practices are processed by the two-region input-output model and related computer programming procedures. However, of primary importance in the pilot study are the data on facility require- ments and land, air and water use impacts of sustained energy shortages and subsequent changes in energy sources, illustrated, for example, by shipments of low sulphur coal from Montana, North Dakota and Wyoming to the coal-consuming industrial plants in the Great Lakes region.

Impact analysis

Of particular concern in the pilot study is the problem of dealing with the projected fiscal and ecologic impacts of new facilities which would be built to handle future changes in energy sources. Because energy-dependent transportation-related activities are of critical impor- tance to the economy of the study region, the transportation sectors are emphasized in the pilot study.

The technical capability for facility impact analysis is demonstrated for the pilot region rather than the entire state, given the known difficul- ties of acquiring detailed local and regional data for the computer simu- lations. However, the procedures are prepared for use in state-level as well as region-level impact analysis and projection.

<u>Fiscal</u> <u>impacts</u> of new energy-related facility development will be derived for a given planning period which is marked by a base-year, i.e., 1970, and a target year. While the base-year is given at this time (because of existing data for the 1970 calendar year), the target year will depend on the time and resource outlay schedule for the proposed facility construction .

Knowledge of the fiscal impacts of energy-related facility construction and use is an important consideration in the regional planning process. Construction of a major new energy facility (or closing of an old facility), seriously affects the tax base and outlays of local governmental units and the residential and business assets of local residents. (17)

In demonstrating strategic planning applications of the impact analysis, data elements from the information system are introduced into the overall regional input-output model. These elements relate the activities associated with the closing down or construction and use of energy-related facilities to both the local units of government and the private sector in the extended eight-county economic region which is served by these facilities. Both public and private income changes are derived.

Shifts in local income-producing activities typically are accompanied by corresponding shifts in land use and taxable valuations. To show the land use and land value changes, a land allocation procedure is introduced into the overall regional system model. The additional procedure is linked to the industrial producing and consuming sectors of the regional input-output model via the facility requirements coefficients (which are derived for each of the 81 producing sectors and six final demand sectors). Shifts in regional land use patterns thus are related to subsequent changes in the total cost

structure of the local economy (as represented by the combined ecologic

and fiscal impacts of the projected facility development).

Ecologic impacts of major new facility construction and use also are

derived from data in the regional information system. Projected facility

requirements are linked to projected energy-resource stocks and flows and

the location, size and function of specific energy-related facility changes.

Transportation and related activity patterns generated by any new major

facilities are determined and the local environmental impacts in terms of

waste emissions per dollar output are derived from the regional input-output

model and the related regional information system (3, 4, 15).

Because ecologic impacts generally are place-specific, the land allo-

cation procedures used in determining fiscal impacts are used, also, in

determining the localization of waste emissions in the eight-county study

area. Both the resource input (e.g., water for a proposed coal gasification

plant in the area) coefficients and waste emissions (e.g., carbon particulates)

coefficients are acquired from available studies and applied to specified

local activities. The pilot study thus serves to identify critical ecologic

data needs. Sensitivity tests can be conducted to determine the planning

consequences of data limitations.

Health impacts are obtained from the analysis of fiscal and ecologic

impacts. Thus, the health impacts are essentially a translation of the fiscal

and ecologic impacts into measures of human environment and human well-being

which translate into consequences for individual households in the area.

Much additional work is needed to transform the estimates and predictions

of ecologic and fiscal impacts into corresponding estimates and predictions

of health impacts. Such a capability is not available in the Minnesota

regional economic systems model. However, the topic is not unfamiliar to

residents of the Duluth study area (because of the current taconite industry

hearings) and, therefore, some effort may be necessary in attempting to include consideration of significant health impacts of projected energy facility development.

Evaluation Criteria

User-oriented criteria are identified for evaluating the regional impact study. The criteria are viewed in terms of the trade-offs which face the managers of energy systems. In this study, the trade-offs are between the level of energy use and the level of economic activity which is directly or indirectly dependent on the level of energy use. While the criteria will be applied to the pilot study, they pertain also to the state-level input-output model; hence, they are presented in general terms with reference to the observable social and economic consequences of the regional impacts of the energy crisis.

Energy utilization

The rate of energy use is a primary concern of energy resource management. Energy use rates will vary between regions, however, because of differences in industry composition. Energy requirements in the basic materials and construction industries, for example, are high; they are low in the service industries (12). Thus, a region with a high concentration of basic materials industries will show a high aggregate energy use per unit of output.

Energy use will vary also because of regional differences in rates of economic growth. A high rate of economic growth is accompanied by increasing industry automation in which energy-intensive processes displace labor-intensive processes. Tactics to be applied in reducing energy use are limited, therefore, by the market conditions which force businesses to adopt

the energy-intensive production processes. Moreover, each region, or group
of regions, requires a certain mix of industry to remain viable economic
entities in a national economy. Thus, a shift from a high-energy to
lower-energy economic base also is limited by the spatial and resource position
of the particular state or region.

Regional growth is accompanied by reduced efficiency of product use
because of the proliferation of products in the major urban areas where
much of the economic growth occurs. Again, some products are more energy
efficient than others (2). Refillable bottles, for example, use about one-
third less energy per unit of output than disposable bottles (1,11). The
bus is about two-thirds as energy intensive as the auto in current intracity
operation (14, 21, 22, 23). Cheese is considerably more energy efficient
than meat, milk or fish. Thus, one life style is likely to have a lower
energy cost than another life style which, in turn, would account for
regional differences in the energy efficiency of product use.

Energy use rates vary with socio-economic attributes of households.
A recent study shows "an energy dependency on food which declines with
income, an energy dependency on housing which rises with income, and an
energy dependency on transportation which peaks with the intermediate income
level" (12). This study also shows that the three consumption categories
account for about 75 percent of the total household direct and indirect
energy use at each income level.

Industry employment

The employment-intensity of industry output also varies between
industries and regions. A hospital or a dairy enterprise is more labor
intensive, for example, than a primary aluminum manufacturer. Because

of industry differences in output multipliers, however, the same proportionate

growth in each industry will result in a new pattern of industry employment

with disproportionate changes in the employment-intensity of industry output.

The regional input-output model provides an approach to impact measure-

ment which takes into account the direct and indirect effects on industry

employment of a given change in industry output (or resource input). Re-

ductions in energy inputs can be translated into corresponding reductions

in industry outputs and, thus, industry employment (and, also, earnings).

The output reductions in one industry subsequently are carried through

into employment cutbacks in other industries, depending on the degree of

internal linkage between the affected industry and all other industries in

the regional economy. Alternative energy sources can be introduced in

successive simulations of the regional economic model to determine the

extent to which energy conservation and substitution processes may reduce

the employment impacts of reduced energy supplies (9).

Year-to-year changes in industry employment can be simulated over

extended time periods, given alternative sets of assumptions regarding

growth rates for export products and energy supplies and also the extent

of substitution among alternative energy resources.

Successive computer simulations of the regional economy will show

different industry employment impacts of a given energy shortage. Industries

which experience the most severe employment impacts, in terms of total

lay-offs, can be identified and special consideration can be given to these

industries in the allocation of existing energy supplies. In addition,

substate areas which would experience particularly severe employment impacts

also can be identified for further study and consideration.

Essential services

The employment impacts of cutbacks in certain essential services, such as health care, may be quite high, but even more important are the consumption cutbacks, especially among the aged and the sick. An important component of the regional economic systems model is, therefore, the demographic breakdown of both the employed and dependent populations.

Again, successive simulation runs of the regional economic model will show the demographic consequences of energy cutbacks for each essential service industry. These consequences can be evaluated by industry and allocation alternative as one step in identifying the critical services deserving special consideration in the forming energy allocation priorities.

Critical materials

Lack of certain critical materials for regional industry may have employment and service impacts as large as those experienced directly from energy cutbacks. These industries are identified in the inter-industry transactions table; they are treated like the energy-producing sectors for which energy use coefficients have been derived. Impacts of shortages in these industry outputs can be demonstrated for each of the industries identified in the preceding two sets of simulation runs (in the same way as the industry impacts of energy shortages were demonstrated).

Additional work is needed in identifying the critical materials produced in a region. Current and alternative future production technologies which offer energy substitution potentials (direct and indirect) also need further observation and study.

Waste emissions

Certain wastes are attributed to each of the energy-producing and energy-using sectors (16). While the waste-intensive processes are likely to have large ecologic impacts, they may or may not have correspondingly large employment and energy use impacts per unit change in gross output. Measurement of the economic trade-off between waste-related impacts and industry employment impacts of alternative energy allocation strategies is an important consideration in the development of a viable regional energy system.

Implied in the concept of economic trade-off is a procedure for assessing the individual allocation criteria, given the variability in (a) the units of measurement and (b) the goals and values of energy decision makers. Waste emissions, for example, are measured in physical units, while the level of essential services are measured in total dollars (or in physical units which are not comparable). These differences call for a series of simulations of the regional economy to show the industry output consequences of alternative energy allocation assumptions.

Summary

In the long-run context, the regional input-output model is supplemented by additional models (or elements of a total regional systems model) which allow a more complete representation of the dynamics of regional growth than is feasible with only the input-output model. The input-output framework helps primarily in achieving consistency in the total set of economic variables which are affected by both internal and external (i.e., export market) changes in the final demands for regional industry input.

Thus, the regional economic systems model, which includes a two-region input-output model as a major component, is viewed as an important part of the energy information systems model. Given the hierarchical structure of the information model, the data outputs of the economic model are prescribed by the model or by the information needs of energy decision makers as these are reported to, and understood by, the research team. The data requirements of the economic model are confined, therefore, to decision-related information, namely, input data which are transformed into specified output data in the computer simulation. Specification of input data is a never-ending process as long as the information needs of energy managers reflect the changing problems and perceptions of the role of information in energy planning.

Literature Cited

1   Berg, Charles, "Energy Conservation through Effective Utilization," National Bureau of Standards, Washington, D.C., 1972.

2   Bullard III, Clark W., "The Illinois Consumer's Role in Energy Conservation," CAC Document No. 78, Center for Advanced Computations, University of Illinois, Urbana, July 13, 1973

3. Center for Advanced Computations, "NARIS A Natural Resource Information System," CAC Document No. 35, University of Illinois, Urbana, August 1972.

4   Center for Advanced Computation, IRIS Illinois Resource Information System, Feasibility Study, Final Report, University of Illinois, Urbana, April 30, 1972.

5   Foell, W.K. and J.E. Rushton, "Energy Use in Wisconsin: A Survey of Energy Flow in the State of Wisconsin," Working Paper 4, Institute of Environmental Studies, University of Wisconsin - Madison, October, 1972

6. Foell, W.K., D.D Shauer, O.S. Goldsmith and M.A. Caruso, "1973 Survey of Energy Use in Wisconsin," Report 10, Institute for Environmental Studies, University of Wisconsin - Madison, September, 1973

7   Foell, W.K., "Simulation Modeling of Energy Systems: A Decision-Making Model," Paper presented at the Summer Workshop on Energy and Environment and Long-Term Decisions," OECD, Paris, August 20-31, 1973

8   Folk, Hugh and Bruce Hannon, "An Energy, Pollution, and Employment Policy Model, Document No 68, Center for Advanced Computations, University of Illinois, Urbana, 61801, February, 1973

9. Folk, Hugh, "Employment Effects of a Mandatory Deposit Regulation," Institute for Environmental Quality, State of Illinois, (309 W Washington, Chicago, 60606), January, 1972.

10. Grot, R and R H Socolow, "Energy Utilization in a Residential Community," Center for Environmental Studies, Princeton University, February, 1973

11 Hannon, Bruce, "System Energy and Recycling· A Study of the Beverage Industry," CAC Document No 23, Center for Advanced Computations, University of Illinois, Urbana, January 5, 1972

12. Hannon, Bruce, "Options for Energy Conservation," Technology Review, p. 25-31, February, 1974.

13. Herendeen, Robert A., An Energy Input-Output Matrix for the United States, 1963: User's Guide, CAC Document No. 69, Center for Advanced Computation, University of Illinois - Urbana, March 4, 1973.

14. Hirst, Eric, "Energy Intensiveness of Passenger and Freight Transport Modes, 1917-1970," ORNL-NSF-EP-44, Oak Ridge National Laboratory, Oak Ridge, Tenn., April, 1973.

15. Knobloch, Peter C. and J. David Naumann, "An Information Systems Design Approach Dealing with Problems of Energy Utilization and Conservation," Management Information Systems Research Center, University of Minnesota, Minneapolis, Minn., January, 1974.

16. Laurent, Eugene A. and James C. Hite, Economic-Ecologic Analysis in the Charleston Metropolitan Area - An Input-Output Study, Report No. 19, Department of Agricultural Economics and Sociology, Clemson University, Clemson, South Carolina, April, 1971.

17. Maki, Wilbur R., Area Financing of Water Resource Development in West Minnesota, Bul. 66, Water Resources Research Center, University of Minnesota, Minneapolis, Minn., January 1974.

18. Maki, Wilbur R. and Ernesto C. Venegas, Economic Impacts of Industry Growth in Minnesota, Minn. Agr. Exp. Sta. Bull.   , University of Minnesota, St. Paul (in process), 1974.

19. Miernyk, Arthur H., Simulating Regional Economic Development, D.C. Heath and Co., Lexington, Mass., 1970.

20. National Economic Research Associates, Inc., "Energy Consumption and Gross National Product in the United States," 80 Broad Street, New York, N.Y., March, 1971.

21. Nordhaus, William D., "The Allocation of Energy Resources," In· Brookings Papers on Economic Activity, p. 529-576, 3, 1973.

22. Rice, Richard A., "System Energy as a Factor in Considering Future Transportation," 70-WA/Ener-8,The American Society of Mechanical Engineers, United Engineering Center, 345 East 47th Street, New York, N.Y., 1970.

23. Rice, Richard A., "System Energy and Future Transportation," Technology Review, p. 31-37, January, 1972.

24. Rice, Richard A., "Toward More Transportation with Less Energy," Technology Review, p. 45-53, February, 1974.

25. U.S. Department of Commerce, Input-Output Structure of the U.S. Economy: 1963, Washington, D.C., 1969.