Staff Paper Series

STAFF PAPER P74-27 December 20, 1974

State/Regional Economic Models for Long-Range Energy Planning

by
Wilbur R. Maki
Ernesto C. Venegas

Department of Agricultural and Applied Economics

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

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Regional Energy Information Systems
and Economic Impact Analysis Project

Sponsored by

Minnesota Energy Agency

in cooperation with

Management Information Systems Research Center
College of Business Administration

and

Agricultural Experiment Station
University of Minnesota

December 20, 1974

STATE/REGIONAL ECONOMIC MODELS FOR LONG-RANGE ENERGY PLANNING[1/]

Wilbur R. Maki and Ernesto C. Venegas [2/]

In this paper, we describe briefly the Minnesota regional energy impact system (MREIS) model and its role in improving long-range energy planning. We are concerned particularly with the energy outlook in the State and its long-run implications for primary resource development in a substate region (which, in this case, includes a seven-county area in Northeast Minnesota).[3/] The model is used to assess the regional economic impacts of both state energy policies and substate industry expansion. The energy systems modeling effort is guided, therefore, by certain long-range planning concerns of (1) the State Energy Agency and (2) the Regional Development Commission.

Specific objectives of the Minnesota energy impact modeling are, among others, to analyze:

(1) the changing industry mix in the State as it relates to future energy requirements;

1/ Prepared for presentation at Energy Modeling Conference sponsored by National Governors' Council, Austin, Texas, November 14-15, 1974.

2/ Professor of Resource Economics, University of Minnesota and Economist, Minnesota Energy Agency, respectively. The authors gratefully acknowledge the helpful comments and colleagues on the Minnesota Energy Economic Impact Analysis Project.

3/ Douglas County, Wisconsin is included, also, in the study currently funded by the Upper Great Lakes Regional Commission.

(2) the total (not simply net or direct) energy requirements of alternative capital expenditure projections for the State and its substate regions;

(3) the fiscal impacts of industry development alternatives identified from the preceding analyses.

Need for effective communication of the results of the modeling efforts is recognized, however, as an important clientele concern. The three objectives are complemented, therefore, by a study design which provides for the implementation and testing of a two-region, policy-constrained, input-output model in a substate region. In this prototype regional system, energy constraints will affect the rate and direction of primary resource development.

The MREIS model is based primarily on the use of secondary data, starting with the preparation of an initial base-year (i. e., 1967) regional input-output model which is updated to a more recent (i. e., 1972) base year. Data from a sample survey of business establishments and households are available, also, from an earlier input-output study of the Duluth-Superior urbanized area (6). Current data from various sources are used in conjunction with model projections to estimate a 1974 intersectoral transactions pattern. In addition, these secondary data -- production (or sales), income and employment -- provide elements of bridge matrices that allow interfacing of the input-output model with other (e. g., shift-share and economic base) components of the overall regional modeling effort.

Computable Model of a Regional System

Given the widely-held views that an input-output model is built primarily to provide output multipliers, a systems approach to regional model-building has been proposed from the very beginning of the current modeling effort (7,12). Moreover, the interfacing of the input-output capability with related models and organizations is emphasized. The technical capability is viewed as part of an interactive model-user-application system where the input-output model interfaces with predictive models ranging from simple shift-share to sophisticated econometric demand models and, in turn, each of these models interfaces the planning functions of several organizational units in state and local governments (fig. 1).

In this study, the information needs of state energy planning are approached in the context of a management information system (11). Information needs emphasized here however, relate to the investment and fiscal impacts of alternative energy strategies. These impacts occur because of (1) changes in the availability, cost of, and demand for, energy inputs for different income-producing and/or service-delivery units and (2) primary resource-related and energy-related infrastructure development which, also, affects these units.

The economic impact studies cover public facility location and investment and related impacts on local governments and, also, the rest of the regional economy (2, 7, 8). While the final demand and market share projections "drive" the input-output models (subject to certain resource-technological constraints in the region and external conditions affecting the national and local economies), the industry output and product utilization projections "drive" the facility location and investment models. Here

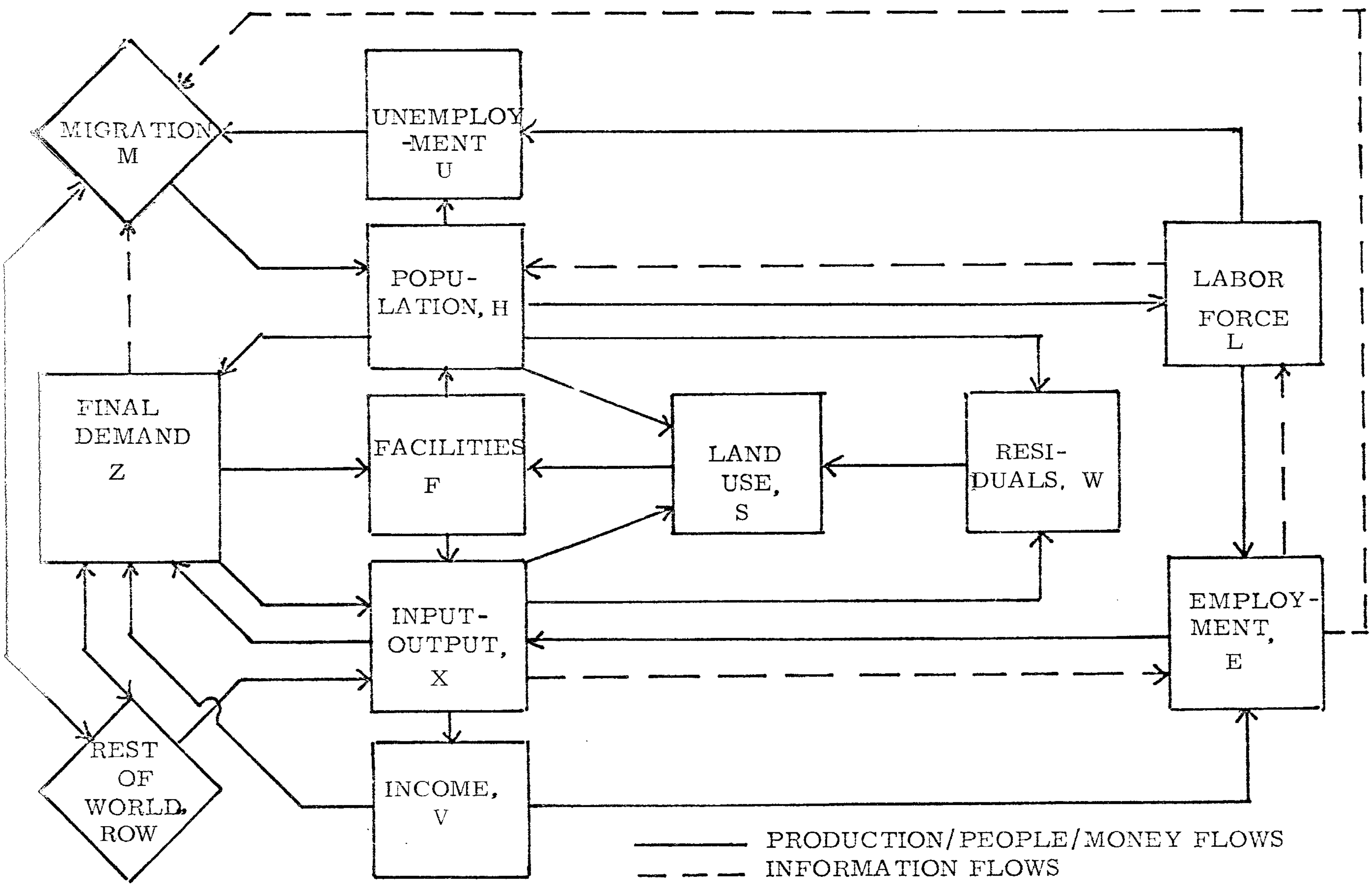

Fig. 1. Basic model components for interfacing regional energy impact system.

the technical interfacing of the input-output model with other models becomes critical for the study. Finally, programming procedures are being prepared for deriving area-specific data series on the regional infrastructure and related fiscal requirements of proposed economic and energy resource development alternatives.

The series of regional models is implemented for planning purposes by a computer program for simulating year-to-year changes in each component of the regional energy system. This model is built around the basic Leontief input-output equation

$$X = AX + Z, \qquad (1.1)$$

where X = vector of sector outputs, Z = vector of sector final demands and A = matrix of interindustry flow coefficients. Output is expressed as a function of final demand by the form

$$X = BZ, \qquad (1.2)$$

where $B = (I - A)^{-1}$, the inverse of the Leontief matrix.

The first equation in the model relates capacity of plant and equipment, including energy-related facilities, to the previous year capacity by the form

$$X_t^k = X_{t-1}^k + (A_1)^{-1}(I_{t-1} \quad A_2 K_t), \qquad (2.1)$$

on which the capacity constraint is represented simply by two components -- the first-of-year existing capacity and the within-year additions to capacity.[4/] The latter includes a certain amount of needed replacement expenditures,

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4/ For description of variables and coefficients, see Tables 14, 15 and 16 in: W. R. Maki, R. E. Suttor, and Jr. R. Barnard, Simulation of Regional Product and Income with Emphasis on Iowa, 1954-1974, Iowa Agr. Ex. Sta., Res. Bul. 548, Sept. 1966, Ames, Iowa.

represented by the term, $A_2 K_t$, and annual business investment, which is a function of available capacity, capital stock and demand, i. e.,

$$I_t = A_2 K_t + A_1(A_3)^2 K^D_{t-1} - A_4 X^K_t. \qquad (2.2)$$

While replacement investment is a function of capital stock, investment in new plant and equipment is viewed as a function of the imbalance between present capacity requirement, $A_4 X^K_t$, and the capacity requirement anticipated for next year, $A_1(A_3)^2 X^D_{t-1}$. In the first four years of model simulation, the matrix A_3 is given. Beginning with the fifth year, however, the coefficients are recomputed for each year. Each diagonal element is computed as an average of 1 plus the rate of growth in output demanded in the previous four years.

Annual investment, finally, is bounded by the form

$$A_2 K_t \leq I_t \leq A_5 K_t. \qquad (2.3)$$

The upper bound represents certain financial and technical constraints that limit the rate of growth of capital stock. The lower bound sets a floor on capacity. Thus, gross investment must be enough, at least, to replace depreciated plant and equipment.

The third major equation relates household expenditures to lagged disposable income by the form

$$h_t = a_1 a_2 (Y_{t-1})^D. \qquad (2.4)$$

In this abbreviated form of a household consumption function, the scaler variable, a_2 (which is computed, beginning with the fifth year, as 1 plus the growth rate of disposable income in the previous four years), relates expected current income to lagged income. A portion of the expected in-

income, a_1, is spent, while the remainder, $1-a$, is saved.

If the derived household expenditure is less than the household expenditure in the previous year, the value of h_t is increased by a portion of the difference. The new value of h_t then becomes

$$h_t + a_3(h_{t-1} - h_t), \; 0 < a_3 < 1. \qquad (2.5)$$

This restriction has the effect of dampening excessive fluctuations in h_t.

The final demand is computed next by using the form

$$Z_t = A_6 h_t + A_7 I_t + (A_8) E_o + A_9 t_{t-1} + A_{10}(a_4)^t \mathcal{f}_o. \qquad (2.6)$$

In this equation, the column vector of parameters A_6 is updated each year by assigning certain growth rates to the coefficients. The coefficients are normalized so that the sum of the elements equals one.

Given the final demand vector, the imput-output equation is used to calculate the demand for sector outputs. Thus,

$$X_t^D = A_{11} Z_t. \qquad (2.7)$$

The vector Z_t in this case excludes the import sector.

Available labor resources by sector are calculated by using the form,

$$L_t = A_{12} A_{13} (L_{t-1})^E. \qquad (2.8)$$

Beginning with the fifth year of the simulation, the growth rates are computed each year as the average of the four previous years' rates . Thus, the labor force in a sector is determined by the projected employment, by occupation, $A_{13}(L_{t-1})$ it is adjusted to allow for normal levels of employment by the matrix A_{12}.

Again, as a gross simplification of regional structures, upper and lower bounds,

$$A_{14}L_{t-1} \leqq L_t \leqq A_{15}L_{t-},\qquad (2.9)$$

are placed on the labor force. These bounds reflect institutional restrictions on the percentage change in the labor force from year to year. Thus, with a limited labor force, a corresponding upper bound to output is given by the expression

$$X_t^L = A_{16}(A_{17})^t L_t.\qquad (2.10)$$

At this point, two additional constraints on regional output are introduced, namely, energy supplies and emission standards. Energy supplies are estimated by the form

$$Q_t = Q_t^S + (Q_t^I - Q_t),\qquad (2.11)$$

which, of course, grossly simplifies the energy supply function by representing energy imports, Q_t^I, and energy exports Q_t as a net change in the starting energy resource inventory, Q_t^S. An upper bound to an energy-constraned regional output is given by the form,

$$X_t^Q = A_{30}A_{31}Q_t.\qquad (2.12)$$

In this form, industry output per energy unit, A_{30} and energy units per physical unit of a given type of energy, A_{31}, are multiplied by total energy supplies, Q_t, to obtain a maximum industry output which is constrained only by limited energy supplies.

Emission standards impose further restrictions on regional output. These standards are applicable when the waste emissions of the preceding production period exceeding the allowable emission levels. The prescribed emission standard for the production period is given by the form,

$$W_t^S = W_o \quad (2.13)$$

while the total output is limited by the form,

$$X_t^W = A_{33} W_t^S, \quad (2.14)$$

Thus, the emission standards and the inverse matrix of emission yield coefficients, A_{33}, establish an upper bound on production (and, also, consumption).

Capital outlays which reduce waste emissions modify the emission yield coefficients. Thus, the modified matrix of emissions yield coefficients is given by the form,

$$A_{36} = A_{32} - A_{34} \ A_{35} \quad (2.15)$$

which shows the modified waste emission coefficients as equal to the initial waste emissions matrix, less the reduction in waste yield per unit of output associated with increase in emissions-reducing capital outlays.

Realized output is the minimum of output demanded, maximum output of the labor force, minimum output allowed by plant and equipment capacity, maximum output allowed by available energy supplies, and maximum output allowed by emission standards. Hence,

$$X_t^R = \min (X_t^K, X_t^L, X_t^D, X_t^R, X_t^W). \quad (2.16)$$

Thus, the actual, or realized, output of a sector is the output demanded, unless the labor force and the capacity of plant and equipment are too small to produce the specified output, energy supplies are inadequate, or waste emissions are excessive. That is, for each sector, the minimum of the sector's elements in the five sectors, X_t^K, X_t^L, X_t^D, X_t^V and X_t^W is selected.

Employment is a function of realized output in the equation

$$L_t^E = [A_{16}(A_{17})^t]1^{-1} X_t^R, \quad (2.17)$$

which follows directly from eq. (2.10). Thus, a demand-oriented sequence of product and resource flows is assumed. The resource constraints result in reduced industry outputs and exports from the levels that would occur without these constraints.

The next six equations are self-explanatory, given the appropriate definitions; i. e.,

$$K_{t-1} = K_t + I_t - A_2 K_t. \quad (2.18)$$

$$V_t = A_{18} X_t^R; \quad (2.19)$$

$$G_t^S = A_{19} X_t^R + A_{20} K_t; \quad (2.20)$$

$$G_t^F = A_{21} X_t^R + A_{22} K; \text{ and} \quad (2.21)$$

$$W_t = A_{36} X_t^R \quad (2.22)$$

$$C_t = V_t - (A_2 K_t - A_{23}(A_{24}) L_t) - (G_t + G_t + A_{25} X_t). \quad (2.23)$$

The last variable, unallocated value added, is obtained by subtracting from total value added, V_t the following: (a) depreciation allowances, A_2K_t; (b) wage and salary payments, $A_{23}(A_{24})L_t^E$; (c) state and local taxes, G_t^S; (d) federal taxes G_t^F; and (e) autonomous retained earnings, $A_{25}X_t^R$. Autonomous retained earnings are a minimum amount of earnings retained. Finally, the unallocated portion is divided between uses, namely, dividends and proprietoral income and additional business savings (i. e., savings in addition to depreciation allowances and autonomous retained earnings).

A matrix, A_{26}, is derived for the purpose of dividing the unallocated value added between the two alternative uses. The diagonal matrix is computed by the equation,

$$A_{26} = [(I_t - A_2K_t)I] (I_t)I]^{-1}. \qquad (2.24)$$

In this equation, I is the identity matrix and $(I - A_2 K_t)$ is the vector of net investment. Thus, the ith diagonal element of A_{26} is the ratio of net investment to gross investment in the ith sector. If gross investment is made up entirely of the replacement of old plant and equipment, then net investment is zero, and the corresponding element of A_{26} is zero. If new additions to sector capacity are large, then the corresponding element A_{26} will be close to one.

The remaining five equations in the basic series are used in computing business savings and personal income payments (S_t and Y_t^B,) personal income (Y_t^P), taxes (t_t), and disposal income (Y_t^D). These equations are

$$S_t^B = A_2K_t + A_{25}X_t^R + A_{26}C_t; \qquad (2.24)$$

$$Y_t^B = A_{23}(A_{24})^t L_t^E + (I - A_{26})C_t; \qquad (2.25)$$

$$Y_t^P = iY_t^B + a\ t_{t-1} + (a_6)(a_4)^t o \qquad (2.26)$$

$$t_t = iG_t^s + a_7 y_t^P \qquad (2.27)$$

$$Y_t^D = (1 - a_7 - a_8) y_t^P \qquad (2.28)$$

The 28 basic equations (plus the auxiliary equations including energy and emissions constraints) form a complete recursive system. Given the initial values of the exogenous variables, the values of the endogenous variables are derived as functions of time, lagged endogenous variables and current endogenous variables calculated earlier in the sequency of equations.

A flow diagram of the structure of the regional development model is presented in fig. 2. The exogenous and lagged endogenous variables are of order zero and appear in the first column. The current endogenous and lagged endogenous variables are enclosed in circles. Variables of order one are dependent upon variables of order zero. Variables of order two depend upon variables of order zero or one, or both. In general, variables of a lower order. Thus, the values of nine series of variables are needed, initially, to obtain the values of all subsequent series of variables for the given year. In the simulation process, the outputs of year (t) become the inputs of year (1 + 1).

The model can be divided into two parts linked together by the fifth-order eq. (2.16). The equations of orders one through four are mainly concerned with determining the level of production, while equations of orders six through 10 are mainly concerned with the distribution of income created in the production process.

In terms of the computer experiments based on the regional simulation model, the well-being of the region is the result of two important factors --

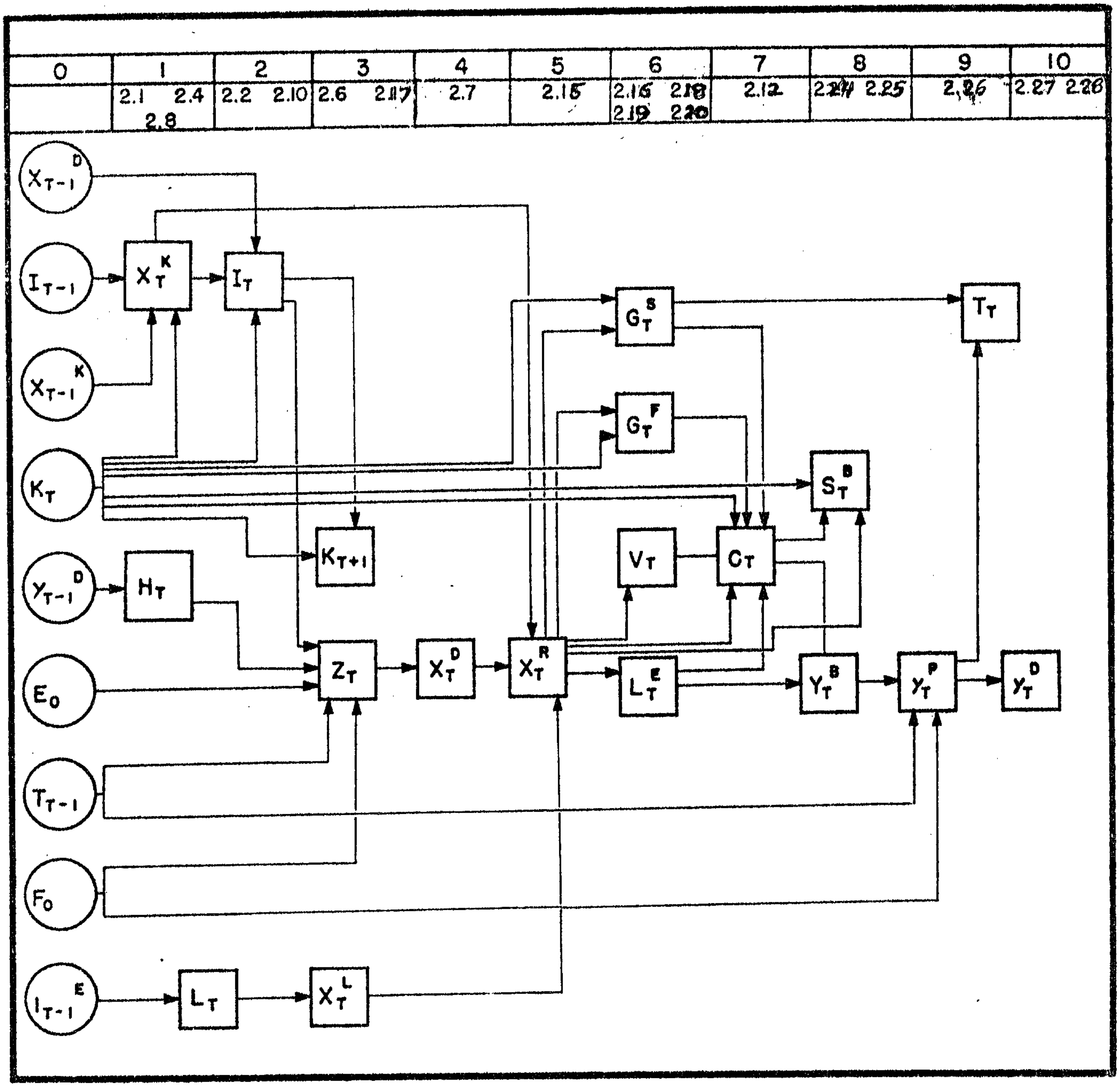

Figure 2. Causal relationships among basic components of regional development system model.

its resource productivity and its terms of trade with the rest of the world. Energy, capital constraints and emission standards limit the total output of the economy. Given this conceptual bias, the production account and the related resource constraints thus are an important means of describing the internal mechanisms of regional growth (7). Moreover, estimates of relationships between the rest-of-world account and the product account, and changes in these relationships, are the empirical measures for achieving year-by-year consistency among the nine series of variables needed to initiate the computer runs of regional growth patterns based on alternative productivity and trade assumptions. Thus, the input-output table and the related data are used as means of reconciling a wide range of economic projections used in regional development planning.

Resource requirements of development alternatives are simulated to show the sequence of construction activity and related financial, material and labor requirements of the projected activity schedules. By detailed staging of the resource development process, using computer simulation, reasonably complete scenarios of state economic futures can be presented for review and commentary by policy-oriented staff and other people in state and local governments.

Substate Impact Analysis and Development Planning

The substate planning region provides the spatial-economic and governmental setting for implementing and testing the computer simulation model as part of a regional energy impact analysis system. The question of manageability in both data processing and problem application makes the regional setting preferable to a state-level orientation. However, the organizational interfacing also will differ and, hence, use of the modeling capability in state energy planning introduces certain problems in regional system implementation and application which also become important concerns of this study.

Substate economic development

For the sutstate region, job creation is a primary concern of development planning. In the past several decades, this region has experienced heavy population outmigration. New jobs would be created now by the expansion of the taconite processing, nickel and copper mining, and timber-producing activities in the region. However, these plans are contingent upon long-term contracts with energy suppliers in the area (table 1).

For some of the proposed expansion, critical environmental impact issues remain unresolved. Regional concern exists, also, over the likely impacts of coal gasification and expanded coal utilization in the region. Future availability of western coal is an important regional concern, too.

When the resolution of resource policy issues is extended from the region of impact to the entire State, then concern about the ecologic impacts of primary resource development becomes important in limiting investment and production expansion plans. State jurisdiction over resource use conflicts thus imposes an additional constraint on regional development planning.

Table 1. Projected capital outlays and labor requirements in specified resource-related development, Northeast Minnesota, 1974-1979.[1/]

	Total outlays	Labor requirements Permanent workforce	Peak construction
	(mil. dol.)	(no.)	(no.)
Iron Range:			
Taconite plants	950	4000	5400
Cooper-nickel to	520	1750	1800
Other major projects[2/]	133	600	1580
Indirect	340	2960	2300
Total (or peak)	1943	7860	(5400)
Other nonmetropolitan areas:			
Major projects	134	585	420
Indirect	17	280	170
Total (or peak)	151	875	(420)
Duluth-Superior area:			
Major projects	144	720	1000
Indirect	46	340	450
Total (or peak)	190	1060	(1000)
All areas	2284	9795	(5400)

1/ "Assesment of Growth Impacts on the Iron Range, May 1974." Arrowhead Regional Development Commission, Duluth, Minnesota, 55802

2/ Including 3,820 new housing units for 12,200 projected population increase; school enrollment is projected to increase by 9505 during this period.

Selection of a substate study region in which job creation is a high development priority focuses attention on the importance of trade-offs between employment and ecologic values in long-range energy planning. For the trade-off analyses to be useful, however, they must relate to industry-specific and place-specific activities, including their public fiscal impacts in the region. Envisioned here is the preparation and use of a series of maps which show the spatial-economic incidence of the fiscal impacts associated with each regional development option.

Regional model implementation

The regional input-output model is implemented, first, as part of an expanded regional economic model and, second, as part of a regional energy information system. In the expanded regional model, population change accounts for corresponding changes in total labor force and potential employment (as illustrated earlier in figs. 1 and 2). An initial indication of final demands is obtained, also, from current projection series on per capital income and total population in the region. Given the initial final demand expectations, industry output levels and, finally, industry employment requirements are derived. Fulfullment of these expectations imply a total labor force and a total population which are more or less than the initially derived labor force and population. Population migration brings potential and projected employment into balance.

An occupational profile for each industry is introduced as a further constraint on the total of labor force in terms of its suitability for the projected industry employment. Both an excess supply of labor and an excess demand for labor may occur simultaneously because of differences in the occupational mix of the supply of labor as compared with labor requirements. Hence, the use of the occupational profile of the employed labor force facilitates the preparation of a gross migration series which would include both in-migration and out-migration projections.

The projected industry outputs imply, also, a certain distribution of producing units according to employment per unit. A shift-share employment model is used to allocate total industry employment among subregions. The projected spatial distribution of employment, together with plant size distributions, yield the total number of producing units in each subregion. The infrastructure and land requirements of these producing units are obtained, finally, for each subregion and the total region.

Thus, the critical technical interfacing occurs between (1) the regional input-output model and the regional employment allocation (i.e., shift-share) model and (2) the regional infrastructure and land requirements model. Spatial programming procedures are used, also, to derive optimal industry location patterns for new producing units. The regional input-output model provides overall industry constraints for each spatial programming model.

The regional economic models are an integral part of a regional energy information system (which is being developed on a demonstration project basis in a three-county study area in Minnesota). The information system has two main components -- the energy accounting subsystem and the energy flow network model (12). The accounting subsystem serves as an interface between the physical energy system itself and the energy flow network model. The network model is a representation of the energy system within specified geographical boundaries and it includes the relationships between energy production, transportation, conversion, storage, and consumption, and it presents these relationships to the decision makers. Thus, the energy information system per se is decision-oriented, but it has a strong historical perspective on information reporting rather than one of projection and analysis of future policy options. The implementation of the regional economic models thus provides for additional uses of an extended energy information system. In turn, the comprehensive data base of energy information is available for periodic updating of all energy components in the economic models.

Energy data discontinuities occur for a variety of reasons, some of which may be remedied only with the enactment of new legislation on reporting of energy stocks, sales and/or purchases of major suppliers, distributors and consumers. The two demonstration projects -- one on input-output modeling, the other on energy database modeling -- are designed to assist in developing new procedures and/or legislation for reporting energy statistics to facilitate the energy planning processes. What is finally recommended as an energy database will depend in part on the interfacing of the input-output models with both the information system and the decision making and the extent to which this interfacing has overcome the initial barriers to acceptance and understanding of input-output modeling in long-range energy planning.

Interfacing state-regional modeling capabilities

With differences in regional development perspectives between state and substate agencies, a state-substate interfacing of the input-output modeling capability is increasingly important. In Minnesota, the substate region is emerging as an organizational entity, not only in the decentralization of state-level functions, but, also, in the coordination and consolidation of local service delivery, including planning and capital improvements of so-called regional impact. State legislation has been enacted already in Minnesota to provide for the pooling of part of the local property tax base in the seven-county Twin City Metropolitan Area (9). The fiscal impacts of substate economic development thus are being internalized within the substate region by fiscal pooling in the case of the metropolitan core area in Minnesota. Meanwhile, the development planning function in the substate study area is being regionalized as a means of facilitating the creation of new jobs through strategic public investments in urban-regional infrastructure. Increasingly, therefore, the substate region is becoming the focus of new approaches in both the development of a regional economic base and the financing of essential regional services.

To deal with divergent goals and approaches towards regional development and growth issues, the input-output modeling efforts are being guided by a Project Steering Committee with representation from State and regional, including private, organizations. From a state energy agency perspective, the modeling capabilities must provide measures of state-level and regional economic impact of alternative energy resource allocation, conservation and development strategies. From a regional perspective, these capabilities must also show the subregional impacts of alternative energy strategies.

Diversity in population and resource endowments among regions requires, finally, a separate development strategy for each region. Therefore, the state modeling efforts must provide for regional differences in growth patterns while the regional model must depend on the state model for establishing consistency among substate plans and projections. Hence, projections of the critical variables which "drive" the regional input-output models are derived for each region in several stages.

Total requirements of each final demand sector are derived, first, from the relationships between personal consumption expenditures and personal income, current public expenditures and economic activity levels, and investment and desired input growth. Public facility investments are identified in a separate final demand category. Finally, the gross expenditures are apportioned among local industries on the basis of observed trade (import) propensities. Exports, however, are estimated on an industry basis from a set or relationships which are external to the input-output model.

Since population serves as a multiplier in deriving personal consumption and current public expenditures, a separate model is built to generate regional population levels over a specified time period. The county becomes a building block in the database to the extent that demographic statistics and other information are stored on a county basis but aggregated on a regional scale for reporting and analysis.

The conventional output multipliers transform the final demand, or net output requirements, into projected industry outputs. In turn, income and employment levels are generated along with expected income of local governments. Net changes in local government outlays are projected, also.

Labor and other resource, including energy constraints, are introduced for added usefulness of the industry analyses and/or projections. Indeed, given specific input restrictions and short-term fixity of technical relationships, a format may be specified that will maximize a particular objective function (e. g., employment, output or income). However, "optimal" levels of industry output may not satisfy projected final demands because of resource and energy constraints, but there is "efficient" input use within the specified goals and technology framework. Thus, a state fuel allocation strategy may become crucial to regional development plans. Scarce fuel supplies may be allocated, for example, on the basis of minimal adverse employment impacts. An energy allocation plan is unlikely which allows a high rate of energy-induced unemployment in any one substate region without re-allocation of available energy supplies.

Finally, increased levels of economic activity are likely to require additional public facility outlays. The location of these facilities will be constrained by their ecologic as well as economic impacts. Alternative facility sites will be identified in an optimizing facility location model. Again, state government agencies oversee the location of new major facilities. The regional economic models provide for restrictions imposed by state and federal governments while the state model allows for different regional facility requirements and regulations.

Demonstrating State-Regional Modeling Applications

Use of a two-regional energy-economic systems approach to the input-output modeling is introduced at this point in developing comparisons of energy and/or economic impacts of specified "external" conditions (e.g., federal or state policies) between two regions. In both the state-level and the regional input-output model, the second region is the "rest-of-Nation." The second region, because it is the larger region, is an important source of data on general economic conditions affecting components of the smaller regional economy. For example, demand relationships which are dependent on rest-of-Nation conditions can be introduced to show the responses of "quantity-adjusters" energy price changes. The price and quantity changes, in turn, may result in changes in the relative value of the gross outputs of the regional economy.

Data sources and computations

Because of the interdependence of state and regional economic systems, all projected economic series are derived within an internally consistent framework by using historical data series reported in (1) the Regional Economic Information System (REIS) of the Bureau of Economic Analysis, U.S. Department of Commerce, (2) the Annual County Business Patterns reports, (3) the U.S. Census of Manufactures, the U.S. Census of Business, and the U.S. Census of Population and Housing, and (4) the national projection series prepared by the Bureau of Economic Analysis for the Water Resources Council. The data series for regional impact analysis thus are based on common data sources which use critical importance in reconciling substate data and differences.

Importance of job creation in the substate region emphasizes the need for a tie-in between regional and national input-output modeling with reference to growth sector analysis. Current studies of industry productivity to 1985 provide a common reference, again, for state and substate industry growth projections (1). Energy-use implications of these projection series thus are being derived, not only at the national level, but, also, at the state and substate levels of resource planning from a more-or-less common database.

Computational procedures for the energy impact modeling are illustrated in the following steps:

1. Preparation of a base-year interindustry transactions table for the given region: industry output totals are estimated, along with specific industry purchases from each of 95 producing sectors and from the primary input sectors and rest-of-Nation. Primary survey data are used to also prepare estimates of disbursements of industry outputs to each of the 95 purchasing sectors and to the final demand sectors, including exports to rest-of-Nation. The "rows only" "columns only" estimation procedures are reconciled on an industry-by-industry basis once the two sets of estimates have been prepared.
2. Preparation of base-year final demand estimates: estimated personal consumption expenditures for each of the 95 industry outputs are derived from national averages. Specific expenditures per $1 total consumption expenditures, including marketing, transportation and financing margins; estimates of state and local government expenditures are obtained from selected reports of federal agencies and the U. S. Congress; estimates gross private capital formation are based on selected local industry surveys, periodic reports on the value of construction under building permits, and secondary data on private capital outlays; estimated end-of-year inventories are based primarily

on secondary data; exports to rest-of-Nation purchasers are represented as residual outputs (i.e., after all intermediate and final demands have been satisfied).

3. Preparation of base-year primary input and import sector estimates: estimated total employee compensation is the product of estimated compensation per employee and estimated total employees in each industry; estimated total indirect taxes from all industries in the region are distributed among individual industries on basis of estimated indirect taxes per $1 total industry outlay; estimated total property-type income, including proprietorial income, is distributed among the 95 industries on the basis of estimated property-type income per $1 total industry outlay; imports from rest-of-Nation are derived initially as negative imports.

4. Preparation of estimated base-year and annual projected levels of industry employment, value added, earnings and personal income, business and personal savings, direct taxes, energy utilization and waste emissions: primary (local survey) and secondary data are used to build prediction equations for deriving the set of output-related variables; this series of prediction equations completes the regional economic system model described earlier (detailed computational procedures are described in ref. 1, 6, 12).

An Operator Manuel will be prepared which carefully documents data sources and adjustments. Results of validation procedures will be presented, also.

Data analyses and application

Potential analyses and applications of the REIS model are cited in a User Manuel which will be prepared as part of this study. Only the set of analyses dealing with the interaction between energy and other resource development in Northeast Minnesota is illustrated at this point. Demonstrated here is the technical capability for effectively organizing the vast amount of data bearing upon regional resource development potentials and conflicts.

Noted, first, are the preliminary findings of the Northeast Minnesota Capital Expenditures (NEMCE) Survey which show substantial growth of resource-based industry -- taconite processing, timber, pulp and paper production, and copper-nickel mining. Projected increases in capital outlays of energy-producing companies and local governments are noted, also. However, the development of regional infrastructure may or may not keep pace with the primary resource development.

The REIS model is being implemented for the purpose of analyzing the impacts of projected capital expenditures in three stages as follows:

1. Base-year industry output, employment and value added estimates are extended from the initial 1967 base-year to the updated 1972 base year and, finally, to 1985.

2. Capital requirements of projected industry from data provided in part in the NEMCE Survey; regional infrastructure estimates and projections obtained from the NEMCE Survey will be compared with the derived infrastructure requirements and differences between the sets of projections will be assessed in terms of their respective assumptions and implications.
3. Energy requirements of existing and projected new industry activity will be derived from data provided in part by the Northeast Minnesota Energy Utilization (NEMEU) Survey; energy requirements of the projected industry expansion will be derived, also, and compared with the projected output levels of the energy-producing sectors.

The capital expenditures and energy utilization components of the REIS model are represented by the Facilities Submodel (see fig. 1). The REIS Model is computerized in the Simulation Laboratory (SIMLAB), which makes use of the series computable models as a teaching aid in a course on Community Development Simulation. Step-by-step procedures in the use of SIMLAB as a demonstration model are presented in Appendix A.

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APPENDIX A: SIMLAB

The Minnesota Simulation Laboratory (SIMLAB) provides for computer interactive modeling experience for students and teachers. Computer models of a regional economy are manipulated by varying input variables and model parameters. The results are noted in terms of changes in critical regional output and quality of life goals and targets. Specific models which have been prepared to depict a regional system include the following:

1. Population: total population is identified by age group and sex and is dependent on last year's population and related death and birth rates and migration.

2. Final demand for goods and services is identified by sector (household, business and government) and is dependent on total population and total income of each sector, and rest-of-world demands.

3. Production: total output of goods and service is identified by industry and is dependent on the final demands and the production limits imposed by facilities, labor supply, and other inputs; both residuals and income are "produced" by the production model.

4. Labor: employment status of labor force is identified by age group and sex and by occupational groups; total labor supply is dependent on total population and labor force participation rates, by age group and sex; total demand for labor is dependent on available industry jobs, by occupation.

5. Income: total income is identified by producing and reserving (i.e. household, incomes and government) sectors; it is dependent on (a) total industry outputs and income yield rates and (b) total income received from rest-of-world.

6. Residuals: waste emissions are identified by industry source and attributes; they orginiate from population (i.e., consumption) and industry activities.

7. Facilities: total space requirements of consumption and production are identified by type of facility (household, commercial, industrial, governmental): facility requirements are dependent upon existing facilities, replacement facilities, and expansion facilities; replacement rates depend on age of, and demand for, old facilities; expansion facilities depend on savings and demand for these facilities.

8. Land use: location of facilities determines land use, which is dependent on facility/production/consumption requirements of population and production activities.

9. Rest-of-world: interregional trade, people and many flows are dependent on factors outside region, which are encompassed in rest-of-world (ROW) model.

Steps in manipulating the model series in computer simulation include the following (see figure 1):

1. Preliminary population labor force and employment estimates are derived from an equation of the form,

$$P'_t = P_{t-1} + B_t - D_t \pm M'_t, \; L'_t = k_l \cdot P'_t, \; E'_t = k_e \cdot L'_t$$

where $M'_t = M_{t-1} + k_u U_{t-1}$ (note, U_{t-1} is final unemployment est.)

2. Preliminary final demand estimates are derived for each of the three sectors using the form,

$$Z'_t = k_{Z1} P'_t \cdot y_{t-1} + k_{Z2} - \frac{EX}{EX_{US}} \quad \text{and} \quad \frac{\Delta Z'_t}{Z_{t-1}} = k_p \left(\frac{\Delta P'_t}{P_{t-1}} \right) + k_y \left(\frac{\Delta y_{t-1}}{y_{t-2}} \right)$$

3. Preliminary industry output estimates are based on the form,

$$X'_t = (I - A)^{-1} Z_t$$

4. Revised industry employment labor force and population estimates are based on the form,

$$E''_t = k_e \cdot X'_t, \; L''_t = k_l E''_t, \; P'' = k_p L''_t$$

(Implied unemployment and population are derived for use in the revised migration equation.)

5. Migration to balance preliminary and implied population estimates is computed by age group and sex based on the form,

   $M_t = (P_t - P_t') + M_t'$ where $M_{ast} = k_{as} - M_t$

6. Final demands and industry gross outputs are recomputed.

7. Employment, labor force and unemployment are recomputed.

8. Income and residuals are derived using the form,

   $W_t = w_t X t$

9. Facility levels (old, replaced, and new) are derived using the form,

   $F_t = f_t Y_t$

10. Land use (by type) is derived using the form,

    $L_t = k_f F_t + k_x X_t + k_z Z_t$

Energy program impacts are assessed by introducing energy facility constraints, and related production and consumption activities, into the regional economic model. Energy use coefficients are introduced, also, but in the same manner as employee input coefficients. Energy output coefficients already are part of the production (i.e., input-output) model.