A Regional Energy Information System
For Minnesota: A Preliminary Design

by

Norman L. Chervany, J. David Naumann,
Ralph Krishnan, Daniel Quillin, and John Schmitt

REGIONAL
ENERGY INFORMATION SYSTEM
AND ECONOMIC
IMPACT ANALYSIS PROJECT

MINNESOTA ENERGY AGENCY

MANAGEMENT INFORMATION SYSTEMS RESEARCH CENTER
COLLEGE OF BUSINESS ADMINISTRATION
UNIVERSITY OF MINNESOTA

AGRICULTURAL EXPERIMENT STATION
INSTITUTE OF AGRICULTURE
UNIVERSITY OF MINNESOTA

A Regional Energy Information System For Minnesota: A Preliminary Design

by

Norman L. Chervany, J. David Naumann,
Ralph Krishnan, Daniel Quillin, and John Schmitt

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

Department of Agriculture and Applied Economics
University of Minnesota

January 1975

MINNESOTA ENERGY AGENCY
740 American Center Building, 160 East Kellogg Boulevard
St. Paul, Minnesota 55101 612-296-5120

Dear Reader:

The Minnesota Energy Agency was established by the Minnesota State Legislature to " . . . encourage thrift in the use of energy, and to maximize use of energy-efficient systems, thereby reducing the rate of growth of energy consumption, prudently conserving energy resources, and assuring statewide environmental protection consistent with an adequate, reliable source of energy."

Accurate, reliable, timely information is essential if the Energy Agency is to fulfill its role.

We are grateful to Governor Wendell Anderson and to the Upper Great Lakes Regional Commission for providing us with the financial assistance under Project No. 10420195 to develop and test the information system and economic model which will help us make better decisions in solving the energy crisis.

John C. McKay

John C. McKay, Director
Minnesota Energy Agency

Acknowledgements

In any project of this size a large number of people make important contributions. We are indebted to all of them. In particular, we want to acknowledge the support and contributions of the following:

- Dr. James E. Carter and the entire staff of the Minnesota Energy Agency for the guidance, direction, and direct contribution to the project.
- Naomi Estes, Sue Scanlan, Lori Redmond, and William Pisarra and the rest of the staff of the Management Information Systems Research Center of the University of Minnesota for their administrative and clerical help with the project.
- Roy Fingerson and the Upper Great Lakes Regional Commission for their financial support of the project.
- University Computing Center of the University of Minnesota for partial support of the computing costs of the project.

Norman L. Chervany

J. David Naumann

Table of Contents

Summary

The major tasks faced by Minnesota policy makers are twofold. First, they must develop an understanding of the State's energy system. Second, they must develop socio-economic plans that explicitly take energy constraints into consideration.

Analysis of energy policy issues and data needs reveals that four types of data

- energy supply/distribution/consumption data
- demographic data
- economic data
- engineering data

are needed to support the short run energy allocation problems and long run energy planning problems. This research report presents the preliminary design of a regional energy information system. The system is designed to collect, store, and report the supply/distribution/consumption data. This data category was focused upon because it is more complex and less available from currently operating systems than the other three data types.

The conclusion of the report is that it is technically feasible to obtain timely, valid data on energy supply, distribution, and consumption. The next step in the development of the energy information system is to specify the procedures (both data collection and computer processing) required to implement the system in Minnesota.

Organization of the Report

I. Introduction

This section briefly describes the energy system operating in the State of Minnesota. This description focuses upon

- a summary of historical Minnesota energy consumption
- a summary of the scope of the energy supply/distribution/consumption system in Minnesota

II. Energy Policy Issues and Data Needs

This section summarizes and classifies the different policy issues that are (or may be) faced in managing the energy system in Minnesota. Based upon the structuring of the energy policy issues, the data required to analyze these problems is identified.

III. REIS Project Research Objectives and Strategy

Within the administrative context defined in Sections I and II the research objectives and strategy of the REIS project are presented. This section discusses

- rationale for focusing upon the data collection system for the energy supply/distribution/consumption system
- rationale for using a demonstration region and database
- an overview of the REIS system

IV. The REIS Design Concept

This section presents the concept of an energy establishment as the basic data collection unit. It then discusses the problems of data dimension and detail faced in the construction of the REIS system.

V. Processing Approach I: SYSTEM 2000

This section discusses the primary data processing structure required to implement the energy establishment concept. A brief summary of the logic of database management system is discussed; within this framework the logic of SYSTEM 2000 is presented. Finally, the database schema employed in the demonstration system and some example reports are presented.

VI. Processing Approach II: The Energy Flow Network Model

This section presents a network formulation of the energy supply/distribution/consumption system. It demonstrates the use of the network model in answering data summarization questions. It also discusses the relationship between the energy establishment databases and the network model.

VII. Analytical Models: The Relationship to the REIS System

This section summarizes the relationships between the REIS system as described in Sections III - VI and the analytical models that are (or may) be constructed to analyze energy policy issues.

VIII. Future Directions

This section outlines the analytical and developmental activities that must be completed in order to implement the REIS system in Minnesota.

I. Introduction

The major tasks faced by Minnesota energy policy makers are two-fold. First, they must develop an understanding of the State's energy system. Second, based upon this understanding, they must develop socio-economic plans for the State's future that explicitly take into consideration the constraints posed by the energy system. The research project described in this report presents the conceptual design of a regional energy information system (REIS). REIS is designed to support the energy-related data needs of the State's planners and policy makers by:

- defining energy data and report requirements
- designing the data collection methods
- developing storage and access methods for these data

Before presenting the results of the research project, it is useful to summarize the major characteristics of Minnesota's energy system. This summary provides a perspective for viewing the major energy issues that will face Minnesota in the future.* Thus, this summary provides guidance for the design of the energy information system.

---

*More extensive background material on Minnesota's energy system has been developed by the Minnesota Energy Project sponsored by the Minnesota State Planning Agency. Readers of this report will find Abrahamson's "Minnesota: A Premier on Energy Options and Implications" [1] enlightening.

Energy Suppliers for Minnesota*

One of the predominant features of Minnesota's energy system is the almost total reliance on others for its primary energy resources.** Presently hydro-electric power is its only "native primary energy resource." This source of energy, however, produces only a very small proportion of the State's total energy needs. In 1972, for example, only .9 of 1 per cent of the State's total energy was produced by hydro-electric power. Thus, 99 per cent of the State's energy needs were met by imported energy sources. The details of the 1972 Minnesota energy supplies presented below are summarized in Figure I.1.

Petroleum -- In 1972, Minnesota was supplied with 4,030.4 million gallons of petroleum. This amount of petroleum equalled 47 per cent of the State's total energy supply. Thirty-nine*** companies presently ship petroleum into Minnesota. This petroleum is distributed by 1,044 licensed distributors to 7,329 retail sales outlets.****

Natural Gas -- In 1972, 344.0 billion cubic feet of natural gas was supplied to Minnesota. This amount equalled 31.6 per cent of the State's total energy supply. Presently, the natural gas is supplied to the State through 7 interstate gas pipeline companies. In turn, the natural gas is distributed by 30 natural gas utility companies.

---

*The data concerning the volume and number of energy establishments in Minnesota were provided by the Minnesota Public Service Commission, the Minnesota Department of Revenue, Petroleum Taxation Division, the Minnesota Energy Agency's Allocation Division, and the Minnesota Energy Agency publication entitled "Minnesota Energy Supply and Use 1972" [19].

**The primary energy resources consumed in Minnesota are crude oil, coal, natural gas, uranium, and hydro-electric power.

***This figure includes 10 companies that are strictly propane suppliers.

****These figures do not include "propane only" distributors or retail outlets.

FIGURE I.1

ENERGY SUPPLIED TO MINNESOTA IN 1972

ENERGY TYPE	AMOUNT		NUMBER OF SUPPLIERS AND DISTRIBUTORS: SUPPLIERS	DISTRIBUTORS	RETAILERS
PETROLEUM	4030.4 MILLION GALS.	(47%)	29	1,044	7,329
NATURAL GAS	344.0 BILLION $FT.^3$	(31.6%)	7	30	
COAL	8.6 MILLION TONS	(16.9%)	3	20-30	
NUCLEAR	3.56 BILLION KWHS.	(3.6%)	3		
HYDRO	.86 BILLION KWHS.	(.9%)	31		
ELECTRICITY	23.04 BILLION KWHS.		202		

Coal -- In 1972, 8.6 million tons of coal were supplied to Minnesota. This amount equalled 16.9 per cent of the State's total energy supply. There are an estimated 5 to 7 coal companies which actually bring coal into the State, and between 20 and 30 retail coal dealers in the State.*

Nuclear Power -- In 1972, nuclear power provided Minnesota with 3.56 billion kilowatt hours of generated electricity. This amount equalled 3.6 per cent of the State's total energy supply. The supply is generated from 3 nuclear power plants in Minnesota.

Hydro Power -- In 1972, hydro power provided Minnesota with .86 billion kilowatt hours of generated electricity. This amount equalled .9 of 1 per cent of the State's total energy supply. The electricity is generated from 31 hydro-electric plants in Minnesota.

Secondary Energy-Electricity -- Presently 202 electric utilities serve Minnesota customers. In 1972, these Minnesota customers purchased 23.04 billion kilowatt hours of electricity.

Energy Consumers in Minnesota

The energy consumption system in Minnesota is even more complex than the supply and distribution system. These complexities arise first because of the geographical characteristics of the State. The State has 84,069 square miles broken down into eighty-seven counties. In 1973, the population of the State was 3.897 million; the number of residential units was 1.220 million.**

---

*These estimates were provided by personnel at the Great Lakes Coal and Dock Company, St. Paul, Minnesota.

**These data were supplied by the economic research activity within the Research Division, Minnesota Energy Agency.

From an economic development perspective, the State is separated into thirteen regions. These regions have different socio-economic characteristics that must be recognized in the State's planning process.* Within these regions there are more than 70,000 diversified business establishments. Figure I.2 presents a summary of the State's industrial and commercial activity.

Summary

The geographic, industrial, and commercial characteristics of Minnesota have a direct impact upon its energy system. The large number of energy suppliers and distributors is a direct result of the geographic dispersion. In addition, the diversity within the private sector implies differing energy needs and problems.

An information system designed to monitor the energy supply, distribution, and consumption system within Minnesota must recognize these complexities. It must have enough capacity to accommodate the large amounts of data that can (and will) be collected. It must be flexible enough to accommodate the (potentially) different types of data that may be required for alternate economic development regions or consumer categories. Finally, it must be adaptable enough to accommodate the changes that will inevitably occur as the energy problems of the State change. The conceptual design described in the succeeding sections has these characteristics.

*A detailed analysis of the thirteen economic development regions is present in [13]. The energy consumption differences among the regions are found in Abrahamson [1; pp. 79-85].

FIGURE I.2

MINNESOTA BUSINESS ESTABLISHMENTS AND EMPLOYMENT*

Major Industry Divisions	Division Title	No. of Estab.	Per Cent	Employment in Each Major Industry Division	Per Cent
Total	All Industries	70,046	100.00	1,158,968	100.00
01-09	Agriculture	637	0.9	3,067	0.3
10-14	Mining	174	0.3	12,962	1.1
15-17	Contract Const.	7,918	11.3	52,557	4.5
19-39	Manufacturing	5,298	7.5	318,722	27.5
41-49	Transportation	3,414	4.9	70,659	6.1
50-59	Trade	28,052	40.0	336,281	29.0
60-67	Fin,Ins, & Real Est.	6,297	9.0	68,072	5.9
70-89	Services	16,997	24.3	215,317	18.6
91-93	Government	1,259	1.8	81,331	7.0

* These statistics were reported for October 1973 by the Minnesota Department of Employment Services Research and Planning Division. The 70,046 business establishments account for 84% of Minnesota's non-agricultural wage and salary employment.

II. Energy Issues and Data Needs

One of the most crucial steps in the development of a management information system is to determine the information needs of the users of the system.* An initial step in the conceptual design of the REIS system was to conduct extensive interviews of personnel within the Minnesota Energy Agency. This section reports the results of those interviews. It concentrates upon the delineation of:

- issues that must be studied in order to manage Minnesota's energy system.
- data needed to support these studies.

The Structure of the Interviews

In order to determine a direction for the REIS system, key people within the Minnesosta Energy Agency were interviewed.** The list of people interviewed is presented in Figure II.1. The objective of these interviews was to obtain the interviewees' perceptions of:

- energy issues faced by Minnesota
- types of data that are needed to study and resolve these issues
- amount of detail required for each data type identified

---

*An interesting summary of alternative methods of determining information requirements is presented by Munro [22]. Conflicting opinions concerning the ability of system users to state their information requirements are found in Ackoff [2], Adams [3], and Adams and Schroeder [4].

**Time did not permit interviews of people outside of the Minnesota Energy Agency. Interviews with personnel from other State Agencies, State Legislators, and other interested parties will be part of Phase II of this project.

FIGURE II.1

Minnesota Energy Agency

Personnel Interviewed

Interviewee	Responsibility
John McKay	Director
Philip Getts	Deputy Director
James Carter	Director of Research
Ernesto Venegas	Research Analyst, Research Division
Daniel Quillin	Research Analyst, Research Division
Rudy Brynolfson	Research Analyst, Research Division
John Peterson	Director of Conservation and Planning
Wes Fisher	Planning Analyst, Conservation and Planning Division
Jay Lujan	Planning Analyst, Conservation and Planning Division
Dixie Diehl	Fuel Allocation Coordinator

The interview was conducted in an open-ended format. Three broad question areas (corresponding to the objectives listed above) were asked. Before the interview started, the interviewees were told not to concern themselves solely with energy data that would have to be part of a computerized information system. Rather, they were instructed to think about energy information requirements in general. It was explained that it would be part of the REIS project team's responsibility to help determine the role of a computer system vis-a-vis these needs.

After each interview was finished, the results were summarized and given back to the interviewee in typewritten form. These summaries were used as the basis for a re-interview as a means of affirming, correcting, and expanding the interviewee's responses. The detailed results of these interviews are presented in Appendix X.1.

Energy Issues Faced in Minnesota*

Although the specific responses of the interviewees varied, a consensus of opinion concerning the major problem areas was found. The major categories of issues facing Minnesota energy policy-makers are:

(1) to have the capability to resolve short-run, crisis allocation problems arising in Minnesota

(2) to gain an understanding of the workings of the Minnesota energy system as it is currently configured

(3) to develop an energy-based, contingency planning capability for Minnesota

Resolution of Short Run Problems -- On an ongoing basis (daily in some emergency situations) the Minnesota Energy Agency must be able to monitor available energy supplies and current energy demand. Where shortfalls

*The reader interested in another view of energy policy issues is referred to Abrahamson [1].

occur (or are predicted to occur), the Agency must be in a position to attempt to eliminate or alleviate the shortfalls. This involves matching and arranging distribution of available energy stocks to the shortfall situations. In the extreme case where shortfall demand cannot be satisfied, other State Agencies (where appropriate) should be notified of the (impending) problem.

Understanding of the Current Energy System -- One characteristic of the management of the energy system (both nationally and at the State level) is the lack of understanding of its components and how these components work together to link energy suppliers with energy consumers. In Minnesota, for example, the first State energy budget was not completed until late 1974.* Thus, a primary responsibility of the Minnesota Energy Agency is to examine and disseminate "facts" concerning the Minnesota energy system.

The detail inherent in understanding something as complex as an energy system is overwhelming. It would be impossible to list completely the topics that must be examined. A partial list, however, would include:

- the development of historical supply and consumption data about various energy types within the State
- the determination of energy consumption by major user sectors (and by process within these sectors) within the State
- an identification of illogical and/or wasteful uses of energy within the State
- a description of the services areas for energy suppliers and distributors operating in the State

*A state energy budget shows the amounts of different energy resources that are consumed by the various sectors of the state's economy. The 1972 Minnesota energy budget [19] is available from the Division of Research, Minnesota Energy Agency.

Development of Long-Run Planning Capability -- Minnesota is an energy consuming state (see Figure I.1). As such, energy conservation and contingency planning for alternative energy supply scenarios become the key long-run issues that must be resolved. These activities will involve:

- the identification of the potential for energy conservation in the various energy consuming processes operating in the State
- the development of predictions of future supply and demand for various energy types in the State
- the development of information concerning the economic and social benefits from alternative uses of energy supplied to the State

Data Required to Support Energy Policy Analysis

The discussion of the above issues led to the identification of four basic types of data required by Minnesota energy policy-makers.

(1) Supply/Distribution/Consumption Data

These data refer to the monitoring of energy flows into the State, through the distribution network, and to the consuming units. These data involve knowledge of the organizational units in the distribution chain and the amount of energy that flows between them. Of particular importance is an identification and enumeration of different energy consuming processes and the amounts of energy that these processes consume.

(2) Demographic Data

These data refer to the numbers, locations, and other characteristics of organizational units in the supply/distribution/consumption chain. On the supply/distribution end, it is necessary to know, for example, who the prime suppliers are, where they ship, and how much storage capacity and inventory is available. On the consumption side, examples of needed data are characteristics (e.g., number of appliances in an "average" residence), location, and numbers of units in various sectors of the economy.

(3) Economic Data

These data refer to the level of economic activity in the various geographic and economic sectors of the State. It is necessary to know, for example, employment generated and contributions to gross state product by each economic sector. In addition, it is necessary to know items such as capital expenditure plans and levels of final demand for the various economic sectors in the State.

(4) Engineering Data

These data refer to the engineering aspects of energy consumption. Examples of these data would include energy efficiencies in various manufacturing processes or heat losses for different types of residential dwellings.

The information system for the Minnesota Energy Agency must provide these data. This does not mean that all of the data must be maintained in a computer system. The results of special engineering studies, for example, may provide the technical data; computerization may not be necessary for these studies. Similarily, there is no implication that these data must be generated from new data collection activities. Existing data sources (e.g., other State Agencies) may currently compile portions of the required data. The important point is that these data - from whatever source available and stored in whatever form necessary - must be available to energy policy-makers.

The Question of Data Detail

In order to specify an information system, it is not sufficient to specify the classes of data that must be collected. In addition, the level of detail for the data must be specified. Figure II.2 lists the basic options that need to be evaluated in the design of the REIS system.* The options outlined would allow for a wide variation in energy information systems. At one extreme, a very macro system could be designed that reported annual supply and broad end-use category consumption on a statewide basis. At the other extreme, a system to report monthly supply and distribution reports detailed by county, companies, and four-digit SIC categories could be developed.

In the interviews within the Minnesota Energy Agency, there was not complete agreement on the appropriate levels within these different dimensions. The actual resolution of these questions must await:

(1) further user evaluation of the REIS system

(2) the results of the cost analyses for the detail different options

However, the current basic opinions concerning the required detail are:

Geographic Detail -- There was unanimous agreement that statewide data, by itself, would not be sufficient. The difference of opinion arose concerning economic development regions versus county data. The longer run energy issues seem to require data disaggregated only to the level of economic development regions. In most instances county lines were felt to be artificial boundaries. In comparison, the short-run allocation problems would appear to require data by counties.

---

*A further discussion of the level of detail and its implication is found in Section IV.

FIGURE II.2

Data Detail Options

For An Energy Type

Dimension	Options
A. Geographic Detail	A.1 Statewide
	A.2 Economic Development Region
	A.3 County
B. End-Use Detail	B.1 Broad User Categories
	B.2 Detailed SIC Categories
	B.3 Some Individual Users Plus Detailed SIC Categories
C. Time Detail	C.1 Annual
	C.2 Quarterly
	C.3 Monthly
D. Supply/Distribtuion Detail	A.1 Supply and End-Use Only
	A.2 Detailed Transactions in the Distribution Chain

End-Use Detail -- In most instances a SIC breakdown was selected as appropriate. This was believed to be necessary to support economic impact and trade-off studies. In addition, SIC categories and (in some instances) company-by-company data, would also be required to support energy conservation decision-making.

Time Detail -- The opinions concerning the appropriate level of time detail are analagous to the discussion of the appropriate level of geographic detail. Planning decisions would seem to require quarterly to annual data; whereas, the short-run allocation problems require monthly (if not shorter) reporting intervals. The most frequently mentioned reporting time frame was quarterly data.

Supply/Distribution Detail -- Detailed supply/distribution reporting refers to data concerning the specific energy shipment/receipt transactions that occur within the Minnesota energy system. At the extreme, this would be reports of all shipments (perhaps larger than some minimum size) into and through the State. This level of detail could be described as data concerning "who shipped what to whom."

None of the interviewees said that this level of detail was required. For some (especially those interested in long range energy planning) knowledge of total supplies into the State and end-use consumption seemed adequate. A compromise position, however, seemed to be:

- knowledge of supplies by individual supplier into the State
- knowledge of the first line (or major) distributor and his inventory
- knowledge of the prime suppliers' and major distributors' service areas

It was felt that this level of detail would monitor supply and inventory. In addition, the service area data would permit projection of geographic areas of potential shortfall based upon knowledge of the general supply conditions for the prime energy suppliers.

Summary

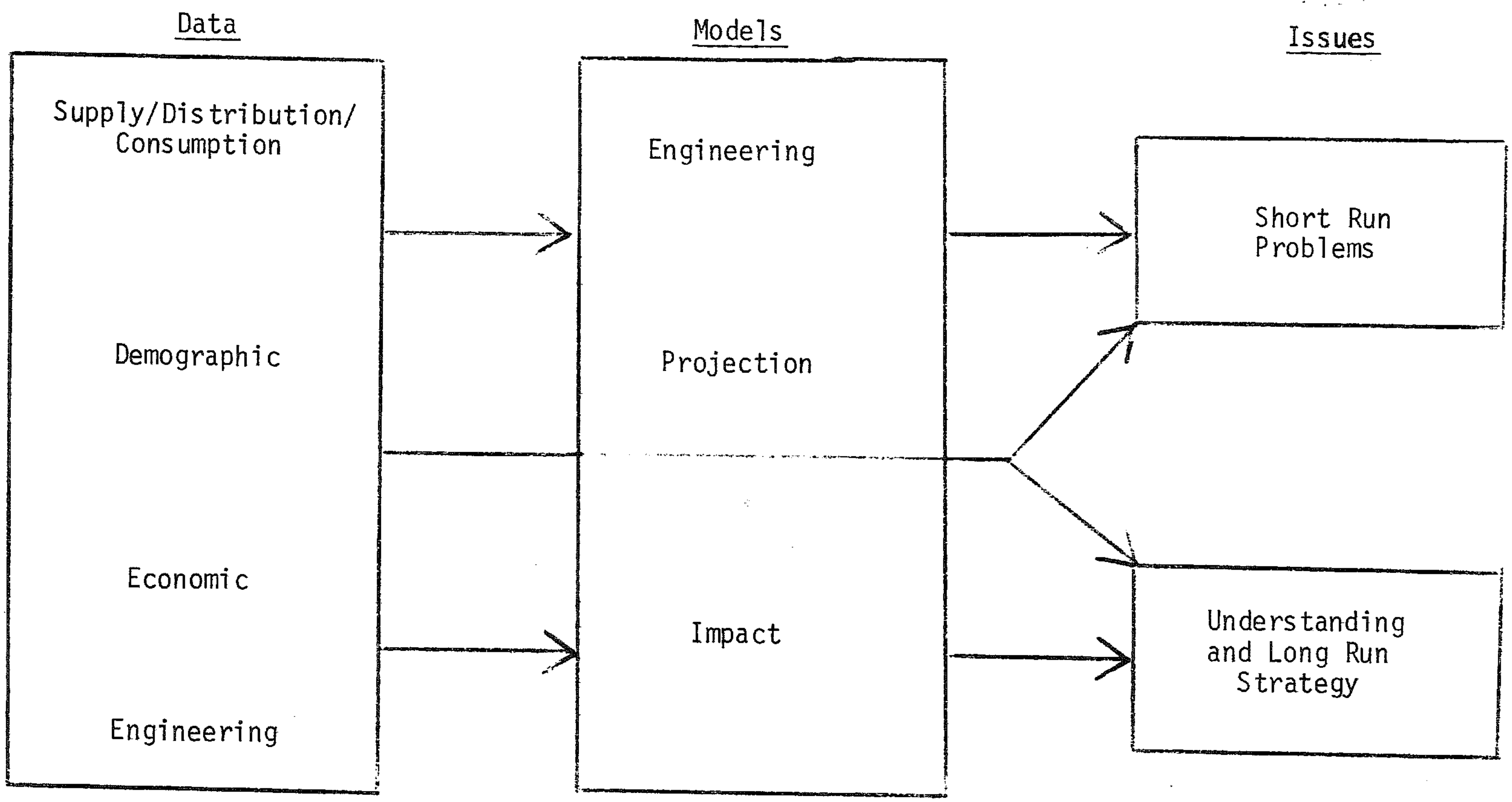
The results of the survey of the Minnesota Energy Agency can be summarized as shown in Figure II.3.* The problem becomes one of selecting upon which components should the REIS system focus. This selection is described in the following section of the report. After this, the remainder of the report is devoted to the conceptual design of the REIS system for the components selected.

---

*The only component not discussed in this section is the analytical models. These represent structured, mathematical and computer decision aids that may utilize the required data to help in problem analysis. More about these models and their relationship to the REIS system is presented in Section VII.

FIGURE II.3

BASIC INFORMATION SYSTEM COMPONENTS OF THE MINNESOTA ENERGY MANAGEMENT SYSTEM



III. REIS Research Objectives and Strategy

The first two sections of this report summarized the environment in which Minnesota's energy information system must operate. First, the state is both large and diverse with respect to its energy distribution and consumption systems. Second, there are numerous energy problem areas and policy issues that must be resolved. This section of the report presents the research approach employed in the project. It also presents an overview of the structure of the energy information system that is proposed.

Research Focus

The objective of this research project is to undertake the conceptual design of a regional energy information system for Minnesota. In order to understand what this means, it is useful to define what is meant by a management information system.* Two useful definitions are:

> A system designed to supply managers ... with information they need to keep informed of ... current status ..., to understand its implications, and to make and implement ... appropriate ... decisions [9; p. 583].

> A system of people, equipment, procedures, documents, and communications that collects, validates, operates on, transforms, stores, and retrieves, presents data for use in planning, budgeting, accounting, controlling, and other management processes ... Information processing systems become management information systems as their purpose transcends a transaction processing orientation in favor of a management decision-making orientation [26; p. 1].

---

*Detailed discussions of management information systems, their problems and resolutions are found in [6], [7], [10], and [27].

The task for this project is to design a management information system (in Schwartz's sense) capable of making these data available to Minnesota energy policy-makers. In particular, the information system discussed in this project is designed primarily for the supply/distribution/consumption data.*

The selection of the supply/distribution/consumption data was based upon an evaluation of the problems inherent in obtaining the data elements in each set. The engineering data, for example, must come from special studies. Some of these studies already exist. Regardless of their current existence, however, these data are small in number and are not likely to require extensive computer storage and reporting capability in order to make them useful. The economic and demographic data, in contrast, will require computerization in order to be useful to energy researchers and policy-makers. The file structure necessary to store and access these data, however, will not be complicated. It is relatively straight forward, for example, to maintain and access economic activity such as employment or sales by Standard Industrial Classification (SIC) code. The data collection problems for these sets can be quite difficult. It is possible, however to modify nationally published data with the results of a small number of carefully constructed primary surveys.

The conclusion was reached that, while important information system design problems must be resolved for the engineering, economic, and demographic data, the initial design work should not focus on these areas. Instead, the major energy data problems lie in the supply/distribution/consumption area. This set has the largest number of potential reporting points. As Figure I.1 illustrates, for example, there are 8,402 organizational units within the petroleum distribution chain without considering the multitude of end-users of petroleum product.

---

*A discussion of what needs to be done in supporting economic, demographic, and engineering data needs is presented in Section VII.

The sheer size of the supply/distribution/consumption data set is not the only problem. Currently, only part of these data are being collected. The Division of Petroleum Taxation of the Minnesota Department of Revenue, for example, has partial data on petroleum shipments into towns in Minnesota. The physical supply network that delivered the product and the use of this product is not currently available. Also, some of the petroleum flows are not subject to State tax. As such, these flows are not currently reported.

Research Approach

The approach employed in this project was one of research and development rather than immediate development and implementation. This approach involved two related research activities that would precede the general system specifications.* First, a series of user interviews were conducted to attempt to determine the energy policy issues and supporting data requirements that were perceived by the staff of the Minnesota Energy Agency. Second, this "top-down" approach to the information systems design was supplemented by a "bottom-up" approach of conceptualizing the basic transactions that occur within the energy supply/distribution/consumption system.** Based upon this conceptualization, a demonstration system was developed to permit the research team to: (1) test the feasibility of a computer approach for data storage and access, and (2) undertake user evaluation of the projected data and reports. A detailed description of the research tasks are given in Appendix X.2.

The results of the user interviews were presented in Section II of this report. Additional interviews (with and without the use of the demonstration

---

*The details of the plan for developing general systems specifications for the REIS system are presented in Section VIII.

**An overview of the conceptual design for REIS is presented in the last part of this section. For an interesting discussion of the top down versus the bottom up approach to systems analysis see Munro [22].

system) are planned for the next phase of the REIS project.* The feasibility of the conceptual design is discussed in Sections IV and V of the report.

It is instructive to summarize and comment upon an alternative strategy that could have been employed in this project. It would have been possible to start immediately on the actual development and implementation of an energy information system. This strategy would have had the advantage of reducing the lead time until an operating information system was available to policy-makers in Minnesota. It would have carried with it, however, a very serious danger. If there was ambiguity or uncertainty in the information needs of the ultimate system users, then a great deal of time and money might be spent on a system that could prove to be inadequate, or worse yet, inappropriate.**

While recent research [2], [3] has indicated managers in business feel that they know and receive the information that they need, the problem of managing a state's energy system is quite different. Very few people have had explicit experience in the identification of energy problems. There has been even less experience in energy problems. A symptom of these conditions is found in the lack of existing energy information system both in Minnesota and elsewhere.*** Thus, implementation of a complex information system without some background research was evaluated as a strategy with an unacceptable risk.

---

*Unavoidable computer delays prohibited complete user evaluation of the demonstration system in this phase of the project.

**Interesting data on MIS implementation problems is found in [7], [25], and [27].

***Most of the energy information systems existing in other states have been developed on an ad hoc basis. The New England Energy Information system [20], [27], currently under development, is one of the few exceptions to this.

An Overview of the REIS System*

The REIS system has been conceptualized as two separate interacting functions. First, the accounting system collects pertinent data from the physical energy supply/distribution/consumption system, Second, the energy flow network model is a mathematical representation of the physical energy system. It depicts the relationships among energy production, transportation, storage, and consumption.

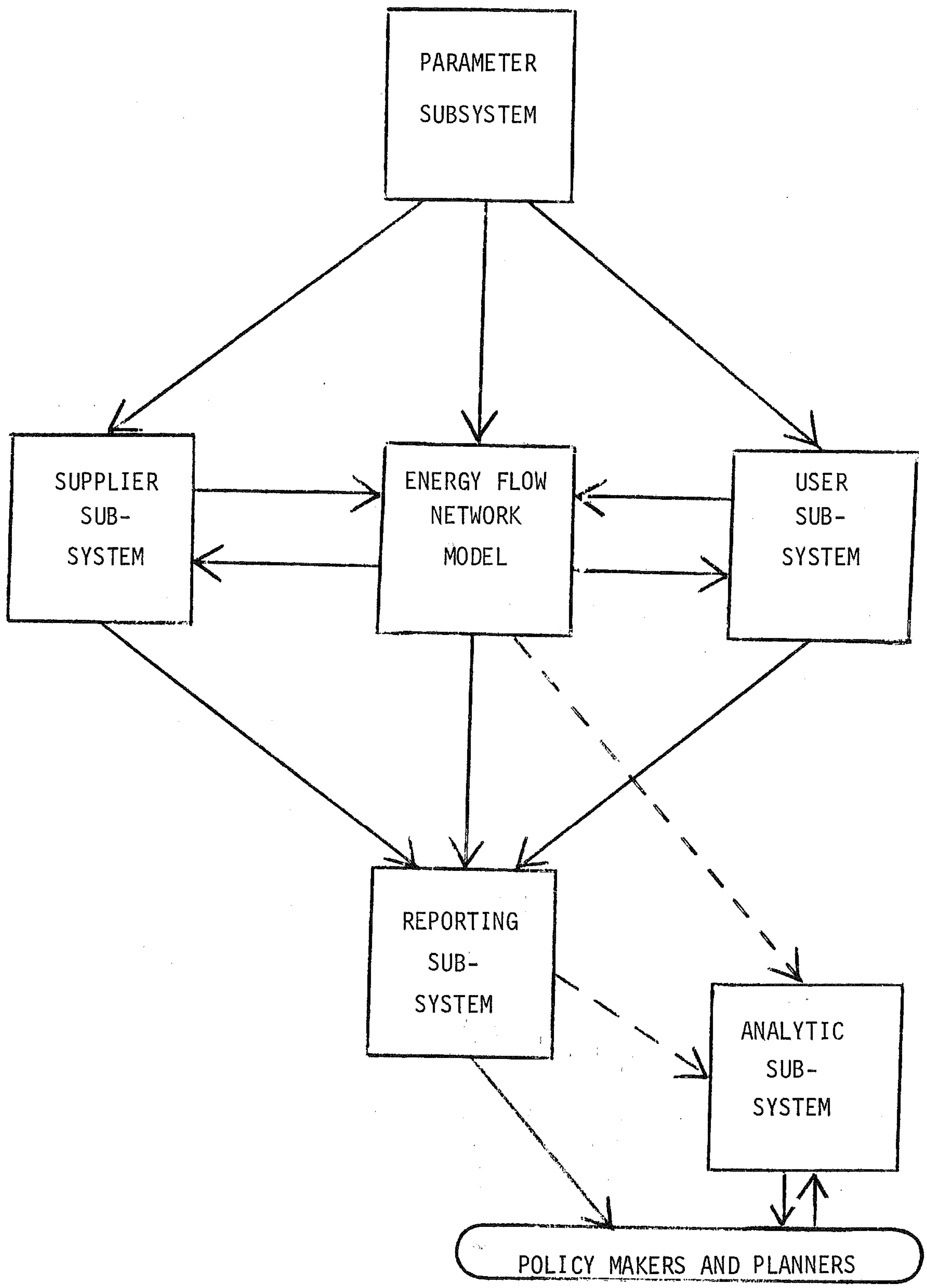
The core of the information system, as depicted in Figure III.1, is the energy flow network model. It interacts with the supplier subsystem and the user subsystem. Data are entered via these interactions, and validation information is derived from the energy flow network model and returned to the subsystems. The key parameters of the system (e.g., lists of suppliers or end-users of an energy type) are maintained in the parameter subsystem. These values are provided to the supplier and user subsystems and the energy flow network model. This structuring enables relatively independent design phases for each subsystem and corresponds to differing input and maintenance characteristics of the final system. The system is further subdivided into a reporting function and an analytic function.

Supplier Subsystem -- The main data-gathering segment of REIS, the supplier subsystem, collects information on the flow of energy in its various forms into the state, and through the distribution, storage, and conversion facilities. A large part of this subsystem is concerned with data verification and validation. The database maintained here is used to provide supply and inventory information to policy-makers and to the energy flow network model.

*Other overviews of the REIS system are found in [15], [17], and [23].

FIGURE III.1

THE ORGANIZATION OF THE REIS SYSTEM



User Subsystem -- In order to assess the impact of changes in the physical energy system, a record of uses and usage patterns must be maintained. Because it is not feasible to account for energy flow from the supply network to individual consumers, another method of accounting for usage must be provided. In this sub ystem, data indicating usage patterns by fuel type for each geographical area will be maintained. Such data, when combined with flows into the area, will provide for consistent, accurate estimation of consumption by user class and using process.

Parameter Subsystem -- While classifications of users, energy types, and locations may be relatively static, this subsystem will permit separate adjustment and will maintain a database of information concerning these system parameters.

Energy Flow Network Model -- This subsystem is a mathematical representation of the flow of energy flow from production or importation, through the distribution channels, to end use. The representation of energy flows in mathematical form enables the efficient manipulation of energy data to summarize supply and consumption, to validate input data on energy movement, and to calculate inventory levels.

Reporting Subsystem -- The massive amounts of data to be collected and maintained by the portions of REIS discussed above will be useless unless they are processed and presented to policy-makers in an appropriate manner. This must include many types of categorization and summarization. Data from the databases and from the network model must be further processed before presentation to policy-makers. The previously defined subsystems can operate in a "batch" mode, where interactions between the database and the policy-maker are not necessary. The reporting subsystem will, on the other hand, be a more effective operating partially in an on-line interactive, "question-and-answer" mode. Where predefined reports do not meet the needs of a user, the reporting subsystem will allow interactions with the data using a powerful, but easily understood, command language for information retrieval.

Analytic Subsystem -- While operational and many tactical level decisions can be supported by information derived directly from the system, many other decisions, especially those with longer range implications, will need to consider data which is not part of the information system. These decisions will be supported by programs and models which obtain part of their information from the database and part externally. The Economic Impact Analysis Project currently underway within the Research Division of the Minnesota Energy Agency is an example of such an analytic model.

Summary

This section has defined the research approach employed in this project. In addition, an overview of the REIS system has been presented. The remaining sections of the report discuss the implementation of the research strategy.

IV. The REIS Design Concept

The collection, organization, and management of energy data is a complex task which reflects the complexity of the various physical systems which supply, distribute, and consume energy. Systems which supply and distribute energy have evolved over a half a century and more, and have been oriented toward a variety of objectives. The consumption of energy is similarly a pattern resulting from many, varied, constantly changing factors.

In contrast, the REIS system must be designed as a single unit, but this unit must accurately portray the complexities of the physical world. To attempt to realize this very difficult goal, systems analysts have developed a number of techniques and concepts -- generality, modularity, evolvability, aggregation, and sampling. These techniques and concepts, defined below, by no means assure successful design of an information system, but they perhaps make it possible.

(1) Generality

In the context of information systems development generality implies the use of resources with the widest possible application (e.g., Generalized Database Management Systems).* Generality also implies standardization, so that concepts or rules or definitions intended for one function are applied system-wide.

(2) Modularity

Modularity is a technique which evolved in the design of mechanical systems and has been a fundamental concept enabling the

---

*Generalized Database Management systems are discussed in detail in Section V.

development of such complex systems as missiles and spacecraft. In essence, the application of modularity involves the successive partitioning of a project from overall objectives down to readily manageable tasks, plus the rigorous application of standards to interface separate modules.

(3) Evolvability

Evolvability is a concept, not a technique, which suggests that designed systems must be able to adjust to changing requirements and environment. We previously discussed briefly the way in which the physical energy system evolved to meet requirements of a changing world. Information system designers have come to realize that their products must also be evolvable if they are not to be almost immediately obsolete. Evolvability is a primary consideration in the development of the REIS system.

(4) Aggregation

Aggregation is a technique which reduces the complexity of the system but at the same time limits possible outputs. Almost all data are aggregate to some extent. Designers must choose a level of aggregation which makes the collection, processing, and storage of data technically and economically feasible while retaining sufficient detail to produce meaningful output.

(5) Sampling

Sampling provides a technique for collecting and processing data into meaningful information without collecting all possible data. Especially in the case of energy consumption, it is not feasible to specifically monitor every user and use of energy. Correct sampling permits economical collection of consumption data with only a small sacrifice in accuracy. These tools have been part of the REIS systems development project to date, and have influenced not only the design of the system but the development and project management techniques and the choice of resources. Specific considerations will be emphasized in the discussion that follows, but the reader will note that these techniques and concepts provide a common thread throughout.

Concept of an Energy Establishment

In order to define, collect, process, and display data some organization is necessary. That is, data cannot stand alone but must be connected to the real-world. Technically, data have the property of reference -- reference to some real world entity. An entity may be a person, place, or thing, or even an abstract concept such as a theory or an idea. To store data, entities referenced by that data must be identified. The concept of an energy establishment provides the identification of relevant entities in the physical energy system.

The REIS system employs this concept to identify energy data collected, stored, and reported. An energy establishment is the fundamental entity about which a set of energy data is focused. An energy establishment might be a single farm, or it might be all dairy farms in a county, or perhaps agriculture use of energy in a development region. The designers, together with potential information users, must decide what units make up a meaningful energy establishment for data collection purposes.

Data are then collected and stored relevant to that energy establishment. It is obvious that the operating costs of the REIS system are in large part a function of the choices of energy establishments. Some desired establishments may be completely infeasible (e.g., the individual farm mentioned above).

It is just as important to note the opposite aspect of this choice. If an energy establishment is agriculture in a development region and energy data are collected and stored with reference to that establishment, then a finer breakdown (e.g., dairy farms in a county) is not possible on the reporting side of the system.

The design choices of energy establishments thus determine both the costs of operation and the output capability of the REIS system.

The Cross-Classification Problem

The Corss-classification problem is a feature designers and users must face in energy information system which must serve multiple users. An example may help clarify this point.

An economist interested in the development of regions within the State may be interested in energy consumption within each such region in very broad terms (e.g., petroleum products in agriculture and electricity in manufacturing). To him, the aggregations by broad categories, in large geographical areas, over relatively long time periods (one or more years) are the most meaningful units and therefore the desired energy establishments. At the same time, however, suppose that a shortage of propane is forecast, and the Minnesota Energy Agency must predict the impact of the shortage upon corn production in each county of the State. In this case, energy establishments must be classified by type of use, by energy type, for each county. The classification satisfactory to the economist would not assist this prediction. Now multiply this simple example by the large number of firms, agencies, and individuals who must make decisions and formulate policy based upon energy information. Much of the information useful for one decision-maker will be irrelevant and even unintelligible to another.

The design tool of aggregation comes to our aid in this problem. While we cannot report data referring to units or classes smaller than an energy establishment for which data have been collected and stored, we can aggregate such data into larger units and consider them to be energy establishments for reporting purposes. All that is necessary is to insure that the energy information is gathered and stored in units small enough to be classified in any way needed by the many different policy-makers. This permits aggregation to take place within the information processing system, and makes feasible the representation of the energy system in different ways to different information users.

It is important to note at this point, that disaggregation is not impossible in certain situations, and will be part of a compromise solution. But disaggregation is essentially a judgemental process which requires much human effort. It contrasts unfavorably with aggregation which can be specified and carried out by a computer.

The cross-classification problem can never be completely solved. To do so would mean that data would have to be collected and stored in the smallest possible units (e.g., by individual households and even by different uses of different types of energy within these households). But a compromise between the need for detailed data in many competing classifications with the cost of data collection and storage can be reached.

The Five Dimensions of Energy Information

The five dimensions of energy information are energy type, geographic location, supplier, end use, and time. The compromise solution to the cross-classification problem must be worked out in terms of those dimensions.

Energy Type -- Five primary forms of energy are usually identified: petroleum, natural gas, coal, nuclear, and hydroelectric. This classification, however, is not especially useful for supporting the solution of many classes of problems. While coal, nuclear, and hydroelectric energy are basically consumed in the form of electricity, the many forms that products derived from petroleum may take and their multiplicity of uses necessitates further categorization.

Energy types may even need to be classified by relatively minor physical differences. It may be necessary, for example, to classify coal on the basis of heat, ash, and sulfur content. Similarly, it may be necessary to distinguish among the many grades and types of gasoline, heating oil, and other petroleum products.

In this phase of the project, the designers have perceived that the important issue is identifying energy types which have either markedly different sources or markedly different uses. Thus, a distinction between western coal and eastern coal is desirable because different supply constraints may operate during a crisis. Similarly, the distinction between grades of motor gasoline are relatively unimportant because of common sources and distribution. The result of this analysis implies that approximately twenty energy types will be needed in the REIS system.

Geographic Location -- Many of the decisions to be made concerning energy will consider the State as a unit. But policy-makers and planners have regionalized the State for their needs. In addition, some energy related decisions must deal with local problems. The overlap among regions established by different groups and agencies also implies that smaller units must be considered for data collection and storage, so that aggregation may take place on the reporting side of the system. An investigation of the geographic categorization relevant to energy information shows that county is the largest feasible geographic area which will meet the varied reporting requirements. The demonstration phase has shown that county units are insufficient in certain instances. The St. Cloud municipal area, for example, overlaps three counties, and data referring to St. Cloud should be separated from other areas in those counties. Therefore, this dimension will require approximately 100 categories for counties and major metropolitan areas.

Supplier -- With the exception of petroleum products, approximately 250 firms are engaged in supplying and distributing energy in Minnesota. Most of these suppliers are utilities, including municipal utilities and Rural Electric Cooperatives. Multiple energy establishments (i.e., generating facilities) are included in some of these firms, but even so, the number is not large.

In contrast, the petroleum products distribution system is large and complex. Approximately thirty firms, including three refineries, import petroleum and petroleum products to the State. Over 1,000 firms are engaged in the distribution of petroleum products, primarily distillate heating oil and motor gasoline; over 7,000 firms retail gasoline and heating oil.

The Petroleum Tax Division of the State Department of Revenue receives reports on approximately 40,000 shipments of petroleum per month, either from suppliers to distributors or from distributors to other distributors or customers. This quantity of data by no means includes all flows in the system of petroleum products distribution. Therefore, the system designers must carefully select the level of detail which best compromises between the cost of data collection and processing and the required level of detail.

In the demonstration phase, shipment data (from the Petroleum Tax Division) was used to show flows not just from supplier to counties but to cities. While the existence of secondary data at this level made its use feasible in the demonstration system, volume prohibits the collection of shipment data at the town level except for metropolitan areas. Similarly, the number of energy establishments at the retail level probably prohibits data collection at those points (except on an infrequent schedule). Even at the distributor level the volume of transactions is very high and will be costly.

End Use -- The number of establishments in the supply and distribution portion of the energy system is so large that some aggregation is needed. Of course, the number of users of energy is much greater -- every individual, home, firm, and farm in the State. This dimension, then, is one where even aggregation is not sufficient to reduce the volume of data to manageable size. The problem is further complicated when an additional categorization -- type of process using energy -- is introduced. For each consuming sector, REIS users need to know the breakdown of type of use (e.g., space heating, lighting, motor fuel, etc.).

Sampling techniques must be applied in this dimension to provide the estimates of consumption of energy for specific purposes by classes of users. For example, the consumption of distillates and gasoline as motor fuel by primary and secondary schools is a meaningful number for several levels of policy-makers and planners. Schools in a county will thus need to be defined as an energy establishment and data will have to be collected, in part by survey and/or sample, to reflect consumption quantities and uses by energy type.

Time -- In the demonstration phase, the time period selected was months, and data were stored and reported to reflect this interval. Two reasons indicate the choice of month as the primary time interval for data collection and storage in the REIS system. First, seasonal patterns of consumption are predominant for most types of energy and for many classes of users in the State; annual or quarterly data are insufficient to define seasonal patterns. Second, the reporting lag in much annual and quarterly reporting greatly reduces the value of system reports. In the event of a critical supply shortage, the reporting lag problems may necessitate an even smaller time interval such as weeks.

Compromise is possible in this area too. Some data reporting will be recurring, on a monthly basis; other data may be reported quarterly or annual.

Summary

System modularity is provided by the overall structure of the REIS system. The preceding discussion has focussed on the collection and storage of data with only incidental attention to the reporting side of the system. The reason for this approach is that the outputs of the REIS system, while limited by the level of detail collected and stored, are not constrained to those levels of detail. An energy establishment, for reporting purposes, may be the same as an energy establishment for which data have been collected and stored, or may be a combination of such establishments. Petroleum distributors might be defined to be energy establishments, and data on monthly receipts and deliveries collected and stored for each. But, a meaningful energy establishment to an information user could be petroleum shipments by county without regard to specific distributors.

The design concepts of the REIS system provide a framework for development of a complex system -- a system which will provide decision makers and planners a comprehensive "image" of the flow of energy through the complex channels of distribution to its ultimate conversion into products and services.* The concept

*A discussion of the importance of a perceived system is found in Boulding [5].

of evolvability -- to the extent that it is achieved -- will assure that the system can be changed to meet evolving needs for information in a changing environment.

V. Processing Approach I: Database Management

The design concepts and techniques presented in the preceding chapter, especially those of modularity and evolvability, call for special consideration in the selection of implementation resources. This section will discuss the need for one such resource, a Generalized Database Management System, and the selection of such a resource, SYSTEM 2000, for the demonstration system.*

The Need for Database Systems

The need for database systems was established early in the design of the REIS system. Designers recognized three critical areas of study during REIS development: (1) user knowledge and support, (2) overall system structure, and (3) data management. Overall system structure is provided by the definition of five dimensions of energy information and by the energy flow network model (see Section VI). User knowledge of the system is of course not "provided" by any single technique, but the use of a database system in the demonstration phase is one of the tools used to promote user knowledge and understanding of the system. Data management is the critical area which is most directly supported by the use of a generalized database management system.

Systems development has gone through two phases in its relatively short history.** First, the overriding concern of the new computer industry was with the design and development of machines. The application of these machines was

---

*SYSTEM 2000 features are summarized in CODASYL [8], and specified in detail in [21]. Appendix X.4 discusses the application of SYSTEM 2000 to energy data.

**For a complete discussion of the evolution of systems development, as well as the data management approach, see Everest [11].

seen as a relatively simple part of the industry, and in any case was considered to be restricted to essentially mathematical problems.

By the late 1950's, however, machines were becoming sufficiently understood, available, and economical, that the emphasis shifted from machine design to problem description (i.e., programming). The 1960's saw a great deal of emphasis placed upon the development of programming languages and operating systems, all of which had the effect of making the programmer and systems designer less dependent on the machine. During this period, hardware development of course continued, adding computing power at the rate of nearly an order of magnitude every 5 years. More important than computing power was the development of storage devices; magnetic tapes, disks, drums, etc. which, for the first time, made technically and economically feasible the storage and processing of huge quantities of data. Many systems which could in 1/10 second find and process any given record from a file containing 100 million characters of data were constructed during this period.

As such systems came into being, emphasis shifted again, from concentration on programs and the programmer, to the management of data. Thinkers in the computing field began to discuss the concept of data as a valuable resource to be managed just like men, materials, or money.* Thus, in the REIS system, we recognize that an objective of system designers is to manage energy information.

Management of energy information is, in a sense, analogous to the role of accounting in our society. Decisions concerning individuals, forms, political bodies, and the nation assume a base of facts developed in a consistent manner so that intelligent comparisons and decisions can be made. Upon this base of consistent facts, economists make historical analyses and prepare predictions

---

*Everest [11] includes an extensive bibliography concerning the evolution of the management of data concept.

of the future. In the same way, a consistent body of facts will permit planners, model builders, and policy makers to understand the role of energy and to make predictions of the future. In this sense, then, the management of energy data is necessary for intelligent decisions concerning this vital resource.

Features of the Database Approach

The use of a generalized database management system provides several specific features to the system developer:

- definition, creation, and revision
- interrogation and update
- integrity and availability

In the REIS system, these features provide support to the information users, and make it possible to meet the goals of evolvability and modularity at reasonable cost.

Definition, Creation, and Revision -- The Database Management System (DMS) allows designers to construct complex structures which accurately reflect the relations which exist among elements of data. Not only is construction of such data representations possible, but it is accomplished economically. When the designers have determined what data are relevant, and how they are interrelated, they prepare a description of each element of data and of the inter-element relationships, and enter this definition into the DMS. The system performs diagnostic routines upon the definition, and, if no errors are detected, establishes the storage structure.

Data may then be entered, with no additional step needed. Thus, instead of having to design a data structure, design programs to create the needed files, and write and test such programs, development proceeds directly from the design of a data structure to file creation. The process not only requires less time, but also greatly reduces development cost.

Most DMS permit revision of existing data definitions. This means that even though files exist and operations are being performed on them, both storing and accessing data, changes can be made easily and economically. Designers can be confident of maintaining the appropriate information system in the face of evolving requirements and a changing environment.

Interrogation and Update -- Data are processed and stored for only one reason - to support intelligent decisions. Given the ability to maintain a database, methods for retrieving facts and processing, ordering, and summarizing them into meaningful reports is necessary. The interrogation function provides such accessibility.

Similar to the interrogation requirements, new or changed data must be inserted as needed. Both the ability to retrieve stored data in a specified form, and the ability to selectively insert or change data in the database are part of the DMS facilities.

Integrity and Availability -- A significant portion of the task of managing energy data is devoted to insuring that it is correct, that it is protected from inadvertent or malicious alteration or destruction, and that it is available when and where needed. These are relatively difficult objectives to meet in conventional systems development, but are part of the resources provided by the DMS.

The DMS as a Communications Tool -- A major consideration in the development of the REIS system is the fact that the management of energy information has not been successfully accomplished. Until the 1973-74 "crisis," little emphasis was placed on the limited supply and increasing consumption of energy resources. Because we have no background in the management of energy, no established organization or procedure existed in this area until early 1974. In contrast to other governmental functions, no clear concept of the problems to be solved, the decisions required, or the policies to be formulated existed.

The development of the REIS system therefore must encompass more than the construction of an information system to meet user needs; it must anticipate future information requirements of still unspecified users.

Early in the planning stages of the REIS system, its designers recognized this situation. The construction of the Demonstration Database, which was completed in this phase, included the objective of providing a means of communication to users and potential users. The demonstration system now produces reports containing data on supply/distribution/consumption of energy in a test area of the state. These demonstration reports have been and will continue to be used to interact with established and potential users of energy information to communicate the potential of the system, to allow exploration of energy data, and most importantly, to communicate information needs back to the designers. This last will help assure that the data provided by the REIS system will support the needs of the many different decision makers involved in Minnesota's energy system.

Demonstration Database and Examples

The demonstration database was specified to include multiple elements in each of the five dimensions of energy information.

Location -- The three counties of Benton, Sherburne, and Stearns, which include the city of St. Cloud, were chosen for the demonstration phase. These central counties include agricultural and recreational areas of the state, plus the St. Cloud metropolitan area.

Energy Type -- Motor gasoline, distillate oils, and coal were selected as energy types because (1) the distribution system for petroleum products is the most complex of any of the forms of energy, and (2) little was known about the distribution of coal to non-utility users.

Supplier -- The choice of suppliers for the demonstration system was a function of the availability of secondary data. The designers decided that collection of data from suppliers would be too costly and time consuming to permit construction of the demonstration system within the time and budget allotted. Additionally, the imposition of data reporting requirements and procedures was not justified by the demonstration-only intentions of this phase.

End User -- The firm user classes selected (airports, public transportation, schools, hospitals, and utilities) were sufficient to test system feasibility and in addition represent the category of critical public services which will be important in the management of short-range energy problems.

Time -- The twelve months of 1973 were chosen because (1) a complete year of data was needed to represent the system's capabilities, and (2) recent data was desirable to represent the potential of the system to include current data.

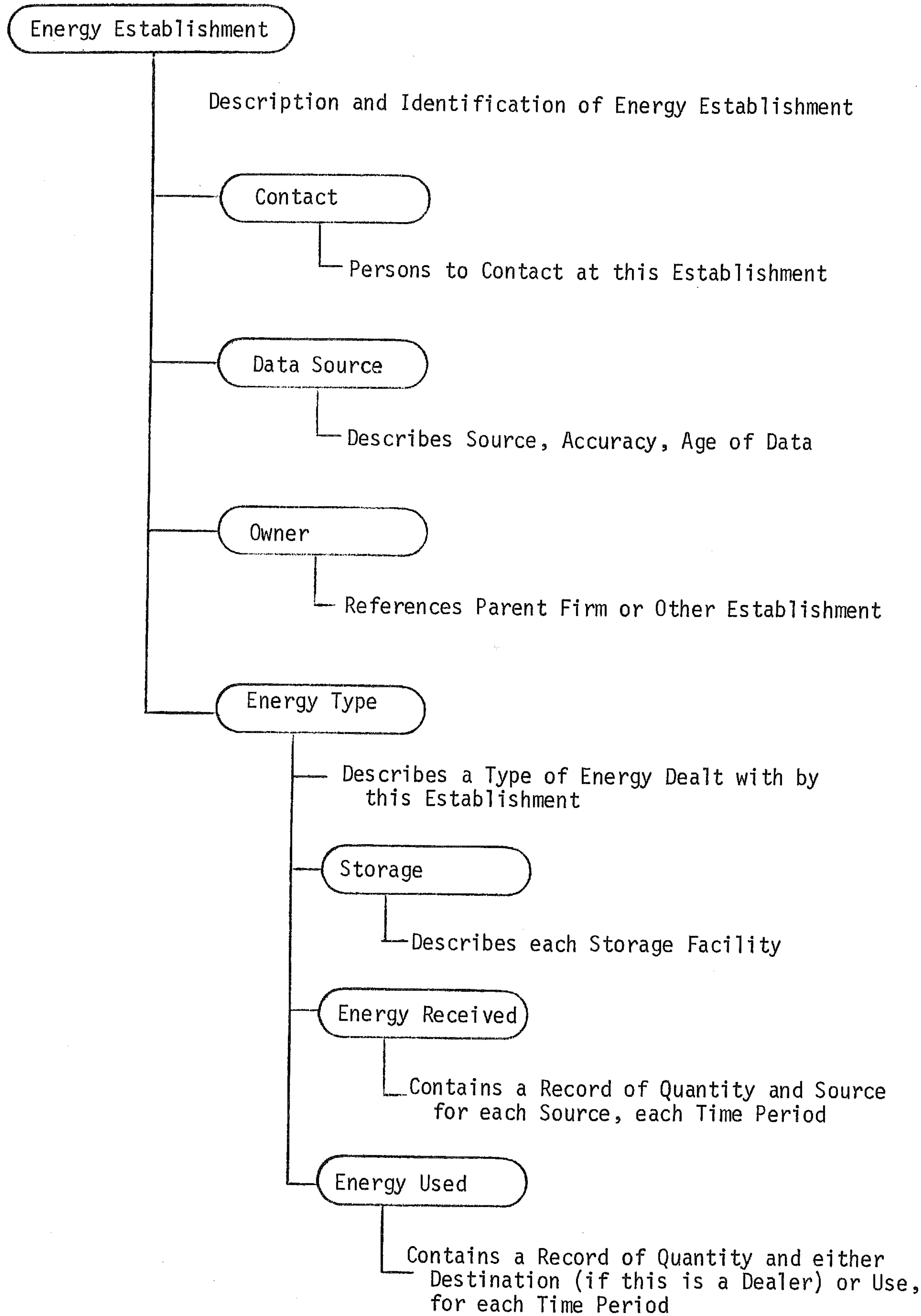
The data, collected from secondary sources, was processed and inserted into the database with the Programming Language Interface (PLI) feature of SYSTEM 2000. Because of the fragmented nature of data gathered from many sources, a relatively significant portion of the development effort went toward recoding and processing data into the demonstration database.

Database structure for the demonstration system employs the energy establishment concept. Within the database entry for each energy establishment, data is structured in the form of a tree (see Appendix X.5). Figure V.1 shows the structure of the entry for each energy establishment. In Figure V.1, each block represents an entry in the database which may include an entire tree beneath it. For example, an energy establishment entry will usually contain several energy type entries; each energy type entry may contain multiple entries for storage facilities, energy receipts, and energy used.

Examples -- Outputs of the demonstration system may take many forms.

FIGURE V.1

DEMONSTRATION DATABASE SCHEMA OUTLINE



Previous discussions have emphasized the lack of restrictions upon output capabilities under the database approach. The following examples represent some of the reports which can be produced from the demonstration system. These samples do not represent the output of the reporting subsystem of REIS, but only sample the reports which may be produced in the on-line interaction mode.

```
************************
 ELEMENT-      ENERGY TYPE NAME
************************
FREQUENCY    VALUE
------------------------
        7       AVIATION GASOLINE
        7       COAL
        4       DIESEL FUEL OIL - TOTAL
      120       DISTILLATE HEATING OIL
       22       DISTILLATE HEATING OIL NO. 2
        1       DISTILLATE HEATING OIL NO. 4
        1       JET FUEL - TOTAL
        1       LIQUIFIED PETROLEUM GAS
      120       MOTOR GASOLINE
        6       MOTOR GASOLINE - TOTAL
        1       PETROLEUM COKE
        2       PROPANE - TOTAL
       29       REFINED PETROLEUM PRODUCTS-TOTAL
        1       RESIDUAL FUEL OIL NO. 5
        1       RESIDUAL FUEL OIL NO. 6
------------------------
       15   UNIQUE VALUES
------------------------
      323   OCCURRENCES
------------------------
```

FIGURE V.2

A list of the energy types included in the demonstration database (DEMODB), this report shows the number of energy entries included, for each different type.

ELEMENT-	COUNTY NAME
FREQUENCY	VALUE
20	ANOKA
9	BENTON
1	BLUE EARTH
2	CARLTON
1	CLAY
2	CLEARWATER
3	DAKOTA
1	DOUGLAS
1	FILLMORE
2	HENNEPIN
4	ISANTI
5	KANDIYOHI
1	LYON
3	MEEKER
11	MILLE LACS
12	MORRISON
1	OLMSTED
6	POPE
8	RAMSEY
1	SCOTT
10	SHERBURNE
1	ST LOUIS
54	STEARNS
11	TODD
2	WASHINGTON
2	WINONA
15	WRIGHT
27	UNIQUE VALUES
189	OCCURRENCES

FIGURE V.3

A "TALLY" of the number of establishments in DEMODB in each county. Note that many counties in addition to the demonstration counties of Benton, Sherburne, and Stearns are included. This illustrates the complexity of the distribution system for petroleum products, since each such entry ships into the three county area.

DEMONSTRATION DATABASE - ESTABLISHMENT LIST PAGE 2
74/12/18.

ESTABLISHMENT NAME	TYPE	MEA ID	COUNTY	TOWN
**				
COLD SPRING SCHOOL DIST	USER	400013	STEARNS	COLD SPRING
KIESS BROS INC	DEALER	105529	STEARNS	COLD SPRING
ELK RIVER MUNICIPAL UTILITY	USER	400027	SHERBURNE	ELK RIVER
ELK RIVER SCHOOL DIST	USER	400007	SHERBURNE	ELK RIVER
SHERBURNE CO FARMERS SERVICE ASN	DEALER	105122	SHERBURNE	ELK RIVER
UNITED POWER ASSOCIATION	USER	400033	SHERBURNE	ELK RIVER
BENTON COUNTY COOP ASSN	DEALER	107890	BENTON	FOLEY
FOLEY SCHOOL DIST	USER	400004	BENTON	FOLEY
OROURKE BUS SERVICE	USER	400034	BENTON	FOLEY
HILTNER + CO	DEALER	106493	STEARNS	FREEPORT
HOLDINGFORD SCHOOL DIST	USER	400008	STEARNS	HOLDINGFORD
KIMBALL MUNICIPAL AIRPORT	USER	400024	STEARNS	KIMBALL
KIMBALL SCHOOL DIST	USER	400003	STEARNS	KIMBALL
LAND O LAKES OIL CO	DEALER	102600	STEARNS	KIMBALL
MELROSE HOSPITAL	USER	400023	STEARNS	MELROSE
MELROSE MUNICIPAL POWER AND LIGHT	USER	400030	STEARNS	MELROSE
MELROSE SCHOOL DIST	USER	400016	STEARNS	MELROSE
FLYNN AIRPORT	USER	400026	SHERBURNE	MONTICELLO
NEW MUNICH OIL CO	DEALER	106687	STEARNS	NEW MUNICH
PAYNESVILLE COMMUNITY HOSPITAL	USER	400029	STEARNS	PAYNESVILLE

FIGURE V.4

The establishment list, which is sequenced alphabetically, shows the name and location of some of the energy establishments in the demonstration area.

DEMONSTRATION DATABASE - STORAGE REPORT
74/12/18.

ESTABLISHMENT NAME	CITY	TOT STOR	STORAGE	U M	E TYPE
•#					
ALBANY COMMUNITY HOS PITAL	ALBANY	4000	4000	GAL	6322
ALBANY SCHOOL DIST	ALBANY	32000	32000	GAL	6322
		5500	5500	GAL	23003
AMERICAN OIL-SAUK CE NTRE	SAUK CENTRE	4830000	4830000	GAL LON S	2000
AVON OIL CO	AVON	21000	16000	GAL	3000
			5000	GAL	
		45000	16000	GAL	6000
			13000	GAL	
			16000	GAL	
BECKER SCHOOL DIST	BECKER	12000	12000	GAL	6322
BELGRADE COOP ASSN	BELGRADE	52000	10000	GAL	3000
			10000	GAL	
			20000	GAL	
			12000	GAL	
		44000	12000	GAL	6000
			12000	GAL	
			20000	GAL	
BELGRADE SCHOOL DIST	BELGRADE	22000	2000	GAL	6322
			12000	GAL	
			8000	GAL	
BENTON COUNTY COOP A SSN	FOLEY	23100	4000	GAL	3000
			19100	GAL	
		28800	16000	GAL	6000
			8800	GAL	
			4000	GAL	

FIGURE V.5

This report shows, in alphabetical sequence, storage capacity of various energy establishments in the demonstration area. Energy type is represented by a standard code (due to printing limitations on the on-line device, energy type name is of course available for printing).

One column shows the total storage volume for each energy type, the other shows the capacity of each storage unit where that data was available.

DEMONSTRATION DATABASE - FLOW REPORT
74/12/18.

** ESTABLISHMENT NAME	ENERGY TYPE	TOT FLOW	MO	MON FLOW
DOWNTOWN 66 SERVICE	DISTILLATE HEATING OIL	1685222	01	88407
			02	104621
			03	47501
			04	116955
			05	415394
			06	28896
			07	332531
			08	
			09	139417
			10	95602
			11	129483
			12	186415
	MOTOR GASOLINE	2551939	01	171706
			02	167235
			03	240980
			04	166776
			05	8200
			06	92800
			07	26601
			08	168280
			09	284219
			10	300518
			11	269954
			12	654670
EAST SIDE OIL CO	DISTILLATE HEATING OIL	2224178	01	180991
			02	205498
			03	117496
			04	78356
			05	154605
			06	70911

FIGURE V.6

This report shows the total volume of each type of energy shipped to an energy establishment, by month.

```
---
? LIST/REPEAT SUPPRESS,TITLE D(22) COAL USERS AND THEIR SUPPLIERS,
---
? F(5Ø)  END-OF-PAGE,L(21)USER NAME,L(2)MONTH,L(5)QUANTITY,
---
? L(25)SUPPLIER NAME/C1,C3Ø51,C312,C3Ø6 WH C322 EQ 1 AND C3Ø6 EXISTS:
```

```
                          COAL USERS AND THEIR SUPPLIERS                        1
                                    75/Ø1/Ø9.

    USER NAME                      MONTH    QUANTITY    SUPPLIER NAME

***
    SARTELL SCHOOL DIST             1Ø            3     TROPEC ENTERPRISES

                                    11            6     TROPEC ENTERPRISES

                                    12            8     TROPEC ENTERPRISES

    ELK RIVER SCHOOL DIST           Ø1           61     GREAT LAKES COAL AND DOCK

                                    Ø2           45     GREAT LAKES COAL AND DOCK

                                    Ø5           22     GREAT LAKES COAL AND DOCK
```

FIGURE V.7

This example shows quantities of coal (in tons) received by coal users, and the supplying establishment name. At the top of Figure V.7 is the complete report specification, including sequencing parameters. Such a report can be compared and processed on-line, with no advance preparation by an information analyst -- or by a user who has knowledge of the request language and the database contents.

The reports shown in examples V.2 through V.7 are relatively simple reports. They represent the sort of data available in DEMODB but of course do not exhaust it. It is reasonable to state that the reporting capability of the REIS system is limited by three factors:

- the basic dimensions chosen for energy information
- the accuracy and effectiveness of data collection
- the imagination, skill, and understanding of information users

These factors can be managed to meet the needs of policy formulations and decision making.

VI. Processing Approach II: The Energy Flow Network Model

The energy flow network model (see Section III) is both the conceptual and processing heart of the REIS system. This section describes the network model and discusses the relationships between it and the other subsystems in REIS.

The physical system that comprises the supply into, distribution throughout, and ultimate consumption of energy in Minnesota can be viewed as a series of shipments and receipts. By various forms of transportation, (e.g., trucks, rail tank cars, natural gas pipelines, and electric transmission lines) energy flows from suppliers to ultimate consumers. One convenient method for modeling this shipment/receipt system is through the use of a matrix formulation. This mathematical formulation is the energy flow network model.

In many respects the energy/flow network model presented in this section is analogous to the standard sales and purchases format of economic input/-output models. James Just et al., in a report for the National Science Foundation [14] presented a general formulation for a National Energy Accounting System that was based upon this analogy. The REIS energy flow network model is a further specification of a portion of Just's work on the energy flow accounts [14; pp. 51-102].

Basic Components of the Model

For purposes of organization the components of the Minnesota energy system can be divided into:

(1) Suppliers - These are organizational units located outside the State borders that supply energy (of any type) into Minnesota. Using this definition, a refinery must be located outside Minnesota to be classified as a supplier.

(2) Distributors - These are organizational units that receive energy from:

- suppliers
- other distributors

for the purpose of resale. In their role as distributors, energy is not purchased for the purpose of final consumption. In other words, the energy purchased is not entered into a process which transforms it into a non-reusable--as energy --form.

(3) End-Users - These are organizational units (or sets of units) that receive energy for final consumption. There will be an end user class for energy shipped out of Minnesota.

The definition of the components of the energy system has several implications that must be recognized.

(1) The electric utilities will be classified as end users of energy. They consume some energy forms (e.g., coal or natural gas) to produce electricity. In addition, they consume electricity in the operation of their facilities.

(2) The electric utilities located in Minnesota will also be classified as distributors. Only the electric utilities located outside Minnesota that transmit electricity into the State will be classified as suppliers.

(3) All distributors will also be classified as end users (or perhaps part of an aggregated end user class) to accomodate the energy that they consume in the operation of their facilities.

Mathematical Representation of the Model

Let X_{ijk}^{t} represent a flow of energy where the indices are defined as:

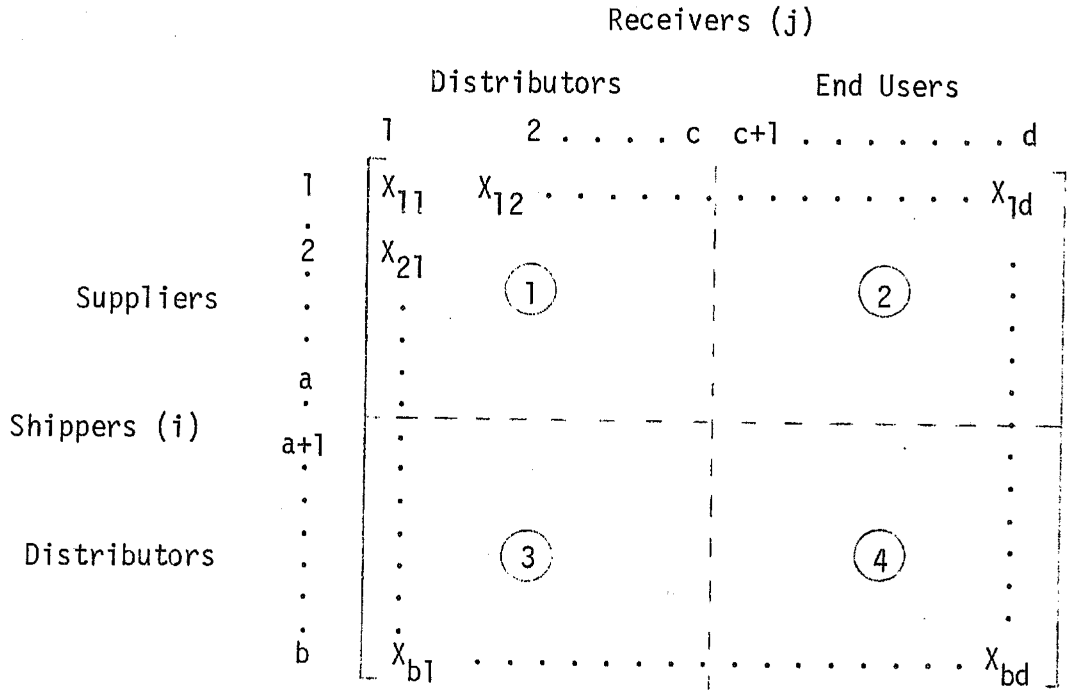
t = time period in which flow occured

i = classification of the shipper of the energy

j = classification of the receiver of the energy

k = type of energy

Using these definitions, we can define the following matrix for flows of energy type k in period t.



where

a = number of suppliers of energy type k into Minnesota

b-a = number of distributors of energy type k in Minnesota

c = number of distributors of energy type k in Minnesota (c = b-a)

d-c = number of end users of energy type k in Minnesota

In the above matrix

Section (1) - contains shipments by suppliers to distributors

Section (2) - contains shipments by suppliers to end users

Section (3) - contains shipments by distributors to other distributors

Section (4) - contains shipments by distributors to end users

In attempting to visualize the meaning of this matrix representation, it is useful to consider an ordering pattern for the rows of shippers and columns of receivers. A tentative* ordering might be as follows:

(1) Since the suppliers are all located outside of Minnesota, they will be ordered alphabetically.

(2) The distributors listed as shippers are identical to those listed as receivers. These energy establishments will be ordered by:

- corporate ownership within
- county within
- economic development region

(3) The end users will be ordered by:

- SIC classification within
- county within
- economic development region

This ordering groups the geographical locations within the State. Within geographical regions it groups common ownership (distributors) and common end users (receivers).

Computations With the Model

The matrix representation of the energy flow network model provides an efficient method for calculating aggregate supplies and uses of energy. In general, suppliers are developed from row totals. Similarly, uses are developed from column totals within the user sector of the matrix.

If, for example, we are interested in determining the amount of gasoline supplied to Minnesota in a specific month by a specific prime

---

*The actual ordering will be determined in the general system specifications developed in Phase II of the REIS project. It will depend upon decisions concerning the level of detail to be included in the supplier and end-user subsystems.

supplier, this would be calculated as*

$$X^t_{i\cdot} = \sum_j X^t_{ij} \qquad \text{(VI.1)}$$

where

i = index value of the supplier under analysis

The total amount of gasoline supplied to Minnesota from all prime suppliers in a specific month would be

$$X^t_{\cdot\cdot} = \sum_{i=1}^{a} X^t_{i\cdot} \qquad \text{(VI.2)}$$

Finally, the total gasoline supplied to Minnesota for a year would be

$$X^{\cdot}_{\cdot\cdot} = \sum_t X^t_{\cdot\cdot} \qquad \text{(VI.3)}$$

In analogous fashion the receipts of energy by an end user class can be determined. If, for example, we are interested in determining the amount of natural gas received by the agriculture sector in a specific month, it could be calculated in two steps.

First, for each county, we calculate

$$X^t_{\cdot j} = \sum_i X^t_{ij} \qquad \text{(VI.4)}$$

where

j = index value for agricultural end use in each county

Then, the results for each county would be summed.

Appendix X.4 contains further examples of the computational use of the energy flow network model. These must be viewed, however, as examples. The actual computations made using the energy flow network model will be determined by the reports that are required by the users of the REIS system.

---

*The dot (·) in place of the subscript indicates summation over that subscript.

Relationship to Other REIS Subsystems

The energy flow network model is the focal point for the REIS system. At a conceptual level it provides a means of organizing the components of the Minnesota energy system. At the processing level, it provides the means of aggregating and summarizing the data concerning energy flows. Both of these perceptions were presented in the first part of this section.

The energy flow network model, however, does not have any substance without the other subsystems that comprise REIS. As Figure VI.1 shows, the data from the physical components of the Minnesota energy system are collected by the supplier, user, and parameter subsystems. The parameter subsystem maintains the lists of suppliers, distributors, and end users. These lists are the means of specifying the number and names of the rows and columns in the energy flow network model. The supplier and user subsystems collect the data on energy flows. These data are the entries in the body of the matrix model. The energy flow network model only operates upon the data supplied from the other subsystems.

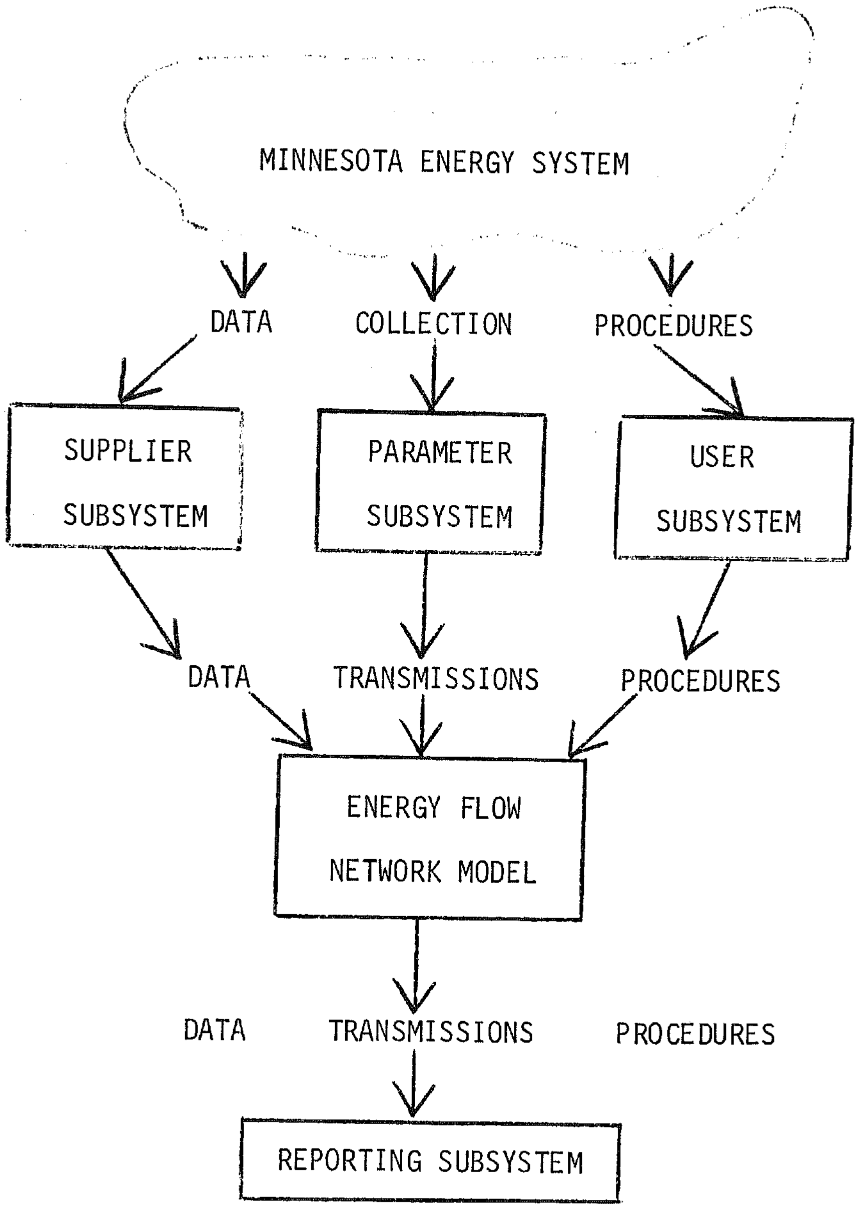
On the output side of the energy flow network model stands the reporting subsystem. The various aggregations and summaries of energy flows must be put into a format that meets the needs of the users of the REIS system. The reporting subsystem provides this interface. It will produce reports that have been specified. It is also the subsystem that will allow for new reports to be requested from the energy flow network model.

The above discussion may leave a wrong impression with the reader. The energy flow network model will do (most of) the summary computations on the energy flow data. This does not mean, however, that the primary databases (i.e., supplier, user, and parameter) cannot be accessed directly. If a user of REIS wants

- a specific list of energy establishments

FIGURE VI.1

THE RELATIONSHIPS OF THE ENERGY FLOW NETWORK MODEL TO OTHER REIS SUBSYSTEMS



- descriptive data on an energy establishment
- small amount of flow data that do involve extensive aggregation

answers to these questions can be obtained effectively from the original databases using the database management language. The processing cost, however, of obtaining large amounts of summarized and unsummarized flow data from the original database is large. Efficient computing algorithms for operating upon matrices exist.* Thus, much of the information for the regular reports will be produced by the energy flow network model.

---

*A discussion of processing methods for matrices is found in [16].

VII. Analytical Models: Their Relationship To The REIS System

As was described in Section II, analytical models represent an interface between the data and the policy issues that are being analyzed. They represent a structured way of organizing, summarizing, and manipulating the data in order to present to policy-makers:

- an identification of meaningful facts, patterns, or trends in the data
- projections of future energy situations
- the "What If" implications of potential energy strategies or plans

Thus, a subset* of the data needs of the policy makers represents the data needs of the analytical models.

While the list of potentially useful models for energy policy-making is long** several key types of models can be identified. These are:

- models for predicting energy supply and demand
- models for describing the interacting competition for and substitutibility among energy resources for the various consuming sectors and processes in the Minnesota economy
- models for analyzing the economic impact of energy utilization by the various consuming sectors in the Minnesota economy
- models for analyzing economic and environmental trade-offs between different types of energy uses

---

*This references the fact that not all of the policy needs may (or can or need to be) be met through the use of formal models. An example would be the data needs necessary to allocate energy supplies to relieve temporary energy shortfalls.

**Several of these models are currently being developed by the Minnesota Energy Agency. Two of these models -- a model of estimating energy requirements and an input-output/linear programming based simulation model -- are described in [12] and [18].

- models for predicting the energy conservation potential of various engineering design changes in the consuming sectors of the Minnesota economy

The information system for the Minnesota Energy Agency must be capable of supporting these types of models.

Most of the models under (or planned for) development focus on the consumption side of the energy system. The current objectives of the REIS system focus upon the information system necessary to collect, maintain, and report data on energy flows in the supply/distribution/consumption system within Minnesota. Thus, the REIS system -- operationalized through the use of the energy establishment concept, the related database management language, and the energy flow network model -- provides two kinds of support for analytical models:

(1) The system will collect and store data on consumption by user class and geographic location over time. Thus, those portions of the models requiring data on energy use will be supported in both data collection and data access.

(2) Other data on energy establishments can be stored within the REIS system. Economic or demographic data pertaining to electric utilities, classes of users, etc. can be stored within the database. The collection of these data will not be part of the initial REIS system. One important exception to this will be the demographic data on numbers and locations of energy establishments throughout the State. In order to collect supply/distribution/consumption data, it is necessary to have lists of energy establishments. Thus, these data will be collected in the initial REIS system.

Once the implementation of the initial REIS system is underway, then it will be possible (and desirable) to work with both the policy-makers and modelers to develop better ways of collecting the other types of data. Even without this, however, the REIS system provides an efficient method for storing and accessing these other data.

VIII. Future Directions

The conclusions of the research conducted in this phase of the REIS project are quite clear. They are:

(1) There is a definite need for an energy information to support energy policy-makers in Minnesota

(2) The most crucial area for the implementation of an energy information system is the collection, maintenance, and reporting of data on the energy supply/distribution/consumption aspects of Minnesota's energy system

(3) The energy establishment concept, using a generalized database management language and linked to an energy flow network model, is a feasible method to organize an energy information system that will meet a substantial portion of the needs of Minnesota policy-makers

(4) The energy information conceptualized in this project will partially meet the data/information system needs of modelers at work on Minnesota energy problems

There is, however, much work remaining to be done. The results of this project have examined the need for and the technical feasibility of an energy information system. This work has not produced:

(1) the general systems specifications required to translate the conceptual ideas into a series of:

- data collection procedures
- computer processing programs
- user reports

(2) the cost estimates required to determine the economic feasibility of the REIS system.

(3) the plan required to implement the general systems specifications

(4) the user documentation and educational materials required to make the REIS system a viable component of Minnesota's energy management system

Appendix X.5 presents the detailed proposal for Phase II of the REIS project. This phase will take the conceptual ideas developed in this project and turn them into a set of general systems specifications that can be transferred (with only moderate ongoing monitoring) to the data processing operation that will actually program, implement, maintain, and operate the REIS system. In addition, Phase II will develop an implementation plan, a cost analysis and the design of the system documentation.

IX. Bibliography

1. Abrahamson, Dean A., "Minnesota: A Primer on Energy Options and Implicating," A preliminary draft report of the Minnesota Energy Project - MEP-74-5, University of Minnesota, Minneapolis, Minnesota, (March, 1974).

2. Ackoff, R. L., "Management Misinformation Systems," Management Science, Vol. 14 (December, 1967), pp. B147-B156.

3. Adams, Carl R., "How Management Users View Information Systems," Graduate School of Business Administration Working Paper No. 14, University of Minnesota, Minneapolis, Minnesota, (August, 1973).

4. Adams, Carl R. and Roger G. Schroeder, "Managers and MIS: They Get What They Want," Business Horizons, Vol. 21 (December, 1973), pp. 63-68.

5. Boulding, Kenneth E., The Image: Knowledge in Life and Society, Ann Arbor, Michigan: University of Michigan Press, (1956).

6. "Business Takes a Second Look at Computers," Business Week, (June 5, 1971), pp. 59-136.

7. Chervany, Norman L., "Management Information Systems: Design Questions From the User's Perspective," Proceedings of the Third Annual Meeting of the Midwest Region of the American Institute of Decision Sciences, University of Cincinnati, Cincinnati, Ohio, (April, 1972).

8. CODASYL Systems Committee, Feature Analysis of Generalized Data Base Management Systems, New York: Association for Computing Machinery, (May, 1971).

9. Davis, Gordon B., Computer Data Processing, New York: McGraw-Hill Book Company, Inc., (1969).

10. _______, Management Information Systems: Conceptual Foundations, Structure, and Development, New York: McGraw-Hill Book Company, Inc., (1974).

11. Everest, Gordon C., "Database Management: Objectives, Organization, and System Functions," a Ph.D. dissertation, University of Pennsylvania, Philadelphia, Pennsylvania, (1974).

12. "Forecasting of Energy Requirements in Minnesota," a presentation for Commission for Minnesota's Future, Minnesota Energy Agency, St. Paul, Minnesota, (December, 1974).

13. Hoyt, John S., Jr., "Minnesota Economic Regions: Their Delineation, Description, and Development Potential," A report of the State Planning Advisory Committee, Minnesota State Planning Agency, St. Paul, Minnesota, (December, 1966).

14. Just, J., B. L. Borko, and J. Morris, "National Energy Flow Accounts," a report prepared for the National Science Foundation, Washington, D.C., (June, 1974).

15. Knobloch, Peter C., "Master Plan for REIS Implementation," a report to the Minnesota Energy Agency, St. Paul, Minnesota, (August, 1974).

16. Knuth, Donald E., The Art of Computer Programming, Volume 1: Fundamental Algorithms, Reading, Massachusetts: Addison-Wesley, (1968).

17. Maki, Wilbur R. and Peter C. Knobloch, "Regional Impacts of Alternative Energy Allocation Strategies," Staff Paper Series, P74-8, Department of Agriculture and Applied Economics, University of Minnesota, St. Paul, Minnesota, (May, 1974).

18. Maki, Wilbur R. and Ernesto C. Venegas, "Regional Energy Impact System Program: A Progress Report," a presentation for the Upper Great Lakes Regional Commission, Minnesota Energy Agency, St. Paul, Minnesota, (December, 1974).

19. "Minnesota Energy Supply and Use - 1972," Minnesota Energy Agency, St. Paul, Minnesota, (November, 1974).

20. "More Data, Not More Computer," Technology Review, (October-November, 1974), p. 94.

21. MRI Systems Corporation, System 2000 Reference Manual: Revision A, Austin, Texas, (July, 1973).

22. Munro, Malcolm C., "A Comparison of the Decision Analysis and Data Analysis Methods for Determining Management's Information Needs," a Ph.D. dissertation, College of Business Administration, University of Minnesota, Minneapolis, Minnesota, (October, 1974).

23. Nauman, J. D., P. C. Knobloch, and N. L. Chervany, "Design Considerations For a Comprehensive Regional Energy Information System," Regional Energy Information System and Economic Impact Analysis Project, Working Paper REIS-WP-74-01, Management Information Systems Research Center, University of Minnesota, Minneapolis, Minnesota, (July, 1974).

24. "New England Energy Management Information System-NEEMIS," a presentation to the Federal State Energy Data Workshop Task Force, Federal Energy Administration, Washington, D.C., (July, 1974).

25. Powers, R. F. and G. W. Dickson, "MIS Project Management: Myths, Opinions, and Reality," California Management Review, (Spring, 1973), pp. 147-156.

26. Schartz, M. H., "MIS Planning," Datamation, (September 1, 1970), pp. 28-31.

27. "Unlocking the Computer's Profit Potential," A Research Report to Management, McKinsey and Company, New York, (1968).

28. "What is a Management Information System?" Research Report Number One, The Society for Management Information Systems, Chicago, Illinois, (June, 1970).

APPENDIX X.1

Minnesota Energy Agency

User Data Needs Interviews

1. John McKay, Director

2. Philip Getts, Deputy Director

3. James Carter, Director of Research
   Ernesto Venegas, Research Analyst
   Dan Quillin, Research Analyst
   Rudy Brynolfson, Research Analyst

4. John Peterson, Director of Conservation and Planning
   Jay Lujan, Planning Analyst
   Weston Fisher, Planning Analyst

5. Dixie Diehl, Fuel Allocation Coordinator

SUMMARY OF

DATA NEEDS INTERVIEW

Interviewee: John McKay
Director
Minnesota Energy Agency

Interviewer: Norman L. Chervany
Principal Investigator
Regional Energy Information System and Economic Impact Analysis Project

Date: November 15, 1974; Re-interview December 23, 1974

I. Policy Issues and Activities to be Supported

The Minnesota Energy Agency has the responsibility to develop an understanding of the energy uses in the State. This understanding is necessary to be able to help to define policies with respect to

(1) reduction of energy resources made available to illogical and/or wasteful energy consuming processes.

(2) identification of the point of diminishing returns of energy application in various energy consuming processes and reduction of energy resources made available beyond these points.

(3) identification of areas of the State where dependence on a specific energy type (or source) is critical and exploration of methods of alleviating (or moderating) this dependence.

In all of these policy areas, the objective is to achieve the required change with the minimal impact on the life style and environment of the people of the state.

II. Data Needs

In order to operationalize policies in the above areas, the data requirements are

(1) Determination of where the energy goes and how it is used

This type of data focuses upon the energy consuming patterns of different sectors in the State. These data may take the form of

- data on energy uses (by usage process) of specific organizations

- data on energy uses (by usage process) of classes of end-users (e.g., how much energy is required by the agricultural sector to produce 100 bushels of corn per acre)

(2) <u>Determination of the economic importance of energy consuming sectors</u>

Economic data (e.g., contribution to State GNP and people employed) is needed to relate energy resource input requirements to the importance of the energy consuming sector to the economy of the State and the welfare of the residents of the State

These data will enable the MEA to determine what industries and occupations in Minnesota consume the most energy. As such they will allow intelligent comparisons among different users of energy when energy trade-off/ allocation decisions are faced.

A question always arises concerning the amount of detailed data that should be collected. The key principle in selecting the required detail must be value of the data for policy making purposes. We must avoid the unnecessary costs of collecting data for its own sake. In the geographic dimension, for example, a decision must be made between data by county and data by economic development region. For planning purposes, data by economic development region should be sufficient; county boundaries are really not relevant.

SUMMARY OF

DATA NEEDS INTERVIEW

Interviewee: Philip Getts
Deputy Director
Minnesota Energy Agency

Interviewer: Norman L. Chervany
Principal Investigator
Regional Energy Information System and
Energy Impact Analysis Project

Date: November 6, 1974; Re-interview November 21, 1974

I. Policy Issues and Activities to be Supported

The most basic responsibility of the Minnesota Energy Agency is to collect and compile reliable energy information for both public and private decision-makers. Within the Minnesota Energy Agency, the primary uses for energy related information are

(1) Medium to Long Range Energy Planning

For the growth of existing businesses and the introduction of new business into the state, the MEA must be able to supply information on the projected energy supplies that will be available.

For the existing energy users in the State (individual, corporate, and public), the MEA must be able to determine the impact of energy shortages and energy conservation programs.

(2) Certificate of Need Program

For new utility projects the MEA must be able to supply information on projected energy supplies to the utility and projected end-use energy demands.

(3) Environmental Impact Program

For environmental impact programs, the MEA must be able to supply information on the energy requirements demanded by the proposed project.

II. Data Needs

The basic data needs can be defined in terms of four questions that the information system must be able to answer for each energy type:

(1) How much energy is coming into the state?

(2) How much energy is stored within the state?

(3) How much energy storage capacity exists in the state?

(4) How much energy is consumed in the state?

The essence of the answers to these questions will allow the MEA to monitor, in a dynamic fashion, where the state is vis-a-vis energy supply and demand.

There are several dimensions necessary for defining the relevant detail for energy related data.

(1) Geographic Detail

The data must be broken down by the thirteen economic development regions within the state. Aggregates for the entire state will not provide useful information because the energy characteristics (supply and consumption patterns) vary significantly among these economic development regions.

(2) End-use Detail

In order to measure the impact of conservation programs end-use information by five major categories:

- residential
  - single family
  - multiple family
- industrial/commercial
  - manufacturing
  - mining
  - service
- transportation
- agriculture
  - crops
  - livestock

- government

is a useful starting point. Beyond this detail, it will be necessary to measure impact by type of user (e.g., SIC classification) and process for which energy is used.

(3) Time Detail

The flow of energy into and through the state should be maintained on an annual or semi-annual basis. While monthly information may be interesting, it will probably be too expensive. The "crisis" allocation problem may, however, be an exception that requires monthly data.

(4) Distribution Detail

There is no need to know "who supplies energy to whom." Supplies to and consumption by end-use category will be adequate information.

SUMMARY OF

DATA NEEDS INTERVIEW

Interviewee: James Carter and Staff
Director of Research
Minnesota Energy Agency

Interviewer: Norman L. Chervany
Principal Investigator
Regional Energy Information System and
Economic Impact Analysis Project

Data: November 8, 1974; Re-interview November 14, 1974

I. Policy Issues and Activities to be Supported

The major activities of the Research Division of the Minnesota Energy Agency are

(1) To prepare energy budgets showing historical supply and consumption by sectors within the state

(2) To prepare forecasts of energy supply and demand for the state as a whole and subregions within the state

(3) To develop analytical models to aid in the analysis of allocation, conservation, and economic planning for the state as a whole and subregions within the state. Some of the specific models required are

- supply prediction
- demand prediction
- analysis of supply/demand interaction and projected shortfall
- impact analysis (e.g., economic consequences) and trade-off (e.g., environmental impact)

II. Data Needs

The Research Division has two categories of data requirements. In a short-run, historical sense, it must collect statistics on actual energy supply and consumption. The major requirements, however, are to collect data necessary for medium and long range evaluation of alternative energy policies. In broad terms this long range focus requires data about

(1) Energy Supplies

- Who supplies energy to the state?
- What are the projections of supply over a five, ten, and twenty year forecast horizon?

- In a critical shortage situation, what are the supply projections for a three month (or shorter) time frame?

(2) Energy Demand

- Who consumes energy?
- How much energy is consumed?
- What amounts of energy are used by energy consumption process?
- What are the technical (i.e., engineering) characteristics of the energy consuming processes?

There are several dimensions that are necessary for defining the relevant detail for energy-related data.

(1) Geographic Detail

The forecasts of energy supply and deamnd mandated by the legislature require a presentation by geographic region. County delineation would by preferable. In some instances, data by towns may be required.

(2) End-use Detail

The basic end-use sectors for data collection are

- transportation (broken by type of transportation system)
- household
- industrial (broken down into manufacturing, mining, and construction)
- commercial (trade, services, public, non-profit)
- agricultural (does not include food processing)
- utilities
- petroleum refining

A detailed end-use breakdown is given in the attachment to this summary. The end-use classes must be consistent with the SIC classification scheme. Within these end-use categories it is important to define the process use of the energy. Of particular interest is the breakdown by space heating, cooking, and lighting versus manufacturing process within the industrial sector. This breakdown is critical because conservation programs can be directed at the heating, cooking, and lighting uses; the manufacturing process use if technically constrained and less amenable to policy action.

(3) Time Detail

Once the base year data are collected (this issue is discussed below) quarterly data should be sufficient. In some cases annual data could be used.

(4) Distribution Detail

It is not necessary to know, in detail, who supplies whom within the energy distribution network. The initial entry into the state by major supplier and the ultimate end-use by major category and process are the only data required.

One important exception to the above is the need to know the service area of the individual suppliers. This will allow prediction of what geographic areas will be affected by changes in the situation of an individual supplier.

(5) Start-up versus Ongoing Detail

With respect to the end-use information there is a problem of start-up. Initially, it is necessary to have detailed process use data. For example, it is necessary to know the relative portions of electricity used for manufacturing processes as compared to lighting. Once these fractions are known, quarterly total energy flows into a consuming sector are adequate. Aperiodically, these usage fractions may have to be updated.

(6) Energy Flow versus Demographic Data

Much of the analytic effort will be dovoted toward determining energy flows per unit of output (e.g., BTU's per dollar of regional GNP). Thus, time series data must be collected. Similarly, data on the types of consuming processes in industrial, agricultural, and utilities and their energy efficiencies must be collected.

Attachment

1. Residential Fuel Use

    - Space heating and cooling
        - Space heating
        - Space cooling
    - Water heating
    - Cooking
    - Food preservation
        - Refrigerators
        - Freezers
    - Lighting
    - Laundry
        - Clothes washers
        - Clothes dryers
    - Entertainment
        - Television
        - Phonograph
        - Radio
    - Dishwashers
    - Other residential

2. Commercial Fuel Use

    - Space heating & cooling
        - Space heating
        - Space cooling
    - Water heating
    - Cooking

Food preservation

- Refrigerators
- Freezers

Lighting

Laundry

- Clothes washers
- Clothes dryers

Entertainment

Dishwashers

Other commercial

3. Industrial Fuel Use and Losses

Space heating and cooling

- Space heating
- Space cooling

Lighting

Processing (non-energy conversion)

- Boiler fuel
- Heat, NEC
- Power for machinery
- Electrolytic
- Other

Processing (energy conversion)

- Gas plant processing
- Petroleum refining
- Coal gasification
- Electricity generation
- Uranium processing
- Other

Other industrial

4. Transportation Fuel Use

   Highway vehicles

      Personal passenger

      Bus

      Truck

      Air

      Rail

      Pipeline equipment (stationary)

      Water

      Other transportation

5. Agriculture energy use

      Land preparation

      Planting

      Cultivation

      Harvesting

      On-farm processing after harvest

      Other agriculture

6. Non-fuel Use of energy Sources

      Petrochemical feedstock

      Other petrochemical

      Non-petrochemical manufacturing

      Construction

      Solvent, NEC

      Other non-fuel uses

7. Miscellaneous Uses and Losses

   Storage and inventory

   Transmission & distribution

   Unspecified uses

   Other losses, NEC

   Export

9. All uses

SUMMARY OF

DATA NEEDS INTERVIEW

Interviewee: John Peterson, Wes Fisher, Jay Lujan
Conservation and Planning Section
Minnesota Energy Agency

Interviewer: Norman L. Chervany
Principal Investigator
Regional Energy Information System and
Energy Impact Analysis Project

Date: November 15, 1974 (Peterson and Fisher)
November 20, 1974 (Fisher and Lujan)
Re-interview December 20, 1974 (Lujan)

I. Policy Issues and Activities to be Supported

The Minnesota Energy Agency has the responsibility for

- identifying and monitoring the usage of energy in the State
- developing the capability for assessing employment and general economic impact of alternative energy supply senarios that Minnesota may face in the future

Within the two objectives there are short and long run perspectives that must be recognized. In the short run the MEA conservation programs must be developed, implemented, and monitored. Once these programs are underway, the task of the Agency becomes one of administration. The long run involves the development and use of a "what if" energy planning capability. This capability must be able to project the future of the State given supply assumptions. This projection capability will allow State policy makers to make integrated plans for the growth of the State while explicitly recognizing energy as a constraint.

II. Data Needs

The fundamental data that are required focus upon understanding the process by which large users (or classes of users) consume energy. This requirement can be broken down into a series of subquestions. For each user it is necessary to know

(1) What amounts and mix of energy are consumed?

(2) When in time do these energy demands occur?

(3) What is the potential for energy conservation?

In addition, the data on energy supply and use must provide a comparative history for policy makers. We need to know for each fuel type where we are today compared to previous years.

There are several dimensions necessary for defining the relevant detail for energy related data.

(1) Geographic Detail

For individual consumers being monitored geographic location is an automatic by-product of the data collection process. For aggregate classes of users (e.g., private residences) the data should be collected at the county level.

(2) End-Use Detail

For the large users in the industrial/commercial sectors data must be collected on a company-by-company basis. Small industrial/commercial users can be aggregated. Other user classes can be aggregated in the following manner

- residential - urban versus rural
- agriculture - by consuming process (e.g., crop drying)

(3) Time Detail

For critical regions of the State (e.g., the Duluth area where unemployment is a major problem) the data should be collected monthly. In general, quarterly reports for

- basic economic data
- comparative supply and demand data
- energy related impact data

should be sufficient.

SUMMARY OF

DATA NEEDS INTERVIEW

Interviewee: Dixie Diehl
Fuel Allocation Coordinator
Minnesota Energy Agency

Interviewer: Norman L. Chervany
Principal Investigator
Regional Energy Information System and
Economic Impact Analysis Project

Date: November 7, 1974; Re-interview November 15, 1974

I. Policy Issues and Activities to be Supported

Primary responsibility lies in the maintenance of the allocation programs of the Minnesota Energy Agency. This involves

(1) Short Run Allocation Crisis Management

On a day-to-day basis the MEA must be responsive to helping consuming units (business, schools, consumers, etc.) find alternative fuels or sources of fuels to meet their needs. One portion of this activity involves the running of the FEA mandatory allocation program by managing the state petroleum set-asides. Current legislative authority does not formally include coal in this activity.

(2) Long Run Identification of Potential Allocation Programs

This activity involves monitoring projected energy demands and energy suppliers in order to

- identify future short-fall situations
- initiate corrective action (where possible) before the actual allocation problem arises

II. Data Needs - Type

The basic data needs are (for each energy type)

(1) monitoring the amount of fuel coming into the state

(2) maintaining a list of original wholesale and retail suppliers operating in the state

(3) identifying and monitoring consumption of major energy users within the state

There are several dimensions necessary for defining the relevant detail for energy related data. Unless otherwise noted, the detail requirements apply to all energy types.

(1) Geographic Detail

The data must be broken down by location that is more detailed than the thirteen economic development regions. Data by individual counties (and sometimes towns within counties) are required for both short and long range problems.

(2) End-use Detail

The data on end-use must be monitored in terms of

- residential (includes apartments)
- transportation (by type)
- industrial
- commercial (includes public/non-profit sector)
- agriculture
- public utilities

Within these end-use categories it is necessary to know the specific consumptive use of the energy. It is of particular importance to identify space heating and lighting uses.

(3) Time Detail

For the short-run problems monthly data on supplies are needed. These data will permit alternative sources of supplies to be identified. For the long run monitoring of potential problems quarterly reports on supply and use should be sufficient. For gasoline statistics, yearly reports should be adequate.

(4) Distribution Detail

Within the distribution area two types of detail are required. First, a list (updated annual) of all supplies, distributors, and retailers operating within the State is required. Second, for the initial supplier and bulk storage facilities, it is necessary to know who supplies whom within the distribution chain. It is not necessary, however, to know the amounts supplied. (This information, if required, can be obtained at the time a supply shortage crisis arises.) After, this major supplier-major storage point in the distribution, it is necessary to know the end-use geographic area served by individual distributors.

These data will be needed even if the Federal mandatory allocation program is terminated.

APPENDIX X.2

REIS Project Specifications

Project Specification
for
State of Minnesota
Energy Agency

Management Information Systems Research Center
College of Business Administration

Norman L. Chervany
Department of Management Sciences
College of Business Administration

J. David Naumann
Technical Consultant
Regional Energy Information Systems Project

June 21, 1974

I. General Guidelines

1. Relationship Between Project Team and Director of Research

The Project Team is responsible for the definition and implementation of the tasks described in Section II. The Director of Research will be consulted with in this effort. Draft copies and the final report will be submitted to the Director of Research for review.

A Steering Committee for the project described in this document will be composed of Norman Chervany, Principal Investigator, College of Business Administration, J. David Naumann, College of Business Administration, John Peterson, Director of Conservation, Minnesota Energy Agency, and Ernesto Venegas, Forecasting Analyst, Minnesota Energy Agency. They have responsibility to oversee the project and will meet at the call of the Director of Research.

2. Transfer of Funds

The agreement between the Minnesota Energy Agency and the University of Minnesota for the project described in this document will be administered by the Management Information Systems Research Center and the College of Business Administration. This requires that the funds be transferred from the Agricultural Experiment Station to the College of Business Administration.

3. Authority to Change Personnel

The authority to hire, fire, or change personnel working on the project described in this document rests with the Principal Investigator under prescribed University procedures.

II. Project Tasks

1. Development Network Model

1.1 Complete conceptualization of energy flows network

1.2 Develop computer program for the network model

1.3 Develop statement of the analytical report capabilities utilizing the network model

1.4 System documentation using PRIDE

This set of activities is devoted to finalizing the logical structure that serves as a foundation for the Regional Energy Information System. Task 1.1 is directed at (1) completing the specification of the network model, (2) integrating the survey of other energy information systems into this model, and (3) providing the rationale for an energy flow perspective as the basis for an energy information system. Task 1.2 will develop the computer programs for a demonstration network model. Task 1.3 will focus on identifying some of the reports that can be generated from the network based energy information system. In addition, a specification of some of the analytical models that can be developed using the energy flow model will be given.

2. Develop Sample Database

2.1 Design the structure for the sample energy flow database

2.2 Generate the sample database

2.3 System documentation using PRIDE

This set of activities is devoted to the creation of a demonstration database for the energy flow network model. This data will be a sample of some of the data that will be collected when a complete energy flow model is developed and implemented. Task 2.1 will develop the logical structure required to collect and organize the required data. Task 2.2 will define the required data and instructions for gathering it. The Minnesota Energy Agency will provide the data.

3. Undertake User Oriented Design of Reports

   3.1 Design sample database reports

   3.2 Produce sample reports

   3.3 Interact with users, revise sample database and network model

This set of activities is devoted to the development of useful reports from the energy flow network model. The major premise is that user/project team interaction is necessary in order to produce valuable decision making reports. Task 3.1 is directed at design of initial sample reports as a discussion vehicle with the ultimate users. Task 3.2 will produce specific reports utilizing the sample database. Task 3.3 will involve discussions with some of the users of the energy flow information system. The specific users to be contacted will be specified by the Minnesota Energy Agency.

4. Provide expert advice to other REIS activities and participate in regional and national energy information activities.

This is an ongoing activity to insure that the input/output model directed by Dr. Wilbur Maki can and will interact successfully with the energy flow information system, and assures that other agencies are apprised of Minnesota Energy Agency Developments.

5. Write Final Report

   5.1 Write network model report

   5.2 Write database report

   5.3 Write reporting subsystem report

   5.4 Write final report

This set of activities will produce the final output of REIS Project 1. The final report will be (1) a compilation of the individual reports, (2) an integrative summary, and (3) implications for additional effort required to develop and implement a complete energy flow model.

A complete activity network is presented in Exhibit 1.

III. Outputs

There are three specific documents as part of the overall report which will be provided as an end product from the project:

1. A document which describes the analytical capabilities of the energy network flow model, specifically outlining:

   1.1 Rationale for structuring the model as energy flows

   1.2 Statement of analytic capabilities of the energy network flow model

   1.3 A computer program of the energy network flow model

2. A document which specifies the database design concepts using the System 2000 database management system available at the University of Minnesota and the computer program which accepts sample input data, and updates the data.

3. A document that summarizes the user evaluation of the sample reports and discusses the implication of this evaluation for the computer energy network flow model.

4. Project summary and recommendations for additional development and implementation.

5. A summary description of events related to regional and national energy information activities.*

Note: Specific agencies to be interacted with:

National -- State Energy Information Sharing Committee, Federal Energy Administration

States -- Wisconsin, Michigan, Oregon, Kansas, Maryland

IV. Project Budget

Line Item Budget

Line Item		
Personnel		$19,524.57
Computer Changes		2,000.00
Supplies		2,000.00
Printing		500.00
Travel		2,000.00
Telephone and other Misc.		975.43
	Total	$27,000.00

*Personnel figure includes fringe benefits

Program/Budget

Direct Costs:	Summer (July 1 - Sept. 15)	Fall (Sept. 16 - Dec. 31)
Personnel		
Faculty	$ 7,827.09	2,991.69
Graduate Students	1.300.00	2,600.00
Secretarial	1,000.00	1,500.00
Computer Charges	500.00	1,500.00
Supplies	1,000.00	1,000.00
Printing		500.00
Travel	1,000.00	1,000.00
Telephone and other Misc.	500.00	475.43
Total direct costs	$13,127.09	11,567.12
Indirect Costs:		
Faculty fringe @ 17.5%	1,369.74	523.55
Secretarial fringe @ 16.5%	165.00	247.50
Total indirect costs	$ 1,534.74	771.05
Total project cost	$13,127.09	11,567.12
	1,534.74	771.05
	$14,661.83	12,338.17

APPENDIX X.3

Sample Computations With

The Energy Flow Network Model

For energy flows within Minnesota X_{ijk}^{t} is defined as an energy flow between a supplier and a receiver. The indices are defined as:

t = time period of shipment

k = type of energy involved

i = classification of shipper of the energy

j = classification of receiver of the energy

In order to illustrate the manipulations possible with the energy flow network model, define the following parameters:

- 5 shippers of energy flow
- 2 suppliers (i = 1, 2) and 3 distributors (i = 3, 4, 5)
- 7 receivers of energy flow
- 3 distributors (j = 1, 2, 3) and 4 users (j = 4, 5, 6, 7,)
- 4 types of energy [gasoline (k = 1), electricity (k = 2), heating oil no. 1 (k = 3), and fuel oil (k = 4)]
- First three months of 1974 [January 1974 (t = 1) through March 1974 (t = 3)]

Hypothetical energy flows for this system are defined in Figures X.3.1 - X.3.12.

Figure X.3.1 Network 1

Energy Type = Gasoline ($k = 1$)
Time Period = January 1974 ($t = 1$)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	0	0	0	0	0	0	0	0
OIL REFINERIES THUNDERBAY i=2	0	0	0	0	0	500 Gals.	4000 Gals.	4500 Gals.
NSP DULUTH i=3	0	0	0	0	0	0	0	0
GUSTAFSON OIL ST. PAUL i=4	0	0	0	0	0	0	0	0
STANDARD REFINERIES ROSEDALE i=5	0	0	0	0	1000 Gals.	2500 Gals.	2000 Gals.	5500 Gals.
TOTAL RECEIVED	0	0	0	0	1000 Gals.	3000 Gals.	6000 Gals.	10,000 Gals.

Figure X.3.2 Network 2

Energy Type = Gasoline (k = 1)
Time Period = February 1974 (t = 2)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	0	0	0	0	0	0	0	0
OIL REFINERIES THUNDERBAY i=2	0	0	0	0	0	500 Gals.	4000 Gals.	4500 Gals.
NSP DULUTH i=3	0	0	0	0	0	0	0	0
GUSTAFSON OIL ST. PAUL i=4	0	0	0	0	0	0	0	0
STANDARD REFINERIES ROSEDALE i=5	0	0	0	0	1000 Gals.	2612 Gals.	1982 Gals.	5594 Gals.
TOTAL RECEIVED	0	0	0	0	1000 Gals.	3112 Gals.	5982 Gals.	10,094 Gals.

Figure X.3.3 Network 3

Energy Type = Gasoline (k = 1)
Time Period = March 1974 (t = 3)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	0	0	0	0	0	0	0	0
OIL REFINERIES THUNDERBAY i=2	0	0	0	0	0	500 Gals.	4000 Gals.	4500 Gals.
NSP DULUTH i=3	0	0	0	0	0	0	0	0
GUSTAFSON OIL ST. PAUL i=4	0	0	0	0	0	0	0	0
STANDARD REFINERIES ROSEDALE i=5	0	0	0	0	1101 Gals.	2617 Gals.	2400 Gals.	6118 Gals.
TOTAL RECEIVED	0	0	0	0	1101 Gals.	3117 Gals.	6400 Gals.	10,618 Gals.

Figure X.3.4 Network 4

Energy Type = Electricity (k = 2)
Time Period = January 1974 (t = 1)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	1300 MWhr.	0	0	0	0	0	0	1300 MWhr.
OIL REFINERIES THUNDERBAY i=2	0	0	0	0	0	0	0	0
NSP DULUTH i=3	0	0	0	20 MWhr.	50 MWhr.	5 MWhr.	5 MWhr.	80 MWhr.
GUSTAFSON OIL ST. PAUL i=4	0	0	0	0	0	0	0	0
STANDARD REFINERIES ROSEDALE i=5	0	0	0	0	0	0	0	0
TOTAL RECEIVED	1300 MWhr.	0	0	20 MWhr.	50 MWhr.	5 MWhr.	5 MWhr.	1380 MWhr.

Figure X.3.5 Network 5

Energy Type = Electricity (k = 2)
Time Period = February 1974 (t = 2)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	1400 MWhr.	0	0	0	0	0	0	1400 MWhr.
OIL REFINERIES THUNDERBAY i=2	0	0	0	0	0	0	0	0
NSP DULUTH i=3	0	0	0	25 MWhr.	40 MWhr.	10 MWhr.	5 MWhr.	80 MWhr.
GUSTAFSON OIL ST. PAUL i=4	0	0	0	0	0	0	0	0
STANDARD REFINERIES ROSEDALE i=5	0	0	0	0	0	0	0	0
TOTAL RECEIVED	1400 MWhr.	0	0	25 MWhr.	40 MWhr.	10 MWhr.	5 MWhr.	1480 MWhr.

Figure X.3.6 Network 6

Energy Type = Electricity (k = 2)
Time Period = March 1974 (t = 3)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	1500 MWhr.	0	0	0	0	0	0	1500 MWhr.
OIL REFINERIES THUNDERBAY i=2	0	0	0	0	0	0	0	0
NSP DULUTH i=3	0	0	0	50 MWhr.	30 MWhr.	10 MWhr.	10 MWhr.	100 MWhr.
GUSTAFSON OIL ST. PAUL i=4	0	0	0	0	0	0	0	0
STANDARD REFINERIES ROSEDALE i=5	0	0	0	0	0	0	0	0
TOTAL RECEIVED	1500 MWhr.	0	0	50 MWhr.	30 MWhr.	10 MWhr.	10 MWhr.	1600 MWhr.

Figure X.3.7 Network 7

Energy Type = Heating Oil No. 1 ($k = 3$)
Time Period = January 1974 ($t = 1$)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP i=1 SUPERIOR	0	0	0	0	0	0	0	0
OIL REFINERIES i=2 THUNDERBAY	0	0	0	8000 Gals.	13,000 Gals.	500 Gals.	4000 Gals.	25,500 Gals.
NSP i=3 DULUTH	0	0	0	0	0	0	0	0
GUSTAFSON OIL i=4 ST. PAUL	0	0	0	700 Gals.	1100 Gals.	400 Gals.	600 Gals.	2800 Gals.
STANDARD REFINERIES i=5 ROSEDALE	0	0	0	400 Gals.	1150 Gals.	2632 Gals.	2268 Gals.	6450 Gals.
TOTAL RECEIVED	0	0	0	9100 Gals.	15,250 Gals.	3532 Gals.	6868 Gals.	34,750 Gals.

Figure X.3.8 Network 8

Energy Type = Heating Oil No. 1 (k = 3)
Time Period = February 1974 (t = 2)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	0	0	0	0	0	0	0	0
OIL REFINERIES THUNDERBAY i=2	0	3700 Gals.	8000 Gals.	8000 Gals.	13,000 Gals.	500 Gals.	4000 Gals.	37,200 Gals.
NSP DULUTH i=3	0	0	0	0	0	0	0	0
GUSTAFSON OIL ST. PAUL i=4	0	0	0	700 Gals.	1100 Gals.	400 Gals.	600 Gals.	2800 Gals.
STANDARD REFINERIES ROSEDALE i=5	0	0	0	400 Gals.	1150 Gals.	2632 Gals.	2268 Gals.	6450 Gals.
TOTAL RECEIVED	0	3700 Gals.	8000 Gals.	9100 Gals.	15,250 Gals.	3532 Gals.	6868 Gals.	46,450 Gals.

Figure X.3.9 Network 9

Energy Type = Heating Oil No. 1 (k = 3)
Time Period = March 1974 (t = 3)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP i=1 SUPERIOR	0	0	0	0	0	0	0	0
OIL REFINERIES i=2 THUNDERBAY	0	3800 Gals.	8900 Gals.	8000 Gals.	13,000 Gals.	500 Gals.	4000 Gals.	37,200 Gals.
NSP i=3 DULUTH	0	0	0	0	0	0	0	0
GUSTAFSON OIL i=4 ST. PAUL	0	0	0	700 Gals.	1100 Gals.	400 Gals.	600 Gals.	2800 Gals.
STANDARD REFINERIES i=5 ROSEDALE	0	0	0	400 Gals.	1150 Gals.	2632 Gals.	2268 Gals.	6450 Gals.
TOTAL RECEIVED	0	3800 Gals.	8900 Gals.	9100 Gals.	15,250 Gals.	3532 Gals.	6868 Gals.	47,450 Gals.

Figure X.3.10 Network 10

Energy Type = Fuel Oil (k = 4)
Time Period = January 1974 (t = 1)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	0	0	0	0	0	0	0	0
OIL REFINERIES THUNDERBAY i=2	7000 Gals.	3000 Gals.	6000 Gals.	1500 Gals.	2000 Gals.	1000 Gals.	1500 Gals.	22,000 Gals.
NSP DULUTH i=3	0	0	0	0	0	0	0	0
GUSTAFSON OIL ST. PAUL i=4	3000 Gals.	0	0	0	0	300 Gals.	200 Gals.	3500 Gals.
STANDARD REFINERIES ROSEDALE i=5	5000 Gals.	1000 Gals.	0	0	0	0	0	6000 Gals.
TOTAL RECEIVED	15,000 Gals.	4000 Gals.	6000 Gals.	1500 Gals.	2000 Gals.	1300 Gals.	1700 Gals.	31,500 Gals.

Figure X.3.11 Network 11

Energy Type = Fuel Oil (k = 4)
Time Period = February 1974 (t = 2)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP SUPERIOR i=1	0	0	0	0	0	0	0	0
OIL REFINERIES THUNDERBAY i=2	7000 Gals.	5000 Gals.	8000 Gals.	1500 Gals.	1000 Gals.	1000 Gals.	500 Gals.	24,000 Gals.
NSP DULUTH i=3	0	0	0	0	0	0	0	0
GUSTAFSON OIL ST. PAUL i=4	3000 Gals.	0	0	0	0	300 Gals.	200 Gals.	3500 Gals.
STANDARD REFINERIES ROSEDALE i=5	5000 Gals.	1000 Gals.	0	0	0	0	0	6000 Gals.
TOTAL RECEIVED	15,000 Gals.	6000 Gals.	8000 Gals.	1500 Gals.	1000 Gals.	1300 Gals.	700 Gals.	33,500 Gals.

Figure X.3.12 Network 12

Energy Type = Fuel Oil (k = 4)
Time Period = March 1974 (t = 3)

RECEIVERS / SHIPPERS	NSP DULUTH j=1	GUSTAFSON OIL ST. PAUL j=2	STANDARD REFINERIES ROSEDALE j=3	ST. CLOUD SCHOOL DISTRICT j=4	ST. MARY'S HOSPITAL MINNEAPOLIS j=5	GREYHOUND BUS DEPOT MINNEAPOLIS j=6	HERTZ CAR RENTAL MINNEAPOLIS j=7	TOTAL SHIPPED
NSP i=1 SUPERIOR	0	0	0	0	0	0	0	0
OIL REFINERIES i=2 THUNDERBAY	7000 Gals.	5000 Gals.	8000 Gals.	1500 Gals.	2000 Gals.	1000 Gals.	1500 Gals.	26,000 Gals.
NSP i=3 DULUTH	0	0	0	0	0	0	0	0
GUSTAFSON OIL i=4 ST. PAUL	3000 Gals.	0	0	0	0	500 Gals.	1200 Gals.	4700 Gals.
STANDARD REFINERIES i=5 ROSEDALE	5000 Gals.	1000 Gals.	0	0	0	500 Gals.	500 Gals.	7000 Gals.
TOTAL RECEIVED	15,000 Gals.	6000 Gals.	8000 Gals.	1500 Gals.	2000 Gals.	2000 Gals.	3200 Gals.	37,700 Gals.

Assume that the above networks represent the flows in the State of Minnesota in small regions (e.g., counties). With the above data it is possible to answer some of the questions that are likely to arise in practice.

Question #1

For gasoline in January 1974, calculate total amount supplied directly:

a) into Minnesota

b) by a specific prime supplier (e.g., Oil Refineries, Thunderbay, Ontario) into Minnesota

c) to a specific user class (e.g., Greyhound Bus Depot, Minneapolis) in Minnesota

d) to a specific user class by a specific prime supplier into Minnesota

Computation #1

Network 1 represents the gasoline flows in January 1974. Using this network:

a) Total amount supplied directly into Minnesota

$$\text{Total} = \sum_{j=1}^{7} \sum_{i=1}^{i=2} X_{ijk}^{t} \quad \text{where } t=1 \text{ and } k=1$$

$$= 0 + 0 + \ldots + 500 + 4{,}000$$

$$= 4{,}500 \text{ Gallons}$$

b) Total amount supplied by Oil Refineries, Thunderbay, Ontario, into Minnesota

$$\text{Total} = \sum_{j=1}^{7} X_{ijk}^{t} \quad \text{where } t=1,\ k=1, \text{ and } i=2$$

$$= 0 + 0 + 0 + 0 + 0 + 0 + 500 + 4{,}000$$

$$= 4{,}500 \text{ Gallons}$$

c) Total amount supplied to Greyhound Bus Depot, Minneapolis

$$\text{Total} = \sum_{i=1}^{5} X_{ijk}^{t} \qquad \text{where } t=1,\ k=1,\ \text{and } j=6$$

$$= 0 + 500 + 0 + 0 + 2{,}500$$

$$= 3{,}000 \text{ Gallons}$$

d) Total amount supplied to Greyhound Bus Depot, Minneapolis by Oil Refineries, Thunderbay, Ontario

$$\text{Total} = X_{ijk}^{t} \qquad \text{where } t=1,\ k=1,\ i=2,\ \text{and } j=6$$

$$= 500 \text{ Gallons}$$

Question #2

For heating oil No. 1 in March 1974, estimate the amount supplied directly and indirectly (i.e., through distributors) by a specific prime supplier (e.g., Oil Refineries, Thunderbay, Ontario) to a specific user (e.g., St. Mary's Hospital, Minneapolis).

Computation #2

Network 9 represents the heating oil No. 1 flows in March 1974.

Total amount supplied to St. Mary's Hospital

$$\text{Total} = \sum_{i=2}^{d} X_{ijk}^{t} \qquad t=3,\ k=3,\ \text{and } j=5$$

$$= \sum_{i=1}^{1} X_{ijk}^{t} + \sum_{i=3}^{i=5} X_{ijk}^{t}$$

= (Amount supplied directly) + (Amount supplied indirectly)

= (13,000) + (0 + 1,100 + 1,150)

= (13,000) + (2,250)

= 15,250 Gallons

The above estimation is simplified due to the fact that there is only one prime supplier of heating oil No. 1. Suppose NSP in Superior, Wisconsin also supplied heating oil No. 1 into the State. Then the above calculation becomes more involved. In such a case, not all the oil from the distributors may be due to the Oil Refineries, Thunderbay. In this situation the fractions of oil supply to the distributors from Oil Refineries, Thunderbay, would have to be calculated from the flow matrix.

Suppose we assume that the fraction of the heating oil no. 1 received by Gustafson Oil, St. Paul and Standard Refineries, Rosedale from the Oil Refineries, Thunderbay, are respectively 0.7 and 0.6.

Now the amount supplies indirectly (through distributors) into St. Mary's Hospital, Minneapolis, by Oil Refineries, Thunderbay.

Total Indirect = 0 + 1,100 x .7 + 1,150 x .6

= 770 + 690

= 1,460 Gallons

Therefore, we need to maintain (or compute) matrices of fractions for distributors for different energy types from different prime suppliers.

Question #3

For a specific user (e.g., Hertz Car Rental, Minneapolis) estimate the BTU equivalent of all forms of energy consumed in February 1974.

Computation #3

Networks 2, 5, 8, and 11 represent the flows in February 1974 for the four energy types being considered in the example. Assume that the total amounts of energy types received are consumed.

Then, the total amount of BTU's consumed by Hertz Car Rental

$$\text{Total} = \sum_{k=1}^{k=4} \sum_{i=1}^{i=5} X_{ijk}^{t} \times \gamma_k \qquad \text{where } t=2 \text{ and } j=7$$

(γ_k, as above, is defined as the BTU conversion factor for the energy type k)

$$= (0 + 4{,}000 + 0 + 0 + 1{,}982) \times \gamma_1$$
$$+ (0 + 0 + 0 + 0 + 0) \times \gamma_2$$
$$+ (0 + 4{,}000 + 0 + 600 + 2{,}268) \times \gamma_3$$
$$+ (0 + 1{,}500 + 0 + 200 + 0) \times \gamma_4$$
$$= (5{,}982 \times \gamma_1) + (0 \times \gamma_2) + (6{,}868 \times \gamma_3) + (1{,}700 \times \gamma_4) \text{ BTU's.}$$

Therefore, a vector (γ_k) of BTU conversion factors for all the energy types must be maintained.

<u>Question #4</u>

For a specific user of electricity and fuel oil (e.g., Greyhound Bus Depot of Minneapolis) estimate the amount of fuel oil consumed in February 1974.

a) directly

b) indirectly via conversion of fuel oil into electricity

<u>Computation #4</u>

Networks 5 and 11 represent the flow of electricity and fuel oil respectively in February 1974.

a) Total amount of fuel oil consumed directly by Greyhound Bus Depot, Minneapolis (Network 11).

$$\text{Total Direct} = \sum_{i=1}^{5} X_{ijk}^{t} \quad \text{where } t=2,\ k=4, \text{ and } j=6$$

$$= 0 + 1{,}000 + 0 + 300 + 0$$

$$= 1{,}300 \text{ Gallons}$$

Let us assume that 60% of fuel oil consumption is for transformation into electricity.

$$= 15{,}000 \times .60$$

$$= 9{,}000 \text{ Gallons}$$

b) Total amount of fuel oil consumed indirectly by Greyhound Bus Depot, Minneapolis through conversion to electricity (Network 5 and 11) can be calculated as follows:

In February 1974 the total amount of fuel oil received by NSP, Duluth (Network 11)

$$\text{Total Fuel Oil} = \sum_{i=1}^{5} X_{ijk}^{t} \quad \text{where } t=2,\ k=4, \text{ and } j=1$$

$$= 0 + 7{,}000 + 0 = 3{,}000 + 5{,}000$$

$$= 15{,}000 \text{ Gallons}$$

Assume that 90% of this is converted to electricity. Therefore, (.90) x (15,000) = 13,5000 gallons of fuel oil was indirectly consumed by consumers of electricity.

In February 1974 the total electricity distributed by NSP Duluth was:

$$\text{Total Electricity} = \sum_{i=1}^{5} \sum_{j=1}^{7} X_{ijk}^{t} \quad t=2 \text{ and } k=4$$

$$= 1{,}480 \text{ mwhr}$$

The amount of electricity consumed by the Greyhound Bus Depot, Minneapolis was 10 mwhr (see Network 5).

Thus, the indirect fuel oil consumption by the Greyhound Bus Depot, Minneapolis was:

$$\text{Total Indirect Fuel Oil} = \left(\frac{10}{1,480}\right) \times \left(13,500\right) = 91.2 \text{ Gallons}$$

APPENDIX X.4

The SYSTEM 2000 Database Management System*

---

*Further information about SYSTEM 2000 features and capabilities are found in [8] and [21].

As the art/science of data management developed, it became evident that many of the functions associated with the maintenance of a large collection of computerized data were similar, no matter what the data were. As such, there occurred a development progression of Database Management Systems (DBMS). This development began with the "general" program to add and delete records from files of sequentially stored records, and has progressed to the rather complex systems we have today.

Specifically, a DBMS is a set of generalized computer programs which provide for the creation, retrieval, updating, security, and reporting of data in a general manner. DBMS usually have the following features and capabilities:

- Ability to accept data regardless of its original structure;
- Ability to operate as a stand-alone process and/or from within some programming language;
- Ability to process the "unanticipated" query;
- Ability to maintain security to the data item level;
- Ability to add, change, or delete data at the record, group, or item level;
- Ability to provide backup and audit trail facilities.

One of the keys to the generality of the DBMS is the disassociation of the physical structure of data from the logical structure. In this vein, the user generally has little or no control over the actual physical storage structure of his data and has no need for such control. Rather, the user presents the logical organization of his data to the DBMS and has only to concern himself with that organization, without regard to disks, tapes, card columns, and the like.

The DBMS selected for use by the REIS Project was SYSTEM 2000 which is a product of MRI Systems Corporation, Austin, Texas. The computer used was a Control Data Corporation Cyber 74 housed at the University of Minnesota. Being a generalized system, SYSTEM 2000 can also be installed on IBM 360 and 370 series and the Univac 1100 series computers.

The basic SYSTEM 2000, with selected optional features, provides the capability for developing information systems tailored to the requirements of the application and the user. In SYSTEM 2000, the user defines both the nature and the boundaries of the database as well as how he would like it organized. Since different types of data suggest different organizations, SYSTEM 2000 provides the user the flexibility to organize or structure his database in the most appropriate manner. The following discussion provides a brief overview of the basic system and some of the optional features.

Basic SYSTEM 2000

Basic SYSTEM 2000 provides the user with a comprehensive set of database management capabilities. These include the ability to define new databases, modify the definition of existing databases, and to retrieve and update values in these databases.

Basic SYSTEM 2000 also provides archival copies of databases and records an audit trail of changes made to a database. It is capable of reconstructing a database by applying the audit trail, completely or in part, to an archival copy of that database.

Immediate Access Feature

The Immediate Access Feature provides a user-oriented language with which a non-programmer may express his requests for retrieval or updating of a database. The English-like language is easily learned. It includes a complete set of easy-to-understand diagnostic messages and is highly suited for interactive use from remote keyboard terminals.

Report Writer Feature

The Report Writer Feature enables the user to prepare report specifications following a set of quickly-learned report formatting conventions. The user specifies column, row and page headings, dates, and footnote captions.

Procedural Language Feature

The Procedural Language Feature enables users to manipulate data in a SYSTEM 2000 data base from a procedural programming language such as COBOL. This feature provides the mechanism for addressing any part of the database of interest to the procedural program, to retrieve data in a sequence and format suitable for procedural processing, and to update the database from the program. Interrelationships between two or more databases can be established which permit network data structures to be defined.

Database Structure

What is database? A database is an organized collection of data about "something." For example, all the inventory records of a company is a database. In the REIS demonstration the database consists of the energy establishments in Stearns, Benton, and Sherburne Counties.

Generally, a database is structured by the user to solve the user's problems and to answer his questions. He does this by choosing appropriate words which will stand for the different types of data which he will store. The user stores numerous quantities of what are called logical entries. A logical entry is all the information about one of the major items being stored. A logical entry is what the name suggests, an entry of data logically organized, as well as logically related, to the user's problem. A database, then, consists of the total collection of all logical entries. A database may have many logical entries or only a few.

SYSTEM 2000 operates on a user defined logical data structure. This data structure must be in the form of a "tree." A "tree" is defined as a structure in which each logical entry is made up of data elements having only one parent and zero, one or more descendants. A simplified pictoral representation of the tree structure of an energy establishment in the demonstration database is shown in Figure X.4.1.

By examining the tree structure, the hierarchical relationships of the data elements or components become evident. These relationships are defined by the database designer and described to SYSTEM 2000 through a database definition or schema. A schema consists of an orderly arrangement of component names or labels. These labels indicate the type of data which is to be loaded into the database. They are not the data values; but, instead, they become identification tags which the user employs in accessing his data. An example of a component name from the demonstration database is ESTAB NAME or C1 which is the label for component number one, an energy establishment name in the database. Figure X.4.2 shows the complete schema for the demonstration database.

The selection of particular logical entries and their data sets from the database is accomplished by qualifying the references to component names in the schema. The technique of qualifying entries will become evident to the reader after examining the PRINT, LIST, AND TALLY retrieval commands in the next section of this appendix.

Figure X.4.1 Logical Entry for an Energy Establishment

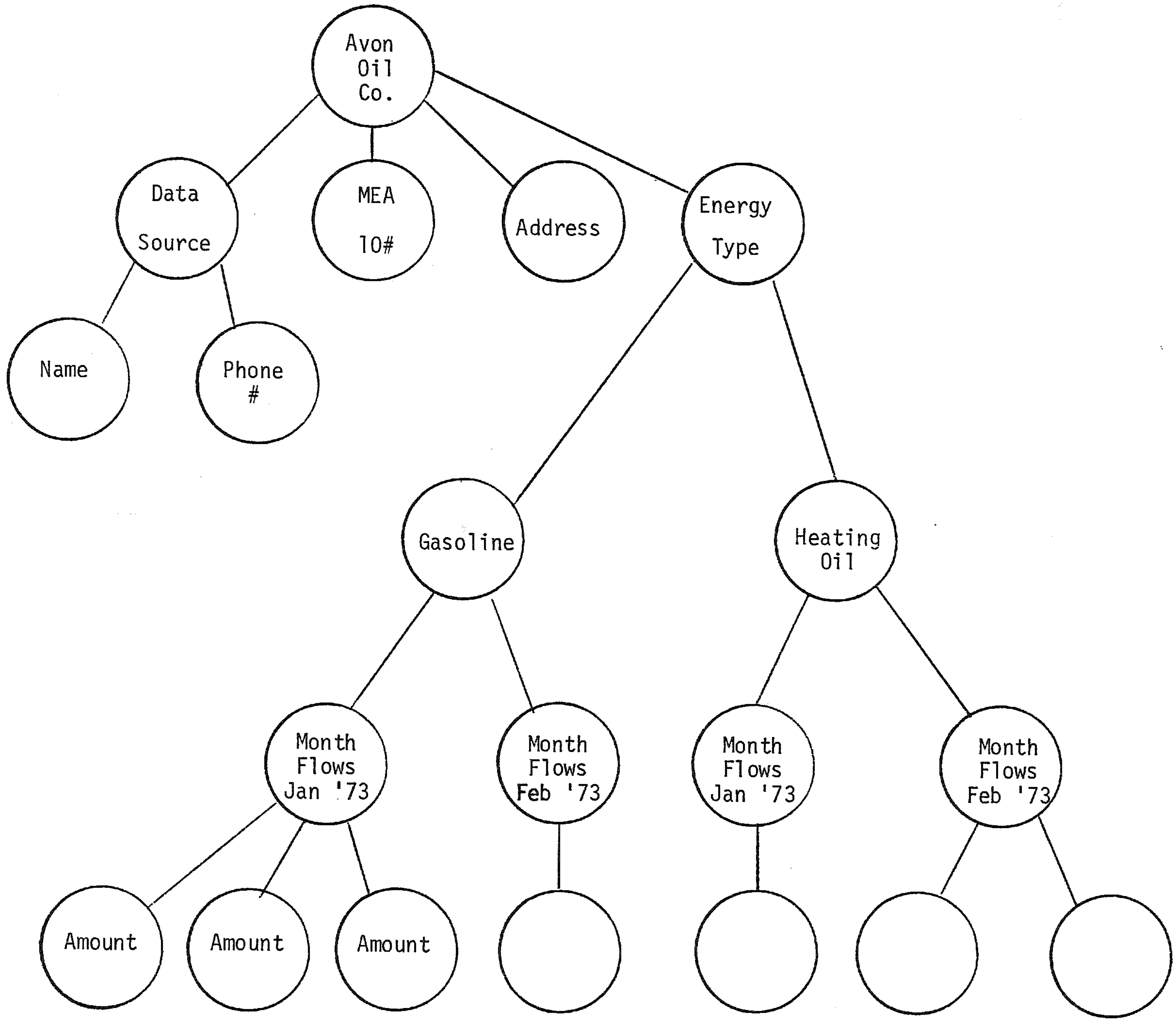


Figure X.4.2

Schema for the Demonstration Database

```
         DESCRIBE:
SYSTEM RELEASE NUMBER        2.30P
DATA BASE NAME IS DEMODB
DEFINITION NUMBER       40
DATA BASE CYCLE       871
   1*  ESTAB NAME (NAME X(20))
   2*  ESTAB TYPE (NAME X(6))
   3*  MEA IDNO (INTEGER NUMBER 9(6))
   4*  LIC NO (INTEGER NUMBER 9999)
   5*  DEALER NO (INTEGER NUMBER 9(5))
   6*  STREET ESTAB (NON-KEY NAME X(15))
   8*  STATE NAME (NAME XX)
   9*  STATE NO (INTEGER NUMBER 99)
  10*  COUNTY NAME (NAME X(10))
  11*  COUNTY NO (INTEGER NUMBER 99)
  12*  GEO LOCATION (NON-KEY NAME X)
  13*  ZIPCODE (INTEGER NUMBER 9(5))
  14*  PHONE NO (NON-KEY NAME X(8))
  15*  EIN (NAME X(10))
  17*  PAD DISTRICT (INTEGER NUMBER 9)
  18*  BOM PET. DISTRICT (INTEGER NUMBER 99)
  19*  BITUMINOUS LIGNITE (INTEGER NUMBER 99)
  20*  GAS PRODUCTION SUPPLY AREA (INTEGER NUMBER 99)
  21*  GAS PRODUCTION SUPPLY SUB AREA (INTEGER NUMBER 99)
  22*  REGIONAL PSA (INTEGER NUMBER 9)
  23*  REG RELI COUNCILS (INTEGER NUMBER 9)
  24*  POWER SUPPLY AREA (INTEGER NUMBER 99)
  25*  RDC (INTEGER NUMBER 99)
  26*  SMSA (INTEGER NUMBER 9(5))
  31*  USER CLASS (NAME X(10))
  71*  CITY (NAME X(10))
  16*  ENERGY INFO CONTACT (RG)
   162*  EIC PHONE NO (NON-KEY NAME X(8) IN 16)
   163*  TITLE (NON-KEY NAME X(20) IN 16)
   161*  PERSON NAME (NON-KEY NAME X(20) IN 16)
  27*  INDUSTRY CLASS (RG)
   271*  SIC CODE (NAME XXXX IN 27)
   272*  INPUT-OUTPUT CODE (NAME X(5) IN 27)
  28*  DATA SOURCE (RG)
   281*  ESTAB DATA FROM (NON-KEY NAME X(10) IN 28)
   282*  DATA BY (NAME X(10) IN 28)
   283*  DATA DATE (DATE IN 28)
  29*  OWNER (RG)
   291*  FIRM NAME (NAME X(20) IN 29)
   292*  FIRM STREET (NON-KEY NAME X(15) IN 29)
   293*  FIRM CITY (NAME X(15) IN 29)
   294*  FIRM STATE (NAME XX IN 29)
   295*  FIRM ZIP (INTEGER NUMBER 9(5) IN 29)
   296*  FIRM COUNTY (NAME X(10) IN 29)
   297*  FIRM TYPE (NAME X(10) IN 29)
   298*  OWNER MEA IDNO (INTEGER NUMBER 9(6) IN 29)
  2992*  OWNER EIN (NAME X(10) IN 29)
   299*  LIC DISTRIBUTION NO (INTEGER NUMBER 9999 IN 29)
  2991*  REG DEALER NO (INTEGER NUMBER 9(5) IN 29)
  30*  ENERGY TYPE (RG)
   301*  ENERGY TYPE NAME (NAME X(10) IN 30)
   302*  ENERGY TYPE CODE (INTEGER NUMBER 9(5) IN 30)
   303*  ENERGY CODE FEA (INTEGER NUMBER 999 IN 30)
   304*  STORAGE FACILITIES (RG IN 30)
    3041*  STORAGE DESCRIPTION (NON-KEY NAME X(10) IN 304)
    3042*  STORAGE CAPACITY (INTEGER NUMBER 9(9) IN 304)
    3043*  UNIT OF MEASURE (NAME X(5) IN 304)
   305*  ENERGY INPUT (RG IN 30)
    3051*  MONTH NUMBER (NAME XX IN 305)
    3052*  YEAR (INTEGER NUMBER 99 IN 305)
    3053*  INFLOW (RG IN 305)
      306*  SUPPLIER NAME (NAME X(10) IN 3053)
      307*  SUPPLIER MEA NO (INTEGER NUMBER 9(6) IN 3053)
      308*  SUPPLIER COUNTY LOC (INTEGER NUMBER 99 IN 3053)
      309*  TRANSPORT METHOD (NAME X(10) IN 3053)
      310*  TYPE OF CONTRACT (NAME X(10) IN 3053)
      311*  PRICE (MONEY $9(6).99 IN 3053)
      312*  QUANTITY (INTEGER NUMBER 9(9) IN 3053)
      313*  INFLOW UNIT OF MEASURE (NAME X(5) IN 3053)
     3080*  SUPPLIER CITY NAME (NAME X(10) IN 3053)
   314*  ENERGY OUTPUT (RG IN 30)
    315*  MONTH NO (INTEGER NUMBER 99 IN 314)
    316*  OUTPUT YEAR (NAME XX IN 314)
    317*  OUTFLOW (RG IN 314)
      318*  DESTINATION NAME (NAME X(10) IN 317)
      319*  DESTINATION MEA NO (INTEGER NUMBER 9(6) IN 317)
      320*  DESTINATION LOC (INTEGER NUMBER 99 IN 317)
      321*  OUTFLOW TRANSPORT METHOD (NAME X(10) IN 317)
      322*  OUTFLOW TYPE OF CONTRACT (NAME X(10) IN 317)
      323*  OUTFLOW PRICE (MONEY $9(6).99 IN 317)
      324*  OUTFLOW QUANTITY (INTEGER NUMBER 9(7) IN 317)
      325*  OUTFLOW UNIT OF MEASURE (NAME X(5) IN 317)
      326*  END USE FEA CODE (NAME X(6) IN 317)
      327*  OUTFLOW CITY NAME (NAME X(10) IN 317)
         EXIT:
         END SYSTEM 2000
```

SYSTEM 2000 Retrieval Commands

This section describes the data access or retrieval commands in SYSTEM 2000.

TALLY Command

The purpose of the TALLY command is to provide statistical information about the unique values of the data elements stored in the database. For example, if the user wanted to know what establishment types were contained in the database and the number of occurrences of each type, the command format is:

TALLY ESTAB TYPE: (or TALLY C2:)

System 2000 interprets the command, accesses the database and builds a table of the data elements defined to be the establishment types. This table is then printed out showing the unique occurrence values for establishment types and the number of establishments in the database with these type codes. An example of the output from this command is shown in Figure X.4.3

Figure X.4.3 Output of Retrieval Command

```
*************************
 ELEMENT-      ESTAB TYPE
*************************
FREQUENCY    VALUE
-------------------------
      122        DEALER
       29        TERMINAL
       38        USER
-------------------------
        3    UNIQUE VALUES
-------------------------
      189    OCCURRENCES
-------------------------
```

PRINT Command

The purpose of the PRINT command is to retrieve data from the database in a specified manner and output the selected data in a simple sequential list. For example, if the user wanted to print the entire logical entry for the Avon Oil Co. the command would be:

PRINT ENTRY WHERE ESTAB NAME
EQ AVON OIL CO:

SYSTEM 2000 would interpret this command and proceed to qualify for printing only those logical entries, or in this case, establishments that have the establishment name "Avon Oil Co." The entire set of elements for the selected establishment would then be printed. The example shown in Figure X.4.4 is a partial printout obtained from the PRINT command shown above.

Figure X.4.4 Output of PRINT Command

```
PRINT ENTRY WHERE ESTAB NAME EQ AVON OIL CO:

1* AVON OIL CO
2* DEALER
3* 106016
4*  961
5*  6016
8* MN
10* STEARNS
11* 73
13*      0
71* AVON

  301* MOTOR GASOLINE
  302*  3000

    3051* 01
    3052* 73
      307* 100961
      312*      40000
      313* GAL

      307* 100190
      312*      63203
      313* GAL

    3051* 02
    3052* 73

      307* 100961
      312*      38000
      313* GAL
```

If the user wanted to know how many establishments in Stearns County were supplied by the Krebsbach Motor Co. the following form of the PRINT command could be used:

```
---
 PRINT COUNT ESTAB NAME WHERE SUPPLIER NAME EQ KREBSBACH MOTOR CO
---
 AND COUNTY NAME EQ STEARNS:
CNT 1* 1
---
```

The response indicates that there is only one establishment in the database with those particular qualifications. To print that establishment name the user could input the command:

```
 PRINT C1 WHERE SAME:
1* TROBECS BUS SERVICE
---
```

which prints C1, the establishment component label, where the same qualifications apply as in the previous retrieval command.

LIST Command

The purpose of the LIST command is to give the user the ability to format simple reports with titles, column headings, page numbers, and page footings. Even though the report format may be simple the retrieval request need not be. The same data set qualification facilities that apply to the PRINT command also apply to the LIST command.

A sample LIST command is:

```
LIST/TITLE D(15) DEMONSTRATION DATABASE - STORAGE REPORT, ESTABLISHMENT
NAME, L(11) CITY, TOT STOR, STORAGE, U M, E TYPE/C1, C71, SUM C3042
BY C30, C3042, C3043, C302, OB C1, C71, C302:
```

The output from this command is shown in Figure X.4.5.

Figure X.4.5 Output of LIST Command

DEMONSTRATION DATABASE - STORAGE REPORT
74/12/18.

ESTABLISHMENT NAME	CITY	TOT STOR	STORAGE	U M	E TYPE
ALBANY COMMUNITY HOSPITAL	ALBANY	4000	4000	GAL	6322
ALBANY SCHOOL DIST	ALBANY	32000	32000	GAL	6322
		5500	5500	GAL	23003
AMERICAN OIL-SAUK CENTRE	SAUK CENTRE	4830000	4830000	GALLONS	2000
AVON OIL CO	AVON	21000	16000	GAL	3000
			5000	GAL	
		45000	16000	GAL	6000
			13000	GAL	
			16000	GAL	
BECKER SCHOOL DIST	BECKER	12000	12000	GAL	6322
BELGRADE COOP ASSN	BELGRADE	52000	10000	GAL	3000
			10000	GAL	
			20000	GAL	
			12000	GAL	
		44000	12000	GAL	6000
			12000	GAL	
			20000	GAL	
BELGRADE SCHOOL DIST	BELGRADE	22000	2000	GAL	6322
			12000	GAL	
			8000	GAL	
BENTON COUNTY COOP ASSN	FOLEY	23100	4000	GAL	3000
			19100	GAL	
		28800	16000	GAL	6000
			8800	GAL	
			4000	GAL	
BIG LAKE SCHOOL DIST	BIG LAKE	20000	20000	GAL	6322
BROOTEN MUNICIPAL AIRPORT	BROOTEN	1825	825	GAL	3102
			1000	GAL	
BROOTEN SCHOOL DIST	BROOTEN	40	40	TON	1
		10000	10000	GAL	6342
		1250	1250	GAL	23200
COLD SPRING SCHOOL DIST	COLD SPRING	52000	52000	GAL	6322
COMMUNITY OIL	SAUK CENTRE	47000	15000	GAL	3000
			12000	GAL	
			20000	GAL	
		36000	6000	GAL	6000
			15000	GAL	
			15000	GAL	
DOWNTOWN 66 SERVICE	ST CLOUD				3000
					6000
EAST SIDE OIL CO	ST CLOUD				3000
					6000
ELK RIVER MUNICIPAL UTILITY	ELK RIVER	80000	80000	GAL	6322
ELK RIVER SCHOOL DIST	ELK RIVER	40	40	TON	1
		37500	37500	GAL	6322
FARMERS UNION OIL CO	ALBANY	24000	12000	GAL	3000
			12000	GAL	
		16000	4000	GAL	6000
			12000	GAL	
FLYNN AIRPORT	MONTICELLO	4000	2000	GAL	3102
			2000	GAL	

Additional Features

Some additional features of SYSTEM 2000 which have already been alluded to include the capability for security down to data element level, back-up, and system diagnostics.

- The security feature allows the data base administrator to set limits not only on the accessibility of the data but also on the copiousness of the retrievals.
- The back-up features of SYSTEM 2000 allow for ease of dumping and loading the data base from disk storage to magnetic tape. There is also the ability to apply updates to an historical copy of the data base for recreation of a damaged data base.
- Diagnostic messages are a feature usually neglected during program development. However, SYSTEM 2000 comes with a complete set of diagnostic messages for all of the subsystem modules.

APPENDIX X.5

Phase II Project Tasks

This Appendix specifies the tasks to be completed in Phase II of the REIS project. Each major heading comprises a sub-project. A report will be produced for each sub-project and all sub-project reports plus a summary of Phase II will be combined into the final Phase II report.

A. Overview (Report)

A discussion of the objectives of this phase of the REIS project and of the system being developed. This report will discuss the system in total and as an assembly of subsystems.

B. General Design

The objectives of the general design are to resolve remaining design issues, estimate volumes, prepare specifications suitable for detailed systems design, and outline plans for implementation

1. Supplier subsystem (Report)

   a. Define data requirements
   b. Develop data collection procedures
   c. Define and describe storage schema
   d. Document data validation rules
   e. Estimate data collection and storage volumes
   f. Prepare subsystem flowcharts and general program specifications
   g. Define interfaces with other subsystems:
      (i) Parameter subsystem
      (ii) Energy Flow Network Model
   h. Prepare implementation plan including:
      (i) development resource requirements
      (ii) time table
      (iii) conversion plan

2. User Subsystem (Report)

   a. Define data requirements
   b. Develop data collection procedures
   c. Define and describe storage schema
   d. Document data validation rules
   e. Estimate data input volumes, frequency of data collection, and storage requirements
   f. Prepare subsystem flowcharts and general program specifications

g. Define interfaces with other subsystems:
   (i) Parameter subsystem
   (ii) Energy Flow Network Model
   (iii) Economic Impact Analysis Project
h. Prepare implementation plan including:
   (i) development resources required
   (ii) time table
   (iii) conversion plans

3. Parameter Subsystem (Report)

   a. Define data requirements
   b. Develop data collection procedures in conjunction with those of the supplier and user subsystems
   c. Define and describe storage schema
   d. Document data validation rules
   e. Estimate volumes (including frequency of change)
   f. Prepare subsystem flowcharts and general program design specifications
   g. Define interfaces:
      (i) Energy Flow Network Model
      (ii) External to REIS
   h. Prepare implementation plan including:
      (i) development resources required
      (ii) time table
      (iii) pilot implementation
   i. Implement temporary procedures and programs to begin collection of parameter value sets

4. Energy Flow Network Model (Report)

   a. Define input requirements and coordinate with other subsystem development tasks
   b. Determine and document output capabilities
   c. Define capabilities of this subsystem for validation interactions with other subsystems
   d. Prepare program specifications including:
      (i) programming language
      (ii) input and output data description
      (iii) discussion of algorithms to be used
   e. Prepare implementation plan including:
      (i) development resources required
      (ii) testing specifications
      (iii) hardware/software requirements

5. Reporting Subsystem (Report)

   a. Continue user survey begun in project Phase I
   b. Analyze joint data collection opportunities and document to include:
      (i) current or planned energy data by other Agencies
      (ii) costs and problems of combining other Agency data into REIS

(iii) potential savings, tangible and intangible, of such combination
(iv) recommended action in each instance
c. Document system reporting capability:
(i) routine and exception reports including content, format discussion, use, and user
(ii) demand reporting capability
(iii) on-line reporting capability and incremental hardware/software requirements
d. Specify reporting program and/or software requirements
e. Prepare implementation plan including:
(i) development resources required
(ii) time table

6. REIS User Documentation Design (Report)

a. Identify REIS information users
b. Classify information users and outline documentation requirements to support each class identified
c. Prepare plan for the preparation of user documentation including:
(i) format
(ii) time table
(iii) development resources required

C. Cost/Resource Analysis (Report)

1. Estimate development costs and resource requirements

a. Prepare detailed requirements by subsystem for:
(i) systems analysis
(ii) programming
(iii) testing (including machine components)
(iv) conversion and start up
b. Prepare cost schedules for each subsystem and overall

2. Estimate recurring system costs and resource requirements

a. hardware and software purchase or rental and amortization
b. alternatives and associated cost differences
c. maintenance costs
d. operating personnel requirements and costs

D. Overall Implementation Plan (Report)

1. Detailed implementation schedule for the entire project

2. Recommended responsibility assignments among:

a. Energy Agency
b. Department of Administration
c. University of Minnesota
d. Contracted services

E. Summary (Report)

The final report will consist of the detailed reports produced during the span of Phase II of the REIS Project. The summary will identify potential problem areas and will identify alternatives and decisions required. Finally, this report will discuss research remaining to be undertaken to continue the development of energy management information systems.