APPENDIX 3.3

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ENERGY PLANNING ANALYTICAL NEEDS
for the
EGYPTIAN ORGANIZATION FOR ENERGY PLANNING

prepared by

Center for International Energy Development
Energy and Environmental Systems Division
Argonne National Laboratory

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ENERGY PLANNING ANALYTICAL NEEDS for the EGYPTIAN ORGANIZATION FOR ENERGY PLANNING

1 BACKGROUND

In April 1983 the Government of Egypt created the Organization for Energy Planning (OEP). The organization was designed as the technical support staff for the Supreme Council on Energy. Among other responsibilities, OEP was charged with providing the Supreme Council with technical studies of energy issues to be used to support the decision-making process. These studies were to be carried out by OEP staff using the most appropriate analytical methods.

The purpose of this report is to define the analytical tools needed by OEP to carry out its function and to recommend the selection of specific tools for implementation at OEP.

In the course of this review, the terms "model" and "analytical tool" are used. In a narrow definition these would refer to specific computer programs with specified structure, input, and output. In a broader sense, the terms would refer to a computational procedure or methodology that may or may not include computer models. It is this broader definition that is employed here. The analytical needs of OEP are considered in terms of data bases, computer models, and analytical structures.

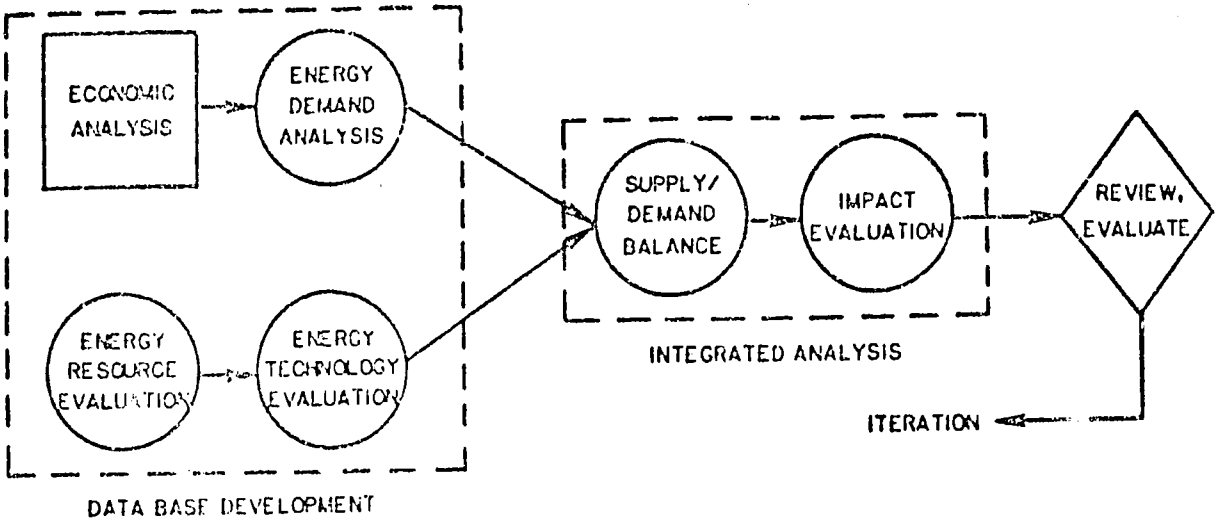
2 THE ENERGY PLANNING PROCESS

The energy planning process requires a complex interaction of professionals from many disciplines: economists, engineers, geologists, operations researchers, and others. The procedure whereby the efforts of each of these individuals is integrated into a concise and coherent picture for use by decision makers is not a straightforward and mechanical operation. Rather, it involves an extensive exchange of specialized studies in specific areas and an integration of these results into a unified whole. Also, the energy planning process is a continuing and iterative procedure that constantly increases the quality of the information and the sophistication of the analysis.

In its supporting role to the Supreme Council on Energy, OEP will need to conduct a wide range of studies. Some will be brief issue papers involving the identification of problems. Others will be major studies taking person-years of effort to complete. Some will address individual energy projects while others will deal with the national energy picture. OEP will need to draw on the technical experience and studies done in other organizations. It will also have to do its own original analyses.

Figure 2-1 illustrates a basic structure for the energy planning process. There is a division of tasks into two groups: Data Base Development and Integrated Analysis. The Data Base Development is designed to assemble all of the necessary information required to conduct an energy analysis.

Figure 2-1 Basic Structure for an Energy Planning Analysis



Because of the diversity and extensive quantity of information needed, this is not a minor undertaking.

The Data Base Development begins with an economic analysis. This is the fundamental set of information upon which the energy analysis is based. The economic analysis includes historical and projected information on the structure and size of the economy. The data include economic forecasts, population growth projections, and other socioeconomic indicators.

The second step in Data Base Development is the energy demand analysis. This step is designed to translate the economic data into energy requirements. Information developed from this step includes historical energy consumption patterns, distribution of energy consumption by useful energy demand, and projections of future energy demand tied to the economic projections.

Simultaneous with the economic and energy demand analyses, data on energy supply must be assembled. The first part is an energy resource evaluation. This involves the determination of available energy resources in the country. It includes fossil fuels (oil, gas, coal), nuclear materials (uranium and thorium), and renewable resources (solar, wind, biomass, hydropower).

Along with energy resource estimates, an evaluation of energy supply system technologies must be made. Cost and performance data for fossil fuel technologies (e.g. refineries, coal processing plants), renewable resource technologies (e.g. solar water heaters, biogas digestors), and electric power technologies (e.g. oil-fired boilers, steam turbines, nuclear plants) must be gathered. Data for both the existing energy supply system and potential candidates for the future system must be collected.

The Integrated Analysis is designed to assemble the data into a consistent picture to provide decision-making information. The first step is to construct a supply/demand balance for the energy system under a series of assumptions about economic growth and supply system configuration. A set of balances is constructed for other assumptions so that the results of alternative scenarios may be compared. For each balance constructed, an impact evaluation is carried out. This determines effects such as capital cost requirements, foreign exchange requirements, environmental effects, employment impacts, etc. of the alternative balances.

The entire process of evaluation is reviewed and repeated to give a comprehensive picture of the viability of alternative developments of the energy system. This is the analytical information presented to decision makers.

To carry out energy planning in this framework requires three fundamental sets of analytical tools. First is a set of data bases from which information can be drawn with ease. Second is a set of models, either computerized or manual, that will allow the planner to make computations regarding the energy system. Third is an analysis procedure that will provide a structure to the work. Each of these three requirements are described in the following section.

3 ANALYTICAL REQUIREMENTS

3.1 DATA BASES

The heart of the energy planning process is the data used for analysis. There is already available in Egypt a sizable quantity of information regarding the energy system. However, much of it is in reports and contractor studies that do not allow for rapid retrieval of consistent information. One of the primary needs is for energy data structured in such a way as to allow for this type of retrieval. The type of data bases needed by OEP include the following:

Economic parameters

Sectoral energy use

Energy resource information

Energy supply system characterization

These data need to be cataloged in such a way that an analyst can get quick access to needed information.

3.1.1 Economic Parameter Data Base

OEP needs to have current and historical records of basic economic parameters including GNP (disaggregated by major sector and meaningful subsector), population, personal income and other social and economic variables. These are used to correlate patterns of energy use to economic variables and to project future trends based on economic growth.

The bulk of this information already exists in statistics compiled by the Central Agency for Public Mobilization and Statistics (CAPMAS). Much of it is published and generally available. OEP needs to develop its own data bank of relevant statistics, using the CAPMAS information, that can be used consistently for all studies.

3.1.2 Sectoral Energy Use Data Base

The historical and current patterns of energy consumption by major sector and subsector need to be compiled into a consistent data base. The major sectors would include industry, agriculture, households, transportation, commercial/institutional, and others. The subsectors can be selected appropriately and might include activities such as cement, aluminum, fertilizers, textiles, iron and steel in the industry sector; urban and rural in the household sector; passenger and freight in transportation; and others.

Basic data for each of the sectors would include activity level (e.g. tons of cement produced, sales of textile goods, number of households, passenger-km traveled), energy consumption by fuel type and efficiency of energy-using equipment. This basic data would be connected to useful energy

demand and distributed by useful energy demand category (e.g. steam, direct heat, motive power, cooking, lighting).

These data are generally not available in Egypt in a comprehensive form. In some sectors or subsectors specialized studies have been done but there is no comprehensive collection of information. Likewise, there is not now any compilation of what information does exist so that most of the piecemeal data are not available for rigorous study.

The data from CAPMAS' surveys represent the most complete set of information; however, this is not sufficient for OEP's needs. The most pressing need is to assemble what is available into a usable format and to develop a systematic program for the collection of missing information.

3.1.3 Energy Resource Data Base

Because of Egypt's fossil fuel resources, there is a wealth of information regarding available oil, gas, and coal. Not all of it is consistent, nor is it without any gaps; nevertheless, there is a good base of information to draw on. The best sources of data on fossil fuels are the Egyptian General Petroleum Corp. and the Egyptian Geological Survey. These organizations have their own files and data bases for storing information; however, these are not in a format suitable for OEP's planning needs. A smaller, more carefully targeted data base is needed by OEP. Historical and current oil, gas, and coal production rates need to be included.

In addition to the fossil fuels, resources of nuclear materials (uranium and thorium) need to be cataloged. The Egyptian Geological Survey and the Nuclear Power Plant Authority have whatever information is available. Again, it is not necessarily in the format needed by OEP.

3.1.4 Energy Supply System Data Base

The structure and characteristics of the current energy supply system in Egypt needs to be compiled. This can be divided into the fossil fuel system, the electric system, and renewable resources.

For the fossil fuel system, the location and operating parameters (including costs) of the refineries need to be compiled. The various pipelines and other means of transporting crude oil and petroleum products need to be cataloged. The historical and current refinery throughput and product slates need to be tabulated.

For natural gas, data on gas processing plants and pipelines need to be tabulated. Also, historical and current production, shipment, and gas sales need to be recorded.

Coal, although not in widespread use in Egypt, has been utilized. The characteristics of the mining and coal transportation system need to be defined.

The electric system data required by OEP includes the number, type (hydro, steam, gas turbines, etc.), and performance of the generating units, the characteristics of the transmission system, and the statistics on electricity sales by consumer (both historical and current). All of this information is available from the Ministry of Electricity, although not in the format OEP needs. An electricity data base needs to be specially designed for OEP.

Renewable resources include solar, wind, biomass and any other renewable energy form. Many studies have been done on one or more of these resources but there is no comprehensive and consistent set of information. The data required includes the extent of the available resource, performance of various technologies, costs, and possible technology deployment scenarios.

3.1.5 Data Base Management System

Each of the preceding four data sets (economic, sectoral energy use, energy resources, and energy supply system) can be viewed as a file of information. Of principal interest to OEP is a data base management system that will allow rapid access to each file in an easy-to-use fashion. Also, the files must be able to be updated with more recent information on a regular basis.

Some of these files are large enough to warrant computerization. Other files may be small enough to be handled manually although computerization could be employed for convenience.

The computerization will require the choice of a data base management system (DBMS) that can handle the different types of files. A relational DBMS that allows the user to selectively call out pieces of information and to update the data base easily is clearly the system of choice. Once the DBMS is chosen, the four data sets can be structured appropriately.

3.2 MODELS

There are six sets of models that OEP will need to carry out its energy planning studies. Recalling that the term "model" is used in its broadest definition to include computational procedures as well as specific computer programs, the six are:

Macroeconomic growth model

Energy demand forecasting model

Integrated supply/demand balance model

Energy-sector-specific analysis models

Energy system impacts model

Project-specific evaluation model

3.2.1 Macroeconomic Growth Model

The principal force that drives the demand for energy is economic growth. The size and structure of the economy generates a demand for energy. The role of the energy planner is to determine how best to meet that demand.

OEP will need to have a method for describing the current size and structure of the economy and for projecting future economic growth. This method will also need to describe social variables such as population, income distribution, geographical demographics, etc. This method may be a computer model (or set of computer models), a manual computation scheme, or a combination of both.

A key issue in the consideration of the choice of analytical approach is the methodology used by the Ministry of Planning. This Ministry has the primary responsibility for conducting economic and socioeconomic studies in Egypt. For the basic economic analyses used to formulate energy policy, OEP should rely on the work of the Ministry of Planning. This will allow for a consistent set of assumptions to be used and will avoid duplication of effort.

With this fundamental premise of relying on the Ministry of Planning for basic economic studies, the economic model(s) selected for OEP must be chosen to supplement the Ministry of Planning's analytical tools. The OEP economic model(s) must meet the following criteria:

(a) The model(s) must consider all of the major energy-consuming sectors of the economy in sufficient detail to allow for an analysis of energy strategies,

(b) The model(s) must address the medium-term (5-10 year) and long-term (10-30 year) planning horizon required for energy investment decisions,

(c) The model(s) must be sensitive to the price of energy and the capital requirements of the energy sector in forecasting economic growth,

(d) The model(s) must allow for easy evaluation of a number of economic and social scenarios that have an influence on energy demand,

(e) The model(s) must utilize Egyptian historical information as a basis for forecasting and allow an update of the basic parameters as new data become available,

(f) The model(s) predictions must be able to be validated against actual information, and

(g) The model(s) must be usable by OEP staff with in-house capability.

The alternative approaches that meet these criteria are discussed in a later section.

3.2.2 Energy Demand Forecasting Model

The second model (or set of models) needed by OEP is an energy demand forecasting model. This tool will use the results of the economic analysis model as input and will generate projections of energy demand as output. This model can be viewed as a "translator" that takes projections of economic growth and "translates" them into corresponding projections of energy demand.

The energy demand forecasting model deals with all of the energy-consuming sectors: industry, agriculture, households, transportation, etc. For each sector the model utilizes some measure of activity (e.g. tons of material produced, vehicle-kilometers traveled), current energy consumption patterns, and forecasts of growth to project future energy demand. The model must satisfy the following criteria:

(a) All major energy-consuming sectors must be included,

(b) The detail contained in each sector must allow for consideration of current energy use (by fuel type), possible future fuel-switching, energy conservation opportunities, and sensitivity of demand to energy prices,

(c) The model must be based on sound economic principles relating energy demand to level of economic activity,

(d) The model must be able to be tied to the outputs of the economic analysis model.

It is possible that the energy demand forecasting model may take the form of a separate procedure for each sector and/or a separate procedure for each energy type (e.g. electricity demand, petroleum demand). In any case, all sectors and all energy types must be available for OEP.

3.2.3 Integrated Supply/Demand Model

An integrated supply/demand model is designed to use the results of a demand forecast as input and generate the "optimum" energy supply system to meet that demand. The integrated model is also used as a means of tracing historical energy flows when it is applied to either the current or earlier year data.

The integrated supply/demand model traces energy flow from primary resource through to delivery to end user. It includes all energy supply systems (fossil fuel, electric, renewable resource) and accounts for all the demand sectors (e.g. industry, agriculture, households). It does the analyses for supply systems and demand sectors simultaneously so that the effects of changes in one part of the system can be seen as changes in other parts. This is the reason for the term "integrated."

The model balances energy flows throughout the supply and demand sectors. It gives a complete accounting of all energy use based on the economic projections and the energy demand forecasts.

This type of model is especially important to OEP, since there is no other energy organization in Egypt charged with the responsibility for taking this type of integrated perspective. This model will be one of the most important tools for OEP since there is no other similar analytical procedure available in Egypt.

The integrated supply/demand model must satisfy the following criteria:

(a) It must include all energy demand sectors and supply system components,

(b) It must trace energy flows from primary resource through to delivery to end users,

(c) It must be based on sound economic theory of energy supply and demand,

(d) The model must be sensitive to changes in energy price assumptions,

(e) The model must allow for analysis of a wide variety of scenarios regarding demand growth and supply system configuration,

(f) It must utilize historical data on the balance of supply and demand and be able to be updated easily,

(g) Its projections must be validated against actual performance, and

(h) Its level of disaggregation must be sufficient to allow for analysis of individual energy projects as well as general energy supply trends.

There are numerous analytical algorithms available for constructing supply/demand balances. These are discussed later.

3.2.4 Energy Supply Sector Specific Models

The integrated energy supply/demand models described in the previous section treat the entire energy system. To do so, they must necessarily reduce the level of detail considered in each individual sector to make the computational process manageable. To supplement the results of the integrated models, a series of sector-specific models are required. These would treat only one particular sector (for example, electricity, petroleum, coal) but would do so in more detail.

It is at this point in the analytical process that OEP must interact with other Egyptian organizations dealing in each sector. It is not desirable for OEP to reproduce the analysis capability and modeling experience that exists in other sectors. To do so would be a duplication of effort and would present potential conflicts between OEP and other groups. Rather, OEP staff should develop a familiarity with the analytical procedures used in these other groups so as to better understand the results that are generated. This

familiarity can be gained by using the same models and analytical methods but at a much less intense level of activity.

In particular, the sector-specific models that need to be exercised by OEP are: electric sector expansion models, oil and gas reservoir models, petroleum refining models, gas sector models, coal models, and renewable resource technology models. Each of these models must meet the following criteria:

(a) The sector model (or at least one of the sector models) must be the same as used for planning in that sector (for example, at least one of the electric sector models must be the same as the one used by the Ministry of Electricity),

(b) The sector model must treat the issues in the sector (for example, capacity expansion, reliability, reservoir depletion) in sufficient detail to allow evaluation of individual projects,

(c) The sector model must be formulated in such a way as to be theoretically sound and suitable for use in investment decisions,

(d) The sector model should have a reasonable history of application in other countries (or in Egypt) so as to have a measure of reliability associated with its results, and

(e) The sector models should be recognized and accepted by professionals in the sector.

As indicated by these criteria, the choice of sector-specific models for OEP is heavily influenced by what is used in other Egyptian organizations.

3.2.5 Energy System Impacts Models

After the integrated supply/demand models and the sector-specific models have been exercised, an analysis of the effects and impacts of the proposed supply system configuration needs to be carried out. A model or set of models that addresses the following impacts needs to be implemented:

- Capital funds requirements,
- Operating funds requirements,
- Foreign exchange requirements,
- Labor requirements,
- Special materials requirements,
- Environmental effects, and
- Socioeconomic effects.

Other parameters necessary to the decision-making process may also be required. The model must be able to take as input the proposed configuration of the energy supply system that has been developed by the previous studies and determine the above parameters. The parameters are computed for as many alternative configurations as are under consideration so as to give decision-makers the ability to compare one approach against another. In a sense, the impacts evaluation model(s) generates the kind of information most important to the decision process.

It is not likely that any one computer model will be able to provide all of the above parameters. In general, a set of models combined with manual computations will be required. The models selected must meet the following criteria:

(a) The models must address the important impact parameters identified above,

(b) The models must compute the parameters in generally accepted and theoretically sound approaches,

(c) The models must be able to be exercised for a number of alternative scenarios in a convenient and expeditious manner so that the alternatives may be compared, and

(d) The models must be readily coupled to other analysis routines so as to provide for ease of use.

Available analytical tools are described later.

3.2.6 Project-Specific Evaluation Models

Most of the previous analytical tools have been concerned with evaluating the entire energy system or a major component of it. In addition to these analyses, OEP will have to carry out studies on individual energy projects and individual facilities. These types of studies will be most important when dealing with projects that will require justification for capital financing. The analysis procedures required for these studies include computation of cash flow (discounted to present value), return on investment, payback period, and others. OEP will require the ability to carry out these computations for individual projects as part of its responsibility to make specific energy project recommendations to the Supreme Council on Energy. Models to be used must meet the following criteria:

(a) The models must be able to compute all of the necessary financial parameters required for a project evaluation,

(b) The models must use techniques that are accepted by international lending institutions that might be involved in financing the projects, and

(c) The models must be easy enough to apply to a large number of projects with minimum effort.

3.3 ANALYTICAL PROCEDURES

In addition to the data bases and models to be used, analytical procedures must be developed by OEP to assemble, integrate, and utilize the information. These procedures are not as easy to prescribe as the data bases or the models since they are primarily organizational approaches and are not items that can be purchased in the marketplace. In effect, OEP must organize itself to carry out the energy planning work in an efficient manner. The

organizational structure must recognize the continuing nature of the planning process and must be established with a view towards the procedures being carried out on a regular (for example, annual or biannual) basis.

3.3.1 Data Collection Procedures

As previously indicated, data requirements for OEP's energy planning are extensive. Also, the data must be assembled from a variety of other Egyptian organizations. A systematic procedure must be established to assemble the data, review it for missing information and obvious errors, load it into the OEP data files, and have it available for use by analysts. The specific procedures required are:

Assembly of Data from Other Organizations. Standardized and routine procedures for transferring data from other Egyptian organizations to OEP must be established. These procedures must provide for a routine transfer of information in a timely fashion and in a readily useable format. The principal organizations with whom such procedures need to be established are the Egyptian General Petroleum Corporation (EGPC), the Egyptian Electricity Authority (EEA), the Egyptian Geological Survey (EGS), and the Central Agency for Public Mobilization and Statistics (CAPMAS). The procedures need to define the data to be transferred, the frequency with which it will be provided to OEP, the format in which it will be provided, and a mechanism by which OEP can obtain clarification and more detailed information where needed. These procedures apply to data that are routinely collected by the other organizations and to data that are collected by these organizations at the special request of OEP.

OEP Processing of Received Data. Whenever a data set is received by OEP from another organization, it must be reviewed and processed by OEP before being used. The data must be checked for missing items, must be reviewed to identify obvious errors, and must be loaded into the OEP data base files for access by analysts. It is important for OEP to establish standard procedures for carrying out this data processing function or information that is received will be lost, will go unverified, and may result in the propagation of errors into all subsequent studies that use the information. The implementation of these procedures requires the efforts of computer data specialists, statisticians, and engineers familiar with the technical contents of the data sets.

Maintenance and Service of Data Files. In order for the data bases that are created to be used, it is important that the information be up to date and readily accessible by analysts. Procedures must be established to keep the data files current as new information is acquired and to provide services to analysts who need information but who may not be familiar with the computerized data systems. OEP needs to establish a procedure whereby an analyst can request a certain set of information from the OEP files and have it provided to him in a timely manner.

3.3.2 Model Installation, Maintenance, and Development

The models that OEP uses will be obtained from different sources and will require installation on OEP computer equipment (if the model is a computer code) and will require continual maintenance to insure that updates

to the model are made available to OEP analysts. In addition, new models will have to be developed to meet evolving requirements. As part of its analytical procedures OEP needs to establish standardized practices in the following areas:

Acquire and Install New Models. Procedures will need to be developed that provide for the acquisition of new models and the installation of them on OEP computer equipment. In some cases modifications to computer codes will be necessary. Appropriate documentation and user's manuals will have to be obtained and made available to OEP analysts. It is important that this be done in a systematic way so as to insure that all models are available to all potential users and the ability to use them will be spread to all OEP staff.

Maintain Existing Models. Existing models will have to be replaced with updated versions as modifications are made. OEP must arrange for these updates to be acquired on a regular basis and for the latest versions to be made available to all staff on a regular basis.

Develop New Models. On occasion new models and analytical tools will need to be developed. As these needs are identified an systematic effort to develop the necessary software will be required. Analysts and computer specialists will need to work together to prepare the necessary codes in a format that is accessible to all OEP staff. It is important to avoid situations where only one person is familiar with a code and it is unavailable to other staff.

3.3.3 Analysis Techniques

OEP must maintain consistency and high quality in the conduct of each energy analysis. While it is theoretically desirable to develop a standardized way of conducting energy studies so that the results are of a consistent high quality, it is practically impossible. Each analysis will require new approaches and information and it will not be possible to prescribe a standard method of carrying out all studies.

With this important caveat, it is conceivable that as OEP conducts more analytical work it will be possible to prescribe a set of procedures that can be followed for a particular type of analysis. For example, if a national energy demand forecast becomes an activity that OEP will be carrying out on an annual basis, then the techniques and data sets used to develop that forecast can be standardized (within limits). This will enable the results of one year's analysis to be compared to results from prior years. It is important in these situations to prescribe enough standardization to allow for consistent comparisons while not, at the same time, over-standardizing the procedure so as to stifle innovative approaches. At this point it is not possible to determine what types of studies OEP will be carrying out on a repetitive basis and might be subject to some measure of standardization. This will come only after more experience is gained. Nevertheless, it is important to keep in mind that this type of consistent approach needs to be developed at some point in the future.

4. ALTERNATIVES AND RECOMMENDATIONS

The following discussion of alternatives and recommended courses of action for OEP is not intended to be a comprehensive review of all alternative data bases, models and analytical procedures. Such reviews have been carried out extensively elsewhere. Rather, the discussion is focused on those alternatives that are realistic choices for OEP at this point in its organizational development. The recommendations are based on Argonne experience with data bases and models used in a number of developing countries.

Figure 4-1 is a preliminary network describing the energy system in Egypt. It is a structure that can be used to organize the data to be collected and the models that need to be applied. (A more detailed network is included in Appendix A.) The primary component is the economic growth analysis (Box 1). This is the portion that requires the economic growth data and the macroeconomic growth models. Next in sequence are the energy demand sectors (Boxes 2.1 to 2.8). These are the components that require the sectoral energy use data and the energy demand forecasting models. Finally, there is the energy supply system (Boxes 3.1 to 3.7) that uses the energy resource and energy supply system data, the integrated supply/demand models, the energy sector specific models, the impacts models and the project specific models. The following sections describe the alternatives and recommendations for each of these components.

4.1 ESTABLISHMENT OF THE DATA BASE

The establishment of the OEP data base, comprised of the four sets of information previously described (economic parameters, sectoral energy use, energy resource information, energy supply system information), is a high priority task. The most pressing need is to assemble available information into a form that is readily accessible by all OEP staff. This is a far more pressing requirement than the need to gather new primary data (for example, from surveys). The assembly of existing information and the creation of a data base structure to handle this information will lay the groundwork for future, more elaborate data-gathering efforts.

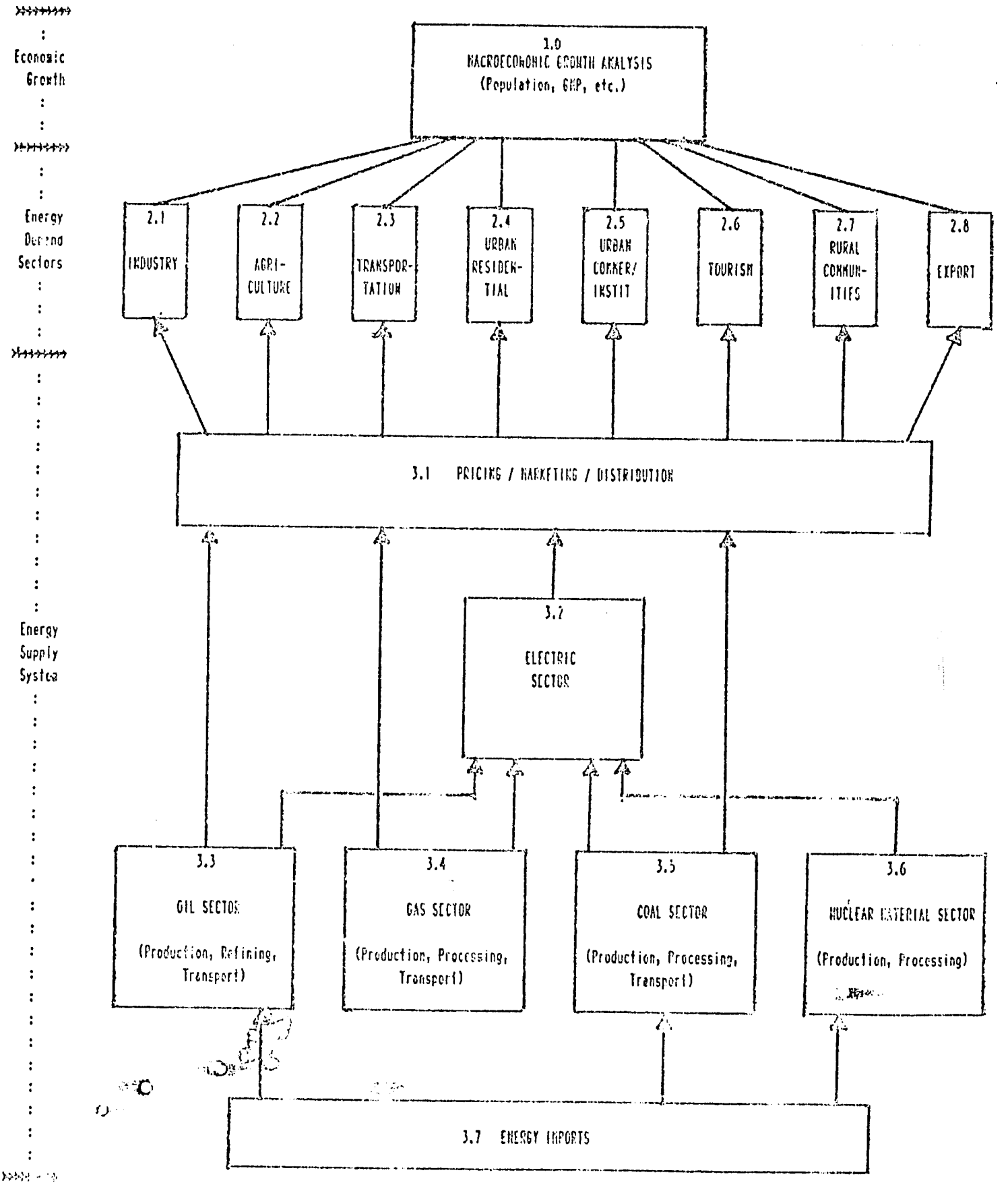
The recommended course of action in establishing the data base is comprised of the following steps:

- Assemble available information,
- Choose data base management system (DBMS),
- Structure, load, and check data files, and
- Develop user access procedures.

4.1.1 Assemble Available Information

There are three basic choices for OEP in the development of its data sets: assemble information from published literature, request special unpublished information from other agencies, and collect its own primary data from surveys. The primary emphasis at this point is on the first two methods. The third will be deferred to a later date.

Figure 4-1. Preliminary Energy Supply and Demand Network



Economic Parameters (Box 1 of Figure 4-1) For this type of information there are sufficient data from published sources to allow OEP to construct an adequate data base. There is not any immediate need to request any special studies or surveys by the Ministry of Planning and/or CAPMAS to add to the economic information already available. The immediate task facing OEP is to develop a data base structure for economic parameters and to fill in that structure with existing information. The primary data sets required for the data base are:

- GNP - disaggregated by major sector and subsector,
- Population - disaggregated by region and urban area, and
- Personal income - disaggregated by income class.

Other social and economic data can be added at a later time to complete the data file.

Sectoral Energy Use (Boxes 2.1 to 2.8 of Figure 4-1. Also see more detailed network in Appendix A.) For this type of information there are sufficient data available from published sources or from available but unpublished records in other agencies. For each sector the information required includes:

- Activity level,
- Energy consumption by fuel type,
- Type and efficiency of energy-using equipment, and
- Distribution of energy consumption by useful energy demand category.

Data on energy consumption in the major sectors of industry, households, and transportation are available from CAPMAS, EGPC, and EEA. There are varying levels of disaggregation to subsectors but a sufficient amount of detail is available for the first OEP data set.

For the commercial/institutional, tourism and agriculture sectors data are not as comprehensive but aggregate totals are available. It is not necessary at this initial stage to undertake any primary data surveys since consumption in these sectors is small relative to the other major sectors.

For non-commercial fuel use in rural communities there is generally very little data. The most complete set exists in a study recently completed but not yet published by the National Research Council. This was done under the auspices of the United Nations Environment Programme. This should be adequate as a starting point.

For the export sector the records of EGPC on petroleum exports should be more than adequate to establish the historical pattern of energy exports.

It is important that, for all sectors, historical data covering at least the last 20 years be compiled wherever possible. This will allow for time series analyses of energy consumption patterns. It is anticipated that earlier years may have less detailed data but should still be adequate for basic computations.

Energy Resource Information (Boxes 3.3 to 3.6 of Figure 4-1 and the more detailed network of Appendix A) At this point in time only a limited

amount of information on energy resources is needed by OEP to satisfy analysis requirements. Specifically, the data required include:

- Oil, gas, and coal reserves by field,
- Historical production rates, and
- Rate of additions to reserves.

EGPC and EGS are the best sources of this information. Much of these data are already published by these organizations and there should be little difficulty in OEP obtaining the required information. For this information, computerization may be a matter of convenience rather than necessity since the quantity of information is not exceptionally large.

Energy Supply System Information (Boxes 3.1 to 3.7 of Figure 4-1 and the more detailed network of Appendix A) Two documents have already been prepared for OEP describing the data needs for the energy supply system.[1,2] Some of this information has been gathered already by OEP. It has not yet been structured into a data base format that is readily usable by all staff.

4.1.2 Choose Data Base Management System

The choice of the DBMS depends on the type of computer hardware selected by OEP. At this point two alternatives are under consideration: a centralized system based on a minicomputer, and a decentralized system based on a linked set of microcomputers. If the centralized system is selected, then the choice of DBMS software will be made by default. (The procurement package for the centralized system includes data base software as a specific deliverable.)

If a decentralized system is selected, then a wider variety of DBMS software is available. A review of microcomputer-based DBMS software by Argonne staff indicates that dBase III, published by Ashton-Tate, Inc. is the most appropriate for OEP. Other software packages offer different features and are, in some cases, simpler to learn, but dBase III offers the full DBMS capability for the type of needs OEP has.

dBase III has already been purchased for OEP and can be used immediately on the equipment currently in Cairo. This same software can be used with an expanded decentralized computer system, should this be chosen.

4.1.3 Structure, Load, and Check Data Files

With the assembly of available data and the selection of the DBMS, the next step is to define the data base formats for the computerized files and to load and check the files. This effort will establish the structure to be used for future data collection procedures.

For each of the four sets of information a data base structure, using the chosen DBMS software, will have to be developed. The structure may consist of a series of files for each data set. For example, for the economic parameters one file may contain information on GNP data, another file may contain population data, and another may contain personal income data. For

the sectoral energy consumption data set one file may contain the industrial consumption data, another the transportation consumption, and another the household consumption. The format for each file for each set of information must be set up using the DBMS chosen. This will provide the necessary structure to compile the available information in a consistent manner. Procedures for defining the data base formats vary with each software type. OEP computer staff must work with the economics and engineering staff to design these formats. Some outside assistance may be necessary to start the process.

Once the structure is defined, the available information can be loaded into the data base and checked for errors. While this is a relatively mechanical operation, it is important that a great deal of cross-checking and quality control be exercised. Since the data base will be used for subsequent studies it is vital that the information loaded be as accurate as possible. Procedures in which one person verifies the inputs of another must be set up to minimize the errors inherent in dealing with a large volume of information.

Although the primary emphasis at this point is on developing the initial data base for OEP to use, the structure and the loading and checking procedures will become standardized for future efforts. Care must be taken in designing both the formats and the loading and checking procedures so that these can be used over and over again in future work.

4.1.4 Develop User Access Procedures

Once the data files have been loaded and checked they must be made available for all OEP staff to use. Since the material will be computerized there are two basic ways that information can be made available. First, the OEP staff who will need the information can be trained in the use of the DBMS software and can retrieve any data they require in the formats they desire. This is a desirable approach in that it gives the analysts full access to the information in the data base. It has the disadvantage that some analysts may not want to become expert enough in the computer system to learn the data base software.

An alternative approach is to have the OEP computer staff prepare standardized reports from the information in the data base. Hard copy tables of the relevant information could be made available on a regular basis for use by the analysts. For example, a report on energy consumption by sector could be prepared on a regular basis for use by all. A variation on this is that the analysts can request special reports be prepared for specialized studies.

It is likely that both approaches will be needed to effectively utilize the data base system. Training should be made available to all analysts on the use of the DBMS software. Simultaneously, a series of standard reports that will have the widest use should be identified and prepared by the computer staff on a regular basis.

4.2 DEVELOPMENT OF THE MODELING SYSTEM

Table 4.2-1 shows several alternatives for the development of the OEP energy modeling system. The alternatives for each of the six modeling areas described in Section 3.2 are shown. These alternatives represent possibilities for OEP implementation and are not intended to represent a comprehensive set of all models available.

Figure 4.2-1 shows how the models could be implemented by OEP. The Basic System is based on the development of those models that are most important to OEP's functions and the use of the most straightforward approach. The Expanded System is based on developing a comprehensive energy modeling capability in OEP and uses the full range of modeling approaches.

4.2.1 Macroeconomic Growth Models

These models are designed to carry out the economic analysis indicated in Box 1 of Figure 4-1.

For the Basic System the use of assumed growth rates and trend extrapolation are the most appropriate techniques. These approaches require basic assumptions regarding economic growth patterns and the use of standard statistical analysis techniques (for example, regression analysis) to develop forecasts of economic growth. Both of these methods can be implemented immediately by OEP staff economists, who have the necessary training and experience. Coordination with the economic projections made by the Ministry of Planning is required.

The Expanded System would involve the use of a more sophisticated economic model such as an input/output model or an econometric model. The development and application of these models is more appropriately done in the Ministry of Planning. OEP's involvement in these types of modeling efforts would be to analyze special cases that are beyond the Ministry of Planning's activities. There are two ways this expanded economic modeling capability can be implemented. First, arrangements can be made with Ministry of Planning staff to have any special cases needed by OEP carried out at the Ministry. This would require Ministry personnel to work with OEP personnel to define the particular case and conduct the analysis with Ministry analytical models. The second alternative would be for an appropriate version of the Ministry's models to be made available at OEP where OEP staff could utilize them directly. In both approaches it is vital that OEP coordinate its economic analyses with the Ministry of Planning to avoid inconsistent approaches.

4.2.2 Energy Demand Forecasting Models

Referring to Figure 4-1 (Boxes 2.1 to 2.8) and the more detailed networks of Appendix A, these models are designed to translate the macroeconomic forecasts developed above into energy demand forecasts by sector.

Table 4.2-1 Alternative Models

Analytical Requirements	Alternatives	Comments
Macroeconomic growth model	Assumed growth	Requires little analysis. Based only on assumption.
	Trend extrapolation	Uses statistical evaluation of historical time series.
	Input/output model	Major data effort. Not appropriate unless supported by Ministry of Planning.
	Econometric model	Major analytical effort. Not appropriate unless supported by Ministry of Planning.
Energy demand forecasting model.	Manual Computation Elasticity on fuel use Useful energy demand	Straightforward to implement.
	MAED model	Demand model supported by International Atomic Energy Agency. Emphasis on electricity forecasting.
	DEMAND model	Microcomputer model for energy demand. Available end 1985.
Integrated supply/demand balance model.	Manual balance	Suitable for base year. Tedious for evaluating future years and alternatives.
	Argonne Integrated Demand and Energy Supply (IDES) model.	Microcomputer model available end 1985. Mainframe version already available.

Table 4.2-1 (Continued)

Analytical Requirements	Alternatives	Comments
Energy Sector Specific models.	Electric system Screening curves	Need to coordiante with EEA. -Straightforward approach for generator expansion.
	WASP model	-Model supported by International Atomic Energy Agency, in use at EEA, microcomputer version available end 1985.
	Refinery operation	Need to coordinate with EGPC.
	Petroleum reservoir	Need to coordinate with EGPC.
Impacts models	Manual calculation of impacts	Straightforward. Tedious for many alternatives.
	Energy Supply Planning Model (ESPM).	Computer model developed by Bechtel, Inc. Data base needs updating.
Project-specific models	Manual calculations of financial parameters.	Straightforward. Tedious for many projects.

Fig. 4.2-1 Basic and Expanded Modeling System for OEP

	MACRO-ECONOMIC GROWTH	EMERGY DEMAND FORECASTING	INTEGRATED SUPPLY/DEMAND BALANCE	ENERGY SECTOR-SPECIFIC	IMPACTS	PROJECT-SPECIFIC
BASIC SYSTEM	0 Assumed growth 0 Trend extrapolation	0 Manual computation	0 Manual balance 0 IDES model	0 Electric System -screening curves -WASP model	0 Manual computation	0 Manual computation
EXPANDED SYSTEM	0 Use of Ministry of Planning models	0 MAED model 0 DEMAND model	0 N/A	0 Refinery operation 0 Petroleum reservoir	0 ESPM	0 Specially-tailored system

For the Basic System OEP can use a manual calculation procedure to forecast energy demand. In its simplest form this involves the application of a specified growth rate (from the macroeconomic analysis) to current energy consumption rates. This can be modified by using elasticity parameters to capture changes in energy use patterns. The manual approach can be implemented immediately by OEP staff. Several have already carried out this type of energy demand forecasting as part of a training exercise at Argonne and as part of other work done prior to joining OEP.

For the Expanded System two specific computer models can be added to OEP's capabilities: the MAED model and the DEMAND model. The MAED (Model of the Analysis of Energy Demand) model is a simulation model of energy demand that is supported and made available through the International Atomic Energy Agency (IAEA) in Vienna, Austria. It is documented in several places.[3,4] The primary focus of MAED is on electricity demand forecasting although other fuels are included in an aggregate way. One of the principal advantages to MAED is that it is supported by the IAEA and there are regular courses scheduled for users. MAED is relatively straightforward to implement and has been used in several developing countries with IAEA assistance.

DEMAND is a model being developed for the U.S. Department of Energy by Argonne as part of the Energy and Nuclear Power Evaluation Program (ENPEP). It is a microcomputer-based code that deals with all energy forms. It can conduct energy demand forecasts using either simple elasticity computations or a more detailed useful energy demand procedure. DEMAND will be available for distribution at the end of 1985.

Both MAED and DEMAND will give OEP a more convenient way to prepare energy demand forecasts for a variety of economic and other scenarios.

4.2.3 Integrated Supply/Demand Balance Models

Refering to Figure 4-1 and Appendix A, these models are designed to construct a complete supply/demand balance from basic energy resource through to final energy users.

As shown on Figure 4.2-1 it is being recommended that OEP begin with a computerized model for both the Basic and Expanded System. The primary reason for this approach is that there is now no other organization in Egypt with either the mandate or the organizational framework to do this type of integrated analysis. Integrated energy analyses are one of OEP's main functions and it is important to develop the necessary analysis methods as quickly as possible.

There are many analytical models available to carry out this type of effort.[5,6,7,8] The recommended approach for the Basic and Expanded System is a combination of a manual balance and the Integrated Demand and Energy Supply (IDES) model. The manual balance relies on a straightforward computation of energy flows throughout the energy supply and demand system. An energy network is usually used to outline the pattern. A preliminary network for Egypt has already been prepared. OEP staff have already done some manual balance calculations using this network and others that they have modified. The manual balance can be implemented at OEP immediately.

The IDES model was developed at Argonne after considerable experimentation and review of other energy planning tools in developing countries. It is based on the generalized equilibrium approach and has the ability to deal with disequilibrium conditions in parts of the energy system. The method has been used and validated in developing countries and represents the state-of-the-art in this type of energy analysis. A microcomputer version of IDES is being incorporated into the ENPEP system previously described.

It is recommended that OEP begin immediately to prepare for the implementation of IDES. It can form the basic framework for all other OEP energy studies. While awaiting the procurement of the computer system, OEP staff can begin to develop a comprehensive network that will be used in IDES. The development of a base year supply/demand balance on this network using manual computation techniques can be started even before the computer system is available.

4.2.4 Energy Sector-Specific Models

From Figure 4-1, these models address the details of specific energy supply sectors (Boxes 3.2 to 3.6).

For the Basic System the only energy sector-specific models recommended for OEP involve the electric system (Box 3.2 in Figure 4-1). The screening curve approach and the WASP (Wein Automatic System Planning) model are recommended. The reasons for emphasizing the electric system are twofold. First, the electric system is the single largest component of the energy system in terms of the fuel requirements and delivered energy. It is important that OEP be able to understand the procedures for evaluating electric power production as part of its overall mission. Second, there is a wealth of experience and training available for electric system planning that does not exist in other sectors.

The screening curve approach is a simple means of estimating the type of electrical generation capacity that is the most economical for new additions. It can be carried out manually with a minimum of basic data. The WASP model is a widely used planning tool supported by the IAEA. Numerous developing countries have used it to do generation expansion planning. EEA uses it as the basis of its own generation planning. Courses in WASP are run by the IAEA on a regular basis.

It is important to emphasize that OEP will need to work closely with EEA in the conduct of electric power studies. There is a large potential for duplicated efforts, and inconsistent planning if there is not a strong working relationship between the two organizations. The mechanism used to implement this relationship may take several forms. OEP may work out an arrangement where EEA will run the WASP model on behalf of OEP to carry out special studies. Alternatively, EEA could assist OEP staff in running their own copy of WASP to meet special needs. In either case, the OEP staff need to be familiar with the electric system expansion planning done by EEA and be able to incorporate those results into OEP studies.

For the Expanded System OEP can add sector models that deal with oil and gas production and refinery operation. The available models in this sector are generally proprietary packages protected by the companies that use them. Special arrangements will need to be worked out with EGPC concerning the use of these tools. These are not a high priority task for OEP and can be delayed to some future date.

4.2.5 Impacts Models

For the Basic System the impacts of alternative energy system configurations (for example, capital cost requirements, foreign exchange requirements, environmental effects, etc.) can be computed manually once the supply/demand balance has been constructed. There is no need to develop a sophisticated computer model for the basic effort.

For the Expanded System the Energy Supply Planning Model (ESPM) can be utilized. This code was developed by Bechtel, Inc. and was used in the 1978 cooperative energy assessment with the Department of Energy. The model was delivered to Egypt at the end of the assessment but was never widely used. ESPM is used to estimate a facility build schedule and to trace the cash flow, labor, and materials needed to build the energy system. It is an accounting model that uses an extensive data base on energy facility construction requirements. This data base would need to be updated before OEP used the model.

4.2.6 Project-Specific Models

For the Basic System project-specific financial analyses can be done manually using standard internal rate of return, payback period, and other parameters. The computational aspects of these analyses are straightforward. One package already available to OEP, the Lotus 1-2-3 spreadsheet software, has some of these functions built in and can be used to reduce the computational workload.

For the Expanded System, a specially-tailored package that deals with the unique features of the Egyptian energy pricing and tax structure needs to be developed. OEP economist staff will have to design the package for OEP computer staff to develop.

5. IMPLEMENTATION SCHEDULE

Figure 5-1 gives a tentative schedule for the implementation of the data bases and analytical tools in OEP. The establishment of the data base and the development of the basic modeling system can begin immediately. Existing OEP staff and computer equipment are adequate to initiate these efforts. Table 5-1 gives a list of elements needed to complete the analytical requirements.

For the establishment of the data base, a critical element is the choice of the DBMS software. Ideally, the structuring of the data sets would not be started until the OEP computer hardware (either the centralized minicomputer or the decentralized microcomputer network) are in place and the DBMS software is installed. Nevertheless it is possible to begin the formatting of the data files so that there is no time lost when the software becomes available. It is not unreasonable to use the existing dBase III software for some of the smaller data sets to give OEP staff experience in constructing and loading a data base. If the decentralized microcomputer system is selected, these files will be useable directly.

With regard to the modeling system, the manual macroeconomic projection procedures and energy demand forecasting procedures can be initiated immediately. OEP staff have experience in these activities as a result of their training at ANL. The IDES model can also be initiated in a relatively short time period since OEP staff have had some exposure to it and ANL can provide the necessary training and support.

The balance of the system can be implemented at a staggered pace.

Figure 5-1. Schedule for Implementation of Analytical Tools at OEP

	1985 3Q	1985 4Q	1986 1Q	1986 2Q	1986 3Q	1986 4Q	1987 1Q	1987 2Q	1987 3Q	1987 4Q
ESTABLISHMENT OF THE DATA BASE										
Assemble existing information										
Structure data files										
Select DBMS software										
Load and check data										
Develop user access procedures										
Repeat process with updated information										
DEVELOPMENT OF THE MODELING SYSTEM										
BASIC SYSTEM										
Develop manual macroeconomic projection procedures										
Develop manual energy demand forecast										
Implement Argonne IDES model										
Acquire and implement IAEA MASP model										
Develop manual impacts computation procedure										
Develop manual project-specific computation procedure										
EXPANDED SYSTEM										
Develop computerized economic model with Min of Planning										
Acquire MAED & DEMAND models										
Acquire other sector-specific models										
Acquire ESPM										
Acquire and implement project-specific models										

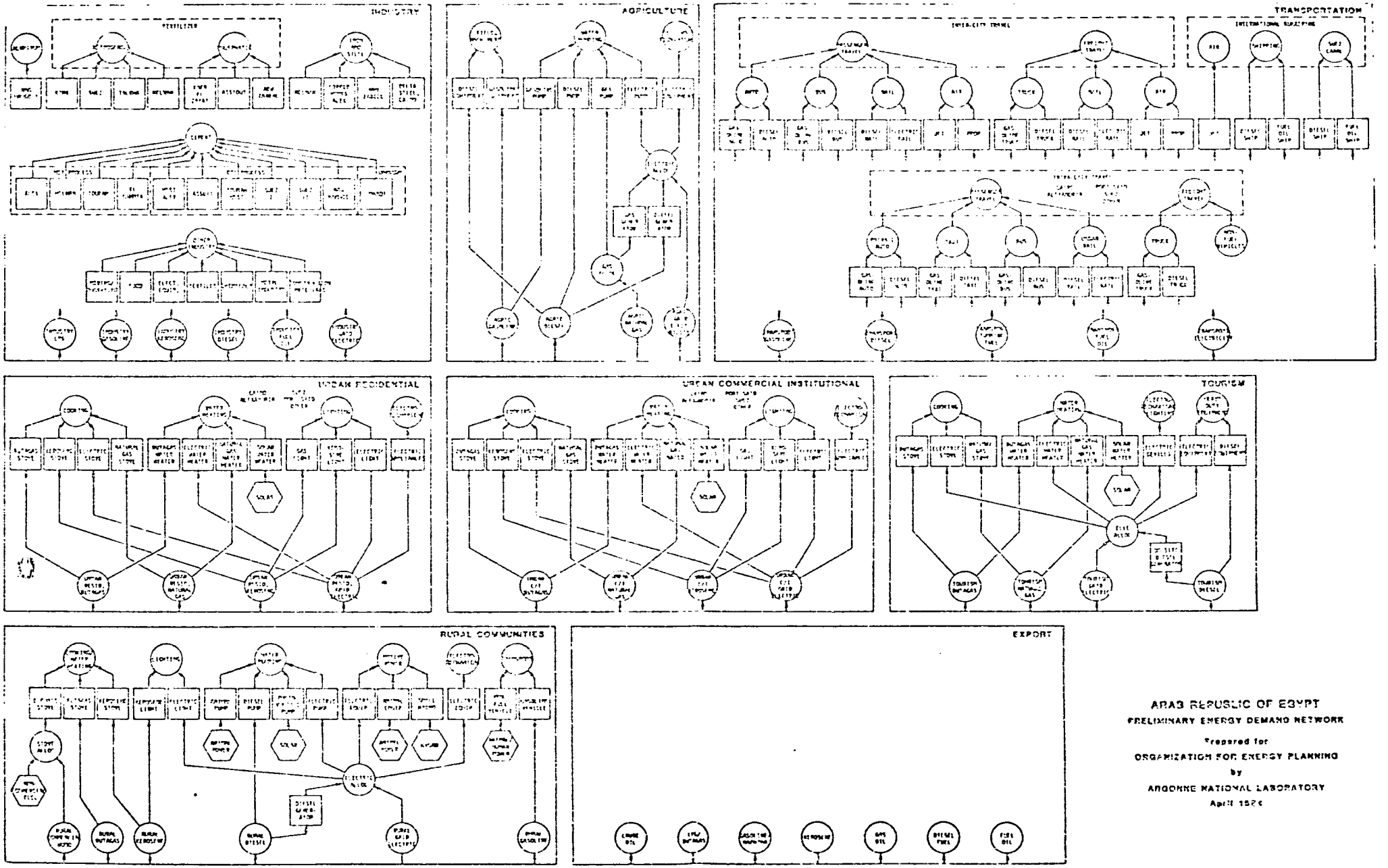
Table 5-1. List of Analytical Elements Required

Element	Items Needed
DATA BASES	
Economic Parameters	GNP by sector and subsector Population by region and urban area Personal income by class
Sectoral Energy Use	Activity level Energy consumption by fuel type and type and efficiency of energy equipment Distribution by useful energy category
Energy Resource Information	Reserves by field Historical production rates Additions to reserves
Energy Supply System Data	See References 1 and 2
MODELS	
Basic System	
Macroeconomic growth	Assumed growth Trend extrapolation
Energy demand forecasting	Manual computation
Integrated supply/ demand balance	Manual balance Argonne IDES model
Energy sector specific	Electric system screening WASP model
Impacts	Manual computation
Project-specific	Manual computation
Expanded System	
Macroeconomic growth	Ministry of Planning models
Energy demand forecasting	MAED model DEMAND model
Energy sector specific	Refinery operation Petroleum reservoir
Impacts	ESPM model
Project-specific	Specially tailored model

APPENDIX A

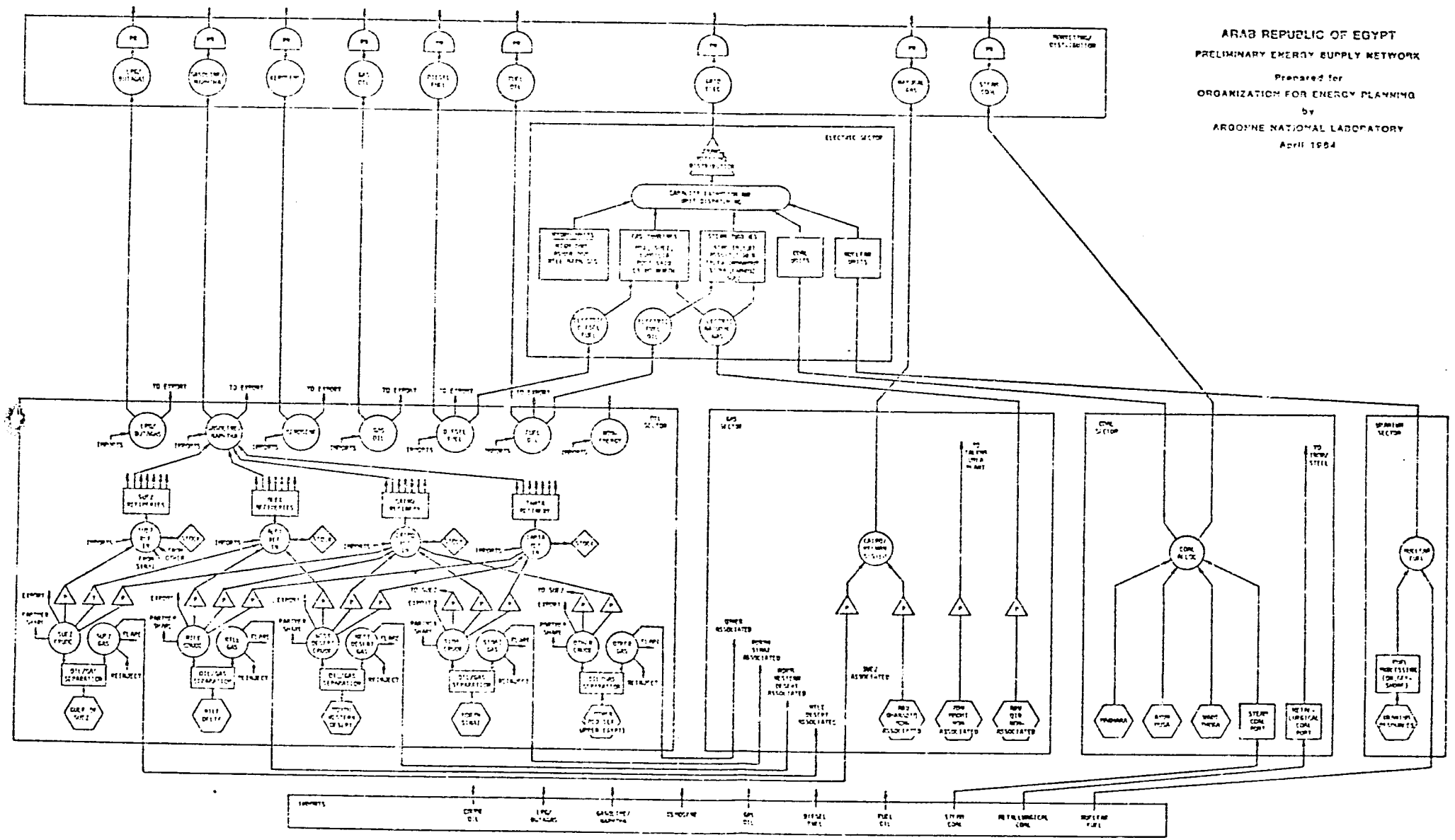
Preliminary Detailed Energy Supply/Demand Network

Figure A-1. Preliminary Energy Demand Network



ARAB REPUBLIC OF EGYPT
PRELIMINARY ENERGY DEMAND NETWORK
Prepared for
ORGANIZATION FOR ENERGY PLANNING
by
ARGONNE NATIONAL LABORATORY
April 1976

Figure A-2. Preliminary Energy Supply Network



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