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# The Integrating Model of the Project Independence Evaluation System

Volume V *Code Documentation*

July 1978

Prepared for:  
**U.S. Department of Energy**  
Energy Information Administration  
Assistant Administrator for Applied Analysis  
Under Contract No. EG-77C-01-8558

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# The Integrating Model of the Project Independence Evaluation System

Volume V. Code Documentation

July 1978

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## EIA Perspective

This contractor report was prepared by Logistics Management Institute and provides documentation of the version of the Project Independence Evaluation System (PIES) as it existed on January 1, 1978. Since that date, PIES has evolved into what is now called the Mid Range Energy Market Model (MEMM), a major component of the Mid Range Energy Forecasting System (MEFS). Major structural changes that have occurred between January 1, 1978 and January 1, 1979, are documented in the supplemental volume entitled, "Revisions to the Midterm Energy Market Model Relating to Natural Gas Regulation, Advanced Technologies, Coal Demand and Dynamics." Together, the six volume set of documentation, plus the supplemental volume on revisions, form the most comprehensive and up-to-date version of MEMM documentation currently available, documentation which significantly surpasses in both form and content the single volume published in January, 1977.

Although this documentation has not gone through the appropriate review process and clearance procedures to be published as an EIA endorsed report, it is currently being made available in its present form as an interim measure to satisfy many outstanding requests for MEMM documentation. As this report has not been submitted to comprehensive review, EIA does not endorse any information contained herein. The documentation is presently being subjected to comprehensive review both inside and outside the Department of Energy. A contract is currently in process to update it to the version used for the 1978 Annual Report to Congress (published in July 1979). This new version of the documentation report is intended to bring the MEMM documentation into conformity with EIA's documentation standards and to respond to any issues raised as a result of the review process. The results of the latter effort will result in a set of MEMM documentation fully cleared and endorsed by EIA, available in 1980.

## PREFACE

This documentation describes the PIES Integrating Model as it existed on January 1, 1978. The complete documentation consists of seven volumes describing the various aspects of the Integrating Model as follows:

- Volume I is an executive summary, providing a simple, nontechnical overview of PIES.
- Volume II is a primer, describing and illustrating the basic inputs to the PIES algorithm.
- Volume III is a user's guide, describing scenario specification and the operational procedures for running the Integrating Model.
- Volume IV is the main model documentation, describing the theoretical basis of the Integrating Model and each of the supply submodels.
- Volume V is code documentation, describing the data processing aspects of PIES: the data flow through the PIES programs, the functions performed by each program, the data inputs and outputs, and the PIES naming conventions.
- Volume VI is data documentation, containing the standard table data used for the April 1978 Administrator's Annual Report, along with primary data sources and the office responsible. It also contains a copy of a PIES Integrating Model Report with a description of its contents.
- Volume VII is a documentation of the PIES capital sector, containing a description of a sample PIES Capital Report, and a discussion of how additional calculations can be used to augment the values in the report.

The data and scenarios used in these volumes are those used in the 1978 EIA Annual Report to Congress, prepared by the Energy Information Administration. In all volumes, we refer to this report as the Administrator's Annual Report (AAR).

# CONTENTS

	<u>Page</u>
PREFACE . . . . .	ii
LIST OF FIGURES . . . . .	iv
LIST OF TABLES . . . . .	v
<u>CHAPTER</u>	
I. OVERVIEW . . . . .	1
A. Introduction . . . . .	1
B. Historical Background of PIES . . . . .	2
C. Computer System Overview . . . . .	3
II. DATA DEFINITION . . . . .	9
A. Introduction . . . . .	9
B. PIES Data Files . . . . .	11
III. NAMING CONVENTIONS . . . . .	15
A. Introduction . . . . .	15
B. Standard Tables . . . . .	17
C. LP Matrix . . . . .	28
D. Definitions of Standardized Codes . . . . .	32
E. Raw Data Formats . . . . .	51
IV. SUBSYSTEMS/PROGRAM DESCRIPTION . . . . .	69
A. Introduction . . . . .	69
B. Satellite Models . . . . .	69
C. PIES Preprocessors . . . . .	74
D. Step 1 . . . . .	77
E. Step 2 . . . . .	79
F. Auxiliary Report Generators . . . . .	85
V. SYSTEM HARDWARE DESCRIPTION . . . . .	87
A. Introduction . . . . .	87
B. PIES Computer Facility . . . . .	87
C. PIES Software Requirements . . . . .	89
D. Privacy and Security . . . . .	90
VI. OPERATIONAL DESCRIPTION . . . . .	91
A. Introduction . . . . .	91
B. Preprocessors . . . . .	91
C. Step 1 . . . . .	95
D. Step 2 . . . . .	96

## FIGURES

<u>Figure</u>		<u>Page</u>
I-1	Process Schematic of PIES . . . . .	4
I-2	Relationships of Satellite Models with PIES . . . . .	6
II-1	PIES Subsystems and Data Flow . . . . .	10
III-1	Utilities Standard Table (Example) . . . . .	19
III-2	Crude Oil Standard Table (Example) . . . . .	21
III-3	Imports Standard Table (Example) . . . . .	23
III-4	Transportation Standard Table (Example) . . . . .	25
III-5	Transportation Standard Table TRCSPLT (Example) . . . . .	26
III-6	Transportation Standard Table THRUPT (Example) . . . . .	27
III-7	Schematic of Integrated Supply Model (Sign Conventions) . . . . .	29
IV-1	PIES Subsystems and Data Flow . . . . .	70
IV-2	Selected PIES Satellite Models . . . . .	71
IV-3	PIES Preprocessors . . . . .	75
IV-4	Step 1 . . . . .	78
IV-5	Step 2 . . . . .	80
IV-6	MPS-III Control Program . . . . .	83
IV-7	QUSER . . . . .	84

## TABLES

<u>Table</u>		<u>Page</u>
II- 1	PIES File Formats . . . . .	11
II- 2	Raw Data Tables - Data Entry and Storage . . . . .	11
III- 1	Standard Table Identification . . . . .	33
III- 2	Supply Sector Scenarios (TABLE TFS) . . . . .	34
III- 3	Target Year . . . . .	35
III- 4	Energy Materials (TABLE ALLMTLS) . . . . .	35
III- 5	Facility Operating Modes (TABLE ALLMODS) . . . . .	37
III- 6	Resource Accumulation Codes . . . . .	45
III- 7	Location/Geographic Region (TABLE ALLOCS) . . . . .	46
III- 8	Supply Curve Steps . . . . .	49
III- 9	Demand Sectors . . . . .	50
III-10	Energy Material/Transportation Mode Combinations . . . . .	50
III-11	Coal Raw Data Tables . . . . .	53
III-12	Geothermal and Solar Raw Data Tables . . . . .	53
III-13	Natural Gas Raw Data Tables . . . . .	54
III-14	Oil Raw Data Tables . . . . .	57
III-15	Refineries Raw Data Tables . . . . .	59
III-16	Synthetics Raw Data Tables . . . . .	60
III-17	Transportation Raw Data Tables . . . . .	61
III-18	Utilities Raw Data Tables . . . . .	64
V- 1	EIA Service Facility Hardware (March 1978) . . . . .	88
V- 2	PIES Data Storage . . . . .	89
VI- 1	Step 1 Resource Utilization (Approximate) . . . . .	96
VI- 2	Step 2 Resource Utilization (Approximate) . . . . .	97

## I. OVERVIEW

### A. INTRODUCTION

This volume is a description of the Project Independence Evaluation System (PIES) as a computer system. It is intended for readers wanting a basic understanding of the computer implementation of PIES rather than an understanding of the modeling methodology.<sup>1</sup> It can assist those who wish to run PIES on the EIA computer facility or to use PIES on their own facilities, or to analyze the PIES computer processing.

The document contains:

- an overview of the computer implementation
- a description of the data and naming conventions used in PIES
- a functional description of PIES data processing
- PIES hardware and software requirements
- an operational description of the PIES processing flow.

This overview defines the scope of PIES in this report and thus governs the computer system descriptions that follow. It also provides an historical view of the development of PIES.

We stress that the perspective used throughout this report describes PIES as a computer system, not as an analytical model. Although these aspects of PIES overlap considerably, there are differences, particularly in discussing PIES functional characteristics, the processing flow, and in defining the scope of PIES and its subsets.

The content of this report is based on the Federal Information Processing Standards (FIPS) for system documentation as specified in FIPS Publication Number 38: Guidelines for Documentation of Computer Programs and Automated Data Systems,

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<sup>1</sup>A description of the PIES model is contained in Volume IV of this documentation series.

February 15, 1976. As the FIPS guidelines support ongoing systems design and development efforts and this report documents an existing system where development issues have already been answered and do not require documentation (e.g., organizational impact), some departure from the guidelines do occur.

## B. HISTORICAL BACKGROUND OF PIES

The OPEC oil embargo of 1973 established an awareness of the world energy situation. One result of this crisis was Project Independence which was established to evaluate the prospects of U.S. independence in energy use and provide a framework for developing a national energy policy. The analysis involved forecasting future U.S. energy production and consumption under a number of alternative strategies. A computer model, PIES, was developed by the Federal Energy Administration, Supply and Integration Analysis Division in 1974. PIES forecasts for 1977, 1980, and 1985 contributed to the 1974 Project Independence Report, published by FEA.

PIES has become larger and more sophisticated in the intervening years. The modeling aspects have been expanded, increasing the volume and detail of the data. As the analyses of energy supply and demand have improved, so have the data and the PIES modeling. For example, the current version includes a breakdown of the demand sector in the LP matrix.<sup>2</sup> This allows a more complete breakdown of the LP solution and a more accurate forecast for energy demand than previously.

While data and modeling have improved, so has the computer system. Changes can be made to supply data in the model without rerunning earlier processes. The equilibrating mechanism for supply and demand has been modularized to increase its processing efficiency and ease of maintenance. Evaluations of mathematical software packages have ensured that PIES software is efficient, easy-to-use, and oriented to appropriate processing functions. On-line data entry and editing allow PIES analysts greater flexibility and efficiency.

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<sup>2</sup>Demand sectors include residential, commercial, and industrial areas, which are within U.S. geographic regions.

A data base maintenance system has been recently completed to provide control and documentation of input data. Customized programs have been written to allow on-line interactive query of PIES solution, matrix, report, data and tracking files.

In addition, more efficient programs and system resource utilization have decreased overall processing time, even though the amount of modeling and volume of data have increased significantly.

Future enhancements of PIES will include:

- standard procedures for public access to PIES
- further data processing improvements
- an easy-to-use run initiator to allow on-line interactive job setup of PIES runs
- validation of PIES data and modeling.

With the creation of the Department of Energy (DOE), the PIES staff became part of the DOE Energy Information Administration. Although analysts throughout EIA provide support for PIES, the staff of the Office of Integrative Analysis' Division of Mid Range Analysis has primary responsibility for the model, and they are referred to as the "PIES staff" in this report. They are the analysts who run the PIES Integrating Model.

PIES is currently used by DOE to forecast energy prices, supplies, demands, and conversion activities.<sup>3</sup> It is also an analytical tool for examining the potential impact of changes in Federal policies through the specification of alternate scenarios.

PIES users include: DOE Energy Information Administration, DOE Office of Policy and Evaluation, the White House, the Congress, the energy industry, researchers and universities, and public interest groups.

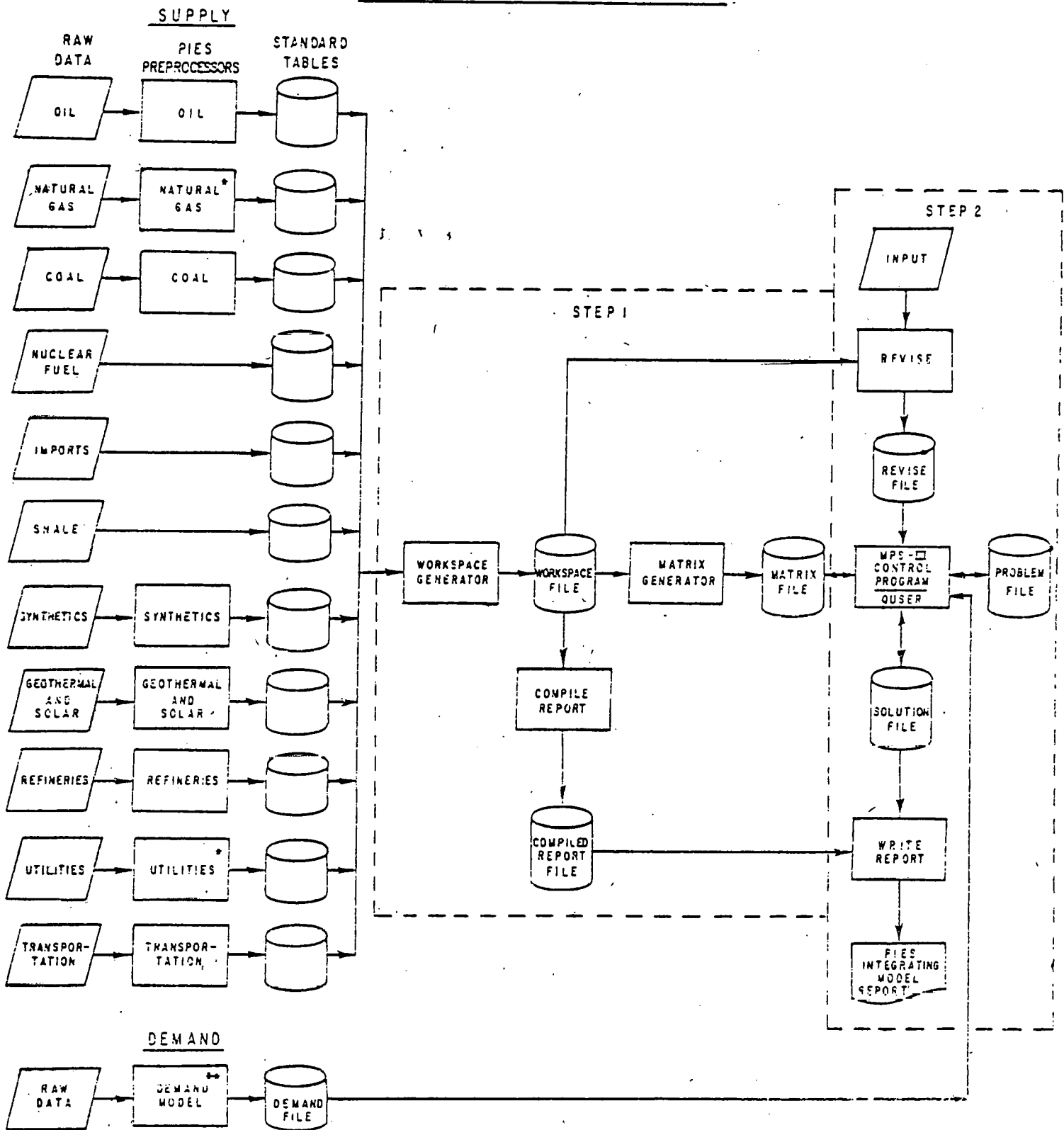
### C. COMPUTER SYSTEM OVERVIEW

PIES is a set of interrelated models, manual analyses, data files, and data processing functions as illustrated in Figure I-1. The PIES computer system, as described in this report, is that of the Integrating Model. The PIES Integrating Model begins with raw data

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<sup>3</sup>The conversion of one form of energy to another, e.g., coal to electricity.

FIGURE I-1  
PROCESS SCHEMATIC OF PIES



\* THERE ARE ACTUALLY TWO PREPROCESSORS FOR MODELING NATURAL GAS AND UTILITY DATA.  
 ++ THE DEMAND MODEL IS A SATELLITE MODEL TO PIES.

inputs from supply and demand "satellite" models and ends with the production of the PIES Integrating Model Report.

PIES initial forecasting is an analysis of the supply and demand of each primary fuel, energy facility type, and energy product (e.g., electricity). These analyses are referred to as satellite models, which are executed manually, by computer, or in combination. Many of these satellite models are independent energy models that focus on a particular energy type (e.g., coal) and provide data to PIES as one of many outputs. Since they are not part of the PIES Integrating Model, they are not considered part of the PIES computer system as described in this report; they are treated as data collection processes supplying inputs to PIES. Figure I-2 illustrates the satellite models and their interface with the PIES Integrating Model, which is described in detail below.

Some satellite models are computerized energy models that provide data to PIES in an automated form. The National Coal Model, for example, is a DOE system that provides coal supply input data to PIES in an on-line disk on the DOE computer.<sup>4</sup> Other input data are generated through DOE analysis of available information. This analysis may involve research from DOE reports, energy industry data, trade publications, etc. Input data on supply from emerging technologies (shale, solar, etc.) are the result of such analyses. Other inputs come from combining outputs from an energy information system (e.g., the Federal Energy Data System) with data collected through manual analyses. There are five satellite models that supply input data to PIES in an automated form and are discussed later in this report: demand (for all energy), coal, refineries, oil, and gas. The rest of the supply inputs are provided through manual or combined manual and automated processes.

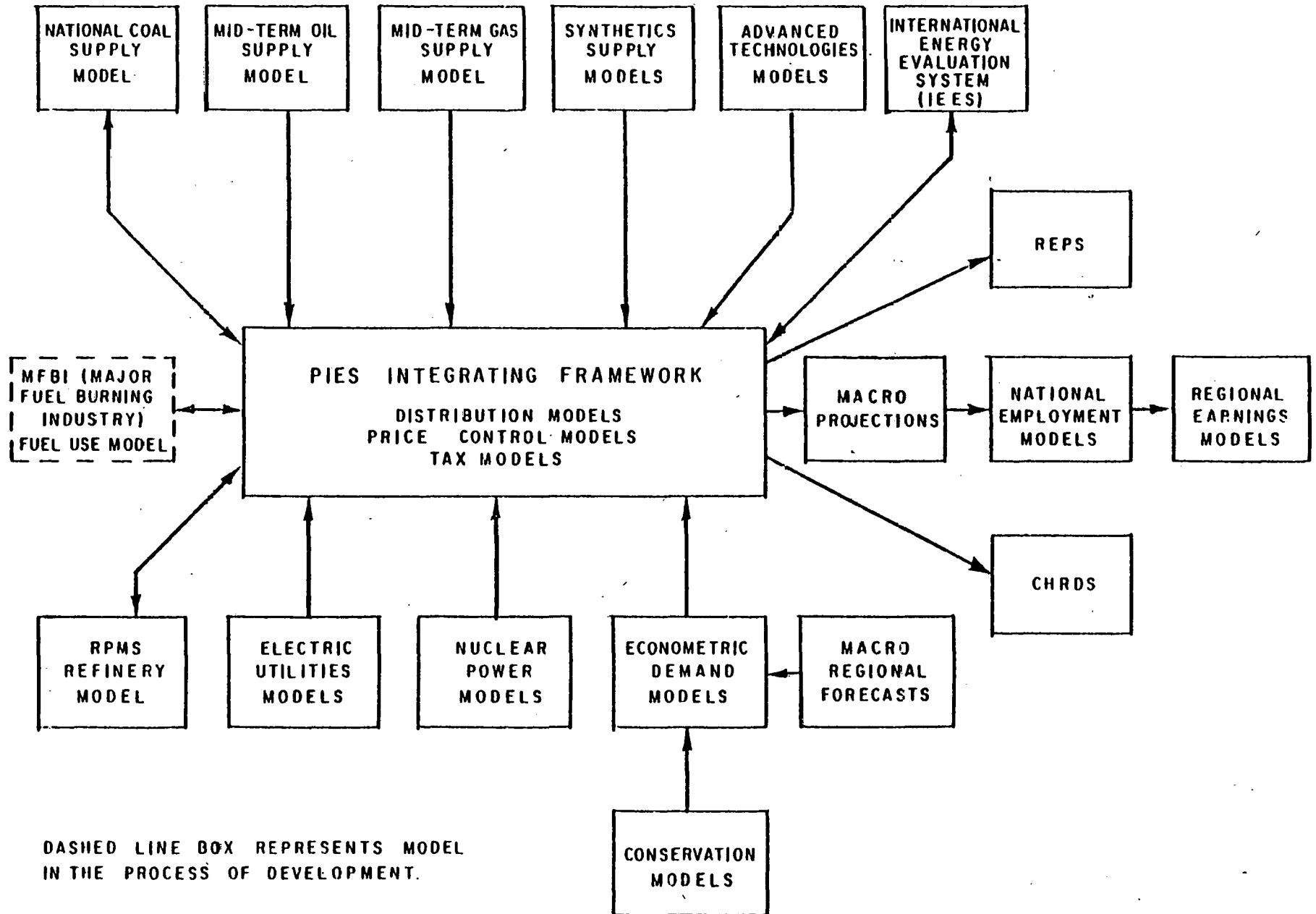
As illustrated in Figure I-1, the PIES Integrating Model begins with the raw data inputs for supply provided by the satellite models. The Demand Model represented in Figure I-1 is specifically designed for the PIES Integrating Model and is a satellite to it.

---

<sup>4</sup>The National Coal Model and PIES are processed on the same DOE computer.

FIGURE 1-2

RELATIONSHIPS OF SATELLITE MODELS WITH PIES



Its outputs are formatted into the demand file that is ready to be entered later in the PIES processing. The PIES processing flow is discussed below.

The first PIES Integrating Model function is the processing of supply, or "raw" data. These inputs to PIES are called raw data tables. They are processed by a set of programs called preprocessors<sup>5</sup> that reformat the raw data into a standardized format and perform some modeling functions. The preprocessor outputs are called standard tables.

Standard tables are then processed in the first step of a two-step process that integrates the supply and demand data and calculates an equilibrium between supply and demand. Step 1 enters all the supply data (in the form of standard tables) and produces the files necessary for the Step 2 functions: the workspace file, the matrix file, and the compiled report file. The workspace file is an integrated set of standard tables, created as the first step in generating the initial LP matrix. The matrix file containing the initial LP matrix is produced next, with only the supply data entries. The compiled report file contains all of the data needed from the workspace file for the PIES Integrating Model Report. Solution file values are picked up in Step 2.

Step 2 is run independently of Step 1, with all three files produced by Step 1 as inputs. The first process, REVISE, accepts as inputs the PIES scenario specification and changes to supply data (entered by Step 1 in the matrix) to reflect the specific data required by the scenario to be run.<sup>6</sup> A REVISE file is created using the workspace file as a basis for updating supply data. The REVISE file is then input to an iterative process of solving the LP matrix, checking for equilibrium between supply and demand, modifying the matrix, and resolving. A problem file and a solution file are used to set up the LP matrix

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<sup>5</sup>These preprocessors are also discussed in Volume IV of this PIES documentation series where they are referred to as submodels. The submodels also include relevant logic from other PIES components.

<sup>6</sup>This permits various PIES scenarios to be run using the same matrix file. Significant supply data changes require rerunning the appropriate preprocessors and Step 1 before running Step 2.

and solve it in the MPS-III Control Program.<sup>7</sup> QUSER checks the solution file for convergence between supply and demand and modifies the matrix if it is not achieved. The demand file is read by QUSER and used to initialize the matrix for the first iteration. Upon convergence (or reaching the maximum number of iterations), the solution file is accessed by the compiled report file to produce the PIES Integrating Model Report.

The following chapters describe the PIES computer system further. Chapter II describes the data files; chapter III, the naming conventions for data elements in the primary data files; chapter IV, the PIES subsystems and programs, chapter V, the DOE computer system on which PIES runs; and chapter VI, the operational sequence used in running PIES. Because this document is a reference guide, there is some overlap between the chapters so that, in most cases, they can be read independently of one another.

---

<sup>7</sup> MPS-III is a math programming system designed for linear programming problems.

## II. DATA DEFINITION

### A. INTRODUCTION

This chapter describes the primary PIES data files: inputs, outputs, and intermediate files. Each file is defined in terms of its function, data content, and data structure.

Figure II-1 illustrates the flow of data through the three PIES subsystems: the preprocessors, Step 1 and Step 2. The primary objective of the preprocessors and Step 1 is to take the initial supply data (raw data tables) and create the LP matrix needed for the PIES equilibrating mechanism. The preprocessors reformat the raw data tables (where necessary) into standard tables. Where computation is required to create the proper data entries for the LP matrix, it is performed in the preprocessors. More complex processing is performed in some preprocessors (e.g., utilities, transportation) to model their activities. All of the standard tables are then integrated into the workspace file, which is used to generate the matrix file, containing the LP matrix; the revise file, used to revise the matrix file; and the compiled report file, used to generate the final report.

These files are passed to Step 2 in which the equilibrating mechanism operates. The demand file is integrated into the matrix file along with any changes or additions for the particular scenario being run (entered via the revise file). Step 2 then goes through an iterative process with the problem file (created from the matrix file); the solution file, representing a "solved" LP step; and the revise file, containing changes to set up the problem file once again. When equilibrium has been reached (or the maximum number of iterations), the report file is produced from the compiled report file and the solution file.

The supply data files are structured as MaGen tables, each with table names, row names, and column names to allow non-ambiguous data access. The file formatting is language-dependent, predominately created through MaGen or MPS-III programs.<sup>1</sup> Table II-1 details language processors generating the file.

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<sup>1</sup>MaGen and MPS-III are mathematical programming languages for linear programming problems.

FIGURE II-1  
PIES SUBSYSTEMS AND DATA FLOW

10

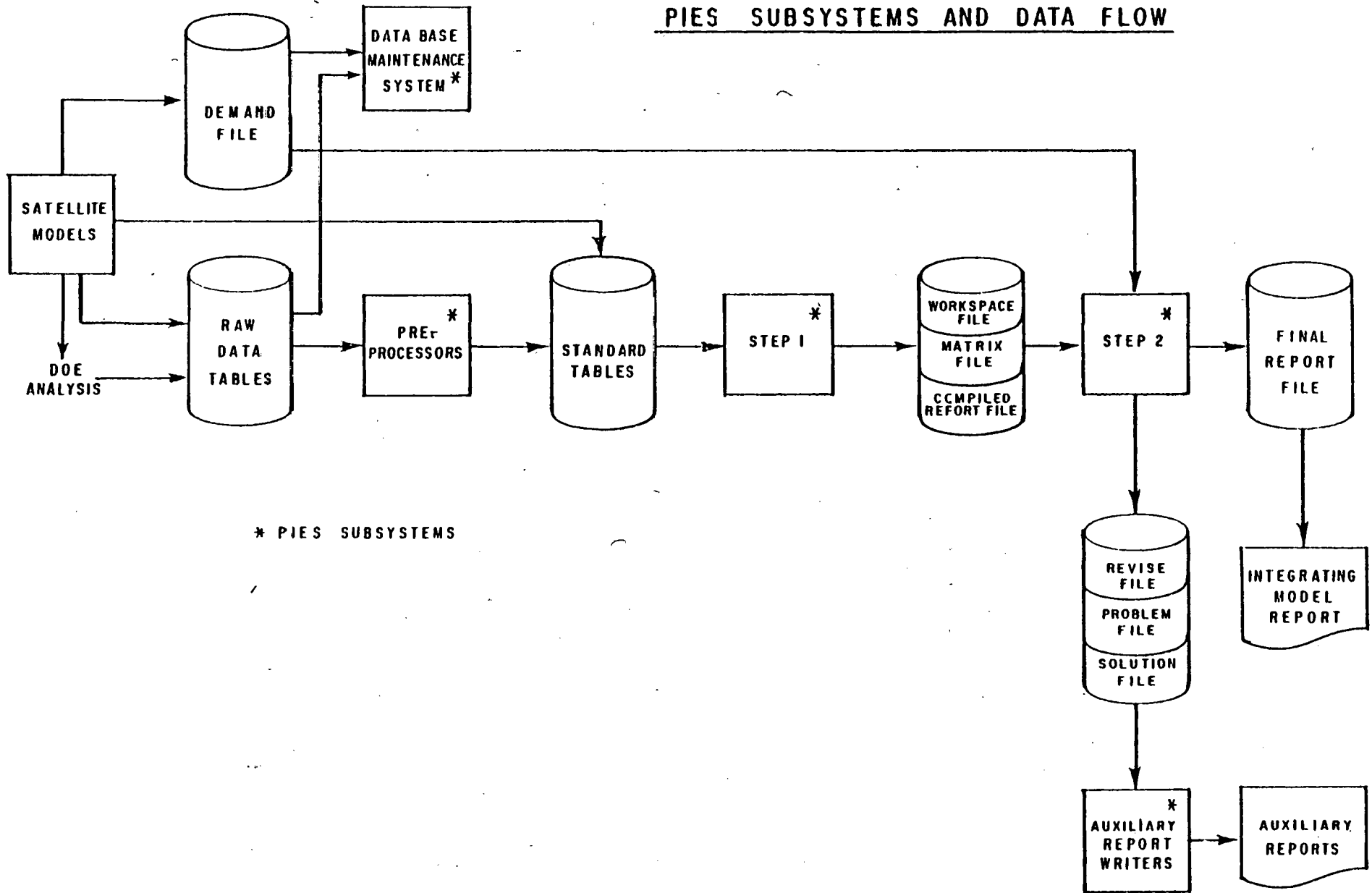


TABLE II-1. PIES FILE FORMATS

<u>File Name</u>	<u>Language Processor</u>
Raw Data Tables	MaGen and Fortran
Standard Tables	MaGen
Workspace File	MaGen (internal format)
Matrix File	MaGen (MPS360 format)
Compiled Report File	MaGen (internal format)
Revise File	MaGen (MPS360 format)
Demand File	Fortran
Problem File	MPS-III (internal format)
Solution File	MPS-III (communications format)
Report File	IBM Print File

Each file is described below in terms of its function and data content.

B. PIES DATA FILES

1. Raw Data Tables

Raw data tables are the initial input of supply data for PIES. They are generated from various sources and structured in different formats. Some of the data come directly from satellite models. These generally are passed directly to PIES in an on-line file, often in the format of the standard tables. Other raw data tables are created through analysis of data from energy industry publications, DOE reports, outputs from other energy systems (including satellite models), and data collected by DOE. This data is entered by manually creating raw data tables in on-line files, to be accessed by the preprocessors, or written directly into the preprocessor program. Table II-2 details the data entry for raw data tables.

TABLE II-2. RAW DATA TABLES DATA ENTRY

<u>Energy Material or Facility</u>	<u>Data Entry</u>
Coal	National Coal Model and Manual
Geothermal and Solar	Manual
Imports	Manual
Natural Gas	Gas Supply Model and Manual
Oil	Oil Supply Model
Refineries	Refinery Model
Shale	Manual
Synthetics	Manual
Transportation	Manual
Nuclear Fuel	Manual
Utilities	Manual

Manual data entry to on-line files and preprocessor programs is done similarly, using SUPERWYLBUR, an on-line interactive text editor. SUPERWYLBUR is used through interactive terminals to enter and modify data.

Once the raw data tables have been created, they are input to the preprocessors.<sup>2</sup> Since they are independent programs, they need only be run when changes are required to the raw data.

Due to the wide variation in formats and naming conventions, raw data tables are described in detail in chapter III, section E.

## 2. Standard Tables

Standard tables contain the supply input data that are output from the preprocessors. These tables are in a standardized format to facilitate the creation of the LP matrix.<sup>3</sup> The standard tables contain the raw data, plus additional information from some modeling performed in specific preprocessors (e.g., utilities, transportation). Except for those standard tables that are initially entered in standard table format (imports, shale, and nuclear fuel), the files are created by preprocessors written in MaGen code. These files are stored in on-line data sets. In general, they are tables, with descriptive row and column headings, as well as a table name. The table names define the use of the tables. The column names define the data entries in terms of the energy material or facility being described. The row names define the data's use in the model, i.e., objective function entry, material balance row entry, activity bound, etc. The naming conventions for the standard tables and examples are described in chapter IV.

## 3. Workspace File

The workspace file is basically an integrated set of standard tables. Step 1 of the Integrating Model (written in MaGen) reads in all the standard tables and creates a workspace file, which is used for creating the matrix file, the compiled report file, and the initial revise file.

---

<sup>2</sup>Raw data tables for imports, shale, and nuclear fuel are not "preprocessed," as they are input in standard table format.

<sup>3</sup>There are some exceptions to this standardized format, as noted in chapter III.

#### 4. Matrix File

Step 1 of the Integrating Model also creates a matrix file with the proper arrangement of rows and columns to represent the PIES LP matrix. The matrix file is created by the matrix generator with the workspace file as input.

#### 5. Compiled Report File

The compiled report file is a special purpose file written by the MaGen report generator code to create the PIES report. The report compiler program in Step 1 extracts required information from the workspace file, creates report header information and partial report tables, defines mathematical calculations requiring solution file variables, and produces the compiled report file. During its execution in Step 2, it accesses the solution file to produce the PIES report.

#### 6. Revise File

A revise file is the means of changing the LP matrix, by modifying existing data or adding new data. Revise files are used in Step 2 of the Integrating Model in two ways. First, they provide a means for entering scenario-specific data to run Step 2. They permit changes to be made to the LP matrix without regenerating the matrix file.<sup>4</sup> Second, a series of revise files contain the LP matrix changes during the iterative Step 2 process of the equilibrating mechanism. Changes to the matrix based on the QUSER processing of the solution file create a revise file that is integrated with the matrix to recreate the problem file, described below.

As these files are used by the MPS-III program for solving the LP, the revise files, generated via Fortran, are written in the MPS 360 format.

#### 7. Problem File

Step 2 of the Integrating Model continuously updates the LP matrix during its iterative process towards an equilibrium. This update requires the creation of a problem file to be used in the MPS-III solution process. The MPS-III control program reads in the

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<sup>4</sup>There are changes that require the LP matrix to be regenerated, depending on the volume and complexity of the changes.

revise file and the matrix file and creates the problem file. Initially, the revise file comes from the scenario specification created by the users. The second and subsequent problem file updates are driven by the QUSER-created revise file. The problem file is in the MPS-III file format.

#### 8. Solution File

The solution file contains the solution to an LP matrix. The initial creation of the solution file is to supply QUSER with information from the matrix which it uses to perform the calculations necessary to complete the initialization of the matrix. In subsequent iterations, the solution file contains the matrix solution produced by the MPS-III LP routine. QUSER examines the solution file to determine if the present solution meets the specified convergence criteria for equilibrium between supply and demand. Upon convergence, the solution file is used in generating the PIES report file.

#### 9. Demand File

The data processing through the initial creation of the solution file uses only supply data. During the first call of QUSER, the demand file, the input data produced by the PIES Demand Model, is entered into the LP matrix via the revise file. The Demand File is a Fortran-created file read by QUSER (also written in Fortran).

#### 10. Report File

The report file is a print-format file containing the output report. This file is produced by executing the compiled report file which extracts data from the solution file to produce the PIES Integrating Model Report.

### III. NAMING CONVENTIONS

#### A. INTRODUCTION

This chapter defines the naming conventions associated with the PIES data flow. Where possible, unique and systematic names have been given to the numerous PIES tables and their data elements for consistency and easy reference. The descriptions of the naming conventions are divided according to the three major data groups: raw data tables, standard tables, and the linear programming (LP) matrix, as described in chapters I and II.

Naming conventions for PIES raw data are the least consistent, due to the way the data are developed. Raw data are generated manually (by DOE analysts) and from automated systems (other energy models) and are often received in a format consistent with their source, rather than with PIES. A detailed description of the raw data names can be found in section E below.

The standard tables, on the other hand, are relatively consistent in their conventions. Most of the tables comply with a basic format for the table names, column names, and row names. The table name identifies the type of information contained in the table, the scenario, and the target year. The row names define the data for use by the LP matrix as either part of the objective function, material balance equation, process limit equation or constraint, accounting equation, or a bound on a specific activity vector. The column names describe either the capacity type, region, and mode for facilities; or the material, region, and supply curve step for fuels. These naming conventions are described in more detail in section B below.

The LP matrix uses strict naming conventions for the rows and columns which are based on the standard table names.<sup>1</sup> The row names define the objective function and the

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<sup>1</sup>The use of the LP matrix in PIES is described in The Integrating Model of the Project Independence Evaluation System, Volume IV, chapter II and the PIES Primer Volume II.

supply and demand constraints. The column names describe the activity variables and the constraint values. The specific naming conventions are described in section C below.

The naming conventions provide standardized data definitions for users and facilitate efficient operation of the modeling functions. The data within the LP matrix must be uniquely and consistently defined so PIES can access specific data elements to perform its operations. The matrix manipulation performed to solve the LP matrix also requires a standardized format (placement of variables within the matrix) to operate.

As described earlier in the report, the preprocessors format the raw data into standard tables for use in generating the LP matrix. The naming conventions used in the standard tables contain codes that are generally consistent with those used by the LP matrix. Each standard table is a subset of the matrix, and in combination with the other standard tables, forms the LP matrix. Thus, the naming conventions, as well as the format, are part of the consistent, methodical process of PIES.

The following sections use a standard format for describing the naming conventions. All variable characters (numbers and letters) are denoted with parentheses and small letters. All standard characters are identified by characters not in parentheses (letters are capitalized). Variables are defined below the naming convention, along with the range of values that may be associated with the variable character. Frequently used variables are identified consistently throughout the chapter and defined in section D below.

For example, consider:

TABLE AX (qq) B (y)

where:

(qq) = energy code (Table III-n)

(y) = energy type (1,2,3)

In this example, "AX" and "B" are standard characters that are always part of the table name. "qq" is a variable two-character energy code which would be defined in Table III-n, where n is a table number in section D. "y" is a single character which may have one of

the three values indicated. Thus, if "q" can be one of five values, this table naming convention may describe as many as fifteen tables (if all values are used).

The standard table and LP matrix naming conventions are described next, followed by standard codes for data used by each. The final section describes the raw data tables.

## B. STANDARD TABLES

The naming conventions for standard tables include the table name, column names, and row names. Every data element can be uniquely defined, since the intersection of a row and column within a particular table will identify one data element. The conventions described below relate synthetics, solar and geothermal, crude oil, coal, refineries, natural gas, shale, nuclear, imports, and utilities standard tables. Standard tables for transportation do not follow the same naming conventions and are described in the latter part of this section.

### 1. Table Names

Standard table names describe the type of information contained, the scenario, and target year in the following format:

(tf) (s) (yr)

where:

(tf) = table identification (Table III-1)

(s) = scenario (Table III-2)

(yr) = target year (Table III-3)

A standard table named "OL185" is a crude oil standard table, with scenario 1, and a target year of 1985. "R3190" denotes a standard table describing refineries in region PADD 3 with scenario 1 and a target year of 1990.<sup>2</sup> It should be noted that the "scenario" used for the standard tables differs from the policy scenario being run, and usually indicates a ranging variable such as world oil price or an estimate of oil and gas reserves.

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<sup>2</sup>The table identification defines either the energy material or the energy material and its region as listed in Table III-1.

## 2. Row Names

Standard table rows are named with three-character codes of eight distinct types:

- PRC: the cost coefficient which enters the objective function named HOLLY in the matrix
- M(mt): denotes entries for a material balance equation in the matrix;<sup>3</sup> (mt) is a material (Table III-4)
- D(cp): denotes entries for a process limit equation,<sup>4</sup> (cp) is a capacity or facility type (Table III-5)
- Q(rs): denotes entries for an accounting equation; (rs) is a resource (these entries appear in some of the standard tables, but are currently not used in PIES) (Table III-6)
- RHS: a constraint for a process limit equation enters the right hand side columns in the matrix
- BND: an upper bound on a specific activity vector which becomes the UPBOUND ROW in the matrix
- BFX: a fixed bound on a specific activity vector which becomes the FXBOUND ROW in the matrix
- BLO: a lower bound on a specific activity vector which becomes the LOBOUND ROW in the matrix

Standard tables have a variable number of rows and may contain one or all of the above rows.

Figure III-1 illustrates part of a utilities standard table. The row name "ME2" and "MCP" are the form M(mt) described above. They represent electricity-intermediate mode and all sub-bituminous coal, as defined in Table III-4.

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<sup>3</sup>The material balance equations force the total inputs of a material to equal the total outputs.

<sup>4</sup>Process limits bound the capacity of facilities or restrict the amount of material available.

FIGURE III-1

UTILITY STANDARD TABLE (EXAMPLE)

TABLE US190		-CONTINUED				
	POU9P2	POUAP2	POU1P5	POU2P5	POU3P5	POU4P5
ME2	.5140	.5140				
ME5			.2570	.2570	.2570	.2570
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
PRC	1.0280	1.0280	.2827	.2827	.2827	.2827
MCC	-1.0280	-1.0280	-.2827	-.2827	-.2827	-.2827
DPO	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
MCP	-.2538	-.2538	-.1223	-.1223	-.1223	-.1223
MZP	-.2538	-.2538	-.1223	-.1223	-.1223	-.1223
TABLE US190		-CONTINUED				
	POU5P5	POU6P5	POU7P5	POU8P5	POU9P5	POUAP5
ME5	.2570	.2570	.2570	.2570	.2570	.2570
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
PRC	.2827	.2827	.2827	.5140	.5140	.5140
MCC	-.2827	-.2827	-.2827	-.5140	-.5140	-.5140
DPO	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
MCP	-.1223	-.1223	-.1223	-.1269	-.1269	-.1269
MZP	-.1223	-.1223	-.1223	-.1269	-.1269	-.1269
TABLE US190		-CONTINUED				
	TOU1T1	TOU2T1	TOU3T1	TOU4T1	TOU5T1	TOU6T1
ME1	.6500	.6500	.6500	.6500	.6500	.6500
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
PRC	1.3000	1.3000	1.3000	1.3000	1.3000	1.3000
MCC	-1.3000	-1.3000	-1.3000	-1.3000	-1.3000	-1.3000
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
MCT	-.3033	-.3033	-.3033	-.3033	-.3033	-.3033
MZT	-.3033	-.3033	-.3033	-.3033	-.3033	-.3033
TABLE US190		-CONTINUED				
	TOU7T1	TOU8T1	TOU9T1	TOUAT1	TOU1T2	TOU2T2
ME1	.6500	.6500	.6500	.6500		
ME2					.5140	.5140
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
PRC	1.3000	1.3000	1.3000	1.3000	1.0280	1.0280
MCC	-1.3000	-1.3000	-1.3000	-1.3000	-1.0280	-1.0280
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
MCT	-.3033	-.3033	-.3033	-.3033	-.2512	-.2512
MZT	-.3033	-.3033	-.3033	-.3033	-.2512	-.2512
TABLE US190		-CONTINUED				
	TOU3T2	TOU4T2	TOU5T2	TOU6T2	TOU7T2	TOU8T2
ME2	.5140	.5140	.5140	.5140	.5140	.5140
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
PRC	1.0280	1.0280	1.0280	1.0280	1.0280	1.0280
MCC	-1.0280	-1.0280	-1.0280	-1.0280	-1.0280	-1.0280
OTD	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000	-1.0000
MCT	-.2512	-.2512	-.2512	-.2512	-.2512	-.2512
MZT	-.2512	-.2512	-.2512	-.2512	-.2512	-.2512

### 3. Column Names

Column names are composed of six characters and fall into two categories: facilities and fuel supplies. Facilities tables (utilities, refineries, nuclear, synthetics, shale, and solar and geothermal) describe types of energy generated from a facility which processes one form of energy by either transferring it (e.g., electrical transmission) or by converting it into another form of energy. The naming convention for columns in facilities tables takes the form:

(cp) (lo) (md)

where:

(cp) = capacity type for build vectors (not necessarily meaningful for operate vectors) (Table III-5)

(lo) = location or geographic region (Table III-7)

(md) = mode of operating a facility or building a facility (Table III-5)

For example, Figure III-1 contains a column named "P0UAP2". This describes the operation of a new sub-bituminous utility plant ("P0"), in the Northwest region ("UA"), that will operate in an intermediate mode ("P2").

The naming convention for columns of tables for fuel supplies (oil, natural gas, coal, and nuclear fuel) is:

(mt) (lo) (ii)

where:

(mt) = material type (Table III-4)

(lo) = location or geographic region (Table III-7)

(ii) = step on the supply curve (Table III-8)

Figure III-2 illustrates a standard table for crude oil. The column, "LNO745," denotes crude oil production as follows. "LN" indicates that the data refer to Louisiana onshore crude oil, "O7" indicates that production takes place in the West Gulf Basin oil supply region, (region 7) and "45" indicates the vintage of the oil field ("4") and the step on the price ramp ("5") to which the supply data relate. The tables in section D can be used to find the above codes as well as most other standard table codes. Exceptions are discussed below.

FIGURE III-2

CRUDE OIL STANDARD TABLE (EXAMPLE)

TABLE OL685		-CONTINUED				
	WM0525	WM0545	WM0555	WT0615	WT0625	WT0645
BND	19.3000	155.80	183.10	110.20	27.1000	748.80
QYT	.9844		1.8350	12.6770	1.1070	
QCF				.9255		
MOG	.6383	.2420	.2659	.8844	.8890	.7167
MGL	.0155	.0096	.0120	.0208	.0221	.0216
MBU	.0414	.0282	.0365	.0553	.0627	.0584
MWM	.8600	.8600	.8600			
MWT				1.0000	1.0000	1.0000
MH3	.1400	.1400	.1400			
MNG		.3062	.3366			.5629
PRC	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
MOI				0.0000	0.0000	0.0000

TABLE OL685		-CONTINUED				
	WT0655	WT0665	LN0715	LN0725	LN0745	LN0755
BND	307.80	333.10	275.50	4.5000	716.90	910.60
QYT	1.9070	3.8937	9.3575	1.1111		1.9119
QCF			.6098			
MOG	.4962		1.1289	1.1559	.5833	.5595
MGL	.0185		.0221	.0222	.0248	.0222
MBU	.0503		.0704	.0666	.0785	.0705
MLN			.4800	.4800	.4800	.4800
MTG			.4000	.4000	.4000	.4000
MET			.1000	.1000	.1000	.1000
MWT	1.0000	1.0000	.0200	.0200	.0200	.0200
MNG	.3897				.5901	.5661
PRC	2.0000	2.0000	2.0000	2.0000	2.0000	2.0000
MOI	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

TABLE OL685		-CONTINUED				
	LN0765	L00815	L00825	L00845	L00855	OK0915
BND	40.2000	307.70	10.2000	236.70	50.4000	124.80
QYT	6.0199	5.9213	.8823		2.2420	23.6058
QCF		.1299				1.8109
MOG						1.6124
MGL		.0169	.0098	.0219	.0218	.0136
MBU		.0276	.0196	.0359	.0337	.0216
MLN	.4800					
MLQ		1.0000	1.0000	1.0000	1.0000	
MTG	.4000					
MET	.1000					
MWT	.0200					.0700
MOK						.9300
MNG		1.1362	1.1541	1.1138	1.1190	

There are two types of standard tables for imports: "IO(s)(yr)" for oil imports and "IM(s)(yr)" for all other imports and exports. These tables follow the above naming conventions for fuels, except in the labeling of columns, as illustrated in Figure III-3. The fifth and sixth characters of the column name (ii), ordinarily the supply curve step, are used differently for IO(s)(yr) and IM(s)(yr) tables. For most of these tables, there is only one price considered and that price is labeled "I1."

When the material (mt) is liquefied natural gas (IG), Canadian natural gas (CG), or Mexican natural gas (MG), the fifth character represents a demand region (for which a price is associated) and the sixth character is one.<sup>5</sup> For instance, IGF121, found on the left-hand side of Figure III-3, refers to liquefied natural gas in demand region 2. The amount given in the BND row, 241.10, is the contract amount of gas for that demand region. PIES is not forced to send that quantity of gas to the indicated demand region; the contract quantity is used for natural gas regulation purposes. The H regions (e.g., IGHIII) are for report writer purposes for the IEES-PIES link.

The right-hand side of Figure III-3 is an example of an oil import standard table (mt=OL). The original structure indicated by the three columns, "I1," "I2," and "I3" was to represent a fixed quantity of imports composed of a specific bundle of crudes (indicated by columns ending in "I2"), with changes allowed to that quantity and the crudes in the bundle by using columns "I1" and "I3." Specifically, "I1" was to "pay back" oil imports and "I3" to model an increased quantity of crude. This original structure remains but the crude bundles are precisely alike as indicated in Figure III-3.

The standard tables for transportation data do not follow the naming conventions common to the other energy materials and facilities. There are two sets of transportation standard tables, one for each target year, 1985 and 1990.

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<sup>5</sup> Actual usage of these gas region prices is set within the LP program and does not always coincide with the price-region reflected in the tables.

## FIGURE III-3 IMPORTS STANDARD TABLE (EXAMPLE)

TABLE IM165

	CMF011	CAH011	CMH011			
BND	99999	99999	99999			
BFY	202.74					
PRC		.001	.001			
HCA	-.24					
MCM	-.76					
HQA	-.24	1				
HQH	-.76		1			
	IGF111	IGF121	IGF131	IGF141	IGF591	IGF151
BND	323.29	241.10	684.93	671.23	1268.49	460.27
PRC	3.25	3.00	2.30	3.00	3.70	3.60
MNG	1	1	1	1	1	1
HUN	-1	-1	-1	-1	-1	-1
	CGFC11	CGFC21	CGFC81	CGFC91	CGFCA1	CGFC51
BND	10.98	16.44	98.63	1073.97	583.56	698.63
PRC	1.78	1.78	1.78	1.78	1.78	1.78
MNG	1	1	1	1	1	1
HUN	-1	-1	-1	-1	-1	-1
	IGH111	IGH511	CGHC11			
BND	99999	99999	99999			
PRC	.001	.001	.001			
HQH	1	1	1			
	HGFM11	HGFM21	HGFM31	HGFM41	HGFM51	
BND	113	305	298	355	329	
PRC	1.78	1.78	1.78	1.78	1.78	
MNG	1	1	1	1	1	
HUN	-1	-1	-1	-1	-1	
	HGFM61	HGFM71	HGFM91	HGHM11		
BND	83	63	303	99999		
PRC	1.78	1.78	1.78	.001		
MNG	1	1	1			
HUN	-1	-1	-1	1		

TABLE IU1RS 1985 BASE

	ULF111	ULF112	ULF113	ULF311	ULF312	ULF313	ULFC12
BND	99999	99999	99999	99999	99999	99999	100
BFY	2083						13.00
PRC	-13.00	13.00	13.01	-12.74	12.74	12.75	1
MCM					6667		
HVM	-0.075	0.075	0.075	-0.007	0.007	0.007	
HLY	-0.064	0.064	0.064	-0.178	0.178	0.178	
HAG	-0.034	0.034	0.034	-0.026	0.026	0.026	
HNT	-0.251	0.251	0.251	-0.077	0.077	0.077	
HIL	-0.040	0.040	0.040	-0.124	0.124	0.124	
HIN	-0.010	0.010	0.010	-0.012	0.012	0.012	
HAI	-0.229	0.229	0.229	-0.249	0.249	0.249	
HAN	-0.035	0.035	0.035	-0.019	0.019	0.019	
HKU	-0.003	0.003	0.003				
HME	-0.026	0.026	0.026	-0.033	0.033	0.033	
HIN	-0.023	0.023	0.023	-0.090	0.090	0.090	
HEC	-0.002	0.002	0.002	-0.011	0.011	0.011	
HRE				-0.007	0.007	0.007	
HCE							
HMX	-0.012	0.012	0.012	-0.078	0.078	0.078	
HNO	-0.033	0.033	0.033	-0.031	0.031	0.031	
HUK	-0.108	0.108	0.108	-0.012	0.012	0.012	
HTR	-0.007	0.007	0.007	-0.013	0.013	0.013	
HBU				-0.001	0.001	0.001	
HEG	-0.025	0.025	0.025	-0.024	0.024	0.024	
HAD	-0.023	0.023	0.023	-0.004	0.004	0.004	
HSA				-0.004	0.004	0.004	
HQU	1	-1	-1	1	-1	-1	-1

Most of the table names for the transportation tables follow the following format:

TR (mm) LPRC

where:

(mm) = energy material/transportation mode combination (Table III-10)

These standard tables have per-unit transportation costs along specific links for a particular material/mode combination. Figure III-4 illustrates some tables of this form.

Exceptions to this standard table naming convention are: TRISPLT, TRBSPLT, TRCSPLT, TRGSPLT, THRUPT, and TRIPLPRC. TRISPLT, TRBSPLT, TRCSPLT and TRGSPLT represent the proportions of fuels from supply regions to demand regions (associated natural gas, natural gas, coproducts, coal, and intrastate gas tables, respectively). Figure III-5 illustrates a TRCSPLT table. THRUPT contains the loss factors for natural gas transmission via pipeline. TRIPLPRC is in the form of the other standard tables, except "IP" is not a material/mode (mm) combination as defined above. This table represents the cost of moving intrastate gas by pipeline.

The row and column headings for the majority of tables are the location or region (Table III-7) of the transportation source or destination. Exceptions to this convention are the row "PR" in the TRCSPLT table (for the dollars/ton penalty for moving industrial coal in non-unit-trains) and the addition of two characters to the row names in THRUPT. This row in THRUPT has the form (lo)(mt), where (mt) is the material transmitted as described in Table III-4. Figure III-6 illustrates THRUPT.

The entries in the tables are the cost of transportation between source and destination in standard units (i.e., dollars per thousand cubic feet, barrel, ton, etc.). Exceptions to this are TRISPLT, TRBSPLT, TRCSPLT, (Figure III-5) and TRGSPLT tables, which contain proportions (from zero to one) and the THRUPT (Figure III-6) table, which contains loss factors (also between zero and one).

FIGURE III-4

TRANSPORTATION STANDARD TABLE (EXAMPLE)

TABLE TRCLLPRC

	T1	T2	T3	T4	T5	T6	T7	T8	T9
C1	9.30	5.89	5.14	14.77	1.59	8.04	3.44	4.47	6.08
C2	9.24	6.83	5.08	11.72	6.97	4.99	4.00	0.31	5.76
C3	13.67	11.26	9.51	9.89	10.73	3.16	7.76	9.63	7.08
C4	12.65	10.24	8.49	11.66	5.99	7.10	3.02	6.25	3.70
C5	15.90	13.49	11.74	14.27	9.18	8.85	6.27	7.34	4.79
C6	19.38	16.97	15.22	14.55	13.71	8.87	10.80	11.87	9.32
C7	21.14	18.73	17.11	19.64	13.75	14.22	11.64	11.91	9.36
C8	24.55	22.14	20.52	23.05	17.16	17.63	15.05	15.32	12.77
C9	24.61	22.20	20.45	22.98	17.89	17.56	14.98	15.05	13.50
CA	27.71	25.30	23.55	23.93	21.28	17.20	18.37	19.44	16.89
CB	33.88	31.47	29.85	32.38	26.49	26.96	24.38	24.65	22.10
CC	41.79	39.38	37.76	40.29	34.40	34.87	32.29	32.56	30.01

TABLE TRCLLPRC-CONTINUED

	TA	TB	TC	TD	TE	TF	TG	TH	TI
C1	6.33	9.80	8.52	8.28	10.76	14.49	23.70	28.11	26.20
C2	4.07	8.40	6.26	8.22	10.70	12.23	23.64	26.17	24.80
C3	5.39	4.72	7.58	6.76	9.24	13.55	22.18	26.59	26.12
C4	2.01	6.34	4.20	5.88	8.36	10.17	21.30	24.11	22.74
C5	3.10	6.20	1.69	8.49	6.54	7.66	20.26	21.60	22.60
C6	7.63	10.48	5.97	1.95	1.12	8.96	14.64	19.25	24.73
C7	8.47	5.64	10.15	13.86	15.00	9.68	23.61	22.74	14.28
C8	11.88	9.05	10.64	14.99	12.51	4.67	18.40	18.61	14.26
C9	11.81	12.50	10.15	14.50	12.02	4.18	12.66	13.06	15.55
CA	15.20	15.89	13.54	11.93	9.45	7.57	12.78	17.19	23.34
CB	21.21	18.38	22.55	26.60	24.42	16.58	14.85	10.44	1.98
CC	29.12	26.29	30.46	34.51	32.33	24.49	22.75	18.35	9.69

TABLE TRCLLPRC-CONTINUED

	TJ	U3	U4	U5	U6	U7	U8	TK	TL
C1	8.00	.01						3.44	6.33
C2	6.05		.01					4.00	4.07
C3	3.35							7.76	5.39
C4	2.47			.01				3.02	2.01
C5	5.08					.01		6.27	3.10
C6	5.36				1.00			10.80	7.63
C7	10.45			2.00			1.50	11.64	6.47
C8	13.86						.01	15.05	11.88
C9	13.79							14.98	11.61
CA	15.34							18.37	15.20
CB	23.19							24.38	21.21
CC	31.10							32.29	29.12

FIGURE III - 5

TRANSPORTATION STANDARD TABLE TRCSPLT (EXAMPLE)

TABLE TRCSPLT									
	D1	D2	D3	D4	D5	D6	D7	D8	D9
T1	1.00								
T2		1.00							
T3			.80						
T4				.40					
T5			.20						
T6				.30					
T7				.30					
T8					.25				
T9					.45				
TA					.10				
TB					.10				
TC							.35		
TD						.35			
TE						.45			
TF								1.00	
TG									.65
TH									.35
TI									
TJ						.20			
TK					.10				
TL							.65		
<b>PR</b>	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00	8.00
TABLE TRCSPLT -CONTINUED									
	DA	U1	U2	U3	U4	U5	U6	U7	U8
T1		1.00							
T2			1.00						
T3				.80					
T4					.40				
T5				.20					
T6					.30				
T7					.30				
T8						.25			
T9						.45			
TA						.10			
TB						.10			
TC								.35	
TD							.35		
TE							.45		
TF									1.00
TI	1.00								
TJ						.20			
TK					.10				
TL							.65		
<b>PR</b>	8.00								
TABLE TRCSPLT -CONTINUED									
	U9	UA	PU						
T3			1.00						
TG	.65								
TH	.35								
TI		1.00							

# FIGURE III-6 TRANSPORTATION STANDARD TABLE THRUPT (EXAMPLE)

GBNG	.90	.95	.95	.96	.97	.98	.96	.98	.95
GCNG	.88	.96	.97	.98	.97	.98	.94	.96	.94
GDNG	.87	.94	.95	.95	.98	.95	.95	.94	.91
GENG	.87	.97	.98	.99	.97	.96	.93	.94	.92
G1NG	.95	.90	.90	.91	.94	.92	.96	.93	.94
G2NG	.89								
C1NG	.88	.96	.97	.98	.97	.98	.94	.96	.94
C2NG	.88	.96	.97	.98	.97	.98	.94	.96	.94
C3NG	.91	.91	.92	.93	.96	.94	.90	.96	.95
C4NG	.90	.95	.96	.96	.97	.98	.96	.98	.95
C5NG	.92	.93	.93	.94	.96	.97	.98	.99	.97
C6NG	.91	.91	.92	.93	.96	.94	.96	.96	.95
C7NG	.95	.91	.91	.91	.92	.95	.95	.96	.98
C8NG	.95	.91	.91	.91	.92	.95	.95	.96	.98
C9NG	.95	.90	.90	.91	.93	.94	.98	.95	.98
CANG	.95	.90	.90	.91	.93	.94	.96	.95	.98
CBNG	.99	.87	.87	.88	.89	.91	.92	.92	.94
CCNG	.89								
GFDG		.99							
GGDG			.99						
GHDG				.99					
GIDG					.99				
GJDG						.99			
GKDG							.99		
GLDG								.99	
GM DG									.99
GNDG	.99								

TABLE THRUPT -CONTINUED

	09	0A	U1	U2	U3	U4	U5	U6	U7
G3NG	.99	.96	.87	.87	.88	.89	.91	.92	.92
G4NG	.98	.94	.86	.87	.88	.90	.90	.93	.92
G5NG	.95	.94	.90	.90	.91	.93	.94	.96	.95
G6NG	.95	.95	.91	.91	.91	.92	.95	.95	.96
G7NG	.93	.90	.91	.92	.92	.95	.94	.98	.96
G8NG	.91	.89	.91	.92	.93	.96	.94	.98	.96
G9NG	.90	.88	.93	.94	.95	.98	.96	.98	.96
GANG	.92	.91	.93	.93	.94	.96	.97	.98	.99
GBNG	.90	.90	.95	.96	.96	.97	.98	.96	.98
GCNG	.88	.87	.96	.97	.96	.97	.98	.94	.96
GDNG	.87	.86	.94	.95	.95	.98	.95	.95	.94
GENG	.87	.87	.97	.98	.99	.97	.96	.93	.94
G1NG	.95	.95	.90	.90	.91	.94	.92	.96	.93
G2NG	.89								
C1NG	.86	.87	.96	.97	.98	.97	.98	.94	.98
C2NG	.88	.87	.96	.97	.98	.97	.98	.94	.98
C3NG	.91	.89	.91	.92	.93	.96	.94	.98	.96
C4NG	.90	.90	.95	.96	.96	.97	.98	.96	.98
C5NG	.92	.91	.93	.93	.94	.96	.97	.98	.99
C6NG	.91	.89	.91	.92	.93	.96	.94	.98	.96
C7NG	.95	.95	.91	.91	.91	.92	.95	.95	.96
C8NG	.95	.95	.91	.91	.91	.92	.95	.95	.96
C9NG	.95	.94	.90	.90	.91	.93	.94	.96	.95

### C. LP MATRIX

The LP matrix is sparse (with approximately 3,000 rows and 9,000 columns) and is stored in the matrix file. Figure III-7 illustrates the format of the LP matrix, including the relative locations of data entries. The matrix rows represent various equations defining the LP model. The first row is the objective function to be minimized (labeled "objective minimization" in Figure III-7). The next set of equations are process limits for refining and electrical facilities. Material balance limits are the next entries, followed by equations for balancing energy demand. The final row contains the activity bounds (limits) on the columns in the matrix.

The columns represent the variables used in the equations, each column (or vector) representing a specific variable. These are split into activity variables, "build" or facility expansion variables, imports and exports, and the demand approximation. The last column (often referred to as the right hand side) represents capacities, supplies, demands, etc.

The LP matrix entries are coefficients for the variables represented by each column (except for the right hand side, which contains values as stated above). Since all variables are represented by the columns, many entries are zero coefficients, where the variable (column) does not relate to a particular equation. Thus, for process limits of refineries, only those variables relating to refining activities and facility expansion contain entries. In Figure III-7, these entries are represented by a box with a code for the applicable coefficient. The blank areas represent zero coefficients. Entries of "+1" or "-1" represent the actual coefficients of these locations.

Each data element in the matrix is uniquely defined by its relative row and column in the matrix. The matrix therefore requires unique and consistent naming conventions for both rows and columns so that each data element may be easily accessed by the programs that update and manipulate the matrix. For the benefit of PIES users and programmers, the standardized codes used are consistent with the standard tables. The codes for column and row names are described below.

FIGURE III-7  
 SCHEMATIC OF INTEGRATED SUPPLY MODEL  
 (SIGN CONVENTIONS)

OBJECTIVE MINIMIZATION		PRIMARY PRODUCTION			PRIMARY TRANSPORTATION			REFINING ACTIVITY	ELECTRICAL GENERATION		PRODUCT TRANSPORTATION		FACILITY EXPANSION	IMPORTS			EXPORTS	DEMAND SECTOR SPLIT	DEMAND APPROXIMATION	CONSTRAINT	
		OIL	GAS	COAL	OIL	GAS	COAL		FOSSIL	NUCLEAR	PETRO-LEUM PRODUCTS	ELEC-TRICITY		OIL	PETRO-LEUM PRODUCTS	GAS				COAL	RETAIL MARKUPS
OBJECTIVE MINIMIZATION		VARIABLE COST OF ACTIVITY																			
PROCESS LIMITS	REFINING							+					-						≤	EXISTING CAPACITY	
	ELECTRICAL								+				-						≤	EXISTING CAPACITY	
PRODUCTION REGIONS	OIL	Ⓚ	Ⓚ		-														≥	○	
	GAS	Ⓚ	Ⓚ		-	-													≥	○	
	COAL			Ⓚ		-	-										-		≥	○	
REFINERY REGIONS	OIL				+			⊖				+							≥	○	
	PETROLEUM PRODUCTS							Ⓚ			-	-							≥	○	
UTILITY REGIONS	GAS				+				⊖						+				≥	○	
	COAL								Ⓚ										≥	○	
	PETROLEUM PRODUCTS								⊖					+					≥	○	
	ELECTRICITY								+	+		-							≥	○	
																				≥	○
DEMAND REGIONS	GAS																+		≥	○	
	COAL																		≥	○	
	PETROLEUM PRODUCTS																+		≥	○	
	ELECTRICITY																		≥	○	
DEMAND SECTORS (END-USE)	GAS																+	±	=	NATURAL GAS DEMAND BY SECTOR	
	COAL																+	±	=	COAL DEMAND BY SECTOR	
	PETROLEUM PRODUCTS																+	±	=	PETROLEUM DEMAND BY SECTOR	
	ELECTRICITY																+	±	=	ELECTRICITY DEMAND BY SECTOR	
ACTIVITY BOUNDS		+	+	+	Ⓚ	Ⓚ	Ⓚ	+	Ⓚ	Ⓚ	Ⓚ	+	Ⓚ	Ⓚ	±	F	Ⓚ	+			

29

- Ⓚ POSITIVE COEFFICIENTS
- ⊖ NEGATIVE COEFFICIENTS
- Ⓚ UPPER BOUNDS OR POSITIVE COEFFICIENTS
- Ⓚ POSITIVE BOUNDS OR UNBOUNDED VARIABLES
- ± UPPER AND LOWER BOUNDS
- F FIXED BOUNDS
- L LOSS FACTOR
- \* REFERS TO THE REPETITION OF COLUMNS

## 1. Column Names

The columns in the matrix are often referred to as vectors or activities. The following lists the primary vectors appearing in the matrix and describes the convention used in the column name.

A (r) (mt) (ds) (i) 1 - Avoid vector (demand approximation)

where: (r) = second character of the demand region code (Table III-7)

(mt) = material type (Table III-4)

(ds) = demand sector (Table III-9)

(i) = step on the demand curve approximation

PRCBND (lo) - Price bound vector for intrastate gas

where: (lo) = intrastate natural gas region (Table III-7)

SLD (lo) XX1 - Shift vector for intrastate gas to interstate regions

where: (lo) = intrastate gas region

SDG (lo) (lo) 1 - Shift vector for intrastate gas to interstate gas in demand regions

where: (lo) = demand region

D (lo) (mt) (ds) 1 - Demand vector (retail price markups)

where: (lo) = demand region (Table III-7)

(mt) = material type (Table III-4)

(ds) = demand sector (Table III-9)

DSG (lo) (ds) 1 - Substitute fuel bundles vector (natural gas substitutes)

where: (lo) = demand region (Table III-7)

(ds) = demand sector (Table III-9)

R (lo) (md) XX1 - Operate vector (electrical generation and refining activity)

where: (lo) = location/region of facility (Table III-7)

(md) = mode of operating facility (Table III-5)

B (lo) (md) XX1 - Build vectors (facility expansion)

where: (lo) = location/region of facility (Table III-7)

(md) = type of facility (Table III-5)

P (mt) (lo) (ii) 1 - Purchase vector (primary production, imports, and exports)

where: (mt) = material type (Table III-4)

(lo) = location region (Table III-7)

(ii) = supply curve step (Table III-8)

(t) (mt) (lo<sub>1</sub>) (lo<sub>2</sub>) 1 - Transportation vector (primary and product transportation)

where: (t) = mode of transporting the material (T = tanker or barge, U = pipeline, V = rail or barge)

(mt) = material type (Table III-4)

(lo<sub>1</sub>) = source (location/region) of material (Table III-7)

(lo<sub>2</sub>) = destination (location/region) of material (Table III-7)

S (mt) (lo<sub>1</sub>) (lo<sub>2</sub>) 1 - Split vector for transportation of material

where: (mt) = material type (Table III-4)

(lo<sub>1</sub>) = source (location/region) of material (Table III-7); if not applicable: lo<sub>1</sub> = "XX"

(lo<sub>2</sub>) = destination (location/region) of material (Table III-7); if not applicable: lo<sub>2</sub> = "XX"

In addition to these columns, the last column on the right-hand side of the matrix is named "RHS1." Other matrix columns not described above are internal variables used to pass information between programs.

## 2. Row Names

We have indicated the five basic row types. In addition to these, the matrix contains entries that pass information (e.g., summaries of columns) to other programs, such as the report generators. The major headings for such rows are also defined.

HOLLY - Objective function

L (lo) (cp) XX1 - Process limit equation

where: (lo) = location/region of facility (Table III-7)

(cp) = operating capacity of the facility (Table III-5)

M (lo) (mt) XX1 - Material balance equation

where: (lo) = location/region (Table III-7)

(mt) = material type (Table III-4)

D (lo) (mt) (ds) 1 - Material balance equation for demand sectors

where: (lo) = demand region (Table III-7)

(mt) = material type (Table III-4)

(ds) = demand sector (Table III-9)

B (lo) (md) XX1 - Build constraint equation

where: (lo) = location/region (Table III-7)

(md) = type of facility (Table III-5)

(xx) BNDROW - Activity bounds

where: (xx) = upper (UP), fixed (FX), or lower (LO) bounds

The following rows are used to pass information to PIES reports:

SUM (lo) (m) (mt) = Coal mine type summary row

where: (lo) = coal region (Table III-7)

(m) = mine type (D = deep mine, S = surface mine)

(mt) = coal type (Table III-4)

SB (lo) (ds) (mt) - Natural gas shift summary row

where: (lo) = demand region (Table III-7)

(ds) = demand sector (Table III-9)

(mt) = material substituted for natural gas<sup>6</sup> (Table III-4)

Other row names not conforming to those above are internal variables used to pass data between programs or within a program for temporary data storage.

#### D. DEFINITIONS OF STANDARDIZED CODES

Many of the PIES naming conventions employ standard codes for their identification. These codes include energy materials and facilities, locations (regions), capacities, etc. They are described here in a series of tables referenced throughout the chapter.

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<sup>6</sup>Natural gas substitutes refer to substitute bundles as described in Volume IV of this documentation series.

Due to the changing requirements of PIES scenarios, the codes listed in this section are subject to modification. Codes directly tied to the scenarios, e.g., Table III-2, are regularly updated to reflect new scenario specifications and are sometimes meaningless for a particular run.

TABLE III-1. STANDARD TABLE IDENTIFICATION<sup>1</sup>

TABLE IDENTIFICATION CODE (tf)	DESCRIPTION
C1	Coal-Northern Appalachian
C2	Coal-Central Appalachian
C3	Coal-Southern Appalachian
C4	Coal-Midwest
C5	Coal-Central West
C6	Coal-Gulf
C7	Coal-Northeast Great Plains
C8	Coal-Northwest Great Plains
C9	Coal-Rockies
CA	Coal-Southwest
CB	Coal-Northwest
CC	Coal-Alaska
GE	Solar and Geothermal
GS	Natural Gas
IM	Non-Oil Imports
IO	Oil and Oil Products Imports
OL	Crude Oil
R1	Refinery - District PAD1A
R2	Refinery - District PAD2A
R3	Refinery - District PAD3
R4	Refinery - District PAD4
R5	Refinery - District PAD5
R6	Refinery - District PAD1B
R7	Refinery - District PAD2B
SY	Synthetics
US	Utility - Coal Types - New Operates
UT	Utility - Non-Coal Types - New Operates
UU	Utility - Non-Coal Types - Existing
UV	Utility - Builds
UW	Utility - Average Cost Pricing and Btu Conversion
UX	Utility - Existing Capacity Constraints
UY	Utility - Interstate/Intrastate Substitutions
UZ	Utility - Coal Types - Existing
UF	Nuclear Fuel

<sup>1</sup>These codes overlap with the tables for materials and location. Since the table identification code usage is not consistent, this table is provided for ease of reference.

TABLE III-2. SUPPLY SECTOR SCENARIOS

Table Identification Code (lf)	Scenario Description	Scenario Code (s)	Table Identification Code (lf)	Scenario Description	Scenario Code(s)
C1	Coal Region 1 Base	1	OL	Oil Base	1
C2	Coal Region 2 Base	2	OL	Oil High Supply/Low Capital	2
C3	Coal Region 3 Base	3	OL	Oil Low Supply/High Capital	3
C4	Coal Region 4 Base	4	OL	Oil Base - 5% Import Price Increase	4
C5	Coal Region 5 Base	5	OL	Oil NEA	6
C6	Coal Region 6 Base	6	R1	Refinery Region 1 Base	1
C7	Coal Region 7 Base	7	R2	Refinery Region 2 Base	1
C8	Coal Region 8 Base	8	R3	Refinery Region 3 Base	1
C9	Coal Region 9 Base	9	R4	Refinery Region 4 Base	1
CA	Coal Region 10 Base	1	R5	Refinery Region 5 Base	1
CB	Coal Region 11 Base	1	R6	Refinery Region 6 Base	1
CC	Coal Region 12 Base	1	R7	Refinery Region 7 Base	1
C1	Coal Region 1 High Supply/Low Capital	2	R1	Refinery Region 1 High Supply/Low Capital	2
C2	Coal Region 2 High Supply/Low Capital	2	R2	Refinery Region 2 High Supply/Low Capital	2
C3	Coal Region 3 High Supply/Low Capital	2	R3	Refinery Region 3 High Supply/Low Capital	2
C4	Coal Region 4 High Supply/Low Capital	2	R4	Refinery Region 4 High Supply/Low Capital	2
C5	Coal Region 5 High Supply/Low Capital	2	R5	Refinery Region 5 High Supply/Low Capital	2
C6	Coal Region 6 High Supply/Low Capital	2	R6	Refinery Region 6 High Supply/Low Capital	2
C7	Coal Region 7 High Supply/Low Capital	2	R7	Refinery Region 7 High Supply/Low Capital	2
C8	Coal Region 8 High Supply/Low Capital	2	R1	Refinery Region 1 Low Supply/High Capital	3
C9	Coal Region 9 High Supply/Low Capital	2	R2	Refinery Region 2 Low Supply/High Capital	3
CA	Coal Region 10 High Supply/Low Capital	2	R3	Refinery Region 3 Low Supply/High Capital	3
CB	Coal Region 11 High Supply/Low Capital	2	R4	Refinery Region 4 Low Supply/High Capital	3
CC	Coal Region 12 High Supply/Low Capital	2	R5	Refinery Region 5 Low Supply/High Capital	3
C1	Coal Region 1 Low Supply/High Capital	3	R6	Refinery Region 6 Low Supply/High Capital	3
C2	Coal Region 2 Low Supply/High Capital	3	R7	Refinery Region 7 Low Supply/High Capital	3
C3	Coal Region 3 Low Supply/High Capital	3	R1	Refinery Region 1 Base - 5% Import Increase	4
C4	Coal Region 4 Low Supply/High Capital	3	R2	Refinery Region 2 Base - 5% Import Increase	4
C5	Coal Region 5 Low Supply/High Capital	3	R3	Refinery Region 3 Base - 5% Import Increase	4
C6	Coal Region 6 Low Supply/High Capital	3	R4	Refinery Region 4 Base - 5% Import Increase	4
C7	Coal Region 7 Low Supply/High Capital	3	R5	Refinery Region 5 Base - 5% Import Increase	4
C8	Coal Region 8 Low Supply/High Capital	3	R6	Refinery Region 6 Base - 5% Import Increase	4
C9	Coal Region 9 Low Supply/High Capital	3	R7	Refinery Region 7 Base - 5% Import Increase	4
CA	Coal Region 10 Low Supply/High Capital	3	S11	Shale Base	1
CB	Coal Region 11 Low Supply/High Capital	3	S11	Shale High Supply/Low Capital	2
CC	Coal Region 12 Low Supply/High Capital	3	S11	Shale Low Supply/High Capital	3
GE	Geo-Solar Base	1	SY	Synthetics Base	1
GE	Geo-Solar High Supply/Low Capital	2	SY	Synthetics High Supply/Low Capital	2
GE	Geo-Solar Low Supply/High Capital	3	SY	Synthetics Low Supply/High Capital	3
GS	Gas Base	1	UF	Uranium Fuel	1
GS	Gas High Supply/Low Capital	2	US	Utility Base	1
GS	Gas Low Supply/High Capital	3	UT	Utility Base	1
GS	Gas Base - 5% Import Price Increase	4	UU	Utility Base	1
GS	Gas NEA	5	UV	Utility Base	1
IM	Imports	1	UW	Utility Base	1
IO	Imports	1	UX	Utility Base	1
IO	Imports	2	UY	Utility Base	1
IO	Imports	3	UZ	Utility Base	1
IO	Imports	4			

TABLE III-3. TARGET YEAR

<u>TARGET YEAR</u> <u>Code (yr)</u>	<u>DESCRIPTION</u>
85	1985
90	1990

TABLE III-4. ENERGY MATERIALS (TABLE ALLMTLS)

<u>MATERIAL</u> <u>CODE (mt)</u>	<u>DESCRIPTION</u>
AG	Algeria
AH	Arabia Heavy
AL	Arabia Light
AN	Alaskan North Slope
AO	Angola/Congo/Zaire
AS	Alaskan South Brooks Range
BO	Bolivia/Peru
BU	Butane
CA	Coal, All High Sulfur
CB	Coal, Industrial
CE	China Export
CG	Natural Gas, Commercial
CH	Coal High Btu, High Sulfur
CI	Coal High Btu, Low Sulfur
CL	Coal, All Low Sulfur
CM	Coal, Metallurgical
CN	Canada
CP	Coal, All Sub-bituminous
CR	Coal, High Btu, Medium Sulfur
CS	Coal, Medium Btu, Medium sulfur
CT	Coal, All Lignite
CU	Coal, Very Low Btu, Medium Sulfur
CV	Coal, Low Btu, Medium Sulfur
CW	Coal, Medium Btu, High sulfur
CX	Coal, Low Btu, Low Sulfur
CY	Coal, Very Low Btu, Low Sulfur
CZ	Coal, Medium Btu, Low Sulfur
DG	Natural Gas, Intrastate
DS	Distillate, All Grades
EC	Ecuador
EG	Egypt/Syria/Bahrain
EL	Electricity
ET	East Texas Mix
E1	Electricity, Base
E2	Electricity, Intermediate
E3	Electricity, Peak
E5	Electricity, Cycle 2
GA	Gasoline, All Grades
GL	Gas Liquids
H2	Heavy Crude, PADD2
H3	Heavy Crude, PADD3
H4	Heavy Crude, PADD4
H5	Heavy Crude, PADD5

Table III-4. ENERGY MATERIALS (TABLE ALLMTLS) (Continued)

IG	Natural Gas, Industrial
IH	Iran Heavy
UL	Iran Light
IN	Indonesia
IR	Iraq
I1	Indigenous I1
I2	Indigenous I2
JF	Jet Fuel/Jet A
KU	Kuwait
LG	Liquid Petroleum Gases
LN	Louisiana Onshore
LO	Louisiana Offshore
LY	Libya
ME	Qatar/U.A.E.
MG	Natural Gas, Raw Material
MR	Military Reserve
MX	Mexico
NA	Naptha
NG	Natural Gas
NI	Nigeria/Gabon
NO	Norway
NP	Naval Petroleum Region 1
N4	Naval Petroleum Region 4
OK	Oklahoma Mix
OT	Other Refined Petroleum
QA	Steam Coal, Aggregate Foreign
QD	Distillate, Aggregate Foreign
QG	Gasoline, Aggregate Foreign
QJ	Jet Fuel, Aggregate Foreign
QL	Liquid Gases, Aggregate Foreign
QM	Metallurgical Coal, Aggregate Foreign
QN	Natural Gas, Aggregate Foreign
QO	Crude Oil, Aggregate foreign
QP	Products, Aggregate foreign
QR	Residual, Aggregate Foreign
QT	Other, Aggregate Foreign
RE	Russia
RG	Natural Gas, Residential
RS	Residual, All Grades
SA	South Asia Mix
SG	Still Gas
SO	Shale Oil
SY	Synthetic Crude
TG	Texas Gulf
TR	Trinidad
UF	Uranium Fuel
UK	United Kingdom
VM	Venezuela
WM	Wyoming Mix
WO	Pacific Offshore
WT	West Texas Mix
W1	West Coast Light
W2	West Coast Heavy

TABLE III-5. FACILITY OPERATING MODES (TABLE ALLMODS)

<u>OPERATING MODE (md)</u> <u>OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C)</u> <u>OPERATE (O)</u>	<u>DESCRIPTION</u>
0A	O	Shift RS to GA (dual pricing constraint)
0B	O	Shift RS to NA (dual pricing constraint)
0C	O	Shift RS to JF (dual pricing constraint)
0D	O	Shift RS to DS (dual pricing constraint)
0E	O	Shift RS to OT (dual pricing constraint)
0F	O	Shift RS to SG (dual pricing constraint)
0G	O	Shift RS to LR (dual pricing constraint)
0H	O	Shift OT to GA (dual pricing constraint)
0I	O	Shift OT to NA (dual pricing constraint)
0J	O	Shift OT to JF (dual pricing constraint)
0K	O	Shift OT to DS (dual pricing constraint)
0L	O	Shift OT to RS (dual pricing constraint)
0M	O	Shift OT to SG (dual pricing constraint)
0N	O	Shift OT to LR (dual pricing constraint)
0O	O	Shift SG to OO (dual pricing constraint)
0P	O	Shift SG to NA (dual pricing constraint)
0Q	O	Shift SG to JF (dual pricing constraint)
0R	O	Shift SG to DS (dual pricing constraint)
0S	O	Shift SG to RS (dual pricing constraint)
0T	O	Shift SG to OT (dual pricing constraint)
0U	O	Shift SG to LR (dual pricing constraint)
10	C	Oil-Fed Steam Build
11	O	Oil-Fed Steam Operate New Base
12	O	Oil-Fed Steam Operate New Intermediate
13	O	Oil-Fed Steam Operate New Peak
14	C	Oil-Fed Steam Build
15	O	Oil-Fed Steam Operate New Cycle 2
16	O	Oil-Fed Steam Operate Existing Cycle 2
17	O	Oil-Fed Steam Operate existing Base
18	O	Oil-Fed Steam Operate Existing Intermediate
19	O	Oil-Fed Steam Operate Existing Peak
20	C	Coal With Scrubber Build
21	O	Coal With Scrubber Operate New Base
22	O	Coal With Scrubber Operate New Intermediate
23	O	Coal With Scrubber Operate New Peak
24	C	Coal With Scrubber Existing
25	O	Coal With Scrubber Operate New Cycle 2
26	O	Coal With Scrubber Operate Existing Cycle 2
27	O	Coal With Scrubber Operate Existing Base
28	O	Coal With Scrubber Operate Existing Intermediate
29	O	Coal With Scrubber Operate Existing Peak
30	C	Coal Without Scrubber Build
31	O	Coal Without Scrubber Operate New Base
32	O	Coal Without Scrubber Operate New Intermediate
33	O	Coal Without Scrubber Operate New Peak
34	C	Coal Without Scrubber Existing
35	O	Coal Without Scrubber Operate New Cycle 2
36	O	Coal Without Scrubber Operate Existing Cycle
37	O	Coal Without Scrubber Operate Existing Base
38	O	Coal Without Scrubber Operate Existing Intermediate

TABLE III-5 (continued, page 2)

<u>OPERATING MODE (md) OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C) OPERATE (O)</u>	<u>DESCRIPTION</u>
39	O	Coal Without Scrubber Operate Existing Peak
3Y	C	Coal Without Scrubber Build
3Z	C	Coal Without Scrubber Build
44	C	Coal Miscellaneous Existing
46	O	Coal Acceptable Operate Existing Cycle
47	O	Coal Acceptable Operate Existing Base
48	O	Coal Acceptable Operate Existing Intermediate
49	O	Coal Acceptable Operate Existing Peak
54	C	Gas Turbine Build
56	O	Gas Turbine Operate Existing Cycle 2
57	O	Gas Turbine Operate Existing Base
58	O	Gas Turbine Operate Existing Intermediate
59	O	Gas Turbine Operate Existing Peak
60	C	Simple With Distillate Build
61	O	Simple With Distillate Operate New Base
62	O	Simple With Distillate Operate New Intermediate
63	O	Simple With Distillate Operate New Peak
64	C	Simple With Distillate Build
65	O	Simple With Distillate Operate New Cycle 2
66	O	Simple With Distillate Operate Existing Cycle
67	O	Simple With Distillate Operate Existing Base
68	O	Simple With Distillate Operate Existing Intermediate
69	O	Simple With Distillate Operate Existing Peak
70	C	Combined With Distillate Build
71	O	Combined With Distillate Operate New Base
72	O	Combined With Distillate Operate New Intermediate
73	O	Combined With Distillate Operate New Peak
74	C	Combined with Distillate Build
75	O	Combined With Distillate Operate New Cycle 2
76	O	Combined With Distillate Operate Existing Cycle
77	O	Combined With Distillate Operate Existing Base
78	O	Combined With Distillate Operate Existing Intermediate
79	O	Combined With Distillate Operate Existing Peak
80	C	Gas-Fed Steam Build
81	O	Gas-Fed Steam Operate New Base
82	O	Gas-Fed Steam Operate New Intermediate
83	O	Gas-Fed Steam Operate New Peak
84	C	Gas-Fed Steam Build
85	O	Gas-Fed Steam Operate New Cycle 2
86	O	Gas-Fed Steam Operate Existing Cycle

TABLE III-5 (continued, page 3)

<u>OPERATING MODE (md) OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C) OPERATE (O)</u>	<u>DESCRIPTION</u>
87	O	Gas-Fed Steam Operate Existing Base
88	O	Gas-Fed Steam Operate Existing Intermediate
89	O	Gas-Fed Steam Operate Existing Peak
90	C	Hydro Build
91	O	Hydro Operate New Base
92	O	Hydro Operate New Intermediate
93	O	Hydro Operate New Peak
94	C	Hydro Build
95	O	Hydro Operate New Cycle 2
96	O	Hydro Operate New Cycle 2
97	O	Hydro Operate Existing Base
98	O	Hydro Operate Existing Intermediate
99	O	Hydro Operate Existing Peak
A1	C	Build Uranium Conversion
A2	C	Uranium Conversion Existing
A3	O	Uranium Conversion Existing Operate
A4	O	Uranium Conversion Existing Operate
A5	O	Uranium Conversion Existing Operate
A6	O	Uranium Conversion Existing Operate
A7	O	Uranium Conversion existing Operate
A8	O	Uranium Conversion Existing Operate
A9	O	Uranium Conversion Existing Operate
AA	O	Uranium Conversion Existing Operate
AB	O	Uranium Conversion Existing Operate
AC	O	Uranium Conversion Existing Operate
AG	O	Operate Algerian
AH	O	Operate Arabian Heavy
AL	O	Operate Arabian Light
AN	O	Operate Alaskan North Slope
AO	O	Operate Angola/Congo/Zaire
AS	O	Operate South Alaskan
BC	C	Accumulate Prod Consumption
BF	C	Force CR as Percent of CD
BN	C	Constrain Use of NC
BO	O	Operate Bolivian/Peruvian
BT	O	Btu Balance
BU	O	Shift BU to LG
CC	O	Capital, Operating, and Maintenance Costs
CD	C	Build Distillation
CE	O	Operate Chinese Export
CN	O	Operate Canadian Mix
CR	C	Build Reforming Unit
DO	C	Distillate-Fed Gas Steam Build
D1	O	Distillate-Fed Gas Steam Operate New Base
D2	O	Distillate-Fed Gas Steam Operate New Intermediate
D3	O	Distillate-Fed Gas Steam Operate New Peak

TABLE III-5 (continued, page 4)

<u>OPERATING MODE (md) OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C) OPERATE (O)</u>	<u>DESCRIPTION</u>
D4	C	Distillate-Fed Gas Steam Existing
D7	O	Distillate-Fed Gas Steam Operate Existing Base
D8	O	Distillate-Fed Gas Steam Operate Existing Intermediate
D9	O	Distillate-Fed Gas Steam Operate Existing Peak
DG	O	Distillate to Gas
E1	O	Transmission Old
E2	O	Transmission New
E4	O	Convert CM to CB Coal
E5	O	Convert CM to CL Coal
E6	O	Convert CT to CL Coal
E7	O	Convert CX to CT Coal
E8	O	Convert CY to CT Coal
E9	O	Convert CZ to CL Coal
EA	O	Convert CU to CT Coal
EB	O	Convert CU to CD Coal
EC	O	Operate Ecuadorian
EE	O	Convert CY to CD Coal
EG	O	Operate Egyptian/Syrian
ET	O	Operate East Texas Mix
EX	O	Utility Retirements
F1	O	Shift JF to OT
F2	O	Shift JF to LR
F3	O	Shift DS to GA
F4	O	Shift DS to NA
F5	O	Shift DS to JF
F6	O	Shift DS to RS
F7	O	Shift DS to OT
F8	O	Shift DS to SG
F9	O	Shift DS to LR
FA	O	Shift LR to GA
FB	O	Shift LR to NA
FC	O	Shift LR to JF
FD	O	Shift LR to DS
FE	O	Shift LR to RS
FF	O	Shift LR to OT
FG	O	Shift LR to SG
FH	O	Shift GA to NA
FI	O	Shift GA to JF
FJ	O	Shift GA to DS
FK	O	Shift GA to RS
FL	O	Shift GA to OT
FM	O	Shift GA to SG
FN	O	Shift GA to LR
FO	O	Shift NA to GA
FP	O	Shift NA to JF

TABLE III-5 (continued, page 5)

<u>OPERATING MODE (md) OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C) OPERATE (O)</u>	<u>DESCRIPTION</u>
FQ	O	Shift NA to DS
FR	O	Shift NA to RS
FS	O	Shift NA to OT
FT	O	Shift NA to SG
FU	O	Shift NA to LR
FV	O	Shift JF to GA
FW	O	Shift JF to DS
FX	O	Shift JF to RS
FY	O	Shift JF to NA
FZ	O	Shift JF to SG
GO	C	Operate Logical Build
GI	O	Operate Geothermal
G2	C	Build Geothermal
GD	O	Operate Wind
GE	C	Build Wind
GF	O	Operate Thermal
GG	C	Build Thermal
GJ	O	Operate Photoelectric
GK	C	Build Photoelectric
GL	O	Shift GL to GA
GN	O	Gas to Oil Interchange New
GO	O	Gas to Oil Interchange
GS	O	Gas Turbine to Distillate
H2	O	Operate PAD II Heavy Crude
H3	O	Operate PAD III Heavy Crude
H4	O	Operate PAD IV Heavy Crude
H5	O	Operate PAD V Heavy Crude
HL	C	Hydro Limit
HR	C	Build De-Sulfurization Unit
I1	O	Operate PAD I Indigenous
I2	O	Operate PAD II Indigenous
IH	O	Operate Iranian Heavy
IL	O	Operate Iranian Light
IN	O	Operate Indonesian
IR	O	Operate Iraqi
KO	C	Pump Storage Build
K2	O	Pump Storage Operate New Intermediate
K3	O	Pump Storage Operate New York
K4	C	Pump Storage Existing
K5	O	Pump Storage Operate New Cycle 2
K6	O	Pump Storage Operate Existing Cycle 2
K8	O	Pump Storage Operate Existing Intermediate

TABLE III-5 (continued, page 6)

<u>OPERATING MODE (md) OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C) OPERATE (O)</u>	<u>DESCRIPTION</u>
K9	O	Pump Storage Operate Existing Peak
KU	O	Operate Kuwaiti Export
L1	C	Build Syncrude
L2	O	Operate Syncrude
L3	C	Build Syngas
L4	O	Operate Syngas
L5	C	Build Fuel Gas
L6	O	Operate Fuel Gas
L7	C	Build Other to Syngas
L8	O	Operate Other to Syngas
LN	O	Operate Louisiana Onshore
LO	O	Operate Louisiana Offshore
LP	O	Shift LR to LG
LY	O	Operate Libyan
ME	O	Operate Mid-Eastern Mix
MX	O	Operate Mexican
N1	O	Operate New Nuclear
N2	C	Build Existing Nuclear
N3	O	Operate Existing Nuclear
N5	O	Operate New Nuclear-Cycling
N6	O	Operate FY Nuclear-Cycling
N7	C	Build New Nuclear
NC	O	Production Consumption-New Distillate
ND	O	Interstate to Intrastate Gas
NI	O	Operate Nigerian & Gabon
NO	O	Operate Norwegian
NP	O	Operate Naval Reserve #1 Crude
NU	C	Build New Nuclear
NY	C	Build New Nuclear
OC	O	Oil to Coal conversion
OG	O	Oil to Gas Interchange
OK	O	Operate Oklahoma Mix
ON	O	Oil to Gas Interchange New
P0	C	Sub-Bituminous Build
P1	O	Sub-Bituminous Operate New Base
P2	O	Sub-Bituminous Operate New Intermediate
P3	O	Sub-Bituminous Operate New Peak
P4	C	Sub-Bituminous Existing
P5	O	Sub-Bituminous Operate New Cycle 2
P6	O	Sub-Bituminous Operate Existing Cycle
P7	O	Sub-Bituminous Operate Existing Base
P8	O	Sub-Bituminous Operate Existing Intermediate
P9	O	Sub-Bituminous Operate Existing Peak
PC	O	Production Consumption-Oils

TABLE III-5 (continued, page 7)

<u>OPERATING MODE (md) OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C) OPERATE (O)</u>	<u>DESCRIPTION</u>
PG	O	Production Consumption-Gas
PY	C	Sub-Bituminous Build
PZ	C	Sub-Bituminous Build
QQ	O	Old Capital (Generation, Transmission, and Distribution)
RC	C	Build Catalytic Cracker
RE	O	Operate Russian Export
S0	C	Operate Logical Build
S1	C	Build Shale
S2	C	Build Shale
S3	C	Build Shale
S4	O	Operate Shale
S5	O	Operate Shale
S6	O	Operate Shale
SA	O	Operate South Asian
SC	O	Gas to Coal Conversion
SO	O	Operate Shale Oil
SY	O	Operate Synthetic Crude
T0	C	Lignite Build
T1	O	Lignite Operate New Base
T2	O	Lignite Operate New Intermediate
T3	O	Lignite Operate New Peak
T4	C	Lignite Existing
T5	O	Lignite Operate New Cycle 2
T6	O	Lignite Operate Existing Cycle 2
T7	O	Lignite Operate Existing Base
T8	O	Lignite Operate Existing Intermediate
T9	O	Lignite Operate New Peak
TD	C	Transmit Electricity New
TG	O	Operate Texas Gulf Coast
TR	O	Operate Trinidad
TY	C	Lignite Build
TZ	C	Lignite Build
U1	O	Convert Electricity
U4	O	Convert CH to CB Coal
U5	O	Convert CW to CB Coal
U6	O	Convert CZ to CB Coal
U8	O	Convert CS to CB Coal
U9	O	Convert CI to CB Coal
UA	O	Convert CR to CB Coal
UC		Utility Capital
UK	O	Operate United Kingdom
V1	O	Convert CZ to CP Coal
V2	O	Convert CI to CP Coal
V3	O	Convert CM to CP Coal
V4	O	Convert CH to CA Coal
V5	O	Convert CW to CA Coal

TABLE III-5 (continued, page 8)

<u>OPERATING MODE (md) OR CAPACITY (cp) CODE</u>	<u>CAPACITY (C) OPERATE (O)</u>	<u>DESCRIPTION</u>
V6	O	Convert CZ to CA Coal
V8	O	Convert CB to CA Coal
V9	O	Convert CI to CA Coal
VA	O	Convert CR to CA Coal
VM	O	Operate Venezuelan Mix
W1	O	Operate West Coast Light
W2	O	Operate West Coast Heavy
WM	O	Operate Wyoming Mix
WO	O	Operate Pacific Offshore
WT	O	Operate West Texas Mix
XD	O	Convert XD to Distillate
XG	O	Convert XG to Gasoline
XJ	O	Convert XJ to Jet Fuel
XN	O	Convert XN to Naphtha
XO	O	Convert XO to Other
XR	O	Convert XR to Residential
ZC	O	Standard Coal Used
ZD	O	Distillate Used
ZG	O	Natural Gas Used
ZL	O	Low-Sulfur Coal Used
ZN	O	Utility Fuel Used
ZP	O	Sub-Bituminous Fuel Used
ZR	O	Residual Fuel Used
ZT	O	Lignite Fuel Used

TABLE III-6. RESOURCE ACCUMULATION CODES

RESOURCE ACCUMULATION CODE Q(rs)	DESCRIPTION
QYT	Cumulative capital investment in millions of dollars per standard units (e.g., thousand barrels per calendar day)
QCF	Cumulative drilling in millions of feet per standard unit
QS(t)	Percent of surface mines (coal) where (t) = coal type, representing the second character of coal types (mt) in Table III-4
QD(t)	Percent of deep mines (coal) where (t) = coal type, representing the second character of coal types (mt) in Table III-4
QUC	Annual capital investment for utility facilities

TABLE III-7. LOCATION/GEOGRAPHIC REGION (TABLE ALLOCS)

DESCRIPTION	LOCATION/REGION (lo) CODE
Uranium Conversion	NF
Foreign Crude Locations	
Other Foreign Sites	FO
Canada	FC
Caribbean	FV
Landed East Coast	F1
Landed Gulf Coast	F3
Landed West Coast	F5
Mexico	FM
Other Foreign Sites/IEES Link	HO
Canada/IEES Link	HC
Caribbean/IEES Link	HV
Landed East Coast/IEES Link	H1
Landed West Coast/IEES Link	H3
Landed West Coast/IEES Link	H5
Mexico/IEES Link	HM
Coal Regions	
Northern Appalachian	C1
Central Appalachian	C2
Southern Appalachian	C3
Midwest	C4
Central West	C5
Gulf	C6
Northeastern Great Plains	C7
Northwestern Great Plains	C8
Rockies	C9
Southwest	CA
Northwest	CB
Alaska	CC
Refining Districts (Source: Modified Petroleum Administration for Defense Districts (PADDs) Company Definitions)	
PAD1A	R1
PAD2A	R2
PAD3	R3
PAD4	R4
PAD5	R5
PAD1B	R6
PAD2B	R7
Utility Regions (Includes Nuclear and Geothermal) (DOE Regions)	
New England	U1
New York/New Jersey	U2
Mid-Atlantic	U3
South Atlantic	U4
Midwest	U5
Southwest	U6
Central	U7

TABLE III-7. LOCATION/GEOGRAPHIC REGION (TABLE ALLOCS) (Continued)

DESCRIPTION	LOCATION/REGION (lo) CODE
North Central	U8
West	U9
Northwest	UA
Demand Regions (DOE regions)	
New England	D1
New York/New Jersey	D2
Mid-Atlantic	D3
South Atlantic	D4
Midwest	D5
Southwest	D6
Central	D7
North Central	D8
West	D9
Northwest	DA
Crude Oil and Natural Gas (NPC Regions and DOE regions)	
1S South Alaska	O1
2 Pacific Coast	O2
2A Pacific Ocean	O3
3 West Rocky Mountains	O4
5 West Texas and East New Mexico	O6
6 West Gulf Basin	O7
6A Gulf of Mexico	O8
7 Midcontinent	O9
8-9-10 Michigan Basin, Eastern Interior, and Appalachians	OA
11 Atlantic Coast	OB
11A Atlantic Ocean	OC
1N North Slope	OD
1N North Slope	G1
1S South Alaska	G2
2 Pacific Coast	G3
2A Pacific Ocean	G4
3 West Rocky Mountains	G5
4 East Rocky Mountains	G6
5 West Texas and East New Mexico	G7
6 West Gulf Basin	G8
6A Gulf of Mexico	G9
7 Midcontinent	GA
8-9 Michigan Basin, Eastern Interior	GB
10 Appalachians	GC
11 Atlantic Coast	GD
11A Atlantic Ocean	GE
New England	GF
New York/New Jersey	GG
Mid-Atlantic	GH
South Atlantic	GI
Midwest	GJ
Southwest	GK
Central	GL
North Central	GM

TABLE III-7. LOCATION/GEOGRAPHIC REGION (TABLE ALLOCS) (Continued)

DESCRIPTION	LOCATION/REGION (1o) CODE
West	GN
Northwest	GO
Shale Regions	
Shale Region 1	S1
Transshipment Cities	
Boston; Rail	T1
New York; Rail	T2
Baltimore-Philadelphia; Rail	T3
Miami; Rail	T4
Pittsburgh; Rail	T5
Atlanta; Rail	T6
Cincinnati, South; Rail	T7
Detroit; Rail	T8
Chicago; Rail	T9
St. Louis, East; Rail	TA
St. Paul-Minneapolis; Rail	TB
Kansas City; Rail	TC
Houston; Rail	TD
Dallas; Rail	TE
Denver; Rail	TF
Los Angeles; Rail	TG
San Francisco; Rail	TH
Seattle; Rail	TI
New Orleans; Rail	TJ
Cincinnati, North	TK
St. Louis, West	TL

TABLE III-8. SUPPLY CURVE STEPS

<u>MATERIAL TYPE</u>	<u>SUPPLY CURVE STEP CODE (ii)</u>	<u>DESCRIPTION</u>
Coal	E1-E9	Existing mines in operation in order of increasing cost
Coal	N1-N9, NA-NZ	Mines which may be opened in the future in order of increasing cost
Oil	first digit = 1-6	Oil field vintage (old primary, old secondary, old tertiary, new primary, new secondary, new tertiary; respectively)
	second digit = 1-9	Price trajectory for the crude oil price ramp table (-5%, -3%, -1%, 1%, 2%, 3%, 5%, respectively)
Natural Gas	first digit = 1,2	Gas field vintage (1 = new, 2 = old)
	second digit = 1-9	Price trajectory for the natural gas price ramp table (-1.5%, -1%, 0%, 1%, 2%, 3%, 4%, 5%, 7%, respectively)

TABLE III-9. DEMAND SECTORS

<u>DEMAND SECTOR CODE (ds)</u>	<u>DESCRIPTION</u>
CM	Commercial
FS	Feedstock
HC	Residential and Commercial
IN	Industrial
RM	Raw Material
RS	Residential
TR	Transportation

TABLE III-10. ENERGY MATERIAL/TRANSPORTATION MODE COMBINATIONS

<u>COMBINATIONS</u>	<u>MATERIAL/MODE CODE (mm)</u>
Oil Products-Barge or Tanker	PB
Residual-Barge or Tanker	RB
Crude Oil-Barge or Tanker	OB
Natural Gas-Pipeline	NP
Oil Products-Pipeline	PP
Crude Oil-Pipeline	OP
Coal-Train or Barge	CL
Electricity Transmission	EL
Nuclear Fuel Transport	UP

## E. RAW DATA FORMATS

Due to the variety of the sources of PIES raw data, there are few naming conventions that universally apply to all the raw data. However, within each energy material or facility type, there are often standard formats used for raw data table names, codes, etc. This section explains the formats for each energy material and facility type. Where the standardized PIES codes defined in section D are applicable, they are referenced in the raw data table descriptions.

### 1. Coal Raw Data Tables

There are 12 raw data tables for coal, all in a standardized format as described in Table III-11.

### 2. Geothermal and Solar Raw Data Tables

The raw data tables for geothermal and solar data are input directly to the preprocessor code in the form of tables described in Table III-12.

### 3. Import Raw Data Tables

Import data come from two sources that provide the standard table format to PIES. Therefore, there are no "raw data" per se for imports.

### 4. Natural Gas Raw Data Tables

Natural gas raw data are contained in six different types of tables, all with the same format. These are described in Table III-13. Common to many of these tables is a code for the pipeline proposal considered (p), where (p) may equal "0" (no pipeline), "A" (Arctic pipeline), "E" (El Paso-Alaskan-pipeline), or "N" (Alcan pipeline).

### 5. Oil Raw Data Tables

Oil raw data tables are very similar to natural gas raw data tables. There are additional tables with supplementary data, such as price ramps and intrastate vs. interstate distribution rations. All are illustrated in Table III-14.

### 6. Refineries Raw Data Tables

Refineries raw data consist of three sets of tables, all with the same format described in Table III-15. Each set of tables represents the target years 1985 and 1990.

7. Shale Oil Raw Data Tables

Shale oil data are entered in standard table format; therefore, there are no raw data to be preprocessed.

8. Synthetics Raw Data Tables

Synthetics data are entered directly into tables in the preprocessor described in Table III-16.

9. Transportation Raw Data Tables

Transportation data, in general, follow the first format described in Table III-17. Exceptions are noted later in the same table. Tables PIPERATE, TNKRATE, and BARGE are from the transportation preprocessor. All other tables are file inputs.

10. Nuclear Fuel Raw Data Tables

Nuclear fuel data, like shale and import data, are input in the form of standard tables.

11. Utilities Raw Data Tables

Utilities raw data are entered directly into the two utilities preprocessors. These are described in Table III-18. Common to many of these tables are the following codes:

(c) = capital expenditure (where: O = new plant, Y = committed plant,  
Z = deferrable plant, 4 = existing plant)

ROW = entries for row "HOLLY" in the LP matrix

ROW 2 = entries for MCC rows in standard tables

LIM and BD = bound indicator (where: "BND" = upper bound, "BLO" lower  
bound, "BFX" = fixed bound)

**TABLE III-11. COAL RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
C(n) C(n) = coal supply region (Table III-7)	Coal production, prices, and capital investment	PROD, PRIC, SURF, ICAP, DCAP PROD = maximum level of production PRIC = minimum acceptable price SURF = proportion of produc- tion from surface mines ICAP = present value of initial capital investment re- quired between 1976 and target year to open new mines DCAP = Fraction of deferred capital spent on new mines	C(x) (ii) C(x) = coal type (Table III-4) (ii) = coal supply curve step (Table III-8)	Column PROD: production in millions of tons per year Column PRIC: price per ton Column SURF: ratio Column ICAP: investment in dollars per annual ton Column DCAP: investment in dollars per annual ton

**TABLE III-12. GEOHERMAL AND SOLAR RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
GE(s) (yr)R (s) = scenario (Table III-2) (yr) = target year (Table III-3)	Partial standard table input	BND, PRC, QYT; as defined for standard table rows (see Section B)	(md) (to) (md) = mode of facility (Table III-5) (to) = utility region (Table III-7)	Standard table entries for column headings as defined for the standard table rows (see Section B)
SCALE	Capacity factors for each plant type	MEI	(md) (md) = mode of geothermal/ solar facility (Table III-5)	Capacity factors

**TABLE III-13. NATURAL GAS RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
GS(lo) (s)PR (lo) = location/gas supply region (Table III-7) (s) = scenario/gas supply convention (Table III-2)	Maximum quantities of natural gas available at the specified price	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Natural gas supply in billions of cubic feet per year
GS(lo) (s)CO (lo) = location/gas supply region (Table III-7) (s) = scenario/gas supply convention (Table III-2)	Cumulative quantities of condensate produced as a co-product of natural gas	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Condensate produced in thousands of barrels per calendar day
GS(lo) (s)LP (lo) = location/gas supply region (Table III-7) (s) = scenario/gas supply convention (Table III-2)	Cumulative quantities of butane produced as a co-product of natural gas  (cumulative over price steps but not over time)	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Butane produced in thousands of barrels per calendar day
GS(lo) (s)CS	Cumulative quantities of gas liquids produced as a co-product of natural gas  (Cumulative over price steps but not over time)	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Gas liquids produced in thousands of barrels per calendar day

**TABLE III-13. NATURAL GAS RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
(lo) = location /gas supply region (Table III-7)  (s) = scenario/gas supply convention (Table III-2)				
GS(lo) (s)CP  (lo) = location/gas supply region (Table III-7)  (s) = scenario/gas supply convention (Table III-2)	Cumulative capital investment required for the production level in the corresponding "PR" tables  (Cumulative over both time and price steps)	1977 through 1991	(ii)  (ii) = supply curve step (Table III-8)	Cumulative investment in millions of dollars
GS(lo) (s)CF	Cumulative drilling requirements for the production level in the corresponding "PR" tables			Cumulative drilling in millions of feet
INTINT	Used to split production of old onshore gas between interstate and intrastate markets	INTER INTRA	G3-GD	Fraction of old gas produced in interstate region sold in interstate (intrastate) market
GSRTOF	Used to share intrastate gas from interstate to intrastate regions	GG-ON intrastate gas regions (DOE regions)	G3-GD interstate gas regions (NPC regions)	Fraction of gas produced in an interstate region which lies in overlapping intrastate region

**TABLE III-13. NATURAL GAS RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
NSGS	North Slope gas production under various pipeline proposals		(yr) (yr) = target year (Table III-2)	Millions of cubic feet per calendar day
WHPR	Well-head price of North Slope gas using residual pricing	(p) (p) = pipeline proposal (see text)	(yr) (yr) = target year (Table III-2)	Price per millions of Btu at 1032 Btu/cf
ORGR	Split of associated gas from oil region OA to gas region GB and GC	(to) (to) = gas region (Table III-7)	(to) (to) = oil region (Table III-7)	Ratio from oil region to gas region
AWARDS	Split of production from gas regions to demand regions	(to) (to) = demand region (Table III-7)	(to) (to) = gas region (Table III-7)  (s) = pipeline proposal (see text)	Ratio from gas region to demand region
ALPT	Throughput factors for Alaskan gas	(to) (to) = demand region (Table III-7)	(to) (p) (to) = gas region (Table III-7)  (s) = pipeline proposal (see text)	Throughput factors
ALPR	Link prices for Alaskan gas	(to) (to) = demand region (Table III-7)	(to) (p) (yr) (to) = gas region (Table III-7)  (p) = pipeline proposal (see text)  (yr) = target year (Table III-2)	Dollars per thousand cubic feet

**TABLE III-14. OIL RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
OI.(lo) (s)CF (lo) = location/oil supply region (Table III-7) (s) = scenario/oil supply convention (Table III-2)	Cumulative drilling requirements (over time and price steps)	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Cumulative drilling in millions of feet
OI.(lo) (s)PR (lo) = location/oil supply region (Table III-7) (s) = scenario/oil supply convention (Table III-2)	Maximum cumulative quantity of oil available (over price steps)	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Cumulative quantity in thousands of barrels per calendar day
OI.(lo) (s)C5 (lo) = location/oil supply region (Table III-7) (s) = scenario/oil supply convention (Table III-2)	Cumulative quantities of gas liquids produced as co-products of crude oil (over price steps)	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Cumulative quantity in thousands of barrels per calendar day
OI.(lo) (s)LP (lo) = location/oil supply region (Table III-7) (s) = scenario/oil supply convention (Table III-2)	Cumulative quantities of butane produced as a co-product of crude oil (over price steps)	1977 through 1991	I(ii) (ii) = supply curve step (Table III-8)	Cumulative quantity in thousands of barrels per calendar day

**TABLE III-14. OIL RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
OL(lo) (s)CP	Cumulative capital investment requirements (over time and price steps)	1977 through 1991	I(ii)  (ii) = supply curve step (Table III-8)	Cumulative investment in millions of dollars
(lo) = location/oil supply region (Table III-7)				
(s) = scenario/oil supply convention (Table III-2)				
OL(lo) (s)AD	Cumulative quantities of associated and dissolved natural gas produced as co-products of crude oil (over price steps)	1977 through 1991	I(ii)  (ii) = supply curve step (Table III-8)	Cumulative quantity in billions of cubic feet per year
(lo) = location/oil supply region (Table III-7)				
(s) = scenario/oil supply convention (Table III-2)				
OLPRC	Oil price ramp table	1977 through 1991	I(i)  (i) = price ramp step (1-9)	1975 dollars per barrel
GSPRC	Non-associated natural gas price ramp table	1977 through 1991	I(i)  (i) = price ramp step (1-9)	1975 dollars per thousand cubic feet
ADPRC	Associated natural gas price ramp table	1977 through 1991	I(ii)  (i) = price ramp step (1-9)	1975 dollars per thousand cubic feet

**TABLE III-14. OIL RAW DATA TABLES**  
(Continued)

<b>GLPRC</b>	Gas liquids price ramp table	1977 through 1991	<b>I(i)</b>  (i) = price ramp step (1-9)	1975 dollars per barrel
<b>ZOL (s) (yr)</b>  (s) = special region scenario  (yr) = target year (85 = 1985, 90 = 1990)	Crude oil supply from non-traditional sources	<b>(M) (lo) (ii)</b>  (M) = material type (Table III-4)  (lo) = location/region (Table III-7)  (ii) = supply step used to differentiate between purchase vectors (the steps do not follow normal conventions)	Normal conventions for standard table rows (see section B)	Normal convention for entries in standard table rows (see section B)
<b>DISPLT</b>	Ratio of crude oil types by region	<b>(lo)</b>  (lo) = oil region (Table III-7)	<b>(M)</b>  (M) = crude oil types (Table III-4)	Ratio of crude oil types
<b>SPLIT</b>	Proportion of interstate and intrastate natural gas	<b>(lo)</b>  (lo) = oil region	<b>M(mt)</b>  (mt) = natural gas types (Table III-4)	Proportion of interstate and intrastate natural gas

59

**TABLE III-15. REFINERIES RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
<b>(lo)</b>  (lo) = refinery region (Table III-7)	All data in standard table format	Standard table column conventions (see section B)	Standard table row conventions (see section B)	Standard table conventions used for entries (see section B)

**TABLE III-16. SYNTHETICS RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
BTUCOAL	Conversion table for physical coal Btu to standard coal Btu	SCALE	(mt)  (mt) = coal type (Table III-4)	Conversion factor
LIMITS	Synthetics plant capacities	BND, BFX, RHS  BND = upper bound capacity BFX = fixed capacity RHS = existing capacity	(md)  (md) = plant mode (Table III-5)	All capacities in millions of cubic feet per day
SYNGAS	Conversion factor from naphtha to synthetic	M(mt), PRC  M(mt) = material (Table III-4)	Row	In columns M(mt): conversion factor  In column PRC: price of conversion per unit
RAW(s) (yr) (s) = scenario (Table III-2) (yr) = target year (Table III-3)	Raw data in reverse standard table format. Consists of quantities, prices, and conversion factors for synthetics from coal	Standard table row heading conventions used (see section B)	Standard table column heading (see section B)	Standard table row entries (see section B)

**TABLE III-17. TRANSPORTATION RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
<p>(tr) (mm) (tt) (dt)</p> <p>(tr) = transportation type (TR = transportation sub-network, FT = imported fuel transportation)</p> <p>(mm) = material/mode (Table III-10)</p> <p>(tt) = table type (LP = price table, LM = mileage)</p> <p>(dt) = data type (for LP tables: TF = tariffs used, RC = generic prices; for LM tables: PC = shipping via Panama Canal, TA = not via Panama Canal, BD = new natural gas pipelines, EX = existing gas pipelines)</p>	<p>Transportation raw data tables containing prices and mileage between modes of the transportation network</p>	<p>(lo)</p> <p>(lo) = location/region (Table III-7) (FEA1, FEA2, etc. = D1, D2, etc.)</p>	<p>(lo)</p> <p>(lo) = location/region (Table III-7) (FEA1, FEA2, etc. = D1, D2, etc.)</p>	<p>For (tt) = LP: prices are in dollars per standard unit (e.g., barrel, thousand cubic feet)</p> <p>For (tt) = LM: distances are in statute miles or nautical miles (shipping only)</p>
<p>TS (tr) (tt)</p> <p>(tr) = transportation type (RR = rail, WW = barge)</p> <p>(tt) = table type (MI = mileage, PR = prices)</p>	<p>Transshipment tables</p>	<p>(lo)</p> <p>(lo) = location/region (Table III-7)</p>	<p>(lo)</p> <p>(lo) = location/region (Table III-7)</p>	<p>For (tt) = MI: mileage between locations</p> <p>For (tt) = PR: prices in dollars per standard units (e.g. barrels, thousands cubic feet)</p>

**TABLE III-17.: TRANSPORTATION RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
TSCCSPTD	Fixed proportions for coal supplied by rail transshipment nodes	(to) (to) = demand regions (Table III-7)	(to) (to) = rail transshipment nodes (Table III-7)	Proportion of coal shipped
TRNPFIX	Additional gathering charges for offshore gas	FIX	(to) (to) = gas region (Table III-7)	Cost per thousand cubic feet
TRISPLT	Intrastate, associated natural gas; ratios by region	(to) (to) = gas region (Table III-7)	(to) (to) = oil region (Table III-7)	Percentage of gas allocated to region
TRBSPLT	Co-products produced with intrastate gas; ratio by region	(to) (to) = oil region (Table III-7)	(to) (to) = gas region (Table III-7)	Percentage of co-products by region
DIRCU	Direct link prices for coal regions to utility regions; minemouth and lignite	(to) (to) = utility regions (Table III-7)	(to) (to) = coal regions (Table III-7)	Link prices per ton
TAPS	Trans-Alaska pipeline charges	(yr) PIC (yr) = target year (Table III-3)	OB and OP OB = Step 1 tariff capacity OP = Step 2 tariff capacity	Dollars per barrel

**TABLE III-17. TRANSPORTATION RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
ALASKOIL	Oil shipped from Alaska for transshipment in either Northern Tier or El Paso pipelines	(to) OP and (to) OB  (to) = refinery region (Table III-7) OP = El Paso-Sohio Pipeline OB = Northern Tier Pipeline	(to)  (to) = oil regions (Table III-7)	Dollars per barrel
TROPLGAT	Gathering charges for crude oil	Cost	(to)  (to) = oil regions (Table III-7)	Cost per barrel
PIPERATE	Pipeline rates for crude oil	BD, EX, and FE  BD = new pipelines EX = existing pipelines FE = additional links to insure feasible solutions	(mm)  (mm) = material/mode (Table III-10)	Dollars per barrel per 100 miles
TNKRATE	Data on oil and petroleum product tankers	DWT, LWT, SEA, PORT, TURN, PCC, KNOTS, SCALE  DWT = tanker capacity in deadweight tons LWT = tanker capacity in long tons SEA = cost at sea PORT = cost in port TURN = turnaround time in port PCC = payload cargo capacity KNOTS = speed SCALE = conversion factor to yield dollars per barrel	(mm) (tr) (mm)  (mm) = material/mode, (Table III-10) (tr) = transportation route (PC = shipped via Panama Canal, TA = not via Panama Canal)	Column DWT: deadweight tons Column LWT: long tons Column SEA: dollars per hour Column PORT: dollars per hour Column TURN: hours Column PCC: tons Column KNOTS: speed in knots Column SCALE: conversion factor
BARGE	Number of barrels per ton conversion factors	SCALE	(mm)  (mm) = material/mode (Table III-10)	Number of barrels per ton

**TABLE III-18. UTILITIES RAW DATA TABLES**

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
AVERAGE	Average system load factor	(s) (yr) (s) = scenario yr) = target year (Table III-3)	(lo) = utility regions (Table III-7) ("US" = total for all regions)	0 average load factor $\leq$ 1.0
BLDFAC	Capital yet to be spent on a project	(c) (c) = capital expenditure (see text)	Row and Row 2 (see text)	Percent of capital not spent
BLDFACNV	Capital yet to be spent on a nuclear plant	(c) (c) = capital expenditure (see text)	Row, Row 2, DEF (not used) (see text)	Percent of capital not spent
BLDLIM(yr) (yr) = target year (Table III-3)	Capacity limitations (build limits) for plant types	(md) (md) = utility plant types (Table III-5)	(lo) and BI (lo) = utility region (Table III-7) BI = bound	Plant capacities in megawatts
BLDNUC(yr) (yr) = target year (Table III-3)	Nuclear plant build limits	(md) (md) = plant type (Table III-5)	I(lo) and LIM (lo) = utility region (Table III-7) LIM = bound (see text)	Build limitations in megawatts
BUMP	Regional heat rate differences for scrubbing new bituminous and sub-bituminous plants	(lo) (lo) = utility region (Table III-7)	(md) (md) = plant type and mode (Table III-5)	Heat rates in Btu per million

**TABLE III-18. UTILITIES RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
CAPCOST	Regional capital costs for plants	(lo) (lo) = utility region (Table III-7)	(m)(yr) (m) = first character of plant type (md) (Table III-3)	Costs in dollars per kw
CAPNUC(yr) (yr) = target year (Table III-3)	Capital costs for nuclear plants	(lo) (lo) = utility region (Table III-7)	NO1, NY1, NZ1, OLI NO1 = new nuclear plants NY1 = committed nuclear plants NZ1 = deferrable nuclear plants OLI = deferred plants	Costs in dollars per kw
COALCONU	Capital cost for converting to coal steam plant	COL	ROW	Costs in dollars per kw
COSTNEW	Operating and maintenance costs for new equipment	(lo) (lo) = utility region (Table III-7)	(m) (m) = first character of plant type (md) (Table III-5)	Costs in .001 dollars per kwh
DCF	Regional fixed charge factors for power plant investment used in computing capital charges	(m) (m) = first character of plant type (md) (Table III-5)	1	Fixed charge factors
DCFA	Regional capital charge factors for determining revenue requirements of new plant additions	(lo) (lo) = utility region (Table III-7)	(yr) (yr) = target year (Table III-3)	Capital charge factors

**TABLE III-18. UTILITIES RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
EXIST	Existing regional plant capacities	(md) (md) = plant type (Table III-5)	(lo) (lo) = location/region (Table III-7)	Capacities in megawatts
FUELCONV	All plant conversion tables	BD, (lo), TC, AI BD = bound (see text) (lo) = utility regions (Table III-7) TC = coal conversion cost indicator AI = indicator for all target years	(md <sub>1</sub> ) (md <sub>2</sub> ) (md <sub>3</sub> ) (yr) (md <sub>1</sub> ) = conversion mode (Table III-5) (md <sub>2</sub> ) = original plant type (Table III-5) (md <sub>3</sub> ) = resultant plant type (Table III-5) (yr) = target year (Table III-3) or all target years if "AI"	In column BD: 1 = fixed limit, blank = upper bound In column (lo) = conversion in megawatts In column TC: 1 indicated a coal conversion cost is incurred In column AI: 1 indicates the values apply to all target years
HEATTRAT	Regional heat rates for existing plants	(lo) (lo) = utility region (Table III-7)	(md) (md) = plant type (Table III-5)	Heat rates in millions per 10 <sup>-3</sup> standard units (barrel, thousands cubic feet, ton)
HEATV	Regional heat content of fossil fuels	SCALE, BUMP SCALE = values BUMP = table revision indicator	(mt) (mt) = fuel types (Table III-4)	In column SCALE: calorific values in millions per 10 <sup>-3</sup> per standard unit (barrel, thousand cubic feet, ton) In column BUMP: 1 indicates that the value is revised by Table BUMP.
HYDCAPFC	Regional capacity factors for hydro plants	(lo) (lo) = utility region (Table III-7)	(yr) (yr) = target year (Table III-3)	Capacity factor
NEWRTTE(yr) (yr) = target year (Table III-3)	Heat rates for new equipment	(d) (d) = second character in plant type (md), electric generation mode (Table III-5)	(m) (m) = first character in plant type (md) (Table III-5)	Heat rates in millions per standard units (barrel, thousands cubic feet, ton)

**TABLE III-18. UTILITIES RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
OLDCOST	Operating and maintenance costs for existing plants	SCALE SCALE = cost factor	(m) (m) = first character of plant type (ind) (Table III-5)	Cost factor in .001 dollars per kwh
OLDMONEY	Revenue required by assets existing on January 1, 1976	(lo) (lo) = utility region (Table III-7)	(yr) (yr) = target year (Table III-3)	Revenue in billions of dollars
RESERVE	Reserve margin requirements	(lo) (lo) = utility region (Table III-7)	ROW	Reserve margin
RETIRE	Retirement rates for fossil fuel plants	(lo) (lo) = utility region (Table III-7)	(yr) (yr) = target year (Table III-3)	Retirement rates
RETRO	Regional add-on costs for retrofitting existing bituminous plants using high	(yr) (yr) = target year (Table III-3)	ROW and (lo)(x) ROW = (see text) (lo) = utility region (Table III-7) (x) = upper ("U") or lower ("L") bound	In row ROW: add-on costs in dollars per kw In row (lo)(x): capacity bounds for retrofitted plants
TDLOSS	Regional transmission and distribution efficiency rates	COL	(lo) (lo) = utility region (Table III-7)	Efficiency rates

**TABLE III-18. UTILITIES RAW DATA TABLES**  
(Continued)

TABLE NAME	DESCRIPTION	COLUMN HEADINGS	ROW HEADINGS	TABLE ENTRIES
TRDIS	Regional transmission and distribution incremental capital costs and operating and maintenance costs	(lo)  (lo) = utility region (Table III-7)	(yr) and OP  (yr) = target year (Table III-3) OP = operating costs	Row (YR): capital costs in dollars per kw  Row OP: costs in dollars per kw per YR
TRLIM	Regional limits on existing transmission and distribution capacity	SCALE	(lo) and TOTAL  (lo) = utility region (Table III-7) TOTAL = total for all regions	Limits in gigawatts

## IV. SUBSYSTEM/PROGRAM DESCRIPTION

### A. INTRODUCTION

Viewing PIES as a single system, from raw data to final outputs, permits the definition of logical subsets, or subsystems, within it. The subsystems, as illustrated in Figure IV-1, perform the main functions of PIES: data input, file creation, modeling, and report production. Although satellite models are not considered part of the PIES Integrating Model as defined in chapter I, those satellite models that provide data directly to PIES software are described below. The PIES subsystems are described in this chapter in terms of their functions and the data they use.

Within each logical subsystem are programs that perform the PIES data processing and modeling. The major programs within each subsystem are described by their function, programming language, and data inputs and outputs.

### B. SATELLITE MODELS

PIES raw data come from a variety of sources including energy models, DOE analyses, energy information systems (e.g., DOE's Respondent Information System), and energy industry publications. For a particular energy material or facility, these data are usually integrated into a series of raw data tables by the PIES staff. However, data on coal, natural gas, oil, and refineries are passed directly to the preprocessors from four energy models, defined here as satellite models. In addition to these satellite supply models there is a PIES Demand Model, also considered here as a satellite model. The Demand Model also supplies data to the PIES Integrating Model. Figure IV-2 depicts the satellite models described in this chapter.

These primary satellite models are described below in terms of function, organizational responsibility, software used, and relationship to PIES. All of these models are run on the EIA computer facility described in chapter V.

FIGURE IV-1

PIES SUBSYSTEMS AND DATA FLOW

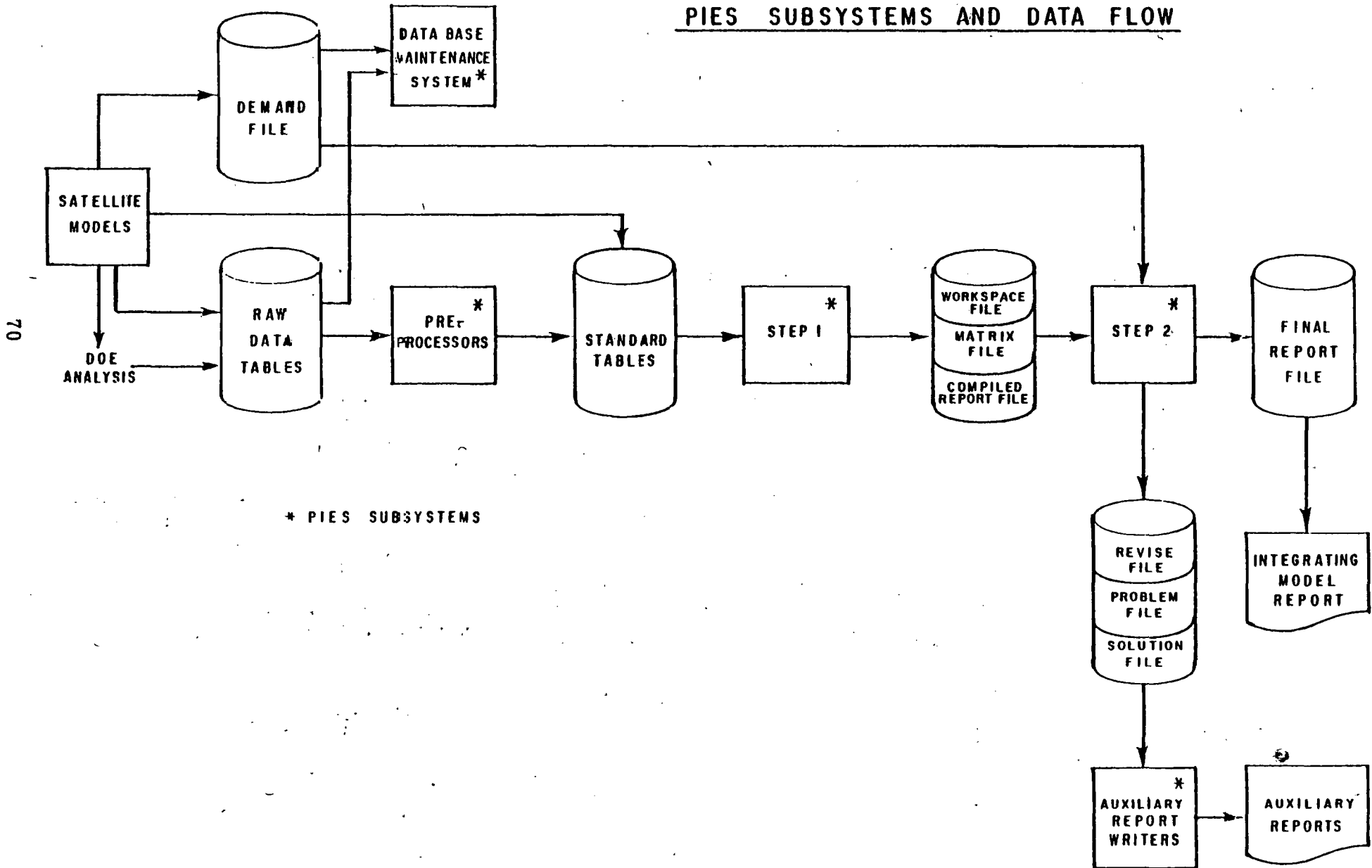
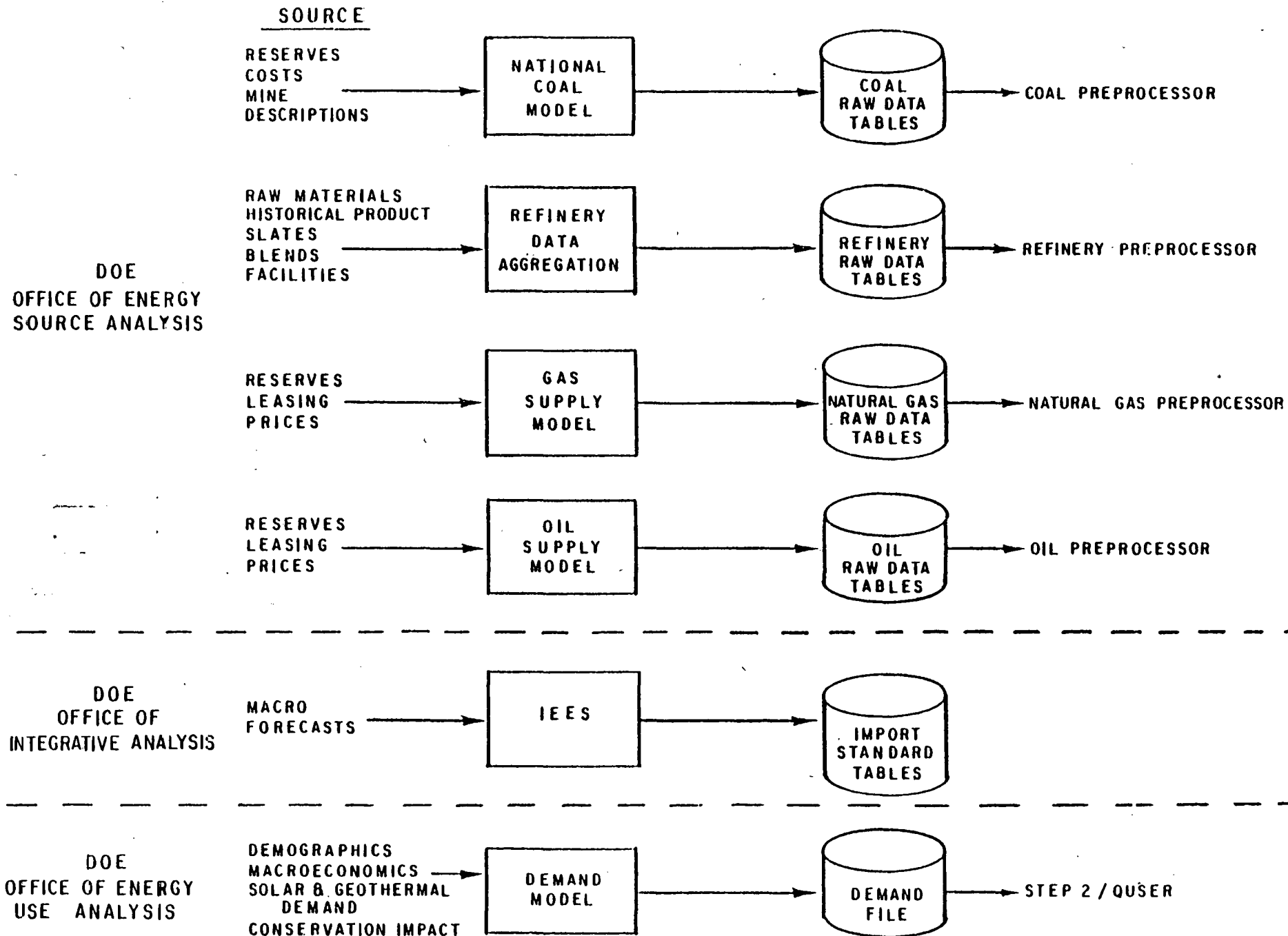


FIGURE IV-2  
SELECTED PIES SATELLITE MODELS



### 1. National Coal Model

The National Coal Model (NCM) forecasts production, consumption, and prices of coal to support DOE analyses of coal-related policy issues. The model is the responsibility of the Coal and Electric Power Analysis Division/Office of Energy Source Analysis/Office of Applied Analysis. The NCM uses LP methodology to produce both short-range and mid-range coal forecasts. Like PIES, it has a number of sub-modules, one of which is a coal supply sub-module. This supply module generates coal supply curves by utilizing a series of resource allocation and mine costing algorithms. Its output is a set of coal supply curves, which when aggregated into PIES coal supply regions by a subroutine creates a file specifically for use by the PIES coal preprocessor. The NCM uses both GAMMA and MPS-III programming languages. One of its output is a file of long-range forecasts, based on PIES coal supply regions, which is generated specifically for use by the PIES coal preprocessor. The NCM uses both GAMMA and MPS-III programming languages.

### 2. Refinery Data Aggregation

Refineries modeling consists of data from the Refinery and Petrochemical Modeling System (RPMS),<sup>1</sup> manual estimations of capacities and costs, and manual Btu adjustment computations. These are integrated into a set of raw data tables by customized programs written in GAMMA, a report and matrix generation programming language simulates MaGen and Fortran. The analysis and operations of RPMS and the table generator are performed by DOE's Oil and Gas Analysis Division/Office of Energy Source Analysis/Office of Applied Analysis. The on-line file containing the regional representation of refinery operation is input to the refinery preprocessor.

### 3. Gas Supply Model

The Gas Supply Model creates natural gas supply curve data in raw data table format for PIES input. The tables are passed directly to the natural gas preprocessor in an on-line file. Reserve estimates, leasing schedules, and price trajectories for gas and coproducts are inputs to the model.

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<sup>1</sup>RPMS is a data base and matrix generator, written in GAMMA, available on the DOE/EIA computer facility.

The Gas Supply Model is written in Fortran and maintained and operated by the DOE Oil and Gas Division/Office of Energy Source Analysis/Office of Applied Analysis. Due to the numerous scenario requests that vary price trajectories, leasing schedules, and reserve estimates, this model and the Oil Supply Model are run more frequently than other satellite models.

#### 4. Oil Supply Model

The Oil Supply Model is similar to the Gas Supply Model in method and organizational responsibility. Oil supply curves are created for PIES input in raw data table format and passed via on-line data files. The model supplies data to the oil preprocessors. Regression analysis techniques using leasing schedules, price trajectories, and reserve estimates to produce the oil supply curves.

The Oil Supply Model is written in Fortran and maintained and operated by the DOE Office of Energy Source Analysis/Office of Applied Analysis. Like the Gas Supply Model, the PIES scenario changes affect this model more than most satellite models, causing frequent runs.

#### 5. Demand Model

The Demand Model generates the on-line demand file for input to the LP matrix in Step 2. The Demand Model is dynamic, using historical econometric data, including fuel prices, demographic forecasts, conservation impacts, and solar and geothermal demand replacement. The Demand Model consists of preprocessor programs, the Regional Demand Forecasting Model (RDFOR), which produces the regional demand curves, and the Demand Interface Program (DFACE), which integrates all of the demand forecasts into the demand file for PIES. The outputs are the parameters of a log-linear demand function to predict quantity demanded as a function of price by fuel and economic sector. The key parameters is an elasticity matrix. The model is written in Fortran and maintained and operated by the DOE Division of Demand Analysis/Office of Energy Use Analysis/Office of Applied Analysis.

## C. PIES PREPROCESSORS

The first step in PIES is to accept raw data that must be edited, reformatted, and sometimes used for preliminary calculations. This preprocessing function creates data files in a standard format, using standard units of measurement for use by the PIES modeling functions. Inputs to this preprocessing are called raw data tables; outputs are called standard tables. Due to the nature of the raw data, its varied sources, formats, and units of measurement, there are separate preprocessors for each energy material and facility type. Since data on shale oil, nuclear fuel, and imports are provided to PIES in standard table format, no preprocessors are necessary for such data. Figure IV-3 illustrates the preprocessor subsystem.

The preprocessors are written and maintained by the PIES staff. The programs, inputs and outputs are stored on disk files. Data entry (except for inputs produced by satellite models ) and program changes are transmitted on-line via terminals in the PIES staff offices.

### 1. Coal Preprocessor

The coal preprocessor accepts raw data tables as input and reformats them into standard tables. The coal raw data tables are generated by a sub-module of the National Coal Model and transmitted to the preprocessor via an on-line disk file. Some computation is performed to aggregate data and change units of measurement. The coal preprocessor is written in MaGen.

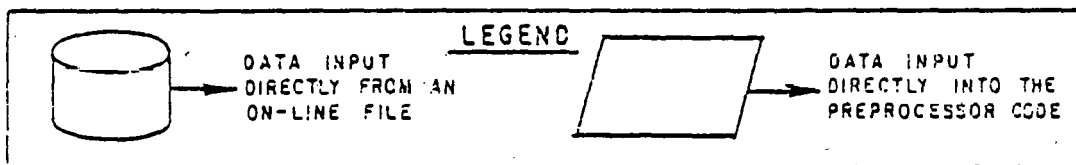
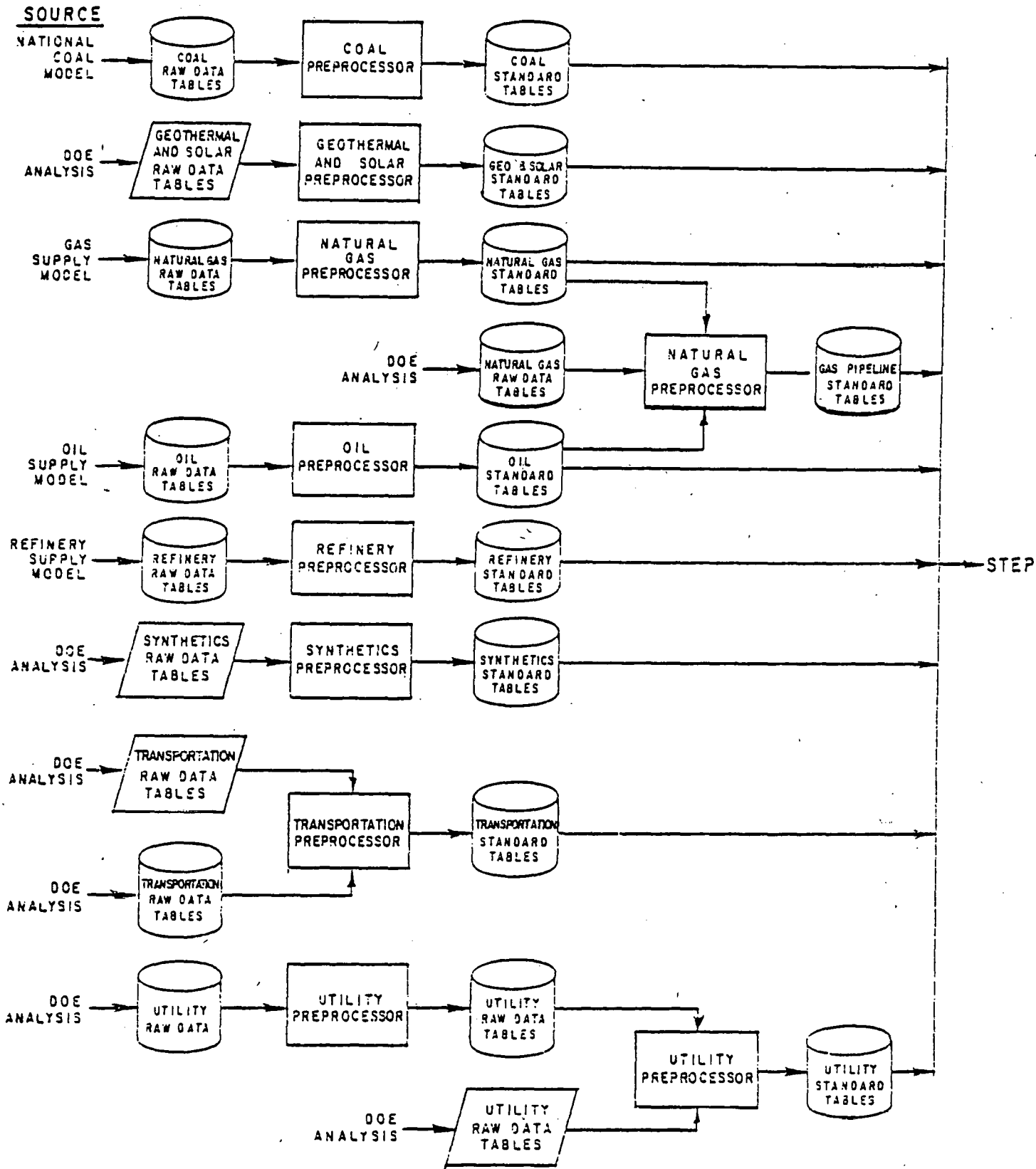
### 2. Geothermal and Solar Preprocessor

All raw data are input directly to the source code of the geothermal and solar preprocessor by the PIES staff. The preprocessor reformats the raw data tables into standard tables, performing limited computation. This preprocessor is written in MaGen.

### 3. Natural Gas Preprocessors

There are two natural gas preprocessors, both written in MaGen. One preprocessor is used to process raw data tables from the Gas Supply Model detailing non-associated natural gas production. These data are passed from the satellite model to the

FIGURE IV-3  
PIES PREPROCESSORS



preprocessor in an on-line disk file. This preprocessor produces the natural gas supply curves in the standard table format.

The second preprocessor uses both raw data tables and the standard tables produced by the first natural gas preprocessor and the oil preprocessor. All inputs to the second preprocessor are entered via disk files. This preprocessor processes the non-associated natural gas data with the associated natural gas data (from the oil preprocessor) to produce standard tables containing interstate pipeline shipment information.

#### 4. Oil Preprocessor

The oil preprocessor accepts the oil raw data tables from the Oil Supply Model as input. These tables are in on-line disk files. Written in MaGen, this preprocessor performs calculations and conversions of data while reformatting the data into standard tables.

#### 5. Refinery Preprocessor

Most data are accepted by the Refineries preprocessor as external file inputs although some tables are built into the MaGen source code. Some computations are performed during the reformatting of data into standard tables.

#### 6. Synthetics Preprocessor

The raw data for synthetics are entered directly into the MaGen source code for this preprocessor. Limited computation is performed in the preprocessor while the data are formatted into standard tables.

#### 7. Transportation Preprocessor

Although some raw data are entered directly into the MaGen source code, most raw data are entered as file input from raw data tables created by the PIES staff. Extensive computation is performed in this preprocessor. The transportation network is modeled here rather than in later PIES Integrating Model programs.

#### 8. Utilities Preprocessors

There are two utilities preprocessors. The first is written in Fortran to calculate and produce the capacity and composition factors to be used by the second

preprocessor. The second preprocessor accepts (as input) the output of the first preprocessor, in addition to raw data tables that are entered directly into the MaGen source code. This two-step process allows the computation performed in the first step to be done in Fortran and permits PIES analysts to review the capacity and composition tables produced before using them for the second preprocessor.

Like the transportation preprocessor, the utilities preprocessor performs most of the modeling as the standard tables are created.

#### D. STEP 1

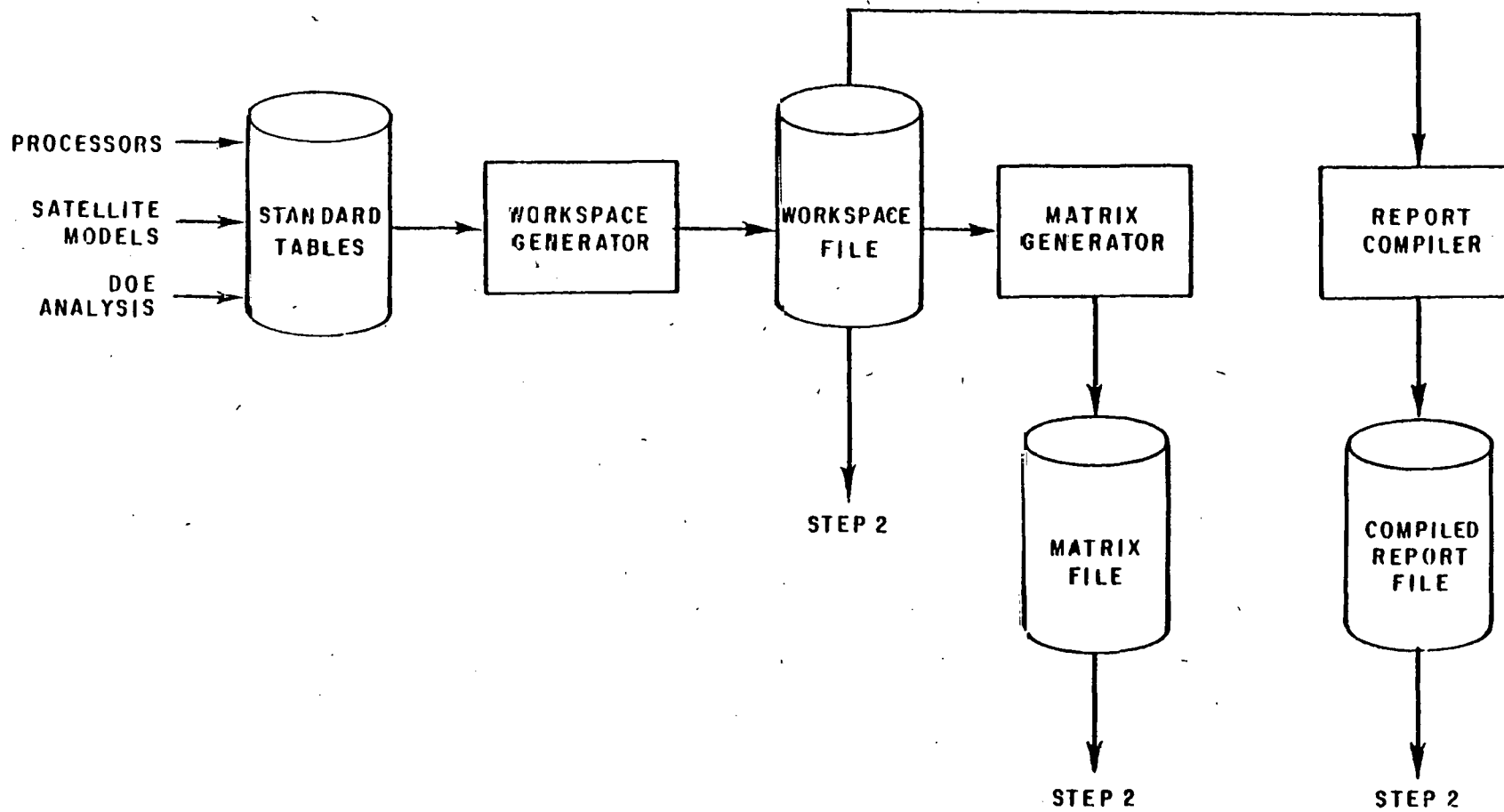
Solving the PIES LP matrix involves two subsystems. The first, Step 1, aggregates the supply data into the initial LP matrix. The second, Step 2, incorporates demand data into the matrix and solves it.

Step 1, as illustrated in Figure IV-4, consists of three processes: workspace generation, matrix generation, and report compilation. The main inputs to Step 1 are the standard tables, most of which are created by the preprocessors described above. Three outputs are produced: a workspace file, a matrix file, and a compiled report file. All three are inputs to Step 2.

The workspace file is an integrated set of standard tables used to create the other two Step 1 files. It is also input to the REVISE program in Step 2, providing modifications to the matrix. The matrix file is the main input to Step 2, containing the supply data in the required format for the LP routines. The compiled report file contains the compiled MaGen code for PIES Integrating Model Report (values from the LP solution reached during Step 2 are accessed during the generation of the report at the end of Step-2).

Step 1 is maintained and operated by the DOE Division of Mid-Range Analysis/Office of Integrative Analysis/Office of Applied Analysis (referred throughout this volume as the PIES staff). Step 1 is performed in a single batch run executed remotely via terminal on the EIA computer facility. All of the code uses the MaGen programming language. The three processes are described below.

FIGURE IV-4  
STEP 1



### 1. Workspace Generator

The workspace generator integrates the standard tables into a single file of all the supply data. Additionally, all material balance row names are identified and combined into a single table. All process limit row names are also identified and combined into a single table. (Material balance and process limit rows are discussed in chapter 3.) Transportation linkages are established. After the workspace file is produced, it is copied onto tape.

### 2. Matrix Generator

The matrix generator uses workspace file data to create the matrix file. The matrix file is copied onto tape after it is produced.

### 3. Report Compiler

The report compiler contains the bulk of the program code in Step 1. Various tables generated specifically for the report are maintained in the program. These tables include: the table of contents for the report, historical data, and descriptive codes, headings, and abbreviations added to the numerical data in the report (e.g., units of measurement).

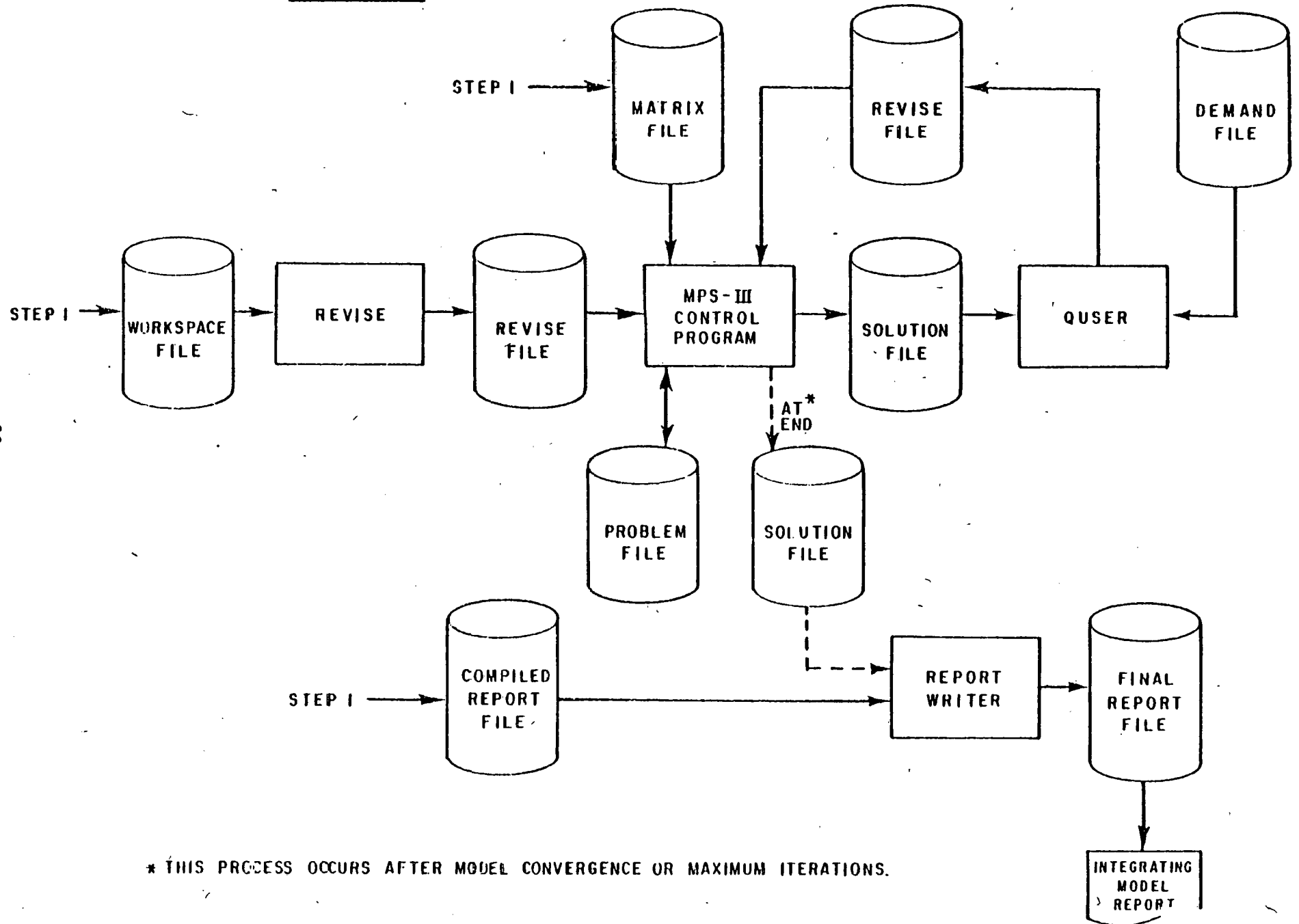
The output from the report compiler, the compiled report file, contains the skeleton report and the proper pointers to the solution file to facilitate the production of the Integrating Model Report upon completion of Step 2. The compiled report file is copied onto tape at the completion of Step 1.

## E. STEP 2

Step 2 takes the LP matrix created in Step 1, adds demand data, solves the matrix and produces the report. This step is designed to permit PIES runs for different scenarios without reprocessing previous preprocessor and Step 1 runs. The LP matrix is temporarily modified via REVISE to reflect the scenario changes, significantly reducing the time and cost of the runs.

Like Step 1, Step 2 is a single batch run executed remotely via terminal. The PIES staff maintains and operates these runs. As illustrated in Figure IV-5, Step 2 is a complex iterative process, using numerous files.

FIGURE IV-5  
STEP 2



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\* THIS PROCESS OCCURS AFTER MODEL CONVERGENCE OR MAXIMUM ITERATIONS.

The initial step is REVISE, providing all scenario-specific changes to the matrix through the revise file. The next steps involve an iteration between solving the LP matrix, determining whether an equilibrium between supply and demand is reached, and adjusting the matrix to be re-solved. Once an equilibrium is reached, the results are merged with the compiled report file from Step 1, and the Integrating Model Report is produced. Each of the Step 2 processes are described below.

1. REVISE

REVISE is a MaGen program that takes the workspace file as input and produces a revise file, which is used to update the matrix file. The scenario specifications and changes input to REVISE are coded in the MaGen program using SUPERWYLBUR for on-line interactive data entry. The output revise file is in MPS360 format as required by the LP routines that follow.

Where feasible, REVISE is used to modify the matrix as required to specify alternate scenarios. At times, the changes needed are either too voluminous or too complex to compute manually. In such cases, PIES must be run beginning from new raw data. For example, this occurs when oil or gas supplies are affected by scenario specifications. In these cases the Oil and/or Gas Supply Model must be run to generate new raw data. Next, the appropriate preprocessors and Step 1 must be rerun before Step 2 can be initiated.

2. MPS-III Control Program

Once the initial revise file is produced, the iterative processing begins. Controlling this processing is a program written in the Control Language for MPS-III, the LP system used to solve the LP matrix. This program creates the problem file from the matrix and revise files; solves the LP matrix (using the MPS-III optimizer WHIZARD), producing the solution file; and calls QUSER to check the solution for supply and demand convergence. If the model has not converged, a new revise file is produced by QUSER, starting the process over again. When either the convergence criteria are met on a

specific number of iterations reached, the processing is automatically ended and the final solution file created. Figure IV-6 illustrates the process flow of the MPS-III control program.<sup>2</sup>

The solution file is saved on tape for use by various auxiliary report generators described in section G below.

### 3. QUSER

QUSER equilibrates supply and demand by interfacing the LP supply model with the Demand Model. Additionally, it represents policy and regulatory structure. As illustrated in Figure IV-7, the first time that QUSER is called is not an actual iteration like those that follow, but an initialization of the program, including interfacing with the Demand Model. Regional elasticities, demands, and price estimates are used to incorporate an approximation of the demand function into the LP matrix (via the revise file).

QUSER is invoked by the MPS-III control program after each LP solution is reached. QUSER performs scenario-specific and price calculations and then determines whether the model has converged. If it has not converged, the demand function is re-approximated.<sup>3</sup>

QUSER is written in Fortran and consists of numerous sub-routines.

### 4. Report Writer

Once the MPS-III control program has completed its functions, Step 2 control goes to the report writer process. The report execution phase of the report writer consists of a few lines of MaGen code, which initiate the merging of the compiled report file with the necessary data in the solution file. The result of this process is an IBM print format file with the PIES Integrating Model Report.

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<sup>2</sup>As noted in Figure IV-6, the initial "iteration" is different from subsequent iterations. The first creation of the solution file does not actually contain a solution, but is merely used to pass data for the initial call to QUSER.

<sup>3</sup>See Chapter II of Volume IV in this documentation series for a fuller description of these iterations.

FIGURE IV-6  
MPS-III CONTROL PROGRAM

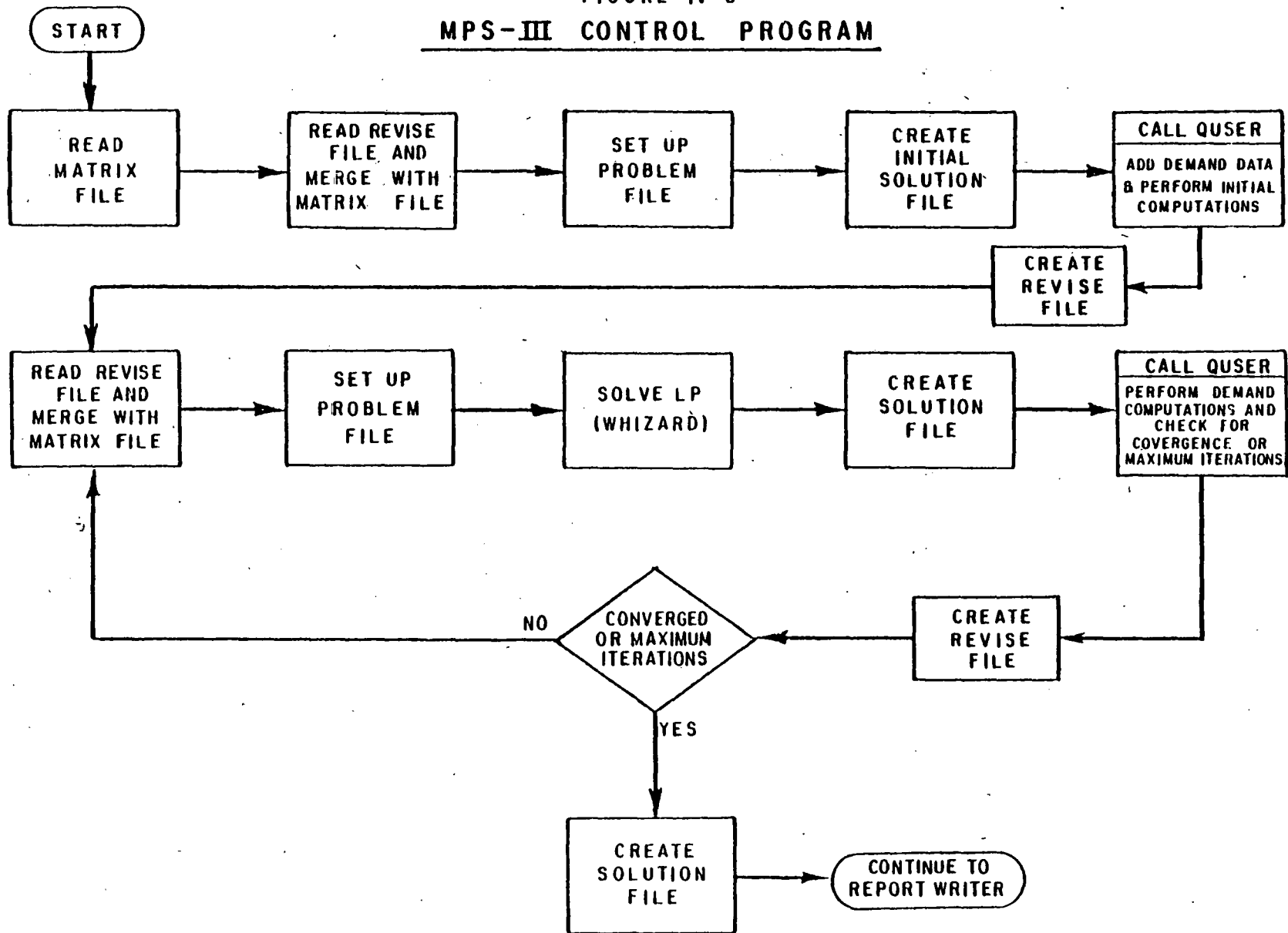
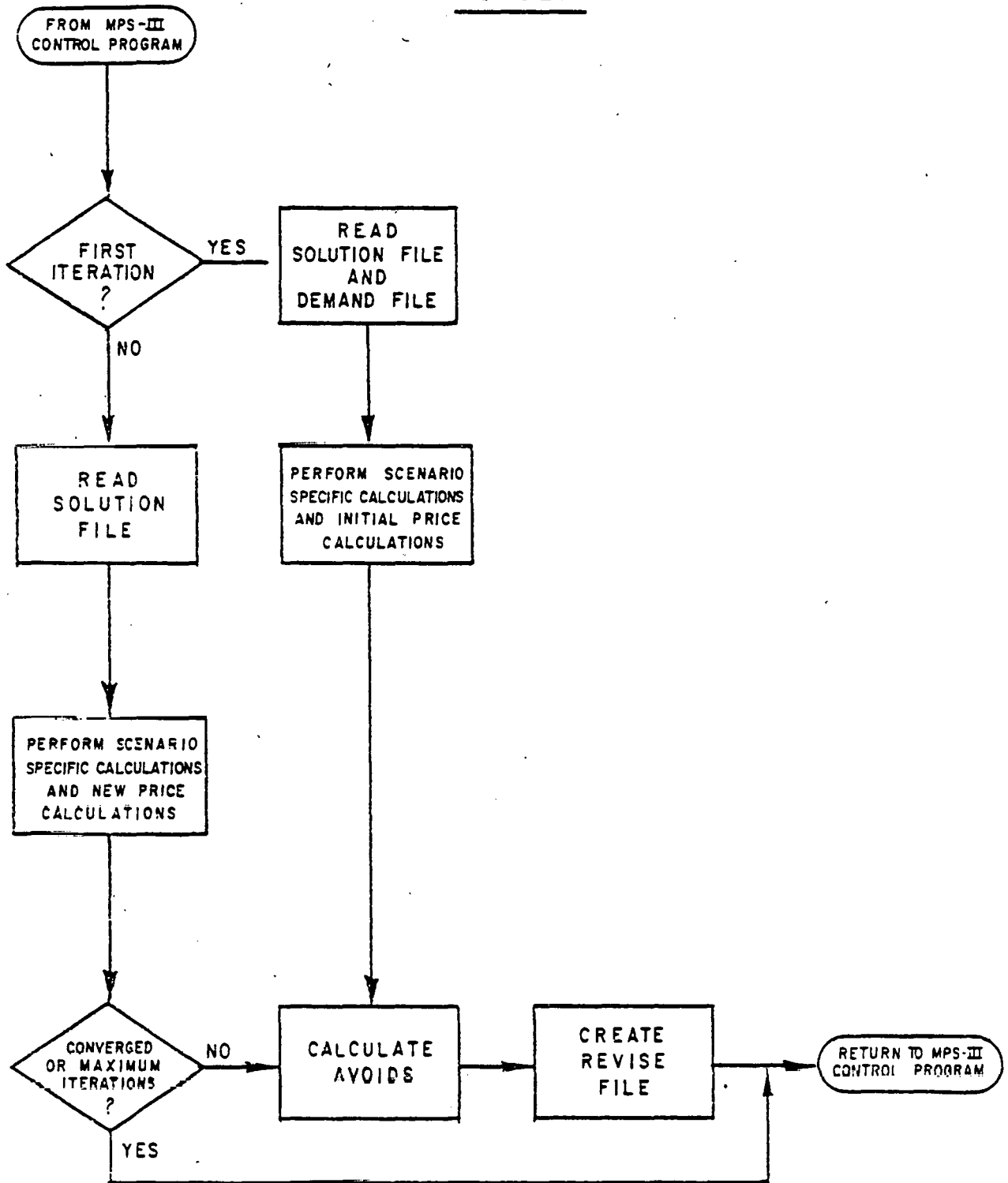


FIGURE IV - 7  
QUSER



## F. AUXILIARY REPORT GENERATORS

In addition to the PIES Integrating Model Report, produced during Step 2 of the Integrating Model run, there are other reporting mechanisms available to the PIES staff. Two of these, PERUSE and Matrix Peruse offer on-line interactive information retrieval. The Coal Transportation Report and the Capital Report writer are special-purpose, remote batch report generators. A series of automated data documentation reports provide documentation for data used in generating all standard tables. Each of these are described below.

### 1. PERUSE

PERUSE is a customized Fortran program maintained by the PIES staff. PERUSE is used for on-line and batch inquiry of the PIES solution file. It permits analysts to retrieve specific data values from the results of a PIES Integrating Model run.

### 2. Matrix PERUSE

Matrix PERUSE is a new addition to the on-line and batch inquiry programs available to the PIES staff. Like PERUSE, Matrix PERUSE is a Fortran program written by the PIES staff. It is available for on-line or batch reporting of the matrix file, to allow the retrieval of specific data values.

### 3. Coal Transportation Report

The Coal Transportation Report is a MaGen report generator that accesses the PIES solution file to select specific data to report in a fixed format. Quantities, prices, and transportation costs of coal are reported by coal type and region. This report generator is maintained by the PIES staff and operated in remote batch mode.

### 4. Capital Report Writer

The Capital Report writer is a MaGen report generator that accesses the PIES workspace and solution files. Capital investment requirements are reported by energy material type in a fixed report format via remote batch mode. The Capital Report writer is maintained and operated by the PIES staff.

5. Automated Data Documentation Reports

The Automated Data Documentation Reports provide documentation of PIES data, primarily standard data, but in some cases raw data. For example, the automated data documentation report for utilities includes some raw data long with the standard table data. The programs which provide these reports are written in MaGen.

## V. SYSTEM HARDWARE DESCRIPTION

### A. INTRODUCTION

This chapter describes the computer facility on which PIES operates. This description may be used as either an overview of the present PIES computer system, or as a guide for determining the hardware requirements necessary to utilize PIES on another computer facility. The following sections detail the PIES computer facility, support software, and security and privacy restrictions.

### B. PIES COMPUTER FACILITY

All PIES software operates on the DOE/EIA computer facility operated by Optimum Systems Incorporated, Rockville, Md. This facility provides a timesharing service for EIA offering remote batch and interactive processing. The EIA hardware facilities are summarized in Table V-1.

#### 1. Central Computer

PIES programs are run on the EIA central computer system, two 370/168 CPUs configured as a multiprocessor under OS/MVS. There are eight million bytes of addressable core available; 1.2 megabytes comprise the nucleus and other resident software, 6.8 megabytes are for shared paging.

#### 2. User/System Interface

Access to the EIA facility is via remote batch terminals or on-line interactive terminals. Remote batch terminals (high-speed) are located at two DOE offices in Washington, D.C.: 12th and Pennsylvania Avenue, N.W., and 2000 M Street, N.W. On-line terminals are available in the PIES staff offices. Terminals are used for both on-line interactive processing and initiating batch processes.

#### 3. Data Storage

Both disk and tape units are used for PIES data storage. IBM 3350 disk drives (317 megabytes per pack) are used for on-line data storage. Raw data tables, standard

TABLE V-1. EIA SERVICE FACILITY HARDWARE (MARCH 1978)

2	IBM 370/168 Model 3 CPUs (eight-million total bytes)
1	IBM 3068 Multisystem Communication Unit
2	IBM 3066-2 Consoles
4	IBM 2880-2 Block Multiplexor Channel Pairs
2	IBM 2880-1 Block Multiplexor Channels
2	IBM 2870 Byte Multiplexor Channels
2	IBM 2860-2 Selector Channel Pairs
2	IBM 3272-2 Control Units
2	IBM 3277-2 CRT Terminals
1	IBM 3288-1 160-CPS Printer
1	IBM 3284-2 40-CPS Printer
1	IBM 2821-1 Control Unit
1	IBM 2540-1 Card Reader Punch Unit
1	IBM 1403-N1 High-Speed Line Printer (850 LPM)
1	IBM 3211 High-Speed Line Printer (2000 LPM)
1	IBM 3811 Control Unit
2	IBM 2835-2 Control Units
2	IBM 2305-2 Fixed-Head Disk Storage Facilities
6	IBM 3830 Disk Control Units
24	IBM 3330-11 Spindles (200 megabytes each)
48	IBM 3350 Spindles (317 megabytes each)
2	STC 3800-III Tape Control Units
10	STC 3470 Tape Drives (nine tracks, 1600/6250 bpi, 160/320 kb/s)
1	STC 3450 Tape Drive (nine tracks, 800/1600 bpi, 100/200 kb/s)
1	STC 3430 Tape Drive (seven tracks, 556/800 bpi, 42/60 kb/s)
1	IBM 3705 Communication Control Unit
2	Comten 3670 Communications Control Units
1	IBM 2914 Manual Switching Unit

tables and the report file are maintained on-line. A packed version of the solution file for use with PERUSE and matrix Peruse is also maintained on-line. The other data files, matrix file, problem file, etc. are stored on tape and copied to on-line disk files when needed for processing. Nine-track tapes with a density of 6250 bits per inch are used. Table V-2 lists the data storage requirements.

TABLE V-2. PIES DATA STORAGE

<u>File</u>	<u>Approximate Storage Requirements on IBM 3350 Disk</u>	<u>Approximate Storage Requirements in Millions of 8-Bit Bytes</u>
Raw Data Tables	150 tracks	2.9 megabytes
Standard Tables	170 tracks	3.2 megabytes
Workspace File	300 tracks	5.7 megabytes
Matrix File	150 tracks	2.9 megabytes
Revise File	25 tracks	.5 megabytes
Solution File	100 tracks	1.7 megabytes
Solution File (packed)	17 tracks	.3 megabytes
Problem File	160 tracks	3.0 megabytes
Demand File	20 tracks	.4 megabytes
Integrating Model Report File	22 tracks	.4 megabytes

### C. PIES SOFTWARE REQUIREMENTS

PIES uses a number of special-purpose software systems in addition to the system software under which it runs. PIES JCL is written for the MVS (release 3) and JES2 operating system on the EIA computer facility. JES2 is the MVS equivalent of HASP. It permits remote job entry from numerous peripheral stations.

Two options are available for interactive use. IBM's TSO (timesharing option) is used when interactive compiling, linkediting, executing, or debugging is necessary. SUPERWYLBUR is used for text editing and remote job entry.<sup>1</sup>

As a text editor, SUPERWYLBUR is used to update files (e.g., raw data tables) and programs. Since data are contained in many PIES programs, SUPERWYLBUR is used to alter data stored directly in the code (e.g. REVISE). In remote job entry, SUPERWYLBUR is used to initiate PIES batch runs via terminals and to route outputs to the proper facility.

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<sup>1</sup>Although TSO can perform these functions, SUPERWYLBUR is often easier and better than TSO for these purposes.

PIES uses three programming languages. Fortran (G1) is used for much of the computation performed (QUSER). Most programs are written in MaGen, which is a special purpose software system for linear programming matrix and report generation. It is especially flexible and easy to use for matrix creation, matrix manipulation report and generation. MPS-III is one of the linear programming systems offered on the EIA facility. While MaGen is used for matrix creation and solution reporting, MPS-III is used to solve the LP matrix. Step 2 employs an MPS-III Control Program using the MPS-III optimizer, WHIZARD.

D. PRIVACY AND SECURITY

PIES does not contain confidential data and does not employ procedures for privacy and security. The EIA facility does, however, offer security to guard against inadvertent loss or destruction of PIES programs and data. Site security is strict, with 24-hour security guards and other necessary restrictions required by its SECRET facility clearance.<sup>2</sup>

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<sup>2</sup>The SECRET clearance is in accordance with the Department of Defense Industrial Security Manual.

## VI. OPERATIONAL DESCRIPTION

### A. INTRODUCTION

PIES processing is a sequential series of programs. The satellite models, DOE analyses, and the Demand Model, create the necessary input data that drive the Integrating Model. The preprocessors are run first, then Step 1, and lastly Step 2. Because of the flexibility of Step 2 (the PIES matrix may be altered without rerunning Step 1) many PIES runs begin with it. For example, in 1976, 500 Step 1's were run, compared to 3000 Step 2's. Likewise, running Step 1 to create a new matrix does not necessarily require running all the preprocessors. If data affecting only one preprocessor are altered, only that preprocessor need be run before Step 1 to recreate the matrix file.

The PIES staff maintain and operate all of the PIES subsystems. This chapter describes the operational procedures carried out by each staff analyst responsible for a particular program. Procedural flow, frequency of runs, mode of operation (on-line/batch), and run times are discussed for each subsystem.

### B. PREPROCESSORS

The preprocessors are separate programs that are run independently (in most cases). The running frequency depends on the availability of raw data and the scenario requirements. Some preprocessors are run infrequently to correspond to raw data updates. Others are run more often to meet the requirements of changing PIES scenarios. Each of the preprocessors is discussed below.

#### 1. Coal Preprocessor

The coal preprocessor is run periodically, when new data are available from the National Coal Model. It is independent of other preprocessors, and one run produces the necessary standard tables for all target years and one scenario. It is also run when new scenarios dictate changes to the input raw data. These require rerunning the National Coal Model prior to the coal preprocessor.

The coal preprocessor is run in remote batch mode using SUPERWYLBUR to initiate the run. CPU time is approximately 4 minutes per run.

## 2. Geothermal and Solar Preprocessor

The geothermal and solar preprocessor is an independent program that is run infrequently. The raw input data are developed through DOE analyses and do not frequently change. Scenario specifications rarely have an impact on the input data.

The raw data tables are part of the preprocessor so that the actual processing only requires remote batch initiation using SUPERWYLBUR from a terminal. One run produces tables for two scenarios and two target years, requiring about 5 seconds CPU time.

## 3. Natural Gas Preprocessors

There are two natural gas preprocessors that are not totally independent as are most other preprocessors. The first preprocessor (labeled "GS") uses the raw data tables produced by the Gas Supply Model to produce standard tables. These standard tables contain data on non-associated natural gas. The second preprocessor (labeled "AL") uses both the standard tables created by the first natural gas preprocessor and the oil standard tables (containing data on associated natural gas) as inputs. It also uses raw data tables created by the PIES staff in an on-line file. This produces standard tables for gas pipelines.

These preprocessors are run frequently, since scenario changes often affect the gas supply data. Each new run of the Gas Supply Model requires runs of both preprocessors. Some data changes may also require changing the raw data tables created by the PIES staff, necessitating a rerun of the AL preprocessor. This is done using SUPERWYLBUR as a text-editor in an on-line interactive mode from a terminal.

Both preprocessors are run in an remote batch mode using SUPERWYLBUR from an on-line terminal to initiate the run. The first preprocessor is normally run for one

scenario and two target years, requiring 25 seconds of CPU time. The second preprocessor is run once for all scenarios and years, with less than 5 seconds of CPU time.

#### 4. Oil Preprocessor

The oil preprocessor is independent of other preprocessors, but uses raw data output from the Oil Supply Model. Like the natural gas preprocessor, the oil preprocessor is run frequently, since scenario specifications often affect oil supply data. Each time it is run, the Oil Supply Model is run to produce raw data tables; then the oil preprocessor is run, with those tables as input.

The oil preprocessor is run in remote batch mode from a terminal, using SUPERWYLBUR to initiate the run. This preprocessor produces one scenario for two target years in a run that uses 25 seconds of CPU time.

#### 5. Refinery Preprocessor

The refinery preprocessor uses raw data tables from the Aggregation of the RPMS Data Base for inputs. Although minor adjustments to the supply data may be made for specific scenarios, in general, major revisions to the refinery data occur two or three times a year. The refinery preprocessor batch run is then initiated using SUPERWYLBUR from a terminal.

#### 6. Synthetics Preprocessor

The synthetics preprocessor requires DOE analysts to create its raw data inputs. These inputs are entered in the preprocessor code using SUPERWYLBUR as an on-line interactive text-editor. Like the geothermal and solar data, the synthetics data do not change frequently, nor do scenario specifications require frequent changes. Thus, the batch run of the synthetics preprocessor is not executed often.

A single run creates tables for two scenarios and two target years. The run is initiated using SUPERWYLBUR for remote job entry and requires about 10 seconds of CPU time.

## 7. Transportation Preprocessor

The transportation preprocessor is also independent of other preprocessors, requiring only changes to its raw data inputs to produce new standard tables. The raw data tables are stored in an on-line file and in the preprocessor code. Either the file or the code can be updated, using SUPERWYLBUR as an on-line interactive text-editor.

The transportation preprocessor is run in remote batch mode using SUPERWYLBUR from a on-line terminal. It is run separately for each target year (there is only one scenario for transportation). Each run requires 5 seconds of CPU time.

## 8. Utilities Preprocessor

The utilities preprocessor is a two-step process. Tables of capacity and composition factors are entered in the first preprocessor from an on-line file. This preprocessor produces a table of these factors that is reviewed before running the second preprocessor. The first preprocessor also creates an on-line file with this output data.

The majority of utilities raw data tables are entered directly in the second preprocessor code. This data can be updated by using SUPERWYLBUR as an on-line text-editor. The second preprocessor is run using the on-line file created by the first preprocessor as input, and creating the utilities standard tables. Although these preprocessors are run in sequence, if scenario-specific charges only affect data in the raw data tables, only the second preprocessor must be run to produce new standard tables.

Both preprocessors are run remote batch, using SUPERWYLBUR from an on-line terminal. Each preprocessor is run once for each scenario for two target years. The first preprocessor requires only a few seconds of CPU time. The second uses less than 80 seconds of CPU time.

### C. STEP 1

The creation of the PIES matrix in Step 1 is dependent on the completed processing of all the preprocessors discussed earlier. A Step 1 run is made when one of the following occurs:

- New raw data are available (e.g., a new run of the National Coal Model).
- Scenario requirements necessitate a change in the matrix that cannot be handled by REVISE.
- Changes to PIES methodology are made that require a new matrix to be generated.

As a general rule, there is a matrix file produced for each scenario and each target year. When runs require slight variations in the assumptions (i.e., prices of specific energy materials), Step 1 is not processed, since Step 2 provides capabilities for temporary matrix modifications. When major changes to the data occur, the preprocessors affected are run, and Step 1 must be run to recreate the matrix file.

In addition to the preprocessor-created inputs to Step 1, three other sets of data in standard table format are required. Nuclear fuel, shale, and import raw data are not preprocessed and are in standard table format. These tables are direct inputs to Step 1. All the standard tables are in on-line files.

The Step 1 run is a single process of four OS/MVS JCL "steps."<sup>1</sup> The first creates the workspace file. The second creates the matrix file. The third and fourth JCL steps create the compiled report file. All three files are on-line disk files that are copied onto tape for storage until they are needed by Step 2 runs.

The Step 1 run is a remote batch run initiated from a terminal in the PIES staff offices using SUPERWYLBUR. Step 1 resource consumption is detailed in Table VI-1.

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<sup>1</sup> Additional steps are performed throughout the run for auxiliary processes, i.e., tape-to-disk copying.

TABLE VI-1. STEP 1 RESOURCE UTILIZATION (APPROXIMATE)

	<u>Step 1 Total</u>	<u>Work Space Generator</u>	<u>Matrix Generator</u>	<u>Report Generator</u>	<u>Other<sup>a</sup></u>
CPU Minutes	11.5	5.0	1.5	4.0	1.0
Core (bytes)	1000K				
Disk Space (IBM 3350 Cylinders)		130	130	230	
Tape Drives (at one time)	1				

<sup>a</sup>Tape and disk handling

To run Step 2 requires the availability of the workspace file, the matrix file, the compiled report file, and the demand file for the given scenario.

#### D. STEP 2

Step 2 contains the LP optimization and equilibrating mechanism. This is run for every scenario, although the previous subsystems may not be. Like the other subsystems, Step 2 is run in a remote batch mode, initiated with SUPERWYLBUR from an on-line terminal.

Data changes are made to Step 2 tables (in REVISE) to specify scenarios and modify matrix entries based on the scenario requirements. These changes are done in an on-line interactive mode, using SUPERWYLBUR as a text-editor (to change tables in the REVISE code).

The resource requirements for Step 2 are listed in Table VI-2.

TABLE VI-2. STEP 2 RESOURCE UTILIZATION APPROXIMATE

	<u>Total</u>	<u>Input Processing</u>	<u>Initial Solution</u>	<u>Iteration<sup>a</sup> Time</u>	<u>Report Writing</u>	<u>Other<sup>b</sup></u>
CPU Minutes	19-57	1.2	5.0	8.5 to 47.5	2.0	2.3
Core (bytes)	1500K					
Disk Space (IBM 3350 Cylinders)		181	31	31	93	
Tape Drives (at one time)	1					

<sup>a</sup>Primarily dependent upon the number of iterations, which varies from 8 to 40, depending on the scenario.

<sup>b</sup>File and tape handling.

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