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SUMMARY REPORT

I INTRODUCTION

A. BACKGROUND AND OBJECTIVES

Energy is at the heart of Indonesia's economic development. Exports of oil and liquefied natural gas (LNG) provide more than three quarters of the country's foreign exchange earnings. At the same time, Indonesia has embarked on a path of economic development which implies a rapid growth of internal energy consumption. The current five-year development plan envisions a growth of the industrial sector which is almost double (9.5 percent per year) the planned growth in the overall economy (5 percent)(1). Petroleum currently provides over 77 percent of the commercial fuel used by the Indonesian economy(2).

It is unlikely that over the long term petroleum production will be able to increase at a rate required to meet growing domestic demands and at the same time maintain historic export levels if current relative fuel use and export patterns are maintained. Thus the Government of Indonesia has initiated a policy of reducing the growth rate of internal consumption of petroleum, both by shifting to other indigenous fuels and by increasing the efficiency of petroleum use in all sectors.

Another objective of the Indonesian energy program, specified in less detail, is to support the economic and social objectives of Repelita IV. In particular, adequate energy supply at reasonable prices is a requirement for growth in employment, health care, education, equity and regional development.

These objectives of energy development in Indonesia present a complex challenge to energy planners. Traditionally, energy planning has been and is carried out at the subsectoral level, by PLN for electricity, Pertamina and MIGAS for petroleum and natural gas, BATAN for nuclear power, etc. But, as is clear from the above discussion, many of the critical energy issues in Indonesia involve substitution

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between fuels, and sector-wide issues such as social implications and macroeconomic impacts: for example on domestic investment requirements and balance of payments. Thus there is a strong need for energy planning and analysis at the sector-wide level, linking with macroeconomic planning.

The Direktorat Jenderal Listrik dan Energi Baru (DJL) of the Ministry of Mines and Energy has a central role in sector-wide energy planning and analysis. The project summarized in this report had as its overall objective the strengthening of the capabilities within DJL to fulfill that role.

This project follows on a previous activity, Energy Planning for Development I, carried out in 1980-81[3]. That project had three components:

- The development of a detailed and consistent set of energy supply-demand projections based on alternative assumptions of economic growth.
- A pilot survey of kerosene and fuelwood use in rural households in eight regions.
- Preliminary assessments of the role that various non-petroleum energy sources could play in Indonesia's energy future. The resources considered included coal, small scale hydropower, geothermal energy, solar energy, wind power and biomass of various kinds.

B. MAJOR PROJECT ELEMENTS

This project was designed to strengthen the energy planning process in Indonesia, specifically by increasing the factual, analytic and human resources within DJL to carry out integrated national energy analysis. The project involved four major components that contributed to accomplishing that objective:

1. Energy Information and Analysis System

A microcomputer-based system was designed, developed and installed at DJL which provides a state-of-the-art capability in

energy information storage and retrieval and in energy systems analysis. The Energy Information and Analysis System for Indonesia (EIASI) has two major components:

- A national energy information system which contains data on energy resources, transformation and demand for various regions and time periods. The information system also includes a bibliographic data base. The system is easily used by the untrained user through menu choices on the microcomputer screen.

- An energy systems analysis model, RESGEN, which is a highly flexible tool to create energy supply-demand networks to analyze a wide variety of energy policy issues. RESGEN was used to create two models of the Indonesian energy system: a detailed eight region model and a more aggregate national model. Complete data sets and projections were prepared for both models.

As shown in Figure 1, the EIASI system also incorporates two flexible, commercial programs: Lotus 1-2-3 and DBASE III. Because of the importance of the linkages between the energy system and the overall economy in Indonesia, protocols were developed for the interaction between RESGEN and the BAPPENAS macroeconomic model.

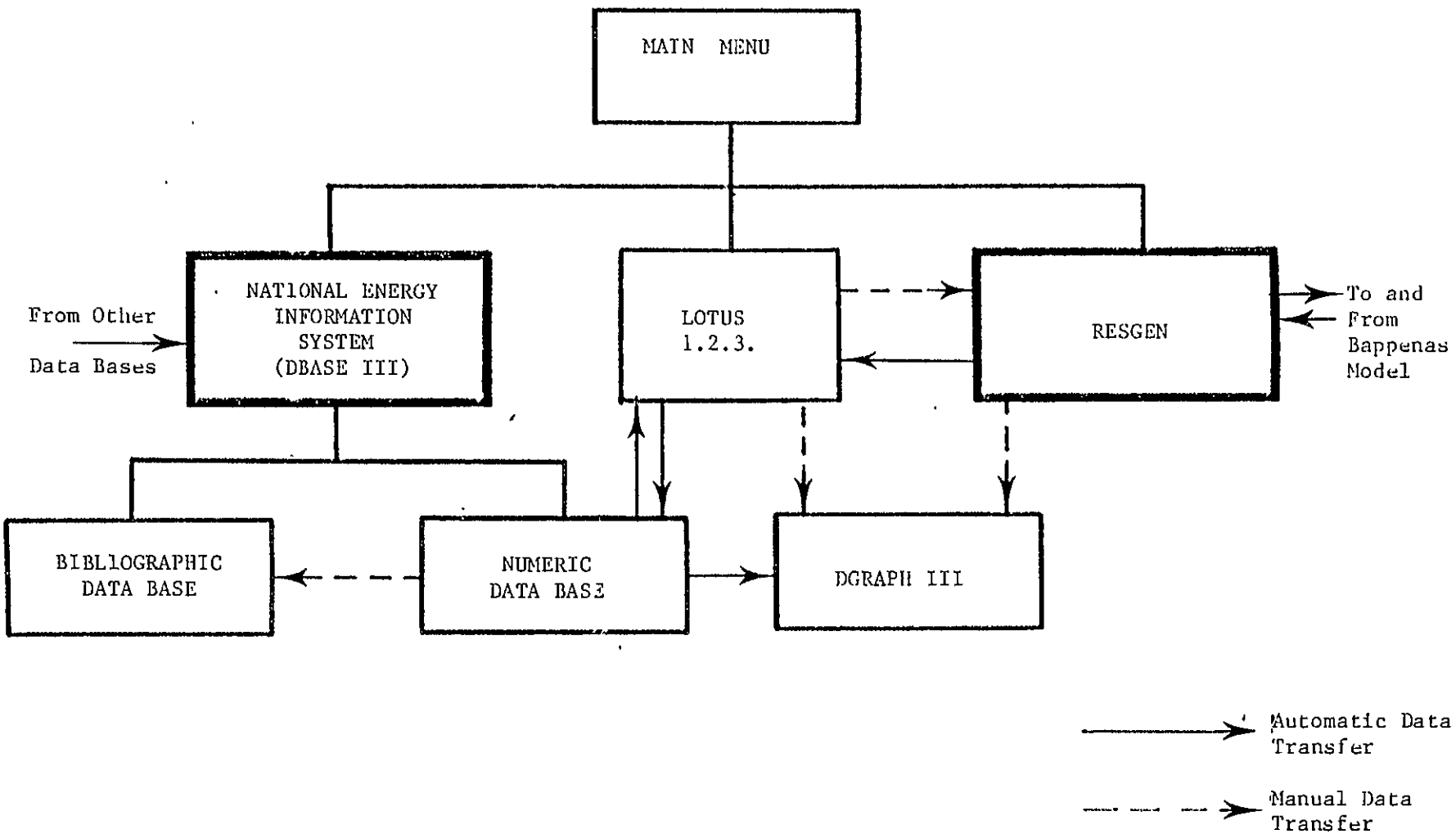
Under the project four microcomputers with expanded capabilities, peripherals and extensive software were installed at DJL.

2. Urban Energy Survey

Effective energy policy analysis in Indonesia is still hindered in some critical areas by the lack of detailed information on energy consumption patterns. This is particularly the case for the household sector. Thus in this project a survey was carried out of energy consumption patterns in some 1,500 households in 8 urban regions: Jakarta, Bogor, Ujung Pandang, Bandung, Medan, Jogjakarta, Surabaya and Semarang. The households surveyed were selected from previous SUSENAS surveys so that information from those surveys could be used in the analysis. The survey, although providing useful information in itself, was designed as a pilot effort to guide more extensive future surveys.

Figure 1

ENERGY INFORMATION AND ANALYSIS SYSTEM FOR INDONESIA



The data collected provide a basis for estimates of direct energy consumption in the urban household sector by fuel and income group and an analysis of fuel use by private vehicles. It was found that kerosene constituted over 70 percent of all household fuel use. Sharp differences were found in energy consumption between income groups, particularly for electricity, presaging continued rapid growth in electricity consumption as the Indonesian economy, and incomes, grow.

3. Productive Use of Rural Electricity

Rural electrification is a high priority in Indonesia's development plan and consumes a significant fraction of total national energy investment. This task addressed ways in which rural electrification programs could meet its social objectives more effectively through a more analytic selection of areas to be electrified and through enhancement of productive uses - e.g. in small scale industry - of electricity provided to rural areas.

4. Technology and Know-How Transfer

As described above, a primary objective of the project was a strengthening of capability within Indonesia, and particularly within DJL, for effective energy policy analysis. In part this was accomplished through the development and installation of the analytic tools and data described above. It was also accomplished through an extensive program of seminars, collaborations and formal and informal training. In addition to numerous staff within DJL and other institutions who collaborated in the various activities of the project, seven DJL staff participated in specially designed training programs in the U.S. of 2 - 12 weeks duration.

Throughout the project a series of seminars was held in Indonesia covering all aspects of the project.

C. THIS REPORT

The following sections of this report describe in more detail each of the major activities of the project. A final chapter

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summarizes the major conclusions of the project and suggests several activities to be undertaken if the full benefits of the project are to be assured. This report is necessarily only a brief summary of the highlights of the project. As indicated in the Table of Contents, the report is accompanied by several technical appendices which provide more technical detail on the project tasks and on the computer software developed in the project.

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CHAPTER I

NOTES AND REFERENCES

1. Repelita IV covers the period April 1, 1984 - March 31, 1989.

2. In 1983/84 Petroleum constituted 77.9 percent of domestic commercial energy consumption (see Chapter II). A summary of energy development plans in Repelita IV is contained in A. Arismunandar, "Energy Plans and Programmes within the Fourth Five-year Development Plan (Repelita IV: 1984/85 - 1988/89)". Direktorat Jenderal Listrik dan Energi Baru, Ministry of Mines and Energy, Republic of Indonesia.

3. Directorate General for Power, Ministry of Energy and Mines and Energy/Development International, "Energy Planning for Development in Indonesia", Three volumes. E/DI, Setauket, N.Y. October 1981. The summary volume (Vol. I) is also published in Indonesian, DJL, Jakarta, 1981.

II ENERGY INFORMATION AND ANALYSIS SYSTEM

A. INTRODUCTION

1. Objectives

The Energy Information and Analysis System for Indonesia was designed with two distinct needs and groups of users in mind. The first group of users are those within DJL, and other government and private groups, including international financial institutions, who want specific detailed information on the Indonesian energy picture. Typically, information is sought on energy resources, production, consumption or prices either historically or currently; at either a regional or a national scale.

The second, more exacting, need is for a flexible and powerful system to analyze various kinds of national energy policy issues. These issues include, for example, the potential for and investment cost of fuel substitution (for example coal for oil), the potential for conservation strategies, the impact of new technologies, or the effects of alternative fuel price structures. In this case the immediate users are DJL analysts while it is the policy makers who are the ultimate users. This capability responds to the need, mentioned above, for national energy analysis at the sectoral level but with links to overall macroeconomic planning.

In both instances it would be highly desirable for the users to have immediate, interactive access to the information and analytic capability of the system. There is also a desire for flexible outputs from the system, in tabular or graphical form to be specified by the user.

A subsidiary design objective was to make maximum use of commercial software in order to minimize dependence on specialized computer skills and to take advantage of the future evolution of software.

2. System Design

The system designed to meet the needs summarized very briefly above was shown above in Figure 1. The overall system is termed The Energy Information and Analysis System for Indonesia, EIASI (pronounced "easy"). Because of quite different requirements and users it was decided to distinguish the information system from the energy systems analysis model, indicated as RESGEN on the figure. As described below, RESGEN is a highly evolved and widely used software package for energy systems analysis. The remainder of the system uses very flexible commercial software packages, LOTUS 1-2-3, dBASE III (for the information system), and dGRAPH III for graphical output. The latter programs are extremely useful in themselves for a variety of analytical and planning purposes.

All elements of the system are accessible from the EIASI Main Menu. The first two screens which appear when the computer is turned on are shown in Figures 2 and 3. As indicated in Figure 1, data can be transferred between several components of the system, in some cases "manually", i.e., by extracting data from one component, reviewing it and inserting it into another. As indicated in the figure, extensive use is made in the system of the commercial software packages LOTUS 1-2-3, dBASE III and dGRAPH III. The user has great flexibility of extracting information in graphical or tabular form according to the users specifications either from RESGEN or the Information System. Communication with other computer systems is easy using standard (ASCII) data formats.

The size of the budget line item in the project was such that considerable flexibility existed on the type of hardware to be acquired - sufficient even for a minicomputer supporting a number of remote stations. However, the experience of other countries shows very clearly that minicomputers are ill-suited to the needs of energy planning agencies, and that a set of modern microcomputers, linked together in a local area network, provide a superior capability.[1] Not only is a system based on microcomputers more resistant to failure than one dependent on a single central computer, but even more

FIGURE 2

EIASI SHELL MENU CHOICES

```
Main Menu
_____________________________

1 - Information System
2 - RESGEN
3 - Lotus 1-2-3
4 - dGRAPH III
5 - Backup Utility
6 - Exit to DOS

Press any number to continue ...
```

FIGURE 3

ENERGY INFORMATION SYSTEM MAIN MENU

```
************** National Energy Data Base **************
   Energy Related Data Bases:
   (1) Numeric Data Base
   (2) Units and Conversions
   (3) Bibliographic Data Base
   (4) File Management
   (Q) Exit the National Energy Data Base

    Enter a selection to continue
```


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important, microcomputers can bring the analytical process closer to the decision maker. A further important reason is the cost and availability of a vast amount of useful software for microcomputers, that is either just not available for minis, or, if available, then only at significant cost. A FORTRAN compiler for an IBM Personal computer, for example, lists at about $350: a comparable compiler for, say, the PRIME Minicomputer, costs $7,000. Moreover, the graphics capabilities of micros and the superior level of reliability afforded by the inherent redundancy of a system based on a number of small independent units, also argue strongly for microcomputers. Indeed, microcomputers have been adopted by energy planning agencies throughout the world over the past few years, and a microcomputer based system for DJL was clearly indicated.

Table 1 summarizes the equipment and software provided under this project. The basic microcomputer configuration recommended for use of EIASI is:

Microsoft DOS
640K Ram
1 floppy disk
1 10 MB hard disk
color monitor
1 Bernoulli Box

A more complete description of the hardware/software system is contained in Appendix 1.

B. ENERGY INFORMATION SYSTEM

1. Concept

The Energy Information System has been designed to address DJL's needs through a two part system:

(1) A Numeric Database with information on energy resources, production, consumption, price information,

TABLE 1
LIST OF HARDWARE AND SOFTWARE PURCHASED BY THE PROJECT

HARDWARE

(1) IBM PC with 640K RAM, 2 diskette drives, color screen, 10 MB harddisk, dual 10MB Bernoulli Box.

(2) IBM PC with 640K RAM, 2 diskette drives, monochrome screen.

(1) Televideo Portable computer 640K RAM.

(1) IBM Graphics Printer
(1) Epson FX-100 Printer
(1) Epson LQ-1500 Letter Quality Printer
(1) HP7475A Color Plotter
(1) Polaroid Palette Slide Producer

Other misc. supplies.

SOFTWARE

DBASE III
DGRAPH III
LOTUS 1-2-3
WORDSTAR
MICROSOLVE OPERATIONS RESEARCH SOFTWARE
MATRIX MANIPULATION SOFTWARE
NUMBER CRUNCHER STATISTICAL SOFTWARE

RESGEN
DBASE III MENU AND MANIPULATION SOFTWARE

OTHER MISC. SOFTWARE

and historical projections on either a regional or national scale.

(2) A Bibliographic Database containing information on publications and reports of various types that address Indonesian energy concerns or information, including information on energy projects underway in Indonesia.

The Numeric Database can interchange data files with LOTUS 1-2-3 or dGRAPH III and can thus make use of extensive graphics, analytic and output options.

The Information System is designed to be menu driven to provide the greatest ease of accessibility for a wide range of potential users. The programming is in dBASE III, a commercial software substructure which is not menu driven in and of itself, but allows for the programming of a menu system and a wide range of automated features. The combination of dBASE III's substantial storage and retrieval capabilities and the ability to create a flexible menu driven shell for operations makes dBASE III the ideal tool for the Energy Information System. As a result, the Information System consists of two elements: a menu system and the data files that contain the energy information of concern to DJL and the other users of the system.

2. Numeric Database

The Numeric Database is designed to contain nine categories of information: Primary Energy Resources, Secondary Energy Conversion Plants, Production and Foreign Trade and others (Figure 4), each of which are further subdivided into sub-categories. Regional and National breakdowns of data are also accessible. It is important to point out that the design is flexible and can be extended to include additional categories or regions. Appropriate data files have been created to store the information in the form that is most efficient for the range of storage and retrieval demands on the system. Users can proceed with a minimum of training through a set of interactive prompts (the "menu tree") to examine the data of their interest.

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FIGURE 4

THE NUMERIC ENERGY DATA BASE MAIN MENU

This menu is produced when the user responds 1 to the Energy Information System Main Menu.

```
************** Numeric Energy Data Base ************
   (1) Primary Energy Resources
   (2) Secondary Energy Conversion Plants
   (3) Production and Foreign Trade
   (4) Demand and Consumption
   (5) Historical Series and Projections
   (6) Energy Prices and Tariffs
   (7) Technology Characteristics
   (8) National Socio-Economic Reports
   (9) International Statistics
   (Q) Return to the Main Menu
   (E) Exit DataBase

      Enter a selection to continue
```

Little training also is needed for data entry operations assigned to enter and update data files.

A command level is available in dBASE III that allows access to the full array of dBASE III data control features to trained analysts and programmers. Those commands give access to the full range of data handling tools: creation of new files, formatting of displays, creation of new menus and preparation of reports and graphs.

2. Bibliographic Database

The Bibliographic Database is designed as a catalogue of publications. It contains titles, authors, subject access number, an abstract etc. (Figure 5). A search system has been designed and programmed to allow users at the menu level to search the Bibliographic Database on a variety of fields and retrieve data in both a full page format with abstract or a listing of titles and authors matching the search criteria. A subsection of the Bibliographic Database is the Energy Projects file. This file has been designed to contain information on the description and status of energy projects underway in Indonesia (Figure 6).

Finally, the Unit Conversion utility contains an infinitely expandable energy units conversion table that contains unit conversion coefficients for a wide range of energy measurements. With this table and the utility, any data set existing in a particular array of energy units can be converted to another unit. Two commercial software packages, LOTUS 1-2-3 and dGRAPH III also reside within the Energy Information System.

C. ENERGY ANALYSIS SYSTEM

1. Design Considerations

In developing an energy model for DJL a number of factors were considered. What is the role of DJL vis-a-vis other institutions in the energy sector, and what functions would an energy model play in meeting this role? What is the level of staff capability in DJL to

FIGURE 5

BIBLIOGRAPHIC DATABASE MENU CHOICES

The Bibliographic Database allows for searches on a variety of fields in the entry form. There is also a utility for entering new records, and a Keyword Utility to provide present and updated list of all subjects/keywords in use in the system.

```
SEARCH BY :   (1) Accession Number
              (2) ISBN Number
              (3) ISSN Number
              (4) Subject
              (5) Author
              (6) Location
              (7) Source Document
              (8) Category Code
              (9) Enter New Keyword
              (K) Keyword Utility
     (E) End Session

Enter a selection to continue
```


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FIGURE 6

ENERGY PROJECTS DATA BASE - SAMPLE ENTRY

A sample entry in the Energy Projects Database. Memo fields indicate fields that can contain up to several pages of text material.

```
Energy Projects Listings                    Code Number E BN 9

Project Title  ASAHAN Hydro Project plants I & III (160
               MW & 200 MW) and associated transmission
               Line.
Location  NORTH SUMATERA PROVINCE

Agency  Directorate General of Electric Power and New
        Energy/Perusahaan umum Listrik Negara (PLN).
        Ministry of Mines and Energy.

          Objectives  Memo    Description  Memo
Total Cost            468.000.000
Local Cost            234.000.000
Foreign Exchange      234.000.000
Technical Assistance

Stage - Feasibility report was undertaken by JICA
        Engineering design is underway financed

(O)bjectives & Description (N)ext (E)dit (P)rint (Q)uit
```


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operate the model, and what resources would be available to develop the database necessary for an adequate modeling activity? Given the many models available, could any be adapted to Indonesia's needs? Finally, to what extent were hardware and software issues related?

The most important issue is the role of DJL, and the functions that an energy model would meet. In many a developing country an energy modeling effort, whatever the intentions, has failed because there was no clear concept of the policy issues that would be put to the model: the modeling effort began before the questions that the model would be asked to analyze had been articulated.

A related issue concerns the relationship between models and the policy process. In most situations, the important energy policy decisions are evaluated on the basis of the decision-makers considering some finite number of policy alternatives, in which each is evaluated on the basis of a set of criteria: economic development, social and/or regional equity, and other goals deemed politically relevant. This process, therefore, argues very strongly for a simulation approach, focussed on impact assessment. Optimization models, that purport to identify the "best" solution, rarely have much credibility, if only because such models require explicit quantification of objectives. Even if one were to accept cost minimization (or some other readily quantifiable objective) as a valid criterion, sufficient detail and accuracy of cost structures is rarely available.

A further objection to optimization models is the difficulty of reconciling computationally tractable models with the need to capture key functional relationships. Linear programming, because of the availability of computationally efficient algorithms, has been the usual technique in energy system optimization models: almost all of the best known models - the Brookhaven BESOM and TESOM models, the IEA MARKAL model, or the french EFOM model - use this approach because one can solve very large models in a matter of minutes. Unfortunately LP models are ineffective in situations involving strong scale economies,

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characteristic of almost all energy facilities. Those techniques that can accommodate scale economies and other non-linear cost functions, such as mixed integer programming, require substantial computation times to the point at which only the largest mainframe computers have the necessary specifications to solve large problems in a finite time.

Energy planning in most developing countries is a hierarchical process, in which several clearly distinct levels of analysis exist. At the first level stands overall macroeconomic development planning, that seeks to define the path for the economy as a whole. At the second stands energy sector wide planning, with its focus on the sector as a whole. Finally, the third level encompasses the subsectoral planning efforts typically conducted by the energy delivery organizations - the electric utility, the refinery, and so on. Of crucial importance is that different and usually distinct institutions occupy the different levels of this hierarchy, and that each of the institutions at the macroeconomic and subsectoral level, usually already have models in place to assist in their particular functions. Thus, in the case of Indonesia, at the macroeconomic level BAPPENAS uses a fairly sophisticated macroeconomic model. At the subsectoral level, many models are already in place - such as the WASP model at PLN and MARKAL at BPPT.

What, then, is DJL's role, and how can and should an energy model assist in this role? In fact, perhaps one of DJL's most important functions is to serve as a bridge between the macroeconomic and subsectoral levels, both in the sense of institutional coordination, as well as in the role of forcing consistency of planning assumptions across the institutions involved in the energy sector. For a model at DJL to be useful, it must therefore be designed not only in such a way as not to duplicate existing modeling efforts, but also to serve as an interface between them. This is an important distinction, because elsewhere energy planning agencies have encountered difficulties as a result of sterile arguments, in any event not subject to resolution, as to who has the "better" model.

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Therefore, one of the most important design criteria in this project was the ability of a model to serve as such an interface. It is not the function of a comprehensive energy planning agency such as DJL to develop its own capacity expansion plan for the electric utility, and therefore a model that includes such a function will inevitably be subject to skepticism on the part of the electric utility. (In fact, this is the fate of many optimization models that include an optimization of the generation mix - because the assumptions are frequently unrealistic.) However, it is the function of an energy planning agency to uncover, and attempt to reconcile, discrepancies between the investment and debt service implications of a capacity expansion plan, and the overall ability at the macroeconomic level to accommodate such expenditures. In sum, then, DJL requires a modeling framework that is suited to this particular role, and which has the flexibility to accommodate inputs from the other levels of the hierarchy. Such a role, represented schematically in Figure 7, coexists at DJL at two levels: first, at the national level, BAPPENAS does macroeconomic planning and several agencies do subsectoral planning. Secondly, at the regional level a similar structure exists. Economic planning is done at the provincial level by the Provincial Planning Boards (BAPPEDA): energy subsectoral planning at the provincial level is generally carried out by the same set of agencies that operate nationally, although the emphasis in their case may not be regional.

2. The Choice of Model

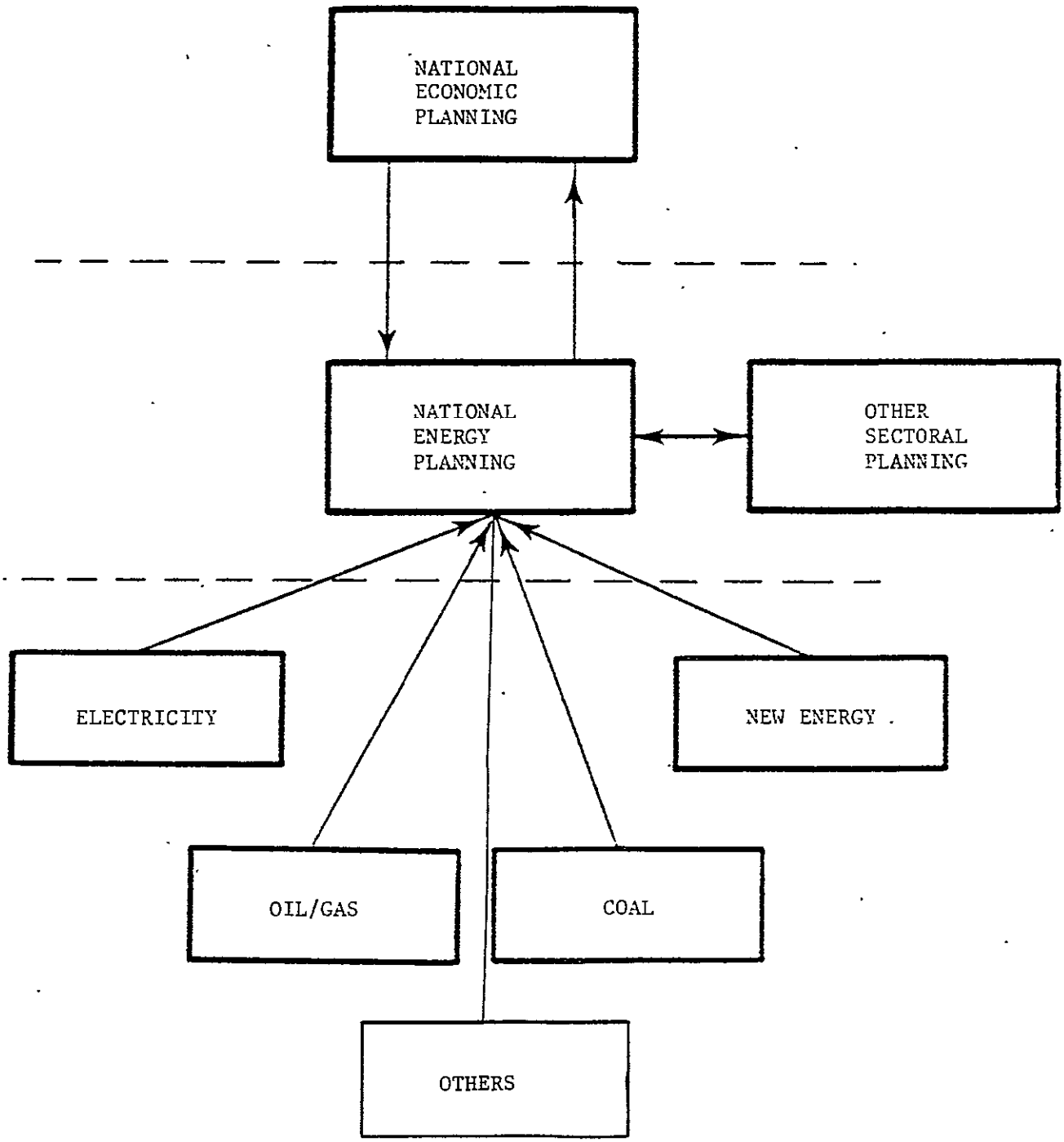
A number of microcomputer models have appeared over the past few years that were potential candidates for the DJL system: a recent symposium sponsored by the U.S. National Academy of Sciences, held in Sri Lanka in November 1984, revealed a number of different models in use in different places.[2] Three general types could be identified:

i. simple energy balance table models, based on spreadsheet-type software, particularly LOTUS 1-2-3;

ii. special purpose models written in languages such as BASIC, PASCAL and FORTRAN, that incorporated energy balance tables as one of their components, but included

FIGURE 7

THE HIERARCHY OF ENERGY/ECONOMIC PLANNING



in their focus various other items such as investment; and

iii. generic software designed to allow the user to formulate his own energy model through state of the art interactive data energy programs.

The disadvantage of LOTUS 1-2-3 is that it is not well suited to complex programming structures - LOTUS macros are cumbersome, difficult to debug and modify, and lack the flexibility of a language such as PASCAL[3].

Energy balance-investment models such as the ENVEST model developed for Morocco tend not to be easily transferable from country to country, and require a major effort to develop (several man years in the case of Morocco). In any event, most lack sufficient flexibility to have been adapted to the complex regional structure of Indonesia, and to the modeling environment in which subsectoral institutions in particular already have operational project-level models of considerable sophistication.

For the Indonesia model we have adopted the third approach, using the RESGEN software to construct the core model. RESGEN is not so much a "model" as software to develop models: just as LOTUS 1-2-3 is software to develop spreadsheets, so can RESGEN be understood as software to develop energy networks[4]. What is unique about RESGEN is its ability to accommodate networks of vastly different levels of complexity and to link different networks together; its ability to communicate with other programs and databases (especially important if one is to successfully integrate the efforts of other institutions); and its ability to address a variety of different structures: econometric demand models, project level consideration of electric sector investment, or alternative resource development scenarios. Moreover, RESGEN comes with a LOTUS 1-2-3 interface, that allows the user to design his own graphics, and/or manipulate output data with complete flexibility.

A further advantage of RESGEN is the fact that it had already been successfully applied in a variety of other countries - most recently in Uruguay, Haiti, the Dominican Republic, Sri Lanka and Thailand. Thus, given the rather limited resources available for development of an Indonesian version, one could emphasize the development of those features unique to Indonesia: the necessity for a regional analysis and regional demand structures, and a framework for linkage with the BAPPENAS and subsectoral models.

D. THE APPLICATION OF RESGEN

During the EPfD II project extensive changes were made to the RESGEN program to satisfy the requirements of energy planning in Indonesia. RESGEN was then used to create the Indonesian Energy Model. A detailed manual of the RESGEN code is presented as Appendix 2 to this report and the detailed description of the Indonesia Energy Model is presented in Appendix 3.

The general approach of the simulation model is as follows:

- Given demographic or economic growth rates for energy consuming sectors of the economy, and the fractions by which different fuels meet those demands, a set of energy demands is calculated. These can be for a region, or the country as a whole as well as for any specific sector such as transportation, households, industry or commerce.

- Modification to energy demand patterns due to changes in prices are introduced by an econometric approach, given the long term price elasticities and changes in relative prices.

- Projected demands for fuels and electricity and constraints on production of fuels as well as energy conversion facilities yield future energy balances that result in imports and exports of fuels from a given region or for the country as a whole.

- An electric sector dispatch simulator is included that selects year by year the plants needed to meet electric demands given a load duration curve and a list of electric facilities ordered by a given criterion and year of construction.

- A refinery sector submodel specifies the amount and type of crude throughput for each existing and planned refinery, with year of start-up or shutdown, and the products out of each refinery by type of crude.

- Year by year production of all other energy forms are specified, nationally or by region: LNG, coal, wood, etc. Up to three scenarios (low, medium and high for example) can be given for selection by the analyst.

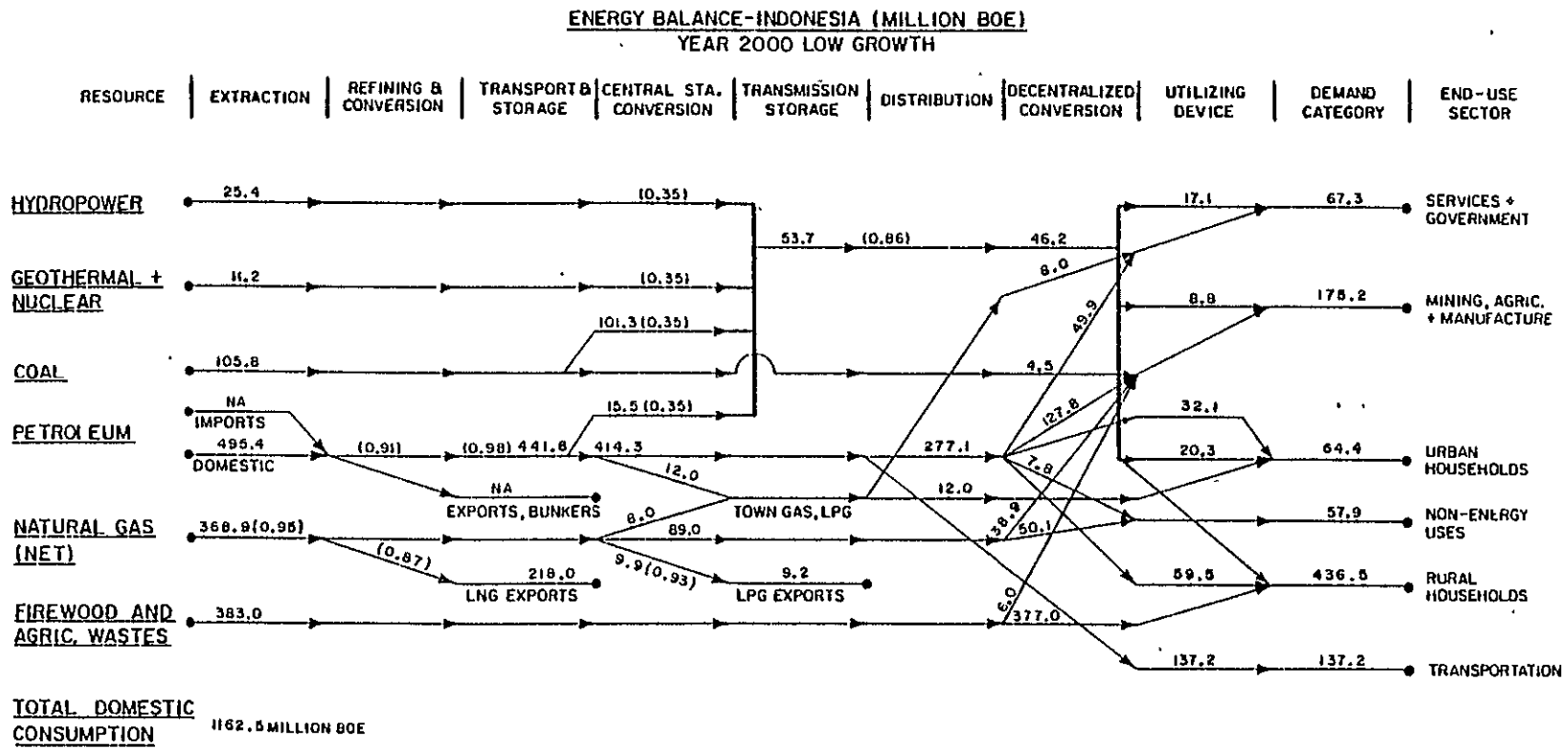
- Given c.i.f. prices for energy imports and f.o.b. prices for energy exports, the model calculates for each year the flows of foreign exchange for the energy sector commodity trade.

- Given capital costs, construction period, loan period, fraction foreign exchange and interest rate, the model will tabulate foreign exchange cash flows for all new energy facilities required during the projection period.

The model is a representation in network format of the flow of energy (or the value of this energy) through the economy, from end-user to supplier or producer. This approach was used in the EPfD I project as shown in Figure 8. The network can be an integrated system representation of all energy forms through all processes, or one where a single fuel from (i.e., wood and wood-based energy products) is analyzed in isolation for a given region. Other segments analyzed in isolation can be a regional demand sector (households) in Java, for example, or an entire region (Java, for example). Trade-offs must take place in the sense that a detailed network encompassing <u>all</u> fuel forms and <u>all</u> regions, for example, would generate large data requirements and lengthy computer processing time, without necessarily yielding more insights than an approach that analyses a specific issue in detail (for example regional coal demand and production) that treats other fuels in less detail.

The emphasis has been given to the design of a flexible model that can be used often by many energy analysts, one where verification of results is straightforward and where no elements of "black box" computer modelling are present. As a simulation technique, the model is designed for easy management of numerous runs with their respective

FIGURE 8



Note: This figure is reproduced from work carried out in the EPfDI Project. The numbers shown are illustrative and do not correspond to projections made in this project.

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results succinctly tabulated and/or graphed for easy interpretation. Examples of graphic output and inputs are shown in Figure 9 and Figure 10.

Another feature of the RESGEN code is its ability to transfer output tables to the LOTUS 1-2-3 spreadsheet software. This opens for the energy model the entire range of graphics capabilities built into the LOTUS software. It is important to note that the model applications described below have been created and tested during the execution of the project. DJL personnel have been trained in the execution of these applications, as well as in all data entry and updating procedures. However, no final results are presented in this report, since data assumptions and other key inputs have up to this point not been discussed within DJL or other agencies. Therefore, the graphical and tabular outputs presented in the following pages, and in particular in Appendix 3, should be viewed only as illustrative of the capabilities of the model applications.

1. Demand Projection Models

Two models for projecting energy demands were designed during EPfD II: a Regional Demand Model for eight regions that contains detailed sector by sector analysis of energy demands by activity (for which linkages to macroeconomic models have been structured, see below); and an Energy Demand Projection Model for Indonesia as a whole that uses an econometric approach to projection of fuel demands. These models are presented in detail in Appendix 3. A third application similar to the Energy Demand Projection Model that separates Java from off-Java demands was created but was applied mostly for training sessions.

a. Regional Demand Model

The eight regions selected for the model are designed around aggregations of Indonesia's 27 provinces. As shown in Table 2, Regions 1 to 4 constitute Sumatra; the island of Java is Region 5; Kalimantan's four provinces are Regions 6 and 7; and the remaining

FIGURE 9
FUELS TO ELECTRICITY (PLN)

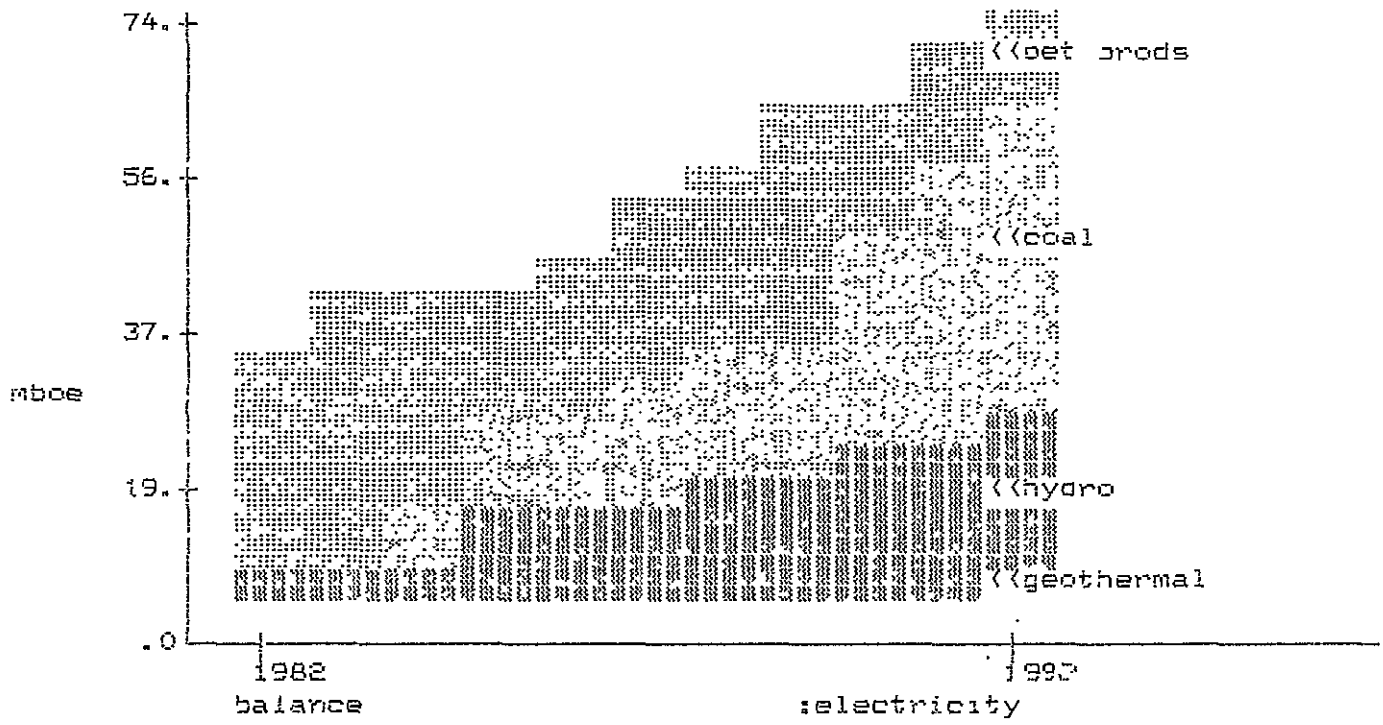

FIGURE 10
FUEL IMPORTS

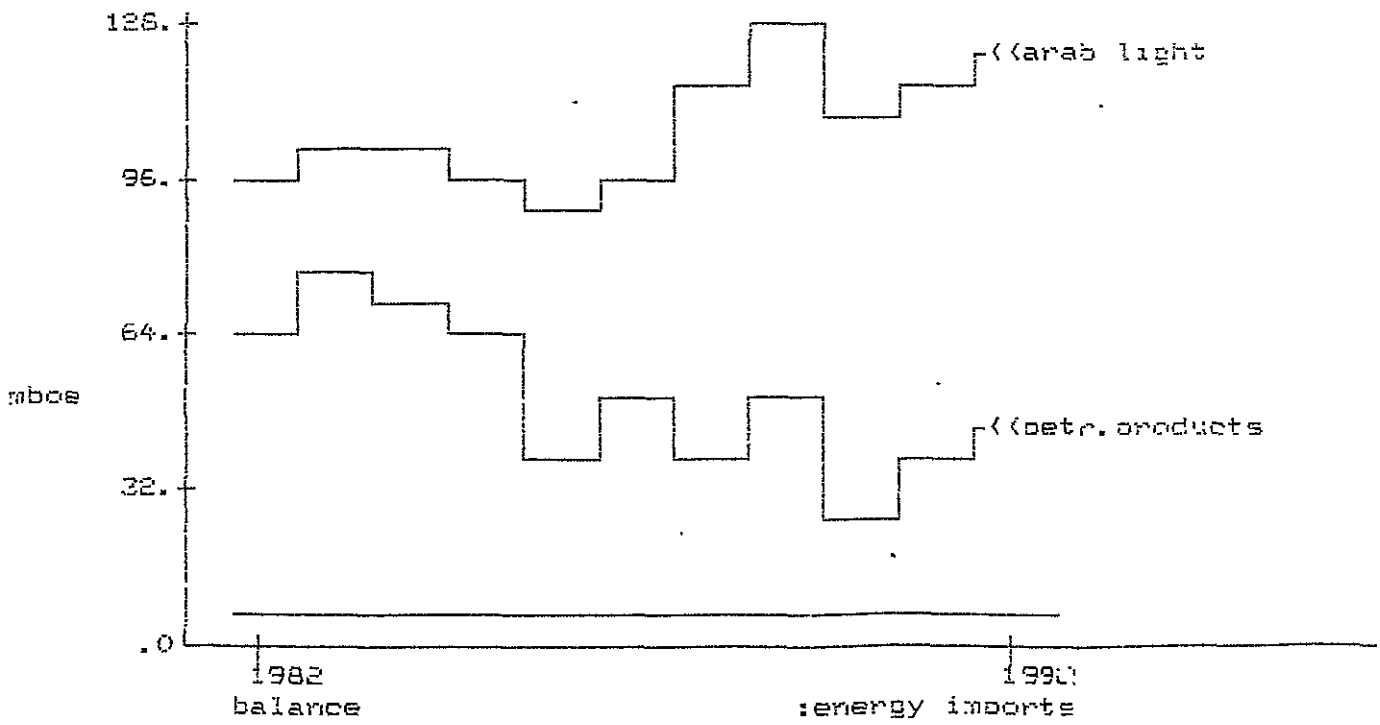

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TABLE 2

EPfD II REGIONS

EPfD II Regions	Provinces	PLN Regions	Pertamina Regions
Region 1	Aceh, Sumatra Utara	I, II	U.P. I
Region 2	Sumatera Barat,	III(1)	
Region 3	Riau	III(1)	
Region 4	Sumatera Selatan, Lampung, Jambi Bengkulu	IV(1)	U.P. II
Region 5	Jawa	XII, XIII Da, Db, K	U.P. III(2), U.P. IV, U.P. V(3)
Region 6	Kalimantan Barat	V	(2)
Region 7	Kalimantan Timur & Tengah & Selatan	VI	(3)
Region 8	Bali, Sulawesi, Nusa Tenggara, Muluku, Irian Jaya	VII, VIII IX, X, XI	U.P. VI, VII, VIII(3)

(1) PLN Regions III and IV overlap EPfD II Regions 3 and 4 in one district of Jambi province. EPfD II Regions 2 and 3 correspond otherwise to PLN Region III, which must be disaggregated.

(2) Kalimantan Barat included in U.P. III

(3) Pertamina Region U.P. V (East Java) includes EPfD II Region 7 and Bali (part of EPfD II Region 8).

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islands from Bali to the east, including Sulawesi, the Moluccas and Irian Jaya are Region 8.

The rationale for this selection, in which DJL staff and Project Steering Committee members participated actively, included:

- Sumatra's rich energy resources, in particular coal, together with its proximity to centers of demand - principally in Java, and the wide range of energy transportation costs to Java from different points in Sumatra, result in four distinctive regions for that island. A similar rationale made it important to separate Kalimantan into two regions.

- Java is best analyzed as a single demand region because it has an integrated electric grid, has an extensive road network linking its three provinces and is generally a net importer of fuels (refined petroleum products, crude oil, coal) from other regions or from other countries.

- Most importantly, the selection of the regions follows the availability of information on energy consumption from a handful of existing sources: BPS Statistics by province for energy consumption by large and medium industries; statistics on petroleum products sales by Pertamina regions (ADP-7), and electricity sales by customer class by PLN regions. An approximate mapping of Pertamina and PLN regions is shown in Table 2. Other regional information can be obtained indirectly: gas sales are identified by major customers (their location is generally known), as are the cities served by city gas (PGN Gas); the future demand of coal in cement plants is known from the location of these plants and so on.

There are four models for each region: households, transport, industry and other sectors. The resulting 32 sectoral demands by region, expressed in thousand barrels oil equivalent (kboe), are then aggregated according to the analysts needs:

Regional Total: an addition of the four sectors for a region produces summary tables of regional demand by sectors (Table 3). The resulting regional totals can be aggregated into a national total demand by region, the result of which (Table 4) is a vector of

TABLE 3

Energy Model

Demand Region 5, Java

1988 Demand by Region (kboe)

	avgas	avtur	gasoline	kerosene	ado	ido	fueloil	petrochem	lubes/vax	asphalt
households	.00	.00	.00	36476.15	.00	.00	.00	.00	.00	.00
transport	53.94	3038.85	20726.25	.00	16178.83	507.99	369.09	.00	.00	.00
industry	.00	.00	.00	.00	14468.48	4570.56	5007.38	.00	.00	.00
other sect	23.63	214.56	1001.26	1083.49	2815.35	189.78	739.41	287.71	548.12	1098.33
.total	77.57	3253.41	21727.51	37559.64	33462.66	5268.33	6115.88	287.71	548.12	1098.33

1988 Demand by Region (cont.): (kboe)

	petr coke	gas	Java-elec	agric was	total
households	.00	.00	3064.81	.00	39540.96
transport	.00	.00	.00	.00	40874.94
industry	.00	21025.82	804.14	1777.01	47653.39
other sect	156.38	.00	6574.81	.00	14732.83
.total	156.38	21025.82	10443.75	1777.01	142802.10

TABLE 4

Indonesia Energy Model

Indonesia Energy Demand by Region (addregs.dat)

sept 5

1988 Total Demand by Region (kboe)

	avgas	avtur	gasoline	kerosene	ado	ido	fueloil	petrochem	lubes/wax	asphalt
N. Sumatra	15.99	457.91	2905.64	3670.31	4260.68	161.41	442.76	.00	.00	.00
W. Sumatra	.11	3.26	692.47	1119.74	1417.08	212.99	271.37	.00	.00	.00
C. Sumatra	.25	2.13	416.98	793.50	723.62	.16	174.01	.00	.00	.00
S. Sumatra	2.95	187.84	2265.19	3528.72	5903.56	1345.76	955.19	.00	.00	.00
Java	77.57	3253.41	21727.51	37559.64	33462.66	5268.33	6115.88	287.71	548.12	1098.33
W. Kaliman	1.06	9.15	279.47	1274.18	447.08	15.55	164.57	.00	.00	.00
E.C.&S.Kalim	1.09	12.48	983.63	1765.71	3594.84	72.00	1234.36	.00	.00	.00
East Indonesia	20.52	747.16	3559.97	18745.52	4988.49	88.98	1632.41	.00	.00	.00
.total	119.53	4673.34	32830.85	68457.33	54798.00	7165.18	10990.55	287.71	548.12	1098.33

1988 Total Demand by Region (cont.): (kboe)

	petr coke	gas	coal	electrici	Java-elec	hydro	agric was	total
N. Sumatra	.00	.00	.75	854.33	.00	4940.48	91.81	17802.07
W. Sumatra	.00	.00	2168.67	163.52	.00	.00	64.37	6113.59
C. Sumatra	.00	.00	.00	744.05	.00	.00	.00	2854.68
S. Sumatra	.00	.00	222.36	1055.49	.00	.00	243.11	15710.17
Java	156.38	21025.82	.00	.00	10443.75	.00	1777.01	142802.10
W. Kaliman	.00	.00	.05	85.48	.00	.00	22.01	2298.60
E.C.&S.Kalim	.00	1012.41	.00	144.05	.00	.00	13.47	8834.05
East Indonesia	.00	.00	67.52	350.85	.00	1431.87	36.29	31669.57
.total	156.38	22038.23	2459.36	3397.79	10443.75	6372.35	2248.07	228084.80

national energy demands that can be used as input to the Energy Supply/ Demand Balance Model (see section 2 below).

Sectoral Totals: the sectoral modules can be aggregated in one step into a national total by sectors (Table 5). The resulting sector of demands is identical to the national total by region and can be used as input to the Energy Supply/Demand Balance Model.

Regional Energy Balances: the regional energy demands can be used directly as input to a file of the type of the Energy Supply/Demand Model, to produce regional energy balances.

For each region, demands are calculated in separate sectoral modules. The household module or model specifies 11 activities: urban/rural cooking, lighting and home industries, as well as electric uses such as air conditioning, hot water, water pumping and other appliances. The transport model is specified by mode: auto, truck, small truck, bus, small bus, motorcycle, rail, ship and air. Industry details food, textile, pulp/paper, rubber, chemicals, fertilizer, cement, ceramics, iron/steel, small industry and other manufacturers. The industry model captures captive power generation as well. The four model other sectors details agriculture (including plantation and forestry), mining (nickel, tin, copper, oil/gas and other), construction, government, commercial and non-energy uses.

The data requirements of the Regional Demand Model are substantial and therefore the models serve as a framework for a comprehensive data base on historical fuel demands by sector in each region. As listed above, the sources of energy data by region are limited, and in many cases national data was disaggregated by indicators (or "location quotients") such as GNP by province, population by province and number of vehicles by province. In this data analysis phase of the project, DJL staff participated actively, utilizing LOTUS 1-2-3 software to manipulate the data.

TABLE 5

Indonesia Energy Model

Indonesia Demands by Sectors (sectors.dat)

sept 3

1988 Demand (kboe)

	avgas	avtur	gasoline	kerosene	ado	ido	fueloil	petrochem	lubes/wax	asphalt
households	.00	.00	.00	66822.48	.00	.00	.00	.00	.00	.00
transport	89.60	4343.83	31393.57	.00	25633.54	639.45	415.60	.00	.00	.00
industry	.00	.00	.00	.00	17352.70	5521.70	7377.96	.00	.00	.00
other sect	29.93	329.51	1437.29	1634.85	11811.76	1004.03	3196.99	287.71	548.12	1098.33
.total	119.53	4673.34	32830.86	68457.34	54798.00	7165.18	10990.55	287.71	548.12	1098.33

>

1988 Demand by Region (cont.): (kboe)

	petr coke	gas	coal	electrici	Java-elec	hydro	agric was	total
households	.00	.00	.00	1019.08	3064.81	.00	.00	70906.38
transport	.00	.00	58.33	.00	.00	.00	.00	62573.92
industry	.00	22038.23	2106.81	132.76	804.14	.00	2248.07	57582.36
other sect	156.38	.00	294.21	2245.95	6574.81	6372.35	.00	37022.21
.total	156.38	22038.23	2459.36	3397.79	10443.75	6372.35	2248.07	228084.80

>

b. Energy Demand Projection Model

This application produces in a single module national energy demand projections. It uses as a data base a complete set of 1982 energy demands by sector prepared by an interagency working group of which DJL was a member. These data contain fuel and electricity use to the major energy consuming sectors: households, transport, industry/services and captive power. Within each sector, selected modes and activities have been separated: kerosene cooking and lighting; wood and agricultural wastes to rural households, roads, rail, ship and air; fertilizer, cement and Krakatau steel from other industry/services users. The projection is econometric in nature, with equations that contain income and price elasticities accompanying the various growth rates. Illustrative results, showing total demand by sector for all fuels (petroleum, gas, coal and biomass) and electricity for the period 1982 - 1998, are shown in Table 6 and in Figure 11. Figure 12 shows the same projection of total demand by type of fuel.

2. Energy Supply/Demand Balance Model

The Indonesia Energy Supply/Demand Balance Model is the principal application of the RESGEN code during the EPfD II project. This Supply/Demand Balance model calculates the following key outputs:

- A detailed Energy Balance for any target year, in which the columns represent primary and secondary energy forms, and the rows represent production, foreign trade, energy conversion and energy consumption.
- A table of the value of energy imports and exports detailed by fuel, for any target year.
- A table of year by year foreign exchange investment outlays for energy projects (for example in electric plants); table also prepares the year-by-year foreign exchange disbursements for interest and principal repayment on the investment outlays.
- A wide range of tabular and graphics outputs on fuel mix by consumption category, projected time series on fuel and electricity demands, projected fuel and electricity production and so on.

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TABLE 6

..fuel by sector :base case 82-98 (million barrels oil equivalent)

	1982	1983	1984	1985	1986	1987	1988
households	149.16	152.53	155.93	161.61	167.60	173.93	180.60
transport	58.08	57.87	59.13	61.66	64.29	67.04	69.91
industry	48.29	49.27	51.96	57.35	65.18	69.34	72.94
captive power	24.51	29.20	29.79	30.15	30.50	30.83	31.14
total	280.05	288.87	296.81	310.77	327.57	341.14	354.59

	1989	1990	1991	1992	1993	1994	1995
households	187.66	195.12	203.01	211.37	220.23	229.62	239.58
transport	72.91	75.93	79.07	82.36	85.78	89.36	93.09
industry	77.44	81.79	87.73	93.09	98.10	102.58	106.51
captive power	31.42	31.68	31.90	32.09	32.24	32.34	32.36
total	369.44	384.51	401.72	418.90	436.35	453.89	471.53

	1996	1997	1998
households	250.15	261.38	273.32
transport	96.98	101.04	105.29
industry	110.68	115.12	119.83
captive power	32.32	32.22	32.05
total	490.13	509.76	530.48

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FIGURE 11
PROJECTED ENERGY DEMAND BY SECTOR
(million barrels of oil equivalent)

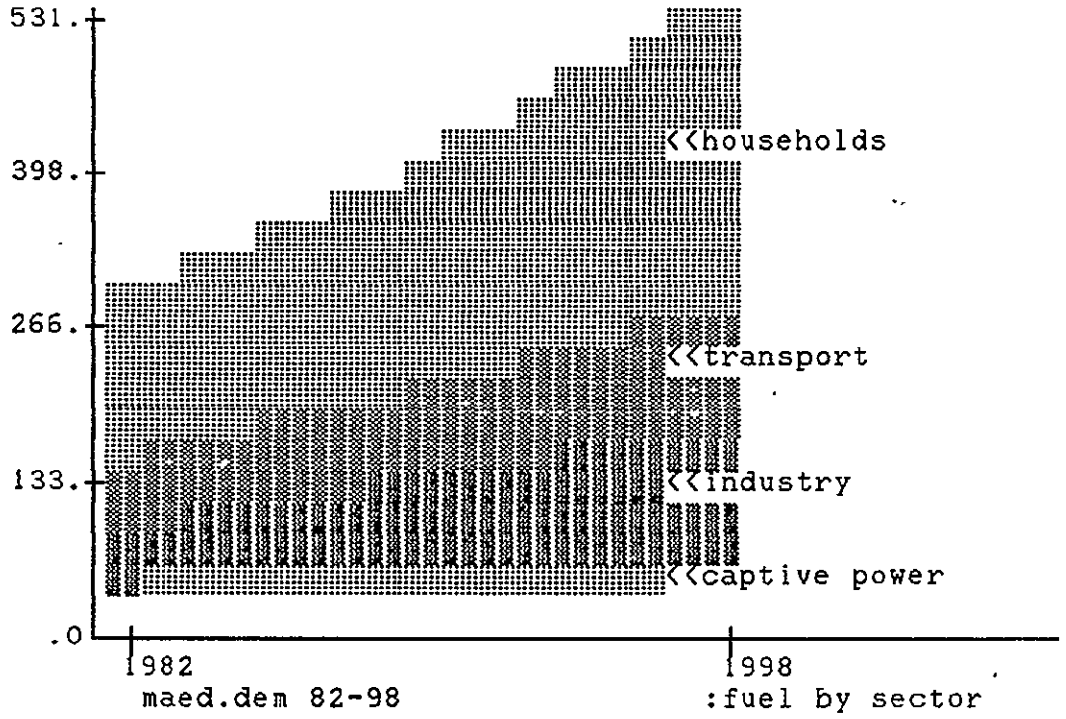
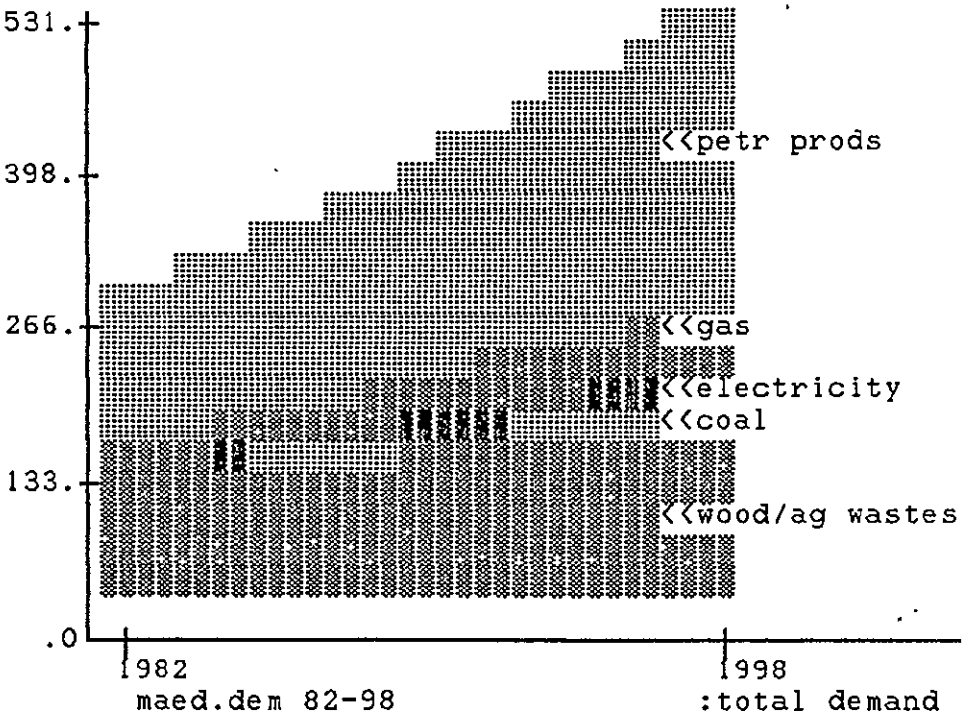


FIGURE 12
PROJECTED FUEL DEMANDS
(million barrels of oil equivalent)



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- By utilizing an option to transfer the results to LOTUS 1-2-3, an even greater range of output representations can be achieved.

The Energy Supply/Demand Balance Model draws upon a set of input data on resource production and utility expansion plans; it allows the user to calculate refinery throughputs according to a wide selection of options, and is "driven" by a set of energy demands chosen by the user.

- Energy Demands: The initial inputs to the model are a set of energy demands. These demands, calculated with other applications of the RESGEN code (a and b above), are selected by the user from a menu.

- Electricity Expansion Plans: Information on PLN's capacity expansion plan is stored in outside files. They contain the name of the project, year of implementation, MW, thermal efficiency and other technical data such as forced outage rates. Associated with this list is a file that contains the investment cost of each plant (year by year during the construction period), and other financial data on the expansion plan. The model has been designed to distinguish between the Java and non-Java systems. It can also be made to run for any of the eight Indonesian regions identified in the EPfD II project.

  The model also allows the user to select the data file containing the information on PLN's expansion plan. If two versions of a plan exist, corresponding to different scenarios or alternatives, stored in their respective data file, the model will permit the user to select which alternative plan he/she wants to use in a particular run of the model.

- Resource Production Scenarios: The Energy Supply/Demand Balance model has been designed to require as inputs year by year production of key domestic energy resources, such as crude oil, and major commodities such as LNG produced under long-term contracts in liquefaction facilities. Because of the uncertainty associated with future resource production, the model allows the user to select from three scenarios (high, medium, low) for each resource. These scenarios appear on the screen graphically at the point during the execution of the model in which it queries the user for a scenario selection.

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- Refinery Production: The model simulates the operation of the refinery sector according to a wide range of options. One option the user can select is to predetermine the amount of crude to be processed in each Indonesian refinery (including Singapore Processing Deal). The model will calculate refinery output according to the technical configuration of each refinery. A second option is to select one product, for example kerosene; the model will determine crude throughput required to meet kerosene demand, and all other products are then either imported or exported to achieve the balance between demand and available supply.

- Energy Balances: The final step in the formulation of future energy balances is to link future production of energy resources and their respective demands. In a simulation approach one alternative is to assign balance between production and demand to imports or to exports. This was selected for crude and petroleum products. A different approach is to equate demand with production for resources that are exploited domestically, or to imports. The model equates demands for coal, wood, agricultural wastes, hydropower and geothermal with production.

Results are shown in several tables that are presented in the following pages. Table 7 is an illustration of an energy balance table for the year 1992. The units are million barrels of oil equivalent (mboe), as indicated. It is created using base case energy demands calculated with the Energy Demand Projection Model (see b. above); these appear in the row "consumption". Domestic crude production that year is estimated to be 580.0 mboe; LNG exports reach 160.0 mboe. Local refineries take 214.9 mboe of this domestic crude, plus 80.0 mboe of imported arab light to produce a range of petroleum products according to yield data entered to the model for each Indonesian refinery, including new expansions at Dumai, Balikpapan and Cilacap. The results show that 16.4 mboe of kerosene and 19.8 mboe of diesel must still be imported, but more than 22.0 mboe of gasoline would be exported. Given a table of import and export prices of fuels, the model prepares a table of the value of this trade in fuels. As shown in Table 8, exports of crude, LNG, LPG and LSWR reach US$22.81 billion based on the assumed fuel prices, while imports of products are US$2.98 billion and exports of products are

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TABLE 7

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 3

1992 Energy Balance Table (mboe)

	crude	arab ligh	lpg	avgas	avtur	gasoline	kerosene	ado	ido	fueloil
primary producti	580.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
imports	.00	80.00	.00	.00	4.39	.00	16.40	10.44	9.27	.00
exports	-365.10	.00	-5.49	-.03	.00	-22.15	.00	.00	.00	-.87
bunkers	.00	.00	.00	.00	-1.00	.00	.00	-.05	-.20	-1.00
stock changes	.00	.00	.00	.00	.00	.00	.03	.00	.07	.01
.subtotal	214.90	80.00	-5.49	-.03	3.39	-22.15	16.42	10.40	9.14	-1.86
refinery	-214.90	-80.00	6.93	.11	2.96	52.59	62.98	49.13	8.35	24.50
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	-5.52	-8.65
gas plant	.00	.00	.00	.00	.00	.00	-.03	.00	-.07	-.01
LNG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	-.12	.00	-.54	-.14	-.14
.total	.00	.00	1.44	.08	6.35	30.32	79.38	58.99	11.75	13.84
consumption	.00	.00	1.44	.08	6.35	30.32	79.38	58.99	11.75	13.84

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TABLE 7

continued

1992 Energy Balance Table (cont.): (mboe)

	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	gas	LNG	LPG exp	coal
primary producti	.00	.00	.00	.00	.00	.00	380.30	.00	.00	51.04
imports	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
exports	-4.94	-.95	-.51	-4.05	-.52	-59.21	.00	-160.00	-4.30	.00
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
stock changes	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.subtotal	-4.94	-.95	-.51	-4.05	-.52	-59.21	380.30	-160.00	-4.30	51.04
refinery	5.19	1.60	1.70	4.20	.52	59.21	.00	.00	.00	.00
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	.00	-34.83
gas plant	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00
LNG plant	.00	.00	.00	.00	.00	.00	-183.07	160.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	-4.43	.00	4.30	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	.00	-151.72	.00	.00	.00
.total	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	16.22
consumption	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	16.22

)

1992 Energy Balance Table (cont.): (mboe)

	electrici	Java-elec	hydro	geothema	wood	agric was	total
primary producti	.00	.00	25.13	5.58	102.74	30.74	1175.53
imports	.00	.00	.00	.00	.00	.00	120.50
exports	.00	.00	.00	.00	.00	.00	-628.12
bunkers	.00	.00	.00	.00	.00	.00	-2.25
stock changes	.00	.00	.00	.00	.00	.00	.11
.subtotal	.00	.00	25.13	5.58	102.74	30.74	665.76
refinery	.00	.00	.00	.00	.00	.00	-14.92
elec generation	3.62	17.00	-18.88	-5.58	.00	.00	-52.84
gas plant	.00	.00	.00	.00	.00	.00	.05
LNG plant	.00	.00	.00	.00	.00	.00	-23.07
LPG plant	.00	.00	.00	.00	.00	.00	-.13
charc/briq	.00	.00	.00	.00	.00	.00	.00
-losses	-.72	-2.55	.00	.00	.00	.00	-155.94
.total	2.89	14.45	6.24	.00	102.74	30.74	418.90
consumption	2.89	14.45	6.24	.00	102.74	30.74	418.90

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TABLE 8

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 3

1992 current account table (US $bill)

	Java-elec	electrici	avgas	avtur	ado	ido	fueloil	LNG	LPG exp	crude
imports	.00	.00	.00	.14	.23	.27	.00	.00	.00	.00
exports	.00	.00	.00	.00	.00	.00	-.02	-10.75	-.15	-10.22
bunkers	.00	.00	.00	-.03	.00	-.01	-.02	.00	.00	.00
.net	.00	.00	.00	.11	.23	.27	-.04	-10.75	-.15	-10.22

1992 current account table (cont.): (US $bill)

	arab ligh	lpg	gasoline	kerosene	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	total
imports	1.76	.00	.00	.57	.00	.00	.00	.00	.00	.00	2.98
exports	.00	-.29	-.74	.00	-.10	-.02	.00	-.06	-.02	-1.69	-24.06
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-.06
.net	1.76	-.29	-.74	.57	-.10	-.02	.00	-.06	-.02	-1.69	-21.15

US$1.25 billion. It is important to point out that these amounts are shown more as illustrations of the capability of the model than as final results, since the world export and import prices of the different fuels used in the calculation have to be reviewed in depth.

The electric sector is simulated in great detail by the model. A total of 17.00 mboe of electricity generated in Java and 3.62 mboe off-Java are met by 34.83 mboe of coal, 18.88 mboe of hydro, 5.58 mboe of geothermal and 14.17 mboe of petroleum, as shown in the "elec generation" row of the Energy Balance. This is the result of a plant by plant dispatch of power plants (Table 9) in which plant efficiency, outage rates, and a load duration curve are all entered to the modelling effort. The model also calculates the total investment outlays for the power plant construction program required to meet the electricity demands: the illustrative results (Table 10) show that they average about US$300 million per year to 1985, reach a peak of US$522 million in 1987 and decrease to US$425 - 440 per year the rest of the decade. Year by year debt service on the foreign portion of this investment, using as inputs 20 year loan periods and 12 percent annual interest are also calculated.

E. MACROECONOMIC LINKAGE

1. Objectives

Energy is a central and crucial part of Indonesia's overall economic development. For this reason national economic planning must deal explicitly and accurately with the energy sector and, likewise, energy planning must mesh with macroeconomic planning. Particular attention was paid in this project, therefore, to linking the RESGEN energy systems models to the BAPPENAS Macroeconomic Model.

There are three principal motivations behind this linkage. First and foremost is the desire to integrate the energy system and economic policy analysis, decision making and planning processes. Second is a desire to base the projections of energy demands, associated investment requirements, petroleum exports and

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TABLE 9

ELECTRIC SECTOR DISPATCH, JAVA SYSTEM (1992)

UNITS AS INDICATED

merit order dispatch for 1992

plant	Mw avail.	Gwh	fuel,mboe	
peak				
java/exist hydro	393.30	298.91	.62	(hydro)
hydro purchase	112.50	85.50	.18	(hydro)
saguling 1-2-3-4	665.00	505.40	1.05	(hydro)
senggaruh	27.55	20.94	.04	(hydro)
cirata I, 1-2-3-4	475.00	361.00	.75	(hydro)
k.umbo	21.85	16.61	.03	(hydro)
tulung angung	28.50	21.66	.04	(hydro)
kesamben	31.35	23.83	.05	(hydro)
mrica	171.00	129.96	.27	(hydro)
suralaya 1	360.00	273.60	.57	(coal)
suralaya 2	360.00	273.60	.57	(coal)
suralaya 3-4	720.00	547.20	1.13	(coal)
paiton 1	360.00	273.60	.57	(coal)
paiton 2	360.00	273.60	.57	(coal)
java/exist geotherm	27.00	20.52	.04	(geothermal)
kamojang 2-3	99.00	75.24	.16	(geothermal)
salak 1	49.50	37.62	.08	(geothermal)
salak 2,dieng 1-2	148.50	112.86	.23	(geothermal)
drajati-2	99.00	75.24	.16	(geothermal)
java/exist steam	791.68	601.68	1.87	(fueloil)
total Mw	5300.73			
intermediate				
java/exist hydro	393.30	786.60	1.63	(hydro)
hydro purchase	112.50	225.00	.47	(hydro)
saguling 1-2-3-4	665.00	1330.00	2.75	(hydro)
senggaruh	24.53	49.06	.10	(hydro)
cirata I, 1-2-3-4	475.00	950.00	1.97	(hydro)
k.umbo	21.85	43.70	.09	(hydro)
tulung angung	28.50	57.00	.12	(hydro)
kesamben	31.35	62.70	.13	(hydro)
mrica	171.00	342.00	.71	(hydro)
suralaya 1	320.00	640.00	1.32	(coal)
suralaya 2	320.00	640.00	1.32	(coal)
suralaya 3-4	640.00	1280.00	2.65	(coal)
paiton 1	320.00	640.00	1.32	(coal)
paiton 2	320.00	640.00	1.32	(coal)
java/exist geotherm	24.00	48.00	.10	(geothermal)
kamojang 2-3	88.00	176.00	.36	(geothermal)
salak 1	44.00	88.00	.18	(geothermal)
salak 2,dieng 1-2	132.00	264.00	.55	(geothermal)
drajati-2	88.00	176.00	.36	(geothermal)
java/exist steam	308.85	617.70	1.92	(fueloil)
total Mw	4527.88			
base				
java/exist hydro	85.75	514.49	1.06	(hydro)
hydro purchase	48.25	289.50	.60	(hydro)
saguling 1-2-3-4	160.77	964.60	2.00	(hydro)
senggaruh	.00	.00	.00	(hydro)
cirata I, 1-2-3-4	114.83	689.00	1.43	(hydro)
k.umbo	1.62	9.69	.02	(hydro)
tulung angung	3.56	21.34	.04	(hydro)
kesamben	2.25	13.47	.03	(hydro)
mrica	38.01	228.04	.47	(hydro)
suralaya 1	320.00	1920.00	3.97	(coal)
suralaya 2	320.00	1920.00	3.97	(coal)
suralaya 3-4	640.00	3840.00	7.94	(coal)
paiton 1	320.00	1920.00	3.97	(coal)
paiton 2	320.00	1920.00	3.97	(coal)
java/exist geotherm	10.30	61.82	.13	(geothermal)
total Mw	2385.33			
total		27396.28	57.94	
total fuel cost			.082	

(power sector data file: power1.dat)

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TABLE 10

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 3

Energy Sector Payments Balance: US$ millions

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
merchandise trade balance	14.4	14.6	18.5	19.3	19.4	20.0	20.3	20.2	21.1	21.1	21.1
..imports	-2.5	-2.6	-2.6	-2.4	-2.1	-2.4	-2.7	-3.1	-2.5	-2.7	-3.0
..exports	16.8	17.1	21.0	21.6	21.4	22.3	22.9	23.2	23.5	23.8	24.1
..bunkers	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
investment outlays	.0	431.6	458.0	439.3	683.2	755.5	622.8	624.5	642.0	655.6	544.9
..electric sector	.0	431.6	458.0	439.3	683.2	755.5	622.8	624.5	642.0	655.6	544.9
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
foreign capital inflows	.0	287.6	296.1	305.7	477.4	522.3	439.8	426.8	431.5	448.6	370.6
..electric sector	.0	287.6	296.1	305.7	477.4	522.3	439.8	426.8	431.5	448.6	370.6
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
debt service: interest	.0	.0	-1.0	-24.9	-27.7	-33.3	-81.8	-98.7	-207.0	-355.4	-269.4
..electric sector	.0	.0	-1.0	-24.9	-27.7	-33.3	-81.8	-98.7	-207.0	-355.4	-269.4
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
debt service: principal	.0	.0	-.4	-10.4	-12.1	-15.0	-36.0	-44.8	-92.2	-1171.3	-128.1
..electric sector	.0	.0	-.4	-10.4	-12.1	-15.0	-36.0	-44.8	-92.2	-1171.3	-128.1
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
net energy payments balance	14.4	14.6	17.1	-16.0	-20.4	-28.4	-97.5	-123.3	-278.1	-1505.7	-376.3

..inflows positive, outflows negative

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imports and other information generated by RESGEN on the economic projections used in developing Indonesia's overall development programs. Third is the need to provide economic development planners with the information generated by RESGEN regarding projected energy demands, energy sector investments, exports, imports etc., to be used as input to the overall economic planning effort. In regard to this third point RESGEN can be used to determine the level and configuration of energy demands associated with alternative economic development strategies being explored by the economic planners. RESGEN potentially can replace or augment the tasks of projecting energy demands, exports, imports, and associated financial flows currently being used in the development of the REPELITAs. RESGEN can also be used to determine the level and configuration of energy sector investments and the associated financial flows required to support alternative economic development strategies. This output from RESGEN can be used as input to the government investment planning process which is an important component of the overall planning effort.

From these objectives it is clear that the desired linkage occurs in two directions; from the BAPPENAS model to RESGEN and from RESGEN to the BAPPENAS model. The former linkage is by far the more technically involved and is described in some detail in the report on Macroeconomic Linkage which constitutes Appendix 4 to this report.

2. The BAPPENAS MODEL and Links to RESGEN

The BAPPENAS Macroeconomic Model consists of two principal submodels: (1) the Core Macroeconometric Model, and (2) the Input-Output Model. There are also additional components such as the the Monetary System Model and a series of equations used to project some of the economic variables that are used as inputs to the Core Model.

The Core Macroeconometric Model generates projections of over 60 economic variables through the use of econometrically estimated behavioral equations and (non-estimated) identities. The behavioral

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equations are a mathematical representation of the prevailing view at BAPPENAS of how the the various macroeconomic variables interact with one another. The identities are merely definitional accounting equations. A complete list of the equations and identities, and the definitions of all the variables are contained in Reference 5.

The variables of the model fall into two categories; endogenous and exogenous. Endogenous variables are those whose values are determined within the model, e.g. Gross Domestic or Gross National Product. Exogenous variables are those whose values must be specified as input to the Core Model. Exogenous variables can be separated into policy and non-policy variables. Exogenous policy variables are those that the government has some control over and can manipulate to achieve specified development goals, e.g. government investment and consumption, taxes, exchange rates. Exogenous non-policy variables are those over which the government has little or no control, e.g. world oil prices, international interest rates, and population growth rates.

The Core Model can be characterized as an expenditure oriented model as compared to the Input-Output model which can be termed a production oriented model. The Core Model generates projections of certain expenditure variables, i.e. private consumption, privated investment, exports, and imports. When the projected values of these variables are added to exogenously projected levels of government investment and consumption the result is projected Gross Domestic Product by expenditure.

Few of the variables projected by the Core Model are used directly in linking the Macroeconomic Model to RESGEN. The ones that are involved are GDP, personal disposable income (both measured in constant prices), and possibly the consumer price index. The principal importance of the Core Model in the context of the linkage is that the projections of GDP by expenditure are used

as input to the Input-Output Model to generate projections of GDP by sector of origin. The major portion of the linkage involves these projections of sectoral economic activity.

The linkage from BAPPENAS to RESGEN involves both the Input-Output model and the Core Macroeconometric model though the major portion of the linkage involves the former. As summarized in Figure 13 the principal components of the linkage are :

(1) Projected value added and/or gross output of the 23 sectors generated by the BAPPENAS I-O Model.

(2) Projected gross domestic product and personal disposable income generated by the Core Model.

(3) Projections of variables exogenous to the BAPPENAS Macroeconomic Model (e.g. population growth rates).

The principal task in linking the BAPPENAS I-O is to reaggregate the 23 sectors so they match the end use sectors of RESGEN. When the BAPPENAS I-O is reaggregated to match RESGEN the projections of sectoral value added and gross output will provide the bases on which to project sectoral energy demands. A list of the 23 sectors of the BAPPENAS I-O and their correspondence to the RESGEN end-use sectors is presented in Table 11.

There are three types of operations involved in this reaggregation. First is the task of mapping the value added and gross output of more than one BAPPENAS sector into one RESGEN sector. Second is the mapping of the value added and gross output of a BAPPENAS sector into an identically defined RESGEN sector. In this case no reaggregation is required. Third is the disaggregation of one BAPPENAS sector into more than one RESGEN sector. The first two cases are trivial. The third is not and requires the use of the 66x66, 170x170, and 340x170 BPS I-O tables for 1980 and the specification of control equations to

FIGURE 13

INTERACTIONS BETWEEN MACROECONOMIC
AND ENERGY MODELS

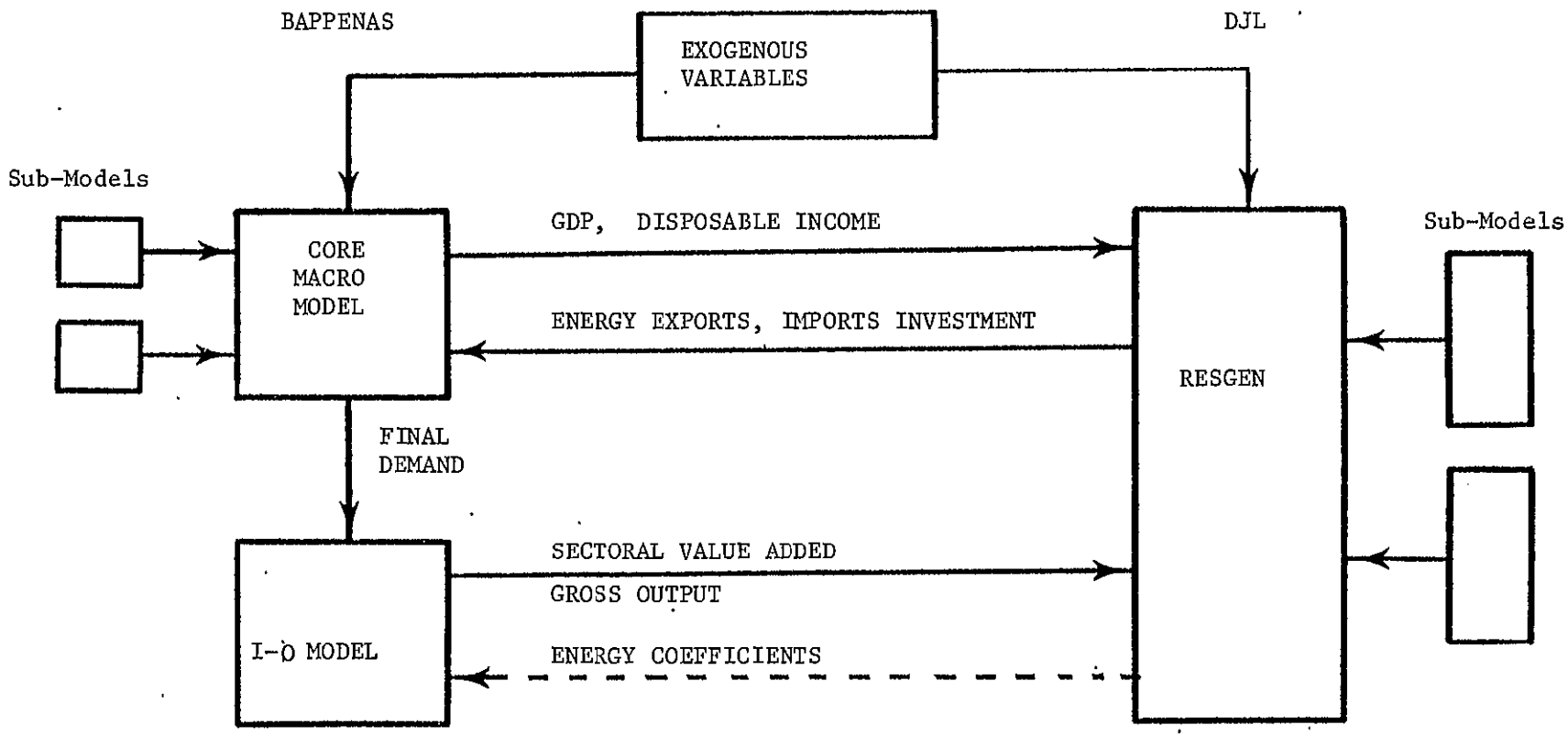

TABLE 11

MAPPING OF BAPPENAS' I-O SECTORS INTO THE RESGEN END-USE SECTORS

	BAPPENAS I-O		RESGEN
01	Agriculture	01	Agriculture
02	Animal Husbandry		
03	Forestry and Hunting		
04	Fishery		
05	Oil Mining	02	Oil and Gas
06	Other Mining and Quarrying	03	Coal
		04	Nickel
		05	Tin
		06	Copper
		07	Other Mining
07	Food, Beverages, and Tobacco	08	Food
08	Textiles, Wearing Apparel, and Leather	09	Textiles
10	Paper, Paper Products, Printing, and Publishing	10	Pulp and Paper
11	Chemicals and Chemical, Petroleum, Coal, Rubber, and Plastic Products	11	Rubber
		12	Fertilizers
		13	Chemicals
12	Non Metallic Mineral Products except Petroleum and Coal Products	14	Cement
		15	Ceramics
13	Basic Metals	16	Iron and Steel
09	Wood and Wood Products including Furniture	17	Other Manufacturing
14	Fabricated Metal Products		
15	Machinery and Equipment		
16	Other Manufacturing		
17	Construction	18	Construction
18	Electricity, Gas, and Water		*
19	Trade	19	Commerce (Electric)
20	Banking and Insurance		
22	Communication		
23	Services not Classified Above		
19	Trade	20	Commerce (Kerosene)
23	Services not Classified Above	21	Service (Fuel Oil and Diesel)

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TABLE 11

MAPPING OF BAPPENAS I-O SECTORS INTO THE RESGEN END-USE SECTORS
continued

BAPPENAS I-O	RESGEN	
21 Transportation and Storage	Method (1)	Method (2)
	22 Rail	22 Rail
	23 Water	23 Water
	24 Air	24 Air
	25 Bus	
	26 Truck	
	27 Taxis	
	28 Bajas and other	
RESGEN sectors not included in BAPPENAS I-O	Private Automobiles Motorcycles Households	
BAPPENAS sectors not included as a RESGEN End-Use Sector. The output and energy inputs of these sectors is projected by RESGEN	Electricity and gas Refinery	

guarantee the consistency between the growth rates of the more detailed RESGEN sectors and the aggregated BAPPENAS sector. The procedures and equations are detailed in Appendix 4, corresponding to BAPPENAS' approach in representing the fundamental input-output relationships. An alternative approach that explicitly takes into account exogenously derived values for imports is also included.

3. Linkage from RESGEN to BAPPENAS

One can consider utilizing the information generated by RESGEN at three different levels; (1) as information to be used directly as input to the BAPPENAS Macroeconomic Model, (2) as information to be synthesized by the analysts responsible for developing the assumptions of the model and used to reassess and possibly change these assumptions, (3) as information to be used directly by the decision makers and policy analysts completely bypassing the Macroeconomic Model.

The actual mechanical linking from RESGEN to the BAPPENAS model is not as extensive or as detailed as that from BAPPENAS to RESGEN and it involves only the Core Model. The most obvious link is that the projected energy balances, imports, and exports generated by RESGEN can replace the BAPPENAS energy sector projections.

Most of the information generated by RESGEN cannot be used directly as input to the BAPPENAS model, but can make a valuable contribution to the modelling process nonetheless. This can be done by using the output of RESGEN to rethink the projections of the exogenous policy variables used in the BAPPENAS model. For example, the energy sector investment projections from RESGEN can be used to reassess the initial projections of government investment used in the Core Model. The results of RESGEN may indicate that the existing dispatching schedule of PLN may be too fast or too slow given the rate and composition of economic growth of the desired economic development plan. Consequently one might expect that the planned levels of government investment in the power sector for a given year would be too high or too low, respectively, and that the

government investment plan should be revised. The revised levels of annual government investment could then replace the old levels in the Core Model and it and the I-O model could be reexecuted to assess the potential impact.

CHAPTER II

NOTES AND REFERENCES

1. T. Owen Carroll, "The Use of Microcomputers in the Energy Sector in Developing Countries", in M. Munasinghe, et al, Eds. Microcomputers for Development: Issues and Policy, Department of Government Printing, Colombo, Sri Lanka 1985. See Also James S. Munson, Philip F. Palmedo et al, "The Use of Microcomputers in Energy Planning for Developing Countries", Energy/Development International, Setauket, N.Y. 1873.

2. M. Munasinghe, op. cit.

3. The project was undertaken before the availability of Release 2 of Lotus 1-2-3. The capability of the latter comes significantly closer to what is required for an effective energy systems model.

4. An energy network is a representation of the flows of energy through all points of production, conversion and final consumption in a country, region or any other geographical area. The representation of an energy network is graphical; RESGEN expresses the graphical representation in matrix algebra form.

5. Revised Core Macroeconomic Model, Sei Kuribayashi, A Quantitative Study on the Medium/Long-Term Prospect of the Indonesia Economy, BAPPENAS Occasional Paper Series No. 24 (December 1982).

III SURVEY OF ENERGY USE IN URBAN HOUSEHOLDS

A. INTRODUCTION

Energy consumption in Indonesia's urban centers continues to be an important component in the growth of commercial energy demand. Urbanization has been an important accompaniment of economic development. The proportion of urban population has risen steadily in the past two decades and has affected the level and composition of commercial energy use, both in aggregate and per capita terms. The primary sources of this growth have been the rising demand for kerosene as a cooking fuel, and the increasing use of electricity, for both lighting and secondary appliance use.

These trends are documented in the available data on kerosene sales, and in the information on electricity sales. Much of the evidence, however, is fragmentary, and available only at a highly aggregate level. There is little information about variations in direct energy consumption among households of different income levels, and about regional variations. There is even less information available about the end-use composition of fuel demand: the relative importance of energy requirements for cooking, lighting, appliance use and personal transportation.

Against this background, this project included as an important component a pilot survey of urban households at a national scale to collect primary information on current energy consumption patterns. This chapter summarizes the results of the pilot survey, the methodology and the steps in its implementation. A preliminary analysis of the collected information has been undertaken and further analysis is recommended. Appendix 5 to this report presents further information on the survey and its analysis.

B. OBJECTIVES

The survey undertaken was a pilot effort to test a methodology for collecting end-use information about urban household energy consumption patterns in a form useful for national energy policy analysis. At the same time, the excercise aimed at creating a regional data base on urban energy consumption which can be updated at a future time to provide policy analysts with historical trends in residential energy use. It was also intended that the survey data provide a preliminary data base on energy consumption consistent with the RESGEN modelling framework now in use at DJL for national energy analysis.

An additional objective was to collect quantitative information on end-use consumption that can be combined with information on expenditures and prices collected by BPS in its SUSENAS survey to examine relationships between energy, income and prices, should such an analysis be required in the future.

An important final objective of the pilot survey was to train Indonesian counterparts in appropriate survey techniques, and data collection methods. All implementation steps, field-work for data collection, and subsequent computer analysis was undertaken by counterpart staff assembled by the Indonesian subcontractor, P.T. Ciprocon, which included DJL staff analysts, and members of the Development Technology Research Center at the Institute of Technology, Bandung.

C. METHODOLOGY

The urban survey employed a direct questionnaire interview to collect information in the following areas:

- household characteristics (household size, and expenditure data, including expenditures on fuels)
- household consumption of fuels (kerosene, electricity, wood, charcoal, LPG and city gas, diesel and gasoline for private transportation)

- energy supply information in the case of electricity, and fuel prices

- end-use device ownership data and daily usage patterns, particularly for secondary electrical appliances and lighting

- information on household public transportation patterns (the frequency and average distances of trips by various modes).

This information was collected to provide a basic profile of energy consumption within the urban household, and a basis for comparing households within different expenditure groups (expenditure being used as a surrogate for income). The resulting data, in conjunction with secondary information on end-use and conversion efficiencies, also allow the construction of a detailed energy balance of the household sector, in the RESGEN modelling framework.

D. IMPLEMENTATION & SAMPLE DESIGN

Implementation of the survey was undertaken in three stages. In the first stage, discussions between DJL staff and Indonesian counterparts were held to clarify the objectives, methodology, and potential sampling designs. The choice of cities to be included was made by DJL. At this stage, the need for secondary data and the scope of available information on urban energy consumption patterns was identified. Discussions were also held with other government agencies such as PLN and BPS to clarify the objectives of the survey.

The decision to utilize the SUSENAS sample frame was made at this stage. A representative subsample of 1,636 households in nine cities, from the 1984 SUSENAS sample was constructed. The random subsample was drawn from each of eleven expenditure groups in the SUSENAS sample. The distribution of selected households by income groups for each of the nine selected cities is shown in Table 12.

In a second stage a preliminary questionnaire was prepared and a one-week training of counterpart staff and supervisors was undertaken.

TABLE 12

DISTRIBUTION OF SAMPLED HOUSEHOLDS BY CITIES AND INCOME GROUPS

City	Total House holds	% of total	Income Groups Low	Medium	High
Jakarta	723	44.2	208	314	201
Bogor	20	1.2	5	7	8
Bandung	120	7.3	51	39	30
Semarang	81	5.0	54	20	7
Surabaya	144	8.8	95	41	8
Malang	90	5.5	60	22	8
Yogyakarta	124	7.6	59	38	27
Ujung Pandang	168	10.3	78	68	22
Medan	166	10.1	64	64	38
Total	1636	100.0	674	613	349
Percent		100	41.2	37.5	21.3

Based on the discussions during this training program a final questionnaire for pre-testing was designed. A pre-test was undertaken at the conclusion of the training program, resulting in refinements and a final questionnaire.

The final stage of field-work was undertaken during an eight week period. Field staff were trained by supervisors and reviewed by subcontractors from ITB, Bandung. The data analysis that followed was undertaken at Bandung and Washington D.C.

E. RESULTS

The data collected provide a basis for estimates of direct energy consumption in the urban household sector, and for comparisons of energy consumption among the eight cities surveyed, and among income groups. A preliminary analysis of the collected data is presented below. This analysis includes:

(a) an overview of the pattern of urban energy consumption;
(b) inter-urban comparisons of energy demand;
(c) comparisons of fuel use among households classified by income groups;
(d) energy demand for private vehicles and
(d) an overview of the end-use pattern of fuel use in the urban sector.

1. Aggregate Energy Consumption

Annual energy consumption in the sample of 1,636 sampled households is estimated at a level of 6,999 barrels of oil equivalent (boe), or 4.28 boe per household, as shown in Tables 13 and 14. If this level of annual consumption is extrapolated to the urban population as a whole (on the assumption that our SUSENAS sample frame is representative), national urban energy demand would amount to an annual level of 27 million boe (mboe).

TABLE 13

Total Fuel Consumption Per Year by Fuel Type
(1636 households, boe)

Fuel	All Income Groups		Low Income (< Rp 20,000)		Medium Income (Rp 20 - 40,000)		High Income (> Rp 40,000)	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	788.33	11.3	166.71	6.5	308.80	11.6	312.81	17.7
Kerosene	5367.83	76.7	2052.76	80.0	2189.48	82.2	1125.59	63.6
L P G	324.13	4.6	12.92	0.5	60.66	2.3	250.57	14.2
Charcoal	213.53	3.1	129.53	5.0	52.26	2.0	31.71	1.8
Wood	294.66	4.2	204.93	8.0	46.30	1.7	43.43	2.5
City Gas	10.86	0.2	0.24	0.0	4.79	0.2	5.83	0.3
Total fuel consumption	6999.34	100	2567.09	100	2662.29	100	1769.94	100

TABLE 14

Average Annual Fuel Consumption Per Household and Per Capita
(1636 Households, boe)

Income Group	Total Fuel Consumption	Number of Househ.	Average Cons. per Househ.	Average Househ. Size	Average Cons. per Capita
All	6999.34	1636	4.28	6.00	0.71
Low	2567.09	674	3.81	6.47	0.59
Medium	2662.29	613	4.34	5.88	0.74
High	1769.94	349	5.07	5.29	0.96

Kerosene, the primary fuel for cooking, is the largest single component of household energy demand, accounting for approximately 5,368 boe, or 77 percent of total direct household fuel consumption. This level of consumption is equivalent to an annual consumption per household of approximately 585 liters, or 97 liters per capita, based on an observed average of 6 persons per house. (The reliance on kerosene as the primary urban fuel is illustrated in Table 15, which shows that 90 percent of all households surveyed reported use of the fuel.)

Total electricity consumption was estimated at 1181 mWh or 788 mboe in fuel equivalent terms. Electricity's share is 11.2 percent of total energy consumption. This corresponds to an annual level of electricity consumption of a little over 788 kWh per household, or 129 kWh per capita. A relatively high 69 percent of all surveyed households reported the use of electricity.

Other fuels jointly account for 843 boe or, approximately, 12 percent of annual fuel consumption. Of these, the share of wood and charcoal are significant (4 and 3 percent of the total, respectively), although relatively few households reported using these fuels (4 percent of all surveyed households, in the case of wood, and a larger 20 percent in the case of charcoal). LPG, which accounts for 324 boe of the total (5 percent), is used by only 8 percent of surveyed households. City gas, whose use was reported by only eight households (in four of the nine surveyed cities), accounts for a negligible share in the total.

The annual levels of consumption for kerosene and electricity appear to be quite reasonable, if compared with the available information on urban sales of these fuels. If 1984 data (the latest available data) are projected to mid 1985, annual sales of kerosene in all urban areas (taking into account an estimated annual decline of approximately 6 percent in the past two years) would amount to approximately 19 mboe, and electricity sales, in fuel equivalent terms, would be 3.5 mboe. Extrapolations of the survey results to the

TABLE 15

Number of Households Consuming Fuels
(1636 households)

Fuel	Total house-holds	% of total	Income Groups: Low	Middle	High
Electricity	1077	65.8	380	425	272
Kerosene	1470	89.9	616	582	272
L P G	138	8.4	7	34	97
Charcoal	325	19.9	197	97	31
Wood	67	4.1	51	9	7
City Gas	7	0.4	1	1	5

urban population as a whole would result in an estimated 20.6 mboe for kerosene and about 3 mboe for electricity. These results are shown in Table 16, which illustrates the fuel mix of the average surveyed household, and extrapolates survey results to the national urban population.

2. Inter-urban Comparisons

The survey data allow a useful comparison of differences in the pattern of energy consumption in the urban population, measured either on the basis of variations in average consumption per household, or in per capita terms.

Among the nine cities surveyed, energy use, measured in terms of average consumption per household, is highest in Malang (5.08 boe), followed by Jakarta (4.52 boe) and Yogyakarta (4.36 boe). These regional differences are illustrated in Figures 14, 15, and 16, illustrating the consumption of electricity, kerosene, and wood, among households reporting the use of these fuels.

Among the nine cities surveyed, Jakarta reports the highest consumption of kerosene and electricity. The consumption of these fuels is well above the national averages: 1,545 kWh/household for electricity, 692 liters/household for kerosene.

Among the other eight cities the variation ranges from 674 kWh annually for Semarang to 1063 kWh for Yogyakarta. The variation is less pronounced for kerosene. The values range from 479 to 634 liters. There is a noticeable variation in the statistics reported for wood consumption.

All cities with the exception of Bogor report the use of wood. Wood consumption varies from an approximate low of 988 kg/year for Surabaya, to a high of 3,835 kg for Semarang. However, given the relatively small sample size for a number of these cities, this wide variation cannot be treated as reliable. The estimates for Jakarta in

TABLE 16

Average_a/ Annual Household Energy Consumption and Estimated Urban Energy Consumption in Indonesia 1985

Fuel	Avg. cons. per househ. (boe)	Fuel share (%)	National Urban Consumption: From survey results _b/ (mboe)	National Urban Consumption: From sales data estimates _c/ (mboe)
Electricity	0.48	11.2	3.05	3.45
Kerosene	3.28	76.6	20.66	19.17
L P G	0.20	4.7	1.26	N.A.
Charcoal	0.13	3.0	0.82	N.A.
Wood	0.18	4.2	1.13	N.A.
City Gas	0.01	0.2	0.06	
Avg. all fuels	4.28	100.0	26.98	N.A.

_a/Averages are computed for the sample as a whole, that is for all 1636 households.

_b/Based on 1980 urban population of 32.8 million and average annual growth of 4% and average household size of 6 persons per house.

_c/Electricity sales projected at an annual growth of 12 per cent and decreasing kerosene sales at 6 per cent.

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FIGURE 14

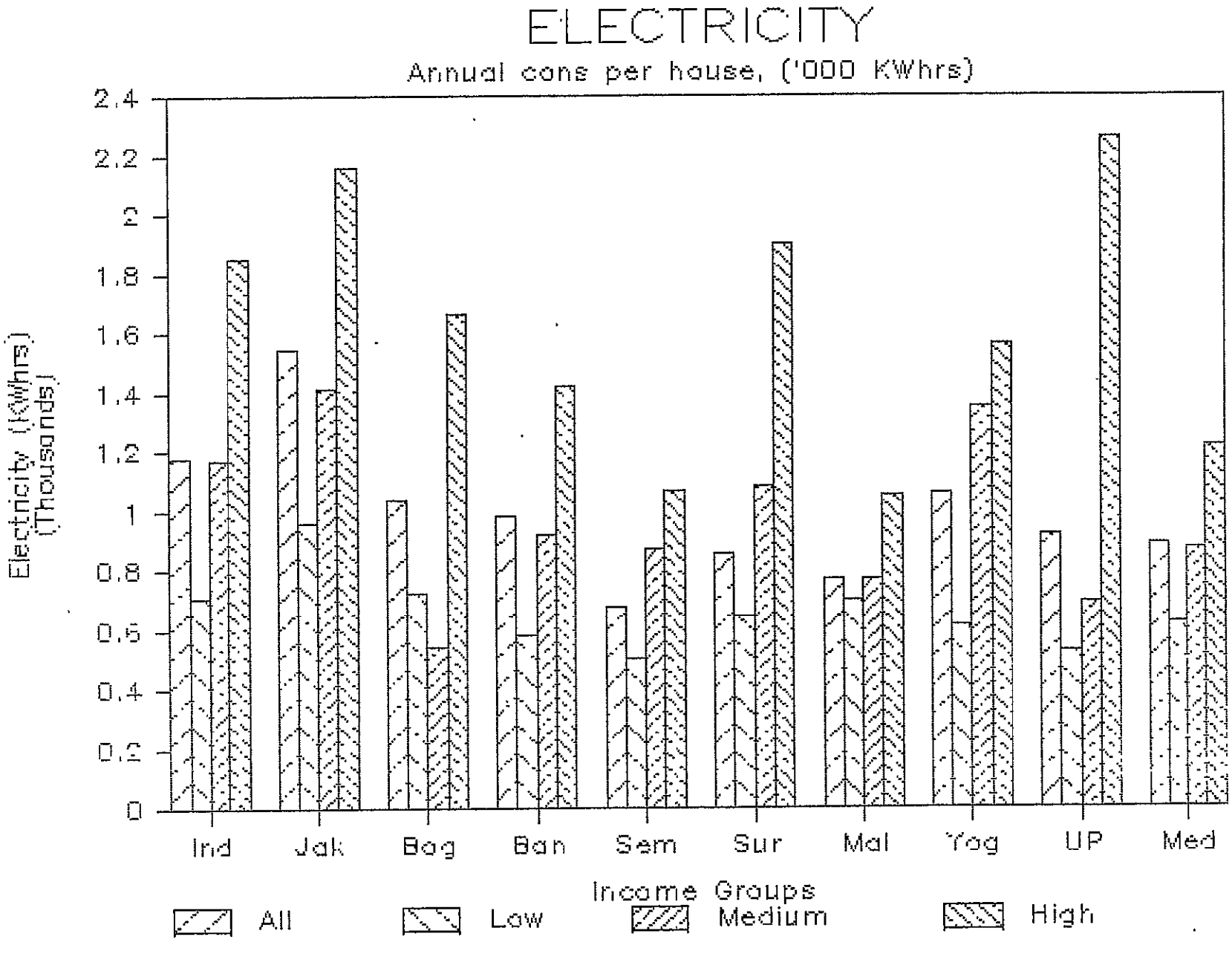
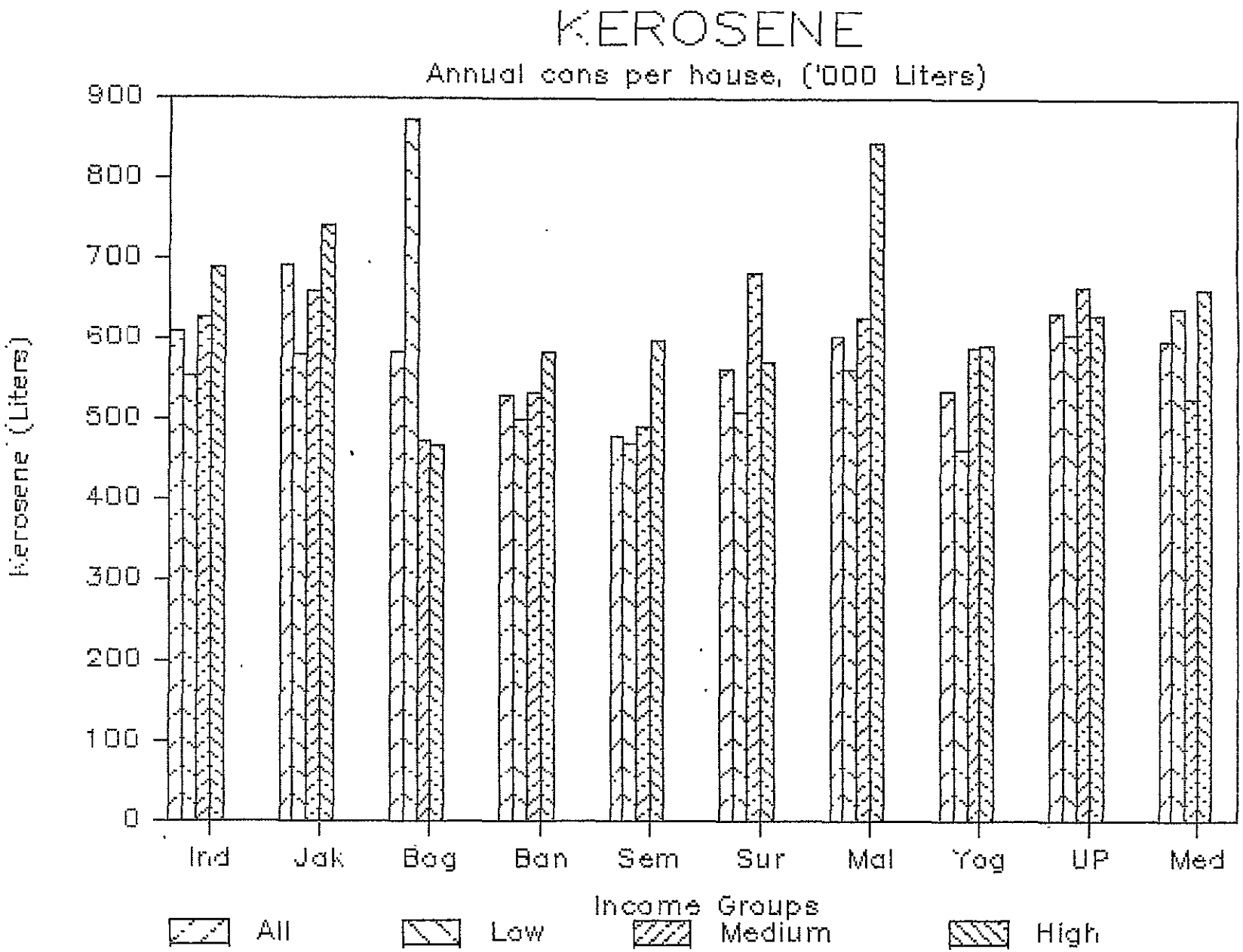
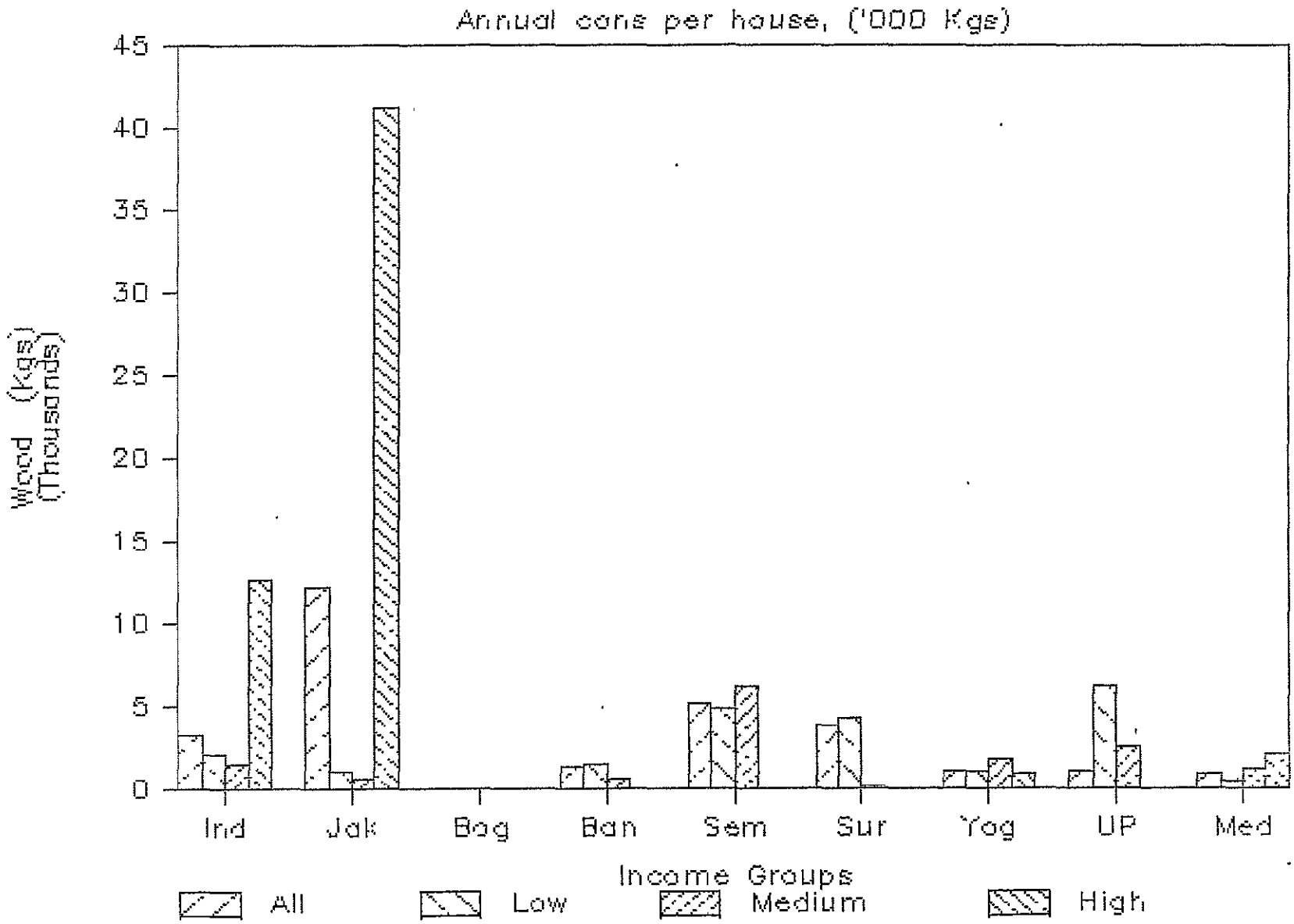

ELECTRICITY
Annual cons per house, ('000 KWhrs)
Electricity (KWhrs) (Thousands)
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Ind
Jak
Bag
Ban
Sem
Sur
Mal
Yog
UP
Med
Income Groups
All
Low
Medium
High

FIGURE 15


KEROSENE
Annual cons per house, ('000 Liters)
Kerosene (Liters)
900
800
700
600
500
400
300
200
100
0
Ind
Jak
Bog
Ban
Sem
Sur
Mal
Yog
UP
Med
Income Groups
All
Low
Medium
High

72

FIGURE 16


WOOD
Annual cons per house, ('000 Kgs)
Wood (Kgs) (Thousands)
45
40
35
30
25
20
15
10
5
0
Ind
Jak
Bag
Ban
Sem
Sur
Yag
UP
Med
Income Groups
All
Low
Medium
High

particular is biased by a very high reported average consumption among two high income households.

3. Income Group Comparisons

For purposes of comparison, households have been stratified into three expenditure categories (i.e., expenditure levels are used as a surrogate for income). Per capita monthly expenditures greater than Rs. 40,000 constitute the high income group, expenditures of Rs. 20-40,000 the medium, and households with expenditures of less than Rs. 20,000 constitute the low income group.

Using these income groups for purposes of comparison a number of differences emerge. Aggregate energy consumption per household increases by 14 percent in moving from low to medium income households. A more noticeable difference is observed between medium and high income households. On an annual basis, high income households consume as much as 33 percent more than low income households and 17 percent more than middle income households. (These differences are shown in Table 13 and 14 above.)

For the two major domestic fuels, electricity and kerosene, the difference between income groups is marked, especially if we examine differences among households reporting actual use of these fuels. In the case of electricity which has multiple end uses and appliance use is correlated to income, middle income households consume 162 percent more than low income households, while high income households consume 225 percent more than low and 58 percent more than middle income households. But, in the case of kerosene, annual consumption per household does not vary significantly by income level probably because kerosene use is primarily limited to providing cooking heat. High income households consume 24 percent more than low income households and 10 percent more than middle income households.

4. Comparison with Rural Energy Survey Results

It is useful to compare the results of the urban survey with those of a survey of rural areas conducted in 1981. In tabulating

this comparison, it is important to keep in mind several important distinctions that explain the large variation between urban and rural households:

1. Rural households do not have access to the variety of fuels of their urban counterparts;

2. few rural households purchase their fuelwood. Typically, they gather as much fuelwood as they need for cooking from their backyard (including significant amounts of agricultural wastes), surrounding public areas and forests; and

3. the relative efficiencies with which the fuels are converted to heat, especially for cooking, are lower in rural households.

The results of the two surveys show that the fuel composition of the average rural and urban household are quite different. As summarized in Table 17, approximately 70 percent of the total fuel requirements of the rural household is fuelwood while over 85 percent of the average urban households fuel requirements are based on commercial fuels. Of this kerosene has the major share (77 percent) followed by electricity (11 percent) and wood accounts for only 4.2 percent of the urban fuel mix.

Because of the fundamental differences in consumption patterns, a comparison in terms of actual energy consumed is problematical. The results of the rural survey showed that annual consumption of all fuels for cooking and lighting per rural household was 6.99 boe, greater than the 4.28 boe for an urban household. On a per capita basis consumption was 1.33 boe and 0.70 boe respectively. On the other hand, in terms of useful energy, the relationship is reversed. For cooking, for example, the estimates of end use efficiency used in reporting the results of the rural survey indicate 0.07 for wood and 0.40 for kerosene. Estimated useful energy for cooking in rural areas is therefore 0.72 boe per household, while in a urban area it reaches 1.26 boe. In energy use for lighting the comparison is even more problematical, because of the wide range of efficiencies among different types of kerosene lamps (open wick, petromax, etc). More importantly, electric lighting, qualitatively superior to kerosene

TABLE 17

COMPARISONS OF CONSUMPTION PATTERNS IN THE RURAL AND URBAN SURVEYS (boe/year)

Fuel		Rural Sector Per House	Rural Sector P.C.	Urban Sector Per House	Urban Sector P.C.
Wood		4.92	0.93	0.18	0.03
Kerosene					
	cooking	0.93	0.18	3.12	0.52
	lighting	1.14	0.22	0.16	0.03
		2.07	0.4	3.28	0.55
Electricity					
	lighting	--	--	0.25	0.04
	others	--	--	0.23	0.03
Charcoal		--	--	0.13	0.02
LPG		--	--	0.20	0.03
City Gas		--	--	0.01	--
Total Fuel Demand		6.99	1.33	4.28	0.70

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lamps, plus all the other amenities offered by electricity, was available in only 8 percent of surveyed rural households in 1981. On a per household basis, the amount of electricity was therefore rather small and were excluded for the tabulated results.

F. TRANSPORT ENERGY USE

Thus far, we have described the pattern of fuel consumption without reference to the consumption of fuels for personal transportation. The survey undertaken made an explicit attempt to collect two types of information on transportation: information about the demand for public transportation and data on the direct consumption of fuels (gasoline and diesel) for private vehicles.

The information on the use of public transportation consists of detailed data on the characteristics of household travel patterns - the distances and frequency of trips by various modes of public transport. This information, in combination with secondary data on the energy intensity of various modes (public buses, taxis, bemos and bajajs) can be used to generate rough estimates of energy use stemming from public transport. This analysis has yet to be completed, since secondary data must be collected.

However, information about the use of energy for private vehicles provides a partial view of transport energy demand among the surveyed households. Gasoline and diesel consumption represent 36 percent of total energy demand. The detailed breakdown of transport fuel consumption by mode is shown in Table 18. Gasoline emerges as the most important transport fuel accounting for 4,201 boe annually, or 94 percent of total household transport fuel consumption for the sample as a whole. This is equivalent to an annual consumption per household of 2.57 boe, or 0.43 boe per capita. A breakdown by income group, shown in Table 19, indicates a wide range in average consumption between low and high income groups.

TABLE 18

Private Transport Energy Consumption Per Year by Fuel Type
(1636 households, boe/year)

Mode	Diesel	Gasoline	Total Fuel
Auto	96.12	1991.88	2088.00
Bajaj/Bemo	0	82.68	82.68
Oplet	61.70	86.22	147.92
Motor Cycle	104.86	2040.37	2145.23
Total consumption	262.7	4201.2	4463.8
Average per household	0.16	2.57	2.73
Average per capita	0.026	0.428	0.455

TABLE 19

Private Transport Energy Consumption Per Year by Income Group
(1636 households, boe/year)

	Income Groups			
Mode	All	Low	Medium	High
Auto	2088.0	8.5	253.1	1839.2
Bajaj/Bemo	82.7	0.0	56.5	26.2
Oplet	147.9	5.9	39.1	102.9
Motor Cycle	2145.2	275.9	621.5	1247.4
Total consumption	4463.8	290.33	970.2	3215.7
Average per household	2.73	0.43	1.58	5.25
Average per capita	0.455	0.067	0.27	0.89

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G. THE PATTERN OF END-USE DEMAND

When energy for private vehicles use is included in the total energy demand estimate for the urban sample, a more complete view of the pattern of end-use energy requirements emerges. The aggregate consumption of energy rises to an annual demand of 11,463 boe. On a per household and per capita basis, this amounts to 7 boe per year and 1.17 boe per year respectively.

The relative importance of particular combinations of fuels by end use for the sample of 1636 households is shown in Table 20. The distribution of fuels by end use shows that cooking is the primary component. Of the total energy demand of 11.5 boe, 52 percent is for cooking, followed by private transport which accounts for 39 percent. Lighting and secondary appliance use account for less than 10 percent of annual energy demand. Viewed from the perspective of its share in energy demand kerosene emerges as the primary fuel accounting for 91 percent of total cooking demand and 38 percent of total lighting demand.

H. CONCLUSIONS

The disaggregated view of urban energy use patterns among households is useful in assessing a number of important policy issues such as the potential for fuel substitutions, and improved end-use efficiency.

The potential for fuel substitutions in the urban sector continues to be an important issue since kerosene continues to be a subsidized fuel. Furthermore, current plans at the national level call for considerably expanded production of LPG. The survey data implicitly suggest that while there is scope for substituting LPG for kerosene as a cooking fuel, substantial costs are likely to be involved.

The importance of kerosene in the average household's energy

TABLE 20

Annual Energy Demand
(1636 Households, boe)

Fuels	Cooking	Lighting	Secondary Appliance	Transport	Total end use
Kerosene _a/	5115.54	252.29	-	-	5367.83
Electricity _b/	-	417.11	371.22	-	788.33
LPG	324.13	-	-	-	324.13
Wood	294.66	-	-	-	294.66
Charcoal	213.53	-	-	-	213.53
City Gas	10.86	-	-	-	10.86
Diesel	-	-	-	262.70	262.70
Gasoline	-	-	-	4201.20	4201.20
Total	5958.72	669.39	371.22	4463.90	11463.24
% of total	52.0	5.8	3.2	38.9	100.0
Total energy demand per household	3.64	0.41	0.23	2.73	7.01

_a/The shares allocated for cooking (95.3%) and lighting (4.7%) were determined from survey data.

_b/Lighting accounted for 52.91% of total electricity consumption. Its share was determined from electric appliance ownership data in the survey.

budget, at all levels of income, and in all the cities surveyed suggests that the demand for this fuel in the urban areas will continue to grow, as urban populations throughout Indonesia expand. Further analysis is needed to understand the dynamics of the reported decline of kerosene sales in recent years. While price increases of recent years have probably served to moderate kerosene consumption in all sectors, its impact in the urban areas is limited by the absence of substitutes.

The survey points also to the relatively infrequent use of LPG, which, even for high income households, is less important than kerosene as a fuel for lighting. This suggests that in the future, some potential may exist for the expanded use of this fuel as a domestic fuel for cooking. However, the relative costs of substitution will require detailed investigation. It is not surprising that LPG today is primarily a fuel for higher income groups: considerable private costs are associated with its use. Any attempt to promote its expanded use will probably require some form of subsidies, especially to lower income households. The national costs of such subsidies will need to be examined in relation to the present subsidies for kerosene users. In addition, the scope for expanded use of charcoal may need to be explored in conjunction with such shifts away from kerosene.

IV PRODUCTIVE USES OF RURAL ELECTRICITY

A. INTRODUCTION

This chapter outlines a strategy for the Government of Indonesia to increase the efficiency of its rural electrification program.[1] The Government of Indonesia has a clearly established policy of rural electrification that emanates from long-standing objectives: to improve the standard of living of the rural population and to reduce differences in the quality of life both between regions and between urban and rural areas. The primary focus of rural electrification has thus been on providing electricity to households, primarily for lighting and small scale productive activities. A program of rural electrification which aims narrowly at achieving these social benefits, however, can be both extremely expensive and less than totally effective. High cost results not only from the low density of consumers in rural areas but also from the low load factors characteristic of such consumers.

Increased attention to productive uses of electricity in rural areas can enhance the achievement of the social objectives of rural electrification in two ways. First, use of electricity by small scale industry or for irrigation pumping (as examples) would, by increasing the load factor, lower the cost of supply to households. Second, and perhaps more importantly, productive uses would create jobs and additional income for rural dwellers. Thus, increased attention to productive uses of electricity can be seen as an important step towards the achievement of the social welfare objectives of the national rural electrification program.

The strategy outlined here is derived from an analysis which places electricity within a broad rural energy framework. This approach is taken since, electricity, though socially and economically important, accounts for a very small fraction of rural energy use, and because any rural electrification (RE) project must compete and be compatible with a variety of other sources of rural energy. The

recommended strategy takes the form of a variety of policy actions - on both the "demand" and "supply" sides - which can increase the economic contribution of RE to Indonesia's developmental process. Specifically, it emphasizes steps which can be taken to increase the productive use of electricity in rural areas. The failure to develop significant productive uses of RE is judged by most to be the biggest single shortcoming of Indonesia's previous RE efforts. In addition, issues relating to the reduction of RE costs - which are relevant for all categories of consumers - are discussed. A more detailed analysis of this subject is contained in Appendix 6 to this report.

The need for such a comprehensive analysis of RE policy in Indonesia exists for a variety of reasons. Some are specific to Indonesia's prior experience with RE, and others arise from more general and recent developments in the energy sector. First of all is the importance of RE to the Government's social development program as discussed above. Second, rural electrification is one of the largest consumers of capital, including foreign exchange, in Indonesia's total energy program. It also has one of the lowest returns on investment, when measured in purely financial terms. Third, electrification is part of the general trend of substituting commercial energy for non-commercial energy. At the same time, the mix of commercial energy is changing. Attempts are underway to reduce Indonesia's domestic consumption of petroleum products, which have increased at an annual rate of more than 10 percent during the 1970's. To accomplish this, the prices of some petroleum products, e.g. gasoline and diesel, have been raised to world levels (or above). Equally important, the mix of electric power generating capacity is being altered in order to substitute the use of domestically produced coal and geothermal energy for fuel oil. For example, in 1984 81 percent of PLN's generation capacity was oil-fired, with the balance supplied from hydro or geothermal sources. By 1994 the mix is expected to be 20 percent oil-fired, 48 percent coal, 22 percent hydro, and 10 percent geothermal. To achieve this, the Government will invest approximately $13.4 billion between 1984/85 - 1993/94 in non oil-fired generation capacity.

One important aspect of the growing commercialization of the energy sector is the Government's plan for RE. RE is viewed as a means of stimulating rural social and economic development while contributing to the increased uses of non-petroleum energy by reducing consumption of kerosene and diesel fuel. While only 6 percent of the rural population had access to electricity in March 1984, Repelita IV set the goals of electrifying 21 percent of rural households by 1994 plus corresponding numbers of other types of consumers. The attainment of this goal will require an investment of about $820 million between 1984/1985 - 1988/1989.

The magnitude of this proposed investment in RE, plus the large number of potential beneficiaries, provide a strong justification for the analysis of the Government's RE program contained in this report. Improvements in the efficiency of the RE program can result in important welfare gains for beneficiaries and cost savings for the country as a whole. The Appendix identifies ways of improving the efficiency of RE and proposes actions required to overcome these constraints.

B. CONSTRAINTS ON THE DEVELOPMENT OF RURAL ELECTRIFICATION

Indonesia has made considerable progress with RE over the last decade. There seems to be a consensus, however, that the potential economic benefits of RE - especially those derived from productive uses of electricity - have not been fully realized at many RE sites. Some of the reasons for this are analyzed in this section.

1. Demand-Side Constraints

The economic benefits of RE can only be realized when potential consumers have an incentive to connect to the RE system and can afford to do so. Evidence suggests that household consumers in Indonesia have a strong incentive to connect to the RE system despite the highly subsidized price of kerosene.

It is clear, in contrast, that consumers who potentially could use electricity for productive purposes have not had a strong incentive to connect to RE systems, and new productive use consumers have not developed in significant numbers. This is evident from the low load factors observed at many RE sites and the predominance of non-productive use consumers. Since productive use consumers demand energy not for its own sake but for its contribution to a production process, i.e. the demand for energy is a derived demand, the factors limiting their incentive to connect must be largely financial or technical.

Energy Pricing:

Over the long-run, there is significant substitutability between different energy sources and in most productive use consumers relative energy prices are likely to be a key determinant in the choice of a particular energy source. In fact, there is reason to believe that part energy pricing policies served as important constraints on the development of productive uses of RE. Prior to recent changes in policy, relative per unit subsidies were greater for diesel and fuel oil than for electricity. This undoubtedly discouraged a switch from auto generation to PLN supplied electricity by productive use consumers.

Since the beginning of Repelita IV in 1983/84 some residential consumers have had access to a credit program funded by the Ministry of Finance through the Bank Rakyat Indonesia. There is no similar credit program available to other types of RE consumers at present, however.

Site Selection

PLN follows a procedure which emphasizes the selection of unelectrified kecamatan and swasembada villages for electrification. However, such villages are not necessarily the ones with the greatest productive use potential. This is especially true since the Government's decision to electrify kecamatans largely reflects an attempt to achieve a balanced geographical distribution of RE sites.

Thus a procedure which more closely linked site selection with productive use potential in a necessary step for increasing the productive use of RE in Indonesia.

Informational/Promotional Programs

Potential productive use consumers are likely to have considerable experience with non-electric sources of energy. As a result, they learn to operate and maintain them efficiently. This is clearly not the case a priori for electric power. Thus, there is a need for programs which inform potential productive use consumers about the possible uses of electric motors and machines.

Complementary Programs

The development of new productive uses may be constrained by the lack of complimentary inputs. In order to develop, productive enterprises require adequate access to markets, credit, infrastructure, transportation, and so on. If any of these are lacking, then the provision of RE may need to be linked with other developmental programs which address these needs. It is not clear that this had occurred in Indonesia.

2. Supply-Side Constraints

Supply Costs

On the supply side, one of the principal constraints to the development of RE is its relatively high cost. One of the reasons for high costs is that RE design standards are not modified to match the specific requirements of RE consumers. It is likely that reliability standards (and hence supply costs) are excessive as a result. Another factor which may contribute to relatively high supply costs at some sights in the choice of energy supply options. Most RE sites receive electricity from either grid extension or diesel generation. It seems likely that in the past alternative (and possibly less expensive) supply options such as mini-hydro were not always given adequate consideration. Even when alternative supply options are utilized there is still room for reducing supply costs. Per unit capacity costs in PLN's existing mini-hydro projects, for example, could

benefit from standardization and increased use of local labor and materials should allow PLN to significantly lower these costs.

C. AN ANALYTICAL FRAMEWORK

We summarize here a conceptual framework for choosing regions to be electrified and sources of electricity production in order to maximize net economic benefits to the country of its RE program. This framework is more fully described in Appendix 6, but we would underline its preliminary conceptual nature.

The objective of this analytic approach is to determine a rank order of potential RE regions in terms of net economic benefit per rupia spent on RE.

To determine this ranking, one must estimate the economic benefits and costs of RE in the regions. Concerning RE costs, the various supply options for each region must be considered. These fall into two general categories: centralized and decentralized.

A simple hypothetical figure can help clarify the relation between location and the relative costs of various supply options. Figure 17 represents a continuum of potential RE sites which are arranged according to increasing distance from the existing grid. For explanatory purposes, three potential sites (A,B, and C) are identified. Sites A and B have little access to alternative energy sources except diesel, while Site C has significant mini-hydro potential. The figure indicates that grid extension is the least cost supply option for Area A, as are small diesel and mini-hydro for Areas B and C respectively.

Under appropriate conditions, RE can produce a variety of social and economic benefits. The most important of these are: 1) economic cost savings resulting from the substitution of electricity for other more costly sources of energy, 2) net increases in the value of economic production, i.e., increased agricultural or industrial

FIGURE 17: LEAST COST RE SUPPLY LOCUS

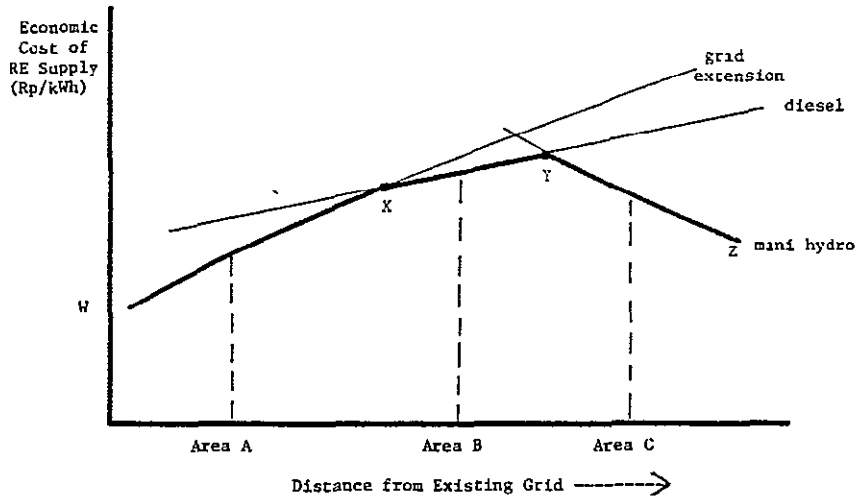
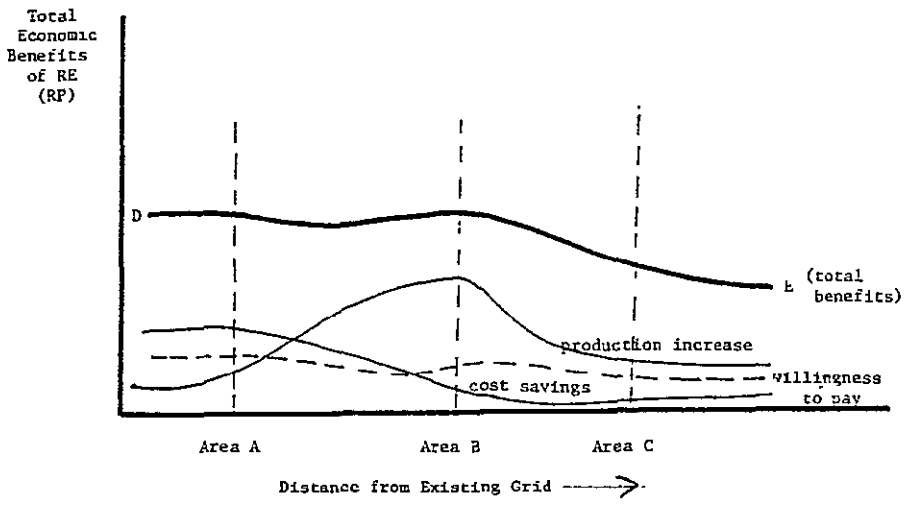


FIGURE 18: TOTAL RE BENEFIT LOCUS



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production and more commercial activity, and (3) improvements in the quality of rural life. Items 1 and 2 can be measured directly, while the value of (3) requires a political decision as well as social analysis. Here we shall take the consumers' willingness-to-pay for electricity as a proxy for social benefits[7].

These RE benefits are clearly site specific. For example, that benefits to Sites A and B may be relatively high due to considerable cost savings and willingness-to-pay in the former and significant increased production and willingness-to-pay in the latter. In contrast, benefits for Site C may be low due to the lack of market activities and low levels of willingness-to-pay. These conditions are represented in Figure 18, which depicts the potential level of RE benefits in different areas.

Figures 17 and 18 can be combined to determine the implications of this example. This is done in Figure 19 which indicates the net economic benefits resulting from the electrification of Sites A,B, and C. Figure 20 translates this into rates of return on the corresponding RE investments. The results indicate that the electrification of Site A is clearly economically justified, while the electrification of Site C is not. While Site B has a positive rate of return it is less than that of other possible investments, as represented by the opportunity cost of capital. Thus it may be decided to electrify Site B.

Another determining factor is the time variable. In order to show the impact of time in the graph above, a third dimension would have to be added to Figure 19. Another approach is to consider that the time dependence of the costs and benefits shown in Figure 17 and 18 have been analyzed and appropriately discounted to the present.

D. OBSERVATIONS/CONCLUSIONS

Indonesia's RE program has been the subject of considerable scrutiny in recent years. Much of this has been focused on the

FIGURE 19: NET ECONOMIC BENEFITS OF RE

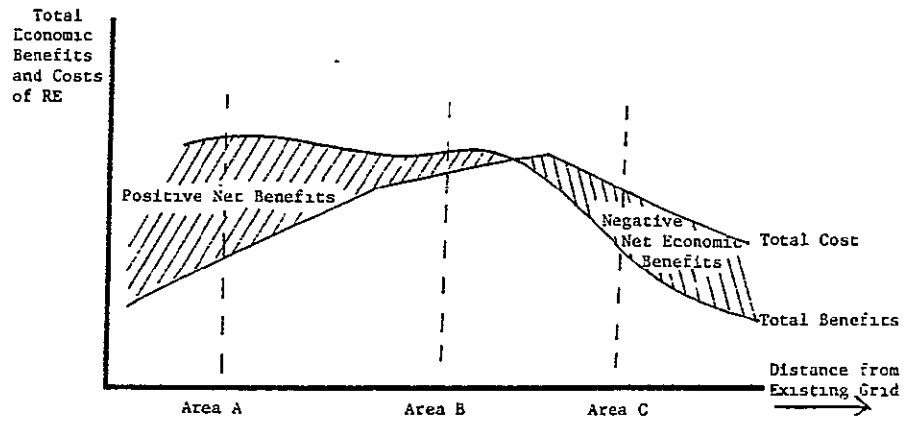
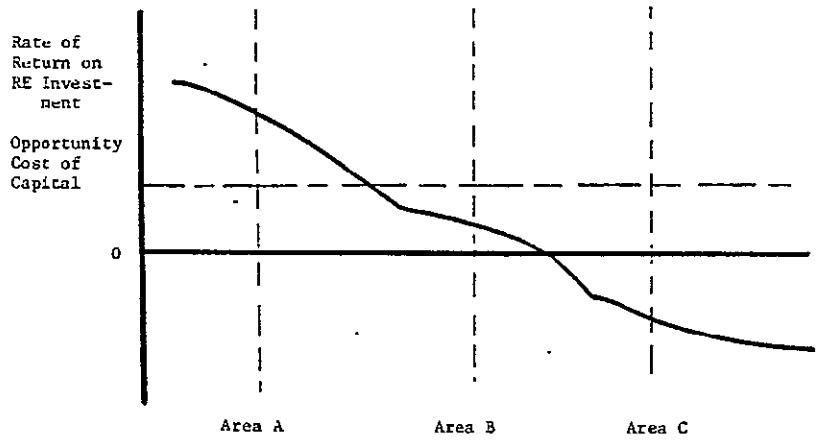


FIGURE 20: RATE OF RETURN ON RE INVESTMENT



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program's relative inability to stimulate significant economic development in most rural areas. In such areas, many existing productive enterprises did not immediately choose to electrify and few new productive uses for electricity developed.

It seems likely, in retrospect, that expectations regarding RE in Indonesia were excessive, and that the RE program itself was probably too narrowly focused. Experience throughout Asia demonstrates that the developmental impact of RE is generally modest and occurs relatively slowly over a number of years. In addition, RE is unlikely, by itself, to lead to significant increases in rural economic activity unless a variety of other conditions (adequate access to markets, credit, and infrastructure) are also satisfied. However, these conditions are not apt to be met in many rural areas of Indonesia unless they are addressed through specific programs.

Nevertheless, a number of problems specific to the RE program in Indonesia have existed in the past and have served to further limit the productive uses of RE. Among these were a relatively distorted energy pricing structure, high costs of initial connection to the RE system, a RE site selection process which gives heavy weight to non-economic factors, and a general lack of information about, or promotion of, the productive uses of RE. Over the last few years a number of these problems have been addressed. Specifically, energy sector prices have, in general, been rationalized and the barrier posed by high connection costs has been reduced for some consumers. It is probably too early, however, for the full impact of these changes to be observed.

The other problems cited above generally remain. Thus DJL, PLN, and other agencies involved with RE are faced with the task of determining areas for RE with significant productive use potential and creating an environment in which RE can compete effectively with alternative commercial energy sources. Assuming RE has inherent economic advantages in certain areas resulting from economies of scale and its use of less expensive fuels, then the challenge in a properly

identified RE area is to create conditions under which productive use consumers: 1) have a financial incentive to connect to the RE system, and 2) recognize that this energy supply option exists and is available to them. In addition, RE agencies must try to maximize the potential cost advantage of RE by using appropriate design standards and operating practices.

In this atmosphere there are a number of needs and requirement if Indonesia is to achieve the development and infrastructure potential of rural electrification. The most important of these, emphasizing those involving DJL's participation and those activities contributing to the development of productive activities are:

- DJL should develop a set of national policy goals and objectives for rural electrification. The Directorate should see that a rural electrification policy is adopted on a national level. In order to accomplish this DJL staff should prepare the information necessary for decisions to be made including an analysis of the issues affecting RE. DJL should also work closely with others involved in RE to assure comprehensiveness.

- Once the RE policy goals and objectives are in place, DJL should focus its attention on producing a strategy to assure accomplishment of the goals and objectives. It is assumed that one or more of the goals will address the need to develop productive uses of electricity in the rural sector of the country. DJL should focus its efforts on producing, and where appropriate implementing, parts of a strategy to encourage and support the development of productive uses of rural electrification.

- A preliminary analytical framework has been presented in Appendix 6 and summarized above for use in identifying sites for rural electrification. This framework can be employed to define those areas which have or which obviously don't have the potential for developing productive uses of RE. DJL should expand and complete the site selection process outlined in the analytical framework. This work will require cooperation with PLN and other agencies working on planning and development in the rural sector. A number of studies and investigations are necessary before this process is complete. DJL should place a high priority on initiating and completing these.

- One of the studies which must be completed to support application of the analytical process is collection of social, economic, technical and political data. DJL should perform these data collection efforts and assure that the data are made available (placed in their newly created data bases) for further and future work.

- When a policy and strategy for RE exists and when the analytical framework described in Appendix 6 is converted into a useable site selection methodology DJL should encourage and support the development of a pilot effort in the field. This pilot effort should serve as a real world mechanism to check the impact of programs, incentives, disincentives, etc. which are being considered as a part of the overall RE strategy. Planning for this pilot effort should begin now although the actual pilot effort may not be deemed necessary until later.

- As a supporting activity to the above key elements DJL should see that a situation monitoring program is developed. This monitoring would collect, analyze and make available data on the successes and failures of RE, particularly in meeting the policy objectives and goals. Special emphasis should be placed on collecting data on productive uses.

- DJL should encourage others to review RE tariffs, evaluate and expand the promotion of RE, investigate technical means to improve service and efficiency etc. In these areas DJL must employ its influence to see that these efforts are initiated.

- There are a number of infrastructure elements along with RE which have been shown to be necessary if productive activities are to be developed in rural areas. DJL must keep track of the development of these elements such as transport, markets, extension services, etc. to be sure that when RE is made available there will be optimum conditions for the development of productive uses.

CHAPTER IV

NOTES AND REFERENCES

1. This chapter is based on work, presented in more detail in Appendix 6, by Mark Gellerson and James D. Westfield.

2. Decisions regarding RE are often affected by non-economic factors. Such influences are not considered in this report, although they must be accounted for when an attempt is made to implement the recommendations presented here.

   For PLN, RE involves supplying electricity to areas which are not kotamadya, kota administratip, ibukota propinsi or ibukota kabupaten. This report, however, defines RE as the supply of electricity to rural areas (defined as above or in terms of a maximum number of consumers (say 10,000) for the principal purpose of fostering economic development. Electric supply activities which are carried out in rural areas for purely commercial reasons, e.g. electrification of a large productive enterprise, are not considered to be part of RE. Overall, it is the motive for electrification, i.e. developmental as opposed to commercial, which determines whether it should be considered as RE. Although most RE consumers will be small, it is not considered meaningful to establish a maximum level of demand below which are RE consumers and above which are non-RE consumers.

   A productive use consumer of RE utilizes electricity in RE areas to produce a good or service which is sold in a market. The use of electric lighting in a place of production should not <u>ipso facto</u> be considered as a productive use of electricity.

3. From an environmental perspective, RE has been viewed as a means of reducing problems of deforestation in certain parts of Indonesia. Recent research, however, raises questions concerning whether firewood consumption contributes significantly to such problems.

Important contributions to the work summarized here were also made by Ir. A. Andoyo, Ir. R. Pasaribu of DJL and Mr. Lalit Sen.

V RECOMMENDATIONS AND CONCLUSIONS

Several recommendations have been made throughout the report on follow-up of the activities carried out in this project. In particular, recommendations are made in Chapter IV regarding a future role for DJL in increasing the effectiveness of Indonesia's rural electrification program. Here we present some recommendations towards strengthening DJL's broader role in energy policy analysis and planning.

A. DATA AND MODEL DEVELOPMENT

Data relevant to energy planning are collected and, in some cases, compiled by a large number of agencies in Indonesia. The data include primary information, such as that compiled by BPS and Pertamina and also analyzed information, such as PLN's demand projections and capacity expansion plans. In some cases the collection and compilation of data are keyed to the development of the Repelitas. Taking these other activities into account, DJL should establish a routine procedure for updating the information contained in the EIASI system (including both the information system and the RESGEN model). It will soon be possible to update the data contained in the RESGEN model to a 1984/85 basis.

In this project we revealed, but could do little about, the inadequacies of data on energy consumption at the regional level. Non commercial fuel information (wood and agricultural wastes) are particularly lacking. If regional energy issues are to be important in the future, these data gaps should be filled, and some form of surveys are probably required to do so.

A further need in the future development of a regionalized model is an improved representation of fuel transportation costs between regions. If credible data can be generated for both supply and transportation costs, it could be useful to implement an optimization module (minimizing supply costs) within the overall RESGEN framework.

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The work carried out in this project to regionalize national energy planning must be considered very preliminary. Work is also being carried out by DJL on energy analysis and development at the local level. It is now an appropriate time to create an approach to coordinated energy analysis and planning at the national, regional and local level.

Figure 21, extended from Figure 2, presents schematically how a regionalization of energy planning might work. The extension must be made at the macroeconomic level, i.e., from BAPPENAS to the BAPPEDAs; at the energy sector level using the regionalization of RESGEN, and at the subsectoral level. The latter level requires no innovation since PLN, Pertamina, etc., already operate at both the local and national levels.

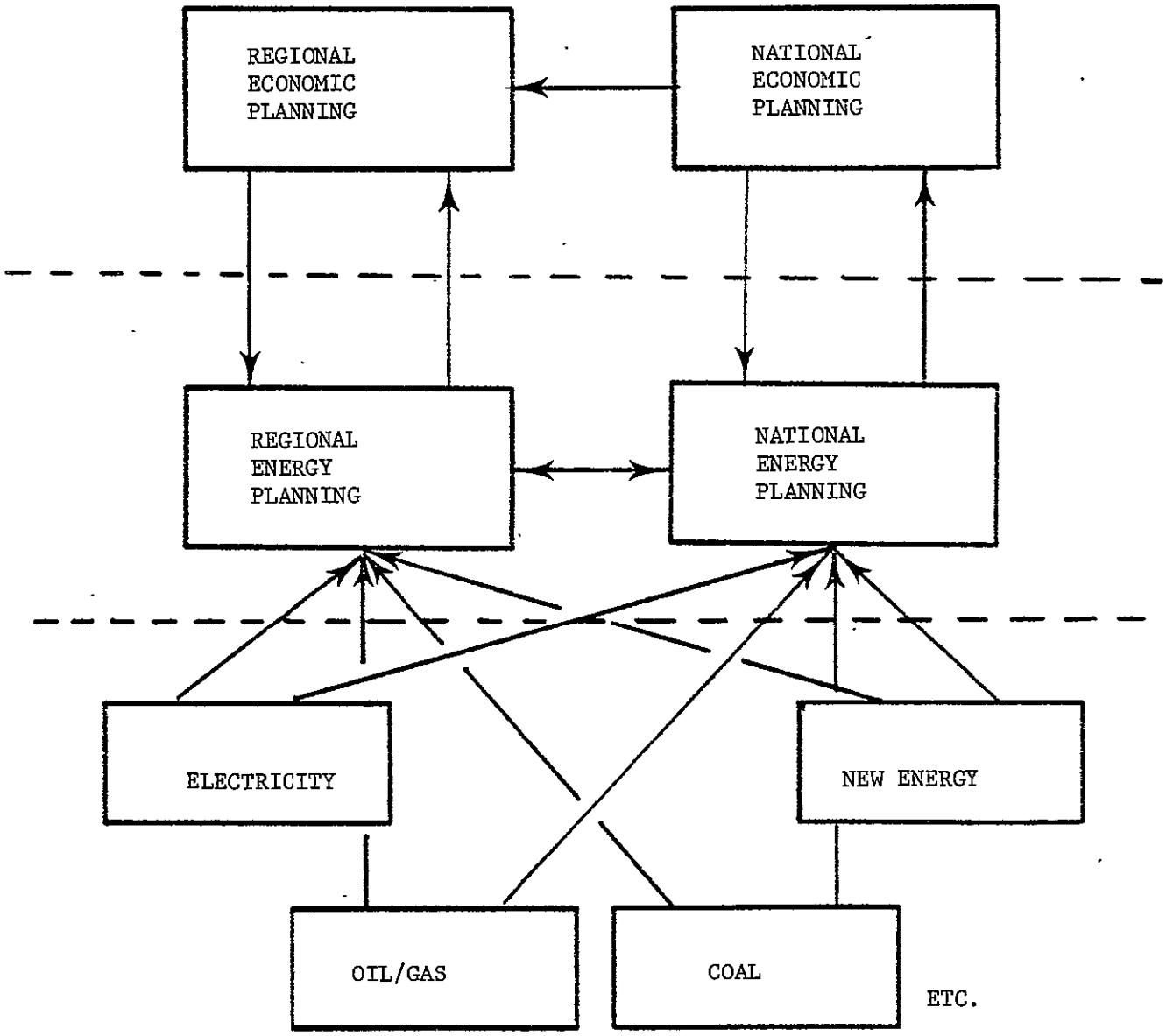
At the regional and local levels the analytic system can deal effectively with individual projects. It is also at this level that one can start to deal effectively with energy's contribution to industrial development (small and large scale). These local considerations, and the energy solutions to which they lead, can then be fed back to energy planning at the national level. Hence the importance of the two way arrow connecting regional and national energy planning in Figure 21.

B. AN EFFECTIVE ENERGY PLANNING GROUP

This project, and work more generally in Indonesia over the last 3 - 4 years, have made clear that to have an effective energy planning process it is necessary for it to be centralized. Many elements of the process are in existence in various agencies throughout the Government. Indeed, one of the difficulties of creating a well focussed effort in energy planning is first the number of separate institutions collecting data and building energy models. As discussed in Chapter II there is a need for a variety of subsectoral energy activities - analyses of electricity capacity expansion,

FIGURE 21

THE REGIONALIZATION OF ENERGY/ECONOMIC PLANNING



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petroleum development, industrial conservation and so forth. But there is also a need for a sector-wide planning effort which integrates those individual subsectoral components and mediates between then and national economic planning at the BAPPENAS level. DJL has the mandate to act in the role of the national energy planning body. and this project was designed to support DJL in that role.

Discussions with various agencies during the course of this project - PLN, MIGAS, BATAN, PERTAMINA, etc. - confirmed that the subsectoral entities recognize the need for relating their planning to overall sectoral issues such as the national supply-demand balance. They also recognize the need to relate capital requirements in their subsector to total capital requirements in energy and in the overall economy.

Through the project an appropriate set of energy planning tools has been implemented at DJL. Some data have been assembled and a considerable amount of training has been carried out. There remain, however, several further steps that have to be taken if DJL is to be able to fulfill its designated role. In particular, two areas require early attention: exercising the EIASI model in a real policy analysis and staffing an Energy Policy Analytic Group at DJL.

Exercising the Model

We recommend that a significant policy analysis be undertaken by DJL to extend the experience with EIASI and to develop institutional collaborative relationships. This exercise should also be used to train further DJL staff in using the EIASI system.

There is a wide choice of possible issues for analysis, issues which are timely, important and which require an integrated national view. Two examples are: natural gas development and coal development. In both instances a number of recent studies have been carried out but there is a need to place the particular resource development in the context of a national energy strategy. There is

also the need to place natural gas and coal development in the context of the national economy. RESGEN, as installed at DJL, and the associated linkages described in the previous chapter are designed to analyze just this kind of issue.

The analysis should be organized by DJL but requires the active participation of the subsector specialists (gas or coal as the case may be) and PLN. It will also require the active participation of staff of BAPPENAS. The exercise will aim to demonstrate these institutional collaborations as much as the analytical methods.

Such a study could be carried out in a period of 6 - 9 months if a concerted effort were made. It should not require any modification of the structure of the RESGEN networks created in this project. The greatest effort would be in formulating scenarios; evaluating and agreeing on the basic data to be put into the model, particularly economic information; and carrying out the analysis of alternative policies and programs. From these analyses, scenarios will emerge that are technically sound and which at the same time are acceptable to decision makers who are seeking a consensus.

Further Development of an Analysis Group

DJL now contains many of the elements of an effective national energy planning group. Perhaps the best way to suggest where the group needs to be strengthened is, without reference to current staffing, to describe the eventual desirable composition of the group. Previous sections of this report, particularly in Chapter II, have clarified the roles of that group and of the analytical techniques implemented in this project.

Senior Policy Analysts

Ultimately the users of the system are the senior analysts who interact with the Minister of Energy and Mines and with other members of BAKOREN and PTE. They are the ones who formulate the issues to be analyzed, decide on the data requirements, specify the analyses to be carried out, decide on the collaborative arrangements to carry out the

analyses, direct the process of policy analysis and interpret the results to decision makers.

Energy Analysts and Economists

It would be a mistake to attempt to create within an Energy Analysis Group subsectoral capability of the sort that exist within PLN, MIGAS, etc. Nevertheless, there should exist within the group - or available to it - people knowledgeable about key energy issues - demand, electricity, oil and gas, coal and particularly those areas which are the special responsibility of DJL, namely "New Energy". The group should include one or more experienced energy economists who can deal with both micro and macro economic energy issues.

Energy Data Specialists

Data of relevance to the EIASI system are being created, compiled and analyzed in a great many places throughout the energy community in Indonesia. The group should include 2 - 3 people who keep in touch with the other key agencies and who supervise the insertion and updating of data into the EIASI system.

Energy - Computer Analysts

The users of the EIASI system, and in particular the users of RESGEN, should be people with technical backgrounds in some aspect of energy analysis: oil and gas development, electric sector planning, energy system analysis, etc. They should then be trained in the use of RESGEN. Since RESGEN has been designed to operate as a higher level language for energy analysis, these people do not need advanced computer programming backgrounds. There should be 2 - 3 such people who can use the system to create new networks, for example, at any time.

Hardware - Operating System Support

At least one technical person is required to install, maintain, arrange for repair, carry out routine operations on the equipment. He/she may also serve to carry out routine analyses.

Commercial Software Support

There should be many users in DJL of multi-purpose software such as dBASE III and LOTUS 1-2-3. Someone should be designated - or someone may naturally emerge - as the local expert in these programs. This person, or preferably an additional person, should understand the computer aspects (as contrasted with the energy systems aspects) of the EIASI system.

This description of staffing requirements assumes that the energy analysis group works in close collaboration with technical experts from subsectoral agencies. A logical way of doing this is to have a technical representative of each agency (PLN, MIGAS, etc.) assigned on secondment to the group. At the minimum there should be a technical coordinating committee involving such persons actively participating in any analyses carried out by the group.

The current staffing and salary restrictions on DJL may preclude the construction of a dynamic, effective energy planning group. If that is the case consideration could be given to the formation of a national center (Pusat) for energy analysis and planning.

Recommendations

Work should continue on putting data into the Information System, including its bibliographic portion. The process of incorporating quantitative information should be guided by the information needs of planners and policy analysts. Much time could be spent uselessly by an unguided data compilation effort.

C. ENERGY AND SOCIAL OBJECTIVES

Central to the objectives of Repelita IV is raising the living standards of the Indonesian people with particular regard to the equitable distribution of welfare. Some energy programs, in particular rural electrification, are designed to contribute to those objectives. On the whole, however, energy planning, since it is

carried out with relatively narrow objectives at the subsectoral level, does not take those social objectives very much into account.

At DJL, these shortcomings have been clearly recognized. It has moved to narrow them by the creation of a Rural Energy Subdirectorate and the development of rural energy projects, carrying out a regional energy studies/assessment in Kalimantan, and studies of household energy consumption in rural areas among others. Its ultimate objective is to view rural energy projects as an aspect of an overall regional development, one in which energy contributes to economic growth and socio-cultural development in a regional context.

Our recommendation in this regard is two fold. As part of its role in integrating and coordinating subsectoral planning, DJL should maintain a concern with the implications of plans and strategies for employment, equity, regional development and the like. Specific methodologies and data should be developed to allow DJL to play this role effectively. Secondly, DJL should carry out a specific study of the social development implications of alternative energy strategies. The participation of social scientists and institutions such as the Institute for Economic and Social Research, Education and Information (LP3ES) and ITB, until recently not normally involved in energy planning in Indonesia, should be continued and expanded. The combination of these two activities should increase the likelihood that Indonesia's energy program contributes significantly to the social development objectives of Repelita IV.

ANNEX A

TRAINING PROGRAM SCHEDULES

A. U.S. TRAINING PROGRAMS

1. Long Term Training, March 11 - May 21, 1985

   Participants: Madrianto Kadri, Abdul Gafar

2. Short Term Program, Analytical System, Energy Modeling and Policy Analysis, April 1 - 19, 1985

   Participants: Tangkas Roesad, Dr. Ukar Soelistijo, Maryam Ayuni

   Schedule: attached

3. Short Term Program, Survey Data Analysis, July 8 - August 2, 1985

   Participants: Suprijo, Indarti, A. Gurning

4. Workshop on Productive Uses of Rural Electrification, April 16, 1985

   Participants: Tangkas Roesad, Ukar Soelistijo, Maryam Ayuni, Madrianto Kadri, Abdul Gafar

   Schedule: attached

B. TRAINING AND PRESENTATIONS IN INDONESIA

1. EIASI SYSTEM PRESENTATIONS, June 27 - July 2, 1985

   Presenters: Dr. P. Palmedo, Dr. P. Meier

   Schedule: attached

2. Technical Meeting, September 19 - 21, 1985

   Presenters: Dr. P. Palmedo, Dr. J. Westfield, Dr. R. Chatterjee, A. Doernberg

3. RESGEN TRAINING, September 12 - 18, 1985

ANALYSIS OF THE ANALYTICAL SYSTEM, ENERGY MODELLING & POLICY ANALYSIS

TRAINING PROGRAM APRIL 1 - 12, 1985

E/DI OFFICE SETAUKET

Monday, April 1
9:00 Introductory Session P.F. Palmedo
1:00 EIASI Data Base System, Session 1 J. Kahn

Tuesday, April 2
9:00 RESGEN Energy Model Session 1 P. Meier
1:00 EPfD II Planning Session P.F. Palmedo

Wednesday, April 3
9:00 RESGEN Energy Model Session 2 P. Meier
1:00 EIASI Data Base System, Session 2 J. Kahn

Thursday, April 4
Schedule to be arranged

Friday, April 5
9:00 BAPPENAS Macroeconomic Model S. Rogers,
all day & linkages to RESGEN

Monday, April 8
9:00 Indonesia Energy Model Discussion A. Doernberg
1:00 EIASI Data Base System Session 3 J. Kahn

Tuesday, April 9
9:00 RESGEN Energy Model Session 3 P. Meier
1:00 to be arranged

Wednesday, April 10
9:00 Microcomputer Applications to Energy P. Love,
Policy Analysis (Brookhaven Natl. Lab)
1:00 Low Cost Solar Collectors W. Wilhelm

Thursday, April 11
9:00 Microcomputer Applications &
Commercial Software Discussion J.S. Munson

Friday, April 12
10:00 Energy-Economic Modelling A. Strout,
all day P.F. Palmedo

A WORKSHOP ON

PRODUCTIVE USES AND RURAL ELECTRIFICATION

WASHINGTON, D.C. April 16, 1985

WORKSHOP SCHEDULE

Morning Program

Speaker		Subject
Dr. Philip Palmedo	E/DI	Introduction
Dr. James.D. Westfield	E/DI	Review of E/DI Task on Productive Uses of Rural Electrification
Dr. Mark Gellerson	USAID	Rural Electrification in Asia: Lessons Learned
Dr. Douglas Barnes	IBRD	Social and Economic Costs and Benefits of Rural Electrification
Mr. James Gibbs	Bureau of the Census	Results of a Rural Electrification Baseline Study in the Klatten and Banyumas Areas of Indonesia

Afternoon Program

Dr. Westfield will present E/DI's preliminary findings and recommendations for DJL's initial activities in developing a rural electrification program which supports and encourages the creation of more productive uses. Following this, a round-table discussion will be held on these findings and recommendations and the overall workshop topic.

ENERGY PLANNING FOR DEVELOPMENT II

PRESENTATIONS ON ENERGY INFORMATION AND
ANALYTIC SYSTEM FOR INDONESIA - EIASI

JAKARTA, INDONESIA JUNE 27 - JULY 2, 1985

- P. F. Palmedo
- P. Meier
- A. B. Doernberg

1.	Thursday - June 27, 1985 Time: 14:00 at DJL	Ditjen Listrik dan Energi Baru and PLN
2.	Friday - June 28, 1985 Time: 09:00 at DJPU	Ditjen Pertambangan Umum, PPTM, and BUMN Batubara
3.	Friday - June 28, 1985 Time: 14:00	USAID 3rd Floor Conference Room
4.	Saturday - June 29, 1985 Time: 09:00 at MIGAS	Ditjen MIGAS, PPTMGB Lemigas and PERTAMINA
5.	Monday - July 1, 1985 Time: 08:00 at PLN	PLN Planning Division
6.	Monday - July 1, 1985 Time: 10:00 at BATAN	BATAN and BPPT
7.	Monday - July 1, 1985 Time: 13:30 at DJL	PTE (+ DJL staff)
8.	Tuesday - July 2, 1985 Time: 07:30 at BAPPENAS	BAPPENAS, BPS and UI

ANNEX B

SCHEMATICS OF THE INDONESIA ENERGY MODEL

The Indonesia energy model inputs and results are presented in tabular form throughout the body of this report. It is also instructive to present the network of fuel links and transformations as figures, in which the actual flows of energy for a specific year are entered into the respective branches of the network.

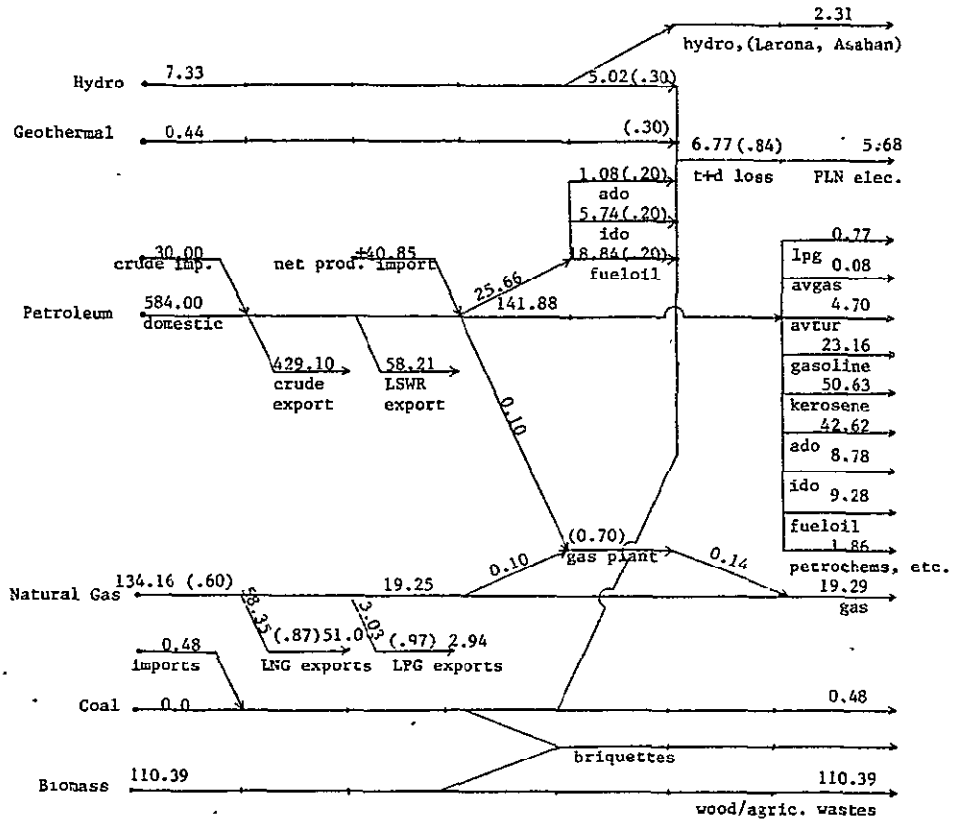
Figure B1 represents the Energy Supply/Demand Balance Model for 1982. The far right hand side of the diagram shows final demand by fuel. It shows PLN electricity sales of 5.68 mboe, and the fuels used in the generation of this electricity, as well as other conversion processes: city gas, LNG and LPG production. The foreign trade of fuels is also indicated.

Figure B2 represents the Energy Demand Projection Model. The left hand side of this figure corresponds exactly with the right hand side of figure B1, only that fuels are disaggregated by end use: households, industry, transport etc. The diagram also shows the fuels to captive power, and its conversion to electricity. Total electricity use in industry (including mining) is 9.69 mboe, of which 1.80 mboe are purchased from PLN and 7.89 mboe oil generated internally. The balance of fuels to industry, for other purposes, are 26.83 mboe as shown.

The fuel demand flows drive the model and correspond exactly to our best estimate of demands in 1982. However, it is important to note that the model results shown here for 1982 have not been "calibrated" to correspond in all categories with historical 1982 data, in particular for the foreign trade portion. Because the main objectives of the model are oriented to future energy balances, several data inputs reflect future developments in, for example, refinery configuration, or losses in the natural gas extraction and conversion processes, and not those existent in 1982. For similar reasons, statistical differences and stock changes that are not relevant to future energy balances are left aside.

SCHEMATIC OF
ENERGY SUPPLY DEMAND BALANCE MODEL
1982 BASE YEAR DATA, MILLION BOE

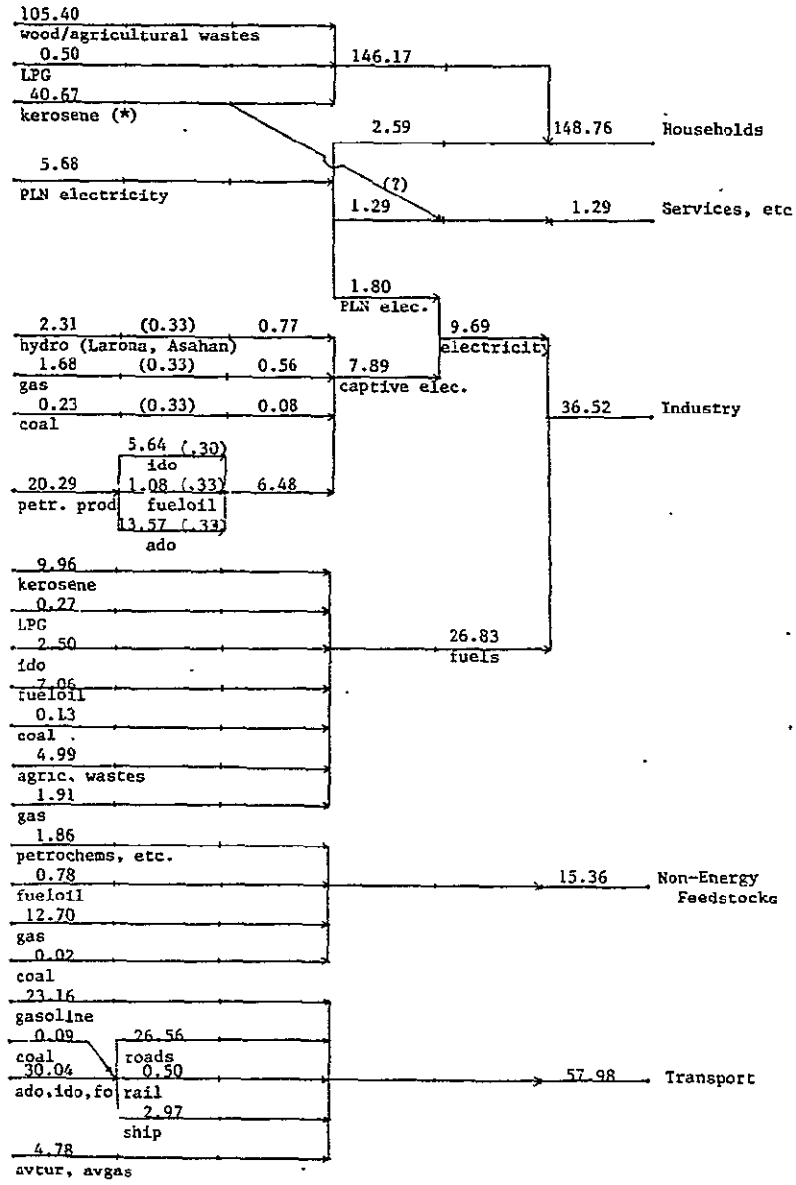
FIGURE B1



TOTAL RESOURCES	:	866.80 MBOE
EXPORTS	:	-541.25 MBOE
TOTAL DOMESTIC CONSUMPTION:		325.55 MBOE

SCHEMATIC OF
ENERGY SUPPLY DEMAND PROJECTION MODEL
1982 BASE YEAR DATA, MILLION BOE

FIGURE B2



ENERGY PLANNING FOR DEVELOPMENT

(Phase II)

APPENDIX 1: EIASI USER'S MANUAL

September, 1985

DIRECTORATE GENERAL OF ELECTRIC POWER AND NEW ENERGY
MINISTRY OF MINES AND ENERGY
REPUBLIC OF INDONESIA

AND

ENERGY/DEVELOPMENT INTERNATIONAL
100 North Country Road
Setauket, N.Y. 11733, U.S.A.

with

INTERNATIONAL DEVELOPMENT AND ENERGY ASSOCIATES
P.T. CIPROCON

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ANNEX III - EIASI Hardware Configuration
ANNEX IV - Programming Notes on Typical EIASI Files

EXECUTIVE SUMMARY

A. OBJECTIVES

The Energy Information Analytical System for Indonesia is designed with a wide range of users in mind: staff members within Directorate General of Electric Power and New Energy (DJL), other government and private groups, and international financial institutions. The Planning Division of DJL is responsible for maintenance and extension of the data base system, and for this purpose staff members have been trained in data base design, data base programming, as well as data entry and retrieval. The EIASI System is designed to provide users with detailed information on the Indonesian energy picture within a flexible and easily accessible structure.

B. DESIGN

The Energy Information System has been designed to address DJL's need through a four part system: (1) A Numeric Database with information on energy resources, production, consumption, price information, and historical projections on either a regional or national scale. (2) A Bibliographic Database containing information on publications and reports of various types that address Indonesian energy concerns or information, including information on energy projects underway in Indonesia. (3) A set of system utilities to facilitate the use and augment the power of these two databases. (4) Two commercial software packages have also been included, Lotus 1-2-3 (an established and powerful analytical tool) and dGRAPH III graphics software. The Numeric Database and these two commercial programs can interchange data files and thereby unite and enhance the applications possible with the stored information.

The Information System is designed to be menu driven to provide the greatest ease of accessibility to a wide range of potential users. The programming is in dBASE III, a commercial software substructure which is not menu driven in and of itself, but allows for the

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programming of a menu system and a wide range of automated features. The combination of dBASE III's substantial storage and retrieval capabilities and the ability to create a flexible menu driven shell for operations makes dBASE III the ideal tool for the Energy Information System. As a result, the Information System consists of two elements: a menu system and the data files that contain the energy information of concern to DJL and the other users of the system.

C. ENERGY INFORMATION SYSTEM COMPONENTS

1. Numeric Database

The Numeric Database is designed to contain nine categories of information, Primary Energy Resources, Secondary Energy Conversion Plants, Production and Foreign Trade and others (Exhibit A), each of which are further subdivided into sub-categories. Regional and National breakdowns of data are also accessible. It is important to point out that the design is flexible and can be extended to include additional categories or regions. The design presented in this report is the result of a collaborative effort between the consultants and the staff at DJL over a period of six months.

The menu system is programmed to meet this design structure. Appropriate data files have been created to store the information in the form that is most efficient for the range of storage and retrieval demands on the system. Each menu ends in a formatted display, also created in collaboration with DJL staff, which displays the appropriate information in an attractive and informative manner. The entire structure, however, is flexible and can be modified by system programmers with a minimum of effort. Menu level users can proceed with a minimum of training through a set of interactive prompts (the "menu tree") to examine the data of their interest. Little training also is needed for data entry operations assigned to enter and update data files designed and formatted for those specific data.

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EXHIBIT A

The Numeric Energy Data Base Main Menu. This menu is produced when the user responds 1 to the Energy Information System Main Menu.

```
****************** Numeric Energy Data Base ****************

  (1) Primary Energy Resources

  (2) Secondary Energy Conversion Plants

  (3) Production and Foreign Trade

  (4) Demand and Consumption

  (5) Historical Series and Projections

  (6) Energy Prices and Tariffs

  (7) Technology Characteristics

  (8) National Socio-Economic Reports

  (9) International Statistics

  (Q) Return to the Main Menu

  (E) Exit DataBase

Enter the number of the area of interest
```

A command level is available in dBASE III that allows access to the full array of dBASE III data control features to trained analysts and programmers.

dBASEIII commands give access to the full range of data handling tools: creation of new files, formatting of displays, creation of new menus, preparation of reports and graphs and so.

2. Bibliographic Database

The Bibliographic Database is designed as a catalogue of publications. It contains titles, authors, subject access number, an abstract etc. (Exhibit B). A search system has been designed and programmed to allow users at the menu level to search the Bibliographic Database on a variety of fields (Exhibit C) and retrieve data in both a full page format with abstract (Exhibit D) or a listing of titles and authors matching the search criteria.

A subsection of the Bibliographic Database is the Energy Projects file. This file has been designed to contain information on the description and status of energy projects underway in Indonesia (Exhibits E & F). The Bibliographic Database (main section and Energy Projects section) allows for the storage of text in a flexible and easily adaptable format. Several DJL staff members have been trained in its use.

3. Additional Information System Components

Two utilities, File Management and Unit Conversion, have been designed and programmed to meet specific needs of DJL and potential users. The File Management Utility contains a set of file directories to administrate the numerous data files contained in Energy Information System; it also contains a facility for reviewing previously generated and stored reports, and a file conversion utility for data file transfers to Lotus 1-2-3 and dGRAPH III. The latter two computer software items allow for additional analysis or graphical displays.

EXHIBIT B

The Bibliographic Database allows for searches on a variety of fields in the entry form. There is also a utility for entering new records, and a Keyword Utiltiy to provide present and updated list of all subjects/keywords in use in the system.

SEARCH BY: (1) Accession Number

(2) ISBN Number

(3) ISSN Number

(4) Subject

(5) Author

(6) Location

(7) Source Document

(8) Category Code

(9) Enter New Records

(K) Keyword Utility

(E) End Session

Enter a selection to continue

EXHIBIT C

A sample of a search for either of 2 SUBJECTS.

Search for SUBJECT: OIL

OR : PETROLEUM

Search in progress...

EXHIBIT D

A sample Bibliographic Entry for a book. The user has a full menu of options with appropriate password protection. The summary field can be up to 50,000 characters of text information.

```
ACCESSION #     3 ISBN # 0-19-582527-60 ISSN #                ENTERED 05/05/85
                                                              REVISED 05/05/85

TITLE           The Petroleum Resources of Indonesia

LANGUAGES       E                                     YEAR PUB.   87

AUTHORS         1 OOI JIN BEE                 2
                3

KEYWORDS        1 PETROLEUM                   2 RESOURCES
                3                             4

DOCUMENTS       1
                2
CATEGORIES      1                                 (N)ext      (E)dit
                2                                 (B)Previous(D)elete
NOTES . .....   HardBack                         (S)ummary   (P)rint
STATUS ......                                     (A)ppend    (Q)uit
LOCATION ....   USA

Enter a selection to continue
```

EXHIBIT E

The Energy Projects Database mirrors the "Blue Book"

Energy Projects DataBase

(1) Title

(2) Location

(3) Agency

(4) Codenumber

(5) Data on Energy project by code #

(6) All data on energy projects by Title

(A) New Entry

(Q) Return to previous menu

Enter a number to continue

EXHIBIT F

A sample entry in the Energy Projects Database. Memo fields indicate fields that can contain up to several pages of text material.

Energy Projects Listings Code number 2 BN 9

Project Title ASAHAN HYDRO POWER PLANTS I & III,(160 MW & 200 MW) AND ASSOCIATED TRANSMISSION LINE

Location NORTH SUMATERA PROVINCE

Agency DIRECTORATE GENERAL OF ELECTRIC POWER AND NEW ENERGY/PERUSAHAAN UMUM LISTRIK NEGARA (PLN), MINISTRY OF MINES AND ENERGY

Objectives memo Description memo

Total Cost	468000000	Implementation Time	6 (SIX) YEARS
Local Cost	234000000	Proposed Commitment	234000000
Foreign Exchange	234000000		
Technical Assistance			

Stage - FEASIBILITY REPORT WAS UNDERTAKEN BY JICA - ENGINEERING DESIGN IS UNDERWAY FINANCED BY OECF

(O)bjectives&Description (N)ext project (E)dit (P)rint (Q)uit

Finally, the Unit Conversion utility contains an infinitely expandable energy units conversion table that contains unit conversion coefficients for a wide range of energy measurements. With this table and the utility, any data set existing in a particular array of energy units can be converted to a common unit. Each data entry in its specific unit is singularly converted using the table to the common unit and a duplicate data set produced is for further examination.

Two commercial software packages, Lotus 1-2-3 and dGRAPH III also reside within the Energy Information System. Lotus 1-2-3 is a superb tool for a wide range of mathematical and financial analyses by itself as well as analysis with data sets transferred from the databases. dGRAPH III provides the sophistication and features of a top level graphical presentation capability for use by DJL and other users.

A concern for data integrity, simplicity of use, and comprehensiveness of format as well as flexibility for growth and change, have been built into every aspect of the system in all phases of design and creation of menus, formatted displays, utility programs and other features. In this way a system is in place with the best resources for success and productive use.

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I GENERAL INFORMATION

A. A PRIMER ON DATABASES

1. Definition of Terms

Data Base - A Data Base is a structured storage/retrieval system which may or may not be computerized. A Data Base may be as simple as a telephone directory (i.e. a report on paper) or as complex as a utilities main frame-based record keeping system.

Record - A record is the building block of the data base - the information for a single person, case or observation.

Field - The subunits of a record that contain actual data. e.g. name, address, telephone number.

Formatted Display - The end product of a retrieval operation. A record or records are displayed in a pre-defined format for screen or paper output.

Report - A standardized form of output of records stored in the data base.

Information System - A structure that generates reports prepared specifically for predetermined users; i.e., the reports are programmed by the information systems specialist to meet the specific needs of the user(s)

Menu - a computer screen listing choices of commands in simple language, which can be executed with no knowledge of computer programming.

Command - The code used for execution of a computer function. Computer programs consist of a set of commands.

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Menu Tree - It is common that menu choices will lead to another menu with a new set of choices. This second menu in turn can lead to a third and a fourth and so on. This chain of related sequential choices is a Menu Tree. Exhibits I-1 to I-3 shows an example.

2. Database functions

a. Storage/Retrieval Function

Storage - Raw or processed data are entered into a data base. A primary benefit of a data base lies in its ability to organize data that has been entered once, into many forms. Another benefit lies in the centralized nature of computer storage.

Retrieval/Sorting - Information from a data base can be sorted by Alphanumerics or Numerics to produce ordered lists. e.g. names ordered alphabetically or an energy type ordered by amount of production.

Reports - One time organization of data as well as regular reports can be generated from a data base automatically with pre-programming. It is in the form of reports that most data will be organized. e.g. An electric utility can keep records of all customers and produce a monthly report (bill).

b. Information System Functions

An information system provides users with processed data. Data base data goes through an analysis/manipulation phase and then is organized. In this way the information system goes beyond storage and retrieval. An information system has to meet the needs of each of the recipients of the processed data, such as a manager or executive, the analysts who process data, and other professionals. These needs drive the data base design.

3. Design of a Data Base

The following information is critical in order to design a data base.

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EXHIBIT I-1

The next series of pages will display other branches of the numeric database system as well as examples of several formatted data displays.

These pages are designed to illustrate the flexiblity and specificity of the system.

NUMERIC
**********PRODUCTION & FOREIGN TRADE**********

(1) Production

(2) Imports

(3) Exports

(4) Stock Change

(Q) Return to Previous Menu

(E) Exit DataBase

Select a number

EXHIBIT I-2

NUMERIC
PRODUCTION / FOREIGN TRADE
**********PRODUCTION**********

(1) Crude Oil - Condensate
(2) Avgas
(3) Avtur
(4) Mogas
(5) Kerosene
(6) Gas Oil
(7) Diesel Oil
(8) Fuel Oil
(9) LPG
(10) Naphtha
(11) LSWR
(12) Natural Gas
(13) HydroPower
(14) Geothermal
(15) Coal
(16) Electricity

(Q) Return to previous menu
(E) Exit DataBase

Enter a selection to continue

EXHIBIT I-3

PRODUCTION
CRUDE OIL CONDENSATE

Region : REGION1

Year : 1985 Month : JANUARY

Units : MBOE

Pertamina :	1.2
Lemigas :	-
Contractors :	3.4
Production Sharing :	3900.1
Total :	3904.7

Footnote : FOOTNOTE 1

Reference No. : 1-11-1111

a. Who are the Users?

o Managers and senior staff: will typically require highly processed data; i.e., fixed reports. Data base approximates an information system in this case.

o Professional staff: will typically require data as reported by their respective sources, in order to attain the largest flexibility for subsequent analysis.

b. What Resources are Available?

o Computer center: institutions with a central computer center based on a mainframe or a mini computer may opt for a data base designed on this equipment. This allows for few limits on amount of data stored, for importation of data files from other institutions with mainframes and minis, and so on.

o Professional office: micro computers are ideal for institutions (or units within a larger organization) where one individual can easily perform all computer management tasks of a separate computer center. Training for this individual need not be in computer programming.

c. Choice of Hardware

o Amount of data to be stored: micro computers will commonly store internally up to 10 million bytes (5 - 7 million characters) and with cartridge backups can store externally in theory an unlimited amount of characters. The limit on data stored at any one time is important, however, in the decision for or against a microcomputer based system.

d. Access to computers:

o micros have a clear advantage, in particular the

design/programming and data entry phases of the data base system.

- o Management control: control over unauthorized editing (insertions, deletions, modifications) of data files can be a problem with microcomputers, solved in part by use of passwords. Confidential information is easier to manage with separate computer centers.

e. Choice of Software

Commercial Software falls into two categories:

i. Filehandlers: best suited for lists of items, to store, sort and retrieve. Does not allow for customized menus. Few mathematical operations on the stored data are available.

ii. Data Base Management Systems: data base software allows large flexibility in access to data stored in separate files, in creation of menus, creation of displays of stored data and creation of reports that involve complex arithmetical operations on this data.

f. Training and Staffing

- o Data retrieval level: a well designed data base provides easy retrieval. Users require a minimum of training.

- o Analysts/Professionals: commercial data base software such as dBASE III permits users to manipulate stored data quite extensively. This requires knowledge of the commands available in the software, a task not unlike computer programming in a high level language. Learning a manual is required.

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- Programmers: at least one individual is required to program the basic structure of the data base, create extensions, write reports and so on. Training is provided by a manual, computerized tutorials and specialized books.

- Data Entry Personnel: training for this class of user is minimal. Supervision is required, depending especially on the number of personnel required for data entry.

4. Data Base Design Case Study

a. Establishing users requirements

The "Energy Planning Unit" (EPU) wishes to create a data base in order to store the information required by the staff to carry out their duties. This involves reports and data prepared on a monthly or a yearly basis by energy producers and energy utilities on production, sales as well as imports, exports, losses and stock changes. The value of these transactions as well as the unit cost and retail prices of energy sources are also collected. Other data routinely needed are up to date evaluations on energy resources, cost of developing these resources and lists of scheduled capacity expansion projects.

Among analyses of energy issues of responsibility to the EPU are predictions of future market trends. The analytical tools used in these predictions often create the need for data on demographic and socioeconomic indicators. The data base should therefore store data on national census statistics, as well as macroeconomic data from sources such as the Central Bank.

The data base is also required to store the reports produced by the EPU itself. For example, an energy balance can be prepared by the staff of the EPU on the basis of all the information stored in the data base, and in turn, the energy balance is stored as part of the data base. Other reports routinely produced by the EPU should also be stored in the data base: results of energy surveys, results of energy audits, results of new energy demonstration projects, etc.

b. Advantage of a computer based system

It is clear that the tasks of the EPU can be adequately executed with traditional methods of storage and retrieval of data: typed reports, books, stored in file cabinets or libraries. The computerized system gives the following advantages:

- o physical centralization of information
- o reduced time for access and ease of search via menus
- o report preparation from stored data
- o updates rather than re-entry of data
- o data manipulation
- o interface with other software/analytical tools

c. Sample menus and data displays

Exhibits I-1 - I-3 shown earlier are examples of printouts of menus for the EPU data base. As can be seen, one of the main design tasks is to organize the information. In the example exhibited, the user accesses "Production" followed by "Fuel Type (i.e. "crude/condensate"), followed by "Region 1". In this case, the user is prompted first on:

"What transaction?"

- o Production
- o Import
- o Export
- o Sales
- o Stock change

"What fuel?" followed by

"What region?"

The layout or format of a data display is at the discretion of the designer or programmer, as long as all text and information in the display be contained within 23 rows and 79 columns (i.e. one screen).

1 character = 1 column

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d. Reports

The arithmetic manipulations of the data in a report are unlimited. Besides the standard ones of creating extra rows and columns that operate on the data contained in a report (i.e. row and column totals or averages, growth rates, etc.), dBASE III allows to refer to each country as a variable in a program. In this way, extensive analysis of data can be performed by computer programming with dBASE III commands, which refer to data contained in the data base files.

5. Extensions of the database

The linkage of dBASE III to other commercial software is an important additional benefit of installing a microcomputer based data base that can evolve into a true information system.

As explained above, by programming the appropriate commands, stored data can be manipulated extensively in the data base. However, an alternative exists that avoids programming in the traditional sense: transferring data base files into commercial software packages that already contain the commands needed for a particular analytical function.

The most useful extension to the data base is the ability to link it with a spreadsheet. For example, Lotus 1 2 3 and dBASE III files can be transferred back and forth. A data set stored in dBASE III can be "imported" into the Lotus 1 2 3 spreadsheet, where it can be manipulated and transformed, as well as laid out in a desired output format. It can also be easily graphed. The resulting analyses and reports can then be transferred back into the data base, for easy search and retrieval by users through menus.

B. GETTING STARTED

1. Turning on the Computer

The actions necessary to begin EIASI depend on the machine involved. The full scale EIASI model with all data files and programs

requires the Color IBM-PC with the 10 MB hard disk and Bernoulli Box. If you are using the 2 drive floppy disk systems, transfer the appropriate files from the color machine to diskettes and use this part of the EIASI system on these machines. For more details on copying see the IBM DOS manual.

In this report references to the IBM are to the the color machine. In order to start the IBM make sure that power to the unit is on. This will almost always be the case as the computer systems manager will be responsible for powering up and down the machines each day. When power is on, flip the red lever in the back right corner of the system unit and the IBM will turn on. The topmost knob of the color monitor is the power switch. Turn the knob to the right and a green light should go on indicating that the monitor is active. The other knobs on the monitor are for brightness and contrast. A green light on the internal hard disk indicates power is on to the hard disk. The Bernoulli Box has an on/off switch similar to the system unit and is located in the rear. The Bernoulli Box should be turned on immediately after the system unit. There is no separate switch for the hard disk, the green light should turn on when the red lever is flipped. During operation, a red light on the floppy or hard drives indicate activity. A small white blinking cursor should appear on the monitor shortly after the red lever has been flipped on the system unit.

If the system is already on and you wish to enter the menu-level users mode you can do so by holding down the [Ctrl] and [Alt] keys simultaneously (located on the left of the keyboard) and pressing the [Del] key (located in the lower right of the keyboard). The screen should blank and the blinking cursor should emerge. Make sure that no floppy diskettes are in the top floppy drive at this time. If a floppy diskette is inside the EIASI system will not enter menu-level mode automatically; to remove a diskette turn the lever to the right and up and retrieve. <u>Place diskettes in a protective sleeve whenever not in use</u>. After approximately one minute, the red light on the top floppy drive should light. The red light on the hard disk will turn on

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next. Text will scroll on the screen. This is software required to configure the IBM and is automatic. Shortly the EIASI main menu will appear.

2. EIASI Main Menu

The EIASI main menu presents users with six options: Information System, RESGEN, Lotus 1-2-3, dGRAPH III, Backup Utility, and Exit to DOS. It is from this menu that users select the software appropriate for each use of the EIASI system.

Information System: The Information System contains the Numeric Database, the Bibliographic Database, and the appropriate File Management and other utilities to run the system.

RESGEN: RESGEN refers to the Reference Energy System Generator. A sub-menu takes users to RESGEN, the main calculation software, Resent and Table, data entry utilities for RESGEN, and Resp, the RESGEN graphing software. For more details on RESGEN and its operation consult the RESGEN Users Manual.(Appendix 2)

Lotus 1-2-3: Lotus 1-2-3 is commercial software which uses a spreadsheet format for structured calculations and graphing. Lotus is a superb tool for analysts and can be accessed through this menu as well as from the Information system and RESGEN. For details consult the Lotus 1-2-3 Users Manual.

dDRAPH III: dGRAPH III is a stand alone graphics program. Data can be graphed from appropriately entered data files or from a dBASE III file. dGRAPH III is more flexible and powerful than Lotus 1-2-3 for presentation graphics; however dGRAPH III takes more time to master and takes longer to produce specific graphs.

Backup Utility: The Backup Utility provides for the backing up of Information System and RESGEN files onto floppy diskettes. Periodic backing up of files should be undertaken, performed by the computer systems manager only.

Exit to DOS: This facility causes the system to exit to the IBM-PC Disk Operating System (DOS). This facility is for analyst-level users only.

II GUIDE FOR MENU LEVEL USERS

A. INTRODUCTION

Three user levels for the information system exist: users who only access the system menus (menu-level users), users who can use dBASE III commands (analyst-level users), and dBASE III programmers (programmer-level users).

This chapter is intended for the menu-level users only. The text below and the menu-screen section (Annex 2) provides sufficient information for menu-level users to retrieve information from EIASI. Chapter III contains a more extensive analyst's section for users who intend to use the Information System at the command level. Chapter IV is prepared for programmers who require information about system programs.

Terms and Syntax:

Throughout these chapters EIASI will refer to the entire set of computer software available. Information System will refer to the dBASE III software, menus, data files and utility programs. System Menu refers to the Main Menu available at start-up (For more information on start-up procedures see Chapter 1). Information System Main Menu refers to the menu available after the Information System option is chosen from the EIASI Main Menu. Numeric Database refers to the menus and numeric data associated with the Information System. Utilities refers to file management and conversion programs. Bibliographic dataBase refers to the search and retrieval system for Bibliographic Data.

Menu choices require a single letter or number to be typed in followed by a carriage return. Unless specifically mentioned, all typing should be performed in Capitals. Words do not require quotes and file names should not have extensions.

Problem Determination:

During normal operation no interruptions should occur. If there is a power failure or other interruption of the computer, turn off the computer and start again. Accidental pressing of the ESC key, located in the upper left of the keyboard may cause an interruption of the Information System Menus. If a message "PROGRAM INTERRUPTED TERMINATE PROGRAM(Y/N)" appears at any time, answer N and the menu system should continue uneffected. If user input cannot be interpreted by the menu system, the system may either ignore the entry and present the menu again or display unexpected information. If necessary move to the previous menu and try again. If you encounter other messages, press ESC answer Y, and then type DO BEGIN or press F10 to restart. If any other problems arise contact a person trained at the command level.

B. OPERATION OF EIASI BY USERS AT THE MENU-LEVEL

To access the Information System at the Menu level select the Information System at the EIASI main menu. A comprehensive listing of all menu screens with explanations appears in Annex II. A Welcome screen will appear (Exhibit II-1). Press any key and you will be faced with the Information System Main Menu. At this menu there are four (4) choices.

Chosing option (1) will take you to the Numeric Database (Exhibit II-2). A series of appropriate menus will lead to a regional breakdown menu (Exhibit II-3). Select the appropriate Region and either a table or other formatted display will appear (Exhibits II-4 - II-7). A menu in the lower right corner allows access to editing, appending, deleting, printing, and scanning options. When necessary you will be prompted for a Password to perform that option. An END OF ENTRIES message indicates no more data. Press any key and return to the Regions menu. You can now retrieve other data or move backwards through the menus to another branch or quit.

EXHIBIT II-1

The Energy Information System Welcome Screen.

Welcome to EIASI

Energy Information and Analysis System For Indonesia

DIREKTORAT JENDERAL LISTRIK DAN ENERGI BARU

DEPARTEMEN PERTAMBANGAN DAN ENERGI

REPUBLIK INDONESIA

Wednesday August 7, 1985 16:11:14

PRESS SPACE BAR TO CONTINUE

EXHIBIT II-2

The Numeric Energy Data Base Main Menu. This menu is produced when the user responds 1 to the Energy Information System Main Menu.

```
****************** Numeric Energy Data Base ****************

  (1) Primary Energy Resources

  (2) Secondary Energy Conversion Plants

  (3) Production and Foreign Trade

  (4) Demand and Consumption

  (5) Historical Series and Projections

  (6) Energy Prices and Tariffs

  (7) Technology Characteristics

  (8) National Socio-Economic Reports

  (9) International Statistics

  (Q) Return to the Main Menu

  (E) Exit DataBase

Enter the number of the area of interest
```

EXHIBIT II-3

The screen appears in almost every branch of the system, with only a varying heading. This menu is usually the last menu of the branch before the data is displayed. This menu provides an option to the user of information by regional breakdowns. Where there is more than one screen or data group for the region, e.g. several refineries, each one will be displayed successively. The User presses [PgDn] to view the next data group.

```
NUMERIC
PRIMARY ENERGY RESOURCES
OIL

(1) Region 1 Data
(2) Region 2 Data
(3) Region 3 Data
(4) Region 4 Data
(5) Region 5 Data
(6) Region 6 Data
(7) Region 7 Data
(8) All Regions
(9) National Data
(10) National and Regional Data

(Q) Return to previous menu
(E) Exit DataBase

Please select a number
```

EXHIBIT II-4

This screen displays a sample formatted data display for Petroleum Refineries in the Conversion Sector. Data is displayed and a short menu is produced for various user options. Append and Edit options will ask for a password. A password will only be asked for once during any one run of the Energy Information System Menus. A run begins with the Loading Message. Each data requirement can have a different formatted display to best suit the data. These displays can also be modified quickly and easily even after data has been entered. Many different formatted displays were developed for the Energy Information System.

SECONDARY ENERGY CONVERSION PLANTS
Petroleum Refineries

Refinery Name : REFINERY1 Units : Region : REGION1

Plant Capacity :	5000	B/D
Gasoline Capacity :	17.8	%
Kerosene Capacity :	26.8	%
Diesel Capacity :	14.8	%
Fuel Oil Capacity :	0.8	%
Lube Oil Capacity :	0.0	%
Waxy Residue :	44.5	%
Bitumen :	1.2	%
Heavy Naphtha Export:	0.0	%
LPG :	NA	%

(N)ext (E)dit
(A)ppend (Q)uit
Print <Shift><PrtSc>

Reference No. : 001

Footnote :

Enter a selection to continue

EXHIBIT II-5

SECONDARY ENERGY CONVERSION PLANTS

Transmission Distribution Lines (Km)

Region : REGION1

Extra High 500 KV :	0	
150 KV :	645	(N)ext (E)dit (A)ppend (Q)uit
70 KV :	970	Print <Shift><PrtSc>
20 KV :	5500	
6 KV :	0	

System Losses (%) : 0 Number of Sub-Stations : 0

Reference No. :

Footnote : SYSTEM LOSSES ARE OWN USE, TRANSMISSION, AND DISTRIBUTION

Enter a selection to continue

EXHIBIT II-6

PRODUCTION
CRUDE OIL CONDENSATE

Region : REGION1

Year : 1985 Month : JANUARY

Units : MBOE

Pertamina :	1.2
Lemigas :	-
Contractors :	3.4
Production Sharing :	3900.1
Total :	3904.7

Footnote : FOOTNOTE 1

Reference No. : 1-11-1111

EXHIBIT II-7

PRODUCTION
NATIONAL
AVGAS
JAN

REFINED PRODUCTS FROM DOMESTIC REFINERIES (in Barrels)

YEAR	P.BRANDAN	DUMAI	S.PAKNING	PLAJU	S.GERONG
1982	0	0	90	0	0
1983	552774	1290680	1437133	2534070	2514551
1984	0	0	0	0	0
1985	0	0	0	0	0
1986	0	0	0	0	0

YEAR	CILACAP	WONOKROMO	BALIKPAPAN	CEPU	PROCESSING DEAL
1982	0	0	0	0	0
1983	4626436	6418	1297007	0	274607
1984	0	0	0	0	0
1985	0	0	0	0	0
1986	0	0	0	0	0

Footnotes can be viewed with the edit option
(C)ontinue (E)dit (A)ppend

Option (2) takes you to the Energy Units Conversion Utility (Exhibit II-8). This utility changes data from a particular energy unit to another. You will be prompted for the data file, new file, and new unit. A conversion takes place. The data can then be accessed through the command level. This activity requires some additional instructions and is geared primarily for analyst level users.

Option (3) takes you to the Bibliographic Database (Exhibit II-9). You choose the appropriate DataBase and are presented with a Search Menu (Exhibit II-10). The Bibliographic DataBase can be searched by Accession number, by ISBN number, by ISSN number, by up to two Authors, by up to two Keywords/Subjects, by up to two Locations, by a Category, or by a Document.

Each search option leads to a search screen (Exhibit II-11). Default values may be present. All data will appear in capitals regardless of how it is typed in. Fields with an X in the first column indicate further ways of narrowing the search that are optional. A return must be pressed after every entry. A carriage return without an entry moves the user to the next field. The last return initiates the search. A search is conducted and the number of entries found that match the search criteria (Exhibit II-12).

The user can return to the search menu to reinitialize a search, print out and/or display accession numbers, titles, and authors. The search menu also allows users to page through all entries. Paging through the data involves viewing data one full screen at a time. Each full screen contains the complete details of a single entry (Exhibit II-13). A command menu appears in the lower left. Users can Append, Delete or Edit data. They will be prompted for a password once during any session with the Information System. Thereafter the password verification is assumed to be valid.

EXHIBIT II-8

This is the Units and Conversion Utility. Information stored in the Numeric Data Base was chosen to remain in the units of orignal processing as often as possible. Analysts, however may wish to have duplicate databases with all data in a common unit. A report form can be created to perform a conversion of units if all the units in a column are the same. When the units in a column are different this utility will convert them all to the unit of the users choice. The conversion table accessed by this utility, CONVERSI.DBF, can be expanded to any size and for any units the user chooses.

In this example the user is converting all units in the Convert database to TOE and storing the data base TOE_DATA.DBF

The original units (i.e., those in the CONVERT file, must be listed in CONVERSI.DBF in order to perform the conversion.

```
******************UNITS CONVERSION UTILTITY****************

Enter the name of the source database CONVERT

Enter the name of the target database TOE_DATA

Enter the units to convert to TOE
```

EXHIBIT II-9

The Bibliographic Date Base has the ability to store text information with a common format and selectively retrieve this information according to a search criteria. The Bibliographic Database has a flexible format to accept entries concerning a wide variety of different sources, Reports, Articles, Survey Analyses etc. The Energy Projects Database focuses on a more narrow data type, Energy Project information that is taking place in Indonesia.

********** Bibliography **********

Bibliographic Data Base :

(1) Bibliographic

(2) Energy Projects

(Q) Return to previous menu

(E) Exit Database

Enter a selection to continue

EXHIBIT II-10

The Bibliographic Database allows for searches on a variety of fields in the entry form. There is also a utility for entering new records, and a Keyword Utiltiy to provide present and updated list of all subjects/keywords in use in the system.

```
SEARCH BY: (1) Accession Number
           (2) ISBN Number
           (3) ISSN Number
           (4) Subject
           (5) Author
           (6) Location
           (7) Source Document
           (8) Category Code
           (9) Enter New Records
           (K) Keyword Utility
  (E) End Session

Enter a selection to continue
```

EXHIBIT II-11

A sample of a search for either of 2 SUBJECTS.

```
Search for SUBJECT:  OIL
                OR :  PETROLEUM


Search in progress...
```

EXHIBIT II-12

A screen that appears after every search. Option 2 will view or send to the printer Title and Author information only.

3 Entries have been found

(1) View all entries

(2) View titles only

(3) Return to Main Menu

Enter a selection to continue

EXHIBIT II-13

A sample Bibliographic Entry for a book. The user has a full menu of options with appropriate password protection. The summary field can be up to 50,000 characters of text information.

```
ACCESSION #     3 ISBN # 0-19-582527-60 ISSN #                ENTERED 05/05/85
                                                              REVISED 05/05/85

TITLE          The Petroleum Resources of Indonesia


LANGUAGES       E                                   YEAR PUB.   82

AUTHORS        1 OOI JIN BEE                 2
               3

KEYWORDS       1 PETROLEUM                   2 RESOURCES
               3                             4

DOCUMENTS      1
               2
CATEGORIES     1
               2                                 (N)ext      (E)dit
NOTES .......   HardBack                         (B)Previous(D)elete
STATUS ......                                    (S)ummary   (P)rint
LOCATION ....   USA                              (A)ppend    (Q)uit

Enter a selection to continue
```

Appending produces a message of the highest accession number to date, a pause, and then a blank screen in the form of an entry display. The user can then enter data which will become part of the Bibliographic DataBase. Editing produces the current data record with a blinking cursor in the upper right corner. The user can then make any editing changes that are required. The command menu contains options for printing the full screen. The user can also view a summary which contains an abstract, further description, or other data. Finally, the user can view the next page, the previous page, or quit and return to the previous menu.

Option (4) is a file management utility (Exhibit II-14). This utility allows users to view directories of files, to view a special directory with file descriptions, to change to the RESGEN sub-directory, transfer files from dBASE III to Lotus 1-2-3, dGRAPH III, and to view previously prepared reports.

C. EXPERT USERS

The analyst level user takes over when a user choses not to quit the Information System using the Exit Menu. An EIASI prompt appears at the command level. At this level and with proper training a user can change all of the dBASE III functions (see chapters III and IV). With this option comes the risk of inadvertently changing the dBASE III code so as to render the system inoperative or make it malfunction. Analyst should be acquainted with those actions that will affect the code. In the event of accidental altering of the code, the correct code can be reinstalled from the master copies of the system or the damage may be repaired by a programmer. Proper training should eliminate the possibility of any damage to the code.

At the analyst level the user can APPEND, DELETE, EDIT or CHANGE any and all data. This is an essential function in the performance of analysis. The user can also graph any data, transfer parts of files to Lotus 1-2-3 for further analysis, or

EXHIBIT II-14

To provide for a more convient user interface, a file management utility was created. With this utility users can access various directories of files, produce an already existing report, move to RESGEN, or convert a data file for use with LOTUS 1-2-3 or dGRAPH III. It is the file interchangability of the Energy Information System that helps to make it an integrated whole and a complete analytical tool.

```
**********************FILE MANAGEMENT*******************

(1) Directories

(2) Report Generation

(3) Resgen

(4) Lotus 1-2-3

(5) Dgraph III

(Q) Return to previous menu

(E) Exit DataBase

Select a choice to continue
```

create reports from selected data. It is expected that at this level users will have been trained thoroughly, reviewed the dBASE III tutorial, and be actively using stored data. It is recommended that analysis always be done with scratch copies (i.e., an original set be stored separately) of the stored data. The user at this level has the considerable power and flexibility of dBASE III at their command.

Programmer-level users for dBASE III require extensive training. Programmers will be able to make any and all necessary modifications or additions to the menus and code as they become necessary. Only the designated programmers should exercise this option. Programmers are also responsible for the required Hardware and Software maintenance of the machine and should be able to consult the DOS 2.1 Users Manual as well as the dBASE III Users Manual, if technical questions arise.

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III ANALYST-LEVEL USERS

A. INTRODUCTION

Before reading this chapter familiarize yourself with both the General Information and Menu-Level Users chapters. In addition, analysts should perform, twice, the entire dBASE III tutorial provided by Ashton-Tate, the software developer. Other required reference tools are the DOS users manual, and the Lotus 1-2-3 and dGRAPH III manuals and tutorials.

B. DOS COMMANDS

DOS or the Disk Operating System is the administrator of the computer. The commands of DOS are used to COPY, DELETE, and RENAME files, edit files, move to different file areas, and transfer files between various application programs. There are three drives on the IBM: the two floppy drives, labeled A and B, and the hard drive labeled C. The hard drive contains a root directory and sub-sections called sub-directories in which various files and programs are permanently stored, while the floppy drives use diskettes which contain files and programs. Floppy diskettes are the storage medium where analysts' files should be kept. Each analyst should keep a copy of their important files on their own diskettes and be in charge of maintaining them. Diskettes are subject to damage, it is therefore important to make appropriate duplicates.

If there is a diskette in the A drive when the IBM is turned on, the programs on the A drive are executed otherwise the C: root drive is accessed automatically. To change drives type the letter corresponding to the appropriate drive plus a :, e.g. A:. To change sub-directories within the C drive type CD \Sub-directory name.

The following are DOS commands are likely to be used by analysts: COPY, FORMAT, DEL, RENAME, DIR, TYPE for details on the function of these commands see the DOS Users manual.

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FILES

All information on the computer is contained within files. Every file has a name. A name can be 1-8 alphanumerics, followed by a period, followed by 0-3 alphanumerics. The first eight characters are called the file name. The characters following the period are called the file extension. Every file has an associated time and date of creation or most recent editing version. File names should be chosen carefully to reflect some element of the files contents. With a large number of files, this procedure becomes all the more essential. Various software requires specific files to have specific extensions.

File	Required Extension
Software	COM or EXE
Batch processing	BAT
Lotus 1-2-3	WKS or PRN
dBASE III	DBF,DBT,FMT,FRM,MNU,SCR,SER,PRG
Text	TXT

Failure to obey these conventions will likely cause serious operating difficulties. Fortunately many of the extensions are included automatically.

FILE HANDLING

File Directory: The DIR command produces a file directory, i.e., a listing of all files in the default (the active) drive or subdirectory, in a column format. The default drive and subdirectory will be displayed to the left of the > symbol when in DOS at the beginning of each line. DIR/P produces a directory in column form with a pause every 20 lines. DIR/W produces a directory horizontally and without time or date information.

Copying Files: The COPY command copies files from one drive to another. The duplicate of the file can be given a name other than the original if desired.

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A > COPY TEST.TXT B: places a duplicate of TEST.TXT in B: B> COPY TEST.TXT C:\SUBDIR copies TEST.TXT to the hard disk in sub-directory SUBDIR. If no sub-directory is specified the file is copied to the default C:\sub-directory. B>COPY TEST.TEXT NEW.TXT creates a duplicate of TEST.TXT called NEW.TXT on B: C: DBASE>COPY TEST.TXT \LOTUS copies files between sub-directories.

Deleting Files: The DEL command deletes a file. e.g.DEL TEST.TXT

Changing File Names: The RENAME command renames files. e.g. RENAME TEST.TXT NEW.TXT renames TEST.TXT to the name NEW.TXT

Displaying the Contents of a File: This command works only with files stored in Ascii text characters. TYPE TEST.TXT will produce a copy of the file to the screen. If strange symbols appear on the screen do not panic, a command to type a non-ascii file has been issued. After the computer stops typing you can proceed.

Wild Cards: to allow processing of more than one file at a time, a wildcard convention allows * to represent any number of characters and ? to represent any single character for DOS commands. For example:

DIR	DIR ONE.*	DIR *.BAT	DIR *.??T
ONE.TXT	ONE.TXT	ONE.BAT	ONE.TXT
ONE.BAT	ONE.BAT	TWO.BAT	ONE.BAT
TWO.BAT			TWO.BAT

PRINTING THE SCREEN

[Ctrl][PrtSc] - Sends all information to the screen and the printer until another [Ctrl][PrtSc] is issued.

[Shift][PrtSc] - Sends the contents of the present screen to the printer.

TYPE TEST.TXT PRN - Sends the results of the TYPE command to the printer instead of the screen.

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ABORTING OPERATIONS

The computer may become locked in an operation you wish to stop. [Ctrl] C, Esc, or [Shift][Break] will often stop execution. In extreme cases [Ctrl][Alt][Del] will restart the machine, however all unsaved information will be lost. In the advent the keyboard is unresponsive a system shut down and restart may be required. To do so turn off the power and wait 10 seconds before restarting the machine. DO NOT PERFORM A SYSTEM POWER DOWN without prior experience or the presence or a knowledgeable system operator.

PREPARING DISKETTES

The preparing of blank diskette for data should be performed by the system maintainer. If no blank diskettes are available perform the following commands.

(1) Locate a new diskette and place it in drive B:
(2) Place a DOS diskette in drive A:
(3) Move to the A: drive in DOS
(4) Issue the command FORMAT B:
(5) Follow subsequent instructions
(6) NEVER ISSUE A FORMAT C: COMMAND AS THIS WILL DESTROY ALL INFORMATION ON THE HARD DISK
(7) If you are unsure of what you are doing, consult the system maintainer.

DISKETTES & MEMORY

All diskettes should have a label. Do not write on a label when it is on a diskette as the pressure of the pen may cause damage. Write on the label and the affix the label to the diskette. Keep diskettes away from dust, heat, magnets, water and smoke. Diskettes will usually contain 360,000 bytes. A byte is a single unit of information. The amount of room remaining on a diskette and the size in bytes of all files can be obtain with the DIR command. The

hard disk contains approximately 10,000,000 bytes. Although this is a vast amount of room, it can quickly become filled if out-of-date files are never removed. Maintenance of the hard disk is the responsibility of the system maintainer, however each user must remove their personal files when they are no longer needed.

ACCESS TO EIASI

To return to the menu-level system at any time from within DOS:

C:
C:\
EIASI

The hard disk contains the following sub-directories: C: C:\DBASE C:\RESGEN C:\LOTUS C:\DGRAPH Each of the subdirectories contains the files appropriate for that application.

If you have difficulties accessing a particular file or applicator, check if you are in the appropriate sub-directory. If you require files for a particular application, copy the appropriate files to the appropriate sub-directory or diskette.

WARNING! By having access to the DOS you take on the responsibility of potentially damaging the system. If you are unsure of a command consult the computer systems maintainer.

C. dBASE III COMMANDS

The following materials are in no way intended to replace the extensive use, by analysts, of the tutorial provided in the dBASE III manual. These materials are supplementary and illustrative only.

1. Selective Retrieval

For example, enter command for retrieval of all data where

production > 500.

Data file is as follows:

Year	Production	Location	
1982	100	Java	Record 1
1983	600	Sumatra	Record 2
1984	1150	Timor	Record 3

dBASE III command for selective retrieval is:

LIST ALL FOR PRODUCTION > 500

Result will appear on screen as follows:

Year	Production	Location
1983	600	Sumatra
1984	1150	Timor

2. <u>Sorting</u>

Permanent sort - SORT command - Rearranges the physical location of data records. SORT is best used when data will only be displayed in one order, e.g. alphabetical. SORT is much slower than INDEX.

Display sort - INDEX command - Rearranges the location of data records for display only. INDEX is best used when the same data will be displayed with several ordering schemes. e.g. alphabetical, chronological, and size.

Result

ORIGINAL RECORDS	SORTED RECORDS	INDEXED RECORDS
Record 1 A	Record 1 A	Record 1 A
Record 2 C	Record 2 B	Record 3 B
Record 3 B	Record 3 C	Record 2 C

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3. Manipulation - addition (+) subtraction (-) Multiplication (*) Division (/) Exponentation (**)

With record pointer on Record 2 of example above:

Command ?PRODUCTION * 1.5

Result 900

4. Creation and editing of files - making a new database

Design - What type of information is to be placed in this file? Is the data sufficiently similar to warrant inclusion in the same database? How many fields must be ALPHANUMERIC characters, NUMERIC numbers, DATE dates, LOGIC (yes/no and true false) and MEMO (more than 254 characters)? These are all questions which must be answered prior to creation of a database structure.

Command CREATE TESTBASE

Result - a full screen display

FIELD CHAR/NUM WIDTH DEC

Enter fields in the order, from left to right, that they will most often be displayed. Use the lowest possible width that still can describe entries meaningfully.

After creation you are prompted, Input data now ?. If you respond No you have an empty database. To enter the first record at a later time you must bring the file into USE and then issue APPEND.

To edit records in an existing file use the EDIT command. [PgDn] and [PgUp] will move you between records.

To edit a specific record number: Type GO record number and then EDIT.

To add a new record to the bottom of a file use APPEND.

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To edit only those records that satisfy a condition, e.g. production 500, issue CHANGE ALL FOR PRODUCTION. 500. CHANGE will jump to the next record that satisfies the condition when you [PgDn]

To delete a record the record must be marked for deletion and then packed. To mark a record for deletion issue a U during browse or editing of the record. When at the prompt issue PACK to remove those records marked for deletion.

To view data in a column format use the BROWSE command. The help F1 feature is very useful with BROWSE. User assistance is available for all dBASE III commands with either HELP or ASSIST.

Analysts will often use the following dBASE III COMMANDS and they should receive extra attention during the tutorial.

APPEND	EDIT ASSIST	ERASE AVERAGE
HELP BROWSE	INDEX CHANGE	INSERT
CLEAR	LIST COPY	QUIT COPY FILE
RENAME COPY STRUCTURE	REPORT FORM COUNT	
SORT CREATE	USE CREATE REPORT	ZAP DELETE
DIR DISPLAY DO		

5. Lotus 1-2-3 interface:

To transfer a dBASE III data file to Lotus, choose this option under the File Management menu or USE FILENAME and then COPY TO FILENAME.PRN DELIMITED. Quit dBASE III and transfer the .PRN file to the LOTUS sub-directory.

D. dBASE III VS LOTUS 1-2-3

One of the central questions that was discussed during the EIASI design and training sessions was when, where, and for what applications is the use of LOTUS 1-2-3 vs dBASE III appropriate. To aid in the transportation of data files around EIASI, LOTUS 1-2-3 has

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been established as the most convenient medium. Analysts should feel comfortable with moving data files and with working in both environments. Movement of data will usually be from a dBASE III file to LOTUS 1-2-3, as the dBASE III databases are designed to store "master copies" of data, and analysts who wish to manipulate data therein should make an appropriate working copy of the file.

LOTUS 1-2-3 is the preferred medium for data sets requiring either complex and repetitive calculations of numeric data, or when numeric data is highly relational (i.e. changing a value should change a whole set of dependent values automatically). dBASE III is the clearly preferred choice for data that is likely to be queried via menus (e.g list of values or character information that satisfies a search criterion, or stored matrices of data, fuel consumption in several areas for several years).

In cases where numeric data are equally suited to both environments, dBASE III is the logical location, as this is the designed medium for storage of all "master copies" of data. The best method for determining the appropriate environment for an applications is a thorough knowledge of both pieces of software, the capabilities and their limitations. Analysts should record the location of various applications that may be used by colleagues so as to minimize time spent searching for another's analysises. Careful planning can insure that applications take the greatest advantage of the tools at hand.

E. OPERATING LOTUS 1-2-3

Before using Lotus 1-2-3 it is strongly recommended that you perform the Lotus 1-2-3 tutorial. To take the tutorial:

(1) Select option 6 to exit to DOS from the EIASI main menu.
(2) Type CD\LOTUS to move to the LOTUS sub-directory
(3) Type TUTOR

(4) If you receive a bad command or filename error, the tutorial is not present on the hard disk. Place the LOTUS tutorial disk in drive A:. From drive A: issue TUTOR.

To operate Lotus 1-2-3 on the color machine the Lotus 1-2-3 system disk must be in drive A: with the drive door closed. This includes selecting the Lotus option from the EIASI main menu as well as when using Lotus 1-2-3 from DOS.

To store and retrieve files from a drive other than C:\LOTUS you must change the file directory command in Lotus 1-2-3. For information on how to do this consult the Lotus 1-2-3 manual.

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IV PROGRAMMER LEVEL USERS

A. INTRODUCTION

This chapter is intended for the computer systems manager and programmers only, and contains a few tips and suggestions not found in the dBASE III manual.

A single major programmer designed and executed EIASI, and so all the programs reflect the same "style". An attempt has been made to document the programs and modularize them as much as possible.

Programming in dBASE III is much like programming in Pascal without the variable definition structures. In general the following rules will provided for the fewest programming difficulties:

(i) Programs should be small as these present the fewest difficulties.

(ii) All programs should be documented

(iii) Work on programs should be performed in a scratch sub-directory

(iv) Backup copies of important files should be created regularly

(v) Programs already in the Information System (See Chapter IV) provide useful example to work from.

(vi) The dBASE III manual and third party books are valuable reference materials and should be used regularly.

(vii) The listings that can be produced for the programs used in the Numeric and Bibliographic Databases are the best source for working programs and should be used for reference.

For details on the DOS Shell read the DOS batch file and copy the program closely, especially the error level logic. The DOS Shell is listed in section B of chapter IV.

B. TECHNIQUES, TIPS AND HINTS

Multiple files: Use the SELECT statements for multiple files. Use DISPLAY STATUS to make sure everything is properly set. To produce multiple file reports keep all files in RAM with SELECT and then use SET RELATION to link the first to the second and the second to the third etc.. use the = notation for referencing the linked files.

SORT versus INDEX: Never SORT, always INDEX. Use QUICK INDEX when the record number exceeds 300. Indexes often produce apparent bugs. Keep track of what is in status. REINDEX may clear up problems.

Files: An attempt has been made to keep the file extensions consistent within similar functions. Use the DIRECTOT.DBF which provides a list of all files and an explanation of each file. Update this directory whenever new files are added. Filenames should be chosen to convey as much information about there contents as possible.

The dBASE III manual: Consult the dBASE III manual often and carefully. The answers to most questions can be discovered in the dBASE III manual or by examining programs already in existence. The tutorial section as well as the sample programs listing in the dBASE III manual are valuable reference tools.

Printers: Escape codes can be generated with the ??CHR(number) syntax, these can be linked with a + sign. Use the @SAY ' '+ syntax and the set device to print syntax to send formatted output to the printer. Look at the Bibliographic print routines in the DISPLAY.DSP program for further information.

Memory Variables: Keep track of memory variables, they will be invisible to the DISPLAY MEMORY command when they have been created within a program. Create them outside a program if you want to debug their behavior.

Debugging: Use the SET TALK ON, and the SET ECHO ON functions to debug. There are others you can also try. Use WAIT and ? often to see where the program breaks down.

C. READING THE dBASE III MANUAL

The dBASE III manual is divided into twelve sections: Section One is the quick reference chart. In general this document is useful for the experienced user who needs only a reminder of commands, but is not very useful for beginners. One exception is the Class of Commands section at the end that groups commands by function.

Section Two is devoted to Getting Started instructions and, in the case of the Version 1.1 manual, a sub-section on changes from Version 1.0.

Section Three is the tutorial. This tutorial is a extremely important for beginners and should be performed at least twice. Users will want to go back to this tutorial for details on certain operations that are described only briefly in the Commands section. Unfortunately, there are many valuable commands that are not used in the tutorial. It is up to the user to learn how to use these from the command page.

Section Four appears only in Version 1.0's manual, a tutorial appendix with the program listings of every file on the sample programs diskette. This reference is contains useful examples of programming techniques and syntax.

Section Five is called the reference section. This contains definitions of file and field types, technical specifications for file sizes etc. Also included are descriptions of multiple file handling, and file interchange formats.

Section Six contains keywords. This section should be merged with the glossary section by rearranging the pages in the dBASE III manual.

Section Seven contains all of the dBASE III commands. This consists of one page of information per command. The contents of the help screens are a subset of this information.

Section Eight contains all of the dBASE III functions in a similar format to the commands section.

Section Nine are Appendices. Appendix A contains two examples of a database structures and the appearance of their data. Appendix B contains all the information about setting dBASE III parameters at startup. Appendix C provides a table of how functions (e.g. End of file markers), are interpreted by dBASE III with varying system parameters in place. Appendix D lists Wordstar "style" full screen and dBASE III word processor commands for cursor commands and [Ctrl][Keystroke] combinations. Appendix E lists the Ascii table and the escape codes for printer controls. Printer escape codes can be sent with the ??CHR$(code #)+CHR$(code #)+... syntax. Many printers require CHR$(27) and then another code #.

Section Ten the Glossary of terms.

Section Eleven is the Index.

Section Twelve is a the dBASE BRIDGE a section which describes the conversion of dBASE II to dBASE III files.

D. dBASE III COMMANDS

The dBASE III manual command section contains one page of explanation about every dBASE III command. The pages are ordered alphabetically by command. Below is a list of commands that would be useful to the programmer. This is list does not include commands

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which are useful for the analyst and which appear above, or commands for which no comment is necessary. These descriptions are not meant to replace the manual only to supplement it:

CREATING FILES

COPY - copies a database in use to another name, but cannot be used for copying a non-database file. The associated .dbt file will also be copied.

COPY FILE - makes a duplicate of a file. All DOS syntax options for copy pertain, (e.g. drive and sub-directory designators). To copy a file to a .prn file add the suffix, DELIMITED.

INDEX - creates an ordering of records for display and editing by creating a complimentary .NDX file.

MODIFY COMMAND - command for creating or editing all but report and database files.

EDITING COMMANDS

BROWSE - is a very useful format for viewing and editing data.

DELETE - only causes a file to be marked for deletion, does not remove it. To remove a record use PACK

READ - required at the end of any formatted data entry screen which accepts user input to a GET.

REPLACE - handy command for making changes to data. Linked with the copy command with conditions can be a powerful data entry technique for mass data entry of similar entries.

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HELP COMMANDS

ASSIST - menu driven approach to issuing commands. Very awkward at first, but useful for learning command syntax.

HELP - a command name issued after HELP will reveal the specific help for that command or the help main menu.

DATA DISPLAY

TEXT - an alternate form to ?' syntax for involved menus. Requires an ENDTEXT command.

MANIPULATING DATABASES

APPEND FORM - adds records from other database files with a similar structure to the database in use, or from an outside delimited file with a columns format.

ERASE - delets a file, requires the extention, cannot work on a file in use. A close databases, format command will allow files to be erased.

For information on other commands see the configuring your system section, and the dBASE III manual.

E. dBASE III FUNCTIONS

In general the dBASE manual has a good discussion of the functions available in dBASE III is good. Here are a few additional hints:

& - MACRO FUNCTION

This function is one of the most powerful available in dBASE III. dBASE III commands take character strings literally. This is fine

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unless you want to operate on a string variable.

e.g. USE DATAFILE brings the database DATAFILE into the workspace, if you want to prompt the user for the database name and automatically USE this file, e.g.

```
ACCEPT 'Enter database name ' TO FILENAME
USE FILENAME
```

This sequence results in an attempt by dBASE III to load FILENAME and not DATAFILE into the workspace because FILENAME in the USE command is taken literally. The following are the appropriate commands.

```
ACCEPT 'Enter database name ' TO FILENAME
USE FILENAME
```

This sequence results in the correct file DATABASE being brought into the workspace. dBASE III interprets the & symbol as, "replace the following string variable with its value for this operation".

A useful technique is to store a variables name to a variable in a program.

```
ACCEPT 'Enter high volume database name 'TO HIGH
ACCEPT 'Enter low volume database name 'TO LOW


IF NUMBER  calculated elsewhere   10
 STORE '&HIGH' TO LEVEL
ELSE
 STORE '&LOW' TO LEVEL
ENDIF

USE &LEVEL
```


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This routine conditionally stores one of two variable names to LEVEL. USE &LEVEL is interpreted as USE the string stored to the string variable HIGH or LOW.

BOF() and EOF() - this functions return true or false to beginning and end of file respectively. More information on what can effect these results is located in the Reference pages of the dBASE III manual. To indicate not BOF() or EOF() in a program use the following syntax:

```
IF .NOT. EOF()
 DO WHILE .NOT. EOF()
```

DATE FUNCTIONS - there is a complete set of date functions provided with dBASE III for both date arithmetic and character representation. Note that the day and year are considered to be numeric data and therefore are allocated 9 spaces. If you try and post todays date on a screen the spacing will be awkward. Here is one way of displaying the date attractively. See the Welcome screen in BEGIN.PRG for an example.

PCOL and PROW - these functions return the current printer column and row position and are useful for printing programs where the next line should be printed conditional further down depending on input. For an example see the dBASE III manual.

UPPER - this function converts a string to uppercase. This function is very useful for statements that evaluate a response to an ACCEPT command such as CASE and IF statements from menu displays. This function will guarantee the correct character match reguardless of case.

(1) Hello
(2) Goodbye
(Q) Quit

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```
ACCEPT 'Enter choice to continue 'TO CHOICE
     DO CASE
     CASE CHOICE = '1'
      STORE 'HELLO' TO MESSAGE
     CASE CHOICE = '2'
      STORE 'GOODBYE' TO MESSAGE
     CASE UPPER(CHOICE) = 'Q'
          note: never put 'q' because this can never match
          an uppercase character
      RETURN
     ENDCASE
```

F. dBASE III REPORT WRITING

1. Report Form Command

dBASE III has a menu driven report writing facility. To create a new report form called REPNAME issue either CREATE REPORT REPNAME or MODIFY REPORT REPNAME at the "." prompt. A full-screen menu assisted report writer will begin. The documentation covers this creation command and the commands for generating a copy of the report. Below is extra help on the features of the report writer.

2. Report Form Features

Heading

The heading section of the report form will appear on the top of the page when the report is processed to screen or printer. The heading starts about 30 spaces in from the left so care should be taken for centering this text. If a heading statement is issued in the report processing command this will precede the first line of the heading text, on the same line. The heading feature of the report processing command will only except 1 line of text.

Subtotals

On page two of the form, reached at with [PgDn], is the subtotals option page. If subtotals are selected, Each unique element in the subtotals field will be grouped with any identical elements and any

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numeric fields subtotaled. Sub-subtotals follow the same rule within each subtotal. A grand total is always given at the bottom. The subtotal heading will precede the field element when it is printed on the report form. All subtotals are appropriately indented. Subtotals are prefaced with 1 * and sub-subtotals with 2 **.

Help

Function key F1 will toggle between cursor key help screen and a schematic of the fields, types, and lengths of the database in use.

Field Contents

This row must contain the field name exactly as it appears in the database structure. A calculated field can be obtained by using and operator (+-*/**) between the first field name and others of constants.

e.g. REVENUE + INCOME
SALES * .075

Decimals indicates how many decimals places for numeric displays of data.

Field Heading

Any string can be placed here and will appear on the top of the column. The width specification on the last row of the form is calculated as soon as the field name is determined. The heading is displayed near the top of the form when you proceed to the next page. If the string is longer than this make sure that the heading displayed near the top of the form is to your liking. Return to the page, with [PgUp] and you may have to retype the string and or change the width.

Columns Remaining

As long as the columns remaining is positive all is okay. If the column defined is between 0 and -52 you will need to print in compressed mode to fit the table on the paper. For details on

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invoking compressed mode form within dBASE III see Printing your output. Files of any length can be sent to Ascii .txt files when the report form processing command is issued.

Problem determination

If columns headings appear chopped off see Field Heading above. If a Syntax error in report form error occurs after a report form command is issued common causes are incorrect fieldnames, no database in use, or illegal fieldname calculation statements. If report does not print make sure printer is on and on line.

To Modifying an existing report form, issue Modify Report Repname

REPORT FORM COMMAND OPTIONS

The easiest way to produce many reports from the same data with different records conditional included is to use the scope and condition options of the REPORT FORM command. This cannot be done using a field calculation statement.

3. Reports from Multiple Databases

Reports from multiple databases can be a very powerful and useful tool. To produce a report form accessing data in different databases you must use the SET RELATION commands. The number of databases that can be linked into one report is limited by the dBASE III files limit and the DOS files allocation in CONFIG.SYS, with ten as an upper limit. Consult the reference section of the dBASE III manual for more details. In order for a database to be used in a report form it must be in use. Up to ten files can be in placed in use with the SELECT command. To verify the status of all files in use and all relations set, use the display status command. Only two files may be linked with a SET RELATION command, but several can be linked with multiple SET RELATION commands. Once two databases are in use and a common field exists between them and that field is index in the linked database, the set relation command will link them. From within a

Report Form in the Field Contents line issue a

FIELDNAME

command where, fieldname is the name of the field in the to be displayed and is contained in a database not in Select area one and linked to the database in Select area one or linked to another database. As long as the database is linked in a direct or indirect fashion with the database in Select area one it can be accessed in the manner.

Below is an example of 3 databases being prepared for inclusion in a report form.

Databases DATA1,DATA2,DATA3 all exist.
DATA1 contains column of interest DATAONE
DATA2 contains column of interest DATATWO
DATA3 contains column of interest DATATHRE
DATA1 and DATA2 both contain the field SECFIELD
DATA2 and DATA3 both contain the field THRFIELD
DATA2 is indexed on SECFIELD to SECOND
DATA3 is indexed on THRFIELD to THIRD

```
SELECT 1
USE DATA1
SELECT 2
USE DATA2 INDEX SECOND
SELECT 3
USE DATA3 INDEX THIRD
```

all 3 files are now in Use

```
SELECT 1
SELECT 2
SET RELATION TO SECFIELD INTO DATA2
SELECT 3
SET RELATION TO THRFIELD INTO DATA3
```

all 3 fields are now linked

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REPORT FORM
FIELD CONTENTS: COLUMN 1 COLUMN 2 COLUMN 3

DATAONE ⇒DATATWO ⇒DATATHRE

Problems can usually be linked to databases either not in use, improperly linked, or improperly indexed. Display status to confirm these database attributes.

G. dBASE III MENU WRITING

1. Purpose of Menus

A menu-driven system has several advantages over a command system. In a command system users must issue commands at a prompt to elicit a reaction or operation from the system. A menu-driven system does not require users to learn a lengthy and often complex set of commands in order to access a computer system, even at a surface level. DOS is an example of a command system in which users must learn a series of commands before any interaction can take place. dBASE III provides a menu creation facility to make custom programs as user-friendly as possible. Not only will users be presented with clear and straight forward choices and a simple medium by which to make selections, but users are prevented from issuing erroneous commands that might have unpleasant or unexpected consequences. Therein lies the disadvantages of menu-driven systems as well. A set of choices is constrained by the foresight of the programmer and users may be unable to issue commands because they were not designed into the menu system. Fortunately, dBASE III has the best of both, a simple and effective way to create a menu system and yet a command mode that both insures the user the full breath of discretion and is as simple a language as possible.

2. Design Concerns

As alluded to above, a menu-driven system must be carefully designed so as not to eliminate user selections that would be

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valuable. A menu design should be careful to include all the foreseeable options for the specific situation. When many choices of an interconnected nature have to be made, the menu-tree is surely the preferred technique. Designs should include a complete but uncluttered and unambiguous display of choices with a plainly marked prompt for input. Menu trees should allow for movement backwards as well as forwards through the system as well as an escape button to drop out of the entire menu tree. Finally, designs should provide for trapping of user input that is out of the range of choices.

3. Sample Menu

Below is a sample dBASE III menu illustrating the issues raised above: The menu is created with a MODIFY COMMAND statement at the "." prompt.

* Sample Menu program (remarks can be placed anywhere in a command file as long as they begin with a * or NOTE).

```
CLEAR                    [Clear screen]
?                        [Skip one space down]
? '(1) Option 1  '       [Text in quotes after ? appears on
?                        screen exactly as it is typed in]
? '(2) Option 2  '
?
? '(Q) Quit      '       [Option to move one level back
?                        through the system]
? '(E) Exit      '       [Escape form entire system]
?
ACCEPT 'Enter a selection to continue 'TO SELECTION
                         [accept wait for user to type string
                         data and issues a carriage return.
                         The string is store to the variable
                         SELECTION.  See WAIT and INPUT for
                         other data accepting commands]
```


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```
DO CASE                          [Case statements are best suited for
CASE SELECTION = '1'              menu displays as they can cleanly
 DO OPTION1.PRG                   handle multiple options.  Numbers
CASE SELECTION = '2'              must be represented as strings to
 DO OPTION2.PRG                   match an ACCEPT variable. Commands
CASE UPPER(SELECTION) = 'Q'       between CASE statements are
 CLEAR                            executed only if the CASE is satis-
 RETURN                           fied.  Upper function controls for
 CASE UPPER(SELECTION) = E        lower case input.  Otherwise traps
 CLEAR                            all other input.]
 DO EXIT.PRG
 OTHERWISE
 CLEAR                            [Clears screen and goes to the top.]
 ENDCASE ENDDO                    [Causes execution to stop here when
                                  a RETURN is issued from a subsequent
                                  command file.  Without this a RETURN
                                  continues back through the system
                                  until an ENDDO is located or the
                                  program is found.]
```

Many examples of menus exist in the dBASE III programs written for the Information System and in the sample programs listings located on the dBASE III diskettes.

H. dBASE III FORMATTED DISPLAY WRITING

1. Introduction

A formatted display is a program that is written in the dBASE III programming language. This program allows the creator to present information linked to a database in a flexible and attractive manner. The EDIT a CHANGE modes for entering and viewing data are functional but unattractive as well as lacking any room for text or instructions. A formatted display solves this problem.

2. Creating the Display

A formatted display called NAME can be created with MODIFY

COMMAND NAME.FMT issued form the prompt. A formatted display is designed on a grid of 23 lines and 79 columns, each 1 character in dimension. The Say..Get command and related commands allow the positioning of text and database fields on this grid. Formatted display designers should be careful not to exceed the boundaries of the grid. Before a formatted display may be used, the format must be brought into the workspace with the SET FORMAT TO command. To edit a formatted display, you may have to close the format with CLOSE FORMAT. Be certain that field names in the GET are exact matches for field names in the companion database. Use intensity on if the GET fields need reverse video. There are many examples of formatted displays in the dBASE III manual and the programs already created for the Energy Information System. These files all have the .FMT extensions.

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V RECOMMENDATIONS

A. GENERAL RECOMMENDATIONS

The success of EIASI as a tool of the Planning Division at DJL relies greatly on the dedication of its analysts to learn and use the system, as well as on the proper staffing and controls for the computer facility. Furthermore, due to the complexity and sophistication of the tools now in place, appropriate management is required for the tools to remain effective.

B. STAFFING REQUIREMENTS

(1) A single individual should be placed in charge of maintaining the computer facilities. This is a full-time job. This individual would be in charge of:

a. keeping the work area organized
b. turning on and off the machines at the beginning and end of each day
c. keeping track of all computer materials and a log of any loans of materials outside the computer facility
d. making sure that consumables are amply stocked
e. making periodic backups of the hard disk system files that have been changed
f. purging the hard disk of no longer needed files
g. answering questions posed by users of the facility.

(2) This individual must have a very strong working knowledge of DOS and a strong familiarity with all hardware and software. The entire operation of the facility may rest on this persons competence. The individual should be selected with care and have demonstrated both aptitude and motivation.

(3) An individual with excellent command of DOS, dBASE III and LOTUS 1-2-3 as well as a familiarity with the other software and hardware in

the system should be available to be a system programmer. Without such an individual the system can neither grow no adapt to change. Those individuals who have undergone extensive training with the system are best suited for this task, but more importantly the individual or individuals should have demonstrated computer programming skills. An outside programmer with no prior experience with dBASE III, but with strong programming skills, should be able to master the system.

(4) Data entry personnel are required to perform the monumental task of inputting data for the system. Individuals should be selected for:

a. data entry typing skills
b. comprehension of computer basics
c. a demonstrated facility with the system
d. flexibility to handle unusual data cases.

Data integrity is important for the system to be useful and proper safeguards should be initiated. Prompt and continual updating of data is essential. The system will become unwieldy and out-of-date without careful control of data entry personnel.

(5) Analysts should be restricted to those with appropriate educational, technical, and institutional credentials.

C. OPERATION OF THE COMPUTER FACILITY

(1) The IBM color computer should be moved as little as possible.
(2) The portable and non-hard disk machines are best used for analyses that do not require the hard disk system.
(3) Work on non-EIASI applications, including Lotus 1-2-3 should be performed on the non-color systems to insure access to the color machine for those applications that require it.

(4) Users are encouraged to maintain personal backup copies of important data as well as keep the hard disk free of out-of-data files.

(5) A log of users and tasks performed on the color machine is useful for tracking activity on the machine and in clearing up confusions associated with the use of the machine.

(6) Lists of files located in the Information System should be kept up-to-date with the File Management Utility to aid in locating desired information and keeping the hard disk clean.

(7) The work area should be clear of any non-computer related materials.

(8) The work area should be kept very clean, as cool as possible, dust free; smoking, eating, and drinking should be prohibited.

ANNEX I

List of EIASI System Files and Listing of Sample Programs

Sample file listing from EIASI

The following is a listing of several sample files in EIASI. This set of listing is only a very small fraction of all the files created for EIASI. A listing of any file can be obtained with the DOS type command. A list of all the files in EIASI and a description of their contents is contained in Annex I

**********Main Menu for the Bibliographic Database*********

```
* Bibliography
* BIB.MNU

SET COLOR TO 6/0,0/6,5
set escape off
CLEAR
?
?
? ' ******************* Bibliography *****************'
?
?
? ' Bibliographic Data Base : '
?
?
? ' (1) Bibliographic '
?
? ' (2) Energy Projects '
?
? ' (Q) Return to previous menu '
?
? ' (E) Exit Database'
?
ACCEPT 'Enter a selection to continue ' TO NUM1
DO CASE
   CASE NUM1 = '1'
     SELECT 1
     DO MAINMENU.SCR
   CASE NUM1 = '2'
     SELECT 2
     DO ENPROJ.MNU
   CASE UPPER(NUM1)='Q'
     CLEAR
     RETURN
   case upper(num1)='E'
     CLEAR
     DO EXIT
   OTHERWISE
     CLEAR
ENDCASE
ENDDO
```

*********Main Menu for the Numeric Database*********

```
*NUMERIC.MNU
SET COLOR TO 6/0,0/6,5
SKIPREGIONS = 0
CLEAR
? '****************** Numeric Energy Data Base ****************'
?
?'  (1) Primary Energy Resources'
?
? '  (2) Secondary Energy Conversion Plants'
?
? '  (3) Production and Foreign Trade'
?
? '  (4) Demand and Consumption'
?
? '  (5) Historical Series and Projections'
?
? '  (6) Energy Prices and Tariffs'
?
? '  (7) Technology Characteristics'
?
? '  (8) National Socio-Economic Reports'
?
? '  (9) International Statistics'
?
? '  (Q) Return to the Main Menu'
?
? '  (E) Exit DataBase'
?
ACCEPT 'Enter the number of the area of interest ' to NUM
IF UPPER(NUM) = 'Q'
   CLEAR
   RETURN
ENDIF
IF UPPER(NUM) = 'E'
   CLEAR
   DO EXIT
ENDIF
DO CASE
   CASE NUM = '1'
    STORE 'PRIMARY ENERGY RESOURCES' TO HEADING2
    DO RESOURCE.MNU
   CASE NUM = '2'
    STORE 'SECONDARY ENERGY CONVERSION PLANTS' TO HEADING2
    DO CONVERSI.MNU
   CASE NUM = '3'
    STORE 'PRODUCTION / FOREIGN TRADE ' TO HEADING2
    DO PRODFTRA.MNU
   CASE NUM = '4'
    STORE 'DEMAND AND CONSUMPTION' TO HEADING2
    DO DEMCONSP.MNU
```

```
    Case Num = '5'
     STORE 'HISTORICAL SERIES AND PROJECTIONS' TO HEADING2
     DO HISTPROJ.MNU
    CASE NUM = '6'
     STORE 'ENERGY PRICES AND TARIFFS' TO HEADING2
     DO ENPRTARI.MNU
    CASE NUM = '7'
      STORE 'TECHNOLOGICAL CHARACTERISTICS' TO HEADING2
      DO TECHCHAR.MNU
    CASE NUM = '8'
      STORE 'NATIONAL SOCIO-ECONOMIC REPORTS' TO HEADING2
      DO NSOCECO.MNU
    CASE NUM = '9'
      STORE 'INTERNATIONAL STATISTICS' TO HEADING2
      DO INTSAT.MNU
  ENDCASE NUM
CLEAR
ENDDO
```

******Format display program for crude & condensate******

```
@1,10 GET HEADING3
@2,10 GET HEADING4
@4,2 SAY 'Region :                'get REGION
@6,2 say 'Year :  'get YEAR
@6,30 say 'Month : 'get MONTH
@8,2 say 'Units : 'get UNITS
@10,2 say 'Pertamina :             'get PERTAMINA
@11,2 SAY 'Lemigas :              'get LEMIGAS
@12,2 SAY 'Contractors :          'get CONTRACTOR
@13,2 SAY 'Production Sharing : 'get PROD_SHARE
@15,4 SAY 'Total :               'get TOTAL
@18,2 SAY 'Footnote :' GET FOOTNOTE
@22,2 SAY 'Reference No. : 'GET REFERENCE
*format screen for electric power plants
CLEAR
@1,30 GET HEADING2
@2,20 SAY 'Electric Power Plants '
@4,1 SAY 'Region : 'GET REGION
@4,50 SAY 'Reference No: 'GET REFERENCE
@6,1 SAY 'Total Installed Capacity : 'GET INSTALLED
@6,55 SAY 'MW'
@7,1 SAY 'Total Effective Capacity : 'GET EFFECTIVE
@7,55 SAY 'MW'
@8,1 SAY 'Number of Interconnected Systems : ' GET CONNECTED
@8,45 SAY 'Number of Isolated Systems : ' GET ISOLATED
@10,1 SAY 'Total Diesel Capacity      : 'GET DIESEL
@10,55 SAY 'MW'
@11,1 SAY 'Total Steam Oil Capacity   : 'GET STEAM_OIL
@11,55 SAY 'MW'
@12,1 SAY 'Total Gas Turbine Capacity : 'GET TURBINE
@12,55 SAY 'MW'
@13,1 SAY 'Total HydroPower Capacity  : 'GET HYDRO
@13,55 SAY 'MW'
@14,1 SAY 'Total Steam Coal Capacity  : 'GET STEAM_COAL
@14,55 SAY 'MW'
@15,1 SAY 'Total Geothermal Capacity  : 'GET GEOTHERMAL
@15,55 SAY 'MW'
@17,1 SAY 'Number of Diesel Plants      : 'GET NO_DIESEL
@17,40 SAY 'Number of Steam Oil Plants  : 'GET NO_STEAM
@18,1 SAY 'Number of Gas Turbine Plants : 'GET NO_GAS
@18,40 SAY 'Number of HydroPower Plants : 'GET NO_HYDRO
@20,1 SAY 'Daily Peak Load : 'GET PEAK_LOAD
@20,45 SAY 'Date of Peak Load : 'GET DATE_PEAK
@22,1 SAY 'Footnote : 'GET FOOTNOTE
accept '(N)ext (A)ppend (E)dit (Q)uit ' to command
*display control for production and foreign trade sector
```

```
*************Sub-Menu for Numeric Database*********

CLEAR
?HEADING3
?REGIONNUM
?HEADING4
?MON
DO CASE
 CASE HEADING3 = 'PRODUCTION'
  STORE 'P'TO TYPE
 CASE HEADING3 = 'EXPORT'
  STORE 'E'TO TYPE
 CASE HEADING3 = 'IMPORT'
  STORE 'I'TO TYPE
 CASE HEADING3 = 'STOCK CHANGE'
  STORE 'S'TO TYPE
ENDCASE
ENDCASE
   DO CASE
    CASE HEADING4 = 'CRUDE OIL CONDENSATE'
     USE CRUDE
     SET FORMAT TO CRUDE
    CASE HEADING4 = 'LPG'
     USE LPG
     SET FORMAT TO LPG
    CASE HEADING4 = 'NATURAL GAS'
     USE NATURAL
     SET FORMAT TO NATURAL
    CASE HEADING4 = 'GEOTHERMAL'
     USE GEOTHERM
     SET FORMAT TO GEOTHERM
    CASE HEADING4 = 'COAL'
     USE COAL
     SET FORMAT TO COAL
    CASE HEADING4 = 'HYDROPOWER'
     USE HYDRO
     SET FORMAT TO HYDRO
    CASE HEADING4 = 'LNG'
     USE LNG
     SET FORMAT TO LNG
    CASE HEADING4 = 'ELECTRICITY'
     CLEAR
     ?'UNDER DESIGN'
     WAIT
     CLEAR
     RETURN
    OTHERWISE
     DO AMKGDFNL.FMT
     if len('&heading4')>8
      store str('&heading4',8) to file
     else
      store '&heading4' to file
```

```
      endif
      use &file
      clear
      RETURN
     ENDCASE

  DO CASE
   CASE REGIONNUM = 'REGIONAL'
    CHANGE ALL FOR REGION <> 'INDONESIA' .AND. TYPE = '&HEADING3'
   CASE REGIONNUM = 'ALL DATA'
    CHANGE ALL FOR TYPE = '&HEADING3'
   CASE REGIONNUM = 'NATIONAL'
    CHANGE ALL FOR TYPE = '&HEADING3' .AND. REGION = 'INDONESIA'
   OTHERWISE
    CHANGE ALL FOR REGION = '&REGIONNUM' .AND. TYPE = '&HEADING3'
  ENDCASE

DO ENDENTRIES
CLEAR
RETURN
ENDIF
```

*********Conversion Utility*********

```
*converts data from mixed units to a common unit
SET COLOR TO 6/0,0/6,7
CLEAR
?
? '*****************UNITS CONVERSION UTILTITY****************'
?
ACCEPT'Enter the name of the source database 'TO SOURCE
?
ACCEPT'Enter the name of the target database 'TO TARGET
?
ACCEPT 'Enter the units to convert to 'TO UNITS
clear
SET INTENSITY OFF
@5,15 SAY 'Converting to '
@5,29 GET UNITS
USE &SOURCE
COPY TO &TARGET
USE &TARGET
REINDEX
GO TOP
COUNTER = 1
COUNT TO NUMRECORDS
  DO WHILE COUNTER <= NUMRECORDS
   GO COUNTER
   STORE UNIT TO SOURCEUNIT
   STORE AMOUNT TO SOURCEAMT
   USE CONVERSION
   SET INDEX TO CONVERSION
   FIND &SOURCEUNIT
   STORE &UNITS TO CONVERFAC
   USE &TARGET
   GO COUNTER
   REPLACE AMOUNT WITH CONVERFAC*SOURCEAMT
   COUNTER = COUNTER+1
 ENDDO
USE &TARGET
REPLACE ALL UNIT WITH "&UNITS"
?
? 'Conversion Complete'
?
?
wait
CLEAR
SET INTENSITY ON
RETURN
```

The following is a listing of the DOS Menu Shell designed for EIASI and for use with a harddisk labeled as volume C: and two floppy diskettes labeled A: and B:. The second listing is for a system with a 2 volume Bernoulli Box with volumes D: and E:. On volume D: resides the Information System and on E: resides RESGEN. For any questions on syntax consult the IBM DOS Users Manual. To change configurations of the system type either GO_HARD or GO_BOX and the appropriate file will be rename to EIASI.BAT

HARDDISK.BAT

```
ECHO OFF
CLS
:BEGIN                                  {Subroutine header}
basica indovew                          {Map of Indonesia}
:MENU
menucolor                               {Sets blue border, green
                                         screen}
TYPE MENU.SCR
:PROMPT
GETKEY                                  {8 Byte .COM file to get a
                                        key from keyboard. Must be
                                        on harddisk}
ECHO            One moment please...
IF ERRORLEVEL = 55 GOTO :ERR            {See DOS manual for
IF ERRORLEVEL = 54 GOTO DOS              details - traps and
IF ERRORLEVEL = 53 GOTO BACK             processes entry}
IF ERRORLEVEL = 52 GOTO DGRAPH
IF ERRORLEVEL = 51 GOTO 123
IF ERRORLEVEL = 50 GOTO RES
IF ERRORLEVEL = 49 GOTO DB
GOTO PROMPT
:ERR
ECHO            Invalid Selection
GOTO MENU
:DB
CD \DBASE
DBASE
CD \
GOTO MENU
```

```
:BACK
CLS
MENUCOLOR
TYPE BACKUP.SCR
:BACKPROMPT
GETKEY
ECHO            One moment please...
IF ERRORLEVEL = 52 GOTO :BACKERR
IF ERRORLEVEL = 51 GOTO MENU
IF ERRORLEVEL = 50 GOTO BRES
IF ERRORLEVEL = 49 GOTO BINFO
GOTO BACKPROMPT
:BACKERR
ECHO            Invalid Selection
GOTO BACK
:BRES
MENUCOLOR
TYPE BACKMSG.SCR
CHKDSK/F
DEL *.CHK
CD \DBASE
DEL *.BAK
CD \RESGEN
DEL *.BAK
CD \
MENUCOLOR
TYPE PUTDISK.SCR
PAUSE
COPY C:\RESGEN\*.* B:
GOTO BACK
:BINFO
MENUCOLOR
TYPE BACKMSG.SCR
CHKDSK/F                                {Marks broken chains}
DEL *.CHK                               {Deletes marked chains}
CD \DBASE
DEL *.BAK                               {Remove old .bak files}
CD \RESGEN
DEL *.BAK
CD \
MENUCOLOR
TYPE PUTDISK.SCR
PAUSE
JET C:\DBASE\*.* B:/d                   {Jet software - manual}
GOTO BACK
```

```
:RES
cls
MENUCOLOR
type resgen.scr
:resprompt
GETKEY
ECHO                One moment please...
IF ERRORLEVEL = 54 GOTO RESERR
IF ERRORLEVEL = 53 GOTO MENU
IF ERRORLEVEL = 52 GOTO RESP
IF ERRORLEVEL = 51 GOTO TABLE
IF ERRORLEVEL = 50 GOTO RESENT
IF ERRORLEVEL = 49 GOTO RESG
GOTO RESPROMPT
:RESERR
ECHO            Invalid Selection
GOTO RES
:RESG
CD \RESGEN
cls
RESGEN
CD \
GOTO RES
:RESENT
CD \RESGEN
CLS
RESENT
CD \
GOTO RES
:TABLE
CD \RESGEN
cls
TABLE
CD \
GOTO RES
:RESP
CLS
cd \resgen
RESP
CD \
GOTO RES
:123
CD \LOTUS
LOTUS
CD \
CLS
GOTO MENU
:DGRAPH
DGRAPH
:DOS
CD \
CLS
SETCOLOR
ECHO Exiting EIASI !
```

The following is a listing of BERNOULLI.BAT - the configuration file for EIASI on a system with a Bernoulli Box. The difference between this and the above listing lies in the drive designations noted by *** or comments in the listing.

```
ECHO OFF
CLS
:BEGIN
basica indovew
:MENU
menucolor
TYPE MENU.SCR
:PROMPT
GETKEY
ECHO            One moment please...
IF ERRORLEVEL = 55 GOTO :ERR
IF ERRORLEVEL = 54 GOTO DOS
IF ERRORLEVEL = 53 GOTO BACK
IF ERRORLEVEL = 52 GOTO DGRAPH
IF ERRORLEVEL = 51 GOTO 123
IF ERRORLEVEL = 50 GOTO RES
IF ERRORLEVEL = 49 GOTO DB
GOTO PROMPT
:ERR
ECHO            Invalid Selection
GOTO MENU
:DB
D:                                      {***}
DBASE
C:
GOTO MENU
```

```
:BACK
CLS
MENUCOLOR
TYPE BOXBACK.SCR
:BACKPROMPT
GETKEY
ECHO            One moment please...
IF ERRORLEVEL = 52 GOTO :BACKERR
IF ERRORLEVEL = 51 GOTO MENU
IF ERRORLEVEL = 50 GOTO BRES
IF ERRORLEVEL = 49 GOTO BINFO
GOTO BACKPROMPT
:BACKERR
ECHO            Invalid Selection
GOTO BACK
:BRES
MENUCOLOR
TYPE BACKMSG.SCR
CHKDSK/F
DEL *.CHK
MENUCOLOR
TYPE BACKMSG.SCR
D:                                      {***}
C: CHKDSK/F                             {***}
DEL *.CHK
DEL *.BAK                               {No subdirectories}
C:                                      {***}
MENUCOLOR
TYPE PUTCART.SCR
PAUSE
COPY D:*.* E:                           {No Jet - Copy of
                                         all files}
GOTO BACK
:BINFO
MENUCOLOR
TYPE BACKMSG.SCR
CHKDSK/F
DEL *.CHK
MENUCOLOR
TYPE BACKMSG.SCR
E:                                      {***}
C: CHKDSK/F                             {***}
DEL *.CHK
DEL *.BAK                               {No subdirectories}
C:                                      {***}
MENUCOLOR
TYPE PUTCART.SCR
PAUSE
JET D:*.* E:                            {***}
GOTO BACK
```

```
:RES
cls
MENUCOLOR
type resgen.scr
:resprompt
GETKEY
ECHO                One moment please...
IF ERRORLEVEL = 54 GOTO RESERR
IF ERRORLEVEL = 53 GOTO MENU
IF ERRORLEVEL = 52 GOTO RESP
IF ERRORLEVEL = 51 GOTO TABLE
IF ERRORLEVEL = 50 GOTO RESENT
IF ERRORLEVEL = 49 GOTO RESG
GOTO RESPROMPT
:RESERR
ECHO            Invalid Selection
GOTO RES
:RESG
E:                                      {***}
cls
RESGEN
C:
GOTO RES
:RESENT
E:                                      {***}
CLS
RESENT
C:
GOTO RES
:TABLE
E:                                      {***}
cls
TABLE
C:
GOTO RES
:RESP
E:                                      {***}
CLS
RESP
C:
GOTO RES
:123
CD \LOTUS
LOTUS
CD \
CLS
GOTO MENU
:DGRAPH
CD \DGRAPH
DGRAPH
:DOS
CD \
CLS
SETCOLOR
ECHO Exiting EIASI !
```

LIST OF ALL FILES IN THE ENERGY INFORMATION SYSTEM

FILENAME	EXTENSION	FILE DESCRIPTION
123PREP	MNU	PREPARES FILES FOR LOTUS 1-2-3
AMKGDFNL	DBF	AVGAS, MOGAS, KEROSENE, GASOIL,DIESELOIL, FUELOIL ,NAPHTHA, LSWR DATA
AMKGDFNL	FMT	AVGAS,MOGAS,KEROSENE,GAS DIESEL & FUEL OILS, NAPHTHA,LSWR FORMAT
ASSIST	HLP	ASSIST OVERLAY
BEGIN	PRG	BEGINS ENTRY TO DATABASE MENU SHELL
BIB	MNU	CHOICES FOR BIBLIOGRAPHIC DATA BASE
BIBLIOGR	DBF	BIBLIOGRAPHICAL DATABASE RECORDS
BIBLIOGR	DBT	MEMO FIELD TEXT FOR BIBLIOGRAPHICAL DATABASE
BIBLIOGR	FMT	BIBLIOGRAPIC DATABASE ENTRY FORMAT
COAL	DBF	COAL DATA
COAL	FMT	COAL FORMAT
CONFIG	DB	DBASE III CONFIGURATION FILE
CONSUMER	MNU	DEMAND AND CONSUMPTION SUB-MENU
CONVERSI	DBF	CONVERSION TABLE SIMILAR TO EDI CARD FOR ENERGY UNITS
CONVERSI	MNU	CONVERSION SECTOR MENU
CONVERSI	NDX	INDEX FOR CONVERSION OF ENERGY UNITS PROGRAM
CONVERT	PRG	CONVERSION OF ENERGY UNITS PROGRAM
CRUDE	DBF	CRUDE AND CONDENSATE DATA
CRUDE	FMT	CRUDE AND CONDENSATE FORMAT
DBASE	EXE	DBASE III PROGRAM
DBASE	OVL	DBASE III OVERLAY
DEMCONSP	MNU	DEMAND AND CONSUMPTION MAIN MENU
DIRECTOR	DBF	THIS FILE
DIRECTOR	MNU	DIECTORY OPTIONS AND DISPLAY
DIRECTOR	PRG	DIRECTORIES PROGRAM
DIRECTS	MNU	MENU OF DIRECTORIES
DIRLIST	PRG	DISPLAY OF DIRECTORY WITH EXPLANATIONS
DISPLAY	PRG	INITIAL DISPLAY ROUTER
DISPLAY1	PRG	DISPLAYS PRODUCTION AND FOREIGN TRADE DATA
DISPLAY2	PRG	CONVERSION SECTOR DISPLAYS
DISPLAY3	PRG	PLN NON-PLN ROUTER
DISPLAY4	PRG	AMKGDFNL FUELS DISPLAY
ELECTRIC	DBF	ELECTRIC POWER PLANTS DATA
ELECTRIC	FMT	ELECTRIC POWER PLANTS FORMAT
ELECTRIC	MNU	PLN / NON-PLN MENU
ENDENTRI	PRG	UNIVERSAL DISPLAY ENDDER
EXIT	PRG	EXIT DATABASE SCREEN
FILEMANG	MNU	FILE MANAGEMENT MENU
GEOTHERM	DBF	GEOTHERMAL DATA
GEOTHERM	FMT	GEOTHERMAL FORMAT
HELP	DBS	HELP FILES FROM DBASE III
HYDRO	DBF	HYDROPOWER DATA
HYDRO	FMT	HYDROPOWER FORMAT
IMPEXPSC	MNU	IMPORTS / EXPORTS / STOCK CHANGES MENU
KEYLIST	PRG	KEYWORD DISPLAY FOR BIBLIOGRAPHICAL DATABASE

KEYWORDS	DBF	LIST OF KEYWORDS
LPG	DBF	LPG DATA
LPG	FMT	LPG FORMAT
MEMORY	MEM	MEMORY VARIABLES
MODE	PRG	MENU FOR PASSWORD ACCESS MODE
NATURAL	FMT	NATURAL GAS FORMAT
NONPLN	DBF	NONPLN DATA
NONPLN	FMT	NON-PLN ELECTRICITY FORMAT
NUMERIC	MNU	NUMERIC DATABASE MAIN MENU
OPENING	MNU	OPENING MENU OF 4 CHOICES
PASSWORD	PRG	PASSWORD VARIFICATION
PLN	DBF	PLN DATA
PLN	FMT	PLN ELECTRICITY FORMCAT
PRODFTRA	MNU	PRODUCTION / FOREIGN TRADE MAIN MENU
PRODUCT	MNU	PRODUCTION MENU
QUIT	PRG	EXIT DBASE III RETURN TO DOS
REFINERY	DBF	PETROLEUM REFINERY DATA
REFINERY	FMT	PETROLEUM REFINERY FORMAT
REGIONS	MNU	UNIVERSAL REGION MENU
RESOURCE	MNU	RESOURCES MENU
SALES	MNU	DEMAND AND CONSUMPTION SUB-MENU
SUBSTITU	PRG	SUBSTITUES / ALTERNATES FOR DATABASES
SUPDBALP	MNU	SUPPLY DEMAND BALANCES & PROJECTIONS
TRANSMIS	DBF	TRANSMISSION LINES DATA
TRANSMIS	FMT	TRANSMISSION LINES FORMAT
UNIT&CON	MNU	UNITS AND CONVERSION UTILTIY MENU
YEAR_MON	GEN	APPENDS NEW RECORDS WITH MONTH & YEAR TO A DATABASE FILE

ANNEX II

EIASI System Menu Screens

EXHIBIT 1

This screen is displayed directly after the Information System is selected from the EIASI Main Menu. During this time the Energy Information System Software is setting inital parameters. The loading message will change with the time of day.

Loading ... Selamat Sore

EXHIBIT 2

The Energy Information System Welcome Screen.

Welcome to EIASI

Energy Information and Analysis System For Indonesia

DIREKTORAT JENDERAL LISTRIK DAN ENERGI BARU

DEPARTEMEN PERTAMBANGAN DAN ENERGI

REPUBLIK INDONESIA

Wednesday August 7, 1985 16:11:14

PRESS SPACE BAR TO CONTINUE

EXHIBIT 3

The Energy Information System Main Menu. This menu is similar to other menus in the system. The User reads the available choices and enters the appropriate letter or number after the prompt. The menu is indifferent to the case of the response. All responses must be followed by a carriage return. If the screen clears and the identical menu is displayed the system was unable to process the response. Responses must be single characters. Some responses take longer to process than others. Please be patient. Pressing keys to elicit a faster response may cause unexpected results.

```
**************** National Energy Data Base ****************

Energy Related Data Bases:

(1) Numeric Data Base

(2) Units and Conversions

(3) Bibliographic Data Base

(4) File management

(Q) Exit the National Energy Data Base

Enter a selection to continue
```

EXHIBIT 4

The Numeric Energy Data Base Main Menu. This menu is produced when the user responds 1 to the Energy Information System Main Menu.

```
****************** Numeric Energy Data Base ****************

  (1) Primary Energy Resources

  (2) Secondary Energy Conversion Plants

  (3) Production and Foreign Trade

  (4) Demand and Consumption

  (5) Historical Series and Projections

  (6) Energy Prices and Tariffs

  (7) Technology Characteristics

  (8) National Socio-Economic Reports

  (9) International Statistics

  (Q) Return to the Main Menu

  (E) Exit DataBase

Enter the number of the area of interest
```

EXHIBIT 5

The Numeric Resources Menu. Numeric Data Base. This menu is produced when the user responds 1 to the Main Menu. Different responses will elicit different sub-menus. The information above the line of stars will keep track of the users position in the menu tree. As the user move to different branches and levels the information will be updated.

```
NUMERIC
*********************RESOURCES******************

(1) Oil
(2) Natural Gas
(3) Coal
(4) HydroPower
(5) Geothermal
(6) Uranium
(7) Wood
(8) Agricultural Wastes
(9) Animal Dung
(10) Wind
(11) Solar
(12) Peat
(13) Ocean Energy

(Q) Return to previous menu
(E) Exit DataBase

Enter Number for Selection
```

EXHIBIT 6

The screen appears in almost every branch of the system, with only a varying heading. This menu is usually the last menu of the branch before the data is displayed. This menu provides an option to the user of information by regional breakdowns. Where there is more than one screen or data group for the region, e.g. several refineries, each one will be displayed successively. The User presses [PgDn] to view the next data group.

```
NUMERIC
PRIMARY ENERGY RESOURCES
OIL

(1) Region 1 Data
(2) Region 2 Data
(3) Region 3 Data
(4) Region 4 Data
(5) Region 5 Data
(6) Region 6 Data
(7) Region 7 Data
(8) All Regions
(9) National Data
(10) National and Regional Data

(Q) Return to previous menu
(E) Exit DataBase

Please select a number
```

EXHIBIT 7

This screen is produced when 2 is entered from the Energy Information System Main Menu.

```
NUMERIC
*********************CONVERSION****************************

(1) Petroleum Refineries

(2) LNG Plants

(3) LPG Plants

(4) Electric Power (Installed Capacity)

(Q) Return to previous menu

(E) Exit DataBase

Enter a selection to continue
```

EXHIBIT 8

This screen displays a sample formatted data display for Petroleum Refineries in the Conversion Sector. Data is displayed and a short menu is produced for various user options. Append and Edit options will ask for a password. A password will only be asked for once during any one run of the Energy Information System Menus. A run begins with the Loading Message. Each data requirement can have a different formatted display to best suit the data. These displays can also be modified quickly and easily even after data has been entered. Many different formatted displays were developed for the Energy Information System.

SECONDARY ENERGY CONVERSION PLANTS
Petroleum Refineries

Refinery Name : REFINERY1 Units : Region : REGIO

Plant Capacity :	5000	B/D
Gasoline Capacity :	17.8	%
Kerosene Capacity :	26.8	%
Diesel Capacity :	14.8	%
Fuel Oil Capacity :	0.8	%
Lube Oil Capacity :	0.0	%
Waxy Residue :	44.5	%
Bitumen :	1.2	%
Heavy Naphtha Export:	0.0	%
LPG :	NA	%

(N)ext (E)dit
(A)ppend (Q)uit
Print <Shift><PrtSc>

Reference No. : 001

Footnote :

Enter a selection to continue

EXHIBIT 9

This menu is produced when the user selects 4 from the conversion sector menu. The next page displays the Transmission Line formatted data display.

```
* NUMERIC :
*
* Secondary Energy Plant
****************** Electric Power (Installed Capacity) *****
*
*       (1) Power Plants
*       (2) Transmission Lines
*       (3) Distribution Lines
*       (4) Substations
*       (5) Load Dispatch centers
*       (Q) Return to previous menu
*       (E) Exit Data Base
 Enter selection to continue
```

EXHIBIT 10

SECONDARY ENERGY CONVERSION PLANTS

Transmission Distribution Lines (Km)

Region : REGION1

Extra High 500 KV :	0	
150 KV :	645	(N)ext (E)dit (A)ppend (Q)uit Print <Shift><PrtSc>
70 KV :	970	
20 KV :	5500	
6 KV :	0	

System Losses (%) : 0 Number of Sub-Stations : 0

Reference No. :

Footnote : SYSTEM LOSSES ARE OWN USE, TRANSMISSION, AND DISTRIBUTION

Enter a selection to continue

EXHIBIT 11

The next series of pages will display other branches of the numeric database system as well as examples of several formatted data displays.

These pages are designed to illustrate the flexiblity and specificity of the system.

NUMERIC

**********PRODUCTION & FOREIGN TRADE**********

(1) Production

(2) Imports

(3) Exports

(4) Stock Change

(Q) Return to Previous Menu

(E) Exit DataBase

Select a number

EXHIBIT 12

NUMERIC
PRODUCTION / FOREIGN TRADE
**********PRODUCTION**********

(1) Crude Oil - Condensate
(2) Avgas
(3) Avtur
(4) Mogas
(5) Kerosene
(6) Gas Oil
(7) Diesel Oil
(8) Fuel Oil
(9) LPG
(10) Naphtha
(11) LSWR
(12) Natural Gas
(13) HydroPower
(14) Geothermal
(15) Coal
(16) Electricity

(Q) Return to previous menu
(E) Exit DataBase

Enter a selection to continue

EXHIBIT 13

PRODUCTION
CRUDE OIL CONDENSATE

Region : REGION1

Year : 1985 Month : JANUARY

Units : MBOE

Pertamina :	1.2
Lemigas :	-
Contractors :	3.4
Production Sharing :	3900.1
Total :	3904.7

Footnote : FOOTNOTE 1

Reference No. : 1-11-1111

EXHIBIT 14

NUMERIC
PRODUCTION / FOREIGN TRADE
PRODUCTION
AVGAS

(1) January
(2) February
(3) March
(4) April
(5) May
(6) June
(7) July
(8) August
(9) September
(10) October
(11) November
(12) December
(Q) Return to previous menu

Enter a choice to continue

EXHIBIT 15

PRODUCTION
NATIONAL
AVGAS
JAN

REFINED PRODUCTS FROM DOMESTIC REFINERIES (in Barrels)

YEAR	P.BRANDAN	DUMAI	S.PAKNING	PLAJU	S.GERONG
1982	0	0	90	0	0
1983	552774	1290680	1437133	2534070	2514551
1984	0	0	0	0	0
1985	0	0	0	0	0
1986	0	0	0	0	0

YEAR	CILACAP	WONOKROMO	BALIKPAPAN	CEPU	PROCESSING DEAL
1982	0	0	0	0	0
1983	4626436	6418	1297007	0	274607
1984	0	0	0	0	0
1985	0	0	0	0	0
1986	0	0	0	0	0

Footnotes can be viewed with the edit option
(C)ontinue (E)dit (A)ppend

EXHIBIT 16

```
NUMERIC
PRODUCTION / FOREIGN TRADE
PRODUCTION
REGION1
*******************ELECTRICITY PRODUCTION****************

(1) NON-PLN
(2) Fuel Oil Steam
(3) Coal Steam
(4) Natural Gas Steam
(5) Gas Turbine
(6) Diesel
(7) HydroPower
(8) Geothermal
(9) Total

(Q) Return to previous menu
(E) Exit DataBase

Enter a selection to continue
```

EXHIBIT 17

NUMERIC
**********DEMAND & CONSUMPTION**********

(1) Sales Reports by Energy Producer

(2) Individual Consumer Level

(Q) Return to previous menu

(E) Exit DataBase

Enter a selection to continue

EXHIBIT 18

NUMERIC
DEMAND AND CONSUMPTION
SALES REPORTS BY PRODUCER

(1) ADP7

(2) Pln Sales

(3) BPS Statistics

(4) Pertamina Natural Gas

(5) PDN Gas

(6) PT Batubara

(Q) Return to previous menu

(E) Exit DataBase

Enter a selection to continue

EXHIBIT 19

NUMERIC
DEMAND AND CONSUMPTION
INDIVIDUAL CONSUMER LEVEL

(1) Industrial Audits

(2) Household Surveys

(3) Transportation Surveys / Studies

(Q) Return to previous menu

(E) Exit DataBase

Enter a selection to continue

EXHIBIT 20

**********Historical Series and Projections**********

(1) Directorate General for Electric Power and New Energy

(2) Directorate General of Oil and Gas / Pertamina

(3) Permanent Technical Committee for Oil Products and Ene

(4) Agency for Assessment and Application of Technology

(Q) Return to Previous Menu

(E) Exit DataBase

Enter the number of intrest

EXHIBIT 21

```
******************Technological Characteristics************
 (1) Refinery
 (2) Power Plants
 (3) Biogas
 (4) Gasifier
 (Q) Return to the Previous Menu
 (E) Exit DataBase
Enter the number of the area of interest :
```

EXHIBIT 22

```
************National Socio-Economic Reports****************

 (1) GDP , Population, Employment

 (2) Income by sectors

 (3) Indicators

 (Q) Return to previous menu

 (E) Exit DataBase

Enter the number of the area of interest :
```

EXHIBIT 23

This is the Units and Conversion Utility. Information stored in the Numeric Data Base was chosen to remain in the units of orignal processing as often as possible. Analysts, however may wish to have duplicate databases with all data in a common unit. A report form can be created to perform a conversion of units if all the units in a column are the same. When the units in a column are different this utility will convert them all to the unit of the users choice. The conversion table accessed by this utility, CONVERSI.DBF, can be expanded to any size and for any units the user chooses.

In this example the user is converting all units in the Convert database to TOE and storing the data base TOE_DATA.DBF

The original units (i.e., those in the CONVERT file, must be listed in CONVERSI.DBF in order to perform the conversion.

```
*****************UNITS CONVERSION UTILTITY****************

Enter the name of the source database CONVERT

Enter the name of the target database TOE_DATA

Enter the units to convert to TOE
```

EXHIBIT 24

Converting to TOE

Conversion Complete

Press any key to continue...

EXHIBIT 25

```
. USE CONVERT
. LIST
     1              76.3300 TOE     1984
     2            3474.7600 GJ      1984
     3              67.7800 BOE     1984
. USE TOE_DATA
. LIST
     1              76.3300 TOE     1984
     2              83.3942 TOE     1984
     3               9.4892 TOE     1984
.
```

EXHIBIT 26

To provide for a more convient user interface, a file management utility was created. With this utility users can access various directories of files, produce an already existing report, move to RESGEN, or convert a data file for use with LOTUS 1-2-3 or dGRAPH III. It is the file interchangability of the Energy Information System that helps to make it an integrated whole and a complete analytical tool.

```
************************FILE MANAGEMENT********************

(1) Directories

(2) Report Generation

(3) Resgen

(4) Lotus 1-2-3

(5) Dgraph III

(Q) Return to previous menu

(E) Exit DataBase

Select a choice to continue
```

EXHIBIT 27

The Bibliographic Date Base has the ability to store text information with a common format and selectively retrieve this information according to a search criteria. The Bibliographic Database has a flexible format to accept entries concerning a wide variety of different sources, Reports, Articles, Survey Analyses etc. The Energy Projects Database focuses on a more narrow data type, Energy Project information that is taking place in Indonesia.

********** Bibliography **********

Bibliographic Data Base :

(1) Bibliographic

(2) Energy Projects

(Q) Return to previous menu

(E) Exit Database

Enter a selection to continue

EXHIBIT 28

The Bibliographic Database allows for searches on a variety of fields in the entry form. There is also a utility for entering new records, and a Keyword Utiltiy to provide present and updated list of all subjects/keywords in use in the system.

SEARCH BY: (1) Accession Number

(2) ISBN Number

(3) ISSN Number

(4) Subject

(5) Author

(6) Location

(7) Source Document

(8) Category Code

(9) Enter New Records

(K) Keyword Utility

(E) End Session

Enter a selection to continue

EXHIBIT 29

A sample of a search for either of 2 SUBJECTS.

Search for SUBJECT: OIL

OR : PETROLEUM

Search in progress...

EXHIBIT 30

A screen that appears after every search. Option 2 will view or send to the printer Title and Author information only.

3 Entries have been found

(1) View all entries

(2) View titles only

(3) Return to Main Menu

Enter a selection to continue

EXHIBIT 31

A sample Bibliographic Entry for a book. The user has a full menu of options with appropriate password protection. The summary field can be up to 50,000 characters of text information.

```
ACCESSION #     3 ISBN # 0-19-582527-60 ISSN #                ENTERED 05/05/85
                                                              REVISED 05/05/85

TITLE         The Petroleum Resources of Indonesia


LANGUAGES      E                                   YEAR PUB.   82

AUTHORS       1 OOI JIN BEE                2
              3

KEYWORDS      1 PETROLEUM                  2 RESOURCES
              3                            4

DOCUMENTS     1
              2
CATEGORIES    1
              2                                (N)ext      (E)dit
NOTES .......  HardBack                        (B)Previous(D)elete
STATUS ......                                  (S)unmary   (P)rint
LOCATION ....  USA                             (A)ppend    (Q)uit

Enter a selection to continue
```

EXHIBIT 32

The Energy Projects Database mirrors the "Blue Book"

Energy Projects DataBase

(1) Title

(2) Location

(3) Agency

(4) Codenumber

(5) Data on Energy project by code #

(6) All data on energy projects by Title

(A) New Entry

(Q) Return to previous menu

Enter a number to continue

EXHIBIT 33

A sample entry in the Energy Projects Database. Memo fields indicate fields that can contain up to several pages of text material.

Energy Projects Listings Code number E BN 9

Project Title ASAHAN HYDRO POWER PLANTS I & III (160 MW & 200 MW) AND ASSOCIA TED TRANSMISSION LINE

Location NORTH SUMATERA PROVINCE

Agency DIRECTORATE GENERAL OF ELECTRIC POWER AND NEW ENERGY/PERUSAHAAN UMUM LISTRIK NEGARA (PLN), MINISTRY OF MINES AND ENERGY

Objectives memo Description memo

Total Cost	46800D000	Implementation Time	6 (SIX) YEARS
Local Cost	234000000	Proposed Commitment	234000000
Foreign Exchange	234000000		
Technical Assistance			

Stage - FEASIBILITY REPORT WAS UNDEPTAKEN BY JICA - ENGINEERING DESIGN IS UND ERWAY FINANCED BY OECF.

(O)bjectives&Description (N)ext project (E)dit (P)rint (Q)uit

EXHIBIT 34

Exiting the Menu System and optionally returning to the EIASI Main Menu or entering the dBASE III command mode. Users can return to the menu system with either F10 or DO BEGIN.

To enter DBase III command mode : <RETURN>.

To return to the DataBase thereafter, type DO BEGIN or F10, at any t

To quit DBase III now type Q. To quit DBASE III from the command mode type QUIT at the EIASI> prompt.

==> Q

EXHIBIT 35

Exiting the Energy Information System and returnning to the EIASI Main Menu.

You are now ready to leave DBASE III

Starting Time 15:09:19 Finishing Time 15:14:18

Press any key to exit

ANNEX III

EIASI Hardware Configuration

Welcome to EIASI

INSTRUCTIONS FOR MOVING

THE COLOR SYSTEM

1) In the root harddisk directory (C:\ ) issue SHIPDISK and 1

2) Place diskettes in both drives & close door

3) Unplug everything
   Keep System Unit HORIZONTAL

4) Restart requires no Software Steps

EIASI HARDWARE CABLES AND POWER-UP

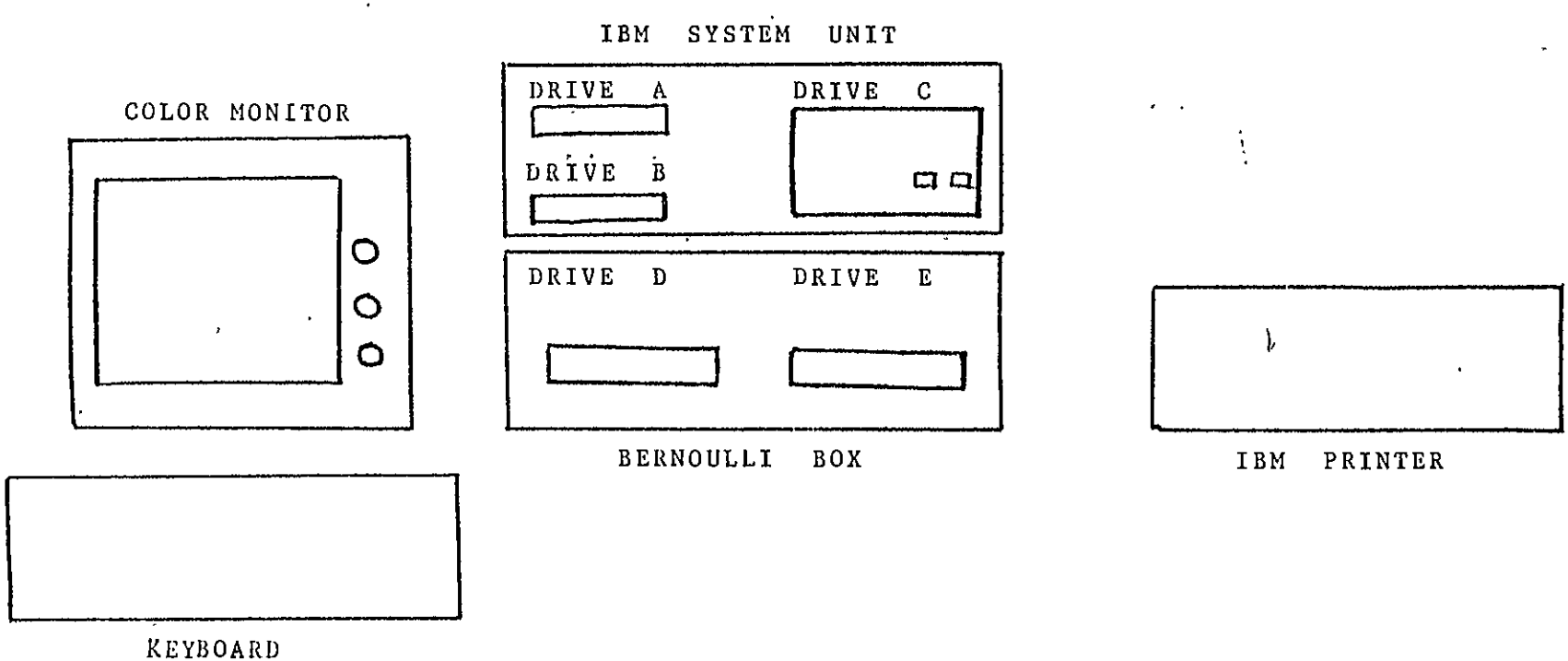
POWERING UP:

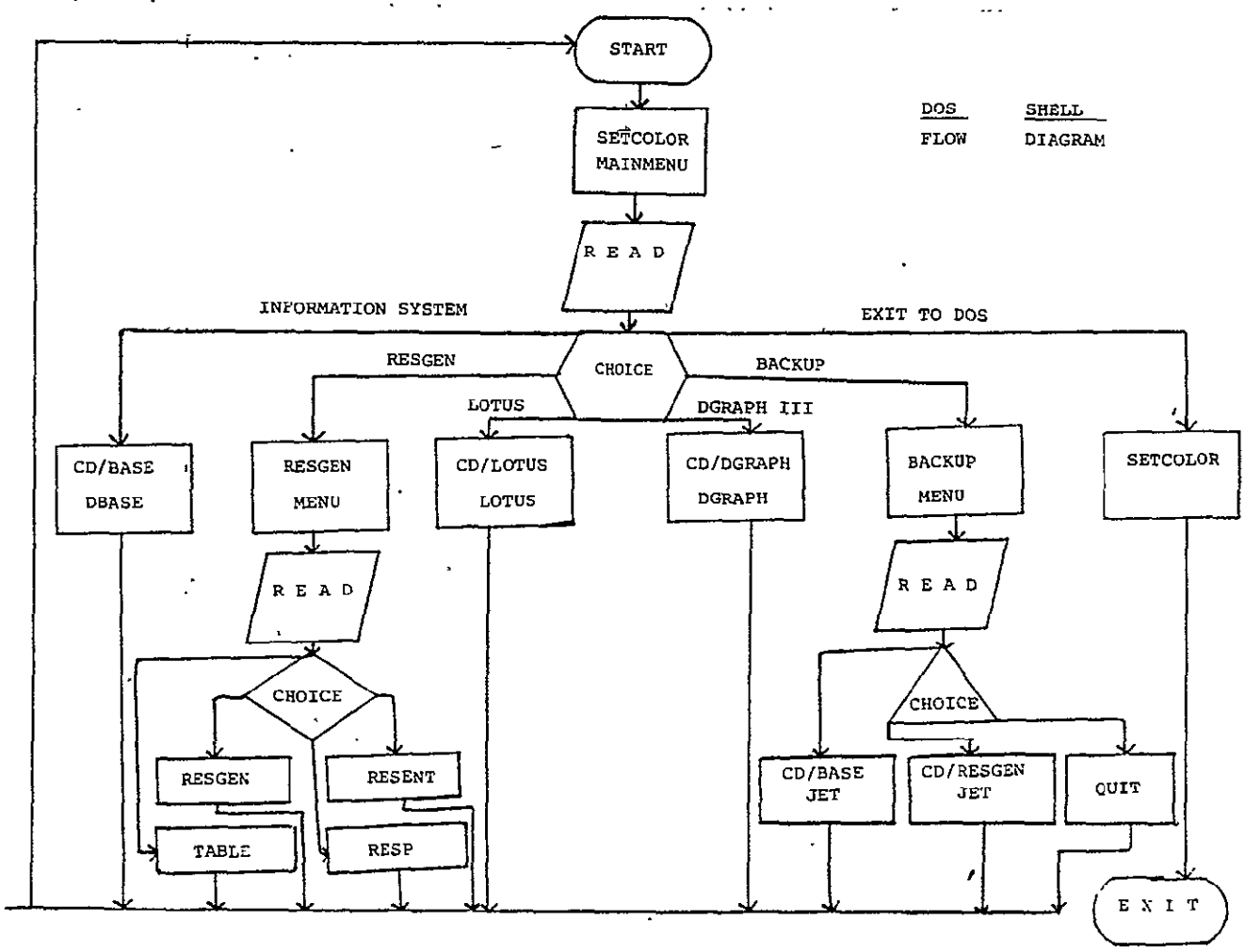
STEP	DEVICE	LOCATION	INDICATOR
1	Powerstrip	Floor	-
2	Bernoulli Box	Right Rear, Up	-
3	System Unit	Right Rear, Up	Green light
4	Color Monitor	Top, Turn Right	Green light
5	IBM Printer	Right Side, Press forward	3 green light

CABLES

CABLE	LOCATION
Keyboard to System Unit	Middle Bottom
Monitor to System Unit	Slot 3 , L --- R
Bernoulli to System Unit	Slot 2 , L --- R
Printer to System Unit	Grey Cable

EIASI: RECOMMENDED COLOR COMPUTER CONFIGURATION




START
SETCOLOR
MAINMENU
DOS
FLOW
SHELL
DIAGRAM
R E A D
INFORMATION SYSTEM
EXIT TO DOS
RESGEN
CHOICE
BACKUP
LOTUS
DGRAPH III
CD/BASE
DBASE
RESGEN
MENU
CD/LOTUS
LOTUS
CD/DGRAPH
DGRAPH
BACKUP
MENU
SETCOLOR
R E A D
R E A D
CHOICE
CHOICE
RESGEN
RESENT
TABLE
RESP
CD/BASE
JET
CD/RESGEN
JET
QUIT
E X I T

BERNOULLI BOX TECHNOLOGY

With the bernoulli box attached to the IBM color machine, the Information System and RESGEN should reside on their own 10 MB cartridges.

At start up, place the Information System cartridge on Drive D: and the Resgen cartridge in Drive E: All DOS functions are the same with the exception on those indicated on the Bernoulli Box owners manual. For backing up of the Information System or Resgen consult the Bernoulli Box owners manual or use the DOS Shell Backup utility.

Place a formatted blank cartridge (consult the owners manual for special cartridge formatting instruction - do not use the DOS format command to format a cartridge) in Drive E: and the cartridge to backup in Drive D: Now execute the backup utility or the I-Omega Bernoulli Box copy utility.

Bernoulli.BAT is the initialization file for a system with the Bernoulli Box. HARDDISK.BAT is the initialization file for a hard disk only system.

This initialization need only be performed once until the configuration is changed. EIASI, in place at the Directorate General of Electricity and New Energy is presently configurated for Harddisk only.

ANNEX IV

PROGRAMMING NOTES ON TYPICAL EIASI FILES

PROGRAMMING NOTES ON TYPICAL EIASI FILES

1. EIASI Display Files

Listed below are explanations of the dBASE III commands used in the program that creates display files, followed by a listing of a typical program that creates displays. A flow diagram is also included.

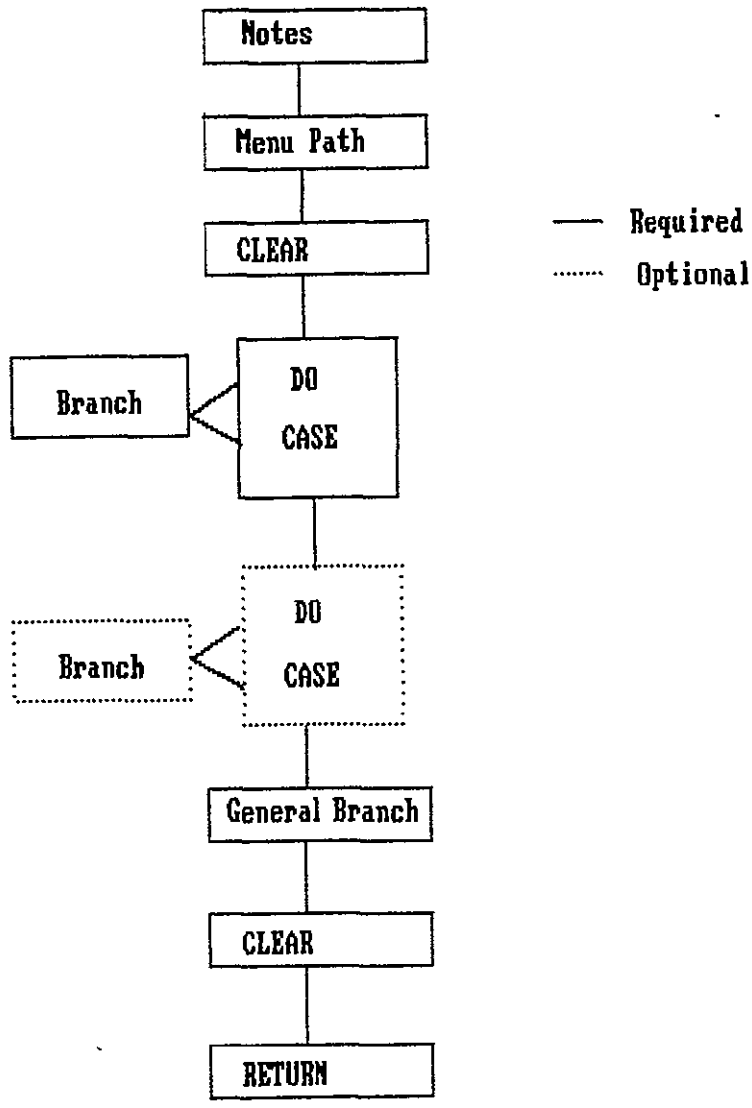
Notes	-The first line of a program is a note that contains the filename and an explaination of the function of the program for later reference. Notes begin with a *.
CLEAR	-A CLEAR command should be issued at the beginning of every file to clear the screen and insure an attractive display.
?Field ?Variable	-These statements allow for the capturing of the menu tree path. During various operations of the menu's variables and fields are sited to display menu position in the tree.
DO CASE	-Performs different commands depending on the menu path.
OTHERWISE	-Traps all cases not covered in the rest of the DO CASE.
DO NEXTCASE	-Often another case statement that works with information posted during the first DO CASE.
DO ENDENTRIES	-Display of end of entries message.
CLEAR	-Clears the screen for attractive display.
RETURN	-Return to the previous program.

PROGRAM LISTING FOR CREATION OF DISPLAY FILES

```
*Display Control for Production and Foreign Trade Sector  {notes}
*DISPLAY1.PRG

CLEAR                                                      {CLEAR}
?HEADING3                                                  {MENU PATH}
?REGIONNUM
?HEADING4
?MON

DO CASE                                  {CASE statement determines which
 CASE HEADING3 = 'PRODUCTION'             field in the database to access}
  STORE 'P'TO TYPE
 CASE HEADING3 = 'EXPORT'
  STORE 'E'TO TYPE
 CASE HEADING3 = 'IMPORT'
  STORE 'I'TO TYPE
 CASE HEADING3 = 'STOCK CHANGE'
  STORE 'S'TO TYPE
ENDCASE

DO CASE                                     {Reads fuel, uses appropriate
    CASE HEADING4 = 'CRUDE OIL CONDENSATE'    file and sets format}
     USE CRUDE
     SET FORMAT TO CRUDE
    CASE HEADING4 = 'LPG'
     USE LPG
     SET FORMAT TO LPG
    CASE HEADING4 = 'NATURAL GAS'
     USE NATURAL
     SET FORMAT TO NATURAL
    CASE HEADING4 = 'GEOTHERMAL'
     USE GEOTHERM
     SET FORMAT TO GEOTHERM
    CASE HEADING4 = 'COAL'
     USE COAL
     SET FORMAT TO COAL
    CASE HEADING4 = 'HYDROPOWER'
     USE HYDRO
     SET FORMAT TO HYDRO
    CASE HEADING4 = 'LNG'
     USE LNG
     SET FORMAT TO LNG
    CASE HEADING4 = 'ELECTRICITY'
     CLEAR
     ?'UNDER DESIGN'
     WAIT
     CLEAR
```

```
    RETURN
   OTHERWISE
    DO AMKGDFNL.FMT
    if len('&heading4')>8
     store str('&heading4',8) to file
    else
     store '&heading4' to file
    endif
    use &file
    clear
    RETURN
ENDCASE

DO CASE                                  {display all for a regional
 CASE REGIONNUM = 'REGIONAL'             match and type subset, in format}
  CHANGE ALL FOR REGION <> 'INDONESIA' .AND. TYPE = '&HEADING3'
 CASE REGIONNUM = 'ALL DATA'
  CHANGE ALL FOR TYPE = '&HEADING3'
 CASE REGIONNUM = 'NATIONAL'
  CHANGE ALL FOR TYPE = '&HEADING3' .AND. REGION = 'INDONESIA'
 OTHERWISE
  CHANGE ALL FOR REGION = '&REGIONNUM' .AND. TYPE = '&HEADING3'
ENDCASE

DO ENDENTRIES                            {standard end of entries message}
CLEAR
RETURN
```

FLOW CHART FOR CREATION OF DISPLAY FILES



2. EIASI Menu Files

Listed below are explanations of the dBASE III commands used in the program that creates menu files, followed by a listing of a typical program that creates menus. A flow diagram is also included.

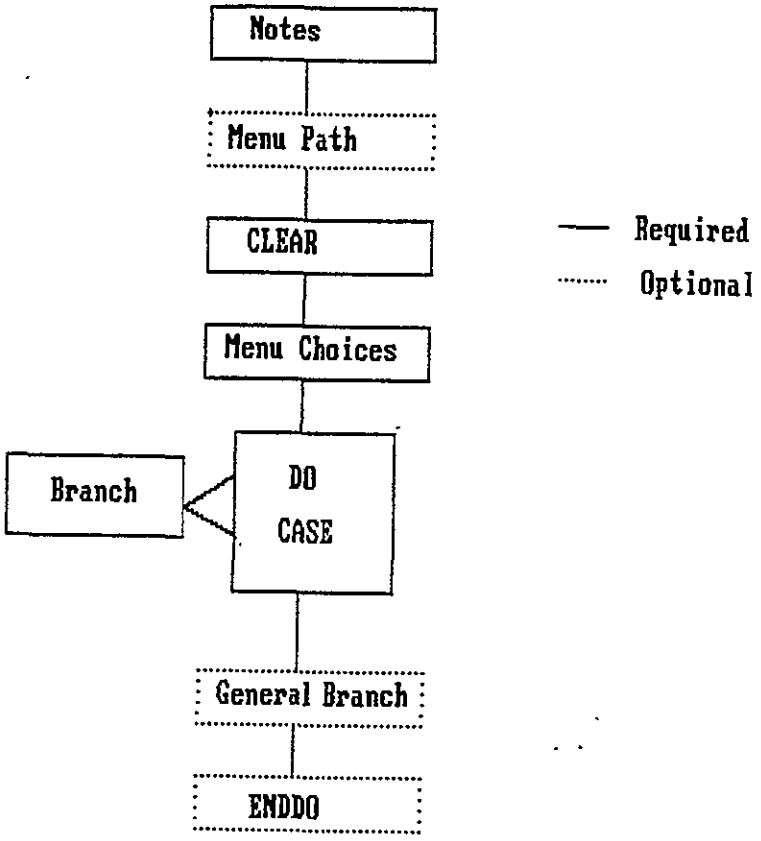
Notes	-The first line of a program is a note that contains the filename and an explaination of the function of the program for later reference. Notes begin with a *.
CLEAR	-A CLEAR command should be issued at the beginning of every file to clear the screen and insure an attractive display.
?Field ?Variable	-These statements allow for the capturing of the menu tree path. During various operations of the menu's variables and fields are sited to display menu position in the tree.
Menu Text	-Use either TEXT-ENDTEXT or ?' syntax the text of the menu is displayed.
ACCEPT	-Use WAIT,ACCEPT, or INPUT to trap the user's menu choice and perform the appropriate operation.
DO CASE	-Performs different commands depending on the menu choice.
QUIT	-If the Quit choice is selected user moves one level back up through the menu.
OTHERWISE	-Traps all menu choices not enumerated in the DO CASE, a CLEAR clears the screen and redisplays the menu.
DO NEXTMENU	-Program to be executed after the CASE is complete.
ENDDO	-Provides for this menu to be redisplayed when a subsequent programs calls a RETURN to the file. Without the ENDDO this file is skiped.

PROGRAM LISTING FOR CREATION OF MENU FILES

```
*Production and Foreign Trade Menu                    {comments/notes}
*PRODUCT.MNU

CLEAR                                                 {CLEAR Statement}
?HEADING1                                             {displays menu path
?HEADING2                                              previously stored}
?'*********************PRODUCTION*********************' {menu text}
?
? '(1) Crude Oil - Condensate'
? '(2) Avgas'
? '(3) Avtur'
? '(4) Mogas'
? '(5) Kerosene'
? '(6) Gas Oil'
? '(7) Diesel Oil'
? '(8) Fuel Oil'
? '(9) LPG'
? '(10) Naphtha'
? '(11) LSWR'
? '(12) Natural Gas'
? '(13) HydroPower'
? '(14) Geothermal'
? '(15) Coal'
? '(16) Electricity'
?
? '(Q) Return to previous menu'
? '(E) Exit DataBase'
?
Accept 'Enter a selection to continue 'TO NUM1          {accept statement}
IF UPPER(NUM1) = 'Q'                                    {check for quit or
  CLEAR                                                 exit}
  RETURN
ENDIF
IF UPPER(NUM1) = 'E'
  DO EXIT
ENDIF

DO CASE                                          {Case Statement}
 CASE NUM1 = '1'
  STORE 'CRUDE OIL CONDENSATE' TO HEADING4       {Storage of a variable}
 CASE NUM1 = '2'
  STORE 'AVGAS' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU                                   {branch to another menu}
 CASE NUM1 = '3'
  STORE 'AVTUR' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 CASE NUM1 = '4'
  STORE 'MOGAS' TO HEADING4
```

```
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 CASE NUM1 = '5'
  STORE 'KEROSENE' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 CASE NUM1 = '6'
  STORE 'GASOIL' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 CASE NUM1 = '7'
  STORE 'FUELOIL' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 CASE NUM1 = '8'
  STORE 'DIESEL' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 CASE NUM1 = '9'
  STORE 'LPG' TO HEADING4
 CASE NUM1 = '10'
  STORE 'NAPHATA' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 CASE NUM1 = '11'
  STORE 'LSWR' TO HEADING4
  STORE 'NATIONAL' TO REGIONNUM
  DO MONTH.MNU
 case num1 = '12'
  STORE 'NATURAL GAS' TO HEADING4
 CASE NUM1 = '13'
  STORE 'HYDROPOWER' TO HEADING4
 CASE NUM1 = '14'
  STORE 'GEOTHERMAL' TO HEADING4
 CASE NUM1 = '15'
  STORE 'COAL' To HEADING4
 CASE NUM1 = '16'
  STORE 'ELECTRICITY' TO HEADING4
ENDCASE
DO REGIONS.MNU                          {General branch}
ENDDO                                   {Menu path stop during
                                        movemnet back through
                                        the system}
```

FLOW CHART FOR CREATION OF MENU FILES



PN-AAY-423

ENERGY PLANNING FOR DEVELOPMENT

(Phase II)

APPENDIX 2: RESGEN USER'S MANUAL

September, 1985

DIRECTORATE GENERAL OF ELECTRIC POWER AND NEW ENERGY
MINISTRY OF MINES AND ENERGY
REPUBLIC OF INDONESIA

AND

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INTERNATIONAL DEVELOPMENT AND ENERGY ASSOCIATES
P.T. CIPROCON

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PART I

MODEL DESCRIPTION

1. INTRODUCTION TO RESGEN

1.1 BACKGROUND

RESGEN is a microcomputer model for energy analysis. This version of RESGEN, 3.0, is for the IBM PC family of microcomputers (PC,XT,AT), and for the so called IBM compatibles such as Televideo COMPAQ, Columbia, and Leading Edge. It will also run on certain other MS-DOS based machines such as the TANDY 2000, and the WANG personal computer when fitted with the IBM emulation board*.

The key differences between this version of RESGEN and the earlier microcomputer versions (1.0, 1.1) are outlined in Annex V.

* RESGEN will run on the WANG even without the IBM emulation board, but the character mode graphics will not be generated properly (because WANG uses a different ASCII character definition).

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1.2 MODEL OVERVIEW

The RESGEN package consists of four programs and a set of data files (exhibit 1.1). In addition a set of utilities is provided for certain special tasks. The programs are:

RESG	That executes the network calculations.
RESP	Output tables and graphics program.
RESENT	A data entry program for the main network.
TABLE	A database manager for all of the other subsidiary data files.

There are three types of data files: network files, that simulate the energy system network, created and modified in the RESENT program; external data files (for such information as the power sector capacity expansion plan, or for prices); and special setup files (for information on summery table row/column labels, initialization of graphics, of time series tables). The last two types of files are created and modified in the TABLE database manager.

The TABLE program is documented in a separate user manual.

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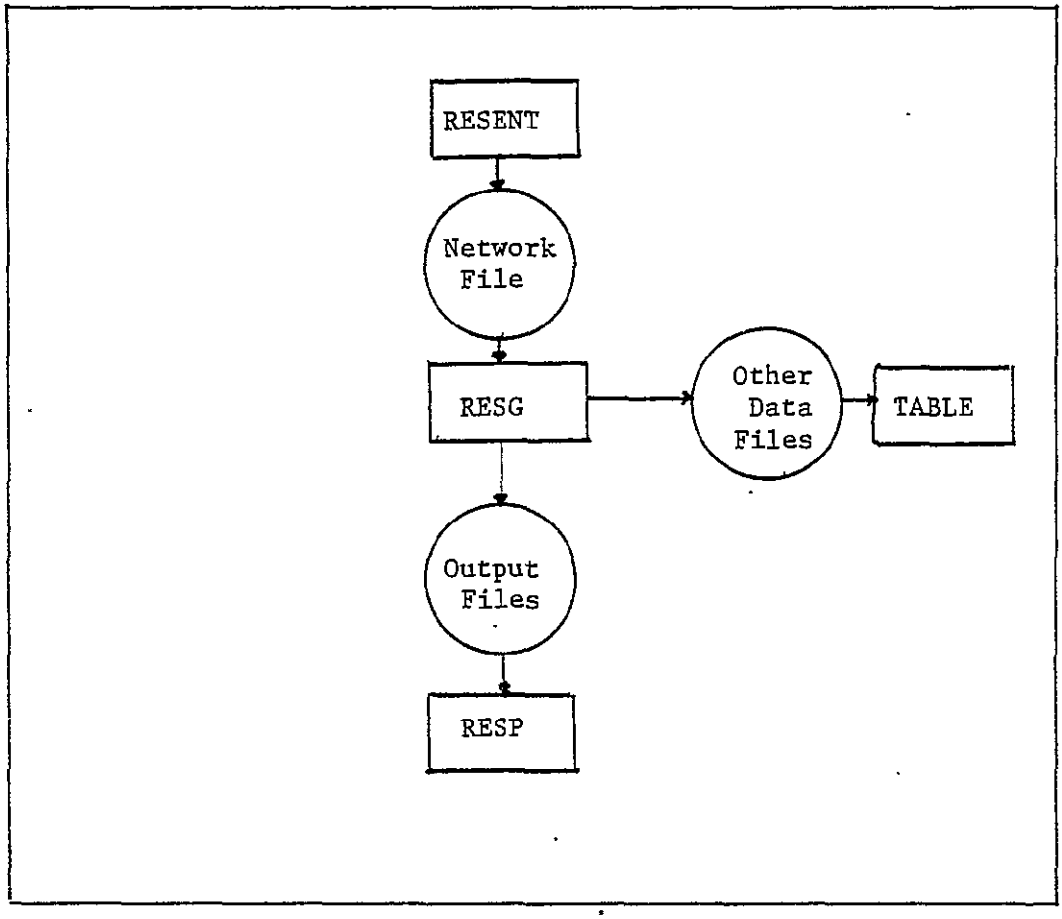
EXHIBIT 1.1: OVERVIEW



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1.3 GETTING STARTED

RESGEN is supplied in four diskettes. Disk A contains the data files; disk B1 the RESG and RESP programs, and disk B2 the RESENT and TABLE programs. Disk U Contains the RESGEN utilities (described in Annex IX.

Hardware Requirements

You must have at least two disk drives (two floppy drives, or a floppy and a hard disk), and at least 384k of Random Access Memory*. The use of a hard disk is strongly recommended, particularly for dynamic RESGEN runs. Alternatively, if you have sufficient memory, transferring the information from the data diskette to so called "RAM-disks" will significantly speed execution times.

Systems without Hard Disks

Disk A should be loaded into drive A, and either B1 or B2 into the floppy drive B. To execute, make sure that A is the default drive, then enter "B: RESG". If B is the default drive, you will obtain a "file not found" error within seconds of the command!

Backup Copies

The diskettes are not copy protected, and you should make backup copies of all of the diskettes. However, it is a violation of U.S. Law to make copies of the diskettes for distribution and/or sale to other parties.

Systems with Hard Disks

The most convenient method when running with a hard disk is to create a DOS subdirectory (if running under MS-DOS 2.0 or higher) in whatever default volume you wish to use, and then copy the contents of all the diskettes into this work space using the copy *.* command. Programs are then executed simply by entry of the program name, e.g. "RESG", or "TABLE".

---

* RESGEN will run on some 256K machines, depending on how much RAM is consumed by the operating system. IBM PC and XT need only 256K when run under DOS 1.1. A special version of RESG is available for 256K IBM PC's on XT's running under DOS 2.0 (& higher) called RESGIBM: this version omits some of the graphics displays.

2. REFERENCE ENERGY SYSTEMS

2.1 REFERENCE ENERGY SYSTEMS

A Reference Energy System (RES) is a format for the graphical display of energy balances. Originally designed as a tool for technology assessment in the U.S., it has since been adapted for use in developing countries, and has been used for energy assessments, and energy policy and planning studies, in numerous countries[1].

Consider, for example, the following energy balance, that is based on the conventional tabular format:

	Hydro Electricity	Electricity	Gasoline	Fuel Oil
Domestic Production	90	--	--	--
Imports	--	--	220	280
Stock Changes	--	--	-20	20
Gross Supply	90	--	200	300
-Elec. inputs	-90	--	--	-100
-Elec. output	--	60	--	--
-Transmission & Dist. losses	--	-12	--	--
Total Consumption		48	200	200
Households		28	200	--
Industry		20	--	200

Following the standard convention, all entries are in tons of oil equivalent (toe), with hydroelectric energy measured in its fossil fuel equivalent[2].

---

(1) Including the Sudan, Peru, Egypt, Dominican Republic, Sri Lanka, Uruguay, Tunisia, Thailand, India, and Indonesia, among others.

(2) For a detailed discussion of Tabular Energy Balances, see e.g. M. Ahmed "Guidelines for the Presentation of Energy Data in Bank Reports", World Bank, Energy Dept. Paper 7, Oct. 1982.

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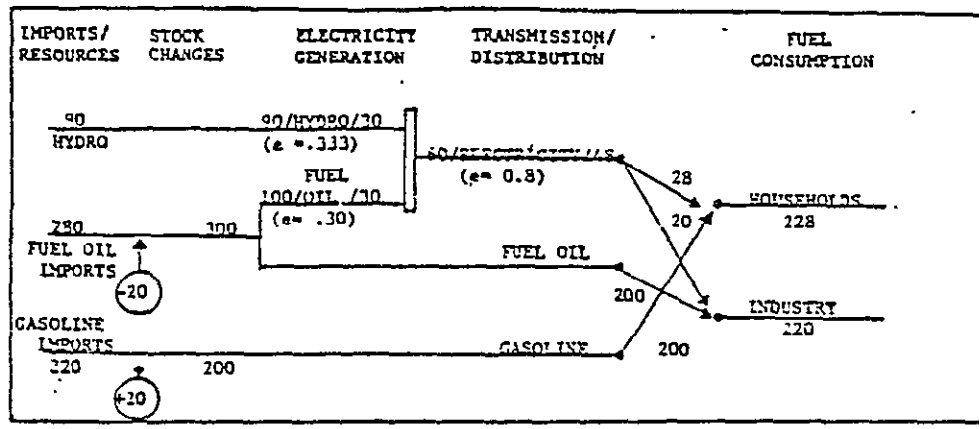
The RES format for this balance is as follows:



An RES thus has the form of a network that describes the flow of energy in an economy. Each link in the network represents some activity—supply, conversion from one energy form to another (such as electric generation), distribution, and use. Some activities involve losses; the notation (e=0.8), implies an efficiency of 80 percent (in the above RES, transmission and distribution of electricity is seen to be 80 percent efficient).

The notation:

$$\xleftarrow[(e = 0.8)]{60 \ / \ \text{electricity} \ / \ 48}$$

indicates that net generation of electricity is 60 toe, the efficiency of transmission and distribution is 80 percent and total electricity consumption is 48 toe. Thus total losses in transmission and distribution are 12 toe, equal to 20 percent of generation.

In such simplified systems, the RES perhaps has little advantage over the tabular balance. However, as soon as the level of information becomes more detailed, particularly by end use, the advantages of the format become more apparent. Suppose, for example, that information is available on the <u>end use</u> of industrial energy consumption: Fuel oil is burned to produce process heat in boilers of

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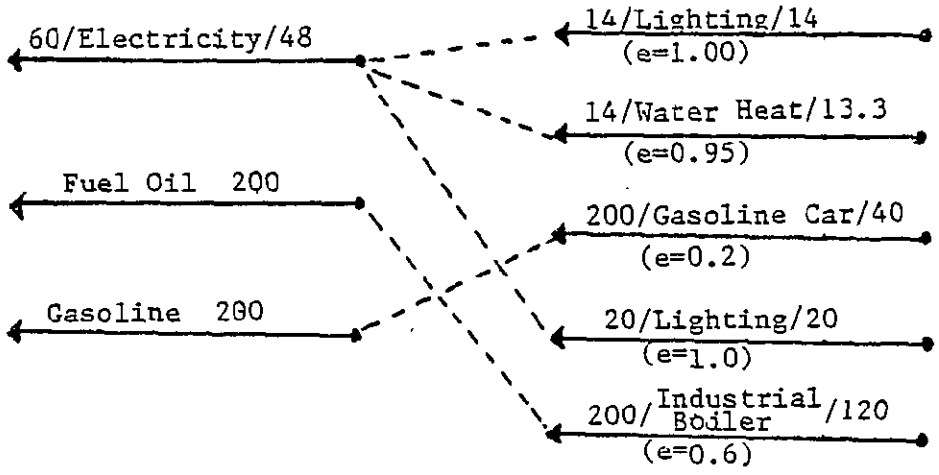
60 percent efficiency, while electricity is used for lighting (at unit efficiency). This information can be displayed as follows:



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2.2 MATRIX ALGEBRIC REPRESENTATION OF RES'S

Consider the hypothetical Reference Energy System of Exhibit 1. Residential space heat is met by two end use devices: electric heaters (40 percent of this use) and oil furnaces (60 percent of this use). Irrigation pumping is met by either diesel (66 percent) or electric pump sets (33 percent). Automobile transportation is met by either diesel (20 percent) or gasoline cars (80 percent). We thus have three end use demands and six end use devices. To calculate the vector of end use demands by device (a vector of 6 elements, say V_2) from the vector of end use demands (a vector of 3 elements, say Y_1) requires the definition of a "transition" matrix whose elements represent the market shares of each device.

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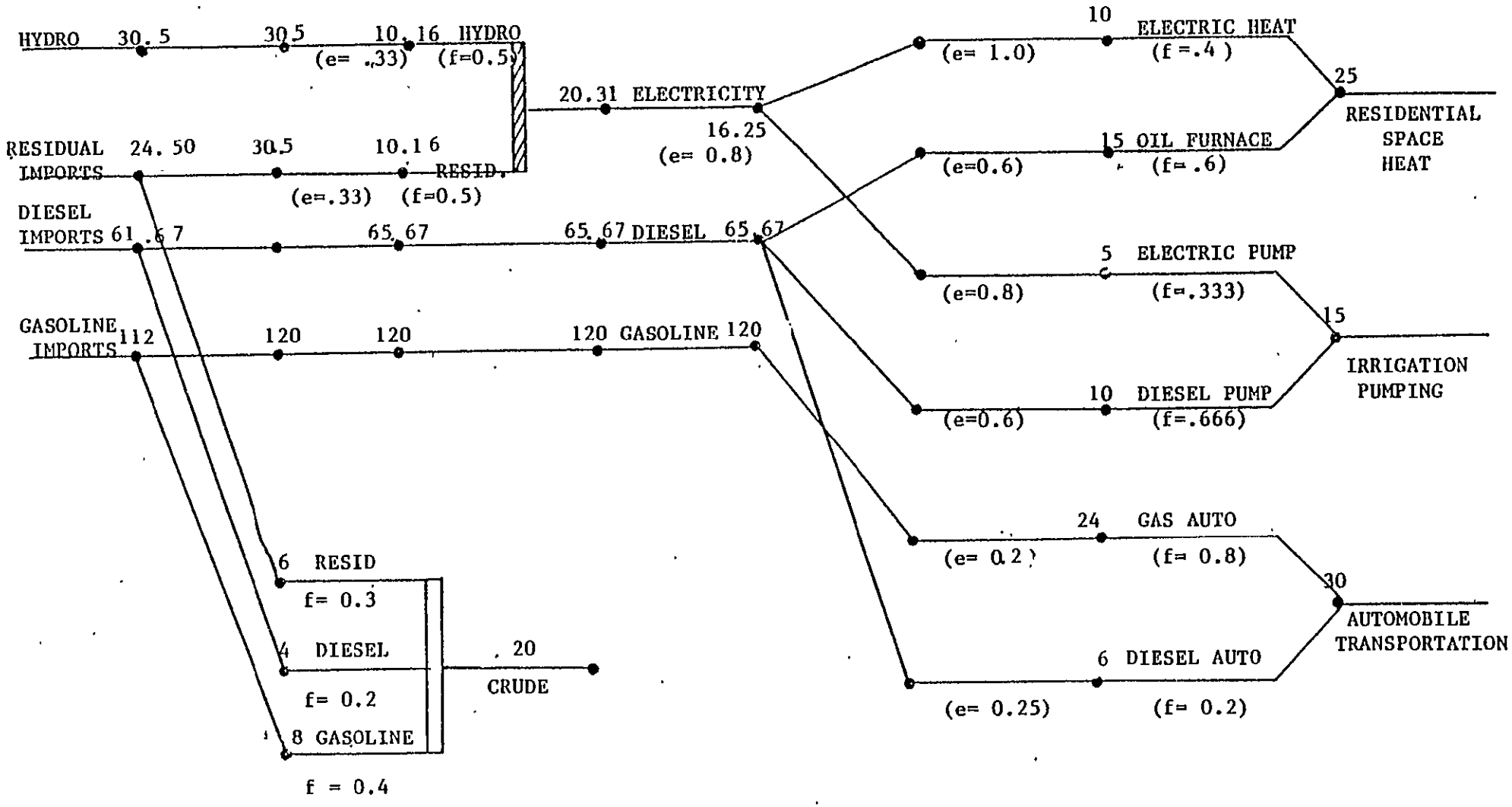
HYDRO 30.5
30.5
10.16 HYDRO
(e= .33) (f=0.5)
RESIDUAL IMPORTS 24.50
30.5
10.16
RESID.
(e=.33) (f=0.5)
DIESEL IMPORTS 61.67
65.67
65.67 DIESEL 65.67
GASOLINE IMPORTS 112
120
120
120 GASOLINE 120
20.31 ELECTRICITY
16.25
(e= 0.8)
(e= 1.0)
10
ELECTRIC HEAT
(f =.4)
(e=0.6)
15 OIL FURNACE
(f= .6)
25
RESIDENTIAL SPACE HEAT
(e=0.8)
5 ELECTRIC PUMP
(f=.333)
(e=0.6)
10 DIESEL PUMP
(f=.666)
15
IRRIGATION PUMPING
(e= 0.2)
24 GAS AUTO
(f= 0.8)
(e= 0.25)
6 DIESEL AUTO
(f= 0.2)
30
AUTOMOBILE TRANSPORTATION
6 RESID
f= 0.3
4 DIESEL
f= 0.2
8 GASOLINE
f = 0.4
20
CRUDE

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Electric Heat	10
Oil Furnace	15
Electric Pump	5
Diesel Pump	10
Gas Auto	24
Diesel Auto	6

=

Residential Space Heat	Irrigation Pumping	Auto Transportation
0.4	0.0	0.0
0.6	0.0	0.0
0.0	0.33	0.0
0.0	0.67	0.0
0.0	0.0	0.2
0.0	0.0	0.8

Res.Sp.Heat	25
Irr. pumping	15
Auto Transp.	30

$$\underset{\substack{\text{End Use by Device} \\ V_2}}{\overset{(6x1)}{}} = \underset{\substack{\text{Market Share} \\ T_{1,2}}}{\overset{(6x3)}{}} \cdot \underset{\substack{\text{End Use by Sector} \\ V_1}}{\overset{(3x1)}{}} \qquad (1)$$

Thus the element $T_{1,2}$ (i,j) represents the market share of device i in end use sector j; the entries in the equation follow from the market shares noted above. The reader should verify the algebra: for example, the first element of V_2 is given by[1]

$$0.4 \times 25 + 0.0 \times 15 + 0.0 \times 30 = 10$$

The next set of links in the network represent fuel use by end-use device: these follow from the relationship between fuel use, efficiency and end use demand,

i.e.

$$\text{End Use Demand} = \text{Efficiency} \times \text{Fuel Use} \qquad (2)$$

hence

$$\text{Fuel Use} = \frac{\text{End Use Demand}}{\text{Efficiency}} \qquad (3)$$

---

[1] See Annex III for 2 presentation of matrix multiplication

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Thus the vector of fuel use by device, V_3 follows from V_2 by the equation:

$$\begin{bmatrix} 10 \\ 25 \\ 6.25 \\ 16.66 \\ 120 \\ 24 \end{bmatrix} = \begin{bmatrix} 1.0 & & & & & \\ & 1/0.6 & & & & \\ & & 1/0.8 & & & \\ & & & 1/0.6 & & \\ & & & & 1/0.21 & \\ & & & & & 1/0.25 \end{bmatrix} \begin{bmatrix} 10 \\ 15 \\ 5 \\ 10 \\ 24 \\ 6 \end{bmatrix}$$

V_3	$T_{2,3}$	V_2
(6x1)	(6x6)	(6x1)
Fuel Use by Device	Device Efficiency	End Use by Device

$T_{2,3}$ is thus a diagonal matrix, whose i-th (diagonal) element represents the reciprocal of the efficiency of the i-th end use device. Again the reader should verify the algebra.

The next step is to aggregate the six entries in the fuel use by device vector (V_3) to the fuel categories -- central electricity, diesel and gasoline.

$$\begin{bmatrix} 16.25 \\ 61.66 \\ 120 \end{bmatrix} = \begin{bmatrix} 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 & 1 & 0 \end{bmatrix} \begin{bmatrix} 10 \\ 25 \\ 6.25 \\ 16.66 \\ 120 \\ 24 \end{bmatrix}$$

(3x1) V_4	(3x6) $T_{3,4}$	(6x1) V_3
Total Fuel Demand	Aggregation Matrix	Fuel Use by Device

The aggregation matrix $T_{3,4}$ consists entirely of zeros and ones: Each device corresponds to one column; each fuel corresponds to a row. Thus for each column (device) one enters a one in that column that corresponds to the fuel. For example, column 2 represents fuel use in oil furnaces; this requires diesel oil as fuel: since diesel fuel is

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defined by row 2, T (2,2) = 1. (and all other entries in column 2 are zero).

Electricity	16.25
Diesel	65.67
Gasoline	120

V_4 (3x1)

=

	Electric Furnace	Oil Furnace	Electric Pumpset	Diesel Pumpset	Gas Auto	Diesel Auto
Electricity	1	0	1	0	0	0
Diesel	0	1	0	1	0	1
Gasoline	0	0	0	0	1	0

$T_{3,4}$ (3x6)

x

Electric Furn.	10
Oil Furnace	25
El. Pump Set	6.25
Diesel Pump	16.66
Gas Auto	120
Diesel Auto	24

V_3 (6x1) (6

The next transition captures the efficiency of fuel transportation and distribution. The major concern here is the loss in electricity transmission and distribution (assumed 80 percent efficient); losses in diesel and gasoline transportation and distribution are assumed at zero. This transition is captured as follows:

Electricity Generation	20.31
Diesel	65.67
Gasoline	120

V_5 (3x1)

=

	Electricity consumption	Diesel	Gasoline
Electricity Generation	$\frac{1}{0.8}$		
Diesel		1.0	
Gasoline			1.0

$T_{4,5}$

x

Electricity Consumption	16.25
Diesel	65.67
Gasoline	120

V_4 (3x1) (7

The next transaction concerns the electric sector: we must disaggregate total electricity generation into generation by plant type. In our example, suppose about 50 percent of annual generation

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is by hydroelectric, 50 percent is by residual oil fired steam electric plants. The next vector, V_6 has 4 elements, and is given by:

Hydro Generation	10.155
Residual Generation	10.155
Diesel	65.67
Gasoline	120.00

V_6

(4x1)

=

	Electric Generation	Diesel	Gasoline
Hydro Generation	0.5		
Residual Generation	0.5		
Diesel		1.0	
Gasoline			1.0

$T_{5,6}$

(4x3)

x

Electric Generation	20.31
Diesel	65.67
Gasoline	120.00

V_5

(3x1)

V_6 gives generation by fuel type in the electric sector. In order to obtain fuel consumption, a further transition is necessary that captures the efficiency (or heat rate) of each plant type. Thus:

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Hydro	30.50
Residual	30.50
Diesel	65.66
Gasoline	120

V_7

(4x1)

=

	Hydro generation	residual generation	diesel	gasoline
Hydro	$\frac{1}{0.33}$			
Residual		$\frac{1}{0.33}$		
Diesel			1.0	
Gasoline				1.0

$T_{6,7}$

(4x4)

•

Hydro Generation	10.16
Residual Generation	10.16
Diesel	65.66
Gasoline	120

V_6

(4x1)

We next turn to the refinery, which has a crude capacity of 20, producing 8 units of gasoline, 4 units of diesel, and 6 units of residual (with losses of 2). The outputs of refined products equals the crude input times the yield coefficient. For example:

$$\underset{\text{(units gasoline)}}{8} = \underset{\left(\frac{\text{units gasoline}}{\text{units of crude}}\right)}{0.4} \quad \underset{\text{(units crude)}}{20}$$

For the complete set of petroleum products, in matrix form, we have:

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							crude
Resid	6	=	Resid	0.3	x	Crude	20
Diesel	4		Diesel	0.2			
Gasoline	8		Gasoline	0.4			
W_2 (3x1)			$R_{1,2}$ (3x1)			W_1 (1x1)	

where the elements of $R_{1,2}$ represent the refinery yield coefficients. Note that these need not sum to unity: here we assume an overall refinery efficiency of 0.9, and thus:

$$\sum_{j=1}^{3} R_{1,2(j)} = 0.9$$

The final vector, V_8, is now obtained by <u>subtracting</u> w_2 from V_7: V_7 represents domestic fuel demand, W_2 domestic refinery output, and the difference represents imports (of refined products). Thus

Hydro	30.50		Hydro	30.50		Hydro	0
Resid. Imports	24.50	≈	Resid. Demand	30.50	-	Resid. Prod.	6
Diesel Imports	61.47		Diesel Demand	65.66		Diesel Prod.	4
Gasoline Imports	112		Gasoline Demand	120		Gasoline Prod.	8
V_8 (4x1)			V_7 (4x1)			W_2* (4x1)	

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Note that in order to keep the vectors conformable for subtraction, all must have the same dimension; thus we have added a dummy entry (for hydroelectricity) to the (3x1) vector W_2 to yield a (4x1) vector $W_2{*}$[1].

---

(1) In the RESGEN software, however, this mathematical formality is automatic for subtraction or addition of vectors.

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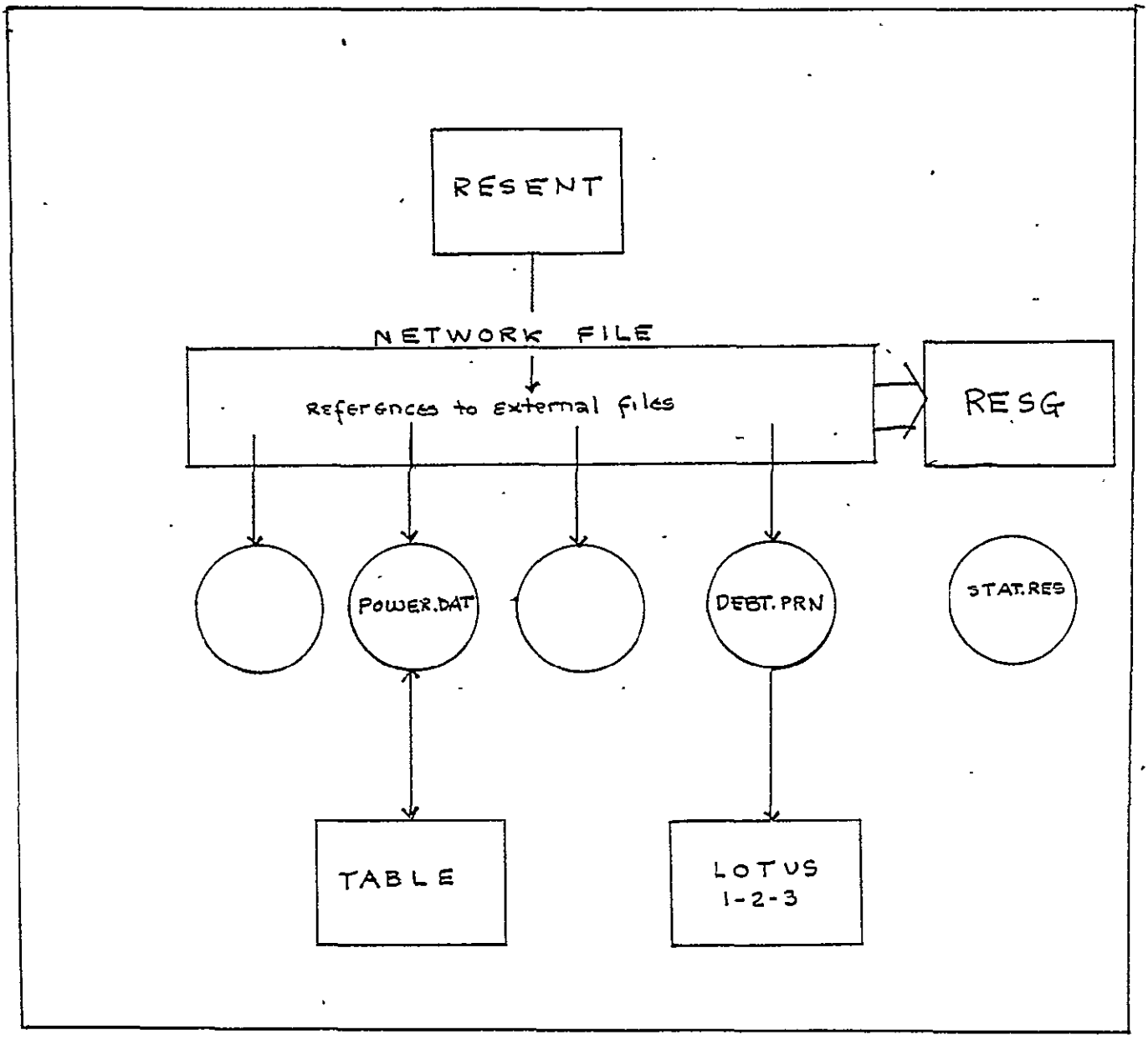
3. DATA STRUCTURE

3.1 OVERVIEW

RESGEN uses three types of file. Every RESGEN structure requires a "network" file, created and modified in the "RESENT" program.

Most subsidiary files are created and modified in the TABLE program. A small number of special purpose files are created in LOTUS 1-2-3 LOTUS print files (that must have the DOS extension ".PRN").

EXHIBIT 3.1: DATA STRUCTURE OVERVIEW



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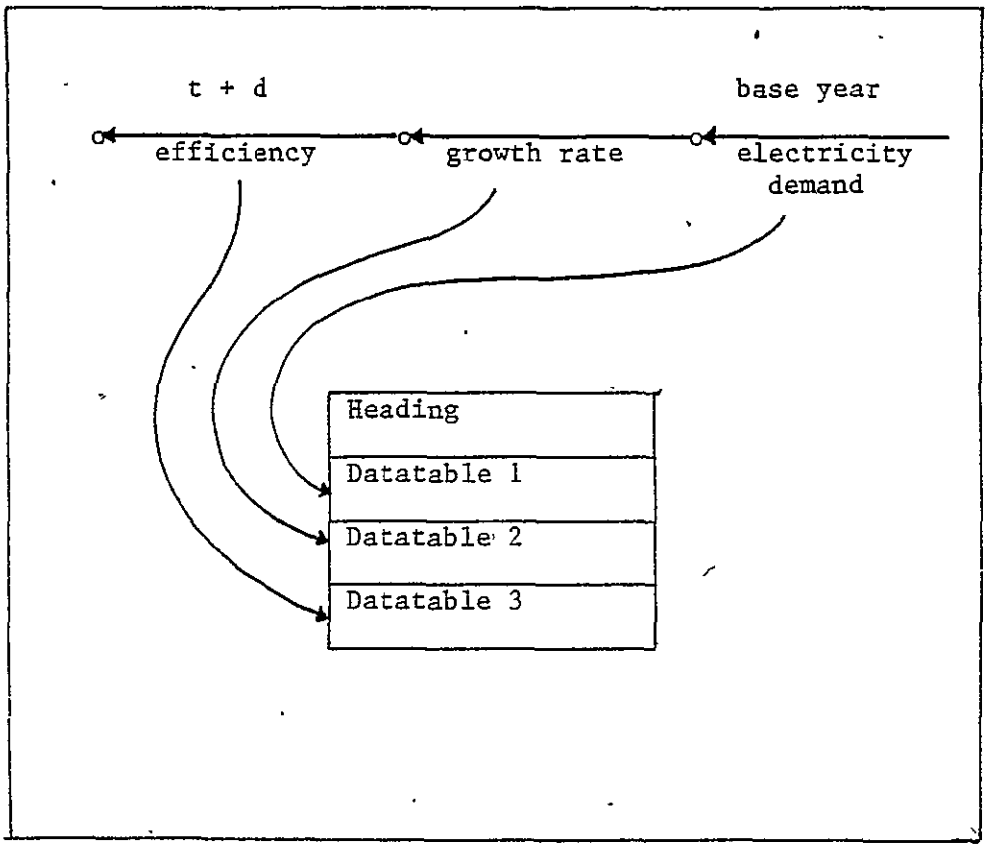
The network file is the basis for every application. Any analytical problem that can be formulated as a network, (including non-energy problems) can be translated into a RESGEN structure: The process of breaking down a network into a series of individual steps in the case of energy has been illustrated in Section 2.2. The network data file is broken down into a heading section, followed by a series of "data tables" that correspond to each vertical "slice" of the network. For example, in the simple network of Exhibit 2.2 the three steps in the network would require three data tables in the network file.

EXHIBIT 3.2: NETWORK FILE



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3.2 HOW TO BUILD RESGEN NETWORKS: A FIRST TUTORIAL

The easiest way of learning how to create RESGEN networks is to use CREATE and QUICK, programs that are included on the RESGEN utilities diskette.

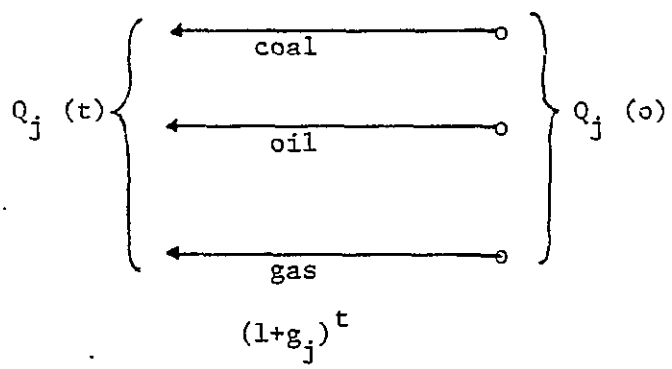
Step 1: Draw the Network. For example, consider the simple demand forecasting model

$$Q_j\ (t) = Q_j\ (o)\ (1+g_j)^t$$

where Q_j (t) is the demand of fuel j at time t

g_j is the growth rate for fuel j

If there are 3 fuels, the network equivalent is:



This network requires two RESGEN data tables: the first contains the base year fuel demands $Q_j(o)$; the second the growth rates g_j

HEADINGS
Table 1 Q_j (o)
Table 2 g_j

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How do we create the data file for this network? To use QUICK, we need two items: first a list of fuelnames; second a list of table specifications. The list of fuels is:

01 coal
02 oil
03 gas

and the list of tables has 5 columns, namely:

Table Type (or "operator")	Table Name	Number of Links	Range of Fuel Names: From	To
projection	base year demand	3	1	3
growth	growth rates	3	1	3

The only thing you really need to learn at this stage is which "operator" should be used. To start a network (with a vector of numbers), the first table is always projection*.

* Use lower case: the use of upper case (e.g. PROJECTION) will simply slow down subsequent calculations.

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Growth rate terms in equations have the quite logical designation growth. You must spell this exactly as indicated in Section 6 of this report, which lists the available operators.

Step 2: Run "CREATE"

Put the utilities diskette in a floppy disk drive and type "CREATE". This will load a version of the TABLE database program suitable for our present purpose. Once in TABLE, first choose selection 1, which loads in a blank fuel list (the file LISTFUEL.NEW). Next, edit in an appropriate list of fuels. Then load in the blank table list (the file LISTAB.NEW), as indicated above. This is how the two files will look for our example:

fuellist template

label	
01	coal
02	oil
03	gas

RESGEN table template

operator	name	lk	fr	to	output name	fr	to
projection	base year demand	03	01	03			
growth	growth rates	03	01	03			

Step 3: Run Quick

Exit the TABLE program, and you will automatically enter QUICK. If for any reason you leave CREATE, You can always run QUICK by itself (since QUICK is a program called by CREATE). QUICK converts the two lists into a data file that contains the network data structure. This structure still needs numbers and coefficients; QUICK simply inserts 1.0 for all values. But the hardest part of the process is now done: all you need now do is to load the new file into RESENT to edit the values of the coefficients.

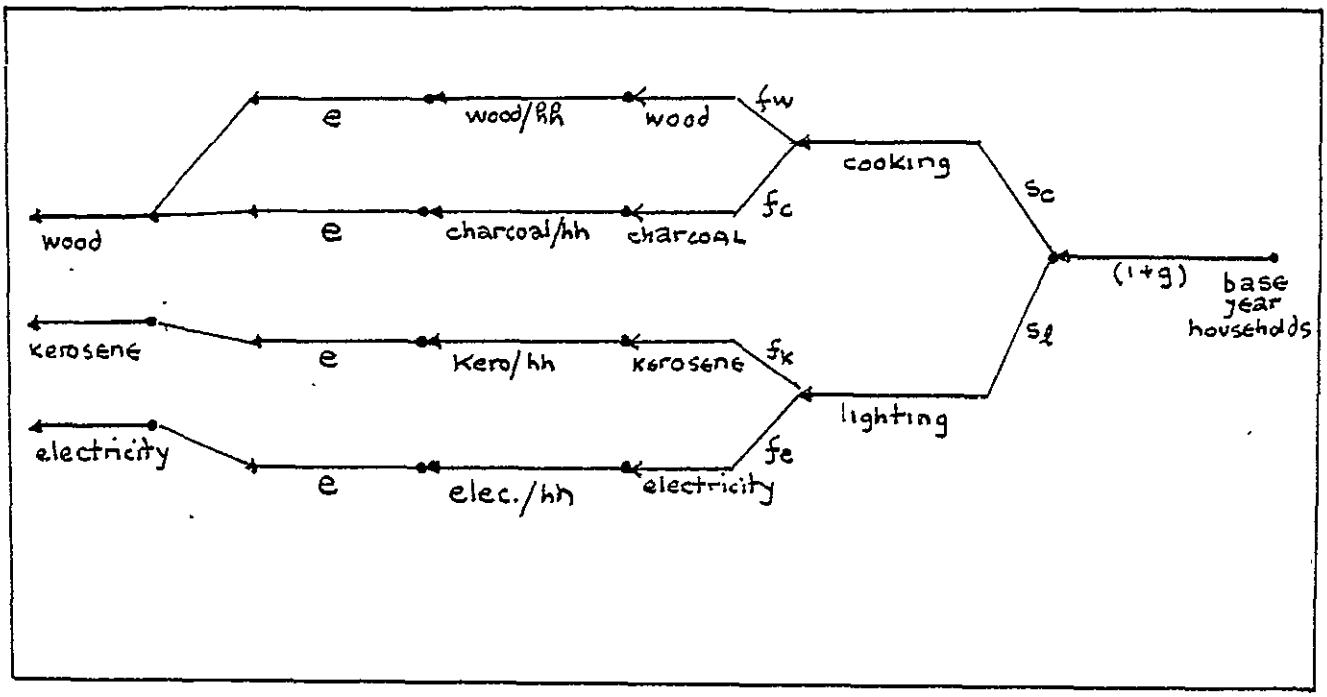
Finally, before you can run the network in RESG, you must add the new file to the network "directory", so that you can call this network from the screen. Do this (at any time) by calling ADDNET.

3.3: MORE ABOUT RESGEN NETWORKS

If you have understood the simple example of Section 3.2 - you are ready for a more complicated network.

Suppose we wish to model energy use in the rural household sector, for which the network shown on figure 3.3 might be used.

EXHIBIT 3.3 A SIMPLE NETWORK FOR RURAL ENERGY USE



For this network we would have the following label list:

usel manual label list

	label
01	households
02	cooking
03	lighting
04	wood
05	charcoal
06	kerosene
07	electricity
08	wood
09	kerosene
10	electricity

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While the data table list is as follows:

RESGEN table template

operator	name	lk	fr	to	output name	fr	to
projection	base year hh	01	01	01	base year hh	01	01
growth	growth rate	01	01	01	scenario hh	01	01
share	saturation level	02	02	03	households/end use	01	02
share	fuel fractions	04	04	07	households/fuel	01	04
diagonal	unit demands	04	04	07	fuel use	01	04
diagonal	efficiency	04	04	07	wood for charcoal	02	02
aggregate	aggregation	03	08	10	total fuel use	01	03

We have added two additional columns to the right hand side of data table list, namely a "print range". This instructs RESG on the range of elements to be printed out and which can be smaller (but not larger) than the total number of elements in any vector.

After leaving the TABLE program, the CREATE utility loads QUICK, which converts the two lists into a RESGEN file. CREATE will give you the step by step details of how to give the RESGEN file a name, and how you must load QUICK. Table 3.1 shows the network file as it is created by QUICK, and which entries must be edited in RESENT; Table 3.2 shows the file <u>after</u> the RESENT editing process, in a form ready for RESG.

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TABLE 3.1: BEFORE EDITING IN RESENT

```
 1:*
 2:    1----------2----------3----------4----------5----------6----------
 3: user manual
 4: ****************************************************************
 5: data table  1
 6: ****************************************************************
 7: projection
 8: matrix name =base year hh
 9: matrix size = 1
10: none        = 1  1
11: none        =
12:    sector
13: -- ------------------- -- ------------------- --------- ----------
14:  1 households              1.000
15: ****************************************************************
16: data table  2
17: ****************************************************************
18: growth
19: consis.check=00
20: matrix name =growth rate
21: output name =scenario hh
22: output units=
23: matrix size = 1  1
24: none        = 1  1
25: none        =
26:    sector
27: -- ------------------- -- ------------------- --------- ----------
28:  1 households            1 households                1.00
29: ****************************************************************
30: data table  3
31: ****************************************************************
32: share
33: consis.check=00
34: matrix name =saturation level
35: output name =households/end u
36: output units=
37: matrix size = 2  1
38: none        = 1  2
39: none        =
40:    sector
41: -- ------------------- -- ------------------- --------- ----------
42:  1 households            1 cooking                   1.00
43:  1 households            2 lighting                  1.00
44: ****************************************************************
45: data table  4
46: ****************************************************************
47: share
48: consis.check=00
49: matrix name =fuel fractions
50: output name =households/fuel
51: output units=
52: matrix size = 4  2
53: none        = 1  4
54: none        =
55:    sector
56: -- ------------------- -- ------------------- --------- ----------
57:  1 cooking               1 wood                      1.00
58:  2 lighting              2 charcoal                  1.00
59:  2 lighting              3 kerosene                  1.00
60:  2 lighting              4 electricity               1.00
```


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```
61: ****************************************************************
62: data table  5
63: ****************************************************************
64: diagonal
65: consis.check=00
66: matrix name =unit demands
67: output name =fuel use
68: output units=
69: matrix size = 4  4
70: none        = 1  4
71: none        =
72:    sector
73: -- ------------------- -- ------------------- ---------- -----------
74:  1 wood                1 wood                   1.00
75:  2 charcoal            2 charcoal               1.00
76:  3 kerosene            3 kerosene               1.00
77:  4 electricity         4 electricity            1.00
78: ****************************************************************
79: data table  6
80: ****************************************************************
81: diagonal
82: consis.check=00
83: matrix name =efficiency
84: output name =wood for charcoa
85: output units=
86: matrix size = 4  4
87: none        = 2  2
88: none        =
89:    sector
90: -- ------------------- -- ------------------- ---------- -----------
91:  1 wood                1 wood                   1.00
92:  2 charcoal            2 charcoal               1.00
93:  3 kerosene            3 kerosene               1.00
94:  4 electricity         4 electricity            1.00
95: ****************************************************************
96: data table  7
97: ****************************************************************
98: aggregate
99: consis.check=00
100: matrix name =aggregation
101: output name =total fuel use
102: output units=
103: matrix size = 3  4
104: none        = 1  3
105: none        =
106:    sector
107: -- ------------------- -- ------------------- ---------- -----------
108:  1 wood
109:  2 kerosene
110:  3 electricity
111: ****************************************************************
112: END
```


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TABLE 3.2: AFTER EDITING IN RESENT

```
1:*                                                                    *
2:    1----------2----------3----------4----------5----------6---------- *
3: user manual                                                         *
4: ************************************************************************
5: data table  1                                                       *
6: ************************************************************************
7: projection                                                          *
8: matrix name =base year hh                                           *
9: matrix size = 1                                                     *
10: none        = 1  1                                                 *
11: none        =                                                      *
12:    sector                                                          *
13: -- ------------------- -- ------------------- ---------- ----------*
14:  1 households              200.000                                 *
15: ************************************************************************
16: data table  2                                                      *
17: ************************************************************************
18: growth                                                             *
19: consis.check=00                                                    *
20: matrix name =growth rate                                           *
21: output name =scenario hh                                           *
22: output units=                                                      *
23: matrix size = 1  1                                                 *
24: none        = 1  1                                                 *
25: none        =                                                      *
26:    sector                                                          *
27: -- ------------------- -- ------------------- ---------- ----------*
28:  1 households            1 households                1.000         *
29: ************************************************************************
30: data table  3                                                      *
31: ************************************************************************
32: share                                                              *
33: consis.check=00                                                    *
34: matrix name =saturation level                                      *
35: output name =households/end u                                      *
36: output units=                                                      *
37: matrix size = 2  1                                                 *
38: none        = 1  2                                                 *
39: none        =                                                      *
40:    sector                                                          *
41: -- ------------------- -- ------------------- ---------- ----------*
42:  1 households            1 cooking                   1.000         *
43:  1 households            2 lighting                  1.000         *
44: ************************************************************************
45: data table  4                                                      *
46: ************************************************************************
47: share                                                              *
48: consis.check=00                                                    *
49: matrix name =fuel fractions                                        *
50: output name =households/fuel                                       *
51: output units=                                                      *
52: matrix size = 4  2                                                 *
53: none        = 1  4                                                 *
54: none        =                                                      *
55:    sector                                                          *
56: -- ------------------- -- ------------------- ---------- ----------*
57:  1 cooking               1 wood                       .500         *
58:  1 cooking               2 charcoal                   .500         *
59:  2 lighting              3 kerosene                   .800         *
60:  2 lighting              4 electricity                .200         *
```


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```
61: ****************************************************************
62: data table  5
63: ****************************************************************
64: diagonal
65: consis.check=00
66: matrix name =unit demands
67: output name =fuel use
68: output units=
69: matrix size = 4  4
70: none        = 1  4
71: none        =
72:    sector
73: -- ------------------- -- ------------------- --------- ----------
74:  1 wood                 1 wood                  10.000
75:  2 charcoal             2 charcoal              10.000
76:  3 kerosene             3 kerosene               1.000
77:  4 electricity          4 electricity            1.000
```

```
78: ****************************************************************
79: data table  6
80: ****************************************************************
81: diagonal
82: consis.check= 0
83: matrix name =efficiency
84: output name =wood for charcoa
85: output units=
86: matrix size = 4  4      .00   0   0
87: none        = 2  2 barch=
88: none        = 0  0 barch=
89:    sector
90: -- ------------------- -- ------------------- --------- ----------
91:  1 wood                 1 wood                  1.000
92:  2 charcoal             2 wood                   .150
93:  3 kerosene             3 kerosene              1.000
94:  4 electricity          4 electricity           1.000
95: ****************************************************************
96: data table  7
97: ****************************************************************
98: aggregate
99: consis.check=00
100: matrix name =aggregation
101: output name =total fuel use
102: output units=
103: matrix size = 3  4
104: none        = 1  3
105: none        =
106:    sector
107: -- ------------------- -- ------------------- --------- ----------
108:  1 wood                 0                        .000
109:  2 kerosene             0                        .000
110:  3 electricity          0                        .000
111: ****************************************************************
112: END
```


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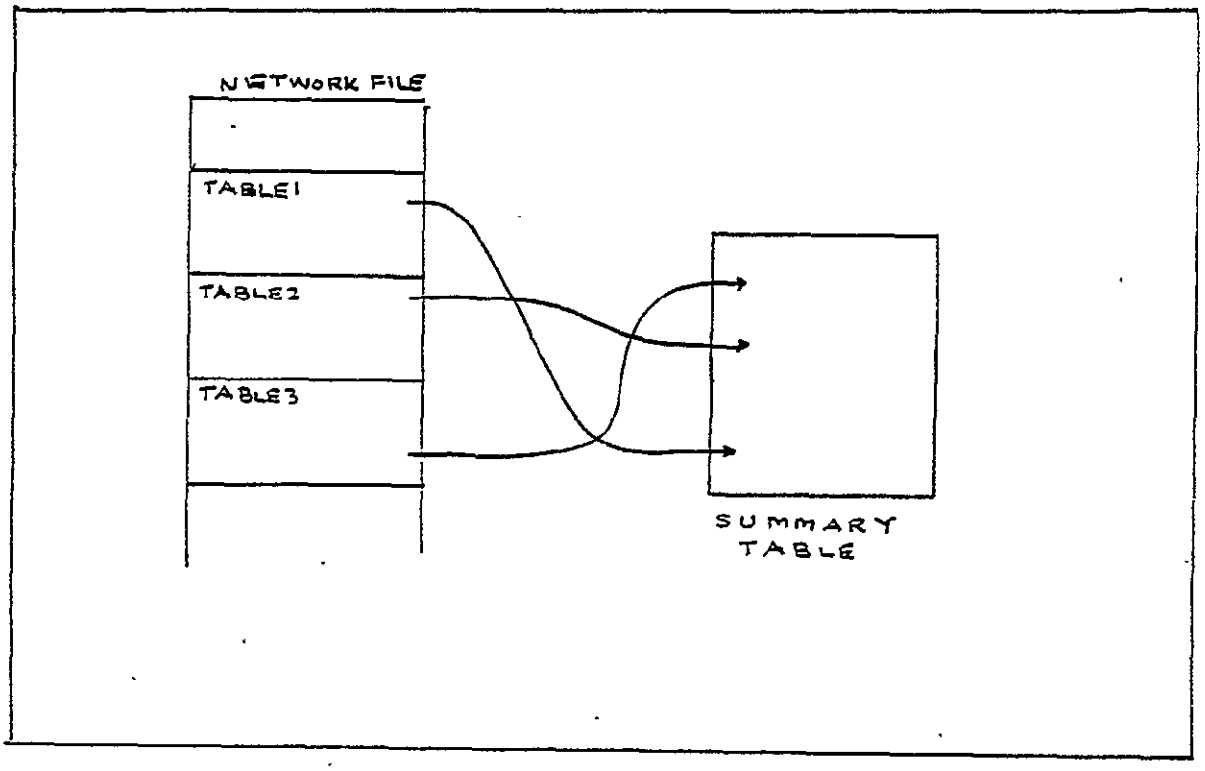
3.4 SUMMARY TABLES

Summary tables can be generated in RESG by moving information from the output of each computation step to a particular row of a summary table. At each step in the calculation, you can transfer values into up to two different rows.

EXHIBIT 3.4: MOVING INFORMATION TO A SUMMARY TABLE



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How would this work for the network discussed in the previous section. Suppose we want to produce a summary table that has the following format:

	KEROSENE	ELECTRICITY	CHARCOAL	WOOD
Lighting				
Cooking				
Total				

The rows of the table would need to be defined in the LABELS.DAT file, and if you want the fuels in exactly the order shown, the columns must be listed in a file of type COLUMNS.DAT. The values for fuel use are generated in data Table 5 of the RESGEN network. (see Table 3.2); all we need do to move the information to the summary table is to replace lines 70 and 71 by:

```
70  cooking  =  1  2
71  lighting =  3  4
```

This results in elements 1 to 2 being moved to the summary table row "cooking", and elements 3 to 4 being moved to the row "lighting". RESG automatically takes care of assigning the values to the correct column (this is done by matching fuel labels).

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4. MODELLING THE ENERGY SYSTEM

4.1 INTRODUCTION

RESGEN provides for a number of generic matrix operations -- addition, subtraction, matrix multiplication, and so on, (see Table 4.1) which could, in theory, be used for all network calculations. However, many of the manipulations necessary for an accurate representation of the electric sector are best performed in special purpose operators -- either because these prove to be more convenient than forcing them into the generic functions, or because the generic functions cannot handle certain calculations -- such as the optional dispatch algorithm necessary for representation of the electric sector. In this section we discuss how energy systems can be modelled in the RESGEN format, and how the special purpose operations are used. The details of the data formats for these operators are given in Annex VIII.

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TABLE 4.1: THE RESGEN OPERATORS

	NAME	FUNCTION
Generic	MATRIX	MATRIX multiplication
	Addition	Add a side branch
	Difference	Subtract a side branch
	Aggregate	Join Network links
	Share	Split network links
	Diagonal	diagonal matrix multiplication
	Growth	
	VGrowth	
	Projection	Start a network with a vector
Special Purpose	* projects	add a list of projects
	i-elasticity	income elasticity
	s-elasticity	income elasticity
	p-elasticity	price elasticity adjustment
	v-elasticity	price elasticity adjustment variable price escalator
	demand	start a side chain from an external file
	supply	start a side chain
	supply=table	start a side chain with a data table
	supply=resources	start a side chain with data from a table of alternative scenarios
Energy Sector Specific	Electric	Electric sector optimization
	Vrefinery	Refinery
	refinery	refinery (with fixed crude input)

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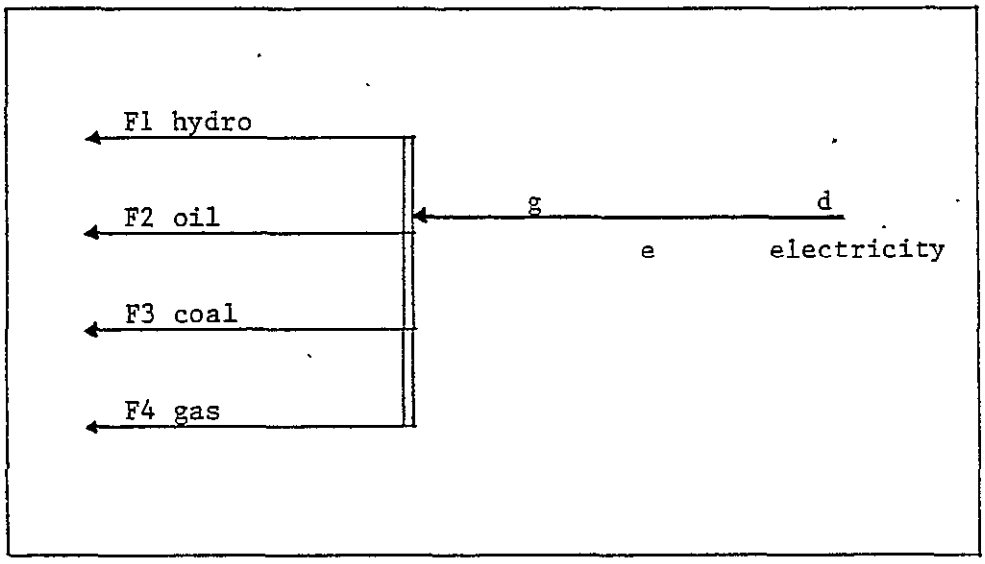
4.2 MODELING THE ELECTRIC SECTOR

In network form the electric sector appears as follows, where g is the total generation, and F1,... are the fuel inputs:

EXHIBIT 4.1: ELECTRIC SECTOR NETWORK



This could be modelled in RESGEN in two steps: a share operator that splits the total generation into the respective shares provided by each fuel, and a diagonal operator that transforms generation into the fuel requirement (by dividing by the thermal efficiency).

While this suffices for portraying an historical energy balance, it leaves much to be desired for constructing scenarios. Obviously, as electric demands rise and fall in response, say, to conservation measures, the contribution of different generation types does not vary in fixed proportion; hydro electricity dispatched into baseload would not be affected by changes to the peak resulting from a conservation program.

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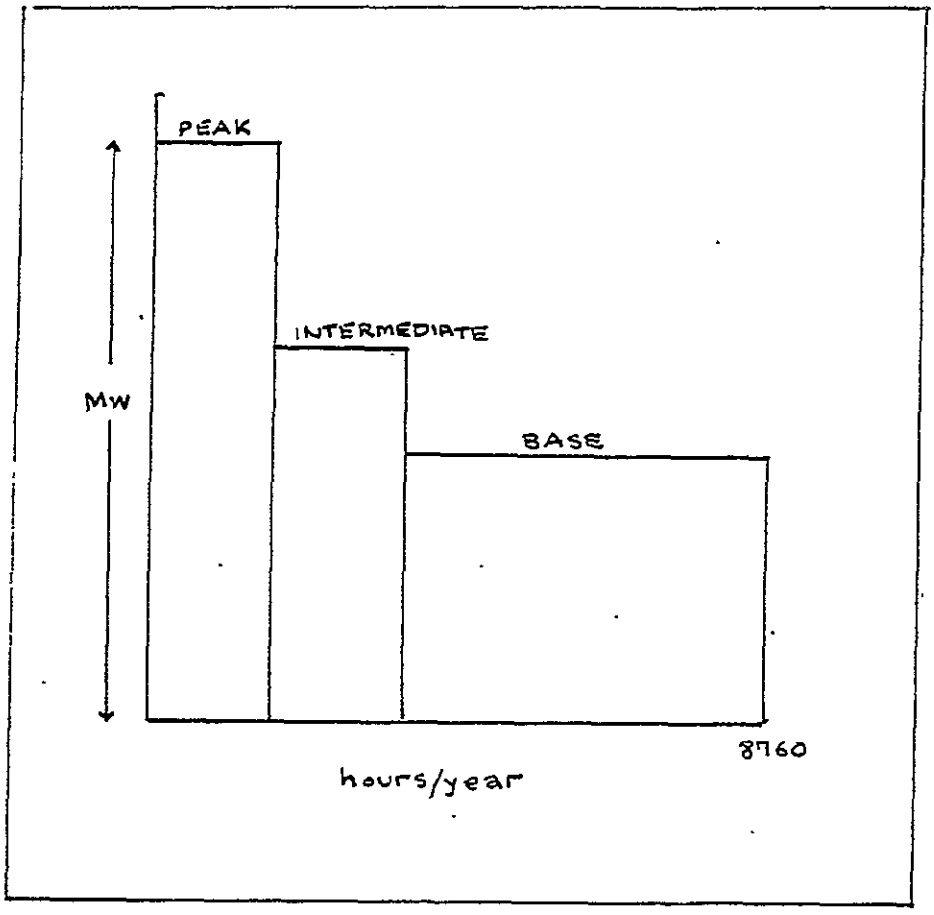
EXHIBIT 4.2: LOAD DURATION CURVE



A much better approach, however, is to make a more complicated and detailed, but technically more credible, computation of fuel requirements by dispatching power plants into a linearized load duration curve (Exhibit 4.2)). In any event, a plant-by-plant approach is necessary for the energy sector investment and debt service calculations (see Section 4.5, below). For this purpose the special operator electric has been developed, which invokes the optimal dispatch algorithm described in detail in Annex X.

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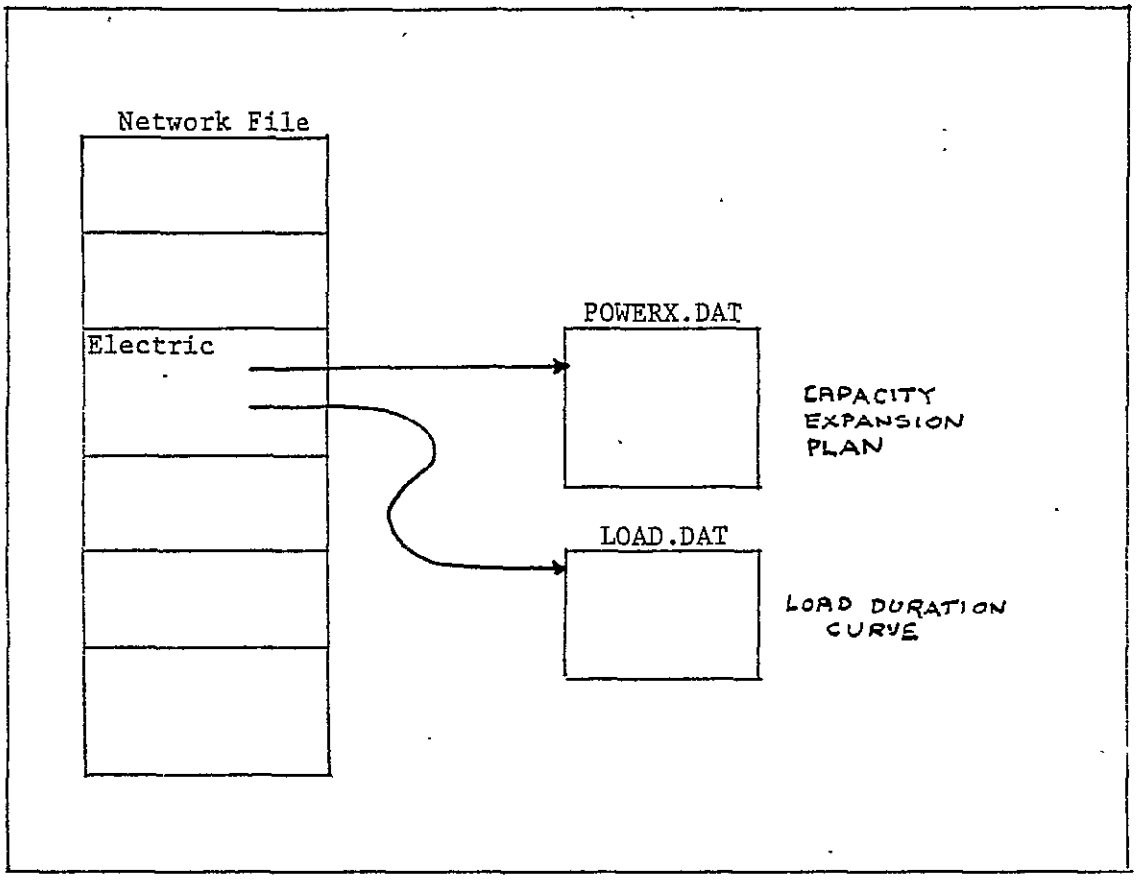
EXHIBIT 4.3: ELECTRIC SECTOR REPRESENTATION



Two outside data files are needed. The LOAD.DAT file defines the shape of the load duration curve: the actual curve is calculated by RESG in such a way that the area under the curve equals the total generation requirement. The list of power plants is contained in a second outside file of the type POWERX.DAT: generally the information in this file is obtained from the capacity expansion plan of the electric utility.

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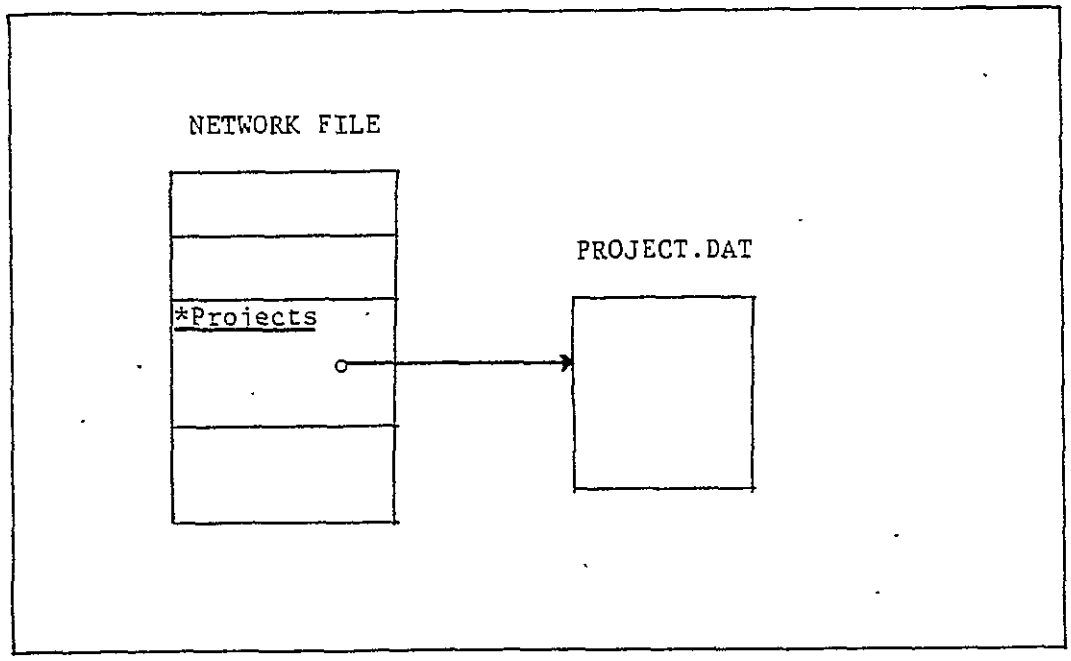
4.3: PROJECT LEVEL DEMAND PROJECTION

For some energy demand sectors functional equations using growth rates are not appropriate, because energy demand increases in the manner of step functions as new capacity is built. This is particularly true of energy intensive industries such as cement, iron & steel and fertilizers, for which the best approach, at least for short to mid term projections, is to project demands from a project list. This is done using a special operator, *projects, that adjusts the network energy flows according to a plant capacity expansion plan that is contained in an outside file of the type PROJECT.DAT.

EXHIBIT 4.4: THE PROJECT.DAT OPERATOR



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4.4 ECONOMETRIC DEMAND STRUCTURES

Consider a demand model of the Form

$$(1) \qquad Q_t = Q_o \left(\frac{P_t}{P_o}\right)^{\alpha} \cdot \left(\frac{Y_t}{Y_o}\right)^{\beta}$$

where

Q_j is the demand at time j

P_j consumer price at time j

Y_t income at time j

α price elasticity

β income elasticity.

Suppose we have a two sector model for electricity and oil, with 1982 demands given by the vector:

$$Q_o = \begin{bmatrix} \text{electricity} & : & 80 \\ \text{oil} & : & 400 \end{bmatrix}$$

Suppose that the applicable elasticities are given by

	Price Elasticity α	Income Elasticity β
Electricity	-0.1	1.5
Oil	-0.3	1.2

and that the 1982 consumer prices and incomes are:

	Consumer Price P_o	Income Y_o
Electricity	20	
		250 (corresponding to the industrial sector)
Oil	10	

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Further, let the scenario require a 6 percent per annum income growth rate, a 3 percent increase in the real price of world oil, and a 2 percent exchange rate adjustment, for a total domestic consumer price rate increase of 5 percent.

Then, by reference to (1) we have for a 1990 projection (i.e for n = 8 years) the following equation for electricity:

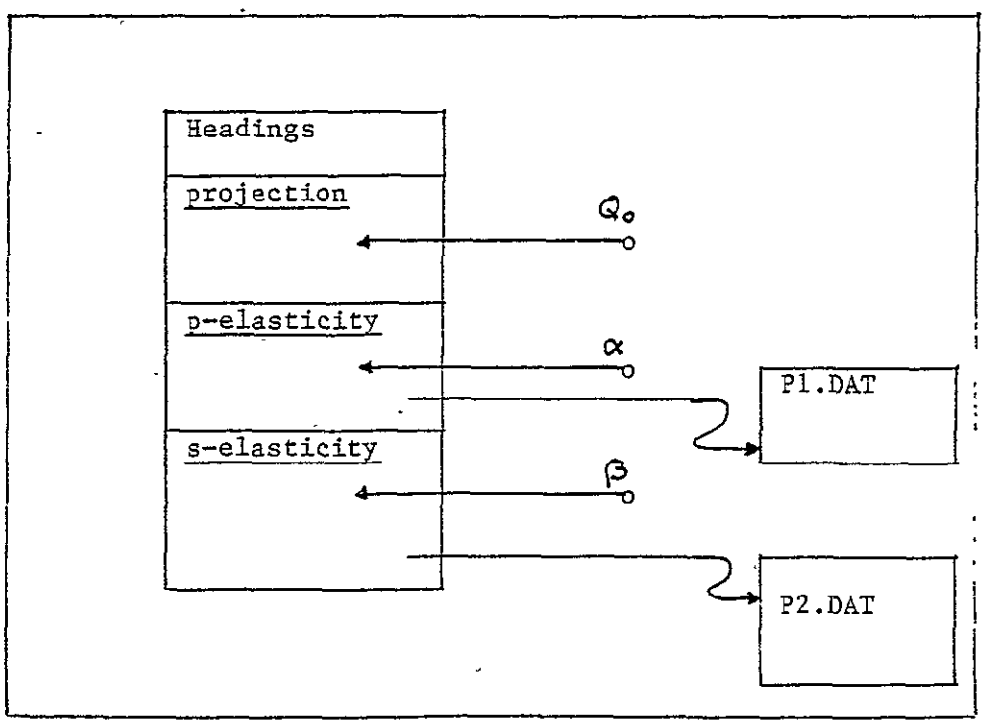
$$Q_t(\text{elec}) = 80 \left[\frac{20(1 + 0.05)^8}{20}\right]^{-0.1} \cdot \left[\frac{250(1 + 0.06)^8}{250}\right]^{1.5} = 154.8$$

and for oil

$$Q_t(\text{oil}) = 400 \left[\frac{10(1 + 0.05)^8}{10}\right]^{-0.3} \cdot \left[\frac{250(1 + 0.06)^8}{250}\right]^{1.2} = 622.50$$

This can be modelled in the RESGEN framework by a sequence of three operators, each representing a separate table in a RESGEN data file, as indicated in Exhibit 4.5: The corresponding RESGEN network file, as created in RESENT (see Annex VII) or CREATE (see Section 3.2) is shown on Table 4.1

EXHIBIT 4.5: AN ECONOMETRIC DEMAND STRUCTURE



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The first table in the network file is projection, which contains the Q_o vector.

The second table uses the p-elasticity operator. This has the price elasticities in its data section, and references an outside file of type PRICE.DAT, called P1.DAT, for the values of the price escalators (i.e. for the 5% increase in price) The P1.DAT file is shown below:

User Manual, P1.DAT

```
fuel                                          p-escal.
l------------------- r-------- r-------- r-------e
oil                                             1.05
electricity                                     1.05
```

The third table uses the s-elasticity operator, which has the income elasticities in its data section, and which references the external file P2.DAT for the income growth rates. P2.DAT is also a PRICE.DAT type file. Note that the s-elasticity operator references by sector label ("industry") where as p-elasticity references by fuel label.

User Manual, P2.DAT

```
sector                                        i-escal.
l------------------- r-------- r-------- r-------e
industry                                        1.06
```


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TABLE 4.1: RESGEN File for Exhibit 4.5

```
*
* 1----------2----------3----------4----------5----------6---------- *
User Manual,section4.4                                                *
*********************************************************************
data table  1                                                         *
*********************************************************************
projection                                                            *
matrix name =base year demand                                         *
matrix size = 2                                                       *
none        = 1  2                                                    *
none        =                                                         *
   sector                                                             *
-- ------------------- -- ------------------- ---------- -----------*
 1 electricity             80.000                                     *
 2 oil                    400.000                                     *
*********************************************************************
data table  2                                                         *
*********************************************************************
p-elasticity                                                          *
consis.check= 0                                                       *
matrix name =p1.dat                                                   *
output name =price adjusted d                                         *
output units=                                                         *
matrix size = 2  2      .00   0   0                                  *
none        = 1  2 barch=                                             *
none        = 0  0 barch=                                             *
   sector                                                             *
-- ------------------- -- ------------------- ---------- -----------*
 1 electricity          1 electricity              -.100              *
 2 oil                  2 oil                      -.300              *
*********************************************************************
data table  3                                                         *
*********************************************************************
s-elasticity                                                          *
consis.check= 0                                                       *
matrix name =p2.dat                                                   *
output name =income adj.deman                                         *
output units=                                                         *
matrix size = 2  2      .00   0   0                                  *
none        = 1  2 barch=                                             *
none        = 0  0 barch=                                             *
   sector                                                             *
-- ------------------- -- ------------------- ---------- -----------*
 1 electricity          1 electricity              1.500 industry     *
 2 oil                  2 oil                      1.200 industry     *
*********************************************************************
END                                                                   *
```

4.5: INVESTMENT AND DEBT SERVICE

RESG can calculate the energy sector investment and debt service requirements if project cost information is available. These requirements are summarized on one of the output tables, as shown below: note that all this information is in U.S.$ (or SDR's), not the local currency. (Local currency equivalents can be generated as an EFAM table).

May 19

Energy Sector Payments Balance:

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
Merchandise Trade Balance	-522.5	-549.3	-544.0	-587.6	-661.3	-709.7	-721.8	-779.4	-827.7	-874.8	-962.1	-988.3
..Imports	-742.0	-791.7	-815.4	-855.1	-908.1	-964.4	-988.1	-1053.3	-1111.8	-1171.8	-1274.6	-1318.5
..Exports	119.8	115.0	155.6	142.5	112.1	109.5	109.7	105.0	101.9	100.6	100.6	101.6
..Bunkers	99.7	107.5	115.9	124.9	134.7	145.3	156.6	168.9	182.2	196.5	211.9	228.5
Investment Outlays	6.4	35.9	89.0	328.1	378.2	253.8	181.5	229.8	313.8	264.8	198.1	138.2
..Electric Sector	6.4	35.9	89.0	328.1	378.2	253.8	181.5	229.8	313.8	264.8	198.1	138.2
..Other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Foreign Capital Inflows	5.1	28.7	71.2	262.5	302.5	203.0	145.2	183.9	251.1	211.9	158.5	110.5
..Electric Sector	5.1	28.7	71.2	262.5	302.5	203.0	145.2	183.9	251.1	211.9	158.5	110.5
..Other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Debt Service: Interest	.0	.0	-22.7	-44.7	-56.8	-75.8	-96.8	-91.4	-110.8	-121.4	-114.0	-151.0
..Electric Sector	.0	.0	-22.7	-44.7	-56.8	-75.8	-96.8	-91.4	-110.8	-121.4	-114.0	-151.0
..Other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Debt Service: Principal	.0	.0	-11.3	-22.9	-30.1	-41.1	-53.7	-53.7	-66.0	-74.7	-74.7	-96.9
..Electric Sector	.0	.0	-11.3	-22.9	-30.1	-41.1	-53.7	-53.7	-66.0	-74.7	-74.7	-96.9
..Other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
Net Energy Payments Balance	-522.5	-569.3	-578.0	-655.3	-748.2	-826.6	-872.3	-924.5	-1004.5	-1070.9	-1150.7	-1236.2

..inflows positive, outflows negative

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There are two ways of generating this information. For the electric sector, power plants are listed in a POWER.DAT file. With the investment calculation active, the name of every power plant that is built over the planning horizon is matched to the list of power plant names in COSTLIST.DAT, a file that contains detailed project financial information. If the name cannot be found here, the file PROJCOST.DAT is searched; this file is for plants for which the level of available detail does not include the year-by-year construction outlays. If a match is still not found, a diagnostic is generated, and the investment/debt service calculations are omitted. (see Figure 4.6).

Non power sector projects, must be listed in a file of type PROJECT.DAT (see Section 4.3); here the project name is matched, directly with the PROJCOST.DAT file, and again a diagnostic is issued if a match is not found.

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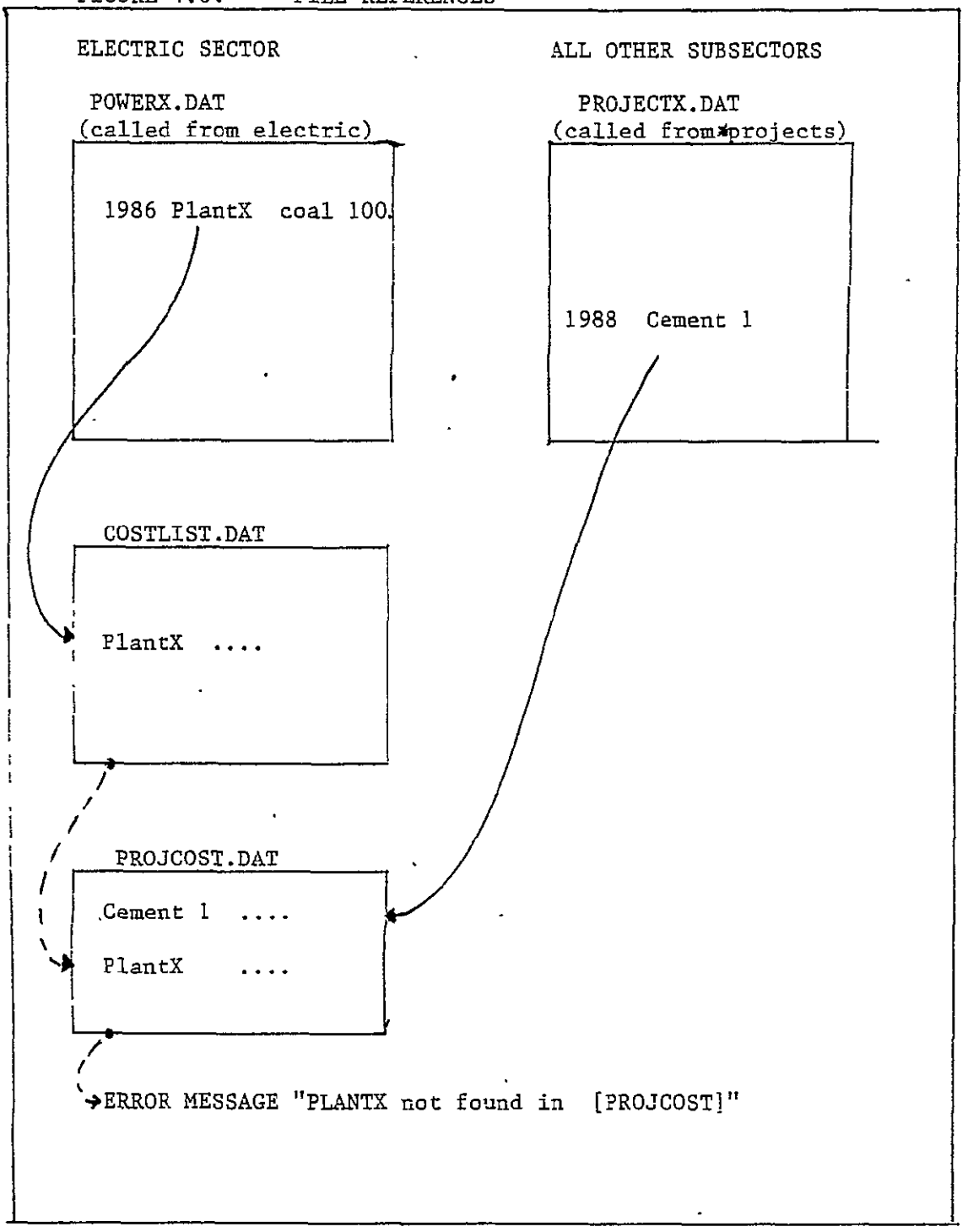
FIGURE 4.6: FILE REFERENCES



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The steps required to generate investment/debt service information are as follows:

1. Go to PARAMO.DAT, and make sure that the entries for "investment tables" and "investment graphics" are set to "yes".

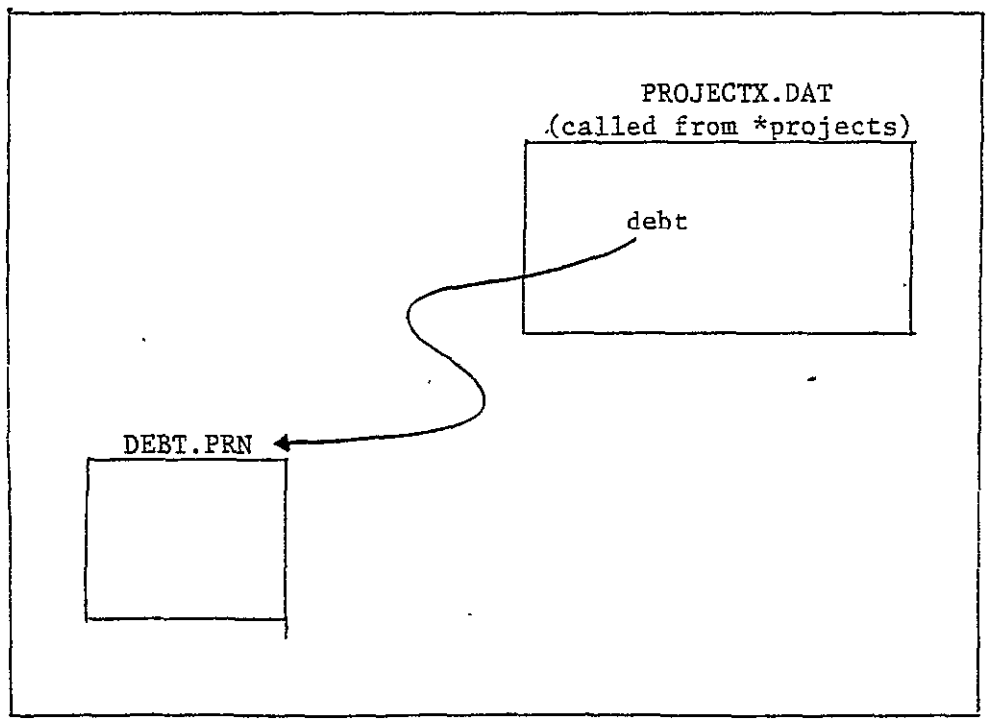
2. If the network includes a power sector representation, make sure that COSTLIST.DAT and/or PROJCOST.DAT files are present. These are mandatory names; copy them from the sample file diskette, enter them into the appropriate TABLE directory, and then edit them for your application in TABLE.

3. If the network includes a project operator, again make sure that PROJCOST.DAT exists.

4. Make sure that the file INVTAB.DAT exists. This contains the labels used in the summary table, and should not be changed.

5. If you wish to include existing debt service obligations (i.e. for plants that came on line before (on in) the base year, include an identifier called "debt" in one of the project files, and make sure a file of the type DEBT.PRN exists. (See Exhibit 4.7)

EXHIBIT 4.7: HOW TO INCLUDE EXISTING DEBT SERVICE OBLIGATIONS



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4.6: ENERGY BALANCE TABLES

The summary table feature introduced in section 3.4 can be used to generate an energy balance table. You must do two things to produce the table: first you must define the rows and the columns of the balance table (in the LABELS.DAT and COLUMNS.DAT files, respectively, as indicated on Exhibit 4.8). The rows and columns of the table will appear in the same order as defined in these files (See Exhibit 4.9).

There are certain rules that you must follow when designing the energy balance table:

1. You may use whatever labels you wish for the rows of the Energy Balance Table, in any language.
   (for exceptions, see items 3-5 below)

2. The prefix - will cause a <u>subtraction</u> to occur in that raw of the energy balance table.

3. The prefix . will cause the program to compute a subtotal. For example, if the first 5 rows are listed as

   imports
   domestic production
   . supply
   - exports
   . net supply

   the energy balance table would calculate the entries for the row "<u>.supply</u>" as

   supply = imports + domestic production

   and for the row "<u>.net supply</u>" as

   . net supply = . supply - exports.

4. Any negative value in the <u>imports</u> row is automatically moved to the <u>exports</u> row. Thus a RESGEN vector that contains both export and import entries (as might be the result of subtracting refinery production from domestic demand) should be assigned to <u>imports</u>.

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Second, you must provide instructions, in the network file, on the values to be transferred to the table: this is done by entering the name(s) of the row to which you wish to move the values on the "transfer" entries of the data tables: in the example below, we move the values in elements 18 to 29 to the Balance Table row "Primary Production".

```
449: ****************************************************************
450: data table 21
451: ****************************************************************
452: aggregate
453: consis.check= 0
454: matrix name =add fuels/charcoal
455: output name =demand
456: output units=mboe
457: matrix size =31 31        .00
458: none        = 1 31
459: primary prod=18 29
460:
461: -- ------------------- -- ------------------- ----------
462:  1 crude
463:  2 arab light
464:  3 lpg
465:  4 avgas
466:  5 avtur
467:  6 gasoline
468:  7 kerosene
469:  8 ado
470:  9 ido
471: 10 fueloil
472: 11 petrochems
473: 12 lubes/waxes
474: 13 asphalt
475: 14 petr coke
476: 15 naphtha
477: 16 LSWR
478: 17 coke
479: 18 gas
480: 19 coal
481: 20 bat muda
482: 21 hydro
483: 22 geothermal
484: 23 nuclear
485: 24 wood
486: 25 agric wastes
487: 26 biogas
488: 27 solar-pv
489: 28 solar
490: 29 wind
491: 30 LNG
492: 31 LPG exp
```


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EXHIBIT 4.8: ENERGY BALANCE TABLE SETUP

BALANCE TABLE ROWS
(LABELS.DAT)

Summary Table Definitions

Energy Balance Table

```
   node
01=primary production
02=imports
03=exports
04=bunkers
05=stock changes
06=.subtotal
07=refinery
09=elec generation
11=gas plant
13 LNG plant
15 LPG plant
17 charc/briq
22 -losses
33 .total
28 consumption
   end
```

BALANCE TABLE COLUMNS
(COLUMNS.DAT)

column

#	column
01	crude
02	area light
03	lpg
04	avgas
05	avtur
06	gasoline
07	kerosene
08	ado
09	ido
10	fueloil
11	petrochems
12	lubes/waxes
13	asphalt
14	petr coke
15	naphtha
16	LSWR
17	gas
18	LNG
19	LPG exp
20	coal
21	bat muda
22	coke
23	electricity
24	f-electricit
25	java-electr
26	hydro
27	geothermal
28	nuclear
29	wood
30	charcoal
31	agric wastes
32	biogas
33	solar-pv
34	solar
35	wind

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Note that if you wish to omit a transfer, use "none" as shown on line 458 of the above example. Note also that the first range (i.e. line 458 of the example) is also used as the print range: therefore if the elements you wish to transfer to the table are not the same as the desired print range (as is the case in this example), make the transfer on the second line (i.e. on line 459). The resulting energy Balance Table is shown on Exhibit 4.9.

It is important to remember that the transfers to summary tables is done by matching row labels. Therefore, in designating the name of the row, an exact match of the first 12 characters in the LABELS.DAT file has to be made.

For each vector, RESG provides for transfers of up to 2 different rows of a balance table. In the example below, elements 1 to 4 are transferred to row name -gasplant, and element 1 is transferred to row name "primary production".

```
263: ***************************************************************
264: data table 10
265: ***************************************************************
266: supply=table
267: matrix name =city gas inputs
268: matrix size = 4  0      .00   0   0
269: -gas plant  = 1  4 barch=04/ov/reg=99/99,99/01,01
270: primary prod= 1  1 barch=04/ov/reg=99/99,99/99,99/01,01
271:
272: -- -------------------- --------------------
273:  1 gas                        0.000 pgn.dat
274:  2 ido                         .000 pgn.dat
275:  3 fueloil                     .000 pgn.dat
276:  4 kerosene                    .000 pgn.dat
```


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EXHIBIT 4.9: ENERGY BALANCE TABLE

1985 Energy Balance Table (mboe)

	crude	arab ligh	lpg	avgas	avtur	gasoline	kerosene	ado	ido	fueloil
primary producti	580.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
imports	.00	30.00	.00	.00	2.33	.00	.00	.00	14.98	.00
exports	-355.10	.00	-5.36	-.48	.00	-9.84	-.64	-3.57	.00	-9.63
bunkers	.00	.00	.00	.00	-1.00	.00	.00	-.05	-.20	-1.00
stock changes	.00	.00	.02	.50	1.20	-8.90	9.10	7.80	.98	.00
.subtotal	224.90	30.00	-5.34	.02	2.53	-18.74	8.46	4.18	15.76	-9.63
refinery	-224.90	-30.00	5.81	.11	2.96	47.79	49.38	45.13	3.55	20.10
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	-8.28	-.85
gas plant	.00	.00	.00	.00	.00	.00	-.03	.00	-.07	-.01
LNG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	-.01	.00	-.12	.03	-.44	-.09	-.06
.total	.00	.00	.48	.13	5.49	28.93	57.84	48.87	10.88	9.55
consumption	.00	.00	.48	.13	5.49	28.93	57.84	48.87	10.88	9.55

1985 Energy Balance Table (cont.): (mboe)

	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	gas	LNG	LPG exp	coal
primary producti	.00	.00	.00	.00	.00	.00	608.29	.00	.00	15.07
imports	.00	.00	.00	.02	.00	.00	.00	.00	.00	.00
exports	-5.12	-.92	-.53	.00	-.52	-59.21	.00	-200.00	-4.94	.00
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
stock changes	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.subtotal	-5.12	-.92	-.53	.02	-.52	-59.21	608.29	-200.00	-4.94	15.07
refinery	5.19	1.60	1.70	.00	.52	59.21	.00	.00	.00	.00
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	.00	-11.73
gas plant	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00
LNG plant	.00	.00	.00	.00	.00	.00	-333.33	200.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	-8.23	.00	4.94	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	.00	-242.92	.00	.00	.00
.total	.07	.68	1.16	.02	.00	.00	23.96	.00	.00	3.35
consumption	.07	.68	1.16	.02	.00	.00	23.96	.00	.00	3.35

1985 Energy Balance Table (cont.): (mboe)

	bat muda	coke	electrici	Java-elec	hydro	geotherma	wood	charcoal	agric was	total
primary producti	.04	.00	.00	.00	10.04	.44	2.45	.00	.82	1217.16
imports	.00	1.12	.00	.00	.00	.00	.00	.00	.00	48.45
exports	.00	.00	.00	.00	.00	.00	.00	.00	.00	-654.86
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	-2.25
stock changes	.00	.00	.00	.00	.00	.00	.00	.00	.00	10.70
.subtotal	.04	1.12	.00	.00	10.04	.44	2.45	.00	.82	619.19
refinery	.00	.00	.00	.00	.00	.00	.00	.00	.00	-11.84
elec generation	.00	.00	1.97	6.52	-10.04	-.44	.00	.00	.00	-22.85
gas plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.05
LNG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	-133.33
LPG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	-3.29
charc/briq	-.04	.00	.00	.00	.00	.00	-1.91	1.79	-.60	-.75
-losses	.00	.00	-.39	-.98	.00	.00	.00	.00	.00	-244.97
.total	.00	1.12	1.57	5.54	.00	.00	.54	1.79	.22	202.20
consumption	.00	1.12	1.57	5.54	.00	.00	.54	1.79	.22	202.20

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4.7: CURRENT ACCOUNT TABLE

RESG produces a second table denominated in money rather than energy units (which we call the "Current Account Table" since its most frequent use is to summarize the oil import/export bill, obtained by multiplying the vector of imports/exports by a vector of border prices). Entries can be made only through the price operator: information is transferred in the same way as in the case of the energy balance table in the transfer lines of the price operator. In the example below, elements 1 to 15 of the price output vector are transferred to the current account table row "imports".

```
581: ****************************************************************
582: data table 27                                                  *
583: ****************************************************************
584: price                                                          *
585: consis.check= 0                                                *
586: matrix name =prices.dat                                        *
587: output name =Current Account Bal                               *
588: output units=mill U.S. $                                       *
589: matrix size =15 15        .00                                  *
590: imports     = 1 15                                             *
591: none                                                           *
592:                                                                *
593: -- ------------------- -- ------------------- ----------       *
594: ****************************************************************
595: END                                                            *
```

The rows of the table are defined in the second half of the LABELS.DAT file: (you are limited to a maximum of 5, rather than 40 rows, however).

```
Summary Table Definitions
-------------------------------
  Energy Balance Table
-------------------------------
  aboe
01=primary production
02=imports
03=exports
04=bunkers
05=stock changes
06=.subtotal
07=refinery
09=elec generation
11=gas plant
13 LNG plant
15 LPG plant
17 charc/briq
22 -losses
23 .total
23 consumption
  end
-- ----------------------------
  current account table
-- ----------------------------
  US $mill
01=imports
02=-exports/bunkers
  =.net
  =end
```

As with the Energy Balance Table, there is as automatic reassignment of negative "imports" to the "exports" column. The resulting table is illustrated below:

Energy Supply/Demand Balance Network

July 12

1985 current account table (US $mill)

	crude	arab ligh	lpg	avgas	avtur	gasoline	kerosene	ado	ido	fueloil
imports	.00	.00	.00	.00	.08	.00	.00	.00	.49	.00
-exports/bunkers	-10.55	.00	-.19	-.02	.00	-.32	-.02	-.09	.00	-.24
.net	-10.55	.00	-.19	-.02	.08	-.32	-.02	-.09	.49	-.24

1985 current account table (cont.): (US $mill)

	petrochem	lubes/wax	asphalt	petr coke	naphtha	total
imports	.00	.00	.00	.00	.00	.57
-exports/bunkers	-.11	-.02	-.01	.00	-.02	11.58
.net	-.11	-.02	-.01	.00	-.02	12.16

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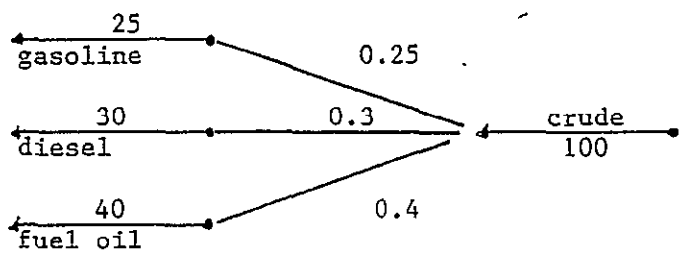
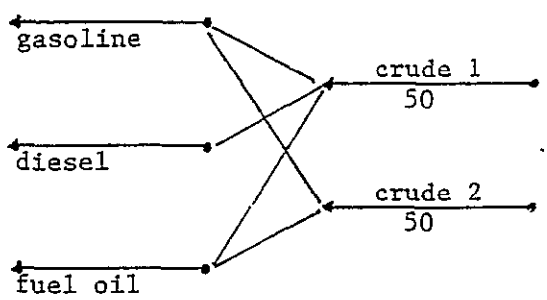
4.8 REFINERIES

Refineries can be represented in several different ways in RESGEN:

1. By use of the share operator that splits crude into a series of petroleum products, and in which the share coefficients represent the yield coefficients for each product. In this case the sum of the coefficients would not in general be equal to unity because of losses and own-use. This is the simplest way of representing a refinery, but has a number of drawbacks. First, the crude input must be known in advance. Second, use of the share operator will not result in a graphic display of the refinery. Third, the configuration of the refinery remains fixed throughout the planning horizon.



2. If there is more than one crude, you can use the matrix operator.



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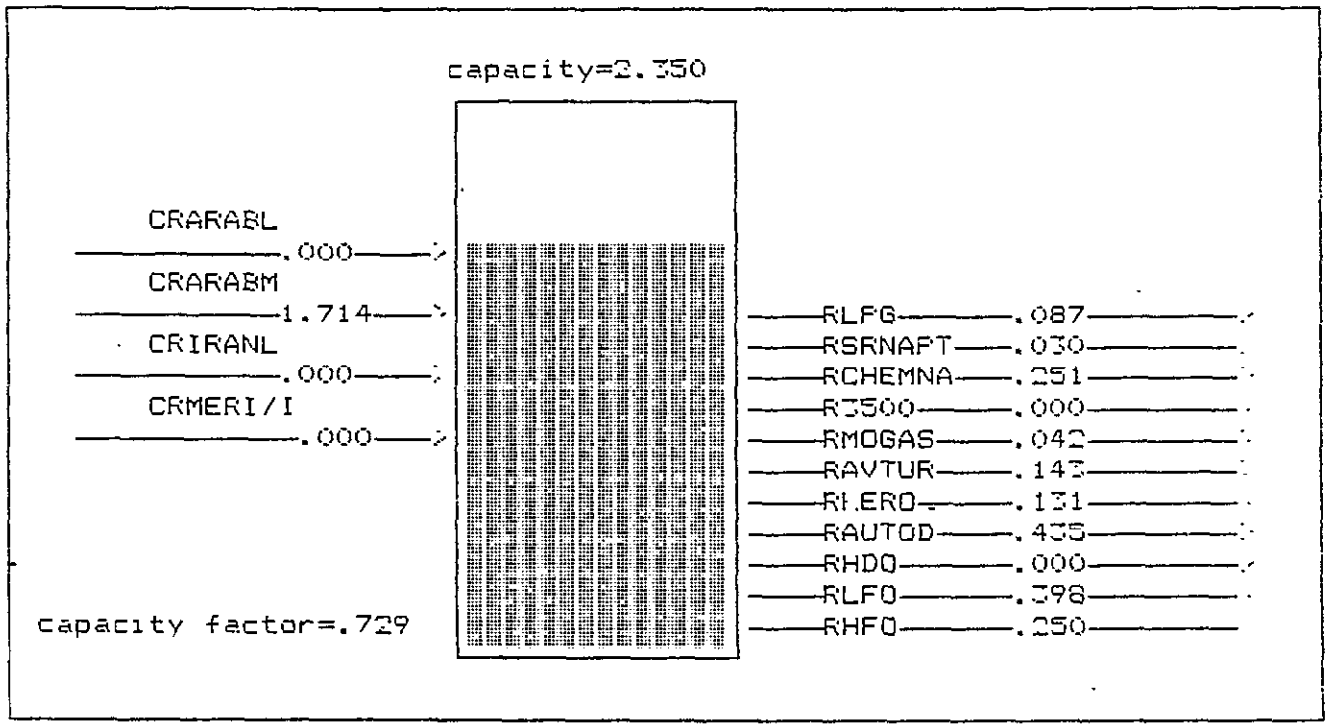
3. In either of the two above cases, there is a special operator called refinery that does not only the necessary arithmetic, but also produces a screen display of the refinery configuration:



The refinery operator would typically be used in the following way:

1. calculate domestic demand (in the main network)
2. start a side chain (using the supply operator), that contains the value of the crude run.
3. use refinery to convert crude to products

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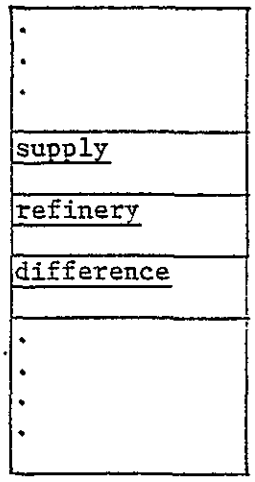
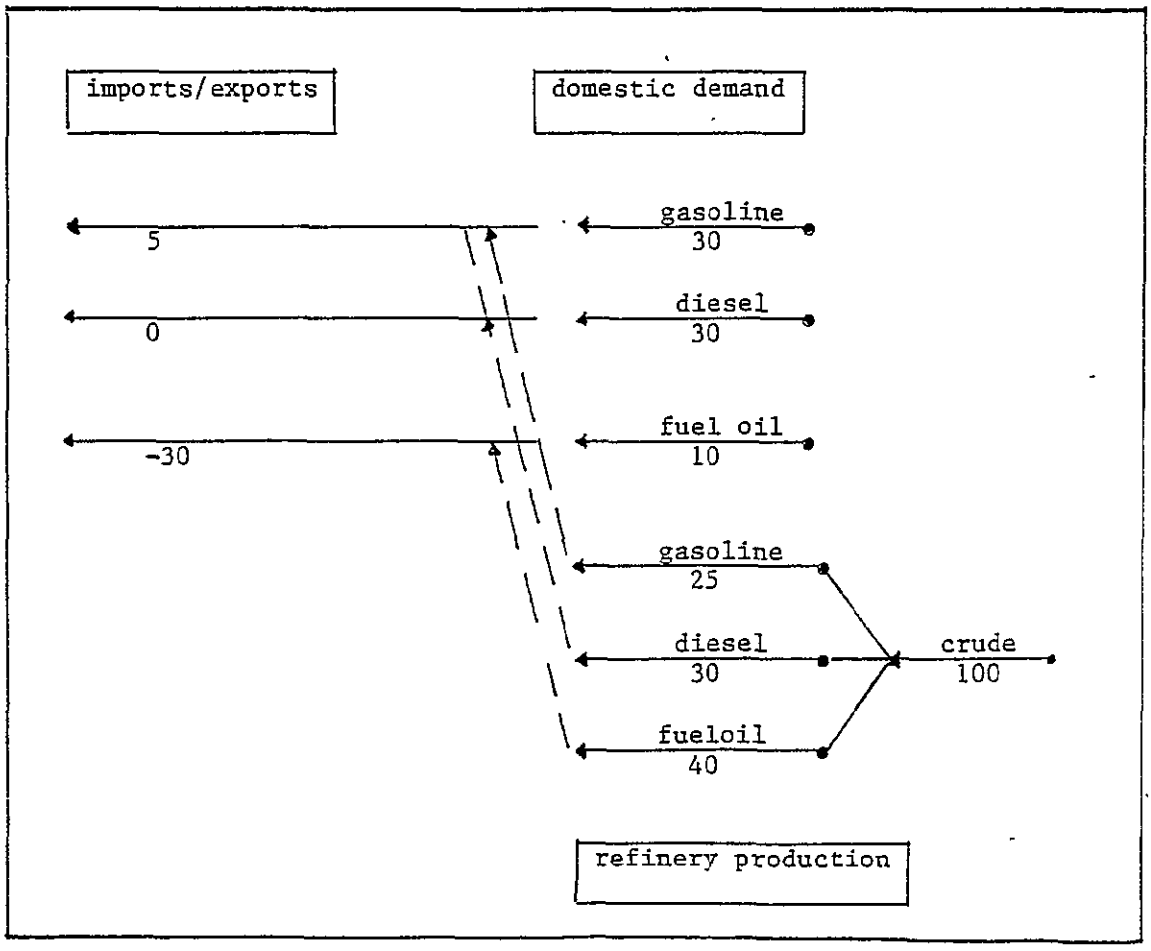
4. use difference to link the side chain to the main network: the result is a vector of petroleum product imports/exports.



Thus in the following example, the result is imports of gasoline of 5 units, and fuel oil exports of 30 units:



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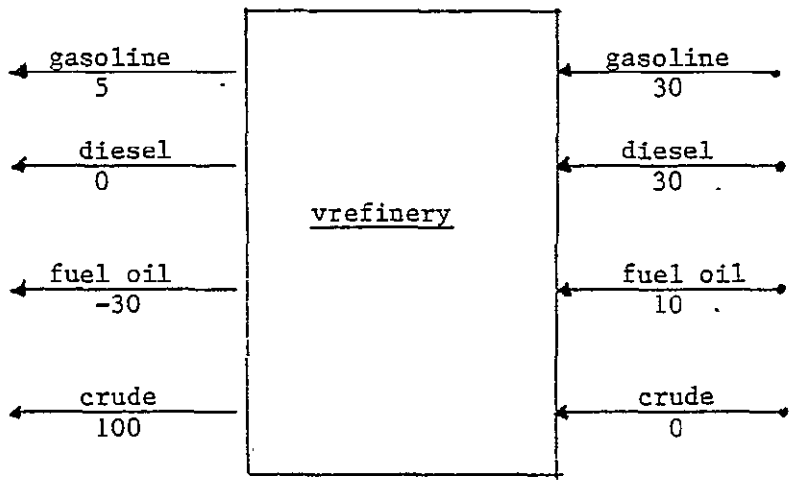
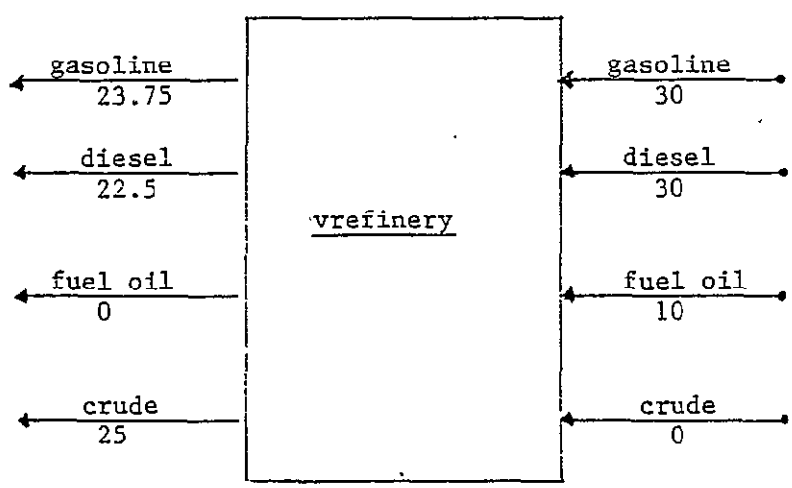
4. If you wish the crude throughout to be determined by the model -for example, run sufficient crude to meet domestic gasoline demand, subject to the capacity limit of the refinery - then you must use the special purpose operator vrefinery.

vrefinery is used not in a side chain, but in the main network: with the same data as above, we would have:



Note that crude must be one of input elements: vrefinery then adds the crude requirement to that element. In this case we could have forced a crude run of 100, or let the model calculate the crude value to meet domestic diesel demand - the result is the same. But if we set the crude run to meet, say, fuel oil demand then with the same yield coefficients the result would be:



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5. THE RESG CODE

5.1: THE RESG SCREEN MENUS

The first screen to require your attention lists the network files that are available:

```
..select a network file:

 1. national network        network.dat
 2. electric sector         elec.dat

     ....enter here >>>> 1
```

If you have a large number of network files, you may wish to organize your data into several directories: in this case the selection of the network file occurs in two stages:

```
..select directory:

 1. national networks
 2. region 1 networks
 3. region 2 networks
 4. region 3 networks
 5. region 4 networks
 6. region 5 networks
 7. region 6 networks
 8. region 7 networks
 9. region 8 networks
10. user manual networks

     ....enter here >>>> 1

..select a network file:

 1. supply/demand balance   indones.dat
 2. preliminary balance     indol.dat
 3. indon demand by region  addregs.dat
 0. return to directory
```

This feature is explained in detail in Section 8 (NESTED NETWORK DIRECTORIES).

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The next menu requests the operating mode:

```
..operating mode:

1.  full output, batch mode
2.  full output, prompt mode
3.  summary tables only

     ....enter here (?HELP) >>>>
```

In the full output modes, all of the intermediate information can be displayed: in the prompt mode the user controls this output from the screen, while in the batch mode user intervention is not required.

The "parameter menu" appears next, which governs the main program parameters: (see Table 5.1)

```
..parameters for this run:

1.  GDP growth rate                  1.05
2.  world oil price growth rate      1.03
3.  paper save mode                   yes
4.  diagnostics                       yes
5.  datafile year                    1982
6.  planning horizon                    8
7.  conservation tables                no
0.  to continue

     ..enter here >>>>
```

The prompts included in the main parameter menu will depend on the particular features of RESGEN that are installed on your machine. For example, if the EFAM and macromodel features are included, the parameter menu will appear as follows:

```
..parameters for this run:

3.  paper save mode                   yes
4.  diagnostics                       yes
5.  datafile year                    1984
6.  planning horizon                   11
7.  conservation tables                no
8.  efam transfer                     yes
9.  GDP,oil prices from macromodel    yes
10. dynamic version                   yes
0.  to continue

     ..enter here >>>>
```

The next screen enables you to reenter a heading that will appear on each output table:

```
..current heading =base case

0. heading o.k.
1. re-enter the heading

     ....enter here >>>>
```


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TABLE 5.1: THE PARAMETER MENU

gdp growth rate	value *	used to escalate GDP
world oil price growth rate	value *	used to escalate rices in price files
paper save mode	yes/no	if no, each output table is printed on a new page
diagnostics	yes/no	if yes, checks every line of the network file for data alingnment
data file year	value*	base year, corresponds to the year for data values in supply and projection operators
planning horizon	value*	number of years in run
conservation tables	yes/no	if no, switches off any datatable in the network file with matrix name=conservation
EFAM transfee(1)	yes/no	if yes, RESG creates the EFAM transfer files PROJ.EFM and TRANS.EFM
GDP from macro model(1)	yes/no	if yes, GDP information is taken from the macromodel transfer file (generated in LOTUS 1-2-3)
dynamic version(1)	yes/no	if yes, then RESG provides a calculation for all years in the planning horizon. If no, calculation made only for last year.

* The default values are set in the file PARAM.DAT

(1) Prompt appears only if the corresponding entry in STAT.RES is set to yes.

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If you are in the prompt and dynamic modes, the next screen enables you to select the years for which you wish to see the full output: in the example below, the full output would be available only for the first 5 years (1984-1989) of the run.

```
..dynamic range = 1984-1995

..enter full output range, from >>>> 1984
                               to >>>> 1989
```

If you are in the prompt mode, the following screen appears, which enables you to control intermediate output. (See Section 5.2 for further details).

```
Data Tables in Current File

 1.1984 base year        9.efficiency          17.aggregate
 2.growth rates         10.power.dat           18.bunkers
 3.project.dat          11.aggregate           19.bunkers growth
 4.projoth.dat          12.charcoal export     20.priceb.dat
 5.pricesc.dat          13.growth rates        21.imports/exports
 6.conservation goals   14.aggregation         22.price.dat
 7.fuel demand          15.refinery
 8.efficiency           16.efficiency

...enter 99 for all tables, no further prompts
...enter 0 to go directly to summary tables

...enter next table for display >>>>
```

As RESG makes its calculations, messages will appear on the screen that indicate progress: both the year and the current vector will be displayed.

```
..please wait, calculations in progress..
     year=1990,vector=25=add stocks
```


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At the conclusion of the RESG calculations, you will get the printer option screen:

```
..printer options:

1. re-enter page heading
2. summary tables to print file =  no
3. columns per page =  80
0. continue

     ....enter here >>>> 3
```

If you want the output tables in compressed mode (132 columns on an 80 column printer), you enter "3": the revised setting will then appear on the screen as follows:

```
..printer options:

1. re-enter page heading
2. summary tables to print file =  no
3. columns per page = 132
0. continue

     ....enter here >>>>
```


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RESG produces several important summary displays: an Energy Balance Table (for the last year of the planning horizon) and a summary transactions table that gives a year-by-year summary of investment, debt service and import/export transactions. These can be viewed by making the appropriate choice from the RESG output menu.

5.2: SENSITIVITY ANALYSIS

RESG has a feature that lets you change values of coefficients and assumptions during a run, a feature particularly useful for sensitivity analysis. Such changes do not affect the data files themselves, and the revised value is used only for the run in question.

To make sure changes, you must be in the "prompt mode":

```
..operating mode:

1.  full output, batch mode
2.  full output, prompt mode
3.  summary tables only

    ....enter here (?HELP) >>>> 2
```

which will produce a display of all of the data tables in the current network file.

```
Data Tables in Current File

 1.1984 base year        9.efficiency          17.aggregate
 2.growth rates         10.power.dat           18.bunkers
 3.project.dat          11.aggregate           19.bunkers growth
 4.projoth.dat          12.charcoal export     20.priceb.dat
 5.pricesc.dat          13.growth rates        21.imports/exports
 6.conservation goals   14.aggregation         22.price.dat
 7.fuel demand          15.refinery
 8.efficiency           16.efficiency

...enter 99 for all tables, no further prompts
...enter 0 to go directly to summary tables

...enter next table for display >>>>
```


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Suppose we wish to change the value for the efficiency of electricity transmission & distribution, in Data Table 8 of the exhibit above. Therefore we enter "8" to the above prompt, and wait for the data table to appear on the screen:

```
                    S r i   L a n k a   Energy Model
 base case

                                                          july 20

Table  1 EFficiency                                          (1984)
  sector              efficiency
 1 electricity                .82   del=06x.01
corresponds to data table   6 of data file: network.dat
   ....line numbers  270 to  271

to change data, enter row number (or zero if o.k.) >>>>
```

At this point, if we enter "1" (to change row 1) we are asked to enter a new value:

```
enter new value for row  1 >>>> 0.81
```

which results in the new table:

```
                    S r i   L a n k a   Energy Model
 base case

                                                          july 20

Table  2 EFficiency                                          (1984)
  sector              efficiency
 1 electricity                .81   del=06x.01
corresponds to data table   6 of data file: network.dat
   ....line numbers  270 to  271
```

For this particular run, the 1984 value of the efficiency will be 0.81: the old value of 0.82 remains in the original data file (and will reappear unchanged, the next time the network is run).

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5.3: THE OUTPUT DIRECTORY

At the end of each RESG run you can store key outputs in an output file for later use in analysis. This is done through option 5 in the output menu:

```
..output options:

1. Energy Balance Table
2. current account table
5. graphics directory
0. to exit

     ....enter here >>>>
```

The entry 5 results in a display of the output directory, which lists all of the previously stored output files.

```
..graphics output files:

dos filename   scenario                          date filed

 1. gdef.out     Energy Supply/Demand Balance N  june 25
 2. g1.out       demo1,82-85                     may  30
 3. g2.out       java transportation             may  30
 4. g3.out       demand model                    may  30

..add current run to directory? enter YES or NO >>>> yes
```

To add the current run to the directory you respond "yes", as shown above: this will result in the following series of prompts in which you must give the new output file a DOS file name:

```
..replace an existing file? enter YES or NO >>>> no

..enter DOS filename (suggest Gx.OUT) >>>> g4.out

..enter comment >>>> test run
```

The next time you access the output directory (either in the next run of RESG, or in the output module RESP) the directory would contain this new file g4.out, as shown below:

```
..graphics files:

#   DOS-file        scenario                        date created

 1. gdef.out        Energy Supply/Demand Balance N  june 25
 2. g1.out          demo1,82-85                     may  30
 3. g2.out          java transportation             may  30
 4. g3.out          demand model                    may  30
 5. g4.out        ‡ test run                        july 20
 0. to exit

‡ indicates last RESG run

..select case # >>>>
```

Note that the date is added automatically.

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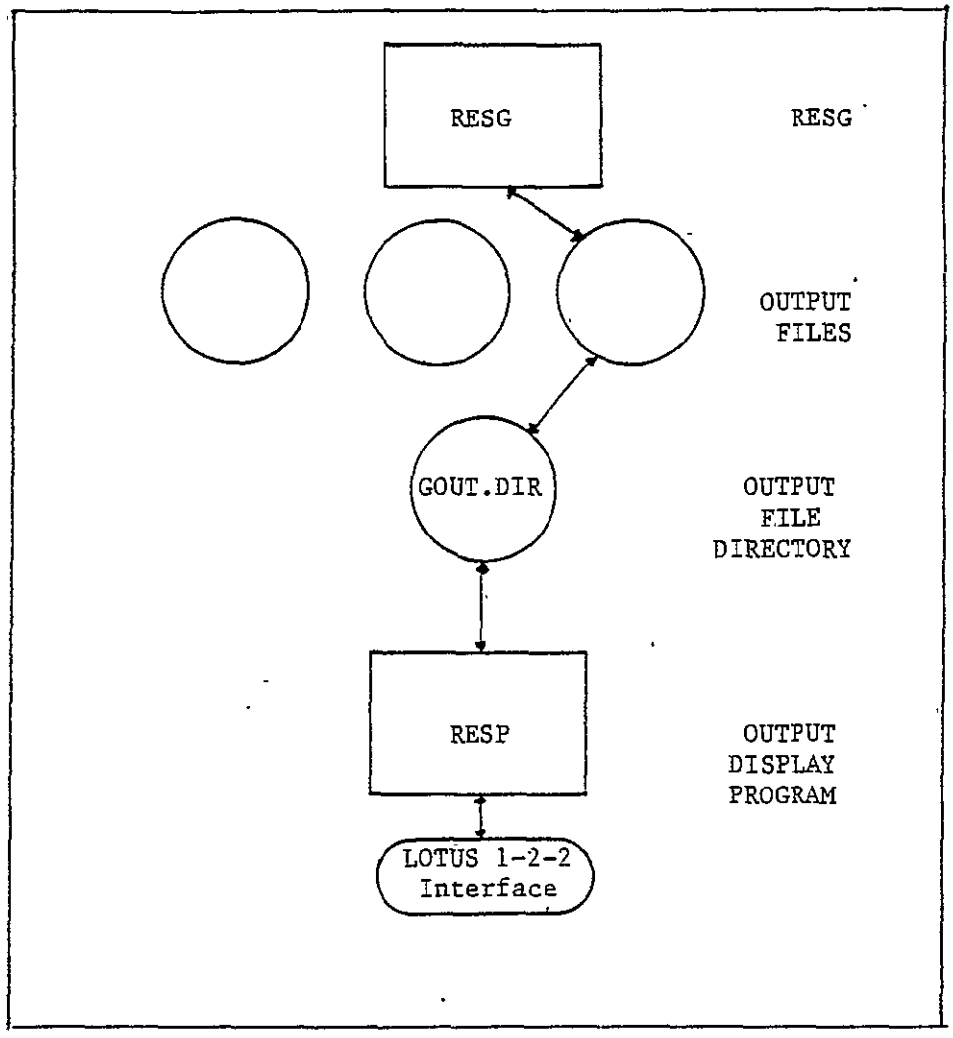
FIGURE 5.1: THE RESGEN OUTPUT SYSTEM



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The following points should also be noted:

1. If you do not explicitly set up an output file (by choosing output option 5 from the screen), then RESG will automatically create an output file under the name GDEF.OUT. Any data in an existing version of GDEF.OUT will be lost, replaced by that of the current RESG run.

2. The contents of the directory can be purged by loading GOUT.DIR into the TABLE program.

5.4 TUTORIALS

RESGEN has a tutorial facility that gives the user an extended message in case of input errors. The tutorial facility is initialized in the file STAT.RES: the help screens themselves must be present on the volume shown. In the example of STAT.RES below, the RESG expects to find the help screen files in volume C, which is the DOS name of the harddisk or disquette storing the help screen files (RESG designates all help screen file with the extension .HEL).

```
 1:*resgen intialization parameters
 2: ***********************************************************************
 3: item
 4: 1--  1----------------------------e
 5: color screen type
 6: no   efam transfer
 7: no   macromodel linkage
 8: yes  extended network directories
 9: C    help screen volume
10: yes  map
11: no   regional disaggregation
12: yes  dynamic
13: yes  delete zero columns in tables
14: yes  use a columns.dat type file
15: yes  tutorial screens
16: yes  time plots
17:      (3x,f9.2,9x,11f9.2)
18:      (20f9.2)
```

If the tutorial facility is set in this way, the following screen will appear at the beginning of the RESG execution. You can switch off the tutorials at this point by simply entering [return]

```
                    Tutorials

This version of RESGEN is initialised to produce a series of help
screens to guide the inexperienced user through the RESG program.

You can switch off these tutorial screens either by changing the
initialization parameter (in the file <STAT.RES>, accessed in the
special file directory in TABLE, or by striking the return key
in response to the next prompt. If you enter "yes", then the
tutorials are retained for this run.

..tutor? enter <YES> or return >>>>
```

For example, suppose RESG encounters an unrecognized operator. Then with the tutorial facility switched on, a series of screens will provide an extended error message:

```
          tutorial : matrix types

You have used an invalid matrix type.  RESGEN 3.0 recognizes only
the following matrix types (note that lower case must be used in
all cases):

       matrix type      function(see user manual for details)
       --------------- ------------------------------------
       addition         link a side chain(by addition)
       aggregate        aggregate fuels within a network
       diagonal         diagonal matrix
       difference       link side chain
       demand           input a dynamic demand file(from another
                            RESGEN network
       electric         electric sector
       i-elasticity     income elasticity
       growth           constant growth rates
       matrix           generalized transition matrix
       *project         project file
```

>

```
          tutorial : matrix types(continued)


       matrix type      function(see user manual for details)
       --------------- ------------------------------------
       price            price vector
       p-elasticity     price elasticity
       projection       the first vector in any network

       share            expand a network
       supply           start a side chain
       supply=resources start a side chain with data from a
                          outside data file of resource scenarios
       vgrowth          variable growth rates
       vrefinery        multiple refineries


you will be asked to re-enter the matrix type after striking the
return key. Please re-enter from the above list.
```

>

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5.5: THE RESP OUTPUT MODULE

RESP an output module that can either be run as part of the RESGEN batch program (which will load RESP after you exit RESG) or independently as RESP. It provides access to the output tables, barcharts, and the LOTUS 1-2-3 transfer facility. The first screen shows the contents of the output file directory GOUT.DIR:

```
..graphics files:

#   OOS-file        scenario                        date created

 1. gdef.out        Energy Supply/Demand Balance N  june 25
 2. g1.out          demo1,82-85                     may  30
 3. g2.out          java transportation             may  30
 4. g3.out          demand model                    may  30
 5. g4.out        * test run                        july 20
 0. to exit

* indicates last RESG run

..select case # >>>>
```

The asterisk indicates the most recent output file from the last RESG run. Having selected the scenario from this menu, the next screen asks you to enter the type of output to be displayed:

```
..graphics option

1. barcharts
2. time series tables
3. time series plots
0. to exit

     ....enter here >>>>
```


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6. THE RESGEN OPERATORS

This section documents the so called RESGEN "OPERATORS", listed in alphabetical order. Each data table in a RESGEN network file must have a valid operator name in the first line of that table: incorrect spelling will produce an error message in RESG that usually results in an immediate program termination.

ADDITION

The addition operator is used to add a side branch to the main network. There is no data section to this operator, as the entries are defined automatically during RESG execution. This operator is quite different to aggregate, which adds network elements within a network or side branch (see aggregate, below).

```
102: ****************************************************************
103: data table  5                                                  *
104: ****************************************************************
105: addition                                                       *
106: consis.check= 0                                                *
107: matrix name =add bunkers                                       *
108: output name =total demand                                      *
109: output units=mboe                                              *
110: matrix size =24 24        .00                                  *
111: none        = 1 24 barch=02/ov/reg=01/01,01
112: none               barch=02/ov/reg=02/02,02
113:                                                                *
114: -- ------------------- -- ------------------- ----------       *
```

The operation of addition is illustrated in the exhibit below. The elements of the output vector are defined as follows: first are transferred the elements of the main network, in sequence. Next, the elements of the side branch are searched for the fuels in the main network: when a match is found, the side branch value is added to the main network value. Finally, any elements in the side branch that do not occur in the main branch are added to the main network and a message to this effect is displayed during the RESG execution. In the exhibit, since fuel oil and gasoil do not occur in the main network, they are added to the output vector in the sequence shown.

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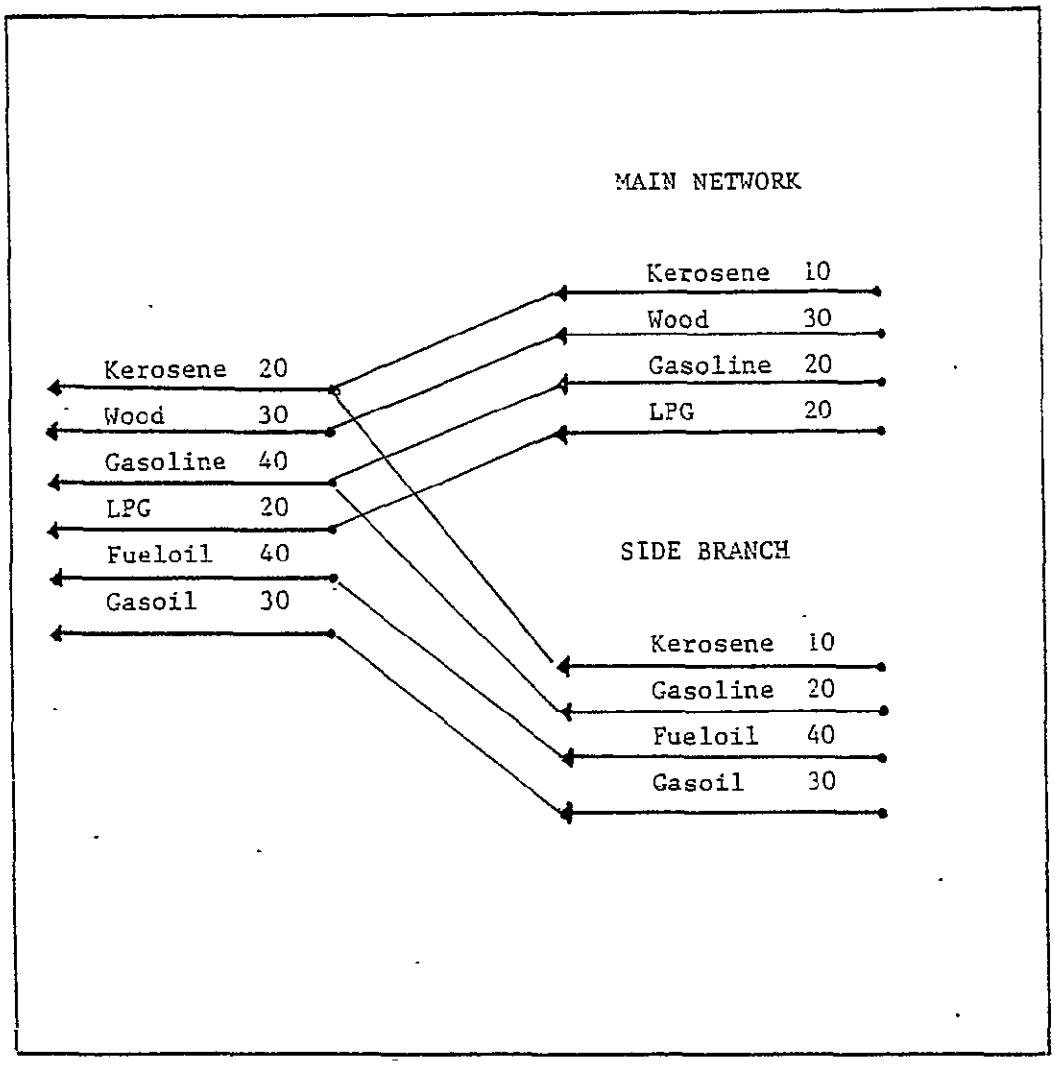
THE ADDITION OPERATOR



332

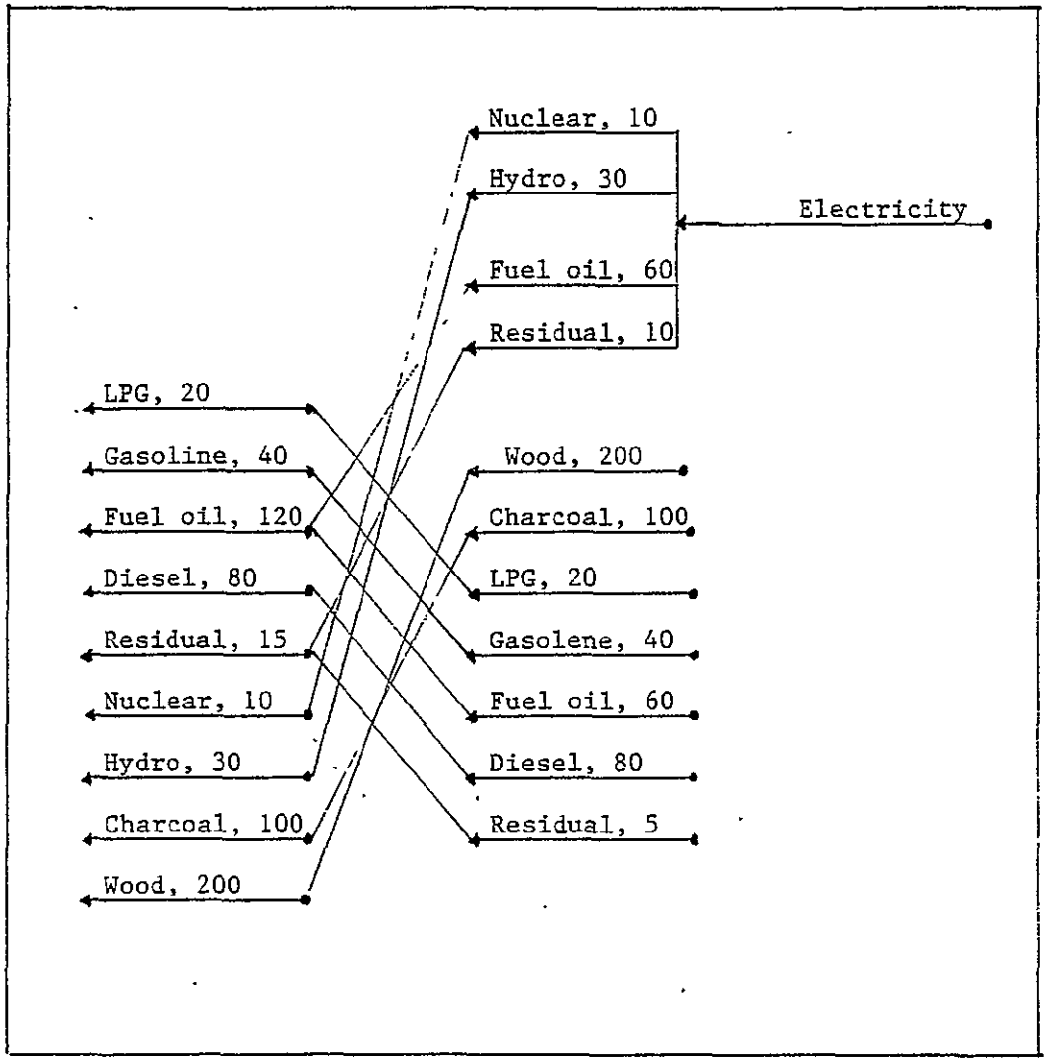
The aggregate operator is used to sum the elements of an input vector into a (usually) smaller output vector. The data section of this operator is simply a list of the aggregated fuels, listed in the order in which they are to appear in the output vector. (In RESENT, you are simply prompted for a list of fuels).

```
222: ****************************************************************
223: data table  9                                                  *
224: ****************************************************************
225: aggregate                                                      *
226: consis.check= 0                                                *
227: matrix name =add fuels/elec                                    *
228: output name =demand                                            *
229: output units=mboe                                              *
230: matrix size =28 28        .00                                  *
231: none        = 1 28                                             *
232: none                                                           *
233:                                                                *
234: -- ------------------- -- ------------------- ----------       *
235:  1 lpg                                                         *
236:  2 avgas                                                       *
237:  3 avtur                                                       *
238:  4 gasoline                                                    *
239:  5 kerosene                                                    *
240:  6 ado                                                         *
241:  7 ido                                                         *
242:  8 fueloil                                                     *
243:  9 petrochems                                                  *
244: 10 lubes/waxes                                                 *
245: 11 asphalt                                                     *
246: 12 petr coke                                                   *
247: 13 gas                                                         *
248: 14 LNG                                                         *
249: 15 LPG exp                                                     *
250: 16 coal                                                        *
251: 17 bat muda                                                    *
252: 18 coke                                                        *
253: 19 hydro                                                       *
254: 20 geothermal                                                  *
255: 21 nuclear                                                     *
256: 22 charcoal                                                    *
257: 23 wood                                                        *
258: 24 agric wastes                                                *
259: 25 biogas                                                      *
260: 26 solar-pv                                                    *
261: 27 solar                                                       *
262: 28 wind                                                        *
---
```

aggregate is used, for example, immediately after the electric operator, in order to add the electric sector fuels to the non-electric fuel demands. This is illustrated in the exhibit below.

333

The AGGREGATE Operator



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DEMAND

This operator is used in place of projection or supply to start a network (or a side branch).

The operator demand reads in an external file into a network. In the network file, the names of the elements are listed, and given the value .000, as shown below. The true values are contained in the external file, referenced-in the "matrix name" row.

```
38: ******************************
39: data table  2
40: ******************************
41: demand
42: matrix name =data=def=ecproj.int
43: matrix size =24  0        .00
44: consumption =01 24
45: none
46:
47: -- ------------------- -------------------
48:  1 Java-electr                .000
49:  2 electricity                .000
50:  3 lpg                        .000
51:  4 avgas                      .000
52:  5 avtur                      .000
53:  6 gasoline                   .000
54:  7 ado                        .000
55:  8 ido                        .000
56:  9 kerosene                   .000
57: 10 fueloil                    .000
58: 11 petrochems                 .000
59: 12 lubes/waxes                .000
60: 13 asphalt                    .000
61: 14 petr coke                  .000
62: 15 gas                        .000
63: 16 charcoal                   .000
64: 17 wood                       .000
65: 18 agric wastes               .000
66: 19 coal                       .000
67: 20 coke                       .000
68: 21 solar-pv                   .000
69: 22 solar                      .000
70: 23 biogas                     .000
71: 24 wind                       .000
```


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The Diagonal operator is used for multiplication by a diagonal matrix. It has a number of important features:

1. The data set is defined in such a way that you need only enter the non-unity elements: all others are automatically set to unity during execution of RESG. In the exhibit below, for example, representing the efficiency of electric transmission and distribution, only the two elements, for electricity, need be defined: the other 22 (of 24) elements will automatically be set to unity during RESG execution.

   Note also the use of a "99" marker to indicate that only two elements are present (Normally, RESG expects the number of entries set in the "matrix size" line). The "99" marker may only be omitted if you have the same number of entries as specified n the "matrix size" line.

2. If the "matrix name" begins with the word "efficiency", then RESG will divide by the entry, rather than multiply (see section 8: Special Purpose Flags). Thus in the example below RESG will define the first output vector element as the input value divided by 0.85. It will also divide the input value by the values given (0.85, 0,80) because "matrix name" is "efficiency/ted". The operator diagonal will ordinarily multiply.

```
115: ****************************************************************
116: data table  6                                                  *
117: ****************************************************************
118: diagonal                                                       *
119: consis.check= 3                                                *
120: matrix name =efficiency/t&d                                    *
121: output name =generation requireme                              *
122: output units=mboe                                              *
123: matrix size =24 24        .00                                  *
124: elec generat= 1  2 barch=02/ov/reg=01/99,99/01,01
125: none               barch=02/ov/reg=02/99,99/02,02
126:    electr sold            electr generated     fraction        *
127: -- -------------------- -- -------------------- ----------     *
128:  1 Java-electr           1 Java-electr               .850      *
129:  2 electricity           2 electricity               .800      *
130: 99                      99                           .000      *
```


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DIFFERENCE

This operator is analogous to the <u>addition</u> operator: it is also used to link side branches to the main network, and follows the same rules for definition of the elements of the output vector. The only difference is that the side chain values are subtracted from the values in the main network.

```
294: ****************************************************************
295: data table 12                                                  *
296: ****************************************************************
297: difference                                                     *
298: consis.check= 0                                                *
299: matrix name =city gas linkup                                   *
300: output name =demand                                            *
301: output units=mboe                                              *
302: matrix size =28 28        .00                                  *
303: none        = 1 28                                             *
304: none                                                           *
305:                                                                *
306: -- ------------------- -- ------------------- ----------       *
```

A typical use for <u>difference</u> is to link a side branch representing a domestic refinery to the main network that contains the total domestic fuel requirements. The resulting output will be the difference between the domestic demand and refinery production: a positive term would indicate imports, a negative term (e.e. refinery production exceeds domestic demand), would indicate a refined product export. This is illustrated on the exhibit overleaf.

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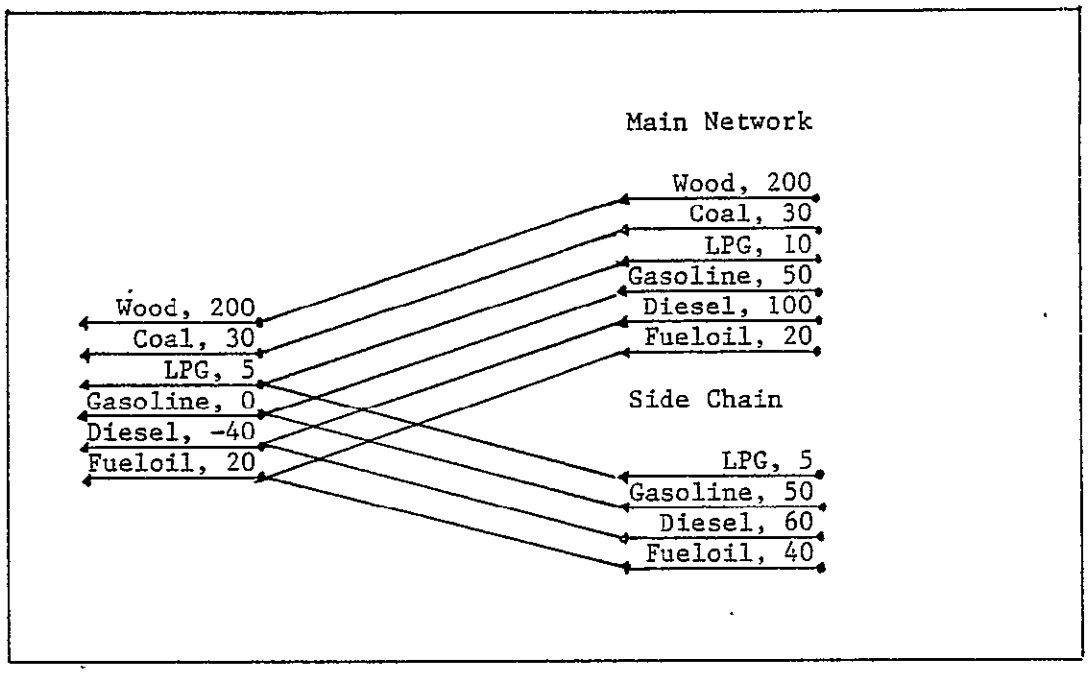
The DIFFERENCE Operator



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ELECTRIC

This operator is described in SECTOR 4.2. Also refer to Annex X for details on the dispatch algorithm.

The parameter value (on the "matrix size" line) indicates the conversion of gWh to the energy units used in the network file. In the example below, the value 1611.10 on the "matrix size" effects the conversion of gWh to the network output units, which in the example shown is million barrels of oil equivalent (mboe), as indicated in the "output units" row of the data table.

```
*****************************************************************
data table  8
*****************************************************************
electric
consis.check= 0
matrix name =power1.dat
output name =non-Java fuels/elec
output units=
matrix size =35 30  1611.00   0   0
-elec genera= 8 13 parch=03/ov/reg=02/08,08/09,09/10,10/11,13
none        = 0  0 barch=

-- -------------------- -- -------------------- ---------
 1 hydro                1 hydro                  1.000
 2 geothermal           2 geothermal             1.000
 3 coal                 3 coal                   1.000
 4 fueloil              4 fueloil                1.000
 5 ado                  5 ado                    1.000
 6 ido                  6 ido                    1.000
 7 nuclear              7 nuclear                1.000
 8 electricity          8 hydro                  1.000
 8 electricity          9 geothermal             1.000
 8 electricity         10 coal                   1.000
 8 electricity         11 fueloil                1.000
 8 electricity         12 ado                    1.000
 8 electricity         13 ido                    1.000
 9 lpg                 14 lpg                    1.000
10 avgas               15 avgas                  1.000
11 avtur               16 avtur                  1.000
12 gasoline            17 gasoline               1.000
13 ado                 18 ado                    1.000
14 ido                 19 ido                    1.000
15 kerosene            20 kerosene               1.000
16 fueloil             21 fueloil                1.000
17 petrochems          22 petrochems             1.000
18 lubes/waxes         23 lubes/waxes            1.000
19 asphalt             24 asphalt                1.000
20 petr coke           25 petr coke              1.000
21 gas                 26 gas                    1.000
22 charcoal            27 charcoal               1.000
23 wood                28 wood                   1.000
24 agric wastes        29 agric wastes           1.000
25 coal                30 coal                   1.000
26 coke                31 coke                   1.000
27 solar-pv            32 solar-pv               1.000
28 solar               33 solar                  1.000
29 biogas              34 biogas                 1.000
30 wind                35 wind                   1.000
*****************************************************************
data table  9
*****************************************************************
```


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The growth operator is used to represent constant yearly growth rates, which RESG automatically compounds the growth rates over the proper interval. In the example below, the yearly growth rate for food is 3.5%, that for textile is 2.0%, etc.

```
23: ****************************************************************
24: data table  2                                                  *
25: ****************************************************************
26: growth                                                         *
27: consis.check= 0                                                *
28: matrix name =Economic Growth                                   *
29: output name =Projected Value Adde                              *
30: output units=billion Rp                                        *
31: matrix size = 9  9        .00                                  *
32: none        = 1  9                                             *
33: none                                                           *
34:    billion Rp              billion Rp          Multiplier      *
35: -- -------------------- -- -------------------- ----------     *
36:  1 Food                 1 Food                    1.035 Multiplier *
37:  2 Textile              2 Textile                 1.020 Multiplier *
38:  3 Pulp,Paper           3 Pulp,Paper              1.050 Multiplier *
39:  4 Rubber               4 Rubber                  1.032 Multiplier *
40:  5 Chemicals            5 Chemicals               1.040 Multiplier *
41:  6 Cement               6 Cement                  1.020 Multiplier *
42:  7 Glass,Brick_         7 Glass,Brick_            1.020 Multiplier *
43:  8 Iron,Steel           8 Iron,Steel              1.034 Multiplier *
44:  9 Other Manuf          9 Other Manuf             1.020 Multiplier *
```

Note that the data field represents a multiplier, i.e. 1,035 represents a 3.5% annual growth rate. If the scenario year is the base year, the multiplier is 1.0. Caution if no growth is projected, the data field must be 1.00.

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Since <u>i-elasticity</u> must be used with an overall GDP growth rate, you will need to generate a corresponding prompt in the main RESG menu. Go to the PARAMO.DAT file and make sure that "gdp prompt" is set to "yes".

```
Resgen parameter file
-------------------------

-------------------------
yes  gdp prompt
 80  columns
yes  energy balance table
yes  current account table
xxx  investment table
xxx  investment graphics
```

In the example overleaf, note that the value of G* is 1.05, entered in the "matrix size" line as the "parameter value".

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```
47: ##########################################################################
48: data table  2
49: ##########################################################################
50: i-elasticity
51: consis.check= 0
52: matrix name =growth rates
53: output name =scenario basis
54: output units=1000 toe
55: matrix size =33 33     1.05
56: none          1 33
57: none
58:    sector                    sector                 growth rates
59: -- -------------------- -- -------------------- ----------
60:  1 electr. domestic      1 electr. domestic          1.190 residential
61:  2 electr. s+m industry  2 electr. s+m industry      1.063 industry
62:  3 electr. large indust  3 electr. large indust      1.047 industry
63:  4 electr. commercial    4 electr. commercial        1.137 commercial
64:  5 electr. street light  5 electr. street light      1.042 misc.
65:  6 electr. LA            6 electr. LA                1.097 local auth
66:  7 electr. hotel         7 electr. hotel             1.125 hotels
67:  8 lpg                   8 lpg                       1.050 residential
68:  9 gasolene              9 gasolene                  1.030 transportat
69: 10 naptha               10 naptha                    1.000 industry
70: 11 a-diesel             11 a-diesel                  1.000 transportat
71: 12 kerosene             12 kerosene                  1.020 residential
72: 13 avtur                13 avtur                     1.050 transportat
73: 14 diesel               14 diesel                    1.050 industry
74: 15 diesel transp.       15 diesel transp.            1.050 transportat
75: 16 diesel cement        16 diesel cement             1.000 industry
76: 17 fuel oil             17 fuel oil                  1.050 industry
77: 18 residual             18 residual                  1.000 industry
78: 19 residual sfmc        19 residual sfmc             1.000 industry
79: 20 asphalt              20 asphalt                   1.000 industry
80: 21 coal railway         21 coal railway              1.000 transportat
81: 22 coal others          22 coal others               1.000 industry
82: 23 coal cement          23 coal cement               1.000 industry
83: 24 bagasse              24 bagasse                   1.000 industry
84: 25 wood industry        25 wood industry             1.020 industry
85: 26 wood domestic        26 wood domestic             1.030 residential
86: 27 charcoal industry    27 charcoal industry         1.060 industry
87: 28 charcoal domestic    28 charcoal domestic         1.000 residential
88: 29 solar                29 solar                     1.000 misc.
89: 30 biogas               30 biogas                    1.000 misc.
90: 31 wind                 31 wind                      1.000 misc.
91: 32 mini-hydro           32 mini-hydro                1.000 misc.
92: 33 ind lpg              33 ind lpg                   1.000 industry
```


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MATRIX

This is the most general operator, providing for matrix multiplication. A special case of matrix is the reverse operation of a share operator. In the example below, the first seven input elements are added together into the single element "electricity" in the output vector, and input elements 21 to 23 are aggregated into the single element "coal".

```
152: ##############################################################################
153: data table  5                                                                 #
154: ##############################################################################
155: matrix                                                                        #
156: consis.check= 0                                                               #
157: matrix name =fuel demand                                                      #
158: output name =fuel by sector                                                   #
159: output units=1000 tce                                                         #
160: matrix size =19 33                                                            #
161: consumption = 1 19                                                            #
162: sector      = 1 19                                                            #
163:    sector                    fuel                  share                      #
164: -- -------------------- -- -------------------- ----------                    #
165:  1 electr. domestic      1 electricity              1.000 residential#
166:  2 electr. s&m industry  1 electricity              1.000 industry   #
167:  3 electr. large indust  1 electricity              1.000 industry   #
168:  4 electr. commercial    1 electricity              1.000 commercial #
169:  5 electr. street light  1 electricity              1.000 misc.      #
170:  6 electr. UDA           1 electricity              1.000 industry   #
171:  7 electr. railway       1 electricity              1.000 transportat#
172:  8 lpg                   2 lpg                      1.000 residential#
173:  9 gasolene              3 gasolene                 1.000 transportat#
174: 10 naphtha               4 naphtha                  1.000 industry   #
175: 11 av gas                5 av gas                   1.000 transportat#
176: 12 kerosene              6 kerosene                 1.000 residential#
177: 13 avtur                 7 jet fuel                 1.000 transportat#
178: 14 diesel                8 diesel                   1.000 industry   #
179: 15 diesel transp.        8 diesel                   1.000 transportat#
180: 16 diesel cement         8 diesel                   1.000 industry   #
181: 17 fuel oil              9 fuel oil                 1.000 industry   #
182: 18 residual             10 residual                 1.000 industry   #
183: 19 residual sfoc        10 residual                 1.000 industry   #
184: 20 asphalt              11 asphalt                  1.000 industry   #
185: 21 coal railway         12 coal                     1.000 transportat#
186: 22 coal others          12 coal                     1.000 industry   #
187: 23 coal cement          12 coal                     1.000 industry   #
188: 24 bagasse              13 bagasse                  1.000 misc.      #
189: 25 wood industry        14 wood                     1.000 industry   #
190: 26 wood domestic        14 wood                     1.000 residential#
191: 27 charcoal industry    15 charcoal                 1.000 industry   #
192: 28 charcoal domestic    15 charcoal                 1.000 residential#
193: 29 solar                16 solar                    1.000 misc.      #
194: 30 biogas               17 biogas                   1.000 misc.      #
195: 31 wind                 18 wind                     1.000 misc.      #
196: 32 mini-hydro           19 mini-hydro               1.000 misc.      #
197: 33 ind lpg               2 lpg                      1.000 industry   #
```


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The price operator is used to multiply the current vector of fuels by a vector of prices, with the result put into the second summary table. For example, if the fuel vector represents bunker sales, then you can use a price operator to multiply by the bunker prices, and put the result into the second summary table that typically represents the energy-related foreign exchange transactions.

The price vector is contained in an outside data file of the type PRICE.DAT, specified in the "matrix name = " entry. In the example below, RESG will look for an external file PRICES.DAT. Note also the absence of a data section.

```
581: ****************************************************************
582: data table 27                                                  *
583: ****************************************************************
584: price                                                          *
585: consis.check= 0                                                *
586: matrix name =prices.dat                                        *
587: output name =Current Account Bal                               *
588: output units=mill U.S. $                                       *
589: matrix size =15 15        .00                                  *
590: imports     = 1 15                                             *
591: none                                                           *
592:                                                                *
593: -- -------------------- -- -------------------- ----------     *
594: ****************************************************************
```

projection is always the first operator in a RESGEN network, and contains a vector of values that corresponds to the extreme right hand side of a Reference Energy System.

```
 4: ****************************************************************
 5: data table  1                                                 *
 6: ****************************************************************
 7: projection                                                    *
 8: matrix name =No. of Households                                *
 9: matrix size = 9  0        .00                                 *
10: none        = 1  9                                            *
11: none                                                          *
12:    households          millions                               *
13: -- -------------------- --------------------                   *
14:  1 Cooking,urban            2.300 millions                    *
15:  2 Lighting,urban           2.300 millions                    *
16:  3 Hotwater,urban            .300 million                     *
17:  4 Aircon                   5.000 million                     *
18:  5 Water pump                .400 million                     *
19:  6 Other electricity        2.300 million                     *
20:  7 Cooking,rural            3.900 million                     *
21:  8 Lighting,rural           3.900 million                     *
22:  9 Home industry,rural       .050 million                     *
```


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p-elasticity implements the elasticity adjustment

$$X_n(t) = X_{n-1}(t) \left(\frac{\lambda_t}{\lambda_o}\right)^{\beta} \qquad [1]$$

output vector — input vector

where β is the price elasticity of demand (usually negative in the case of price elasticity), and λ_t is the price at time t.

However, since

$$\lambda_t = \lambda_o \ (1 + g_\lambda)^t$$

where g is the rate of price escalation, we can rewrite [1] as

$$X_n(t) = X_{n-1}(t) \ (1+g_\lambda)^{\beta t}$$

The escalation factor g is taken from the external file of type PRICE.DAT. If no escalation factor is given in this file for a particular fule, then the default value of the world oil price escalator (set in line 2 of the parameter menu) is used:

```
..parameters for this run:

1.  GDP growth rate                  1.05
2.  world oil price growth rate      1.03
3.  paper save mode                   yes
4.  diagnostics                       yes
5.  datafile year                    1982
6.  planning horizon                    8
7.  conservation tables                no
0.  to continue

    ..enter here >>>>
```


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In the example below, the consumer prices are contained in the external file PRICES.DAT.

```
106: ##############################################################################
107: data table  5                                                                 #
108: ##############################################################################
109: p-elasticity                                                                  #
110: consis.check= 0                                                               #
111: matrix name =pricesc.dat                                                      #
112: output name =prices adj.demand                                                #
113: output units=1000 toe                                                         #
114: matrix size =33 33                                                            #
115: none        = 1 33                                                            #
116: none                                                                          #
117:    sector                    sector                p-elasticity               #
118: -- -------------------- -- -------------------- ----------                   #
119:  1 electr. domestic      1 electr. domestic          -.200                    #
120:  2 electr. sm industry   2 electr. sm industry       -.200                    #
121:  3 electr. large indust  3 electr. large indust      -.200                    #
122:  4 electr. commercial    4 electr. commercial        -.200                    #
123:  5 electr. street light  5 electr. street light      -.200                    #
124:  6 electr. UDA           6 electr. UDA               -.200                    #
125:  7 electr. railway       7 electr. railway           -.200                    #
126:  8 lpg                   8 lpg                       -.200                    #
127:  9 gasolene              9 gasolene                  -.200                    #
128: 10 naptha               10 naptha                    -.200                    #
129: 11 av gas               11 av gas                    -.200                    #
130: 12 kerosene             12 kerosene                  -.200                    #
131: 13 avtur                13 avtur                     -.200                    #
132: 14 diesel               14 diesel                    -.200                    #
133: 15 diesel transp.       15 diesel transp.            -.200                    #
134: 16 diesel cement        16 diesel cement             -.200                    #
135: 17 fuel oil             17 fuel oil                  -.200                    #
136: 18 residual             18 residual                  -.200                    #
137: 19 residual sfac        19 residual sfac             -.200                    #
138: 20 asphalt              20 asphalt                   -.200                    #
139: 21 coal railway         21 coal railway              -.200                    #
140: 22 coal others          22 coal others               -.200                    #
141: 23 coal cement          23 coal cement               -.200                    #
```


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*PROJECTS

This operator is used to adjust energy demands for the impact of large projects (not readily captured by percentage growth increments). For example, a large new cement plant coming on live in 1988 would produce a sudden increase in coal demand in that year. The * projects operator is illustrated below: it makes reference to an external file PROJECT.DAT that contains a list of projects. The output name is used as a four-letter code that allows you to choose only a subset of the listed projects. This four letter code ("demd" in the example below) has to match the code in the respective PROJECT.DAT file.

```
 93:*****************************************************************
 94: data table  3                                                 *
 95: *****************************************************************
 96: *projects                                                     *
 97: consis.check= 0                                               *
 98: matrix name =project.dat                                      *
 99: output name =demd                                             *
100: output units=1000 toe                                         *
101: matrix size =33 33                                            *
102: none        = 1 33                                            *
103: none                                                          *
104:    fuel                    1000 toe                           *
105: -- ------------------- -------------------                    *
*e
```


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If the project list file PROJECT.DAT is

project.dat: project list.

year	i.d.	project	+fuel	fuel
1988	demd		14.79	electr. UDA
1987	demd		44.00	ind lpg
1988	demd		7.83	electr. railw
1988	demd	cement plant	191.53	coal cement
1990	supp	oil port fac.		

then only the first four projects with i.d.=demd, would be picked up at this point. However, if you use the code "all" as the *projects output name, then all the projects in the above file would be picked up.

In the exhibit overleaf, note that no adjustment is made to the main network for 1987 for gas, since the gas project comes on line only in 1989. Note also that the fuel amount listed in the PROJECT.DAT file can be negative (to simulate conservation and/or fuel substitution projects)

Capital investment costs can be entered for listed projects by referencing the project name (third column of PROJECT.DAT) in the PROJCOST.DAT file.

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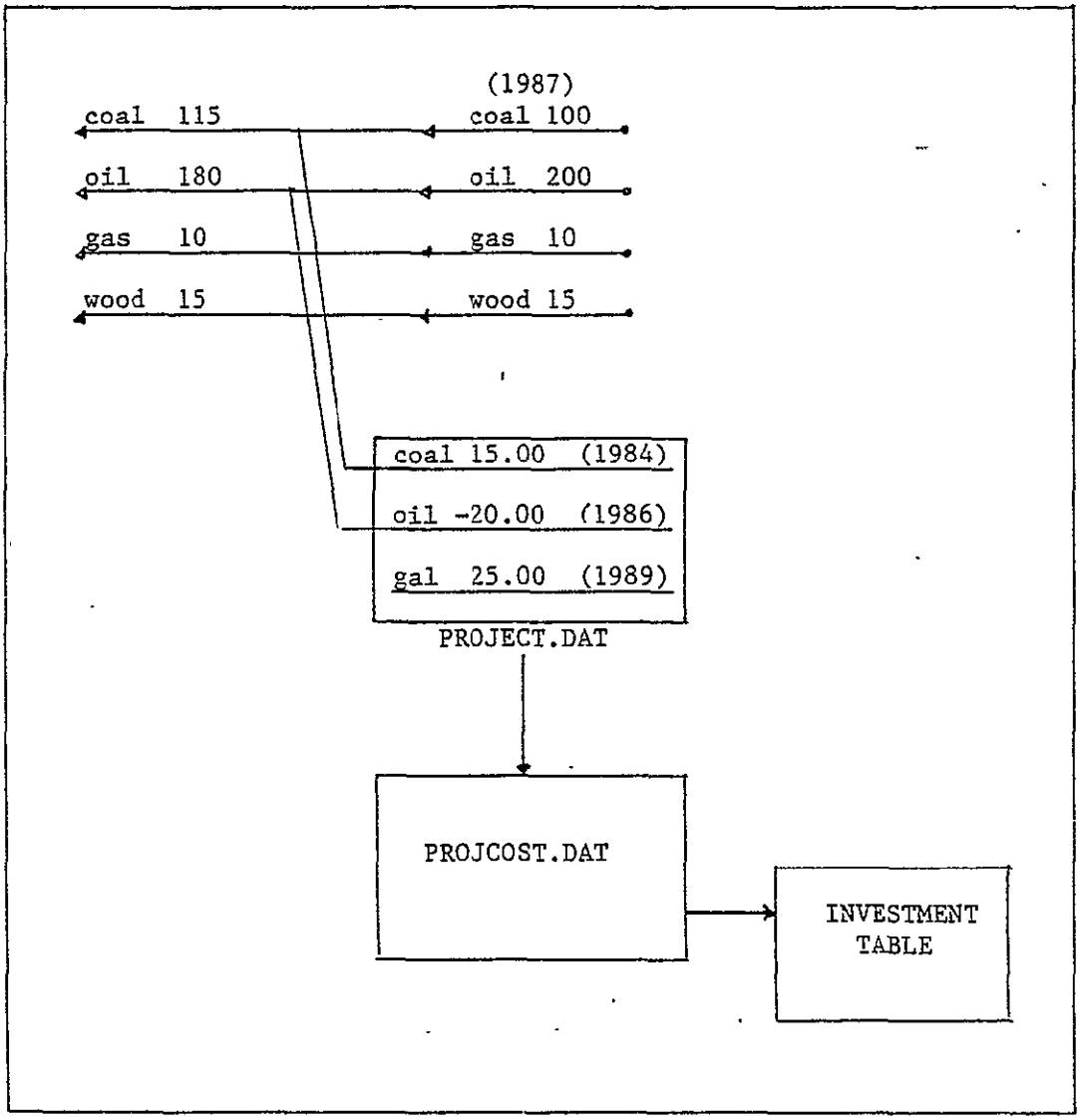
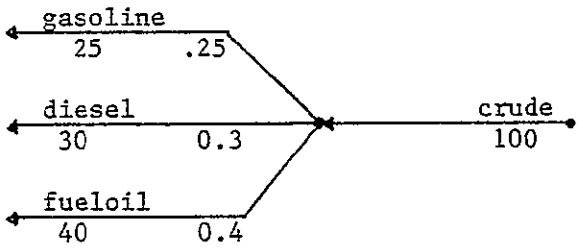
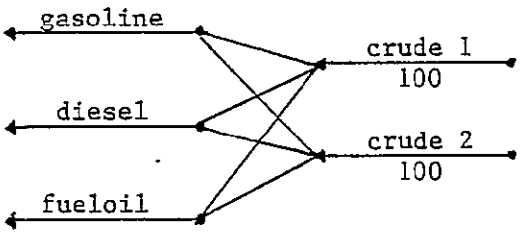
The *PROJECTS Operator



The refinery operator is a special case of the matrix operator, used to model a refinery where the crude input(s) is fixed. For example, for a single crude input:



or for two crudes of different product yields



Note that for the single crude, you could also use the share operator, while for multiple crudes, you could also use the matrix operator. However, the refinery operator will produce a graphical display of the refinery configuration. For this you must enter so the parameter value (on the matrix size line), the refinery capacity. The data section contains the yield coefficients.

If you want the crude throughput determined by the model (e.g. to meet domestic gasoline demand), then you must use the vrefinery operator.

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S-ELASTICITY

This operator is similar to p-elasticity except that income rather than price elasticities are involved. Thus the s-elasticity operator makes an adjustment of the type

$$X_n(t) = X_{n-1}(t) \cdot \left(\frac{Y_t}{Y_o}\right)^{\alpha} \qquad [1]$$

output vector input vector

where α is the income elasticity, and Y_t is the income at time t.

But since

$$Y_t = Y_o \cdot (1+g_Y)^t$$

where g_Y is the growth of the Yth sector, [1] can be rewritten as:

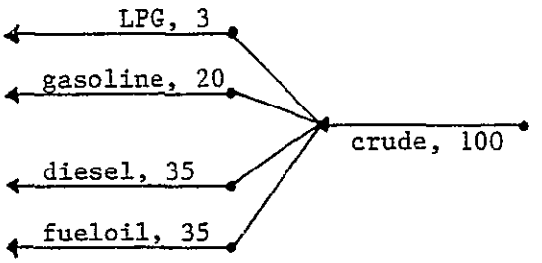
$$X_n(t) = X_{n-1}(t) \cdot (1+g_Y)^{\alpha t}$$

The $(1+g_Y)$ factor is taken from an external file of type PRICE.DAT. However, while in p-elasticity the (1+g) factors related to fuels, and thus the associated PRICE.DAT lists fuel price escalation rates, in s-elasticity the (1+g) factors relate to the income of sectors, and hence the associated PRICE.DAT file must contain a list of sectors, with sectoral income growth rates.

Note that for the s-elasticity operator RESG matches the sector labels in the network file against the labels in the PRICE.DAT file, whereas in p-elasticity, RESG matches the fuel labels (i.e. vector labels). Section 4.4 illustrates the use of this operator, and the differences between p-elasticity and s-elasticity

SHARE

The share operator is used in situations where a link splits into two or more parts. For example, a refinery could be represented as follows:



thus the crude is split into refined products in the proportions corresponding to the yield coefficients. Obviously the output vector of a share operator will always have a larger number of elements than the input vector.

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In the example below, the nine input links are split into 29 output links:

```
80: ****************************************************************
81: data table  5                                                  *
82: ****************************************************************
83: share                                                          *
84: consis.check= 3                                                *
85: matrix name =Fractions Useful Dem                              *
86: output name =Useful Energy by Typ                              *
87: output units=mboe(useful)                                      *
88: matrix size =29  9        .00                                  *
89: none        = 1 29                                             *
90: none                                                           *
91:    mboe(useful)            mboe(useful)        fraction        *
92: -- -------------------- -- -------------------- ----------     *
93:  1 Cooking,urban         1 gas                      .050 Cooking,urb*
94:  1 Cooking,urban         2 lpg                      .090 Cooking,urb*
95:  1 Cooking,urban         3 kerosene                 .800 Cooking.urb*
96:  1 Cooking,urban         4 electricity              .000 Cooking,urb*
97:  1 Cooking,urban         5 wood                     .100 Cooking,urb*
98:  1 Cooking,urban         6 agric wastes             .050 Cooking,urb*
99:  2 Lighting,urban        7 electricity              .500 Light,urb  *
100: 2 Lighting,urban        8 kerosene                 .500 Light,urb  *
101: 3 Hotwater,urban        9 electricity              .800 Hotwater   *
102: 3 Hotwater,urban       10 lpg                      .050 Hotwater   *
103: 3 Hotwater,urban       11 gas                      .020 Hotwater   *
104: 3 Hotwater,urban       12 solar                    .000 Hotwater   *
105: 4 Aircon               13 electricity             1.000 Aircondit  *
106: 5 Water pump           14 electricity              .800 Water pump *
107: 5 Water pump           15 ado                      .200 Water pump *
108: 5 Water pump           16 solar-pv                 .000 Water pump *
109: 5 Water pump           17 wind                     .000 Water pump *
110: 6 Other,electricity    18 electricity             1.000 Other elect*
111: 7 Cooking,rural        19 kerosene                 .300 Cooking,rur*
112: 7 Cooking,rural        20 wood                     .600 Cooking,rur*
113: 7 Cooking,rural        21 agric wastes             .150 Cooking,rur*
114: 7 Cooking,rural        22 biogas                   .000 Cooking,rur*
115: 8 Lighting,rural       23 kerosene                 .950 Light,rur  *
116: 8 Lighting,rural       24 electricity              .050 Light,rur  *
117: 9 Home industry        25 electricity              .050 Home indust*
118: 9 Home industry        26 kerosene                 .200 Home indust*
119: 9 Home industry        27 wood                     .800 Home indut *
120: 9 Home industry        28 charcoal                 .050 Home indut *
121: 9 Home industry        29 biogas                   .000 Home indut *
```


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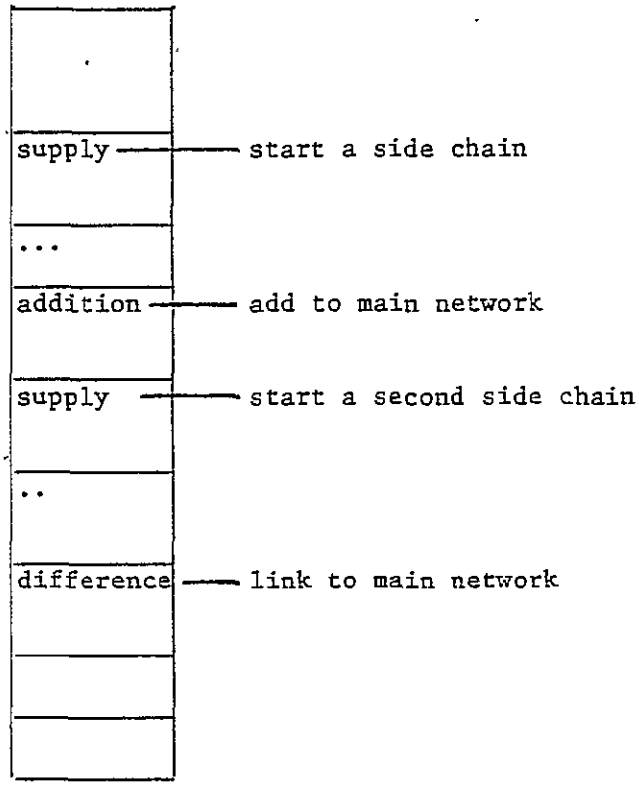
SUPPLY

The supply operator is similar in function to the projection operator: it enters a vector of numbers. Supply is used in particular to start a side chain to the main network. Note that every side chain must eventually be linked to the main network by the addition or difference operator, and that only 1 side chain can be active at one moment. For example:



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SUPPLY=RESOURCES

This is similar to the supply operator: it also starts a side chain to the main network. Its main use is to specify a scenario for domestic energy production: instead of specifying some fixed value, as would be the case for supply, this operator makes reference to an external file (say CRUDE.DAT for domestic crude oil production, or GAS.DAT, etc.). The name of the external file is indicated in the sector column. For example, in the exhibit below, the value for crude production is taken from the file "CRUDE.DAT", and for Arab light imports from the file "ARABL.DAT".

```
519: ****************************************************************
520: data table 23
521: ****************************************************************
522: supply=resources
523: matrix name =crude production
524: matrix size = 2  0        .00
525: primary prod= 1  1 barch=05/ov/reg=99/02,02
526: imports     = 2  2 barch=04/ov/reg=99/01,01
527:    mboe                  mboe/year
528: -- -------------------- --------------------
529:  1 crude                        .000 crude.dat
530:  2 arab light                   .000 arabl.dat
```

The outside files contain scenarios for resource production by year. If there is more than one scenario in this file, RESG will generate a graphics display of the various scenarios available, from which you must chose one particular scenario. (For details on the external file, see "RESOURCE.DAT").

If there is more than 1 scenario in the outside file, and you wish to pre-select one particular scenario, then the scenario may be selected by entering its number in the value column of the operator. Thus in the above example, if there are 3 production scenarios in the file CRUDE.DAT, and you want to run with scenario 2, change ".000" to "2.000". This will eliminate the scenario choice from the screen during RESG execution as shown below:

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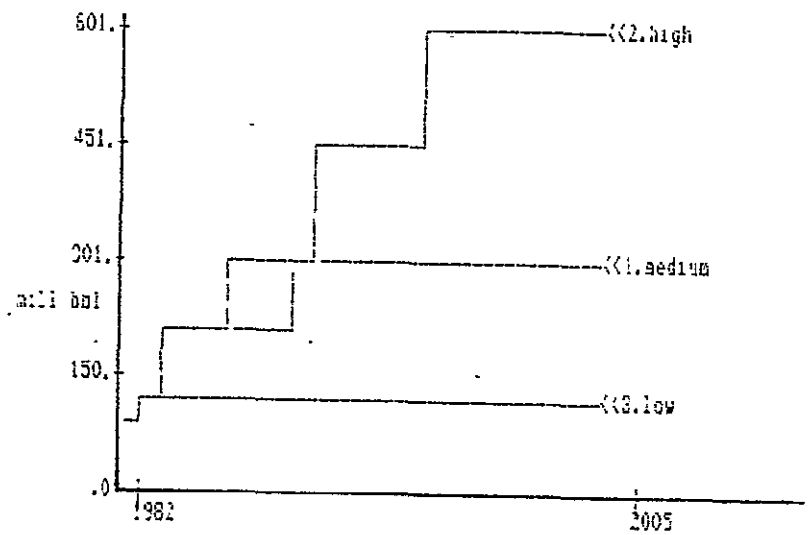
When running RESG, this operator will produce a screen from which the user must select an appropriate scenario: for example, if the external file is:

gas production for lng exports

year	1.medium	2.high	3.low
1982	90.00	90.00	90.00
1983	93.00	93.00	93.00
1984	190.00	200.00	100.00
1985	190.00	200.00	100.00
1986	190.00	200.00	100.00
1987	190.00	300.00	100.00
1988	190.00	300.00	100.00
1989	190.00	300.00	100.00
1990	272.00	300.00	100.00
1991	272.00	450.00	100.00
1992	272.00	450.00	100.00
1993	272.00	450.00	100.00
1994	272.00	450.00	100.00
1995	272.00	450.00	100.00
1996	272.00	600.00	100.00
1997	272.00	600.00	100.00
1998	272.00	600.00	100.00
1999	272.00	600.00	100.00
2000	272.00	600.00	100.00
2001	272.00	600.00	100.00
2002	272.00	600.00	100.00
2003	272.00	600.00	100.00
2004	272.00	600.00	100.00
2005	272.00	600.00	100.00

Then a reference to this file in a <u>supply=resources</u> operator will produce the following screen:



..select gas production for lng exports1,..3? >>>>

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SUPPLY=TABLE

This operator is similar to supply=resource: again reference is made to an external file. However, in this case the table consists of values for different fuels, that are brought into the main network for each year as needed. In the example below, the file PGN.DAT will be called for values of the fuels. Different fuels can be called from more than one outside file if desired.

```
263: ***************************************************************
264: data table 10                                                 *
265: ***************************************************************
266: supply=table                                                  *
267: matrix name =city gas inputs                                  *
268: matrix size = 4  0      .00   0   0                          *
269: -gas plant  = 1  4 barch=04/ov/reg=99/99,99/01,01             *
270: primary prod= 1  1 barch=04/ov/reg=99/99,99/99,99/01,01
271:                                                               *
272: -- ------------------- ------------------                     *
273:  1 gas                      0.000 pgn.dat                     *
274:  2 ido                       .000 pgn.dat                     *
275:  3 fueloil                   .000 pgn.dat                     *
276:  4 kerosene                  .000 pgn.dat                     *
```

The format for the outside table is given in SECTION 7 under "TABLE.DAT".

358

V-ELASTICITY

This operator is similar to p-elasticity, except that the external file is of type VGROWTH.DAT rather than PRICE.DAT. p-elasticity implements the elasticity adjustment

$$X_n(t) = X_{n-1}(t) \left(\frac{\lambda_t}{\lambda_o}\right)^{\beta}$$

but since

$$\lambda_t = \lambda_o \ (1+g_\lambda)^t$$

where g_λ is the fuel price escalation factor, the adjustment is equal to

$$X_n(t) = X_{n-1}(t) \ (1+g_\lambda)^{\beta t}$$

In p-elasticity, the $(1+g_\lambda)$ factor is taken from the external file of type PRICE.DAT.

In the v-elasticity operator, the price escalation factors can be varied from year to year:

$$X_n(t) = X_{n-1}(t) \left[(1+g_\lambda[1]) \ (1+g_\lambda[2])\ldots(1+g_\lambda[t])\right]^{\beta}$$

where the individual $(1+g_\lambda(t))$ entries are found in the columns of the VGROWTH.DAT file.

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The vgrowth operator is used in place of the growth operator when the annual growth rates are not constant. It allows you to vary the growth rate from year to year, or over ranges of years.

The actual growth rates to be used with the vgrowth operator are contained in an external file, specified in the "matrix name" entry. In the example below, the matrix name is specified as VGROWTH.DAT: this file must be present in the DATA directory, and contains the year by year growth rates.

The VGROWTH.DAT file is described in SECTION 7 of this Manual.

```
23: ****************************************************************
24: data table  2                                                  *
25: ****************************************************************
26: vgrowth                                                        *
27: consis.check= 0                                                *
28: matrix name =grhouse.dat                                       *
29: output name =Projected households                              *
30: output units=million units                                     *
31: matrix size = 9  9      .00   0   0                           *
32: none        = 1  9 barch=                                      *
33: none        = 0  0 barch=                                      *
34:                                                                *
35: -- ------------------- -- ------------------- ----------       *
```


360

The VREFINERY operator is used to model refinery operation. Each line in the data section results in a call to an outside data file of the type REFINEx.DAT

```
493: ****************************************************************
494: data table 22                                                   *
495: ****************************************************************
496: vrefinery                                                       *
497: consis.check= 0                                                 *
498: matrix name =refineries                                         *
499: output name =refinery outputs                                   *
500: output units=mboe                                               *
501: matrix size =31 31        .00                                   *
502: none        = 3 16                                              *
503: -refinery   = 1  2                                              *
504:    name                    capacity              mboe/year      *
505: -- -------------------- -- -------------------- ----------      *
506:  1 P.Brandan             1 P.Brandan                 1.600 refine1.dat*
507:  2 Dumai                 2 Dumai                    17.600 refine2.dat*
508:  3 S.Pakning             3 S.Pakning                 6.700 refine3.dat*
509:  4 Plaju                 4 Plaju                    14.400 refine4.dat*
510:  5 S.Gerong              5 S.Gerong                 11.300 refine5.dat*
511:  6 Cilacap               6 Cilacap                  30.000 refine6.dat*
512:  7 Balikpapan            7 Balikpapan                8.300 refine7.dat*
513:  8 Singapore Proc Deal   8 Singapore Proc Deal      95.000 refine8.dat*
514:  9 Balikp New ph 1       9 Balikp New ph1          20.000 refine9.dat*
515: 10 Balikp New ph 2Deal  10 Balikp New ph 2         20.000 refin10.dat*
516: 11 Dumai new            11 Dumai new               20.000 refin11.dat*
517: 12 Cilacap new ph 1     12 Cilacap new ph 2        20.000 refin12.dat*
518: 13 Cilacap new ph 2     13 Cilacap new ph 2        30.000 refin13.dat*
```

If a refinery is built at some point over the planning horizon, then a call is made to the PROJCOST.DAT file, which enables you to enter the capital costs of that refinery construction.

The "matrix name" entry must correspond with the energy balance row identification for the refinery if you wish the refinery output to be transferred to the summary table. In the above example, "matrix name=refinery" indicates that "refinery" is the corresponding entry in the file "LABELS.DAT".

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VREFINERY can also be run in such a way that the crude run is calculated on the basis of the refinery (or refineries) production having to meet the domestic consumption of <u>one</u> petroleum product (subject to the capacity limit). This is done by entering the target product in the "output name" entry. In the example below, the crude run will be set to meet the domestic gasoline demand.

```
*****************************************************************
data table 15
*****************************************************************
vrefinery
consis.check= 2
matrix name =refinery
output name =gasolene
output units=1000 toe
matrix size =20 20  2000.00   0   0
none        = 1 10 barcn=04/ov/reg=01/02,02/05,05/06,07/08,08
-refinery   =11 11
   crude                    refined products     yield coefficients
-- -------------------- -- -------------------- ----------
 1 colombo refinery      1                          0.00 refine.tst
*****************************************************************
```


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7. DATA FILES

This section describes in alphabetical order the data files necessary for the RESG system. Those files that have mandatory names are indicated by an asterisk after the name (*); those without the asterisk(*) can be named as the user wishes.

The manadatory names are programmed into the RESG code and are required to exist with exactly those names for any RESG run. An error of the type "File not found" will result if any of these files are absent!

COLORMAP.DAT*

This file is necessary only if you have initialized RESG for color graphics displays. It can be accessed through the appropriate data file directory in TABLE. COLORMAP.DAT specifies the colors to be used for various parts of the bar chart map displays.

color codes:map

item	col	cha
bar shade 1	014	004
bar shade 2	010	004
bar shade 3	012	004
bar shade 4	013	004
not used		
y-axis max. value	002	
bar chart labels	007	
frame	002	
map shade	007	

The colors, in the column "col", are coded to the following:

0	black	8	gray
1	blue	9	light blue
2	green	10	light green
3	cyan	11	light cyan
4	red	12	light red
5	magenta	13	light magenta
6	brown	14	yellow
7	white	15	high intensity white

The colors from 8 to 14 are brighter shades, or "high intensity" colors: some monitors are not capable of producing these high intensity colors, or may not produce all of them. Trial and error will be needed to identify the valid set for your monitor, and/or to find a color combination that you like.

The column "cha" identifies the ASCII character to be used for the bar charts. These are coded as follows:

001 = CHAR (176)
002 = CHAR (177)
003 = CHAR (178)
004 = CHAR (219)

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COLORPLT.DAT*

This file is needed only when RESG is initialized for color graphics displays. It sets the colors to be used for the time series plots in RESG. The color codes, in the column "col", are coded as for the COLORMAP.DAT file (see previous page). The ASCII character codes are also coded as in the COLORMAP.DAT file.

color codes:map

item	col	cha
data 1	009	004
data 2	010	004
data 3	011	004
data 4	012	004
data 5	013	004
data 6	014	004
data 7	015	004
data 8	002	004
data 9	003	004
data 10	001	004
not used	002	
not used	002	
labels	007	
axes	002	
axis tick marks	002	

Since the color plot routine supports up to 10 time series, the first 10 rows of this table correspond to the 10 possible time lines. In the above example, if there is only one line in a particular plot, it will appear in light blue (color code = 009). As in the case of COLORMAP.DAT, if you plan to dump the screen to a black&white dot matrix graphics printer, you should use a different ASCII character for adjacent colors, otherwise the printed output is unable to differentiate among the different entries.

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COLORGRA.DAT*

This file is needed only when RESG is initialized for color graphics. It sets the colors to be used for the refinery and electric sector dispatch displays. The color codes are defined in the COLORMAP.DAT section.

color codes:map

item	col	cha
refinery:frame	007	
box	007	
fill box	011	
arrows	012	
text	013	
values	014	
other	015	
elec:frame	002	
box	007	
plant names	001	
axis info.	002	
load bl.1	002	
load bl.2	007	
load bl.3	002	
misc.info	002	

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CONVER.DAT*

This file contains conversion factors for the units used in the energy balance table. All the price tables should be specified in cost per physical unit, such as $/ton: this is the form in which most oil companies maintain their statistics. However, the energy balance table, and the units in the main network, are usually based on ton oil equivalent, or barrel of oil equivalent: the conversion factors are contained in this file.

```
conversion factors
******************************************
fuel        factor
l-------    r--------e
lpg            1.06
gasolene       1.09
kerosene       1.05
jet fuel       1.05
diesel         1.05
a-diesel       1.05
fuel oil        .98
asphalt         .89
residual        .95
crude          1.03
naptha         1.09
```

Note that the conversion factors above represent the tons of oil equivalent per ton of fuel!

CONVER.DAT is used whenever a PRICE.DAT file is called: if a match of fuel labels is not found, the conversion factor is simply assumed as 1.0.

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COLUMNS.DAT

COLUMNS.DAT contains the column labels for the energy balance table. The order in which the fuel labels appear in this file will determine the order, from left to right, in which the fuels will appear in the energy balance table.

columns

#	coluan
01	crude
02	arab light
03	lpg
04	avgas
05	avtur
06	gasoline
07	kerosene
08	ado
09	ido
10	fueloil
11	petrochems
12	lubes/waxes
13	asphalt
14	petr coke
15	naphtha
16	LSWR
17	gas
18	LNG
19	LPG exp
20	coal
21	bat muda
22	coke
23	electricity
24	f-electricit
25	Java-electr
26	hydro
27	geothermal
28	nuclear
29	wood
30	charcoal
31	agric wastes
32	biogas
33	solar-pv
34	solar
35	wind

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COLUMNS.DAT can be accessed in the Special File Directory in the TABLE program. A maximum of 40 columns are allowed.

If for some reason a fuel is passed to the energy balance table that does not appear in COLUMNS.DAT, then that fuel will be added to the table (an an additional column on the right). For example, if you enter "gasoline" in COLUMNS.DAT, and "Gasoline" in the RESGEN network file, both names will appear in the energy balance table. If you switch on the "diagnostics" in the RESGEN system menu, then the spelling will be checked against COLUMNS.DAT as the network file enters RESGEN, and an appropriate error message will be printed out.

By making the appropriate entry in STAT.RES (see below in this section) the energy balance or summary table will suppress printing any fuel that has zero flows in the year being tabulated. If a RESG run that has only three fuels that are non-zero for example kerosene, electricity and gas), the summary table will only have these three columns even if the COLUMNS.DAT file being referenced has 35 fuels listed.

COSTLIST.DAT*

COSTLIST.DAT contains a list of power plants whose year-by-year construction outlays are known. Each plant occupies two lines: the four entries on the first line are:

1) the total capital cost, in U.S.$ million
2) the foreign fraction
3) loan period, in years
4) interest rate.

The second line contains the percentage of the total construction cost incurred in each year of the construction period. In the sample file below, for example, 57.50% of the cost of Rantembe is incurred in the second year. The maximum number of years for construction is seven years.

c.e.b.investment plan

plant	1	2	3	4	5	6	7
rantembe	274.60	.67	20.00	.12			
rantembe	9.80	57.50	32.70				
trincomalee 1	309.00	.67	20.00	.12			
trincomalee 1	5.10	15.70	25.00	28.00	17.40	8.80	
trincomalee 2	216.00	.67	20.00	.12			
trincomalee 2	5.10	15.70	25.00	28.00	17.40	8.80	
trincomalee 3	353.00	.67	20.00	.12			
trincomalee 3	5.50	16.90	27.30	31.20	19.10		
trincomalee 4	195.00	.67	20.00	.12			
trincomalee 4	6.90	20.90	33.70	38.50			
broadlands	8.68	.67	20.00	.12			
broadlands	5.20	26.20	48.20	20.40			
samanalaweva	305.00	.67	20.00	.12			
samanalaweva	.40	5.20	25.70	46.90	21.80		
calidonia	556.00	.67	20.00	.12			
calidonia	2.70	6.70	20.80	36.90	24.90	8.00	

Note that the actual years the investments are incurred depends on the year that the power plan dispatch algorithm (see operator electric in section 4.2) selects that plant to enter the load duration curve. If it selects Rantembe for the year 1987, it will incur 9.8% of the investment in 1985, 57.5% in 1986 and 32.7% in 1987. If the base year being run is 1986, RESG will ignore the 9.8% incurred earlier.

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In order to generate the investment calculation, you must switch on "yes" the appropriate selections in PARAMO.DAT.

The investment calculation assumes that interest and principal payments initiate in the first year of operation (1987 in the example above). In this RESG differs from actual utility financial planning, which has to consider loans with a wide array of terms, such as grace periods, interest during construction and special fees. It is not the intent of RESG to duplicate such an effort; moreover, such a detailed financial projection requires information on the exact package of loans (soft loans, commercial loans, supplier credits, own funds) that make up the actual construction of a power plant.

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DEMANDx.DYN

Files of this type are used as the interface between RESGEN networks: they are created as outputs of one network, and can be read in as data in another (see LINKING NETWORKS, in Section 8 of this manual). For convenience, it is recommended to assign all interface files a common 3 letter extension, such as .INT (for interface)

```
24  1985  1985
Java-electr
electricity
lpg
avgas
avtur
gasoline
ado
ido
kerosene
fueloil
petrochems
lubes/waxes
asphalt
petr coke
gas
charcoal
wood
agric wastes
coal
coke
solar-pv
solar
biogas
wind
  year=1985
     5.800
     1.200
      .034
      .139
      .225
    26.802
    66.890
     5.917
      .337
    58.222
      .064
      .096
      .128
      .016
     7.042
     1.550
      .451
      .197
     6.231
      .000
      .000
      .000
      .000
      .000
```


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These files cannot be loaded into TABLE, as they have a somewhat different format to the other RESG files. If you wish to create such a file in LOTUS, EDLIN or WORDSTAR, say if you wish to offer RESG the ability to use a set of demand projections taken from some report or from official projections, then the following points should be noted:

The first record contains the number of elements (fuels) in each vector, and the year range of the file (FORTRAN format 12,2x,14,2x,14). The spelling of the fuel labels must be consistent with those used in the network file in the DEMAND operator.

Each set of values corresponds to the order in the labels section: the value may be put into any of the first 10 fields, and may be left justified for convenience of entry. (when the file is created by another RESG run, the values appear in right-justified form).

Each set of values follows the year identification: the year must appear in columns 8 through 11.

The number of entries for each year, (which also equals the number of labels) must be exactly as specified in the first field: if there are more, or less than is stated in the first record, a FORTRAN read error will occur and the program will abort.

If the file is created in LOTUS, special care is required to produce the respective LOTUS.PRN file readable by RESG (you must eliminate the header, footer and margin default settings for .PRN files in LOTUS!). It is recommended that a LOTUS macro program be written to make the transformation.

GRAPHICS.DAT defines the map/barchart displays. You may specify up to 10 such displays (in the example below, five displays are initialized).

graphics parameters

#	display title	#	regional/item label	bar label
01	exports	01	1982	crude
		02	1985	lng
		03	1990	
02	electricity	01	java	demand
		02	o-java	generation
03	generation mix	01	java/grid	hydro
		02	o-java	geothermal
				coal
				oil
04	domestic production	01	1982	crude
		02	1985	gas/lng
		03	1990	gas/domestic
				coal
05	imports	01	1982	crude
		02	1985	coal
		03	1990	diesel
				fueloil

Each map display can contain 1,2 or 3 barcharts: in the above example, displays 1, 4 and 5 will have 3 barcharts, displays 2 and 3 will have 2 barcharts. The label for each barchart is indicated in the "regional/item label" column. Finally, the barcharts may contain up to 4 bars each, specified under the "bar label". For example, display number 3 will have only two barcharts, (java/grid, and o-java). Both barcharts will have 4 bars each, representing hydro, geothermal, coal and oil. Display number 5 will have 3 barcharts, (1982, 1985 and 1990); each will show, for the year in question, imports of crude, coal, diesel and fuel oil.

Note: GRAPHICS.DAT serves only to initialize the barchart displays, and define the labels. You must also initialize the map itself (data file RESMAP.DAT), and pass the numerical values from the network with the "BARCH" command (see section 8).

LABELS.DAT

LABELS.DAT defines the rows of the two summary tables. The normal use of the summary tables in a national energy model would be for an energy balance table, and a table of foreign exchange transactions: this is the use illustrated in the exhibit below.

```
Summary Table Definitions
-------------------------------
  Energy Balance Table
-------------------------------
  mtoe
01=primary production
02=imports
03=exports
04=bunkers
05=stock changes
06=.subtotal
07=refinery
09=elec generation
11=gas plant
13 LNG plant
15 LPG plant
17 charc/briq
22 -losses
23 .total
23 consumption
  end
-- ---------------------------
  current account table
-- ---------------------------
  US $mill
01=imports
02=-exports/bunkers
 =.net
 =end
-------------------------------
```

As explained in SECTION 3 of this report, you may define several files of this type (LABELS1.DAT, LABELS2.DAT etc.). This section should also be consulted for an explanation of the "." and "-" prefixes.

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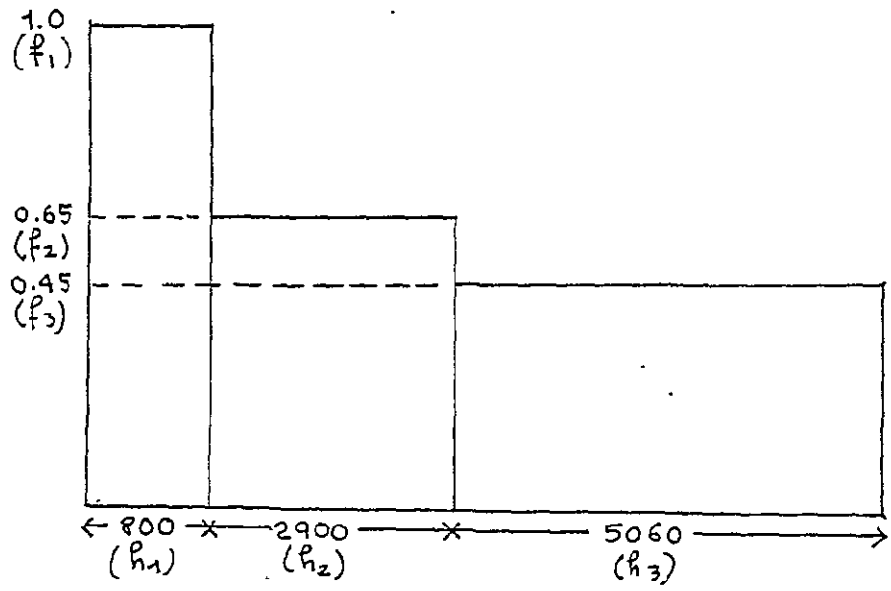
LOAD.DAT (Load Duration Curve)*

LOAD.DAT contains the annualized load duration curve for the electric sector, and can be accessed in the DATA directory.

load duration curve

f	hours	segment
.45	5060.	base
.65	2900.	intermediate
1.00	800.	peak
.550		slf

The first three lines of this file correspond to the linearized load duration curve:



Note that the sum of the hours is 8760, and that the f-value for the peak is always 1. The f-values for the other blocks signify the fraction of the peak value (and must therefore be less than 1).

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The "slf" entry signifies the system load factor. If you wish to vary this through time, then additional lines can be added, as in the following example:

load duration curve

f	hours	segment
.45	5060.	base
.65	2900.	intermediate
1.00	800.	peak
.550		slf
.555		
.560		

Here the "slf" for the base year is 0.55; for the second year 0.555, and for the third (an all years there after) 0.560.

It should be noted that the system load factor is defined by

$$slf = \frac{h1f1+h2f2+h3f3}{8760}$$

If there is any discrepancy between the stated value of slf (0.55 in the above example) and the f and h values, then RESG recalculates the value of f2 to assure consistency. In the above example, the calculated value of slf is

$$= \frac{800 + 0.65.2900 + 5060.0.45}{8760} = 0.5664$$

Since this is inconsistent with a stated value of 0.55 for the base year, f2 is recalculated as:

$$h_2 = \frac{8760 \ . \ 0.55 - 800 - 5060.0.45}{2900}$$

$$= 0.60$$

This recalculation is done for every year when multiple values of slf are entered in the LOAD.DAT file.

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PARAM.DAT*

PARAM.DAT sets the default values for certain parameters as they will appear in the RESGEN parameter menu. This file can be accessed in the SPECIAL FILE directory in TABLE.

```
Resgen parameter file
---------------------------------

---------------------------------
1.05        gdp growth rate
1.03        oil price growth rate
1982        base year
   8        planning horizon
---------------------------------
```

Since the parameter value occupies four fields, be careful to enter the planning horizon as a right justified number. Thus to change the horizon to, say, 10 years, move the cursor to the corresponding field, and enter 0010. If you enter "10", then the planning horizon will be read as 1000 years, because RESGEN expects a right justified number. (Actually RESGEN does make a consistency check: if the planning horizon is greater than 50, it will assume an input error has been made, and will insert 10 as the default value into the parameter menu!).

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PARAMO.DAT*

This file controls the default settings of some of the RESG screen menus

```
Resgen parameter file
---------------------------

---------------------------
yes  gdp prompt
 80  columns
yes  energy balance table
yes  current account table
xxx  investment table
xxx  investment graphics
---------------------------
```

"gdp prompt": controls the corresponding entry in the main parameter menu. If you have, say, a demand model that does not include the i-elasticity operator, you may want to suppress the prompt (by entering "no").

"investment table, graphics": you many suppress the corresponding prompts in the output menu--for example in a demand network, by entering "xxx". The entry "yes" also controls project investment calculations. (see Section 4.5).

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POWER.DAT

The POWER.DAT file contains the electric sector capacity expansion plan. The individual entries should be listed in the merit order.

power sector file

year	fuel	plant	mw	b-a	gwh	eff.	reg	p-a
1984	coal	suralaya 1	400.	.80		.33	005	.90
1985	coal	suralaya 2	400.	.80		.33	005	.90
1988	coal	suralaya 3-4	800.	.80		.33	005	.90
1988	coal	suralaya 5-6	1200.	.80		.33	005	.90
1988	coal	paiton 1	400.	.80		.33	005	.90
1989	coal	paiton 2	400.	.80		.33	005	.90
1982	geotherm	java/exist geotherm	30.	.80		.33	005	.90
1987	geotherm	kamojang 2-3	110.	.80		.33	005	.90
1988	geotherm	dieng 1	55.	.60		.33	005	.90
1989	geotherm	dieng 2	55.	.60		.33	005	.90
1990	geotherm	dieng 3-4	110.	.60		.33	005	.90
1988	geotherm	salak 1	55.	.60		.33	005	.90
1989	geotherm	salak 2-3-4	165.	.80		.33	005	.90
1989	geotherm	drajati-2	110.	.80		.33	005	.90
1989	geotherm	cisolok 1-2	110.	.80		.33	005	.90
1982	hydro	java/exist hydro	437.	.80	1600.	.33	005	.90
1982	hydro	hydro purchase	125.	.60	600.	.33	005	.90
1985	hydro	saguling 1-2-3-4	700.	.80	2800.	.33	005	.95
1987	hydro	senggaruh	29.	.60	70.	.33	005	.95
1987	hydro	wadaslintang	16.	.60	60.	.33	005	.95
1988	hydro	cirata I, 1-2-3-4	500.	.60	2000.	.33	005	.95
1989	hydro	mrica 1-2-3-4	180.	.60	720.	.33	005	.95
1989	hydro	kesamben	33.	.60	66.	.33	005	.95
1982	fueloil	java/exist steam	1306.	.60		.25	005	.90
1986	fueloil	comb.cycle	100.	.60		.26	005	.90
1986	fueloil	gresik 3	200.	.60		.33	005	.90
1987	fueloil	gresik 4	200.	.60		.33	005	.90
1982	ado	java/exist.comb.turb	735.	.40		.20	005	.90
1982	ido	java/exist diesel	69.	.60		.20	005	.90

The columns in this data file are as follows:

- year — start-up year.
- fuel — fuel (whose spelling must correspond to that in the main network file).
- plant — name of the power plant.
- MW — the installed capacity, in MW(e).
- b-a — base period availability.
- gWh — energy limit for hydro plants. If entry is omitted will compute on the basis of the base period availability.
- eff — thermal efficiency.
- reg — regional identification. This is optional, and needed only if RESG has been initialized for multi-regional operation.
- p-a — peak period availability (1-Forced Outage Rate).

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The following points must be noted when listing power plants in a POWER.DAT file

1. The order of the plants is in the assumed merit order. The most efficient plants are at the top, the least efficient at the bottom.

2. To make sure that all hydro energy is used, hydro plants should be listed at the top of the file (see example above).

3. After the hydro plants, list the thermal plants in order of efficiency (most efficient plants first, least efficient plants last).

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PRICE.DAT

This file is called from the price operator and typically contains border prices of fuels imported and exported.

Sri Lanka, Price Table:price.dat

fuel	import	export	growth
crude	210.00	210.00	
lpg	334.60	300.00	
gasolene	280.00	280.00	
naphtha	233.00	243.00	
a-diesel	236.00	216.00	
kerosene	265.00	242.00	
jet fuel	265.00	240.00	
diesel	230.00	200.00	.00
fuel oil	180.00	169.00	
residual	150.00	169.00	
asphalt	100.00	90.00	
coal	55.00	55.00	

RESG will apply "import" prices to positive energy flows, "export" prices to negative energy flows; this corresponds to the signs of a vector of import/export residuals. The "growth" column can be used to override the rate of oil price escalation set as a default value in the main parameter menu.

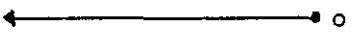
The prices should be given in $/unit ($/ton or $/bbl). These will be converted to $/ton oil equivalent (or $/barrel oil equivalent), the unit typical of RESGEN energy networks, by the conversion factors in CONVER.DAT.

For example, suppose we multiply the following vector of fuel imports(+) and exports(-) by the price table shown above:

crude 200

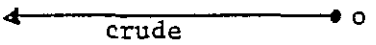
fueloil -100

diesel 10

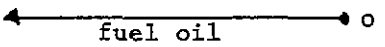


Then the foreign exchange vector computes to

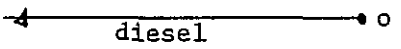
200 x 210 = 42000



-100 x 169 = -16900



10 x 230 = 2300



PROJECT.DAT

PROJECT.DAT is called from the *projects operator, and contains a list of projects and their energy impact (if any).

The energy impact may be negative (as in the example below) to represent a conservation (or fuel substitution) project.

project.dat: project list, Sri Lanka

year	i.d.	project	+fuel	fuel
1988	demd		57.40	coal cement
1988	demd		12.00	diesel
1984	demd	debt		
1986	demd	ind.energy cons. 1	-6.00	fuel oil
1987	demd	ind.energy cons. 2	-6.00	fuel oil
1988	demd	ind.energy cons. 3	-6.00	fuel oil

The "fuel" label entry must, as usual, correspond with the labels used in the main network file. The name under "i.d." must match the 'output name" in *projects (unless you use the "all" designation in *projects).

When running with EFAM, the i.d. designator is taken as the institution label.

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PROJCOST.DAT*

This files contains project cost information:

project costs

facility/plant type	capcos	f(foreig	i-rate	c-year	ln-yea
spbm	40.00	.90	.09	2.00	10.0
ind.energy cons. 1	0.5	0.63	.12	1.0	3.0
ind.energy cons. 2	0.5	0.63	.12	1.0	3.0
ind.energy cons. 3	0.5	0.63	.12	1.0	3.0

capcos	capital cost in million $ per energy unit (the one used for the flows in the network)
f (foreig)	fraction of capital cost that is foreign exchange
i-rate	interest rate on loan
c-year	the construction period, in years. The capital cost is apportioned uniformly over this construction period.
ln-year	loan period, in years.

If PROJCOST.DAT is called for a project that has no energy flow associated with it, then the "capcos" entry is in million $. For example, the "spbm" project costs U.S.$ 40 million

project.dat: project list, Sri Lanka

year	i.d.	project	+fuel	fuel
1988	CPC	spbm		

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On the other hand, if there is an energy flow associated with the project, then the capital cost is "capcos" x fuel. For example, the total capital cost of the 1986 industrial energy conservation program 1 is:

capcos = 0.5 x (fuel = 6.00) = $3.00 million

project.dat: project list, Sri Lanka

year	i.d.	project	+fuel	fuel
1988	demd		57.40	coal cement
1988	demd		12.00	diesel
1984	demd	debt		
1986	demd	ind.energy cons. 1	-6.00	fuel oil
1987	demd	ind.energy cons. 2	-6.00	fuel oil
1988	demd	ind.energy cons. 3	-6.00	fuel oil

See also Section 4.5 on how to use these files.

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REFINEx.DAT

Whenever the VREFINERY operator is used in the RESGEN network, reference must be made to a data file of the type REFINEx.DAT, where "x" is a numeric identifier. This file is accessed through the appropriate directory, and contains technical information about the refinery.

P.Brandan

#	#	item	parameter	crude	arab ligh
1972	2005	capacity	3.00		
		ratios	.00	1.00	.00
		lpg		.00	
		avgas			
		avtur		.00	
		gasoline		.36	
		kerosene		.16	
		ado		.18	
		ido			
		fueloil		.00	
		petrochems		.05	
		lubes/waxes			
		asphalt		.06	
		petr coke		.00	
		naphtha		.01	
		LSWR		.00	

The first line in the file contains the start-up year (column 1), the retirement year (col.2), the mandatory identifier "capacity" (column 3), and the refinery capacity (column 4). The refinery capacity refers to the annual capacity in whatever units are being used in the RESGEN network.

Up to four different crudes can be specified for use in any refinery, occupying columns 5,6,7 and 8. The labels used to identify the crudes must of course correspond to the crude label used in the main network file.

If more than one crude is to be used, then the second line in the file must be identified as "ratios" in column 3 (as above). This line specifies in what proportion the crudes are to be blended (in the above example, the blend is 100% crude, and 0% Arab light.

The remaining rows are used to set the yield coefficients for each refined product, specified as a fraction of the input. As usual, the spelling of the fuels must be consistent with the main network.

If several REFINx.DAT files are called from the VREFINERY operator, all must use the same set of crude labels. For example, if a refinery in the same set as the above example, that uses only arab light, would require the following format: note that you cannot label the first column "arab light" (because in the other refinery the first column is "crude".

Cilacap

#	#	item	parameter	crude	arab ligh
1972	2005	capacity	30.00		
		ratios	.00	.00	1.00
		lpg		.00	.00
		avgas		.00	.00
		avtur		.00	.00
		gasoline		.00	.16
		kerosene		.00	.23
		ado		.00	.09
		ido		.00	.07
		fueloil		.00	.25
		petrochems		.00	.00
		lubes/waxes		.00	.02
		asphalt		.00	.02
		petr coke		.00	.00
		naphtha		.00	.00
		LSWR		.00	.00

RESOURCE.DAT

Files of type RESOURCE.DAT are used in conjunction with the SUPPLY=RESOURCES operator. The name is flexible, being defined in the main data file. In the example below, the SUPPLY=RESOURCES operator in the main data file makes a reference to LNG.DAT , a file that contains scenarios of natural gas production for LNG exports:

```
307: ****************************************************************
308: data table 13                                                   *
309: ****************************************************************
310: supply=resources                                                *
311: matrix name =LNG production
312: matrix size = 1  0      .00   0   0                            *
313: LNG plant   = 1  1 barch=04/ov/reg=99/99,99/01,01               *
314: -imports    = 1  1 barch=04/ov/reg=99/99,99/01,01
315:    mboe                                                         *
316: -- -------------------- --------------------                    *
317:  1 LNG                        .000 lng.dat                      *
```

The format for files of this type is as follows (in this case the file LNG.DAT):

LNG production (mboe)

year	1.medium	2.high	3.low
1982	51.00	51.00	51.00
1983	55.80	55.80	55.80
1984	114.00	120.00	60.00
1985	114.00	120.00	60.00
1986	114.00	120.00	60.00
1987	114.00	180.00	60.00
1988	114.00	180.00	60.00
1989	114.00	180.00	60.00
1990	114.00	180.00	60.00
1991	114.00	270.00	60.00
1992	114.00	270.00	60.00
1993	114.00	270.00	60.00
1994	114.00	270.00	60.00
1995	114.00	270.00	60.00
1996	114.00	360.00	60.00
1997	114.00	360.00	60.00
1998	114.00	360.00	60.00
1999	114.00	360.00	60.00
2000	114.00	360.00	60.00
2001	114.00	360.00	60.00
2002	114.00	360.00	60.00
2003	114.00	360.00	60.00
2004	114.00	360.00	60.00
2005	114.00	360.00	60.00

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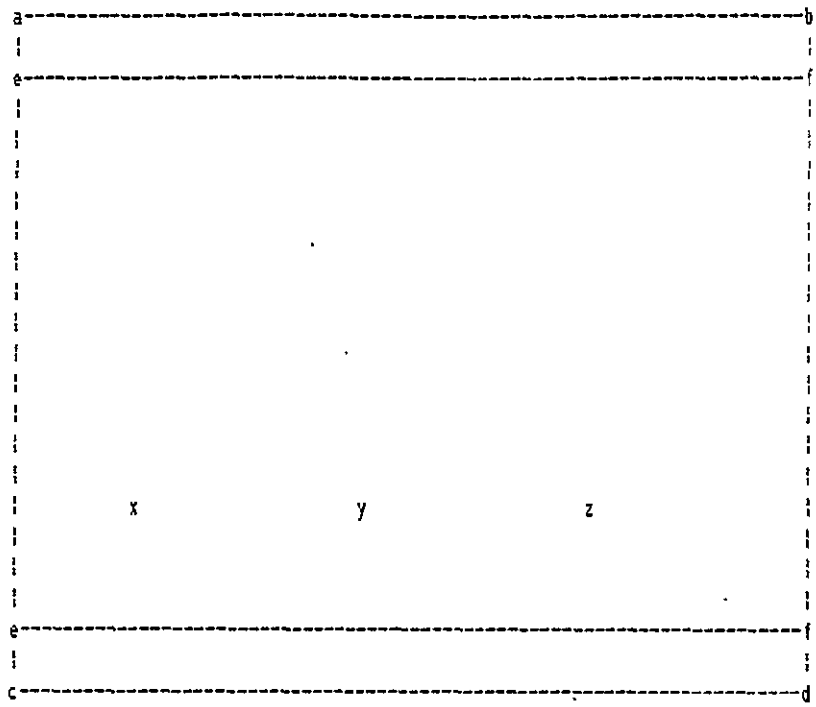
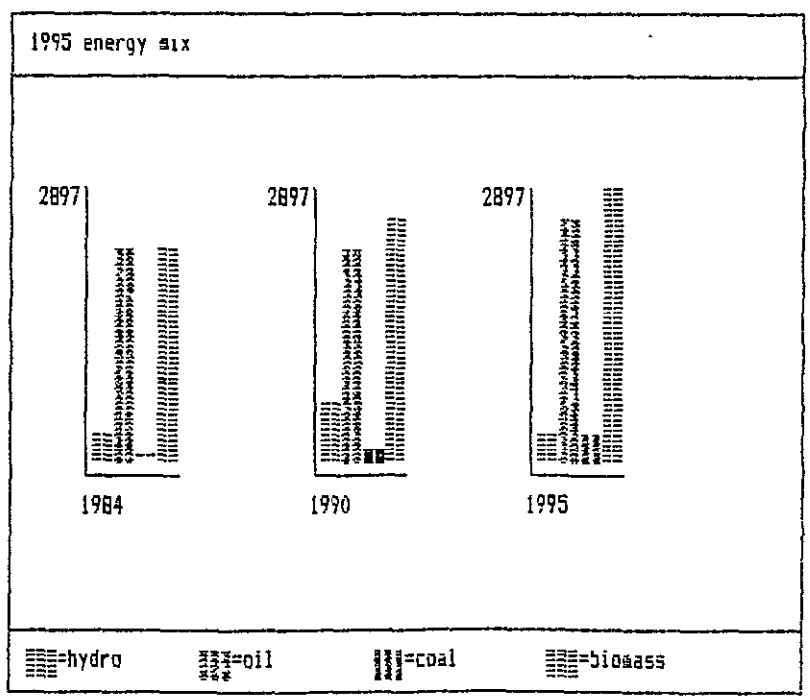
RESMAP.DAT*

This file must be created in the editor, and is used to position the barcharts onto the screen. The x,y,z entries in this file correspond to the origins of the barcharts. The a,b,c,d,e and f codes are used to position the corners of the boxes





STAT.RES*

STAT.RES initializes RESG for certain modes of operation.

```
 1:*resgen intialization parameters
 2: ***********************************************************
 3: item
 4: 1-- 1----------------------------e
 5: color screen type
 6: no   efam transfer
 7: no   macromodel linkage
 8: yes  extended network directories
 9: C    help screen volume
10: yes  map
11: no   regional disaggregation
12: yes  dynamic
13: yes  delete zero columns in tables
14: yes  use a columns.dat type file
15: yes  tutorial screens
16: yes  time plots
17:      (3x,f9.2,9x,11f9.2)
18:      (20f9.2)
```

Screen type: must be set to "color" for color screens, "mono" for monochrome, or "herc" if a hercules high resolution graphics card is fitted.

efam: If set to "yes", RESG can be linked to the EFAM model by generating the efam transfer files PROJ.EFM and TRANS.EFM. See LINKAGES TO EFAM MODEL in SECTION 4 for further details.

macromodel: If set to "yes", RESG can be interfaced to the ENMAC energy-macroeconomic model.

extended network directories:
If set to "yes", individual RESGEN networks can be accessed through a set of nested subdirectories, rather than the single default directory NETWORK.DIR. See NESTED NETWORK DIRECTORIES in SECTION 8 of this manual for further details.

help screen volume:
This defines the drive (volume) that contains the help screens.

map: Initializes RESG for the map/barchart output displays.

regional disaggregation:
Initializes RESG for multi-regional operation.

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dynamic operation:
Initializes RESG for dynamic (multi-year) operation.

zero columns: If set "yes", then energy balance tables will be printed out in such a way as to omit any column that consists entirely of zeros.

columns.dat: For dynamic runs, RESG always refers to the file of type columns.dat for the order of columns in the energy balance table. For single year runs you have a choice: if this flag is set to "no", then the columns are defined during execution of RESG (and will be in the order in which they are transferred from the network). Setting this flag with "yes" will result in a call to columns.dat.

tutorials: Set to "yes" or "no". See SECTION 5.4 for further details.

time plots: Can be switched off if desired.

f1: The format for information passed from a LOTUS 1,2,3 macromodel. Not used if macromodel linkage set to "no".

f2: The format for passing RESGEN Information back to a LOTUS 1,2,3, macromodel. Not used if macromodel linkage set to "no".

TAB.DAT

Files of this type are used in conjunction with the SUPPLY=TABLE operator. The file name used is flexible, being defined in the network file. In the example below, the SUPPLY=TABLE operator makes a call to the file PGN.DAT, which contains the year-by-year values of the four fuels.

```
263: ****************************************************************
264: data table 10
265: ****************************************************************
266: supply=table
267: matrix name =city gas inputs
268: matrix size = 4  0      .00   0   0
269: -gas plant  = 1  4 barch=04/ov/reg=99/99,99/01,01
270: primary prod= 1  1 barch=04/ov/reg=99/99,99/99,99/01,01
271:
272: -- -------------------- --------------------
273:  1 gas                        0.000 pgn.dat
274:  2 ido                         .000 pgn.dat
275:  3 fueloil                     .000 pgn.dat
276:  4 kerosene                    .000 pgn.dat
```

The PGN.DAT file is shown below:

Fuels for PGN

year	gas	ido	fueloil	kerosene
1982	.0982	.0638	.01166	.02613
1983	1.	.07	.012	.026
1984	1.	.07	.012	.026
1985	1.	.07	.012	.026
1986	1.	.07	.012	.026
1987	1.	.07	.012	.026
1988	1.	.07	.012	.026
1989	1.	.07	.012	.026
1990	1.	.07	.012	.026
1991	1.	.07	.012	.026
1992	1.	.07	.012	.026
1993	1.	.07	.012	.026
1994	1.	.07	.012	.026
1995	1.	.07	.012	.026
1996	1.	.07	.012	.026
1997	1.	.07	.012	.026
1998	1.	.07	.012	.026
1999	1.	.07	.012	.026
2000	1.	.07	.012	.026
2001	1.	.07	.012	.026
2002	1.	.07	.012	.026
2003	1.	.07	.012	.026
2004	1.	.07	.012	.026
2005	1.	.07	.012	.026

This datafile initializes the timeplot graphic displays, and is mandatory for dynamic operation of RESG. You may specify up to 10 timeplot displays. The timeplots find their numerical values from some particular row of the energy balance table.

time plot parameters

#	display	bal.table ro	label	#	#
01	generation mix	elec generat	hydro	26	26
			coal	20	20
			geothermal	27	27
			oil	08	10
02	energy exports	-exports	crude	01	01
			lng	18	18
03	domestic consumption	consumption	oil	03	16
			electricity	23	23
			biomass,renew.	29	35
			gas	17	17

In the above example, three displays will be generated. The first display will search the "elec generat" row of the energy balance tables for its entries. As usual, the spelling must be exactly as it appears in the LABELS.DAT file that defines the rows of the energy balance table. This display will contain four time lines, labelled "hydro", "coal", "geothermal", and "oil", as specified in the "labels" column. The two columns marked "#" define which columns of the energy balance table are to be included in each time line. The column numbers correspond to the column numbers as defined in the "COLUMNS.DAT" file. (See a display of COLUMNS.DAT and verify that hydro is in column 26, coal in column 20, geothermal in column 27 and the fuels labelled "oil" are ado, ido and fueloil, found in column 8 through 10 of COLUMNS.DAT. The resulting time series plot is shown below:

Similarly, the third display in the above exhibit is to portray domestic consumption, to be taken from the energy balance table row "consumption". Oil products correspond to columns 3 through 16, electricity is column 23, coal is column 20, and gas is column 17.

columns

#	column
01	crude
02	arab light
03	lpg
04	avgas
05	avtur
06	gasoline
07	kerosene
08	ado
09	ido
10	fueloil
11	petrochems
12	lubes/waxes
13	asphalt
14	petr coke
15	naphtha
16	LSWR
17	gas
18	LNG
19	LPG exp
20	coal
21	bat auda
22	coke
23	electricity
24	f-electricit
25	Java-electr
26	hydro
27	geothermal
28	nuclear
29	wood
30	charcoal
31	agric wastes
32	biogas
33	solar-pv
34	solar
35	wind

To generate the entry for "oil", we wish to sum columns 8 through 10 - hence the corresponding entry in the "#" columns of the TIMEPLOT file.

The third display in the above exhibit is to portray domestic consumption, to be taken from the energy balance table row "consumption". Oil products correspond to columns 3 through 16, electricity is column 23, coal is column 20, and gas is column 17.

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VGROWTH.DAT

Whenever the VGROWTH operator is used in the main network file, a reference must also be made to a file name that contains the matrix of growth rates. The name of this file is not fixed: a typical usage might be VGROWTH1.DAT, and/or VGROWTH2.DAT (if there is more than one such usage, say to represent different scenarios).

vgrowth rates

label	1982	1984	1990	2000	2005
auto/gasoline	2.00	3.00	5.00	7.00	7.00
auto/diesel	4.00	4.00	4.00	4.00	4.00
truck/gasoline	2.00	2.00	3.00	3.00	4.00
truck/diesel	3.00	5.00	6.00	8.00	8.00
bus/diesel	2.00	2.00	2.00	2.00	2.00
motorcyc./gasoline	.00	.00	1.00	.00	.00

The columns represent the year range in which the particular growth rate is to apply. In the above example, auto gasoline demand grows by 2% in 81/82 and 82/83; by 3% in 83/84 to 88/89; 5% from 89/90 to 98/99, and 7% thereafter.

8. ADVANCED FEATURES

Network files are stored in the network directory NETWORK.DIR, whose contents are displayed in RESG as a menu for the user to select. HOwever, in some cases, where there may exist a large number of network files, it may be more convenient to subdivide the networks into sub-directories. This is done by first initializing the STAT.RES file for "extended network directories", as in the example below:

```
 1:*resgen intialization parameters
 2: ***********************************************************
 3: item
 4: I--  I-----------------------------e
 5: color screen type
 6: no   efam transfer
 7: no   macromodel linkage
 8: yes  extended network directories
 9: C    help screen volume
10: yes  map
11: no   regional disaggregation
12: yes  dynamic
13: yes  delete zero columns in tables
14: yes  use a columns.dat type file
15: yes  tutorial screens
16: yes  time plots
17:      (3x,f9.2,9x,11f9.2)
18:      (20f9.2)
```

You must then define a directory file NETMENU.DIR, that contains a list of directories, which in turn contain the actual network file names. NETMENU.DIR is the mandatory filename that RESG searches when STAT.RES is set to "yes" for "extended network directories".

For example, suppose we create, in the TABLE program, "NETMENU.DIR" with the following contents:

directory: netmenu.dir

	file descriptor	DOS-filename	last access
1	national networks	indones.dir	may 9
2	region 1 networks	region1.dir	may 9
3	region 2 networks	region2.dir	may 8
4	region 3 networks	region3.dir	may 8
5	region 4 networks	region4.dir	may 8
6	region 5 networks	region5.dir	may 8
7	region 6 networks	region6.dir	may 8
8	region 7 networks	region7.dir	may 8
9	region 8 networks	region8.dir	may 9
10	user manual networks	manual.dir	may 9

..enter table # (or 0 to exit, x to delete,n for new table) >>>>

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where, for example, the sub directory "region1.dir" is:

```
network directory for region 1
-----------------------------------------------
file
-----------------------------------------------
household module        hholdr1.dat  may 8
transport module        tranr1.dat   may 8
industry module         indusr1.dat  may 8
other sectors module    otherr1.dat  may 8
summary module          region1.dat  may 8
-----------------------------------------------
```

Then RESG will produce a series of identical menus from which you can choose the network of your choice:

```
-----------------------------------------------
..select directory:
-----------------------------------------------
 1. national networks
 2. region 1 networks
 3. region 2 networks
 4. region 3 networks
 5. region 4 networks
 6. region 5 networks
 7. region 6 networks
 8. region 7 networks
 9. region 8 networks
10. user manual networks

    ....enter here >>>>
```

If you respond with "2", then you will next see the screen:

```
-----------------------------------------------
..select a network file:
-----------------------------------------------
 1. household module      hholdr1.dat
 2. transport module      tranr1.dat
 3. industry module       indusr1.dat
 4. other sectors module  otherr1.dat
 5. summary module        region1.dat

    ....enter here >>>> 1
-----------------
```

The entry "1" will result in the network "hholdr1.dat" being run. Only NETMENU.DIR is a mandatory filename. The directories nested within NETMENU.DIR (INDONES.DIR, REGIONS.DIR etc) are selected by the user, and created in the TABLE program.

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TIME DEPENDENT COEFFICIENTS

When running in the dynamic mode for a series of years, the assumption of fixed coefficients may not be valid. RESG allows you to vary coefficients through time as linear trends by using the "sector" field in the network file with an instruction of the format

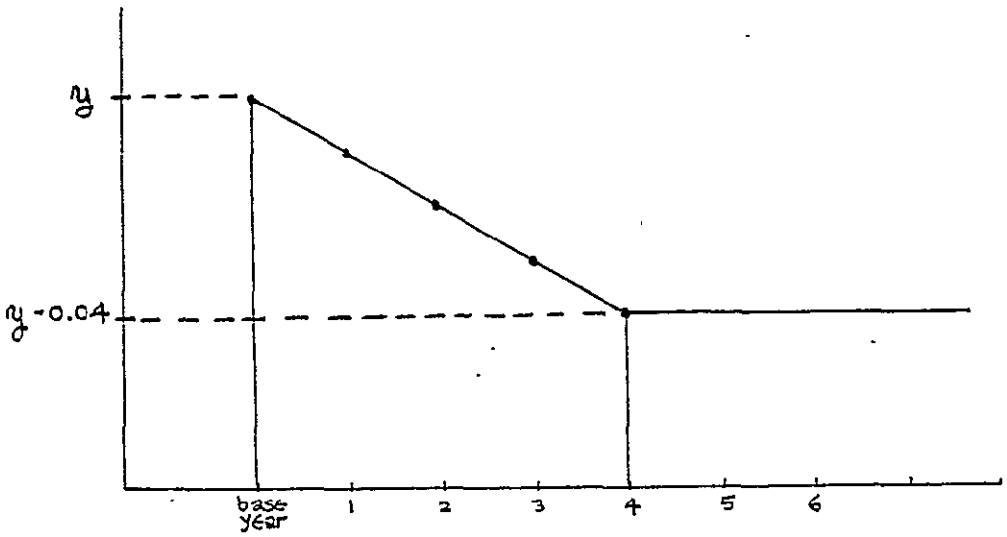
del = iixz

where ii is a two digit integer, and z is the trend value.

Thus the instruction

del = 04x -0.01

instructs RESG to increment the coefficient by -0.01 over each of four years; resulting in the following pattern



For example, suppose you want to replicate a loss reduction program in the electric utility: the base year t+d losses are, say, 18%, which will be reduced by 1% per year over a six year period to 12%. The corresponding efficiencies are 0.82 increasing to 0.88. This would be simulated in the datafile for t+d losses as shown below: the instruction "del=06x0.01" in the "sector" column will produce an automatic adjustment. Beyond the 6th year, the assumed efficiency will remain at 0.88.

```
244: ****************************************************************
245: data table. 6
246: ****************************************************************
247: diagonal
248: consis.check= 3
249: matrix name =efficiency
250: output name =electric generation
251: output units=1000 toe
252: matrix size =19 19
253: electric gen= 1  1
254: none
255:    sector                  sector              efficiency
256: -- ------------------- -- ------------------- ---------- -----------*
257:  1 electricity          1 electricity            .8161   del=06x.01 *
258: 99
```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TRANSFERRING DATA TO LOTUS 1-2-3

Information can be transferred to LOTUS 1-2-3 in the form of any table that is available in the output files. These tables are produced in the RESP program (see Section 5.3).

For example, suppose we select the following table for the generation mix. This is first displayed on the screen. Followed by a prompt for LOTUS 123 transfer. If you respond with "yes", you are next asked for a file name (that must have the extension "PRN".

..generation mix :base case

	1984	1985	1986	1987	1988	1989	1990
hydro	426.00	426.00	696.76	732.16	838.67	888.02	1017.39
coal	.00	.00	.00	.00	.00	.00	.00
diesel	180.13	203.78	40.97	88.37	148.07	168.46	151.48
fuel oil	34.05	87.22	.00	.00	11.11	49.39	.00
total	640.18	717.00	737.72	820.52	997.85	1105.87	1168.87

>

..generation mix :base case

	1991	1992	1993	1994	1995
hydro	1017.39	1017.39	1011.52	1017.39	1217.46
coal	.00	238.28	526.89	526.89	526.89
diesel	183.08	156.71	17.52	169.27	110.35
fuel oil	74.65	.00	.00	.00	.00
total	1275.12	1412.39	1555.93	1713.55	1854.69

>

..write an output for for LOTUS 1-2-3 ? enter YES or NO >>>> yes

..enter a name for the LOTUS .PRN file >>>> eleca.prn

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This creates a file ELECA.PRN, which appears as follows (when you enter TYPE ELECA.PRN):

```
"generation mix      "
"------------------------------------------------------------------------------------------------------------------------------
-------------------------------"
"                    ",  1984,   1985,   1986,   1987,   1988,   1989,   1990,   1991,   1992,
     1993,     1994,   1995,
"------------------------------------------------------------------------------------------------------------------------------
-------------------------------"
"hydro               ",  426.00,  426.00,  696.76,  732.16,  838.67,  888.02,  1017.39,  1017.39,  1017.39,
   1011.52,  1017.39,  1217.46,
"coal                ",  .00,     .00,     .00,     .00,     .00,     .00,     .00,     238.26,
    526.89,   526.89,   526.89,
"diesel              ",  180.13,  203.78,  40.97,   88.37,   148.07,  168.46,  151.48,  183.08,  156.
     17.52,   169.27,   110.35,
"fuel oil            ",  34.05,   87.22,   .00,     .00,     11.11,   49.39,   .00,     74.65,   .00,
       .00,      .00,      .00,
"------------------------------------------------------------------------------------------------------------------------------
-------------------------------"
```

Note that label information is enclosed in quotes, and that commas separate the numerical entries. This is required by most versions of LOTUS to distinguish text information in a numerical file. This file can be loaded into LOTUS by the command:

/fineleca (/File, Import, Numbers, filename)

with the following result once the file is loaded.

A1: 'generation mix READY

	A	B	C	D	E	F	G	H
1	generation mix							
2								
3		1984	1985	1986	1987	1988	1989	1990
4								
5	hydro	426	426	696.76	732.16	838.67	888.02	1017.39
6	coal	0	0	0	0	0	0	0
7	diesel	180.13	203.78	40.97	88.37	148.07	168.46	151.48
8	fuel oil	34.05	87.22	0	0	11.11	49.39	0
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

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SPECIAL PURPOSE FLAGS: EFFICIENCY

Normally, the input vector is multiplied by the given coefficient to yield the output vector. For example, to get from electricity demand d to generation g you multiply by a coefficient c,

generation

$$\xleftarrow{\quad c \quad} \text{demand}$$

g d

It is usual practice, however, to state the relationship between g and d by the efficiency, i.e.

$$d = g \cdot e$$

from which follows that

$$c = \frac{1}{e}$$

If you wish to enter efficiencies directly, rather than c = 1/e, then you must make sure that the first two letters of the MATRIX name are "ef", which signals to the RESG code that the multipliers are the reciprocals of the entered coefficients. In the example below, note the MATRIX name "efficiency/t+d"; the first two letters "ef" ensure that the multiplier is one divided by the efficiency.

```
115: ****************************************************************
116: data table  6                                                   *
117: ****************************************************************
118: diagonal                                                        *
119: consis.check= 3                                                 *
120: matrix name =efficiency/t&d                                     *
121: output name =generation requireme                               *
122: output units=mboe                                               *
123: matrix size =24 24        .00                                   *
124: elec generat= 1  2 barch=02/ov/reg=01/99,99/01,01
125: none               barch=02/ov/reg=02/99,99/02,02
126:    electr soid            electr generated     fraction         *
127: -- ------------------- -- ------------------- ----------        *
128:  1 Java-electr          1 Java-electr               .850        *
129:  2 electricity          2 electricity               .800        *
130: 99                     99                           .000        *
```


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RESGEN allows you to link networks. For example, you could create separate networks to project energy demands in the residential, industrial and commercial sectors, and a network to portray the supply side. Each network can be run separately, and/or the supply side network can be linked to the individual demand models.

The mechanism for linkage is through intermediate data files (see DEMAND.INT in section 7), that can be created as the output of one network, and read in as data in another. These intermediate files are contained in two directories: DYNAMIC.DIR, and INTER.DIR. The dynamic directory contains files that link dynamic networks, INTER.DIR contain files used to link single-year networks.

RESG loads intermediate files by instruction on the matrix name line of one of the following forms:

1) matrix name=data=
2) matrix name=data=def=
3) matrix name=data=dynamic=
4) matrix name=data=filename=
5) matrix name=data=def=filename
6) matrix name=data=dynamic=filename

In cases (1) to (3), RESG will prompt you for the filename, by displaying the contents of INTER.DIR (case [1]), or DYNAMIC.DIR (in cases [2] + [3]). For example, if you specify

matrix name=data=dynamic

you will get a RESG menu of the type:

```
Indonesia Energy Model, dynamic intermediate files

 1. demand case 1        demand.dyn
 2. demand case 2        demand2.dyn

     ....enter here >>>>
```


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In cases (4) and (6), RESG will load the specified file without any prompt. In case (5), suppose you enter

```
matrix name=data=def=ecproj.int
```

then you will get a RESG menu of the type:

```
---------------------------------------------
..input file
---------------------------------------------

1. from directory
0. from specified input file <ecproj.int >

      ....enter here >>>>
```

If you now enter "1", then RESG provides a menu of all the files in the directory.

```
---------------------------------------------------
..select an intermediate file for data input:
---------------------------------------------------
 1. econometric projection    ecproj.int
 2. econometric demand m      dummy.int
 0. default to main datafile indones.dat

      ....enter here >>>>
```


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To create an intermediate file, the same format is used, but on the "output name" line of the operator. Thus if you specify

output name=out=dynamic=

you will obtain the menu:

```
Indonesia Energy Model, dynamic intermediate files

1. demand case 1        demand.dyn
2. demand case 2        demand2.dyn
3. create new file
0. create no file


....enter here >>>>
```

In this case, if you enter "1", then the old version of demand.dyn will be lost, and a new version, generated from the current run, will be created. If you enter "3", then you will subsequently be asked for a DOS filename, and the resulting file will automatically be added to the directory, and will appear in subsequent menu displays.

However, if you specify

output name=out=dynamic=out.int

then no further menu prompt is issued, and out.int will be created in all cases.

The following points should also be noted:

A dynamic file can be read by a single-year network model: RESG will automatically search the file for the correct year.

The dynamic file need not contain projections for every single year. For example, you could create a dynamic intermediate file with values spaced at 5 (or any other) interval. When this file is read, RESG will automatically interpolate geometrically for any year not explicitly included.

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SPECIAL PURPOSE FLAGS: CONSERVATION

It is sometimes convenient to include in a network file a matrix that represents the impact of a conservation program, which reduces the rate of growth of particular fuels by some percentage amount. In the example overleaf, for example, the conservation program reduces the demand for "electr.domestic" by 1% per year. However, for some runs, such a table may wish to be omitted. There is a feature in the main menu that allows you to include or exclude any data table whose "matrix name" begins with "cons". (in the example overleaf, the matrix name is "conservation goals").

Normally, the "conservation tables" feature is switched off, as indicated in the main parameter menu: any table whose matrix name begins with "cons" is omitted:

```
..parameters for this run:
3.  paper save mode                    yes
4.  diagnostics                        yes
5.  datafile year                     1984
6.  planning horizon                    11
7.  conservation tables                 no
8.  efam transfer                      yes
9.  GDP,oil prices from macromodel     yes
10. dynamic version                    yes
0.  to continue                         .

    ..enter here >>>>
```

The switch is build into the main parameter menu of RESG. It is pre-set to "no" in the RESG program.

If you want to <u>include</u> the conservation table(s) in a run, just enter "7" in the above menu, and the conservation table flag change to "yes", as indicated below:

```
..parameters for this run:
3.  paper save mode                    yes
4.  diagnostics                        yes
5.  datafile year                     1984
6.  planning horizon                    11
7.  conservation tables                yes
8.  efam transfer                      yes
9.  GDP,oil prices from macromodel     yes
10. dynamic version                    yes
0.  to continue

    ..enter here >>>>
```


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```
152: ##################################################################
153: data table 4
154: ##################################################################
155: growth
156: consis.check=0
157: matrix name =conservation goals
158: output name =conserv.adjusted demand
159: output units=1000 toe
160: matrix size =33 33
161: none        = 1 33
162: none
163:     sector
164: -- -------------------- -- -------------------- ---------- -----------¥
165: 01 electr. domestic     01 electr. domestic      0.99
166: 02 electr. s+m industry 02 electr. s+m industry  0.98
167: 03 electr. large indust 03 electr. large indust  0.97
168: 04 electr. commercial   04 electr. commercial    0.98
169: 05 street light         05 street light          0.99
170: 06 electr. LA           06 electr. LA            0.99
171: 07 electr. hotel        07 electr. hotel         0.98
172: 08 lpg                  08 lpg                   1.00
173: 09 gasolene             09 gasolene              0.98
174: 10 naphtha              10 naphtha               1.00
175: 11 a-diesel             11 a-diesel              1.00
176: 12 kerosene             12 kerosene              1.00
177: 13 jet fuel             13 jet fuel              1.00
178: 14 diesel               14 diesel                1.00
179: 15 diesel transp.       15 diesel transp.        0.98
180: 16 diesel cement        16 diesel cement         1.00
181: 17 fuel oil             17 fuel oil              0.98
182: 18 residual             18 residual              1.00
183: 19 residual sfmc        19 residual sfmc         1.00
184: 20 asphalt              20 asphalt               1.00
185: 21 coal railway         21 coal railway          1.00
186: 22 caol others          22 coal others           1.00
187: 23 coal cement          23 coal cement           1.00
188: 24 bagasse              24 bagasse               1.00
189: 25 wood industry        25 wood industry         0.98
190: 26 wood domestic        26 wood domestic         0.95
191: 27 chacoal industry     27 charcoal industry     1.0
192: 28 charcoal domestic    28 charcoal domestic     1.00
193: 29 solar                29 solar                 1.00
194: 30 biogas               30 biogas                1.00
195: 31 wind                 31 wind                  1.00
196: 32 min-hydro            32 mini-hydro            1.00
197: 33 ind lpg              33 ind lpg               1.00
```


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THE "SECTOR" COMMAND

When transferring fuel consumption to the energy balance table you may wish to assign each value to an end use sector. For example, in the energy balance table shown below, consumption is disaggregated into 7 sectors:

1995 energy balance table (mtoe)

	electrici	lpg	gasolene	jet fuel	kerosene	a-diesel	diesel	fuel oil	residual	asphalt
primary producti	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
imports	.00	149.79	.00	66.70	.00	.00	131.54	50.48	2809.86	.00
exports	.00	.00	.00	.00	.00	-141.76	.00	.00	.00	-19.78
bunkers	.00	.00	.00	-138.28	.00	.00	-75.58	-489.16	.00	.00
.total	.00	149.79	.00	-71.58	.00	-141.76	55.96	-438.67	2809.86	-19.78
refinery	.00	46.80	48.33	111.60	.00	360.00	244.80	496.80	192.60	21.60
electric gen.	584.97	.00	.00	.00	.00	.00	-132.79	-14.90	.00	.00
charcoal-making	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.domestic demand	584.97	196.59	48.33	40.01	.00	218.24	167.97	43.23	3002.46	1.82
-transp.losses	.00	-147.98	98.93	8.07	195.61	463.35	-96.90	171.52	-3002.46	38.19
-t+d losses	-72.48	.00	.00	.00	.00	.00	.00	.00	.00	.00
.total	512.50	48.61	147.26	48.08	195.61	681.59	71.07	214.75	.00	40.01
consumption	512.50	48.61	147.26	48.08	195.61	681.59	71.07	214.75	.00	40.01
residential	165.52	10.23	.00	.00	195.61	.00	.00	.00	.00	.00
transportation	.00	.00	147.26	48.08	.00	681.59	.00	.00	.00	.00
industry	120.90	38.38	.00	.00	.00	.00	71.07	214.75	.00	40.01
commercial	80.71	.00	.00	.00	.00	.00	.00	.00	.00	.00
misc.	1.52	.00	.00	.00	.00	.00	.00	.00	.00	.00
hotels	132.23	.00	.00	.00	.00	.00	.00	.00	.00	.00
local auth	11.61	.00	.00	.00	.00	.00	.00	.00	.00	.00

Normally, when information is moved to the energy balance table, a single row of the table must be specified in the network file. If instead of naming the row explicitly, you enter "sector", then RESG will look for the energy balance table ROW in the sectors field of the table (the last 11 columns of each line). In the example below, note the correspondence between these entries (e.g. "hotels" on line 217) and the energy balance table rows.

```
198: ****************************************************************
199: data table  5
200: ****************************************************************
201: matrix
202: consis.check= 0
203: matrix name =fuel demand
204: output name =fuel by sector
205: output units=1000 toe
206: matrix size =19 33      .00   0   0
207: consumption = 1 19 barch=04/ov/reg=03/03,03/06,06/05,05/09,09
208: sector      = 1 19 barch=
209:    sector                  fuel                share
210: -- ------------------- -- ------------------- ----------
211:  1 electr. domestic      1 electricity            1.000 residential*
212:  2 electr. s+m industry  1 electricity            1.000 industry   *
213:  3 electr. large indust  1 electricity            1.000 industry   *
214:  4 electr. commercial    1 electricity            1.000 commercial *
215:  5 electr. street light  1 electricity            1.000 misc.      *
216:  6 electr. LA            1 electricity            1.000 local auth *
217:  7 electr. hotel         1 electricity            1.000 hotels     *
218:  8 lpg                   2 lpg                    1.000 residential*
219:  9 gasolene              3 gasolene               1.000 transportat*
220: 10 naphtha               4 naphtha                1.000 industry   *
221: 11 a-diesel              5 a-diesel               1.000 transportat*
222: 12 kerosene              6 kerosene               1.000 residential*
223: 13 avtur                 7 jet fuel               1.000 transportat*
224: 14 diesel                8 diesel                 1.000 industry   *
225: 15 diesel transp.        5 a-diesel               1.000 transportat*
226: 16 diesel cement         8 diesel                 1.000 industry   *
227: 17 fuel oil              9 fuel oil               1.000 industry   *
228: 18 residual             10 residual               1.000 industry   *
229: 19 residual sfac        10 residual               1.000 industry   *
230: 20 asphalt              11 asphalt                1.000 industry   *
231: 21 coal railway         12 coal                   1.000 transportat*
232: 22 coal others          12 coal                   1.000 industry   *
233: 23 coal cement          12 coal                   1.000 industry   *
234: 24 baggasse             13 bagasse                1.000 misc.      *
235: 25 wood industry        14 wood                   1.000 industry   *
236: 26 wood domestic        14 wood                   1.000 residential*
237: 27 charcoal industry    15 charcoal               1.000 industry   *
238: 28 charcoal domestic    15 charcoal               1.000 residential*
239: 29 solar                16 solar                  1.000 misc.      *
240: 30 biogas               17 biogas                 1.000 misc.      *
241: 31 wind                 18 wind                   1.000 misc.      *
242: 32 min-hydro            19 mini-hydro             1.000 misc.      *
243: 33 ind lpg               2 lpg                    1.000 industry   *
```


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LINKAGES TO THE EFAM MODEL

RESGEN is designed to be used with the Energy Finance Assessment Model (EFAM), which generates the cash flows associated with energy transactions on an institution-by-institution basis. EFAM also simulates the financial statements (income statement, sources and uses of funds, balance sheets) for the major energy sector institutions.

RESGEN creates two files to pass the necessary information to EFAM. Information relating to projects (investment, debt service, construction outlays, etc.) are passed in the file PROJ.EFM. The energy transactions between institutions are passed to the TRANS.EFM. (These transactions are multiplied by the applicable prices to generate the cash flows in EFAM)

To effect the EFAM transfer, you must make sure that the appropriate setting is made in the STAT.RES file.

```
resgen initialization parameters
****************************************************
item
l-- l----------------------------e
color
yes  efam transfer
yes  macromodel linkage
no   extended network directories
a    help screen volume
yes  map
no   regional disaggregation
yes  dynamic
no   delete zero columns in tables
yes  use <columns.dat>
yes  tutorial screens
yes  time plots
     (3x,f9.2,9x,11f9.2)
     (20f9.2)
```

In addition, you must identify the institutions involved by an appropriate entry in the network file. This is done by adding to the consistency check line of the data table an entry of the type:

EFAM/fromXXXX/to=YYYY

Where XXXX is a four letter code that identifies the selling institution, and YYYY is the code that identifies the buying institution. For example, in the exhibit below, RESGEN makes at this point a calculation of bunkers consumption. This involves in EFAM terms, a transaction between the oil company (in this case CPC denotes the Ceylon Petroleum Corporation), and consumers of bunkers, with the code BCON.

413

```
*****************************************************************
data table 20
*****************************************************************
i-elasticity
consis.check= 0,efam/from=CPC /to=BCON
matrix name =bunkers growth
output name =scenario year bunker
output units=1000 toe
matrix size =03 03   1.055
-bunkers    = 1  3
none
   fuel
-- ------------------- -- ------------------- ----------
 1 jet fuel             1 jet fuel                1.050
 2 diesel               2 diesel                  1.030
 3 fuel oil             3 fuel oil                1.050
```

This instruction will result in entries in the TRANS.EFM file for all non-zero entries, within the print range, in the output vector for the data table. In the example above, three entries would be generated (for jet fuel, diesel and fuel oil), each with the institutional identification CPC/BCON which identifies these energy flows as corresponding to a CPC sale to bunkers consumers.

In some cases, one may wish to transfer to EFAM a set of entries that does not correspond to the current print range. In this case, the EFAM entry is of the type

EFAM/from=XXXX/to=YYYY/range=nn,mm

where nn,mm is the range of the output vector entries to be transferred. This is illustrated in the exhibit on the following page, where we wish to transfer electricity sales from the electric utility to consumers (CEB to CONS): however, only the first seven elements represent electricity, hence we specify nn-01, mm=07.

It may sometimes happen that a single vector in RESGEN involves several institutions: most frequently several buyers (from one seller), or several sellers to a single buyer. For example, in the exhibit overleaf, instead of just a single group of consumers identified as CONS, we may wish to distinguish between sales to different sectors (especially where different tariffs apply to different consuming groups).

414

```
152: ##################################################################
153: data table  5                                                    #
154: ##################################################################
155: matrix                                                           #
156: consis.check= 0,efam/from=CEB /to=CONS/range=01,07/option=1      #
157: matrix name =fuel demand                                         #
158: output name =fuel by sector                                      #
159: output units=1000 toe                                            #
160: matrix size =19 33      .00   0   0                             #
161: consumption = 1 19 barch=02/ov/reg=99/01,01/02,03/04,07          #
162: sector      = 1 19 barch=                                        #
163:    sector                  fuel                share              #
164: -- -------------------- -- -------------------- ----------       #
165:  1 electr. domestic      1 electricity              1.000 residential#
166:  2 electr. s+m industry  1 electricity              1.000 industry   #
167:  3 electr. large indust  1 electricity              1.000 industry   #
168:  4 electr. commercial    1 electricity              1.000 commercial #
169:  5 electr. street light  1 electricity              1.000 misc.      #
170:  6 electr. UDA           1 electricity              1.000 industry   #
171:  7 electr. railway       1 electricity              1.000 transportat#
172:  8 lpg                   2 lpg                      1.000 residential#
173:  9 gasolene              3 gasolene                 1.000 transportat#
174: 10 naphtha               4 naphtha                  1.000 industry   #
175: 11 av gas                5 av gas                   1.000 transportat#
176: 12 kerosene              6 kerosene                 1.000 residential#
177: 13 avtur                 7 jet fuel                 1.000 transportat#
178: 14 diesel                8 diesel                   1.000 industry   #
179: 15 diesel transp.        8 diesel                   1.000 transportat#
180: 16 diesel cement         8 diesel                   1.000 industry   #
181: 17 fuel oil              9 fuel oil                 1.000 industry   #
182: 18 residual             10 residual                 1.000 industry   #
183: 19 residual sfac        10 residual                 1.000 industry   #
184: 20 asphalt              11 asphalt                  1.000 industry   #
185: 21 coal railway         12 coal                     1.000 transportat#
186: 22 coal others          12 coal                     1.000 industry   #
187: 23 coal cement          12 coal                     1.000 industry   #
188: 24 bagasse              13 bagasse                  1.000 misc.      #
189: 25 wood industry        14 wood                     1.000 industry   #
190: 26 wood domestic        14 wood                     1.000 residential#
191: 27 charcoal industry    15 charcoal                 1.000 industry   #
192: 28 charcoal domestic    15 charcoal                 1.000 residential#
193: 29 solar                16 solar                    1.000 misc.      #
194: 30 biogas               17 biogas                   1.000 misc.      #
195: 31 wind                 18 wind                     1.000 misc.      #
196: 32 min-hydro            19 mini-hydro               1.000 misc.      #
197: 33 ind lpg               2 lpg                      1.000 industry   #
```

In the above exhibit, each of the first 7 electricity elements is associated with a different sector, identified in the "sector" column. By making the additional entry "/option=1" on the EFAM transfer line, the buying institution CONS is replaced by the label in the sector column. Thus, the first transfer, corresponding to the first element in the output vector, will be identified as a sale from CEB to residential consumers, the second as a sale from CEB to industry, and so on.

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The institution codes used for the EFAM transfer must of course be consistent with the codes used in the EFAM model. The codes are contained in the file INSTLIST.EFM, to be found in the EFAM file directory. In the case of the use of sector column entries, only the first four letters are used as the code: note the correspondence between the above exhibit, and the codes in the sample INSTLIST.EFM file below:

institutions

code	label	bal.sheet
CEB	Ceylon Electric Bd.	balance1.efm
CPC	Ceylon Petr. Corp.	
BCON	Consumers(bunkers)	
resi	residential consumer	
indu	industrial consumers	
tran	transport	
comm	commercial consumers	
misc	other consumers	
DIST	Petr. Product Distr.	
CWG	Colombo Water+Gas	

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9. GRAPHICS

If you specify option=2, then <u>only the sector column</u> is used for identifying the buying and selling instituion, and the institutions listed in the EFAM command lines are ignored (or you can simply use xxxx, as in the example below). If the sector line is blank, then no EFAM transaction is generated for that line.

```
*****************************************************************
data table  8
*****************************************************************
electric
consis.check= 1,efam/from=CPC /to=CEB /range=02,05/option=2
matrix name =power1.dat
output name =generation by type
output units=1000 toe
matrix size =23 19    11.36   0   0
-electric ge= 1  5 barch=03/ov/reg=01/01,01/05,05/02,04
none        = 0  0 barch=
                                 fuel                  genmix
-- -------------------- -- -------------------- ----------
 1 electricity           1 hydro                      .000
 1 electricity           2 diesel                     .000 CPC /CEB
 1 electricity           3 fuel oil                   .059 CPC /CEB
 1 electricity           4 residual                   .199 CPC /CEB
 1 electricity           5 coal                       .742 CPC /COAL
 2 lpg                   6 lpg                       1.000
 3 gasolene              7 gasolene                  1.000
 4 naphtha               8 naphtha                   1.000
 5 a-diesel              9 a-diesel                  1.000
 6 kerosene             10 kerosene                  1.000
```


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RESG generates a variety of character-mode graphics displays. These fall into two categories: those that are generated automatically, having a fixed format and requiring no particular user instruction: and those that require an explicit set of user directions. Examples of the first category are the load duration curve produced for the electric sector (generated automatically in the prompt mode by the electric operator), or the refinery display (generated by the refinery and vrefinery operators). Examples of the latter are the time series plots produced in the dynamic mode, and the map/bar chart displays: these are produced in the RESP program. This section documents the latter category of graphic displays and describe what you must do to produce them.

It should be noted that all graphic displays produced in RESG are in the so-called character mode, and can therefore be run on any screen, including the IBM monochrome monitor. You do not need a graphics board (e.g. a HERCULES board) to produce the RESGEN displays with the monochrome monitor. Indeed, unless you have a high quality color display, the monochrome monitor may be preferable as it considerably reduces eye strain when working with many data tables. (However the screen type present must be initialized in STAT.RES).

The Character mode graphics are also independent of the pixel resolution of the color monitor: you cannot improve the resolution of the graphics by a screen with higher pixel resolution (although the color quality will improve).

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DEFAULT FILE NAMES FOR GRAPHICS

Unless otherwise specified, the following file names are used as defaults:

Map Outline for Barcharts	RESMAP.DAT
Barchart Specifications	GRAPH.DAT
Timeplot Specifications	TIMEPLT.DAT

These file name identifications are contained on line 1 of each Network File; blanks are equivalent to the above default names.

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COLOR GRAPHICS

The barchart/map displays, and the time series plots can be produced in color if your machine has a color graphics board and a color monitor. To obtain color graphics with such a screen, you must do the following:

1. In the STAT.RES file, you must set the screen type to "color", as in the exhibit below:

```
*resgen intialization parameters
*****************************************************************************
item
1--  1----------------------------e
color screen type
no   efam transfer
no   macromodel linkage
yes  extended network directories
C    help screen volume
yes  map
no   regional disaggregation
yes  dynamic
yes  delete zero columns in tables
yes  use a columns.dat type file
yes  tutorial screens
yes  time plots
     (3x,f9.2,9x,11f9.2)
     (20f9.2)
```

2. You must create the files COLORMAP.DAT and COLORPLT.DAT to set the colors for the barchart/map, and time series plots, respectively. If you initialize STAT.RES for color, and these files are not present, an error message of the type "file not found" will be generated.

Sample files of this type are provided on diskette A; if you did not use them when you first set up RESGEN, copy them from your write protected diskette.

The details of these files, and the color codes that apply, are included in Section 7 of this manual (see COLORMAP.DAT and COLORPLT.DAT). You can experiment with different color schemes if you do not like those in the sample files provided.

To generate barcharts you must do two things: first you must define the barchart format in a GRAPHICS.DAT file (see Section 7). Second, you must instruct the program which numerical values are to be transferred to which barchart: this is done by means of the BARCH instruction in the network files (on the same two lines as the transfer of information to the energy balance table, as shown on the example below, in which two barchart transfers are made. (You may of course omit the "barch" command, or include only one command which may be on <u>either</u> of the two transfer lines).

```
519: ***********************************************************************
520: data table 23                                                         *
521: ***********************************************************************
522: supply=resources                                                      *
523: matrix name =crude production                                         *
524: matrix size = 2  0        .00                                         *
525: primary prod= 1  1 barch=05/ov/reg=99/02,02
526: imports     = 2  2 barch=04/ov/reg=99/01,01
527:    mboe                 mboe/year                                    *
528: -- ------------------- --------------------                           *
529:  1 crude                     .000 crude.dat                           *
530:  2 arab light                .000 arabl.dat                           *
```

The format of the "barch" command is

barch=ii/ov/reg=jj/range1/range2/range3/range4/

where ii is a (two digit) integer that identifies the display number
jj is a (two digit) integer that identifies the regional/item label

range (k) is a range specification that identifies the values of the output vector to be put into the k-th bar

graphics parameters

#	display title	#	regional/item label	bar label
01	exports	01	1982	crude
		02	1985	lng
		03	1990	
02	electricity	01	java	demand
		02	o-java	generation
03	generation mix	01	java/grid	hydro
		02	o-java	geothermal
				coal
				oil
04	domestic production	01	1982	crude
		02	1985	gas/lng
		03	1990	gas/domestic
				coal
05	imports	01	1982	crude
		02	1985	coal
		03	1990	diesel
				fueloil

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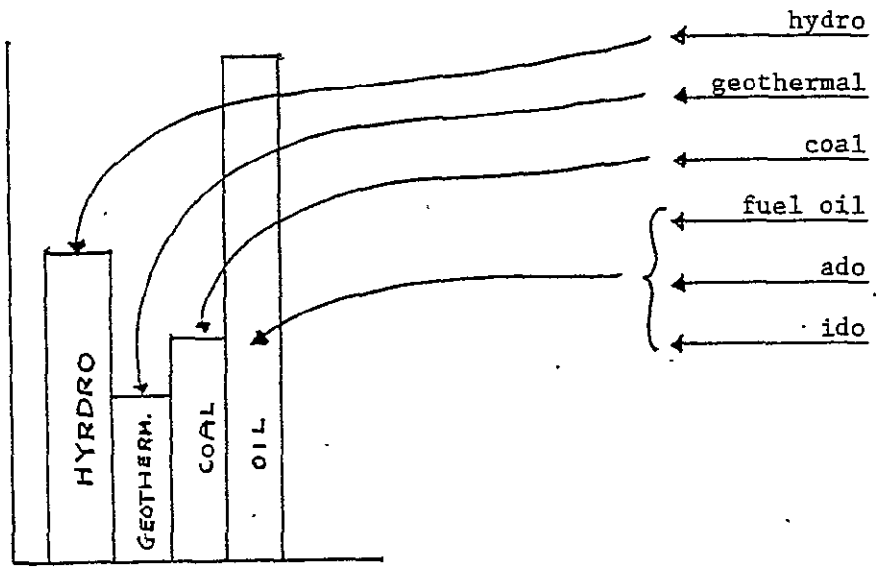
The use of the "barch" command is best illustrated by example. Suppose you wish to transfer the vector of fuel inputs for the java grid into display 3 initialized as shown above in a GRAPHICS.DAT file.



Thus you wish to transfer the output elements in the range (01,01) to the first bar, (02,02) to the second bar, (03,03) to the third bar, and the sum of 4,5 and 6, I.e. the range (04,06) to the fourth bar.

Therefore the command is:

barch=03/ov/reg=01/01,01/02,02/03,03/04,06

The correspondence between the "barch" command, the output elements, and the GRAPHICS.DAT file are shown on Exhibit 9.1

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EXHIBIT 9.1: BARCHART INSTRUCTIONS

```
131: ****************************************************************
132: data table  7
133: ****************************************************************
134: electric
135: consis.check= 0
136: matrix name =power1.dat
137: output name =java fuels/electric
138: output units=mboe
139: matrix size =30 24  1611.10   0   0
140: -elec genera= 1  7 barch=03/ov/reg=01/01,01/02,02/03,03/04,06
141: none        = 0  0 barch=
142:    java electricity        java fuels to electr
143: -- ------------------- -- ------------------------ ---------
144:  1 electr Java           1 hydro                    1.000
145:  1 electr Java           2 geothermal               1.000
146:  1 electr Java           3 coal                     1.000
147:  1 electr Java           4 fueloil                  1.000
148:  1 electr Java           5 ado                      1.000
149:  1 electr Java           6 ido                      1.000
150:  1 electr Java           7 nuclear                  1.000
151:  2 electricity           8 electricity              1.000
152:  3 lpg                   9 lpg                      1.000
153:  4 avgas                10 avgas                    1.000
154:  5 avtur                11 avtur                    1.000
155:  6 gasoline             12 gasoline                 1.000
156:  7 ado                  13 ado                      1.000
157:  8 ido                  14 ido                      1.000
158:  9 kerosene             15 kerosene                 1.000
159: 10 fueloil              16 fueloil                  1.000
160: 11 petrochems           17 petrochems               1.000
161: 12 lubes/waxes          18 lubes/waxes              1.000
162: 13 asphalt              19 asphalt                  1.000
163: 14 petr coke            20 petr coke                1.000
164: 15 gas                  21 gas                      1.000
165: 16 charcoal             22 charcoal                 1.000
166: 17 wood                 23 wood                     1.000
167: 18 agric wastes         24 agric wastes             1.000
168: 19 coal                 25 coal                     1.000
169: 20 coke                 26 coke                     1.000
170: 21 solar-pv             27 solar-pv                 1.000
171: 22 solar                28 solar                    1.000
172: 23 biogas               29 biogas                   1.000
173: 24 wind                 30 wind                     1.000
```

graphics parameters

#	display title	#	regional/item label	bar label
01	exports	01	1982	crude
		02	1985	lng
		03	1990	
02	electricity	01	java	demand-
		02	o-java	generatic.
03	generation mix	01	java/grid	hydro
		02	o-java	geothe[illegible]
				coal
				oil
04	domestic production	01	1982	crude
		02	1985	gas/lng
		03	1990	gas/domestic
				coal
05	imports	01	1982	crude
		02	1985	coal
		03	1990	diesel
				fueloil

4.24

ANNEX I

EXAMPLE: SETTING UP A NETWORK FILE

This annex illustrates the use of the CREATE utility to generate a RESGEN network file (using the example of Section 3.3). CREATE is a DOS batchfile that calls a number of screen displays and programs during execution. In the exhibit below, the user responses (circled). To commence, enter "CREATE" and the first screen will appear:

CREATE : RESGEN network utility

This program will copy blank templates into the files LISTFUEL.NEW and LISTTAB.NEW, which you should edit in the TABLE program for your application.

The TABLE file directory also contains the sample files discussed in the RESGEN user manual (SAMPLE1.DAT, SAMPLE2.DAT). Consult these files if you are uncertain about the entries.

```
C>pause
Strike a key when ready . . .

C>copy listtab.blk listtab.new
        1 File(s) copied
C>copy listfuel.blk listfuel.new
        1 File(s) copied
```


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```
C>table

                    ..please wait, reading data files

directory: quick.dir
-------------------------------------------------------------
       file descriptor            DOS-filename   last access
-------------------------------------------------------------
  1    fuel list template         listfuel.new   aug.  2
  2    table list template        listtab.new    aug.  2
  3    user manual, table 3.2     sample1.new    july 14
  4    usel manual label list     sample2.new    july 14
-------------------------------------------------------------
..enter table # (or 0 to exit, x to delete,n for new table) >>>> 1
```

which will produce a blank fuel list display: Edit in the numbers until you reach this point:

```
fuellist template
---------------------
    label
---------------------
01  coal
02  oil
03  gas
---------------------
```

Now press ESC, and you return to the table directory

```
directory: quick.dir
-------------------------------------------------------------
       file descriptor            DOS-filename   last access
-------------------------------------------------------------
  1    fuel list template         listfuel.new   sept  2
  2    table list template        listtab.new    aug.  2
  3    user manual, table 3.2     sample1.new    july 14
  4    usel manual label list     sample2.new    july 14
-------------------------------------------------------------
..enter table # (or 0 to exit, x to delete,n for new table) >>>> 2
```

Now fill in the entries for the table list:

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RESGEN table template

operator	name	lk	fr	to	output name	fr	to
projection	base year demand	03	01	03	..	01	03
growth	growth rates	03	01	03	scenario demand	01	03

Exit back to the directory with ESC, then exit the directory with 0:

directory: quick.dir

	file descriptor	DOS-filename	last access
1	fuel list template	listfuel.new	sept 2
2	table list template	listtab.new	sept 2
3	user manual, table 3.2	sample1.new	july 14
4	usel manual label list	sample2.new	july 14

..enter table # (or 0 to exit, x to delete,n for new table) >>>>

C>type display2

You must now give the files a NAME, then enter

STARTQ NAME

This will result in the files you have just created in TABLE being copied to the name you select (LISTFUEL.NEW becomes NAME.fue, and LISTTAB.NEW becomes NAME.tab.

Subsequently, the QUICK program will be loaded, which converts these two files into a RESGEN network file.

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Now enter STARTQ TEST1, and then respond as shown:

```
C>
C>startq test1
C>copy listfuel.new test1.fue
        1 File(s) copied
C>copy listtab.new test1.tab
        1 File(s) copied
C>quick
                    QUICK: RESGEN network utility
_____________________________________________________________
..enter DOS filename for output >>>> test1.res
..enter network description >>>> appendix 1 network
..enter input file name >>>> test1
        ..please wait, loading datafiles..
..file <test1.res        > complete!: load into RESENT for editing
C>
```

You are now ready to load TEST1.RES into RESENT for editing of the values

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ANNEX II

RESGEN UTILITIES

The data Diskette contains a number of utilities that are useful to the RESGEN user. Most of these are all so called "batch" files, and therefore have the ".BAT" extension. To invoke, you need enter only the utility name: .BAT is not required. Thus, for example, enter

RESGEN

rather than RESGEN.BAT

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COPYDAT1 is a utility to copy (or back up) the set of RESGEN datafiles. The format is

```
COPYDAT1     source     target
              drive      drive
```

thus to copy from B to C, enter

```
COPYDAT1  B  C
```

note that there must be a space between the entries. COPYDAT1 should be used when running under DOS1.1. When running under DOS2.0 or higher, you should use COPYDAT2, for which you may enter a subdirectory designation (or copy from one subdirectory to another). For example:

```
COPYDAT2  A  B:\RESGEN
```

Note: COPYDAT2 requires the presence, on the default drive, of a systems utility called JET.COM.*

* This is a program available from Tall Tree Systems Inc, and is highly recommended.

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RESGEN

RESGEN is a batch file that loads the various programs in the proper sequence, puts messages onto the screen while loading the programs (useful when running from floppy disks because it takes some time to load into memory), and perform other housekeeping drives to keep the data drive free of unneeded files (also important when running off disketts of limited storage capacity). You can thus enter "RESGEN" in place of "RESG"; RESG will be loaded as the first step, followed by RESP (and EFAMFILE if EFAM is installed).

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EFAMFILE

When running with EFAM, RESG creates two files of information that are used by a subsequent EFAM run. (called PROJ.EFM and TRANS.EFM) These are fairly large files, and one should therefore avoid having many such files present on the default volume. The recommended approach when running a large number of RESG scenarios is to transfer these two files to a floppy disk after every run. This is best done by using the EFAMFILE utility: just enter "EFAMFILE": this will generate detailed instructions.

Note: to run EFAMFILE you must also have present the EFAMT utility.

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ANNEX III

MATRIX ALGEBRA

MATRICES

A matrix is a rectangular array of numbers. The number of rows and columns are called the dimensions of the matrix. Thus a matrix with two rows and three columns is said to be of dimension 2x3 ("two by three").

Conventional notation is for the matrix to be represented by an upper case letter, an element in the matrix by a lower case letter whose subscripts indicate the row number and column number, respectively. Thus if

$$A = \begin{bmatrix} 2 & 3 \\ 4 & 5 \end{bmatrix}$$

Then $a_{12} = 3$; (thus a_{12} represents the element in row 1 and column 2). It is good practice to indicate, immediately below its upper case symbol, the dimension of a matrix by enclosing the rows and columns in parentheses. For example,

$$\underset{(3x4)}{A} = \begin{bmatrix} 1 & 0 & 0 & 2 \\ 2 & 0 & 1 & 3 \\ 0 & 1 & 0 & 4 \end{bmatrix}$$

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MATRIX ADDITION AND SUBTRACTION

Two matrices can be added or subtracted if they have the same dimensions (the same number of rows and columns). Thus the matrices:

$$A = \begin{bmatrix} 2 & 3 \\ 1 & 0 \end{bmatrix} \quad \text{and } B = \begin{bmatrix} 1 & 1 \\ 1 & 1 \end{bmatrix}$$

can be added and subtracted:

$$C = A + B = \begin{bmatrix} 2 + 1 = 3 & 3 + 1 = 4 \\ 1 + 1 = 2 & 0 + 1 = 1 \end{bmatrix}$$

$$= \begin{bmatrix} 3 & 4 \\ 2 & 1 \end{bmatrix}$$

Thus each element in matrix C is defined by addition (or subtraction) of the corresponding element in A and B. In general, for all rows i and columns j,

$$C_{ij} = a_{ij} + b_{ij}$$

or

$$C_{ij} = a_{ij} - b_{ij}$$

Note that we cannot add (or subtract) matrices of different dimensions. Therefore, if A is (2x1) and B is (3x2), C = A + B has no meaning.

MATRIX MULTIPLICATION

If A is (nxm), and B is (mxp), then the product C is (nxp), whose elements are defined by

$$C_{ij} = \sum_{k=1}^{m} a_{ik} \cdot b_{kj} \qquad \text{for all } \begin{array}{l} i = 1,..n \\ j = 1,..p \end{array}$$

Thus, for multiplication to be valid, the number of columns in the first matrix must equal the number of rows in the second matrix.

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In the case where p = 1 (i.e. B is a column vector), then A is also a column section, namely

$$\underset{(n \times 1)}{C} = \underset{(n \times m)}{A} \quad \underset{(m \times 1)}{b}$$

Whose elements are given by

$$C_i = \sum_{k=1}^{m} a_{ik} b_k \quad \text{for } i - 1,\ldots n$$

Note that $A \cdot B \neq B \cdot A$; indeed, $B \cdot A$ may not be defined even if $A \cdot B$ is valid.

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ANNEX IV

INITIALIZING RESGEN

RESGEN version 3.0 supports a number of different hardware options, and must be initialized for the type of monitor present. You must also initialize the printer.

STEP 1: THE PRINTER

RESGEN makes extensive use of character mode graphics that can be displayed on the high resolution IBM monochrome screen (or its equivalent). The ASCII character set employed is known as the "IBM Graphics Character Set", and to obtain paper copies of the screen graphics displays the printer must support this particular graphics set. If you have an IBM Graphics Printer you need not do anything further, and can go directly to Step 2.

STEP 2: THE SCREEN

RESGEN invokes different graphic routines for different hardware configurations. Presently three different systems are supported:

(i) IBM High Resolution Monochrome Screen (or its equivalents), fitted with the IBM monochrome monitor card. In this configuration RESG produces monochrome, text mode graphics.

(ii) IBM Monochrome Screen fitted with the Hercules Graphics Card. In this mode RESG generates some of its graphics in the form of high resolution displays.

(iii) IBM (Medium Resolution) color display fitted with the IBM (or hercules) color graphics card. In this configuration RESG generates color graphics in the text mode.

You must initialize RESG for one of these configurations. This is done by loading the file STAT.RES into TABLE (as shown on Exhibit); the entry on line 1 must be one of the following:

"mon"	for monochrome
"her"	for hercules card
"col"	for color graphics.

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ANNEX V

COMPATIBILITY OF VERSION 3.0 WITH EARLIER MS-DOS VERSIONS (1.0, 1.1)

In general, Version 3.0 has retained the basic structure of earlier versions, and you should be able to run a network file prepared for the older versions with a few additional changes. In particular, for version 3.0 to run, you must create a file STAT.RES, and a file TZ.DAT, without which versions 3.0 will not run.

The main differences between version 3.0 and the earlier versions can be summarized as follows:

1. Version 3.0 supports many new matrix types (operators). SUPPLY = RESOURCES, DEMAND, VGROWTH and VREFINERY were not supported by versions 1.0 and 1.1.

2. In the earlier versions, the load duration curve, and the power sector capacity expansion plan were contained in a single file. In version 3.0 these are contained in separate files. The old POWER.DAT file must be split when running under version 3.0. The new version of LOAD.DAT has a different format, and <u>must be changed</u> for correct functioning of the <u>electric</u> operator.

3. Version 3.0 supports automated linkages to a number of other models such as the EFAM Energy Finance Assessment Model, the ENMAC macroeconomic accounting framework, and LOTUS 1-2-3.

4. Version 3.0 incorporates color graphics, and the ability to run in a dynamic, multi-year mode.

5. The first line of RESGEN network files is used to identify graphics file names: when running with an old file, just leave the first line blank.

If you have any problems in upgrading from versions 1.0 and 1.1 to 3.0, please contact IDEA with a written description of any problems you are having, and include a hard copy of the screen output to illustrate where unexpected error messages have occurred.

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ANNEX VI

MAXIMUM TABLE AND VECTOR SIZES

MAXIMUM SIZE

Energy Balance Table	
Columns	40
Rows	40
Current Account Table	
Columns	25
Rows	5
Main Network	
Number of Links in a vector	60
Number of vectors (RES slices)	No Limit
Power Sector	
Number of power plants in a POWER.DAT file	50

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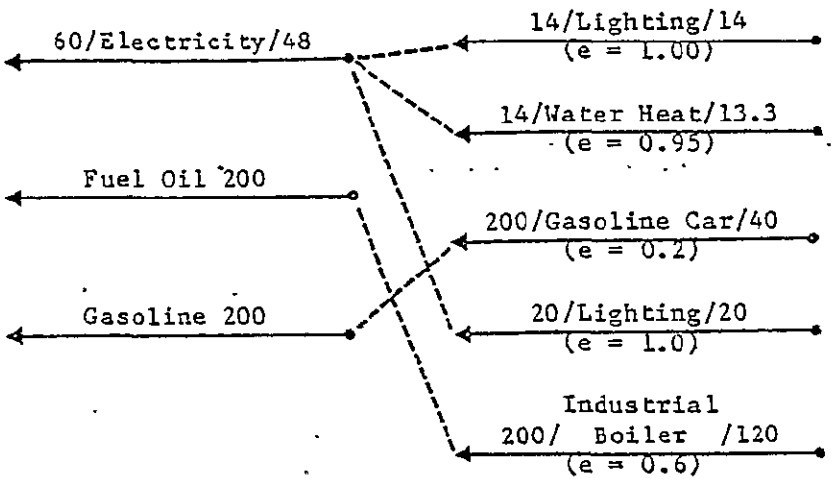
ANNEX VII

THE RESENT PROGRAM

RESENT is an interactive program that allows you to create RESGEN network files from the screen. Its use is best illustrated by example. On the following pages we use RESENT to create the following network (taken from Section 2.1)



You should run RESENT in exactly the way shown on the following pages. When you are finished, use the ADDNET utility to add the file to a network directory; you can then test the network in RESG.

```
*****************************************************************************
*                                                                           *
*                                                                           *
*              RESENT 3.0 : interactive data entry for RESGEN               *
*                                                                           *
*                                                                           *
*     (c)copyright International Development and Energy Associates,Inc.     *
*                            I D E A                                        *
*                                                                           *
*                                                                           *
*****************************************************************************

 ---------------------------------------------------------------------------

 ..If you have doubts about the response to a prompt marked with ?HELP
   enter HELP.  This will provide further information on the correct response

 ---------------------------------------------------------------------------

 ..enter DOS filename (?HELP) >>>> manual1.dat

 to start a new data file                enter 1
 to add data tables to existing file     enter 2
 to insert a data table                  enter 3
 to change a values in an existing file  enter 4
 to delete a data table                  enter 5

      ...enter here >>>> 1

 ..are you sure?  Any existing file with name manual1.dat will be erased
                                              ===========
        enter YES or NO >>>> yes
 ..file names:

 1. energy balance table rows        labels.dat
 2. energy balance table columns     columns.dat
 3. time series plots                timeplt.dat
 4. map setup                        graph.dat
 5. map outline                      resmap.dat
 6. output menu                      paramo.dat


      ....enter here >>>>

 ..enter file description (?HELP) >>>> manual1.dat

            entries for data table  1
            ========================

.enter the matrix type (?HELP) >>>> projection

..enter the matrix name (?HELP) >>>> base year

..number of output elements >>>> 5
```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```
..energy balance table row (?HELP) >>>> none

..print range, lower bound >>>> 1
..             upper bound >>>> 5

..second energy balance table row(or none) (?HELP) >>>> none

..entry of column labels

.enter input label (?HELP) >>>> sector

.enter coefficient label (?HELP) >>>>
                    entry of coefficients
                    ======================


..check spelling of labels? enter YES or NO >>>> no

.output link = 1
----------------
....output label >>>>> lighting/households

...value for lighting/households  >>>> 14

...sector label, if any >>>>

.output link = 2
----------------
....output label >>>>> water heat/housholds

...value for water heat/housholds >>>> 13.3

...sector label, if any >>>>

.output link = 3
----------------
....output label >>>>> gasoline/auto

...value for gasoline/auto        >>>> 40

...sector label, if any >>>>

.output link = 4
----------------
....output label >>>>> lighting/industry

...value for lighting/industry    >>>> 20

...sector label, if any >>>>
```


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```
.output link = 5
----------------
....output label >>>>> boilers

...value for boilers              >>>> 120

...sector label, if any >>>>

 current contents of data table  1: base year
 ---------------------------------------------------------------------------
  M  output label              value    sector
 ---------------------------------------------------------------------------
  1  lighting/households       14.00
  2  water heat/housholds      13.30
  3  gasoline/auto             40.00
  4  lighting/industry         20.00
  5  boilers                  120.00
 ---------------------------------------------------------------------------
.enter row number to change(or 0 to exit) >>>> 2

.enter (N),(output(label)),(M),(input(label)),(value) or (sector) >>>> o

 ..enter new output label for row  2 >>>> water heat/households

 current contents of data table  1: base year
 ---------------------------------------------------------------------------
  M  output label              value    sector
 ---------------------------------------------------------------------------
  1  lighting/households       14.00
  2  water heat/household      13.30
  3  gasoline/auto             40.00
  4  lighting/industry         20.00
  5  boilers                  120.00
 ---------------------------------------------------------------------------
.enter row number to change(or 0 to exit) >>>>

 ..another data table? enter YES or NO >>>> yes

            entries for data table  2
            =========================

.enter the matrix type (?HELP) >>>> diagonal

 consistency check

   none                              enter 0
   sum of elements .EQ. 1            enter 1
   sum of elements .LE. 1            enter 2
   each element .LE. 1               enter 3

     ..enter here >>>> 3

 ..enter the matrix name (?HELP) >>>> efficiency/device

.enter output name (?HELP) >>>> energy by device

.enter output units (?HELP) >>> atoe
```


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```
..number of input elements >>>> 5

..number of output elements >>>> 5

..energy balance table row (?HELP) >>>> none

..print range, lower bound >>>> 1

..             upper bound >>>> 5

..second energy balance table row(or none) (?HELP) >>>> none

..entry of column labels

.enter input label (?HELP) >>>> device

.enter output label (?HELP) >>>>

.enter coefficient label (?HELP) >>>> efficiency
                   entry of coefficients
                   =====================


..check spelling of labels? enter YES or NO >>>> no

..output label = input label? enter YES or NO >>>> yes
#############################################################################
:                                                                           :
:  For matrices of type DIAGONAL you need only enter those links            :
:  whose value is not equal to 1.0.                                         :
:                   ================                                        :
:                                                                           :
:  You will be asked for the link numbers you wish to enter: when you       :
:  have finished, enter 99 as the link number, and the entry sequence       :
:  will terminate.                                                          :
:                                                                           :
#############################################################################

..enter element number >>>> 2

....input label >>>>> electricity

...value for electricity          >>>> 1.0

...sector label, if any >>>>

..enter element number >>>> 2

....input label >>>>> electricity

...value for electricity          >>>> 0.95

...sector label, if any >>>> water heat

..enter element number >>>> 3

....input label >>>>> gasoline
```

```
...value for gasoline            >>>> 0.2

...sector label, if any >>>> auto

 ..enter element number >>>> 4

....input label >>>>> lighting

...value for lighting            >>>> 1.0

...sector label, if any >>>> industry

 ..enter element number >>>> 5

....input label >>>>> fueloil

...value for fueloil             >>>> 0.6

...sector label, if any >>>> industry

 current contents of data table  2: efficiency/device
 ----------------------------------------------------------------------
  N  input label          M  output label          value   sector label
 ----------------------------------------------------------------------
  2  electricity          2  electricity            1.00
  2  electricity          2  electricity             .95   water heat
  3  gasoline             3  gasoline                .20   auto
  4  lighting             4  lighting               1.00   industry
  5  fueloil              5  fueloil                 .60   industry
 ----------------------------------------------------------------------
 .enter row number to change(or 0 to exit) >>>> 1

 .enter <N>,<output(label)>,<M>,<input(label)>,<value> or <sector> >>>> n

 ..enter new value for N, input link number >>>> 1

 current contents of data table  2: efficiency/device
 ----------------------------------------------------------------------
  N  input label          M  output label          value   sector label
 ----------------------------------------------------------------------
  2  electricity          2  electricity            1.00
  2  electricity          2  electricity             .95   water heat
  3  gasoline             3  gasoline                .20   auto
  4  lighting             4  lighting               1.00   industry
  5  fueloil              5  fueloil                 .60   industry
 ----------------------------------------------------------------------
 .enter row number to change(or 0 to exit) >>>> 1

 .enter <N>,<output(label)>,<M>,<input(label)>,<value> or <sector> >>>> s

 ..enter new sector for row electricity          >>>> lighting
```


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```
current contents of data table  2: efficiency/device
-----------------------------------------------------------------------------
 N  input label            M  output label            value   sector label
-----------------------------------------------------------------------------
 2  electricity            2  electricity              1.00
 2  electricity            2  electricity               .95   water heat
 3  gasoline               3  gasoline                  .20   auto
 4  lighting               4  lighting                 1.00   industry
 5  fueloil                5  fueloil                   .60   industry
-----------------------------------------------------------------------------
.enter row number to change(or 0 to exit) >>>> 2

.enter <N>,<output(label)>,<M>,<input(label)>,<value> or <sector> >>>> s

 ..enter new sector for row electricity         >>>> lighting

current contents of data table  2: efficiency/device
-----------------------------------------------------------------------------
 N  input label            M  output label            value   sector label
-----------------------------------------------------------------------------
 2  electricity            2  electricity              1.00
 2  electricity            2  electricity               .95   lighting
 3  gasoline               3  gasoline                  .20-  auto
 4  lighting               4  lighting                 1.00   industry
 5  fueloil                5  fueloil                   .60   industry
-----------------------------------------------------------------------------
.enter row number to change(or 0 to exit) >>>> 0

 ..another data table? enter YES or NO >>>> yes

            entries for data table  3
            =========================

.enter the matrix type (?HELP) >>>> aggregate

 ..enter the matrix name (?HELP) >>>> total fuel

.enter output name (?HELP) >>>> total fuel

.enter output units (?HELP) >>> mtoe

 ..number of output elements >>>> 3

 ..energy balance table row (?HELP) >>>> none

 ..print range, lower bound >>>> 1

 ..             upper bound >>>> 3
```


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```
..second energy balance table row(or none) (?HELP) >>>> none

..entry of column labels

.enter input label (?HELP) >>>>

.enter output label (?HELP) >>>>

.enter coefficient label (?HELP) >>>>
                  entry of coefficients
                  ======================


..check spelling of labels? enter YES or NO >>>> no

.output link = 1
---------------
....output label >>>>> electricity

.output link = 2
---------------
....output label >>>>> fueloil

.output link = 3
---------------
....output label >>>>> gasoline

current contents of data table  3: total fuel
-----------------------------------------------------------------------------
 N  input label           M  output label           value   sector label
-----------------------------------------------------------------------------
                          1  electricity
                          2  fueloil
                          3  gasoline
-----------------------------------------------------------------------------
.enter row number to change(or 0 to exit) >>>>

..another data table? enter YES or NO >>>> no

..review file? enter YES and NO >>>> yes
```


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EXHIBIT A: THE NETWORK FILE

```
 1:    labels.dat columns.dattimeplt.datgraph.dat  resmap.dat paramo.dat  *
 2:    1----------2----------3----------4----------5----------6---------- *
 3: manual1.dat                                                          *
 4: ************************************************************************
 5: DATA TABLE  1                                                        *
 6: ************************************************************************
 7: projection                                                           *
 8: matrix name =base year                                               *
 9: matrix size = 5  0        .00                                        *
10: none        = 1  5                                                   *
11: none                                                                 *
12:    sector                                                            *
13: -- ------------------- -------------------                            *
14:  1 lighting/households      14.000                                   *
15:  2 water heat/household     13.300                                   *
16:  3 gasoline/auto            40.000                                   *
17:  4 lighting/industry        20.000                                   *
18:  5 boilers                 120.000                                   *
19: ************************************************************************
20: DATA TABLE  2                                                        *
21: ************************************************************************
22: diagonal                                                             *
23: consis.check= 3                                                      *
24: matrix name =efficiency/device                                       *
25: output name =energy by device                                        *
26: output units=mtoe                                                    *
27: matrix size = 5  5        .00                                        *
28: none        = 1  5                                                   *
29: none                                                                 *
30:    device                                     efficiency             *
31: -- ------------------- -- ------------------- ----------             *
32:* 1 electricity          1 electricity              1.000             *
33:  2 electricity          2 electricity               .950 lighting    *
34:  3 gasoline             3 gasoline                  .200 auto        *
35:  4 lighting             4 lighting                 1.000 industry    *
36:  5 fueloil              5 fueloil                   .600 industry    *
37: ************************************************************************
38: DATA TABLE  3                                                        *
39: ************************************************************************
40: aggregate                                                            *
41: consis.check= 0                                                      *
42: matrix name =total fuel                                              *
43: output name =total fuel                                              *
44: output units=mtoe                                                    *
45: matrix size = 3  3        .00                                        *
46: none        = 1  3                                                   *
47: none                                                                 *
48:                                                                      *
49: -- ------------------- -- ------------------- ----------             *
50:  1 electricity                                                       *
51:  2 fueloil                                                           *
52:  3 gasoline                                                          *
53: ************************************************************************
54: END                                                                  *
```


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ANNEX VIII

DATAFILE FORMATS

This Annex details the datafile format for the main network files. Since we urge that you use RESENT to make changes to network files, ordinarily you need not be concerned with the file format. However, should you run into someproblem with RESENT, the changes can be made directly to the file by loading into the EDLIN editor (or equivalent).

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MATRIX TYPES (other than SUPPLY, DEMAND & PROJECTION)

Each data table consists of two sections — the parameters, and data:

```
178: ****************************************************************
179: data table  7                                                   *
180: ****************************************************************
181: share                                                           *
182: consis.check= 0                                                 *
183: matrix name =Autugen Fraction                                   *
184: output name =Elect by Source                                    *
185: output units=mboe                                               *
186: matrix size =13 11      .00                                     *
187: none          1 13                                              *
188: none                                                            *
189:    mboe                    mboe                fraction         *
190: -- -------------------- -- -------------------- ---------      *
191:  1 fueloil              1 fueloil                1.000          *
192:  2 ado                  2 ado                    1.000          *
193:  3 ido                  3 ido                    1.000          *
194:  4 electricity          4 electricity             .100          *
195:  4 electricity          5 autogeneration          .900          *
196:  5 lpg                  6 lpg                    1.000          *
197:  6 kerosene             7 kerosene               1.000          *
198:  7 gas                  8 gas                    1.000          *
199:  8 coal                 9 coal                   1.000          *
200:  9 wood                10 wood                   1.000          *
201: 10 agric wastes        11 agric wastes           1.000          *
202: 11 f-electricity       12 electricity             .300          *
203: 11 f-electricity       13 autogenaration          .700          *
```

PARAMETER

DATA

The parameter section for all matrix types (except Supply, Demand and Projection) is as follows:

Line 1: The matrix Type (e.g., MATRIX, AGGREGATE, etc.)
(Input format = 3A4

Line 2: Consistency check
= 0 for no check
= 1 if the sum of elements (in the printrange) = 1
= 2 if the sum of elements (in the printrange) 1
= 3 if <u>each</u> element __ 1. This line is also used for EFAM commands (see SECTION 8)
(Input Format = 13X, I2).

Line 3: Matrix Name. Description of the matrix (e.g., device shares, or "Efficiency")
(Input Format = 13X, 5A4)

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Line 4: Output Name. Description of the output vector that results from multiplying the input vector by the current matrix (e.g., "fuel use by device", or "refinery output")
(Input Format = 13X, 5A4)

Line 5: Output Units. For example: TOE (for ton oil equivalent), or KBOE (for thousand barrels of oil equivalent)
(Input Format = 13X, 5A4)

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Line 6: Matrix Size. Number of output, and input elements in the output vector, a special parameter (usually zero)*, and the region range.
(Input Format = 13X, I2, 1X, I2, 1X, F8.2, 1X, I3, 1X,I3).

Line 7: Print Range (see Section 3.4). The first twelve columns of this line either contain the words "NONE* or the name of the energy balance table row. The two integers describe the print range.
(Input Format = 3A4, 1x, I2, 1x, I1).

Line 8: Second Energy Balance Table Row. If there is no such entry, then the word "NONE" should be used. The two integers identify the transfer range.
(Input Format = 3A4, 1x, I2, 1x, I2).

Line 9: Table Labels. Three labels appear here, one each for the input vector, the output vector, and the coefficient.
(Input Format = 3X, 5A4, 4X, 5A4, 1x, 5A4).

Line 10: Marker. This line serves no other purpose than to indicate the positions of the data entries in the coefficient section.
(Input Format = 2(1H-), 1X, 20(1H-), 1X, 2(1H-), 1X, 20(1H-), 1X, 10(1H-))

---

* For file type REFINE, this parameter indicates the capacity of the refinery. For file type P-ELASTICITY, this represents the annual rate of foreign exchange adjustment (assumed to be a constant percentage devaluation). For file type "ELECTRICITY", it represents the conversion from the standard unit to gWh (e.g., if the energy table unit is 1000 toe, the parameter value is 11.36).

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Lines 7 and 8 are also used for barchart generation: see SECTION 9.

The Data Section consists of the following entries, one set for each record.

```
input link number  (I2)
input link label   (5A4)
output link number (I2)
output link label  (5A4)
value (F10.2)
Sector (3A4)
```


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PROJECTION, SUPPLY, SUPPLY=TABLE, SUPPLY=RESOURCES AND DEMAND

The data tables for these types follow closely the format for the matrix data types. The following lines occur:

Line 1: Matrix type (i.e., either PROJECTION, SUPPLY, DEMAND)
(Input Format = A4)

Line 2: Matrix Name (a description of the vector, e.g., projection basis)
(Input Format = 13X, 5A4)

Line 3: Matrix Size. The number of output elements, and input elements (=0 for vectors)
(Input Format = 13X, I2, 1X, I2)

Line 4: Print Range (see SECTION 3)
(Input Format = 3A4, 1X, I2, 1X, I2)

Line 5: Second Energy Balance Table Row (or "NONE"), with range.
(Input Format = 3A4, 1X, I2, 1X, I2)

Line 6: Table Labels. Two labels appear here, the first for the element labels, the second for the coefficients.
(Input Format = 2(1H-), 1X,20(1H-), 1X,10(1H-)).

This is followed by a series of records, one for each element (as given in the matrix size). The format is:

element number (I2)
element label (5A4)
value (F10.3)
sector (if any) (3A4)

In the format statement (I2, 1X, 5A4, 1X, F10.3, 1X, 3A4). These format specifications should be compared against the sample below:

```
358: ****************************************************************
359: data table 11
360: ****************************************************************
361: growth
362: consis.check= 0
363: matrix name =growth rates
364: output name =scenario basis
365: output units=100 toe
366: matrix size = 1  1
367: -exports    = 1  1
368: none
369:    fuel                    fuel                 growth
370: -- -------------------- -- -------------------- ----------
371:  1 charcoal              1 charcoal                 1.060
```

ANNEX IX

ERRORS

ENERGY BALANCE TABLE ERRORS

Experience shows that energy balance table errors are the most likely source of problems for the user. The first indicator of trouble is usually an excessive value of losses, as in the example below:

Indonesia Energy Model

Energy Supply/Demand Balance Network

july 12

1985 Energy Balance Table (mboe)

	crude	arab ligh	lpg	avgas	avtur	gasoline	kerosene	ado	ido	fueloil
primary producti	530.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
imports	.00	30.00	.00	.00	2.33	.00	.00	.00	14.98	.00
exports	-255.10	.00	-5.36	-.48	.00	-9.84	-.64	-3.57	.00	-8.63
bunkers	.00	.00	.00	.00	-1.00	.00	.00	-.05	-.20	-1.00
stock changes	.00	.00	.02	.50	1.20	-8.90	9.10	7.80	.98	.00
.subtotal	224.90	30.00	-5.34	.02	2.53	-18.74	8.46	4.18	15.76	-9.63
refinery	-224.90	-30.00	.00	.00	.00	.00	.00	.00	.00	.00
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	-8.28	-.55
gas plant	.00	.00	.00	.00	.00	.00	-.03	.00	-.07	-.01
LNG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	5.81	.11	2.96	47.67	49.40	44.68	3.46	20.05
.total	.00	.00	.48	.13	5.49	28.93	57.84	48.87	10.98	9.55
consumption	.00	.00	.48	.13	5.49	28.93	57.84	48.87	10.98	9.55

Note: Gasoline losses of 47.67, twice the value of gasoline consumption!

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Inspection of the table indicates that the refinery output is missing. If VRefinery is used, a likely source of trouble is the special rule that requires the matrix name to be the same as the energy balance table row for refineries: indeed, the data reveals the following entry for the VRefinery table:

```
496: vrefinery
497: consis.check= 0
498:*matrix name =refineries
499: output name =refinery outputs
500: output units=mboe
501: matrix size =31 31        .00
502: none-        = 3 16
503: -refinery    = 1  2
504:    name                    capacity              mboe/year
505: -- -------------------- -- -------------------- ----------
506:  1 P.Brandan             1 P.Brandan                 1.600 refine1.dat
507:  2 Dumai                 2 Dumai                    17.600 refine2.dat
508:  3 S.Pakning             3 S.Pakning                 6.700 refine3.dat
509:  4 Plaju                 4 Plaju                    14.400 refine4.dat
510:  5 S.Gerong              5 S.Gerong                 11.300 refine5.dat
511:  6 Cilacap               6 Cilacap                  30.000 refine6.dat
512:  7 Balikpapan            7 Balikpapan                8.300 refine7.dat
513:  8 Singapore Proc Deal   8 Singapore Proc Deal      95.000 refine8.dat
514:  9 Balikp New ph 1       9 Balikp New ph1          20.000 refine9.dat
515: 10 Balikp New ph 2Deal  10 Balikp New ph 2          20.000 refin10.dat
516: 11 Dumai new            11 Dumai new                20.000 refin11.dat
517: 12 Cilacap new ph 1     12 Cilacap new ph 2         20.000 refin12.dat
518: 13 Cilacap new ph 2     13 Cilacap new ph 2         30.000 refin13.dat
```

Since "refineries" is different to "refinery", RESG omits the transfer of refinery output (since it cannot find "refineries" as a balance table row! If we correct line 498, with the following Vrefinery table, then the correct balance, as shown in Section 4.7, is produced.

```
493: ***********************************************************************
494: data table 22
495: ***********************************************************************
496: vrefinery
497: consis.check= 0
498:*matrix name =refinery
499: output name =refinery outputs
500: output units=mboe
501: matrix size =31 31        .00
502: none         = 3 16
503: -refinery    = 1  2
504:    name                    capacity              mboe/year
505: -- -------------------- -- -------------------- ----------
506:  1 P.Brandan             1 P.Brandan                 1.600 refine1.dat
507:  2 Dumai                 2 Dumai                    17.600 refine2.dat
508:  3 S.Pakning             3 S.Pakning                 6.700 refine3.dat
509:  4 Plaju                 4 Plaju                    14.400 refine4.dat
510:  5 S.Gerong              5 S.Gerong                 11.300 refine5.dat
511:  6 Cilacap               6 Cilacap                  30.000 refine6.dat
512:  7 Balikpapan            7 Balikpapan                8.300 refine7.dat
513:  8 Singapore Proc Deal   8 Singapore Proc Deal      95.000 refine8.dat
514:  9 Balikp New ph 1       9 Balikp New ph1          20.000 refine9.dat
515: 10 Balikp New ph 2Deal  10 Balikp New ph 2          20.000 refin10.dat
516: 11 Dumai new            11 Dumai new                20.000 refin11.dat
517: 12 Cilacap new ph 1     12 Cilacap new ph 2         20.000 refin12.dat
518: 13 Cilacap new ph 2     13 Cilacap new ph 2         30.000 refin13.dat
```


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ANNEX X

ELECTRIC SECTOR OPTIMAL DISPATCH

ELECTRIC SECTOR OPTIMAL DISPATCH MODEL

RESGEN incorporates an optimal dispatch model that calculates electric sector fuel consumption for a given demand level and a given capacity expansion plan. The annual load duration curve is linearized into three blocks, peak, intermediate and base. The shape of this curve is entered in the file LOAD.DAT, and applied to the total annual energy demand from the demand projection to produce the energy and power requirements for each vertical load curve block for the year in question.

In a strictly thermal system, dispatching available plants into this curve would be a fairly straight forward matter, since dispatch by strict merit order (i.e. in order of marginal costs) provides the optimum dispatch. In such cases, it is readily shown that optimality requires

$$X_p \geq X_i \geq X_b \geq 0$$

where X_j is the dispatch of the plant into the (p)eak, (i)ntermediate and (b)ase blocks. In words, this means that a plant that is dispatched in the base period block must be dispatched to at least the same level in the intermediate block; and a plant dispatched into the intermediate block must be dispatched to at least the same level in the peak block. This is true also when consideration is given to availability rates: since the peak period availability is almost always higher than off-peak (since scheduled maintenance is presumably conducted in the off-peak periods).

Thus, if X(inst) is the installed capacity, and AV_j the availability rate in the j-th load curve block, and X_j the dispatch into the j-th block,

$$X_j \leq X(inst) \cdot AV$$

In mixed thermal-hydro systems optimal dispatch is a much more complicated matter because of the presence of energy limits on hydro plants. For each hydro plant, the condition

$$\sum_j X_j \, h_j \leq E(max)$$

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where E(max) is the annual energy limit, X the dispatch in the j-th load curve block, and h the hours in the j-th block, must always be met.

The algorithm used by RESGEN to dispatch plants in such systems is best illustrated by example: an iterative heuristic has been designed to provide reasonable, and in almost all cases optimal dispatch pattern to minimize total fuel costs.

One begins with a strict baseload dispatching of hydro plants, with all plants in their strict merit order. Thus hydro plants are dispatched first, fossil plants last. In such baseload dispatching, the dispatch level of the hydro plants can be taken to be given by

$$X_p = X_i = X_b = \frac{E(max)}{8760}$$

This results in the dispatch sequence shown overleaf (for a 1989 scenario taken from the application to Sri Lanka).

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S r i L a n k a Energy Model

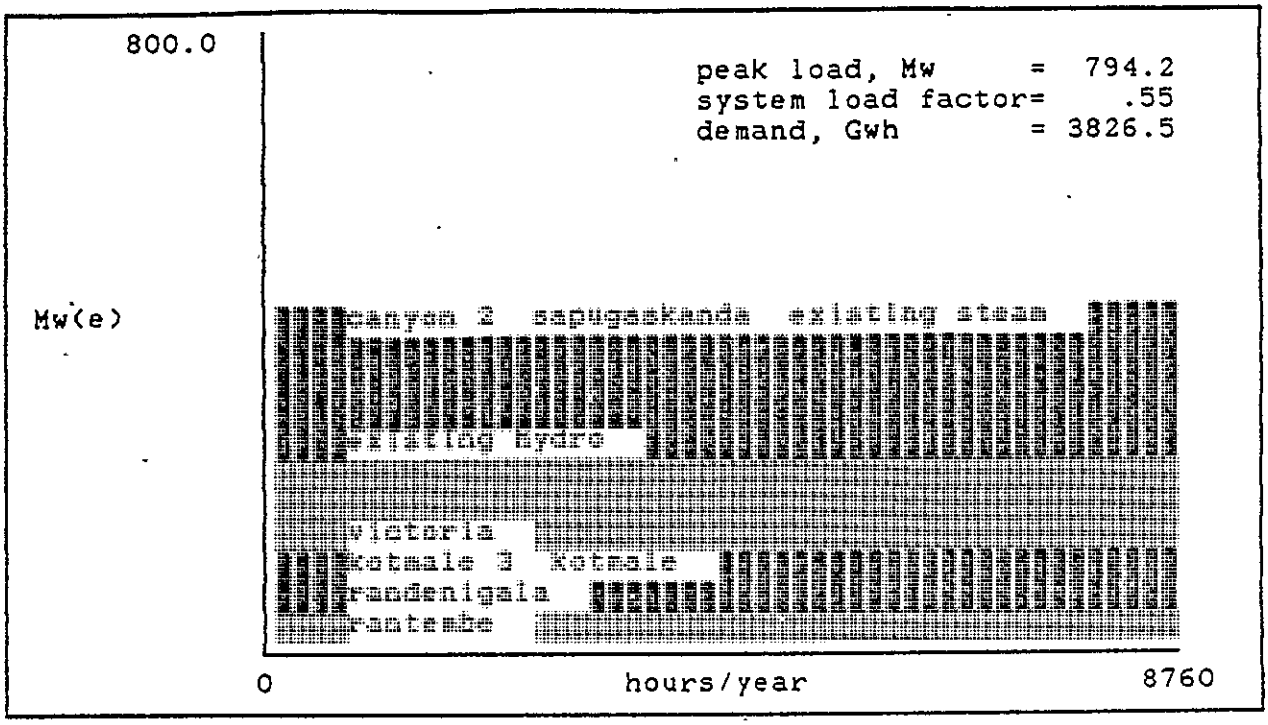
base case

may 25

merit order dispatch for 1989

plant	Mw avail.	Gwh	fuel,1000 toe	
peak				
rantembe	21.12	16.89	4.51	(hydro)
randenigala	44.52	35.62	9.50	(hydro)
kotmale 3	13.70	10.96	2.92	(hydro)
kotmale	28.31	22.65	6.04	(hydro)
victoria	87.56	70.05	18.68	(hydro)
existing hydro	182.31	145.84	38.90	(hydro)
canyon 2	2.51	2.01	.54	(hydro)
sapugaskanda	72.80	58.24	18.31	(diesel)
existing steam	36.80	29.44	9.97	(fuel oil)
existing comb.turbi	109.20	87.36	32.04	(diesel)
existing diesel	18.20	14.56	5.34	(diesel)
new gas turbines	108.00	86.40	31.69	(diesel)
total Mw	725.02			
intermediate				
rantembe	21.12	61.24	16.34	(hydro)
randenigala	44.52	129.11	34.44	(hydro)
kotmale 3	13.70	39.73	10.60	(hydro)
kotmale	28.31	82.10	21.90	(hydro)
victoria	87.56	253.92	67.73	(hydro)
existing hydro	182.31	528.69	141.03	(hydro)
canyon 2	2.51	7.28	1.94	(hydro)
sapugaskanda	60.00	174.00	54.70	(diesel)
existing steam	24.00	69.60	23.56	(fuel oil)
existing comb.turbi	12.78	37.06	13.59	(diesel)
total Mw	476.80			
base				
rantembe	21.12	106.86	28.51	(hydro)
randenigala	44.52	225.27	60.09	(hydro)
kotmale 3	13.70	69.32	18.49	(hydro)
kotmale	28.31	143.25	38.21	(hydro)
victoria	87.56	443.04	118.18	(hydro)
existing hydro	162.19	820.68	218.92	(hydro)
total Mw	357.40			
total		3771.16	1046.68	
total fuel cost			.879	

(power sector data file: power.dat)



load duration curve/plant dispatch,1989

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As can be seen from the graphic, the peak load of 794Mw is not met by this strategy. The next step, therefore, is to increase the peak period hydro dispatch until the the peak load is exactly met. Thus, on Table 2, we see that Rantembe is dispatched to its full peak period capacity, and Randenigala is increased from 44.5Mw to 82.59Mw. With these increases in peak hydro dispatch, the solution is feasible.

This solution, whilst feasible, is far from optimal. First, we note that the total energy for existing hydro is 145.84 + 528.69 + 879.84 = 1554.37, which is less than the upper limit of 1597 Gwh. Therefore, by increasing the peak period hydro, one pushes out part (or all) of the most inefficient thermal plant (in this example the gas turbines), and adding what is taken away from the base period (since more peak means less base for a hydro plant) by any hydro energy slack, or, more usually, by the next most efficient thermal plant. The objective of the algorithm is thus to displace relatively expensive plants from the peak period by increasing the dispatch of relatively efficient thermal plants in the base period.

The next sequence of tables illustrates this process. Not all tables are included: typically it takes 5-10 iterations to obtain the optimal solution. Note how thermal plants are gradually removed from the peak and intermediate periods, and replaced by the increased generation in the most efficient thermal plant (assumed here to be the Sapugaskanda diesel).

4-10

merit order dispatch for 1989

plant	Mw avail.	Gwh	fuel,1000 toe	
peak				
rantembe	57.00	45.60	12.16	(hydro)
randenigala	82.59	66.07	17.63	(hydro)
kotmale 3	13.70	10.96	2.92	(hydro)
kotmale	28.31	22.65	6.04	(hydro)
victoria	87.56	70.05	18.68	(hydro)
existing hydro	182.31	145.84	38.90	(hydro)
canyon 2	2.51	2.01	.54	(hydro)
sapugaskanda	72.80	58.24	18.31	(diesel)
existing steam	36.80	29.44	9.97	(fuel oil)
existing comb.turbi	109.20	87.36	32.04	(diesel)
existing diesel	18.20	14.56	5.34	(diesel)
new gas turbines	103.23	82.59	30.29	(diesel)
total Mw	794.21			
intermediate				
rantembe	21.12	61.24	16.34	(hydro)
randenigala	44.52	129.11	34.44	(hydro)
kotmale 3	13.70	39.73	10.60	(hydro)
kotmale	28.31	82.10	21.90	(hydro)
victoria	87.56	253.92	67.73	(hydro)
existing hydro	182.31	528.69	141.03	(hydro)
canyon 2	2.51	7.28	1.94	(hydro)
sapugaskanda	60.00	174.00	54.70	(diesel)
existing steam	24.00	69.60	23.56	(fuel oil)
existing comb.turbi	12.78	37.06	13.59	(diesel)
total Mw	476.80			
base				
rantembe	15.45	78.16	20.85	(hydro)
randenigala	38.50	194.82	51.97	(hydro)
kotmale 3	13.70	69.32	18.49	(hydro)
kotmale	28.31	143.25	38.21	(hydro)
victoria	87.56	443.04	118.18	(hydro)
existing hydro	173.88	879.84	234.70	(hydro)
total Mw	357.40			
total		3826.51	1061.07	
total fuel cost			.872	

(power sector data file: power.dat)

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merit order dispatch for 1989

plant	Mw avail.	Gwh	fuel,1000 toe	
peak				
rantembe	57.00	45.60	12.16	(hydro)
randenigala	115.90	92.72	24.73	(hydro)
kotmale 3	63.65	50.92	13.58	(hydro)
kotmale	130.15	104.12	27.77	(hydro)
victoria	135.61	108.48	28.94	(hydro)
existing hydro	182.31	145.84	38.90	(hydro)
canyon 2	.00	.00	.00	(hydro)
sapugaskanda	72.80	58.24	18.31	(diesel)
existing steam	36.80	29.44	9.97	(fuel oil)
total Mw	794.21			
intermediate				
rantembe	48.07	139.40	37.19	(hydro)
randenigala	56.86	164.89	43.99	(hydro)
kotmale 3	13.70	39.73	10.60	(hydro)
kotmale	28.31	82.10	21.90	(hydro)
victoria	87.56	253.92	67.73	(hydro)
existing hydro	182.31	528.69	141.03	(hydro)
canyon 2	.00	.00	.00	(hydro)
sapugaskanda	60.00	174.00	54.70	(diesel)
total Mw	476.80			
base				
rantembe	.00	.00	.00	(hydro)
randenigala	26.16	132.39	35.31	(hydro)
kotmale 3	5.80	29.35	7.83	(hydro)
kotmale	12.21	61.78	16.48	(hydro)
victoria	79.96	404.60	107.93	(hydro)
existing hydro	182.31	922.47	246.07	(hydro)
canyon 2	2.51	12.71	3.39	(hydro)
sapugaskanda	48.44	245.12	77.06	(diesel)
total Mw	357.40			
total		3826.51	1045.58	
total fuel cost			.780	

(power sector data file: power.dat)

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At this point, table 7, among the thermal plants only the Sapugaskanda and existing steam plants remain in the peak, and Sapugaskanda in base and intermediate blocks. In the final table, we see that the existing steam plant is also removed from the peak block, in this case by increasing the Sapugaskanda base dispatch from 48.44 to 54.26Mw.

This dispatch pattern is in fact optimal. Notice that the condition

$$X_p \geq X_i \geq X_b \geq 0$$

has been met for all thermal plants at every step of the algorithm. Any further displacement of the thermal plant in either the peak or intermediate block would result in an unchanged solution to the point at which Sapugaskanda is at its maximum base load dispatch (of Mw). Beyond this point, one would bring back into the solution some of the more inefficient thermal plants.

Finally it should be noted that the total fuel cost should decline monotonically at each step of the iteration. In this example we note that in fact the fuel cost over the last two tables has risen: this is simply a reflection of the fact that the merit order, and the sequence of plants used here, is not consistent with the actual marginal costs.

merit order dispatch for 1989

plant	Mw avail.	Gwh	fuel,1000 toe	
peak				
rantembe	57.00	45.60	12.16	(hydro)
randenigala	115.90	92.72	24.73	(hydro)
kotmale 3	63.65	50.92	13.58	(hydro)
kotmale	130.15	104.12	27.77	(hydro)
victoria	172.41	137.92	36.79	(hydro)
existing hydro	182.31	145.84	38.90	(hydro)
canyon 2	.00	.00	.00	(hydro)
sapugaskanda	72.80	58.24	18.31	(diesel)
existing steam	.00	.00	.00	(fuel oil)
total Mw	794.21			
intermediate				
rantembe	48.07	139.40	37.19	(hydro)
randenigala	56.86	164.89	43.99	(hydro)
kotmale 3	13.70	39.73	10.60	(hydro)
kotmale	28.31	82.10	21.90	(hydro)
victoria	87.56	253.92	67.73	(hydro)
existing hydro	182.31	528.69	141.03	(hydro)
canyon 2	.00	.00	.00	(hydro)
sapugaskanda	60.00	174.00	54.70	(diesel)
total Mw	476.80			
base				
rantembe	.00	.00	.00	(hydro)
randenigala	26.16	132.39	35.31	(hydro)
kotmale 3	5.80	29.35	7.83	(hydro)
kotmale	12.21	61.78	16.48	(hydro)
victoria	74.14	375.16	100.07	(hydro)
existing hydro	182.31	922.47	246.07	(hydro)
canyon 2	2.51	12.71	3.39	(hydro)
sapugaskanda	54.26	274.56	86.32	(diesel)
total Mw	357.40			
total		3826.51	1044.87	
total fuel cost			.797	

(power sector data file: power.dat)

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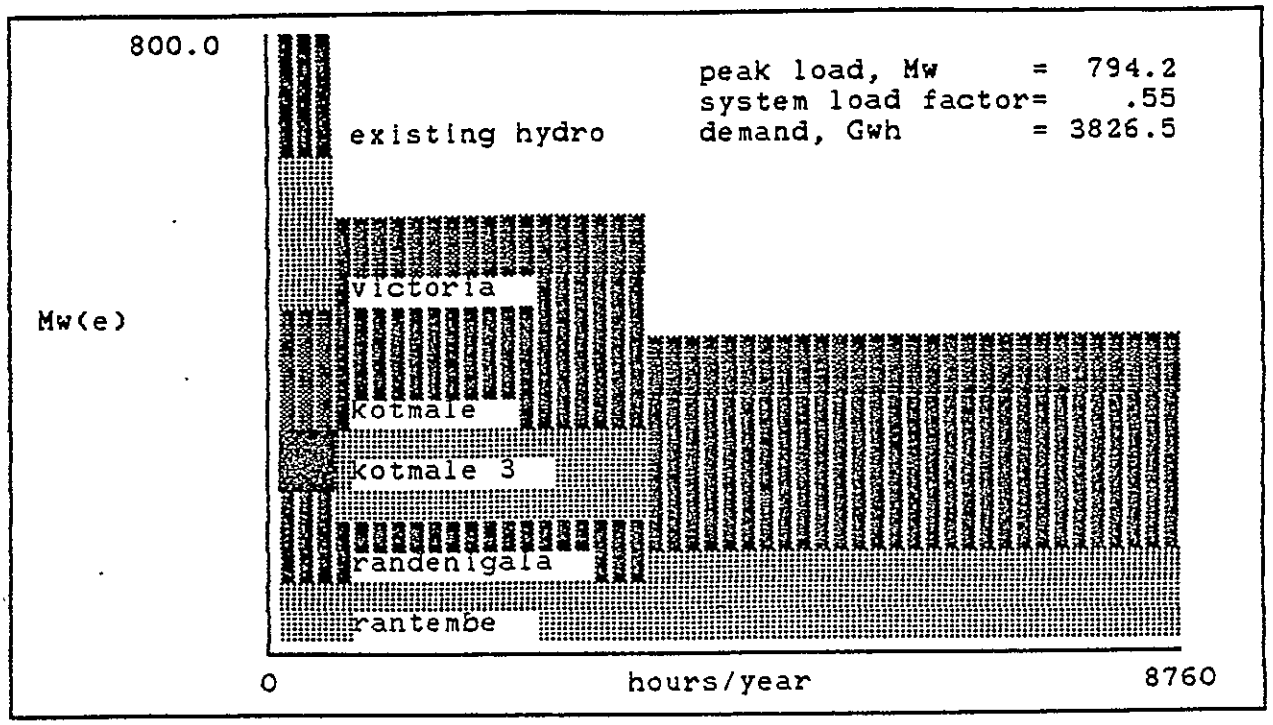

load duration curve/plant dispatch,1989

The algorithm can be speeded up by using an initial approximation, derived as follows. Let the total energy (under the load curve) be

$$E = \sum P_j \; h_j$$

Now since all of the available hydro energy will be used, calculate the balance to be supplied by the thermal plants, E

$$E^{*} = E - \sum E(max)$$

If E^{*} is negative, then the hydro energy sufficies for the entire system. If there is also sufficient installed hydro capacity to meet the peak, then the thermal plants can simply be dropped from the merit order(for that year). If the installed hydro capacity is insufficient to meet the peak, then one adds sufficient thermal plants so that the peak is met.

If E^{*} is positive, then thermal plants are needed for energy (as well as possibly for peak demand). Assume that the amount of thermal energy available from the j-th plant is

$$Z = X \text{ (inst) } (1. - BAR) \; 8.76$$

which is an underestimate, since the energy available during the peak periods will be somwehat higher to reflect only the forced outage rate(rather than both forced and scheduled). We then add sufficient energy from thermal plants until E^{*} is zero, and then add any further plants if the intalled capacity is insufficient.

This initial solution typically reduces the number of iterations necessary to find the optimum to about 4-6.

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PN-AAA 423

ENERGY PLANNING FOR DEVELOPMENT

(Phase II)

APPENDIX 3: INDONESIA REGIONAL ENERGY MODEL

September, 1985

DIRECTORATE GENERAL OF ELECTRIC POWER AND NEW ENERGY
MINISTRY OF MINES AND ENERGY
REPUBLIC OF INDONESIA

AND

ENERGY/DEVELOPMENT INTERNATIONAL
100 North Country Road
Setauket, N.Y. 11733, U.S.A.

with

INTERNATIONAL DEVELOPMENT AND ENERGY ASSOCIATES
P.T. CIPROCON

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A NOTE ON UNITS

The unit of energy production and consumption selected for the Indonesia Energy Model is the "barrel of equivalent", abbreviated "boe". For convenience, the Energy Supply/Demand Balance Model uses million barrels of oil equivalent ("mboe"), whereas the Energy Demand Model and the Regional Demand Model present outputs generally in thousand barrels of oil equivalent ("kboe").

I. INTRODUCTION

A. THE MODELLING APPROACH

The Indonesia Regional Energy Model is a regionalized simulation model designed to analyze a wide range of energy planning and policy issues. The model can be used to project future energy supply/demand balances for the country or for a region. The model is hierarchical and flexible, in that for each policy issue or regional study a special model application can be designed that best focuses on that specific issue. During the EPfD II project, several applications were designed which are described in this report. More importantly the emphasis during EPfD II was as much on training DJL personnel in becoming experts in the use of the underlying software, as in the applications themselves.

The software that runs the Indonesia Regional Energy Model is RESGEN, a set of programs written in IBM FORTRAN able to be run on a number of the IBM-PC compatible microcomputers available. The RESGEN program makes it possible for a user to create simple or complex energy supply-demand representations at the keyboard (without engaging in Fortran programming). During the EPfD II project extensive changes were made to the RESGEN program to satisfy the requirements of energy planning in Indonesia. RESGEN was then used to create the Indonesian Energy Model. A detailed manual of the RESGEN code is presented as Appendix 2 to the EPfD II project. This manual is divided into two sections. One describes the mathematical formulae and equations that can be represented by the model, together with the matrix and vector manipulation algebra involved. This section also contains a brief primer on energy systems analysis. The second part is a manual on the operation of the code proper.

The general approach of the simulation model is as follows:

- Given demographic or economic growth rates for energy consuming sectors of the economy, and the fractions by which different fuels meet those demands, a set of

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energy demands is calculated. These can be for a region, province, or the country as a whole as well as for any specific sector such as transportation, households, industry or commerce.

- Modification to energy demand patterns due to changes in prices are introduced by an econometric approach, given the long term price elasticities and changes in relative prices.

- Projected demands for fuels and electricity and constraints on production of fuels as well as energy conversion facilities yield future energy balances that result in imports and exports of fuels from a given region or for the country as a whole. A sample energy balance for a future year is shown in Exhibit I-1.

- An electric sector dispatch simulator is included that selects year by year the plants needed to meet electric demands given a load duration curve and a list of electric facilities ordered by a given criterion and year of construction.

- A refinery sector submodel specifies the amount and type of crude throughput for each existing and planned refinery, with year or start-up or shutdown, and the products out of each refinery by type of crude.

- Year by year production of all other energy forms are specified, nationally or by region: LNG, coal, wood, etc. Up to three scenarios (low, medium and high for example) can be given for selection by the analyst.

- Given c.i.f. prices for energy imports and f.o.b. prices for energy exports, the model calculates for each year the flows of foreign exchange for the energy sector commodity trade.

- Given capital costs, construction period, loan period, fraction foreign exchange and interest rate, the model will tabulate foreign exchange cash flows for all new energy facilities required during the projection period.

The model is a representation in network format of the flow of energy (or the value of this energy) through the economy, from end-user to supplier or producer. The network can be an integrated system representation of all energy forms through all processes, or one where a single fuel from (i.e., wood and wood-based energy products) is analyzed in isolation for a given region. Other segments

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EXHIBIT I-1

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 20

1992 Energy Balance Table (mboe)

	crude	arab ligh	lpg	avgas	avtur	gasoline	kerosene	ado	ido	fueloil
primary producti	580.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
imports	.00	80.00	.00	.00	4.39	.00	16.40	10.44	8.11	.00
exports	-365.10	.00	-5.49	-.03	.00	-22.15	.00	.00	.00	-.46
bunkers	.00	.00	.00	.00	-1.00	.00	.00	-.05	-.20	-1.00
stock changes	.00	.00	.00	.00	.00	.00	.03	.00	.07	.01
.subtotal	214.90	80.00	-5.49	-.03	3.39	-22.15	16.42	10.40	7.98	-1.45
refinery	-214.90	-80.00	6.93	.11	2.96	52.59	62.98	49.13	8.35	24.50
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	-4.38	-9.06
gas plant	.00	.00	.00	.00	.00	.00	-.03	.00	-.07	-.01
LNG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	-.12	.00	-.54	-.13	-.14
.total	.00	.00	1.44	.08	6.35	30.32	79.38	58.99	11.75	13.84
consumption	.00	.00	1.44	.08	6.35	30.32	79.38	58.99	11.75	13.84

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EXHIBIT I-1 (continued)

1992 Energy Balance Table (cont.): (mboe)

	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	gas	LNG	LPG exp	coal
primary producti	.00	.00	.00	.00	.00	.00	380.30	.00	.00	54.76
imports	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
exports	-4.94	-.95	-.51	-4.05	-.52	-59.21	.00	-160.00	-4.30	.00
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
stock changes	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.subtotal	-4.94	-.95	-.51	-4.05	-.52	-59.21	380.30	-160.00	-4.30	54.76
refinery	5.19	1.60	1.70	4.20	.52	59.21	.00	.00	.00	.00
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	.00	-38.55
gas plant	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00
LNG plant	.00	.00	.00	.00	.00	.00	-183.07	160.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	-4.43	.00	4.30	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	.00	-151.72	.00	.00	.00
.total	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	16.22
consumption	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	16.22

)

1992 Energy Balance Table (cont.): (mboe)

	electrici	Java-elec	hydro	geotherma	wood	agric was	total
primary producti	.00	.00	25.13	2.35	102.74	30.74	1176.02
imports	.00	.00	.00	.00	.00	.00	119.34
exports	.00	.00	.00	.00	.00	.00	-627.71
bunkers	.00	.00	.00	.00	.00	.00	-2.25
stock changes	.00	.00	.00	.00	.00	.00	.11
.subtotal	.00	.00	25.13	2.35	102.74	30.74	665.51
refinery	.00	.00	.00	.00	.00	.00	-14.92
elec generation	3.62	17.00	-18.88	-2.35	.00	.00	-52.60
gas plant	.00	.00	.00	.00	.00	.00	.05
LNG plant	.00	.00	.00	.00	.00	.00	-23.07
LPG plant	.00	.00	.00	.00	.00	.00	-.13
charc/briq	.00	.00	.00	.00	.00	.00	.00
-losses	-.72	-2.55	.00	.00	.00	.00	-155.93
.total	2.89	14.45	6.24	.00	102.74	30.74	418.90
consumption	2.89	14.45	6.24	.00	102.74	30.74	418.90

)

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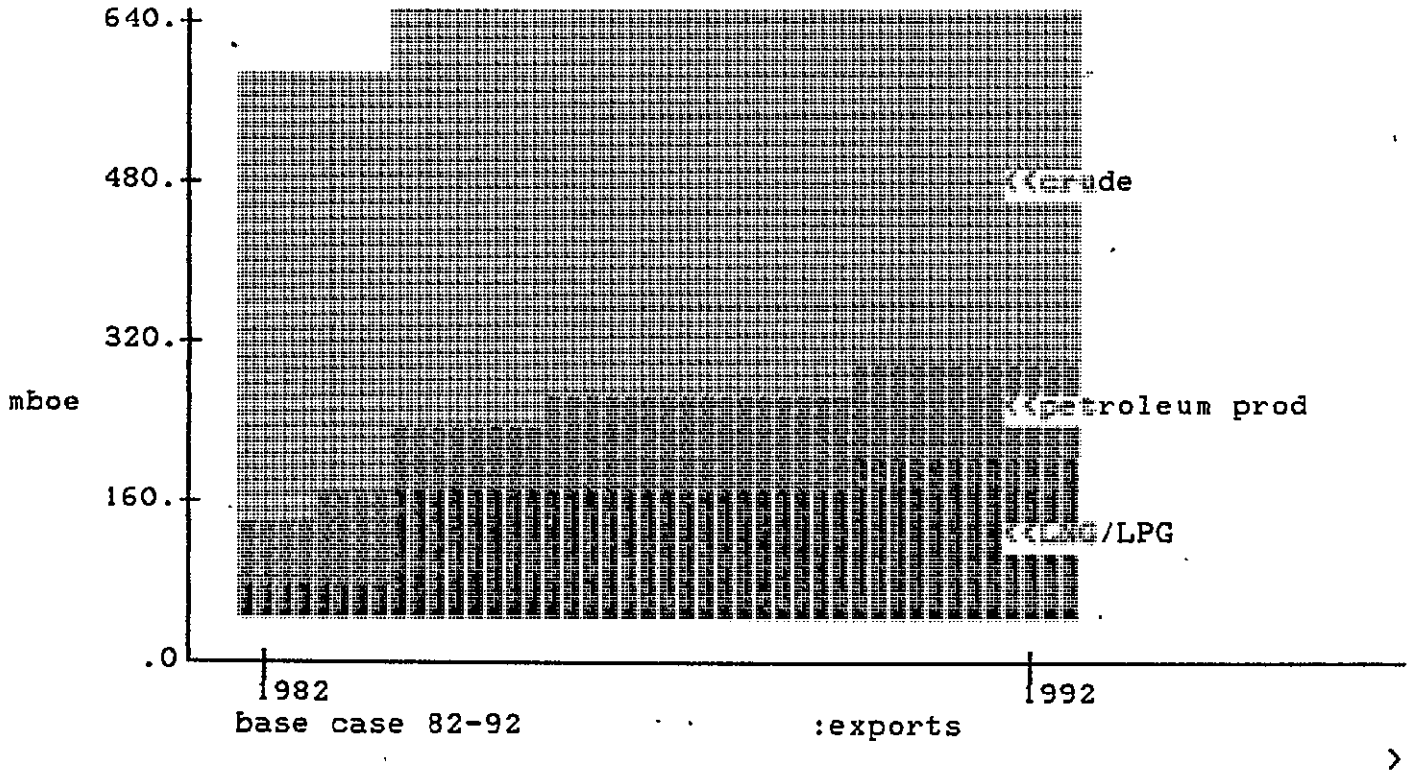
FIGURE I-1

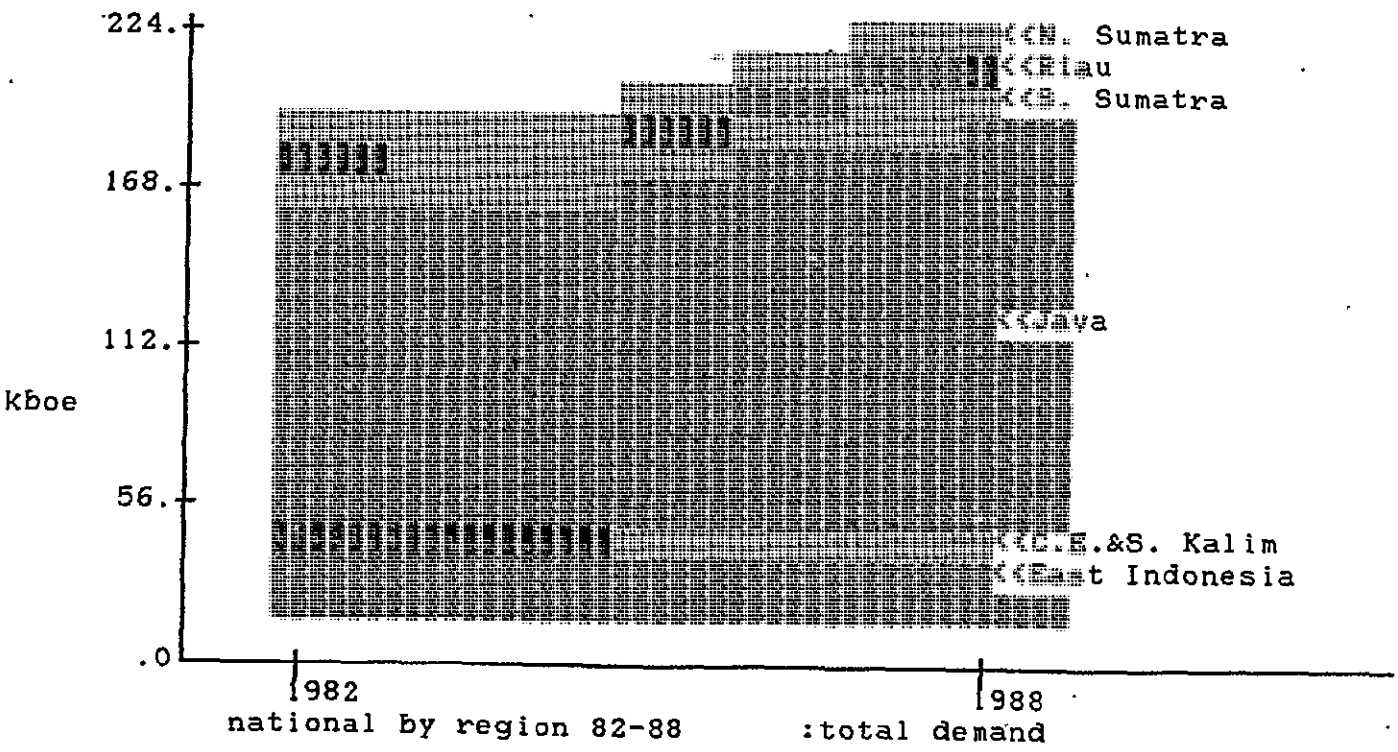


4.84

FIGURE I-2

..total demand :national by region 82-88 (mboe)

	1982	1983	1984	1985	1986	1987	1988
N. Sumatra	10.64	10.79	10.93	11.47	11.90	12.37	12.86
W. Sumatra	5.23	5.30	5.38	5.58	5.75	5.93	6.11
Riau	2.40	2.43	2.46	2.57	2.66	2.75	2.85
S. Sumatra	13.34	13.50	13.67	14.24	14.70	15.19	15.71
Java	118.66	120.33	121.99	127.77	132.48	137.44	142.80
W. Kalimantan	1.85	1.85	1.85	1.98	2.08	2.19	2.30
C.E.&S. Kalim	7.40	7.52	7.64	7.97	8.24	8.53	8.83
East Indonesia	25.52	25.38	25.22	27.21	28.60	30.08	31.67
total	185.02	187.09	189.14	198.78	206.41	214.46	223.14



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analyzed in isolation can be a regional demand sector (households) in Java, for example, or an entire region (rural Java, for example). Trade-offs must take place in the sense that a detailed network encompassing all fuel forms and all regions, for example, would generate large data requirements and lengthy computer processing time, without necessarily yielding more insights than an approach that analyses a specific issue in detail (for example regional coal demand and production) that treats other fuels in less detail. The emphasis has been one where priority is given to the design of a model that can be used often by many energy analysts, one where verification of results is straightforward and where no elements of "black box" computer modelling are present. As a simulation technique, the model is designed for easy management of numerous runs with their respective results succinctly tabulated and/or graphed for easy interpretation. Data inputs are in general as easily tabulated or graphed. Examples of graphic output and inputs are shown in Figure I-1 and Figure I-2.

Another feature of the RESGEN code is its ability to transfer output tables to the LOTUS 1-2-3 spreadsheet software. This opens for the energy model the entire range of graphics capabilities built into the LOTUS software. An example of the model output transferred to LOTUS and graphed is shown in Figure I-3.

B. THIS REPORT

The following chapters describe the application of the RESGEN code designed for the EPfD II project.

Chapter II describes the Indonesia energy model network. This network uses as a starting point a set of projected demands for final energy, and creates an energy supply/demand balance. It details the electric generation, transmission and distribution sector, the refinery sector, foreign trade, charcoal production, natural gas production and gas liquefaction sectors.

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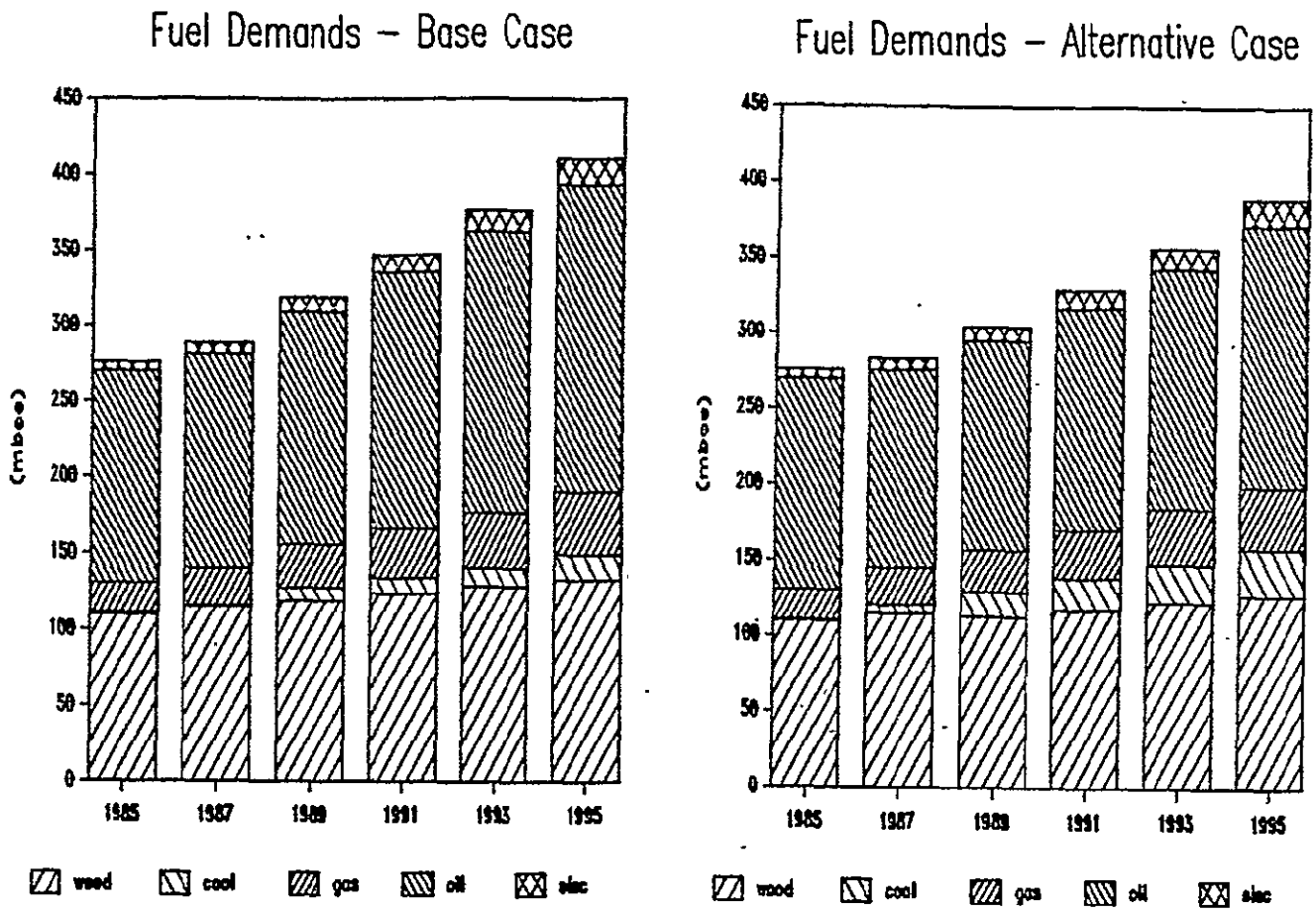
FIGURE I-3

EXAMPLE OF GRAPHIC OUTPUT
(million barrels of oil equivalent)



One of the many forms of output from an analysis using RESGEN, these figures show the effect in Indonesia of a combination of energy efficiency and coal substitution measures.

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Chapter IV presents the regional energy demand modules that use as a starting point a detailed data base for 1982 energy demand by activity, and project future demand according to economic, demographic as well as econometric parameters. The 27 provinces in the country are grouped into eight regions, as shown in Exhibit I-2. For each region, separate demand networks (or modules) have been prepared: households, transportation, industry and "other" sectors. Nearly 200 flows of energy forms to 46 energy demand activities are identified for each region. These regional demand modules serve as a regional energy demand data base as well as a regional energy demand projection tool. The 32 modules, in turn aggregated into 8 regional modules and one aggregate national energy demand module, are linked by a system of file inputs and outputs that in effect "nest" the separate networks into one national energy model.

Chapter III presents a second energy demand projection methodology, that uses the RESGEN code to create different equations to those used in the approach described in Chapter III. In many instances, policy issues to be analyzed by the model do not require the extensive sectoral and regional detail incorporated to the Indonesia Regional Energy Model, and faster execution time can be gained from a more simplified approach. This application of the RESGEN code presents a national energy demand projection that provides less subsectoral detail but emphasizes particular fuel substitution alternatives, such as natural gas and coal for petroleum products. Plans for new energy-intensive industrial facilities, for example, are explicitly listed with their respective energy demands by year and fuel types.

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EXHIBIT I-2

EPfD II REGIONS

EPfD II Regions	Provinces	PLN Regions	Pertamina Regions
Region 1	Aceh, Sumatra Utara	I, II	U.P. I
Region 2	Sumatera Barat,	III(1)	
Region 3	Riau	III(1)	
Region 4	Sumatera Selatan, Lampung, Jambi Bengkulu	IV(1)	U.P. II
Region 5	Jawa	XII, XIII Da, Db, K	U.P. III(2), U.P. IV, U.P. V(3)
Region 6	Kalimantan Barat	V	(2)
Region 7	Kalimantan Timur & Tengah & Selatan	VI	(3)
Region 8	Bali, Sulawesi, Nusa Tenggara, Muluku, Irian Jaya	VII, VIII IX, X, XI	U.P. VI, VII, VIII(3)

(1) PLN Regions III and IV overlap EPfD II Regions 3 and 4 in one district of Jambi province. EPfD II Regions 2 and 3 correspond otherwise to PLN Region III, which must be disaggregated.

(2) Kalimantan Barat included in U.P. III

(3) Pertamina Region U.P. V (East Java) includes EPfD II Region 7 and Bali (part of EPfD II Region 8).

II INDONESIA ENERGY SUPPLY/DEMAND BALANCE MODEL

A. INTRODUCTION

The Indonesia Energy Supply/Demand Balance Model is the principal application of the RESGEN code during the EPfDII project. This Supply/Demand Balance model calculates the following key outputs:

- A detailed Energy Balance for any target year, in which the columns represent primary and secondary energy forms, and the rows represent production, foreign trade, energy conversion and energy consumption.
- A table of the value of energy imports and exports detailed by fuel, for any target year.
- A table of year by year foreign exchange investment outlays for energy projects (for example in electric plants); table also prepares the year-by-year foreign exchange disbursements for interest and principal repayment on the investment outlays.
- A wide range of tabular and graphics outputs on fuel mix by consumption category, projected time series on fuel and electricity demands, projected fuel and electricity production and so on.
- By utilizing an option to transfer the results to Lotus 1.2.3., an even greater range of output representations can be achieved.

The Energy Supply/Demand Balance Model can be run with great flexibility. It draws upon a set of input data on resource production and utility expansion plans; it allows to calculate refinery throughputs according to a wide selection of options, and is "driven" by a set of energy demands chosen by the user. These features are:

- Energy Demands: the initial inputs to the model are a set of energy demands. These demands, calculated with other applications of the RESGEN code (see Chapters III and IV), are selected by the user from a menu.
- Electricity Expansion Plans: information on PLN's capacity expansion plan is stored in outside files. They contain name of the project, year of implementation, MW, thermal efficiency and other

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technical data such as forced outage rates. Associated with this list is a file that contains the investment cost of each plant (year by year during the construction period), and other financial data on the expansion plan. The model has been designed to distinguish between the Java and non-Java systems. It can also be made to run for any of the eight Indonesian regions identified in the EPfDII project.

The model also allows to select the data file containing the information on PLN's expansion plan. If two versions of a plan exist, corresponding to different scenarios or alternatives, stored in their respective datafile, the model will permit the user to select which alternative plan it wants to use in a particular run of the model.

- Resource Production Scenarios: the Energy Supply/Demand Balance model has been designed to require as inputs information of year by year production of key domestic energy resources, such as crude oil, and major commodities such as LNG produced under long-term contracts in liquefaction facilities. Because of the uncertainty associated with future resource production, the model allows the user to select from three scenarios (high, medium, low) for each resource. These scenarios appear on the screen graphically at the point during the execution of the model in which it queries the user for a scenario selection.

- Refinery Production: the model simulates the operation of the refinery sector according to a wide range of options. One option the user can select is to predetermine the amount of crude to be processed in each Indonesian refinery (including Singapore Processing Deal). The model will calculate refinery output according to the technical configuration of each refinery. A second option is to select one product, for example kerosene; the model will determine crude throughput required to meet kerosene demand, and all other products are then either imported or exported to achieve the balance between demand and available supply.

B. ENERGY SUPPLY/DEMAND NETWORK FILE

This section presents the detailed configuration of the RESGEN network file that is used as input to the Energy Supply/Demand Balance model. It also details all external files called by the network file.

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The reader should refer to the RESGEN Model Description and Program Documentation (Appendix 2) for a description of the terms used in this section.

1. Data Tables 1 - 3: Reading in the Demand File (Exhibit II-1)

Data Table 1 simply serves to define the 25 fuels that have been selected to represent Indonesia's energy balance. Data Table 2 is a demand type file that reads in an external file that contains the energy demand projections used in the run. The default filename is INDODEM.INT; additional files containing optional demand projection scenarios can be selected from a menu during a RESG execution. These values are entered into the "consumption" row of the Energy Balance. Data Table 3 adds into the main network branch the demand projections read in from the outside file.

2. Data Tables 4 - 6: Adding Bunker Fuels to the Energy Balance (Exhibit II-2)

Bunker sales to foreign vessels and aircraft must be added to domestic demand in order to obtain total internal fuel requirements in the country. Levels of bunker sales are read in from an external file BUNKERS.DAT (Exhibit II-3), and entered into the "bunkers" row of the energy balance (as a negative number) as shown in data table 4. Note that these data tables can also be used to model electricity imports or exports (as a national level between Indonesia and Singapore or Malaysia, or between regions). The value of this electricity trade would have to be entered exogenously in the BUNKERS.DAT file.

Data table 5 makes reference to the prices of the bunker fuels traded by calling the external file BUNKPR.DAT (Exhibit II-4) and the resulting values (quantity times unit price) are automatically entered into the Current Account Balance table (Exhibit II-5).

3. Data Table 7: Electricity T&D Losses (Exhibit II-6)

Transmission and distribution losses are calculated in this sequence. Data is entered into data table 7 as 1 minus the fractional loss, i.e., a 15 percent loss in the Java system is entered as 0.85,

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EXHIBIT II-1

```
 1:*   labels.dat            balplot.dat
 2:    1----------2----------3----------4---------
 3: Energy Supply/Demand Balance Network
 4: ***********************************************
 5: data table  1
 6: ***********************************************
 7: projection
 8: matrix name =initialization
 9: matrix size =25  0        .00
10: none        = 1 25
11: none
12:
13: -- ------------------- -------------------
14:  1 Java-electr                .000
15:  2 electricity                .000
16:  3 lpg                        .000
17:  4 avgas                      .000
18:  5 avtur                      .000
19:  6 gasoline                   .000
20:  7 ado                        .000
21:  8 ido                        .000
22:  9 kerosene                   .000
23: 10 fueloil                    .000
24: 11 petrochems                 .000
25: 12 lubes/waxes                .000
26: 13 asphalt                    .000
27: 14 petr coke                  .000
28: 15 gas                        .000
29: 16 charcoal                   .000
30: 17 wood                       .000
31: 18 agric wastes               .000
32: 19 coal                       .000
33: 20 coke                       .000
34: 21 solar-pv                   .000
35: 22 solar                      .000
36: 23 biogas                     .000
37: 24 wind                       .000
38: 25 hydro                      .000
39: ***********************************************
40: data table  2
41: ***********************************************
42: demand
43: matrix name =data=def=indodem.int
44: matrix size =25  0        .00
45: consumption =01 25
46: none
47:
48: -- ------------------- -------------------
49:  1 Java-electr                .000
50:  2 electricity                .000
51:  3 lpg                        .000
52:  4 avgas                      .000
53:  5 avtur                      .000
54:  6 gasoline                   .000
55:  7 ado                        .000
56:  8 ido                        .000
57:  9 kerosene                   .000
58: 10 fueloil                    .000
59: 11 petrochems                 .000
60: 12 lubes/waxes                .000
61: 13 asphalt                    .000
62: 14 petr coke                  .000
63: 15 gas                        .000
64: 16 charcoal                   .000
65: 17 wood                       .000
66: 18 agric wastes               .000
67: 19 coal                       .000
68: 20 coke                       .000
69: 21 solar-pv                   .000
70: 22 solar                      .000
71: 23 biogas                     .000
72: 24 wind                       .000
73: 25 hydro                      .000
74: ***********************************************
75: data table  3
76: ***********************************************
77: addition
78: consis.check= 0
79: matrix name =add demand
80: output name =total demand
81: output units=
82: matrix size =25 25        .00
83: none        =
84: none
85:
86: -- ------------------- -- ------------------- -------
```


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EXHIBIT II-2

```
87: ****************************************************************
88: data table  4
89: ****************************************************************
90: supply=table
91: matrix name =elec imp/exp,bunkers
92: matrix size = 7  0        .00
93: -bunkers    = 1  7
94: none
95:    mboe
96: -- ------------------- -------------------
97:  1 Java-electr                .000 bunkers.dat
98:  2 electricity                .000 bunkers.dat
99:  3 avgas                      .000 bunkers.dat
100:  4 avtur                     .000 bunkers.dat
101:  5 ado                       .000 bunkers.dat
102:  6 ido                       .000 bunkers.dat
103:  7 fueloil                   .000 bunkers.dat.
104: ****************************************************************
105: data table  5
106: ****************************************************************
107: price
108: consis.check= 0
109: matrix name =bunkpr.dat
110: output name =bunker sales
111: output units=bill U.S.$
112: matrix size = 7  7      .00   0   0
113: -bunkers    = 1  7 barch=
114: none        = 0  0 barch=
115:
116: -- ------------------- -- ------------------- ----------
117: ****************************************************************
118: data table  6
119: ****************************************************************
120: addition
121: consis.check= 0
122: matrix name =add bunkers
123: output name =total demand
124: output units=mboe
125: matrix size =25 25        .00
126: none        = 1 25 barch=02/ov/reg=01/01,01
127: none               barch=02/ov/reg=02/02,02
128:
129: -- ------------------- -- ------------------- ----------
```


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EXHIBIT II-3

Future bunkers, elec imp/exports .

year	avgas	avtur	ado	ido	fueloil	Java-ele	electric
1982	.0036	.978	.046	.2	.981	0	0
1983	.0016	.719	.046	.174	1.07		
1984	.0015	1.	.05	.2	1.		
1985	.0015	1.	.05	.2	1.		0
1986	.0015	1.	.05	.2	1.		
1987	.0015	1.	.05	.2	1.		
1988	.0015	1.	.05	.2	1.		
1989	.0015	1.	.05	.2	1.		
1990	.0015	1.	.05	.2	1.		
1991	.0015	1.	.05	.2	1.		
1992	.0015	1.	.05	.2	1.		
1993	.0015	1.	.05	.2	1.		
1994	.0015	1.	.05	.2	1.		
1995	.0015	1.	.05	.2	1.		
1996	.0015	1.	.05	.2	1.		
1997	.0015	1.	.05	.2	1.		
1998	.0015	1.	.05	.2	1.		
1999	.0015	1.	.05	.2	1.		
2000	.0015	1.	.05	.2	1.		
2001	.0015	1.	.05	.2	1.		
2002	.0015	1.	.05	.2	1.		
2003	.0015	1.	.05	.2	1.		
2004	.0015	1.	.05	.2	1.		
2005	.0015	1.	.05	.2	1.		

EXHIBIT II-4

bunker prices bunkpr.dat

fuel	import	export	growth
Java-electr	150.00	150.00	1.00
electricity	150.00	150.00	1.00
avgas	38.00	38.00	1.00
avtur	32.00	32.00	1.00
ado	22.00	22.00	1.00
ido	30.00	30.00	1.00
fueloil	25.00	25.00	1.00

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EXHIBIT II-5

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 20

1992 current account table (US $bill)

	Java-elec	electrici	avgas	avtur	ado	ido	fueloil	LNG	LPG exp	crude
imports	.00	.00	.00	.14	.23	.24	.00	.00	.00	.00
exports	.00	.00	.00	.00	.00	.00	-.01	-10.75	-.15	-10.22
bunkers	.00	.00	.00	-.03	.00	-.01	-.02	.00	.00	.00
.net	.00	.00	.00	.11	.23	.23	-.03	-10.75	-.15	-10.22

1992 current account table (cont.): (US $bill)

	arab ligh	lpg	gasoline	kerosene	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	total
imports	1.76	.00	.00	.57	.00	.00	.00	.00	.00	.00	2.35
exports	.00	-.29	-.74	.00	-.10	-.02	.00	-.06	-.02	-1.69	-24.05
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-.06
.net	1.76	-.29	-.74	.57	-.10	-.02	.00	-.06	-.02	-1.69	-21.17

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and 20 percent loss for all systems outside Java as 0.80. The output of this step is electricity generation; these values are sent to the "elec generation" row of the Energy Balance. The difference between electricity generation and electricity consumption (i.e., the amount of T&D loss) is automatically entered in the "loss" row of the Energy Balance; this instruction is read off file BALSYM.DAT (Exhibit II-7).

4. Data Tables 8 - 10: Electricity Generation (Exhibit II-8)

Electricity generation requirements are met by existing and new electric plants dispatched according to the optimization routine embedded into the RESGEN code. The fuel requirements for electricity generation are then added to all other fuel requirements in data table 10.

Two operators of the type electric are used in the model, one for the Java system and the other for outside Java. For Java (data table 8) the model refers to the external file POWER1.DAT, which contains a list of existing and new power plants obtained from PLN (Exhibit II-9). Similarly file POWER2.DAT lists plants outside Java (Exhibit II-10). Note that column 7 contains a number from 001 to 008 to denote the region. To run the model for one specific region, enter the region number in the fourth field of the "matrix size" row of the electric operator. If value is 0 (as shown) all plants in the list will be used.

The order of plants in the list is crucial to the dispatch algorithm, since the merit order searches according to the following parameters:

- Year of availability
- Thermal efficiency
- Order on the list

Therefore, after the code selects the most efficient plants available in a particular year, it dispatches plants according to their order on the list. The dispatch algorithm also uses as inputs the shape of the load duration curve stored in file LOAD.DAT (Exhibit

EXHIBIT II-6

```
130: ****************************************************************
131: data table  7
132: ****************************************************************
133: diagonal
134: consis.check= 3
135: matrix name =efficiency/t&d
136: output name =generation requireme
137: output units=mboe
138: matrix size =25 25        .00
139: elec generat= 1  2 barch=02/ov/reg=01/99,99/01,01
140: none               barch=02/ov/reg=02/99,99/02,02
141:    electr sold                 electr generated     fraction
142: -- -------------------- -- -------------------- ----------
143:  1 Java-electr           1 Java-electr                .850
144:  2 electricity           2 electricity                .800
145: 99                      99                            .000
```

EXHIBIT II-7

```
balance table adjustaents
*****************************************************************
code          item
l----------   l----------------------e
-losses       misc. losses
              t+d losses
consumption   consumption
imports       imports
exports       exports
electricity   electricity
```


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EXHIBIT II-8

```
146: ***********************************************************
147: data table  8
148: ***********************************************************
149: electric
150: consis.check= 0
151: matrix name =power1.dat
152: output name =java fuels/electric
153: output units=mboe
154: matrix size =31 25  1611.10   0   0
155: -elec genera= 1  7 barch=03/ov/reg=01/01,01/02,02/03,03/04,06
156: none        = 0  0 barch=
157:    java electricity        java fuels to electr
158: -- -------------------- -- -------------------- ----------
159:  1 electr Java           1 hydro                  1.000
160:  1 electr Java           2 geothermal             1.000
161:  1 electr Java           3 coal                   1.000
162:  1 electr Java           4 fueloil                1.000
163:  1 electr Java           5 ado                    1.000
164:  1 electr Java           6 ido                    1.000
165:  1 electr Java           7 nuclear                1.000
166:  2 electricity           8 electricity            1.000
167:  3 lpg                   9 lpg                    1.000
168:  4 avgas                10 avgas                  1.000
169:  5 avtur                11 avtur                  1.000
170:  6 gasoline             12 gasoline               1.000
171:  7 ado                  13 ado                    1.000
172:  8 ido                  14 ido                    1.000
173:  9 kerosene             15 kerosene               1.000
174: 10 fueloil              16 fueloil                1.000
175: 11 petrochems           17 petrochems             1.000
176: 12 lubes/waxes          18 lubes/waxes            1.000
177: 13 asphalt              19 asphalt                1.000
178: 14 petr coke            20 petr coke              1.000
179: 15 gas                  21 gas                    1.000
180: 16 charcoal             22 charcoal               1.000
181: 17 wood                 23 wood                   1.000
182: 18 agric wastes         24 agric wastes           1.000
183: 19 coal                 25 coal                   1.000
184: 20 coke                 26 coke                   1.000
185: 21 solar-pv             27 solar-pv               1.000
186: 22 solar                28 solar                  1.000
187: 23 biogas               29 biogas                 1.000
188: 24 wind                 30 wind                   1.000
189: 25 hydro                31 hydro                  1.000
```

```
190: ***********************************************************
191: data table  9
192: ***********************************************************
193: electric
194: consis.check= 0
195: matrix name =power2.dat
196: output name =non-java fuels/elec
197: output units=
198: matrix size =36 31  1611.00   0   0
199: -elec genera= 8 13 barch=03/ov/reg=02/08,08/09,09/10,10/11,13
200: none        = 0  0 barch=
201:
202: -- -------------------- -- -------------------- ----------
203:  1 hydro                1 hydro                  1.000
204:  2 geothermal           2 geothermal             1.000
205:  3 coal                 3 coal                   1.000
206:  4 fueloil              4 fueloil                1.000
207:  5 ado                  5 ado                    1.000
208:  6 ido                  6 ido                    1.000
209:  7 nuclear              7 nuclear                1.000
210:  8 electricity          8 hydro                  1.000
211:  8 electricity          9 geothermal             1.000
212:  8 electricity         10 coal                   1.000
213:  8 electricity         11 fueloil                1.000
214:  8 electricity         12 ado                    1.000
215:  8 electricity         13 ido                    1.000
216:  9 lpg                 14 lpg                    1.000
217: 10 avgas               15 avgas                  1.000
218: 11 avtur               16 avtur                  1.000
219: 12 gasoline            17 gasoline               1.000
220: 13 ado                 18 ado                    1.000
221: 14 ido                 19 ido                    1.000
222: 15 kerosene            20 kerosene               1.000
223: 16 fueloil             21 fueloil                1.000
224: 17 petrochems          22 petrochems             1.000
225: 18 lubes/waxes         23 lubes/waxes            1.000
226: 19 asphalt             24 asphalt                1.000
227: 20 petr coke           25 petr coke              1.000
228: 21 gas                 26 gas                    1.000
229: 22 charcoal            27 charcoal               1.000
230: 23 wood                28 wood                   1.000
231: 24 agric wastes        29 agric wastes           1.000
232: 25 coal                30 coal                   1.000
233: 26 coke                31 coke                   1.000
234: 27 solar-pv            32 solar-pv               1.000
235: 28 solar               33 solar                  1.000
236: 29 biogas              34 biogas                 1.000
237: 30 wind                35 wind                   1.000
238: 31 hydro               36 hydro                  1.000
```


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EXHIBIT II - 8 (cont)

```
239: ****************************************************************
240: data table 10
241: ****************************************************************
242: aggregate
243: consis.check= 0
244: matrix name =add fuels/elec
245: output name =demand
246: output units=mboe
247: matrix size =28 28      .00   0   0
248: none        = 1 28 barch=
249: none        = 0  0 barch=
250:
251: -- -------------------- -- -------------------- ----------
252:  1 lpg                  0                          .000
253:  2 avgas                0                          .000
254:  3 avtur                0                          .000
255:  4 gasoline             0                          .000
256:  5 kerosene             0                          .000
257:  6 ado                  0                          .000
258:  7 ido                  0                          .000
259:  8 fueloil              0                          .000
260:  9 petrochems           0                          .000
261: 10 lubes/waxes          0                          .000
262: 11 asphalt              0                          .000
263: 12 petr coke            0                          .000
264: 13 gas                  0                          .000
265: 14 LNG                  0                          .000
266: 15 LPG exp              0                          .000
267: 16 coal                 0                          .000
268: 17 bat muda             0                          .000
269: 18 coke                 0                          .000
270: 19 hydro                0                          .000
271: 20 geothermal           0                          .000
272: 21 nuclear              0                          .000
273: 22 charcoal             0                          .000
274: 23 wood                 0                          .000
275: 24 agric wastes         0                          .000
276: 25 biogas               0                          .000
277: 26 solar-pv             0                          .000
278: 27 solar                0                          .000
279: 28 wind                 0                          .000
```


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EXHIBIT II-9

power sector file

year	fuel	plant	mw	b-a	gwh	eff.		p-a
1---	1-------	1----------	R----	r---	R-----	r---	1--	r--e
1982	hydro	java/exist hydro	437.		1600.	.33	005	.90
1982	hydro	hydro purchase	125.		600.	.33	005	.90
1985	hydro	saguling 1-2-3-4	700.		2800.	.33	005	.95
1989	hydro	senggaruh	23.		70.	.33	005	.95
1993	hydro	jatidege	175.		600.	.33	005	.95
1988	hydro	cirata I, 1-2-3-4	500.		2000.	.33	005	.95
1989	hydro	k.umbo	23.		70.	.33	005	.95
1989	hydro	tulung angung	30.		100.	.33	005	.95
1990	hydro	kesamben	33.		100.	.33	005	.95
1990	hydro	arica	180.		700.	.33	005	.95
1984	coal	suralaya 1	400.	.80		.33	005	.90
1985	coal	suralaya 2	400.	.80		.33	005	.90
1990	coal	suralaya 3-4	800.	.80		.33	005	.90
1995	coal	suralaya 5-6	800.	.80		.33	005	.90
1991	coal	paiton 1	400.	.80		.33	005	.90
1992	coal	paiton 2	400.	.80		.33	005	.90
1994	coal	paiton 3	400.	.80		.33	005	.90
1996	coal	paiton 4	400.	.80		.33	005	.90
1982	geotherm	java/exist geotherm	30.	.80		.33	005	.90
1987	geotherm	kamojang 2-3	110.	.80		.33	005	.90
1990	geotherm	salak 1	55.	.80		.33	005	.90
1992	geotherm	salak 2,dieng 1-2	165.	.80		.33	005	.90
1992	geotherm	drajat1-2	110.	.80		.33	005	.90
1982	fueloil	java/exist steam	1306.	.60		.25	005	.90
1995	ado	comb.cycle	100.	.40		.26	005	.90
1988	fueloil	gresik 3	200.	.60		.33	005	.90
1989	fueloil	gresik 4	200.	.60		.33	005	.90
1982	ado	java/exist.comb.turb	735.	.40		.20	005	.90
1982	ido	java/exist diesel	69.	.60		.20	005	.90

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EXHIBIT II-10

power sector file

year	fuel	plant	mw	b-a	gwh	eff.		p-a
1---	1-------	1----------	R----	r---	R-----	r---	1--	r--e
1982	hydro	exist hydro 02_3	11.		33.	.33	002	.95
1982	hydro	exist hydro 04	1.		4.	.33	004	.95
1982	hydro	exist hydro 07	30.		120.	.33	007	.95
1982	hydro	exist hydro 08	17.		68.	.33	008	.95
1993	hydro	asahan I 1	90.		350.	.33	001	.95
1994	hydro	asahan I 2	90.		350.	.33	001	.95
1988	hydro	tes	16.		64.	.33	004	.95
1991	hydro	p.kembayung 1	10.		30.	.33	006	.95
1992	hydro	p.kembayung 2-3	20.		40.	.33	006	.95
1987	hydro	tanggari I, 1-2	17.		60.	.33	008	.95
1989	hydro	tanggari II	19.		67.	.33	008	.95
1991	hydro	bakuru 1,2	126.		390.	.33	008	.95
1992	hydro	sentani I, 1-2	13.		45.	.33	008	.95
1992	hydro	riam kiwa	42.		165.	.33	007	.95
1995	hydro	musi	34.		150.	.33	004	.95
1995	hydro	besai	31.		150.	.33	004	.95
1994	hydro	singkarak 1-2	100.		350.	.33	003	.95
1995	hydro	singkarak 3-4	100.		350.	.33	003	.95
1996	hydro	renun	90.		325.	.33	001	.95
1986	coal	bukit assam 1-2	130.	.80		.33	004	.90
1990	coal	ombilin 1-2	100.	.80		.33	003	.90
1996	coal	ombilin 3-4	100.	.80		.33	003	.90
1993	coal	tarahan I	50.	.80		.33	004	.90
1984	fueloil	belawan 1-2	130.	.60		.28	001	.90
1990	fueloil	belawan 3-4	130.	.60		.28	001	.90
1982	fueloil	exist steam	25.	.60		.25	004	.90
1982	fueloil	exist steam	25.	.60		.25	008	.90
1982	ido	exist ido/01	109.	.60		.25	001	.90
1982	ido	exist ido/02_3	66.	.60		.25	002	.90
1982	ido	exist ido/04	77.	.60		.25	004	.90
1982	ido	exist ido/06	29.	.60		.25	006	.90
1982	ido	exist ido/07	82.	.60		.25	007	.90
1982	ido	exist ido/08	230.	.60		.25	008	.90
1982	ido	misc. ido (non java)	1100.	.60		.25	002	.90
1982	ado	exist comb.turb 01	104.	.40		.20	001	.90
1982	ado	exist comb.turb 02_3	21.	.40		.20	002	.90
1982	ado	exist comb.turb 04	43.	.40		.20	004	.90
1982	ado	exist comb.turb 08	14.	.40		.20	008	.90
1985	ado	denpasar	20.	.40		.25	008	.90
1993	coal	loakulu 1	50.	.80		.33	007	.90
1994	coal	loakulu 2	50.	.80		.33	007	.90
1994	coal	banjarmasin	50.	.80		.33	007	.90
1995	coal	banjarmasin 2	50.	.80		.33	007	.90

EXHIBIT II-11

load duration curve

f	hours	segment
r---	R-----	1----------e
.45	6000.	base
.55	2000.	intermediate
1.00	760.	peak
.59		system load f.

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II-11). A sample output of the model for this segment is shown in Exhibit II-12.

Fuel inputs to electric generation are sent to the Energy Balance for the appropriate rows in data tables 8 and 9 by entering "elec generation" with a negative sign. Fuels are expressed in million barrels of oil equivalent (mboe); hydropower and geothermal are expressed in fuel equivalent utilizing a thermal efficiency of 0.33. The unit conversion between gWh and the units chosen for the Energy Balance Table is entered in the third field of the "matrix size" row: 1 mboe (e) ≈ 1611.1 gWh.

The investment costs of the new power plants selected by the model are summarized at the end of the execution of the program. To view the table, select "payments balance" at the appropriate prompt. The information on electric plant investments is stored in file COSTLIST.DAT (Exhibit II-12A). The information is entered in two rows. In the first row column 1 contains total investment in US$ (million), column 2 the fraction of total investment that is in foreign exchange, column 3 the loan period (20 years) and column 4 the interest rate (12% per year is shown). The second row shows the fraction of total investment disbursed during each year of construction for up to 7 years. The fractions need not add to unity. The data displayed here is used in the model; it was obtained from PLN.

5. Data Tables 11 - 14: City Gas (Exhibit II-13)

There are about half a dozen cities in Indonesia served by city gas provided by the PGN Gas Company. PGN supplies three cities with natural gas, and the others with city gas manufactured from ido and fuel oil. PGN also reports use of kerosene. The total feedstock requirements of PGN are extremely small when compared to Indonesia's total demand for gas in fertilizer, steel and cement plants. Moreover, the future use of feedstocks by PGN Gas will probably remain stable unless a major investment program in gas distribution lines is undertaken. Therefore, the model has been designed such that the

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EXHIBIT II-12

merit order dispatch for 1992

plant	Mw avail.	Gwh	fuel,mboe	
peak				
java/exist hydro	393.30	298.91	.62	(hydro)
hydro purchase	112.50	85.50	.18	(hydro)
saguling 1-2-3-4	665.00	505.40	1.05	(hydro)
senggaruh	27.55	20.94	.04	(hydro)
cirata I, 1-2-3-4	475.00	361.00	.75	(hydro)
k.umbo	21.85	16.61	.03	(hydro)
tulung angung	28.50	21.66	.04	(hydro)
kesamben	31.35	23.83	.05	(hydro)
mrica	171.00	129.96	.27	(hydro)
suralaya 1	360.00	273.60	.57	(coal)
suralaya 2	360.00	273.60	.57	(coal)
suralaya 3-4	720.00	547.20	1.13	(coal)
paiton 1	360.00	273.60	.57	(coal)
paiton 2	360.00	273.60	.57	(coal)
java/exist geotherm	27.00	20.52	.04	(geothermal)
kamojang 2-3	99.00	75.24	.16	(geothermal)
salak 1	49.50	37.62	.08	(geothermal)
salak 2,dieng 1-2	148.50	112.86	.23	(geothermal)
drajati-2	99.00	75.24	.16	(geothermal)
java/exist steam	791.68	601.68	1.87	(fueloil)
total Mw	5300.73			
intermediate				
java/exist hydro	393.30	786.60	1.63	(hydro)
hydro purchase	112.50	225.00	.47	(hydro)
saguling 1-2-3-4	665.00	1330.00	2.75	(hydro)
senggaruh	24.53	49.06	.10	(hydro)
cirata I, 1-2-3-4	475.00	950.00	1.97	(hydro)
k.umbo	21.85	43.70	.09	(hydro)
tulung angung	28.50	57.00	.12	(hydro)
kesamben	31.35	62.70	.13	(hydro)
mrica	171.00	342.00	.71	(hydro)
suralaya 1	320.00	640.00	1.32	(coal)
suralaya 2	320.00	640.00	1.32	(coal)
suralaya 3-4	640.00	1280.00	2.65	(coal)
paiton 1	320.00	640.00	1.32	(coal)
paiton 2	320.00	640.00	1.32	(coal)
java/exist geotherm	24.00	48.00	.10	(geothermal)
kamojang 2-3	88.00	176.00	.36	(geothermal)
salak 1	44.00	88.00	.18	(geothermal)
salak 2,dieng 1-2	132.00	264.00	.55	(geothermal)
drajati-2	88.00	176.00	.36	(geothermal)
java/exist steam	308.85	617.70	1.92	(fueloil)
total Mw	4527.88			
base				
java/exist hydro	85.75	514.49	1.06	(hydro)
hydro purchase	48.25	289.50	.60	(hydro)
saguling 1-2-3-4	160.77	964.60	2.00	(hydro)
senggaruh	.00	.00	.00	(hydro)
cirata I, 1-2-3-4	114.83	689.00	1.43	(hydro)
k.umbo	1.62	9.69	.02	(hydro)
tulung angung	3.56	21.34	.04	(hydro)
kesamben	2.25	13.47	.03	(hydro)
mrica	38.01	228.04	.47	(hydro)
suralaya 1	320.00	1920.00	3.97	(coal)
suralaya 2	320.00	1920.00	3.97	(coal)
suralaya 3-4	640.00	3840.00	7.94	(coal)
paiton 1	320.00	1920.00	3.97	(coal)
paiton 2	320.00	1920.00	3.97	(coal)
java/exist geotherm	10.30	61.82	.13	(geothermal)
total Mw	2385.33			
total		27396.28	57.94	
total fuel cost			.082	

(power sector data file: power1.dat)

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EXHIBIT II - 12A

PLN Investment Plan

plant	1	2	3	4	5	6	7
suralaya 1	.000	.00	20.000	.12			
suralaya 1							
suralaya 2	.00	.00	20.00	.00			
suralaya 2							
suralaya 3-4	403.80	.76	20.00	.12			
suralaya 3-4	12.60	23.77	35.07	15.40	7.10	6.50	
suralaya 5-6	652.00	.70	20.00	.12			
suralaya 5-6	6.50	21.50	33.50	23.50	10.00	5.00	
paiton 1	325.40	.70	20.00	.12			
paiton 1	6.52	16.53	28.58	28.58	15.03	5.00	
paiton 2	325.40	.70	20.00	.12			
paiton 2	6.52	16.53	28.58	28.58	15.03	5.00	
paiton 3	325.40	.70	20.00	.12			
paiton 3	6.52	16.53	28.58	28.58	15.03	5.00	
paiton 4	325.40	.70	20.00	.12			
paiton 4	6.52	16.53	28.58	28.58	15.03	5.00	
kamojang 2-3	64.80	.75	20.00	.12			
kamojang 2-3	48.45	20.30	6.90	1.80			
salak 1	27.80	.77	20.00	.12			
salak 1	6.11	21.22	33.81	23.74	9.70	5.00	
salak 2,dieng 1-2	83.40	.77	20.00	.12			
salak 2,dieng 1-2	6.11	21.22	33.81	23.74	9.70	5.00	
drajat1-2	55.60	.77	20.00	.12			
drajat1-2	6.11	21.22	33.81	23.74	9.70	5.00	
saguling 1-2-3-4	301.00	.65	20.00	.12			
saguling 1-2-3-4	56.30	43.70					
senggaruh	74.10	.64	20.00	.12			
senggaruh	8.50	35.76	39.27	8.63	7.84		
jatidege	203.30	.69	20.00	.12			
jatidege	3.25	8.00	12.10	21.64	30.05	25.00	
cirata I, 1-2-3-4	528.30	.54	20.00	.12			
cirata I, 1-2-3-4	10.48	20.90	11.04	21.10	23.09	13.38	
k.umbo	16.60	.58	20.00	.12			
k.umbo	9.00	30.10	33.13	23.50	4.80		
tulung angung	42.20	.58	20.00	.12			
tulung angung	9.20	29.60	32.22	23.22	5.45		
kesamben	76.00	.74	20.00	.12			
kesamben	6.30	16.30	25.00	28.68	18.68	5.00	
mrica	544.00	.72	20.00	.12			
mrica	29.90	10.70	12.74	13.46	14.63	12.60	6.00
gresik 3	139.90	.83	20.00	.12			
gresik 3	1.00	20.22	27.50	31.02	20.22		
gresik 4	93.40	.89	20.00	.12			
gresik 4	1.50	30.30	41.22	46.47	30.30		
comb.cycle	27.50	.84	20.00	.12			
comb.cycle	43.27	56.73					
bukit assam 1-2	64.60	.52	20.00	.12			
bukit assam 1-2	6.46	55.05	30.34	17.65	.60		
ombilin 1-2	96.60	.79	20.00	.12			
ombilin 1-2	17.80	35.00	26.92	19.87			
ombilin 3-4	90.20	.81	20.00	.12			
ombilin 3-4	17.80	35.00	26.92	19.87			
tarahan 1	48.30	.79	20.00	.12			
tarahan 1	6.00	20.91	33.95	23.80	9.94	4.96	
tarahan 2	48.30	.79	20.00	.12			
tarahan 2	6.00	20.91	33.95	23.80	9.94	4.96	
asahan I 1	71.50	.67	20.00	.12			
asahan I 1	6.71	16.84	25.00	28.40	16.90	5.03	
asahan I 2	71.50	.67	20.00	.12			
asahan I 2	6.71	16.64	25.00	28.40	16.90	5.03	
tes	27.20	.65	20.00	.12			
tes	2.90	28.87	50.74	17.60			

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EXHIBIT II - 12A (cont)

p.kembayung 1	50.10	.70	20.00	.12		
p.kembayung 1	6.58	16.56	25.15	28.54	18.56	5.19
p.kembayung 2-3	100.10	.70	20.00	.12		
p.kembayung 2-3	6.58	16.56	25.15	28.54	18.56	5.19
tanggari I, 1-2	21.20	.50	20.00	.12		
tanggari I, 1-2	24.50	25.50	27.80	17.50	4.70	
tanggari II	23.80	.50	20.00	.12		
tanggari II	7.56	17.65	25.20	27.73	17.60	5.00
bakuru 1,2	246.00	.52	.12	1.00		
bakuru 1,2	3.50	8.90	19.80	20.00	27.80	20.00
sentani I, 1-2	18.30	.57	20.00	.12		
sentani I, 1-2	25.00	26.00	28.40	18.00	4.90	
belawan 1-2	16.40	.53	20.00	.12		
belawan 1-2	.62	.38				
belawan 3-4	128.70	.74	20.00	.12		
belawan 3-4	7.61	26.34	38.70	18.60	8.70	
denpasar	5.00	.70	20.00	.12		
denpasar	.82	.18				
loakulu 1	38.10	.76	20.00	.12		
loakulu 1	6.56	21.25	33.85	23.62	10.00	5.00
loakulu 2	38.10	.76	20.00	.12		
loakulu 2	6.56	21.25	33.85	23.62	10.00	5.00
banjarmasin	48.30	.79	20.00	.12		
banjarmasin	7.00	25.88	38.92	18.84	8.90	
banjarmasin 2	48.30	.79	20.00	.12		
banjarmasin 2	7.00	25.88	38.92	18.84	8.90	
riam kiwa	68.80	.57	20.00	.12		
riam kiwa	2.60	4.94	22.40	29.65	34.88	5.52
musi	54.90	.59	20.00	.12		
musi	6.92	17.10	25.00	27.86	18.03	5.10
besai	62.00	.50	20.00	.12		
besai	7.74	17.40	25.16	27.74	17.40	5.20
singkarak 1-2	136.40	.60	20.00	.12		
singkarak 1-2	2.64	15.10	22.87	24.78	24.92	10.00
singkarak 3-4	131.20	.64	20.00	.12		
singkarak 3-4	2.13	14.86	22.86	25.08	25.00	10.00
renun	127.10	.57	20.00	.12		
renun	7.08	17.15	25.02	24.00	24.00	3.00

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EXHIBIT II-13

```
280: ****************************************************************
281: data table 11
282: ****************************************************************
283: supply=table
284: matrix name =city gas inputs
285: matrix size = 4  0      .00   0   0
286: -gas plant  = 1  4 barch=04/ov/reg=99/99,99/01,01
287: primary prod= 1  1 barch=04/ov/reg=99/99,99/99,99/01,01
288:
289: -- ------------------- -------------------
290:  1 gas                        0.000 pgn.dat
291:  2 ido                         .000 pgn.dat
292:  3 fueloil                     .000 pgn.dat
293:  4 kerosene                    .000 pgn.dat
294: ****************************************************************
295: data table 12
296: ****************************************************************
297: diagonal
298: consis.check= 0
299: matrix name =add pgn to consumpti
300: output name =dummy sequence
301: output units=mboe
302: matrix size = 4  4      .00   0   0
303: stock change= 2  4 barch=
304: none        = 0  0 barch=
305:
306: -- ------------------- -- ------------------- ---------
307:  1 gas                 1 gas                      1.000
308:  2 ido                 2 ido                      1.000
309:  3 fueloil             3 fueloil                  1.000
310:  4 kerosene            4 kerosene                 1.000
311: ****************************************************************
312: data table 13
313: ****************************************************************
314: diagonal
315: consis.check= 0
316: matrix name =effic. city gas
317: output name =city gas prod
318: output units=mboe
319: matrix size = 4  4        .00
320: gas plant   = 1  4
321: none
322:
323: -- ------------------- -- ------------------- ---------
324:  1 gas                 1 gas                       .990
325:  2 ido                 2 gas                       .750
326:  3 fueloil             3 gas                       .750
327:  4 kerosene            4 gas                       .750
328: ****************************************************************
329: data table 14
330: ****************************************************************
331: difference
332: consis.check= 0
333: matrix name =city gas linkup
334: output name =demand
335: output units=mboe
336: matrix size =28 28        .00
337: none        = 1 28
338: none
339:
340: -- ------------------- -- ------------------- ---------
```


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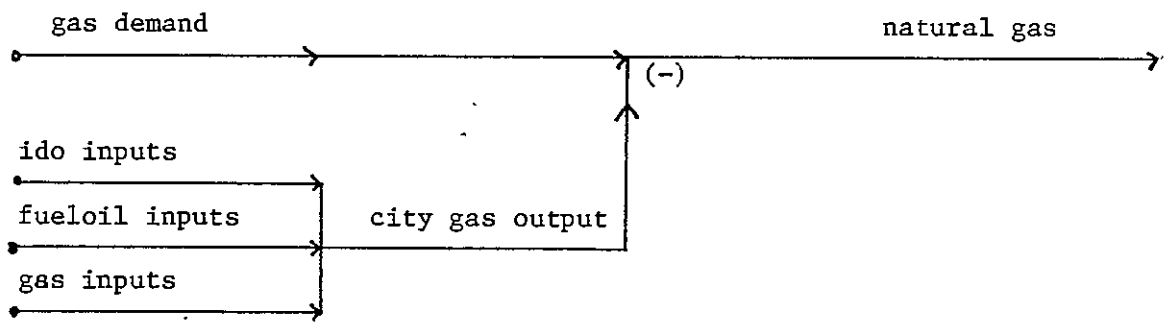
feedstock inputs, to PGN are read from an external file PGN.DAT (Exhibit II-14) and the gas produced from this feedstock is deducted from total demand for gas (data table 14): the difference between gas demand and gas provided by PGN is subsequently met by natural gas (see Figure II-1). Instructions to enter inputs to gas plants to the Energy Balance are given in data table 11 (with a negative sign) and for outputs in data table 13. Losses (about 25 percent of PGN's feedstock inputs are lost in conversion, as indicated in the data field of data table 13) are automatically entered in the "losses" row of the Energy Balance. Data table 12 is inserted as a dummy sequence in order to model an overall balance: inputs to gas plants are sent to the "stocks change" row of the Energy Balance.

FIGURE II-1



6. Data Tables 15 - 22: LNG and LPG Plants (Exhibit II-15)

Production of LNG (Arun, Badak, etc.) and LPG (Rantau, Mundu, Arjuna, Santan) requires large natural gas feedstocks. These feedstocks are calculated in the model on the basis of projected LNG and LPG exports, and added to total gas demand as shown in Figure II-2.

FIGURE II-2

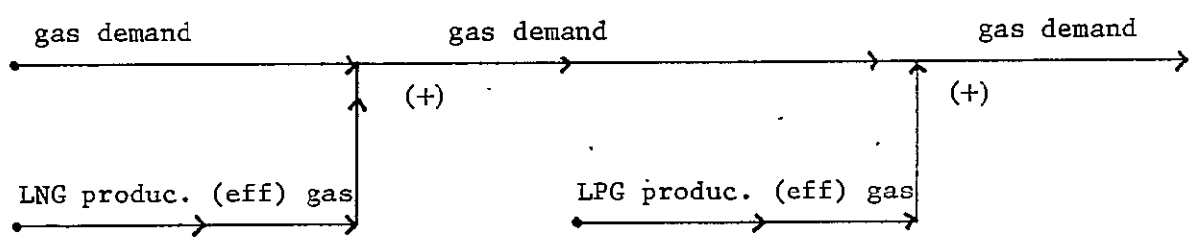


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EXHIBIT II-14

Fuels for PGN

year	gas	ido	fueloil	kerosene
1982	.0982	.0638	.01166	.02613
1983	1.	.07	.012	.026
1984	1.	.07	.012	.026
1985	1.	.07	.012	.026
1986	1.	.07	.012	.026
1987	1.	.07	.012	.026
1988	1.	.07	.012	.026
1989	1.	.07	.012	.026
1990	1.	.07	.012	.026
1991	1.	.07	.012	.026
1992	1.	.07	.012	.026
1993	1.	.07	.012	.026
1994	1.	.07	.012	.026
1995	1.	.07	.012	.026
1996	1.	.07	.012	.026
1997	1.	.07	.012	.026
1998	1.	.07	.012	.026
1999	1.	.07	.012	.026
2000	1.	.07	.012	.026
2001	1.	.07	.012	.026
2002	1.	.07	.012	.026
2003	1.	.07	.012	.026
2004	1.	.07	.012	.026
2005	1.	.07	.012	.026

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EXHIBIT II-15

```
341: ****************************************************************
342: data table 15
343: ****************************************************************
344: supply=resources
345: matrix name =LNG production
346: matrix size = 1  0      .00   0   0
347: LNG plant    = 1  1 barch=04/ov/reg=99/99,99/01,01
348: -imports     = 1  1 barch=04/ov/reg=99/99,99/01,01
349:    mboe
350: -- -------------------- --------------------
351:  1 LNG                          1.000 lng.dat
352: ****************************************************************
353: DATA TABLE 16
354: ****************************************************************
355: price
356: consis.check= 0
357: matrix name =lngpr.dat
358: output name =value lng exports
359: output units=bill US $
360: matrix size = 1  1        .00
361: -imports     = 1  1
362: none
363:
364: -- -------------------- -- -------------------- ----------
365: ****************************************************************
366: data table 17
367: ****************************************************************
368: diagonal
369: consis.check= 0
370: matrix name =effic LNG production
371: output name =lng production
372: output units=mboe
373: matrix size = 1  1        .00
374: -LNG plant  = 1  1
375: none        = 1  1 barch=01/ov/reg=99/99,99/01,01
376:
377: -- -------------------- -- -------------------- ----------
378:  1 LNG                    1 gas                        .874
379: ****************************************************************
380: data table 18
381: ****************************************************************
382: addition
383: consis.check= 0
384: matrix name =lng link
385: output name =lng chain linkup
386: output units=mboe
387: matrix size =28 28        .00
388: none        = 1 28
389: none
390:
391: -- -------------------- -- -------------------- ----------
392: ****************************************************************
393: data table 19
394: ****************************************************************
395: supply=resources
396: matrix name =LPG exports
397: matrix size = 1  0        .00
398: LPG plant    = 1  1
399: -imports     = 1  1 barch=04/ov/reg=99/99,99/99,99/01,01
400:    mboe
401: -- -------------------- --------------------
402:  1 LPG exp                      1.000 lpg.dat
403: ****************************************************************
404: DATA TABLE 20
405: ****************************************************************
406: price
407: consis.check= 0
408: matrix name =lpgpr.dat
409: output name =value lpg exp
410: output units=bill US $
411: matrix size = 1  1        .00
412: -imports     = 1  1
413: none
414:
415: -- -------------------- -- -------------------- ----------
416: ****************************************************************
417: data table 21
418: ****************************************************************
419: diagonal
420: consis.check= 0
421: matrix name =effic LPG production
422: output name =lpg exports prod
423: output units=mboe
424: matrix size = 1  1        .00
425: -LPG plant  = 1  1
426: none        = 1  1
427:
428: -- -------------------- -- -------------------- ----------
429:  1 LPG exp                  1 gas                        .976
430: ****************************************************************
431: data table 22
432: ****************************************************************
433: addition
434: consis.check= 0
435: matrix name =lpg export link
436: output name =lpg chain linkup
437: output units=mboe
438: matrix size =28 28        .00
439: none        = 1 28
440: charc/briq  =22 22
441:
442: -- -------------------- -- -------------------- ----------
```


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Data tables 15 to 18 correspond to the LNG sector and a similar sequence data tables 19 to 22 correspond to LPG. The first step is to read an outside file containing projected LNG production (LNG.DAT, see Exhibit II-16) and LPG production (LPG.DAT, see Exhibit II-17). Because these products are exported, the model enters them into the exports row (in fact, the data file indicates "-imports") of the Energy Balance. The value of these exports are entered into the current account Balance with a price operator that calls outside files containing US$/mboe values for LNG (in LNGPR.DAT) and LPG (in LPGPR.DAT),

Fuel use in LNG and LPG production are accounted for in data tables 17 and 21 respectively. LNG plants use about 12.6 percent of their inputs as fuel; LPG plants are projected to use only about 3 percent as fuel, although currently use as much as 25 - 30 percent of total gas inputs. These fuel uses appear in the Energy Balance in the row "losses".

7. Data tables 23 - 25: Miscellaneous Conversion and Other Losses (Exhibit II-18)

A share operator allows for specifying fraction of charcoal manufactured from different sources: wood, agricultural wastes or lignite (batubara muda). The next sequence (data table 24) contains the conversion efficiencies of charcoal production as well as miscellaneous small losses in petroleum products that correspond to Own Use Consumption by Pertamina and PDN Pertamina. Finally, 40 percent of all natural gas produced is used as fuel or feedstock. According to MIGAS 40 percent of the gas is used for gas injection, gas lift or fuel by gas producers, or is not utilized (they indicate 87 percent of gas production as utilized PEMANFAATAN).

Three uses of gas and petroleum products appear in the Energy Balance in the row "losses". Feedstocks to charcoal production appears in the row "charc/briquettes" with negative signs (data table 24); charcoal outputs appear in the same row with positive sign (data table 22).

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EXHIBIT II-16

LNG production (mboe)

year	1.medium	2.high	3.low
1982	51.00	51.00	51.00
1983	55.80	55.80	55.80
1984	126.60	120.00	60.00
1985	134.60	120.00	60.00
1986	138.40	120.00	60.00
1987	150.70	180.00	60.00
1988	151.80	180.00	60.00
1989	152.60	180.00	60.00
1990	160.00	180.00	60.00
1991	160.00	270.00	60.00
1992	160.00	270.00	60.00
1993	160.00	270.00	60.00
1994	160.00	270.00	60.00
1995	160.00	270.00	60.00
1996	160.00	360.00	60.00
1997	160.00	360.00	60.00
1998	160.00	360.00	60.00
1999	160.00	360.00	60.00
2000	160.00	360.00	60.00
2001	160.00	360.00	60.00
2002	160.00	360.00	60.00
2003	160.00	360.00	60.00
2004	160.00	360.00	60.00
2005	160.00	360.00	60.00

LNG prices

fuel	export	growth
LNG	50.00	

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EXHIBIT II-17

Production of LPG export plants

year	1.high	2.medium	3.low
1982	2.94	2.94	2.94
1983	2.94	2.94	2.94
1984	4.70	2.94	2.94
1985	4.60	2.94	2.94
1986	4.30	2.94	2.94
1987	4.20	2.94	2.94
1988	4.00	2.94	2.94
1989	4.10	2.94	2.94
1990	4.20	2.94	2.94
1991	4.30	2.94	2.94
1992	4.30	2.94	2.94
1993	4.30	2.94	2.94
1994	4.30	2.94	2.94
1995	4.30	2.94	2.94
1996	4.30	2.94	2.94
1997	4.30	2.94	2.94
1998	4.30	2.94	2.94
1999	4.30	2.94	2.94
2000	4.30	2.94	2.94
2001	4.30	2.94	2.94
2002	4.30	2.94	2.94
2003	4.30	2.94	2.94
2004	4.30	2.94	2.94
2005	4.30	2.94	2.94

LPG exp Price lpgpr.dat

fuel	import	export	growth
LPG exp	35.00	35.00	1.00

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EXHIBIT II-18

```
443: ****************************************************************
444: data table 23
445: ****************************************************************
446: share
447: consis.check= 0
448: matrix name =charcoal production
449: output name =fuels/charcoal
450: output units=mboe
451: matrix size =30 28        .00
452: none        =22 24
453: none
454:    mboe                    mboe                  fraction
455: -- -------------------- -- -------------------- ----------
456:  1 lpg                   1 lpg                       1.000
457:  2 avgas                 2 avgas                     1.000
458:  3 avtur                 3 avtur                     1.000
459:  4 gasoline              4 gasoline                  1.000
460:  5 kerosene              5 kerosene                  1.000
461:  6 ado                   6 ado                       1.000
462:  7 ido                   7 ido                       1.000
463:  8 fueloil               8 fueloil                   1.000
464:  9 petrochems            9 petrochems                1.000
465: 10 lubes/waxes          10 lubes/waxes               1.000
466: 11 asphalt              11 asphalt                   1.000
467: 12 petr coke            12 petr coke                 1.000
468: 13 gas                  13 gas                       1.000
469: 14 LNG                  14 LNG                       1.000
470: 15 LPG exp              15 LPG exp                   1.000
471: 16 coal                 16 coal                      1.000
472: 17 bat muda             17 bat muda                  1.000
473: 18 coke                 18 coke                      1.000
474: 19 hydro                19 hydro                     1.000
475: 20 geothermal           20 geothermal                1.000
476: 21 nuclear              21 nuclear                   1.000
477: 22 charcoal             22 wood                       .800
478: 22 charcoal             23 agric wastes               .200
479: 22 charcoal             24 bat auda                   .010
480: 23 wood                 25 wood                      1.000
481: 24 agric wastes         26 agric wastes              1.000
482: 25 biogas               27 biogas                    1.000
483: 26 solar-pv             28 solar-pv                  1.000
484: 27 solar                29 solar                     1.000
485: 28 wind                 30 wind                      1.000
486: ****************************************************************
487: data table 24
488: ****************************************************************
489: diagonal
490: consis.check= 0
491: matrix name =eff charc prod, own use PDN, gas losses
492: output name =fuels to charcoal
493: output units=mboe
494: matrix size =30 30        .00
495: -charc/briq =22 24
496: none
497:
498: -- -------------------- -- -------------------- ----------
499:  2 avgas                 2 avgas                      .957
500:  4 gasoline              4 gasoline                  .996
501:  6 ado                   6 ado                       .991
502:  7 ido                   7 ido                       .992
503:  8 fueloil               8 fueloil                   .994
504: 13 gas                  13 gas                       .600
505: 22 wood                 22 wood                      .750
506: 23 agric wastes         23 agric wastes              .500
507: 24 bat auda             24 bat auda                  .500
508: 99                      99                           .000
```

```
509: ****************************************************************
510: data table 25
511: ****************************************************************
512: aggregate
513: consis.check= 0
514: matrix name =add fuels/charcoal
515: output name =demand
516: output units=mboe
517: matrix size =31 31        .00
518: none        = 1 31
519: primary prod=18 29
520:
521: -- -------------------- -- --------------
522:  1 crude
523:  2 arab light
524:  3 lpg
525:  4 avgas
526:  5 avtur
527:  6 gasoline
528:  7 kerosene
529:  8 ado
530:  9 ido
531: 10 fueloil
532: 11 petrochems
533: 12 lubes/waxes
534: 13 asphalt
535: 14 petr coke
536: 15 naphtha
537: 16 LSWR
538: 17 LNG
539: 18 LPG exp
540: 19 coal
541: 20 gas
542: 21 hydro
543: 22 geothermal
544: 23 nuclear
545: 24 wood
546: 25 agric wastes
547: 26 biogas
548: 27 solar-pv
549: 28 solar
550: 29 wind
551: 30 coke
552: 31 bat auda
```


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8. Data Table 26: Refinery Sector (Exhibit II-19)

The operator vrefinery simulates the refinery sector of Indonesia. The model is given the amount of crude to be processed in each refinery, which is entered in the data field of data table 26: 17.6 mboe per year at Dumai, 14.4 mboe per year at Plaju, etc. All seven Indonesian refineries are included, plus another entry representing Singapore Processing Deal. In addition, planned expansion at Balikpapan, Dumai and Cilacap are included in a staggered fashion, depending on the year they begin operation. Associated with each refinery listed is an external file of the type REFINE.DAT. As shown in Exhibit II-19A, these files contain: first year of operation (or the base year of analysis), year of shutdown, type of crude it processes (in the model two types are identified: domestic crude and imported arab light), refinery capacity, and fraction of each product produced by the refinery.

Refinery outputs are automatically entered into the Energy Balance Table "refinery" row. Crude inputs to refineries are entered into the same row with a negative sign as indicated by the parameter section of data table 26, for crude and arab light.

9. Optional Data Table 26: Alternative Refinery Sector Configuration (Exhibit II-20)

A version of the model's refinery sector has been prepared that calculates the amount of crude needed to meet the demand of a particular product, in this case kerosene. To run the model in this mode, all that is needed is to enter the name of the fuel selected in the row "output name =". It will then go down the list of refineries until kerosene production equals kerosene demand: the balance of all other petroleum products will either be imported or exported.

Note that for this configuration, the list of refineries has been collapsed into a total corresponding to all refineries, and the fractional outputs correspond to a weighted average. The parameters of this aggregation of refineries are similarly stored in an external file EXISREF.DAT.

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EXHIBIT II-19

```
553: ****************************************************************
554: data table 26
555: ****************************************************************
556: vrefinery
557: consis.check= 0
558: matrix name =refinery
559: output name =refinery
560: output units=mboe
561: matrix size =31 31        .00
562: none        = 3 16
563: -refinery   = 1  2
564:    name                    capacity              mboe/year
565: -- -------------------- -- -------------------- ----------
566:  1 P.Brandan             1 P.Brandan                 1.600 refine1.dat*
567:  2 Dumai                 2 Dumai                    17.600 refine2.dat*
568:  3 S.Pakning             3 S.Pakning                 6.700 refine3.dat*
569:  4 Plaju                 4 Plaju                    14.400 refine4.dat*
570:  5 S.Gerong              5 S.Gerong                 11.300 refine5.dat*
571:  6 Cilacap               6 Cilacap                  30.000 refine6.dat*
572:  7 Balikpapan            7 Balikpapan                8.300 refine7.dat*
573:  8 Singapore Proc Deal   8 Singapore Proc Deal      95.000 refine8.dat*
574:  9 Balikp New ph 1       9 Balikp New ph1          20.000 refine9.dat*
575: 10 Balikp New ph 2Deal  10 Balikp New ph 2         20.000 refin10.dat*
576: 11 Dumai new            11 Dumai new               20.000 refin11.dat*
577: 12 Cilacap new ph 1     12 Cilacap new ph 1        20.000 refin12.dat*
578: 13 Cilacap new ph 2     13 Cilacap new ph 2        30.000 refin13.dat*
```


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EXHIBIT II - 19A

Dumai

#	#	item	parameter	crude	arab light
1972	2005	capacity	29.20		
		ratios	.00	1.00	.00
		lpg		.00	
		avgas			
		avtur		.00	
		gasoline		.07	
		kerosene		.18	
		ado		.15	
		ido			
		fueloil		.01	
		petrochems			
		lubes/waxes			
		asphalt			
		petr coke			
		naphtha		.00	
		LSWR		.58	

Cilacap

#	#	item	parameter	crude	arab light
1972	2005	capacity	30.00		
		ratios	.00	.00	1.00
		lpg		.00	.00
		avgas		.00	.00
		avtur		.00	.00
		gasoline		.00	.16
		kerosene		.00	.23
		ado		.00	.09
		ido		.00	.07
		fueloil		.00	.26
		petrochems		.00	.00
		lubes/waxes		.00	.02
		asphalt		.00	.02
		petr coke		.00	.00
		naphtha		.00	.00
		LSWR		.00	.00

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EXHIBIT II-20

```
555: ##################################################################
556: vrefinery
557: consis.check= 0
558: matrix name =refinery
559: output name =kerosene
560: output units=mboe
561: matrix size =31 31        .00
562: none        = 3 16
563: -refinery   = 1  2
564:    name                    capacity              mboe/year
565: -- ------------------- -- ------------------- ----------
566:  1 Existing refineries   1 Existing refineries     200.000 exisref.dat
567:  2 Cilacap               2 Cilacap                 30.000 refine6.dat
568:  3 New refineries        3 New refineries          65.000 newrefs.dat
569:  4 New Cilacap           4 New Cilacap             58.000 cilcnew.dat
```


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10. Data Tables 27 - 28: Domestic Crude Production (Exhibit II-21)

Projections of Indonesia production of crude are entered into an external file CRUDE.DAT (Exhibit II-22) and read into the network in data table 27. Two scenarios (medium and low) are given; the version of the model exhibited has pre-selected scenario No. 1. This pre-selection is made by entering the scenario number in the data field of the data section in data table 27. The value is entered into the Energy Balance row "primary production" as shown. Note that the amount of arab light (the other source of crude into refineries), is entered into the "imports" row of the Energy Balance at a later sequence (data table 30).

In data table 28, the difference between crude production and crude used in refineries is calculated, and entered into the "imports" row of the Energy Balance.

11. Data Table 29 - 30: Stocks Change (Exhibit II-23)

The values for stock change are stored in two data files STOCK1.DAT and STOCK2.DAT. Two files are required because the limit of number of columns (or fuels) in each file of the supply=table type is seven. There is little sense to project future stock changes. The main reason to include this sequence, and enter the values into the "stock change" row of the Energy Balance, is to be able to replicate historical balances with the model.

Data table 30 simply adds or subtracts the value of stock changes, depending if they are negative or positive. In this sequence the final balance between petroleum products demand and domestic production is made: positive differences are entered in the "imports" row of the Energy Balance and negative differences are entered into the "exports" row.

12. Data Table 31: Current Accounts Table (Exhibit II-24)

The operator price makes reference to the external file PRICES.DAT (Exhibit II-25) that contains import prices (cif) and export prices (f.o.b.) for petroleum products. These are entered in

EXHIBIT II-21

```
579: ##################################################################
580: data table 27
581: ##################################################################
582: supply=resources
583: matrix name =crude production
584: matrix size = 1  0        .00
585: primary prod= 1  1 barch=05/ov/reg=99/02,02
586: none               barch=04/ov/reg=99/01,01
587:    mboe                 mboe/year
588: -- ------------------- -------------------
589:  1 crude                      1.000 crude.dat
590: ##################################################################
591: data table 28
592: ##################################################################
593: difference
594: consis.check= 0
595: matrix name =pet prods imp/exp
596: output name =import/export pet pr
597: output units=mboe
598: matrix size =31 31        .00
599: none        = 1 31
600: imports     = 1  1 barch=01/ov/reg=99/01,01
601:
602: -- ------------------- -- ------------------- ----------
```

EXHIBIT II-22

production scenario,crude 1

year	1.bechtel	2.low
1982	584.00	580.00
1983	584.00	580.00
1984	584.00	580.00
1985	584.00	580.00
1986	580.00	580.00
1987	580.00	580.00
1988	580.00	580.00
1989	580.00	580.00
1990	580.00	580.00
1991	580.00	580.00
1992	580.00	440.00
1993	590.00	430.00
1994	580.00	420.00
1995	580.00	410.00
1996	580.00	400.00
1997	580.00	380.00
1998	580.00	360.00
1999	580.00	350.00
2000	580.00	340.00
2001	580.00	330.00
2002	580.00	320.00
2003	580.00	310.00
2004	580.00	300.00
2005	580.00	300.00

EXHIBIT II-23

```
603: ****************************************************************
604: data table 29
605: ****************************************************************
606: supply=table
607: matrix name =stocks change
608: matrix size =14  0        .00
609: stock change= 1 14
610: none
611:
612: -- -------------------- --------------------
613:  1 lpg                        .000 stocks1.dat
614:  2 avgas                      .000 stocks1.dat
615:  3 avtur                      .000 stocks1.dat
616:  4 gasoline                   .000 stocks1.dat
617:  5 kerosene                   .000 stocks1.dat
618:  6 ado                        .000 stocks1.dat
619:  7 ido                        .000 stocks1.dat
620:  8 fueloil                    .000 stocks2.dat
621:  9 petrochems                 .000 stocks2.dat
622: 10 lubes/waxes                .000 stocks2.dat
623: 11 asphalt                    .000 stocks2.dat
624: 12 petr coke                  .000 stocks2.dat
625: 13 naphtha                    .000 stocks2.dat
626: 14 LSWR                       .000 stocks2.dat
627: ****************************************************************
628: data table 30
629: ****************************************************************
630: difference
631: consis.check= 0
632: matrix name =add stocks
633: output name =Production Primary Energy (exc Crude)
634: output units=mboe
635: matrix size =31 31        .00
636: none        = 0  0
637: imports     = 2 17 barch=05/ov/reg=99/99,99/99,99/08,09/10,10        *
638:
639: -- -------------------- -- -------------------- ----------
```

EXHIBIT II-24

```
640: ****************************************************************
641: data table 31
642: ****************************************************************
643: price
644: consis.check= 0
645: matrix name =prices.dat
646: output name =Current Account Bal
647: output units=bill U.S. $
648: matrix size =16 16        .00
649: imports     = 1 16
650: none
651:
652: -- -------------------- -- -------------------- ----------
653: ****************************************************************
654: END
```


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EXHIBIT II-25

Indonesia, Price Table: Prices.dat

fuel	import	export	growth
crude	28.00	28.00	1.00
arab light	22.00	22.00	1.00
lpg	35.00	35.00	1.00
avgas	38.00	38.00	1.00
avtur	32.00	32.00	1.00
gasoline	30.00	30.00	1.00
kerosene	34.00	34.00	1.00
ado	22.00	22.00	1.00
ido	30.00	30.00	1.00
fueloil	25.00	25.00	1.00
petrochems	20.00	20.00	1.00
lubes/waxes	20.00	20.00	1.00
asphalt	10.00	10.00	1.00
petr coke	15.00	15.00	1.00
naphtha	29.00	29.00	1.00
LSWR	30.00	30.00	1.00
LNG	50.00	50.00	1.00
LPG exp	35.00	35.00	1.00
coal	18.00	18.00	1.00

EXHIBIT II-26

conversion factors

fuel	boe/bbl
lpg	0.67
avgas	0.90
avtur	0.97
gasoline	0.90
kerosene	0.97
ado	1.00
ido	1.02
fueloil	1.05
petrochems	1.00
lubes	1.00
asphalt	1.21
petr coke	1.00
naphtha	0.90
LSWR	1.05

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US$/boe, dividing by the values read off CONVER.DAT, shown in Exhibit II-26. The price operator enters into the Current Account Balance table (expressed in billions of US$) the value of petroleum imports and exports in their appropriate rows (see Exhibit II-5 above). Note that it contains all values of imports, exports or bunkers in the Energy Balance, from the four segments in the model that the operator price is being involved.

C. RESULTS

1. Setup of Presentation of Results

A large number of runs of this model have been made during EPfDII project. In this section we present some typical results.

The first step is to select a set of demand projections. These can be any of several projections prepared with the Indonesia Regional Model (see Chapter IV) or the Indonesia National Model (see Chapter III). All projections must be specified consistent with the 25 fuels defined in the first data table of the Energy Supply/Demand Balance Model. Exhibit II-27 shows a typical file of demand projections, which contains data for the period 1982 - 1988.

The model produces a large variety of tabular and graphical displays. There are tables and displays selected by the user. Special data files are created to design tabular and graphical display. The "labels" file contains the rows of the summary table, in this case, the Energy Balance Table file name LABELS.DAT (Exhibit II-28). The "columns" label file contains the names of all fuels that will appear (in the order specified in the file) in the summary table. All networks designed for DJL (including applications described in Chapters III and IV) make reference to a columns file names COLUMNS.DAT (Exhibit II-29). Note that if a fuel is not utilized in a given scenario, the column is deleted from the summary table. For this reason, summary tables can be as small as 2 or 3 columns wide, and as wide as 35 columns, requiring several panels (or pages) to display it. Finally, a file that specifies the "time series" tables

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EXHIBIT II-27

25 1982 1988	year=1982	year=1983	year=1984	year=1985	year=1986	year=1987	year=1988
Java-electr	8.278	8.610	8.921	9.266	9.633	10.025	10.444
electricity	2.689	2.797	2.899	3.012	3.132	3.261	3.398
lpg	.000	.000	.000	.000	.000	.000	.000
avgas	.105	.107	.110	.112	.114	.117	.120
avtur	3.726	3.869	4.018	4.172	4.333	4.500	4.673
gasoline	29.877	30.323	30.774	31.232	31.696	32.167	32.831
ado	46.835	48.049	49.304	50.619	51.972	53.365	54.798
ido	6.219	6.365	6.516	6.672	6.832	6.996	7.165
kerosene	51.791	50.598	49.316	55.464	59.488	63.811	68.457
fueloil	9.479	9.706	9.939	10.191	10.450	10.716	10.991
petrochems	.255	.261	.266	.271	.277	.282	.288
lubes/waxes	.487	.496	.506	.517	.527	.537	.548
asphalt	.975	.995	1.015	1.035	1.056	1.077	1.098
petr coke	.147	.149	.150	.152	.153	.155	.156
gas	18.790	19.296	19.815	20.348	20.896	21.459	22.038
charcoal	.000	.000	.000	.000	.000	.000	.000
wood	.000	.000	.000	.000	.000	.000	.000
agric wastes	1.852	1.913	1.975	2.040	2.107	2.176	2.248
coal	2.140	2.184	2.236	2.290	2.345	2.401	2.459
coke	.000	.000	.000	.000	.000	.000	.000
solar-pv	.000	.000	.000	.000	.000	.000	.000
solar	.000	.000	.000	.000	.000	.000	.000
biogas	.000	.000	.000	.000	.000	.000	.000
wind	.000	.000	.000	.000	.000	.000	.000
hydro	1.376	1.376	1.376	1.390	1.404	1.418	1.432

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EXHIBIT II-28

```
Summary Table Definitions
##########################################################################
   Energy Balance Table
I- I----------------------------e
   mboe
01=primary production
02=imports
03=exports
04=bunkers
05=stock changes
06=.subtotal
07=refinery
09=elec generation
11=gas plant
13 LNG plant
15 LPG plant
17 charc/briq
22 -losses
23 .total
23 consumption
   end
-- ----------------------------
   current account table
-- ----------------------------
   US $bill
01=imports
02=exports
03=bunkers
  =.net
  =end
```

EXHIBIT II-29

```
columns
##########################################################################
#   column
I-  I----------e
01  crude
02  arab light
03  lpg
04  avgas
05  avtur
06  gasoline
07  kerosene
08  ado
09  ido
10  fueloil
11  petrochems
12  lubes/waxes
13  asphalt
14  petr coke
15  naphtha
16  LSWR
17  gas
18  LNG
19  LPG exp
20  coal
21  bat muda
22  coke
23  electricity
24  f-electricit
25  Java-electr
26  hydro
27  geothermal
28  nuclear
29  wood
30  charcoal
31  agric wastes
32  biogas
33  solar-pv
34  solar
35  wind
```


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and graphs is created. For the Energy Supply/Demand Balance model, this file is named BALPLOTS.DAT (Exhibit II-30). Consult the Users Manual to learn the use of these special features.

A sampling of tables and graphs produced by the model is shown in Exhibits II-31 - Exhibits II-34.

2. Results of Energy Supply/Demand Balance Model

Utilizing the data presented in Section B above yields a set of tables that are presented in the following pages. Exhibit II-35 is an energy balance table for the year 1992. It is created using base case energy demands calculated with the Energy Demand Projection Model (see Exhibit II-27 above); these appear in the row "consumption". Domestic crude production that year is estimated to be 580.0 mboe; LNG exports reach 160.0 mboe. Local refineries take 214.9 mboe of this domestic crude, plus 80.0 mboe of imported arab light to produce a range of petroleum products according to yield data entered to the model for each Indonesian refinery, including new expansions as Dumai, Balikpapan and Cilacap. The results show that 16.4 mboe of kerosene and 18.6 mboe of diesel must be still imported, but more than 22.0 mboe of gasoline would be exported. Given a table of import and export prices of fuels, the model prepares a table of the value of this trade in fuels; as shown in Exhibit II-36, exports of crude, LNG, LPG and LSWR reach US$21.12 billion, while imports of products are US$2.95 billion and exports of products are US$2.93. These values are obtained using as inputs the import and export prices for fuels assumed for this run of the model (see Exhibits II-4, 16, 17 and 25 shown above). It is important to point out that these amounts are shown more as illustrations of the capability of the model than as final results, since the world export and import prices of the different fuels used in the calculation have to be reviewed in depth.

The electric sector is simulated in great detail by the model. A total of 17.00 mboe of electricity generated in Java and 3.62 mboe off-Java are met by 38.55 mboe of coal, 18.88 mboe of hydro, 2.35 mboe of geothermal and 13.44 mboe of petroleum, as shown in the "elec

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EXHIBIT II-30

parameters for energy balance

#	display	bal.table ro	label	#	#
01	primary production	primary prod	wood/ag wastes	29	31
			petroleum	01	01
			gas	17	17
			hydro/geo	26	27
			coal	20	21
02	energy imports	imports	arab light	02	02
			petr.products	03	10
			coal/coke	20	22
03	exports	exports	crude	01	01
			petroleum prod	03	16
			LNG/LPG	18	19
04	consumption	consumption	electricity	23	25
			gasoline	06	06
			kerosene	07	07
			ado-ido	08	09
			fuel oil	10	10
			other pet prods	03	05
			gas	17	17
			coal	20	22
			wood/ag wastes	29	31
05	electricity	elec generat	pet prods	08	10
			coal	20	20
			hydro	26	26
			geothermal	27	27

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EXHIBIT II-31

ENERGY INPUTS TO ELECTRIC GENERATION (PLN)

..electricity :base case 82-92 (mboe)

	1982	1983	1984	1985	1986	1987	1988
pet prods	25.67	31.91	28.46	16.21	19.05	22.66	23.05
coal	.00	.00	5.86	11.73	13.63	13.63	13.63
hydro	5.02	5.02	5.02	10.81	10.81	10.94	15.20
geothermal	.44	.44	.44	.44	.44	2.05	2.05
total	31.12	37.37	39.78	39.18	43.93	49.28	53.93

..electricity :base case 82-92 (mboe)

	1989	1990	1991	1992
pet prods	30.73	14.04	14.75	14.18
coal	12.50	26.82	32.36	34.83
hydro	15.84	17.50	18.36	18.88
geothermal	1.85	2.86	1.83	5.58
total	60.92	61.22	67.29	73.46

base case 82-92 :electricity

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EXHIBIT II-32

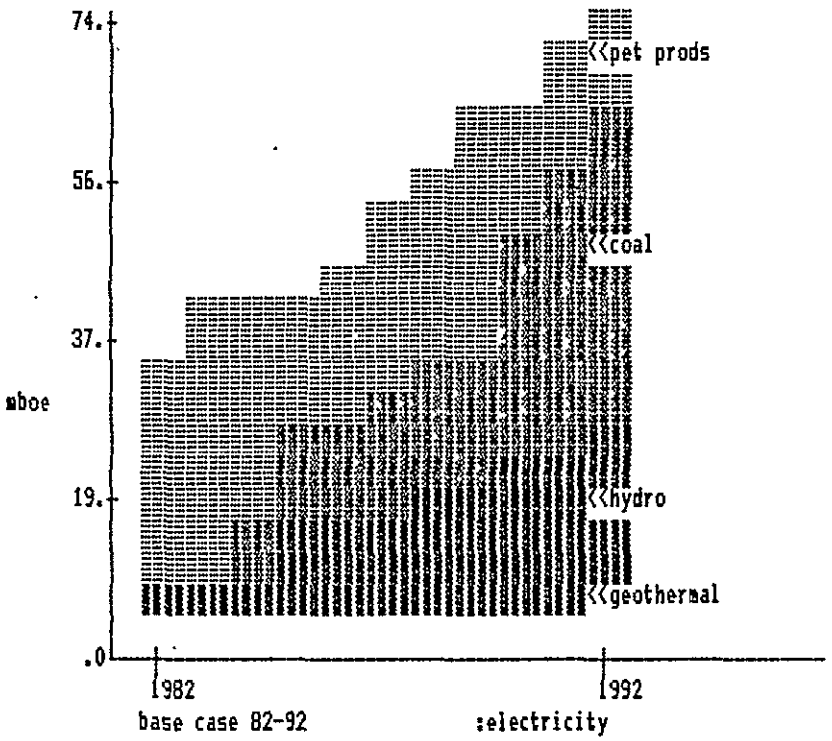

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EXHIBIT II-33

PRODUCTION OF ENERGY RESOURCES

..primary production :base case 82-92 (mboe)

	1982	1983	1984	1985	1986	1987	1988
wood/ag wastes	110.39	112.50	114.65	116.85	119.08	121.36	123.69
petroleum	584.00	584.00	584.00	584.00	580.00	580.00	580.00
gas	134.16	146.04	289.71	307.45	317.10	343.59	348.90
hydro/geo	7.77	11.70	11.70	17.50	17.50	19.23	23.50
coal	.48	.49	6.37	15.23	22.31	23.55	23.91
total	836.80	854.74	1006.43	1041.01	1055.98	1087.74	1100.00

..primary production :base case 82-92 (mboe)

	1989	1990	1991	1992
wood/ag wastes	126.07	128.49	130.96	133.48
petroleum	580.00	580.00	580.00	580.00
gas	354.52	372.32	376.26	380.30
hydro/geo	23.94	26.60	26.43	30.70
coal	23.73	39.11	47.04	51.04
total	1108.25	1146.51	1160.69	1175.53

EXHIBIT II-34

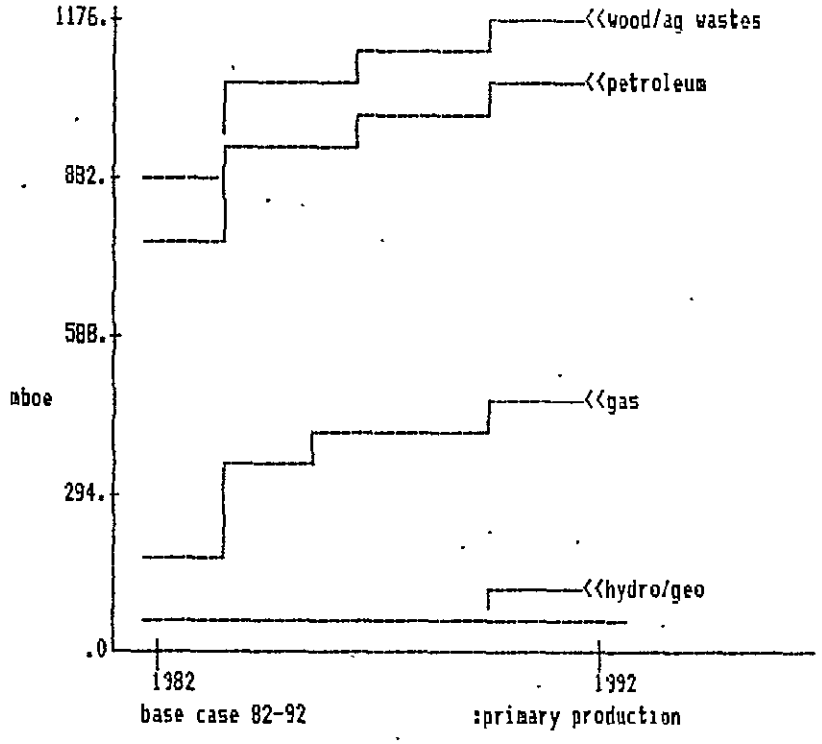

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EXHIBIT II-35

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 20

1992 Energy Balance Table (mboe)

	crude	arab ligh	lpg	avgas	avtur	gasoline	kerosene	ado	ido	fueloil
primary producti	580.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
imports	.00	80.00	.00	.00	4.39	.00	16.40	10.44	8.11	.00
exports	-365.10	.00	-5.49	-.03	.00	-22.15	.00	.00	.00	-.46
bunkers	.00	.00	.00	.00	-1.00	.00	.00	-.05	-.20	-1.00
stock changes	.00	.00	.00	.00	.00	.00	.03	.00	.07	.01
.subtotal	214.90	80.00	-5.49	-.03	3.39	-22.15	16.42	10.40	7.98	-1.45
refinery	-214.90	-80.00	6.93	.11	2.96	52.59	62.98	49.13	8.35	24.50
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	-4.38	-9.06
gas plant	.00	.00	.00	.00	.00	.00	-.03	.00	-.07	-.01
LNG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	-.12	.00	-.54	-.13	-.14
.total	.00	.00	1.44	.08	6.35	30.32	79.38	58.99	11.75	13.84
consumption	.00	.00	1.44	.08	6.35	30.32	79.38	58.99	11.75	13.84

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1992 Energy Balance Table (cont.): (mboe)

	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	gas	LNG	LPG exp	coal
primary producti	.00	.00	.00	.00	.00	.00	380.30	.00	.00	54.76
imports	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
exports	-4.94	-.95	-.51	-4.05	-.52	-59.21	.00	-160.00	-4.30	.00
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
stock changes	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.subtotal	-4.94	-.95	-.51	-4.05	-.52	-59.21	380.30	-160.00	-4.30	54.76
refinery	5.19	1.60	1.70	4.20	.52	59.21	.00	.00	.00	.00
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	.00	-38.55
gas plant	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00
LNG plant	.00	.00	.00	.00	.00	.00	-183.07	160.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	-4.43	.00	4.30	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	.00	-151.72	.00	.00	.00
.total	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	16.22
consumption	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	16.22

)

1992 Energy Balance Table (cont.): (mboe)

	electrici	Java-elec	hydro	geotherma	wood	agric was	total
primary producti	.00	.00	25.13	2.35	102.74	30.74	1176.02
imports	.00	.00	.00	.00	.00	.00	119.34
exports	.00	.00	.00	.00	.00	.00	-627.71
bunkers	.00	.00	.00	.00	.00	.00	-2.25
stock changes	.00	.00	.00	.00	.00	.00	.11
.subtotal	.00	.00	25.13	2.35	102.74	30.74	665.51
refinery	.00	.00	.00	.00	.00	.00	-14.92
elec generation	3.62	17.00	-18.88	-2.35	.00	.00	-52.60
gas plant	.00	.00	.00	.00	.00	.00	.05
LNG plant	.00	.00	.00	.00	.00	.00	-23.07
LPG plant	.00	.00	.00	.00	.00	.00	-.13
charc/briq	.00	.00	.00	.00	.00	.00	.00
-losses	-.72	-2.55	.00	.00	.00	.00	-155.93
.total	2.89	14.45	6.24	.00	102.74	30.74	418.90
consumption	2.89	14.45	6.24	.00	102.74	30.74	418.90

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EXHIBIT II-36

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 20

1992 current account table (US $bill)

	Java-elec	electrici	avgas	avtur	ado	ido	fueloil	LNG	LPG exp	crude
imports	.00	.00	.00	.14	.23	.24	.00	.00	.00	.00
exports	.00	.00	.00	.00	.00	.00	-.01	-10.75	-.15	-10.22
bunkers	.00	.00	.00	-.03	.00	-.01	-.02	.00	.00	.00
.net	.00	.00	.00	.11	.23	.23	-.03	-10.75	-.15	-10.22

)

1992 current account table (cont.): (US $bill)

	arab ligh	lpg	gasoline	kerosene	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	total
imports	1.76	.00	.00	.57	.00	.00	.00	.00	.00	.00	2.95
exports	.00	-.29	-.74	.00	-.10	-.02	.00	-.06	-.02	-1.69	-24.05
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-.06
.net	1.76	-.29	-.74	.57	-.10	-.02	.00	-.06	-.02	-1.69	-21.17

)

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generation" row of the Energy Balance. This is the result of a plant by plant dispatch of power plants in which plant efficiency, outage rates, and a load duration curve are all entered to the modelling effort. The merit order dispatch for Java (see Exhibit II-12 above) shows the plant by plant dispatch for peak, intermediate and base load, the electricity generated and the corresponding fuel consumption (for hydro and geothermal, this is an equivalent fossil fuel consumption). A similar table (not shown) is produced for the electric system of the other islands. The model also calculates the total foreign capital investment outlays for the power plant construction program required to meet the electricity demands: as shown in Exhibit II-37, they average about US$300 million per year to 1985, reach a peak of US$522 million in 1987 and decrease to US$425 - 440 per year the rest of the decade. The debt service on the foreign portion of this investment, using 20 year loan periods and 12 percent annual interest, is shown at the bottom of the table.

3. Case Study: Substitution to Coal

Indonesia is at present undertaking an ambitious program of greatly increasing the use of coal in electric generation and in industry, in particular at cement factories. This program is reflected in demands for coal reaching 51.04 mboe in 1992, 68 percent of which is for PLN and 32 percent for use in cement plants. The schedule of coal demands by existing and new cement plants is obtained from information prepared by PTE, and a set of revised energy demands that reflect a scenario of substitution to coal was calculated using the Energy Demand Projection Model (Chapter III).

The potential for accelerating the use of coal in Indonesia exists, although its introduction in households and transport (with the exception of transport of coal itself by rail) is not likely. In this analysis, the substitution centers in two areas:

- Coal use as fuel in industry: currently about 48 percent of fuel use for boilers and kilns in Indonesia is fuel oil and 17 percent is industrial diesel oil. Coal is less than 1 percent, the remainder is bagasse

EXHIBIT II-37

Indonesia Energy Model

Energy Supply/Demand Balance Network

sept 20

Energy Sector Payments Balance:

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
merchandise trade balance	14.4	14.6	18.5	19.3	19.4	20.0	20.3	20.2	21.1	21.1	21.2
..imports	-2.5	-2.6	-2.6	-2.4	-2.1	-2.4	-2.7	-3.0	-2.5	-2.7	-2.9
..exports	16.8	17.1	21.0	21.6	21.4	22.3	22.9	23.2	23.5	23.8	24.1
..bunkers	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
investment outlays	.0	431.6	458.0	439.3	683.2	755.5	622.8	624.5	642.0	655.6	544.9
..electric sector	.0	431.6	458.0	439.3	683.2	755.5	622.8	624.5	642.0	655.6	544.9
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
foreign capital inflows	.0	287.6	296.1	305.7	477.4	522.3	439.8	426.8	431.5	448.6	370.6
..electric sector	.0	287.6	296.1	305.7	477.4	522.3	439.8	426.8	431.5	448.6	370.6
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
debt service: interest	.0	.0	-1.0	-24.9	-27.7	-33.3	-81.8	-98.7	-207.0	-355.4	-269.4
..electric sector	.0	.0	-1.0	-24.9	-27.7	-33.3	-81.8	-98.7	-207.0	-355.4	-269.4
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
debt service: principal	.0	.0	-.4	-10.4	-12.1	-15.0	-36.0	-44.8	-92.2	-1171.3	-128.1
..electric sector	.0	.0	-.4	-10.4	-12.1	-15.0	-36.0	-44.8	-92.2	-1171.3	-128.1
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
net energy payments balance	14.4	14.6	17.1	-16.0	-20.4	-28.4	-97.5	-123.3	-278.1	-1505.7	-376.3

..inflows positive, outflows negative

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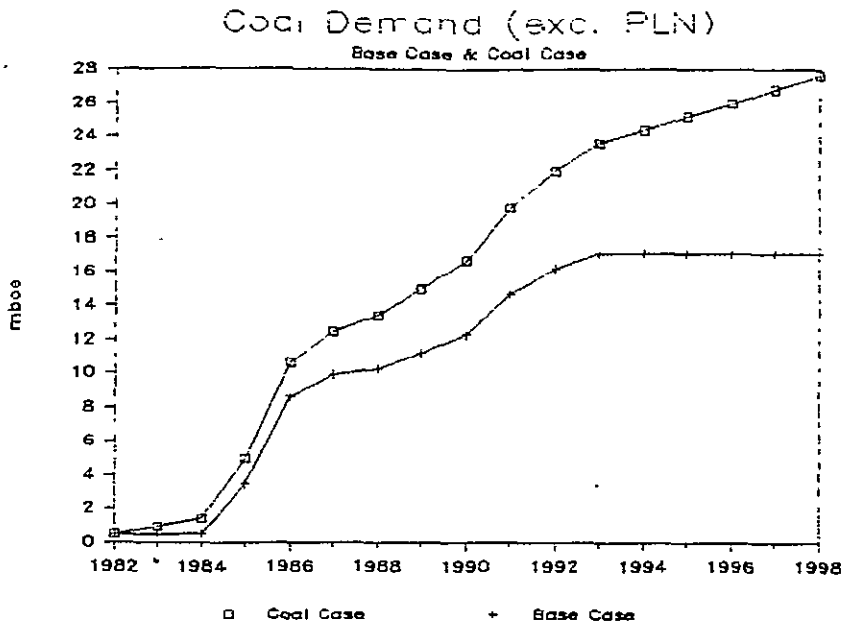
to the sugar industry. The coal scenario proposes a substitution of these shares of 3 percent per year over the planning horizon between coal and fuel oil.

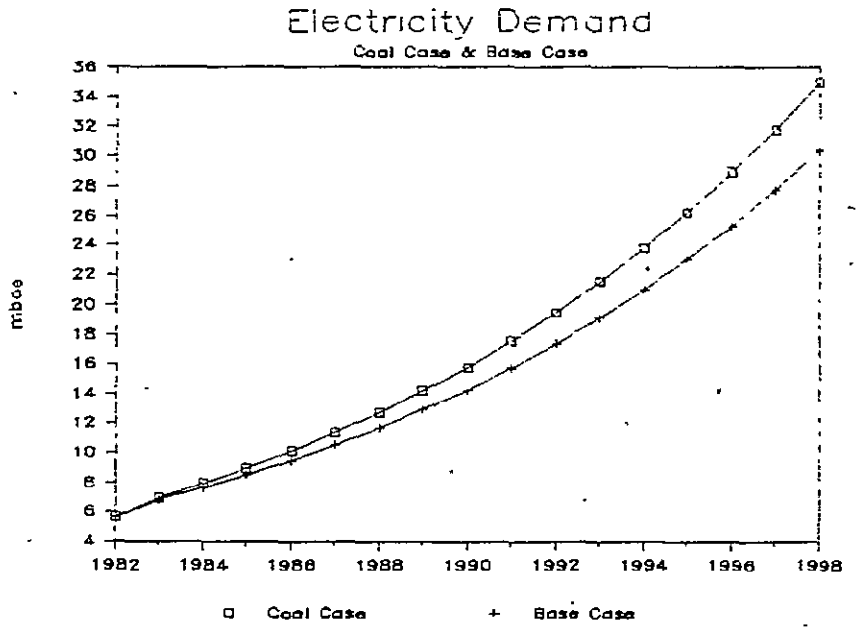
- Connection of Captive Power to the grid: the use of petroleum products for generation of electricity in industry amounts to about 6,500 thousand boe. The base case incorporates a gradual substitution of captive power by grid electricity in Java of 3 percent per year. This rate is accelerated to 5 percent in the coal case; as a result, less petroleum is used in industry and the extra electricity generation will require more coal steam power plants.

The results are shown in two steps. First, is comparison of fuel and electricity demands in the base case and the coal case. As shown in Exhibit II-38, coal demand in 1998 increases from 17,000 kboe to 27,600 kboe and PLN demand from 30,400 kboe to 35,000 kboe. Note that coal demand here includes direct uses in industry (and mines) only, and excludes coal use in the generation of electricity by PLN. At the same time, petroleum demand decreases in 1998 from 271,200 kboe to 242,000 kboe.

The second step is to analyze the impact on the supply side of the picture. The Energy Supply/Demand Balance Model is run using as input the revised energy demands that incorporate the substitution to coal; the run also uses as input a revised list of available power plants in Java that includes an additional 400 MW coal steam power plant. The resulting energy balance is shown in Exhibit II-39. It shows coal consumption for electricity growing to 44.34 mboe, from 38.55 mboe in the base case (shown in Exhibit II-35 above). The value of petroleum exports grow from $10.27 billion in the base case (see Exhibit II-36 above) to $10.54 billion as shown in Exhibit II-40, due to a reduced demand for petroleum that allows for an annual $270 million greater exports (or fewer imports) of crude and petroleum products. This is offset by a larger investment in power plants, to account for the additional coal steam power station. Given a cost of $570/kw, the resulting payments schedule for the coal case is shown in Exhibit II-41 (to be compared against the base case payments schedule shown in Exhibit II-37 above). The Java system merit order dispatch

EXHIBIT II-38





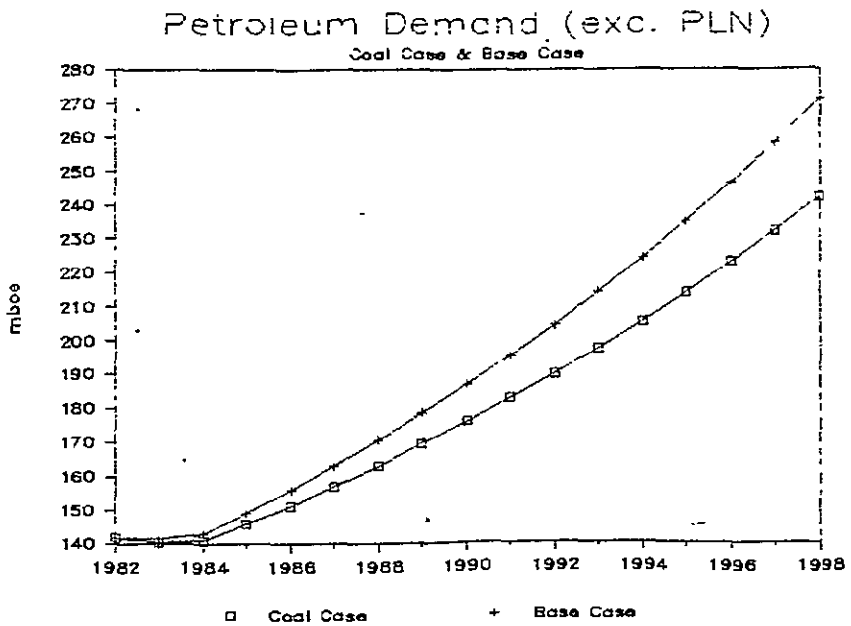


EXHIBIT II-39

Indonesia Energy Model

coal case powerco.dat & coal.int

sept 20

1992 Energy Balance Table (mboe)

	crude	arab ligh	lpg	avgas	avtur	gasoline	kerosene	ado	ido	fueloil
primary producti	580.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
imports	.00	80.00	.00	.00	4.39	.00	16.40	5.99	3.81	.00
exports	-365.10	.00	-5.49	-.03	.00	-22.15	.00	.00	.00	-2.40
bunkers	.00	.00	.00	.00	-1.00	.00	.00	-.05	-.20	-1.00
stock changes	.00	.00	.00	.00	.00	.00	.03	.00	.07	.01
.subtotal	214.90	80.00	-5.49	-.03	3.39	-22.15	16.42	5.93	3.68	-3.39
refinery	-214.90	-80.00	6.93	.11	2.96	52.59	62.98	49.13	8.35	24.50
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	-4.38	-12.96
gas plant	.00	.00	.00	.00	.00	.00	-.03	.00	-.07	-.01
LNG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	-.12	.00	-.50	-.10	-.13
.total	.00	.00	1.44	.08	6.35	30.32	79.38	54.56	7.49	8.01
consumption	.00	.00	1.44	.08	6.35	30.32	79.38	54.56	7.49	8.01

)

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EXHIBIT II-39 (continued)

1992 Energy Balance Table (cont.): (mboe)

	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	gas	LNG	LPG exp	coal
primary producti	.00	.00	.00	.00	.00	.00	380.30	.00	.00	66.32
imports	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
exports	-4.94	-.95	-.51	-4.05	-.52	-59.21	.00	-160.00	-4.30	.00
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
stock changes	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
.subtotal	-4.94	-.95	-.51	-4.05	-.52	-59.21	380.30	-160.00	-4.30	66.32
refinery	5.19	1.60	1.70	4.20	.52	59.21	.00	.00	.00	.00
elec generation	.00	.00	.00	.00	.00	.00	.00	.00	.00	-44.34
gas plant	.00	.00	.00	.00	.00	.00	.15	.00	.00	.00
LNG plant	.00	.00	.00	.00	.00	.00	-183.07	160.00	.00	.00
LPG plant	.00	.00	.00	.00	.00	.00	-4.43	.00	4.30	.00
charc/briq	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
-losses	.00	.00	.00	.00	.00	.00	-151.72	.00	.00	.00
.total	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	21.99
consumption	.25	.65	1.19	.15	.00	.00	41.24	.00	.00	21.99

1992 Energy Balance Table (cont.): (mboe)

	electrici	Java-elec	hydro	geotherma	wood	agric was	total
primary producti	.00	.00	25.13	2.22	102.74	30.74	1187.45
imports	.00	.00	.00	.00	.00	.00	110.58
exports	.00	.00	.00	.00	.00	.00	-623.65
bunkers	.00	.00	.00	.00	.00	.00	-2.25
stock changes	.00	.00	.00	.00	.00	.00	.11
.subtotal	.00	.00	25.13	2.22	102.74	30.74	665.24
refinery	.00	.00	.00	.00	.00	.00	-14.92
elec generation	3.62	19.49	-18.88	-2.22	.00	.00	-59.67
gas plant	.00	.00	.00	.00	.00	.00	.05
LNG plant	.00	.00	.00	.00	.00	.00	-23.07
LPG plant	.00	.00	.00	.00	.00	.00	-.13
charc/briq	.00	.00	.00	.00	.00	.00	.00
-losses	-.72	-2.92	.00	.00	.00	.00	-156.22
.total	2.89	16.57	6.24	.00	102.74	30.74	412.27
consumption	2.89	16.57	6.24	.00	102.74	30.74	412.27

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EXHIBIT II-40

Indonesia Energy Model

coal case powerco.dat & coal.int

sept 20

1992 current account table (US $bill)

	Java-elec	electrici	avgas	avtur	ado	ido	fueloil	LNG	LPG exp	crude
imports	.00	.00	.00	.14	.13	.11	.00	.00	.00	.00
exports	.00	.00	.00	.00	.00	.00	-.06	-10.75	-.15	-10.22
bunkers	.00	.00	.00	-.03	.00	-.01	-.02	.00	.00	.00
.net	.00	.00	- .00	.11	.13	.11	-.08	-10.75	-.15	-10.22

1992 current account table (cont.): (US $bill)

	arab ligh	lpg	gasoline	kerosene	petrochem	lubes/wax	asphalt	petr coke	naphtha	LSWR	total
imports	1.76	.00	.00	.57	.00	.00	.00	.00	.00	.00	2.72
exports	.00	-.29	-.74	.00	-.10	-.02	.00	-.06	-.02	-1.69	-24.10
bunkers	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00	-.06
.net	1.76	-.29	-.74	.57	-.10	-.02	.00	-.06	-.02	-1.69	-21.44

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EXHIBIT II-41

Indonesia Energy Model

coal case powerco.dat & coal.int

sept 20

Energy Sector Payments Balance:

	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
merchandise trade balance	14.4	14.6	18.6	19.3	19.4	20.0	20.4	20.7	21.4	21.5	21.4
..imports	-2.5	-2.6	-2.5	-2.4	-2.1	-2.3	-2.6	-2.6	-2.3	-2.5	-2.7
..exports	16.8	17.1	21.0	21.6	21.4	22.3	22.9	23.2	23.7	23.9	24.1
..bunkers	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1	.1
investment outlays	.0	482.5	562.3	576.8	713.6	820.4	689.2	717.8	703.9	569.3	424.2
..electric sector	.0	482.5	562.3	576.8	713.6	820.4	689.2	717.8	703.9	569.3	424.2
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
foreign capital inflows	.0	326.3	371.8	404.6	493.8	565.7	486.2	490.5	474.8	388.2	286.2
..electric sector	.0	326.3	371.8	404.6	493.8	565.7	486.2	490.5	474.8	388.2	286.2
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
debt service: interest	.0	.0	-1.0	-24.9	-27.7	-33.3	-81.8	-135.5	-251.7	-397.8	-282.1
..electric sector	.0	.0	-1.0	-24.9	-27.7	-33.3	-81.8	-135.5	-251.7	-397.8	-282.1
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
debt service: principal	.0	.0	-.4	-10.4	-12.1	-15.0	-36.0	-60.2	-111.6	-1190.7	-136.1
..electric sector	.0	.0	-.4	-10.4	-12.1	-15.0	-36.0	-60.2	-111.6	-1190.7	-136.1
..other	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0	.0
net energy payments balance	14.4	14.6	17.1	-16.0	-20.3	-28.3	-97.4	-175.0	-341.8	-1567.0	-396.7

..inflows positive, outflows negative

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for this coal scenario is shown in Exhibit II-42.

This analysis excludes the cost of retrofit in industry, and any costs associated with distributing electricity by the grid to remote sites. These costs, if known, can be added to the analysis. The case can be further expanded by varying the assumptions on prices of crude and petroleum products, in particular the growth rate in real prices.

EXHIBIT II-42

I n d o n e s i a Energy Model

coal case powerco.dat & coal.int

sept 20

merit order dispatch for 1992

plant	Mw avail.	Gwh	fuel, mboe	
peak				
java/exist hydro	393.30	298.91	.62	(hydro)
hydro purchase	112.50	85.50	.18	(hydro)
saguling 1-2-3-4	665.00	505.40	1.05	(hydro)
senggaruh	27.55	20.94	.04	(hydro)
cirata I, 1-2-3-4	475.00	361.00	.75	(hydro)
k.umbo	21.85	16.61	.03	(hydro)
tulung angung	28.50	21.66	.04	(hydro)
kesamben	31.35	23.83	.05	(hydro)
mrica	171.00	129.96	.27	(hydro)
suralaya 1	360.00	273.60	.57	(coal)
suralaya 2	360.00	273.60	.57	(coal)
suralaya 3-4	720.00	547.20	1.13	(coal)
coal steam	360.00	273.60	.57	(coal)
paiton 1	360.00	273.60	.57	(coal)
paiton 2	360.00	273.60	.57	(coal)
java/exist geotherm	27.00	20.52	.04	(geothermal)
kamojang 2-3	99.00	75.24	.16	(geothermal)
salak 1	49.50	37.62	.08	(geothermal)
salak 2,dieng 1-2	148.50	112.86	.23	(geothermal)
drajat1-2	99.00	75.24	.16	(geothermal)
java/exist steam	1175.40	893.30	2.77	(fueloil)
gresik 3	30.45	23.14	.05	(fueloil)
total Mw	6074.90			

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intermediate

java/exist hydro	393.30	786.60	1.63	(hydro)
hydro purchase	112.50	225.00	.47	(hydro)
saguling 1-2-3-4	665.00	1330.00	2.75	(hydro)
senggaruh	24.53	49.06	.10	(hydro)
cirata I, 1-2-3-4	475.00	950.00	1.97	(hydro)
k.umbo	16.51	33.01	.07	(hydro)
tulung angung	11.42	22.83	.05	(hydro)
kesamben	11.42	22.83	.05	(hydro)
mrica	79.91	159.82	.33	(hydro)
suralaya 1	320.00	640.00	1.32	(coal)
suralaya 2	320.00	640.00	1.32	(coal)
suralaya 3-4	640.00	1280.00	2.65	(coal)
coal steam	320.00	640.00	1.32	(coal)
paiton 1	320.00	640.00	1.32	(coal)
paiton 2	320.00	640.00	1.32	(coal)
java/exist geotherm	24.00	48.00	.10	(geothermal)
kamojang 2-3	88.00	176.00	.36	(geothermal)
salak 1	44.00	88.00	.18	(geothermal)
salak 2,dieng 1-2	132.00	264.00	.55	(geothermal)
drajat1-2	88.00	176.00	.36	(geothermal)
java/exist steam	783.60	1567.20	4.86	(fueloil)
gresik 3	.00	.00	.00	(fueloil)
total Mw	5189.18			

base

java/exist hydro	85.75	514.49	1.06	(hydro)
hydro purchase	48.25	289.50	.60	(hydro)
saguling 1-2-3-4	160.77	964.60	2.00	(hydro)
senggaruh	.00	.00	.00	(hydro)
cirata I, 1-2-3-4	114.83	689.00	1.43	(hydro)
k.umbo	3.40	20.38	.04	(hydro)
tulung angung	9.25	55.51	.11	(hydro)
kesamben	8.89	53.34	.11	(hydro)
mrica	68.37	410.22	.85	(hydro)
suralaya 1	320.00	1920.00	3.97	(coal)
suralaya 2	320.00	1920.00	3.97	(coal)
suralaya 3-4	640.00	3840.00	7.94	(coal)
coal steam	320.00	1920.00	3.97	(coal)
paiton 1	320.00	1920.00	3.97	(coal)
paiton 2	314.20	1885.17	3.90	(coal)
total Mw	2733.70			

total	31397.50	67.51
total fuel cost		.105

(power sector data file: powerco.dat)

III ENERGY DEMAND PROJECTION MODEL

A. INTRODUCTION

There are a wide range of approaches to energy demand projection methodologies, all of which can be modelled with the RESGEN code. These approaches all share one common reality, one of data availability. In many cases, a modelling approach that attempts a very detailed analysis of the demand systems falls short of its objectives because of data limitations. The Regional Energy Model, presented in Chapter IV, is an attempt at a detailed regional representation of energy demand in Indonesia from which the problems of data availability clearly become evident. In the case described in this chapter, the reverse approach is selected: given a set of reliable data on energy demands for base year 1982, a system of equations for projecting energy demands was created. The following section describes these equations and presents the data in detail.

The set of data used in this chapter was prepared by an interagency working group put together by BATAN for the operation of the MAED/MEDEE model. DJL is a participant in this working group. The data uses as primary sources all conventional Indonesian statistics on energy consumption (MIGAS Oil Statistics, Pertamina ADP-7, PLN statistics). Utilizing these sources, the working group has taken one step forward by using judgement to allocate fuels to uses that are not documented by suppliers: kerosene consumption between residential/commercial and industry; automotive diesel oil (ado) used in industry allocated between electric self-generation and transportation; uses in industry broken down between feedstock and process heat; etc.

Finally, an estimate of fuelwood and agricultural wastes used in households (and services) has been added to the data set. The rate of consumption is $0.80m^3$ per capita, of which 80 percent is met by wood and 20 percent by agricultural wastes.

The results of this model application are a set of future demands for all fuels and electricity for Indonesia. These results are tabulated and graphed as shown in the example output of Exhibit III-1. They are also stored as a RESGEN file to be retrieved by the Energy Supply/Demand Balance Model (see Chapter II), to be used as starting points for modelling future energy balances.

B. ECONOMETRIC DEMAND PROJECTIONS

The general methodological approach to energy demand projection used in this application of the software is econometric, that is:

$$Q_t = Q_0 * (1+g_1)^{\alpha} * (1+g_2)^{\beta}$$

where

Q_t = energy demand in the year t

Q_0 = energy demand in base year

g_1 = growth rate in income

g_2 = growth rate in prices

α = elasticity with respect to income (income elasticity)

β = elasticity with respect to price (price elasticity, generally a negative value)

The operator in RESGEN that performs the calculation of the type (1+g) is the v-elasticity operator. The RESGEN network data table contains the values for the elasticities and makes reference to external files of the type VGROWTH.DAT containing yearly growth rates. The projection horizon can be broken down into as many as six sub-periods. The income and price growth tables used in this section have the time horizon broken into the following sub-periods:

1. 1982-1983 historical growth
2. 1983-1984 historical growth
3. 1984-1989 Repelita IV
4. 1989-1994 Repelita V

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EXHIBIT III-1

1998 Energy Balance Table (kboe)

	lpg	avgas	avtur	gasoline	kerosene
households	1512.64	.00	.00	.00	115281.20
transport	.00	76.44	7582.47	38365.28	.00
industry	589.38	.00	.00	.00	3109.18
captive power	.00	.00	.00	.00	.00
.total	2102.02	76.44	7582.47	38365.28	118390.40

1998 Energy Balance Table (cont.): (kboe)

	ado	ido	fueloil	petrochem	lubes/wax
households	.00	.00	.00	.00	.00
transport	56522.75	1831.26	819.72	.00	.00
industry	.00	5000.60	14929.85	255.40	781.49
captive power	15398.59	6402.07	1230.51	.00	.00
.total	71921.34	13233.92	16980.08	255.40	781.49

1998 Energy Balance Table (cont.): (kboe)

	asphalt	petr coke	gas	coal	electrici
households	.00	.00	.00	.00	2952.85
transport	.00	.00	.00	88.00	.00
industry	1338.47	147.30	53560.16	16531.72	1920.70
captive power	.00	.00	2249.33	524.31	.00
.total	1338.47	147.30	55809.48	17144.03	4873.55

1998 Energy Balance Table (cont.): (kboe)

	Java-elec	hydro	wood	agric was	total
households	8878.41	.00	115698.40	28993.23	273316.70
transport	.00	.00	.00	.00	105205.90
industry	16671.51	.00	.00	4993.75	119829.50
captive power	.00	6245.10	.00	.00	32049.90
.total	25549.92	6245.10	115698.40	33986.98	530482.10

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5. 1994-1999 Repelita VI

6. 1999-2004 Repelita VII

The Network file that contains this econometric model is named MAED.DEM. External files that contain the yearly growth rates are named MAED1.DEM to MAED8.DEM. Note that in these files the corresponding headings for the sub-periods selected are: 1983, 1984, 1985, 1990, 1995, 2000. (Consult RESGEN User Manual, Appendix 2).

1. Data Tables 1 - 7: Household Sector (Exhibit III-2)

Fuel and electricity demand for the household sector in 1982 are used as a starting point. The fuels are kerosene, LPG, gas, wood, agricultural wastes and charcoal. Electricity sales to households are broken down between Java and outside-Java, the latter labelled simply "electricity", as shown in data table 1. All units are in thousand barrels of oil equivalent, abbreviated kboe.

Kerosene usage (40,269 kboe in 1982) includes households and services, and amounts to 80 percent of total kerosene sales, as estimated by the MAED Working Group. LPG use in households has not been analyzed in any depth by statistical organizations in Indonesia. Of a total 100,000 tons of LPG sold (779 kboe), 60 percent of allocated to households, corresponding to about half a million homes country wide (the remainder is allocated to services-industry). Gas consumption corresponds to total PGN sales to households (from manufactured gas a well as natural gas). Wood and agricultural wastes estimates made by DJL are explained above.

In data table 2, a share operator disaggregates kerosene consumption between urban cooking (34 percent), urban lighting (9 percent) rural cooking (19 percent) and rural lighting (39 percent). These are national averages obtained from the EPfD I project report and are subject to revision. They can also be modelled to vary linearly by use of the "del" feature in the RESGEN code (see RESGEN User Manual, Appendix 2).

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EXHIBIT III-2

```
   1maed.dem            maedplt.dem                                  *
   1---------2---------3---------4---------5---------6---------- *
Demand projection, MAED data (maed.dem)                              *
*********************************************************************
data table  1                                                        *
*********************************************************************
projection                                                           *
matrix name =household demand                                        *
matrix size = 8  0        .00                                        *
none        = 1  8        .                                          *
none                                                                 *
   kerosene             kboe                                         *
-- -------------------- --------------------                          *
 1 kerosene             40269.052 kboe                               *
 2 lpg                    500.000 kboe                               *
 3 Java-electr           1944.750 kboe                               *
 4 electricity            646.800 kboe                               *
 5 gas                       .000 kboe                               *
 6 wood                 84280.000 kboe                               *
 7 agric wastes         21120.000 kboe                               *
 8 charcoal                  .000 kboe                               *
*********************************************************************
data table  2                                                        *
*********************************************************************
share                                                                *
consis.check= 0                                                      *
matrix name =kero by activity                                        *
output name =kero cooking/lightin                                    *
output units=kboe                                                    *
matrix size =11  8        .00                                        *
none        = 1  4                                                   *
none                                                                 *
   fuel                   activity            fraction               *
-- ------------------- -- ------------------- ----------             *
 1 kerosene             1 urban cooking/kero        .340            *
 1 kerosene             2 urban lighting/kero       .090            *
 1 kerosene             3 rural cooking/kero        .190            *
 1 kerosene             4 rural lighting/kero       .390            *
 2 lpg                  5 lpg                      1.000            *
 3 Java-electr          6 Java-electr              1.000            *
 4 electricity          7 electricity              1.000            *
 5 gas                  8 gas                      1.000            *
 6 wood                 9 wood                     1.000            *
 7 agric wastes        10 agric wastes             1.000            *
 8 charcoal            11 charcoal                 1.000            *
*********************************************************************
data table  3                                                        *
*********************************************************************
vgrowth                                                              *
consis.check= 0                                                      *
matrix name =maedi.dem                                               *
output name =growth households                                       *
output units=kboe                                                    *
matrix size =11 11        .00                                        *
none        = 1 11                                                   *
none                                                                 *
   kboe                   kboe                multiplier              *
```


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```
-- -------------------- -- -------------------- ----------
**********************************************************
data table  4
**********************************************************
v-elasticity
consis.check= 0
matrix name =maed2.dem
output name =income adj demands
output units=kboe
matrix size =11 11      .00
none          1 11
none
                                          multiplier
-- -------------------- -- -------------------- ----------
 1 urban cooking/kero    1 urban cooking/kero       1.000 income elas*
 2 urban lighting/kero   2 urban lighting/kero      1.000 income elas*
 3 rural cooking/kero    3 rural cooking/kero       1.000 income elas*
 4 rural lighting/kero   4 rural lighting/kero      1.000 income elas*
 5 lpg                   5 lpg                      2.000 income elas*
 6 Java-electr           6 Java-electr              2.500 income elas*
 7 electricity           7 electricity              2.500 income elas*
 8 gas                   8 gas                      1.000 income elas*
 9 wood                  9 wood                      .900 income elas*
10 agric wastes         10 agric wastes              .900 income elas*
11 charcoal             11 charcoal                 1.000 income elas*
**********************************************************
data table  5
**********************************************************
matrix
consis.check= 0
matrix name =aggregate fuels
output name =income adj demand
output units=kboe
matrix size = 8 11      .00
none          1  8
none
   fuel/activity          fuel
-- -------------------- -- -------------------- -------
 1 urban cooking/kero    1 kerosene                 1.0
 2 urban lighting/kero   1 kerosene                 1.0
 3 rural cooking/kero    1 kerosene                 1.0
 4 rural lighting/kero   1 kerosene                 1.0
 5 lpg                   2 lpg                      1.0
 6 Java-electr           3 Java-electr              1.0
 7 electricity           4 electricity              1.0
 8 gas                   5 gas                      1.0
 9 wood                  6 wood                     1.0
10 agric wastes          7 agric wastes             1.0
11 charcoal              8 charcoal                 1.0
```

```
**********************************************************
data table  6
**********************************************************
v-elasticity
consis.check= 0
matrix name =maed3.dem
output name =price adj demands
output units=kboe
matrix size = 8  8      .00
households    1  8
none
   fuel                   fuel                   price elasticity
-- -------------------- -- -------------------- ----------
 1 kerosene              1 kerosene                   -.010
 2 lpg                   2 lpg                        -.100
 3 Java-electr           3 Java-electr                -.020
 4 electricity           4 electricity                -.020
 5 gas                   5 gas                        -.010
 6 wood                  6 wood                       -.010
 7 agric wastes          7 agric wastes               -.020
 8 charcoal              8 charcoal                   -.010
**********************************************************
data table  7
**********************************************************
aggregate
consis.check= 0
matrix name =dummy sequence
output name =dummy sequence
output units=
matrix size =15 15      .00   0   0
none        = 0  0 barch=
none        = 0  0 barch=

-- -------------------- -- -------------------- ----------
 1 lpg
 2 kerosene
 3 electricity
 4 gas
 5 wood
 6 agric wastes
 7 charcoal
 8 gasoline
 9 ado
10 ido
11 fueloil
12 avgas
13 avtur
14 coal
15 Java-electr
```


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The first step in the projection is to account for demographic trends. The external file MAED1.DEM, made reference to in the v-growth operator of data table 3, contains household growth rates shown in Exhibit III-3.

The next component of the equation corresponds to income elasticity in data table 4: the income elasticities are shown in the value field of the operator v-elasticity, and the yearly income growth rates in the external file MAED2.DEM shown in Exhibit III-4 below.

Impacts due to price changes are modelled in data table 6: the price elasticities are entered into the value field of the data table, and the growth rates in prices are contained in the external file MAED3.DEM. No price changes are modelled into the model at this point, therefore this file contains only zeros. Note that the resulting demands are instructed to be entered into the "household" row of the summary table.

Data table 5 simply aggregates all kerosene-consuming categories under the label "kerosene". The operator is the general purpose matrix type, which takes the first four elements in the input vector and sums them (after multiplying by the coefficient in the value field, which in this case is 1.0) as the first element of the output vector.

The final step is an aggregate type operator, a sequence only needed to increase the number of elements from 8 (the fuels to households) to 15, that is, adding the fuels for the transport sector to the list.

2. Data Tables 8 - 13: Transport Sector (Exhibit III-5)

The transportation sector corresponds to a side branch of the network file. It is initiated by a supply type operator (data table 8) that defines fuel demands for the following demand sectors: roads gasoline, roads ado, roads LPG (none in 1982), rail for ado, ido fuel oil and coal; ship for ado, ido and fuel oil, avgas and avtur.

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EXHIBIT III-3

household growth

label	1983	1984	1985	1990	1995	2000
urban cooking/kero	1.80	1.80	1.80	1.80	1.80	1.80
urban lighting/kero	1.80	1.80	1.80	1.80	1.80	1.80
rural cooking/kero	2.60	2.60	2.60	2.60	2.60	2.60
rural lighting/kero	2.60	2.60	2.60	2.60	2.60	2.60
lpg	2.00	2.00	2.00	2.00	2.00	2.00
Java-electr	2.00	2.00	2.00	2.00	2.00	2.00
electricity	2.00	2.00	2.00	2.00	2.00	2.00
gas	2.00	2.00	2.00	2.00	2.00	2.00
wood	2.00	2.00	2.00	2.00	2.00	2.00
agric wastes	2.00	2.00	2.00	2.00	2.00	2.00
charcoal	2.00	2.00	2.00	2.00	2.00	2.00

EXHIBIT III-4

household income growth

label	1983	1984	1985	1990	1995	2000
urban cooking/kero	.00	.00	5.00	5.00	5.00	5.00
urban lighting/kero	.00	.00	5.00	5.00	5.00	5.00
rural cooking/kero	.00	.00	5.00	5.00	5.00	5.00
rural lighting/kero	.00	.00	5.00	5.00	5.00	5.00
lpg	2.50	2.50	2.50	2.50	2.50	2.50
Java-electr	4.00	2.80	3.00	3.00	3.00	3.00
electricity	4.00	2.80	3.00	3.00	3.00	3.00
gas	.00	.00	.00	.00	.00	.00
wood	.00	.00	.00	.00	.00	.00
agric wastes	.00	.00	.00	.00	.00	.00
charcoal	.00	.00	.00	.00	.00	.00

EXHIBIT III-5

```
****************************************************
data table  8
****************************************************
supply
matrix name =transport fuels
matrix size =12  0        .00
none        = 1 12
none
   sector                 kboe
-- -------------------- -------------------
 1 roads,gasoline        23163.290 kboe
 2 roads,ado             26555.000 kboe
 3 roads,lpg                 .000
 4 rail,ado                391.000 kboe
 5 rail,ido                  8.000 kboe
 6 rail,fueloil            120.000 kboe
 7 rail,coal                88.000 kboe
 8 ship,ado               2106.000 kboe
 9 ship,ido                636.000 kboe
10 ship,fueloil            231.000 kboe
11 avgas                    84.000 kboe
12 avtur                  4699.000 kboe
****************************************************
data table  9
****************************************************
v-elasticity
consis.check= 0
matrix name =maed4.dem
output name =income adj demands
output units=kboe
matrix size =12 12         .00
none        = 1 12
none
   sectors                sectors              income elast
-- -------------------- -- -------------------- ----------
 1 roads,gasoline        1 roads,gasoline            1.0
 2 roads,ado             2 roads,ado                 1.00
 3 roads,lpg             3 roads,lpg                 1.
 4 rail,ado              4 rail,ado                  1.
 5 rail,ido              5 rail,ido                  1.
 6 rail,fueloil          6 rail,fueloil              1.
 7 rail,coal             7 rail,coal                 1.
 8 ship,ado              8 ship,ado                  1.
 9 ship,ido              9 ship,ido                  1.
10 ship,fueloil         10 ship,fueloil              1.
11 avgas                11 avgas                     1.00
12 avtur                12 avtur                     1.00
****************************************************
data table 10
****************************************************
matrix
consis.check= 0
matrix name =aggreg fuels
output name =fuel demand
output units=kboe
matrix size = 8 12         .00
none        = 1  8
none
   sector                 fuel
-- -------------------- -- -------------------- ----------
 1 roads,gasoline        1 gasoline                  1.000
 2 roads,ado             2 ado                       1.000
 3 roads,lpg             3 lpg                       1.000
 4 rail,ado              2 ado                       1.000
 5 rail,ido              4 ido                       1.000
 6 rail,fueloil          5 fueloil                   1.000
 7 rail,coal             6 coal                      1.000
 8 ship,ado              2 ado                       1.000
 9 ship,ido              4 ido                       1.000
10 ship,fueloil          5 fueloil                   1.000
11 avgas                 7 avgas                     1.000
12 avtur                 8 avtur                     1.000
****************************************************
data table 11
****************************************************
v-elasticity
consis.check= 0
matrix name =maed5.dem
output name =price adj demands
output units=kboe
matrix size = 8  8         .00
transport   = 1  8
none
   fuel                   fuel                 price elast
-- -------------------- -- -------------------- ----------
 1 gasoline              1 gasoline                 -.050
 2 ado                   2 ado                      -.100
 3 lpg                   3 lpg                       .000
 4 ido                   4 ido                       .000
 5 fueloil               5 fueloil                   .000
 6 coal                  6 coal                      .000
 7 avgas                 7 avgas                     .000
 8 avtur                 8 avtur                     .000
****************************************************
data table 12
****************************************************
addition
consis.check= 0
matrix name =add transport
output name =partial demand
output units=kboe
matrix size =15 15         .00
none        = 1 15
none

-- -------------------- -- -------------------- ----------
****************************************************
data table 13
****************************************************
aggregate
consis.check= 0
matrix name =dummy sequence
output name =
output units=
matrix size =25 25         .00
none        =
none

-- -------------------- -- -------------------- ----------
 1 Java-electr
 2 electricity
 3 lpg
 4 avgas
 5 avtur
 6 gasoline
 7 ado
 8 ido
 9 kerosene
10 fueloil
11 petrochems
12 lubes/waxes
13 asphalt
14 petr coke
15 gas
16 charcoal
17 wood
18 agric wastes
19 coal
20 coke
21 solar-pv
22 solar
23 biogas
24 wind
25 hydro
```

Data source for rail and ship is ADP-7; avgas and avtur source is MIGAS and includes military. Gasoline corresponds to all domestic sales. ADO is a MAED Working Group estimate: sales by dealers plus 39.9 percent of ado sold to industry plus 300,000 kl sold to the agriculture sector. Note that two categories of fuel use sometimes allocated to the transport sector, "PDN own use" and "Refinery use" are excluded here; the fuel use by Pertamina in refinery production and fuel distribution is accounted for in the Energy Supply/Demand Balance Model and appear in the Balance Table in the line "losses".

Data tables 9 and 11 contain income and price elasticities respectively, and make reference to external file MAED4.DEM that contains fuel growth rates (EXHIBIT III-6) and MAED5.DEM that contains price changes for transportation fuels (all zero at this time). The resulting energy demand projections for the transport sector are entered into the "transport" row of the Summary Table, indicated in the appropriate line of data table 11.

Data table 10 performs an aggregation of fuels similar to the operation of data table 7, that is, ado use in roads, ship and rail is collapsed into a single demand for ado in transport and so on. Data table 12 performs the addition of transport sector demands (in a side branch initiated in data table 8) to the main branch of the network. Data table 13 is an artificial sequence meant to increase the number of fuels to 25, in order to accommodate fuels used in subsequent data tables. Note that the number of fuels, labels and the order of these elements in this vector correspond exactly to those used as input to the Energy Supply/Demand Balance model. In this way, the results of the Econometric Demand Projection model can be automatically stored and used as input to the Energy Supply/Demand Balance Model.

3. Data Tables 14 - 18: Industrial/Commercial Sector (Exhibit III-7)

Data table 14 contains the fuel demands for 17 categories of industrial and commercial uses in 1982. Elements 1, 2, 10, 11 are electricity sales data for services and industry for Java and outside Java respectively, obtained from PLN. Elements 4 to 7 are sales of

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EXHIBIT III-6

transport fuels growth rates

label	1983	1984	1985	1990	1995	2000
roads,gasoline	-5.30	1.00	4.00	4.00	4.00	4.00
roads,ado	-1.00	2.50	4.00	4.00	4.00	4.00
roads,lpg	.00	.00	.00	.00	.00	.00
rail,ado	5.00	5.00	5.00	5.00	5.00	5.00
rail,ido	-9.00	-9.00	.00	.00	.00	.00
rail,fueloil	-9.00	-9.00	.00	.00	.00	.00
rail,coal	.00	.00	.00	.00	.00	.00
ship,ado	55.00	7.00	7.00	7.00	7.00	7.00
ship,ido	38.00	5.00	5.00	5.00	5.00	5.00
ship,fueloil	50.00	5.00	5.00	5.00	5.00	5.00
avgas	-9.00	.00	.00	.00	.00	.00
avtur	-5.00	2.00	5.00	3.00	3.00	3.00

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EXHIBIT III-7

```
**********************************************************
data table 14
**********************************************************
supply
matrix name =industry,services
matrix size =17  0        .00
none        = 1 17
none
   activity/fuel      .  misc units
-- ------------------- --------------------
 1 Java Services electr    967.720 kboe
 2 Luar Services electr    320.300 kboe
 3 dummy                      .000 gwh
 4 asphalt                 975.000 kboe
 5 lubes/waxes             487.000 kboe
 6 petrochems              255.400 kboe
 7 petr coke               147.300 kboe
 8 Misc Industry fuel    14687.500 kboe
 9 Industry kerosene      9961.730 kboe
10 Java Industry PLN      1602.110 kboe
11 Luar Industry PLN       200.000 kboe
12 Industry gas           1910.000 kboe
13 Lpg industry/service    270.000 kboe
14 Peleburan                24.530 kboe
15 Krak feedstock         3000.000 kboe
16 Fertil fuel & feeds   12700.000 kboe
17 fueloil feedstock       781.100 kboe
**********************************************************
data table 15
**********************************************************
share
consis.check= 0
matrix name =fuel shares
output name =base year demand
output units=
matrix size =21 17        .00
none        = 1 21
none

-- ------------------- -- ------------------- ----------
 1 Java Services electr  1 Java-electr              1.000
 2 Luar Services electr  2 electricity              1.000
 3 dummy                 3 electricity              1.000
 4 asphalt               4 asphalt                  1.000
 5 lubes/waxes           5 lubes/waxes              1.000
 6 petrochems            6 petrochems               1.000
 7 petr coke             7 petr coke                1.000
 8 Misc Industry fuel    8 ido                       .17
 8 Misc Industry fuel    9 fueloil                   .481
 8 Misc Industry fuel   10 coal                      .009
 8 Misc Industry fuel   11 wood                      .000
 8 Misc Industry fuel   12 agric wastes              .340
 9 Industry kerosene    13 kerosene                 1.000
10 Java Industry PLN    14 Java-electr              1.000
11 Luar Industry PLN    15 electricity              1.000
12 Industry gas         16 gas                      1.000
13 Lpg industry/service 17 lpg                      1.000
14 Peleburan            18 coal                     1.000
15 Krak feedstocks      19 gas                      1.000
16 Fertil fuel & feeds  20 gas                      1.000
17 fueloil feedstock    21 fueloil                  1.000
```

```
**********************************************************
data table 16
**********************************************************
vgrowth
consis.check= 0
matrix name =maed6.dem
output name =projected demands
output units=
matrix size =21 21        .00
none        = 1 21
none

-- ------------------- -- ------------------- ----------
**********************************************************
data table 17
**********************************************************
projects
consis.check= 0
matrix name =project.dem
output name =demd
output units=
matrix size =21 21        .00
industry    = 1 21
none

-- ------------------- -- ------------------- ----------
**********************************************************
data table 18
**********************************************************
addition
consis.check= 0
matrix name =add industry
output name =part total
output units=
matrix size =25 25        .00
none        = 1 25
none

-- ------------------- -- ------------------- ----------
```


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non-energy petroleum products: asphalt, lubes/waxes, petrochemicals, and petroleum coke. The data source is MIGAS Oil Statistics[1].

Industrial use of fossil fuels is separated between usage as fuel proper, as feedstocks and as inputs to auto-generation of electricity (i.e., captive power). Captive power uses of fuels are accounted for later. Feedstock uses are identified by fuel type: elements 14 to 16 contain 1982 demands of coal, natural gas and fuel oil as feedstocks to Peleburan, Krakatau Steel and the fertilizer industry respectively (element 15, natural gas use by the fertilizer industry, also includes the gas used as fuel by that sector).

The remaining fuels are used as inputs to boilers and kilns, as well as other unspecified uses such as lighting. Kerosene use (element 9) is estimated by the MAED Working Group at 20 percent of total sales; LPG (element 13) is estimated here at 35 percent of total sales. Natural gas (element 12) corresponds to sales to cement plants and sales by PGN to small industries. Finally, miscellaneous fuels to industry (element 8) corresponds to a total consumption of ido, fuel oil, coal, wood and agricultural wastes as fuels in 1982. The fractional shares of these fuels are indicated in data table 15. Note that the amounts for wood has not been estimated at this point.

Data table 16 is a vgrowth operator that references the external file MAED6.DEM (Exhibit III-8) for growth rates for each fuel category. These yearly growth rates in existing industry/services fuel demands are supplemented in data table 17 by a *projects type file that makes reference to an external file PROJECTS.DEM (Exhibit III-9). This file contains a list of large projects known to be constructed during the time horizon of the projection. The file shown contains the coal scheduled to be consumed by existing and new cement plants in Indonesia. For each kboe of coal scheduled to be used in existing cement plants, a similar amount of fuel oil or gas can be deducted from demand, by inserting the appropriate negative fuel demand in the external data file. See the RESGEN User Manual for more details on the *projects type file.

EXHIBIT III-8

Industry/service growth rates

label	1983	1984	1985	1990	1995	2000
Java-Services electr	10.40	6.20	8.00	8.00	8.00	8.00
Luar Services electr	10.40	6.20	8.00	8.00	8.00	8.00
dummy	.00	.00	.00	.00	.00	.00
asphalt	2.00	2.00	2.00	2.00	2.00	2.00
lubes/waxes	3.00	3.00	3.00	3.00	3.00	3.00
petrochems	.00	.00	.00	.00	.00	.00
petr coke	.00	.00	.00	.00	.00	.00
Misc Industry ido	5.00	5.00	5.00	4.00	4.00	4.00
Misc Industry fueloi	5.00	5.00	5.00	4.00	4.00	4.00
Misc Industry coal	.00	.00	.00	.00	.00	.00
Misc Industry wood	.00	.00	.00	.00	.00	.00
Misc Industry ag was	.00	.00	.00	.00	.00	.00
Industry kerosene	-20.0	-20.0	-5.00	-5.00	-5.00	.00
Java Industry PLN	25.40	11.00	8.00	8.00	8.00	8.00
Luar Industry PLN	25.40	11.00	8.00	8.00	8.00	8.00
Industry gas	.00	.00	.00	.00	.00	.00
Lpg industry/service	5.00	5.00	5.00	5.00	5.00	5.00
Peleburan	.00	.00	.00	.00	.00	.00
Krak feedstock	.00	10.00	17.00	10.00	5.00	5.00
Fertil fuel & feeds	13.00	20.00	6.00	6.00	5.00	5.00
fueloil feedstock	0.00	0.00	0.00	0.00	0.00	0.00

EXHIBIT III-9

project.dem: project list, cement plants

year	i.d.	project	+fuel	fuel
1985	demd	cement plants	2971.00	coal
1986	demd	cement plants	5155.00	coal
1987	demd	cement plants	1218.00	coal
1988	demd	cement plants	344.00	coal
1989	demd	cement plants	925.00	coal
1990	demd	cement plants	1032.00	coal
1991	demd	cement plants	2365.00	coal
1992	demd	cement plants	1505.00	coal
1993	demd	cement plants	860.00	coal

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Total fuel and electricity demand in industry (except for fuel used in the generation of captive electricity) is entered into the "industry" row of the Summary Table by the appropriate entry in data table 17.

Industry sector fuels are added to the household/transport totals in data table 18.

4. Data Table 19 - 24: Captive Power Sector (Exhibit III-10)

A third side branch of the network contains fuel projections for captive power. Four subsectors (or elements) are identified: captive power in miscellaneous large and medium sized industries, Krakatan Steel, P.T. Timah and Larona/Asahan.

Production of electricity by these subsectors is expressed in kboe of electricity (1 kboe (e) = 1611.1 mWh). Krakatau Steel generated in 1982 an estimated 800 gWh of electricity using natural gas (source: MAED Working Group); P.T. Timah generated 125 gWh using coal as fuel (source: MAED Working Group); the hydro electric plant at Larona (nickel) and Asahan (aluminum) generated that year 1242 gWh (source: PTE). Captive electricity generated by all other large and medium sized industries in the country (including agriculture as well as emergency generation in use in buildings, hotels, hospitals, etc.) is estimated by the MAED Working Group to have reached 10,438 gWh in 1982.

Data table 20 is a vgrowth type operator that makes reference to an external file MAED7.DEM that contains growth rates for the four captive power subsectors (Exhibit III-11). In data table 21 a share type operator allows for modelling a gradual shift from captive power to PLN supplied electricity for the Java grid (outside Java such a shift is less likely because PLN will generally not be able to provide self-generators with electricity). This shift is indicated in lines 440 and 441 by the "del" command in the sector field of the data table: starting in the base year 1982, when zero percent of the captive power is supplied by PLN, the following year 3 percent is

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EXHIBIT III-10

```
data table 19
supply
matrix name =captive power
matrix size = 4  0        .00
none        = 1  4
none
   activity              kboe(e)
-- -------------------- --------------------
 1 Captive power          6479.320 kboe
 2 Krakatau captive        558.700 kboe
 3 Timah captive            77.600 kboe
 4 Larona/Asahan           771.000 kboe
data table 20
vgrowth
consis.check= 0
matrix name =maed7.dem
output name =preojected captive
output units=kboe
matrix size = 4  4        .00
none        = 1  4
none

-- -------------------- -- -------------------- ----------
data table 21
share
consis.check= 0
matrix name =share to PLN
output name =captive
output units=kboe
matrix size = 5  4        .00
none        = 1  5
none

-- -------------------- -- -------------------- ----------
 1 captive power          1 Java-electr              0.000 del=25x+.03
 1 captive power          2 captive power            1.000 del=25x-.03
 2 Krakatau captive       3 captive electr           1.000
 3 Timah captive          4 captive electr           1.000
 4 Larona/Asahan          5 captive hydro            1.000
data table 22
share
consis.check= 0
matrix name =fuels to captive
output name =fuels to captive pow
output units=kboe
matrix size = 7  5        .00
none        = 1  7
none

-- -------------------- -- -------------------- ----------
 1 Java-electr            1 Java-electr              1.000
 2 captive power          2 ido                       .260
 2 captive power          3 fueloil                   .055
 2 captive power          4 ado                       .684
 3 captive power          5 gas                      1.000
 4 captive power          6 coal                     1.000
 5 captive hydro          7 hydro                    1.000
```

```
data table 23
diagonal
consis.check= 0
matrix name =fuels to captive
output name =fuels to captive
output units=kboe
matrix size = 7  7        .00
captive powe= 2  7
industry    = 1  1
   source                 fuel                 fuel/elec
-- -------------------- -- -------------------- ---------
 1 Java-electr          1 Java-electr              1.00
 2 ido                  2 ido                      3.34
 3 fueloil              3 fueloil                  3.04
 4 ado                  4 ado                      3.06
 5 gas                  5 gas                      3.00
 6 coal                 6 coal                     3.00
 7 hydro                7 hydro                    3.00
data table 24
addition
consis.check= 0
matrix name =add captive
output name =demand
output units=misc units
matrix size =25 25        .00
none        = 1 25
none

-- -------------------- -- -------------------- ----------
```


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supplied by PLN, and 97 percent by captive power, and 6 percent and 94 percent respectively the year after that and so on for 25 periods, when 75 percent of this demand will be supplied by PLN and 25 percent by self-generators. This option can be suppressed by deleting the "del" command in lines 440 and 441.

Data table 22 is a share type operator that establishes the share of petroleum products to captive generation. These are 68.4 percent ado, 26.0 percent ido and 5.5 percent fuel oil (source: MAED Working Group). Data table 23 contains the fuel efficiencies expressed in boe(fuel)/kboe(elec) for each source; ado, ido and fuel oil are obtained from the MAED Working Group; for Larona, Asahan, Krakatau Steel and P.T. Timah, a value of 3.0 boe(fuel)/kboe(elec) is used. Energy to captive power is entered in the "Captive Power" row of the Summary Table. The fraction supplied by PLN is entered in the "industry" row.

5. Data Table 25: Store Outputs (Exhibit III-12)

The final sequence in the network serves two functions. It converts thousand barrels of oil equivalent (kboe) into million barrels of oil equivalent (mboe), in order to be consistent with the units required in the Energy Supply/Demand Balance Model. The second command is to store the resulting energy demand projections under the default filename MAED.INT, or any other file name specified by the user, and entered into the DYNAMIC.DIR directory for selection as input to INDONES.DAT, the network file of the Energy Supply/Demand Balance Model.

C. RESULTS

1. Output Configuration Files

The output of Econometric Projections model is tabulated in a Summary Table. LMAED.DEM is the file name that contains the row labels of the Summary Table (Exhibit III-13). Additional tables are specified in the file MAEDPLT.DEM (Exhibit III-14).

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EXHIBIT III-11

captive power growth

label	1983	1984	1985	1990	1995	2000
Captive power	5.00	5.00	5.00	5.00	5.00	5.00
Krakatau captive	22.00	10.00	.00	.00	.00	.00
Timah captive	7.00	7.00	7.00	7.00	.00	.00
Larona/Asahan	170.0	00.00	00.00	0.0	.00	.00

EXHIBIT III-12

```
data table 25
matrix
consis.check= 0
matrix name =units conversion
output name =out=dynamic=def=maed.int
output units=mboe
matrix size =25 25      .00   0   0
none        = 1 25 barch=
none        = 0  0 barch=
```

	fuels (misc units)		Fuels(mboe)	conversion
1	Java-electr	1	Java-electr	.001
2	electricity	2	electricity	.001
3	lpg	3	lpg	.001
4	avgas	4	avgas	.001
5	avtur	5	avtur	.001
6	gasoline	6	gasoline	.001
7	ado	7	ado	.001
8	ido	8	ido	.001
9	kerosene	9	kerosene	.001
10	fueloil	10	fueloil	.001
11	petrochems	11	petrochems	.001
12	lubes/waxes	12	lubes/waxes	.001
13	asphalt	13	asphalt	.001
14	petr coke	14	petr coke	.001
15	gas	15	gas	.001
16	charcoal	16	charcoal	.001
17	wood	17	wood	.001
18	agric wastes	18	agric wastes	.001
19	coal	19	coal	.001
20	coke	20	coke	.001
21	solar-pv	21	solar-pv	.000
22	solar	22	solar	.000
23	biogas	23	biogas	.001
24	wind	24	wind	.000
25	hydro	25	hydro	.001

```
END
```


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EXHIBIT III-13

```
Summary Table Definitions
*****************************************************************************

1- 1---------------------------e

01=households
02=transport
03=industry
04=captive power
05=.total
   end
-- ----------------------------
   current account table
-- ----------------------------
   US $mill
01=imports
02=-exports/bunkers
  =.net
  =end
```

EXHIBIT III-14

```
time plot parameters
*****************************************************************************
#   display              bal.table ro  label                 #   #
1-  1------------------  1-----------  1------------------  1-  1-e
01  total demand         .total        petr prods          03  16
                                       gas                 17  17
                                       electricity         23  25
                                       coal                20  20
                                       wood/ag wastes      29  31
                                       hydro               26  26
02  fuel by sector       households    households          03  35
                         transport     transport           03  35
                         industry      industry            03  35
                         captive powe  captive power       03  35
```


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NOTES AND REFERENCES

CHAPTER III

1. MIGAS Oil Statistics, 1983
   Petrochemicals: White spirits, Super Benzex, Solvent, TBO/POD, LS+O/Mineral Turp, Waxes/parafin
   lubes/waxes: Lub oil
   petroleum coke: cokes

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IV REGIONAL DEMAND MODEL

A. INTRODUCTION

The Regional Demand Model has as an objective the generation of detailed energy demand projections by sector for eight regions of Indonesia. Because of the level of detail selected for this model, its data requirements serve as a comprehensive data base of regional energy demands. The model also serves as a framework for identification of data gaps at the regional level. As will be discussed throughout this chapter, these gaps are numerous; in most cases national data has been disaggregated by indicators (or "location quotients") such as GNP by province, population by province and number of vehicles by province.

The eight regions selected for the model are designed around aggregations of Indonesia's 27 provinces. As shown in Exhibit IV-1, Regions 1 to 4 are in Sumatra, the island of Java is Region 5, Kalimantan's four provinces are Regions 6 and 7, and the remaining islands from Bali to the east, including Sulawesi, the Moluccas and Irian Jaya are Region 8.

The rationale in this selection, in which DJL staff and Project Steering Committee members participated actively, was varied:

- Sumatra's rich energy resources, in particular coal, together with its proximity to centers of demand-principally in Java, and the wide range of energy transportation cost to Java from different points in Sumatra, results in four distinctive regions for that island. A similar rationale made it important to separate Kalimantan into two regions.

- Java is best analyzed as a single demand region because it has an integrated electric grid, has an extensive road network linking its three provinces and is generally a net importer of fuels (refined petroleum products, crude oil, coal) from other regions or from other countries.

- Most importantly, the selection of the regions follow the availability of information on energy consumption from a handful of existing sources: BPS Statistics by

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Exhibit IV-1

EPfD II REGIONS

EPfD II Regions	Provinces	PLN Regions	Pertamina Regions
Region 1	Aceh, Sumatra Utara	I, II	U.P. I
Region 2	Sumatera Barat,	III(1)	
Region 3	Riau	III(1)	
Region 4	Sumatera Selatan, Lampung, Jambi Bengkulu	IV(1)	U.P. II
Region 5	Jawa	XII, XIII Da, Db, K	U.P. III(2), U.P. IV, U.P. V(3)
Region 6	Kalimantan Barat	V	(2)
Region 7	Kalimantan Timur & Tengah & Selatan	VI	(3)
Region 8	Bali, Sulawesi, Nusa Tenggara, Muluku, Irian Jaya	VII, VIII IX, X, XI	U.P. VI, VII, VIII(3)

(1) PLN Regions III and IV overlap EPfD II Regions 3 and 4 in one district of Jambi province. EPfD II Regions 2 and 3 correspond otherwise to PLN Region III, which must be disaggregated.

(2) Kalimantan Barat included in U.P. III

(3) Pertamina Region U.P. V (East Java) includes EPfD II Region 7 and Bali (part of EPfD II Region 8).

province for energy consumption by large and medium industries; statistics on petroleum products sales by Pertamina regions (ADP-7), and electricity sales by customer class by PLN regions. An approximate mapping of Pertamina and PLN regions is shown in Exhibit IV-1. Other regional information can be obtained indirectly: gas sales are identified by major customers (their location is generally known), as are the cities served by PGN Gas; the future demand of coal in cement plants is known from the location of these plants and so on.

B. STRUCTURE OF THE REGIONAL DEMAND MODEL

The model is structured to allow for maximum flexibility. There are four models for each region: households, transport, industry and other sectors. The resulting sectoral demands by region are tabulated in summary tables as those shown in Exhibits IV-2 to IV-5.

The next step allows two options:

1. Regional Total: an addition of the four sectors for a region produces summary tables of regional demand by sectors (Exhibit IV-6). The resulting regional totals can be aggregated into a national total demand by region, the result of which (Exhibit IV-7) is a vector of national energy demands that can be used as input to the Energy Supply Demand Balance Model.

2. Regional Energy Balances: the regional energy demands obtained in (1) above can be used directly with as input to a file of the type of the Energy Supply/Demand Model, to produce regional energy balances. The network file (INDONES.DAT) and external data files described in Chapter II can be copied and adjusted to reflect the particular regional characteristics: list of power plants, refineries, crude oil production etc.

3. Sectoral Totals: the sectoral modules can be aggregated in one step into a national total by sectors (Exhibit IV-8). The resulting sector of demands is identical to the national total by region (see (1) above), and can be used as input to the Energy Supply/Demand Balance Model.

EXHIBIT IV-2

Indonesia Energy Model

Household Region 5 (Java, hholdr5.dat)

sept 2

1988 Household Sector (kboe)

	kerosene	Java-elec	total
Urb.cooking	12635.95	.00	12635.95
Urb.light	2881.70	.00	2881.70
Hotwater	.00	.00	.00
Airconditio	.00	.00	.00
Water pump	.00	.00	.00
Urb.oth.ele	.00	3064.81	3064.81
Rur.oth.ele	.00	.00	.00
Rur.cooking	7262.33	.00	7262.33
Rur.light	13696.17	.00	13696.17
Urb.hom/ind	.00	.00	.00
Rur.hom/ind	.00	.00	.00
.total	36476.15	3064.81	39540.96

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EXHIBIT IV-3

Indonesia Energy Model

Transport Region 5 (Java, tranr5.dat)

sept 2

1988 Transportation Sector (kboe)

	avgas	avtur	gasoline	ado	ido	fueloil	total
auto	.00	.00	5936.22	446.32	.00	.00	6382.53
truck	.00	.00	755.49	6938.95	.00	.00	7694.44
sm. truck	.00	.00	8022.99	2275.69	.00	.00	10298.67
bus	.00	.00	535.64	4199.75	.00	.00	4735.38
sm. bus	.00	.00	1100.13	265.06	.00	.00	1365.19
motorcycle	.00	.00	4375.80	.00	.00	.00	4375.80
rail	.00	.00	.00	336.60	19.95	186.26	542.81
ship	.00	.00	.00	1716.47	488.04	182.82	2387.33
air	53.94	3038.85	.00	.00	.00	.00	3092.79
.total	53.94	3038.85	20726.25	16178.83	507.99	369.09	40874.94

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EXHIBIT IV-4

Indonesia Energy Model

Industry Region 5 (Java, indusr5.dat)

sept 2

1988 Industry Sector (kboe)

	ado	ido	fueloil	gas	f-electri	Java-elec	agric was	total
Food	1444.53	1061.39	786.98	.00	533.28	.00	1351.33	5177.51
Textile	991.54	728.30	1811.98	.00	855.53	.00	.00	4387.36
Pulp,Paper	476.86	348.89	325.99	.00	.00	196.67	.00	1348.42
Rubber	.00	.00	182.21	.00	84.57	.00	.00	266.78
Chemicals	30.76	22.70	465.05	.00	.00	213.85	.00	732.36
Cement	1516.09	1108.31	564.61	1683.38	.00	355.50	.00	5227.90
Ceramics	1145.47	841.47	321.02	.00	.00	124.03	.00	2432.00
Iron,Steel	543.95	398.90	340.88	5816.66	.00	159.56	.00	7259.95
Other Manuf	7.44	5.15	180.94	.00	379.05	.00	.00	572.59
Fertilizer	83.15	55.43	27.72	13525.78	.00	166.30	.00	13858.38
Small indus	.00	.00	.00	.00	.00	.00	.00	.00
.total	6239.80	4570.56	5007.38	21025.82	1852.44	1215.91	1351.33	41263.25

)

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EXHIBIT IV-5

Other Sectors Region 5 (Java, otherr5.dat)

sept 2

1988 Comm/Agric/Mining & Other (kboe)

	avgas	avtur	gasoline	kerosene	ado	ido	fueloil	petrochem	lubes/wax	asphalt
agriculture	.00	.00	.00	.00	298.06	14.39	.00	.00	.00	.00
plantation	.00	.00	.00	.00	224.38	98.77	18.24	.00	.00	.00
forestry	.00	.00	.00	.00	144.87	1.17	.00	.00	.00	.00
oil/gas explor	.00	.00	.00	.00	1101.58	.00	675.15	.00	.00	.00
coal	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
nickel	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
tin	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
copper	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
mining,other	.00	.00	.00	.00	26.35	.00	.00	.00	.00	.00
konstruksi	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
government	.00	.00	.00	.00	489.52	75.45	46.01	.00	.00	.00
commercial	.00	.00	.00	1083.49	.00	.00	.00	.00	.00	.00
institutions	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
street lighting	.00	.00	.00	.00	.00	.00	.00	.00	.00	.00
strategic	23.63	214.56	1001.26	.00	530.57	.00	.00	.00	.00	.00
non-energy	.00	.00	.00	.00	.00	.00	.00	287.71	548.12	1098.33
.total	23.63	214.56	1001.26	1083.49	2815.35	189.78	739.41	287.71	548.12	1098.33

1988 Comm/Agric/Mining & Other (cont.): (kboe)

	petr coke	Java-elec	total
agriculture	.00	.00	312.45
plantation	.00	.00	341.40
forestry	.00	.00	146.04
oil/gas explor	.00	.00	1776.75
coal	.00	.00	.00
nickel	.00	.00	.00
tin	.00	.00	.00
copper	.00	.00	.00
mining,other	.00	.00	26.35
konstruksi	.00	.00	.00
government	.00	.00	610.99
commercial	.00	6489.40	7572.89
institutions	.00	85.41	85.41
street lighting	.00	.00	.00
strategic	.00	.00	1770.02
non-energy	156.38	.00	2090.54
.total	156.38	6574.81	14732.83

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EXHIBIT IV-6

Indonesia Energy Model

Demand Region 5, Java

1988 Demand by Region (kboe)

	avgas	avtur	gasoline	kerosene	ado	ido	fueloil	petrochem	lubes/wax	asphalt
households	.00	.00	.00	36476.15	.00	.00	.00	.00	.00	.00
transport	53.94	3038.85	20726.25	.00	16178.83	507.99	369.09	.00	.00	.00
industry	.00	.00	.00	.00	14468.48	4570.56	5007.38	.00	.00	.00
other sect	23.63	214.56	1001.26	1083.49	2815.35	189.78	739.41	287.71	548.12	1098.33
.total	77.57	3253.41	21727.51	37559.64	33462.66	5268.33	6115.88	287.71	548.12	1098.33

)

1988 Demand by Region (cont.): (kboe)

	petr coke	gas	Java-elec	agric was	total
households	.00	.00	3064.81	.00	39540.96
transport	.00	.00	.00	.00	40874.94
industry	.00	21025.82	804.14	1777.01	47653.39
other sect	156.38	.00	6574.81	.00	14732.83
.total	156.38	21025.82	10443.75	1777.01	142802.10

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EXHIBIT IV-7

Indonesia Energy Model

Indonesia Energy Demand by Region (addregs.dat)

sept 3

1988 Total Demand by Region (kboe)

	avgas	avtur	gasoline	kerosene	ado	ido	fueloil	petrochem	lubes/wax	asphalt
N. Sumatra	15.99	457.91	2905.64	3670.31	4260.68	161.41	442.76	.00	.00	.00
W. Sumatra	.11	3.26	692.47	1119.74	1417.08	212.99	271.37	.00	.00	.00
C. Sumatra	.25	2.13	416.98	793.50	723.62	.16	174.01	.00	.00	.00
S. Sumatra	2.95	187.84	2265.19	3528.72	5903.56	1345.76	955.19	.00	.00	.00
Java	77.57	3253.41	21727.51	37559.64	33462.66	5268.33	6115.88	287.71	548.12	1098.33
W. Kaliman	1.06	9.15	279.47	1274.18	447.08	15.55	164.57	.00	.00	.00
E.C.&S.Kalim	1.09	12.48	983.63	1765.71	3594.84	72.00	1234.36	.00	.00	.00
East Indonesia	20.52	747.16	3559.97	18745.52	4988.49	88.98	1632.41	.00	.00	.00
.total	119.53	4673.34	32830.85	68457.33	54798.00	7165.18	10990.55	287.71	548.12	1098.33

1988 Total Demand by Region (cont.): (kboe).

	petr coke	gas	coal	electrici	Java-elec	hydro	agric vas	hydro	total
N. Sumatra	.00	.00	.75	854.33	.00	.00	91.81	4940.48	17802.07
W. Sumatra	.00	.00	2168.67	163.52	.00	.00	64.37	.00	6113.59
C. Sumatra	.00	.00	.00	744.05	.00	.00	.00	.00	2854.68
S. Sumatra	.00	.00	222.36	1055.49	.00	.00	243.11	.00	15710.17
Java	156.38	21025.82	.00	.00	10443.75	.00	1777.01	.00	142802.10
W. Kaliman	.00	.00	.05	85.48	.00	.00	22.01	.00	2298.60
E.C.&S.Kalim	.00	1012.41	.00	144.05	.00	.00	13.47	.00	8834.05
East Indonesia	.00	.00	67.52	350.85	.00	1431.87	36.29	.00	31669.57
.total	156.38	22038.23	2459.36	3397.79	10443.75	1431.87	2248.07	4940.48	228084.80

EXHIBIT IV-8

Indonesia Energy Model

Indonesia Demands by Sectors (sectors.dat)

sept 3

1988 Demand (kboe)

	avgas	avtur	gasoline	kerosene	ado	ido	fueloil	petrochem	lubes/wax	asphalt
households	.00	.00	.00	66822.48	.00	.00	.00	.00	.00	.00
transport	89.60	4343.83	31393.57	.00	25633.54	639.45	415.60	.00	.00	.00
industry	.00	.00	.00	.00	17352.70	5521.70	7377.96	.00	.00	.00
other sect	29.93	329.51	1437.29	1634.85	11811.76	1004.03	3196.99	287.71	548.12	1098.33
.total	119.53	4673.34	32830.86	68457.34	54798.00	7165.18	10990.55	287.71	548.12	1098.33

1988 Demand by Region (cont.): (kboe)

	petr coke	gas	coal	electrici	Java-elec	hydro	agric was	total
households	.00	.00	.00	1019.08	3064.81	.00	.00	70906.38
transport	.00	.00	58.33	.00	.00	.00	.00	62573.92
industry	.00	22038.23	2106.81	132.76	804.14	.00	2248.07	57582.36
other sect	156.38	.00	294.21	2245.95	6574.81	6372.35	.00	37022.21
.total	156.38	22038.23	2459.36	3397.79	10443.75	6372.35	2248.07	228084.80

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A schematic of this flexible structure is shown in Figure IV-1 which also includes the RESGEN network filenames associated with each module. The filenames are:

Sectoral Modules (32 network files)
Households, for 8 regions:
HHOLDR1.DAT, HHOLDR2.DAT,...HHOLDR8.DAT
Transport, for 8 regions:
TRANR.DAT, TRANR2.DAT,...TRANR8.DAT
Industry, for 8 regions:
INDUSR1.DAT, INDUSR2.DAT,...INDUSR8.DAT
Other Sectors, for 8 regions
OTHERR1.,DAT, OTHERR2.DAT,...OTHERR8.DAT

Regional Modules (8 network files)
Eight regions:
REGION1.DAT, REGION2.DAT...REGION8.DAT

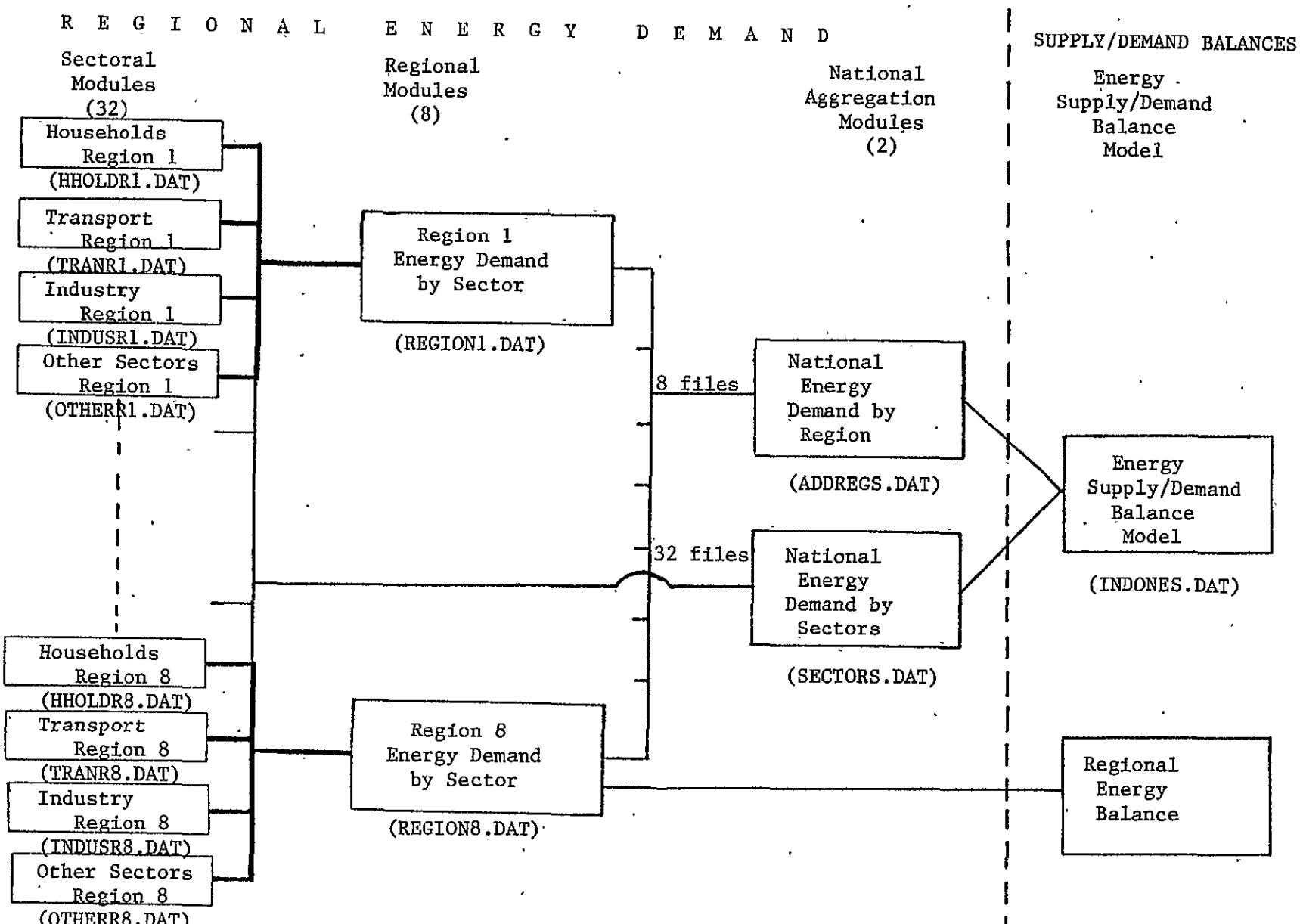
National Totals (2 options)
Aggregation of eight regional totals:
ADDREGS.DAT
Aggregation of 32 sectoral modules
directly: SECTORS.DAT

The network files listed here are stored in RESGEN directories for each region. Directory REGION1.DIR contains the four sector modules and the regional aggregation models for Region 1, and similarly for REGION2.DIR to REGION8.DIR. The network files that produce national totals (ADDREGS.DAT and SECTORS.DAT) are listed in the national directory INDONES.DIR.

The sections that follow detail the equations used in projecting energy demands for each sector of demand (sectoral modules). The regional modules are networks that simply add the sectoral modules together to produce a regional total. Annex 2 contains a listing of a network file of the REGION1.DAT type. The national totals are additions of regions (ADDREGS.DAT, for listing see Annex 2), or of all sectors for all regions (SECTORS.DAT, not shown, since it is similar to a REGION1.DAT type file, with all regions included).

FIGURE IV-1

SCHEMATIC OF RESGEN APPLICATIONS FOR INDONESIA



Network filenames are in parenthesis.

C. HOUSEHOLDS MODULE

1. Sub-Sectoral Disaggregation

The household module has been designed as an ambitious attempt to create a comprehensive and detailed analytical tool and data base for this important energy-use sector. Issues of importance such as urban rural demands, disaggregation of cooking, lighting and other uses, and inclusion of home industries to isolate them from other household uses have been considered. The subsectoral demands selected are shown in Exhibit IV-9 which corresponds to the row labels of the summary table (file LHOUSEH.DAT).

2. Data Tables 1 to 4: Projection of Useful Energy Demand (Exhibit IV-10)

Data table 1 contains the number of households (in thousands) for the region, followed by a vgrowth operator that refers to an external file (GRHOUSE.DAT) that contains household growth rates (Exhibit IV-11). At this point, all regions share the identical external file (i.e., urban and rural population growth rates are the same for all regions) to avoid proliferation of files; it would be quite simple, however, to create files with region-specific population growth rates.

Data table 3 defines useful energy demands per household for the 11 subsectors selected. The values shown here are provisional: they correspond to base year kerosene sales allocated to cooking and lighting assuming an end-use efficiency of 0.20 for cooking and 1.00 for lighting, and all PLN electricity sold to the household sector for each region is allocated to element 6 (Other electricity urban). The Statistical Annex contains the information in its original form (ADP-7 sales by region, PLN sales by RESGEN region) and the transformations of these data to fit the requirements of this module.

Data table 4 has been introduced to account for increasing energy demands due to increases in income, i.e., total useful energy demands independent of fuel substitution, grow as a function of household income growth. An operator v-elasticity is introduced: it performs

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EXHIBIT IV-9

```
**********************************************************************
   Household Sector
1- 1----------------------------e
   kboe
01=Urb.cooking
02=Urb.light
03=Hotwater
04 Airconditio
05 Water pump
06 Urb.oth.ele
07 Rur.oth.ele
08 Rur.cooking
09 Rur.light
10 Urb.hom/ind
11 Rur.hom/ind
12 .total
   end
-- ----------------------------
   current account table
-- ----------------------------
   US $mill
01=imports
02=-exports
03=-bunkers
  =.net
  =end
```


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EXHIBIT IV-10

```
   lhouseh.dat          hplots.dat
   1----------2----------3----------4----------
Household Region 5 (Java, hholdr5.dat)
*****************************************
data table  1
*****************************************
projection
matrix name =No. of Households
matrix size =11  0        .00
none        = 1 11
none
   households            thousands
-- -------------------- --------------------
 1 Urb cooking            3170.100
 2 Urb lighting           3170.100
 3 Hotwater,urban             .000
 4 Aircon                     .000
 5 Water pump                 .000
 6 Urb other elect        3170.100
 7 Rur other elect            .000
 8 Rur cooking           12680.500
 9 Rur lighting          12680.500
10 Urb home indus            0.000
11 Rur home indus             .000
*****************************************
data table  2
*****************************************
vgrowth
consis.check= 0
matrix name =grhouse.dat
output name =Projected households
output units=million units
matrix size =11 11      .00   0   0
none        = 1 11 barch=
none        = 0  0 barch=

-- -------------------- -- --------------------
```

```
*****************************************************************
data table  3
*****************************************************************
diagonal
consis.check= 0
matrix name =Useful energy/househ
output name =Useful energy
output units=kboe(useful)
matrix size =11 11        .00
none        = 1 11
none
   thous.  households      sector                boe/household
-- -------------------- -- -------------------- ----------
 1 Urb cooking          1 Urb cooking              .590
 2 Urb lighting         2 Urb lighting             .740 del=01x-.07
 3 Hotwater,urban       3 Hotwater,urban           .050 boe/year
 4 Aircon               4 Aircon                   .056 boe/year
 5 Water pump           5 Water pump               .006 boe/year
 6 Urb other elect      6 Urb other elect          .556 boe/year
 7 Rur other elect      7 Rur other elect          .059 boe/year
 8 Rur cooking          8 Rur cooking              .080
 9 Rur lighting         9 Rur lighting             .840 del=01x-.08
10 Urb home indus      10 Urb home indus          2.50  boe/year
11 Rur home indus      11 Rur home indus          1.300 boe/year
*****************************************************************
data table  4
*****************************************************************
v-elasticity
consis.check= 0
matrix name =grhinc.dat
output name =Projected Useful Ene
output units=kboe(useful)
matrix size =11 11      .00   0   0
none        = 1 11 barch=
none        = 0  0 barch=
   kboe(useful)            sector
-- -------------------- -- -------------------- ----------
 1 Urb cooking          1 Urb cooking             1.300 household
 2 Urb lighting         2 Urb lighting            1.400 household
 3 Hotwater,urban       3 Hotwater,urban          1.000 household
 4 Aircon               4 Aircon                  1.750 household
 5 Water pump           5 Water pump              1.000 household
 6 Urb other elect      6 Urb other elect         1.500 household
 7 Rur other elect      7 Rur other elect         1.100 household
 8 Rur cooking          8 Rur cooking             1.050 household
 9 Rur lighting         9 Rur lighting            1.200 household
10 Urb home indus      10 Urb home indus          1.000 household
11 Rur home indus      11 Rur home indus          1.000 household
```


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an operation of the type (1+g) where "g" is an income growth rate and the " " are elasticities of household energy demand by activity with respect to income. It makes reference to an external file GRHINC.DAT for yearly growth rates (Exhibit IV-12).

2. Data tables 5 to 7: Fuels to End-Uses (Exhibit IV-13)

The fractions of each fuel to meet the different energy consuming household activities are entered in data table 5. There are 7 possibilities for urban cooking, 2 for urban lighting, 4 each for urban hotwater and water pumping, 6 possibilities for rural cooking, 2 for rural lighting, and 8 and 11 fuels to urban and rural home industries respectively. Electricity is the only fuel to air conditioning and "other electricity" activities for both urban and rural households. The fuel possibilities include existing ones such as kerosene, wood, agricultural wastes and electricity, and future possible ones such as biogas, solar and charcoal.

Note that the shares entered into the data file are the fractions of useful energy demand (or basic energy demands). In order to obtain actual fuel inputs to households, the values must be divided by the end-use efficiency. This step is taken in data table 6, which lists the appropriate efficiencies in the data field of this data table. A special case of the operator diagonal where "matrix name =" is "effic of conversion" is used , which makes the operator divide by the value in the data field. The results of this operation yield projected fuel demand by household activity; note the command "sectors" in the 1st energy balance field of data table 6. The resulting summary table is shown in Exhibit IV-2, shown above.

4. Data table 8: Price Adjustments (Exhibit IV-14)

Household demands are aggregated by activity in data table 7, after which the detail by end-use (cooking, lighting, etc) is lost.

The final data table allows to make adjustments for price increases using an operator of the type p-elasticity. Price elasticities are entered in the data field of data table 8, and price

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EXHIBIT IV-11

households gr rate (grhouse.dat)

label	1983	1984	1985	1990	1995
Urb cooking	1.80	1.80	1.80	1.80	1.80
Urb lighting	1.80	1.80	1.80	1.80	1.80
Hotwater	2.00	2.00	3.00	3.00	4.00
Aircondit	3.00	5.00	6.00	8.00	8.00
Water pump	2.00	2.00	2.00	2.00	2.00
Urb other elect	1.80	1.80	1.80	1.80	1.80
Rur other elect	.00	.00	.00	.00	.00
Rur cooking	2.60	2.60	2.60	2.60	2.60
Rur cooking	2.60	2.60	2.60	2.60	2.60
Urb home indus					
Rur home indus					

EXHIBIT IV-12

hhold income gr rates(grhinc.dat)

label	1983	1984	1985	1990	1995
Urb cooking	.00	.00	3.80	3.80	3.80
Urb lighting	.00	.00	3.60	3.60	3.60
Hotwater	.00	.00	.00	.00	.00
Aircondit	.00	.00	.00	.00	.00
Water pump	.00	.00	.00	.00	.00
Urb other elect	6.00	4.50	5.00	5.00	5.00
Rur other elect	.00	.00	.00	.00	.00
Rur cooking	.00	.00	5.00	5.00	5.00
Rur cooking	.00	.00	4.20	4.20	4.20
Urb home indus	.00	.00	.00	.00	.00
Rur home indus	.00	.00	.00	.00	.00

EXHIBIT IV-13

```
*****************************************************************
data table  5                                                   *
*****************************************************************
share                                                           *
consis.check= 0                                                 *
matrix name =Fractions Useful Dem                               *
output name =Useful Energy by Typ                               *
output units=kboe(useful)                                       *
matrix size =47 11        .00                                   *
none        = 1 47                                              *
none                                                            *
   kboe(useful)            kboe(useful)          fraction       *
-- -------------------- -- -------------------- ----------      *
 1 Urb cooking          1 gas                        .000 Urb.cooking*
 1 Urb cooking          2 lpg                        .000 Urb.cooking*
 1 Urb cooking          3 kerosene                  1.000 Urb.cooking*
 1 Urb cooking          4 Java-electr                .000 Urb.cooking*
 1 Urb cooking          5 wood                       .000 Urb.cooking*
 1 Urb cooking          6 agric wastes               .000 Urb.cooking*
 1 Urb cooking          7 charcoal                   .000 Urb.cooking*
 2 Urb lighting         8 Java-electr                .000 Urb.light  *
 2 Urb lighting         9 kerosene                  1.000 Urb.light  *
 3 Hotwater,urban      10 Java-electr                .000 Hotwater   *
 3 Hotwater,urban      11 lpg                        .000 Hotwater   *
 3 Hotwater,urban      12 gas                        .000 Hotwater   *
 3 Hotwater,urban      13 solar                      .000 Hotwater   *
 4 Aircon              14 Java-electr               1.000 Aircondit  *
 5 Water pump          15 Java-electr                .000 Water pump *
 5 Water pump          16 ado                        .000 Water pump *
 5 Water pump          17 solar-pv                   .000 Water pump *
 5 Water pump          18 wind                       .000 Water pump *
 6 Urb other electan   19 Java-electr               1.000 Urb.oth.ele*
 7 Rur other elect     20 Java-electr               1.000 Rur.oth.ele*
 8 Rur cooking         21 kerosene                  1.000 Rur.cooking*
 8 Rur cooking         22 wood                       .000 Rur.cooking*
 8 Rur cooking         23 agric wastes               .000 Rur.cooking*
 8 Rur cooking         24 biogas                     .000 Rur.cooking*
 8 Rur cooking         25 lpg                        .000 Rur.cooking*
 8 Rur cooking         26 charcoal                   .000 Rur.cooking*
 9 Rur lighting        27 kerosene                  1.000 Rur.light  *
 9 Rur lighting        28 Java-electr                .000 Rur.light  *
10 Urb home indus      29 Java-electr                .000 Urb.hom/ind*
10 Urb home indus      30 kerosene                   .000 Urb.hom/ind*
10 Urb home indus      31 wood                       .000 Urb.hom/ind*
10 Urb home indus      32 charcoal                   .000 Urb.hom/ind*
10 Urb home indus      33 lpg                        .000 Urb.hom/ind*
10 Urb home indus      34 agric wastes               .000 Urb.hom/ind*
10 Urb home indus      35 coke                       .000 Urb.hom/ind*
10 Urb home indus      36 gas                        .000 Urb.hom/ind*
11 Rur home indus      37 lpg                        .000 Rur.hom/ind*
11 Rur home indus      38 kerosene                   .000 Rur.hom/ind*
11 Rur home indus      39 Java-electr                .000 Rur.hom/ind*
11 Rur home indus      40 wood                       .000 Rur.hom/ind*
11 Rur home indus      41 agric wastes               .000 Rur.hom/ind*
11 Rur home indus      42 ado                        .000 Rur.hom/ind*
11 Rur home indus      43 solar-pv                   .000 Rur.hom/ind*
11 Rur home indus      44 wind                       .000 Rur.hom/ind*
11 Rur home indus      45 biogas                     .000 Rur.hom/ind*
11 Rur home indus      46 charcoal                   .000 Rur.hom/ind*
11 Rur home indus      47 coke                       .000 Rur.hom/ind*
```


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EXHIBIT IV-13 (cont)

```
data table  6
diagonal
consis.check= 0
matrix name =effic of conversion
output name =Energy demands (fuel
output units=kboe(fuel)
matrix size =47 47        .00
sectors     = 1 47
none
   kboe(useful)            kboe(fuel)
-- -------------------- -- -------------------- ----------
 1 gas                   1 gas                        .400 Urb.cooking
 2 lpg                   2 lpg                        .400 Urb.cooking
 3 kerosene              3 kerosene                   .200 Urb.cooking
 4 Java-electr           4 Java-electr                .950 Urb.cooking
 5 wood                  5 wood                       .080 Urb.cooking
 6 agric wastes          6 agric wastes               .080 Urb.cooking
 7 charcoal              7 charcoal                   .100 Urb.cooking
11 lpg                  11 lpg                        .800 Hotwater
12 gas                  12 gas                        .800 Hotwater
21 kerosene             21 kerosene                   .200 Rur.cooking
22 wood                 22 wood                       .080 Rur.cooking
23 agric wastes         23 agric wastes               .080 Rur.cooking
24 biogas               24 biogas                     .150 Rur.cooking
25 lpg                  25 lpg                        .400 Rur.cooking
26 charcoal             26 charcoal                   .100 Rur.cooking
99                      99                            .000
data table  7
aggregate
consis.check= 0
matrix name =Aggregation
output name =Household Demand (un
output units=kboe
matrix size =13 13        .00
none        = 1 13
none
   kboe                    kboe
-- -------------------- -- -------------------- ----------
 1 Java-electr
 2 gas
 3 lpg
 4 kerosene
 5 wood
 6 agric wastes
 7 solar
 8 solar-pv
 9 wind
10 charcoal
11 biogas
12 ado
13 coke
```


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increases are entered into the external file FUELPR.DAT common to all regions.

5. Data table 9: Reaggregation (Exhibit IV-15)

The final step is an aggregate type matrix that simply reorders the list of energy demands in order that the results be used as inputs to regional or national demand aggregation networks.

The resulting regional household demands are stored for later retrieval for regional or national aggregation. The filename is HHOLDR1.DAT corresponding to Region 1, HHOLDR2.DAT for Region 2, etc.

D. TRANSPORT MODULE

1. Sub-Sectoral Disaggregation

The transport sector network file is divided into two branches: one for road transport and one for off-road transport (rail, ship, air). The road sector takes into account auto, truck, small truck, bus, small bus and motorcycle.

The subsector activities are specified in the row labels of the summary table (file LTRANS.DAT (Exhibit IV-16).

2. Data tables 1-3: Projection of Vehicles (Exhibit IV-17)

The number of vehicles by type for each region are entered in data table 1. The source of data is BPS (see Statistical Annex). Data table 2 indicates the vehicle types by fuel (auto gasoline, auto diesel, auto LPG), for the base year. The "del=" feature can be used to simulate future shifts in the share of fuels by vehicle type.

Data table 3 projects number of vehicles with annual rates stored in external file VGROWTH.DAT (EXHIBIT IV-18). This file is used for all regions; if different vehicle growth rates among regions are to be used, new files the type of VGROWTH.DAT will have to be named and

EXHIBIT IV-14

```
*****************************************************************
data table  8                                                   *
*****************************************************************
p-elasticity                                                    *
consis.check= 0                                                 *
matrix name =fuelpr.dat                                         *
output name =adj dems
output units=kboe                                               *
matrix size =13 13        .00                                   *
none        = 1 13                                              *
none                                                            *
   mboe                    mboe                                 *
-- -------------------- -- -------------------- ----------      *
 1 Java-electr           1 Java-electr                .000      *
 2 gas                   2 gas                        .000      *
 3 lpg                   3 lpg                        .000      *
 4 kerosene              4 kerosene                   .000      *
 5 wood                  5 wood                       .000      *
 6 agric wastes          6 agric wastes               .000      *
 7 solar                 7 solar                      .000      *
 8 solar-pv              8 solar-pv                   .000      *
 9 wind                  9 wind                       .000      *
10 charcoal             10 charcoal                   .000      *
11 biogas               11 biogas                     .000      *
12 ado                  12 ado                        .000      *
13 coke                 13 coke                       .000      *
```

EXHIBIT IV-15

```
*****************************************************************
DATA TABLE  9
*****************************************************************
aggregate
consis.check= 0
matrix name =aggregate
output name =out=dynamic=hholdr5.int
output units=kboe
matrix size =14 14        .00
none        = 1 14
none

-- -------------------- -- -------------------- ----------
 1 Java-electr
 2 electricity
 3 lpg
 4 kerosene
 5 ado
 6 gas
 7 wood
 8 agric wastes
 9 charcoal
10 biogas
11 solar
12 solar-pv
13 wind
14 coke
*****************************************************************
END                                                             *
```


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EXHIBIT IV-16

```
**********************************************************************
   Transportation Sector
1- I-----------------------------e
   kboe
01=auto
02=truck
03.sm. truck
04=bus
05 sm. bus
06 motorcycle
07 rail
08 ship
09 air
10 .total
   end
-- ----------------------------
   current account table
-- ----------------------------
   US $mill
01=imports
02=-exports
03=-bunkers
  =.net
  =end
```


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EXHIBIT IV-17

```
   ltrans.dat            tplots.dat
   1----------2----------3----------4----------5----------6----------
Transport Region 1 (North   Sumatra, tranr1.dat)
****************************************************************
data table  1
****************************************************************
projection
matrix name =vehicle numbers
matrix size = 6  0        .00
none        = 1  6
none
   sector                tho. veh
-- -------------------- -------------------
 1 auto                    34.512
 2 truck                   16.619
 3 sm. truck               27.265
 4 bus                      8.145
 5 sm. bus                  2.952
 6 motorcycle             340.536
****************************************************************
data table  2
****************************************************************
share
consis.check= 0
matrix name =fuel shares
output name =vehicles by fuel
output units=#vehicles
matrix size =14  6        .00
none        = 1 14
none
   mode                   fuel type            fraction
-- -------------------- -- -------------------- ----------
 1 auto                 1 gasoline                  .900
 1 auto                 2 ado                       .100
 1 auto                 3 lpg                       .0
 2 truck                4 ado                      0.938
 2 truck                5 gasoline                  .062
 2 truck                6 lpg                       .000
 3 sm. truck            7 gasoline                  .687
 3 sm. truck            8 ado                       .313
 4 bus                  9 ado                       .911
 4 bus                 10 gasoline                  .089
 5 sm. bus             11 gasoline                  .764
 5 sm. bus             12 ado                       .236
 5 sm. bus             13 lpg                       .000
 6 motorcycle          14 gasoline                 1.000
****************************************************************
data table  3
****************************************************************
vgrowth
consis.check= 0
matrix name =vgrowth.dat
output name =scenario year vehicl
output units=#vehicles
matrix size =14 14      .00
none        = 1 14
none

-- -------------------- -- -------------------- ----------
```


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created, and the appropriate filename entered into the "matrix name=" row of data table 3.

3. Data tables 4-7: Fuels by Vehicle Type (Exhibit IV-19)

The numbers of vehicles are multiplied by yearly kilometers per year, to obtain yearly vehicle kilometers (in millions). The kilometers per vehicle are entered into the data column of data table 4, which is an operator of the type diagonal. Fuel demands by vehicle type are calculated in data table 5, where the fuel efficiencies are defined in boe/thousand km and the resulting fuel demands are expressed in thousand boe (kboe). Decreases in boe/km (i.e., improved efficiencies) ratings can be simulated with the "del=" feature in the sectors column of data table 5.

Data table 6 is a dummy sequence (i.e. it performs no calculation) inserted for purposes of presenting a summary table of fuel demands by vehicle type. The vehicle types are entered into the sectors column, and the specification "sectors" is entered in either the first or second summary table row (in this case it is the second row). The resulting summary table for this sector is shown in Exhibit IV-3 above (off road modes are also included; see data table 9).

Data table 7 aggregates all road vehicles by type into the fuel totals, and introduces new fuels to the list used in off-road modes.

4. Data tables 8-11: Off-road Transportation Modes (Exhibit IV-20)

Data table 8 initializes a side calculation that contains fuel demands for rail, ship and air. Data is obtained from ADP-7 for petroleum products and PTE for coal to rail. Data table 9 projects these demands at annual growth rates stored in the external file VGROW1.DAT Exhibit IV-21). Again, this file would be used for all regions; in order to use different rates among regions, new files of this kind would have to be created, named and made reference to in the appropriate network file. The projected off-road modes are sent to the summary table at this point.

EXHIBIT IV-18

vgrowth rates(vgrowth.dat)

label		1983	1984	1985	1990	1995	2000
auto	mogas	3.00	3.00	3.00	3.00	3.00	3.00
auto	ado	4.00	4.00	4.00	4.00	4.00	4.00
auto	lpg	.00	.00	.00	.00	.00	.00
truck	ado	2.00	2.00	2.00	2.00	2.00	2.00
truck	mogas	1.00	1.00	1.00	1.00	1.00	1.00
truck	lpg	.00	.00	.00	.00	.00	.00
sm. truck	mogas	1.00	1.00	1.00	1.00	1.00	1.00
sm. truck	ado	3.00	3.00	3.00	3.00	3.00	3.00
bus	ado	3.00	3.00	3.00	3.00	3.00	3.00
bus	mogas	1.00	1.00	1.00	1.00	1.00	1.00
sm. bus	mogas	2.00	2.00	2.00	2.00	2.00	2.00
sm. bus	ado	3.00	3.00	3.00	3.00	3.00	3.00
sm. bus	lpg	.00	.00	.00	.00	.00	.00
motorcycle	mogas	2.00	2.00	2.00	2.00	2.00	2.00

EXHIBIT IV-19

data table 4

diagonal
consis.check= 0
matrix name =km/vehicle
output name =km/fuel/vehicle
output units=km
matrix size =14 14 .00
none = 1 14
none

				tho.km/veh	
1	gasoline	1	gasoline	12.000	auto
2	ado	2	ado	12.000	auto
3	lpg	3	lpg	12.000	auto
4	ado	4	ado	40.000	truck
5	gasoline	5	gasoline	45.000	truck
6	lpg	6	lpg	45.000	truck
7	gasoline	7	gasoline	35.000	sm. truck
8	ado	8	ado	30.000	sm. truck
9	ado	9	ado	70.000	bus
10	gasoline	10	gasoline	60.000	bus
11	gasoline	11	gasoline	50.000	sm. bus
12	ado	12	ado	50.000	sm. bus
13	lpg	13	lpg	50.000	sm. bus
14	gasoline	14	gasoline	9.000	motorcycle

```
*****************************************************************
data table  5                                                   *
*****************************************************************
diagonal                                                        *
consis.check= 0                                                 *
matrix name =fuel per km                                        *
output name =fuel consumption                                   *
output units=kboe                                               *
matrix size =14 14      .00                                     *
none        = 1 14                                              *
none                                                            *
                                              boe/000 km        *
-- ------------------- -- ------------------- ----------        *
 1 gasoline             1 gasoline                 0.870 del=04x-.01*
 2 ado                  2 ado                      0.530        *
 3 lpg                  3 lpg                      0.87         *
 4 ado                  4 ado                      1.500 truck  *
 5 gasoline             5 gasoline                 2.330 truck  *
 6 lpg                  6 lpg                      1.500 truck  *
 7 gasoline             7 gasoline                 1.750 sm. truck *
 8 ado                  8 ado                      1.130 sm. truck *
 9 ado                  9 ado                      1.360 bus    *
10 gasoline            10 gasoline                 2.330 bus    *
11 gasoline            11 gasoline                 1.740 sm. bus *
12 ado                 12 ado                      1.280 sm. bus *
13 lpg                 13 lpg                      1.740 sm. bus *
14 gasoline            14 gasoline                 0.230 motorcycle *
*****************************************************************
data table  6                                                   *
*****************************************************************
diagonal                                                        *
consis.check= 0                                                 *
matrix name =dummy sequence                                     *
output name =                                                   *
output units=                                                   *
matrix size =14 14      .00   0   0                             *
none        =      barch=                                       *
sectors     = 1 14 barch=                                       *
                                                                *
-- ------------------- -- ------------------- ----------        *
 1 gasoline             1 gasoline                 1.000 auto   *
 2 ado                  2 ado                      1.000 auto   *
 3 lpg                  3 lpg                      1.000 auto   *
 4 ado                  4 ado                      1.000 truck  *
 5 gasoline             5 gasoline                 1.000 truck  *
 6 lpg                  6 lpg                      1.000 truck  *
 7 gasoline             7 gasoline                 1.000 sm. truck *
 8 ado                  8 ado                      1.000 sm. truck *
 9 ado                  9 ado                      1.000 bus    *
10 gasoline            10 gasoline                 1.000 bus    *
11 gasoline            11 gasoline                 1.000 sm. bus *
12 ado                 12 ado                      1.000 sm. bus *
13 lpg                 13 lpg                      1.000 sm. bus *
14 gasoline            14 gasoline                 1.000 motorcycle *
*****************************************************************
DATA TABLE  7                                                   *
*****************************************************************
aggregate                                                       *
consis.check= 0                                                 *
matrix name =aggregation                                        *
output name =Road Transp Total                                  *
output units=kboe                                               *
matrix size = 8  8        .00                                   *
none        = 1  8                                              *
none                                                            *
                                                                *
-- ------------------- -- ------------------- ----------        *
 1 gasoline                                                     *
 2 ado                                                          *
 3 lpg                                                          *
 4 ido                                                          *
 5 fueloil                                                      *
 6 coal                                                         *
 7 avgas                                                        *
 8 avtur                                                        *
```


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EXHIBIT IV-20

```
*****************************************************************
data table  8                                                   *
*****************************************************************
supply                                                          *
matrix name =air/ship/rail                                      *
matrix size = 9  0        .00                                   *
none        = 1  9                                              *
none                                                            *
                        boe x 1000                              *
-- ------------------- -------------------                      *
 1 ado                     31.480 rail                          *
 2 ido                      0.000 rail                          *
 3 fueloil                   .000 rail                          *
 4 coal                     0.000 rail                          *
 5 ado                     80.640 ship                          *
 6 ido                     11.040 ship                          *
 7 fueloil                  6.460 ship                          *
 8 avgas                   13.080 air                           *
 9 avtur                  353.480 air                           *
*****************************************************************
data table  9                                                   *
*****************************************************************
vgrowth                                                         *
consis.check= 0                                                 *
matrix name =vgrow1.dat                                         *
output name =scenario fuel                                      *
output units=kboe                                               *
matrix size = 9  9        .00                                   *
sectors     = 1  9                                              *
none                                                            *
                                                                *
-- ------------------- -- ------------------- ----------        *
*****************************************************************
data table 10                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =total fuel                                         *
output name =demand
output units=kboe                                               *
matrix size = 8  8        .00                                   *
none        = 1  8
none                                                            *
                                                                *
-- ------------------- -- ------------------- ----------        *
*****************************************************************
DATA TABLE 11
*****************************************************************
aggregate
consis.check= 0
matrix name =aggregate
output name =out=dynamic=tranr1.int
output units=kboe
matrix size = 8  8        .00
none        = 1  8
none

-- ------------------- -- ------------------- ----------
 1 avgas
 2 avtur
 3 gasoline
 4 ado
 5 fueloil
 6 ido
 7 lpg
 8 coal
*****************************************************************
END                                                             *
```


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EXHIBIT IV-21

```
% yearly growth rate (vgrow1.dat)
*****************************************************************************
label                  1983   1984   1985   1990   1995   2000
l------------------    r----  r----  r----  r----  r----  r----e
ado          rail       1.00   1.00   1.00   1.00   1.00   1.00
ido          rail       1.00   1.00   1.00    .00    .00    .00
fueloil      rail       1.00   1.00   1.00   1.00   1.00   1.00
coal         rail       5.00   5.00   5.00   4.00   3.00   2.00
ado          ship       4.00   4.00   4.00   4.00   4.00   4.00
ido          ship       1.00   1.00   1.00   1.00   1.00   1.00
fueloil      ship       3.00   3.00   3.00   3.00   3.00   3.00
avgas        air        3.00   3.00   3.00   3.00   3.00   3.00
avtur        air        4.00   4.00   4.00   4.00   4.00   4.00
```

EXHIBIT IV-22

```
*****************************************************************************
   Industry Sector
1- l----------------------------e
   kboe
01=Food
02=Textile
03=Pulp,Paper
04 Rubber
05 Chemicals
06 Cement
07 Ceramics
08 Iron,Steel
09 Other Manuf
10 Fertilizer
11 Small indus
18 .total
   end
-- ----------------------------
   current account table
-- ----------------------------
   US $mill
01=imports
02=-exports
03=-bunkers
  =.net
  =end
```

The final step is the addition of this side branch to the main branch that carries the fuels to road vehicles followed by data table 11 that reorders the list of fuels for purposes of aggregation to regional or national fuel totals. The resulting fuels to transport sector of each region are stored in files named TRANR1.INT, TRANR2.INT to TRANR8.INT respectively.

E. INDUSTRY MODULE

1. Sub-Sectoral Disaggregation

Industry energy demand has been disaggregated into 11 subsectors consistent with sub-sectoral definitions of BPS, and macroeconomic models including the I-O tables of Indonesia. These are: food, textiles, pulp and paper, rubber, chemicals (exc. fertilizer and revenues), cement, ceramics (or other non-metallic minerals) iron and steel and other manufacturers. Two other subsectors defined are fertilizer and small industry. Energy consumption for the latter is not tabulated by BPS or by ADP-7 explicitly.

Energy consumption for base year 1982 by subsector and fuel type are obtained from unpublished BPS data by province. These have been aggregated by region as defined by the Regional Demand Model. This data and subsequent analysis on it are included in the Statistical Annex.

Summary table rows are specified in file LINDUS.DAT (Exhibit IV-22).

2. Data tables 1-6: Projection of Industry Demand by Subsector and Fuel Type (Exhibit IV-23)

Projections are based on value added, which get multiplied by a coefficient of energy per unit of value added and the shares of each fuel type. Data table 1 contains value added in billion Rupiah for 9 industrial subsectors. Data table 2 is an operator of the type growth in which a single yearly growth rate is entered directly in the data column of the data table. This is an alternative configuration that

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EXHIBIT IV-23

```
   lindus.dat            iplots.dat
xxx1---------2---------3---------4---------5---------
Industry Region 2 (W. Sumatra, indusr2.dat
*****************************************************
data table  1
*****************************************************
projection
matrix name =Value Added
matrix size = 9  0        .00
none        = 1  9
none
   value added,bilion R billion Rp
-- -------------------- --------------------
 1 Food                    3.821 billion
 2 Textile                 0.664 billion
 3 Pulp,Paper               .858 billion
 4 Rubber                  5.417 billion
 5 Chemicals                .501 billion
 6 Cement                 27.105 billion
 7 Ceramics                 .075 billion
 8 Iron,Steel               .000 billion
 9 Other Manuf            18.231 billion
*****************************************************
data table  2
*****************************************************
growth
consis.check= 0
matrix name =Economic Growth
output name =Projected Value Adde
output units=billion Rp
matrix size = 9  9        .00
none        = 1  9
none
   billion Rp           billion Rp          Multiplier
-- -------------------- -------------------- ----------
 1 Food                 1 Food                    1.035
 2 Textile              2 Textile                 1.020
 3 Pulp,Paper           3 Pulp,Paper              1.050
 4 Rubber               4 Rubber                  1.032
 5 Chemicals            5 Chemicals               1.040
 6 Cement               6 Cement                  1.020
 7 Ceramics             7 Ceramics                1.020
 8 Iron,Steel           8 Iron,Steel              1.034
 9 Other Manuf          9 Other Manuf             1.020
*****************************************************
data table  3
*****************************************************
diagonal
consis.check= 0
matrix name =Energy/Unit of V.A
output name =Projected Useful Ene
output units=kboe
matrix size = 9  9        .00
none        = 1  9
none
   billion Rp           fuel                boe/mill Rp
-- -------------------- -------------------- ----------
 1 Food                 1 Food                   10.630
 2 Textile              2 Textile                 0.300
 3 Pulp,Paper           3 Pulp,Paper               .470
 4 Rubber               4 Rubber                  7.480
 5 Chemicals            5 Chemicals               8.580
 6 Cement               6 Cement                 89.400
 7 Ceramics             7 Ceramics                5.330
 8 Iron,Steel           8 Iron,Steel               .000
 9 Other Manuf          9 Other Manuf             5.880
*****************************************************
data table  4
*****************************************************
share
consis.check= 3
matrix name =Fuel by Type
output name =Fuel by Type
output units=kboe
matrix size =60  9      .00   0   0
            = 1 60 barch=
none        = 0  0 barch=
   sector               fuel                 fraction
-- -------------------- -------------------- ---------
 1 Food                 1 fueloil                 .933 Food
 1 Food                 2 ado                     .000 Food
 1 Food                 3 ido                     .000 Food
 1 Food                 4 wood                    .000 Food
 1 Food                 5 agric wastes            .000 Food
 1 Food                 6 f-electricity           .067 Food
 1 Food                 7 gas                     .000 Food
 1 Food                 8 lpg                     .000 Food
 1 Food                 9 coal                    .000 Food
 2 Textile             10 fueloil                 .000 Textile
 2 Textile             11 ado                     .000 Textile
 2 Textile             12 ido                     .000 Textile
 2 Textile             13 f-electricity          1.000 Textile
 2 Textile             14 gas                     .000 Textile
 2 Textile             15 coal                    .000 Textile
 3 Pulp,Paper          16 fueloil                 .000 Pulp,Paper
 3 Pulp,Paper          17 ado                     .144 Pulp,Paper
 3 Pulp,Paper          18 ido                     .106 Pulp,Paper
 3 Pulp,Paper          19 electricity             .750 Pulp,Paper
 3 Pulp,Paper          20 wood                    .000 Pulp,Paper
 3 Pulp,Paper          21 coal                    .000 Pulp,Paper
 4 Rubber              22 fueloil                 .706 Rubber
 4 Rubber              23 ado                     .000 Rubber
 4 Rubber              24 ido                     .000 Rubber
 4 Rubber              25 f-electricity           .294 Rubber
 4 Rubber              26 gas                     .000 Rubber
 4 Rubber              27 coal                    .000 Rubber
 5 Chemicals           28 fueloil                 .907 Chemicals
 5 Chemicals           29 ado                     .000 Chemicals
 5 Chemicals           30 ido                     .000 Chemicals
 5 Chemicals           31 electricity             .093 Chemicals
 5 Chemicals           32 gas                     .000 Chemicals
 5 Chemicals           33 coal                    .000 Chemicals
 6 Cement              34 fueloil                 .035 Cement
 6 Cement              35 ado                     .107 Cement
 6 Cement              36 ido                     .078 Cement
 6 Cement              37 coal                    .747 Cement
 6 Cement              38 gas                     .000 Cement
 6 Cement              39 electricity             .033 Cement
 7 Ceramics            40 fueloil                1.000 Ceramics
 7 Ceramics            41 ado                     .000 Ceramics
 7 Ceramics            42 ido                     .000 Ceramics
 7 Ceramics            43 lpg                     .000 Ceramics
 7 Ceramics            44 electricity             .000 Ceramics
 7 Ceramics            45 coal                    .000 Ceramics
 7 Ceramics            46 wood                    .000 Ceramics
 8 Iron,Steel          47 fueloil                 .230 Iron,Steel
 8 Iron,Steel          48 ado                     .210 Iron,Steel
 8 Iron,Steel          49 ido                     .090 Iron,Steel
 8 Iron,Steel          50 electricity             .280 Iron,Steel
 8 Iron,Steel          51 gas                     .330 Iron,Steel
 8 Iron,Steel          52 coal                    .150 Iron,Steel
 9 Other Manuf         53 fueloil                 .740 Other Manuf
 9 Other Manuf         54 ado                     .000 Other Manuf
 9 Other Manuf         55 ido                     .000 Other Manuf
 9 Other Manuf         56 coal                    .000 Other Manuf
 9 Other Manuf         57 f-electricity           .260 Other Manuf
 9 Other Manuf         58 wood                    .000 Other Manuf
 9 Other Manuf         59 lpg                     .000 Other Manuf
 9 Other Manuf         60 kerosene                .000 Other Manuf
```


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EXHIBIT IV-23

```
**************************************************************
data table  5                                                *
**************************************************************
diagonal                                                     *
consis.check= 0                                              *
matrix name =0                                               *
output name =Adjusted Demand (Con                            *
output units=kboe                                            *
matrix size =60 60      .00   0   0                          *
none        = 1 60 barch=                                    *
sectors     = 1 60 barch=                                    *
   fuel                    fuel                  fraction    *
-- -------------------- -- -------------------- ----------   *
 1 fueloil               1 fueloil                 1.000 Food *
 2 ado                   2 ado                     1.000 Food *
 3 ido                   3 ido                     1.000 Food *
 4 wood                  4 wood                    1.000 Food *
 5 agric wastes          5 agric wastes            1.000 Food *
 6 f-electricity         6 f-electricity           1.000 Food *
 7 gas                   7 gas                     1.000 Food *
 8 lpg                   8 lpg                     1.000 Food *
 9 coal                  9 coal                    1.000 Food *
10 fueloil              10 fueloil                 1.000 Textile *
11 ado                  11 ado                     1.000 Textile *
12 ido                  12 ido                     1.000 Textile *
13 f-electricity        13 f-electricity           1.000 Textile *
14 gas                  14 gas                     1.000 Textile *
15 coal                 15 coal                    1.000 Textile *
16 fueloil              16 fueloil                 1.000 Pulp,Paper *
17 ado                  17 ado                     1.000 Pulp,Paper *
18 ido                  18 ido                     1.000 Pulp,Paper *
19 electricity          19 electricity             1.000 Pulp,Paper *
20 wood                 20 wood                    1.000 Pulp,Paper *
21 coal                 21 coal                    1.000 Pulp,Paper *
22 fueloil              22 fueloil                 1.000 Rubber *
23 ado                  23 ado                     1.000 Rubber *
24 ido                  24 ido                     1.000 Rubber *
25 f-electricity        25 f-electricity           1.000 Rubber *
26 gas                  26 gas                     1.000 Rubber *
27 coal                 27 coal                    1.000 Rubber *
28 fueloil              28 fueloil                 1.000 Chemicals *
29 ado                  29 ado                     1.000 Chemicals *
30 ido                  30 ido                     1.000 Chemicals *
31 electricity          31 electricity             1.000 Chemicals *
32 gas                  32 gas                     1.000 Chemicals *
33 coal                 33 coal                    1.000 Chemicals *
34 fueloil              34 fueloil                 1.000 Cement *
35 ado                  35 ado                     1.000 Cement *
36 ido                  36 ido                     1.000 Cement *
37 coal                 37 coal                    1.000 Cement *
38 gas                  38 gas                     1.000 Cement *
39 electricity          39 electricity             1.000 Cement *
40 fueloil              40 fueloil                 1.000 Ceramics *
41 ado                  41 ado                     1.000 Ceramics *
42 ido                  42 ido                     1.000 Ceramics *
43 lpg                  43 lpg                     1.000 Ceramics *
44 electricity          44 electricity             1.000 Ceramics *
45 coal                 45 coal                    1.000 Ceramics *
46 wood                 46 wood                    1.000 Ceramics *
47 fueloil              47 fueloil                 1.000 Iron,Steel *
48 ado                  48 ado                     1.000 Iron,Steel *
49 ido                  49 ido                     1.000 Iron,Steel *
50 electricity          50 electricity             1.000 Iron,Steel *
51 gas                  51 gas                     1.000 Iron,Steel *
52 coal                 52 coal                    1.000 Iron,Steel *
53 fueloil              53 fueloil                 1.000 Other Manuf*
54 ado                  54 ado                     1.000 Other Manuf*
55 ido                  55 ido                     1.000 Other Manuf*
56 coal                 56 coal                    1.000 Other Manuf*
57 f-electricity        57 f-electricity           1.000 Other Manuf*
58 wood                 58 wood                    1.000 Other Manuf*
59 lpg                  59 lpg                     1.000 Other Manuf*
60 kerosene             60 kerosene                1.000 Other Manuf*
```

```
**************************************************
data table  6                                    *
**************************************************
aggregate                                        *
consis.check= 0                                  *
matrix name =aggregation                         *
output name =partial total                       *
output units=kboe                                *
matrix size =13 11        .00                    *
none        = 1 13                               *
none                                             *
-- -------------------- -- -------------------- -
 1 fueloil
 2 ado
 3 ido
 4 electricity
 5 lpg
 6 kerosene
 7 gas
 8 coal
 9 wood
10 agric wastes
11 f-electricity
12 charcoal
13 coke
```


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avoids creation of an external data file containing yearly growth rates; it is, however limited to a single yearly growth rate to be applied to the entire planning horizon. The configuration selected allows to enter different regional growth rates of value added by simply entering the values in the appropriate network file.

Data table 3 contains the coefficients of total energy use per unit of value added, expressed in boe per million Rp. The resulting multiplication (via an operator of the type diagonal yields total energy demand by industry subsector.

The next sequence, data table 4, allocates total demand by fuel type. Fuel types include existing and future possible choices such as coal. A total of 60 links of 13 different fuel types to 9 subsectors are provided. Note that 60 links are the maximum number of elements permitted in a RESGEN vector. As will be seen below, this does not represent a real limitation of the system, because any additional industrial subsectors can be entered into the network file as a side-branch of the main network.

One unusual feature of the design is that electricity (or Java-electr in the case of Region 5, Java) is assigned to two labels: the name "electricity" proper is used for one grouping consisting of pulp and paper, chemicals, cement, ceramics and iron and steel, while the name f-electricity (to the model, therefore, a different fuel) is used for another grouping consisting of food, textile, rubber, and other manufacturers. In this module, electricity and f-electricity represent PLN-purchased electricity plus self-generated (or captive generation). Two industrial groupings were designed in order to distinguish between those that are likely to substitute captive generation for PLN generation faster than the other group. Those industries that consume the energy type labelled f-electricity are those with generally smaller plants located near population centers that are more likely to switch over to PLN electricity earlier that the second group of mostly large individual industries. The option of

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captive power (or selfgeneration) is designed into the network file at a later stage.

Note that the "del=" command can be used in data table 4 to modify on a year-by-year basis the fractions of the different fuels to any industrial subsector. Data table 5 has two functions. It allows to make adjustments for a conservation scenario by multiplying fuel flows by a factor (for example, for 10% conservation, enter 0.90 in the data column of the appropriate fuel type). The second function is to enter the values of the projected fuel types by subsector to the summary table. An example of the summary table is shown in Exhibit IV-5 above.

3. Data Tables 7-11: Additional Subsectors (Exhibit IV-24)

A similar set of calculations at those described in data tables 1 through 6 are used to project fuel demand from two additional sectors: fertilizer and small industry. As noted above, the breakdown is due to size limitation of RESGEN vectors and not due to the configuration of the energy system itself. Data table 7 initializes the side growth, data table 8 contains annual growth rates for value added, data table 9 the coefficients of total energy demand per unit of value added and data table 10 the shares of fuel types to subsector. This segment also contains the instructions to enter the projected fuel demands to the summary table. Finally, data table 11 adds these additional fuel demands to the main branch of the network.

4. Data Tables 12 to 16: Captive Power (Exhibit IV-25)

Large fractions of total electricity consumed by industry in Indonesia are selfgenerated. These fractions are entered into data table 12 which show for each region the portion of total electricity consumed that is selfgenerated (label "autogeneration") and the portion that is purchased from PLN (Label electricity or Java-electricity). These fractions are given for the two groups of industries: those that purchase "electricity" and those that purchase electricity labelled "f-electricity". In future years, the proportion of captive to purchase electricity can be varied by use of the "del="

EXHIBIT IV-24

```
**************************************************
data table  7
**************************************************
supply
matrix name =Added sectors
matrix size = 2  0        .00
none        = 1  2
none
   Sector                 billion Rp
-- -------------------- --------------------
 1 Fertilizer                  0.000
 2 Small Industry               .000
**************************************************
data table  8
**************************************************
growth
consis.check= 0
matrix name =G.R. Added Sectors
output name =Proj. Value Added
output units=billion Rp
matrix size = 2  2        .00
none        = 1  2
none
   sector                   sector                Billion Rp
-- -------------------- -- -------------------- ----------
 1 Fertilizer             1 Fertilizer                 1.025
 2 Small Industry         2 Small Industry             1.015
**************************************************
data table  9
**************************************************
diagonal
consis.check= 0
matrix name =boe/va, Add Sectors
output name =demand, add. sectors
output units=kboe
matrix size = 2  2        .00
none        = 1  2
none
   sector                   sector                boe/m Rp
-- -------------------- -- -------------------- ----------
 1 Fertilizer             1 Fertilizer                 .000
 2 Small Industry         2 Small Industry             .000
```

```
**************************************************
data table 10
**************************************************
share
consis.check= 0
matrix name =Fuels to Add. Sect
output name =Fuels to Add. Sect
output units=kboe
matrix size =16  2        .00
sectors     = 1 16
none
   sector                   fuel                  fraction
-- -------------------- -- -------------------- ----------
 1 Fertilizer             1 gas                        .650 Fertilizer
 1 Fertilizer             2 fueloil                    .200 Fertilizer
 1 Fertilizer             3 ado                        .050 Fertilizer
 1 Fertilizer             4 ido                        .020 Fertilizer
 1 Fertilizer             5 electricity                .050 Fertilizer
 1 Fertilizer             6 lpg                        .000 Fertilizer
 2 Small industry         7 fueloil                    .300 Small indus
 2 Small industry         8 ado                        .600 Small indus
 2 Small industry         9 ido                        .020 Small indus
 2 Small industry        10 electricity                .050 Small indus
 2 Small industry        11 charcoal                   .050 Small indus
 2 Small industry        12 coke                       .010 Small indus
 2 Small industry        13 coal                       .020 Small indus
 2 Small industry        14 gas                        .050 Small indus
 2 Small industry        15 wood                       .150 Small indus
 2 Small industry        16 agric wastes               .090 Small indus
**************************************************
data table 11
**************************************************
addition
consis.check= 0
matrix name =Total fuels
output name =total fuels
output units=kboe
matrix size =13 13        .00
none        = 1 13
none
-- -------------------- -- -------------------- ----------
```


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command. The rate of change towards PLN-generated power can be made faster for the "f-electricity" consumers,for example and kept at 1982 levels for the "electricity" consumers.

Data table 13 indicates the fraction of fuels used as inputs to autogeneration: ado, ido, fueloil, gas, or agricultural wastes (i.e. via gasification of biomass). The next step data table 14 is to calculate the actual levels of fuels used in autogeneration, by dividing by a conversion efficiency. The final step is to aggregate these fuels used for autogeneration with the fuels used directly for process heat, kilns, etc., calculated earlier.

Note that by data table 15, the label "electricity" (or Java-electricity") represents purchased electricity from PLN. The label "f-electricity", used as an artifice to create different rates of substitution away from captive generation and towards PLN electricity, reverts to "electricity" in data table 12, after which it is not needed.

Data table 16 contains aggregated regional industrial fuel demand for purposes of linkage with other sectors to form regional (and national) demand totals. Results are stored in filename INDUSR1.INT for Region 1, INDUSR2.INT for Region 2 etc.

F. OTHER SECTORS MODULE

1. Description of Subsectors

This module projects energy demands for the Agricultural Sector (subdivided into agriculture proper, plantations, and forestry), the Mining Sector (subsector oil and gas exploration, coal, nickel, tin, copper and other mining), the Construction Sector, Government and Commercial Sectors, Strategic (i.e. Military), as well as special electricity consuming sectors (street lighting, etc.) and non-energy uses of petroleum (asphalt, buses, etc.).

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EXHIBIT IV-25

```
**********************************************************
data table 12
**********************************************************
share
consis.check= 0
matrix name =Autugen Fraction
output name =Elect by Source
output units=kboe
matrix size =15 13        .00
none          1 13
none
   kboe                    kboe                    fraction
-- -------------------- -- -------------------- ----------
 1 fueloil              1 fueloil                   1.000
 2 ado                  2 ado                       1.000
 3 ido                  3 ido                       1.000
 4 electricity          4 electricity                .220
 4 electricity          5 autogeneration             .780
 5 lpg                  6 lpg                       1.000
 6 kerosene             7 kerosene                  1.000
 7 gas                  8 gas                       1.000
 8 coal                 9 coal                      1.000
 9 wood                10 wood                      1.000
10 agric wastes        11 agric wastes              1.000
11 f-electricity       12 electricity                .090
11 f-electricity       13 autogeneration             .910
12 charcoal            14 charcoal                  1.000
13 coke                15 coke                      1.000
**********************************************************
data table 13
**********************************************************
share
consis.check= 0
matrix name =fuels to autogen
output name =autogen by type
output units=mboe
matrix size =23 15        .00
none        = 1 21
none
   mboe                    mboe(e)                 fraction
-- -------------------- -- -------------------- ----------
 1 fueloil              1 fueloil                   1.000
 2 ado                  2 ado                       1.000
 3 ido                  3 ido                       1.000
 4 electricity          4 electricity               1.000
 5 autogeneration       5 ado                       1.000
 5 autogeneration       6 ido                        .000
 5 autogeneration       7 fueloil                    .000
 5 autogeneration       8 agric wastes               .000
 5 autogeneration       9 gas                        .000
 6 lpg                 10 lpg                       1.000
 7 kerosene            11 kerosene                  1.000
 8 gas                 12 gas                       1.000
 9 coal                13 coal                      1.000
10 coal                14 coal                      1.000
11 agric wastes        15 agric wastes              1.000
12 electricity         16 electricity               1.000
13 autogeneration      17 ado                        .530
13 autogeneration      18 ido                        .000
13 autogeneration      19 fueloil                    .000
13 autogeneration      20 agric wastes               .473
13 autogeneration      21 gas                        .000
14 charcoal            22 charcoal                  1.000
15 coke                23 coke                      1.000
**********************************************************
```

```
data table 14
**********************************************************
diagonal
consis.check= 0
matrix name =efficiecy/autogenera
output name =fuels to autogenerat
output units=kboe(fuel)
matrix size =23 23        .00
none        = 4 23
none
                                                   efficiency
-- -------------------- -- -------------------- ----------
 5 ado                  5 ado                        .250
 6 ido                  6 ido                        .280
 7 fueloil              7 fueloil                    .330
 8 agric wastes         8 agric wastes               .330
 9 gas                  9 gas                        .330
17 ado                 17 ado                        .250
18 ido                 18 ido                        .280
19 fueloil             19 fueloil                    .330
20 agric wastes        20 agric wastes               .330
21 gas                 21 gas                        .330
99                     99                            .000
**********************************************************
data table 15
**********************************************************
aggregate
consis.check= 0
matrix name =aggregation
output name =demands
output units=kboe
matrix size =12 23        .00   0   0
none        = 1 12 barch=
none        = 0  0 barch=

-- -------------------- -- -------------------- ----------
 1 fueloil
 2 ado
 3 ido
 4 electricity
 5 lpg
 6 kerosene
 7 gas
 8 coal
 9 wood
10 agric wastes
11 charcoal
12 coke
**********************************************************
DATA TABLE 16
**********************************************************
aggregate
consis.check= 0
matrix name =aggregate
output name =out=dynamic=indusr2.int
output units=kboe
matrix size =13 13        .00
none        = 1 13
none

-- -------------------- -- -------------------- ----------
 1 Java-electr
 2 electricity
 3 lpg
 4 kerosene
 5 ado
 6 ido
 7 fueloil
 8 gas
 9 wood
10 agric wastes
11 coal
12 charcoal
13 coke
**********************************************************
```


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Data sources are BPS for value added by province (aggregated to conform with Regional Demand Model regions); fuel consumption data for the base year are estimated from ADP-7. (See Statistical Annex).

The row labels of the summary table are contained in file LOTHER.DAT (Exhibit IV-26).

2. Data Tables 1-5 (Exhibit IV-27)

A list of 13 subsectors is defined in data table 1 (additional subsectors are defined in data table 6). For those sectors where regional value added (in billion Rupiah) is available or defined, those values are entered; for other sectors, 1.000 is entered. This is followed by a projection of value added (or escalation factor to the unit coefficient defined in data table 1) that makes reference to an external file GROTHER.DAT (Exhibit IV-28).

Data table 3 contains total energy per unit of value added for those subsectors where value added is defined: agriculture, plantation, forestry and construction. For other subsectors the value entered is total energy consumed in the base year: oil and gas exploration, coal, metal, tin, copper, other mining, government (petroleum products), commercial kerosene and commercial electricity: Note that many of these sectors are highly region specific: nickel is in Region 8 only (and zero elsewhere), tin is in Region 3 only and so on.

Data table 4 allocates total demand by fuel type. Note that the Larona hydro plant is introduced, as one of the fuel types to nickel production; similarly, the Asahan plant is introduced under fuels to "other mining". This represents a hydro consumption of final demand sectors, as opposed to hydro consumption by the public utility sector, which only appears in the Energy Supply (Demand Balance Model). Data table 4 also contains the commands to enter the fuel projections by subsector activity into the summary table (Exhibit IV-5, above).

EXHIBIT IV-26

```
****************************************************************************
   Comm/Agric/Mining & Other
1- 1---------------------------e
   kboe
01=agriculture
02=plantation
03=forestry
04 oil/gas explor
05 coal
06 nickel
07 tin
08 copper
09 mining,other
10 konstruksi
11 government
12 commercial
13 institutions
15 street lighting
16 strategic
17 non-energy
18 .total
   end
-- ----------------------------
   current account table
-- ----------------------------
   US $mill
01=imports
02=-exports
03=-bunkers
  =.net
  =end
```


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EXHIBIT IV-27

```
>  lother.dat            oplots.dat
   1----------2----------3----------4----------5----------6---------
Other Sectors Region 8 (East Indonesia,, otherr8.dat)
*****************************************************************
data table  1
*****************************************************************
projection
matrix name =value added
matrix size =13  0        .00
none        = 1 13
none
   sectors                 billion Rp.
-- -------------------- --------------------

 1 agriculture              19.310
 2 plantation                0.000
 3 forestry                  9.480
 4 oil/gas exploration       1.000
 5 coal                      1.000
 6 nickel                    1.000
 7 tin                       1.000
 8 copper                    1.000
 9 mining,other              1.000
10 konstruksi               11.310
11 governaent                1.000
12 commercial                1.000
13 com. electricity          1.000
*****************************************************************
data table  2
*****************************************************************
vgrowth
consis.check= 0
matrix name =grother.dat
output name =projected value adde
output units=billion Rp.
matrix size =13 13        .00
none        = 1 13
none
   sectors                  sectors                 billion Rp
-- -------------------- -- -------------------- ----------
*****************************************************************
data table  3
*****************************************************************
diagonal
consis.check= 0
matrix name =boe/value added
output name =energy consumption b
output units=kboe
matrix size =13 13        .00
none        = 1 13
none
   sectors                  sectors                 boe/mill Rp
-- -------------------- -- -------------------- ----------

 1 agriculture            1 agriculture               11.520
 2 plantation             2 plantation                  .000
 3 forestry               3 forestry                  33.850
 4 oil/gas exploration    4 oil/gas exploration       41.000
 5 coal                   5 coal                        .000
 6 nickel                 6 nickel                   2752.000
 7 tin                    7 tin                         .000
 8 copper                 8 copper                      .000
 9 mining,other           9 mining,other              12.900
10 konstruksi            11 konstruksi n              28.890
11 government            12 government               143.100
12 commercial            13 commercial                 .700
13 com. electricity      14 com. electricity         137.600
```


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```
data table  4
share
consis.check= 0
matrix name =sectors by fuel
output name =fuel
output units=kboe
matrix size =37 13      .00   0   0
sectors     = 1 37 barch=
none        = 0  0 barch=
   sectors                 fuels                fraction
-- -------------------- -- ------------------- ----------
 1 agriculture           1 ado                      1.000 agriculture
 1 agriculture           2 ido                       .000 agriculture
 1 agriculture           3 fueloil                   .000 agriculture
 2 plantation            4 ado                       .000 plantation
 2 plantation            5 ido                       .000 plantation
 2 plantation            6 fueloil                   .000 plantation
 3 forestry              7 ado                       .999 forestry
 3 forestry              8 ido                       .001 forestry
 3 forestry              9 fueloil                   .000 forestry
 4 oil/gas exploration  10 ado                       .170 oil/gas exp
 4 oil/gas exploration  11 fueloil                   .830 oil/gas exp
 5 coal                 12 coal                     1.000 coal
 5 coal                 13 ado                       .000 coal
 5 coal                 14 ido                       .000 coal
 6 nickel               15 ado                       .088 nickel
 6 nickel               16 ido                       .000 nickel
 6 nickel               17 fueloil                   .405 nickel
 6 nickel               18 hydro                     .500 nickel
 7 tin                  19 ado                       .000 tin
 7 tin                  20 ido                       .000 tin
 8 copper               21 ado                       .000 copper
 8 copper               22 ido                       .000 copper
 8 copper               23 fueloil                   .000 copper
 9 mining,other         24 ado                      1.000 mining,othe
 9 mining,other         25 ido                       .000 mining,othe
 9 mining,other         26 hydro                     .000 mining,othe
10 konstruksi           27 ado                       .951 konstruksi
10 konstruksi           28 ido                       .004 konstruksi
10 konstruksi           29 fueloil                   .042 konstruksi
11 government           30 ado                       .951 government
11 government           31 ido                       .042 government
11 government           32 fueloil                   .006 government
12 commercial           33 kerosene                 1.000 commercial
12 commercial           34 gas                       .000 commercial
12 commercial           35 lpg                       .000 commercial
12 commercial           36 electricity               .000 commercial
13 com. electricity     37 electricity              1.000 commercial
DATA TABLE  5
aggregate
consis.check= 0
matrix name =aggregation
output name =partial total
output units=kboe
matrix size =16 16        .00
none        = 1 16
none

-- ------------------- -- ------------------ ----------
 1 ado
 2 ido
 3 fueloil
 4 coal
 5 kerosene
 6 gas
 7 electricity
 8 avtur
 9 avgas
10 gasoline
11 asphalt
12 lubes/waxes
13 petrochems
14 petr coke
15 lpg
16 hydro
```

EXHIBIT IV-28

vgrowth rates (grother.dat)

label	1983	1984	1985	1990	1995
agriculture	2.00	3.00	3.00	3.00	3.00
plantation	4.00	4.00	4.00	4.00	4.00
forestry	2.00	2.00	3.00	3.00	4.00
oil/gas exploration	3.00	3.00	3.00	3.00	3.00
coal	2.00	5.00	5.00	2.00	2.00
nickel	.00	.00	1.00	.00	.00
tin	1.00	1.00	1.00	1.00	1.00
copper	2.00	2.00	2.00	1.00	1.00
mining,other	2.00	2.00	2.00	2.00	2.00
konstruksi	3.00	3.00	3.00	3.00	3.00
government	1.00	1.00	1.00	1.00	1.00
commercial	2.00	2.00	2.00	2.00	2.00
com. electricity	4.00	4.00	4.00	4.00	4.00

EXHIBIT IV-30

vgrowth rates (gother2.dat)

label	1983	1984	1985	1990	1995
inst. electricity	2.00	3.00	5.00	7.00	7.00
street lighting	4.00	4.00	4.00	4.00	4.00
strategic ado	2.00	2.00	2.00	2.00	2.00
strategic ido	3.00	3.00	3.00	3.00	3.00
strategic fueloil	2.00	2.00	2.00	2.00	2.00
strategic avtur	2.00	2.00	2.00	2.00	2.00
stategic avgas	.00	.00	.00	.00	.00
strategic gasoline	2.00	2.00	2.00	2.00	2.00
asphalt	2.00	2.00	2.00	2.00	2.00
lubes/waxes	2.00	2.00	2.00	2.00	2.00
petrochems	2.00	2.00	2.00	2.00	2.00
petr. coke	1.00	1.00	1.00	1.00	1.00

EXHIBIT IV-29

```
*****************************************************************
data table  6                                                   *
*****************************************************************
supply                                                          *
matrix name =additional sectors                                 *
matrix size = 4  0        .00                                   *
none        = 1  4                                              *
none                                                            *
   Additional Energy    kboe                                    *
-- -------------------- --------------------                     *
 1 Institutions              0.000                              *
 2 Street Lighting          14.600                              *
 3 Strategic               362.700                              *
 4 Non Energy                0.000                              *
*****************************************************************
data table  7                                                   *
*****************************************************************
share                                                           *
consis.check= 0                                                 *
matrix name =fuels to additional                                *
output name =Addit. sectors by fu                               *
output units=kboe                                               *
matrix size =12 .4        .00                                   *
none        = 1 12                                              *
none                                                            *
   fuels by type          Fuels by type        fraction         *
-- -------------------- -- -------------------- ----------      *
 1 Institutions          1 electricity              1.000 institutio *
 2 Street Lighting       2 electricity              1.000 institutio *
 3 strategic             3 ado                       .393 strategic  *
 3 strategic             4 ido                       .000 strategic  *
 3 strategic             5 fueloil                   .000 strategic  *
 3 strategic             6 avtur                     .186 strategic  *
 3 strategic             7 avgas                     .009 strategic  *
 3 strategic             8 gasoline                  .466 strategic  *
 4 non-energy            9 asphalt                   .000 non-energy *
 4 non-energy           10 lubes/waxes               .000 non-energy *
 4 non-energy           11 petrochems                .000 non-energy *
 4 non-energy           12 petr coke                 .000 non-energy *
*****************************************************************
data table  8                                                   *
*****************************************************************
vgrowth                                                         *
consis.check= 0                                                 *
matrix name =gother2.dat                                        *
output name =projected addit sect                               *
output units=kboe                                               *
matrix size =12 12      .00                                     *
sectors       1 12                                              *
none                                                            *
   mboe                   mboe                multiplier         *
-- -------------------- -- -------------------- ----------      *
```

```
*****************************************************************
data table  9                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =addition                                           *
output name =demands                                            *
output units=kboe                                               *
matrix size =16 16      .00   0   0                             *
none        = 0  0 barch=                                       *
none        =`0  0 barch=                                       *
   mboe                    mboe                                 *
-- -------------------- -- -------------------- ----------      *
*****************************************************************
DATA TABLE 10                                                   *
*****************************************************************
aggregate                                                       *
consis.check= 0                                                 *
matrix name =aggregate                                          *
output name =out=dynamic=otherr8.int                            *
output units=kboe                                               *
matrix size =17 17        .00                                   *
none        = 1 17                                              *
none                                                            *

-- -------------------- -- -------------------- ----------      *
 1 Java-electr
 2 electricity
 3 avgas
 4 avtur
 5 gasoline
 6 kerosene
 7 ado
 8 ido
 9 fueloil
10 lpg
11 gas
12 lubes/waxes
13 petrochems
14 asphalt
15 coal
16 petr coke
17 hydro
*****************************************************************
END
```


606

Data table 5 aggregates the projected fuel demands by subsectors into a subtotal demand fuel.

3. Data Tables 6 to 10: Additional Sectors (Exhibit IV-29)

The values initializing this side branch are total energy demands in the base year for the following subsectors: institutions (electricity sales to public sector), street lighting (as PLN sales to this tariff class), Strategic (petroleum products consumed by the military) and non-energy (petroleum products used as feedstocks such as petrochemicals, asphalt, lubes/waxes etc. Data sources are PLN, ADP-7 and MIGAS Oil Statistics for non-energy uses.

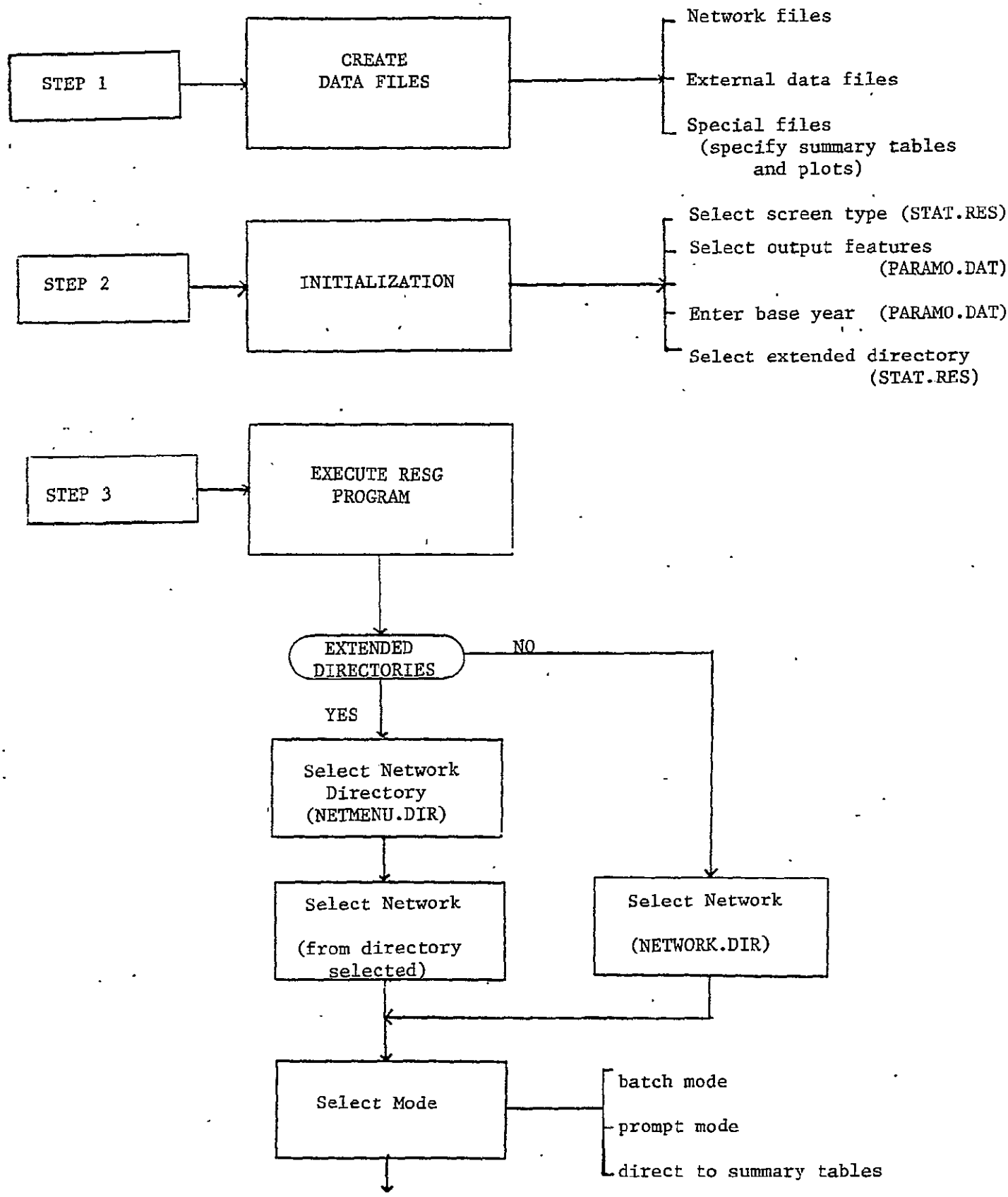
The values are projected in data table 8 by reference to the external file GOTHER2.DAT (Exhibit IV-30), where the resulting values are also instructed to be entered into the summary table by using the "sectors" command. After reaggregation in data table 10, the results are stored in files OTHERR1.INT, OTHERR2.INT etc. respectively.

ANNEX 1

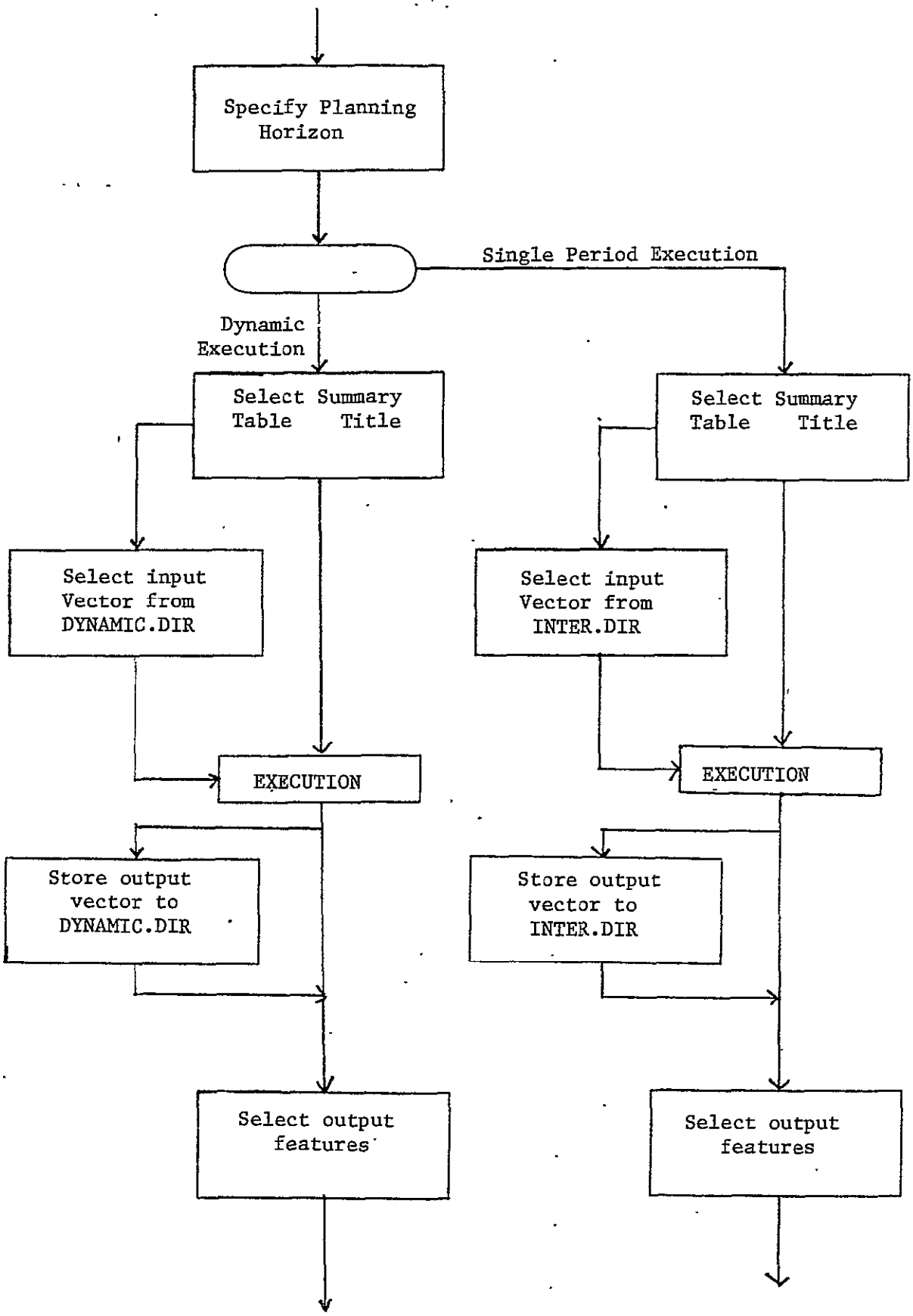
Schematic of a RESGEN Run

608

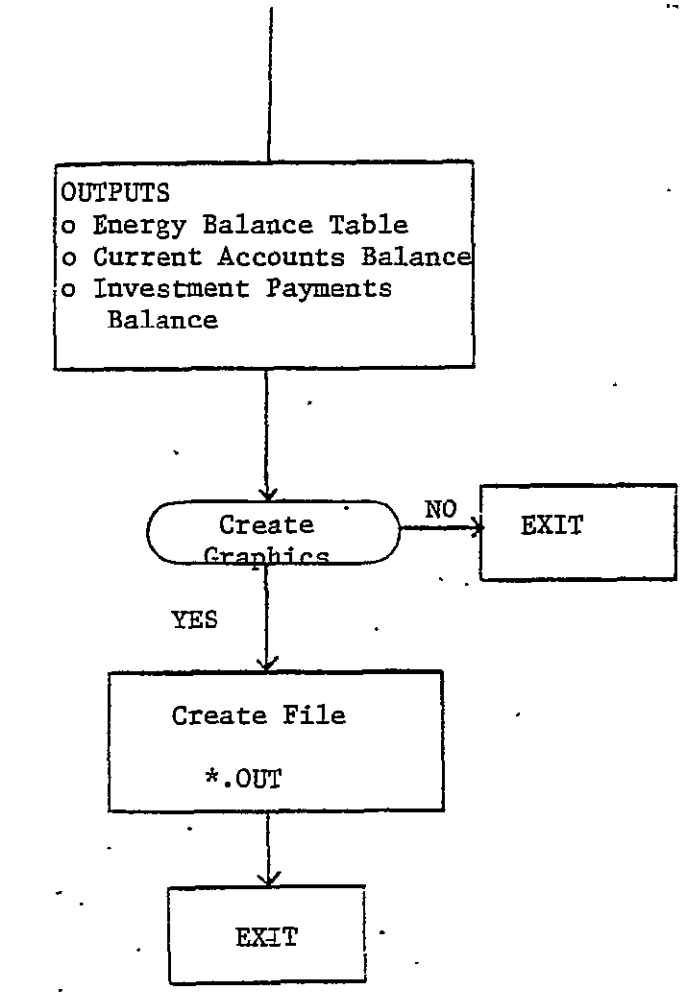
RUNNING RESGEN

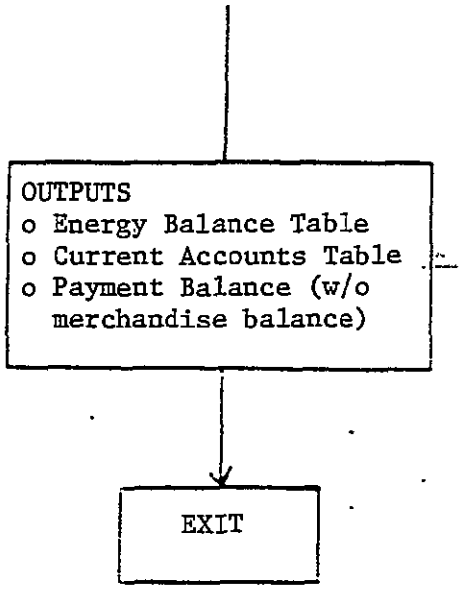


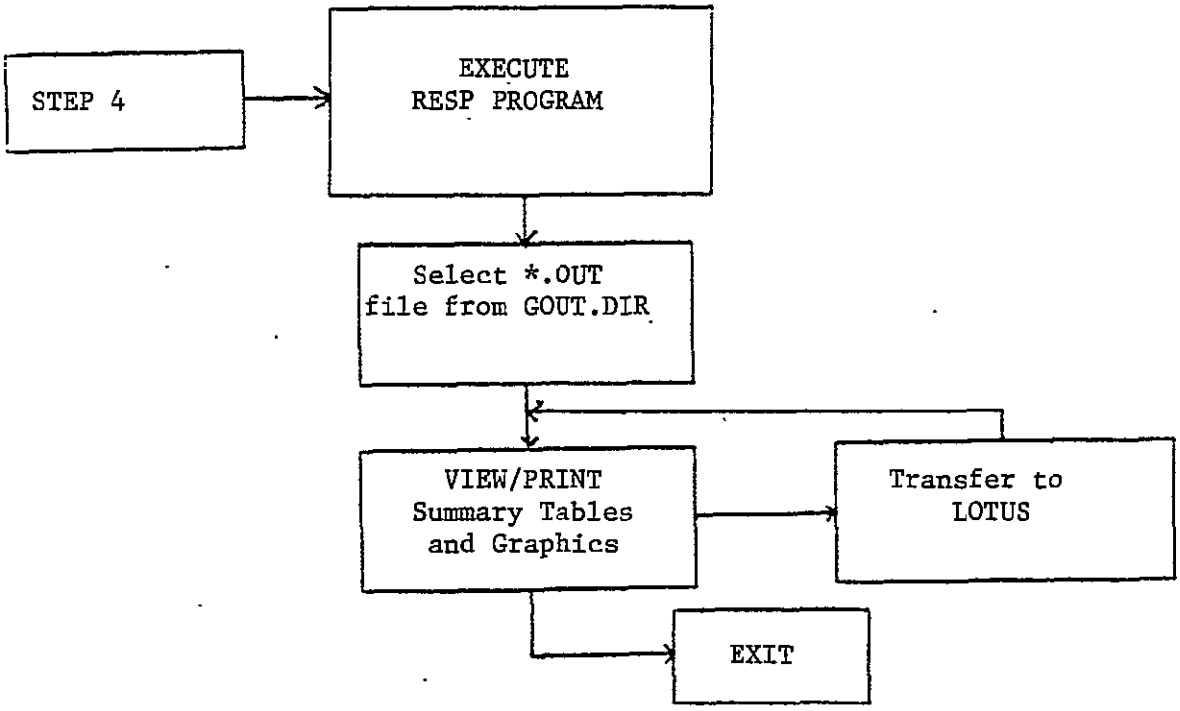
609


Specify Planning Horizon
Single Period Execution
Dynamic Execution
Select Summary Table Title
Select Summary Table Title
Select input Vector from DYNAMIC.DIR
Select input Vector from INTER.DIR
EXECUTION
EXECUTION
Store output vector to DYNAMIC.DIR
Store output vector to INTER.DIR
Select output features
Select output features

610


OUTPUTS
o Energy Balance Table
o Current Accounts Balance
o Investment Payments Balance
Create Graphics
NO
EXIT
YES
Create File
*.OUT
EXIT


OUTPUTS
o Energy Balance Table
o Current Accounts Table
o Payment Balance (w/o merchandise balance)
EXIT


STEP 4
EXECUTE
RESP PROGRAM
Select *.OUT
file from GOUT.DIR
VIEW/PRINT
Summary Tables
and Graphics
Transfer to
LOTUS
EXIT

ANNEX 2

FILE LISTING FOR NATIONAL AGGREGATION NETWORKS

1. REGION.DAT
2. ADDREGS.DAT

612

```
   lregion.dat          rplots.dat                                  *
   1---------2---------3---------4---------5---------6--------- *
Demand, Region 3                                                   *
*******************************************************************
data table  1                                                      *
*******************************************************************
projection                                                         *
matrix name =startup                                               *
matrix size =14  0        .00                                      *
none        =                                                      *
none                                                               *
                                                                   *
-- ---------------- ---------------                                *
 1 Java-electr              .000                                   *
 2 electricity              .000                                   *
 3 lpg                      .000                                   *
 4 kerosene                 .000                                   *
 5 ado                      .000                                   *
 6 gas                      .000                                   *
 7 wood                     .000                                   *
 8 agric wastes             .000                                   *
 9 charcoal                 .000                                   *
10 biogas                   .000                                   *
11 solar                    .000                                   *
12 solar-pv                 .000                                   *
13 wind                     .000                                   *
14 coke                     .000                                   *
*******************************************************************
data table  2                                                      *
*******************************************************************
demand                                                             *
matrix name =data=hholdr3.int                                      *
matrix size =14  0        .00                                      *
none        =                                                      *
households  = 1 14                                                 *
                                                                   *
-- ---------------- ---------------                                *
 1 Java-electr              .000                                   *
 2 electricity              .000                                   *
 3 lpg                      .000                                   *
 4 kerosene                 .000                                   *
 5 ado                      .000                                   *
 6 gas                      .000                                   *
 7 wood                     .000                                   *
 8 agric wastes             .000                                   *
 9 charcoal                 .000                                   *
10 biogas                   .000                                   *
11 solar                    .000                                   *
12 solar-pv                 .000                                   *
13 wind                     .000                                   *
14 coke                     .000                                   *
*******************************************************************
DATA TABLE  3                                                      *
*******************************************************************
addition                                                           *
consis.check= 0                                                    *
matrix name =households                                            *
output name =                                                      *
output units=                                                      *
matrix size =14 14        .00                                      *
none        =                                                      *
none                                                               *
                                                                   *
-- ---------------- -- ---------------- --------                   *
```


613

```
*****************************************************************
DATA TABLE  4                                                   *
*****************************************************************
demand                                                          *
matrix name =data=tranr3.int                                    *
matrix size = 8  0        .00                                   *
none        =                                                   *
transport   = 1  8                                              *
                                                                *
-- ---------------- ---------------                              *
 1 avgas                    .000                                *
 2 avtur                    .000                                *
 3 gasoline                 .000                                *
 4 ado                      .000                                *
 5 fueloil                  .000                                *
 6 ido                      .000                                *
 7 lpg                      .000                                *
 8 coal                     .000                                *
*****************************************************************
DATA TABLE  5                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =transport                                          *
output name =                                                   *
output units=                                                   *
matrix size =20 14        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- --------                *
*****************************************************************
DATA TABLE  6                                                   *
*****************************************************************
demand                                                          *
matrix name =data=indusr3.int                                   *
matrix size =13  0        .00                                   *
none        =                                                   *
industry    = 1 13                                              *
                                                                *
-- ---------------- ---------------                              *
 1 Java-electr              .000                                *
 2 electricity              .000                                *
 3 lpg                      .000                                *
 4 kerosene                 .000                                *
 5 ado                      .000                                *
 6 ido                      .000                                *
 7 fueloil                  .000                                *
 8 gas                      .000                                *
 9 wood                     .000                                *
10 agric wastes             .000                                *
11 coal                     .000                                *
12 charcoal                                                     *
13 coke                                                         *
*****************************************************************
DATA TABLE  7                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =industry                                           *
output name =                                                   *
output units=                                                   *
matrix size =20 20        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- --------                *
```


614

```
DATA TABLE  8
demand
matrix name =data=otherr3.int
matrix size =17  0        .00
none        =
other sect  = 1 17

 1 Java-electr              .000
 2 electricity              .000
 3 avgas                    .000
 4 avtur                    .000
 5 gasoline                 .000
 6 kerosene                 .000
 7 ado                      .000
 8 ido                      .000
 9 fueloil                  .000
10 lpg                      .000
11 gas                      .000
12 lubes/waxes              .000
13 petrochems               .000
14 asphalt                  .000
15 coal                     .000
16 petr coke                .000
17 hydro                    .000
```

```
DATA TABLE  9
addition
consis.check= 0
matrix name =other sectors
output name =demands
output units=
matrix size =24 20        .00
none        = 1 24
none
```


616

```
*****************************************************************
DATA TABLE 10
*****************************************************************
aggregate
consis.check= 0
matrix name =aggregate
output name =out=dynamic=region3.int
output units=kboe
matrix size =25 25        .00
none        = 1 25
none

-- ---------------- -- ---------------- --------

 1 Java-electr
 2 electricity
 3 lpg
 4 avgas
 5 avtur
 6 gasoline
 7 ado
 8 ido
 9 kerosene
10 fueloil
11 petrochems
12 lubes/waxes
13 asphalt
14 petr coke
15 gas
16 charcoal
17 wood
18 agric wastes
19 coal
20 coke
21 solar-pv
22 solar
23 biogas
24 wind
25 hydro
*****************************************************************
END
```


616

```
  laddreg.dat          addplt.dat                                  *
  1---------2---------3---------4---------5---------6---------*
Indonesia Energy Demand by Region (addregs.dat)                    *
*******************************************************************
DATA TABLE  1                                                      *
*******************************************************************
projection                                                         *
matrix name =initialization                                        *
matrix size =25  0        .00                                      *
none        =                                                      *
none                                                               *
                                                                   *
-- ---------------- ---------------                                *
 1 Java-electr              .000                                   *
 2 electricity              .000                                   *
 3 lpg                      .000                                   *
 4 avgas                    .000                                   *
 5 avtur                    .000                                   *
 6 gasoline                 .000                                   *
 7 ado                      .000                                   *
 8 ido                      .000                                   *
 9 kerosene                 .000                                   *
10 fueloil                  .000                                   *
11 petrochems               .000                                   *
12 lubes/waxes              .000                                   *
13 asphalt                  .000                                   *
14 petr coke                .000                                   *
15 gas                      .000                                   *
16 charcoal                 .000                                   *
17 wood                     .000                                   *
18 agric wastes             .000                                   *
19 coal                     .000                                   *
20 coke                     .000                                   *
21 solar-pv                 .000                                   *
22 solar                    .000                                   *
23 biogas                   .000                                   *
24 wind                     .000                                   *
25 hydro                    .000                                   *
*******************************************************************
DATA TABLE  2                                                      *
*******************************************************************
demand                                                             *
matrix name =data=region1.int                                      *
matrix size =25  0        .00                                      *
none        =                                                      *
N. Sumatra  = 1 25                                                 *
                                                                   *
-- ---------------- ---------------                                *
 1 Java-electr              .000                                   *
 2 electricity              .000                                   *
 3 lpg                      .000                                   *
 4 avgas                    .000                                   *
 5 avtur                    .000                                   *
 6 gasoline                 .000                                   *
 7 ado                      .000                                   *
 8 ido                      .000                                   *
 9 kerosene                 .000                                   *
10 fueloil                  .000                                   *
11 petrochems               .000                                   *
12 lubes/waxes              .000                                   *
13 asphalt                  .000                                   *
14 petr coke                .000                                   *
15 gas                      .000                                   *
16 charcoal                 .000                                   *
17 wood                     .000                                   *
18 agric wastes             .000                                   *
19 coal                     .000                                   *
20 coke                     .000                                   *
21 solar-pv                 .000                                   *
22 solar                    .000                                   *
23 biogas                   .000                                   *
24 wind                     .000                                   *
25 hydro                    .000
-------------------------------------------------------------------
```


617

```
*****************************************************************
DATA TABLE  3                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=                                                   *
matrix size =25 25        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- --------                *
*****************************************************************
DATA TABLE  4                                                   *
*****************************************************************
demand                                                          *
matrix name =data=region2.int                                   *
matrix size =25  0        .00                                   *
none        =                                                   *
W. Sumatra  = 1 25                                              *
                                                                *
-- ---------------- ---------------                              *
 1 Java-electr              .000                                *
 2 electricity              .000                                *
 3 lpg                      .000                                *
 4 avgas                    .000                                *
 5 avtur                    .000                                *
 6 gasoline                 .000                                *
 7 ado                      .000                                *
 8 ido                      .000                                *
 9 kerosene                 .000                                *
10 fueloil                  .000                                *
11 petrochems               .000                                *
12 lubes/waxes              .000                                *
13 asphalt                  .000                                *
14 petr coke                .000                                *
15 gas                      .000                                *
16 charcoal                 .000                                *
17 wood                     .000                                *
18 agric wastes             .000                                *
19 coal                     .000                                *
20 coke                     .000                                *
21 solar-pv                 .000                                *
22 solar                    .000                                *
23 biogas                   .000                                *
24 wind                     .000                                *
25 hydro                    .000                                *
*****************************************************************
DATA TABLE  5
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=                                                   *
matrix size =25 25        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- --------                *
```


618

```
*****************************************************************
DATA TABLE  6
*****************************************************************
demand                                                          *
matrix name =data=region3.int                                   *
matrix size =25  0        .00                                   *
none        =                                                   *
C. Sumatra  = 1 25                                              *
                                                                *
-- ---------------- ----------------                            *
 1 Java-electr              .000                                *
 2 electricity              .000                                *
 3 lpg                      .000                                *
 4 avgas                    .000                                *
 5 avtur                    .000                                *
 6 gasoline                 .000                                *
 7 ado                      .000                                *
 8 ido                      .000                                *
 9 kerosene                 .000                                *
10 fueloil                  .000                                *
11 petrochems               .000                                *
12 lubes/waxes              .000                                *
13 asphalt                  .000                                *
14 petr coke                .000                                *
15 gas                      .000                                *
16 charcoal                 .000                                *
17 wood                     .000                                *
18 agric wastes             .000                                *
19 coal                     .000                                *
20 coke                     .000                                *
21 solar-pv                 .000                                *
22 solar                    .000                                *
23 biogas                   .000                                *
24 wind                     .000
25 hydro                    .000
*****************************************************************
DATA TABLE  7                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=                                                   *
matrix size =25 25        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- --------                *
```


619

```
*****************************************************************
DATA TABLE  8                                                   *
*****************************************************************
demand                                                          *
matrix name =data=region4.int                                   *
matrix size =25  0        .00                                   *
none        =                                                   *
S. Sumatra  = 1 25                                              *
                                                                *
-- ---------------- ---------------                              *
 1 Java-electr                .000                              *
 2 electricity                .000                              *
 3 lpg                        .000                              *
 4 avgas                      .000                              *
 5 avtur                      .000                              *
 6 gasoline                   .000                              *
 7 ado                        .000                              *
 8 ido                        .000                              *
 9 kerosene                   .000                              *
10 fueloil                    .000                              *
11 petrochems                 .000                              *
12 lubes/waxes                .000                              *
13 asphalt                    .000                              *
14 petr coke                  .000                              *
15 gas                        .000                              *
16 charcoal                   .000                              *
17 wood                       .000                              *
18 agric wastes               .000                              *
19 coal                       .000                              *
20 coke                       .000                              *
21 solar-pv                   .000                              *
22 solar                      .000                              *
23 biogas                     .000                              *
24 wind                       .000                              *
25 hydro                      .000
*****************************************************************
DATA TABLE  9                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=
matrix size =25 25        .00
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- --------                *
```


620

```
*****************************************************************
DATA TABLE 10                                                   *
*****************************************************************
demand                                                          *
matrix name =data=region5.int                                   *
matrix size =25  0        .00                                   *
none        =                                                   *
Java        = 1 25                                              *
                                                                *
-- ---------------- ----------------                            *
 1 Java-electr              .000                                *
 2 electricity              .000                                *
 3 lpg                      .000                                *
 4 avgas                    .000                                *
 5 avtur                    .000                                *
 6 gasoline                 .000                                *
 7 ado                      .000                                *
 8 ido                      .000                                *
 9 kerosene                 .000                                *
10 fueloil                  .000                                *
11 petrochems               .000                                *
12 lubes/waxes              .000                                *
13 asphalt                  .000                                *
14 petr coke                .000                                *
15 gas                      .000                                *
16 charcoal                 .000                                *
17 wood                     .000                                *
18 agric wastes             .000                                *
19 coal                     .000                                *
20 coke                     .000                                *
21 solar-pv                 .000                                *
22 solar                    .000                                *
23 biogas                   .000                                *
24 wind                     .000                                *
25 hydro                    .000
*****************************************************************
DATA TABLE 11                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=                                                   *
matrix size =25 25        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- ---------               *
```


621

```
*****************************************************************
DATA TABLE 12                                                   *
*****************************************************************
demand                                                          *
matrix name =data=region6.int                                   *
matrix size =25  0        .00                                   *
none        =                                                   *
W. Kaliman  = 1 25                                              *
                                                                *
-- ---------------- ---------------                              *
 1 Java-electr              .000                                *
 2 electricity              .000                                *
 3 lpg                      .000                                *
 4 avgas                    .000                                *
 5 avtur                    .000                                *
 6 gasoline                 .000                                *
 7 ado                      .000                                *
 8 ido                      .000                                *
 9 kerosene                 .000                                *
10 fueloil                  .000                                *
11 petrochems               .000                                *
12 lubes/waxes              .000                                *
13 asphalt                  .000                                *
14 petr coke                .000                                *
15 gas                      .000                                *
16 charcoal                 .000                                *
17 wood                     .000                                *
18 agric wastes             .000                                *
19 coal                     .000                                *
20 coke                     .000                                *
21 solar-pv                 .000                                *
22 solar                    .000                                *
23 biogas                   .000                                *
24 wind                     .000                                *
25 hydro                    .000
*****************************************************************
DATA TABLE 13                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=                                                   *
matrix size =25 25        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ---------------- -- ---------------- --------                *
```


622

```
*****************************************************************
DATA TABLE 14
*****************************************************************
demand                                                          *
matrix name =data=region7.int                                   *
matrix size =25  0        .00                                   *
none        =                                                   *
E.C.&S.Kal  = 1 25                                              *
                                                                *
-- ----------------- ----------------                           *
 1 Java-electr              .000                                *
 2 electricity              .000                                *
 3 lpg                      .000                                *
 4 avgas                    .000                                *
 5 avtur                    .000                                *
 6 gasoline                 .000                                *
 7 ado                      .000                                *
 8 ido                      .000                                *
 9 kerosene                 .000                                *
10 fueloil                  .000                                *
11 petrochems               .000                                *
12 lubes/waxes              .000                                *
13 asphalt                  .000                                *
14 petr coke                .000                                *
15 gas                      .000                                *
16 charcoal                 .000                                *
17 wood                     .000                                *
18 agric wastes             .000                                *
19 coal                     .000                                *
20 coke                     .000                                *
21 solar-pv                 .000                                *
22 solar                    .000                                *
23 biogas                   .000                                *
24 wind                     .000                                *
25 hydro                    .000
*****************************************************************
DATA TABLE 15                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=                                                   *
matrix size =25 25        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ----------------- -- ----------------- --------              *
```


623

```
*****************************************************************
DATA TABLE 16
*****************************************************************
demand                                                          *
matrix name =data=region8.int                                   *
matrix size =25  0        .00                                   *
none        =                                                   *
East Indon  = 1 25                                              *
                                                                *
-- ------------------ ------------------                         *
 1 Java-electr              .000                                *
 2 electricity              .000                                *
 3 lpg                      .000                                *
 4 avgas                    .000                                *
 5 avtur                    .000                                *
 6 gasoline                 .000                                *
 7 ado                      .000                                *
 8 ido                      .000                                *
 9 kerosene                 .000                                *
10 fueloil                  .000                                *
11 petrochems               .000                                *
12 lubes/waxes              .000                                *
13 asphalt                  .000                                *
14 petr coke                .000                                *
15 gas                      .000                                *
16 charcoal                 .000                                *
17 wood                     .000                                *
18 agric wastes             .000                                *
19 coal                     .000                                *
20 coke                     .000                                *
21 solar-pv                 .000                                *
22 solar                    .000                                *
23 biogas                   .000                                *
24 wind                     .000                                *
25 hydro                    .000
*****************************************************************
DATA TABLE 17                                                   *
*****************************************************************
addition                                                        *
consis.check= 0                                                 *
matrix name =add region                                         *
output name =part nat. total                                    *
output units=                                                   *
matrix size =25 25        .00                                   *
none        =                                                   *
none                                                            *
                                                                *
-- ------------------ -- ------------------ ---------           *
```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```
*****************************************************************
DATA TABLE 18                                                   *
*****************************************************************
diagonal                                                        *
consis.check= 0                                                 *
matrix name =Units to mboe                                      *
output name =out=dynamic=indodem.int                            *
output units=mboe                                               *
matrix size =25 25        .00                                   *
none        = 1 25                                              *
none                                                            *
   kboe                    mboe                                 *
-- ------------------- -- ------------------- ---------         *
 1 Java-electr          1 Java-electr              .001         *
 2 electricity          2 electricity              .001         *
 3 lpg                  3 lpg                      .001         *
 4 avgas                4 avgas                    .001         *
 5 gasoline             5 avtur                    .001         *
 6 gasoline             6 gasoline                 .001         *
 7 ado                  7 ado                      .001         *
 8 ido                  8 ido                      .001         *
 9 kerosene             9 kerosene                 .001         *
10 fueloil             10 fueloil                  .001         *
11 petrochems          11 petrochems               .001         *
12 lubes/waxes         12 lubes/waxes              .001         *
13 asphalt             13 asphalt                  .001         *
14 petr coke           14 petr coke                .001         *
15 gas                 15 gas                      .001         *
16 charcoal            16 charcoal                 .001         *
17 wood                17 wood                     .001         *
18 agric wastes        18 agric wastes             .001         *
19 coal                19 coal                     .001         *
20 coke                20 coke                     .001         *
21 solar-pv            21 solar-pv                 .001         *
22 solar               22 solar                    .001         *
23 biogas              23 biogas                   .001         *
24 wind                24 wind                     .001         *
25 hydro               25 hydro                    .001         *
*****************************************************************
END                                                             *
```


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ENERGY PLANNING FOR DEVELOPMENT

(Phase II)

APPENDIX 4: LINKAGE OF MACROECONOMIC AND ENERGY MODELS

September, 1985

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EXECUTIVE SUMMARY

This report outlines a methodology by which the RESGEN energy system model can be linked to the BAPPENAS Macroeconomic Model. There are three principal motivations for this linkage. First is to integrate the energy and economic planning processes. Second is to base the energy demand projections generated by RESGEN on the projections of aggregate and sectoral economic activity projected by the BAPPENAS Macroeconomic Model. Third is to provide the economic planners with detailed projections of energy demands, energy sector investments, financial flows, etc. as input into both the BAPPENAS Macroeconomic Model and the economic planning process in general.

The linkage occurs in two directions: from the BAPPENAS model to RESGEN and from RESGEN to the BAPPENAS model. The former linkage is by far the more technically involved and its description constitutes the vast portion of this report. The BAPPENAS model is composed of two principal parts: the Core Macroeconometric Model and the Input-Output Model. Projections of energy consumed by households and in certain modes of transportation generated by RESGEN are linked to projections of certain macroeconomic variables generated by the Core Model. Projections of energy consumption in the producing sectors of the economy (i.e. agriculture, mining, industry, commerce, etc.) are linked to the projections of sectoral value added or gross output generated by the Input-Output Model. Mathematical relationships between energy consumption and the measures of economic activity used in the BAPPENAS model must be econometrically estimated (or at least assumed).

The principal purpose of this report is to demonstrate how this linkage can be made and to suggest some mathematical relationships between energy consumption and economic activity that can be estimated. The actual mechanical linking of the models and the estimation of the suggested relationships is not performed. The report does include a listing and explanation of all equations

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that will link the models. This report is written so that the reader can perform the linkage with a minimum prior knowledge of economic models (consequently it is fairly technical in nature). The estimation of the relationships between energy consumption and economic activity, on the other hand, require at least some understanding of economic theory and econometric techniques.

Part I of this report is the introduction. Part II is an overview of the BAPPENAS Macroeconomic Model, in particular, the Core Macroeconometric Model and the Input-Output Model. Part III presents the actual (detailed) BAPPENAS-to-RESGEN linkage and contains the equations that create it. The principal task in this linkage is the mapping of the projections of value added and gross output generated by the Input-Output Model into the RESGEN energy end-use sectors. Part IV discusses the estimation of the relationships between energy consumption and the measures of economic activity used in the BAPPENAS model and suggests some equations to be estimated. Part V is a brief discussion of the linkage from RESGEN to the BAPPENAS model. This linkage involves replacing a few equations in the Core Model with projections generated by RESGEN. This final section also suggests ways in which information generated by RESGEN can be used in a non-mechanical manner as input to the economic planning process.

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I. INTRODUCTION

This report describes a methodology by which the BAPPENAS Macroeconomic Model, used in the development of Indonesia's REPELITAs (Five Year Plans), can be linked to RESGEN, an energy systems model currently being used by the Direktorat Jenderal Listrik dan Energy Baru.

There are three principal motivations behind this linkage. First and foremost is the desire to integrate the energy system and economic policy analysis, decision making and planning processes. Second is a desire to base the projections of energy demands, associated investment requirements, petroleum exports and imports and other information generated by RESGEN on the economic projections used in developing Indonesia's overall development programs. Third, is the objective of providing economic development planners with more detailed information on the energy sector in particular the information generated by RESGEN regarding projected energy demands, energy sector investments, exports, imports etc., to be used as input to the overall economic planning effort. In regard to this third point RESGEN can be used to determine the level and configuration of energy demands associated with the alternative economic development strategies that may be explored by the economic planners. RESGEN potentially can replace or augment the procedures for projecting energy demands, exports, imports, and associated financial flows currently being used in the development of the REPELITAs. RESGEN can also be used to determine the level and configuration of energy sector investments and the associated financial flows required to support alternative economic development strategies. This output from RESGEN can be used as input to the government investment planning process which is an important component of the overall planning effort.

A linkage between the BAPPENAS Model and RESGEN is not the only means to achieve these ends. DJL could develop its own macroeconomic model or modify one used in another country. Such

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alternative models could still generate projections of sectoral economic activity to drive the RESGEN model. The linkage with the BAPPENAS model, however, has distinct advantages over these alternatives. First, a linkage with the BAPPENAS model would insure that the results of the RESGEN model are consistent with the overall economic development plans of the Indonesian Government as reflected in economic projections of the BAPPENAS Macroeconomic Model. Second, DJL will not be duplicating work already being done at BAPPENAS. Third, DJL can draw on the large pool of expertise and experience regarding economic analysis and planning available at BAPPENAS.

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II. OVERVIEW OF THE BAPPENAS MACROECONOMIC MODEL

The BAPPENAS Macroeconomic Model consists of two principal submodels: (1) the Core Macroeconometric Model, and (2) the Input-Output Model. There are also additional components such as the the Monetary System Model and a series of equations used to project some of the economic variables that are used as inputs to the Core Model. The linkage between the BAPPENAS model and RESGEN, however, principally concerns the Input-Output Model and to a lesser extent the Core Model. Since the Core Model generates projections of economic variables that are used to drive the Input-Output Model it will discussed first.

A. THE CORE MACROECONOMETRIC MODEL

The Core Macroeconomcetric Model generates projections of over 60 economic variables through the use of econometrically estimated behavioral equations and (non-estimated) identities. The behavioral equations are a mathematical representation of the prevailing view at BAPPENAS of how the the various macroeconomic variables interact with one another. The identities are merely definitional accounting equations. A complete list of the equations and identities, and the definitions of all the variables are contained in Reference 2.

The variables of the model fall into two categories; endogenous and exogenous. Endogenous variables are those whose values are determined within the model, e.g. Gross Domestic or Gross National Product. Exogenous variables are those whose values must be specified as input to the Core Model. Exogenous variables can be separated into policy and non-policy variables. Exogenous policy variables are those that the government has some control over and can manipulate to achieve specified development goals, e.g. government investment and consumption, taxes, exchange rates. Exogenous non-policy variables are those over which the government has little or no control, e.g. world oil

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prices, international interest rates, and population growth rates.

The Core Model can be characterized as an expenditure oriented model as compared to the Input-Output model which can be termed a production oriented model. The Core Model generates projections of certain expenditure variables, i.e. private consumption, private investment, exports, and imports. When the projected values of these variables are added to exogenously projected levels of government investment and consumption the result is projected Gross Domestic Product by expenditure.

Few of the variables projected by the Core Model are used directly in linking the Macroeconomic Model to RESGEN. The ones that are involved are GDP, personal disposable income (both measured in constant prices), and possibly the consumer price index. The principal importance of the Core Model in the context of the linkage is that the projections of GDP by expenditure are used as input to the Input-Output Model to generate projections of GDP by sector of origin. The major portion of the linkage involves these projections of sectoral economic activity.

After the endogenous expenditure variables generated by the Core Model are projected they, along with the exogenously specified levels of government investment and operating expenditures must be distributed among the various producing sectors in the economy. For example, the Core Model will project the level of private consumption in the aggregate. Total private consumption must then be divided up into its various components such as consumption of food and beverages, textiles, appliances, etc. This distribution must be performed for each of the expenditure variables. Once this has been accomplished the projections of final demand and imports are summed according to the producing sector in which the expenditure occurs. This horizontal summation (across all producing sectors) yields a single column vector of final demands and imports that drives the Input-Output model. The Input-Output

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Model calculates levels of sectoral economic activity required to meet the projected level and configuration of expenditures. Since this point may be illustrated best in the context of an input-output table perhaps this is the best point to proceed to the discussion of the Input- Output Model.

B. THE INPUT-OUTPUT MODEL

The presentation of the Input-Output Model can be made clearer by preceding it with a discussion of an input-output table (from which input-output models are derived). The difference between an input-output table and an input-output model is that the former is an actual accounting of economic flows for a given year. An input-output model uses this same accounting table to generate projections of sectoral economic activity by projecting certain components of the table and manipulating some matrices and vectors. This process will be outlined below.

To explain the structure of an input output table and the relationship among its various components the 1980 BPS 19 sector input-output table has been collapsed to 3 producing sectors and is presented on Table II-1. The table consists of four principal components: (1) the table of final demands and imports (i.e. the components of GDP by expenditure mentioned above), (2) the table of interindustry transactions, (3) the (column) vector of sectoral gross outputs, and (4) the (row) vector of sectoral gross value added.

1. The Table of Final Demands and Imports

The components of final demand are divided into private consumption, investment (both private and government as well as changes in inventories), government operating expenditures, and exports. Imports appear in the table as negative numbers. The figures at the bottom of each column in the final demand and

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TABLE II-1
1980 BPS INPUT OUTPUT TABLE (at Producers Prices)
(19 x 19 Collapsed to 3 x 3) Billion Rp

	Inter-Industry Transactions 1	2	3	190	Final Demands 301	302	303+304	305	Imports 409	Gross Output 600
1	X_{11}	X_{12}	X_{13}	7.5	6.3	0	0.3	2.0	-.4	15.8
2	X_{21}	X_{22}	X_{23}	13.0	9.3	0.4	4.2	12.9	-9.1	30.8
3	X_{31}	X_{32}	X_{33}	7.8	10.0	4.7	7.3	0.8	-1.0	29.7
190	3.9	13.4	10.7	28.0*	25.6	5.1	11.8	15.7	-10.5	

* Row sum is not equal to column sum due to roundings.

	201	2.4	1.7	7.6
	202	9.1	15.1	10.2
Value Added	203	0.3	0.9	1.4
	204 & 205	0.1	-0.3	-0.2
	209	11.9	17.4	19.0
	210	15.8	30.8	29.7

Sector Definitions

1 = Agriculture
2 = Mining & Industry
3 = Other
190 = Total Intermediate Inputs (as a row)
Total Intermediate Output (as a column)
201 = Wages and Salaries
202 = Operating Surplus
203 = Depreciation
204 = Indirect Taxes
205 = Subsidies
209 = Gross Value Added (201 - 204)
210 = Gross Input
301 = Private Consumption
302 = Government Consumption Expenditures
303 = Gross Fixed Capital Formation (Private & Government Investment
304 = Change in inventories

import table are the totals of each type of expenditure. It is these totals that the Core Model projects (with the exceptions of government investment and operating expenditures which are exogenous policy variables). In the example of Table II-1 these expenditures are divided up among the three producing sectors agriculture, manufacturing, and other. For the year in which the I-O table is constructed these figures are actual (estimated) expenditures. The totals are estimated every year and appear in the National Accounts in the table of Gross Domestic Product by type of expenditure. The distribution of the various expenditures by sector of purchase are estimated only for those years when the I-O is constructed (i.e. 1971, 1975, and 1980 in the case of Indonesia) or when the latest table is updated (as is currently being done in updating the 1980 I-O to 1983).

If each row of the table of final demands and imports is summed the result is a 3x1 vector of final demands less imports. This vector measures the value of domestically produced goods and services that were consumed directly or invested and were not used in the production of some other good or service during the year. The latter are recorded in the interindustry transactions table to which we now turn.

2. Inter-industry Transactions

To the left of the table of final demands and imports is the table of inter-industry transactions. The inter-industry transactions table records all transactions between the various producing sectors.(1) This table can be read in two ways; either along each row or up and down each column. If read across each row the figures represent the sales of each sector on the left to the producing sectors listed at the top of each column. If read down each column the figures represent the purchases of the sector listed at the top of the column from the sectors listed at the left of each row. Below the transactions table is row 190. This row lists the value of all inter-industry purchases by the sector at the

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top of the column. These values are commonly referred to as total intermediate inputs.

3. Gross Output

To the right of the table of final demands and imports is the column of gross outputs (column 600). The figures in this column represent the value of all sales of domestically produced outputs of the sector listed on the left during the year. The gross output of a sector is defined by the following expression.

$$X_i = x_{i1} + x_{i2} + x_{i3} + FD_i - M_i \quad (i = 1,2,3)$$

Where X_i = gross output of sector i

x_{ij} = sales of sector i to sector j

FD_i = final demand of sector i

M_i = imports in sector i

4. Value Added

Below the row of total intermediate inputs (row 190) lie rows 201 through 204 and row 209. Rows 201 through 204 are the components of value added, row 209 is their sum and is referred to as gross value added. The four components of value added are wages and salaries (row 201), operating surplus (also known as profits, row 202), depreciation of capital stock (row 203), and taxes less subsidies (row 204).

Sectoral gross value added is also known as sectoral GDP at market prices and appears in the national accounts as GDP by sector of industrial origin at market prices. If one takes the sum of wages and salaries and operating surplus alone (rows 201 and 202) one has what is knows as sector value added at factor cost. The sum of all sectoral value added at factor cost equals GDP at factor cost.

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Below the row of gross value added lies the row of gross inputs. The values in this row are the sums as rows 190 and 209 for each column, i.e. the gross input to a sector is equal to the sum of the value of intermediate inputs and gross value added of that sector. Note that the gross input of a sector is equivalent to its gross output (compare the values in row 210 with those in column 600). This equivalence is one of the basic accounting identities of input-output analysis.

C. MATHEMATICAL TREATMENT OF THE INPUT OUTPUT-TABLE AND THE INPUT-OUTPUT MODEL

Let the gross output of each of the three sectors be represented by X1, X2, and X3, respectively. Let xij represent the sales from sector i to sector j. The gross output of each sector can be represented by the following expressions :

(1) $x11 + x12 + x13 + Y1 = X1$

(2) $x21 + x22 + x23 + Y2 = X2$

(3) $x31 + x32 + x33 + Y3 = X3$

Where $Yi = FDi - Mi$, FDi represents the sales of sector i to final demand and Mi represents imports of sector i.

Similarly the inputs into each sector can be represented by the following expression

(4) $x11 + x21 + x31 + VA1 = X1$

(5) $x12 + x22 + x32 + VA2 = X2$

(6) $x13 + x23 + x33 + VA3 = X3$

Consider the result of dividing the left hand side of equations 4 through 6 by X1, X2, and X3, respectively

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$$(4.1)\quad \frac{x11}{X1} + \frac{x21}{X1} + \frac{x31}{X1} + \frac{VA1}{X1} = 1$$

$$(4.2)\quad \frac{x12}{X2} + \frac{x22}{X2} + \frac{x32}{X2} + \frac{VA2}{X2} = 1$$

$$(4.3)\quad \frac{x13}{X3} + \frac{x23}{X2} + \frac{x33}{X3} + \frac{VA3}{X3} = 1$$

Define (7) $\frac{xij}{Xj} = aij$

(8) $\frac{VAj}{Xj} = Vj$

Equations (7) and (8) define the input-output and value added coefficients of each producing sector. Each aij is the value of output from sector i used to produce a unit of output in sector j. Each Vj is the amount of value added (or sectoral GDP) generated per unit of output from j. Using equation (7) equations (1) through (3) can be rewritten as :

(9) a11*X1 + a12*X2 + a13*X3 + Y1 = X1

(10) a21*X1 + a22*X2 + a23*X3 + Y2 = X2

(11) a31*X1 + a32*X2 + a33*X3 + Y3 = X3

These equations can be written in matrix form

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$$(12)\quad \begin{bmatrix} a11 & a12 & a13 \\ a21 & a22 & a23 \\ a31 & a32 & a33 \end{bmatrix} * \begin{bmatrix} X1 \\ X2 \\ X3 \end{bmatrix} + \begin{bmatrix} Y1 \\ Y2 \\ Y3 \end{bmatrix} = \begin{bmatrix} X1 \\ X2 \\ X3 \end{bmatrix}$$

or more succinctly

$$(13)\qquad AX + Y = X$$

The equation in (13) is fundamental to input output analysis.[1] By rearranging terms we get :

$$(14)\quad Y = X - AX$$

$$(15)\quad Y = (I - A)X$$

$$(16)\quad (I - A)^{-1} \quad Y = X$$

Equation (16) forms the basis of the BAPPENAS and other input output models. By projecting the vector (Y) of final demand and imports by sector (which is what the Core Macroeconometric model does), the input output model determines the level of sectoral gross output that would be required to meet the projected level and configuration of final demands and imports.

Sectoral value added (ie. GDP by sector) is determined by multiplying the projected level of sectoral gross outputs by their corresponding value added coefficients. Value added in Sector i = Vai * Xi. The input output model generates projections of sectoral value added that are consistent with the projected level and configuration of projected expenditures (the Y vector).

Note that the matrix of input output coefficients remains constant while making projections. A fixed coefficient input-

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output model does not allow for substitutions between inputs or for changing technologies. Such information, if desired, must be supplied by the analyst by manually changing the coefficients in the A matrix. This is rarely done in input-output modelling.

D. THE RELATIONSHIP BETWEEN THE INPUT-OUTPUT TABLE AND GDP

There are three ways of measuring GDP:

1. By expenditure
2. By Value added
3. By income

No matter which method is used the same numerical result is obtained. The Core Model estimates and projects GDP by expenditure (i.e. consumption, investment, government, exports and imports) while the Input- Output model, using projections of GDP by expenditures as inputs, generates projections of GDP by sector of origin. These relationships can be shown as follows.

$$(17) \quad \sum_{j=1}^{3} X_{ij} + Y_i = X_j \qquad (i=1,2,3)$$

$$(18) \quad \sum_{i=1}^{3} X_{ij} + V_j = X_j \qquad (j=1,2,3)$$

Equation (17) says that the sum of sales by sector (i) to producing sectors plus its sales to final demand less imports is equal to the gross output of that sector. Equation (18) says that the sum of all purchases of sector (j) from all producing sectors and its purchases of primary inputs (i.e. value added) is equal to the gross output of that sector (gross output = gross input). Since

$$\sum_{i=1}^{3} X_{i.} = \sum_{j=1}^{3} X_j$$

(17) and (18) can be combined to yield j

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$$(19) \quad \sum_{i=1}^{3} \sum_{j=1}^{3} X_{ji} + \sum_{i=1}^{3} Y_i = \sum_{j=1}^{3} \sum_{i=1}^{3} X_{ij} + \sum_{j=1}^{3} V_j$$

or

$$(20) \quad \sum_{i=1}^{3} Y_i = \sum_{j=1}^{3} V_j$$

The left hand side of (20) is equivalent to GDP by expenditure (i.e. it is the sum of all expenditures on final demand and imports. This is what the Core Model projects. The right hand side value is equivalent to GDP by value added (i.e. it is the sum of sectoral value added). This is what the Input-Output Model projects. As equation (20) indicates, the two are equivalent.

E. METHODS OF ECONOMIC PROJECTIONS

The process of generating economic projections with the BAPPENAS Macroeconomic Model is basically the following. The monetary and other submodels generate projections of certain variables used as inputs to the Core Model. These variables include money supply, credit to the private sector, world prices of oil and natural gas, world prices of imports etc. Projections of policy variables and other exogenous variables used in the Core Model must also be made. When projections of all variables exogenous to the Core Model have been completed the Model is run to generate projections of the economic variables discussed previously. Among

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the projected variables are the components of final demand and imports measured in constant prices. These projections of final expenditure are then disaggregated into expenditures on the goods and services produced by the various economic producing sectors (23 in the case of the BAPPENAS model). This process yields projections of the table of final demands and imports. The columns of these tables are summed horizontally to yield the (Y) vector that drives the Input-Output model. The I-O model is solved for the levels of sectoral gross outputs required to meet the level and configuration of projected final expenditures (i.e. the projected (Y) vector). These sectoral gross outputs are multiplied by the sectoral value added coefficients to yield projections of GDP by sector of origin that are consistent with the projections of GDP by expenditure. At this point the participants in the planning effort evaluate the projected rates of growth of sectoral GDP based on their judgement of what is possible and desirable. If they determine that some rates are too high then they reassess the assumptions and results of the Core Model, perhaps reducing the level of government investment or exports. If they feel the projected is rate lower than desired and possible they similarly reassess the assumptions and results of the Core Model, perhaps increasing government investment or reducing the volume of imports.

The BAPPENAS Macroeconomic Model is strictly speaking a planning "tool". The results of the model are not interpreted as what will in fact happen, but rather they are used to guide the decision makers in their assessments of what is a feasible as well as desirable path and rate of social and economic development.

F. CURRENT STATUS AND FUTURE EXTENSIONS OF THE BAPPENAS MODEL

The BAPPENAS Macroeconomic Model currently incorporates an aggregated version of the 1975 66 sector BPS Input-Output Table. This table was updated to 1980 and collapsed to 23 sectors. The relationship between the 23 sectors in the BAPPENAS I-O and the 66 sectors of the BPS I-O is shown in Table II-2. The BAPPENAS I-O

TABLE II-2

SECTOR CLASSIFICATION OF THE BAPPENAS INPUT-OUTPUT MODEL

	BAPPENAS I-O	BPS 66 SECTOR I-O
01	Agriculture	1 - 17
02	Animal Husbandry	18 - 20
03	Forestry and Hunting	21 - 22
04	Fishery	23
05	Oil Mining	25
06	Other Mining and Quarrying	24 ,26
07	Mfg. of Food Beverage and Tobacco	27 - 34
08	Mfg. of Textile, Wearing Apparel and Leather	35, 36
09	Mfg. of Wood and Wood Products including Furniture	37
10	Mfg. of Paper, Paper Products, Printing and Publishing	38
11	Mfg. of Chemicals and Chemical, Petroleum, Coal, Rubber, and Plastic Products	39 - 42
12	Mfg. of Non-Metallic Mineral Products except Products of Petroleum and Coal	43. 44
13	Mfg. of Basic Metals	45, 46
14	Mfg. of Fabricated Metal Products	47
15	Mfg. of Machinery and Equipment	48, 49
16	Other Mfg. Products	50
17	Construction	52
18	Electricity, Gas, and Water Supply	51
19	Trade	53, 54
20	Banking and Insurance	61
21	Transportation and Storage	55 - 59
22	Communication	60
23	Services not Classified Above	62 - 66

model generates projections of value added and gross output by sector in constant 1980 prices. The model has been used to make projections to 1990.

BAPPENAS is currently incorporating a collapsed version of the 1980 BPS 66 sector I-O table updated to 1983 which will be the new base year for future projections. BAPPENAS hopes to have this task completed by the end of the summer. It also plans to extend the projections with the I-O model to the year 2000.

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CHAPTER II

NOTES AND REFERENCES

1. An expanded approach is suggested by Dr. Ukar Soelistijo, who as counterpart of DJL actively contributed to the formulation described in this report.

By explicitly taking account of imports, M, in the fundamental equation AX + F = X, where:

A = technical coefficient
X = gross domestic output
F = final demand,

the matrix equation should be:

$$\underset{\text{(demand)}}{AX + F} = \underset{\text{(supply)}}{X + M}$$

then $X = (I - A)^{-1} (F - M)$

In this case, M is an <u>exogenous</u> variable, for example determined by the government's plan on imports.

If M is an endogenous variable, then the import matrix could be estimated from the assumption that the import of each sector is proportional to the corresponding sector's output. This proportion, labelled import coefficient (U_i, i = 1, 2, ..., n,) is then

$$U_i = \frac{\text{import of sector i}}{\text{intermediate demand i + final demand i - export i}}$$

If F_i^e = final demand i - export i, then

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$$U_i = \frac{M_i}{\Sigma_j X_{ij} + F_i^e} \quad , \; i = 1, 2, \ldots\ldots\ldots, n \quad j = 1, 2, \ldots\ldots\ldots, n$$

$$M_i = U_i \quad (\sum_j X_{ij} + F_i^e)$$

The imports coefficient can be stated as diagonal matrix, $\hat{M}$, which has elements at the main diagonal. $\hat{M}$ is called import coefficient matrix. Then:

$$AX + F = X + M$$
$$AX + F - M = X$$

Since $F = F^e + E$ (E = export) and $M = \hat{M}\ (AX + F^e)$, then

$$X = AX + F^e + E - \hat{M}\ (AX + F^e)$$
$$X = AX + F^e + E - \hat{M}\ AX + MF^e$$
$$X - AX + \hat{M}\ AX = F^e - \hat{M}F^e + E$$
$$X = [I - (I - \hat{M})\ A]^{-1}\ \ [(I - \hat{M})\ F^e + E]$$

An explicit accounting of imports results in an alternative formulation for Value Added Projection:

$$V_k = V\ [I - (I - \hat{M})\ A]^{-1}\ (I - M)\ F_k$$
$$V_{305} = V\ [I - (I - \hat{M})\ A]^{-1}\ E$$

$$V = \begin{bmatrix} d_1 & o & o \\ o & d_2 & o \\ . & . & . \\ . & . & . \\ o & o & d_n \end{bmatrix} \quad , \; d_j \quad \frac{\text{value added of sector j}}{\text{output of sector j}}$$

(= valued added coefficient)

These formulations emphasize the importance of including the import coefficient to compute or predict value added or other I-O variables.

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III. LINKAGE OF THE BAPPENAS AND RESGEN MODELS

A. FROM BAPPENAS TO RESGEN

The linkage from BAPPENAS to RESGEN involves both the Input-Output model and the Core Macroeconometric model though the major portion of the linkage involves the former. The principal components of the linkage are :

(1) Projected value added and/or gross output of the 23 sectors generated by the BAPPENAS I-O Model.

(2) Projected gross domestic product and personal disposable income generated by the Core Model.

(3) Projections of variables exogenous to the BAPPENAS Macroeconomic Model (e.g. population growth rates).

What follows is a methodology for linking the BAPPENAS model to an application of RESGEN recently developed at DJL. This linkage is from a national macromodel (BAPPENAS) to a national energy model. Because RESGEN can be readily applied at the regional level, it is necessary to develop regional level macroeconomic and I-O models in order to effect the linkage at the regional level as well.

1. Linking Energy Consumption to Sectoral Value Added or Gross Output

The principal task in linking the BAPPENAS I-O is to reaggregate the 23 sectors so they match the end use sectors of RESGEN. When the BAPPENAS I-O is reaggregated to match RESGEN the projections of sectoral value added and gross output will provide the bases on which to project sectoral energy demands. A list of the 23 sectors of the BAPPENAS I-O and their correspondence to the RESGEN end-use sectors is presented in Table III-1.

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TABLE III-1
MAPPING OF BAPPENAS I-O SECTORS INTO THE RESGEN END-USE SECTORS

	BAPPENAS I-O		RESGEN
01	Agriculture	01	Agriculture
02	Animal Husbandry		
03	Forestry and Hunting		
04	Fishery		
05	Oil Mining	02	Oil and Gas
06	Other Mining and Quarrying	03	Coal
		04	Nickel
		05	Tin
		06	Copper
		07	Other Mining
07	Food, Beverages, and Tobacco	08	Food
08	Textiles, Wearing Apparel, and Leather	09	Textiles
10	Paper, Paper Products, Printing, and Publishing	10	Pulp and Paper
11	Chemicals and Chemical, Petroleum, Coal, Rubber, and Plastic Products	11	Rubber
		12	Fertilizers
		13	Chemicals
12	Non Metallic Mineral Products except Petroleum and Coal Products	14	Cement
		15	Ceramics
13	Basic Metals	16	Iron and Steel
09	Wood and Wood Products including Furniture	17	Other Manufacturing
14	Fabricated Metal Products		
15	Machinery and Equipment		
16	Other Manufacturing		
17	Construction	18	Construction
18	Electricity, Gas, and Water		*
19	Trade	19	Commerce (Electric)
20	Banking and Insurance		
22	Communication		
23	Services not Classified Above		
19	Trade	20	Commerce (Kerosene)
23	Services not Classified Above	21	Service (Fuel Oil and Diesel)

TABLE III-1
MAPPING OF BAPPENAS I-O SECTORS INTO THE RESGEN END-USE SECTORS
continued

BAPPENAS I-O	RESGEN	
21 Transportation and Storage	Method (1)	Method (2)
	22 Rail	22 Rail
	23 Water	23 Water
	24 Air	24 Air
	25 Bus	
	26 Truck	
	27 Taxis	
	28 Bajajs and other	
RESGEN sectors not included in BAPPENAS I-O	Private Automobiles the Motorcycles Households	
BAPPENAS sectors not included as a RESGEN End-Use Sector. The output and energy inputs of these sectors is projected by RESGEN	Electricity and gas Refinery	

There are three types of operations involved in this reaggregation. First is the task of mapping the value added and gross output of more than one BAPPENAS sector into one RESGEN sector. Second is the mapping of the value added and gross output of a BAPPENAS sector into an identically defined RESGEN sector. In this case no reaggregation is required. Third is the disaggregation of one BAPPENAS sector into more than one RESGEN sector. The first two cases are trivial. The third is not and requires the use of the 66x66, 170x170, and 340x170 BPS I-O tables for 1980 and the specification of control equations to guarantee the consistency between the growth rates of the more detailed RESGEN sectors and the aggregated BAPPENAS sector.

What follows is the series of equations that reaggregate the value added and gross output of the BAPPENAS I-O sectors so that they correspond to the RESGEN end-use sectors. This reaggregation must be performed for each year that energy demands are projected. This process will yield projected value added and gross output for each of the RESGEN sectors. Based on the estimated relationship between these measures of economic activity and energy consumption energy demands can be projected. Table III-2 lists the value added and gross output for each of the BAPPENAS I-O sectors for 1980. The reaggregation will be performed on these numbers.

The operations that follow are demonstrative in that if and when the actual linkage takes place the I-O table currently being used in the BAPPENAS model will have been replaced by an aggregated version of the 1980 BPS I-O table updated to 1983. Some sector numbers may change as a result but the basic operations will be the same. If the sector definitions used by BAPPENAS in its new I-O table do not change then one can merely replace all 1980 subscripts in the equations that follow with 1983 and proceed exactly as outlined.

TABLE III-2

GROSS VALUE ADDED AND GROSS OUTPUT BY SECTOR
(23 sector BAPPENAS INPUT OUTPUT MODEL)
(billions of Rupiahs)

SECTOR NUMBER	GROSS VALUE ADDED	GROSS OUTPUT
01	8 024.81	10 546.72
02	1 035.92	1 746.10
03	1 401.20	1 904.42
04	857.49	1 288.17
05	10 545.01	11 559.59
06	570.51	761.11
07	1 675.52	6 827.88
08	395.78	1 177.36
09	289.66	814.57
10	92.94	329.92
11	441.23	5 391.24
12	234.39	429.88
13	335.92	1 156.94
14	136.54	514.94
15	1 080.25	3 575.76
16	55.61	159.72
17	2 518.85	7 051.76
18	269.34	506.52
19	6 394.56	8 627.58
20	794.37	896.86
21	2 118.48	3 806.08
22	152.03	265.20
23	6 082.90	7 090.25

Many of the mechanical operations described by the following equations involve disaggregating the value added and gross output of the BAPPENAS I-O sectors according to their distribution in the 1980 BPS I-O table. These operations are required at this time because the sectoral values in the BAPPENAS I-O are not the same as those in the 1980 BPS I-O since the former is an updated version of the 1975 I-O whereas the latter was compiled from actual 1980 data. When the 1980 BPS I-O is updated to 1983 and incorporated into the BAPPENAS model then the sectoral values should match and one can refer directly to the BPS updated I-O and not have to worry about the distribution of value added and gross output in percentage terms as is done here.

The following terms will be used.

a) $VA^{B}_{i,t}$ = Value added of BAPPENAS I-O sector i in year t

b) $VA^{R}_{i,t}$ = Value added of RESGEN sector i in year t

c) $VA^{RC}_{i,t}$ = Value added of RESGEN control sector j in year t These values are for control purposes only and do not correspond to a RESGEN end-use sector.

d) $VA^{66}_{i,\ 1980}$ = Value added of sector i in the 1980 BPS 66 sector I-O table

e) $VA^{170}_{i,\ 1980}$ = Value added of sector i in the 1980 BPS 170 sector I-O table

f) $VA^{BPS}_{i,\ 1980}$ = Value added of sector i in 1980 obtained from unpublished BPS worksheets. These data must be used when more detail than is available in the 170 sector I-O is needed.

g) $GO^{B}_{i,t}$ = Gross output of BAPPENAS sector i in year t

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h) $GO^{R}_{i,t}$ = Gross output of RESGEN sector i in year t

i) $GO^{RC}_{i,t}$ = Gross output of RESGEN control sector j in year t (see note in (c) above)

j) $GO^{66}_{i,\ 1980}$ = Gross output of sector i in the 1980 BPS 66 sector I-O table

k) $GO^{170}_{i,\ 1980}$ = Gross output of sector i in the 1980 BPS 170 sector I-O table

l) $GO^{340}_{i,1980}$ = Gross ouput of sector i in the 1980 BPS 340x170 sector I-O table

<u>AGRICULTURE</u>: RESGEN Sector 1/BAPPENAS Sectors 1-4

1980 Reaggregated Values

(1) $VA^{R}_{1,\ 1980} = \sum_{i=1}^{4} VA^{B}_{1,\ 1980}$ = Rp 11,319.42 billion

(2) $GO^{R}_{1,\ 1980} = \sum_{i=1}^{4} GO^{B}_{i,\ 1980}$ = Rp 15,485.41 billion

Projections

(3) $VA^{R}_{1,t} = \sum_{i=1}^{4} VA^{B}_{i,t}$

(4) $GO^{R}_{i,t} = \sum_{i=1}^{4} GO^{B}_{i,t}$

No control totals are needed.

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OIL AND GAS EXPLORATION: RESGEN Sector 2/BAPPENAS Sector 5

This sector is defined identically in both RESGEN and the BAPPENAS I-O .

1980 Values

(5) $VA^{R}_{2,\ 1980} = VA^{B}_{5,\ 1980} =$ Rp 10,545.61 billion

(6) $GO^{R}_{2,\ 1980} = GO^{B}_{5,\ 1980} =$ Rp 11,559.59 billion

Projections

(7) $VA^{R}_{2,t} = VA^{B}_{5,t}$

(8) $GO^{R}_{2,t} = GO^{B}_{5,t}$

No control totals are needed.

COAL,NICKEL, TIN, COPPER and other Mining: RESGEN SECTORS 3-7/BAPPENAS SECTOR 6

The task here is one of disaggregating the "other mining and quarrying" sector of the BAPPENAS I-O into these five RESGEN sectors. This can be accomplished using the 1980 170 sector BPS I-O table. Each of these sectors is treated separately in this table. The value added and gross output in the BAPPENAS sector is distributed among the five RESGEN sub sectors so that the share of each is equivalent (in percentage terms) to its share in the 170 sector I-O. Once the base year subsector values are derived then separate growth rates are applied to each. These growth rates must be developed by the analyst as they are not supplied by the BAPPENAS model. To insure that the subsector growth rates supplied by the analyst are consistent with the over all sectoral growth rate obtained from the BAPPENAS model control totals must be used. The control totals insure that the sums of projected subsector value added and gross output are equal to the values projected by BAPPENAS for the sector as a whole.

There is a basic difference in the way the mining sector is defined in BAPPENAS and RESGEN. In the former model the mining sector is defined to include only the process of ore extraction; the basic fabrication process is accounted for in the basic metals sector (13). In the latter model both ore extraction and basic fabrication are included in the mining sector. RESEGEN does not

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distinguish between these activities because when the energy data were collected it was not possible to distinguish between the energy used in the ore extraction process from that consumed in the basic fabrication process. This lack of distinction arises because even though the extraction and basic fabrication processes are conceptually distinct they usually occur at the same site. The ore is mined and then brought to the fabrication plant for processing.

This difference in treatment by the two models renders a direct and consistent link between the sectors unlikely and can cause distortions in the projections of energy consumption in the mining and fabrication industries. Consider the tin mining and fabrication industries as an example. RESGEN contains data on the energy consumption for both activities as a whole while the BAPPENAS I-O model contains information on economic activity for each sector separately (although the information in 'implicit' in that it is buried in the other mining and quarrying and basic metals sectors). If RESGEN projects energy demands for both sectors as a whole based on the projected rate of growth in mining while the fabrication sector is projected to grow at a slower rate then it will 'overproject' energy consumption. On the other hand if fabrication is expected to grow more rapidly than mining then RESGEN will 'underproject' energy consumption. The former case could arise if as the tin mining sector grows proportionately more of the output is exported rather than processed in the fabrication sector. The latter case could arise if proportionately more is used in the fabrication industry and less is exported. If both sectors are projected to grow at exactly the same rate then it does not matter which activity energy consumption is tied to in RESGEN.

One should note, however, that these problems are primarily conceptual n that the mining and fabricating industries consume relatively little energy. The types of errors that are likely to arise will probably be lost in the 'noise' of the model.

The following disaggregation is performed, nonetheless, as if the mining sector in RESGEN includes only the extraction activity. This assumption is required if any link is to be made.

1980 Reaggregated Values:
Coal

$$(9) \quad VA^{R}_{3,1980} = \frac{VA^{170}_{41,1980}}{\sum_{i=41}^{53} VA^{170}_{i,\,1980} \quad (i \neq 42)} * VA^{B}_{6,1980} = \text{Rp 3.17 billion}$$

$$(10) \quad GO^{R}_{3,1980} = \frac{GO^{170}_{41,1980}}{\sum_{i=41}^{53} GO^{170}_{i,1980} \quad (i \neq 42)} * GO^{B}_{6,1980} = \text{Rp 5.13 billion}$$

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Nickel

$$(11)\quad VA^{R}_{4,\,1980} = \frac{VA^{170}_{45,\,1980}}{\sum_{i=41}^{53} VA^{170}_{i,1980}\ (i \neq 42)} * VA^{B}_{6,\,1980} = \text{Rp 25.03 billion}$$

$$(12)\quad GO^{R}_{4,\,1980} = \frac{GO^{170}_{45,\,1980}}{\sum_{i=41}^{53} GO^{170}_{i,\,1980}\ (i \neq 42)} * GO^{B}_{6,1980} = \text{Rp 40.31 billion}$$

Tin

$$(13)\quad VA^{R}_{5,\,1980} = \frac{VA^{170}_{44,\,1980}}{\sum_{i=41}^{53} VA^{170}_{i,\,1980}\ (i \neq 42)} * VA^{B}_{6,\,1980} = \text{Rp 190.62 billion}$$

$$(14)\quad GO^{R}_{5,\,1980} = \frac{GO^{170}_{44,\,1980}}{\sum_{i=41}^{53} GO^{170}_{i,\,1980}\ (i \neq 42)} * GO^{B}_{6,\,1980} = \text{Rp 279.17 billion}$$

Copper

$$(15)\quad VA^{R}_{6,\,1980} = \frac{VA^{170}_{47,1980}}{\sum_{i=41}^{53} VA^{170}_{i,\,1980}\ (i \neq 42)} * VA^{B}_{6,\,1980} = \text{Rp 50.47 billion}$$

$$(16)\quad GO^{R}_{6,\,1980} = \frac{GO^{170}_{47,1980}}{\sum_{i=41}^{53} GO^{170}_{i,\,1980}\ (i \neq 42)} * GO^{B}_{6,\,1980} = \text{Rp 71.69 billion}$$

Other Mining

$$(17)\quad VA^{R}_{7,\,1980} = \frac{\sum_{i} VA^{170}_{i,\,1980}\ (i=43,46,48\text{-}53)}{\sum_{i=41}^{53} VA^{170}_{i,\,1980}\ (i \neq 42)} * VA^{B}_{6,\,1980} = \text{Rp 301.22 billion}$$

$$(18)\quad GO^{R}_{7,\,1980} = \frac{\sum_{i} GO^{170}_{i,\,1980}\ (i=43,46,48\text{-}53)}{\sum_{i=41}^{53} GO^{170}_{i,\,1980}\ (i \neq 42)} * GO^{B}_{6,\,1980} = \text{Rp 364.81 billion}$$

Subsector Projections

$$(19)\quad VA^{R}_{i,t} = VA^{R}_{i,\,1980}\ (1 + gr_i)^{t-1980}$$

$$(20)\quad GO^{R}_{i,t} = GO^{R}_{i,\,1980}\ (1 + gr_i)^{t-1980}$$

$i = 3,4,5,6,7$

gr_i = annual growth rate of subsector i

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Control Totals

(21) $\sum_{i=3}^{7} VA^{R}_{i,t} = VA^{B}_{6,t}$

(22) $\sum_{i=3}^{7} GO^{R}_{i,t} = GO^{B}_{6,t}$

FOOD, TEXTILES, PULP and PAPER: RESGEN Sectors 8,9,10/BAPPENAS Sectors 7,8,10

The treatment of the next three RESGEN sectors is straight forward as they are defined exactly as they are in the BAPPENAS I-O.
1980 Values
Food

(23) $VA^{R}_{8,\ 1980} = VA^{B}_{7,\ 1980}$ = Rp 1,675.52 billion

(24) $GO^{R}_{8,\ 1980} = GO^{B}_{7,1980}$ = Rp 6,827.88 billion

Textiles

(25) $VA^{R}_{9,\ 1980} = VA^{B}_{8,\ 1980}$ = Rp 395.78 billion

(26) $GO^{R}_{9,\ 1980} = GO^{B}_{8,\ 1980}$ = Rp 1,177.36 billion

Pulp and Paper

(27) $VA^{R}_{10,\ 1980} = VA^{B}_{10,\ 1980}$ = Rp 289.66 billion

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(28) $GO^{R}_{10,\ 1980} = GO^{B}_{10,\ 1980} = \text{Rp } 814.57 \text{ billion}$

Projections

(29) $VA^{R}_{i,t} = VA^{B}_{j,t}$

$i = 8,9,10$
$j = 7,8,10$

(30) $GO^{R}_{i,t} = GO^{B}_{i,\ t}$

No control totals are needed.

RUBBER, FERTILIZERS, CHEMICALS: RESGEN sectors 11,12,13/BAPPENAS sector 11

The task here, through essentially the same as in the mining sector, is complicated by the treatment of the fertilizer sector in the BPS I-O tables and the treatment of the oil refinery sector by RESGEN. Given available data the value added of the fertilizer industry cannot be separated from that of the pesticide industry as they are both included in sector 97 in the 1980 BPS 170 sector I-O. The gross output of these two sectors can be separated for 1980 using the 340 x 170 sector BPS supporting tables. BPS may have some unpublished data that will allow for the disaggregation of the value added of these two industries. If no other information is available then the value added of the fertilizer and pesticide sector in the 1980 BPS 170 sector I-O can be allocated to each industry in proportion to each industry's gross output. Also, the value added and gross output of the refinery sector is included in the BAPPENAS sector and must be extracted to make it consistent with the RESGEN sector, RESGEN treats the oil refinery sector separately.

1980 Disaggregated Values

Rubber

(31) $$VA^{R}_{11,\ 1980} = \frac{\sum_{i=106}^{107} VA^{170}_{i,1980}}{\sum_{i=96}^{108} VA^{170}_{i,\ 1980}} * VA^{B}_{11,\ 1980} = \text{Rp } 39.94 \text{ billion}$$

(32) $$GO^{R}_{11,\ 1980} = \frac{\sum_{i=106}^{107} GO^{170}_{i,\ 1980}}{\sum_{i=96}^{108} GO^{170}_{i,\ 1980}} * GO^{B}_{11,\ 1980} = \text{Rp } 231.14 \text{ billion}$$

Fertilizers

The following level of disaggregation of value added can be performed given the available data.

$$(33)\quad VA^{R}_{12,\,1980} + VA_{Pesticides,\,1980} = \frac{VA^{170}_{97,\,1980}}{\sum_{i=96}^{108} VA^{170}_{i,\,1980}} * VA^{B}_{11,\,1980} = \text{Rp } 77.10 \text{ billion}$$

If the fertilizer and pesticides sector (sector 97) of the 170 sector BPS I-O can be disaggregated using unpublished BPS data then this equation can be rewritten as the following two equations.

$$(34)\quad VA^{R}_{12,\,1980} = \frac{VA^{BPS}_{Fertilizers,\,1980}}{\sum_{i=96}^{108} VA^{170}_{i,\,1980}} * VA^{B}_{11,\,1980}$$

$$(35)\quad VA^{R}_{Pesticides,\,1980} = \frac{VA^{BPS}_{Pesticides,\,1980}}{\sum_{i=96}^{108} VA^{170}_{i,\,1980}} * VA^{B}_{11,\,1980}$$

Equation (34) isolates the value added of the fertilizer industry and equation (35) that of the pesticide industry. If the data permit this disaggregation then the value added and gross output of the pesticide industry can be mapped into the RESGEN "chemicals" sector where the energy consumption of this industry is recorded.

The gross output of the fertilizer and pesticide industries can be disaggregated using the 340x170 sector BPS I-O table. These disaggregations appear below.

$$(36)\quad GO^{R}_{12,\,1980} = \frac{GO^{340}_{971,\,1980}}{\sum_{i=96}^{108} GO^{170}_{i,\,1980}} * GO^{B}_{11,\,1980} = \text{Rp } 572.18 \text{ billion}$$

$$(37)\quad GO^{R}_{Pesticides,\,1980} = \frac{GO^{340}_{972,\,1980}}{\sum_{i=96}^{108} GO^{170}_{i,\,1980}} * GO^{B}_{11,\,1980} = \text{Rp } 185.49 \text{ billion}$$

Chemicals

This sector includes all other chemicals and chemical products except refinery products. If the value added of the fertilizer industry cannot be separated from that of the pesticide industry then the following equations apply. These equations are the counterparts to equation (33) in that they exclude the value added and gross output of the pesticide industry.

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$$(38)\quad VA^{R}_{13,\,1980} = \frac{\sum_{i} VA^{170}_{i,\,1980} \quad (i=96,98\text{-}103,105,108)}{\sum_{i=96}^{108} VA^{170}_{i,\,1980}} * VA^{B}_{11,\,1980} = \text{Rp } 241.20 \text{ billion}$$

$$(39)\quad GO^{R}_{13,\,1980} = \frac{\sum_{i} GO^{170}_{i,\,1980} \quad (i=96,98\text{-}103,105,108)}{\sum_{i=96}^{108} GO^{170}_{i,\,1980}} * GO^{B}_{11,\,1980} = \text{Rp } 1{,}718.37 \text{ billion}$$

If the value added in the fertilizer industry can be separated from that in the pesticide industry the following equations apply. These equations are the counterparts to equation (36) and (37) in that they include the value added and gross output of the pesticide industry.

$$(40)\quad VA^{R}_{13,\,1980} = \frac{VA^{BPS}_{Pesticides,\,1980} + \sum_{i} VA^{170}_{i,\,1980} \quad (i=96,98\text{-}103,105,108)}{\sum_{i=96}^{108} VA^{170}_{i,\,1980}} * VA^{B}_{11,\,1980}$$

$$(41)\quad GO^{R}_{13,\,1980} = \frac{GO^{340}_{972,\,1980} + \sum_{i} GO^{170}_{i,\,1980} \quad (i=96,98\text{-}103,105,108)}{\sum_{i=96}^{108} GO^{170}_{i,\,1980}} * GO^{B}_{11,\,1980}$$

Fertilizers and Pesticides	= sector 97	
Refinery	= sector 104	1980 BPS 170
Rubber	= sectors 106-107	sector I-0
BAPPENAS sector 11	= sectors 96-108	classifications
Fertilizers	= sector 971	1980 BPS 340x170
Pesticides	= sector 972	sector I-0
		classifications

Subsector Projections

$$(42)\quad VA^{R}_{i,t} = VA^{R}_{i,\,1980} \quad (1+gr_i)^{t-1980}$$

$$i = 11,12,13$$

$$(43)\quad GO^{R}_{i,t} = GO^{R}_{i,\,1980} \quad (1+gr_i)^{t-1980}$$

Control Totals

Control totals are difficult to derive in these cases because the refinery sector is included in the BAPPENAS I-0 sector (11) but not in any of the 3 RESGEN sectors. The refinery sector accounted for only 15% of the value added and 53% of the gross output of the chemicals and related products sector (i.e. sectors 96-108) in 1980.

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These shares can be used as rough control totals.

$$(44) \quad \sum_{i=11}^{13} VA^{R}_{i,t} \cong .85 \; VA^{B'}_{11,t}$$

$$(45) \quad \sum_{i=11}^{13} GO^{R}_{i,t} \cong .47 \; GO^{B}_{11,t}$$

<u>CEMENT AND CERAMICS</u>: RESGEN sectors 14,15/BAPPENAS sector 12

1980 Reaggregated Values

Cement

$$(46) \quad VA^{R}_{14,\,1980} = \frac{VA^{66}_{44,\,1980}}{\sum_{i=43}^{44} VA^{66}_{i,\,1980}} * VA^{B}_{12,\,1980} = \text{Rp } 111.13 \text{ billion}$$

$$(47) \quad GO^{R}_{14,\,1980} = \frac{GO^{66}_{44,\,1980}}{\sum_{i=43}^{44} GO^{66}_{i,\,1980}} * GO^{B}_{12,\,1980} = \text{Rp } 183.42 \text{ billion}$$

Ceramics

$$(48) \quad VA^{R}_{15,\,1980} = \frac{VA^{66}_{43,\,1980}}{\sum_{i=43}^{44} VA^{66}_{i,\,1980}} * VA^{B}_{12,\,1980} = \text{Rp } 123.22 \text{ billion}$$

$$(49) \quad GO^{R}_{15,\,1980} = \frac{GO^{66}_{43,\,1980}}{\sum_{i=43}^{44} GO^{66}_{i,\,1980}} * GO^{B}_{12,\,1980} = \text{Rp } 246.46 \text{ billion}$$

Subsector Projections

$$(50) \quad VA^{R}_{i,t} = VA^{R}_{i,\,1980} \; (1+gr_i)^{t-1980}$$

$$i=14,15$$

$$(51) \quad GO^{R}_{i,t} = GO^{R}_{i,\,1980} \; (1+gr_i)^{t-1980}$$

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Control Totals

$$(52) \quad \sum_{i=14}^{15} VA^{R}_{i,t} = VA^{B}_{12,t}$$

$$(53) \quad \sum_{i=14}^{15} GO^{R}_{i,t} = GO^{B}_{12,t}$$

IRON AND STEEL: RESGEN Sector 16/part of BAPPENAS Sector 13

The BAPPENAS basic metals sector includes both iron and steel basic industries and non-ferrous basic metals industries. The problem with this sector is that the energy associated with the fabrication of non-ferrous basic metals is included in the mining subsectors in the RESGEN model. The reader is referred to the section on Mining for details of this problem.

The value added and gross output of the iron and steel industry and the fabrication industries can be disaggregated as the other sectors have been.

1980 Reaggregated Values

Iron and Steel

$$(54) \quad VA^{R}_{16,1980} = \frac{VA^{66}_{45,\ 1980}}{\sum_{i=45}^{46} VA^{66}_{i,\ 1980}} * VA^{B}_{13,1980} = \text{Rp 223.01 billion}$$

$$(55) \quad GO^{R}_{16,\ 1980} = \frac{GO^{66}_{45,\ 1980}}{\sum_{i=45}^{46} GO^{66}_{i,1980}} * GO^{B}_{13,\ 1980} = \text{Rp 565.79 billion}$$

Fabrication

$$(56) \quad VA^{RC}_{Fabrication,\ 1980} = \frac{VA^{66}_{46,\ 1980}}{\sum_{i=46}^{46} VA^{66}_{i,1980}} * VA^{B}_{13,\ 1980} = \text{Rp 112.91 billion}$$

$$(57) \quad GO^{RC}_{Fabrication,\ 1980} = \frac{GO^{66}_{46,\ 1980}}{\sum_{i=45}^{46} GO^{66}_{i,\ 1980}} * GO^{B}_{13,\ 1980} = \text{Rp 591.15 billion}$$

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Subsector Projections

Iron and Steel

(58) $VA^{R}_{16,t} = VA^{R}_{16,\ 1980} \quad (1 + gr_{16})^{t-1980}$

(59) $GO^{R}_{16,t} = GO^{R}_{16,1980} \quad (1 + gr_{16})^{t-1980}$

Fabrication

(60) $VA^{RC}_{Fabrication,\ t} = VA^{RC}_{Fabrication,\ 1980} \quad (1 + gr_{fab.})^{t-1980}$

(61) $GO^{RC}_{Fabrication,\ t} = GO^{RC}_{Fabrication,\ 1980} \quad (1 + gr_{fab.})^{t-1980}$

Control Totals

(62) $VA^{R}_{16,t} + VA^{RC}_{Fabrication,\ t} = VA^{B}_{13,t}$

(63) $GO^{R}_{16,t} + GO^{RC}_{Fabrication,\ t} = GO^{B}_{13,t}$

<u>OTHER MANUFACTURING</u>: RESGEN Sector 17/BAPPENAS Sectors 09, 14-16

1980 Reaggregated Values

(64) $VA^{R}_{17,\ 1980} = VA^{B}_{9,\ 1980} + \sum_{i=14}^{16} VA^{B}_{i,\ 1980} = \text{Rp } 1{,}562.06 \text{ billion}$

(65) $GO^{R}_{17,\ 1980} = GO^{B}_{9,\ 1980} + \sum_{i=14}^{16} GO^{B}_{i,\ 1980} = \text{Rp } 5{,}065.01 \text{ billion}$

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Subsector Projections

$$(66) \quad VA^R_{17,t} = VA^B_{9,t} + \sum_{i=14}^{16} VA^B_{i,t}$$

$$(67) \quad GO^R_{17,t} = GO^B_{9,t} + \sum_{i=14}^{16} GO^B_{i,t}$$

No control totals are needed.

<u>CONSTRUCTION</u>: RESGEN Sector 18/BAPPENAS Sector 17

The construction sector is identically defined in both models.

1980 Reaggregated Values

$$(68) \quad VA^R_{18,\ 1980} = VA^B_{17,\ 1980} = \text{Rp } 2{,}518.85 \text{ billion}$$

$$(69) \quad GO^R_{18,\ 1980} = GO^B_{17,\ 1980} = \text{Rp } 7{,}051.76 \text{ billion}$$

Projections

$$(70) \quad VA^R_{18,t} = VA^B_{17,t}$$

$$(71) \quad GO^R_{18,t} = GO^B_{17,t}$$

No control totals are needed.

<u>COMMERCE AND SERVICES (ELECTRIC)</u>: RESGEN Sector 19/BAPPENAS Sectors 19,20, 22,23

This sector includes all the commercial and service activities that use electricity.

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1980 Reaggregated Values

$$(72) \quad VA^{R}_{19,1980} = \sum_{i=19}^{23} VA^{B}_{i,1980} \quad (i \neq 21) = \text{Rp } 13{,}423.86 \text{ billion}$$

$$(73) \quad GO^{R}_{19,1980} = \sum_{i=19}^{23} GO^{B}_{i,1980} \quad (i \neq 21) = \text{Rp } 16{,}879.89 \text{ billion}$$

Projections

$$(74) \quad VA^{R}_{19,t} = \sum_{i=19}^{23} VA^{B}_{i,t} \quad (i \neq 21)$$

$$(75) \quad GO^{R}_{19,t} = \sum_{i=19}^{23} GO^{B}_{i,t} \quad (i \neq 21)$$

No control totals are needed.

<u>COMMERCE (KEROSENE)</u>: RESGEN Sector 20/BAPPENAS Sector 19

This RESGEN sector is defined as those commercial sectors that use kerosene. Most of the kerosene is probably consumed in the hotel and restaurant subsectors. The value added and gross output of these two subsectors are included with the wholesale and retail trade industries to form the 'trade' sector in the BAPPENAS I-O model (sector 19). In most economic projections these subsectors are usually projected to grow at the same rate. Consequently separating the economic activity of hotels and restaurants from that of wholesale and retail trade is not usually necessary, though it is possible to do so. In order to extend the possibilities of analysis the disaggregation is provided below. If the analyst does not with to distinguish between these various subsectors then 'commerce (kerosene)' sector in RESGEN may be interpreted as being identical to the 'trade' sector in BAPPENAS. If this interpretation is made then the control totals are not needed.

1980 Disaggregated Values

Restaurants and Hotels

$$(76) \quad VA^{R}_{20,1980} = \frac{VA^{66}_{54,1980}}{\sum_{i=53}^{54} VA^{66}_{i,1980}} * VA^{B}_{19,1980} = \text{Rp } 957.09 \text{ billion}$$

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$$(77)\quad GO^{R}_{20,1980} = \frac{GO^{66}_{54,1980}}{\sum_{i=23}^{54} GO^{66}_{i,1980}} * GO^{B}_{19,1980} = \text{Rp } 2{,}298.26 \text{ billion}$$

Wholesale and Retail Trade

$$(78)\quad VA^{RC}_{WRT,1980} = \frac{VA^{66}_{53,1980}}{\sum_{i=53}^{54} VA^{66}_{i,1980}} * VA^{B}_{19,1980} = \text{Rp } 5{,}437.47 \text{ billion}$$

$$(79)\quad GO^{RC}_{WRT,1980} = \frac{GO^{66}_{54,1980}}{\sum_{i=53}^{54} GO^{66}_{i,1980}} * GO^{B}_{19,1980} = \text{Rp } 6{,}329.32 \text{ billion}$$

Subsector Projections

Hotels and Restaurants

$$(80)\quad VA^{R}_{20,t} = VA^{R}_{20,1980}\ (1 + gr_{20})^{t-1980}$$

$$(81)\quad GO^{R}_{20,t} = GO^{R}_{20,\ 1980}\ (1+gr_{20})^{t-1980}$$

Wholesale and Retail Trade

$$(82)\quad VA^{RC}_{WRT,t} = VA^{RC}_{WRT,\ 1980}\ (1+gr_{WRT})^{t-1980}$$

$$(83)\quad GO^{RC}_{WRT,t} = GO^{RC}_{WRT,\ 1980}\ (1+gr_{WRT})^{t-1980}$$

Control Totals

$$(84)\quad VA^{R}_{20,t} + VA^{RC}_{WRT,t} = VA^{B}_{19,t}$$

$$(85)\quad GO^{R}_{20,t} + GO^{RC}_{WAT,t} = GO^{B}_{19,t}$$

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SERVICES (FUEL OIL AND DIESEL): RESGEN Sector 21/BAPPENAS Sector 23

This sector consists of those service sectors that consume fuel oil and diesel fuel. The principal consumer is public administration and defense, but other subsectors such as garbage and waste disposal, schools, hospitals, research institutes and related activities also consume significant amounts. These subsectors constitute the BAPPENAS I-O sector 'services not classified elsewhere' (sector 23).

1980 Reaggregated Values

(86) $VA^{R}_{21,\ 1980} = VA^{B}_{23,\ 1980}$ = Rp 6,082.90 billion

(87) $GO^{R}_{21,\ 1980} = GO^{B}_{23,\ 1980}$ = Rp 7,090.25 billion

Projections

(88) $VA^{R}_{21,t} = VA^{B}_{23,\ t}$

(89) $GO^{R}_{21,t} = GO^{B}_{23,\ t}$

No control totals are needed.

The reader should be aware that in the I-O tables published by BPS the public administration and defense sector is not, strictly speaking the same as the government sector. The former is treated as a producing sector and appears as both a row and column in the inter-industry transactions table. The latter is a component of final demand and appears as a column in the final demand table; it is strictly a consuming sector in this context just as are households. This distinction is to a degree semantic, but the importance is that government consumption of refined oil products, electricity, and gas appear in the column of government consumption in the table of final demands and not as inputs to the public administration sector in the transactions table. In fact the public administration and defense sector has no column entries in the transactions table. The only entries are the value added components. The public administration and defense sector in the I-O is merely an accounting device to keep track of value added in

the government sector (the principal components of which are wages and salaries). The entry in the government consumption column of the table of final demands that appears in the public administration and defense row represents total government payments to the components of value added.

This treatment suggests an alternative method of linking these sectors and that is to link fuel oil and diesel consumption in the RESGEN sector to projected government consumption which is an exogenous variable in the Core Macroeconometric Model. If one assumes that government consumption of fuel oil and diesel are proportional to payments to the various components of value added (principally wages and salaries) then this method is the same as linking fuel consumption to value added in the public administration and defense sector. If one does not wish to make this assumption then this alternative method of linkage may be superior. One could estimate energy consumption by the government sector as a function of government consumption (adjusted for inflation) and use this estimated relationship to project government energy demands by using the same projected levels of government consumption that is used in the Core Model. Using this method, however would result in the neglect of the other service sectors that consume fuel oil and diesel.

TRANSPORTATION: RESGEN Sectors 22-29/BAPPENAS Sector 21

The linkage between the BAPPENAS and RESGEN transportation sector is more complicated than the others. The BAPPENAS I-O model generates projections of value added and gross output for the transportation and storage sector as a whole and does not distinguish between the various transport modes. The BAPPENAS transportation and storage sector includes rail, water, air, land (i.e. road) transportation, and services allied to transportation, although the individual sectors are not identified. The land transport subsector includes trucks, buses, taxis, bajajs, and other forms of commercial road transport. RESGEN on the other hand disaggregates this sector into rail, water, air, trucks, buses, passenger vehicles, and motorcycles.

At first glance this problem may appear to be no different than previous disaggregations, but there is one distinction. Even after disaggregating the BAPPENAS sector into its component subsectors in the base year there is still no accounting of household use of private automobiles or motorcycles. This is because these modes of transport are not revenue generating activities and consequently do not appear even implicitly in the transactions table of any I-O. The use of these modes is reflected in the private consumption of refinery products in the the private consumption column in the table of final demands. Unfortunately these figures also include household consumption of kerosene and other products as well as gasoline for transportation and there is no way to disaggregate this total.

There are at least two ways of dealing with this problem. One

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is to redefine the RESGEN land transport sectors to correspond with those contained in the BAPPENAS transport sector. The previously discussed methods of disaggregation and use of control totals would then apply. This treatment would require disaggregating passenger vehicles in RESGEN into taxis, bajas, and other commercial petroleum consuming modes of passenger transportation and private automobiles. This method would require obtaining unpublished data from BPS and probably involves a fair amount of data manipulation. It would also require separating the gasoline consumed in commercial vehicles from that consume in private vehicles. This task alone may render this method impractical The use of private (noncommercial automobiles) and motorcycles could be treated separately and linked to the projections of personal disposable income or gross domestic product generated by the Core Model.

The second method is to deal with the road transport sector completely outside the I-O model and link all of it to the Core Model. The advantage of this approach is that virtually all of the required data are available in published sources. Extensive times series exist in BPS publications on the number of trucks, buses, passenger cars, and motorcycles. This method would also not require separating gasoline consumed in commercial vehicles from that consumed in private vehicles. Two relationships could be econometrically estimated; that between GDP or personal disposable income and the number of each type of vehicle, and that between the number of vehicles and fuel consumption. The subsectors of RESGEN would not have to be redefined and unpublished BPS data would not have to be obtained. The disadvantage is that the projections of road transportation would not be consistent with the BAPPENAS projections, and the road transport sector accounts for well over half of the value added of the transport and storage sector.

The linkage under each of these methods will be presented. The treatment of the non land transport subsectors is the same in each method. In the first method the analyst must make some projections of "services allied to transport" and subsector to generate the required control totals. In the second method the control totals are much more difficult to formulate since the method involves stepping outside the I-O model.

Method (1)

The rail, water, and air subsectors as well as those of the "services allied to transport" and can be separated using the 66 and 170 sector 1980 BPS I-O tables. The land transportation subsector can be disaggregated further into trucks, buses, taxis, bajas and other three wheeled passenger vehicles, and other modes with the use of unpublished data from BPS. Projections must be made for each of the subsectors including the allied services subsector. These projections must be such that the sum of subsector value added and gross output equal those projected for the

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transport and storage sector of BAPPENAS. Projections of fuel consumption in private automobiles and motorcycles are then linked to the Core Model.

1980 Reaggregated Values

Rail

$$(90)\quad VA^{R}_{22,1980} = \frac{VA^{66}_{55,1980}}{\sum_{i=55}^{59} VA^{66}_{i,1980}} * VA^{B}_{21,1980} = \text{Rp 22.5 billion}$$

$$(91)\quad GO^{R}_{22,1980} = \frac{GO^{66}_{55,1980}}{\sum_{i=55}^{59} GO^{66}_{i,1980}} * GO^{B}_{21,1980} = \text{Rp 54.05 billion}$$

Water

$$(92)\quad VA^{R}_{23,1980} = \frac{VA^{66}_{57,1980}}{\sum_{i=55}^{59} VA^{66}_{i,1980}} * VA^{B}_{21,1980} = \text{Rp 326.04 billion}$$

$$(93)\quad GO^{R}_{23,1980} = \frac{GO^{66}_{57,1980}}{\sum_{i=55}^{59} GO^{66}_{i,1980}} * GO^{B}_{21,1980} = \text{Rp 677.94 billion}$$

Air

$$(94)\quad VA^{R}_{24,1980} = \frac{VA^{66}_{58,1980}}{\sum_{i=55}^{59} VA^{66}_{i,1980}} * VA^{B}_{21,1980} = \text{Rp 155.36 billion}$$

$$(95)\quad GO^{R}_{24,1980} = \frac{GO^{66}_{58,1980}}{\sum_{i=55}^{59} GO^{66}_{i,1980}} * GO^{B}_{21,1980} = \text{Rp 462.15 billion}$$

Buses

$$(96)\quad VA^{R}_{25,1980} = \frac{VA^{BPS}_{BUSES,1980}}{\sum_{i=55}^{59} VA^{66}_{i,1980}} * VA^{B}_{21,1980}$$

$$(97)\quad GO^{R}_{25,1980} = \frac{GO^{BPS}_{BUSES,1980}}{\sum_{i=55}^{59} GO^{66}_{i,1980}} * GO^{B}_{21,1980}$$

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Trucks

$$(98)\quad VA^{R}_{26,1980} = \frac{VA^{BPS}_{TRUCKS,\ 1980}}{\sum_{i=55}^{59} VA^{66}_{i,1980}} * VA^{B}_{21,1980}$$

$$(99)\quad GO^{R}_{26,1980} = \frac{GO^{BPS}_{TRUCKS,\ 1980}}{\sum_{i=55}^{59} GO^{66}_{i,1980}} * GO^{B}_{21,1980}$$

Taxis

$$(100)\quad VA^{R}_{27,1980} = \frac{VA^{BPS}_{TAXIS,\ 1980}}{\sum_{i=55}^{59} VA^{66}_{i,1980}} * VA^{B}_{21,1980}$$

$$(101)\quad GO^{R}_{27,1980} = \frac{GO^{BPS}_{TAXIS,1980}}{\sum_{i=55}^{59} GO^{66}_{i,1980}} * GO^{B}_{21,1980}$$

"Bajas" and Other Petroleum Consuming Passenger Vehicles

$$(102)\quad VA^{R}_{28,\ 1980} = \frac{VA^{BPS}_{Bajas,\ 1980}}{\sum_{i=55}^{59} VA^{66}_{i,\ 1980}} * VA^{B}_{21,\ 1980}$$

$$(103)\quad GO^{R}_{28,\ 1980} = \frac{GO^{BPS}_{Bajas,\ 1980}}{\sum_{i=55}^{59} GO^{66}_{i,\ 1980}} * GO^{B}_{21,\ 1980}$$

Non Petroleum Transportation

$$(104)\quad VA^{RC}_{NPT,\ 1980} = \frac{VA^{BPS}_{NPT,\ 1980}}{\sum_{i=55}^{59} VA^{66}_{i,\ 1980}} * VA^{B}_{21,\ 1980}$$

$$(105)\quad GO^{RC}_{NPT,\ 1980} = \frac{GO^{BPS}_{NPT,\ 1980}}{\sum_{i=55}^{59} GO^{66}_{i,\ 1980}} * GO^{B}_{21,\ 1980}$$

Services Allied to Transport

$$(106)\quad VA^{RC}_{SAT,\ 1980} = \frac{VA^{BPS}_{SAT,\ 1980}}{\sum_{i=55}^{59} VA^{66}_{i,\ 1980}} * VA^{B}_{21,\ 1980}$$

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$$(107)\quad GO^{RC}_{SAT,\ 1980} = \frac{GO^{BPS}_{SAT,\ 1980}}{\sum_{i=55}^{59} GO^{66}_{i,\ 1980}} * GO^{B}_{21,\ 1980}$$

Subsector Projections

$$(108)\quad VA^{R}_{i,t} = VA^{R}_{i,\ 1980}\ (1+gr_i)^{t-1980}$$

$$i=22,\ldots,28$$

$$(109)\quad GO^{R}_{i,t} = GO^{R}_{i,\ 1980}\ (1+gr_i)^{t-1980}$$

$$(110)\quad VA^{RC}_{j,t} = VA^{RC}_{j,\ 1980}\ (1+gr_j)^{t-1980}$$

$$j=NPT,SAT$$

$$(111)\quad GO^{RC}_{j,t} = GO^{RC}_{j,\ 1980}\ (1+gr_j)^{t-1980}$$

Control Totals

$$(112)\quad \sum_i VA^{R}_{i,t} + \sum_j VA^{RC}_{j,t} = VA^{B}_{21,t}$$

$$i = 22,\ldots,28$$

$$j = NPT,\ SAT$$

$$(113)\quad \sum_i GO^{R}_{i,t} + \sum_j GO^{RC}_{j,t} = GO^{B}_{21,t}$$

Private Automobiles and Motorcycles

The use of private automobiles and motorcycles are linked to the Core Macroeconometric Model. This link will be discussed in the next section.

Method (2)

The equations for method (2) are the same as those in method (1) except that all land transportation is linked to the Core Model whereas in method(1) only the use of private automobiles and motorcycles was. If method (2) is used control equations for the land transport sector is required to insure the consistency of the growth of the other subsectors (i.e. rail, water, and air transportation) with the projected growth of the transportation and storage sector of the BAPPENAS I-O model. This can be accomplished by using equations (96) through (103) and the associated projection equations as control equations only and not

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basing projections of fuel consumption on them. Alternatively these equations can be replace by aggregating the land transportation subsectors into one land transportation sector and applying control equations to this sector. In either case fuel demands are projected on the basis of projected number of vehicles and not on subsector value added or gross output as is the case in method (1). This linkage is also discussed in the next section.

2. Linkages with the Core Macroeconometric Model

a. Transportation

The form of the linkage between the BAPPENAS model and RESGEN is the same in both methods (1) and (2). The difference is that in method (1) only the use of private automobiles and motorcycles is linked to the Core Model whereas in method (2) the entire land transportation sector is linked to the Core Model.

The linkage has two steps: first to project the number of vehicles based on projections of GDP or personal disposable income generated by the Core Model, and second to project fuel consumption based on the projected number of vehicles (or vehicle equivalents which will be discussed below).

Method (1)

In this method the number of private automobiles and and motorcycles is linked to the projected level of personal disposable income (corrected for inflation) generated by the Core Model. The analyst may also wish to incorporate prices of vehicle into this link, but they would have to be supplied by the analyst as BAPPENAS does not generate projections of the relevant prices. Linking the number of vehicles to personal disposable income is preferable to linking it to GDP because households' decisions to purchase cars and motorcycles are more likely functions of the income available to them to spend (both present and past) rather than to GDP.

The first step is to econometrically estimate a functional relationship between the number of vehicles and personal

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disposable income (adjusted for inflation) and prices (if desired). The second step is to estimate a functional relationship between the number of vehicle equivalents and the quantity of fuel consumed. When the parameters of the first equation have been satisfactorily estimated the actual values of the explanatory variables are replaced by the projected values generated by the Core Model (and the analyst if explanatory variables that do not appear in the Core Model are used). This process will yield projections of the number of vehicles that are directly linked to the Core Model projections of personal disposable income. The projected values of the number of vehicles are then put into the estimated equation relating fuel consumption to the number of vehicles (or vehicle equivalents). This process will yield projections of fuel consumption in private automobiles and motorcycles.

The number of private automobiles and motorcycles must be converted to the number of vehicle equivalents before the second relationship can be estimated because they exhibit distinctly different conversion efficiencies in terms of liters/km. The number of vehicle equivalents in this case is a weighted sum of cars and motorcycles where the weights are their relative fuel efficiencies. For example, if motorcycles on average consume 1/5 as much gasoline per km than do cars then the number of vehicle equivalents would be equal to the number of cars plus 1/5 of the number of motorcycles.

The relationships between the number of vehicles and personal disposable income, and fuel consumption and the number of vehicle equivalents can be represented by a variety of mathematical expressions. Some examples are given in the section on estimating relationships between economic activity and energy consumption that follows. The analyst is encouraged to explore other possibilities. The decision to use a set of equations should be based both on the theoretical underpinnings and the statistical properties of their estimated parameters.

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Method (2)

This method differs from the previous one in that the entire land transportation sector is linked to the Core Model. The approach is basically the same as in method (1) except that different explanatory variables are used to project the number of buses and trucks. This method has three advantages over the first method. The first is that it is more compatible with existing published data. The second is that it does not require redefining the land transportation subsectors of RESGEN. The third is that it permits categorizing land vehicles conveniently into two groups; diesel consuming and gasoline consuming.

The process is basically the same as in method (1). Equations relating the number of each type of vehicle to GDP or personal disposable income, and fuel consumption to the number of vehicle equivalents. are econometrically estimated using historical time series. Projections of each type of vehicle are made by replacing the actual values of the explanatory variables by the values projected by the Core Model (again, projections of any explanatory variables not used in the Core Model must be supplied by the analyst). When projections of the number of vehicles have been generated the vehicles are separated into diesel and gasoline consuming vehicles. The number of vehicle equivalents is a weighted sum with the weights reflecting the relative fuel efficiency of the vehicles within each category. The actual number of vehicle equivalents used in estimating the relationship between the fuel consumption and the number of vehicle equivalents are replaced with the projected number of equivalents. This process yields projections of diesel and gasoline consumption in the land transportation sector.

b. Households

The only sector yet to be addressed is that of household consumption of energy unrelated to transportation. Household consumption of various fuels and electricity can be linked to

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projections of personal disposable income generated by the Core Model. The projections of the consumer price index generated by the Core Model may also prove useful in this linkage if the analyst wishes to analyze the possible future impact of pricing policies on household energy consumption. The procedure here is to estimate an equation relating energy consumption (by type of fuel or in toe) to personal disposable income and prices (if desired). One way to incorporate price effects is to include the ratio of a price index for the specific fuel (or electricity) to the consumer price index. This ratio will reflect the change in the price of fuels relative to all other consumer prices over time.

These relationships may take several forms and may include several different explanatory variable, but at least one of the explanatory variables must be projected by the Core Model for a link to be established. Examples of equations that can be estimated will be presented in the next section.

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IV. ESTIMATING RELATIONSHIPS BETWEEN ECONOMIC ACTIVITY AND ENERGY CONSUMPTION

A. SECTORAL VALUE ADDED AND GROSS OUTPUT: THE LINK WITH THE INPUT-OUTPUT MODEL

The task here is to econometrically estimate a relationship between sectoral energy consumption and sectoral value added or gross output (corrected for inflation). Ideally one would like to estimate these relationships for each of the RESGEN end-use sectors. Sufficient data may not exist, however, so the analyst may have to settle for estimating the relationships for more broadly defined categories and using the results of the estimates as guidelines for projecting subsector energy consumption.

Equations (1) through (4) below are some simple examples of relationships that can be estimated. Equations (1) and (3) imply that energy consumption in each sector is directly proportional to real value added or gross output and that the production process does not become more or less energy intensive over time. Equations (2) and (4) are expressed in logarithmic form and are generally preferable. If the coefficient of the right hand side log variables are equal to one then these equations are equivalent to equations (1) and (3) without the constant. If the coefficients are greater than one then the sector becomes more energy intensive with time and if less than one they become less energy intensive.

There is no guarantee that the estimation of these or other equations relating energy consumption or demand to sectoral value added or gross output will yield any useful results. The equations specified here implicitly assume some relationship between value added or gross output and energy consumption at a subsector level. The results may reveal a very weak relationship in some cases and consequently the usefulness of the equations as tools for making energy consumption projections may be extremely limited. The usefulness of the estimated equations, however, may depend on how

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they are used. For example, a given equation may severely underestimate energy consumption in some years and overestimate it in others. Such an equation may not be very useful for making projections of energy consumption for a given future year. The same equation, however, may perform very well in estimating sectoral energy consumption over an interval of say two or three years. While the equation may not be useful in making point projections it may be very useful in making interval projections.

(1) $boe_{i,j,t} = a + b * VA^{R}_{i,t}$

(2) $\log boe_{i,j,t} = c + d * \log VA^{R}_{i,t}$

(3) $boe_{i,j,t} = e + f * GO^{R}_{i,t}$

(4) $\log boe_{i,j,t} = g + h * \log GO^{R}_{i,t}$

Where i = RESGEN sector (i) or some aggregation of sectors
j = type of energy in physical units (e.g. boe, kwh)
t = year

Price variables can be introduced easily at a conceptual level, but the required data may be difficult to obtain. One way to capture price effects is to use price indices. This way one could estimate the impact of changing relative input prices on sectoral energy demand and would permit the potential effect of energy pricing policies. Examples are given below.

(5) $\log boe_{i,j,t} = k + l * \log VA^{R}_{i,t} + m*\log (\frac{Pj}{Pm})_{t}$

$$(6) \quad \log boe_{i,j,t} = n + p * \log GO^{R}_{i,t} + g*\log \left(\frac{Pj}{Pm}\right)_t$$

Where Pj = Price index of energy type (j)

Pm = Price index of all production inputs into sector (i)

(The analyst may wish to experiment by using the producer price index as a proxy for Pm)

The theoretical attraction of equations (5) and (6) is that they are capable of accounting for an erratic relationship between sectoral economic activity and energy consumption. For example, an increase in sectoral value added would indicate that energy consumption should increase as well, all other things being equal. If at the same time, however, the price of energy increases relative to other inputs one would expect energy consumption to fall (all other things being equal). These equations are capable of explaining why energy consumption may move in the same direction as value added or gross output during one period and move in the opposite direction in another.

B. GROSS DOMESTIC PRODUCT AND PERSONAL DISPOSABLE INCOME: THE LINE WITH THE CORE MACROECONOMIC MODEL

This section concerns the transportation and household sectors and describes some equations that can be estimated and used to link energy consumption in these sectors to projections of gross domestic product and personal disposable income generated by the Core Macroeconometric Model.

TRANSPORTATION

Method (1)

The tasks here are to estimate first the relationship between the number of private automobiles and motorcycles and personal disposable income and second the relationship between gasoline consumption and the number of vehicles. The data requirements may render this method impractical. Total gasoline

consumption must be divided between that consumed in taxis and bajajs and that consumed by private automobiles and motorcycles. This estimation of this data from known quantities would introduce additional problems of errors of measurement and reduce the quality of the estimated equations. The following equations assume that the data are obtainable with a minimum of measurement error. This method is not highly recommended.

Estimating the Number of Vehicles

(1) $NCAR_t = a + b * PDI_t + c * NCAR_{t-1}$

(2) $\log NCAR_t = d + e * \log PDI_t + f * \log \left(\frac{PNCAR}{PCPI}\right)_t$

(3) $\log NCAR_t = g + h * \log PDI_t + k * \log \left(\frac{PNCAR}{PCPI}\right)_t + l \times \log \left(\frac{\Delta CRH}{PCPI}\right)_t$

(4) $\log NCAR_t = m + n * \log PDI_t + p * \log \left(\frac{PNCAR}{PCPI}\right)_t + q * \log NCAR_{t-1}$

Where NCAR = The number of newly registered cars per capita
PDI = Personal Disposable Income per capita (corrected for inflation)
PNCAR = Price Index for Private Automobiles
PCPI = Consumer Price Index
CRH = A measure of bank credit to households

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After the per capita levels have been projected they must be multiplied by the projected levels of population. The projections should be the same ones that are use as input to the BAPPENAS Model to insure a consistent link. The number of motorcycles can be estimated in the same way.

Estimating Gasoline Consumption

In the following equations gasoline consumed in private automobiles and motorcycles is estimated as a function of the number of vehicle equivalents and the relative price of gasoline.

(5) $LGASO_t = r + s * NVEHEQ_t$

(6) $\log LGASO_t = t + u * \log NVEHEQ_t$

(7) $\log LGASO_t = v + w * \log NVEHEQ_t + y * \log \left(\frac{PGAS}{PCPI}\right)_t$

Where LGASO = Liters of Gasoline consumed by private automobiles and motorcycles in time t

NVEHEQ = Number of vehicle equivalents

PGAS = Price index for gasoline

PCPI = Consumer price index

One can bypass the first set of equations all together and estimate gasoline consumption by households as a function of real personal disposable income and the relative price of gasoline as in the following equation.

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$$(8) \quad \log LGASO_t = a' + b' * \log PDI_t + c' * \log \left(\frac{PGAS}{PCPI}\right)_t$$

Method (2)

In this method the entire land transportation sector is linked to the Core Macroeconometric Model. The advantages of this method is that gasoline need not be divided into that consumed by commercial vehicles and private vehicles, and that passenger vehicles need not be divided into taxis and private automobiles. Furthermore, all vehicles can be divided into diesel consumers and gasoline consumers. The method is otherwise the same as in the previous paragraphs and the equations take on the same general forms.

Estimating the Number of Vehicles

$$(9) \quad NBUS_t = d' + e' * GDPC_t$$

$$(10) \quad \log NBUS_t = f' + g' * \log GDPC_t$$

$$(11) \quad NTRUCK_t = l' + k' * GDPC_t$$

$$(12) \quad \log NTRUCK_t = l' + m' * \log GDPC_t$$

Where NBUS = The number of newly registered buses per capita

NTRUCK = The number of newly registered trucks per capita

GDPC = Gross Domestic Product per capita (corrected for inflation)

t = year

Equations (1) through (4) can be used to estimate the number of automobiles and motorcycles. The variable 'NCAR' must be redefined to include taxis and bajas. The relationship between diesel fuel consumption and the number of buses and trucks can be estimated in the same general manner as was the relationship between gasoline consumption and vehicle equivalents in method (1)

HOUSEHOLD ENERGY CONSUMPTION (except transportation)

Household consumption of various types of energy can be estimated as functions of real personal disposable income and relative prices. Some examples are given below.

$$(13)\quad ENERGY_{j,t} = n' + p' * PDI_t + q' * ENERGY_{j,t-1}$$

$$(14)\quad \log ENERGY_{j,t} = r' + s' * \log PDI_t + t' * \log \left(\frac{Pj}{PCPI}\right)_t$$

$$(15)\quad \log ENERGY_{j,t} = u' + v' * \log PDI_t + w' * \log \left(\frac{Pj}{PCPI}\right)_t + y' * \log ENERGY_{t-1}$$

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Where Energy j = Energy type (j) per capita measured in physical units

PDI = Personal Disposable Income per capita (corrected for inflation)

Pj = Price index for energy type (j)

PCPI = Consumer Price Index

The analyst may wish to explore cross price elasticities between various energy types. These elasticities can be estimated by including as a right hand side variable the ratio of the price index of the fuel on the left hand side to that of some other fuel. Such an equation would allow the analyst to estimate, for example, the effect of an increase in the price of kerosene relative to that of electricity on the demand for kerosene.

Some interpretation of the equations listed above and their relative merits may be helpful. Equation (13) is similar to a typical aggregate consumption function often used in macroeconomic models only here it is applied to one good rather than to total private consumption. The coefficient (p') is the is the fraction of current personal disposable income spent on energy type (j) (per capita) in year (t). This is called the 'induced effect' in the jargon of economics. The quantity of energy type (j), lagged one period appears on the right hand side of the equation. The coefficient (q') captures the lagged effect of personal disposable income earned in previous periods. This can be seen by expanding equation (13) by recursive substitution as is done in equation (16) below.

$$(16)\quad ENERGY_{j,t} = n' + n'q' + n'q'^2 + n'q'^3 + \ldots + p'\,PDI_t + p'q'PDI_{t-1} + p'q'^2PDI_{t-2} + \ldots$$

short run mpc = p'

long run mpc = $p' + p'q' + p'q'^2 + \ldots$

As the expression indicates, past levels of per capita income effect household energy consumption in the current period. The total effect, or the long run marginal propensity to consume energy type (j) is equivalent to the limit of the geometric series of the coefficients in equation (16) which is $p'/(1-q')$. Theoretically q' should be less than one or else the long run marginal propensity to consume energy type (j) will be greater than one which means that not only are people spending more than they earn (which is not uncommon), but that they are spending more than they earn on energy type (j) alone.

One deficiency of equation (13) is that it does not capture price effects. Equation (14), on the other hand, does. The coefficient (s') in equation (14) is the income elasticity of demand for energy type (j) and (t') is the price elasticity of demand (measured in relative prices). The advantage of this equation is that it is easily interpreted and permits the analysis of potential impacts of energy pricing policies. The deficiency is that the elasticities imbedded in this equation are short run elasticities and do not capture the long run effects of past income and prices. This can be a problem when projections of 10 to 20 years are being performed.

One way to address these shortcomings is the use of equation (15). The drawback of this equation is that it is not so easily interpreted. If the equation is expanded through recursive substitution, as is done in equation (17) below, the interpretation is clearer. The coefficient (v') captures the short run income elasticity of demand and (w') captures the short price elasticity. The coefficients in the last two groups of terms capture the effects of past income and past prices, respectively. The long run income and price elasticities of demand are given by the limit of the two geometric series of the coefficients, $v'/(1-y')$ and $w'/(1-y')$, respectively.

$$
\begin{aligned}
(17)\quad \log \mathrm{ENERGY}_{j,t} &= u' + u'y' + u'y'^2 = u'y'^3 + \ldots \\
&+ v'\log \mathrm{PDI}_t = v'y' \log \mathrm{PDI}_{t-1} + v'y'^2 \log \mathrm{PDI}_{t-2} + \ldots \\
&+ w'\log\left(\frac{Pj}{PCPI}\right)_t + w'y'\log\left(\frac{Pj}{PCPI}\right)_{t-1} + w'y'^2\log\left(\frac{Pj}{PCPI}\right)_{t-2} + \ldots
\end{aligned}
$$

Short run Income Elasticity of Demand $= v'$

Long run Income Elasticity of Demand $= v' + v'y' + v'y'^2 + v'y'^3 + \ldots$

Short run Price Elasticity of Demand $= w'$

Long Run Price Elasticity of Demand $= w' + w'y' + w'y'^2 + w'y'^3 + \ldots$

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V. LINKAGE FROM RESGEN TO BAPPENAS

One can consider utilizing the information generated by RESGEN at three different levels; (1) as information to be used directly as input to the BAPPENAS Macroeconomic Model, (2) as information to be synthesized by the analysts responsible for developing the assumptions of the model and used to reassess and possibly change these assumptions, (3) as information to be used directly by the decision makers and policy analysts completely bypassing the Macroeconomic Model.

In regard to this third level the reader should be aware that RESGEN generates a great deal of information that cannot be used directly as input to the BAPPENAS Macroeconomic Model in the same mechanical manner that the output from the Macroeconomic Model can be used by RESGEN. The inability to mechanically link much of the output of RESGEN to the Macroeconomic Model is no reason, of course, not to use this information as input to the economic decision making process. This principal objective, after all, is not the linking of models per se, but the linking of decision making processes.

The following discussion is presented in three parts. First is a general description of the type of information generated by RESGEN. Second is how this information can be utilized both directly and indirectly as input to the BAPPENAS model.

A. RESGEN OUTPUT

RESGEN generates projections of a wide variety of energy related variables. Four broad categories can be identified.

(1) RESGEN generates a complete energy balance for a given level and configuration of economic activity year by year. This balance includes projections of energy consumption by type of fuel for each of the economic end use sectors identified in RESGEN (see Table III-1). Projections of electricity demands are also generated at the same level of detail. RESGEN then calculates the

total consumption of all types of fuels and electricity at a regional and national level. After RESGEN has projected total electricity consumption it then calculates the energy inputs required to generate that electricity based on the types of power plants that PLN expects to construct in the future. Finally, RESGEN generates projections of total primary energy (e.g. crude oil, coal, hydro, biomass) required to sustain the projected level and configuration of economic activity.

2) Given the expected levels of domestic energy production and the projections of domestic energy consumption discussed above, RESGEN calculates energy exports and imports by type of fuel. If RESGEN is given the projections of non energy imports and exports generated by the Core Macroeconometric Model it can supply the energy component and keep track of the impact of the energy sector on Indonesia's current and capital accounts.

3) RESGEN calculates the level and configuration of energy sector investments year by year required to meet the projected energy demands based on specified energy sector expansion plans and capital costs. For example, PLN has plans to build specific power plants with specific capital costs and plans to construct them in a specific order. If RESGEN is given the order and costs it will calculate the dispatching schedule required to meet the projected growth of electricity consumption and it will calculate the annual capital costs associated with that schedule. These calculations can also be performed for petroleum refineries and other energy infrastructure.

4) RESGEN will calculate the annual financial flows, both domestic and foreign, associated with both the projected energy imports and exports and the energy sector investments discussed above. For example, RESGEN can calculate the annual financing requirements (i.e. payment of principal and interest) for each new power plant and keep a running total of all such financial flows. RESGEN thus provides a simple framework in which to analyze the effects of alternative power sector dispatching schedules (based on RESGEN's energy demand projections) on Indonesia's current and capital accounts as well as on domestical financial flows. This information should prove extremely useful since the electric sector is expected to account for roughly 20% of total government investment during REPILITA IV.

B. LINKAGE WITH THE BAPPENAS MACROECONOMIC MODEL

1. Direct Linkage

The actual mechanical linking from RESGEN to the BAPPENAS model is not as extensive or as detailed as that from BAPPENAS to RESGEN and it involves only the Core Model. The most obvious link is that the projected energy balances, imports, and exports generated

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by RESGEN can replace the BAPPENAS energy sector projections. In particular this means replacing equations (6) through (11), (35), and (36) of the Core Model (see appendix 1)

2. Indirect Linkage

Most of the information generated by RESGEN cannot be used directly as input to the BAPPENAS model, but can make a valuable contribution to the modelling process nonetheless. This can be done by using the output of RESGEN to rethink the projections of the exogenous policy variables used in the BAPPENAS model. For example, the energy sector investment projections from RESGEN can be used to reassess the initial projections of government investment used in the Core Model. The results of RESGEN may indicate that the existing dispatching schedule of PLN may be too fast or too slow given the rate and composition of economic growth of the desired economic development plan. Consequently one might expect that the planned levels of government investment in the power sector for a given year would be too high or too low, respectively, and that the government investment plan should be revised. The revised levels of annual government investment could then replace the old levels in the Core Model and it and the I-O model could be reexecuted to assess the potential impact.

VI SECTORAL-REGIONAL ECONOMIC PROJECTIONS

The following tables contain a set of economic projections for Java and the rest of Indonesia (non-Java) from 1982 to 2000. These projections are unrelated to the previous chapters of this report and their primary purpose is to demonstrate the capabilities of the RESGEN energy system model.

The economic projections for Indonesia as a whole through 1988 are based on the growth rates used in Repelita III. The regionalization of these national growth rates is based on historical trends. In particular, the trend of the relative rates of economic growth in Java and non-Java exhibited from 1975 to 1982 is assumed to continue through 1988. After that year the relative rates of growth are projected to converge. When possible the projections of sectoral growth rates were based on specific expansion plans.

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TABLE VI-1

PROJECTED RATES OF GROWTH; GDP BY SECTOR % PER ANNUM
(based on 1975 prices)

INDONESIA

	1982-88	1988-2000
Agriculture	3.3	3.5
Mining	2.3	2.4
-Oil & Gas	2.1	2.2
-Nickel	9.1	7.0
-Tin	9.8	7.0
-Other	2.7	2.9
Industry	8.2	9.0
-Cement	14.4	7.3
-Other Non-Metallic Mineral Products	7.8	11.2
-Pulp and Paper	8.6	9.2
-Fertilizer	8.9	6.4
-Other Chemicals	7.0	8.7
-Iron and Steel	10.5	14.3
-Other Industry	7.4	8.8
Construction	5.2	5.5
Commerce and Services (Electric)	4.9	5.5
Commerce (Kerosene)	4.9	5.5
Services (Fuel Oil and Diesel)	4.9	5.5
Transportation	5.2	6.0
-Rail	6.2	7.4
-Air	4.8	5.7
-Water	3.3	4.0
-Land	5.5	6.4
TOTAL GDP	4.6	5.4
Population	2.1	2.1
GDP per capita	2.5	3.2
# Vehicles % pa		
-Buses	11.4	9.0
-Trucks	10.1	12.0
-Passenger Cars	6.6	7.3
-Motorcycles	9.4	10.7

TABLE VI-1

PROJECTED RATES OF GROWTH; GDP BY SECTOR % PER ANNUM
(based on 1975 prices)
continued

Number of Vehicles per 1,000,000 Persons

	1970	1982	1988	2000
Buses	270	869	1465	3186
Trucks	1513	4249	6687	20154
Pass. Cars	2951	5115	6641	7564
Motorcycles	9182	29340	367897	= 96377

Number Persons per Vehicle

Buses	1150.1	682.65	313.9
Trucks	235.3	149.5	49.6
Pass. Cars	195.5	150.6	132.2
Motorcycles	41.1	27.2	10.4

TABLE VI-2

JAVA

PROJECTED RATES OF GROWTH: GDP BY SECTOR % PER ANNUM
(based on constant 1975 prices)

	1982-1988	1988-2000
Agriculture	4.8	4.5
Mining	2.3	2.4
-Oil and Gas	2.1	2.2
-Other	4.1	4.2
Industry	5.3	6.3
-Cement	16.7	5.9
-Other Non-Metallic Mineral Products	7.6	10.0
-Pulp and Paper	6.0	6.6
-Fertilizers	5.4	5.1
-Other Chemicals	4.4	6.1
-Iron and Steel	10.5	14.2
-Other Industry	4.4	4.7
Construction	8.4	7.2
Commerce and Services (Electric)	5.9	6.0
Commerce (Kerosene)	5.9	6.0
Services (Fuel Oil and Diesel)	5.9	6.0
Transportation	4.9	5.4
-Rail	6.1	7.4
-Air	4.0	5.3
-Water	2.9	3.1
-Land	5.1	5.5
GDP (TOTAL)	5.5	5.6
Population	1.8	1.8
GDP per Capita	3.7	3.8
Vehicles % pa		
-Buses	13.1	8.5
-Trucks	10.4	10.7
-Passenger Cars	7.1	7.2
-Motorcycles	9.7	9.9

TABLE VI-3

NON-JAVA

PROJECTED RATES OF GRWOTH: GDP BY SECTOR % PER ANNUM
(based on 1975 prices)

	1982-1988	1988-2000
Agriculture	1.1	1.5
Mining	2.4	2.4
-Oil and Gas	2.1	2.2
-Nickel	9.1	7.0
-Tin	9.8	7.0
-Other	2.3	2.4
Industry	10.7	10.7
-Cement	8.4	10.8
-Other Non-Metallic Mineral Products	7.6	12.3
-Pulp and Paper	11.1	10.8
-Fertilizers	11.7	7.1
-Other Chemicals	9.4	10.3
-Iron and Steel	--	--
-Other Industry	10.8	10.7
Construction	2.6	3.5
Commerce and Services (Electric)	2.3	3.8
Commerce (Kerosene)	2.3	3.8
Services (Fuel Oil and Diesel)	2.3	3.8
Transportation	5.4	6.5
-Rail	6.4	7.4
-Air	5.5	5.7
-Water	3.4	4.0
-Land	5.9	6.4
GDP (TOTAL)	3.6	5.2
Population	2.7	2.7
GDP per Capita	1.0	2.4
Vehicles % pa		
Buses	8.3	10.0
Trucks	9.6	12.0
Passenger Cars	4.9	7.8
Motorcycles	8.8	10.7

TABLE VI-4

PROJECTION OF RATE OF GROWTH: GDP BY SECTOR OF ORIGIN

REPELITA IV (official)

Percent Per Annum
1983/84 - 1988/89

1.	Agriculture	3.0
2.	Mining	2.4
3.	Manufacturing	9.5
	a. Metal and Machinery	(17.0)
	b. Basic Chemicals	(17.2)
	c. Misc. Industries	(6.0)
	d. Small Scale Industry	(6.0)
4.	Construction	5.0
5.	Transportation and Communication	5.2
6.	Other	5.0
	TOTAL GDP	5.0
Population: Indonesia		2.1
	a. Java	(1.8)
	b. Non-Java	(2.6)
	GDP Per Capita	2.8

Source: REPELITA IV (A Summary) May 1984; Official English Translation.

TABLE VI-5

PROJECTIONS OF VEHICLES
JAVA AND NON-JAVA

Rate of Growth of # of Vehicles per capita	1982-1988		1988-2000	
	Java	Non-Java	Java	Non-Java
-Buses	11.1	5.5	11.4	13.2
-Trucks	8.5	6.7	8.7	16.1
-Passenger Cars	5.2	2.1	5.3	5.0
-Motorcycles	7.8	5.9	8.0	14.2

Rate of Growth * of # of Vehicles (TOTAL)	1982-1988		1988-2000	
	Java	Non-Java	Java	Non-Java
-Buses	13.1	8.3	10.0	10.0
-Trucks	10.4	9.6	10.7	14.0
-Passenger Cars	7.1	4.9	7.2	7.8
-Motorcycles	9.7	8.8	9.9	12.0

* Projections: [Rate of growth of vehicles per capita (1975-1981) ÷ Rate of growth of GDP per capita (1975-1981)],* projected rate of growth of GDP per capita, * projected rate of growth of population. Except that 1988-2000 Non-Java rates have been adjusted downwards because the original projections based on this method were too high. Also - 1988-2000 Java bus rate adjusted downward.

TABLE VI-6

INDONESIA
NUMBER OF VEHICLES (REGISTERED)

Year	Passenger Cars (incl.bajajs)	Motorcycles	Vehicle Equivilant	Buses	Trucks
1983	865,940	4,135,677		160,260	717,873
1982	791,019	3,764,442		134,430	657,104
1981	719,336	3,207,499		113,509	589,439
1980	639,464	2,671,978		86,284	473,831
1979	581,531	2,307,215		68,770	393,109
1978	535,442	1,990,250		53,389	336,753
1977	479,335	1,704,964		48,089	278,979
1976	420,945	1,419,375		40,001	223,062
1975	383,061	1,191,771		35,103	196,416
1974	337,789	944,733		31,439	166,457
1973	306,713	714,333		30,036	143,252
1972	277,210	615,220		26,488	131,175
1971	259,282	528,079		22,797	115,082
1970	238,924	440,005		23,547	102,265
1969	218,866	368,724		19,367	94,065
1968	201,743	303,404		19,610	93,415
1967	186,109	284,578		18,449	92,298
1966	179,494	281,779		19,584	92,891
1965	166,845	235,413		18,414	84,646
1964	157,474	220,953		19,541	83,571
1963	143,189	196,223		23,146	77,264
1962	128,303	172,917		18,148	69,738
1961	129,262	152,228		17,852	69,837
1960	103,254	133,444		17,885	75,488

Source: Bullitin Statistic Bulanan
June 1984, p.119
Statistik Indonesia 1977, p.822
1975, p.767
Statistik Indonesia Pocket Book 1972/73, p.293
1968/69, p.272

TABLE VI-7

NUMBER OF VEHICLES FOR 1,000,000 PERSONS

	Java			Non-Java		
	1975	1981	% pa	1975	1981	% pa
Buses	237	707	20.0	327	820	16.6
Trucks	1641	3889	15.5	1296	3906	20.2
Passenger Cars	3554	5993	9.1	1922	2758	6.2
Motorcycles	9981	21581	13.7	7818	20579	17.5

GROWTH OF GDP VS. GROWTH OF VEHICLES

	1975-1981 % pa		
	Indonesia	Java	Non-Java
GDP	7.6	9.0	6.2
GDP per capita	5.6	6.6	3.0
Number of Buses	21.6	22.6	20.2
Number of Trucks	20.1	18.0	24.0
Number of Passenger Cars	11.1	11.5	9.6
Number of Motorcycles	17.9	16.2	21.3

	Indonesia % p.a.
	1981 - 1983
GDP	2.6
GDP per capita	0.3
Number of Buses	18.8
Number of Trucks	10.4
Number of Passenger Cars	9.7
Number of Motorcycles	13.6

	Indonesia % pa	
	1960-1983	1967-1983
Buses	10.0	14.5
Trucks	10.3	13.7
Passenger Cars	9.7	10.1
Motorcycles	16.1	18.3

TABLE VI-7
continued

RATIOS: GROWTH OF NUMBER OF VEHICLES TO GROWTH OF GDP

GROWTH OF NUMBER OF VEHICLES PER CAPITA TO GDP PER CAPITA

	1975-1981 P.A.		
	Indonesia	Java	Non-Java
% Number of Vehicles/% GDP			
Buses	2.8	2.5	3.3
Trucks	2.6	2.0	3.9
Passenger Cars	1.5	1.3	1.5
Motorcycles	2.4	1.8	3.4
% Number Vehicle per capita/ % GDP per capita			
Buses	3.3	3.0	5.5
Trucks	3.0	2.3	6.7
Passenger Cars	1.5	1.4	2.1
Motorcycles	2.7	2.1	5.8

TABLE VI-8

PROJECTED DISTRIBUTION OF FERTILIZER PRODUCTION
(000 ton)

	1984	1985	1986	1987	1988	1989	1990-2000
UREP	2733	3724	3919	4168	4651	5568	5708
Java	542	540	540	540	540	540	540
Non-Java	2191	3184	3379	3628	4111	5028	5168
Za (Java)	292	445	495	645	645	645	645
TSP (Java)	1000	1000	1000	1150	1500	1500	1500
TOTAL	4025	5169	5414	5963	6796	7713	7853
Java	1834	1445	1495	1804	2685	2685	2685
Non-Java	2191	3184	3379	3628	4114	5028	5168

Source: Migas Indonesian Gas Utilization Study
Appendix E. Table E.5

PROJECTED DISTRIBUTION OF CEMENT COSTS

	1988	1993	1998	2003
Java	16.2	19.2	28.2	35.4
Non-Java	4.9	8.5	14.7	21.5
TOTAL	21.1	27.7	42.9	56.9

Source: Migas Indonesia Gas Utilization Study, "High Case"

TABLE VI-9

GDP BY SECTOR: LEVEL AND GROWTH:
ACTUAL, ESTIMATED, PROJECTED

INDONESIA

	Billion 1975 Rp				%Per Annum			
	1982	1983	1988	2000	82-83	83-88	82-88	88-2000
Agriculture	5226.5	5476.9	6349.2	9609.2	4.8	3.0	3.3	3.5
Mining	2820.0	2870.1	3231.4	4295.3	1.8	2.4	2.3	2.4.
-Oil and Gas	2677.6	2725.1	3032.7	3936.4		2.2	2.1	2.2
-Nickel	6.3	6.4	10.6	23.8		10.7	9.1	7.0
-Tin	47.6	48.4	84.2	189.5		11.2	9.8	7.0
-Other	88.5	90.2	103.9	145.6		2.9	2.7	2.9
Industry	2579.0	2574.4	4048.2	11386.2	2.2	9.5	8.2	9.0
-Cement	59.3	60.6	132.9	309.5	2.2	17.0	14.4	7.3
-Other Non-Metallic Mineral Products	65.8	67.2	103.4	369.6	2.2	9.0	7.8	11.2
-Pulp and Paper	64.5	65.9	106.1	305.1	2.2	10.0	8.6	9.2
-Fertilizers and Pesticides	59.5	60.8	99.3	209.0	2.2	10.3	8.9	6.4
-Other Chemicals (Excl.Refinery)	151.7	155.0	227.7	619.6	2.2	8.0	7.0	8.7
-Iron and Steel	74.6	76.2	135.5	673.7	2.2	12.2	10.5	14.3
-Other Industry (Including Refinery)	2043.6	2088.7	3243.3	8899.7	2.2	9.2	7.4	8.8
Construction	1224.8	1300.3	1659.5	3155.1	6.2	5.0	5.2	5.5
Commerce and Services (Elective)	6733.7	7035.5	8979.3	17071.5	4.5	5.0	4.9	5.5
Commerce (Kerosene)	3510.2	3642.5	4618.9	8838.5	3.8	5.0	4.8	5.5
Services (Fuel oil and Diesel)	2348.8	2460.7	3140.5	5970.7	4.8	5.0	5.0	5.5
Transportation and Storage	1150.1	1207.7	1557.1	3133.2	5.0	5.2	5.2	6.0

TABLE VI-9
continued

-Rail	12.2	12.8	17.5	41.2	5.0	6.4	6.2	7.4
-Air	84.3	88.5	111.9	217.6	5.0	4.8	4.8	5.7
-Water	177.0	185.9	214.5	342.2	5.0	2.9	3.3	4.0
-Land	167.8	744.3	977.4	2057.7	5.0	6.0	5.8	6.0
-Allied Services	167.8	176.2	235.8	474.5	5.0	6.0	5.8	6.0
Electricity, Gas, Water	178.8	191.9	244.8	465.5	7.4	5.0	5.4	5.5
Total GDP	19852.9	20656.8	26069.6	49115.6	4.0	4.8	4.6	5.4
Population (millions)	154.7	158.1	175.6	226.8	2.2	2.1	2.1	2.1
GDP per Capita	128.3	130.6	148.5	216.6	1.8	2.6	2.5	3.2

TABLE VI-10

JAVA

GDP BY SECTOR: LEVEL AND GROWTH;
ESTIMATED, PROJECTED

	(Billion 1975 Rp)				Percent Per Annum			
	1982	1983	1988	2000	82-83	83-88	82-88	88-2000
Agriculture	3019.3	3249.3	3996.4	6796.1	7.6	4.2	4.8	4.5
Mining	233.1	237.4	267.3	355.3	1.8	2.4	2.3	2.4
-Oil and Gas	214.2	218.2	243.3	315.9	1.9	2.2	2.1	2.2
-Nickel	0.0	0.0	0.0	0.0			---	---
-Tin	0.0	0.0	0.0	0.0			---	---
-Other	18.9	19.2	24.0	39.4	1.6	4.6	4.1	4.2
Industry	1262.9	1276.6	1741.8	3606.3	1.1	6.4	5.3	6.3
-Cement	40.3	41.2	102.0	203.4		20.6	16.7	5.9
-Other Non-Metallic Mineral Products	32.9	33.6	51.2	106.7		8.8*	7.6	10.0
-Pulp and Paper	32.3	33.0	45.7	98.3		6.7	6.0	6.6
-Fertilizers and Pesticides	28.6	30.4	39.2	71.5		5.2	5.4	5.1
-Other Chemicals (excl. Refinery)	75.9	77.5	98.0	199.5		4.8	4.4	6.1
-Iron and Steel	74.6	76.2	135.5	673.7		12.2	10.5	14.2
-Other Industry (incl. Refinery)	978.3	984.7	1270.2	2199.2		5.2	11.4	4.7
Construction	507.5	554.4	821.9	1889.4	9.2	8.2	8.4	7.2
Commerce and Services (Electric)	4755.0	4990.8	6710.4	13502.6	5.0	6.1	5.9	6.0
Commerce (Kerosene)	2706.4	2840.6				6.1		
Services (Fuel Oil and Diesel)						6.1		
Transportation and Storage	535.0	558.3	711.5	1332.8	4.4	5.0	4.9	5.4
-Rail	9.8	10.3	14.0	33.0	5.1	6.3	4.9	5.4
-Air	39.6	41.3	50.2	93.4	4.3	4.0	4.0	5.3
-Water	53.1	55.4	63.2	91.4	4.3	2.7	2.9	3.1
-Land	354.3	369.7	476.6	907.6	4.4	5.2	5.1	5.5
-Allied Services	78.2	81.6	107.8	207.4	4.3	5.7	5.5	5.6

TABLE VI-10
continued

Electric, Gas, Water	120.9	131.3	179.7	360.7	8.6	6.5	6.8	6.0
Total GDP (Billions 1975 Rp)	10433.7	10998.1	14429.0	27843.2	5.4	5.6	5.5	5.6
Population (Millions)	75.1	96.9	106.0	131.3	1.9	1.8	1.8	1.8
GDP Per Capita (000 1975 Rp)	109.7	113.5	136.1	212.1	3.5	3.7	3.7	3.8

TABLE VI-11

NON-JAVA

GDP BY SECTOR: LEVEL AND GROWTH;
ESTIMATED AND PROJECTED

	1982	1983	1988	2000	82-83	83-88	82-88	88-2000
Agriculture	2207.2	2227.6	2352.8	2913.1	0.9	1.1	1.1	1.5
Mining	2586.9	2632.7	2964.1	3940.0	1.8	2.4	2.3	2.4
-Oil and Gas	2463.4	2506.9	2789.4	3620.5		2.2	2.1	2.2
-Nickel	6.3	6.4	10.6	23.8		10.7	9.1	7.0
-Tin	47.6	48.4	84.2	189.5		11.7	9.8	7.0
-Other	69.6	71.0	79.9	106.2		2.4	2.3	2.4
Industry	1256.1	1297.8	2306.4	7779.9	3.3	12.2	10.7	10.7
-Cement	19.0	19.4	30.9	106.1		9.8	8.4	10.8
-Other Non-Metallic Mineral Products	32.9	33.6	52.2	208.9		9.2	7.6	12.3
-Pulp and Paper	32.2	32.9	60.4	206.8		13.6	11.1	10.8
-Fertilizers and Pesticides	30.9	30.4	60.1	137.5		14.6	11.7	7.1
-Other Chemicals (Excl. Refinery)	75.8	77.5	129.7	420.1		10.8	9.4	10.3
-Iron and Steel	0.0	0.0	0.0	0.0		0.0	0.0	0.0
-Other Industry (Incl. Refinery)	1065.3	1104.0	1973.1	6700.5		12.3	10.8	10.7
Construction	717.3	745.9	837.6	1265.7	4.0	2.3	2.6	3.5
Commerce and Services (Electricity)	1978.7	2044.7	2268.9	3568.9	3.3	2.1	2.3	3.8
Commerce								
Services (Fuel Oil and (Diesel)								
Transportation and Storage	615.1	647.4	845.6	1600.4	5.6	5.4	5.4	6.5
-Rail	2.4	2.5	3.5	8.2	4.2	4.0	6.4	7.4
-Air	44.7	47.2	61.7	124.2	5.6	5.5	5.5	5.7
-Water	123.9	130.5	151.3	250.8	5.3	3.0	3.4	4.0
-Land	354.4	374.6	500.8	1150.1	5.7	6.0	5.9	6.4
-Allied Services	89.7	94.5	128.3	267.1	5.4	6.3	6.1	6.0
Electricity, Gas Water	57.9	60.6	65.2	104.4	4.7	1.5	2.0	4.0

TABLE VI-11
continued

Total GDP	9419.2	9658.7	11640.6	21272.4	2.5	3.8	3.6	5.2
Population (Millions)	559.6	61.2	69.6	95.5	2.7	2.7	2.7	2.7
GDP Per Capita (000's 1975 Rp)	158.0	157.8	167.3	222.7	0.1	1.1	1.0	2.4

NOTES AND REFERENCES

1. Actual values are not shown due to the volume of calculations that would be required (over 400). Each xij represents the sales of sector i to sector j, or alternatively, the purchase of sector j from sector i.

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PN AAU-423

ENERGY PLANNING FOR DEVELOPMENT

(Phase II)

APPENDIX 5: SURVEY OF ENERGY USE IN URBAN HOUSEHOLDS

September, 1985

DIRECTORATE GENERAL OF ELECTRIC POWER AND NEW ENERGY
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Appendix

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1. BACKGROUND

1.1 Introduction

The collection of baseline energy consumption data is a central function of energy planning agencies such as the Direktorat Jendral Listrik dan Energi Baru (DJL). Early in the agency's existence the need was recognized for the collection of primary information on energy consumption in the household sector. The information base is scant for this sector, as in many other developing countries. End-use information is of particular relevance to the consideration of energy policy options, especially when decisions concerning energy efficiency, fuel substitution, or energy pricing are involved.

The present report summarizes the results of an urban household survey undertaken in a three-month period in early 1985 in nine major urban areas. This survey was a follow-on to an earlier rural household survey carried out in 1980 to collect baseline information on rural energy consumption patterns.

1.2 The Changing Characteristics of Energy Consumption

While the survey was undertaken as part of DJL's mandate to improve the available information base on energy consumption, it is important to recognize that the present context of energy policy issues in the country creates an urgent need for a more detailed view of energy consumption patterns.

The energy sector plays a central role in Indonesia's economic and social development. The export of petroleum products has played a strategic role in the country's economic life, and has contributed significantly to the rapid growth rates experienced in the past decade, which have averaged 7.6 percent annually. Oil products meet over 80 percent of the country's commer-

cial energy needs and finance almost all of the non-oil imports. Oil and LNG exports accounted for approximately 75% of total exports, and 60% of total budgetary revenues during much of this period. While meeting national energy needs is a basic commitment of national policy, there is also a pragmatic need to examine current energy consumption patterns and future requirements, particularly for petroleum and commercial fuels. Rapid economic growth has been achieved, in part, as a result of the ready availability of petroleum fuels. Continued growth will, in all likelihood, continue to be based upon petroleum as a principal energy source. But in view of the opportunity costs of domestic petroleum consumption, and the continuing importance of oil exports to national development objectives, there is a need to understand the structure of domestic energy demand, and to identify least-cost strategies to meet future growth.

1.3 The Pattern of Demand Growth

The growth of primary energy demand through much of the 1970s and early 1980s has been rapid, averaging 11.7% per year during the period 1970 - 1983.[1] Gross domestic product during the same period grew at 7.6% per year.

Households account for a very large share of primary energy consumption. This sector accounted for approximately 65 percent of national energy demand according to estimates for the period 1978 - 1984. Much of this large component of demand originates in the countryside, where more than 80 percent of Indonesia's population resides. Non-commercial biomass fuels for cooking are the primary source of residential energy demand. Increasingly, however,

[1]World Bank estimate, 1984, personal communication.

commercial fuels provide for a significant portion of the average household's needs. Kerosene for cooking and lighting, as well as electricity are becoming important components of the residential energy budget, a trend that accelerated during the 1970s. As a result, it is now estimated that household consumption accounts for approximately 25 percent of national commercial energy demand. If personal transport energy demand were to be added to fuel for cooking and lighting, it is likely that this share would be much larger.

Since the shift in the pattern of residential consumption has emphasized petroleum products, particularly kerosene, much of the rapid growth of national petroleum demand can be attributed to the residential sector. Petroleum product demand grew at an average annual rate of 10.8% between 1970 - 1983.[2] Kerosene was the largest single contributor, growing at an annual rate of 13 percent. In the early 1980s this trend seems to have considerably slackened, in response to higher domestic prices. As a result, kerosene's share of total product demand has declined from 40% in the early seventies to 30% in recent years. Electricity consumption also grew during the same period at a rapid 11% per year. The rapid growth of electricity demand is likely to continue since the proportion of electrified households continues to be small. Only 6% of all Indonesian households presently have access to electricity.

1.4 Urbanization and Residential Energy Demand

The rapid rate of growth of kerosene and electricity in the seventies was associated with rising incomes and demographic trends. While population

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[2] Ibid.

growth averaged 2.4 percent annually, Indonesia's urban population grew at a much more rapid rate of 4 percent.[3] The rapid movement of people towards Indonesia's cities undoubtedly added momentum to the growing reliance on commercial fuels. This trend is expected to continue through most of this century. Current projections suggest that at its present pace of growth, the country's urban population by the year 2000 will have approximately doubled its present size, reaching a level of 72 million people.[4]

Even if some moderation in the future pace of urban population growth is possible, urban energy requirements are likely to grow more rapidly than national energy demand. Such a scenario has important policy implications.

First, urban population centers will, for the foreseeable future, continue to be a source of increasing petroleum demand. This is particularly true if personal transportation needs are viewed as a component of household demand. Residential electricity requirements will also continue to rise rapidly in response to urban population growth.

By extension, a second implication is that costs to the national economy of providing for residential energy needs will grow in relative importance. As a result, the search for an economically efficient fuel mix to satisfy these needs will become an increasing preoccupation of national energy policy and may focus on appropriate substitutes for kerosene as a cooking fuel such as LPG, or, in some regions, charcoal or other briquetted fuels.

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[3] Ibid.
[4] Ibid.

Measures to influence and to manage the growth of urban demand will also become a focus for national policy. The rate of future urban demand growth and the choice of particular fuels by urban Indonesians are both likely to be influenced by relative fuel prices. An appropriate fuel pricing policy will inevitably require a continuing examination of subsidy issues. While kerosene subsidy policy has historically absorbed considerable national attention, new questions are likely to arise. Who are the beneficiaries of a particular subsidy, and what transfer payments are implicit in a particular policy?

1.5 Information Needs for Policy Analysis and Objectives of the Survey

The policy issues discussed above underscore that present interest in urban energy consumption is hardly academic when viewed from the perspective of social policy. Population growth, rising per capita income and accompanying shifts in consumption patterns have contributed to a growing national demand for petroleum products, and to increasing per capita energy consumption. The energy needs of Indonesia's households must be met since they are among the most basic social needs.

However, the effort to formulate a coherent national policy to meet these needs now confronts basic deficiencies in the quality of available information. Detailed analysis of policy choices is difficult at present due to the absence of historical information on the end-use consumption of urban fuel demand, and on income and regional variations in this pattern.

1.6 Objectives

The survey undertaken was a pilot effort to test a methodology for collecting end-use information about urban household energy consumption patterns

in a form useful for national energy policy analysis. At the same time, the exercise aimed at creating a regional data base on urban energy consumption which can be updated at a future time to provide policy analysts with historical trends in residential energy use. It was also intended that the survey data provide a preliminary data base on energy consumption consistent with the RESGEN modelling framework now in use at DJL for national energy analysis.

An additional objective was to collect quantitative information on end-use consumption that can be combined with information on expenditures and prices collected by BPS in its SUSENAS survey to examine relationships between energy, income and prices, should such an analysis be required in the future.

An important final objective of the pilot survey was to train Indonesian counterparts in appropriate survey techniques, and data collection methods. All implementation steps, field-work for data collection, and subsequent computer analysis was undertaken by counterpart staff assembled by the Indonesian subcontractor, which included DJL staff analysts, and members of the Development Technology Research Center at the Institute of Technology, Bandung.

1.7 Methodology

The urban survey employed a direct questionnaire interview to collect information in the following areas:

- household characteristics (household size, and expenditure data, including expenditures on fuels)
- household consumption of fuels (kerosene, electricity, wood, charcoal, LPG and city gas, diesel, and gasoline for private transportation)

- energy supply information in the case of electricity, and fuel prices
- end-use device ownership data and daily usage patterns, particularly for secondary electrical appliances and lighting information on household public transportation patterns (the frequency and average distances of trips by various modes).

This information was collected to provide a basic profile of energy consumption within the urban household, and a basis for comparing households within different expenditure groups (expenditure being used as a surrogate for income). The resulting data, in conjunction with secondary information on end-use and conversion efficiencies, also allow the construction of a detailed energy balance of the household sector, in the RESGEN modelling framework.

1.8 Implementation and Sample Design

Implementation of the survey was undertaken in three primary stages. In the first stage, discussions between DJL staff, and Indonesian counterparts were held to clarify the objectives, methodology, and potential sampling designs. The choice of cities to be included was made by DJL. At this stage, the need for secondary data, and the scope of available information on urban energy consumption patterns was identified. Discussions were also held with other government agencies such as PLN and BPS to clarify the objectives of the survey.

The decision to utilize the SUSENAS sample frame was made at this stage. A representative subsample of 1,636 households in nine cities, from the 1984 SUSENAS sample was constructed. The cities selected for the survey represent over 50% of the total urban population. The total population and its growth rate between 1971 - 1980 in each of the selected cities is shown

in Table 1. The random subsample was drawn from each of eleven expenditure groups in the SUSENAS sample. The distribution of selected households by income groups for each of the nine selected cities is shown in Table 2.

In the second stage, the contractor prepared a preliminary questionnaire, and undertook a one-week training of counterpart staff and supervisors. Based on the discussions during this training program, a final questionnaire for pre-testing was designed. A pre-test was undertaken at the conclusion of the training program, resulting in refinements and a final questionnaire. The final stage of field-work was undertaken during an eight-week period. Field staff were trained by supervisors and reviewed by subcontractors from ITB, Bandung. (The Appendix contains copies of the questionnaire in English and Indonesian as well as two reports in Indonesian summarizing results of the training and field work in three of the nine surveyed cities. Additional field work reports are available at ITB, Bandung.) The data analysis that followed was undertaken at Bandung and Washington, D.C.

2. RESULTS

2.1 Overview

The survey results provide a detailed view of the level of urban energy consumption as a whole, of its composition by fuels, and by end uses. Differences in the energy budget among households at different levels of income, and among the surveyed cities also emerge from an examination of the survey's results.

The results also allow a comparison with earlier estimates of rural household energy consumption obtained from the 1980 data. Viewing all urban

TABLE 1
Population Growth 1971-80 in Sampled Cities

City	Total Population 1980	% Growth Rate 1971-1980
Jakarta	6,503.4	3.9
Bogor	247.4	2.6
Bandung	1,462.6	2.2
Semarang	1,026.7	5.2
Surabaya	2,027.9	2.9
Malang	511.8	2.1
Yogyakarta	398.7	1.7
Ujung Pandang	709.0	5.5
Medan	1,379.0	8.5
Total Urban Population in Indonesia	32,846.0	4.0
Total Population in Indonesia	146,935.0	2.3

Source: Biro Pusat Statistik, for individual cities, and World Bank for total urban population.

TABLE 2
Distribution of Sampled Households by Cities and Income Groups

City	Total House holds	% of total	Income Groups Low	Medium	High
Jakarta	723	44.2	208	314	201
Bogor	20	1.2	5	7	8
Bandung	120	7.3	51	39	30
Semarang	81	5.0	54	20	7
Surabaya	144	8.8	95	41	8
Malang	90	5.5	60	22	8
Yogyakarta	124	7.6	59	38	27
Ujung Pandang	168	10.3	78	68	22
Medan	166	10.1	64	64	38
Total	1636	100.0	674	613	349
Percent		100	41.2	37.5	21.3

areas and the households as a group, annual direct energy requirements for cooking, lighting, and electrical appliances was found to be an average of 4.3 boe per household. This is equivalent to a level of 0.7 boe per capita.

Extrapolating these results to the national urban population as a whole would result in an urban level of fuel demand of 27 mboe annually. In 1984, total household demand was estimated to be approximately 156 mboe. Thus the urban share, based on survey results would be 17 percent of total residential demand. This result is consistent with expectations, since the urban population base is considerably smaller than the rural.

It is also consistent with the underlying differences in the fuels consumed by rural and urban households: biomass fuels which make up the major component of rural energy budgets are consumed at much lower end-use efficiencies. If allowance is made for these differences, a quite different picture emerges in which the useful energy consumed by the average urban household (basic energy demand) is considerably higher than its rural counterpart.

Such differences are likely to be accentuated by the inclusion of transportation energy requirements in the average energy budget. Although the survey results show a very marked disparity in the consumption of transport fuels among low- and high-income households, the consumption of these fuels adds significantly to total urban demand, and results in a much higher consumption level of 7 boe per household, annually.

The survey confirmed the great importance of kerosene in the urban household energy budget. This was found to be true at all levels of household income, with kerosene providing an average of 77 percent of total energy

needs for domestic uses, and 47 percent of the total inclusive of transport fuels. Annual kerosene demand was estimated at 547 liters (3.3 boe) per household. These results are largely consistent with available national kerosene sales data.

The estimate of per capita energy consumption levels in the urban sector of 0.71 boe annually underscores the relatively low consumption of energy by the average urban citizen by comparison with his developed country counterpart. However, a comparison with neighboring Thailand shows that the urban Indonesian consumes more energy annually than the average resident of Bangkok, where a 1980 estimate showed an annual per capita consumption level of 0.51 boe.

A more detailed view of the survey results is presented in the following sections.

2.2 Total Urban Demand

Annual energy consumption in the sample of 1,636 households was estimated at a level of 6,999 boe, or 4.28 boe per household, as shown in Tables 3 and 4. If this level of annual consumption is extrapolated to the urban population as a whole (on the assumption that our SUSENAS sample frame is representative), national urban energy demand would amount to an annual level of 27 mboe.

Annual energy consumption for the household sector in Indonesia in 1984 was estimated at 155.93 mboe[5] which represented 53% of national energy con-

[5]Energy/Development International, Energy Planning for Development II, Summary Report, Sept. 1985.

TABLE 3
Total Fuel Consumption Per Year by Fuel Type
(1636 households, boe)

	All Income Groups		Low Income (< Rp 20,000)		Medium Income (Rp 20 - 40,000)		High Income (> Rp 40,000)	
Fuel	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	788.33	11.3	166.71	6.5	308.80	11.6	312.81	17.7
Kerosene	5367.83	76.7	2052.76	80.0	2189.48	82.2	1125.59	63.6
L P G	324.13	4.6	12.92	0.5	60.66	2.3	250.57	14.2
Charcoal	213.53	3.1	129.53	5.0	52.26	2.0	31.71	1.8
Wood	294.66	4.2	204.93	8.0	46.30	1.7	43.43	2.5
City Gas	10.86	0.2	0.24	0.0	4.79	0.2	5.83	0.3
Total fuel consumption	6999.34	100	2567.09	100	2662.29	100	1769.94	100

TABLE 4
Average Annual Fuel Consumption Per Household and Per Capita
(boe)

Income Group	Total Fuel Consumption	Number of Houses	Average Cons. per House	Average Househ. Size	Average Cons. per Capita
All	6999.34	1636	4.28	6.00	0.71
Low	2567.09	674	3.81	6.47	0.59
Medium	2662.29	613	4.34	5.88	0.74
High	1769.94	349	5.07	5.29	0.96

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sumption as a whole. The urban component, using the level derived from the survey of 27 mboe represents 17.3% of total household demand.

The estimated levels of consumption for kerosene and electricity appear to be quite reasonable, if compared with the available information on urban sales of these fuels. If 1984 data (the latest available data) are projected to mid-1985, annual sales of kerosene in all urban areas (taking into account estimated annual decline of approximately 6 percent in the past two years) would amount to approximately 19 mboe, and electricity sales in fuel equivalent terms would be 3.5 mboe. If the survey results are translated into quantities on an aggregate basis to the urban population as a whole, they would result in an estimated 20.6 mboe for kerosene and about 3 mboe for electricity. These results are shown in Table 5.

2.2.1 Kerosene

Kerosene is the largest single component of household energy demand, accounting for approximately 5,368 boe, or 77 percent of total direct household fuel consumption. The survey confirmed that kerosene is the primary cooking fuel in urban Indonesia. (Kerosene use for lighting was reported by a relatively small number of households probably because the sample contained a majority of households that have access to electricity.) This level of consumption is equivalent to an annual consumption per household of approximately 547 liters, or 91 liters per capita, based on an observed average of 6 persons per house. The reliance on kerosene as the primary urban fuel is further reinforced in Table 6, which shows that 90 percent of all households surveyed reported use of the fuel.

TABLE 5
Average_a/ Annual Energy Consumption of Domestic Fuels
for Cooking Lighting and Appliances

Fuel	Avg. cons. per house (boe)	Fuel share (%)	Total Urban Consumption, 1985: From survey results_b/ (mboe)	Total Urban Consumption, 1985: From sales data estimates _c/ (mboe)
Electricity	0.48	11.2	3.05	3.45
Kerosene	3.28	76.6	20.66	19.17
L P G	0.20	4.7	1.26	N.A.
Charcoal	0.13	3.0	0.82	N.A.
Wood	0.18	4.2	1.13	N.A.
City Gas	0.01	0.2	0.06	
Avg. all fuels	4.28	100.0	26.98	N.A.

_a/Averages are computed for the sample as a whole, that is for all 1636 households.

_b/Based on 1980 urban population of 32.8 million and average annual growth of 4% and average household size of 6 persons per house.

_c/Electricity sales projected at an annual growth of 12 per cent and decreasing kerosene sales at 6 per cent.

TABLE 6
Number of Households Consuming Fuels
(1636 households)

Fuel	Total house-holds	% of sample	Income Groups Low	Middle	High
Electricity	1077	65.8	380	425	272
Kerosene	1470	89.9	616	582	272
L P G	138	8.4	7	34	97
Charcoal	325	19.9	197	97	31
Wood	67	4.1	51	9	7
City Gas	7	0.4	1	1	5

2.2.2 Electricity

A relatively high proportion of households, 66 percent of the total number surveyed, reported using electricity. The survey collected two types of information on electricity consumption: billing information and information on the ownership and use of electrical devices. The latter information is likely to be useful in examining the future growth of electricity demand. It is also useful for the purpose of obtaining a disaggregation of electricity demand by end use.

Information on appliance use covered twenty device categories. Specific data was collected on the number of appliances and lighting characteristics, the size of appliances and daily hours of use. Appliance ownership information is summarized in Table 7. The majority of households used electricity as the primary lighting source. The use of fluorescent tubes and lightbulbs was therefore widespread. A very high proportion of households, 72 percent, owned televisions. Irons and radio cassettes were also found to be in wide use, with high proportions of surveyed households reporting the ownership of these appliances (59% and 45% respectively). Detailed information on fifteen appliances is shown in Tables A.8 of the Appendix.

Not surprisingly, the pattern of appliance ownership was quite closely tied to household income. Low- and middle-income households were found to own smaller appliances such as televisions, irons, and radios, while the ownership of durables such as refrigerators and air conditioners was confined to the upper income groups.

Total electricity consumption estimated from billing data was 1.3 GWh on an annual basis for the total sample (788 boe in fuel equivalent terms). On

TABLE 7
Electrical Device Ownership

(Percent of all Households)

Income Groups	Bulbs	Fluorescent Lamp	AC	TV	Refrigerator	Water Pump	Radio Cassette	Cassette	Radio	Video	Iron
All	86.4	76.6	2.3	72.2	25.8	19.4	45.2	19.6	12.3	9.3	59.3
Low	31.9	27.6	0.1	24.8	2.4	3.1	12.2	5.4	4.2	0.5	16.3
Middle	34.4	30.1	0.6	28.4	10.8	6.2	19.7	7.1	3.0	2.6	25.7
High	20.0	18.9	1.7	19.0	12.5	10.1	25.6	7.0	3.0	6.2	17.3

this basis, electricity's share is 11.3 percent of total energy consumption. This corresponds to an average level of electricity consumption of 777.5 kWh per household, or 129.6 kWh per capita.

Extrapolating the information on device ownership and use to annual consumption levels resulted in a higher annual consumption level than indicated by the information on customer billing. Total consumption of electricity on this basis was calculated to be 907 kWh for the sample as a whole, as summarized in Table 8. Actual usage levels therefore may be higher than indicated by billing information alone. However, the survey data on electricity consumption computed from device information in Table 8, where, for instance, in the low income group one household reported an annual airconditioning demand of 7776 kWh! Information on the use of other appliances such as refrigerators is also imprecise.

The data collected should, however, prove useful in undertaking a more detailed analysis of electricity demand. For example, it should be possible to examine the relationship between the level of electricity consumption and exogenous variables such as income, household size, and the number and size of appliances, through the use of simple regression techniques.

2.2.3 Other Fuels

The survey pointed to the relative insignificance of other fuels in the urban household energy budget. Other fuels jointly account for 843 boe or, approximately 12 percent of annual fuel consumption as shown in Table 3. Of these, wood and charcoal amount to 4 and 3 percent of the total respectively. Relatively few households reported the use of wood (4 percent of all surveyed households) and a larger share (20 percent) reported using char-

TABLE 8
Device Ownership and Electricity Use

Device	All Income		Low Income		Middle Income		High Income	
	No. of houses owning	Kilo-watt hours	No. of houses owning	Kilo-watt hours	No. of houses owning	Kilo-watt hours	No. of houses owning	Kilo-watt hours
Bulbs	1413	330	522	222	563	322	328	515
Fluorescent lamp	1253	166	451	105	492	142	310	288
A C	37	2904	1	7776	9	1783	27	3105
T V	1182	99	406	81	465	100	311	122
Refrigerator	422	934	40	632	177	845	205	1069
Water pump	317	238	51	166	101	259	165	247
Radio cassette	740	25	199	19	322	22	419	34
Cassette	320	34	89	15	116	29	115	54
Radio	202	14	69	13	49	16	49	12
Video	152	23	8	26	43	22	101	23
Iron	970	83	266	55	421	74	283	121
Total annual use (Kwhr)		1484562		258498		532753		697487
Average use per household (Kwhr)		907.43		158.01		325.64		426.34

coal. LPG, which is considered as a viable alternative to replace kerosene accounted for 324 boe or less than 5% of total energy consumption. LPG was used by only 8 percent of surveyed households. The use of city gas was reported by only seven households (in four of the nine surveyed cities), accounting for a negligible share in the total.

2.3 End-Use Patterns of Consumption

The survey data allow a breakdown of fuel consumption levels by major categories of end use: cooking, lighting, and appliance use. The results of this analysis are shown in Tables 9 and 10, which examine both fuel demand and basic energy demand.

2.3.1 Fuel Demand by End Use

Cooking, as expected, is the major end-use category accounting for 85% of the average fuel demand per household. The major component of cooking demand is kerosene, which accounts for 86 percent of all cooking requirements. Lighting is the other major category of end use and accounts for ten percent of the average energy budget. Electricity is the primary energy form for lighting. Appliance use, the remaining end-use category, is a relatively small component of the total and is entirely electricity based.

2.3.2 Basic Energy Demand

To analyze potential fuel substitutions or efficiency improvements, the consumption of useful energy (basic energy demand) is essential. Assumed end-use conversion efficiencies allow such a calculation from the end use fuel consumption estimates reported above. The structure of basic energy demand is shown in Table 10. An average annual basic energy demand level of 1.97 boe per household was estimated from the survey data.

Table 9
End-Use Fuel Consumption Per Household for Domestic Uses
(BOE Per Year)

	Income Groups							
End Use	All	% of Total	Low	% of Total	Middle	% of Total	High	% of Total
Cooking:	3.64	100.0	3.41	100.0	3.67	100.0	4.02	100.0
Kerosene	3.12	85.7	2.90	85.0	3.40	92.6	3.07	76.4
LPG	0.20	5.5	0.02	0.6	0.10	2.7	0.72	17.9
Wood	0.18	4.9	0.30	8.8	0.08	2.2	0.12	3.0
Charcoal	0.13	3.6	0.19	5.6	0.08	2.2	0.09	2.2
City Gas	0.01	0.3	-	-	0.01	0.3	0.02	0.5
Lighting:	0.41	100.0	0.28	100.0	0.44	100.0	0.62	100.0
Electricity	0.25	61.0	0.13	46.4	0.27	61.4	0.47	75.8
Kerosene	0.16	39.0	0.15	53.6	0.17	38.6	0.15	24.2
Appliances:	0.23	100.0	0.12	100.0	0.23	100.0	0.43	100.0
Electricity	0.23		0.12		0.23		0.43	
Total	4.28		3.81		4.34		5.07	

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TABLE 10
Basic Energy Demand Per Household -- Domestic Uses, by End Use _a/
(BOE Per Year)

	Income Groups							
End Use	All	% of Total	Low	% of Total	Middle	% of Total	High	% of Total
Cooking:	1.44	100.0	1.30	100.0	1.51	100.0	1.65	100.0
Kerosene	1.30	90.3	1.22	93.8	1.43	94.7	1.29	78.2
LPG	0.09	6.3	0.01	0.8	0.05	3.3	0.32	19.4
Wood	0.01	0.7	0.02	1.5	0.01	0.7	0.01	0.6
Charcoal	0.03	2.1	0.05	3.8	0.02	1.3	0.02	1.2
City Gas	0.01	0.7	-	-	-		0.01	0.6
Lighting:	0.31	100.0	0.31	100.0	0.38	100.0	0.53	100.0
Electricity	0.25	80.6	0.25	80.6	0.27	71.1	0.47	88.7
Kerosene	0.06	19.4	0.06	19.4	0.11	28.9	0.06	11.3
Appliances:	0.23	100.0	0.12	100.0	0.23	100.0	0.43	100.0
Electricity	0.23		0.12		0.23		0.43	
Total	1.97		1.73		2.12		2.61	

_a/ Relative efficiencies used for calculation of Basic Energy Demand were as follows: Electricity:100%; Kerosene (Cooking):42%; Kerosene (Lighting):40%; Wood:7%; Charcoal:25%; City Gas:42%; LPG:45%.

In terms of the end-use composition of basic energy demand, cooking remains the most important component, although its share of the total changes to 73 percent as shown in Table 10. Since wood and charcoal are used at a much lower efficiency than kerosene, the share of these fuels in basic energy demand is greatly reduced. The relative importance of other end-use categories is increased. Lighting accounts for 15 percent of basic energy demand and appliance use increases to 12 percent of the total.

2.4 Inter Urban Comparisons

The survey data allow a useful comparison of differences and similarities in the level and composition of fuels consumed by households across the nine surveyed cities. There are significant differences, for instance, in the total level of consumption, which ranges from a high of 5.1 boe per household in Malang (not an unexpected result, due to the greater reliance in this city on wood), to a low of 3.5 boe in the case of Semarang. The average levels of consumption in Jakarta and Yogyakarta (4.5 and 4.3 boe respectively) are closer to the national average for all urban households. These comparisons are shown in Figure 1. (Data for Figure 1 are contained in Appendix Tables A.1).

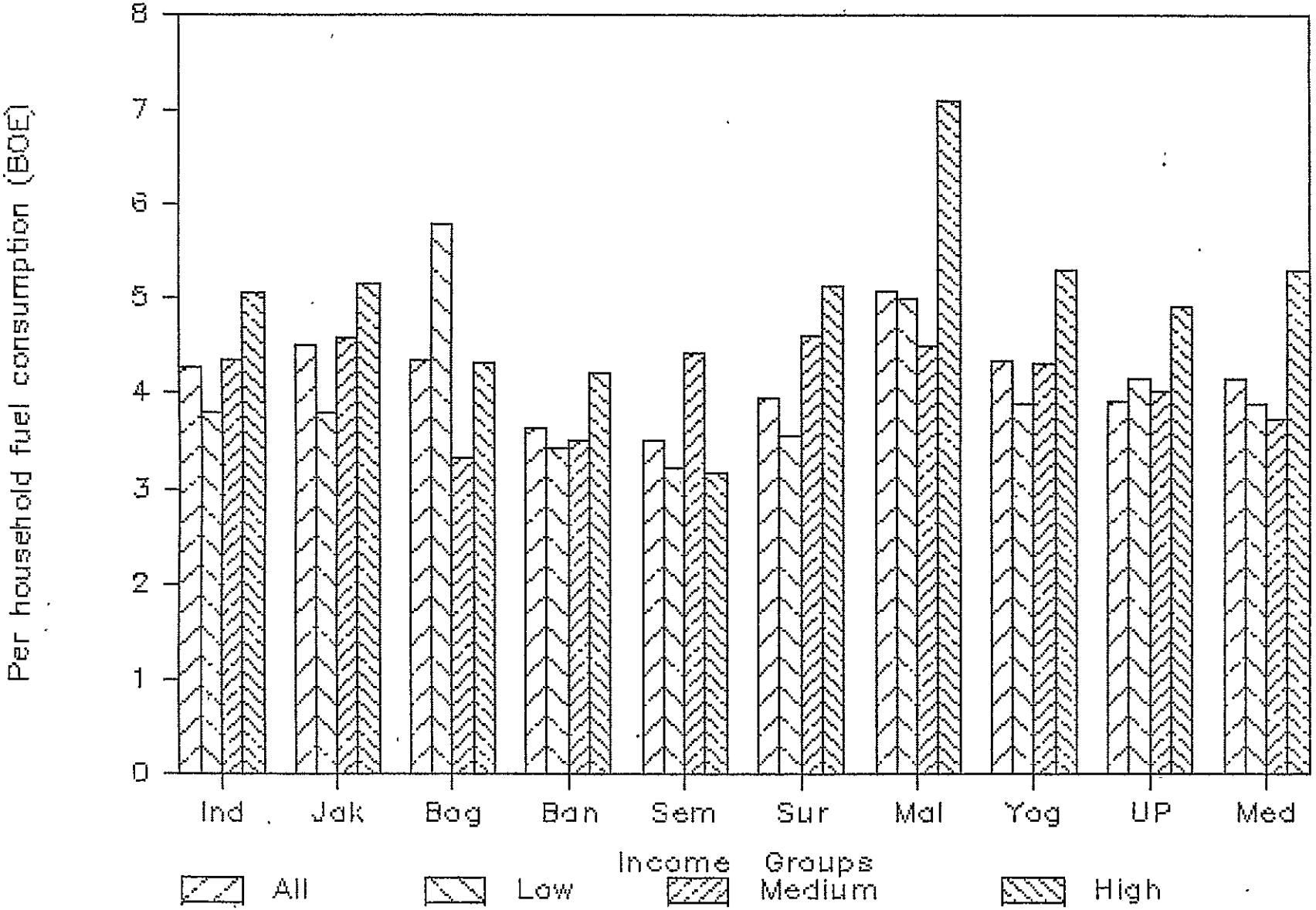
While broad similarities exist in the pattern of fuels consumed among the nine cities, significant variations are also evident. Kerosene is the primary fuel and is the largest component of energy demand in all nine cities. However, the share of kerosene in total consumption varies from a low of 63 percent in Vogyakarta to a high of 84 percent in Ujung Pandang.

Electricity's share of total demand varies from 10 to 14 percent of aggregate energy use in the majority of the cities. Exceptions to this are

FIG. 1

Annual Consumption Per Household

Urban Indonesia



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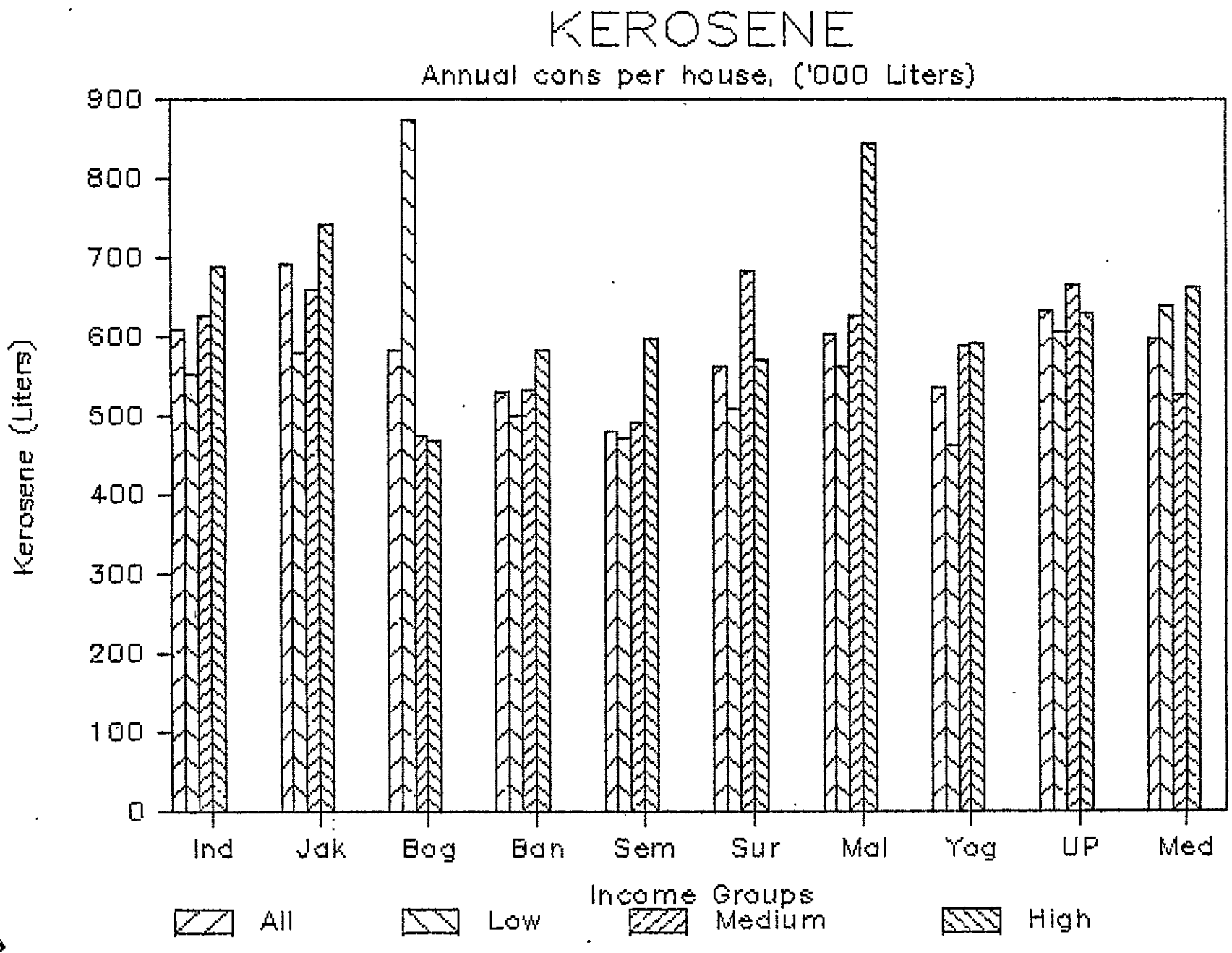
the cases of Malang and Semarang, where wood is the second most important component next to kerosene. Wood accounts for 18 percent of average consumption per household in Malang, while electricity's share is only 5 percent.

The survey confirmed the relatively minor role of LPG in aggregate household consumption, with the exception of Bogor, where its use accounted for 11 percent of total fuel consumption. In most other cities its share ranged from 2 to 6 percent of total consumption.

Inter-city differences in the consumption of kerosene, electricity, and wood among the households using these fuels are shown in Figure 2, 3, and 4. (Data for Figures 2 - 4 are contained in Appendix Tables A.2, A.3, and A.6.

Among the nine cities surveyed, Jakarta reported the highest consumption of kerosene and electricity. The consumption of these fuels is well above the national averages: 1,545 kWh/household for electricity, 692 liters/household for kerosene. Among the remaining cities electricity consumption ranged from 674 kWh annually for Semarang to a level almost twice as high, or 1,063 kWh for Yogyakarta. A much less pronounced variation was noted in kerosene consumption among cities, which ranged from 479 liters per household in Semarang to 634 liters per household in Ujung Pandang. There is a noticeable variation in the statistics reported for wood consumption.

The consumption of wood as a cooking fuel was noted in all nine cities. However, the very high variation in consumption levels shown in Figure 4, ranging from a level of 988 kg per year per household in Surabaya to a high of 3,835 kg per year in Semarang may not be as reliable as comparisons for other fuels because of the small size of the sample. For the sample as a



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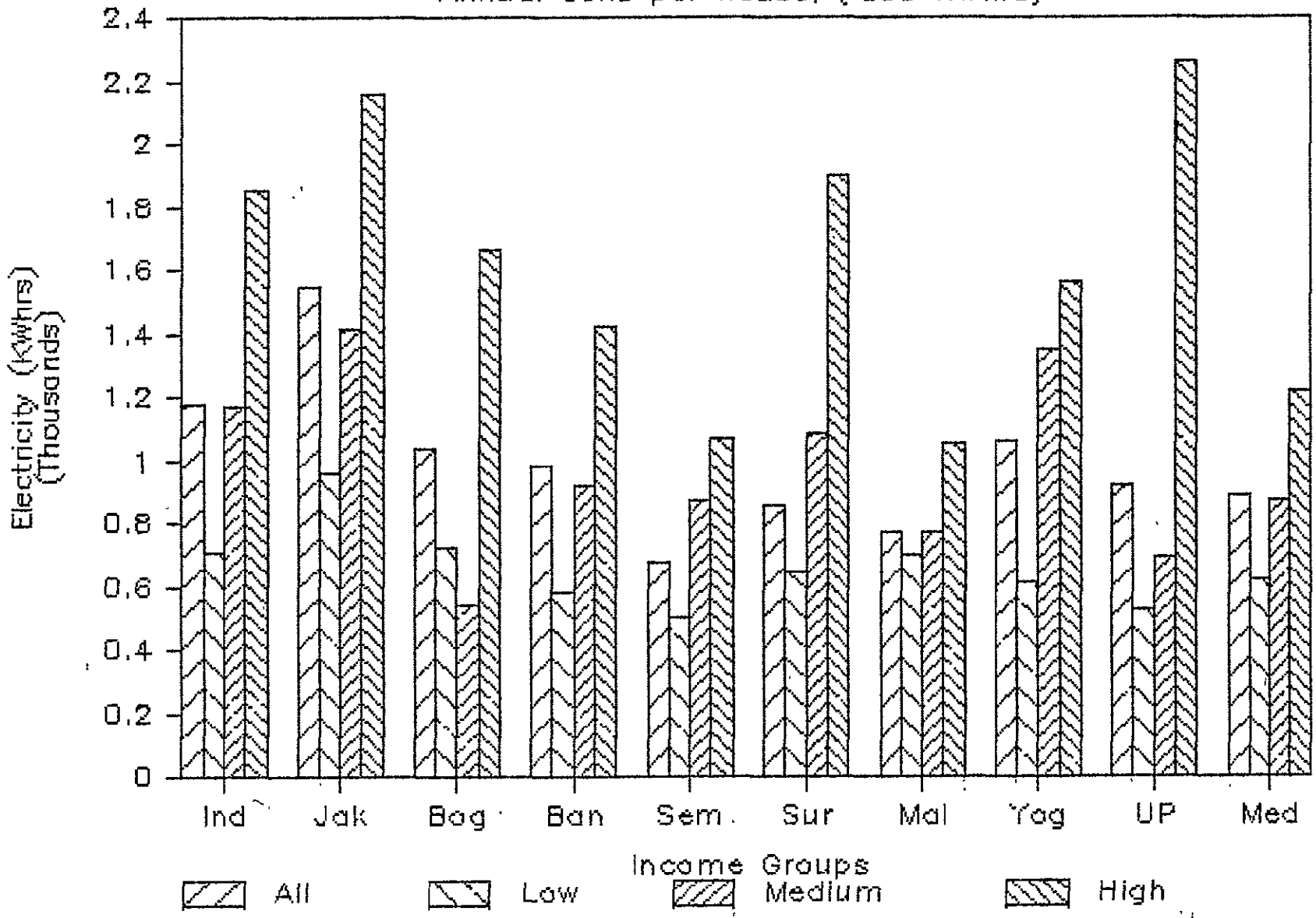
ELECTRICITY

Annual cons per house, ('000 KWhrs)



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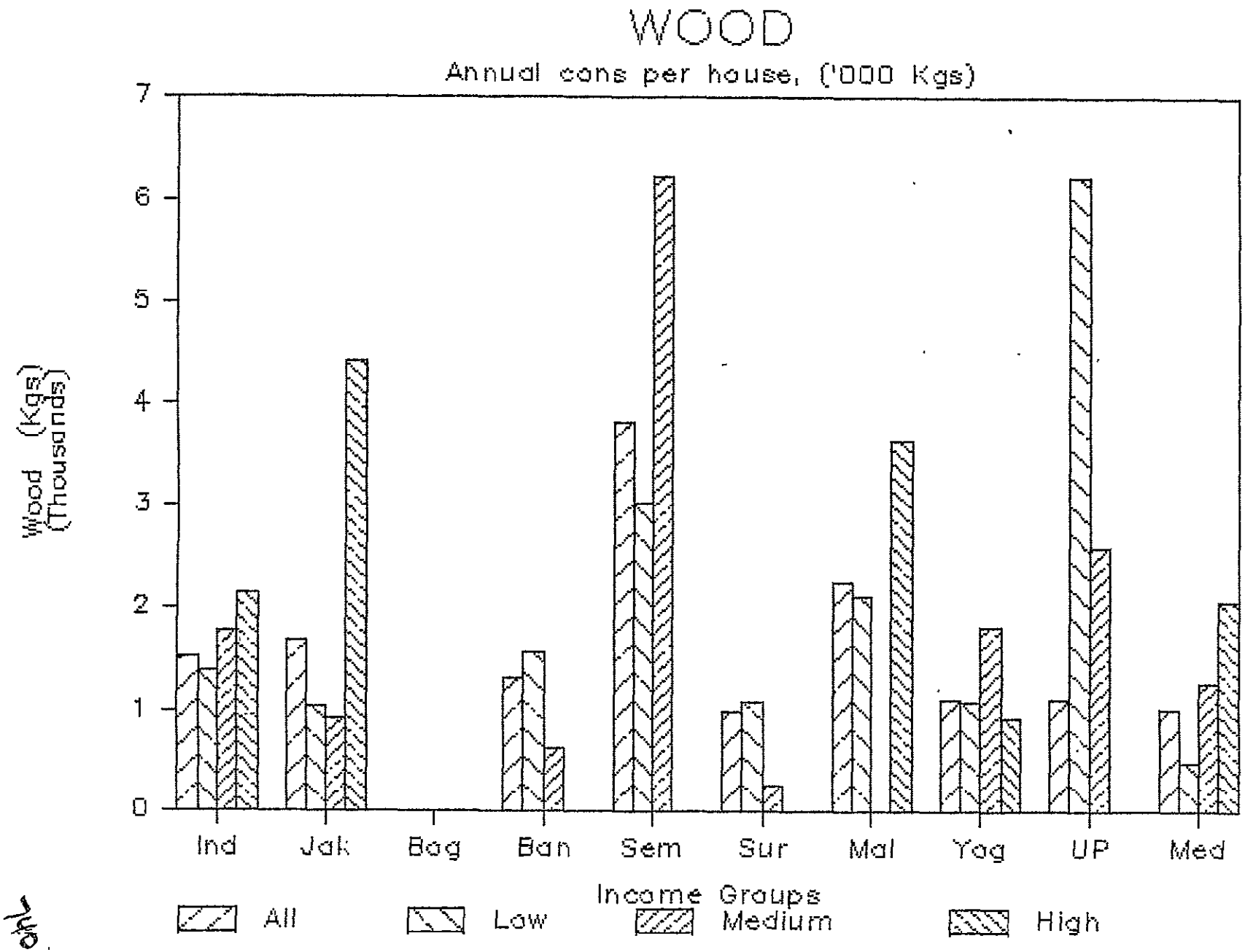

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whole, only 4 percent of all households reported the use of wood (67 households). Some of these households are known to have reported its use for commercial purposes, and the larger consumption levels associated with a few households (as in Jakarta and Semarang) may reflect such uses.

2.5 Income Group Comparisons and End-Use Patterns of Consumption

2.5.1 Income Group Comparisons of Fuel

Income growth is an important determinant of energy demand. As incomes increase households consume more energy, and also substitute one energy source for another. To investigate these variations, households were grouped into three expenditure categories (expenditure levels were used as a surrogate for income), and variations among patterns of consumption were analyzed.

Households with expenditures greater than Rp.40,000 were classified in the high income group. Those with expenditures between Rp.20,000 and 40,000 fell into the middle income group. Households with annual expenditures of less than Rp.20,000 were classifed in the low income group.

Significant differences were noted among these income groups, especially among low- and high-income households. As shown in Table 4, aggregate energy consumption per household increases by 14% in moving from low- to medium-income households. High-income households consume as much as 33% more than low-income households and 17% more than middle-income households. Per capita differences in energy consumption are even more pronounced because household size declines with rising household income. For the two major domestic fuels, electricity and kerosene, the difference between income groups is marked, especially if we examine differences among households reporting actu-

al use of these fuels (as shown in Table A.2 of the Appendix). Electricity consumption patterns were found to vary quite dramatically among income groups, a not unexpected result. Among high-income households, the greater diversity of appliance ownership, which increases with rising income, results in sharp increases in electricity consumption.

Variations in kerosene consumption were found to be less pronounced, since kerosene is primarily used for cooking. Unlike electricity, therefore, its use is not tied to a diverse set of appliances and end uses. Nonetheless, differences among income groups were found to exist in all the cities. On average, high-income households consumed 24 percent more than low-income households, and 10 percent more than middle-income households (as shown in Table A.3 of the Appendix).

2.5.2 Income Group Variation in End-Use Patterns of Consumption

We have already noted that there are significant differences in aggregate energy consumption levels among households at different income levels. These differences are further clarified by reference to the pattern of end-use demands. As an example, high-income households consume more fuel than low-income households for all major end-use categories. The difference is most pronounced for appliances and lighting than for cooking.

A comparison of end-use consumption patterns according to income groups shows that for all income groups cooking is the primary end use. However, the relative importance of particular end-use categories varies significantly among income groups. These variations are shown in Table 9. Cooking accounts for 90% of the average fuel demand among low-income households.

Lighting and appliance use account for the remaining 10%. The relative importance of cooking declines as household income increases.

For all end-use categories, differences in basic energy demand are even more pronounced as shown in Table 10. High-income households consume almost 27 percent more useful energy demand for cooking, 70 percent more in the case of lighting, and 350 percent more for appliances than low-income households.

2.6 Transport Energy Use

The survey collected two types of information on transportation: information about the demand for public transportation and data on the direct consumption of fuels (gasoline and diesel) for private vehicles.

Information collected on the use of public transportation consists of detailed data on the characteristics of household travel patterns -- the purpose of travel, the distances and frequency of trips by various modes of public transport. This information, in combination with secondary data on the energy intensity and loading factors of various modes (public buses, taxis, bemos, and bajaj) yet to be collected, will be useful in making estimates of the household component of public transportation energy needs.

The breakdown of the total kilometers travelled by mode and purpose is shown in Table 11. The average household travels 6,942 kms per year using public transport. The bus is the most popular mode of public transport accounting for 38 percent of the total kilometers travelled, followed by the bajaj and private car. The bus is used mostly for travel to school and work. An analysis of the total distance travelled by purpose shows that public transport is most specifically for travel for other purposes, such as

TABLE 11
Public Transport Demand
(Kms Per Year)

Mode	Kilometers by Purpose _a/ Work	School	Market	Other	Total Kilometers	Average Kms/Household _b/	% of Total
Bus	1,281,359	2,397,382	253,596	92,820	4,025,157	2,631	37.90
Taxi	11,284	-	1,248	6,391	18,923	12	0.18
Bajaj/Bemo	118,000	112,590	282,744	1,289,562	1,802,896	1,178	16.98
Oplet	340,290	368,676	100,730	148,365	958,061	626	9.02
Ojek	1,710	16,380	1,144	17,568	36,802	24	0.35
Becak	33,784	105,764	26,180	571,578	737,306	482	6.94
Private Car	650,091	517,426	2,076	536,751	1,706,344	1,115	16.07
Train	28,800	6,240	-	1,300,000	1,335,040	873	12.57
Total Kms.	2,465,318	3,524,458	667,718	3,963,035	10,620,529	6,942	100.00
Avg. Kms/ Purpose Across Modes	1611	2304	436	2590	6942		
% of Total	23.21	33.19	6.29	37.31	100		

_a/ The data are reported for all cities except Malang.
_b/ Averages are computed for 1530 households.

recreational travel. Travel to work is the third most important purpose of travel by public transportation, which appears to be a surprising result.

2.6.1 Fuels for Private Vehicles

In the detailed breakdown of transport fuel consumption by mode shown in Table 12, gasoline emerges as the most important transport fuel accounting for 94% of total household transport fuel consumption, 4,201 boe annually. This is equivalent to an annual consumption per household of 2.57 boe, or 0.43 boe per capital. Automobiles and motorcycles are the two modes consuming the major share of this fuel. Table 13 shows that approximately two-thirds of the total demand is accounted for by high-income households using motor cycles and automobiles. Among low-income households, gasoline is primarily for use in motor cycles, accounting for 6 percent of annual gasoline consumption.

2.7 End-Use Energy Including Private Vehicle Use

The inclusion of fuels for private vehicles increases the estimate of annual household consumption to an aggregate level of 11,463 boe, which is equivalent to 7 boe per household, and 1.17 boe per capita. Kerosene remains the most important of domestic fuels accounting for 46 percent of total fuel demand.

The relative importance of fuels and categories of end use with the inclusion of transport energy is shown in Table 14.

Cooking remains the main end-use requirement, accounting for 52 percent of the total, followed by transport which accounts for 39 percent. Lighting and appliance use jointly account for approximately 9 percent.

TABLE 12
Private Transport Energy Consumption Per Year by Fuel Type
(1636 households, boe/year)

Mode	Diesel	Gasoline	Total Fuel
Auto	96.12	1991.88	2088.00
Bajaj/Bemo	0	82.68	82.68
Oplet	61.70	86.22	147.92
Motor Cycle	104.86	2040.37	2145.23
Total consumption	262.7	4201.2	4463.8
Average per household	0.16	2.57	2.73
Average per capita	0.026	0.428	0.455

TABLE 13
Private Transport Energy Consumption Per Year by Income Group
(1636 households, boe/year)

	Income Groups			
Mode	All	Low	Medium	High
Auto	2088.0	8.5	253.1	1839.2
Bajaj/Bemo	82.7	0.0	56.5	26.2
Oplet	147.9	5.9	39.1	102.9
Motor Cycle	2145.2	275.9	621.5	1247.4
Total consumption	4463.8	290.33	970.2	3215.7
Average per household	2.73	0.43	1.58	5.25
Average per capita	0.455	0.067	0.27	0.89

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TABLE 14
Annual Consumption - All Uses
(1636 Households, boe)

Fuels	Cooking	Lighting	Appliances	Transport	Total end use
Kerosene	5115.54	252.29	-	-	5367.83
Electricity	-	417.11	371.22	-	788.33
LPG	324.13	-	-	-	324.13
Wood	294.66	-	-	-	294.66
Charcoal	213.53	-	-	-	213.53
City Gas	10.86	-	-	-	10.86
Diesel	-	-	-	262.70	262.70
Gasoline	-	-	-	4201.20	4201.20
Total	5958.72	669.39	371.22	4463.90	11463.24
% of total	52.0	5.8	3.2	38.9	100.0
Total energy demand per household	3.64	0.41	0.23	2.73	7.01

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2.8 Trends in Urban Energy Consumption: 1981 - 1985

To complement the information on end-use consumption of fuels, respondents were querried about their energy consumption trends and preferences, about the share of energy expenditures in the household budget, and about other household characteristics relevant to energy consumption patterns. These aspects of the survey results which provide useful qualitative background information are discussed in the following sections.

The widest perception among households was the feeling that their consumption patterns during the past five years had remained relatively stable. For each of the major fuels (gasoline, electricity, kerosene, and LPG), 76 - 80 percent of households reported that no change had occurred in the quantities of fuel consumed during the period 1981 - 1985.

A significant proportion of kerosene using households reported that consumption had increased during this period. Of these, nearly one half cited growing household size as the major reason for increased consumption, while a quarter indicated that increased income had made kerosene more affordable.

Among the relatively few kerosene using households reporting a decline, 29 percent cited higher prices as the major reason for reducing their consumption. But other reasons, such as smaller families were cited as the reason by almost as many households.

Reported increases in urban kerosene consumption during the past five year period run counter to the observed overall decline in national kerosene sales of recent years. Although the available sales data do not easily allow a disaggregation of sales by major sectors, this result may not be necessar-

ily inconsistent. It is possible that the decline in aggregate sales is accounted for by lower rural or industrial consumption, and that urban sales continue to grow in rough proportion to population growth in the urban areas. This is not unreasonable because rural households, across a wider range of incomes, have access to cheaper biomass fuels for cooking; and kerosene has substitutes when used as an industrial fuel. In urban household use there are few convenient, and affordable substitutes for kerosene. If survey responses are an accurate reflection of reality, the implication for policy purposes is that measures to manage the growth of kerosene demand should place emphasis on providing urban consumers with affordable and convenient substitutes, since price measures alone are unlikely to result in significant changes in the pattern of urban consumption.

Increased consumption of both gasoline and electricity was also primarily attributed to the growth of households and to higher incomes among those who reported an increasing trend. Higher prices, or declining incomes were cited as primary reasons for reduced consumption among those who reported decreasing consumption of these energy sources.

Responses to questions concerning consumption trends are summarized in Table 15. In general, the pattern of responses suggests that while energy consumption levels have remained fairly stable during the past five years, demographic changes and higher incomes have probably exerted upward pressure on urban energy consumption levels and have outweighed the impact of higher prices.

TABLE 15
Changes in Fuel Consumption Patterns, 1981-1985.

	Gasoline		Electricity		Kerosene		L P G	
No. of households reporting consumption increases due to:		(%)		(%)		(%)		(%)
- increase in household size	33	38	82	40	66	47	6	20
- increase in affordability	22	26	60	29	33	24	6	20
- increase in number of appliances	11	13	17	8	15	11	4	13
- other reasons	20	23	47	23	26	19	14	47
Total	86	100	206	100	140	100	30	100
No. of households reporting consumption decrease due to:		(%)		(%)		(%)		(%)
- household size	5	26	11	28	13	25	2	100
- higher prices	7	37	15	38	15	29	0	0
- lower income	4	21	13	33	12	24	0	0
- other reasons	3	16	1	3	11	22	0	0
Total	19	100	40	100	51	100	2	100

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2.9 Fuel Preferences

The survey confirmed the importance of kerosene and electricity among urban households of all income groups. The selection of fuels is determined by an interaction of factors: price and income, the availability of substitutes and the convenience of use are among the most important determinants. A qualitative assessment of the relative importance of these factors was undertaken during the survey by asking each household for its reasons for not consuming a particular fuel. The results are shown in Table 16.

Since electricity in the urban environment is used primarily for lighting and appliance use, and has no substitutes, it was not surprising that low income households who do not at present consume electricity identified incomes as the main barrier.

For low-income households the high cost of obtaining an electricity connection was the most frequently cited reason for not consuming electricity. Of 161 responding households without electricity, "high investment costs" rather than price was the major barrier.

City gas and LPG are possible substitutes for kerosene for cooking. However, the supply of these fuels, particularly city gas, is presently limited. The availability of city-gas is restricted to only a few urban areas in the country, which imposes a binding constraint on its wider use. An additional restraint on expanded use of both these fuels is the high investment costs associated with their use.

Wood and charcoal in the urban environment are often viewed as inferior fuels from the standpoint of convenience. This perception was widely report-

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TABLE 16
Household Fuel Selection

		Reasons for Not Using a Fuel							
Fuel	Number of Responding Households	High Investm. Cost	% of Total	High Price	% of Total	Unavail. Supply	% of Total	Incon-venience	% of Total
Electricity	161	113	70	29	18	15	9	4	2
Kerosene	131	18	14	28	21	8	6	77	59
L P G	1462	918	63	405	28	78	5	61	4
City Gas	1621	643	40	230	14	700	43	48	3
Wood	1511	23	2	31	2	216	14	1241	82
Charcoal	1275	16	1	45	4	93	7	1121	88

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ed among those households who do not consume these fuels (a majority of the sampled households). This finding is relevant to future attempts at promoting substitutes for kerosene. Some consideration, for example, has been given to the possiblity of promoting the use of briquetted biomass residues, and charcoal as urban cooking fuels. The survey results indicate a need for a more detailed examination of consumer acceptance of such fuels before such policies are adopted.

2.10 Energy Expenditures and the Urban Budget

Thus far we have made references to the pattern of fuel consumption, pattern of device ownership and pattern of fuel preferences. To complete the basic profile of energy consumption within an urban household, the questionnaire requested information on the annual amounts expended on food, clothing, housing, fuel and light, transportation, durable goods, saving and other miscellaneous expenditures. This data permits one to place energy in the financial context of the urban household, and thereby allows a better understanding of energy decisions. The expenditure data were also used to classify households according to income (using expenditures as a surrogate for income).

Since the categories of expenditure are consistent with the SUSENAS format, this information should also permit a future comparison of the survey results with the SUSENAS survey. It should be noted that the questions on expenditure patterns were necessarily limited in number, and not as detailed as the comparable sections of the SUSENAS survey. As a result, it is likely that responses obtained in the present survey may not be as reliable as those obtained in the SUSENAS survey. Nonetheless, the information collected is

useful for relating energy expenditures to household income and expenditure as a whole.

Expenditure patterns among households of low-, middle-, and high-income groups is shown in Table 17. Among all surveyed households, energy expenditures averaged approximately 17 percent of total annual expenditures, although there were considerable variations in this ratio from a low of about 13.5 percent in Bandung, to a high of 25.5 percent in Semarang. The data confirm an expected decrease in the share of energy with rising income. The few cases which do not follow this general pattern in particular cities, probably reflect underlying uncertainties in the quality of collected information.

2.10.1 The Influence of Income and Price on Fuel Consumption

Kerosene occupies a dominant role in urban energy consumption, as we have already noted. Accordingly, a very preliminary attempt was made to analyze the effect of household income and prices on levels of kerosene consumption using regression techniques. The primary limitation in this analysis was the need to use group means instead of direct household data on consumption, expenditures and prices. (Original data tapes created in Indonesia were not in a form that allowed easy transportability to U.S. computers where this analysis was undertaken.) As a consequence, the results presented here are primarily for illustrative purposes. It is recommended that a similar analysis be undertaken in Indonesia in the near future using the original household-level information. This step should result in a considerable improvement in the quality of analysis.

TABLE 17
Energy Expenditure as Share of Annual Household Expenditures
(Per Cent)

Cities	Income Groups			
	All	Low	Middle	High
Indonesia	16.9	17.6	15.2	15.9
Jakarta	17.0	17.0	14.9	17.2
Bogor	15.0	9.4	9.9	17.5
Bandung	13.5	16.7	16.7	10.9
Semarang	25.5	21.0	21.1	30.2
Surabaya	15.6	18.0	15.2	5.7
Yogyakarta	14.4	17.7	14.0	11.9
Ujung Pandang	20.0	18.5	17.2	20.7
Medan	15.0	16.5	14.0	12.9

The regression analysis employed kerosene consumption data which were pooled for the eight cities, yielding twenty-four data points. Using a log-linear equational form, per capita kerosene consumption was regressed on price and per capita income. This first specification yielded unsatisfactory results, in which only 5 percent of the observed variation in kerosene consumption was explained by the independent variables (income and price). The use of group means probably accounts for this result. To overcome this limitation, a second specification was employed in which three dummy variables were added to the same log-linear equational form.

This specification resulted in a high R-squared of 0.99. The estimated price elasticity of 0.93 was statistically insignificant and of the wrong sign, while the income elasticity of 0.94 was significant at the 95 percent confidence level. Results of both exercises are summarized in Exhibits A.1 and A.2 in the Appendix.

In order to improve the quality of these results, it is recommended that the regression analysis be repeated using individual household data. This would result in a much larger cross section of observations, and would probably yield quite a different set of estimates of both price and income elasticities. It should be noted, however, that for more realistic estimates of price elasticities, time series data are essential. Therefore, the real value of the present data in the context making behavioral predictions is quite limited.

3. URBAN AND RURAL HOUSEHOLDS COMPARED

Urban and rural consumers of energy are likely to display very different patterns of consumption which are relevant to policy makers' concerns. Providing access to adequate levels of energy and to particular forms of energy to all consumers is one area of concern. Also of concern is the need to promote the efficient use of national energy and economic resources, but such policies will usually need to be tailored to specific sectors. Among households, patterns of consumption will probably vary considerably among rural and urban regions, requiring policies which will differ in emphasis. The present survey provides a preliminary basis for comparing rural and urban energy consumption patterns, since its methodology and definitions are consistent with the 1980 rural household survey undertaken by DJL.

There are significant differences to be noted in both the level and composition of fuel demand of each sector. (For purposes of this comparison, attention is confined to cooking and lighting requirements.) Rural households, according to results of the 1980 survey,[6] consume an average of almost 7 boe annually, mostly in the form of wood for cooking. This level of consumption is equivalent to approximately 1.33 boe per capita. The use of kerosene, the only other rural fuel of significance, was estimated at an annual level of approximately 2.1 boe (0.4 boe per capita). While some kerosene consumption in rural areas is for cooking, its primary use is as a lighting fuel. (This is related to the virtual absence of electricity in the areas covered by the 1980 survey, a phenomenon that may now be changing with

[6]Chatterjee, R., "Energy Consumption in Rural Households," Energy Planning for Development in Indonesia, Energy/Development International, October 1981.

the increasing pace of rural electrification in intervening years.) Because of the low relative efficiency of wood consumption for cooking, the basic energy demand (useful energy at end use) of the average rural household was estimated in 1980 to be a much lower figure of approximately 1.19 boe (0.22 boe per capita). These findings are summarized in Table 18.

By contrast, the average urban household consumes considerably less fuel: an annual fuel demand of 4.28 boe (0.7 boe per capita). However, urban consumption in terms of useful energy delivered for particular uses is almost 50 percent higher: a basic energy demand level of 1.75 boe per urban home. In per capita terms, the average urban resident consumes a little over 30 percent more than his rural counterpart (0.29 boe per capita, annually). This difference is attributed to the greater reliance on kerosene and other commercial fuels converted to useful energy for cooking at significantly higher efficiencies than wood. Higher levels of per capita basic energy requirements for cooking among urban consumers probably reflect underlying differences in income although such a conclusion must be substantiated by further study. An unexplained difference is noted in lighting requirements: the average rural household, by 1980 survey estimates consumed significantly more useful energy than the average urban household (80 percent more, in per capita terms). This suggests that in an urban setting, the average household, while displaying a more diverse set of energy uses (in the form of electrical appliance use), places less emphasis on lighting than the average rural household. The reasons for this difference are not intuitively obvious, and also bear further investigation.

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TABLE 18
A Comparison of Urban and Rural Household Fuel Consumption
(BOE Per Year)

Fuel	Rural Sector		Urban Sector	
	Per house	Per Capita	Per house	Per Capita
Fuel Demand				
Wood	4.92	0.93	0.18	0.03
Kerosene				
cooking	0.93	0.18	3.12	0.52
lighting	1.14	0.22	0.16	0.03
	2.07	0.4	3.28	0.55
Electricity				
lighting	-	-	0.25	0.04
others	-	-	0.23	0.03
			0.48	0.07
Charcoal	-	-	0.13	0.02
L P G	-	-	0.20	0.03
City Gas	-	-	0.01	-
Total fuel demand	6.99	1.33	4.28	0.70
Basic Energy Demand for Cooking & Lighting				
Cooking	0.73	0.13	1.44	0.24
Lighting	0.46	0.09	0.31	0.05
	1.19	0.22	1.75	0.29

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4. A COMPARISON OF URBAN ENERGY CONSUMPTION IN INDONESIA, THAILAND, AND SRI LANKA

It is useful to view the survey results from the perspective of a comparison with urban consumption patterns in other countries. Comparable data for other urban regions in the developing countries is sparse. However, similar information is available for Bangkok (Thailand) in 1980,[7] and for urban areas as a whole in Sri Lanka in 1979.[8]

Comparisons of Indonesia, Thailand, and Sri Lanka, made on an aggregate per capita basis, show that energy consumption for domestic uses (excluding transport) in Indonesia is very close to the consumption level of Sri Lanka (0.71 and 0.76 boe respectively). Urban consumption levels in Bangkok are considerably lower (0.5 boe), as shown in Table 19.

Because the data are limited, comparisons of both fuel composition and end-use consumption patterns are possible only for Bangkok (Table 19). By contrast with Indonesia, most households in Bangkok use LPG for cooking; kerosene use is negligible, either for cooking or lighting. There is a dramatic difference in overall fuel demand for cooking, which cannot be explained by the difference in fuel composition. Cooking requirements in Bangkok are about 0.22 boe per capita, compared with approximately 0.6 boe per capita for the average urban household in Indonesia. If the data are

[7]National Energy Administration, Royal Thai Government, Report on the Bangkok Urban Household Survey 1980, as quoted in "Energy Data Systems in Thailand," Suchai Limsumalee, National Energy Data Systems, Eds. D.R. Ahuja et al., Concept Publishing Co., New Delhi, 1984.

[8]DeSilva, L., Residential Fuelwood Demand Analysis in an LDC Context: A Case Study of Sri Lanka, Ph.D. Dissertation, George Washington University, Washington, D.C.

TABLE 19
Inter-Country Urban Energy Consumption Patterns
(BOE Per Year)

	Indonesia		Thailand _a/		SriLanka _b/	
Fuel	Per Capita	% of Total	Per Capita	% of Total	Per Capita	% of Total
Electricity	0.08	11.2	0.32	62.9	0.04	5.3
Kerosene	0.55	76.6	-	-	0.2	25.8
L P G	0.03	4.7	0.12	23.0	-	-
Charcoal	0.02	3.0	0.07	13.2	-	-
Wood	0.03	4.2	-	-	0.52	68.6
City Gas	insig.	-	-	-	insig.	-
Total Demand	0.71	100.0	0.51	100.0	0.76	100.0

_a/ Source: NEA: Report on the Bangkok Urban Household Survey (1980)

_b/ Source: DeSilva, L., Residential Fuelwood Demand Analysis in an LDC Context: A Case Study of Sri Lanka.

accurate, this difference may reflect underlying dietary differences. Lighting requirements, in per capita terms, in Bangkok, are almost twice as high as in Indonesia's urban household.

The average urban household in Sri Lanka is much more dependent on wood which accounts for almost 67 percent of total per capita consumption. Kerosene, which is next in order of importance (and is used primarily for cooking), accounts for approximately 26 percent of consumption. Urban electricity consumption in Sri Lanka is about half the level noted for Indonesian households.

5. SUMMARY AND RECOMMENDATIONS

5.1 Summary

The disaggregated view of urban energy use patterns among households provided by the survey will prove useful in assessing future policies to develop national energy resources, and to reduce the economic costs of supplying the nation's energy requirements. The importance of the household sector in the national energy balance has already been pointed out. The survey, as indicated in the discussion of results, provides important quantitative detail to the available information on consumption patterns in this sector.

The importance of kerosene in the average household's energy budget, at all levels of income, and in all the cities surveyed suggests that the demand for this fuel in the urban areas will continue to grow, as urban populations throughout Indonesia expand. Additional surveys, based on the methodology of the present survey, will be needed to understand changing consumption pat-

terns over time. The survey provides a base-line for future efforts to monitor such changes.

The information collected will prove immediately useful in undertaking quantitative policy evaluations of alternatives to the expanded use of kerosene through the introduction of new fuels, or in evaluating the impact of expanding electricity consumption on electricity load forecasts.

The potential for fuel substitutions in the urban sector is an important issue since kerosene continues to be a subsidized fuel. Furthermore, current plans at the national level call for considerably expanded production of LPG. The survey data allow a more detailed approach to forecasting the future use of LPG as a substitute fuel.

The survey accomplished all the major objectives of DJL: the establishment of a methodology for primary data collection; a preliminary data base for policy analysis compatible with DJL's overall information system; and analytical results from the pilot survey. In the remainder of this report we focus on recommended follow up actions for DJL's attention in the months ahead.

These recommendations focus on three broad areas:

(a) ANALYSIS: Further analysis to improve on the reliability of results reported in the present report; additional analysis, to complete the analysis we have reported on in this report, using some secondary data which was not possible to collect during the course of this project; selected applications of the survey data to analyze policy issues such as LPG substitution, and fuel price policy.

(b) TRAINING: Additional analysis should be accompanied by some additional training of DJL staff in the use of survey data.

(c) EXPANDING THE SURVEY BEYOND THE PILOT PHASE: The survey that has been completed was a pilot study to allow a more expanded data collection effort in the future. This expanded effort can draw on the experience of the pilot survey to improve the survey instrument and can selectively add to the list of cities to improve the overall reliability of the results.

Each of these areas are discussed in further detail in the remaining sections of this report.

5.2 Analysis

(a) Public Transport Energy Requirements

Analysis of the survey results in the area of public transportation requires some secondary data which was not possible to obtain in the allotted time. As we have pointed out in the discussion of results, the survey collected information on the pattern of personal transportation requirements in each major category of public transport (bus, taxi, bajaj, etc.). This information is essential to evaluate energy requirements of urban public transport. Additional data are required on fuel consumption coefficients and typical loading factors for each of the major transport modes: kilometers per liter of fuel, and the number of passengers per average trip. Annual distances travelled by each mode per household (from the survey) can be combined with this additional information to provide a profile of public transportation energy needs for the average urban household. The effort required is marginal, and can be relatively easily accomplished by obtaining representative data from a number of urban transportation studies that have been carried out by government agencies in recent years.

(b) Improving the Reliability of Energy Estimates

The reliability of estimates of energy consumption based on survey data rests ultimately on the reliability of the sample in terms of how representative it is of the population as a whole. The present survey relied upon the SUSENAS sample frame. The scope of the present study did not allow an evaluation of the SUSENAS sampling design.

With some small additional effort, the reliability of the results presented in this report can be improved. As a first step we suggest that the existing sample of approximately 1650 households should be reduced after a more careful examination of the questionnaires to account for reporting errors and missing data. (A number of inconsistencies were noted in the course of analysis: for example, the exact count of electricity using households, based on billing information is inconsistent with those households reporting the use of electrical devices.) This step should result in reducing the dispersion of energy estimates noted in the present analysis.

A second step involves regrouping households according to a more refined set of income classes. The present analysis revealed that there was a very high dispersion of energy consumption levels within the three chosen income groups. Because of the logistical problems of data analysis it was not possible to do several inspections of the data to refine the income group classification.

The choice of income groups for the present analysis was based on the SUSENAS survey classification in which eleven income groups are used. Our analysis reduced the number of income groups to three by aggregation. A more appropriate approach to reduce the noted dispersion would be to inspect the

observed scatterplots of fuel consumption and household income, and then to select boundaries for income group classification on the basis of observed "break points" in the scatterplots. This process can be repeated t eventually provide a set of income groups that is more relevant to energy consumption patterns than those employed by SUSENAS, which are probably most suited to an analysis of household expenditure patterns as a whole. The use of narrower income group boundaries should reduce the high dispersions noted.

(c) Applications of the Survey Data to Policy Analysis: LPG Demand Forecasts*

The disaggregated view of energy use patterns among households is useful in assessing a number of important policy issues such as the potential for fuel substitution in the urban sector. LPG policy is an example.

The Government of Indonesia is actively examining the benefits of a national policy to encourage the use of LPG. Provided that its economic value in alternative future uses exceeds production costs, it is possible that a national LPG fuel substitution policy can result in significant increases in net foreign exchange earnings. The potential for such substitution may be quite large, given the very small share of LPG in national petroleum product demand at present: less than one half of one percent of the total.

The future use of LPG as a cooking fuel to substitute for kerosene is of obvious relevance to such a policy. As we have pointed out, only 8 percent of the surveyed households reported using LPG. This low proportion of house-

*Data for the following discussion were drawn from the EPFDII main report and from informal communications with DJL.

holds is consistent with available LPG sales information, from which it is estimated that this fuel accounts for approximately 1.5 percent of residential energy requirements. At the same time, the residential market is at present the most important component of national LPG sales, accounting for almost 70 percent of total sales.

LPG production and supply capacity expanded rapidly from 7,000 metric tons in 1971 to a level of 686,000 tons in 1984. This level of production is expected to expand even more dramatically in the immediate future, as four new refineries, with considerably expanded LPG capacity are commissioned. On the basis of present refinery expansion plans, LPG production is expected to rise to a level of nearly 4,000,000 tons per year by 1990.

The small domestic market for LPG has meant that approximately 84 percent of annual production is earmarked for export. But foreign exchange earnings from LPG is recent years have faced major downward pressure due to changing world market conditions. Indonesian propane prices have declined between 1981 and 1985 from a level of US $417 per ton to US $245 per ton.

The share of imports in total kerosene consumption is expected to decline over the next ten year period, but imports will continue to be important in absolute terms. Imports of kerosene in 1984 amounted to approximately 17 mboe. Current projections of production capacity and consumption growth suggest that by 1992 annual kerosene imports will fall slightly to 16 mboe.

The major rationale for an LPG substitution policy in the household sector is that LPG can substitute for imported kerosene at considerable net

benefit to the country's foreign exchange position. Based on the energy values of kerosene and LPG, and based on projected import and export prices of these fuels, a calculation of these benefits shows that each ton of exported LPG, if substituted for domestic kerosene consumption, would result in net foreign exchange gains of US $44.00 at present prices, rising to US $74.00 in 1990, and US $70.00 by 1995.

The Government is now commissioning a major study of the potential future market for LPG. Preliminary results indicate that LPG residential sales may grow between the period 1985 to 2005 at an annual rate of 12 percent, to an estimated level of 415,000 tons in 1995 and 785,000 tons in 2005.

These projections are based on key underlying assumptions. It is assumed that upper income groups will be the primary source of sales growth, and that future penetration rates will be based on historical growth rates exhibited in the period 1975 - 1984. It is also assumed that relative prices of kerosene and LPG will remain constant, and that the start-up costs of LPG consumption borne by the individual household will not change. The national estimates of future demand are also based on assumptions about national economic growth and regional population growth patterns.

These projections need to be supplemented by a more detailed analysis of fuel substitution possibilities based on the present survey. The projections of future demand do not explicitly consider the potential for such substitution: future LPG sales growth is based on a relatively simple extrapolation of past sales behavior. A supplementary approach would require simulating alternative substitution scenarios using survey data in a RESGEN modelling framework now available to DJL.

Such an approach can project a more varied set of scenarios, including a consideration of alternative policies to subsidize the use of LPG among middle- and low-income households. This would require a more detailed approach to projecting market penetration of LPG using survey data on current patterns of expenditure and consumption among households at different income levels. (Necessary secondary information on stove costs, bottle deposits and other start-up costs are already available.)

A more complete analysis of the net benefits to the national economy of particular scenarios will necessarily focus on the relative costs of subsidizing LPG users compared with existing subsidies to kerosene users. This involves answers to three separate questions:

Will there be a net gain in foreign exchange earnings by displacing kerosene with LPG (i.e., will the fob value of LPG exports exceed the import cost of kerosene)?

Will the delivered cost of LPG to the consumer (after adjusting for thermal efficiency and operating costs) be less than the delivered cost of kerosene?

Will the value of LPG used for residential purposes exceed the incremental costs of production?

While such an expanded examination of the future market for LPG will involve some additional data collection, the effort should prove valuable in providing the Government with a more robust set of policy alternatives. Moreover, such applications are the primary reason for consumption surveys of the present type.

(d) Examining Subsidy Issues and Other Fuel Substitution Possibilities

We recommend that the survey data be used in the near future to undertake a study of particular subsidy issues. Kerosene subsidies, while much reduced through higher consumer prices that have been implemented in recent years, continue to absorb national resources. The disaggregated data from the survey can be used to examine the distribution of subsidies among income groups.

The survey indicates the proportion of energy expenditures on kerosene and quantities consumed by income group. The highest income group consumes 24 percent more kerosene compared to the lowest group and 8 percent more than the middle group. The total subsidy and its distribution can be calculated using a combination of survey data, secondary information on production costs, distribution and refinery margins and income distribution patterns in the urban population.

In addition, we recommend that the data be used to conduct a more adequate cross-sectional regression analysis, along the lines described earlier, using information on fuel prices, household size, and income to estimate income and price elasticities.

We have pointed out the drawbacks of using cross-sectional survey data to estimate elasticities since the data reflect observable differences in behavioral patterns at only one point of time. This can be overcome by pooling the survey data with the earlier SUSENAS data. The urban sample was drawn from the SUSENAS sample and should be comparable. Such elasticities should be useful in evaluating the impact of proposed changes in energy policy and when demand forecasts are required.

In conclusion, we recommend that the follow-on analysis recommended above should be viewed as an important task, for implementation in the relatively short-term. Using the collected information will strengthen the ability of DJL to continually update the results of the survey.

5.3 Training

The additional analysis we have recommended should be undertaken in conjunction with a concentrated, two to three week training program of DJL's staff. While a concentrated training effort was included in implementing the survey, the proposed training effort should be broader. It should focus on both the methodology of the present survey, and on applied uses of the data. The Institute of Teknologi staff at the Development Research Centre, who participated in implementing the survey, are fully equipped to undertake such training.

5.4 Recommendations for Expanding the Survey Effort

In considering what appropriate future data collection steps should be undertaken, two recommendations are relevant:

(a) the number of cities should be expanded. This will improve the reliability of aggregate results, and should also provide a clearer view of regional variations in the pattern of urban consumption. The case for such an expanded survey is strenghtened by DJL's effort to now create a better data base for regional analysis of energy policy options.

In any future expansion of the survey, we recommend that some categories in the questionnaire can be conveniently excluded to reduce costs. Among potential areas for exclusion are the sections of the present questionnaire

dealing with public transportation demand. This recommendation is made not for the reasons that the data generated are not useful. On the contrary, the present survey goes beyond other similar surveys in having included this important area of investigation. On the other hand, inclusion of public transportation demand in the scope of the survey considerably adds to the time required for interviews. Any expanded effort will necessarily confront the matter of incremental costs.

It has been estimated that these costs are likely to be US $3,750.00 per additional city, if it is assumed that 150 households per additional city are surveyed. (This estimate of US $33.00 per household includes the costs of field-work and analysis, using representative costs at ITB, Bandung.)

(b) Early plans should be made for a resurvey of the cities covered by the present pilot study, for implementation within the next three to four years. This recommendation is made on the grounds that the real utility of such information as is contained in the present survey will be much greater if available in time serial form. This would allow more adequate techniques of analysis than data for one point in time allow. Appropriate institutional arrangements might include the implementation of field work by Bureau Pusat Statistik, or other suitable national survey organizations.

APPENDIX

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STATISTICAL TABLES

TABLE A.1
Total Annual Fuel Consumption & Annual Consumption Per Household and Per Capita by City
(BOE)

ALL CITIES

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	788.33	11.26	166.71	6.49	308.80	11.60	312.81	17.67
Kerosene	5367.83	76.69	2052.76	79.96	2189.48	82.24	1125.59	63.59
L P G	324.13	4.63	12.92	0.50	60.66	2.28	250.57	14.16
Charcoal	213.53	3.05	129.53	5.05	52.26	1.96	31.71	1.79
Wood	294.66	4.21	204.93	7.98	46.30	1.74	43.43	2.45
City Gas	10.86	0.16	0.24	0.01	4.79	0.18	5.83	0.33
Total fuel consump:	6999.34	100.0	2567.09	100.0	2662.28	100.0	1769.95	100.0
Total households:	1636		674		613		349	
Avg. consump/house:	4.28		3.81		4.34		5.07	
Avg. household size:	6.04		6.00		5.90		5.30	
Avg. consump/capita:	0.71		0.63		0.74		0.96	

JAKARTA

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	443.54	13.56	64.54	8.14	183.41	12.70	195.59	18.91
Kerosene	2559.27	78.25	684.73	86.36	1201.47	83.23	673.07	65.08
L P G	180.05	5.50	0.68	0.09	28.85	2.00	150.53	14.55
Charcoal	63.42	1.94	36.92	4.66	24.45	1.69	2.08	0.20
Wood	24.28	0.74	6.03	0.76	5.43	0.38	12.82	1.24
City Gas	0.22	0.01	0.00	0.00	0.00	0.00	0.22	0.02
Total fuel consump:	3270.77	100.0	792.91	100.0	1443.60	100.0	1034.29	100.0
Total households:	723.00		208.00		314.00		201.00	
Avg. consump/house:	4.52		3.81		4.60		5.15	
Avg. household size:	6.26		7.10		6.25		5.30	
Avg. consump/capita:	0.72		0.54		0.74		0.97	

Table A.1 (Cont'd)

BOGOR

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	12.90	14.83	2.25	7.78	2.36	10.11	8.28	23.9
Kerosene	63.03	72.49	26.21	90.43	19.97	85.44	16.85	48.71
L P G	9.46	10.88	0.00	0.00	0.00	0.00	9.46	27.3
Charcoal	1.56	1.79	0.52	1.79	1.04	4.45	0.00	0.0
Wood	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
City Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total fuel consump:	86.95	100.0	28.98	100.0	23.37	100.0	34.59	100.
Total households:	20.00		5.00		7.00		8.00	
Avg. consump/house:	4.35		5.80		3.34		4.32	
Avg. household size:	6.25		8.40		5.00		6.00	
Avg. consump/capita:	0.70		0.69		0.67		0.72	

BANDUNG

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% o Tota
Electricity	46.77	10.64	9.81	5.60	13.18	9.56	23.79	18.7
Kerosene	346.16	78.76	147.26	84.12	118.17	85.77	80.76	63.7
L P G	25.75	5.86	0.00	0.00	3.83	2.78	21.91	17.2
Charcoal	5.46	1.24	4.42	2.52	0.78	0.57	0.26	0.2
Wood	15.38	3.50	13.57	7.75	1.81	1.31	0.00	0.0
City Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0
Total fuel consump:	439.52	100.0	175.06	100.0	137.77	100.0	126.72	100.0
Total households:	120.00		51.00		39.00		30.00	
Avg. consump/house:	3.66		3.43		3.53		4.22	
Avg. household size:	5.75		6.10		5.30		5.50	
Avg. consump/capita:	0.64		0.56		0.67		0.77	

Table A.1 (Cont'd)

SEMARANG

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	23.84	8.36	10.68	6.13	9.18	10.32	3.99	17.90
Kerosene	207.07	72.60	132.82	76.31	56.32	63.35	17.93	80.47
L P G	0.10	0.04	0.00	0.00	0.00	0.00	0.10	0.47
Charcoal	4.94	1.73	4.16	2.39	0.52	0.58	0.26	1.17
Wood	44.49	15.60	26.39	15.16	18.10	20.36	0.00	0.00
City Gas	4.79	1.68	0.00	0.00	4.79	5.39	0.00	0.00
Total fuel consump:	285.23	100.0	174.05	100.0	88.90	100.0	22.28	100.0
Total households:	81.00		54.00		20.00		7.00	
Avg. consump/house:	3.52		3.22		4.44		3.18	
Avg. household size:	5.42		5.50		5.60		3.80	
Avg. consump/capita:	0.65		0.59		0.79		0.84	

SURABAYA

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	54.61	9.60	25.78	7.62	22.93	12.10	5.90	14.40
Kerosene	455.63	80.09	272.45	80.52	155.72	82.15	27.48	67.01
L P G	16.54	2.91	1.35	0.40	8.35	4.40	6.85	16.70
Charcoal	18.98	3.34	16.38	4.84	1.82	0.96	0.78	1.90
Wood	22.92	4.03	22.17	6.55	0.75	0.40	0.00	0.00
City Gas	0.24	0.04	0.24	0.07	0.00	0.00	0.00	0.00
Total fuel consump:	568.92	100.0	338.37	100.0	189.57	100.0	41.01	100.0
Total households:	144.00		95.00		41.00		8.00	
Avg. consump/house:	3.95		3.56		4.62		5.13	
Avg. household size:	5.95		6.00		5.70		5.20	
Avg. consump/capita:	0.66		0.59		0.81		0.99	

Table A.1 (Cont'd)

MALANG

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	23.57	5.16	10.42	3.46	8.58	8.64	4.57	8.03
Kerosene	315.71	69.07	192.44	63.96	82.68	83.29	40.56	71.31
L P G	7.59	1.66	5.41	1.80	1.25	1.26	0.94	1.65
Charcoal	25.74	5.63	18.73	6.22	6.76	6.81	0.26	0.46
Wood	84.45	18.48	73.89	24.56	0.00	0.00	10.56	18.5[illegible]
City Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total fuel consump:	457.05	100.0	300.89	100.0	99.27	100.0	56.88	100.[illegible]
Total households:	90.00		60.00		22.00		8.00	
Avg. consump/house:	5.08		5.01		4.51		7.11	

YOGYAKARTA

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% o Tota
Electricity	69.18	12.83	18.22	7.87	27.71	16.86	23.26	16.2
Kerosene	337.43	62.60	127.90	55.29	120.60	73.39	88.92	62.0[illegible]
L P G	5.60	1.04	0.00	0.00	3.73	2.27	1.87	1.3
Charcoal	63.18	11.72	34.84	15.06	7.02	4.27	21.32	14.8[illegible]
Wood	63.64	11.81	50.37	21.77	5.28	3.21	7.99	5.5[illegible]
City Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.0[illegible]
Total fuel consump:	539.02	100.0	231.32	100.0	164.34	100.0	143.36	100.0
Total households:	124.00		59.00		38.00		27.00	
Avg. consump/house:	4.35		3.92		4.32		5.31	
Avg. household size:	5.55		5.90		5.60		4.50	
Avg. consump/capita:	0.78		0.66		0.77		1.18	

Table A.1 (Cont'd)

UJUNG PANDANG

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	49.14	7.45	10.75	3.31	15.94	5.79	22.45	20.65
Kerosene	555.38	84.20	254.60	78.47	243.98	88.64	56.78	52.22
L P G	35.46	5.38	4.58	1.41	7.00	2.54	23.88	21.96
Charcoal	1.04	0.16	0.26	0.08	0.78	0.28	0.00	0.00
Wood	12.97	1.97	54.29	16.73	7.54	2.74	0.00	0.00
City Gas	5.62	0.85	0.00	0.00	0.00	0.00	5.62	5.17
Total fuel consump:	659.60	100.0	324.48	100.0	275.23	100.0	108.73	100.0
Total households:	168.00		78.00		68.00		22.00	
Avg. consump/house:	3.93		4.16		4.05		4.94	
Avg. household size:	6.01		6.60		5.20		6.00	
Avg. consump/capita:	0.65		0.63		0.78		0.82	

MEDAN

Fuel	All Income		Low Income		Middle Income		High Income	
	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total	Total Consumption	% of Total
Electricity	64.78	9.36	14.25	5.70	25.53	10.63	25.00	12.37
Kerosene	528.32	76.31	214.50	85.80	190.48	79.32	123.32	61.00
L P G	43.57	6.29	0.90	0.36	7.66	3.19	35.02	17.32
Charcoal	29.12	4.21	13.25	5.30	9.10	3.79	6.76	3.34
Wood	26.54	3.83	7.09	2.83	7.39	3.08	12.06	5.97
City Gas	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Total fuel consump:	692.33	100.0	250.01	100.0	240.14	100.0	202.16	100.0
Total households:	166.00		64.00		64.00		38.00	
Avg. consump/house:	4.17		3.91		3.75		5.32	
Avg. household size:	6.07		6.80		5.80		5.10	
Avg. consump/capita:	0.69		0.57		0.65		1.04	

TABLE A.2

Inter-Urban Comparison of Annual Electricity Consumption (Kwhrs Per Year)

City	All Income		Low Income		Middle Income		High Income	
	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses
Indonesia	1180.6	1077	707.6	380	1171.9	425	1854.9	272
Jakarta	1545.1	463	963.9	108	1415.4	209	2160.7	146
Bogor	1040.0	20	727.2	5	544.3	7	1669.3	8
Bandung	979.6	77	585.8	27	924.0	23	1420.9	27
Semarang	674.7	57	506.5	34	870.8	17	1072.0	6
Surabaya	855.2	103	649.7	64	1087.7	34	1904.4	5
Malang	775.8	49	700.5	24	768.7	18	1052.6	7
Yogyakart	1062.7	105	612.1	48	1354.2	33	1563.0	24
Ujung Pan	921.6	86	525.5	33	694.7	37	2263.5	16
Medan	893.0	117	621.4	37	876.0	47	1221.8	33

TABLE A.3

Inter-Urban Comparison of Annual Kerosene Consumption (Liters Per Year)

City	All Income		Low Income		Middle Income		High Income	
	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses
Indonesia	608.6	1470	555.4	616	627.0	582	689.7	272
Jakarta	692.4	616	579.3	197	658.7	304	742.9	151
Bogor	583.6	18	873.6	5	475.4	7	468.0	6
Bandung	529.3	109	500.9	49	532.3	37	585.2	23
Semarang	479.3	72	471.0	47	494.0	19	597.6	5
Surabaya	562.5	135	510.2	89	683.0	38	572.5	8
Malang	604.8	87	562.7	57	626.4	22	845	8
Yogyakart	535.6	105	463.4	46	591.2	34	592.8	25
Ujung Pan	634.0	146	606.2	70	666.6	61	630.9	15
Medan	599.0	147	638.4	56	529.1	60	663.0	31

TABLE A.4

Inter-Urban Comparison of Annual LPG Consumption (Kgs. Per Year)

City	All Income		Low Income		Middle Income		High Income	
	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses
Indonesia	293.6	138	230.7	7	223.0	34	322.9	97
Jakarta	308.3	73	85.0	1	240.4	15	330.1	57
Bogor	394.3	3	0.0	0	0.0	0	394.3	3
Bandung	229.9	14	0.0	0	159.7	3	249.0	11
Semarang	13.0	1	0.0	0	0.0	0	13.0	1
Surabaya	295.4	7	169.0	1	260.8	4	428.0	2
Malang	316.3	3	676	1	156	1	117	1
Yogyakart	175.0	4	0.0	0	233.0	2	117.0	2
Ujung Pan	277.0	16	190.7	3	218.8	4	331.7	9
Medan	320.4	17	113.0	1	191.4	5	397.9	11

TABLE A.5

Inter-Urban Comparison of Annual Charcoal Consumption (Kgs. Per Year)

City	All Income		Low Income		Middle Income		High Income	
	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses
Indonesia	131.4	325	131.5	197	107.8	97	204.6	31
Jakarta	110.3	115	119.1	62	106.3	46	59.4	7
Bogor	62.4	5	52.0	2	69.3	3	0.0	0
Bandung	54.6	20	55.3	16	52.0	3	52.0	1
Semarang	61.8	16	64.0	13	52.0	2	52.0	1
Surabaya	146.0	26	163.8	20	91.0	4	78.0	2
Malang	156	33	149.8	25	193.1	7	52	1
Yogyakart	332.5	38	290.3	24	156.0	9	852.8	5
Ujung Pan	104.0	2	52.0	1	156.0	1	0.0	0
Medan	83.2	70	78.0	34	82.7	22	96.6	14

TABLE A.6

Inter-Urban Comparison of Annual Wood Consumption (Kgs. Per Year)

City	All Income		Low Income		Middle Income		High Income	
	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses
Indonesia	1516.5	67	1385.6	51	1773.8	9	2139.4	7
Jakarta	1674.4	5	1040.0	2	936.0	2	4420.0	1
Bogor	0.0	0	0.0	0	0.0	0	0.0	0
Bandung	1326.0	4	1560.0	3	624.0	1	0.0	0
Semarang	3835.0	4	3033.3	3	6240.0	1	0.0	0
Surabaya	988.0	8	1092.0	7	260.0	1	0.0	0
Malang	2240.0	13	2123.3	12	0	0	3640	1
Yogyakart	1097.2	20	1085.5	16	1820.0	1	918.7	3
Ujung Pan	1118.0	4	6240.0	3	2600.0	1	0.0	0
Medan	1016.9	9	488.8	5	1274.0	2	2080.0	2

TABLE A.7

Inter-Urban Comparison of Annual City Gas Consumption (Cu. Meters Per Year)

City	All Income		Low Income		Middle Income		High Income	
	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses	Cons. per house	No. of Houses
Indonesia	517.1	7	80.0	1	1596.0	1	388.8	5
Jakarta	18.0	4	0.0	0	0.0	0	18.0	4
Bogor	0.0	0	0.0	0	0.0	0	0.0	0
Bandung	0.0	0	0.0	0	0.0	0	0.0	0
Semarang	1596.0	1	0.0	0	1596.0	1	0.0	0
Surabaya	80.0	1	80.0	1	0.0	0	0.0	0
Malang	0	0	0	0	0	0	0	0
Yogyakart	0.0	0	0.0	0	0.0	0	0.0	0
Ujung Pan	1872.0	1	0.0	0	0.0	0	1872.0	1
Medan	0.0	0	0.0	0	0.0	0	0.0	0

TABLE A.8

Inter-Urban Ownership and Use Pattern for Selected Electrical Devices

Device 1: Bulbs

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	1413	86.4%	522	80.7%	563	91.8%	328	94.0%
Jakarta	643	88.9%	166	79.8%	289	92.0%	188	93.5%
Bogor	19	95.0%	4	80.0%	7	100.0%	8	100.0%
Bandung	106	88.3%	43	84.3%	35	89.7%	28	93.3%
Semarang	61	75.3%	36	66.7%	18	90.0%	7	100.0%
Yogyakarta	108	87.1%	46	78.0%	36	94.7%	26	96.3%
Surabaya	127	88.2%	79	83.2%	40	97.6%	8	100.0%
Malang	70	77.8%	43	71.7%	20	90.9%	7	87.5%
Ujung Pandang	137	81.5%	55	70.5%	61	89.7%	21	95.5%
Medan	142	85.5%	50	78.1%	57	89.1%	35	92.1%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	127.3	329628.0	77.3	222025.0	129.9	321553.0	202.4	514734.0
Jakarta	142.1	403450.0	88.5	257300.0	123.8	368212.0	217.5	586668.0
Bogor	241.8	710861.0	120.0	419400.0	132.1	364885.0	398.8	1159320.0
Bandung	104.5	8244809.0	61.0	174123.0	99.6	248077.0	177.3	349278.0
Semarang	73.3	208269.0	61.8	180750.0	106.4	301200.0	47.1	110830.0
Yogyakarta	113.9	324838.0	63.3	195183.0	117.9	358150.0	198.3	508107.0
Surabaya	110.5	279704.0	99.3	250094.0	114.8	303902.0	206.6	451125.0
Malang	72.1	232296.0	63.8	233656.0	59.5	279180.0	93.6	212845.0
Ujung Pandang	83.1	207168.0	52.2	159047.0	78.4	197153.0	177.0	322293.0
Medan	179.9	274231.0	79.2	216867.0	275.8	268481.0	167.7	365461.0

Table A.8 (Cont'd)

Device 2: Fluorescent Lamp

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	1253	76.6%	451	69.7%	492	80.3%	310	88.8%
Jakarta	564	78.0%	129	62.0%	238	75.8%	179	89.1%
Bogor	15	75.0%	4	80.0%	5	71.4%	6	75.0%
Bandung	72	60.0%	21	41.2%	24	61.5%	27	90.0%
Semarang	62	76.5%	36	66.7%	19	95.0%	7	100.0%
Yogyakarta	100	80.6%	44	74.6%	32	84.2%	24	88.9%
Surabaya	123	85.4%	77	81.1%	38	92.7%	8	100.0%
Malang	59	65.6%	34	56.7%	19	86.4%	6	75.0%
Ujung Pandang	139	82.7%	57	73.1%	61	89.7%	21	95.5%
Medan	137	82.5%	49	76.6%	55	87.5%	32	84.2%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	65.9	165690.0	44.4	107449.0	60.1	142308.0	106.6	288054.0
Jakarta	62.8	172493.0	38.9	103299.0	54.7	141873.0	90.7	263582.0
Bogor	92.3	283560.0	41.3	148500.0	50.0	27480.0	161.7	537000.0
Bandung	56.6	176143.0	21.2	116914.0	35.6	78204.0	102.8	309267.0
Semarang	55.0	130338.0	40.6	98200.0	65.8	158345.0	100.0	219600.0
Yogyakarta	77.9	205688.0	37.2	82694.0	80.0	188681.0	149.0	453855.0
Surabaya	69.4	161089.0	58.9	142664.0	80.8	170928.0	116.9	291715.0
Malang	72.1	111459.0	36.7	81520.0	59.5	152485.0	93.6	151200.0
Ujung Pandang	60.0	137039.0	46.2	92932.0	52.4	127860.0	119.0	290281.0
Medan	84.8	163145.0	58.3	119792.0	75.7	137197.0	141.3	273582.0

Table A.8 (Cont'd)

Device 6: Air Conditioners

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	37	2.3%	1	0.2%	9	1.5%	27	7.7%
Jakarta	24	3.3%	0	0.0%	4	1.3%	20	10.0%
Bogor	1	5.0%	0	0.0%	0	0.0%	1	12.5%
Bandung	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Semarang	1	1.2%	0	0.0%	0	0.0%	1	14.3%
Yogyakarta	1	0.8%	0	0.0%	0	0.0%	1	3.7%
Surabaya	4	2.8%	1	1.1%	3	7.3%	0	0.0%
Malang	1	1.1%	0	0.0%	2	9.1%	0	0.0%
Ujung Pandang	2	1.2%	0	0.0%	0	0.0%	2	9.1%
Medan	3	1.8%	0	0.0%	1	1.6%	2	5.3%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	1256.2	2903820.0	3600.0	7776000.0	735.0	1782600.0	1343.2	3104543.0
Jakarta	1266.8	3062269.0	0.0	0.0	653.8	500850.0	1389.4	3601515.0
Bogor	1350.0	172800.0	0.0	0.0	0.0	0.0	1350.0	172800.0
Bandung	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Semarang	1500.0	225000.0	0.0	0.0	0.0	0.0	1500.0	225000.0
Yogyakarta	500.0	1800000.0	0.0	0.0	0.0	0.0	500.0	1800000.0
Surabaya	1850.0	5364000.0	3600.0	7776000.0	1266.7	4560000.0	0.0	0.0
Malang	100.0	216000.0	0.0	0.0	100.0	216000.0	0.0	0.0
Ujung Pandang	714.0	599760.0	0.0	0.0	0.0	0.0	714.0	599760.0
Medan	1266.7	3012000.0	0.0	0.0	100.0	144000.0	1850.0	4446000.0

Table A.8 (Cont'd)

Device 7: Televisions

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	1182	72.2%	406	62.8%	465	75.9%	311	89.1%
Jakarta	550	76.1%	128	61.5%	238	75.8%	184	91.5%
Bogor	17	85.0%	4	80.0%	7	100.0%	6	75.0%
Bandung	88	73.3%	31	60.8%	32	82.1%	25	83.3%
Semarang	60	74.1%	34	63.0%	19	95.0%	7	100.0%
Yogyakarta	91	73.4%	37	62.7%	30	78.9%	24	88.9%
Surabaya	103	71.5%	65	68.4%	32	78.0%	6	75.0%
Malang	49	54.4%	27	45.0%	15	68.2%	7	87.5%
Ujung Pandang	97	57.7%	37	47.4%	42	61.8%	18	81.8%
Medan	127	76.5%	43	67.2%	50	78.1%	34	89.5%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	58.4	99138.0	47.7	81048.0	57.5	99612.0	73.8	122049.0
Jakarta	57.7	99249.0	47.8	78412.0	55.7	94645.0	66.9	119674.0
Bogor	53.4	172800.0	50.5	102600.0	53.6	92442.0	55.0	72300.0
Bandung	52.8	91327.0	42.2	74868.0	49.5	91856.0	70.2	111060.0
Semarang	50.7	91728.0	38.1	61867.0	63.8	115143.0	76.1	173211.0
Yogyakarta	58.8	104796.0	37.6	65928.6	57.9	106788.0	92.7	162225.0
Surabaya	54.1	78246.0	49.7	65844.0	58.3	94781.0	79.2	124417.0
Malang	56.9	86131.0	37.7	72733.0	62.0	109080.0	120.3	88269.0
Ujung Pandang	68.9	140474.0	59.4	132888.6	68.1	131126.0	90.1	177880.0
Medan	65.7	95443.0	60.4	103116.0	57.9	92698.0	83.9	89778.0

Table A.8 (Cont'd)

Device 8: Refrigerators

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	422	25.8%	40	6.2%	177	28.9%	205	58.7%
Jakarta	246	34.0%	17	8.2%	104	33.1%	125	62.2%
Bogor	12	60.0%	1	20.0%	5	71.4%	6	75.0%
Bandung	22	18.3%	0	0.0%	6	15.4%	16	53.3%
Semarang	6	7.4%	0	0.0%	4	20.0%	2	28.6%
Yogyakarta	18	14.5%	1	1.7%	6	15.8%	11	40.7%
Surabaya	28	19.4%	12	12.6%	10	24.4%	6	75.0%
Malang	8	8.9%	1	1.7%	5	22.7%	2	25.0%
Ujung Pandang	35	20.8%	4	5.1%	15	22.1%	16	72.7%
Medan	47	28.3%	4	6.3%	22	34.4%	21	55.3%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	123.5	933990.0	110.7	632404.0	113.4	845156.0	134.6	1069178.0
Jakarta	116.9	911419.0	91.5	480918.0	103.1	804524.0	131.8	1060433.0
Bogor	172.9	1341660.0	55.0	475200.0	108.0	855360.0	246.7	1891320.0
Bandung	170.0	1465470.0	0.0	0.0	166.7	1305720.0	171.3	1518720.0
Semarang	110.8	91728.0	0.0	0.0	110.0	492750.0	112.5	972000.0
Yogyakarta	121.5	728960.0	89.0	768960.0	133.8	796320.0	117.8	688582.0
Surabaya	172.9	1236598.0	142.1	886691.0	220.0	1630890.0	155.8	1220940.0
Malang	96.1	719190.0	110.0	950400.0	117.0	838080.0	37.0	306360.0
Ujung Pandang	90.0	733783.0	83.8	723600.0	87.7	691200.0	93.7	776250.0
Medan	125.9	846715.0	145.0	411400.0	112.0	755218.0	136.6	1025486.0

Table A.8 (Cont'd)

Device 19: Water Pumps

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	317	19.4%	51	7.9%	101	16.5%	165	
Jakarta	194	26.8%	17	8.2%	68	21.7%	109	54.2%
Bogor	1	5.0%	0	0.0%	0	0.0%	1	12.5%
Bandung	18	15.0%	5	9.8%	2	5.1%	11	36.7%
Semarang	4	4.9%	1	1.9%	2	10.0%	1	14.3%
Yogyakarta	22	17.7%	2	3.4%	8	21.1%	12	44.4%
Surabaya	24	16.7%	11	11.6%	9	22.0%	4	50.0%
Malang	0	0.0%	0	0.0%	0	0.0%	0	0.0%
Ujung Pandang	20	11.9%	1	1.3%	6	8.8%	13	59.1%
Medan	31	18.7%	11	17.2%	6	9.4%	14	36.8%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	139.9	237503.0	126.9	166352.0	127.5	258841.0	151.8	246562.0
Jakarta	140.1	197457.0	114.7	143689.0	361.3	203505.0	154.7	202105.0
Bogor	100.0	144000.0	0.0	0.0	0.0	0.0	100.0	144000.0
Bandung	125.8	280067.0	139.0	78480.0	105.0	225900.0	123.6	381545.0
Semarang	146.2	138600.0	60.0	21600.0	177.5	220500.0	170.0	91800.0
Yogyakarta	200.2	225204.0	187.5	112500.0	196.8	289237.0	204.6	201300.0
Surabaya	112.6	167784.0	82.3	136581.0	119.2	240413.0	181.3	90175.0
Malang	400.0	672000.0	400.0	672000.0	0.0	0.0	0.0	0.0
Ujung Pandang	147.5	873900.0	150.0	1296000.0	125.0	1080000.0	157.7	746307.0
Medan	95.3	87958.7	103.1	53440.0	83.3	66480.0	94.3	124285.7

Table A.8 (Cont'd)

Device 13: Radio Cassettes

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	740	45.2%	199	30.8%	322	52.5%	419	120.1%
Jakarta	419	58.0%	92	44.2%	183	58.3%	144	71.6%
Bogor	10	50.0%	3	60.0%	2	28.6%	5	62.5%
Bandung	49	40.8%	14	27.5%	20	51.3%	15	50.0%
Semarang	17	21.0%	3	5.6%	11	55.0%	3	42.9%
Yogyakarta	40	32.3%	9	15.3%	17	44.7%	14	51.9%
Surabaya	50	34.7%	28	29.5%	19	46.3%	3	37.5%
Malang	18	20.0%	10	16.7%	5	22.7%	3	37.5%
Ujung Pandang	78	46.4%	27	34.6%	39	57.4%	12	54.5%
Medan	59	35.5%	13	20.3%	26	40.6%	20	52.6%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	28.1	24813.0	22.8	18896.0	28.2	22264.0	32.8	33764.0
Jakarta	29.3	26563.0	23.0	20806.0	28.0	21459.0	34.9	36493.0
Bogor	25.3	13950.0	13.3	6200.0	21.5	3420.0	34.0	22812.0
Bandung	19.9	12019.0	14.4	9486.8	21.4	14162.0	23.1	11668.0
Semarang	27.9	24317.0	23.3	23400.0	29.1	23181.0	28.3	29400.0
Yogyakarta	27.6	33665.0	16.0	24120.0	26.3	29565.0	36.7	44486.0
Surabaya	31.8	19177.0	26.0	13829.0	39.2	23927.0	70.0	37217.0
Malang	16.3	20901.0	14.0	10800.0	19.8	13464.0		63600.0
Ujung Pandang	26.3	25094.0	22.9	21573.0	26.9	24065.0	31.8	36360.0
Medan	30.3	24716.0	36.4	24946.0	31.3	28006.0	24.9	20289.0

Table A.8 (Cont'd)

Device 14: Cassette Recorders

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	320	19.6%	89	13.8%	116	18.9%	115	33.0%
Jakarta	126	17.4%	16	7.7%	53	16.9%	57	28.4%
Bogor	4	20.0%	1	20.0%	2	28.6%	1	12.5%
Bandung	22	18.3%	4	7.8%	3	7.7%	15	50.0%
Semarang	24	29.6%	16	29.6%	5	25.0%	3	42.9%
Yogyakarta	27	21.8%	8	13.6%	8	21.1%	11	40.7%
Surabaya	36	25.0%	21	22.1%	12	29.3%	3	37.5%
Malang	16	17.8%	10	16.7%	5	22.7%	1	12.5%
Ujung Pandang	21	12.5%	3	3.8%	7	10.3%	11	50.0%
Medan	44	26.5%	10	15.6%	21	32.8%	13	34.2%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	49.8	34148.0	25.9	15354.0	42.4	28509.0	75.6	54081.0
Jakarta	51.9	35670.0	25.4	6803.0	46.8	29074.0	64.2	49054.0
Bogor	42.5	65700.0	25.0	27000.0	65.0	115200.0	15.0	5400.0
Bandung	70.8	21951.0	20.0	7920.0	257.8	17520.0	92.4	26909.0
Semarang	21.0	14725.0	21.8	14910.0	11.2	6888.0	33.3	26800.0
Yogyakarta	43.9	52627.0	20.8	25113.0	34.4	39405.0	67.7	82255.0
Surabaya	35.6	17730.0	33.5	9760.0	30.6	16608.0	70.0	78000.0
Malang	25.6	12672.0	16.0	10720.0	34.0	12960.0	80.0	28800.0
Ujung Pandang	47.4	39909.0	12.3	9240.0	48.9	41091.0	56.0	47520.0
Medan	74.4	50142.0	38.1	40648.0	48.1	27783.0	144.9	93563.0

Table A.8 (Cont'd)

Device 12: Radios

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	202	12.3%	69	10.7%	49	8.0%	49	14.0%
Jakarta	65	9.0%	10	4.8%	32	10.2%	23	11.4%
Bogor	3	15.0%	1	20.0%	1	14.3%	1	12.5%
Bandung	10	8.3%	2	3.9%	5	12.8%	3	10.0%
Semarang	14	17.3%	10	18.5%	1	5.0%	3	42.9%
Yogyakarta	34	27.4%	15	25.4%	12	31.6%	7	25.9%
Surabaya	36	25.0%	20	21.1%	14	34.1%	2	25.0%
Malang	10	11.1%	4	6.7%	4	18.2%	2	25.0%
Ujung Pandang	14	8.3%	2	2.6%	6	8.8%	6	27.3%
Medan	16	9.6%	5	7.8%	9	14.1%	2	5.3%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	15.4	13676.0	13.2	12884.0	17.8	15582.0	14.3	11587.0
Jakarta	13.3	10514.0	9.5	10762.0	14.0	9424.0	14.0	11830.0
Bogor	5.0	3145.0	5.0	7200.0	5.0	435.0	5.0	1800.0
Bandung	17.3	4716.0	7.5	7200.0	25.6	4296.0	10.0	3760.0
Semarang	9.7	10706.0	9.1	11208.0	15.0	5400.0	10.0	10800.0
Yogyakarta	15.8	21880.0	11.2	20904.0	21.3	27223.0	16.3	14811.0
Surabaya	17.9	18169.0	18.5	7510.0	17.3	32402.0	17.5	19800.0
Malang	16.5	9360.0	12.5	11250.0	13.8	6750.0	30.0	10800.0
Ujung Pandang	16.2	13577.6	18.0	12960.0	17.3	14941.0	14.5	12420.0
Medan	21.6	11826.0	16.8	21528.0	26.9	7864.0	10.0	5400.0

Table A.8 (Cont'd)

Device 20: Video Recorders

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	152	9.3%	8	1.2%	43	7.0%	101	28.9%
Jakarta	79	10.9%	1	0.5%	22	7.0%	56	27.9%
Bogor	3	15.0%	0	0.0%	0	0.0%	3	37.5%
Bandung	12	10.0%	0	0.0%	1	2.6%	11	36.7%
Semarang	1	1.2%	0	0.0%	1	5.0%	0	0.0%
Yogyakarta	5	4.0%	1	1.7%	1	2.6%	3	11.1%
Surabaya	9	6.3%	3	3.2%	4	9.8%	2	25.0%
Malang	3	3.3%	1	1.7%	2	9.1%	0	0.0%
Ujung Pandang	18	10.7%	1	1.3%	4	5.9%	13	59.1%
Medan	22	13.3%	1	1.6%	8	12.5%	13	34.2%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	57.9	22867.0	78.3	26272.0	52.5	22129.0	58.5	22911.0
Jakarta	54.6	20266.0	40.0	19200.0	49.6	17954.0	56.9	21209.0
Bogor	81.7	30420.0	0.0	0.0	0.0	0.0	81.7	30420.0
Bandung	40.0	19880.0	0.0	0.0	40.0	960.0	40.0	21600.0
Semarang	30.0	21600.0	0.0	0.0	30.0	21600.0	0.0	0.0
Yogyakarta	85.0	35520.0	85.0	16320.0	100.0	108000.0	80.0	17760.0
Surabaya	82.8	51842.0	86.7	3067.0	60.0	60300.0	122.5	108090.0
Malang	45.0	11600.0	35.0	25200.0	50.0	4800.0	0.0	0.0
Ujung Pandang	47.2	11360.0	56.0	33256.0	45.0	8280.0	47.0	136470.0
Medan	71.4	27330.0	150.0	108000.0	59.4	17760.0	72.7	27013.0

Table A.8 (Cont'd)

Device 15: Irons

(a) Ownership Pattern

City	All Income		Low Income		Medium Income		High Income	
	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample	No. of houses owning	Percent of total sample
Indonesia	970	59.3%	266	41.1%	421	68.7%	283	81.1%
Jakarta	509	70.4%	102	49.0%	235	74.8%	172	85.6%
Bogor	11	55.0%	1	20.0%	3	42.9%	7	87.5%
Bandung	70	58.3%	16	31.4%	26	66.7%	28	93.3%
Semarang	34	42.0%	16	29.6%	12	60.0%	6	85.7%
Yogyakarta	71	57.3%	22	37.3%	26	68.4%	23	85.2%
Surabaya	86	59.7%	48	50.5%	31	75.6%	7	87.5%
Malang	34	37.8%	16	26.7%	13	59.1%	5	62.5%
Ujung Pandang	86	51.2%	28	35.9%	42	61.8%	16	72.7%
Medan	69	41.6%	17	26.6%	33	51.6%	19	50.0%

(b) Watt Size and Watt Hours Per Household

City	All Income		Low Income		Medium Income		High Income	
	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours	Watt size	Annual watt hours
Indonesia	285.8	82901.0	271.5	55415.0	282.9	73988.0	303.6	121317.0
Jakarta	288.8	91511.0	288.7	59510.0	283.9	77341.0	295.6	129583.0
Bogor	331.8	183900.0	300.0	162000.0	300.0	54000.0	350.0	224143.0
Bandung	273.3	66796.3	243.8	31987.5	257.9	35432.3	304.4	115810.7
Semarang	250.4	96667.0	243.8	66600.0	242.9	104875.0	283.3	155416.6
Yogyakarta	277.3	72261.0	259.1	55506.8	261.5	90396.1	312.4	67785.0
Surabaya	258.7	69393.0	236.7	50607.0	298.4	84247.0	234.3	129743.0
Malang	252.9	86909.0	259.4	101800.0	234.6	[illegible]	280.0	81000.0
Ujung Pandang	283.7	71178.0	278.5	45622.0	276.2	67551.0	312.5	123600.0
Medan	347.8	54273.0	332.4	22875.0	338.1	5678[illegible].5	378.4	76345.3

Exhibit A.1
Regression Results
Specification 1

LS // Dependent Variable is LC

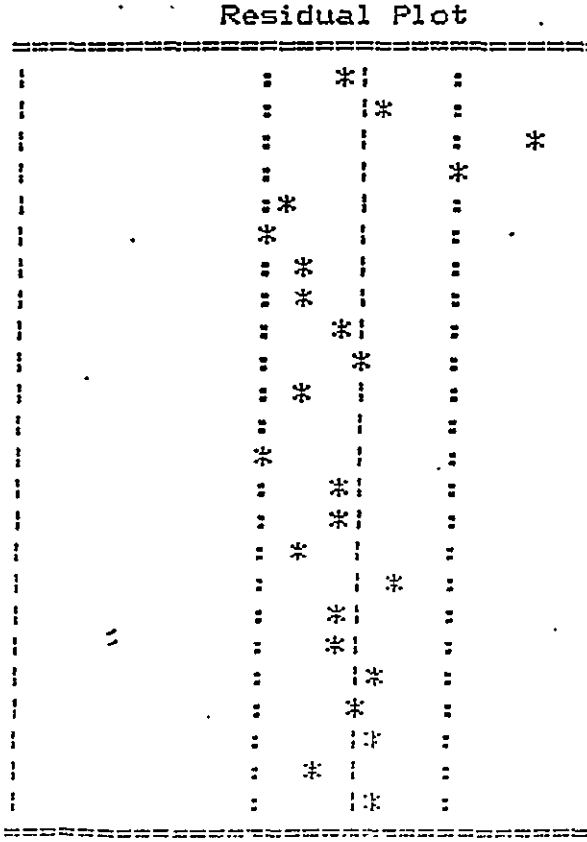
SMPL 1 - 24
24 Observations

	COEFFICIENT	STANDARD ERROR	T-STATISTIC
C	7.0107804	0.5714703	12.267970
LP	-0.1072300	0.1052519	-1.0187938
LI	0.0007821	0.0018977	0.4121492

R-squared	0.051278	Mean of dependent var	6.432228
Adjusted R-squared	-0.039077	S.D. of dependent var	0.301024
S.E. of regression	0.306849	Sum of squared resid	1.977283
Durbin-Watson stat	2.193333	F-statistic	0.567516
Log likelihood	-4.098562		

Covariance Matrix

C,C	0.32657829	C	-0.05978593
C,LI	0.00010715	LP	0.01107796
LP,LI	-2.0022D-05	LI	3.6012D-06



obs	RESIDUAL	ACTUAL	FITTED
1	-0.08145	6.36657	6.44802
2	0.04145	6.48990	6.44845
3	0.62203	7.07804	6.45601
4	0.31599	6.77262	6.45663
5	-0.29004	6.16416	6.45420
6	-0.30591	6.14847	6.45438
7	-0.22318	6.21639	6.43957
8	-0.16549	6.27719	6.44267
9	-0.07274	6.37197	6.44471
10	0.01875	6.15475	6.13601
11	-0.19907	6.25167	6.45075
12	0.99158	7.44503	6.45344
13	-0.32244	6.13407	6.45651
14	-0.06000	6.39641	6.45641
15	-0.07687	6.38486	6.46173
16	-0.20411	6.24582	6.44992
17	0.11818	6.57524	6.45706
18	-0.07123	6.38831	6.45954
19	-0.05402	6.40424	6.45825
20	0.03532	6.50219	6.46687
21	-0.03034	6.44720	6.47753
22	0.06242	6.44125	6.37883
23	-0.10926	6.27140	6.38066
24	0.06042	6.44572	6.38530

Exhibit A.2
Regression Results
Specification 2

LS // Dependent Variable is LC

SMPL 1 - 24

24 Observations

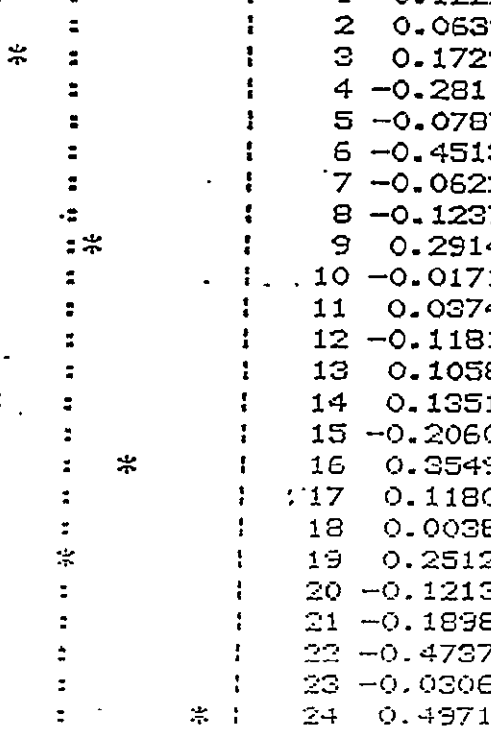
	COEFFICIENT	STANDARD ERROR	T-STATISTIC
LOW	-5.1684983	0.5353639	-9.6541770
MID	-5.6112758	0.5000375	-11.221711
HI	-6.1382300	0.4966416	-12.359477
LP	0.0186589	0.0931133	0.2003896
LI	0.9366368	0.0015920	588.33632

R-squared	0.999946	Mean of dependent var	-5.300270
Adjusted R-squared	0.999934	S.D. of dependent var	31.73735
S.E. of regression	0.257099	Sum of squared resid	1.255894
Durbin-Watson stat	1.722142	F-statistic	87616.57
Log likelihood	1.347947		

Covariance Matrix

LOW,LOW	0.28661455	LOW	0.25941927
LOW,HI	0.25759497	LOW	-0.04912571
LOW,LI	9.3984D-05	MID	0.25003746
MID,HI	0.24007591	MID	-0.04578440
MID,LI	8.6190D-05	HI	0.24665284
HI,GENRLP	-0.04546258	HI	8.3571D-05
LP, LP	0.00867009	LP	-1.6408D-05
LI,LI	2.5345D-06		

Residual Plot



obs	RESIDUAL	ACTUAL	FITTED
1	0.12227	6.36657	6.24430
2	0.06390	6.48990	6.42600
3	0.17291	7.07804	6.90513
4	-0.28114	6.21639	6.49753
5	-0.07872	6.27719	6.35591
6	-0.45136	6.37197	6.82333
7	-0.06222	6.15475	6.21698
8	-0.12379	6.25167	6.37546
9	0.29147	7.44503	7.15355
10	-0.01715	6.13407	6.15122
11	0.03743	6.39641	6.35899
12	-0.11812	6.38486	6.50298
13	0.10580	6.24582	6.14002
14	0.13510	6.57524	6.44014
15	-0.20608	6.38831	6.59439
16	0.35491	6.40424	6.04932
17	0.11803	6.50219	6.38416
18	0.00386	6.44720	6.44333
19	0.25126	6.44125	6.18999
20	-0.12132	6.27140	6.39272
21	-0.18981	6.44572	6.63553
22	-0.47372	-87.4982	-87.0245
23	-0.03063	-87.4982	-87.4676
24	0.49713	-87.4982	-87.9954

idea

International Development &
Energy Associates, Inc

QUESTIONNAIRE

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MODULE I	: IDENTICATION & CONTROL	P 1
MODULE II	: TYPE/SIZE OF RESIDENCE	P 1
MODULE III	: HOUSEHOLD ROSTER	PP 2-3
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URBAN HOUSEHOLD ENERGY USE QUESTIONAIRE

I INTERVIEW IDENTIFICATION AND CONTROL
(To be completed on arrival by interviewer of residence)

MODULE I

1). Name of interviewer: _____

2). Sample household number: _____

3). Sample Household Location Zone _____

Street _____

4). Time of Interviewer Arrival: Month _____ Day _____ Hour _____ Min. _____

5). Interview Status (Circle one)
(To be completed on departure by interviewer)

a) interviewed

b) moved out

c) refused

d) respondent unqualified

e) other --- specify _____

MODULE II

TYPE/AREA OF RESIDENCE

1). Total Area _____ Sq metres rooms

2). No. of rooms _____

3). Type of building ☐

Multi family low rise = 0
Single family = 1
Apartment building = 2

MODULE III - HOUSEHOLD ROSTER

Questions and Instructions	Person No. 1	Person No. 2	Person No. 3	Person No. 4	Person No. 5	Person No. 6
1) "First, I would like to know how many people usually live here and eat together in this household, counting all adults, children, and infants. Please tell me who they are". Enter names in columns at right. One name per column starting with head.						
2) "What is the relationship of this person to the head of the household". Enter relationship of each household member in be below his name.						
3) "How long was he/she present in this household during the past 12 months? (e.g., less than 6 months, 6 months, more than 6 months).						
4) How old is this person (years)?						

5) Household members < 6 months [ ][ ] > 6 months [ ][ ] Total No. [ ][ ] See instructions

Probes --"Just to make sure I have a complete listing:" (see instructions).

a) "Are there any persons who usualy lived here and ate with you during the past year but ar away temporarily for some reason?"

number: < 6 months > 6 months Total No.

b) "Are there any other people such as children, infants, or londgers who were eating in th house who were with you during most of the past year or lead 6 mos and have yet bee mentioned?"

c) "Are there any visitors of friends who wre living and eating with you for 6 months or mor who we have not included?"

(If yes, continue entering names, relationship to head, and length of time in successiv columns to the right of questions 1, 2 and 3 above).

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MODULE III - HOUSEHOLD ROSTER

Questions and Instructions	Person No. 7	Person No. 8	Person No. 9	Person No. 10	Person No. 11	Person No. 12
1) "First, I would like to know how many people usually live here and eat together in this household, counting all adults, children, and infants. Please tell me who they are". Enter names in columns at right. One name per column starting with head.						
2) "What is the relationship of this person to the head of the household". Enter relationship of each household member in be below his name.						
3) "How long was he/she present in this household during the past 12 months? (e.g., less than 6 months, 6 months, more than 6 months).						
4) How old is this person (years)?						

5) Household members < 6 months [ ] > 6 months [ ] Total No. [ ] See instructions

Probes --"Just to make sure I have a complete listing:" (see instructions).

a) "Are there any persons who usualy lived here and ate with you during the past year but are away temporarily for some reason?"

number: < 6 months > 6 months Total No.

b) "Are there any other people such as children, infants, or londgers who were eating in the house who were with you during most of the past year or lead 6 mos and have yet been mentioned?"

c) "Are there any visitors of friends who wre living and eating with you for 6 months or more who we have not included?"

(If yes, continue entering names, relationship to head, and length of time in successive columns to the right of questions 1, 2 and 3 above).

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MODULE IV TRANSPORT

Questions and Instructions	Person No. 1	Person No. 2	Person No. 3	Person No. 4	Person No. 5	Person No. 6
Bring names forward from Module III						
1) "In a typical week does he/she take any bus rides within the city?" (1) No → Go to Q. 5 (2) Yes → Go to Q. 2						
2) "How many bus rides does he/she take in a week (defining a ride as a one way trip)?"						
3) "What is the major purpose of these trips? (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
4) "What is the average (one way) distance of a bus trip?" (kilometer)						
5) "In a typical week does he/she take any taxi rides within the city?" (1) No → Go to ~~next module~~ Q.16 2) Yes → Go to next question						
6) "How many taxi rides does he/she take in a week (defining a ride as a one way trip)?"						
7) "What is the major purpose of the trips?" (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
8) "What is the average (one way) distance of a taxi ride?"						

MODULE IV TRANSPORT

Questions and Instructions (Ask for all persons	Person No. 7	Person No. 8	Person No. 9	Person No. 10	Person No. 11	Per No.
Bring names forward from Module III						
9) "In a typical week does he/she take any bus rides within the city?" (1) No (2) Yes Go to Q. 13 Go to Q. 10						
10) "How many bus rides does he/she take in a week (defining a ride as a one way trip)?"						
11) "What is the major purpose of these trips? (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
12) "What is the average (one way) distance of a trip?" (kilometer)						
13) "In a typical week does he/she take any taxi rides within the city?" (1) No 2) Yes Go to ~~next module~~ Q. 16 Go to next question						
14) "How many taxi rides does he/she take in a week (defining a ride as a one way trip)?"						
15) "What is the major purpose of the trips?" (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
16) "What is the average (one way) distance of a taxi ride?"						

Questions and Instructions (Ask for all persons 5 and over)	Person No. 1	Person No. 2	Person No. 3	Person No. 4	Person No. 5	Person No. 6
Bring names forward from						
16) "In a typical week does he/she take any bajaj/bemo within the city?" (1) No (2) Yes Go to Q. 20 Go to Q. 17						
17) "How many bajaj does he/she take in a week (defining a ride as a one way trip)?"						
18) "What is the major purpose of these trips? (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
19) "What is the average (one way) distance of a bemo/bajaj trip?"						
20) "In a typical week does he/she take any ojek rides within the city?" (1) No 2) Yes Go to ~~next module~~ Q.32 Go to next question						
21) "How many ojek rides does he/she take in a week (defining a ride as a one way trip)?" *						
22) "What is the major purpose of the trips?" (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
23) "What is the average (one way) distance of a ride?"						

* see instructions

MODULE IV TRANSPORT

Questions and Instructions (Ask for all persons 5 and over)	Person No. 7	Person No. 8	Person No. 9	Person No. 10	Person No. 11	Perso No. 1
Bring names forward from						
24) "In a typical week does he/she take any bajaj/Becak within the city?" (1) No (2) Yes Go to Q. 28 Go to Q. 25						
25) "How many bajaj does he/she take in a week (defining a ride as a one way trip)?"						
26) "What is the major purpose of these trips? (enter code: work, school, market, other). W=1, S=2, M=3, O=4"						
27) "What is the average (one way) distance of a trip?"						
28) "In a typical week does he/she take any ojek rides within the city?" (1) No 2) Yes Go to ~~next module~~ Q.32 Go to next question						
29) "How many ojek rides does he/she take in a week (defining a ride as a one way trip)?" *						
30) "What is the major purpose of the trips?" (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
31) "What is the average (one way) distance of a ojek ride?"						

* see instructions

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MODULE IV TRANSPORT

Questions and Instructions (Ask for all persons 5 and over)	Person No. 1	Person No. 2	Person No. 3	Person No. 4	Person No. 5	Person No. 6
Bring names forward from prior sheet						
32) "In a typical week does he/she take any oplet rides within the city?" (1) No. (2) Yes Go to Q. 36 Go to Q. 33						
33) "How many oplet does he/she take in a week (defining a ride as a one way trip)?"						
34) "What is the major purpose of these trips? (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
35) "What is the average (one way) distance of a oplet trip?"						
36) "In a typical week does he/she take any motor cycle within the city?" (1) No 2) Yes Go to next module Go to next question						
37) "How many motor cycle does he/she take in a week (defining a ride as a one way trip)?"						
38) "What is the major purpose of the trips?" (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
39) "What is the average (one way) distance of a motor cycle?"						

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MODULE IV TRANSPORT

Questions and Instructions (Ask for all persons 5 and over)	Person No. 7	Person No. 8	Person No. 9	Person No. 10	Person No. 11	Person No. 12
Bring names forward from prior sheet						
40) "In a typical week does he/she take any oplet rides within the city?" (1) No (2) Yes Go to Q. 44 Go to Q. 41						
41) "How many oplet does he/she take in a week (defining a ride as a one way trip)?"						
42) "What is the major purpose of these trips? (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
43) "What is the average (one way) distance of a oplet trip?"						
44) "In a typical week does he/she take any motor cycle within the city?" (1) No 2) Yes Go to next module Go to next question						
45) "How many motor cycle does he/she take in a week (defining a ride as a one way trip)?"						
46) "What is the major purpose of the trips?" (enter code: work, school, market, other). W=1, S=2, M=3, O=4						
47) "What is the average (one way) distance of a motor cycle?"						

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MODULE IV TRANSPORT (continue)

Family vehicles — I would now like to get some information on your family motor vehicles.

Code: Automobile = 0 Bajaj/Bemo = 1
Oplet = 2 Motor cycle = 3

For each vehicle owned or operated, please provide the following information	Vehicle No. 1	No. 2	3	4	5	6
48) Vehicle type:						
49) Owned (=0)/leased "in" (=1)						
50) Fuel used (gasoline = 0/diesel = 1)						
51) "Primary use" (0 = commercial or for hire 1 = non-commercial-personal 2 = both)						
52) How many kilometers does each vehicle go on one litre of fuel? (km/ltr)						
53) How many kms do you use each vehicle each week, on average? (kms)						
54) Compute weekly fuel consumption (liters) per week?						
55) What is your weekly expenditure on fuel?						

MODULE V ELECTRICITY

1). "Do your use electricity in this residence ?" Yes ___ No ___

2). "Is electricity used for commercial/trade purpose?" Yes ___ No ___

3). List electric appliances.

Name	No. of units
Lightbulbs	___
fluorescent tubes	___
Cooker/Electric stove	___
Hot water heater	___
Air conditioner	___
Television	___
Refrigerator	___
Dishwasher	___
Clothes washer	___
Record player	___
Radio	___
Iron	___
Blender	___
Fans	___
Toaster	___
Water pump	___
Rice coocker	___
Video recorder	___
Other _____	___
Other _____	___
Other _____	___

3). For each device fill in Schedule V.1 - V.7

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MODULE V - ELECTRICITY
SCHEDULE V.1

Electric Device/Appliance: Light Bulbs
Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1				
No. 2				
No. 3				
No. 4				
No. 5				
No. 6				
No. 7				
No. 8				
No. 9				
No. 10				
No. 11				
No. 12				
No. 13				
No. 14				
No. 15				
No. 16				
No. 17				
No. 18				
No. 19				
No. 20				
No. 21				
No. 22				
No. 23				
No. 24				

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MODULE V - ELECTRICITY
SCHEDULE V.2

Electric Device/Appliance: Fluorescent tubes
Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1				
No. 2				
No. 3				
No. 4				
No. 5				
No. 6				
No. 7				
No. 8				
No. 9				
No. 10				
No. 11				
No. 12				
No. 13				
No. 14				
No. 15				
No. 16				
No. 17				
No. 18				
No. 19				
No. 20				
No. 21				
No. 22				
No. 23				
No. 24				

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MODULE V - ELECTRICITY

SCHEDULE V.3

Electric Device/Appliance: Television

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1				
No. 2				
No. 3				
No. 4				
No. 5				

Electric Device/Appliance: Refrigerator

Number of units:

Unit	Size in Watts	Average Use per Day	Number of days/month	Months per year
No. 1				
No. 2				
No. 3				
No. 4				
No. 5				

Electric Device/Appliance: Dishwasher

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1				
No. 2				
No. 3				
No. 4				
No. 5				

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MODULE V - ELECTRICITY

SCHEDULE V.4

Electric Device/Appliance: Clothes washer

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Record Player

Number of units:

Unit	Size in Watts	Average Use per Day	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Radio

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

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MODULE V - ELECTRICITY

SCHEDULE V.5

Electric Device/Appliance: Iron

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Blender

Number of units:

Unit	Size in Watts	Average Use per Day	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Fan

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

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MODULE V - ELECTRICITY

SCHEDULE V.6

Electric Device/Appliance: Toaster

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Water Pump

Number of units:

Unit	Size in Watts	Average Use per Day	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Rice Cooker

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

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MODULE V - ELECTRICITY

SCHEDULE V.7

Electric Device/Appliance: Cooker

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No.1				
No. 2				
No. 3				
No. 4				
No. 5				

Electric Device/Appliance: Hot Water Heater

Number of units:

Unit	Size in Watts	Average Use per Day	Number of days/month	Months per year
No. 1				
No. 2				
No. 3				
No. 4				
No. 5				

Electric Device/Appliance: Air Conditioner

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1				
No. 2				
No. 3				
No. 4				
No. 5				

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MODULE " - ELECTRICITY

SCHEDULE V.8

Electric Device/Appliance: Video Recorder

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Other _____

Number of units:

Unit	Size in Watts	Average Use per Day	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

Electric Device/Appliance: Other _____

Number of units:

Unit	Size in Watts	Average Use per Day (hrs)	Number of days/month	Months per year
No. 1	_____	_____	_____	_____
No. 2	_____	_____	_____	_____
No. 3	_____	_____	_____	_____
No. 4	_____	_____	_____	_____
No. 5	_____	_____	_____	_____

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MODULE 7 - ELECTRICITY

4). "Where do you obtain electricity?" (check)

(1) Private Genset ___ -------> (Go to 5,6,7) Metered Service? Yes ___ No ___

(2) PLN ___ (Go to 8,9,10,11)

(3) Local Cov't ___ Yes ___ No ___

(4) Other Yes ___ No ___
(Specify) _____

5) "What is the capacity of your genset?" ___ VA -------> ___ Diesel ___ Other

6) Average hours genset used per month _____ hours x 12 = _____ /yr

7) "What is your operation and maintenance cost per month for the genset?" _____ Rp.

8) When you last paid for electricity, how much did you pay?
(Request to se last Bill if available) _____ Rp.

9) Period of last bill or payment _____ months

10) Amount of electricity used for this period _____ kWh
(if available)

11) "What voltage and s1/e electric connection do you have?" (Check) ___ 110 V ___ 220 V

___ 450 VA ___ 500 VA ___ 900 VA ___ 1300 VA ___ 2200 VA

___ 4400 VA Other _____ VA

12) "Do you use accumulators in this house?" No _____ Yes _____
(If yes go to Q. 13-15)

13) "How many accumulators do you use?" _____ *(see instructions)

14) "How many times per month is each accumulator charged?" (average)

15) "How much do you spend per charge?" _____ Rp.

16) Compute cost per month on accumulators _____ Rp.
([13] x [14] x [15])

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MODULE VI - LIQUID GAS

1) "Do you use liquid gas in this residence?" Yes ___ No ___
(If no go to next Module)

2) Is liquid gas used for commercial/trade purposes Yes ___ No ___

3) (For each cylinder indicate purpose, size, and average length of time it lasts)

	No.(1)	No.(2)	No.(3)
Size	____ kg	____ kg	____ kg
Time/ cylinder	____ wks	____ wks	____ wks
Primary Purpose: cooking	____	____	____
water heat	____	____	____
other	____	____	____
No. of Weeks used per year	____	Weeks/year ____	Weeks/year ____

4) For each cylinder: Annual consumption:
Compute average kg per week x 52

No. 1	No. 2	No. 3
____	____	____

Note: Average kg per week = cylinder size (from [4] & [8]) no. of weeks each cylinder fasts (from [6] & [8]).

5) Compute average annual consumption of LPG ____
(sum average kg/yr for each cylinder)

		No.1	No.2	No.3
6) What is the cost per cylinder filling	Rp.	____	____	____
7) What is the expenditure per month	Rp.	____	____	____

8) Compute annual average expenditure on LPG
12 months x (No. of cylinders per month) x from [11] Rp.) ____

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MODULE 7 - ELECTRICITY

4). "Where do you obtain electricity?" (check)

(1) Private Genset ___ ------> (Go to 5,6,7) Metered Service? Yes ___ No ___

(2) PLN ___

(Go to 8,9,10,11)

(3) Local Cov't ___ Yes ___ No ___

(4) Other Yes ___ No ___
(Specify) _____

5) "What is the capacity of your genset?" ___ VA ------> ___ Diesel ___ Other

6) Average hours genset used per month _____ hours x 12 = _____ /yr

7) "What is your operation and maintenance cost per month for the genset?" _____ Rp.

8) When you last paid for electricity, how much did you pay?
(Request to se last Bill if available) _____ Rp.

9) Period of last bill or payment _____ months

10) Amount of electricity used for this period _____ kWh
(if available)

11) "What voltage and sl/e electric connection do you have?" (Check) ___ 110 V ___ 220 V

___ 450 VA ___ 500 VA ___ 900 VA ___ 1300 VA ___ 2200 VA

___ 4400 VA Other _____ VA

12) "Do you use accumulators in this house?" No _____ Yes _____
(If yes go to Q. 13-15)

13) "How many accumulators do you use?" _____ *(see instructions)

14) "How many times per month is each accumulator charged?" (average)

15) "How much do you spend per charge?" _____ Rp.

16) Compute cost per month on accumulators _____ Rp.
([13] x [14] x [15])

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MODULE VII - CITY GAS

1). Do you use city gas in this residence? ____ Yes ____ No

2). Is city gas used for commercial/trade purposes? ____ Yes ____ No

3). Is your service metered? ____ Yes ____ No

4). When you last paid for city gas
how much did you pay? Rp. _____
(Request to see last bill if available)

5). Period of last bill, or payment _____ months

6). Amount of city gas used in this period.(if available) _____ m3

7). Compute annual consumption of city gas _____ m3

8). Compute annual expenditure on city gas _____ Rp./year

9). What is the primary purpose of city gas? Cooking ____

Water heat ____

Other ____

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MODULE VIII - CHARCOAL

1). "Do you use charcoal?" _____ Yes _____ No
(If no go to next module)

2). Is charcoal used for commercial/trade purposes? _____ Yes _____ No

3). "In what units do you purchase charcoal?" (see instructions)

(1) _____ sacks kg equivalent ____

(2) _____ kilos kg equivalent ____

(3) _____ tins Specify size _____ kg equivalent ____

(4) _____ other Specify _____ kg equivalent ____

4). "How much does charcoal cost?" Specify Rp _____ /kg

5). "How much charcoal do you purchase per week?"_____ kg per week

6). "For how many weeks per year is charcoal consumed?"_____ weeks

7). "What is total charcoal consumption per year (4x5)."_____ kgs

8). "For what primary purpose is charcoal used,

(Check) Cooking _____

Water heating _____

Ironing _____

Other _____

9). Total annual expenditure on charcoal _____ Rp.

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MODULE IX - WOOD

1). "Do you use wood?" _____ Yes _____ No
(If no go to next Module)

2). "Is wood used for commercial/trade purposes? Yes _____ No _____

3). "In what units do you purchase wood?"

(1) _____ bundles kg equivalent ___

(2) _____ kilos kg equivalent ___

(3) _____ other Specify _____ kg equivalent ___

4). "How much does wood cost?" Specify Rp. _____ /kg

5). "How much wood do you purchase per week?" _____ kg per week

6). "For how many weeks per year is wood consumed?" _____ weeks

7). "What is total wood consumption per year (4x5)" _____ kgs

8). "For what primary purpose is wood used?"

(check) Cooking _____

Water heating _____

Other _____

9). Total annual expenditure on wood _____ Rp.

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MODULE X - KEROSENE

1). "Do you use kerosene in this residence? Yes _____ No _____
(If no go to next Module)

2). Is kerosene used for commercial/trade purposes? Yes _____ No _____

3). "Do you use kerosene for lighting?" Yes _____ No _____
If no g to 0.5

4). "Do you have .....

a) hurricane lamp _____No _____Yes How many? _____

b) chimney lamps _____No _____Yes How many? _____

c) open wick lamps _____No _____Yes How many? _____

5). "Do you have a kerosene cooker:" Yes _____ No _____ How many? _____

6). "In what units do you purchase kerosene?"

Bottles _____ _____liter/equivalent

Tins _____ _____liter/equivalent

Other _____ _____liter/equivalent

7). "How much does kerosene cost?" Rp. _____/liter

8). "How much kerosene do you purchase per week?" _____ liters/wk

9). "For how many weeks per year is kerosene consumed?" _____ weeks

10). Total kerosene consumption per year (7x8) _____ liters

11). Stove size and consumption rate * see instructions

	Size 1	Amount in stove	meals	~~liters/we~~
Stove #1	_____	_____	_____	_____
Stove #2	_____	_____	_____	_____
Stove #3	_____	_____	_____	_____

12). Average consumption kerosene for cooking or lighting per week _____ liters

13). Compute average kerosene consumption per week for cooking and other use lighting [12]). _____

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14). Compute annual kerosene consumption for light and other uses cooking.

Cooking _____ liters/yr ([13]x[9])

Lighting & otherness _____ liters/yr ([19]x[9])

15). Total annual expenditures on kerosene ([10]x[9]) _____ Rp/year

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MODULE XI - HOUSEHOLD EXPENDITURES AND INCOME

A. EXPENDITURES

Please indicate the following information about household expenses (for all persons who live here and share their expenses).

How often does your household spend money on the following items (Week = 1 , Month = 2 , Year = 3	Frequency	The last time you spent money did you spend? (Rupiah)	Total Yearly Expenditure (Rupiah)
1. Food	Rice		
	Lauk pauk		
	Other		
2. Clothing			
3. Electricity			
4. Other fuels			
5. Water			
6. Housing [Rent			
7. Durable Goods			
8. Miscellaneous goods/ Service (Schooling,etc)			
9. Parties/Ceremonies/ Social Uses			
10. Transportation			
11. Taxes/Premiums/Installment			
12. Savings			

Income Sources/Household Business

13. Please indicate the main source of family income:

Occupation: (Sources of salary income)

(a) Gov't. Employee	____	(e) Teacher	____
(b) Military	____	(f) Other	____
(c) Retail Trade	____	(g) Household Business Type of Business	____ (Enter code)
(d) Employee Professional	____	(h) Income from rental property	____

14. If household business uses electricity and fuels please indicate monthly expenditures if possible:

(a) Electricity	Rp.	_____
(b) LPG	Rp.	_____
(c) City Gas	Rp.	_____
(d) Gasoline	Rp.	_____
(e) Diesel	Rp.	_____
(f) Kerosene	Rp.	_____
(g) Charcoal	Rp.	_____
(h) Wood	Rp.	_____

Household Business Code:

0 = Food preparation
1 = Retail trade/whole sale trade
2 = Transportation
3 = Services
4 = Manufacturing - small scale
5 = Other

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MODULE XII

ENERGY CONSUMPTION TRENDS/PREFERENCES

Please answer the following questions concerning your past consumption, your reasons for changing fuels and other preferences:

	Fuel:	Elec.	Gasoline	Diesel	Kerosene	LPG	Town-gas	Wood	Charcoal
1. Since 1981 has consumption or more recently (Mark One)	increased	___	___	___	___	___	___	___	___
	decreased	___	___	___	___	___	___	___	___
	constant	___	___	___	___	___	___	___	___
2. Most important reason for increase (Mark one)									
- Household size increased		___	___	___	___	___	___	___	___
- Can afford more		___	___	___	___	___	___	___	___
- More appliances		___	___	___	___	___	___	___	___
- Most convenient to use		___	___	___	___	___	___	___	___
- Unavailability of other fuels		___	___	___	___	___	___	___	___
3. Reasons for decrease (Mark one)									
- Household size		___	___	___	___	___	___	___	___
- Higher prices		___	___	___	___	___	___	___	___
- Lower income		___	___	___	___	___	___	___	___
- Higher income		___	___	___	___	___	___	___	___
- Less convenient to use		___	___	___	___	___	___	___	___
- Not enough supply		___	___	___	___	___	___	___	___
4. If consumption has decresed, how has household adjusted?									
- More efficient cooking		___	___	___	___	___	___	___	___
- fewer lights		___	___	___	___	___	___	___	___
- smaller lights/lamps		___	___	___	___	___	___	___	___
- less hours of lights per day		___	___	___	___	___	___	___	___
- less use of appliances		___	___	___	___	___	___	___	___
- fewer appliances		___	___	___	___	___	___	___	___
- less use of vehicles		___	___	___	___	___	___	___	___
- other ways		___	___	___	___	___	___	___	___
- none of the above					___	___	___	___	___

MODULE XII (cont')

Fuel:	Elec.	Gasoline	Diesel	Kerosene	LPG	Town-gas	Wood	Charcoal
5. Has supply been enough to meet needs? Yes	___	___	___	___	___	___	___	___
No	___	___	___	___	___	___	___	___
6. For fuels not used, list main reason (Mark one)								
- Required investment too high	___	___	___	___	___	___	___	___
- Price too high	___	___	___	___	___	___	___	___
- Unavailable	___	___	___	___	___	___	___	___
- Inconvenient to use	___	___	___	___	___	___	___	___

7. If you use kerosene for cooking:

a. If price increases ~~"significantly"(?)~~ much higher than its present level
Will you change to another cheaper fuel if it is available? Yes ___ No ___

b. If yes, what fuel would you use (mark one)?

LPG ___

Wood ___

Charcoal ___

L A M P I R A N II

KUESIONER RUMAH TANGGA URBANES

1 9 8 5

TEAM PUSAT PENELITIAN ENERGI , LP-ITB

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DIREKTORAT JENDERAL LISTRIK DAN ENERGI BARU
DEPARTEMEN PERTAMBANGAN DAN ENERGI

bekerja sama dengan

.....

SURVAI ENERGI PERKOTAAN
MARET 1985

KUESIONER RUMAH TANGGA
No. : .....

DAFTAR ISI

MODUL 1 : IDENTIFIKASI RESPONDEN
MODUL 2 : JENIS/LINGKUNGAN PEMUKIMAN
MODUL 3 : DATA ANGGOTA RUMAH TANGGA
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B. TRANSPORTASI PRIBADI
MODUL 5 : PEMAKAIAN LISTRIK
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MODUL 9 : PEMAKAIAN KAYU
MODUL 10 : PEMAKAIAN MINYAK TANAH
MODUL 11 : PENGELUARAN RUMAH TANGGA
MODUL 12 : PREFERENSI KONSUMSI ENERGI

Nama Surveyor : ..... CATATAN:
Tanggal survey:
- Kedatangan I : .....
- Kedatangan II : .....

Tandatangan:

(.....)

Telah diperiksa dan disetujui
oleh Surveyor Kepala:

(.....)

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MODUL I

IDENTITAS RESPONDEN

Nama Responden	: .....
Alamat	: .....
Kecamatan	: .....
Desa	: .....
Wilayah pencacahan	: .....
Blok Sensus	: .....
Nomor Bangunan Fisik	: .....
Nomor Bangunan Sensus	: .....
Nomor Urut Rumah Tangga	: .....

MODUL 2. JENIS/LINGKUNGAN PEMUKIMAN

1. Luas bangunan : m^2
2. Jumlah ruangan : kamar/ruangan
3. Jenis bangunan : * (lihat petunjuk)

satu bangunan, banyak keluarga = 0
satu bangunan/satu keluarga = 1
apartment = 2

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Nama penghuni tetap													
1.1. *Bis kota*													
1. Apakah anggota keluarga menggunakan bis kota setiap minggu. 0 = ya ; 1 = tidak *Jika tidak pindah ke pertanyaan 4.2.*													
2. Apakah tujuan utama dari perjalanan tersebut (kerja = 1, sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.													
3. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. berarti 2 kali).													
4. Berapa rata-rata jarak satu kali perjalanan (km)													
5. Berapa biaya penggunaan bis kota untuk 1 kali perjalanan													

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga											
	1	2	3	4	5	6	7	8	9	10	11	12
Nama penghuni tetap												
4.2. Taximeter 6. Apakah anggota keluarga menggunakan taximeter setiap minggu. 0 = ya ; 1 = tidak Jika tidak pindah ke pertanyaan 4.3.												
7. Apakah tujuan utama dari perjalanan tersebut (kerja = 1, sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.												
8. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. berarti 2 kali).												
9. Berapa rata-rata jarak satu kali perjalanan (km)												
10. Berapa biaya penggunaan taximeter untuk 1 kali perjalanan												

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Nama penghuni tetap													
4.3. Bajaj/bemo 11. Apakah anggota keluarga menggunakan bajaj/bemo setiap minggu. 0 = ya ; 1 = tidak Jika tidak pindah ke pertanyaan 4.4.													
12. Apakah tujuan utama dari perjalanan tersebut (kerja = 1; sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.													
13. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. berarti 2 kali).													
14. Berapa rata-rata jarak satu kali perjalanan (km)													
15. Berapa biaya penggunaan bajaj/bemo untuk 1 kali perjalanan													

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Nama penghuni tetap													
4.4. Oplet 16. Apakah anggota keluarga menggunakan oplet setiap minggu. 0 = ya ; 1 = tidak Jika tidak pindah ke pertanyaan 4.5.													
17. Apalah tujuan utama dari perjalanan tersebut (kerja = 1, sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.													
18. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. berarti 2 kali).													
19. Berapa rata-rata jarak satu kali perjalanan (km)													
20. Berapa biaya penggunaan oplet untuk 1 kali perjalanan													

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Nama penghuni tetap													
4.5. Sepeda motor (ojek) 21. Apakah anggota keluarga menggunakan sepeda motor (ojek) setiap minggu. 0 = ya ; 1 = tidak Jika tidak pindah ke pertanyaan 4.6.													
22. Apakah tujuan utama dari perjalanan tersebut (kerja = 1, sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.													
23. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. berarti 2 kali).													
24. Berapa rata-rata jarak satu kali perjalanan (km)													
25. Berapa biaya penggunaan sepeda motor (ojek) untuk 1 kali perjalanan													

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Nama penghuni tetap													
4.6. Becak 26. *Apakah anggota keluarga menggunakan becak setiap minggu.* 0 = ya ; 1 = tidak Jika tidak pindah ke *pertanyaan* 4.7.													
27. Apakah tujuan utama dari perjalanan tersebut (kerja = 1, sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.													
28. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. *berarti* 2 kali).													
29. Berapa rata-rata jarak satu kali perjalanan (km)													
30. Berapa biaya penggunaan becak untuk 1 kali perjalanan													

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Nama penghuni tetap													
4.7. Kereta api listrik (KRL)													
31. Apakah anggota keluarga menggunakan kereta api listrik (KRL) setiap minggu. 0 = ya : 1 = tidak Jika tidak pindah ke pertanyaan 4.8.													
32. Apakah tujuan utama dari perjalanan tersebut (kerja = 1, sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.													
33. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. berarti 2 kali).													
34. Berapa rata-rata jarak satu kali perjalanan (km)													
35. Berapa biaya penggunaan kereta api listrik untuk 1 kali perjalanan													

MODUL 4. A. TRANSPORTASI UMUM

Pertanyaan	Anggota Rumah Tangga												
	1	2	3	4	5	6	7	8	9	10	11	12	13
Nama penghuni tetap													
4.B. Angkutan umum pribadi (lihat petunjuk)													
36. Apakah anggota keluarga menggunakan angkutan umum pribadi setiap minggu. 0 = ya ; 1 = tidak Jika tidak pindah ke pertanyaan 4.B.													
37. Apakah tujuan utama dari perjalanan tersebut (kerja = 1, sekolah = 2, pasar = 3, lainnya = 4), masukkan satu angka.													
38. Sebutkan jumlah perjalanan yang dilakukan setiap minggu (1 kali berarti 1 jalan, p.p. berarti 2 kali).													
39. Berapa rata-rata jarak satu kali perjalanan (km)													
40. Berapa biaya penggunaan angkutan umum pribadi untuk 1 kali perjalanan													

MODUL 4. B. TRANSPORTASI PRIBADI

	Kendaraan no.						
	1	2	3	4	5	6	7
41. Jenis kendaraan: Sedan/pick up/jeep/minibus = 0 Bajaj/bemo = 1 Oplet = 2 Sepeda motor = 3							
42. Milik sendiri = 0 Menyewa = 1							
43. Bahan bakar: Bensin = 0 Diesel = 1							
44. Penggunaan utama kendaraan Komersial/disewakan = 0 Non Komersial = 1 Keduanya = 2							
45. Berapa km jarak yang ditempuh untuk penggunaan 1 liter (km/liter)							
46. Berapa rata-rata penggunaan setiap minggu (km)							
47. Berapa pemakaian bahan bakar per minggu							
48. Berapa pengeluaran anda untuk bahan bakar setiap minggu (Rp.)							

MODUL 4. B. TRANSPORTASI PRIBADI

	Kendaraan no.						
	1	2	3	4	5	6	7
41. Jenis kendaraan: Sedan/pick up/jeep/minibus = 0 Bajaj/bemo = 1 Oplet = 2 Sepeda motor = 3							
42. Milik sendiri = 0 Menyewa = 1							
43. Bahan bakar: Bensin = 0 Diesel = 1							
44. Penggunaan utama kendaraan Komersial/disewakan = 0 Non komersial = 1 Keduanya = 2							
45. Berapa km jarak yang ditempuh untuk penggunaan 1 liter (km/liter)							
46. Berapa rata-rata penggunaan setiap minggu (km)							
47. Berapa pemakaian bahan bakar per minggu							
48. Berapa pengeluaran anda untuk bahan bakar setiap minggu (Rp.)							

MODUL 5. PEMAKAIAN LISTRIK

1. Apakah anda menggunakan listrik dalam rumah tangga
   (0 = Ya , 1 = tidak)

2. Apakah digunakan untuk keperluan komersial/perdagangan
   (0 = Ya , 1 = tidak)

3. Sebutkan alat-alat listrik

Nama	Jumlah
1. Lampu pijar	
2. Lampu neon (TL)	
3. Kompor listrik	
4. Rice cooker	
5. Pemanas air (water heater)	
6. AC	
7. TV	
8. Lemari Es	
9. Pencuci piring listrik	
10. Pencuci baju listrik	
11. Piringan Hitam	
12. Radio	
13. Radio cassette	
14. Cassette	
15. Setrika listrik	
16. Blender	
17. Kipas Angin	
18. Pembakar roti	
19. Pompa air	
20. Video	
21.	
22.	
23.	

4. Untuk setiap alat tabulasikan penggunaan masing-masing pada tabel

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MODUL 5.1. Lampu Pijar

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				

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MODUL 5.2. Lampu neon (TL)

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan. (hari)	tahun (bulan)
1.				
2.				
3.				
4.				
5.				
6.				
7.				
8.				
9.				
10.				
11.				
12.				
13.				
14.				
15.				
16.				
17.				
18.				
19.				
20.				
21.				
22.				
23.				
24.				

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MODUL 5.3. Alat-alat listrik

Nama alat: AC

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: TV

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Lemari Es

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

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MODUL 5.3. Alat-alat listrik

Nama alat: Pencuci piring listrik

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Pencuci baju listrik

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Piringan hitam

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

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MODUL 5.3. Alat-alat listrik

Nama alat: Radio

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Radio Cassette

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Cassette

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

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MODUL 5.3. Alat-alat listrik

Nama alat: Setrika listrik

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Blender

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Kipas angin

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

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Nama alat: Pembakar roti

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Pompa air.

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: Video

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: .....

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: .....

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

Nama alat: .....

Jumlah	Watt	Penggunaan rata-rata		
		per hari (jam)	per bulan (hari)	tahun (bulan)
1. ..... 2. ..... 3. ..... 4. ..... 5. ..... 6. ..... 7. ..... 8.				

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MODUL 5.4. BIAYA PEMAKAIAN LISTRIK

Darimana anda memperoleh sambungan listrik Meter

(1). Genset - (pindah ke pertanyaan 6,7,8) Ya Tidak
(2). PLN - Ya Tidak
(3). Pemerintah setempat - (pindah ke pertanyaan Ya Tidak
(4). Lainnya - 9,10,11,12) Ya Tidak

Berapa kapasitas gen-set VA ------>
0 = diesel
1 = lampu

Penggunaan rata-rata per bulan: jam x 12 = /thn.

Berapa biaya operasi dan pemeliharaan per bulan: Rp.

Berapa pembayaran listrik anda bulan lalu Rp.
(lihat kuitansi pembayaran)

Perioda (bulan) pembayaran terakhir bulan

Berapa besar penggunaan listrik untuk perioda diatas kWh
(periksa kuitansi atau kartu)

Berapa daya terpasang dalam rumah tangga ? 110 V 220 V

450 VA 500 VA 900 VA 1300 VA

2200 VA 4400 VA Lainnya VA

Apakah bapak/ibu menggunakan aki
0 = Ya 1 = Tidak
(jika tidak lanjutkan ke modul selanjutnya)

Berapa buah aki yang dipergunakan buah

Berapa kapasitas aki yang dipergunakan (amp.jam).

	No.	1	2	3	4	5	6
Amp. jam							

Digunakan untuk keperluan apa saja. (pilih satu)

Radio Radio cassette Cassette TV

Lainnya

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17. Apakah tujuan penggunaan aki tersebut;

Komersial

non Komersial

keduanya

18. Berapa kali dalam 1 bulan aki di 'charge' kembali (rata-rata)?

1	2	3	4	5	6

19. Berapa biaya setiap kali 'charging' (Rp.)

20. Hitung biaya untuk aki per bulan
(14 x 18 x 19)

MODUL VI. LPG

1. Apakah bapak/ibu menggunakan LPG?
   (Ya = 0 Tidak = 1)
   Jika tidak lanjutkan ke modul selanjutnya

2. Apakah LPG digunakan untuk kepentingan komersial/perdagangan?
   (Ya = 0 Tidak = 1)

3. Berapa jumlah silinder yang digunakan _____ buah

4. Tabulasikan ukuran dan waktu penggunaan tiap silinder.

Silinder no:	1	2	3	4	5	6
Ukuran (kg)						
Penggunaan (minggu/silinder)						
Lama penggunaan dalam 1 tahun (minggu)						
Penggunaan - memasak - pemanas air mandi - lainnya						
Pemakaian/1 tahun (kg)						
Harga (Rp.)						
Pengeluaran/bulan (Rp.)						

5. Penggunaan total rata-rata/tahun _____ kg

6. Pengeluaran total rata-rata/tahun _____ Rp.

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MODUL VII. GAS KOTA

1. Apakah bapak/ibu menggunakan gas kota
   (Ya = 0 , Tidak = 1)
   Jika tidak lanjutkan ke modul selanjutnya.

2. Apakah gas kota digunakan untuk kepentingan komersial
   (Ya = 0 , Tidak = 1)

3. Apakah sambungan gas melalui meter pengukuran.
   (Ya = 0 , Tidak = 1)

4. Berapa pembayaran terakhir yang bapak/ibu keluarkan Rp
   (lihat kuitansi)

5. Perioda pembayaran terakhir bulan

6. Jumlah penggunaan pada perioda diatas (5) m3

7. Hitung penggunaan tahunan m3

8. Hitung pengeluaran tahunan Rp/tahun

9. Penggunaan gas kota:

   memasak

   pemanas air

   lainnya

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MODUL VIII. ARANG

1. Apakah bapak/ibu menggunakan arang
   (Ya = 0, Tidak = 1)
   Jika tidak lanjutkan ke modul selanjutnya.

2. Apakah arang digunakan untuk keperluan komersial
   (Ya = 0, Tidak = 1)

3. Berapa/bagaimana satuan pembelian yang dilakukan.

   (1). ..... karung kg
   (2): ..... kantung plastik kg
   (3). ..... keranjang kg
   (4). ..... lainnya, nyatakan ..... kg

4. Berapa harga arang kayu per kg Rp/kg

5. Berapa kg pembelian per minggu kg/minggu

6. Berapa minggu dalam setahun anda menggunakan arang mingg

7. Penggunaan total per tahun (5x6) kg

8. Pengeluaran total per tahun (7x7) Rp.

9. Penggunaan arang kayu:

   memasak

   pemanas air

   setrika

   lainnya

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MODUL IX. KAYU BAKAR

1. Apakah bapak/ibu menggunakan kayu bakar ?
   (ya = 0 , tidak = 1)
   Jika tidak lanjutkan ke modul selanjutnya

2. Apakah bapak/ibu membeli sebagian besar dari kayu bakar yang digunakan.
   (Ya = 0, Tidak = 1)
   (Jika pembelian < 25% dari jumlah total, lanjutkan ke modul selanjutnya)

3. Apakah kayu bakar digunakan untuk keperluan komersial
   (Ya = 0, Tidak = 1)

4. Berapa/bagaimana satuan pembelian yang dilakukan.

   (1). ..... ikat kg
   (2). ..... karung kg
   (3). ..... lainnya, nyatakan ..... kg

5. Berapa harga kayu bakar per kg Rp/kg

6. Berapa kg pembelian per minggu kg/minggu

7. Berapa minggu dalam setahun anda menggunakan kayu bakar

8. Penggunaan total per tahun (5x6) kg

9. Pengeluaran total per tahun (7x7) Rp.

10. Penggunaan kayu bakar:

    memasak

    pemanas air

    lainnya

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MODUL 4 : MINYAK TANAH

Apakah bapak/ibu menggunakan minyak tanah
(Ya = 0 , Tidak = 1)
Jika tidak lanjutkan ke modul selanjutnya.

Apakah minyak tanah digunakan untuk kegiatan komersial
(Ya = 0 , Tidak = 1)

Apakah minyak tanah digunakan untuk penerangan
(Ya = 0 , Tidak = 1)
Jika tidak lanjutkan ke pertanyaan 5.

Apakah bapak/ibu mempunyai:

a. lampu badai/petromaks	tidak	ya, berapa?
b. lampu semprong	tidak	ya, berapa?
c. lainnya	tidak	ya, berapa?

Apakah bapak/ibu mempunyai kompor minyak tanah ya tidak dan berapa jumlahnya;

kompor no:	ukuran (liter)
1	
2	
3	
4	

Berapa/bagaimana satuan pembelian yang dilakukan:

Botol ..... liter
Jerigen ..... liter
Kaleng ..... liter
lainnya ..... liter

Berapa harga minyak tanah Rp/ltr.

Berapa liter pembelian minyak tanah per minggu ltr/minggu

Berapa minggu dalam 1 tahun minyak tanah dipergunakan minggu

- Penggunaan total minyak tanah per tahun (8x9) . minggu
- Pertanyaan ini hanya digunakan jika minyak tanah digunakan untuk masak dan penerangan,

kompor no:	kunjungan 1 isi dalam kompor	kunjungan 2 jumlah makan sesudah kunjungan pertama	jumlah hari	(ltr/ming

- Penggunaan rata-rata konsumsi minyak tanah untuk memasak perminggu li

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Hitung pengunaan rata-rata minyak tanah untuk penerangan per minggu

Hitung pengeluaran total tahunan minyak tanah untuk penerangan & memasak.

memasak	ltr/tahun	
penerangan/lampu	ltr/tahun	

Pengeluaran total minyak tanah per tahun Rp/tahun

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MODUL VI. PENGELUARAN RUMAH TANGGA I PENDAPATAN

A. Pengeluaran.
(digunakan untuk semua anggota keluarga yang tinggal & turut bertanggung jawab pada pengeluaran sehari-hari dan didasarkan atas pengeluaran terakhir sesuai dengan frekuensi yang dilakukan).

Bagaimana frekuensi pengeluaran yang dilakukan:

0 = harian , 1 = mingguan
2 = bulanan, 3 = tahunan

	Frekuensi	Besar pengeluaran (Rp)	Total tahunan (Rp)
1. Makanan — Beras			
Lauk pauk			
Lainnya			
2. Pakaian			
3. Pemakaian listrik			
4. Bahan bakar lain			
5. Air			
6. Perumahan (sewa)			
7. Barang-barang rumah tangga			
8. Keperluan lain (jasa sekolah)			
9. Pesta/upacara/kegiatan sosial			
10. Transportasi Umum			
11. Pajak/cicilan			
12. Tabungan			

Sumber pendapatan :

13. Sebutkan sumber utama penghasilan keluarga:

a. Pegawai negeri	e. Guru/Dosen	
b. Militer	f. Lainnya	
c. Pedagang/toko	g. Usaha rumah tangga	(masukkan kode)
d. Pegawai swasta	h. Pendapatan dari penyewaan rumah/ruangan	

14. Jika usaha rumah tangga menggunakan listrik dan bahan bakar minyak, sebutkan pengeluaran setiap bulan.

(a). Listrik	Rp.
(b). LPG	Rp.
(c). Gas kota	Rp.
(d). Bensin	Rp.
(e). Diesel	Rp.
(f). Minyak tanah	Rp.
(g). Arang	Rp.
(h). Kayu	Rp.

Kode usaha rumah tangga:

0 = catering
1 = pedagang kecil
2 = penyewa kendaraan
3 = jasa
4 = manufaktur dalam skala kecil
5 = lainnya.

7. a). Sejak kenaikan harga minyak tanah apakah bapak/ibu menurunkan penggunaan (Ya = 0, tidak = 1)

b). Jika anda mengganti dengan bahan bakar lain, sebutkan macamnya.

LPG

Kayu

Arang

8. Jika bapak/ibu menggunakan minyak tanah untuk memasak:

a). Jika harga naik dan jauh lebih tinggi dari saat ini apakah anda akan menggunakan bahan bakar lain yang lebih murah (Ya = 0, Tidak = 1).

b). Jika ya, anda gunakan yang mana (pilih satu).

LPG

Kayu

Arang

ENERGY PLANNING FOR DEVELOPMENT

(Phase II)

APPENDIX 6: PRODUCTIVE USES OF RURAL ELECTRICITY

September, 1985

DIRECTORATE GENERAL OF ELECTRIC POWER AND NEW ENERGY
MINISTRY OF MINES AND ENERGY
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I INTRODUCTION AND CONCLUSIONS

A. INTRODUCTION

This report outlines a strategy for the Government of Indonesia to follow in order to increase the efficiency of its rural electrification (RE) program[1]. The strategy is derived from an analysis which places RE within a broad rural energy framework. This approach is taken since electricity, though socially and economically important, accounts for, at best, a small fraction of rural energy use, and because any RE project must compete and be compatible with a variety of other sources of rural energy. The recommended strategy takes the form of a variety of policy actions - on both the "demand" and "supply" sides - which can increase the economic contribution of RE to Indonesia's developmental process. Specifically, it emphasizes steps which can be taken to increase the productive use of electricity in rural areas.. The Government's major objectives for the power sector include a diversification of primary fuel sources, an extension of electrification benefits to as many households as possible and the provision of economical power for productive activities. Increasing productive activities therefore merits attention and effort, especially if it is to be accomplished in the rural sector. The failure to develop significant productive uses of RE is judged by many to be the biggest single shortcoming of Indonesia's previous RE efforts. In addition, issues relating to the reduction of RE costs - which are relevant for all categories of consumers - are discussed.

The need for such a comprehensive analysis of RE policy in Indonesia exists for a variety of reasons. Some are specific to Indonesia's prior experience with RE, and others arise from more general and recent developments in the energy sector. Commercial energy is being substituted for non-commercial energy[2] and at the same time, the mix of commercial energy is changing. Attempts are underway to reduce Indonesia's domestic consumption of petroleum products, which increased at an annual rate of more than 10 percent

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during the 1970's, so as to make more available for exports. To accomplish this, the prices of some petroleum products, e.g. gasoline and diesel, have been raised to, or above, world levels. Equally important, the mix of electric power generating capacity is being altered in order to substitute the use of fuel oil[3]. For example, in 1984, 81% of PLN's generation capacity was oil-fired, with the balance supplied from hydro or geothermal sources. By 1994 the mix is expected to be 20 percent oil-fired, 48 percent coal, 22 percent hydro, and 10 percent geothermal. To achieve this, the Government will invest approximately $13.4 billion between 1984/85 - 1993/94 in non oil-fired generation capacity.

One important aspect of the growing commercialization of the energy sector is the Government's plan for RE. RE is viewed as a means of stimulating rural economic development while contributing to the increased uses of non-petroleum based energy by reducing consumption of kerosene and diesel fuel[4]. While only 6 percent of the rural population had access to electricity in March 1984, Repelita IV set the goal of electrifying 21 percent of rural households by 1994 plus corresponding numbers of other types of consumers. The attainment of this goal will require an investment of about $820 million between 1984/1985 and 1988/1989. The magnitude of this proposed investment, plus the large number of potential beneficiaries, provide a strong justification for increased attention to the return on national investment in RE. Improvements in the efficiency of the RE program can result in important welfare gains for beneficiaries and cost savings for the Government. While the report emphasizes, almost entirely, productive use development it is important to note again that this is part of only one of three major objectives for the power sector. The provision of electricity to more households, the stimulation of productive activities in the urban sector and the diversification of primary fuels while not treated in this study are still important pieces of the overall power sector program of the Government.

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Increased attention to productive uses of electricity in rural areas can enhance the achievement of the social objectives of rural electrification in two ways. First, use of electricity by small scale industry or for irrigation pumping (as examples) would, by increasing the load factor, lower the cost of supply to households. Second, and perhaps more importantly, productive uses would create jobs and additional income for rural dwellers. Thus, increased attention to productive uses of electricity can be seen as an important step towards the achievement of the social welfare objectives of the national rural electrification program.

This report identifies ways of improving the efficiency of RE and proposes actions required to overcome various constraints to achieving that end. Chapter II describes Indonesia's experience with, and current approach to, RE. With this as a basis, Chapter III identifies supply and demand side constraints on the development of RE. Chapter IV presents an analytical framework which describes, at a conceptual level, an efficient approach to RE planning. This framework provides a basis for the proposed RE strategy outlined in Chapter V. This strategy offers specific suggestions concerning ways to relax the constraints of RE development identified previously. Finally, Chapter VI provides a discussion of the initial steps which the Government and DJL in particular might take in order to help implement this strategy.

B. CONCLUSIONS

Indonesia's RE program has been the subject of considerable scrutiny in recent years. Part of this is focused on the program's relative inability to stimulate significant economic development in the rural sector. In rural areas, many existing productive enterprises did not immediately choose to electrify or to switch from diesels to the grid and few new productive uses for electricity developed.

It seems likely, in retrospect, that expectations regarding RE in Indonesia were excessive, and that the RE program itself was probably

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too narrowly focused. Experience throughout Asia demonstrates that the developmental impact of RE is generally modest and occurs relatively slowly over a number of years. In addition, RE is unlikely, by itself, to lead to significant increases in rural economic activity unless a variety of other conditions (adequate access to markets, credit, and infrastructure) are also satisfied. However, these conditions are not apt to be met in many rural areas of Indonesia unless they are created through specific programs.

Nevertheless, a number of problems specific to the RE program existed in the near past and these served to further limit the productive uses of RE. Among these were a relatively distorted energy pricing structure, high costs of initial connection to the RE system, a RE site selection process which gave heavy weight to non-economic factors, and a general lack of information about, or promotion of, the productive uses of RE. Over the last few years a number of these problems have been addressed. Specifically, energy sector prices have, in general, been rationalized and the barrier posed by high connection costs are being reduced for some consumers. It is probably too early, however, for the full impact of these changes to be observed and there are still other steps which are necessary if significant improvement is to be achieved.

The other problems cited above generally remain. Thus DJL, PLN, and other agencies involved with RE are faced with the task of determining areas for RE with significant productive use potential and creating an environment in which RE can compete effectively with alternative commercial energy sources. Assuming RE has inherent economic advantages in certain areas resulting from economies of scale and its use of less expensive fuels, then the challenge in a properly identified RE area is to create conditions under which productive use consumers: 1) have a financial incentive to connect to the RE system, and 2) recognize that this energy supply option exists and is available to them. In addition, RE agencies must try to maximize the potential cost advantage of RE by using appropriate design standards and operating practices.

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In this context, a strategy to increase the economic benefits derived from RE should include efforts to:

1. develop a detailed rural electrification strategy for all of Indonesia which includes elements addressing the creation of productive uses;

2. develop and apply an improved method of RE site selection;

3. revise certain tariff/connection charge policies;

4. develop improved informational/promotional programs which encourage the productive use of RE;

5. investigate the potential cost savings which can be realized through acceptable modifications of RE design standards, and construction and operating practices; and

6. develop a pilot effort which implements activities (3) and (4) and monitors the results.

While all six activities listed above are important, attention is focused in this report on activity (1) and (2). These are judged to be the most important activities and the ones which are most consistent with DJL's mandate[5].

Thus in Chapter VI of this report a process for developing a strategy is presented and detailed "terms of reference" are provided for a proposed study aimed at developing an efficient procedure for selecting RE sites.

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CHAPTER I

NOTES AND REFERENCES

1. Decisions regarding RE are often affected by non-economic factors. Such influences are not considered in this report, although they must be accounted for when an attempt is made to implement the recommendations presented here.

   For PLN, RE involves supplying electricity to areas which are not kotamadya, kota administratip, ibukota propinsi or ibukota kabupaten. This report, however, defines RE as the supply of electricity to rural areas (defined as above or in terms of a maximum number of consumers (say 10,000) for the principal purposes of electrifying households and fostering economic development. Electric supply activities which are carried out in rural areas for purely commercial reasons, e.g. electrification of a large productive enterprise, are not considered to be part of RE. Overall, it is the motive for electrification, i.e. developmental as opposed to commercial, which determines whether it should be considered as RE. Although most RE consumers will be small, it is not considered meaningful to establish a maximum level of demand below which are RE consumers and above which are non-RE consumers.

   A productive use consumer of RE utilizes electricity in RE areas to produce a good or service which is sold in a market. The use of electric lighting in a place of production should not ipso facto be considered as a productive use of electricity.

2. In 1978, approximately 63 percent of energy used in Indonesia was derived from non-commercial sources (firewood and agricultural wastes). By 2000, this figure is expected to be between 20-33 percent. Source: Energy Planning for Development in Indonesia, Vol.1, pp.102-107. Energy/Development International, 1982.

3. Another aspect of this policy is the Government's efforts to replace most captive power generation with grid supplied electricity.

4. From an environmental perspective, RE has been viewed as a means of reducing problems of deforestation in certain parts of Indonesia. Recent research, however, raises questions concerning whether firewood consumption contributes significantly to such problems.

5. Activities (2), (3), (4) and (5) should be viewed as joint DJL-PLN undertakings since they have significant technical aspects or require considerable implementation capabilities. DJL as the energy policy and coordinating body of the Government is responsible for seeing that policies exist, are implemented or

changed and that the actions of all entities operating in the energy sector are coordinated.

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II RURAL ELECTRIFICATION IN INDONESIA

A. DEVELOPMENT OF RURAL ELECTRIFICATION

In Indonesia, electricity supply is regarded as one of the basic infrastructure services - along with roads and water supply which the Government is expected to supply. In 1972, Government Decree No. 18 directed PLN to undertake RE along with urban electrification, and in 1976, PLN established a sub-directorate for RE. USAID gave significant impetus to RE efforts in 1977 by funding a RE project which was modeled after RE efforts in the Philippines. At that time, 10 RE sites were identified. PLN was responsible for the seven sites on Java, and they utilized PLN supplied electricity. Three electric cooperatives utilizing diesel generators were established on outer islands. The U.S based National Rural Electric Cooperatives Association provided technical assistance for all sites.

RE activities have increased rapidly since the 1970's. As of 1984, about 6 percent of the rural population had access to electricity; and the plan is to increase the electrification level to 21 percent of the rural population in 1994 by electrifying 7000 villages during Repelita IV and 9000 villages during Repelita V[1]. Significant disparities in electrification levels for different geographical areas exist at present, and are likely to be maintained or increased during Repelita IV. Results from Table 1 indicate that the percent of unelectrified villages at the end of Repelita III varied between 41.9 percent in Bali and 90 percent in Kalimantan. By the end of Repelita IV, all villages in Bali should be electrified while 84.5 percent of the villages in Kalimantan will remain unelectrified. In absolute terms, the largest increases in RE (in terms of villages electrified) during Repelita IV will be in Java and Sumatra, while the largest percentage increases will occur in Bali and Java.

The source of RE energy supply also varies by region. New Java sites are to be supplied primarily by grid extension and occasionally

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TABLE:1 GEOGRAPHICAL DISTRIBUTION OF RURAL ELECTRIFICATION

Island	Total Villages	Unelect. Villages at End of Repelita III		Village to be Elect. During Replita IV	Unelect. Villages at End of Repelita IV	
		#	% of Total Villages		#	% of Total Villages
Sumatra	21778	17428	80.0	1820	15608	71.7
Java	22272	16138	72.5	3425	12713	57.1
Bali	589	247	41.9	247	0	0
Nusa Tenggara	2303	1971	85.6	178	1793	77.9
Irian Jaya	900	799	88.8	40	759	84.3
Maluku	1722	1504	87.3	165	1339	77.8
Sulawesi	4403	2824	64.1	600	2224	50.5
Kalimantan	8004	7187	89.8	420	6767	84.5
Timor Timur	1727	1702	98.6	105	1597	92.5
	63698	49800		7000	42800	

Source: PLN

by minihydro. The use of isolated diesel units is more prevalent on the outer islands. The current PLN policy with regard to isolated diesel power generation is that no new sites will be established on Java and when the central grid replaces an isolated diesel supply the relocation site for the diesel generator set will be off Java.

While PLN is the dominant actor on the RE scene, other organizations such as the Ministry of Trade and Cooperatives and the Ministry of Transmigration are involved as well. In 1983, cooperatives supplied electricity to about 1600 villages. All but about 160 of these used power purchased from PLN. By 1988/89, cooperatives are expected to supply another 1250 villages. Small private, municipal, or village-level utilities also exist in many areas. These represent marginal energy supply activities, however, and are gradually being absorbed by PLN in many areas. Finally, there is significant captive or individual user power generation for productive purposes (much of it in rural areas) accounting for about 35 percent of total electric consumption in 1983/84.

The Government of Indonesia has no discrete rural electrification strategy addressing productive use development nor a comprehensive and coordinated program to encourage the creation and support of productive activities through RE. Although there is a recognition of the need for this within the Ministry of Mines and Energy and in particular in PLN and DJL. Because the need is recognized, the analysis reported here is timely. Through this analysis we have suggested an approach to a strategy for creating and supporting productive activities in the rural sector through rural electrification.

B. TARIFFS/CONNECTION CHARGES

RE consumers at PLN sites and registered electric cooperatives pay the same tariffs as other PLN consumers. There is no geographical variation in tariffs; and tariffs are the same regardless of whether

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TABLE 2: PLN TARIFF SCHEDULE 1984
(Effective: March 1984)

Consumer Category	Code of Tariff	Contracted Power	Demand Charge Rp/kVA	Energy Charge Rp/kWh	Projected Av. Revenue Rp/kWh
S: Social Institutions	S1	/200 VA	(a)		
	S2	250 VA/200 KVA	2,100	43.50	60.57
R: Residential	R1	250 VA/500 VA	2,100	70.50	85.19
	R2	501 VA/2200 VA	2,100	84.50	98.41
	R3	2201 VA/6600 VA	3,680	126.50	156.42
	R4	6601 VA & Over	3,680	158	184.10
U: Commercial	U1	250 VA/2200 VA	3,680	134	160.10
	U2	2201 VA/200 KVA	3,680	150	185.73
	U3/MV	201 KVA & Over	2,300	P=158 OP=99	123.17
	U4			307	307
I: Industrial	I1	Up to 99 KVA	2,300	P=106 OP=66	93.97
	I2	100 KVA/200 KVA	2,300	P=100 OP=62.50	85.51
	I3/MV	201 KVA & Over	2,100	P=96.50 OP=60.50	75.88
	I4/HV	5000 kVA & Over	1,970	P=81.50 OP=52	61.13
G: Offices	G1	250 VA/200 KVA	3,680	96	120.86
	G2/MV	201 KVA & Over	1,970	P=99 OP=65	84.92
J: Street Lighting	J			76.50	76.50
		Average:			98.315

(a) Tariff S1: 100 VA = Rp 2,510/month
150 VA = Rp 3,765/month
200 VA = Rp 5,025/month

Note: P = Peak Hours (18.00 - 22.00)
OP = Off Peak Hours (22.00 - 18.00)

Source: PLN

electricity is supplied from the PLN grid or from autogeneration. Tariffs currently in effect are summarized in Table 2.

Virtually all consumers pay a per KVA demand charge and a per kWh energy charge. For residential consumers, per unit demand and energy charges increase with the amount of contracted power. Per unit demand charges are constant for small and medium sized commercial consumers, while per unit energy charges increase slightly. Demand and energy charges decrease with the size of connected load for industrial consumers. They also pay peak/off-peak energy charges. During the off-peak period (22:00 - 18:00), per unit energy charges are reduced by roughly 40 percent. Finally, unlike many developing countries there is no separate tariff for agricultural consumers. In many other asian countries agricultural use of electricity is subsidized.

The long run marginal cost (LRMC) of power supply measures the economic cost of supplying electricity. This cost typically varies with the time of day (and year) and the type of consumer. By comparing actual electric tariffs with estimates of LRMC, one obtains indications of the accuracy of price signals provided by the tariff structure and the magnitudes of relative subsidies/taxes which various types of consumers face. Such a comparison of tariffs and LRMC for consumers connected to the PLN grid suggests that small residential and industrial consumers in rural areas (tariff categories R1, I1, I2) are highly subsidized. That is, LRMC for such consumers is at least 50-70 percent higher than average tariffs[2]. While both demand and energy charges are subsidized, relative subsidies are greater for the former. Commercial consumers, in contrast, pay average tariffs which exceed LRMC. While their demand charges are actually less than long run marginal capacity costs, their energy charges exceed long run marginal energy costs by between 40-70 percent.

Connection charges for PLN consumers vary with the contracted load and the PLN region (Wilayah) in which consumers are located. Some of these connection charges are summarized in Table 3, together with estimates of average connection costs.

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TABLE 3: PER UNIT CONNECTION CHARGES AND AVERAGE CONNECTION COSTS: 1984

	Per Unit Connection Charge (Rp/KVA) Tariff Category			Average Connection Costs (Rp)		
PLN Region	R1	V1-V2	I1	R1 (a)	V1-V2 (b)	I1 (c)
E. Java	120	70	85	54000	63000	425000
C. Java	120	70	85	54000	63000	425000
W. Java	120	70	85	54000	63000	425000
Jakarta	120	70	85	54000	63000	425000
Wil.I (Banda Aceh)	45	45	30	20250	40500	150000
Wil.II (Meden)	110	110	65	49500	99000	325000
Wil.III (Padang)	100	100	55	45000	90000	275000
Wil.IV (Palembang)	45	45	25	20250	40500	125000
Wil.VI (Banjar Baru)	50	50	30	22500	45000	150000
Wil. VII (Manado)	105	105	60	47250	94500	300000
Wil. VIII (Ujung Pandang)	125	125	70	56250	112500	350000
Wil. IX (Ambon)	50	50	35	22500	45000	175000
Wil. X (Irian Jaya)	100	100	55	45000	90000	275000
Wil. XI (Denpasar)	100	100	50	45000	90000	250000

(a) Assumes a connected load of 450 VA
(b) Assumes a connected load of 900 VA
(c) Assumes a connected load of 5KVA.

Source: PLN

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It is clear that the regional variation in connection charges is significant. Variations of 100 percent or more are found for all three categories of consumers[3]. In most regions, average connection costs are considerable and are likely to provide a significant barrier to connection unless appropriate steps are taken[4]

C. SITE SELECTION PROCEDURES

PLN follows a well established procedure for selecting areas for RE. For Repelita IV, first priority is given to rural subdivision capitals (Kecamatan) which are not electrified. Next comes so-called Swasembada villages. These two categories of villages account for 555 and 5985 respectively of the 7000 villages to be electrified[5]. The remaining villages to be electrified fall in the Swakarya and Swadaya categories.

To understand the implications of this selection procedure, one must understand the Indonesian method of classifying villages. This procedure, which is undertaken by the Ministry of Internal Affairs and used by other Government offices in addition to PLN, ranks villages according to their level of "development". In this case, "development" is measured by ten indicators: 1) population density, 2) productivity of the land, 3) distance from district (or sub-district) capital, 4) occupational distribution of the labor force (agricultural, industrial, service), 5) village income, 6) habits, 7) existence of institutions, 8) average level of education, 9) community relations, and 10) availability of infrastructure.

Some of these indicators are related to a villages productive use potential, e.g. (2), (4), and (10), or to the likely level of non-productive use demand for electricity, e.g. (1), (5), and (8). Nevertheless, there is little reason to believe that Swasembada villages are necessarily the ones for which RE can have the greatest development impact. The selection of these villages is principally a response to power sector goal of extending electrification benefits to as many households as possible. Because there have been shortfalls in

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meeting electrification targets any methodology which can prioritize sites in terms of potential benefits will be useful in the execution of rural electrification programs.

D. DESIGN STANDARDS

The design standards utilized in PLN and cooperative RE projects are the same as those used in the main PLN grid. In contrast, the various small private, municipal, or village utilities often employ design standards which are inferior to those used by PLN.

Considerable work has been done during the last decade to demonstrate that, in general, significant economic gains can result from matching the design standards used in a power system with the particular needs of consumers being supplied. Since an optimally designed power system is one which minimizes the discounted sum of system costs and economic losses resulting from power outages, appropriate design standards are typically higher/lower in more/less developed areas.

In this context, the fact that PLN design standards, which are established primarily for relatively urban areas, are also applied in RE areas suggests that the quality of supply built into RE projects may, in many cases, be too high.

A comparison of per unit RE costs in Asian countries with significant RE programs indicates that these costs are relatively high in Indonesia. For example, per kilometer costs for HV and LV lines and costs of distribution transformer stations are among the highest found in a selection of countries which includes Thailand, India, Bangladesh, the Philippines, and Pakistan[6]. One must be cautious when making such intercountry cost comparisons, however. Only part of the observed cost variations is likely to be attributable to differences in design standards or the relative efficiencies of RE programs since economies of scale and domestic production capabilities are also apt to be important. Nevertheless, comparative cost data do

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suggest that there are opportunities for lowering the cost of Indonesian RE by modifying design standards and construction practices.

E. OVERVIEW

In the past decade, Indonesia has made considerable progress electrifying rural areas. This has largely taken the form of supplying electricity for lighting to rural households and public consumers. The development of productive uses of electricity has generally been modest and limited to relatively few areas. During this period, PLN has been the dominant actor on the RE scene; and this pattern is expected to continue in the future as PLN accelerates its RE activities for Repelita IV and consolidates various other small private and public electricity supply operations.

PLN's planned RE activities represent a significant commitment of resources. They are also likely to impose a significant financial burden on PLN and the Government. For example, revenues generated by PLN's RE investment during Repelita IV are expected to fall short of the corresponding financing costs by roughly Rp. 859 million. These factors highlight the importance of ensuring that Indonesia's RE program is structured so as to maximize its financial and economic benefits. Before recommending specific steps to help accomplish this objective, Chapter III identifies some of the factors which have constrained the growth of RE benefits in the past.

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CHAPTER II

NOTES AND REFERENCES

1. The resulting electrification rate of 21 percent is still below those currently found in Malaysia, Thailand, or the Philippines.

2. This is likely to be an underestimate since rural consumers in any category are more costly to supply, on average, than non-rural consumers in the same category.

3. The extent to which these variations reflect actual differences in supply costs is unknown.

4. For example, connection costs for residential consumers can be compared with annual per capita GDP of about Rp 450,000 in 1983.

5. At the end of Repelita III there were 8688 unelectrified Swasembada villages. The choices concerning which Swasembada villages to electrify within a Province are made at the district (Wilayah) level with the help of the Province planning board. distance to the existing grid is apparently an important factor when determining which Swasembada villages to electrify. Non - Swasembada villages may be electrified due to their proximity to a Swasembada village which is being electrified.

6. Detailed cost comparisons are provided in the Asian Development Bank's forthcoming "Rural Electrification Handbooks".

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III CONSTRAINTS ON THE DEVELOPMENT OF RURAL ELECTRIFICATION

As discussed in Chapter II, Indonesia has made considerable progress with RE over the last decade. About 1400 villages were targeted for electrification by the end of Repelita III and another 7000 villages are targeted for electrification during Repelita IV. There does seem to be a consensus, however, that the potential economic benefits of RE - especially those derived from productive uses of electricity - have not been fully realized at many RE sites. Some of the reasons for this are analyzed in this section. Since the realization of RE benefits depends upon consumers' willingness to use RE and the producer's ability to supply RE, the analysis presented here is organized along those lines. That is, demand-side constraints are discussed first and then supply-side constraints are considered. This analysis of constraints on the development of RE in Indonesia provides the basis for the RE strategy which is presented later in the report.

A. DEMAND-SIDE CONSTRAINTS

The economic benefits of RE can only be realized when potential consumers have an incentive to connect to the RE system and can afford to do so. Evidence suggests that household consumers in Indonesia have a strong incentive to connect to the RE system despite the highly subsidized price of kerosene (see Table 4). This probably results from the higher quality and convenience of electricity and its broad social appeal. This incentive is tempered in many instances, however, by affordability concerns.

It is clear, in contrast, that potential productive use consumers have not had a strong incentive to connect to RE systems, and new productive use consumers have not developed in significant numbers. This is evident from the low load factors observed at many RE sites and the predominance of non-productive use consumers. Since productive use consumers demand energy not for its own sake but for its contribution to a production process, i.e. the demand for energy

TABLE 4: DOMESTIC AND ECONOMIC PRICES OF PETROLEUM PRODUCTS

Category	Share of Consumption % (a)	Domestic Price (Rp/liter in nominal prices) 1970	1974	1980	1982	1984	Economic Price in 1984 (Rp/liter) (b)	Ratio of Domestic to Economic Price in 1984 (b)	% Increase in Price 1974-80 N (c)	1974-80 R (d)	1980-82 N	1980-82 R	1982-84 N	1982-84 R (est)	1980-84 N	1980-84 R (est)
Aviation Turbo	3.2	30	50	150	240	300	239	1.25	200	59	60	41	25	-5	100	44
Gasoline Super	0.2	35	55	220	360	400	269	1.50	300	159	64	45	11	-19	82	26
Gasoline Regular	16.8	30	46	150	240	350	229	1.53	226	85	60	41	46	16	133	77
Kerosene	32.6	10	13	37.5	60	150	236	0.64	188	47	60	41	150	120	300	244
Motor Diesel	30.0	12.5	19	52.5	85	220	211	1.04	176	35	62	43	159	129	319	263
Industrial Diesel	5.8	8	13	45	75	200	205	0.98	246	105	67	48	167	137	344	288
Fuel Oil	11.0	6	12	45	75	200	185	1.08	275	134	67	48	167	137	344	288
Total/ Average	100.0					219	220	1.00								

(a) As of 1984.
(b) Singapore prices in December 1983 plus 5% distribution cost, converted at US$1 = Rp 1000.
(c) N = nominal price increase
(d) R = real price increase. Between 1974-80, 1980-82, and 1982-84, The average price level increased 141%, 19% and 30% (est) respectively.

Source: World Bank Data.

is a derived demand, the factors limiting their incentive to connect must be largely financial or technical.

1. Energy Sector Pricing

Over the long run, there is significant substitutability between different energy sources and for most productive use consumers relative energy prices are likely to be a key determinant in the choice of a particular energy source. In fact, there is reason to believe that energy sector pricing policies have served as important constraints on the development of productive uses of RE.

Information of the domestic pricing of petroleum products in Indonesia in presented in Table 4. It indicates that until 1984 the fuels which competed most directly with electricity as energy sources for productive use consumers (diesel and fuel oil) were subsidized, i.e. sold at financial prices which were below their economic prices. Table 5 summarizes average electricity prices for selected tariff categories between 1980-1984. Results presented there indicate that average electric tariffs were also subsidized before and after 1984. However, it is clear from Tables 4 and 5 that relative per unit subsidies were greater for diesel and fuel oil than for electricity during most of this period. This undoubtedly discouraged a switch from auto generation to PLN supplied electricity by productive use consumers.

This problem should be less serious in the future for small industrial consumers. Subsidies for petroleum products (except kerosene) have been eliminated(1). At the same time, electricity tariffs for such consumers are still subsidized and off-peak energy prices are available. In contrast, commercial uses of RE may be discouraged by average tariffs which exceed corresponding LRMC.

In addition, the magnitude of connection charges (see Table 3), and the fact that payment was required in one lump sum, have often been cited as barriers to the development of productive uses of RE. It is clear that, in the absence of adequate credit markets, a

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TABLE 5: AVERAGE ELECTRICITY PRICES AND LRMC FOR PLN CONSUMERS
(Rp/kWh)

Tariff Category	Average Prices May 1980	February 1982	February 1984	January 1984	% Increase in Average Prices 1981-82		1982-83		1983-84		1980-84	
					N[a]	R[b]	N	R	N	-R	N	R
R1 (small residential)	38.34	48.85	67.19	85.19	27	8	38	23	27	12	122	66
W (small commercial)	66.16	84.67	119.36	160.10	28	9	41	26	34	19	142	86
I1 (small industrial)	41.77	53.33	74.03	93.97	28	9	39	24	27	12	125	69
Average for all consumer categories	42.23	53.91	74.72	98.32	27	8	39	24	32	17	133	77

a) See Table 4

b) See Table 4

Source: PLN

requirement of full payment prior to connection has inhibited connections in the past. Since the beginning of Repelita IV in 1983/84, however, some residential consumers have had access to a credit program funded by the Ministry of Finance through the Bank Rakyat Indonesia. This program covers both connection and housewiring expenses up to a total of Rp 56,700 per consumer. The resulting loan must be repaid in 1-4 years at an annual interest rate of 6 percent. There is no similar credit program available to other types of RE consumers at present.

2. Site Selection

As discussed above, PLN follows a procedure which emphasizes the selection of unelectrified kecamatan and swasembada villages for electrification. However, such villages are not necessarily the ones with the greatest productive use potential. This is especially true since the Government's decision to electrify kecamatans largely reflects an attempt to achieve a balanced geographical distribution of RE sites. Thus a procedure which more closely linked and emphasized the connection between site selection and productive use potential is a necessary step for increasing the productive use of RE in Indonesia. This shift in emphasis can still allow electrification benefits to reach an equal number of households as under current site selection procedures. It would also produce a number of other benefits not currently realized.

3. Informational/Promotional Programs:

Potential productive use consumers are likely to have considerable experience with non-electric sources of energy. As a result, they learn to operate and maintain them efficiently. This is clearly not necessarily the case for electric power. Thus, there is a need for programs which inform potential productive use consumers about the possible uses of electric motors and machines. PLN has not done this in the past[2]. In addition, PLN does not actively seek out new productive use consumers. Instead, it relies on potential consumers registering on waiting lists. This passive approach may have had some justification in the 1970's when there was inadequate

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generation capacity. This generation constraint has now been relaxed somewhat and more open promotional efforts on PLN's part may be appropriate in order to compete with aggressive salesmen for other energy sources.

4. Complementary Programs

The above discussion implicitly assumes that the potential productive use consumers of RE already exist in rural areas. The challenge regarding such consumers is to create the right incentives so that they are willing to switch to RE. An additional challenge is to encourage the development of new productive uses. The demand-side constraints described above are just as important for new productive use consumers as for existing ones. In addition, however, the development of new productive uses may be constrained by the lack of other complementary inputs. In order to develop, productive enterprises require adequate access to markets, credit, infrastructure, transportation, and so on. If any of these are lacking, then the provision of RE may need to be linked with other developmental programs which address these needs. It is not clear that this had occurred in Indonesia.

B. SUPPLY-SIDE CONSTRAINTS

1. Supply Costs[4]

On the supply side, one of the principal constraints to the development of RE is its relatively high cost[4]. This occurs for a variety of reasons. As discussed above, RE design standards are not modified to match the specific requirements of RE consumers. It is likely that reliability standards (and hence supply costs) are excessive as a result.

Another factor which may contribute to relatively high supply costs at some sites is the choice of energy supply options. Most RE sites receive electricity from either grid extension or diesel generation. It seems likely that in the past alternative, and possibly less expensive, supply options (such as mini-hydro) were not

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always given adequate consideration. This is changing, however, as PLN expands its mini-hydro program and more actively considers other alternative energy sources. For example, 400 villages are programmed to be electrified during Repelita IV using mini-hydro schemes and the rural renewable energy potential of Kalimantan is being studied. In addition, plans are underway to investigate a variety of alternative energy sources for RE - gasifiers in transmigration areas, small gas deposits in Sumatra and biomass in Nusa Tengara Timur.

Even when alternative supply options are utilized there is still room for reducing supply costs. Per unit capacity costs in PLN's existing mini-hydro projects are relatively high. This may be partially explained by PLN's relative lack of experience with mini-hydro. Nevertheless, these costs are significantly above those found in some other Asian countries. Standardizing its approach and increasing use of local labor and materials should allow PLN to significantly lower these costs.

2. Uncertainty

In some cases, PLN has not been responsive to the planning needs of productive use consumers. There have often been relatively long lead times (at least three months) and uncertain delays between the application for power and the actual connection. This makes reliable planning difficult. It also makes alternative power supply options more attractive. This short run attractiveness and the feeling of having control over supply can often override the long term lower cost benefits of PLN supply.

CHAPTER III

NOTES AND REFERENCES

1. The subsidy for kerosene has likely been maintained for distributional reasons since kerosene lamps are the chief source of light in low income households. However, kerosene also has productive use applications, e.g. the drying of agricultural products.

2. Some progress is being made, however. USAID funded the activities of a "productive use advisor" in Central Java for several years. PLN has recently trained a few "productive use coordinators" on a pilot basis. Finally, electric cooperatives sometimes establish "pilot project", e.g. an electrified rice mill, so that other potential productive users can observe and learn from the experience.

3. The factors discussed in this subsection limit the benefits realized from all categories of consumers.

4. These costs are not directly passed on to RE consumers via specific RE tariffs, but they do serve to reduce the number of electrification areas and probably place upward pressure on tariffs in general.

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IV ANALYTICAL FRAMEWORK

A. OVERVIEW

The process of determing an efficient strategy for RE should begin with the recognition that different RE programs can have different objectives. For example, RE may be undertaken primarily to stimulate rural economic development, improve rural standards of living, or achieve security objectives. That is, the emphasis can be on growth, equity, or security. A different"approach" to RE is required in each case in order to achieve the particular objective as efficiently as possible(1). Following this logic, a clear statement of all of the objectives of RE in Indonesia is needed before an efficient strategy can be determined. Such a statement of objectives is now available but there are ambiguities concerning the definition of rural areas and productive activities. Presently there is very significant emphasis on household electrification and during the early years of RE the principal objective has been to improve rural standards of living. This focus seems to be shifting in a direction which places increased emphasis on RE's contribution to rural economic development. This is perhaps due to greater recognition of both the financial and economic implications associated with RE and the possible efficiency gains resulting from substituting RE for other energy sources. The objective of maximizing RE's contribution to rural economic development underlies the RE strategy described below(2).

Given the principal objectives of the RE program, an appropriate analytical framework can be developed. This framework should place RE within a broad rural energy/development context since:

1. RE will, at best, meet only a relatively small fraction of rural energy needs. It may supply energy for lighting and mechanical power. It is unlikely, however, to be a viable source of energy for cooking and transportation which are usually the largest uses of energy in rural areas.

2. Pricing and supply policies for other potential sources of rural energy affect the viability of RE.

3. A successful approach to RE induced and supported by productive activities often requires the presence of complementary programs aimed at providing such inputs as credit, marketing services, and other forms of infrastructure which are outside the narrowly defined limits of RE programs.

Within this broad rural energy/development context, an analytical framework is needed to:

1. identify the economic benefits and costs of RE and their determinants, and

2. specify how the net economic benefits of RE, i.e. the difference between discounted economic benefits and discounted economic costs, can be maximized. The RE strategy then describes an actual procedure by which this analytical framework can be applied to achieve the desired efficient outcome.

B. SPECIFICS

1. Introduction

The objective of this analytical framework is to determine how the Government should choose regions to be electrified, and methods of electrification, so as to maximize the net economic benefits to the country. There are several reasons why careful analysis has not often been performed to address these issues. First, some of the benefits of RE are difficult to quantify, especially before the fact. Second, RE decisions have often been dominated by political and social benefit considerations, which were either not susceptible to analysis or wary of the understanding that analysis could provide. Third, institutional or technical factors may limit the type of analysis which RE decisions undergo. For example, most utilities focus on electrification via central grid extension. As a result, the option of electrifying certain areas by using local energy resources and decentralized generation technologies may not receive adequate consideration.

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The analytical framework presented below addresses the first constraint listed above, i.e. the difficulty of quantifying RE benefits and then combining benefit and cost estimates in order to rationalize the site selection procedure. Additional political, institutional and technical constraints may be more appropriately addressed once such a framework is available.

2. Analytic Approach

The two fundamental questions which must be addressed by an analytic approach to RE are:

a) what regions should be electrified, and

b) what supply options should be used[3].

Since the objective of this analytic approach is to determine economically efficient answers to these questions, political and distributional considerations are ignored.

Conceptually, the objective of this analytic approach is to determine a rank order of potential RE regions. This ordering should be from the "best" region, i.e. the one with the highest net economic benefit per rupia spent on RE, to the "worst" region. It can then be used to select RE regions. The procedure should be to start at the top of the ranking and work down choosing as many regions with positive net economic benefits for electrification as is consistent with the resources available for RE and the electric power supply-demand balance. Criteria to establish the ranking could either be selective, if a particular type of outcome was desired such as achieving the most productive uses, or general if all costs and benefits were included.

To determine this general ranking, one must estimate the economic benefits and costs of RE in the regions. Concerning RE costs, the various supply options for each region must be considered. These fall into two general categories: centralized and decentralized. The cost of the centralized option will depend among other things on the

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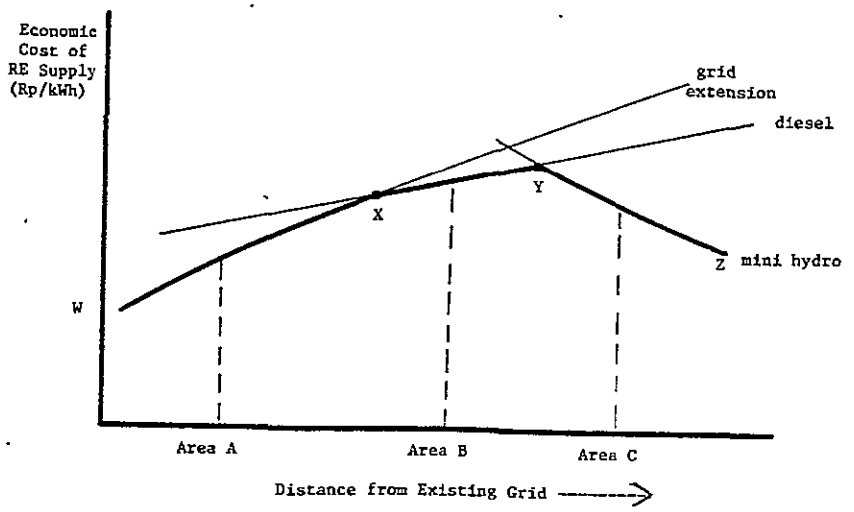
location of current and potential generation sites (hydro, thermal, or geothermal) and the cost of transmission. Costs of decentralized options depend among other things on the location and energy density of various resources such as wind, small hydro, agricultural wastes, and isolated diesel.

A simple hypothetical figure can help clarify the relation between location and the relative costs of various supply options. Figure 1 represents a continuum of potential RE sites which are arranged according to increasing distance from the existing grid[4]. For explanatory purposes, three potential sites (A,B, and C) are identified. Sites A and B have little access to alternative energy sources except diesel, while Site C has significant mini-hydro potential. This translates, given appropriate cost parameters, into the "least cost locus" (WXYZ) in Figure 1. This locus indicates that grid extension is the least cost supply option for Area A, as are small diesel and mini-hydro for Areas B and C respectively[5].

FIGURE 1: LEAST COST RE SUPPLY LOCUS



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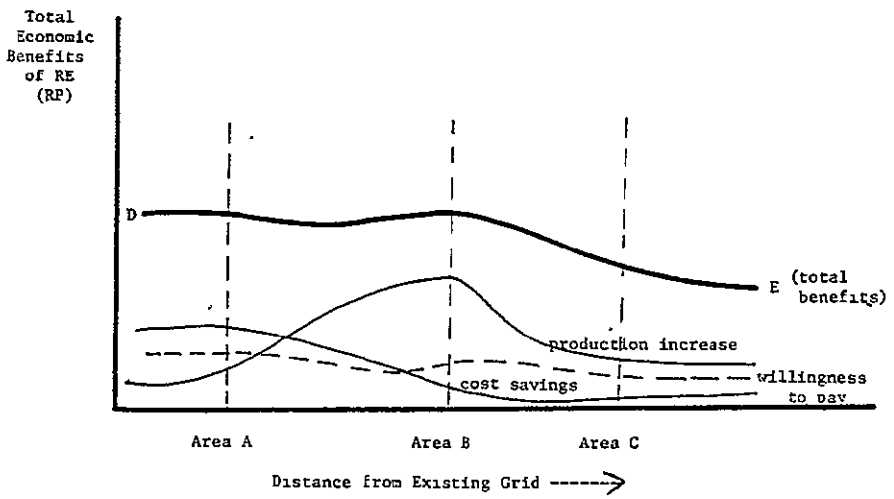
Under appropriate conditions, RE can produce a variety of economic benefits. The most important of these are: 1) economic cost savings resulting from the substitution of electricity for other more costly sources of energy, 2) net increases in the value of economic production, i.e., increased agricultural or industrial production and more commercial activity, and (3) improvements in the quality of rural life. Items 1 and 2 can be measured directly, while the value of (3) requires a political decision as well as social analysis. Here we shall take the consumers' willingness-to-pay for electricity as a proxy for social benefits[7].

These RE benefits are clearly site specific. That is, they depend on the economic base of the area being electrified and on the socio-economic conditions of the population there as well as on other things. Thus, RE benefits are unlikely to be related in a simple fashion to the distance from the existing grid. Assume, for example, that benefits to Sites A and B are relatively high due to considerable cost savings and willingness-to-pay in the former and significant increased production and willingness-to-pay in the latter. In contrast, benefits for Site C may be low due to the lack of market activities and low levels of willingness-to-pay. These conditions are represented in Figure 2, which depicts the potential level of RE benefits in different areas. These potential benefits determine a corresponding "total benefit locus" (DE)[8] [9].

FIGURE 2: TOTAL RE BENEFIT LOCUS



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Figures 1 and 2 can be combined to determine the implications of this example. This is done in Figure 3 which indicates the net economic benefits resulting from the electrification of Sites A, B, and C. Figure 4 translates this into rates of return on the corresponding RE investments. The results indicate that the electrification of Site A is clearly economically justified, while the electrification of Site C is not. While Site B has a positive rate of return it is less than that of other possible investments, as represented by the opportunity cost of capital. Thus it may be decided to electrify Site B.

Another determining factor is the time variable. In order to show the impact of time in the graph above, a third dimension would have to be added to Figure 19. Another approach is to consider that the time dependence of the costs and benefits shown in Figure 17 and 18 have been analyzed and appropriately discounted to the present.

C. APPLICATION

Given this analytic approach, the question is how it can be applied in practice. It is clearly not feasible to go through the complete procedure outlined above to obtain a rank ordering for all unelectrified areas. Many can be immediately eliminated due to their obvious low potential for economic benefits. Those areas remaining merit more detailed consideration. One way to proceed is to begin by determing approximate RE supply costs for various phototypical areas (characterized by potential RE demand and distribution requirements) under the assumption that diesel generators are used[12]. Non-electrified areas not already eliminated can then be classified as resembling a certain prototype. As a first pass and as further screening of all areas it may be useful to rank areas by considering only productive use benefits. This will show which areas are highly oriented to producing productive uses. Later screenings can be made to identify those areas among the above which also have high levels of social benefits and household connections. The task is then to determine if the likely economic benefits in a given area are

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FIGURE 3: NET ECONOMIC BENEFITS OF RURAL ELECTRIFICATION

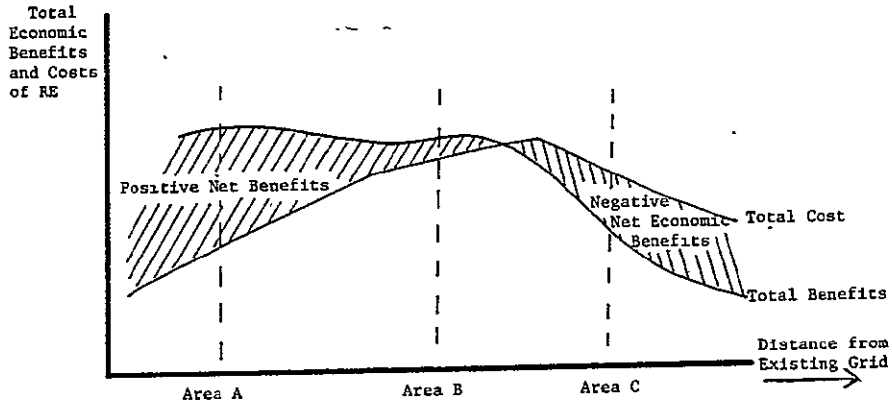
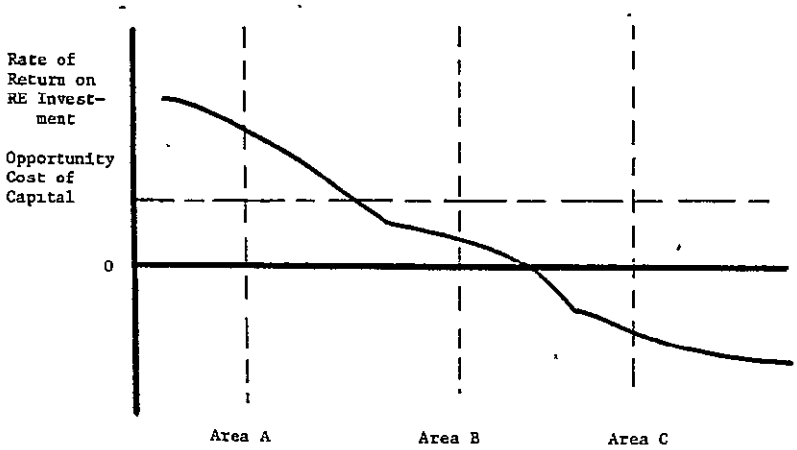


FIGURE 4: RATE OF RETURN ON RURAL ELECTRIFICATION INVESTMENTS



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sufficient to justify these costs.

Indonesia should by now have enough experience with RE to begin to investigate which socio-economic characteristics are associated with relatively high levels of RE demand. Eventually, an attempt should be made to quantify the relationship between such characteristics and RE demand[13]. It might be possible in this way to determine quickly, and with reasonable accuracy, which areas are likely to generate economic benefits in excess of supply costs. More details concerning how this analytical approach might be implemented in Indonesia are presented in Chapter VI.

Once this initial selection procedure is completed, more detailed analysis of selected sites is likely to be required to determine the specific areas to be electrified (and the order of electrification). This may involve more detailed economic analysis and consideration of financial and distributional issues. At that time, spatial concerns should be addressed. That is, once the principal target areas for RE are identified then decisions have to be made concerning which sites peripheral to these areas should also be electrified.

CHAPTER IV

NOTES AND REFERENCES

1. An "approach" to RE includes such factors as site selection, design standards, pricing and complementary programs.

2. It is likely that any RE program will also have to accomplish certain equity objectives. The challenge will be to do this at the lowest possible cost of reduced growth.

3. These two questions cannot be considered separately. The choice of supply option determines the cost of RE at a specific site. At the same time, it is the comparison of RE costs and benefits in different regions that determines (on efficiency grounds) which regions should be electrified.

4. It is assumed that all potential RE sites lie at some distance from the same grid. Thus this analyses is carried out, for simplicity, at a regional level. It would, in theory, be done at a more macro level, but it would be more difficult to represent and explain. Per kM grid extension costs are assumed constant throughout the region.

5. This example is constructed to reflect the general finding that decentralized supply options are more economically and financially competitive with grid extension in remote areas. The analysis is simplified in a number of ways. One simplification is to neglect interraction between the costs of various sites. Electrification of Site N by extension of the central grid may be strongly affected by whether Site N-1 has been electrified.

6. The benefits of increased employment are already captured by (2). The contribution of RE to reduced rates of fertility or rural-urban migration has not been well-established.

7. A more detailed discussion of RE benefit estimation procedures is provided in the ADB's "Rural Electrification Handbook" (about to be issued).

8. Just as RE costs at a particular site depend upon the choice of supply option, RE benefits depend upon the way in which the RE program is designed and implemented. Figure 2 assumes an efficient approach to RE which maximizes each benefit component. More general energy sector pricing policies also affect the level of benefits.

9. Benefits in areas between A,B, and C are assumed to follow the same patterns as in these areas.

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10. The least cost locus from Figure 1 is transposed into a minimized total cost locus by multiplying through by RE consumption in each area.

11. That is, net economic benefits are positive and the rates of return exceeds the opportunity cost of capital. Results indicate that Site A should be higher in the ranking of potential RE sites than in Site B.

12. This establishes an upper bound cost estimate since RE areas can utilize other supply options if they are available and less costly.

13. This approach is similar to one recommended by World Bank consultants as a means of identifying suitable RE projects.

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V RURAL ELECTRIFICATION POLICY AND STRATEGY

In this section, an expanded policy and implementation strategy which the Government might follow in order to achieve a more efficient approach to RE is described. The combination of a more detailed policy and strategy is aimed at making the Government approach to RE consistent with the analytical approach described in Chapter IV. The focus is on the development of adequate productive uses of RE without furnishing the number of households electrified) since this is judged to be the area the study emphasized and where remedial policies are most called for. At the same time, however, recommendations are also made concerning other aspects of Indonesia's RE program. The discussion in this section is divided into three parts: general, demand-side, and supply-side.

A. GENERAL

The need for a more detailed Government policy and strategy for rural electrification has already been discussed. The appropriateness of DJL coordinating the development of both has also been mentioned. This chapter will present a recommended approach to developing these, will suggest candidate elements of both and will define where the analytical framework described in Chapter IV can be useful during and after development of the strategy. Some of the issues which need to be addressed in a RE policy for Indonesia include: (1) How should urban and rural be defined in order to best identify targets, establish programs and account/monitor progress? (2) What are the principal objectives of rural versus urban electrifications in Indonesia? (3) How should RE be organized and supplied off Java? (4) To what extent should RE be coordinated with other rural development activities? (5) To what extent should RE be substituted for captive generation? (6) What are appropriate RE tariffs and (7) what agencies should be involved in the planning and the delivery of RE? Decisions concerning these issues are required from Indonesian policy makers. However, before such decisions can be made in an informed manner, the underlying issues need to be analyzed. This

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analyses would be an appropriate task for DJL[1]. Once the issues have been analyzed a more complete rural electrification policy can be enunciated. The policy which now exists identifies major targets but leaves some of the above questions unanswered.

For a RE policy to be successfully implemented, the responsible agency must find it in its own self-interest to do so. This does not appear to be the case up to now in Indonesia since PLN which receives no direct benefit from rural development has borne much of the financial burden of RE. In addition, successful implementation requires technical and institutional capabilities which are not required for conventional grid extension. Once again, PLN may lack some of these capabilities.

Additionally, a RE policy for Indonesia must incorporate multiple objectives for rural electrification such as:

- to distribute the benefits of electricity to as many households as is possible;
- to contribute to the development of infrastructure in Indonesia, especially off Java;
- to provide support to Government development programs including transmigration;
- to provide electricity to the public at an acceptable cost;
- to support existing and stimulate new productive activities in the rural sector;
- to be as cost effective (if not self-supporting) as possible.

A completion of the above list along with other RE policy statements and adoption by the Government would constitute the first phase of this process. This report is principally focused at addressing productive uses but it has not completely ignored the other necessary components of a strategy. The analytical framework we have suggested is a least cost optimization driven by the need to create

productive uses. To make an implementation strategy acceptable a set of compatible objectives for rural electrification must be adopted.

Therefore, the next thing DJL can do after analyzing the issues to initiate this process is to see that a set of quantifiable policy goals or objectives for rural electrification in Indonesia is adopted. This process can be accomplished by starting with the policy objectives and working with PLN, the Ministry of Transmigration, the Ministry of Trade and Cooperatives, the Ministry of Agriculture and other institutions working in rural Indonesia to define needs for and expectations of rural electrification. Repelita IV and planning for Repelita V must also be considered. On the basis of this investigation the nature of the need and set of expectations for electricity in rural Indonesia can be defined. Using this definition and working with PLN a preliminary RE strategy can be formulated. It is highly likely that entities other than PLN (such as Cooperatives) will be involved in generation and supply of electricity, especially off Java. Also the existing large amount of captive generation capacity in the rural sector influences both present and future courses of action for RE. It would be useful to include in this process all those institutions and groups which impact the future of RE.

If, at the present, there is no representative as is the case for both private and cooperative owned/managed RE systems and captive generation their positions should still be considered and incorporated. While PLN is now and will be for some time the dominant force in RE it may not always be. It is important that the RE strategy be more than a PLN RE strategy and that it contain elements which address objectives in addition to those relating to increased electrification of households.

Once a strategy is developed it should be adopted by the Government and used in creating future Repelitas and in coordinating rural development programs. This can be done in a number of ways. Some of the important issues the strategy must address include:

- Should there be a separate institutional arrangement for rural electrification or should electrification programs be divided by geographic boundaries? This is the same issue which was discussed in the recent World Bank review of electrification.

- What will be PLN's role and how will they interact with others involved in RE?

- Are there productive uses of electricity in the rural sector which should be given higher priority than others?

- What will DJL's role be?

- Who will monitor progress and performance?

- How much subsidy is justified and in what form will it be required for the chosen strategy?

- How can productive uses be stimulated without diminishing the benefits of rural electrification to households?

B. DEMAND-SIDE

This section describes a number of demand-side steps which can be taken in order to increase the economic benefits derived from RE. These are steps to ensure that the "best" areas for RE are identified and that maximum economic benefits are achieved as a result of electrification.

1. Site Selection

On the demand side, it seems clear that a pressing need is to rationalize the RE site selection procedure. This involves applying the analytic framework described in Chapter IV. Specifically, efforts are needed to identify the unelectrified areas which will benefit most from RE[(2)]. In most cases, these areas will have significant potential for developing such productive uses as grain and saw mills, dairy and meat processing, ice making, weaving and various commercial activities. Water pumping for irrigation may also be an important productive use of electricity in some areas.

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2. Energy Pricing

Considerable progress rationalizing energy prices has been made in recent years. Diesel and fuel oil subsidies have been largely eliminated; and on average, financial and economic prices coincide for petroleum products. The same general pattern is observed for electricity tariffs. Average tariffs have increased by over 130 percent since 1980 and now are only slightly below average LRMC[3]. There are, however, relative price distortions present in both the petroleum product pricing structure and the electricity tariff structure. These result in relatively large per unit subsidies to kerosene consumers and to small residential and industrial electric consumers. Such subsidies for kerosene consumers and residential electric consumers may be justified on equity grounds, but are likely to result in efficiency losses[5]. Large residential and commercial consumers finance electric power subsidies, in effect, by paying tariffs which exceed LRMC.

It is unlikely that the pattern of energy pricing described above will act in the future as a strong deterrent to the efficient development of RE in Indonesia. Prices for competing commercial energy sources used in households (kerosene and electricity) are roughly the same proportion of corresponding economic supply costs. Therefore, relative price distortions are minimal. Since industrial electric tariffs are somewhat subsidized (especially for small consumers), while prices of competing fuels (diesel and fuel oil) are not, there is even a relative price bias in favor of the use of electricity for productive purposes[6]. It does seem likely, however, that electric tariffs for commercial consumers discourage the electrification of commercial establishments in rural areas. The Government and PLN should carefully reconsider the rationale for this pricing policy[7].

3. Connection Charges

The adoption of a credit program for residential consumers at the beginning of Repelita IV which allows connection charges to be paid over 1-4 years represents an initial effort to reduce the barrier

posed by high connection charges. Every effort should be made, however, to make such a credit program available to productive use RE consumers.

4. Informational/promotional Programs

If RE is to have a greater productive use impact, it is necessary that PLN and other agencies involved with RE more actively encourage the development and connection of productive use consumers. In other words, PLN must more vigorously compete in the rural productive use energy market, and, it must actively attempt to enlarge that market. An informational/promotional program might include: (1)productive use advisors who provide potential productive use consumers with information on the uses, costs, and benefits of RE, (2) demonstration sites where productive use applications can be observed, (3) punctual connection services, (4) possible "sales" or discounts on connection costs during limited periods after the electrification of an area, (5) help with resale of displaced capital equipment, e.g. diesel engines (6) Develop materials to better educate all possible users in the benefits and proper uses of electricity. Such activities are likely to require expertise not readily available in PLN. If this is the case, steps should be taken to meet these manpower needs.

5. Complementary Programs

As part of site selection and promotional procedures, PLN and other RE agencies should more explicitly consider the various economic conditions required for the growth of productive uses of electricity in rural areas. Either RE areas with adequate access to credit, infrastructure and markets should be chosen; or perhaps more likely, greater efforts should be made to coordinate RE activities in particular areas with complementary programs aimed at satisfying other development needs.

C. SUPPLY-SIDE

To implement the analytical approach described in Chapter IV, RE agencies must identify the least cost means of supplying electricity

at appropriate levels of quality and reliability to particular rural areas. They must also have the capacity to carry out the electrification and connection process in an orderly manner so that consumers can plan accordingly. Specific steps which might be taken to help accomplish these objectives are discussed below.

1. Identifying Supply Options

Current RE supply options in Indonesia are limited to grid extension, isolated diesel, and mini-hydro. In theory, other supply options exist using peat, wood, small gas deposits, or solar and wind energy. However, these options have not been sufficiently identified or studied in most regions. As mentioned in Chapter III, the Kalimantan study is the first attempt to do this. Similar assessments are needed in other regions and PLN should be closely involved so as to begin to develop expertise in these areas.

2. Supply Costs

Comparative RE cost data described in Chapter III suggests that RE supply costs are relatively high in Indonesia. This might be the result of design standards or construction and operating practices Consequently, PLN should investigate the feasibility/acceptability of modifying RE design standards so as to reduce RE supply costs. Possible modifications include: (1) use of shorter poles made of lower cost materials such as wood or prestressed concrete, (2) reductions in statutory voltage regulations, (3) sizing of conductors and transformers for loads expected in the more immediate future, and (4) use of improved conductors instead of old types to reduce the likelihood of conductor snapping.

Other actions might involve the increased use of local materials and labor in the construction of RE projects, and greater reliance on local organizations for routing operation, maintenance, and billing procedures[8].

D. OVERVIEW

Chapter III of this report discussed a variety of factors which, in the past, constrained the efficient development of RE in Indonesia. Some of these problems have been addressed in recent years. In particular, energy prices have been rationalized to a large extent, and the barrier posed by high connection costs has been at least partially reduced for residential consumers. It thus appears that, on the demand side, the remaining challenges confronting PLN and other RE agencies are to: (1) determine appropriate areas for RE and, (2) create an environment in those areas so that RE can compete effectively with alternative commercial energy sources. Concerning the latter, if RE has inherent cost advantages, in certain areas, over alternative energy sources, then the task is to achieve conditions under which consumers: (1) have a financial incentive to connect to the RE system, and (2) recognize that this option exists and is available to them. In addition, RE agencies must strive to ensure that the cost advantage of RE is maximized by using appropriate design standards and efficient construction and operating practices. The final chapter of this report describes specific initial steps which can be taken to address one of the remaining problems confronting RE in Indonesia.

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CHAPTER V

NOTES AND REFERENCES

1. When developing a RE policy it is important to recognize: (1) what RE can accomplish, and (2) the conditions required to achieve these accomplishments. Concerning (2) RE by itself is unlikely to stimulate significant increases in rural economic activity. Such activities arise when a variety of conditions - including adequate infrastructure, access to markets, and credit - are met. Thus RE's impact on rural economic activities is apt to be significant only if such other conditions are already satisfied in the areas to be electrified, or if RE activities are coordinated with other rural development activities aimed at fulfilling these other conditions. Concerning (1), even under optimal conditions RE is unlikely to make a drastic and immediate impact on the economic development of a region. Experience from other Asian countries with relatively long histories of RE suggests that the impact of RE takes time to develop and spread.

2. As discussed in Chapter IV, site selection procedure must consider RE supply costs as well as benefit potential. While in reality such supply and demand factors jointly determing appropriate RE sites, they are discussed separately here.

3. LRMC estimates should be viewed with caution since there is debate concerning the type of operating capacity (gas turbine of hydro) which will be used to supply marginal capacity in the future.

4. In addition, electricity demand charges are subsidized relative to energy charges.

5. Such losses associated with kerosene consumption would be reduced if subsidized kerosene was distributed so as to ensure that it was consumed only by residential consumers.

6. Of course, many non-price factors such as reliability of supply, high connection charges and sunk investments in capital equipment which act to dissuade industrial and other productive users are not considered here.

7. It was noted in Chapter II that PLN does not have a separate tariff for agricultural consumers. Many countries involved with RE have such a tariff and it is often one of the lowest. While a subsidized agricultural tariff is unlikely to be justified on narrow efficiency grounds, it may have merit in the context of general agricultural and macroeconomic policies.

8. PLN already has a program whereby village cooperatives, almost all of which buy their electricity from PLN, are responsible for such activities. It is recommended here that PLN investigate the possibility of using local organizations to help operate and maintain its own RE projects.

VI IMPLEMENTING THE STRATEGY

A policy basis and implementation strategy which the Government might follow in order to achieve an efficient approach to RE was described in Chapter V. These elements must focus on addressing the problems which limit the economic benefits derived from RE. On the demand side, these problems take the form of constraints on the development of productive uses of electricity in RE areas. Specifically, RE site selection procedures, pricing and connection charge policies for certain types of productive use consumers[1], and methods of "marketing" RE need to be improved. On the supply side, problems arise because of the relatively high costs of RE.

The types of actions which need to be taken in order to implement an RE strategy include: (1) investigating and describing the current issues which are important to the development of productive use of RE, (2) developing an improved method of RE site selection, (3) revising certain tariff and connection charge policies, (4) developing improved informational/promotional programs which encourage the productive use of RE, (5) investigating the potential cost savings which can be realized through acceptable modifications of RE design standards and construction and operating practices, (6) overseeing and monitoring a pilot effort which implements activities (4) and (5) above, and (7) developing a monitoring program to collect information on successes and failures of RE efforts in the rural area.

Because the focus of this investigation is productive uses of RE, it was considered most appropriate to describe in this chapter the steps DJL should take in order to implement the single activity, out of the seven listed above, which is judged to be most appropriate (following the creation of a policy and strategy) given DJL's mandate and its involvement in the country's overall energy program. Therefore, detailed attention is given to activity (2). Activities (3), (4), (5), (6) and (7) might be more appropriately viewed as undertakings accomplished by a number of institutions and

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organizations since they either have significant technical aspects, [(3), (5), and (6)], or require considerable implementation capabilities, [(4), (6) and (7)] [2].

A. IMPROVING SITE SELECTION

As discussed in Chapter II, the current RE site selection procedure does not necessarily identify those areas in which the economic benefits derived from RE will be greatest[3]. Such economic benefits are derived from both productive use and non-productive use consumers. Most rural areas in Indonesia with significant productive use potential are also likely to have considerable non-productive use demand for RE. The converse, however, is not necessarily the case. Therefore, it is recommended that DJL develop a selection procedure which concentrates on identifying areas with significant productive use potential. A specific approach to developing such a selection procedure is described below.

This selection procedure should be viewed as a means of implementing the analytic framework outlined in Chapter IV. To accomplish this, a two stage procedure can be followed. The first stage has a macro-focus and eliminates from consideration areas which are clearly lacking productive use potential at present. The second stage takes a more detailed look at remaining possible sites in order to determine the ones with the most promising energy demand and supply conditions.

Following this logic, DJL's efforts to develop an improved site selection procedure can be divided into two steps. First, DJL should collect and utilize already available information to identify broad areas which apparently have the potential to benefit significantly from RE. At the same time areas should be identified which obviously are not currently candidates for RE (which have no identifiable potential to develop productive uses). This information would focus on factors which affect the potential demand for electricity. These are likely to include average level of income, extent of commercial

and small industrial activities, use of pump irrigation, and availability of other types of infrastructure[4]. Useful information for this purpose can be obtained from census data, e.g. the Annual Socio-Economic Survey (SUSENAS) and the annual Industrial Survey, and from data on irrigation potential collected by Projek Penyediaan Air Tanah (P_2AT)[5]. Second, more detailed analysis of energy supply and demand conditions in the remaining potential RE sites will be required. Some disaggregated data may be available from census materials or from Bappedas. However, it will probably be necessary to supplement these data with information collected through surveys conducted at the level of the Kabupaten or below[6].

It is also recommended that DJL supplement this effort with an ex-post study which attempts to determine the socio-economic characteristics of RE areas which are associated with RE "success". That study should identify the common characteristics of RE areas which have experienced relatively high levels of RE demand. This could be done by first selecting a cross sectional sample of previously electrified RE sites (some more successful and others less successful)[7]. Then, regression analysis or discriminant analysis could be used to identify the socio-economic characteristics of an area associated with RE "success". The ultimate result would be a simple forecasting model that would allow RE planners to more readily identify the most promising RE areas. Thus work on the model would contribute to the refinement of the two stage selection procedure outlined above.

B. TERMS OF REFERENCE

1. Study: Development of an Effective RE Site Selection Procedure.

2. Objective: To develop a site selection procedure that identifies areas where RE investments produce their greatest economic return.

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3. Approach:

Part I: Initial Screening Procedure

a. identify aggregate indicators of the likely economic impact of RE in a region, e.g. value of industrial and commercial production, potential for pump irrigation, level of rural income, and so on;

b. determine sources of data on aggregate indicators and collect actual data;

c. analyze data collected in (b) and prepare preliminary determination of potentially feasible RE areas.

Part II: Detailed Selection Procedure

a. collect existing regional/local data on indicators of likely economic impact of RE in areas identified by (1C);

b. develop survey instrument to collect additional required data;

c. undertake surveys and analyze data collected;

d. identify RE energy supply options, and estimate supply costs for surveyed areas;

e. prepare priority ranking of potential RE sites.

Part III: Statistical Analysis of RE Experience:

a. identification of sample RE sites

b. collection of data on load growth and socio-economic characteristics

c. model estimation and interpretation

4. Timing:

Project duration: 10 months

Proposed timetable:

TASK	MONTH									
	1	2	3	4	5	6	7	8	9	10
Part 1	X									
Part 2		X	----	----	----	----	----	----	X	
Part 3		X	X							
Final Report										X

5. Manpower Requirements:

Part I:	1	person months
Part II:	16	person months
Part III:	2	person months
Final Report:	1	person months
TOTAL:	20	person months

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CHAPTER VI

NOTES AND REFERENCES

1. Specifically, the rationale for setting commercial tariffs above LRMC should be assessed and a connection charge credit program should be adopted for productive use consumers. The possibility of permitting seasonal productive use consumers to pay reduced fixed charges during the off-season should also be considered. Concerning commercial tariffs it might be appropriate for DJL to work closely with PLN in evaluating the economic, financial and distributional pros and cons associated with existing and alternative tariffs. DJL might also study the financial costs and organizational requirements of a more widely available connection charge credit program.

2. It should be emphasized that all five activities are important of RE is to make its greatest possible contribution to rural economic development in Indonesia.

3. Even if distributional or political factors ultimately influence the choice of sites, the existence of an efficient selection procedure will allow the economic costs if deviating from this procedure to be more clearly identified and weighed.

4. The supplemental study of previously electrified areas in Indonesia proposed later in this section should help identify the most important determinants of RE demand.

5. This is a ground water survey group in the Ministry of Public Works.

6. There are 242 Kabupaten in Indonesia.

7. Ideally, the types of data used in this study should be similar to those collected in steps one and two of DJL's effort to identify promising RE areas. The availability of relevant data should be one of the key determinants of the choice of RE sites to include in the sample.

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ENERGY PLANNING FOR DEVELOPMENT

(Phase II)

APPENDIX 7: ENERGY FROM BIOMASS IN INDONESIA

September, 1985

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EXECUTIVE SUMMARY

Declining foreign exhange earnings from oil exports have become a problem of some magnitude to the Indonesian Government and attention is being directed to ways to prevent any further increases in the consumption of domestically produced petroleum. In this context this report focuses on the potential for energy generated from biomass and presents some preliminary analyses of the technical and economic feasibility of increasing the consumption of biomass energy in Indonesia to substitute for petroleum consumption.

The analyses are based on a benchmark goal of substituting 10 percent of the kerosene consumption in the household sector and 10 percent of the diesel consumed for electricity production with biomass energy. The purpose of the analyses is to illustrate, in economic terms, the actions that will have to be set in motion in order to generate the amount of biomass required to meet the goal.

The basic issues and problems addressed in the report are as follows : 1. To what extent can biomass energy replace domestic oil consumption in Indonesia, now and in the future? 2. Is there already enough biomass produced consistently to make a significant impact on the energy balance in Indonesia, or will it first have to be produced? 3. What is the financial and economic feasibility of producing biomass for energy in Indonesia? It is important to note that this report does not offer any solutions to the biomass for energy problems in Indonesia, nor does it recommend any large scale biomass for energy projects for the sake of promoting biomass over other energy resources. The literature on these matters in Indonesia is quite voluminous and often conflicting in its recommendations and this report refrains from passing judgement on who is right and who is wrong. Instead, it puts the whole biomass for energy question in perspective as to what is likely to work and what is not. It is based on what seems to be the consensus of expert opinions as to the potential future of biomass as a competitive energy source in Indonesia. As a result, several biomass production/conversion scenarios were discussed as possibilities after having been subjected to preliminary financial and economic analyses. It should be emphasized, however, that the analyses are only preliminary and thus only indicative of technical and economic feasibility.

Some of the more significant conclusions/recommendations of the study include the following:

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1. Although the conversion of biomass to energy is technically feasible, the high costs of transportation from areas where supplies are relatively more abundant, for example from Kalimantan to Java, preclude economic feasibility.

2. Biomass energy is technically feasible and posssibly economically competitive if the feedstock supply is located near the end-use point. For example, sawmills and wood processing industries can be energized by wood residues, and food processing industries by agricultural residues.

3. The potential for biogas generation from animal waste is rated low because livestock confinement in Indonesia is the exception rather than the rule; and, there are social obstacles to this form of energy generation. Animal wastes are also currently fully used as soil amendment.

4. Anaerobic digestion from municipal solid waste is rated medium potential. The city of Jakarta generates approximately 1,750 tons of organic municipal solid waste suitable for anaerobic digestion. The energy content of the biogas would roughly be equal to 1.5 million BOE's per year.

5. Increased use of most agricultural residues for energy other than rice husks is rated low potential. The total consumption of agricultural residues for energy purposes will undoubtedly increase as population and therefore agricultural production increase, but the proportion of the wastes currently used for energy purposes will probably not change much. Any additional increases in the consumption of agricultural residues over and above the normal trends driven by population increases, however, will make fewer residues available as soil amendment. This, in turn, will have a negative effect on soil fertility.

The potential for gasification of rice husks, however, is promising. Rice husks are largely an unused energy resource eminently suitable for gasification or direct combustion. Because of its high silica content it is not a good soil amendment resource. On a national scale the generation of electricity through gasification of rice husks could potentially save petroleum products at a total value of 49 billion rupias per year based on 1985 diesel fuel prices.

6. Woody biomass is rated high potential. It is fairly obvious that fuelwood and charcoal have the potential of contributing substantially to the energy supply in Indonesia. Technically, and now also economically it is argued that there should be few barriers to large scale substitution of biomass for fossil fuel energy. However, the resource base is being depleted

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and further losses must be halted before fuelwood and charcoal can be considered serious alternatives to fossil fuels. Only after having halted the depletion of the resource base, which would require a substantial effort over and above the current level of effort, can one begin to think of the potential for fuelwood and charcoal as possible substitutes for fossil fuels.

7. Wood energy plantations are, in general, economically feasible. This conclusion was drawn on the basis of the results of several break-even analyses to determine how much wood would have to be produced per hectare per year given a set of realistic base case assumptions. Nearly all of the economic analyses options studied were judged feasible. Only approximately one-fourth of the financial analysis options studied, however, were judged feasible.

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1. INTRODUCTION

1.1 Background

This report presents to the Direktorat Jenderal Listrik dan Energi Baru, Ministry of Mines and Energy, Republic of Indonesia (DJL) and USAID/Indonesia, preliminary analyses of the technical and economic feasibility of producing enough energy from biomass to make an impact on the overall energy balance in Indonesia. How significant this impact should be is a matter of policy and is not addressed in this report.

The report is divided into five chapters and annexes. Chapter 1 presents an overview of the problems with which the report is concerned, states the objectives of the study, and lists the limitations, i.e., what the report will and will not address. Chapter 2 focuses on the biomass production problems and potentials in Indonesia with a stronger emphasis on energy generation from rice husks and on woody biomass. Chapter 3 discusses the feasibility of substituting biomass for kerosene in the household sector and for diesel oil used to generate electricity. Chapter 4 presents some preliminary financial and economic evaluations of biomass production alternatives, and Chapter 5 discusses biomass energy as an input to E/DI's RESGEN model.

The source documents for this report are the several different consulting reports prepared for this project, and secondary data (from statistical yearbooks etc.) which comprises only a fraction of the voluminous literature on natural resources and biomass energy problems that exists in Indonesia. An exhaustive literature review was not conducted because of time and budgetary constraints. For this reason, the analyses of the biomass production/conversion possibilities in this report are only preliminary and as such only indicative of technical and economic feasibility. They are, however, based on what seems to be the consensus of expert opinions (see summaries of topics discussed in meetings with several experts in the trip report, Annex 1) as to the potential future of biomass as a competitive energy source in Indonesia.

The eight regions of the country, as used in the RESGEN model are given in Table 1.1 and the total area, population and population growth rate by region, are given in Tables 1.2 and 1.3. The regional breakdown does not correspond to the breakdown normally given for most published statistics. This has made data collection most difficult.

1.2 Problems

The basic issues and problems addressed in the report are as follows:

1. To what extent can biomass energy replace domestic oil consumption in Indonesia, now and in the future?

2. Is there already enough biomass produced consistently to

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Table 1.1 Geographical Regions

Regions	Provinces
1	Aceh, Sumatra Utara
2	West Sumatra
3	Riau
4	Sumatra Selatan, Lampung, Jambi, Bengkulu
5	Java
6	Kalimantan Barat
7	Kalimantan Timur, Tengah, Selatan
8	Sulawesia, Nusa Tenggera, Maluku, Irian Jaya, Bali

Table 1.2 Area, Population and Population Growth Rate by Region

Regions	Area (Sq km)	Population (1980)	Pop. Growth Rate (1971-80)
1	126,179	10,972,165	2.7
2	49,778	3,406,816	2.2
3	94,562	2,168,535	3.1
4	203,087	11,468,644	3.6
5	132,187	91,269,528	2.0
6	146,760	2,486,068	2.3
7	392,700	4,237,018	3.6
8	774,190	21,481,524	2.2
Total	1,919,443	147,490,298	2.3

Source: Statistik Indonesia, 1982

Table 1.3 Projected Population, Indonesia

Year	Projected Population
1980	147,490,298
1981	151,314,600
1982	154,661,700
1983	158,082,700

Source: Statistik Indonesia 1983

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make a significant impact on the energy balance in Indonesia, or will it first have to be produced?

3. What is the financial and economic feasibility of producing biomass for energy in Indonesia?

Even though Indonesia is richly endowed with with biomass resources in comparison with most other developing countries, it is also true that the resource base, particularly the forests, is declining--consumption exceeds the biomass generated through reforestation efforts plus the annual increments in growth each year. According to one source, fuelwood demand will increase to 441 million m3 by the year 2000 based on an estimated population of 210 million people at that time (Alrasjid 1981).

In view of these trends, the availability and adequacy of feedstock supplies must be taken into account before any biomass for energy program can be seriously considered. To grow the biomass, however, is no simple matter because often it is not economically feasible, land is not readily available, and alternative land uses often bring higher returns. Nevertheless, as the Government of Indonesia (GOI) desires to prevent any further deterioration of the resource base and at the same time opts for an increase in the use of biomass energy to reduce the consumption of domestically produced oil, the issues of increased biomass energy production and consumption cannot be separated.

The problem is of a dynamic nature, not a static one. For example, to replace 10 percent of the consumption of kerosene with biomass in the household sector means that the quantities of biomass feedstock required will be increasing over time, over and above the expected increases in total consumption attributable to the increases in population. Unless more biomass is produced, first to keep pace with the expanding population, and second, to meet the 10 percent goal, the resource base, particularly the forests, will be depleted at an accelerated rate. This is much akin to interest and principal--if interest earnings are to increase over time beyond the normal compounding rate, additions must be made to the principal. The resource base (standing biomass volumes) plus the annual growth increment equals the total feedstock available each year. If this growth increment is less than the rate of consumption, the resource base must, by definition be declining.

The problem, therefore, is to reconcile the two trends--biomass consumption and production, and not to, by recommending increases in biomass consumption, further accelerate the rate of depletion of the resource base over time. Scenarios of increases in biomass energy consumption presented in this report, therefore, always take into account the availability of the feedstock supplies.

1.3 Objectives

The objectives of this report are to:

1. Identify where and conditions under which biomass energy

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can make a significant contribution to the balance of energy in Indonesia.

2. Determine the preliminary investment feasibility of growing woody biomass for energy under alternative management regimes in Indonesia.

3. Establish limits for biomass energy in E/DI's RESGEN model.

The analyses are based on benchmark goals of substituting biomass energy for 10 percent of the kerosene consumption for cooking in the household sector and 10 percent of the diesel consumed by PLN for electricity generation. The purpose of the analyses is to illustrate, in economic terms, the events that will have to be set in motion in order to generate the amount of biomass required to meet the goals.

The overall assumption used in this report is that biomass can indeed become a more significant contributor to the overall energy balance in Indonesia if the biomass can be produced and converted economically, at least to the point where it competes favorably with other energy supply sources. If biomass does not compete well there would be little incentive to launch extensive biomass for energy programs, unless of course, GOI decides to promote biomass as an energy source at the same time with subsidies.

1.4 Limitations

The limitations of the study are as follows:

1. The report focuses on how much feedstock supply will have to be made available in order to generate enough energy to replace up to 10 percent of the consumption of domestically produced oil in the household and power generating sectors (National Electricity Enterprise--PLN). It does not directly consider how to produce the feedstock--whether it should be in intensive energy plantations or through village participation programs.

2. The financial and economic analyses (Ch. 4) considers only the fuelwood component of the total energy problem. Alternative biomass for energy sources such as municipal solid waste and agricultural residues are discussed, but not subjected to finanacial and economic analyses.

3. The analyses do not directly consider opportunity costs. The product sought is energy, not poles, sawtimber, or any other product the land may be capable of producing. It may well be that to use the site for the production of other products instead of fuelwood, will yield higher economic returns which GOI (or private investors) would forego. Furthermore, since land is in limited supply, particularly on Java, energy plantations consisting of very tight tree spacing to maximize biomass

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production, may be required. Such plantations, however, are more costly to install and maintain and are generally less economically attractive than wider spaced plantations.

4. Because information on energy consumption is not generally published or even available at the provincial level in Indonesia (E/DI 1985), the analyses and discussions presented are province specific only where possible.

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2. BIOMASS ENERGY PROBLEMS AND POTENTIALS

2.1 Introduction

This chapter identifies which biomass resources have the best potential for making an impact on the energy balance in Indonesia, and discusses the prospects for increasing the production of biomass in the future. In sum, woody biomass is rated high potential as an energy source, despite the fact that the forest resource base has declined drastically over the past decade (Statistik Indonesia 1982), because of increases in logging, overcutting for fuelwood, and clearing land for agricultural and industrial uses. Gasification of rice husks is also rated high potential. Digestion of organic municipal solid waste is rated medium potential and agricultural residue biomass, other than rice husks, is rated low potential.

It should be emphasized that while both woody biomass and agricultural residues are presently major contributors to the overall energy balance in Indonesia, this report is concerned not so much with what they presently contribute, but rather their potentials for additional contributions in the future. These additions are the feedstock supplies that would be required to meet the 10 percent goals specified above--which would be over and above the supplies required to meet the increasing demands caused by population increases.

2.2 Woody Biomass

There are a number of characteristics of woody biomass that should be considered if this feedstock is to be used for energy:

1. It has to be grown over a relatively large area.

2. It requires a relatively long time to produce, i. e., from growing seedlings in the nursery, to plantation establishment and harvesting. This sequence of events may take several years or longer depending on site productivity and species. Large scale efforts of this kind require professional skills and a competent management organization.

3. Woody biomass is bulky and heavy and not easily transported. Drying the wood at the harvest site will reduce weight. Extreme reduction in weight is achieved by converting to charcoal.

For the purposes of this report, three levels of woody biomass consumption are recognized:

1. Low. This is the household consumption level where wood or charcoal is used primarily for cooking. Consumption of wood per capita in Indonesia is roughly .85 m3 per year based on a number of estimates (see Islam 1984, p. 94). This is a dispersed use and can be met by dispersed production in small plantings, except where located close to population centers.

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2. Medium. This level of consumption corresponds to that of small industries in rural areas where the level of consumption would be up to 500 m3 per year per user. Production of the wood must be well under control in order to assure timely and dependable supplies.

3. High. This is the level of consumption associated with medium and large industry and utilities (retrofitted diesel generators for example) which requires large and steady supplies of wood on a daily basis. Amounts involved would range from 500 to several thousand m3 of wood or more per user per year. This would require large plantations grown under precise control, located fairly close to the end-use point.

The growth of wood per hectare per year covers a wide range of values--from as low as 10 m3/ha per year for some species to more than 60 m3 on fertile bottom lands with ample and well distributed rainfall. Few reliable growth and yield figures, however, are available for the tree species growing in Indonesia, either in natural forests or in plantations. The best figures obtained are given in Table 2.1 below showing the growth and energy content of selected fast growing species in Indonesia. These are the best performers among many species tested from the point of view of both growth and energy content.

Which species to choose depends on several factors--suitability to the environment, the calorific content, growth rate, ability to coppice, and availability of seeds (Alrasjid 1981). Of the species listed, calliandra calothyrsus and leucaena leucocophala are rated as the most promising for energy production. Successful small scale plantations have already been established on Java. In addition to fuelwood, both are excellent fodder species and the calliandra is also favored for honey production (Boom 1984, and Perum Perhutani 1977).

2.3 Municipal Solid Waste

Generation of energy from municipal solid waste in major cities in Indonesia (Jakarta, Bandung, Surabaya etc.) is rated medium potential, not perhaps because it may be economically feasible to do so, but rather because of the current political climate "to do something about the garbage problem." The average level of waste production per capita per day is .65 kg in Jakarta, .50 kg in Bandung and .52 kg in Surabaya. These volumes are increasing over time in direct proportion to increases in income. The capacity of local governments, however, to collect and dispose of the garbage has declined because many cannot afford to pay the fees and areas are often not accessible for the garbage trucks. Now, only an estimated 60 percent of the garbage generated is actually picked up and hauled to the garbage dump. Thus, the problems of health hazards and sanitation continue and multiply (Poerbo 1985).

The composition of the urban waste for the city of Bandung is given in Table 2.2. Of the total, 74.6 percent is organic waste--vegetable and other food scraps etc., which can be turned

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into compost directly and sold as fertilizer, or alternatively,

Table 2.1 Growth and Energy Content of Selected Fast Growing Species in Indonesia

Species	Stocking Density (m)	Rotation (Yrs)	MAI (m3/Ha/Yr)	Wood Density (W/V)*	Energy Prod. (GJ/Ha/Yr)
Causuarina junghuhniana	2x3	10	25.0	1.04	452.5
Eucalyptus justigata	2x2	8	24.5	.76	325.8
Calliandra calothyrsus	1x1	5	32.0	.70	384.0
Eucalyptus maculata	2x2	8	28.0	1.05	512.0
Eucalyptus maedenii	2x2	8	27.5	.70	388.3
Leucaena leucocephala	1x2	5	21.0	.82	309.0

Sources: Webb 1980, Alrasjid 1981

* Wood density (specific gravity) = weight/volume. I is an indicator of heating value at constant moisture content:

Over .90, superior
.75 - .90, very good
.60 - .75, good
<.60, moderate to poor

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Table 2.2 Composition of Urban Waste in Bandung (% by Weight)

Material	% by Weight
Paper	9.7
Glass	.3
Metals	1.3
Plastic and Rubber	4.8
Textiles (rags etc.)	2.5
Bones	.7
Other	6.1
Total, Non-Organic	25.4
Organic	74.6
Total	100.0

Source: Poerbo, 1985

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sold as better fertilizer after having been anaerobically digested to produce biogas. The latter process, of course, is more expensive given the capitalization and operating costs required to install and operate a biogas generation facility.

The potential organic waste feedstock supply for the city of Jakarta is roughly estimated at 1,750 tons per day. This is based on a population of six million people, each generating .65 kg of waste per day multiplied by the 74.6 percent proportion of organic waste (assuming the same proportion for Jakarta as in Bandung) for a total of 2.9 million kg of organic wastes per day generated. The 2.9 million kg multiplied by the 60 percent actually picked up gives a total potential feedstock supply of approximately 1,750 tons per day of organic waste. The biogas energy content of this amount of waste is roughly equivalent to 1.5 million BOE's per year.

2.4 Agricultural Biomass

2.4.1 General

The potential for increased use of agricultural residues other than rice husks, for energy in the future is rated low. The amount of agricultural waste generated will indeed increase in the future as more food will be produced to feed an increasing population. Therefore, total consumption of energy from agricultural wastes will also increase. But, more importantly, it is the fraction of the wastes currently used for energy purposes one should look closely at. Any additional increases in the consumption of agricultural residues over and above the normal trends attributable to population increases, will increase this fraction, thereby making fewer residues available as soil amendment. This, in turn, would have a negative effect on soil fertility. For purposes of this report, it is assumed to be preferred that the division between energy and non-energy uses of agricultural residues remain undisturbed.

2.4.2 Rice Husks

A "high" rating is given to the apparently technically and economically feasible potential for generating energy in rural areas by way of gasification of rice husks. Presently, uses of rice husks in Indonesia are limited to fuel for households stoves, brick firing, and some uses in the poultry industry. Further, because of their high silica content, rice husks are not a good soil amendment resource.

On a national scale, the potential availability of rice husks is estimated at 10.1 million tons annually (Manurung 1985). The primary potential users of this largely untapped energy resource would be the 1,144 large (more than one ton rice output capacity per hour) and 28,059 small (less than one ton per hour) rice mills in Indonesia. The small capacity mills have typical mechanical power requirements of 10 - 30 HP and are normally powered by gasoline or diesel engines. Roughly 20 kwh of electricity (7.5 liters of diesel oil taking into account engine

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efficiency) are needed to process one ton of paddy. The energy generated from one kg of rice husks is 9,100 kj, or approximately the equivalent to .234 liters of diesel oil. Based on Manurung's (1985) calculations the potential amount of diesel oil savings is 6.3 liters per ton of paddy milled assuming that 1.2 liters of diesel will be mixed with the gas to minimize the loss of engine efficiency. This saving is equivalent to 204 million liters of diesel fuel per year assuming the 34 million tons of paddy processed in 1984. In terms of value, the 204 million liters saved would be equivalent to nearly 49 billion rupias saved per year based on 1985 diesel prices (Manurung 1985).

The technical improvements to make rice husk gasification technically feasible on a small scale--15 - 25 kw capacity, is well underway at the Institut Teknology in Bandung (ITB). The developments at ITB have generated considerable interest among the small (target) rice mills. Economic feasibility, however, is more elusive, although the preliminary analyses look favorable. The following is a preliminary analysis of financial feasibility based on data obtained at ITB:

<u>Assumptions</u>

1.	Costs ('000 rupias)	
	* Capitalization costs--gasifier to be retrofitted onto existing diesel engine	5,000
	* Labor	360
	* Maintenance	500
	* Diesel fuel (to be used in addition to the gas--20 percent)	384
2.	Benefits	
	* Diesel oil saved	1,344
	* Sales of excess electricity (1)	1,510
3.	Period of analysis	7 yrs (0-6)
4.	Value of gasifier in yr 6	0
5.	Operating hours (1)	4,000/hrs/yr
6.	Discount rate	12 percent
7.	Costs and prices over time	Constant
8.	Gasifier capacity	25 kw

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(1) A 25 kw capacity gasifier will need to operate 2,000 hours per year to meet all of the power generating requirements of a small rice mill. If the installation operates 4,000/hrs/yr, however, it will be able to generate excess electricity that can be sold to the grid for 75 rp/kwh.

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Table 2.3 shows the cash flows over the seven year period. Given the assumptions, small scale rice husk gasification appears economically feasible since the net present value (NPV) is a positive 3.2 million rupias.

The major obstacle to realizing the rice husk gasification potential is the investment requirement for the gasifier. Small rice mill operators are generally cash poor and cannot easily raise the 4.5 - 5 million rupias capital required. For this reason, ITB is recommending that the GOI initiate a program of granting three-year soft loans to participants through the Kredit Investasi Kecil (KIK). Soft loan interest rates would range from 9 to 18 percent per year. Even at the soft rates, however, the cash flows generated would not be sufficient to pay back the interest and principal over the three year period.

Alternatively, if self-energization of the rice mills appears out of reach for financial reasons for the time being, rice husk gasification could still be used to energize perhaps PLN diesel power installations or other, neighboring industries that can afford to make the necessary investments.

2.4.3 Animal Wastes

Another form of agricultural waste with potential for energy is livestock manure which, when subjected to anaerobic digestion, will produce methane rich fuel gas that can be used for cooking or generating electricity. In Indonesia, however, it would be unrealistic to count on this potential since livestock confinement, a condition that must exist for the collection of manure, is the exception rather than the rule. Also, there are social obstacles to this form of energy generation; and animal wastes are currently used as soil amendment.

Table 2.3 Rice husk gasification, Cash Flows

Costs and Benefits ('000 Rp)	Years 0	1	2-6
<u>Costs</u>			
Gasifier	5,000		
Labor	360	360	360
Maintenance	500	500	500
Diesel fuel	384	384	384

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Total Cost	6,244	1,244	1,244
<u>Benefits</u>			
Diesel savings	1,344	1,344	1,344
Sale, excess elec.	1,510	1,510	1,510
Total benefits	2,854	2,854	2,854
Net cash flow	-3,390	1,610	1,610

Source: Data obtained from ITB, Bandung

NPV @ 12 percent = 3.2 million rupias

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3. SUBSTITUTION OF BIOMASS FOR KEROSENE AND DIESEL

3.1 Introduction

This chapter discusses the potentials and problems associated with substituting biomass energy for kerosene used for cooking in the household sector, and for diesel used to generate electricity. Annex 2 briefly adds some other possibilities for substitution in irrigation pumping, through char-oil slurries, and in the transportation sector. Also briefly discussed in Annex 2 is the biomass production requirements for low technology charcoaling processes.

3.2 Kerosene

3.2.1 Consumption of Kerosene for Cooking

The total consumption and of kerosene in Indonesia has increased substantially over the past few years as shown in Table 3.1 (although it has decreased in recent years). This is primarily due to the subsidy on kerosene which, in 1981, amounted to 88.2 rp per liter, more than twice the amount paid per liter by the consumer (37.5 rp/liter) in that year (Islam et al, 1984). The retail price for kerosene today is 150 rp/liter which is subsidized by at least approximately rp per liter.

Of this total amount of consumption (Table 3.1), approximately 25 percent, or roughly 2,100 million liters is used for cooking purposes (Islam et al 1984). The 2,100 million liters is equivalent to 13.2 million barrels of oil (159 liters per barrel) which is also nearly equal to the 16.5 million barrels of kerosene that Indonesia had to import in 1981.

3.2.2 Substitution of Biomass for Kerosene

The target goal of substitution, for purposes of illustration in this report, of biomass energy for kerosene, is 10 percent of the 13.2 million barrels of oil equivalent (BOE), or 1.32 million BOE's. Assuming that one ton of hardwood equals 1.6 BOE, approximately

$$\frac{1,320,000}{1.6} = 825,000 \text{ tons}$$

of hardwood, or roughly 1.16 million m3 assuming one ton = 1.4 m3, would have to be produced on a sustained basis per year. The number of hectares required to produce this amount of hardwood, by productivity class, is given in Table 3.2.

A most important factor to consider in fuelwood production is, of course, financial and economic feasibility (see chapter 4). Yields vary considerably with management intensity as do economic returns. While intensive forest management--dense spacings, fertilization and thinning regimes bring high yields, they are also costly. It is therefore important to strike an optimal balance between biological and economic management of the

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forests. If the figures given in Table 3.2 are based on economic

Table 3.1 Kerosene Consumption, Imports and Subsidies

Year	Consumption (Million Liters)	Imports (Million Liters)	Kerosene Subsidy (Rp/Liter)
1977	5,480	795	14.60
1978	6,631	695	17.90
1979	7,228	878	33.00
1980	7,787	1186	62.50
1981	8,347	2638	88.20
1982	8,232	546	N/A
1983	7,653	227	150.00 (est)

Source: Islam et al 1984, MIGAS
Consumption includes domestic production and imports

Table 3.2 Hectarage Requirement to Produce Fuelwood Equivalent to 1.32 Million BOE's of Kerosene by Land Productivity Class

Productivity (m3/Ha/Yr)	No. Hectares Required (Rounded)
10	116,000
14	82,900
18	64,000
22	52,700
26	44,600
30	38,700

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management; i.e., to maximize profits, it is safe to assume that the hectarage requirements could be substantially lowered under biological management where maximization of yields is the objective, but also much more costly.

3.3 Diesel

3.3.1 Consumption of Diesel Oil/Electricity Generation

The total consumption of diesel oil by the electric utility PLN is given in Table 3.3 for the years 1982, 1983, and 1984. The consumption increased from 10.4 million BOE in 1982 to 13.1 million BOE in 1984, or an average increase of roughly 13 percent per year. In addition, an estimated 13.6 million boe of diesel are used for electric generation by dispersed generators in industry, mines, agriculture and others. This estimate is for 1982 and assumes, as a basis, that 60.1 % of all automotive diesel sold to large industrial/mining facilities is used for electric generation.

The production of diesel generated electricity by PLN in fiscal year 1983/84 was approximately 1.65 billion kwh (Table 3.4). This production was spread over 1,675 generating units of an average installed capacity of 468 kw, well above the minimum generating capacity considered feasible for gasification installations. Non-PLN diesel generation in 1982 is estimated at 7,143.5 Gwh. Total installed, non-PLN, dispersed diesel capacity is 1310 MW (1980 data), of which less than 30% is standby; over 70 % is pure autogeneration.

3.3.2 Substitution of Biomass for Diesel Oil

As in the kerosene for cooking example discussed above the target goal of substitution of biomass energy for diesel, assumed for illustrative purposes in this paper, is 10 percent of the latest figure available--13.1 million BOE for 1984 (Table 3.3), or 1.31 million BOE worth of fuelwood. Again, as assumed in the kerosene example, one ton of hardwood equals 1.6 BOE, which means that 825,000 tons, or 1,160,000 m3 of hardwood would have to be produced on a sustained basis each year. The number of hectares required to produce this amount of hardwood by different productivity classes, would be the same figures as those given in Table 3.2.

3.4 Discussion

This section intends to put the previous two sections in perspective in terms of the overall potential for replacing fossil fuel energy with biomass energy. According to Table 3.2, if for example, the average yield is 22 m3/ha/year it would take

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nearly 53,000 hectares of land to produce enough woody biomass to replace the consumption of 1.32 million BOE of kerosene. That, however, was in 1981. Upon applying the nine percent average annual rate of increase in consumption in Table 3.1, consumption will have reached 15,300 million liters by 1990. Therefore, in addition to the 53,000 hectares one would have to add another 43,000 hectares by 1990, or nearly 5,000 hectares per year to maintain the 10 percent substitution factor of biomass for kerosene, over time.

Table 3.3 Consumption of Diesel by the Electricity Utility

Year	Million BOE
1982	10.4
1983	11.9
1984	13.9

Source: Pertambangan dan Energi, No. 2, 1985

Table 3.4 Electricity Production by PLN by Diesel Oil and Inspalled Diesel Generating Capacity, 1983/84

Region	Production of Electricity ('000 Kwh)	No. of Generating Units	Installed Capacity (Kw)	Average (Kw)
1	307,573	306	129,245	422
2 & 3	166,934	151	81,937	543
4	214,960	162	93,293	576
5	67,792	200	67,951	340
6	104,827	65	34,683	534
7	233,460	145	103,923	717
8	435,562	646	273,353	423
Total	1,654,134	1,675	784,385	468

Source: DJL

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The same situation applies to the diesel substitution as well. At an average productivity of 22 m3/ha/year it would take approximately 53,000 hectares to satisfy the diesel substitution target of 10 percent for 1984. But, when applying the 13 percent average annual increase in diesel consumption between 1984 and 1990 (29 million BOE annually by 1990), another 60,000 hectares at 22 m3/ha productivity will have to be added by that year in order to maintain the 10 percent substitution factor over time. A total of over 106,000 hectares for the first kerosene and diesel substitution examples plus another 103,000 hectares required by 1990 plus the required additions in the future, are large areas indeed. And, they could probably not be found in contiguous blocks, certainly not on Java. Also, it would have to be in addition to the very ambitious ongoing energy plantation program in the current five-year plan--320,000 hectares of which only 10 percent will be on Java, assuming that these plantations only replace what was lost in the past.

The magnitude of the land requirements is indicative of the limits to the use of biomass energy. Even with the modest target of replacing only 10 percent of the kerosene now consumed for cooking with woody biomass, it still translates into logistical, land availability, managerial, and financial problems that perhaps were not anticipated. Moreover, it should again be repeated that 1. the bulk of the demand is on Java where land is scarce and 2. transportation of biomass energy is too costly, at least for the time being. Therefore, it stands to reason that most of the land area required to produce enough woody biomass to meet these goals, would have to be on Java.

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4. FINANCIAL AND ECONOMIC EVALUATIONS/WOODY BIOMASS

4.1 Introduction

This Chapter gives the results of break-even analyses of several management alternatives. These analyses determine the volume of woody biomass required to break even on an investment, i.e., when the net present value (NPV) of the investment is equal to zero using the financial and economic assumptions given in Section 4.3 below. When the NPV's are equal to zero the discount rates can also be interpreted as internal rates of return (IRR's) for each of the management regimes considered.

The break-even approach, far from ideal, is used because reliable data on growth and yield of different species under different site productivity conditions and management alternatives, are not readily available in Indonesia. In the absence of this information, the next best approach is to know how much production of woody biomass would be required in order to break even on the investments under the assumptions specified. If the quantity required to break even is, for example 20 m3/ha/year, and the foresters are certain that at least 30 m3/ha/year can be produced on the site, then the investment is in all probability feasible.

It is strongly emphasized that the analyses are presented only as very preliminary guidelines to selection between biomass production alternatives. A thorough analysis can only be conducted with reliable growth and yield data which are not readily available in Indonesia. In these simplified analyses answers are only sought as to how much fuelwood will have to be produced per hectare in order to break even five years after the initial investment. They therefore say nothing about optimal rotation ages, nor about the economic contribution of subsequent coppice crops.

4.2 Method of Analysis/Base Case

The economic and financial analyses presented below are patterned after "Investment Analyses of Fuelwood Plantations in Sri Lanka," by Medema, Hatch, and Christophersen, 1981.

The analytical results include both financial and economic analyses. A financial analysis focuses on measuring the returns to an investor based on the costs and revenues actually occurring to the investor. This reflects the perspective of a private enterprise investor. Prevailing market prices are used to measure the relative values of revenues and costs.

In an economic analysis one takes a broader perspective by measuring the returns that accrue to society as a whole. This more likely reflects the government perspective. In this analysis, market prices are replaced with "shadow prices" where appropriate, that intend to reflect the "real" values to society of revenues and costs. The shadow prices may differ from market prices because of various market distortions resulting from subsidies, taxes and various other government controls or externalities that have an impact on the functioning of markets.

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In view of the uncertainty associated with analyzing alternative investment schemes in energy plantations, the financial and economic analyses include a base case scenario of investment assumptions and a sensitivity analysis of these assumptions. The base case reflects the most realistic estimate, based on past trends, of future market conditions for biomass energy in Indonesia. The sensitivity analysis reflects alternative expectations of future market conditions and also the extent to which assumptions used are critical. If, for example, the sensitivity analysis indicates that a relatively small change in the base case assumption results in a small change in the analytical results, the precision with which that assumption is estimated is not critical. When a small change in the base case assumption results in a large change in the analytical results, however, the assumption is critical.

In estimating future revenues and costs, the analysis uses real prices and cost appreciation rates and real discount rates. Real rates are simply the nominal rates corrected for inflation. Consistent use of real or nominal rates will yield the same analytical results since the "effective" rate is the same in either case. However, by using real instead of nominal rates, one does not have to predict the rate of inflation.

4.3 Assumptions

The base case assumptions are given in Table 4.1. For the economic analysis shadow prices are approximated for labor costs and the discount rate. Labor costs are shadow priced at 50 percent of the base case assumption used in the financial analysis to reflect the availability of labor for planting and stand maintenance activities. To the extent that the GOI is successful in absorbing otherwise unemployed labor in these activites, a shadow price for labor less than the market price is warranted. The discount rate is set two percentage points lower in the economic analysis to reflect the prioritization the GOI is assumed to give to reforestation and energy production, and a lower risk premium on these investments because of the diversification and magnitude of the GOI total investment profile. The derivation of each assumption is discussed briefly below.

4.3.1 Discount Rate

The base case discount rate is eight percent in real terms for the financial analysis and six percent for the economic analysis. The determination of an appropriate rate of discount is, at best, a difficult undertaking. Ideally, it should reflect an investor's opportunity cost of capital which is measured by returns on possible alternative investments. The latter, however, are often difficult to determine since investments are not homogeneous and returns reflect different levels of risk.

The empirical determination of the real discount rate was based on a comparison between a measure of the annual rate of inflation and the interest (nominal) rates charged by major

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Table 4.1 Base Case Financial and Economic Assumptions

Assumptions	Financial	Economic
1. Discount Rate	8%	6%
2. Stumpage Value	2,200 rp/m3	2,200 rp/m3
3. Plantation Establishment Costs		
a. 1x2 m (5,000 trees/ha)		
* Planting labor (incl. site preparation)	150,000/Ha	75,000/Ha
* Seedling costs (1)	100,000	100,000
* Weeding, pruning costs/yr 1	35,000/Ha	17,500/Ha
b. 1x3 m (3,330 trees/ha)		
* Planting labor	100,000	50,000
* Seedling cost (1)	66,600	66,600
* Weeding, pruning costs/yr 1	35,000	17,500
c. 2x2 m (2,500 trees/ha)		
* Planting labor	75,000	37,500
* Seedling costs (1)	50,000	50,000
* Weeding, pruning costs/yr 1	30,000	15,000
* Weeding/yr 2	20,000	10,000
d. 2x3 m (1,650 trees/ha)		
* Planting labor	50,000	25,000
* Seedling costs (1)	33,000	33,000
* Weeding, pruning costs/yr 1	24,000	12,000
* Weeding/yr 2	15,000	7,500
4. Administrative Costs	20,000/ha/yr	20,000/ha/yr
5. Time Horizon	5 yrs	5 yrs

(1) Seedlings are assumed to cost 20 rp each

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lending institutions. Table 4.2 measures an average rate of inflation of 19.2 percent between 1974 and 1983 based on changes in the Gross Domestic Product (GDP) over time (Pendapatan Nansional 1983, and Statistik Indonesia 1982). The present rate of inflation is approximately 14 percent. Over the same time period, lending institutions have charged up to 24 percent interest on short term loans (Statistik Indonesia 1982). The real discount rate is determined as follows:

$$\text{Real rate} = \left(\frac{1 + \text{nominal rate}}{1 + \text{inflation rate}} - 1.0\right) \times 100$$

or, for the purposes of this analysis

$$\text{Real rate} = \frac{1.24}{1.17} - 1.0 \times 100 = 6 \text{ percent}$$

An inflation rate of 17 percent was used to take into account the lowering of the rate of inflation between 1983 and 1985.

The difference between the six percent real rate as calculated above and the eight percent used in the analysis represents the differences in risk between investments. Bank lending rates are likely to be based on lower risk ventures compared to investments in fuelwood plantations where natural disasters--insect and disease damage, weather damage and the widespread problem of illicit tree felling can result in large losses. These risks translate into a need for a higher return on investment in order to attract investors.

4.3.2 Stumpage Value

The base case stumpage value for fuelwood is 2,200 rp per m3 for both the financial and economic analysis. The stumpage value is held constant for the analytical period. The retail fuelwood prices by dimensions, sold through Perum Perhutani (Java State Forest Corporation) outlets, are given in Table 4.3. The retail price of 10.400 per m3 for the larger dimensions fuelwood is broken down into various cost components including harvesting, loading and unloading and transportation costs in Table 4.4. The stumpage value is obtained by deducting all of the costs associated with bringing the fuelwood to market, from the retail price. The stumpage value, therefore, is the residual; or, as in this case

$$10{,}400 - 8{,}200 = 2{,}200 \text{ rp/m3}$$

This can also be interpreted as an entrepreneurial profit margin of 21 percent.

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Table 4.2 Average Rate of Inflation, 1974 - 1983 (Percent of GDP Deflator, 1973 = 100)

Year	Percent Change
1983	14.5
1982	8.0
1981	10.0
1980	29.1
1979	32.5
1978	11.0
1977	13.0
1976	14.4
1975	12.5
1974	47.3
Average	19.2

Source: Adapted from Pendapatan Nansional Indonesia 1979 - 83, pp 3, 4 and Statistik Indonesia, 1982.

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Table 4.3 Perum Perhutani: Hardwood Fuelwood Prices, 1984

Dimensions Length	Diam	Price Rp./Sm*	Conversions Sm to m3	Price Rp/m3
1 m	2 - 4 cm.	1500	.444	3,378
1	5 - 8	4000	.444	9,009
1	9 - 15	5250	.5	10,400
1	16 - 20	5200	.5	10,400

Source : Boom 1984

* sm = stabel meter (measures 1 m3 stacked)

Table 4.4 Stumpage Values

Costs Rp/m3 (16-20 Cm Diam. Category)	
1. Felling/bucking	1,100
2. Transport in field (800 m)	3,250
3. Loading	800
4. Transportation 10 km @225/ton	2,250
5. Unloading	800
Total cost	8,200

Source : Boom 1984

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4.3.3 Plantation Establishment Costs

The plantation establishment costs for the base case financial and economic analysis are composed of two factors--plantation labor and seedling costs. For all of the spacing density alternatives given in Table 4.1 the seedlings are assumed to cost 20 rp each. Also it is assumed existing nurseries can accommodate the increases in the demand for seedlings as required. Planting labor costs vary with the stocking densities given in Table 4.1--1x2, 1x3, 2x2, and 2x3 m. For this analysis it is assumed that one worker can plant 50 seedlings per day including site preparation and that he is being paid 1,500 rp per day. Planting labor costs are shadow priced at 50 percent of the financial base case assumption for the economic analysis (see also section 4.2.).

4.3.4 Weeding and Pruning Costs

It is assumed that weeding will have to be done once in year one to keep competitive growth down. An additional weeding will have to be done on the wider 2 x 2 and 2 x 3 spacing densities because crown closure will occur later. Competitive growth in the denser plantations is assumed to be naturally held down after year one because of early crown closure. Pruning is also required for all of the stocking density options in year one but not in subsequent years. Costs are declining for the wider densities because there are fewer trees to weed and prune.

4.3.5 Administrative costs

The administrative costs are assumed to be 20,000 rp/ha/year, based on information obtained in interviews with Perum Perhutani officials. It is noted, however that this assumption is not well documented since administrative costs associated with fuelwood plantations are not identified separately. According to Perum Perhutani officials the administrative budget for the high value teak plantations is as high as 200,000 rp/ha/year. The fuelwood plantations, on the other hand are placed in buffer zones around the teak plantations to protect them, or in between the teak rows to improve soil fertility. For these reasons, the 20,000 rp/ha/year (10 percent) was suggested as a reasonable administrative annual costs figure attributable to the fuelwood plantations only. It is also assumed that the administrative costs remain constant over the period analyzed.

4.3.6 Time Horizon

The time horizon, as mentioned in Section 4.1 above, is set at five years. Fuelwood plantations are normally harvested for the first time three to five years after the initial planting after having reached merchantable size, at least nine centimeters

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in diameter. The economic contribution of the subsequent coppice crops are not accounted for in the analysis.

4.4 Results

The results of the financial and economic base cases and sensitivity analyses are given in a series of tables--4.5 - 4.11. Tables 4.5 and 4.6 show the base case results and Tables 4.7 - 4.11 show the sensitivity analyses results. The tables compare the production levels required (m3/ha/year) by different stocking densities in order to break even on the investments. All options judged to be feasible, either financially or economically, are contained within the heavily marked lines in each table.

4.4.1 Base Case

On a preliminary basis, fuelwood plantations are not financially viable for the three narrowest stocking densities--1 x 2, 1 x 3 and 2 x 2 given the assumptions. The three spacing densities would require 38, 32, and 30 m3/ha/year of production in order to break even on the investment (Table 4.5). This level of required production is higher than the levels actually achieved when compared with the growth figures given in Table 2.1 (1). As the stocking density declines to 2 x 3, the required level of production also declines to 25 m3/ha/year which is just about the minimum production level required to break even on the investment. The actual growth rates given for the eucalyptus justigata, eucalyptus maculata, and eucalyptus maedenii (2 x 2 m), and causuarina junghuhniana (2 x 3 m), in Table 2.1, however, to which the base case break-even production levels are compared, are based on rotation ages that are longer than the five-year time horizon used in the analyses. To get a more precise estimate of the feasibility, Table 4.6 indicates the volumes required to break even when the time horizons are changed to eight and/or 10 years to correspond with the rotation ages given in Table 2.1. All of the break-even production levels, except for one, are roughly equal to or below the actual yields reported in Table 2.1, which indicates financial feasibility.

For the base case economic analyses the break-even production levels given in Tables 4.5 and 4.6 all fall within the feasibility range given the assumptions, including the most dense (1 x 2 m) stocking of the site.

4.4.2 Sensitivity Analyses

A sensitivity analysis estimates the magnitude of change from the base case result attributable to a given change in the

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(1) The 38 m3/ha/year level of production is well below the 60 m3/ha/year often quoted as the actual yields obtained with a 1 x 2 m spacing productive sites. On Perum Perhutani lands, however, the productive areas are used for to teak production and energy plantations are located on the less productive sites.

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Table 4.5 Break-Even Analyses: Results, Base Case

Management Alternatives (Stocking Density)	Volumes Required (m3/Ha/Yr)	
	Financial	Economic
1 x 2	38	24
1 x 3	32	21
2 x 2	30	20
2 x 3	25	18

Table 4.6 Break -Even Analyses: Changing Time Horizons, Base Case

Species	Actual Yield (m3/Ha/Yr)	Volumes Required (m3/Ha/Yr)			
		Financial		Economic	
		8 Yrs*	10 Yrs*	8 Yrs	10 Yrs
Eucalyptus justigata (2 x 2 m)	24.5	28	NA**	20	NA
Causuarina junghuhniana (2 x 3 m)	25.0	NA	25	NA	19
Eucalyptus maculata (2 x 2 m)	28.0	28	NA	20	NA
Eucalyptus maedinii (2 x 2 m)	27.5	28	NA	20	NA

* Rotation ages and actual yield column taken from Table 2.1
** NA = Not Applicable

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Table 4.7 Sensitivity Analyses: Plantation Establishment Costs

Management Alternatives (Stocking Density)	Volume Required (m3/Ha/Yr) Financial 30/ Day*	Base Case	70/ Day*	Economic 30/ Day	Base Case	70/ Day
1 x 2	52	38	33	30	24	22
1 x 3	41	32	28	25	21	19
2 x 2	37	30.	27	23	20	19
2 x 3	30	25	23	20	18	17

* One person plants 30 or 70 seedlings/day instead of the base case assumption of 50 seedlings/day.

Table 4.8 Sensitivity Analyses: Weeding and Pruning Costs

Management Alternatives (Stocking Density)	Volumes Required (m3/Ha/Yr) Financial 20,000 Rp/Ha*	Base Case	50,000 Rp/Ha	Economic 5,000 Rp/Ha	Base Case	25,000 Rp/Ha
1 x 2	36	38	40	22	24	24
1 x 3	30	32	34	19	21	21
2 x 2	29	30	36	18	20	20
2 x 3	24	25	32	17	18	19

* Weeding and pruning costs are varied around the base case assumption. The sensitivity results are slightly biased in favor of the wider stocking densities where weeding and pruning costs are lower. These lower costs are not taken into account in the sensitivity analyses.

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Table 4.9 Sensitivity Analyses: Administrative Costs

Management Alternatives (Stocking Density)	Volumes Required (m3/Ha/Year)					
	Financial			Economic		
	10,000 Ha/Yr*	Base Case	40,000 Ha/Yr*	10,000 Ha/Yr	Base Case	40,000 Ha/Yr
1 x 2	31	38	53	18	24	38
1 x 3	25	32	46	15	21	34
2 x 2	23	30	44	14	20	34
2 x 3	18	25	39	12	18	32

* Administrative costs are either 10,000 or 40,000 rp/ha/year instead of the base case assumption of 20,000 rp/ha/year.

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base case assumption. For this study, the base case assumptions are changed one by one, while all other assumptions remain as before. The results are given in Tables 4.7 through 4.11.

Table 4.7 shows the range of production levels required if plantation establishment costs were either higher or lower than those used in the base case. If, in the financial analysis, for example, one person could only plant 30 seedlings per day including site preparation, perhaps because of difficult terrain, then it would take 52 m3/ha/year for the 1 x 2 m spacing density option to break even on the investment--clearly not financially feasible. If, on the other hand, this person could plant as many as 70 seedlings per day, because of easy terrain, then only 33 m3/ha/year would be required. This level of production for the densest stocking option at least approaches financial feasibility. As the stocking density declines so do the required break-even production levels.

Table 4.8 shows the results of varying the weeding and pruning costs around the base case assumptions. The range of production levels required under the different assumptions is not large indicating that the assumption is not highly sensitive.

Table 4.9 shows the results of varying the administrative costs. If they were as low as 10,000 rp/ha/year even the 1 x 3 m stocking density option is financially feasible. If, however, these costs were as high as 40,000 rp/ha/year none of the options, financial and economic, would be feasible.

Table 4.10 shows the results of varying the stumpage values from as low as 1,500 rp/m3 to 3,000 rp/m3 instead of the base case assumption of 2,200 rp/m3. This assumption also appears to be the most critical since the results exhibit the widest range. For the financial analysis it appears that all stocking densities, except 1 x 2 m, are feasible if stumpage values are 3,000 rp/m3. All of the densities for the economic analysis are feasible given the 3,000 rp stumpage value. If the value is only 1,500 rp/m3, however, none of the financial or economic alternatives are feasible.

The sensitivity of the discount rate is given in Table 4.11. The rates were varied from as low as four percent to as high as 12 percent for the financial analysis, and from two to 10 percent for the economic analysis, holding all other assumptions constant at their base case levels. The results indicate that the discount rate is not a very sensitive assumption given the narrow range of the results. For example, with a four percent rate the required production level only drops from 38 to 33 m3/ha/year for the 1 x 2 m stocking density option for the financial analysis. For the economic analysis, only a drop from 24 to 21 m3/ha/year is shown for the same stocking density option as the discount rate drops from six to two percent.

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Table 4.10 Sensitivity Analyses: Stumpage Values

Management Alternatives (Stocking Density)	Volumes Required (m3/Ha/Yr) Financial 1,500 Rp/m3*	Base Case	3,000 Rp/m3*	Economic 1,500 Rp/m3	Base Case	3,000 Rp/m3
1 x 2	56	38	28	36	24	18
1 x 3	46	32	23	31	21	15
2 x 2	44	30	22	30	20	15
2 x 3	37	25	18	27	18	13

* Stumpage values are assumed to be either 1,500 or 3,000 rp/m3 instead of the base case assumption of 2,200 rp/m3.

Table 4.11 Sensitivity Analyses: Discount Rates

Management Alternatives (Stocking Density)	Volumes Required (m3/Ha/Yr) Financial 4%	6%	Base Case	10%	12%	Economic 2%	4%	Base Case	8%	10%
1 x 2	33	35	38	41	45	21	22	24	26	28
1 x 3	27	29	32	34	37	18	20	21	23	24
2 x 2	26	28	30	32	35	18	19	20	22	24
2 x 3	22	24	25	27	29	16	17	18	20	21

* Discount rates are varied around the base case assumption of eight percent.

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5. BIOMASS ENERGY AS AN INPUT TO THE RESGEN MODEL

5.1 Introduction

What is important to take into account in the RESGEN model, as far as the biomass component is concerned, is that there are limits to what biomass can realistically contribute to the overall energy balance in Indonesia. This stems from the fact one cannot separate the issues of bimass energy consumption from biomass production, particularly when the productive resource base in Indonesia is already declining at a rapid pace. To talk about any further increases in biomass consumption, over and above those attributable to population increases, will only serve to accelerate the depletion of the resource base. Obviously this would not be in the national interest. Therefore, care has been taken in this report to consider the biomass production side.

There have been numerous studies done on the biomass for energy subject which may have left the impression that biomass is almost a panacea. The technologies for conversion have become more efficient and modern, less costly methods of harvesting etc. are available. The studies, however, rarely take into account the fact that biomass consumption is increasing and production is declining over time, nor that production and consumption areas rarely coincide, and that transportation of biomass energy is almost never economically feasible.

The target goals specified in this report are modest indeed. But, even as modest as they are, they will require a substantial amount of land to produce the biomass. In addition, since Java is the major consuming region of the country, most of the biomass production would also have to take place on Java, in close proximity to the end-use point.

5.2 Biomass Energy and the RESGEN Model

In the RESGEN model all the end-use sectors have a "menu" of energy supply sources from which choices can be made for analytical purposes. If the use of one source is increased the other sources will be adjusted accordingly so that total energy supply will always equal 100 percent.

As part of the menu the biomass energy sources listed in the RESGEN model are:

* Wood and charcoal
* Agricultural wastes
* Biogas

All of these resources have been discussed to some extent in the previous chapters where some were given a "high" potential rating and others a "low" rating. These potential energy sources are briefly discussed below in terms of the RESGEN model.

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5.2.1 Wood and Charcoal

If woody biomass, including charcoal, is to become a more significant contributor to the overall energy balance in Indonesia, two factors must be considered--first, is it economically feasible to produce the wood, and second, what is the realistic maximum potential for this energy source? The answer to the first question is, at least in a preliminary sense: yes, wood can be produced economically provided that the management prescriptions are followed (according to Chapter 4--avoid the narrowest stocking densities and produce the wood as close to the end-use point as possible etc.).

The answer to the second question does not exist, except for perhaps "...it depends." First and foremost, it depends on land availability, and second, it certainly depends on the professional and budgetary capacity of the Forest Service to implement any large scale energy plantations in addition to those already undertaken. The current five-year plan calls for 320,000 ha of energy plantations to be installed which is reflective of the present budgetary capacity (budgets for planting, stand maintenance, vehicles, gasoline, etc.). In terms of the professional capacity (qualified manpower) several of the Forest Service personnel interviewed indicated that, globally, perhaps as many as 600,000 ha of plantations could be implemented and managed over a five-year period without having to add substantially to the existing professional staff. This would nearly double the present energy plantation five-year plan of 320,000 ha. If this was done, however, the quality of management would, of course, decline because each professional forester would have less time to give proper attention to each plantation.

In the absence of any other "hard" information, a figure of 280,000 ha for five years, representing the additional plantations the Forest Service may be able to handle with its existing staff, or 56,000 ha/year, is suggested as the maximum potential for woody biomass. This means that roughly .9 million tons of wood for energy (assuming 22 m3/ha/year productivity) could be made available annually. This amount is roughly equivalent to 1.4 million BOE's per year. For the RESGEN model, this 1.4 million BOE's per year is the total amount available to be divided between various end-use sectors. Thus, if a portion of the wood is used in the household sector, perhaps as a substitute for kerosene used for cooking, less will be made available as alternative feedstock for industrial fuel-oil boilers or diesel generators. The important message is, of course, that the RESGEN model should not be used to generate numbers that are totally unrealistic, or without limit, but should instead recognize the practical limits of substitution between energy sources.

5.2.2 Agricultural Wastes

The only agricultural waste considered a high potential energy source in this report is rice husks. Other agricultural wastes were rated low potential for reasons given in Chapter 2.

The maximum potential supply of rice husks is 10.1 million

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tons annually (see Section 2.4.2) of which a large portion is simply being burned in the field. Assuming that 25 percent is actually being used for cooking in households or to energize small rural industries (brick making etc.), the remaining potential supply is 7.5 million tons annually. Of this amount, approximately 2.5 million tons would be used to meet the energy requirements for the rice mills themselves (Manurung 1985), assuming that all of the mills participate. This leaves a total excess supply of five million tons of husks annually.

Of course, not all of the rice mills will participate unless appropriate incentives are provided. And, among those who do, it is not at all certain whether they would actually run the gasifiers to generate electricity beyond their own needs that they could sell, either to the grid or to individual users, even if the suplly of husks were virtually limitless. For the RESGEN model, however, the 7.5 million tons are suggested as the upper limit since it is conceivable that, with the appropriate incentive structures, the utilization of most all of the rice husks for energy could be achieved in the future. This could certainly be the case when and if, the subsidies on petroleum products consumed domestically were lifted. The maximum energy generating potential from this biomass resource would be roughly equivalent to 11 million BOE's annually.

5.2.3 Biogas

The upper limit on the potential for biogas generated from organic municipal solid waste in Indonesia is pure conjecture. It was estimated in Section 2.3 that the city of Jakarta generates 1,750 tons of organic waste per day from which roughly 1.5 million BOE's worth of biogas could be generated annually. For other major cities in Indonesia, however, similar estimates were not obtained. Nor is it known whether it would be economically feasible to generate biogas energy from organic municipal solid waste given the considerable capital investments that would have to be made.

For the RESGEN model, however, an upper limit to the potential for biogas energy ought to be specified, since this energy source, as with the other biomass sources, is not open ended. To this effect, it is suggested that a maximum practical potential is set at 10,000 tons per day, or roughly six times the estimated potential for the city of Jakarta. The biogas energy content from this much organic municipal waste would be nearly nine million BOE's annually. The energy would probably be in the form of electricity sold to the grid, which in turn, would lessen the pressure to generate electricity using diesel and/or fuel oil as feedstocks.

5.3 Some Concluding Remarks

The RESGEN model is a very versatile tool that can be used to trace the implications on the energy balance as different policies concerning energy consumption are implemented. For example, as part of the policy to reduce the consumption of domestically produced oil the GOI is about to launch a major

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program of transporting coal from Kalimantan to Java for use by industry on Java in lieu of diesel and fuel oil. Similarly, proposals for increased use of biomass in lieu of fossil fuels are under study, and energy plantations have been installed and are under management. As alternative energy sources come on line the RESGEN model will show how many BOE's one can expect to save.

This paper, however, has focused on the production side--how much biomass can one reasonably expect to be made consistently available on a yearly basis? Unless this question is raised one could easily be tempted to treat biomass as an open-ended resource in the model; i.e., essentially without any limits. For example, based on Indonesia's production forest area, estimated at nearly 34 million hectares, and an average productivity of 22 m3/ha/year, the incremental growth per year would be equivalent to roughly 850 million BOE's per year. This figure could be run on the model and the results will show that biomass can solve all of Indonesia's energy problems. This, of course is completely unrealistic. Prudent use of the model would dictate that realistic upper limits on the substitutability between energy sources be specified.

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ANNEX 1

TRIP REPORT

The trip report lists the people and organizations met and gives a brief summary of the topics discussed.

2 July, 1985

Arrived Jakarta. 2 PM, brief orientation meeting with Phil Palmedo and Andres Doernberg.

3 July

9:30 AM, Dr. A. J. Surjadi, Director of New Energy Development, Mr. Singgih Riphat, Head of New Energy Demonstration Section, and A. Doernberg.

* Discussed ways by which the biomass component of the total energy balance in Indonesia can be best represented in the RESGEN model.

2:30 PM. Desmond O'Riordan and Irwan Surjadi, USAID.

* Mr. O'Riordan gave several leads on people and organizations to contact.

* Says gasification has generated more interest as a biomass conversion technology than other technologies in Indonesia.

4 July

Noon. Dr. Max Meulenhoff, Head of Forest Products Dept., Min. of Forestry. Dr. Meulenhoff is the Indonesian representative for the USAID/ST/EY Biomass Users Network (BUN).

* Discussed biomass for energy potential in general. The problem--pressure on the biomass resources on Java is very high. While feedstock supplies are relatively more abundant outside of Java, particularly Kalimantan, preliminary results from several transportation studies indicate that transportation of fuelwood, charcoal, and/or any other biomass energy resources is not economically feasible. Favors use of biomass energy in local industry where the feedstock supply is near the end-use point. Sawmills, for example, could easily be energized this way.

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* Should keep in mind that kerosene is a much more convenient energy form than biomass. No guarantee, for example, that people will reduce their consumption of kerosene for cooking even if fuelwood or charcoal can be made available at lower costs.

* Suggested that a reasonable target for biomass energy would be retrofitting diesel generators with gasifiers to generate electricity in the government sector.

1:30 PM. Dr. Don Anson, Battelle (BPPT, Jakarta).

* Battelle has a contract to help organize an energy research institute emphasizing non-oil resources, particularly coal. Supplies of low grade brown coal in Kalimantan and also elsewhere in Indonesia are plentiful, but not yet developed to make a significant contribution.

* Charcoal, although having roughly the same energy content as coal by weight, is much less dense and therefore too costly to transport. Only densified charcoal could possibly be transported economically (under study). Of all of the non-oil energy resources available on Kalimantan, according to Anson, only coal is worth considering for transport to Java.

* The consumption of kerosene for cooking is increasing because it is a more convenient fuel and also subsidized and therefore price competitive. Fuelwood, on the other hand, is becoming increasingly scarce because of overcutting and also because of indiscriminate cutting practices, i.e., cutting small trees (saplings etc.) near home to avoid handling and transportation problems etc.

* The problem with gasification to generate electricity in the rural areas is that the smallest gasifier worth considering (50 kw capacity) is much too large for the electrical needs in many rural areas. Small efficient diesel generators (5 kw or less), on the other hand, are available. He did not rule out, however, the possibility that more efficient smaller scale gasifiers could be developed.

* Germans (GTZ) are currently installing 50 gasifiers (200 kw capacity) to generate electricity for water pumping.

* Anson believes there is a good possibility for generating biogas energy from municipal solid waste, particularly in Jakarta. The waste has a very high organic content suitable for digestion. The value of the energy generated, however, would not by itself be sufficient to pay for the necessary investments. The other benefits of municipal solid waste digestion would be the sterilization of toxic wastes and the fertilizer value of the digested materials.

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* The potential for biogas digestion of animal wastes in Indonesia is low because relatively few animals are held in confinement.

3 PM, Dr. Dirk Lyersen, Bechtel (BPPT, Jakarta)

* Dr. Lyersen just finished a draft report on the technical and economic feasibility of transporting coal from Kalimantan to Java. He concludes that coal transportation is feasible relative to the benchmark of $8 per ton for coal shipped from Australia, but only if the right transportation facilities and large capacity vessels are used.

* Germans (GTZ) have studied the feasibility of transporting charcoal from Kalimantan to Java. Conclusion: Far too expensive. Biomass energy, in general, is not transportable economically.

* Based on the coal transportation study, it will be possible to deliver the coal to the end-user on Java, up to 300 km from the ship unloading port, for US $60 - 70 per ton. This is based on a cargo of 10,000 tons, round trip of 10 days of which three days are spent loading and unloading. The ship consumes approximately 120,000 liters of fuel per round trip. Additional energy will be consumed for transporting the coal from the mines to the loading point, and from the unloading point to the end-use point. It is estimated that approximately 11 million tons of coal will be shipped from Kalimantan to Java in this fashion each year, or roughly 1,100 round trips per year.

* Estimated ship transportation charges from Kalimantan :
  Sulawesi : $4/ton
  East Java: $7.50/ton
  West Java: $8 to 9.50/ton

5 July

10 AM. Dr. Kamaruddin Abdullah, Associate Dean of the Graduate School, Bogor Agricultural Institute (Institute Pertanian Bogor--IPB), Mr. Kosasih, Subdirectorate of rural energy, and Mr. Singgih Riphat, Head of the New Energy Demonstration Section.

* Dr. Kamaruddin is the head of the Technical Committee for Energy Resources--a think tank for energy problems. This committee approved the launching of biomass for energy programs in Indonesia. First priority--how best to integrate biomass into the energy mix in Indonesia.

* Dr. Kamaruddin has been studying the potential for biomass energy in Indonesia for some time. His efforts (not yet published) have culminated in macro supply and demand models, looking at the resource base and consumption trends over time. The resource base, he found, is declining rapidly on Java and

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less rapidly elsewhere. The reasons: Increases in fuelwood cutting, the logging industry, new settlements clearing land for agriculture, industrial development etc.

* According to Dr. Kamaruddin, the best potentials for reducing dependence on petroleum products are in the household and rural industry sectors. In the household sector, concentrate on reducing kerosene consumption for cooking which accounts for approximately 30 percent of the total energy consumed. The GOI eventually wants to abolish the subsidies for kerosene which will make wood and charcoal much more attractive. In the rural industry sector concentrate on estate plantations--rubber, sugar, tobacco, ceramics, brick making, lime stone, and other small scale industries. These are generally energized by diesel power and often for process heat as well. The diesel generators can easily be retrofitted with gasifiers.

* Dr. Kamaruddin is not optimistic about the potential for digestion of animal wastes, primarily because of the social obstacles. Nor is he very optimistic about the potential for biomass production schemes on Java because of the heavy population pressure and alternative, perhaps more valuable, land uses. He does not rule out, however, the potential for intensive energy plantations. He feels that the issue of transporting biomass energy from Kalimantan to Java should be studied further.

* High quality charcoal can sell for as much as 300 rs/kg in major cities, which is roughly $275 per ton. How competitive charcoal is with coal would depend on production and transportation costs.

* Most of Dr. Kamaruddin's work has been on woody biomass on a global, not a regional basis. Regional data is not readily available.

4 PM. William Knowland, Environmental Advisor, USAID

* Brief meeting discussing the potential for increased biomass energy use in Indonesia. Best potential is found in the rural industries and households, as substitutes for diesel and kerosene.

<u>6 July</u>

9 AM. Brief meeting with Luluk Sumiarso, Direktorate General of Mining and New Energy, to inform him of the progress of the work.

<u>7 - 12 July</u>

Data gathering, preparing outlines and methodologies for analyses to be undertaken etc.

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13 July

10 AM. Forest Products Research Station (Perum Perhutani), Bogor. Met with Dr. Kyriakos Maniatis, Project Leader, Belgian Rural Energy Project and other representatives of the Belgian project now underway to look at the technical feasibility of gasification and anaerobic digestion. Also present was Mr R. Sudragat, Perum Pehutani.

* Only large scale gasifiers tend to be economically feasible. However, developments are underway to make smaller scale gasifiers much more efficient. Some say only megawatt capacity will be economically feasible.

* With gasifiers one should take into account the loss in efficiency. Where a higher calorific value fuel (diesel) is replaced by a lower calorific value gas (from gasification of wood and other materials), using the same engine, the engine becomes less efficient. The alternative is to mix 10 to 15 percent diesel in with the gas and avoid a significant loss in efficiency.

* Biggest problem with gasification is the dissemination of the units in the field. Investment requirements are too high for individuals and the smaller industries. To retrofit the larger diesel generators with gasifiers to generate electricity would be less difficult from the point of view of dissemination if it was done in the government sector.

* Charcoal sells for 100 rp/kg in Bogor. Charcoal made on Sumatra is exported to Singapore (two-hour boat ride)--export price fob is between 80 to 90 rp per kg for high quality charcoal. Lower quality charcoal is exported for 60 to 70 rp per kg. The charcoal operations on Sumatra is being financed by Singapore. Cost of charcoal on Java is increasing because of increasing industrial demand--pig iron and rayon production in particular. The pig iron industry in Lampung, for example, consumes 25 tons of charcoal per day. Production cost for charcoal: 30 - 45 rp per kg. Conversion efficiency: 15 - 20 kg of charcoal for every 100 kg of green wood input (40 -60 percent moisture content). Charcoal kilns on Java are the traditional inefficient dirt mounds. Sumatra use stationary brick kilns of a Brasilian design.

* Fuelwood in Bogor sells for 6 - 8000 rp per m3. The wood is transported 10 - 20 km.

1 PM. Met with Dr. Kamaruddin and Mr Abdul Kohar Irwanto, Bogor Agricultural Institute.

* Little on-the-ground work is presently being done about rural electrification. It has, however, become a discipline at

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the BAI where courses in rural electrification are being taught.

* Potential for biomass production on Java is limited because of alternative land use preferences. There is, however, room for fairly large scale plantations on government lands.

16 July

10 AM. Perum Perhutani, State Forest Corporation.

* Perum Perhutani is a state institution set up to manage approximately three million hectares of state owned forest land on Java only. Sixty percent of the area is in natural forest. Approximately 30 percent is in plantation forestry. Emphasis: planting high value species such as teak for furniture manufacturing etc.

* Energy plantations are established as buffer zones around the teak and pine plantations. Fuelwood is not the primary product in any of the Perum Perhutani forests. Fuelwood species are also often planted in between the teak rows.

* Energy plantations are usually in 2 x 2 or 2 x 1 spacing.

* Calliandra is considered the best fuelwood species.

17 July

10 AM. Dr. Soerjono, Ministry of Forestry, Jakarta

* Stumpage value of 2,200 rp/m3 is a realistic base case assumption.

* Perum Perhutani is in business to produce fuelwood for the people and to grow high value sawtimber, primarily teak, that can be sold at a profit. The teak plantations are the most important resources managed by Perum Perhutani, fuelwood plantations are only secondary. Fuelwood species are planted in dense buffer strips around the teak plantations and/or in between the teak rows to stabilize the soils and provide good ground cover.

* Fuelwood is rarely planted as a primary crop. When it occurs it would be on the poorer lands.

* Perum Perhutani practices agroforestry under the Taungya system. Tree spacing of 2 x 3 m allows farming between the rows for two seasons.

* Workers are paid up to 1,500 rp per day in the more expensive regions (near Jakarta). Otherwise, salaries tend to be lower.

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* The worker can plant approximately 75 seedling per day.

* Under the Taungya system site preparation consists of clearing the entire site of all vegetative cover prior to planting. This is done by the farmers. If the Taungya system is not followed, site preparation consists only of clearing the area where the tree will be planted (about one meter in diameter).

* Seedlings cost approximately 20 - 25 rp each.

* Rotation age for fuelwood crops--3 - 5 years, coppice management.

* Perum Perhutani probably has room to accommodate another 100,000 ha worth of buffer fuelwood plantations on Java.

18 July

9 AM. Met with Dr. Saswinadi Sasmojo, Acting Chairman, Institute for Research, Institute Teknologi Bandung, P. O. Box 54, Bandung, and Mr. Robert Manurung, PhD Candidate, Chem. Eng. Dept., ITB.

* In addition to substituting for kerosene in cooking and diesel in electricity generation with biomass we should also consider retrofitting fuel oil boilers that produce electricity through steam generation. Current plan is to fuel these boilers with coal shipped from Sumatra.

* ITB has developed small capacity (15 - 25 kw) wood and rice husk gasifiers to be used for rural electrification. They are built from local resources (no imported parts) and are simple to operate. One unit costs approximately US $4,500. A "turnkey" operation, including the gasifier and the diesel engine would cost approximately US $20,000. Of particular interest is the rice husk gasifier which can be used to energize the several thousand rice mills in the country. These mills do not generally use the husks to meet their energy requirements but burn them in the field to get rid of them. Husks are not good for soil amendment so if not used for energy, the resource is wasted. The 15 - 25 gasifier capacity is more than sufficient to ensure energy self sufficiency for the majority of rice mills in the country.

* Problem--small rice mills are generally too cash poor to afford the initial investment; and, the diesel saving generated are not sufficient to pay back the loans under the terms suggested.

* Discussed potential for shipping charcoal from Kalimantan to Java. Presently, the cost of transportation would amount to roughly 40 percent of the price.

* Kerosene sells for 150 rp/liter (subsidized). Charcoal

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from Kalimantan could conceivably become competitive with kerosene when kerosene prices reaches 250 rp/liter.

* Diesel fuel sells for a subsidized price of 242 rp/liter. Overall production cost is 350 rp/liter; the subsidy is the difference.

22 July

10 AM. Met with Dr. Hadi Soesastro, Center for Strategic and International Studies, Tanah Abang III/27, Jakarta.

* Kerosene price today is 150 rp/liter, cost of production is 350 rp/liter; the difference is the subsidy. GOI wants to eliminate the subsidies on petroleum products, but to do so slowly. Ther is evidence that consumption has indeed shifted away from kerosene as prices have increased.

* Kerosene prices have declined in real terms over time with the subsidies, which has increased consumption. Moreover, it is not only prices that affect the level of consumption, it is also that the distribution system has developed to the point where kerosene has become very easy to obtain anywhere. It is also a cleaner and more convenient fuel than fuelwood.

* Price of firewood is fluctuating with the seasons. During the wet season the price is generally much higher (up to three times as high) because of transporttion problems.

25 July

9AM. Met with Mr. Tato Muhammad and others at the Forest Servic office in Lampung.

* Verified all of the assumptions used in the economic and financial analyses conducted in Chapter 4 of the report. Land costs are not considered in any of their analyses since plantations are only located on state lands.

* The majority of energy plantations are established with a 1 x 3 m spacing. Forest Service is experimenting with 2 x 2, 2 x 1, and 2 x 4 m spacing densities.

* Concept of energy plantations is relatively new, therefore they have no idea about likely coppice behavior for the different species used. They count on three harvests after the initial plantation.

* Seedlings are raised in nurseries in plastic bags.

* Pruning and weeding in the plantations are absolutely necessary in year one, and probably in year two for the less densely stocked stands.

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Plantations are located on medium quality land; expected yields are in the neighborhood of 20 - 25 m3/ha/year.

* Fertilizer has been tried on an experimental basis with no noticeable increase in growth and yield.

* Two-year old stands already reach crown closure, average height of the trees--12 -13 m.

* Best charcoal species is the ipil ipil.

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ANNEX 2

Other Possibilities for Biomass Energy Substitution

1. Irrigation Pumping

If industry and agriculture are powered primarily by fossil fuels there is great potential for substituting with fuelwood, charcoal, or agricultural wastes through gasification, or direct combustion. For example, irrigation pumping is accomplished with shaft power using diesel engines. Biomass fueled gasifiers can easily provide a fuel gas to these same diesel engines and accomplish the same water pumping objectives. A 250 kw gasifier to produce fuel gas to drive irrigation pumps in lieu of diesel power, operating at 50 percent capacity, would require roughly 2,190 m3 of wood per year. At an average yield of 22 m3/ha/year this translates into a land requirement to produce the feedstock of 100 hectares.

2. Char-oil Slurry

Large scale projects have the potential of exerting a significant impact on fuel oil use, but will require large tonnages of wood or agricultural residues delivered to a single site. An example would be a biomass derived char-oil slurry (50 percent char). An industrial boiler that produces 20,000 - 25,000 kg/hour of sturated steam would require one metric ton/hour of charcoal. If the boiler operates 24 hours per day, 330 days per year, the facility would require in excess of 7,900 metric tons per year of char. At a 25 percent yield (dry basis) of charcoal from wood, 32,000 dry metric tons per year of wood must be pyrolized. The use of the char would replace the use of 4,500 metric tons of fuel oil or over 31,000 barrels per year of oil (or seven dry metric tons wood/metric tons of petroleum). The 32,000 metric tons of wood is roughly equal to 64,000 m3 which translates into a land requirement of 2,900 hectares producing 22 m3/ha/year on the average.

3. Transportation

The use of air blown gasifiers mounted on vehicles or trailers to provide a fuel gas for vehicles is another means of substituting biomass for fossil fuels. At the community level, for example, vehicles (tractors, short haul trucks and buses) could be retrofitted with wood and charcoal gasifiers. During world War II, over 800,000 biomass gasifiers were used worldwide for buses, trucks, automobiles, boats and even motorcycles. The feedstock requirement for a gasifier driving a 300 HP engine at 40 percent load, where 90 percent of the fuel demand comes from wood, and assuming 2,000 hours/year of operation, is roughly 164 dry metric tons per year, or 410 m3 per year. At a productivity of 22 m3/ha/year this would require 19 hectares of forested land.

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4. Charcoaling

In many countries the dirt mound process of charcoaling is still widespread. This process is highly inefficient and time consuming and could be substantially improved. One possibility is the use of more efficient portable metal kilns that can easily be transported between sites. Assuming a kiln with a capacity of six metric tons of charcoal product per month where four dry tons of wood equals one ton of charcoal, the feedstock requirement would be 288 dry metric tons per year, or roughly 720 m3 of wood. At 22 m3/ha/year production, one kiln would require 33 ha of forested land.

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