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ENERGY PLANNING FOR DEVELOPMENT IN INDONESIA

DIRECTORATE GENERAL FOR POWER
Ministry of Mines and Energy
Jakarta

and

ENERGY/DEVELOPMENT INTERNATIONAL

with

Development Sciences Inc.
GSA International
International Science and Technology Institute Inc.
Olympic Associates

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APPENDICES

ENERGY PLANNING FOR DEVELOPMENT IN INDONESIA

A. MACROECONOMIC STRUCTURE AND ENERGY DEMAND: INDONESIA TO THE YEAR 2000, Alan M. Strout.

B. ENERGY DEMAND PROJECTIONS, Andres B. Doernberg and Scott Rogers.

C. ENERGY USE FOR PRODUCTIVE PURPOSES IN THE RURAL SECTOR IN INDONESIA, Thomas E. Cobbald.

D. DOMESTIC ENERGY CONSUMPTION IN RURAL AREAS OF INDONESIA, Romir Chatterjee.

E. THE COAL POTENTIAL IN INDONESIA, M.D. Schlesinger.

F. ASSESSMENT OF BIOMASS AS AN ENERGY RESOURCE IN INDONESIA, Olympic Associates Co., Seattle, Washington.

G. SMALL SCALE HYDROPOWER AND GEOTHERMAL ENERGY IN INDONESIA, based on reports by Kenneth Grover GSA International

H. AN ASSESSMENT OF SOLAR AND WIND ENERGY IN INDONESIA, James D. Westfield.

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INDONESIAN PROJECT PARTICIPANTS

STEERING COMMITTEE

Ir. Wiyarso (Chairman)	Director General, Oil and Natural Gas Chairman, Technical Committee on Energy Resources (PTE)
Prof. Dr. Samaun Samadikun (Deputy Chairman)	Director General of Power Deputy Chairman, PTE
Prof. Dr. A. Arismunandar (Secretary)	Director for Energy Resources Development Secretary, PTE
Ir. C. Situmorang (to Feb. 1981)	Member PTE Chief, Planning Bureau, Ministry of Mines and Energy
replaced by	
Ir. Sri Sediono	Member, PTE Chief, Planning Bureau, Ministry of Mines and Energy
Ir. Bambang Soelasmoro	Member, PTE Head, Mines Technology Development Center (PPTM)

OTHER INDONESIAN PARTICIPANTS

Dr. A. J. Surjadi	Chief, Subdirectorate of Power Development
Ir. E. Darianto	Chief, Subdirectorate of Power Data - Energy Information System
Ir. M. Pandjaitan	Regulations and Administration of Power Development - Rural Surveys and Environmental Assessment
Ir. Tangkas Roesad	Chief, Implementation of Power Development - Biomass
Ir. Endro Utomo	Secretary, Energy Planning for Development - Coal
Ir. Irzal Chatab	Urban Demand
Ir. Luluk Sumiarso	Hydro and Geothermal
Drs. Suwardjaka	Solar and Wind
Drs. M.A. Hudaya	Urban and Regional Energy Planning
Ir. Sutarto	Geothermal Energy
Ir. Suharto Satibi	Energy Demand Analysis
Ir. Tjarinto	Rural Energy Survey and Solar Energy
Ir. Supriyo	Wind Energy and Assistant Secretary, Energy Planning for Development
Ir. Kampiun Sitohang	Design and Development of Energy Information System
Ir. Imam Djajono	Data Analysis
Aan Sanwas	Chief Programmer, PLN - Data Programming
Ir. Sucipto	PLN - Solar and Wind
Didi Sulasdi	PLN - Geothermal
Ir. Sedya Sebayang	PLN - Minihydro
Ir. Nugroho Hadi	LEMIGAS - Biomass
Ir. Nasution	LEMIGAS - Coal

Ir. Ukar Sulistyo	PPTM, Institute for Minerals Research - Coal
Ir. Umar Said	LEMIGAS - Demand Analysis
Ir. Razief Razak	PME - Rural energy
Ir. Sumarto Sudiman	PME - Rural energy

MEMBERS OF RURAL SURVEY ADVISORY COMMITTEE

Dr. Ir. Aryadi Suwono	Bandung Institute of Technology
Dr. Nurwati	Bandung Institute of Technology
Dr. Komaruddin	Bogor Institute of Agriculture
Dr. Rachmatsyah	Bogor Institute of Agriculture
Ir. Sutomo	Bogor Institute of Agriculture
Dr. Anwar Hafid	Hasanuddin University
Ir. Soepardi	Diponegoro University

U.S. PROJECT PARTICIPANTS

Energy/Development International

Philip F. Palmedo, Project Manager
Romir Chatterjee, Energy Surveys
Andres Doernberg, Energy Demand Analysis
M. D. Schlesinger (Consultant), Coal Assessment
Alan Strout (Consultant), Economic Analysis

Development Sciences Inc.

Morton Gorden, Project Review
William Schaffer, In-Country Coordination
James Westfield, Solar and Wind Energy

G.S.A. International

Kenneth Grover, Geothermal and Small Scale Hydropower

International Science & Technology Institute, Inc.

Thomas Cobbald (Consultant), Rural Energy

Olympic Associates

Rolf Skrinde, Biomass

Conversions Used in This Report

Energy Equivalents

The standard unit of energy used throughout this report is the "barrel of oil equivalent (boe)". The unit is defined as:

$$1 \text{ boe} = 5.8 \times 10^{9} \text{ Joules (GJ)}$$
1000 boe = kboe
1 million boe = Mboe

and converts to the following energy units:

$$1 \text{ boe} = 1610 \text{ kwh} = 1.39 \times 10^{6} \text{ kcal}$$

On the basis of 7 million kilocalories per metric ton of coal equivalent (tce) and of 10 million kilocalories per metric ton of oil equivalent (toe), the following conversions apply

1 boe = 0.19 tce	1 tce = 5.05 boe
1 boe = 0.14 tce	1 toc = 7.21 boe

Physical Units to Energy Equivalents:

1 barrel of LPG equals	0.700 boe
1 barrel of gasoline equals	0.914 boe
1 barrel of kerosene equals	0.970 boe
1 barrel of diesel equals	1.005 boe
1 barrel of fuel oil equals	1.055 boe

1 thousand cubic feet of natural gas equals 0.19 boe
1 ton of Ombilin coal equals 5.05 boe (1 ton = 1 tce)
1 ton of Bukit Asam coal equals 3.75 boe (1 ton = 0.743 tce)
1 metric ton of LNG equals 8.40 boe (48.7 GJ)
1 metric ton of dry natural gas equals 7.22 boe (41.9 GJ)

Useful Conversions

1 kiloliter = 6.29 barrels

1 m^3 = 35.3 cubic feet

Densities

Liquid petroleum products have a density of 1.00 (1.0 liter = 1.0 kg)

LPG: 1 bbl = 192.5 lbs
LNG: 1 metric ton = 48.7 GJ (net calorific value)
Natural Gas (dry) 1 metric ton = 41.9 GJ

I INTRODUCTION

A. BACKGROUND

A new urgency now attaches to national energy planning throughout the world. Whether a country imports or exports petroleum, and whatever fraction of its energy consumption is from traditional fuels, the change in world oil prices over the last several years has changed a major element in national economic and social planning. The prospect of major shortages of petroleum on a global scale over the long term also requires countries to think anew about the energy aspects of development strategies. Just as petroleum fuels on which traditional development has been based are becoming more valuable, the traditional fuels on which the survival of much of the population of developing countries depend are becoming more costly in economic, human and environmental terms.

These conditions apply in a critical way to Indonesia. Oil exports, which now account for more than 60 percent of total export earnings are threatened by a rate of increase of domestic demand for oil that far exceeds the expected increase in the rate of new oil production.(1)* The domestic demand for petroleum is thus a crucial and complex element in the economic development equation. High rates of growth of internal demand result in part from high levels of oil exports but, at the same time, jeopardize those exports. This is clearly not simply an energy issue, involving as it does the structure and development of the entire Indonesian economy.

Indonesia also manifests the problems of what has been called "the other energy crisis" - the increasing difficulty of obtaining adequate supplies of

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*Notes and references are given at the end of each chapter.

wood and other commercial fuels. Serious deforestation, with attendant environmental, economic and social costs, is occuring particularly on Java. The fuel wood and oil problems are linked in an important way. Kerosene is the traditional substitute for fuel wood for cooking as income or the difficulty of obtaining non-commercial fuels increases. The current economic cost of the subsidy for kerosene, however, has been estimated at about U.S. $3 billion per year.[2]

These energy problems are of major national proportions. But fortunately the basic energy resource base of Indonesia is also very large. The petroleum and natural gas resources now appear to be able to sustain production levels higher than present ones. In addition, coal, hydropower, solar energy, windpower, geothermal energy and various types of biomass[3] all appear to have significant potential. It is evident, however, that if serious economic problems are to be avoided, the current path of energy development must be rethought. A new path must be taken which is based on the needs of national economic and social development, is attuned to the new world energy economic situation and makes optimal use of the full energy resource base of the country.

Although the general objectives of this new path have been established, and expressed in Repelita III[4], the development of a consistent set of national energy strategies and plans is an urgent need. It was in this context that the Energy Planning for Development Project was conceived. The project has been carried out by means of a collaboration between the Directorate General of Power of the Ministry of Energy and Mines and Energy/Development International and associated firms and consultants. The project was supported by the U.S. Agency for International Development.

B. OBJECTIVES AND SCOPE OF THE PROJECT

The Energy Planning for Development Project has two principal objectives:

1) To foster a better understanding of the effect of energy and economic development plans and programs on the energy situation of the country, as well as the social, economic and environmental consequences of decisions concerning energy pricing, energy technologies and resource development; and

2) To enhance the capabilities of Indonesian planners to analyse the role which energy plays in development, and to plan a national energy program.

To accomplish these objectives, several tasks were undertaken. The three principal task areas were:

1. Pilot Surveys of Firewood and Kerosene Use

As a basis for governmental decisions or kerosene prices, fuelwood programs, and other actions affecting domestic energy consumption a much better understanding is required of the use of kerosene, wood and other fuels by households. Building on surveys carried out by various Indonesian groups in the past, a coordinated set of pilot surveys of fuel consumption by households was carried out in several rural regions of the country. Eight universities and institutes participated in the surveys. Although of a pilot nature, the surveys have provided useful information to the project and energy planning in general and have established methods and institutional capabilities for other types and more extensive surveys.

2. Energy Demand Analyses

A prime prerequisite of national energy policy analysis and planning is a consistent view of the current energy supply-demand situation and a view of how that situation will evolve in the future under alternative

policies and programs. Under this task the first steps were taken to develop such a consistent data base. Energy demand projections drew on the results of the fuelwood-kerosene survey, existing information on energy consumption patterns and alternative projections of social and economic development. Because of the importance of the development of rural areas, particular attention was paid to the energy implications of rural industry and agriculture.

3. Technology Assessment

A central goal of Indonesian energy policy is the diversification of energy sources. In this task, preliminary assessments were carried out of the role that various non-petroleum energy sources could play in Indonesia's future and the steps that need to be taken to advance the application of these sources. The resources that were considered were: coal, small scale hydropower, geothermal energy, solar and wind energy and biomass of various kinds.

It should be emphasized that each of these project elements was preliminary and partial. None represented an end in itself. The pilot household energy surveys, for example, were intended primarily to lay the methodological and institutional foundations for future, more complete survey activities. The technology assessments were also selective; a number of resources and technologies such as nuclear power and large scale hydropower were not addressed, in part because other studies had been completed or are under way on those subjects. As will be discussed later, the energy demand projections were also preliminary and require further elaboration. Since the emphasis in the project was on alternative energy sources, our consideration of future oil and gas development was drawn from existing studies.

As stated above an important objective of the project was to enhance the capability within the DJK (Directorate General of Power) to analyze

national energy issues and policies. Thus professional development and training was an important, integral component of the project. Counterparts were assigned by the DJK to each project subcomponent and to each visiting consultant and two DJK staff members participated in the portion of the demand analysis carried out in the U.S. Thus this report is only one product of this project, the other being an increased capability within the Ministry of Energy and Mines in both the details and the broader policy aspects of national energy planning. By means of the pilot survey of energy use in rural households that capability - at least in the important area of demand analysis - was extended to an important cross-section of the academic community.

The intent of the project was not to complete a process, but rather to begin one: to begin the process of national energy planning and policy analysis. In that sense the collaborations between the members of the U.S. project team and their counterparts within the DJK and other Indonesian institutions were a central element of the project.

C. THIS REPORT

The project documentation is presented in two sections. In this volume we present a concise synthesis and overview of the project with emphasis on its conclusions and recommendations. This is supported by a number of technical reports which are contained in the appendices.

In the next section of this volume we summarize the socio-economic assumptions we have used, particularly for the demand analyses. This is followed by a chapter which summarizes the results of the household energy survey. Chapter IV presents the results of the energy demand projections and Chapter V the results of the various technology assessments.

In order to demonstrate the use of demand and supply data for policy analysis we have performed a preliminary analysis of an energy diversification strategy. This is contained in Chapter VI.

We have emphasized the fact that this project represents some initial first steps in the process of developing a capability for energy policy analysis. In the final chapter of the report we recommend several "next steps" to be taken along those lines.

CHAPTER I

Notes and References

1. Supply and demand projections are discussed in Chapter IV, with detail on the demand analysis given in Appendix B.

2. World Bank. The subsidy as it appears in the national budget is considerably less (and thus understated) since it does not reflect world market prices. Nevertheless in the 1981/82 budget the budgetary subsidy is $3.4 billion, or 15% of the total budget.

3. By "biomass" we mean available photosynthetically produced material such as trees, bushes and agricultural waste, and animal and human wastes.

4. "Repelita III: The Third Five Year Development Plan" (1979-80 - 1984-85).

II ECONOMIC DEVELOPMENT CONTEXT

A. ECONOMIC TRENDS

The 1970's were a decade of considerable growth for Indonesia. The growth of gross domestic product (GDP) averaged 7.6 percent per year between 1970 and 1979, a significantly more rapid rate of growth than the 3.5 percent average of the 1960's[1]. The rate of growth in population, which had been estimated to be 2.0 percent per year for the period 1971 to 1980, has been recently revised upwards to 2.34 percent per year for that period on the basis of preliminary results of the 1980 census, thereby slightly lowering existing estimates of per capita GDP growth to 5.8 percent per year during the 1970's. Per capita GDP grew by only 2.3 percent per year in the 1960's[2].

Per capita GDP in 1980 reached Rp 208 thousand or US $350, based on a provisional estimate of GDP and a revised population figure of over 147 million persons, 4.5 percent higher in real terms than the previous year. Inflation in 1979 was 20 percent, double that of the two preceeding years, and similar to the rates prevalent in the early part of the 1970's.

Indonesia's economy has experienced significant structural change since 1960. The share of GDP accounted for by agriculture decreased from 54 percent in 1960 to 30 percent in 1979 while that of industry increased from 14 percent to 33 percent and that of services from 32 percent to 37 percent. Table II-1 shows the growth rates for these sectors for several periods. As indicated, industry

TABLE II - 1

AVERAGE ANNUAL GROWTH RATES (PERCENT)

	Agriculture	Industry	Services
1960-1970	2.5	5.0	8.0
1971-1973	5.4	19.7	10.3
1974-1979	2.7	8.4	8.7

Source: BPS [4]; industry includes mining, manufacturing, construction, electricity, gas and water.

experienced significantly higher growth rates in the 1970's, and certain segments have exhibited exceptional growth in the latter part of the 1970's. Cement, paper, fertilizer and the transportation and construction sectors have been especially dynamic, as indicated in Table II-2. Up to 1979 foreign investment in manufacturing has totalled US $2.4 billion dollars (since 1969), 34 percent of which is in textiles, followed by metal products (including vehicles) with 18 percent, and chemicals, fertilizer and rubber with 14 percent. Foreign investment in mining, most of which is for petroleum and natural gas, amounts to US $0.4 billion.

A significant contributing factor to the relatively high growth rates in the 1970's have been the exports of petroleum and natural gas. Indonesia's current account balance (before interest payment on external public debt) increased from a deficit of US $289 million

TABLE II -2

GROWTH RATES OF SELECTED SECTORS 1977-1979
(percent per year average)

		1977-1979
Cement (tons)		42.4
Paper (tons)		12.6
Fertilizers (tons)		30.0
Construction (value added)		11.5
Transportation (#vehicles registered)*		
	Autos	12.2
	Motorcycles	20.5
	Buses	17.0
	Trucks	19.4
	Aircraft	8.8

*(1974-1978 average)

Sources: BPS [3,4]

in 1970 to a surplus of US $2 billion in fiscal year 1979/80; in the interval, the share of exports represented by oil and natural gas products has increased from 40 percent to about 65 percent. Net balance of payments effect of oil and LNG exports is calculated by the World Bank to be US $7.0 billion in 1979/80, up from US $640 million in 1973/74. Table II-3 summarizes the balance of payments for the past seven years.

Non oil exports consist of traditional agricultural products such as coffee, palm oil, pepper, copra, tea and tobacco, and rubber. Traditionally, the most important of these has been rubber, with exports amounting to $ 1 billion in 1979, and although the value has grown by about 21 percent per year, volume output has not increased much during the last decade. The largest and fastest growing non oil export (both in terms of value and volume) is timber, which in 1979 amounted to nearly $2.0 billion.

Exports of minerals amounted to about $0.5 billion in 1979, most of which was tin. Other metals exported are copper and nickel. The volume of minerals exported has remained nearly constant during the last decade, but new facilities such as a nickel smelter has increased the value of the resources exported. Exports of industrial goods amounted to nearly $1.0 billion in 1979, made up of petrochemicals, cement and textiles. Large-scale investments are planned by the government in the industrial sector, with expansions in non-oil exports expected in petrochemicals (methanol) and an aluminum smelter that will process imported alumina until the time that an alumina plant is built that will process Indonesian bauxite.

TABLE II - 3

BALANCE OF PAYMENTS (US $ MILLIONS)

	Fiscal Years			
	1973	1975	1977	1979
1 Net Oil	641	3138	4352	6308
2 Net LNG	-		93	667
3 Non Oil (net)	-1397	-3972	-5135	-4985
(a) Exports f.o.b.	1905	1873	3507	6165
(b) Imports c.&.f	-2938	-5090	-7241	-9230
(c) Service (non freight)	-364	-755	-1401	-1920
4 Current Account (1+2+3)	-756	-854	-690	1990
5 Official Transfers, capital and SDR's	643	1995	2106	2560
6 Debt repayment	-81	-77	-761	-692
7 Miscellaneous capital	549	-1075	176	-1315
8 Total (4 through 7)	355	-11	831	2543
9 Errors and omissions	5	-353	-180	-853
10 Monetary movements	-360	364	-651	-1690

Source: Bank of Indonesia, in (7).

B. HISTORICAL TRENDS IN ENERGY CONSUMPTION

Consumption of primary energy resources has shown patterns of growth similar to those of GDP. The growth rate of primary energy consumption (excluding firewood and agricultural wastes) averaged 5.1 percent between 1963 and 1970, and it climbed to an average of 13.8 percent per year between 1970 and 1977[5]. As indicated in Table II-4 between 1977 and 1979 primary energy consumption grew by an average of 16 percent per year.

The breakdown of energy consumption among commercial energy resources shows fewer changes from the 1960's to the 1970's. Petroleum contributed nearly 90 percent of the total from 1965 through 1975 and has only decreased its share in the later years to about 82 percent at the expense of natural gas, which has nearly doubled its share to 15 percent of total fuel consumption (Table II-5). The increase in consumption of natural gas has ocurred both from a growth in natural gas production and a gas utilization infrastructure that has been put into place in recent years: fertilizer plants, LNG plants and LPG plants. These plants, whose output is exported, consume in their processing a large part of the natural gas accounted for here as part of domestic energy consumption.

Besides petroleum and natural gas, other resources have minor importance. Hydroelectricity is less than 2 percent of total energy and generation has grown more slowly than the utilization rates of oil and gas. Coal, which has experienced steady declines in production since its peaks over three decades ago, accounts for less than 1 percent of energy currently.

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TABLE II - 5

COMMERCIAL ENERGY CONSUMPTION BY SOURCE (PERCENT)

Source	1965	1970	1975	1978
1. Natural Gas	7.2	8.9	7.1	15.8
2. LPG	0.00	0.00	0.3	
3. Petroleum	87.2	87.9	90.2	82.2
4. Hydroelectric	1.4	1.6	1.4	1.3
5. Coal	4.2	1.7	1.1	0.7
Total	100	100	100	100

Source: PTE [5]

TABLE II - 6

DOMESTIC SALES OF PETROLEUM PRODUCTS
(in million barrels)

Type	1974	1975	1976	1977	1978	1979
Aviation Gas	.139	.139	.143	.128	.134	.126
Jet Fuel	2.150	2.579	2.758	2.913	3.494	3.665
Gasoline	.496	.661	.706	.710	.728	.618
Premium Gasoline	12.787	14.284	15.606	17.356	19.608	21.294
Kerosene	26.769	30.623	33.259	36.880	41.717	45.457
Light Diesel	14.524	18.023	22.749	27.041	31.709	34.542
Industrial Diesel	4.022	4.673	5.429	6.239	6.744	7.333
Fuel Oil	8.755	7.844	8.222	10.296	11.061	11.894
Total	69.642	78.826	88.872	101.563	115.195	124.929

Source: DJK [6]

Sales of petroleum products have grown by 12.4 percent between 1974 and 1979[6]. As indicated in Table II-6 the fastest growing product has been light diesel oil, used mostly by vehicles and in private electric generation, which grew at an average annual rate of 18.9 percent. Other fuels used in transportation grew more slowly, with gasoline at 10.7 percent per year and jet fuel at 11.3 percent. Kerosene, used mainly by households grew at 11.2 percent and industrial diesel and fuel oil at 12.9 percent and 6.3 percent respectively. Fuel oil consumption is currently growing faster as new steam-power plants are added to the utility's generation system.

A central issue in Indonesia's energy policy is the pricing of petroleum products. In order to alleviate poverty and control inflation subsidies have been instituted that have in effect decreased the price in real terms by an average of 25 percent between 1973 and 1979, with automotive diesel and kerosene decreasing by 32 and 29 percent respectively. A series of increases in 1980 have changed this situation somewhat. Current year prices are presented in Table II-7. The current subsidy amounts to Rp 1.5 billion ($2.4 billion), or 71 percent of total government subsidies to producers and consumers (food staples such as rice, corn and sugar, and fertilizer receive the remaining subsidies). The budgetary subsidy for oil however, is much smaller than the true economic cost of about $3 billion (3.5 percent of GDP), calculated as the difference between the international price of oil of $36 and the domestic price averaging $17[7].

Consumption of kerosene and diesel (automotive and industrial) amounted to 61 percent of total liquid fuels demand in 1978 and to 66 percent in 1979. Production of kerosene and diesel in domestic refineries and those in Singapore that process Indonesian crude for Indonesian consumption cannot keep up with domestic demand. While

TABLE II - 7

DOMESTIC PRICE OF PETROLEUM PRODUCTS
(Rp per liter)

	1972	1976	1980
Gasoline (premium)	40	90	280
Kerosene	10	18	37.5
Light diesel	14	25	52.5
Industrial diesel	8.5	22	45
Fuel oil	6.5	22	45

Exchange rate in 1980: approximately 625 Rp/US$

Source: World Bank[7]

the disproportionately high consumption of middle distillates has been a characteristic of Indonesian liquid fuels demand and its refineries are designed to maximize the output of those products, the shortfall amounted to 19 percent in 1978 and 16 percent in 1979. This shortfall has to be imported at world prices, which introduces an element of the true economic cost of the subsidy to the budgetary one. Imports of kerosene grew by 26 percent in 1979, to 5.5 million barrels, and those of automotive diesel decreased by 18 percent to 5.5 million barrels.

CHAPTER II

Notes and References

1. The World Bank: World Development Report, 1979 Washington, D.C. (1979) and updated World Bank statistics.

2. Revised population figures would yield an average 5.1 percent growth in GDP per Capita for 1971 to 1979. World Bank: World Tables (2nd ed.) 1980 and updated statistics.

3. Biro Pusat Statistik (BPS): Indikator Ekonomi (Jan 1981)

4. BPS: Statistik Indonesia 1978/79.

5. Panitia Teknik Sumberdaya Energi, unpublished tables.

6. Direktorat Jenderal Ketenagaan (DJK): unpublished tables (February 1981).

7. World Bank (1981).

III HOUSEHOLD ENERGY CONSUMPTION

A. INTRODUCTION

In this chapter we summarize the background, approach and results of the rural household energy survey. These points are covered in more detail and a copy of the survey questionnaire is included in Appendix D.

The subject of household energy consumption has taken on great significance in discussions of energy planning priorities in Indonesia. Two factors account for this trend. First the sector accounts for approximately 65 percent of total national energy consumption, and 25 percent if only commercial fuels are taken into account. Meeting the basic needs of Indonesia's 28 million households (81 percent of these being in the rural areas) is of fundamental national importance. The second factor is related to the need to design appropriate responses to the rapid increase in kerosene consumption in the past decade. Thus, the current interest in household energy consumption reflects a long-term concern with welfare and basic needs, and a short-term need to review national policies that have a bearing on commercial energy consumption in the sector. That interest has revealed very large uncertainties in knowledge of household energy use. Since the demographic composition of the country is primarily rural, the focus of effort under the Energy Planning for Development project has been placed on defining an appropriate survey methodology for information gathering in the rural areas and carrying out a pilot survey as first steps towards filling the large gaps in knowledge about the level and composition of fuel requirements in rural households.

A pilot survey of eight regions in Java, Sumatra and Sulawesi was conducted in the months of October and November of 1980 with several objectives in mind. First among these was the need to establish a minimal data base for policy analysis. With this end in mind, the survey aimed at collecting data to construct a profile of household energy use, for each of three broad income groups. It is intended that the primary data from the field survey will be combined with secondary data dealing with the energy content of fuelwood species, and about the relative efficiencies of energy conversion. This will allow an examination of alternative scenarios for the future in which the possible effects of income change, fuel substitutions or changes in technology can be explored by policy makers.

Given the demographic, economic and physical diversity of Indonesia, the scope of the overall project allowed only a pilot effort. With this limitation, the survey had the second important objective of making a practical contribution towards the development of a local capability to undertake the design and supervision of such a data collection and analysis exercise. The project was planned from the outset as a cooperative undertaking to include the active participation of several university teams, thereby to enlarge the range of experience and awareness about rural energy issues, and to draw upon the considerable range of expertise about such issues among institutions outside the Ministry of Mines and Energy. Any future effort to expand the scope of data collection to a national level will require the human resources and support of such institutions.

The pilot survey also provided an important opportunity to develop an appropriate survey instrument and methodology for future application to a representative national sample. While a number of small-scale regional surveys have been undertaken in the past ten years to examine patterns of

rural energy consumption, there have been no previous attempts at defining the appropriate design for a national rural energy data base. While the U.S. project staff developed the initial questionnaire based on previous surveys in other countries, the final design was the product of a collective effort on the part of the U.S. project team, an advisory team of Indonesian experts and staff of the DJK. In refining the questionnaire several pre-tests were carried out in various regions.

All phases of preparatory training and of the field work were carried out under the supervision of DJK's staff, in association with university team leaders. The data analysis (including tabulation) also was the result of a cooperative effort. In the first phase, data reduction (to reduce the costs of processing) and a preliminary analysis of local (i.e., university team) results were carried out by the university teams. During the second phase, after a discussion of these results and of the field experience in a special week-long workshop, a centralized data analysis effort was undertaken under DJK's supervision. A university team assisted in this final phase of data analysis.

In the remaining parts of this section on rural energy consumption, after a brief review of the existing information, we present an overview of the methodology followed by a discussion of the major findings. In conclusion, recommendations are made for appropriate follow-on steps.

B. EXISTING INFORMATION ON RURAL ENERGY CONSUMPTION

Since 1971, when the Forest Products Research Institute, Bogor (LPHH), carried out a survey of 1,250 households in East Java[1], there have been numerous studies of rural household energy consumption in Indonesia. From

a review of these studies, it is possible to place the current survey in perspective. Its purposes, while overlapping a number of previous surveys, are somewhat distinct from earlier efforts. The review of these studies suggests that existing information on rural household consumption is limited in regional scope, and contains very large uncertainties.

There is a very wide divergence of views on the level of aggregate, or per capita, energy consumption in rural households, especially with respect to the consumption of traditional biomass fuels (primarily wood, agricultural waste, and, to a smaller degree, charcoal). In the case of commercial fuels, primarily kerosene, per capita estimates from sales information are more reliable, but there is considerable variation in estimates developed on the basis of survey data. The great variation in results is shown in Table III-1, which shows per capita estimates of energy consumption of biomass fuels, from a number of the more important recent studies.

Estimates at the national level tend to converge towards a relatively narrow range of .7 - .9 cubic meters of wood equivalent. The precise methodologies employed to arrive at this level are unclear. Presumably, the results of various local small-scale studies, concentrating for the most part on the regions of Java, were combined through some weighting procedure to arrive at national estimates. But, as the table shows, there is no unanimity among these local studies. This is true even of those studies carried out within periods close to each other, and within the same geographic region. Examples are the 1975 and 1976 estimates for the Solo watershed region in Central Java, and for West Java in 1977 and 1978. In fact, the differences in the West Java case are extremely large, with

TABLE III-1

PER CAPITA BIOMASS ENERGY CONSUMPTION IN RURAL INDONESIA
(cubic meter of wood equivalent per capita per year)

Location	Year	Consumption (m^3/capita/year)	Source/Study by
All Indonesia	1956	0.5	Team Survey LPHH (1970)
	1970	0.7	FAO Estimate; T. Silitonga (1974)
	1975	0.9	Chandrasekharan (1977)
	1976	0.8	R. Atje (1979)
Java	1976	0.8	R. Atje (1979)
	1978	1.0	S. Hadi et al.(1979)
East Java	1971	0.5	Sumarna & Sudiono (1973)
	1978	1.3	S. Hadi et al.(1979)
Central Java			
Whole province	1978	0.6	S. Hadi et al. (1979)
Solo watershed	1969	0.7	LPHH (1969)
Solo watershed	1975	0.4	Wiersum (1976)
Solo watershed	1976	1.1	Wangsadidjaja et al. (1979)
Wonogiri area	1968	0.8-0.9	Directorate of land Use (1969)
Wonogiri area	1977	0.5	Yudodibroto (1978)
West Java			
Whole province	1977	2.1	H. Haeruman et al. (1977)
	1978	0.4	S. Hadi et al. (1979)
Citanduy watershed	1977	2.2	Nasendi (1978)
Cimanuk watershed	1978	0.5-1.2	Cited by H. Haeruman et al. (1979)
Citarum watershed (seguling)	1979	2.5	Rusydi et al. (1979)
Sukabumi area	1977	0.4	(Cited by Wiersum, 1979)
Bogor area (Babakan)	1977	0.4	Komarudin (1977)
Bandung area (Salamungakl)	1979	1.0	O.S. Abdoellah (1979)
Outside Java	1976	1.0	R. Atje (1979)
Bali	1978	1.1	S. Hadi et al. (1979)

Source: H. Soesastro, Reference (2).

Haeruman's figures showing a level of consumption five times the level estimated by Hadi (2.1 m^3 versus 0.4 m^3)[2]. Very little confidence can be attached, therefore, to the national estimates shown in the table.

The great variations probably arise as much from differences in methodology and definition as they do from inaccuracies embedded in the field measurement of fuel consumption in rural areas. There are differences among the studies with respect to what is included in the definition of fuelwood (some include agricultural wastes and charcoal, others do not), who is included in the 'household', and what constitutes 'household consumption' of fuel (for example, some include household industry, while others restrict themselves to cooking and lighting alone).

A second hallmark of the existing information on rural energy consumption is the absence of quantitative views of its trend over time. This is hardly surprising in view of the uncertainty of estimates for the country as a whole in any single time period. Indeed, most field surveys have not addressed themselves to the methodological survey design problems of capturing the main policy issues to be faced by decision makers over any given planning horizon. (In fairness, this is primarily a question of limited physical resources, and only secondarily one of perspective.) If the static estimates of energy consumption are clouded, therefore, the picture over time is more clouded still.

It is possible to find, for example, alternative views on the annual growth of aggregate fuel consumption in the scope of a single report[3]. In the period 1967 to 1976, the growth of wood consumption has been estimated by one government report at an annual compound growth rate of 2.35 percent[4]. For roughly the same period, a more recent government agency shows wood consumption growing at an annual rate of 11.3 percent, and more rapidly than

the recent growth in kerosene consumption[5]. Needless to say, such drastically differing views on changes in the relative importance of fuels in the country make the rational design of national policy an impossibility.

In general, estimates of kerosene consumption for household uses, and its trend over time are more reliably known because sales information at the national and regional levels is available. This information shows, for 1978, a level of 0.4 liters per household per day. Total sales between 1970 and 1979 grew at an annual rate of 10.4 percent, much faster than population growth in the same period, and almost twice as rapidly as the annual growth of GDP in the same period (approximately 5.6 percent).

Survey data show levels of household consumption in rural areas to be considerably higher than that shown by sales information. In one recent study based on surveys carried out in West Java by CSIS[6], average consumption per household, while varying within a wide range depending upon locality and household income, was noted at 1.7 liters per day. Another recently completed survey, carried out by Weatherly and Arnold, also showed kerosene consumption to be higher than the national average[7].

This points to the existence of large regional variations in the importance of kerosene as a domestic fuel. The last two mentioned estimates were based on careful measurement over several months. Even allowing for seasonal variations which might reduce the stated annual estimates of kerosene consumption, it is likely that the observed levels are indicative of much higher <u>regional</u> consumption than suggested by the national average consumption level.

The regional sales data allow a preliminary analysis of these variations. Java accounts for about 75 percent of all kerosene consumed

in rural areas of the country. But per capita variations among regions can be analyzed only in very broad terms. Since Java accounts for 75 percent of sales and 65 percent of the rural population, its per capita consumption is higher than in the outer islands. But the reasons for these regional variations, even on Java, are not clear.

The pattern of regional variations is likely to be much affected by income variations. Recent studies of national kerosene consumption, based on historical sales information between 1970 and 1979, show that well over half the growth of 10.4 percent per year can be accounted for by changes in per capita income. The balance of this very rapid growth is probably due to the relative change in kerosene prices in the period, which in real terms, declined at an annual rate of about 7 percent each year[8]. However, there is no confirmation of such behavior at the level of subregions to clarify the nature of the relationship between household income and kerosene consumption other than the information contained in SUSENAS' data from household budget surveys[9], which shows predictably that household income and expenditure on kerosene are positively related. Since kerosene consumption in Indonesia is primarily a rural phenomenon[10], it is likely that the pattern of regional variations is closely tied to the characteristics of local agronomic activity, to the availability of other fuels, and to the pattern of labor allocation within households.

While it is possible to arrive at an estimate of aggregate kerosene consumption and, to some extent, analyze its trend over time, there is much less evidence on how kerosene is used in the rural household, especially in relation to other traditional fuels. The available information allows

alternative judgments about the use of kerosene as a fuel for cooking and for lighting. From survey data, the fraction of total kerosene sales used for cooking and lighting has been estimated by Strout to be in the ratio 40:60, while S. Hadi's estimates for roughly the same period show a ratio of 80:20. Such inconsistent views make it very difficult, if not impossible to evaluate the impact of selected national policies.

For instance, there is much evidence to show that the very rapid growth of kerosene consumption is tied to a national policy of providing subsidies to consumers through controlled prices for petroleum products at great national economic cost (direct costs to the national treasury have been calculated to be about $630 million, with real costs to the economy much higher). One can claim that these subsidies benefit richer families more than they do the poorest sections of the population. Data from national budget surveys carried out by SUSENAS show that kerosene purchases account for only 6 percent of expenditures in the poorest households. These households, the lower 40 percent of the income ladder, apparently consume only 20 percent of all kerosene sold.

However, a consistent national picture of regional variations in this overall pattern is not available. If kerosene is more important as a cooking fuel than as a fuel for lighting as Hadi estimates, then the removal of kerosene subsidies will undoubtedly have a more serious impact than is commonly assumed. But, as in the case of biomass fuels, there is no basis for making a consistent regional comparison of kerosene consumption in relation to other domestic fuels.

C. SURVEY METHODOLOGY

Analytical Framework

The survey designed and carried out in this project shares a number of the same concerns with earlier studies. But there are differences in perspective. We have focussed on the consumption of fuels. Previous studies, by contrast, emphasized the supply-side effects of current consumption, especially with respect to fuelwood. The interrelationships between fuels have been largely neglected by previous studies, although the already mentioned efforts of CSIS and of Weatherly and Arnold are notable exceptions to this rule.

In defining an appropriate methodology the main considerations have been:

- to develop a simple, cost-effective questionnaire for application in a national sample, allowing consistent regional comparisons.
- to develop an analytic approach capable of highlighting the structural composition of current demand in relation to fuels used, end uses, and income variations among households, and allowing a simulation of the impact of income growth, technology changes and fuel substitutions in the future.
- to allow for uncertainty in the quality of data, and the use of existing information from secondary sources, and capable of absorbing new and improved data as these become available in the future.
- to adopt an information-systems approach in which data on the rural sector is seen as only one component of a larger body of energy demand data that will be collected and maintained over time.

The chosen analytical approach utilizes a modification of the Reference Energy System (RES) framework which has been widely used to analyze national energy options. The principal feature of the RES approach is the integration of a set of estimated energy demands, energy conversion technologies, fuel allocations and energy resources into an overall energy

suppy-demand balance at the sectoral, regional and national level. For a view of the energy system as a whole, the RES approach requires information about the details of demand by end use, and the efficiencies with which each demand is satisfied by each fuel.

The categories of data collected in the survey are shown in Table III-2. The questionnaire focused on three categories of information: (a) household characteristics and income-related information, (b) fuel consumption based on the recall of respondents and (c) information on energy using devices.

An important requirement of the field work involved the field measurement of daily fuel consumption for cooking and lighting. Measurement occurred on three consecutive days in each household to permit an estimate of consumption over a 48 hour period.

Field Measurement Procedure

During a pretest of the questionnaire it became apparent that as many as ten fuels may be stockpiled (in small amounts) in the homestead for use as cooking fuels. This fact influenced the field approach adopted in the actual survey. Given the limitations imposed by the pilot scale of the study and the time and manpower allotted to field work, a comprehensive measurement of all cooking fuels was ruled out. Instead, households were required to preselect a particular fuel for use during the measurement period, based on household preference and availability.

A stockpile of the selected fuel was measured by the interview team, sufficient to cover at least a full day's consumption for cooking. The daily rate of cooking fuel consumption was estimated at the end of each 24 hour period by noting changes in the stockpile. (Households were required to record changes in the stockpile through collection or purchases during the measurement period to allow accurate consumption estimates.)

TABLE III-2

PRINCIPAL DATA COLLECTED

I. HOUSEHOLD CHARACTISTICS Income-Related Information	II. FUEL DATA (from Recall)	III. FUEL MEASUREMENT OF COOKING AND LIGHTING FUELS
1. Family Size & Composition	1. No. of Fuels used & Type __collected fuels __purchased fuels	1. Cooking Fuels Solid Fuels - quantity used in weight, day 1, day 2. Liquid Fuels - quantity used in liters, day 1, day 2. Number of Persons fed - day 1, day 2.
2. No. of Persons Eating Meals at Home	2. Fuel Collection __sources __labor required per week (in time)	2. Lighting (Kerosene) - quantity used day 1, day 2.
3. Family Income from: __wages (cash) __wages in kind __other income(cash) __other income(in kind)	3. Fuel prices __by type	
4. Land Ownership, Area Farmed, Cattle Ownership.	4. Electricity Use __source __fuel used for local generation __no. of persons using shared generator.	
5. Transport Requirements by Principal Mode	5. Seasonal variations for each fuel used: __estimated use per month in: __months of some use __months of high use __number of months of use __high use __some use	

TABLE III-2
(continued)

IV. DEVICE DATA from direct observation & recall, by type of device (cooking, lighting & appliances)	V. LOCAL CHARACTERISTICS OF FUEL USE (Village level data from observation and interviews)	VI. SECONDARY DATA DATA FROM PUBLISHED SOURCES OR INTERVIEWS
_ Number owned	1. Fuel Prices	_ Fuel content of wood species & agricultural wastes by weight
_ Size characteristics if applicable	_ kerosene	_ device conversion efficiency
_ Full consumption rate if applicable or available	_ wood	_ agroeconomic characteristics (wages by occupations & agricultural characteristics of region, water requirements_
_ Weekly fuel consumption if applicable	_ charcoal	
	2. Main Energy Using Establishments	
	_ schools, churches etc.	
	_ commercial establishments	
	_ types of fuels used by end used	
	3. Fuel Supply Issues	
	_ sources of purchased fuel	
	_ export of fuels	
	_ uses of agricultural waste for purposes other than fuel	
	_ shortages, if any	
	_ deforestation	

Kerosene consumption was measured in an analogous way by measuring liquid stocks on hand, including the contents of stoves and lamps, at the start of each 24 hour period.

The Sample

The sample of households was randomly drawn from the list of rural census blocks in each of the kabupatans (districts) adjacent to the university locations. The lists were made available by BPS. The sample for the current study is a subsample of the SUSENAS national survey carried out in January 1980. This sampling procedure was guided by the need to limit field work to a one month period, within regions defined by considerations of accessibility. One hundred households were randomly selected within each of the eight regions contiguous to the university locations. The national samples, therefore, consisted of an initial selection of 800 households. As Table III-3 shows, a preliminary review of questionnaire responses reduced the number of households to 793 (a further discussion of the sample selection procedure is contained in Appendix D.). This procedure had the advantage of eliminating the expensive task of assembling a sample frame. In addition it makes possible a future comparison and cross check of data collected in the BPS survey. This will be particularly important in revising estimates of household income, which in the present survey design were based on a very simple approach using respondent recall and reported occupational structure.

Each category of data collected served a particular purpose in the analysis:

(a) Data on Household Characteristics: The primary purpose of the information on households and income-related characteristics of the household was to allow a comparison of energy consumption patterns among households at different levels of economic well-being and to examine

TABLE III-3

REGIONAL DISTRIBUTION OF SAMPLED HOUSEHOLDS BY LOCATION

UNIVERSITY	PROVINCE	KABUPATAN (DISTRICT)	NUMBER OF HOUSEHOLDS SURVEYED
Universitas Sumatera Utara, Medan (USU)	North Sumatra	DELI SERDANG	106
Lembaga Penelitian Hasil Hutan (LPHH), Bogor	West Java	BOGOR	99
Institut Pertanian Bogor (IPB) Bogor	West Java	BOGOR	97
Institut Teknologi Bandung (ITB) Bandung	West Java	BANDUNG	108
Universitas Diponegoro (UNDIP) Samayang	Central Java	SEMARANG DEMAK KENDAL	91
Universitas Gajha Mada (GAMA) Jogjakarta	Central Java	JOGJAKARTA SLEMAN BANTUL KULONPROGO GUNUNG KIDUL	99
Institut Teknologi Surabaya (ITS) Surabaya	East Java	SURABAYA LAMONGAN SIDOARJO	90
Universitas Hasanuddin (UNHAS) Ujungpandang	South Sulawesi	GOWA MAROS	96
	Total Number of Households:		783

these differences according to the major uses of fuels.

(b) Fuel Consumption Data: Based on the recall of respondents, the questionnaire sought information on the types and quantities of various fuels used. Of particular importance was the information on how traditional fuels are collected, and their sources. This information was used as a cross check on field measurements, and used to relate the observed level of fuel consumption to the particular characteristics of local fuel supplies. The information on seasonal variations was necessary for purposes of computing an annual level of fuel consumption from the observations during field measurement.

(c) Data on Energy Using Devices: This information was required primarily to determine the level of electricity consumption, based on the numbers and capabilities of devices present in the household. In the case of other fuels, estimates provided by the respondents on weekly use allowed a further cross check of field measurements. Lastly, the information collected on devices is important in projecting possible effects of changes in technology or utilization practices.

(d) Local Characteristics of Fuel Use and Secondary Data for Analysis: Each university team was called upon to gather background on economic activity and energy utilization at the community level. Also included were data on local species of wood, and about supply conditions. This information was combined with other data from published sources to convert physical quantities of fuel to energy units.

D. RESULTS

Fuel Demand: The pattern of fuel consumption for domestic uses in the average sampled household is shown in Table III-4 according to fuels and end uses. On average, among all regions studied the annual consumption of all fuels for cooking and lighting amounted to 6.99 boe per household. This is equivalent to a per capita consumption of 1.33 boe per year.

Wood for cooking is the primary component of domestic energy consumption accounting for about 70 percent of the total. The annual per capita consumption level of 0.93 boe is equivalent to a level of approximately 0.88 kg per day per capita.

Per capita kerosene consumption of 0.40 boe annually is equivalent to approximately 0.2 liters per capita per day. Kerosene is primarily a lighting fuel, accounting for 16.3 per cent of total energy demand. Kerosene use for cooking accounts for the remaining 14 percent of annual consumption.

Basic Energy Demand: Differences exist in the relative efficiency with which fuels are converted to light or to the effective heat delivered to the cooking pot. These differences are reflected in the calculation of basic energy demand shown in Table III-5. On a per capita basis the useful energy consumed amounted to 0.17 boe annually. We have assumed the following relative efficiencies in the use of fuels:

Lighting kerosene:	0.18
Cooking	
Wood and agricultural waste:	0.06
Kerosene:	0.40

TABLE III-4

ANNUAL FUEL DEMAND
(Barrels of Oil Equivalent)
(Average for all regions - 783 households)

Fuel/End-Use	Per Household	Per Capita
Wood and Agricultural Waste for Cooking	4.92	.93
Kerosene		
Cooking	.93	.18
Lighting	1.14	.22
Total Kerosene	2.07	.40
Annual Fuel Demand	6.99	1.33

TABLE III-5

ANNUAL BASIC ENERGY DEMAND PER CAPITA
(Barrels of Oil Equivalent and Shares)

Fuel/End-Use	Basic Energy Demand	Shares (%)
Wood and Agricultural Waste for Cooking	0.06	35.3
Kerosene		
Cooking	0.07	41.2
Lighting	0.04	23.5
Total Kerosene	0.11	64.7
Total Annual Basic Energy Demand	0.17	100.0

Viewed from the perspective of its share in total basic energy demand, kerosene, as shown in Table III-5, emerges as the primary fuel, its share of 65.0 per cent being more than one and a half times the share of wood (35 percent) The reason, clearly, is the higher efficiency with which kerosene is used as a lighting or cooking fuel.

Resource Requirements: There are efficiency losses in the processes of refining, conversion and delivery by which fuels are supplied to consumers. Assuming an overall efficiency of petroleum refining and delivery of 0.88 in the production of kerosene, the total resource requirement is 1.39 boe per capita. This is shown in Table III-6. (It is assumed that there are no conversion losses in the supply of wood and agricultural waste.)

Income Variations in Fuel Demand: To explore variations in energy consumption among different income groups, the sample of 783 households was partitioned into three broad income groups. As shown in Table III-7, high income households tend to consume only slightly more fuel than middle and low income households (8.4 boe compared with 7.8 and 7.4 boe for middle and low income households). A comparison of per capita consumption levels among income groups show lower consumption at high levels of income than at low levels of income. This apparent contradiction is explained in part by the larger size of high income households, and in part by a marked tendency towards the substitution of kerosene for wood to satisfy cooking needs as income rises.

This is reflected in the sharp increase in kerosene consumption as income rises. The average high income household tends to consume five times as much kerosene as the average low income household. There is a corresponding decline in wood consumption.

TABLE III-6

ANNUAL PER CAPITA RESOURCE REQUIREMENTS (BOE)

Fuel/End-Use	Resource Requirement	Assumed Efficiency of Resource Conversion and Distribution
Wood and Waste for Cooking	0.93	1.00
Kerosene		
Cooking	0.21	0.88
Lighting	0.25	0.88
Total Kerosene	0.46	0.88
Annual Resource Requirement	1.39	

TABLE III-7

ANNUAL FUEL DEMAND (BOE) BY INCOME GROUP

Fuel/End-Use	Low Income		Middle Income (Rp 228,000-480,000)		High Income (Rp 480,000+)	
	Per House	Per Capita	Per House	Per Capita	Per House	Per Capita
Wood for Cooking	6.12	1.43	5.69	1.12	5.41	0.92
Kerosene						
Cooking	0.28	0.07	0.93	0.18	1.41	0.24
Lighting	0.91	0.21	1.21	0.24	1.54	0.26
Total Kerosene	1.19	0.28	2.14	.042	2.95	0.50
Total Annual Fuel Demand	7.37	1.71	7.83	1.54	8.36	1.42

A clearer comparison of how households differ with respect to the consumption of particular fuels appears in the information contained in Table III-8. Here the relative importance of fuels according to their uses is shown for each income group. While cooking remains the dominant fuel-using activity among all income groups, the importance of wood in the total declines from 83 percent for low income groups to approximately 65 percent for high income groups. There is a corresponding four-fold increase in the importance of kerosene as a cooking fuel. Kerosene as a lighting fuel also increases in importance with rising income, but its growth is less sharp (its share in the total rising from 12 percent to 18 percent).

Income Variations in Basic Energy Demand: Differences in amounts of useful energy consumed among income groups have important policy implications. These differences emerge in Table III-9 which shows a trend in basic energy demand quite different from that of fuel consumption (seen in Table III-8). Though per capita fuel consumption declines with rising income, the consumption of useful energy increases. This not unexpected result is accounted for by the relatively higher efficiency of kerosene use, which, as we have seen, plays a more important part in the consumption pattern of higher income households.

For projection purposes, these differences in energy consumption imply that a 10 percent increase in basic energy demand among high income households requires almost twice as much oil as would be required by a similar increase in consumption levels among poor income households (a 10 percent increase in basic energy requirements generates approximately .03 boe per capita additional oil resource demand for low income households compared with .06 boe for high income households.

Electricity Use: The consumption of electricity in the areas covered

TABLE III-8

THE STRUCTURE OF ANNUAL FUEL DEMAND BY INCOME GROUPS (%)

Fuel/End-Use	Low Income	Middle Income	High Income
Wood for Cooking	83	72.7	64.4
Kerosene			
Cooking	3.8	11.9	16.9
Lighting	12.3	15.4	18.4
(Total Kerosene)	(16.1)	(27.3)	(35.3)
	100	100	100

TABLE III-9

ANNUAL BASIC ENERGY DEMAND PER CAPITA BY INCOME GROUPS (BOE)

Fuel/End-Use	Low Income	Middle Income	High Income
Wood for Cooking	0.09	0.07	0.06
Kerosene			
Cooking	0.03	0.07	0.10
Lighting	0.04	0.04	0.05
Total Kerosene	0.07	0.11	0.15
Total Annual Basic Energy Demand	0.16	0.18	0.21

by the survey is limited by the low proportion of electrified villages. With the exception of South Sulawesi, and Bandung, under 30 percent of the villages in each region are served by electricity. The proportion of households reporting the use of electricity in any form was consequently a very small 8 percent, with most of these in the high income group. A preliminary estimate of electricity consumption in each income group shows annual levels of per capita consumption well below the 1 kilowatt-hour level. Average electricity use amoung households in each income group is illustrated in Table III-10. We have excluded electricity use in the earlier estimates of fuel consumption for the reason that a full analysis of the collected data on electricity sources has yet to be completed. It is safe to assume, however, that the inclusion of centralized electricity use in the present sample will not significantly alter the relative composition of fuel demand among income groups, because of its infrequency of use.

Prices: The purchase of wood and other biomass fuels was reported in only a very small proportion of all the households surveyed. There is little evidence of large-scale commercialization of these fuels, although some households reported the availability of wood in local markets. By and large, wood remains a non-commercial fuel collected by family members who spend, on average, less than four hours each week gathering wood from gardens, fields and nearby forested areas. Prices, as reported by households (and confirmed by informal interviews conducted in each location by the survey teams), show considerable variation between regions and even within a given region, as shown in Table III-11.

While commercial sales of firewood for domestic use are not widely reported, the use of wood in rural industries was reported in such industries as tile and brickmaking, food processing (such as the manufacture of cassava

TABLE III-10

ELECTRICITY USE - PRELIMINARY ESTIMATES

Income Group	No. of Electrified Households Villages	% of All Households	Annual Per Capita Consumption	
			KWH	BOE
Low	6	2%	.18	.11
Middle	12	4%	.21	.13
High	47		.82	.50
All Households	65	8%	.42	.26

chips) and eating establishments. Prices reported in these instances were in a narrower range of Rps. 6 to 12 per kilogram.

Kerosene prices as shown in Table III-11 also showed variation among the regions surveyed. The highest prices reported were in South Sulawesi and Central Java (Rp 76 per liter). To examine the relative importance of income and price in explaining observed variations in kerosene consumption a preliminary econometric estimation of income and price elasticities was attempted using observed levels of kerosene consumption, household income and prices paid as reported by each household. The estimated income elasticity of 0.40 and price elasticity of 0.45 did not appear to be statistically reliable. This suggests that there is considerable room for improvement in the reliability of the collected information on both income and prices.

A Comparison of Results: The annual levels of fuel consumption we have estimated from the survey data have been based on an approximate adjustment procedure to account for seasonal variations during the year. The effects of seasonal variations are to raise slightly the levels of both daily kerosene and wood consumption.

The estimated level of kerosene consumption (on average, for all households after adjustment for seasonal variations) is 0.9 liters per household per day. This is considerably lower than the recent survey of rural households in West Java, carried out by C.S.I.S., where average consumption was estimated at 1.7 liters per household[6]. However, it is considerably closer to levels of kerosene consumption indicated by national sales data which puts average rural household consumption at a level of 0.6-0.7 liters per household each day. They are also close to the estimates of Weatherly and Arnold. Aggregating their results for Central Java, South Sulawesi and East Lombok, and adjusting them for purposes of comparison, kerosene consumption (in all 164

TABLE III-11

AVERAGE FUEL PRICES (Rp. per Kg)

Region	Wood	Kerosene
N. Sumatra	13.6	57.8
W. Java	6.1	56.9
	15.7	62.3
	16.3	48.2
C. Java	18.0	57.2
	-	76.1
	15.2	59.4
C. Java	11.7	56.8
	10.7	59.7
	10.0	69.9
	9.5	53.5
E. Java	13.1	64.3
	-	53.3
S. Sulawesi	32.3	69.2
	16.0	75.9

households studied by them) averaged .81 liters per household each day.

There is a noticeable tendency for most survey results to suggest levels of rural kerosene consumption considerabley higher than those that can be derived from the data on kerosene sales. The present results share this feature with other recent studies, though the difference is narrower. However, for purposes of national energy planning, it is advisable to examine this difference more closely. Survey results are often biased by their regional composition. The present study is no exception. Even among the regions covered by the present study we have made note of significant regional variations in both the composition of fuel demand and the absolute levels of consumption recorded for each fuel. In the case of kerosene, for example, the range was from a low of 0.51 (Central Java) to a high of 1.1 liters per household (West Java - Bogor). There were significant intraregional differences in consumption levels as well. (In contiguous subregions of West Java the difference in kerosene consumption was 60 percent.) Only larger and more regionally representative samples can clarify these regional variations to arrive at more reliable national estimates of fuel demand.

The recent surveys by C.S.I.S. and by Weatherly and Arnold show the presence of wide variation in wood consumption levels as well. This is confirmed also by the results of the present survey. The range of average household wood consumption in the present study was from a low of approximately 4 kilograms (East Java) to a high of 8.5 kilograms (Central Java) per day. The C.S.I.S study in West Java found a range of 0.1 to 41.1 kilograms per day. Weatherly and Arnold reported for the regions of Central Java, South Sulawesi and Eas Lombok a range of approximately 6.3 to 8.2 kilograms per day. The average level of wood consumption in the present study (for all households in all regions), 4.6 kilograms per day, is lower than these previous surveys

(8.1 and 7 kilograms per day respectively, for the C.S.I.S and Weatherly/Arnold studies). The meaning of these different estimates, as with the estimates of kerosene consumption, can be clarified only through more regionally comprehensive surveys. Variations in the level of wood consumption depend upon the penetration of kerosene as a cooking fuel, on income differences, and the availability of wood and biomass fuels, all of which vary widely from region to region.

Policy Issues: We have referred to the variability and uncertainties attached to the results of these surveys. On the other hand, the EPfD survey employed the broadest national sample to date and highlighted several key policy issues.

- Kerosene Consumption: The importance of kerosene consumption in total energy for domestic uses is represented by its dominance in per capita basic energy demand. The significance of kerosene is confirmed not only by its importance in basic energy demand, but also by the very high proportion of households who use the fuel for some portion of their energy needs: 99 percent of all households in the present sample. In fact, a substantial 22 percent of all sampled households used kerosene as the exclusive domestic fuel.

Policy alternatives to reduce the rapid growth of kerosene demand must be formulated in the face of such concrete evidence of its widespread use. Since it is apparent that in the regions covered by the present survey kerosene is important to both lighting and cooking requirements, attempts to reduce the growth rate of its use require consideration of specific technological options. There are few alternatives to its use as a lighting fuel, in the absence of centralized or decentralized rural electrification strategies. As a cooking fuel, its displacement implies a substantial increase in the demand for biomass

fuels. While the survey did not indicate the presence of severe shortages of biomass fuels (primarily wood), the scattered evidence from other studies suggests that there is the the potential for severe degradation in the biomass resource base of many rural areas of the country. For policy design, the implication is that any efforts to limit the use of kerosene in rural areas should be accompanied by a substantial effort to examine ways of guaranteeing the efficient use of biomass resources.

- The Relative Importance of Income and Price on Fuel Consumption: The preliminary statistical analysis of survey data does not provide a firm quantitative basis for estimating the relative importance of income and price influences on the consumption patterns observed in the studied regions. There is evidence enough, however, to conclude that the composition of fuel demand changes with rising income in favor of kerosene, and that kerosene demand is responsive to price changes. In addition, the information collected provides an adequate view of the degree of reliance on kerosene among low, middle and high income families. From this information it is possible to conclude that kerosene is clearly of much more significance in high income than in low income households. (See Table III-8 & III-9). On the other hand, almost all (99 percent) low income households reported the use of kerosene for some part of total needs. In the case of the average low-income household, almost half of its useful energy requirements are provided by kerosene. It is quite likely that changes in its availability, either as a result of concerted policy efforts, or of temporary disruptions in supply will have a very broad impact on all segments of the rural population in the regions covered by the current survey.

E. CONCLUSIONS AND RECOMMENDATIONS

The present pilot survey was successful in establishing a workable methodology for expanded effort in the future. The survey instrument and field procedures, with some refinement, can provide the basis for a more regionally comprehensive survey. Most important of all, all those who participated in the pilot study gained valuable experience in all the phases of carrying out energy surveys in rural Indonesia--from preparation and training, to pre-testing, implementation and analysis. For future efforts, some recommendations in the form of guidelines based on the present experience are relevant:

Design of a National Survey:

The sample for a national survey must, quite obviously, be considerably enlarged if estimates of national rural energy consumption are to be made. The most cost-effective approach to sampling will be to use an existing sample frame such as exists for the SUSENAS survey, carried out by BPS. For an expanded survey, adequate time must be devoted to sample design so that the sample can be truly representative of regional and income related variations in energy consumption. The sample should be determined on the basis of the accuracy required of the results. The SUSENAS sample frame for 1980, which was utilized as a basis for the sample in the present survey, contains approximately 35,000 rural households. A ten percent sample of these households should be a minimum sample size.

While the pilot study contributed to the design of a working methodology and survey instrument, extension of the survey to the national level will require more adequate pre-testing than was possible within the scope of the present survey. Given the large scope for regional variations, the questionnaire design of the present survey should be pre-tested in locations other than those chosen for the pilot study. This effort will require a minimum effort of six months. The pre-test should focus on the areas which were not well represented in the pilot study.

An additional component of any national survey should involve a more extended time period for field work. Rural energy consumption is innately seasonal when traditional fuels are a large fraction of total fuel consumption. Patterns of fuel consumption tend to vary with the seasonal availability of fuels and with the allocation of labor within the households to seasonal tasks. It is advisable to extend the period of data collection to a full year covering all seasons. An extended survey should therefore include several visits per household, depending upon climatic and agricultural seasons in each region.

To improve the reliability of the results from the present sample, an intermediate step, prior to a full-scale national survey, might involve a resurvey of a sub-set of households drawn from the present sample to be visited in the immediate year ahead. If properly timed, these visits might result in an improved evaluation of the importance of seasonal variations, and to reduce the uncertainty of the present estimates of annual consumption levels. Such a step is highly recommended because it will require minimal financial support. It is a practical step, as well, from the standpoint of implementation. There is clear interest among the university teams for follow-up activities, and there is now the necessary experience accumulated during the 1980 survey effort to allow adequate supervision and management by DJK.

Training

The week-long training workshop held in Jakarta in August 1980 was an important contributing factor to the success of the pilot study. It is advisable in the future, however, to seperate the training of supervisory staff from the training of interviewers. In general, a distinction is required during training for a field survey between transferring an understanding of the methodology and purposes of a survey, and an understanding of field procedures and techniques. A two-phase training in which supervisors are first thoroughly grounded in the purposes of the survey and then are required to participate in the training of interview and measurement teams is essential. For an expanded national survey, the time allotted to the training tasks will require considerably more than one week. As far as possible, the survey should utilize the services of professional interviewers rather than student help.

Supervision

The present survey was successful in part due to the enthusiasm of all participants, including the supervisory staff. An expanded national effort will require, however, a greater attention to the details of day-to-day management. For this purpose, it is recommended that the DJK undertake a review of the management experience gained during the pilot study. In particular, it will be important during a national survey to establish lines of communication between those in the field and all supervisory levels. This allows for a valuable exchange of field experience during implementation, and for corrective action when unanticipated difficulties arise during the course of field work, as is inevitably the case.

Data Analysis

The pilot study attempted to decentralize the tasks of analysis with a view to reducing data processing costs. Given the difficulties experienced in this effort, it is recommended that in the future, regardless of the scale of the survey, all data analysis tasks from questionaire screening, data reduction, keypunching and analysis be a centralized responsibility.

Chapter III

Notes and References

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IV ENERGY DEMAND PROJECTIONS

A. INTRODUCTION

A fundamental requirement for the formulation of national energy policy is a clear view of the future evolutions of energy demand under alternative circumstances. This project has shown that there is both opportunity and choice in the Indonesian energy future. The opportunities derive from the range of energy resources available to the country and the increasing diversity of industrialization opportunities.

In this context, the choice of the optimal energy development path is complex and must be founded upon a clear and flexible view of the future.

To be most useful for energy policy analysis and for making energy decisions projections of energy demand must have the following characteristics:

1. The assumptions and all steps in the calculation should be clear. In this case detailed assumptions are included in Appendix A.

2. The projections should reflect future uncertainties. For this reason a number of alternative cases have been defined. Indications are also given of areas of largest uncertainties in the projections.

3. Sufficient detail should be included in the projections to allow analysis of fuel and technology substitution for specific uses of energy. An example of such detail is included in Chapter III on the household sector.

4. The relationship between energy demand and economic activity should be explicit so that interrelationships can be examined.

The projections briefly summarized in this chapter and described more fully in Appendix A.

B. CURRENT ENERGY USE PATTERNS

Consumption of fossil fuels and hydro has grown at an average rate of about 12 percent per year in the last decade. The latter part of the decade starting in 1977 has experienced extraordinary high rates of increase surpassing 20 percent yearly. Growth rates of this magnitude would be expected to be continued in the near future as the country experiences development of an infrastructure in electric generation, cement and fertilizer production, and an urban population with access to motorized public transport and private vehicle ownership.

Accounting for energy consumption in Indonesia presents various problems because of its large energy production sector (crude oil and natural gas) which utilizes significant amounts of fuels in processing, refining, liquefying and transporting. A large fraction of this energy produced is exported as a commodity. In the accounting selected in this study, all fuels utilized in this large conversion sector, plus fuels destined to international bunker are omitted from what is labelled Domestic Energy Demand. Table IV-1 summarizes this information for 1978 by sector of energy consumption. Total energy demand amounted to 385.2 million barrels of oil equivalent (Mboe), of which 68 percent or 262.6 Mboe is accounted for by the estimated energy content of firewood and agricultural wastes used in households and small-scale industrial and commercial establishments. The remaining 32 percent is predominantely based on petroleum, at 107.5 Mboe or 88 percent of commercial energy consumed. Natural gas comprises 9 percent of commercial energy and

TABLE IV - 1

DOMESTIC ENERGY DEMAND BY SECTOR - 1978
(Thousand Barrels Oil Equivalent - Kboe)

	Petroleum Products	Coal	Natural Gas	LPG	Hydro*	Total Com'l.	Firewood & Agric. Wastes	Total Energy
Agriculture	3,413					3,413	716	4,129
Mining	1,464	61				1,525	1,158	2,683
Manufacturing	18,930	238	10,665			29,833	742	30,575
Construction	1,080					1,080		1,080
Services	8,920					8,920		8,920
Transportation	33,242	155				33,397		33,397
Households	32,015		262	348		32,625	260,000	292,625
Electric Generation	8,432				3,900	12,332		12,332
	107,496	454	10,927	348	3,900	123,125**	262,612	385,260

* Expressed as fossil fuel equivalent

** Excludes energy used in the refining, production and distribution of petroleum, and in production of natural gas and coal; also excluded are natural gas used in production of LNG and LPG for exports and international bunkers.

Source: Appendix B

hydropower 3 percent; small amounts of coal are also utilized.

Excluded from the tabulation are about 10-11 Mboe of petroleum products used in the exploration, refining and transportation of petroleum, and 68-69 Mboe of natural gas utilized in the production of LNG and LPG (and which is exported), and utilized as fuel in gas fields and separation plants. These utilization rates correspond to 1978 and will change significantly from year to year as new liquefaction and separation plants are built, and as new refining and hydrocracking capacities are brought on-stream. Details on the petroleum and natural gas supply and transformation section can be found in Appendix B, Section I.

Households are the largest energy consuming sector, using 76 percent of total commercial and non-commercial energy. The use of firewood and agricultural wastes for cooking in rural areas is widespread in Indonesia, as detailed in Chapter III; the relative inefficiency of the hearths in which the biomass resource is burned is partially the reason that the energy content of the biomass is twice that of all fossil resources utilized in one year. Kerosene use in households accounts for one tenth of total energy estimated to be used in households, and for wholly 30 percent of total petroleum products. The growth in kerosene sales has averaged 11.6 percent per year as a process of substitution between it and fuelwood for cooking and vegetable oil for lighting, plus increased urbanization has taken place. This process of substitution is far from saturation levels, although the price of kerosene (versus "free" home garden wastes and in some cases "free" firewood) and the preference of biomass fuels for certain types of food preparation will have a significant impact in the future growth rate of kerosene sales.

Natural gas and coal are used principally in the industrial sector,

as fuel for cement kilns and metals smelters, and as feedstock for fertilizer. A small fraction of natural gas is distributed by the town gas company to households and commercial users, and coal is used in railroads in the coal mining region. The limited role of these fuels in Indonesia's current domestic use patterns contrasts with the ample reserves of these resources. This may well change in the future as coal is increasingly used in electric generation and in industry subject to overcoming barriers in transportation between the coal producing regions in Sumatra and centers of demand in Java. Growth in internal utilization of natural gas is hampered by the distance between production areas and centers of consumption. Expansion of liquefaction capability in the country, however is expected to lead to further exports of LNG.

Petroleum products account for 87 percent of commercial energy use, and about 30 percent of them are used in each of the major consuming sectors: industry, households and transportation (Table IV-2). About 8 percent is used by the public utility sector. This fraction of petroleum used for public utility electric generation is low by international comparisons (considering that except for small amounts of hydro, petroleum is the only source for generation) and is an indication of the relatively low level of development of this sector. No more than 10 percent of the population has access to electricity from the public utility; more importantly, the private generation sector (mostly captive generation in mines and industry) is nearly as large as that of the public utility and is consuming nearly one half of the petroleum used by the industrial sector.

TABLE IV - 2

PETROLEUM PRODUCT DEMAND BY SECTOR - 1978
(Thousand Barrels Oil Equivalent)

	Diesel & Fuel Oil	Kerosene Jet Fuel	Gasoline	Total Petroleum	
Agriculture	3,413	—	—	3,413	3%
Mining	1,464	—	—	1,464	1%
Manufacture	18,930	—	—	18,930	18%
Construction	1,080	—	—	1,080	1%
Services	916	8,004		8,920	8%
Transportation	12,112	2,558	18,913	32,242	30%
Households	—	32,015	—	32,015	30%
Electric Generation	8,432	—	—	8,432	8%
	46,347	43,529	18,913	107,496	

Source: Appendix B

Manufacturing

Energy purchased by the manufacturing sector in 1978 amounted to 30.5 Mboe, of which 27 percent was light diesel oil, 16 percent was industrial diesel, 20 percent fuel oil, 35 percent natural gas and 1.3 percent electricity purchased from the utility. Purchased electricity amounts to no more than 14 percent of total electricity use in manufacturing, which for the most part is generated internally. The energy used in generating this captive electricity accounts for nearly one half of the petroleum products purchased by the sector. Table IV-3 presents the consumption in 1978 for the following sectors: food and beverages, textiles, pulp and paper, cement, other non-metallic minerals, iron and steel, fertilizer, other chemicals, rubber and other. Largest consumption is in fertilizer, in which natural gas is utilized as a feedstock for production of nitrogenous fertilizer. Cement is the largest consumer of petroleum products, followed by textiles and food and beverages. Energy is used in these sectors in widely varying applications: besides electric generation discussed above, cement requires high temperature direct heating in kilns, textiles utilizes fuels in generating steam and hot water for operating machinery and washing and finishing of materials, and the food industry uses fuels to raise steam for washing containers and heating water to low temperatures for cooking. In most cases, the energy requirements in these industries can be met by fuels other than petroleum. At present, the cement industry is the most diversified, using principally coal as fuel in one plant, and, starting in 1979, natural gas in another. Consumption of fuels by the manufacturing sector grew by 29.5 percent from 1978 to 1979. Use of petroleum products, grew by 17.9 percent, natural gas use by 58.9 percent and purchased electricity by 30.9 percent.

TABLE IV - 3

ENERGY CONSUMPTION IN MANUFACTURING, 1978 (kboe)

Energy Uses	Light Diesel Oil	Industrial Diesel Oil	Fuel Oil	Natural Gas	Coal	Purchased Electricity	Total
Food and Beverages	1800	722	1230	--	--	36	3788
Textiles	2687	1303	358	--	--	129	4477
Pulp and Paper	343	202	286	--	--	28	859
Cement	266	1107	1952	--	238	117	3680
Other Non Met. Miner.	693	851	695	--	NA		2239
Iron and Steel	516	353	506	25		13	1493
Fertilizer	54	--	872	6575			7501
Other Chemicals	693	110	41			49	895
Rubber	755	165	64				984
Other Manufacturing	424	89	91			38	642
Subtotal	8,233	4,902	6,095	6,600	238	411	26,478
Feedstock Uses							
Fertilizer	--	--	--	4044	--	--	4,044
Iron and Steel	--	--	--	21	--	--	21
Total	8,233	4,902	6,095	10,665	238	411	30,543

Source: See Appendix B

Transportation

Petroleum used in the transportation sector amounted to 33.2 Mboe in 1978 and 36.3 Mboe in 1979, for a growth of 9.1 percent. In addition, small amounts of coal and firewood are used by railroads. In 1978, road transport comprised 82 percent of the total petroleum products used in the sector; the remainder is used by ships (7.8 percent), air (7.8 percent) and railraods (2.1 percent). These amounts exclude air and ship international bunkers, and fuel use in shipping of crude oil by Pertamina.

Estimates based on vehicle registration statistics, assumptions on vehicle miles travelled and fuel efficiencies indicate that trucks consume 42 percent of fuels used in road transport, automobiles consume 22 percent, buses 24 percent and motorcycles 12 percent (Table IV-4). Gasoline comprises 68 percent of this usage, and diesel 32 percent. These figures are very uncertain and warrent better definition. It is clearly of importance to estimate this breakdown more accurately (for which the Ministry of Transport and Communications publishes different figures) as a first step in establishing a fuel conservation policy for the transport sector. The nature of fuel consumption in this sector is such that besides conservation oriented regulations no near term alternatives exist to reduce growth in petroleum based fuels.

Households

The household sector, as mentioned above, consumes 76 percent of all commercial and non-commercial energy used in the country. An estimated 260 million boe (112.7 million m^3) of firewood and agricultural wastes were used in 1978; kerosene use amounted to 32 million boe and LPG 339 kboe. Household uses are principally cooking (for which firewood is largely used as discussed in Chapter II) and lighting.

TABLE IV-4

FUEL CONSUMPTION IN ROAD TRANSPORT
BY MODE, 1978

	Registration, (Vehicles)	Inventory Factor	Utilization km/vehicle per year	Fuel Efficiency (km/liter)	Fuel Consumption Gasoline (kboe)	Fuel Consumption Diesel (kboe)	Total (kboe)
Trucks	331,658	0.75	30,000	3.8	7565	4097	11662
Automobiles	532,299	1.00	15,000	7.6	6037	—	6037
Buses	58,365	0.75					
Intercity	50% (est.)		100,000	2.9	—	4773	4773
Urban	50% (est.)		45,000	3.2	1771	—	1771
Motorcycles	1,960,237	0.70					
3 wheel	20% (est.)		24,000	21.0	1805	—	1805
2 wheel	80% (est.)		7,200	32.0	1420	—	1420
All Modes					18,598	8,870	27,468

Note: Automobiles, motorcycles and urban buses use gasoline, intercity buses use diesel; by difference, 67% of fuel (in volume) used by trucks is gasoline and 33% is diesel.

Source: E/DI estimates

About 2 million out of Indonesia's 28 million households use electricity for lighting; according to most sources, the remainder of households use kerosene lamps, although locally produced fuels such as coconut oil are known to be used in remote areas. Electricity is used in households to power appliances such as TV sets, refrigerators and irons; electric water heating is rare even in urban areas and electric cooking is also insignificant.

The estimate of firewood consumption (260 million boe) is obtained from the CSIS observation of approximately 2900 Kgs of firewood per household per year (1.8 Kgs per capita per day). The energy content of the biomass is estimated at 4500 Kcal/day. A national total is obtained for 1978 on the basis of 27.9 million rural households. Firewood use in urban households, which number less than 2 million, has been estimated to be no more than 5 percent of rural household use.

Kerosene has been estimated to be used 50 percent for lighting and 50 percent for cooking. About 42 percent of kerosene is used in urban areas and 58 percent in rural areas. Table IV-5 summarizes this information and indicates the assumptions made for obtaining these estimates. These estimates, which add a new set of figures to the existing literature on the subject, have been derived in order to form a basis for projecting future demand based on results of the rural energy survey (see Appendix D).

Other Sectors

Sectors of final demand not included above are agriculture, mining, construction, commerce and government institutions. The largest fraction

TABLE IV - 5

HOUSEHOLD KEROSENE CONSUMPTION 1978

Lighting	Fraction*	Yearly Per Capita Consumption (boe)	Total (kboe)
Urban	0.60	0.21	3,541
Rural	0.80	0.15	13,512
Subtotal			17,053
Cooking			
Urban	0.80	0.47	10,566
Rural	0.15	0.35	5,912
Subtotal			16,478
Total Kerosene			33,531

Population (millions)	140.7
Urban	28.1
Rural	112.6

*Refers to the fraction of the population using kerosene as the predominant fuel for this purpose.

Source: Appendix B Supplement

of the 3413 kboe of petroleum products used by agriculture is in forestry, most of which is diesel to power equipment and vehicles. Other users in this sector are plantations and mid-sized farms. Consumption grew by 18 percent between 1978 and 1979. The mining sector consumed 1525 kboe of petroleum products and 61 kboe of coal in 1978, and the largest consumer in this sector (about one half of the liquid fuels and all the coal) are the tin mines and smelters. Nickel consumes about one third of the total petroleum used in this sector, and in addition generates electricity for its own use from a 125 Mw hydroelectric facility. Consumption of fossil fuels grew by 33 percent between 1978 and 1979.

The construction sector utilizes predominantly diesel for trucks and other on-site vehicles. Consumption in 1978 amounted to 1,080 kboe. The government and services sectors consumed a similar amount of diesel (916 kboe); in addition, 20 percent of total kerosene sales (8,000 kboe) are estimated to be consumed in this sector by rural commercial establishments, for lighting and foodstalls and similar outlets for cooking. Nearly 35 percent of the electricity sold by the public utility is destined to office buildings, stoves, warehouses and hotels that are part of the services sector.

Utility Electric Generation

The public utility generation system in Indonesia currently consists of over 300 isolated systems that are scattered throughout the islands where, with the exception of Java, peak demands are relatively low. Of a total 2710 Mw installed by March, 1980, (including some hydroelectric sites operated by institutions other than the state-owned public utility, PLN) over 70 percent, or 1976 Mw are on the island of Java. Two of the

largest load centers on Java have recently completed an interconnection; elsewhere on the island, isolated systems also persist.

Indonesia's geography, coupled to the relative lack of development of the utility system are reflected in the breakdown of installed capacity in the system (Table IV-6). Diesel generators represent 19 percent of total installed capacity nationwide, but 59 percent of that in the islands other than Java. Most of the growth in the early 1970's was met by relatively inefficient gas turbines, which represent 33 percent of total capacity. These operate currently at low plant factors in Java as steam generation has been brought on line. Steam generation (utilizing fuel oil) has reached 36 percent of total installed capacity on Java and is scheduled to grow; outside Java, only 7 percent of capacity is via steam generators.

Sales by PLN (including its purchases of hydropower generated by other institutions) have grown at an average yearly rate of 17.5 percent between fiscal year 1975 and 1979. Residential customers purchase about 45 percent, commercial customers 35 percent and industrial customers 19 percent (Table IV-7). Fastest growth has been that by industrial customers, which grew annually by 20 percent between 1975 and 1979. These purchases, however, represent less than 15 percent of total industrial electricity needs. Thus, the future growth in generation by PLN is closely linked to policies regarding self-generation versus grid-generated electricity by the expanding industrial base of the country. In the case where future industrial electrical needs will be met by the grid (geographical considerations aside), a substantially reduced growth rate in diesel fuel sales to the sector will be observed; on the other hand, PLN generation, which historically has already been growing at the 17.5 percent annual rate mentioned above, without substantially changing the historical pattern

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TABLE IV-7

ELECTRICITY SALES BY SECTOR (Gwh)

	Residential	Industrial	Commercial and Government	Total
1975/76	1290	500	1014	2804
1976/77	1420	551	1111	3082
1977/78	1640	637	1250	3527
1978/79	1962	793	1532	4287
1979/80	2428	1036	1879	5343

Note: Residential: Tariff classes S1, R1 to R4
Industrial : Tariff classes I1 to I4
Commercial : Tariff classes U1 to U4, H1, H2, S2, G1, G2, J.

Source: See Appendix B

between self-generation and purchases by industry, will have to grow substantially faster in order to provide the bulk of industrial electricity needs.

Rural, Non-household Sector

Little reliable information exists on energy use by the rural non-household sector, taken here to include agriculture, most agro-industry, forestry and timber, dispersed extractive industries such as clay, sand and gravel and minor mineral deposits, and rural craft, textile and food industries. This sector consumed in 1978 approximately 14 million boe, of which 2.6 Mboe were firewood and charcoal, 2.7 Mboe in equivalent human and animal power in agriculture with the remainder for the most part consisting of diesel, fuel oil, kerosene and other petroleum products (Table IV-8). A large fraction of the oil used outside households in the rural sector is accounted for in the energy balance presented above under traditional economic activity headings of agriculture, mining and manufacture; however, nowhere in the existing publications on energy demand in Indonesia is a separate analysis of this sector available. Appendix C: Energy Use for Productive Purposes in the Rural Sector in Indonesia contains such an analysis and its principal findings are summarized here.

The rural non-households sector consumes 8 percent of total petroleum products sold, but 60 percent of this energy is accounted for by large-scale enterprises (in particular plantations, sugar and rubber primary processing and timber extraction) that, in statistical terms, provide for a relatively small proportion of the total rural

TABLE IV - 8

RURAL SECTOR ENERGY INPUTS FOR PRODUCTIVE PURPOSES
(Thousand Barrels Oil Equivalent)

	Kerosene	Light Diesel	Other Oil Products	Other Commercial	Firewood & Charcoal	Human & Animal	Total
Agriculture	-	1012	341	-	-	2655	4008
Agro-Industry							
Sugar	533	191	1232	40	505	-	2501
Rubber	14	432	81	10	31	-	568
Milling	1	888	3	0	-	-	891
Edible Oils	7	89	44	5	13	-	158
Crop Drying	30	34	4	0	126	-	194
Other	-	-			41		41
Forestry	2	2157	80	2	-	-	2242
Extractive Industries	5	138	669	3	1159	-	1974
Food Industries	435	26	-	-	578	-	1039
Craft Industries	59	-	-	-	74	-	132
Textiles	25	-	-	-	51	-	76
Other	5	38	-	-	40	-	82
Water, Etc.	-	76	-	-	-	-	76
Totals	1115	5080	2454	61	2616	2655	13981 (2)

(1) Electricity, gas, coke and coal

(2) Due to rounding, totals may differ from the sum of individual elements

workforce. The small-scale subsector is also concentrated, with 85 percent of small-scale usage of purchased energy accounted for by the sugar, milling and food subsectors. On the other hand, energy inputs to agriculture, even when human and animal effort are included in the calculation, is relatively small. Mechanical equipment associated with food crop production (tractors and pumps) account for less than 1 percent of the energy inputs to the rural, non-household sector. About 75 percent of the purchased energy by the large-scale subsector, and 50 percent of that of the small-scale subsector is used to produce rotating shaft power.

Biomass use is estimated at 2.5 Mboe (excluding charcoal), based on information on expenditures for fuels to various economic segments; this estimate is on the low end of the range, whereas other sources cite what appear less reliable estimates nearly three times larger. More important than the actual amounts is the recognition of the coexistence of a "low energy" system that embodies mostly practices or technologies that require little other than animate power, with a modern or modernizing segment that at present has an almost universal preference for oil-derived energy. The exceptions are the energy intensive processes that include 'closed system' biomass resources, such as in rubber, sugar and tobacco.

The general effect of the availability of cheap, and indeed subsidized, oil-derived fuels has been to reinforce the development of a bimodal rural economy and a corresponding bimodal energy consumption pattern. The "low energy" pattern persists where for reasons of scale, the technical characteristics of the product, the demands of the market, or the relative costs of the different types of energy dictate continued reliance on biomass

in one way or another. Specific examples of where the oil-derived fuels find little application are: small-scale agriculture (except where there are opportunities for technical irrigation and/or micro-mechanization), small-scale manufacture of bricks and tiles, small-scale limeburning, fire-cured tobacco, small-scale rubber smoking and certain fish preservation processes.

The complementary mode is the modern sub sector, with a relatively "high energy" pattern. This description is warranted not only because in absolute terms the modern sector takes the larger share of the total of purchased energy, but also because the activities and processes involved are generally more energy-intensive as measured by both the labor inputs and the product outputs.

Although in general terms this bimodal pattern can be discerned, the distinction is not clearcut. Use of kerosene has spread throughout the sector, for industrial as well as domestic purposes. This development, which has accelerated in recent years, has undoubtedly been assisted by pricing policies which have (at ever-increasing subsidy cost) effectively maintained a rough parity in terms of cost per unit of delivered heat between kerosene and much of the commercially traded firewood. The investment needed to utilize kerosene either domestically or for small-scale industrial processes is relatively small and it is not, therefore, surprising that it has become the main complement or substitute for firewood.

It seems likely that the price structure adopted for all oil-derived fuels-involving, in recent years, an element of subsidy throughout the range-has led to some usage practices that would not have occurred had true cost prices obtained. The use of kerosene for the drying of tobacco in larger-scale enterprises is probably an example. So, too, is the use of

light diesel for the firing of bricks, again in larger-scale enterprises. This raises the possibility (for which there is much general supportive evidence) that much of the oil-related structural change in the rural economy owes as much to the actual cheapness of the energy provided by oil-derived fuels as it does to their capacity to promote innovation.

Oil and Gas Sectors

Large amounts of petroleum and natural gas are consumed in Indonesia in the course of extracting, transporting and processing the crude oil and natural gas produced in the country. Because a large fraction of this production is ultimately exported, the energy utilized by these activities have been omitted from what has been labelled "Domestic Demand" (see Table IV-1). It is however important to include this information in order to obtain a total of the true internal consumption of petroleum and natural gas in the country. This is presented in Table IV-9.

The national petroleum company consumes energy in the transport of crude to refineries (mostly waterborne), in the refining process and in the distribution of petroleum products (both overland and by tankers). Both national and foreign companies consume fuel in the production of crude. In 1978 these activities consumed about 15.0 Mboe of petroleum products and 1.2 Mboe of natural gas, and of this total 10.2 Mboe were consumed by refineries. This total, which is equivalent to about 0.1 boe per barrel of crude refined, excludes the energy consumed in refineries in Singapore that process crude destined to Indonesian markets.

Natural gas used as fuel in LNG plants amounted to an estimated 6.0 Mboe

TABLE IV - 9

ENERGY CONSUMPTION OF OIL AND GAS SECTORS, 1978
(Thousand Barrels Oil Equivalent)

	Petroleum Products[1]	Natural Gas
Crude Production	1496	-
Refineries	8943	1226
Petroleum Transportation and Distribution	3242	
LNG Plants	-	6050
LPG Plants	-	837
Natural Gas Production	-	8372
	13681	16485

[1] Includes Refinery Gas

Source: Appendix B

in 1978, and that used as fuel in LPG plants is estimated at 0.8 Mboe. The LNG and LPG produced are sold overseas; besides its use as fuel, other losses and shringakes occur so that the energy content of the LNG and LPG finally exported is smaller than the energy content of the natural gas used as feedstock and fuel in these plants.

Natural gas is also used as fuel in gas fields. In 1978, this use amounted to 8.4 Mboe.

C. MACROECONOMIC PROJECTIONS

The basic economic projections utilized in this study are provided by the Social and Economic Research Institute of the University of Indonesia (LPEM). These projections are based upon assumptions of the growth of per capita GDP and population. Two sets of assumptions are used in order to generate a low and a high rate of aggregate economic growth. Population growth rate, which remains unchanged in both cases, is assumed to be 1.9 percent per year between 1978 and 1990 and 1.8 percent per year between 1990 and 2000. In the low growth case, GDP is projected to grow 5.8 percent per year between 1978 and 1990 and 5.5 percent per year between 1990 and 2000. Per capita GDP is projected to grow at an average rate of 3.8 and 3.6 percent per year in the two periods respectively. In the high growth case, aggregate GDP is projected as growing 7.0 percent per year throughout the projection period. GDP per capita is projected to grow 5.0 percent and 5.1 percent per year respectively during the two projection periods (Table IV-10).

Recent information collected by the 1980 census, not available at the time of the LPEM report, indicates that the current prpulation growth

rate is 2.34 percent p.a. (1971-1980), substantially higher than the 2.0 percent estimated earlier. The sensitivity of the higher population growth rate to energy demand was explored for the case of household energy consumption; revised government estimates hold population probable rates at considerable larger than 2.0 percent p.a. through 1989 (see note in Table IV-10).

The LPEM analysis provides growth rates for the Indonesian economy at a seven sector level: agriculture, mining, manufacturing, construction, electricity, gas and water, services, and transportation and communication (Table IV-11). A detailed discussion of these projections and the imbedded assumptions is offered in Appendix A. A discussion of the fashion in which the LPEM sectoral growth rates have been utilized in generating energy demand projections is contained in Appendix B (for example, the growth in the electric generation sector is not obtained from the LPEM projections). These projections are obtained in part from a "bottom up" approach in which planned additions to plant capacity are explicity considered and in part from macro-economic methods. The various subsectors within the manufacturing and transportation sectors grow at rates obtained from several sources (LPEM only provides growth rates at a more aggregate level). For example, in the manufacturing sector independent projections are made for the food, beverages and tobacco, textiles, cement, iron and steel, fertilizer subsectors. The remaining sectors (accounting for approximately 60 percent of total value added in manufacturing) are projected so that growth of overall manufacturing output is consistent with the LPEM projections.

TABLE IV-10

ECONOMIC GROWTH RATE ASSUMPTIONS
(percent per year)

	1978-1990	1990-2000
Low Growth		
Population	1.9	1.8
GDP	5.8	5.5
GDP per capita	3.8	3.6
High Growth		
Population	1.9	1.8
GDP	7.0	7.0
GDP per capita	5.0	5.1

Note: Preliminary findings of the 1980 census of population indicate an average yearly growth rate between 1971-1980 of 2.35 percent, higher than the 2.0 percent that had been estimated at the time of the LPEM projections. Revised population growth rates are 2.3 percent p.a. to 1984, 2.15 percent p.a. to 1989, 2.0 percent p.a. to 1994 and 1.85 percent to 1999. (KUBE Committee).

Source: LPEM[1]

TABLE IV-11

SECTOR GROWTH RATES OF VALUE ADDED, % PER ANNUM

Sector	1978-1990		1990-2000	
	Low	High	Low	High
Agriculture	3.2	4.0	4.4	5.0
Mining	3.4	4.0	4.5	5.3
Manufacturing	9.9	11.6	7.6	9.7
Construction	7.2	8.7	5.5	7.0
Transportation & Communication	8.5	10.4	6.9	9.5
Other Services	6.7	8.1	5.1	6.6
GDP	5.8	7.0	5.5	7.0

Source: LPEM[1]

D. ENERGY DEMAND PROJECTIONS

The levels of consumption of energy and the mix of fuels existing in 1979 have been used as a basis for the energy demand projections. Except where mentioned below, the growth of sectoral energy consumption is assumed to be directly proportional to the projections of sectoral value added. This is the case for the agriculture, mining, construction and services sectors and most manufacturing and transportation subsectors. The exceptions are the basic iron and steel production sector, the public utility electricity generation sector, automobiles, motorcycles and households. In the cases of basic iron and steel and public utility electricity sectors the growth in production and energy consumption is obtained from published expansion plans. Projections of energy use by automobiles and motorcycles are based upon escalation rates of the numbers of registered vehicles and assumptions regarding vehicle miles per vehicle and vehicle efficiencies. Projections of household energy consumption are based upon projections of growth in the number of households, rate of urbanization and substitution of fuels (e.g. increased electrification).

Where the growth of sectoral energy consumption is tied directly to value added the underlying assumption is that the relationship between value added (measured in 1978 rupiahs), output as measured by 1978 rupiahs, output as measured by physical quantity and energy consumption remain fixed throughout the entire projection period. This assumption is identical to that employed in fixed coefficient input-output analysis. The assumption implies that as value added doubles so do output and energy consumption. Thus all relevant segments of economic activity exhibit elasticities of energy demand with respect to economic growth of one. This does not

mean that a unit elasticity is used for the manufacturing and transportation sectors as a whole. If proportionately more growth (in terms of value added) is experienced in the energy intensive subsectors than the less intensive ones then the aggregate elasticity will be greater than one.

Energy consumption is projected as a function of value added in order to ensure consistency with the macroeconomic assumptions of future growth. It is also expedient because value added statistics are available in some detail for Indonesia. This consistency between individual sectoral growth projections and the more aggregate ones of GDP could not be ensured if individual projections were made in terms of physical quantities alone (e.g. tons of cement). In this study the manufacturing and transportation sectors are disaggregated into 11 and 7 subsectors respectively. Table IV-12 summarizes the projection assumptions.

The projections of fuels used for electricity generation are based on estimates of future electricity production made by PLN. The PLN Plan[2] indicates a growth in electricity generation averaging 15.7 percent per year for the period 1978 to 2000 for the entire system (the PLN Plan only projects generation in the Outer Island[(5)], to 1990; the extrapolation to 2000 is an E/DI estimate). This ambitious expansion plan has been associated in this analysis with the high GDP growth case of 7.0 percent per year. For the low GDP growth case, the same ratio between electricity growth and GDP growth implicit in the high case (+2.24) has been applied to the lower 5.8-5.5 percent GDP growth rates. These result in growth rates of electricity generation of 12.7 percent per year.

TABLE IV - 12

ENERGY DEMAND PROJECTIONS SUMMARY OF ASSUMPTIONS

Sector	Basis for Projection
Economic Projections	Low GDP growth: 5.8%p.a. 1978-1990 5.5%p.a. 1990-2000 High GDP growth: 7.0%p.a. 1978-2000 LPEM Macroeconomic model with disaggregation based on Chenery-Syrquin (World Bank)
Agriculture, Mining	Sectoral Growth rates (LPEM)
Manufacturing	
steel, cement, paper,	Plant Capacity Expansions
food, textiles etc.	Subsector Prognoses
other	Overall sector growth (LPEM)
Services, Government etc.	Sectoral Growth Rates (LPEM)
Transportation	
Autos, motorcycles	Urban households, income
Air, ship, rail	Histrocial trends
Trucks	Manufacturing sector growth
Households	Growth in households, urban-rural breakdown, substitution of fuels (e.g. increased electrification)
Electricity Generation (Supply constrained)	High GDP: Based on PLN Plan (15.7% p.a. to 2000) Low GDP: Ratio of electricity growth to GDP growth of +2.24 (12.7% p.a. to 2000)

E. PROJECTION RESULTS

Tables IV-13 through IV-16 present the projected energy balances for the low and high growth cases.

By the year 2000 total commercial and non-commercial energy consumption is projected to be 1,019 million boe in the low growth case and the 1,202 million in the high growth case. These projections represent an average annual growth rate of 4.5 and 5.3 percent respectively over the 1978 level of 385 million boe. Commercial energy consumption alone is expected to grow at a much faster pace, averaging 7.8 and 9.6 percent per year between 1978 and 2000 for the low and high growth cases respectively. These growth rates imply total income elasticities of energy consumption of approximately 1.4 in both cases.

The mix of fuels meeting future energy demands follow, with a few exceptions, historical patterns. No major shifts in patterns of fuel choice or relative fuel prices are introduced. Liquid fuels, which almost exclusively power the transportation, household and industrial sectors, are all obtained from crude petroleum. Usage of natural gas is assumed to increase only as new plants planned for the petrochemical sector are introduced into the energy projection. The same is the case for the increased use of coal. The major exception is the electric generation sector, in which the PLN Plan from which the tabulated projections are derived, pursues a policy of substitution of oil for other sources. Coal becomes a major input to electricity, together with an expansion of hydroelectric capacity and the introduction of geothermal electricity. Nuclear plants are introduced in 1997 according to the PLN Plan and by the year 2000 amount to 9100 MW. In order to quantify the impact of a less ambitious nuclear construction schedule, a second case was prepared

TABLE IV-13

DOMESTIC ENERGY DEMAND BY SECTOR

1990 Low Growth
(Thousand Barrels Oil Equivalent - kboe)

	Petroleum Products	Coal	Natural Gas[2]	LPG	Hydro Geo. & Nuclear	Total Com'l.	Firewood & Agric. Wastes	Total Energy
Oil and Gas Sector	30,600	-	38,600			69,200		69,200
Agriculture	6,027	-	-	N/A		6,027	1,045	7,072
Mining	2,833	77	-			2,910	1,730	4,640
Manufacturing	55,783	7,043	54,900	N/A		117,726	1,083	118,809
Construction	2,041	-	-			2,041		2,041
Services	23,818	-	-			23,818		23,818
Transportation	75,803	-	-	N/A		75,803		75,803
Households	59,772		-	N/A		59,772	349,000	408,772
Electric Generation	16,459	17,812	-		22,091	56,362		56,362
	273,136	24,932	93,500	5,500	22,091	419,159	352,858	772,077

Note: number of decimal places retained for consistency and do not indicate accuracy

1. Includes refining, transportation, separation and liquifaction
2. Includes feedstocks for city gas fertilizer plants; excludes feedstocks for LNG and LPG plants

TABLE IV-14

DOMESTIC ENERGY DEMAND BY SECTOR

1990 High Growth
(kboe)

	Petroleum Products	Coal	Natural Gas	LPG	Hydro Geo. & Nuclear	Total Com'l.	Firewood & Agric. Wastes	Total Energy
Oil and Gas Sector	36,700		38,600			75,300		75,300
Agriculture	6,562					6,562	1,146	7,708
Mining	3,019	82				3,101	1,854	4,955
Manufacturing	65,324	7,043	57,900			130,267	1,188	131,455
Construction	2,379					2,379		2,379
Services	28,829					28,829		28,829
Transportation	90,031					90,031		90,031
Households	64,581					64,581	305,000	369,581
Electric Generation	30,893	29,936			22,091	82,920		82,920
	328,318	37,061	96,500	5,500	22,091	489,471	309,188	798,659

Note: number of decimal places retained for consistency and do not indicate accuracy

1. Includes refining, transportation, separation and liquifaction
2. Includes feedstocks for city gas fertilizer plants; excludes feedstocks for LNG and LPG plants

TABLE IV-15

DOMESTIC ENERGY DEMAND BY SECTOR

2000 Low Growth
(kboe)

	Petroleum Products	Coal	Natural Gas[2]	LPG	Hydro Geo. & Nuclear	Total Com'l.	Firewood & Agric. Wastes	Total Energy
Oil and Gas Sector	53,600	-	52,700			106.300		106,300
Agriculture	9,270			N/A		9,270	1,607	10,877
Mining	4,399	120				4,519	2,687	7,206
Manufacturing	114,179	7,043	89,000	N/A		210,222	1,666	211,888
Construction	3,486					3,486	-	3,486
Services	46,418					46,418	-	46,418
Transportation	137,152			N/A		137,152	-	137,152
Households	91,587			N/A		91,587	377,000	468,587
Electric Generation	15,486	101,333			36,555	153,374	-	153,374
	475,577	108,496	141,700	12,000	36,555	774,328	382,960	1,157,288

Note: number of decimal places retained for consistency and do not indicate accuracy

1. Includes refining, transportation, separation and liquifaction
2. Includes feedstocks for city gas fertilizer plants; excludes feedstocks for LNG and LPG plants

DOMESTIC ENERGY DEMAND BY SECTOR

2000 High Growth
(kboe)

	Petroleum Products	Coal	Natural Gas	LPG	Hydro Geo. & Nuclear	Total Com'l.	Firewood & Agric. Wastes	Total Energy
Oil and Gas Sector	73,900	-	52,700	N/A		126,600		126,600
Agriculture	10,688					10,688	1,867	12,500
Mining	5,061	137				5,198	3,107	8,305
Manufacturing	158,956	7,043	100,600	N/A		266,599	1,935	268,534
Construction	4,680					4,680	-	4,680
Services	70,795					70,795	-	70,795
Transportation	198,653			N/A		198,653	-	198.653
Households	102,315			N/A		102,315	270,000	372,315
Electric Generation								
PLN Plan	34,998	105,846			126,549	267,393	-	267,393
Limited Nuclear	118,188	105,846			43,359	267,393	-	
TOTAL Diversification Plan	660,046	113,026	153,300	12,000	126,549	1,065,241	276,909	1,342,150
Limited Nucl.	743,556	113,026	153,300	12,000	43,359	1,065,241	276,909	1,342,150

Note: number of decimal places retained for consistency and do not indicate accuracy
1. Includes refining, transportation, separation and liquifaction
2. Includes feedstocks for city gas fertilizer plants; excludes feedstocks for LNG and LPG plants

and labelled "Limited Nuclear", in which only 1300 MW are assumed to be in place by the year 2000 with the difference filled by oil. For the low GDP case, in which total electricity generation is substantially lower than the high GDP case, nuclear capacity by the year 2000 is a single 600 MW plant.

Projected Demand for Fuels

The rate of increase of the consumption of petroleum products is the lowest of all energy forms. The 476 million boe which are projected to be consumed in the end year of the low growth case projection reflects an average annual increase of 6.5 percent for the 22 year period. Consumption of oil products is expected to climb to between 660 and 744 million boe for the high growth case, implying annual growth rates of 8.1 and 8.7 percent respectively. The spread comes about from different rates of introduction of nuclear power plants within the projection period. In the case where this introduction falls short of the one stated in PLN's Diversification Plan, petroleum based electricity supplies the difference.

Use of coal expands more rapidly than any other fuel, reaching a level of 108 million boe and 113 million boe by 2000 in the low and high growth cases respectively. These levels imply average annual growth rates of 28 and 28.5 percent for the 22 year period. Most of this growth occurs in the 1978-1990 period during which time coal use is expected to grow 37 and 43 percent per year in the low and high cases respectively due to large-scale implementation of power stations.

Use of natural gas also expands rapidly reaching a level of 89 million boe in the low growth case and 101 million boe in the high growth case implying average annual growth rates of 10 and 11 percent respectively.

These growth rates exclude all natural gas required for LNG and LPG exports as well as other natural gas used by the gas production sector.

Table IV-17 shows the composition of the commercial energy system by type of fuel. Petroleum products accounted for slightly more than 87 percent of total commercial energy consumption in 1978 and while oil continues to dominate the energy under both growth assumptions, its role is substantially reduced in the low growth case and high growth case (PLN Plan). In the low growth case this share is projected to decrease to 70 percent by 1990 and to 63 percent by 2000 as coal becomes the principal fuel in the electric sector and as proportionately more coal and natural gas penetrate the cement and steel industries. Coal and natural gas become increasingly prominent fuels throughout the 22 year period accounting for 16.2 and 13.3 percent of total commercial energy in 2000 compared to 0.4 and 9.0 percent in 1978. The share of total commercial energy accounted for by hydro electricity increases to about 5-6 percent in 1990 and then declines over the next 10 years to 4 percent as the rate of expansion of hydro projects levels off. In the case of a reduced level of construction of nuclear plants, petroleum products remain at over 70 percent of total commercial energy, or similar to the levels reached in 1990. The assumption used in the analysis, as indicated above, is that petroleum based electricity takes up the slack of the reduction in nuclear plants.

As can be seen from this brief summary of the projection methodology and results, the growth in demand for fuels uses as a consistent basis of projection a framework of economic growth obtained from LPEM. The exception is the electric generation sector which, because of large components of current unmet demands, is entirely dependent on growth

TABLE IV- 17

COMPOSITION OF COMMERCIAL ENERGY SYSTEM*
(Percent)

	1978	1990		2000		
		Low GDP	High GDP	Low GDP	High GDP PLN Plan	High GDP Limited Nuclear Plan
Petroleum Products (incl. oil to elect. generation)	87.3	69.3	70.4	63.2	62.5	71.4
Coal	0.4	7.1	9.0	16.2	12.0	12.0
Natural Gas	8.9	15.7	14.0	13.3	10.7	10.7
LPG	0.3	1.6	1.3	1.8	1.3	1.3
Hydro	3.2	5.8	4.5	4.0	2.7	2.7
Nuclear	-	-	-	1.0	10.4	1.5
Geothermal	-	0.7	0.7	0.6	0.4	0.4

* Excludes demand of the oil and gas sector.

by the expansion schedule of the electric utility. This schedule is not a function of overall GDP growth (at least not explicitly) and can best be described in terms of capital available for expansion of electric generation infraestructure. In these terms, the PLN Plan (used for the High GDP case in this analysis) seems quite ambitious and will not be easily met. The terms of the ratio of electric generation to total commercial energy delivered, the projection presented here (High GDP case) yields a figure of 0.15; as a comparison, the current ratio for the U.S. is 0.13, one of the highest in the world. On the other hand, the low GDP case departs from the PLN Plan and by the year 2000 would be generating only 57 percent of the electricity indicated by the PLN Plan. In this case, the ratio of electricity to total delivered energy is 0.10, a figure which compares better with the realities of the energy systems of other countries.

Projected Energy Demands by Sector

Table IV-18 presents a picture of the distribution of projected energy demand (for all commercial energy) by sector of economic activity. The proportion of total commercial energy accounted for by the manufacturing and electric sectors increase steadily throughout the 1980's, from 24 percent to 30-34 percent in manufacturing and from 10 percent to 16-20 percent in electric generation. Towards the year 2000, the share of commercial energy consumed by the manufacturing sector decreases somewhat from levels reached in 1990. The share consumed by the electric sector continues to rise in both low and high GDP growth cases, increasing to 23 and 29 percent of the total energy in 2000. The proportion of commercial energy consumed by households declines sharply from 26.5 percent in 1978 to 11 - 14 percent in the final year. The

TABLE IV-18

DISTRIBUTION OF TOTAL COMMERCIAL ENERGY DEMAND*
(percent)

	1978	1990		2000	
		Low	High	Low	High
Agriculture	2.8	1.7	1.6	0.9	1.1
Mining	1.2	0.8	0.8	0.7	0.6
Manufacturing	24.2	33.6	31.5	31.5	28.4
Construction	1.0	0.6	0.6	0.5	0.5
Services	7.2	6.8	7.0	7.0	7.5
Transportation	27.1	21.4	21.7	20.5	21.1
Households	26.5	17.1	15.6	13.7	10.9
Electric Generation	10.0	16.1	20.0	23.0	28.5

* Excludes oil and gas sector demand

transportation, construction, mining and agriculture sectors also account for a smaller share of total commercial energy consumption by the year 2000 in both cases.

The use of petroleum products remains prevalent in all sectors of the economy throughout the projection. However, the distribution of oil consumption is significantly altered as the result of substitution effects in the electric and household sectors, and because of the differential growth rates between sectors. The change of the distribution of consumption is shown in Table IV-19. The shares of total consumption accounted for by the manufacturing and services sectors steadily increase throughout the projection period under both cases. Those of agriculture and households steadily decline in all cases and all years while those of mining and construction remain essentially unchanged.

The share of total consumption of the manufacturing sector grows very rapidly, from 18 percent in 1978 to 27 percent in the year 2000. The transportation sector increases its share to 34 percent in 2000 from 30 percent in 1978. On the other hand, the household sector decreases its share of petroleum demand from 30 percent in 1978 to 18-22 percent in the year 2000. This drop is derived from the relatively slower growth rate in petroleum demand from households, as compared to manufacturing and transportation. The share of petroleum used in electric generation varies throughout the projection years depending on assumptions or the penetration rate of other sources of energy. This is discussed separately below. The distribution of natural gas consumption among the four economic activities that are projected to utilize it is indicated in Table IV-20 for 1978, 1979 and all projection years (no natural gas is projected to be used outside the manufacturing sector). Although the

TABLE IV-19

TOTAL PETROLEUM PRODUCT DEMAND BY SECTOR[2]
(Percent)

	1978	1990		2000	
		Low	High	Low	High[1]
Agriculture	3.0	2.5	2.3	2.2	1.8 1.6
Mining	1.0	1.2	1.0	1.0	0.9 0.8
Manufacturing	18.0	23.0	22.4	27.1	27.1 23.7
Construction	1.0	0.8	0.8	0.8	0.8 0.7
Services	8.0	9.8	9.9	11.0	12.1 10.6
Transportation	30.0	31.3	30.9	32.5	33.9 29.7
Households	30.0	24.7	22.2	21.7	17.5 15.3
Electric Generation	8.0	6.8	10.6	3.7	6.0 17.7

1 Upper line is PLN Plan
Lower line is Limited Nuclear

2 Excludes Oil and Gas Sector

TABLE IV-20

DISTRIBUTION OF NATURAL GAS (%)

Sector	1978	1979	1990 Low GDP	1990 High GDP	2000 Low GDP	2000 High GDP
Cement	-	7	25	24	16	14
Iron & Steel	1	12	9	9	11	10
Fertilizer	100	79	54	56	66	70
Other Chemicals	-	3	12	11	7	7
Total (%)	100	100	100	100	100	100
Total (kboe)	10,665	16,945	54,900	57,900	89,000	100,600

Note: excludes LNG and LPG plants; includes feedstocks used in fertilizer and cement industries.

Source: Appendix B, Supplement

fertilizer industry is projected to remain the principal consumer of natural gas, the cement and iron and steel industries will become increasingly significant users throughout the 1980's and 1990's.

In comparison with other fuels, only small amounts of coal are projected to be consumed within mining, manufacturing and services. The proportion of total coal use accounted for by the electric sector ranges from a low of 87 percent to a high of 96 percent in the years 1990 and 2000 in the low growth case. The corresponding shares in the high growth case are 92 and 95 percent. The cement and other non-metallic mineral products industries consume all but a small fraction of the remainder with the mining sector accounting for less than 1 percent of the total. Coal potentially could take up major shares of fuel use in these sectors, subject to infrastructural changes regarding its transportation, storage and the devices used in combustion.

Energy Resources to the Electric Sector

As indicated in Table IV-21, the fuel mix of the electric sector is projected to alter significantly during the next 10 years. In 1978 oil products accounted for approximately 68 percent of total energy to electric generation by the utility with hydro accounting for the balance. The fuel mix is projected to change dramatically as soon as 1990. At this time oil is expected to constitute 29 and 37 percent of total fuel use in the low and high growth cases respectively. Coal is expected to be the principal substitute for oil at this time, accounting for 32 and 36 percent of fuel use in the two cases. The contribution of hydro is projected to increase to 34.5 percent of total generation in the low case but to decrease to a little over 23 percent in the high growth case. In the latter case the expansion of hydro generation is not expected to keep pace

TABLE IV-21

COMPOSITION OF RESOURCES TO THE ELECTRIC SECTOR
(Percent)

	1978	1990		2000		
		Low Growth GDP	High Growth GDP	Low Growth GDP	High GDP Growth PLN Plan	High GDP Limited Nuclear
Petroleum Products	68.4	29.2	37.3	10.1	13.1	44.2
Coal	-	31.6	36.1	66.0	39.6	39.6
Hydro	31.6	34.5	23.4	16.6	9.5	9.5
Geothermal	-	4.7	3.2	2.5	1.5	1.5
Nuclear	-	-	-	4.7	36.4	5.2

with the projected increase of electricity demand. Consequently the system will have to rely more heavily upon oil and coal relative to the low case.

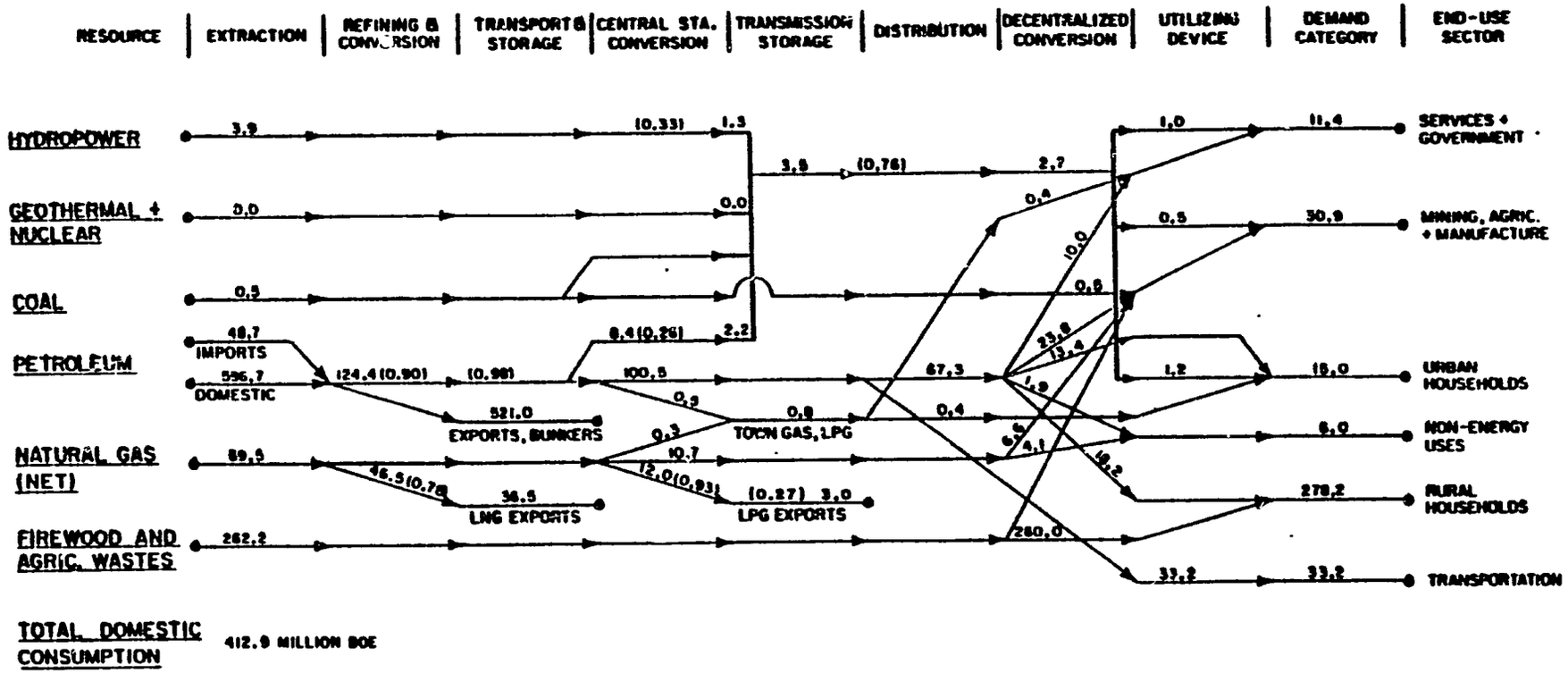
The projection to the year 2000 shows that the importance of oil continues to decline, accounting for 10 to 13 percent of total fuel input. The contribution of hydro also declines from its 1990 share. Geothermal as shown here has a limited role according to what is contained in the PLN Plan; a much larger expansion of over 3000 MW is envisioned by the Ministry of Mines and Energy, which will generate electricity for sale to PLN (see Chapter VI). In the high GDP case, and using as a basis the PLN Plan, coal contributes to 40 percent of total resources to electricity and nuclear energy 36 percent. In the low GDP case, the rate of construction of coal fired plants is kept equal to that of the high GDP case, with the consequence that 66 percent of required generation would be met with coal. A single 600 MW nuclear plant would contribute less than 5 percent. In the case of high electricity requirement with a limitation of nuclear plants to 1300 MW, the contribution of nuclear would be 5 percent;in this case petroleum products fill the gap and constitute 44 percent of resources into electric generation in the year 2000.

F. SUMMARY AND DISCUSSION

A complete configuration of Indonesia's energy system for 1978 is contained in figure IV-1. In this figure, sectoral energy demands, described in detail in this chapter of the report, are linked to energy supplies and energy production rates by a flow diagram or Reference Energy System.

FIGURE IV - 1

ENERGY BALANCE-INDONESIA (MILLION BOE)
YEAR 1978



Shown in the diagram are flows of domestic production, energy, exports, and losses in refining and other conversion and transportation losses[3]. Total domestic consumption, which amounted to 413 million barrels of oil equivalent (Mboe) in 1978, is the sum of all energy resources consumed in the country less net exports. It differs from domestic demand tabulated earlier in this chapter (see Table IV-1) in that the totals here include energy consumption by refineries, by LPG and LNG producers and other uses such as lubricants and other non-energy petroleum products. In 1978, exports of crude oil, petroleum products and sales to international air and ship bunkers amounted to 521 million boe: LNG exports to 36.5 million boe and LPG exports to 11.1 million boe.

Figures IV-2 to IV-5 contain Reference Energy Systems for 1990 and 2000 for both the low and high GDP growth cases. Total domestic consumption grows to 772 million boe in 1990 (low GDP) and 800 Mboe (high GDP) respectively; year 2000 projections total 1163 Mboe (low GDP) and 1351 Mboe (high GDP)[4]. Exports of LNG amount to 145 Mboe in 1990 and 218 Mboe in 2000[5], and processing efficiency is taken as 57 percent. LPG exports are projected to be 9.2 Mboe[6]; crude oil production and exports are too uncertain to quantify meaningfully and have been omitted from the diagrams. Table IV-22 summarizes the resources consumed for all cases and reference years. Totals indicated here are crude oil needed to meet internal demands, and natural gas used in the country by final consumers and by oil companies; excluded are the natural gas feedstocks for LNG and LPG plants earmarked for exports.

It is important to emphasize again in this summary the assumptions that are critical to the formulation of future energy demands presented here. Most of the uncertainties linked to these assumptions have been

FIGURE IV-2

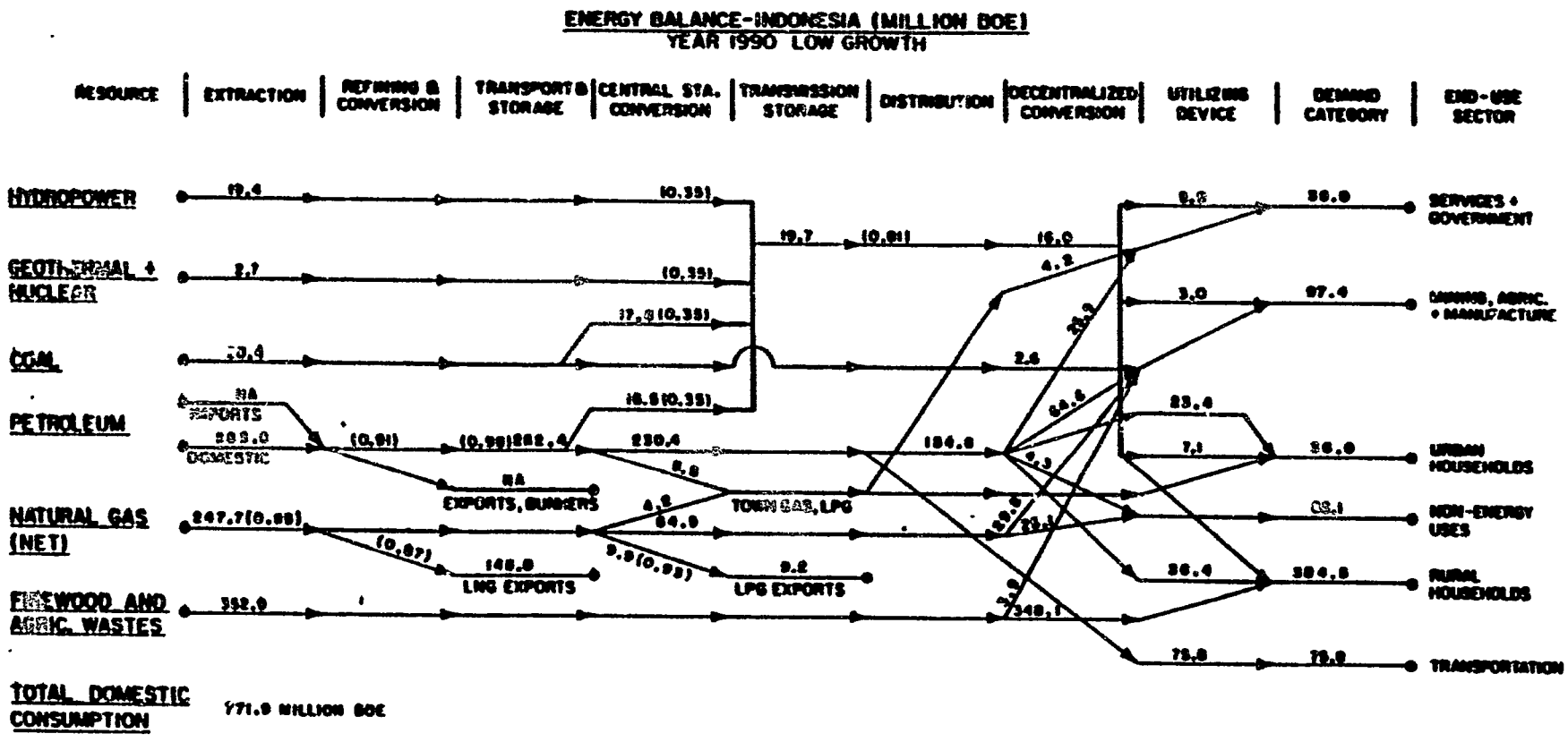

ENERGY BALANCE-INDONESIA (MILLION BOE)
YEAR 1990 LOW GROWTH
RESOURCE
EXTRACTION
REFINING & CONVERSION
TRANSPORT & STORAGE
CENTRAL STA. CONVERSION
TRANSMISSION STORAGE
DISTRIBUTION
DECENTRALIZED CONVERSION
UTILIZING DEVICE
DEMAND CATEGORY
END-USE SECTOR
HYDROPOWER
GEOTHERMAL & NUCLEAR
COAL
PETROLEUM
NATURAL GAS (NET)
FIREWOOD AND AGRIC. WASTES
TOTAL DOMESTIC CONSUMPTION
771.9 MILLION BOE
EXPORTS, BUNKERS
LNG EXPORTS
LPG EXPORTS
TOWN GAS, LPG
SERVICES + GOVERNMENT
MINING, AGRIC. + MANUFACTURE
URBAN HOUSEHOLDS
NON-ENERGY USES
RURAL HOUSEHOLDS
TRANSPORTATION

FIGURE IV-3

ENERGY BALANCE-INDONESIA (MILLION BOE)
YEAR 1990 HIGH GROWTH

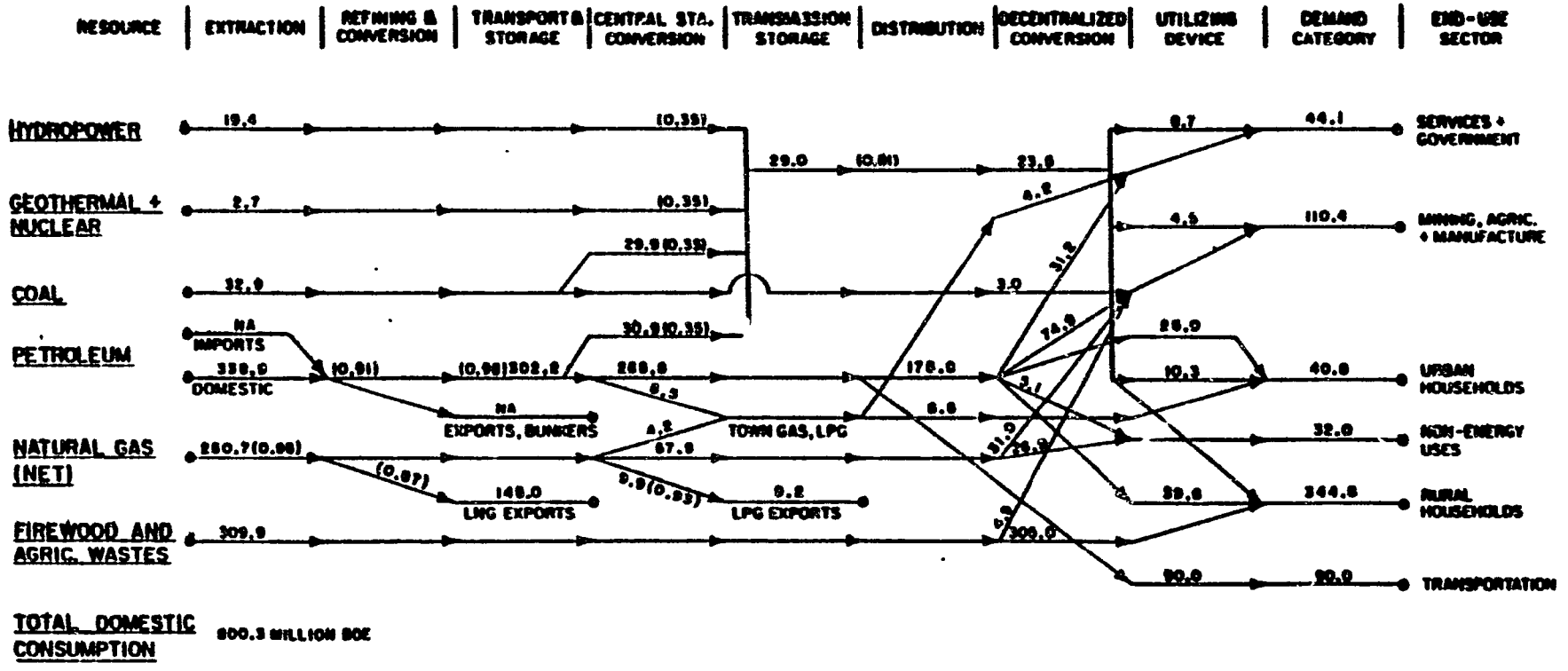


FIGURE IV-4

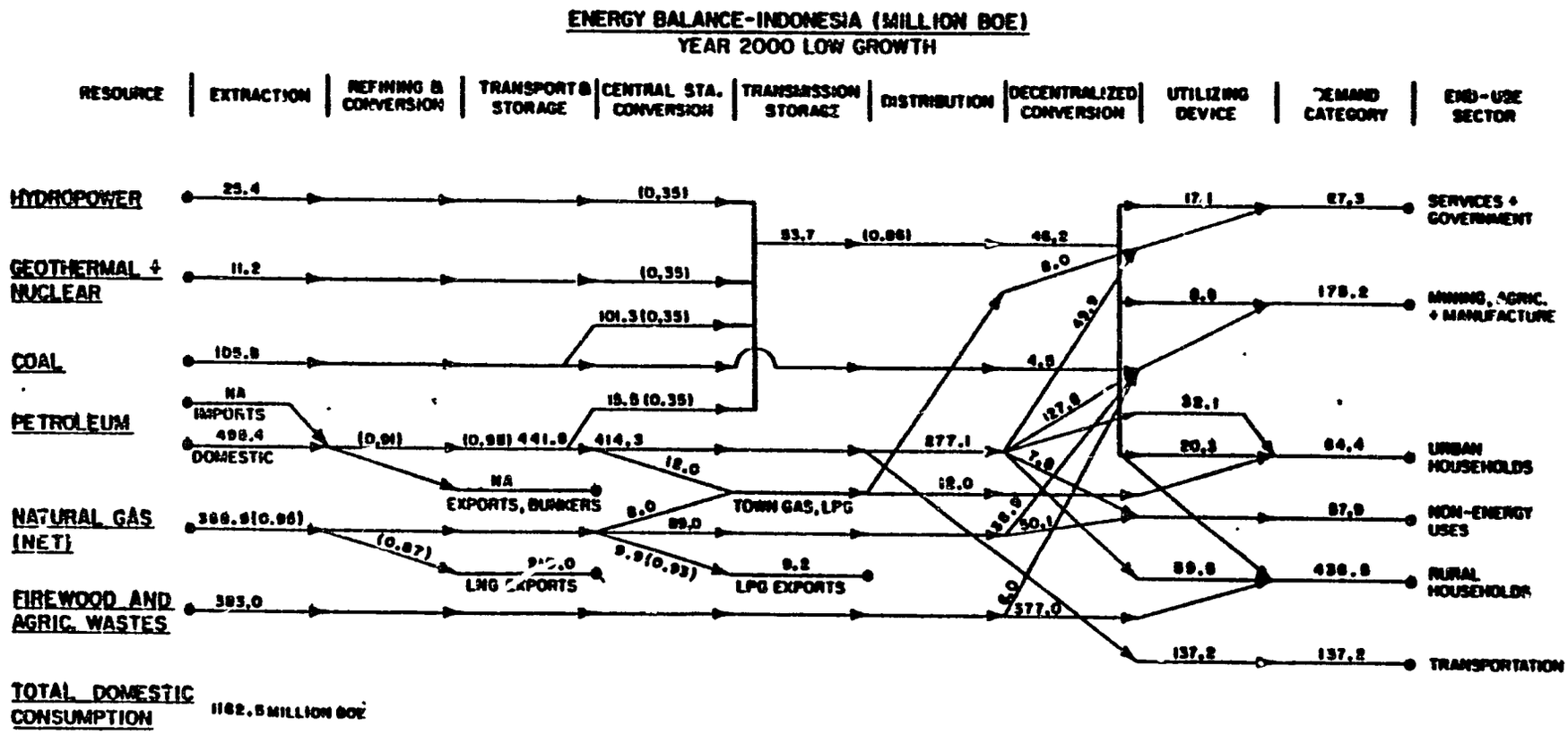

ENERGY BALANCE-INDONESIA (MILLION BOE)
YEAR 2000 LOW GROWTH
RESOURCE
EXTRACTION
REFINING & CONVERSION
TRANSPORT & STORAGE
CENTRAL STA. CONVERSION
TRANSMISSION STORAGE
DISTRIBUTION
DECENTRALIZED CONVERSION
UTILIZING DEVICE
DEMAND CATEGORY
END-USE SECTOR
HYDROPOWER
GEOTHERMAL + NUCLEAR
COAL
PETROLEUM
NATURAL GAS (NET)
FIREWOOD AND AGRIC. WASTES
TOTAL DOMESTIC CONSUMPTION
1162.5 MILLION BOE
IMPORTS
DOMESTIC
EXPORTS, BUNKERS
LNG EXPORTS
LPG EXPORTS
TOWN GAS, LPG
SERVICES + GOVERNMENT
MINING, AGRIC. + MANUFACTURE
URBAN HOUSEHOLDS
NON-ENERGY USES
RURAL HOUSEHOLDS
TRANSPORTATION

FIGURE IV-5

ENERGY BALANCE-INDONESIA (MILLION BOE)
YEAR 2000 HIGH GROWTH

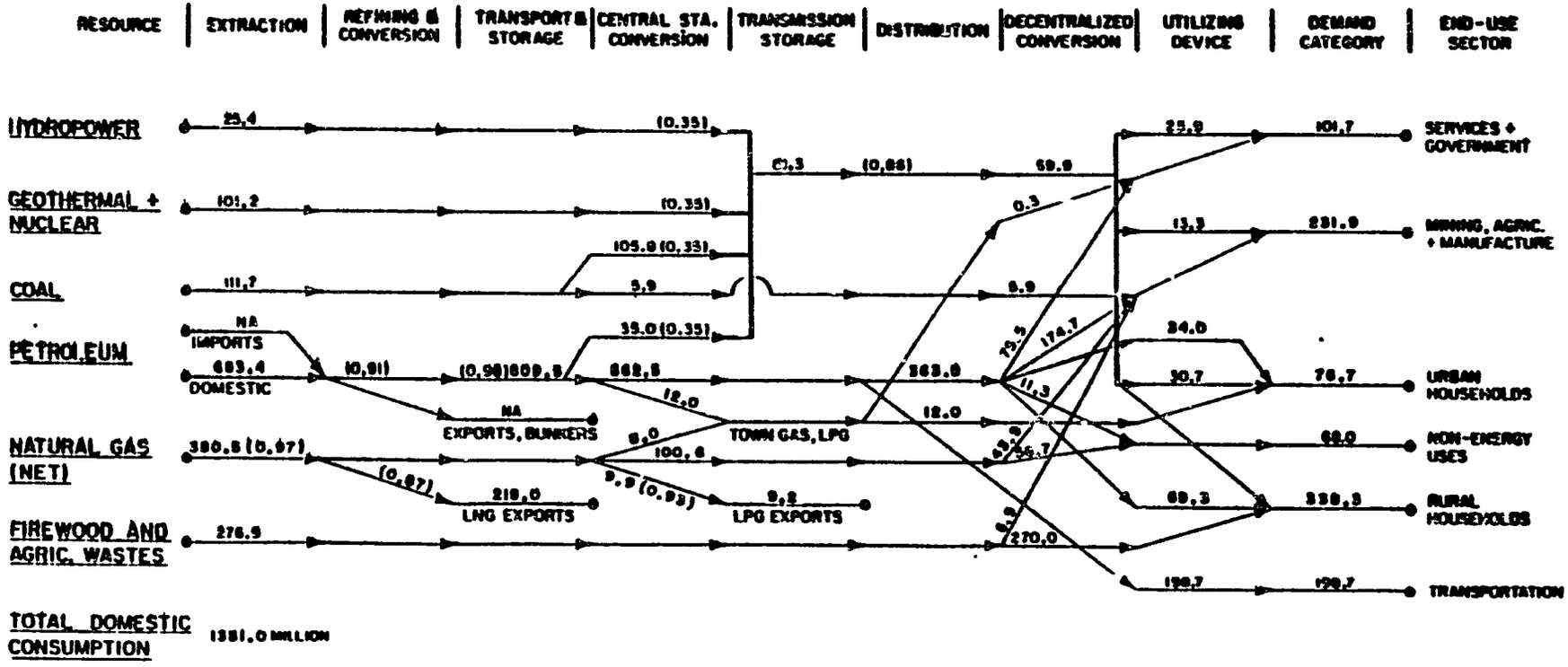


TABLE IV-22

DOMESTIC RESOURCE CONSUMPTION
(MILLION BARRELS OIL EQUIVALENT)

	1990		2000	
	Low	High	Low	High
Crude Oil	283.0	338.9	495.0	683.4
Natural Gas	93.5	96.5	141.7	153.3
Coal	20.4	32.9	105.8	111.7
Hydropower	19.4	19.4	25.4	25.4
Firewood	352.9	309.9	383.0	276.9
Nuclear, geothermal	2.7	2.7	11.2	101.2
Total	771.9	800.3	1162.5	1351.0

already mentioned in this chapter but it is valuable to reiterate them here.

First and most important is the issue of population growth. The latest information on higher than expected growth rates have led to revisions of GDP projections; whereas LPEM in 1980 uses 5.8 percent p.a. as a low rate and 7.0 percent per year as a high rate, the revised population growth rate has led to an upwards revision of GDP growth of 6.1 percent per year for a low case and 8 percent per year for a high case[7]. Higher GDP growth assumptions lead to higher sectoral growth rates than the ones used in these projections, and thus higher energy demands. For example, kerosene demand for households are projected to be 99.0-110.6 million boe on the basis of the revised population projections, as compared to 91.6-102.3 million boe (used in this report) based on lower population growth rates.

Another important souce of uncertainty are the growth rates in electric generation cited from PLN. As mentioned elsewhere, they seem high by international standards vis a vis energy demands for other energy forms. This issue is compounded by the limited knowledge on the future role of the self generation sector in industry. According to PLN, their high growth rates are in part justified by a policy of gradual absorption into the grid of self-generators (whose electricity output in 1978 was approximately equivalent to that of PLN). PLN's goal is also to provide electricity to all new industries created in the future. Incorporation of this policy into the projection would result in a substantial reduction of the projected petroleum demand for the manufacturing sector. The 1978 levels of petroleum consumption by this sector would be adjusted to reflect only usages unrelated to electric generation. This results in a basis for projection approximately one half

of that actually used. Future demand for petroleum in manufacturing would appear breaking significantly with historical trends. The impact of this adjustment on total demand for petroleum products is of a decrease of more than 12 percent.

Lastly, there is no historical basis to project utilization of firewood and other biomass resources. Its usage grows with increases in population and households income; these two factors may be offset by a drecrease in the proportion of the population using traditional fuels for cooking. This is the result the year 2000 projection high GDP case; in all other cases, the resulting projection shows slight increases in firewood demand. These examples underline the heuristic nature of any energy demand projections made at this time for policy analysis and underline the necessity of keeping the inate uncertainty of energy projections in mind when carrying out energy policy analysis.

Chapter IV

Notes and References

1. "Perspektip Jangka Panjang Perekonomia Indonesia Tahun 2000: Berberapa Alternatip Skenario Perekonomian Indonesia", Lembaga Penyehdidikan Ekonomi dan Masyarakar (LPEM), Fakultas Ekonomi, Universitas Indonesia, 1980. Laporan untuk LEMKAS-LIPI: Jakarta: LPEM-FEUI.

2. PLN Perusahaan Umum Listrik Negara Pusat: Usaha Usaha Diversifikasi Energi Dalam Sektor Tenaga Listrik (Jakarta, April 1980).

3. The figures in the Reference Energy System indicated in parentheses are efficiencies of energy transportation and conversion processes: petroleum refining (90 percent), petroleum transportation and distribution (98 percent), LNG and LPG manufacture (78 percent and 93 percent respectively), electric generation (26 percent) and electric transmission and distribution (76 percent). For hydropower, a "fossil-fuel equivalent" efficiency of 33 percent is used. Energy flows indicated in Figure IV-1 include petroleum products not used as energy sources (such as lubricants and asphalts - 1.9 million boe); excluded from the diagram are small uses such as coal and firewood to the transport sector (railroads), electricity to rural households and LPG to industry.
LPG exports in 1978 amounted to 4.3 million barrels, or 3.0 million boe. The difference between natural gas inputs and LPG output not accounted for as fuel us in the LPG separation plant is shown as a process conversion factor of 0.27.

4. Reference energy systems for 1990 and 2000 contain the following assumptions; the breakdown of electricity demand by sector is the same as existed in 1978, transmission and distribution efficiency increased from 76 percent to 81 percent in 1990 and to 86 percent in 2000 according to PLN estimates and refining efficiency is 91 percent. Non energy uses of petroleum products are included as a fixed percentage of transportation fuels, using 1978 data as a basis.

5. Pertamina: Perkiraan Pendapatan Indonesia Dari Export LNG (February 5, 1980), indicates exports of 234 Mboe; the source for the amounts shown here is MIGAS (see Appendix B).

6. MIGAS estimate of LPG exports.

7. GDP growth rates being used by MIGAS in current (June 1981) projection analysis, provided by Ir. Sumbaryono, Directorate General of Oil and Gas.

V TECHNOLOGY ASSESSMENTS

A. EVALUATING ALTERNATIVES

Indonesia has the basic good fortune to have a substantial set of alternatives to oil. Oil remains the easiest to use and the cheapest to produce, but the relatively cheap and easy past is phasing into a more difficult and expensive future. The significance of this chapter is that it outlines the clear availability of alternatives in coal, biomass, hydropower, geothermal, solar, and wind energy. It also notes, however, none of these alternatives can be put in place without spending considerable capital and developing expanded organizational capability. In the past Indonesia made a formidable effort to gain control of its oil resources. A substantial effort will have to be made again to substitute other fuels for some of those oil resources. The discussion in this chapter provides a sense of what is needed to successfully supplement the current national energy program.

The scope of this project did not allow new field measurements or resource evaluations for the resources. Rather, using existing information and extensive interviews, the assessments attempted to evaluate each of these alternatives in a consistent manner and within a common framework of future energy demand.

In each case the following issues were addressed:

- Extent of the basic resource
- Extent of current expoloitation of the resource
- Potential future use of the resource/technology
- Barriers to be overcome if the resource/technology is to achieve its potential level of use
- Most important next steps to be taken to develop the technology

In judging the future potential of a technology we have considered

economic feasibility; we assume no introduction of a technology unless it is cost competitive relative to the world price of oil. In many cases, if wide-spread application of the technology is to be accomplished a number of financial, institutional and commercial barriers must be overcome. Our evaluations give some idea of the nature of those barriers and of the benefits to be obtained by overcoming them.

B. THE POTENTIAL FOR COAL USE*

The Resource Base

Coal represents Indonesia's most significant energy resource for growth in the intermediate term. The nation's coal resources, some 15 billion tons, have an energy content 2 - 3 times that of oil and gas combined. Peat may be a resource of comparable magnitude. Table V-1 shows some current estimates of coal reserves.

Table V-1

COAL RESERVES
million metric tons

Region	Hard Coals	Lignite
West and Central Sumatra	200-300	
South Sumatra	200-250	15,000
N.E. Kalimantan	100-150	
E. Kalimantan	100-150	500
S.E. Kalimantan	150-200	
W. Java	10- 20	

There also appear to be very large unevaluated deposits on Kalimantan

* Details of this assessment are to be found in Appendix E, "The Coal Potential in Indonesia", by M. D. Schlesinger.

probably of lignite quality.

To our knowledge peat has never been considered seriously as an energy resource in Indonesia. However, what evidence there is suggests that there may be up to 140 billion tonnes of coal equivalent (200 billion tonnes of peat) available. Indonesian peat (considered as an organic soil) has been analyzed by the Soil Research Institute at Bogor to have a carbon content of 40 - 60 percent.

Historical and Current Use

Coal production in 1941 attained a level of two million tonnes a year, about a third of which was exported. A low point in production was reached in 1973 (about 150,000 tonnes) but by 1979 production had reached almost 280,000 tonnes. Of that amount about one tenth was exported. The current use of coal is discussed elsewhere in this report but it should be noted here that about a third is used for power generation at and near the mines and none for central station generation away from mines. The cement industry (about 50,000 tonnes)and railroads (about 30,000 tonnes) are also major users.

Potential Future Use

Plans are now complete for increasing the production of coal at Bukit Asam from about 200,000 tonnes per year to 2.5 million tonnes per year by 1983/84. Most of the output will go by rail and barge to the new Suralaya power complex. The Suralaya plant will have a capacity of 800 Mw in its first phase but consideration has been given to a doubling of the entire chain (mining to power) by the late 1980's. The Ombilin mine, now serving a partially loaded power plant of 12 Mw, could be a significant energy source - at least for the Central Sumatra region. Its sustainable production could be at the level of 1 - 1.5 million tonnes per

year. The resources at Banko in South Sumatra represent the largest identified source of coal. Future possible production levels are highly speculative but 8 - 10 million tonnes by 1990 and 20 - 30 million tonnes by 2000 are not inconceivable. To judge from current experience, coal will be an economical replacement for oil. Even Bukit Asam coal delivered to Suralaya (at $70 per tonne) is half the price of oil (at world market prices). Ombilin coal delivered to Padan is considerably cheaper ($44/tonne). Several million tonnes of peat could also be produced by 2000 at comparable energy costs.

In addition to use in central station power plants and industry, such as cement, there is the possibility of using coal for domestic cooking. There is some evidence that coal is being so used informally around existing mines (see Appendix). Although it would have to be devolatilized and briquetted, coal fuel would probably be considerably cheaper than kerosene. The small mines on Java would be an advantageous source; levels of use of 100,000 tonnes in 1990 and 200,000 tonnes in 2000 are quite possible (1,300 and 2,600 barrels of oil equivalent, boe, per day). Peat could be used in a similar way. Total levels of coal and peat use in households could be 300,000 tonnes in 1990 and 800,000 tonnes in 2000.

Barriers to Future Development and Use

There are barriers of various kinds to the full exploitation of Indonesian coal resources. Among these are:

1. Lack of adequate characterization of the coal resources; geological and chemical

2. Remoteness of the resource relative to users and the attendant need to develop a transport infrastructure in an uncertain investment climate.

3. Lack of trained personnel at various levels but particularly in middle management in coal development and use.

The recommendations cited below address these barriers.

Recommendations

Background for many of the following recommendations is to be found in Appendix E.

1. A national coal development plan should be created. The plan should address issues such as resource appraisal, mine and infrastructure development, supporting R&D, manpower development, future coal use possibilities, environmental and social concerns and should arrive at a national coal investment plan. That plan could then be the basis of future discussions with possible investors and financial institutions.

2. An evaluation should be made of peat as an energy source for Indonesia. This evaluation should include a survey of international peat use, a resource evaluation, and assessments of means for using peat for power production, industrial heat and domestic uses. This could be part of the national coal development plan.

3. One or more coal research and testing centers should be established. One of the centers should establish a coal bank consisting of carefully selected representative samples (amounting to a few tons each). An active program of coal chemistry, catalysis and combustion (including coal-oil and coal-water mixtures) should be developed. Research on peat should be included in one of the centers. The centers should be based at or affiliated with universities in order to support appropriate manpower development.

4. Field testing should begin on domestic use of coal for cooking. This would require preparation of various types of coal and briquets, and stoves and a technical-sociological testing program in a number of areas. The program should also include evaluation of small-scale, labor intensive mining.

5. Although eventually it may be advantageous to produce gaseous and liquid fuels from coal, given Indonesia's gas and oil resources and projected costs of synthetics, synthetic fuels from coal should not be accorded a high priority at this time. They should be considered after simpler alternatives such as coal-oil mixtures.

6. It would appear that the national level coal coordinating committee, which exists on paper, should begin to funciton actively. The development of a vigorous coal program will involve many agencies and institutions and it is of some importance to establish a network of coal researchers and planners. A great deal of information must flow through the system - much more from abroad than in now the case - and that flow must be managed. The coordinating committee should be able to draw on experienced Indonesian and foreign technical experts as required. The committee should oversee the study recommended in point 1 above.

C. ENERGY FROM BIOMASS*

Introduction

Biomass in its largest sense refers to all living matter. Here we use the term to refer to material of vegetable origin, such as wood, rice husks, farm and animal wastes that can be burned directly or converted to a fuel such as charcoal or biogas. The challenge for future biomass use in Indonesia is to reduce the economic, environmental and social cost of current biomass - particularly wood fuel - use and to take advantage of the vast biomass potential of the country to reduce its dependency on finite oil resources.

The Resource Base

The forests of Indonesia produce annually an amount of renewable energy equivalent to over 2 billion barrels of oil (boe), far more than current oil production and more than 20 times current fuel-wood use. Because of its location,

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* Details of this assessment are to be found in Appendix F, "Assessment of Biomass as an Energy Resource in Indonesia", by Olympic Associates. See also Appendix C.

and high unit energy transport cost, only local resources are now being used, leading to serious local deforestation, erosion, high fuel prices and pressure on kerosene supply.

Currently, 122 million hectares are in forest and are classified as 47 million hectares production forest, 40 million hectares protection forest, 10 million hectares conservation forest, and 25 million hectares reserved forest. Unproductive land in Indonesia amounts to 42 million hectares. Current use of woody biomass continues to increase, exceeding recorded production by some 36 million tonnes in 1976 on Java alone. Very large uncertainties attach, however, to both the supply and the demand side of the biomass picture (see Appendix C).

Current Use

As discussed in Chapter IV about 45 percent of current energy use is in the form of fuelwood, while agricultural wastes account for an additional 15 percent.

Potential Future Use

On Java alone the four million ha of so-called wasteland (i.e. marginal land not well suited for agriculture) could produce 40 million additional tonnes of biomass by the year 1990, equivalent to at least 80 million boe, and if the remaining 16 million ha of wasteland in Indonesia could be forested by year 2000, the total fuelwood production from forests could be 200 million tonnes, equivalent to at least 400 million boe. Much of this energy could be used directly without conversion to charcoal, but even if charcoal were to be developed and used extensively on Java, the loss in charcoal conversion of 50 percent would still result in 200 million boe for household use on Java. It may be reasonable to expect that 10 percent of this potential could be attained by 2000.

The opportunities for expanding the current use of biomass in the industrial sector, particularly the forest products industries, and the introduction of biomass as a fuel for electricity generation in remote and isolated areas of Indonesia are promising. The forest products industry, particularly plywood and pulp, and paper, are growing rapidly. Almost all the existing saw mills and plywood mills use diesel generators for supply of plant power requirements. The wastes available from the saw and plywood mills can be used to generate the energy requirements of these mills and wood-fired cogeneration is perfectly suited to the plywood industry. With an aggressive effort, the forest products industry could become energy self-sufficient within the next 10 - 15 years. Forest product wastes have the energy content of several hundred boe.

Electricity generation by small wood-fired electric power plants should be considered for Sumatra, Kalimantan and other forest-rich islands. These islands not only have the resource, but also provide ideal sites for demonstrating the technical and economic feasibility of small scale (0.5-10Mw) wood-fired power plants. The gasification option could also be considered for retrofitting existing small (less than 10 Mw) PLN oil-fired electricity-generating plants in Sumatra and Kalimantan. The relative economics of direct combustion vs. gasification systems tends to suggest that existing facilities could best be retrofitted with gasification systems, while new facilities could best be served by direct combustion technology.

For household energy use, technological advances in the fields of silviculture, charcoal production and charcoal stove design will make

increased use of natural growth of biomass and charcoal a technically and economically feasible method to meet energy needs of the householder in the next 10 - 15 years. Methane production from organic wastes for household use is perceived to have a limited potential in Indonesia, primarily because of several technical, economic and social barriers.

There are a number of possibilities of producing liquid fuels - ethanol or methanol - from biomass. A project is now getting started to produce 5 million litres a year of ethanol from sweet potatoes in South Sumatra and there are ambitious plans to multiply that project in other transmigration areas. Whether agricultural crops or wood should be used for alcohol production is still a question but, based on other countries' experience (particularly Brazil) an aggressive program should be able to produce 25 million boe by 2000 and perhaps 5 - 10 million boe by 1990.

Where there is a shortage of fuelwood, such as on Java, the use of agricultural wastes and the home garden's potential for firewood are important. Data indicate that if home gardens were well managed they could contribute up to 60 percent of the fuel demand of a village community. Agricultural residues on Java will not increase significantly, since the agricultural productivity is presently at nearly its maximum level, and therefore the potential from agricultural wastes would be another 8 million tonnes, or, at a rate of two boe per tonne, approximately 16 million boe. Some of this could be supplied in the form of charcoal, for example, produced by pyrolysis of rice husks.

There are several programs underway to increase biomass resources. These include dissemination of seeds and seedlings of fast growing trees, experimental plots of fast growing trees, and research on soil characteristics relating to increased biomass production.

Barriers to Future Development and Use

Three types of barriers must be addressed in the increased use of biomass:

technological: more efficient technologies must be adapted. These include charcoal production, fast growing trees (more efficient solar conversion), pyrolysis etc. The logicities and economics of the use of ethanol produced on small scale farms present difficulties.

geographical: if the major biomass producing areas are to be used effectively higher energy density products - charcoal, methanol, ethanol - must be developed at large scale.

socio-cultural: social patterns may have to be adapted to new energy forms such as charcoal use for cooking, and the growing of new tree varieties.

Recommendations

Details of the following recommendations are provided in Appendix F.

1. One of the major difficulties in this area as elsewhere in the energy system is the large uncertainties that attach to important pieces of information. One source, for example, attributes an uncertainty of a factor of 1000 to wood used by industry off-Java. Generally subsector output figures are used to derive fuel use - a very unsatisfactory approach. Thus a high priority should be given to obtaining better information on biomass supply, particularly as it is currently used and as it can be used by rural industry and households.

2. An accelerated program of research on fast growing trees is recommended (specific species are identified in Appendix F). Tests should be made of single-row culture which should be expanded to village programs to encourage hedge-row planting of fast growing varieties. These varieties could also be used for village woodlots and large fuelwood plantations on Java.

3. Increased use of charcoal from ravaged forests or woodlots and increases in the efficiency of charcoal production can play a positive role in avoiding the dual problems of deforestation and increased kerosene use. Development and demonstration programs are recommended on: adaptation of efficient charcoal production methods, the charcoal marketing and distribution system particularly the concept of charcoal centers, improved cooking devices, and charcoal production from agricultural wastes.

4. Very large amounts of logging and sawmill wastes (many million cubic meters annually) are available for more effective use. Energy self-sufficiency of the wood products industry should be a near term goal. Efforts should be made to develop data on conversion units (combustion - steam turbine - electricity or gasification) and promote their acquisition by the wood products industry.

5. Wood based power plants are worth increased attention. At a minimum, one or more pilot scale dendrothermal (wood-burning) power plants should be built, with experience derived from the current pilot scale dendrothermal project in the Philippines. One or more demonstrations are warrented of wood gasifier power plants.

6. Accelerated research is recommended on large as well as small scale pyrolysis units and the commercialization of this technology should be supported. Large scale pyrolysis units should be investigated based on wood and wood residues; tests are required on the use of pyrolytic oil as a substitute for industrial use of fuel oil. The application of gasifiers based on agricultural wastes and powering agricultural equipment should also be investigated. Support should also be continued for the current biogas program.

7. A national program for alternative liquid fuels production from biomass should be developed subject to an evaluation of the non-technical aspects of such a program. Initially, parallel tracks may have to be followed on ethanol production from crops such as cassava or from wood and methanol production from wood.

D. SMALL SCALE HYDROPOWER*

The Resource Base

The total hydropower potential of Indonesia has been estimated at 31,000 Mw with roughly one third of that amount being on Irian Jaya. Currently there are 523 Mw capacity installed. In considering small scale hydropower (in the 10kw - 500kw range) the applicable resource is limited considerably by population distribution since the resource is used locally. Furthermore, small scale hydropower generally will not

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* Details of this assessment are to be found in Appendix G, "Small Scale Hydropower and Geothermal Energy in Indonesia," based on work by Kenneth Grover.

be used in areas now served by the central grid and initially will find its greatest value in serving remote areas in place of diesel generation. Taking these elements into consideration, the small scale hydro resource base is roughly 500 - 1000 Mw.

The Potential for Future Use

We have estimated that approximately 9 million people in rural areas of Sumatra, Kalimantan and Sulawesi could be served by small scale hydro in the next 15 - 20 years. For all purposes we have assumed a per capita usage of 50 watts. This corresponds to 450 Mw of connected load. The size of the units would vary from 25 kw (for villages of around 500 people) to 150 kw for groupings of 3000 people. By 1990 it could be possible to install 100 - 150 Mw of small scale hydropower.

Barriers to Use

The technology is available, economical and can, at least in part be manufactured locally. Two major barriers to the use of small scale hydropower would seem to be:

1. Lack of adequately trained manpower and an adequate development program.

2. Insufficient attention to decentralized alternatives for rural electrification.

Recommendations

In order to extend a small scale hydropower program beyond what currently is being implemented, the following steps are recommended. The emphasis should be on more rapid deployment of small scale (up to 150 kw) units:

1. A survey should be carried out of areas in Kalimantan, Sumatra and Sulawesi to select and collect data on 20-25 sites according to criteria enumerated in Appendix G. Approximately 100 guaging stations should be installed to develop flow- duration curves for a group of separated river basins.

2. A training and professional development program should be initiated. This could include a regional small hydro workshop, held in Indonesia.

3. An analysis should be carried out of the economics of decentralized rural electrification based on small hydro in comparison with central and decentralized alternatives, in particular that of an extension of the grid.

4. A target should be set for small hydro power development - perhaps the 450 Mw by 2000 in this report - and the manufacturing capability developed to achieve that goal. The first step is to achieve this target is to establish a clear design philosophy.

E. GEOTHERMAL ENERGY*

The Resource Base

The geography of Indonesia is obviously favorable for geothermal energy. The three requirements needed to create geothermal energy recovery possibilities are:

a) presence of magma near the earth's surface.

b) sufficient elevation above sea-level to give adequate hydraulic load in the re-charge water circuit.

c) proper sub-surface rock conditions to permit heat exchange between the hot magma and the re-charge water.

The high rate of rainfall (2000 mm) in Indonesia completed the picture through adequate supply of re-charge water. The total exploitable of geothermal potential of Indonesia has been estimated at 8,000 - 10,000 Mw, with about half of that total on Java.

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* Details of this assessment are to be found in Appendix E, "Small Scale Hydropower and Geothermal Energy in Indonesia", based on work by Kenneth Grover.

There is a 150 kw unit in operation (currently at 100 kw) at Kamojang in West Java and a 2 Mw unit just starting up on Dieng Plateau in West Java. The government has identified seven areas on Java for development and has invited foreign firms to submit proposals for exploration, development and possibly power generation. In Sumatra there are six locations identified and in Sulawesi three.

Potential for Future Use

Although it would require a considerable effort, we would estimate that the 3400 Mw of geothermal power being planned could be on line by 2000. This estimate is due in part to the availability of the technology and the favorable power costs - about 2.5¢/kwh to be expected.

Recommendations

1. If the potential of geothermal energy is to be achieved, exploratory drilling must be increased substantially. Currently 3 drilling rigs are in operation. Achievement of a 3400 Mw target by 2000 would require roughly 10 times that number.

2. Once promising field are identified, rural electrification programs should be funded in areas where small monoblock units can be installed to yield small blocks of local power and, at the same time, to "prove-out" the field.

3. A training program should be designed for geothermal geologists and power development engineers.

4. An investigation should be carried out of the feasibility of basing thermal energy intensive industries in geothermal areas. Food, paper, textile and other industries now using fossil fuels could profitably be sited in such areas.

F. SOLAR ENERGY*

The Resource Base

The application of solar energy in Indonesia is not limited by the total resource; even on Java the amount of solar radiation reaching the ground is extremely large compared with current energy consumption. In a year every square Km absorbs the equivalent of a million barrels of oil. There are quite large variations of solar intensity over the country, however and current information is not adequate to form firm conclusions about the economics of various applications. In particular there is very large uncertainty in the ratio of direct to diffuse radiation which affects the applicability of concentrating collectors.

Current Use

There are a number of solar experimental programs under way at Indonesian universities and institutes. Although some of these involve the participation of industry, for example in testing crop dryers and solar water heaters, none has reached the commercial stage. There is some photovoltaic electricity production, in small scale applications and a number of tests underway of various imported systems.

Potential Future Use

The potential for the use of solar in Indonesia is large. The areas of early adoption will be single hot water systems for individual homes and other small uses, institutional solar hot water heating (hotels, military, public housing projects, etc.), industrial hot water heating (beverages

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* Details of this assessment are to be found in Appendix H, "An Assessment of Solar and Wind Energy in Indonesia", by James D. Westfield.

and food preparation), agricultural uses such as crop drying, and stand-alone electrification with photovoltaics.

A small solar hot water heating system built in Indonesia has been developed and demonstrated, and as soon as these systems are commercially available (probably 1983) there should be an excellent market for them. If the growth of the market for hot water heating increases as it has in the past, a total of approximately 10,000 new units will be required each year. If a locally constructed system could sell for $500 US, the size of the potential annual market from only this use would be $5 million US. If only 20 percent of this demand were supplied by solar units, the annual solar market would be $1 million US. By 1995 approximately 40 percent of the annual installations could be solar. Larger solar hot water heating installations for commercial and industrial establishments are also likely. The installation of these will likely start in the late 1980s with imported systems, and in the 1990s Indonesian systems should be available.

A large potential market for more sophisticated solar hot water heating is hotels. Once this market is opened, other institutions such as hospitals, the military, etc., and certain industries will also be targets for solar hot water heating. Because the economics of institutional solar hot water heating are very much determined by the system design and cost, it is difficult to estimate specific market penetration rates or savings. However, by the year 2000 a target of 30 percent of the hot water to hotels, hospitals and industry to be provided by solar is not unreasonable. There are numerous reliable systems available for commercial solar hot water heating which can be imported and installed. The Indonesian market is already attracting interest on the part of exporting countries. Despite the desirability of solar energy replacing oil, that goal can be combined

with the aim of local employment and participation, particularly with these technologies.

The overall impact of solar water heating is not expected to be large. Even at the levels discussed above, less than one percent of consumption in the year 2000 could be replaced, representing an oil savings of 5.6 mboe. Solar crop drying can represent a significant contribution to the agricultural sector if not to the reduction of oil demand.

Photovoltaics are another area of possible major solar involvement. At present, research is underway into assembly and partial manufacture of photovoltaic modules. It is likely that no meaningful in-country manufacture will take place until:

- Simplified and less expensive manufacturing techniques are developed in the United States, Germany or Japan, and adopted by Indonesian industry.
- An existing manufacturer decides to locate a facility in Indonesia.

The total impact on energy use will be small until either of these two steps is accomplished or prices of internationally manufactured cells drops significantly. The 1990s will be a growth period for photovoltaics and many specialized uses are possible. When they become economically competitive with other alternatives, which is projected as happening some time in the 1990s and at least by the year 2000, as much as one-tenth of one percent of the electricity demand could be supplied by photovoltaics. This 0.1 percent would be in areas off Java where decentralized diesel power is now located. One-tenth of one percent of the electricity demand would be approximately 300 Gwh in 2000. Using current efficiencies and an average solar radiation intensity of Indonesia this would require 2.7 million

square meters of photovoltaics.

There are other solar systems which should also be considered as possibly important to Indonesia's energy future. Concentrating solar thermal electric (power tower) and ocean thermal (OTEC) systems are both under consideration as major sources of electricity for the grid or for individual industrial or agricultural applications. If world testing and development continue at their present rate and are successful, these two should be available by the late 1990s. At the present, the use of concentrating solar thermal systems is questionable because of the possibly high percentage of diffuse radiation in Indonesia. Very little performance or cost information is available for OTEC, but the minimum thermal gradient necessary to consider applying this is found in the waters off Indonesia (37°F difference between surface and 1000 meters below the surface). Thus, this may be a solar technology of the future for Indonesia, but we will be able to say very little about the potential until the 1990s.

Barriers to Future Development and Use

The most important barriers to the use of solar energy in Indonesia are:

1. Lack of knowledge of solar resource.

2. Lack of understanding in potential manufacturing and using public of potential for solar applications.

3. Lack of infrastructure to manufacture, supply, operate and maintain solar equipment.

4. Marginal cost competitiveness of most feasible solar technologies (water heating) and non-competitiveness of others (photovoltaics, OTEC, etc.).

These barriers will not be overcome, however, and even the modest contributions described above will not be attained, unless a much more vigorous program on the part of the Government is undertaken to implement

commercially available solar technologies, particularly solar water heating.

Recommendations

The foundations for a major solar energy program exists in Indonesia but there are several additional components which must be added if solar energy is to contribute to the country's energy future. The following steps are recommended. Because of their complementarity, recommendations regarding wind power are included here. Details on all of these recommendations are contained in Appendix H.

1. An overall solar and wind development plan should be prepared. Presently, numerous agencies and entities are involved in the field and it is evident that often their activities are unsufficiently coordinated. This effort should focus on resource characterization, publicity and public information and application stimulation.

2. As soon as a plan is prepared (no more than six months) a public and professional meeting should be held to introduce the plan and announce the state of solar and wind development in Indonesia. This meeting could be held in conjunction with an equipment and technology show.

3. Twenty small meteorological stations should be purchased and located in various places in Indonesia. At least 12 should be located outside Java. The stations should measure and continuously record at least total global solar radiation, temperature and wind velocity. The stations could be operated and maintained by the Meteorology and Geophysical Institute with assistance from DJK and LAPAN.

4. DJK should establish an information system on solar and wind research, study, demonstration and applications. There are many people and institutions involved in solar and wind research and the center would provide a very useful service to all those engaged in solar and wind research, potential manufacturers and users and to DJK itself in its planning and coordination role.

5. Complementary to current work on solar water heaters for domestic use and rural applications of solar energy, the Government of Indonesia should encourage solar and wind

research and technology demonstrations pertinent to commercial, industrial and institutional use. This activity should emphasize government use of technologies such as solar hot water heating. This program should also emphasize and support demonstrations of solar crop drying and cooling or refrigeration of vegetables. In this area, commercial size dryers and coolers should be constructed and demonstrated. Funds for testing of solar technologies useful in heating hot water for food processing and beverage production should also be included. If possible, the government should encourage industry to participate and share some of the costs in this effort.

6. An economic policy analysis is required to establish a set of subsidies or incentives for the encouragement of renewable energy sources. Solar, wind, microhydro, biomass, etc., should be considered and specific incentives and subsidy programs should be developed to encourage the introduction and use of these technologies. The programs developed under this activity should be long-term and directed at creating a healthy Indonesian renewable resource industry. Installation, maintenance, assembly and manufacturing of technologies should be emphasized.

G. WIND POWER*

The Resource Base

The data on wind velocity and direction in Indonesia are very poor. Despite the long records of wind velocity and direction at numerous stations throughout Indonesia these data are inappropriate for wind energy estimation purposes. Wind data from the usual airport locations are not useful to describe the wind regimes because of their atypical locations.

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* Details of this assessment are to be found in Appendix H, "An Assessment of Solar and Wind Energy in Indonesia", by James D. Westfield.

The other wind data available in Indonesia are high-level, above one mile, wind measurements for use in predicting long-term weather trends. There is almost no reliable continuous record of surface winds at any location in the country. BPPT and LPANA have begun to accurately measure wind at several sites, but there is not enough data to prepare a wind velocity map similar to the solar radiation map. It is likely that wind resources can be developed, but there is not enough information to estimate the quantity or quality of surface winds and thus the economics of wind power.

Current Use

There are no major uses of wind energy in Indonesia currently but there are a number of small scale applications and projects. There are several wind powered water pumps throughout Java, but there seems to be no plans to expand this use at present. Also, because some of the earlier attempts to use wind were not successful, there is presently a negative feeling about the potential for wind powered pumping. Wind powered electrification is also being considered, but only two prototype machines have been built and tested. The machines (combinations of Savonious and Darius rotors) have had problems and are undergoing redesign by LAPAN and ITB.

Potential Future Use

In spite of some local optimism, wind electrification will not take hold in Indonesia until a medium-scale, cost effective technology (1-50 kilowatt sizes) is available and/or manufactured in the country. Assuming

100 watts average as a minimum capacity for a rural household, a 50 kilowatt system would only serve a village of 500 households at a maximum. If wind electrification is to be used for commercial or small industrial applications this size range is also appropriate. The availability of a cost competitive 1-50 kilowatt wind machine should occur in Indonesia between 1985 and 1990; and, thus, the adoption rate or level of wind use for electrification will be small until after 1990.

If wind power is to contribute significantly to electricity production, even off-Java where the wind regime is expected to be favorable, machines of much larger size that 50 kw will be required*. There are machines in testing in the U.S. with 2 - 2.5 Mw capacity (MOD-1 and MOD-2) but these are not expected to be commercially available until after 1990. By 2000 if 50 large machines (of 2.5 Mw capacity) were installed this would produce about 185 Gwh of electricity per year, or only 0.1 percent of anticipated demand.

The use of wind to produce mechanical power has a large number of possible applications, especially off-Java. In the islands where small-scale agriculture is being emphasized, where diesel fuel supply is difficult and average wind velocities are at least 3.5 m/s, wind pumping should be considered. This type of application can affect a large number of people and be of great benefit in terms of agricultural production but in terms

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* As shown in the appendix, the supply of only 0.1% of off-Java electricity by 1990 would require 30,000 to 150,000 machines of 50 kw size.

of the overall amount of oil saved by the year 2000, the impact will be small. Furthermore, the use of wind power for pumping will be minimal until an Indonesian wind pumping system is available. It is hoped that this will happen before 1990. By the year 2000 a large number of wind pumping installations could be in place on the islands.

Barriers and Recommendations

Barriers to the future use of wind power and recommendations regarding future work were included in the discussion of solar energy above.

H. RELATIVE ECONOMICS

The cost of energy from any of the options discussed in this section depends on a large number of local factors including the cost of labor, the intensity of the source, the cost of transporting fuels or energy produced, the time characteristics of use and the cost of capital. A rough comparison of costs can be obtained, however, from international experience. Such a comparison is shown in Table V-2.

TABLE V - 2

RELATIVE COST OF ENERGY FROM VARIOUS SOURCES

Fuels	Relative Cost, $/bbl
Crude Oil[a]	34
Gasoline[b]	45
Kerosene[b]	47
Ethanol from Sugarcane	30 - 50
Methanol from Natural Gas[c]	25 - 45
Gasoline, Diesel Fuel from Coal	40 - 60
Solar Heat	40 - 90
Geothermal Heat	9 - 11
Electricity	**Power Cost US¢/Kwh**
Large Hydropower	2 - 3
Small Scale Hydropower	2.5 - 4
Geothermal, dry steam	2 - 3
Diesel, small scale	10 - 13
Coal Fired Steam, large	5 - 6
Oil Fired Steam, large	7 - 8
Wood, small scale	9 - 10

Sources: World Bank (1)

Notes: a) Reference world market price
b) Based on $34/bbl crude
c) Based on gas price of US$0.40 - 1.50 per Mcf.

CHAPTER V

Notes and References

1. The World Bank, "Energy in the Developing Countries" Washington, D.C. August, 1980.

VI A DIVERSIFICATION STRATEGY

A. FUTURE OIL PRODUCTION AND CONSUMPTION

Petroleum products, accounting for well over half of the total value of exports, are currently the single largest source of foreign exchange for Indonesia. The contribution of petroleum exports to Indonesia's economic growth is no less significant; revenues from oil exports equalled 20 percent of GDP in 1978 and are larger today.

There is currently a wide variety of views regarding future oil production in Indonesia. While Repelita III has set a target of 4 percent growth per year, and that growth rate has been used by others[1], other analysts have predicted constant output while several others have anticipated growth from the current level of around 580 million barrels per year to about 725 million barrels per year by 1990 and that level being sustained through 2000[2]. We are in no position to add a new set of numbers to this set and thus have chosen a range between constant production and a growth rate of 4 percent per year. In doing so we would attribute a somewhat higher probability to the lower end of that range.

Figure VI-1 indicates the relationship between oil production and demand under the various cases defined above. If petroleum production increases rapidly (at the 4 percent rate) then significant levels of exports will be able to be maintained through the year 2000 even under high demand assumptions. On the other hand, if production remains constant, and demand grows at a high rate, demand will outpace

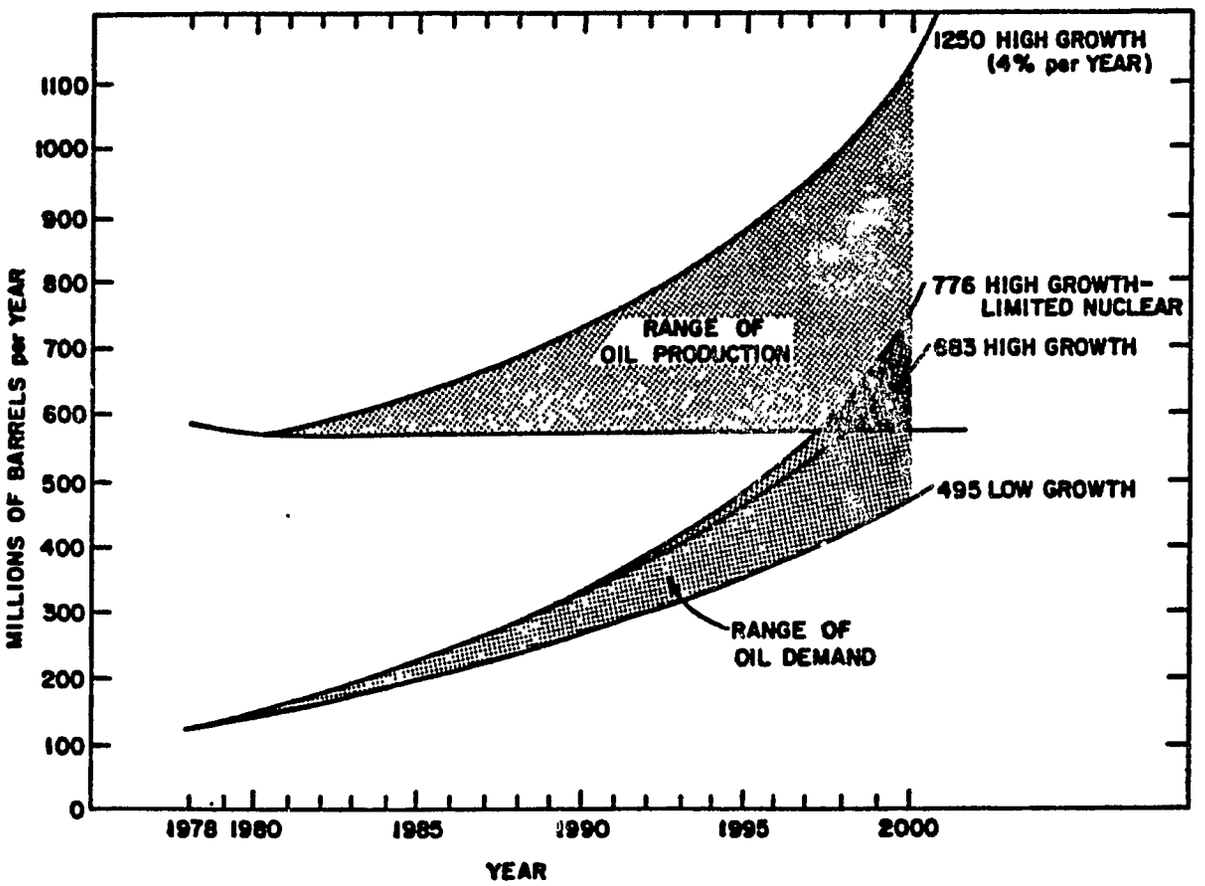


FIGURE VI-1: RANGES OF FUTURE PETROLEUM PRODUCTION AND PROJECTED DEMANDS

production in the late 1990's. Even in the low demand case, the potential for petroleum exports dwindles rapidly towards the year 2000.

Figure IV-2 presents estimated revenues from the export of crude oil for 1990 and 2000 under the two production assumptions. In each case, a 2 percent per year increase in the real price of oil is assumed, starting from a base price of $36/bbl in 1981. The left hand side of each set of bars reflects the level oil production assumption and the right bar of each pair reflects the 4 percent yearly growth assumption for oil production.

Under the high GDP growth-level oil production assumption Indonesia will be a net importer of oil in the year 2000 at which time a net oil import bill of $6 billion is projected. The low GDP growth-level oil production yields revenues of $4.6 billion, which is less than the current $6.3 billion achieved in 1978. Under the high GDP growth-high oil production assumptions, the contribution of oil revenues to growth is projected to be approximately equal to $30 billion or 10 percent of GDP. In the low GDP growth-high oil production case oil revenues are projected to maintain their contribution to economic growth, amounting to $39 billion or 18 percent of GDP.

B. OPTIONS FOR DIVERSIFICATION

This section presents an analysis of the impact on total petroleum demand in the year 2000 of implementing the technologies and resources discussed in Chapter VI. It is important to summarize salient points incorporated into the energy demand projections presented in Chapter IV: with few exceptions, no technologies are incorporated into the energy system that substitute current petroleum fuels by non-petroleum sources, and no explicit assumptions are made on incorporating improved end-use devices

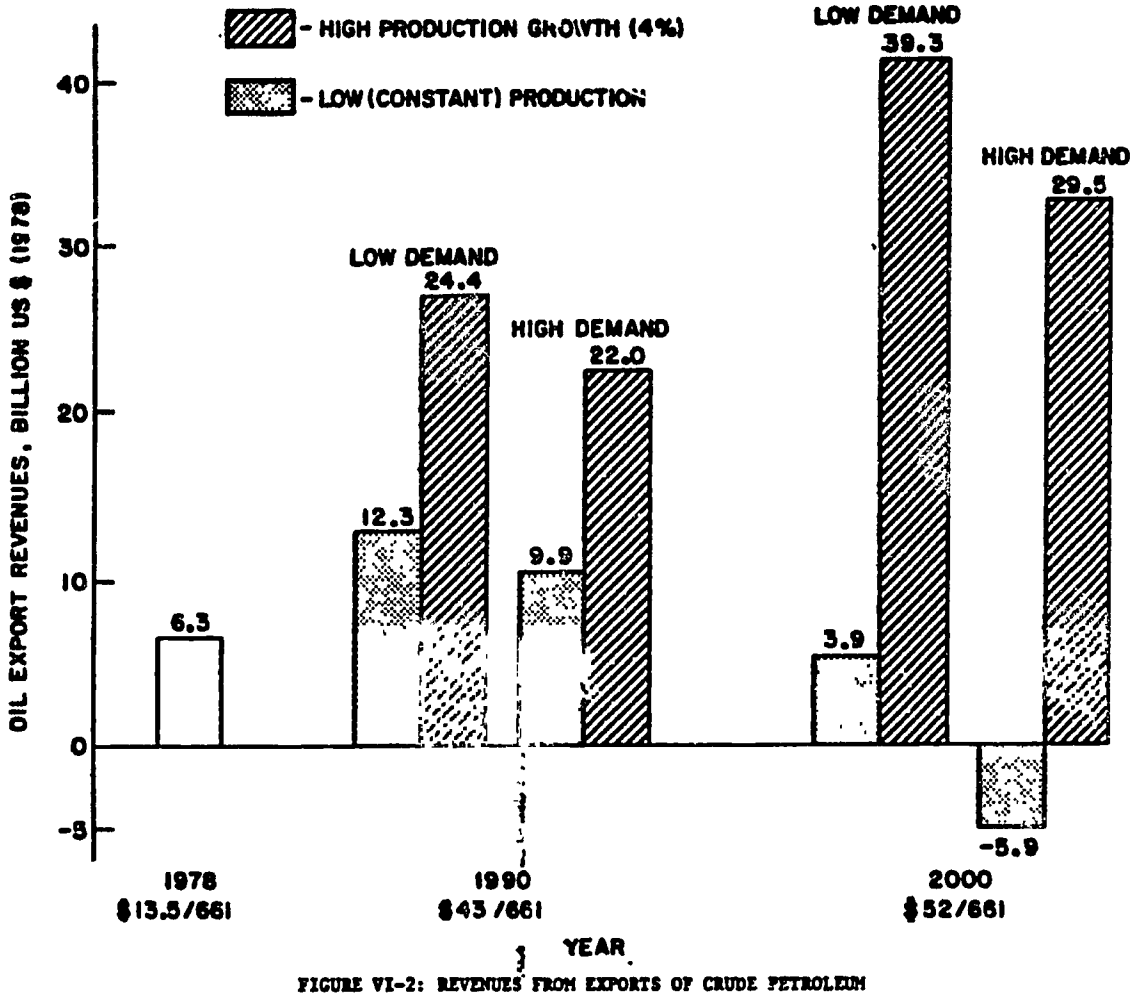


FIGURE VI-2: REVENUES FROM EXPORTS OF CRUDE PETROLEUM

that bring about reduced petroleum demand (i.e., energy conversation). The exceptions are the utilization of 22-28 million tons of coal to the public utility electric generation sector, of 240 Mw of geothermal, and of up to 9100 Mw of nuclear, as specified in PLN's Diversification Plan, which effectively keep petroleum used for electric generation from increasing beyond 1990. Outside the electric sector, the demand projections include few departures from historical trends; one of these is the growing share of natural gas used in manufacturing, due to new facilities scheduled to use natural gas and not from a deliberate substitution of petroleum products.

Technologies and resources introduced below are all assumed to substitute for petroleum products, in order to maximize the difference between domestic crude production and domestic demand, or minimize petroleum imports. A summary is shown in Table VI-1 (3).

Coal to Industry:

The utilization of 10.5 million tons of coal in industry by the year 2000 could replace about 39.9 million boe of petroleum products (assuming a heat content of 0.713 tons of coal equivalent per ton of coal typical of South Sumatran deposits). This represents 25 percent of the projected demand for petroleum products of 159 million boe. This substitution can be achieved by replacing projected demands of fuel oil and industrial diesel oil in the following segments: cement (12.5 million boe), other non-metallic mineral products (construction materials, lime etc. at 18.2 million boe), and iron and steel products fabrication (9.2 million boe).

Coal and Peat Briquettes to Households:

The use of coal and peat resources is a way of reducing growth in

TABLE VI-1: DIVERSIFICATION OPTIONS

Option	Utilization Rate	Petroleum Savings (Million boe)
Coal to Industry	10 million tons	39.9
Coal and Peat to Households (briquettes)	400,000 tons	2.0
Charcoal from Firewood to Households	20 million tons	10.0
Charcoal from Agricultural Wastes to Households	10 million tons	5.0
Forestry Industry	Wood Wastes	2.5
Liquids from Biomass	25.0 kboe methanol	25.0
Geothermal Heat to Industry	1000 Mw	4.9
Geothermal Electricity	3445 Mw	48.0
Wood Thermal Electric	1000 Mw	10.9
Peat Central Station Elec.	6 million tons	15.2
Small Scale Hydro	450 Mw	2.1
Solar Thermal	30% Commercial Use	5.6
Solar Electric	150 Gwh	0.3
Wind	185 Gwh	0.3
		171.7

kerosene consumption for cooking. In order to decrease growth in kerosene by 2.0 million boe (or less than 3 percent of total kerosene demand for cooking of 71.4 million boe), about 400,000 tons of coal and peat would have to be produced.

Charcoal to Households:

The potential for charcoal manufacture from firewood is vast, with a total energy content of the same magnitude as total current consumption of fossil fuels. A significant resource is also present in charcoal manufacture from agricultural wastes. A utilization rate of 20 million tons of charcoal from firewood and 5 million tons of agricultural wastes is assumed for the year 2000, replacing 15 million boe of kerosene, or 20 percent of its projected demand for cooking that year. Expressed in different terms, it signifies that approximately one out of three additional households projected to switch to kerosene would instead switch to charcoal.

Forestry Byproducts:

Rationalization of fuels used in the forestry industry, replacing petroleum products used for raising steam and heat with wastes from sawmill operations. Forestry consumes about 50 percent of the agriculture sector's fuel demand; about one half of this amount, or 2.5 million boe, are estimated to be replaced.

Liquids from Biomass:

Transportation fuels obtained from cassava, sweet potatoes or wood-based methanol are introduced at the rate of 25 million boe by the year 2000, or one eighth of total transportation needs that year.

Geothermal Heat:

Heat from geothermal sources amounting to 1000 Mw are assumed to

be installed by the year 2000. This would replace 11.0 million boe of petroleum based electricity (applied to the high GDP growth, limited nuclear case).

Geothermal Electricity:

There are plans to develop by the Ministry of Mines and Energy a total of 3445 Mw of geothermal electricity. This electricity, sold to PLN, would displace 48 million boe of petroleum or other resources to electric generation-most likely nuclear or coal.

Wood-fired Thermal Electric Plants:

A total of 1000 Mw electric plants fired with forest resources are assumed to be in place by the year 2000. These are in units ranging from 0.5 Mw to 10Mw, and could replace an estimated 10.9 million boe of petroleum fuels, or about one third of the petroleum fuels projected to be utilized for electric generation outside Java.

Peat Central Station Electric:

An estimated 6 million tons of peat could be utilized for electric generation, substituting 15.2 million boe of petroleum products (the substitution is applied to the high GDP growth, limited nuclear case). This estimate assumes that one ton of peat has one half the heat content of coal.

Small Scale Hydro:

For purposes of this analysis a total of 450 Mw of small-scale hydro are added to the system, replacing an estimated 2.1 million boe of diesel to electric generation.

Solar Thermal Systems:

A vigorous program to implement solar thermal systems primarily in commercial buildings and industry was estimated above as replacing some 5.6 million boe of fuel oil.

Solar Electric Systems:

The most prominent option to convert sunlight to electricity, other than through biomass production, is by photovoltaics. We assume that, by 2000, this or other solar systems such as power towers or OTEC could contribute 0.1 percent of electricity production in 2000. This amounts to about 150 Gwh or an oil savings of 0.3 million boe.

Wind:

The installation of 50 wind machines generating 185 Gwh would replace 0.3 million boe of diesel for electric generation.

C. IMPACTS OF DIVERSIFICATION

The total savings in petroleum products enumerated above amount to 171.7 million boe. These reductions in demand have been applied to the year 2000 high growth, limited nuclear case. The results are presented in Figures VI-3 and VI-4 (expressed in barrels of crude oil). The first diagram shows resources employed to meet domestic energy demands for 1978, low and high GDP growth cases for 1990, and low and high GDP growth cases for the year 2000, (derived from Figures IV-1 to IV-5), and finally, the diversification case prepared in this section. The second shows for all the cases the total demand for crude oil broken down by sector of economic activity; households, commerce, transportation, electric generation and lastly, refining and other uses.

FIGURE VI - 3

PETROLEUM DEMAND BY SECTOR

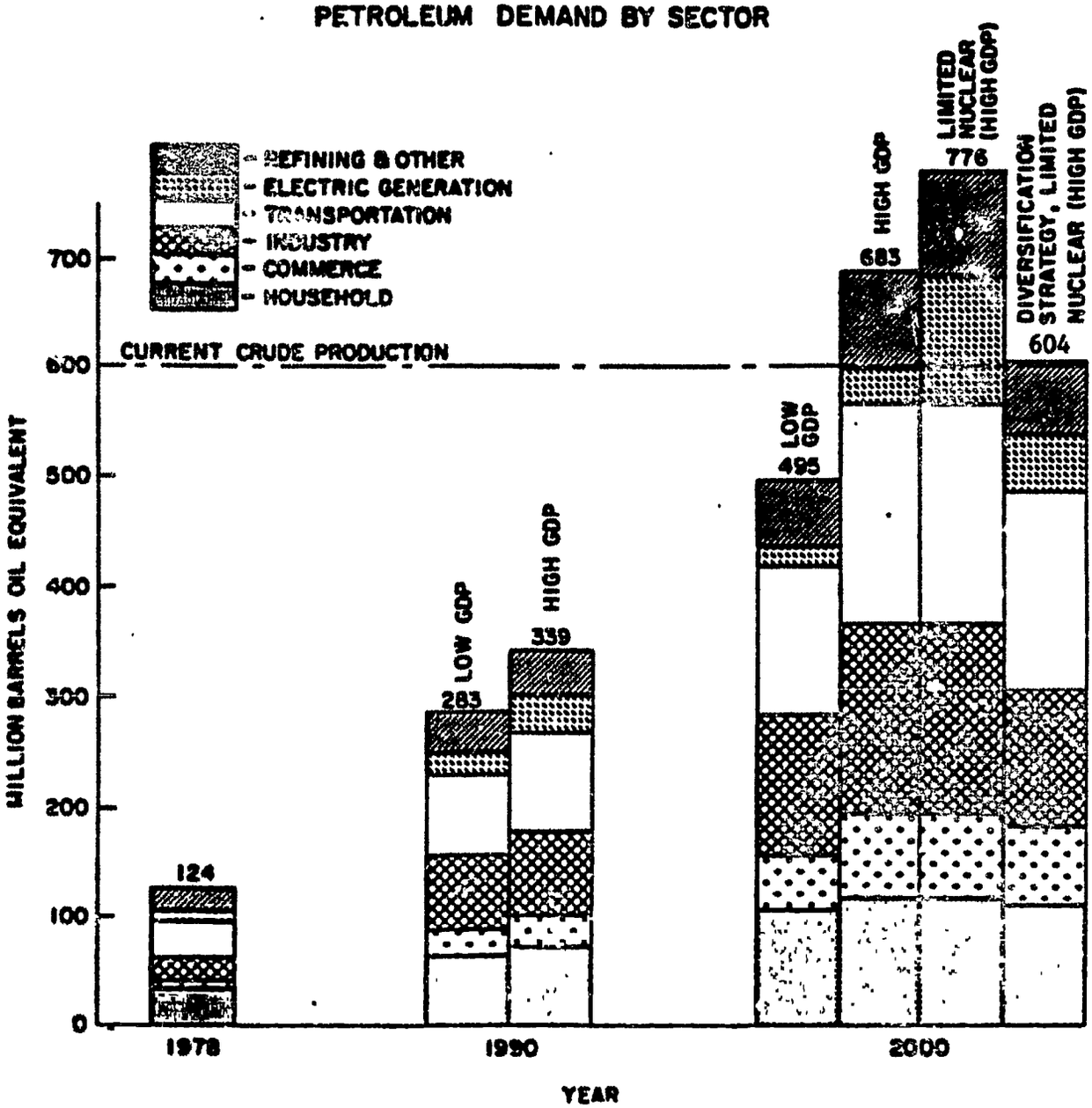
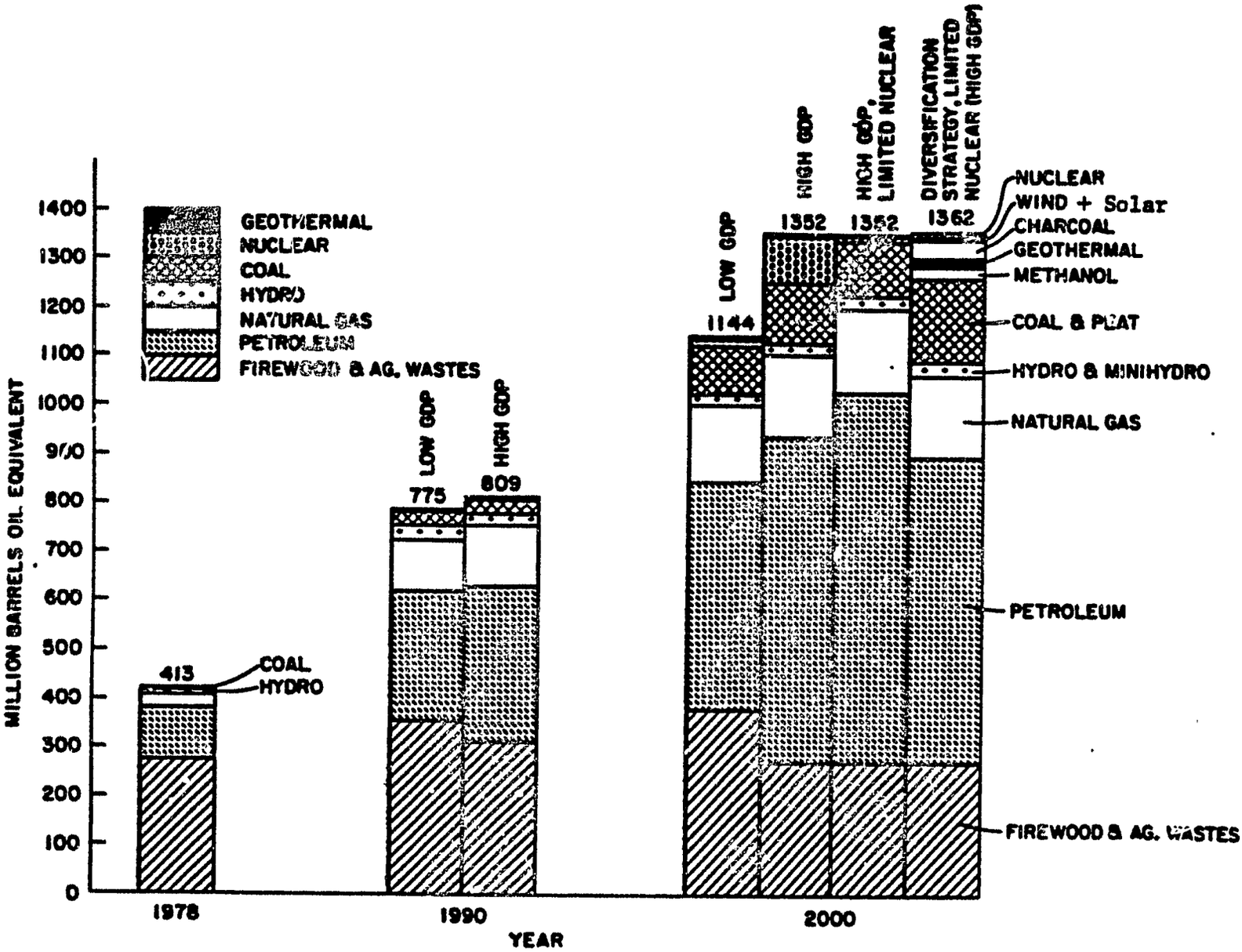


FIGURE VI - 4

PROJECTED ENERGY DEMANDS BY ENERGY SOURCE
(EXCLUDES EXPORTS)



CHAPTER VI

Notes and References

(1) See, for example LPEM, Faknetas Ekonomi, Universitas Indonesia, Perspektip Jangka Panjang Perekonomia Indonesia Tahun 2000: Berberapa Alternatip Skenario Perekonomian Indonesia, Laporan untuk LEKNAS-LIPI (Jakarta: LPEM-FEUI).

(2) See, for example L.M.L. Tobing, "Energy Policy" paper presented at the 7th General Assembly, World Federation of Engineering Organizations, Jakarta, Nov., 1979. Also, Petro Canada and Petroleos de Venezuela, "World Oil Supply Prospects" February, 1980. A recent study for BATAN/PLN by NIRA, "A Long Term Economic Development and Energy Policy in Indonesia," in 3 vols., a report of the PLTN-ITALINDO project, projected a peaking production but also moving towards 700 million barrels per year by 2000.

(3) These estimates of implementation rates are based on material provided in the appendices and summarized in Chapter V.

VII CONCLUSIONS AND RECOMMENDATIONS

A. CONCLUSIONS

This project was not structured or intended to arrive at conclusions regarding Indonesian energy policy or strategies. The emphasis was upon adding to the analytical capability of the DJK through the acquisition of basic data (from the household survey), the construction of a consistent set of demand projections and through strengthening of professional capability within the Directorate. Nonetheless, several conclusions have emerged quite naturally from the analysis and can be noted here.

First, it has become clear that a drastic erosion of oil exports due to increased domestic demand in the next 10-15 years is by no means inevitable. Nonetheless, severely reduced levels of oil export earnings are a distinct possibility unless concerted action is taken to substitute alternative fuels and technologies for internal consumption of oil.

Both future production and future demand for oil are highly uncertain, but conservative assumptions should be made in developing policies regarding alternative energy systems. For example it should not be assumed that oil production will increase much above current levels until such increases are secure. This approach to policy underlines the importance of the alternative energy measures discussed in this report. Indeed, if oil production remains constant, in only one of the demand cases considered (see Figure IV-4) will internal oil consumption be below production in 2000. There then arises the question of whether non-oil exports can increase rapidly enough to make the high GDP growth cases consistent with the low oil production case.

This study has indicated that if vigorous programs are carried out

to develop and implement alternative energy sources domestic oil requirements could be reduced by some 170 million barrels in the year 2000. This corresponds to over 20 percent of demand projected for that time. Whether this scenario is too modest from the point of view of a desire to maintain petroleum exports, or too demanding from the point of view of the capital and organizational effort required is a key policy issue raised by this study.

A large number of energy options can play a role in diversifying Indonesias energy system. Coal appears to be a particularly importent element of a diversification strategy, accounting for more than one fourth of the oil displaced in the diversification strategy. At least ten other resource/technologic combinations appear to hold significant potential for the future. Each of these and perhaps others require further analysis to determine their potential role and benefits to the nation. Some of the options examined here such as solar and wind electricity production make rather modest contributions, even by the year 2000. The energy supply-demand problems of Indonesia will not disappear by that time, however and, given the very long lead times for the development and exploitation of energy systems, one cannot afford to ignore the period beyond 2000 in energy planning.

There would appear to be a significant potential for the greater use of natural gas and LPG in Indonesia's energy system. Although this subject fell outside the scope of the current project, there's the possibility for significantly higher production of LPG for use as a domestic fuel.

Another strategy which should play a large role in future Indonesian energy

policy and which was not included in this study is increased energy efficiency, or energy conservation. Experience from other countries would indicate that 20 - 25 percent savings in oil consumption are possible while maintaining economic growth and the services supplied by energy. This means that the oil consumption characteristics of our low GDP case (around 500 mboe) could be achieved by a combination of conservation and alternative energy strategies, even at high GDP growth rates.

Transportation and Households

This and other recent studies of energy in Indonesia have shown that there are a large number of options for future expansion of electricity supply that do not depend on oil. These include coal, nuclear power, geothermal energy, wood and both large and small scale hydropower in the near and intermediate term. Even if one or more of these options are ruled out, for one reason or another, (with the possible exception of coal) it will be possible to reduce oil use for electricity generation to very low levels in the future (perhaps only for peaking service). In the longer run other options such as solar thermal and photovoltaic electricity generation, ocean thermal energy systems, wind power and fusion can be added to the list of electricity supply possibilities. In industry it will also be possible to substitute natural gas, biomass (particularly wood) and solar energy for oil.

Much more difficult, however is the substitution for oil in the household and transportation sectors. This emphasizes the importance of those options that would supply alternative fuels to those uses. For households charcoal (which we have discussed in this report and the appendices), LPG (which was [illegible] in this analysis) and [illegible] electricity require close attention.

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From this perspective alternatives for producing liquid fuels on a sustainable basis, say from wood or specially grown crops, to supply both households and the transportation sector are of great potential importance.

Energy Prices and Strategies

There is a complex set of relationships between energy pricing policy and the implementation of the energy diversification strategies discussed in this report. The technologies discussed are economical compared to world oil prices but many are not competitive with petroleum based fuels (and electricity based on those fuels) as currently subsidized in Indonesia. We have already referred to the very large costs of those subsidies to the national economy. As has been seen, furthermore, a reduction in the petroleum-intensity of Indonesian economic growth can only be brought about through the simultaneous implementation of a large variety of alternative sources of energy and measures for increasing energy efficiency. It is difficult to conceive of a manageable system of incentives and subsidies which could bring about the implementation of these measures at desirable rates in the context of current price subsidies. At the same time reducing the subsidy on, for example, kerosene can be made more acceptable socially and politically if at the same time acceptable alternatives, such as charcoal or LPG, are provided. This reasoning would argue for the simultaneous consideration of pricing policy and alternative technology development.

Planning and Management

This report has evoked the picture of an energy system based on a wide diversity of energy sources serving both the rural, traditional sectors and the modern, industrial sector. Such a system is a natural requirement [illegible] an almost exclusive reliance on oil in the modern [illegible]

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sector and wood in the rural sector. But such a system has very different implications for planning and support to implementation than traditional oil-based systems. An entirely new level - at least an order of magnitude greater - of planning and management is required if this kind of diversification is to come about. This is particularly true because of the decentralized nature of many of the important options. Consider the difference between contracting for one 1000 Mw oil fired power plant and installing 500 units of wind, solar, wood, small scale hydro and other technologies. This planning and management challenge must be faced frankly and vigorously if a national energy diversification strategy is to materialize.

B. RECOMMENDATIONS

Several specific recommendations were made in Chapter V regarding the steps required to implement various alternative energy strategies. Here we direct our attention to the development of a national energy planning capability and outline several steps that should be taken in policy analysis and assessment, building on this Energy Planning for Development Project.

Increased Energy Efficiency

In projecting energy demand for this study we have assumed modest increases in the efficiency of energy use coming about from fuel price increases. There are undoubtedly major opportunities for increased efficiency of energy use beyond what is included in these projections. An energy conservation analysis should be implemented to do the following:

1. Create an increased energy efficiency scenario with emphasis on potential oil savings in the household, industrial and transportation sectors. The scenario will include those measures which are technically and economically feasible.

2. Specify the barriers to the implementation of the measures identified in 1. These will include existing pricing policies, information gaps, institutional problems, lack of incentives, etc.

3. Identify a set of programs and policies which can accomplish the energy conservation goals set in 1.

4. Calculate the investment schedule necessary to accomplish the programs defined in 3 and identify possible financing sources and modes.

The most immediate targets for this study would be the household sector, in which more efficient kerosene, wood and charcoal using appliances should be investigated, and the industrial sector where substantial short term savings are probably available.

Energy-Economic Methodology Development

This project has assembled a substantial set of integrated energy demand information. These data will allow first order analyses of the technical feasibility of major national energy strategies. The next step is to develop a more formal analytical framework or model to examine energy strategies in the context of national economic development.

The development of an energy-economic model is of interest to BAPPANAS and to the Techno-Economic Group at Lemigas as well as the DJK. Thus a collaborative development program may be in order.

The logical way to proceed on this task would be to adapt energy-economic models already developed, for example those of the Brookhaven National Laboratory. These models have a substantial pedigree, are available at no cost, and use the same analytical approach in the energy sector as that used in this project.

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The elements of this task feasible within a year would be to:

1. Review existing economic and energy data, computer hardware and analytic capabilities.

2. Adapt and install an existing energy-economic model. This is a substantial task and maximum use should be made of existing Indonesian macro-economic and input-output models.

3. Identify and begin collection of data required for the model and not now currently available.

4. Run some preliminary cases to test the analytic framework.

Regional Energy Data

In this project we were restricted for the most part to the development of energy demand information at the national level. It is clear, however, that the geographical dimension is critical to the energy problems of Indonesia and a consistent regional data base on demand and supply should be developed. These data should eventually be placed in a computerized information system to provide convenient access to the basic information and various aggregates of interest.

Urban Energy Use Survey

An urban energy use survey should be carried out corresponding to the rural survey carried out in this project. It should again be a pilot survey, carried out in 3 – 5 urban regions, depending on funding availability and the willingness and ability of local institutions. It should again concentrate on households and attempt to define energy consumption as a function of income. If financing permits, small commercial establishments should be included since there is very little information available on such establishments.

[illegible]

[illegible] strategies defined here [illegible]

establish the economics of the various options and the investments required to implement them. The first phase dealt primarily with technical feasibility. The second phase should deal with economic and financial feasibility. The options that should be dealt with are:

1. Solar and wind power development
2. Biomass development for energy
3. Small scale hydropower
4. Geothermal energy
5. Coal development
6. Increased energy efficiency in industry.

These options should be assembled into a composite oil replacement strategy and the following issues addressed:

1. Contribution to energy supply in the years 1990 and 2000.

2. Capital investment required in order to implement the combined strategy.

3. Major social and economic impacts that will result from such a strategy including effects on energy prices to various income groups.

4. Barriers of various kinds to be overcome if the strategy is to be implemented.

5. Possible financing methods taking into account energy pricing required to generate the revenue to support the investment identified in 2 above.

Environmental Assessment

The activities of this project have given only very minor attention to the environmental implications of the options addressed. These implications can be important. Environmental impacts can represent substantial real economic costs and, based on the experience of developed countries, environmental concerns can lead to major impediments to progress if they are not anticipated early.

The intent of this task would be to take at least one energy strategy, [illegible] for example, the increased use of coal and to analyze in a preliminary way

all associated environmental problems. The analysis would consider the following issues:

1. Environmental residuals (emissions of air and water pollutants) at each stage of the coal cycle: mining, transport, combustion.

2. Social cost associated with each major pollutant. Primary receptors/effects.

3. Cost of alternative control technologies.

4. Analytical framework required to incorporate environmental effects into energy policy analysis.

5. Regulatory framework required to manage environmental effects of energy processes.

This task should be considered a first step in linking the development of energy policy and environmental policy. It should involve the appropriate Ministries or agencies of the Indonesian Government.

University Involvement

The survey of rural household energy use demonstrated the very great advantages (as well as some of the difficulties) of an active network of university groups. The involvement of such a network in the DJK's energy projects has a number of advantages including:

1. a regional basis for analyzing and implementing energy programs,

2. an expanded group of professional talent, familiar with DJK programs and policies on which to draw, and

3. the production of a group of graduates familiar with at least some aspects of energy analysis or technologies.

It is recommended that the network of institutions initiated in this project be supported and extended, and that that network be used as much as possible in the implementation of the future activities suggested above.

APPENDIX A

MACROECONOMIC STRUCTURE AND ENERGY DEMAND: INDONESIA TO THE YEAR 2000

Alan M. Strout
Department of Urban Studies
and Planning, Massachusetts
Institute of Technology

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ENERGY/DEVELOPMENT INTERNATIONAL
505 Main Street
Port Jefferson, N.Y. 11777

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A Taken from Chapters 3 and 8 of
B Population, Resources and the Environment in Indonesia's Future by Alan M. Strout in press. Not included in this copy.

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INTRODUCTION

Energy today is almost always consumed indirectly. Consumer and industry demand is not so much for energy itself as it is for the goods and services in which energy is incorporated: steel, transportation, space and process heat, cooking, lighting, and refrigeration. To understand how energy is "really" used in a society, in at least a mechanical and technical sense, it is useful to examine, measure and catalogue each one of energy's myriad uses in the production of other goods and services.

This encyclopedic approach to energy consumption can also be used when projecting future energy demand, especially when the number of years is small, and it may be particularly useful for answering certain types of policy questions. Examples would include the effect of an energy price increase on the price of fertilizer and ultimately on the price of bread, or the relative merits, when trying to reduce gasoline consumption, of a tax on gasoline or on motor vehicles.

For longer periods, however, it is difficult to make detailed projections of all energy-using commodities and services and of their corresponding energy use. This is because both tastes and means of production change over time. To some extent changes <u>within</u> broad categories of goods may be more pronounced and difficult to predict than is demand for the broad category itself. Thus the demand for transportation or food may change in a more gradual and predictable manner than does the demand for diesel automobiles or cassava chips. When, in addition, the average energy content of the broad class of commodities also changes in a gradual, moderately predictable fashion, then it may be better to organize longer-run demand projections for energy around broader and more stable as opposed to the more detailed and perhaps volatile categories of goods and services.

This paper reviews current thinking about a number of broad indicators of future demographic and economic change (and indirectly of energy use) in Indonesia. The time horizon will extend, with modest confidence, to the year 2000 and with considerably more recklessness to the year 2050. Left to others will be the task of filling in or estimating any subsidiary details which may be of

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interest in particular situations and also of the specific energy use implications of the broad, macro projections. The first topics to be considered below will be population growth and locational distribution. This will be followed by a discussion of growth rate possibilities for gross domestic product (GDP), including some technical matters relating to how GDP is to be measured in the longer run. The final section of the paper will deal with GDP projections by sector of origin. Two annexes, taken from an earlier study by the author of Indonesia's longer-run growth prospects, provide additional methodological details on GDP measurement and on the projection of structural change among GDP components.

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POPULATION GROWTH

The first point to dispose of concerns Indonesia's current population. Official estimates are based upon the 1971 Population Census, annual population registrations, and a 1976 intercensal population survey. Estimates usually do not include rural population in Irian Jaya, and they are always subject to various other degrees of underenumeration. In addition, published estimates prior to 1979 did not tend to include the population of East Timor, annexed by Indonesia in July 1976.

The U.S. Bureau of the Census has estimated that total undercounting in 1971, over and above the omission of rural Irian Jaya population, homeless persons on shipboard, etc., was about 5662 thousands, or 4.75% of the enumerated population. (See Table I.) Such an adjustment is speculative, however, and is not usually made in the estimates of others, including those of Indonesia's Biro Pusat Statistik (BPS, or Central Bureau of Statistics). Several sets of estimates for the years 1971-1978 are shown in Table I.

The World Bank estimates shown in Table I appear to be consistent with those of the Biro Pusat Statistik after allowing for East Timor and the rural population of Irian Jaya. They are to be prefered when population estimates prior to 1978 are desired.

For 1978 and for projections of future years, the estimates cited in LPEM (1980), also shown in Table I, are probably the best available at the present time. They are derived from the Series K, No. 2 projection of BPS and are in rough agreement with the current estimates and projections of the World Bank. It should be noted in passing that the current LPEM estimates represent a significant drop from the semi-official, "low fertility" estimates made in 1976 by Aldon Speare and shown in the last line of Table I. This latter estimate of 210 millions in the year 2000 may in turn be compared with the previous "best estimate" made by Sumitro (1975, p.214) of 250 millions by the end of the year 2000.

The sharp downward adjustments in Indonesia's population forecasts follow from the success of family planning on Java and Bali, documented more fully in Sinquefield and Sungkono (1979). There is at least a chance,

TABLE I

ALTERNATIVE RECENT ESTIMATES AND PROJECTIONS OF INDONESIA'S POPULATIONS, 1971-2000
(in millions of persons, mid-year)

	1971	1973	1975	1977	1978	1985	2000
BPS (1979)[a]	119.1	-	-	132.5	135.3	155.5	205.0
LPEM (1980)					136.3	156.5	205.5
U.S. Bureau of Census (1978), excl. E. Timor							
- Enumerated	119.2[b]						
- Adjusted	124.9[b]						
U.S. Bureau of Census (1979), with E. Timor:							
- Excluded	124.7[c]						
- Included	125.4	131.0	136.6	142.2	145.1		
The World Bank							
(1979a), moderate mortality decline				132.6[f]		155.5[f]	205.0[f]
(1980a)[d]	119.7	124.1	128.7	133.5			
(1980b)					136.0		204.0
Speare (1976),[e] excluding E. Timor	118.7[f]	125.2[f]	131.9	137.9[f]	140.9[f]	163.6	210.0

Notes to the table are given on the next page.

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TABLE 1, FOOTNOTES

[a]Original source of the 1977-2000 projections shown was BPS (1978). Projections exclude the rural population of Irian Jaya, estimated at 772,654 in September 1971. 1977-2000 numbers shown have been interpolated from published end-of-year estimates.

[b]As of the date of the 1971 Census of Population: Sept. 24, 1971.

[c]The east Timor population was estimated at 609,000 as of December 1970 (U.S. Bureau of the Census, 1979, Table A-2).

[d]Based upon data available through August 1979.

[e]Estimates for year 2000 later published in Speare (1979). The variant shown assumes low fertility, low transmigration, and high urbanization.

[f]Interpolated (assuming constant annual growth rate between adjoining years) from data shown in the original source.

however, that family limitations may not have the immediate appeal on some of the less-crowded outer islands as they have had on Java and Bali. There is still some doubt about the year 2000 forecast of 205.5 millions (or the slightly more optimistic World Bank projection of 204 millions), but the number does come close to being a consensus figure at the present time.

What about population growth in the years following 2000? The World Bank (1980b) has projected a "hypothetical size of stationary population" for Indonesia equal to 350 millions, reached in 2155 and based upon reaching a net reproduction rate NNR of 1.0 in the year 2020. Earlier, the Population Council (1974) had published a series of projections to the year 2150. Two of these, projections number 3 based upon reaching NNR=1 during 2000-2005 and number 4 based upon NNR=1 during 2020-2025, are shown in figure 1. The World Bank has not published intermediate data for their hypothetical forecast between 2000 and 2155, and it appears that the World Bank's projection may not be entirely consistent with that of the Population Council. (Otherwise, the World Bank's stationary population of 350 millions should lie closer, both in magnitude and in year reached, to the 433 million maximum of the Council's projection 4.)

Nevertheless, it would also appear, as shown in Fig. 1, that if the Population Council's projection 3 were permitted to have a somewhat more gradual transition to a stationary population, then the projection 3 estimates through 2050 could easily be consistent with reaching a stationary population of about 350 millions over the following 100 years.

Unless access to the World Bank's detailed projections can be arranged, it would seem reasonable to use the Population Council's projection 3 estimates for the period 2010-2050 if such longer run rate should be required for the energy demand analysis. (See Table 2.) It should also be noted, however, that the uncertainty attached to projections beyond 2000 is at least several times greater than for the rest of the current century. (Thus for the three more central projections made by the Population Council in 1974, the mean 1990 projection was about 173 millions, with a range of about 30 millions. For 2050 the mean of the same three projections was 307 millions, and the range between the high and low estimate was 177 millions.)

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TABLE 2

LONGER-RUN PROJECTIONS OF INDONESIA'S POPULATION,

1970 - 2155

(Interpolated values derived from the sources shown have been placed in parentheses[a])

Year	Population Council (1974) Projection 3 (NRR=1 in 2000-2005) (1)	Population Council (1974) Projection 4 (NRR=1 in 2020-2025) (2)	World Bank (1980b), p. 142 (NN$=1 in 2020) (3)	"Actual" (World Bank, 1980a) (4)	LPEM (1980) Projections (5)
1970	118.7	118.7		117.6	
1975	132.2	132.8		128.7	
1980	146.4	148.3	142		(141.7)
1985	161.8	166.1	(156.5)		156.5
--					
2000	206.6	227.7	(205.5)		205.5
2025	(263.4)	(327.7)	(263.4)		
2050	298.0	400.5	(300)		
2075	307.0	429.5	(323)		
2100	308.5	433.4	(339)		
2125	308.5	433.5	(347)		
2150	308.1	433.1	(350)		
2155	-	-	350		

[a]For the data upon which the interpolations of Col. (3) are based, see Figure 1, dashed line.

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Finally, what can be said about the locational distribution of Indonesia's future population? The Series K, No. 2 projections of BPS, already referred to, include detail by province but only on the assumption of no migration among provinces. (BPS, 1978a.) The Speare projections (1976, 1978) included a "low" and "high" migration alternative. Speare's "low" transmigration assumption would appear to reduce Java's year 2000 population by about 2 millions below the result when no out-migration is assumed. A "high" rate of transmigration, as defined for the 1976 study, would reduce Java's year 2000 population by a further 8 millions. (See Speare, 1978, for further discussion.) If geographic details should be needed for the energy demand projections, the existing BPS Series K estimates may be used and may be modified by whatever rough estimates about transmigration are desired.

A possibly more serious gap in the data, for energy demand projections, concerns projections for urban population. About the only semi-official estimates available are those from Speare (1976), and they cover only a "low" and a questionable "high" alternative. Even under the high urbanization projections, furthermore, Java and Bali would experience a pronounced increase in the absolute numbers of rural inhabitants. In terms of the number of hectares of farm and estate land per rural person, the average at the end of 1970 was probably about .102 hectares or only 1030 square meters. (The 1973 farmed area, according to BPS, 1978b, p.335, was about 6.45 million hectares. Java's population in this and the following comparisons is from Speare, 1978, Table 1.) Assuming both a high urbanization and a high transmigration rate, farm land per person might drop to 900 square meters by 2000 while, if transmigration continued at closer to low historical rates, the average area might drop to only 800 square meters per rural inhabitant.

In a situation where rural population densities are already among the highest in the world and where future GDP could easily grow at several times the rate in urban as in rural areas, the question must be raised about the political acceptability of significant further population growth in rural areas and the concomitant worsening of the urban-rural income gap which would accompany such growth. Very rapid

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urbanization could also cause political problems, of course, but it can be argued that the Speare projections may tend to underestimate the growth of future urban population, at least on Java.

Aside from the problem of deciding how rapid the rate of urbanization is likely to be, it is quite easy mechanically to project the future urban population share for any assumption about the overall rate of population growth. The overall growth can be viewed as a weighted average of urban and rural rates with the initial urban and rural population shares serving as the weights. Expressing growth rates in the continuous, logarithmic terms favored by economists rather than the more common, year-to-year or discrete rates, we have:

$$e^{nt} = w_u e^{n_u t} + w_r e^{n_r t} \qquad (1)$$

where:

n = population growth rate, per year, continuous

t = number of years elapsed

w = initial population weight, the sum of whose components total 1.0. (thus $w_u + w_r = 1$)

u,r = subscripts denoting, respectively, urban and rural; lack of subscript means total population

e = base of Napierian or natural logarithms

Remembering that $w_r = (1 - w_u)$, the urban population ratio in year t, R_t, can be solved as follows:

$$R_t = \frac{w_u}{\left(\frac{1 - w_u}{e^{dt}}\right) + w_u} \qquad (2)$$

where : $d = n_u - n_r$

The symbol, d, representing the difference between urban and rural rates of growth, is a commonly used measure of urbanization "tempo" and is in fact assumed to be a constant in urban population projections made by the United Nations Population Division. (See, for example, Renaud, 1979, p.22.) Renaud (1979) has published 1950-1970 values of d as estimated by the U.N. for 124 countries. Among those larger countries whose 1950

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population was 15 millions or greater, the median d over this period was .0289 (2.89%) while the range of values went from -.0041 (for the U.K.) to .0571 for South Korea.

Comparing the projections of Speare with hypothetical estimates based upon various values of constant d, as shown in Table 3, reveals that the Speare low projection is basically that of continuing the recent historical (1971-1976) trend. This trend, in turn, falls near the lower end of values encountered among all countries. The Speare "high" projection is closely consistent with an average d value of .03, about the mid-point of the larger-country sample. Although perhaps high by Indonesia's historical record (the 1950-1970 d value has been estimated as .0232, as shown in Renaud, 1979, p.23), a value of .03 is not high by inter-country standards. Given the political and social equity questions raised above, if urbanization should be judged an important variable for energy demand projections it would be wise to investigate a range of urbanization possibilities, with a high probability attached to d values as large as .05.

Another reason for closely considering the possibility of future rapid urbanization in Indonesia is that, by international standards, Indonesia's current level of urbanization is low. Urbanization is closely related to per capita income, as shown by the following cross-country regression equation based upon 1975 and 1977 data for 36, non-centrally-planned countries representing all income levels. (see Chenery and Syrquin, 1976, p.49, for a similar equation derived from 317 observations and covering the period 1950 - 1970. The Chenery-Syrquin equation includes a number of additional variables, none of which is statistically significant.)

$$\ln U = -\underset{(1.26)}{1.8413} + \underset{(3.01)}{1.2710} \ln GDPN (\$'77) - \underset{(2.20)}{.06527} (\ln GDPN, \$'77)^2 \qquad (3)$$

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TABLE 3

ALTERNATIVE ESTIMATES OF URBANIZATION,

1976 - 2050

	Level or Urbanization, in Percent					
	1976	1980	1985	2000	2025	2050
BPS (1979)	18.6					
World Bank (1980b)	-	20.				
Speare (1976)[a]						
Low		19.5	20.6	24.0		
High		22.0	24.8	34.1		
Hypothetical projections, assuming 18.6% urban in 1976 and "urbanization rate"[b] of :						
Low (d=0.5%)		18.9	19.3	20.5	22.6	24.9
Avg., '71-'76 (d=1.36%)		19.4	20.5	24.1	30.8	38.5
Low-medium (d=2.2%)		20.0	21.8	27.9	40.2	53.8
Medium (d=2.9%		20.4	22.9	31.4	48.6	66.1
Medium-high (d=3.5%)		20.8	23.8	34.6	55.9	75.3
High (d=4.9%)		21.8	26.2	42.6	71.6[c]	89.6[c]
Based on cross-country regressions for 1975-1977[d]						
Lower GDP growth	26.0	-	33.0	43.5	60.2	71.4
Higher GDP growth	26.0	-	34.2	49.5	68.0	75.5

Footnotes are given on the next page.

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TABLE 3, FOOTNOTES

[a]Assumes low fertility, low transmigration, and continuous "low" or "high" urbanization rates after the 1970 base year.

[b]The urbanization rate equals the difference, d, between the projected annual growth rates (measured as continuous, logarithmic growth rates) for urban and rural areas. The "low" and "high" values of d are the averages for the four lowest and four highest countries, recorded among the world's larger countries between 1950 and 1970. ("Larger" was defined as having a 1950 population of 15 millions or more. Both North and South Korea were included in the sample since their combined population in 1950 came to 30.1 mil. See Renaud, 1979, Table 2.2, for the actual data used). The medium-low and medium-high values of d represent the lower and upper quartile points in the same sample, while the median d value corresponds to the median sample value.

[c]Included for illustrative purposes only. It is unlikely that such a rapid rate of urbanization would continue for so many years.

[d]Estimated using equation (3) in text. The corresponding projected values of GDP per capita are equal to the 1970 US$ nominal values shown below, Table 5, multiplied by a 1977/1970 US dollar conversion rate of 2.752.

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where: $\bar{R}^2$ = .726, the standard error of estimate = .290,

t- ratios are shown in parentheses, and where

U = urbanization ratio, in percent, in 1975 (from World Bank, 1979b, Annex Table 20).

GDPM($'77) = per capita GNP in nominal 1977 US dollars (from World Bank, 1979b, Annex Table 1)

ln = natural logarithm

Judging by this equation, Indonesia's 1976 urbanization level of about 18.6% was lower than the GDP-corrected cross-country average of 26.0 by a little more than one standard deviation. (See Table 3). As shown in Table 3, it would take a "high" urbanization rate to bring Indonesia up to the international "norm" by 2000 and a "medium high" rate to reach the average by 2050. (See the Structural Change section of this paper, below, for further cross-country analysis).

THE GROWTH OF GROSS DOMESTIC PRODUCT

After a period of slow growth in real GDP per capita during the 1960's (2.25% per year according to World Bank, 1980a), Indonesia's per capita growth rate rose to 5.8% between 1970 and 1978. (World Bank, 1980a; LPEM, 1980). The growth rate in 1979 may have dropped to a little under 3% (Warr, 1980), but for the decade it will probably average close to 5.5%.

Most analysts foresee a continuation of the recent high growth rates for at least a decade or two while oil revenues or international capital flows remain strong. Professor Sumitro in his pioneering 1975 projections to the year 2000 foresaw a strong probability of overall GDP growing at 7.0% between 1980 and 2000 with a slightly higher rate prior to 1980. (Sumitro, 1975, p.225). The implied per capita growth rate between 1973 and 2000 of this medium projection was 4.47%. A lower possibility averaged out to 3.93% annually over the same period while the high variant of the 1975 Sumitro projections came to 5.01% per year. In the most recent version of the year 2000 projections, Moh. Arsjad Anwar and his colleagues in the Institute for Economic and Social Research (LPEM) at the University of Indonesia,

are projecting a lower overall growth rate but almost the same range of per capita rates: 3.91% and 4.99% for the period 1973-2000. (LPEM, 1980).

The World Bank in early 1979 projected a 4.4% annual growth of per capital GDP through 1990, bringing the 1973-1990 average rate to 4.54% per year. (World Bank, 1979a, Appendix). This average was close to the mid-point of the range investigated by LPEM.

All of the above growth rates, on the other hand, are rather high by international standards. Between 1970 and 1977 only eight other large countries (above 10 million population) exceeded an average per capita GDP growth of 4.5% per year. There also appears to be some tendency for growth rates to drop as per capita income increased beyond $1500 or so in 1975 US dollars. (Strout, 1980). It was partly for this reason that Ridker and Watson (1980; unpublished worksheets) projected a gradual decline in Indonesia's growth rate of GNP per capita from 5.99% in 1980-1985, to 5.11% during 1985 - 2000, and 3.66% annually in the 25 years following 2000. Strout, in an earlier exercise, had guessed that per capita growth of GDP might fall to an average of 2.7% annually for the fifty year period, 2000-2050, irrespective of whether Indonesia prior to 2000 was able to maintain a high (6.0% per year) or a lower (3.9% per year) average growth rate. (Strout, 1979a) chap. 3; reproduced as Annex A of the current paper).

For the purposes of medium-term and longer-run projection of energy demand, it would seem appropriate to use the Arsjad/LPEM projected rates through 2000. After that, if further GDP per capita estimates should be needed, a gradually declining rate might be indicated. Thus, for a base year of 1978 and for constant price projections in values of 1978:

	Lower Alt.	Higher Alt.	
1978-1985	3.9%	4.9%	(LPEM, 1980)
1985-2000	3.6	5.1	" "
2000-2025	3.1	3.5	(Annex A, T. 3.8)
2025-2050	2.3	2.0	" " "

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THE PROBLEM OF INTERTEMPORAL COMPARISONS OF GDP

Any macro-economic projection exercise must have explicit rules for converting values expressed in one particular set of prices or currencies into those of another year or another type of exchange. At the level of aggregate GDP this can be handled, at least for relatively short run comparisons, through the medium of implicit GDP price delators and official exchange rates. For the current undertaking, it is likely that rupiah and U.S. dollar values in the prices of either 1973 or 1978 will be needed at one time or another. The base year for the most recent BPS estimates of GDP and its components is 1973, while 1978 is the year chosen as base for the Arsjad/LPEM projections. In addition, conversions into prices of the years 1970 and 1964 may be needed for some purposes, as will be discussed below.

The year 1970 provides a fairly good starting point since foreign exchange rates were probably close to an equilibrium value, and the distortions brought about by the large price increases in petroleum had not yet been introduced into the Indonesian economy. (By 1973, another possible starting point, exchange rate adjustments had begun to lag behind the increase of domestic prices relative to international - U.S. dollar - prices). Using the rupiah/US$ exchange rate for 1970 of 365:1 (World Bank, 1980a) and the implicit GDP price deflators for various years as estimated by the Biro Pusat Statistik, the set of year-to-year conversion factors shown in Table 4 may be derived. (For the conversions to 1964 US$ prices it was assumed that the US dollar depreciated by a factor of .841 between 1964 and 1970, based upon the implicit price deflator for United States exports.)

Over a longer period of time a new problem arises which is not satisfactorily handled by assuming unchanging, base year prices as commonly done when calculating GDP price deflators. The constant price technique is useful for removing inflationary trends in the short run, but in the longer run the very structure of prices can be expected to change. This is to say that commodities and services which were relatively inexpensive at one stage of economic development may become considerably more expensive relative to other goods and services (or vice versa) at a later developmental stage. Thus correcting for inflation

TABLE 4

CURRENCY CONVERSION FACTORS, RUPIAH AND US DOLLARS, 1964, 1970, 1973, and 1978

Multiply units at left by factor shown to find the equivalent value in the units listed at the top:[a]

	1964$	1970$	1970 Rp.	1973 Rp.	1978 Rp.	1978$
1964 US$	1.00	1.189[b]	433.99	667.89	1549.37	3.511
1970 US$	.841	1.00	365[c]	561.7	1303.1	2.953
1970 Rp.	.002304	.002740	1.00	1.539[d]	3.570	.008091
1973 Rp.	.001497	.001780	.650	1.00	2.320[e]	.005257
1978 Rp.	.000645	.000767	.280	.431	1.00	.002266
1978 US$	.2848	.3386	123.60	190.21	441.25[f]	1.00

[a]Note that each off-diagonal element above the diagonal equals the reciprocal of the symetrical off-diagonal element below the diagonal. Thus, for example, 1978 Rp/1970 Rp = 1/.280 = 3.571.

[b]Equals value of US dollar in 1964 divided by value in 1970, as measured by the implicit national accounts price deflator for U.S. exports. See Council of Economic Advisors (1980), Table B-3, p.207.

[c]Official exchange rate (average for the year). The World Bank (1980a), p. 104.

[d]Implicit GDP price deflator for 1973 (1970 = 1.00). The World Bank (1980a), pp. 104-105.

[e]Implicit GDP price deflator for 1978 (1973 = 1.00). BPS (1979), Table XI.1 and XI.2.

[f]Implicit average exchange rate, from LPEM (1980), Table 1.

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is no longer the sole concern of pricing adjustments, and imposing a rigid set of "base year" prices on a comparison may provide a distorted measure of "true" growth when relative prices within the economy have been changing as part of the growth process. (This is a variant, it may be noted, of the familiar index number problem.)

The problem can partially be resolved by finding average prices for a large number of countries at different stages of development and revaluing a given country's GDP in terms of these average, "international" prices. This will permit a greater degree of comparability among countries and at least a no less valid comparison between years for the same country as would the use of base year prices from a single country. The studies of Irving Kravis and his associates in recent years (1975, 1978a, 1978b) have been addressed to improving inter-country comparisons of GDP and its components. A common set of international prices was found for the year 1970, and the GDP's for a number of countries have in fact been reestimated in terms of these common prices. Comparing the reestimated GDPs with those originally calculated by means of the country's own prices and official exchange rates permits measurements to be made of the implicit average price "distortions" at various stages of economic development.

These points and the theoretical reasons for structural changes in prices (plus the empirical evidence on the same phenomenon) are discussed at some length in Annex A. Based upon this analysis it is suggested that, for the purpose of comparing income levels of Indonesia with those of other countries, per capita GDP be projected in both "real" (constant price) and nominal terms. The nominal results produce measures which change over time in a manner similar to the changes among countries at different development stages as observed about the year 1970. As can be seen from the numerical example given in Tables 3.1 and 3.2 of Annex A, over a 40 year period constant price growth rates might range from 4.64% to 5.30% annually, depending upon which of several pricing systems was used (Laspeyres, Paasche, "ideal," chain-linked, etc.) The "nominal" growth rate over this period, however, derived by a method analagous to that lying behind the real-world determination of equilibrium exchange rates, would be over 7.0 percent per year.

Nominal measures of GDP, it should be noted, are not only of general

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interest when making inter-country comparisons, but are <u>essential</u> to use if some form of inter-country comparison is relied upon to fill in data gaps for the country in question. This is because formal cross-country analysis almost inevitably relies upon GDP measures derived from conventional exchange rates, thus producing "nominal" values which are widely recognized as noncomparable in terms of a common set of prices or purchasing-power equivalents.

As will be seen in the next section, cross-country comparisons are often used when projecting changing economic structure such as the gradual rise of manufacturing at the expense (in relative terms, at any rate) of agriculture. For this reason nominal as well as constant-price measures of Indonesia's future GDP will be needed and may be found through the following, five-step procedure:

1. Convert current year rupiah values to 1970 US dollar values using the GDP constant price implicit deflator (1970 = 100) and an exchange rate of 365:1. Divide by current year population to give GDP per capita in 1970 US dollar.
2. Convert this value to "international" (constant purchasing power) values, still in 1970 prices, using the following simplified relationship found for 1970 between nominal and internationally-priced measures of GDP. (For a more extended discussion of the equation, including comparisons with a similar approach used by Kravis and his colleagues, see Annex A.)

$$\ln GDPR(\$'70) = \underset{(0.47)}{.495} + \underset{(4.03)}{1.340} \ln GDPN(\$'70) - \underset{(1.85)}{.047} (\ln GDPN,\$'70)^2 \qquad (4)$$

where: $\overline{R^2}$ = .986, SEE = .1092, t-ratios are in parentheses, and where:

GDPR($'70) = real per capita GDP in international dollars

GDPN($70') = nominal per capita GDP, in 1970 US dollars, converted at official exchange rates

ln - natural logarithm

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3. Apply whatever assumptions are to be made about constant price growth of per capita GDP to the calculated value of real or internationally-priced GDP per capita (that is, to the value of GDPR, \$'70 found in Step 2). If the assumed growth rate, for example, is r, then for a particular year t which is n years away from the current year, then:

$$GDPR(\$'70)_t = (1+r)^n \; GDPR(\$'70)_o \qquad (5)$$

where the subscripts t and o denote, respectively the future year and the current (base) year.

4. Convert the value of $GDPR(\$'70)_t$ found in step 3 to nominal 1970 US dollars by solving equation (4) for GDPN(\$'70). Thus:

$$\ln GDPN(\$'70) = \frac{1.340^2 + .047(4)\,(.495 - \ln GDPR)^{\frac{1}{2}} - 1.340}{2(-.047)}$$

$$= \frac{(1.88866 - .188 \ln GDPR,\$'70)^{\frac{1}{2}} - 1.340}{-.094} \qquad (4)$$

5. Finally, convert 1970 US dollars into the dollar value of whatever year is desired, using a dollar price deflator. This latter could be the United States GNP price deflator or a measure of the purchasing power of the U.S. dollar in international trade. One such possible deflator for the years 1978 and 1970 is given in Table 4 as 2.953 (1970 = 1.0).

Note that this method implicitly assumes that a constant price GDP growth rate measured in base year prices for the country itself will be the same as the constant price growth rate measured in "international" prices. In fact, the latter growth rate will usually be slower than the country's own prices would suggest because the production of relatively high priced commodities such as manufactured items and other "tradables" will usually be at faster rates than commodities and services which initially are relatively low priced. Thus the computed nominal growth rate will be biased upward by an unknown degree. If the numerical example given in Annex A is at all representative, however, and an effort was made to make the example as realistic as possible, then the bias may be relatively small. (Compare the constant international price growth rate of 4.99% shown in Table 3.2, p.3-9, with the year-zero price weighted or chain-linked rates of 5.29% and 5.30%.)

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When the prospective growth rates given above are combined with the five-step procedure just described, the estimates of future GDP per capita are found which are shown in Table 5. The constant rupiah values shown in column (4) are conceptually the same as those in LPEM (1980, Table 1). (They differ very slightly in detail because of rounding errors in the 4-place growth rates given in column 3.) The constant international price estimates of column (2) have the same growth rates as shown in column (3) and consequently are simple multiples of column (4).

What is of chief interest in Table 5 is the large difference between real and nominal rates of growth. Under the lower of the two alternatives Indonesia would increase its constant-price GDP per capita by a factor of 8.4 between 1978 and 2050. Measured in nominal values, designed to allow for changing price structures and thus to afford better comparability with other countries in the world, the 1978 to 2050 increase would be exactly twice as great, 16.8:1. This suggests that by 2000 Indonesia would have almost reached the 1978 level of Malaysia and by 2050 it would have surpassed the 1978 per capita GDP of the United Kingdom. Results for the higher growth alternative would be even more striking: the 1978 level of Mexico would be surpassed by Indonesia by 2000 and the 1978 level of the United States surpassed by 2050. (All comparisons are based upon the 1978 GDP data in World Bank, 1980b, Annex Table 1.)

The results from Table 5 may be compared with the earlier set of similarly-derived projections shown in Table 3.7 of Annex A, p.3-30. The Annex estimates show a generally similar pattern but have been based upon slightly different growth rates, especially for the higher alternative, and for a different starting year. It may be noted too, in passing, that the nominal-real projection technique just described has not yet, to the author's knowledge, been described formally in the professional literature. Both Chenery, Ahluwalia and Carter (1979) and Summers, Kravis and Heston (1980) have used "Kravis adjustment factors" for converting base year nominal GNP to dollars of equivalent purchasing power. In both cases, projections forward (or backward) in time are made using real rates of growth and no effort is made to translate the resulting estimates back into "nominal" US dollars. Chenery (1979, p.114) subdivides his "period of transition" into four sub-periods, measured in

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TABLE 5

ALTERNATIVE PROJECTIONS OF INDONESIA PER CAPITA GDP,

1970 AND 1978 PRICES, 1978-2050

Year	1970 US$ Prices: Nominal	1970 US$ Prices: Real or International	Assumed growth rate from previous year shown	1978 Prices: Constant rupiah ('000)	1978 Prices: Nominal US$
	(1)	(2)	(3)	(4)	(5)
1978	$ 123	$ 348	-	Rp.159.89	$ 362
I. Lower growth rate alternative					
1985	167	456	.0392	209.27	493
2000	317	775	.0360	355.72	935
2025	875	1602	.031	763.09	2584
2050	2063	2934	.023	1347.31	6092
II. Higher growth rate alternative					
1985	130	487	.0490	223.49	533
2000	452	1023	.0508	469.95	1335
2025	1523	2419	.035	1110.60	4498
2050	3415	3968	.020	1822.06	10085

Source: See text. Col, (4) and (2) are based upon constant price "real" growth rates of col. (3). The 1978 values of cols. (1), (4) and (5) are derived from BPS (1979) and World Bank (1980a); the -alue in col. (2) is derived using eq. (4). Subsequent values of col. (1) are derived from col. (2), using eq. (5). Col. (5) equals col. (1) times 2.953, the 1978/1970 dollar price inflator from Table 4.

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both nominal and real (purchasing power equivalent) income, again based upon base year relationships and with no explicit mention of how these base year relationships might be expected to change over time.

On the other hand in actual projection exercises for individual countries, analysts have begun to use techniques which are conceptually quite similar to those described in this paper. See, for example, Korean Development Institute (1978) and, for Indonesia, NIRA (1980).

PROJECTING STRUCTURAL CHANGE

If accurate projections could be made of the growth of individual industries and of the changing intensity of energy use by these industries, then the job of projecting overall energy consumption would be more than half completed. (Still needed would be estimates of direct energy use by the so-called final demand sectors, private and government consumers, stock changes and exports.) One of the earliest-used methods for making such projections of industry growth has been to estimate past growth rates as a function of some quite independent variable, usually aggregate GDP, and then to assume that the historical relationship continues into the future. The difficulty for developing countries, of course, is that historical time series of data are often limited. There is also no easy mechanical way, in part because the historical record is so short, for projecting assorted non-linearities in the future relationship between the growth of a single industry and, say, that of overall GDP.

Since the widespread introduction of input-output methodology, it has become theoretically possible to project the future level and composition of "final demand" and then to use detailed input-output tables for the country to estimate the needed mix of domestic production and imports for the satisfaction of final demand. This is the methodology used by the Korean Development Institute (1978) for fifteen-year projections of energy use in the Republic of Korea. The Korean analysis illustrates both the strengths and weaknesse of the basic approach. It was possible, for example, to build into the projections some very considerable shifts in industrial specialization towards heavy industry, both in metals and chemicals, and to estimate industrial energy demand in considerable detail. On the other hand it apparently

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was not possible or feasible to estimate technical change for individual industries in their use of energy. Consequently, industrial energy use fifteen years in the future was projected on the basis of current, "good practice" energy coefficients, and no consideration was given to the potentially important energy savings which could be particularly important for the so-called heavy, or more energy-intensive industries. (For a further discussion of the Korean 15-year energy projections, see Strout, 1979b.)

A third method for projecting the future growth of industrial sectors relies upon inter-country comparisons and stems from the work of Chenery and several colleagues (Chenery, 1960; Chenery and Taylor, 1968; and Chenery and Syrquin, 1975; see also Chenery, 1979, Part One). In this technique, total GDP is disaggregated into a number of sector shares by industrial origin, and each share is related to a number of measures of aggregate economic size on the basis of cross-country statistical analysis. The aggregate measures generally include per capita GDP and total population, expressed in logarithms, plus the squared values of the same logarithmic variables. In his more recent work, Chenery has also introduced the ratio to GDP of total net capital inflow as an additional explanatory variable. (Chenery and Syrquin, 1975.) Conceptually a number of other variables could also be used to help capture particular types of country characteristics. (Chenery and his colleagues have accomplished much the same purpose by dividing their world-wide sample into "large" countries, "small primary-oriented" countries, and "small industry-oriented" countries and calculating separate statistical relationships for each group.)

Because this third method relies upon evidence from a large number of countries, the statistical equations can incorporate subtle non-linearities in the growth process such as those captured by the use of quadratic (squared) logarithmic terms. The method will also capture some of the technological and structual changes <u>within</u> broad economic sectors which have occurred in the past as the result of the normal growth process. The analyses available to date, however, center on the year 1965 with dummy variables used to judge any changes over the 20-year period, 1950-1970. This means that any world-wide changes in economic structures following the oil price shocks of 1973-74 and

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thereafter will not have had a chance to affect the statistical results.

Another difficulty in applying cross-country norms to the projections for an individual country is to judge the rate at which the country in question will move closer to or possibly away from the norm. The best approach is to estimate why the country differs from international norm in some base year and then to project the extent to which the initial differences will continue in the future. Table 6, for example, compares actual sectoral shares for Indonesia with intercountry norms as calculated for 1970 and 1978. In 1970, the actual share of the primary, the industrial and the utilities (including transportation) sectors came very close to that predicted on the basis of international norms. Only "other services" differed from the norm by more than 1½ percentage points.

By 1978, however, higher prices for Indonesia's oil exports caused the primary sector share to substantially exceed the international norm. (Shares in Table 6 have been calculated in prices of the current year.) Shares for the other three sectoral groups, as a consequence, dropped below the cross-country norm.

Also shown in Table 6 are 1985 and year 2000 projections for the same sectors as made for LPEM (1980) and as made on the basis of the same pre-1970 international relationships as used for the 1970 and 1978 comparisons. Points for all four years are also shown graphically, along with cross-coutry-based projections to the year 2050, in Figure 2. (The year 2025 and 2050 projections use the same GDP and population assumptions shown earlier in Table 2 and 5. Details of the projections may be found in Table 7.) The LPEM analysts apparently relied heavily on the "Chenery-Taylor-Carter" model, but in the report cited they do not give the actual estimating equations nor the specific literature referred to. They undoubtedly also tempered their projections with their own judgements about the future. Thus, as can most easily be seen in Figure 2, primary sector output was projected as maintaining approximately the same relationship to international norms as observed in the LPEM base year, 1978. Similarly, the actual future share of manufacturing and construction might continue to lie at roughly the same relative distance below the large-country norm. (Note that Figure 2 shows both a higher and a lower projection. The lower LPEM projection should always be compared with the

TABLE 6

COMPARISON OF GDP SECTOR SHARES WITH 'NORMS'
DERIVED FROM CHENERY-SYRQUIN-CARTER EQUATIONS,
1970 - 2000

	1970	1978	1985		2000	
GDP Growth Assumption	-	-	Lower	Higher	Lower	Higher
Population, millions	117.59	136.27	156.53		205.47	
Per Capita GDP:						
1978 rupiahs ('000)	101.40	159.89	209.30	223.52	355.97	469.81
1970 US$	77.8	123	167	180	317	452
1964 US$	65.4	103	140	152	266	380
Capita Inflow/GDP	.045	.016	.017	.028	.012	.020
Sector Shares, GDP by Industrial Origin (%)						
Agriculture	47.15	31.12	26.43	25.88	20.79	18.35
Mining	5.17	17.76	15.29	14.89	12.33	10.76
Primary Subtotal	52.3	48.9	41.7	40.7	33.1	29.1
(Intercountry norm)	(53.7)	(44.2)	(37.9)	(36.0)	(27.1)	(21.6)
Manufacturing	9.33	9.34	12.49	12.85	17.91	19.71
Construction	3.00	5.18	5.72	5.81	6.14	6.32
Industrial Subtotal	12.3	14.5	18.2	18.7	24.0	26.0
(Intercountry norm)	(12.4)	(17.4)	(21.0)	(22.3)	(27.1)	(30.6)
Transportation & Communication	2.87	4.69	5.67	5.94	7.32	8.54
Electricity, Gas, Water	.45	.53	.89	.96	1.76	2.23
Utilities Subtotal	3.3	5.2	6.6	6.9	9.1	10.8
(Intercountry norm)	(4.4)	(5.7)	(6.5)	(6.6)	(7.9)	(8.4)
Other Services	32.0	31.4	33.5	33.8	33.8	34.1
(Intercountry norm)	(29.9)	(33.1)	(35.1)	(35.6)	(38.4)	(40.0)

Sources: See next page.

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TABLE 6

continued

Sources:

1970 population and national accounts, in rupiahs: World Bank (1980a, p. 104).

1978, 1985, 2000 population and GDP shares: LPEM (1980), Tables 3.B and 17.C (for electricity, gas and water), except that electricity, gas and water for 1978 has been taken from BPS (1979), Table XI.1, p. 1230.

Capital inflow (from the same sources) equals Import of goods and non-factor services minus Exports of goods and non-factor services plus Net factor income to abroad.

1979 US$ values of GDP per capita are from Table 5

1964 US$ values of GDP per capita equal 1970 $ values times .841 (from Table 4).

Equations for computing sector shares are from Chenery and Syrquin (1975) and Carter (1973) as shown in Annex B, Table 8.3, p. 8-23.

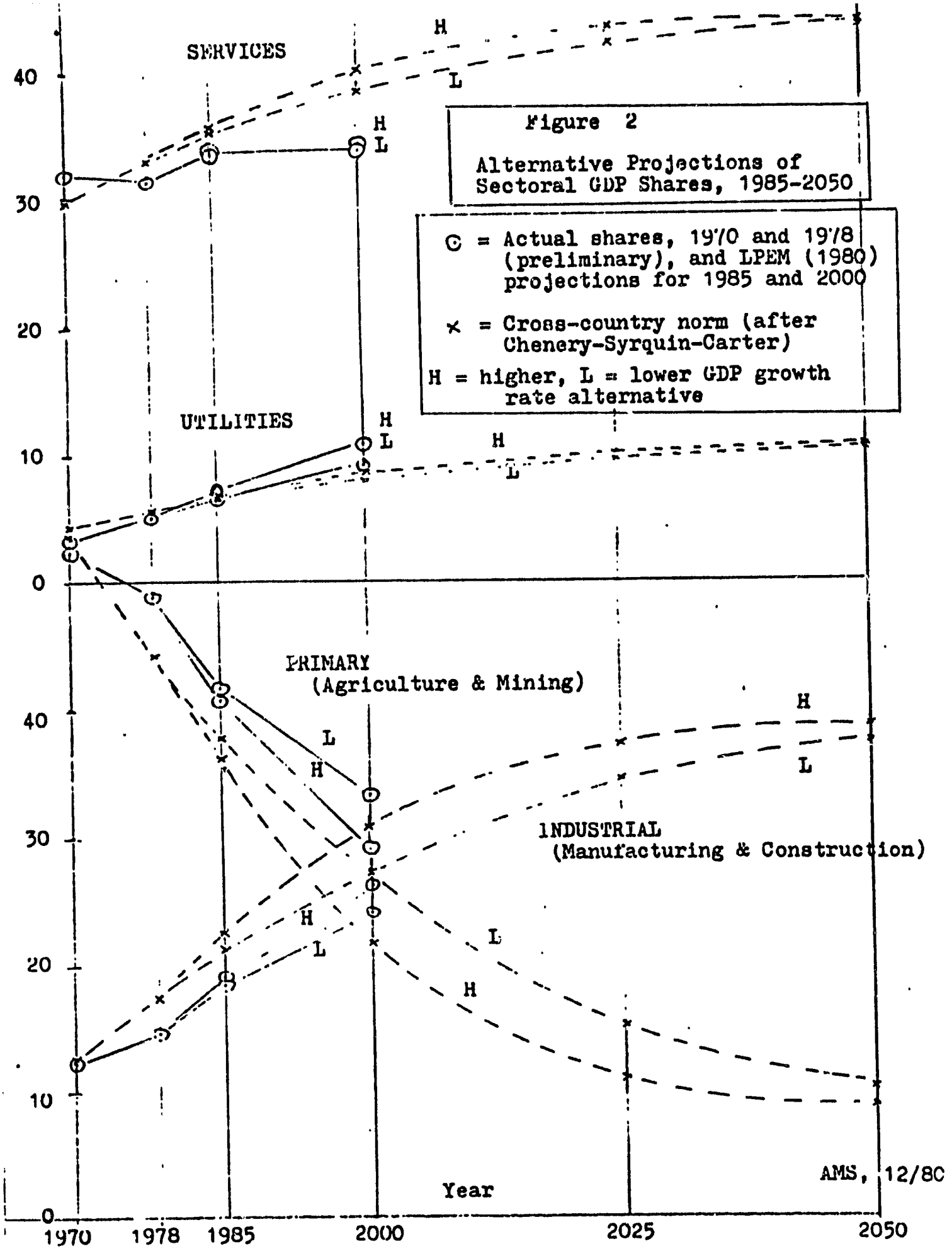

Figure 2

Alternative Projections of Sectoral GDP Shares, 1985-2050

⊙ = Actual shares, 1970 and 1978 (preliminary), and LPEM (1980) projections for 1985 and 2000

× = Cross-country norm (after Chenery-Syrquin-Carter)

H = higher, L = lower GDP growth rate alternative

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TABLE 7

PROJECTION OF GDP SECTOR SHARES FOR INDONESIA, 2025 AND 2050, BASED UPON 1950-1970 INTERCOUNTRY NORMS (AFTER CHENERY-SYRQUIN-CARTER)

	2025		2050	
GDP Growth Assumption	Lower	Higher	Lower	Higher
Population, millions	263.4		300.0	
Per capita GDP:				
In 1970 US$	875	1523	2063	3415
In 1964 US$	736	1281	1735	2872
Capital inflow/GDP	.01	.01	.00	.00
Sector Shares (%)*				
Primary	15.0	10.7	10.0	8.7
Industrial	34.3	37.0	37.4	38.4
Utilities, Transp.	9.4	9.8	10.1	10.2
Services	42.0	43.2	43.4	43.6

* Detail will not add to 100.0% because of rounding in the estimating equations.

Sources: Population and per capita GDP in 1979 US$ are from Tables 2 and 5. The 1964 US$ values equal the 1970 US$ values times .841 (from Table 4). The same procedure for calculating the sector shares was used as for Table 6. (See notes to that table for further details.)

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lower cross-country-based projection and similarly for the higher projections.)

For services and utilities, however, there appears to be distinct differences between the time trends projected from large-country norms and those projected by LPEM. The reason for this is not known, but it could conceivably arise from a misinterpretation of the sector definitions. The electricity, gas, and water sector, for example, was included in the LPEM "all other" service sector rather than in "utilities, including transportation." Electricity, gas, and water has accordingly been shifted to the latter sector for the comparisons shown in Table 6 and Figure 2. This was done because in the Chenery-Syrquin source, relied upon most heavily for the current study, "utilities" very explicitly include "electricity, gas, and water, as well as transportation and communication, including storage" (Chenery and Syrquin, 1975, p.184). If the shift of electricity, gas and water had not been made and the original LPEM classification had been left intact, then "all other services" (lainya) would be much closer to the cross-country norm for "services", and "transportation and communication" (excluding electricity, gas, and water), to the large-country norm for "utilities."

For energy-projection purposes, given no further information on this point, it would be well to use the LPEM (1980) sectoral breakdowns of 1985 and 2000 production, extrapolating these beyond 2000, if necessary, to gradually approach the large-country, international norm by perhaps the year 2050. This seems a reasonable procedure in any case for the primary and industrial sectors. For services and utilities, however, if the opportunity should present itself it would be wise to learn more about the specific LPEM projection methodology.

Projecting sectoral shares for the broad economic groups discussed above may of course be only the first step in estimating industrial composition at a finer level of detail. Most of the additional detail will be required for the "manufacturing and construction" sector, especially for those energy-intensive industries such as primary metals, cement, pulp and paper, heavy chemicals, etc. A starting place for these estimates should be Indonesia's Input-Output table for 1975 (BPS, 1980), but the difficulty is that Indonesia's 1975 structure of manufacturing was quite rudimentary compared to the likely situation by 2000 or 2050. Projecting the future output from individual manufacturing sectors

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requires attention to domestic demand growth; export possibilities, import substitution, and technological change. (Chenery /9, pp.108 ff.) Unpublished cross-country equations for major manufactu. sectors are apparently available within the World Bank (Prakash, 1978), and Chenery has compared these estimates with alternatives derived from a simulation model of the process of industrial growth. Growth elasticities from the simulation model tend to be generally higher than those calculated from cross-country regressions. Unfortunately neither method is described in sufficient detail to be useful for projecting future manufacturing growth in Indonesia. (See Chenery, 1979, Chapter 3.)

The best projection procedure for individual manufacturing sectors in Indonesia might therefore be to work from analogy with other large developing countries which are currently at income levels which Indonesia can be expected to reach during the period under review. (Examples might be the Republic of Korea, Mexico, and Brazil.) In any case a range of values should be chosen to explore the implications on energy use of a "heavy" versus a "light" industry path of development.

CONCLUSION

This paper has surveyed currently available estimates for future growth of population and per capita GDP in Indonesia. High and low variant concensus estimates emerge to the year 2000, but beyond that the case for both population and GDP growth becomes considerably more speculative. It is likely that domestic and perhaps world-wide resource constraints will become more important over this period and that even the lower of the two post-2000 projections shown above can provide no more than an upper limit to Indonesia's growth aspirations. This is the pessimistic conclusion reached in the NIRA study of a "Long Term Economic Development and Energy Policy in Indonesia" (1980), and it must certainly be a principal concern of any long-range forecasting exercise.

With respect to projecting sectoral and sub-sectoral detail for Indonesia, cross-country comparison modified by a knowledge of Indonesia's own growth parculiarities is clearly the preferred methodology. The LPEM projections to 2000 provide a good starting point, at least for the major subaggregates of GDP, although a question has been raised about the service and utilities sectors which could benefit from further

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clarification. For projections of individual manufacturing groups, there appear to be as yet no concensus estimates of output, even prior to 2000. Drawing upon the experience of a few other developing countries could provide one set of answers to the projection process, and it might also be possible to gain access to the unpublished World Bank regression estimates made in 1978 by Prakash.

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ANNEX A

ECONOMIC GROWTH

Chapter 3 from

Population, Resources and The Environment
in Indonesia's Future

by Alan M. Strout

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ECONOMIC GROWTH

One of the major factors affecting materials consumption, as will be seen in the empirical sections later on, is per capita gross product. This is also the most commonly used yardstick for measuring the progress of economic growth. Gross product measures the total output, in money terms, of a society and as such is largely determined by supplies of labor, capital equipment, and raw materials, including agricultural land. It is strongly influenced also by the level of available technology, by export markets, and by public policies taken to ensure the full utilization of productive capacity.

The growth of gross domestic product (GDP) over time is determined by the same set of factors. Capital accumulation, export markets, technological change, and government policies appear to be especially important in the medium- and longer-run. Most of these factors, in turn, are amenable to human influence and intervention. Although at any given time countries must overcome various degrees of handicap in order to grow economically, and although initial stocks of natural resources have favored many countries, it would appear that in many cases the lack of natural resources may be compensated for by vigorous economic policies and activities.

In the much longer-run, say beyond the turn of the century, today's conventional wisdom holds that natural resource shortages may become increasingly important in determining a nation's standard of living. Indonesia's planning objective, therefore, should be to consider which

policies might permit the greatest growth (or degree of human welfare) given its stock of natural resources. The purpose of the current study is to consider the interrelationships between economic growth and natural resource consumption and to examine the possibility of longer-run constraints on growth resulting from world-wide resource scarcity.

To do this, we must specify several paths of future economic growth, estimate natural resource requirements under existing technology, and consider whether or not the natural resource demands and the probable environmental impacts of increasing material production and consumption are within the bounds of "reasonableness". If not, then what is the likelihood that technological developments may come to the rescue?

Several problems arise when trying to specify desired economic growth targets for the distant future. The first concerns the widely recognized inadequacies of GDP in measuring economic well-being for all segments of the population. Alternatives to the per capita GDP yardstick exist, but linking a diverse number of welfare indicators, including those reflecting income equality, to natural resource demands is beyond the capacity of this current study. Food adequacy (but not distribution by income class) is implicit in the calculations of agricultural growth reported in Chapter 6, but it has not been possible to pay attention explicitly to other "basic requirements" such as clothing, health, and education facilities.[1]

The problem becomes particularly acute once certain minimum welfare needs have been met for the bulk of the population, possibly at a per

[1]Compare with the statement of welfare goals in Sumitro (1975).

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capita GDP level as low as $400-600. Beyond this point the standard of living, as conventionally measured by average GDP per capita, can presumably increase almost indefinitely.[1] Goods and services fall increasingly in the category of "luxuries". Some of these, such as the family automobile, may have a profound impact on the location of human habitation, the design of cities, atmospheric pollution, the demand for supporting services and goods, and the "need" for additional natural resources, especially fuel. In terms of "quality of life" for the bulk of a nation's inhabitants, it is conceivable that an average GDP per person of $3,000 could provide for as much (or more?) welfare as an average income that was much higher. The difference between the two situations would lie partly in the patterns of physical infrastructure and of goods and services produced.

It is clear that the consumption of natural resources is largely determined by per capita income levels, although there is a tendency for the per capita consumption of some materials to increase less rapidly than income at higher levels (see Chapter 9). If future world-wide scarcities of steel, aluminum, copper, wood, paper, etc. could not be compensated for by technological innovation, then it is highly probable that income growth would be affected. What is not clear and what has not been investigated by this study is by how much the quality of life for the majority would be affected by changes in average per capita GDP.

[1]In its long-term projections of electricity consumption by the nations of the world, the International Atomic Energy Agency has considered GNP growth paths leading to average per capita levels as high as $50,000 (in 1963 prices). See Lane (1975, Appendix D, Figure D-4, p. 166).

Pricing Biases in GDP Projections

A second and somewhat related problem in projecting desired future GDP targets is that of the pricing biases inherent in our conventional measures of domestic product. It has long been recognized that pricing and exchange rate difficulties could affect the comparison of incomes between two countries. Recent work by Irving Kravis and his associates leads to the conclusion that these biases bear a systematic relationship to the level of per capita GDP (as conventionally measured and as converted to dollar equivalents at official exchange rates).[1]

In the discussion below, it will be necessary to distinguish among four different measures of GDP growth over time. The constant, "own price" growth rate, conventionally called the "real" growth rate by most analysts and planning bureaus, refers to the change in GDP when valued at a common set of domestic prices from a particular base year. A closely related growth measure is valued not in domestic prices but in a set of "international" prices which are essentially weighted averages of prices observed for a more or less representative sample of countries and after conversion to a common currency.

The objection to both the constant own price and the constant international price measures is the assumption that comparisons, to be meaning-

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[1]Kravis and others (1975, 1978a, 1978b). The systematic nature of the pricing biases uncovered by the Kravis studies will be described below.

ful, must compensate for all changes in relative prices. Prices, in short, must be held constant even during long growth periods encompassing significant structural change.

Relative prices, of course, do not remain constant. Some goods and services become less expensive relative to others, usually as a result of technical change or economies of scale. Lower relative prices are ordinarily accompanied by increased relative demand. More is consumed of those goods which become relatively less expensive while less is consumed of those goods whose relative prices increase. The normal pattern of growth, in short, involves continual change in taste, consumption patterns, technology, and relative prices.

Growth rate deflation procedures which are tied to an unchanging set of prices will fail to do justice to the normal changes which occur during the growth process. Specifically, if base prices are chosen from near the beginning of a long-run growth sequence, the measured growth rate is likely to be biased upward. This is because the prices of fast-growing sectors are assumed not to fall as output expands, thus giving too great a weight to the high growth portions of the economy. Conversely, if base prices are those from near the end of a long growth process, these will give too great a weight to those industries whose growth has lagged and whose relative prices have remained or have become high. GDP growth in this latter case will be understated, and the measured growth rate will be biased downward.[1]

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[1]This discussion is merely a restatement of the well-known "index number problem" in which there is no simple and unambiguous choice possible between the use of a Laspeyres (prior year weights) or Paasche (current or subsequent year weights) index. See for example the discussion in Abraham (1969, Chapter 4).

Another approach to measuring GDP growth, then, and one which may give a quite different result from that based upon the use of constant prices, would permit relative prices to vary over time much as they do in the real world. One variant of this approach, which might be called a deflated, variable price growth rate measure, would be to maintain the assumption of constant prices for only a relatively short period, say for ten years or so. Prices (or quantity weights if a price index rather than a GDP index is being considered) would then be shifted to a new base and linked to the old through the use of data for a common year. Such a chain-linked index would have the advantage of permitting relative price variation as the price weights are changed over time while holding the general price level constant.

A second variable price procedure and the fourth GDP growth measure considered in this section would be to assume constant prices over time for one class of goods or group of industries. Other prices would be deflated using the price index for this single class. The price relationships among the various classes of goods would thus be allowed to vary over time. This may be called a partially deflated, variable price measure of gross domestic product. If the prices of other goods rose relative to the class of goods whose price was held constant, for example, there would be an upward bias to the resulting overall measure of GDP growth.

While the discussion so far may appear theoretical, each of the four measures has its counterpart in actual practice. A correct appreciation of the theoretical differences, furthermore, is essential if cross-country relationships taken from a particular point in time are to be extrapolated correctly to changes over time for a particular country or group of countries.

If cross-country relationships, for instance, are derived from a country sample whose per capita GDPs are expressed in constant international prices (the second measure discussed above) then projections of GDP change over time should also be expressed in the same type of constant prices.

In actual practice, projections of GDP growth are most likely to be made, implicitly at any rate, in terms of constant domestic prices from a base year fairly close to the present. This procedure is analagous to the first GDP growth measure noted above. In almost no instance is an effort made to project systematic price changes over time for a whole set of commodities and services.[1] On the other hand, when GDPs for a number of countries are compared through the use of conventional exchange rates, this is analagous, as will be seen below, to deflating each country's GDP by an index which holds one particular class of goods - those which enter international trade - constant among countries.

Numerical Examples of Pricing Biases

The real world counterparts of the several alternative growth measures are illustrated in Tables 3.1 and 3.2. In this numerical example, a hypothetical country is assumed to produce two categories of commodities, A and B, whose consumption and prices increase over a 40-year period. Commodity group A represents those goods and services which are traded internationally in significant quantities. The definition is thus narrower than that of potentially traded or tradable goods as used by Kravis and associates (1978a, p. 123). Commodity group B includes all other goods and services, including

[1]One partial exception is the projections made for the 1977-1981 Korean Prospective Plan. These projections, at least on the macro level, are expressed not only in terms of constant Korean prices but in terms of the nominal relationship between Korean prices and (changing) USA prices. See Korean Development Institute (1978).

Table 3.1
Forty-Year Growth Path of Per Capita Gross Domestic Product, Hypothetical Country

Time period (t)		Current Year Prices Commodity Group A	B	Total	Weighted Using Prior Period Price Weights Commodity Group A	B	Total
0	Price	8	16		-	-	-
	Quantity	4	12				
	Value	32	192	224			
10	Price	10	22		8	16	
	Quantity	16	16		16	16	
	Value	160	352	512	128	256	384
20	Price	12	30		10	22	
	Quantity	40	22		40	22	
	Value	480	660	1140	400	484	884
30	Price	15	49		12	30	
	Quantity	70	34		70	34	
	Value	1050	1666	2716	840	1020	1860
40	Price	18	100		15	49	
	Quantity	100	60		100	60	
	Value	1800	6000	7800	1500	2940	4440

Source: Relative prices and quantities are roughly based upon the relationships implicit for country groups I, II, III, IV, and V from Kravis and others (1978a, Chapter 4), where "Commodity A" is durables (consumer plus producer durables less furniture and fixtures) and fuels and "Commodity B" represents all other goods and services.

Table 3.2
Alternative Measures of 40-Year Growth Rates of Per Capita GDP, Hypothetical Country Shown in Table 3.1

Constant, own-price growth rates:	Value. Per Capita GDP			Annual Growth Rate
	Year 0	Year 40	Ratio	
Year zero prices (Laspeyres index)	224	1760[a]	7.857	5.29%
Year 40 prices (Paasche index)	1272[b]	7800	6.132	4.64
Geometric mean of Laspeyres and Paasche indexes (Fisher or ideal index)	533.8[c]	3705.1[c]	6.941	4.96
Constant, "international" price growth rates, where $P_A = 12$, $P_B = 36$	480[d]	3360[e]	7.000	4.99
Chain-linked (variable price weight) growth, using prior 10-year period price weights	224	1768.4[f]	7.895	5.30
Nominal growth rate assuming commodity group A prices remain constant	224	3666.7[g]	15.48	7.09

Source: Table 3.1

[a]Equals (8 x 100) + (16 x 60).

[b]Equals (18 x 4) + (100 x 12).

[c]Equals square root of the product of the previous two per capita GDP's. Thus, for example, (224 x 1272) = 533.8.

[d]Equals (12 x 4) + (36 x 12).

[e]Equals (12 x 100) + (36 x 60).

[f]Equals $224 \times (\frac{384}{224}) \times (\frac{884}{512}) \times (\frac{1860}{1140}) \times (\frac{4440}{2716})$.

[g]Equals (8 x 100) + (8/18)(100 x 60).

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some which are potentially tradable but which do not in fact contribute greatly to international trade (as with widely available or low value products where transportation costs are significant such as most foodstuffs, many non-durable goods, and durables such as ordinary furniture). The hypothesized price and quantity changes for commodity groups A and B, shown in Table 3.1, are roughly comparable to observed differences among various groups of countries as measured by Kravis and others.[1]

Table 3.1 shows estimates of per capita GDP which are uncorrected for price changes. Thus over the supposed forty year period the prices of commodity A increase by only 2-1/4 times, from 8 to 18, while per capita consumption grows by a factor of 25, from 4 to 100. The price of commodity B, meanwhile, is assumed to increase at more rapid, six-fold rate, from 16 to 100, resulting in a relatively more limited increase in per capita consumption for that commodity group. In undeflated values, per capita consumption of A plus B grows by almost 35 times (from 224 to 7800) over the 40 years.

Table 3.1 also shows one type of price deflation in which price weights are those of a ten year prior base period. Thus, in the prices of year 10, per capita consumption in year 20 would have a value of 884. This may be compared with its "current year" value of 1140 and with the year 10 value in year 10 prices of 512. In comparing year 20 consumption with that of year zero, however, a two-step process is needed since the price deflation procedure shown is applicable for only ten years at a time. Thus, the 884 figure from year 20 is comparable with the 512 figure from year 10, as already

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[1]Thus, the hypothetical country in year zero is roughly equivalent to the composite, low-income, group I countries in Kravis and Others (1978a, Chapter 4) while the year 40 situation represents real country averages at a considerably higher level of per capita GDP.

noted, while the year 10 figure of 384 (in year 0 prices) is comparable with year zero consumption of 224. Year 20 consumption using this "chain-link" procedure (illustrated further in Table 3.2) is thus 884/512 times 384/224 or 2.960 times that of year zero.

In Table 3.2, the hypothetical country's growth rate over forty years is measured according to six different methods. The first two involve the use either of year zero prices for measuring year 40 consumption or year 40 prices for valuing both year 0 and year 40 consumption. The former, since it assigns a relatively higher price weight to the faster-growing group A of commodities, produces a significantly higher measure of per capita GDP (a 5.29% annual growth rate compared to a 4.64% rate when price weights are taken from year 40). When a geometric mean is taken of the two growth measures, a compromise growth rate (4.96%) is obtained which is known as Fisher's "ideal" index (see Abraham, 1969, pp. 137-139).

The international purchasing power procedure of Professor Irving Kravis and his associates, as already noted, is to derive a common set of prices which are broadly representative of countries covering a range of per capita incomes. For 1970, on a basis which is comparable with the other prices and quantities shown in Table 3.1, the commodity A prices had a relative weight of about 12 and those of commodity B about 36. If the hypothetical country's consumption in both year 0 and year 40 are weighted using these international prices, then growth over the 40-year period is seen from Table 3.2 to have been about 4.99% per year. The near coincidence of this growth rate with that determined from the "ideal" index is an accident although the internationally-priced measure, based as it is upon a weighted average of various country prices, will always lie between growth rates obtained from price weights taken from either extreme of the observed price range.

When price weights are permitted to change every 10 years, a chain-linked growth rate is obtained, as described above, which averages 5.30% per year over the 40-year period. This is marginally higher than any of the measures so far considered although very close in this particular example to that obtained when zero year prices are used for weighting both year 0 and year 40 consumption.

Finally, the last growth rate calculated in Table 3.2 differs from all of the others shown in being only partly deflated for price changes. In calculating this "nominal" growth rate, prices of commodity group A have been held constant at 8 between year 0 and year 40. The price of commodity group B, however, has been deflated using the implicit price index for group A. In year 40, for example, the implicit group A price index would be the actual price divided by the year zero price, or 18/8 = 2.25. When the group B price of 100 in year 40 is divided by the group A price index, 2.25, the deflated group B price become 100/2.25 = 44.44. The year 40 ratio between the B and A price thus remains unchanged at 100/18 = 44.44/8 and differs sharply from the equivalent ratio between the two commodity groups in year 0, 16/8.

Because under this procedure the 40-year change in per capita consumption is not fully deflated for changes in the <u>average</u> purchasing power of currency, the nominal growth rate is considerably higher than any of the fully price-deflated measures. The nominal measure might thus seem to have little practical interest, but in fact it is exactly analagous to the cross-country differences obtained when official (or better, equilibrium) exchange rates are used to convert national currencies into common units. This is because commodity A in this example, has been defined to consist of those goods which are actively traded among countries. It is this class of goods

which largely determines a country's equilibrium exchange rates. Put differently, after converting national prices to international prices using equilibrium exchange rates (which in many countries are closely approximated by the official exchange rates), the prices of group A commodities will be very similar or almost identical in most countries.[1]

Cross-Country Evidence on Relative Prices

One way to confirm this point empirically is to compare price indexes for various commodity groups among the sixteen countries for which Kravis and his collaborators have made direct estimates as of 1978. In computing these indexes, a country's expenditure on a commodity or group of commodities is converted to dollars using the official exchange rate and then divided by a measure of relative quantity for the same commodity or group of commodities. The resultant measure of relative price is then divided by a similar price measure calculated for the United States. The U.S. index will thus always equal 100 while for commodities which show a large degree of commonality among countries, the country price indexes will also be close to 100.

The commodity classifications shown in Table 3.3 represents an attempt to identify those commodities which move in international trade in significant amounts and whose domestic prices are relatively free from distortion. While there is usually substantial variation from country-to-country, it can be seen that the relative prices for consumer durables (with some omissions)

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[1]To be more correct, this statement should define prices as "shadow" prices or prices before including the effects of taxes, tariffs, subsidies, rationing, or other domestic price-distorting policies. For this reason commodities which are freely and frequently traded but whose domestic prices are often subject to a strong degree of government control--as, for example, tobacco, alcoholic beverages, automotive gasoline, and subsidized foodstuffs--should not be included in commodity group A.

Table 3.3
Price Indexes Relative to United States (USA=100)
for Selected Commodity Groups, Kravis Sample
of Countries, 1970

Countries and groups[a]	Durables (excluding furniture & fixtures) Consumer[b]	Producer	Total	Fuel and power	Food	Clothing and footwear	All goods (services excluded)	Tradable goods[c]	Services
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Group I	103.8	109.0	105.1	70.0	52.6	45.6	53.1	56.5	18.7
Kenya	130.0	103.0	104.8	38.7			62.2	63.7	27.6
India	82.9	103.3	97.1	78.0			44.2	49.6	11.1
Philippines	102.1	117.8	111.9	103.2			46.7	50.2	13.6
Korea, Rep.	100.3	112.0	106.7	60.2			59.5	62.7	22.5
Group II	123.2	107.6	108.5	85.0	53.9	42.1	52.1	59.5	25.6
Colombia	155.7	118.6	123.3	39.2			51.2	58.8	24.5
Malaysia	101.8	102.7	101.4	123.5			51.6	59.2	28.4
Iran	112.2	101.5	100.9	92.4			53.4	60.5	24.0
Group III	100.3	92.7	93.0	98.4	84.4	73.9	80.1	83.3	44.3
Hungary	106.0	100.3	99.0	57.3			69.8	72.3	23.8
Italy	101.1	86.5	89.3	95.9			86.8	92.6	52.1
Japan	84.7	89.9	86.5	121.7			82.8	82.5	43.2
United Kingdom	109.6	94.1	97.4	118.8			81.0	85.7	58.2
Group IV	117.1	102.4	104.9	139.4	96.9	98.3	89.0	95.1	62.5
Netherlands	117.9	111.1	111.9	102.3			83.1	91.2	61.4
Belgium	119.1	109.8	111.0	156.0			91.2	96.2	54.2
France	118.5	91.3	96.8	155.9			89.2	92.7	66.0
Germany, F.R.	113.1	97.6	100.0	143.4			92.4	100.1	68.2
Group V									
United States	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Kravis and others (1978a, Chapter 4). Columns 5 and 6 are taken from Table 4.13; columns 7, 8, & 9, from Table 4.17, columns (6) and (8). Columns 1-4 are derived from disaggregated data Kravis and others (1978a), Appendix Tables 4.1 and 4.5, according to the formula:

$$100 \times (\sum Q_j P_j / \sum Q_{US} P_{US}) / (\sum Q_j P_I / \sum Q_{US} P_I) / \text{exchange rate}$$

where: $Q_j P_j$ and $Q_{US} P_{US}$ = per capita expenditures in national currencies, either of country j or of USA, from Appen. Table 4.1

$Q_j P_I$ and $Q_{US} P_I$ = quantities per capita valued at international prices, Appen. Table 4.5

exchange rate = official exchange rate between national currency and the U.S. dollar, 1970, from Table 1.2

Table 3.3, Continued

Footnotes:

[a]Countries are arranged in ascending order of 1970 per capita GDP, measured in international prices. The groups are those of Kravis and others (1978a), and the group averages are unweighted means of the countries included.

[b]In addition to furniture, excludes household textiles and utensiles; books, papers and magazines; stationery; educational supplies; toilet articles; and drugs, medical supplies and therepeutic equipment. Includes Kravis lines 61-66, 79-81, and 92-94 (1978a, Appendix Tables, Chapter 4), namely: household appliances, personal transportation and accessories, electronic goods, and recreational equipment.

[c]Tradable goods differs from "all goods" in that construction has been excluded.

and producers durables, lie close to 100. Fuel and power prices, on the other hand, appear to be depressed in poorer countries and considerably higher than the United States average in richer countries other than the U.S., presumably as a result of deliberate government policies. Both food and apparel prices (clothing and footwear) appear to increase relative to those in the USA as per capita incomes rise. The relative price of services shows the greatest range, averaging less than one-fifth of the relative U.S. price in the lowest income group of countries.

Table 3.3 illustrates the wide variation of commodity prices which exists among countries, the tendency of certain categories of prices to rise relative to other categories as per capita incomes rise, and the tendency of a few categories of goods to have similar prices among countries when converted to a common currency at official exchange rates. It seems reasonable to suppose that prices would be similar throughout the world for those goods which are actively traded internationally. What is less clear is why prices are not similar for all goods which are internationally traded and why relative domestic prices should vary so greatly at different income levels.

Reasons for Inter-Country Differences in Relative Prices

The answers lie partly with classification and measurement conventions and partly with the nature of productivity differences among countries. The category of "food", for example, includes a multitude of products many of which (root crops, fresh milk, and most fresh vegetable, for instances) are traded internationally to only a minor degree. Even when a more narrow definition of commodities is employed, however, large price differences may still remain among countries. Thus, Table 3.4 shows 1961-65 cereal prices averaged for a sample of 97 countries. The higher income group of countries

Table 3.4. Average Grain Prices by Level of Per Capita GNP, 1961-1965

Number of Countries[a]	Per Capita GNP Range 1963, Current U.S. $	Average Grain Price, U.S. $ Per Metric Ton
25	less than $100	$54.6
22	$100 to $199	$69.0
32	$200 to $900	$79.4[b]
18	$1,000 +	$83.1
97	Total Sample	$71.3

Source: GNP estimates in current prices from World Bank, Economic Analysis and Projections Department, computer listing of February 3, 1975; grain prices and quantities (for determining average prices) from U.S. Department of Agriculture, Economic Research Service, "Indices of Agricultural Production," for various regions, average 1961-65 and annual 1964 through 1973, May and June, 1974. Local prices have been translated into dollars by the USDA in most cases, using official exchange rates.

[a]All countries have been included for which it was possible to obtain income and grain price estimates from the two sources. Not included are any socialist bloc countries, either in Europe or Asia.

[b]The average grain price for Japan was $186.50. Excluding Japan from this group would lower the group average to $75.9.

reported domestic prices which, in U.S. dollar equivalents, were over half again as large as the average for the lowest income country group. In this case, although cereals are widely traded, the bulk of a country's consumption is almost always produced domestically, and the prices shown in Table 3.4 are far more heavily influenced by domestic than by international sales.

Domestic prices will reflect domestic costs of production and the relative insulation of domestic from international markets when trade restrictions exist or transportation and distribution costs are significant. Domestic production costs differ among countries as a reflection of productivity differences. These differences are likely to be greatest among internationally-traded manufactured goods. But if prices are similar (in international currency units) where productivity differences are largest, then prices must differ (again in the same international currency) where productivity differences are smaller.

Professor Kravis and his colleagues have summarized this "productivity differential model" as follows:[1]

1. International competition makes the prices of traded goods equal in all countries.
2. Wages in each country's traded goods industries will depend upon the productivity of labor in those industries.
3. The wages established in each country's traded goods industries will prevail in nontraded goods industries as well.
4. Productivity differentials are smaller in nontraded goods industries than in traded goods industries.

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[1]Kravis and Others (1978a, p. 127-128, and 1978b, p. 219). See also the reasoning of Raoises Syrquin in his "Technical Appendix" in Chenery and Syrquin (1975, pp. 145-153).

5. It follows that nontraded goods, of which services are a major component, will be relatively cheap in low income countries. That is, low wages of low-income countries, established by their low productivity in traded goods production, extend to the nontraded goods industries in which relatively better productivity produces low prices.

To this line of reasoning can be added the point noted earlier that the domestic prices of traded goods may be heavily influenced in the real world by public policies. Domestic prices as measured furthermore may reflect prices in different markets and a range of product qualities or variants, some of which may not in fact be traded internationally. A second point is that productivity increases tend to be associated during the course of economic development with the faster-growing, usually more capital intensive manufacturing sector. Productivity increases in other sectors, especially in agriculture and the more labor-intensive services, tend to lag manufacturing. This gives rise to a wider range in labor productivity differences, as between manufacturing and services and agriculture for example, at higher income levels.

The shift in emphasis from the so-called primary products (agriculture and mining) towards manufacturing, utilities, and some services was documented many years ago by Colin Clark (1957). More recently, Hollis Chenery and Moises Syrquin (1975) have measured these trends with greater precision and have discovered that production patterns appear to be influenced also by country size (measured by population), by the degree of export orientation (especially among smaller countries), and by net flows of foreign capital. Table 3.5 illustrates the rapid relative growth of "industry" (manufacturing and construction) which is found at higher levels of per capita GNP.[1] The share of agriculture and

[1] Table 3.5 is in fact derived from an earlier and in some ways more detailed World Bank working paper by a colleague of Chenery and Syrquin, Nicho-

Table 3.5. "Normal" Composition of Gross National Product at Increasing Per Capita Income[a]

Sector[b]	Per Capita GNP (1964 US $)							
	50	100	200	300	500	1000	1500	3000
I. Population = 100 millions								
Primary	.621	.452	.315	.248	.179	.112	.086	.067
Industrial	.070	.167	.248	.287	.329	.371	.387	.402
Utilities	.036	.057	.072	.080	.087	.094	.096	.097
Services	.275	.327	.370	.390	.411	.431	.438	.442
II. Population = 500 millions								
Primary	.664	.496	.358	.291	.222	.155	.130	.110
Industrial	.036	.133	.214	.254	.295	.337	.353	.368
Utilities	.047	.066	.081	.088	.095	.102	.105	.106
Services	.258	.311	.354	.374	.395	.414	.421	.425

Source: Carter (1973): See also Chenery and Syrquin (1975, Table S9) for similar data on primary and industrial output.

[a]Ratios are of GNP component shown in left-hand column to total GNP, holding population constant and assuming zero net capital inflow. Sum of component shares should equal 1,000 except for rounding errors.

[b]Primary = agriculture and mining
Industrial = manufacturing and construction
Utilities = electricity, gas, water, transportation (including storage) and communication
Services = all other, including government not classified elsewhere

mining, in sharp contrast, drops dramatically. The share of "services" (including government) also appears to increase at higher income levels although the work of Kravis suggests that this increase may be more apparent than real, reflecting price differences rather than a larger share of output in real terms (Kravis and others, 1978a, p. 127).

The Relationship Between Nominal and Constant Price GDP

A constant price measure of GDP such as usually employed by country planners assumes, by definition, unchanging prices during the period under review. As noted already, relative prices do change as a matter of course in the real world, the changes appear to be systematically related to level of income and industrial structure, and the price differences are greater the greater are the differences in per capita income and industrial structure. When measures of per capita GDP are compared in nominal terms (that is when they are converted to a common currency using equilibrium or official exchange rates) a part of this price variability will be allowed for, but the GDP measures will lack comparability because of differences in the domestic purchasing power of the international currency when both traded and non-traded goods are taken into account.

Purchasing power comparability may be imposed in a mechanical fashion by repricing all goods and services with a common set of "international" prices. This has been the method followed by Kravis for making comparison among countries and it is somewhat analagous to using an "ideal" price index for comparing GDP for a single country at two different periods of time. There seems to be no generally accepted method, however, for permitting normal price variability over time while assuring purchasing power comparability.

Two problems arise, therefore, when making longer-run projections for a single country. First, expressing GDP growth in constant prices will fail to reflect the "catching-up" process with respect to higher income countries. Referring back to Table 3.2, for example, it can be seen that GDP per capita in year 40, when expressed in prices of year 0, would be 1760. In nominal terms, however, this would be comparable to a country which in year 0 had had a per capita GDP of 3667. The real or constant price growth rate over the forty years would have been 5.3% per year, but the nominal or "catching-up" growth rate would have been 7.1 percent per year. Put another way, the Kravis data show that the real (internationally-priced) difference between U.S. and Indian per capita GDP in 1970 was about 14.5:1 (Kravis and others, 1978a, Table 1.2). If India were to increase its nominal 1970 GDP of $99 per person by 14.5 times, however, it would reach only $1435. In real terms this would represent a complete catching up to where the United States had been in 1970, even though the nominal 1970 GDP of the U.S. was $4790 per capita.

The second problem, as noted earlier, is that when projections over time are based upon relationships derived from cross-country data, the GDP time series measures must be comparable to those used for the original cross-country analysis. If India and the United States, for instance, are included in the same cross-country sample at their nominal per capita incomes, then the structural change or other statistical relationships derived from the sample are only applical to changes over time which are expressed in nominal rather than real income terms.

To ensure this comparability when nominal GDP's have been used as explanatory variables in the cross-country analysis (as they have been in the present study), Indonesia's projected GDP growth rate in "real" terms

must be converted to growth in nominal terms. This can be done using a two-stage procedure. The initial 1970 GDP level in nominal U.S. dollars is converted to international dollars using the implicit relationship between international and nominal prices from the 1970 Kravis data. Constant-price projections of GDP growth are then applied to the 1970 GDP expressed in international prices, and future-year estimates in international prices are then converted back to nominal values using the same implicit relationship employed for the first step. In this way, GDP in both international and nominal prices may be projected for any year desired.

Implicit in the Kravis results is a very strong statistical relationship between nominal and internationally-priced per capita GDP. This relationship can be expressed as follows:[1]

$$\ln \text{GDPR} (\$'70) = \underset{(0.47)}{.495} + \underset{(4.03)}{1.340} \ln \text{GDPN} (\$'70) - \underset{(1.55)}{.047} (\ln \text{GDPN}, \$'70)^2 \qquad (3.1)$$

$$\bar{R}^2 = .986$$

SEE = .1092 = approximately 12% of mean value of the dependent variable

t-ratios are in parentheses

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[1]Kravis and associates computed the same equation, except that country GDPs were expressed as ratios to United States GDP on both sides of the equal sign, with comparable statistical results. They also introduced two additional explanatory variables, a measure of "openness" to international trade and a measure of "price isolation" or domestic price movements as contrasted with "world" price movements. These two additional variables are suggested by the theory of purchasing power differences, and they increase the statistical fit from an R^2 of .986 to .991 (Kravis and others, 1978b, p. 226, Table 2). In the case of Indonesia, however, the addition of these two factors would make a difference of only 5 percent in estimated 1970 GDP (Kravis and others, 1978b, Table 4, p. 232). Since it would be difficult to predict how the two factors might change over time, they will not be employed when converting projected, constant price GDP for Indonesia to real and nominal prices.

where GDPR ($'70) = real per capita GDP in 1970 "international" dollars, as calculated by Kravis and others (1978a, Table 1.2)

GDPN ($'70) = nominal per capita GDP, in 1970 US dollars, converted at official exchange rates, from the same source

Equation (3.1) shows that real per capita GDP exceeds nominal GDP at nominal income levels up to about US $4,800, and extrapolation of the Equation (3.1) results suggests that above US$ 4.800 per capita real income begins to fall below nominal income.

The implications of Equation (3.1) are further illuminated by the numerical exercise shown in Table 3.6. In these calculations, real income (Column 1) is presumed to grow at a constant annual rate of 5 percent. Nominal per capita GDP (Column 3) is seen to grow at rates above 5 percent (Column 4), accelerating until a 9 percent (nominal) annual growth rate is reached between real GDP levels of $3,326 and $5,417 per capita.

Thus, although relatively large differences exist between real and nominal GDP at low-income levels, the bias in the growth rate can be expected to be relatively minor at low levels of per capita GDP. The nominal growth rate begins to exceed the real rate by two percentage points, however, by the time nominal GDP reaches about US $600 (in 1970 prices, as is the case throughout this discussion).

Choice of Per Capita Income Targets

The conclusions to be drawn from the preceding analysis are that the relationship between GNP and human welfare is obscure and that even our perceptions of what constitutes "acceptable" GDP growth rates may be biased, particularly at higher income levels, by systematic price changes occurring during the course of development. Based upon the inter-country evidence so

Table 3.6. Numerical Illustration of the Difference between Real and Nominal Growth Rates at Increasing Levels of Per Capita GDP

Real per capita GDP (1970 international dollars)[a]	Elapsed years from previous GDP level	Nominal per capita GDP (1970 US dollars)[b]	Implicit annual growth rate, nominal per capita GDP
(1)	(2)	(3)	(4)
$200	-	$100	-
472	10	174	5.7
770	10	314	6.1
1,254	10	592	6.5
2,042	10	1,180	7.1
3,326	10	2,530	7.9
5,417	10	6,023	9.1
Intermediate years			
742		300	
3,680		3,000	
4,800[c]		4,800	

[a]Real per capita GDP is assumed to grow at 5 percent per year throughout the period.

[b]Nominal per capita GDP has been calculated from real per capita GDP using Equation (3.1).

[c]Approximately equal to the nominal/real per capita GDP of the United States in 1970 (Kravis and others, 1978a, Table 1.2).

far available, constant-price GDP growth rates for a particular country may underestimate that country's progress in achieving parity with richer countries. The nominal GDP growth rate exceeds the constant price growth rate, in other words, over most if not all per capita incomes, and there may be a tendency for the divergence to become greater at higher income levels.

In the case of Indonesia in the year 1970, its per capita income, as conventionally measured using international exchange rates, appeared to be about one-fiftieth that of the United States. "Catching-up" with 1970 U.S. living standards would therefore require fifty-eight years at an annual rate of 7 percent. This latter rate might seem a rather high target for such a long period, but the implication of Equation (3.1), for example, is that the corresponding "real" or constant price growth rate for a fifty-eight year period might be in the order of only 5 percent per year.[1]

These differences are apparently not great at lower per capita incomes and will not have much significance for Indonesia over the next twenty-five

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[1]The 1970 estimate was taken from World Bank (1976, p. 123) data and equals the mean of 1969+1970+1971 total GDP in US dollars at average 1967-69 price and exchange rates times the 1970 ratio of GDP in current market prices to GDP in US dollars at average 1967-69 prices and exchange rates, divided by 365 (the average exchange rate for 1970), and divided again by 115.57 millions, the mid-1970 population of Indonesia from the same World Bank source. These calculations gave a 1970 (actually, 1969-71 mean) GDP per capita of $79. The corresponding figure for 1975 in 1970 US dollars was $102, rounded down to $100 in this study for projection purposes. This latter estimate was based upon the extrapolation to 1975 of the 1970 estimated per capita GDP, using constant price GDP series from BPS, Statistik Indonesia, 1974/75 (1975, p. 523) and Statistik Indonesia, 1976 (1978, p. 985). A more recent World Bank (1977, p. 23) source lists 1975 per capita GNP for Indonesia as $220 in 1975 market prices, and an unpublished set of national accounts used for Five Year Plan purposes in Jakarta in the summer of 1978, if converted at the official exchange rate of 415:1, would give a 1975 per capita GDP of about $270. These large apparent differences reflect the fact that Indonesia's domestic prices have increased much faster than have world prices since 1970 while the official exchange rate had increased hardly at all (by 14 percent between 1970 and 1972 and not at all until late in 1978). If the 1975 per capita GDP were converted to 1975 US dollars using the same inflation rate as experienced, say, by the United States, the figure would be about $160.

years. They should become of greater importance after the turn of the century, however, and must be taken into consideration when setting the year 2025 and 2050 income targets needed for the current study.

A broader and more judgmental conclusion; derived from personal observation of real-world target-setting in macro-economic plans and model construction, is that the choice of an income target is largely arbitrary. The choice is usually not based upon a careful consideration of the steps needed to achieve certain welfare standards, but upon the maximum growth that appears consistent with the country's export and foreign assistance prospects. For many years, a two or three percent annual per capita growth rate was considered a reasonable target, especially when population was also expected to be growing at close to the same rate. In more recent years, as the difficulty has become apparent of meeting employment objectives in many countries at per capita growth rates of less than four or five percent per year, more explicit welfare considerations have begun to enter the target-setting process.

In the case of Indonesia, the 1973-2000 growth rate targets initially examined by Professor Sumitro ranged from 3.9 percent to 5.0 percent per capita, and a rate averaging about 4.5 percent was considered to be a "realizable" possibility.[1] While Professor Sumitro, as already noted, considered a number of welfare goals quite explicitly in his study, no attempt was made to link goal attainment with a particular GNP growth rate.

World Bank analysts, in contrast, have reached the conclusion from a detailed macro-economic model that it would be difficult to achieve Indonesia employment goals, particularly on Java, at growth rates as low as those selected by Professor Sumitro and his colleagues. The growth rate implicit

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[1]Sumitro Djojohadikusumo (1975, p. 225 and Table 4B, p. 252).

in the Bank's 1975 economic report and projections, therefore, was closer to 7 percent per capita per year for the next twenty years or so (Gupta, 1975).

For the current set of projections we have taken Professor Sumitro's "realizable" rate as a Low alternative and the Bank's 6.8 percent Alternative XI(a) as a High alternative. The lower of the two growth rates is projected to drop from 4.2 percent during 1975-90 to 3.6 percent during the next fifteen-year period, averaging 4.0 percent for 1975-2000. Each succeeding fifteen-year interval after 1990 is projected to experience declining average annual growth rate assumed equal to about 85 percent of the previous fifteen-year period.[1] This path would result in nominal per capita GDP by the year 2000 of about $264, or a little higher than the Republic of Korea in 1970. (See Table 3.4 and Kravis and others, 1978a, Table 1.2.) By the year 2050, nominal per capita GDP would have reached $2,024 (accompanying a tenfold increase in real GDP). The nominal year 2050 level would thus be close to that of the United Kingdom in 1970 (Kravis and others, 1978a, Table 1.2).

Under the "High" alternative, it is assumed that Indonesia would reach a real per capita GDP level by the year 2050 comparable to that of the United States in 1970. This is accomplished by growth during 1975-1990 at 6.8 percent per year with the average rate declining in each subsequent fifteen-year period by a factor of about 0.7.[2] Nominal per capita GDP under this alternative would have increased to $585 by the year 2000, somewhat above the 1970 level for Brazil and

[1] The projected annual growth rates will thus be: 1975-1990 (4.2%), 1990-2005 (3.6%), 2005-2020 (3.0%), 2020-2035 (2.6%), and 2035-2050 (2.2%).

[2] Thus, the projected annual rates of per capita GDP growth will be: 1975-1990 (6.8%), 1990-2005 (4.8%), 2005-2020 (3.4%), 2020-2035 (2.4%), and 2035-2050 (1.7%).

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below that of Mexico in the same year. (See Table 3.4 and Kravis and others, 1978b, Table 4) As shown in Table 3.4, real per capita GDP under the High alternative would increase by more than sixteen times during the seventy-five year period, 1975-2050. After about the year 2000, per capita GDP under the High alternative is 60-80 percent more than under the Low alternative.

Table 3.7 illustrates the differences among the various ways of expressing per capita income growth. Lines 1 and 4 are analogous to those with which today's macro-economic planners usually work. Today's official exchange rates give a particular per capita GDP (US $100 in the case of Indonesia in 1970 prices), and this is projected to increase over time at a particular "real" or constant domestic price rate of growth. In Line 2 the Line 1 projections are based not on the official exchange rate for 1970 but on a "purchasing power equivalent" rate similar to that calculated for 1970 by Irving Kravis and his associates using a common set of international prices and under the assumption that the index for the United States equals 100. (Recall, however, that such a rate for Indonesia has so far <u>not</u> been directly calculated. The rates used for the Line 2 and 5 estimates have been derived by analogy with the Kravis purchasing power indexes found in 1970 for other low-income countries, principally India, Kenya, and the Philippines.)

Table 3.7. Per Capita GDP Projections and Assumptions, Indonesia, 1975-2050

Line	Target Year (Annual compound growth rates from the year previously shown are given in parentheses) 1975	1985	2000	2025	2050
"Low" Assumption					
1 Constant-domestic price projection	$100 -	$151 (4.2)	$264 (3.8)	$558 (3.0)	$1,000 (2.4)
2 Constant international price projection	290 -	438 (4.2)	766 (3.8)	1,618 (3.0)	2,900 (2.4)
3 Nominal GDP	100 -	159 (4.7)	312 (4.6)	843 (4.1)	2,024 (3.6)
"High" Assumption					
4 Constant-domestic price projection	100 -	193 (6.8)	429 (5.5)	1,008 (3.5)	1,645 (2.0)
5 Constant international price projection	290 -	560 (6.8)	1,243 (5.5)	2,922 (3.5)	4,770 (2.0)
6 Nominal GDP	100 -	213 (7.9)	585 (7.0)	2,049 (5.1)	4,744 (3.4)

Notes:

Lines 1 and 4 - Constant price projections from 1975 GDP in 1970 prices, converted to US dollars at 1970 exchange rate. "Low" assumption calls for 15% decline in average growth rate every 15 years, starting from 4.2% annual growth rate in 1975-90. "High" assumption begins with 6.8% annual rate and declines by 30% each 15-year period thereafter. See text for actual growth rates used each period.

Lines 2 and 5 - Same growth rates assumed as for constant-domestic price projections, but value shown for 1970 has been

Table 3.7 (continued)

adjusted for differences in international purchasing power. Since a growth rate measured in constant international prices may differ in practice from the same rate measured in constant domestic prices (see Table 3.2), the implicit assumption is made that the rates shown in lines 1 and 4 are based upon some form of "ideal" index rather than a Laspeyres or Paasche weighting scheme.

Lines 3 and 6 - Converted from internationally-priced GDP per capita (lines 2 and 5) using equation (3.1).

An attempt has been made in Line 3 and 6 under each assumption to convert the constant price estimates to nominal GDP based upon the observed 1970 system of exchange rates. The assumption here is that in a given year the official exchange rates bear a systematic relationship to the domestic and international prices of goods moving in international trade and that this relationship is largely a function of per capita income. This relationship, expressed above in equation (3.1) is assumed to remain constant over time. The Line 3 and 6 GDP levels are equivalent to those which would have been measured in 1970, at the various nominal levels of income, using the system of official exchange rates that were in existence in 1970. The levels are thus comparable to those registered by other countries in 1970 at various stages of development, and for this reason, as already mentioned, they have been termed nominal Gross Domestic Product.

Note in particular that the modest "Low" assumption projects only a ten-fold increase in real per capita GDP over a seventy-five year period. In terms that are comparable to the per capita incomes observed among countries in 1970, however, this would be equivalent to a twenty-fold increase. (Note, too, however, that there is a much smaller difference in the relative increases shown for these two measurement systems between 1975 and 2000.)

Under the High growth assumption, a sixteen-fold increase in constant price terms is projected over the seventy-five year period. The equivalent nominal increase, in striking contrast, would be almost fifty-fold. At the higher projected 1975-2000 growth rates under this assumption, the divergence between the two measuring systems would be appreciable even before the turn of the century.

Combinations of Population Assumptions and Income Targets

It is probable that the future labor force contribution to economic growth in Indonesia will be of considerably less importance than will capital investment, technological change, export markets, and natural resources. This is to say, that increases in total (real) domestic product will not be greatly influenced by differences in population growth. As a consequence, per capita GDP may be largely determined after the fact through the division of realized GDP among the existing population in a particular year.

We have seen in the previous chapter that the year 2050 population for Indonesia could easily range from 300 to 600 millions. For the purposes of this study we will assume that the high per capita income assumption is probably not compatible with the highest population growth rate possibility. (This combination would imply an average real total GDP growth for seventy-five years at 5.9 percent per year, or a seventy-four-fold increase in all. An increase of this magnitude is probably not realistic to assume.) Five other combinations of population growth and per capita income assumptions will be investigated, ranging from low population and low-income to medium population and high income. (The total GDP under the high population and low-income assumption falls below that of both the low and medium population growth in combination with the high per capita income assumption.) These combinations, along with the nominal and constant price growth rates of total GDP are shown in Table 3.8.

In preparing Table 3.8, in view of the general hazard of indulging in such long-run projections, the various figures represent no more

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Table 3.8. Alternative Combinations of Population and Per Capita GDP Assumptions, 2000-2050

	Assumption					Annual Growth Rates	
	Population	GDP Capita	2000	2025	2050	1975-2000[a]	2000-2050
Population ($x10^6$)	Low	-	210	260	300	1.8	0.7
	Med.	-	230	335	420	2.2	1.2
	High	-	250	410	540	2.6	1.6
GDP Per Capita							
At 1970 prices (US $)	-	Low	260	560	1,000	3.9	2.7
	-	High	430	1,010	1,650	6.0	2.7
Nominal (1970 US $)	-	Low	310	840	2,020	4.6	3.8
	-	High	590	2,050	4,740	7.4	4.3
Total GDP							
At 1970 prices (US$ $x10^9$)	Low	Low	55	146	300	5.8	3.5
	Low	High	90	263	495	7.9	3.5
	Med.	Low	60	146	420	6.2	4.0
	Med.	High	99	238	693	8.4	4.0
	High	Low	65	230	540	6.6	4.3
Nominal (US$ $x10^9$)	Low	Low	65	218	606	6.6	4.6
	Low	High	124	533	1,422	9.3	5.0
	Med.	Low	71	281	848	6.9	5.1
	Med.	High	136	687	1,991	9.7	5.5
	High	Low	77.5	344	1,091	7.3	5.4

[a]1975 population assumed to be roughly 133 millions and per capita GDP about US$100. Total GDP was thus about US$13.3 $x10^9$ in 1975.

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than rough orders of magnitude. They have been accordingly rounded off liberally from those shown earlier in Tables 2.1 and 3.4. In general, the "low" population estimate corresponds to the Population Council's Projection 3 (Line L1 in Table 2.1), while the "high" population is that from Line H2 in the same table. The "medium" population projection is simply an unweighted mean of the low and high estimates.

The GDP per capita lines in Table 3.8 are comparable to Lines 1 and 4 from Table 3.7. 1975 GDP per capita was roughly U.S. $100 and total GDP was therefore equivalent to about U.S. $13.3 billions. In real (constant price or constant purchasing power equivalent) terms, Table 3.8 suggests that average per capita GDP might increase by two-and-one-half to four-and-one-half times by the end of the century and that total GDP might increase from four to seven times.

By the year 2050, the inexorable progress of compound growth, in spite of the sharp declines in annual rates assumed for both population and per capita income after 2000, will possibly have led to far greater increases. Per capita GDP in real terms, as already mentioned, could be ten to sixteen times above that in 1975 while total GDP might increase by a factor of from 23 to 52.

Expressed in terms of nominal incomes, assuming the same relationships between income and commodity price structure as found in 1970, the increases would be even greater. By the year 2000, Indonesia's total GDP might be as much as ten times greater than in 1975. A further fifteen-fold increase during the next fifty years might bring the 2050-1975 ratio to almost 150:1.

The nominal "1970 exchange rate" figures shown in Table 3.8 are meant to be directly comparable to those observed among the world's economies in 1970. Indonesia under the low-income and medium population assumptions would thus reach a total (not per capita) GDP in 2050 that was close to that of the USA in 1965.[1] Under the medium population and high-income growth assumptions, total GDP might be almost twice the total GDP of the United States in 1975. (U.S. total GDP in 1975, in turn, was over two times that of the next richest country, the U.S.S.R.)

The Influence of Income Distribution

To what extent might these results be affected by differences of income distribution within the country? Three points can be made on this subject. The first is that there has been an apparent tendency historically for income distribution to worsen during the early stages of development, say between per capita GDPs in 1970 prices of between $100 and $700. Higher-income countries, on the other hand, seem to have been able to achieve a more equitable distribution of income.[2]

The second point is that within any given income range there appears to be large differences in income distribution. Among larger countries of less than $300 per capita GDP (1970 prices), for example, a number of countries (Pakistan, Bangladesh, Republic of Korea) had relatively equitable income distribution in the sense that the top 10 percent of households received no more than 25-30 percent of total income. In the Philippines, on the other hand, this group of wealthier households in 1971 received 37 percent of total income, while the com-

[1]Total U.S. GDP in 1965 (in 1970 prices) was $841 billions, according to the Council of Economic Advisors (1976, Tables B-6 and B-7, pp. 178-9).

[2]This phenomenon has been attributed by earlier investigators such as Kuznets and Myrdal to the belief that in the low-income stages of development, economic growth tends to concentrate in the relatively narrow "modern" sectors, thus leading to a worsening of income distribution, especially as between agriculture and manufacturing. It is only later, "at relatively high levels of income, that technological progress affects the bulk of the economy and that redistribution through income transfers becomes significant." See Chenery and Syrquin (1975, p. 60); and Ahluwalia (1976).

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parable figure in Indonesia was reported to be close to 41 percent (Jain, 1975). It is likely that the differences would be even more striking if mainland China could be included in the comparison. (In Taiwan, 10 percent of households were reported to have received 22 percent of total income in 1972, and on the mainland the proscribed range of incomes has apparently been limited to relatively narrow bands. See Henle, 1974, pp. 28-33.) Among the middle-income countries, the extremes are even larger. Venezuela and Poland both had 1970 per capita GDP in the neighborhood of $1,100, but in Venezuela 51 percent of total income was received by just 10 percent of the "economically active population", while in Poland the income share received by the wealthiest 10 percent of "workers" was only 21 percent (Jain, 1975). On the other hand, in the richest countries, such as Canada and the United States (as well as smaller rich nations such as Denmark and Sweden), the income share gained by the wealthiest 10 percent was ordinarily closer to 25 percent. (In the USA the 1972 percent was ordinarily closer to 25 percent. In the USA, the 1972 figure for households was 28 percent; in Canada, it was 24 percent in 1965. See Jain, 1975.)

The third point is that a more equitable distribution of income would not greatly affect our measures of average per capita income. Imagine, for example, a country with an average income of $1,000 and an income distribution such as Indonesia in which four-tenths of the income went to the wealthiest 10 percent of the population. If the income distribution of Taiwan or Poland could be achieved, then the poorer nine-tenths of the population would be just as well off at a per capita income of perhaps $760. The latter figure is about three-fourths of the former, but the difference represents less than six years' growth at a GDP growth rate of 5 percent per year.

The question will be raised in Chapter 9 concerning the extent to which material consumption may be expected to differ with differences in income distribution. In the meanwhile, it will merely be noted once more that most of our "normal" materials consumption patterns will be derived from cross-country comparisons using nominal (1970 official exchange rate) measures of per capita GDP. Because of the tendency for income distribution to be systematically related to per capita income, a part of any income distribution effect on materials use may in any case be picked up statistically by the per capita GDP variable.

ANNEX B

STRUCTURAL CHANGE

Chapter 8 from

Population, Resources and The Environment
in Indonesia's Future

by Alan M. Strout

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STRUCTURAL CHANGE

The consumption of raw and bulk materials is related to the production of intermediate and finished goods and services. These in turn are functions of country size, levels of living, and the rate of economic growth. As per capita income increases, the consumption of manufactured goods and the consumption of services (trade, transportation, communication, business services, etc.) typically grow faster than does the consumption of agricultural goods. The rate of economic growth at any time is at least partly determined by additions to capital stock, and this will largely determine the consumption of producers' durable equipment (both new and replacement), buildings, plant and economic infrastructure.

Conceptually, the consumption of materials can be seen as derived from the demand for, in increasing order of remoteness from the raw material base: semi-finished goods, finished goods, intermediate and final services, additions to capital stock, and final consumption by private consumers and by government. The situation is complicated by possibilities for foreign trade and inventory changes at most steps in the process and by the fact of circularity throughout the system in the relationship between supply and demand. (That is, for example, the demand for construction materials will lead to a demand for steel and iron ore but this, in turn, will create an additional demand for construc-

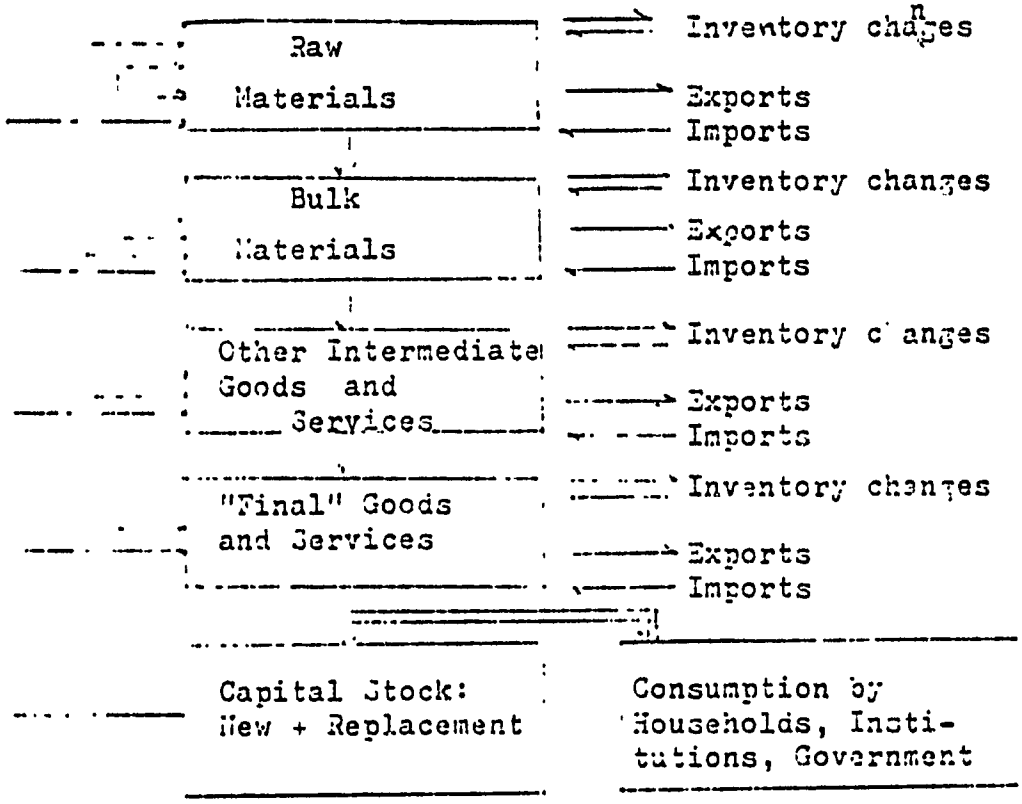
tion materials will lead to a demand for steel and iron ore but this, in turn, will create an additional demand for construction materials.) The materials demand situation is illustrated schematically in Figure 8.1.

This study deals with the consumption of bulk materials (crude steel, paper pulp, washed-and-cleaned coal) rather than raw materials (iron ore, pulp wood, run-of-the-mine uncleaned coal) partly for statistical convenience, partly in the interest of dealing with more homogeneous products, and partly because the consumption of bulk materials tends to be geographically closer to final demand. The relationship between a bulk material and its chief raw material constituents are usually fixed, however, and thus it is relatively simple to calculate the implicit iron ore consumption of a given grade, say, that has been incorporated in each ton of crude steel consumed by an economy.

The most accurate projections of raw materials will be obtained from precise predictions of bulk material production. Bulk material projections will be most accurate when the demand is known for the good or service at next higher stage of production or fabrication. One widely-used and relatively accurate projection method for the short run, for example, is to project the consumption of automobiles, glass bottles, electric energy, railroad transportation, and other individual items and groups of items, on the basis of population and per capita income growth. If desired, any particular basket of final or semi-final goods and services can be analyzed further, using various technical

Figure 8.1

Schematic Illustration of Steps in Demand for Raw Materials



coefficients and relationships, to discover the quantities of bulk and raw materials needed for the production of the goods involved.

In the longer run it is fairly clear that new goods will be invented, older goods will be transformed drastically, and technical production relationships will be altered. An audacious analyst with an unusually perceptive crystal ball will occasionally venture a guess about the direction and magnitude of these changes 25 to 50 years in the future. Such a study, for example, has been made for the United States extending to the year 2000, and the raw materials consumption implications of these projections have been used by its authors as a guide to materials consumption elsewhere in the world.[1]

An alternative projection approach is to work with broader economic aggregates such as the usual "industrial" divisions of gross domestic product (agriculture, mining, manufacturing, utilities, transportation, other services) and to establish links between the value added or output of each of these sectors and the probable consumption of individual materials. Sectoral projections can then be made using various techniques or combinations of techniques. These will ordinarily include time trend projections, analogies with the experience of other countries, or the employment of special knowledge about the particular economic, social, or resource characteristics of the country in question.

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[1]Ridker and Watson (1979). The materials projections are discussed further in Chapter 5.

Once long-run estimates have been made of broader sectoral outputs, technology-based reasoning may be used to guess at the amounts of steel, petroleum, lumber, and other bulk materials that will be required by each sector.

The assumption behind this latter type of projection is that although we may not be able to predict precisely what goods and services will be consumed in the future (or how each will be produced), it will be possible to say something about broader agglomerations of goods, and these agglomerations, on the average, will not be as affected by change in material composition over time as may be (for example) the output of individual manufacturing sectors.

A related technique that is applicable to projecting the future of today's poorer countries is to assume that as they grow richer over time, their consumption patterns will approximate that of today's more affluent countries. This is essentially the technique that has been used for the current study of Indonesia. It does not give much credit to possibilities for future substitution among materials and says, in effect, that the major future force shaping materials' consumption will be population and economic growth plus future structural changes in both. These, in turn, will be similar to those experienced in the past and which can be observed among countries at various income levels in the world today. Changes in population, particularly the shift from agriculture to industry and from rural to urban locations, were discussed in Chapter 2. The present chapter deals with the

analogous changes that can be expected over time in the structure of economic activities.

It should be noted at this point that the possibility of future price changes in material costs can affect the analysis in two ways. Where we suspect that the price of one class of material, say aluminum, will rise less rapidly in the future than another class of partially competing material, say copper, we can argue that our projection of aluminum consumption, based as it will be upon the historical relationship between material use and economic structure, will probably be too low and that for copper too high. (A time-trend analysis of the markets for aluminum and copper, which this current study has not employed, would do a better job of reflecting this phenomenon since there has already begun to be considerable substitution of aluminum for copper.) Where prices in raw materials rise in general, relative to the prices of all other goods and services (chiefly human labor), substitution among materials may be less important than would be the reduced use of all materials.

Another way to put this latter point is to note that personal income or product would be reduced by the increased amounts of labor and capital expended on materials production. It is assumed that this "income effect," reflected by a retarded growth rate in per capita domestic product, would account for all or most of the reduced material consumption. The projected future relationship between per capita income and per capita bulk material consumption may be reasonably accurate, in other words, but a general

increase in materials prices may mean that our projections of the future increases of per capita income (and hence of per capita materials use) have been overly optimistic.

There is one further assumption of possible importance that may be contained in the notion that today's poorer countries will duplicate the consumption patterns of today's richer countries at some time in the future. This is that changes in income distribution will occur in the future as they have in the past. If consumption patterns (with respect to raw material use) are affected by the degree of income inequality in the population, then any change in historical trends in income distribution could cause serious biases in future commodity projections. This is not to say that such changes appear imminent. There has been increasing public concern, however, about the uneven distribution of the fruits of development, and it is possible that these concerns might be translated into effective income-equalization policies in some countries. For this reason the link between income distribution and economic structure will be examined further in the following section.

A Macro-Economic Model for Indonesia

The current study of longer-run Indonesian growth has been fortunate in being able to draw upon economic modeling studies of Indonesia which have been underway for a number of years at the World Bank. One recent Bank product is a very detailed and ambitious macro-model executed by Dr. Syamaprasard Gupta and his

assistant, Ellen Andersson (Gupta, 1975, 1977). The model was developed in conjunction with 1974/1975 Bank economic studies of Indonesia, and it has been further refined and improved since then.

The Gupta model places particular emphasis on the relationships among economic and population growth, income distribution, and employment.[2] It can be used to project major economic variables as well as to give a quite detailed rendition of likely income distribution by productive subsector. Different policy alternatives, foreign, aid constraints, and technological possibilities may be taken into account.

The model contains approximately 700 equations, many of them non-linear, which are used to simulate activities from year to year. (In the computer runs under discussion, base year data were for 1973, and calculated output was obtained for each subsequent year until 1997.) Each year's solution depends on current and preceding values of variables but not on future values. Figure 8.2 shows a broad and somewhat loose overview of the various equation blocks that make up the model.

The production or output block forms the heart of the model and is the most important from the viewpoint of materials consumption. The output of each of twenty-four sectors is either demand or supply constrained or is determined exogenously. Oil is not considered an integral part of the model except insofar as earnings of the oil sector contribute to government revenues

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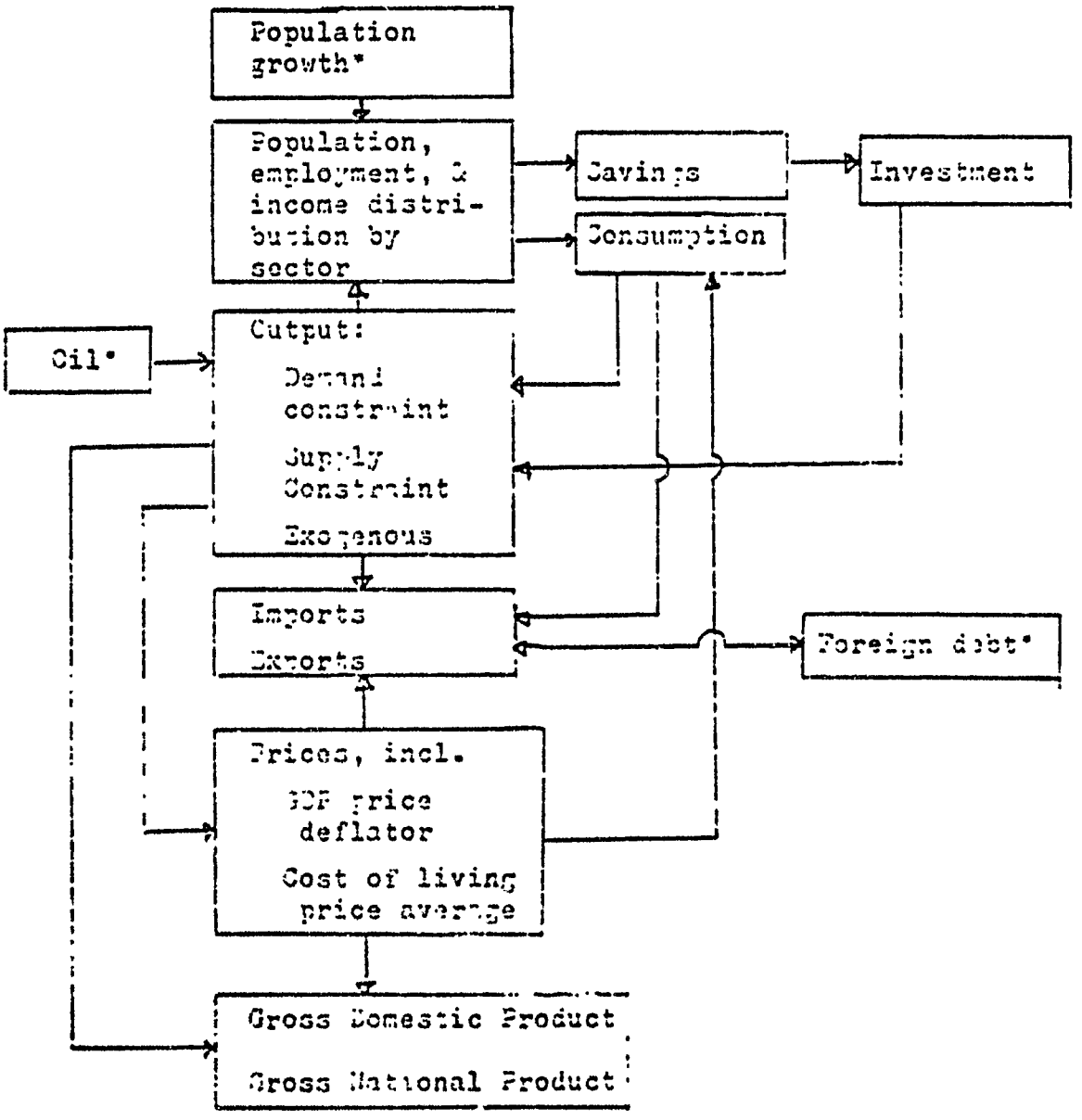
[2]This section draws heavily upon a working paper by Sudeep Anand (1975).

Figure 8.2

Schematic Diagram of the Gupta (World Bank) Macro-Economic Model for Indonesia



*Not in the main macro-model but taken from independent analyses or separate sub-models.

and foreign exchange earnings from oil increase total exports. Investments and imports of the oil sector are assumed to be self-financing; hence the oil sector represents only a net flow. See Table 8.1 for a list of the production sectors and the principal output-determinant for each.

Production of the various sectors is coupled with the output of a population submodel to determine employment and income distribution. Income is then divided into savings and consumption. Consumption is further divided into food and other goods based upon fixed expenditure elasticities for the various income groups. Savings form a pool of investable funds which feed back into the production process. Imports and exports essentially balance domestic supply and demand, and import-substituting production may be increased over time to compensate for shortfalls in foreign capital inflows. Prices are computed, partly with the help of a small input-output table, mainly on the basis of production costs. Manpower which cannot be absorbed in regular production activities at the normal labor-use relationships is allocated to a very low productivity "labor absorbtion sector." There are also "public work" and "traditional industry" sectors in the model so that the labor absorbtion sector essentially represents the redundant, make-work activities of low or zero marginal productivity, which may be created from necessity on the fringes of the agricultural, trade, and service sectors.

Although materials balances are computed within the model for most commodity-producing sectors, the model results cannot be

Table 8.1

Constraints on Sectoral Outputs,
Gupta Macro-Economic Model for Indonesia

Identification Number	Sector Name
I. Supply-constrained sectors	
203	Tree crops
240	Rice
204	Other Agriculture
540	Capital Goods Manufacturing
542	Intermediate Goods Manufacturing
544	Consumption Goods Manufacturing, Capital Intensive
545	Consumption Goods Manufacturing, Labor Intensive
267	Labor Absorbing Sectors: Agriculture, Trade, Services
II. Demand-constrained sectors	
323	Vegetables[a]
324	Livestock[b]
206	Fisheries
250	Trade
251	Transportation
252	Banking and Professional Services
538	Other Business and Personal Services
248	Construction
254	Electricity
546	Traditional Manufacturing
III. Exogenously determined sectoral output	
205	Forestry
311	Petroleum
247	Hard minerals
253	Public Administration
25[illegible]	Dwellings (services)
272	Public Works

[a]Upper limit to annual growth rate of 8 per cent assumed to result from land (supply) constraint.

[b]Some supply constraint operates [illegible]

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used directly to estimate future consumption requirements of the major non-food bulk materials. The projection task is assisted considerably, however, by the availability of output estimates for the more important materials-consuming sectors such as manufacturing, construction, electricity and transportation.

Two features, on the other hand, handicap the model for use in long term natural resource projections. The first is that the model is basically a short and medium-term model. Although when given a rather small amount of exogenous information, the model can mechanically project sector outputs for many years into the future, the projections have tended to show accelerated GDP growth after ten or fifteen years. Since, as noted below, most runs of the model have been made so as to yield relatively high growth rates over the next 10-15 years, further increases beyond that point can easily become questionable. Some work has gone into trying to tailor the model so as to produce more reasonable results in the longer run, but by the summer of 1976 the results were still not convincing.

The second difficulty, which could have been corrected in time, is that the model has been used chiefly to explore the effect of alternative economic policies (and of alternative assumptions about the future) within a rather narrow range of economic growth rates. These tend to be the rates within which a medium run solution of Indonesia's employment problem is feasible, and the economic growth rates thus turn out to be rather high. It is quite possible that the resulting rates (ranging from 5 to 8 per-

cent per year for per capita GDP) will in fact be achieved by Indonesia, but the model results so far do not cover a wide enough range of growth rate alternatives to fully explore the relationships between material use (via sectoral outputs) and overall economic growth. The high growth rates in the near term, as noted above, also tend to be followed by even faster economic growth rates toward the end of the 1973-1997 period. If Indonesia's current, oil- and forestry-assisted growth rate spurt should continue for another ten to fifteen years, one might then argue on the basis of historical experience of other countries that some decline in the growth rate, say to three or four percent increase annually in per capita income, might be more realistic than further acceleration.

The projection task, therefore, becomes one of finding a method for extrapolating the Gupta model results into the more distant future at slightly lower and possibly more realistic growth rates. This task can be approached by first comparing model results with those derived from cross-country statistical comparisons. If the two sets of estimates agree or bear predictable relationships with one another, then projections based upon past inter-country comparisons can be used to modify or supplement those from the World Bank country-specific model for Indonesia.

The Gupta macro-model was designed to give special attention to income distribution, and to some extent it can be used to investigate differences in production arising from differences

in income distribution. Household savings and tax collections are affected by income distribution in the model as also may be the demand for most agricultural goods and for manufactured consumption goods taken as a whole (Gupta, 1975, p. 42). On the other hand, much of the demand information by income classes is weak or highly aggregated. Domestic demand effects, in addition, may have a greater influence on imports than on domestic production in those several cases where supply constraints are the principal determinants of output levels.

In this connection two of the special runs made by Dr. Gupta on behalf of the present study are of particular interest. "Alternative III" of January 1976 incorporated income redistribution policies in an attempt to simulate a moderately equitable income distribution (1985 Gini coefficient: 0.364). The improved income distribution in contrast to that of the Basic Alternative (which had no assumed transfer payments to redistribute income and a significantly higher Gini coefficient of .569) led to a 13 percent lower rate of national savings (see Table 8.2). Cumulative investment during 1974-84 was consequently lower under Alternative III, and the annual GDP growth rate was 8.2 percent as opposed to 8.5 percent for the Basic run.

The savings, investment, and GDP growth rate differences become even more pronounced during 1985-1995, partly because average income for the lower income groups under the Basic Alternative fall to what would probably be politically unacceptable levels. The ratio between average income in the highest and

Table 8.2

Structural Differences Associated with Two Variants of Income Distribution, World Bank (Gupta) Macro-Model for Indonesia, 1985 and 1995

Variable No.		1985 Basic	1985 Alt III	1995 Basic	1995 Alt III
450 +318 -302	Gross Domestic Product, 1973 Rupiah x 10^9 Average per capita income, .000 rp.	16.996	16.553	37.832	33.534
567	Class 1	8.9	19.0	7.5	18.5
568	2	22.7	49.5	18.8	48.7
569	3	98.1	103.5	112.1	117.7
570	4	271.8	183.7	460.3	345.7
(570) -(567)	Ratio, class 4 to class 1	30.5:1	9.7:1	61.4:1	18.7:1
393	Gini coefficient	.569	.364	.635	.501
	Value added in: (Rp x 10^9)				
240	Rice growing	1205	1205	1622	1622
323	Vegetables	1220	1031	1845	1733
234	Total agriculture	4960	5044	8823	8570
546	Traditional manufactures	286	354	466	577
544 +545	Manufacture of consumption goods	1325	1162	2637	2122
?	All manufacturing	2578	2353	7350	5932
248	Construction	793	715	2142	1710
280	Total investment	4131	3694	11495	9266
499	National savings	3260	2829	?	7418

Source: World Bank, unpublished computer printouts of January 6, 1976; see also Gupta, 1977.

lowest of four income groups is 30:1 in 1985 under the Basic Alternative and rises to 61:1 by 1995. As shown in Table 8.2 the corresponding Gini coefficient increases from .569 to .635. In contrast, under the alternative incorporating redistribution policies the ratio of Class 4 to Class 1 average incomes increases from 9.7:1 to 18.7:1, and the Gini coefficient rises a comparably lesser extent. As a consequence, under the Basic run domestic savings are greater, and gross investment during 1985-95 exceed that for Alternative III by 26 percent. The growth rate of GDP for the Basic run during this period is a full one percentage point higher than for Alternative III (8.3 percent per year under the Basic case as opposed to 7.3 percent under Alternative III).

Although the income deterioration observed in the Basic Alternative is undoubtedly unrealistic, what is important for the present discussion is the estimated effect on industrial structure of such an extreme outcome. According to the Gupta model under consideration, the differences between the Basic and the Income Redistribution Alternatives with respect to the share of industrial output (and hence, presumably, of bulk material consumption per unit of GDP) are relatively minor. A more equitable income distribution is associated with a slightly higher proportion of GDP originating in agriculture, increased absolute production of traditional manufactures, and lower absolute <u>and</u> relative production of domestic manufactured consumer goods and construction (see Table 8.2). The major differences between the two alternatives reflect the GDP growth rate factor. The share

of GDP components relative to total GDP (in other words what is meant by "structure" in the current chapter) did not differ in most cases by more than a percentage point of two.

Because of data inadequacies and aggregation problems, however, the full effect of income distribution on industrial structure cannot be completely described in the Gupta model for Indonesia, and further study of this important topic is needed.

Cross-country Comparisons of Structural Change

Hollis Chenery and several colleagues have over the years done more than anyone else to explore how sectoral growth varies among countries with level of economic development. In his earliest article on the subject, Chenery statistically "explained" inter-country differences by using two measures of country size: population and national income (Chenery, 1960). The model was in logarithmic form and implied, for example, constant income elasticities among countries of per capita value added with respect to per capita national income. It was also assumed that the elasticity of per capita value added would remain constant with respect to country size (as measured by number of inhabitants) over the 51-country sample population range of 0-85 to 358 millions.

In the most recent and sophisticated treatment of the subject, Hollis Chenery and Moises Syrquin have added to the two earlier explanatory variables (population and per capita income) the square of the logs of the two variables, a foreign capital inflow variable, and a time trend (Chenery and Syrquin, 1975).

Separate statistical analyses, furthermore, have been made for different countries grouped according to their main pattern of resource allocation, namely: large countries with balanced allocation, small countries with specialization in primary products, and small countries with specialization in industry (Chenery and Syrquin, 1975, p. 4). A "small" country for these purposes was defined as having less than 15 million inhabitants in 1960 (Chenery and Syrquin, 1975, p. 67-68). Other differences were that the dependent variable was measured as a share of GNP rather than in per capita terms and per capita GNP replaced per capita national income as an independent variable.

The log-quadratic form of the per capita income term in the Chenery-Syrquin equations has the important effect of permitti income elasticities to change as per capita incomes increase and to yield in effect an approximate S-shaped curve with asymptotes at high and low income levels. Variable income elasticity is a widely observed empirical phenomenon which has already been noted under the discussion of agricultural demand in Chapter 6. The log-quadratic form of the population variable is less easily justifiable on theoretical grounds although empirically it is very useful in accounting for differences between India and countries with much smaller populations. The foreign capital variable was important statistically (although generally far less important quantitatively because of its ordinary small magnitude), but the effect of the dummy time variables (representing the five year periods between 1950 and 1970) was mixed.

The authors concluded that "the hypothesis that continuous structural change is related to the growth of income is better supported by our statistical analysis than is the alternative hypothesis that different structural relationships characterize developed and developing countries (Chenery and Syrquin, 1975, p. 135). The logistic or S-shaped nature of the statistical function reflected the tendency of most structural measures, such as the ratios of savings or sectoral output to GNP, to exhibit more rapid change over certain levels of per capita income and much less variation with income at either very low or relatively high levels of per capita GNP (Chenery and Syrquin, 1975, p. 8). It should be noted in this connection that per capita GNP levels were measured using official exchange rates, with some minor modifications in selected cases, and thus take no account of the changes of purchasing power which seem to also occur during the course of development (see the discussion of this phenomenon in Chapter 3). The authors provide an explicit, technical discussion of the exchange rate conversion problem and recognize that purchasing power biases exaggerate apparent income differences between rich and poor countries (Chenery and Syrquin, 1975, p. 145-146 ff.).

Chenery and Syrquin (1975, p. 152) conclude, however, "that while the systematic bias in national income converted at official exchange rates is a well-established phenomenon, there is not at present any preferred alternative." Furthermore, these distortions are likely to change systematically in the future just as

they have in the past as the relationships between traded and non-traded goods have shifted with the growth of real income. It can be argued therefore, the authors continue, "that the uncorrected estimates of statistically-determined coefficients are the more relevant, even though they combine both quantity (real) and price effects." For some purposes this latter argument is acceptable, but when the statistical coefficients are used to project changes in economic structure over a long period of time, one must be sure (as pointed out in Chapter 3) to employ an "internationally comparable" growth rate of income rather than one in which price relationships are kept equal to those of some base period.

Structural Change Comparisons: Macro-Model vs. Cross-Country

The Chenery-Syrquin equations may be used to project near-term structural characteristics of the Indonesian economy, and these may then be compared with similar measures obtained from the World Bank macro-economic model discussed earlier.[3] Such a comparison is shown in Table 8.3 for the years 1974 and 1985.[4]

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[3]The Chenery-Syrquin equations used for this comparison have had the time variable suppressed and relate to the "large country" (population in 1960 beyond 15 million) sample. See Carter (1973).

[4]Compare with Gupta (1975, Appendix III). For the first published report of Dr. Gupta's World Bank model, the "basic" solution was extended only to 1985. GDP growth rate between 1974 and 1985 came to 8.4% per year excluding the oil sector and 8.2% when oil GDP (variable 311, GDPOIL, from Appendix VI, same source) is included. These growth rates are based upon "real" GDP in 1973 prices and factor costs. In market prices the growth rate would be 8.8 annual, oil included. At the low per capita incomes and the relatively short time period involved, the nominal

The macro model referred to in Table 8.3 is the "more equitable income distribution" variant (Alternative III) discussed above.

In both 1974 and 1985, the cross-country results produce higher estimates of industrial GDP (manufacturing, construction and public works) than does the macro model, but the percentage difference decreases over time. For utility value added (electricity and transportation) the differences are in the same direction but increase rather than decrease over time. For industry the macro model reflects the initial level of Indonesian industrial activity which was low by world standards even after taking into account the low average income levels. Over time industrial output could be expected to make up for the initial small size, and the macro model in fact shows that the 1985 level might be somewhat closer to that based on cross-country norms. In the case of the expansion of utilities output, the problem may lie in the macro model's projection of electricity production. Electricity growth rate per capita is projected at only 12.0 per cent per year (implying a per capita income elasticity of 2.1), but per capita growth of 17 to 20 percent per year probably would be more

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4 (continued)
GDP growth rate (from equation 3.1) would be only moderately higher, 9.7 percent per year, than the constant price growth rate in market prices. For the market price GDP measures, constant price indirect taxes (variable no. 318, INTXCO) were added and constant price subsidies (variable 302, GSUBCO) subtracted from GDP in factor costs. The values of variable 302 and 318 were furnished by Dr. Gupta from unpublished machine runs. The "Alternative III" values shown in Table 8.3, also from unpublished machine runs, suggest a 1974-1985 GDP growth rate of 8.2% per year in market prices, or significantly less than the original "basic" solution.

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Table 8.3

Comparison Between Macro Model and Chenery-Syrquin Projections of Various Structural Characteristics of the Indonesian Economy, 1974 and 1985

	1974		1985	
	Macro model	Chenery-Syrquin	Macro model	Chenery-Syrquin
I. Macro-model values used for Chenery-Syrquin projections[a]				
Population, millions	129.0	129.0	167.5	167.5
Per capita, market prices				
1973 rupiahs	53,922		95,075	
1970 U.S. dollars[b]	95		167	
1964 U.S. dollars[c]	80	80	141	141
Ratio foreign capital/GDP	.063	.063	.054	.054
II. Projected values, billion 1973 rupiahs[d]				
A. Primary value added	3.270	3.360	6.249	5.829
(or which: Agriculture)	(2.770)		(5.044)	
B. Industrial value added	942	1.099	3.293	3.551
(of which: Manufacturing)	(647)		(2.353)	
C. Utilities value added	323	341	870	1.003
(of which: Electricity	(47)		(213)	
Transportation)	(276)		(656)	
D. Services	2.598	2.191	5.962	5.606
E. Total Capital Investment	1.287	1.016	3.694	2.946
F. National Savings	850	584	2.829	2.118

[a]Population and GNP values used for the Chenery-Syrquin projects have been taken from the IBRD macro model (variables no. 379 and 526).

[b]Converted from 1973 rupiahs at an exchange rate of 569:1. This is the rate which, when applied to the IBRD base period data for 1973, gives a 1973 per capita GDP in 1970 prices of

Table 8.3 (continued)

US$ 11:603 millions. The latter, in turn, is derived from the 1970 rupiah GDP, the average 1970 exchange rate, and the 1973/1970 constant price GDP increase found in World Bank (1976, p. 123).

[c]Assumes a 2.9% annual decline in the value of the U.S. dollar between 1964 and 1970, based on the respective GNP price deflators for United States export earnings.

[d]The actual equation coefficients used for these computations were:

Dependent variable as ratio to GNP	Intercept	Coefficients: $\ln \frac{GNP}{POP}$	$(\ln \frac{GNP}{POP})^2$	$\ln POP$	$(\ln POP^2)$	F
Agriculture + Mining VA	2.4760	-.5119	.0316	-.1473	.0161	-.3453
Manufacturing + construction + public works	-.9661	.2898	-.0175	.0797	-.0093	.3569
Transportation + Electricity + Gas & Water	-.0667	.0585	-.0037	-.0293	.0032	-.0498*
Services	-.4434	.1635	-.0103	.0969	-.0099	.0383*
National Savings	-.3346	.2199	-.0161	-.0832	.0093	-.8100
Gross Investment	-.3418	.2187	-.0160	-.0802	.0090	.2061

*Not statistically significant at 10% level.

Where GNP = gross national product in 1964 US dollars
POP = mid-year population
F = ratio of net foreign capital in flow (equals imports of goods and services, both factor and non-factor, minus exports of same) to GNP

Table 8.3 (continued)

Source:

Macro model: Gupta (World Bank) macro model for Indonesia, high fertility and high mortality variant with income distribution adjusted to approximate that of the 1975 IBRD economic report on Indonesia; machine runs of January 7, 1976, Alternative III.

Chenery-Syrquin: Regression equation taken from "large country" samples, Carter (1973, Table II). See also Chenery and Syrquin, 1975.

likely if per capita income growth rates were to reach close to six percent annually as implied by the macro model solution in question. (See Chapter 11 for estimates of electricity demand derived from cross-country comparisons.)

Value added calculated from cross-country equations for the service sector in large countries is 16 percent less than the macro-model results in 1974 and 6 percent less in 1985. The macro model and Chenery-Syrquin results for "primary" output are similar for 1974, but the macro model gives higher results for 1985. The latter, however, should be expected because the increased value of petroleum will give Indonesia a higher-than-normal primary value added.

A more significant difference from the viewpoint of materials consumption occurs in the estimates of fixed capital formation. The cross-country-based estimate is much lower than that from the macro model. This is because the cross-country "normal" investment is consistent with a "normal" GDP growth rate of 5-6 percent per year. Indonesia, however, grows at over 8 percent annually between 1974 and 1985 according to this macro-model projection and therefore requires that a considerably higher proportion of GDP be allocated to capital investment.

Another way to view the differences between cross-country and macro-results for Indonesia is to note that the latter does a superior job of incorporating effects resulting from "abnormally" large oil revenues, especially in the short and medium run. These oil revenues are assumed to increase 1985 GDP by about $12 per

capita (in 1970 U.S. dollars). Domestic manufacturing output and perhaps transportation take time to adjust to the oil-inflated average income level and are more nearly compatible, in terms of international norms, to incomes without the additional oil revenues.

In the longer-run, however, it is anticipated that Indonesia's economic growth rate will drop to more normal levels and that its industrial structure will adjust to whatever per capita income levels are actually achieved. Thus, cross-country-based estimates of bulk materials consumption (based for example on a Chenery-Syrquin type of estimating equation) might tend to underestimate Indonesian consumption while GDP growth rates are very high (because of the underestimation of the materials needed for fixed capital formation). In the longer run, as GDP growth rates become more normal, the estimates of bulk material consumption should improve.

(In practice, we may expect that the correspondence between cross-country and macro-model based estimates of bulk material consumption would be even closer. This is because much of the material used for the abnormally high medium term capital investment would be imported in fabricated form. As such it would not be included in our measure of "bulk materials." Cross-country estimating equations for bulk material consumption are discussed further in Chapter 9.)

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Projections of Longer-Run Structural Change

Projections of Indonesian industrial structure are shown in Table 8.4 through the year 2050. Both the low and high population assumptions from Table 3.5 are shown, implying a year 2000 population of 210-250 millions and a year 2050 population of 300-540 millions. Nominal per capita GDP assumptions have been taken from the same table in Chapter 3. The lower assumption gives a per capita income level of $310 (1970 prices and 1970 exchange rate relationships) in 2000 and $2020 in 2050. The higher assumption yields a $590 per person average in 2000 and $4740 by 2050. For ease in comparison, all industrial structure measures are shown as a fraction of Gross Domestic Product. For the year 1995, published results are given from the "high mortality, high fertility" macro-economic results.[5] These are included for the sake of completeness even though they show the typical model tendency towards accelerated growth after fifteen years or so. (For this particular run of the Gupta model, GDP growth rates in constant market prices averaged 8.2 percent per year between 1974 and 1985. The rate fell to 6.4 percent between 1985 and 1990, but then rose to an average of 8.0 percent between 1900 and 1995.)

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[5]Gupta (1975, Appendix VI), machine run of 7/3/75. This run is meant to represent the computer simulation results for alternative "XI(c)" as defined on page 58 of the main text and in Table 28, pp. 30-31, of Appendix IV. The results from this alternative summarized on p. 34 of Appendix IV, however, show minor differences, especially with regard to population characteristics, when compared with the full printout from Appendix VI.

Table 8.4

Alternative Projections of Longer Run Structural Change, Indonesia, 1974-2050

Projection assumptions	1975	1995	2000	2050
I. Data used for making projections				
A. Population assumptions (millions)				
Low (L)			210	300
High (H)			250	540
Macro model	132	211	-	-
B. Per capita GNP, market prices, 1964 US$[a]				
Low (L)			243	1582
High (H)			462	3711
Macro model	84	245	-	-
C. Ratio to GNP of Net foreign capital	.069	.059	.056	.030
II. Projected structure, ratio to GDP, based on Chenery-Syrquin equations[b]				
A. Primary value added				
Low pop, low GDP (LL)			.271	.094
Low pop, high GDP (LH)			.179	.077
High pop, low GDP (HL)			.276	.121
High pop, high GDP (HH)			.184	.104
Macro model (macro)	.469	.269	-	-
B. Industrial value added				
Low pop, low GDP (LL)			.278	.382
Low pop, high GDP (LH)			.333	.396
High pop, low GDP (HL)			.274	.363
High pop, high GDP (HH)			.330	.378
Macro model (macro)	.166	.280	-	-

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Table 8.4 (continued)

Projection assumptions	1975	1995	2000	2050
C. Utilities value added				
Low pop., low GDP (LL)			.075	.099
Low pop., high GDP (LH)			.085	.100
High pop., low GDP (HL)			.076	.104
High pop., high GDP (HH)			.086	.105
Macro model (macro)	.050	.075	-	-
D. Fixed capital investment				
Low pop., low GDP (LL)			.217	.243
Low pop., high GDP (LH)			.238	.216
High pop., low GDP (HL)			.220	.259
High pop., high GDP (HH)			.241	.233
Macro model (macro)	.150	.218	-	-

[a]Assumes 2.9% annual deterioration in the international purchasing power of the U.S. dollar between 1964 and 1970. This assumption is derived from the GNP price deflator for U.S. exports. Thus 1964 values equal .842 times those in 1970 prices. Note that values shown are for Gross National Product rather than Gross Domestic Product as found in Table 3.5 from which the per capita income figures were taken. It is assumed that the ratio of GNP to GDP will remain constant at 0.93 throughout the period. The per capita GDP projections in Table 8.4 thus equal .842 x .93 x the corresponding GDP per capita figures from Table 3.5.

[b]Estimating equations are given in footnote d, Table 8.3.

In Table 8.4 the medium-term trends shown in Table 8.3 are continued into the longer run as per capita income continues to increase and population to grow. The agricultural share of GNP would be expected to fall to 18-28 percent by the year 2000 and to 8-12 percent after a further fifty years. Industrial value added over the 1975-2000 period almost doubles as a fraction of GNP, growing from 17 percent to 27-33 percent. By the year 2050 the industrial share might rise to 36-40 percent of GNP. The contribution to GNP of utilities, including transportation, increases at a somewhat slower pace, doubling between 1975 and 2050. The capital investment share could be expected to grow the most slowly of all, increasing by about one-half between 1975 and 2000 and remaining at roughly the year 2000 level thereafter.

The principal factor at work in Table 8.4 is the growth of per capita GNP. This is seen both in the projected changes over time and in the relatively large differences in some instances between the "high" and the "low" per capita alternatives. The lower of the per capita GNP assumptions, as would be expected, operates in the same direction as does the more equitable income distribution variant shown in Table 8.3. Both a slower GNP growth rate and a more equitable distribution of income result in lower capital investment (at least until sometime after the year 2000 in the case of Table 8.4), lower industrial and utility shares of production, and a higher contribution to GDP of agriculture and other primary activities. In contrast, the differential effect on GNP shares of the high and low population assumptions is almost insignificant.

Conclusions

The conclusion of this chapter is that the cross-country statistical comparisons of the Chenery-Syrquin type appear to capture many of the longer-run structural changes reflected in the Gupta (World Bank) macro-model for Indonesia. Basing materials consumption projections on the cross-country results may produce underestimates of heavy industrial goods during periods of rapid economic growth. These differences should be less pronounced if we ignore, as has been done in the present study, the consumption of raw materials imported in finished or fabricated form--as, for example, metals incorporated in capital equipment and machinery.

When looking into the distant future it becomes progressively more difficult to achieve realistic projections from a detailed macro model, but at the same time it can be expected that Indonesia's economic growth may slow to the more normal levels that have characterized the past growth of most countries. Under these conditions the cross-country approach to materials projections may prove as good or better than that based upon a macro-model. If GDP growth should slow still further, however, to atypically low levels when judged by recent reference country experience, then the cross country approach might lead to overestimates of many bulk materials.

In using the cross-country approach, it should be noted, it is not necessary to estimate GDP components first and then the

amounts of bulk materials associated with each component. A "reduced form" of the model may be used in which materials consumption in physical units is statistically related to the fundamental growth factors of population and income or GDP. The procedure can also be expanded to incorporate other structural factors in a manner analogous to the Chenery-Syrquin use of net foreign capital inflows. Materials demand equations derived from cross-country data will be discussed further in Chapter 9 and will be the basis for most of the demand projections of Chapter 11.

APPENDIX B

DRAFT

ENERGY DEMAND PROJECTIONS

ENERGY PLANNING FOR DEVELOPMENT IN INDONESIA

Andres B. Doernberg

May 1981

ENERGY/DEVELOPMENT INTERNATIONAL
505 Main Street
Port Jefferson, N.Y. 11777

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I. Energy Production and Transformation Sectors

I.1. Petroleum

I.1.1. Petroleum Supply Sector

Crude production in 1980 fell 2 percent, to 569.5 million barrels[1], after a 2.8 percent drop in production in 1979. This was a third consecutive drop from a record of 615.1 million barrels achieved in 1977. Table I-1 summarizes crude production for recent years. Prospects for 1981 are of a 1 percent increase to 1.58 million barrels a day (576.7 million barrels).

Exports of crude and petroleum products have fallen much faster than production, by nearly 11 percent between 1978 and 1979. This decrease is a reflection of the rise in domestic consumption of about that magnitude, coupled with the decrease in production. Petroleum exports, which accounted for 64 percent of Indonesias export earnings in 1978, are mostly in the form of crude (85%), the rest being heavy residual (LSWR, low sulphur waxy residual) and condensates.

A summary of the petroleum supply system is shown in Table I - 2, using data for 1978. Of a total 159.5 million barrels used as input to refineries, nearly one third is processed in Singapore and the output shipped back via the so called "processing agreement", and the rest refined in nine refining units in the country. The processing agreements expire in 1982 and after that date all crude destined for domestic consumption will be refined in Indonesia. A hydrocracking unit is planned that will convert LSWR, now exported, into products for the domestic market. A new refinary and other expansions are also planned.

1: Asian Wall Street Journel February 11, 1981.

TABLE I - 1

Crude Oil Production and Export
Million barrels

	Crude Production	Crude Exports	Condensate Exports	Product Export[1]	Total Export
1975	476.9				
1976	550.3				
1977	615.1				
1978	596.7	461.9	10.1	38.6	510.6
1979	580.4	394.4	16.4	49.4	460.2
1980	569.5				
1981 (est.)	5[illegible].7				

[1] Mostly low sulphur waxy residual oil (LSWR)

Imports of Petroleum Products
(Million barrels)

	1978	1979
Jet Fuel	3.1	1.9
Kerosene	4.4	5.5
Light Diesel	9.4	7.5
Indust. Diesel	____	0.3
Subtotal	16.9	15.2
Special Crudes	31.8	31.4
Total	48.7	46.6
Crude Inputs to Refinery	159.5	186.0

Source: MIGAS

TABLE I - 2

Petroleum Supply System Balance 1978
(million barrels)

Crude Production	596.[illegible]
Crude Exports	461.9
Condensate Exports	10.1
	124.7
Statistical Difference and Stockpile	- 13.7
Domestic crude inputs to refineries	111.0
Imported Crude Inputs	47.3
Other Inputs	1.2
	159.5

Refinery Output

Petroleum Products	104.2
LSWR Exports	38.7
Naphtha	7.5
Lubes, Asphalts etc	4.0
Refinery Gas	1.5
Losses	3.6
	159.5

Source:

Imported crude inputs to refineries amounted to 47.3 million barrels, or nearly 30 percent of total inputs. This crude, imported from Saudi Arabia, is used in one dedicated refinery for production of oil products not obtainable from Indonesian crudes.

Total output of petroleum products amounted to 104.2 million barrels in 1978. This was supplemented by imports of 16.9 million barrels. Output from refineries grew to million barrels in 1979, and product imports dropped to 15.2 million barrels. Table I-3 summarizes this information, in which barrels are expressed in barrels of oil equivalent (thousand boe, or kboe). The largest fractions of petroleum products are kerosene (33 percent) and light diesel oil* (27 percent), with smaller fractions of gasoline, fuel oil and industrial diesel.

* Automotive diesel, see Glossary.

TABLE I - 3

Petroleum Products, Domestic and Imported

10^3KL	Domestic Production[1]		Imports		Total Supply	
	1978	1979	1978	1979	1978	1979
Fuels						
Av. Gasoline		24.6		-		24.6
Jet Fuel		367.2		309.5		676.7
Gasoline		3095.7		-		3095.7
Kerosene		5558.8		877.5		6436.3
Light Diesel		4133.1		1197.6		5330.7
Industrial Diesel		1256.5		40.8		1297.3
Fuel Oil		2882.2		-		2882.2
Sub Total		17318.3		2393.6		19711.9

[1] Includes production by processing deals
Source: MIGAS

I.1.2 Energy Use in Petroleum Production

Areas of petroleum production in Indonesia are primarily centered onshore in three regions of Sumatera and West Kalimantan, and offshore in Northern Java. New exploration and production is taking place in Irian Jaya. About one half of the oil is produced by Indonesian subsidiaries of multinational oil companies, 5 percent is produced by Pertamina (the state-owned oil company) and the remaining 45 percent by production sharing agreements between Pertamina and foreign oil companies. Table I-4 presents recent production by company.

Of total crude production, onshore sources at present amount to 65 percent of the total, and offshore 35 percent. First offshore production came in 1971, and by the mid 1970's it had amounted to 20 percent of the total.

TABLE I - 4

Crude Production in 1979

	1979 10^3 bbls	Percent %
Pertamina	30,316	5.22
Production Sharing	271,203	46.73
Caltex Pacific Indonesia	266,048	45.84
Stanvac Indonesia	10,811	1.86
Galasiatic & Toppco	1,856	0.32
Lemigas	212	0.03
	580,447	

Energy consumption in the production of crude petroleum is obtained from Pertamina's statistics on own use (exclusive of refining use) and from Pertamina sales of petroleum products to other crude oil producers (Table I-4a). Although most of these fuels are used for transportation purposes, their energy use is an integral part of the crude oil production process; future demand for these fuels is thus estimated according to future crude production rates.

TABLE I - 4a

Energy Consumption in Crude Oil Production

10^3 bbls	1978			1979		
	Light Diesel	Industrial Diesel	Fuel Oil	Light Diesel	Industrial Diesel	Fuel Oil
Pertamina	144.0	449.7	1348.6	222.0(est)	209.5(est)	1230.3(est)
Other Companies	1112.1	139.6	69.2	1377.5	92.5	37.7
Total	1256.1	589.3	1417.8	1599.5	302.0	1268.0
kboe	1262.4	592.2	1495.8	1607.5	303.5	1337.7

Source: Pertamina sales data and Pertamina own use data.

I.1.3 Energy Use in Crude Oil Refining

Crude intakes into refineries for 1979 amounted to 186.0 million barrels, of which 79 percent (147.7 million barrels) were obtained from domestic crudes, and 21 percent (38.3 million barrels) from imported Arabian light crudes. Of this total, 65 percent (120.5 million barrels) were refined in Indonesian refineries and the rest in refineries in Singapore via processing deals; the output from the Singapore refineries is destined to Indonesian consumption. Refining capacity in Indonesia is presented in Table I-5. Statistics on energy consumption in refining exclude the energy used in the refineries in Singapore. Sources for this information are not entirely consistent, because Pertamina reports total consumption for the aggergate divisions of exploration, production and refining. Table I-6 summarizes available data and estimates.

TABLE I-5

Refining Capacity in Indonesia

		Thousand bbls/day Capacity Production in 1979
Plaju	, Sumatra	49
Gerong	, Sumatra	49
Balikpapan,	Kalimantan	49
Dumai	, Sumatra	76
Pakning	, Sumatra	27
Cilacap	, Java	73
Others		6
		329

Table I-6

Energy Consumption in Petroleum Refining

	1978	1979	
Refinery gas[1]	1905.9×10^3 bbls	1840.5×10^3 bbls	
Light Diesel Oil[2]	450.0 "	667.4 "	(est)
Industrial Diesel[2]	915.2 "	427.1 "	(est)
Fuel Oil[2]	5917.6 "	5397.4 "	(est)
Natural Gas[3]	6453.8×10^6 SCF	8237.9×10^6 SCF	
	= 1173.9×10^3 BOE	1498.4×10^3 BOE	
Total Energy Use	~ $10,362.5 \times 10^3$ BBLS	9830.8×10^3 BOE	
Crude Processed excl. processing deals		120.5×10^6 BBL	
Specific Consumption		~ 0.08 BOE/BBL	(8%)

1: Sources: Umar Said for 1978, Refinery Report for 1979.
2: Umar Said for 1978, 1979 data are estimates based on 1978 breakdown between refining and other Pertamina uses (Total Pertamina uses for exploration and refinery is from Table).
3: Source: Table I-

I.2. Natural Gas

I.2.1 Natural Gas Production

Production of wet natural gas reached 998.5 billion cubic feet (BSCF) in 1979 (189,707 kboe), and is projected to increase by about 50 percent by the end of Pelita III in fiscal year 1983. Production grew by nearly 22 percent from 1978 levels, and in the four years since 1976 its production has more than tripled. More importantly, the effective utilization of the gas, as a fuel for industry, petrochemical feedstock and in liquefaction plants (LNG) has grown even faster.

The use of natural gas as a fuel in Indonesia has been limited by geographical considerations. Most associated gas from oil fields that are distant to population centers had not been utilized until the first LNG facility was completed in 1977. This production is exported to Japan and is scheduled to increase in the future. Natural gas produced on the island of Java is being consumed in its entirety by several industrial customers and by a town gas distribution system.

In 1979, flared and lost gas amounted to 22.7 percent of production, down from 47.9 percent in 1977. Another 26.3 percent was used for gas lift and as fuel in the fields in 1979, leaving just over 50 percent for export and internal consumption. This utilization figure has grown from about 31 percent in 1977. (Table I-6a)

The use of natural gas in manufacturing represent about 8 percent of gross wet gas production or 16 percent of the gas effectively used. The 80 billion cubic feet (15,234 kboe) are used in Java and South Sumatera as inputs to fertilizer plants, the integrated steel mill

TABLE I - 6a

Natural Gas Production and Utilization

	1976	1977	1978	1979
Million cubic feet				
Production	312,368.1	542,764.2	820,130.3	998,456.7
kboe	59,350	103,125	159,825	189,707
Utilization	NA			
LNG plants	--	57,103.4	244,932.0	383,302.8
LPG plants	--	67,806.9	62,911.9	35,853.5
Gas lift, injection	--	73,503.7	173,739.8	214,669.1
Town gas company	--	1,503.5	1,378.8	2,127.0
Manufacturing*	--	40,557.3	59,350.6	80,179.9
Fuel use in production	--	39,822.7	44,064.0	47,443.0
Losses, flared		259,883.1	223,578.1	226,643.4
Petroleum Refinery Fuel	NA	--	6,453.8	8,237.9
Natural Gasoline		2,603.4	3,670.0	--
		542,764.2	820,130.3	998,456.7
Flared and loss (percent)		47.9	27.3	22.7
Fuel Use in Production of Natural Gas (percent of total production)		7.3	5.4	4.8

* Detailed in Section III.3; includes fertilizer plants, carbon black plant cement and steel.

Source: MIGAS

project under development and other users. These are quantified in Section III.2, Energy Use in Manufacturing. The growth in these uses are severely limited by the production of gas in these two areas. The fertilizer plant in South Sumatra is currently producing below capacity because of the limitations in gas supply in the region (associated gas from the Palembang area oil fields). Important pricing issues have to be resolved before any investments are undertaken for long distance gathering lines from other fields in Sumatra, or for new exploration in the Palembang area. Natural gas production in the island of Java (onshore and offshore) is not expected to increase; this is the reason, for example, that its use in electric generation by the public utility is not considered in PLN's resource diversification planning.

I.2.2. LNG Production

Production of liquified natural gas (LNG) began in 1977 and at present the two facilities in operation in Bontang (East Kalimantan) and Arun (North Sumatra) make Indonesia the largest producer in the world. Export earnings rose from $1.1 billion in 1979 to $2.3 billion in 1980; they now reach 10 percent of total export earnings and they are projected to grow much faster than export earnings for petroleum (which in 1979 were still over eight times those of LNG). Current price is about $4.20 per thousand cubic feet fob (about $22 per boe), and new contracts are being negotiated at 40-60 percent higher prices.

Current production is 9 million tons per year (about 74,000 kboe) and contracts are being negotiated for additional exports of 6.2 million tons (52,000 kboe) to Japan in 1983 for 20 years, and of 4.5 million tons (38,000 kboe) to the West Coast of the United States. Long term export estimates from Pertamina total 27.9 million tons (234,000 kboe) by 1990, an amount equivalent in energy to 50 percent of current crude exports. (Table I-7).

TABLE I-7

Long Term Estimates of LNG Exports

Million tons/year	1985	1990	1995	2000
Arun, planned	7.5	9.0	9.0	9.0
potential	4.5	4.5	4.5	4.5
Badak, planned	6.4	6.4	6.4	6.4
potential	--	8.0	8.0	8.0
Total exports	18.4	27.9	27.9	27.9
in billion cubic feet	831.9	1261.1	1261.1	1261.1
in kboe	155,000	234,000	234,000	234,000

Source: Pertamina;
Current plans do not envision an expansion in LNG exports beyond 1990.

TABLE I-8

Natural Gas Use for LNG Production

Year	Inputs to LNG plants 10^9 Cubic ft.	LNG Exports 10^9 cubic ft.	Fuel Use in liquefaction 10^9 Cubic feet	Statistical Difference
1977	57.1	NA	NA	NA
1978	244.9	192.3	31.8	+ 20.8
1979	383.3	326.1	49.8	+ 7.4
1980	447.7 (est)	389.5	58.2 (est)	--
1985	966.2	831.9	124.3	
1990	1449.5	1261.1	188.4	
1995	1449.5	1261.1	188.4	
2000	1449.5	1261.1	188.4	

Conversions: 1 ton LNG = 48.7 GJ
1 kboe = 0.19 million cubic feet

Source: 1977 - 1979: MIGAS, assuming 1000 Btu/SCF and that 13 percent of natural gas inputs to liquefaction plants is consumed as fuel
1985 - 2000: Pertamina
1980 exports: Asian Wall Street Journal Feb. 13, 1981

II. Petroleum Products Balance

The total consumption of petroleum products in Indonesia is made up of domestic sales by Pertamina, the sales to international bunkers and the consumption of Pertamina in the production, transportation, refining and distribution of fuels. Petroleum products are obtained from refineries in Indonesia and in Singapore through processing deals, using domestic crude as inputs. A fraction of domestic demand is met by products imported directly, and asphalts and other non-energy products are obtained from domestic refineries utilizing foreign crudes as inputs. The Petroleum products supply sector is detailed in section I.1.1.

Information on 1978 consumption of petroleum products is obtained from LEMIGAS*, and is presented in Table II-1. Total consumption in 1978 was 122,883 kboe of which 2.3 percent or 2800 kboe was sold to international bunkers (non-Indonesian air and waterborne carriers), and Pertamina consumed 8.8 percent or 10858 kboe. The LEMIGAS source quotes the following breakdown for Pertaminas consumption: own use by its marketing and distribution divisions, which is mostly transportation fuel for trucks and small ships, own use by its production and exploration divisions, in which all diesel and fuel oil is used by tankers, and lastly,own use by the refineries. The latter utilize in addition to the tabulated petroleum products a total of 1907 kboe of refinery gas. Table II-2 summarizes this information for 1979, in which total internal consumption grew by 8.2 percent to 132,883 kboe. Domestic sales grew at 9.2 percent to 119,314 kboe.

* Konsumi Energi 1978, Ir.Umar Said, Dr. P. Sinuraya, LEMIGAS

Table II-1: Internal Consumption of Petroleum Products, 1978

Kboe	Domestic Consumption	Pertamina Use Marketing	Production	Refining	International Bunkers	Total Internal Consumption
Aviation Gasoline	116	--	--	--	6	122
Jet Fuel	2453	2	6	--	938	3399
Gasoline	17,901	114	227	--	--	18,242
Kerosene	40,459	21	218	--	--	40,698
Light Diesel Oil	31,779	382	145	453	59	32,818
Industrial Diesel	6558	62	452	920	238	8,230
Fuel Oil	9959	190	1423	6243	1559	19,374
Total	109,225	771	2471	7616	2800	122,883

Source: Konsumi Energi 1978, In Umar Said, Dr. P. Sinuraya, LEMIGAS

1 An additional 1907 kboe of refinery gas are consumed in the refining process.

Table II-2: Internal Consumption of Petroleum Products, 1979

Kboe	Domestic Consumption	Pertamina Use[1] Marketing	Production	Refining	International[1] Bunkers	Total Internal Consumption
Aviation Gasoline	107	—	—	—	8	115
Jet Fuel	2,668	3	277	—	887	3835
Gasoline	20,030	135	851	—	—	21,016
Kerosene	44,098	31	57	—	—	44,186
Light Diesel Oil	34.665	434	223(est)	671(est)	54	36,047
Industrial Diesel	7,116	72	211(est)	429(est)	254	8,082
Fuel Oil	10,630	167	1298(est)	5694(est)	1919	19,708
Total	119,314	842	2917	6794	3122	132,989

[1] Data is for 1979/80 fiscal year (March 1979 to February 1980)

Sources: obtained from unpublished tables prepared by DJK and MIGAS Situasi Pemakaran Energi; Production and Refining totals (MIGAS data) broken down in proportion to 1978 data.

Utilizing Pertamina sales figures, a picture can be obtained of the final destination of petroleum products in the economy. Table II-3 presents a summary for 1978 of domestic consumption of petroleum for industry, transportation, households, electric generation and for town gas manufacture based on sales reported by Pertamina. A column of statistical differences quantifies the closure of the balance with total domestic consumption in Table II-1

In order to summarize Pertamina's sales information, the following allocations were made:

Households: they are assumed to purchase 80 percent of all kerosene delivered to dealers, plus small amounts of kerosene delivered to the Armed Forces. This allocation may overestimate the household use by incorporating only an estimate of kerosene used by restaurants and food vendors, and other small non-residential users of kerosene. Other possible destinations are non-sanctioned transportation uses and illegal exports.

Industry: includes sales of light diesel oil, industrial diesel oil and fuel oil to agricultural, mining and manufacturing. The commercial sector, which is comprised of government institutions, commercial buildings and large hotels and construction companies is also included as is an estimate of the use of kerosene in the commercial sector (restaurants and food vendors). Excluded are the aviation fuels and gasoline sold to these firms, which are assigned to the transportation sector. Also excluded from this allocation would be any purchases of light diesel oil by small farms, cottage industries and mines using service stations as fuel suppliers. The amounts of industrial diesel and fuel oil sold by retailers are insignificant. A major uncertainty in this allocation is the light diesel oil purchased by industry, a part of which is used in freight handling and other properly transportation uses

Table II-3

Petroleum Products Consumption, 1978

Kboe	Industry[1] & Commercial	Transport[2]	Households	Electric Generation[3]	Town Gas	Statistical Differences	Total Domestic Consumpti
Aviation Gasoline		118				-2	116
Jet Fuel		2,440				+13	2453
Gasoline		18,572				-671	17,901
Kerosene	8,004	—	32,015	—	—	+440	40,459
Light Diesel Oil	15,584	11,090	—	5,213	32	-140	31,779
Industrial Oil	5,567	494	—	230	83	+184	6,558
Fuel Oil	6,520	528	—	2,989		-78	9,959
Total	35,675	33,242	32,015	8,432	115	-250	109,225
	32.7%	30.4%	29.3%	7.7%	0.1%		

1 Excludes fuel use in refining of petroleum products.

2 Includes Military

3 Public Utility only

Table II-4

Petroleum Products Consumption, 1979

Kboe	Industry[1] & Commercial	Transport[2]	Households	Electric Generation[3]	Town Gas	Statistical Differences	Total Domestic Consumpti
Aviation Gasoline	—	116	—			-9	107
Jet Fuel	—	2,632	—			+36	2,668
Gasoline	—	20,013	—			+17	20,030
Kerosene	8,823	—	35,291			-16	44,098
Light Diesel Oil	17,435	12,717	—	4507	39	-33	34,665
Industrial Oil	6,605	527		183	86	-285	7,116
Fuel Oil	7,191	449	—	5086	—	-2096	10,630
Total	40,054	36,454	35,291	14466	125	-2386	119,314
	33.6%	30.6%	29.6%	12.1%	0.1%		

1 Excludes fuel use in refining of petroleum products.

2 Includes Military

3 Public Utility only

(this is especially so in the construction industry). It is however impossible to separate transportation uses within industry from uses of light diesel in electric generation or as boiler fuel.

Transportation: includes sales to airline companies, railroads, shipping lines and road transport companies, in addition to all sales of gasoline and light diesel oil to retailers (i.e. gasoline stations) gasoline sales to industrial firms are also included. Finally, all sales to the five branches of the Armed Forces are ascribed to the transport sector (except those of domestic keroesne). To this total would have to be added about 3250 kboe of fuels used by Pertamina in what is mostly transportation uses, 60 percent for tankers and the rest for distribution of fuels by trucks and transportation of personnel. The subsequent analysis, however, will omit this Pertamina consumption, which will be projected separately.

Electric Generation: sales to the national electric utility (PLN) only; actual utilization by PLN for electric generation may be slightly higher because isolated generation sites can avail themselves of diesel fuel through retailers. A check of PLN sources appears to indicate that such purchases would be very small.

Town Gas: purchases of diesel fuel by PDN, the town gas manufacturer.

Statistical Differences: obtained from comparison of total sales with domestic consumption in 1978 shown in Table I-1 (and in Table II-2 for 1979). There is excellent agreement among sources, yielding a total discrepancy of one fourth of one percent, with the largest amounting to 3.7 percent in the case of gasoline.

The largest consumer of petroleum products is the industrial-commercial sector, with 33 percent of the total followed by transport

with 30-31 percent. The household sector may be slightly overestimated, as indicated above; on the other hand, the transportation sector may be underestimated in light of the allocation to the industrial sector of all light diesel oil sold to industry (part of which is used for freight) and the exclusion of Pertaminas transportation usage.

III Final Energy Consumption

III.1 Agriculture and Mining Sectors

III.1.1 Agriculture

Information available on energy consumption in agriculture refers to the organized, large-scale producers. The vast small-scale farming, lumber and milling operations are discussed separately*. The distinction made is between customers that purchase directly from Pertamina, whose fuel use data is readily available, and those agricultural activities which obtain their petroleum fuels, if any, from retail outlets. The use of firewood and agricultural wastes in both large-scale and small-scale agriculture is not included. Estimates based on survey information from Biro Pusal Statistik and reported by Cobbald* amount to 716 kboe of firewood and charcoal used largely in the sugar industry (505 kboe), drying of tea (59.9 kboe), drying of tobacco (66.5 kboe), rubber (30 kboe) and the vegetable oil industry (13.3 kboe). The industrial activities listed above are more appropriately classified under the manufacturing sector (Section III.3); the use of petroleum products in the food processing industry is accounted for in that section of this report.

*T.E. Cobbald: Rural Sector Energy Estimates, 1978, Project Paper for Energy Planning for Development in Indonesia

The large scale agriculture activities consumed 3353 kboe of light diesel and smaller amounts of industrial diesel and fuel oil in 1978 (Table III.1). Forestry is the largest user, followed by plantations (rubber, sugar cane, tea, palm oil and tobacco). The largest use of fuels is for vehicles and electric generation; farm machinery (tractors, combines etc) are relatively rare even in the estate segment of Indonesia's agriculture.

TABLE III . 1

Energy Use in Large Scale Agriculture

Kboe	Light Diesel 1978	Light Diesel 1979	Ind. Diesel 1978	Ind. Diesel 1979	Fuel Oil 1978	Fuel Oil 1979
Agriculture	46	192	--	--	--	--
Plantations	768	785	196	207	34	47
Forestry	1796	2245	19	19	4	8
Others	743	743	7	17	--	--
Total	3353	3965	222	243	38	55

Source: Pertamina Sales

III.1.2 Mining (excluding Coal and Petroleum Extraction)

Metallic mining activities in Indonesia consist primarily of tin production and smelting in islands off the Sumatra coast, nickel mining and smelting in South East Sulawesi and bauxite mining in the island of Palau Bintan, near Singapore. An aluminum smelter is being built in northern Sumatra.

Energy use in this sector includes petroleum products (mostly light diesel), coal from West Sumatra used in tin smelters, and captive hydroelectric generation. The 165 MW plant at Larona is part of the nickel smelting operation; a 603 MW hydroelectric facility at Asahan (Northern Sumatra) will generate power for the aluminum smelter under construction. Both facilities have 50 MW surpluses for sale to PLN. A part of the 1070 kboe of light diesel consumed by the industry is also for electric generation at the mine site; no electricity is purchased by the mines.

TABLE III-2

Energy Consumption in Metals Mining

Kboe	Light Diesel 1978	Light Diesel 1979	Ind. Diesel 1978	Ind. Diesel 1979	Fuel Oil 1978	Fuel Oil 1979	Coal 1978	Coal 1979
Tin	427	797	351	430	--	40	61	53
Nickel	205	174	15	18	301	394	--	--
Iron Sand	18	4	--	--				
Other *	147	96	--	8				
Total	797	1071	366	456	301	434	61	53

* Includes bauxite, copper, manganese, gold and silver.

Sources: Pertamina Sales data; coal from MIGAS, using 0.71 TCE/ton of Bukit Asam coal, and 5.05 BOE per TCE.

TABLE III-3

Production of Metallic Mineral Ores

	Tin Ore 10^3 Tons	Nickel Ore 10^3 Tons	Bauxite 10^3 Tons	Iron Sand Concentrates 10^3 Tons	Copper Concentrates 10^3 Tons
1970	191	600	1229	--	--
1975	244	801	993	353	201
1976	222	829	940	292	223
1977	240	968	1301	312	189
1978	240	1207	1007	193	180
1979	252	1552	1051	80	189

Source: Biro Perencaan

TABLE III- 4

Production of Processed Ores, Current and Pelita III Targets

(Tons)	Tin Concentrates	Nickel Matte	Aluminum	Copper Concentrates
1979/80	32,775	22,700	--	225,000
1983/84	36,611	47,600	225,000	225,000

Source: Dept. of Mines and Energy: Mining and Energy (1979) Third Five Year Development Plan.

III.2 Manufacturing Sector

Energy Consumption in manufacturing is characterized by the extremely rapid growth in selected energy intensive industries in the last part of the decade, in particular fertilizer and cement, and by the relatively slow growth in the traditional subsectors, such as food products and textiles. It is also important to highlight the role of natural gas and coal as energy inputs to the manufacturing sectors that make it the most diversified sector in the use of commercial energy sources. Tables III-5 and III-6 summarize recent statistics on energy use by the manufacturing sector.

A total of 30,244 kboe was consumed in manufacturing in 1978, of which 63 percent was petroleum products, 35 percent natural gas, 0.8 percent coal and the remaining 1.2 percent purchased electricity. In order of importance, the largest is fertilizer, followed by cement and iron and steel. Both iron and steel, and cement are planned to expand production considerably; in 1979, the latest year for which data is presented, the integrated steel mill that utilized natural gas for ore reduction was not completed. Upon completion, natural gas use at the Krakatao steel complex will increase considerably.

Besides the industries mentioned above, there is significant petroleum consumption by the tile, brick and glass industries ("other non-metallic minerals"), in pulp and paper and chemicals (paints, drugs) and rubber processing. Listed under "other manufacturing" in Tables III and III- are machinery and electrical equipment, transport equipment, workshops and appliance manufacture.

Petroleum: The largest fraction of petroleum use in manufacturing is light diesel, which grew from 7,933 kboe in 1978 to 9,269 kboe in 1979 at a 16.8 percent growth rate.

About one half of this fuel is used in the generation of electricity by the 1300 MW of diesel generators installed in industry in Indonesia (part of this capacity, however, is installed outside the manufacturing sector in mines, agricultural estates, sawmills, public buildings, hotels, etc). The generation of electricty in the manufacturing sector is presented separately.

The remaining light diesel is used primarily in vehicles. This fuel use is excluded from the freight transportation sector because its patterns of consumption, and future growth rate, are tied to the growth in output of the respective segment of industry.

The industrial diesel and fuel oil use, amounting to 10,997 kboe in 1978 and 12,410 kboe in 1979, are used primarily as boiler fuel and in kilns for direct heating applications. Installed capacity of steam generators outside the PLN system is limited; besides one 200 MW plant that does not belong to the manufacturing sector, the remainder totals only about 90 MW. It is not known if any of this capacity is operated to generate heat and electricity jointly (cogeneration); for the most part, industrial diesel and fuel oil are used as direct heat in cement kilns (28 percent),lime and brick kilns (14 percent) and in heating water and raising steam in the food processing and textiles industry (33 percent).

Natural Gas: The bulk of the natural gas used in manufacturing is for feedstock in two large fertilizer plants; in the future, ore reduction in steel-making will add to its use as feedstock. The same industries use natural gas as fuel also; besides these, the only other manufacturing uses of natural gas are in cement and feedstock for carbon black.

TABLE III - 5

Energy Consumption in Manufacturing, 1978 (kboe)

Energy Uses	Light Diesel Oil	Industrial Diesel Oil	Fuel Oil	Natural Gas	Coal	Purchased Electricity
Food and Beverages	1800	722	1230	--	--	36
Textiles	2687	1303	358	--	--	129
Pulp and Paper	343	202	286	--	--	28
Cement	266	1107	1952	--	238	117
Other Non Met. Miner.	693	851	695	--	NA	
Iron and Steel	516	353	506	25		13
Fertilizer	54	--	872	6575		49
Other Chemicals	695	110	41			
Rubber	755	165	64			
Other Manufacturing	424	89	91			38
Subtotal	7,933	4,902	6,095			411
Feedstock Uses						
Fertilizer				4044		
Iron and Steel				21		
Total	7,933	4,902	6,095	10,665	238	411

TABLE III - 6

Energy Consumption in Manufacturing, 1979 (kboe)

Energy Uses	Light Diesel Oil	Industrial Diesel Oil	Fuel Oil	Natural Gas	Coal	Purchased Electricity
Food and Beverages	1969	918	1066	—		
Textiles	3060	1279	368	—		
Pulp and Paper	334	236	332	—		
Cement	325	1529	2372	1153	368	
Other Non Met. Miner.	812	962	890	—	25	
Iron and Steel	494	330	618	125		
Fertilizer	31	41	836	6252		
Other Chemicals	954	199	44	418		
Rubber	841	154	72	—		
Other Manufacturing	449	78	86	—		
Subtotal	9269	5726	6684	7948		
Feedstock Uses						
Fertilizer				7116		
Iron and Steel				1881		
Total	9269	5726	6684	16945	393	558

The natural gas delivered to the town gas company (PDN) is allocated to the residential sector, although it is not know if small manufacturing firms are PDN customers. The total natural gas delivered to PDN is less than 2 percent of its use in the uses described here.

Electricity Consumption: The manufacturing sector in Indonesia generates internally about 85 percent of the electricity it consumes with diesel generators. This proportion varies little among the different segments of manufacturing activity; that is, captive generation is not only commonplace among large chemical and cement plants, but also among the numerous firms in the textile or food products industries. Table III - 7 shows the proportion of captive versus purchased electricity for nine industrial sub sectors. The information is for calendar year 1978 from the Industrial Statistics 1978 (Biro Pusat Statistik); the total purchases of 661.6 Gwh are in good agreement with PLN sales to industry of 792.5 Gwh (rates classes I1, I2, I3 and I4, formerly rates E and CI) for fiscal year 1978/79. The difference between the sources, beside the lack of overlap between calendar and fiscal year, is likely to be from PLN sales to a few large consumers outside the manufacturing sector. Another source of discrepancy between BPS information and PLN sales is that the report on Industrial Statistics is based on a reporting system by industries; firms may be left out or underreporting may occur.

The latest year that BPS statistics are available is 1978; since that year, major projects in the fertilizer, cement and steel sectors have been completed which have signified large increases in the own production for the respective subsectors. A large part of this captive generation is with natural gas and not diesel oil. The sales of PLN to industries has also surged; between fiscal year 1978/79 and 1979/80, sales increased by 31 percent (Table III-8).

TABLE III-7

Electricity Consumption in Manufacturing 1978 (Gwh)

	Own Production	Sales	Purchased	Net Total Consumption	Fraction Own Production
Food Processing Incl. Tobacco	507.7	5.1	57.7	560.3	0.91
Textile, Apparel, leather	1072.5	21.7	207.8	1258.6	0.89
Lumber and Wood Products	105.7	--	5.2	110.9	0.95
Pulp, Paper, Printing	154.7	0.1	45.8	200.4	0.77
Chemicals, fertilizer, rubber[1]	1065.4	5.0	78.8	1139.2	0.94
Stone, Clay, Glass	473.5	1.1	189.2	661.6	0.72
Iron and Steel	52.5	--	21.4	73.9	0.71
Metal Prods, Elec. Equip.[2]	289.3	0.5	55.1	343.9	0.84
Other	7.0	--	0.6	7.6	0.92
	3,728.2	33.4	661.6	4356.4	0.86

[1] Excludes petroleum refining, includes plastics and pharmaceuticals

[2] Includes machinery,vehicles, ships

Source: Biro Pusat Statistik: Industrial Statistics 1978

TABLE III-8

Electricity Sales to Industrial Customers
(Tariffs I1, I2, I3, I4) - Gwh

	1975/76	1976/77	1977/78	1978/79	1979/80
Tariff I1	109.6	112.4	118.1	123.7	138.1
Tariffs I2 - I4	390.5	438.9	518.8	668.8	897.9
Total	500.1	551.3	636.9	792.5	1036.0
Yearly Growth Rate	1.10	1.16	1.24	1.31	

Source: PLN

Energy Consumption for captive power generation: with the exception of one cement plant using coal as its main source of fuel, and the Pusri fertilizer plant using natural gas, the manufacturing sector in 1978 was totally fueled with petroleum products. In order to generate 3700 Gwh, approximately 11,500 x 10^3 boe of petroleum products are needed (assuming an efficiency of 20 percent, and making no adjustments for electricity generated by other than petroleum). Total petroleum products used in this sector that year amounts to nearly 21,000 x 10^3 boe, half of which is diesel and the rest are boiler fuels with which electricity can be produced in steam generators jointly with steam required for other industrial processes. Installed capacity of captive power generators is tabulated by PLN for all non-PLN generation (see Table III-9). The usefulness of this data is limited, because no breakdown is provided by sector of economic activity of the total 1310 MW of captive diesel generators existing in 1980. Important fractions are outside the manufacturing sector in mines, agricultural plantations, forestry operations, in hotels and other large buildings. Also, no information is available on the nature of the captive generation: a part of it could be stand-by equipment, and not dedicated captive power.

TABLE III-9

Non-PLN Installed Capacity - 1980 (MW)

	Hydro	Steam	Gas Turbines	Diesel
Java	126.4	259.2	2.2	1006.1
Outside Java	169.5	32.9	231.8	304.2
Total	295.9*	292.1	234.0	1310.3

* Includes 125 MW dedicated to sales to PLN and 165 MW for the Larona nickel smelter.

Source: PLN Statistical Yearbook 1979/80

III.3 Transportation Sector

The transportation sector consumes about 30 percent of Indonesia's total domestic use of petroleum products. Fuel use in this sector, which is virtually all oil products except for small amounts of coal used in railroads, has been estimated to be growing at a rate of about 14 percent per year for the period 1960-1977 (MIGAS), but more detailed analysis of destination of fuels, especially light diesel oil, yields a growth rate of 9.7 percent between 1978 and 1979. Total consumption in 1978 amounted to 33,242 kboe (excluding bunkers and Pertamina use), and in 1979 it grew to 36,454 kboe. International bunkers amounted to 2800 kboe in 1978, consisting mostly of jet fuel and fuel oil for ships; Pertamina's use for its tankers and truck fleets adds another estimated 3242 kboe to transportation uses of fuel in the country, bringing the total to 39,284 kboe, or 32 percent of total petroleum use in the country. The inclusion of these two categories of transportation users is consistent with MIGAS accounting for transportation fuels. For purposes of the projection of domestic demand for transportation fuels, these two categories will be analysed elsewhere. Table III-10 shows total petroleum use in transportation for domestic use, international bunkers and Pertamina own use. Gasoline comprises 57 percent of total domestic use, and light diesel oil another 31 percent. Fastest growing fuel is light diesel oil; trends in use of bunker fuels for ships are more volatile and depend largely on the comparative fuel prices in neighboring countries.

Table III-10 Petroleum Consumption in Transportation

Kboe	Transportation Sector[1]		International Bunkers		Pertamina Own Use		Total	
	1978	1979	1978	1979	1978	1979	1978	1979
Aviation Gasoline	118	116	6	8	--	--	124	124
Jet Fuel	2,440	2,632	938	887	8	280	3,386	3,799
Gasoline	18,572	20,013	--	--	341	986	18,913	20,999
Lt. Diesel Oil	11,090	12,717	59	54	527	657	11,676	13,428
Industrial Diesel	494	527	238	254	514	283	1,246	1,064
Fuel Oil	528	449	1559	1919	1613	1465	3,700	3,833
	33,242	36,454	2800	3122	3242	3671	39,045	43,247

[1] Includes all uses by the Military.

Fuel use by transportation mode is presented in Table III-11 and III-12 for 1978 and 1979 respectively. Road transport consumes more than 80 percent of the total and is detailed in the sector below, broken down into trucks, automobile, bus and motorcycle usages. The remaining modes are air, which uses 7-8 percent of total transport fuels, ships at 7-8 percent also (this includes all uses by shipping lines and freight, all uses by the Navy, and excludes use by Pertamina ships and sales to international bunkers). Railroad use of petroleum products amounted to 711 kboe in 1978 and is declining over the years; in addition some tons of coal (kboe) are used in railroads in the coal mining region of West Sumatra. Fuel use for air transport tabulated here includes all jet fuel and aviation gasoline sold in the country, consisting of scheduled airlines, private aircraft (mostly in petroleum exploration activities) and the Armed Forces.

Road Transport: All gasoline reported by Pertamina as sold to dealers, industrial and commercial customers and the Armed Forces are assumed to be used in road transport. In addition, all light diesel oil sold by retailers (service stations) and that consumed by the military. This allocation implies that light diesel oil purchases by industries (and which can be in part used for trucks owned by such firms) are excluded from road transport totals. Because there is no justifiable way to separate the transport uses from other uses in industry it was decided to omit this diesel from the transport sector as defined here. The escalation in use of diesel within industry for trucks is a function of economic activity in industry, and will be

TABLE III-11

Transportation Sector Fuel Use by Mode 1978

Kboe

	Gasoline	Aviation Gas Jet Fuel	Light Diesel Oil	Industrial Diesel Oil	Fuel Oil	Total
Air	--	2565	--	--	--	2565
Railroad	--	--	364	14	333	711
Road Transp.	18572	--	8813	--	--	27,385
Ship	--	--	1912	480	194	2,586
	18572	2565	11089	494	527	33,247

TABLE III-12

Transportation Sector Fuel Use by Mode 1979

Kboe	Gasoline	Aviation Gas Jet Fuel	Light Diesel Oil	Industrial Diesel Oil	Fuel Oil	Total
Air	--	2596	--	--	--	2,596
Railroad	--	--	411	23	241	652
Road Transp.	20,013	--	10,181	--	--	30,194
Ship	--	--	2,125	504	208	2,837
	20,013	2596	12,717	527	449	36,279

captured in the projections under that sector.

The assumption that all light diesel oil sold by dealers (i.e., service stations) is used in vehicles for transportation also merits attention. For example, it is known that isolated systems of the national electric utility (PLN) on occasion purchase diesel locally from dealers. However, a comparison of fuel usage as reported by PLN with the amount reported as sold to PLN by Pertamina yeilds no such differential. Even taking into account stockpiling by PLN, it would appear that PLN purchases from dealers are negligible. Other non-transportation uses of diesel sold at dealers are small industry, irrigation pumps and farm machinery. Outside of plantation agriculture, whose fuel consumption is accounted for elsewhere, very few tractors and agricultural equipment exists in the country. Irrigation is overwhelmingly achieved by gravity flow and diesel use for pumping is also quite small. Lastly, the use of diesel by small industry (i.e., by concerns that purchase it from dealers such as gas stations and distributors) is small as described in a separate report. While gas stations in 1970 sold 7117 kboe of automotive diesel, other distributors sold 228 kboe thousand or 3 percent of this amount.

Road transport modes of importance in Indonesia are trucks, buses, automobiles and motorcycles. An estimate of the gasoline and light diesel oil used by each of these modes can be made based on available information on number of vehicles of each type. No other reliable source of information for this analysis exist, except of a Ministry of Transport estimate that breaks total fuel use in road transport as follows: Cargo 57.5 percent, bus 12.2 percent, automobiles 19,8 percent and motorcycles 10.5 percent. A revised breakdown is presented in this section.

Trucks: The inventory of registered trucks will have to be broken down by size - or tonnage, in order to arrive at a more meaningful estimate of fuel use by freight on roads. Visits to transportation companies, that is, those companies that own fleets of trucks and have freight on long term contracts such as for cement, and interviews with independent truck operators should be conducted. From these sources, estimates of fuel use per day, or kilometers travelled per year can be obtained. Small trucks, used mainly for distribution of goods in urban areas, for providing personal transportation in service occupations (such as hospitals or the telephone company) and for private transportation are more difficult to survey and can be estimated by difference.

Buses: it is important to be able to separate intercity bus transportation from urban bus transport. The largest fraction of registered buses are servicing the urban areas: urban buses have typically large loads of passengers and slow speeds in traffic, so that their average fuel economy is low. Intercity buses are the main mode of transportation within islands, especially in Java where there are extensive road networks, but also in the more sparsely populated islands such as Sumatra where, despite the poor condition of roads, buses provide the only mode of passenger transport between cities besides the airlines. Intercity buses are high on yearly kilometers travelled, and can obtain better efficiences than urban buses because of limited stops and higher speeds. Visits to large bus companies are an important source of information on average distance travelled per year and consumption of gasoline.

Motorcycles: The analysis has to focus separately on three-wheel motorcycles and on 2-wheel motorcycles. The latter are used predominately for private transportation in urban environments, and have low yearly kilometer use and high efficiency. Three-wheel motorcycles are part of the public transportation sector.

Fuel Use in Road Transport: Gasoline use in 1978 amounted to 18,572 kboe, and diesel 8813 kboe. The breakdown by mode was made according to assumptions on fuel efficiency and utilization rates (Km per vehicle per year) indicated in Table III-13. In addition, the published statistics on the number of registered trucks, buses, motorcycles and automobiles were modified slightly to account for retirements of vehicles from the fleet. Finally, the split between gasoline and diesel-powered vehicles had to be made without supporting statistical evidence: all automobiles, motorcycles and urban buses are assumed to have gasoline engines, all intercity buses to have diesel engine and trucks are assumed to be one third diesel and two thirds gasoline powered.

The estimations outlined above yield a total of 18,598 kboe of gasoline and 8870 kboe or diesel, with 42 percent of this fuel used by trucks, 22 percent by autos, 24 percent by buses and 12 percent by motorcycles.

Vehicle registration statistics are not available for 1979, in which road transport use of gasoline grew at 7.8 percent to 20,013 kboe and of diesel at 15.5 percent to 10,181 kboe. This is consistent with recent trends in vehicle registration growth: between 1975 and 1978, the yearly growth rate in truck registration was 19.1 percent and that of buses 18.5 percent, while that of automobiles was 11.6 percent and that of motorcycles 18.0 percent. Table III-14 shows registrations of vehicles for 1970 and 1975 through 1978. The higher rate of growth in registrations when compared with the lower growth rate in fuel consumption does not have a straightforward explanation. In part it could be that vehicle inventory is in fact growing more slowly than the registration statistics indicate (in the case where discarded vehicles remain listed in the rolls); another explanation which is extremely unlikely

TABLE III-13

Fuel Consumption In Road Transport

Estimation by Mode, 1978

	Registration	Inventory Factor	Utilization	Fuel Eff.	Fuel Consumption Gasoline	Diesel	Total
	Vehicles		Km /vehicle per year	Km /liter	Kboe	Kboe	Kboe
Trucks	331,658	0.75	30,000	3.8	7565	4097	11662
Automobiles	532,299	1.00	15,000	7.6	6037	—	6037
Buses	58,365	0.75					
Intercity	50% (est.)		100,000	2.9	—	4773	4773
Urban	50% (est.)		45,000	3.2	1771	—	1771
Motorcycles	1,960,237	0.70					
3 wheel	20% (est.)		24,000	21.0	1805	—	1805
2 wheel	80% (est.)		7,200	32.0	1420	—	1420
All Modes					18,598	8,870	27,468

Note: Automobiles, motorcycles and urban buses use gasoline, intercity buses use diesel; by difference, 67% of fuel (in volume) used by trucks is gasoline and 33% is diesel.

Source: E/DI estimates

TABLE III-14

Vehicle Registrations

	Trucks	Autos	Buses	Motorcycles
1970	99,814	235,816	20,451	424,809
1975	196,416	383,061	35,103	1,191,771
1976	223,062	420,945	40,001	1,419,375
1977	278,979	479,335	48,089	1,704,964
1978	331,658	532,299	58,365	1,960,237
1975-78 Growth Rate	19.1%p.a.	11.6%p.a	18.5%p.a.	18.0%p.a.

Source: Biro Pusat Statistik: Statistik Indonesia 1977-78

is that total kilometers travelled per year is decreasing or that fuel efficicency has improved appreciably. Lowered kilometers travelled could come about with an oversupply of trucks (i.e., trucks growing faster than ton-kilometers of freight to be transported), leaving a large proportion of idle time per truck; for automobiles, decrease in average travel per vehicle can be caused by an increasing proportion of second cars (which is not likely in Indonesia). Other factors such as congestion, especially in urban areas, lead if anything to higher consumption of fuel per vehicle, and not less as is the observed trend.

III.4 Commerdial Sector

The commercial sector consists of a variety of economic activities that are grouped for the sake of convenience. This sector includes all office buildings, retail establishments, warehouses, government buildings and services such as public works and street lighting, hotels, food outlets etc. The construction sector is also included.

Total energy used in the commercial sector grew from 10,951 kboe in 1978 to 11,826 kboe in 1979.(Table III-15). Three-fourths of this amount is kerosene; the amount is an estimate that assumes that 20 percent of sales of kerosene are for the commercial sector (and the rest to households). The use of kerosene in the commercial sector is for cooking and lighting, same as in the household sector. The commercial sectors cooking is in restaurants and other food establishments such as roadside stalls. The use of kerosene in lighting of shops, restaurants and public gathering places in areas without access to electricity makes up the rest of this consumption.

The consumption of light diesel and industrial diesel is obtained from Pertamina sales data. The largest of these is the construction industry, which in 1978 used about 1 million boe of light diesel. Part of this consumption, and that of government and commercial buildings is for generation of electricity.

The use of town gas and LPG by the commercial sector (restaurants, hotels etc) is not known. In light of the limited total amount of these fuels sold to all sectors, the share of its use in the commercial sector cannot be very significant.

TABLE III-15

Energy Consumption Commercial Sector (kboe)

	Kerosene		Light Diesel		Industrial Diesel		Electricity*	
	1978	1979	1978	1979	1978	1979	1978	1979
Foodstalls, restaurants etc.	8004	8823	--	--	--	--	--	--
Govt. and other institutions	--	--	871	820	45	66	--	--
Construction			1021	923	59	27		
Total Commercial Sector	8004	8823	1892	1743	104	93	951	1167

*Data are for fiscal years; a breakdown by subsector is shown in Table

Electricity, which amounts to about ten percent of total energy consumption in this sector is used in buildings, stores, hospitals street lights and so on. Electricity purchases by the commercial sector represent 35 percent of total PLN sales, and have been growing at nearly 17 percent per year in the period 1975/76 - 1979/80. The most significant uses of electricity are in lighting and air conditioning; other uses include fans, elevators, and office equipment. Electricity sales to the commercial sector are broken down by tariff classes (Table III-16). Fastest growing are the sales to the tariff class that includes hotels (23.1% per year) and government buildings (23.1%). The latter consumes one fourth of total electricity purchases of the sector. Nearly forty percent is used in shop markets, retail stores and other such consumers. The largest individual commercial consumers are hospitals, hotels and office buildings that have monthly usages of upwards of 1,000,000 Kwh.

TABLE III-16

Commercial Sector, Electricity Purchases

	Tariff Class	Growth Rate 1978-79	1978/79 Gwh	1979/80 Gwh
Buildings (offices etc)	G1	6.7%	221.6	239.7
Governments Buildings	G2	23.1%	363.5	487.9
Street Lighting	J	15.9%	116.2	134.6
Hospitals	S2	14.9%	124.3	150.2
Hotels etc	H2	23.1%	103.6	139.1
Retail, restaurants, other Large Comm.	U1-U4,H1	16.5%	603.0	728.2
		16.7%	1532.2	1879.7

GLOSSARY

A common terminology has been utilized throughout this report to denote terms that can cause confusion because different authors refer to them by several synonyms. The terminology utilized in this report is given in upper case in this glossary, followed by english synonyms and occasional Indonesian usage.

LIGHT DIESEL OIL: middle distillate used as fuel in vehicles and electric generation; automotive diesel (ADO), high-speed diesel (HSD), minyak solar.

INDUSTRIAL DIESEL OIL: middle distillate with same chemical characteristics as light diesel oil, used as boiler fuel by industry and in ships; IDO, heavy diesel oil (HDO), minyak diesel.

FUEL OIL: heavy distillate used as boiler fuel in industry, in ships and in steam driven electric generation; residual oil, minyak bumi.

TOWN GAS: high energy gas manufactured from petroleum, or natural gas; city gas.

ENERGY PLANNING FOR DEVELOPMENT IN INDONESIA

Appendix C

ENERGY USE FOR PRODUCTIVE PURPOSES IN THE RURAL SECTOR IN INDONESIA

Thomas E. Cobbald

EldoConsult and consultant to
International Science & Technology
Institute.

May, 1981.

ENERGY/DEVELOPMENT INTERNATIONAL
505 Main Street
Port Jefferson, N.Y. 11777

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I INTRODUCTION

This study was carried out as part of the first phase of a USAID-supported project - entitled "Energy Planning for Development in Indonesia" - initiated in May 1980 by the Directorate-General for Power of the Ministry of Mines and Energy of the Government of Indonesia.

The study has covered the use of energy for productive purposes in the rural sector, and has been oriented towards two principal objectives, viz:

Firstly: to provide data needed for the completion of a preliminary macro-scale "Reference Energy System"[1] that will, with due refinement, chart the relationship between all significant sources and consumers of energy in the Indonesian economy,

Secondly: to yield an improved knowledge of the sectoral energy consumption pattern such as will allow inter-sectoral comparisons to be made of relative energy intensity, and assessments of the economic returns to energy consumption within the sector, taking into consideration the social and environmental costs as well as those borne directly by the energy user.

These insights are needed if there are to be objective assessments of the energy implications of alternative development strategies. Development implies change, and this change will invariably extend to the pattern of demand for energy and the supply systems operating to meet that demand. Specific institutional interventions may well be necessary to ensure that the direction and extent of that change accords with more general economic, social and environmental objectives. The available intervention instruments may include pricing control, physical supply regulation, investment incentives, purposive research and development, etc.; the modalities of adjustment may include, inter alia, improved usage efficiency, substitution and the use of alternative (and possible innovative) energy sources.

Without a clear understanding of the present pattern of usage, of the factors that have tended to determine it, and of the economic and technical constraints to adjustment, the shaping of intervention policy, and the choice of the appropriate instruments, cannot be soundly based.

The need for more accurate information on the sectoral energy pattern is underscored by the widely divergent estimates of current consumption - and the equally divergent opinions as to where the thrust of institutional effort should be directed. Although, for reasons of time constraints and imperfect data, the outcome of the present study is inevitably lacking in detail and accuracy, it is hoped that it may prove useful as a precursor of a more systematic approach. This will, undoubtedly, require the collection, generation and processing of a substantial corpus of data - derived from both the disaggregation of macro-level data and the synthesis of micro-level data. For this task to be carried out expeditiously and efficiently it is vital that the relative importance of the separately identifiable energy flows should be recognized from the onset, so as to avoid wasting time and resources on insignificant minutae. It is hoped that this study will contribute towards that end.

II THE RURAL SECTOR

For the purposes of the present study, economic activities have been deemed to fall within the rural sector provided that they meet the following conditions:

i) They take place in the rural areas,

ii) They are in the primary or secondary subsectors,

iii) Their products are at least potentially tradable,

iv) The activities have a reasonably wide geographical distribution.

On this basis, the rural sector has been taken to include:

i) Agriculture, whether on a plantation, estate farm or smallholding scale,

ii) Most agro-industry on the downstream side (i.e. deriving the bulk of its raw material input from agriculture),

iii) Forestry, timber extraction and most primary conversion,

iv) Extractive industry, as composed of clay and lime industries, stone quarrying, sand and gravel workings, and the small-scale working of well-distributed minor mineral deposits (such as kaolin, fullers' earth, calcite, perlite, manganese, etc.),

v) Rural craft, textile and food industries,

vi) Discrete supply services (i.e. small water and electricity supply schemes).

The important exclusions are domestic activities catering solely for household needs, the transport sector (except where vertically integrated with specifically-included sector activities), and that part of extractive industry (more especially that conducted on a larger scale) that can more rightly be regarded as being part of the mining sector rather than the rural sector. The choice of definitional descriptors has, to some extent, been determined by the collateral studies being made under the project.

These have included a special survey of the domestic consumptions of firewood and kerosene. The energy demand in industry and commerce and for transportation in the entire economy has been separately addressed. By avoiding overlap the task of final synthesis will be that much easier to perform.

Inevitably there has been an element of arbitrariness in the selection of subsectors to be included. This can be defended on the grounds that the principal objective has been a better understanding of the important energy flows, and that little would be gained by adhering to a strict homomorphic categorization or by straining to conform with other institutional definitions.

III STUDY METHODOLOGY

To arrive at a correct understanding of the pattern of energy flow in the rural sector it is important to recognize that both open and closed subsystems are involved. In the former category are those subsystems where the energy source (or, less commonly, the point of energy utilization) lies outside the activity/product envelope. Typical examples are the activities relying on petroleum fuels or electricity sourced outside the rural sector and, in the reverse sense, activities where a rurally-generated fuel, such as firewood or charcoal, leave the sector for utilization elsewhere.

The completely closed subsystems, by contrast, neither rely on exogenous fuels or energy nor do they 'export' energy to non-rural sectors. A typical example is subsistence level smallholder agriculture - the energy for cultivation is supplied by the self-produced food and fodder that essentially fuels the human and animal power inputs. In practice a number of hybrid systems operate. The sugar industry uses both petroleum fuels and self-produced bagasse. (Cane residue after the extraction of sugar.) Similarly, the rubber industry may use rubber stemwood from replaced plantations as an internal source of energy. At the micro-level the cocoa-sugar producer will rely for fuel, to some extent, on plant debris from the same trees that produce the sap from which the sugar is extracted. It will be readily apparent that the degree of 'openness' or 'closedness' of the sub-systems reflects the extent to which the overall system is conceptually disaggregated - if it were completely dissected there would, of course, be no closed systems. These distinctions are important in the context of analysis because of the need to adopt tractable procedures; if too great

a disaggregation is attempted then there are likely to be more open systems, to which energy vectors can be attached, than can conveniently be dealt with; conversely, if too little disaggregation is made then the calculations of flows external to the activity envelope will convey little useful information. The degree of disaggregation appropriate to a particular study will normally be a matter of judgment, taking into account the quantity and quality of available data, and the resources that can be used to collect or generate additional data. For reasons stated earlier, the present study has necessarily been somewhat superficial and therefore, in terms of depth and degree of disaggregation, falls short of what is properly required if robust conclusions are to be drawn. So, though serviceable enough for present purposes, the analytical framework used here should not be taken to represent a methodological norm.

Indonesia compares favorably with many other countries at a similar stage of development in that there has been a sustained effort to generate time series and periodic enumerative data relating to industrial strength and throughput. At the upper end of the industrial scale spectrum there is an annual survey of Large and Medium Scale Manufacturing Industries[2], categorized according to the ISIC code[3] at the 5-digit level. Published by the Central Bureau of Statistics (Biro Pusat Statistik - BPS), the results show the numbers of operating units, the persons employed, the outputs and inputs, and summarized financial data. At the lower end of the spectrum there have been periodic censuses covering household, cottage and small-scale industry[4]. At the time of writing (March 1981) the latest census of this sort for which results have been published was held in 1974/75; more recent data are reportedly available at the provincial-level offices of the Ministry of Industry, but have yet to be collated centrally.

Data on the hectarages under cultivation, annual and perennial, and on the calculated output, are published annually by BPS. Corresponding data on animal and mechanical power inputs are, unfortunately, lacking; for the numbers of tractors and irrigation pumps employed for agricultural purposes other than on the large estates and plantations there are available, however, the results of a Ministry of Agriculture enumeration of the serviceable units in 1977. Thus, with the exception of non-manufacturing industries such as timber extraction, and non-industrial activities such as forestry establishment and management, non-PLN electricity generation and private or community-owned water supply, the data from official sources provide a reasonably comprehensive picture, in a quantitative sense, of the consumption points for energy in the rural sector.

Equivalent correlative econometric data on the supply side are, however, either not readily available or are totally lacking. The sectoral distribution of the sales of petroleum products from Pertamina's regional depots, as shown in the consolidated monthly returns, are insufficiently disaggregated for them to be of much value as a check on consumption distribution, except in a very general way. Rural consumption of PLN-generated electricity, coal, coke and natural gas is not, on the evidence of usage, statistically very important, and the non-availability or corrobative sectoral supply data is, therefore, not a serious handicap to analysis.

As regards the overall contribution of biomass to the energy supply, there are at present no hard data[5]. Hardjodarsono's 1978 paper[6] has been accorded a seminal status by various authors[7] but did not purport to present more than very approximate estimates. A full critique of the paper cannot be attempted here; it can perhaps be noted that after presenting the (widely-cited) estimates for firewood and non-wood

(agricultural residues) fuel for 1967-76 (32.43 - 36.70 m tons on Java, 35.01 - 51.87 m tons outside Java) the author with commendable candor states that 'not much use is made of the waste products' comprising 94-97 percent of totals given for Java and 58-84 percent of the totals given for outside Java. He suggests that what is actually used is the unrecorded and unestimated production of home gardens and public land. Although it could be a valid conclusion that the latter supply equilibrates demand it clearly is not safe to use these figures (as is attempted by some authors) as a basis for positive statements on the adequacy or otherwise of the supply. Comparable uncertainties attach to the demand estimates as discussed below.

Thus, in general, although there are considerable amounts of relevant data the coverage is uneven, many are out-of-date, and reliability cannot always be assumed. Some of these difficulties arise because until now energy matters have not been widely regarded as deserving special attention in the more general surveys, and as a consequence, although the data may be embodied in more general statistics they may be difficult to extract. Regarding data quality, others[8] have emphasized the need for caution before attempts are made to derive conclusions from cross-sectional data. The principal reason for this is that the distinctions between enumerative data, secondarily-generated data and putative data are often not explicitly stated. Accordingly, it is often impossible to be sure (unless there is access to the original sources) of the provenance of presented figures and to what extent they are essentially conjectural. This is particularly a problem when the 'informal' subsector is under consideration. In the rural areas there is often overlap with the agricultural sector because farmers and farm workers will engage in non-agricultural activities during

slack agricultural periods. With a very large proportion of the economically active population engaged in agriculture it can be no easy task to get a measure of this off-farm activity, and careful scrutiny of some regional statistics has shown that they are to a large extent artificial[9].

On the theoretical level, two alternative approaches to the assessment of a sector's energy consumption may be feasible, viz:

i) Calculation of energy inputs needed to produce the measured or estimated quantities of output, using techncial coefficients that specify the average energy cost (in physical terms) per unit of output,

ii) Summation of the estimates or measured energy inputs, again in physical terms, from aggregated enterprise or subsectoral data.

The first alternative offers very considerable savings in analysis time and effort if it can be used. This depends on whether or not there are available reliable data on output and equally reliable technical coefficients. At the start of an assessment it will probably be impossible to establish a position on this until some empirical tests have been carried out on the available data. This should explain why it is not possible to prescribe a 'standard' approach to studies of this sort. Each case needs to be dealt with on its merits.

In the present study an attempt was made to derive technical coefficients from the results of the 1978 Survey of Large and Medium Scale Manufacturing enterprises. Calculations were made of the energy consumption in barrels of oil equivalent (BOE) per unit of output in a number of rurally-located industry subsectors. While conforming to the rough rank order to be expected from the nature of the processes involved, the actual coefficients were in some cases significantly at variance with consumptions recorded elsewhere for similar processes. Some of these differences could be attributed to

difficulties in properly apportioning energy inputs in the cases of subsectors with multiple outputs; in some cases the apparently too high technical coefficients could be related to probable under-reporting of output (as is likely, for instance, in the rice-milling subsector, where rice from custom-milling is properly 'output' but will not feature as such in an enterprise's accounts). Since there was no way to be sure that outputs had been accurately recorded the uncertainty would not be dispelled even if internationally-accepted coefficients were used[10].

As a result it was necessary to rely on a hybrid construct of energy inputs. For rural industries, subsector-wide aggregates of energy consumption were arrived at either directly from recorded inputs or from the calculated physical equivalents of reported financial expenditures. In the case of agriculture, the energy consumption for mechanized cultivation and irrigation equipment was derived directly from the known inventory by making assumptions regarding the hourly consumption and the number of hours worked per year. For human and animal power input for cultivation, the energy input per hectare has been calculated on the basis of the fuel cost of performing the same work mechanically[11]. Inputs of energy to the forestry extraction subsector, the quarrying subsector and the large-scale estates and plantations subsector (where not covered by the Industry subsector) have been derived from the Pertamina distribution statistics for 1979. For non-PLN Electricity and Water Supply the energy consumption has been calculated from anecdotal evidence of inventory and assumed annual performance.

All estimates of energy consumption have been brought to a common time base of the year 1978, by the use of appropriate adjustment coefficients. More complete details of the compilation methodology are given in Appendix 1 of this report.

It is somewhat unfortunate that the adopted methodology owes less to what could be described as a 'textbook' approach, and more to the fortuitous availability of data and references at the time of the study; obviously this detracts from whatever heuristic value attaches to it. The point needs to be made, however, that an opportunist and judgmental approach is likely to be needed in any case, if the exercise is repeated in the shorter term. It is likely to be some time before the survey and enumeration techniques of departments not expressly concerned with energy are oriented towards explicit energy information extraction.

To conclude this section on methodology, it must be emphasised that the heavy reliance on data collected or generated by other hands is a source of weakness, if for no other reason that there is an observed tendency, in the pursuit of aggregate figures, to treat 'n.a.' entries as zeroes. Distortions introduced in this way are difficult to detect. A further source of error is the use of widely differing standards of measurement[12]. This underscores the point that to produce reliable results the methodology adopted for any future studies of this sort needs to incorporate a substantial element of empirical work, so as to ensure that the analysis rests on a solid foundation of fact.

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IV RURAL SECTOR ENERGY ESTIMATES, 1978

The estimates of the 1978 rural sector energy usage, obtained by employing the methodology described in the previous section, and using data and coefficients shown in Appendix 1, are presented in text Tables 1 - 6[13]. In the interests of presenting a synopic view there has been some consolidation of the data shown more fully in the Appendix. In some cases analogous subsectors have been subsumed under a general heading and in others subsectoral detail has been omitted. There has also been some rearrangement of the data (e.g. transfer of fish processing and tanneries to 'Food Industries' and'Other Industries' respectively in Table 2 et seq.) to eliminate insignificant detail.

Table 1 shows the inputs of energy to the different subsector groups and the form in which that energy is supplied. The estimates for the 'oil equivalent' (BOE) of the human and animal inputs for agricultural cultivation for food crops (the small-holder agricultural sector) are included, to yield a total sectoral input of some 14 m BOE/yr. The Large Scale and Small Scale shares of each subsector's energy consumption are also shown. Table 2 shows the intra-subsector distribution of purchased energy consumption as between the Large Scale and Small Scale elements. In this table the supplies of petroleum fuels (other than Kerosene) are shown under one heading. Table 3 shows, for the subsector groups and subsectors (with disaggregation into Large Scale and Small Scale elements), the proportionate importance of each main supply source of purchased energy. Table 4 shows how the supply ofpurchased energy from each main supply source is distributed over the various consuming subsectors. The distribution is also shown of the share of the total supply taken by the Large Scale and Small Scale elements

TABLE 1

ENERGY INPUTS, RURAL SECTOR (INCLUDING FOOD CROP PRODUCTION), CONSUMPTION BY SUBSECTORS AND SOURCES, BOE, ESTIMATES, 1978.

	Gasoline (Bensin)	A.D.O. (Solar)	I.D.O. (Diesel)	Kerosene	Residual Oil	Firewood & Charcoal	Electricity, Natural Gas, Coke & Coal	Human and Animal Power	Totals	% Large Scale	% Small Scale
	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE		
AGRICULTURE											
- Food Crops	-	83 695	-	-	-	-	-	2 655 000	2 738 695	-	100
- Other Crops	98 681	928 414	197 407	-	44 925	-	-	-	1 269 427	100	-
(Subtotals)	(98 681)	(1 012 109)	(197 407)	-	(44 925)	-	-	(2 655 000)	(4 008 122)	31.7	68.3
AGRO INDUSTRY											
- Sugar	90 056	191 490	475 188	533 038	666 324	505 000	39 820	-	2 500 916	58.5	41.5
- Rubber	8 240	431 927	63 744	14 256	9 296	30 500	9 666	-	567 629	91.3	8.7
(Subtotals)	(98 296)	(623 417)	(538 932)	(547 294)	(675 620)	(535 500)	(49 486)	-	(3 068 545)	64.6	35.4
- Milling etc.											
- Rice	696	774 755	765	433	-	-	-	-	776 649	2.7	97.3
- Other Grain	-	84 339	-	-	-	-	-	-	84 339	-	100
- Animal Feed	1 138	28 448	-	287	-	-	145	-	30 018	89.1	10.9
(Subtotals)	(1 834)	(887 542)	(765)	(720)	-	-	(145)		(891 006)	5.3	94.7
- Vegetable Oils etc.											
- Coconut Oil	2 771	76 514	24 237	1 995	-	11 300	3 395	-	120 212	78.1	21.9
- Other Edible Oils	517	12 406	16 344	4 514		2 000	1 615	-	37 396	90.2	9.8
(Subtotals)	(3 288)	(88 920)	(40 581)	(6 509)		(13 300)	(5 010)	-	(157 608)	80.9	19.1
- Crop Drying etc.											
- Tea	701	22 662	607	3 776	-	59 900	124	-	87 770	79.9	20.1
- Tobacco	2 122	3 868	82	25 693	-	66 500	103	-	98 368	85.4	14.6
- Coffee	230	7 009	32	366	-	-	186	-	7 823	41.5	58.5
(Subtotals)	(3 053)	(33 539)	(721)	(29 835)	-	(126 400)	(413)	-	(193 961)	81.1	18.9
- Fish Processing	-	-	-	-	-	37 700	-	-	37 700	-	100
- Tanneries	-	-	-	-	-	3 100	-	-	3 100	-	100
(Subtotals: Agro-Industry)	(106 471)	(1 633 418)	(580 999)	(584 358)	(675 620)	(716 000)	(55 054)	-	(4 351 920)	53.2	46.8
FORESTRY											
- Extraction	37 860	1 898 478	16 371	-	6 450	-	-	-	1 959 159	100	-
- Conversion	17 762	258 496	1 668	2 385	-	-	2 070	-	282 381	93.2	6.8
(Subtotals)	(55 622)	(2 156 974)	(18 039)	(2 385)	(6 450)	-	(2 070)	-	(2 241 540)	99.1	0.9
EXTRACTIVE INDUSTRY											
-Quarrying and Minerals	1 072	87 347	84 186	18	16 600	-	186	-	189 409	94.4	5.6
-Lime	931	37 819	13 992	2 361	245 680	209 500	3 058	-	513 341	59.2	40.8
- Clay Products	236	12 450	34 406	2 263	272 240	949 200	145	-	1 270 940	25.3	74.7
(Subtotals)	(2 239)	(137 616)	(132 584)	(4 642)	(534 520)	(1 158 700)	(3 389)		(1 973 690)	40.8	59.2
FOOD INDUSTRIES	-	26 127	-	435 119	-	577 802	-	-	1 039 048	-	100
CRAFT INDUSTRIES	-	-	-	58 804	-	73 542	-	-	132 346	-	100
TEXTILE INDUSTRIES	-	-	-	25 034	-	50 700	-	-	75 734	-	100
OTHER INDUSTRIES	-	37 714	-	5 075	-	39 700	-	-	82 489	-	100
SOCIAL (Water, Amenity Elec.)	-	75 840	-	-	-	-	-	-	75 840	-	100
TOTALS	263 013	5 079 789	929 029	1 115 417	1 261 515	2 616 444	60 513	2 655 000	13 980 729	47.3	52.7
(Totals, Excluding Human and Animal Power)	(263 013)	(5 079 789	(929 029)	(1 115 417)	(1 261 515)	(2 616 444)	(60 513)	-	(11 325 729)	58.4	41.6

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TABLE 2

PURCHASE ENERGY, RURAL SECTOR (INCLUDING FOOD CROP PRODUCTION): LARGE SCALE AND SMALL SCALE CONSUMPTION SHARES (BOE BASIS), ESTIMATES, 1978

	Gasoline (Benzin), A.D.O. (Solar), I.D.O. (Diesel), & Residual Oil.	Kerosene	Firewood & Charcoal	Electricity, Natural Gas, Coke & Coal	TOTALS	% Large Scale	% Small Scale
	BOE	BOE	BOE	BOE	BOE		
AGRICULTURE							
- Food Crops (Small Scale)	83 695	-	-	-	83 695		
- Other Crops (Large Scale)	1 269 427	-	-	-	1 269 427		
(Subtotals)	(1 353 122)	-	-	-	(1 353 122)	93.8	6.2
AGRO-INDUSTRY							
- Sugar and Rubber							
- Large Scale	1 917 464	15 403	-	49 486	1 982 353		
- Small Scale	18 801	531 891	535 500	-	1 086 192		
(Subtotals)	(1 936 265)	(547 294)	(535 500)	(49 486)	(3 068 545)	64.6	35.4
- Milling (Rice, Grain, Feed)							
- Large Scale	46 757	720	-	145	47 622		
- Small Scale	843 384	-	-	-	843 384		
(Subtotals)	(890 141)	(720)		(145)	(891 006)	5.3	94.7
- Veg.Oils (Coconut, Edible Oils)							
- Large Scale	106 424	2 837	13 300	5 010	127 571		
- Small Scale	26 365	3 672	-	-	30 037		
(Subtotals)	(132 789)	(6 509)	(13 300)	(5 010)	(157 608)	80.9	19.1
-Crop Drying (Tea,Tobacco,Coffee)							
- Large Scale	24 238	29 835	102 900	413	157 386		
- Small Scale	13 075	-	23 500	-	36 575		
(Subtotals)	(37 313)	(29 835)	(126 400)	(413)	(193 961)	81.1	18.9
FORESTRY							
- Extraction (Large Scale)	1 959 159	-	-	-	1 959 159	100	-
- Conversion							
- Large Scale	258 749	2 385	-	2 070	263 204		
- Small Scale	19 177	-	-	-	19 177		
(Subtotals)	(277 926)	(2 385)	-	(2 070)	(282 381)	93.2	6.8
EXTRACTIVE INDUSTRY							
- Quarrying & Minerals							
- Large Scale	178 527	18	-	186	178 731		
- Small Scale	10 678	-	-	-	10 678		
(Subtotals)	(189 205)	(18)	-	(186)	(189 409)	94.4	5.6
- Lime and Clay(Bricks & Tiles)							
- Large Scale	617 754	4 624	-	3 203	625 581		
- Small Scale	-	-	1 158 700	-	1 158 700		
(Subtotals)	(617 754)	(4 624)	(1 158 700)	(3 203)	(1 784 281)	35.1	64.9
FOOD INDUSTRIES (Including Fish Processing) (Small Scale)	26 127	435 119	615 502	-	1 076 748		100
CRAFT INDUSTRIES (Small Scale)	-	58 804	73 542	-	132 346	-	100
TEXTILE INDUSTRIES (Small Scale)	-	25 034	50 700	-	75 734	-	100
OTHER INDUSTRIES (Including Tanneries) (Small Scale)	37 714	5 075	42 800	-	85 589	-	100
SOCIAL (Water, Amenity Elec.) (Small Scale)	75 840	-	-	-	75 840	-	100
T O T A L S	7 533 355	1 115 417	2 616 444	60 513	11 325 729	58.4	41.6

Source: Study Estimates

TABLE 3

PURCHASED ENERGY, RURAL SECTOR (INCLUDING FOOD CROP PRODUCTION): SUBSECTOR SOURCES (BOE BASIS), ESTIMATES, 1978.

	Gasoline (Bensin), A.D.O. (Solar), I.D.O. (Diesel), & Residual Oil	Kerosene	Firewood & Charcoal, (Bio-mass)	Electricity, Natural Gas, Coke and Coal	Totals	Non-Biomass
	(BOE) %	(BOE) %	(BOE) %	(BOE) %	(BOE) %	(BOE) %
AGRICULTURE (Food and other Crops)	100	-	-	-	100	100
AGRO-INDUSTRY	69.5	13.6	15.7	1.3	100	84.3
- Sugar and Rubber	63.1	17.8	17.5	1.6	100	82.5
(Large Scale Share)	(96.7)	(0.8)	-	(2.5)	(100)	(100)
(Small Scale Share)	(1.7)	(49.0)	(49.3)	-	(100)	(50.7)
- Milling (Rice Grain, Feed)	99.9	0.1	-	-	100	100
(Large Scale Share)	(98.2)	(1.5)	-	(0.3)	(100)	(100)
(Small Scale Share)	(100)	-	-	-	(100)	(100)
- Vegetable Oils (Coconut, Edible)	84.3	4.1	8.4	3.2	100	91.6
(Large Scale Share)	(83.4)	(2.2)	(10.4)	(3.9)	(100)	(89.6)
(Small Scale Share)	(87.8)	(12.2)	-	-	(100)	(100)
- Crop Drying (Tea, Tobacco, Coffee)	19.2	15.4	65.2	0.2	100	34.8
(Large Scale Share)	(15.4)	(19.0)	(65.4)	(0.3)	(100)	(34.6)
(Small Scale Share)	(35.7)	-	(64.3)	-	(100)	(35.7)
FORESTRY	99.8	0.1	-	0.1	100	100
- Extraction	100	-	-	-	100	100
- Conversion	98.4	0.8	-	0.7	100	100
(Large Scale Share)	(98.3)	(0.9)	-	(0.8)	(100)	(100)
(Small Scale Share)	(100)	-	-	-	(100)	(100)
EXTRACTIVE INDUSTRY	40.9	0.2	58.7	0.2	100	41.3
- Quarrying & Minerals	99.9	-	-	0.1	100	100
(Large Scale Share)	(99.9)	-	-	(0.1)	(100)	(100)
(Small Scale Share)	(100)	-	-	-	(100)	(100)
- Lime and Clay (Bricks, Tiles)	34.5	0.3	64.9	0.2	100	35.1
(Large Scale Share)	(98.7)	(0.7)	-	(0.5)	(100)	(100)
(Small Scale Share)	-	-	(100)	-	(100)	None
FOOD INDUSTRIES (Including Fish Processing) (Small Scale)	2.4	40.4	57.2	-	100	42.8
CRAFT INDUSTRIES (Small Scale)	-	44.4	55.6	-	100	44.4
TEXTILE INDUSTRIES (Small Scale)	-	33.1	66.9	-	100	33.1
OTHER INDUSTRIES (Including Tanneries) (Small Scale)	44.1	5.9	50.0	-	100	50.0
SOCIAL (Water, Amenity Electricity) (Small Scale)	100	-	-	-	100	100
TOTAL	66.5	9.8	23.1	0.5	100	76.9
(Large Scale Share)	(96.5)	(0.8)	(1.8)	(0.9)	(100)	(98.2)
(Small Scale Share)	(24.5)	(22.5)	(53.0)	-	(100)	(47.0)

Source: Study Estimates.

TABLE 4

PURCHASES ENERGY, RURAL SECTOR (INCLUDING FOOD CROP PRODUCTION);
SUBSECTORAL DISTRIBUTION OF ENERGY (BOE BASIS), ESTIMATES, 1978

	Gasoline (Bensin), A.D.O. (Solar), I.D.O. (Diesel), & Residual Oil (BOE) %	Kerosene (BOE) %	Firewood & Charcoal (BOE) %	Electricity, Natural Gas, Coke & Coal. (BOE) %	TOTALS (BOE) %	Large Scale Share of Overall total (BOE) %	Small Scale Share of Overall total (BOE) %
AGRICULTURE							
- Food Crops	1.1	-	-	-	0.7	-	1.8
- Other Crops	16.9	-	-	-	11.2	19.2	-
AGRO-INDUSTRY							
- Sugar and Rubber	25.7	49.1	20.5	81.8	27.1	30.0	23.0
- Milling (Rice,Grain,Feed)	11.8	0.1	-	0.2	7.9	0.7	17.9
- Vegetable Oils (Coconut & Edible Oils)	1.8	0.6	0.5	8.3	1.4	1.9	0.6
- Crop Drying (Tea,Tobacco and Coffee)	0.5	2.7	4.8	0.7	1.7	2.4	0.8
FORESTRY							
- Extraction	26.0	-	-	-	17.3	29.6	-
- Conversion	3.7	0.2	-	3.4	2.5	4.0	0.4
EXTRACTIVE INDUSTRY							
- Quarrying and Minerals	2.5	-	-	0.3	1.7	2.7	0.2
- Lime and Clay(Bricks & Tiles)	8.2	0.4	44.3	5.3	15.8	9.5	24.6
FOOD INDUSTRIES	0.3	39.0	23.5	-	9.5	-	22.8
CRAFT INDUSTRIES	-	5.3	2.8	-	1.2	-	2.8
TEXTILE INDUSTRIES	-	2.2	1.9	-	0.7	-	1.6
OTHER INDUSTRIES	0.5	0.5	1.6	-	0.8	-	1.8
SOCIAL (Water, Amenity Electricity)	1.0	-	-	-	0.7	-	1.6
TOTALS	100	100	100	100	100	100	100
Large Scale Share	84.7	5.0	4.4	100	58.4		
Small Scale Share	15.3	95.0	95.6	-	41.6		
Large Scale Share (Excluding Rice and Grain Milling Subsectors)	95.3						
Small Scale Share (Excluding Rice and Grain Milling Subsectors)	4.7						
Large Scale Share (Excluding Tobacco Subsector)		2.8					
Small Scale Share " " "		97.2					

Source: Study Estimates.

respectively. Shares taken by Large Scale and Small Scale elements of each supply source total are also shown. Table 5 shows the distribution (by major subsector groups, by subsectors within the Large Scale and Small Scale elements, and by supply group) of the total purchased energy. Table 6 shows the estimate (based on judgmental attribution) of the usage of energy for different purposes in the sector, on a proportionate basis. Table 6 is derived from the unconsolidated data shown in the Appendix.

TABLE 5

PURCHASED ENERGY, RURAL SECTOR (INCLUDING FOOD CROP PRODUCTION);
CONSUMPTION DISTRIBUTION BY SUBSECTOR AND BY ENERGY TYPE (BOE BASIS), ESTIMATES, 1978.

	Gasoline (Bensin), A.D.O.(Solar), I.D.O.(Diesel) & Residual Oil	Kerosene	Firewood & Charcoal	Electricity, Natural Gas, Coke & Coal	Group/Subsector Totals
LARGE SCALE + SMALL SCALE	(BOE) %	(BOE) %	(BOE) %	(BOE) %	(BOE) %
AGRICULTURE	11.95	-	-	-	11.95
AGRO-INDUSTRY	26.46	5.16	5.96	0.49	38.06
FORESTRY	19.75	6.02	-	0.02	19.79
EXTRACTIVE INDUSTRY	7.13	0.04	10.23	0.03	17.43
FOOD INDUSTRIES	0.23	3.84	5.43	-	9.51
CRAFT INDUSTRIES	-	0.52	6.65	-	1.17
TEXTILE INDUSTRIES	-	0.22	0.45	-	0.67
OTHER INDUSTRIES	0.33	0.04	0.38	-	0.76
SOCIAL (Water, Amenity Electricity)	0.67	-	-	-	0.67
Energy Source Totals	66.52	9.85	23.10	0.53	100
LARGE SCALE					
Agriculture (Plantations, Estates)	11.21	-	-	-	11.21
Agro-Industry:					
- Sugar and Rubber	16.93	0.14	-	0.44	17.50
- Milling (Rice, Grain, Feed)	0.41	0.01	-	-	0.42
- Veg. Oils (Coconut, Edible)	0.94	0.03	0.12	0.04	1.13
- Crop Frying (Tea, Tobacco, Coffee)	0.21	0.26	0.91	-	1.39
Forestry					
- Extraction	17.30	-	-	0.02	17.30
- Conversion	2.28	0.02	-	0.02	2.32
Extractive Industry:					
- Quarrying and Minerals	1.58	-	-	-	1.58
- Lime & Clay (Bricks, Tiles)	5.45	0.04	-	0.03	5.52
Energy Source Totals	56.32	0.49	1.03	0.53	58.37
SMALL SCALE					
Agriculture (Food Crops)	0.74	-	-	-	0.74
Agro-Industry:					
- Sugar and Rubber	0.17	4.70	4.73	-	9.59
- Milling (Rice, Grain, Feed)	7.45	-	-	-	7.45
- Veg. Oils (Coconut, Edible)	0.23	0.03	-	-	0.27
- Crop Frying (Tea, Tobacco, Coffee)	0.12	-	0.21	-	0.27
Forestry (Conversion)	0.17	-	-	-	0.17
Extractive Industry:					
- Quarrying and Minerals	0.09	-	-	-	0.09
- Lime and Clay (bricks, Tiles)	-	-	10.23	-	10.23
Food Industries	0.23	3.84	5.43	-	9.51
Craft Industries	-	0.52	0.65	-	1.17
Textile Industries	-	0.22	0.45	-	0.67
Other Industries	0.33	0.04	0.38	-	0.76
Social (Water, Amenity Electricity)	0.67	-	-	-	0.67
Energy Source Totals	10.20	9.36	22.08	-	41.63

Source: Study Estimates

TABLE 6

ENERGY INPUTS AND PURCHASED ENERGY, RURAL SECTOR (INCLUDING FOOD CROP PRODUCTION).

USAGE OF ENERGY BY APPLICATIONS AND LARGE SCALE AND SMALL SCALE SECTOR SHARES, (BOE BASIS), ESTIMATES, 1978.

USAGE CATEGORY	TOTAL ENERGY 1/			PURCHASED ENERGY 2/			LARGE SCALE PURCHASED ENERGY	SMALL SCALE	
	Large Scale Share (BOE) %	Small Scale Share (BOE) %	Total (BOE) %	Large Scale Share (BOE) %	Small Scale Share (BOE) %	Total (BOE) %	(BOE) %	TOTAL 1/ (BOE) %	PURCHASED 2/ (BOE) %
Food Crop Cultivations:									
- Hand Tools	-	12.7	12.7	-	-	-	-	24.0	-
- Animal Draft Equipment	-	6.3	6.3	-	-	-	-	12.0	-
(Subtotal)	-	(19.0)	(19.0)	-	-	-	-	(36.0)	-
(Rotating)Shaft Power:									
- Mobile (Vehicles, Tractors, Moveable Plant and Pumps, etc.) 3/	18.9	0.6	19.5	23.3	0.7	24.1	40.0	1.1	1.8
- Static:									
- Milling Equipment (Rice Mills, Grain Mills, Feed Mills.)	0.3	6.0	6.4	0.4	7.4	7.8	0.7	11.4	17.9
- Sawmills (Timber)	1.7	0.1	1.9	2.1	0.2	2.3	3.7	0.3	0.4
- Others (Process Machinery, Electrical Generators Pumps, etc.)	14.2	1.0	15.2	17.5	1.2	18.7	30.1	1.8	2.8
(Subtotal: Static Equipment)	(16.3)	(7.1)	(23.4)	(20.1)	(8.8)	(28.9)	(34.4)	(13.5)	(21.1)
(Subtotal: Mobile & Static Eqpt.)	(35.2)	(7.7)	(42.9)	(43.4)	(9.5)	(53.0)	(74.4)	(14.7)	(22.9)
Process Heat									
- Directly Applied (Bricks, Tiles, Lime, Blacksmithing etc.)	4.0	8.8	12.8	5.0	10.8	15.8	8.5	16.7	26.0
- Indirectly Applied (Steam, Process plant, Drying, Curing, Concentrating, etc.)	16.8	8.0	24.8	9.9	20.7	30.6	17.0	31.9	49.8
(Subtotal: Process Heat)	(12.1)	(25.6)	(37.6)	(14.9)	(31.6)	(46.5)	(25.5)	(48.5)	(75.8)
Lighting, Catering, Misc.	0.1	0.4	0.5	0.1	0.5	0.6	0.1	0.8	1.3
TOTALS	47.3	52.7	100	58.4	41.6	100	100	100	100

1/ Includes Human and Animal Power inputs for Agricultural Cultivations
2/ Excludes " " " " " " " "

3/ In Small Scale Subsector: Tractors and Irrigation Pumps used for Food crop production.

Source : Study Estimates.

V THE ENERGY CONSUMPTION PATTERN

RESERVATIONS

It is axiomatic that estimates of the sort attempted here can reflect reality only to the extent that the underlying data are comprehensive and accurate, and the statistical transformations do not introduce distortions. From what has been stated earlier, it will be clear that no claims can be made that the present estimates are either free of bias or that the degree of disaggregation is adequate. Several sources of possible error can be identified, viz:

i) Use of stale data on activities in the Household, Cottage and Small Scale Subsectors. It is to be expected that there have been structural changes (varying compositional strength) and positive or negative growth in the period between the last relevant census (1974/75) and the estimates base date (1978); except where there is corrobarative evidence (such as that showing recession in the small-scale textile subsector) it has not been possible to make appropriate adjustments for these changes.

ii) The non-representativeness of financial data; this could be so because of misreporting for fiscal reasons, or because reported expenditures do not strictly relate to energy consumptions within a survey time frame. Errors arising from non-contemporanity are likely to be more serious in the case of the larger scale enterprises taking fuel supplies on account. Comparisons of reported expenditures on energy with reported output values afford a means, however, of ensuring that no gross errors are introduced in this way. It is foreseeable that the use of financial surrogates will be unavoidable, for quite some time, in future wide-ranging energy usage assessments.

iii) Double-counting of energy consumptions where the activities of individual enterprises are included in a number of classification subsectors (for each of which the aggregate consumptions may be arrived at by different estimation routes). This is likely to occur where there is a marked degree of vertical integration - as, for example, in the sugar industry - where an enterprise may engage in production, primary and secondary processing, transport etc. In the context of the present study 'transport', per se, has been excluded from consideration in the interests of facilitating the overall project analysis. Undoubtedly, however, there will be an overlap as between the energy consumptions attributable to 'internal' transportation purposes - e.g. own account operation

of cars, tractors and lorries on estates and plantations, forests, quarries etc. - and the fuel consumptions of similar vehicles operating on the ordinary road network. This particular overlap can be allowed for by making appropriate adjustments when estimating the national 'transport' energy consumptions; there has been no basis, though, for estimating the extent of the overlap between, say, the consumptions recorded by Pertamina as being by the large scale agricultural sector and that recorded (or estimated) by the industrial surveys in various agro-industry subsectors.

iv) The non-inclusion of non-commercial fuels (e.g. self-collected firewood and combustible agricultural waste) that may be used to augment purchased fuels. While in some cases it would appear that census enumerators have estimated the value of used inputs in the informal sector, in other cases it is possible that the available data relate only to recollected actual expenditures. At the lower end of the size spectrum of informal sector enterprises there are likely to be errors arising because of failure to distinguish between non-domestic and domestic energy consumptions.

v) Underestimation on account of energy elements of 'closed' systems; self-generated biomass does (or can) contribute importantly to the energy used by agriculture-cum-agro-industry and forestry enterprises but data are not readily available to allow a quantitative assessment to be made of the actual amount of energy obtained in this way.

vi) General lack of precision in the basic census and survey data, and the Pertamina sectoral attributions.

vii) Incorrect assumptions made in the course of the study analysis; in particular these relate to the attribution, to specific fuels, of expenditures (at the Large and Medium enterprise level) entered under 'other fuels'; to the assumed employment and energy-intensity in the Small Scale enterprises; to the proportions of the various subsectors treated as being respectively urban and rural; and the purposes for which purchased fuels are used. In connection with the last point it should be mentioned that there is anecdotal evidence that the relatively low price of automotive diesel fuel (A.D.O. - 'Solar'), and the small price differential between it and other non-gasoline fuels, has encouraged its use simply as a burning oil. (Supply constraints on other fuels have been an additional reason.) Some allowance for this fact has been made in the analysis.

As regards disaggregation, a serious defect of the analysis is the general lack of any identification of the regional variations in the energy consumption pattern, These are known to be considerable, reflecting, as they must, the demographic pattern and the distribution of resources.

The absence of regional differentiation stems mainly from the time constraints imposed on the study, which forced concentration on national aggregates. Data of the quality used in the analysis are available for at least some of the regions and it is to be expected that they would be amenable to an extension of the present analysis. It is perhaps arguable, however, that it would be preferable to improve the quality of the analysis at the national level (by establishing a more factual basis for assumptions and by eliminating other sources of error) before focusing on the regional aspects.

There are thus good reasons why important caveats attach to the findings of this study, and it is opportune to reemphasize here that no particular significance should be read into the use of unrounded figures in the presented tables. What is of significance is the level of confidence with which the figures can be regarded as representing the general magnitude of the variable under consideration. This, in turn, depends on the quality of the data and the extent to which unsubstantiated assumptions have had to be incorporated in the estimation procedure. In the case of tractors used for food crop production the relevant energy consumption estimate is unlikely to be seriously in error because it is derived from a detailed contemporary enumeration; in the case of small scale jaggery production the estimates must be treated as being inherently less reliable simply because some very general assumptions will have had to be made before even arriving at the number of producers, let alone average production parameters. There is thus a lack of uniformity in the results as regards reliability, which in many cases is likely to vitiate any conclusions essentially resting on proportionately small differences between comparable values.

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CONCLUSIONS

Notwithstanding the reservations stated above, it is nevertheless believed that the general picture that emerges from the study provides a fair representation of the energy consumption pattern in the rural sector. Salient features are:

i) The importance of large-scale enterprises as consumers of energy within the sector. These enterprises account for close to 60 percent of the total purchased energy, notwithstanding the fact that, in statistical terms, they provide employment for a relatively small proportion of the total rural workforce.

ii) The concentration, within the Large Scale subsector, of energy consumption in three main areas, viz: (1) plantations and estates, (2) sugar and rubber primary processing and (3) timber extraction. These activities together account for approximately 45 percent of the purchased energy used by the sector.

iii) The concentration, within the Small Scale subsector of purchased energy consumption in the sugar, milling, extractive and food subsectors. These activities account for some 85 percent of the small scale usage of purchased energy.

iv) The very marked differentiation between the Large Scale and Small Scale subsectors in terms of the types of fuels used. The consumption of petroleum fuels, other than kerosene, is largely concentrated in the larger scale enterprises; if the milling subsector is excluded then these enterprises account for some 95 percent of the energy consumed in this form. On the other hand, kerosene consumption is concentrated in the Small Scale subsector. Apart from the unquantified consumptions within 'closed' systems there is virtually no consumption of biomass fuels by the large scale enterprises; the Small Scale subsector, however, derives about half of its purchased energy from such fuels.

v) The relative smallness, in absolute terms, of the energy inputs to food crop agriculture even when human and animal effort are included in the calculation. The requirements of mechanical equipment - tractors and irrigation pumps - associated with food crop production account for less than 1 percent of the energy used in the sector as a whole.

vi) The high proportion of the purchased energy supply - about 75 percent in the Large Scale subsector and about 50 percent overall - that is used to produce rotating shaft power.

As far as is known no comparable studies have been made covering the

entire spectrum of energy inputs to the rural sector, and it is thus not possible to check the validity of the supposed consumption pattern against the results of other work. Some support for the assessment of the biomass consumption is afforded, however, by the compositional detail of Hardjodarsono's aggregate demand estimates. For 1971, his estimate for the consumption of firewood by 'food' and 'non-food' industries on Java was 345,000 tons (556,000 m^3). This estimate was arrived at by applying unit enterprise demand (from a survey that year in E. Java) to the most recent census enumeration of enterprise units. This tonnage converts to 827,000 BOE, using the coefficient employed in the present study[14]. This is somewhat below the present estimate of 1,915,000 BOE (2,517,000 BOE total less the estimated consumptions for the sugar, rubber and tobacco subsectors which are considered separately by Hardjodarsono). It is noted, however, that the numbers of enterprise units used by Hardjodarsono for his calculations are substantially smaller than those recorded in the 1974/75 census. An adjustment of Hardjodarsono's estimate on this account cannot be undertaken because of uncertainties regarding the scale definitions of the two censuses; it nevertheless seems likely that if this could be done it would suffice to align the two estimates. So, although the evidence from this source is tenuous it can at least be said that it is not inconsistent with the present findings.

The present assessment of the total amount of biomass used for fuel industrially in the rural sector is, however, very much at variance with Hardjodarsono's total estimate. This is because there is a very wide divergence of the estimates of the consumptions for the rubber, sugar and tobacco subsectors. The present estimates for these total some 1 million m^3 (shown as 602,000 BOE in the presented tables). At 250 kg/m^3

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this would weigh 250,000 tons. Associated with this is an estimated consumption of some 530,000 BOE of kerosene thought to be used in small-scale jaggery production. If this is, in fact, an incorrect attribution of the reported financial expenditure and it should rightly have been attributed to firewood, then the estimate would need to be raised to some 470,000 tons[15]. Given the general unreliability of the basic data the estimate could perhaps be raised to 750,000 tons; to go beyond that would almost certainly require collateral adjustment of the production estimates. But this is still a long way short of Jardjodarsono's estimate under this heading; this totalled 6.442 million tons on Java and a further 1,000 to 980,000 tons outside Java. The compositional detail of this very substantial increment to the food and non-food industrial estimate is not given; it is stated, however, that for the native (i.e. small scale) tobacco drying and rubber smoking processes the consumptions of firewood per ton of product are 15 m^3 and 2.5 m^3 respectively. These quantities would be very much at variance with observed consumptions elsewhere if Hardjodarsono's density coefficient (620 kg/m^3) is applied. The 1,000 - fold variation as between the 'high' and 'low' estimates for the Outside Java consumption suggest a high degree of uncertainty as to actual production basis for this particular estimate. Taking these two factors together, there would seem to be legitimate grounds for questioning the accuracy of this particular element of Hardjodarsono's estimate. There is, to be sure, a welcome correspondence between the estimates for fish processing; although not included in his aggregates, Hardjodarsono's estimate for the use of firewood for the pemindangan ikan and fish smoking process (93 percent of production on Java) was 26,000 m^3 in 1976. Using his density coefficient this converts to 16,000 tons; this is very close to the present estimate of 15,708 tons (shown as 37,700 BOE).

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This does not suffice to dispel the more general doubts about the correctness of Hardjodarsono's estimates for the industrial use of firewood, placed at about 7.5 million to 8.5 million tons in 1976. Other authors have undoubtedly been influenced by these assessments; Soemarwoto (1979), for example, when discussing the general biomass balance, cites Hadi et al.'s data suggesting that fuelwood and wastes consumption in industries increased from about 10 million m^3 to about 12 million m^3 between 1969 and 1978. This corresponds roughly with the starting level and trend estimated by Hardjodarsono[16]. No further empirical evidence appears to have been offered to support estimates of industrial consumption of biomass at these levels The present study has tended to show that there are inherent risks of substantial error if too much reliance is placed on reported or calculated output as the basis for the calculation of inputs. As Hardjodarsono's estimates rely heavily on such methodology there does not appear to be a strong argument for adjusting the present findings in the light of the earlier global estimates for industrial biomass usage.

The present estimates are not, of course, immune to epistemic questioning, and further research could well show that the total arrived at for the non-domestic biomass consumption errs on the low side by perhaps as much as the earlier estimates appear (in the light of the current findings) to have erred on the high side. This notwithstanding, the contrast between the estimates is striking: about 4 million m^3 (shown as 2,517,000 BOE) from the present study as against about 10 million m^3 or more of alternative estimates. A part of the difference may be explicable in terms of the inclusion or exclusion of 'closed system' biomass[17]; it seems likely, nevertheless, that even when this is taken into account the remaining difference will still be large.

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In terms of the overall national production of wood that can be used for fuel, and also in terms of the amount of fuelwood used domestically, the unaccounted-for difference between the estimates is not so large. Translated, however, into a conceptual increment to the distributed pressure of industrial demand on supply it could profoundly affect the outcome of calculations of the adequacy of resources within specific areas. In the realm of policy, the choice of intervention instruments and modalities will most normally be determined by conditions at the margin; if in default of better information these are assessed on the basis of aggregates then it must be advantageous to have accurate aggregates available. The attention now focussed on the role of biomass as an energy source serves to underline this need; the discrepancy as between the estimates tends to suggest that it is not at present being met and that further efforts to obtain up-to-date and reliable data could be readily justified.

To return to a more general consideration of the pattern of rural energy usage that emerges from the study, it can be observed that it conforms closely to what could be expected, bearing in mind the distribution of resources and the developmental path that has been followed by Indonesia. The underlying pattern is that typified by energy use in the traditional forms of small-scale agriculture and village level industry; this reflects an historical adaptation to the access only to biomass fuels which, in the context of the investment affordable, have had utility only as sources of heat. The only power available has been that provided by human and animal muscles; this, too, derives from the biomass. Limitations on what can be usefully done with heat obtainable from the direct combustion of biomass, and constraints on the outputs of man and beast, have combined to create a typical 'low energy' system that embodies few practices or technologies

that require large energy inputs; where it does so require then there will often be some degree of location-specificity dictated by resource availability (which in turn may depend upon the extent to which there are competing claims from different types of economic activity).

Superimposed on this basic, essentially autarkic, pattern is the energy usage of the modern and modernizing subsectors of the rural economy. Although in an earlier phase the introduction of large-scale agricultural and plantation units was accompanied by investment in equipment capable of converting biomass to power and process heat, the present preference is almost universally for oil-derived energy except where there are biomass-utilizing 'closed' systems. Two factors can be seen as determining this preference. On the one hand, the oil-derived fuels have opened up technical and commercial opportunities that did not exist when there was necessarily dependence on biomass for energy. These stem from the easy transportation of liquid fuels (which in turn has been facilitated by developments in the communications infrastructure) and from the fact that distillate-powered internal combustion engines provide compact and relatively cheap sources of rotating shaft power that can be used in both static and mobile modes. On the other hand, at the micro level the price to the consumer of oil-derived energy has been highly competitive with those ruling for the more traditional forms. Thus, where other conditions have been favorable the adoption of oil-derived fuels as an energy source has not only reflected perceptions of opportunities for development in an absolute sense, it has also often reflected an optimal factor choice in the micro-economic sense.

The salients of modernity that have developed in the rural economy have, to a very large extent, come about because of the availability of newer forms of energy. In more recent years the consumer prices for

oil-derived fuels have rarely reflected the full opportunity costs. The advantage that this has afforded to subsectors technically capable of exploiting oil-derived fuels shows up in the changes that have taken place in the general structure and spatial distribution of rural industry. Many activities that were once widely distributed have tended to become more concentrated and to be operated on a larger scale. Craft industries have tended to diminish. To be sure, improved infrastructure has played a part in this process, and has served in some respects to neutralize the effects of the change it has wrought, inasmuch that for the rural consumer the loss of some local sources of supply has been balanced by easier access to supplies from elsewhere. But change has not been without social cost; the widespread introduction of small rice and grain mills (that have here been estimated to account for some 75 percent of the diesel fuel used by the small-scale enterprises in the rural areas) has in many cases resulted in the loss of employment for women who formerly performed the same work by hand. (The wider implications of such developments cannot be explored here; it seems likely, however, that this is probably a typical instance of where diesel power has proved cheaper than human power. It serves to illustrate the truism that the technological choice that best satisfies commercial criteria may not be the one that would be indicated if employment creation were the main objective.)

The general effect of the availability of cheap, and indeed subsidized, oil-derived fuels has been to reinforce the development of a bimodal rural economy and a corresponding bimodal energy consumption pattern. The 'low energy' pattern persists where for reasons of scale, the technical characteristics of the product, the demands of the market, or the relative costs of the different types of energy dictate continued reliance on biomass in one way or another. Less proximate reasons may be the general level of

development, the economic status of the people, the geographical location, the standard of infrastructure provision, and even cultural attitudes. Specific examples of where the oil-derived fuels find little application are: small-scale agriculture (except where there are opportunities for technical irrigation and/or micro-mechanization), small-scale manufacture of bricks and tiles, small-scale limeburning, fire-cured tobacco, small-scale rubber smoking and certain fish preservation processes. In an economic sense these are activities that are not scale-neutral to the application of oil-derived fuels; unless a certain level of output per enterprise is reached it will simply not be economic to invest in the equipment needed to utilize the non-biomass fuels. (It is, of course, true that for some processes, e.g. fish smoking, biomass is a necessary input. More usually, however, it is technically possible to produce a substitutable product without the use of biomass.) The economic viability of many of these small biomass-utilizing activities is often sensitive to local demand. It has, for example, long been the practice in the rural areas to fire bricks using rice husks for fuel. The product has little structural strength, but has been found useful for non-load-bearing applications. Because it is a low value product, heavy and susceptible to damage, it will normally only find a market close to the site of production. This may hold up only for as long as competitive substitutes, e.g. trass blocks, are not available.

The complementary mode is the modern subsector, with a relatively 'high energy' pattern. This description is warranted not only because in absolute terms the modern sector takes the larger share of the total of purchased energy, but also because the activities and processes involved are generally more energy-intensive as measured by both the labor inputs and the product outputs. It is difficult to adduce meaningful indices to illustrate this as the modern sector is not scale-

specific. The generalization is, however, well-supported by the data. To take the instance of the agro-industry subsector, the large-scale enterprises as a group and the small-scale milling enterprises can be regarded as representing the modern sector. Together they account for around 70 percent of the total energy used by the subsector, but they only account for about 30 percent of the employment. For the remaining small-scale enterprises, which represent the traditional sector, the proportions are reversed. On these aggregates it can be said that employment is over five times more energy-intensive in the modern sector than it is in the traditional sector.

Although in general terms this bimodal pattern can be discerned, the distinction is not clearcut. Use of kerosene has spread throughout the sector, for industrial as well as domestic purposes. This development, which has accelerated in recent years, has undoubtedly been assisted by pricing policies which have (at ever-increasing subsidy cost) effectively maintained a rough parity(in terms of cost per unit of heat producible) between kerosene and much of the commercially traded firewood. The investment needed to utilize kerosene either domestically or for small-scale industrial processes is relatively small[18] and it is not, therefore, surprising that it has become the main complement or substitute for firewood. It is, of course, widely used for lighting, and it is possible that in the present analysis there has been significant error in apportioning the small-scale consumption as between heating and lighting usage.

It seems likely that the price structure adopted for all oil-derived fuels - involving, in recent years, an element of subsidy throughout the range - has led to some usage practices that would not have occurred had true cost prices obtained. The use of kerosene for the drying of tobacco in larger-scale enterprises is probably an example. So, too, is the use of

A.D.O. (solar) for the firing of bricks, again in larger-scale enterprises. Reportedly, in the latter instance, the additional cost of A.D.O as compared with Residual Oil, is economically bearable[19]. Supportive evidence that an artificial price structure can induce an anomalous usage pattern comes from outside the sector - in 1976 and 1977 the cement industry accounted for 66 percent and 76 percent of the reported total industrial usage of kerosene[20]. In 1979, the same industry's consumption of A.D.O. and I.D.O. amounted to 82 percent of its consumption of Residual Oil[21]. Without further investigation it is not possible to make firm conclusions on this evidence; it does tend to suggest, however, that for efficiency enterprises (or those with some special advantage) the general level of prices that have obtained for oil-derived fuels have allowed trading margins that have been large in relation to the price differentials between fuel types. This raises the possibility (for which there is much general supportive evidence) that much of the oil-related structural change in the rural economy owes as much to the actual cheapness of the energy provided by oil-derived fuels as it does to their capacity to promote innovation.

This, of course, conforms to the observation made earlier that the choice of energy systems, and the technologies that go with them, is as much a matter of micro-economics as it is a matter of technical or social appropriateness. It is clear that the wider availability of oil-derived energy has been a potent agent for change and development in the rural areas. It is also clear that the incidence of change has been skewed towards the subsectors where there have been predisposing factors - of which enhanced comparative advantage afforded by low fuel prices will be one - that have favored the adoption of the associated technology. What is less clear

is whether this characteristic imprint of the newer, oil-based, economy accords with the perceived overall economic and social goals. Arguably it does not, if only on the grounds that good crop agriculture's gain, at least in a direct sense, from the 'energy revolution' has been minimal. Many rural industries may have been casualties rather than beneficiaries. These and other cognate issues cannot be pursued fully in this report; that they can be identified as issues serves to stress, however, the importance of all efforts to obtain a clearer understanding of the energy usage pattern and the reasons for its characteristics.

VI DEVELOPMENTAL OPPORTUNITIES

With an increasing population, finite reserves of fossil fuels and an economy that is becoming progressively more energy-intensive, Indonesia has good reasons to share the world-wide interest in finding new ways to conserve energy and to use it more efficiently, and in the exploitation of hitherto untapped resources, particularly the renewable ones. Considerable manpower and research resources are being devoted to exploring the potentials in these areas. But if the potentials uncovered are to be meaningful in developmental terms they need to be realized in the working of the economy and in the lives of the people. An integral and necessary part of the more general effort must therefore be an examination of where and how newer forms of energy, or new utilizing devices, can be usefully introduced, and of the constraints that will tend to determine the pace and scale of introduction. In a wider perspective, whether or not some innovation can rightly be termed 'useful' will be determined by the net improvement effected on the entire socio-economic fabric. The assessment of the value of specific technical proposals cannot, therefore, proceed without reference to the more general economic and social contexts.

From the purely technical point of view, the opportunities to change the pattern of energy usage in Indonesia's rural economy are legion, even if there is access only to the world's shelf of tried and proven technologies. Whether it is a question of using novel fuels, such as coal or peat or converted biomass, or of capturing locally the energy content of sunshine or wind, or of employing energy-efficient equipment and methods, there will be few cases where there are no precedents showing how this can be done. On-going adaptive and applied research and development efforts

are continually discovering new variations of these techniques and widening the range of technically feasible options.

But in the world of economic reality the choice of what can actually be used will be within the subset that is covered by what can be afforded, by what gives an acceptable return to the investment involved, by what is available through the supply mechanisms and by what is perceived as meeting felt needs. The subset may be further reduced if it must also be covered by what is socially acceptable or desirable, by what conforms with political and developmental aims, and by what is culturally acceptable.

In many ways Government may be in a position to influence the size of the usable subset of technologies. It can support purposive research that seeks to extend the area of technical choice. With appropriate instruments it can regulate the economic constraints. Legislatively it can control or inhibit trends adjudged to be contrary to social or developmental policy. And in the formulation of its policies and in the design of its programs and projects it can take cognizance of the energy implications and, if need be, make adjustments in the interests of securing overall improvement in the supply and use of energy. On the supply side it lies within the power of Government to channel investment resources appropriately. The domain of energy planning, even in relation to the rural sector, is thus large and, because it needs to know the returns it may expect from its interventions, Government has a vital interest in the developmental opportunities, in the energy sense, in the various rural subsectors. Some of these are discussed below to the extent that they have been elucidated by the present study. It must be emphasized, however, that the conclusions are based on exiguous data, and that confirmatory evidence should be sought before they are used to support any policy decisions.

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Agriculture

If the share of the total energy applied were a measure of relative importance, then food crop agriculture would probably appear at the bottom of any table ranking the major groups of economic activity. This is so despite the fact that this is the activity that provides the livelihood of the majority of the population and to which most of the developed land resources - the product of piecemeal investment over centuries - is devoted. By some standards this must be judged an anomalous situation, considering the present and future importance of food crop production in the life of the nation, and the pressing need to raise rural living standards. It may seem even more anomalous when it is remembered that in recent years Indonesia has been a major importer of rice.

The low energy inputs to food crop agriculture - contributed for the most part by human and animal labor - reflect the systems that have evolved in a situation where neither the energy resources nor the technology were available for them to be otherwise Increasing population pressure on the limited land resources has caused these systems - at least on the more densely-peopled islands - to become fixed features of the rural economy. There is ample evidence that increased energy inputs to agriculture - allowing faster, more timely and, in some cases, more extensive or more frequent cultivation - would increase land productivity through increased yields and higher cropping intensity; it is also evident that for this to happen many of the traditional systems would need to be supplanted by newer systems that would require, inter alia, adjustment of usufructory and tenurial arrangements. Discussion of the conditions for such change is beyond the scope of this paper; it must suffice to say that in the short to medium term there is little prospect that it will happen. The

negligible impact of the attempts to introduce farm mechanization in Java bears eloquent witness of this. So, although the technical means are at hand for increasing agricultural output through the injection of more energy, non-technical constraints largely bar their application.

But arguably this is not universally true. Currently the land allocation in the transmigration areas is two hectares per settler family. Reportedly the average area that settler families are able to cultivate and raise food crops on is only 0.7 hectare[22]. The reason given for this is that to do more is beyond the capability of the average family when they only have the traditional means of cultivation - muscle power - available. Evidence from many other sources lends credence to this explanation. This would seem to provide a good example of where the absence of a means to apply energy is actively constraining production. In contradistinction to many of the more populous localities, the transmigration areas offer many more opportunities to introduce new farming systems. So far, however, institutional support for any form of food crop mechanization has been lacking from the transmigration programs. Consequently there is, by and large, adherence to the traditional systems. In the wider context, it would seem difficult to justify this attitude, although it is easy to see that with competing claims on available investment and development resources the funding of these programs will often have been insufficient to allow full rein to expansionist and innovative ideas. For, to be sure, if mechanization were to be an integral part of resettlement programs the totality of investment needed - in both machines and in initial land preparation (and, in many cases, irrigation, drainage and protection works) - would be considerably greater than is now the case.

The justifications for such higher levels of investment - which could

well include the inducing of a greater flow of transmigrants than now obtains[23] - is not the purpose of this paper; meriting discussion, however, are two of the arguments that have and are being advanced in some quarters against farm mechanization per se. On the one hand it is claimed that mechanization displaces labor and that this exacerbates the social problems of unemployment: on the other hand it is said that mechanization is oil-dependent, consumes energy and generally places food supply in thrall to a continuing oil supply.

In relation to the transmigration areas it is difficult to see why the first argument should carry any weight at all. As regards the second argument, the findings of this study, together with those of the collateral studies under the project, suggest that the fears expressed with regard to oil-dependency etc. are misplaced, simply because the quantities of oil-derived fuels that would be demanded by even a fully mechanized agriculture would be so small in relation to the current total consumption that it is difficult to envisage the circumstances where they could not be afforded however stringent supplies may become. It is obvious that there are many areas of consumption, of far lower priority in social terms than food production, where economies could and would be made first. It shoud be mentioned here that some of the fuel consumption estimates for mechanization that have been quoted in relevant literature are grossly misleading - they can only relate to very different circumstances (if, that is, they relate to anything). In Indonesian conditions 20-40 liters of diesel fuel per hectare per year will substitute for the inputs for cultivation now almost universally provided by man and beast; this is a modest investment in relation to the returns expectable.

The purpose of this particular discussion is to dispose of argument

that mechanization should be discounted simply because it is costly in energy terms. Manifestly it is not, either in absolute or relative senses. It is indeed arguable that nationally the diversion of a part of the present energy consumption into agriculture in this way would substantially raise the gross returns, in welfare terms, from energy expenditure. This said, it has to be emphasized that the energy cost is only one aspect of mechanization: many other factors are relevant. They relate to an array of agronomic, edaphic, environmental, econonic and commercial issues that cannot be addressed here. But to conclude this section the suggestion can perhaps be allowed that at the policy-making level the conventional wisdom' on mechanization (at least in the transmigration areas) should be reappraised.

Agro-Industry

Although the agro-industry subsector covers a wide spectrum of activities a near common feature of most enterprises is an easy access to combustible agricultural waste material. This will normally be available either as discarded material that can be purchased or simply taken away from the agricultural production site - the 'farm gate' - or as a by-product of an agro-industry's own process.

The energy requirements of most agro-industries relate to the provision of shaft power, or relatively large amounts of process heat. The identification of where there may be opportunities to change the pattern of energy consumption in a beneficial way essentially turns on an examination of the ways in which this biomass is or can be applied to meet these requirements.

Increasing the industrial usage of agricultural wastes is likely to result in some net reduction of the demand for oil-derived fuels, of which

there is at present a large consumption in the agro-industry subsector. This gain is not likely to be made at the expense of other consumers since, by and large, agricultural wastes are not an important source of energy (discounting grubbed tree crops, etc.). Intensive use of this material tends to be restricted to the areas with the most severe fuel deficits. The reason for the more general neglect is that many crop residues are inconvenient to use because of bulkiness, high water retentivity and smokiness when burnt, and because much more attention to the fire is often needed.

Where the demand is for heat then the direct combustion of the wastes will in most cases be the most efficient way of capturing and utilizing the energy they contain; routes involving fermentation, gasification, carbonization, etc., cannot offer any increase in the absolute yield of heat. Efficient direct burning may require special types of appliances, such as the IRRI-type husk burner[24] and Petersen-type boilers; designs are available for these. Where the demand is for shaft power, then the utilization of biomass inevitably requires most complicated and most costly plant. Processes will normally involve either steam-raising with associated piston or turbine engines[25], or gasification with associated I.C. engines. Again, basic designs are available though some adaptive development may be necessary to match the characteristics of the local wastes.

Determining whether there are opportunities to usefully introduce and promote this sort of technology and hardward cannot be undertaken in the abstract, since essential elements in necessary economic appraisal will include, inter alia, the operating margins, the availability and opportunity cost of capital, the costs of alternative equipments, the oil-derived fuels, the (in-plant) cost of available biomass. Also to be taken

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into account will be the question of the seasonality of the biomass supply; this may or may not coincide with the plant's cycle of operations. With this number of variables it is clearly infeasible to try to identify here very specific examples of possible applications of these technologies.

There is a substantial body of opinion that holds, however, that unless and until there is a substantial reduction of the gap between the realized price for oil-derived fuels in the domestic market, and the relevant shadow prices, then in the absence of actual physical shortages there will be little incentive for energy users who have already adopted the oil-based technology to swing back to biomass. If this is true, and in the hypothetical situation where the gap between the two price levels is not changed, then it could be that the main energy savings could come from industries that already use biomass, such as bagasse, and are willing to invest simply to improve usage efficiency.

Certainly it is difficult to see the smaller agro-industry units, such as the small rice mills, being weaned away from diesel power while fuel prices remain low, unless there are some very special incentives, such as concessionary credit terms. Possibly these could relate to additional equipment such as pyrolysis plants, currently the focus of empirical work at Bandung. This process differs somewhat from those considered above in that it ranks as an energy-producer not an energy-consumer, hence its treatment separately. The future for this process in Indonesia will be determined by relative prices: if the prices of petroleum-derived fuels and wood charcoal stand above the break-even prices for pyrolysis oil and char, then there is a change that it may become popular. If they stand below then it is unlikely.

Given the present state-of-the-art, it seems unlikely that in the

agro-industry subsector there is very much scope at present for the application of solar power, windpower or methane. If the coal resources were to be more intensively developed then, provided the price relativities allow, coal could replace some oil-derived fuels, and, indeed, possibly some of the currently used wood fuels. Given the prevailing prices for electrical energy as supplied by PLN it seems unlikely that there will be much development of the use of energy from this source. Larger plants will continue auto-generation, mostly diesel-powered.

Forestry and Timber Subsectors

Forestry and timber extraction offer few opportunities to vary the rural sector energy consumption pattern, other than through the household consumption of by products. For the internal operations they are heavily dependent on diesel-driven mobile equipment; there are no substitues, at present, for these. Major conversion plants, on the other hand, can use wood waste for the development of shaft power for static equipment. Many older plants were equipped to do this through the steam route; some more modern plants have utilized gasifier plants. It seems likely that the use of such plants could be extended. As in the case of agro-industries, a precondition for this to happen could be rise in the price of oil-derived fuels.

There are undoubtedly many opportunities to increase the useful yield of the forest resources by utilizing biomass that now goes to waste for the purpose of making charcoal in either static or mobile plants. This fuel has never gained the popularity in Indonesia that it has in some other countries - fortunately, some may be disposed to argue - and the concomitant of any significant development of this resource is a change in the domestic energy consumption pattern

so as to favor this fuel. It is by no means certain that this would happen spontaneously on a significant scale in the absence of a substantial rise in the kerosene price. Some advocates of charcoal have accordingly suggested institutional effort to promote the distribution and use of charcoal. If this should be necessary it may be a legitimate question to ask if timber concessionaires will consider the prospects of the market sufficiently good to invest in the manufacturing operation. Possibly institutional support may be needed in this area, too. To some observers the case for attempting to develop a much larger charcoal industry is far from self-evident, and it is clear that there should be careful appraisal of all the ramifications of any proposed charcoal project.

It has been estimated that some 4 million m^3 of timber are still pit-sawn into planks annually in Indonesia[26]. In energy terms this is perhaps not very important; it does nevertheless provide an example of the difficulties attaching to developmental planning in Indonesia. Technically the equipment is obsolete; economically the productivity may be low, and socially the reqards may be inadequate. Substitute mechanical saws and the productivity will certainly increase (and the energy consumption will increase), but unless the market expands some sawyers will now get no rewards at all. Almost invariably there is a social cost of this sort somewhere as a concomitant of a technical change.

Extractive Industries

The usage of energy in the extractive industries is predominantly for providing the process heat used for calcining limestone or for firing clay. As with the cement industry (also extractive but

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regarded here as part of the industrial rather than the rural sector) neither process is fuel specific. With appropriate methods the common calcareous raw materials can be calcified using wood or coal or oil. For clay products the range is even wider, reflecting the product diversification. In addition to the fossil fuels the biomass materials that may be burnt include rice husks and straw. Both processes antedate the oil era, and neither necessarily demands sophisticated or costly plants.

With the availability of cheap oil-derived fuels there has been a marked switch to this mode, showing a standard micro-economic response. It would also seem that this has been accompanied by some degree of structural change in these subsectors, with more of the activity in the hands of larger enterprises, and also some degree of spatial shift, with the loci of industry moving away from the biomass sources and nearer to the best input material sources and oil sources. Although of varying quality, calcareous material and clays suitable for brickmaking etc. are well distributed in Indonesia. There have been social benefits and disbenefits attaching to these moves; environmentally there has been some relief for overpressed firewood resources, but at the same time a source of income has been lost to many who have no other activity in which to engage.

At the risk of some over-simplification - production is geographically well distributed so generalizations tend to be difficult - the prospects for change that appear most attractive relate to the possible use of coal on a much wider scale. Technically this would pose few problems at the consumption end, except perhaps in relation to the high water content of most Sumatra coal. Assuming supplies were to be more readily available, the subsector could be

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expected to switch to coal if the price relativites so favor; notwithstanding the evidence in relation to the use of A.D.O. as a substitute for residual oil, micro-economic appreciations can be keen, as the use of used automobile sump oil as a supplement to R.O. for limeburning testifies.

As has been mentioned earlier there is some use of rice husks to produce low quality bricks. Research has shown that the product can be improved by perforating. Under the Ministry of Industry's BIPIK Project for assisting small-scale industries there are arrangements for the provision of suitable extruders to small brickyards adopting this practice. Other relevant energy-related research efforts are those being carried out by LIPI/LFN[27] and the Cermanics Research Institute (Bandung) on improved kilns for wood-fired limeburning. These hold promise of reducing the amounts of wood fuel needed, where this method is feasible and acceptable. Consumers have shown a preference for wood-burnt lime because, generally, it is of higher quality than oil-burnt lime.

It is impossible to predict the effect, on the overall energy demand of the extractive subsector, of contemporary developments of cement manufacturing capacity. In the form of cement renderings, concrete blocks and cement/trass blocks cement competes with many other extractive industry products, and it would seem likely that as cement capacity grows it will make inroads into the markets now held by the more traditional products. Some indications on this would be desirable before contemplating specific interventions to, say, promote the use of coal. In energy planning terms there would be little point in seeking to minimize oil consumption in the brick

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subsector, for example, if marginally higher costs are likely to simply divert demand to a cement subsector continuing to use oil.

Small-scale Manufacturing Industry, Food Industries etc.

Very limited generalizations are possible when the lower end of the industry scale is under consideration. Partly this is because it is the area where least reliance can be placed on the available data; it is also most diverse in terms of the activities undertaken. Economic behavior is less predictable; by all other standards the returns may sometimes be vanishingly small when other opportunities for enterprise or employment are scant.

Kerosene and firewood figure strongly in the energy budgets of many small enterprises, and it would seem reasonable to suppose that for heating purposes the choice is often simply determined by relative costs. It can be surmised that in thermal terms many of the utilizing devices for firwood are of low efficiency and it could be expected that as and when there is the adoption of more optimal designs at the household level then there will be some spin-off to the informal productive sector. Depending on their field staff strengths some of the concerned agencies may be able to exert a direct influence on small scale users of firewood, and persuade them to upgrade their appliances.

Charcoal is the usual fuel of Indonesian blacksmiths, and there is an observed preference for teak charcoal. If good quality coke can be obtained, then this can satisfactorily substitute for charcoal.

Considerable weight has been placed in some quarters on the potential of rural electrification schemes to promote small-scale rural industries. It is certainly true if the machines and processes

of typical small-scale rural industries are listed then a large proportion of them can, indeed, be powered by electricity. But at the same time it will also be found that a very high proportion of these functions can also be powered in alternative ways, which in practice will prove cheaper. The number of processes for which electricity is a necessary adjunct are, in fact, small. In many ways the situation with rural industry is analagous to that in agriculture: historically the systems that have evolved and developed linkages with supplies, markets and skills have been the ones requiring low energy inputs. It will take a lot more than the simple supply of a new source of energy to bring about any major transformation in this area. (It is worth observing that the relevant comparable experiences elsewhere are the contemporary ones, not even those of ten or fifteen years ago. The tremendous growth in motorized transport in the rural areas in the intervening period has had significant effect on the lives and spending propensities of rural people; the prospects for rural industry have to be viewed in today's conditions.) Those in charge of the BIPIK Project do not express any confidence that electric power will be a potent force for change; where they give support for the installation of powered equipment they favor engine-driven layshafts etc. rather than electric motor drives. At present price levels the cost of on-site diesel power is probably less than half the cost of delivered electric power. With Yanmar-type engines currently costing (bare shaft basis) around Rp 50,000 per hp, the capital cost of diesel and electric installations will be around the same level.

Small Water and Electricity Supply Schemes

It is to be expected that the number of such schemes will continue to grow. Spontaneous development is likely to center on diesel powered

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units; institutional support will certainly be needed if there is to be any significant exploitation of renewable energy sources- micro-hydro, wind-power, solar power, etc. Blanket assessment of the inherent feasibility of the latter is not possible; not only are conditions in potential sites variable, but the yardsticks for comparison- diesel installation cost and diesel running costs per Kw and Kwh, or m^3/hr and m^3 - may well change if fuel prices are adjusted. An increasing output from the Indo-Diesel plant in Surabaya could be an influencing factor.

VII POLICY OPTIONS

Government has a wide area of choice as regards policy options that can be used to modify directly or indirectly the pattern of energy usage in the rural sector. On the supply side it can, for instance:

i) Encourage, through its rural development programs and projects, increased production of fuelwood from homegardens, division strips and banks, woodlots, etc.

ii) Increase the supply of firewood, and charcoal, from the forest reserves.

iii) Increase the output and improve the distribution systems for coal.

iv) Regulate the amount and mix of oil-derived fuels released on the market.

v) Increase centralized and decentralized electricity generating capacity and extend the distribution networks.

vi) Promote research and development of alternative energy sources, such as solar energy and wind energy, and biomass conversion.

vii) Exercise control over the pricing structure for fuels and power supply.

The policy instruments at hand to exercise these options include the funding of central or local government projects, investment in parastatal operations, research grants, management of refinery capacity[28] and tariff regulation.

On the demand side Government can, again through development programs, influence usage. Through its attitudes towards, and support for, farm mechanization proposals it can profoundly affect the input of energy to agriculture, and in so doing contribute to raising agricultural productivity. It can develop the linkages in the distribution chain that will be needed if there is to be a higher level of coal consumption for purposes that currently consume oil-derived fuels.

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Support for research and development work can help the evolution of appropriate energy using devices, such as steam prime movers[29] biomass fireboxes, solar driers, etc. Assistance can also be given to raise the indigenous output of diesel engines suitable for rural area use[30]. Appropriate programs can endeavor to raise the efficiency of biomass consumption in the informal enterprises subsector.

Forecasting the effectiveness and areas of impact of the policy instruments, and thus evaluating the policy options, will call for keen economic judgment. It would seem to be a reasonable proposition that the corollary of a large gap between the shadow and realized prices for fuel inputs to local industry may be a similar gap as between the realized and shadow prices for the products, assuming not too imperfect markets. This could be expected to make for low demand/price elasticities. (The evidence from the brick industry is consistent with this). It is possible to see that in such a situation the inclination to switch fuels, inresponse to price escalation relating to one type, may well be sensitive to the steepness of the escalation over time (and the degree of inter-enterprise competition).

Impacts must be judged, however, by more than economic criteria. A whole array of social and environmental side-effects need to be taken into account. This will be particularly true in relation to biomass exploitation, where there are risks of insidious soil depletion and degradation that may only become apparent after some years use of some practices.

It is manifest that much more needs to be known about the entire pattern of energy use in the rural areas, the more especially on the biomass supply side. If there is to be a pinpointing of where

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pressure on biomass resources needs to be relieved by some sort of remedial action (either on the demand or on the supply side) then it follows that disaggregated data for biomass production will be needed. Given that resources may be scarce then identification of critical areas is a sine qua non for establishing intervention priorities.

The discussion above has centered on what may be the energy-purposive elements of policy. But equally important are the energy implications of the more general alternative developmental strategies, insofar that they are relevant to and affect the rural areas. Three cases can be considered here, viz:

i) Agriculture is treated as a dependent variable, and the prices of oil-derived fuels raised towards the shadow level.

ii) Agriculture is treated as an independent variable, stimulated with mechanization in the transmigration areas; no adjustment of shadow/realized price relativities.

iii) Agriculture as in case (ii); fuel prices as in case (i).

In case (i) it is to be expected that there would be a net drop in the sector's oil demand; increased biomass demand; some sharp local biomass price increases; (level agricultural output, level agro-industry, reduced small-scale manufacture and worsened income distribution). In case (ii) the expectation is that there would be a rise in the sector's oil demand; more or less level biomass demand and prices; (increased agricultural production; some growth of rural industry able to benefit, locally, from increased agricultural incomes). In case (iii) total oil demand would remain level or drop slightly; pressure on biomass increased severely in some areas; (increased agricultural production, structural and spatial adjustment of non-farm economic activity, locally worsening income distributions). Case (ii) favors the sector, but at the cost of fuel subsidies; the return on the modest increase in oil consumption is

likely to be good. Case (iii) probably provides the conditions for the best returns on the development of alternative energy sources, but not without social costs in the system. These are at best only indicative conclusions and it should be obvious that to be of planning value more elaborate and refined models are required and the scenarios to which they apply need to be regionally referenced in real terms. It is towards the meaningful execution of such exercises that the present project is intended to move.

VIII DEMAND PROJECTIONS

The same qualifications apply to the projections of demand for purchased fuel for the years 1990 and 2000 that are presented in Table 7. The rationale for the growth rates applied to the 1978 base figure is as follows:

- Food Crop Agriculture - 10 percent
  Assumes steady mechanization from a very small base.

- Plantations and Estates - 3 percent
  Discounted from Repelita III target for Agriculture (3.5%) and realized Agricultural Growth 1973-78 (3.4%) to cover diminishing returns to inputs and limits to spatial expansion.

- Agro-Industry - 3 percent
  Assumed to grow pari passu with Agriculture.

- Forestry - 2 percent
  Reflects medium-term diminution of forest reserves.

- Extractive Industry - 5 percent
  Shares Construction growth (Repelita III target - 9.0%) but discounted below GDP growth to cover urban skew and substitutes.

- Food Industries - 4 percent
  Assumed slightly above Agriculture.

- Small-scale Industries N.E.S. - 3 percent
  Assumed to grow pari passu with Agriculture.

- Social (Water and Electricity) - 10 percent
  Assumes steady growth from a very small base.

When these growth rates are applied to the 1978 estimates the overall growth rate of purchased energy approximates 3.5 percent; the rate for the biomass element is 4.2 percent and the rate for the non-biomass is 3.3 percent.

TABLE 7

PURCHASED ENERGY, RURAL SECTOR: PROJECTIONS - 1990, 2000; BOE x 10^6 (MBOE)

	Assumed Growth Rate 1/	1978			1990			2000		
	%	Non- Biomass MBOE	Biomass MBOE	Totals MBOE	Non-Biomass MBOE	Biomass MBOE	Totals MBOE	Non-Biomass MBOE	Biomass MBOE	Totals MBOE
Agriculture:										
- Food Crops	10%	0.08	-	0.08	0.25	-	0.25	0.65	-	0.65
- Plantations and Estates	3%	1.27	-	1.27	1.81	-	1.81	2.43	-	2.43
Agro-Industry 2/	3%	3.63	0.72	4.35	5.18	1.03	6.21	6.95	1.38	8.33
Forestryand Sawmills	2%	2.24	-	2.24	2.84	-	2.84	3.46	-	3.46
Extractive Industry	5%	0.81	1.16	1.97	1.45	2.08	3.53	2.37	3.39	5.76
Food Industries	4%	0.46	0.58	1.04	0.74	0.93	1.67	1.09	1.37	2.46
Small-Scale Industries N.E.C. 3/	3%	0.13	0.16	0.29	0.18	0.23	0.41	0.25	0.30	0.55
Social (Water, Electricity)	10%	0.08	-	0.08	0.25	-	0.25	0.65	-	0.65
TOTALS (Non-Biomass)	(3.3%)									
TOTALS (Biomass)	(4.2%)	8.70	2.62	11.32	12.70	4.27	16.97	17.85	6.44	24.29
TOTALS (Total)	(3.5%)									

1/ 1978-2000, Compound.

2/ Includes Fish Processing and Tanneries.

3/ Includes Craft and Textiles Industries.

Source: Study Estimates.

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NOTES AND REFERENCES

1. The 'Reference Energy System' (RES) approach was developed at Brookhaven National Laboratory, USA, as a standardized vectorial analysis of energy flows from sources, through conversion and transfer subsystems, to utilizing devices and end uses. Its use is described in a comparison report on "Energy Demand in Indonesia" by A. Doernburg.

2. The definitions of what constitute 'Large' and 'Medium' scale enterprises have been subject to period adjustment, more particularly with respect the fixed and working capital employed. For most purposes, however, the employment of upwards of 100 persons places an enterprise in the 'large' category, and the employment of between 20 and 100 persons places it in the 'medium' bracket.

3. ISIC: International Standard Industrial Classification. (UN. 1968)

4. 'Small-scale' industrial enterprises are those employing between 5 and 20 people. 'Household' or 'Cottage' enterprises are those employing fewer than 5 people. It should be noted that the term ' industry' is commonly used to denote any manufacturing enterprise.

5. This conclusion is reached notwithstanding the validity of the data generated by various valuable studies on the reliance on biomass fuels, and the adequacy of supply, in a number of specific areas. The coverage of such studies needs to be much wider, however, before a synthesis can be made showing the overall pattern.

6. S. Hardjodarsons: 'The situation of wood and agricultural waste products as fuel in Indonesia at this moment and its prospect'.

7. Figures given in Hardjodarsono's paper have been widely cited, or used as a basis for calculation by, inter alia: O. Soemarwoto; H. Soesastro; S. Hadi, Buharman, B. Pernama and Hartoyo; Arismunandar and Kadir. R.T. Skrinde's Preliminary draft - 'Assessment of Biomass as an Energy Resource in Indonesia' also relies heavily on Hardjodarsono's figures.

8. See A.M. Strout, BIES XV (1) March 1979.

9. Indicated, for instance, by a complete lack of stochastic variability of employment per enterprise in the household industries subsector in the regencies of D.I. Yogyakarta. A priori assumptions of employment in household and cottage industries possible feature more frequently than some authors have recognized. The conclusions of one study attempting to correlate labor-intensity and energy-intensity are unconvincing on this account.

10. For brick and tile making, limeburning, tobacco curing etc. the range of energy inputs per unit of output is confined within fairly close limits. These coefficients are useful for checking purposes.

11. For agriculture cross checks have included the areas cultivable and irrigable by the inputs assumed from mechanical equipment, and calculations of human and animal capabilities using ergonomic performance findings.

12. For example, Soelistijo has calculated firewood consumption on the basis of a supposed bulk density of 125 kg/m^3 (as used in 'World Energy Supplies, 1950-74, UN) whereas Hardjodarsono (1978) converts on the basis of 620 kg/m^3. If variability on account of varying moisture content is allowed for, then the energy content attributable to what is termed ' a m^3 of firewood' will span a range of values embodying a factor of 6 or more.

13. It needs to be emphasized that throughout these tables the amounts (and derived percentages) shown are the values arising from the arithmetical techniques used. Full figures have been retained only to avoid the compounding of approximation errors in successive stages of the analysis; accordingly they should not be regarded as indicating either the absolute precision of the analysis or the 'confidence level' of the estimates (see following Section V).

14. 2.4 BOE/ton or 0.6 BOE per m^3 of 250 kg.

15. As it so happens that the rupiah cost of a gross calorific energy is not greatly different as between kerosene and firewood (taking the cost and thermal values adopted for this study) this hypothetical adjustment is thermally inconsequential.

16. Although when presenting industrial consumption estimates Hardjodarsono refers only to '<u>firewood</u>', he juxtaposes these estimates (together with those for household consumption) with his estimates for '<u>firewood and non-wood</u>' (i.e. waste from food crops, coconut, oil palm and tea) when estimating apparent surplus or deficit.

17. Hardjodarsono explicitly refers to 'sugar factory' in his consumption estimates but does not include waste from sugar plantations in his estimation of non-wood fuels (which, in any case, he says are not in fact much used).

18. High aromatics vaporizing oil, as used for kerosene-fuelled I.C. engines, has not been widely available in Indonesia. The investment here referred to is, therefore, that for heat production.

19. It would appear that the use of A.D.O. is not merely a temporary substitution to overcome the periodic R.O. supply shortages; once the investment has been made in the equipment to burn A.D.O. then the tendency is to stay with that fuel.

20. BPS, Statistik Industri, 1976 and 1977.

21. Volume comparison. Pertamina data.

22. Direktorat Bina Produksi Tanaman Pangan

23. For the period to January 1981, the realization of Repelita III transmigration targets was less than 40 percent overall. Direktorat Jenderal Transmigrasi.

24. For larger throughputs some research by the Directorate of Building Research, Bandung on fluidised-bed burning of rice husk (for rice hush ash pozzolana) may be relevant.

25. Early steam threshing plants on the N. American prairies burnt straw.

26. LPHH, Bogor.

27. National Institute of Physics, Indonesian Institute of Sciences.

28. Under Repelita III output of residual oil is projected to almost double as between 1979/80 and 1983/84. Hydrocracker capacity coming on stream is intended to diminish residual oil production and increase yield of kerosene. Operations clearly need to be monitored in relation to the market demands.

29. e.g. Ricardo-type. Developed in the 1950's, with flash fired biomass boilers.

30. During Repelita III sawah areas are projected to rise by 350,000 ha and further technical irrigation will certainly be needed.

APPENDIX 1

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APPENDIX 1

RURAL SECTOR ENERGY CONSUMPTION ESTIMATES: 1978

DATA SOURCES, METHODS OF CALCULATION AND CONVERSION FACTORS

AGRICULTURE

- Cultivation: (Food Crop Areas)

  - Mechanical

    Tractor inventory (adjusted for 1978)(see Table A4) converted to aggregate horsepower.

    Total annual fuel consumption from aggregate hp x hours/yr. x hourly consumption (diesel fuel)/hphr.

    Converted to BOE

    (check: ha expected performance v. ha 'mechanized')

  - Human and Animal

    Ratio of horsepower-hours inputs:

    Nos x power x hrs/day x days/yr (see Table A1)

    Performance:

    Ha x fuel equivalent/ha.

    Converted to BOE and apportioned according to input ratio.

    (check: correspondence of input and output)

- Irrigation

  Pump inventory (adjusted for 1978)(see Table A4) converted to aggregate horsepower.

  Total annual fuel consumption from aggregate hp x hours/yr x hourly consumption (diesel fuel)/hphr.

  Converted to BOE (check ha x m expected performance v. ha 'technically irrigated')

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- Estates Subsector

  Pertamina distribution (see Table A3), adjusted for 1978, Converted to BOE.

- Plantations Subsector

  As for Estates Subsector above.

AGRO-INDUSTRY

All industry data derived from various tables in BPS publications (see Appendix 2) showing the results of the Industrial Census 1974/75, and from the Annual Surveys of Manufacturing Industry (1975 and 1978).

- Large Scale

  (Large and Medium Scale Manufacturing Enterprises)

  - Petroleum Fuels (except Residual Oil), Natural Gas, Coal & Coke:

    1978 Physical quantities (at ISIC 5-digit level) converted to BOE, judgmental apportionment of sector share (see Table A2)

  - Electricity

    1978 costs from difference between total fuels, lubricants and electricity costs, and fuels and lubricants costs. Converted to Mwh. Converted to BOE; judgmental apportionment of sector shares (see Table A2).

  - Other Fuels (Firewood, Residual Oil)

    Judgmental attribution of "other fuels" costs to fuel type. Converted to physical quantities. Converted to BOE. Judgmental apportionment of sector share (see Table A2).

    (Check: consumptions, rubber, sugar and other agro-industries compared with Pertamina direct distributions to 'rubber', 'sugar' and 'other agriculture' (see Table A3).

- Small-Scale

  (Household, Cottage and 'Small-Scale' Enterprises).

  - Household and Cottage Industry

    Subsector costs (at ISIC 5-digit level) for "other materials consumed" (SI 76-01 Tab. 3.6) in toto equal consolidated fuels costs plus consolidated containers etc., costs (SI 77-04(1A) Tab. 5.00).

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(Fuel costs total disaggregated into subtotals for kerosene, wood, charcoal and 'other'.)

Judgmental attribution of costs to fuel types.

(check: Summation of fuel type costs compared against the sector-wide subtotals in census data)

Conversion of 1974/75 costs to 1978 costs (see note below).

Conversion to Physical units. Conversion to BOE.

Judgmental apportionment of sector share (see Table A2).

- 'Small-Scale' Industry

Units assumed to employ 10 persons (between definitional limits of 5 - 20). Per capita energy consumption assumed equal per capita consumption in Household and Cottage Industries subsector. Energy consumption from units x 10/employmemt H & C subsector. (i.e. SS sub-sector treated as numerical extension of H & C sub-sector). Monetary units to physical units. Converted to BOE. Judgmental apportionment of sector share (see Table A2).

Note: Escalation of user prices for energy, 1974/75 to 1978 calculated at 34%, this being the weighted average (mid-term subsectoral total costs as weights) of changes in energy costs/unit physical output in individual subsectors, at the large and medium enterprise level.

FORESTRY

- Extraction

Pertamina Distribution (see Table A3) adjusted for 1978. Less Large and Medium Scale Sawmilling Estimates

- Conversion (Large and Small Scale)

As for Agro-Industry

EXTRACTIVE INDUSTRY

- Quarry

Pertamina Distribution (see Table A3) adjusted for 1978. 10% 'Other' of Extractive Subsector.

- Bricks and Tiles

As for Agro-Industry, but plus judgmental increment to Residual Oil consumption in light of Pertamina Distribution.

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- Lime

As for Bricks and Tiles, above.

- Other Extractive

As for Agro-Industry.

FOOD, CRAFT, TEXTILE AND OTHER INDUSTRIES

As for Agro-Industry, above.

NON-PLN ELECTRICITY

Units x hp x hrs/yr x litres/hphr. Conversion to BOE.

WATER SUPPLY

Assumed equivalent to Non-PLN Electricity.

3,84

TABLE A1

RURAL SECTOR ENERGY INPUTS: UNITS, RATINGS, PERFORMANCE, SPECIFIC CONSUMPTIONS AND UNIT COSTS, ETC.

TRACTORS:	Hp	Hrs/yr	Litres (Diesel)/hphr.
2-wheel	8	1 000	0.2
Mini-tractor	15	1 000	0.2
Standard	30	1 000	0.2
Tracked	50	1 000	0.2

IRRIGATION PUMPS	Hp	Hrs/yr	Litres(Diesel)/hphr
2"	10	500	0.2
4"	20	500	0.2
6"	30	500	0.2
8"	40	500	0.2
8"+	50	500	0.2

(Note: Diameter normally varies inversely with duty head, hence linearity diameter - power)

CULTIVATIONS (Food Crops)

- Inputs

	No.	Hp.	Hrs/day	Days/yr
- Human	40m	0.05	6	120
- Animal	3m	0.4	5	120

- Task	Ha.	Hphrs/ha	Litres(Diesel)/ha
	13m	150	30

(Note: 150 hphrs/ha represents input required for double-pass cultivation. Work actually performed on soil varies with the physical characteristics, depth of cultivation, degree of pulverisation etc., but will normally amount to about 25 hphr/ha/pass

NON-PLN ELECTRICITY
(Excluding Estates)

No.	Hp	Hrs/yr	Litres(Diesel)/Hph
4,000	5	1 500	0.2

ENERGY COSTS (1978)

	Unit	Rp
Electricity (PLN)	Kwh	30
A.D.O. (Solar)	litre	29
I.D.O. (Diesel)	"	26
Kerosene	"	25
Charcoal	ton	40 000
Firewood	m^3 (250 kg)	2 500

(Note: Estimates for other commercial fuels based on physical data, and therefore insensitive to average consumer price assumptions)

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.... Contd.

Table A1 (Contn.)

BOE CONVERSIONS (On net calorific basis)

	Unit	BOE (Barrels Oil Equivalent)
Gasoline(Bensin)	Kl	5.75
ADO/IDO	"	6.32
Kerosene	"	6.10
Residual Oil	"	6.64
Natural Gas	m^3	0.00578
Coal (Sumatra)	tonne	5.05
Coke	"	4.84
Charcoal	"	5.02
Firewood	m^3	0.6
Electricity	Kwh	0.000621

TEMPORAL ADJUSTMENTS

Tractors and Irrigation Pumps, (Food Crops), Nos of units, 1977 to 1978	+ 5%
Pertamina Distributions to Sector, 1978 to 1979	+ 5%
Energy Consumption (Physical units), Small-Scale, Cottage and Household Industry, 1974/5 to 1978	Nil

EMPLOYMENT

Average no. of persons engaged per Small-Scale Industry unit	10

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TABLE A2

INDUSTRY SUBSECTORS INCLUDED IN RURAL ENERGY ASSESSMENT: ISIC CODES, RURAL SECTOR SHARES. 1/

Industry Group/Subsector	ISIC Code	Rural Sector Share,% 2/ Household & Cottage Industry	Small-scale Industry	Large Medium Scale Industry.
- Agro-Industry				
- Sugar Production	31181	100	100	100
- Rice Milling	31161/2	100	100	90
- Rubber Processing	35521/2/3	-.	100	100
- Coconut Oil	31151	100	100	100
-Grain Milling	31169	100	100	-
- Tea (Drying)	31220	100	100	100
-Edible Oils	31159	90	90	50
- Tobacco (Drying)	31410	100	100	100
- Animal Feed Milling	31280	-	100	100
- Coffee (Washing)	31163	-	100	100
- Fish Processing	31140	100	-	-
- Tanneries	32310	-	100	-
- Extractive Industry				
- Sawmilling	33111	100	100	100
- Bricks, Tiles	36410/20/90	100	100	100
- Lime	36330	100	100	100
- Minerals	36900	100	100	100
- Other Clay Products	36120	100	-	-
- Food Industries				
- Tahu & Tempe	31242	90	80	-
- Emping	31250	80	80	-
- Bakeries	31179	80	50	-
- Dairy Products	31120	50	-	-
- Beverages	31310	100	100	-
- Tapioca	31210	100	100	-
- Other Food Products NES	31290	80	80	-
- Craft Industries				
- Blacksmithing (Agric.Tools)	38111	100	100	-
- Bamboo and Rattan Products	33130	100	-	-
- Blacksmithing (General)	38112/90	80	80	-
- " (Boat Fittings)	38411	100	-	-
- Furniture Making	33210	80	80	-
-Handicrafts	32115/30 32290/330 33112/20/40/90 33220	80	80	-
- Rope Making	32150	100	-	-
- Footware	32400	80	80	-
- Textiles				
- Spinning and Dyeing	32111	100	-	-
- Weaving	32112	80	80	-
- Batik	32114	80	80	-
- Garments	32210	80	80	-
- Other Textiles NES	32120	80	80	-
- Other Industries NES				
- Manufactures NES	39090	80	80	-
- Others NES	-	80	-	-

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..... Contd. (footnote

Table A2 (Contn.)

1/ Energy consumption in the following subsectors has been disregarded, either because the recorded expenditures on fuels are relatively small or because they are not likely to be strongly represented in the rural areas.

ISIC Code	Scale (HC: Household/Cottage SS: Small-scale)
32150	SS
33130	SS
34112	HC/SS
34190	HC/SS
34200	HC/SS
35600	HC
36110	HC/SS
36190	HC
38114	SS
38120	HC/SS
38140	SS
38411	SS
39010	HC/SS

2/ Study Estimate.

TABLE A3

PERTAMINA DIRECT SALES, 1979,

(Selected Sectors) 1/ Kilolitres

	Gasoline	Automotive Diesel Oil	Industrial Diesel Oil	Residual Oil
AGRICULTURAL SECTOR				
- Agriculture	371	30 076	38	
- Plantations	17 649	124 170	32 759	7 104
- Forestry	10 157	355 172	2 997	1 020
- Others	128	117 783	2 640	99
LOW-INDUSTRY				
- Sugar	13 382	38 404	36 590	104 226
- Rubber 2/	180	82 732	7 909	3 511
EXTRACTIVE SECTOR				
- Bricks, Tiles and Lime		24 938	28 909	89 039
- Others 3/	341	103 606	123 274	45 127
(Dealer Network Sales)	(3 208 573)	(1 500 339)	(236)	(45)

Notes: 1/ Excludes Aviation Fuel Sales, Agricultural Sector.

2/ " Rubber manufactures.

3/ " Cement manufacture.

Source:

Pemakian BBM Seluruh Indonesia, Tahun 1979.

Pertamina DJT. PDN. (Consolidation of data reported monthly by 8 Pertamina districts)

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TABLE A4

Tractors and Irrigation Pumps employed for Food Production, 1978 (Estimated

(Excludes equipment in Estates and Plantations subsectors)

	Type	No of Units		
		Java/Bali	Outer Islands	Total
Tractors	2-Wheeled	1 530	153	1 683
	Mini-tractors	72	249	321
	Standard	95	89	184
	Tracked	3	47	50
Irrigation Pumps	2"	1 542	27	1 569
	4"	637	6	643
	6"	518	70	588
	8"	500	26	526
	8"+	239	13	252

Source: Inventarisasi Alat Dan Mesin Pertanian di Indonesia, 1974-78. Direktorat Bina Produksi, Direktorat Jeneral Pertanian Tanaman Pangan, Departemen Pertanian, Jakarta, 1981.

(Note: Some data relate only to 1974-7. 1977 figures have been upwardly adjusted by 5% to yield 1978 estimates)

TABLE A5

PURCHASED FUELS: LARGE AND MEDIUM SCALE INDUSTRIES (RURAL SECTOR), ESTIMATES, 1978, MOF.

Industry Group/Subsector	Electricity	Natural Gas	Gasoline (Bensin)	A.D.O. (Solar)	I.D.O. (Diesel)	Kerosene	Residual Oil	Coke	Coal	Charcoal	Firewood	Totals
- Agro-Industry												
- Sugar Production	5 816	518	90 056	191 490	475 188	1 147	666 324	31 537	1 949	-	-	1 464 025
- Rice Milling	-	-	696	18 979	765	433	-	-	-	-		20 873
- Rubber Processing 1/	9 666	-	8 240	413 126	63 744	14 256	9 296	-	-	-	-	518 328
- Coconut Oil	3 395	-	2 771	50 149	24 237	1 995	-	-	-	-	11 300	93 847
- Tea (Drying)	124	-	701	14 163	607	3 776	-	-	-	-	50 800	70 171
- Edible Oils and Fats 2/	1 615	-	517	12 406	16 344	842	-	-	-	-	2 000	33 724
- Tobacco (Drying)	103	-	2 122	3 868	82	25 693	-	-	-	-	52 100	83 968
- Animal Feed Milling 3/	145	-	1 138	25 179	-	287	-	-	-	-	-	26 749
- Coffee (Washing)	186	-	230	2 433	32	366	-	-	-	-	-	3 247
(Subtotals)	(21 050)	(518)	(106 471)	(731 793)	(580 999)	(48 795)	(675 620)	(31 537)	(1 949)	-	(116 200)	(2 314 932)
- Extractive Industry												
- Sawmilling 4/	2 070	-	17 762	239 319	1 668	2 385	-	-	-	-	-	263 204
- Bricks, Tiles etc. 5/	145	-	236	12 450	34 406	2 263	272 240	-	-	-	-	321 740
- Lime	-	3 058	931	37 819	13 997	2 361	245 680	-	-	-	-	303 841
- Minerals 6/	186	-	885	16 308	9 987	18	16 600	-	-	-	-	41 984
(Subtotals)	(2 401)	(3 058)	(19 814)	(303 896)	(60 053)	(7 027)	(534 520)					(930 769)
TOTALS	23 451	3 576	126 285	1 035 689	641 052	55 822	1 210 140	31 537	1 949	-	116 200	3 245 701

1/ Includes Smoking, remilling and crumb rubber production.

2/ Includes soap-making

3/ Includes cassava processing

4/ Entered under Forestry in consolidated Energy Table (Table A10)

5/ Includes structural clay products

6/ Includes Kaolin, Aggregate, Sand etc.

Source: Study Estimates.

TABLE A6

PURCHASED FUELS: HOUSEHOLD, COTTAGE & SMALL-SCALE INDUSTRIES (RURAL SECTOR), ESTIMATES, 1978, BOE.

Industry Group/Subsectors	A.D.O. (Solar)	Kerosene	Charcoal	Firewood	Totals
- Agro-Industry					
- Rice Milling	755 776	-	-	-	755 776
- Rubber Processing	18 801	-	-	30 500	49 301
- Sugar Production	-	531 891	-	505 000	1036 891
- Coconut Oil	26 365	-	-	-	26 365
- Grain Milling	84 339	-	-	-	84 339
- Tea (Drying)	8 499	-	-	9 100	17 599
- Edible Oils & Fats 1/	-	3 672	-	-	3 672
- Tobacco (Drying)	-	-	-	14 400	14 400
- Animal Feed Milling 2/	3 269	-	-	-	3 269
- Coffee (Washing)	4 576	-	-	-	4 576
- Fish Processing	-	-	-	37 700	37 700
- Tanneries	-	-	-	3 100	3 100
(Subtotals)	(901 625)	(535 563)	-	(599 800)	(2036 988)
- Extractive Industry					
- Sawmilling 3/	19 177	-	-	-	19 177
- Bricks, Tiles etc 4/	-	-	-	902 200	902 200
- Lime	-	-	-	209 500	209 500
- Minerals 5/	10 678	-	-	-	10 678
- Other Clay Products	-	-	-	47 000	47 000
(Subtotals)	(29 855)	-	-	(1 158 700)	(1 188 555)
- Food Industries					
- Tahu and Tempe	-	311 450	-	295 700	607 150
- Emping	-	89 997	-	85 400	175 397
- Bakeries	26 127	-	-	65 200	91 327
- Dairy Products	-	14 884	-	-	14 884
- Beverages	-	10 492	-	-	10 492
- Tapioca	-	8 296	-	-	8 296
- Other Food Products NES	-		25 702	105 800	131 502
(Subtotals)	(26 127)	(435 119)	(25 702)	(552 100)	(1 039 048)
- Craft Industries					
- Blacksmith (Agric.Tools)	-	-	55 847	-	55 847
- Bamboo and Rattan Products	-	41 480	-	-	41 480
- Blacksmithing, (General and Boat Fittings)	-	-	17 695	-	17 695
- Furniture Making	-	8 003	-	-	8 003
- Handicrafts	-	4 490	-	-	4 490
- Rope Making	-	2 684	-	-	2 684
- Footware	-	2 147	-	-	2 147
(Subtotals)	-	(58 804)	(73 542)	-	(132 346)
- Textiles					
- Spinning and Dyeing	-	3 172	-	-	3 172
- Weaving	-	7 222	-	-	7 222
- Batik	-	-	-	50 700	50 700
- Garments	-	4 880	-	-	4 880
- Other Textiles NES	-	9 760	-	-	9 760
(Subtotals)	-	(25 034)	-	(50 700)	(75 734)
- Other Industries NES					
- Manufactures NES	-	5 075	-	-	5 075
- Others NES	37 714	-	-	39 700	77 414
(Subtotals)	(37 714)	(5 075)	-	(39 700)	(82 489)
TOTALS	995 321	1 059 595	99 244	2 401 000	4 555 160

.....Contd. (Footnotes)

Table A6 (Contn).

1/ Includes soap-making

2/ Includes cassava processing

3/ Entered under 'Forestry' in consolidated Energy Table (Table A10)

4/ Includes structural clay products

5/ Includes Kaolin, Aggregate, Sand, etc.

Source: Study Estimates.

TABLE A8

INDUSTRY SUBSECTORS INCLUDED IN RURAL ENERGY ASSESSMENT: NUMBERS OF INDUSTRY UNITS, (RURAL SHARE) 1/

Industry Group/Subsectors	Household & Cottage Industries (1974/5)	Small-Scale Industries (1974/5)	Large and Medium Scale Industries (1978)
- Agro-Industry			
-Sugar Production	240 878	1 243	56
-Rice Milling	13 362	10 934	165
- Rubber Processing	-	316	101
- Coconut Oil	9 595	468	103
- Grain Milling	24 328	486	-
- Tea (Drying)	830	368	59
- Edible Oils	881	46	16
- Tobacco (Drying)	2 238	1 125	500
- Animal Feed Milling	-	31	26
- Coffee (Washing)	-	70	14
- Fish Processing	4 667	-	-
- Tanneries	-	53	-
(Subtotals)	(296 779)	(15 140)	(1 040)
- Extractive Industry			
- Sawmilling	14 981	2 253	389
- Bricks, Tiles,	49 793	4 095	212
- Lime	3 588	1 472	70
- Minerals	5 252	102	47
- Other Clay Products	19 323	-	-
(subtotals)	(92 937)	(7 922)	(718)
- Food Industries			
- Tahu and Tempe	55 427	8 848	-
- Emping	20 209	1 664	-
- Bakeries	4 990	810	-
- Dairy Products	717	-	-
- Beverages	1 172	44	-
- Tapioca	5 011	858	-
- Other Food Products NES	25 286	710	-
(Subtotals)	(112 812)	(12 934)	-
- Craft Industries			
- Blacksmithing(Agric.Tools)	5 090	893	-
- Bamboo and Rattan Products	476 896	-	-
- Blacksmithing (General and Boat Fittings)	5 951	326	-
- Furniture Making	19 696	1 560	-
- Handicrafts	19 316	483	-
- Rope Making	21 752	-	-
- Footware	1 175	290	-
(Substotals)	(549 876)	(3 552)	-
- Textiles			
- Spinning and Dyeing	3 278	-	-
- Weaving	29 951	1 785	-
- Batik	39 694	1 277	-
- Garments	5 051	421	-
- Other Textiles NES	8 810	330	-
(Subtotals)	(86 784)	(3 813)	-
-Other Industries NES			
- Manufactures NES	13 702	366	-
- Others NES	10 532	-	-
(Subtotals)	(24 234)	(366)	-
TOTALS	1 163 422	43 727	1 758

1/ Rural Share calculated using apportionment from Table A2

Data Source: BPS

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TABLE A9

INDUSTRY SUBSECTORS INCLUDED IN RURAL ENERGY ASSESSMENT:
NUMBERS OF PERSONS ENGAGED, (RURAL SHARE). 1/

Industry Group/Subsectors	Household & Cottage Industries (1974/5)	Small-Scale Industries (1974/5) 2/	Large and Medium Scale Industries (1978)
- Agro-Industry			
- Sugar Production	730 223	12 430	67 407
- Rice Milling	54 870	109 340	4 939
- Rubber Processing	-	3 160	17.948
- Coconut Oil	32 447	4 680	5 110
- Grain Milling	83 912	4 860	-
- Tea (Drying)	3 602	3 680	3 145
- Edible Oils	3 084	460	1 168
- Tobacco (Drying)	9 831	11 250	33 731
- Animal Feed Milling	-	310	2 504
- Coffee (Washing)	-	700	849
- Fish Processing	15 905	-	-
- Tanneries	-	530	-
(Substotals)	(933 874)	(151 400)	(136 801)
- Extractive Industry			
- Sawmilling	51 136	22 530	29 432
- Bricks, Tiles	166 097	40 950	6 731
- Lime	15 169	14 720	2 099
- Minerals	16 617	1 020	2 367
- Other Clay Products	56 448	-	-
(Subtotals)	(305 467)	(79 220)	(40 679)
- Food Industries			
- Tahu and Tempe	183 323	88 480	-
- Emping	71 001	16 640	-
- Bakeries	18 630	8 100	-
- Dairy Products	2 812	-	-
- Beverages	3 632	440	-
- Tapioca	13 750	8 580	-
- Other Food Products NES	85 477	7 100	-
(Subtotals)	(378 625)	(129 340)	-
- Craft Industries			
- Blacksmithing(Agric.Tools)	19 800	8 930	-
- Bamboo and Rattan Products	1 451 194	-	-
- Blacksmithing (General and Boat Fittings)	19 968	3 260	-
- Furniture Making	65 024	15 600	-
- Handicrafts	67 054	4 830	-
- Rope Making	67 867	-	-
-Footware	4 605	2 900	-
(Subtotals)	(1 695 512)	(35 520)	-
- Textiles			
- Spinning and Dyeing	11 097	-	-
- Weaving	91 426	17 850	-
- Batik	122 347	12 770	-
- Garments	17 409	4 210	-
- Other Textiles NES	27 182	3 300	-
(Subtotals)	(269 461)	(38 130)	-
- Other Industries NES			
- Manufactures NES	43 405	3 660	-
- Others NES	42 136	-	-
(Subtotals)	(85 541)	(3 660)	
TOTALS	3 668 480	437 270	177 480

1/ Rural Share calculated using apportionment from Table A2
2/ Assumes average of 10 persons engaged per Small-scale Industry Unit.

Data Source: BPS

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TABLE A10

ENERGY INPUTS: RURAL SECTOR, ESTIMATES, 1978, BOE.

	Electricity	Nat. Gas	Gasoline (Bensin)	A.D.O. (Solar)	I.D.O. (Diesel)	Kerosene	Residual Oil	Coke	Coal	Charcoal	Firewood	Human	Animal	Totals
	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE
AGRICULTURE														
- Food Crops														
-Cultivations	-	-	-	33 243	-	-	-	-	-	-	-	1 770 000	885 000	2 688 243
-Irrigation	-	-	-	50 452	-	-	-	-	-	-	-	-	-	50 452
- Estates	-	-	2 031	181.029	229	-	-	-	-	-	-	-	-	183 289
- Plantations	-	-	96 650	747 385	197 178	-	44 925	-	-	-	-	-	-	1 086 138
(Subtotals)	-	-	(98 681)	(1 012 109)	(197 407)	-	(44 925)	-	-	-	-	(1 770 000)	(885 000)	(4 008 122)
AGRO-INDUSTRY														
-Large-Scale 1/														
- Sugar Production	5 816	518	90 056	191 490	475 188	1 147	666 324	31 537	1 949	-	-	-	-	1 464 025
- Rubber Processing	9 666	-	8 240	413 126	63 744	14 256	9 296	-	-	-	-	-	-	518 328
- Coconut Oil	3 395	-	2 771	50 149	24 237	1 995	-	-	-	-	11 300	-	-	93 847
- Tobacco (Drying)	103	-	2 122	3 068	82	25 693	-	-	-	-	52 100	-	-	83 968
- Edible Oils & Fats	1 615		517	12 406	16 344	842	-	-	-	-	2 000	-	-	33 724
- Animal Feed Milling	145	-	1 138	25 179	-	287	-	-	-	-	-	-	-	26 749
- Tea(Drying)	124	-	701	14 163	607	3 776	-	-	-	-	50 800	-	-	70 171
- Rice Milling	-	-	696	18 979	765	433	-	-	-	-		-	-	20 873
- Coffee (Washing)	186	-	230	2 433	32	366	-	-	-	-	-	-	-	3 247
(Subtotals)	(21 050)	(518)	(10[illegible] 471)	(731 793)	(500 999)	(48 795)	(675 620)	(31 537)	(1 949)	-	(116 200)	-	-	(2 314 932)
- Small-Scale 2/														
- Rice Milling	-	-	-	755 776	-	-	-	-	-	-	-	-	-	755 776
- Sugar Production	-	-	-	-	-	531 891	-	-	-	-	505 000	-	-	1 036 891
- Grain Milling	-	-	-	84 339	-	-	-	-	-	-	-	-	-	84 339
- Coconut Oil	-	-	-	26 365	-	-	-	-	-	-	-	-	-	26 365
- Rubber Processing	-	-	-	18 801	-	-	-	-	-	-	30 500	-	-	49 301
- Tea (Drying)	-	-	-	8 499	-	-	-	-	-	-	9 100	-	-	17 599
- Coffee (Washing)	-	-	-	4 576	-	-	-	-	-	-	-	-	-	4 576
- Edible Oils and Fats	-	-	-	-	-	3 672	-	-	-	-	-	-	-	3 672
- Animal Feed Milling	-	-	-	3 269	-	-	-	-	-	-	-	-	-	3 269
- Fish Processing	-	-	-	-	-	-	-	-	-	-	37 700	-	-	37 700
- Tobacco (Drying)	-	-	-	-	-	-	-	-	-	-	14 400	-	-	14 400
- Tanneries	-	-	-	-	-	-	-	-	-	-	3 100	-	-	3 100
(Subtotals)	-	-	-	(901 625)	-	(535 563)	-	-	-	-	(599 800)		-	(2 036 988)
FORESTRY														
- Extraction	-	-	37 860	1 838 478	16 371	-	6 450	-	-	-	-	-	-	1 959 159
- Conversion														
- Large Scale 1/	2 070	-	17 762	239 319	1 668	2 385	-	-	-	-	-	-	-	263 204
- Small Scale 2/	-	-	-	19 177	-	-	-	-	-	-	-	-	-	19 177
(Subtotals)	(2 070)	-	(55 622)	(2 156 974)	(18 039)	(2 385)	(6 450)	-	-	-	-	-	-	(2 241 540)

1/ Large and Medium Scale Enterprises

2/ Household, Cottage and Small-scale Enterprises

.....Contd.

TABLE A10
continued

	Electricity	Nat. Gas	(Bensin)	A.D.O. (Solar)	I.D.O. (Diesel)	Kerosene	Residual Oil	Coke	Coal	Charcoal	Firewood	Human	Animal	Totals
	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE	BOE
EXTRACTIVE INDUSTRY														
- Quarrying	-	-	187	62 361	74 199	-	-	-	-	-	-	-	-	136 747
- Minerals														
- Large Scale 1/	186	-	885	14 308	9 987	18	16 600	-	-	-	-	-	-	41 984
- Small Scale 2/	-	-	-	10 678	-	-	-	-	-	-	-	-	-	10 678
- Lime														
- Large Scale 1/	-	3 058	931	37 819	13 992	2 361	245 680	-	-	-	-	-	-	303 841
- Small Scale 2/	-	-	-	-	-	-	-	-	-	-	209 500	-	-	209 500
- Clay Products														
- Large Scale 1/														
- Bricks, Tiles	145	-	236	12 450	34 406	2 263	272 240	-	-	-	-	-	-	321 740
- Small Scale 2/														
- Bricks, Tiles	-	-	-	-	-	-	-	-	-	-	902 200	-	-	902 200
- OtherProducts	-	-	-	-	-	-	-	-	-	-	47 000	-	-	47 000
(Subtotal)	(331)	(3 058)	(2 239)	(137 616)	(132 584)	(4 642)	(534 520)	-	-	-	(1 158 700)	-	-	(1 973 690)
FOOD INDUSTRIES 1/														
- Tahu and Tempe	-	-	-	-	-	311 450	-	-	-	-	295 700	-	-	607 150
- Emping	-	-	-	-	-	89 997	-	-	-	-	85 400	-	-	175 397
- Bakeries	-	-	-	26 127	-	-	-	-	-	-	65 200	-	-	91 327
- Dairy Products	-	-	-	-	-	14 884	-	-	-	-	-	-	-	14 884
- Beverages	-	-	-	-	-	10 492	-	-	-	-	-	-	-	10 492
- Tapioca	-	-	-	-	-	8 296	-	-	-	-	-	-	-	8 296
- Other Food Products	-	-	-	-	-	-	-	-	-	25 702	105 800	-	-	131 502
(Subtotals)	-	-	-	(26 127)	-	(435 119)	-	-	-	(25 702)	(552 100)	-	-	(1 039 048)
CRAFT INDUSTRIES 1/														
- Blacksmithing (Agric)	-	-	-	-	-	-	-	-	-	55 847	-	-	-	55 847
- Bamboo and Rattan	-	-	-	-	-	41 480	-	-	-	-	-	-	-	41 480
- Blacksmithing (Gen.)	-	-	-	-	-	-	-	-	-	17 695	-	-	-	17 695
- Furniture	-	-	-	-	-	8 003	-	-	-	-	-	-	-	8 003
- Ropemaking	-	-	-	-	-	2 684	-	-	-	-	-	-	-	2 684
- Footware	-	-	-	-	-	2 147	-	-	-	-	-	-	-	2 147
(Subtotals)	-	-		-	-	(58 804)	-	-	-	(73 542)	-	-	-	(132 346)
TEXTILES 1/														
- Weaving	-	-	-	-	-	7 222	-	-	-	-	-	-	-	7 222
- Batik	-	-	-	-	-	-	-	-	-	-	50 700	-	-	50 700
- Garments	-	-	-	-	-	4 880	-	-	-	-	-	-	-	4 880
- Spinning and Dyeing	-	-	-	-	-	3 172	-	-	-	-	-	-	-	3 172
- Other Textile Inds.	-	-	-	-	-	9 760	-	-	-	-	-	-	-	9 760
(Subtotals)	-	-	-	-	-	(25 034)	-	-	-	-	(50 700)	-	-	(75 734)
OTHER INDUSTRIES 1/														
- Manufactures	-	-	-	-	-	5 075	-	-	-	-	-	-	-	5 075
- Others	-	-	-	37 714	-	-	-	-	-	-	39 700	-	-	77 414
(Subtotals)	-	-	-	(37 714)	-	(5 075)	-	-	-	-	(39 700)	-	-	(82 489)
NON-PLN ELECTRICITY	-	-	-	37 920	-	-	-	-	-	-	-	-	-	37 920
WATER SUPPLY	-	-	-	37 920	-	-	-	-	-	-	-	-	-	37 920
T O T A L S	23 451	3 576	263 013	5 079 789	929 029	1 115 417	1261 515	31 537	1 949	99 244	2 517 200	1 770 000	885 000	13 980 729

1/ Large and Medium Scale Enterprises. 2/ Household, Cottge and Small-scale Enterprises

Source : Study Estimates.

APPENDIX 2

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ENERGY PLANNING FOR DEVELOPMENT: APPENDIX D

ENERGY CONSUMPTION IN RURAL HOUSEHOLDS

Romir Chatterjee

e/di
ENERGY / DEVELOPMENT INTERNATIONAL

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ENERGY PLANNING FOR DEVELOPMENT

ENERGY CONSUMPTION IN RURAL HOUSEHOLDS

Romir Chatterjee

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A. Introduction

Meeting the energy needs of rural areas ranks high among the current priorities of energy planning in Indonesia. Household energy use is of particular importance. It is recognized that the use of energy in the home, together with its costs, has a direct relationship to welfare and basic needs. The Indonesian government is concerned, therefore, with the need to review national policies that have a bearing on energy consumption in the household sector. This sector accounts for about 65 per cent of total national energy consumption (or, a significant 25 per cent, if only commercial fuels are taken into account).

Meeting the basic fuel needs of Indonesia's 28 million households (81 per cent of whom are in the rural areas) is of fundamental importance. And there is an urgent need to design appropriate responses to the rapid increase in kerosene consumption in the past decade.

The current interest in rural energy problems and resulting investigations have revealed very great uncertainties and gaps in the knowledge of household energy use. The primary area of uncertainty is the level and composition of fuel demand for domestic uses. Since the demographic composition of the

country is predominantly rural, the Energy Planning for Development Project focused its effort on defining an appropriate methodology for collecting data in rural areas through a household survey. The analysis of this information reported here is a first step towards acquiring a fuller understanding of the current level and composition of fuel demand in rural Indonesia.

The rural household energy survey carried out under this project was designed as a pilot survey. It was conducted in eight regions of the country, in Java, North Sumatera and Sulawesi, during the months of October and November, 1980. The following were the objectives of the survey:

1) To establish a minimal data base for policy analysis.
2) Develop local capability to collect and analyze energy data.
3) Develop a methodology and survey instrument for future use.
4) Strengthen the capacity of the DJK to manage such efforts.

The survey aimed at collecting data to construct a profile of household energy use for each of three broad income groups. It was intended that the primary data be collected on physical

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levels of consumption of fuels. This data in conjunction with secondary data on the energy content of fuelwood species, and on relative efficiencies of energy conversion would be used to estimate present levels of energy consumption. Such a profile is useful in examining the possible effects of income change, fuel substitutions or changes in technology for policy-making.

Given the demographic, economic and physical variety of Indonesia, the scope of the project was explicitly a pilot effort to test a methodology. With this limitation, the survey had the second important objective of making a practical contribution towards the development of a local capability to undertake the design and supervision of such a data collection and analysis exercise. The project was planned from the outset as a cooperative undertaking to include the active participation of several university teams, thereby to enlarge the range of experience and awareness about rural energy issues, and to draw upon the considerable range of expertise about such issues among institutions outside the Ministry of Mines and Energy. Any future effort to expand the scope of data collection to a national level will require the human resources and continued support of such institutions.

The pilot survey also provided an important opportunity to

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develop an appropriate survey questionnaire and methodology for future application in a representative national sample. A number of small-scale regional surveys have been undertaken in the past ten years to examine patterns of rural energy consumption, but there have been no previous attempts at defining the appropriate design for a national rural energy data base. While the U.S. project staff developed the initial questionnaire based on previous surveys in other countries, the final design was the product of a collective effort on the part of the U.S. project team, an advisory team of Indonesian experts, and staff of the DJK. In refining the questionnaire several pre-tests were carried out in various regions.

All phases of preparatory training and of the field work were carried out under the supervision of DJK's staff, in association with university team leaders. The data analysis (including tabulation) also was the result of a cooperative effort. In a first phase, certain data were selected for analysis, so as to reduce the costs of processing, and a preliminary analysis of local (i.e., university team) results was carried out by the university teams in their respective regions. During a second phase, after a discussion in Jakarta of these results and of the field experience in a special week-long workshop, a centralized

data analysis effort was undertaken under DJK's supervision. A university team assisted in this final phase of data analysis. Portions of the collected data remain to be analyzed at a future stage by DJK. It will be an important future step to revise the estimates of energy consumption reported here when more reliable information on income is made available for the households surveyed from data collected in the SUSENAS survey of the same households conducted in January, 1980. These data were unavailable at the time of the EPFD survey. It is quite likely that this information will substantially alter the pattern of fuel consumption among various income groups as reported here. The present results should be treated, therefore, as preliminary.

In the remaining parts of the Appendix, we review the uncertainties in existing information on rural energy consumption based on a selected number of previous studies, present an overview of the methodology of the EPFD survey and then present its major findings. In conclusion, recommendations are made for appropriate follow-on steps.

B. Uncertainties in Existing Information

There has been a considerable amount of previous work on rural energy consumption in Indonesia, and it is useful to

review these, in order to place the current survey in perspective. One of the most interesting facts about this previous work is the great variety of the conclusions with respect to per capita consumption in rural households. Table 1 illustrates this variety in all major efforts to date that have attempted to make estimates of biomass consumption. It is apparent from these independent data since 1971, when the first major survey was carried out by the Forest Products Research Institute (for 1,250 households in East Java[1], there has been no consensus as to actual consumption. Our review of these major studies suggests that while existing information is often limited to particular regions, they contain large uncertainties.

The divergence of views on the level of energy consumption in rural households, is especially great with respect to the consumption of traditional biomass fuels (primarily wood, agricultural waste, and, to a small degree, charcoal); in the case of commercial fuels, primarily kerosene, per capita estimates from sales information are more reliable, but there is still considerable variation in estimates developed on the basis of survey data.

Estimates in earlier studies at the national level tend to converge towards a relatively narrow range of .7 - .9 cubic meters of wood equivalent per capita. The precise methodologies employed

Table 1

Per Capita Biomass Energy Consumption in Rural Indonesia
(Cubic meter of wood equivalent per capita per year)

Location	Year	Consumption (m^3/capita/yr.)	Source/Study by
All Indonesia	1956	0.5	Team Survey LPHH (1970)
	1970	0.7	FAO Estimate; T. Silitonga (1974)
	1975	0.9	Chandrasekharan (1977)
	1976	0.8	R. Atje (1979)
Java	1976	0.8	R. Atje (1979)
	1978	1.0	S. Hadi et al. (1979)
East Java	1971	0.5	Sumarna & Sudiono (1973)
	1978	1.3	S. Hadi et al. (1979)
Central Java			
Whole province	1978	0.6	S. Hadi et al. (1979)
Solo watershed	1969	0.7	LPHH (1969)
Solo watershed	1975	0.4	Wiersum (1976)
Solo watershed	1976	1.1	Wangsadidjaja et al. (1979)
Wonogiri area	1968	0.8-0.9	Directorate of Land Use (1969)
Wonogiri area	1977	0.5	Yudodibroto (1978)
West Java			
Whole province	1977	2.1	H. Haeruman et al. (1977)
	1978	0.4	S. Hadi et al. (1979)
Citanduy watershed	1977	2.2	Nasendi (1978)
Cimanuk watershed	1978	0.5-1.2	Cited by H. Haeruman et al. (1979)
Citarum watershed (seguling)	1979	2.5	Rusydi et al. (1979)
Sukabumi area	1977	0.4	(Cited by Wiersum, 1979)
Bogor area (Babakan)	1977	0.4	Komarudin (1977)
Bandung area (Salamungakl)	1979	1.0	O.S. Abdoellah (1979)
Outside Java	1976	1.0	R. Atje (1979)
Bali	1978	1.1	S. Hadi et al. (1979)

Source: H. Soesastro, Reference (2).

to arrive at this national level are unclear. Presumably, the results of various local small-scale studies, concentrating for the most part on the regions of Java, were combined through some weighting procedure to arrive at national estimates. But, as Table 1 shows, there is no unanimity among these local studies. This is true even of those studies carried out within periods close to each other, and within the same geographic region. Examples are the 1975 and 1976 estimates for the Solo watershed region in Central Java, and for West Java in 1977 and 1978. In fact, the differences in the West Java case are extremely large, with Haeruman's figures showing a level of consumption five times the level estimated by Hadi (2.1m^3 versus 0.4 m^3)(2). Very little confidence can be attached, therefore, to the national estimates shown in the table.

The great variations probably arise as much from differences in methodology and definition as they do from inaccuracies embedded in the field measurement of fuel consumption in rural areas. There are differences among the studies with respect to what is included in the definition of fuelwood (some include agricultural wastes and charcoal, others do not), who is included in the "household", and what constitutes "household consumption" of fuel (for example, some include household industry, while

others restrict themselves to cooking and lighting alone).

A second hallmark of the existing information on rural energy consumption is the absence of quantitative views of its trend over time. This is hardly surprising in view of the uncertainty of estimates for the country as a whole in any single time period. Indeed, most field surveys have not addressed themselves to the relationship of survey design to policy problems faced by decision-makers which necessitate an historical perspective. This does not mean that those who have prepared and conducted such surveys are unaware of the necessity to consider the time trends in energy consumption, but rather it reflects the limited physical and financial resources that have traditionally restricted the scope of field work to short periods, and to small samples. Nonetheless, it remains that the picture of changes in rural energy consumption over time is even more clouded than the static view.

It is possible to find, for example, alternative views on the annual growth of aggregate fuel consumption in the scope of a single report(3). In the period 1967 to 1976, the growth of wood consumption has been estimated by one government report at an annual compound growth rate of 2.35 per cent(4). For roughly the same period, a more recent government agency shows wood consumption growing at an annual rate of 11.3 per cent, and

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more rapidly than the recent growth in kerosene consumption[5]. Needless to say, such drastically differing views on changes in the relative importance of fuels in the country make the rational design of national policy an impossibility.

In general, estimates of kerosene consumption for household uses, and its trend over time, are more reliably known because sales information at the national and regional levels are available. This information shows a current level of 0.6 - 0.7 liters per household per day. Total sales between 1970 and 1979 grew at an annual rate of 10.4 per cent, much faster than population growth in the same period, and almost twice as rapidly as the annual growth of GDP in the same period (approximately 5.6 per cent).

Survey data show levels of household consumption in rural areas to be considerably higher than shown by sales information. In one recent study based on surveys carried out in West Java by CSIS[6], average consumption per household, while varying within a wide range, depending upon locality and household income, was noted at 1.7 liters per day. Another recently completed survey, carried out by Weatherly and Arnold, also showed kerosene consumption to be higher than the national average[7].

This points to the existence of large regional variations

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in the importance of kerosene as a domestic fuel. The last two mentioned estimates were based on careful measurement over several months. Even allowing for seasonal variations which might account for some variance, it is likely that the observed levels in survey data are indicative of much higher consumption in particular regions than the national average.

The regional sales data allow a preliminary analysis of per capita variations among regions, but only in the broadest terms. Since Java accounts for 75 per cent of sales and 65 per cent of the rural population, its per capita consumption is higher than in the outer islands. The actual reasons for regional variations can be only speculatively assessed. A plausible view is that kerosene consumption is affected by variations in regional income.

Recent studies of national kerosene consumption, based on historical sales information between 1970 and 1979, show that well over half the growth in total kerosene sales of 10.4 per cent per year can be accounted for by changes in per capita income. The balance of this very rapid growth is probably due to the relative change in kerosene prices in the period, which in real terms, declined at an annual rate of about 7 per cent each year[8] However, there is no confirmation of such behavior at the level

of sub-regions to clarify the nature of the relationship between household income and kerosene consumption, other than the information contained in SUSENAS' information from household budget surveys[9], which shows predictably that household income and expenditure on kerosene are positively related.

Since kerosene consumption is primarily a rural phenomenon[10], it can be speculated that factors other than income can affect the relative importance of kerosene in different regions. These factors might include local physical endowments of woodfuels, or the pattern of labor availability and its allocation to household tasks such as a fuel collection.

While it is possible to arrive at an estimate of aggregate kerosene consumption, and, to some extent, analyze its trend over time, there is much less evidence on how kerosene is used in the rural household, especially in relation to other traditional fuels. The available information allows alternative judgments about the use of kerosene as a fuel for cooking and for lighting. From survey data, the fraction of total kerosene sales used for cooking and lighting has been estimated by Strout to be 40 and 60 per cent. S. Hadi's estimates for roughly the same period are 80 and 20 per cent. Such inconsistent views make it very difficult, if not impossible, to evaluate the impact of selected national policies.

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For instance, there is much evidence to show that the very rapid growth of kerosene consumption is tied to a national policy of providing subsidies to consumers through controlled prices for petroleum products, at great national economic cost (direct costs to the national treasury have been calculated to be about $630 million, with real costs to the economy much higher). One can claim that these subsidies benefit richer families more than they do the poorest sections of the population. Data from national budget surveys carried out by SUSENAS show that kerosene purchases account for only 6 per cent of the poorest households. These households, the lower 40 per cent of the income ladder, apparently consume only 20 per cent of all kerosene sold(11).

However, a consistent national picture of regional variations in this overall pattern is not available. If kerosene is more important as a cooking fuel than as a fuel for lighting as suggested by S. Hadi's estimates, then the removal of kerosene subsidies will undoubtedly have a more serious impact than is commonly assumed. The collection of national data on a consistent basis becomes imperative in order to evaluate an issue such as this.

C. Methodology of the Present Survey

C.1 Analytical Framework

The methodology developed for the rural household energy

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survey was intended to result in a simple, and cost effective questionnaire, which could be used at a later time in a nation-wide survey, allowing consistent regional comparisons. The methodology also was designed to allow for uncertainty in the quality of the data, and the use of information from secondary sources, while retaining the ability to absorb new and improved data as these become available.

Another main consideration was to have an analytic approach capable of highlighting the structural composition of current energy demand, in relation to different types of fuels used, "end uses" (cooking, lighting, transport, etc.), and allowing a simulation of the impact of income growth, technology changes and fuel substitutions in the future. And, finally, it was deemed important to adopt an information-systems approach in which data on the rural sector are seen as only one component of a larger body of energy demand data that will be collected and maintained over time.

The present survey shares a number of concerns with the earlier work we have cited; we have focused on the consumption of fuels. Previous studies, by contrast, emphasized the supply-side effects of current consumption, especially with respect to fuelwood. The interrelationships between fuels have been largely neglected

in previous work, with the notable exception of the above-mentioned efforts of CSIS, and of Weatherly and Arnold.

The chosen analytical approach utilizes a modification of the Reference Energy System (RES) framework which has been widely used to analyze national energy options. The principal feature of the RES approach is the integration of a set of estimated energy demands, energy conversion technologies, fuel allocations and energy resources into an overall energy supply-demand balance, at the sectoral, regional and national levels. For a view of the energy system as a whole, the RES approach requires information about the details of demand by end use, and efficiencies with which each demand is satisfied by each fuel.

An additional requirement guiding the choice of methodology is a need for a projection technique using a simple econometric estimation procedure in which household fuel demands are related to a set of explanatory variables, such as the income and demographic composition of households, cooking habits, supply-side influences such as the availability of wood and other collected fuels and relative prices. If the statistical analysis reveals a strong relationship between the explanatory variables and the level of household fuel demand, the estimated relationship from survey data can be used to predict fuel requirements, based upon alternative

assumptions about changes in the set of explanatory variables.

There are some well-known problems to be overcome in the use of such a projection approach. The choice of explanatory variables (i.e., "specification" of the model) is often extremely difficult, especially when the explanatory (or "independent") variables are themselves systematically related in some unknown way. Furthermore, the use of cross-sectional data collected at a single point in time to predict changes over time is subject to numerous criticisms. The essential predictive relationships can quite readily change over time. Therefore, it is always preferable to use "pooled" cross-sectional data, collected over a sufficient period of time (several years, at least) when a projection model is to be developed. A much more fundamental criticism at the methodological level is that econometric techniques of projection are often inappropriate to the analysis of socio-economic phenomena in developing countries. In settings where "non-market" forces, such as tradition and caste status, are important determinants of group behavior, a more qualitative approach may be more appropriate. In principle, complex models can be built to take into account this multi-layered set of influences that affect the behavior of rural groups. In practice, however, the data requirements (and hence, the costs) of such

complex models are so enormous as to severely reduce their utility to policy-makers.

With these limitations in mind, the methodology adopted in the present study placed emphasis on the data for the much simpler RES similation approach. However, sufficient data categories have been included to allow the specification of very simple log linear regression equations to analyze variations in the pattern of energy demand among the households sampled[12].

The regression analysis will be completed in a future phase of the present study. The results presented in this report focus on profiles of fuel consumption in the RES format. But it is important to recognize that the methodology of the survey was constructed to allow this important further analytical step. This step will eventually contribute towards a more complete understanding of patterns of household energy use presented in the RES format.

C.2 Data Collection Procedures and Scope of Data

The categories of data collected in the survey are shown in Table 2. A fixed interview technique with a questionnaire, combined with field measurements of fuel consumption, was utilized. The questionnaire focused on three categories of information:

(a) household characteristics and income-related information,

Table 2

Principal Data Collected

I. HOUSEHOLD CHARACTISTICS

Income-Related Information

1. Family Size & Composition

2. No. of Persons Eating Meals at Home

3. Family Income from:
   - __wages (cash)
   - __wages in kind
   - __other income(cash)
   - __other income(in kind)

4. Land Ownership, Area Farmed, Cattle Ownership.

5. Transport Requirements by Principal Mode

II. FUEL DATA (from Recall)

1. No. of Fuels used & Type
   - __collected fuels
   - __purchased fuels

2. Fuel Collection
   - __sources
   - __labor required per week (in time)

3. Fuel prices
   - __by type

4. Electricity Use
   - __source
   - __fuel used for local generation
   - __no. of persons using shared generator.

5. Seasonal variations for each fuel used:
   - __estimated use per month in:
     - __months of some use
     - __months of high use
   - __number of months of use
   - __high use
   - __some use

III. FUEL MEASUREMENT OF COOKING AND LIGHTING FUELS

1. Cooking Fuels

   Solid Fuels
   - quantity used in weight, day 1, day 2.

   Liquid Fuels
   - quantity used in liters, day 1, day 2.

   Number of Persons fed
   - day 1, day 2.

2. Lighting (Kerosene)
   - quantity used day 1, day 2.

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Table 2
(continued)

IV. DEVICE DATA from direct observation & recall, by type of device (cooking, lighting & appliances)	V. LOCAL CHARACTERISTICS OF FUEL USE (Village level data from observation and interviews)	VI. SECONDARY DATA DATA FROM PUBLISHED SOURCES OR INTERVIEWS
_ Number owned	1. Fuel Prices	_ Fuel content of wood species & agricultural wastes by weight
_ Size characteristics if applicable	_ kerosene	_ device conversion efficiency
_ Full consumption rate if applicable or available	_ wood	_ agroeconomic characteristics (wages by occupations & agricultural characteristics of region, water requirements_
_ Weekly fuel consumption if applicable	_ charcoal	
	2. Main Energy Using Establishments	
	_ schools, churches etc.	
	_ commercial establishments	
	_ types of fuels used by end used	
	3. Fuel Supply Issues	
	_ sources of purchased fuel	
	_ export of fuels	
	_ uses of agricultural waste for purposes other than fuel	
	_ shortages, if any	
	_ deforestation	

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(b) fuel consumption based on the recall of respondents, and

(c) information on energy-using devices.

Each category of data collected served a particular purpose in the analysis:

(a) Data on Household Characteristics: The primary purpose of the information on households and income-related characteristics of the household was to allow a comparison of energy consumption patterns among households at different levels of economic well-being and to examine these differences according to the major uses of fuels.

(b) Fuel Consumption Data: Based on the recall of respondents, the questionnaire sought information on the types and quantities of various fuel uses. Of particular importance was the information on how traditional fuels are collected, and their sources. This information was used as a cross-check on field measurements, and used to relate the observed level of fuel consumption to the particular characteristics of local fuel supplies. The information on seasonal variations was necessary for purposes of computing an annual level of fuel consumption from the observations during field measurement.

(c) Data on Energy-using Devices: This information was required primarily to determine the level of electricity consumption,

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based on the numbers and capacities of devices present in the household. In the case of other fuels, estimates provided by the respondents on the weekly use of devices allowed a cross-check of field measurements. Lastly, the information collected on devices is important in projecting possible effects of changes in technology or utilization practices.

(d) Local Characteristics of Fuel Use and Secondary Data for Analysis: Each university team was called upon to gather background on economic activity and energy utilization at the community level. Also included were data on local species of wood, and information about supply conditions. This information was combined with other data from published sources to convert physical quantities of fuel to energy units. Price data, particularly for kerosene, were also collected.

C.3 Field Measurement Procedure

An important requirement of the field work involves the field measurement of daily fuel consumption for cooking and lighting. Measurement occurred on three consecutive days in each household to permit an estimate of consumption over a 48-hour period.

During a pretest of the questionnaire, it became apparent that as many as ten fuels may be stockpiled (in small amounts) in the homestead for use as cooking fuels. This fact influenced

the field approach adopted in the actual survey. Given the limitations imposed by the pilot scale of the study and the time and manpower allotted to field work, a comprehensive measurement of all cooking fuels was ruled out. Instead, households were required to preselect a particular fuel for use during the measurement period, based on household preference and availability.

A stockpile of the selected fuel was measured by the interview team, sufficient to cover at least a full day's consumption for cooking. The daily rate of cooking fuel consumption was estimated at the end of each 24-hour period by noting changes in the stockpile. (Households were required to record changes in the stockpile through collection or purchasing during the measurement period to allow accurate consumption estimates.)

Kerosene consumption was measured in a similar way by measuring liquid stock on hand, including the contents of stoves and lamps, at the start of each 24-hour period.

C.4 The Sample

In principle, sampling for a national or regional survey can be approached in a number of alternative ways. A multi-step, stratified sampling approach is applicable when the target population is very large. In Indonesia, given its large rural population and wide variations in economic and physical characteristics, stratified

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sampling would be appropriate. The proper approach in sampling design would be to select criteria for sampling that would capture the major differences in regional characteristics. These may include upland or lowland agriculture, variations in physical location that influences energy consumption such as topographical differences, variations in biomass resources, and economic variation among regions based on per capita income, income distribution, landholding, or the pattern of rural industry. Another question to be faced in sampling design includes the decision to use a random or purposive approach. If the purpose at hand is to understand the dynamics of household energy consumption among various socio-economic groups, it is often useful to use a purposive rather than a random approach[13].

The choice of households to be included in the present survey did not employ a systematic sampling design that took these factors into consideration due to limitations of time and resources. Since the survey was designed as a pilot study, a pragmatic view required the use of an existing sample frame.

The sample of households was randomly drawn from the list of rural census blocks defined in the SUSENAS survey, ca ied out in January 1980. The lists were made available by BPS. The sample for the current study is a subsample of the SUSENAS national survey

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carried out in January 1980. Each census block covered from one to five Kabupatans (districts). This sampling procedure was guided by the need to limit field work to a one-month period, within regions defined by considerations of accessibility. One hundred households were randomly selected within each of eight census blocks contiguous to the eight university locations. The total sample consisted of an initial 800 households. As Table 3 shows, the final sample, after sorting for enumeration errors, was reduced to 793. This procedure had the advantage of eliminating the expensive task of assembling a sample frame. In addition, it will allow a future comparison with energy and income data collected in the BPS survey. This will be particularly important in revising estimates of household income, which in the present survey design were based on a very simple approach using respondent recall and reported occupational structure.

The limitations of this sampling procedure should be kept in mind when considering the results. The estimates of 'regional' patterns of consumption are, strictly speaking, reliable only for the selected Kabupatans (districts) in which the survey was conducted. (This assumes, of course, that the SUSENAS sample is representative.)

Since the sample was not drawn to represent a cross-section

Table 3

Distribution of Households by Income Group

Province	Income Group (Rupiahs)			Total
	Less than 228,000	228,000-480,000	Greater than 480,000	
N. Sumatra (Medan)	12	52	42	106
W. Java (Bogor) 1	28	31	40	99
W. Java (Bogor) 2	16	31	51	98
W. Java (Bandung) 3	50	29	23	102
C. Java (Semarang) 1	57	25	9	91
C. Java (Jogjakarta) 2	42	26	31	99
E. Java (Surabaya)	26	33	31	90
S. Sulawesi (Ujungpandang)	30	36	32	98
All Regions	261	263	259	783

Table 4

Districts Surveyed in Each Province and Participating University

University	Province	Kabupatan District
Universitas Sumatera Utara, Medan (USU)	North Sumatra	Deli Serdang
Lembaga Penelitian Hasil Hutan (LPHH), Bogor	West Java	Bogor
Institut Pertanian Bogor (IPB), Bogor	West Java	Bogor
Institut Teknologi Bandung (ITB), Bandung	West Java	Bandung
Universitas Diponegoro (UNDIP), Samayang	Central Java	Semarang Demak Kendal
Universitas Gajha Mada (GAMA), Jogjakarta	Central Java	Jogjakarta Sleman Bantul Kulonprogo Gunung Kidul
Institut Teknologi Surabaya (ITS), Surabaya	East Java	Surabaya Lamongan Sidoarjo
Universitas Hasanuddin (UNHAS), Ujungpandang	South Sulawesi	Gowa Marcos

Total Number of Households: 783

of income groups among the households of each district, the approach to disaggregating the sample according to household income employed an 'ex poste' approach. Survey data on the reported occupational structure and reported annual income (in cash and in kind) of each household were examined. The observed rank distribution of income for all 783 households was the basis for defining three income classes of equal size. The highest income group was defined as the income range of the top third of the distribution, the middle income group as those in the range of income of the next third, and the low income group as those in the income range of the lowest third.

D. Results

D.1 Fuel Demand

The pattern of fuel consumption for domestic uses in the average sampled household is shown in Table 5 according to fuels and end uses. On average, among all regions studied, the annual consumption of all fuels for cooking and lighting amounted to 6.99 b.e.e. per household. This is equivalent to a per capita consumption of 1.33 b.o.e. per year.

Wood for cooking is the primary component of domestic energy consumption accounting for about 70 per cent of the total.

Table 5

Annual Fuel Demand
(Barrels of Oil Equivalent)
(Average for all regions - 783 households)

Fuel/End-Use	Per Household	Per Capita
Wood and Agricultural Waste for Cooking	4.92	.93
Kerosene		
Cooking	.93	.18
Lighting	1.14	.22
Total Kerosene	2.07	.40
Annual Fuel Demand	6.99	1.33

The annual per capita consumption level of 0.93 b.o.e. is equivalent to a level of approximately 0.88 kg per day.

Per capita kerosene consumption of 0.40 b.o.e. annually is equivalent to approximately 0.2 liters per capita per day. Kerosene is primarily a lighting fuel, accounting for 16.3 per cent of total energy demand. Kerosene use for cooking accounts for the remaining 14 per cent of annual fuel consumption.

D.2 Basic Energy Demand

Differences exist in the relative efficiency with which fuels are converted to light or to the effective heat delivered to the cooking pot. These differences are reflected in the calculation of basic energy demand shown in Table 6. On a per capita basis the useful energy consumed amounted to 0.17 b.o.e. annually. We have assumed the following relative efficiencies in the use of fuels:

Lighting kerosene:	0.18
Cooking	
Wood and agricultural waste:	0.06
Kerosene:	0.40

Viewed from the perspective of its share in total basic energy demand, kerosene, as shown in Table 6, emerges as the primary fuel, its share of 65 per cent being more than one and

Table 6

Annual Basic Energy Demand Per Capita
(Barrels of Oil Equivalent and Shares)

Fuel/End-Use	Basic Energy Demand	Shares (%)
Wood and Agricultural Waste for Cooking	0.06	35.3
Kerosene		
Cooking	0.07	41.2
Lighting	0.04	23.5
Total Kerosene	0.11	64.7
Total Annual Basic Energy Demand	0.17	100.0

half times the share of wood (35 per cent). The reason, clearly, is the higher efficiency of kerosene use as a lighting or cooking fuel.

D.3 Resource Requirements

There are efficiency losses in the process of refining, conversion and delivery through which fuels are supplied to consumers. Assuming an overall efficiency of petroleum refining and delivery of 0.88 in the production of kerosene, the total resource requirement is 1.39 b.o.e. per capita. This is shown in Table 7 (it is assumed that there are no conversion losses in the supply of wood and agricultural waste).

D.4 Income Variations in Fuel Demand

To explore variations in energy consumption among different income groups, the sample of 783 households was partitioned into three broad income groups. As Table 8 shows, high income households tend to consume only slightly more fuel than middle and low income households (8.36 b.o.e. compared with 7.83 and 7.37 b.o.e. for middle and low income households). On a per capita basis, fuel consumption declines, explained in part by the larger size of high income households, and in part by a marked tendency towards the substitution of kerosene for wood to satisfy cooking needs as income rises.

Table 7

Annual Per Capita Resource Requirements (BOE)

Fuel/End-Use	Resource Requirement	Assumed Efficiency of Resource Conversion and Distribution
Wood and Waste for Cooking	0.93	1.00
Kerosene		
Cooking	0.21	0.88
Lighting	0.25	0.88
Total Kerosene	0.46	0.88
Annual Resource Requirement	1.39	

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Table 8

Annual Fuel Demand (BOE) by Income Group

Fuel/End-Use	Low Income		Middle Income (Rp 228,000--480,000)		High Income (Rp 480,000+)	
	Per House	Per Capita	Per House	Per Capita	Per House	Per Capita
Wood for Cooking	6.12	1.43	5.69	1.12	5.41	0.92
Kerosene						
Cooking	0.28	0.07	0.93	0.18	1.41	0.24
Lighting	0.91	0.21	1.21	0.24	1.54	0.26
Total Kerosene	1.19	0.28	2.14	.42	2.95	0.50
Total Annual Fuel Demand	7.37	1.71	7.83	1.54	8.36	1.42

This is reflected in the sharp increase in kerosene consumption as income rises. The average high income household tends to consume five times as much kerosene as the average low income household. There is a corresponding decline in wood consumption.

A clearer comparison of how households differ with respect to the consumption of particular fuels appears in the information contained in Table 9. Here the relative importance of fuels according to their uses is shown for each income group. While cooking remains the dominant fuel-using activity among all income groups, the importance of wood in the total declines from 83 per cent to approximately 65 per cent in the case of low and high income groups. There is a corresponding four-fold increase in the importance of kerosene as a cooking fuel. Kerosene as a lighting fuel also increases in importance with rising income, but its growth is less sharp (its share in the total rising from 12 per cent to 18 per cent).

The relative importance of particular combinations of fuels and end-uses for each income group and for the sample as a whole is shown in Table 10. The distribution of households in each of six categories of fuel/end use show that the use of wood for cooking and kerosene for lighting is the single most important

Table 9

The Structure of Annual Fuel Demand by Income Groups (%)

Fuel/End-Use	Low Income	Middle Income	High Income
Wood for Cooking	83	72.7	64.4
Kerosene			
Cooking	3.8	11.9	16.9
Lighting	12.3	15.4	18.4
(Total Kerosene)	(16.1)	(27.3)	(35.3)
	100	100	100

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Table 10

Annual Basic Energy Demand Per Capita by Income Groups (BOE)

Fuel/End-Use	Low Income	Middle Income	High Income
Wood for Cooking	0.09	0.07	0.06
Kerosene			
Cooking	0.03	0.07	0.10
Lighting	0.04	0.04	0.05
(Total Kerosene)	0.07	0.11	0.15
Total Annual Basic Energy Demand	0.16	0.18	0.21

category; 59 per cent of all sampled households fall into this group. Households who use kerosene exclusively are a very significant 22.6 per cent of the total (category 5 and 6 in Table 10), followed in order of significance by households who use both kerosene and wood for cooking, and kerosene for lighting (category 3 in Table 10).

D.5 Income Variations in Basic Energy Demand

Differences in amounts of useful energy consumed among income groups have important policy implications. These differences emerge in Table 11 which shows a trend quite different from that of fuel consumption (seen in Table 8). Though per capita fuel consumption declines with rising income, the consumption of useful energy increases. This not unexpected result is accounted for by the relatively higher efficiency of kerosene use, which, as we have seen, plays a more important part in the consumption pattern of higher income households.

For projection purposes, these differences in energy consumption imply that a 10 per cent increase in basic energy demand among high income households requires almost twice as much oil as would be required by a similar increase in consumption levels among poor income households (A 10 per cent increase in basic energy requirements generates approximately .03 b.o.e. per

Table 11

The Distribution of Households
According to Fuel Mix & End Use

Income Group	Fuel Mix and End-Use Combinations*						
	1	2	3	4	5	6	Total
Low	3	211	18		24	5	261
Middle	1	150	61	1	54	5	263
High	5	102	52	2	76	22	259
Total	9	463	131	3	145	32	783
% of Total Sample	1	59	17	.4	18.5	4.1	100

* Note:

1 - Wood for cooking
2 - Wood for cooking, kerosene for lighting
3 - Wood and kerosene for cooking, kerosene for lighting
4 - Wood and kerosene for cooking only (no lighting)
5 - No wood, kerosene for cooking, kerosene for lighting
6 - No wood, kerosene for cooking only

capita additional oil resource demand compared with .06 b.o.e. in the case of low and high income households, respectively.

D.6 Regional Comparisons

The comparative view provided by the survey of the pattern of energy use among regions is one of striking differences in the level and composition of fuel consumption. There are some underlying similarities as well.

Most obvious among the similarities is confirmation of the trends already noted for the sample as a whole. Fuel demands per capita fall, and basic energy demands rise with rising income in most regions. Wood is everywhere the primary fuel though its use declines in absolute and relative amounts among higher income households. For middle income and high income households in all regions, however, kerosene provides the larger share of useful energy needs for cooking. (North Sumatra and the Jogjakarta area of Central Java are exceptions.) But the similarities are overshadowed by the contrasts among regions, as Tables 12, 13 and 14 show.

There are very substantial differences in average fuel and basic energy demands. In the average household in Semarang, annual per capita fuel consumption is almost three times as high as in East Java (2.51 b.o.e. as compared with .91 b.o.e.).

Table 12

Regional Variations in Fuel Demand
(BOE Per Capita Per Year)

Province	Low Income	Middle Income	High Income	Average (All Households)
N. Sumatra	2.42	1.56	1.37	1.48
W. Java (Bogor)	1.36	1.11	.94	1.07
W. Java (Bandung)	1.60	1.38	.96	1.31
C. Java (Semarang)	2.57	2.59	2.33	2.51
C. Java (Jogjakarta)	1.15	1.42	1.43	1.34
E. Java	1.02	.94	.90	.91
S. Sulawesi	1.20	1.06	.99	1.02

Table 13

Regional Variations in Basic Energy Demand
(BOE Per Capita Per Year)

Province	Low Income	Middle Income	High Income	Average (All Households)
N. Sumatra	0.21	0.15	0.16	0.17
W. Java (Bogor)	0.12	0.14	0.16	0.15
W. Java (Bandung)	0.16	0.20	0.23	0.19
C. Java (Semarang)	0.20	0.35	0.38	0.26
C. Java (Jogjakarta)	0.09	0.11	0.23	0.11
E. Java	0.13	0.16	0.14	0.14
S. Sulawesi	0.12	0.14	0.22	0.16

Table 12

Regional Variations in Fuel Demand
(BOE Per Capita Per Year)

Province	Low Income	Middle Income	High Income	Average (All Households)
N. Sumatra	2.42	1.56	1.37	1.48
W. Java (Bogor)	1.36	1.11	.94	1.07
W. Java (Bandung)	1.60	1.38	.96	1.31
C. Java (Semarang)	2.57	2.59	2.33	2.51
C. Java (Jogjakarta)	1.15	1.42	1.43	1.34
E. Java	1.02	.94	.90	.91
S. Sulawesi	1.20	1.06	.99	1.02

Table 14

The Structure of Fuel Demand
By Fuel/End-Use & Income Group in Each Province
(% of Total Fuel Demand)

Fuel/ End-Use	North Sumatra	W. Java (Bogor)	W. Java (Bandung)	C. Java (Semarang)	C. Java (Jogjakarta)	E. Java	S. Sulawesi
Low Income							
Wood (Cooking)	83.5	84.0	81.2	89.6	87.0	58.8	75.0
Kerosene:							
(Cooking)	2.9	5.0	8.8	.7	.0	7.8	10.0
(Lighting)	13.6	1.0	10.0	9.7	13.0	33.4	15.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Middle Income							
Wood (Cooking)	76.9	68.0	69.6	69.5	84.5	52.2	66.0
Kerosene:							
(Cooking)	5.2	16.0	19.6	18.9	.0	20.2	17.0
(Lighting)	17.9	16.0	10.8	11.6	15.5	26.6	17.0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0
High Income							
Wood (Cooking)	69.3	52.0	38.5	60.1	76.9	55.6	40.4
Kerosene:							
(Cooking)	11.7	25.0	51.0	23.6	3.5	20.0	41.4
(Lighting)	19.0	23.0	10.5	16.3	19.6	24.4	18.2
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Differences in basic energy demand are almost as sharp. The differences are magnified when comparisons are made across regions for households at comparable levels of income. They arise from underlying differences in the relative importance of cooking in total fuel demand, and from differences in the proportion of kerosene in the total. Dependence on kerosene is highest in the regions of East and West Java, and in South Sulawesi. Among high income households, kerosene consumption is of relatively greatest significance in the Bandung region of West Java. Among low income households, those in East Java tend to rely most heavily on kerosene, where its use as a lighting fuel appears to be a much more significant component of total fuel demand than elsewhere.

D.7 Electricity Use

The consumption of electricity in the areas covered by the survey is limited by the low proportion of electrified villages. With the exception of South Sulawesi and Bandung, under 30 per cent of the villages in each region are served by electricity. The proportion of households reporting the use of electricity in any form was consequently a very small 8 per cent, with most of these in the high income group. A preliminary estimate of electricity consumption in each income group shows annual levels

of per capita consumption well below the 1 kilowatt-hour level. Average electricity use among households in each income group is illustrated in Table 15. We have excluded electricity use in the earlier estimates of fuel consumption for the reason that a full analysis of the collected data on electricity sources has yet to be completed. It is safe to assume, however, that the inclusion of centralized electricity use in the present sample will not significantly alter the relative composition of fuel demand among income groups, because of its infrequency of use.

D.8 Prices

The purchase of wood and other biomass fuels was reported in only a very small proportion of all the households surveyed. There is little evidence of large-scale commercialization of these fuels, although some households reported the availability of wood in local markets. By and large, wood remains a non-commercial fuel collected by family members who spend, on average, less than four hours each week gathering wood from gardens, fields and nearby forested areas. Prices, as reported by households (and confirmed by informal interviews conducted in each location by the survey teams), show considerable variation between regions and even within a given region, as shown in Table 16.

Table 15

Electricity Use - Preliminary Estimates

Income Group	No. of Electrified Households Villages	% of All Households	Annual Per Capita Consumption	
			KWH	BOE
Low	6	2	.18	.11
Middle	12	4	.21	.13
High	47		.82	.50
All Households	65	8	.42	.26

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Table 16

Average Fuel Prices
(Rp per Kg)

Region	Wood	Kerosene
N. Sumatra	13.6	57.8
W. Java	6.1	56.9
	15.7	62.3
	16.3	48.2
C. Java	18.0	57.2
	-	76.1
	15.2	59.4
C. Java	11.7	56.8
	10.7	59.7
	10.0	69.9
	9.5	53.5
E. Java	13.1	64.3
	-	53.3
S. Sulawesi	32.3	69.2
	16.0	75.9

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While commercial sales of firewood for domestic use are not widely reported, the use of wood in rural industries was reported in such industries as tile and brickmaking, food processing (such as the manufacture of cassava chips) and eating establishments. Prices reported in these instances were in a narrower range of Rps. 6 to 12 per kilogram.

Kerosene prices as shown in Table 16 also showed variation among the regions surveyed. The highest prices reported were in South Sulawesi and Central Java (Rp 76 per liter). To examine the relative importance of income and price in explaining observed variations in kerosene consumption a preliminary econometric estimation of income and price elasticities was attempted using observed levels of kerosene consumption, household income and prices paid as reported by each household. The estimated income elasticity of 0.40 and price elasticity of 0.45 did not appear to be statistically reliable. This suggests that there is considerable room for improvement in the reliability of the collected information on both income and prices.

D.9 A Comparison of Results

The annual levels of fuel consumption we have estimated from the survey data have been based on an approximate adjustment procedure to account for seasonal variations during the year.

The effects of seasonal variations are to raise slightly the levels of both daily kerosene and wood consumption.

The estimated level of kerosene consumption (on average, for all households after adjustment for seasonal variations) is 0.9 liters per household per day. This is considerably lower than the recent survey of rural households in West Java, carried out by C.S.I.S., where average consumption was estimated at 1.7 liters per household[14]. However, it is considerably closer to levels of kerosene consumption indicated by national sales data which puts average rural household consumption at a level of 0.6-0.7 liters per household each day. They are also close to the estimates of Weatherly and Arnold. Aggregating their results for Central Java, South Sulawesi and East Lombok, and adjusting them for purposes of comparison, kerosene consumption (in all 164 households studied by them) averaged .81 liters per household each day.

There is a noticeable tendency for most survey results to suggest levels of rural kerosene consumption considerably higher than those that can be derived from the data on kerosene sales. The present results share this feature with other recent studies, though the difference is narrower. However, for purposes of national energy planning, it is advisable to examine this difference

more closely. Survey results are often biased by their regional composition. The present study is no exception. Even among the regions covered by the present study we have made note of significant regional variations in both the composition of fuel demand and the absolute levels of consumption recorded for each fuel. In the case of kerosene, for example, the range was from a low of 0.51 (Central Java) to a high of 1.1 liters per household (West Java - Bogor). There were significant intraregional differences in consumption levels as well. (In contiguous sub-regions of West Java, the difference in kerosene consumption was 60 per cent.) Only larger and more regionally representative samples can clarify these regional variations to arrive at more reliable national estimates of fuel demand.

The recent surveys by CSIS and by Weatherly and Arnold show the presence of wide variation in wood consumption levels as well. This is confirmed also by the results of the present survey. The range of average household wood consumption in the present study was from a low of approximately 4 kilograms (East Java) to a high of 8.5 kilograms (Central Java) per day. The C.S.I.S. study in West Java found a range of 0.1 to 41.1 kilograms per day. Weatherly and Arnold reported for the regions of Central Java, South Sulawesi and East Lombok a range of

approximately 6.3 to 8.2 kilograms per day. The average level of wood consumption in the present study (for all households in all regions), 4.6 kilograms per day, is lower than these previous surveys (8.1 and 7 kilograms per day respectively, for the C.S.I.S. and Weatherly/Arnold studies). The meaning of these different estimates, as with the estimates of kerosene consumption, can be clarified only through more regionally comprehensive surveys. Variations in the level of wood consumption depend upon the penetration of kerosene as a cooking fuel, on income differences, and the availability of wood and biomass fuels, all of which vary widely from region to region.

D.10 Policy Issues

We have referred to the variability and uncertainties attached to the results of these surveys. On the other hand, the EPFD survey employed the broadest national sample to date and highlighted several key policy issues.

(a) Kerosene Consumption: The importance of kerosene consumption in total energy for domestic uses is represented by its dominance in per capita basic energy demand. The significance of kerosene is confirmed not only by its importance in basic energy demand, but also by the very high proportion of households who use the fuel for some portion of their energy needs:

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99 per cent of all households in the present sample. In fact, a substantial 22 per cent of all sampled households used kerosene as the exclusive domestic fuel.

Policy alternatives to reduce the rapid growth of kerosene demand must be formulated in the face of such concrete evidence of its widespread use. Since it is apparent that in the regions covered by the present survey, kerosene is important to both lighting and cooking requirements, attempts to reduce the growth rate of its use require consideration of specific technological options. There are few alternatives to its use as a lighting fuel, in the absence of centralized or decentralized rural electrification strategies. As a cooking fuel, its displacement implies a substantial increase in the demand for biomass fuels. While the survey did not indicate the presence of severe shortages of biomass fuels (primarily wood), the scattered evidence from other studies suggests that there is the potential for severe degradation in the biomass resource base of many rural areas of the country. For policy design, the implication is that any efforts to limit the use of kerosene in rural areas should be accompanied by a substantial effort to examine ways of guaranteeing the efficient use of biomass resources.

(b) <u>The Relative Importance of Income and Price on</u>

Fuel Consumption: The preliminary statistical analysis of survey data does not provide a firm quantitative basis for estimating the relative importance of income and price influences on the consumption patterns observed in the studied regions. There is evidence enough, however, to conclude that the composition of fuel demand changes with rising income in favor of kerosene, and that kerosene demand is responsive to price changes. In addition, the information collected provides an adequate view of the degree of reliance on kerosene among low, middle and high income families. From this information, it is possible to conclude that kerosene is clearly of much more significance in high income than in low income households. (See Tables 9 and 10.) On the other hand, almost all (99 per cent) low income households reported the use of kerosene for some part of total needs. In the case of the average low income household, almost half of its useful energy requirements are provided by kerosene. It is quite likely that changes in its availability, either as a result of concerted policy efforts or of temporary disruptions in supply, will have a very broad impact on all segments of the rural population in the regions covered by the current survey.

E. Conclusions and Recommendations

The present pilot survey was successful in establishing a

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workable methodology for expanded effort in the future. The survey instrument and field procedures, with some refinement, can provide the basis for a more regionally comprehensive survey. Most important of all, all those who participated in the pilot study gained valuable experience in all the phases of carrying out energy surveys in rural Indonesia -- from preparation and training, to pre-testing, implementation and analysis. For future efforts, some recommendations in the form of guidelines based on the present experience are relevant:

E.1 Design of a National Survey

The sample for a national survey must, quite obviously, be considerably enlarged if estimates of national rural energy co.. ·ion are to be made. The most cost-effective approach to sampling will be to use an existing sample frame such as exists for the SUSENAS survey, carried out by BPS. For an expanded survey, adequate time must be devoted to sample design so that the sample can be truly representative of regional and income-related variations in energy consumption. The sample should be determined on the basis of the accuracy required of the results. The SUSENAS sample frame for 1980, which was utilized as a basis for the sample in the present survey, contains approximately 35,000 rural households. A ten per cent sample of these households should be a minimum

sample size.

While the pilot study contributed to the design of a working methodology and survey instrument, extension of the survey to the national level will require more adequate pre-testing than was possible within the scope of the present survey. Given the large scope for regional variations, the questionnaire design of the present survey should be pre-tested in locations other than those chosen for the pilot study. This effort will require a minimum effort of six months. The pre-test should focus on the areas which were not well represented in the pilot study.

An additional component of any national survey should involve a more extended time period for field work. Rural energy consumption is innately seasonal when traditional fuels are a large fraction of total fuel consumption. Patterns of fuel consumption tend to vary with the seasonal availability of fuels and with the allocation of labor within the households to seasonal tasks. It is advisable to extend the period of data collection to a full year covering all seasons. An extended survey should therefore include several visits per household, depending upon climatic and agricultural seasons in each region.

To improve the reliability of the results from the present sample, an intermediate step, prior to a full-scale national survey,

might involve a resurvey of a sub-set of households drawn from the present sample to be visited in the immediate year ahead. If properly timed, these visits might result in an improved evaluation of the importance of seasonal variations, and to reduce the uncertainty of the present estimates of annual consumption levels. Such a step is highly recommended because it will require minimal financial support. It is a practical step, as well, from the standpoint of implementation. There is clear interest among the university teams for follow-up activities, and there is now the necessary experience accumulated during the 1980 survey effort to allow adequate supervision and management by DJK.

E.2 Training

The week-long training workshop held in Jakarta in August 1980 was an important contributing factor to the success of the pilot study. It is advisable in the future, however, to separate the training of supervisory staff from the training of interviewers. In general, a distinction is required during training for a field survey between transferring an understanding of the methodology and purposes of a survey, and an understanding of field procedures and techniques. A two-phase training in which supervisors are first thoroughly grounded in the purposes of the survey and then are required to participate in the training of interview and measurement

teams is essential. For an expanded national survey, the time allotted to the training tasks will require considerably more than one week. As far as possible, the survey should utilize the services of professional interviewers rather than student help.

E.3 Supervision

The present survey was successful in part due to the enthusiasm of all participants, including the supervisory staff. An expanded national effort will require, however, a greater attention to the details of day-to-day management. For this purpose, it is recommended that the DJK undertake a review of the management experience gained during the pilot study. In particular, it will be important during a national survey to establish lines of communication between those in the field and all supervisory levels. This allows for a valuable exchange of field experience during implementation, and for corrective action when unanticipated difficulties arise during the course of field work, as is inevitably the case.

E.3 Data Analysis

The pilot study attempted to decentralize the tasks of analysis with a view to reducing data processing costs. Given the difficulties experienced in this effort, it is recommended that

in the future, regardless of the scale of the survey, all data analysis tasks from questionnaire screening, data reduction, keypunching and analysis be a centralized responsibility.

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Notes and References

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(3) Ir. Moh. Soenarjo Hardjodarsono, "The Situation of Wood and Agricultural Waste Products as Fuel in Indonesia at this Moment and its Prospects," Komite Nacional Indonesia Energy Conference, Jakarta, 1978.

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(5) Private communication, DJK staff, February 1981.

(6) Reported in Raymond Atje and James Tarrant, "Aspects of Rural Energy Use and Resources in West Java: A Preliminary Analysis of the Household Sector," in Energy Analysis in Rural Regions: Indonesia, Nepal and the Philippines, East-West Center, September 1980.

(7) John Arnold, "A Revised Methodology for Energy Demand Surveys," Workshop on Energy Assessment Methodologies, Jekyll Island, Janaury 1980.

W. Paul Weatherly, "Outline Environmental Assessment of the Rural Electrification Project", USAID, Jakarta, 1980.

(8) Malcolm Gillis, "Energy Demand in Indonesia: Projections and Policies", Harvard Institute for International Development, April, 1980.

(9) National Household Sample Surveys (SUSENAS), BPS, Jakarta, as referred to in A. Strout's, "The Demand for Kerosene in Indonesia". July 1978.

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(10) Basing himself on published national data, Strout has estimated that in 1976 about 63 per cent of kerosene sold was to the rural areas. (Unpublished communication)

(11) Ibid.

(12) These equations are of the well-known form:

$$\text{Log } E = a + b_1 . \text{Log } B_1 + b_2 . \text{Log } B_2 \ldots\ldots + b_n . \text{Log } B_n$$

where E may be household or per capita demand for a single fuel, or a group of fuels, and the explanatory variables $B_1 \ldots\ldots B_n$ are selected from a number of relevant economic or physical data (such as income or prices, or data on regional resources). The estimated parameters $b_1 \ldots b_n$ are interpreted as partial elasticities with respect to these selected variables. They show the relative responsiveness of energy demand to changes in these 'independent' variables.

Using the collected data on household income and kerosene prices, the following equation was estimated for 259 households from the group of 783 surveyed households (selected on the basis of households using kerosene, and reporting price data):

$$\text{Log } E = \underset{(1.61)}{-3.55} + \underset{(0.097)}{0.395} . \text{Log } B_1 - \underset{(0.224)}{0.454} . \text{Log } B_2$$

The combined influence of income (B_1) and price (B_2) explained only 7.5 per cent of the observed variations in household kerosene consumption ($R^2 = 7.5$) and the possible error in the estimated elasticities (shown by the standard deviations of the estimated constants in parentheses) was judged to be statistically too high to allow confident predictions of household kerosene consumption on the basis of this equation.

A number of possible explanations arise for the absence of a stronger relationship than estimated above. Most likely among these is that household income data collected are unreliable.

(13) Ramesh Bhatia, "Energy Survey Methodologies: A Framework for Measuring Non-conventional Energy Sources in Developing Countries," ESCAP/IEA Workshop on Energy Statistics, Karachi, October, 1980

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"HOUSEHOLD QUESTIONNAIRE"

SCHEDULE I

VILLAGE ENERGY SURVEY

Location: Census Block:

Village :

District :

Province :

Sample number :

Name of head of family :

Date of visits : first date

second date

third date

DIRECTORATE GENERAL OF POWER

MINISTRY OF MINING AND ENERGY

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Sample Number : Village :

Census block : District :

FUEL CODE

TYPE OF FUEL	NAME	CODE NUMBER
Firewood	1. _____ (local name)	0.1
	2. _____ (local name)	0.2
	3. _____ (local name)	0.3
	4. _____ (local name)	0.4
	5. twigs, branches, etc. - indicate type	0.5
	6. wood sha[illegible], sawdust	0.6
Bamboo		1.1
Coconut	1. Coconut fronds	2.1
	2. Coconut fibres	2.2
	3. Coconut husks	2.3
	4. Coconut palm trunks	2.4
	5. Others,(indicate)	2.5
Agricultural wastes	1. hulls	3.1
	2. paddy stalks	3.2
	3. other agricultural wastes (specify: such as cane pulp, peanut shells, corn or tapioca stalks, etc.)	
	a. _____	3.3
	b. _____	3.4
	c. _____	3.5
Charcoal	1. bought	4.1
	2. self-made	[illegible].2
		5
Liquid fuels	1. kerosene	6.1
	2. gasoline	6.2
	3. diesel oil	6.3
	4. alcohol	6.4
	5. coconut oil	6.5
L P G		7
Electricity	1. PLN	8.1
	2. Self-generated	8.2
	3. Other, non-PLN	8.3

FUEL CODE
Page 2

TYPE OF FUEL	NAME	CODE NUMBER
Battery	1. Dry Cells	9.1
	2. Wet Cells	9.2
Other	Specify: 1. _____	10.1
	2. _____	10.2
	3. _____	10.3

Sample Number:

Census Block:

Village:

District:

DETAILS ON COLLECTION - PRIMARY SOURCE, FIRST LOCATION

(Only for collected fuels)

Fuel Code *						
Fuel Name						
Source Code **						
Distance to Collection point (meters) ***						
Time of travel to collection point (minutes) ****						
Amount collected in one trip (local units)						
Amount collected in one trip (kg)						
Time required to collect above amount (minutes)						
Frequency of collection per week						
Time between collections (days)						
Who usually collects *****						

*) Fuel Code bakar (see fuel code)

**) Source Code:
1 = purchased and carried home by household/purchaser
2 = purchased and delivered to household
3 = collected in the yard
4 = collected in garden
5 = collected in fields
6 = collected in forest
7 = collected elsewhere

***) Usual distance

*****) Person Collecting:
1. adult male
2. adult female
3. children (under 12)

****) If transport is used, indicate what type (bicycle, cart, etc.)

Sample Number:

Census Block:

Village:

District:

DETAILS ON COLLECTION - PRIMARY SOURCE, SECOND LOCATION

(Only for collected fuels)

Fuel Code *						
Fuel Name						
Source Code **						
Distance to Collection point (meters) ***						
Time of travel to collection point (minutes) ****						
Amount collected in one trip (local units)						
Amount collected in one trip (kg)						
Time required to collect above amount (minutes)						
Frequency of collection per week						
Time between collections (days)						
Who usually collects *****						

*) Fuel Code bakar (see fuel code)

**) Source Code: 1 = purchased and carried home by household/purchaser
2 = purchased and delivered to household
3 = collected in the yard
4 = collected in garden
5 = collected in fields
6 = collected in forest
7 = collected elsewhere

***) Usual distance

*****) Person Collecting: 1. adult male
2. adult female
3. children (under 12)

****) If transport is used, indicate what type (bicycle, cart, etc.)

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Sample Number:

Census Block:

Village:

District:

DETAILS ON COLLECTION - SECONDARY SOURCE, FIRST LOCATION

(Only for collected fuels)

Fuel Code *						
Fuel Name						
Source Code **						
Distance Collection point (meters) ***						
Time of travel to collection point (minutes) ****						
Amount collected in one trip (local units)						
Amount collected in one trip (kg)						
Time required to collect above amount (minutes)						
Frequency of collection per week						
Time between collections (days)						
Who usually collects *****						

*) Fuel Code bakar (see fuel code)

**) Source Code: 1 = purchased and carried home by household/purchaser
2 = purchased and delivered to household
3 = collected in the yard
4 = collected in garden
5 = collected in fields
6 = collected in forest
7 = collected elsewhere

***) Usual distance

*****) Person Collecting: 1. adult male
2. adult female
3. children (under 12)

****) If transport is used, indicate what type (bicycle, cart, etc.)

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Sample Number:

Census Block:

Village:

District:

DETAILS ON COLLECTION - SECONDARY SOURCE, SECOND LOCATION

(Only for collected fuels)

Fuel Code *						
Fuel Name						
Source Code **						
Distance to Collection point (meters) ***						
Time of travel to collection point (minutes) ****						
Amount collected in one trip (local units)						
Amount collected in one trip (kg)						
Time required to collect above amount (minutes)						
Frequency of collection per week						
Time between collections (days)						
Who usually collects *****						

*) Fuel Code bakar (see fuel code)

**) Source Code: 1 = purchased and carried home by household/purchaser
2 = purchased and delivered to household
3 = collected in the yard
4 = collected in garden
5 = collected in fields
6 = collected in forest
7 = collected elsewhere

***) Usual distance

*****) Person Collecting: 1. adult male
2. adult female
3. children (under 12)

****) If transport is used, indicate what type (bicycle, cart, etc.)

Sample Number:

Census Block:

Village:

District:

UNITS OF MEASUREMENT AND PRICES

FUEL / EXPLANATION	No.: Name	No.: Name	No.: Name	No.: Name	No.: Name	No.: Name	No.: Name	No.: Name	No.: Name	No.: Name	No.: Name	No.. Name
SOLID FUEL - local unit of measurement												
- equivalent in Kg.												
- purchase price/local unit of measurement												
- highest prices/local unit of measurement												
- highest prices/local unit of measurement												
LIQUID FUEL - local unit of measurement												
- equivalent in liter												
- purchase price/local unit of measurement												
- highest prices/local unit of measurement												
- highest prices/local unit of measurement												

4/2

Sample Number:

Census Block:

PATTERN OF CONSUMPTION OF FUEL

Village:

District:

Code and name of fuel	Present Use													Past Use		
	Month of use (circle months in rows corresponding to level of use in one year.													Consumption of fuels in months of highest use. Insert also the unit of measurement used - e.g., loads/months, liters/month, etc.	Past Use (**): higher = 2, same = 1, lower = 0	How many years ago did high use begin?	Reason for switching from this fuel. ***)
_____	highest (*)	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				
_____	highest	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				
_____	highest	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				

For notes, see page 12

Sample Number:

Census Block:

PATTERN OF CONSUMPTION OF FUEL

Village:

District:

Code and name of fuel	Present Use													Past Use		
	Month of use (circle months in rows corresponding to level of use in one year.													Consumption of fuels in months of highest use. Insert also the unit of measurement used - e.g., loads/months, liters/month, etc.	Past Use (**): higher = 2 same = 1 lower = 0	How many years ago did high use begin?	Reason for switching from this fuel. ***)
_____	highest (*)	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				
_____	highest	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				
_____	highest	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				

For notes, see page 12

Sample Number:

Census Block:

PATTERN OF CONSUMPTION OF FUEL

Village:

District:

Code and name of fuel	Present Use: Month of use (circle months in rows corresponding to level of use in one year.												Consumption of fuels in months of highest use. Insert also the unit of measurement used - e.g., loads/months, liters/month, etc.	Past Use: Past Use (**): higher = 2, same = 1, lower = 0	How many years ago did high use begin?	Reason for switching from this fuel. ***)
_____	highest (*)	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				
_____	highest	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				
_____	highest	1	2	3	4	5	6	7	8	9	10	11	12				
	medium	1	2	3	4	5	6	7	8	9	10	11	12				
	none	1	2	3	4	5	6	7	8	9	10	11	12				

For notes, see page 12

*) "Highest" in this case means: months when this particular fuel was used more frequently than the average.

**) "Past" means three or more years ago.

***) "Reasons for switching fuel:

1 = family is larger
2 = family is smaller
3 = harder to find
4 = easier to find
5 = other fuel used
6 = other household devices earlier
7 = more devices now
8 = higher income now
9 = lower income now
10 = shorter collection time now
11 = longer collection time now
12 = other

Sample Number:

Census Block:

Village:

District:

FUEL USES

Fill in with 0 if not used: 1 if used

Fuel Code	Cooking for Sale	Cooking for Family	Lighting	Ironing	Space Heating	Drying	Others	
							1	2

Notes "others" includes - use in household industry such as workshop firing bricks or tiles and other similar activities

Sample Number:

Census Block:

REASONS FOR USING FUELS

(*) Indicate reasons using numbers corresponding to code below

Village:

District:

Fuel / Use		Cooking	Lighting	Ironing	Space Heating	Drying	Other
No. Code	Name						

*) Reasons:
1 = easy to use and relatively cheap
2 = fuel has preferred characteristics
3 = can be used in relatively cheap devices
4 = no other alternative
5 = used to it
6 = easier to use

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Sample Number: Village:

Census Block: District:

DEVICE CODE FOR FUEL USE

Type of Use	Fuel	Name of Devices	Code Number
Cooking	- Wood and agriculture waste	Hearth, specify:	
		1 _____	001
		2 _____	002
		3 _____	003
	Charcoal	Charcoal Stove	004
	Kerosene	Kerosene Stove	005
		Kerosene Pump Stove	006
	Alcohol	Alcohol Stove	007
	Gasoline	Stove	008
	LPG	Stove	009
	Electricity	Electric Stove	010
	Other	Specify: 1 _____	011
		2 _____	012
Lighting	Kerosene	Petromax	101
		Lamp	102
		Small lamp	103
		torch	104
	Coconut oil	Coconut Oil Lamp	105
	Alcohol	Alcohol Lamp	106
	Electricity	Incandescent Bulbs	107
		Neon/fluorescent	108
		Battery Lights	109
	LPG	LPG lamp	110
	Wax	Candles	111
Others		Ironing	201
		Radio	202
		Fan	203
		Car	204
		Motorcycle	205
		Tractor	206
		Generator	207
		Electric motor	208
		Pump	209
		Other devices	
		1_____	210
		2_____	211

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Sample Number:

Census Block:

FUEL-CONSUMING DEVICES

Village:

District:

Device Code							
Principal Fuel Used							
Number of these devices used							
Capacity							
lenght of use each day, (minutes; distance, in case of vehicles)							
Rate of fuel use (liters/km; liters/day)							
Other fuels used with this device, if any							

Note: If two or more devices of different capacities exist, use separate column; e.g., if three sizes of light bulbs (40W, 60W, 100a) use 3 columns, one for each size.

Sample Number:

Census Block:

FUEL-CONSUMING DEVICES

Village:

District:

Device Code							
Principal Fuel Used							
Number of these devices used							
Capacity							
lenght of use each day, (minutes; distance, in case of vehicles)							
Rate of fuel use (liters/km; liters/day)							
Other fuels used with this device, if any							

Note: If two or more devices of different capacities exist, use separate column; e.g., if three sizes of light bulbs (40W, 60W, 100a) use 3 columns, one for each size.

Sample Number:

Census Block:

FUEL-CONSUMING DEVICES

Village:

District:

Device Code							
Principal Fuel Used							
Number of these devices used							
Capacity							
lenght of use each day, (minutes; distance, in case of vehicles)							
Rate of fuel use (liters/km; liters/day)							
Other fuels used with this device, if any							

Note: If two or more devices of different capacities exist, use separate column; e.g., if three sizes of light bulbs (40W, 60W, 100a) use 3 columns, one for each size.

Sample Number: Village:

Census Block: District:

ELECTRICITY AND BATTERY USE

Electricity Source	PLN	Local Utility	Self Generated	Wet Cell	Dry Cell
Source used					
Year of since first Use					
Fuel code for self-generated electricity					
Quantity of fuel used each week					
Number of occupants in all houses, if electricity is connected and used by more than this household alone					

Note: *) write [1] if used

and [0] if not

483

No. Sample :

Village :

Census Block :

District :

KEROSENE CONSUMPTION MEASUREMENTS

FIRST VISIT - Date: _____

SECOND VISIT - Date: _____

Use	Observation	Result of Observation								
Cooking	Amount measured prior to use (in first visit)									
	Amount after use (measured in 2nd visit)									
	Additions to fuel (units added in liters)									
	Total use									
	How many times was a meal prepared between the two visits?									
	Total number of persons eating each time	1	2	3	4	5	6	7	8	
Lighting	Measurement before use (first visit)									
	Amount after use (second visit)									
	Amounts added in litres									
	Total use									

No. Sample :

Village :

Census Block :

District :

MEASUREMENT OF SOLD FUEL CONSUMPTION

FUEL CODE _____

Visit	Activity	Amount
1	Measurement Total amount of available fuel	
	Total amount of fuel set aside for use	
2	Total amount of fuel set aside for use	
	Amount added to solid fuels set aside	
	Amount taken from fuel set aside	
3	Total amount of fuel set aside for use	
	Amount added to solid fuels set aside	
	Amount taken from fuel set aside	

Visit	Number of people eating at each meal								
2	Number of people eating at each meal	1	2	3	4	5	6	7	8
3	Number of people eating at each meal	1	2	3	4	5	6	7	8

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"HOUSEHOLD QUESTIONNAIRE"

IDENTIFICATION AND ECONOMIC CHARACTERISTICS
OF HOUSEHOLDS

SCHEDULE II

IDENTIFICATION AND ECONOMIC CHARACTERISTICS OF HOUSEHOLDS

No. Sample :

Census Block :

Village :

Subdistrict :

District :

Province :

Interviewer

1. Name :
2. University/Institute/Organization :

DIRECTORATE GENERAL OF POWER

MINISTRY OF MINING AND ENERGY

No. Sample : Village :

Census Block : District :

Identity of the Respondent

Visit	1	2	3
Name			
Age			
Sex			
Education *			
Status within the family **			
Social status ***			

Fill in:

* 1. Illiterate
2. PBH Type of School
3. SD " " "
4. SLP " " "
5. SLTA " " "
6. SM " " "
7. Sarjana College

** 1. Head of family
2. Wife/Husband
3. Child
4. Brother
5. Relative
6. Other person in dwelling

*** 1. Non government employee
2. Government employee

No. Sample :

Census Block:

LIST OF PERSONS STAYING IN HOUSEHOLD AND INCOME FROM EMPLOYMENT

District:

Village :

No.	Name	Status in Household	Sex	Age	Education	Work	Income			Notes (name of in kind payment)
							in money		in kind per year (physical units)	
							monthly	no. of months per year		

* 1. Head of family
2. Wife/Husband
3. Child
4. Relative
5. Other person in dwelling

** 1. Illiterate
2. PBH Type of school
3. SD " " "
4. SLTP " " "
5. SLTA " " "
6. College

*** 1. Does not work
2. Skilled worker (carpenter, chauffeur, repairman, etc.)
3. Agricultural labor
4. Government employee
5. Work in private office
6. Factory labor
7. Professional (lawyer, doctor, engineer, accountant etc.)
8. Other (specify)

No. Sample : Village :

Census Block : District :

INCOME FROM SELF-EMPLOYMENT

(in the last year)

	Yearly income		
	In money	In kind	In Rupiah
Agriculture			
- Rice			
- Second crop			
- other (most important)			
Livestock products			
- Beef			
- Milk			
- Eggs			
- Live animals			
Fish			
Household industry			
Trade			
- store,			
- restaurant			
- market			
Rental of land			
Rental of things			
- house			
- car			
- animals			
- money credit			
- other			
Other			
- barber			
- wood peddlar			
- repairman			

No. Sample : Village :

Census Block : District :

AGRICULTURAL PRODUCE IN ONE YEAR

Name of Crop	Total Yearly Production in local units	Amount Sold in local units

Equivalent of local units in Kg

1.
2.
3.

No. Sample :

Village :

Census Block :

District :

USE OF AGRICULTURAL LAND

Operated Area / Type of Farming (By Irrigation)	Amount owned (in local units)	Amount rented-out (in local units)	Amount of land rented-in, or share-cropped (in local units)	Unused land (in local units)	Total amount of cul-tivated land (in local units)
Irrigated Acreage					
Unirrigated Acreage					

Equivalent of local units in M^2

No. Sample :

Village :

Census Block :

District :

OWNERSHIP OF LIVESTOCK

Type	Number Owned Male	Number Owned Female	Number Owned Young
Water Buffalo			
Cows			
Pigs			
Goats, sheep			
Other, specify			
1. _____			
2. _____			

No. Sample :

Village :

Census Block :

District :

HOUSING

Ownership of house ☐

a. owned ☐

b. rented ☐ rent per year

c. mortgaged ☐

Observations

Walls \ Roof and Floor	Roof					Floor					
	Tiles	Corrugated	Shingle	Thatch	Other	Earth	Wood	Bamboo	Plaster		Other
Masonry											
Half masonry											
Board/wood											
Woven bamboo											

Dimensions of house ☐

a. less than 20 m^2 ☐

b. 21 - 40 m^2 ☐

c. 41 - 60 m^2 ☐

d. 60 - 80 m^2 ☐

e. greater than 80 m^2 ☐

4944

No. Sample : Village :

Census Block : District :

PERSONS EATING IN HOUSEHOLD

No.	N a m e	How many times eating in one week	
		Meals cooked in household	Meals cooked outside household
A	Family members		
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
B	Non Family Members		
1			
2			
3			
4			
5			

No. Sample :

Census Block :

MOTORIZED TRANSPORT NEEDS

HOUSEHOLD MEMBERS

Village :

District :

	Mode of transport	Bus	Minibus	Van	Motorcycle
A	Number of persons who traveled last week *				
B	Distance traveled for trips				
C	**				

* If the number of persons traveling make more than one trip, include total trip in the calculator.

** Number of household members

F A C E S H E E T

HOUSEHOLD AND FAMILY INCOME DATA

I Family data

Size of family

Number of children

Average age

Family members who eat at home (weekly)

Non family members who eat at home (weekly)

Total average number of meals per person

Average number of meals per person eaten outside home

II Yearly family income (rupiah)

Total money wage income

Total money non-wage income

Total other income in money

Total non money income

TOTAL YEARLY INCOME

III Use of agricultural land and income in 1 year

Size of cultivated area

	Hectares

Name of crop	Size of planting this year (hectares)	Level of production in 1 year (rupiah)	Level of production sold in 1 year
1.			
2.			
3.			

IV. Livestock

Number of water buffaloes

Number of cows

Number of pigs

Number of goats

Other

V. Size of floorspace (square meters)

VI. Transport

Most frequent (from page 9, line A)

Average total kilometers each person each week - most frequently used.

FUEL DATA

I. Number of type of fuel used

Collected fuels

Purchased fuels

II. Collected fuels

Source (Enter fuel code)	Main Source		Secondary Source	
	1st location	2nd location	1st location	2nd location
1.				
2.				
3.				
4.				
5.				

Amount and labor times required

Fuel Code	Total amount collected weekly (all sources and places) in Kg.	Weekly labor time and amou- t collected for each type of labor from all locations					
		Male		Female		Children	
1.							
2.							
3.							
4.							
5							
6.							

III. Price of fuels (purchased)

Fuel Code			
1.			
2.			
3.			
4.			
5.			

IV. <u>Electric supply</u>

Self-generated

Fuels used

Amount of fuel/week

Number of persons using such generaor together

4999

V. Measurement of fuel use

Cooking (solid fuel)

Fuel Code

Amount used between visits 1 & 2

Amount of mealtimes between visits 1 & 2

Amount used between visits 2 & 3

Amount of meal times between visits 2 & 3

Cooking kerosene

Fuel Code

Amount used between visits 1 & 2

Amount of mealtimes between visits 1 & 2

Amount used between visits 2 & 3

Amount of meal times between visits 2 & 3

Lighting (kerosene)

Fuel Code

Amount used between visits 1 & 2

Amount used between visits 2 & 3

VI. **Devices**

Device Code	Fuel Code	Other Fuel Used	Amount of Devices Owned	Measure/Capacity

Rate of use of fuel	Unit of Measurement	Amount work/ week	Unit of Measurement

VII. Seasonal Variations & Fuel Use (see fuels-puchased and collected)

Full Code from Page 1	End Use From Page 12	Reasons for using this fuel from p. 11 For each end use, indicate (2 boxes, on g

Fuel Code	Number of years since first use	Reasons for change, if any. Enter up to 6 reasons

UNIVERSITY TEAM - SUMMARY DATA SHEETS

To be filled in by University Team

Summary (for all 100 households)

I. Income/Land Ownership

Total households divided into three groups by income and three classes of land ownership

Land Ownership

Rupiah Income	0 - 1,99 Hectares	1 to 2 hectares	2 hectares or more
0 - 149,999			
150,000 - 249,999			
250,000 and higher			

(Total of households in all boxes should be 100)

II. Consumption pattern of fuel in physical units

(1) * Average consumption of firewood per household and per capita and standard deviation.

(2) * Average consumption of waste per household and per capita and standard deviation

(3) ** Average consumption of kerosene per household per capita and standard deviation

(4) *** Average consumption of electricity per household per capita and standard deviation

(5) Average consumption of other fuels: - charcoal
- diesel, gasoline

*) (1) and (2) are based on three groupings of information for the questionnaire:

a) collection details
b) seasonal variations (patterns of fuel use)
c) measurements

**) (3) based on:

1) seasonal variations (Patterns of fuel use)
2) use of fuel devices
3) measurements

(4) based on information on device use and information on device capacity.

III. See following page

	AVERAGE CONSUMPTION				
Income (Rp.)	Firewood per household/ per capita (kg) SD*	Agricultural Waste per household/ per capita (kg) SD*	Kerosene per household/ per capita (lt) SD*	Electricity per household/ per capita (watt) SD*	Other Fuel (charcoal, diesel, gasoline, etc.) SD*
0 - 149,999					
150.000 - 249.000					
250.000 dan lebih					

*) SD = Standar Deviasi

**) cross out unneeded category

"ANNEX - EXCERPTS FROM UNIVERSITY TEAM REPORTS"

A. INSTITUT TEKNOLOGI BANDUNG (BANDUNG, WEST JAVA)

Village Observation

1. Langensari Village, Lembang Sub-district, a type of Self-work Village II

   a. Fuel supplies are:

      Firewood from fields or gardens.

      Kerosene, generally purchased in small shops

      - shopowners: village people

      - price : ± Rp. (50 - 60)/ltr.

      Electrical energy is not available.

   b. Fuel consumption:

      - collectively/group : none

      - home industry : none

      Villagers are in general farm labourers; and most of the village is inaccessible to vehicles.

      Family planning program can be applied to 10 - 15 percent of the village.

      Dry farming is the rule.

2. Jati Village, Banjaran Sub-district, a type of Self-work Village II

   a. Fuel supplies are:

      Firewood obtained from fields, and forests.

      Kerosene from village markets, and small shops.

      Price : Rp. (50 - 60)/ltr.

      Electrical energy is not available.

   b. Fuel consumption:

      Collectively : a mosque uses batteries for its loud speakers.

      Home industry : none

      Village income derived from farming. Being a remote village, it is inaccessible to vehicles; and also to family planning programs.

3. Biru Village, Majalaya Sub-district, a type of Self-work Village I

   a. Fuel supplies are:

      from : dry fields.

      a hill about 400 meters away from the village (Albasia wood and twigs).

      Kerosene : can be purchased in local small shops.

b. Fuel consumption : 24 textile power looms.

c. Electricity is available to about 25 percent of the village.

Transportation consists of two-wheeled vehicles.

Family planning programs are accessible to 15 - 25 percent of the village.

Education facilities:

- 3 Inpres Elementary Schools
- 3 Government Elementary Schools
- 1 Subsidized Islamic Elementary School
- 1 Subsidized Islamic Religious Elementary School

d. Village economy:

± 75 percent farm workers/textile factory laborers

± 25 percent farmers/rice field owners

4. <u>Panyirapan Village, Soreang Sub-district, a type of Self-work Village I</u>

a. Fuel supplies are:

Kerosene - the stalls or shops purchase from a dealer around Soreang sub-district about 2 kms away; from Pertamina tank-cars (5000 liters) once in 4 - 5 days against payment of Rp. 43, or Rp. 45,-/liter.

Retail price is Rp 60 per liter.

Firewood - directly obtainable from a nearby plantation of albasia wood, or purchased from shops at Rp. 600, - per "pikulan" (± 137 lbs.).

Diesel - no retail sale, and available only at RP. 65, - per liter.

Charcoal - is sold in plastic packages (of ± 0,25 kg.) at RP. 40, - per package.

b. Places that require a lot of fuel:

The only two hullers of the village, who both use Kubota machines.

Three privately owned stone-crushers that use dynamite. However, during this survey, the crushing was done manually as the SAFUJAGAT* Operation (OPSCAT) was being enforced by the Government at the time. Group activities are of private ownership; and manual labour is from the village.

c. Locations and other information:

The village is situated north of Soreang sub-district (about 2 kms. off the mainroad), and has quite good and clean streets.

Population:	male	: 2.550 people
	female	: 2.564 people
	total	: 5.114 people

* supression of firearms and explosives.

Consisting of 1.288 heads of family.

d. Break-up on skills, professions etc.:

Army	:	4 people
Government employees	:	46 people
Village authorities	:	9 people
Pensioners	:	36 people
Private employees	:	11 people
Farmers		1049 people
Traders	:	156 people
Laborers	:	89 people
University students	:	4 people
Students (school)	:	1582 people

Land Ownership:

Privately owned	:	wet fields	:	121 ha
		land	:	413,350 ha
		fishponds	:	0,750 ha
Village ownership	:	dry fields	:	1,645 ha
		cemetary	:	0,250 ha
Government land	:	EIGN	:	0,975 ha
		GG	:	0,925 ha

Buildings:

Education:

Elementary Schools	:	3 buildings
Islamic Schools	:	1 building
Courses	:	1 building

Buildings

Other:

Village Council Hall

Public Health Center (opening weekly)

Family Planning Center

Neighborhood office

Civil Defense post

Guard Post

10 mosques

37 prayer houses

Number of radios : 326 radios

TV sets : 20 sets

Village transportation - Bicycles, and a few motor cycles. Transport to Soreang mainroad is by dogcarts at RP. 50, -

The Village Unit Cooperative is inadequate and handles only the savings and loans of harvest yields. Fertilizers have to be purchased at sub-district level. Urea/TSP costs rp. 70, -/kg.

Family Planning Program - 463 use pills; 21 use IUD; other means are not favoured. Some people though sympathetic to the program, do not make use of the facilities available in the village.

5. Kopo Village, Soreang Sub-district, a type of Self-work Village II

a. Some difficulties undergone during the survey:

- inability of meeting respondents' members of family who generally are at work on rice fields.
- problems of communication.

b. Fuel supplies:

- cooking is by firewood collected from dry fields, and lighting is by kerosene sold in small shops or by retailers at Rp. 50, -/liter.
- wood and kerosene are easily available because of good transportation

c. The two privately owned rice-hullers of the village make use of solar energy.

d. Other information:

- of the population of 8120 people, 90 percent live by farming, either as farmers or as farm workers. The majority own their lands.
- water for domestic needs is from wells. Water supply for farming/ irrigation purposes is good. Electricity is not available.
- transportation within the village and outside is by mini-buses (colts) The fare to Soreang (± 3 kms. away) is Rp. 75,-/per head.
- Central Government Service:

  Family planning program - usually held in Soreang sub-district or through information at the Village Council Hall.

  Mass Guidance - fertilizers credits with the approval of the village head.

6. Kamasan Village, Banjaran Sub-district, a type of Self-Supporting Village I

a. Fuel is available at small shops. A kerosene distributor sells the kerosene at Rp. 50,-/per liter and there is no report so far about the difficulties in obtaining fuel.

b. Industrial use of fuel:

- four privately owned rice hullers use solar fuel.
- four roof-tile factories privately owned use firewood.
- one privately owned brick-factory uses firewood.

c. Means of livelihood: farming, trading

Home water supply: wells, wet fields, irrigation

Electricity supply : available

Transport within the village : dog-carts, colt minibus

Government programs : family planning, Mass Guidance, credits granted through Bank Rakyat Indonesia.

7. Kiangroke Village, Banjaran Sub-district, a type of Self-supporting Village I

a. Fuel supplies

1. Generally available at small shops or through dealers.
2. The existing kerosene dealer is P.T. Asia Saxta Motor. The price is Rp. 55,-/liter.
3. There is no report about difficulties in obtaining fuel.

b. Places with fuel consuming activities:

No.	Type	Total	Type of Fuel	Managed by	Capacity
1	huller	1	solar	individual	-

c. Other information:

1. Population of 5990 people - farmers, farm workers, laborers, traders.
2. Water supply is from:
   - field irrigation, and
   - 70 percent of the houses use PLN electricity.

   Transport outside the village is by:
   - colt, daihatsu, honda
3. Central Government Services:
   - Electricity
   - Mass Guidance, Mass Intensification
   - Family Planning

8. <u>Tenjolaya Village, Pasirjambu Sub-district, a type of Self-supporting Village I</u>

a. Fuel supplies - Retailers purchase either directly from PERTAMINA State Enterprise at Rp. 45,-/liter and sell for Rp. 50,-/liter; or to other retailers who then sell at Rp. 55,-/ or -Rp. 60, - per liter, depending on the distance they cover to make it available. The Pertamina agent is in Ciwidey, about 5 kms. away from the village.

Firewood - People collect from their gardens or dry fields; and rarely from the woods. It can be purchased at Rp. 750,- per "pikulan" (± 137 lbs.).

b. Fuel-requiring places - Three rice mills require solar fuel for their diesel machines. "Suka Tani" rice mill, that was visited, uses diesel machines BUKH G 105, 1970, 1 cylinder ex. Denmark, with an average fuel consumption of 1 liter/hour; and generally operates 12 hours a day. The mill employs two males and three females and generally produces 3 quintals rice a day. All rice mills of the village are privately owned.

An apple Plantation (± 4 HA), privately owned, uses generators both for the day's work and for its lighting from 18.00 - 23.00. A third fuel-consuming industry of the village manufactures roof-tiles and purchases firewood from local people at Rp. 4000,- per m3. It employs 5 workers and generally a worker produces 100 tiles a day.

c. Other information - The village is located ± 3 kms. north and of Ciwidey (the surveyed area is ± kms) and is off the mainroad and with poor streets).

Population:

male	3183
female	3385
total	6569

consisting of 1550 families

Means of livelihood:

Farm workers	1335 people
Industrial laborers	65 people
Service/traders	1817 people
Government employees/army members	±15 percent

Area break-up:

Wet fields	185 ha
Yards	365 ha
Plantation	450 ha
State forests	2500 ha

Water-supply is from wells while electricity is from PLN (Electricity State Enterprise), except in Plantations that have their own generators.

There is no public transport between villages because of bad roads and relatively short distances.

Authorities' Service -

Government Elementary Schools	:	3 schools
Inpres Elementary Schools	:	1 school
Islamic Elementary Schools	:	2 schools

Family Planning, Mass Guidance Programs and the Public Health Center are sub-district facilities available about 5 kms away from the village.

Participants of Family Planning program are about 300.

Social activities involve youth activities of sports (badminton, football, volleyball, pencak silat or a system of self-defense) and arts (calung music, reog dance, ketuk tilu dance).

Village Unit Cooperative has been established at the Kampong Organization level but does not run efficiently. A rice barn helps during the time of scarcity before harvest, and is a kind of saving and loaning cooperative on farm produce.

The use of electricity in this village consists of:

From PLN and Plantation which is totally around 20 percent of families.

47 television sets, 646 radios and 1 telephone.

9. <u>Cikoneng Village, Pasirjambu Sub-District, Self-Work Village</u>

Particularly with Sukatani Village, its remote location and accessibility only on foot, posed survey problems. During the rains, even vehicles can not get to the village.

a. Fuel supplies:

Kerosene is sold in small shops; firewood is collected from dry fields (bamboo garden) or the forest.

b. 90 percent of the village earns a livlihood by bamboo weaving sold to collectors who visit the village, or at Soreang. Farm produce is generally rice and second crops (sweet potatoes, cassava, and beans). Inter-village transport is through colt mini buses (to Ciwidev). The narrow paths of Sukatani village renders it inaccessible to motor-cars, and to the village office that is a long distance away (± 7,5 km).

10. Maruyung Village, Pacet Sub-District, First Self-Supporting Village

a. Fuel supplies:

1. Generally purchased from small shops or dealers.
2. The kerosene dealer is from Pertamina and charges Rp. 55-/liter. The wholesale price is Rp. 50,-/liter.
3. Fuel supply is hampered by badly damaged roads, and consequent poor transportation.

b. Fuel Consuming places/groups in the village

No.	Types of activities	Types of fuel	Managed by
1	Brick making	Firewood	Private entrepreneur
2	Crisp chip factory	Kerosene	Private entrepreneur
3	Fried soybean cake-making	Kerosene	Private entrepreneur
4	Diesel-powered electric generator	Solar diesel	State Electric company

c. Other information:

1. Of the total population of 12.067, 44.5 percent are male;

farmers	:	65 percent
traders	:	25 percent
employees	:	10 percent

2. Development of water and electricity supplies:
   - Electricity - since 1978, diesel-powered electric generator from the State Electric Company, provides to villages nearby Village Center (Sub-district center).
   - Water - irrigated from Citarum river
   - Vehicles outside of the village: motor vehicles (opelet, colt, daihatsu, kijang) and a few own motor cycles.
3. Central Government's Service:
   - Family planning program is quite successful (± percent of the women participate in it)
   - Mass Guidance involves the circulation of money of Rp. 2 million/season.

11. Andir Village, Pameungpeuk Sub-district, a type of Self-supporting Village II

a. People generally purchase fuel/kerosene from small shops. The kerosene agent is at Dayeuhkolot, and charges Rp. 45,-/liter.

b. Industrial activities are: Five roof-tile factories owned by local people; and the fuel used is bamboo. The two textile industries belong to Foreign Investment Company and Domestic Investment Company; and the fuel used is diesel.

c. Means of livelihood: farmers comprise 70 percent; factory and building workers 20 percent; traders, etc.

Water supply: - for houses : taken from wells

- for fields : taken from Bojongmalaka irrigation

Transport: within the village, bicycles; out of the village, dog-carts or colt mini buses.

Government's programs:

- Family Planning program gained appreciation from the Regent
- Mass Guidenace and Mass Intensification - combined with Dayeuhkolot
- Public Health Center - combined with Dayeuhkolot
- Small Investment Credits, "Candak Kulak" Credits, are given through local bank.

12. Parungserab Village, Pameungpeuk Sub-district, a type of Self-work Village V

a. Kerosene is easily avaiable at small shops, through two kerosene agents from Pertamina, who charge Rp. 42.50/liter.

b. There are no places/groups consuming much fuel in this village.

c. Farming is the chief means of livelihood (80 percent); and others are building workers, traders, etc.

Domestic water supply from wells; and fields obtain water from irrigation facilities.

Vehicles in the village: motor cycles and dog-carts.

Vehicles outside of the village: colt/honda, dog-carts, motor cycles.

Government programs, generally adequate, are: Family planning, Mass Guidance, Public Health Center (to be combined with Soreang).

d. Field areas measure 274.780 ha.

Yards measure 67.330 ha.

13. Lebak Muncang Village, Ciwidey Sub-district, a type of Self-supporting Village II

a. Fuel supplies:

Kerosene, widely used, is available at most small shops at Rp. 50.-/liter. One of the kerosene sellers supplied by a private entrepreneur in Ciwidey by tank-car sells at Rp. 46.50/liter.

Firewood, available only at a distance, is generally for cold days and purchased at Rp. 500,-/"pikul", and suffices for 4 - 5 days' cooking. Small low-income families consume only about 1 liter of kerosene for cooking. Firewood from yards is minimal.

Cooking-stoves were introduced about 2 - 3 years ago.

b. Fuel consuming places/groups:

Four rice mills use solar fuel.

c. Village livlihood:

Majority are traders and farmers; a few earn from fishery.

d. Village development:

Water	:	from wells, neither very deep or clean.
Electricity	:	Not available
Vehicles	:	There are not many within the village; and about 4 colt mini buses operating to Ciwidey at Rp. 150-/person.
Health	:	A Public Health Center at the Village Office functions twice a week.

14. Rawabogo Village, Ciwidey Sub-district, a type of Self-supporting Village I

Information on this village posed a problem. The respondents' were widely scattered (± 3 kms away); and was the only means of communication.

a. Fuel Supplies:

- kerosene obtained from small shops.
- firewood collected from dry fields/woods

b. Fuel consumption: In Bayund Bog village, a privately owned roof-tile factory uses husks and wood for fuel. In Legak Sala, a privately owned rice mill uses solar fuel.

c. The people generally live as farmers and farmworkers (a few run their farmlands)

Water supplies: obtained from water sources in "Tambak Ruyung" mountain for field irrigation, while water for houses is obtained from wells.

- Vehicles in the village and inter-villages are colt mini buses (some of them belong to village people).
- Government's Service: Family Planning Program in Ciwidey, Mass Guidance and Small Investment Credits.

15. Cikalong Village, Pangalengan Sub-district, a type of Self-work Village V

a. Fuel supplies:

Most people have used kerosene for cooking; a few use firewood, dry fallen branches and twigs, and bamboo collected from their yards or from Gunung Tiga mountain which is ± 10 kms away. Of the four kerosene dealers, two are "large" suppliers, provisioned with about 10 - 20 drums, refilled once or twice a month by tank-cars. The smaller dealers, supply capacity of about 4 drums each. They wholesale price from tank-cars is Rp. 44,-/ per liter and sold to retailers at Rp. 47.50 per liter; the price of kerosene for consumers at small shops is Rp. 50,- per liter.

b. Fuel consuming groups:

There are two rice-shedding machines and six rice mills. A group visited during the survey, used 2 diesel machines consuming 30 liters of diesel per day when in full operation; and the local price of solar is Rp. 65,-/ per liter.

c. Village Life:

People live mostly from farming and vegetable gardening. Water for houses is obtained from wells besides other clean water sources. There are a lot of public vehicles (Cikalong - Pangalengan, Cikalong - Banjaran - Bandung). Irrigation water supply is good. Electricity is enjoyed by only 0.20 percent of a total of about 1,700 families. A committee is being established for the installment of electricity at the village.

d. Government's Service:

Public Health Center	: 1
Birth Clinic/Mothers and Children Welfare Center	: 1
Family Planning Post	: 1

The village has about 700 TV sets, 2000 radios and 2 welding places.

16. Pangalengan Village, Pangalengan Sub-district, a type of Self-supporting Village II

Particularly Ranca Manyar Village.

Problems in collecting data:

- Most respondents are employees of PTP XIII and go home at 15.00.
- The place is quite far from Bandung.

a. Fuel supplies:

Kerosene is purchased at retailing shops at Rp. 70,-/liter.

Firewood is purchased in Pangalengan/village.

b. Fuel consuming places/groups of the village are:

Tea and quinine plantations owned by PTP XIII which use diesel/solar fuel and electricity supply from PLN in Lamajang.

c. Most people earn their living by planting cabbage, potatoes, squash, etc.; working as laborers in PTP XIII factories; and by breeding milch cows (they get credits from the Government).

Water is supplied from wells (1 well is used by 3 - 4 families). Baths are taken from source water channelled through small bamboos or small drains.

Inter-village means of transport is colt mini buses (the distance to the nearest town is ± 5 kms and the fare is Rp. 150-/ per person).

Public Health Center for village people is in Ciwidey while that for PTP XIII employees is in Kertamanah.

17. Cikasungka Village, Cicalengka Sub-district, a type of Self-work Village II

a. Fuel supplies:

Available at small shops. There is no kerosene dealer in the village. They have problems in getting certain types of fuel.

b. Fuel consuming places/groups:

No.	Type of groups	Total	Types of fuel	Managed by	Capacity
1	Rice Mill	7	Solar	private entrepreneur	-
2	Roof tile making	7	Firewood	private entrepreneur	4 m3/10000 pcs.
3	Brick making	13	Rice husks	private entrepreneur	450 kgs./ 2500 pcs.

18. Tenjolaya, Cicalengka Sub-district, a type of Self-work Village V

A. Village people purchase fuel/kerosene from small shops. There is no agent/dealer.

b. Eight home centers make crisp chips; and fuel used is kerosene. Each center

needs 0.5 drum of kerosene/day.

c. Means of livelihood:

Farm workers	1060 people
Farmers	825 people
Traders	228 people
Government employees	1250 people
Total	10.126 people

Water supply for houses is from wells; and fields are irrigated.

Electricity was introduced to the village in 1974-1975.

Inter-village vehicles are dog-carts, colt, honda, daihatsu.

Family planning program has been 15 percent successful.

Government's service is Small Investment Credits which were just introduced. There is no Cooperative, Village Unit Cooperative or Village Unit Committee.

19. Linggar Village, Rancaekek Sub-district, a type of Self-supporting Village I

Fuel supplies:

- generally purchased through small shops or dealers. The kerosene dealer of this village is PT Masum, who sells the fuel at Rp. 50,-/liter. The problems of obtaining certain types of fuel is poor transportation.

b. Fuel consuming places/groups

No.	Type of Groups	Total	Types of fuel	Managed by	Capacity
1	Chip crisp factories	2	kerosene	individual	-
2	Cassava chip factories	6	charcoal/ firewood	individual	-
3	Vonex weaving	7	electricity/ diesel	private	-
4	Rice Mills	6	solar	individual	-

c. Other information:

1. Means of livelihood:

Farmers	35%
Government employees	12%
Private employees	15%
Traders	3%
Cattle breeder	1%
masons	1%
farm workers	35%

Population: 10.119 people

2. Development of water and electricity supplies:

   - Irrigation, introduced in 1976
   - PLN electricity, introduced in 1978, of which 10 percent is for domestic use.

   Vehicles in the village: dog-carts; Inter-village vehicles are colt, honda, daihatsu, Kijang, opelet and buses (Garut/Tasik - Bandung)

3. Government's service:

   Family planning program (538 participants), Public Health Center, Mass Guidance and Mass Intensification. The target of Mass Guidance and Mass Intensification is 200 ha - Rp. 6.200.000- per season.

20. <u>Haurpugur Village, Rancaekek Sub-district, a type of Self-supporting Village I</u>

    a. Fuel is usually purchased at or through a private dealer who buys ±10 drums of kerosene, and sells at Rp. 50,-/liter. There are no problems in obtaining the fuel.

    b. There are no fuel-consuming places/groups.

    c. The people live by farming. When work in the fields is over, they go to towns to work as masons/bricklayers. Water-supply for houses is from wells. Fields are irrigated. Government's services include Family Planning Program and Public Health Center which usually run smoothly.

B. INSTITUT PERTANIAN BOGOR (BOGOR, WEST JAVA)

1. Characteristics of Agro-Economy

Planting season in all regencies is relatively the same. In the rainy season, rice is planted in the months of October through February. In the dry season, rice cultivation is limited to those sub-districts that are served by irrigation.

In all eleven sample villages, the use of fertilizers and pesticides is widespread. Only one village uses tractors for cultivation. Mechanized rice hullers were reported in use in 77 percent of the sampled villages.

2. Transportation in the Region

Four-wheeled motor vehicles were reported in use in 90 percent of sample villages. Motor cycles were used in all villages. Motorized transport is not new to the region, though it has not completely displaced traditional modes such as carts and two-wheeled horse-drawn carriages.

3. Fuel Prices

Average prices of fuels in the sub-districts of the region were reported as shown below:

Fuel Prices

Sub-district	Average price of firewood (Rp/kg)		Price of Kerosene (rp/lt)		Price of Charcoal (rp/kg)	
	Jan 79	Nop 80	Jan 79	Nop 80	Jan 79	Nop 80
Ciomass	000.0	000.0	30.0	55.0	160.0	175.0
Ciampea	10.0	12.5	25.0	60.0	000.0	000.0
Cigudeg	00.0	00.0	47.5	67.5	37.5	50.0
Cijeruk	00.0	00.0	40.0	60.0	125.0	125.0
Cisarua	00.0	00.0	-	60.0	-	50.0
Cimanggis	1500.0*	2000.0*	25.0	50.0	150.0	250.0

Note: * Rp/m^3

4. Energy Consumption by Government and the Commercial Sector

Kerosene or electric lights have been commonly used by government authorities or private bodies. Almost all shops/kiosks and food stalls use kerosene lamps for their lighting. Data on the use of electricity and kerosene lamps are not available.

Government authorities rarely seem to have their own cooking facilities or transportation means.

Table V-5 gives complete information on fuel consumption in 11 sample villages.

5. Fuel Supplies

Observation of the region shows that traditional fuel supplies are being strained, while oil prices are rising. In such a situation people tend to use a variety of biomass fuels obtained from various locations and sources. Firewood is rarely purchased.

C. UNIVESITAS GADJAH MADA (JOGJAKARTA)

1. Farming Area

Most selected respondents (88%) are workers in the farming sector, while the rest work as laborers, service sellers, etc. Farmers generally own their land which measures less than 1 HA on the average. However, the yields from their lands constitute their main source of income.

a. Land Cultivation:

The farmers of this survey cultivate their land traditionally, namely by applying inherited farming methods. For instance, cattle are still used to plough and rake rice fields prior to the planting season. The survey found instances of mechanized farming. However, it was noted that all farmers had used fertilizers, either manure or artificial. Pesticides were also frequently used.

b. Irrigation Problems:

Irrigation is an important factor in farming. In general the villages intersected by rivers, had irrigation channels. Whereas some villages, despite irrigation channels, still depend on rainwater. The surveyed villages in Gunung Kidul Regency, depend entirely on rain water. Of the twenty-eight villages surveyed, ton have irrigated fields, four have both irrigated fields and fields dependant on rainwater. The remaining fourteen villages entirely depend on rainwater.

c. Staple Crops:

The staple crop of both irrigated and non-irrigated fields is rice. The variety planted in wet fields is generally of IR 36 type; and Gogo rice in dry fields. Well irrigated fields can be planted twiece a year, while fields dependent on rainwater can only be planted once, namely in the rainy season. In the dry seasons, crops such as cassava, soya beans, peanuts, and corn are raised. In some villages in Kulon Progo Regency, farmers also grow onions and tobacco.

Some areas near Madukismo sugar factory are rented for sugar-cane plantation. The rental period is 24 months. Farmers generally plant rice in the months of January through April and second crops from May to August. For the months of September through December, irrigated fields are planted with rice, while poorly irrigated fields are planted with second crops.

d. Crop Productivity:

Average produce of various crops in Special Area of Jogyakarta is as follows:

Rice	57,20 quintals/ha
Corn	14,72 quintals/ha
Cassava	90,83 quintals/ha
Peanuts	8,28 quintals/ha
Soya beans	7,37 quintals/ha

The average produce of various crops in each regency surveyed can be seen in Table I.

e. Prices of various crops:

Prices usually vary according to the seasons. The lowest prices occur during the harvest season; and the highest during the time of scarcity before harvest. Price fluctuation of various produce, from the lowest to the highest, can be seen in Table 2.

f. Farmers' Income:

The sample survey of farmers' way of living shows that most of the rice yield siffices their daily needs - the rest of the rice yield is then sold.

The farmers' annual income depends very much on production output and the prices set on the sale of first crops.

Farmers generally get addtional income by selling garden produce such as in Turi sub-district, where they earn quite a lot from their salad gardens. In Sentolo and Wates sub-districts they earn extra income from their coconut gardens.

The workers hired for field cultivation are usually from the farmers' families/relatives. If such help is insufficient, other farm workers are called upon. Workers employed are males and adult females. The payment is in cash. However, in some surveyed areas, farm workers get their payment for certain types of work in the form of meals, drinks and the farm produce.

Table 3 illustrates the wages of different activities, and the difference in such wages that occurs because of varying work loans. For payment of wages in the form of money and farm produce, the value of the farm produce has been compensated.

Table 1

AVERAGE PRODUCTIVITY OF VARIOUS TYPES

OF CROPS IN SEVERAL REGENCIES

IN 1980

(KW/HA)

Types of crops	Regencies			
	Kulon Progo	Bantul	GunungKidul	Sleman
Wet field rice	47,58	52,09	29,0	50,48
Dry field rice	20,70	18,00	18,35	-
Corn	18,47	19,28	15,48	20,89
Cassava	102,28	170,52	74,39	141,13
Sweet Potatoes	56,02	159,41	34,38	86,57
Peanuts	9,29	12,02	5,09	5,47
Soya beans	5,82	12,82	7,63	11,17
	5,40	5,27	2,54	6,48

D. UNIVERSITAS HASANUDDIN (UDJUNG PANDANG)

GENERAL CONDITION OF RESEARCHED AREAS

1. Geographical location

The geographical features of South Sulawesi provincial area cover coastal areas, low plains and plateaus; and so the smaple areas selected for research contain such geographical features.

The researched areas comprise two regencies, i.e. Maros Regency and Gowa Regency. Maros Regency is situated north to the Ujung Pandang Municipality while Gowa Regency is south to the Ujung Pandang Municipality.

Having surveyed the geographical condition of the two areas, we can state that the researched areas in Maros Regency contain two coastal villages, spread over three Sub-district areas (Table II/1).

The researched areas in Gowa Regency boast of one coastal village, nine low-plain villages and three plateau villages, spread over seven Sub-district areas (Table II/1).

Table II/1

Classification of Sample Villages

based on geographical location

Regency	Sub-district	Name of Village	Geographical Classification
Maros	Maros Baru	1. Borikamase	Coastal Village
		2. Allepolea	Coastal Village
		3. Boribellaya	Low-plain Village
	Mandai	1. Allaere	Low-plain Village
		2. Hasanuddin	Low-plain Village
		3. Tompobulu	Plateau Village
	Camba	1. Campaniga	Plateau Village
Gowa	Somba Opu	1. Samata	Low-plain Village
		2. Sungguminasa	Low-plain Village
		3. Katangka	Low-plain Village
	Palangga	1. Bontoala	Low-plain Village
		2. Julubori	Low-plain Village
		3. Moncobalang	Coastal Village

Bontomarannu	1. Pakatto	Low-plain Village
	2. Timbuseng	Low-plain Village
Bajeng	1. Bontosunggu	Low-plain Village
Bontonompo	1. Bontolangkasa	Low-plain Village
Parangloe	1. Pattalikang	Plateau Village
Tompobulu	1. Rappolemba	Plateau Village
	2. Datara	Plateau Village

Table II/1 above shows that in the two regencies to be surveyed there are ten Sub-districts and twenty Sample Villages.

Geographically, there are:

3 coastal villages

12 low-plain villages

5 plateau villages

2. Sample Villages according to village typology classification:

Village typology classification is a norm of evaluation to assess the progress of a village. The classification and description and the spreading rate of sample villages with their typology is revealed in the following table II/2:

Table II/2

Sample Villages according to

Classification of Village Typography

Regency	Sub-district	Name of Village	Classification of Village Typology
Maros	Maros Baru	1. Borikamase	Self-help
		2. Allepolea	Self-supporting
		3. Boribellaya	Self-work
	Mandai	1. Allaere	Self-help
		2. Hasanuddin	Self-supporting
		3. Tompobulu	Self-supporting
	Camba	1. Cempaniga	Self-work
Gowa	Somba Opu	1. Samata	Self-supporting
		2. Sungguminasa	Self-supporting
		3. Katangka	Self-supporting

Palangga	1. Bontoala	Self-work
	2. Julubori	Self-work
	3. Moncobalang	Self-work
Bontomarannu	1. Pakatto	Self-work
	2. Timbuseng	Self-work
Bajeng	1. Bontosunggu	Self-work
Bontonompo	1. Bontolangkasa	Self-work
Parangloe	1. Pattalikang	Self-work
Tompobulu	1. Rappolemba	Self-help
	2. Datara	Self-work

It can be seen from Table II/2 that out of 20 sample villages, there are 4 self-help villages, 11 self-work villages, and 5 self-supporting villages.

3. People's Means of Livelihood:

The means of livelihood in the 20 sample villages can be seen in the following table (Table II/3).

It reveals that most people live by farming, except in villages nearer to towns to which people are lured for a living as traders or employees. In the coastal areas, fish breeding and fishing are further means of livelihood.

4. Sources and Supplies of Water in Sample Villages:

The daily needs of the 20 sample villages are supplied by ground water from shallow wells.

Rivers as a water source are found only in Boribellaya village and Tompobulu village. In addition, there is a village which has springs, i.e. Pattalikang village.

The description of sources and supplies of water in sample villages can be seen in Table II/6.

5. Government Programs in Sample Villages:

The existing government programs in sample villages can be seen in Table II/7.

The table reveals that the Family Planning Program has been adopted in all sample villages, while Mass Guidance (Bimas) and Mass Intensification (Inmas) programs do not exist in three out of these villages, i.e., in Tompobulu, Rappolemba and Datara villages, that are situated in the mountains.

Health facilities such as Public Health Centers (Puskesmas) and Clinics are found only in seven out of the twenty sample villages. They are in Allaere, Hasanudin, Tompobulu, Campaniga, Samata, Sungguminasa and Katangka villages.

E. UNIVERSITAS SUMATERA UTARA (MEDAN)

1. Farm Land Use and its Ownership and the Annual Yields

Viewed from its characteristics, and can be divided into two categories, i.e.: tilled land and owned land. Tilled land is tilled or cultivated, and can be privately owned or rented or borrowed from other people.

Data tabulation of tilled land can be seen in attachment 2.

The following facts are obtained from the data processing:

- Average width of land tilled by each family is 0,3175 HA.

  Deviation Standard: 0,3976 HA.

Data tabulation of land owned by each family can be seen in attachment 2.

- Average width of land owned by each family is 0,3268 HA.

  Deviation Standard: 0,4951 HA.

Based on respondent (family) grouping into three different types of income groups and three classes of land owners, the distribution of income groups over land ownership is as follows:

TABLE I: INCOME AND OWNERSHIP OF LAND

Land Ownership (HA) / Income (RP)	0,00-0,99 HA	1,00-1,09 HA	2 HA and more
000.000-149.999	7%	0	0
150.000-249.999	6%	1%	1%
250.00-and more	75%	7%	3%

2. Cattle and animal ownership

The cattle surveyed in this research is that which really belongs to the respondents and is not just entrusted or lent by other people.

Information obtained from the survey is that the types of cattled owned are: water buffaloes, cows, pigs, sheep and chickens.

Data tabulation of cattle ownership can be seen in Attachment 3.

3. House floor width and house ownership

The results of data tabulation and data processing show that the width of house floors occupied by village people (respondents) is as follows:

3% reside in houses measuring less than 20 m2.

36% reside in houses measuring from 21 to 40 m2.

39% reside in houses measuring from 41 to 60 m2.

17% reside in houses measuring from 61 to 80 m2.

5% reside in houses measuring more than 80 m2.

The average width of floow resided by each family is 47,485 m2.

Viewed from their characteristics, the occupied houses can be classified into three categories:

First: own property

Second: rented (contracted)

Third: lent (without paymant)

Percentage of respondents residing in houses categorized above is as follows:

- 60% reside in their own houses
- 2% reside in rented/contracted houses
- 38% reside in lent houses (without payment)

The result of survey and interviews with heads of villages reveal that the average house rent is Rp. 12.000,-per year.

The condition of dwelled houses gathered during the survey and its data tabulation are depicted in Table 2.

4. Transport

The survey reveals that transport, public and private, is fuel-driven: cars, buses, minibuses, motor-cycles, etc. Data tabulation of transport gathered during the survey can be seen in Attachment 4.

From data processing it is understood that:

- 18% of total respondents use public buses as their means of transport
- 1% of total respondents use private cars as their means of transport
- 7% of total respondents use public mini bus as their means of transport
  7% of total respondents use privately owned motor cycles as their means of transport
- Average distance to be covered by bus as a means of transport is 6,841 kms/week/person.
- Average distance to be covered by mini bus/opellet as a means of transport is 1,296 kms/week/person.

Appendix E

THE COAL POTENTIAL IN INDONESIA

M. D. Schlesinger

Consultant

January 2, 1981

ENERGY/DEVELOPMENT INTERNATIONAL
505 Main Street
Port Jefferson, N.Y. 11777

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SUMMARY

The needs for energy in Indonesia in the future are reasonably well known from many feasibility studies, estimates and projections. Because of the lead-times involved it is important to establish an active coal development program in Indonesia.

Carbonaceous resources are very large but generally of low rank in the coal classification. Thus, the material must be consumed within a short distance from the mine mainly because of its high moisture content and/or because of its low calorific value. A considerable amount of new electric power supply is needed in Java which makes the present project at Suralaya feasible. However, consideration should also be given to previous suggestions of energy centers near the source of fuel, in Sumatra and Kalimantan. This relocation could be coordinated with the transmigration efforts.

Peat is an immense source of energy which, until now, was not considered by anyone with whom I talked. The technology for its recovery and use is well developed in other parts of the world.

Indonesian development work on all coal resources should include more detailed exploration and such areas of coal research as sampling, analysis, coal chemistry, carbonization and combustion.

Major recommendations are as follows:

1. Establish research centers with a staff dedicated to the problems of coal utilization.

2. Explore in more detail the sources for future coal development. Sample collection and analytical data are needed.

3. Determine the products that can be made from available coal deposits. Concentrate first on forms of energy that can be integrated easily into the existing patterns.

4. Coordinate coal development through groups which 1) know the administrative procedures and 2) have the experience to apply the appropriate technology.

Adoption of these and other ideas would be based on the Indonesian administration's perspective in developing a sound technical base and having personnel become expert in coal technology.

INTRODUCTION

Indonesia is rich in coal. If the lowest ranks such as peat are included, the amount exceeds the most optimistic estimates of the past.

The amount of planning, discussion and thought already given to the introduction of more coal into the energy economy of Indonesia is impressive. Not only have technical personnel made significant contributions to the progress already achieved, but they have integrated the expertise from other countries. Cooperation with other countries is supported by mutual interests; for example, raw materials needed by those with technological know-how versus domestic needs for Indonesia. What Indonesia hopes to achieve in the period 1979/1980 to 1983/1984 is presented in Appendix I, a translation of the Mining and Energy Chapter of Repelita III. These plans and some other data presented here are known but are included for continuity and background.

Historically, modern Indonesia is a young country that has extensive resources but a relatively new technological base. The need for a competent infrastructure is recognized and it is developing rapidly as higher education turns out scientists and technologists capable of maintaining and improving the installed industrial complexes. Already, personnel who are experienced in petroleum technology are being transferred to work on coal. Their background provides a good basis for the transfer of technology to a related science where many similarities exist. In fact,

once the primary conversion of coal into a gas or liquid is completed, the downstream processing may be identical - distillation, hydrotreating, catalytic processing, etc.

Comparison is often made with other countries which have a larger coal component in their energy distribution, but they developed within other frames of reference, that is, different climates, natural resource distributions, and technological development. Population pressures did much to transform western societies from small rural, wood-consuming communities to urban centers that industrialized as the various "Ages" developed. Except in rare cases, it was the available energy source and the ingenuity of man that brought about changes that are now coming rapidly to Indonesia.

The current status of planning for the utilization of coal in Indonesia was reassessed recently for a joint meeting with representatives of the Federal Republic of Germany (1-20).* Organization of the seminar held from October 19-26, 1980, was under the auspices of the Agency for the Development and Application of Technology (BPPT), the Mineral Technology Development Center (PPTM), and the German Federal Ministry of Research and Technology and the Federal Ministry for Economy. One purpose of the seminar was to survey the German technologies that might be applicable to the utilization of Indonesian coals and to establish a long-term coal program. Another useful purpose was to review and

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* References are shown in parentheses.

update the coal resource evaluations already accomplished in Indonesia.

Alternative or supporting technology for the coal development program in Indonesia could come from many sources. Primarily, the program should develop from within and support the needs of Indonesia. In countries where coal is a major energy source, appropriate research is part of the ongoing national policy and goals and is designed to fit their indigenous raw materials and what the country will need in the future.

One of the problems recognized in Indonesia relates to the studies already made and those proposed. From an editorial in the Indonesian Times of December 1, 1980, I quote:

> "Minister Coordinator Suorno urged at the close of a seminar that the results of that seminar must not be kept in an ice box. He said that the results of many seminars were not followed up with practical application. Minister Coordinator Emil Salim also once disclosed his feeling of disappointment on the same matter.
>
> ...It seems we are only able to talk about a problem and fail to transform the results of discussion into action. ..."

This is an action report. The material presented is intended to provide some directions for work that must begin in the near future. Specific items are not all-inclusive but are my personal reactions to many hours of travel and discussions with administrators, engineers, geologists, chemists and other experienced personnel, listed in Appendix II A and B. It is well known that Indonesia could

consume all of its petroleum production within a few years if the projected rate of growth continues. There is a waiting list for all of the energy that can be produced. Oil provides a major source of needed foreign exchange as well as most of the non-wood energy. Only coal can fill the gap within a short time. A crash program in the face of an emergency will be costly and will upset the normal balance of trade. Furthermore, foreign credits could erode with time as inflation increases. It is time to grab a pick and shovel and dig into the coal program.

ACKNOWLEDGMENT

The efforts of the individuals who made my task possible are worthy of the highest praise. Their knowledge of the technology and the organization of the complex energy administration made visits possible to offices and field sites. Special credit goes to Endro Utomo, my counterpart, for whom I have the highest regard as an engineer and as a fine person. Our hours of discussion were always lively and informative. Yanti, who kept the office moving with pleasant efficiency even when the pressure of work was unusual, was also helpful.

It was gratifying to have open discussions with the personnel of the many organizations I visited. A picture of the energy situation emerged so rapidly that, in a short time, it was possible to reach a clear understanding of the problems facing Indonesia.

Thanks also are due to William Littlewood, US AID, Science and Technology Advisor, for the back-up arrangements that made the project possible. Last but not least there was Bill Schaffer who got me off on the right foot with his great love for and knowledge of Indonesia.

PURPOSE

Coal production is at a relatively low level at the present time but plans have been made for its eventual utilization on a large scale. Within the limits of the data available, the following factors were considered:

1. Resource base
2. Resource quality
3. Current projects
4. Proposed research and development efforts
5. Barriers to use
6. Recommendations

Subsidiary conditions related to these primary concerns include the availability of other forms of energy and the preferability of introducing coal or coal-derived products into the economy. A discussion of the above factors should be a guide to some of these important questions:

What is available to replace petroleum?

How should it be used?

What will be the impact of large-scale coal utilization on society and the economy of Indonesia?

Economics, per se, is beyond the purview of this discussion. Potential inputs such as biomass, geothermal, wind and solar energy are the subject of other parts of this Energy Planning for Development program.

The problem is to introduce coal into the market place on a large scale. New industries should base their energy needs on coal either directly or indirectly. A coal-derived fuel should be made available for domestic use to replace wood as should equipment for the proper combustion of the new fuel. Existing oil-fired boilers should be converted to coal or a coal-derived product, especially if the boiler is replaced for any reason.

Coal is defined as any carbonaceous material of plant origin that has undergone the coalification process - peat to anthracite.

WORLD COAL STUDY

Key industrial, government and academic energy experts from 16 major coal-using and coal-producing countries (including Indonesia), made a global study of the production, use and trade of coal. Coal is the only fuel seen as capable of filling the energy gap that will occur when oil production levels off, as expected in the late 1980 s. Nuclear and alternative sources of energy will not be sufficient to meet the world's growing energy needs (21). Some other conclusions of the World Coal Study were:

--Coal now supplies more than 25 percent of the world's energy.

--Economically recoverable reserves are many times those of oil and gas and capable of meeting future demands.

--Coal will supply one-half to two-thirds of the energy needs by the end of the century, about 7 billion metric tons compared to 2.5 billion tons this year.

--There is a need for prompt action by all concerned producers, consumers, public authorities and governments. Decisions must be made very soon because of the long lead-times required.

--Coal can be produced and used in ways that are safe, meet health standards and protect the environment.

--Coal is competitive in most locations and will become more so as the price of petroleum continues to increase.

--Coal technology is well established and is still improving.

--The capital required for the expanded use of coal is within the capacity of the existing finance system - about US $940 billion.

If actual Indonesian energy consumption data are plotted and extrapolated to 1984, the curves in Figure 1 are obtained. Petroleum supplies 90 percent of the non-wood energy demand and will probably continue to do so in the future. Consumption of oil in 1977 represents only about 25 percent of the production but by 1984, if the projection is correct, the percentage increases to about 40 percent assuming that production can be maintained at the present level of 585×10^6 barrels per year. A further extrapolation shows that all of the oil produced would be needed in Indonesia by 1993. If productivity of the oil fields declines, as it eventually will, total internal consumption will occur at an earlier date.

An alternative picture is possible if other energy sources are considered. Figure 2 shows what could happen when coal and other alternaitve energy resources are brought into the energy mix immediately. (See Appendix IV)

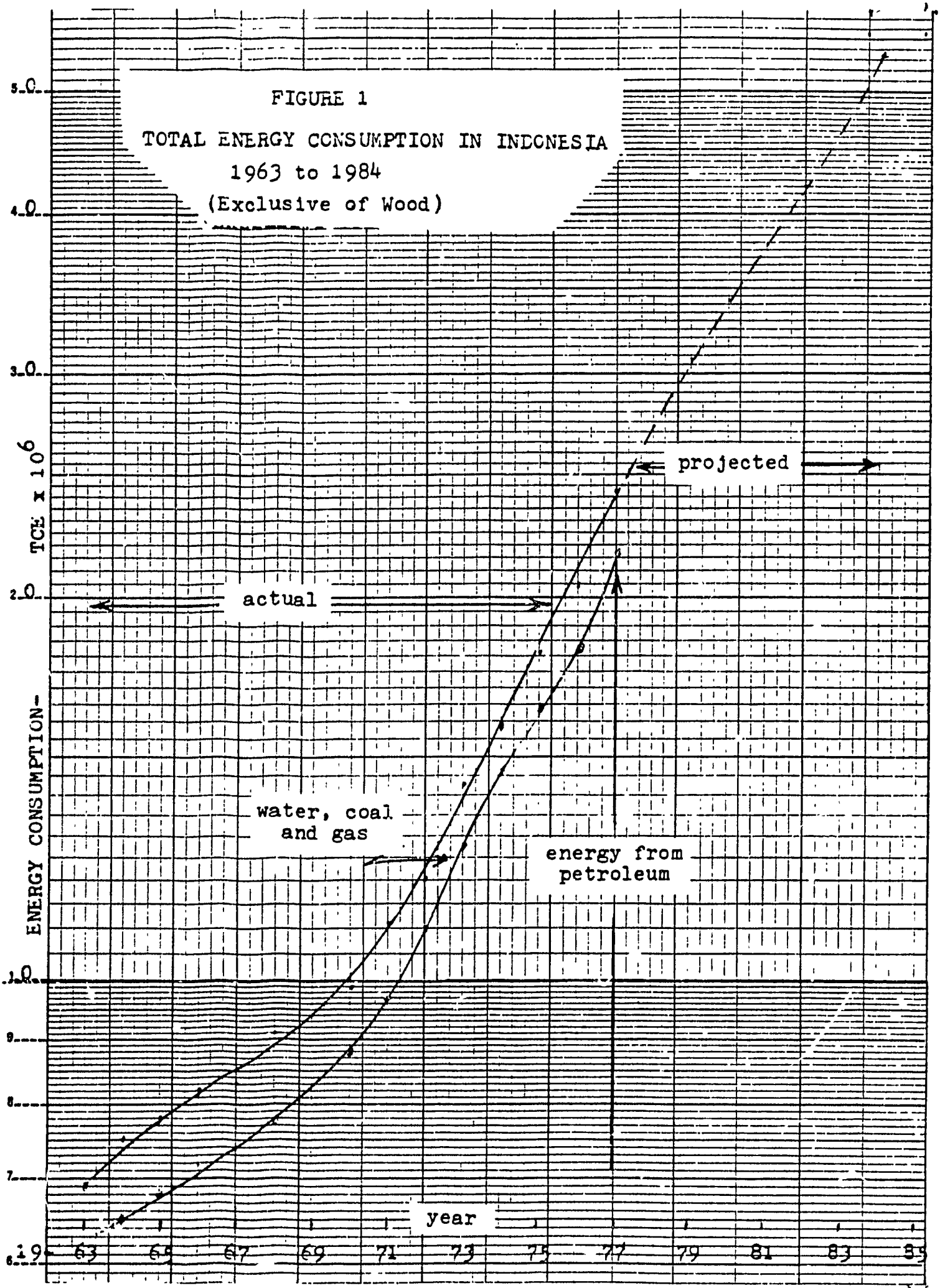
FIGURE 1
TOTAL ENERGY CONSUMPTION IN INDONESIA
1963 to 1984
(Exclusive of Wood)
ENERGY CONSUMPTION- TCE x 10^6
5.0
4.0
3.0
2.0
1.0
.9
.8
.7
.6
projected
actual
water, coal and gas
energy from petroleum
year
1963
65
67
69
71
73
75
77
79
81
83
85

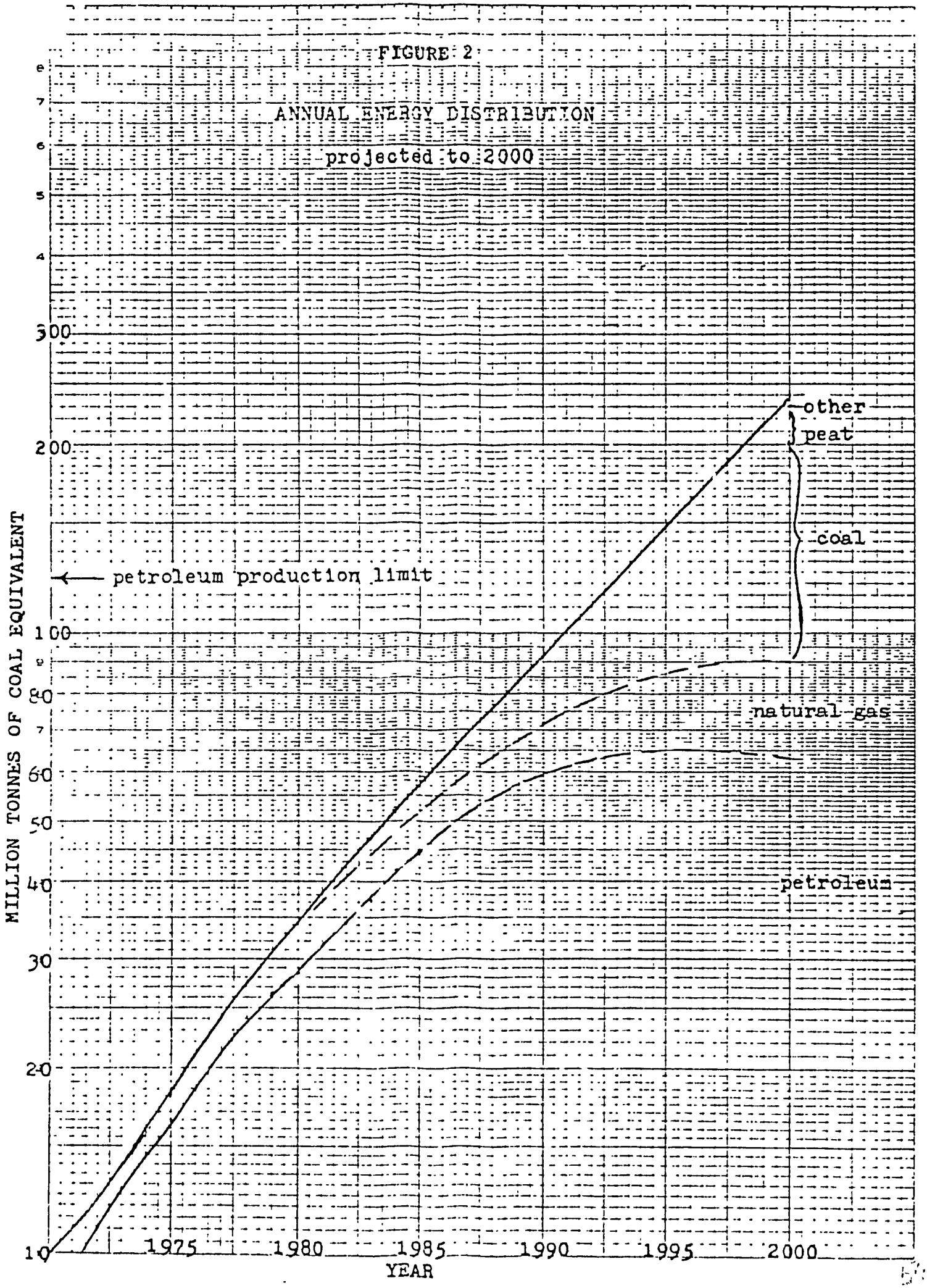
FIGURE 2
ANNUAL ENERGY DISTRIBUTION
projected to 2000
MILLION TONNES OF COAL EQUIVALENT
YEAR
10
20
30
40
50
60
70
80
100
200
300
1975
1980
1985
1990
1995
2000
other
peat
coal
petroleum production limit
natural gas
petroleum

COAL RESOURCES AND AVAILABILITY

Exploration of the Indonesian land masses for coal deposits has been going on for some time. Based on data from several sources, including its own minerals exploration program, the Geological Survey of Indonesia has been able to draw a detailed map showing the location of all known deposits. One source was the extensive survey done by N.V. Shell Mynbouw. The Shell team explored a 71,450 sq. km. area but concentrated its maximum effort on the 150 sq. km. Banko area where 490 boreholes and 50 shafts, trenches or test pits were made. All of the boreholes were cored and analyzed. Reserves in place amounted to 435 million tonnes within the following framework:

Coal as mined (including moisture)	
Maximum depth	50 m.
Seam thickness	> 5 m.
Slope	< 15°

A large amount of coal is thus excluded from the summation. If the reserve includes coal to a depth of 100 meters there is another 15 billion tonnes of coal, not all within the above limits. Composition of the mineable coal falls within a narrow range -

Total Moisture	27-50%
Volatile matter	47-52% (MAF)
Fixed Carbon	44-49%
Ash	3- 6%
Sulfur	< 0.5 %
Calorific Value	6300 to 7250 cal./gm.

The apparent high value for the calorific value is explained partly by the lower than normal ash content and partly by the high volatile matter content. Shell explored this coal area with the intent of marketing the coal. Upon analysis they decided that the coal was not marketable on a commercial basis, primarily because of the high content of water. Details of the above work are given in a report by Shell (22) and a thesis by U.W. Soelistiyo (23).

Work is going on in East Kalimantan by oil companies drilling in the area. No detailed data are available but from past work the known and inferred reserves are reasonably well delineated. Lignite is the largest component of the reserve.

Below are shown the best estimates of the coal reserves in Sumatra and Kalimantan:

	10^6 Metric Tonnes (Te)	
	10^6Te	
	Hard Coals	Lignite
West and Central Sumatra	200 - 300	
South Sumatra	200 - 250	15,000
NE Kalimantan	100 - 150	
East Kalimantan	100 - 150	500
SE Kalimantan	150 - 200	

The unspecified lignite deposits could be extensive.

Some facts presented by Kadir (24) are of interest. Energy consumption is distributed roughly as follows:

Household	30%
Industry	30%
Transportation	30%
Electric Power	6-7%

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About half of the total energy demand comes from firewood and agricultural wastes. Specific coal usage in 1978 follows:

Small Industries	7,009 tonnes
Metal Processing	22,240
Power Generation	24,000
Export	24,018
Railway	30,748
Cement	47,219
Coal Mine Operation	67,100

The last number is of particular interest since it represents almost a quarter of the coal production.

Small Mines

One field trip was made to the southwestern coast of West Java in the Bayah area. The first stop, after a day's hard travel from Bandung, was at an experimental lime kiln. Local coal is interlayered with limestone and the charge, either continuous or batch, works its way down the shaft. A run requires about eight tons of coal that is supplied from a mine about 5 km. away in Madur Hill. It was not possible to reach the mine because of a swollen river that a car could not ford. Furthermore, the mine is now on a concession and access is restricted. From a miner who works there we learned that ten men produce four tons a month. The yield comes from either a 6-meter deep underground mine or it is strip mined when the roof is not sound. The coal is carried 3 km. to and across the river, where it is loaded on a truck. Thus, it takes two

months of work to prepare for a run in the lime kiln. This mine also supplies local consumers such as the blacksmith.

The next stop was at a rice field in Cisiik. After leaving the car we walked about two kilometers to a stream. It would have been difficult to walk up the fast running stream to the mine that is an outcrop and not being worked the day visited. The rest of the hike was aborted. At the stopping point there was a small outcrop that gave some idea of the bedding of the coal in situ. We did get to see some coal samples from the mine - low density, friable and lignitic.

Thus, two attempts were made to reach coal sources but we were turned back by natural conditions. Perhaps this gives some idea of the problems that might be encountered in working coal sources in remote areas.

There are about sixty other known coal deposits in Java with various levels of accessibility. No attempt was made to reach any of them because of the limited amount of time available.

Production

Production figures for coal are well documented and the following brief summary is included for support of the later discussions. Coal production in Indonesia was as high as 2 million tonnes per year in 1941. At that time about a third

was exported (700,000 Te) and the balance used domestically for shipping (650,000 Te), railroads (400,000 Te) and industry (250,000 Te). After World War II the demand for coal decreased continually as less costly, more efficient, cleaner-handling petroleum products became available. By 1973 only two coal-producing areas remained and plans for their closing (except as a training site) had been made. Production had fallen below 150,000 tonnes per year. In recent years the demand has increased despite the loss of the shipping and most of the railroad markets. In 1979 production reached almost 280,000 tonnes.

Bukit Asam

Plans are now almost complete for increasing the production of coal at Bukit Asam from about 200,000 tonnes per year to about 2.5 million tonnes per year by 1983/1984. German technology similar to that used for braunkohle strip mining will be applied at the Bukit Asam mine site.

Most of the output will go 450 km. by rail to Tarahan and 8.5 km. across Salat Sunda before reaching the new Suralaya power complex. No visit was made to Bukit Asam because decisions had already been made regarding the upgrading that will start in the near future.

Ombilin

Ombilin mine, located back in the hills of West Sumatra at Sawahlunto, is an awakening giant. With limited

finances the production is ready to move ahead, plans are already in place, the studies are made, customers are waiting and the staff is eager to act as soon as the expected financial support is received.

There is a wide coal-bearing area suitable for both open cast and underground mining. There are three seams easily mined and "red dog" available for road building from a burned-out seam. The underground operation is a drift mine with slopes inside to reach each seam. The underground coal is two to six meters thick, with no partings. After extraction, the void is filled hydraulically with sand from an ample supply above the mine. Thus, after mining, little preparation is needed except for sizing and water washing. The product delivered to trucks and trains is clean and bright. Already available for future expansion is a power plant capable of producing 12 megawatts. When we visited the site, the plant was loafing along at only 2.4 megawatts, enough for the mine and the town of Sawahlunto.

There are two bottlenecks. The one on-site is about to be corrected; the other one is off-site. The on-site bottleneck is a steep slope down which three 1-ton capacity mine cars at a time are lowered by a cable attached to a drum hoist. The return trip brings back three empties for return to the mine. Cycle time is relatively short, so that about 70 Te per hour are moved. A new system almost completed eliminates the slope by dropping the coal into a silo that feeds a belt conveyor at its outlet. The silo can hold 2,000 Te

and is similar to one used at a Canadian mine site. With the new system the capacity of the output will be increased by 50 percent, from about 650 to 1,000 tonnes per shift. Thus, by operating two shifts the mine output can meet the planned capacity of 600,000 TPY - 250,000 TPY to the Indarung cement plant and 350,000 TPY to the port of Teluk Bayur.

The off-site bottleneck is the capacity of the railroad, about 130,000 TPY. Proposed methods of upgrading are already in the completed studies and are awaiting approval, hopefully before a crisis, so that the work can be done in a logical, planned way. The railroad has 170 hopper cars with a 5-day turnaround. More cars with a larger capacity can be provided to handle the projected output of the mine.

With an estimated investment of US $12 million and interest at 12 percent, the payout time would be about 20 years. The plant should reach the break-even point in five years. Equally important as the financing is the fact that continued operation would provide job security and make available a high quality coal. The mining conditions lend themselves to hand operation and the low labor costs favor a continuation in the present mode with experienced miners. The population supported by the mine is about 7,000 persons. The rest of the population in Sawahlunto, about 6,000, are supported directly or indirectly by the railroad, by logging and by local contracting.

Coal being mined at present has the following average composition:

Moisture	4 - 6 percent
Volatile Matter	35 - 40 "
Ash	4 - 7 "
Sulfur	0.5 "
Chlorine	0.2 - 0.4 "
Free Swelling Index	1 - 5
Hardgrove Grindability Index	40 - 60
Calorific Value	6800 - 7000 cal/gm.
Ash fusion	1400 - 1470°C

Note the low values for moisture, ash and sulfur.

ASH ANALYSIS:

SiO_2	60 percent
Al_2O_3	26 "
Fe_2O_3	9 "
CaO	4.6 "
Na_2O	0.4 "

An interesting set of analyses was obtained for samples taken from the areas where the present operations can be expanded. They are on Table 1. Again, the samples have low concentrations of moisture and ash, although the sulfur content is somewhat higher. If the sulfur occurs as discrete

pyrite particles it may be easy to clean. A petrographic analysis would answer this question. The calorific value is very high, over 7200 cal/gm (13,000 BTU/lb).

TABLE 1

Ombilin Coals (Future Mining)
Analyses of Selected Core Samples
(Waringin - Sugar)

Thickness, m.	2.7	4.8	11.6
Proximate Analysis, %			
Moisture	4.7	3.5	3.1
VM	39.4	39.1	37.6
FC	52.6	50.6	52.9
Ash	3.3	6.8	6.4
Ultimate Analysis, %			
C	78.1	75.8	76.4
H	5.5	5.8	5.1
O	10.2	8.8	8.5
N	2.1	1.7	1.8
S	0.6	1.0	1.7
Cal. Value, cal./gm.	7,440	7,280	7,440
Ash Fusion - °C			
Initial Deform.	1,240	1,230	1,340
Fluid	1,390	1,250	1,370
Plasticity			
Softening, °C	413	-	404
Max. Fluid DDPM	1.4	-	4.5
Max. Fluid °C	426	-	430
Solid °C	453	-	456
Ash Composition, %			
SiO_2	48.7	39.5	29.1
Al_2O_3	27.3	8.7	23.8
Fe_2O_3	15.3	8.4	23.0
CaO	1.98	21.3	14.6
SO_3	1.82	9.69	5.15
MgO	1.55	10.77	1.67
K_2O	1.58	0.20	0.67
Na_2O	0.84	0.56	0.65
TiO_2	0.63	0.33	0.58
Other	(0.30)	(0.55)	(0.78)

* * *

Analyzed by Tokyo Coal & Mineral Research Institute.
Raw coal basis.

Maintenance at the mine area and surrounding structures seemed to be reasonably good. Some refurbishing is needed in the preparation plant but, since a new one will be built next year, no one seems to be particularly concerned.

A problem of future concern at the mine is the availability of suitable trees for mine timbers. As with firewood, the supply lines become longer and longer. An active reforestation program is in order since the mine site will be producing coal for many years and several generations of trees could be produced in the mine area. Certainly the climate is conducive to the growth of almost anything. This problem merits serious consideration as part of the mine development.

On the mine site, a beehive-type oven periodically makes coke for experimental purposes. Unlike the crude beehive ovens used commercially, this one has a steel shell, ports to control the carbonization and ducting for the off-gases. The product is gray and hard although it is badly fissured and probably not strong enough for a high shaft smelter. However, there is the possibility that it could be used in a low shaft furnace or gasifier where the burden pressure is less. Another possibility is the blending back of some breeze (-6 mm), perhaps 8 to 10 percent to improve the structure. Reactivity and combustion tests are necessary. No information on coke quality was offered.

One of the questions raised repeatedly, and basic to this project has to do with introducing coal into the market

place. Handling, smoke, dirt and relative cost are given as factors cited as negatives for coal, yet, at Ombilin we noted an interesting phenomenon. Coal lumps had been dropped from trucks along the rough road. Residents were picking up the coal for home use despite its many drawbacks, including the fact that it burns hotter than wood and can burn out a stove. Some workers were also observed carrying large lumps of coal, apparently from distances further away, to their homes. Thus, if even an undesirable fuel is available with less expenditure of energy or funds, it might be adopted. Perhaps a future experiment could be planned where a community is given a choice between fuels but coal (as mined or smokeless) is most accessible - a pile of free coal placed nearby. Suitable burners for the coal should also be made available.

Peat

In discussions I brought up the question of peat several times but this was usually dismissed as irrelevant until someone mentioned the fact that peat research is done in the Soil Research Institute at Bogor. And so it was, but it was considered as an organic soil. Peat is an energy source in several parts of the world; used for domestic heating and cooking and for commercial power production. True, it contains a lot of water in its natural state and its heating value is low, but if it is available at little or no cost, adjacent to its point of usage, it provides net energy. If peat is now considered as an energy source, with coal and lignite, the

energy reserves of Indonesia can probably be multiplied many times. Processes are now being developed in other countries to improve the utilization of peat--pelletizing and gasification, for example.

The area of peat fields in Indonesia is about 17 million hectares, according to the surveys already completed. It is difficult to estimate the total amount available because of limitations in the number of surveys made and the size of the auger used (1.5 meters long). Peat bogs were sampled several meters down into the mineral sediment.

Peats are classified at the Institute (L. P. Tanah) in the following way:

Fibric	=	over 66% organic matter
Hemic	=	33 to 66% organic matter
Sapric	=	less than 30% organic matter

The specific gravity for dry peat is 0.2 to 0.3 gm/ml. Analyses of peats taken during a soil survey are given in the attached three tables taken from a report (Title page also reproduced) available at the Soil Institute. The column of prime interest is the percent carbon in the sample dried at 105°C, from 42 to over 60 percent. Some of the peat is close to cellulose in carbon content but the higher values reflect advanced anaerobic decay and coalification.

A simplistic calculation was made to estimate the reserves assuming that 1) 10 million hectares were recoverable to a depth of 10 meters and 2) the density is 0.2 gm/ml. The

conservative estimate is that there is 2 X 10^{11} or 200 billion metric tons of peat around. It is located mainly along the east coast of Sumatra and the west coast of Kalimantan. The heating value for moisture and ash-free peat should be around 5000 cal/gm.

Besides the two consumers mentioned earlier (power and domestic) other major uses have been for soil improvement and for preparing potting soils. Total world production in 1979 was about 224 million tonnes, 95 percent of which is used in the USSR alone (25). The U.S.A. produces about 200,000 TPY--59 percent reed-sedge, 23 percent humus, 3 percent hypnum, 2 percent sphagnum and 13 percent other.

PROYEK PEMBUKAAN PERSAWAHAN PASANG SURUT (P4S)
DIREKTORAT JENDERAL PENGAIRAN

LAPORAN

SURVEY DAN PEMETAAN TANAH

DAERAH BUNUT - KUALA KAMPAR
RIAU

OLEH

TEAM LEMBAGA PENELITIAN TANAH
BOGOR

1975

BUKU II

DATA LAMPIRAN

DEPARTEMEN PEKERJAAN UMUM & TENAGA LISTRIK

DEPARTEMEN PERTANIAN

Diterbitkan oleh LPT no. 10/1975

No. Contoh		Dalam lapisan	E.C.	Tekstur			pH			terhadap 100 gr contoh tanah kering 105°C							Kebutuhan kapur pH 6,5 Gram $CaCO_3$ per 100g contoh	Nilai tukar Kation				Nilai Kation (S)	Kapasitas adsorpsi (T)	Kejenuhan basa (B)
L.P. Tanah	Pengisian	Cm	mho	pasir %	debu %	liat %	pH lapang	pH lab. H_2O	pH lab. KCl	Zat Organik C g	Zat Organik N g	Zat Organik C/N	dalam HCl 25% P_2O_5 mg	dalam HCl 25% K_2O mg	dalam asam sitrat 2% P_2O_5	dalam asam sitrat 2% K_2O		Ca m.e	Mg m.e	K m.e	Na m.e	m.e	m.e	(B) m.e
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
8. Tanah aluvial dibelakang tanggul sungai (back swamp), histic epipedon setebal 20–50 cm diatas horison C yang berdebu kasar, kejenuhan basa lapisan mineral tinggi lebih dari 35%.																								
175811	MS. 116/I	0–50	–	–	–	–	Tanah habis			45,31	1,37	33	tidak bisa diekstrak											
744	116/II	50–90	0,265	1	91	8	5,5	4,7	3,9	0,91	0,04	23	9	14	6	6	0,253	1,3	3,1	0,1	0,4	4,9	7,5	65
745	116/III	90–110	0,245	0	94	6	5,2	5,2	4,3	0,70	0,04	18	6	13	4	5	–	1,3	2,9	0,1	0,6	4,9	5,3	93
746	116/IV	110–150	0,400	1	95	4	5,8	5,0	4,3	0,96	0,03	32	5	12	4	5	–	1,0	2,0	0,1	0,1	3,2	5,7	56
9. Tanah organik pada gambut topogen, histic epipedon bervariasi dari hemik sampai fibrik dan terletak diatas horison C dari mineral berdebu halus sampai berliat diatas lapisan berdebu kasar dan kejenuhan basa lapisan mineral tinggi lebih dari 50%, kedalaman 51–100 cm.																								
175616	KS. 38/II	10–60	–	–	–	–	5,3	Tanah habis		48,47	1,67	29	26	35	2	31	2,40	8,5	19,9	0,2	13,5	42,1	114,9	37
619	38/III	60–100	–	–	–	–	5,1	4,5	3,9	42,20	3,51	12	–	–	–	–	–	–	–	–	–	–	–	–
767	38/IV	100–180	1,000	1	56	43	5,1	4,7	4,0	2,13	0,12	18	19	69	10	29	0,514	3,6	13,9	0,9	0,9	19,3	28,0	69
768	38/V	180–250	0,460	1	95	4	5,8	5,2	4,7	0,64	0,03	21	6	16	5	8	–	1,3	2,6	0,1	0,1	4,1	5,7	72
175615	KS. 40/I	0–100	–	–	–	–	4,5	tanah habis		55,73	1,79	31	36	33	7	28	–	4,3	10,1	1,0	1,5	16,9	121,1	14
752	40/II	100–240	0,650	1	78	21	5,6	5,4	4,7	2,26	0,09	25	14	39	11	16	0,244	2,8	4,2	0,2	0,2	7,4	7,4	100
753	40/III	240–350	0,850	1	91	8	6,4	5,6	5,0	1,36	0,05	27	11	24	8	9	–	2,7	4,8	0,2	0,1	7,8	9,6	81
10. Tanah organik pada gambut topogen, histik epipedon bervariasi dari hemik sampai fibrik dan terletak diatas horison C dari mineral berdebu kasar dan kejenuhan basa sedang, kurang dari 50%, kedalaman 51–100 cm.																								
175618	HDK. 33/I	0–95	–	–	–	–	3,5	Tanah habis		51,55	1,38	37	tidak bisa diekstrak		12	60	Tanah habis			Tanah habis				
754	33/II	95–200	0,145	1	94	5	5,5	4,8	3,9	1,50	0,05	30	4	10	2	4	0,264	1,3	1,9	0,0	0,0	3,2	8,7	37
175617	MS. 11/I	0–75	0,145	–	–	–	4,0	3,9	2,7	57,17	2,08	27	38	24	1	14	2,70	5,8	13,4	1,1	0,7	21,0	128,8	16
755	11/II	75–90	0,350	1	85	14	4,7	4,4	3,8	4,33	0,16	27	4	16	1	7	0,571	1,1	4,7	0,2	0,1	6,1	21,1	29
756	11/III	90–200	0,240	1	95	4	5,8	4,6	3,9	0,43	0,03	14	3	11	3	5	–	0,5	2,0	0,1	0,2	2,8	3,9	72
175612	HR. 4/I	0–90	0,135	–	–	–	3,3	3,7	2,5	47,62	1,70	28	47	49	18	32	4,36	1,5	3,7	1,1	0,7	7,0	117,4	6
747	4/I	90–110	0,170	0	93	7	4,2	4,1	3,4	2,87	0,11	26	3	6	0	5	0,633	0,4	1,3	0,2	0,1	2,0	16,8	12
748	4/III	110–165	0,250	1	91	8	6,0	4,2	3,6	1,29	0,05	26	3	11	1	6	–	0,5	1,7	0,1	0,1	2,4	8,4	29
749	4/IV	165–190	0,295	0	96	4	–	4,3	3,7	0,78	0,03	26	4	11	2	6	–	0,5	1,6	0,1	0,1	2,3	5,1	45
11. Tanah organik pada gambut topogen/ombrogen, histik epipedon dari bahan saprik dan atau hemik terletak diatas horison C dari mineral berliat, kedalaman 101–200 cm.																								
175633	MS. 63/I	0–50	0,195	–	–	–	3,7	3,3	2,3	57,55	1,37	42	49	24	20	18	4,07	0,5	2,7	0,5	0,9	4,6	131,3	4
634	63/II	50–200	–	–	–	–	3,5	3,5	2,3	57,57	1,23	47	–	–	–	–	–	–	–	–	–	–	–	–
773	63/III	200–230	2,750	1	56	43	5,0	5,6	4,5	3,70	0,24	15	23	64	6	37	–	3,9	11,6	0,6	6,1	22,5	33,5	67
774	63/IV	230–400	1,850	1	25	74	5,5	3,7	3,1	4,43	0,13	34	13	33	3	23	–	1,3	17,8	0,7	0,3	20,1	43,8	46

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No. Contoh		Dalam lapisan	E.C.	Tekstur			pH			terhadap 100 gr contoh tanah kering 105°C							Kebutuhan kapur pH 6,5 Gram $CaCO_3$ per 100g contoh	Nilai tukar Kation				Nilai Kation (S)	Kapasitas adsorpsi (T)	Kejenuhan base (B)
L.P. Tanah	Pengirim	Cm	mho	pasir %	debu %	liat %	pH lapang	pH lab. H_2O	pH lab. KCl	Zat Organik C-g	Zat Organik N g	Zat Organik C/N	dalam HCl 25% P_2O_5 mg	dalam HCl 25% K_2O mg	dalam asam sitrat 2% P_2O_5	dalam asam sitrat 2% K_2O		Ca m.e	Mg m.e	K m.e	Na m.e	m.e	m.e	(B) m.e
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
175635	MS. 118/I	0–50	0,087	–	–	–	3,2	3,7	2,6	60,00	1,67	38	30	21	23	32	3,80	1,7	3,3	0,7	1,2	6,9	117,8	6
636	118/II	50–180	–	–	–	–	3,2	4,3	2,5	59,11	1,44	41	–	–	–	–	–	–	–	–	–	–	–	–
775	118/III	180–200	0,350	0	58	42	4,0	3,6	3,2	5,13	0,17	30	4	14	1	8	–	0,7	6,4	0,2	0,2	7,5	34,8	22
776	118/IV	(200)	0,350	1	92	7	4,7	3,0	3,4	1,56	0,05	31	3	8	1	4	–	0,5	2,0	0,1	0,1	2,7	9,3	29
12. Tanah organik pada gambut topogen/ombrogen, histik epipedon dari bahan fibrik terletak diatas horison C dari mineral berdebu kasar, kedalaman 101–200 cm.																								
175627	KS. 9/I	0–150	–	–	–	–	3,9	Tanah habis		57,80	1,60	36	42	51	17	44	–	–	–	–	–	–	–	–
765	9/III	160–210	0,205	1	97	2	5,8	4,2	3,7	0,36	0,03	12	1	8	1	4	–	0,2	0,8	0,0	0,1	1,1	2,8	39
175628	KS. 85/I	0–115	0,170	–	–	–	3,5	4,0	2,9	59,05	2,16	27	85	64	21	56	2,20	1,8	3,1	1,0	1,5	7,4	128,0	6
766	85/II	115–135	0,290	1	64	35	4,4	4,2	3,5	2,74	0,14	20	9	29	4	13	–	1,3	6,1	0,3	0,2	7,9	23,4	34
767	85/III	135–200	0,087	1	96	3	6,1	4,1	3,8	0,93	0,04	23	5	14	3	6	–	1,0	1,7	0,1	0,1	2,9	6,2	47
175626	KS. 88/I	0–170	0,195	–	–	–	3,0	3,7	2,6	52,75	1,88	28	66	40	14	21	2,80	1,7	8,2	2,8	1,6	14,3	177,3	8
764	88/II	170–200	0,245	2	94	4	6,0	4,3	3,8	0,86	0,03	29	3	9	1	5	–	0,7	1,1	0,0	0,1	1,9	15,1	37
175625	HDK. 35/I	0–140	0,050	–	–	–	3,6	3,7	2,6	55,61	1,65	34	tidak bisa diekstrak		24	62	3,40	16,1	36,7	0,9	21,0	74,7	107,8	69
762	35/II	140–200	0,028	0	96	4	5,8	5,0	4,0	0,36	0,03	12	3	6	1	4	–	0,2	0,3	0,0	0,0	0,5	2,8	18
763	35/III	200–300	0,240	1	94	5	6,0	4,4	3,8	0,40	0,03	13	4	11	3	6	–	0,7	1,3	0,1	0,1	2,2	3,7	60
13. Tanah organik pada gambut ombrogen dengan bahan hemik, saprik dan atau hemik, kedalaman lebih dari 200 cm.																								
175648	HDK. 52/I	0–15	0,350	–	–	–	3,4	3,6	2,5	60,48	2,09	29	60	86	33	75	4,20	0,5	4,2	1,6	2,8	8,6	141,9	6
649	52/II	15–475	–	–	–	–	3,4	4,1	2,3	62,66	1,43	44	–	–	–	–	–	Tanah habis						
175650	HDK. 82/I	0–30	–	–	–	–	3,0	Tanah habis		57,50	1,95	29	94	113	39	85	–	–	–	–	–	–	–	–
651	82/II	30–475	–	–	–	–	3,1	4,3	2,8	55,22	1,68	33	–	–	–	–	–	1,3	7,9	0,6	1,5	11,3	80,1	14
175652	MS. 23/I	0–100	0,350	–	–	–	3,0	3,6	2,6	56,65	1,68	34	31	22	11	17	5,80	–	–	–	–	–	–	–
653	23/II	100–200	–	–	–	–	3,0	4,3	3,7	56,26	1,53	37	–	–	–	–	–	–	–	–	–	–	–	–
654	23/III	200–300	–	–	–	–	3,5	3,8	3,1	58,63	1,28	46	–	–	–	–	–	–	–	–	–	–	–	–
779	23/IV	300–320	1,900	2	43	55	4,2	3,4	3,2	18,05	0,32	56	6	21	2	14	–	0,8	4,2	0,3	0,4	5,7	77,9	7
780	23/V	320–370	2,760	4	40	56	5,5	3,4	3,1	0,49	0,18	53	6	30	2	25	–	3,0	10,3	0,5	0,7	14,5	44,1	33
175655	MS. 121/I	0–40	0,140	–	–	–	–	3,6	2,8	61,78	1,81	29	84	72	32	55	5,80	4,1	9,9	2,1	1,5	17,6	165,0	11
656	121/II	40–370	–	–	–	–	3,3	3,8	2,4	53,12	1,51	35	–	–	–	–	–	–	–	–	–	–	–	–
781	121/IV	370–420	[illegible]	1	[illegible]	29	6,0	4,6	3,7	2,00	0,09	22	3	11	1	7	–	0,0	7,5	0,2	0,8	8,5	18,2	47
782	121/V	420 +	0,500	0	[illegible]	10	6,0	4,7	3,9	0,74	0,03	25	15	9	14	5	–	0,0	3,1	0,1	0,1	3,9	5,8	67

SAMBUNGAN Lampiran • III . 5

No. Contoh L.P. Tanah	Pengirim		Dalam lapisan Cm	E.C. mho	Tekstur pasir %	Tekstur debu %	Tekstur liat %	pH pH lapang	pH pH lab. H_2O	pH pH lab. KCl	terhadap 100 gr contoh tanah kering 105°C Zat Organik C g	Zat Organik N g	Zat Organik C/N	dalam HCl 25% P_2O_5 mg	dalam HCl 25% K_2O mg	dalam asam sitrat 2% P_2O_5	dalam asam sitrat 2% K_2O	Kebutuhan kapur pH 6.5 Gram $CaCO_3$ per 100g contoh	Nilai tukar Kation Ca m.e	Nilai tukar Kation Mg m.e	Nilai tukar Kation K m.e	Nilai tukar Kation Na m.e	Nilai Kation (S) m.e	Kapasitas adsorpsi (T) m.e	Kejenuhan basa (B) m.e
1	2		3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
175646	HDK.	24/I	0–10	–	–	–	–	3,2	3,8	2,3	67,54	2,10	27	–	–	–	–	–	–	–	–	–	–	–	–
647		24/II	10–475	0,350	–	–	–	3,7	3,3	2,1	69,26	1,82	33	87	33	29	26	5,0	0,9	3,4	0,7	2,0	7,0	94,2	7
175639	EK.	37/I	0–20	0,400	–	–	–	3,5	3,5	2,5	68,89	2.12	28	113	74	50	57	5,60	7,4	5,6	1,4	1,5	9,9	16,2	61
640		37/II	20–70	–	–	–	–	3,6	4,2	3,4	57,44	1,50	38	–	–	–	–	–	–	–	–	–	–	–	–
175658	EK.	44/I	0–40	0,275	–	–	–	3,8	3,8	2,7	57,03	1,70	34	82	61	30	51	5,00	5,2	4,7	1,2	1,6	12,7	120,2	11
659		44/II	40–250	–	–	–	–	3,8	4,1	3,0	61,58	1,12	55	–	–	–	–	–	–	–	–	–	–	–	–
660		44/III	250–390	–	–	–	–	4,6	3,7	2,7	67,85	1,13	51	–	–	–	–	–	–	–	–	–	–	–	–
783		44/IV	(390)+	1,050	1	27	72	4,9	4,1	3,5	9,67	0,22	44	19	28	11	18	–	1,6	13,3	0,5	0,8	16,2	57,0	28
175661	T.	46/I	0–150	0,120	–	–	–	3,6	3,8	2,8	63,83	2,33	23	80	97	39	85	5,20	2,5	5,0	2,5	1,9	11,9	19,4	10
662		46/II	150–175	–	–	–	–	4,9	4,0	2,9	60,84	1,69	36	–	–	–	–	–	–	–	–	–	–	–	–
14. Tanah organik pada gambut embrogen dengan bahan hemik dan atau fibrik, kedalaman lebih dari 200 cm.																									
175663	T.	79/I	0–60	0,070	–	–	–	3,5	3,9	2,9	55,06	2,08	26	94	78	47	72	5,80	2,3	9,5	2,3	2,2	16,3	136,4	12
664		79/II	60–475	–	–	–	–	3,5	3,8	2,4	57,46	1,81	32	–	–	–	–	–	–	–	–	–	–	–	–
175665	MS.	109/I	0–30	0,350	–	–	–	3,0	3,4	2,2	58,71	1,82	32	93	106	35	33	6,00	1,0	4,9	1,5	1,7	9,1	129,7	7
666		109/II	30–475	–	–	–	–	3,4	3,8	2,2	60,87	1,50	40	–	–	–	–	–	–	–	–	–	–	–	–
175667	HDK.	67/I	0–15	0,350	–	–	–	3,3	4,2	2,5	61,19	2,16	28	122	64	46	51	3,40	5,6	7,0	1,9	2,0	16,5	142,2	12
668		67/II	15–475	–	–	–	–	3,5	3,5	2,5	61,34	1,84	33	–	–	–	–	–	–	–	–	–	–	–	–
175669	EK.	52/I	0–40	0,115	–	–	–	3,6	3,9	2,4	57,75	2,06	28	57	43	40	94	5,40	3,6	5,9	2,6	1,1	13,2	135,6	10
670		52/II	40–200	–	–	–	–	3,5	3,8	2,2	60,16	1,53	39	–	–	–	–	–	0,9	5,0	1,0	2,2	9,1	120,7	8
175671	KS.	57/I	0–125	0,275	–	–	–	3,4	3,5	2,5	55,03	2,39	23	98	121	49	49	3,93	–	–	–	–	–	–	–
672		57/II	125–475	–	–	–	–	3,4	4,4	2,5	57,55	1,90	41	–	–	–	–	–	–	–	–	–	–	–	–
15. Tanah organik pada gambut topogen yang dicirikan oleh bahan endapan fluviatil marin diatas bahan organik.																									
176024	Ag.	88/I	0–19	–	1	53	46	5,0	5,0	3,7	8,17	0,43	19	29	48	10	31	0,343	2,7	8,3	0,8	2,0	13,8	36,5	38
025		88/II	19–55	–	3	42	55		4,4	3,2	29,49	0,90	33	26	40	6	27	–	2,8	7,6	0,8	1,1	12,3	62,8	20
038	0	88/III	55–90	–	–	–	–		4,0	3,1	64,98	1,65	39	–	–	–	–	–	–	–	–	–	–	–	–
039		88/IV	90–200	–	–	–	–		4,2	3,1	59,22	1,28	46	–	–	–	–	–	–	–	–	–	–	–	–

RESEARCH AND DEVELOPMENT

There exists a list of Research and Development Projects Related to Coal, 1980-1981. It covers a wide range of interests but, upon reading, one senses a somewhat restricted attitude. Most of the topics consist of ongoing studies, evaluations, investigations and elaborations. It is possible that the titles do not reflect the content. There are few projects directed to actual experimental work that impinge on the problems at hand. It is recognized that there is a lack of technical personnel to carry out the experimental program but more of a start must be made, perhaps in university laboratories or small research organizations. These projects need not be oriented to a specific utilization scheme but rather to knowledge about coal composition and its basic reactions. If combustion is decided to be the priority application of a particular coal, experiments to understand its composition, reactivity and other characteristics should be under way.

Discussions with many people led me to the following list of activities that I felt should be going on in a serious fashion:

Exploration should be a first priority as soon as a decision is made to develop a particular area. There are few reliable figures on the extent and quality of the coal reserves. Past and present exploration has indicated much about the coals but more is to be learned. Exploration on a systematic basis is essential. This activity must be an ongoing effort related to

specific expansion plans. For example, if a power plant is to be built, a proven reserve equivalent to about 50 years of operation must be developed and in production when the plant starts.

Sampling methods are well-established in all producing countries, so that a reasonable estimate can be made about the quality of the coal being produced. It must be a continuing activity since coal quality can change along a seam. This is especially true in Indonesia where localized coalification has been accelerated by geological activity.

Coal Bank

As coal samples become available and research programs develop there will be a need for representative coals. As experienced elsewhere, those working on coal research projects go to mines to collect their own samples. Coal, being a unique material, varies in composition as mining advances or new seams are opened for production. The research results based on the samples collected as needed, although excellent, may bear only a limited relation to similar work done by other researchers. There is a documented solution to the above problem (26). Without going into great detail, the system involves the careful selection of representative samples amounting to a few tons of coal. From mine to laboratory care must be exercised not to change the chemical nature of the sample due to oxidation or contamination. After preparation and analysis the samples are

stored carefully so that changes are again minimized because these samples will be consumed over many years. Even though the samples are large they are finite; therefore control should be exercised.

--Samples should go only to established researchers. Some idea should be given to the coal bank control concerning the experiments to be made.

--Experimental results should be submitted to the coal bank for correlation with data received from other research workers.

--Information in the data bank should be available for the testing of models or re-evaluation based on new technology.

At least three somewhat similar banks are operating in the United States: The U.S. Bureau of Standards, Pennsylvania State University and Exxon Corporation. An extension of the coal bank idea was proposed a few years ago--an international maceral bank, possibly located at Bergbau-Forschung in West Germany. Macerals are the physical components in coal that have their derivation in different plant species, parts of the plant, or are the result of physical changes such as forest fires or geological stress. The limitations of this proposal were the extensive manpower required with very specialized skills. Maceral separation for research is now generally done by petrographers associated with any good coal research laboratory.

The coal bank described above requires considerable planning, financial commitment and skilled control. The net effect is reliable data that is acceptable to the scientific community.

Analysis of coal is a critical function because of the knowledge it provides. Since coal is a complex material, the results are sensitive to the methods applied. Methods of coal analysis are well-known and updated periodically, as done recently by Dr. Clarence Karr of the Morgantown Energy Technology Center (27).

Some Indonesian coals are unique and may require modified procedures. One example is an unusual sample from a new area at Ombilin that exhibited a very low alumina content but extremely high calcium oxide and magnesia levels. There is a real possibility that interference would occur in a wet analysis or that the levels would be outside the calibration range of a spectograph unless precautions are taken.

Classification of coal seemed to be a subject of considerable concern regarding which system should be used - the ASTM, Polish, or British. There are two important points: first, a standard should be decided upon for all Indonesian coals; second, specific foreign markets may be based on a system other than the one adopted. When contracts are developed it may be necessary to have correlations available or an outside certified laboratory to provide the needed data. Since none of

the methods are accepted universally, the one that seems most applicable to Indonesian coals should be adopted. There is some international activity to develop a set of methods agreeable to all; but this is several years away and it is important that men and equipment get trained and assigned to coal development.

Coal Petrography also tells us a lot about the composition of coal. What are the components (macerals) in the coal and what is their source? This information obtained by the microscopic examination of thin sections a few microns thick, may identify the reactive and inert components. It might also explain the reason for the high heating value observed in so many samples.

The distribution of minerals observed could give clues to means of coal preparation that could be applied for ash and sulfur removal.

Coal chemistry is another important building block of fuel science. Those working with coal should have at least a working knowledge of some reactions that coal can undergo and what are the needed physical conditions of temperature, pressure and composition of the atmosphere. Coal is a complex compound described as a gel, a polymer, a radical, etc., that no one is willing t define precisely. The discussion continues on the binding forces and reactions of coal fragments. From the coal model we may derive the type of compounds that might form during pyrolysis, hydrogenation, alkylation or other possible reactions.

Equipment for this type of work is available in most standard chemistry laboratories. The only unusual apparatus might be the autoclaves (rocking, magne-dash or rotating) designed for operation up to about 500 atm. and 500° C. Also required are a recovery system and serious safety precautions.

Catalysis can play an important part in coal research just as it does in the petroleum laboratory and refinery. Primary products from a coal conversion system are generally not saleable directly to the market place. Again, like petroleum products, catalysts designed for specific reactions can direct the conversion in the desired direction. Catalysis is a specialized branch of research and the direction of the work depends upon the desired end products needed by the economy and the society.

Carbonization was mentioned previously in the discussion of the Ombilin mine. Much more can be done on a laboratory scale, e.g., differential thermal analysis (DTA) and thermogravimetric analysis (TGA) are well-known techniques that are useful. Other analytical tools that would be useful are a thermal decomposition apparatus to recover the volatile products and try to improve the coking properties of Indonesian coals. Another important study would be the preparation of smokeless, clean burning fuels for domestic use. A lot of information such as reactivity, strength, compounding, etc. must be known before the product is made available to the public.

Combustion of coal is practiced widely and it will grow rapidly in the future. If it does not yet exist, a laboratory devoted to combustion technology is vital. As already mentioned, Indonesian coals have unique properties and to use them efficiently some group must have the know-how about combustion as an aid to industry. Besides simple combustion are the methods of feeding coal to a boiler and its effect on flame configurations and boiler efficiency. Combustion laboratory personnel can be trained to test boilers, to determine whether they are functioning at their most efficient level, not only concerning carbon burnout, but also pollution levels and heat transfer.

Coal can be transported and pumped to a boiler as a suspension in water or fuel oil. Coal-water slurries may tend to derate a boiler because of the energy required to vaporize the water, but the ease of transport could compensate for the loss. Another important slurry system is coal-in-oil. Besides saving oil, such suspensions can be used to reduce transportation costs and make available for combustion, coals or oils that might not be used otherwise. Compensating specifications can result in an acceptable fuel composition.

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Liquefaction

There is no question that most of the coals found in Indonesia are amenable to liquefaction. Subbituminous coals and lignites have been hydrogenated in laboratories all over the world. The important data to be gained from the present state of development are the conditions required for conversion and product distributions. Without great expense, several laboratories already exist that could do the work needed. Equipment can be sophisticated or kept at a practical level. Specifically, autoclaves of several types (rocking, magnetic stirrers, rotating, etc.) are suitable. Operating conditions would be a function of the ultimate product in mind - fuel oil, diesel oil, gasoline or chemicals. There is still a lot of research to be done that is of interest internationally concerning the reaction mechanisms involved in coal conversion.

A major aspect of coal liquefaction is the development of suitable catalysts for coal conversion. With few exceptions, such as iron, the catalysts applied to coal were borrowed or modified from those used in the petroleum industry. The use of iron as a hydrogenation catalyst is from the Bergius Process (German) technology. Catalyst studies, as well as other related research, must continue throughout the development stage, at least on a small scale. If a large plant is built in the distant future it must be borne in mind that a laboratory with experienced personnel is needed as a pilot.

Gasification

There is no question that the coals found in Indonesia can be gasified. Existing gasifiers located in many parts of the world are consuming a wide range of coal ranks, from anthracitic coals to high ash carbonaceous matter. Currently, the Institute of Gas Technology has a research program on the gasification of peat. In fact, they are introducing a university course in Indonesia through the US AID program. Although carbonaceous materials can be gasified, it is not considered commercially feasible in Indonesia at present except under specific conditions. A typical situation might be where the gasifier is part of a chemical complex and the product gas is used within the plant for synthesis or as a reductant.

Pilot plants have been suggested as part of the evolving research and development program, but much later in the chain of priorities. Pilot plants are usually designed to operate within specific parameters and should be based on the research goals. They are costly to build and require a large commitment in space and manpower, particularly if they are high temperature and/or high pressure systems that may require several days of continuous operation before they come to equilibrium and data can be obtained.

Furthermore, some pilot plants are available in the laboratories of engineering contractors. If a particular process is of serious interest, some companies will process their customers' raw material.

Development of up-to-date processes for the conversion of coal to liquid fuels is found in all of the developed countries and international cooperative agreements exist. Offers are being made for new cooperative agreements between those who have the technology and those who have raw materials. Typical is the offer made by a representative of the Federal Republic of Germany (20) during the Indonesian-German Seminar on Coal Technology, October 19-26, 1980 in Jakarta. The Germans offer to do feasibility studies which include test runs in a suitable pilot plant, engineering evaluation of the results, an economic assessment and an analysis of the environmental impact. From the developed studies a decision can be made whether to proceed with the large investment of a commercial installation. During the study period the Indonesian experts would work with the German team so that both sides are acquainted with the problems and the solutions.

Excluded from the above consideration should be research scale equipment that is flexible and readily altered to suit the necessary process evaluation. These small units would range in coal inputs from a few grams to about 5 kg. of coal per charge.

Proposals by LIPI (Indonesian Institute of Sciences)

Toward the end of my stay in Jakarta, I was asked to look at some proposals made by the Indonesian Institute of Sciences (LIPI). A few of the proposals are worthy of note and support.

Projects for the upgrading of low rank coals and equipment for their utilization in rural industries and households are sound. Coals in Indonesia often contain large amounts of volatile matter which apparently does not form a pitch but rather seems to crack thermally and goes out with the product gas. It is this volatile material that causes smoke, soot and bad odors. The problem can usually be alleviated by reducing the volatile content to about 20 percent and then burning the char in some form (briquets), in an appropriately designed system.

If we assume that a non-agglomerating coal is devolatilized partially, the particulate residue can then be shaped into specialized briquets at the preparation plant or in the home. Both of these systems are known in other parts of the world but the application of Indonesian coals must be determined both as to the method of preparation and the equipment for home application.

If the new fuel is made available at little or no cost and it takes less effort to acquire than going to the hillside for wood, its adoption is almost assured. Some public education and a test area might be a wise investment.

I cannot support the idea of in situ gasification for small electricity generators. This technique, although attractive in principle, has many drawbacks. Extensive experiments in several countries have not been successful, especially where physical conditions are not ideal, such as the existence of geological faults or the presence of ground water. Some of the

coal deposits in Indonesia may not be deep enough to contain the products of combustion or exclude air sufficiently. Such problems should be considered carefully before any work is done because underground fires and subsidence under a rice field can have long-range impacts. My feeling is that this project should be abandoned or be reconsidered in the future. Consider, instead, small-scale gasifiers similar to those used previously for portable gas supplies (28). Ruben Hardy has technical papers describing several such devices.

The other proposals in the group relating to non-conventional sources of energy are outside of the coal area and should be reviewed by others.

Another document described the coal liquefaction program. This subject is discussed elsewhere in the report as a long-range project. Some components of the liquefaction proposal are also covered in the suggestions for basic work on coal, namely exploration, analysis, chemistry, etc. Training of the chemists and engineers at the research level will lead to larger projects as the professionals develop. Decisions must be made concerning the needs of the Indonesian economy for specific products. With firm objectives technology can meet demand.

COORDINATION OF COAL DEVELOPMENT

Development of the infrastructure for coal utilization is under way. Those responsible for this development phase are well aware of its importance now and in the future. However, it was found that while one agency expressed a need for certain information, it was unaware that another agency had already developed such information. A coordinating committee on coal made up of knowledgeable members representing each concerned group should meet regularly. To be effective, the committee should be limited to five to eight members.

About a year ago the need for a coordinating committee was recognized and plans were made for one to be formed. Until now, no action was taken for a number of internal reasons. The initial meeting was scheduled for sometime in December 1980. Since the committee exists in principle, the following ideas are presented from the managerial point of view. In fact, two committees are suggested, each with specific tasks.

A coordinating committee consisting of representatives of coal-consuming agencies should be organized. This group, through mutual discussions, should schedule the projects so that material, manpower, sites and utilization are ready when needed. There should be consensus on the timing shown on a network chart so that all of the goals are realistic. Although the subject of a chart was brought up several times, none was ever offered or discussed.

It is time to consider a parallel group that will

advise on the technical application of the new coal-related industries. Besides the group's function as advisors to the committee mentioned above, each expert would have available to him a few recent graduates from Indonesian schools who would learn some of the expertise necessary to function in the completed plant or project. There would be a replacement schedule as trained personnel move to higher positions with their experience. The composition of this second coordinating group would be foreign experts who would remain only long enough to see their phase of the work completed and the personnel available who can continue. A combustion expert, for example, could help with the selection of designs best suited for the coal being fired and the selection of boiler systems. There are choices to be made because all companies do not participate in foreign trade, train personnel or service equipment.

The basic concern of both committees would be to be sure that, e.g., a new power plant would have available the fuel needed and have the composition for which the unit is designed. Commercial enterprises represent a large investment which, if idle, can be very costly. A subsidiary function of these committees would be to train by hands on experience new chemists and engineers in skills needed for middle management. All of the skills discussed here and in other sections of the report require long lead-times in which to develop manpower, equipment and techniques. Action on these matters must be seriously underway soon or they will not be at the level required when the industrial component is in operation. An administration organization on which to build the coordination already exists.

TECHNICAL INFORMATION EXCHANGE

A universal problem in developing countries is the availability of current technical information from countries that have societies or similar groups devoted to the dissemination of current knowledge. During a discussion at the Geological Survey I learned that there is an active Geological Society that meets annually to present papers and work on cooperative projects. One such current project is the preparation of a coal map for Indonesia. This project will be a subject of discussion at the next meeting.

Certainly other technical groups exist, but this matter was not explored in any detail. What was determined, however, was that a lack of current literature exists. A few current book lists I brought to Indonesia were welcomed. There are a few ways of acquiring the current information on research activities and available literature. One method is for active workers to become members of technical societies abroad. It is not unusual for organizations - companies, governments or libraries - to pay the membership fees for individuals so that the flow of information occurs. Many of the technical societies make the preprints of meetings available free or at low cost. Symposium volumes are usually available to society members at greatly reduced prices. Book lists of relevant literature are usually published by these technical organizations and distributed to the membership, thus saving considerable time in scanning the lists put out by book publishers. A typical list is APPENDIX IV.

I left behind a list of books that those doing research on coal should have available. Included are some classics, some current publications and proceedings of meetings. A new supplement of The Chemistry of Coal Utilization from John Wiley and Sons will be available soon.

Another list contained names of coal research centers in the United States that might accept foreign visitors. A tour of research centers is planned and the list may be used as a basis for contacts to be made by US AID or others in planning the itinerary. Included are university research centers, the Department of Energy, and some corporations who are under contract to DOE. During the tour it is possible that one or more scientific meetings relating to coal research will be in progress and attendance can be arranged.

The second method of technical information acquisition could be the appointment of correspondents in countries where active research is going on and have them scan the current literature they receive. When an item, article, book or pamphlet seems to be of interest, they can notify their counterpart in Indonesia so that it can be ordered. An alternative arrangement could be for the correspondent to duplicate or acquire the material of interest and send it to the counterpart. The most important aspect of this proposal is that the acquired information be disseminated to those who need to know in Indonesia, not just stored in a library.

One other information exchange problem encountered was attendance at technical meetings. Papers worthy of presentation

have been submitted and accepted. Unfortunately, the individual who did the research and wrote the paper was not permitted to attend the meeting. Too often, higher officials remote from the actual work, availed themselves of the opportunity to travel abroad.

FIRST TARGETS FOR INCREASED COAL USE

Power production is the obvious first choice for expansion. As already stated, all of the expansion proposed in Repelita III has waiting customers. The larger generators will be on the island of Java, since it is the most populated and industrialized. Some manufacturing centers are or will be beyond the range of economical transmission of electric power. For these installations a number of packaged boilers are available, units that can be factory-built and skid-mounted. The larger units, of fixed design, may be assembled in the field.

Cement plants are also awaiting increased supplies of coal so that they can expand and satisfy their customers. Raw materials are available but it is still necessary to import large tonnages of cement to meet the need (29).

Other imported commodities that could be produced in Indonesia, if the energy were available, include brick, tile and lime.

It is the tonnage industries such as those mentioned above that require large amounts of energy, either directly or indirectly. Regardless of the energy source the coordination of supplier and consumer must be scheduled, especially when there are multiple sources and users at different locations. Distances are critical in Indonesia because of the lack of transport and the number of modes required - truck, rail and ship, in many cases.

The home cooking market is not to be overlooked. It is potentially large but generally some distance from the energy source. If coal is to be introduced, it may be necessary to cover most of the cost as well as bring the energy source close to the users in the form of convenient stockpiles or a similar mechanism. In some locations (if not being done already) it may be beneficial to teach people how to use a local energy source, such as peat in Sumatra, or coal from previously exploited coal reserves in Java. Although the reserves in a particular area may be small, the population centers are not large and they could be serviced for several years by small mines until a more sophisticated system of energy supply can be developed. The higher technology could supply gas for the larger cities and electricity or smokeless briquets in the rural areas.

As discussed earlier, there is a dual benefit of introducing coal and related fossil fuels into the home-use market. Deforestation is reduced and firewood is replaced by alternate fuels. The forests might even regenerate or be suitable for controlled reforestation with selected stands of timber. Furthermore, coal derived fuels can be more efficient on an energy per pound basis. The second benefit derives from a reduction in the use of kerosene.

ENERGY CONVERSION EFFICIENCY

One short-term possibility is to make a clean, gaseous fuel, where the presence of ash would contaminate the product. Equipment for this purpose is generally available from several manufacturers of gas producers. But to make high Btu gas or liquid hydrocarbons requires a loss of 50 percent or more of the energy in the coal. In terms of electric power generation, energy to the user is generally 30 to 35 percent of the original source, oil or coal or gas. The advantage of electric power is that its conversion to heat or motive power is very high. Recent values for the efficiencies of coal conversion (30) are:

Powdered Coal Combustion	95%
Solvent Refined Coal	87
Synthetic Oil	70
Distillate	63
Gasoline/Diesel Fuel	55
Methanol	43
Fischer Tropsch	37
Ethanol from Biomass	35
Electricity Production	32

There are other statistics of interest to any energy study in the reference article.

BARRIERS TO APPLICATION OF TECHNOLOGY

Despite many studies relating to the implementation of coal conversion into the economy of Indonesia, some problems and gaps remain. The highest and lowest levels of management in the energy structure are reasonably well filled. Likewise, at the young graduate level the dedication and expertise are commendable. It is the middle management level where there is most difficulty in attracting personnel for the tasks that must be carried out. This problem may be alleviated as the younger technical people gain experience and become willing to apply their expertise to the management of programs and projects.

One of the implications of the gap described above is the difficulty in communicating results of field developments to those who make the political and budgetary decisions. Conversely, these same individuals are vital for interpretation of decisions from the top echelons to the field.

Another barrier to the application of costly technology is the amount of labor available and the low wage rate. Mechanization can certainly produce at a high rate and possibly reduce costs, but high employment is also a major goal in Indonesia. There is no good resolution to this Catch-22 situation. Obviously, the political decision has been made in some cases that the social problems are more important and the cost is subsidized

or an operation is maintained for some reason--mining is an example. These decisions concerning whether to modernize or not should accommodate the Indonesian culture rather than to impose the way things are done elsewhere. Each situation is different and progress can be made if appropriate technology is applied.

APPROPRIATE TECHNOLOGY

Examples are found in all cultures where local materials are put to good use, often not in their usual confuguration. Indonesia is no different. Using an old automobile radiator as a heat exchanger was one device being designed into an experimental gasifier. Manual work often succeeds where elaborate equipment fails, even when the operator is trained adequately. Small is Beautiful, when applied in an appropriate manner.

Economy of scale is not always the important factor in Indonesia. While cost/benefit ratios seem important on a macro-scale, the social/benefit rations may be more important at the micro-level.

RECOMMENDATIONS

Even if the coal research efforts are started at the basic levels - developing analytical procedures, collecting samples in mines, coring, etc., there will be no lost effort as development proceeds to more applied levels. The much-needed information on coal will eventually be applied industrially on a sound basis. This approach stresses the importance of growth from within rather than trying to apply known technology from abroad directly.

A program must be developed that will study the coals that might be applied to future conversion processes. With this approach, engineers and others concerned with utilization can have a better understanding of the processes in operation or the new ones coming from the research centers. The goal may be obtained in the following ways:

1. Establish an energy research center.
2. Assemble a staff of engineers, chemists and some from related disciplines, to direct and carry out coal research.
3. Expand the exploration capability and concentrate on areas to be developed in the near future.
4. Samples should be collected carefully so that the necessary analytical, petrographic and geological information can be correlated.

5. Carry out laboratory experiments on the reactions that can take place with Indonesian coals. Catalysis studies for coal conversion and upgrading of products could be part of the coal chemistry program.

6. Experimental work should continue on blending of coals to make specialized cokes and smokeless fuels.

7. Combustion studies of coal, coal-oil mixtures and coal-water slurries should be emphasized. The near-term use of coal is combustion and a group should be available to study problems as they arise in industry, as they will.

8. Minimize any effort on liquefaction and gasification until a basis for an expanded program beyond small laboratory experimenting is justified.

9. One or two coordinating committees are necessary to establish goals for each coal activity. These groups would also provide the link between the administration and the field.

10. The urgency of starting a coal research program must be emphasized. Lead-times for development, design, construction and training are already close to critical.

11. Select sites for future energy centers that use local sources of peat or other low-rank coals as their fuel source.

A good description of the dilemmas faced by Asia is given in a recent article in "Science" (31).

One major solution is that: "Unless they can discover more fossil fuel resources within their own borders, they must either incur dangerously growing foreign exchange deficits or slow their economic growth." Indonesia has the potential to meet this criterion.

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APPENDIX I

Repelita III - Mining and Energy

THIRD FIVE YEARS DEVELOPMENT PLAN
1979/1980 – 1983/1984

MINING AND ENERGY

DEPARTMENT OF MINES AND ENERGY, REPUBLIC OF INDONESIA
1979

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MINISTER OF MINES AND ENERGY
REPUBLIC OF INDONESIA

FOREWORD

This English translation of the Mining and Energy Chapter of Repelita III, Indonesian's Third Five Years Development Plan, is not intended to be an official translation, but rather is designed to serve as a convenient reference on the mining and energy sectors of the Indonesian Economy during Repelita III for interested readers who do not under stand the Indonesian language.

As such it is hoped that this English translation will be useful to the international mining and energy professional community.

Jakarta, July, 1979
MINISTER OF MINES AND ENERGY

SUBROTO

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MINING AND ENERGY

INTRODUCTION

The mining and energy sector has a very important role in development. It is the main source of foreign exchange earnings, it provides the largest part of energy resources, and creates employment opportunities. As a source of foreign exchange, the contribution of this sector increased during the Second Five-Year Development Plan, Repelita II. At the beginning of Repelita II, 55% of foreign exchange earnings came from the mining and energy sector, while at the end of Repelita II, 70% of such earnings came from this sector. Even more promising is that now there is more variety in the kinds of minerals produced and exported as a result of the success of diversification efforts during Repelita II.

In addition, a large part of the energy resources utilized in the Indonesian economy originates from the mining sector, e.g. crude oil and coal. With the availability of these mining products there is no need to import energy resources, rather most of the output of these products can be exported. Further development in the mining and energy sector proceeded rapidly during Repelita II so that many employment opportunities were created. Moreover, because of the very high technology utilized in this sector, the quality of the labour employed in mining and energy is also improving.

One way of utilizing energy resources is to generate electric power which is needed very much in the development of other sectors. During Repelita II the electric power supply showed a promising growth. Since the generation of electricity is based on energy resources, electricity development during Repelita III will be linked to the National Energy Policy.

There is a very large potential for the development of the mining and energy sector, however development of this sector also poses considerable and significant challenges and problems Since the majority of mining products are for overseas markets, the development of this sector is very much influenced by price fluctuations on the world market. In order to lesson the negative influences of price fluctuations, efforts to diversify our mineral output will be continued during Repelita III.

Another problem to be faced is the lack of balance in the use of energy resources. Although various energy resources are available in great quantities in Indonesia, as yet the pattern of their utilization is far from balanced. In 1977, 98.8% of the energy consumption was based upon crude oil as the fuel, 8.6% used gas and LPG, 0.7% used coal, and 0.9% used water power. Taking into account the importance of the role of crude oil exports as a source of Government income in general and of foreign

exchange income in particular and the fact that this resource cannot be renewed, attempts will be made during Repelita III to ensure that our energy economy does not lean so heavily on crude oil only and that other energy sources will be utilized as much as possible.

Electric power is a critical requirement for the achievement of our development targets. Although there was considerable growth in electric power output during Repelita II, there was an even faster growth in the demand for electric power from the community. Moreover, the present lack of balance between the electricity centres and the transmission and distribution networks has resulted in an incomplete utilization of the facilities. Also the efficiency of electricity generation is not yet fully satisfactory.

Based on the above considerations and guided by the State's Main Guidelines (Garis-garis Besar Haluan Negara, GBHN) the mining sector's main targets during Repelita III are: to accelerate the development and to improve the management of mines and utilization of energy resources; to carry out an energy policy which can give maximum support to national development, taking into special consideration the role of the mining sector as the main source of foreign exchange income needed for the financing of the development of the Indonesian economy, and to increase the electric power supply with the purpose of increasing urban welfare and to facilitate and motivate economic activities. Therefore, the basic target of development in mining and energy is to attempt to realize the second element of the three principles of development (Trilogi Pembangunan), i.e. economic growth which constitutes the development priority in Repelita III.

A. MINING

During the last 10 years, the mining sector has shown a very promising development. Due to expanded exploratory activities for oil, natural gas and other minerals during Repelita I, a number of new mining projects were successfully developed during Repelita II. However, as a result of the world economic recession, growth in this sector experienced a decrease during 1975 and 1976. Nevertheless, on an overall basis the development of the mining sector achieved two Repelita II targets in mining, i.e., diversification and increased domestic mineral processing.

Based on the achievements in Repelita I and II, mining development in Repelita III will aim to increase or at least to assure the maintenance of the mineral production life of those minerals which at present already have an international market. In addition, further diversification and processing of mineral products will be promoted.

1. THE PRESENT SITUATION

a. Oil and natural gas

During the period from 1974/1975 through 1977/1978, Indonesian crude oil production increased an average of 8.4% per year. Good market conditions caused this production increase; however, during 1978 market conditions deteriorated as a result of the abundant world oil production. Crude oil production in 1978/1979 is expected to decrease compared with the production of previous year.

Domestic oil refinery capacity, although it was increased by the Cilacap refinery, the construction of which was completed in 1976, is not yet able to meet domestic fuel oil requirements which increase annually, particularly kerosene and solar oil requirements. At the end of Repelita II, around 24% of the domestic requirement for oil products still had to be processed abroad.

The production of natural gas was also successfully increased during Repelita II. Natural gas is utilized domestically in liquified form and also as the raw material for the manufacturing of urea fertilizer. The increase in domestic utilization of natural gas was mainly due to the completion of the PUSRI III and PUSRI IV expansions to the fertilizer factories in Palembang and Pupuk Kujang and the Krakatau Steelworks in west Java.

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TABLE 1
CRUDE OIL PRODUCTION
1974/75 – 1978/79
(millions of barrels)

Year	Production
1974/1975	485,5
1975/1976	498,0
1976/1977	568,3
1977/1978	616,0
1978/1979*)	587,0

*) Estimate

TABLE 2
PRODUCTION AND UTILIZATION OF NATURAL GAS
1974/75 – 1978/79
(billions of cubic feet)

Year	Production	Utilization **)
1974/1975	206,2	24,2
1975/1976	239,2	27,4
1976/1977	344,4	76,8
1977/1978	633,3	197,4
1978/1979	813,6	459,2

**) Not including gas utilized in the field for oil production purposes.

b. Coal

The mining of coal in Indonesia declined from 1960 through 1973 as a result of a declining domestic market. However, as a consequence of the oil crisis at the end of 1973, the prospects for coal development, which were previously disheartening, underwent a rapid change. Since then, the possibility of developing coal on a large scale has come under consideration with the objective that coal might replace crude oil in certain uses. With the continuous increase in the price of oil, it is apparent that the prospects for coal redevelopment and re utilization on a large scale, for instance as the fuel for electric and industrial power generation, are improving.

In 1974 steps were initiated to maintain and gradually increase the production capability of the Ombilin and Bukit Asam mines. At the end of 1976 it was confirmed as Government policy that first priority should be given to coal for electric power generation and new industrial purposes.

The above developments meant that coal mining activities both in Bukit Asam and Ombilin could be gradually increased. Coal production in the final year of Repelita II had increased by more than 45% compared to the first year.

At this time it was definitely known that the coal reserves in the Bukit Asam mine amounted to around 100 million tons, which could be worked as an open pit mine in the area of Air Laya. Out side Air Laya, the amount of low quality coal reserves in south Sumatra are estimated at about 10 billions tons – a great potential for meeting our energy requirements in the future.

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The size of the coal reserves in the mining area of Ombilin is not definitely known. At present exploration activities are still being continued. The greatest part of the coal reserves of this area is located in deep seams, so that only underground mining is feasible.

In addition to those in South and West Sumatra, considerable potential coal reserves are also known to exist in east and south Kalimantan. These last two areas still need to be investigated further.

c. Tin

Tin is our main metal mineral commodity, and is the second largest earner of foreign exchange after crude oil. It is characterized by a reasonably stable production development as long as the market does not weaken. To prevent a continuing price decline the International Tin Council implemented a limitation on tin exports for member producer countries in 1975 and 1976.

In 1977 the tin market improved. This provided a motivation to improve production facilities and to expand exploration activities, so that in 1978 Indonesian tin production increased. With the completion in the middle of 1975 of the expansion of the tin smelter in Mentok, Bangka, with a production capacity of 33,000 tons of tin per year, all Indonesian tin concentrate could be domestically smelted starting from 1976. In the first year of Repelita II the production of tin concentrate and tin were 24,800 and 15,000 tons respectively. By the end of Repelita II these figures had increased to 28,000 and 27,000 tons respectively.

d. Nickel

With the completion of the nickel processing facilities at Pomalaa in 1975 and in Soroako in the beginning of 1977, during Repelita II, Indonesia has started to produce and export ferronickel from Pomalaa and nickel matte from Soroako in addition to the export of nickel ores.

Ore production during the past five years has shown a considerable improvement, while ferronickel has been produced at factory capacity. With the world market nickel price decline, the nickel matte operation in Soroako was halted and it was only possible to initiate exports from that project at the beginning of 1978.

Meanwhile, the large scale exploration carried out in Gebe island, north Maluku and in the Waigeo islands, and Gag island in Irian Jaya has resulted in the discovery of laterite nickel ores in great quantities. The feasibility study of nickel ore mining and processing in Gag island concluded that the project has good technical and economic prospects. However, the large capital requirements and the nickel price decline on the world market over the last 2 years have caused the execution of the development to be temporarily postponed.

e. Copper

The only producing copper mine, with an output of concentrate, is located in Gunung Bijih, Irian Jaya. This mine has a concentrate production capacity of about 225,000 tons or around 65,000 tons of copper metal per year. Due to the slumping copper market since 1975, production during the last couple of years has not achieved capacity levels.

f. Bauxite

Although bauxite is widely available in great quantities in the Riau Islands and in West Kalimantan, at present bauxite mining in Indonesia is limited to high grade ore deposits in Bintan island and its surrounding area, the output of which is exported. Bauxite production and export during the last couple of years has been quite strong.

A study has been carried out on the possibility of utilizing low grade bauxite ore for domestic production of alumina which would be used as a raw material for the aluminum smelter project at Asahan, north Sumatra.

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During Repelita II, the production of minerals such as gold and silver, iron sand, manganese, granite, and natural asphalt did not grow.

g. Other minerals

Mining of non-metallic minerals like kaolin, quartz sand, marble, etc. is done on a small scale in various parts of Indonesia. The limited and sometimes irregular demand in the domestic market has made it difficult for these mineral enterprises to develop. It is different with enterprises producing building materials such as lime for making cement, etc.; clay for making bricks and roof tiles; volcanic trass for bataco bricks, etc. Enterprises producing these materials have been expanding considerably in various locations, many of them developing as small-scale industry or rural industry activities.

2. POLICY AND STEPS

As the main source of foreign exchange earnings and of energy resources, the mining sector plays an important role in the achievement of development targets. With the expansion of development activities in all sectors, the need for both foreign exchange and energy resources to carry out development will increase.

To meet these requirements, the main development target of the mining sector is to attempt to increase the output and improve the management of mineral and energy resources. To achieve this target, a number of policy steps will be taken. First, attempts will be made to assure the continuity and to increase production of minerals which already have an International market. In addition, programs to diversify production and increase processing of mineral commodities will be continued and promoted.

Efforts to develop energy resources, especially oil, natural gas and coal, which constitute strategic commodities for the support of long term national development and the welfare of the nation will be given first priority. The development and utilization of alternative energy resources, e.g. geothermal heat, will be promoted in the attempt to diversify energy resources. These development efforts will be adjusted to the general policy concerning energy and fuel.

To support the efforts to achieve the mining sector's main targets, steps already taken in Repelita II will be continued and developed, e.g., resource inventory, mapping, exploration and investment in the exploitation of mineral and energy resources. In addition, the development of mining technology will continue, including studies of mineral deposits and the processing of various kinds of minerals.

In the programs for the development and management of mineral and energy resources, the maintenance of the life supporting environment and the strong possibilities for integrated regional development will be taken into consideration. Furthermore, the development of mining and employment agencies which deal with studies, investigations, education and training will be promoted in line with progress in science and technology and demands for national development.

The basic economic characteristics of mining include high risk long gestation periods, advanced technology, and capital intensive. Therefore, until domestic capital and technological capability are sufficient to carry out large-scale mineral operations, the development of mining enterprises will utilize the possibility of foreign capital participation. However, the development of national mining enterprises will still be continued. The main weakness in this sub-sector the availability of capital can hopefully be solved gradually through the willingness of private national businessmen to mine through joint venture enterprises with foreign private concerns. In this connection, guidance will continue to be given during Repelita III to Indonesian entrepreneurs, especially in the technical and management fields, so that national private concerns can take, as soon as possible, an active part in the efforts to develop the mining sector.

To this end, an organized, directed guidance program will be established to promote the capability of the national private mining business in general by means of mining projects which can be easily developed, particularly the mining of non-metallic minerals which already have a strong domestic market position. Similarly, small-scale mining activities will continue to be developed. It is recommended that mining activities, conducted by private national as well as by small-scale mining enterprises operating in the same business and the same area, should be merged into a cooperative. This will facilitate the guidance and development efforts which can be given by the Government and foster the growth of these activities.

To enhance the business world in the mining sector, licences will be reviewed, both as to their content and as to the procedures to obtain them. Licences provisions which are no longer in conformity with policy objectives will be reworked, whereas licence procedures will be simplified to speed up services and to give certainty to the business world.

Licence fees will also be reviewed. Fees which are a heavy burden on the business world will be cancelled. The result of this review of the licensing process should be to expedite and increase the efficiency of the development of business activities in the mining sector.

Meanwhile, the development of state-owned companies in this sector will be further encouraged so that they will be well managed in accordance with economic principles which are sound, efficient, and economical. Thus they will be able to augment the State's revenue and their services to the community will be promoted. Furthermore, state-owned enterprises, as components of the state apparatus, should actively participate in maintaining the effectiveness of the Government's policy program to develop the economically weak business world, to achieve economic stability, and other economic policies.

3. PRODUCTION

Oil and Natural Gas

The production program during Repelita III covers exploration activities, crude oil production, natural gas production and utilization, crude oil processing and natural gas refining, marketing and domestic distribution of fuel oil (BBM) and the export of crude oil and oil products.

In order to obtain the necessary level of reserves, oil and natural gas exploration activities will be further increased. The probability of discoveries of new reserves through increased exploration is quite good.

During the first two years of Repelita III, it is expected that Indonesian crude oil production will be lower than the output of the last year of Repelita II. This, among other reasons, is because in general a large part of the fields controlled by Pertamina and the "Contract of work" companies, and oil fields will be experiencing a natural decline in rate of production.

In addition, the world economic recession and the delaying tactics adopted by foreign oil companies in the face of contract renegotiations with the Government and Pertamina, and the additional problem of possible double taxation for U.S. companies raised by the IRS issues, adversely influenced exploration activities in 1975 – 1977.

Starting from the third year of Repelita III, it is hoped that crude oil production will begin to increase again and continue to do so until the end of Repelita III. This will be made possible by the increase in the "secondary recovery" efforts in fields both on land and offshore which will be encouraged by the incentives given by the Government for oil produced through secondary recovery programs. In additon, it can be expected that there will be additonal oil resulting from maintenance and

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continuing work done on old wells. In new fields it is expected that operational activities will continue to expand due to the incentives given to oil produced from new fields.

It is estimated that oil operational activities will increase generally, more especially in view of the possibility of world oil shortages at the end of the 1980. As we approach that period it is expected that the price of oil will become sufficiently attractive for foreign oil contractors to enhance their commercial efforts in Indonesia, specially in operating oil fields and reserves which are difficult to reach.

Oil fields where exploration was completed during Repelita II but which could not yet be developed because their reserves were insufficient of their access difficult may get a more positive evaluation during Repelita III when the price of oil has increased.

TABLE 3
ESTIMATE OF CRUDE OIL PRODUCTION
1979/80 – 1983/84
(millions of barrels)

Year	Amount
1979/80	582
1980/81	572
1981/82	604
1982/83	640
1983/84	668

Natural Gas production and utilization

Estimated natural gas production during Repelita III is shown in Table 4. Natural gas production, of both "associated" and "non-associated" gas, will in general be utilized for projects which are especially built to utilize either of these two types. With the completion of the LNG projects at Bontang and Arun each of which processes "non-associated" natural gas, a possibility will be opened for using "associated gas" from the oil fields which are situated close to the two LNG facilities. In addition, natural gas is also utilized as fuel for various industries like cement, as raw materials for the fertilizer industry, and is used in the iron ore reduction process in the Krakatau Steel steel mill. Natural gas is also utilized by the State Gas Company to fill household requirements.

Although at present the supply of gas to the P.T. PUSRI urea fertilizer plant in south Sumatra is sufficient, drilling of new wells is still needed to increase the gas supply if required. This activity will be completed by the installation of the gas pipe collecting network. Additional gas supplies are also planned to meet industrial requirement in east and west Java.

TABLE 4
ESTIMATED GAS PRODUCTION
1979/80 – 1983/84
(billions of cubic feet)

Year	Total
1979/80	1,019
1980/81	1,013
1981/82	1,049
1982/83	1,578
1983/84	1,595

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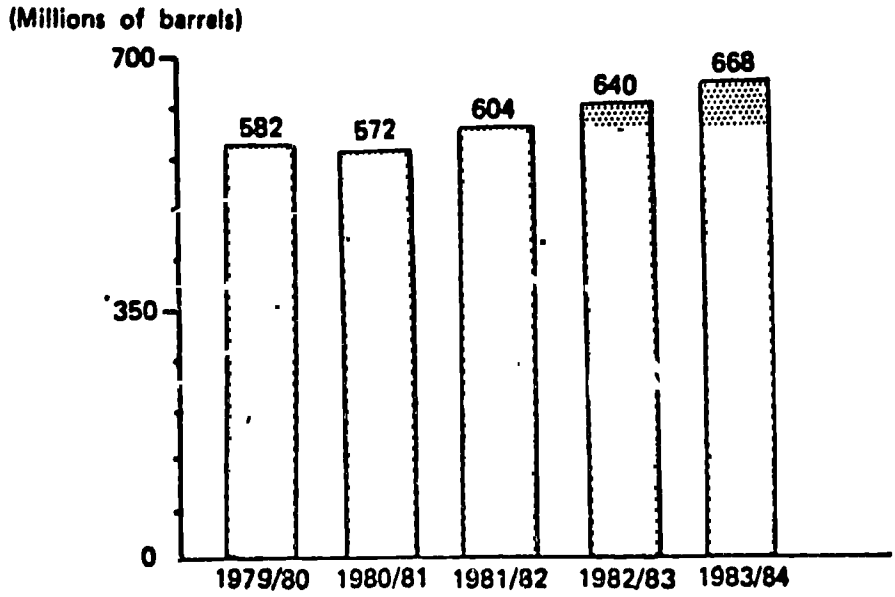
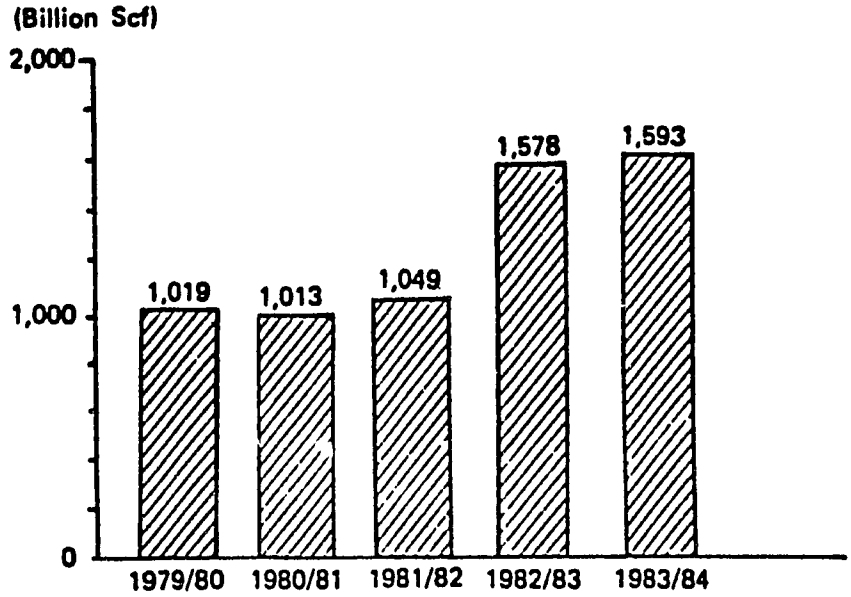


GRAPH 1
ESTIMATED CRUDE OIL PRODUCTION
1979/80 – 1983/84



GRAPH 2
ESTIMATED GAS PRODUCTION
1979/80 – 1983/84

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TABLE 5
ESTIMATED GAS SUPPLY TO BE UTILIZED AS RAW MATERIAL AND FUEL FOR INDUSTRIES AND HOUSEHOLDS
1979/80 – 1983/84
(Billions of Scf)

Year	Total
1979/80	595
1980/81	627
1981/82	693
1982/83	1,175
1983/84	1,178

Processing of Crude Oil

Parallel to the population growth, the domestic requirement of fuel oils (BBM) will continue to increase. It is going to be difficult to obtain a balance between this expanding requirement, and the current domestic refinery capacity because, in addition to their ageing-condition, their pattern of processing output does not conform any longer with the domestic consumption pattern of fuel oil. In order to solve this problem, it will be necessary to import fuel oil and to increase crude oil processing through agreements overseas.

During the first period of Repelita III crude oil processed in the domestic refineries will amount to approximately 370,000 barrels per day, i.e. almost the same level as at the end of Repelita II. Starting from the fourth year onwards, with the plan to construct new refineries and to expand existing refineries, it is expected that domestic crude oil processing can be increased.

The Dumai refinery expansion with the addition of a hydrocracking unit with a capacity of 85,000 barrels per day is planned to process "low sulphur waxy residue" (LSWR) into fuel products. The new refinery on Batam Island which will have a hydrocracking unit with a capacity of 200,000 barrels per day is intended to process Minas and Kuwait crudes, while the expansion of the Balikpapan refinery with a capacity of 100,000 barrels per day is planned to process the Kalimantan crude oil.

TABLE 6
ESTIMATED CRUDE OIL PROCESSING
1979/80 – 1983/84
(thousands of barrels)

Year	Domestic Refineries (including imported crude oil)	Processing Agreement
1979/80	133,000	32,900
1980/81	135,000	32,900
1981/82	137,000	32,900
1982/83	149,700	–
1983/84	221,300	–

In the first and second year of Repelita III, the requirement for crude oil to be processed will amount to 460,000 barrels per day, including the crude oil processed overseas which amounts to 90,000 barrels per day. In the fifth year of Repelita III the capacity of domestic oil refineries will

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increase to 610,000 barrels per day, including processing at the new refinery on the Batam Island and the Balikpapan refinery expansion.

The product mix from domestic refining as shown in Table 7 and the import of oil products as shown in Table 8 are those necessary to meet domestic requirements. The processing by-products, among others naphtha and LSWR, are planned for export. Some of the naphtha could be utilized as raw material for the domestic petrochemical industry in an aromatic centre project.

Milling of Natural Gas

In Repelita III the utilization of natural gas which is processed into liquified natural gas (LNG) will continue to increase. An increase in LNG production in 1982/83 and 1983/84 will be made possible by the completion of the construction of 2 additional trains for the Badak Liquifaction facility and 3 additional trains for the Arun gas facility.

TABLE 7
ESTIMATED DOMESTIC PROCESSING PRODUCTS*
1979/80 – 1983/84
(thousands of barrels)

	Petroleum Fuel Products							Non-Petroleum Fuel Products	
Year	Oil for Turbo Engines	Oil for Jet Engines	Gasoline/ Naphtha	Kerosene	Diesel for transportation	Diesel for Industry	Fuel oil	LSWR**	Others
1979/80	130	–	26,980	35,420	21,400	7,860	14,140	51,240	2,400
1980/81	120	–	26,980	35,420	21,400	7,860	14,410	51,240	2,400
1981/82	120	–	26,980	35,420	21,400	7,860	14,410	51,240	2,400
1982/83	120	–	27,930	43,920	23,590	8,440	16,070	17,740	4,320
1983/84	110	–	54,220	53,020	51,160	8,440	23,150	17,740	10,660

* Including the result of "processing agreements" of 1979/80 – 1981/82
** Resin which contains wax and low-content sulphur

Meanwhile, it is estimated that production of liquified petroleum gas (LPG) will be lower, as seen in Table 9. This is due to the decrease in the associated gas production from the west Java offshore fields as oil in those fields declines.

Domestic Marketing and Distribution of Petroleum Fuels

Until the end of Repelita III Petroleum fuel will still be the main commercial energy resources for Indonesia, although the utilization of other energy resources will start to be actively developed. The requirement for fuel oil during Repelita III is expected to increase steadily by 10% per year on average (see Table 10). The domestic LPG requirement during Repelita III is projected to increase as much as 16% per year (see Table 11).

In order to increase the efficiency of fuel oil services and distribution, the development, improvement, and maintenance of distribution network facilities and oil storage tanks throughout Indonesia should be by means of both sea depots and land depots. Moreover, addititonal new tank,as well as replacements for a number of old tanks are necessary for the sea depots. New sea depots need to be built in order to increase storage capacity in large harbour districts, i.e. 1. Jakarta, with an additional capacity of approximately 150,000 kl. to be built in 1983; 2. Semarang, with an additional capacity of approximately 60,000 Kl. to be carried out in 1981; and 3. Surabaya, to support the Tanjung Perak and Bandaran depots, with a capacity of 100,000 Kl. which will be carried out in 1981.

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TABLE 8
ESTIMATED OIL PRODUCT IMPORT
1979/80 –1983/84
(thousands of barrels)

Year	Petroleum Fuel Types					
	Oil for Jet Engines	Gasoline	Kerosene	HSD*	Diesel for Industry	Fuel oil
1979/80	3,800	–	8,100	18,300	950	9,020
1980/81	4,110	–	10,700	22,750	1,640	8,570
1981/82	4,500	590	13,540	27,320	2,490	12,300
1982/83	4,740	2,400	7,960	30,070	2,540	14,570
1983/84	5,320	–	2,020	8,150	3,160	12,480

* Diesel for high speed engines

TABLE 9
PROJECTED NATURAL GAS PROCESSING
1979/80 – 1983/84

Year	LNG (millions of tons)	LPG (thousands of tons)
1979/80	6,0	524,0
1980/81	7,5	524,0
1981/82	7,5	463,0
1982/83	10,2	402,0
1983/84	13,9	402,0

TABLE 10
ESTIMATED OF PETROLEUM FUEL REQUIREMENTS*
1979/80 – 1983/84
(thousands of barrels)

Year	Petroleum Fuel						
	Oil for Turbo Engines	Oil for Jet Engines	Gasoline	Kerosene	HSD**	Diesel for Industry	Fuel oil
1979/80	130	3,800	22,710	43,520	39,700	8,810	19,160
1980/81	120	4,110	25,000	46,120	44,150	9,500	22,710
1981/82	120	4,500	25,570	48,960	48,720	10,350	26,440
1982/83	120	4,740	30,330	51,880	53,660	10,890	30,640
1983/84	110	5,320	33,410	55,040	59,310	11,600	35,630

* Including requirements for aircraft fuel international bunker and refinery usages
** Diesel for high speed engines

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TABLE 11
ESTIMATED LPG REQUIREMENTS
1979/80 – 1983/84
(Tons)

Year	LPG Requirements
1979/80	58,000
1980/81	68,000
1981/82	73,000
1982/83	90,000
1983/84	105,000

Apart from the above large projects, new sea depots need to be built to increase the storage capacity in the ports of Padang, Sabang, Sibolga, Lhok Seumawe, Kertapati, Jambi, Pontianak, Cilacap, Banjarmasin, Samarinda, Tarakan, Kupang, Ambon and Sorong. Also, for expansion of the distribution network, new depots need to be constructed in Meulaboh, Tanjung Balai, Bengkulu, Singkawang, Ketapang, Palangkaraya, Pacitan, Camplong, and Banjarbaru. Besides the new developments above, a depot will also be built in Ampenan to replace the old one.

In order to serve the needs in the island districts, improvements in storage tank capacities at the land depots will be made during Repelita III, i.e. at Pematang Siantar, Kisaran, Baturaja, Sukabumi, Tasikmalaya, Lahat, Solo, Tegal, Maos, Rewulu, Kediri, Madiun and Jember with total capacity of 60,500 Kl.

Improvement of fuel oil domestic distribution and supply will still require various additional means of transportation, e.g. oil tank carriages, tank cars/trucks, oil pipelines, tanker ships, etc.; also infrastructure facility additions and expansion in the form of oil ports, gasoline stations, dock facilities, bunker facilities, telecommunications equipment, etc.

Crude Oil Export and Oil Products

On the whole, annual crude oil exports during Repelita III are not expected to show a marked increase. This is because the part of the production to be processed for domestic fuel oil supply will increased rapidly.

To safeguard crude oil exports, various steps will be taken. Until now, Japan and the west coast of the United States have been the main Indonesian oil market. Attempts will be made towards market diversification to other countries, as well as the possibility of increased sales to other south-east Asian countries

Development of Petrochemical Projects

In order to bring about the maximum improvement in the utilization of oil and natural gas, an effort will be made to develop four petrochemical industries as joint ventures, i.e.: *the Olefin Centre Project, the Aromatic Centre Project, the Methanol Project,* and *the Carbon Black Project.*

The above projects have significance, not only for the supply of raw materials for domestic industrial requirements, but also as export products.

The 4 projects are planned as follows:

1) *The Olefin Centre Project*

The Olefin Centre Project will produce raw materials for the plastic industries. The project's raw material will be ethane extracted from natural gas from the Arun field in Aceh or from condensates.

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In addition to meeting domestic requirements, a part of the olefin centre output will also be utilized for export. The project is planned to be built in Arun, Aceh, with an ethane extraction capacity of 450,000 tons/year ethane and an ethane cracking of 350,000 tons/year ethylene output. It will produce 120,000 tons LDPE products/year; 60,000 tons HDPE products/year; 60,000 tons/year MEG products (for polyester) and 15,000 tons PS/year.

2) *The Aromatic Centre Project*

The Aromatic Centre Project will produce raw materials for the domestic textile industry, i.e for synthetic polyester fibres (PTE) and nylon fibres (N6). Polyester is made of IMT and MEG, whereas N6 is made of caprolactam. The aromatic centre raw material will be naphta or condensate.

It is planned to build the aromatic centre in Plaju with the following capacity: benzine; 453,000 tons/year, and paraxylene: 100,000 tons/year; it will produce the following cyclohexane: 62,000 tons/year, and IMT: 100,000 tons/year. Benzene will be utilized to make PS (olefin centre), and also as the raw material for cyclohexane which will be further processed into caprolactum, and the remaining amount can be exported.

The aromatic centre will be related to the olefin centre by the availability of PS and MEG products from the latter. Caprolactum facilities are planned to be constructed in Gresik.

3) *The Methanol Project*

It is planned to build the Methanol Project on Bunyu island. It will produce chemical methanol for domestic requirements and also for some exports. The raw material will be domestic natural gas which has not been utilized before. Chemical methanol can, among other uses, be utilized as raw material for the production of IMT (textile material), plywood glue, solvent, pharmaceuticals, etc. To date the entire methanol requirement has been imported. The planned production capacity of the Methanol Project is 1,000 tons/day.

4) *The Carbon Black Project*

Carbon black is utilized for the tire industry, colouring materials and printing ink. The raw material for this project is called waxy residue. The Carbon Black Project is planned to be built in Dumai or Sei Pakning with a carbon black production capacity of 15,000 tons/year.

Coal

In line with the energy policy to develop and utilize non-oil energy resources, from the later part of Repelita II steps have been taken to redevelop coal mining in Bukit Asam, in south Sumatra and Ombilin in west Sumatra. Exploration has proved the availability of coal reserves in a sufficiently large volume in Bukit Asam and these will form the basis for a mine development with a production capacity of 2 to 3 million tons a year. Exploration in Ombilin has not yet been fully completed, and will be continued in Repelita III. Apart from these sources, the availability of lower calory coal reserves in great quantities, more than 10 billion tons, in south Sumatra has been confirmed by the exploration which was carried out in Repelita II by foreign contractors.

The plan to re-utilize coal on a big scale will be coordinated with the plan to develop new steam power plants (PLTU) which will utilize coal as fuel. It is expected that the first big coal fired PLTU will be completed in Suralaya, west Java, but only towards the end of Repelita III. Meanwhile, coal will be utilized domestically in limited amounts in cement factories, carbide factories, coke factories, etc.; while efforts will be made for old consumers to stick to coal and if possible to increase their coal consumption.

In addition, attempts will be made during Repelita III to obtain overseas markets for coal, especially in Asian countries (Bangladesh, Japan, Singapore, Taiwan, etc.). In this connection, the Ombilin mine which has relatively good quality coal will find overseas markets more easily if production and transportation costs can be brought down to a reasonable level.

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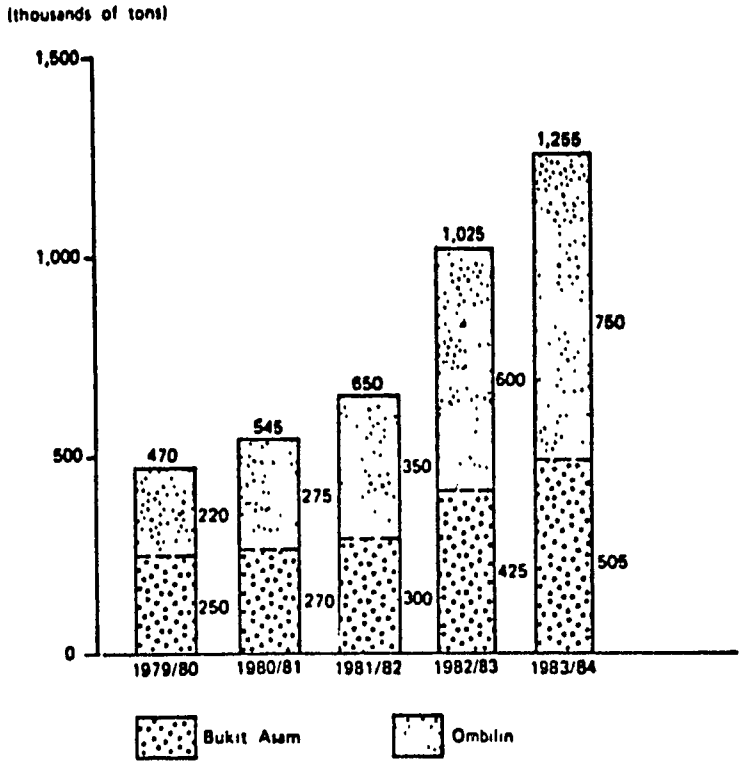

GRAPH 3
ESTIMATED COAL PRODUCTION
1979/80 – 1983/84

With the market as described above, it is hoped that Ombilin and Bukit Asam coal production can be increased phase by phase during Repelita III.

TABLE 12
ESTIMATED COAL PRODUCTION
1979/80 – 1983/84
(thousands of tons)

Year	Bukit Asam Production Unit	Ombilin Production Unit	Quantity
1979/80	250	220	470
1980/81	270	275	545
1981/82	300	350	650
1982/83	425	600	1,025
1983/84	505	750	1,255

In order for an increase in coal production to be achieved according to the above plan, in addition to the rehabilitation of existing mining equipment, new equipment will also be needed. Phased development is needed not only to meet market requirements, but as preliminary steps to prepare the development of the coal enterprise for the very large-scale expansion which is expected to be carried out in Repelita IV.

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Tin

In Repelita III tin production is expected to increase steadily as a result of exploration and development activities and the rehabilitation of tin mining facilities which was carried out in Repelita II. In addition to the state owned eneterprise, PT Tambang Timah, which is the largest producer, there are three private foreign companies which are also mining for tin in Indonesia.

With the continuous decline of reserves on land, tin mining activities will move more and more to offshore areas in the coming years, and thus mining will become increasingly more difficult and expensive. In order to assure the continuity and development of the enterprise, exploration will continue in order to discover new reserves. Furthermore, old or broken equipment will be replaced or rehabilitated and there will be additions of new equipment. Particularly for the purposes of mining reserves in water depths of between 30 and 40 meters, the construction of new dredgers able to dredge ores from those depths is still needed. A number of new open mines on land will be established, and with the reduced availability of secondary tin reserves, primary tin reserves will start to be developed, either through open pit mines or underground mines.

TABLE 13
ESTIMATED PRODUCTION OF TIN-IN-CONCENTRATES
1979/80 – 1983/84
(tons)

Year	Quantity
1979/80	32,775
1980/81	33,744
1981/82	34,385
1982/83	35,583
1983/84	36,611

To improve commercial results, efforts will be made to increase the "recovery" of various kinds of associated minerals which exist together with the tin reserves, for example monanize, xenotim wolframite, tantalum, columbium, etc.

So that the entire production of tin ore can be smelted domestically, a program will be implemented to expand the PELTIM tin smelter in Mentok, Bangka.

TABLE 14
PRODUCTION PLAN OF TIN METAL
1979/80 – 1983/84
(tons)

Year	Quantity
1979/80	30,291
1980/81	34,351
1981/82	34,684
1982/83	34,649
1983/84	35,379

The greater part of Indonesian tin production will be exported and only a small part of it will be marketed domestically.

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TABLE 15

ESTIMATED INDONESIAN TIN EXPORT
1979/80 – 1983/84
(tons)

Year	Quantity
1979/80	29,791
1980/81	32,801
1981/82	34,109
1982/83	34,074
1983/84	35,379

TABLE 16

ESTIMATED DOMESTIC TIN MARKETING
1979/80 – 1983/84
(tons)

Year	Quantity
1979/80	500
1980/81	550
1981/82	575
1982/83	575
1983/84	625

Nickel

The exploration for nickel ore during Repelita I and Repelita II proved the availability of potential nickel ore reserves of a very considerable size in south and southeast Sulawesi, north Maluku, especially in Gebe island, and Gag island, Waigeo island, and the surrounding area.

PT Aneka Tambang is continuing its nickel ore feasibility study and exploration in Gebe island in order to determine the possibilities for mining and export to Japan.

Meanwhile, it is estimated that production will amount to 1,200,000 tons per year, and an increase in exports is expected because of better market conditions, i.e. from 800,000 tons at the end of Repelita II to 900,000 tons.

With the expectation that by the end of Repelita III the nickel market will again be good, studies have been carried out since 1978 with regard to the possibility of expanding the production capacity of the Pomalaa ferronickel smelter, this would be implemented by PT Aneka Tambang.

The construction of a "nickel matte" mill in Soroako, which has fallen behind schedule as a result of the slackening of nickel market, is expected to be completed and to achieve full capacity production in the third year of Repelita III.

TABLE 17

NICKEL MATTE PRODUCTION AND EXPORT
1979/80 – 1983/84
(tons)

Year	Production	Export
1979/80	22,700	22,700
1980/81	38,600	38,600
1981/82	47,600	47,600
1982/83	47,600	47,600
1983/84	47,600	47,600

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Bauxite

Indonesian bauxite production and exports from mining interprise in Bintan Island in Repelita III are expected to maintain the same level as during Repelita II, that varies from 1.1 million tons to 1.2 million tons.

Meanwhile, the reserves of export quality bauxite in Bintan Island are no longer so large. To deal with this problem, it is currently planned to process low quality bauxite into alumina to serve as raw material for aluminium smelter project at Asahan. If the price of the alumina products are competitive and reasonable, bauxite production in Repelita III will increase from 1.1 million tons to 2.7 million tons.

Meanwhile it is estimated that the aluminium smelter project will start production which by the end of Repelita III amounting to 225 thousand tons of aluminium metal.

Copper

The decline of copper prices during the last few years has had a negative effect on the copper mining enterprises at Gunung Bijih, Irian Jaya. The ore reserves for open pit mining have become very thin, so that further operations will be in the form of underground mining of reserve in the Gunung Bijih Timur area.

If the copper market improves during Repelita III, the plan to mine the reserves in Gunung Bijih Timur can be carried out with a production target of 225,000 tons per year copper concentrate during the period of 1979/80–1983/84 with a copper content of more or less 31.0%.

Other Minerals

Other minerals which stil now have been produced only in small amounts are silver, gold, iron sand and manganese, apart from various non-metallic or industrial minerals which are utilized by domestic industries.

In Repelita III, continued production of gold and silver is expected from the Cikotok gold mine in west Java where up to now regular mining has taken place. During Repelita III an effort will be made to process lead and zinc which are available together with gold and silver ores in Cikotok, and which so far have not been processed. In the period 1979/80 – 1983/84 the Cikotok gold mine will have an estimated production of 160 kg and 3,500 kg. per year of gold and silver respectively, while the production of lead and zinc is estimated at 600 tons and 750 tons per years respectively.

The export of iron sand to Japan was halted at the end of Repelita II because the amount was too small and proceeds were no longer in balance with production costs. Therefore, iron sand mining in Repelita III will only be directed to fill the requirements of domestic cement factories.

Manganese, although it is an export commodity, does not as yet have a stable production due to the characteristics of the reserves, which in general are small in size, widely distributed, and irregular. In Repelita III attempts will be made to mining the manganese reserves in west Java with an estimated production of 30,000 tons/year on average.

Granite, has recently been regularly quarried on Karimun island in Riau province. A part of its production will be exported to Singapore and Malaysia, and the remainder will be marketed domestically.

In addition to the above minerals, mining activities also produce other minerals which have a reasonably significant importance for domestic economic activities. Insufficient statistical data and the dispersion and irregular of the enterprises have prevented the preparation of a national production estimate, especially as often this mining is carried out only at certain times or seasons or only when there is a requirement for some development activities in the area concerned. Lime and various kinds of clay and sand, will be produced in great quantities during Repelita III for the purposes of manufacturing cement, coal, roof tiles, and various other development requirements. The production of other non-metallic minerals will also include volcanic trass, marble, quart-sand, kaolin, sulphur, natural asphalt, etc.

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City Gas

The distribution of gas for small industrial purposes and city gas is carried out by the State Gas Company (PNG) which has 8 units, one each in Medan, Jakarta, Bogor, Bandung, Cirebon, Semarang, Surabaya, and Ujung Pandang. For its total business PNG possesses a pipe network of ± 924 km. Part of the gas distributed is artificial (made from oil and/or coal) while the remainder is derived from natural gas.

The gas enterprise development plan for small industries and city gas in Repelita III will place greater emphasis on the distribution of natural gas. In this connection the following development activities will be carried out:

a. expansion of gas production and distribution in Jakarta and Bogor by distribution natural gas from the Cimalaya–Cilegon main pipeline, via the Cimanggis–Jakarta transmission and the Jakarta–Bogor interconnection;
b. completion of the gas network to Medan and its surrounding area from the natural gas field of the Wampu river, including that piped for PLTU in Belawan;
c. investigation of the possibilities of piping natural gas from the Cepu and Poleng fields (in the offshore area north of Madura) for the gas network of Surabaya and its surrounding area;
d. investigation of the possibilities of supplying gas to Palembang by utilizing the surplus pipeline capacity to the PUSRI fertilizer factory.

Studies of the possibilities of utilizing Ombilin coal for manufacturing coke and gas supply for the Indarung and Padang Cement Factory will be continued in the hope of meeting the domestic requirement of coke which still has to be met by imports from abroad.

TABLE 18
ESTIMATED GAS SALES
1979/80 – 1983/84
(millions of cubic feet)

Year	Quantity
1979/80	2,220
1980/81	6,595
1981/82	8,180
1982/83	14,885
1983/84	19,045

Supporting activities

In order to implement the mining sector's development plan which is in part presented in the above production programs, a harmonious business climate and adequate means of Government administration are required. In this connection, the capability of the Government apparatus will be improved so that it can motivate and support the planned development activities on one hand, and on the other hand give better guidance and supervision of the development process itself.

The attempts to improve the capability of the Government apparatus are embodied in the supporting programs which include personnel and material aspects, and various means of administration, investigation and development.

The activities in the personnel field will include programs to improve skills and expertise through training and education, both in or outside the country. This effort will not be limited to special fields of expertise or to certain levels of rank or position, but will be carried out in all fields and at all levels considered necessary for the smooth execution of development.

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The supporting activities in the material field will include replacement and addition of work equipment and apparatus, i.e. expansion and addition of buildings and laboratory equipment, means of transport both for field work or for office staff transportation, and supply of various kinds of tools and equipment for carrying out Government administrative activities, field work or labotaroty studies.

The supporting program in research and development will cover activities in geology, geochemistry, geophysics, geotectonics, volcanology, hydrogeology, exploration for crude oil and other minerals, various kinds of laboratory and field research for scientific purposes or as applied investigations. The main purpose of the various activities is to support the development and utilization of the natural resource potential of land, minerals, water and geothermal heat, paying attention to the welfare of the structure of the environment.

The supporting program in administration will include various efforts to complete or perfect regulations and laws, such as those connected with licences and supervision, and perfection or improvement in the manner of supervision, control and management of mining enterprises.

The basic aim of the supporting program for the development of the mining sector is to improve the capability of the Government apparatus so that development in the mining sector can be accomplished in accordance with guidelines of the GBHN (the State's Main Guidelines) and the Sapta Krida Kabinet Pembangunan III.

B. ENERGY

1. INTRODUCTION

Energy constitutes one of the determining factors for the achievement of the development target. During Repelita I and II energy supply was not a problem because the energy requirements of the sectors could be easily met. This was so because of the various natural energy resource potentials possessed by Indonesia, such as oil and natural gas, coal, water and geothermal heat. Moreover, as a tropical country Indonesia can utilize solar heat and various kinds of plants which produce firewood for energy supply in rural areas.

However, facing the problems of rapid population growth and an increasing pace of industrialization in the years ahead, management of the various energy resources should be implemented as early as possible in a rational and effective manner. The development of energy consumption during the last 15 years has clearly proved the importance of a cohesive energy organization structure, not only to see to the efficient development and utilization of various energy resources, but also to pay attention to the protection of the environmental structure.

The available data starting from 1963 shows that during the period 1963 – 1969 the increase in total commercial energy consumption in Indonesia was an average of 5.2% per year, whereas for the period 1970 – 1977 the increase was 13.7% per year on average. "Commercial energy" does not include energy originating from firewood and agricultural sources or, which, despite its extensive use in the rural areas, data are not yet available. Surveys have estimated that non-commercial energy consumption is probably larger than the commercial energy consumption at present.

Commercial energy resources utilized in Indonesia so far are crude oil, natural gas, liquified petroleum gas (LPG), coal and water power. Although these energy resources are available in great amounts, the pattern of energy resource utilization is as yet unbalanced. For 1977, 89,8% of the energy consumption came from crude oil, 8,6% from natural gas and LPG, 0,7% from coal and 0,9% from water power.

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Taking into account the importance of the role of crude oil as a source of state income and foreign exchange, and the fact that this natural resources cannot be renewed, it is necessary to take immediate steps to ensure that the Indonesian energy economy does not lean too heavily on crude oil and use as much of the other energy resources as possible.

Based on these considerations, the development of a balanced energy policy will receive first priority during Repelita III. The policy will concern various aspects of the daily life of the people and have an especially close connection with the population growth and the rate of economic growth.

Although Indonesia is blessed with various energy resource potentials on a large scale, the problem she faces in the development of any one type of energy is the long lead time, i.e. from the time the decision is taken up to the time when the energy can be effectively utilized. Moreover, energy plants are usually capital intensive and technology intensive. Furthermore, all the side effects of the development of an energy resource on a large scale must be calculated from the start. In other words, in order to be able to utilize any given of energy in the coming decade, preparations must start now.

With the economic growth target of 6.5% during Repelita III, the requirement of domestic energy consumption in 1985 will reach approximately 53 million tons coal equivalent (TCE), whereas the domestic energy consumption in 1977 only amounted to 24 million TCE. In other words energy consumption at the end of Repelita III will increase by around 100% compared to the energy consumption in 1977.

As discussed in the introduction, the energy economy at present depends very much on crude oil in the energy economy was 84.0%, but the role increased to 87.9% in 1970 and 89.8% in 1977. It is clear from those figures that the other energy resources, i.e. natural gas, coal and water power have played a very small role. If this tendency continues the crude oil requirement for the domestic energy supply will continue to increase. Therefore, there is no other choice than to make in immediate attempt to develop and use other energy resources. Apart from oil and natural gas, the Indonesian soil contains coal and lignite reserves in great quantities.

In addition, on the Indonesian islands there are big rivers and lakes which can be used for the development of water power. From the magmatic process there are also signs of the existence of geothermal heat potential. There are also indications of the availability of radioactive minerals which in the future can probably be made into fuel for nuclear reactors. Besides these, the tropical climate makes possible the use of all aspects of solar power for heating, electricity generation (photovoltaic), mechanical (wind), biological (bio-gas), or chemical (photo-synthetic or thermal chemical). Lastly, in the large expanse of Indonesian jurisdiction there is still a lot of land with critical soil conditions which can be systematically utilized for energy plantations. These energy plantations, apart from functioning as an energy resources, can at the same time function as a tool for land recovery, protection of watersheds, and erosion prevention.

The following brief summary describes possibilities for the utilization of various potential energy resources which are available in Indonesia.

Oil and Natural Gas

In line with the development of exploration activities which started in increase in 1967, Indonesian crude oil reserves continue to improve. In 1971 the production of crude oil from offshore fields have started and since than Indonesian crude oil production has been increased, from 0.75 million B/D in 1969 to 1.7 million B/D in 1977. Nevertheless, exploration activities have covered only about 20% of the prospective area; and the area which has not been carefully studies as yet, both on land and offshore, is still extensive.

Taking into account that crude oil has an important role in the Indonesian economy, i.e. as state foreign exchange income and a domestic energy resources, the intensification and extensification of new resource discoveries and increased production from existing wells will continue to be carried out.

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Meanwhile, Indonesia also has natural gas resources. So far, natural gas fields have been discovered as the by-product of oil exploration. Since it is estimated that the Indonesian soil still contains a lot of natural gas, discoveries of new resources need to be intensified, especially in areas close to consumption centres like west Java. In this connection, the piece of natural gas will be fixed in such a way so that it can be paid by users in the community and that at the same time it gives enough incentive for discoveries and development of new gas fields. Increased production and utilization will lessen the load which is at present borne by crude oil. With a reasonable price arrangement, natural gas can also function as the raw material for petrochemical industries.

Coal

It has recently been proved that the Indonesia soil contains an extensive amount of coal. It is estimated that more than 10 billion tons are available in south Sumatra in the form of relatively shallow deposits. Coal deposits are also available in Kalimantan and central Sumatra in large amounts. The Indonesian coal reserves as a whole have a caloric value which is much higher than the crude oil reserves known at present. Therefore it would be beneficial if Indonesian coal can be developed and utilized on a large scale, especially for electricity generation.

In addition, coal can also be used as a raw material for the chemical industry and as briquets as fuel. In the long term the large Indonesian coal reserves can be projected to produce gas and liquid fuels.

During Repelita III steps were therefore taken to use coal as a replacement fuel, especially for generating electric power. If coal is expected to replace oil domestically, its production must be increased soon. The current problems are those of transportation and price.

The development of coal in south Sumatra will as far as possible be connected with the development of the region. This will increasingly open–up south Sumatra and it is hoped that spontaneous transmigration from Java will continue to increase.

Water Power

The installed capacity of hydro power plants (PLTA) was only 450 MW in 1977, whereas the theoretical water power potential in the whole of Indonesia is estimated to be up to 31,000 MW. The power potential near consumption centre like Java which has not yet been utilized is estimated to be 4,000 MW. This potential would become significant if it could be utilized to generate electric power and thus could replace fuel oil.

Apart from this, the use of water power enables the execution of multipurpose projects (flood control, erosion control, water conservation, protection of the environment and recreation) which is very beneficial for society. However, one of the difficulties in the development of water power is the high level of front end financing required.

Geothermal Heat

Geothermal heat resources in their conventional form (heat water and steam) in locations which have already been identified in Indonesia are estimated to amount to 1,500 MW, of which 890 MW is in Java. Since it is estimated that electric and geothermal heat power production costs are competitive compared to electricity generation by oil and coal, geothermal heat in Indonesia will be developed whereever possible.

The chief problem in the development of geothermal heat is that of organization. There is also the problem of the price of steam, which is important to encourage discoveries of new resources An inventarization of geothermal resources will be carried out integrated with the development of areas where resources are found, especially isolated areas.

Radioactive Minerals

Survey and exploration efforts have discovered some indications of uranium in a number of places in Indonesia, such as in Kalimantan. If the potential reserve is large, it is possible that in the future Indonesia will utilize self-produced uranium fuel for its nuclear power plant (PLTN). However, since nuclear power development is very expensive and requires a truly advanced technology, various aspects will need to be considered in taking steps towards its development, especially the feasibility and techno–economical factors, as well as safety and environmental factors. The tendency of oil prices to increase continuously may enable nuclear power to compete with the other types of power.

Solar Energy

In the long term, the sun constitutes an energy resources which will never be used–up and which will not cause pollution. Indonesia which is situated in the tropics, can utilized solar energy in a variety of ways, e.g. for electric power, heating, mechanical power and also biological and chemical power.

What could be implemented immediately is the utilization of solar energy in the thermal field, i.e. for drying or cooling (preservation), utilization of bio-gas and utilization of wind power, especially in the eastern part of Indonesia and in the rural areas.

Apart from this, the use of solar power in a passive manner should be develop, i.e. arranging the life environment (residential areas) in such a way that sunshine and wind can be used to the maximum for lighting and natural ventilation.

Although this field is comparatively new a number of uses of solar heat technology can be directly applied through adaptation. In this case the use of domectic components will be chosen.

Firewood

As in other developing countries, the utilization of non-commercial energy in Indonesia is estimated to be very large. Firewood, for example, still has a very important role as an energy source, especially for households and rural industries.

In 1974, it was estimated that the consumption of firewood for all Indonesia amounted to about 40 million tons. Its supply is still a big problem. On the one hand supplies are short in densely populated areas like Java and Bali, on the other hand an extensive supply is available in other areas. The lack of firewood in Java and Bali is widely felt in those islands. Deforestation as a result of the gathering of firewood results in the erosion of banks, sides of ravines, and mountain slopes which in turn cause flooding. Deforestation still occurs although replanting and greening have been intensified since 1974.

Outside Java, together with the production of wood for export and domestic requirements, by–products such as chips, brush, ends of stumps or trunks, branches and twigs are also obtained which at present amount to more or less 26 million M^3 per year. These by–products cannot be utilized as yet to cover the short supplies of firewood in the densely populated areas due to the high cost of transportation and the low price of firewood.

Indonesia as a tropical country has a large potential for the production of firewood. The planting of suitable types of firewood on critical soils will not lessen the protective function of the plants, cutting can be carried out close to the end of the raini season, so that at the beginning of the following rainy season new growth is already dense, and covers the land effectively.

As an energy source, firewood can be processed into a better quality fuel in the form of solids, liquids or gas, which besides being used for household requirements could also be utilized for industrial and transportation purposes. This matter will be studied further.

2. POLICIES AND MEASURES

Based on the recent situation and the analysis of the existing alternate energy resources, and in accordance with the GBHN, the development and utilization of energy will be based on an energy policy which is comprehensive and harmonious in character, taking into account increased demands, both for export and domestic consumption, and the strategic energy supply capacity in the long term.

The overall target of the energy policy is as follows:

a. To guarantee a continuous energy supply which meets national demands in both quality and quantity, at a reasonable price to generate a well-distributed increase in the standard of living of the Indonesian people and the achievement of high economic growth rate.
b. To guarantee that, apart from fulfilling national needs, the energy supply also provides export commodities in order to support the balance of payments.
c. To guarantee that the development of energy resources is accompanied by an efficient and wise management of a life supporting environmental structure in order to achieve a better quality of life for the Indonesian people.
d. To make every effort to ensure that the overall supply and management of energy resources increases the capability and strength of the Indonesian people to face the future.

The main target of the energy policy is to decrease dependence on crude oil and gradually move from a mono-energy economy to a poly-energy economy.

In order to achieve the national policy target for energy, steps will be taken in various fields including exploration and development of non-conventional energy resources, development of manpower capability, financial resources, tariffs, taxation, duties and excise and administrative bodies.

The exploration for oil and natural gas, coal, water power, geothermal heat and radioactive minerals will be promoted, especially in acreas close to consumption centres. For isolated areas where exploration activities are difficult to carry out, reasonable and attractive incentive will be considered for investors.

Research and development in the field of non-conventional energy resources will be encouraged and supported, so that in time they can replace the role of conventional resources. In connection with energy development programs, the expansion of the technological capability of each energy type to be developed needs to be considered. This means that in the very near future scientific and research personnel in the fields of oil, coal, natural gas, water power, geothermal heat, nuclear power, solar energy and firewood must be increased and trained.

Meanwhile research institutions relevant to energy development, will be strengthened and improved. Thus improvement in national capabilities in science and technology can be expected. In this connection, necessary research programs will be outlined.

The capital intensive nature of the energy sector makes a large amount of funds necessary for energy development. Taking into consideration our limited capacity to raise funds and in technology, foreign finance and expertise will be utilized where necessary.

Tariffs and prices are important tools to achieve the targets which have been fixed as part of the national energy policy, in connection with the economic growth rate, energy enterprises, energy diversification, or shifts in the pattern of consumption. Therefore, pricing policies will aim to achieve a balance of various objectives, i.e. supply of energy at reasonable prices, improvement in the efficiency of energy utilization and sound energy enterprises.

The tax and customs policy in the energy sector will aim at increasing conservation as well as improving the management of production in the energy field.

3. PROGRAM

In order to achieve the overall target described above, all energy resources should be used optimally. The target embodies seven basic elements, i.e.:

(1) increase and expansion in exploration and production of all energy resources, i.e. oil and natural gas, coal, water power, geothermal heat, and radioactive minerals;

(2) a reduction in the domestic utilization of crude oil and the promotion of crude oil as a prime export commodity through an extensive diversification program that increases the utilization of other energy resources;

(3) conservation directed to a more efficient use of energy;

(4) institutional development in order to be able to formulate a national energy policy and to guarantee its implementation a review as and when necessary;

(5) information and data development to complete the information and data on conventional and non-conventional energy resources and energy requirements;

(6) information to promote understanding among the community of the energy policy undertaken the Government;

(7) monitoring and evaluation of the implementation and the laws and regulations stimulated in the framework of the national energy policy, in order to take measures for their improvement as required.

The energy policy consists of three basic programs founded on the above elements. First, a short–term program with a target of intensification and extensification of exploration of the present main energy resources, i.e. oil and natural gas, and an increase in the production of firewood. Second, a mid–term program with a target of extensive diversification to achieve an optimal utilization of all energy resources. The steps to be carried out to achieve diversification are:

a. Efforts to achieve an efficient utilization of energy;

b. The rapid development of coal production and its use for domestic purposes, especially for generating electricity and for industrial and household purposes both in the cities and in the villages;

c. Utilizing water power and geothermal heat in areas where those resources are available for generating electrical energy;

d. Increasing the production of firewood by encouraging the people to participate in promoting replanting and greening, and by establishing plantations on critical lands, and in addition utilizing waste by–products from firewood cutting as fuel;

e. Encouraging the use of solar power with the available technological capability, utilizing domestic components as much as possible;

f. Utilizing nuclear power as long as it is techno-economically feasible;

g. Making sufficient investment for the promotion of national capability in the development of energy research and technology, and strengthening and improving the existing research bodies;

h. Making efforts to assure the availability of funds and equipment both for exploration and exploitation of new energy resources, or for the utilization of the existing resources.

Third, a long–term program starting from now consisting of efforts to achieve extens nd sustained coservation in various fields accompanied by attempts to use energy resources which n be renewed, thus assuring a wiser way of life. Extensive conservation would, for instance, give priority to the use of public transportation and of transport networks economical in their use f energy, the utilization of solar power in a passive way or through direct conversion; and utilization of equipment needed for daily life which designed on the principles of economy and efficiency.

In the long run, conservation will be very important and will require a new way of life because in the end the problem of energy is not only a question of its supply, but of its production also. Moreover, a concern for the welfare of the environment and community life in general will play a greater

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role in the future. The supply of energy in the future must take these matters into account or it will eventually cause an increase in costs to the economy which ultimately means a higher investment requirement.

The above short–term and mid–term programs can be broken down further into the development plans of the various commercial energy resources which are available, producing a quantitative estimate of the development up to 1983/1984 as follows.

In the future, the utilization of natural gas will increase, because a number of new industries will use natural gas as their energy source. Among others, industries which are natural gas are fertilizer factories, the LNG projects, some cement factories, and a number of steam power plants in Banda Aceh, Belawan, and Balikpapan. The total energy consumption originating from natural gas in 1984 is expected to be as much as 606 MMCFD or the equivalent of 8.3 million tons of coal. In addition, LPG consumption is expected to continue to increase in the future and in 1984 will reach 105,000 tons or 190,000 TCE.

Similarly, the consumption of coal will also increase, especially as a result of the development of the steam power plant project at Suralaya and some small industries. It is estimated that the consumption of coal will increase to 1.2 ton in 1984.

In the period 1977–1984 the State Electricity Company plans to build hydro power plants in a number of areas in Indonesia with a total capacity of 307 MW. In 1980/81 it is expected that the hydro power plant in Jatiluhur will be expanded to 150 MW, while Asahan (603 MW) will be completed in 1984. With reference to the development plan, it is estimated that in 1984 the installed capacity of hydro power plants will come to about 1550 MW or 1 million TCE.

In 1981 the first geothermal power plant (PLTB) in Kamojang is expected to be completed, with a capacity of 30 MW, followed by one in the Dieng mountains with the same capacity, so that in 1984 installed geothermal power plant capacity in Indonesia is expected to be 60 MW.

This development of non-oil energy resources will moderate the increase in the level of oil consumption in the future. The increase in the level of oil consumption in the period of 1970-1977 was on the average 13.7% per year. In 1977–1984 it will go down to 9.5% per year. This estimated growth can be reduced still further through the adjustment of the domestic price of fuel oil.

If an assumption is made that energy consumption during 1977–1984 will increase by an average of 11.5% per year (compared to 13.7% per year during 1970–1977), the total energy requirement in 1984 will reach 52,780,000 TCE. This would mean that the role of crude oil as an energy resource will decrease from 89.8% in 1977 to 79.4% in 1984.

Energy requirements could be filled without any problems if well focused plans are made from now on, particularly with the aim of developing more non oil resources.

In Table 19, the estimate of the growth of energy requirements in Indonesia for 1978–1984 is given, with details of the primary resources, on the basis of the above assumption.

TABLE 19
ESTIMATED ENERGY REQUIREMENTS
1978 – 1984
(million TCE)

Kinds of Materials	1978		1979		1980		1981		1982		1983		1984	
	TCE	%	TCE	%	TCE	%	TCE	%	TCE	%	TCE	%	TCE	%
1. Natural Gas	3.137	(11.30)	4.375	(13.80)	4.885	(13.90)	5.435	(14.09)	6.647	(15.52)	8.050	(16.97)	8.339	(15.80)
2. LPG	0.078	(0.28)	0.091	(0.29)	0.107	(0.30)	0.123	(0.32)	0.141	(0.33)	0.165	(0.35)	0.189	(0.36)
3. Coal	0.190	(0.68)	0.225	(0.71)	0.327	(0.94)	0.397	(1.03)	0.522	(1.22)	0.644	(1.36)	1.254	(2.38)
4. Water Power	0.311	(1.12)	0.398	(1.26)	0.510	(1.45)	0.516	(1.34)	0.521	(1.21)	0.548	(1.15)	1.084	(2.05)
5. Geothermal Heat	–	(0.00)	–	(0.00)	–	(0.00)	0.007	(0.02)	0.007	(0.02)	0.007	(0.01)	0.015	(0.03)
6. Fuel Oil	24.059	(86.62)	26.619	(83.95)	29.315	(83.41)	32.096	(83.20)	34.999	(81.70)	38.035	(80.16)	41.899	(79.38)
Total:	27.775	(100%)	31.708	(100%)	35.144	(100%)	38.574	(100%)	42.837	(100%)	47.449	(100%)	52.780	(100%)

TCE = Ton Coal Equivalent

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It is clear that the problem of energy affects extensive areas of community life, especially the vitality of the economy and capital requirements, technology, the labour force and administrative bodies, environmental issues, the social structure and the gestation period involved in major energy programs.

In order to guarantee that energy policies can be effectively and harmoniously implemented, studies will be carried out on the quality of the management of various exploration, production, distribution and consumption activities in relation to institutional aspects in conjunction with comprehensive efforts to increase the national vitality.

C. ELECTRIC POWER

1. INTRODUCTION

Electric power for both industrial and household uses has an important role in the attempt to achieve our development target. As a production infrastructure, the availability of electric power in sufficient amounts and quality and at the right time will support development in other sectors. In addition, the wide availability of electric power which is utilized extensively for daily purposes will promote community welfare and the national resiliency. The State's Main Guidelines (GBHN) stated that development of electricity should aim to promote the welfare of rural and city communities and to enhance economic activities.

Thus, electrical development will influence the three elements in Trilogi Pembangunan (the Three Principles of Development), i.e. equally distributed development and its benefits, high economic growth, and a healthy and dynamic national stability. During Repelita III, the policy and steps which will be taken to achieve targets will be based on the Three Principles of Development. Moreover, considering that the generation of electric power requires the use of energy resources, the development policy for electricity will be integrated into the national energy policy. Furthermore, continuous careful evaluation of its impact on the life–supporting environment will be carried out to ensure that it is safe.

Development of the electrical sector is capital intensive and involves long gestation periods for planning and execution. During Repelita I and II, most of the development funds came from Government investment. In Repelita III a more extensive participation of private parties will be considered in order to meet the electric power requirements.

2. THE PRESENT SITUATION

Total installed capacity at the end of Repelita II amounted to approximately 3,791 MW, of which 2,283 MW was managed by PLN while the remainder of 1,688 MW was owned by industries which operated the electricity generators for their own use.

During Repelita II the following were accomplished in the development of the PLN electricity system: completion of electric power plants with a capacity of 1,337 MW; completion of transmission networks of 2,758 kms; completion of main sub–stations with a capacity of 3,137 MVA; addition of a medium voltage distribution network of 7,625 kms and low voltage distribution network of 7,177 kms with 14,518 kms with 14,518 sub–stations. During Repelita II, preparations were made for the development of rural electrification both by PLN and by the electrical cooperation organization.

As a result of the development and rehabilitation of electric generating plants and its accompanying transmission and distribution networks, additional installed capacity was obtained, which resulted in production and sales increases of electric power during Repelita II.

With the increase in economic growth during Repelita II, there were also increased requirements for electric power from the community. This occurred particularly in cities which constituted the load centres. The fast growing demand caused the necessity to build a number of gas power plants (PLTG)

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in big cities as the development of PLTG can be carried out in a relatively short of time. As a result of this policy, in comparison with the beginning of Repelita II, the PLN generation system will depend heavily on PLTG units. Power generating by PLTG units requires a relatively larger amount of fuel for each KW.

With the completion of the electrification projects, apart from the electrification of some new areas, it has been possible to reduce the interruptions of electricity in some areas, particularly in some provincial capitals. Moreover, it has been possible to carry out phased maintenance of electrical generating centres in a more orderly fashion.

At the beginning of Repelita II, of 233 regency capitals it was determied that only 192 capitals are getting electricity from PLN, 30 capitals obtained electricity from the local Government or private companies, and 11 had not obtained electricity at all. Just before Repelita III, of the 285 regency capitals and administrative cities, only an estimated 5 regency capitals had no electricity and only 2 others obtained it from private companies. The remainder of such cities were already receiving electricity from PLN.

TABLE 20
PLN ELECTRIC POWER ENTERPRISE
1974/75 – 1978/79

Description	1974/75	1975/76	1976/77	1977/78	1978/79 *
Electric power production (MWH)	3,345,241	3,770,294	4,127,391	4,704,833	5,746,753
Electric power sales (MWH)	2,444,107	2,803,613	3,081,817	3,528,625	4,425,000
Connected power (KVA)	1,261,815	1,426,376	1,694,800	2,017,000	2,482,600
Installed power (MW)	1,117	1,284	1,376	1,870	2,283

* Estimated figure

At present there are still areas with limited generating or distribution facilities, and there are areas which are inadequately provided with both. In order to make the utmost use of the available electrical facilities, attempts are being made to obtain a system balance between the generating centres and the transmission and distribution network.

3. POLICIES AND STEPS

Based on the State's Main Guidelines (GBHN) and current conditions, the main target of electrification development during Repelita III is to improve the rural and city community welfare and to motivate and enhance economic activities.

To achieve the target, a number of policies and steps will be taken during Repelita III.

a. Improvement of the electricity supply apparatus

It is hoped that the supply of electric power of good quality and in sufficient amounts can be achieved at a minimum cost through optimal planning, development, and management. The optimization carried out in planning is based on a series of policies which are designed to be effective in the long term. The plan for the improvement of electric supply facilities is based on the policy which unites the entire electrical power sector in one overall planning unit. Moreover, the improvement of electric power production facilities both in Repelita III and in the longer term needs to be adjusted to the national energy policy and to be based on the following criteria:

(a) expanding the utilization of water power potential
(b) expanding the utilization of coal and natural gas
(c) expanding the utilization of geothermal heat

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(d) utilization of nuclear power, and
(e) utilization of non-conventional energy.

The policy reflects the efforts to guarantee crude oil as a foreign exchange resource. With regard to long term this policy is in line with the national energy policy.

Another policy element employed to improve the electric power supply apparatus is to increase the rate of utilization of electric power production facilities. At present, in Indonesia, there are several electric network systems which are separate from one other, so that the amount of the installed reserve capacity in relatively large and inefficient. To improve the efficiency of the production facilities, an interconnection between the systems will be established. The advantages of the interconnection include:

(a) increasing the utilization factor of generating facilities, which in the long run will also mean economising on investment
(b) facilitating achievement of an economic scale for the system
(c) speeding up the utilization of electric power.

In connection with the policy of regional development, the program for the improvement of the electric supply facilities cannot be separated from Government attempts to develop the regions, the feasibility of an electric program should not stand by itself but should be integrated in multi-sectoral activities.

Lastly the policy regarding the structure and level of electricity tariffs in the future is intended to encourage industrial development, or in other words to create an improved industrial climate which is balanced and harmonious, while at the same time giving consideration to the needs of small and weak consumers. The tariff level will be adjusted in the light of price developments and increases in efficiency. Nationally the annual increase of electric power requirements during Repelita III is estimated to be as much as 14% – 18% per year. To meet these requirements the electric power sector under PLN is programmed for an installed capacity increase of 17% per year on average.

b. Increase in the supply of electric power

In order to meet the community's requirements in the programs to increase electricity connections, policies and steps will be planned to provide an opportunity for private participation in the generating of electric power and its distribution.

c. Increase in the supply of electric power for the rural community

In accordance with the general policy already outlined, rural electrification efforts will be increased in Repelita III. Based on the latest study, the number of villages in Indonesia which do not have electricity is estimated at 49,000. The rural electrification in Repelita III will start primarily with an effort to include all self–supporting villages in implementation of the program. In addition, a number of "swakarya" (self–working) villages and "swadaya" (self–attempting) villages will also be included when the expansion of the distribution network makes it possible to reach the villages concerned.

d Improvement in the national electric power enterprise

With the achievement of operational balance the policy structure for electric power operations by PLN will be reformed. The improvement of electric power operation will be implemented to enhance the efficiency of the enterprise and to reduce PLN's dependence for its investments on funds from the Government. Relevant to this, by paying attention to norms which are generally applied in industry and trade, by making efforts to meet electricity with power of good quality, high dependability and safely, and by providing good service with reasonable tariffs, PLN will be required to participate in the financing of the entire cost of the electricity development to a minimum extent of 20% in the first two years an 25% in the last three years of Repelita III.

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These efforts will be accompanied by the following measures:

1) promoting efforts to decrease the network system losses by 0.5% per year until a minimum limit is obtained;
2) developing load dispatch centres to promote and improve the generation and distribution in a rational and economic way and by paying attention to dependability of services;
3) improving the guidance and supervision of the utilization of electric power by consumers so that maximum economy and safety are achieved.

The improvement in the capacity to supply will be supported by the improvements in the implementation of the development plan and also in the commercial operation of electric power. In this connection the organization of the management of the development program and the electric power enterprise will be strengthened so that optimum results and efficiency can be obtained.

e. Research and development in the supply of electric power

In support of the program to increase the electric power supply, research and development is being carried out. This include: the development of energy and electric power information, research on the electric power system, energy resources, generating equipment, fuel and lubrication, and lightning and environmental impact of electric power installation.

f. Standardization industrial development and technical services

To support the development and operation of electric power supply systems, various technical service activities will be carried out such as: standardization, verification, weights & measurements,etc. Also efforts will be made to develop and expand domestic electric equipment industries.

g. Energy

Taking into consideration the present energy situation and the probabilities of its development in the coming decades, the electric power sector, development program needs to be arranged within the national energy policy as follows.

1) In the short term, energy conservation: i.e. economizing on energy consumption with a rational, wise and efficient utilization of energy
2) In the mid term, a shift of primary energy from oil to coal, water power, geothermal heat, etc.
3) In the long term, research and development in the field of non-conventional energy resources utilizing technology which is the result of research and development carried out in the developed countries.

4. PROGRAM

Taking into consideration commercial technical factors such as peak load, the amount of reserve capacity and the system's reliability in order to balance the growth rate of the demand for electric power and to promote services to the electric power consuming community, the overall time scheduling of the physical program of PLN electric development in Repelita III has the following elements:

a. New electric power generating facilities with a capacity of more or less 2,729 MW, with the following details.

– Hydro power plant (PLTA)	296 MW
– Steam power plant (PLTU)	1780 MW
– Diesel power plant (PLTD)	478 MW
– Geothermal power plant (PLTP)	30 MW
– Microhydro power plant (PLTM)	15 MW
– Electric power plant utilized for rural electrification	130 MW

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b. Transmission netwotk and main sub–station with the following details.

1) Transmission network of 10,402 kms, divided into:

– Extra high voltage transmission network (TST/EHV)	784 kms.
– 150 KV transmission network	6,586 kms.
– 70 KV transmission network	3,032 kms.
Total :	10,402 kms.

2) 134 main sub–stations with a total capacity of 6,829 MVA, consisting of:

Voltage (KV)	Total (units)	Capacity (MVA)
– TST/150	6	1,800
– 150/70	16	995
– 275/150/20	1	30
– 150/30 – 150/20	58	2,946
– 70/30/30 – 70/30 – 70/20/6 – 70/20 – 70/11.5 – 70/6.3	51	1,058
Total :	132	6,829

c. Distribution network facility together with the distribution sub-stations with the following details.

– Medium voltage distribution network (JMT) of	14,703 kms.
– Low voltage distribution network (JTR) of	45,655 kms.
– Distribution sub–stations with total capacity of	4,488 MVA
– New consumer connections	1,000,000 consumers
– Change from low voltage to higher voltage (PTR)	330,000 consumers

Although it is estimated that the water power potential in Indonesia amounts to 31,000 MW, at present the development of water power is still limited to potential close to the load centres. This is due to the large investment required for the development of hydro power plants and the rather slow growth of electric power demand in rural areas. The requirements of electric power in rural areas can be filled by diesel power units.

The development or expansion of hydro power plants which according to plan will be completed in Repelita III, amounting to 296 MW, among others consist of:

– PLTA Sadang I/II – South Sulawesi	62 MW
– PLTA Tonsea Lama – North Sulawesi	5 MW
– PLTA Riam Kanan III – South Kalimantan	10 MW
– PLTA Sentani I/II – Irian Jaya	13 MW
– PLTA Tes – Bengkulu	13 MW
– PLTA Maninjau I/IV – West Sumatra	68 MW
– PLTA Garung – Central Java	28 MW
– PLTA Sempor – Central Java	2 MW
– PLTA Wonogiri – Central Java	13 MW
– PLTA Sengguh – East Java	29 MW
– PLTA Lodoyo – East Java	29 MW
– PLTA Juanda/Jatiluhur VI – West Java	25 MW

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In addition, considering that development of PLTA requires pre–investment activities, such as feasibility study, technical planning and field investigation, during Repelita III those activities will be carried out for the following hydro power plants (PLTAs):

- PLTA Tangguri – North Sulawesi. According to the feasibility study an electric power generating station can be built with an installed capacity of 2 x 8.5 MW. The technical planning will be started soon.
- PLTA Mrica – Central Java. According to the feasibility study an electric power generating station can be built with an installed capacity of 2 x 85 MW. At present the technical design is being prepared.
- PLTA Saguling – West Java. According to its feasibility study an electric power generating station can be built with an installed capacity of 4 x 175 MW. At present the technical design is being prepared.
- PLTA Ayung – Bali. A feasibility study will be carried out.
- PLTA Sengguruh and Kesamben, situated upstream and downstream respectively of PLTA Karangkates, East Java. The technical design will be prepared soon and development will then be carried out.

In addition, surveys will be carried out for the rivers Asahan, Musi, Way Besay (Lampung), Sungai Landak (West Kalimantan), Riam Kiwa (South Kalimantan). Poigar (North Sulawesi), Banyuripan Karang Sembung, Maung, Cimanuk/Cipasang, Cirata, Matenggong (Citanduy).

According to the long term plan already prepared, the development of steam power plants which is expected to be completed in Repelita III with a capacity of 1,780 MW include:

– PLTU Muara Karang III/IV/V – DKI Jakarta Raya	600 MW
– PLTU Semarang III – Central Java	200 MW
– PLTU Gresik I/II/III – East Java	400 MW
– PLTU Belawan I/II – North Sumatra	130 MW
– PLTU Balikpapan I – East Kalimantan	25 MW
– PLTU Bukit Asam I/IV – South Sumatra	200 MW

Besides the above, there are a number of PLTUs for which development will start in Repelita III and which are expected to be completed in Repelita IV. One of them is:

– Suralaya I/II – West Java	750 MW

In the attemp to utilize geothermal energy it is hoped that the development of a geothermal electric power station in Kamojang – West Java with a capacity of 30 MW can be completed in Repelita III. Further development will be carried out in Dieng – Central Java; Sungai Penuh – Central Sumatra; Lahendong – North Sulawesi, and in Bali, which hopefully can be started soon and completed in Repelita IV.

In order to increase the supply of electric power to areas which are isolated from the main system, dispersed diesel electric stations (diesel power plant – PLTD) will be constructed. In areas outside Java, PLTDs will be constructed with a total installed capacity of 478 MW. In addition, if the condition of the location permits it, micro-hydro power generating stations will be constructed in several places with an installed capacity of about 15 MW. Diesel power and micro–hydro electric stationswill support the development of rural electrification.

For isolated systems in Java it is hoped that a high voltage interconnection can be started in the first phase of Repelita III, and in addition, an extra high voltage (TST) interconnection between west Java and central Java is hoped to be completed at the end of Repelita III. This interconnection, apart from increasing the system's dependability, can also make the most efficient use of electric generators which to date function as reserve capacity only

The rural electrification program will be promoted. The latest study shows that 80% of Indonesia's population consists of people who are living in about 57,000 villages divided into 55.6%

"swakarya" (self–working) villages, 38% "swadaya" (self–attempting) villages, and 6.4% "swasembada" (self–supporting) villages. Rural electrification program has been started in several villages of Central Java, Lampung, South Sulawesi (Luwu) and Nusa Tenggara Barat (Lombok), and will be extended to cover villages in the regions of Aceh, North Sumatra, West Sumatra, North Sulawesi, Bali, Maluku, East Java, West Java, etcetera. Considering the limitations of the enterprise and the local conditions, rural electrification is expected to reach 37,700 self–supporting villages. Electrification of self–attempting and self–working villages will be effected by tapping the network which goes through the villages or which will reach them by extension. Rural electrification program will also involve the participation of cooperative organization; for this purpose 10 rural electric cooperatives will be established. As a physical target during Repelita III it is hoped that the rural electrification program can reach as many as 1,085,000 customers, with a connected capacity of 312 MW; installed capacity of 178 MW; distribution sub-stations of 272 MVA; medium voltage network of 11,100 kms; low voltage network of 11,100 kms. This target includes electrification to be undertaken by electric cooperatives which are expected to serve 1000 villages covering 460,000 customers with total installed capacity of 48 MW. In carrying out this program, participation of cooperative organizations in rural electric power distribution will be increased. Electricity development is also undertaken by private sector. In general private sector undertakes electricity development for industrial purpose and to meet the requirements of the surrounding communities. However private sector or community in general can also undertakes rural electricity. In the near future the electric power requirement, especially for the industrial sector, will not be able to be filled entirely by the State General Electric Company (PLN). In order to meet the demand, opportunities will be given to the private sector to participate in electricity development.

Large projects which are developing electricity generating capacity for their own purpose are: the Krakatau Steel project in Cilegon, west Java which constructed a steam power plant with a capacity of 5 x 80 MW, the aluminum smelting centre in Kuala Tanjung which will construct a hydro power plant in Asahan with a total capacity of 603 MW; and the nickel smelter in Soroako, Sulawesi, which has constructed a hydro power plant in the Larona river with a 165 MW capacity.

With regards to the Asahan project, 50 MW will be delivered to the State Electric Company which will be distributed through its transmission network to the city of Medan. The surplus of 50MW electricity from the nickel smelter in Soroako is delivered to the State General Electrical Company to be distributed to the surrounding community. In addition, a number of large electricity generating plants will be constructed for the hydrocracker project in Dumai and in east Kalimantan, for the olefin centre in Aceh, and for the industrial estate on Batam.

The details of the activities in the electric power sector according to PLN work regions is summarized in the chapter on regional development.

With the planned expansion of the electricity generating capacity, transmission network and main sub–stations, and the distribution network with distribution sub–stations, the supply of electricity to the community and its services can be improved.

Technically, the transmission and distribution networks must reduce the power losses. With the addition of new transmission and distribution networks it is hoped that the network losses can be reduced by an average of 0.5% per year.

Furthermore, based on the electric supply and the system loss reduction targets, efforts to secure new consumers or additions to connected capacities will be continuously pursued in order to achieve the target fixed for electric power sale.

Implementation of the physical improvement program and the electric commercial activities during Repelita III as described above needs to be accompanied by programs to improve various supporting facilities: a program to improve labour training and education; a research and development improvement program, and a program to survey energy resources for the generation of electric power.

The improvement of supporting facilities constitutes activities to improve physical and non-physical elements which are not included directly in the electric power supply facilities but which are important to support the implementation of an overall program of improvement of electric power.

TABLE 21

ELECTRIC POWER IN REPELITA III
(COMPARED TO REPELITA I AND II)

Types of activities (1)	Unit (2)	Repelita I (3)	Repelita II (4)	Repelita III (5)
Electric power plants	MW			
PLN		284	1,337	2,729 3)
Non-PLN		–	–	1,168 1)
Total		284	1,337	3,897
Transmission Networks	kms 2)			
PLN		496	2,758	10,402
Non–PLN		–	–	300
Total		496	2,758	10,702
Main Sub–Stations	MVA	415	3,137	6,829
Distribution Networks	Kms	1,619	7,625	14,703
Medium Voltage Distribution Networks	Kms	1,420	7,177	45,665
Low Voltage Distributio Sub–Stations	MVA	–	–	4,488
Household Connections	consumers	–	–	1,000,000
Low Voltage Changes	consumers	–	153,588	330,000
Rural Electrification				
PLN:				
– Villages	village	–	–	3,700
– Installed capacity	MW	–	–	130
– Household connections	consumers	–	–	625,000
Cooperative Organization				
– Villages	village	–	–	1,000
– Installed capacity	MW	–	–	48
– Household connections	consumers	–	–	460,000

1) Consist of: (1) Krakatau Steel 5 x 80 MW
(2) Asahan Project 603 MW
(3) Nickel Project, Soroako 165 MW

2) Kms: circuit kilometers

3) Including installed capacity for PLN village electrification

TABLE 22

TARGET OF ADDITIONAL CONSUMERS, ADDITIONAL CONNECTED CAPACITY ELECTRIC POWER SALES

Repelita III

Target \ Year	1979/80	1980/81	1981/82	1982/83	1983/84
Additional consumers	230,000	275,000	320,000	375,000	425,000
Additional connected capacity (MVA)	602	753	930	1,147	1,369
Sales (million KWH)	5,330	6,502	7,933	9,678	11,711

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The necessary programs to improve labour training and education include expansion of facilities, equipment and tools in existing training and education centres, the construction of new education and training centres in Ujung Pandang and Semarang, and expansion and quality improvement of lectures and of the education and training system itself.

In order to improve the services of research and development for electrification, efforts will be made to improve the utilization of scientific and technical information to support planning and the production of electric power supply apparatus; to increase the amount of research and development equipment; to augment the numbers and improve the expertise and skill of the workers; and to assist to development of the required laboratories in the Wilayah.

The experience in Repelita I and II provide guidance to improve the organization and financing procedures. In line with that, efforts will be made to achieve a balance between the development mechanism and the company's general practices eventuating in an overall budgeting system, either originating from the company budget or from the state budget, with a well focused control.

In accordance with the national energy policy, to promote the use of non–oil energy resources, surveys and inventories of those energy resources also need to be improved, starting with reconnaissance activities and feasibility study.

In addition, if the economic structure is already slanted towards electrical power dependent industries, measures should be taken so that most of the available electric power can be utilized for industrial purposes.

Thus at the end of Repelita III, it is estimated that in Indonesia, electric power installed capacity of 50 watt per capita with a production of 130 KWH per capita per year can be reached, assuming a population growth rate of 2.0 – 2.3% per year.

Improvement of the efficiency and control of the Government apparatus

To improve the Government apparatus and control, a Government Apparatus Efficiency Improvement Program will be carried out with the following objectives.

(a) To improve the effectiveness and efficiency of the apparatus in the mining and energy sector, including electricity, in carrying out the Government's main tasks in this sector, both routine and development tasks, and

(b) To improve control and inspection so that implementation of routine activities and the development program in the mining and energy sector, including electricity, can be successful, efficient and effective, and in accordance with a fixed plan and policy.

To improve the efficiency of the apparatus the following steps will be taken:

(a) Improvement of the functional capability to design, monitor, and evaluate development of the mining and energy sector;
(b) Improvement of the capability and development of personnel, based on career and achievement, increase in work descipline etc.
(c) Improvement of the current operational efforts to put order into the performance of duties so as to eliminate divergences or deviations in the performance of those duties which might cause losses to the Government.
(d) Improvement of the administration of offices, equipment and finance as well as data collection and the writing of reports on the realization of financial budget.
(e) On going improvement of the organization and the service system including institutional organization, procedures and working mechanism which comprise standardization and reporting system, etc.
(f) Improving the information flow on policy in the mining and energy sector including electrification.

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In order for the policy and activities to be carried out as planned and to achieve the target fixed, the supervision function must be improved, including control, evaluation on development implementation and actions to maintain order in operations. The improvement of the supervision function is done to facilitate monitoring the execution of all the policies and programs in the mining and energy sector including electrification, so that necessary action can be taken is an obstruction, violation or other similar event occurs.

The supervision function is not merely carried by the inspectorate general and other elements of the supervisional apparatus, but it is also an activity and responsibility which attaches to the leadership function of every departmental organization unit. Control which aims to promote order for the sake of a clean and responsible Government will be encouraged on the basis of a planned, directed and balanced program.

Supervision is not limited to physical programs, but should be developed and should cover supervision of the quality of the service of the state apparatus to the community. For this purpose, the following steps will be taken.

(a) establishment and/or improvement of the criteria for supervision and examination;
(b) collection and processing of data which have been verified no inputs for control and evaluation;
(c) improvement of the quality of the functional supervision apparatus both in technical knowledge and skill and in administrative knowledge and skill.
(d) improvement of the supervision and examination of routine programs and development projects;
(e) improvement of analytic activities and evaluation of inspection results in order to determine whether an activity is reaching or at least is heading towards target fixed;
(f) improvement of functional supervision of the programs carried out by the mining and energy institutional circle including electrification;
(g) improvement of the operational supervision of the management of each organizational unit in the carying out of duties and tasks by its staff.

TABLE 23

FINANCING OF THE THIRD FIVE YEARS DEVELOPMENT PLAN
1979/80 – 1983/84
(millions of rupiah)

Mining and Energy

Code Number	Sector/Sub-Sector/Program	1979/80 Development Budget	1979/80–1983/84 Development Budget
03	The Mining and Energy Sector	392,854.3	2,943,893.0
03.1	*Mining Sub-Sector*	*36.381.6*	*415,323.0*
03.1.01	Mining Development Program	31,299.9	364,899.0
03.1.02	Geology Development Program	5,081.7	50,424.0
03.2	*Energy Sub-Sector*	*356,463.7*	*2,528,570.0*
03.2.01	Electric Power Development Program	353,578.7	2,507,320.0
03.2.02	Gas Power and Other Energies Development Program	2,885.0	21,250.0

APPENDIX II A

ITINERARY AND ORGANIZATIONS VISITED

1980

October	28	Washington, D.C. - World Bank, Bo Stenberg
November	15	Depart Pittsburgh
	17	Arrive Jakarta
	18	Office in Gedung Jaya Endro Utomo
	19	Prof. Dr. Ir. Arismunandar, Director of Power Development, DJK (Directorate General of Power)
		To office of Dr. Ir. Firman Tambunan
	20	A. S. Nasution Ministry of Petroleum
		Dr. Firman Tambunan, Ministry of Power
		Omar Hasan, P. N. Tambang Batabura
	21	Dr. Ir. Muljo Harsono, BPPT (Agency for the Development and Application of Technology)
		Faqir Iqbal, UNIDO
		William Littlewood, US AID, Science and Technology Advisor
	22	Office
	23	Jakarta
	24	Train to Bandung
		Ir. Ukar W. Sulistiyo, Research Engineer, PPTM/MTDC (Mineral Technology Development Center)
		Bamang Sulasmoro, Director PPTM Samsa Gandadisastra Yuyun Basyuni, Chemist

November	25	A staff member of the Director, Geological Survey of Indonesia
		Hardjono, Geologist, GSI Renar Dadar, Geologist, GSI
		Suharto Oemar, Analytical Chemist, GSI
	26	Prof. Sudarno, Chem. Eng.
		Prof. Kho, Chem. Eng.
		Dr. Ambio Mangunwidjaya, Mining Eng.
		Wibowo Suryo Dosen, Chem. Eng.
		One other from Dr. Ambio's staff.
		To Pelabuhanratu
	27	Lime kiln in Bayah area
		Cimadur River - Madur Hill mine
		To Cisiik
		To Jakarta
	28	Office
		A. Deeleman, President, Shell Indonesia
		W. Littlewood, AID
	29	Office
		Ruben Hardy
	30	Jakarta
December	1	To Padang - To Sawahlunto (Ombilin) with Endro Utomo and A. S. Nasution
		Soeharto — Vice Dir. of Mine D. Projinto — Mechanical Engineer Somad — Mining Engineer
	2	Meeting with Ombilin personnel and Director Suhandoyo
		To Jakarta
	3	Office

December	4	Ministry of Industry Ir. Soebardi Soeria Atmaja
		Directorate General of Power Ir. Samaun Samadikun
	5	To L. P. Tanah (Institute for Soil Research) at Bogor
		Mr. Suhardjo
		Return to Jakarta
	6	Office
		Completed paper work
	7	Jakarta to Hong Kong
	8	Hong Kong to Pittsburgh

APPENDIX II B

INDONESIAN PERSONNEL CONTACTED
NOVEMBER 18 TO DECEMBER 6, 1980

Ir. Endro Utomo	Energy Resource Development (PKS)
Prof. Dr. Ir. Arismunandar	Director of Power Development (DPK)
Ir. A. S. Nasution	Ministry of Petroleum
Dr. Firman Tambunan	Ministry of Power (BKM)
Omar Hasam	PN Tambang Batubara
Dr. Ir. Muljo Harsono	BPPT, Agency for the Development and Application of Technology
Ir. Ukar W. Sulistiyo	PPTM, Mineral Technology Development Center
Bamang Sulasmoro	Director PPTM
Samsa Gandadisastra	(Office of Director)
Yuyun Basyuni	Chemist
Hardjorno	Geologist, Geological Survey of Indonesia
Renar Dadar	Geologist, Geological Survey of Indonesia
Suharto Oemar	Analytical Chemist, Geological Survey of Indonesia
Prof. Sudarno	Chemical Engineer
Prof. Kho	Chemical Engineer
Dr. Ambio	Mining Engineer
Wiboro Suryo	Instructor, Chemical Engineer
Soeharto	Vice Director, Ombilin Mine

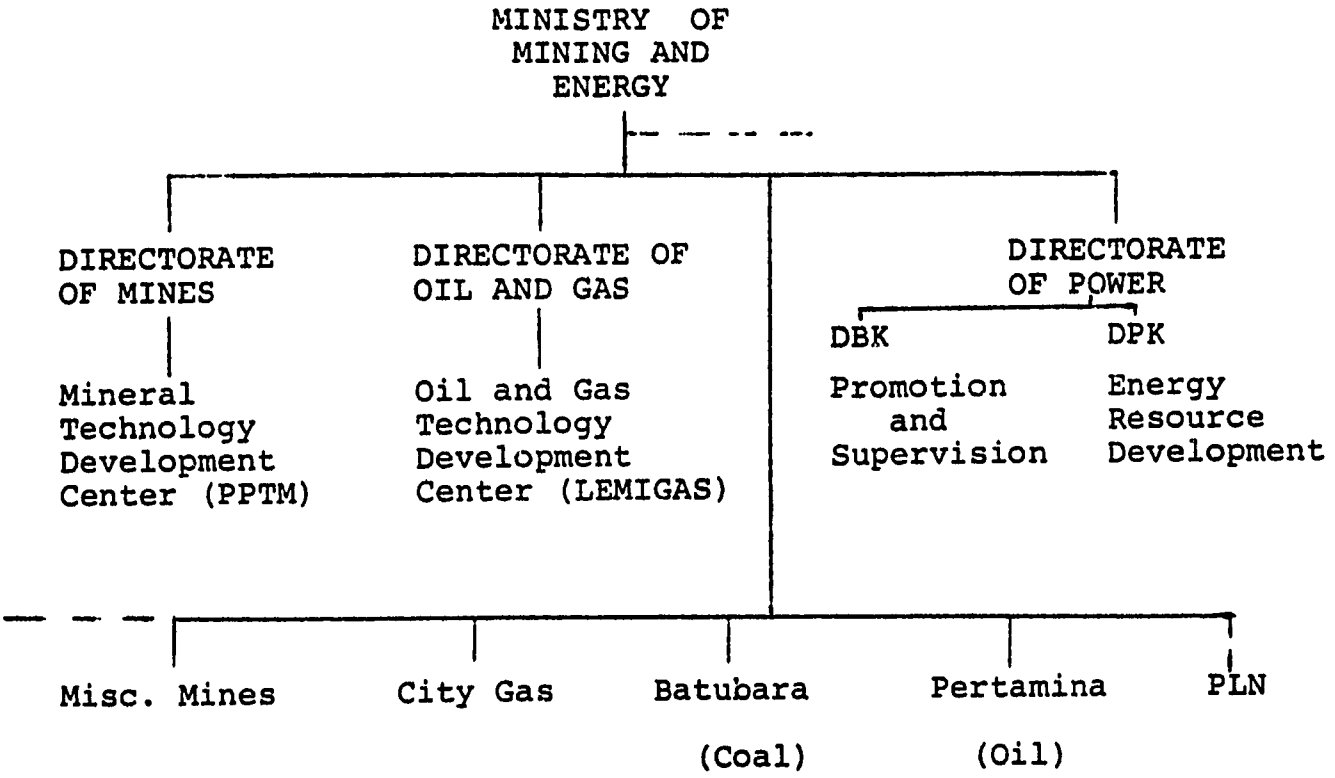
(continued)

EXHIBIT II B

INDONESIAN PERSONNEL CONTACTED (continued)
Page Two

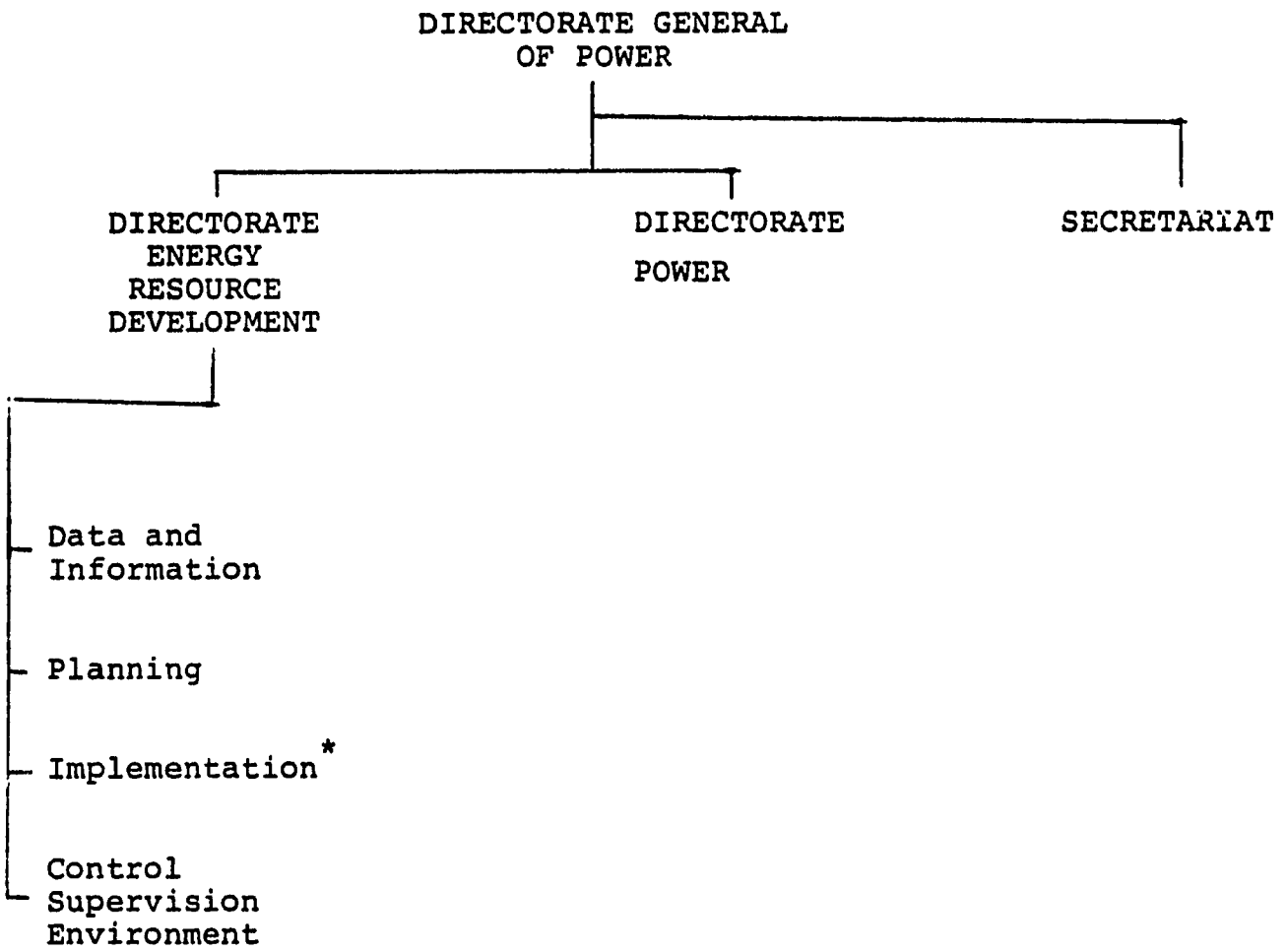
D. Projinto	Mechanical Engineer, Ombilin Mine
Somad	Mining Engineer, Ombilin Mine
Dir. Suhandayo	Director
Ir. Soebardi Soeria Atmaja	Ministry of Industry
Ir. Samaun Samadikun	Directorate General of Power
Suhardjo	Soil Research Institute

APPENDIX III A



PARTIAL STRUCTURE OF THE MINISTRY OF MINING AND ENERGY

APPENDIX III B



*Sponsoring Subdirectorate

PARTIAL STRUCTURE OF THE DIRECTORATE GENERAL OF POWER

APPENDIX IV

THE COAL POTENTIAL IN INDONESIA

Addendum 1-January 23,1981.

The following is an addendum to my January 2, 1981 report entitled "The Coal Potential in Indonesia". Facts of the coal situation and several recommendations were made in the report. This addendum is to answer some specific questions, some asked in previous E/DI memoranda and others raised during the preparation of the report.

In order to keep the data consistent, the following base values and conversion factors are used:

1 metric ton = tonne = Te = 2205 lbs.

Coal = 12,600 Btu/lb = 7,000 cal/gm (MAF)*

1 Te coal = 27.8×10^6 Btu = 0.278×10^6 cu. ft. natural gas

= 4.8 bbl petroleum

@ US$10/Te = $0.36/million Btu

Peat = 9,200 Btu/lb = 5,100 Cal/gm (MAF)

1 Te peat = 0.73 TeCE*

1 Bbl petrcleum = 5.8×10^6 Btu = 0.23 TeCE

@ US$50/bbl = $8.62/million Btu

Natural gas = 1,000 Btu/cu ft = 8,900 Kcal/cu m.

1 Million cu. ft. = 36 TeCE = 28,329 cu. m.

*MAF = Moisture and ash free

TeCE = Tonnes of coal equivalent

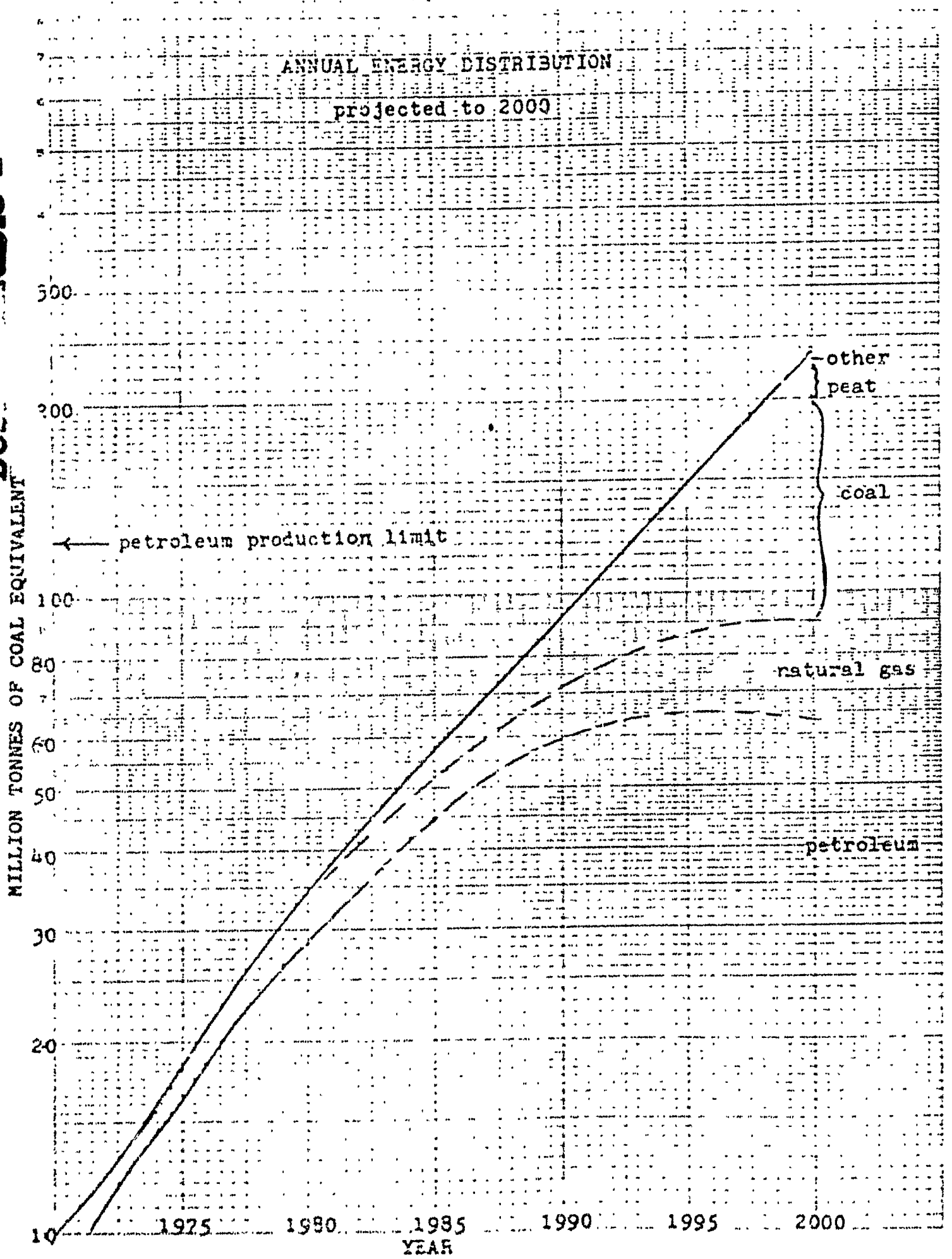
1054.6 Joules = 1 Btu

Assuming that the present production rate of 1.6 million barrels of petroleum per day (585×10^6 bbl/yr) will continue until about 1990, the equivalent annual oil production amounts to 122×10^6 TeCe. An attempt must be made to limit the domestic consumption of petroleum to no more than 65×10^6 TeCE. The ever increasing energy deficit must then be made up with 1 - hydroelectric plants, 2 - biomass, solar, wind or other renewable resource system and 3 - coal and peat. Hydroelectric power systems are limited because the source of much of the usable water is remote from the population centers or industrial areas. Biomass also would have only local impact; unless an energy dense, derived product is made its transportation would be uneconomical.

As a basis for the projection of total energy demand to the year 2000, data developed by Hartarto and Hidayat (reference 9 in the report) was used. Revised projections of the individual energy sources were extrapolated. Next, it was assumed that present petroleum production of 585 million barrels a year (122 TeCE) would begin to decline about 1990 and its contribution to the domestic energy demand would also decrease. Natural gas would also reach its peak production at about the same time but its contribution to the total energy demand would increase either directly or indirectly in the form of alcohol or other synthetic fuel (Figure 1). It should be kept in mind that the export of petroleum and natural gas provides a large share of Indonesia's income. Furthermore, the estimated reserves are about 11×10^9 barrels. At the present rate of

Best Available Document

Figure 1



production, this resource will last about 20 years. Production does not cease precipitously but declines after some point, now estimated to be about 1990.

ESTIMATED ANNUAL ENERGY NEEDS (non-wood)
Million tonnes coal equiv.

	1985	1990	1995	2000
Petroleum	43	60	65	63
Gas	9.6	12	21	27
Water	1.2	2	2	2
Coal	2	15.5	43	110
Peat	0	1	13	25
Other*	2	3	5	10
Total	57.8	93.5	149	237
%/year	10	9.7	9.7	

* Solar, wind, geothermal, etc.

In 1990, total energy needed will be 93.5 TeCE x 10^6 of which 60 comes from petroleum, 15.5 from coal and 12 from gas. The contribution from other sources is small. The table should demonstrate the urgency of beginning work on the development of energy sources other than petroleum. In fact, costs at an economic level may prove to be secondary as the need develops. Coal from the Bukit Asam area is projected to cost US$70 per Te ($2.70/million Btu) delivered at Suralaya. However, this is still about half the cost of petroleum at 1980 prices. Other fossil fuel costs of interest are Ombilin coal produced at US$28 Te and delivered at Padan for $44 a Te. Peat should be available at about

the same cost per tonne but the heating value would be about 73 percent of the base coal used in this paper.

If you look back to estimates of only five or six years ago (23), the expected coal production in 1980 was to be 5 to 6 million tonnes per year. In 2000 Indonesia hoped to produce 26 to 36 million tonnes. These figures depended almost entirely on the production and export of coal by N.V. Shell Mijnbouw. The Shell project foundered about 1975 and it seems that only limited consideration was given to domestic expansion. Extrapolation of current data, taking into consideration the role of petroleum, indicates that domestic consumption rates will be higher than originally thought.

The harvesting, briqueting and utilization of peat as an energy source and an agricultural medium are well established. Under certain circumstances it would be reasonable to transport products made from peat to the areas of consumption. Two possibilities are briquets and alcohols. If there is serious interest in the utilization of peat, contact has already been made with Bill Littlewood of USAID by me and by the Institute of Gas Technology (IGT) on the subject. In July 1979, IGT presented a three day conference on Peat Management. Many interesting papers were presented. Indonesian reserves of peat were not included because no one knew about them. As part of the planned tour by Indonesian experts, I would recommend that they plan to visit IGT and even return home via Ireland, Finland and Russia.

This is just a wild idea for the record concerning peat. Most of the rivers I observed in Indonesia seemed to run heavy with suspended matter that ends up deposited in the ocean or as deltas that obstruct transportation. The reasoning follows:

1. One of the recommendations being made is to utilize peat which occurs mainly in low lying areas.

2. Attempts have been made in the past to establish farms on peat deposits but without success because of high acidity and low nutrient content.

3. The suspended solids in rivers are rich in nutrients leached from the inland areas.

4. The voids left after peat extraction can be used as settling basins for river water before it flows into the ocean. These deposits can then be developed as farm areas free of the acidic peat.

If this plan is considered to be feasible, the development of peat bogs would be engineered with the above ideas in mind. More specifically, the direction of advance, handling of spoil, diversion of water, etc., would be different from peat recovery alone.

The prospect of synthetic fuels production is brought up often. This general term should also include chemicals such as alcohols that can be used as solvents, a raw material for industrial conversion to other chemicals or to hydrocarbon fuels. Another important point to consider is plant size. Production of 50,000 to 100,000 barrels per day of synthetic liquid fuels is considered to be of economic size in developed countries. Quantities of this magnitude

would require large amounts of coal. At three barrels of oil per ton of coal, a 75,000 BPD plant would require about 10 million tonnes a year. If this amount is added to the amount estimated for the year 2000 (110×10^6 Te) the burden of production could be excessive since I doubt that even the basic level can be achieved. In retrospect, synthetic liquid fuels should be deferred indefinitely.

Synthetic gaseous fuels, on the other hand, are more reasonable to contemplate. Although no plants will operate before the year 2000, the product is more amenable to the generation of a clean gas for fuel or conversion catalytically to chemicals or to liquid fuels. Again plant size is an important consideration. Small fuel gas plants can be purchased today from several suppliers.

The energy development plan must be moved into high gear if anything significant is to take place by 1984. It is anticipated that action taken during Repilita III would be the bridge to Repilita IV. A good bridge needs a sound base.

ENERGY PLANNING FOR DEVELOPMENT IN INDONESIA

Appendix F

ASSESSMENT OF BIOMASS AS AN ENERGY RESOURCE IN INDONESIA

OLYMPIC ASSOCIATES CO.
SEATTLE, WASHINGTON

March 25, 1981

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

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e/di

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ACKNOWLEDGEMENT

The assistance, enthusiasm and hospitality of all the Indonesian representatives associated with the project reported herein are gratefully acknowledged. Their attention and support in compiling information and arranging for meetings with appropriate personnel in the government and associated universities and institutes resulted in the background information necessary to carry out this assessment of biomass as an energy resource in Indonesia.

In lieu of naming each person individually, I would acknowledge first the support of Prof. Dr. A. Arismunandar, Director for Energy Resource Development, and Ir. Tangkas Roesad, Sub-Director of Implementation, JKD. Ir. Tangkas worked closely with me on a daily basis as my counterpart, and arranged for meetings, accompanied me on visits and participated in our technical discussions.

The staff of the A.I.D. Mission in Jakarta was extremely helpful, and I am especially grateful for the assistance of Mr. William H. Littlewood and Dr. W. Paul Weatherly for their hospitality, advice, and assistance during my stay in Indonesia.

Rolf T. Skrinde

Rolf T. Skrinde, Ph.D., P.E.

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EXECUTIVE SUMMARY

1.0 Introduction

In May 1980 the first phase of the Energy Planning for Development project was initiated, with the Biomass Assessment task carried out in November. Biomass has historically been the primary energy source in Indonesia, and acceleration of its development and use is of great significance in order to avoid economic and social problems as the limited supplies of kerosene being substituted for biomass become exhausted or continue to escalate in price.

The significance of emphasizing biomass as an energy source is that because of the climate, rainfall, and fertile conditions of the soil in Indonesia there are great opportunities to grow vast amounts of this resource which can be converted into energy. Programs of accelerated growth of biomass and conversion to energy should be implemented now while there are funds available from the sale of fossil fuels, and in preparation for future years when available fossil fuels will be diminishing in quantity while population growth and increasing use of energy continues.

Biomass is one of the major renewable energy sources which can be harnessed for future use. An accelerated biomass program should provide the greatest amount of energy in the near term at least cost. It also is a program which can be carried out simultaneously throughout the entire country in small-sized projects which will benefit not only the people individually but also the national government if the government can reduce or eliminate the present cost of subsidizing

kerosene use. Biomass energy should therefore be given the highest priority in early implementation programs in order to develop energy self-sufficiency for Indonesia without the use of fossil fuels.

This Biomass Assessment component of the Energy Planning for Development Project is intended to assist in the development of policies and programs to enhance the use of biomass as an energy resource.

2.0 Biomass Resource Base

Section 2.0 describes the biomass resource base in Indonesia. Indonesia is blessed with abundant renewable resources of biomass. The question is whether these renewable resources can supply significantly more energy, commercial as well as non-commercial, without adverse effects on the food and fiber supply. Currently, 122 million hectares are in forest and are classified as 47 million hectares production forest, 40 million hectares protection forest, 10 million hectares conservation forest, and 25 million hectares reserved forest. Unproductive land in Indonesia amounts to 42 million hectares. Current use of woody biomass for energy has increased by 2.2 percent per year during the period 1969-1976, with consumption exceeding recorded production by some 36 million tonnes in 1976 on Java alone.

Where there is a shortage of fuelwood, such as on Java, the use of agricultural wastes and the home garden's potential for firewood are important. Data indicate that if home gardens were well managed they could contribute up to 60% of the fuel demand of a village community.

Table 2-4 provides an estimate by the Forest Products Research Institute of Bogor, of the TCE (Tonnes Coal Equivalent) of energy produced from combined firewood and agricultural waste production from 1969 to 1978. The corresponding BOE (Barrels of Oil Equivalent) can be obtained by multiplying these figures by a factor of 5.05.

Table 2-5 shows that approximately 122 million of the 190 million hectares of land in Indonesia are in forests, with the remaining used for agriculture or comprising wasteland. According to the Directorate of Reforestation and Rehabilitation, unproductive land in Indonesia in need of rehabilitation amounts to 42 million hectares, broken down as follows:

Denuded forests and second growth	23 million hectares
Denuded soils and alang alang	16 million hectares
Rainfed agricultural land	3 million hectares

Twenty million of the 42 million unproductive hectares are considered critical or seriously eroded:

Alang alang (Imperata cylindrica)	13 million hectares
Secondary growth (belukar)	4 million hectares
Rainfed cropland (tegalan)	3 million hectares

Wastelands on Java count 4 million hectares or more than 30 percent of the total land area.

Development of biomass for energy on the 42 million unproductive hectares alone would provide much of the fuelwood required to meet cooking needs on Java and the outer islands. Currently, non-wood residues are not being fully exploited for energy, and although

reliable data are lacking, such residues are extremely significant especially for densely populated areas such as Java.

3.0 Trends in Extent of Biomass Resource Base

On Java a burgeoning population uses more and more land to grow food, and in doing so leaves less and less land to grow fuelwood, the traditional cooking fuel for the rural and large parts of the urban population. The rural population can no longer supply the needed fuelwood from private properties, and in pilfering from public lands contributes to deforestation and attendant erosion. Scarce populations, abundant renewable resources, forest exploitation, and clearing for transmigration projects characterize significant portions of the outer islands, however, especially Kalimantan and Sumatra.

It is apparent that deforestation is continuing of mountain slopes previously unexploited. The expansion of new transmigration populations in portions of previously uninhabited islands is also resulting in further deforestation in those areas as forest lands are put into agricultural production. The consequence of such patterns is reflected in the reduction of production of fuelwood and agricultural wastes in heavily populated areas such as Java, as shown in Table 2-4.

4.0 Current Utilization of Biomass

Section 4.0 describes the current utilization of biomass. It is seen that, on an equivalent basis, firewood and waste still contribute about 50% of the energy of the country, although the use of gas and oil is increasing dramatically. The fossil fuel resource is rapidly declining, however, while firewood and wastes are renewable resources.

It therefore cannot be over-emphasized that all possible efforts must be made to reverse the trend and expand the renewable firewood and waste resource base in order to conserve and become increasingly independent of fossil fuels.

5.0 Potential for Future Use

There are several programs underway to increase biomass resources in Java and other densely populated islands. These include dissemination of seeds and seedlings of fast growing trees, experimental plots of fast growing trees, and research on soil characteristics relating to increased biomass production. It is envisioned that extensive fuelwood plantations could be developed on the so-called wastelands of Java, comprising some four million hectares. The yields of these impoverished soils could be improved by the planting of leguminous trees, and an annual yield of only 10 tonnes per hectare would be more than the present fuelwood consumption on Java. A significant portion of the fuelwood demand on Java by the years 1990 and 2000 could be provided, especially if the remaining 16 million hectares of marginal land were put into production.

It is also possible to convert biomass on other islands with surpluses to higher forms of energy for transport to Java and other areas of biomass deficiencies. This potential is described in detail in Section 5.0.

6.0 Barriers to Use

The barriers to increased biomass use are described in Section 6.0.

These include availability of land, potential for nutrient depletion, unknown effects of introducing new tree species into the agricultural sector, high cost of converting biomass to more concentrated energy forms, and difficulty of transport in order to balance areas with biomass surpluses with areas of deficiencies.

7.0 Current Policies and Projects

Repelita III, the third five-year plan (1980-1984) emphasizes several major points relating to energy. One is to enhance conservation of kerosene and other oil resources by substituting other energy sources such as biomass, and another is implementation of programs to use renewable energy sources such as biomass.

The government of Indonesia is therefore implementing a large number of important biomass projects, which are described in Section 7.0. Although the effort currently being made is great, further acceleration is necessary in order to provide sufficient biomass for energy in the future and reverse the trend of deforestation and attendant erosion problems.

8.0 Recommended Steps in Development of Biomass Resources

A comprehensive program of recommendations to develop additional renewable biomass energy sources is provided in Section 8.0. Some of these recommendations are:

1. Fast growing trees and development of an integrated wood energy village concept for transmigration areas: Several new tree species are recommended for evaluation, and the Terms of

Reference for a demonstration wood energy village is provided in Appendix C.

2. Charcoal Production and Use: Increased use of charcoal from ravaged forests or woodlots and increases in the efficiency of charcoal production can play a positive role in avoiding the dual problems of deforestation and increased kerosene use. Development and demonstration programs are recommended on: the charcoal marketing and distribution system particularly the concept of charcoal centers, improved cooking devices, and charcoal production from agricultural wastes.

3. Utilization of Wood Residues: Very large amounts of logging and sawmill wastes (many million cubic meters annually) are available for more effective use - particularly by the wood products industry itself. Studies are required of possibilities of satisfying internal needs and the possibility of charcoal production.

4. Advanced Conversion Technology: Additional improvements in pyrolysis technology should be supported and the commercialization of this technology should be accelerated through low interest loans or other means. Research and development on low calorific gas generators using agricultural wastes, advanced wood and wood residue gasifiers should continue to be supported.

ASSESSMENT OF BIOMASS AS AN ENERGY RESOURCE IN INDONESIA

1.0 INTRODUCTION

Biomass has traditionally been the primary energy source in Indonesia, but as population densities have increased on various islands, especially Java, biomass materials have often become insufficient to meet the demand. The result has been deforestation of not only those areas where food production is necessary to support the population, but also some mountainous areas which are unsuitable for growing of crops. These steeply sloping areas which have become denuded of forests are often subjected to severe erosion problems.

The rapid development of oil and gas in the past decade has provided a degree of energy relief, since kerosene can be used as a cooking fuel as well as for lighting purposes. The government is assisting the people to meet high energy costs by subsidizing the cost of kerosene. However, this subsidy, estimated to amount to 360 million U.S. dollars in 1979 alone, is cutting drastically into export earnings. Since 80% of Indonesia's population live in rural areas, many of which are taking advantage of the subsidy to convert to kerosene-based cooking, it will become an increasingly serious national problem of demand for this fossil fuel unless the biomass resource base is developed and used more efficiently.

The Government of Indonesia's (GOI) response to the problem of meeting the country's energy demands while maximizing petroleum export earnings is found in Repelita III, the third five-year plan (1980-1984). The

plan emphasizes three points relating to energy: 1) accelerated exploration of conventional fossil fuel sources; 2) enhanced conservation of kerosene and other oil resources by substituting other energy sources; and 3) intensified research, development and use of renewable sources such as biomass.

The report which follows is an assessment of biomass as an energy resource in Indonesia. Of course, many highly qualified engineers and scientists in Indonesia and from abroad have made related assessments, and in this case the data available are used to provide the biomass component of the Energy Planning for Development Project. The results are intended to assist in the development of policies and programs to enhance the use of biomass as an energy resource.

Included in the biomass assessment reported herein is an estimate of the extent of the resource base and trends which would affect the biomass resources available for energy. The extent to which biomass is currently used for energy purposes is then quantified. Estimates are then made of the technical potential for economical use of wood and crop residues as an energy resource in the future, as well as the major barriers that must be overcome if the various biomass resources are to be used at their maximum potential.

Current policies and projects relating to biomass energy research, demonstration, pilot plants, and operational plants are described. Section 8 consists of recommended programs in the development of increased fulfillment of energy needs through the use of biomass. Finally, an evaluation is made of the significance of the conclusions

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drawn on the biomass assessment, the benefits which could be derived, and further general recommendations with respect to Energy Planning for Development.

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2.0 BIOMASS RESOURCE BASE

Indonesia is blessed with abundant renewable resources; it is the extremely high population density on Java and Madura that threatens to overwhelm the resources of these two islands.

2.1 Fuelwood

Long before using other material as fuel, the Indonesian community has used firewood and agricultural waste products. These materials are used as fuel mainly in the village community, where because of the low income level, firewood and agricultural waste products play an important role for cooking purposes. Villagers obtain much of their firewood and agricultural waste products from their own home garden (pekarangan). When this supply becomes exhausted they look for firewood on public lands such as Government forests.

The home garden's potential for firewood is important. Many studies have been made of fuelwood production and consumption. Hardjodarsono (1978) stated that a coconut tree, for instance, can give a fuel supply from the leaf's mid rib as large as 48 kg/year; from the coconut-fiber and shell the estimated production is 0.5678 m^3/year. The trees at the home garden produce an average yield of 1,622 m^3/family/year. According to a survey of the LPHH (Research Institute for Forest Products) in 1971 the average need of firewood for one family is 2,510 m^3/year in East Java. Based on these data, if all home gardens were well managed, they could contribute 60% of the fuel demanded by the village community.

Table 2-1 describes production and consumption of fuelwood in 1976 on Java and the outer islands. On Java, consumption exceeded recorded production by some 36 million tonnes in 1976. The discrepancy is made up of fuelwood production in home gardens, farm plot boundaries, community lands, and pilfering from public lands, in what proportions is not known.

TABLE 2-1.

FUELWOOD PRODUCTION AND CONSUMPTION IN FORESTS IN 1976* (TONNES)

	Java	Outer Islands	Total
Production	1,251,046	21,303,819	22,554,865
Consumption	37,126,680	23,107,751	60,234,431

(after Hardjodarsono, 1978)

*Production is measured and recorded as thinnings from managed forests, logging, and forest industry residues, as well as wood from estates and agricultural enterprises (e.g., rubber trees) which is used as fuelwood. It does not include total biomass production by photosynthesis in Indonesia.

Consumption is based on a conservative estimate of per capita consumption. A number of studies are being made on present and future fuelwood consumption.

2.2 Agricultural Residues

The amount of agricultural products produced in 1978 has been estimated (Statistical Pocketbook of Indonesia 1978/1979) to be as shown in Table 2-2.

TABLE 2-2.

AGRICULTURAL PRODUCTION IN 1978

Wet Land Paddy		
Total Area		7,653,046 ha
Production	Total	24,265,578 tonnes
	Java and Madura	15,205,652 tonnes
	Other Islands	9,059,926 tonnes
Dry Paddy		
Total Area		1,240,334 ha
Production	Total	1,614,460 tonnes
	Java and Madura	436,446 tonnes
	Other Islands	1,177,014 tonnes
Maize		
Total Area		3,027,849 ha
Production	Total	3,885,389 tonnes
	Java and Madura	2,818,637 tonnes
	Other Islands	1,036,752 tonnes
Cassava		
Total Area		1,382,854 ha
Production	Total	12,960,655 tonnes
	Java and Madura	9,470,679 tonnes
	Other Islands	3,489,976 tonnes
Sweet Potatoes		
Total Area		292,550 ha
Production	Total	2,234,559 tonnes
	Java and Madura	1,007,077 tonnes
	Other Islands	1,227,482 tonnes

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TABLE 2-2. (CONT'D)

AGRICULTURAL PRODUCTION IN 1978

Peanuts		
Total Area		514,077 ha
Production	Total	439,221 tonnes
	Java and Madura	322,029 tonnes
	Other Islands	117,152 tonnes
Soybeans		
Total Area		741,252 ha
Production	Total	570,861 tonnes
	Java and Madura	450,466 tonnes
	Other Islands	120,395 tonnes

(Statistical Pocketbook of Indonesia 1978/1979, 1979)

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The agricultural wastes produced in 1977 are estimated to be as shown in Table 2-3.

TABLE 2-3.

CROP RESIDUES IN 1977

	1000's of Tonnes
Dried Stalk Paddy	933.89
Rice Hulls	337.32
Maize	62.83
Sweet Potatoes	246.04
Cassava	1,201.56
Soybeans	30.60
Peanut (unshelled)	34.06
Coconut (unshelled)	1,434.11
Fruits	363.01
Vegetables	151.55
Bagasse	3,137.18
Total	7,932.18

(Statistical Pocketbook of Indonesia 1977/1978)

A compilation of combined firewood and agricultural waste production in Java and outside Java for the years 1969-1978 has been prepared by the Forest Product Research Institute as follows and shown in Table 2-4.

TABLE 2-4.

FIREWOOD AND AGRICULTURAL WASTE PRODUCTION IN JAVA AND OUTSIDE JAVA, 1969-1978 (TCE)[1]

Year	Java	Outside Java	Total
1969	21,455,562	26,054,774	47,510,336
1970	22,457,946	28,493,981	50,951,927
1971	22,592,511	30,398,157	52,990,668
1972	22,013,257	30,341,687	52,354,944
1973	24,070,068	35,986,539	60,056,607
1974	24,441,829	36,136,553	60,578,382
1975	23,759,481	29,969,299	53,728,780
1976	22,492,734	32,491,492	53,984,226
1977	21,518,186	32,105,386	53,623,572
1978	20,543,639	32,718,759	53,262,398

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[1]TCE = Tonnes Coal Equivalent

Note: 1 TCE = 5.05 BOE

Source: Research Institute of Forest Products, Bogor

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2.3 Forestry and Forest Product Residues

Forests are an important source of biomass as shown in Table 2-5.

TABLE 2-5.

FOREST AREA IN INDONESIA

Island	Land Area (1,000,000 ha)	Forest Area (1,000,000 ha)	Ratio to Total Land (Percent)
Java & Madura	13.2	2.9	21.8
Sumatera	47.4	28.4	60.0
Kalimantan	53.9	41.5	76.9
Sulawesi	18.9	9.9	42.4
Nusa Tenggara & Bali	7.4	2.0	27.7
Maluku & Irian Jaya	49.7	37.5	75.5
Total	190.5	122.2	64.2

(Source: Directorate General of Forestry, 1975)

Of the 190 million hectares of land in Indonesia, about 24 million hectares or 13 percent can safely be used for agricultural purposes. An additional 26 percent or 51 million hectares can be used for agriculture provided appropriate conservation measures be taken. Some 60 percent or 115 million hectares should be in forest.

Currently, less than half of the total forest area is classified as production forest as is shown in Table 2-6.

TABLE 2-6.

CLASSIFICATION AND AREA OF FORESTS

Classification	Area (1,000,000 ha)	Percent of Total Forest Area
Production Forest	40	32.8
Protection Forest	47	28.5
Conservation Forest	10	8.2
Reserved Forest	25	20.5
Total	122	100

(Source: Directorate General of Forestry, 1975)

On the islands of Java and Madura, 1,845,000 ha (64 percent of total forest area) are classified as production forest out of a total forest area of 2,900,000 ha and total land area of 13,200,000 ha, which represents only 14 percent of the total land area on the two islands. Most of this production forest is man made and consists of teak (Tectona grondis), pine (Pinus merkusii) and several other species.

According to DITSI (Directorate of Reforestation and Land Rehabilitation) there are 42 million hectares of unproductive land in Indonesia in need of rehabilitation, and of these, 20 million hectares are considered critical or seriously eroded. The breakdown of these critical land areas is as follows:

13 million hectares alang-alang (Imperata cylindrica)
4 million hectares secondary growth (beluka)
3 million hectares rainfed agricultural land (tegalan)

20 million hectares

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Four million hectares of waste land are on Java and constitute more than 30 percent of the total land area. (Source: Forestry for Industrial and Rural Development in Indonesia, Forestry Faculty IPB, Bogor, 1979.)

Predictions are that the situation is rapidly getting worse, especially on Java.

In comparing Table 2-1 with Table 2-5 it is seen that much of the potential for obtaining firewood from forests in Indonesia is presently not utilized. For example, the 122.2 million ha of forest area shown in Table 2-5 produces annually at least 10 tonnes of biomass per ha by normal photosynthetic growth, which amounts to 1222 million tonnes annually. This is more than 50 times the amount which is used for fuelwood, shown in Table 2-1. On a conservative basis of two BOE equivalent to one tonne of wood, the energy potentially available annually from forests in Indonesia is 2444 million BOE, far more than the present oil production of the country.

3.0 TRENDS IN EXTENT OF BIOMASS RESOURCE BASE

3.1 Deforestation

Although estimates of potential biomass resource available in the form of normal unharvested growth suggest vast energy supplies in the form of biomass, deforestation is already an acute problem in Indonesia. On Java, a burgeoning population uses more and more land to grow food and in doing so leaves less and less land to grow fuelwood, a traditional cooking fuel for the rural and large parts of the urban population.

The rural population can no longer supply the needed fuelwood from its own property, and in pilfering from public lands contributes to deforestation and attendant erosion, serious problems in their own right. Scarce populations, abundant renewable resources, forest exploitation, and clearing for transmigration projects characterize significant portions of the outer islands, however, especially Kalimantan and Sumatra.

In this situation, it is apparent that deforestation is continuing to spread on Java into additional areas such as fertile river banks and mountain slopes previously unexploited. The expansion of new transmigration populations in portions of previously uninhabited islands is also resulting in further deforestation in those areas as forest lands are put into agricultural production. The consequence of such patterns is reflected in the reduction of production of fuelwood and agricultural waste products, such as shown in Table 2-4 above. Combined with an annual increase in fuelwood consumption similar to that reported by the Ministry of Agriculture during the period of 1969-1976 of 2.2 percent per year, the trends suggest the need for increasing the role of alternative energy production strategies.

3.2 Agricultural Crops Which Produce Residues

One opportunity to increase biomass availability for regions (such as Java) with large discrepancies between production and consumption is to export surplus agricultural and woody residues from the transmigration areas to the supply short regions. In this context, it is expected that traditionally grown crops such as sweet potatoes and cassava and residues such as straw, hulls, leaves, inflorescences, etc., harvested in new areas may supply useful residues for energy purposes. While these crops do not hold much promise for direct export to fuel deficient areas such as Java, their conversion to other fuel products such as charcoal or densified pellets may enhance the viability of export of such residues.

A second opportunity to increase the amount of agricultural crops or residues available for energy consumption involves the production of alternative fuel feedstocks from biomass such as *Euphorbia* sp. and other petroleum plants, or from Lalang or *Imperata*, a small genus of closely allied grasses of the family *Gramineae*. Such feedstocks have the potential to increase production of biomass energy, although their use at present is only minimal.

4.0 CURRENT UTILIZATION OF BIOMASS

Included in this chapter is a summary of current patterns of biomass utilization in Indonesia, emphasizing technologies, and current consumption patterns which relate to the use of biomass for energy. Consumption of fuel wood and agricultural waste is examined. Official and unofficial policies and/or programs instituted by the government to promote biomass energy are included wherever appropriate.

Firewood is the most widely accepted and used biomass resource in Indonesia at the present time, with its main use being for household and industrial purposes. Uses in the household, especially in rural areas is almost exclusively for cooking. In smaller industries, firewood is used as a fuel in the food processing (soya bean cake factories, bakeries) industries, while non-food industries such as batik manufacturing, tobacco manufacturing, tea plantations, leather factories, and brick and tile manufacturing also resort to firewood for energy. In the transport sector, only old locomotives of the railroads still burn firewood as a fuel.

The use of agricultural waste for energy purposes has been more limited than that of firewood. Several reasons are offered for this, including technical, economic and social constraints such as diseconomies in collection and pre-processing of waste materials, present use and adaptation as fertilizer for crops, and reluctance to adopt new methods of handling waste products (for further discussion of constraints to

use of biomass resources for energy, see Section 6.0). Table 4-1 illustrates best available data on total consumption of fuelwood and agricultural wastes in Indonesia, according to geographical region and economic sector (i.e., household, industry and transportation). Because of population density differences, the fuelwood conditions of Java and the other islands are considered separately.

Excellent summaries of biomass production, consumption and relationships to other energy sources utilized in Indonesia have been prepared by Arismunandar (1979), Kadir (1979) and Kadir and Arismunandar (1980). Excerpts from these papers are presented below.

Table 4-2 gives figures on production and consumption of firewood and agricultural waste from 1967 up to 1976.

The above table shows that, on the whole, a surplus consists of production over consumption of firewood and agricultural waste. This surplus, however, stems from outside Java. On Java itself, consumption is gradually growing faster than production, and since 1976 consumption has overtaken production on Java.

Table 4-3 compares the consumption of firewood and agricultural waste to that of oil in Indonesia, expressed in million tonnes coal equivalent.

It is seen in Table 4-3 that growth trends of both firewood and waste and those of oil were about the same in the years 1967 up to 1971. Starting from 1972 oil consumption grew at a much faster rate, in 1976 reaching a consumption more than twice of that in 1967, while

Table 4-1

Consumption of fuelwood and agricultural waste

(In Million Tonnes)

YEAR	J A V A				OUTSIDE JAVA			GRAND TOTAL	
	House-hold	Indus-try	Trans-port	Total	House-hold	Indus-try	Total	Total	Growth (%)
1967	16,03	5,55	0,11	21,69	11,83	0,89	12,72	34.41	-
1968	17,15	5,14	0,07	22,36	12,77	0,90	13.67	36.03	4.7
1969	18,36	6,32	0,10	24,78	13.79	0.99	14.78	39.56	9.8
1970	19,66	6,15	0.09	25,90	14.90	0.94	15.84	41.74	5.5
1971	20,91	6.79	0,07	27,77	15,97	0,98	16.94	44.71	7.1
1972	22,05	7,86	0,03	29,94	16,91	0,99	17,90	47.84	7.0
1973	23,66	6,92	0,01	30,59	18,26	1,03	19,29	49.88	4.3
1974	25.27	8,54	0,02	33,83	19,71	1,02	20.73	54.56	9.4
1975	27,04	8,04	0,07	35,15	21,26	1,06	22,32	57.47	5.3
1976	29,54	7,53	0.06	37,13	23,11	1,07	24,18	61.31	6.7

Source : Ir. H.M.S. Hardjodarsono M.Sc. : Firewood and Agricultural Waste and its Prospects in Indonesia (1978)

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Table 4-2

Production and consumption of firewood and agricultural waste

(In Million Tonnes)

YEAR	JAVA			OUTSIDE JAVA			TOTAL		
	Production	Consumption	Surplus	Production	Consumption	Surplus	Production	Consumption	Surplus
1967	32.43	21.69	10.74	35.01	12.72	22.29	67.44	34.41	33.03
1968	35.62	22.36	13.26	41.27	13.67	27.60	76.89	36.03	40.86
1969	35.01	24.78	10.23	35.03	14.78	20.25	70.38	39.56	30.82
1970	36.64	25.90	10.74	44.03	15.84	28.19	80.67	41.74	38.93
1971	36.86	27.77	9.09	47.96	16.94	31.02	84.81	44.71	40.10
1972	35.58	29.94	5.64	47.44	17.90	29.54	83.03	47.84	35.19
1973	39.27	30.59	8.68	51.61	19.29	32.32	96.89	49.88	47.01
1974	39.88	33.83	6.05	54.72	20.73	33.99	94.59	54.56	50.03
1975	38.77	35.15	3.62	50.88	22.32	28.56	89.70	57.47	32.23
1976	36.70	37.13	0.43	51.87	24.18	27.69	88.57	61.31	27.26

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Table 4-3

Consumption of firewood and agricultural waste, and oil

(In Million Tonnes Coal Equivalent or TCE)

YEAR	FIREWOOD + WASTE		OIL		TOTAL		RATIO
	10^6TCE (A)	%	10^6TCE (B)	%	10^6TCE (C)	%	A : C %
1967	11.47	100	7.38	100	18.85	100	60.8
1968	12.01	104.7	7.72	104.6	19.73	104.6	60.9
1969	13.19	114.9	8.07	109.3	21.26	112.8	62.0
1970	13.91	121.2	8.66	117.3	22.57	119.7	61.6
1971	14.90	129.9	9.55	129.4	24.45	129.7	60.9
1972	15.95	139.1	10.96	148.5	26.91	142.7	59.3
1973	16.63	144.9	12.78	173.2	29.41	156.0	56.5
1974	18.19	158.6	14.56	197.3	32.75	173.7	55.5
1975	19.16	167.0	16.37	221.8	35.53	188.5	53.9
1976	20.44	178.2	18.42	249.5	38.86	206.2	52.6

Source: (For Oil) : TKT.BBM.E Department for Mines

Note: The above Table indicates that firewood and waste consumption increased at percentage rates greater than the percent increase in population from 1967 to 1976. This is probably not the case, since kerosene has been used increasingly as a cooking fuel substitute, and illustrates the need for more detailed data on firewood and waste consumption.

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firewood and waste grew only about 78% in the same span of years.

It may be interesting also to draw a total picture of consumption of all kinds of primary energy, which shows the role which firewood and waste plays in this total energy budget. Table 4-4 shows the consumption of firewood and waste, oil, gas, coal and waterpower for the years 1967 to 1976, expressed in million tonnes of coal equivalent.

From Figure 4-4 it is observed that the two main ingredients of the energy budget are firewood and oil: firewood as a strong first in the Sixties, and oil as a second, together making up for more than 95% of total consumption, and the balance being made up by gas, coal and hydropower.

In the Seventies relative weights changed. Although in absolute terms still growing, percentage-wise consumption of firewood declined. On the other hand, consumption of oil grew, both in absolute amounts as well as in percentage, arriving in 1976 as a very close second in total energy use, and most probably overtaking wood and agricultural waste within a short time.

In the absence of sufficient quantities of firewood materials for household cooking, it has been necessary to resort to the use of increasing amounts of kerosene for both cooking and lighting purposes. Table 4-5 shows a recent compilation of household energy uses from which it is seen that kerosene use is increasing by approximately 10% per year, while charcoal, which is a common fuel source in many countries, is not being developed in Indonesia.

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Table 4 - 4

Consumption of Primary Energy

(In Million Tonnes Coal Equivalent)

YEAR	FIREWOOD*		OIL		GAS**		COAL		HYDRO		TOTAL	
	10^6TCE	%	10^6TCE	%	10^6TCE	%	10^6TCE	%	10^6TCE	%	10^6TCE	%
1967	11.47	57.9	7.38	37.3	0.66	3.3	0.17	0.9	0.11	0.6	19.79	100
1968	12.01	56.8	7.72	36.5	1.13	5.3	0.15	0.7	0.14	0.7	21.15	100
1969	13.19	58.4	8.07	35.7	1.02	4.5	0.17	0.8	0.15	0.6	22.60	100
1970	13.91	58.5	8.66	36.4	0.88	3.7	0.16	0.8	0.15	0.6	23.76	100
1971	14.90	57.3	9.55	36.7	1.19	4.6	0.19	0.7	0.18	0.7	26.01	100
1972	15.95	57.0	10.96	39.2	0.72	2.6	0.19	0.7	0.16	0.5	27.98	100
1973	16.63	55.5	12.78	42.7	0.23	0.8	0.13	0.4	0.19	0.6	29.96	100
1974	18.19	53.5	14.56	42.8	0.90	2.6	0.15	0.4	0.23	0.7	34.03	100
1975	19.16	50.9	16.37	43.5	1.69	4.5	0.19	0.5	0.24	0.6	37.65	100
1976	20.44	49.4	18.42	44.5	2.02	4.8	0.27	0.6	0.22	0.5	41.37	100

*) Including Agricultural Waste

**) Natural Gas and Liquified Petroleum Gas

Source: (For Oil and Gas) ; TKT,BBME, Department for Mines

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Table 4 - 5

QUANTITY OF ENERGY USED BY HOUSEHOLDS IN INDONESIA *

X 1000 TCE

YEAR	ENERGY TYPE			
	OIL (KEROSENE)	LPG	CHARCOAL	FIREWOOD & AGRICULTURAL WASTE
1974	3 171	22	34	17 349
1975	3 636	33	42	19 038
1976	3 948	38	44	21 221
1977	4 390	41	52	23 158
1978	4 786	30	38	25 310
1979	5 269	32	34	27 315

*) BPPT/Bechtel program of energy modeling: report under preparation (1980)

In order to provide assistance to the people with low income levels who must resort to the use of kerosene, the Indonesian government has subsidized its cost. This has resulted in benefits to the poor people, but since 1969 the increase in kerosene use has become so great that substantial amounts must now be imported to meet the demand. It has been seen in the many surveys made that dependence on kerosene increases with proximity to cities and heavily populated areas, and that 80% of household consumption is for cooking, with 20% for lighting purposes.

The amount of kerosene used for household purposes in the period 1969-1978 is shown in Table 4-6.

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Table 4 - 6

CONSUMPTION OF KEROSENE BY THE HOUSEHOLDS *

1969 - 1978 (kilo litre)

Year	Sale of kerosene	Consumption of kerosene by the households	Consumption of kerosene for cooking only
1969	2.700.067	2.160.053	1.728.042
1970	2.732.195	2.185.756	1.748.604
1971	2.817.548	2.254.038	1.803.230
1972	3.306.580	2.645.264	2.116.211
1973	3.681,977	2.945.581	2.356.464
1974	4,258.050	3.406.440	2.725.152
1975	4.882.663	3.906.130	3.124.904
1976	5.302.722	4.242,177	3.393.741
1977	5,895.330	4.716.264	3.773.011
1978	6.426.000	5.140.800	4.112.640

* Source: Directorate General of Oil and Natural Gas (1978)
Progress Report "Utilization of Firewood and Agricutlural Waste in Indonesia", Satyawati Hadi, et al, LPHH (April 1979).

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5.0 POTENTIAL FOR FUTURE USE

In order to assess the potential for future use of biomass as an energy resource, it is necessary to consider the geographic and demographic characteristics of Indonesia. Each island is an entity unto itself, and movement of biomass fuels between islands would include transportation to dockside, loading onto boats, ship transport to the island of destination, offloading of the boats, and transportation to distribution networks on the receiving island. This multi-handling process results in very high transportation costs between islands, and firewood which has not been processed to charcoal or other concentrated energy forms does not have sufficient energy per unit weight or per unit volume to justify the transportation costs.

In further consideration of geography and demography, Java has an extremely high population; densities on most of the other islands are comparatively low. Some 70% of the population of Indonesia lives on Java alone. Therefore, while firewood and agricultural wastes are used for household cooking purposes throughout Indonesia, it is only on Java and on a few other heavily populated islands that there has become a scarcity of biomass resources for energy purposes. On Java there are essentially no old forests of trees remaining for fuelwood use, and the population must resort increasingly to that which grows annually, along with agricultural residue and house garden materials which are combustible. High value wood products such as lumber are imported to Java.

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A major purpose then in assessing the potential for future use of biomass as an energy source is to determine the feasibility of developing a larger biomass base for Java and to prevent the deforestation conditions of Java from occuring on the other islands. It may also be possible to convert biomass on islands with surpluses to higher forms of energy for shipment to Java and other areas of biomass deficiencies.

5.1 Programs to Increase Biomass Production

There are several programs underway to increase biomass resources on Java and other densely populated islands. These include dissemination of seeds of fast growing trees, experimental plots of fast growing trees, and research on soil characteristics relating to increased biomass production. On the island of Java nearly every square meter of land is utilized intensively for agricultural purposes, and therefore there is a competition between biomass for energy vs. biomass for food. Fast growing trees would economically produce more biomass on less land, and therefore have the potential of meeting energy needs while allowing food crop production to continue. There are also about 20 million ha of marginal land not well suited to agriculture, where fast growing trees would provide the potential of meeting much of the islands' firewood needs. For example, it is envisioned that extensive fuelwood plantations on the so-called wastelands of Java (4 million hectares) could be developed by the year 1990. Here is where the soil improving capacity of many of the leguminous tree species would pay off handsomely. The yields of these impoverished soils would be lower than average but would

increase as time went by. At a yield of only 10 tonnes of biomass per hectare per year the 4 million hectares would yield 40 million tonnes annually more than the total present fuelwood consumption on Java. At a conservative value of two BOE per tonne, assuming minimal transport costs between the production and consumption sector, this biomass would supply a significant portion of the fuelwood demand on Java by the year 1990. If the remaining 16 million hectares of marginal land in Indonesia were put into production of fuelwood by the year 2000, the yield of the entire 20 million hectares at 10 tonnes per hectire could be 200 million tonnes, which at two BOE per tonne would be equal in energy to 400 million BOE.

It may also be possible to convert biomass on other islands with surpluses to higher forms of energy for transport to Java and other areas of biomass deficiencies. As an example, a rule of thumb states that firewood can be transported economically only up to 80 kilometers while charcoal can be transported up to as much as 600 kilometers. Here is an opportunity to supply urban centers on Java or other densely populated islands with harvested biomass from large plantations. The biomass could be converted to charcoal in small portable metal kilns, for which economical processing techniques and technology exists. As transport costs are reduced through improvements in shipment technology, it is anticipated that such biomass supplies may become feasible within the time frame considered here, to the year 2000.

5.2 Direct Combustion

Direct combustion of biomass already provides the bulk of household

energy needs in rural areas. On a limited scale, biomass is also being used to provide energy in certain industries. For example, palm oil mills utilize a large portion of the waste (fiber and fruit shell) to produce steam and electric power for in-plant use. Also, most of the existing plywood mills use their own wood waste to produce steam for drying the lumber and finished products. Almost all the small-scale brick and roof tile manufacturing operations use wood and other agricultural wastes to fire their kilns.

The opportunities for expanding the current use of biomass in the industrial sector, particularly the forest products industries, and the introduction of biomass as a fuel for electricity generation in remote and isolated areas of Indonesia are promising. The forest products industry is rapidly growing and is expected to continue expanding throughout the next 20 years. Plywood and pulp and paper operations are expanding most rapidly. Almost all the existing saw mills and plywood mills use diesel generators for supply of plant power requirements. This is particularly true of plants which are located on the islands of Sumatra and Kalimantan. The wastes available from the saw and plywood mills can be used to generate the energy requirements of these mills.

For example, an average size saw mill processes approximately 50,000 m^3 of logs per year. About 30 to 40 percent of this quantity is generally considered to be waste material. The average power requirement of such a mill is 500 kW; the waste material, burned in wood-fired boilers, could produce energy in excess of the mill needs. In the plywood

mills, wood-fired cogeneration (simultaneous production of electricity and steam) would be an ideal application of emerging biomass energy technology. Assuming an aggressive effort to promote the use of such technologies, it is anticipated that the forest products industry could become energy self-sufficient within the time frame of the next 10 to 15 years.

As shown in Section 2.3, the forest area in production consists of 40 million ha. The normal practice of forest harvesting to provide logs, lumber, plywood, and other forest products results in approximately 50 percent of the tree and root system to be used as product material and the remainder is left in the forest as waste. In processing of logs to produce lumber and plywood another 35 percent is waste material, and therefore the energy potential from the production forest area is about 67 percent of forest biomass being grown for harvesting.

Since Ellis (1978) reports forest biomass production of up to 18.4 oven dry tonnes per ha per year, using a figure of 10 tonnes per year is a conservative estimate of forest growth through normal photosynthetic activity. Therefore, if 40 million ha of production forest were to produce 10 tonnes per ha, the forest production would be 400 million tonnes per year, 67 percent of which would be waste which could be converted to energy. This would, at a conversion factor of two BOE per tonne, amount to 540 million BOE per year.

Electricity generation by small wood-fired electric power plants should be considered for the islands of Sumatra, Kalimantan and other forest-rich islands. These islands not only have the resource, but

also provide ideal sites for demonstrating the technical and economic feasibility of small scale (0.5-10 MW) wood-fired power plants. However, as the island of Java is scheduled to have a large coal-fired central electric power plant generating station by 1983, it will be almost impossible for any wood-based electric plant to be cost competitive on this island in the time frame considered here.

At the present time, about half of the electricity generation on the islands of Sumatra, Kalimantan, and Sulawesi is done by the PLN (state-owned utility). PLN currently has about 584 MW of oil-fired installed capacity on these three islands, with the majority of the plants diesel engine/generators with an output capacity of about 1 MW or less. Since most of the forest resources are present on these islands and the islands serve as preferred regions for translocation of some of Java's large population, the use of wood and forest products residues for local electrical consumption appears to be a viable option. These plants would operate with capacities from 500kW to 10 MW generating capacity, depending on location and size of the local market. Successful implementation of these plants would be dependent upon cooperation between PLN, the Department of Forestry and the forest products industry, and would parallel the growth of transmigration populations in those regions.

For household energy use, technological advances in the fields of silviculture, charcoal production and charcoal stove design will make increased use of natural growth of biomass and charcoal a technically and economically feasible method to meet energy needs

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of the householder in the next 10-15 years as other options and alternatives are investigated on Java and the other densely populated islands. Curiously enough, however, rather than concentrate on programs of reforestation with fast growing trees and more efficient charcoal production and usage, emphasis has been placed on increased kerosene usage, now becoming a burden to the government, as discussed earlier. Within the next decade, it is absolutely essential that the decline in household energy use supplied by biomass be reversed, and a strong government effort must be undertaken to promote the use of fast-growing trees, charcoal use and efficient stove design.

5.3 Gasification

Gasification is the thermal decomposition of solid carbonaceous fuels (i.e., coal, wood, agricultural waste) in the presence of limited (less than stiochiometric amount) supply of air to produce low-BTU combustible gases. Since air-blown biomass gasification technology for producing low-calorific value gas is commercially available in the near term, this technology should find ready application in different Indonesian energy-consuming sectors. The low-BTU value gas produced from air-blown gasifiers can be used to operate internal combustion engines, or fire boilers, drying kilns, etc.

In the forest products industry, the large amounts of wood waste, estimated above to amount to as much as 270 million tonnes per year, can be converted to supply in-plant energy needs of these mills, using atmospheric pressure air-blown gasifiers. Gasification recovers between 45-90 percent of the energy value of the feedstock material, depending upon the biomass resource, thus yielding between 240 and 490 million BOE.

The suitability of this technology as a preferred alternative to direct combustion of the wood waste in the forest products industry, however, largely depends on the relative economics, ease of operation and compatibility with the existing energy supply system. If a new mill is being constructed, a direct combustion system would probably have an economic advantage over gasification systems. However, in the case of existing mills, the gasification option offers better flexibility and compatibility with the existing energy generation system of the mill. For example, the gasification system provides the opportunity of retrofitting existing diesel generators, either mobile or stationary. In such a manner, both mill energy and mobile field equipment energy usage can be supplied by biomass. The simple design, quick start-up and minimum operation and maintenance of small gasification systems would enable rapid and complete conversion of existing facilities and operations to biomass energy, and enable future plants to utilize biomass as well.

The gasification option could also be considered for retrofitting existing small (less than 10 MW) PLN oil-fired electricity-generating plants in Sumatra and Kalimantan. Again, the relative economics of direct combustion vs. gasification systems tends to suggest that existing facilities could best be retrofitted with gasification systems, while new facilities could best be served by direct combustion technology. Such a scenario implies conversion of existing facilities and development of new generating plants on the outer islands to use the available biomass resource such that most present and future energy demands in these sectors are met with biomass through the next 20 years.

Gasification technology is also suitable for supplying energy for different agriculture and/or related operations. For example, agricultural waste (crop residues) can be used to produce a low calorific value gas which, in turn, could power a retrofitted diesel generator to drive either an irrigation pump or rice mill. In Indonesia, rice husks and rice straw are the most commonly available agricultural residue. The higher ash content (silica) of the husks creates some operational difficulties for gas generators, but these modifications can be overcome by design modifications. Assuming a strong government effort to promote the use of such technology then, it is anticipated that gasification systems for the agricultural sector could play a significant role in meeting the energy needs for irrigation or food processing during the next 20 years, provided that alternative uses of the feedstock are not a problem. Other barriers to the use of such technology in the agricultural sector are discussed in Section 6.0.

In the long term, advanced gasification technologies (eg., high pressure gasification, fluid-bed gasification, oxygen-blown gasification and catalytic gasification) may play an important role in supplying different chemicals and fuels from biomass. For example, methanol is one of the chemical fuels which could be produced via this biomass gasification (oxygen-blown) and subsequent catalytic synthesis route. Since methanol is one of the liquid fuels which is being given high priority as a substitute fuel in the transportation sector, such technologies should become viable options for increased biomass energy usage, although the potential for widespread use in Indonesia is most likely limited to beyond the next decade.

5.4 Pyrolysis

Pyrolysis is the thermal decomposition of solid carbonaceous fuels in the absence of air, which produces combustible gases, oils (tars), and solid char residue. Since pyrolysis of biomass results in a number of products, local markets must be assured for not only one but three separate products if the technology is to be economically feasible. The oils produced in pyrolysis are the most easily shipped, and their production amounts to approximately 0.5-1.0 BOE per tonne of biomass pyrolyzed.

It has been found that pyrolysis of rice husks gives powdered char, which contains more than 40 percent ash (silica). Also, the product gases, except for direct burning, cannot be directly (without extensive cleaning) used in internal combustion engines. In this sense, pyrolysis does not convert biomass directly to usable energy products, but it produces three different products that can be further processed or refined for intended application. As a result, a small-scale (1 tonne/day) pyrolysis plant may not be able to process and market the energy products (particularly oil and char) effectively. Moreover, since the quantity and the quality of different pyrolysis* products are extremely dependent upon the operating conditions, a close control of these operating conditions is essential for obtaining a proper yield of consistent quality energy products.

Because of this inherent requirement of a pyrolysis process, it would be very difficult to obtain a consistent quality energy product from a simple inexpensive small pyrolysis unit. If all the required controls

*The term pyrolysis refers to low-temperature pyrolysis process

are used to improve the performance of a small pyrolysis plant, it would no longer be an inexpensive system. Therefore, it seems that the ability of the pyrolysis process to extract a range of more valuable hydrocarbons from biomass may only be exploited at a large-scale (at least 100 tonnes/day of bone dry biomass) operation. Small-scale biomass conversion systems should be primarily restricted to combustion and air-blown gasification technologies.

A review of the biomass resource availability in Indonesia would indicate that only wood and wood residue could sustain the operation of large-scale pyrolysis plants. Once again, because of the wood fuel transportation cost limitations, these plants would have to be located near the wood resources; this would require the plants to be located on the islands of Sumatra and/or Kalimantan. The economic feasibility of large wood-based pyrolysis plants would very much depend on the marketability of pyrolytic oil and char. Based on the results of studies conducted in the U.S.A., it could be safely assumed that the pyrolytic oil, after necessary equipment modifications, could be used in industrial residual fuel oil-fired installations. On the basis of 270 million tonnes of wood waste estimated previously, the potential of pyrolytic oils would be between 135-270 million BOE per year.

The product char could be used for household (particularly rural) energy needs. Another emerging application for the product char is its use in existing residual oil-fired industrial and utility boilers as a char/oil mixture. The feasibility of this application, however, depends on the successful adoption of coal/oil mixture combustion technology for the char/oil mixture combustion. It should be recognized

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that char, depending on its volatile content, has different combustion properties than most of the coals.

As such, it appears that the technical potential for pyrolysis in the years 1990 and 2000 would be limited to the islands of Sumatra, Kalimantan or other forested islands where a combination of local markets for each by-product and ready availability of woody biomass could support development of the technology. In one scenario, both the pyrolytic oil and char would be used to fire local industrial oil-fired generating plants and supply household cooking fuel, while the product gas could be used to supply the pyrolysis unit with heat and in-plant power to run the equipment. Under such a scenario, it is anticipated that large-scale pyrolysis units would become cost competitive with alternative fuels only after large local markets could be developed and process refinements completed, which most likely limits its potential use to the long-term when the local population and industrial base expands. Even then, the total of all by-product streams would probably not be sufficient to meet all the energy needs of the local markets, and additional measures would be necessary to meet demand.

5.5 Alcohol Fermentation

The technology of alcohol fermentation is well known throughout the world, although recent process and design alterations have resulted in several refinements in the technology. Fermentation technology has been given high priority for development within the country, and already the technology is being adapted by the government to the

peculiarities of Indonesia. As such, it is anticipated that within the next 20 years, if the government's plans and programs are fruitful, some 20 million kiloliters or over 50 percent of the transportation sector's energy demand will be met by production of power alcohol from sugar and starch crops such as molasses, cassava, sweet potatoes, Sago palm, etc.

Not mentioned in government plans but potentially as valuable to productive capacity as sugar or starch crops, cellulosic biomass (agricultural residues such as corn stover, bagasse, and other cellulosic materials such as wood, municipal solid wastes, etc.) may prove to be a preferred feedstock in the event that the food vs. fuel question cannot be resolved. This is especially important in that many of the alcohol production facilities will likely be located in remote regions to stimulate relocation of large numbers of the population to these unsettled regions. Should production of sugar or starch crops in these areas not reach expected production levels, abundant lignocellulosic and cellulosic biomass could become the preferred feedstock, although additional refinements in processing technology would be required. Such technology is currently in the process of refinement in the U.S.A. and other developed countries and thus would likely not be available for use in Indonesia for the next several years unless a concentrated effort were begun soon.

At present, government projects designed to stimulate development of alcohol fermentation technology should ultimately lead to widespread use of power alcohol as a direct substitute for gasoline or diesel in the transportation sector. However, widespread use will probably

not occur until subsidies on gasoline and diesel are removed, or direct subsidies are given to use of power alcohol since the present price of power alcohol is about twice that of gasoline. Despite such government intervention into the price structure of liquid fuels used by the transportation sector, it is likely that by 1990 production of power alcohol will be able to supplant a significant portion of the gasoline and diesel fuel demand, and by the year 2000, as stated above, supply more than 50 percent of that sector's energy demand.

5.6 Methane Fermentation

The production of fuel gas (biogas) from digestion of organic wastes to methane and carbon dioxide is widely practiced throughout the world, and has been utilized to some extent in Indonesia as well. However, due to several technical, economic and social barriers to use of the technology (see discussion in 6.6), it is anticipated that methane fermentation will play only a very limited role in supplying energy to the industrial/commercial and residential sectors. Major feedstocks for methane fermentation now and into the future are rather limited to animal excreta and water hyacinth for householder or villager use, and other similar feedstocks for commercial/industrial use. The availability, quantity and quality of these feedstocks are not expected to change drastically in the foreseeable future, resulting in only limited production by 1990 and 2000. Economically, the value of the gas produced could very well be cost competitive to projected costs of oil on the world market at that time, although it is likely that widespread and dispersed utilization of the technology would be hampered by the inability of the individual or collective users

to pay the capital cost of such facilities and maintain units in proper fashion.

5.7 Summary of Potential for Future Use

As seen in Section 2.3, there are approximately 122.2 million ha of forest lands in Indonesia. At a photosynthetic growth rate of 10 tonnes annually per ha, 1220 million tonnes of biomass are estimated to be produced per year, which is equivalent to at least 2440 million BOE per year. This is equivalent to about four times the present oil production of Indonesia, but of course much of this biomass is in protected and conservation forests or otherwise unavailable in densely populated areas where it is needed.

In Section 5.1 it is seen that on Java alone the four million ha of so-called wasteland could produce 40 million tonnes of biomass by the year 1990, equivalent to at least 80 million BOE, and if the remaining 16 million ha of wasteland in Indonesia could be forested by the year 2000, the fuelwood production from forests could be 20 million hectares at 10 tonnes per hectare, or 200 million tonnes, equivalent to at least 400 million BOE. Much of this energy could be used directly without conversion to charcoal, but even if charcoal were to be developed and used extensively on Java, the loss in charcoal conversion of 50 percent would still result in 200 million BOE for household use on Java. Agricultural residues on Java will not increase significantly, since the agricultural productivity is presently at nearly its maximum level, and therefore the potential from agricultural wastes would be another 8 million tonnes (Section 2.2), or, at a rate of two BOE per tonne, approximately 16 million BOE.

In Section 5.2 it is seen that forestry in production primarily outside Java produces waste products which have a value of at least 540 million BOE.

It can be concluded that biomass production for energy use has tremendous potential both on Java and on the outer islands. The total amount available from both forests and farms is considerably more than four times the equivalent amount of oil presently being pumped, and the only barriers to use of this vast renewable resource are those of conversion to products which are more easily transported as solid fuels or more easily used in existing equipment in the form of liquid and gaseous fuels.

6.0 BARRIERS TO USE

Planning of programs to increase the use of biomass materials for energy must take into account those barriers which are associated with accelerated development of these forms of renewable energy. Included in this section are some of the more significant barriers to increased biomass production and conversion to energy sources.

6.1 Increased Biomass Production

There are three major barriers to increased biomass production. These are availability of land, potential for nutrient depletion, and the unknown effects of introducing new tree species which are more suitable for fuelwood into the agricultural sector. With respect to the availability of land, there is intensive utilization of nearly every square meter of productive land for rice and other food crops on Java and in other densely populated areas. There thus could become significant competition between food crops and energy biomass "crops" if there were few sources of energy other than biomass. There are areas of Java and outside Java which are not suitable for intensive food production, however, and these could produce greater amounts of biomass if managed carefully and planted with fast growing trees.

The use of greater amounts of biomass for energy purposes without returning the residues to the soil could result eventually in a decrease in soil fertility. The high fertility and productivity of Indonesian soil has been recognized throughout the world, and it is important to maintain this fertility and even enhance it

in order to assure a productive and prospe ous agricultural society in the future. Depletion of soil fertility would not be a significant barrier if the biomass residue were returned to the soil or if fertilizing nutrients were added to compensate for those used in biomass production.

A final important consideration is the unknown effects of introducing fast growing trees into the pattern of agricultural practices. For example, foliage or canopy of many of the present trees grown in "house gardens" and as hedgerows is not dense, and sufficient sunlight filters through to allow the production of food crops such as taro under the trees. It is not known what the effects will be when food crops are grown under Calliandra, Leucaena and other such fast growing trees. If the trees were to cause sufficient shade so as to reduce food crop production, the beneficial effects of increased energy supply could be offset by their effects on food production.

6.2 Direct Combustion

The major barrier to direct combustion of biomass materials for energy sources is transportation costs, since as unprocessed materials they are bulky and are not a concentrated energy form in terms of calorific values per unit weight or volume. It has been stated generally by energy specialists interviewed that 75 to 150 km is the maximum distance that fuelwood can be transported economically in Indonesia. Another barrier which is largely overcome with the ingenuity of householders and research at government centers is stove design. Poorly designed stoces provide only about 10%

transfer of heat energy, while some designs developed by inventors in Indonesia used with specific biomass materials have achieved as high as 20 to 35% efficiency of heat transfer.

In the case of dendrothermal projects in which large acreages of fast growing trees would be harvested and burned directly to provide electricity, the major barriers would be the amount of land required and the capital costs of facilities for storage, processing, and electricity generation.

6.3 Charcoal Production

One of the barriers to developing a charcoal energy system is that of social acceptance. There are two components to this barrier. The poorer people who have always burned wood and biomass materials directly may not want to switch to charcoal because it is a different material with different characteristics. For example, it takes longer to get a fire started when using charcoal. On the other hand, people with higher income levels who now use kerosene may feel that it is a step backward in their pattern of living to switch to charcoal, since charcoal is not such a clean fuel as kerosene.

Another barrier to charcoal production is lack of a marketing and distribution system, since charcoal is used to such a small degree presently. Additionally, the technology of charcoal production throughout the country would have to be improved, using modern methods presently developed in other countries. Technology from Japan is apparently being introduced on Sumatera presently, and

there is discussion of charcoal production by Japan from mangrove trees.

If larger charcoal plants are to be considered, the availability of biomass feedstock would require that they be built on Kalimantan or another island outside Java. Transportation costs to Java and other areas of high population densities would then be significant barriers. Closely related to transportation is the need for packaging and storage facilities. In the high humidity of tropical climates, these could be barriers in the sense that charcoal tends to absorb moisture, and packaging and shipping must be carried out so as to minimize the amount of moisture pick-up.

6.4 Gasification

Gasification is relatively high technology processing, and a primary barrier to commercialization of the process is lack of technology de-development, not only in Indonesia but throughout the world. That is not to say that the technology is not available, but rather that it is not yet simple and easy to use. Very little new technological development has occured since more than 30 years ago, when gasification was nearly terminated because of the availability of inexpensive gas and oil. In recent years, however, more simple designs of systems have begun to be developed.

Another barrier to gasification is the high capital cost and maintenance requirements of gasifiers. Also, for existing equipment now operated by diesel or gasoline power, there is the need for retrofitting of the engines for conversion to gas.

For operation of gasifiers to be as trouble free as possible, a low moisture content of less than 30% is desirable. Therefore, drying of the biomass material could become a barrier to its use.

6.5 Pyrolysis

In Indonesia research and development work on low temperature pyrolysis has focused primarily on developing small one tonne per day rice husk pyrolysis systems for local rice mills. The initial data obtained has resulted in process modifications, and development has been carried nearly to the point of commercialization for rice mills on Java.

One of the barriers to pyrolysis commercialization is that three products are produced, and therefore markets must be found for each. It has been found that pyrolytic oil is not a suitable substitute for kerosene, and therefore other uses for this product must be developed. Also the charcoal produced by pyrolysis in some cases is not of high quality. For example, the ash content of charcoal from rice hulls is nearly 45%, and therefore the charcoal briquettes do not burn as well as charcoal with a lower ash content. In some respects a high ash content may not be totally undesirable, however, since there is a market for the ash as scouring powder and other such uses.

As in the case of barriers to charcoal use mentioned in Section 6.3, there is again the need for social acceptability of the charcoal, along with its marketing and distribution, as well as the problem of moisture absorption. These can be handled if a charcoal energy

system becomes developed, but if charcoal energy in general is not accepted by the public, then the specific problems of marketing the charcoal produced from pyrolysis could be more severe.

The capital cost and maintenance of pyrolysis plants are other major factors which are barriers to commercialization. As long as diesel and gasoline are low in cost, high technology processes such as gasification and pyrolysis will not be readily commercialized. If the subsidies on these fuels were removed and additional further price increases were to occur, however, there would be a noticeable shift to these technologies.

6.6 Ethanol

Ethanol production for use as a fuel and for export is being seriously considered for certain areas of Indonesia which have low population density and where there is need to provide additional jobs and income. Ethanol facilities are thus targeted initially for transmigration areas. There are certain barriers to extensive alcohol production which are briefly summarized below.

Alcohol production is, like gasification and pyrolysis, another high technology processing system. The technological development has been carried out primarily in Europe and the U.S.A., and application on a large scale will require modifications in accordance with the conditions of Indonesia. For example, typical yeast strains used throughout the world cannot tolerate temperatures much above 32°C, while the climate plus heat of reaction for fermentation in Indonesia

results in a fermentation temperature of more than 35° . The same temperature characteristics are important in design modifications to distillation apparatus and heat exchangers so as to obtain the greatest efficiencies possible.

Another barrier to ethanol production on a large scale is the capital cost of processing plants and the economics of competing with subsidized fossil fuels in sale of the alcohol as a fuel. Maintenance and storage problems using this high technology must also be dealt with.

Disposal of fermentation residue, whether to livestock as feed or to land as fertilizer, must also be taken irto account in alcohol fermentation. Additionally, the problem of water pollution from ethanol plants must be addressed.

6.6 Methane Fermentation

As discussed earlier, methane production from organic wastes and residues is perceived to have somewhat limited potential as a major energy source in Indonesia, primarily because of several technical, economic and social barriers. First, technical constraints are evident in that animal manure type feedstocks are often dispersed in the fields where the animals graze, and are not readily available near homes where biogas plants would be located. This is different from China, where biogas plants provide significant energy to millions of homes because several pigs and other animals are always present in the yards adjacent to these homes. Biogas plants in Indonesia therefore are limited primarily to cattle farms, chicken farms, and ponds containing water hyacinths. Each such facility could produce useful biogas, but the

total number of families served could be counted in the thousands, as compared to the tens of millions of families in the country.

The conditions required for biogas use are a barrier to large scale implementation, in that methane, unlike propane and butane, cannot be economically compressed to a liquid for ease of transport. It therefore is almost always piped from the fermenter to its place of use, and is generally not readily adapted to mobile equipment such as tractors and automobiles. Although compressed biogas and large gas bags have been used under wartime conditions for mobile equipment powered by biogas in the past, liquid fuels such as ethanol or methanol are generally considered to be much more suitable.

Social acceptance of biogas plants could be a barrier to widespread use, since in many cases the feedstock is animal and human waste in countries like China, and biogas thereby produced is considered by some to be unsuitable for use in the home as a cooking fuel. Additionally, in areas where animal dung has traditionally been dried and burned as fuel, the introduction of biogas plants would have to be accompanied by considerable social readjustment.

Other barriers to use of methane fermentation are capital costs, maintenance and disposal of spent residues. These are similar in nature to ethanol plants, except that biogas facilities are somewhat more simple to construct and operate.

Since biogas is highly flammable and can cause explosions, the matter of safety is a potential barrier to its use. This can be overcome readily by proper education and fermenter design.

7.0 CURRENT POLICIES AND PROJECTS

As stated in the Introduction, Repelita III, the third five-year plan (1980-1984) emphasizes several major points relating to energy. One is to enhance conservation of kerosene and other oil resources by substituting other energy sources, and another is intensified research, development, and implementation of programs to use renewable energy sources such as biomass. The Government of Indonesia (GOI) is therefore implementing projects which assess the biomass energy demands more fully, produce greater quantities of biomass, and convert the biomass more efficiently to energy use.

A number of studies are currently being undertaken on consumption patterns of fuelwood and other biomass energy sources. These studies will provide information about the amount of cooking fuel needed in the country now and in the future.

Much basic silvicultural and yield information on fuelwood species is needed. A few rather fragmented studies on fast-growing species are underway, but much more coordinated work will be necessary in order to begin to answer questions of what species to grow, where, and what production will ensue.

As stated in Section 1, the GOI is subsidizing the cost of kerosene as a substitute cooking fuel in order to provide assistance to people with low income levels who must resort to kerosene in place of firewood. Kerosene use is therefore increasing by approximately 10% per year, and since 1969 the increase in kerosene use has been so great that substantial amounts must now be imported to meet the demand.

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On a limited scale, biomass is currently being used to provide energy in certain industries. For example, the palm oil mills utilize a large portion of the waste (fiber and fruit shell) to produce steam and electric power for the in-plant use. Also, most of the existing plywood mills use their own wood waste to produce steam for drying the lumber and finished products. Almost all the small-scale brick and roof tile manufacturing operations use wood and other agricultural wastes to fire their kilns.

At the present time, an Imbert gas generator and retrofitted diesel engine (25 kW output) is operating at the solar village in Picon. This gasifier diesel generator set is currently being used to pump irrigation water. A small bench-scale (about 3 kg/hr) gasifier is presently being tested for different biomass feedstock at ITB in Bandung. At the BPP Teknologi, plans are currently underway to construct a small charcoal gasifier to produce DC electricity. The capacity of this gasifier-engine generator will be about 5 kW. Also, a technical and economic feasibility study is being conducted to assess the potential of biomass-based methanol production technology in Indonesia.

Research and development work on low temperature pyrolysis has primarily focused on developing small (1 tonne/day) rice husk pyrolysis systems for the local rice mills. Two one-tonne-per-day pyrolysis systems have been installed near Bandung; one of these units is installed at an existing rice mill. The main purpose of this ongoing research and development activity is to test the operation

of a small rice husk pyrolysis unit and find appropriate utilization for the pyrolysis products. The initial data obtained from the operation of the pyrolysis unit have resulted in several process modifications. These modifications are expected to improve the system performance. So far, the oil yields have been lower than the original expectations. Also, it was found that the pyrolysis oil was not a suitable substitute for domestic kerosene use.

An ambitious program is aimed at the ultimate development of new alcohol production capacity of nearly 20,000,000 Kl/yr of power alcohol by the year 2000. By contrast, current production of ethanol from biomass in Indonesia totals only approximately 30,000 Kl/yr from 9 plants, the majority being exported for beverage purposes, while production capacity in Brazil is expected to be only between 4-6 million Kl/yr in 1985. Using the Brazil program as an example, it took nearly 30 years to reach a production level of 1.5 million Kl/yr. Considering land area and population of Brazil as compared with Indonesia, an equivalent rate of development would indicate that Indonesia would produce approximately 5 million Kl by 1990 and 10 million Kl by the year 2000. An effort considerably greater than that of Brazil would therefore be necessary in order to produce 20 million Kl annually by the year 2000.

The new program, conceived to consist of as many as 4,000 5,000 Kl/yr ethanol plants, is a key component in the new transmigration program developed by the government to redistribute the country's population more evenly among the thousands of island land masses comprising the nation. These 5,000 Kl/yr alcohol plants, using locally grown

surplus agricultural crops such as sweet potatoes and cassava, and Sago palm harvested from nearby tropical marsh forestlands, will serve as the local fuel base for individual transmigration areas (4,000 families) or for export purposes. Already, the first of these plants is scheduled for construction in 1981 in a transmigration area located in South Sumatra with technical assistance from West Germany.

In the vicinity of this plant feedstock consisting of sweet potatoes will be grown by individual farmers on their individual 2 ha farms, with ¼ ha being allocated on each farm for production of the feedstock. With proper crop management, it is anticipated by Indonesian planners that the centralized ethanol plant will be able to continuously process feedstock and produce power alcohol for distribution to distant markets or use within the area, providing both employment and a fuel base for continued expansion.

In addition to the above, a new program in alcohol research is being funded by a grant in aid from Japan in the amount of $8 million. The total alcohol program of B.P.P.T. for 1981/1982 is shown in Table 7-1.

The feasibility of a wide-scale implementation of anaerobic fermentation technology as it relates to conditions in Indonesia is being investigated. Research efforts are currently underway to assess available biomass resources for use as feedstocks for anaerobic digestion units, particularly quantities and availability of water hyacinth (eichornia crassipes). This macrophyte, growing in nutrient-rich, warm, fresh water frequently obstructs drainage of farm lands,

TABLE 7-1.

B.P.P.T. ALCOHOL PROGRAM IN INDONESIA
(By B.P.P.T Teknology (Agency for Development and Application of Technology)
Fiscal Year: 1981/1982

A. PRODUCTION SIDE

1. Pilot plant (15000 liter/day)
   - By November 1982 will produce alcohol 95%.
   - Design by B.P.P.T.
   - Build by Indonesian Firm (tender)
   - Site: Tuland Bawang (Transmigration Area in Lampung
2. Agricultural Research Station for sweet potato (10 Ha)
3. Total budget for A, B, and C, U.S. $3 million (1981/1982)
4. Grant aid from Japan, U.S.$ 8 million, Biomass Research Center in Lampung. Consisting of:
   a. Alcohol plant (15000 liter/day)
   b. Research Center for:
      - Agriculture
      - Saccharification fermentation, distillation
      - Other biomass feedstock

B. SOFT WARE

National Alcohol Team (introduction of alcohol fuels in Indonesia)

a. Agriculture
b. Technology and Production
c. Economic/Marketing
d. Social Impacts

Members from: 7 Departments, and 7 University; approx. 50 people

C. DEMAND SIDE

1. Testing (June 1981)
   a. Straight alcohol:
      1 car, 1 genset 120 KW 5 cycles, 3 alcohol equipment
   b. Gasohol (10/90 and 20/80 with hydrated alcohol) 50 cars
   c. Methanol (two cars)

encroaches upon aquaculture ponds and completely encloses fresh water pools behind hydro-electric dam facilities. Estimates of water hyacinth growth and extent in Indonesia are incomplete, but preliminary estimates indicate approximately 6 million hectares of fresh water surface area in the country are covered by water hyacinth. Being rich in nutrients such as nitrogen and phosphorus, and being approximately 90% water, 10% solids (of which 80% are volatile), the water hyacinth has been reported to be a good substrate for anaerobic fermentation processes.

Other biomass materials available for use as potential feedstocks for production of biogas include, but are not limited to, animal and human wastes, and agricultural residues such as rice straw, bagasse, peanut wastes, etc.

Within the framework of various technical and economic constraints, investigations have been undertaken by various groups and institutions within the country to evaluate the feasibility of using these residues for production of biogas via methane fermentation. At the Bandung Technological Institute (ITB), several simple small-scale experimental digesters have been constructed and installed in the field at Cicurug and Lembang using animal wastes as the feedstocks. The Indonesian Petroleum Institute (LEMIGAS) is sponsoring two methane fermentation projects at Gajah Mada University, one a pilot scale fermentation tank of the Chinese design located at the research farm of the Department of Animal Husbandry and the other a bench scale study of digestion of animal wastes. LEMIGAS is also supporting anaerobic fermentation research at Cepu.

Other current anaerobic fermentation projects include the bag anaerobic digesters installed at P3T in Ciawi, operating in the mesophilic mode utilizing animal wastes; the Chinese style fixed-dome digester constructed at the Solar Village of Picon; the pilot scale digester developed by Biotrap near Bogor; and the water hyacinth digester operated in the mesophilic mode at Cilangkap. Also planned for construction and operation in the immediate future is a thermophilic anaerobic digestion system to be installed at Serpong, utilizing cattle dung as feedstock.

The nature and scope of these various on-going or completed projects are wide-ranging, including evaluation of both small (family size) and larger size (industrial/commercial scale) digestion units. Variables evaluated include: use of different feedstocks such as water hyacinth or animal wastes feedstocks; different design configurations (e.g., Chinese fixed-cover and Indian floating cover) and level of complexity; various materials of construction such as steel, ferrocement, cement and rubber-based products (e.g., butyl digestion bags at Ciawi), and both mesophilic and thermophilic digester design.

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8.0 RECOMMENDED STEPS IN DEVELOPMENT OF BIOMASS RESOURCES

The development of renewable energy sources is critical to supplying the energy needs of Indonesia in the future. Biomass can and should be a major component of this energy source, and with a well planned development program, it can continue to supply major amounts of energy without creating a drain on natural forest areas or adverse effects from overharvesting of firewood in rural areas.

It is important initially for all Ministries of the Government and for the people as a whole to continue receiving the most up-to-date figures available on biomass productivity and consumption, so that they will make increased efforts to produce more biomass for energy and improve biomass conversion procedures. It will then be possible to concentrate the energy component of biomass for economical shipment from rural to urban areas. Facts such as those brought out by Arismunandar and Kadir (1979 and 1980) should be used to provide increased incentive to develop biomass programs. A summary of these facts shows that consumption of firewood and agricultural waste has risen from 34.4 million tonnes in 1967 to 44.7 million tonnes in 1971, to 61.3 million tonnes in 1976. Java, being the most densely inhabited island in Indonesia, with more than 60% of total population, and less than 7% of total land area, consumed most of this firewood; 21.7 million tonnes or 63.0% in 1967, 27.8 million tonnes or 62.1% in 1971, and 37.1 million tonnes or 60.6% in 1976.

Total energy consumption in Indonesia in those years mentioned were

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19.8 million TCE (tonnes coal equivalent) in 1967, 26.0 million TCE in 1971, and 41.4 million TCE in 1976, with oil providing 7.4 million TCE in 1967 , or 37.3% of total, 9.6 million TCE in 1971, or 36.7%, and 18.4 million TCE in 1976, or 44.5% of total energy consumption. Other forms of energy, like water power, coal, and natural gas contributed but a comparatively small amount. However, they are expected to increase significantly in the future, especially coal and natural gas.

The programs recommended below to increase the production and use of biomass should result in at least a partial substitution of this form of energy for the kerosene presently used for cooking purposes. The recommended steps, in order of highest priority in the opinion of the writer, are enumerated below.

8.1 Fast Growing Trees

8.1.1 General

A major way of overcoming the fuelwood dilemma is to accelerate the development of fast growing trees throughout Indonesia and especially in Java and the NTT area. There is now a program to distribute seeds for fast growing trees, and it should be supported and accelerated. It should not be restrained while waiting for research results, but should go forward with increased distribution of seeds and seedlings representing two or three of the most promising types of fast growing trees which have been developed in other tropical countries.

At the same time, the present program of research and

development of fast growing trees which are suited especially for the climate and conditions in Indonesia should be encouraged and accelerated.

Some field trials of Leucaena leucacephala have recently been started. One small plantation near the school of forestry in Yogyakarta showed excellent growth under very favorable circumstances. Other plantations on critically eroded soil did not grow nearly as well. This is to be expected but should not cause disappointment. Eroded soils are relatively poor now but with nitrogen fixing legumes should improve with time, resulting in increased growth. Meanwhile, the soils are covered with useful vegetation, lessening erosion and producing fodder and firewood in modest quantities. It should be pointed out that on Java the 4 million hectares of critically eroded soils and 20 million of class four lands not suitable for agricultural production is where opportunity lies for planting fuelwood trees even if their growth will be less than excellent.

8.1.2 Specific Recommendations

8.1.2.1 Species Recommended for Evaluation. In relation to a program of research and development of suitable fast growing trees, the following species are recommended for evaluation:

Acacia auriculiformis

Acacia mangium

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Calliandra confusa (callothyrsus)

Casuarina equisitifolia

Gliricidia maculata

Leucanea leucocephala

Sesbania grandiflora

8.1.2.2 Hedge Row System. Parallel to a program of field plot trials (as outlined in 8.1.1 above) there should be a series of tests designed to obtain comparative growth and yield information of species planted in single rows. This type of information should then be expanded into a systematic village program to encourage each small farm or "house garden" owner to plant trees along the edge of his fields or small gardens to become self sufficient in his own fuel needs.

8.1.2.3 Small Energy Farms. A program which should be considered for the islands of Java and the NTT area is establishing two small energy farms at the village level. According to one estimate, a small village with 2000 to 3000 inhabitants would need an energy forest of about 125 ha if planted with fast growing trees such as Calliandra. They would be able to produce firewood within four or five years (Kadir, 1979).

If small forests were managed at the village level, they would not only provide energy, but would also constitute some protection of the soil from erosion caused by years of deforestation. The average rural household, traditionally accustomed to using firewood for cooking, would have no

problems of adaptation to small energy farms, and in this way the use of kerosene for household needs would also be minimized.

The chief advantage of small energy farms is that fuelwood transportation costs would be minimal. Unfortunately, the long waiting time of four to five years necessary to harvest the first crop would require a substantial investment by the owner. The government could possibly assist with low interest loans, however, as an alternative to the substantial funds now being committed to kerosene subsidy.

The Terms of Reference for a proposed Integrated Wood Energy Village are shown in Appendix C.

8.2 Charcoal Production

8.2.1 General

Standard practice which has been used for generations on a worldwide basis for concentrating the energy values in fuelwood and agricultural wastes so that they can be transported and used economically in populated areas is their conversion to charcoal. It is a curious fact that charcoal is used only very slightly in Indonesia for cooking purposes, and its use is not increasing in spite of the need to transport firewood for longer and longer distances. Rather than concentrate on charcoal, the dependence has been placed on increased kerosene usage, which is now becoming a burden to the government, and could become a nearly

intolerable burden to both the government and the low income population if allowed to accelerate into the future.

8.2.2 Specific Recommendations

8.2.2.1 Accelerated Development of Charcoal Production. Accelerated development of charcoal production techniques should be undertaken. The old method of producing charcoal in a pit, with the biomass covered with soil to limit oxygen supply in the process has been replaced in other countries by modern metal charcoal plants (retorts), which can be stationary or transportable. These can be manufactured in Indonesia and used efficiently for both firewood and agricultural wastes.

Development of standard designs for specific feedstocks should be carried out, and demonstration plants using firewood should be built in West Java, Central Java, and East Java.

8.2.2.2 Charcoal Marketing and Distribution System. In nearly all of the larger cities of Java now there is a very loose system of charcoal distribution and marketing. The charcoal is primarily used for ironing and specialty food vendors (satay). There is virtually no distribution system for supply to smaller villages and there are very few large processing centers. If a charcoal energy economy is to be developed, it should first be aimed at the rural villages in central Java and Madura where firewood usage is already denuding the landscape and then be directed to the larger urban areas for replacing kerosene. Such a program will require a rather concentrated and sustained effort by the government to reorganize

and improve the packaging, transportation and marketing system. For this report, it will suffice to focus attention on this problem which must be undertaken. Specific procedures for implementation are obviously of sufficient magnitude to require a detailed study and report in itself.

8.2.2.3 Cooking Appliance Improvement. Stoves for direct combustion of charcoal commonly operate at 10 to 20% efficiency, but some designs are stated to have as high as 35% efficiency of heating energy. Development of more efficient stoves is well underway and should be accelerated, with standard designs developed for each particular biomass feedstock.

8.3 Utilization of Agricultural Wastes and Plantation Wastes

8.3.1 General

The development of a charcoal energy system referred to in 8.2 above will aid substantially in making more use of agricultural wastes which are now burned in the fields or at processing plants. The production of charcoal from wastes at estates should be especially fruitful in making this energy form available to village and urban dwellers. For example, a great deal of fuelwood is available from rubber estates, since rubber trees must be replanted approximately every 25 years, and the old trees make excellent fuel.

8.3.2 Specific Recommendations

8.3.2.1 Establishment of "Charcoal Centers". If residue of plantations and estates is to be utilized effectively and a

program of village utilization is established for charcoal, then an excellent opportunity exists for establishment of charcoal production centers adjacent to or as a part of a typical plantation operation. There are two clearly viable approaches to the establishment of such centers. The first approach and perhaps the most simple to implement is to pattern such a center after the thousands of small rice mills which have been in operation and organizationally assimilated into the Indonesian management system from the colonial era. This approach would require financial loans by the central government, perhaps through the local channels of KUD (Village Co-op).

The second approach could be to convince the local plantation and estate owners that they should establish and manage their own centers, and thereby increase their profit position. This approach would perhaps be very effective with the larger plantations which are generally owned and operated as government enterprises, because the central theme for these government enterprises (as often stated by the Central Government) is to devise ways to improve the living conditions of the people in their area. This program would serve that purpose plus give them an extra commodity for income.

8.4 Utilization of Wood Residue

8.4.1 General

Logging and forest product manufacture create vast amounts of

wood residue that form a potential source of energy. Estimates of logging residue amount to about 50 percent of the standing volume harvested. Sawmill residue runs to 35-40 percent of log volume processed. While total volume harvested varies considerably on the outer islands, it is safe to say that logging and sawmill waste run into many million cubic meters annually.

Energy self-sufficiency of the wood products industry should be a near term goal in Indonesia. Efforts should be made to develop data on conversion units (combustion - steam turbine - electricity or gasification) and promote their acquisition by the wood products industry.

Direct combustion of this waste to produce steam and use of turbine-generators to supply electricity for mills is one of the most common approaches. The energy needs of mills can also be met by using gasifiers. The suitability of these two alternative energy supply systems would largely depend on the relative economics, ease of operation, and comparability with the existing energy supply system, if a new mill is being constructed, then direct combustion systems would probably have an economic advantage over a gasification system. However, in the case of existing mills, the gasification option could offer better compatibility with the existing energy generation system of the mill.

8.4.2 Specific Recommendations

8.4.2.1 Sawmill/Forest Residue Conversion to Charcoal. Sawmill residue in excess of self-sufficiency needs and logging residue could be studied with respect to volume, sizes, concentrating the residue at roadside or mill-site, chipping costs, quality of chips. Continued de-development should be made of the potential of producing charcoal on Kalimantan and other islands for shipment to Java.

8.4.2.2 Portable Charcoal Retorts Development. In Indonesia logging operations require an extraordinary amount of capital equipment and expense to bring out the logs to a transportation site. During the felling operation, many secondary trees are felled or otherwise rendered as waste. This residue is left for two reasons. First, because there is no market and the cost to bring out the waste is the same or slightly more than to bring out the good logs. Secondly, because while there is a fee levied on all felled trees, the government is lax on enforcing the "letter of the law" if the contractors do not bring out the product. Large sums of money are saved by not being forced to pay the fee on trees not used. However, this causes excessive losses of biomass resource.

To help the contractors to make better use of this waste, an aggressive program of portable charcoal kilns should

be initiated. In this manner, the contractors can convert the waste "on the spot", and remove the charcoal to the transportation site without the need for heavy equipment. This would lower the tree removal cost substantially and provide the necessary incentive for contractors' participation.

8.5 Advanced Conversion Technology

The above sections 8.1-8.4 are extensions of present technology and should be strongly emphasized in order to increase the biomass to energy potential in Indonesia. Section 8.5 considers four new technologies which are being developed and which have longer-term implications. These are gasification, pyrolysis, ethanol production, and methane fermentation.

8.5.1 Pyrolysis

8.5.1.1 General. Development of pyrolysis has already occurred in Indonesia. This is especially true in the case of small appropriate technology units, but larger units could be developed.

It is recommended that support of additional improvements in pyrolysis technology be provided, and that commercialization be encouraged through low interest loans or other means.

8.5.1.2 Specific Recommendations for Large Scale Pyrolysis. A quick look at the biomass resource availability in Indonesia would indicate that only wood and wood residue could sustain the operation of large scale pyrolysis plants. Because of the fuel transportation cost limitations, these plants would have

to be located near the wood resources; this would require the plants to be located on the islands of Sumatera and/or Kalimantan. The economic feasibility of large wood-based pyrolysis plants would generally depend on the marketability of pyrolytic oil and char. Based on the results of studies conducted in the U.S.A., it could be safely assumed that the pyrolytic oil, after necessary equipment modifications, could be used in industrial residual fuel oil fired installations. The charcoal could be added to the same distribution and marketing system that should be established for kiln produced charcoal.

The gaseous product of a pyrolysis process has low to intermediate energy content, thus it cannot be economically transported over long distances. The best use of this product would be at the plant site. For example, it could be used to supply the pyrolysis heat and in-plant power to run the equipment.

The final decision on whether to install a rather capital intensive pyrolysis conversion system over a more conventional kiln system would have to be made after a careful economic study of specific site conditions and market trends.

8.5.1.3. Specific Recommendations for Small Scale Pyrolysis. At the ITB Technology Development Center in Bandung, research and development work has primarily focused on developing small rice husk pyrolysis systems for the local rice mills. Two one tonne per day pyrolysis systems have been installed near Bandung. One of these units is installed at an existing rice

mill. The main purpose of the on-going research and development activity is to test the operation of a small rice husk pyrolysis unit and fine appropriate utilization of the pyrolysis products.

Once again, from initial observations of the resource availability and economic calculations, as reported in their most recent report dated October, 1980, it is believed that there is potential application of the program that is underway now at ITB. It is recommended that this program be observed closely.

8.5.2 Gasification

8.5.2.1 General. In Indonesia research and development work is slowly expanding in the biomass gasification area. At the present time an Imbert gas generator and retrofitted diesel engine (25 kW output) is operating at the solar village in Picon. This gasifier diesel-generator set is currently being used to pump irrigation water. A small bench scale (about 3.0 kg/hr) gasifier is presently being tested for different biomass feedstock at ITB in Bandung. At the BPP Teknologi (PUSPIPTEK) plans are currently underway to construct a small charcoal gasifier to produce DC electricity. The capacity of this gasifier-engine generator will be about 5 Kw.

The low calorific (low BTU) value gas produced from an air blown biomass gasifier can be used to operate internal combustion engines, to fire boilers, to generate electricity, as fuel for drying kilns, etc. Since the gasification technology for producing low-calorific value gas is available, in the near term this technology would find application in different Indonesian energy consuming sectors. Application of this technology in

different sectors is given below.

8.5.2.2 Specific Recommendations.

8.5.2.2.1 Forest Products Industry.

The existing sawmill and plywood mills produce a sizable amount of waste wood. This waste wood can be converted to supply the in-plant energy needs of these mills through gasification. For example, with gasification the existing diesel-generators and/or engines can be used to run on a mixture (90% gas and 10% diesel fuel) of gas and diesel fuel or the engines can be retrofitted and run on 100 percent gas. In the latter case the engine will be derated considerably, however, since most of the existing diesel engines are oversized, the derating would not seriously impact the normal mill operation.

The relative economics of these two alternative energy supply options should be evaluated, however, the simple design, quick startup, and minimum attendance requirement of small gas generator plants cannot be denied.

8.5.2.2.2 Electricity Generation.

Consideration should be given to retrofitting the existing small (10 mwe) PLN oil fired electricity generating plants, in Sumatera and Kalimantan. On the island of Java, because of the lack of wood resources and the planned large (400 mwe) coal-fired central stations, small wood-based electricity production plants will not be cost competitive. For the other wood producing areas, however, it should be very cost competitive.

8.5.2.2.3 Agriculture.

Low calorific gas generators are suitable for supplying energy for different agriculture or related operations. For example, agricultural waste (crop residue) can be used to produce a low calorific gas which in turn could power a retrofitted diesel generator to drive either an irrigation pump or a rice mill. In Indonesia, rice husks and rice straw are the most commonly available agricultural residues. The higher ash content (silica) of rice husks does create some operational difficulties for the gas generators, but these difficulties can be overcome by certain design modifications.

All of the following are feasible feedstocks for gasification:

Rice husks	Cocoanut fibre
Paddy stalks	Sugar cane fibre
Ground nut shells	Oil nut fibre
Corn cobs	Peat
Coconut shells	Alang-alang grass (Imperata Spec.)

8.5.2.2.4 Application of Advance Gasification Technologies.

Advance gasification technologies, i.e., high pressure gasification, fluid-bed gasification, oxygen-blown gasification, and catalytic gasification, are being developed in the U.S.A. for the production of synthesis gas (CO/H_2) on a large scale. This synthesis gas in turn could be used in the production of different chemicals and fuels. Methanol is one of the chemical fuels which could be produced via this biomass gasification (oxygen-blown) and subsequent catalytic synthesis route. Since

methanol is one of the liquid fuels which is seriously being considered as a gasoline additive, in the short run, and gasoline substitute in the long run, the need for developing advance biomass gasification technologies cannot be over-emphasized.

In Indonesia there is a great amount of interest in developing an alcohol fuel (both ethanol and methanol) industry. In line with this interest, serious efforts should be made to develop advanced biomass gasification technologies, particularly for gasifying wood and wood residue.

8.5.3 Ethanol Production

As indicated in Section 7, an ethanol production plant of 5,000 kiloliters/year capacity is scheduled for construction in 1981 in a transmigration area located in South Sumatera. Feedstock will consist of sweet potatoes grown by individual farmers on their respective farms.

It is recommended that the alcohol plant in South Sumatera be observed carefully to determine the potential for further development of this program.

8.5.4 Methane Fermentation

While biogas production from animal waste, garbage and refuse, and plant materials has considerable potential, each plant requires substantial capital expenditure when constructed according to present designs. Continued development of this natural process pf producing energy from waste matter and plant materials should be encouraged, with special attention

to low cost designs which require little operation and maintenance.

8.5.5 Dendrothermal Plants

The potential of growing trees for direct combustion to produce electricity is substantial in less densely populated areas outside Java. A pilot scale dendrothermal project is on-going presently in the Philippines, where the climate and biomass production conditions are similar to those in Indonesia. It is recommended that this program be monitored by obtaining permission from the Philippine government to station a technical person on site in the Philippines to obtain data and determine potential for dendrothermal application in Indonesia.

8.5.6 Methanol

Currently, research effort in alcohol fuels production is being shared in Indonesia between ethanol and methanol production. With such a large quantity of wood residues (Section 5.2) available, considerable attention should be directed towards finding means of converting that biomass to methanol, since methanol production technology includes a gasification step most suitable for that type of waste (i.e., wood waste from forest products industry). In contrast to several thousand planned decentralized alcohol production facilities, relatively few larger methanol production plants could be built near the source of wood wastes (i.e., at saw and plywood mills or pulp mills), and be managed for export in the same manner as the finished products of the respective facility, thus keeping additional transportation costs at a minimum.

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9.0 EVALUATION

Section 2 describes the biomass resource base in Indonesia. It is seen that on Java the intensive use of land for food production because of high population density has resulted in a large deficit in fuelwood production as compared with demand, while on the outer islands the production and demand are in relative balance. Where there is a shortage of fuelwood, such as on Java, the use of agricultural wastes and the home garden's potential for firewood are important. In fact, data indicate that if home gardens were well managed, they could contribute up to 60% of the fuel demand of a village community.

Section 4 describes the current utilization of biomass. It is seen that, on an equivalent energy basis, firewood and waste contribute about 50% of the energy of the country, with most of the remaining energy coming from oil. The fossil fuel resource is rapidly being depleted, however, while firewood and wastes are renewable resources. It therefore cannot be over-emphasized that all possible efforts must be made to expand the renewable firewood and waste resource base in order to conserve and become increasingly independent of fossil fuels.

Section 3 describes the trends in the extent of the biomass resource base, such as deforestation of heavily populated areas, but on the positive side there is reforestation and the introduction of fast-growing trees. Section 5 describes the potential for future use of biomass, and Section 8 describes specific recommended steps in the increased develpoment of biomass resources for energy.

The significance of emphasizing biomass as an energy source is that because of the climate, rainfall, and fertile conditions of the soil in Indonesia there are great opportunities to grow vast amounts of biomass which can be converted to energy. Programs of accelerated growth of biomass and conversion to energy should be implemented now while there are funds available from sale of fossil fuels, and in preparation for the future years when available fossil fuels will be diminishing in quantity while the population growth and increasing use of energy continues. It is well known that the internal domestic consumption of fossil fuel energy is growing at a rate which is much more rapid than the development of new fossil fuel supplies, and that at the present rate of growth, within nearly a decade, the country would have to begin to import fossil fuels at the extremely high prices which will prevail in the 1990's. It is absolutely necessary that the country use its resources and the technologies of other countries in order to become energy self-sufficient, with much of the energy coming from biomass.

Another important significance of the potential for future use and recommended steps in the development of biomass resources for energy is that the amount of kerosene being used as an energy source is increasing at an alarming rate, and the subsidy provided is already of great economic concern. It is therefore also absolutely necessary to develop more biomass to replace kerosene, so that in the 1990's the use of kerosene as an energy source will be greatly diminished.

The benefits derived by Indonesia from the project Energy Planning For Development are extremely great. The present Five-Year Plan

emphasizes development of industry and technology throughout the country. This development cannot occur without the use of vast amounts of energy. In other words, energy must be available as one of the primary conditions to development. It appears from an examination of the amounts of energy being used that by the end of the present Five-Year Plan the amount of energy available could be the primary deterrent to achieving the goals desired in the area of industrial development. Therefore, energy planning for development is an absolute necessity in order to achieve the goals of the present Five-Year Plan and especially in order to use these goals as the foundation for developing the next Five-Year Plan.

There are several types of energy which can be harnessed for future use and which is renewable. Biomass is one of the major such energy sources, others being hydro power, solar energy, photovoltaic energy, and wind energy. The accelerated use of biomass is by far the program which will provide the largest near-term results at the least cost. It also is a program which can be carried out simultaneously throughout the entire country in small-sized projects at the village level which will benefit not only the villagers individually but also the national government if the government can reduce or eliminate the present energy and cost of subsidizing kerosene use. Biomass energy should therefore be given the highest priority in early implementation programs in order to develop self-sufficiency for Indonesia without the use of fossil fuels.

Further analyses are required in determining more specifically the amount of biomass energy which is required per family or per person

throughout the entire country. Published data on biomass requirements vary by as much as an entire order of magnitude, and therefore one of the highest priority studies, some of which are now on-going, is to develop better current data on biomass use.

Another recommendation for further analysis is to evaluate the improvement of transport between the islands. This is vitally necessary because of a disparity in distribution of population and natural resources such as biomass. Studies should be made and programs implemented to improve the transport systems by both ship and rail, and especially the construction of dock facilities in order to improve the efficiency and decrease the cost of inter-island shipping. Such shipping improvements would improve the shipping of coal, woody biomass products, and food between the islands, allowing an equal distribution in spite of the unequal distribution of population and natural resources at the present time.

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APPENDIX A

LIST OF PERSONS CONTACTED

Prof. A. Arismunandar	Director for Resource Development, DJK
Ir. Tangkas Roesad	DJK
Dr. A. J. Suryadi	DJK
Ir. E. Darianto	DJK
Ir. M. Pandjaitan	DJK
Ir. E. Utomo	DJK
Ir. L. Sumiaroso	DJK
Prof. Herman Johannes	U. Gajah Mada
Prof. Ida Bagus Agra	U. Gajah Mada
Prof. Sri Warnajati	U. Gajah Mada
Prof. Sukoharto	U. Gajah Mada
Dr. Ir. Z. Coto	I.P.B., Bogor
Dr. H. H. Sitompul	I.P.B., Bogor
Dr. K. Abdullah	I.P.B., Bogor
Dr. S. Sumintawikarta	Min. of Agriculture
Ir. H. Soewandi	Min. of Agriculture
Dr. S. Sapiie	ITB, Bandung
Dr. F. Harahap	ITB, Bandung
Dr. S. Sasmojo	ITB, Bandung
Dr. Saswanadi	ITB, Bandung
Mr. Sumariyo Hardjodarsono	Director, LPHH
Dr. [illegible] Hartoyo	LPHH
Dr. O. Sumarwoto	Pajajara University, Bandung
Ir. Noegroho Hadi, HS.	Lemigas
Dr. L. M. Panggabean	BPPT
Ir. Wardiman	BPPT
Ambassador E. Masters	U.S. Embassy
A. W. Trick, Agricultural Counselor	U.S. Embassy
T. Niblock, Chief of Mission	USAID
W. H. Littlewood	USAID
Dr. W. P. Weatherly	USAID
R. Vincent	USAID
K. A. Prussner	USAID
M. J. Korin	USAID
E. M. Barrau	USAID
P. F. Narten	USGS
Dr. J. R. Ege	USGS
D. Fisher	President, ITCI
Dr. John Tatom	Consultant
R. D. Hardy	Consultant

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APPENDIX B

DAILY LOG OF MEETINGS AND SCHEDULE OF

DR. ROLF T. SKRINDE

OCTOBER 17 TO NOVEMBER 3, 1980 AND NOVEMBER 21-24, 1980

October 17

Departed from Seattle, Washington, U.S.A.

October 19

Arrived Jakarta, Indonesia - Sari Pacific Hotel

Met at airport by William H. Littlewood of USAID. We had a brief discussion of my assignment on the biomass task, Energy Planning for Development.

October 20

Met Ir. Tangkas Roesad, my counterpart associate in the Energy Resource Development Directorate of DJK. He introduced me to Dr. A. J. Surjadi of DJK. We discussed the organization of DJK. Met Ir. Endro Utomo Notodisuryo of DJK and Secretary Yanti Suyunus. Met Kenneth M. Grover of E/DI (mini-hydro, micro-hydro and geothermal) and his counterpart associate Luluk Sumiarso of DJK.

October 21

Telephone discussion with W. H. Littlewood regarding the project. Met Dr. John W. Tatom, consultant to ITB Bandung (Dr. Filino Harahap) on pyrolysis project, and Ruben Hardy, who is consultant to USAID project with BPPT on use of D.C. electrical current for remote villages not connected to central power grids.

October 22

Meeting with Dr. Paul Weatherly of USAID - Environmental Planning (He made a detailed village survey of fuel wood and kerosene uses in Klaten (Central Java), Lombok, and Luwu (S. Sulawesi) to determine the effects of rural electrification on village cultural and living habits.

Discussed biogas and alcohol projects in Indonesia with Ir. Tangkas.

October 23

Discussed program with Ir. Tangkas. Made plans to visit Bogor and Bandung. Invited to dinner at W. H. Littlewood's house. Met Mr. Tom Niblock, Director of USAID in Indonesia.

October 24

Meeting with Kenneth A. Prussner (USAID Agricultural Advisor). Meeting with Dr. Cool A. Dutto (USAID Rural Development Division). Meeting with Enrique M. Barrau (USAID Agricultural Extension Advisor) and Retno S. Sidarta of USAID Agricultural section. Met with Alan White Trick, Counselor for Agricultural Affairs, U.S. Embassy. Ir. Tangkas and I met with Dr. Antono Arismunandar, DJK Director for Energy Resource Development. We discussed the objectives of the biomass energy policy effort and my schedule taking into consideration my duties on the biomass team which will be associated with BPPT for three weeks in November.

October 25

Ir. Tangkas and I drove to Bogor, held several meetings, and returned the same day. At ITB we met with Dr. Komaruddin Abdullah, Dr. Helen H. Sitompul, and Dr. Ir. Zahrial Coto. At LPHH (Forest Products Research Institute)

we met with Director Sunariyo Hardjodarsono and also the head of the Chemical Processing Division, Mr. Hartoyo Wardi.

October 26

The day was spent in studying reports and preparing notes for use in my final report. I discussed my work in a telephone conversation with Mr. Littlewood.

October 27

Most of the day was spent in studying reports and meeting with Ir. Tangkas. He has arranged for meetings in Bandung on October 28. Met with Dr. Paul Weatherly of USAID to discuss his report on the use of wood and other biomass materials for cooking purposes in villages.

October 28

Ir. Tangkas and I went by train to Bandung. We met with Dr. Filino Harahap, Director of the Development Technology Center of ITB. We also met with Dr. Saswinadi Sasmojo, Vice-Director of DTC, and Dr. John Tatom, who serves as a consultant to Dr. Filino in the pyrolysis of biomass waste materials (rice husks). I later met briefly with Dr. Soedjana Sapiie of ITB and BPPT to make an appointment for the first meeting of the four-member USAID biomass team, which will begin a study regarding the PUSPIPTEK Energy Laboratory on November 4. We returned to Jakarta by car late in the evening.

October 29

Most of the day was spent at our DJK office reviewing reports and discussing biomass energy with Ir. Tangkas. I also visited the office of Mr. Littlewood of USAID and discussed the various energy projects in Indonesia with which

he is associated. In the afternoon I had a meeting with Mr. David Fisher, President of International Timber Corp., which is partly owned by Weyerhaeuser of U.S.A. We discussed the use of timber waste materials for energy purposes. Address: Kartika Plaza Building, Jalan Thamrin 10, First Floor, Tel.: 342206 or 354740.

October 30

Visited Robert Vincent of USAID regarding forestry in Indonesia. Received report from him on forest research carried out at Bogor. Ir. Tangkas and I visited the Ministry of Agriculture Research and Development Agency in Jakarta. The Head of Research and Development is Mr. S. W. Sadikin. We actually met with Ir. Hariwijaya Soewandi of Information Service and Abdul Hammand of Statistical Data.

October 31

Most of the day was spent in review of biomass energy reports. Visited briefly with Mr. Perry F. Narten of U.S. Geological Survey, who suggested that a New Zealand company is interested in using waste biomass materials for purposes such as housing. The company is P. T. Sudagu. The sales executive is Oemar H. Wirasaputra, with an office at Jalan Kali Besar Timur, Tel.: 673303 or 673317.

November 1

I reported to Dr. A. Arismunandar on my progress to date. Later in the day Ir. Tangkas and I met with Ir. Soedjadi Martodiwirjo, Director of Perum Perhutani, and Mr. Sujadi, Chief of the Bureau of Production. Fermentation expert Kurt H. Vause from my company arrived in Jakarta today. We spent several hours discussing the use of biogas and alcohol plants in Indonesia

to provide energy sources. Ir. Tangkas arranged for Mr. Vause and me to meet with faculty of Gajah Mada University in Yogyakarta on November 3.

November 2

Ir. Tangkas, Mr. Vause, and I traveled to Yogyakarta and visited rural areas to understand more fully the relationship between food production and use of biomass materials for food and waste products as energy sources.

November 3

Ir. Tangkas, Mr. Vause and I held meetings with the following faculty members of Gajah Mada University:

Prof. Herman Johannes - Biomass production

Prof. Ida Bagus Agra - Pyrolysis of biomass waste products

Prof. Sri Warnajati - Chemical processing of biomass materials

Prof. Sukoharto - Methane fermentation of animal wastes

We returned to Jakarta in the evening. During our return trip we discussed the assignments that Mr. Vause and I will have during the first part of November, and how we will continue to make progress on the Energy Planning for Development - Biomass Sub-task - during that time.

November 4-21

I participated as coordinator of a Biomass Energy Team consisting of four specialists who were responsible to recommend design concepts and equipment requirements for biomass activities which may be carried out at PUSPIPTEK Laboratories. The four-person team specialized in forestry and biomass production, thermo-chemical conversion of biomass to energy, and fermentation processes for converting biomass to energy. Meetings were held with officials and research and development personnel in the field of biomass

energy at Bandung, Bogor, Surabaya, Kalimantan, and Jakarta. These meetings and the interaction with other members of the Biomass Energy Team were helpful in gaining additional knowledge relating to the Biomass Sub-task in the program of Energy Planning for Development. Mr. Kurt H. Vause was helpful especially in providing assistance to me for several days after completing his assignment as a member of the Biomass Energy Team.

November 22-24

Analysis of documents and notes taken during previous five weeks of meetings were completed in preparation for preparing recommendations for the Biomass Sub-task report.

November 25

Ir. Tangkas and I met with Ir. Neogroho Hadi, HS., who is responsible for the biogas program at LEMIGAS. A good discussion was held of the biogas projects which have been completed thus far on a pilot scale, using both animal waste and garbage and solid wastes as feedstocks. One demonstration project each is presently planned for Cepu, Bali, and East Java. These projects are funded by DJK.

APPENDIX C

TERMS OF REFERENCE

INTEGRATED WOOD ENERGY VILLAGE FOR TRANSMIGRATION

OBJECTIVE

An integrated energy village using wood from fast growing trees as the biomass resource base for the primary purpose of producing power for use in a transmigration area is planned. The power produced would be used to improve the life of the people in the transmigration area, provide lighting, operate low energy consuming appliances such as refrigerators and TV sets, and for commercial activities which may be undertaken in the area. Activities which consume large amounts of energy, such as cooking of food, will also be supplied by the integrated wood energy village. In this case the wood used will be grown on the wood plantation, but rather than conversion to electricity it will be used most efficiently if burned directly or converted to charcoal or other materials prior to use as a cooking fuel.

Power production from the integrated wood energy village will serve as a demonstration of the use of the vast biomass potential available near transmigration areas for energy purposes. So-called dendrothermal plants are already in use in some countries where the biomass availability is less than in Indonesia, such as in the United States, and other projects are being started in the Philippines.

To summarize, the objective of the integrated wood energy village is to provide power and energy required for a transmigration area, thereby

improving the quality of life of the people and making them totally self-sufficient in energy. The goal in commercialization would be to manufacture the dendrothermal plants and other conversion units such as pelletizing plants and charcoal kilns in Indonesia, thus adding jobs and enhancing development.

SCOPE

It is estimated that a transmigration area will contain 4,000 families, or a total population of about 25,000. During the feasibility study the following two concepts should be investigated. One would be to locate the wood village in a central area, surrounded by the transmigration farms. This would allow the shortest and most equitable distances from the wood growing area to the individual farms for electric power lines and the transport of cooking fuels. The other concept would be to have the wood growing village located adjacent to the transmigration area. For a transmigration area of 4,000 families or 8,000 Ha, it is estimated that approximately 2,000 Ha of wood village would be required, but this number should be analyzed more carefully during the feasibility study.

The estimated 2,000 Ha of land near the transmigration area would be initially a forested area, and therefore the production of power using these forests could occur as soon as the power plant were constructed. Additionally, some of the biomass removed in clearing the land for farming by the transmigration farmers could be used as feedstock to the dendrothermal plant.

The scope of the project would consist of initial site preparation, construction of the electric power plant, and development of the power supply grid of electric lines to the homes of the transmigration families. In

order to conserve electricity so that it is not used for such high energy consuming activities as cooking, the next step in the scope of work will be to provide sufficient cooking fuel to serve the transmigration area. After the first area of plantation has been used for the dendrothermal plant and for cooking fuels, then the planting of fast growing trees will occur on a continuous basis, so that a constant supply of trees will be growing and thus provide energy indefinitely to the transmigration area.

The cooking fuels used in the homes of the transmigration area will consist of firewood which can be burned directly, for those people who are located close to the wood energy forest. For those who live several km away there may be interest in converting the firewood to higher energy forms for ease and economy of shipment. For this reason, a program will be undertaken to convert some firewood into charcoal, and to pelletize firewood and residues. Other biomass conversion processes which would be economical on the scale of serving a transmigration area may be utilized as the technology develops throughout Indonesia.

PROGRAM SCHEDULE

The program is expected to have a duration of six years. This time period is divided as follows:

1. Year 1 - Feasibility study, selection of site, site preparation for initial planting of fast growing trees
2. Year 2 - Continuation of site preparation and planting of trees. Beginning of design of dendrothermal power plant.
3. Year 3 - Maintenance of tree farm, beginning construction of dendrothermal power plant, construction of pelletizing plant, and charcoal kiln.
4. Year 4 - Construction of dendrothermal plant for electric power generation, continuation of tree farm maintenance.

5. Year 5 - Installation of distribution lines, completion of dendrothermal power plant.

6. Year 6 - Beginning of operation of dendrothermal power plant. Operation of other facilities for firewood conversion, such as pelletizing and charcoal kilns.

EVALUATIONS TO BE MADE

As the program progresses, and especially after initial results are obtained sufficient for establishment of equilibrium conditions, evaluations will be made to determine the potential of large scale commercialization of the concept of integrated wood energy villages. These evaluations will include the following:

1. Technical feasibility - Technical feasibility evaluations will relate to the best type of fast growing trees, technical aspects of their conversion to electric power in dendrothermal plants, and conversion to such fuelwood sources as charcoal and wood pellets.

2. Socio-economic evaluations - Analyses will be made of the social acceptance of the integrated wood energy village concept. Special attention will be given to the potential for providing power for sale to outlying areas away from the transmigration area, and thereby bringing in a source of revenue to the transmigration people. Cost/benefit evaluations will be made as to the economics of providing energy using the integrated wood energy village concept for both the transmigration area inhabitants and for potentially other customers for the energy who live near the area.

3. Energy input/output - Evaluations will be made of the total energy budget in providing energy self-sufficiency to the transmigration area through the integrated wood energy village concept. This includes

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analyses of energy inputs and outputs, as well as energy modelling to develop predicative models for improving the later commercialization of this energy system.

ENERGY PLANNING FOR DEVELOPMENT IN INDONESIA

Appendix G

SMALL SCALE HYDROPOWER AND GEOTHERMAL ENERGY IN INDONESIA

based on reports by

Kenneth Grover

GSA International

May 1981

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

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e/di

I. INTRODUCTION

This report presents a brief analysis of the potential for the use of geothermal energy and small scale hydropower in Indonesia. This report was prepared as a contribution to the Energy Planning for Development project being carried out by Energy/Development International and associated firms for the Ministry of Mines and Energy. The overall project included energy demand projections and a survey of rural energy use as well as a set of technology assessments. All of these elements were designed to contribute to the formulation of national energy plans and policies. The emphasis was on an overview of future energy demand and the role that various alternative (non-fossil fuel) technologies could play in that future.

An important consideration in all elements of the overall project was the development of capabilities within the Directorate General of Power to carry out effective energy planning. Accordingly, much of the work carried out on this assignment involved training, discussions and briefings of various sorts which can not be reflected adequately in this report.

The issues assessed for each of the technologies considered were the following:

1. Resource Base: an evaluation of the resource base economically exploitable by current technology. Where possible the geographical distribution of the resource is specified.

2. Current Utilization: recent trends in the development and use of the resource, including the end uses served by the resource and its utilizing technologies.

3. Potential For Future Use: the technical potential for economical use of the resource is evaluated for the years 1990 and 2000. By "technical potential" is meant the level of exploitation taking only technical factors

into account, assuming that institutional and financing constraints can be overcome. Technical constraints on the rate at which new geothermal wells can be drilled, dams can be built, new transportation systems developed, etc. are important technical constraints that are considered explicitly. "Economical use" is defined in terms of competition with oil at world market prices of $38/bbl in 1990 and $50/bbl in 2000 (1980 dollars). Geographical aspects of resource development and use are discussed where possible and the cost of energy to the system is estimated.

4. Barriers to Use: the major barriers that must be overcome if the resource is to be used at the potential defined above are identified.

5. Current Projects and Policies: current policies towards the use of the resource and current projects (research, demonstration, pilot plants, construction or operational plants) for its use are identified.

6. Next Steps: the next steps are identified that the government should take in the development of the resource.

The next two sections of the report summarize the results of this analysis for small scale hydropower and geothermal energy.

II. SMALL SCALE HYDROPOWER

A. Introduction

Hydropower development in Indonesia dates back to the beginning of the 19th Century. Some of the units installed by Dutch engineers before 1940, ranging in size from 35 kw to 3 Mw, are still in operation. By the mid 1940's hydropower accounted for greater that 80 percent of total electricity generation[1]. That fraction has steadily decreased despite continual increases in hydro capacity. Today there is 552 Mw of installed capacity, representing 20 percent of the electric capacity used by the public utility. Much of this installed capacity is on Java where with dams used also for irrigation water supply. This results in low plant factors because of the higher priority needed for irrigation water.

Small scale hydropower systems - sizes from 1kw to 5000 kw would appear to have an enormous potential - particularly in remote areas of Sumatra, Kalimantan, Sulawesi and Irian Jaya not served by a central grid. This potential is essentially unexploited and even very little explored.

Small hydro does not find its greatest social and economic potential in areas served, or soon to be served, by network power from major power stations. Its contribution to an emerging society is a maximum when: it is geographically remote from areas served by network power; when its power has a maximum effect in reducing man hours per task; when its availability increases the disposable income from the area served and at the same time when it delivers an improvement in the health and other social aspects of the lives of the people who would not otherwise receive these benefits in the absence of electrical power.

B. The Resource Base

In the absense of any systematic evaluation of the small river hydro resource base, a rough appoximation can be obtained from general geographical and rainfall data. In terms of rainfall and the ratio of mountains to lowlands, Kalimantan and Sulawesi are the most favorable overall, but N. Sumatra and parts of Java also appear attractive. Irian Jaya may be the most economical of all, but the use of small scale hydropower there is limited by the very small population. Table I gives some very approximate numbers for the amount of small scale hydro power potential in the promising areas. Rather conservative assumptions have been used in these calculations - for example that only 1 - 2 percent of the theoretically potential hydro resource can be utilized. In these areas, then a total potential of some 484 Mw of capacity is estimated. The per capita figures in the table are only indicative since they are based on an estimate (also shown in the table) of the fraction of the total population that live in areas that a) are not currently served by central power sources and b) are in favorable rainfall-topography zones. In Sumatra, for example, the estimated 8 million is out of a total population of 26.6 million. If only a fraction of that population were served, the watts per capita shown in the last column would be even higher. Even the per capita figures given, however, are higher than the current national average per capita consumption of about 6 watts/capita.

C. Current Utilization

Although there is currently no significant utilization of small hydro in Indonesia, there appears to be a wide-spread recognition of the potential viability of this option. It is recognized to be an instrument

TABLE I

ESTIMATES OF SMALL SCALE HYDROPOWER

Region	Area million hectares	Run-Off mm	Av. Elev. meters	Theoretical Power Mw	Practical Power Mw	Available Population, million	Practical Power Per Capita (watts/capita)
N. Sumatra	15.0	1470	400	4,370	44	6	7.28
Kalimantan	53.9	1590	400	17,000	170	6	28.3
Sulawesi	18.9	1200	1200	13,500	270	8	33.74

to achieve the government's policy goal to "develop rural energy to permit cheap energy supply in rural areas so that damage to forests, land and water can be minimized" and to "increase the development of electric power for the improvement of the welfare of the society in rural and urban areas and to push and trigger economic activities".

D. Potential for Future Use

Based on the analysis above we have estimated that approximately 9 million people in rural areas of Sumatra, Kalimantan and Sulawesi could be served by small scale hydro in the next 15 years. For all purposes we have assumed a per capita usage of 50 watts. This corresponds to 450 Mw of connected load serving 9 million people.

Sizing of the stations is dependent on the population density in areas of developable hydro resources. For villages of 500 people with consumption of .05 kw/capita we would choose the 25 kw size. For small towns and local areas of 2000 people we would use 100 kw size. When 3000 people are clustered together we would need a 150 kw plant. However, in most locations where 2000 people are concentrated some diesel power is available and consumption exceeds 50 watts/capita. We have optimized at 100 watts/capita: thus 1500 people will use 150 kw within 3 years of start-up.

If 450 Mw is to be supplied even by stations of the largest size considered, 150 kw, this would require 3000 units. Lest this appear an unreasonable number, it should be recalled that 49,000 small dams in the U.S. are now being reconditioned. In the People's Republic of China there are reported to be over 60,000 small hydro units in operation. Most of these were built in the last 20 years. The first 60,000 units

had a maximum size of 1 Mw but an average size of 90 kw. Most of the units were built by People's Communes (rural cooperatives) at the county level. Financial support was provided by the central government. It should further be noted that our 3000 station estimate is limited by market proximity, not by site availability. That number can expand as rural population does.

On this basis we have assumed an installed capacity of 450 Mw in 2000 and 150 Mw by 1990.

E. Barriers to Use

The development of an effective small hydro program requires a sequence of activities, the first and most important of which are indicated below. Despite interest at a high level in small hydro, refered to above, one of the reasons that it has not been pushed ahead would appear to be the prevailing attitudes at the planning and operational levels regarding rural electrification. Although the desirability of proceeding with rural electric power development is virtually universally endorsed, the prevailing philosophy is to depend on extensions of the central grid. This approach limits rural service improvement essentially to Java and a small part of Sumatra.

It appears that insufficient attention is currently being given to decentralized alternatives to rural electrification. There tends to be a bias in many foreign consultant reports towards central grid extension reflecting, perhaps, the conditions of the industrialized countries and the era of cheap central station power more than the Indonesian situation and modern relative costs. In particular, unrealistically high costs have been attributed to small scale hydro. As examples of expenditures which

are appropriate for large scale hydro which have erroneously been attributed to small hydro are: detailed soil investigations, expensive and time consuming hydrology studies and expensive civil work on tunnels, dams, etc. Such attribution reveals a lack of understanding and experience in small hydro design, installation and operation.

F. Next Steps

In order to implement a small hydro program, the following steps are recommended:

1. A small-area site survey should be carried out, preferably by a team consisting of foreign small hydro experts together with Indonesian counterparts in Kalimantan, Sumatra, and Sulawesi for the purpose of selection and data collection on 21 sites. The criteria in this selection should include:

   a) Year-round water supply with dry season minimum flow in excess of small hydro plant needs (water rights controlled by power - not irrigation.).

   b) Market for power to be evaluated with social, cultural and economic benefits recognized.

   c) Installation requires minimum civil facilities; non-dam, low cost water supply system to be 50 percent or less of equipment cost.

   d) Possible secondary use of water (irrigation or other).

   e) No existing or planned network service to area to be served by the small hydro system, for at least 10 years.

   f) Minimum of distribution facilities cost. Demand load is at site or nearby.

   g) Positive indication of growth in area GDP as a result of the small hydro installation.

   h) Access to site for equipment transport and erection.

   i) Local people who can be trained to operate and maintain the plant.

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j) Local government interest to assure record keeping and "visibility" to other government sectors, cooperatives, and PLN.

2. With photos, site drawings and local need data in hand, the rural electrification authorities should choose one or more sites for a "typical" demonstration unit on each island. It is recommended that the first units be limited to 50 kw. It should be possible to get external assistance funding for the cost of the hardware F.O.B. Jakarta (approximately $50,000 each).

3. While steps 1 and 2 are in progress, a series of approximately 100 gauging stations should be installed by Indonesians (perhaps with technical assistance) to develop flow-duration curves for a group of selected river basins. Similar basin models can then be created for the entire applicable area using these data and aerial photos.

4. During the early part of the work outlined in step 1, two Indonesians should be sent to the U.S. to see several small hydro plants operating in accordance with the site selection criteria given above, and without dams, tunnels or expensive civil work.

5. An evaluation should be made of the economics of decentralized rural electrification, particularly by small hydro, giving consideration to the effects on regional development, social value and support to the government's transmigration program. In this analysis the cost of small hydropower development should be compared with alternative decentralized systems, particularly diesel (with fuel based on world costs or shadow prices) as well as grid extension. The decentralized option should be considered in some regions as a step towards access to the central grid, making that extension more cost effective.

6. We recommend that Indonesia act as host to a regional workshop

on small hydropower, before the initial selection of 20 sites has commenced, so that the workshop information will be in the possession of the Indonesian members of the survey team as well as the two specialists sent to the U.S. under step #4.

7. Several important phases and tasks would be completed on the same time table, perhaps September 1981.

a) The 20-site inventory and technical site-data task.

b) The small hydro workshop and U.S. site visit could complete.

c) Gauging stations installed and data being gathered.

d) Indonesian knowledge and confidence in small hydro exists.

Against this background the government can proceed in two ways:

1) They could have already ordered a 50 kw impulse turbine for 50 meters head and 7-8 cfs (about 0.23 meters^3) or;

2) They can order it at this time for about $50,000 U.S. and 5 months delivery at factory.

The site can be selected <u>to fit the turbine</u> in this case to shorten program time.

8. We recommend this unit be carefully installed and operated as a learning machine - but in a remote location where social and economic values can be obtained. This is not a technical exercise alone but a social and commercial tool. An excellent site exists at a small village in West Sumatra about 100 km from Padang.

9. At this stage (say January, 1982) the data can be analyzed to identify areas in which the criteria defined above are satisfied. With the best areas identified, the survey is greatly reduced in cost and scope. The areas of interest can now be mapped, photographed from lower altitudes and interferences such as irrigation, etc., determined. At this point the

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task becomes one of picking the best sites from the thousands of possibilities displayed. There will be in excess of 500 such sites in Sumatra alone. Units should be standardized: perhaps four runner diameters and vary nozzles to vary power.

The program could be implemented initially with a few packaged systems available in the U.S. today (from any one of three manufacturers). The impulse turbines should soon be manufactured in Indonesia, with only a few critical parts purchased abroad.

III. GEOTHERMAL ENERGY

A. Introduction

The very large potential for geothermal power development in Indonesia has been recognized since the early part of the Century. Indeed, throughout the archipelago there are unavoidable signs of geothermal activity - hundreds of volcanos, many of which are still active, craters, and hot springs. Unlike small scale hydro, discussed above, a program directed towards commercial geothermal power development is under way. Its scope, however, does not appear to be consistent with the very large potential of this resource.

Exploration for geothermal (volcanic) steam dates back to 1918 with more recent exploratory efforts having been carried out by the Geological Survey of Indonesia, Pertamina's geological survey office, as well as foreign teams from the UN (1964-65, 1972), France (1968), the U.S. (1970), New Zealand (1971) and Japan (from 1974)[2].

B. The Resource Base

The resource base in geothermal energy is defined by an "L" -shaped area of high volcanic activity. The base of the "L" lies along a mountain range with its center at Kamojang in West Central Java. The vertical leg of the "L" follows a highly faulted and volcanic trend northeasterly from the north shore of Java to a locus of points along the eastern coast of Kalimantan and western Sulawesi.

The "L" shaped area of Geothermal interest has developed by the confluence of 3 Tectonic plates. Over many thousands of years this plate activity has produced the three requirements needed to create Geothermal energy

recovery possibilities, i.e.

a) presence of magma near the earth's surface.

b) sufficient elevation above sea-level to give adequate hydraulic load in the re-charge water circuit.

c) proper sub-surface rock conditions to permit heat exchange between the hot magma and the re-charge water.

The high rate of rainfall (2000 mm) in Indonesia completes the picture through adequate supply of re-charge water. The principal areas of Indonesia which are thought to be worthy of commercial development according to the latest investigations by the Directorate Vulcanology Bandung are:

Sumatra

1. Seulawah Agam	Aceh, Sumatera	(PT)
2. Muaralabuh	West Sumatera	(PT)
3. Pasaman	West Sumatera	(PF)
4. Lempur and Semurup	Jambi	(PT)
5. Serampas	Jambi	(PF)
6. Ratai	Lampung	(PF)

Where PF indicates Prospective

PT indicates Potential

PI indicates Producing

The Padang and Posumah areas lie along the Great Sumatra Fault Zone. Hot Springs and fumarolos are numerous along this line for 1650 km from Aceh in the northwest to Semangko Bay in the southwest.

Java

1. Danau Volcanic Area	Banten	(PT)
2. Cisolok-Cisukarame	Cisolok Area	(PT)
3. Kamojang and Drajat	South Priangan	(PI)

4. Perbakti-Kiaraberes	Salak Volcano	(PT)
5. Kawah Karaha	Talagabodas	(PT)
6. Tampomas	Tampomas	(PT)
7. Dieng-Sikidang	Dieng Plateau	(PI)

Kalimantan

Ten hot springs are known to exist on this large land mass. In the southeast section an area of prospective Geothermal promise is thought to exist. Much work remains to be done before any plans can be formulated here.

Sulawesi

The southwestern section along Makasar Strait appears to have Geothermal potential. Part of the northern peninsula and central area is dotted with hot springs and is worthy of more study. The Great Sunda mountain system is intersected by the East Asia Arc Tectonic System and thus the magma is brought near the surface. Particularly the south area looks promising due to the presence of Tertiary sediments including reservoir and capping layers. The Lahendong-Tompaso area in Minahasa, North Sulawesi is under development and the Kotamobago area is another potential area in the North Sumatra. The following are other areas of potential power recovery:

1.	Minahasa	Volcanic region in inner arc
2.	Central Sulawesi	300 km Fossa Sarvasiu Fault
3.	Para Thermal Field	South Sulawesi
4.	Mamasa Thermal Field	South Sulawesi
5.	Somba Thermal Field	South Sulawesi
6.	Songola Thermal Field	South Sulawesi
7.	Pambu Swan Thermal Field	South Sulawesi
8.	Sutili Thermal Field	South Sulawesi
9.	Masope Thermal Field	South Sulawesi
10.	Simjai Thermal Field	South Sulawesi
11.	Midawa Thermal Field	South Sulawesi

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Since these areas are somewhat dispersed, they are worthy of consideration for small decentralized power generation for local users.

Bali and Flores

The Buyan - Bratan area in Buyan-Bratan Caldera is a potential site as is the Ulumbu area in West Nusatenggara.

Many surveys of Indonesia Geothermal potential have been made during the period from 1926 thru 1974. Sumatra, Java and Sulawesi probably have the greatest opportunities for economic energy recovery. No accurate estimate of GW hours is available but the natural heat flow liquid water of the entire Dieng System is 7700 Kcal/sec or at 100 percent efficiency about equal to a continuous power output of 32,500 kilowatts (32.5 Mw). When we consider that this is natural heat flow, we must also recognize the great increase in heat availability from drilled production wells.

We would concur with the estimates given in the report, "Conclusions, Energy Workshop in Jakarta, April 17 - 18, 1080" regarding exploitable resources, namely:

Java	5,500 Mw
Sumatra	1,100 Mw
Sulawesi	1,400 Mw

There are additional reserves of about 3000 Mw in other inland locations. Overall 8,000 to 10,000 Mw appear to be available for development.

C. Current Utilization

The first geothermal plant is a 250 kw "monoblock"[3] turbine generator unit at Kamojang in West Java. This has been in operation for about a year and produces about 100 kw in pilot operation. The unit receives steam from a vapor dominated reservoir and has experienced normal maintenance

problems associated with vapor-dominated reservoirs. Deposits, thought to be mainly boron compounds have been removed recently from the interior and analysis will be available in the near future. There has not been enough power demand to permit full-load operation and this introduces higher turbine discharge temperatures than design. This high temperature operation is a more favorable operating condition than will be experienced at full load.

The second plant, a 2 Mw unit at Dieng Plateau in West Java will utilize a large resistor to obtain full loading for the turbine. These data starting about mid-1981 will provide useful information for future projects and policies.

D. Potential for Future Use

The long range technical potential of geothermal power has been estimated above as 8,000 - 10,000 Mw. Although it would require a substantial effort, we would estimate that about 3000 Mw of geothermal power could be on line by 2000.

We base this rather expansive estimate on the relative economics of geothermal power relative to other sources. D.R. Wilson[4] has estimated the cost of power from geothermal sources in Indonesia as 1.5¢/kwh (1.1¢/kwh capital costs and 0.4¢ operating and maintenance). This is based on units of 200 Mw size, and thus may incorporate an economy of scale which is not applicable to Indonesia. We would prefer a figure for overall power costs of about 2.5¢/kwh. But this number is far less than even the fuel component of oil based thermal power (about 4.5¢/kwh). The greatest potential for future use will be along the central Sumatra, North Central Java and Sulawesi Volcanic areas. Plant sizes may vary

from 250 kw (Monoblock-Type) plants to larger central power stations up to about 100 Mw.

E. Current Projects and Policies

At this time, the major effort expended has centered in exploration for and evaluation of reservoirs. The Kamojang field, known since 1926, has been partly defined insofar as area is concerned and well defined as a vapor-dominated reservoir. The Dieng Plateau geothermal area has also been drilled extensively and exploration continues.

In view of the potential of this resource, currently exploration is proceeding at a slow pace. Only 3 drilling rigs were in operation at the time of this study (1980). Exploration rigs average 1.4 wells per year. Success ratio for production drilling is 67 percent and these wells average 4.2 Mw per well. Thus, to meet the 3000 Mw of geothermal power targeted in Repelita III by year 2000, 32 drilling rigs must drill from 1980 forward for 20 years. This would be a very significant acceleration from the current program.

At this time the classical problem of geothermal energy utilization has not been solved. The primary energy-form developed from geothermal fields is electricity. Geothermal deposits are located along the edges of Tectonic plates with attendant high risks of earthquake activity, volcanic eruptions and generally are in mountainous areas. These are generally not the areas most likely to be served by transmission lines able to receive the power developed by a geothermal station. Since most fields will need to be piloted by smaller "Monoblock-Type" units before larger station design should be attempted, some small amount of power will be wasted before transmission lines could be justified into the area.

The Government has identified five areas on Java for geothermal development and has invited foreign investors to submit proposals along 3 general lines[5]:

1. Field Exploration and development, selling steam to PLN for power generation.

2. Field exploration and development plus construction of a power plant selling power to PLN.

3. Field exploration and development plus construction of a power plant with investor taking all or part of the power.

F. Next Steps

1. As discussed above, the achievement of several thousand Mw of geothermal electricity by 2000 will require a significant increase in exploratory drilling activity.

2. Once promising fields are identified, rural electrification programs should be funded in areas where small monoblock units can be installed to yield small blocks of local power and, at the same time, to "prove-out" the field.

3. A training program should be deisgned for geothermal geologists and power development engineers.

4. An investigation should be carried out of the feasibility of basing thermal intensive industries in geothermal areas. Food, paper, textile and other industries now using fossil fuels could profitably be cited in such areas.

Notes and References

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3. A "monoblock" unit is a combined turbine-generator-control package.

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ENERGY PLANNING FOR DEVELOPMENT IN INDONESIA

Appendix H

AN ASSESSMENT OF SOLAR AND WIND ENERGY IN INDONESIA

James D. Westfield

Development Sciences Inc.

January 1981

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

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INTRODUCTION

The work reported on in this document involved a one-month assignment in Indonesia working with representatives of the Indonesian government and other members of the EDI, DSI project team. This assignment included visits to major centers and institutions in Java to collect information on solar and wind resources, technologies and applications. The report covers the following topics:

- Resource base -- estimates of the quantity and quality of the solar and wind resources.
- Current status of and trends in production and use.
- Potential future use of solar and wind energy.
- Barriers to further development and use.
- Current policies and projects.
- Recommendations for government actions to develop solar and wind resources.

For each of the above topics a report chapter has been prepared. In each chapter both solar and wind are covered. Solar refers to photovoltaics (PV) and solar thermal (high and low temperature). In the wind area both mechanical and electrical energy production are considered, but emphasis is placed on electricity production. The other resource and technology areas often included under the term solar are either covered elsewhere (i.e., biomass) or are not relevant to this study (i.e., tidal, ocean thermal, and passive solar energy).

In addition to the above chapters several appendices are included. The first appendix (A) contains a list of common abbreviations used in this report. Appendix B contains a summary of my agenda while in Indonesia and summary reports on each of the principal visits or interviews conducted while in Indonesia. The other appendices contain background data and information to support the findings in the main body of the report. In the final appendix answers to the following questions are included:

- The significance of the conclusions drawn in your report for Indonesian energy policy and planning.
- The benefits derived by Indonesia from the overall project and your component of it and a critique of the overall assistance project.

CHAPTER I
SOLAR AND WIND RESOURCE BASE

SOLAR

In Indonesia there are two types of solar radiation data. The first type or primary data includes total global radiation and hours of sunshine data taken by various agencies including The Ministry of Communications (Meteorological and Geophysical Institute), The Bandung Institute of Technology (Mechanical Engineering and Engineering Physics), The University of Indonesia (Physics Department), The Institute of Aeronautics and Space (LAPAN), and The Ministry of Research and Technology (BPPT). These data are measured at meteorology and research stations, and summaries are published annually or contained in research reports. The attached reference list, especially references 1, 2, 5, 6 and 8, identifies some of the major sources. In addition to measurements of hours of sunlight by Campbell-Stokes type sunshine-indicating radiometers and various types of pyranometers, there are a few measurements of radiation data with pyrheliometers and silicon cell solar radiometers.

Secondary data include calculations of global and diffuse radiation for places where no actual measurements were taken, as well as measurements of cloudiness, visibility, evaporation rate, rainfall and temperature. There are a number of stations which regularly report secondary data and there have been several studies which have contributed secondary global radiation estimates, especially reference 8 (seasonal iso-intensity maps of global radiation for Java). A copy of the map showing calculated average annual values of global radiation on Java is included in Appendix C. Some excellent early data on solar radiation in Java were taken by the Dutch and published in reference 17. This publication shows that for the years 1928 to 1932 the mean average global solar radiation for Jakarta was 400 langleys. This compares favorably with the current average of approximately 364 for the years from 1964 to 1978. The lower value for today's readings is likely due to air pollution in Jakarta.

Two of the major problems with existing primary solar data are:

A) The distribution of stations reporting global radiation and/or hours of sunlight data is limited, and there are also few years of record.

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B) The accuracy of the reported data, even hours of sunlight, is questionable because of instrument calibration and maintenance problems. (In most instances no one has checked to see if the readings being reported are accurate).

Another limitation is that almost no measurements have been made on the composition of solar radiation; i.e., what percentage is diffuse and direct. This is an important factor in defining the type of uses and technologies appropriate for particular areas of the country.

The iso-intensity map for Java (Appendix C) was computed by establishing relationships for Jakarta and Bandung between hours of sunlight and measured global solar radiation (langleys). The relationship for Jakarta was assumed valid for all stations having elevations less than 250 meters and the relationship for Bandung was assumed valid for all stations with elevations above 250 meters. Values of total global radiation were calculated for all stations reporting hours of sunlight using the general relationships.

Thus, the values on the map are calculated using a questionable relationship and should be considered as only a first and gross estimate. Table C-2 in Appendix C contains hours of sunlight data for numerous stations in Indonesia including several in locations other than Java. The stations in Table C-2 were selected by reviewing all existing meteorological records and recording data for all locations with more than 50 percent reported sunshine (see map C-1 for station locations). The months of record with the highest and the lowest number of hours of sunshine are also listed. If the relationships between global solar radiation and hours of sunlight described above are valid for areas other than Java, it appears that there are many sites where the solar regime is excellent for use as an energy source. These readings were not converted to langleys because there was not even one of the stations which had global radiation values with which to check the relationship. When comparisons are available, and if the hours of sunlight data are reliable, an excellent first step solar radiation map of all of Indonesia can be constructed.

Because humidity, haze, pollution and other atmospheric components will affect the quality of the solar radiation (change direct radiation into diffuse), it is necessary to know the percentage of the radiation reaching the

surface of the earth in Java which is direct and the percentage which is diffuse. Very few measurements of this have been made. Data developed at Bandung at the ITB for a few months in 1980 show that as much as 60 percent of the radiation reaching the ground is diffuse. Diffuse radiation is difficult to concentrate and, thus, concentrating collectors may not be appropriate for all or part of Indonesia.

An analysis of the solar radiation map in Appendix C shows that the average annual solar radiation on Java varies between 340 to 460 langleys per day. Assuming a 100 percent conversion and the lowest average value, it would be theoretically possible to capture almost 4 kilowatt hours of electricity per square meter of surface area per day. Today's photovoltaic panels convert approximately 8 percent of the incident energy to electricity; using current technology, 0.3 kilowatt hours of electricity per day can be developed per square meter of PV panel surface area. This converts to approximately 3 square meters of panel for each kilowatt hour of electricity. The top end of the average solar radiation range (460 langleys) would deliver approximately 35 percent more electricity per square meter of panel.

To convert the sun's energy to heat at 100 percent efficiency it would be theoretically possible to capture between 13,505 and 18,271 Btus per square meter per day on Java. Since a good conversion efficiency for state-of-the-art thermal hot water collectors is approximately 35 percent, in actuality between 4,726 and 6,395 Btus per square meter per day of heating can be accomplished.

All of the solar resource is available for recovery and the cost is not only in the recovery but also in the transformation to a useful form. At present, solar radiation is used for agricultural purposes and passive heating. The cost of recovery for the simplest hot water or hot air heaters is less than $10 per million per Btus. For example, if a simple open hot water heating system with a two-meter square collector can be constructed and installed for $300 US, it would have to operate for approximately 13 years to meet the $10 per million Btu figure. However, the cost used for this calculation includes both recovery and conversion to a useful form.

WIND

The data on wind velocity and direction in Indonesia are very poor. There are long records of wind velocity and direction at numerous stations throughout Indonesia; however, these data are inappropriate for wind energy estimation purposes. The meteorological stations reporting wind data are for the most part at airports and data are taken only at three or four times during the daylight hours. Wind data from airport locations are not useful to describe the wind regimes because airports are normally located where the wind regime is unique (constant winds, no winds, unidirectional, etc.).

The other wind data available in Indonesia are high-level, above one mile, wind measurements for use in predicting long-term weather trends. There is almost no reliable continuous record of surface winds at any location in the country. Wind velocity measurements reported for the central observatory in Jakarta (the Office of the Meteorological Institute) are even questionable. The recording annimometer on the roof of one of the buildings is shielded from winds by a nearby (15 meters away) building. Winds from almost a 30° vector would be substantially under reported by the annimometer because of the nearby building. Some short-term records are available at ITB and at locations near the coast of Java. BPPT and LAPAN have begun to accurately measure wind at several sites, but there is not enough data to prepare a wind velocity map similar to the solar radiation map. It is likely that wind resources can be developed, but there is not enough information to estimate the quantity or quality of surface winds. Average wind data for several locations in Indonesia are presented in Appendix C.

CHAPTER II

CURRENT STATUS OF AND TRENDS IN PRODUCTION AND USE OF SOLAR AND WIND RESOURCES

As was pointed out earlier, it is difficult to separate resource production from transformation. Unlike most other energy resources solar and wind energy development involves a hybrid process which often includes both capture and transformation in one step. A solar collector usually captures the heat energy and transfers it to another fluid which can be used directly (hot water or hot air space heating, for example) or which can be further transformed to do work. Solar and wind energy production and use are often both accomplished at one site. This is because most solar and wind energy uses are small-scale and because, except for large wind or solar thermal (power tower or ocean thermal) central electrification, most technologies are designed to produce energy in a form tailored to a limited number of uses. For the above reasons, production and use will be discussed together. The word "use" will also be generally used to signify both production and use.

There are no major uses of solar or wind energy in Indonesia at the present time. One Indonesian manufacturer builds and markets an assembleable solar cooker. This is made from foil covered cardboard and is more a toy or model than a useful item.

Numerous Indonesian universities and institutes are experimenting with solar thermal technologies to produce hot water and refrigeration for small health clinic and household uses. Each of these experimental projects is more thoroughly described in the summaries of the interviews in Appendix B. These experiments may lead to the development of locally manufactured technologies or they may promote uses of foreign technologies, but the outcome is not yet known. Several institutes, particularly ITB and Padjadoran University, are experimenting with prototypes for industrial crop drying and wind electrification. Dr. Seno of the Padjadoran University and Dr. Suono of ITB are each working with industries to develop nationally manufactured solar technologies. In one case, a prototype of a solar assisted crop dryer is being jointly tested and in the other a solar hot water heating system is being developed. Aside from this and direct drying of crops in the sun (a

widespread agricultural practice for the small-scale farmer), the only other use of solar and wind energy is for water pumping. There are several wind powered water pumps throughout Java, but there seems to be no plans to expand this use at the present time. The wind regime is not well enough defined to generate much interest in wind powered pumping applications at this time. Also, because some of the earlier attempts to use wind were not successful, there is presently a negative feeling about the potential for wind powered pumping (see Appendix B, page B-11, for more details). Wind powered electrification is also being considered, but only two prototype machines have been built and tested. The machines (combinations of Savonious and Darius rotors) have had problems and are undergoing redesign by LAPAN and ITB. There is not any current direct industrial use of solar thermal technologies and as far as could be determined in this study none is seriously considered at this time.

Photovoltaic electrification is being used in several small-scale applications and much testing of various commercial systems is underway. BPPT and LEN have both cooperated in a project to produce PV cells from purchased silicon wafers. There is no short-term hope of producing PV modules locally, but there is a number of experiments with foreign built PV panels at universities and research institutes.

In summary, both foreign produced and locally built solar and wind technologies are being tested and studied in Indonesia. A few tests have progressed to the point that industries are beginning to consider manufacturing and marketing (solar hot air crop drying and solar hot water heating). At this time, however, there is not any appreciable end use of solar or wind energy other than traditional open air solar drying of grains and other crops.

CHAPTER III

POTENTIAL FUTURE USE OF SOLAR AND WIND ENERGY

The potential for the use of solar and wind resources is optimistically touted by numerous Indonesian government agencies and institutes. However, this optimism is based on very little economic or pilot study analysis. Market studies and government support or subsidy programs do not for the most part exist. Local manufacture or aggressive marketing of foreign solar and wind technologies is also lacking. In fact, in the published summary from the 1980 Energy Workshop held in Jakarta (reference 10) a figure presenting expected supply sources for the electric power sector for Java shows only oil, hydro, geothermal, coal and nuclear sources as contributing to supply by the year 2000. There also seems to be no real expectation that solar or wind power will be even minor contributors to the electric power sector even outside Java on Sumatra, Sulawesi, Nusa Tenggara, Moluccas or Irian. In these areas water power and coal are projected to supply over 50 percent of the electricity by the year 2000. Because of the above and the absence of any current uses of these resources, it is difficult to discuss adoption rates or estimate target levels for solar or wind energy use.

WIND

In the wind area, LAPAN has issued publications and news releases such as the following:

> "The two major applications of wind energy that show significant promise are: water pumping and electricity generation. Water pumping is usually performed by utilizing small to medium scale windmills (ranging from 0.1 kw for domestic water supply to 1 kw for irrigation), while for electricity generation, small (under 1 kw) to very large (in MW range) wind energy conversion systems are commercially available (on the world market) or under development. Thus, the use of windmills for water pumping in rural areas and the use of wind energy conversion system for electricity generation for remote areas have been given considerable attention in development work on wind energy utilization in Indonesia.
>
> "One of the relevant aspects that leads to wider utilization of wind energy conversion systems is the price of the produced electricity. There is a tendency that the price of electricity from the wind is gradually decreasing compared to the price of conventionally produced electricity (from petroleum), although initial investment

of wind energy conversion system is relatively higher than conventional electricity generating system. Unit price of wind turbine will decrease with its increasing size if wind turbines are mass produced."*

In spite of the optimism, wind electrification will not take hold in Indonesia until a mdeium-scale, cost-effective technology (1-50 kilowatt sizes) is available and/or manufactured in the country. Assuming 300 watts average as a minimum capacity for a rural household, a 50 kilowatt system would only serve a village of 166 households at a maximum. The number of households served would in fact depend on the actual load profile, the wind regime and the amount of storage provided. If wind electrification is to be used for commercial or small industrial applications such as 6- or 12-volt battery charging, grain drying, refrigeration, etc., this size range is also appropriate. By 1985, a preliminary definition of the wind regime in Java and some other parts of Indonesia should be available. The technical barrier of system cost competiveness with other electrification systems has not been overcome anywhere in the world and only in the United States and a few other developed countries is it near. The availability of a cost competitive 1-50 kilowatt wind machine should occur in Indonesia between 1985 and 1990; and, thus, the adoption rate or level of wind use for electrification will be small until after 1990.

It is interesting to note that in reference 10 the estimated amount of electricity generated by oil in 1990 on the major Indonesian islands other than Java is estimated to be approximately 53 percent or 6525 Gwh per year. If the wind regime is as good on these islands as it is thought to be and wind were to supply only .01 percent of the annual off-Java demand, this would be 0.65 Gwh. Wind electrification must be assumed to provide a substitute for expensive installed capacity. A windmill cannot completely replace existing or future generating capacity, it can only be relied upon to produce electricity when there is wind. Because of this, a 50 kw windmill will supply less than the theoretically possible 438,000 kwh (50 x 365 x 24) of electricity per year. Data cited below for Indonesia assume between 750 and 3,700 kwh of electricity per year per installed kw of wind electrification

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* Reference 16, page 6.

capacity. Using this factor, a 50-kw windmill would generate between 37,500 and 185,000 kwh of electricity per year. To produce 0.65 Gwh, you would need between 17,333 and 3,514 50-kw machines. From this exercise it is evident that for wind electrification to contribute to any extent to the electricity supply sector in the off-Java islands, the machines must be substantially larger than 50 kw. Much larger and possibly more appropriate machines are being tested in the United States now. MOD-1 and MOD-2 have between 2 and 2.5 MW capacity. These machines are expected to produce between 3 and 9 Gwh/year at an average wind speed of approximately 8 m/sec (reference 20). Commercial availability depends on these tests and other factors, but is not to be expected before 1990. Thus, for wind electrification to contribute to any extent to the supply of electricity in Indonesia, large machines, much larger than 50 kw, must be available. For this reason no appreciable contribution to the electricity sector is expected by 2000.

There are no believable or reliable cost estimates for the large windmills; however, $45,000 on site in Indonesia is a reasonable estimate of the price for a 50-kw machine (reference 20). The cost per kilowatt hour, assuming 10 years life and $1,500 per year O&M for a $45,000 windmill (amortized over 10 years at 12 percent), is approximately $0.08 per kilowatt hour. This compares favorably with today's cost for small decentralized diesels. Table III-1 presents a summary of electric power costs from various sources. Based on the above analysis, wind power will be reasonable in areas where the wind velocity averages 8 m/sec and power is presently supplied by small decentralized diesel. It will be better to initially install windmills to substitute for existing expensive-to-operate deisel capacity since wind power may not be as reliable as diesel in that it will supply power only when there is wind. If wind is to be the only source of electricity, expensive batteries must be provided to supply power during non-wind times. If this is not possible, there will be periods of little or no power.

Using global wind energy maps and the few credible wind energy data published by Indonesian agencies (see Appendix D), a series of application rate estimates has been made. Calculations using these data show that annual wind energy values ranging from 750 kilowatt hours per kilowatt of generating capacity to 3,700 kilowatt hours per kilowatt of generating capacity. These

Table III-1

ELECTRIC POWER COST ESTIMATES
(1980 Costs, Except as Noted, Delivered to Major Consumers)

Fuel/Generator Type	Capital Cost 1980 $/kw	Fuel Cost ¢/kwh	Power Cost ¢/kwh
Small Decentralized Diesel			
(1980)	800	10.9	13.2
(2000)(a)	800	13.5	15.8
Large Coal-Fired Central Station	1000	2.7	5.2
Large Imported Oil Fired Central Station			
(1980)	800	5.5	7.5
(2000)	800	8.0	-
Single Small Nuclear Unit	2200	1.0	7.4
50 kw Windmill(b)	900	1.35(c)	8.5

(a) Crude oil prices taken as $70/bbl in 2000.

(b) Calculations made using existing windmill prices.

(c) O&M costs -- fuel is free.

Source: World Bank, "Energy in the Developing Countries," 1980; and E/DI estimates.

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calculations assume 25 miles per hour or 11.2 meters per second velocities, speeds which are very high and found only on coastal or elevated locations. However, the estimates of the number of kilowatt hours produced are very low, ranging from 0.09 to 0.42 percent of theoretical.

In locations where this type of wind regime is found, electrification to tie into the grid or as a stand-alone system is possible. As was mentioned above, these systems should be available by 1990. However, it is not anticipated that a large amount of electricity will be supplied by these systems. If one MOD-1 type windmill were installed and operating in Indonesia by 1990, approximately 3.7 Gwh of electricity could be expected each year. This would supply only 0.03 percent of the total off-Java islands electricity demand in 1990. Furthermore, since most of the islands do not have a central grid the machine would likely be too big for any such application. If built on Java in 1990, one of these machines would supply only approximately 0.01 percent of the total demand. These machines could not replace installed capacity, but could serve to generate electricity when there was wind and during these times they could substitute for expensive generating capacity.

The use of wind to produce mechanical power has a large number of possible applications, especially off Java. In the islands where small-scale agriculture is being emphasized, diesel fuel supply is difficult and average wind velocities are at least 3.5 m/s, wind pumping should be considered. This type of application can affect a large number of people, but in terms of the overall amount of pumping carried on its impact by the year 2000 will be small. The use of wind power for pumping will be minimal until an Indonesian wind pumping system is available. It is expected that this will not happen until 1990. By the year 2000 a large number of wind pumping installations should be in place on the islands.

SOLAR

The potential for the use of solar in Indonesia is large. The areas of early adoption will be single hot water systems for individual homes and other small uses, institutional solar hot water heating (hotels, military,

public housing projects, etc.), industrial hot water heating (beverages and food preparation), agricultural uses such as crop drying, and stand-alone electrification with photovoltaics.

A small solar open hot water heating system built in Indonesia has been developed and demonstrated, and as soon as these systems are commercially available (probably 1983) there should be an excellent market for these. It is expected that the initial purchase will be by individuals who would otherwise buy imported electric hot water heating systems (references 14 and 18). In 1976 there were approximately 9,000 imported electric hot water heaters sold in Indonesia at an average cost of $400 US for a 50-liter capacity system. If the growth of the market for hot water heating increases as it has in the past, a total of approximately 10,000 new units will be required each year. If a locally constructed system could sell for $500 US, the size of the potential annual market from only this use would be $5 million US. If only 20 percent of this demand were supplied by solar units, the annual solar market would be $1 million US. If the solar market grows by 10 percent per year and the total market each year increases by 10,000 units, the figures in Table III-2 would result. By the year 2000,

Table III-2

POSSIBLE MARKET FOR INDIVIDUAL HOME SOLAR HOT WATER HEATING SYSTEMS

Year	Total Units in Place	Solar Units in Place	Percent Which is Solar
1985	100,000	10,000	10%
1986	110,000	11,000	10%
1990	150,000	16,105	10.7%
1995	155,000	25,937	16.7%
2000	160,000	41,772	26%

approximately 40 percent of the annual installations would be solar. The figures in Table III-2 are very conservative and probably represent the minimum to be expected. Larger solar hot water heating installations for commercial

and industrial establishments are also likely. The installation of these will likely start in the late 1980s with imported systems, and in the 1990s Indonesian systems should be available.

A large potential market for more sophisticated solar hot water heating is hotels. In Indonesia in 1978, according to data in reference 21, there were 57,160 rooms and 3,120 hotels. Java accounts for approximately 55 percent of both of these. There are numerous reliable commercially available systems for solar hot water heating which can be imported and installed. Presently, there are no installations in Indonesia; however, because of the size of the market and the nearness of Indonesia to a major supplier, Japan, there will soon be some systems installed. Once this market is opened, other institutions such as hospitals, the military, etc., and certain industries will also be targets for solar hot water heating. Because the economics of institutional solar hot water heating are very much determined by the system design and cost, it is not possible to estimate specific market penetration rates or savings. However, by the year 2000 a target of 10 percent of the hot water to hotels to be provided by solar is not unreasonable. In terms of reducing overall electricity or diesel use in Indonesia, this substitution will be extremely small and inconsequential. Even 100 percent replacement (which is not possible) would not make a noticeable impact on oil use in Indonesia. The impact of this type of sbustitution will be twofold; savings to the owner of the hotel or institution and development of a market for a nationally manufactured system. There are no data on which to make an estimate of possible solar use in industry. However, based on data from other countries the beverage and food processing industries are ideal candidates for early introduction of solar heat.

In solar crop drying the earliest a unit is expected to be available is 1984-1985. There were no statistics available on the amount of diesel used to dry crops; however, it is known that a large amount of oil-fired drying is taking place. Crops now being dryed in large amounts include cocoa, coffee, tea, corn, rice and some other grains. There is interest in fruits, vegetables and fish drying also. The solar powered dryers now being developed have a solar assisted drying capacity with back-up diesel burners and a small amount of electricity to power a blower.

Data on cocoa in reference 21 indicate that in 1978 there were almost 200,000 hectares of land in Indonesia under cultivation for cocoa. Most of this is on 50 large estates; in 1977, 70 percent of the acreage under cultivation for cocoa was on large estates. In terms of yield, 85 percent of the 1977 production of cocoa came from these estates. Thus, the market for solar assisted cocoa drying is well-defined and, though limited to less than 100 large installations, each application could be very large. The markets for solar assisted drying for other crops are similar, a relatively few large applications. There are variations in drying requirements for each crop and example, humidity control is very important in rice drying while it is not so critical for cocoa. Because of this, a standard modularized design for all crops is unlikely. It is more probable that a system with different components for different applications will be required.

There are other solar systems which should also be considered as possibly important to Indonesia's energy future. Concentrating solar thermal (power tower) and ocean thermal (OTEC) are both under consideration as major sources of electricity for the grid or for individual industrial or agricultural applications. If world testing and development continue at their present rate and are successful, these two should be available by the late 1990s. At the present, concentrating solar thermal is questionable because of the possibly high percentage of diffuse radiation found in the few measurements which have been taken in Indonesia. If this is characteristic, large-scale application of concentrating solar thermal for electrification will not be feasible. Very little performance or cost information is available for OTEC, but the minimum thermal gradient necessary to consider applying this is found in the waters off Indonesia (37°F difference between surface and 1000 meters below the surface). Thus, this may be a solar technology of the future for Indonesia, but we will be able to say very little about the potential until the 1990s.

Photovoltaics are the third area of possible major solar involvement. At present, research is underway into assembly and partial manufacture of PV modules. It is likely that no meaningful in-country manufacture will take place until:

- Simplified and less expensive manufacturing techniques are developed in the United States, Germany or Japan, and adopted by Indonesian industry.
- An existing manufacturer decides to locate a facility in Indonesia.

If the first path is taken, manufacture will not occur until the 1990s. It is possible that the second path could occur a little earlier. The use of PV in Indonesia will be limited to specialized systems such as corrosion control, communications, remote sensing, military uses, and small amounts of power for isolated areas (stand-alone power systems). The total impact on energy use will be small until either of the two in-country manufacturing steps is accomplished or prices of internationally manufactured PV drops significantly. The 1990s will be a growth period for photovoltaics and many specialized uses are possible. When they become economically competitive with other alternatives, which is projected as happening some time in the 1990s and at least by the year 2000, as much as one-tenth of one percent of the electricity demand off Java could be supplied by photovoltaics. This 0.1 percent would be in areas off Java where decentralized diesel power is now located. One-tenth of one percent of the electricity demand would be approximately 300 Gwh in 2000. Using current efficiencies and an average solar radiation intensity of Indonesia (see rationale in Chapter III), approximately 0.3 kwh per day per square meter of panel is possible. This is 110 kwh per year per square meter of PV panel. To produce 3000 Gwh you would need 2.7 million square meters of PV panels. It is likely that some improvement in capture efficiency will also be experienced in PV before 1990 so this estimate is likely high. This power source, like wind electrification, duplicates installed capacity; it must serve either as a substitute for expensive installed capacity in a central grid or provide electricity to users who can deal with the possible variations in supply consistent with solar sources. As can be seen from the above assumption-laden PV use calculation, even one-tenth of one percent of the electricity demand for a part of Indonesia (the off-Java islands) will be difficult, if not impossible, to supply with PV by the year 2000.

SUMMARY

In summary, there is a very large number of applications where wind and solar resources and technologies can provide economically competitive alternatives to oil. However, in combination these applications will not diminish total oil use by even one percent before the year 2000. The largest impact

on oil use by 2000 can come in wind electrification; however, this is dependent on finding locations close to the grid which have excellent wind regimes and to a lesser extent on the development of a windmill manufacturing capability in Indonesia.

In terms of solar applications institutional, industrial and agricultural heating and hot water uses are large in terms of numbers, but not in terms of oil use. However, by 2000 up to 50 percent of institutional and industrial hot water use could be provided by solar technologies. Solar crop drying is also an area where solar assisted heating can be important.

The introduction of PV into Indonesia is dependent on reductions in cost and this is not under the control of Indonesian institutions. If costs are reduced to the levels predicted by US DOE ($0.50 per peak watt by 1990), PV could have a large impact on electricity delivery by 2000. This impact, however, is not expected to make the total solar electrification capability near one-tenth of the total electricity supply.

Possibly the regional area where solar and wind can have the most impact is on the off-Java islands. These islands will have rapidly expanding electricity demand, and the existing solar and wind data (though sketchy) seem to indicate that the islands are good locations for the technologies. Thus, if planners concentrate on these islands and other conditions mentioned earlier are met, solar and wind applications can have a substantial impact on these islands.

Figures III-1 and III-2 present a time-phased summary of predictions for solar and wind systems use in Indonesia. The items included in the figures represent conservative estimates of possibilities for the application of various systems and indicate the major barriers which must be overcome before solar and wind resources can begin to serve as energy sources in the Indonesian economy. The estimates developed in this chapter and summarized in the two figures should be considered as targets rather than predictions. If the government supports and encourages the use of solar and wind resources and technologies and if technology costs are lowered, it is very possible to achieve these use levels by the times indicated. However, without strong encouragement by the government the predicted levels will not be met. The government must lead in the use of solar and wind if it expects any significant substitution; and if the minimum steps and actions recommended in this report are not taken, it is almost certain that the predictions will turn out to be optimistic.

Figure III-1

A PROFILE OF WIND POWER DEVELOPMENT POTENTIAL FOR INDONESIA
EMPHASIZING PREDICTIONS OF TIMING FOR IMPORTANT EVENTS

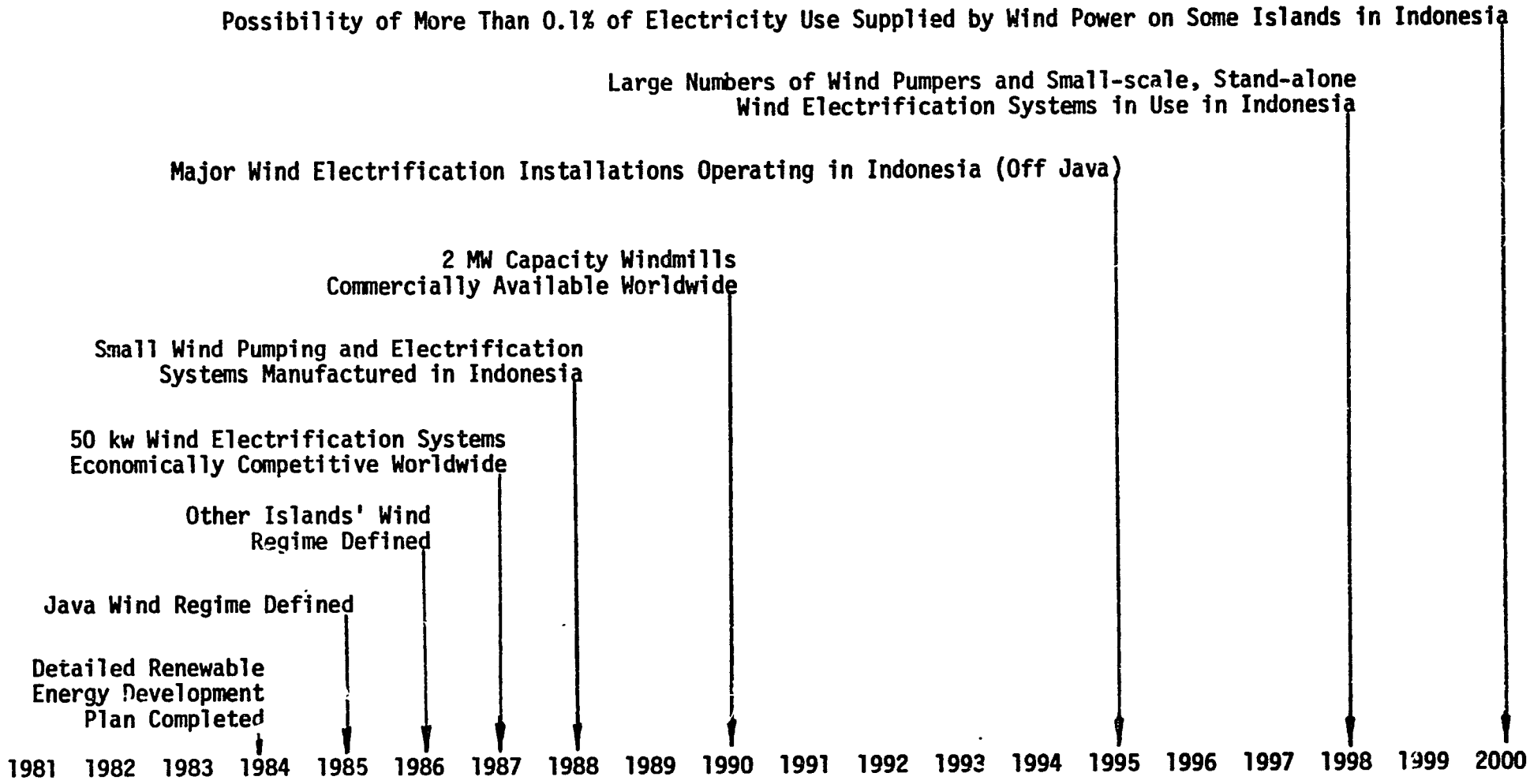
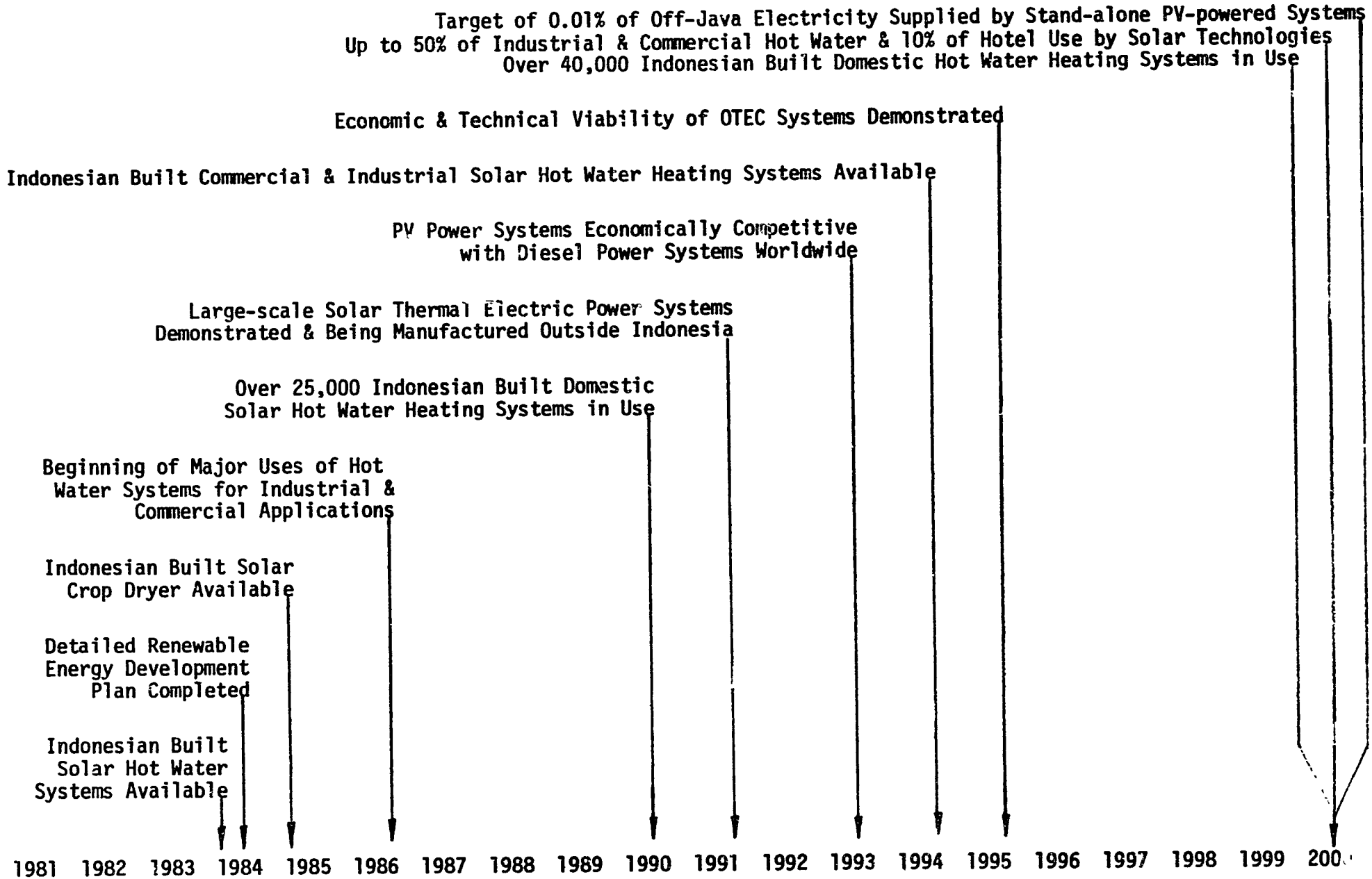


Figure III-2

A PROFILE OF SOLAR POWER DEVELOPMENT POTENTIAL FOR INDONESIA
EMPHASIZING PREDICTIONS OF TIMING FOR IMPORTANT EVENTS



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CHAPTER IV
BARRIERS TO FUTURE DEVELOPMENT AND USE

The barriers which can affect the employment of solar and wind power to the levels assumed in the previous chapter are for the most part under the control of Indonesian institutions. Most of these barriers are not unique to Indonesia, but exist everywhere in the world. The following list presents the barriers in general order of importance which will affect solar and wind resource development and use in Indonesia. These barriers apply equally to solar and wind, and thus wind and solar are discussed together.

The first set of barriers is those which Indonesian policy and actions can appreciably affect and the second set is those which are controlled by forces outside of Indonesia.

Indonesian-Specific Barriers

1. Lack of knowledge of opportunities and markets.
2. Little support or encouragement for applications.
3. Examples of technologies and uses are not widespread in Indonesia.
4. Infrastructure not in place to support applications.
   a. local manufacturing
   b. local suppliers or manufacturers representatives
   c. installation, operation and maintenance skills not available

Worldwide Barriers

1. Technologies not cost competitive with alternatives.
2. Systems not available which are tailored to developing country social, cultural and climatic situations.

Until more reliable information is available about solar radiation and wind velocity, especially in the off-Java islands, the use of these resources will be retarded. This is the most important barrier and the one which must be erased before there is any large amount of development or use of solar and wind. Once this part is accomplished, the using public must be educated to the existence of these resources and technologies.

The second most important barrier to future development is the lack of commitment to application of solar and wind technologies. The government is spending small amounts of money to collect data, study technologies and in general conduct research. However, there is no serious commitment to apply solar and wind even though the technology is available. At present, this hesitancy to finance or subsidize applications may seem realistic, but until there is a subsidy and some direct applications there will be little use of solar and wind. There are many opportunities to introduce solar hot water heating into the health sector, military installations, government buildings, university settings, etc.; however, these are not being done.

The third barrier is in part a duplication of the second and in part it is different. Until people see the technologies and know that they are available and can perform as well as fossil fuel powered alternatives, there will be an artificial limit on the use of solar and wind. The important part of this barrier which is not treated above is that there must be examples of uses in order to stimulate people to think about how solar and wind could be useful to them.

The final barrier in this list treats infrastructure and the private sector. There will be a limited market until there is a real supply of technologies and systems to install and maintain them. This usually follows a demand or is built up as a demand is being met. Whatever the catalyst or process of creation, an infrastructure or even the beginnings of one does not exist in Indonesia.

The list of barriers discussed above is both in order of importance and in order of how they must be addressed. Attention must be paid to barrier one, opportunities and markets, before applications of these are encouraged. Examples of technology application will grow out of emphasis on eliminating the first two barriers and only a limited amount of effort should be applied in anticipation of this happening by itself. The same is true of the fourth barrier.

Of the two barriers mostly outside the control of Indonesia, the first is being addressed by many interests. Private industry and developed country

governments are trying to lower costs for solar and wind technologies. With some of the technologies, specifically photovoltaics and concentrating solar thermal, a technology breakthrough is necessary. With others, such as wind electrification, economic competitiveness is more tied to mass production and an increase in demand. Overcoming this barrier will greatly enhance the opportunity for applications in Indonesia. The second barrier is not being addressed to any large extent by either the private sector or by the governments of developed countries. When economically competitive systems tailored to developing country needs are available, there will be a large market in Indonesia. However, this barrier may only be overcome at the time the first four Indonesian-specific barriers are eliminated.

CHAPTER V
CURRENT POLICIES AND PROJECTS

The current policies in Indonesia towards the use of solar and wind are principally focused on research and development. Furthermore, the Indonesian government is relying on and is actively encouraging the foreign financing of solar and wind R&D demonstrations. The United States, Austrailians, and Germans each have solar and wind activities with the Indonesian government. There is very little encouragement through other mechanisms. There are no incentives such as tax writeoffs, inexpensive loans, etc. to encourage use of solar and wind. Furthermore, the government does not have any program to stimulate the industry by direct purchase for governmental use.

There is a significant amount of R&D activity at universities, institutes and in the government. These projects are described in Appendix B in the interviews. The following list summarizes the major ongoing activities by resource:

WIND

- LAPAN data collection and development of a wind map for Java
- LAPAN and ITB joint research and development project to build and test a small wind electrification system
- Numerous windmill testing projects involving government agencies, universities and local entities

SOLAR

- BPPT's solar village project at Picon
- The BPPT and LEN project to produce PV modules
- The Puspiptek solar center development project with BPPT and LAPAN
- ITB research on solar thermal and PV and their solar measurement program
- PV testing by ITB and LMK
- Solar crop drying research at the University of Padjoran
- Numerous solar research projects at institutes, universities and government agencies

CHAPTER VI
RECOMMENDATIONS

Solar and wind resources in Indonesia have been determined to be possible energy sources for Indonesia. The ongoing R&D in solar and wind in Indonesia is as advanced as any developing country in the world. The knowledge of technologies and systems, especially in solar, is quite extensive. There is also a good start in training technical personnel in solar and wind subjects at universities and institutes. The foundation for a major program in solar and wind exists in Indonesia, however, there are several additional components which need to be added if solar and wind resources are to contribute to Indonesias' energy future. The following paragraphs identify the components of an overall program which must be instituted if solar and wind resources are to be developed to their maximum level. These recommendations are presented in three sections: The first section covers activities which must be initiated or completed before any significant development can take place; the second section covers those activities which should be considered following initiation or completion of the first group; and the third section covers actions which can have a positive impact on solar and wind resource use, but which should be considered only if cost of technologies are lowered to the point where solar and wind are competitive with other energy resources.

The first category of actions includes the development of an overall plan for solar and wind use emphasizing regions of the country and sectors of the economy, the completion of solar and wind resource definition, and a program to inform people where and how solar and wind can be useful sources of energy.

It is evident that solar and wind resources can supply a significant amount of energy in Indonesia. However, costs and the existing state of technology development indicate that this will not happen by the year 2000. Since the potential, especially for solar, is so great, it is important that a well thought out plan for developing and implementing solar and wind resources is prepared. Thus, the most important recommendation of this report is that DJK follow up this report with the following steps:

- An overall solar and wind development plan should be prepared. Presently, numerous agencies and entities are involved in the field and it is evident that often their activities are not coordinated or well publicized. DJK should work with the major entities; LAPAN, BPPT, LEN, universities, The Meteorological and Geophysical Institute, etc. to formulate a National Solar and Wind Energy Development Plan. This effort should focus on resource characterization, publicity and public information and application stimulation. The plan should also be prepared considering where other renewable resources including geothermal, microhydro and biomass can contribute. Solar and wind development should be targeted in those geographic and economic sectors where it is more appropriate than other renewables.

- As soon as a plan is prepared, the initial planning process should take no more than six months, a public and professional meeting should be held to introduce the plan and announce the state of solar and wind development in Indonesia. This meeting could be held in conjunction with an equipment and technology show. Manufacturers of solar and wind equipment could be invited to display their products. As an incentive, the government could encourage agency procurement agents and program managers to attend and consider the use of these systems to solve their problems. This may sound as though it is an unnecessary step, however, as was mentioned in the chapter on barriers, one of the most important impediments to use of solar and wind resources is the lack of examples of technologies. This meeting and equipment show could go a long way to overcome this barrier.

In this planning process, special emphasis should be placed on providing services and energy to the non-Java islands. It is already evident that both wind and solar technologies can improve productivity and the quality of life in non-urban areas and are especially appropriate in isolated areas. Because of this, the special and early emphasis on the other islands in Indonesia can lead to the largest benefit to the nation.

The second most important recommendation in this category is that 20 small meteorological stations be purchased and located in various places in Indonesia. At least 12 should be located outside Java. The stations should measure and continuously record at least total global solar radiation, temperature and wind velocity. The stations should be operated and maintained by the Meteorology and Geophysical Institute with assistance from DJK and LAPAN.

Additionally, at least 8 locations should include measurement and recording of diffuse solar radiation. In addition to the stations, a thorough training course in solar and wind measurement, instrument operations and care, data analysis, and wind and solar energy data use should be developed and given to selected personnel in the Meteorology and Geophysical Institute, DJK, BPPT, LAPAN and universities. The last part of this recommendation is the purchase of 5 sets of Epply pyranometers and 5 annamometers to be used by universities in supporting their solar and wind research and studies programs. One pyranometer of each set should be equipped to measure total radiation and the other to measure diffuse radiation. It is important that this program be coordinated with several other ongoing solar and wind measurement projects and that the Meteorology and Geophysical Institute be a principal partner of DJK in this activity. The output of this several year resource characterization will be surface solar and wind velocity maps for Indonesia. At least two years of data will be necessary to complete initial maps, however, following collection of one years data, comparisons with existing data can be made. This comparison can identify what part of the old data is accurate. Theoretical calculations can also be performed to convert existing secondary data to statistics on solar and wind resource quantity and quality. The existance of comprehensive and accurate solar and wind profiles of the country is an absolute necessity if wise resource development and use decisions are to be made.

The third recommendation in this category is that DJK establish a solar and wind research, study, demonstration and application information system. There are many people and institutions involved in solar and wind research, and one agency should monitor and collect information on all activities. DJK, as a planning agency, can serve as a central information center and can disseminate this information to others to assure that those people needing information can have the most current and complete solar and wind information from one source. This will also be very helpful to DJK in the planning and coordination role that it has adopted. The development of this system will at first involve one person and files. However, this should rapidly expand to include computer storage and printout of information. An initial investment of one person full time and one part-time secretary, plus funding for

the design study for the information system should be sufficient for the first year. During the second year, computer programming, storage and data entry will be required. An annual summary report should also be prepared; however, this report will only be useful if it is published in a timely manner of quarterly installments and assembled into one volume at the end of each year. This report should contain radiation and wind velocity maps; summaries of projects and studies; data on technology cost, performance, suppliers and maintenance; information from other countries; and other useful information on solar and wind. It is important to include data from all sources including universities and institutes, however, accuracy should be assured. For this reason, the person in charge of this activity should be very familiar with the solar and wind field. This effort should focus on keeping up to date on solar and wind developments and should form one component of a government backed information and publicity program.

The second category of recommendations includes those activities which are known in general to be necessary and desirable to advance the use of solar and wind, but which at the present time lack specific targets. As a result of the activities in the first category, targets will be identified and these second category actions can be implemented. This is particularly true if a solar and wind development plan is completed and when solar and wind resource maps are prepared.

The first major recommendation of the second category is that DJK concentrate on encouraging solar and wind research and technology demonstrations pertinent to commercial, industrial and institutional use. This activity should emphasize government use of technologies such as solar hot water heating. The military and ministry offices, schools, and health centers (without electricity) should be the first places to use solar and wind technologies. This program should also emphasize and support demonstrations of solar crop drying and cooling or refrigeration of vegetables. In this area, commercial size dryers and coolers should be constructed and demonstrated. Funds for testing of solar technologies useful in heating hot water for food processing and beverage production should also be included. This program should not replace the current government program emphasizing renewable energy applications in rural areas, it should be a companion effort. If

possible, the government should encourage industry to participate and share some of the costs in this effort. If government provides some incentives and shares some of the early costs with industry, commercial and industrial uses of solar and wind can be accelerated and substantial energy savings are possible through widespread use of existing technologies. The specific targets for this program will be identified in the development plan and as a result of the completion of resource maps.

The second major recommendation of this category is a subsidy or incentive program for the encouragement of renewable resource use. Solar, wind, microhydro, biomass, etc. should be considered and specific incentives and subsidy programs should be developed to encourage the introduction and use of these technologies. The programs developed under this activity should be long-term and directed at creating a healthy Indonesian renewable resource industry. Installation, maintenance, assembly and manufacturing of technologies should be emphasized. Government programs to assure that the potential of solar and wind use in Indonesia is recognized should be created. DJK should be responsible for proposing the programs, monitoring their impact and recommending changes and improvements.

The third category of activities will include government efforts to accelerate the development and impact of specific solar and wind technologies or applications. When targets and costs for each technology are known and as the solar and wind alternatives become cost competitive, the government will want to consider accelerating the use of these. This will be especially true if the social and environmental benefits of these technologies match government priorities. Resettlement, migration, rural development, and environmental protection programs often can be enhanced by including renewable resource development activities. The government will also want to consider the utility of actively participating in the development and possibly ownership of national industries such as PV and wind electric manufacturing. This is not a recommendation to participate through ownership, but a suggestion to consider the implications of such a role.

The government, through DJK, must immediately take a position of leadership in solar and wind resource development and use or progress will be very slow. This study has shown that solar and wind can contribute to the national energy future, but only in regionally and economic sector specific areas. The overall impact on energy supply will be small by 2000, even if the government does take the steps recommended here. However, because of the magnitude of the solar resource and its potential for use beyond the year 2000, the government must begin now to lead the economy. Much of what must be done is minimal in terms of cost and personnel application, however, the return on this investment can be substantial. A plan and a public and professional education program will begin this activity and should begin to create the interest and initiative necessary to reach the potential of solar and wind in Indonesia.

APPENDIX A

FREQUENTLY USED ABBREVIATIONS

ITB	Bandung Institute of Technology
DJK	Directorate General of Power
BPPT	Agency for Development & Application of Technology (Ministry of Research & Technology)

M/S = Meters/Second

KM/hr = Kilometers/Hour

Langley = 1 calorie/cm^2/day

GWH = 1,000,000,000 watt hours

MWH = 1,000,000 watt hours

APPENDIX B

AGENDA OF J. D. WESTFIELD
&
MEETING SUMMARIES

J. D. WESTFIELD DAILY SCHEDULE
ENERGY PLANNING FOR DEVELOPMENT PROJECT

12 September 1980
Left home at 5 p.m. and traveled to Hyannis for flight to New York via Boston. Flight to Jakarta from Kennedy left too early Saturday morning to allow Saturday morning departure from home or Boston. I therefore stayed one night in New York.

13 September 1980
Left Kennedy for Singapor and Jakarta. Stopped at San Francisco. Flew all day and all night.

14 September 1980
Flew to Hong Kong and stopped overnight in Singapor. I took a noon flight to Jakarta.

15 September 1980
Arrived in Jakarta at noon. I met with Bill Schaffer and Romir Chattergy in the afternoon.

16 September 1980
I visited the project office in the morning and met with my counterpart Mr. Suwardjaka and Mr. Darianto. In the afternoon we visited the Electrical Power Research Institute (LMK). We spoke to Mr. Hentiono Hendardji and the director of the Institute. We viewed their photovoltaic and wind electric power testing facilities. Following this we visited the University of Indonesia and Dr. Parangtopo of the Physics Department. Dr. Parangtopo discussed his solar data collection and analysis research. Other staff members and students participated in the discussion.

17 September 1980
Visited the Jakarta headquarters of the Meterological and Geophysical Institude, the Research Division. We spoke with Dr. Moersidi about meterological data and with Mr. Rodjali head of the Instrument Section. We also visited the meterological station on the roof of the observatory building. Following this we visited the Institute of Aeronautics and space (LAPAN) Mr. Darwin Sebayang to discuss wind research. Dr. Harijono Djojodihardjo was not there so little information was gained.

18 September 1980
Worked in the project office in the morning and took the train to Bandung in the afternoon. I traveled with Mr. Schaffer and Mr. Endro Utomo.

J. D. WESTFIELD DAILY SCHEDULE

19 September 1980
Met in the morning with Dr. Suoujono of the Mechanical Engineering Department of the Institute of Technology at Bandung (ITB). I also met with Dr. Sugiarmadji, Laboratory Director of the Aerodynamics and Hydrodynamics Laboratory. In the afternoon we traveled to Lembung to view a meterological station.

20 September 1980
We visited the Bandung Foundation for Research (LAPI) and Dr. Iskandar the Director in the morning. Following this we went to the ITB Engineering Physics Department and spoke with Dr. Prouptowipopo, Department Head and several staff. Later in the day we visited Dr. Nilyardi Kaher Assistant Director of the National Institute of Physics (LFN).

21 September 1980
We rented a car for the trip back to Jakarta.

22 September 1980
Worked in the office in the morning and met for several hours with Personnel from the Ministry of Research and Technology - The Agency for Development and Application of Technology (BPPT). Dr. Lolo Panggabean is in charge of most of the wind and solar projects.

23 September 1980
Met with Mr. Suryadi of DJK in the morning and in the afternoon I returned to BPPT to discuss their Solar Village project. I met with Dr. Panggabean and other staff. I also spoke with Mr. Iman Sudanwo and S. H. Nasutton who are involved with the project.

24 September 1980
Worked in the project office in the morning with the staff and in the afternoon I met with Mr. Littlewood of USAID, Science, Technology and Energy Department Head.

25 September 1980
Worked in the office on data analysis and meeting descriptions. In the afternoon worked on schedule for remainder of visit.

26 September 1980
Visited the Meterology and Geophysical Institute in an attempt to collect additional wind and solar data.

27 September 1980
Visited Mr. Susardjo in the library and Mr. Sutomo in the instrument section of Meterology and Geophysical Institute. I worked on data and translation of articles and reports in the afternoon.

J. D. WESTFIELD DAILY SCHEDULE

29 September 1980
Visited the BPPT Solar Village in Picon all day. I was accompanied by Mr. Schaffer and Mr. Littlewood of AID. Spoke to the BPPT Project Manager Mr. Chayun Budiono. In the afternoon met with Mr. Pratt and Dr. Calder of AID Public Health Division.

30 September 1980
Flew to Yogyakarta in the morning. In the morning we visited the Physics and Mechanical Engineering Departments of Padjadoran University. Met with Mr. Huryanto and Mr. Sukrisno. Also the assistant of Dr. Seno in Mechanical Engineering.

1 October 1980
Rented a car to travel to Semarang to meet with personnel from the Research and Development Center of the University of Diponegoro. I met with Dr. Soehardi, Director of the Center, and several staff members. We returned to Yogyakarta by car in the evening.

2 October 1980
Revisited the University of Padjoran to view solar and wind research projects. Spoke with Dr. Seno Sastroamidjojo's assistant. Returned to Jakarta by airplane in the evening.

3 October 1980
Rented a car early in the morning to travel to Bandung. Met at 10 a.m. with research personnel at ITB working on solar measurement. In the afternoon I met with personnel from Lembaga Elektrotekmica Nasional (LEN) the National Electronics Institute. We discussed their Photovoltaic Manufacturing Program with Ms. Ika Ismet.

4 October 1980
In the morning I spoke again to Dr. Suowono of ITB and also with the engineering students. In the afternoon took the train back to Jakarta.

5 October 1980
In the morning I met with Dr. Arismunindar of DJK and summarized findings to that time. Following made a similar presentation to Mr. Suryad. In the afternoon I met with Mr. Littlewood of AID. At this meeting a summary of findings and a discussion of other activities was to be accomplished.

7 October 1980
Traveled by air to Surabaya and met with personnel at the Technology Institute of Surabaya. We met with Abdul Salam Husin of the Physics Department, Mr. Hariono Sigit of the Architectual Engineering School and personnel of the Mechanical Engineering Department. Attempts were made to contact industrial representatives but this was not possible.

J. D. WESTFIELD DAILY SCHEDULE

8 October 1980

In the morning a meeting was held with Dr. Hurijono and Ir Wisnu of Lapan. Wind energy research was discussed. In the afternoon a presentation was made to engineering and science students about solar and wind measurement and technology. A summary discussion on my work was also held with Mr. Suryudi and Mr. Sucuardjaica. A draft summary of my recommendations was prepared and left with Mr. Suryadi.

9 October 1980

Left Jakarta to return home.

LEMBAGA MASALAH KETENAGAAN (LMK)

Electrical Power Research Institute in PLN, The State Electricity Enterprise

Ir. Sucipto Suwono
Ir. Hentiono Hendardji
Jl. Duren Tiga -- Kali Bata

September 16, 1980 -- 11:30 a.m.

with: Suwardjaka, DJK
Tjarinto, DJK

The office is in the south of Jakarta; it is dedicated to electrical power research.

They have purchased panels from Arco Solar, Phillips and Solarex to test their performance. Two panels are on the roof of a building (5 meters), one is horizontal and the other is tilted. The panels are connected to a recorder and then into batteries. There are some records of current produced on a daily basis but the measurement system is not continuous, calibrated or standardized. There is also no solar radiation measuring system. The batteries are manufactured especially for PV system (by Phillips). Several cells under glass and rubber/plastic are corroding. The panels have been in place for 2 to 3 months.

The purpose of the program is to compare panel performance of various manufacturers. They also hope to look at problems with storing electricity and with failure modes of systems. The emphasis is on examining power output characteristics of various panels.

There is also an Australian windmill rated a 2 kw. It is mounted 10 meters above the ground and connected to the same battery bank as the cells. There is a small wind velocity, direction, humidity and barometric pressure measuring station mounted on the tower. The velocity measuring instrument seemed to be in error. The windmill was turning when the instrument read only 0.8 to 1.2 M/S. The cut-in speed of the windmill is at least 3 mls. They are having trouble recording the output of windmill (recorder too sensitive). The windmill is also not ballanced (rotor is vibrating at low speeds). They estimated that average wind velocities are 3 to 9 mls. The windmill is located between two buildings and wind velocities are less in that location than in the open.

UNIVERSITAS INDONESIA - DEPARTEMEN FISIKA

University of Indonesia - Physics Department

Dr. Parangtopo - Graduate student working on solar data

Dr. A. Harsono

September 16, 1980 - 1:30 - 3:45PM

with - Suwardjaka DJK

- Tjarinto DJK

The physics department is undertaking a program to measure global solar radiation (total and diffuse). They wish to have good, reliable solar radiation data on which to base development decisions. They have a feeling that the published global radiation data may be insufficient and in error because instruments aren't calibrated frequently enough. There are no data on the amount of direct and diffuse radiation and there are not measurement stations in enough locations. Their program is to establish a measurement station on the roof of the physics building in Jakarta, using Japanese equipment of the pyranometer type (black and white). They will have one to measure total global radiation and one shaded to measure diffuse radiation. These will be connected to an integrating recorder and instantaneous and integrated data will be generated. This equipment will be installed in October or November of this year.

They have undertaken an analysis of the published data from Jakarta for recent years using existing theoretical equations to develop a relationship between diffuse and total global radiation. The theoretical calculations indicate that between February and October the diffuse radiation is 30-40% of the total and during October - January, it is as high as 60-70%. Since there is no actual data on diffuse radiation, this has not been confirmed.

DEPARTEMEN PERHUBUNGAN - PUSAT METEOROLOGI DAN GEOFISIKA

Research Division - Meteorological & Geophysical Institute, Ministry of Communication

Dr. Moersidi Soepawidjaja - Agricultural Climatologist
Mr. Rodjali - Head of Instrument Section

September 17, 1980 - 10:00 am

with: Suwardjaka, DJK

The meteorobgical institute collects data and publishes meteorológical statistics and performs special research studies pertaining to meteorology and data collection. They also have a section that provides help and advice to others. The data on solar radiation is taken routinely at 8 major stations*:

Station	City	Type of Instument
4	Jakarta	Eppley Pyranometer
201	Denpaser	Kipp and Zonen Solarmeter
219	Kupang	Eppley Pyranometer
116	Palembang	" "
145	Banjarmasin	" "
35	Semarang	" "
	Manado	" ") These are old stations not
	Lambang	Kipp and Zonen) currently in operation

In addition to data taken by this institute, the following institutions may also have information on solar and wind:

- National Physics Institute
- ITB (Technical Institute of Bandung)
- LAPAN (also wind) (Mr. Rodjali)
- Department of Agriculture (for wind also)
- Directorate General of Agricultural Plantations (wind)
- Public Works DPMA Bandung - Mr. Uson Lubix
- Central Agricultural Research Station Bandung - Mrs. Panacia

The institute maintains an instrument section which is responsible for the stations and instrument calibration. The institute has:

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* See ISSN: 0303 - 1969, Data iklim di Indonesia - 1977 for map and other meterological station data.
There is another publication with data: Pub. #34, Solar Radiation, Measurements in the Netherlands Indies by Prof. D. J. Boerema and Dr. H. P. Berlage, Jr., in 3 parts.

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DEPARTEMEN PERHUBUNGAN, September 17, 1980 - 10:00 am, Page 2

- 7 Kiddleton net radiometers	- 6 in stations 1 in the institute central building
- 2 Angstrom pyrheliometers	- 2 in the institute central building
- 4 Albedo meters	- 4 in several locations

The Angstrom pyrheliometers are used to standardize other instruments. They are sent to Australia every 3-5 years to be restandardized and are maintained in the observatory at Jakarta. The instruments in the various stations are not routinely calibrated. Every 5 years or sooner, if they are discovered to be broken or not functioning, they are serviced and recalibrated. A visit was made to the central observatory meteorological station in Jakarta. At this station on the roof of the institute building, there was an Eppley pyranometer, three Japanese instruments -- 2 were pyranometers and the 3rd was a 3-band wavelength instrument (3 separate receptors were exposed with each sensitive to different wavelengths).

The output of this instrument was being compared with one of the other Japanese pyranometers. There was also a Campbell-Stokes sunshine - indicating radiometer. The pyranometers were connected to recorders in a room on the top floor of the building.

There was also a cup anemometer and wind direction (wind vane) indicator. This was located on a tower approximately 5 meters above the roof. However, there is a building to the North, 15 meters from the tower at approximately the same elevation as the anemometer. Thus, the wind velocity measurement will not be accurate from this instrument.

The meteorological institute collects solar and surface wind data at a large number of stations and publishes annual and subject summaries. They do not issue analyses of the data, nor do they prepare transforms or specific studies for special users. In general, the meteorologists do not understand how the wind and solar radiation data is used to decide on energy matters.

L A P A N - LEMBAGA PENERBANGAN DAN ANTARIKSA NASIONAL

Indonesian National Institute of Aeronautics and Space

September 17, 1980

with: Ir. Darwin Sebayang, LAPAN
Mr. Suwardjaka, DJK
Mr. Tjarinto, DJK

The Ministry of Research and Technology has given wind research to LAPAN, especially large systems for electricity production. LAPAN also has worked closely with ITB and the Aerodynamics and Hydrodynamics laboratory (under the direction of Dr. Sugiarmadji). Prior to 1979, they also had the solar research and technology program; however, this is now handled by BPPT. The LAPAN wind program is managed by Dr. Harijono, who is also a professor at ITB. Dr. Harijono is now out of the country and will not return until the first part of October. He has material on the LAPAN program and on a preliminary wind data analysis, but this is available only if I can meet with him. Several papers were delivered by LAPAN at a May 1980 symposium and workshop on solar and wind use in Indonesia. These papers contained data and program information; however, they have no copies.

LAPAN has found that for several areas in Indonesia, especially on the coast of Java, wind electrification is possible. Two major demonstrations of a combination of Savonius and Darrieus rotors are underway in Java. These are between 2 and 5 kw machines. Both are now not operating because of accidents. A prototype is also operating at ITB. LAPAN has also just completed a study of past uses of wind in Jakarta. In the 1970's, the Australians gave several water pumping windmills to the Indonesian Government. These were installed in several neighborhoods to supply water. None of the windmills now work. There is also a report entitled Development of Wind Energy Application, May 1980. This paper covers a project involving a Mr. Freim of Germany, Mr. Piepers of Holland, and LAPAN personnel. LAPAN has a two-year project to measure wind velocity in the country. They are developing a surface wind map and in approximately two months this will be completed.

A more thorough discussion of LAPAN work and programs in wind must wait until Dr. Harijono returns.

INSTITUT TEKNOLOGI BANDUNG (ITB)

Bandung Institute of Technology

Dr. Aryadi Suwono - LDKESPP, Departemen Mesin (Mechanical Engineering)
Ir. Nurwatti - Engineering Science Department
Dr. Taftazani - Engineering Science Department

September 19, 1980 - 8:30 am

with: W. Schaffer, DSI

The university works closely with other institutes and ministries in solar and wind energy research. The Department has a number of studies underway on solar technologies and a number of prototypes. They have developed a 10 M^2 Flat plate thermosphon hotwater system. This has been installed in health clinics. One is now operating in Rajawali and there are several others. The system was designed, built and tested at ITB with funding help from the United Nations Energy Project (UNEP). They also have a concentrating hot water system design for pasturization and sterilization using mirrors and a flat plate collector system. There are several models of ammonia ice and refrigeration systems and some solar crop dryers for rice. They have a silica gel experiment (refrigeration and a solar thermal (Freon) pump). ITB has a series of publications on technologies they have developed. These guidebooks from the Center for Technology Development describe how to build and operate each technology and are available to anyone for the cost of publishing. This has not yet been done for solar technologies but one is underway for the solar hot water heater.

ITB is also testing photovoltaic panels. They have several ARCO Solar modules and are testing the output. In less than 1 year the collection efficiency has gone from 6% to 4% or it has decreased by 38%. They believe that this is due to corrosion of cells. Corrosion is evident in many cells (sides and along junctions).

ITB is collecting data on direct and diffuse radiation. Mr. Saut, from the Department of Geophysics and Meteorology, has been taking data at ITB for two years. They are also measuring horizontal and titled total radiations with various pyranometers. They have one pyranometer for total global radiation and one for diffuse (a shading bar is used) radiation. The technologies are built and tested by senior students and used as part of one class. ITB also works closely with LAPI. ITB is very interested in the engineering, economic and social aspects of technologies and their studies emphasize collection of data on all three areas.

ITB AERODYNAMICS AND HYDRODYNAMICS LABORATORY

Dr. Sugiarmadji - Laboratory Director

September 19, 1980 - 11:00 am

with: W. Schaffer, DSI

The laboratory program emphasizes education and research. They work closely with LAPAN because the program director is Dr. Harijono, who is also in charge of the wind program of LAPAN. The university has a combination savonius - darrieus wind electricity system. The prototype produces 1870 watts at peak speeds, has a cut in speed of 6 meters/second and operates at 98 rpm. It is on a bamboo and steel tower and was designed and fabricated (including the generator) at ITB. Slightly larger models of this are located in Rumping and Cilant/Eiereum (LAPAN project). At the university, there is also a smaller savonius machine and a three bladed electricity producing machine. All of the above were built at the university.

The director believes that there is sufficient reason to expect wind electrification to be applicable in several places in Indonesia. It is, therefore, time to begin to demonstrate technologies and have applications of wind energy for electrification. They are hoping to work with Holland and Germany in this area.

In 1970, the Australian Government gave 12 multivane windmills to Indonesian Government for water pumping use in Jakarta. Many factors, including previous water sellers damaging these so they could get their business back, have created a situation where not one windmill works.

The university sponsors a Technology consortium yearly to get university and industry together to discuss problems and needs. Many people who teach also consult to and work for industry; thus, research and study findings can get transferred to industry and implemented. LAPI also works on technology transfer.

L A P I - FOUNDATION FOR RESEARCH AND INDUSTRIAL AFFILIATION AT BANDUNG

Dr. Kskandar Danusugondho - Director
Dr. Aman Mustovan - Research Associate

September 20, 1980 - 8:00 am

with: W. Schaffer, DSI
Endro Utoma, DJK

LAPI has many interests in solar and wind technologies and uses. They are looking for village applications for solar water heaters and wind pumping. They are working with government agencies involved with Population and Transmigration issues to identify needs. They do not believe there are many sites where wind electrification is feasible, but solar hot water heaters can be applied in many places. They mentioned that several people in Indonesia are considering the manufacture of solar thermal flat plate collectors and that an Australian firm was looking for dealers of their FP collector system. LAPI has funded many of ITB's technology projects.

ITB -- Departemen Fisika Teknik
Engineering Physics Department

Dr. Prapto Widodo, Department Head
Dr. Aman Mostofan, Research Associate
Dr. Taftazani, Professor
Ms. Nurwati, M.Sc., Professor

September 20, 1980 -- 9:00 a.m.

with: W. Schaffer, DSI
Endro Utomo, DJK

Their program involves instruction in solar and wind for use in building design. Passive solar, lighting, heating, etc., are covered. They have also had many senior projects on solar and wind. Many of the studies have involved data analysis for solar and wind, and some have been funded by LAPI. They are interested in studying the application of solar and wind technologies for villages. For example, the use of photovoltaics for battery charging is being studied. They work closely with the Mechanical Engineering Department and with the Aerodynamics and Hydrodynamics Laboratory. They gave us a publication showing all their thesis work in solar with a short summary of each project.

LIPI - LEMBAGA ILMU PENGETAHUAN INDONESIA

LFN - LEMBAGA FISIKA NASIONAL

National Institute of Physics

Dr. Nilyardi Kahar - Assistant Director

September 20, 1980 - 10:00 am

with - Endrò Utomo DJK

- Aman Mostovan LFN

- W. Schaffer DSI

LFN is just starting in the energy area, having only been involved for one year. Their main function is research and development of appropriate technology. They are looking at solar and wind applications appropriate for rural villages. They have studied water and energy supply systems and have recently built a savonius rotor windmill for pumping water near Bandung. The system pumps water against a 13 meter head. They are studying community energy needs and are planning a study into energy use patterns in small villages. They have an energy proposal under consideration by LIPI. This will be a small pilot project to supply energy to a village with renewable technologies and if successful, it will be expanded to include more villages. In addition to studies, they are maintaining contact with other people and institutions working on energy problems. They want to be a coordinating and information transfer group as well as one which conducts research and studies. They believe that with over 60,000 villages in Indonesia, there is a need for many groups and a wide range of activities in the renewable energy field.

BPPT - BADAN PENELITIAN DAN PEMBANGUNAN TEKNOLOGI

Agency for Development and Application of Technology
in the Ministry of Research and Technology

Dr. Lolo Panggabean

September 22, 1980 - 9:00 am

September 23, 1980 - 1:30 pm

with - Suwardjaka DJK

- Supriyo DJK

There are several solar and wind activities underway in BPPT. The financing for these activities comes from USAID, The Republic of Germany and the Indonesian Government. The projects are briefly described in the following paragraphs:

- They have an ongoing research program to manufacture photovoltaic cells starting with silicon waters purchased from the U.S. They have manufactured cells (in the laboratory) with 4-5% capture efficiency. They intend to continue this research at the National Electronics Laboratory (LAPI) in Bandung until they receive their own equipment.

- They have had a study of the feasibility of building a major energy laboratory at PUSPIPTEK. The study was financed by AID and the study team included Professor Adams from Argonne National Labs; S. Ergun from Berkeley; R. Beck from DOE in California; Dr. Miller from MIT; and George Warfield from SERI. Their report has been finalized and delivered to AID and BPPT. The center will include experimentation, testing, standards development and training, emphasis will be placed on coal, biomass and direct solar conversion. It is hoped that the center will be built before 1985. In the center, there will be an energy planning and analysis group, a pilot plant development group, and an energy industry group. A Mr. Wardiman of BPPT is involved in the energy industry group.

- A project titled Development and Utilization of Renewable Energy Technologies and Resources, having four parts, is underway. One part involves a solar village, the second involves the use of agricultural products for energy, the third covers the production of methanol from agricultural residues and the fourth is the development of an energy model for the country. The first activity is under the direction of Iman Sudanwo and Mr. S.H. Nasution of BPPT and is a joint effort with the German government.

There will actually be two villages for the solar work. The first is now equipped and has been producing electricity from photovoltaics for one year. It is located at Picon, near Jakarta and involves agricultural irrigation and water supply. At present, there is 5.5 peak kw a photovoltaic avray

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for the pumping and only a small amount of battery storage. In July 1980, a wood pyrolysis unit was installed. This will produce 22 kw and will later be converted to use rice hulls. The second village, Citvis, will be started later. This village project will emphasize fish processing and have a $5m^3$/day, 3 phase reverse osmosis photovoltaic powered desalinization unit and ice making. The photovoltaic powered ice making initially will be commercial compression technology, but they hope later to switch to common absorption. There will also be a scientific and solar technology transfer program to encourage more village applications. This solar village program involves a joint cooperation between the Ministry of Research and Technology of Germany and Indonesia. The estimated cost of the PV power system (panels, controls, and storage) is approximately $15 per watt peak. The Indonesian government has over 30 people working full time on the project.

The second project of the program is just beginning and includes the growth of lucina for combustion as well as the use of leaves for cattle feed. This study is being done by BPPT in Bogor in cooperation with the Australian government. The third project, ethanol from agricultural products, was not discussed. The development of an energy model is being funded at this time by the Indonesian Government (BPPT) and involves advice from Bechtel. At the present time, they are considering various types of models to adopt.

Dr. Panggabean is managing a project funded by AID looking for opportunities and needs for electricity production in villages. There are at least 12 Indonesian engineers and a permanent resident consultant, Mr. Rubin Hardy, working full time. There have also been several consultants from the U.S. The survey was organized around several assumptions and criteria; these are listed below with preliminary findings. The study was designed to locate areas where wind and small hydro could supply existing electricity needs.

a) The survey was organized to look at two areas of Java identified as having at least 6M/sec. wind 50 percent of the time. These areas were identified using data from a paper authored by Dr. Haryono Djojodihardjo (LAN) entitled ASPEK TEKNO-EKONOMI DARI PEMANFAATAN ENERGI ANGIN DI INDONESIA. The location of areas to survey was further defined by selecting areas where there was dispersed population.

b) The teams visited one area in central Java on the south coast and in east Java in an area of high elevation.

c) The teams looked for dispersed population - less than 20 households. It was felt that with this number or fewer people, 500 watts of electricity or less would be sufficient for battery recharging and other small energy demands. The team also looked for water availability and rice or other agricultural activity. At the places where they found all three conditions, they looked for wind or small hydro possibilities.

d) The 500 watt figure was based on an assumption that a 500 watt windmill could be built wholly from skills and material available in Indonesia. If demand was higher and a larger windmill was required, the project team felt that it would not be possible to wholly produce this in Indonesia.

e) If they found an area which had people, water, and agricultural activity, they had a simple device to leave at the site for one month to measure the time that winds were equal or greater than 6M/sec. In over 200 sites that they found people, they only found five sites with water and agricultural activities. At these sites there was only 15 minutes or less of wind over 6M/sec. during the time measured. (Mid August to mid-September, 1980).

f) They are going to look at other areas in Java later in September and early October.

g) They did find a large number of people using 6 and 12 volt car and motorcycle batteries for TV and cassette players. Radios were run by dry cells. The 6 and 12 volt batteries were recharged 3-4 times per week. Many people also had small hydro or diesel generators to charge batteries.

h) They did not look for wind pumping opportunities or for wind less than 6M/sec. or for wind data. Their principal interest was to find a situation where wind could be used if other criteria were met.

I) Some of their preliminary findings are that where wind velocity is 6M/s or more, the elevation is high and thus, groundwater is deep. The people they spoke to indicated that the wind is variable with long periods of no wind and frequent high winds. Wherever they found water and agricultural opportunities there were many people, thus 500 watts would not be sufficient to meet electrical needs.

At the second meeting, a discussion of wind and solar technologies was held and I showed a number of slides of various technologies and applications. The reports and information I had from the U.S. were reviewed and they asked Mr. Suwardjaka for copies.

DISCUSSION WITH MR. SURYADI AT HIS OFFICE AT DJK (DIRECTORATE GENERAL FOR POWER)

September 23, 1980 - 9:00 am

with: W. Schaffer, DSI

He has asked people at ITB to begin to study and develop criteria for applying photovoltaics in Indonesia. They should consider the solar regime, the uses, the costs and alternative power sources. Some type of procedure for selecting sites and types of applications should be developed. He also indicated that people in the Ministry of Transportation or in the Railroad Agency (AEG) will also know about solar uses. A trip to Yogyakarta, Solo and Semarang would be helpful. In Yogya we should see a Mr. Seno of GAMA, in Semarang we should see UNDIP (Diponegoro University). I discussed a return trip to Bandung to collect global and diffuse radiation data from Mr. Saut of G & M a Department of ITB and to visit L E N. I will speak to Mr. Suwardjaka and Dr. Suwono of ITB to schedule a return trip. Mr. Surjadi will be at an energy conference in Bali from today through the 30th. He also plans to go to a UN sponsored (ESCAP) conference in Bangkok, Thailand, in November (28 November - 5 December 1980). The conference will cover Solar Technology and have country reports and solar technology displays. Mr. Suryadi also suggested that I contact Dr. Parangtopo at the University of Indonesia and other universities and arrange for a talk to faculty and students on the prospects of using solar energy in tropical countries. Either Saturday from 11 am - 1 pm or Thursday from 2 - 4 pm would be a good time for this.

RESEARCH DIVISION - METEOROLOGICAL AND GEOPHYSICAL INSTITUTE MINISTRY OF COMMUNICATIONS

Mr. Susardjo, Library
Mr. Sutomo, Instrument Section

September 27, 1980

with: Suwardjaka, DJK

The library has both reference books and copies of data. The data held in the library on solar global radiation and hours of sunlight is not different than held by DJK. I was able to purchase a copy of publication 43, which contains global radiation data for Jakarta taken between 1917 and 1925. I asked about instruction books, etc covering operation of meteorological stations, but there were none.

I asked the instrument people about the 8-hour measurement period on the Campbell-Stokes radiometer. I know that there is more than 8 hours of sunlight, but want to know why only 8 hours are reported. I could not find out, but will try again next week. Mr. Sutomo said that the C-S radiometer is not calibrated in country and confirmed the schedule and process for calibration of other instruments mentioned in an earlier visit. I accidentally noticed an ongoing research project where five Phillips PBX-47A photovoltare modules were being tested/calibrated. The Kimball-Hobbs pyranometer was used as a standard and every ½ hour, current measurements were being made on the modules. Each module was inclined at a different angle between horizontal and $\approx 20^{o}$. There was a theadolite to measure the solar angle. The research was being done for Dr. H.W. Iratmodjo, and a student, Aqus Selim Danski, at the physics college of in Bandung. The experiment will go on from 4 September through 3 October 1980. Mr. Sutomo said that they will begin to measure diffuse radiation in 1981.

SOLAR VILLAGE AT PICON

Chayun Bjdiono BPPT Project Manager

September 29, 1980

with: W. Littlewood, AID
W. Schaffer, DSI
Suwardjaka, DJK
Tjarinto, DJK

Under an agreement between the German Federal Ministry for Research and Technology and the Indonesian Ministry for Research and Technology, a 5-year joint solar village project has been planned and implemented. The project site is PICON, a village of approximately 75 houses in the Serang Regency of West Java (approximately 75 kilometers west of Jakarta). The purpose of the project is to test various solar and biomass energy conversion systems in a rural agricultural setting to demonstrate their utility is supplying energy for daily needs. The project was initiated through a joint agreement in February of 1979; the first technology, a wood pyrolysis unit and a biomass digester have also been added. The village power systems include:

- The village has a 5.5 peak kilowatt capacity array of both mono and polly crystaline photovoltaic cells manufactured by AEG telefunken. There are 9 arrays of 1.2 and 4.8 meters or approximately 52 M^2 of Array. The panels are TSG-P-36/0 Telefunken models. The system also includes 420 amp hours of "Varta" lead-cadmium storage batteries (30 cells). The system produces alternating current of 22 volts and 50 HZ to power a $30M^3$/hr irrigation pump. The pump is located approximately 400 meters from the array and delivers water to 72 hectares of rice. The rice fields are owned by approximately 75 different people. The system has operated for approximately one year without major problems. At present, it is being operated and maintained entirely by personnel from the Agency for the Development and Application of Technology (BPPT). There is now no charge for the water and any distribution disagreements or water use problems are handled by the village. The village center is located adjacent to the array and has a separate PV powered television (with lead-acid storage battery) in the village center. They have no solar radiation measuring instruments and rely on data from Jakarta. A solar measuring laboratory is planned sometime in the future. They also plan to turn over operation and maintenance to villagers in year 3 or 4 of the project. The PV power system at maximum solar radiation produces approximately 4 kilowatts. BPPT personnel believe that this is because solar radiation at PICON is less than they had expected and is also less than in Jakarta.

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- In addition to the PV power system, there is a pyrolytic converter manufactured in Germany. The system produces a gas which is burnt to produce electricity to power a 180 M^3/hr irrigation and water supply pump. The system has just been installed and has been in operation for less than two months. It uses 15 Kg/wood per cycle of 1 hour or ≈ 60 kg of wood for a 4-hour run. The wood costs 6,000 rapias per M^3. This system will also be used to supply approximately 100 watts/household to each village home for several hours each night sometime in the future.

- A third system is a small underground bio digester adjacent to the solar panels. This system has just been installed and is not yet operating. The digester will be charged with vegetable wastes, cattle waste and other agricultural waste. They hope to use the methane gas to produce electricity and use the digester pumpings for fertilizer. This digester is a pilot model and will only be used for study. A larger digester will be installed later if the project is successful.

The total project is very simple and except for a large 30 meter tall steel tower for radio communication with Jakarta, it is almost not noticeable. There are several control buildings with space for future laboratory and research work but the entire project area is fenced and located on approximately .5 hectares. The one serious problem I see with the project is that solar radiation has not been measured and record keeping has been minimal.

AID PUBLIC HEALTH - UNITED STATES EMBASSY

Mr. Pratt - Director
Mr. Stodsimsky - Assistant Director
Dr. David Calder - Manager for the AID-CDC Cold Chain Immunization Project

September 29, 1980

AID with the U.S. Communicable Disease Center of Atlanta has an expanded program in improving the Immunization Services in Indonesia. They are studying ways to improve the "cold chain" allowing longer useful lives for vaccinations and medicines in hospitals and health centers. They have been approached by U.S. NASA and CDC and asked to consider the utility of testing a photovoltaics powered refrigerator.

There are approximately 45,000 Public Health Centers in Indonesia, some have electricity and power but most do not. Each of these serve 30,000 to 40,000 people. These serve 4 - 5 satellite and small centers. The centers have vaccines and they are suppose to have a full-time doctor. At present where refrigeration is provided, it is by electrolux kerosine refrigerators. The problems with these include:

- Combustion systems which foul,
- Spare parts are difficult to get,
- They do not freeze well.

There is also some interest in solar hot water and sterilization. Those should be developed by further discussions between Indonesian personnel.

PADJADARAN UNIVERSITY, YOGYAKARTA

Mechanical Engineering Department

Mr. Haryanto, Lecturer
Mr. Sukrisno, Lecturer

September 30, 1980 -- 10:00 a.m.

with: Suwardjaka, DJK

Their program is very new and emphasizes the production of mechanical energy. They have performed some solar energy measurements; however, their data are only for short periods of time. They have Japanese "EKO" total radiation pyranometers and digital integrators. They can also measure direct radiation. They have done some work with a concentrator to produce hot water that they built, but this was with students and it is used as a teaching device. Some students under their direction built a windmill to pump sea water for a salt drying project. This project was south of Yogyakarta on the shore. It was a multibladed windmill. They have problems with the pump in-take due to tidal fluctuations and with pump corrosion. They have only a hand-held annometer to measure wind velocity.

Their mechanical engineering lab is very complete and they have a thermal refrigeration system as well as several heating systems, and other test equipment. They have 240 students in the Mechanical Engineering Department, and graduated 19 last year. They need training in solar and wind, and library and textbooks. They also need examples of solar and wind devices. They hope to do more experimentation and to get more students. They work with Mr. Seno in Physics, but his program is older and larger. They have done little data analysis and know very little about the state-of-the-art in solar and wind. They are interested, and hope to get help and training so they can develop their program.

UNIVERSITAS DIPONEGORO SEMARANG
Pusat Risei. Dan Pengembangan (PRP)
Research and Development Center - SEMARANG

Dr. Soehardi, Director of the Institute
Dr. Fx Sublaganto. In Charge of Solar Projects
Mr. Mundaris, Responsible for Solar-Photovoltaics
Several other institute members

October 1, 1980 - 10:00 am

with: Suwardjaka

The institute has a variety of programs and is like LAPI at Bandung. Their programs include:

1. Coordination of University research activities
2. Training
3. Handling interdisciplinary R&D activities
   a. Population Studies
   b. Environmental Studies
   c. Marine Resources Research
   d. Regional Development Studies
4. Extension services to rural areas
   a. Services of students to help rural people - advise
   b. Center for Appropriate Technology
      (1) Solar
      (2) Biomass
   c. Center for Regional Development

The solar program is reasonably new. It started in 1978. A shortage of wood in the country and in their area lead to their interest in alternative fuels and technologies. They started out with a system to produce hot or boiling water for cooking rice. They started in the laboratory to develop and test various types of solar hot water heaters. They went to more and more efficient devices. They have several examples of technology. They have progressed to a solar refrigerator for ice making using ammonia. Once these are tested under laboratory conditions, they will go to field testing. They have also developed a very simple photovoltaic system using transistors. These are expensive -- 700 rupia per transistor; $\approx$ 10 to run a calculator; and 300 to run a clock. They get $\approx$ 300 millivolts/transistor in strong sunlight. They need funding, contacts with other people, training and instruments to measure solar radiation. They could use the loan of a person to help in their program or grant money to finance field testing. They hope to start a wind project also. They have a pump (mechanical) made from Bamboo. They feel it will cost 2,000 rupias to build in mass production, assuming one man can build 2 per day.

UNIVERSITAS PADJADARAN - MECHANICAL ENGINEERING DEPARTMENT

Assistant to Dr. Seno Sastroamidjojo

October 2, 1980 10:00 P.M.

with: Suwardjaka, DJK

The University is carrying out several solar projects. These include several types of concentrating dish and parobolic collectors and a major solar crop drying demonstration. The solar crop dryer is being used to dry cocoa from a plantation in the Surabaya area. The dryer is on the university grounds, it will handle one ton of cocoa and uses some electricity for the blower (0.8 kw motor). The department does not have instrumentation to measure solar radiation, they are on order. They are building a dryer at the plantation (PTP) in Surabaya. This is being done by Bavata an Indonesian Steel Company with Dr. Seno serving us an advisor. If this is successful, others may be built and marketed. Many plantations and growers of coffee, tea, cocoa, rice and corn use oil heat to dry crops.

The dish concentrator was used in research to produce N_2 and H_2 gas from NH_3 at approximately 3000°C for heat storage. It was built in conjunction with people from the Australian National University (ANU). It is undergoing a testing program.

Dr. Seno is also involved in research on Biomass to create alcohol or benzone from different feed stocks. Wind studies are being conducted with ITS in Surabaya. This is just beginning and Dr. Seno is acting as an advisor.

TECHNOLOGY INSTITUTE OF BANDUNG - MECHANICAL ENGINEERING DEPARTMENT

Dr. Aryadi Suwono and ITB Engineering Students

October 3, 1980 10:00 A.M. and October 4, 1980 9:00 A.M.

with: Suwardjaka, DJK

The initial meeting was dedicated to discussing the findings of the project so far and on future needs. I was starting to summarize my impressions for people to see their response and to confirm or correct my recommendations. Dr. Suwono indicated that he had seen data from the Ministry of Agriculture that showed a spoilage rate of over 40% of vegetables between harvesting and marketing. Almost 30% of the spoilage took place during transportation and storage. Thus both solar drying and cooling could be important technologies if they were reliable, available and economical. He also felt that the current emphasis of the government on solar and wind for rural applications might not be too successful. There were many needs and opportunities, however, the people could not afford to buy and the government wasn't spending enough to encourage the manufacture and supply of solar and wind devices. He felt that a large percentage of the population and some of the commercial and industrial activity was still decentralized in Indonesia and thus small scale solar and wind technologies could contribute to solving problems.

There also seems to be a problem at the government level. Nowhere in ITB is solar or wind used although the Mechanical Engineering, Physics and Hydrodynamics and Aerodynamics Laboratory have developed several prototypes which could be duplicated and used. This is true in other government areas; i.e., the military won't as yet buy solar or wind technology, agriculture is increasing production not energy conservation and the urban population emphasis is transmigration. In 1972 ITB personnel produced a paper on rice drying and the use of solar powered dryers. This was widely distributed and discovered but the government has not yet invested in this.

Dr. Suwono felt that the following technologies and activities were important:

- Wind pumping for salt production on the coast.
- A collector capable of extended (several hours) temperature of over 70°C for refrigeration with ammonia.
- Solar thermal pumping.

Dr. Suwono also said that in Lembang there is a rice dryer which is a hybrid technology, oil heating with a solar assist. It was built by students on a rice plantation but because of cloudiness and humidity in the area, the solar assist does not function well.

TECHNOLOGY INSTITUTE OF BANDUNG - MECHANICAL ENGINEERING DEPARTMENT
October 3, 1980 and October 4, 1980. Page 2

Data that has been developed on diffuse and total global radiation in Bandung for several months in 1980 shows that in March the diffuse was approximately 30% of the total and in April it was over 40%. The program and instrumentation is excellent and valuable information should result from this effort.

The solar map prepared for Java (see Reference 8) was developed using global solar radiation from Jalcarta and Bandung. Separate equations relating total global radiation and hours of sunlight was developed with the Jalcarta equation being assumed valid for all places below 100 meters in elevation and the Bandung equation was used for all places above 100 meters. Then hours of sunlight data which exist (or many stations in Java were used in the same equations to calculate total global radiation for the various stations. Following this 180 intensity lines were drawn thru points to produce the seasonal and yearly average maps. There is a need to complete a map for all of Indonesia but both solar radiation measuring equipment and support for data collection is necessary.

A MS Thesis done in the Philippines by a former ITB student discusses "The Feasibility of Manufacturing and Marketing Solar Hot Water Heaters in Indonesia". The thesis was done in 1978 by Eugenio Lopez Foundation at the Asian Institute of Management. The thesis contained cost data on imported hot water heater. In 1975 there were 3366 electric hot water heating systems imported into Java. In 1976 there were 8849 imports. In 1975 the rupia cost for a home gas fired heater was $98,000 and it cost $240,000 rupia for an imported electric hot water heater. The exchange rate at that time was approximately $1 U.S. for $15 rupia. Today the exchange rate is $1 U.S. for 625 rupia. The thesis presented a detailed economic analysis of a solar hot water heating business. The emphasis was on manufacturing panels and fabricating open hot water systems in Indonesia. The analysis was very favorable to starting a business however no one yet has done this. Dr. Suwono indicated that there was over 100mz of panels for hot water heating now in place in Surabaya.

LEMBAGA ELEKTROTEKNIKA NASIONAL (LEN) IN BANDUNG
(A Part of the Ministry of Research and Technology)

Ms. Ika Ismet

October 3, 1980 1:45 P.M.

with: Suwardjaka, DJK

LEN is involved in electronics research. They are sponsoring and conducting research on semi-conductor manufacturing. At this time they are emphasizing diod manufacture. They hope to establish the foundation for an electronics industry in Indonesia. This has let them to start other semi-conductor research projects. Currently they also have projects covering transistors and silicon based photovoltaics. In their PV research they have purchased or fabricated the equipment necessary to start with silicon wafers purchased from Monsanto in the United States and produce single PV calls. They have made several cells but most of their effort has been directed to investigating various steps in the manufacturing process. They have just purchased many new Japanese and United States instruments and processes to replace their old models. They will shortly have a complete and modern system in their laboratory to perform research on all the steps in the manufacture of silicon PV cells. They lack trained personnel to conduct this research as at this time Ms. Ismet is the only full time researcher involved in the project. They hope to work with BPPT and others to advance their research.

(Following this visit I discovered that the Puspitek Laboratory Project funded by AID included the purchase of a similar PV research setup. I discovered that the BPPT PV cell I had seen earlier had been made using LENs equipment. I also believe that BPPT knowingly plans to duplicate this capacity at the Puspitek Laboratory.)

INSTITUTE TECHNOLOGY SURABAYA (ITS)

Physics Department

October 7, 1980 - 9:00 A.M.

with: Suwardjaka, DJK
Aboul Salom Husian

Many projects have been undertaken but they are not a part of a master research program. Since April, 1978, studies have been ongoing. They have only measured solar radiation over short periods of time and only total radiation. They have also looked at Savonious rotors. In total they have had 8 principal solar and wind student projects since 1978. They do not have budgets especially for solar or wind. Sometimes the students have to pay for the equipment to do the research and thus the projects are small. They want to make a concentrator for producing steam but they do not have funds as yet. They have made a prototype of a cabinet natural convection hot air dryer with a collector and drawers. It is to be used for rice and other crops. The parobolic collector will be used to produce 150°c to be used to salt out crystals from a solution. This is a joint study with the Chemistry Department. Through chemistry they hope to go further and commercialize this process. Some industries have contracted money to research projects in hope of developing equipment. So far this has not been successful because the prototypes need much more development and the industries do not have people to continue this work. Now three faculty are studying abroad to get masters and PhD's in solar. One is in Australia and two are in the United States.

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INSTITUTE TECHNOLOGI SURABAYA ITS

Ingr. Hariono Sigit - Arsitek (architect)

October 7, 1980 - 10:30 A.M.

with: Suwardjaka, DJK

This is one of the principal architectural schools in the country. There are 40-50 graduates each year. They have been involved in solar and wind projects but there is no formal course or any laboratories. The projects have been student research projects. For example, several students and Ing. Sigit built a prototype solar hot water heater in Compong improvement village near Surabaya. It was done on a very small budget and does not work now (it was not maintained). A new enlarged school campus is being built using architects from Singapore. The financing comes from ADB and they encourage the use of Singapore or established architects. There is some passive design being incorporated but very little active solar or wind is included. They are not emphasizing solar.

They need more facilities, specialized knowledge and references if they are to teach solar-wind-renewable energy design. They especially need labs and equipment to emphasize solar and wind.

L A P A N - LEMBAGA PENERBANGAN DAN ANTARIKSA NASIONAL

Indonesian National Institute of Aeronautics and Space

October 8, 1980 - 9:00 A.M.

with: Dr. Harijono Dojodihardjo LAPAN
Ir. WISNU, LAPAN
Mr. Suwardjaka, DJK

Dr. Harijono confirmed much of what was said at the September 17 meeting at LAPAN. They are emphasizing an assessment of wind energy potential and to introduce and stimulate wind energy technology. They are trying to organize a national wind velocity measurement system. They are working on a cooperative program with Germany. Their surface wind maps are not good, infact, they will not publish wind velocity profiles until better data is available. They believe wind power is appropriate for certain applications and are attempting to determine where and how wind can be used.

INSTITUTE TECHNOLOGI SURABAYA ITS

Mechanical Engineering Department (school is on the other side of town from main campus)

Ingr. Najnavk

October 7, 1980 - 11:45 A.M.

with: Suwardjaka

They have constructed a windmill to produce mechanical energy for pumping and grain milling (rice). The project was a joint government and university effort. The windmill, in a village outside Surabaya, was built entirely from local materials (a Diahatsu transmission was used). The windmill has been working for a year. Wind is a special interest of the school especially to create mechanical energy. They intent to do other similar projects.

MEMORANDUM

TO: Mr. William Littlewood, Director
Science, Technology & Energy -- USAID

FROM: J. D. Westfield, Consultant
Working on AID/Indonesian Energy Planning for Development Project

DATE: October 20, 1980

SUBJECT: Comments on July, 1980, USDOE Team Report on Preliminary Planning Study for Puspiptek Energy Research Laboratory

As you requested, I have reviewed the above report paying particular attention to the Direct Solar Conversion Program recommendations. The following brief comments represent my evaluation of the report. I have been in Indonesia approximately one month visiting and talking with a wide variety of people involved in solar and wind research and applications. I do not know what the DOE team found in their interviews except as described in their report. I feel somewhat uncomfortable in reviewing their findings without having the opportunity to speak first with Dr. Adams. This is especially true because I do not agree with his recommendations on photovoltaics; I feel that instrumentation to measure wind and solar radiation has not been given enough emphasis and believe wind technology has not been covered. In some respects this disagreement is probably due to a difference in our opinion; however, I believe that the disagreement over the photovoltaic recommendations may be due to a difference in knowledge of on-going studies and work in Indonesia. I have attempted to indicate in the following paragraph why I believe that the lab should not support photovoltaic cell production.

I agree completely with paragraph two on page 42 of the report. Furthermore, I know that LEN (the National Electronics Institute) in Bandung has an on-going program to produce photovoltaic cells. They now have equipment and are in the process of buying new models, many of which are similar to that proposed on pages 71-75, Appendix C of the Report. I, also, know LIPI and BPPT are hoping to buy similar equipment (possibly this project will finance this purchase). If it were up to me, I would not recommend that AID spend $250,000 or more to purchase even one set of equipment for Indonesia. I am totally against AID or the U.S. financing a second set. As I said, LEN already has or is getting almost the same equipment. The second reason I am against this line of research and funding is that there is a serious lack of solar and wind data in Indonesia, and $250,000 would finance badly needed training and equipment for solar and wind measurement. I believe that spending money for this will be a much more important and valuable contribution to promoting the use of solar and wind resources than funding photovoltaic research. The solar and wind report I am producing will document this need and recommend where and how solar and wind measurements should be made.

My final feeling about the DOE team report is that the Puspiptek Laboratory should have more equipment for testing wind power and some equipment to test batteries, voltage regulators, alternators, etc.

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PRELIMINARY RECOMMENDATIONS COVERING SOLAR AND WIND RESOURCES AND TECHNOLOGY

In order to provide DJK personnel with preliminary recommendations resulting from the solar and wind energy portion of the project and to provide some guidance as to priorities for DJK spending, the following summary has been prepared. The final report covering the one-month work in Indonesia will be completed in the United States. This report, when completed, will contain information to support the recommendations and present them in more detail.

The first and most important recommendation is that 20 small meteorological stations be purchased and located in various places in Indonesia. At least 12 should be located outside Java. The stations should measure and continuously record total global solar radiation, temperature and wind velocity. The stations should be operated and maintained by the Meteorology and Geophysical Institute with assistance from DJK and LAPAN. Additionally, at least 8 locations should include measurement and recording of diffuse solar radiation. These meteorological stations will cost approximately $8,000 U.S. each or $160,000 U.S. total. In addition to the stations, a thorough training course in solar and wind measurement, instrument operations and care, data analysis, and wind and solar energy data use should be developed and given to selected personnel in the Meteorology and Geophysical Institute, DJK, BPPT, LAPAN and universities. The last part of this recommendation is the purchase of 5 sets of Epply pyranometers and 5 annamometers to be used by universities in supporting their solar and wind research and studies programs. One pyranometer of the set should be equipped to measure total radiation and the other to measure diffuse radiation.

The second major recommendation is that DJK establish a solar and wind research, study, demonstration and application information system. There are many people and institutions involved in solar and wind research, and one agency should monitor and collect information on all activities. DJK, as a planning agency, can serve as a central information center and can disseminate this information to others to assure that those people needing information can have the most current and complete solar and wind information from one source. This will also be very helpful to DJK in the planning and coordination role that it has adopted. The development of this system will at first involve one person and files. However, this should rapidly expand to include computer storage and printout of information. An initial investment of one person full time and one part-time secretary, plus funding for the design study for the information system should be sufficient for the first year. During the second year, computer programming, storage and data entry will be required. An annual summary report should also be prepared; however, this report will only be useful if it is published in a timely manner of quarterly installments and assembled into one volume at the end of each year. This report should contain radiation and wind velocity maps; summaries of projects and studies; data on technology cost, performance, suppliers and maintenance; information from other countries; and other useful information on solar and wind.

The third major recommendation is that DJK concentrate on starting solar and wind research and technology demonstrations pertinent to commercial, industrial and institutional use. This activity should emphasize government use of technologies such as solar hot water heating. The military and ministry offices, schools, and health centers (without electricity) should be the first places to use solar and wind technologies. This program should also emphasize and support demonstrations of solar crop drying and cooling or refrigeration of vegetables. In this area, commercial size dryers and coolers should be constructed and demonstrated. Funds for testing of solar technologies useful in heating hot water for food processing and beverage production should also be included. This program should not replace the current government program emphasizing renewable energy applications in rural areas, it should be a companion effort. If possible, the government should encourage industry to participate and share some of the costs in this effort. If government provides some incentives and shares some of the early costs with industry, commercial and industrial uses of solar and wind can be accelerated and substantial energy savings are possible through widespread use of existing technologies.

There will be several other recommendations involving bringing U.S. technologists and technologies to Indonesia; however, they must be thought out before being written. The technology demonstrations will emphasize technologies such as cooling and freezing which can be applied to agriculture health posts, industry, etc.

APPENDIX C

SOLAR RADIATION, HOURS OF SUNLIGHT AND WIND VELOCITY DATA FOR INDONESIA

TABLE C-1

Comparison of Global Radiation and Hours of Sunlight Data for Selected Stations on JAVA

Station & Remarks	J	F	M	A	M	J	J	A	S	O	N	D	Avg.
Ⓐ JAK OBS													
Percent	13	55	53	74	77	87	84	84	80	66	51	42	64
Hours	1	4.4	4.2	5.9	6.2	7.0	6.7	6.7	6.4	5.3	4.1	3.4	5
Ⓑ JAK OBS													
Langley	216	327	289	271	297	319	285	304	325	384	295	304	301
Rainfall MM	691	105	405	96	81	21	0	173	82	84	97	159	166
Langley	305	305	362	385	369	350	369	397	407	403	357	346	363
Ⓒ KUPANG													
Percent	43	33	50	73	78	58	65	62	57	65	58	38	567
Hours	3.4	2.6	4	5.8	6.2	4.6	5.2	5	4.6	5.2	4.6	3	4.5
Ⓓ KUPANG													
Langley	306	339	391	406	439	365	375	373	461	465	395	337	388
MM Rainfall	458	562	206	34	1	0	1	0	0	0	17	234	126

Ⓐ Jakarta Observatory hours and sunlight data for 1976 taken from Reference 5. All data is only for an 8 hour recording period between 8 a.m. and 9 p.m. It is assumed that the percent of sunshine during these hours is reflective to the total percent during all sunlight hours. The number of hours figure under reports the actual number because there is frequently sunlight before 8 a.m. and after 9 p.m.

Ⓑ Jakarta Observatory global radiation and rainfall data for 1976 taken from Reference 2. Also in the third row 1969 - 1978 averages from the same reference.

Ⓒ Kupang sunlight data for 1977 from Reference 5.

Ⓓ Kupang global radiation data for 1977 from Reference 6.

TABLE C-2

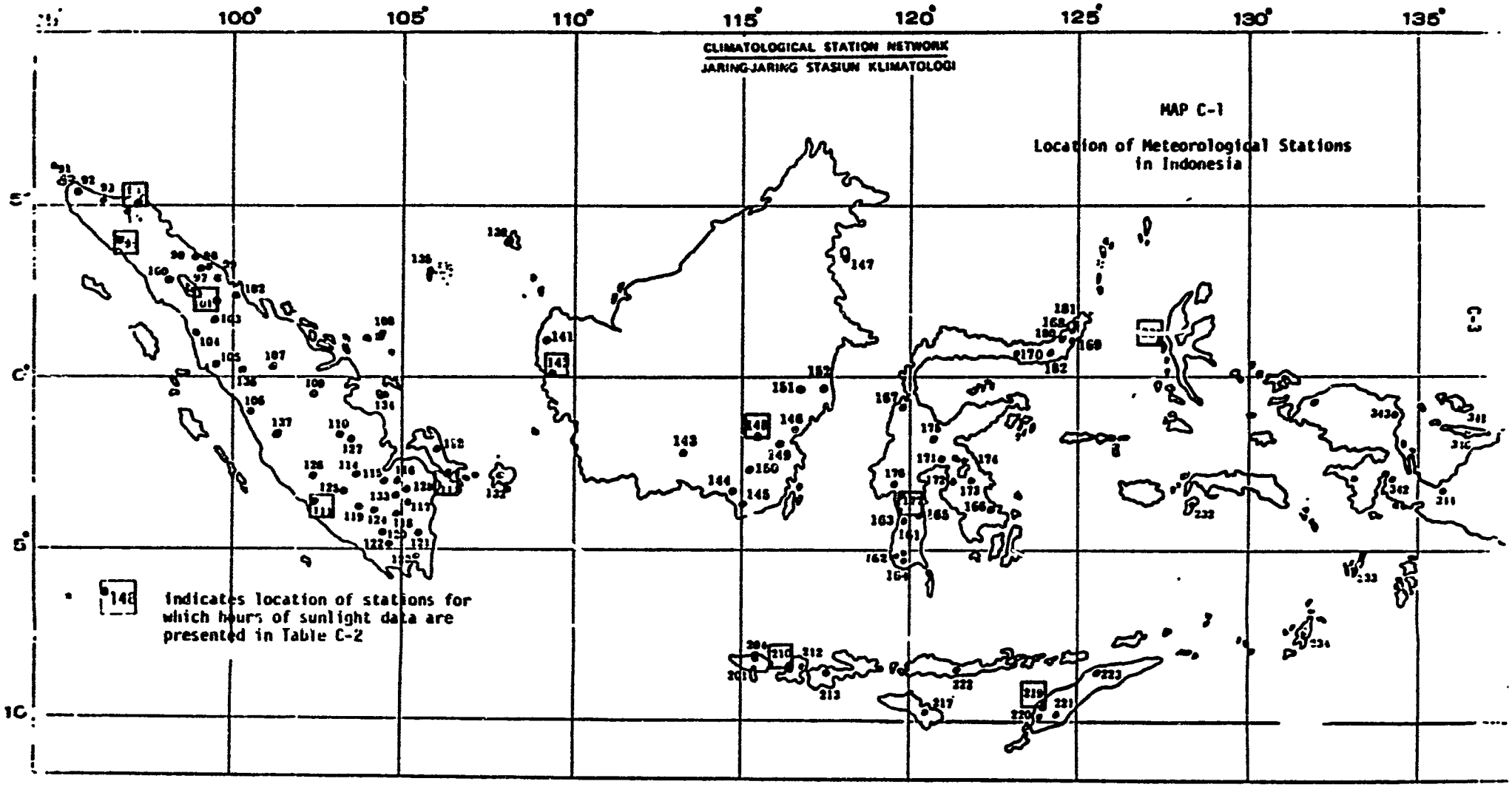
Hours of Sunlight Data for Selected Reporting Stations in Indonesia*

Ordinal	Station		Elev.	Hours of Sunlight**		
				Ave.		
#	#	Name	M	%	Hi***	Low
2	94	Got Girek	25	62.3	74 Jul.	31 Oct.
2				53.6	79 Jan.	36 Nov.
2				50.6	76 May	18 Oct.
10	101	Marinat St.	369	64.3	80 Dec.	30 Oct.
6				58.6	71 May	43 Sept.
4				55.2	68 Aug.	46 June
32	113	Rias Toboali	6	61	71 Apr.	49 May
29				67.6	85 Aug.	60 Apr.
19				63	73 Aug.	58 Feb.
38	111	Bengkulu Pd. Kweiling	15	68.4	80 May	58 Feb.
35				62.1	78 May	48 Oct.
25				58.7	68 July	50 Feb.
47	19	Geofisika Bandung	791	61.3	84 July	31 Feb.
42				62.7	85 July	29 Jan.
33				48.8	79 June	30 Feb.
75	37	Semarang MPB	03	73.8	95 Aug.	38 Feb.
67				71.6	95 July	41 Jan.
57				67.5	93 Aug.	43 Dec.
90	73	Karangkates	222	85.7	100 Aug.	63 Dec.
78				87.2	99 Aug.	76 Jan.
68				66.7	97 June	28 Jan.
136	210	Rembiga	03	75.8	90 Oct.	48 Feb.
123				79.7	89 Sept.	69 Jan.
107				61.8	79 Jan.	47 Feb.
146	231	Ternate	33	66.1	30 May	44 Feb.
132				72.8	34 Sept.	18 June
113				63.7	76 Oct.	48 July
62	4	Jakarta	07	61.8	91 July	22 Feb.
5[illegible]				63.8	87 Jun.	13 Jan.
45				58.8	79 Aug.	41 Dec.
113	148	Sie Malang-Amuntai	05	59.9	79 July	30 Feb.
96				58.8	75 May	42 Feb.
124	177	Mamasa Polmas	1130	60.9	86 Sept.	43 Jan.
110				59.1	70 June	97 Jan.
96				51.5	65 Aug.	35 Dec.
109	142	Supadio-Pontainak	03	62	76 Sept.	38 Feb.
95				57.7	74 July	37 Feb.

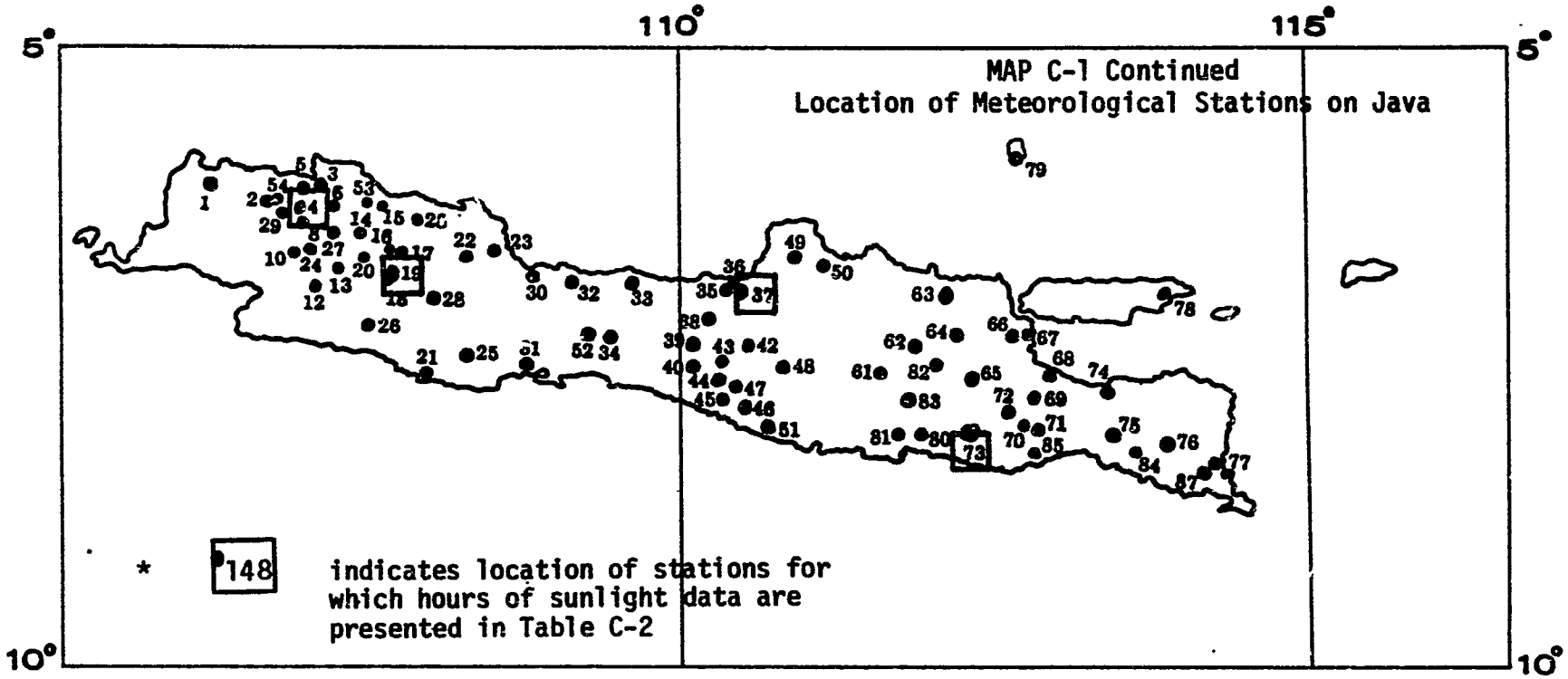
* 1969, 1970 and 1971 data taken from Reference 2 and Station Locations are shown on Map C-1.

** The percent of the hours of the day (8 AM - 6 PM) during which the sun shines.

*** 74 July indicates the highest average percent and the month in which it occured.



Best Available Document


5°
110°
115°
5°
10°
10°
MAP C-1 Continued
Location of Meteorological Stations on Java
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indicates location of stations for which hours of sunlight data are presented in Table C-2

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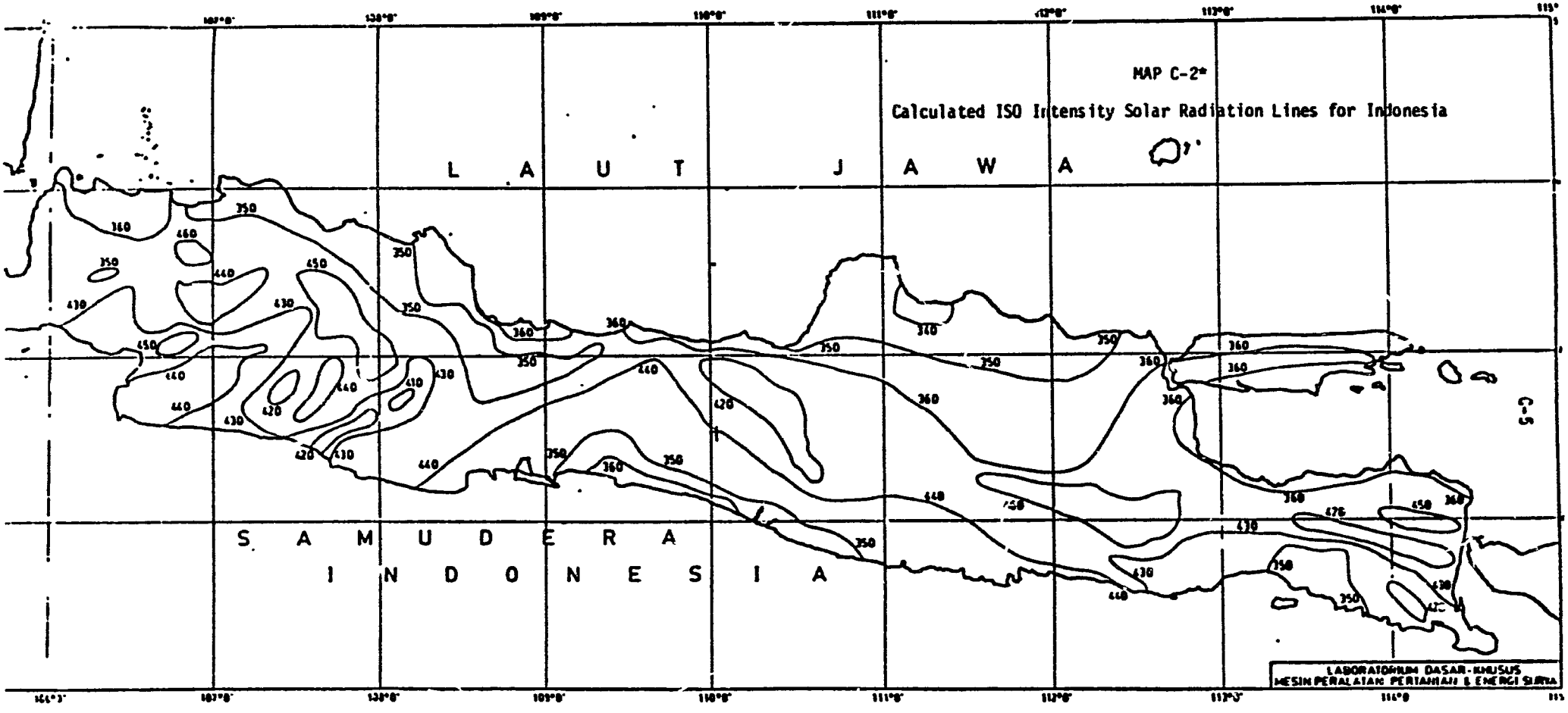

*Reference 8

Gambar 2 (c) Peta iso-intensitas radiasi surya tahunan, satuan intensitas adalah Langley/hari.

A SAMPLE OF WIND SPEED DATA FOR VARIOUS LOCATIONS IN INDONESIA (1977)*

STATIONS \ MONTHS		MEAN WIND SPEED (Km/hr)												MAX WIND SPEED (Km/hr)
		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
ACEH	: Blang Bintang	12.9	12.9	10.8	11.1	11.1	12.9	14.8	14.8	14.8	11.1	11.1	12.9	74.12
NORTH SUMATERA	: Pinanguori	9.26	12.9	11.1	11.1	11.1	9.26	11.1	9.26	9.26	9.26	9.26	9.26	10.76
WEST SUMATERA	: Tabing	7.41	9.26	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41	7.41	61.85
SOUTH SUMATERA	: Pangkalpinang	14.8	12.4	14.8	11.1	11.1	11.1	16.6	16.6	14.8	14.8	9.2	9.2	37.06
WEST JAVA	: Atang Sonjaya, Bogor	9.26	9.2	9.2	9.2	7.4	9.2	9.2	9.2	18.5	9.2	9.2	7.4	51.9
JAKARTA	: Jakarta Obe	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	9.2	7.4	7.4	37.06
CENTRAL JAVA	: Somarang Maritim	18.5	22.2	16.6	11.1	11.1	--	12.9	12.9	16.6	16.6	14.8	11.1	55.6
EAST JAVA	: Iswahyudi	14.8	12.9	14.8	14.8	14.8	20.4	31.5	33.4	31.5	33.4	22.2	14.8	66.7
EAST KALIMANTAN	: Balikpapan	7.4	7.4	7.4	7.4	9.2	9.2	14.8	12.9	14.8	11.1	9.2	9.2	46.32
BALI	: Denpasar	12.9	14.8	7.4	11.1	14.8	16.6	20.3	16.6	14.8	9.2	7.4	7.4	55.6
SOUTH SULAWESI	: Hasanudin	5.56	7.4	5.5	5.5	3.7	5.7	5.5	7.4	7.4	9.2	9.2	5.5	63
CENTRAL SULAWESI	: Palu	9.2	9.2	9.2	9.2	9.2	7.4	7.4	7.4	9.2	9.2	9.2	9.2	55.6
NORTH SULAWESI	: Mapanget	11.1	9.2	12.9	12.9	9.2	11.1	16.6	16.6	14.8	7.4	9.2	7.4	48.2
WEST NUSATENGGARA	: Sumbawa	14.8	14.8	16.6	12.9	14.8	12.9	16.6	14.8	14.8	16.6	16.6	14.8	55.6
MALUKU	: Ternate	12.9	11.1	12.9	11.1	9.2	7.4	12.9	12.9	14.8	11.1	11.1	14.9	40.76

*Reference 16

(To convert from Km/hr to MS multiply by 0.28)

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APPENDIX D

WIND AND SOLAR DATA SOURCES

1. Statistik Indonesia, 1978/1979, Biro Pusat Statistik Jakarta.

   - Tables on mean duration of sunshine in percent and average and maximum wind velocity in selected places.

2. Solar Radiation Data, Pusat Meteorologi dan Geofisika Departemen Perhubungan Jakarta.

   - Solar Radiation Data

	Place	Dates
1	Jakarta	1964-1968
3	Jakarta	1969-1971
4	Denpasar	1969-1973
5	Jakarta	1972-1976
6	Kupang	1972-1976

3. Meteorological Data of Indonesian Aerodromes, 1966, Ministry of Communications, Meteorological and Geophysical Institute, Jakarta, Indonesia.

   - Tables showing frequency of surface winds and horizontal visibility; low cloud height; present weather and simultaneous occurance of clouds for 54 airports in Indonesia.

4. Sutrisno, C. Meteorological Note Number 5 Montaly mean resultant winds over Indonesia and other South East Asian regions, Departemen Perhubungan, Direktorat Jendral Perhubungan Udara Direktorat Meterologi dan Geogisika Jakarta, Indonesia, 1966.

   - Maps of Upper wind velocities over Indonesia at 5,000; 1,000; 2,000 and 3,000 feet above sea level.

5. Jl. A R Hakim Number 3, Data Iklim di Indonesia, Departemen Perhubungan Pusat Meterologi dan Geofisika Jakarta, 1971, 1972, 1973, 1974, 1975, 1976, and 1977.

   - Temperature, rainfall, sunshine, pressure, relative humidity, wind velocity (mean and maximum) and prevailing wind direction data for all climatological stations in Indonesia (approximately 150 in 1977).

6. M Pardede, Pengumpulan Data Intensitas Radiasi Matahari Dibeberapa Tempat Di Pulau Jawa, Pusat Riset Dirgantara Lembaga Penerbangan dan Antariksa Nasional, Lokakarya Pengembangan Energi Non Konvensional, Jakarta 28-29 Januari 1980.

   - Summary of solar radiation data from Jakarta, Lembang, Kupang and Bandung

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7. Paragtopo & Harsono, Correlation of Diffuse Solar Radiation Distribution with Climate Characteristics in Indonesia, a paper submitted to the Symposium on Solar Science and Technology, Bangkok, Thailand, 25 November - 4 December 1980.

- Calculations of diffuse solar radiation and clearness index from total solar radiation data for various stations in Indonesia using a theoretical model developed by Collares-Pereira & Rabl.

8. Harahap F., Lubis S., Malik F., Kamsar, I. J. S. and Suwono A., Kegiatan Pengumpulan Data Energi Radiasi Surya, Pengujian Peralatan Perman Faatn Ya dan Program Pemet' n Intensitasnya, Lokakarya Pengemgangan Energi non Konvensional, Jakarta, 28-29 Januari 1980.

- Solar radiation data collection activities of ITB including a iso intensity solar radiation map of Java using actual and calculated data. There is also information on heating, drying and photovoltaic projects and measurements.

9. Laporan Kegiatan Penelitian dan Pengembangan Helioteknologi (Tenaga Radiasi Matahari), 1979, Laboratorium Helioteknologi Departemen Fisika Teknik Fakultas Teknologi Industri Institut Teknologi Bandung, 1979.

- Summaries of studies, senior papers and published thesises on solar measurements, instrumentation, technologies and research project results. (Some information in English.)

10. Conclusions, 1980, Energy Workshop, World Energy Conference -- Indonesia National Committee, Jakarta, 17-18 April 1980.

11. Sastroamidjojo, Dr. M. S. A., Large Scale Electric-power Generators using solar energy for intermediate industries and rural development in Indonesia (a paper translated from Indonesian).

12. Sastroamidjojo, Dr. M. S. A., A Multipurpose solar air dryer for research and development, Solar Energy Research Center, Gadjah Mada University, Yogyakarta, Indonesia.

13. Preliminary Planning Study for Puspiptek Energy Research Laboratory, Report of US DOE Team, Office of International Affairs, July 1980.

14. Universitas Diponegoeo, Solar Water Heater, a discussion and plans for construction.

15. Harsono,A. & Parangtopo, Correlation of Diffuse Solar Radiation Distribution with Climatic Characteristics in Indonesia, An Abstract, October 1980.

16. Djojodihardjo, H., Some Observations on the Prospect of Wind Energy Utilization in Indonesia. A paper to be presented, 7th General Assembly, World Federation of Engineering Organization, Jakarta, 16-17 November 1979.

17. Solar Radiation Measurements in the Netherland Indies, Volume #37, Departemen van Verkeer, Enorgie en Mijnwezen, Meteorologische en Geophysicscho Dienst.

18. Prasetyo, Heru, "The Feasibility of Manufacturing and Marketing Solar Hot Water Heaters in Indonesia," an MS Thesis at the Asian Institute of Management in the Philippines, 1978.

19. Power Supply Statistics for Indonesia, PLN Annual Report, 1980.

20. Going With The Winds, EPRI Journal, Volume 5, No. 2, March, 1980, p. 11.

21. Statistical Abstract of Indonesia, 1980.

APPENDIX E

ANSWERS TO SPECIFIC QUESTIONS NOT COVERED IN THE ORIGINAL SCOPE OF WORK

The significance of the conclusions of this report for Indonesian Energy Policy and Planning is covered briefly in the last chapter of the report. In summary it is not likely that solar and wind resources will supply even 0.1 percent of the total year 2000 energy demand. However, if demand is disaggregated into regional and economic sector components, the impact of solar and wind can be greater. Also, the total amount of the solar energy available for development dwarfs any of the other sources of energy supply. As capture and conversion technologies become more efficient and economical, the potential impact of solar and wind will increase. It is in the decades beyond 2000 which solar and wind can make their major impact on the overall energy supply picture. The steps recommended in this report will allow this to happen without delay.

The benefits derived by Indonesia from this project depend on how the results are used. This was the first and a necessary step in the development of solar and wind resources and, if successful, it will cause other steps to be taken. Hopefully the study will cause the government to immediately focus on planning and resource evaluation. The importance of the findings are as follows:

1) An initial estimate of the importance of solar and wind energy by geographic region and economic sector has been provided.

2) Solar data previously not commonly heldhave been described in one place.

3) A description of the many ongoing research activities has been developed and the location and names of investigators have been assembled.

4) A program and priorities for government action have been developed.

5) DJK staff have been introduced to solar and wind planners and researchers in all areas of Java.

It has been difficult to develop specific market penetration estimates or solar and wind resource use because:

A) Energy use in specific economic sectors and geographic regions is not known.

B) Solar and wind resources are not being used to any extent now.

A possible critique of the overall project could be that not enough emphasis was placed on defining existing energy supply and demand. This is not a critical drawback and is probably only important to the renewable energy sector. If this information is provided as a part of a near term study it should not adversely affect the utilization of solar and wind.

A general recommendation for future activities is that solar and wind efforts be coordinated with other renewable energy programs, especially biomass and microhydro. There is only a limited amount of money and technical ability for the renewable energy sector and it is important that it is applied most appropriately. One way to assure a reasonable apportionment of funds and efforts is to coordinate the overall renewable energy program. Because DJK has been designated as the overall planning agency in this area, it will be relatively easy to deal with planning. The major problem will be in coordinating and influencing the actions of other agencies, i.e., seeing that planning is implemented.