THE FINAL REPORT FOR THE FEASIBILITY STUDY ON EFFECTIVE UTILIZATION OF BANKO COAL IN THE REPUBLIC OF INDONESIA Volume I

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FOR
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THE REPUBLIC OF INDONESIA

Volume I

March 1989

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Republic of Indonesia, the Japanese Government decided to conduct a feasibility study on Effective Utilization of Banko Coal and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA has sent to Indonesia a study team headed by Mr. Takehiko Sato, the Institute of Energy Economics, Japan, as many as eighteen times during the period of five years from May 9, 1984 to December 20, 1988.

The team has had a series of discussions with concerned officials of the Government of the Republic of Indonesia, and conducted field surveys, gasification tests, and so on. After the team returned to Japan, further studies were made and the present report was prepared.

I hope that this report will contribute to the development of the project and to the promotion of friendly relations between our two countries.

I wish to express my sincerest appreciation to the concerned officials of the Government of the Republic of Indonesia for their close cooperation extended to the team.

March, 1988

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

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Acronyms and Abbreviations

Acronyms and Abbreviations

A

A : ampere
A.B.D.: apparent bulk density
AC : alternating current
AECI : African Explosives and Chemical Industries
AER : anion exchange resin
AFB : atmospheric fluidized bed
A/F ratio : air fuel ratio
A.M. : as mined
API : American Petroleum Institute
A/S : air separation
ASTM : American Society for Testing Materials
A.T. : ambient temperature

B

BASF : Badische Anilin und Soda-Fabrik AG
BFW : boiler feed water
B/L : buttery limit
BOD : biochemical oxygen demand
BOE : barrel of oil equivalent
BOF : basic oxygen furnace
BOT : build, operate and transfer
BPD : barrel per day
BPPT : Badan Pengkajian dan Penerapan Teknologi
(Agency for the Assessment and Application of Technology)
B.S. : booster station
BTU : british thermal unit
BWE : bucket wheel excavator

C

°C : centigrade degree

CAT (cat): catalyst
CB : circuit breaker
CBR : California bearing ratio
CEC : California Energy Commission
CER : cation exchange resin
cf : cubic feet
CFB : circulating fluidized bed
CGCC: coal gasification combined-cycle
C/H : carbon/hydrogen
c.i.f. : cost, insurance and frieght
cm : centimeter
CMRC: Coal Mining Research Center
COD : chemical oxygen demand
CPEs : centrally planned economies
CRT : cathode ray tube
cSt : centistokes
CT : current transformer
C/T : cooling tower
C.V. : calorific value
CW : cooling water

D

d : day
d.a.f. : dry ash free
DC : direct current
DCF : discount cash flow
DDA : Detroit Diesel Allison
d, d.b. : dry base
DDC : Detroit Diesel Corporation
DME : dimethyl ether
DMT : dimethyl terephthalate
DO : dissolved oxygen
DOC : Directorate of Coal
DPMA: Directorate Penylidikan Masalar Air
DS : disconnection switch

DTG : dimethyl ether-to-gasoline

DWT : dead weight ton

E

EIRR : economic internal rate of return

ELB : earth leakage breaker

EOR : enhanced oil recovery

EP : end point

EPDC : Electric Power Development Co., Ltd.

F

FBB : fluidized bed combustion boiler

FBC : fluidizedbed combustion

F.C. : fixed carbon

FDF : forced draft fan

FFV : flexible fuel vehicle

FG : fuel gas

FIRR : financial internal rate of return

FLG : flare gas

FOB : free on boad

FW : fire water

FY : fiscal year

G

g : gram

G : gauge pressure

gal : gallon

GHSV : gaseous hourly space velocity

G.L. : ground level

GM : General Motors

GNP : gross national product

GPT : ground potential transformer

G/T : gas turbine

H

H : height
h : hour
ΔH : rising smoke height
He : effective stack height
HMctt : high speed magnetic contactor
Ho : actual stack height
HP : high pressure, horse power
HPS : high pressure steam
HRSG : heat recovery steam generator
H.W.L : highest water level
Hz : hertz

I

IA : instrument air
IBP : initial boiling point
ICI : Imperial Chemical Industries PLC
ID : inside diameter
IDCP : interest during construction period
IDF : induced draft fan
IEA : International Energy Agency
IER : ion exchange resin
IFP : Institute Francais du P'etrole
IGT : Institute of Gas Technology
IRR : internal rate of return
IW : industrial water

J

JICA : Japan International Cooperation Agency
JIS : Japan Industrial Standard

K

kg : kilogram
kg/cm^2G : kilogram per square centimeter gauge
KHD : KHD Humboldt Wedag AG, Klöckner Humboldt Deutz

KVA : kilovolt ampere

L

ℓ : litre

LBS : load breaker switch

LD50 : median lethel dose

LHSV : liquid hourly space velocity

LIBOR: London interbank offering rate

LNG : liquefied natural gas

LOI : loss of ignition

LP : low pressure

Lp : sound level (dB(A))

LPC : low pressure steam

LPG : liquefied petroleum gas

LV : linear velocity

Lw : power level (dB(A))

L.W.L.: lowest water level

M

m : meter

M-Alkali : methyl orange (red) - alkali

MAN : Maschinen-fabrik Augsburg Nürnberg

mBOE : million BOE

MCB : motor circuit breaker

MEFOS : Metallurgical Research Institute, Lurea, Sweden

mg/ℓ : miligram per liter

m^3/H : cubic meter per hour

MIGAS : Direktorat Jenderal Minyak dan Gas Bumi

Mil. : million

MILE : methanol in large engines

MIP : Molten iron pure gas

MITI : Ministry of International Trade and Industry

MJ/H : megajoule per hour

ML : meter level

mℓ : millilitre

MM : million

mm : millimeter
MMA : methyl methacrylate
MMUS$: million US dollars
Mo : moisture
MON : motor octane number
MTBE : methyl tertiary butyl ether
MTG : methanol-to-gasoline
MW : megawatt
μ : micron
μS/cm : micro siemens per square centi-meter

N

NA : not available
NEDO : New Energy & Industrial Technology Development Organization
NFPA : National Fire Protection Association
N-Hex : normal hexane extracted
Nm : newton-meter
Nm^3 : normal cubic meter
NOx : nitrogen oxides

O

OECF : Overseas Economic Cooperation Fund
OPEC : Organization of Petroleum Exporting Countries
Op. Year : operation year

P

PAC : polyaluminum chloride
PC : prestressed concrete
PCB : polychlorinated biphenyl
PE : polyethylene
PERTAMINA : Perusahaan Pertambangan Minyak dan Gas Bumi National (state-owned oil company)
PF : power fuse
PFD : process flow diagram
PH (pH): hydrogen-ion concentration
PHC : prestressed high grade concrete

PID : piping & instrumentation diagram

PLC : programable logic controller

PLN : Perusahaan umum Listrik Negara (the state electric corporation)

ppb : part per billion

ppm : part per million

PPTM : *Pusat Pengembangan Teknologi Mineral*

PTB : Perum Tambang Batubara (the state coal corporation)

PTBA : PT Tambang Batubara Bukit Asam (the state coal corporation Bukit Asam mine)

PT unit: potential transformer unit

PUSPIPTEK: Pusat Pengembangan Ilmn Pengatahuan dam Teknologi (The National Center for Research, Science and Technology Project)

PUSRI: state-owned fertilizer company

R

RACC: Research Association for C_1 Chemistry

RAPAD: Research Association for Petroleum Alternative Development

R & D: research and development

REPELITA: Rencana Pembangunan Lima Tahun (Five-Year Development Plan)

RON : research octane number

Rp : Rupiah

rpm : rotation per minute

S

SA : service air

SASOL: South African Synthetic Oil Limited

SC : steam condensate

SCF : standard conversion factor

SCP : single cell protein

SDAB : Svensk Drivmedelsteknik AB (Swedish Motor Fuel Technology Co.)

SG : synthesis gas

S.J. : Suban Jeriji

SMI : Sumitomo Metal Industries Ltd.

SOx : sulphur oxides

S.P.P. : steel pipe pile
SS : suspended solids (mg/ℓ)
S/T : steam turbine, shovel and truck
STG : synthesis gas-to-gasoline
ST'M : steam
SW : service water

T

t : ton
TCE : ton coal equivalent
tcf : trillion cubic feet
TDC : top dead center
TDS : total dissolved solids
TEL : tetraethyl lead
TLV : threshold limit value
TOC : total organic carbon
TOE : ton oil equivalent
TR : transformer
TVA : Tennessee Valley Authority
tWh : tera watt hour
t/y : ton per year

V

V : volt
VCB : vacuum circuit breaker
V.M. : volatile matter
Vol. : volume
VVVF : variable voltage variable frequency device

W

WHSV : weight hourly space velocity
Wt : weight
W/T : water treatment
WW : waste water

Y

y : year

¥ : Yen

Z

ZCT : zero current transformer

1. INTRODUCTION

In response to the request of the Government of the Republic of Indonesia, the Government of Japan decided to conduct the Feasibility Study on Banko Coal Effective Utilization as one of the international cooperation programs for the social and economic development of developing countries.

The Japan International Cooperation Agency (JICA), the official agency responsible for the implementation of the technical cooperation programs of the Government of Japan, and the Agency for the Assessment and Application of Technology (Badan Pengkajian dan Penerapan Teknologi: BPPT) as a counterpart agency concluded the Agreement (Scope of Work) on February 24, 1984.

The Institute of Energy Economics, Japan (IEE, Japan), as the consultant for the implementation of the Study (Japanese Study Team), is undertaking the Study in close cooperation with the counterpart.

The Study will be carried out in the following three (3) stages:

First stage	:	Strategic Investigation Stage (1 year)
Second stage	:	Coal Gasification Test Stage (2.5 years)
Third stage	:	Feasibility Study Stage (1.5 years)

The strategic investigation stage is to establish a master plan of Banko coal effective utilization and to select optimum technology for the Banko coal gasification test stage.

The coal gasification test stage is to grasp characteristics of gasification of Banko coal and to select coal basin to be studied in the following stage.

The feasibility study stage encompasses analysis and synthesis of collected information and data at the previous stages, investigation of various project plans of Banko coal effective utilization, and preparation of the proposed Project.

2. BACKGROUND OF THE STUDY

During the past decade, the environment of energy problems has greatly changed with the two oil crises as turning points. That is, the oil crises triggered sharp oil price increases followed by worldwide recessions and developments of alternative energy resources, resulting to urge for oil producing countries to cut its crude oil prices as well as the amount of export. These structural changes in oil supply-demand and prices have naturally produced great impacts on national alternative energy development policies throughout the world.

In particular, development plans of synthetic fuel, from coal through gasification and liquefaction, which have brilliantly started after the first oil crisis under the initiative taken by Japan, the United States and West Europe, are recently exposed to a severe trial because of the surplus and price cutting of crude oil.

However, during the past decade, conventional alternative energies, including coal, natural gas and nuclear power, have constantly expanded their shares in primary energy, thus greatly contributing to save the consumption of oil.

On the other hand, alternative energy development in developing countries has various aspects different from development plans designed for advanced countries. In other words, alternative energy development in developing countries should not merely pursue introduction of energy sources to substitute for oil but be closely related to their industrialization plans.

This constitute a need to promote industries, expand employment and improve income levels through energy development. In this point Indonesia is not exceptional.

To maintain exports of oil and natural gas at the maximum possible level, the Indonesian Government has been adopting policies designed to save domestic consumption of those energy resources and to facilitate the development of alternative energies.

Fig. 2-1 shows crude oil production, domestic demand and export of oil and oil products in Indonesia.

Among national programs, given priorities by the Indonesian Government are to develop alternative energies, to promote the transmigration and to develop industries.

Banko coal available in South Sumatra is the most potential natural resources in view of above mentioned programs, because its estimated reserves are abundant (see Fig. 2-2 and 2-3) and South Sumatra is nominated as one of the most prospective sites for the transmigration from Java.

On the other hand, Banko coal, classified into brown coal which has low calorific value as fuel and troublesome features such as spontaneous combustion, denies long-distance transport from both technical and economic aspects.

Therefore the typical utilization as fuel for electric generation or industrial heat source is practically difficult in view of technical and economic aspects.

From a technical standpoint, gasification of Banko coal and production of the derivatives seem to be a potential plan (see Fig. 2-4).

From these prospective, the Indonesian Government requests the Japanese Government to conduct a development survey which will be essential for the preparation of the Banko coal development and its utilization plan.

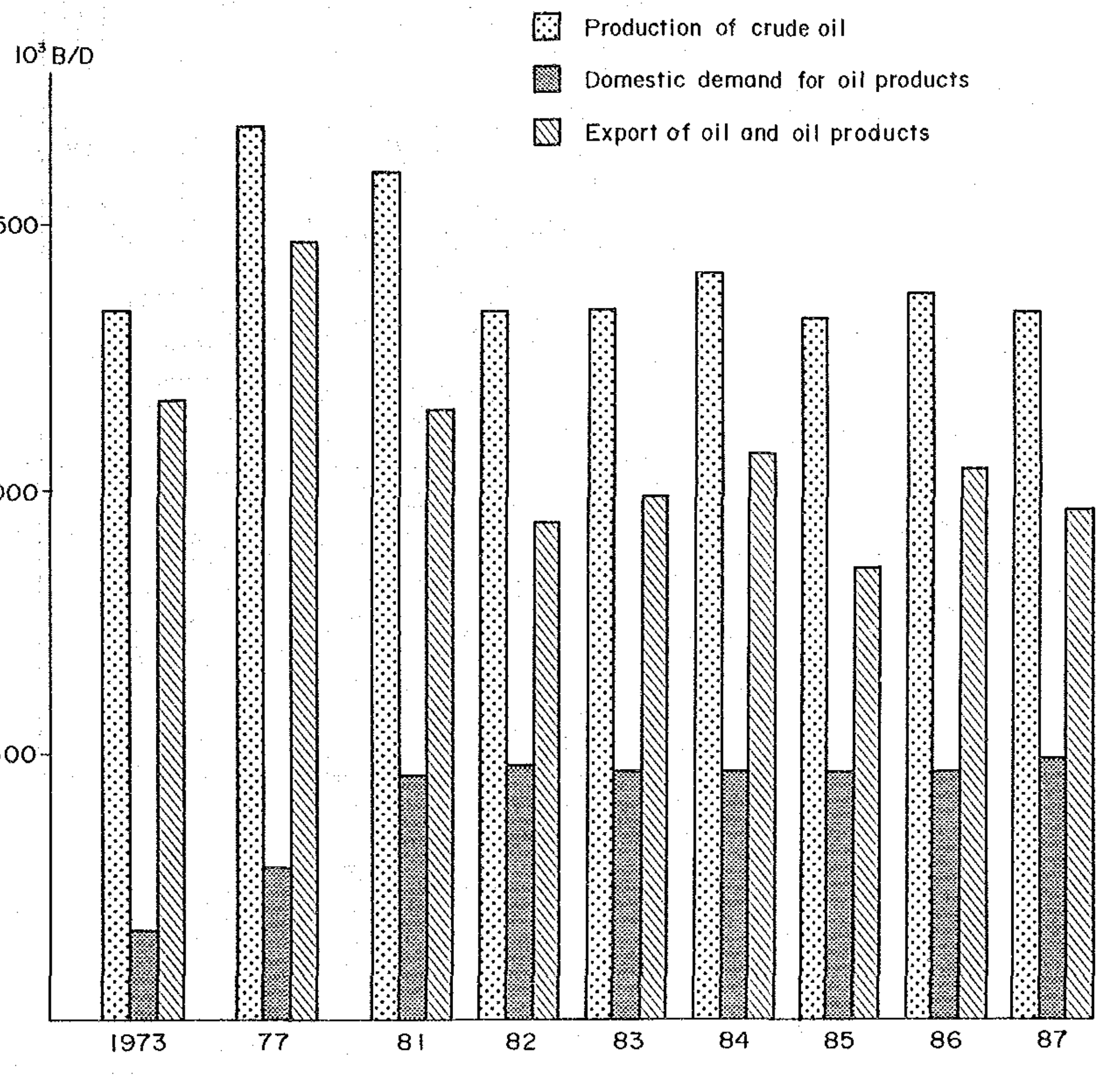
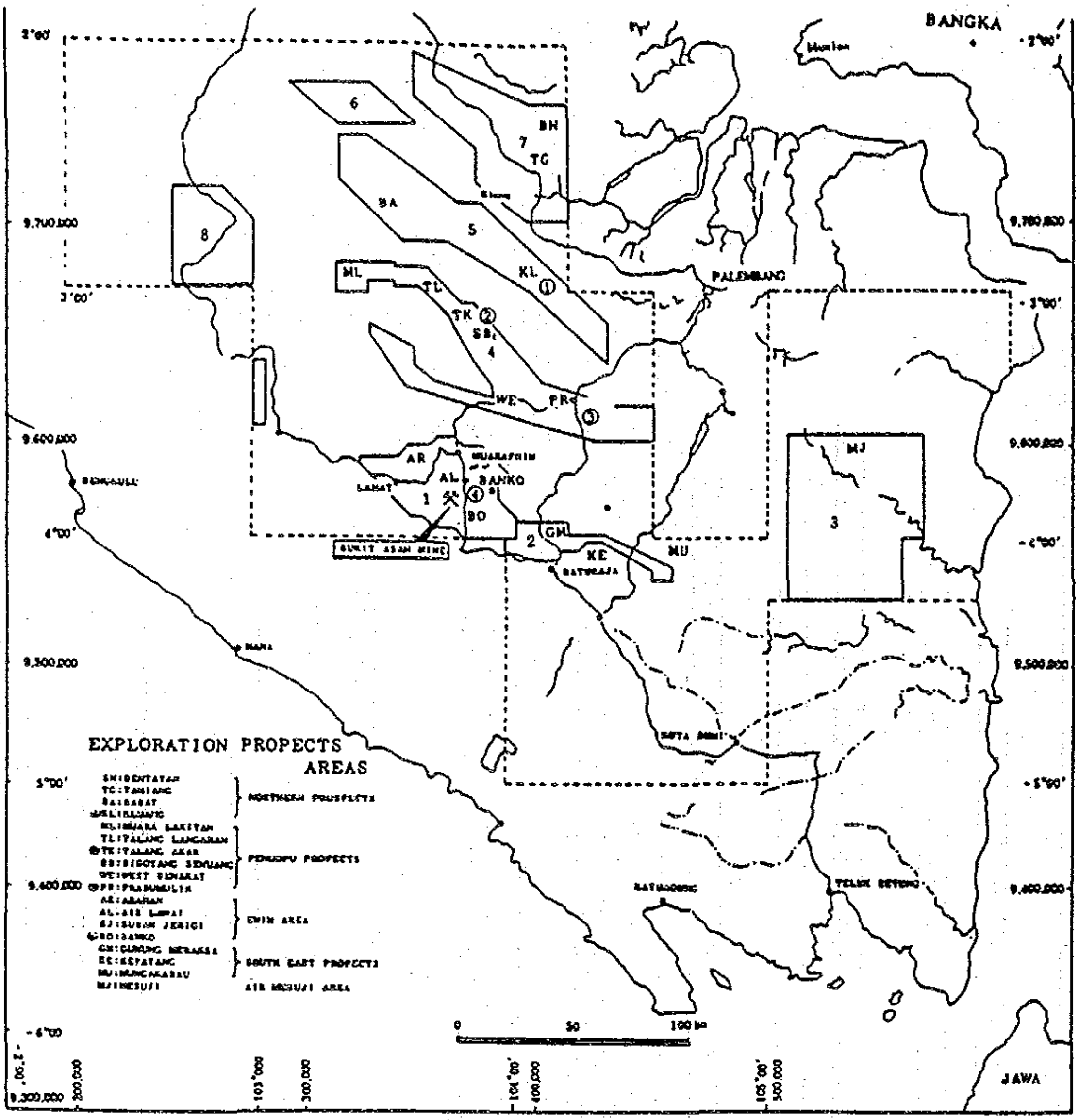


Fig. 2-1 Oil Production, Export and Demand in Indonesia



Estimated Reserves in Major Blocks of South Sumatra Coal Field (up to 50 m in depth)

Area	Approximate volumes of coal resources to 50 m. depth. million cubic metres
Bentayan	75
N. Tamiang	100
S. E. Tamiang	40
① N. Kluang	200
S. Kluang(Musi)	1,300
N. Babat	220
S. Babat	90
N. Pendopo(Muara Lakitan, Talang Langaran)	300
② Pendopo North Flank(Talang Akar, Sigoyang Benuang)	1,330
③ Prabumulih	400
West Enim(Arahan, Air Lawai)	120
④ East Enim(Banko, Suban Jerigi)	450
Merakas	110
Baturaja(Kepayung, Muncakabau)	150
Mesuji	250
Total :	5,135

Fig. 2-2 Map of Blocks for Coal Exploration in South Sumatra

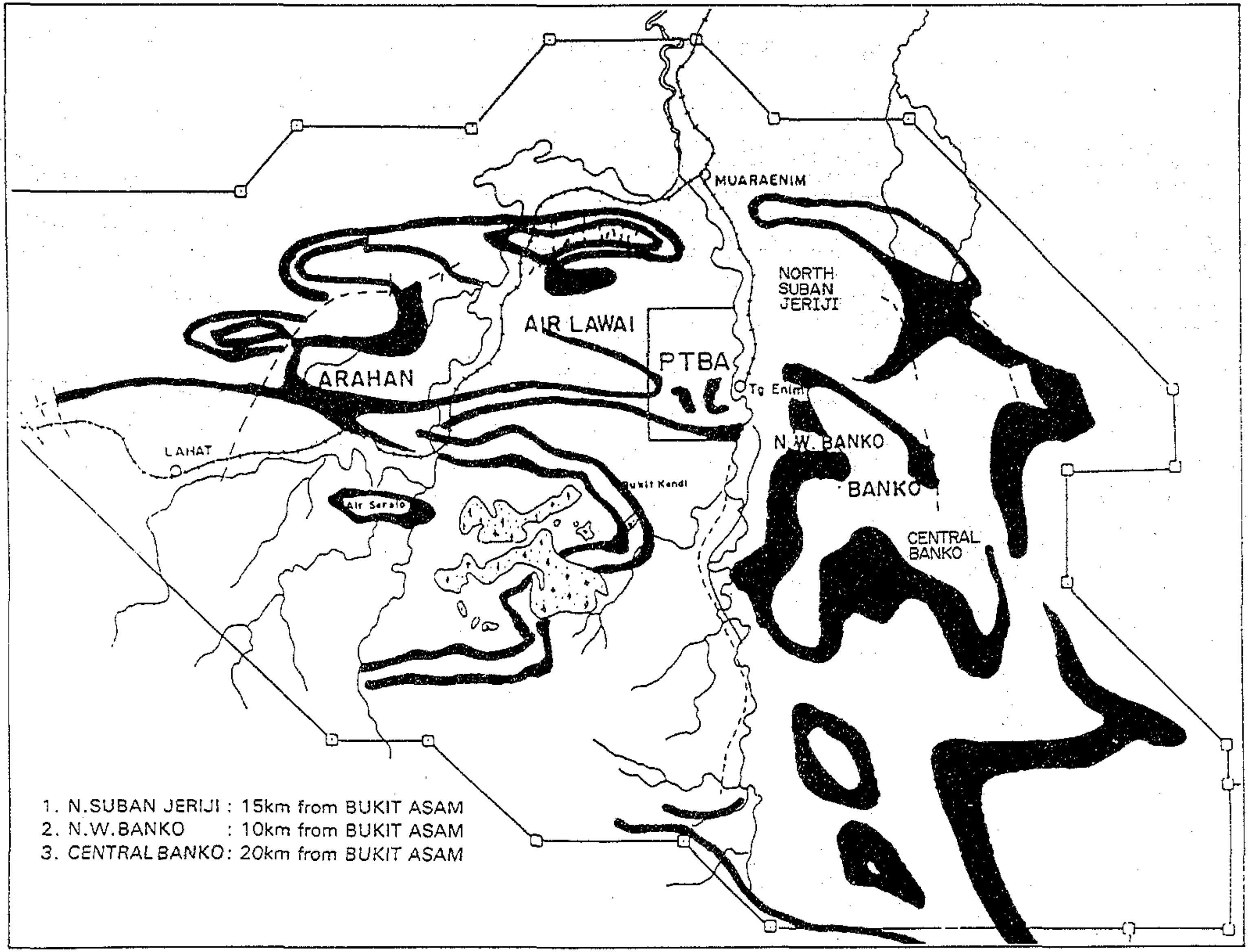


Fig. 2-3 Coal Resources in Western Part of South Sumatra Area

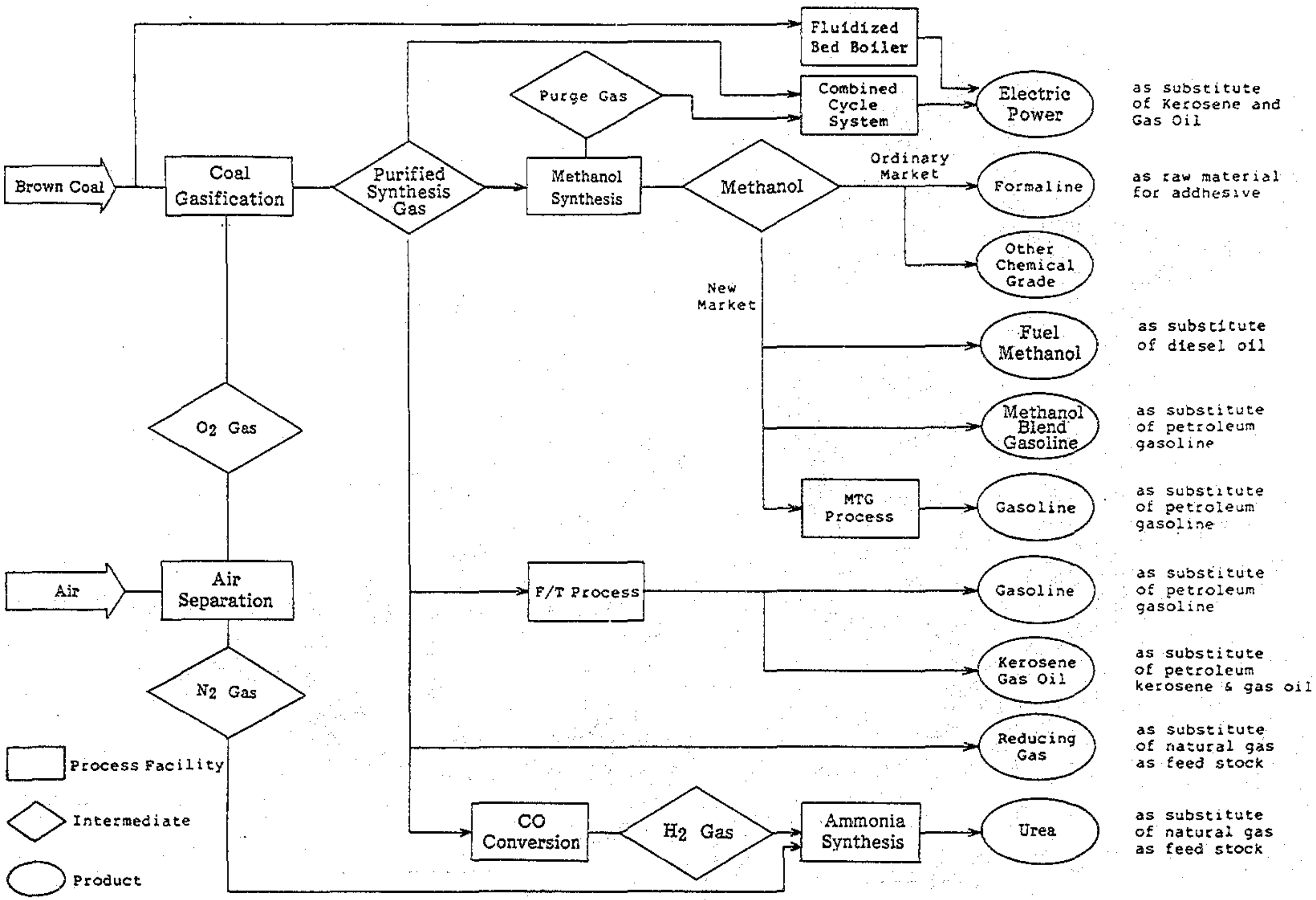


Fig. 2-4 Flow Scheme for Brown Coal Utilization

3. HISTORY OF THE AGREEMENT

(1) In November 1981, the Ministry of International Trade and Industry (MITI) dispatched a mission to Indonesia to investigate preliminarily the feasibility of producing methanol from coal.
As a result of this investigation, the Japanese Government found a possibility to produce methanol from Banko coal.

(2) In March 1982, Prof. Dr. Ing. B.J. Habibie, the Minister of Research and Technology, in his visit to Japan made a request to MITI and the Ministry of Foreign Affairs for the implementation of the feasibility study by Japanese experts.

(3) In the 6th Indonesia-Japan Technology Cooperation Conference held in June 1982, Japanese and Indonesian Governments agreed on the implementation of the study in their research and development program.

(4) Following this agreement, in November 1982, JICA dispatched a delegation in order to confirm the policy and implementation plan of the Indonesian Government.

(5) In February 24, 1984, JICA concluded the Agreement with BPPT for the implementation of this study and recorded the details in the Scope of Work.

4. OUTLINE OF THE STUDY

4-1 AGREEMENT

Based on the above mentioned background, BPPT and JICA agreed upon the development survey which is titled "Effective Utilization of Banko Coal", on 24 February, 1984. The Agreement set forth the scope of work in details with regard to the Study.

The contents of the Agreement are as follows:

- I. Introduction
- II. Objective of the Study
- III. Scope of the Study
- IV. Schedule of the Study
- V. Reports
- VI. Undertaking of the Government of the Republic of Indonesia
- VII. Undertaking of the Government of Japan
- VIII. Technical Undertaking of Both Governments
- IX. Consultation

APPENDIX

- I. Flow Chart of the Implementation Plan
- II. Schedule of the Study
- III. Division of Technical Undertaking

4-2 OBJECTIVE OF THE STUDY

The objective of the Study is to establish an appropriate master plan of effective utilization of Banko coal and to examine its technical, economic and financial feasibility, including coal gasification study, and to prepare the reports synthesizing the result of overall investigations and studies.

4-3 SCOPE OF THE STUDY

The Study will be carried out in the following three (3) stages:

1. Strategic Investigation Stage
2. Coal Gasification Test Stage
3. Feasibility Study Stage

The strategic investigation stage is to establish a master plan of Banko coal effective utilization and to select optimum technology for the Banko coal gasification test stage.
The coal gasification test stage is to grasp characteristics of gasification of Banko coal and to select coal basin to be studied in the following stage.
The feasibility study stage encompasses analysis and synthesis of collected information and data at the previous stages, investigation of various project plans to Banko coal effective utilization, and preparation of the proposed Project.
The outline of the Scope of the Study and the consulting procedure for the Scope of Work of each stage are summarized on the flow chart of the implementation plan attached as Fig. 4-1.

4-4 SCHEDULE OF THE STUDY

Total period required for the Study will be about five (5) years, and is divided into three (3) stages.

Strategic Investigation Stage	:	One (1) year
Coal Gasification Test Stage	:	Two and half (2.5) years
Feasibility Study Stage	:	One and half (1.5) years

The overall schedule of the Study is detailed in Fig. 4-2.

4-5 STRATEGIC POINTS OF THE STUDY

4-5-1 Coal Gasification Technology

For the Study on Banko coal effective utilization, coal gasification and synthesis process were selected as principle technology as well as direct use as energy.

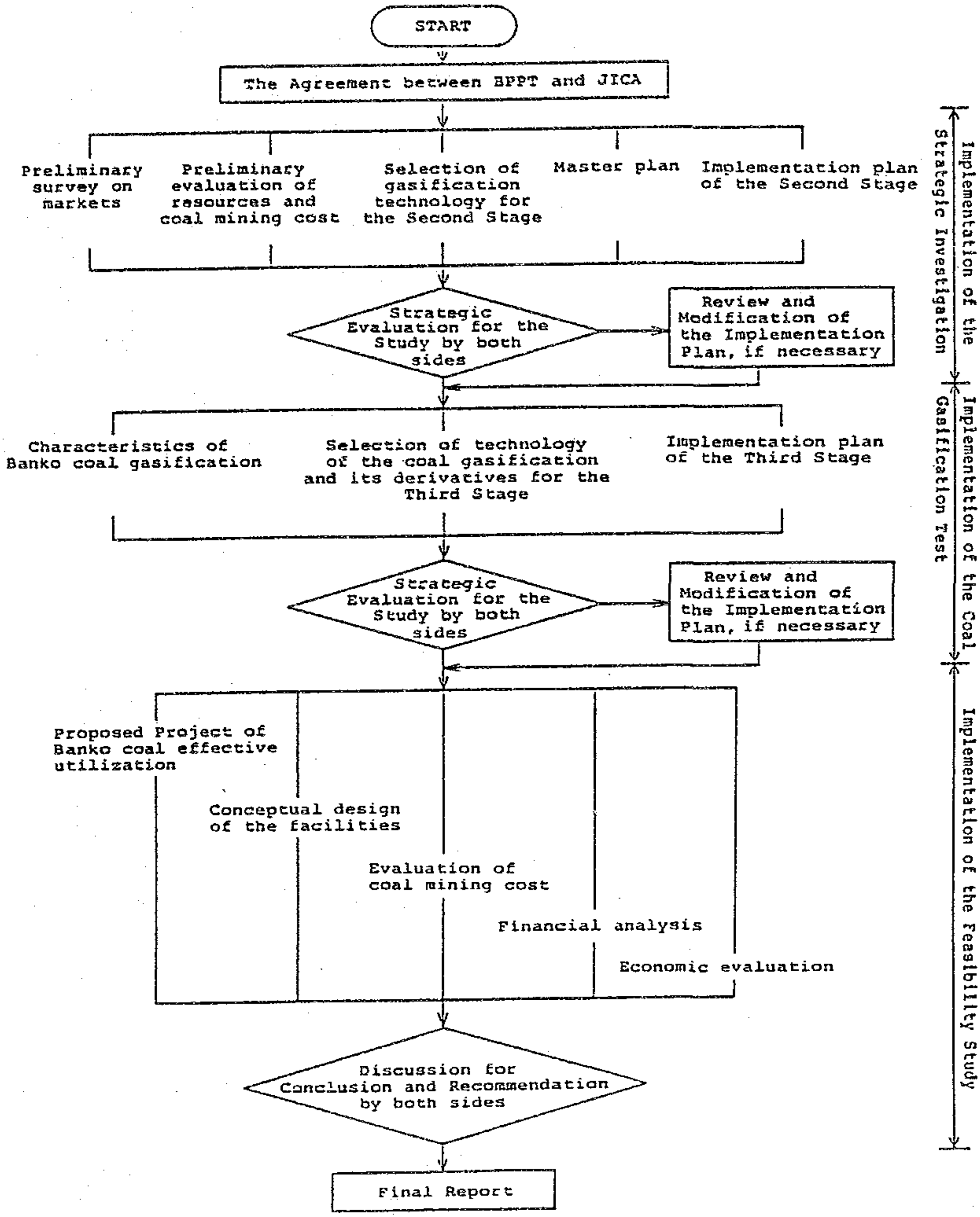


Fig. 4-1 Flow Chart of Implementation Plan

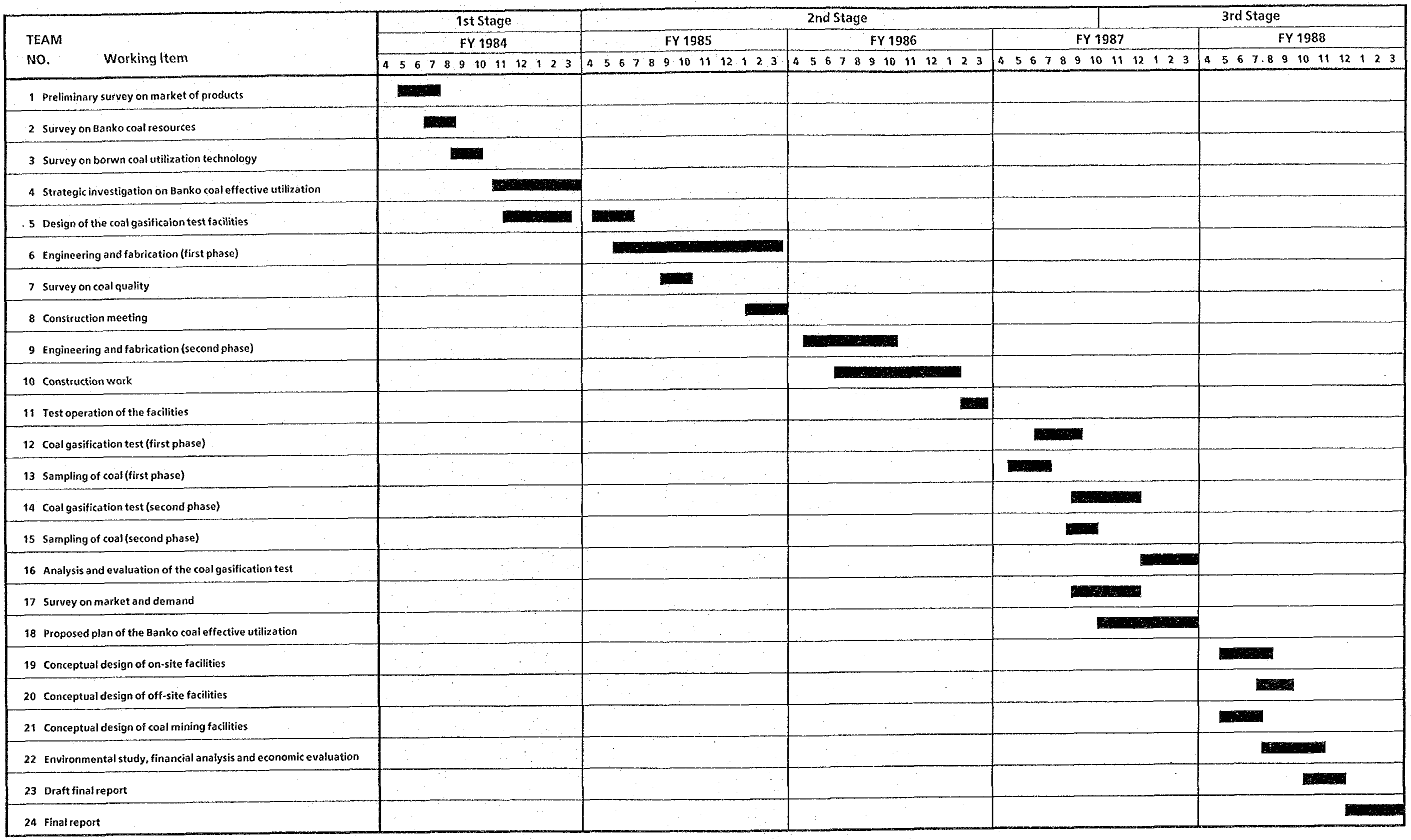


Fig. 4-2 Schedule of the Study

- Banko coal
  - Direct use
    - Conventional combustion
    - Fluidized bed combustion
  - Conversion
    - Gasification and synthesis
    - Gasification and electricity generation

Coke production and direct liquefaction were excluded from scope of study, because there is no technology for coke production from brown coal and direct liquefaction is still at the beginning stage of technical development.

In particular, the study shall put emphasis on survey of coal gasification technology, including coal gasification test, because it is reported by previous study that the type of coal of Banko area varies widely by area and seam, and the coal gasification technology to be selected for the Project must be able to gasify such a wide variety of brown coal without any technical difficulty.

The selection of the coal gasification technology shall also influence on the field of utilization of produced gas, either electricity generation or synthesis of produced gas. The reliability of the technology in commercial operation is also other important factor. Such a study mentioned above shall be deeply investigated through the Study.

4-5-2 Market of Derivatives/Energy Policy

As described in Fig. 2-4, synthetic fuel and basic chemicals such as methanol, gasoline, kerosene, gas oil and urea can be produced by coal gasification and synthesis of produced gas from a technical standpoint.

It is needless to say that the kinds and amount of derivatives to be produced in the Project shall be selected in accordance with the demand in Indonesia, considering some amount of export.

On the other hand, the prices of oil products and urea, which are produced from crude oil and natural gas and compete with the derivatives of the Project, are controlled by the Goverment in a view of the national economic and energy policy.

Therefore, the relation between demand and price of the derivatives must be carefully investigated with the highest priority given to the economic and energy policy of Indonesia.

The endeavors required for the market development of the derivatives shall be also examined in the course of the Study.

4-5-3 Mining Cost and Quality of Coal

Roughly speaking, the production cost of synthesis gas in Japan breaks down to 30% for coal, 20% for oxygen, 20% for facilities and 30% for utilities and others.
Therefore the mining cost is one of important factors for economic and financial feasibility of the Project. It is important to investigate the mining cost of coal as feed stock for gasification, considering geological features, coal seam structure, coal quality, infrastructure required and mining system to be employed.
In particular, the mining system to be applied shall be studied in relation with development of employment opportunities in the Banko area.
Coal quality is another important subject to be investigated because coal quality is one of the key factors for selection of coal gasification technology to be applied in the Project.

4-5-4 Transmigration Policy/Employment Opportunity

The Project has deep relation with trasmigration policy and industrialization policy of Indonesia.
In particular, the development of Banko coal resources and the effective utilization are expected to contribute not only to the production of an alternative energy and basic chemicals but also to the promotion of employment with reasonable working gain for the transmigrants.
In view of national economy, working gain at the transmigration area will be evaluated as benefit for the country.
From the above-mentioned prospects, the design and engineering of the Project should be carried out in such a manner so as to increase employment with minimum investment.

4-5-5 Infrastructure Development Plan of South Sumatra

The infrastructure required for the Project shall be studied in relation with development plans of South Sumatra.
In particular, the development plans related to the expansion project of the BUKIT ASAM shall be studied in detail.
The plant site shall be decided considering the development plans, distance from the transmigration area and the coal mining field as well as other industrial projects in future.
Required infrastructure shall be designed to contribute to and harmonize with the overall development plan of South Sumatra.

The undertaking of the Indonesian Government and the Project for the construction of the infrastructure shall be discussed and clarified in the course of the Study.

5. ENERGY SECTOR OVERVIEW AND POTENTIAL MARKET FOR BROWN COAL AND ITS DERIVATIVES

5-1 BASIC ECONOMIC STRUCTURE AND ECONOMIC POLICY IN INDONESIA

5-1-1 Basic Economic Structure

The world economy has experienced a major stuctural change since the 1970s, mostly due to the two oil crises of 1973-74 and 1978-80, and the decline in the oil prices in the 1980s.

Indonesia, a capital-importing oil exporter, according to IMF classification, was one of those countries which were seriously hit by the changing world petroleum market situations in the 1980s and has had to undergo a series of structural adjustment policies.

Macro-economic indicators for Indonesia have been improving since the 1970s. In fact, the country had been classified as a "low-income economy" in the 1970s by the World Bank. However, it is now classified as a "lower middle-income economy", according to the Bank's World Economic Report 1988. Its per capita GNP (Gross National Product) was US$490 in 1986, which compares favarably with that of the Philippines, i.e., US$560.

The country had been enjoying rapid economic growth up until 1980, and thereafter it had somewhat slowed down. The annual average GDP (Gross Domestic Product) growth rate during the period from 1965 to 1980 was 7.9%: from 1980 to 1986, it dropped to 3.4% due to strains on its petroleum-dependent national economic structure.

Recent GDP growth rate is still slow: it grew at 2.3, 3.2 and 3.2% for years 1985, 1986 and 1987, respectively. The GDP growth rate for the year 1988 is expected to be 3.4%.

Distribution of GDP in Indonesia shows high percentage shares for the mining and manufacturing sectors, which accounted for 17.7% and 13.5%, respectively, of the GDP in 1986 (see Table 5-1-1). The majority of the mining sector contribution to the GDP was made by the crude petroleum and natural gas sectors.

The percentage share for agricultural and other sectors in 1986 were 23.9 and 34.6%, respectively.

However, in terms of the contribution to employment, the mining and manufacturing sectors absorbed only 8.2% of the labor force employed in 1986. The rest of the labor force was absorbed by the agricultural (55.1%) and the other (36.7%) sectors.

The Indonesian economy is highly dependent on external trade. Export dependency rate (percentage share of exports of goods and services divided by GDP) has risen dramatically, from 5% in 1965 to 26% in 1986. Crude oil and petroleum products constitute the core of exports, accounting for more than half of total exports of goods until recently. However, the rate is expected to decline to 43% in the fiscal year 1988/89, reflecting the world oil market situations together with the Government policy to promote non-petroleum exports.

Table 5-1-1 Sectoral Contribution to GDP

	1977	78	79	80	81	82	1983	84	85	86
Agriculture Forestry Fishery	33.6	32.8	32.0	30.7	29.8	29.8	24.0	23.6	24.0	23.9
Mining	12.1	11.0	10.3	9.3	8.9	7.6	19.0	18.9	17.5	17.7
Manufacturing	11.9	12.9	13.7	15.3	15.6	15.4	11.0	12.5	13.2	13.5
Construction	5.2	5.5	5.5	5.7	6.0	6.1	6.2	5.6	5.6	5.4
Transport & Communication	4.8	5.4	5.5	5.5	5.6	5.8	5.4	5.1	5.1	4.9
Other Sectors	32.4	32.4	33.0	33.5	34.1	35.3	34.4	34.3	34.6	34.6
Total	100	100	100	100	100	100	100	100	100	100

Note: There is statistical discrepancy before and after 1983.

Source: Pendapatan Nasional Indonesia, 1983-1985.
Biro Pusat Statistik, Statistik Indonesia: 1987.

5-1-2 Industrialization Policy

The Government of Indonesia has been implementing four consecutive Five Year Plans - Rencana Pembangunan Lima Tahun or "Repelita" - to encourage the Indonesian economy to "take-off" by the end of this century. Repelita I dealt with the urgent needs for stabilization and rehabilitation of the economy in order to establish a base for development. The main objective of Repelita II was to build up foundation for balanced economic growth. Policy goals established under Repelita II included: expanding employment opportunities; raising the level of income while achieving greater equality in income distribution among the various strata of people as well as regions; meeting with basic human needs; improving the nutrition and living standard of the people. The main objective of Repelita III was continued economic development with more equitable distribution of its fruits. Policy goals established under Repelita III included promotion of non-oil exports. During the Repelita III period, continued efforts had also been made toward the goals already established under the previous Repelita II.

In addition to pursuing the policy goals established in the Repelita II and III, on-going Repelita IV (1984/April - 1989/March) emphasizes the achievement of self-sufficiency in food production and industrial development which will activate the industrial base of the economy.

The industrial development policy of Repelita IV will continue under Repelita V and serve as a guideline for any new projects, including the proposed project in this document (hereafter the Project.)

The objectives of the industrial development policy in Repelita IV are:

* Increased opportunity for employment
* Export promotion
* Saving foreign currencies
* Increased regional development
* Utilization of natural resources, energy resources and human resources
* Establishment of equal business opportunities

Policy guidelines set forth by Repelita IV for achieving the above-mentioned targets include:

i) Industrial development should be a harmonized one. The industrial sector and the other sectors should play supplementary roles to each other, thereby developing the economic structure of the country.

ii) The industrial structure should further be strengthened through facilitating close relationships within and among each industry. In addition, domestic industries should be protected by prioritizing the use of domestically produced goods. Moreover, pricing and tax policies shall be utilized to develop small scale industries.

iii) Continued effort in promoting small scale industries should aim at not only providing job opportunities but also increasing the role of value added activities.

iv) The role of the Indonesian people in industrial development should be increased through improving capabilities in the areas of business management, production management methodology and development. Programs for speeding up techonology transfer and developing software capabilities should continuously be promoted.

v) Export promotion should be a national project. Efforts should be made to strengthen international competitiveness in terms of costs, quality and service.

vi) Industrial development program should pursue the shift from an agriculture-based economy to an industry-based one, while realizing autonomous development, prosperity and a fair society.

The target growth rate for GDP was 5.0% under Repelita IV. However, Indonesia had to face the sluggish world petroleum market, which resulted in the decline of petroleum and gas revenue and the accumulated foreign debts. The Government thus had to initiate structural adjustment policies, including: the devaluation of Rupiah in 1983 and 1986, cutting subsidies for petroleum and agricultural products since 1982, and a series of de-regulation of economic activities. The GDP growth rate for the Repelita IV period, therefore, is expected to be below the target growth rate, due to the aforementioned problems and the resultant structural adjustment policies. The task for the next Five Year Plan (Repelita V: 1989/April-1994/March) is not only to solve the problems just mentioned, but also to strengthen the bases for development and prepare for the economic "take-off" which is expected to start with Repelita VI.

It is assumed that the speed of industrialization under Repelita V will be intensified, particularly in export-oriented industries and industries with large employment effects. At the same time, the Government has pledged to encourage the non-fuel export industries and the tourism industry.

The GNP and population growth targets under Repelita V are expected to be 5.0% and 1.9%, respectively, thus pointing to a per capita growth target of 3.1%. The Government considers that the 5.0% economic growth is essential to provide sufficient job opportunities for the labor force which will increase by 2 million persons per year. Of course, feasibility of those targets depends to a great extent on the economic activities of the industrialized countries, exchange rates of key currencies, and world petroleum prices in the period.

5-1-3 Transmigration Policy

Indonesia is a country with a population of over 170 million, of which about 60% resides in Java, an island accouting for 7% of the total land. Thus, the population density in the island is as high as 785 per km^2. About 20% of the population lives in Sumatra, and the balance in the rest of the country, consisting of 13,000 islands.

The transmigration program is construed to be a multi-objective program. First, it is intended to provide land for the landless in Java, Bali, and Lombok thereby improving the population distribution pattern. Second, it aims at providing manpower in labor-scarce areas for production activities in general, and for agricultural production in particular. Third, the transmigration program is considered as a vehicle to promote national stability and integration.

According to the statistics for general transmigration in 1984, 16% of a total of 26,000 families migrated to the southern part of Sumatra, 14% to Central Sumatra, 13% to the southern part of Kalimantan. As for origins, the majority of transmigrants were from eastern and central parts of Java.

During the period of Repelita IV, the Government expects 750,000 families to transmigrate. However, there have been cases of transmigrants abandoning the newly established settlements, due to soil problems, lack of access to market centers, and insufficient social infrastructure.

There are several types of transmigration settlements: 1) food crop 2) fishery 3) plain estate 4) cattle breeding 5) industry and mining 6) defense and 7) agro-forestry.

The Government has concrete programs for settlements for food crop production, and plain estate, and it plans to develop programs for fishery, and cattle breeding. As to the settlements geared toward industry and mining, and defense, the Government intends to formulate concrete programs after the Repelita IV period. Concerning transmigration geared to agro-forestry, no concrete plan has been formulated so far. Implications of the proposed Project "Fuel Methanol Production" for transmigration in the industry and mining sectors will be discussed in detail in Chapter 16.

5-2 ENERGY SECTOR OVERVIEW

5-2-1 Energy Resources

Indonesia is endowed with abundant and varied indigenous energy resources, which provide a wide range of options for meeting her energy requirements, including pertroleum, natural gas, coal, hydropower and geothermal.

(1) Pertroleum

There has been a number of geological assessments of the petroleum resources in Indonesia. In 1985, Pertamina's two experts, Mr. Atik Suardy and Mr. J. Taruno P.H., conducted a re-evaluation of Indonesian petroleum resources. They concluded that a total of 60 hydrocarbon sedimentary basins have been identified with combined estimated reserves of 84.54 billion BOE - 48.4 billion BOE and 36.1 billion BOE of petroleum and natural gas reserves, respectively. Of the 60 basins, 27% is on-shore and 73% is off-shore. Of the on-shore sedimentary basins, 17% is located in difficult terrains. Of the off-shore sedimentary basins, 31% is located in deep sea areas, thus making it difficult to explore resources in these areas. Exploration activities have been conducted in 34 sedimentary basins, out of which 14 basins have been assessed as producing basins.

In 1984, the US Department of Energy estimated that Indonesia's oil in original reserves at 72.1 billion bbl, and the proven recoverable oil reserves at 20.7 billion bbl, leaving proven remaining reserves at 10.1 billion bbl.

The World Bank's "Indonesia: Energy Option Review, 1987", states that the proven recoverable oil reserves of Indonesia is about 20.1 billion bbl of which about 10.6 billion bbl had been produced by 1986, leaving 9.5 billion bbl of proven remaining reserves.

Petroleum production in 1987 was about 1.3 million bbl/d, including condensate, down from 1.58 million bbl/d in 1980 and its peak of 1.69 milllion bbl/d in 1977, due to the gradual depletion of reserves and OPEC production quotas set at about 1.35 million bbl/d, including condensate, or 1.19 million bbl/d excluding condensate as of October 1988.

(2) Gas

The remaining proven natural gas reserves are estimated at 83.1 tcf (trillion cubic feet), located mostly in the South China Sea (the Natuna fields), Kalimantan, and Sumatra. Probable reserves are estimated at 109.1 tcf. Production of natural gas rapidly expanded from 1.05 tcf in 1980 to 1.63 tcf in 1986. The flared portion accounts for only 8% of the total natural gas produced, down from 63% in 1971. Of the total gas produced, over half is for LNG plants (Table 5-2-1).

Table 5-2-1 Utilization of Natural Gas (1986)

(Unit: tcf)

Use	Volume (%)
LNG plants	0.83 (51%)
Consumption in oil and gas fields	0.38 (23%)
Fertilizer plants	0.13 (8%)
Other users	0.16 (10%)
Flared gas	0.13 (8%)
Total	1.63 (100%)

Source: Japan National Oil Corporation, "Recent Status of Oil Exploration and Development"

LNG exports, started in 1977, have steadily icreased to the level of 15 million t, earning US$ 2.9 billion in 1986 (Table 5-2-2).

Table 5-2-2 LNG Exports

Year	Volume of exports (million t)	Value (billion US$)
1982	9.3	2.6
1983	9.8	2.5
1984	15.0	3.4
1985	15.5	3.8
1986	15.3	2.9

Source: Japan National Oil Corporation, ibid.

Given currently sluggish demand growth for LNG in the Far Eastern export markets, future growth in LNG exports is expected to level off. The Government is now considering the expansion of natural gas in the domestic market.

(3) Coal

As of today, Indonesia's total coal resources are believed to be 23.2 billion t, of which about 18 billion t are classified as brown coal. Demonstrated reserves amount to about 2.5 billion t and demonstrated plus inferred reserves amount to about 3.5 billion t (see Table 5-2-3).

Coal reserves are concentrated in south and central Sumatra, and Kalimantan. In south Sumatra, reserves (demonstrated and inferred total) include those in Bukit Asam and the adjacent Muara Tiga and Banko, and have been estimated at 1,371 million t. In central Sumatra, reserves at Ombilin are estimated at 166 million t. The largest reserves are in Kalimantan, where total reserves are estimated at 1,776 million t.

Coal production in Indonesia has been accelerated with the opening of the Ombilin mine in 1892 and the Bukit Asam in 1919. Production level reached 2 million t/y in 1940s. However, due to the substitution of petroleum for coal within and outside of the country in the following years, production level dropped to 150,000 t/y in 1973. The Government started in 1978/79 to rehabilitate its state-owned mines in Ombilin and Bukit Asam.

(4) Hydropower

Indonesia has a large hydropower potential estimated at about 78 GW, of which 32 GW is considered to be economically feasible for development. Out of the total hydropower potential of 78 GW, 0.5~1 GW is small-hydro potential (Note: An installed capacity of 1~19 MW is considered to be small-hydro). The majority of hydropower potential lies in areas remote from the demand centers. Large hydropower potential lies in Kalimantan and Irian Jaya, where electric power demands accounts for only 3.3 and 0.5% of the total, respectively. On the other hand, hydropower potential in Java, where the country's electricity demand is concentrated, accounts for only 5.7% of the total.

Table 5-2-3 Identified[1] Coal Resources of Indonesia

REGION	BASIN/AREA	COAL RESOURCES (million t) Demonstrated	Inferred	Total	Depth (m)
West Sumatra	Ombilin	162.1	4.1	166.4	300
Jambi	Sinamar		109.0	109.0	100
South Sumatra	Bukit Asam:				
	Air Laya	158.8	13.2	172.0	100
	Suban	5.4		5.4	50
	Muara Tiga Kecil	53.7		53.7	
	Muara Tiga Besar	114.7	80.0	194.7	50
	Northwest Banko	129.5		129.5	
	Central Banko	127.5		127.5	
	West-central Banko	178.5		178.5	
	Merkasa		110.0	110.0	50
	Baturaja		150.0	150.0	50
	Mesuji		250.0	250.0	50
	Sub total	768.1	603.2	1371.1	
Kalimantan	Kutai Basin:				
	Loa Kulu	34.9		34.9	300
	Loa Haur	14.8		14.8	300
	Prangat Selatan	120.0	62.6	182.6	300
	Sukakanan	25.6	41.4	67.0	
	Pelarang	109.0	22.6	131.6	
	Kamboja	291.7	112.1	403.8	
	Bukit Merah	114.4	8.0	122.4	
	Badak Tengah	201.3	-	201.3	
	Samarungu	250.6		250.6	150
	Senakin	300.0		300.0	150
	Pasir:				
	Petangis	30.0		30.0	100
	Bindu	32.0		32.0	100
	Betitit	5.0		5.0	100
	Sub total	1529.3	246.7	1776.0	
West Java	Bojongmanik		7.9	7.9	
	Cimandiri		14.5	14.5	
	Bayah		7.9	7.9	
	Sub total		30.3	30.3	
	TOTAL	2459.5	993.5	3453.0	

Note: 1) In addition to demonstrated and inferred resources, Indonesian sources report some 19.7 billion t of hypothetical coal resources, bringing total coal resources to 23.2 billion t.

Source: ADB, ASEAN Coal Development Project, p. 6-63, Manila, March 1985.

Table 5-2-4 Hydropower Potential

Area	Number of Potential Sites	Hydropower Potential (GW)	Potential Share (%)	Electric Power Demand Share (%) (As of 1983)
Sumatra	466	15.8	(20.3)	(11.4)
Java	166	4.4	(5.7)	(79.2)
Kalimantan	178	23.0	(29.6)	(3.3)
Sulawesi	121	11.4	(14.7)	(3.4)
Irian Jaya	208	22.1	(28.4)	(0.5)
Nusa Tenggara & Malaku	176	1.0	(1.3)	(2.3)
Total	1,315	77.7	(100.0)	(100.0)

Source: IEE, Energy Situations in ASEAN Countries, p. 89, IEE-SR183, July 1986. (Original Table is in PLN, Key Issues in the Power Sector Development: Indonesia, 1984.)

Total installed hydropower capacity in Indonesia is about 1.4 GW, out of which about 87% is located in Java. The potential for additional hydropower development in Java lies primarily in a few moderate-size (50~100 MW) sites. Large (500~700 MW) capacity increments are expected only in plants that are already operating or under construction.

(5) Geothermal

Total geothermal resources feasible for development in Indonesia has been estimated at 10 GW, scattered throughout the archipelago. The resources feasible for development are small, compared to the theoretical potential of 75 GW, but are well-distributed. Out of the 10 GW, 5.5 GW can be tapped in Java, 1.1 GW in Sumatra, 1.4 GW in Sulawesi, and 2.0 GW in other areas. Notably, the larger geothermal resources are found in Java and other high-demand areas.

Table 5-2-5 Geothermal Potential by Area

Area	Geothermal Potential (GW)	Share of Electric Power Demand (%) (As of 1983)
Java	5.5	(79.1)
Sumatra	1.1	(11.4)
Sulawesi	1.4	(3.4)
Other Islands	2.0	(6.1)
Total	10.0	(100.0)

Source: IEE, Energy Situations in ASEAN Countries, p. 91 & p. 102, IEE-SR183, 1986, Tokyo.

Until now, only 20 of the 76 prospective geothermal areas have been geologically investigated. Several of the geothermal resources identified have been developed by Pertamina itself, one in cooperation with the Government of New Zealand, and other areas are contracted out to production sharing contractors.

Areas being contracted or being considered for development include:

- Kamojang (West Java): The first unit of 30 MW has been operating since 1982 with development assistance from the New Zealand Government. A project is under way to raise the capacity to 140 MW under a World Bank loan.
- Gunung Salak (West Java): Operated by Union Geothermal, a subsidiary of Union Oil. Potential capacity of 800 MW has been identifed.
- Darajat (West Java): Operated by Amoseas under a Joint Operating and Energy Sales Agreement. Planned capacity is 110 MW.
- Wayang Wihdhu (West Java): The contractor has not been determined.
- Dieng Plateau (West Java): Operated by Pertamina. A 2 MW unit is in operation.
- Lahendong (Bali): Operated by Pertamina
- Banten (West Java): Operated by Pertamina
- Lahendong (North Sulawesi): Operated by Pertamina.
  This area is expected to produce 85 MW.

(6) Uranium Resources

It is believed that uranium resources exist in Kalimantan. An evaluation of these resources will be available by 1990.

(7) A Comparison of Energy Resources Potential

This table summarizes the discussion in this section and to compare the resources potential of various types of energy (Table 5-2-6).

Table 5-2-6 Energy Resources Potential in Indonesia(1)

Resource	Potential Reserve	Proven Reserve	Production (10^6 BOE: 1986)	Proven Reserve/ Production
Oil	72.1 10^9 bbl(2)	9.5 10^9 bbl(3)	459	21
Natural Gas	109.1 10^{12} cf(4) (19.6 10^9 BOE)	80.2 10^{12} cf(5) (14.4 10^9 BOE)	286	50
Coal	23.2 10^9 t(6) (97.4 10^9 BOE)	3.5 10^9 t(7) (14.7 10^9 BOE)	7	2,100
Hydro	77.7 GW(8)	-	21	-
Geothermal	10 GW(9)	-	0.5	-

Notes: (1) Conversion Factors used in this table are as follows:

Natural Gas : 1 million cf = (179.6 BOE)

Coal : 1 t = (4.2 BOE)

(Indonesian Average)

(2) US Department of Energy, 1984.
(3) World Bank, 1987.
(4) Sardjono and Sudja, op. cit.
(5) Sardjono and Sudja, op. cit.
(6) ADB, op. cit.
(7) ADB, op. cit.
(8) IEE, op. cit.
(9) World Bank, op. cit.

It is noted from the Table 5-2-6 that coal reserves exceed the oil or gas reserves. The table also shows the energy production in 1986, including that for export. If no new energy sources are found in the future and if the production level of 1986 be maintained, the proven reserves of oil, natural gas, and coal will be exhausted within 21, 50 and 2,100 years, respectively. Thus, coal could be considered now as the biggest energy resource endowment of Indonesia.

5-2-2 Current Energy Demand and Supply

(1) Primary Energy Production, Imports and Exports by Source

Table 5-2-7 illustrates the salient features of the energy supply and demand structure in Indonesia.

In 1974, most of the primary energy domestically produced was in the form of crude oil, accounting for 92.6% of the total. In 1986, a total of 772.9 million BOE of primary energy was produced, of which 59.3% was crude oil whereas 37.0% was natural gas. Share of coal, hydropower, and geothermal energy supply increased somewhat from 0.9% in 1973 to 3.7% in 1986.

One of the notable features of the energy supply and demand pattern in Indonesia is that the share of energy exports in total energy production has been larger than that of energy consumed domestically. Even though the share of the energy produced for export has been reduced since 1973, it still accounts for over two thirds of the total in 1986. The largest energy export item in that year was crude oil, which constituted 54.8% of total energy exports in terms of common energy unit. It is at the same time noted that non-crude oil energy exports have recently been increasing. In particular, exports of LNG and LPG now accounts for 27.8% of total energy exports in terms of common energy unit.

It is also noted from the table that small amounts of crude oil (Arabian Light) and petroleum products have been imported to meet the domestic demand for kerosene and diesel oil.

A total of 241 million BOE of primary energy was consumed in the domestic market in 1987, which is about three times that of 1974. Primary energy consumption grew at around 10% per year during the period from 1974, to 1984, but the annual growth rates in the last several years have declined.

Diversification of energy sources for primary energy requirements has also been accelerated. Petroleum accounted for 89.2% in 1973, whereas in 1986 the share of petroleum was reduced to 67.4%. The growth of domestic demand for petroleum in the last several years has been leveled off mainly because of a price increasing policy by the Government.

On the other hand, demand for non-oil energy resources has also been increased, from 5.4% in 1974 to 22.3% in 1986 for natural gas, from 1.0% to 1.4% for coal, from 4.4% to 9% for hydropower and geothermal power.

Table 5-2-7 Trend of Energy Demand and Supply in Indonesia

(Unit: 10^3 BOE)

	1974	1984	1985	1986
I. Production				
Primary Energy Production	(%)	(%)	(%)	(%)
Oil	501,838 (92.6)	468,513 (62.1)	431,238 (59.0)	458,736 (59.3)
Gas	35,489 (6.5)	266,862 (35.4)	277,134 (37.9)	285,712 (37.0)
Coal	873 (0.2)	4,149 (0.5)	5,952 (0.8)	6,923 (0.9)
Hydro	3,648 (0.7)	14,712 (1.9)	15,829 (2.2)	21,090 (2.7)
Geothermal		447 (0.1)	429 (0.1)	464 (0.1)
Total	541,848 (100.0)	754,683 (100.0)	730,582 (100.0)	772,925 (100.0)
Secondary Energy Production				
Electricity	5,308	28,914	31,744	33,849
II. Consumption				
Primary Energy Consumption	(%)	(%)	(%)	(%)
Oil	73,931 (89.2)	164,144 (72.4)	164,706 (70.3)	162,319 (67.4)
Gas	4,507 (5.4)	45,672 (20.1)	50,376 (21.5)	53,688 (22.3)
Coal	797 (1.0)	1,816 (0.8)	2,803 (1.2)	3,396 (1.4)
Hydro	3,648 (4.4)	14,712 (6.5)	15,828 (6.8)	21,090 (8.8)
Geothermal		447 (0.2)	429 (0.2)	464 (0.2)
Total	82,883 (100.0)	226,791 (100.0)	234,143 (100.0)	240,957 (100.0)
Secondary Energy Consumption				
Electricity	4,913	25,388	26,249	29,239
Final Energy Consumption by Sector	(%)	(%)	(%)	(%)
Industry	24,149 (29.1)	88,580 (39.1)	92,373 (39.5)	92,735 (37.7)
Transportation	25,466 (30.7)	55,469 (24.5)	57,381 (24.5)	61,845 (25.1)
Household	26,769 (32.3)	45,953 (20.3)	44,814 (19.1)	45,175 (18.3)
Electricity	6,499 (7.8)	36,789 (16.2)	39,575 (16.9)	46,627 (18.9)
Total	82,883 (100.0)	226,791 (100.0)	234,143 (100.0)	246,382 (100.0)
III. Export	(%)	(%)	(%)	(%)
Crude Oil	378,905 (95.7)	320,679 (57.2)	257,564 (52.3)	289,613 (54.8)
Petroleum Products		66,012 (11.8)	47,329 (9.6)	52,753 (1.0)
LNG & LPG	16,910 (4.3)	138,301 (24.6)	147,331 (29.9)	146,794 (27.8)
Condensate		33,655 (6.0)	37,510 (7.6)	37,806 (7.1)
Coal		2,416 (0.4)	2,780 (0.6)	1,906 (0.4)
Total	395,815 (100.0)	561,063 (100.0)	492,514 (100.0)	528,872 (100.0)
IV. Import	(%)	(%)	(%)	(%)
Crude Oil		34,172 (87.2)	32,361 (92.2)	27,713 (83.7)
Petroleum Products	12,792 (100.0)	5,025 (12.8)	2,731 (7.8)	5,392 (16.3)
Total	12,792 (100.0)	39,197 (100.0)	35,092 (100.0)	33,105 (100.0)

Source: Department of Mines and Energy, "Statistik Energi. Indonesia: 1987"

(2) Energy Demand by Sector

Table 5-2-7 also shows secondary energy consumption by demand sector. In 1986, energy consumption by industrial, transport, household and power sectors accounted for 37.7, 25.1, 18.3 and 18.9%, respectively. The transportation and household sectors are reducing their share and the industrial and power generation sectors show an upward trend.

The table does not take into account the consumption of traditional sources of energy, such as firewood, charcoal and agricultural residues, which are widely used in residential and small industry sectors in rural areas. If the consumption of traditional sources of energy were considered, the share of the residential sector in total energy consumption would be much larger.

1) Power Sector

The electric power generation sector consists mainly of:

- PLN, the public utility primarily responsible for all generation, transmission and distribution of electricity in the country;
- Captive plant installation primarily for industrial purposes; and
- Small municipal and cooperative franchises.

Total electric power generation capacity at the end of 1986/1987 was 11,678 MW, of which PLN accounted for 6,082 MW. The balance, 5,596 MW was in plants outside PLN.

Of PLN's electric power generation capacity, almost 60% is provided by oil-firing plants, generating power through gas turbines, diesel or steam power plants. Hydropower plants account for 22% of total PLN capacity. About 13% of PLN's electric power capacity is coal. Shares of natural gas and geothermal are 3 and 2%, respectively (Table 5-2-8).

Table 5-2-8 Electricity Generation Capacity of PLN in 1987/88

(Unit: MW)

Plant type	Java	Outside Java	PLN total	(Share)
Hydropower	1,235	182	1,417	(22.1%)
Diesel				
Distillate Oil	0	1,420	1,420	(22.1%)
Steam				
Residual Oil	1,475	180	1,655	(25.7%)
Natural Gas	0	0	0	(0.0%)
Coal	800	65	865	(13.5%)
Gas turbine				
Distillate Oil	550	183	733	(11.4%)
Natural Gas	80	111	191	(3.0%)
Geothermal power plant	140	0	140	(2.2%)
Combined Cycle	0	0	0	(0.0%)
Total	4,280	2,141	6,421	(100.0%)

Source: PLN, February 1988.

2) Transport Sector

Petroleum products provide for virtually all of the energy consumed by the transport sector in Indonesia. According to the estimation by the UN Statistical Office, the sector accounted for about 40% of total consumption of petroleum products in 1984.

It is estimated that road transport accounts for around 60% of energy consumed in the sector. Inland and coastal waterways transport is the second most important mode in terms of fuel usage, accounting for about 30% of total sectorial consumption. Air accounts for 10%. Railway system exists in Java and Madura, and in Sumatra, running with coal-driven locomotives. However coal consumption by railway accounts for less than 1% of total sector consumption.

The number of vehicles is growing rapidly, and in 1986 there were over a million cars, 257,000 buses, 882,000 trucks, and more than 5 million motor cycles registered. In addition, a large number of human-propelled pedicabs (becak) and animal-drawn carts are used.

The road system has expanded drastically since early 1970s, especially those under the responsibility of regencies, and in 1987, there were 2.3 million km of roads. Nevertheless, about 40% of them were classified as "damaged" or "heavily damaged".

3) Industry sector

The industrial sector has been one of the fastest-growing sectors since the early 1970s. During the period from 1974 to 1982, GDP contribution at constant price by the manufacturing and construction industries grew at about 12 and 11% per year, respectively, significantly higher than the annual GDP growth for this period, 6.8%. The manufacturing industry's high growth has been maintained since 1982. Its growth rate during the period from 1983 to 1986 was 10%, whereas the annual GDP growth was 3.8%. Consequently, energy consumption by the industry sector grew rapidly.

In 1986, the total industrial commercial energy consumption amounted to 92.7 million BOE (18.6 million TCE). Of the 92.7 million BOE, an estinated 20% was consumed by energy-intensive heavy industries, such as fertilizers, iron and steel. Roughly 10% was consumed by refineries and LNG/LPG plants, and the rest by other industry and construction.

In 1984, petroleum products accounted for 64% of the commercial energy consumption by the sector. A significant part of industrial diesel oil consumption involved generating electricity in captive plants. Natural gas accounted for about 30% of the total commercial energy consumption by the sector, of which the bulk was consumed in the fertilizer and cement industry. Coal accounted for less than 2% of the total industrial consumption. The current share of coal in the industry sector should be larger than 2%, due to the recent fuel substitution in the cement industry.

4) Household Sector

In 1986, commercial energy consumption by the household sector, including agriculture and other usage such as commercial and public buildings, amounted to 45.1 million BOE (9 million TCE).

Of the 45.1 million BOE, 83% was in the form of kerosene, 16% in the form of electricity, and the rest in LPG and city gas. Use of briquette is not common.

The number of households which have access to electricity for lighting is still limited, and a large number of the population is still relying on kerosene and other sources such as candles (see Fig. 5-2-1).

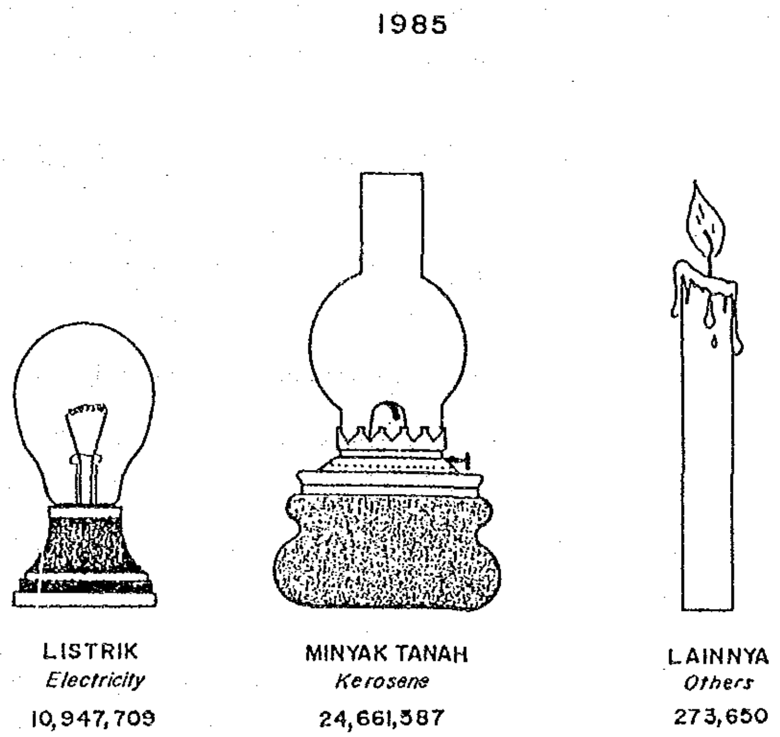


Fig. 5-2-1 Number of Households by Fuel for Lighting

Source: Biro Pusat Statistik, Statistik Indonesia: 1987, p. 119, 1988, Jakarta.

For cooking and agricultural processing, traditional fuels such as firewood and agricultural residue are widely used. Household traditional-energy consumption is estimated to be twice as large as the sector's commercial energy consumption.

5-2-3 Current Energy Policy

Indonesia's energy consumption level is not so high when compared with those of industrialized countries such as the USA (7.82 TOE/capita in 1987) and Japan (3.31 TOE/capita in 1987). However, the rapid economic growth in the 1970s, particularly that of the industrial sector, coupled with steady population growth, brought about the increased demand for energy resources, particularly for petroleum products. The increased petroleum consumption in the domestic market will reduce oil export potential, meaning less foreign currency earnings will be available for economic development in the future. Consequently, in the late 1970s, the Government of Indonesia embarked on an ambitious program to divert domestic energy consumption away from crude oil while maximizing the oil available for export. It was in this context that the Government established four basic energy policy guidelines as follows:

i) <u>Intensification</u> in the exploration and development effort for all energy resources.

ii) <u>Diversification</u> of the energy sources used to meet the rapidly growing domestic demand, thereby conserving oil for export.

iii) <u>Conservation</u> in the use of energy consumed domestically.

iv) <u>Indexation</u> of the best and most efficient energy source for each particular energy demand.

Following with these guidelines, the Government has been implementing various policies, including those described below.

(1) Relaxation of Government Control in Exploration and Development of Energy Resources.

The basic philosophy of the Government of Indonesia concerning exploitation and development of natural resources is stated in Article 33 of the 1945 constitution as follows:

"All the rights in the soils and waters are under the jurisdiction of the State and shall be utilized for the greatest welfare of the nation."

In addition, Law No. 44 of 1960 stipulates that:

"Petroleum and natural gas as national resources are controlled by the State and can only be exploited by the State through State enterprises."

"The Minister may appoint other parties as contractors for State enterprises, if required, for the execution of operations which can not or can not yet be executed by State enterprises."

The Government of Indonesia has been taking various measures to intensify and accelerate the exploration and development of energy resources in general, and petroleum resources in particular, within the aforementioned legal framework.
As regards petroleum resources, the identification of additional reserves has attracted and encouraged foreign contractors to continue and/or initiate efforts concerning exploration and development of oil resources.
The Government measures to support this trend include:

1) Change in Granting Government Authorization for Procurement of Materials by Production Sharing Contractors

   Previous authorization by MIGAS and SECNEG as well as Pertamina was necessary for procurement of materials valued at over 100 million Rupiah by subcontractors of Pertamina.
   As of 1987, such procurement requires only the authorization by Pertamina, thereby simplifying the procedure for exploration and development activities.

2) Extension of Production-sharing Contract Periods

   Many production-sharing contracts will expire before the turn of the century. The Government is now considering the extension of such production-sharing contracts to maintain production as well as exploration efforts by the subcontractors.

3) Awarding New Production-sharing Contracts

   To encourage exploration and development in the deep-sea and more remote on-shore areas, Pertamina has been granting more production sharing contracts to foreign subcontractors than before.

4) Joint EOR Projects

   Until recently, enhanced oil recovery (EOR) in the Pertamina-operated fields was primarily carried out by Pertamina, and only a few foreign contractors were invited to enter into joint ventures concerning EOR. The Government is now promoting foreign participation in the EOR projects in the Pertamina-operated fields.

In the coal sector, the Government has awarded contracts to ten foreign mining companies for exploration work in Kalimantan since 1981. Several of the identified coal deposits on Kalimantan are now being evaluated.

(2) Energy Pricing Policy

The status of energy pricing policies for petroleum products is an area of great interest, in view of their implications in substituting alternative energy sources for petroleum products.

The domestic prices of eight petroleum products (AVGAS, AVTUR, super gasoline, premium gasoline, kerosene, ADO, IDO and fuel oil) have been set by the Government. These prices could be considered "depot prices". The depot price of a petroleum product is identical for each demand area. Pertamina is responsible for production, processing and distributing these products to the domestic market. If the income from the sale of these products does not meet costs (including crude, refining, storage, transportation and marketing), the Government makes direct subsidies to Pertamina to cover the difference.

Following the sharp rise in crude prices in 1973, Pertamina's estimate of the cost of providing these products began to outstrip income from sales. In FY 1977/1978, the Government provided the US$ equivalent of $77 million to Pertamina to offset unrecovered costs. By FY 1981/82, the subsidy had surpassed the US$ equivalent of $2 billion, 10.8% of the Government budget. In an effort to gain control of the situation, domestic retail prices were increased in January 1982 (by 58% on a weighted average basis), January 1983 (by 53%), and again in January 1984 (by 16%). In addition, the ten per cent value-added tax was introduced on April 1985, which also had the effect of raising petroleum product prices.

However, in 1986, the Government lowered petroleum products prices to reflect the drop in international oil prices. Nonetheless, the Indonesian public did not receive the full benefit of the fall in energy prices. In spite of the over-60% drop in international crude oil prices from 1985 to 1986, prices of gasoline and kerosene were unchanged in Indonesia. The prices of Avgas, Avtur, automotive diesel, industrial diesel oil and fuel oil declined by 24%, 24%, 17%, 9%, and 9%, respectively (Table 5-2-9).

Table 5-2-9 Prices of Petroleum Products in Indonecia

(Rp/ℓ)

Products	May 3 1979	May 1 1980	Jan 4 1982	Jan 7 1983	Jan 12 1984	Apr 1 1985	Jul 10 1986	1985/1986 (% change)
Avgas	100	150	240	300	300	330	250	−24
Avtur	100	150	240	300	300	330	250	−24
Super Gasoline	140	220	360	400	400	440	440	0
Premium Gasoline	100	150	240	320	350	385	385	0
Kerosene	25	37.5	60	100	150	165	165	0
Automotive Diesel Oil	35	52.5	85	145	220	242	200	−17
Industrial Diesel Oil	30	52.5	85	145	200	220	200	−9
Fuel Oil	30	45	75	125	200	220	200	−9

Source: US Embassy to Indonesia, Jakarta, "The Petroleum Report Indonesia", July 1987

Thus, the adjustment of petroleum product prices in the domestic market is not a one-time policy decision. A series of price increases has had two obvious effects, i) to reduce the subsidy and ii) to dampen demand. As for reducing the subsidy as a whole, the adjustment has been successful as is indicated in Table 5-2-10.

Concerning the price effect on demand, quantification is rather difficult, as the reduction in the demand for petroleum products coincided with the slow economic growth of that period. Nevertheless, the higher product prices seem to have contributed to lowering the demand in general, and encouraging some users to switch to other sources of energy.

Table 5-2-10 Consumption of Petroleum Products and Subsidies

Financial Year	Consumption of Petroleum Products (10^3 kl)	Subsidy Billion Rp	Subsidy Million US$
1978/79	NA	197.0	394.0
1979/80	NA	535.0	853.3
1980/81	NA	1,021.7	1,629.5
1981/82	25,270	1,316.4	2,056.2
1982/83	28,168	961.5	1,413.9
1983/84	26,300	928.1	938.7
1984/85	27,000	1,147[1]/506.7[2]	480.3
1985/86	26,200	532.3[1]/374.2[2]	598.8
1986/87	25,800	Nil	Nil
1987/88	24,920	Nil	Nil

1) Original budget estimate

2) Revised budget estimate

Source: US Embassy to Indonesia, Jakarta, "The Petroleum Report Indonesia", July 1987

Attempts toward lowering or maintaining petroleum products prices to reflect world market fluctuations is a delicate problem. On the one hand, the Government has the long term policy to diversify energy sources in the domestic market. Higher petroleum product prices in the domestic market will encourage more efficient utilization of such products and also accelerate the utilization of other alternate sources of energy, such as natural gas and coal. On the other hand, the effects of raising domestic prices has been the object of some concern, with debate centering on such issues as:

i) Social equity problems -- Higher kerosene prices might principally affect the poor, who rely on kerosene for cooking and lighting and can not afford to select alternate energy sources such as LPG and electric power. In addition, higher diesel oil prices might hit rural populations which are not covered by the electricity grid, and which have to rely on small diesel-based private generation plants.

ii) Environmental implications -- Higher kerosene prices might cause the demand to shift toward firewood, thereby accelerating the deforestation problem.

iii) Competitiveness of industries -- Manufacturers who pay higher cost for industrial diesel and fuel oil have to incorporate these increases into production costs, and, therefore, might be at a disadvantage vis-a-vis their competitors in other countries.

Consequently, the Government has been cautious in resorting to energy pricing policy as a measure to control the demand for petroleum products. It is the belief of the Government that the future energy pricing policy should be a balanced one, paying due attention to the welfare of the Indonesian people and at the same time accelerating the efficient use of energy.

(3) Energy Conservation Policy

In addition to the upward adjustment in petroleum product prices, the Government has been promoting energy conservation measures including:

i) Identification of potential energy savings by sector

ii) Provision of information and educational programs

iii) Establishment of an energy conservation center

Concerning the sectorial identification of potential energy savings, several studies and surveys have been conducted, including:

i) A study on "Policies and Programs for the Conservation of Energy/Petroleum Products in the Transport Sector," prepared by the Ministry of Communications in 1981.

ii) A study on a number of large establishments in industrial, transport and power sectors, conducted under the French-Indonesian Cooperation Program in 1984.

These studies provided indications of the magnitude of savings that could be realized in energy-consuming sectors if energy conservation programs were implemented. For example, the study under the French-Indonesian Cooperation Program estimated that more than 20% of total energy consumed in 67 major industrial plants could be saved through conservation measures. Of this amount, one-third could be saved in the short run through better housekeeping measures and improved operation practices, and the rest in the medium term through modest plant investments.

Being aware of the energy saving potential, the Government has been providing information to consumers through a periodic bulletin ("Energy Dan Kita") which contains practical energy conservation techniques. Efforts have also been made by PLN in giving information to customers on how to conserve electric power and by Damri, a public bus company encompassing all the major cities of Indonesia other than Jakarta, in providing its drivers with a course on fuel-saving measures. The Government's policy of levying taxes on and restricting importation of vehicles also has some conservation effects. In addition, the Government of Indonesia, through the Presidential decree No. 9 of 1982, has issued instructions for energy conservation, particularly in government buildings. Recommendations for energy conservation measures related to lighting, air conditioning, machinery and office equipment were also issued.

Despite various measures already taken to achieve energy conservation, there is still a need for a comprehensive and yet more user-specific program together with a mechanism for its regulation. It is in this context that the Government is now developing a comprehensive energy rationalization program. One of the components of this program is to establish, with World Bank assistance, the Energy Conservation Center (KONEBA) to assist in reducing energy costs through conservation and rationalization activities. It is expected the KONEBA will be the focal entity for all energy conservation activities in Indonesia.

5-3 PROSPECTS FOR ENERGY DEMAND AND SUPPLY

5-3-1 Demand and Supply for the Future

(1) Main Assumption for Forecasting

Future demand for energy in Indonesia is forecasted in a report titled "Energy Strategies, Energy R&D Strategies and Techonology Assessment for Indonesia" prepared by the Indonesian Government and the German Government (Hereafter BPPT report). There are two scenarios, namely high scenario and low scenario. The high scenario means high price of crude oil and high rate of economic growth. The low scenario means low price of crude oil and low rate of economic growth.

Oil prices of both scenarios are shown in Fig. 5-3-1. Future crude oil price are estimated as follows.

YEAR	(H)	(L)
2000	28 $/bbl	21 $/bbl
2005	36	25
2010	45	29

Average growth rate of GDP is shown in Table 5-3-1 and 5-3-2. In addition to two scenarios, two cases are set in the BPPT report in order to reach the optimal supply of energy (see Fig. 5-3-2). One is the "the cost minimization case" and another "the reduced oil use case".

Future demand for energy is calculated according to these two scenarios and two cases, and four sets of figures on demand for energy are forecast in the report.

(2) Primary Energy Consumption

Primary energy consumption is the sum of domestic production plus energy imports minus all energy exports. Table 5-3-3 shows the primary energy consumption for the two scenarios and the two cases.

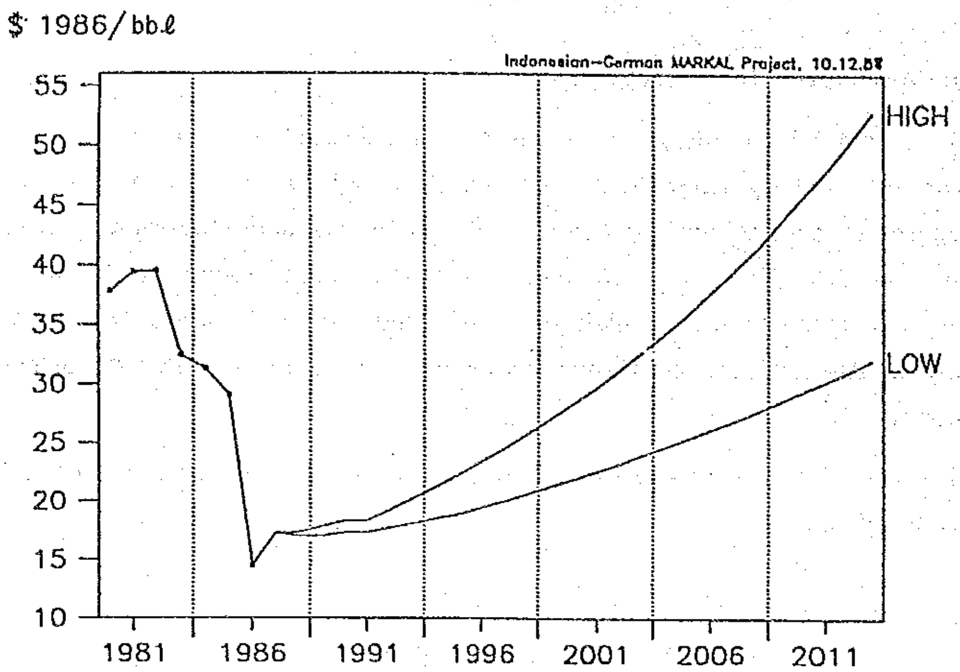


Fig. 5-3-1 Oil Export Price ($1986 per barrel)

Table 5-3-1 High Scenario-Average Annual Growth Rate (%) of the GDP and its Components

Repelita	IV 1984-89	V 1989-94	VI 1994-99	VII 1999-04	VIII 2004-09	IX 2009-14
Private Cons.	3.7	4.5	4.8	5.1	5.2	5.3
Govern. Cons.	2.8	4.5	4.8	4.9	4.9	5.0
Investments	0.8	4.3	4.6	4.8	4.8	4.9
Exports	−3.0	4.0	4.4	3.7	3.7	3.6
Imports	−2.4	3.5	3.8	4.3	4.5	4.7
GDP	3.0	4.5	4.8	4.9	4.9	5.0
GDP/capita	0.8	2.3	2.7	2.8	2.9	3.0

Table 5-3-2 Low Scenario-Average Annual Growth Rate (%) of the GDP and its Components

Repelita	IV 1984-89	V 1989-94	VI 1994-99	VII 1999-04	VIII 2004-09	IX 2009-14
Private Cons.	3.6	3.8	3.7	3.7	3.2	2.9
Govern. Cons.	2.6	3.5	3.5	3.5	3.0	2.8
Investments	0.6	3.4	3.4	3.4	2.9	2.7
Exports	−4.6	1.8	2.2	2.0	2.1	2.0
Imports	−2.6	2.8	2.8	3.0	2.5	2.3
GDP	2.6	3.5	3.5	3.5	3.0	2.8
GDP/capita	0.4	1.4	1.4	1.4	1.0	0.8

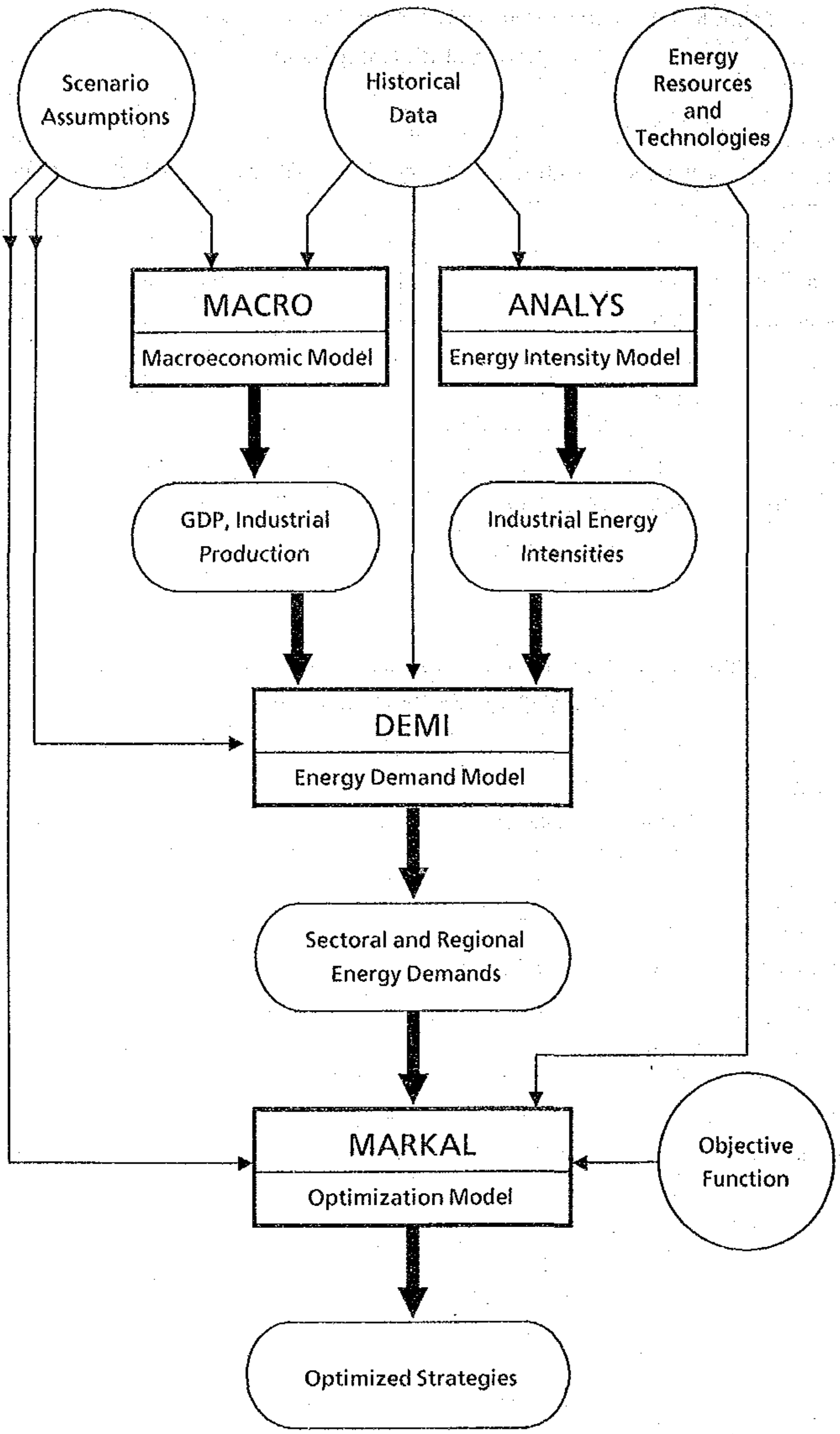


Fig. 5-3-2 Principle Execution Flow Chart

Table 5-3-3 Domestic Primary Energy Consumption

(H Case, Minimum)

(Unit : 1,000 TOE)

	1986	1991	1996	2001	2006	2011
OIL	27,467.9	32,747.9	35,489.9	38,376.0	43,072.6	47,836.8
PETROCHEMICAL	284.1	631.7	969.7	1,328.7	1,715.3	2,218.7
GAS	8,589.7	10,578.8	16,167.7	22,884.6	25,267.6	25,151.7
COAL & COKE	898.2	3,892.0	5,031.3	5,991.4	12,588.5	30,986.3
HYD. + GEO.	1,905.9	3,093.8	4,580.2	6,294.4	9,123.2	10,652.4
BIOMASS	25,946.4	28,348.5	30,730.3	33,409.7	36,048.9	38,729.9
TOTAL	65,092.2	79,292.7	92,969.1	108,284.8	12,7816.1	15,576.0

(L Case, Minimum)

(Unit : 1,000 TOE)

	1986	1991	1996	2001	2006	2011
OIL	26,712.9	31,439.5	34,068.5	34,022.4	36,243.5	37,245.7
PETROCHEMICAL	280.6	599.9	882.8	1,148.1	1,386.2	16,33.3
GAS	8,530.4	10,231.9	13,826.1	19,882.9	22,304.6	21,161.8
COAL & COKE	1,543.2	3,760.3	4,805.2	5,490.8	6,983.7	18,595.0
HYD. + GEO.	1,905.9	3,093.8	4,225.8	5,309.0	6,737.3	8,915.3
BIOMASS	25,938.5	28,272.8	30,498.3	32,946.9	35,420.3	37,673.8
TOTAL	64,911.4	77,398.2	88,305.7	98,800.2	10,9075.5	12,5225.0

(H Case, Reduced)

(Unit : 1,000 TOE)

	1986	1991	1996	2001	2006	2011
OIL	26,735.3	30,415.7	30,677.3	31,985.4	33,108.1	38,323.5
PETROCHEMICAL	284.1	631.7	969.7	1,328.7	1,738.7	2,218.7
GAS	8,654.1	12,287.4	19,529.0	2,726.3	30,393.9	30,496.5
COAL & COKE	1,549.7	3,907.9	5,249.7	6,901.7	16,744.4	35,596.7
HYD. + GEO.	1,905.9	3,093.8	5,239.9	6,833.5	9,893.2	10,832.7
BIOMASS	25,951.6	28,372.1	30,800.2	33,550.1	36,198.4	38,861.2
TOTAL	65,080.7	78,708.5	92,465.7	83,325.8	128,076.8	156,329.3

(L Case, Reduced)

(Unit : 1,000 TOE)

	1986	1991	1996	2001	2006	2011
OIL	26,629.2	2,9081.3	29,674.9	28,620.9	27,613.6	28,153.7
PETROCHEMICAL	280.6	599.9	882.8	1,148.1	1,386.2	1,633.3
GAS	8,603.5	11,905.0	17,239.0	23,631.7	27,350.6	27,985.7
COAL & COKE	1,543.2	3,767.5	4,822.4	5,538.7	11,036.0	19,367.1
HYD. + GEO.	1,905.9	3,093.8	4,437.7	5,920.4	7,418.9	9,273.2
BIOMASS	25,938.5	28,317.7	30,765.1	33,479.1	36,111.8	38,700.7
TOTAL	64,900.9	76,765.2	87,821.9	98,338.8	11,0917.0	12,5113.8

In both cases, domestic energy consumption increases at 3.5 %/y in H scenario during the projection period, while at 2.7 %/y in L scenario. Comparing with the minimum cost cases, in the reduced oil use case, the domestic consumption is by definition 15% lower. These amounts of oil are substituted by other energy sources except biomass. Therefore the share of crude oil consumption drops from about 41% (1986) to about 30% (2011) for the minimum cases and from about 23% to 25% for the reduced oil use cases.
Among energy sources, coal indicates the highest growth rate of 10.6% to 13.4% in reduced oil use case while 10.5% to 12.5% in minimum cost case. Hydro power and geothermal show secondly high growth rate of 6 to 7 %/y in both cases. Gas will grow moderately at 4 to 5 %/y in both cases. Biomass keeps the highest share among energy sources, but grows by the lowest rate of around 1.5 %/y.

(3) Final Energy Consumption

Final energy consumption is composed of these energy sources which are consumed by end use technology to be converted to useful energy. These energy sources include fuel wood, gas, LPG, refined products, coal, briquettes and electricity.
Table. 5-3-4 shows the prospects of final energy consumption. From 1986 to 2011, the average growth rate of them is on the range of 3.1 %/y (H scenario) and 2.3 %/y (L scenario) in both cases.

1) Biomass

The biggest share of the final energy is represented by biomass. The share will decline from 50.3% in 1986 to 41% in 2011 in the L scenario and it is reduced to only 35.3% in 2011 in the H scenario. The consumption of biomass will slightly increase with annual growth rate of 1.6% in both scenarios. The consumption of biomass is mainly in various small households for cooking and small industries, which produces heat and steam. Though the consumption of biomass will decline, it will continue to play an important role in rural areas especially outside Java. Table 5-3-5 shows the biomass consumption by region in H scenario of reduced oil use case. Even outside Java, in some densely populated destricts in Sumatera and south Sulawesi, firewood is becoming scarce.
Conserving biomass fuels is one of the most important policy issues to preserve environments particularly in Java.

Table 5-3-4 Final Energy Consumption

(High Scenaro, Minimum Cost Case)

	1986	(%)	1991	(%)	1996	(%)	2001	(%)	2006	(%)	2011	(%)	1986-1990 (%/y)	1991-2001 (%/y)	2001-2011 (%/y)
Coal & Coke	527.5	1.0	1,296.7	2.1	2,148.4	3.1	3,045.7	3.8	4,431.6	4.7	6,513.9	5.9	19.7	18.6	16.4
Gasoline	3,422.9	6.6	4,463.9	7.3	5,375.4	7.6	6,367.9	7.8	7,489.2	8.0	8,833.8	8.1	5.5	7.4	6.8
Kerosene	6,747.3	13.1	7,546.0	12.3	7,936.8	11.3	8,530.1	10.5	9,061.6	9.7	9,353.8	8.5	2.3	2.5	1.9
ADO+IDO	5,594.0	10.8	7,032.1	11.5	8,248.2	11.7	9,634.8	11.9	11,356.5	12.1	13,215.2	12.1	4.7	6.5	6.5
Fuel Oil	1,191.4	2.3	1,273.8	2.1	1,507.2	2.1	1,786.6	2.2	2,129.5	2.3	2,725.9	2.5	1.3	7.0	8.8
LPG	272.4	0.5	314.2	0.5	363.2	0.5	427.7	0.5	504.3	0.5	593.3	0.5	2.9	6.4	6.8
Petrochemicals	284.1	0.6	631.7	1.3	969.7	1.4	1,328.7	1.6	1,715.3	1.8	2,218.7	2.0	17.3	16.0	10.8
Gas	4,726.0	9.2	6,281.0	10.2	7,387.4	10.5	8,834.1	10.9	10,447.3	11.1	12,562.8	11.5	5.9	7.1	7.3
Lubricants	163.5	0.3	209.8	0.3	260.0	0.4	321.4	0.4	393.6	0.4	485.0	0.4	5.1	8.9	8.6
Biomass	25,946.7	50.3	28,348.5	46.2	30,730.3	43.7	33,409.5	41.2	36,049.2	38.4	38,729.9	35.3	1.8	3.3	3.0
Electricity	200.9	5.2	3,936.9	6.4	5,379.1	7.7	7,452.5	9.2	10,302.7	11.0	14,378.1	13.1	7.8	13.6	14.0
Total	51,576.5	100	61,334.5	100.0	70,305.7	100.0	81,139.1	100.0	93,880.8	100.0	10,9610.3	100.0	3.2	5.8	6.2

(Low Scenario, Minimum Cost Case)

[Unit: 1,000 TOE]

	1986	(%)	1991	(%)	1996	(%)	2001	(%)	2006	(%)	2011	(%)	1986-1990 (%/y)	1991-2001 (%/y)	2001-2011 (%/y)
Coal & Coke	520.9	1.0	1,165.0	1.9	1,921.8	2.9	2,545.3	3.4	3,397.0	4.1	4,707.0	5.1	17.5	16.9	13.1
Gasoline	3,417.8	6.6	4,323.7	7.2	4,801.9	7.1	5,085.2	6.8	5,694.2	6.8	6,221.2	6.8	4.8	3.3	4.1
Kerosene	6,744.5	13.1	7,538.7	12.5	7,885.6	11.7	8,465.9	11.3	8,949.4	10.7	9,046.2	9.9	2.3	2.3	1.3
ADO+IDO	5,584.0	10.8	6,823.9	11.3	7,608.8	11.3	8,338.4	11.1	9,000.4	10.8	9,449.1	10.3	4.1	4.1	2.5
Fuel Oil	1,189.0	2.3	1,256.5	2.1	1,460.0	2.2	1,690.8	2.2	1,946.6	2.3	2,314.5	2.5	1.1	6.1	6.5
LPG	272.1	0.5	312.1	0.5	475.6	0.7	743.3	1.0	681.9	0.8	554.8	0.6	2.8	19.0	-5.7
Petrochemicals	280.6	0.5	599.9	1.0	882.8	1.3	1,148.1	1.5	1,386.2	1.7	1,633.3	1.8	16.4	13.9	7.3
Gas	4,674.1	9.1	5,939.0	9.9	6,730.0	10.0	7,661.1	10.2	8,630.1	10.3	9,542.3	10.4	4.9	5.2	4.5
Lubricants	162.8	0.3	203.0	0.3	237.8	0.4	273.3	0.4	309.8	0.4	342.0	0.4	4.5	6.1	4.6
Biomass	25,938.7	50.4	28,273.1	47.0	30,498.3	45.3	32,946.9	43.8	35,420.3	42.4	37,673.8	41.1	1.7	3.1	2.7
Electricity	2,685.7	5.2	3749.7	6.2	4,843.5	7.2	6,276.6	8.3	8075.3	9.7	10,185.7	11.1	6.9	10.9	10.2
Total	51,470.3	100	60,184.7	100.0	67,346.2	100.0	75,175.0	100.0	83,491.2	100.0	91,670.0	100.0	3.2	4.5	4.0

(High Scenario, Reduced Oil Use Case)

	1986	(%)	1991	(%)	1996	(%)	2001	(%)	2006	(%)	2011	(%)	1986-1990 (%/y)	1991-2001 (%/y)	2001-2011 (%/y)
Coal & Coke	527.5	1.0	1,313.1	2.1	2,366.6	3.4	3,421.1	4.2	5,432.6	5.8	7,925.6	7.2	20.0	21.1	18.3
Gasoline	3,422.9	6.6	4,307.6	7.0	4,968.2	7.1	5,282.2	6.5	5,948.4	6.4	7,021.8	6.4	4.7	4.2	5.9
Kerosene	6,745.7	13.1	7,529.9	12.3	7,402.8	10.5	7,869.5	9.7	7,455.1	8.0	8,414.3	7.7	2.2	0.9	1.3
ADO+IDO	5,578.8	10.8	7,015.7	11.4	8,093.8	11.5	9,392.1	11.6	10,735.6	11.5	12,471.4	11.4	4.7	6.0	5.8
Fuel Oil	1,207.5	2.3	1,272.2	2.1	1,508.6	2.1	1,777.0	2.2	1,979.8	2.1	2,364.7	2.2	1.0	6.9	5.9
LPG	272.4	0.5	455.1	0.7	1,014.8	1.4	1,309.1	1.6	2,171.3	2.3	1,672.1	1.5	10.8	23.5	5.0
Petrochemicals	284.1	0.6	631.7	1.0	969.7	1.4	1,328.7	1.6	1,715.3	1.8	2,218.7	2.0	17.3	16.0	10.8
Gas	4,726.4	9.2	6,281.0	10.2	7,409.3	10.6	9,263.6	11.4	11,254.1	12.0	13,729.8	12.5	5.9	8.1	8.2
Lubricants	163.5	0.3	209.8	0.3	260.0	0.4	321.4	0.4	393.6	0.4	485.0	0.4	5.1	8.9	8.6
Biomass	25,951.8	50.3	28,372.1	46.3	30,800.2	43.9	33,550.1	41.4	36,198.4	38.7	38,861.2	35.5	1.8	3.4	3.0
Electricity	2,700.9	5.2	3,937.1	6.4	5,383.8	7.7	7,467.0	9.2	10,332.6	11.0	14,419.9	13.2	7.8	13.7	14.1
Total	51,581.4	100	61,325.1	100.0	70,177.6	100.0	80,981.9	100.0	93,616.8	100.0	10,9584.6	100.0	3.5	5.7	6.2

(Low Scenario, Reduced Oil Use Case)

	1986	(%)	1991	(%)	1996	(%)	2001	(%)	2006	(%)	2011	(%)	1986-1990 (%/y)	1991-2001 (%/y)	2001-2011 (%/y)
Coal & Coke	520.9	1.0	1,172.4	1.9	1,939.1	2.9	2,593.0	3.5	4,001.6	4.8	5,492.9	6.0	17.6	17.2	16.2
Gasoline	3,417.8	6.6	4,199.9	7.0	4,621.3	6.9	4,580.2	6.1	4,731.1	5.7	5,168.9	5.7	4.2	1.7	2.4
Kerosene	6,743.1	13.1	7,525.7	12.5	7,665.8	11.4	7,566.1	10.1	6,745.7	8.1	7,260.1	7.9	2.2	0.1	-0.8
ADO+IDO	5,583.7	10.8	6,793.3	11.3	7,413.8	11.0	8,020.4	10.7	8,429.0	10.1	8,789.9	9.6	4.0	3.4	1.8
Fuel Oil	1,189.3	2.3	1,256.5	2.1	1,446.2	2.1	1,627.5	2.2	1,686.1	2.0	1,696.2	1.9	1.1	5.3	0.8
LPG	272.1	0.5	422.6	0.7	762.0	1.1	1,419.8	1.9	2,454.9	3.0	1,958.3	2.1	9.2	27.4	6.6
Petrochemicals	280.6	0.5	599.9	1.0	882.8	1.3	1,148.1	1.5	1,386.2	1.7	1,633.3	1.8	16.4	13.9	7.3
Gas	4,675.7	9.1	5,939.0	9.9	6,740.8	10.0	8,010.8	10.7	9,141.0	11.0	10,202.0	11.2	4.9	6.2	5.0
Lubricants	162.8	0.3	203.0	0.3	237.8	0.4	273.3	0.4	309.8	0.4	342.0	0.4	4.5	6.1	4.6
Biomass	25,938.7	50.4	28,317.7	47.1	30,765.1	45.7	33,479.1	44.6	36,111.8	43.5	38,700.7	42.3	1.8	3.4	2.9
Electricity	2,685.7	5.2	3,750.0	6.2	4,843.7	7.2	6,283.8	8.4	8,095.2	9.7	10,210.9	11.2	6.9	10.9	10.2
Total	51,470.5	100	60,180.0	100.0	67,318.4	100.0	75,002.2	100.0	83,092.2	100.0	91,670.0	100.0	3.2	4.5	4.0

Table 5-3-5 Biomass Consumption by Region (H Scenario)

(Unit: Million t)

	1986	1991	1996	2001	2006	2011
JAVA	49.13	50.88	52.27	53.78	54.95	56.34
SUMATRA	16.59	20.17	23.90	28.15	32.18	35.84
KALIMANTAN	4.55	5.37	6.33	7.40	8.49	9.53
OTHER ISLANDS	12.02	13.54	15.16	17.06	19.16	21.52
TOTAL	82.29	89.96	97.66	106.38	114.78	123.22

2) Petroleum Products

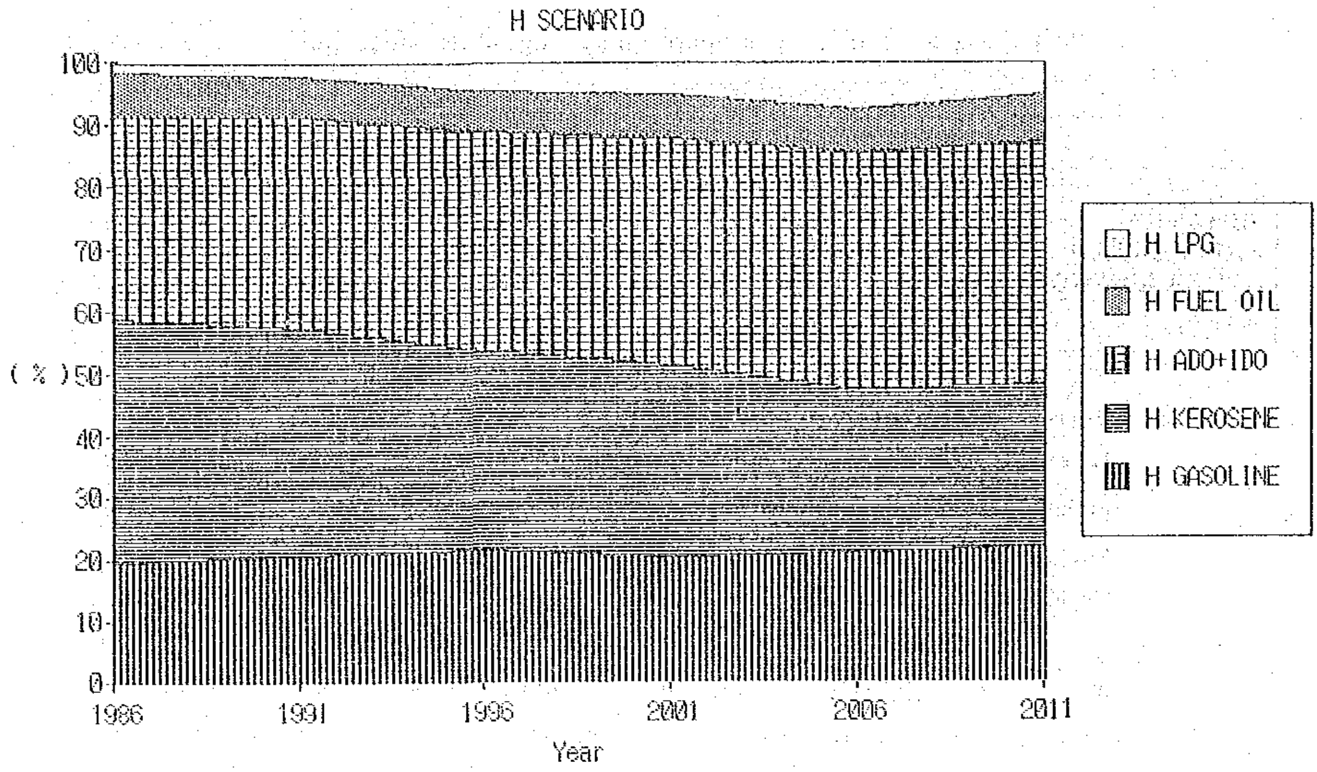
Next to biomass, the second biggest contribution to final energy consumption comes from refined products, which include LPG, gasoline, kerosene, middle distillate (ADO+IDO), fuel oil and lubricants.

Table 5-3-4 also shows the forecast of the demand for the petroleum products and Fig. 5-3-3 shows the share of petroleum products. The share and the growth rate of petroleum products is lower than other energy sources. The share of kerosene will decrease remarkably from around 13.0% in 1986 to 6.0~9.0% in 2011 in these four scenarios. The demand of kerosene for lighting is forecasted to be replaced during the period.

The share of gasoline keeps constantly around 6.5% in both scenarios. But the amount of gasoline increases moderately by 2.9% (H scenario) and 1.7% (L scenario) in reduced oil use case, while 3.9% and 2.4% in minimum cost case. This is because the demand in the transportation sector will increase.

The demand of ADO+IDO also will increase with a growth rate of around 3.3 %/y in both H scenarios. This is caused by demand increase of ADO in the transportation sector.

The demand of LPG seems to increase at the highest growth rate among petroleum products by 7.5 %/y (H scenario) and 8.2 %/y (L scenario). Mainly LPG is produced for export and the actual domestic demand of LPG is in relatively low level. Therefore such a high growth rate seems to be realized without difficulty. This forecast is slightly lower than the forecast done by Pertamina which is 10 %/y.



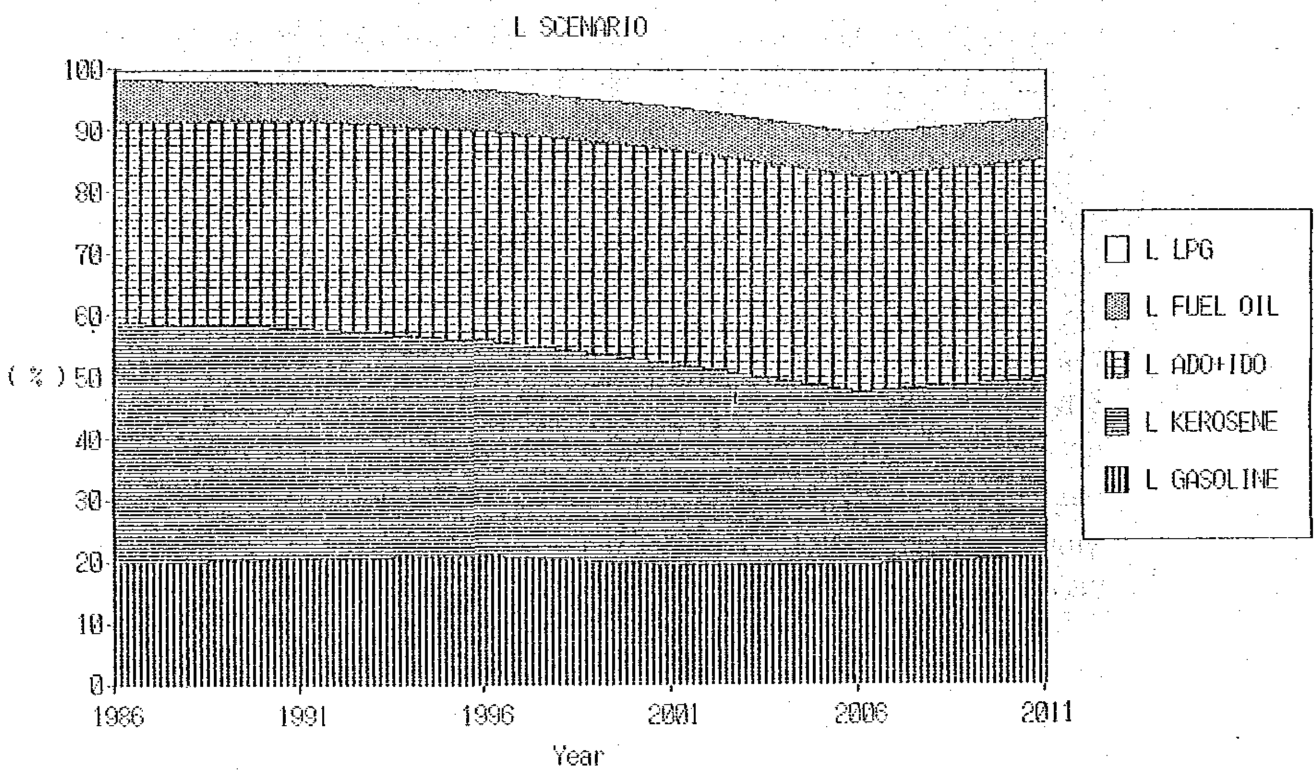


Fig. 5-3-3 The Share of Petroleum Products

3) Gas

Final use of gas grows more moderately by 4.5% (H scenario) and 3.2% (L scenario) per annum in both cases. But gas consumption for power sector is not included in Table 5-3-4.

Domestic production of natural gas is forecasted to increase steadily in Indonesia. Table 5-3-6 shows the natural gas production forecast in H scenario of reduced oil case. Total natural gas production will increase with annual growth rate of 4.2% (1986 - 2001) then 0.8% (2001 - 2011).

Natural gas from Natuna which is thought to be exported to Singapore, starts production in the early 1990's and reaches the full capacity during 1994 - 1998. And production from Natuna is forecasted to extend in the 2000's. Batan island which is located in near Sumatra island will supply the maximum level of 1,100 BSCF/y in 2001 then slightly decrease.

In Indonesia, natural gas has been used to make LNG for export. In 1986, about 63% of the total production was converted to LNG. And excluding the gas used for injection and lifting on the field, and captive power for gas field, gas consumption for domestic industry was only about 10%. But industrial use of natural gas has grown continuously. Main consumption sectors for natural gas are fertilizer industries.

Table 5-3-7 shows the forecast of natural gas consumption by region in reduced oil use case. The outline of natural gas consumption differs in each region. In Sumatra and Kalimantan, the consumption is determined by the production of LNG for export. On Java island, the consumption is determined by industry (Non-LNG use). And Java island is forecasted to become the biggest market for gas in the future.

Gas reserves on Java island are not sufficient for the long time supply. So establishment of a gas distribution system (ex. pipelines) may be needed in the near future.

Table 5-3-6 Natural Gas Production by Region (H Scenario)

(Unit: BSCF/y)

	1986	1991	1996	2001	2006	2011
JAVA	89.92	164.90	220.97	233.60	240.65	166.53
SUMATRA	878.20	897.12	1,067.89	1,093.41	878.84	630.21
NATUNA	0.00	45.44	227.45	275.13	686.39	1,505.07
KALIMANTAN	392.47	509.17	569.04	914.70	852.01	427.44
OTHER ISLAND	1.52	2.02	2.70	4.85	6.67	9.03
TOTAL	1,362.10	1,618.65	2,088.05	2,521.69	2,664.56	2,738.28

Table 5-3-7 Gas Consumption in Indonesia by Region

(Unit: BSCF/y)

	1986	1991	1996	2001	2006	2011
JAVA	87.92	164.89	311.84	554.56	606.00	529.82
SUMATRA	878.28	98.11	1,161.61	1,216.05	1,284.30	1,640.94
KALIMANTAN	392.47	509.17	478.18	593.83	531.15	240.90
TOTAL	1,360.59	1,572.17	1,951.63	2,364.44	2,421.45	2,411.66

(Note) 1. Reduced oil use case, H scenario

4) Coal

Coal, as a final energy source, is growing significantly and it will reach about 6% in 2011. Most of the coal is used for electricity generation, but this fuel for power generation is also not included in the final energy consumption.

Table 5-3-8 shows demand and supply forecast in H scenario of reduced oil use case based on BPPT study.

On supply side, production from Ombilin mine will increase to 2 million t level in mid 1990's, then will keep constant. Production from Bukit Asam mine will increase with high growth rate of 12.0% (1986 - 2001) then 16.5% (2001 - 2006) and reach 12.4 million t in 2011. For Kalimantan coal production, an annual growth rate of 21.3% is forecasted and reaches 51.2 million t in 2011.

The biggest consumer of coal is the power sector. Their coal demand in power sector will increase with relatively high growth rate of 15.1% (1986 - 2006) then 21.9% (2006 - 2011). Table 5-3-9 shows the gross electricity generation by energy source in H scenario of reduced oil use case, which is the basic data to calculate the coal demand.

In H scenario, the coal-fired power plant will increase the share in total generating capacity from 11.6% in 1986 to 12.8% in 2001. Then in 2011, half of the total generation will be by coal-fired. In L scenario, the share of coal-fired will be 13.0% in 2001 then 37.2% in 2011.

The cement industry in Indonsia has converted its fuel from oil to coal along with the government policy. Until now, all but two companies (Cibinong Cement and Tridaya Mannungal Perkasa) use coal as fuel. These two companies use gas. They do not have any plan to convert to coal in the near future. Coal demand in the cement industry is forecasted to increase by 4.5 %/y during 1986 - 2011.

Coal demand in other industries are in a small level of 0.2 millon t in 1986. These demands are mainly in railway, direct and indirect heat and small scale captive power sectors. The future coal demand in other industry is forecasted to increase to 5.1 million t in 2001 and 13.1 millon t in 2011. In other industries, industrial direct and indirect heat generation and briquette fabrication are expected to expand the coal usage.

Table 5-3-8 Coal Demand and Supply in Indonesia

(Unit: Million t/y)

	1986	1991	1996	2001	2006	2011
[Demand]						
POWER	0.83	4.75	5.54	6.83	21.16	49.52
CEMENT	0.49	0.73	0.86	1.03	1.22	1.48
OTHER	0.21	1.46	3.60	5.07	8.31	13.07
EXPORT	0.76	5.74	8.93	15.04	15.91	1.92
TOTAL	2.29	12.68	18.93	27.97	46.60	65.99
[Supply]						
OMBILIN	0.82	1.75	2.12	2.50	2.49	2.50
BUKIT ASAM	1.06	3.34	4.57	5.75	12.36	12.37
KALIMANTAN	0.41	7.59	12.24	19.72	31.75	51.12
TOTAL	2.29	12.68	18.93	27.97	46.60	65.99

Table 5-3-9 Gross Electricity Generation of Indonesia

(H Scenaio)

(Unit: tWh)

	1986	1991	1996	2001	2006	2011
NUCLEAR	0.00	0.00	0.00	0.00	0.00	0.00
M.D. (ADO+IDO)	11.43	12.79	7.77	6.81	3.73	4.37
FUEL OIL	14.35	10.12	8.47	4.21	3.69	8.78
HYDRO, GEOTH.	9.05	14.60	23.96	31.25	45.25	45.54
NAT. GAS	2.09	11.05	28.49	53.61	53.31	37.86
COAL	4.86	11.10	11.90	14.11	45.28	110.40
TOTAL	41.79	59.66	80.59	110.00	151.25	210.96

(L Scenaio)

(Unit: tWh)

	1986	1991	1996	2001	2006	2011
NUCLEAR	0.00	0.00	0.00	0.00	0.00	0.00
M.D. (ADO+IDO)	11.43	12.83	9.66	6.24	4.55	3.67
FUEL OIL	14.10	7.11	7.03	3.54	2.11	1.78
HYDRO, GEOTH.	9.05	14.60	20.29	27.08	33.93	42.41
NAT. GAS	2.09	11.05	23.60	43.70	49.85	45.77
COAL	4.86	11.10	11.90	12.00	27.92	55.38
TOTAL	41.53	56.70	72.48	92.55	118.36	149.02

The coal export will increase from 0.8 million t in 1986 to maximum value of 15.9 millon t in 2006. The sources of coal export are Ombilin and Kalimantan coal. The amount of Ombilin coal is small and the maximum level of 1.67 million t in 2001. Main source of coal export is Kalimantan. These export volumes are significantly below export projections of the Asean Coal Development Project studied by ADB in 1983.

According to the projection, coal export will decline to 1.9 million t in 2011. It seems that domestic demand in Indonesia expands in the 2000's and coal supply to domestic market will be given the first priority. So the shortage caused between coal demand and domestic production will effect the amount of export to decrease.

Import of coal is not discussed in the report studied by BPPT. In Indonesia, due to delays in the completion of the "Bukit Asam Coal Development and Transportation Project", they have to import coal since 1985 for the Suralaya I and II power plant and huge Indocement plant. The Government of Indonesia does not publicize the forecast of coal import. But the import of coal seems to continue at a constant level until early 1990's.

5) Electricity

Electricity as final energy increases on average between 5.4 %/y in L scenario and 6.9 %/y in H scenario. The total gross generation of Indonesia by region in minimum cost case is shown in Table 5-3-10. The result of reduced oil use cases is almost the same as minimum cost cases.

In both scenarios, Java region is forecasted to increse at the highest growth rate in total Indonesia by 7.5% (H scenario) and 6.0% (L scenario) during the projection period. In H scenareio, the second highest growth is forecasted in Kalimantan region at 5.4% while in Sumatra region at 3.6% in L scenario.

Table 5-3-10 Gross Electricity Generation by Region

(H Scenario, Minimum Cost Case)

(Unit: tWh/y)

	1986	1991	1996	2001	2006	2011
JAVA	24.40	36.59	51.41	72.77	103.18	147.71
SUMATRA	11.10	14.56	18.15	22.33	28.10	37.02
KALIMANTAN	2.86	4.05	5.05	6.70	8.57	10.62
OTHER ISLANDS	3.42	4.59	6.04	8.07	10.90	14.80
TOTAL	41.77	59.79	80.65	109.87	150.75	210.14

(L Scenario, Minimum Cost Case)

(Unit: tWh/y)

	1986	1991	1996	2001	2006	2011
JAVA	24.32	34.77	46.30	61.23	80.60	103.96
SUMATRA	10.99	13.82	16.33	19.09	22.20	26.85
KALIMANTAN	2.83	3.85	4.51	5.51	6.97	7.73
OTHER ISLANDS	3.41	4.41	5.44	6.74	8.39	10.22
TOTAL	41.55	56.84	72.58	92.57	118.15	148.77

5-3-2 Energy Substitution Potential

Given the considerable amount of alternative energy resources potential in Indonesia, the country's energy consuming sectors have various options for reducing the share of oil consumption and increasing the use of such resources. However, the recent decline in oil revenue has been bringing about budget constraints, favoring investment in less capital intensive schemes. Thus an emphasis has been made on two criteria, among others, for the development and utilization of alternative energy sources:

- The exportability or non-exportability of the energy source.
- The commercial value of the energy source.

These two criteria have a close relationship with the price and quality of the energy source concerned. If the energy source is not identified as exportable, it will be consumed in the domestic market. It should be noted however that the Government gives higher priority to the development of exportable energy sources. At the same time, the Government gives favorable consideration to the renewable energy sources for domestic supply.

Development and utilization of each energy source should be done with due consideration to the aforementioned criteria. For example, hydropower is renewable and the cost depends upon the the size of the potential output, geographical conditions, location, etc. Natural gas is a depletable energy source and its exportability depends upon, among other factors, the size of production potential and its location. Even when a gas reserve is identified as not exportable, it may be sufficiently large for domestic fertilizer and power plants. Similarly, there are coal mines producing exportable quality coal such as Ombilin coal, whereas some mines are only for domestic supply. Waste wood and agricultural residue are not exportable and are therefore promoted for domestic use. Geothermal is obviously not exportable but the locations of many sites are close to the demand centers.

To consider these factors in detail, it is imperative to review the energy substitution potential in each demand sector.

(1) Electricity Generation Sector

As reviewed in Section 5-3-1, demand for electric power generated by PLN is expected to grow at a rate of 5.4%/y under the "L scenario" and 6.9%/y under the "H scenario".

Concerning the substitution potential for PLN's oil-based power plants up to 1995, the present status of construction and plans already made for non-oil-based plants will basically determine the substitution potential. In Java, the capacity of hydro, coal and natural gas is expected to grow rapidly, as shown in Table 5-3-11.

Table 5-3-11 Power Development Plan of PLN

Region : Java

	1987/88	1990/91	1995/96	2000/01
Hydropower Plant	1,235	1,983	2,056	2,556
Steam Power Plant				
Residual Oil	1,475	1,400	1,200	1,200
Natural Gas	0	400	600	600
Coal	800	1,600	4,200	10,200
Gas Turbine Power Plant				
Distillate Oil	550	530	500	720
Natural Gas	80	80	80	0
Geothermal Power Plant	140	140	360	360
Combined Cycle	0	0	900	900
TOTAL	4,280	6,133	9,896	16,536

(Note) Installed capacity (MW)
Source: PLN

Outside Java, the capacity of hydro, natural gas and coal-fired power stations is also expected to grow significantly, as shown in Table 5-3-12.

Table 5-3-12 Power Development Plan of PLN

Region : Outside Java

	1987/88	1990/91	1995/96	2000/01
Hydropower Plant	182	215	636	1,462
Diesel				
Distillate Oil	1,420	1,595	1,536	1,422
Residual Oil	0	24	24	24
Steam Power Plant				
Natural gas	0	155	305	830
Coal	65	130	675	830
Residual Oil	180	155	155	130
Geothermal	0	0	5	35
Gas Turbine Power Plant				
Natural Gas	111	141	141	42
Distillate Oil	183	158	158	498
Combined Cycle	0	300	600	600
TOTAL	2,141	2,873	4,258	5,895

(Note) Installed capacity (MW)

Source: PLN

In the absence of reliable information as to the future prices of alternative energy sources, the availability of natural gas pipeline systems currently under consideration, the feasibility of the nuclear option, etc., it is rather difficult to quantify substitution potential for PLN's power system beyond 1995. Thus the discussion here is only a tentative one.

Coal is identified by a PLN evaluation as the most economic option for future electricity generation for the base load. The assumptions for this evaluation are based on currently available information on fuel prices and quality (See Table 5-3-13, 5-3-14).

Table 5-3-13 Cost Comparison of Base Load Generation

		Coal Fired Steam Plant	Oil Gas Fired Steam Plant	Gas Fired Comb. Cycle	Geothermal	Nuclear
Installed Capacity	[MW]	4×600	2×400	2×300	2×55	2×938
Base Cost	[$/kW]	600	529	500	581	2000
Construction time	[Year]	5	5	3	5	7
Interest During Const.	[$/kW]	175	155	82	170	874
Total Capacity Cost	[$/kW]	775	684	582	751	2874
Life time		25	25	20	25	25
Availability	[%]	70	65	65	70	70
Capital Recovery Factor (with Discount rate 12 %/y)		0.1275	0.1275	0.1339	0.1275	0.1275
Annual Capital Cost	[$/kW]	98.86	87.16	77.93	95.75	366.43
Annual O & M Cost	[$/kW. Year]	9.84	8.04	7.27	12.08	29.4
Fuel type		Coal	MFO	Natural Gas	Geothermal	Uranium
Capital Cost	[mills/kWh]	16.12	15.31	13.69	15.61	59.76
Fuel Cost	[mills/kWh]	12.82	31.08	16.65	46.87	7.40
O & M Cost	[mills/kWh]	1.60	1.41	1.28	1.83	4.79
Total Gen. Cost	[mills/kWh]	30.54	47.80	31.61	64.31	71.95

Source : Sardjono and Sudja, "Competition of Coal and Natural Gas for Power Generation," a paper submitted for the 1987 Coal Contractors Conference.

Table 5-3-14 Data on Fuel for Electricity Generation

Type of Fuel	Price of Fuel	Heat Content	Thermal Heat Price [$/$10^6$ kcal]	Thermal Efficiency [%]	Fuel Price Component Electricity Generation [mills/kWh]
Coal	33.09 $/t	6,000 kcal/kg	5.51	37	12.82
Oil (Marine Fuel Oil)	200 Rp/1t*) (19.34 $/bbl)	10,000 kcal/kg	12.24	34	30.97
	12.7 $/bbl**)	246,000 kcal/MCF	8.04	34	20.34
Natural Gas	2 $/MCF		8.13	42	16.65***)
	3		12.20	42	24.98***)
	2		8.13	37	21.97****)
	3		12.20	37	32.96****)
Geothermal Steam	–	–	8.18	15	46.87
Nuclear Fuel	–	–	2.75	32	7.40

(Note) 1 $ = 1644 Rp, 1 MCF = 246,000 kcal, 1 MCF = 10^3 CF

*) Domestic Price

**) International Price

***) Combined Cycle

****) Gas-fired Steam Power Plant

Source : Sardjono and Sudja, ibid.

It is noted from the above two tables that electricity generation with a coal-fired power plant can be considered competitive with a gas-fired combined cycle, with prices of coal at 33 US$/t and natural gas at 2 US$/mcf.

However, it should also be stressed that such calculations depend very much upon assumptions for fuel prices and capacity factors. As can be seen from the figure, gas turbine plants and gas-fired combined cycle plants are competitive vis-a-vis coal-fired steam plants at a low capacity factor. Should the cost of natural gas become more competitive vis-a-vis coal, it may develop that gas-fired combined cycle plants are used in base load.

Concerning the long-term fuel supply prospects for Java, PLN is currently considering the allocation of natural gas resources in East Kalimantan and Natuna. The East Kalimantan scheme requires the installation of a pipeline of about 900 km. The Natuna scheme requires an even longer delivery system and has significant investment implications.

Concerning the hydropower option, a problem may exist in financing large hydropower projects, if current budgetary constraints prevail. It is particularly so in light of the cost-benefit pattern of hydropower schemes, in which expenses are "up front" whereas the benefits accrue during the life of power plants. The Government must have a convincing argument for hydropower schemes to allocate scarce development funds. Of course the feasibility of such schemes very much depends on future crude oil prices, and the Government's financial situation as well as the "savings" of oil resources to be achieved by large hydropower projects. As regards small-, micro- and mini- hydro schemes, future feasibility may be higher in certain locations.

Concerning geothermal power, a major problem for PLN is the difficulty in assessing the cost of geothermal steam. However, it is envisioned that geothermal potential could somehow contribute to a reduction in the consumption of energy sources for base-load, if the cost of geothermal steam is properly determined.

If nuclear power is to be introduced in the Java System, it would substitute for the coal requirement. However, a nuclear option is not economically justifiable for base load even for the long term future, according to an assessment made by PLN.

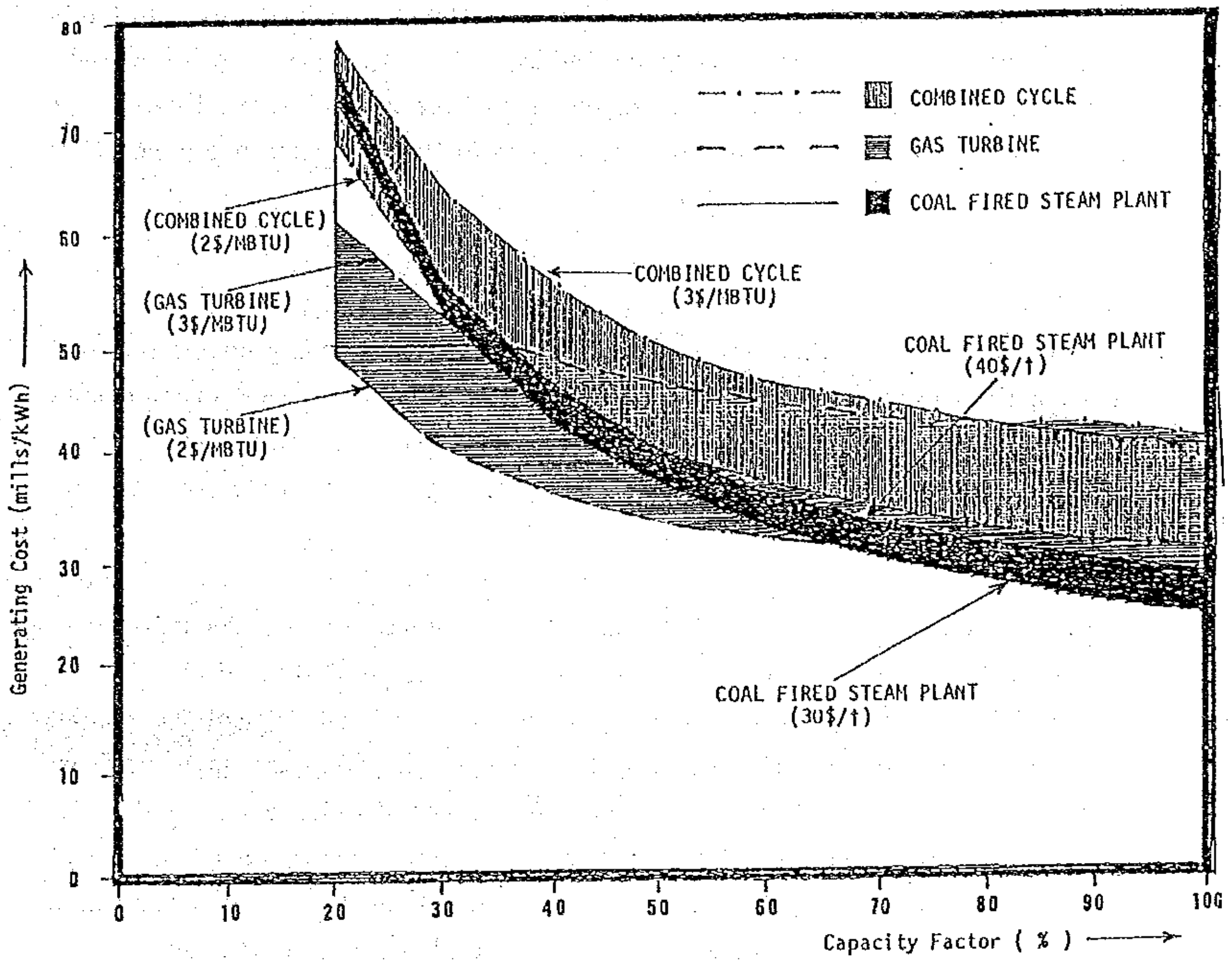


Fig. 5-3-4 Generating Cost vs Capacity Factor

(Note) Capital cost of the gas turbine ≒ 300$/kW
Thermal efficiency of turbine = 30%
Discount rate = 12% per annum
Other economic factors as mentioned in Tables 5-3-13 and 5-3-14

Source: Sardjono and Sudja, ibid.

There exist other options, such as palm oil residue, methanol and ethanol. Though the amount of electricity generated by such energy sources will play only a marginal role in the total power supply, they may become attractive energy sources for small captive power plants, subject to their location and generation costs.

(2) Transport Sector

As was stated before, this sector depends heavily on petroleum products for road and maritime transportation. In view of the fact that road transport accounts for about 60% of the commercial energy consumption in this sector, every possible effort for fuel substitution should be made to contribute to the diversification of energy sources here.

CNG, compressed natural gas, is currently being tested on 500 taxies equipped with converters. Once this test, executed by Pertamina, is satisfactorily completed, the Government will be able to determine the potential of the CNG market. In the implementation of the project, the Government granted a special electricity tariff to the CNG supply system. CNG converters are imported from New Zealand, Italy and Canada, and the Government of Indonesia exempted the CNG project from import duties for such converters. The main advantage of CNG is that it is very cheap, costing to only 1/2 of the price of gasoline. However, the maximum trip one can make with a CNG car is around 150 km.

LPG has been identified as marginally economical by such studies as "LPG Feasibility Study" by the World Bank and "Energy Strategies: Energy R&D Strategies: Technology Assessment under the Joint Indonesian-German Research Project". However, the latter at the same time noted that LPG can be used in a limited market, such as for taxis.

Methanol can also contribute to the diversification of oil sources in this sector through:

- Low level methanol blending in gasoline
- Neat methanol for gasoline substitution
- Neat methanol for diesel oil substitution

To realize such potential, a pilot test project similar to the CNG project would be useful.