

**FEASIBILITY STUDY  
ON  
LIGNITE BRIQUETTE DEVELOPMENT  
IN  
THE KINGDOM OF THAILAND**

**NOVEMBER 1991**

**JAPAN INTERNATIONAL COOPERATION AGENCY**

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## Preface

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on Lignite Briquette Development in Thailand and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr. Koji Tanaka, Techno Consultants, Inc. three times between November 1989 and October 1991.

The team held discussions with the officials concerned of the Government of Thailand, and conducted field surveys at the study area. 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 promotion of the project and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation extended to the team.

November 1991



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Kensuke Yanagiya

President

Japan International Cooperation Agency



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## Abbreviation

AC, ac	Alternating current
Al <sub>2</sub> O <sub>3</sub>	Aluminum Oxide
ASEAN, Asean	The Association of East Asian Nations
ASTM	The American Society for Testing and Materials
Aq	Aqueous
Av, Av.	Average
Aviat'n	Aviation
bbl	Barrels, 42 gallons
BEP, bep	Break-even point
b/d	Barrels per day
bpd	Barrels per day
Bht, bht	Baht
Bhts, bhts	Bahts
briq'tes	Briquettes
Bs	Bahts
BS	The British Standards
BTU	British Thermal Unit, a unit of heat energy, 1 BTU = 0.252 Kcal
C3	Propane
C4	Butanes
Cal, cal	Calorie, a unit of heat energy, an amount of heat required to raise the temperature of one gram of water from 14.5 to 15.5 degrees Cen- tigrade, or 4.1868 joules
CaO	Calcium oxide, the oxide of calcium, a chemical formula
CC	Charcoal
CFC	Standard Factor Cost
CFM, cfm	Cubic feet per minute, a unit of volumetric flow
char	Charcoal
CIF, cif	Cost, insurance and freight
CO	Carbon Monoxide, a chemical formula
CO <sub>2</sub>	Carbon dioxide, a chemical formula
Com	Commercial

Construct'n	Construction
Consumpt'n	Consumption
Corporat'n	Corporation
Const	Construction
cp	Commercial plant
dc	Direct current
dia	Diameter
DMR	The Department of Mineral Resources
DOAE	The Department of Agricultural Extension
DSR	Debt service coverage ratio
EGAT	The Electricity Generating Authority of Thailand
EIRR	Economic Internal Rate of Return
elec	Electricity
EX	F.O.B value of export
FAO	Food and Agriculture Organization of the United Nations
Fe <sub>2</sub> O <sub>3</sub>	Ferric oxide, an oxide of iron, a chemical for- mula
FIRR	Financial Internal Rate of Return
FIRROE	Financial Internal Rate of Return on Equity
FIRROI	Financial Internal Rate of Return on Investment
ft.	Feet, a unit of length, 1 ft = 30.48 centimeters
GDP	Gross domestic products
gr	Gram
GWH, GWh	Giga watt-hours, 10 <sup>9</sup> watt-hours, a unit of electric energy
HGI, hgi	Hardgrove Grindability Index, an index of rela- tive grindability of ores and minerals
hr	Hour
IDC	Interest During Construction
in.	Inch
IMP	C.I.F. value of import
JICA	The Japan International Cooperation Agency
JIS	The Japan Industrial Standards
K <sub>2</sub> O	Potassium oxide, the oxide of potassium, a chemical formula

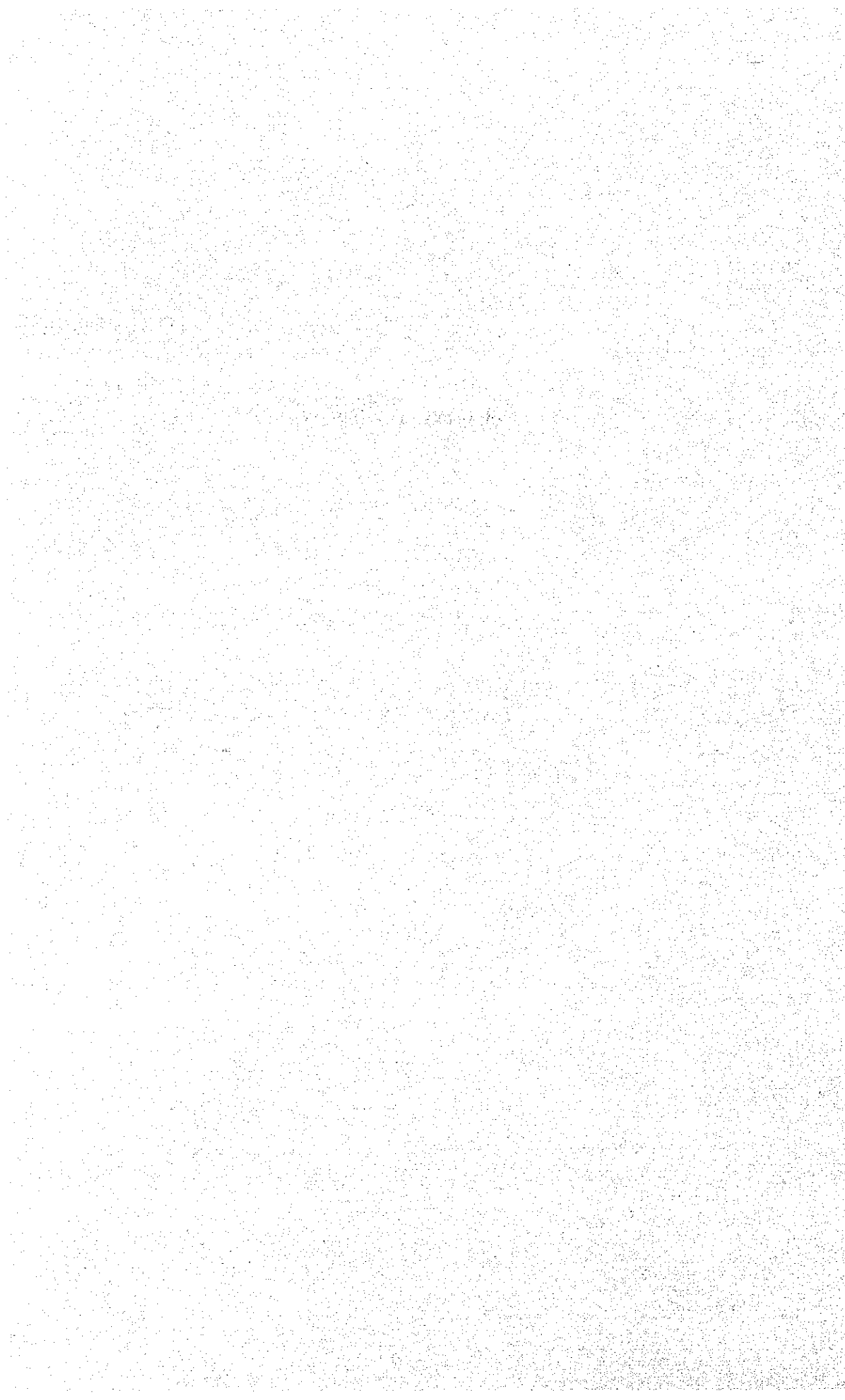
Kcal, kcal	Kilocalory, 1,000 calories
Kero	Kerosene
Kgf	Kilogram-force, a unit of force, 1 Kgf = about 9.8 Newtons
kgOE	Kilogram Oil Equivalent
Kl	Kiloliter
kIOE	Kiloliter Oil Equivalent
KTON, kton	Kiloton, 1,000 tons
kv, kilovolt	1,000 volts
KVA	Kilovolt-Ampere
KW, kw	Kilowatt, a unit of electric power
KWh, kwh	Kilowatt-hour, a unit of electric energy equivalent to 3,414.4 BTU or 860.4 kilocalories
LB, lb	Lignite Briquettes
Lig	Lignite
LPG	Liquefied Petroleum Gas
Lub	Lubricating oil
Maint	Maintenance
Matl	Material
MEA	The Metropolitan Electricity Authority
MgO	Magnesium oxide, the oxide of magnesium, a chemical formula
MM	Million, a Roman number
mmaq	Millimeter of aqueous column
MMBTU, MMBtu	Million British Thermal Unit
MMCFD	Million Cubic Feet per Day
MMton	Million tons
M'politan	Metropolitan
MVA	Thousand volt-amperes
MW	Mega watt, 10 <sup>6</sup> watts
MWh, MWh	Mega watt-hour, 10 <sup>6</sup> watt-hours, a unit of electric energy
Na <sub>2</sub> O	Sodium oxide, the oxide of sodium, a chemical formula
NEA	The National Energy Administration
NESDB	The National Economic and Social Development Board

NGL	Natural Gas Liquid
NIES	Newly Industrialized Economies
NL	North latitude
NO <sub>2</sub>	Nitrogen peroxide, an oxide of nitrogen, a chemical formula
NSO	National Statistical Office
OER	Official exchange rate
oprat'n	Operation
PEA	The Provincial Electricity Authority
Petro	Petroleum
Prdct	Product
Product'n	Production
pp	Pilot plant
ppm	Parts per million
psi	Pound per square inch, a unit of pressure
PTT	Petroleum Authority of Thailand
RAEO	Regional Agricultural Extension Office
rai	A Thai unit of area, about 1,600 m <sup>2</sup>
SER	Shadow exchange rate
SCF, scf	Standard cubic foot, a unit of volume used for measuring gas, cubic foot at one atmospheric pressure and 60 degrees Fahrenheit
SFC	Standard factor cost
SiO <sub>2</sub>	Silicon oxide, the oxide of silicon, a chemical formula
SO <sub>2</sub>	Sulfur dioxide, an oxide of sulfur, a chemical formula
SO <sub>3</sub>	Sulfur trioxide, an oxide of sulfur, a chemical formula
SO <sub>x</sub>	Sulfur oxides, a collective nomenclature, a chemical formula
SRT	The State Railway of Thailand
Tax <sup>ex</sup>	Weighted average of export tax rate
Tax <sup>imp</sup>	Weighted average of import tax rate
TQ <sup>imp</sup>	Import tax rate equivalent to import restriction value
TORC	Name of a petroleum refining company

UAE	The United Arab Emirates
UNIDO	United Nations Industrial Development Organization
WC, wc	Working capital
wt	Weight



## **Chapter 1 Summary**





## Chapter 1 Summary

### 1-1 Objectives and Results

#### (1) Objective of the Feasibility

The objective of this feasibility study is to study the feasibility of the Thai government plant to build a pilot plant for the production of lignite briquettes as a substitute for wood fuel, and to recommend appropriate measures for the implementation of the project and dissemination of lignite briquettes among people, provided that the project is found feasible.

#### (2) Feasibility of the Pilot Plant

The pilot plant per se is not financially feasible. However, a commercial plant with a capacity of 50,000 tons per year is found financially feasible. The investment in the pilot plant is recoverable by a commercial plant of this size. The commercialization of lignite briquettes will bring about a variety of great socio-economic benefits; therefore, the pilot plant is worth implementing as a first step towards commercialization of lignite briquettes.

#### (3) Market

A large market is expected for lignite briquettes as a substitute for charcoal for cooking use.

#### (4) Manufacturing

- 1) It is found technically possible to manufacture lignite briquettes meeting the required quality based on a proven technology of bio-coal, by adding a process to decrease generation of smoke at the time of combustion.
- 2) Capacities of the pilot plant and the commercial plant are set at 3,000 and 50,000 tons per year, respectively.

## **(5) Justification against Background of Project**

The pilot plant project conforms to the policy of the government, the need to protect the forest, endowment of the raw materials, and lifestyles of the ordinary people of Thailand.

### **1-2 Background**

#### **(1) Policy of the Government**

As mentioned in the Sixth Five Year Plan, the government of Thailand promotes utilization of lignite for industrial and household purposes as its important policy objective of diversifying sources of the supply of energy. This project has been conceived in line with such a policy objective of the government of Thailand.

#### **(2) Deforestation**

Charcoal and firewood are the most important cooking fuels for most Thai people, collectively accounting for about 80 percent of the total consumption of cooking fuel. The consumption of such a large amount of wood fuel has been causing a serious deforestation. In 1961, forest constituted 53.3 percent of the total land area; this figure drastically reduced to 28.0 percent in 1988. Lignite briquettes, if commercialized on a large scale, will make a substantial contribution to the prevention of forest destruction.

#### **(3) Raw Material**

The main raw material is lignite. Although lignite is the largest of all energy resources Thailand has, it has not been effectively utilized. Rice straws, the selected biomass raw material, and slaked lime are abundantly available in Thailand. This project leads to effective utilization of these domestic resources, which are not made effective use of.

#### (4) Lifestyle

The lifestyle and cooking habits of the ordinary Thai people are found to accommodate lignite briquettes as cooking fuel.

#### 1-3 Market

##### (1) Substitution of Charcoal for Cooking

Shortage in the supply of charcoal was forecast from the forecast deforestation. Along with this, it was found by an opinion survey on 374 recovered questionnaires that 60 percent of the consumers would accept lignite briquettes if lignite briquettes are priced at 60 percent of charcoal. The demand for lignite briquettes was forecast at 60 percent of the forecast shortage of charcoal. The price of lignite briquettes was forecast to be 60 percent of charcoal in large bag based on the opinion survey. The forecast demands and prices are shown below.

Table 1-1 Forecast Demand and Price of Lignite Briquettes

Year	1995	2000	2005	2010
Demand in KTOE	229	518	711	831
Demand in thousand tons	573	1,295	1,778	2,078
Price, Bahts/kg on 1990 price				
Charcoal in large bag	4.63	4.77	4.97	5.23
Lignite briquettes, retail	2.78	2.86	2.98	3.14
Lignite briquettes, ex-plant	2.17	2.24	2.35	2.49
Charcoal in small bag	7.4	7.6	7.9	8.3
LPG	11.5	11.9	12.4	13.0

##### (2) Substitution of Firewood

- 1) Lignite briquettes will not be competitive with firewood in price.
- 2) Substantial modifications are necessary to enable the industrial furnaces now burning firewood to burn lignite briquettes. Ironi-

cally, if such modifications are made, these furnaces would be able to burn lignite rather than lignite briquettes, the former much cheaper than the latter.

- 3) Furthermore, at high temperatures prevailing in the industrial furnaces, the ability of slaked lime, one of the components, to reduce pollution by removing sulfur dioxide would be greatly reduced.

### (3) Substitution of LPG

Lignite briquettes will be competitive with LPG in price; however, lignite briquettes will not be a substitute for LPG, because of the convenience of LPG not to be competed by lignite briquettes.

### 1-4 Raw Material

There will be sufficient supply of raw materials to the pilot plant or even to the commercial production of about two million tons of lignite briquettes. However, lignite of low quality may have to be used after improvement by washing. Rice straws are selected as the biomass raw material. Slaked lime is added to lignite briquettes to catch sulfur dioxide that is generated at the time of combustion from sulfur originally contained in the lignite feed. The requirement of each raw material is shown below.

**Table 1-2 Unit Requirement of Raw Materials**

(Unit: tons/ton lignite briquettes)

	Raw materials	After desmoking	Blending ratio
Lignite	1.059	0.682	75
Rice straws	0.246	0.227	25
Slaked lime	0.092	0.091	10
<b>Total</b>	<b>1.397</b>	<b>1.000</b>	<b>110</b>

### 1-5 Plant Site

The plant site was selected at an appropriate location in the premises

of the Ban Pa Kha mine. There is no need to improve infrastructure at the expense of this project. Electricity, telephone connection and water can be easily obtained. The soil is so solid that it may not pose any difficulty in construction of the plants. The site is safe from natural disasters. The site can accommodate the pilot plant and one commercial plant of 50,000 tons per year capacity.

#### **1-6 Quality of Product**

The quality of lignite briquettes are designed to be used without the need for changing cooking stoves and utensils. Lignite briquettes will meet the following items of quality.

- |                     |   |
|---------------------|---|
| 1) Ignition         | Fire should become stable within eight to 10 minutes from ignition.             |
| 2) Strength of fire | The heat content of lignite briquettes should be more than 4,000 kcal/kg.       |
| 3) Smoke and odor   | Lignite briquettes should not generate smoke or odor to any disagreeable degree |
| 4) Safety           | Combustion gas and ash should be safe.  |
| 5) Control of fire  | The strength of fire should be easily controllable.                             |
| 6) Strength         | Lignite briquettes should have a strength greater than 100 kilograms.           |

#### **1-7 Manufacturing Technology**

It was confirmed technically feasible to manufacture lignite briquettes meeting the above quality requirements from the Thai raw materials.

This study incorporates in the manufacturing scheme a facility to remove a portion of the volatile matter in order to reduce generation of smoke at the time of combustion.

#### **1-8 Financial Feasibility**

The pilot plant per se is not financially feasible. However, a commercial

plant with a capacity of 50,000 tons per year is financially feasible. The investment in the pilot plant is recoverable by a commercial plant of this size. Shown below are the plant costs, total capital requirements and parameters of financial feasibility for the pilot plant and commercial plant.

**Table 1-3 Results of Financial Analysis**

	Pilot plant	Commercial plant
Plant cost, 1,000 Bahts	56,987	186,445
Total capital requirement, 1,000 Bahts	68,043	208,182
Production & sales cost, Bahts/kg (the year 2005)	9.1	2.2
FIRROI, before tax, %	Negative	11.6
FIRROI, after tax, %	Negative	10.0
FIRROE, before tax, %	Negative	14.3
FIRROE, after tax, %	Negative	11.7

#### 1-9 Economic Feasibility

The economic internal rates of return for the pilot plant and commercial plant are obtained as shown below.

**1-4 Results of Economic Analysis**

	Pilot plant	Commercial plant
Economic internal rate of return, %	Negative	14.5

From the economic viewpoint, the pilot plant is not feasible while the commercial plant is feasible. The commercialization of lignite briquettes on a large scale bring about a variety of great benefits: protection of forest, prevention of hazards associated with deforestation, saving of foreign currency needed for the importation of LPG, increase of employment opportunities and technology transfer.

### **1-10 Dissemination of Lignite Briquettes**

The deforestation is an issue of national dimension. The ability the government has in various ministries and departments should be rallied for the sake of disseminating lignite briquettes in order to prevent deforestation. Committees should be established under the cabinet with participation by the concerned ministries and departments. Task forces should be formed under the committees. The Department of Agricultural Extension and the Department of Agricultural Cooperatives should have their members in the task forces, along with the National Energy Administration. The Department of Agricultural Extension has a marvelous record in dissemination of biogas. The dissemination activities should be well timed according to the different phases of the project: before the start of the pilot plant, after the start of the pilot plant but before the start of commercial plant, and the start of the commercial plant. The budgets necessary for dissemination should be provided.

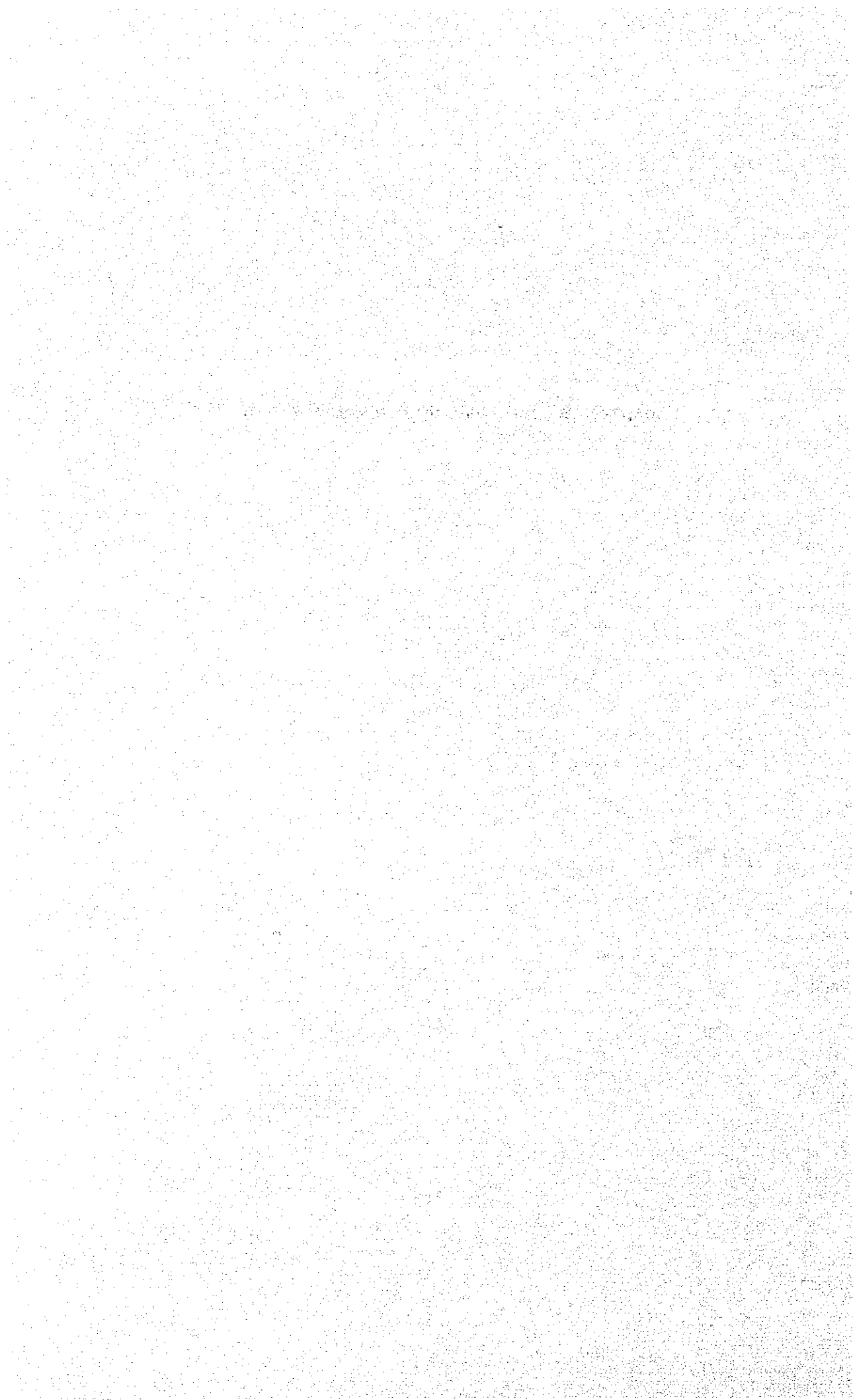
### **1-11 Recommendations**

- (1) The construction of the pilot plant is worth realizing in order to facilitate the commercialization of lignite briquettes, thereby bringing about all the benefits mentioned above to the nation and people.
- (2) All the procedures for the construction of the plant should conform to the recommended schemes for the construction so as to ensure smooth implementation of the project.
- (3) In parallel with such implementation, the recommendations for the strategy for the dissemination of lignite briquettes given in Chapter 17 should be adopted to develop the market for lignite briquettes, from the standpoint of preserving the endangered Thai forest.





## **Chapter 2 Purpose and Background of the Study**



## **Chapter 2 Purpose and Background of the Study**

This is the final report for the FEASIBILITY STUDY ON LIGNITE BRIQUETTE DEVELOPMENT IN THE KINGDOM OF THAILAND. This feasibility study was conducted in accordance with the Scope of Work agreed upon in Bangkok on July 26, 1989 by the representatives of the National Energy Administration of the Ministry of Science, Technology and Energy, the Kingdom of Thailand and the Japan International Cooperation Agency (JICA).

### **2-1 Purpose of the Study**

The purpose of this study is to examine and evaluate the feasibility of the Thai government plan for establishing a pilot plant for the production of lignite briquettes that could be a substitute for wood fuel, and to make recommendations for the implementation of the project, as well as for the dissemination of lignite briquettes for popular use, provided that the project is found feasible.

### **2-2 Background of the Study**

Thailand was once blessed with rich forest resources and was an exporter of wood including teak. Recently, however, Thailand has lost much of its forest and, consequently, has become a net importer of wood. A large number of trees are cut down to produce firewood and charcoal, the most important cooking fuels for most Thai people, and this is greatly responsible for the destruction of the nation's forest. In 1961, the forests constituted about 53 percent of the total area of the kingdom; the forest area had declined to about 28 percent of the total area by 1988. Today, deforestation is still under way at an alarming rate. The deforestation has made many places, including those remote from and seemingly unrelated to the places where deforestation has taken place, vulnerable to floods, landslides or droughts which give rise to serious social problems. The use of lignite briquettes in place of firewood and charcoal would help save the nation's diminishing forests and preserve the environment before it is too late. Therefore, this project has a particular importance in the context of environmen-

tal conservation.

Charcoal and firewood are a traditional fuel, representing daily necessities for most Thai people; therefore, the policy of protecting forests will never be effectively implemented unless a suitable substitute fuel is made available to them. For the purpose of producing a substitute fuel for charcoal and firewood, the government of Thailand has encouraged research into the development of briquettes from lignite and biomass, both of which are available in abundance in Thailand. The briquettes so far produced in Thailand generate a considerable amount of smoke, as well as an odor, when they burn. The technology needed to produce lignite briquettes of good quality that could be a substitute for charcoal and firewood has not yet been established in Thailand.

Under these circumstances, the government of Thailand requested the government of Japan in December 1988 to conduct a feasibility study on the development of technology for the manufacture of lignite briquettes using biomass as a raw material, as well as on their market potential. In response to this request, JICA dispatched in July 1989 a preliminary survey team consisting of JICA officials and experts in the relevant fields to Thailand. The team and the officials of the National Energy Administration, and the other offices concerned in Thailand had a series of discussions about the details for the implementation of the feasibility study. Both parties agreed and signed the Scope of Work which defined the contents of the study and the conditions for implementation. This study has been conducted in accordance with the Scope of Work.

### **2-3 Scope of Work**

The Scope of Work agreed on July 26, 1989 specifies that the study should be conducted in the following two stages:

First stage: Market study

Second stage: Techno-economic feasibility study and overall conclusion.

The first stage study consists of the background survey and the market study of the lignite briquette. Before the commencement of the second stage, an interim report should be presented.

The second stage study consists of the technical and economic evaluation of the lignite briquette production and overall conclusion.

The scopes of work for the respective stages are as follows:

**(1) First Stage**

(1) Review of the background

- 1) National policy on, and present situation of, the energy in Thailand
- 2) Present situation of coal industry in Thailand

(2) Study on the energy consumption

- 1) Classification of energy use by industrial sectors and household sectors
- 2) Trend of energy consumption by sectors
- 3) Acts and regulations governing usage of fuels

(3) Study on the prospective market for lignite briquette and its distribution system

- 1) Review of the studies carried out so far
- 2) Price trends of lignite briquette and its alternatives
- 3) Quality and quantity demand for lignite briquette by sectors
- 4) Reasonable price structure for the consumer side by sectors
- 5) Consumers' response to different types of fuels
- 6) Identification of the prospective market for lignite briquette
- 7) Present and potential distribution system of coal briquettes and other fuels

- (4) Production test of lignite briquette
  - 1) Test and analysis of production of lignite briquette
  - 2) Test and analysis of combustion of lignite briquette
- (5) Survey on the acceptability of lignite briquette in the market
- (6) Overall evaluation on the market feasibility

**(2) Second Stage**

- (1) Study on resources and materials for producing the lignite briquettes
  - 1) Volume and quality of lignite at the Ban Pa Kha mine and others, if necessary
  - 2) Quality and supply of other materials for briquettes production
- (2) Review of production technology of briquettes
  - 1) Review of lignite briquette production technology developed in Thailand
  - 2) Review of the production test at the first stage
  - 3) Preparation of production process flow diagram
  - 4) Transportation and supply scheme of lignite and other relevant raw material
- (3) Construction study of the lignite briquettes manufacturing pilot plant
  - 1) Site selection
  - 2) Conceptual design and cost estimation of the plant
  - 3) Supply methods of resources and material
  - 4) Utilities (water, sewerage, electricity, etc.)
  - 5) Construction schedule
- (4) Formulation of operation plan
  - 1) Operation schedule
  - 2) Operation and management organization of the project

- (5) Financial, economic and social evaluation of the project
  - 1) Financial analysis of the project
  - 2) Economic and social evaluation
  - 3) Economic comparison between lignite briquette and other existing fuels
  - 4) Environmental consideration on production and utilization of lignite briquette
- (6) Strategy formulation for dissemination of lignite briquette
- (7) Conclusion and recommendations

#### **2-4 Outline of the Study**

This study was conducted in two stages as specified by the Scope of Work. In the first stage, lasting from November 1989 to March 1991, study was made mainly of the market potential of lignite briquettes. The study on the market potential included assessment of the possibility of using lignite briquettes as a substitute for firewood and charcoal for household and industrial uses, and that for lignite now used by small industries, and identification of the prospective market.

The second-stage study, which immediately followed the completion of the first-stage study, consisted of a techno-economic analysis and the formulation of strategies for the dissemination of lignite briquettes for popular use.

As a result of the first-stage study, the prospective markets for lignite briquettes and the potential demands were identified. Charcoal for cooking purpose was identified as the most prospective target of substitution by lignite briquettes. It was found difficult, however, to use lignite briquettes as a substitute for firewood. The estimated price of lignite briquettes is not competitive with firewood for both household and industrial uses. In addition, many industrial furnaces have to be modified before they can burn lignite briquettes. Ironically, if such modifications are made, they can burn lignite rather than lignite briquettes, the former being much cheaper than the latter. Be-

sides, the temperature could be so high in the industrial furnaces that slaked lime, blended into lignite briquettes as desulfurization agent, would not be effective enough in catching sulfur oxide. Regarding substitution for lignite in industrial applications, there is not a great merit in the use of lignite briquettes in place of lignite, if desulfurization is not expected.

As part of the first-stage study, lignite briquettes were experimentally produced from the domestic raw materials both in Japan and in Thailand. Burning tests were conducted to evaluate the performance of the experimentally produced briquettes. The burning tests also led to the development of the designs of cooking stoves suited to burning lignite briquettes. A bench-scale plant was installed at the Fuel Test Center of NEA in Rangsit near Bangkok. The study team of JICA assisted NEA in the installation and startup of the bench-scale plant, thereby transferring the related technologies to NEA. JICA invited three engineers of NEA to Japan to study technologies of coal briquette production at a coal briquette plant, as part of its programs to ensure transfer of technology.

A large amount of lignite briquettes produced by this bench-scale plant enabled demonstrations to be conducted at various locations and a number of samples to be distributed among the potential users of lignite briquettes. Their opinions on the quality of the lignite briquettes were polled. Although charcoal is more convenient than lignite briquettes as cooking fuel, about 60 percent of the respondents said they would accept lignite briquettes on conditions that the price was 60 percent of that of charcoal, and that charcoal becomes hard to obtain.

It was also discovered that the nation's already diminished forest will no longer be able to provide charcoal and firewood as much as to meet the forecast demand without becoming exhausted in a matter of only two decades. This is where lignite briquettes will have important roles to play. The results of the first-stage study were reported in the interim report submitted in February 1991.



In the second stage, techno-economic analyses were conducted. These included studies on the raw materials, production technology of lignite briquettes, sites, conceptual design, estimation of the cost, construction, utility and infrastructure, construction schedule, organization for operation, financial, economic and social evaluations; and strategies for the dissemination of lignite briquettes were recommended.

The Scope of Work defined the framework of this study and specified that the Ban Pa Kha lignite would be the main raw material and (an) appropriate kind(s) of biomass would be blended. Within the framework, this study specifies in detail the capacity of the pilot plant; the quality of the product; the kinds of raw materials and their blending ratios; the processing scheme; the location of the plant. To evaluate possibility of recovering the investment in the pilot plant during the subsequent commercial stage, a commercial plant is assumed to start following the pilot plant. The study also recommends an appropriate system of the project management. As will be explained later, this study recommends that the capacity of the pilot plant be 3,000 tons per year and that of the commercial plant be 50,000 tons per year; the raw materials be Ban Pa Kha lignite, rice straws and slaked lime; and the site be on the premises of Ban Pa Kha mine.

The first stage of this study started in November 1989 and completed in March 1991. The second stage started immediately after completion of the first stage. The experts assigned to this study are Koji TANAKA as the leader of the study team, Yoshitaka IMAEDA, Akinori HASHIMOTO, Kunio KAWADA, Ryu-ichi HIRAIWA, Kiyoji DEGUCHI, Masumi KURIBAYASHI, Yukio MIYAMOTO and Shizuo KAMIKURA. The successful completion of this study owes a great deal to the devoted support by NEA and cooperation extended by the concerned offices of the government of Thailand.



### **Chapter 3 Background to the Project**

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## Chapter 3 Background to the Project

### 3-1 General Condition of Thailand

#### 3-1-1 Natural Conditions

##### (1) Geographical Aspect

Thailand is situated on the southeastern part of the Asian continent, between 6 and 21 degrees in NL, and between 97 and 107 in EL. Thailand shares a border with the Democratic People's Republic of Laos and Democratic Kampuchea on the northeast and east, with the Union of Myanmar on the north and the west, and with Malaysia in the south in the middle of the Malay Peninsula. Thailand extends over about 1,600 kilometers from north to south and about 750 kilometers from east to west, having a total land area of 513,000 square kilometers. Thailand is divided geographically into four regions, namely: northern, northeastern, central and southern.

Northern Region is a basin surrounded by mountainous areas, with an average altitude of 1,500 meters. Here intensive farming has traditionally been carried out. The northern and western mountains in this region are famous for the production of teak and other varieties of wood.

Northeastern Region, consisting mainly of Korat Plateau, is a plateau with an altitude of some 200 meters above sea level. The soil in this region is mostly laterite which is not suitable for agriculture. This area chronically suffers from an insufficient supply of water during the long dry season, when the crops need water, though it sometimes pours during the rainy season. Due to the poor soil and erratic rainfall, the agricultural productivity of this region is low compared with other regions. However, stock-raising flourishes in this region, and livestock such as cattle and buffalo has been supplied to Central Region.

Central Region, the vast alluvial plain of the Chao Phraya River, is the

heart of the country, and is the center of paddy production. Bangkok, the capital of Thailand, is located at the southern end of this region, 30 kilometers from the mouth of the Chao Phraya River.

Southern Region occupies the long narrow neck of the Malay Peninsula, which runs from north to south. Here a number of low mountains form a gentle undulating topography. This region is rich in agricultural products, minerals and marine resources. The lower part of the peninsula produces rubber.

## **(2) Climate**

The climate of Thailand is a tropical monsoon climate clearly divisible into the following two seasons: the rainy season, lasting from May to October and the dry season, lasting from November to April. The dry season can be further divided into the cold season, from November to February, and the hot season, from March to April. The average precipitation is about 1,800 millimeters.

## **3-1-2 Social Conditions**

### **(1) Population, Ethnic Composition and Religion**

The total population of Thailand in 1988, as shown in Table 3-1, was about 54.96 million, and the average population density was 107 persons per square kilometer. The average population growth rate from 1980 to 1988 was approximately 2.0 percent. The population by region and province is summarized in Table 3-2.

From the ethnic viewpoint, the Thai tribes, Siam and Lao, share more than 80 percent of the country's total population. The next largest population in Thailand is the Chinese, which comprises approximately 10 percent of the total population. About one million of Malays live mainly in southern provinces bordering Malaysia. A variety of hill minority groups live on the northern borders.

In Thailand, though the freedom of religion is guaranteed by the con-

stitution, Buddhism is followed by more than 95 percent of the population. Islam and Christianity are followed by four and 0.6 percent of the population, respectively.

**Table 3-1 Population of Thailand: 1980-1988**

Year	Population, as of 31 December			Population per Sq. Km.
	Male	Female	Total	
1980	23,627,727	23,333,611	46,961,338	91.52
1981	24,067,597	23,807,405	47,875,002	93.30
1982	24,549,873	24,297,054	48,846,927	95.20
1983	24,911,684	24,603,390	49,515,074	96.50
1984	25,449,044	25,134,061	50,583,105	98.58
1985	26,059,668	25,735,983	51,795,651	100.94
1986	26,642,889	26,326,315	52,969,204	103.23
1987	27,070,155	26,803,017	53,873,172	104.99
1988	27,574,256	27,386,661	54,960,917	107.10

Source: Statistical Yearbook, National Statistical Office  
Statistical Handbook, National Statistical Office

## (2) Politics and Administration

Thailand is a constitutional monarchy with the King as Head of State. The parliament is that of a bicameral system consisting of Upper and Lower Houses. The cabinet consists of the Office of the Prime Minister, twelve ministries and Office of University Affairs. Administration is executed through provinces, down to districts and villages. The provincial governors and district officers are civil officers appointed by the Minister of Interior.

Table 3-2 Population and Area by Region and Province: 1988

(1/2)

Region and Province	Population (Thousand)	Area Sq. km.	Population Per Sq. km.
Whole Kingdom	54,960.9	513,115.0	107.1
Central Region	18,114.0	103,901.2	174.3
Bangkok Metropolis	5,716.8	1,565.2	3,652.4
Chai Nat	353.1	2,469.7	143.0
Nonthaburi	596.4	622.3	958.3
Pathum Thani	435.4	1,525.9	285.3
Phranakorn Sri Ayutthaya	677.6	2,556.6	265.0
Lop Buri	735.5	6,199.7	118.6
Sara Buri	521.0	3,576.5	145.7
Sing Buri	226.9	822.5	275.9
Ang Thong	277.8	968.4	286.9
Chanthaburi	422.5	6,338.0	66.7
Chachoengsao	569.4	5,351.0	106.4
Chon Buri	897.2	4,363.0	205.6
That	188.4	2,819.0	66.8
Nakhon Nayok	223.2	2,122.0	105.2
Prachin Buri	854.2	11,957.5	71.4
Rayong	440.3	3,552.0	123.9
Samut Prakan	789.1	1,004.1	785.8
Kanchanaburi	663.5	19,483.2	34.1
Nakhon Pathom	630.8	2,168.3	290.9
Prachuap Khiri Khan	413.9	6,367.6	65.0
Phetchaburi	418.8	6,225.1	67.3
Ratchaburi	705.1	5,196.5	135.7
Samut Songkhram	204.8	416.7	491.5
Samut Sakhon	341.0	872.4	390.8
Suphan Buri	811.3	5,358.0	151.4
Northeastern Region	19,254.2	168,854.3	114.0
Kalasin	870.3	6,946.7	125.3
Khon Kaen	1,649.5	10,886.0	151.5
Chaiyaphum	1,016.0	12,778.3	79.5
Nakhon Phanom	616.7	5,512.7	111.9
Nakhon Ratchasima	2,325.1	20,494.0	113.5
Buri Ram	1,403.4	10,321.9	136.0
Maha Sarakham	880.2	5,291.7	166.3
Mukdahan	282.4	4,339.8	65.1
Yasothon	512.2	4,161.6	123.1
Roi Et	1,202.6	8,299.4	144.9
Loei	536.1	11,424.6	46.9
Si Sa Ket	1,282.3	8,840.0	145.1
Sakon Nakhon	938.0	9,605.8	97.7
Surin	1,258.1	8,124.0	154.9
Nong Khai	850.6	7,332.3	116.0
Udon Thani	1,768.2	15,589.4	113.4
Ubon Ratchathani	1,862.4	18,906.1	98.5



Region and Province	Population (Thousand)	Area Sq. km.	Population Per Sq. km.
Northern Region	10,731.6	169,644.3	63.3
Kamphaeng Phet	643.8	8,607.5	74.8
Chiang Rai	1,009.6	11,678.4	86.5
Chiang Mai	1,345.7	20,107.1	66.9
Tak	336.7	16,406.6	20.5
Nakhon Sawan	1,072.9	9,597.7	111.8
Nan	432.2	11,472.1	37.6
Phayao	492.8	6,335.1	77.8
Phichit	547.9	4,531.0	120.9
Phitsanulok	767.4	10,815.8	70.9
Phetchabun	931.0	12,668.4	73.5
Phrae	489.4	6,538.6	74.8
Mae Hong Son	165.8	12,681.2	13.1
Lampang	756.1	12,534.0	60.3
Lamphun	409.4	4,505.9	90.8
Sukhothai	582.8	6,596.1	88.4
Uttaradit	452.3	7,838.6	57.7
Uthai Thani	295.8	6,730.2	44.0
Southern Region	6,861.1	70,715.2	97.0
Krabi	280.8	4,708.5	59.6
Chumphon	383.3	6,009.0	63.8
Trang	503.0	4,917.5	102.3
Nakhon Si Thammarat	1,396.2	9,942.5	140.4
Narathiwat	536.8	4,475.4	119.9
Pattani	518.1	1,940.4	267.0
Phangnga	206.0	4,170.9	49.4
Phthalung	448.6	3,424.5	131.0
Phuket	155.4	543.0	286.1
Yala	339.2	4,521.1	75.0
Ranong	107.8	3,298.0	32.7
Songkhla	1,060.0	7,393.9	143.4
Satun	212.4	2,479.0	85.7
Surat Thani	713.5	12,891.5	55.3

Source: Statistical Yearbook, National Statistical Office

### 3-2 Economic Condition

#### 3-2-1 General

The economy of Thailand expanded steadily at average annual rates of 7.9 percent in the 1960's and 6.9 percent in the 1970's based on GDP. After the second energy crisis, the economy of Thailand was affected by the worsening economic situation of the developed nations along with the soft prices of primary products. GDP grew by only 3.5 percent in 1985. The economy took an upward turn in 1986; GDP achieved a high growth rate of 11 percent in 1988 as may be noted from Table 3-3. GNP per capita in 1988 was 26,412 Bahts, or approximately US\$ 1,000, and Thailand is now expected to become one of the NIES in the near future. The major reasons for the rapid expansion of the economy are as follows:

- (1) Increased foreign capital investment, chiefly by Japan and Taiwan in export-oriented industries,
- (2) A drop in the price of crude oil,
- (3) Higher prices of primary products including agricultural products, and
- (4) Increased competitiveness in exports, stemming chiefly from the devaluation of the Baht.

Table 3-3 Major Economic Indicators

	1984	1985	1986	1987	1988	1989
GDP at 1972 Prices (Million Bahts)	380,738	394,113	413,498	452,635	512,467	575,016
Growth Rate, %	7.1	3.5	4.9	9.5	11.3	12.2
GNP per Capita (1)	18,968	19,287	20,364	22,599	26,412	n.a.
Rate of Increase						
Consumer Price Index, %	0.8	2.4	1.9	2.5	3.8	5.3
Producer Price Index, %	-3.1	-0.1	-0.4	5.9	8.2	4.6

Note: (1) Current prices, Bahts

Source: National Income of Thailand, NESDB

Statistical Handbook, National Statistical Office

Commodity prices have been stable in terms of both the consumer price

index and the producer price index. In 1988, the consumer price index rose by 8.2 percent; this could be attributable mainly to the higher prices of agricultural products caused by the reduced outputs resulting from the drought experienced in the previous year.

The industrial structure of Thailand is shifting from one that is heavily dependent on agriculture which accounted for more than 50 percent of GDP in the 1950's to one in which the manufacturing and service sectors lead the economy. As shown in Table 3-4, the manufacturing sector contributed more to GDP than the agricultural sector. The major industrial activities are food processing, beverages, tobacco, and textiles; these three sectors together account for more than half the manufacturing added value. Other important products include a wide range of construction materials and consumer goods. The production of intermediate goods such as chemicals and metals and that of capital goods such as machinery are still relatively small. Thai industry is being converted from one that produces simple consumer goods for import substitution into one producing goods which can compete internationally.

**Table 3-4 Configuration of GDP by Sector at Current Market Price**  
(Unit: %)

	1984	1985	1986	1987	1988
Agriculture	18.0	16.7	16.5	16.1	16.9
Mining & Quarrying	3.4	4.0	3.1	3.1	3.0
Manufacturing	22.4	22.1	23.3	23.9	24.4
Construction	5.8	5.6	5.2	5.1	5.1
Electricity & Water Supply	1.9	2.3	2.6	2.6	2.6
Transportation & Communications	7.1	7.7	7.8	7.5	7.3
Wholesale & Retail Trade	15.9	15.1	15.5	15.6	15.8
Banking, Insurance & Real Estate	3.5	3.5	3.4	3.9	4.1
Home Ownership	3.8	4.1	4.1	4.0	3.6
Public Administration & Defense	4.6	4.8	4.6	4.3	3.8
Services	13.5	14.1	13.8	13.9	13.4
<b>TOTAL</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>	<b>100.0</b>

Source: National Income of Thailand, NESDB

As shown in Table 3-5, farming activities account for about 70 percent of total employment. If the people indirectly engaged in agribusiness

activities are added, the labor force engaged in agriculture is as high as nearly 90 percent of the total labor force. The manufacturing sector employs only 8 percent.

Table 3-5 shows the balance of international payments. While the trade balance per se has been continuously minus, the overall balance has steadily recorded substantial surpluses by virtue of the positive balance of the service industry, mainly tourism, and capital. The foreign currency reserve is also showing a steady increase.

Such primary products as rice, maize, tin, marine products and oil seeds have been major export products. In recent years, exports of textile products, cement, electrical-electronic components have been increasing, and are expected to increase even further in the future. On the other hand, with the development of domestic industries, imports of raw materials, capital goods and oil/oil products are also increasing; and this has caused a trade imbalance. The major trading partners are Japan, the U.S.A., West European countries and the ASEAN. In addition to these countries, Thailand is positively promoting trade with China, the U.S.S.R., and East European countries. Trade with Laos, Kampuchea, Vietnam and Myanmar is also increasing.

### **3-2-2 Economic Development Plan**

The first economic development plan commenced in January 1961 as a six-year plan. Later, the plan was modified to a five-year plan. Thailand has completed its sixth plan which covers from October 1986 to September 1991. During these five development plans, the national economy, as well as the standard of living of the people, has improved significantly. GNP, for example, increased 18 times from a nominal 58,900 million Bahts in 1961 to a nominal 1,077,100 million Bahts in 1986, and per capita income about 10 times from a nominal 2,150 Bahts in 1961 to a nominal 20,456 Bahts. In the field of social development, the quality of education and public welfare has been greatly improved. Looking at the economic structure of Thailand, the country may be regarded as having changed from an agricultural economy to an industrial one based on agriculture.

Table 3-5 Balance of Payments

(Unit: Million of Baht)

	1984	1985	1986	1987	1988	1989
<b>Merchandise</b>						
Export(f.o.b.)	173,520	191,703	231,481	298,099	399,230	509,544
Import(c.i.f.)	-242,284	-253,334	-245,690	-341,376	-501,401	-650,704
Non-monetary Gold	-32	-41	-160	-551	-1	--
Trade Balance	-68,796	-61,672	-14,369	-43,828	-102,171	-141,106
<b>Services</b>						
Receipt	72,742	85,880	87,665	107,187	150,337	182,619
Payment	-57,542	-70,627	-72,695	-78,474	-95,961	-111,470
Net Services	15,199	15,253	14,970	28,713	54,377	71,150
<b>Net Goods and Services</b>	-53,596	-46,419	601	-15,114	-47,795	-70,011
<b>Unrequited Transfers</b>						
Private	4,128	4,494	5,914	5,795	5,971	6,251
Central Government	1,407	1,274	1,673	2,581	1,179	1,186
Central Government	2,721	3,221	4,240	3,214	4,793	5,065
<b>Balance on Goods and Services and Unrequited Transfers</b>	-49,468	-41,925	6,515	-9,319	-41,823	-63,760
<b>Capital Movements</b>						
Direct Investment	58,365	51,433	11,354	21,112	72,605	150,208
Other Private Long-term	9,624	4,379	6,880	4,712	27,358	42,457
Other Private Short-term	27,197	20,952	2,048	946	1,892	78,011
Central Government	15,878	7,099	9,057	4,111	33,342	42,980
Central Government	5,666	19,003	-6,631	11,342	10,013	-13,241
<b>Net Errors and Omissions</b>	1,692	2,956	15,710	6,390	9,708	25,007
<b>Overall Balance</b>	10,588	12,464	33,578	18,183	40,489	111,455
<b>Foreign Currency Reserve (Million US Dollar)</b>	2,689	3,004	3,776	5,211	7,112	10,509

Source: Bank of Thailand

Table 3-6 Exports &amp; Imports by Commodity

(Unit: %)

	1984	1985	1986	1987	1988	1989
<b>Exports</b>						
Food	49.4	44.8	43.5	36.5	34.1	33.6
Beverages & Tobacco	1.0	0.9	0.7	0.5	0.4	0.3
Crude Materials	10.8	10.1	8.8	8.9	8.8	6.8
Mineral Fuel & Lubricants	0.2	1.3	0.8	0.7	0.8	0.7
Animal & Vegetable Oils & Fats	0.2	0.3	0.1	0.1	0.1	0.1
Chemicals	1.2	1.3	1.4	1.5	1.2	1.3
Manufactured Goods	16.7	18.5	18.6	19.6	19.0	18.1
Machinery	6.8	8.8	10.6	11.8	15.8	17.8
Others	13.7	14.1	15.4	20.4	19.8	21.3
<b>Imports</b>						
Food	3.1	3.8	5.4	4.2	4.7	4.5
Beverages & Tobacco	0.7	0.9	0.8	0.5	0.5	0.5
Crude Materials	6.3	6.6	6.7	7.4	6.8	6.8
Mineral Fuel & Lubricants	23.4	22.6	13.4	13.4	7.6	9.0
Animal & Vegetable Oils & Fats	0.5	0.2	0.1	0.1	0.1	0.1
Chemicals	12.9	14.0	16.1	15.3	12.6	11.2
Manufactured Goods	15.9	16.8	18.1	19.6	21.4	23.0
Machinery	29.4	28.1	30.7	32.3	39.6	37.9
Others	7.9	7.1	8.7	7.3	6.8	7.0

Source: Statistical Handbook, National Statistical Office

One of the principal goals of the Sixth Plan is to solve the socio-economic problems that have lingered unsolved so as to clear the way for future development and prosperity. The plan consists of 10 programs, the major ones of which concern overall economic development, population, social and cultural development, the development of natural resources and environmental conservation, the development of infrastructure, and rural development. The plan emphasizes mainly the solution of the problem of poverty and unemployment in rural areas. In order to attain these objectives, the overall development targets shown in Table 3-7 have been defined.

Table 3-7 Macro Economic Targets of the Sixth Plan (1987-1991)

Item	Fifth Plan (Actual)	Sixth Plan (Target)
Trade deficit (current prices)		
Average value per year (million baht)	55,600	35,900
Trade deficit/GDP (%)	5.8	2.7
Current account deficit (current prices)		
Average value per year (million baht)	36,000	11,800
Current account deficit/GDP (%)	3.8	0.9
Exports of goods and services		
Value growth rate (% p.a.)	9.8	9.9
Volume growth rate (% p.a.)	8.4	7.4
Export of goods		
Value growth rate (% p.a.)	8.4	10.7
Volume growth rate (% p.a.)	8.3	8.1
Average value per year (million baht)	177,500	290,700
Income from tourism (current prices)		
Value growth rate (% p.a.)	12.2	7.4
Imports of goods and services		
Value growth rate (% p.a.)	3.7	9.3
Volume growth rate (% p.a.)	2.0	4.5
Import of goods		
Value growth rate (% p.a.)	2.9	9.5
Volume growth rate (% p.a.)	2.9	4.6
Average value per year (million baht)	233,100	326,700
Economic expansion (% p.a. at constant prices)		
Agriculture	2.1	2.9
Manufacturing	5.1	6.6
Mining (including natural gas)	6.1	6.4
Natural gas (million cubic feet per day)	320 <sup>/1</sup>	720 <sup>/2</sup>
Gross domestic product	4.4	5.0
Expenditure growth (% p.a. at constant prices)		
Private sector		
- Consumption	4.3	3.7
- Investment	0.8	8.1
Public sector		
- Consumption	3.3	5.3
- Investment	1.8	1.0
Government revenue/GDP (%)	14.8	15.8
Population growth rate (% p.a.)	1.7 <sup>/1</sup>	1.3 <sup>/2</sup>
Per capita income (baht)	21,395 <sup>/1</sup>	27,783 <sup>/2</sup>
Inflation (% per year)	2.9	2.3

Note: <sup>/1</sup>: In 1986      <sup>/2</sup>: In 1991

Source: The Sixth National Economic and Social Development Plan, NESDB

Meanwhile, the Sixth Development Plan was revised in 1989 in consideration of the favorable economic development of Thailand and the good economic situation of the world. The revised plan aims at achieving an average economic growth of 7.5 percent per annum from 1989 to 1991, a current account deficit of less than 4 percent of GDP, government revenue equivalent to 17.1 percent of GDP against the original plan of 15.8 percent, and a government account deficit of less than 1 percent of GDP against the original plan of 1.3 percent. In addition, the amounts of annual government expenditure and investment expenditure will be increased by 6 percent and 20.6 percent over the original plan, respectively. In the fields of public investment, the budget is significantly increased in order to improve and expand the infrastructure such as electricity, telephone lines, harbor facilities and industrial water facilities.

### **3-3 Present Situation of Energy**

Table 3-8 shows the primary energy supply and final energy consumption in 1989.

The final energy consumption of Thailand in 1989 was 26,775 KTOE, or per capita consumption was only 479 kgOE. In recent years, energy consumption has been rapidly increasing at a rate of approximately 7 percent per annum mainly as a result of the rapid increase in consumption by the transportation sector. The primary energy supply in that year was 37,255 KTOE, with petroleum and petroleum products collectively accounting for 44 percent of the total supply. The rest came from natural gas, coal and lignite, hydro electricity, wood fuel and agricultural wastes, each representing 13.9, 7.4, 3.3, 22.7 and 8.3 percent, respectively. About 40 percent of the commercial energy supply and about 60 percent of the total energy supply came from domestic sources. A short account of supply and demand by source is given below.



Table 3-8 Primary Energy Supply & Final Energy Consumption: 1989

	Primary Energy Supply		Final Energy Consumption	
	Volume (KTOE)	Share (%)	Volume (KTOE)	Share (%)
MODERN ENERGY	25,726	69.1	19,196	71.7
Solid Fossil Energy	2,763	7.4	1,082	4.0
Coal & Coke	300	0.8	300	1.1
Lignite	2,463	6.6	782	2.9
Petroleum/Petroleum Prod.	16,482	44.2	15,168	56.6
Crude Oil	11,118	29.8	0	0.0
Condensate	139	0.4	27	0.1
Natural Gasoline	-8	0.0	7	0.0
LPG	448	1.2	1,009	3.8
Premium Gasoline	290	0.8	1,142	4.3
Regular Gasoline	178	0.5	1,337	5.0
Jet Fuel/Aviation Gasoline	426	1.1	1,774	6.6
Kerosene	-7	0.0	98	0.4
Diesel Oil	3,717	10.0	7,330	27.4
Fuel Oil	183	0.5	2,311	8.6
Bitumen	-2	0.0	167	0.6
Natural Gas	5,194	13.9	114	0.4
Electricity	1,234	3.3	2,798	10.5
RENEWABLE ENERGY	11,529	30.9	7,579	28.3
Firewood	8,496	22.8	2,798	10.5
Charcoal	-50	-0.1	2,008	7.5
Paddy Husks	1,194	3.2	884	3.3
Bagasse	1,889	5.1	1,889	7.1
Others	0	0.0	0	0.0
TOTAL ENERGY	37,255	100.0	26,775	100.0

Source: Thailand Energy Situation, NEA

### 3-3-1 Commercial Energy

#### (1) Petroleum

Petroleum is the most important source of commercial energy in Thailand in terms of quantity; the share of petroleum in the supply of commercial energy was 64 percent in 1989. The domestic reserve of petroleum including natural gas has been estimated at approximately 600 million TOE; and some 20 million TOE of crude oil and condensate

have been identified. In 1989, the consumption of crude oil was 11,118 KTOE. Thailand consumes more LPG, gasoline, aviation fuel and diesel oil than the nation's refineries produce. The shortage of these products is covered by imports. The shortage of diesel oil in particular has been serious. Imports of diesel oil in 1989 were approximately 3.7 million TOE, corresponding to 50 percent of the total consumption.

## **(2) Natural Gas**

The proven and probable reserves of natural gas are 3.7 trillion cubic feet, or 90 million TOE, and 13 trillion cubic feet, or 320 million TOE, respectively. The production of natural gas started in 1981; the production reached 211,400 million cubic feet, or 5.2 million TOE, in 1989. Natural gas is used almost entirely for power generation.

## **(3) Coal and Lignite**

The share of coal and lignite in the primary energy supply has increased from 0.3 percent in 1980 to 6.6 percent in 1989. As much as 80 percent of lignite is used for power generation, the rest used for industrial purposes like cement production. They are not used for household purposes. The bulk of the coal resources in Thailand is of low rank, or lignite. Coal of high quality is imported when needed. The geological lignite reserve is estimated at approximately 2,400 million tons, or 490 million TOE. The important deposits of lignite are located in the Mae Moh area in the northern part and in the Krabi area in the southern part of Thailand.

## **(4) Electricity**

Thermal power generation is the principal source of electricity in Thailand with hydroelectric generation of secondary importance. The generating capacity of the Electricity Generating Authority of Thailand (EGAT) as of 1989 is 7,366MW of which the thermal electric capacity is 3,982MW, or 54 percent, and the hydroelectric capacity 2,271MW, or 31 percent. The electricity generated in 1989 was 37,026GWh, the breakdown

of which is 70 percent thermal and 15 percent hydro. The electricity supply in that year was 38,026GWh. The shortage of electricity was covered by imports from Laos.

### **3-3-2 Non-commercial Energy**

Biomass such as firewood, charcoal and agricultural waste has been used traditionally as an important source of energy. Although in urban areas the dependence on biomass energy has been rapidly decreasing with the spread of LPG and electricity, in rural areas biomass is still a predominantly important source of energy. Wood fuel, or charcoal and firewood, is the most important source of non-commercial energy, representing about 63 percent of the final non-commercial energy consumption of the whole kingdom. Agricultural wastes are available in abundance the year round; however, they are not made good use of except for bagasse and rice husks.

#### **(1) Firewood**

In Thailand, firewood is a traditional fuel still predominantly used in rural areas along with charcoal. The supply of firewood in 1989 was 8,496 KTOE, approximately 70 percent of which was used for charcoal making. The final consumption of firewood in that year was 2,798 KTOE, of which the breakdown of use is 80 percent for household purposes and 20 percent for industrial uses.

#### **(2) Charcoal**

The production of charcoal in 1989 was about 2,000 KTOE, almost all of which was consumed as cooking fuel. In southern areas, waste rubber trees and mangroves are the main sources of charcoal; in other areas, various kinds of tree, including eucalyptus and pine trees, are used for charcoal making.

#### **(3) Others**

More than 50 million tons of agricultural wastes are annually produced

from the principal agricultural products such as rice, sugar cane, maize and cassava. However, only 20 percent of the agricultural wastes are utilized as fuel. More than 10 million tons of bagasse are used as boiler fuel in sugar mills. Rice husks are used as boiler fuel in rice mills, fuel at brickyards and as household fuel. The consumption of rice husks for the above uses is estimated to be more than 2.6 million tons.

### **3-3-3 Issues concerning the Supply and Demand of Energy**

The basic principle behind the energy policy of Thailand is to increase the degree of dependence on domestic energy. Under the above policy, indigenous energy sources -- natural gas, lignite and oil -- have been vigorously explored and developed. As a result, the rate of self-sufficiency has rapidly increased. However, under such a policy, some industrial sectors are obliged to use domestic energy at higher prices compared with imported energy, with a result that export competitiveness is adversely affected in such industries.

With regard to petroleum products, the imbalance between consumption and domestic refining production exists presumably as a result of the artificial control of prices. In the transportation sector, for example, the demand for gasoline remains weak due to its higher price, while the demands for diesel oil and LPG have rapidly increased because of their cheaper prices. An oversupply of fuel oil has become apparent as conversion from fuel oil to natural gas or lignite progresses at power plants.

In rural areas, while firewood and charcoal remain as the principal energy sources, the utilization of abundant agricultural wastes is still limited. Since the use of firewood and charcoal is one of the major causes of deforestation, improved efficiency in the use of wood fuel and the need to promote the development and utilization of substitute fuels are emphasized.

There is still a great deal to do with regard to the conservation of energy in Thailand as in many countries. In the transportation sector,

the need to improve efficiency with the congested conditions of traffic in Bangkok has been pointed out.

### **3-4 National Policy on Energy**

#### **3-4-1 General**

Before 1980, Thailand depended heavily on imported energy. More than 90 percent of the commercial energy and more than 50 percent of the total energy requirements were imported. Accordingly, the impacts of the energy crises of the 1970's were seriously felt. In 1981, the payment for imported oil and oil products amounted to 2.7 billion US dollars, corresponding to 45 percent of the total export value. The dependence to such an extent on imported energy was a crucial economic and security problem. Under these circumstances, Thailand has been accelerating the exploration and development of indigenous energy sources such as natural gas, lignite and petroleum. As a result, until 1988, the dependence on imports of commercial energy and the total energy requirement was reduced to less than 60 percent and some 30 percent, respectively. The Sixth Five-year Plan aims at improving the degree of self-sufficiency in the supply of energy; for this purpose, the plan established the following basic policies. The policy targets for development according to the plan are summarized in Table 3-9.

- (1) To reduce the dependence on imported energy and to diversify the number of energy sources by accelerating the exploration and development of domestic energy sources; that is, natural gas, lignite, hydro-power, crude oil and various forms of non-traditional energy,
- (2) To restructure the prices of commercial energy, particularly those of petroleum products and electricity, in order to encourage the efficient use of energy,
- (3) To promote the efficient use of energy by stressing energy conservation in transport, industry, commercial buildings and cooking fuels by wood and charcoal,

- (4) To encourage the private sector to participate more in energy investment in order to relieve the government of part of its financial burden,
- (5) To promote and support the procurement of appropriate types of energy to satisfy rural demand,
- (6) To apportion energy consumption by taking into consideration the impact on the environment.

**Table 3-9 Energy Development Targets of the Sixth Plan**

Item	Target (1991)	Actual (1985)
1. Energy Consumption Growth Rate, % p.a.	3.7	4.1
2. Dependence on Imported Energy, % of Commercial Energy Consumption	49	58
3. Natural Gas Production, MMCFD	720	354
4. Condensate Production, BPD	18,500	14,250
5. Crude Oil Production, BPD	28,600	20,800
6. Consumption of Natural Gas for Power Generation, MMCFD	>500	250
7. Consumption of Lignite for Power Generation, kttons/year	9,000	5,000
8. Consumption of Lignite for Industrial Uses, kttons/year	1,000	500
9. Reserve Capacity for Electricity Generation, % of Maximum Electricity Demand	15 to 20	--
10. Additional Rural Electrification (Villages)	10,700	--
11. Consumption of Imported Coal, kttons/year	500	200
12. Energy Saving in the Transport, Industrial and Residential Sectors, KLOE	390,000	--

Source: Sixth National Economic and Social Development Plan, NESDB

The measures to develop energy according to the above policies are mentioned below.

### **3-4-2 Development of Domestic Energy Resources**

#### **(1) Oil and Natural gas**

Thailand will promote the exploration and development of oil and natural gas resources by the following measures. On the other hand, concerning the imported oil and refined products, diversification of the sources of supply and adjustment of the terms and conditions of the purchase contracts will be promoted in order to secure a stable energy supply.

- (1) To revise the Petroleum Act in a manner that will encourage exploration and development,
- (2) To encourage the diversification and expansion of the natural gas market,
- (3) To speed up the cooperative agreement with Malaysia in the joint development of natural gas.

#### **(2) Lignite**

The consumption of lignite, of which a huge amount of resources has been identified by the Department of Mineral Resources (DMR), has been rapidly increasing for power generation in recent years. The government emphasizes the need for detailed surveys on lignite resources in Mae Moh, Krabi and other economically viable sites, and will further promote the utilization of lignite for power generation. Research and development on expanding the use of lignite in the industrial sector are also being promoted. In addition, research and development on equipment and apparatus for environmental conservation that may become necessary as a result of the use of lignite are being positively promoted. These will be in great demand as the consumption of lignite increases.

### **(3) Hydro Power**

The exploration and development of water resources for power generation are being undertaken by EGAT. In the case of multipurpose hydroelectric projects, the construction cost will be meted out to the beneficiaries. Small hydroelectric projects will be promoted mainly by the National Energy Administration.

#### **3-4-3 Energy Pricing**

The consumption of petroleum products in Thailand may be characterized by the large consumption of diesel fuel and LPG and the relatively small consumption of gasoline in the transportation sector. The major reason for this pattern of demand is the price of gasoline artificially set rather high which prompts consumers to turn to diesel fuel and LPG. Another characteristic is the decreasing consumption of fuel oil as conversion at power plants from fuel oil to natural gas and lignite progresses. Under these circumstances, the government of Thailand intends to optimize the pattern of energy consumption by adopting a policy of basically liberalizing the control of energy prices which have direct effects on the pattern of energy consumption.

#### **3-4-4 Expansion of the Refinery Capacity and Imports Petroleum Products**

The government of Thailand has publicly announced a policy of relaxing the controls on the expansion and modification of petroleum refineries so that they will be given flexibility to meet the increase and changes in the patterns of demand for products. In addition, in order to increase export competitiveness, the government intends to decrease the gap in the price of petroleum products between the domestic and international markets by allowing imports of petroleum products.

#### **3-4-5 Research and Development of Non-conventional Forms of Energy**

Research and development of high-efficiency cooking stoves on the one hand, and the plantation of the kinds of trees suitable for charcoal



making on the other, are being promoted. The private sector is encouraged to grow trees for commercial purposes. Research and development of technologies which facilitate the better utilization of non-conventional energy such as solar, fuel-cell, and geothermal energy, as well as biomass, are also being promoted. Biomass in particular is considered important as one of the most important types of energy for households and industries in rural areas. As for the technology for the better utilization of biomass energy, improvements to the burning apparatus for direct burning, the compression of soft biomass into solid fuels, dendro-thermal power generation, the generation of bio-gas and the production of alcohol from cassava are being studied. The increased production and use of appropriate non-conventional energy would help activate the areas which have been lagging behind in development.

#### **3-4-6 Energy Conservation**

In order to promote the conservation of energy in the transportation sector, the amelioration of the traffic congestion in Bangkok and its outskirts is being planned. For the above purpose, the establishment of a central organization in charge of administration and planning for the traffic and transportation of this area is being planned. The construction of new roads and revisions to the tax system relevant to transportation are also being considered.

To promote the conservation of energy in the sectors of industry and commercial buildings, the Energy Conservation Center of Thailand was established. Financing at low-interest rates and tax reductions for materials and equipment have been provided in order to facilitate energy conservation. Energy-saving technology has been introduced from abroad.

In the household sector, NEA is developing thermally more efficient cooking stoves and charcoal kilns, and is promoting their use.

### 3-5 Present Situation of Coal Industry

#### 3-5-1 Coal Resources

Thailand's coal resources consist of lignite and sub-bituminous coal found in tertiary basins. More than 95 percent of these resources are lignite of low heating values, 2,500 to 3,000kcal/kg, and high moisture and high ash contents. These low-grade lignites are located mainly in Lampang in northern Thailand with the rest scattered around Krabi in the southern part of the country. Lignites of higher grades with heating values ranging from 3,200 to 5,000kcal/kg and sub-bituminous coal with heating values from 5,000 to 6,000kcal/kg exist in much smaller deposits in northern Thailand, mainly in Li Mine in Lamphun. Small deposits of anthracite have been found in the northeast, but the exact reserves are not known. As shown in Table 3-10, the geological coal reserve is estimated at 2.4 billion tons.

Table 3-10 Reserves of Coal Resources in Tertiary Basins in Thailand  
(Unit: Million tons)

Province	Mine or Deposit	Original Coal in Place
Lampang	Mae Moh	1,490.5
Lampang	Mae Teeb	11.0
Lampang	Mae Tha	1.5
Lampang	Jae Hom	30.8
Lampang	Hua Sua	1.8
Lampang	Wang Nua	25.3
Lampang	Ngao	102.4
Lamphun	Li	225.3
Krabi	Krabi	120.8
Tak	Mae Tun	1.2
Tak	Mae Lamao	4.0
Tak	Mae Ramat	2.5
Petchaburi	Nong Ya Plong	2.4
Phayao	Chiang Muan	17.5
Chiang Mai	Wiang Haeng	127.1
Chiang Mai	Bo Luang	0.6
Surat Thani	Khlan Sa	55.4
Krabi/Nakhon Si Thammarat	Sin Pun	94.8
Song Khla	Saba Yol	100.0
<b>Total</b>		<b>2,414.9</b>

Source: DMR, NEA, EGAT and Private Companies

The proven reserves are only less than 0.9 billion tons as shown in Table 3-11, presumably because of the limited scale of exploration so far conducted. It is expected that the proven reserves will be greatly increased by additional exploration.

**Table 3-11 Reserves of Coal Resources in Thailand**

Location	Reserve in Million Metric Tons		Type of Coal
	Proven	Probable	
Lampang Province			
- Mae Moh	802.0	1,300.0	Lignite-Sub-bituminous
- Mae Teeb	1.0	20.0	Sub-bituminous-Bituminous
- Ngao	22.8	24.8	Lignite-Sub-bituminous
- Jae Kon	15.5	15.5	Lignite-Sub-bituminous
- Jae Hom	1.5	27.4	Lignite-Sub-bituminous
Lamphun Province			
- Pa Kha, Li	18.5	18.5	Sub-bituminous
- Ban Pu, Li	4.0	4.0	Sub-bituminous
- Ban Na Sai	5.0	20.0	Lignite-Sub-bituminous
Krabi Province			
- Bang Poo Dam	25.0	53.0	Lignite-Sub-bituminous
- Sin Poon	N.A.	16.0	Lignite-Sub-bituminous
Chiang Mai Province			
- Wiang Haeng	1.5	45.0	Lignite-Sub-bituminous
Tak Province			
- Mae Tuen, Mae Ramat	1.3	3.5	Sub-bituminous-Bituminous
Loei Province			
- Na Duang	0.5	N.A.	Semi-anthracite-Anthracite
Udon Thani Province			
- Na Klang	N.A.	N.A.	Anthracite
Petchaburi Province			
- Nong Ya Plong	1.4	N.A.	Sub-bituminous-Bituminous
Song Khla Province			
- Saba Yoi	N.A.	100.0	N.A.
<b>Total</b>	<b>899.9</b>	<b>1,647.7</b>	

Source: NEA

### 3-5-2 History of Coal Development

The development of coal resources in Thailand started in 1892 when lignite was first discovered in Krabi Province in southern Thailand. Since then, endeavors have been made to expand the use of coal resources; those worth mentioning are shown below.

- (1) An attempt to use lignite as a fuel for steam locomotives was made in 1917. However, this project turned out to be unfeasible because of the low heating value of lignite and the difficulty associated with the transportation of lignite.
- (2) In 1960, the first lignite-fired power plant with a capacity of 12.5 MW was commissioned. However, the further development and utilization of lignite for power generation was limited for a while because of the cheap price of oil prevailing at that time.
- (3) In 1966, lignite was used for the production of chemical fertilizers. However, the process did not accommodate the poor quality of lignite available in Thailand.
- (4) In 1970, production of lignite was increased in the North to encourage the tobacco industries to use lignite instead of firewood, because the use of firewood was recognized as a major cause of deforestation.
- (5) After the energy crisis, the government placed a high priority on the development and utilization of domestic coal resources in order to save foreign currency exchanges. This has made industries like the cement, paper and food processing industries become interested in the use of coal and lignite to replace fuel oil. However, the use of lignite for industries has made little progress, since it has been hampered by technical difficulties encountered in the processes of conversion from conventional fuels to lignite.
- (6) In spite of the recent decline in the price of oil, the government continues to push the development and utilization of lignite. Today, lignite has come to play an important role in power generation and is increasingly being accepted by other industries.

### 3-5-3 Production and Consumption

#### (1) Production and Imports

Table 3-12 shows the historical production of coal in Thailand. All mines are open-pit mines. In 1989, as shown in the table, the total production amounted to 8.90 million tons, a 22.6 percent increase over that of 1988. The major coal suppliers are the governmental mines in Mae Moh and Krabi; and the majority of the coal from these mines is used for power generation. Private mines produce coal of higher grades for industrial consumption.

In 1989, 480 thousand tons of coal comprising bituminous coal, anthracite, coke, etc. were imported, registering an increase of 25 percent over the previous year. This imported coal was consumed by such industries as the cement, metallurgy and carbide manufacturing industries.

Table 3-12 Historical Production of Coal in Thailand  
(Unit: Thousand tons)

Year	Mae Moh	Krabi	Li	Others	Total
1978	279	275	83	6	642
1979	941	304	100	11	1,356
1980	935	385	94	12	1,427
1981	1,204	338	103	40	1,686
1982	1,300	380	92	192	1,964
1983	1,248	335	134	149	1,866
1984	1,659	280	193	295	2,337
1985	4,217	395	350	184	5,146
1986	4,557	212	668	110	5,547
1987	5,565	191	946	186	6,887
1988	5,717	221	n.a.	1,321	7,259
1989	6,541	319	n.a.	2,041	8,901

Source: DMR and NEA

#### (2) Consumption

In recent years, the consumption of lignite has increased rapidly, as may be seen in Table 3-13. A short account of consumption by sector is given below.

### 1) Power Generation

Since 1985, the consumption of lignite for mine-mouth power generation has been rapidly increasing in line with the vast program to reduce dependence on imported energy under the Fifth Five-year Plan. Using the bulk of the available lignite, more than 80 percent, for mine-mouth power generation seems a sensible option because the transportation of low-grade lignite with its high-ash and high-moisture content to be used for other purposes at remote places could hardly be viable from an economical viewpoint.

Table 3-13 Lignite Consumption in Thailand

(Unit: Thousand tons)

Year	Electricity	Tobacco	Cement	Others	Total
1980	1,321	80	4	43	1,448
1981	1,534	100	50	12	1,695
1982	1,687	122	203	30	2,042
1983	1,573	99	196	52	1,920
1984	1,945	76	224	61	2,305
1985	4,597	92	387	56	5,132
1986	4,685	80	532	129	5,426
1987	5,727	78	658	360	6,823
1988	5,896	60	874	369	7,199
1989	6,780	110	1,265	418	8,573

Source: Thailand Energy Situation, NEA

### 2) Cement Industry

After power plants, the cement industry is the next largest consumer of coal in Thailand. However, the use of domestic coal in cement plants is limited by the following factors.

-Cement manufacturers have to blend Thai coal with either oil or imported coal to compensate for its low quality.

-Domestic coals of higher quality are produced too far away from most cement plants to be transported economically. Therefore, it is more economical for most plants, especially those located south of Bangkok, to use 100 percent imported coal.

### **3) Other Industries**

The other users of coal are small industries, mainly the tobacco curing industry. These industries use coal and lignite of quality better than those used for power generation, but not good enough to use in cement plants. The use of lignite by small industries is still limited mainly for the following reasons:

- Prohibitive cost of inland transportation
- Inconsistent quality and unreliability of supply
- Additional financial burden for fuel conversion
- Technical difficulties associated with storage and ash disposal.

### **4) Household Fuel**

In Thailand, lignite is not used as household fuel, primarily for the following reasons:

- Lignite generates smoke, as well as a bad smell, if burned in ordinary cooking stoves.
- Lignite has a tendency for autogeneous ignition.
- Lignite cannot be made into smokeless briquettes without pretreatment by costly carbonization.
- Electricity and LPG are far more convenient to use than solid fuels.

However, if smokeless or smoke-controlled briquettes are produced, the consumers now using chiefly firewood and charcoal would accept them.

### **3-5-4 Distribution and Marketing**

As mentioned earlier, more than 80 percent of domestic coal is used at mine mouths. Accordingly, the amount of coal actually distributed is about one million tons. Coal is transported by truck from coal mines in Northern Region to cement plants in Central Region. Coal for tobacco curing is also transported by truck from mines in Northern Region to tobacco growing areas such as Chiang Mai, Chiang Rai and Lampang. Likewise, coal is transported almost entirely by truck for

other purposes, too. Large users buy coal directly from producers. The prices are not controlled except that for tobacco curing which is regulated by the government.

### **3-6 National Policy on the Coal Industry**

The policy priority on energy is to increase the degree of self-sufficiency of the energy supply by promoting exploration and development of the indigenous energy sources. Under the above policy, Thailand has promoted the development and utilization of natural gas and coal resources. The development and utilization of coal will be ever more important given that it is estimated that the natural gas reserve will be exhausted at the beginning of the 21st Century. Against such a background, the Sixth Five-year Plan regards coal as the most important indigenous energy source requiring development and utilization for the following reasons:

- (1) The total probable reserve of coal is about 442 million TOE, which is the largest of all indigenous energy sources.
- (2) The development of coal is cheaper than that of oil or natural gas. In addition, the exploration and development of coal require relatively simple technology as compared to oil and natural gas, and can be carried out solely by local industries.
- (3) As lignite resources are located in various remote areas, the development of lignite can meet the energy demand in these areas.
- (4) The development of lignite resources scattered about throughout the country will increase the number of employment opportunities in these areas.

In order to attain the targets of coal utilization in the Sixth Five-year Plan, the following strategies have been formulated:



- (1) To speed up the development of coal resources. As a part of the above strategy, the Department of Mineral Resources (DMR) is undertaking the exploration of 13 prospective coal mines;
- (2) To promote the construction of lignite-burning power stations. EGAT has 10 power stations, Nos. 10 to 19, with a total capacity of 3,000 MW already approved for commissioning by 1997 in Mae Moh in Northern Region. In addition, EGAT has plans already approved to construct four units, a total of 900 MW in Song Khla Province where a lignite deposit of 100 million tons has been recently discovered;
- (3) To support the research and development activities in order to promote lignite utilization for industrial and household uses in rural areas;
- (4) To allow the private sector to play a more important role in investments in the energy sector in order to reduce the government's financial burden;
- (5) To monitor and control the environmental pollution caused by the development and utilization of lignite.

### **3-7 Forest Resources**

#### **3-7-1 Features of Thailand's Forests**

Thailand's forests continue to disappear at an alarming rate as shown in Table 3-14. In 1961, for example, some 53 percent of the country, or 270 thousand square kilometers, was covered by forest, a proportion which declined dramatically to the 1988 figure of 28 percent, or 140 thousand square kilometers. In other words, Thailand lost about 130 square kilometers of its forests over a period of 27 years, or at a rate of 4,800 square kilometers per year.

**Table 3-14 Forest Area in Thailand, 1961-1988**

(Unit: %)

Area	1961	1973	1976	1978	1982	1985	1988
North	68.54	66.96	60.32	55.96	51.75	49.59	47.37
Northeast	41.90	30.01	24.57	18.49	15.33	15.15	14.03
South	41.89	26.07	28.46	24.89	23.25	21.90	20.69
Central	52.91	35.50	32.38	30.31	27.47	26.24	25.59
East	57.98	41.19	34.00	30.24	21.92	21.89	21.46
Whole Kingdom	53.33	43.21	38.07	34.15	30.52	29.05	28.03

Source: Royal Forest Department

### 3-7-2 Role of Forests

Tropical forests provide habitats to some 2.5 to 5 million species of plants and animals. The forests provide human beings with food and materials for firewood, buildings and industry. In addition to the tangible benefits above, tropical forests provide the following economical and environmental benefits.

#### (1) Stabilization of the Climate

Tropical forests have a great effect on the global climate. The effects of the forests on the climate are not fully understood. However, it is evident that they serve greatly to moderate and stabilize the climate. The destruction of forests may adversely affect worldwide agriculture by decreasing rainfall. The increase in the amount of carbon dioxide caused by deforestation may warm the earth by the "greenhouse effect" and increase the level of the ocean with the melting of the polar ice caps.

#### (2) Water Conservation

The forests, natural or nearly natural, act as natural water reservoirs which retain water and release it gradually. Forest watersheds thus

maintain a reliable supply of water for downstream agriculture, industry, human consumption and hydroelectric facilities. More than 40 percent of the farmers in developing countries are supposedly dependent on the sponge effects of forests to absorb and release water slowly. Forests reduce the frequency and extent of floods and droughts, so deforested areas are often plagued by floods and droughts, thereby giving rise to serious social problems.

The mangrove ecosystems of the intertidal zone provide nurseries for a variety of marine creatures and help prevent coastal erosion.

### **(3) Soil Protection**

Tropical forests shelter the soil underneath from wind and rain, and at the same time stabilize it. The soil under tropical forests is usually fragile and of poor quality, and therefore generally unsuitable for agriculture. Almost all the nutrients are found in the living vegetation rather than in the soil. With deforestation, the top soil rapidly deteriorates and loses its fertility, leaving hard packed clay or sand that is unsuitable for cultivation. The silt washed away into the rivers causes the quality of the water to deteriorate and damages the river delta fisheries. The silt accumulates on the beds of dams and greatly reduces their hydroelectric potentials.

### **3-7-3 Major Causes of Deforestation**

The major causes of deforestation are following seven items.

- Agricultural Expansion
- Firewoods and Charcoal Production
- Overcutting
- Infrastructure Development
- Settlement
- Development of Mineral Resources
- Shrimp Culture

### 3-7-4 Reforestation

Systematic forest protection started with the implementation of the Forest Act in 1960 and the National Forest Reserve Act in 1964. Other important acts concerning forest protection include the Wild Animal Reservation and Protection Act of 1960, and the National Park Act of 1961. The government has set forth a number of policies, regulations and rules which should help provide the legal and administrative framework for forest management. For example, commitments to forest protection were made in every National Development Plan. The Sixth Five-year Plan includes the following forestry objectives:

- (1) To increase the forest area from 29 to 40 percent,
- (2) To divide Thailand's forest into two categories: protected forest and economic forest, and to increase the former to 15 percent and the latter to 25 percent of the country,
- (3) To revise the laws and regulations governing the management of forest land, and to encourage private sector initiatives,
- (4) To develop coherent short-, medium- and long-term plans for fostering forests and the forest industry,
- (5) To review forest administration in line with the above plans,
- (6) To introduce technologies designed to boost reforestation,
- (7) To promote public awareness programs so as to educate and inform people about the importance of forest resources.

To restore the forest coverage to 40 percent of the country, the following measures have been adopted:

- (1) To specify areas requiring a high degree of protection such as national parks, wildlife sanctuaries and watersheds in the forests to be protected,

- (2) To promote the plantation of fast growing trees such as the acacia and eucalyptus in the productive forest areas, and to allow the cutting down of planted trees under community control,
- (3) To promote the resettlement of farmers from forests to be protected to other places with certain incentives,
- (4) To prohibit the cutting down of forest trees since January 1989.

To prevent the destruction of mangrove forests, the following measures have been adopted:

- (1) The Royal Forestry Department imposes a royalty on the cutting down of mangrove forests for firewood and charcoal production.
- (2) In some areas, the Royal Forestry Department affords cutting-down concessions on condition that concessionaires replant after cutting.
- (3) Prior to mining mineral resources in a mangrove forest, the Royal Forestry Department and the Department of Mineral Resources examine the project from the viewpoints of forestry and mining, respectively. Only when both parties agree that the planned mining is clearly beneficial to the state, is the cutting down of the mangrove forest permitted. In the case where mining is to be carried out in a small area within the replanted area and the crop age is less than two years, the miner must provide compensation by paying for the cost of replanting. If the crop age is more than two years and the mining area is large, mining will have to wait until the trees have become big enough for logging.
- (4) The Royal Forestry Department releases the requested land to shrimp farmers only when the Fishery Department approves

the project. If the land is located in the National Forest Reserves, the shrimp farmers must pay a user's fee.

### **3-8 Significance of the Project**

Thailand used to have rich forest resources until the 1950's. However, these forest resources have been seriously depleted since then. The most important cause of deforestation was the development of more land for farming; however, the production of firewood and charcoal is the greatest cause of deforestation now. Deforested areas suffer from floods, landslides and droughts which give rise to serious social problems. Under these circumstances, in January 1989, the government announced a ban on the cutting down of trees. However, since fuel is an essential commodity, the above measure would not be complete without the provision of adequate alternative fuels for firewood and charcoal.

As has repeatedly been stated, the basic policy on the energy of Thailand lies in reducing the country's dependence on imported energy and the diversification of energy sources by accelerating the exploration and development of indigenous energy sources. The development and utilization of the abundant lignite resources are emphasized in particular.

As a part of the lignite utilization program, research and development of lignite briquettes for households and small industries have been promoted. However, the lignite briquettes produced in Thailand are not acceptable because the problems of smoke, an irritating smell and insufficient strength have remained unsolved. Although smokeless briquettes are produced in small quantities using the carbonization process, these briquettes cannot compete with firewood and charcoal in terms of price.

Thailand is basically an agricultural country, and more than 50 million tons of agricultural wastes are annually obtained from major crops. Thailand has promoted not only the utilization of agricultural wastes but also the development and utilization of high-efficiency stoves for

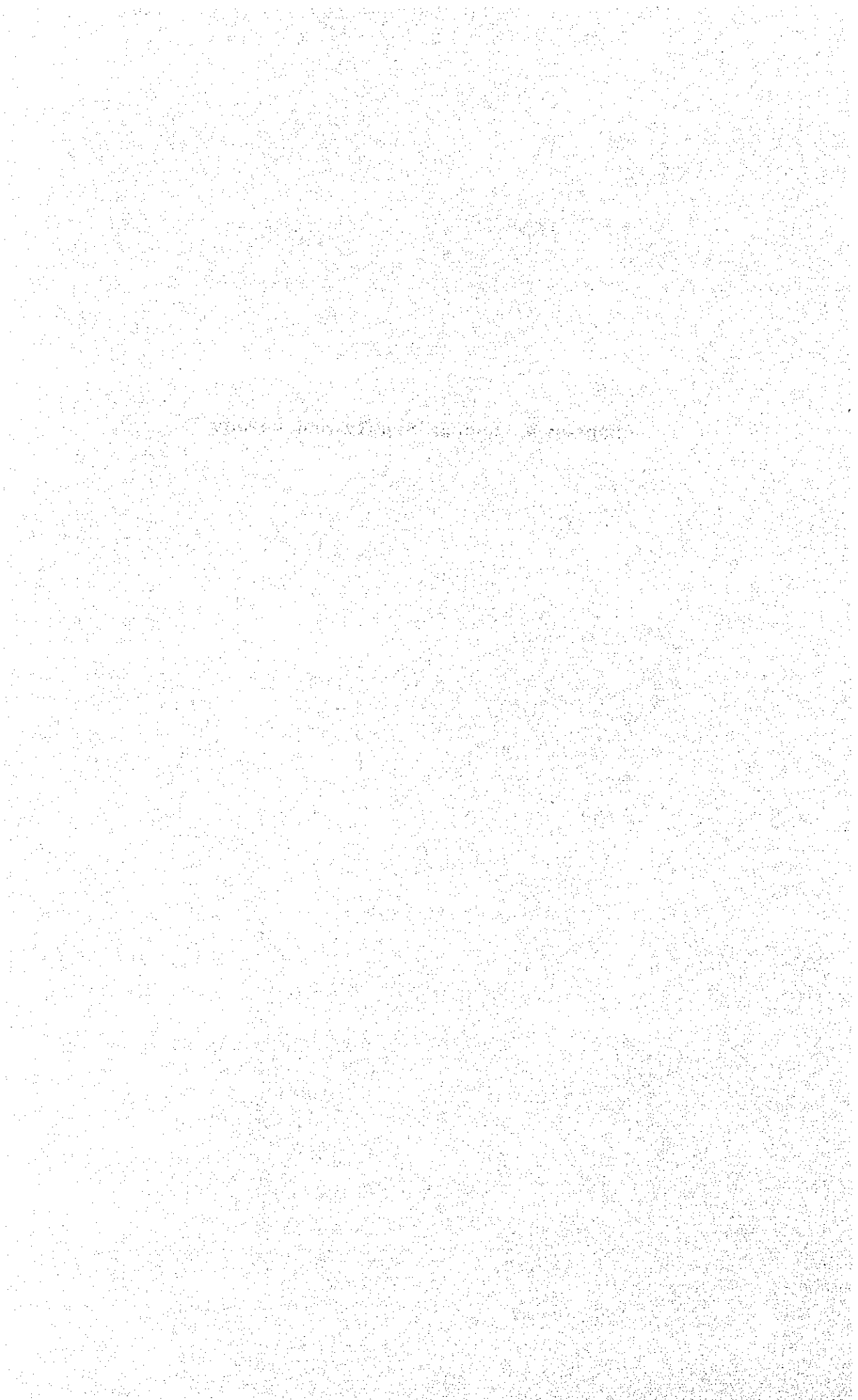
burning agricultural wastes. However, only 20 percent of agricultural wastes are utilized.

Against such a background, it would be very meaningful, from the standpoints of the national policies on energy and reforestation, to produce lignite briquettes of acceptable quality by applying Japanese technology to Thai lignite and distributing them extensively among the people as a substitute for charcoal and firewood at competitive prices. In addition, the project would be meaningful in the sense that such lignite briquettes would make effective use of biomass, a domestic resource not very effectively utilized at present.





## **Chapter 4 Energy Supply and Demand**



## Chapter 4 Energy Supply and Demand

This chapter is about the history of the supply and demand of energy in Thailand, followed by a summary of the trends by type of energy and service. This chapter also discusses energy consumption, with particular emphasis on the residential and commercial sector and the manufacturing sector, where lignite briquettes are expected to be a substitute for charcoal and firewood.

### 4-1 History of the Supply and Demand of Energy

#### 4-1-1 Energy Consumption

##### (1) Overview

The major economic indicators and energy consumption in the past are summarized in Table 4-1.

**Table 4-1 Economic Indicators and Energy Consumption**

	1982	1983	1984	1985	1986	1987	1988	1989
Population (Million)	48.8	49.4	50.6	51.8	53.0	53.9	55.0	55.9
GDP at 1972 Price (Billion Bahts)	331.4	355.4	380.7	394.1	411.8	446.4	495.4	575.0
GDP per Capita (Bahts)	6,784	7,190	7,527	7,609	7,774	8,285	9,013	10,415
Final Energy Consumption Total(KTOE)	16,221	17,022	18,272	18,856	19,556	21,048	22,927	26,574
Per Capita (KGOE)	332	344	361	364	369	391	417	475
Per GDP(KGOE/1,000 Bahts)	49	48	48	48	48	47	46	46

Source: Thailand Energy Situation, NEA

Note: Minor inconsistencies with other tables arising from difference of sources are not reconciled.

Final energy consumption in Thailand increased from 16,221 KTOE in 1982 to 26,574 KTOE in 1989 at an average rate of 7.3 percent per year. GDP, on the fixed price base of 1972, on the other hand, increased from 331.4 billion Bahts in 1982 to 575.0 billion Bahts in 1989; the rate of growth

was 8.2 percent per year on average. It follows therefore that the elasticity of energy consumption to GDP is 0.90. Energy consumption per capita increased from 332 KGOE in 1982 to 479 KGOE in 1989.

Table 4-2 shows past consumption separately for modern energy, or commercial energy, and for non-commercial energy, or renewable energy. The consumption of commercial energy increased at 10.8 percent per year on average, a rate exceeding the growth rate of GDP. By contrast, the consumption of non-commercial energy increased at a low rate of 1.5 percent per year on average which was even lower than the average growth rate of the population. As a result, the share of non-commercial energy in the final energy consumption declined from 42.2 percent in 1982 to 28.3 percent in 1989. The conversion of charcoal and firewood into commercial energy such as LPG and electricity has taken place, especially in urban areas. This explains the higher growth rate of the consumption of commercial energy compared with that of non-commercial energy.

**Table 4-2 Final Energy Consumption**

(Unit: KTOE)

	1982	1983	1984	1985	1986	1987	1988	1989
<b>Modern Energy</b>								
Coal	101	108	144	213	141	196	240	300
Lignite	155	151	157	233	323	478	568	782
Petro. Prdct.	7,834	8,639	9,342	9,463	10,071	11,263	12,747	15,001
Natural Gas	--	32	194	178	87	40	60	114
Electricity	1,281	1,441	1,583	1,707	1,878	2,121	2,408	2,798
Sub-total	9,371	10,371	11,420	11,794	12,500	14,098	16,023	18,995
	(57.8)	(60.9)	(62.5)	(62.5)	(63.9)	(67.0)	(69.9)	(71.5)
<b>Renewable Energy</b>								
Firewood	2,676	2,740	2,837	2,875	2,885	2,835	2,825	2,798
Charcoal	2,227	2,183	2,161	2,138	2,103	2,103	2,066	2,008
Paddy Husks	560	564	742	830	838	788	729	884
Bagasse	1,387	1,164	1,112	1,219	1,230	1,224	1,284	1,889
Sub-total	6,850	6,651	6,852	7,062	7,056	6,950	6,904	7,579
	(42.2)	(39.1)	(37.5)	(37.5)	(36.1)	(33.0)	(30.1)	(28.5)
<b>Total</b>	<b>16,221</b>	<b>17,022</b>	<b>18,272</b>	<b>18,856</b>	<b>19,556</b>	<b>21,048</b>	<b>22,927</b>	<b>26,571</b>

Note: Figures in parentheses are in percentage.

Minor inconsistencies with other tables arising from difference of sources are not reconciled.

Source: Thailand Energy Situation, NEA

Petroleum products have had the largest share in terms of consumption for many years. Recently, however, the consumption of lignite and electricity has been increasing. The consumption of natural gas and lignite has increased significantly as fuel to generate electricity. As a result, the share of oil in the consumption of commercial energy declined from 83.6 percent in 1982 to 79.2 percent in 1989.

Table 4-3 shows the past consumption of energy by sector. It may be noted from the table that the transportation, residential and commercial, and manufacturing sectors consumed large amounts of energy, collectively accounting for 93 percent of the total energy consumption in 1989. The consumption by the transportation sector increased at the highest rate of 12.2 percent during the period from 1982 to 1989, the rate far exceeding the growth rate of GDP for the same period.

**Table 4-3 Energy Consumption by Sector**

(Unit: KTOE)

	1982	1985	1986	1987	1988	1989
Agriculture	1,128	1,355	1,405	1,441	1,523	1,639
Mining	74	74	53	49	49	56
Manufacturing	4,728	5,219	5,250	5,598	6,062	7,712
Construction	111	125	123	111	99	109
Residential/Commercial	5,669	6,058	6,233	6,421	6,674	6,889
Transportation	4,551	6,025	6,429	7,428	8,520	10,169
Total	16,221	18,856	19,556	21,048	22,927	26,574

Note: Minor inconsistencies with other tables arising from difference of sources are not reconciled.

Source: Thailand Energy Situation, NEA

The final consumption of energy is summarized by sector as follows: agriculture and fishery, mining, manufacturing, construction, residential and commercial, and transportation.

## (2) Agriculture and fishery

This sector consumed 1,639 KTOE in 1989, accounting for only 6.2 percent of the total energy consumption in Thailand. Petroleum products, diesel fuel in particular, constituted more than 90 percent of the consumption, the rest being electricity for irrigation pumps. Of petroleum

products, diesel oil is the most important.

### **(3) Mining**

This sector consumed only 56 KTOE in 1989, representing only 0.2 percent of the total. Almost all the consumption is oil products.

### **(4) Manufacturing**

The manufacturing sector consumed 7,712 KTOE in 1989, or 29.0 percent of the total. Non-commercial energy such as firewood, rice husks and bagasse supplied 39.7 percent of this, or 3,064 KTOE. They are used as boiler fuel in sugar mills and rice mills, or as a heat source in the ceramic industry. The consumption of commercial energy such as coal, lignite, petroleum products, natural gas and electricity was 4,648 KTOE. Coal and lignite are used for metal smelting, cement production, tobacco curing, and other miscellaneous purposes.

### **(5) Construction**

This sector has been consuming about 100 KTOE per year. The consumption in 1989 was 109 KTOE, representing only 0.4 percent of the total. This sector consumes petroleum products only.

### **(6) Residential and commercial**

Reference should be made to Table 4-26. Energy consumption in this sector increased from 5,502 KTOE in 1982 to 6,889 KTOE in 1989 at a rate of 3.3 percent per year on average. The consumption in 1989 represents 25.7 percent of the total energy consumption. The consumption of non-commercial energy such as charcoal and firewood was 4,495 KTOE in 1982, or 81.7 percent of the total; while in 1989 their consumption was 4,515 KTOE, or 65.6 percent of the total. Non-commercial energy is used mainly for cooking in households or by roadside ready-made food vendors. Of the consumption of commercial energy in 1989, LPG, kerosene, fuel oil and electricity accounted for 11.6, 0.8, 0.6 and 21.4 percent, respectively. The consumption of LPG and electricity has been increasing

rapidly because of their convenience as the distribution system of LPG expands and rural areas are electrified.

#### (7) Transportation

Consumption in this sector rose significantly from 4,328 KTOE in 1982 to 10,169 KTOE in 1989 at an average annual growth rate of 13.0 percent. In 1989, the consumption accounted for as much as 38.0 percent of the total. This sector uses petroleum products only. Energy consumption in Thailand's transportation sector is characterized by a rapid substitution of diesel oil for gasoline prompted by heavy taxation on gasoline. Diesel oil consumed in 1989 was 5,456 KTOE, or 54 percent of the total energy consumption in this sector, thus outweighing the gasoline share of 24 percent. LPG consumption shows a tendency to decline. LPG is used mainly by taxi cabs; nearly all taxi cabs running in Bangkok use LPG. On the other hand, the consumption of aviation fuel has been increasing as the number of tourists flying in Thailand rises.

**Table 4-4 Energy Consumption in Transportation Sector**  
(Unit: KTOE)

	1982	1985	1986	1987	1988	1989
LPG	129	257	209	178	115	111
Premium Gasoline	487	597	656	794	961	1,135
Regular Gasoline	852	829	901	1,017	1,158	1,287
Jet Fuel & Aviation Kero.	884	1,012	1,120	1,218	1,500	1,774
Kerosene	4	1	2	1	0	0
High Speed Diesel	1,779	3,467	3,647	4,303	4,879	5,370
Low Speed Diesel	20	32	41	64	71	86
Fuel Oil	173	165	244	300	239	406
Total	4,328	6,360	6,820	7,875	8,914	10,169

Note: Minor inconsistencies with other tables arising from difference of sources are not reconciled.

Source: Thailand Energy Situation, NEA

#### 4-1-2 Energy supply

Table 4-5 and Figure 4-1 show the history of the supply of primary energy. It may be noted from the table that the pattern of the demand and supply of energy in Thailand has had the following characteristics:

(1) a high degree of dependence on non-commercial energy, (2) a high degree of dependence on imported energy, and (3) a high degree of dependence on oil for the supply of commercial energy. However, the structure of energy consumption in Thailand has been changing since the energy crisis.

The supply of non-commercial energy in 1979 was 10,506 KTOE, accounting for as much as 46.3 percent of the total supply of primary energy. Since then, the total supply of energy has been steadily increasing as the economy grew. However, the supply of non-commercial energy has remained almost unchanged. Its share in the supply of primary energy declined to 30.9 percent in 1989, although the supply amounted to as much as 11,529 KTOE.

The degree of self-sufficiency is improving. In 1979, Thailand depended on imports to the extent of 48.7 and 90 percent for the supply of the total energy requirement and for that of the commercial energy requirement, respectively. As a result of the development and utilization of domestic energy, the dependence on imports had declined until 1988 to 36 and 55 percent of the total energy consumption and commercial energy consumption respectively. During this period, the supplies of domestic natural gas and lignite increased greatly, both for the purpose of power generation. The production of natural gas started in 1981. Its supply increased 19.5 times from 1981 to 1988. The supply of lignite increased from 385 KTOE in 1979 to 2,049 KTOE in 1988 at an average rate of 20 percent per year. In addition, the rate of crude oil self-sufficiency has been increasing as the production of crude oil and condensate, the latter being produced in association with crude oil, increases.

The degree of dependence on oil in the supply of primary energy has been declining year by year. In 1979, the share of oil was 90 percent with a total supply of 11,115 KTOE, consisting of 8,299 KTOE of crude oil and condensate together and 2,816 KTOE of petroleum products, out of a total supply of commercial energy of 12,332 KTOE. This share was 61 percent in 1988 with a crude oil supply of 12,991 KTOE and a commercial energy supply of 21,352 KTOE.



Table 4-5 Primary Energy Supply

(Unit: KTOE)

	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989
<b>Production of Primary Energy</b>											
Lignite	385	408	461	608	577	667	1,401	1,508	1,932	2,049	2,592
Crude Oil	12	14	15	15	328	737	1,083	1,058	894	1,017	1,066
Condensate	--	--	58	252	303	374	649	648	690	815	838
Natural Gas	--	--	266	1,158	1,394	2,101	3,250	3,139	4,390	5,200	5,194
Hydroelectric	723	282	659	850	811	904	818	1,230	903	837	1,234
Renewable Energy	10,528	10,285	10,678	11,158	10,912	11,061	11,246	11,149	11,058	10,890	11,589
Sub-Total	11,648	10,989	12,137	14,041	14,325	15,844	8,447	18,732	19,867	20,808	22,513
<b>Imports</b>											
Coal	44	60	43	102	109	144	213	141	197	240	300
Crude Oil	8,287	7,866	7,913	7,247	7,791	6,811	6,751	7,178	7,868	7,509	10,143
Petroleum Products	2,822	4,020	2,704	2,027	2,802	3,575	2,367	2,151	3,258	4,326	5,268
Electricity	67	65	63	64	60	61	62	64	35	37	55
Renewable Energy	--	1	2	3	5	9	8	9	10	11	26
Sub-Total	11,220	12,012	10,725	9,443	10,767	10,600	9,401	9,543	11,368	12,123	15,792
<b>Exports</b>											
Coal & Lignite	1	1	1	1	1	--	--	--	1	--	--
Condensate	--	--	--	--	63	126	403	493	445	676	704
Petroleum Products	6	47	1	3	2	3	37	76	29	--	7
Electricity	1	1	1	1	2	2	2	1	1	2	2
Renewable Energy	22	27	35	44	48	38	32	26	37	15	86
Sub-Total	30	43	38	49	116	169	474	596	513	693	799
Stock Changes	-135	-424	178	329	-106	55	21	315	-186	464	-251
Primary Energy Supply	22,703	22,534	23,002	23,764	24,870	26,330	27,395	27,994	30,536	32,702	37,255
Energy Independence(%)	51.31	48.77	52.76	59.09	57.60	60.17	67.34	66.91	65.06	63.63	60.43

Source: Thailand Energy Situation, NEA

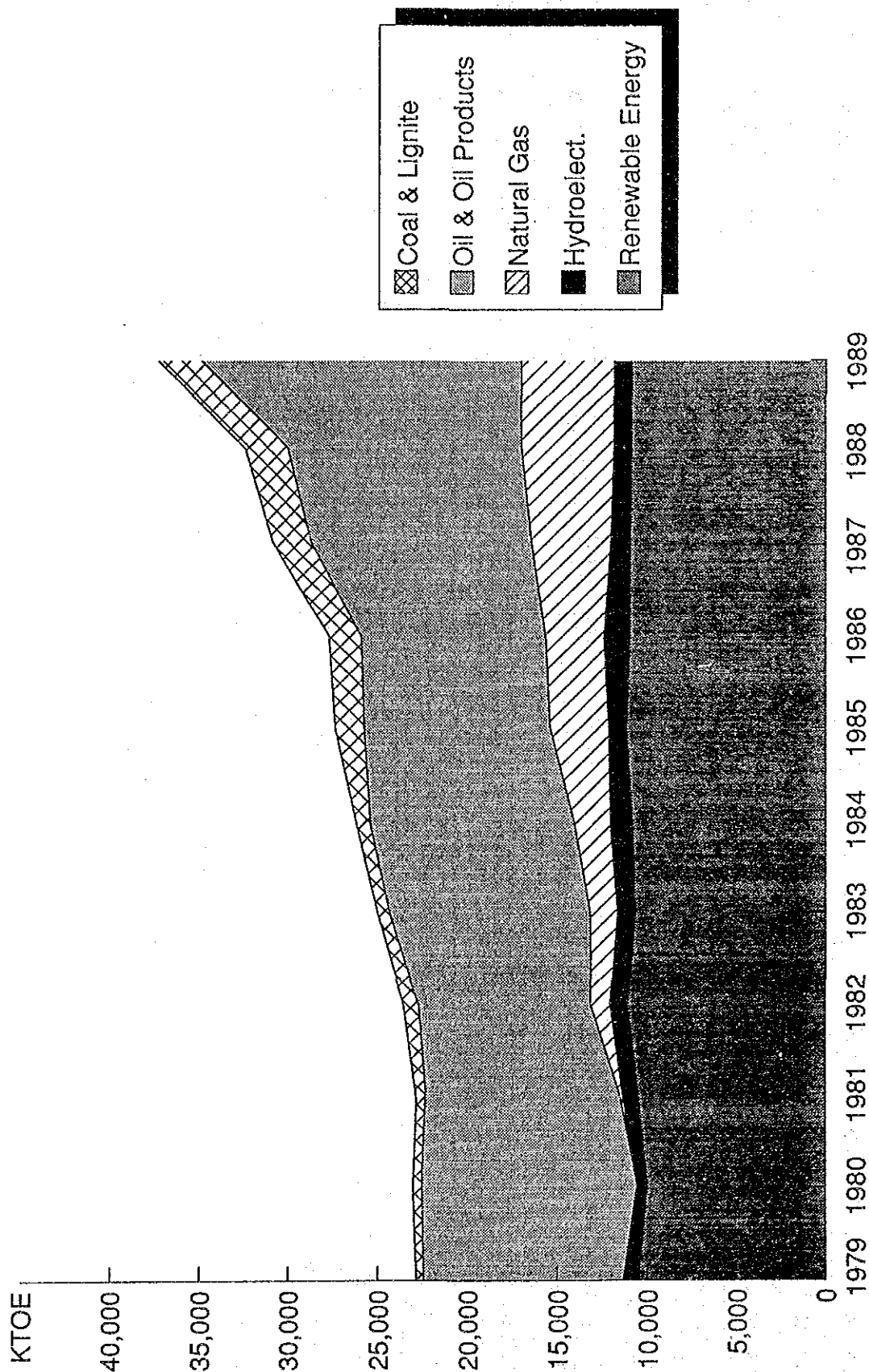


Figure 4-1 Primary Energy Supply

The decline of the share of oil was brought about by the increased domestic production of natural gas and lignite in line with the government policy.

The dependence on imported energy in 1989 increased to 40 percent from 36 percent in the preceding year, reflecting the very active business activities. The dependence on oil also increased to 64 percent from 61 percent in the preceding year.

#### 4-1-3 Energy Reserves

Energy in Thailand may be classified by source into three groups: renewable energy like charcoal, firewood, rice husks and bagasse; fossil energy like lignite, natural gas, condensate, petroleum and oil shale; and others including hydropower. The reserves and production of the major sources of energy in Thailand are summarized in Table 4-6.

Table 4-6 Energy Reserves and Production

	Proven Reserves	Possible Reserves	Total	Production in 1989
Lignite(Million Tons)				
Mae Moh	820.9	--	820.9	6.541
Krabi	83.6	--	83.6	0.319
Li	28.0	--	28.0	n.a.
Other	17.7	--	17.7	2.041
Hydro Potential(MW)				
Indigenous Projects	--	--	10,586.0	5,571(GWh)
International Projects	--	--	15,637.0	--
Natural Gas(Billion scf)				
Off Shore	6,261.6	7,447.1	13,708.7	199.5
On Shore	648.6	1,198.0	1,846.6	11.9
Condensate(Million Barrels)				
Off Shore	150.5	87.6	238.1	6.7
On Shore	--	--	--	--
Oil Shale(Million Tons)				
Tak Province Deposit	--	--	18,500.0	--
Crude Oil(Million Barrels)				
Lan Krabue	58.2	22.9	88.1	7.8
Nang Nuan	22.0	--	22.0	--

Source: Thailand Energy Situation, NEA