JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

DEPARTMENT OF MINERAL RESOURCES
MINISTRY OF INDUSTRY
THE KINGDOM OF THAILAND

THE STUDY
ON
COAL EXPLORATION AND ASSESSMENT
IN
THE KINGDOM OF THAILAND

FINAL REPORT

DECEMBER 1997

MITSUBISHI MATERIALS CORPORATION
MITSUI MINING ENGINEERING CO., LTD.

JAPAN

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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 the Technical Cooperation for the Study on Coal Exploration and Assessment in the Kingdom of Thailand and entrusted the Study to the Japan International Cooperation Agency (JICA).

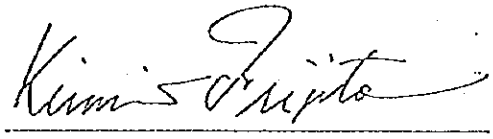
JICA sent a study team led by Mr. Jiro Muraoka of Mitsubishi Materials Corporation to the Kingdom of Thailand seven times from July 1995 to October 1997.

The Team held discussions with officials concerned of the Government of the Kingdom of Thailand, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Kingdom of Thailand for their close cooperation through the Study.

December 1997



Kimio FUJITA
President
Japan International Cooperation Agency

December 1997

Mr. Kimio Fujita
President
Japan International Cooperation Agency
Tokyo, Japan

Dear Mr. Fujita:

Letter of Transmittal

We are pleased to submit to you the report on the Study on Coal Exploration and Assessment in the Kingdom of Thailand. The report contains the advice and suggestions of the authorities concerned of the Government of Japan and your Agency as well as formulations of the above mentioned study. Also included are comments made by the Department of Mineral Resources (DMR), the Ministry of Industry, during technical discussions on the draft report which were held in Bangkok.

The report presents results of the exploration, assessment and conceptual mine development plan in the Phrae Basin, the Nong Plab Basin and the Mae Lamao Basin. Also included are the details and results of the technical transfer was carried out satisfactory on the study.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs and the Ministry of International Trade and Industry. We also wish to express our deep gratitude to the Department of Mineral Resources and other authorities concerned the Government of the Kingdom Thailand for the close cooperation and assistance extended to us during our study.

Very truly yours,

村岡 次郎

Jiro Muraoka
Team Leader
The Study on Coal Exploration and Assessment in the Kingdom of Thailand

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1 Introduction

1.1 Background of the Study

In the Kingdom of Thailand (hereinafter referred to as "Thailand"), Coal Exploration and Assessment Project (CEP) has been setting up in 1987 by the Department of Mineral Resources of Ministry of Industry (hereinafter referred to as "DMR"), which is the authorities concerning of the Government in charge of the development of indigenous energy and mineral resources, according to the Government's Policy on Energy. Its main objective is to conduct the exploration as well as an economic and quality evaluation programs for coal and lignite deposits throughout the country. The results have been used in the National Energy Planning Scheme serving the energy demand for the industrial and power generating purposes.

To boost a new method and model in coal exploration together with upgrading the exploration results and speed up the project's works, DMR requires more modern equipment and advanced technology as well as advanced knowledge in the fields of coal geology and geophysical exploration. In accordance with such requirements, the Government of Thailand requested the Government of Japan to provide a joint coal exploration program in accordance with the Agreement on Technical Cooperation between the Government of Japan and the Government of Thailand signed on November 5, 1981. The joint exploration program was expected that advanced technology with the modern equipment would be applied in it and it would create a new coal exploration scheme in Thailand, furthermore DMR personnel might absorb invaluable experience and know-how from Japanese experts.

In response to the request of the Government of Thailand, the Government of Japan decided to conduct the Study on Coal Exploration and Assessment (hereinafter referred to as "the Study") in accordance with the Agreement. Accordingly, the Japan International Cooperation Agency (hereinafter referred to as "JICA"), the official agency responsible for the implementation of the technical cooperation program of the Government of Japan, agreed to undertake the Study in close cooperation with DMR. JICA assigned a joint study team (hereinafter referred to as "the Study Team"), composed of Mitsubishi Materials

Corporation and Mitsui Mining Engineering Co., Ltd. to carry out the Study in accordance with the agreement between DMR and JICA signed on February 28,1995. The Study in Thailand was executed by the Study Team and DMR in close cooperation from July, 1995 to July, 1997 and the whole study was completed successfully in October, 1997. This Report is the results of the Study.

1.2 Objectives of the Study

The main objectives of the Study are:

(1) Coal exploration and assessment for the selected basins (hereinafter referred to as "the Study Sites") by joint action of Japanese side and Thai side.

(2) Technology transfer to DMR personnel from the Study Team in the course of cooperative study in both Thailand and Japan.

The Study includes :

1) To formulate the comprehensive coal exploration plan,

2) To explore and to assess the coal resources,

3) To evaluate the deep coal deposits,

4) To compile and to use the geological data,

5) To consider the environmental impact by the Study.

1.3 Study Sites

The Study Sites are as follows:

(1) Phrae Basin, Phrae.

The study for the Kantang Basin in Trang was the substitute for the Phrae Basin. However, occurrence of the coal resources in the Phrae Basin was confirmed. Consequently, the study for the Kangtang Basin was canceled.

(2) Nong Plab Basin, Prachuabkirikan.

(3) Mae Lamao Basin, Tak.

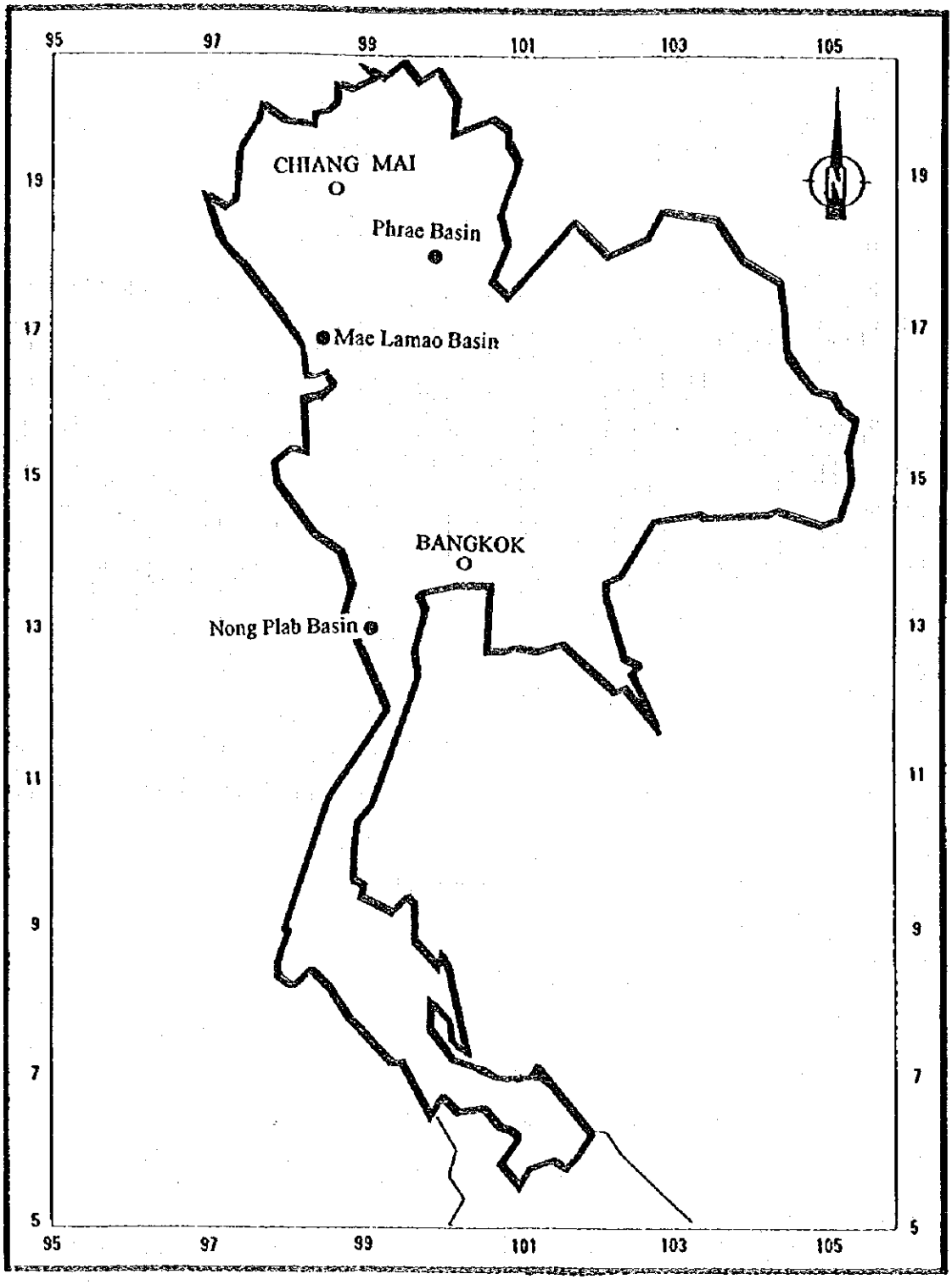


Fig. 1.1-1 Location of the Study Sites

1.4 Scope of the Study

The Study consists of the following two parts :

(1) Collection and review of data and information.

(2) Cooperative joint study for exploration and assessment of coal resources in the Study Sites.

1.4.1 Collection and review of data and information

The collection and review of data and information are carried out on the following items.

1) General data and information on energy, especially coal consumption, demand and resources in Thailand.

2) General coal exploration and development systems, methods and machinery in Thailand.

3) Data and information for exploration and assessment in the Study Sites.

4) National policy and estimation of the future indigenous coal development, etc.

1.4.2 Coal exploration and assessment study

(1) The Study Sites and nain targets.

The coal exploration and assessment study in the Study Sites are executed jointly with DMR personnel. The name of Study Sites and the targets of the Study at each Study Site are as follows:

1) Phrae Basin (exploration and assessment)

2) Nong Plab Basin (assessment)

3) Mae Lamao Basin (assessment)

(2) The study items for each study site

1) Phrae Basin (Exploration and Assessment)

a) Confirmation of topographical and geological maps in the Study Site.

b) Study in the outcrops.

c) Investigation and execution for effective drillings (logging) and seismic survey.

d) Study for the key beds.

e) Study for coal seams, sampling and analysis.

f) Study for strike and dip of seams, fault and folds.

g) Assessment of these data and drawing of geological map, columnar and geological section maps.

h) Calculation of coal reserves.

i) Conceptual coal mine development plan.

j) Coal quality control plan and estimated standard coal quality of clean coal.

2) Nong Plab Basin and Mae Lamao Basin (Assessment)

The Study for Nong Plab Basin and Mae Lamao Basin were the assessment of the data mainly.

a) Assessment of drilling, logging, seismic survey data.

b) Drawing of geological maps.

c) Conceptual coal mine development plan.

d) Study on coal reserves and quality.

3) Others

The general technical items to be transferred to DMR personnel are the followings:

a) Interpretation for geological data.
(Well-logging data, Seismic time section etc.)

b) Geological database.

c) Environmental impact study in deep coal mines.

d) General information for the examples of coal mining methods in deep coal mines.

e) General information on the criteria for the reserves in deep coal mines.

f) General information for worldwide coal quality evaluation standard.

g) General information for coal utilization for each Study Site.

2 Coal Resources Management of Thailand

2.1 Present state of the Coal Exploration and Development Section of DMR

2.1.1 Organization

The Coal Exploration and Development Section of DMR, the counterpart study team of the Study, consists of the following members at present.

Table 2.1-1 Main members of the Coal Exploration and Development Section

Position	Name	Duty
Chief	Songpope Polachan	Nominal
Acting chief	Nawee Pitchayakul	Management
Senior geologist	Somchai Poom-im	Ditto, Technical supervisor
	Surachai Krobbuaban	Ditto, Geophysical supervisor
Geologist	Phumee Srisuwon	Statistics and information
	Apichart Jeenagool	Chief of exploration team
	Wuttipong Khongphetesok	Ditto
	Kriangkrai Pomin	Ditto
	Tinnakorn Sunee	Ditto

Each exploration team consists of a chief and a few junior geologists with surveyors, technicians and drivers.

2.1.2 Function

The present functions of the Section are as follows:

- Exploration of the coal basins out of the budget of coal exploration and assessment project (CEP),
- Publication of the exploration data for public and private sectors;
- Coal data statistics;
- Investigation of various coal utilization systems.

DMR has been historically contributing to the country by means of orderly development of the resources which were identified and to permit for concessions. DMR announces in the

annual report 1996 that it has investigated 20 high coal-potential areas with a total resources of 1,530 million tones during 1987-1996.

2.1.3 Exploration method

DMR is conducting exploration by means of outcrop survey, drilling borehole, geophysical logging of borehole and seismic survey. The coal samples are collected from the recovered borehole cores and analysed. These methods are not different from the ordinary exploration method conducted in the countries where coal mining has industrial importance. But DMR only arranges the obtained data for publication without further geological analysis. Here exists the significant difference in exploration between DMR's method and the ordinary method, which necessitates further geological analysis for the purpose of development.

2.1.4 Expansion plan of the Coal Exploration Section

Coal Exploration Section of DMR was changed its title to Coal Exploration and Development Section during the Study in March 1996. This denomination obviously express the expansion of the section's function from only coal exploration to coal development and a need of innovation in exploration technology from the conventional method to what the Study Team transferred. However actual measures for this expansion have not been provided except for denomination of the section. Hence DMR requested the Study from JICA. For achievement of the purpose, the innovated exploration technology must be educated with further training for the existing geologists, and must be established deep relationship with the mining section and relevant sections. Furthermore DMR plans restructuring of its organization which the section will become a part of a division which will have responsibility for exploration, utilization and development of all kinds of solid energy resources.

2.2 Coal resources management of Thailand

DMR enacted The Master Plan for Coal Resources Management of Thailand (dated April, 1996) in September, 1996. The objectives of the Master Plan are as follows;

(1) to set the policy for the coal industry and other related industries,
(2) to forecast the future trend for coal development both in the country and neighboring countries, particularly for imported coal,
(3) to study the way to minimize the environmental impact from the development and utilization of coal,
(4) to introduce modern technologies for the coal industry,
(5) to stabilize the security of energy supply in the country.

The Master Plan contains important information and policy concerning coal in Thailand. Therefore, some chapters of the Master Plan, important and related to the Study, are shown hereinafter.

2.2.1 Background

The 8th National Economic and Social Development Plan of Thailand (1997-2001) has assigned the important issue related to the coal management as follows :

(1) Accelerate the effort in exploration for coal reserve of the country.
(2) Accelerate the bidding process for those coal basins explored by DMR.
(3) Determine new clean coal technology to minimize the environment impact.

Currently, the total coal reserves in Thailand are estimated at approximately 2,800 million tons. At present, about 1,000 million tons of coal have not been planned for development. The coal reserves of Thailand are mainly lignite. About 72% of the annual coal production are consumed for electric power generation, the remaining 20% are used by the cement industry, and the rest other industrial consumers such as paper industry, food industry, tobacco drying, sugar industry, lime works etc.

The coal deposits in Thailand have been mined recently from 12 basins (Fig. 2.2-1). Other discovered coal deposits are in 17 basins which have not been exploited (Fig. 2.2-2). It is also expected that there may be some coal deposits remaining to be discovered in the future.

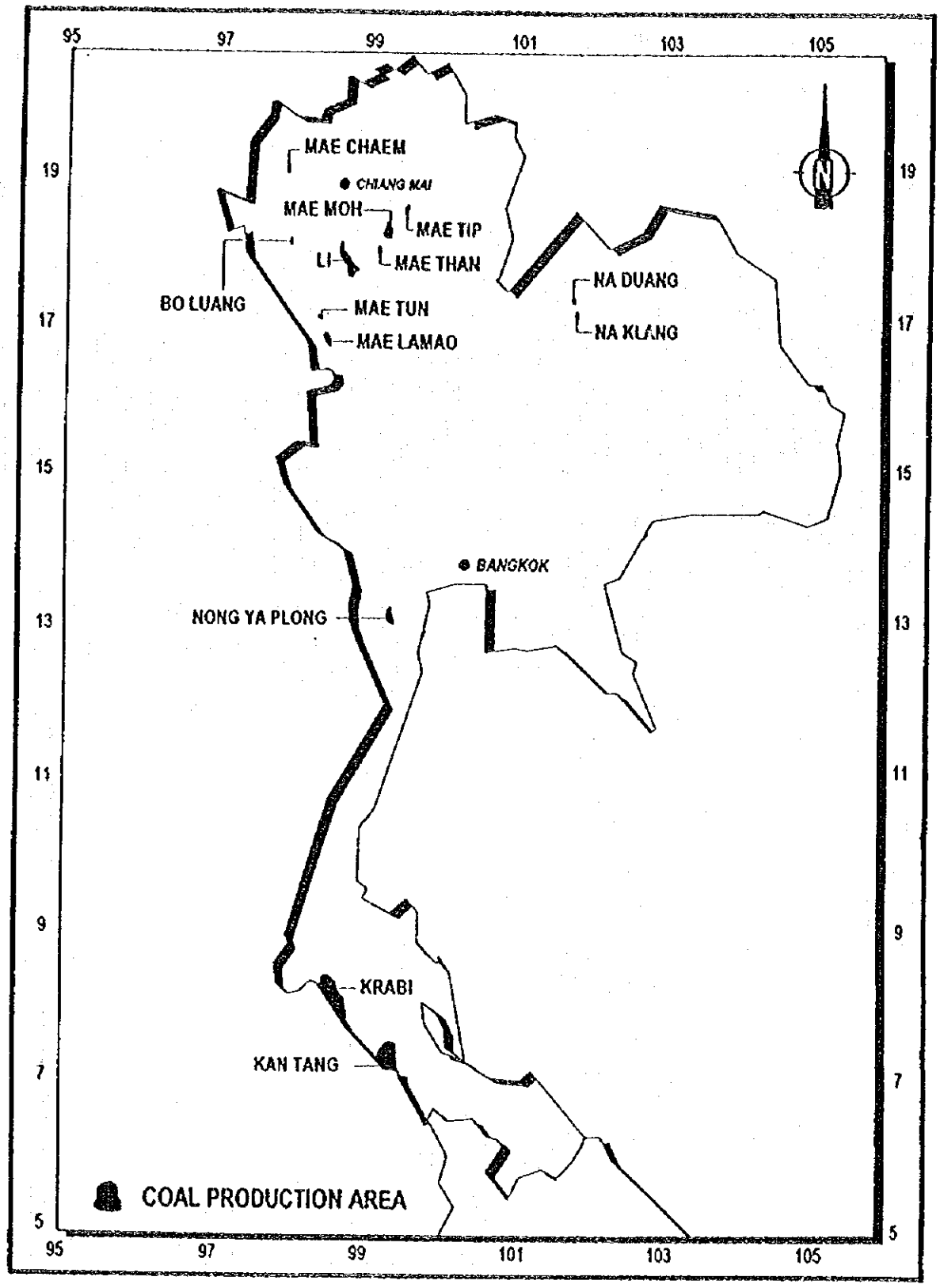


Fig. 2.2-1 Map of Coal Production Area in Thailand

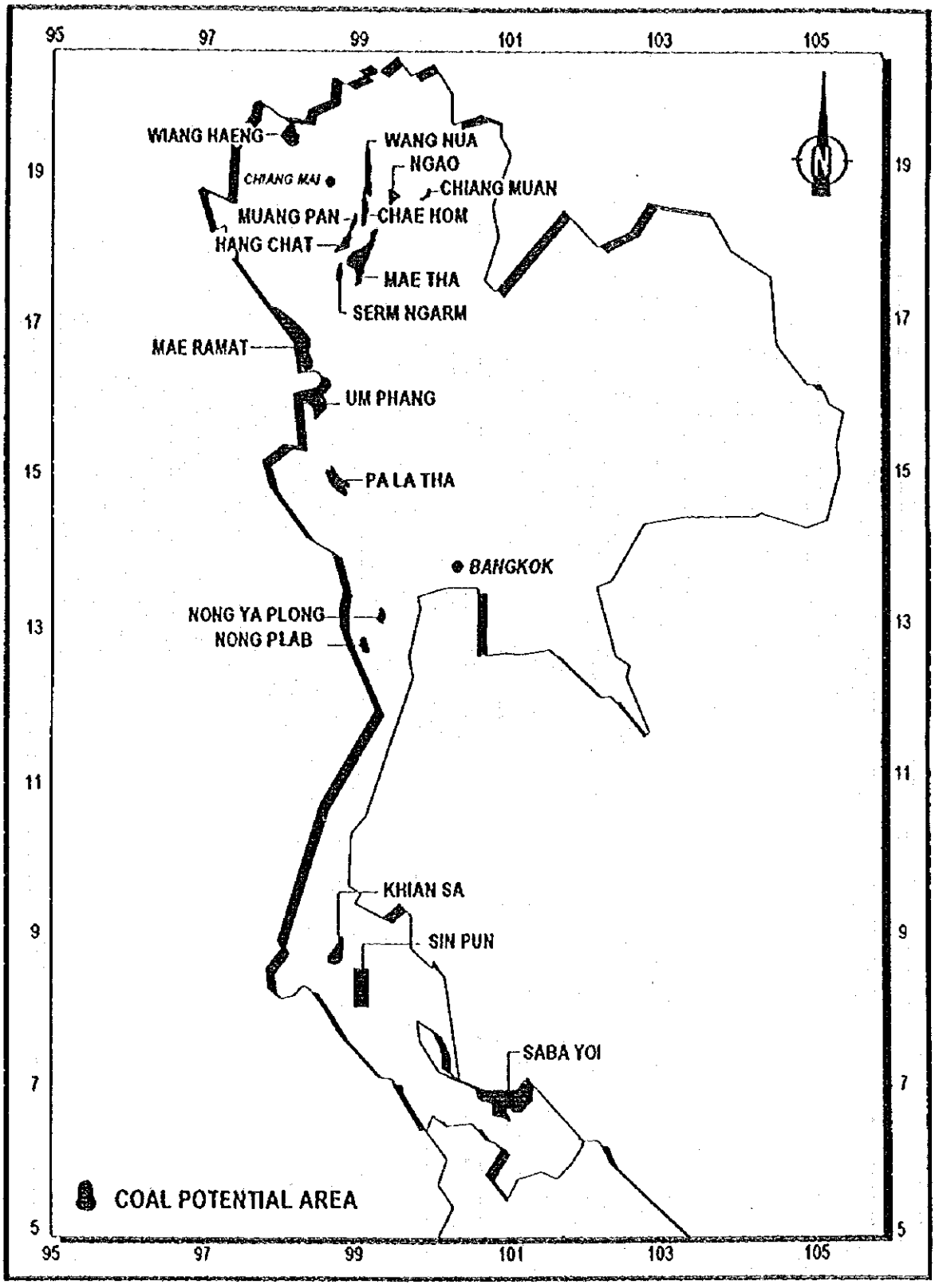


Fig. 2.2-2 Map of Coal Potential Area in Thailand

2.2.2 Economic growth and energy consumption and demand

In Thailand, the economic growth has reached considerable growth rates in the past several years. Among others, the growth of the Gross Domestic Product (GDP) is considered a significant measure of this trend. A secure energy basis is a precondition of growth as well. Based on the statistics relating to economic growth and energy consumption as well as energy intensity, sufficiently reliable prognostic estimates can be made with regard to primary and final energy requirements and, in comparison with international trends, objectives relating to the efficient use of energy can be derived as well. To determine the future primary and final energy requirements, the following basic conditions of earlier forecasts or new ones were specified:

(1) Inclusion of renewable sources of energy into primary energy consumption/demand figures at an annual growth rate of 1%.

(2) The economic growth, expressed by the increase of the GDP following the price adjustment.

1994 - 1996 Estimated of 7.6% GDP growth per annum
1997 - 2001 Estimated of 6.3% GDP growth per annum
2002 - 2006 Estimated of 6.0% GDP growth per annum
2007 - 2011 Estimated of 5.5% GDP growth per annum
2012 - 2016 Estimated of 5.0% GDP growth per annum

The above estimate shows that the GDP growth rate tends to decline for the sale of Thailand's price stability and the narrowing current account deficit. Although in estimated GDP growth rates for 1997 - 2011 may be slower than the present growth rate, they still consider high. Factors which will continue to spur the Thai economy are, among a few, the level of domestic investment, especially those of government and state enterprise, and export growth, which, although having declined lately, remains strong. The country will, however, continue to suffer the trade deficit and, consequently, the current account deficit. This is due to the nature of Thailand's production structure which depends heavily on imported raw materials. Besides, as Thailand has increasingly exported more high-tech products such as computer parts

and components, electronics and electrical appliances, the country sees its dependence on rising as never before.

(3) Based on the statistics of Thailand, as the GDP growth rises by 1 %, primary energy consumption will rise by more than 1% (as seen in Table 2.2-1 and 2.2-2). However, after two oil crises resulting in rising which pushes prices of all forms of energy to soar, there have been attempts towards an efficient use of energy. This results in a reduction in primary energy consumption from 0.9 % of every 1% GDP growth to 0.7%. Based on the above conditions, the primary energy demand for every 1% economic growth will be:

1996 - 2001 1.0% (max.) 0.9% (min.)

(4) The rate of inflation was set at 4% for the total period of time.

(5) According to the statistics, the parity of the US-dollar to the Baht was set at 0.5% per year, but it is not taken into account.

This specified basic conditions were used to determine the future demand for primary energy as a function of the development of the GDP.

To meet the future primary energy demand according to the basic conditions, measures directed towards an efficient and economic use of energy have to become an integral part of the future energy policy.

For important industrial processes exist in the time, the specific energy supply is as follows :

production of electricity :	<2,150	kcal/kWatt Electric
production of cement :	700 - 800	kcal/1 kg clinker
lime-burning :	< 850	kcal/1 kg CaO
ceramic :	350 - 475	kcal/ kg
kitchenware, china :	<4,700	kcal/ kg
sanitary china :	900 - 1,000	kcal/ kg
fire resistant refractory :	1,100 - 2,200	kcal/ kg
base metallurgy :	<4,500	kcal/ kg raw steel
	< 450	kg coke/ kg raw steel

glass industry - lead-glass	1,300 - 1,500	kcal/kg
- flat glass	2,300 - 2,700	kcal/ kg
- resotherm	<3,500	kcal/ kg

In Table 2..2-3 the primary energy demand is shown up to the year 2016. The maximum value are based on a primary energy growth of 1% for every 1% GDP growth. Furthermore, the primary energy intensity per 1,000 US$ of real GDP and the consumption/demand per capita are given.

(Notes)

The Thai economy took an unexpected downturn in 1996. The economic growth for 1996 was 6.4%, the first year of below 8% growth since 1993. In 1997, the GDP was expected 5.3% at the early of the year, is expected 2.5 to 3.0 % at middle of the year. However, the Thai economy still has potentialities, therefore it is not too much to say that the above estimate of GDP growth rate is still reasonable.

The tight money policy followed by the Bank of Thailand since 1995 in order to contain incipient pressures on inflation and the current account have had the desired effect on economic stability. However, the coincidental strap slowdown of exports and capital inflows in 1996, together with problems in financial institutions resulted in a rapid deceleration of investment and growth. Calls for a relaxation of monetary policy evoked widespread speculation that exchange rate policy might be adjusted to allow for reduction in interest rates. The authorities' interventions were successful in containing speculative pressure in foreign exchange markets for a while. However, the speculative pressure in the markets increased day by day. In order to end uncertainty over Thailand's exchange rate policy, Thailand's exchange rate system was shifted from the basket system to the management float system on July 2, 1997. The baht depreciated with respect to the US dollar, exchange rate is about 30 bahts/dollar in the end of August against a yearly average of 25.34 baht/dollar last year. It is depreciated about 20%. The situation of the Thailand economy is very unpromising.

Table 2.2-1 Development of Economy and Energy at Prices 1984

Years	Real GDP %	Primary Energy %	Final Energy %	Real GDP mill US$	Primary Energy 1,000 toe	Final Energy 1,000 toe
1984	100.0	100.0	100.0	55,339	25,731	17,420
1985	104.6	104.5	106.5	57,904	26,899	18,554
1986	110.3	110.5	113.1	61,066	28,433	19,698
1987	121.0	123.2	123.8	66,043	31,706	21,560
1988	137.0	134.4	136.5	75,829	34,592	23,749
1989	153.8	155.5	159.6	85,086	40,010	27,799
1990	171.6	175.4	175.9	94,936	45,122	30,642
1991	185.4	187.9	186.0	102,620	48,361	32,407
1992	199.6	204.2	201.5	110,431	52,535	35,104
1993	215.1	220.0	225.8	119,060	56,616	39,328
1994	231.8	252.9	251.7	128,265	65,069	43,849

* Final Energy with Renewable Energy

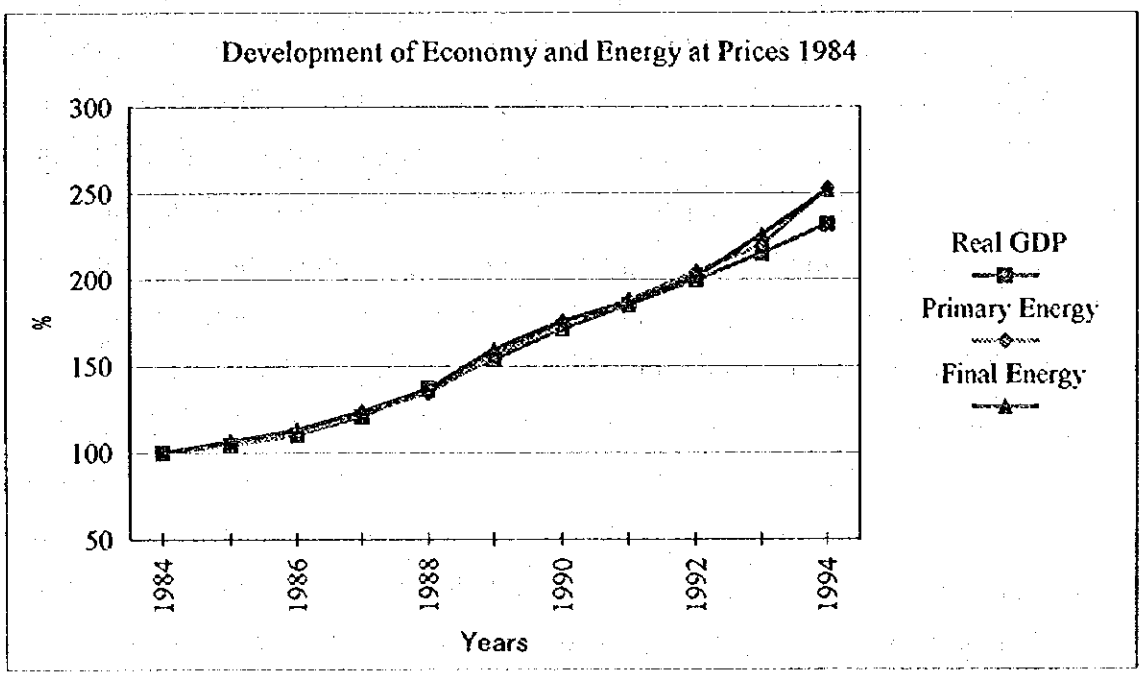


Table 2.2-2 Development of Economy and Energy at Prices 1973

Years	Real GDP %	Primary Energ %	Final Energy %	Real GDP mill. US$	Primary Ener 1,000 toe	Final Energy 1,000 toe
1973	100.0	100.0	100.0	28,137	15,990	7,020
1974	105.4	99.9	95.8	29,654	15,970	6,724
1975	114.8	104.4	100.5	32,290	16,700	7,057
1976	126.1	112.3	112.1	35,484	17,960	7,872
1977	135.2	119.4	121.2	38,046	19,100	8,507
1978	150.5	124.8	125.2	42,352	19,960	8,787
1979	154.5	131.9	137.9	43,479	21,090	9,682
1980	157.3	131.6	136.6	44,249	21,040	9,586
1981	167.1	134.0	135.3	47,028	21,430	9,499
1982	176.2	139.0	137.1	49,591	22,230	9,622
1983	185.9	153.9	155.0	52,305	24,610	10,878
1984	196.7	160.9	169.9	55,339	25,731	11,927
1985	205.8	168.2	168.2	57,904	26,899	11,807
1986	217.0	177.8	181.9	61,066	28,433	12,766
1987	234.7	198.3	210.6	66,043	31,706	14,784
1988	269.5	216.3	232.9	75,829	34,592	16,353
1989	302.4	250.2	275.7	85,086	40,010	19,353
1990	337.4	282.2	305.7	94,936	45,122	21,462
1991	364.7	302.4	339.4	102,620	48,361	23,826
1992	392.5	328.5	372.8	110,431	52,535	26,169
1993	423.1	354.1	424.4	119,060	56,616	29,793
1994	455.9	406.9	480.5	128,265	65,069	33,730

* Final Energy without Renewable Energy

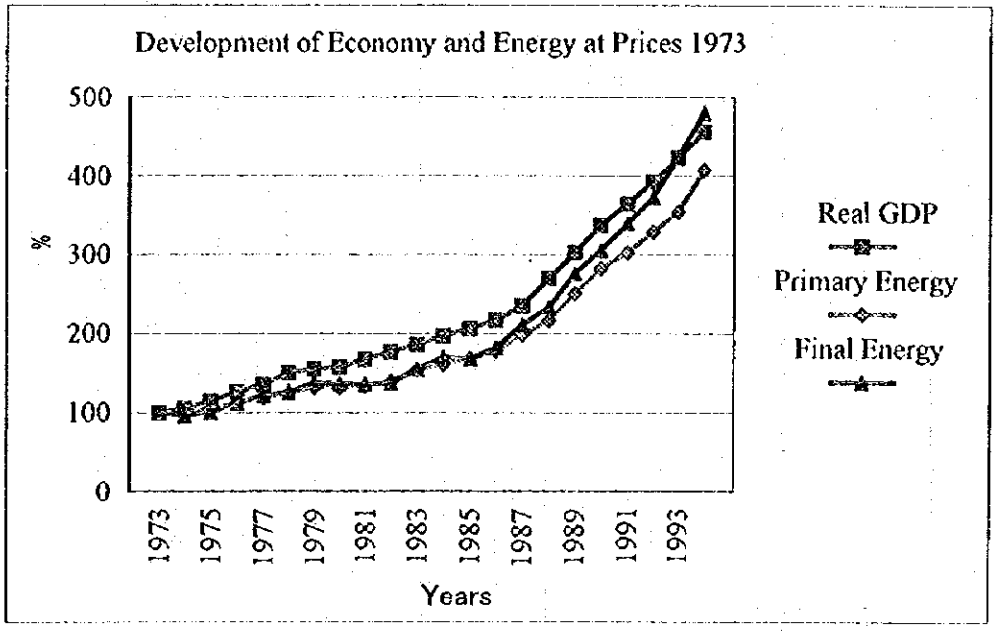


Table 2.2-3 Economy and Primary Energy Consumption / Demand at Price 1992

Years	GDP at Curr. Market Prices Nominal Baht mill Baht	GDP at Curr. Market Prices Real Baht mill Baht	GDP at Curr. Market Prices Nominal Exchange Rate mill US $	Real GDP at Count. 1992 Real Rate 1992 mill US $	Deflator rate Implicit GDP %	Foreign Exch. Rate	Population Persons	Pr. Energy Cons./Dem. 1,000 toe 90% min.	Pr. Energy Cons./Dem. 1,000 toe 100% max.	GDP/Capita. Curr. US $	Pr. Energy./ Capita. toe min.	Pr. Energy./ Capita. toe max.	Energy Intensity toe/ 1,000 US$ min.	Energy Intensity toe/ 1,000 US$ max.
1976	346,516	902,385	16,986	35,527	38.4	20.400	3,213,711	17,960	17,960	393	0.416	0.416	0.506	0.506
1981	760,356	1,193,651	34,647	46,994	63.7	21.820	7,875,002	21,430	21,430	728	0.448	0.448	0.456	0.456
1986	1,133,397	1,552,599	43,097	61,127	73.0	26.299	2,969,204	28,433	28,433	814	0.537	0.537	0.465	0.465
1991	2,505,629	2,607,314	98,194	102,650	96.1	25.517	6,961,030	48,361	48,361	1,724	0.849	0.849	0.471	0.471
1994	3,690,800	3,417,407	146,653	134,544	108.0	25.170	9,095,000	65,069	65,069	2,481	1.101	1.101	0.484	0.484
1996	4,621,806	3,956,592	185,474	155,772	116.8	24.919	0,044,302	74,275	75,335	3,089	1.237	1.255	0.477	0.484
2001	7,450,404	5,370,165	306,574	211,424	138.7	24.302	2,484,811	97,859	102,250	4,906	1.566	1.636	0.463	0.484
2006	11,841,613	7,186,492	499,633	282,933	164.8	23.701	5,024,515	127,293	136,834	7,684	1.958	2.104	0.450	0.484
2011	18,381,245	9,392,458	795,242	369,782	195.7	23.114	7,667,446	162,075	178,837	11,752	2.395	2.643	0.438	0.484
2016	27,862,698	11,987,421	1,236,039	471,946	232.4	22.542	0,417,799	201,975	228,246	17,553	2.868	3.241	0.428	0.484

Conditions :

1997 - 2001	Real GDP growth rate average 6.3 %
2002 - 2006	Real GDP growth rate average 6.0 %
2007 - 2011	Real GDP growth rate average 5.5 %
2012 - 2016	Real GDP growth rate average 5.0 %
1995 - 1996	Real GDP growth rate average 7.6 %
1997 - 2016	1 % real GDP growth rate demand = 1.0 % Primary Energy growth rate (max.)
	1 % real GDP growth rate demand = 1.0 % Primary Energy growth rate (min.)
1997 - 2016	Populations growth rate 0.8 %
1995 - 2016	Inflation rate 4 %
1995 - 2016	Growth rate Baht / US$ = 0.5 %

Table 2.2-4-1 Primary Energy Supply / Demand by Sources of Coal (ktoe)

Unit : ktoe
: %

Sources	1986	1991	1994	1996	2001	2006	2011	2016
Total Coal	1,627	4,466	6,122	6,931	14,455	24,080	34,563	47,221
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Domestic Coal	1,486	4,135	5,158	5,579	7,120	9,087	11,598	14,802
	91.3	92.6	84.3	80.5	49.3	37.7	33.6	31.3
Imported Coal	141	331	960	1,352	7,335	14,993	22,965	32,419
	8.7	7.4	15.7	19.5	50.7	62.3	66.4	68.7

1994 -1996 growth rate Domestic Coal = 4.0 % / Year
1997 -2016 growth rate Domestic Coal = 5.0 % / Year
1994 -2016 Imported Coal = Coal Total - Domestic Coal

Table 2.2-4-2 Primary Energy Supply / Demand by Sources of Coal (kt)

Unit : kt
: %

Sources	1986	1991	1994	1996	2001	2006	2011	2016
Total Coal	5,145	14,217	18,611	20,632	35,318	54,097	75,180	100,930
	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
Domestic Coal	4,919	13,687	17,073	18,466	23,568	30,079	38,390	48,996
	95.6	96.3	91.7	89.5	66.7	55.6	51.1	48.5
Imported Coal	226	530	1,538	2,166	11,750	24,018	36,790	51,934
	4.4	3.7	8.3	10.5	33.3	44.4	48.9	51.5

1994 -1996 growth rate Domestic Coal = 4.0 % / Year
1997 -2016 growth rate Domestic Coal = 5.0 % / Year
1994 -2016 Imported Coal = Coal Total - Domestic Coal

The consumption and demand of final energy from basic data of coal in Thailand are shown in Table 2.2-4 and 2.2-5.

Table 2.2-5 Possibility of Final Energy Demand by Sources of Coal

Unit: 1,000 tons

Sources	1996	2001	2006	2011	2016
Domestic Coal	18,466.1	23,568.0	30,079.4	38,389.8	48,996.2
Power Plants*1	15,162.0	15,490.0	15,490.0	14,444.0	19,444.0
Others = (Final Energy)	3,304.1	8,078.0	14,589.0	23,945.8	29,552.2
Imported Coal	2,166.1	11,750.3	24,018.1	36,789.7	51,934.5
Power Plants	-	-	2,499.0	11,110.0	16,110.0
Others = (Final Energy)	-	-	21,519.1	25,679.7	35,824.5
Final Energy Coals	15,162.0	15,490.0	17,989.0	25,554.0	35,554.0
Coal Total	20,632.2	35,318.3	54,097.5	75,179.5	100,930.6

1994 - 1996 Growth Rate Domestic Coal = 4.0% / Year

1997 - 2016 Growth Rate Domestic Coal = 5.0% / Year

1994 - 1996 Growth Rate Imported Coal = Total Coal - Domestic Coal

*1 not calculated as final energy

The demand of coal for power station is obtained the information from Electricity Generating Authority of Thailand (EGAT) up to year 2011. The electricity intensity and the consumption of electricity are shown in Table 2.2-6 and 2.2-7.

From the statistics of Thailand for the last 10 year, an electricity growth rate of 1.38% has been obtained for every 1% of economic growth. Here again, a high electricity intensity of the Thailand economy is obvious in comparison with other countries where figures of only 1% for every 1% of economic growth are dominant. However, a reduction in electricity intensity in Thailand has been forecasted for the period from 2006

to 2016. The coverage of primary energy consumption according to energy sources has been taken from statistics of Thailand. In the future, Thailand intends to increase a higher share of domestic coals and imported coals for meeting the primary energy demand. This objective is based on the world reserves of coal as well as favorable and stable prices.

Table 2.2-6 Development of Economy and Electricity Consumption

Years	Real GDP (at Prices 1985)		Electricity Consumption		Electricity Intensity per GDP	Electricity Consumption per Capita
	Mill Baht	%	GWU	%	kWh/1,000 Baht	kWh / Pers.
1984	-	-	18,586	-	-	-
1985	1,119,125	100.00	20,041	100.00	17.91	386
1986	1,257,177	105.50	21,049	110.00	17.53	416
1987	1,376,847	115.60	24,902	124.30	18.09	462
1988	1,559,804	130.90	28,272	141.00	18.13	514
1989	1,749,952	146.90	32,381	161.60	18.50	579
1990	1,953,382	164.00	38,203	190.60	19.55	678
1991	2,117,582	177.80	44,239	220.70	20.89	776
1992	2,285,339	191.80	49,331	246.20	21.59	854
1993	2,477,278	208.00	55,231	275.60	22.30	947
1994	2,692,801	226.00	62,559	312.20	23.23	1,059

Table 2.2-7 Electricity Consumption for the Whole Country

Years	Residential	Business	Industrial	Agriculture	Others	EGAT(Direct -Customers)	Total
1990	8,063.19	9,406.81	16,717.23	96.23	2,470.43	1,449.07	38,202.96
1991	9,122.71	11,352.91	19,406.02	90.94	2,735.05	1,531.24	44,238.87
1992	10,199.84	12,515.27	21,641.01	117.69	3,132.51	1,724.85	49,331.17
1993	11,390.12	14,009.97	24,321.28	133.19	3,551.31	1,825.42	55,231.29
1994	12,866.83	15,808.35	27,758.43	95.75	4,057.54	1,974.09	62,558.02

From statistical review of world energy reserves and forecast of world electricity generation (Table 2.2-8 and 2.2-9), a distinct growth of the coals share in primary and final energy consumption is obvious.

Table 2.2-8 World Energy Reserves

Energy Sources	Unit	Reserves	Years
Oil	Bill. toe	135	43
Natural Gas	Bill. m^3	124	59
Hard Coal	Bill. tons	521	172
Brown Coal	Bill. tons	519	387

Table 2.2-9 Forecast of World Electricity Generation According to Energy Sources up to 2020

Energy Sources	Years					
	1990		2010		2020	
	PWh/a	%	PWh/a	%	PWh/a	%
Coal	4.47	38.20	5.96	35.40	7.33	36.60
Oil	1.43	12.20	1.50	8.90	1.47	7.30
Natural Gas	1.52	13.00	3.02	17.90	3.34	16.70
Nuclear	2.06	17.60	3.15	18.70	4.07	20.30
Hydro	2.17	18.50	3.06	18.20	3.64	18.10
Other Renewable Energy	0.05	0.40	0.15	0.90	0.20	1.00
Total	11.70	100.00	16.84	100.00	20.05	100.00

According to the future demand of Thailand for primary and final energy, a first rough estimate of the shares of domestic and imported coals was made as shown in Table 2.2-10. For this purpose, the basic condition of the share of petroleum/petroleum

products was increased from currently 60% to 67% in the year 2016 and for renewable energies an annual growth rate of 1% was assumed. Electric energy based on water power was regarded constant. Pumped storage power stations have been given consideration here.

Table 2.2-10 Primary Energy Supply / Demand by Sources

Unit : 1,000 tons

Sources	1986	1991	1994	1996	2001	2006	2011	2016
Total Coal	1,627	4,466	6,122	6,931	14,455	24,080	34,563	47,221
(%)	5.7	9.2	9.4	9.2	14.1	17.6	19.3	20.7
Petroleum /NG/ Petroleum products	13,942	27,546	38,501	44,824	63,312	86,865	116,396	152,305
(%)	49.0	57.0	59.2	59.5	61.9	63.5	65.1	66.7
Electricity	1,293	1,063	1,070	1,070	1,070	1,070	1,070	1,070
(%)	4.5	2.2	1.6	1.4	1.0	0.8	0.6	0.5
Renewable Energy	11,571	15,286	19,376	22,475	23,413	24,819	26,808	27,650
(%)	40.7	31.6	29.8	29.8	22.9	18.1	15.0	12.1
Total	28,443	48,361	65,069	75,300	102,250	136,834	178,837	228,246
(%)	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

1994 - 2016 Hydro Electricity = Constant

1997 - 2016 Growth Rate Renewable Energy = 1.0 % / Year

1997 - 2001 Growth Rate Petroleum /NG/ Petroleum Products = 0.8 % / Year

2002 - 2016 Growth Rate Petroleum /NG/ Petroleum Products = 0.5 % / Year

Consequently, the coal quantities required in the year 2016 will amount to approximately 47,220 k tones. This mean that approximately 100 million tones of coal will have to be made available, a quantity which is about five times the amount consumed at the present (see Table 2.2-4). Whether this estimate can be maintained, this could be checked with data in Table 2.2-11.

The forecast trends in Table 2.2-10 and 2.2-11 show that in 2016, domestic coals mining/utilization of 47 million tones annually is regarded possible. Considering that EGAT have planned to use about 14.4 million tones of domestic coal for electricity

generation in 2011 (Table 2.2-12) and that further additional 5 million tones will be available for electricity generation to 2016, about 29 million tones per annum will remain for the use in industry and other areas.

Table 2.2-11 Supply / Demand of Electricity

Years	MW	Increase (%)	Unit GWh	Increase (%)	Utilization Factor (%)
1984	3,547.30	10.70	21,066.44	10.49	67.79
1985	3,878.40	9.33	23,356.57	10.87	68.75
1986	4,180.90	7.80	24,779.53	6.09	67.66
1987	4,733.90	13.23	28,193.16	13.78	67.99
1988	5,444.00	15.00	31,996.94	13.49	67.09
1989	6,232.70	14.49	36,457.09	13.94	66.77
1990	7,093.70	13.81	43,188.79	18.46	69.50
1991	8,045.00	13.41	49,225.03	13.98	69.85
1992	8,876.90	10.34	56,006.44	13.78	72.02
1993	9,730.00	9.61	62,179.73	11.02	72.95
1994	10,708.80	10.06	69,651.14	12.02	74.25
(1985 - 1994)		(11.68)		(12.70)	
1995	11,880.00	10.94	78,023.00	12.02	74.97
1996	13,009.00	9.50	85,571.00	9.67	75.09
1997	14,193.00	9.10	92,879.00	8.54	74.70
1998	15,315.00	7.91	100,383.00	8.08	74.82
1999	16,446.00	7.38	108,160.00	7.75	75.08
2000	17,685.00	7.53	116,795.00	7.98	75.39
2001	19,029.00	7.60	126,025.00	7.90	75.60
2002	20,237.00	6.35	134,041.00	6.36	75.61
2003	21,440.00	5.94	142,849.00	6.57	76.06
2004	22,690.00	5.83	152,529.00	6.78	76.74
2005	23,997.00	5.76	162,187.00	6.33	77.15
2006	25,371.00	5.73	171,745.00	5.89	77.28
2007	26,835.00	5.77	181,745.00	5.82	77.31
2008	28,409.00	5.87	193,505.00	6.47	77.76
2009	30,044.00	5.76	204,956.00	5.92	77.88
2010	31,749.00	5.68	216,428.00	5.60	77.82
2011	33,532.00	5.62	228,445.00	5.55	77.77

Table 2.2-12 Forecast Demand of Electricity (Information by EGAT)

Energy	Unit	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Hydro	GWh	4,299	4,555	4,555	4,711	4,711	5,040	5,205	5,205	5,452	6,064	6,428	6,428	6,428	7,338	7,779	7,779	7,779
	%	5.5	5.3	4.9	4.7	4.4	4.3	4.1	3.9	3.8	4.0	4.0	3.7	3.5	3.8	3.8	3.6	3.4
Natural Gas	GWh	26,390	18,818	19,438	20,005	36,706	38,521	39,571	39,809	38,240	41,106	40,952	41,006	39,706	39,706	33,243	28,774	23,813
(indigenous)	%	33.8	22.0	20.9	28.9	33.9	33.0	31.5	29.7	26.8	26.9	25.2	23.9	21.8	20.3	16.2	13.3	10.4
	million ft3/day	673	501	516	672	819	862	890	892	850	927	922	922	880	868	716	605	492
Natural Gas	GWh	0	0	0	701	10,819	18,560	18,692	18,692	18,551	18,692	18,692	18,691	18,691	18,691	18,691	18,691	18,691
(Burma)	%	0.0	0.0	0.0	0.7	10.0	15.9	14.8	13.9	13.0	12.3	11.5	10.9	10.3	9.7	9.1	8.6	8.2
	million ft3/day	0	0	0	29	408	525	525	525	521	525	525	525	525	525	525	525	525
Fuel Oil	GWh	22,630	26,418	27,917	27,170	14,133	6,603	6,747	4,028	4,769	4,260	4,163	2,995	3,585	3,785	3,750	8,476	18,597
	%	29.0	30.9	30.1	27.1	13.1	5.7	5.4	3.0	3.3	2.8	2.6	1.7	2.0	2.0	1.8	3.9	8.1
	million litters	5,609	6,512	6,865	6,628	3,402	1,610	1,586	959	1,175	981	961	704	837	883	847	1,934	4,184
Diesel	GWh	2,015	2,757	4,782	2,303	302	302	302	302	302	302	302	302	302	302	302	385	450
	%	2.6	3.2	5.1	2.3	0.3	0.3	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
	million litters	579.0	757.0	1,450.0	566.9	160.4	160.7	160.7	161.0	161.0	161.3	174.5	187.7	201.1	214.4	227.9	250.1	272.7
Domestic Coal	GWh	14,447	16,697	19,418	18,395	17,255	17,255	17,255	17,255	17,255	17,255	17,255	17,255	17,255	17,255	16,270	16,270	16,270
	%	18.5	19.5	20.9	18.3	16.0	14.8	13.7	12.9	12.1	11.3	10.6	10.0	9.5	8.9	7.9	7.5	7.1
	million tons	12.283	15.162	17.669	16.513	15.490	15.490	15.490	15.490	15.490	15.490	15.490	15.490	15.490	15.490	14.444	14.444	14.444
Imported Coal	GWh	0	0	0	0	0	0	0	0	0	0	3,285	7,388	11,528	15,938	27,531	32,628	32,850
	%	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.0	4.3	6.3	8.2	13.4	15.1	14.4
	million tons	0	0	0	0	0	0	0	0	0	0	1,111	2,499	3,899	5,390	9,311	11,035	11,110
IPP and others	GWh	8,242	16,326	16,769	18,089	24,216	30,496	38,055	48,732	58,262	64,832	71,092	77,662	84,232	90,802	97,372	103,425	109,995
	%	10.6	19.1	18.1	18.0	22.4	26.1	30.2	36.4	40.8	42.5	43.8	45.2	46.3	46.9	47.5	47.8	48.1
Total	GWh	78,023	85,571	92,879	100,383	108,160	116,795	126,025	134,041	142,849	152,529	162,187	171,745	181,745	193,505	204,956	216,428	228,445
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

2.2.3 Coal in Thailand

(1) Coal Deposits and Coal Production in Thailand

Currently Thailand has coal reserves amounting to a total of approximately 2,800 million tones. Approximately 1,100 million tones of coal are regarded as measured reserve. Most of the coal deposits are located in the north region of Thailand (Fig. 2.2-1 and 2.2-2). The Mae Moh deposit in Changwat Lampang being the largest deposit with 1,400 million tones reserve, is also situated in this region. There are only few deposits in the central and southern parts of Thailand. Coals are classified mostly to lignite and subbituminous.

Currently, there are 14 coal deposits that have been developed. In 1996, coal was mined from 9 deposits in which a total of about 21.5 million tons was produced and consumed. In addition, about 2.5 million tones of coal and coal products (coke and briquette) were imported and consumed. Table 2.2-13 illustrates details of reserves and qualities of productive coal deposits and discovered coal basins in Thailand.

For each coal deposit; figures on moisture, ash, sulfur contents and calorific value relating to volatile matter as well as fixed carbon are available. However, others details about ash composition, ash fusibility, ash distribution in the seam, forms of sulfur bonding and further qualitative characteristic are not available at present. Table 2.2-13 shows the cumulative coal production in Thailand subdivided according to deposits for the period from 1955 to 1996.

(Note)

JICA provided three coal quality analysis equipment for the Study and they were donated to DMR at the end of the Study. These three analysis equipment are, "Ash Fusibility Determinator", " Thermalgravimetric Determinator", "Sulfur Determinator". It is available to analyze the details about the most of matters which are mentioned above by DMR at present.

Table 2.2-13 Geological Reserves of Coal and Quality of Coal in Thailand

Deposit Locations	Country	Province	Measured Reserves (Million t)	Reserves (Million t)	Heating Value (raw) (kcal/kg)	Moisture (raw) (%)	Ash (raw) (%)	VM (raw) (%)	Fix Carbon (raw) (%)	S (dry) (%)	Density (g/cm3)	Average Heating Value (kcal/kg)	Vertical Stripping Ratio	Number of Nain Seams (m)	Accumulated Thickness of Seams (m)	Production 1995 (t)	Operator/Owner
Northern Area																	
Mae Moh	Mae Moh	Lampang	820.90	1,408.00	1,900-4,600	30.2	25.4	28.5	16.5	3.0	1.5	2,700	1:5.1	3	20-30	13,191,850	EGAT/active
Li	Li	Lamphun	28.00	-	2,800-6,600	10.4	16.4	26.5	46.7	1.6	1.4	5,350		1-2	3-30	2,902,594	DEDP/active
Mae Chaem	Mae Chaem	Chiang Mai	1.20	N.A.	2,800-6,600									1	0.5	203,762	DEDP/active
Mae Teep	Ngao	Lampang	11.0	N.A.	2,400-?	12.3	14.0	31.0	42.8	2.2	1.5	3,800			10	0	Private/active
Mae Tum	Mae Ramat	Tak	1.23	N.A.	1,700-?											0	Private/active
Mae Lamao	Mae Sot	Tak	13.90	34.21	3,300-5,200	14.6	30.8	27.9	26.7	3.0	-	3,100		2		85,902	Private/active
Mae Than	Mae Tha	Lampang	-	35.00	3,600-5,800	20.0	30.4	26.5	23.1	4.0	1.5	3,068		2	15-20	2,583,110	Private/active
Wiang Haeng	Wiang Haeng	Chiang Mai	93.02	125.14	1,616-5,256	24.3	32.2	23.5	20.1	0.9	1.7	2,908		2	0.1-21.5		Feasibility Study Non Power use
Wang Nua	Wang Nua	Lampang	9.01	31.16	1,636-4,965	16.9	36.0	28.0	19.2	2.5	1.6	2,980		1-2	0.2-5.0		Preliminary
Ngao	Ngao	Lampang	48.38	99.10	1,041-3,972	16.0	45.0	27.4	11.7	5.0	1.7	2,100		2	0.1-42.4		Feasibility Study Power use
Chae Hom	Chae Hom Muang	Pan Lampang	16.20	57.23	1,130-4,427	14.3	48.9	25.0	11.9	3.7	1.7	2,044		1	0.3-6.9		Non active Preliminary
Serm Ngam	Serm Ngam	Lampang	6.19	19.40	1,800-4,910	22.3	13.9	32.7	31.1	2.4	1.4	4,127		1	0.3-5.5		
Mae Ramat	Mae Ramat	Tak	14.00	46.00	4,469	7.0	30.2	27.4	35.5	7.8	1.6	4,469		5-10	0.1-22.9		
Hua Sua Pha	Mae Tha	Lampang	1.85	N.A.	N.A.												
Chiang Muan	Chiang Muan	Phayao	25.30	43.30	1,300-4,457	23.0	26.6	30.4	20.0	3.1	1.5	3,213		1	3.5-16.9		Feasibility Study Non Power use
Mae Tha	Mae Tha	Lampang	15.30	60.70	1,282-5,542	16.02	33.1	28.5	22.4	5.4		3,600		2-3	0.12-11.9		
Bo Luang	Hod	Chiang Mai	0.63	N.A.	N.A.											185,151	Private/active
Hang Chat		Lampang	10.32	28.26		17.2	30.1	31.7	21.0	3.4	1.6	2,907		1.5	0.17-15.3		
Pa La Tha		Tak	4.60	14.80										3	0.5-11		
Om Phang		Tak	3.40	6.83		14.0	38.0	25.4	22.6	3.4	1.6	3,100		2	0.3-4.3		
Pobphra			-	-		11.1	43.2	30.4	15.3	3.9	1.7	2,627					
Central Area																	
Nong Ya Plong	Nong Ya Plong	Petchaburi	1.40	N.A.	2,400-7,800	12.3	14.0	31.0	42.8	0.8	1.4	5,444		1	0.3-0.9	0	Private/suspend.
Nong Plab		Prachuap Khiri Khan	11.20	14.90		16.8	25.6	30.3	27.3	3.6	1.4	3,834		1-2	0.1-8.6		
Southern Area																	
Krabi	Klong Thom	Krabi	83.60	120.80	1,600-4,700	23.7	19.8	32.7	23.9	1.9	1.4	3,545				144,253	EGAT/active
Sin Pun	Thung Yai	Krabi	91.06	91.06	1,210-4,763	24.4	18.5	32.8	24.3	6.2	1.4	3,534		2	8.4-11.7		Feasibility Study Power use
Khian Sa	Khian Sa	Surat Thani	15.41	55.42	1,743-5,869	13.8	23.0	31.8	31.4	7.0	1.3	3,936		1-4	0.5-4.2		
Saba Yoi	Saba Yoi	Songkhla	350.00	605.00	2,530	29.2	28.7	26.4	17.8	2.7	1.4	2,530					Feasibility Study Power use
Kantang		Trang				14.5	20.3	35.8	28.5	4.2	nd.	3,580				0	Private/active
North Eastern Area																	
Na Duang		Loei				3.0	27.0	5.3	64.7	0.8	1.4	6,000		1	2-3	5,000	Private/active
Na Klang		Udon Thani	N.A.	13.50	2,200-4,000							6,000					Non active

Table 2.2-14 Coal Production in Thailand during 1955-1996

Unit : tons

Years	Mae Moh	Krabi	Li	Mae Taen	Mae Teep	Nong Ya Plong	Na Duang	Na Kiang	Mae Lamao	Mae Than	Mae Chaem	Kang Tang	Bo Luang	Chiang Muan	Total
1955	22,118.0														22,118.0
1956	27,826.0														27,826.0
1957	59,782.8														59,782.8
1958	105,843.7														105,843.7
1959	118,781.9														118,781.9
1960	101,719.2														101,719.2
1961	118,583.7														118,583.7
1962	129,767.0														129,767.0
1963	139,113.0														139,113.0
1964	104,749.0	4,384.4													109,133.4
1965	49,313.5	62,648.5													111,962.0
1966	42,795.5	105,847.3													148,642.8
1967	124,913.0	177,162.9													302,075.9
1968	118,245.0	211,851.5													330,096.5
1969	102,129.5	208,553.1													310,682.6
1970	145,560.5	229,627.2	6,463.7												381,651.4
1971	154,148.5	292,978.1	4,678.2												451,804.8
1972	117,976.0	258,109.8	7,157.4		1,900.0										385,143.2
1973	111,864.9	249,569.8	7,449.3		3,100.0										371,984.0
1974	171,093.9	263,367.4	26,922.0		450.0										461,831.3
1975	195,754.4	332,082.2	57,434.5	600.0	295.0										586,166.1
1976	177,315.0	313,683.6	72,425.0	0.0	670.0										564,093.6
1977	162,717.0	294,600.9	101,722.0	0.0	3,970.0										563,009.9
1978	179,793.0	268,177.4	110,106.5	0.0	5,500.0										563,576.9
1979	875,143.6	283,125.3	108,439.5	0.0	10,900.0										1,277,608.4
1980	875,425.4	363,806.3	165,447.2	0.0	11,900.0										1,416,578.9
1981	1,184,936.6	362,403.4	181,874.7	2,592.0	37,695.8										1,769,442.5
1982	1,193,433.3	372,301.6	233,963.4	83,499.9	102,266.3		6,120.0								1,991,584.5
1983	1,278,660.6	353,749.9	229,421.0	66,689.0	68,781.0		11,100.0	2,050.0							2,008,251.5
1984	1,525,360.8	278,245.7	250,821.6	80,222.0	57,895.0	62,763.0	0.0	4,350.0							2,252,658.1
1985	4,217,537.1	395,000.0	350,243.2	41,090.0	23,413.0	118,992.0	3,000.0	75.0							5,149,350.3
1986	4,556,916.7	212,000.0	668,293.2	20,032.0	2,420.0	87,626.0	2,500.0	0.0							5,549,787.9
1987	5,564,536.7	193,000.0	945,720.2	28,764.0	48,892.0	85,662.0	8,350.0	0.0	18,747.0	3,500.0					6,895,161.9
1988	5,717,249.0	237,356.2	1,292,537.4	0.0	52,389.0	21,854.0	15,330.0	0.0	37,156.0	3,761.0	3,600.0				7,290,602.6
1989	6,543,191.3	318,584.8	1,558,426.8	0.0	86,848.0	89,050.0	15,340.0	0.0	82,029.0	88,341.0	134,524.0	800.0			8,914,734.9
1990	9,652,991.3	156,262.4	2,028,983.3	0.0	132,681.0	8,000.0	20,600.0	0.0	77,507.0	113,178.0	165,937.0	0.0			12,356,240.0
1991	11,513,774.8	242,689.4	2,392,436.6	0.0	168,477.0	0.0	14,300.0	0.0	93,303.0	90,200.0	188,049.0	0.0			14,703,229.8
1992	12,155,910.3	263,950.0	2,475,292.0	0.0	59,572.0	0.0	22,000.0	0.0	73,450.0	326,897.0	249,254.0	2,800.0	12,004.5		15,640,229.6
1993	11,221,088.0	216,800.0	2,923,548.6	0.0	0.0	0.0	15,500.0	0.0	85,717.0	689,044.1	392,268.0	6,390.0	57,891.5		15,608,186.6
1994	11,906,553.0	266,487.6	3,176,079.0	0.0	0.0	0.0	11,900.0	0.0	92,019.0	1,265,824.0	250,841.0	0.0	141,781.0		17,111,481.6
1995	13,191,850.0	144,232.6	2,902,594.0	0.0	0.0	0.0	5,000.0	0.0	85,802.0	2,583,110.0	203,762.0	0.0	185,151.0		19,301,501.6
1996	16,262,262.0	0.0	2,939,838.0	0.0	0.0	23,315.0	3,000.0	0.0	74,869.0	1,762,736.0	143,057.0	0.0	169,902.0	182,705.0	21,561,677.0
Total	122,301,622.3	7,928,719.3	25,128,310.7	323,459.9	879,915.1	496,592.0	154,040.0	6,475.0	729,699.0	6,926,588.1	1,731,232.0	9,590.0	566,730.0	182,705.0	167,349,707.4

(2) Possible Uses of Domestic Coals

The domestic coals have qualitative characteristics as shown in Table 2.2-13. Generally, the coal deposits of Thailand are characterized by high contents of ash ranging from 14 to 50%, contents of sulfur 1 to 7 %, moisture contents from 10 to 30%, and calorific value ranging from 2,500 to 5,000 kcal/kg (Dry Basis).

The requirements to be met in coal utilization according to available processes and technology are summarized in Table 2.2-15. It should be noted that the conditions required are only regarded as proximate values. In particular, in the threshold regions, individual case studies and assessments will decide on utilization.

The use of domestic coals is mainly governed by economic and material parameters such as ash and sulfur contents. With this regard, the amount of ash and sulfur will have a strong impact on the economic consideration due to expenses for ecological impact.
An important prerequisite for using domestic coals instead of other energy sources (imported coal, oil) in the industry is an improvement in transportation capability, economy and in handling properties. Measures to be taken to this effect are:

1) selective mining or preparation of coals, with included coal drying;
2) produced coal, should be prepared and controlled the chemical and physical properties, on the site of the mine which concern the preparation of :
   - lump coals for fixed-bed firing,
   - steaming coals for fluid-bed combustion,
   - powder coals for pulverized-fuel firing, possibly with addition of limestone.

The necessity to reduce the specific energy demand per unit of the real GDP at the present time forces the industry sector to use low-energy consumption technologies and economy saving measures. This type of fuel supply will be capable to handle uncontrolled coal losses during transportation, handling and storage processes. Besides, they will reduce both transport expenses and investment on the consumer side. Table 2.2-16 illustrates grouping of coals in Thailand according to their production process and utilization on basis of the data in the Tables 2.2-13 and 2.2-15. From Table 2.2-16, it follows that cooking of these coals to produce fine cokes (as active cokes) for waste-gas and water purification or to produce lump cokes are not suitable.

Table 2.2-15 Properties of Coal for Various Uses

Conditions and Analysis	Combustion					Briquetting		Gasification		Pyrolysis		Liquefaction of Coal	Coal Preparation	Coal Powder for Combustion and Cement	Fine Coal for Fluid-Bed Combustion
	Power Station	Boiler	Cement	Tobacco	Residential Combustion	without Binder	with Binder	Low-C Gas Production	High-C Gas Production	Coke for Water and Gas Cleaning	Coke for Metallurgy Process	Process for Berguis Piere			
Type of Coal	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite Hard Coal Anthracite	Lignite	Lignite Hard Coal Anthracite	Lignite Hard Coal	Lignite Hard Coal	Lignite	Lignite Hard Coal	Lignite	Lignite Hard Coal Anthracite	Lignite Brown Coal	Lignite Brown Coal
Moisture (%)	< 60	< 20	< 15	< 20	< 20	> 40 (insitu Seam) (dry up) <20	< 15	< 15	< 20	> 45 (insitu Seam)	< 10	< 55 (<2% after Drying)	< 45	< 15 > 30 Drying	< 15 > 30 Drying
Ash (Ad) (%)	< 50	< 20	< 15	< 50	< 15	< 15	< 15	< 15	< 20	< 5	< 10	< 12	< 15	< 15	< 15
Heating Value (kcal/kg)	> 1,100	> 4,000	> 4,500	> 4,000	> 4,000		> 4,000	> 4,000	> 3,500					> 4,000	> 4,000
VM (%)	X	X	X	X	< 20 (mf)	X	< 20 (mf)			>50					
Sulfur (%)	< 5	< 2	> 1 - 3	< 1	< 1 > 1 - 2 add Lime	< 2 bei 1 - 2 % add Lime	< 2 bei 1 - 2 % add Lime	< 0.6 % > 0.6 % with H2S Cleaning	> 1 - 5	< 1	< 1	< 3		< 1 1 - 2 (Mixing with Limestone)	< 1 1 - 2 (Mixing with Limestone)
Sulfur Binding (%)	X	X			X										
Coal Elemental Analysis (%) C/H/N/S/O	X														
Ash Oxide Analysis (%)	X		X				X	X	X	X		X		X	X
Ash Fusion TEMP. (C) tA/tB/tC	tB > 1,100	tB > 1,100		tB > 1,060				tB > 1,100	tB > 1,150					tB > 1,100	X
Grain Size (mm)	X	0.5/0 4/0 80/10		0.5/0 4/0 80/10	> 20/ < 100	< 5/0	< 5/0	50/10	70/10	70/6		< 0.5/0		0.5/0	6/0
Carbonization Analysis								X	X	X		X			
Ash Particle Analysis (%)						X							X		
Coal Preparation Analysis													X		
Strength of Coal Hardgrove Abrasive Strength	X		X					X X	X X				X		
Content of Bitumen												X			
Swelling Index											X				
Maceral Analysis										X	X	X			

Table 2.2-16 Recommendation for Utilization of Coal in Thailand According to the Coal Quality

Deposit Location	Moisture (raw)	Ash (raw)	VM (raw)	Fix Carbon (raw)	S (dry)	Density	Average Heating Value	Use												
	%	%	%	%	%	g/m3	kcal/kg	Coal Preparation	Powder Coal	Fluid-Bed Coal for Boiler	Briquettes without Binder	Briquettes with Binder	Gasification Weak Gas	Gasification Rich Gas	Coal Lique-faction	Combustion Power Station	Combustion Boiler	Combustion Cement	Combustion Tobacco	Residential
Mae Moh	30.2	25.4	28.5	16.5	3.0	1.5	2,700	XP								X	X			
Krabi	23.7	19.8	32.7	23.9	1.9	1.4	3,545	XP		XP						X	X	X		
Li	10.4	16.4	26.5	46.7	1.6	1.4	5,350					XP					X	X		Briquettes X
Mae Teep	12.3	14.0	31.0	42.8	2.2	1.5		X	X								X		X	
Nong Ya Plong	12.3	14.0	31.0	42.8	0.8	1.4	5,444		X								X			Briquettes X
Mae Than	20.0	30.4	26.5	23.1	4.0	1.5	3,068	XP								X	X			
Wiang Haeng	24.3	32.2	23.5	20.1	0.9	1.7	2,908	XP								X	X		X	Briquettes X
Sin Pun	24.4	18.5	32.8	24.3	6.2	1.4	3,534	XP								X		XP		
Khian Sa	13.8	23.0	31.8	31.4	7.0	1.3	3,936	XP										XP		
Saba Yoi	29.2	28.7	26.4	17.8	2.7	nd.	2,530	XP								X	X	X		
Wang Nua	16.9	36.0	28.0	19.2	2.5	1.6	2,980	X									X	X		
Ngao	16.0	45.0	27.4	11.7	5.0	1.7	2,100	XP								X	X	X		
Chae Hom	14.3	48.9	25.0	11.9	3.7	1.7	2,044	X									X			
Serm Ngam	22.3	13.9	32.7	31.1	2.4	1.4	4,127										X			
Mae Ramat	7.	30.2	27.4	35.5	7.8	1.6	4,469	XP								X	X			
Chiang Muan	23.0	26.6	30.4	20.0	3.1	1.5	3,213	XP									X	X	X	
Mae Tha	16.0	33.1	28.5	22.4	5.4			XP												
Kantang	14.5	20.3	35.8	28.5	4.2	1.4	3,580													
Na Duang	3.	27.0	5.3	64.7	0.8		6,000					XP					X	X	X	Briquettes X
Na Klang							6,000					XP					X	X	X	Briquettes X
Um Phang	14.0	38.0	25.4	22.0	3.4	1.6	3,100										X			

The production of montan waxes from coal extraction can not be evaluated because information about extractable bitumen is not available. High-sulphur coals are recommended for gasification which the process involves the necessity of gas desulpferization prior to gas combustion. Furthermore, it should be taken into consideration that coal gasification, especially for production of high calorific value gas, requires very cost-intensive processes. Coal briquetting without binder is also not recommended.

Taking into consideration the utilization of coal at the present time as well as coal reserves and available producing (active) plants, grouping of deposits can be made according to their regional/local importance (to industries) (Table 2.2-17). Regional importance is considered from (minimum production rates of 0.1 million tons per annum for 15 years) sufficient for electricity generation or other uses within the distance of 250 km from the deposit. For coal industry need to be developed, the following investigations should be carried out :

- Investigation of selective mining of high-quality coals;
- Investigation of utilization of the remaining coal of high-ash content;
- Investigation of washability of coal particles of high ash contents such as, float-and-sink analyses;
- Feasibility studies relating to coal preparation plants;
- Construction of coal preparation plants;
- Preparing and establishing logistics systems, possibly including returning and dumping of ashes into the mine pits;
- Supporting the use of low-energy consumption technology;
- Setting up coal customer oriented departments in the centers of coal mine to provide technical and economic advice, up to the planning stage in the coal consumption plants;
- Training/education of energy;
- Determination of prices for domestic coals according to calorific value, ash and sulfur contents;
- Check with EGAT whether high-quality coals can be made available for purchasing from their mines;

Table 2.2-17 Grouping of Coal Deposits for Various Kinds of Utilization

Coal Deposits of Thailand

12 Deposits active		12 Deposits active	
Regional Importance 6 Deposits	Local Importance 6 Deposits	Regional Importance 8 Deposits	Local Importance 4 Deposits
Mae Moh, Li, Krabi Mae Lamao Mae Than Mae Chaem	Mae Teep Nong Ya Plong Mae Tuen, Kantang, Na Duang, Na Klang	Wiang Haeng Chiang Muan Ngao, Saba Yoi Sin Pun, Wang Nua, Mae Ramat, Chae Hom	Mae Tha Serm Ngam, Khian Sa, Nong Plab

Power Stations	Boiler (regional)	Cement	Drying Tobacco	Boiler (local)	Briquettes	Ceramics	Glass	Asphalt-Mix Plants
Mae Moh Krabi Saba Yoi Ngao Sin Pun	Li Krabi Mae Lamao Mae Than Wiang Haeng Chiang Muan Saba Yoi Hang Chat Wang Nua	Li Krabi Wiang Haeng Khian Sa 1) Sin Pun 1) Saba Yoi Chae Hom	Na Duang Na Klang Nong Ya Plong Li	Wang Nua Mae Tha Serm Ngam Mae Chaem Mae Tuen Wang Nua Chae Hom Na Duang Na Klang	Li Nong Ya Plong Wiang Haeng Na Duang 2) Na Klang 2)	Li Sin Pun Khian Sa Others } *	Li Sin Pun Khian Sa Others } *	Wiang Haeng Saba Yoi Wang Nua Krabi Mae Ramat Hang Chat Chae Hom Chiang Muan

1) Partially use (mix with imported coal)
2) only coal < 6 mm grain size
*) Gasification

- Check with EGAT whether coal particles (crushed and predried) can be made available for purchasing from their existing electricity generation plants;
- Check with EGAT whether the existing generation plants and those being built can buy drying coal at reasonable price;
- Feasibility studies of coal drying and grinding;
- Market analysis for coal and coal products from the three mining centers in Thailand (see the details in 2.2.4);
- Market analysis and strategic study for imported coals;
- Planning the wholesale system for imported coals;
- Preparation of the wholesale logistics system;
- Specifying the requirements for imported coal ports, receiving terminals, preparation/selection of sites for imported coal ports. This requires consideration of construction plan for new electricity generation plant in the area nearby the port (under the assistance by EGAT);
- Preparation of feasibility studies for imported coals.

(3) Demand for Coals in Various Branches of Industry

Currently the use of coals in the individual branches of industry is shown in Table 2.2-19. As shown, the domestic coals are utilized mainly for electricity generation and cement industry. A small share is used for heat generation process in other branches of industry. This utilization is expected to be similar trend in the future for both domestic and imported coals.

Future economic development in Thailand will require utilization of coals/cokes, particularly for base metallurgy. A demand for coal in lime production will arise due to increase of lime demand. This is resulted from the use of lime in SO_2 emission reduction of the energy generation sector and in the building sector which are being expanded. Other areas for coal/lignite utilization are asphalt-mix plants, glass industry (via gasification), ceramics (via gasification) and agricultural drying plants. In the household and commercial sectors, the use of briquettes is possible. Possible uses of domestic coals are determined by their quality, means and distances of transport as well as prices. To improve quality and reduce transport costs in relation to the heat content, in particular,

measures directed towards selective mining of coals, coal preparation and coal drying are necessary.

Table 2.2-18 Coal Utilization in Various Industries

Unit : tons / year

Years / Industry	1992		1993		1994	
	Quantity	%	Quantity	%	Quantity	%
Electricity	12,370,639	78.80	11,490,327	73.00	12,164,222	71.50
Cement	2,166,726	13.80	2,918,098	18.50	3,438,147	20.20
Lime	63,194	0.40	51,569	0.30	77,262	0.45
Tobacco	154,186	0.98	227,257	1.40	63,009	0.37
Pulp	505,865	3.22	524,004	3.30	873,050	5.13
Food	58,791	0.37	54,313	0.30	74,900	0.44
Polymer	55,015	0.35	119,271	0.80	115,800	0.68
Metal	12,386	0.08	10,826	0.07	3,500	0.02
Battery	4,400	0.03	5,230	0.03	837	0.00
Others	307,652	1.96	338,911	2.20	205,808	1.21
Total	15,698,856	100.00	15,739,806	100.00	17,016,534	100.00

The utilization of imported coals is also determined by transport means and distances. The location of receiving terminals should be considered. Possible uses of domestic coals as well as imported coals, can be estimated for each individual industry on the following basic conditions:

- share of coals in electricity generation by EGAT which is about 20% at present, (see Table 2.2-12)
- increase in the share of coals in electricity generation by Independent Power Producer (IPP) and others,
- increase in the share of coals for heat generation (boiler) in the industry and coal industry,

- growth of energy consumption in the cement industry,
- use of coal for lime burning,
- use of coal in base metallurgy,
- use of coal as heat supply in glass industry and ceramics industry via the stage of coal gasification,
- increase in the use of powder coal in asphalt-mix plants.

Table 2.2-19 and 2.2-20 display estimation of the future coals demand according to domestic and imported coals.

Table 2.2-19 Estimated Demand for Domestic Coals According to Sectors / Branches of Industry

Unit : million tons / year

Industry	Years				
	1996	2001	2006	2011	2016
Power Stations	15.2	15.5	15.5	14.5 - 15.5	18.0 - 20.0
Boilers/Industry	1.0	5.5	7.0 - 8.0	9.0 - 10.5	11.0 - 13.0
Cement	3.0	3.5	4.0	4.5	4.5
Coal Industry	0.1	0.4	1.0	1.5	2.0
Lime	0.1	0.4	0.6	0.8	1.0
Base Metallurgy	0.1	0.4	0.5	0.5	0.7
Glass			0.1	0.2	0.3
Ceramics			0.4	0.7	1.1
Agriculture/Tobacco	0.1	0.2	0.2	0.2	0.2
Asphalt-Mix Plants		0.1	0.2	0.3	0.4
Others	0.3	0.4	0.6	1.0	1.4
Total	19.9	25.4	30.1 - 31.1	33.2 -35.7	40.6 - 44.6

Table 2.2-20 Estimated Demand for Imported Coals According to Sectors / Branches of Industry

Unit : million tons / year

Industry	Years				
	1996	2001	2006	2011	2016
Power Stations			2.5	11.2	18.0 - 20.0
Boilers/Industry	0.5	5.0 - 6.0	7.0 - 8.0	9.0 - 10.5	12.0 - 15.0
Cement	1.0	1.1	1.2 - 1.4	1.5 - 2.0	2.5 - 4.0
Lime	0.1	0.1 - 0.2	0.3	0.4 - 0.5	0.6 - 1.0
Base Metallurgy	0.2	0.5	0.8	1.0 - 1.4	1.5 - 2.5
Glass		0.1	0.2	0.3	0.5
Ceramics		0.3	0.5	0.8	1.0 - 1.5
Agriculture/Tobacco	0.1	0.1	0.2	0.2	0.3 - 0.5
Asphalt-Mix Plants		0.2	0.3	0.4	0.5
Others	0.5 - 0.9	1.0 - 1.6	2.0 - 2.5	3.0	3.5 - 4.5
Total	2.4 - 2.8	8.3 - 10.0	15.0 - 16.7	28.0 -30.4	40.3 - 50.0

2.2.4 Development of coal deposits in Thailand

Almost all coal deposits in Thailand occurred in the Tertiary basins. According to the geologic map, Tertiary basins are found;

(1) To the north in Changwat Lampang and in the vicinity,

(2) To the northwest in Changwat Tak,

(3) To the south in Changwat Krabi and in the vicinity.

The rocks in the Tertiary basins comprise mainly mudstone, sandstone and coal. Coal seams generally occur in several layers. The coal beds are gentle dipping and extend down to the depths of 200 to 300m. Dislocation of coal seams is normal due to faulting. Coal seam thickness range from 1m (lower mineability limit) up to 20m (including dirt bands). Most of the deposits are narrow and long shape; rarely found as circular shape.

Consideration of three main Tertiary basins mentioned above, three central regions of coal production and utilization could be classified including the northern region having Mae Moh deposit as center, the northwestern region having Mae Lamao and Mae Ramat deposits as center, and the southern center having Krabi and Saba Yoi deposits as center. In the northern region, the largest deposit is Mae Moh deposits in Changwat Lampang with 18 km in length and 9 km in width. The deposits contain coal reserves of approximately. 1,400 million tons from three main coal seams with the total thickness of 20 - 30m. The northwestern region contains Mae Lamao and Mae Ramat deposits as the center. Mae Lamao basin is about 7 - 8 km wide and about 12 km long. The basin aligns along the northwest-southeast trending and contains coal reserve of about 34 million tons. Mae Ramat basin contain coal reserve of about 46 million tons.

The southern region has Krabi and Saba Yoi deposits as the center. Krabi basin is characterized by long shape and aligning along the northwest-southeast trending. The basin is about 10 km wide and 40 km long surrounded by mountainous areas, except to the south where it opens to the Andaman Sea. Krabi basin contains coal reserves of about 120 million tons. Saba Yoi basin is about 12 km wide and 30 km long and has long shape which opens to the north into the Gulf of Thailand. The basin contains coal reserves of about 2,500 million tons and have three main coal seams. In addition, the other coal deposits are small deposits. With their characteristics of long shape and

dipping of their coal seams, they could be mined for only 2-5 million tons per year by opencast mining. If the lives of opencast mines and consumer plants are 20 years, it can be seen that the deposits with reserves of over 40 million tons should be considered for development and exploitation. It should be noted that geographical location of the coal deposit is also an important factor that make small coal deposits to be developed.

Development of Domestic Coal Deposits

According to the information above three main Tertiary basins, three main centers for exploration and utilization are as follows :

1) The northern region having Mae Moh deposits as center surrounded by Wiang Haeng, Chae Hom, Hang Chat, Mae Tha, Ngao, Serm Ngam, Wang Nua, Mae Chang.
2) The northwestern region having Mae Lamao and Mae Ramat deposits as center surrounded by Pala Tha, Um Phang.
3) The southern region having Krabi and Saba Yoi deposits as center.

In each region, the coal should be produced directly for electricity generation. In Thailand, coals having calorific values less than 2,700 kcal/kg should be used locally. For regional usage, coals should be prepared/dried to upgrading the heating value to approximately 4,000 kcal/kg or more. Table 2.2-21 displays the heating values of domestic coals after preparation /drying.

Table 2.2-21 Increase in Heating Values of Coal by Preparation/Drying

Unit : kcal/kg

Deposits	Run-of-Mine Coal	Prepared Coal	Dry Coal
Mae Moh	2,700	3,300	3,850
Wiang Haeng	2,900	3,650	3,850
Wang Nua	2,980	4,000	4,600
Chiang Muan	3,200	3,700	4,100
Hang Chut	2,900	3,800	-
Mae Ramat	4,470	5,300	-
Saba Yoi	2,530	3,050	3,500

Study on coal preparation and drying to increase calorific value of coal indicates that they require low mining costs in order to be competitive with the products of "powder coal " and "fluid-bed coal"; particularly those from Wiang Haeng and Saba Yoi deposits. The heating price of powder coal can be compared with the heating price of fuel oil as shown in Table 2.2-25. The development of domestic coal, on the basis of available data of coal deposits and quality, could be considered as presented in Table 2.2-22. In addition, there are other 5 coal deposits that have potential to be developed as shown in Table 2.2-22.

Table 2.2-22 Possibility of Coal Production from Various Deposits at Each Time Period

Unit : Million tons/Year

Deposits	1996	2001	2006	2011	2016
Wiang Haeng	-	-	1.0	2.0	5.0
Wang Nua	-	-	0.5	1.0	1.5
Chiang Muan	-	-	-	1.0	-
Hang Chat	-	-	-	0.5	1.0
Mae Ramat	-	-	-	1.0	2.0
Saba Yoi	-	-	1.0	2.0	7.0
Chae Hom	-	-	-	1.0	2.0
Mae Moh	15.0	15.0	15.5	15.5	15.5
Li	2.6	4.0	6.0	6.0	5.0
Krabi	0	1.0	1.0	1.0	1.0
Mae Teep	0	-	-	-	-
Mae Than	1.0	12.5	2.0	1.0	-
Mae Lamao	0.5	1.0	1.5	1.5	1.0
Mae Chaem	0.8	1.0	1.0	0.5	-
Others	0.5	1.0	1.0	2.0	3.0
Total	20.4	24.5	30.5	35.5	44.0

Table 2.2- 23 Possibility of Development of Five Additional Coal Deposits

Unit : Million tons/Year

Deposits	1996	2001	2006	2011	2016
Serm Ngam	-	-	0.5	1.0	1.0
Ngao	-	-	-	-	2.0
Mae Tha	-	-	-	-	1.5
Khian Sa	-	-	-	-	1.0
Sin Pun	-	-	-	-	3.0
Total	-	-	0.5	1.0	8.5

For Serm Ngam coal deposit; although the deposit contains good quality coal, it has small reserves and the coal seams are relatively thin. Therefore, to open the bidding for private sector, more detailed study should be undertaken in the area to reduce the risk. For other remaining 4 coal deposits, the coals contain relatively high sulfur contents which required the following study prior to bidding;

- Total Sulfur content
- Total inorganic Sulfur content
- Forms of sulfur
- Ash composition

After the results of the above studies have been evaluated for those 5 coal deposits, the decision could be made regarding to their utilization and mine planning for each individual stage. Table 2.2-24 displays the forecast of possible production of coals which are upgraded by several processes for the period of 5 years.

It is forecasted that the domestic coals could be supplied to consumers for at least 20 years. Therefore, coals with high sulfur contents should not be exploited at the present time unless there are some suitable technologies introduced to the market, particularly combined-cycle power plant using coal gasification. In Thailand where there are considerable transportation distance between the coal producing areas and the customers, increasing in energy density and improving handling system of coals are considered very important. They are also include the investigation and evaluation of coal competitiveness in market and economical situations.

Table 2.2-24 Possibility of Production of Prepared Coal, Powder Coal, Fluid-Bed Coal and Briquettes

(calculated as run-of-mine coal) Unit : Million tons/Year

Produce	1996	2001	2006	2011	2016
Prepared Coal		1.0	3.0 - 4.0	5.0 - 6.0	7.0 - 7.5
Powder Coal				1.0 - 2.0	3.0 - 3.5
Fluid-Bed Coal			1.0	2.0 - 2.5	3.0 - 3.5
Briquettes		0.1	0.3	0.5	0.6 - 1.0

As presented in Table 2.2-25, it is suggested that preparation of coal is the most economically justified process, followed by the production of fluid-bed coal and powder coal. The gasification and briquetting of coal is not economical according to the present prices situation. The coal gasification may be economically justified, in case the gaseous fuel is utilized nearby the mine site. Similarly, the production of synthesis gas for chemical process is not economically viable under the present price situation (in comparing with the price of oil and natural gas).

Table 2.2-25 Cost of Coal Processes

Processes	Unit of Price	Price
Preparation of Coal	US$ / t Prep. Coal	25.61
Produce of Powder Coal	US$ / t Prep. Coal	46.10
Produce of Fluid-Bed Coal	US$ / t F-B. Coal	42.08
Briquetting with Binder (without Drying of Coal)	US$ / t Briq.	45.98
Briquetting with Binder (with Drying of Coal)	US$ / t Briq.	68.77
Produce of Low Heating Gas	US$ / t Mwh	26.41

2.2.5 Managing conditions and regulations

(1) Managing Conditions and Regulations Management

Previous government policies on coal resources management are determined through cabinet resolutions which can be concluded as follows:

- Cabinet Resolution on June 9, 1987.

  Assign the government agencies which involve in coal development.

  - National Energy Policy Office (NEPO) was authorized for policy formulation and coordination with those agencies concerning with coal resources development.
  - Department of Mineral Resources (DMR) was authorized for coal exploration and contract bidding.
  - Electricity Generating Authority of Thailand (EGAT) was authorized for producing coal for power generating and has a special privilege in choosing coal basin prior to DMR bidding.
  - Department of Energy Development and Promotion (DEDP) was authorized for research in coal utilization.

- Cabinet resolution on July 12, 1988.
  - Endorsing DMR to call for bidding for Khian Sa coal basin
  - Endorsing DMR to reserve Wiang Haeng and Sin Pun coal basins for EGAT's power generating scheme.

- Cabinet resolution in June 1990
  - Endorsing DMR to call for bidding for Chiang Muan, Chae Hom, and Wang Nua coal basins.
  - Endorsing DMR to reserve Ngao coal basin for EGAT.

- Cabinet resolution in May 1992
  - Endorsing the return of Wiang Haeng coal basin from EGAT to DMR for bidding.
  - Revoking EGAT's privilege made on June 9, 1987, making EGAT to compete with private sectors in bidding for coal basins in the areas announced under sub-clause 6 of the Mining Act.

In addition, there are some recommendations from the above Cabinet Resolutions as follows:

1) Assignment for those agencies concerned: DMR has responsible for provide clean coal technology such as coal water mixture, coal gasification, underground coal gasification, and coking plant in coal deposits discovered by DMR but other inactive and the undeveloped coal deposits of EGAT. Thailand has to prevent the environmental impact problem.

2) Bidding: DMR has to accelerate bidding process for coal development in basins reserved under sub-clause 6 of the Mining Act in order to cope with the increasing demand of Independent Power Producer (IPP) to be in operation in 2003-2006.

3) EGAT's privilege: Such privilege must be revoked and allow the right to IPP to develop, because those basins given to EGAT under the Cabinet Resolutions made in July 1988 and 1990 have not been developed yet.

4) Revoking all mining leases given to DEDP because DEDP has subcontract with private firms to mine which, result in unnecessary high production costs.

- Furthermore, private firms have to pay special bonus about 80-100 baths/ton to DEDP.
- Regarding the Cabinet Resolution, DEDP has no authority to run mining business.
- DEDP has the same status as DMR, the position thereby, not appropriate to occupy the Mining Lease.

(2) Arrangement by State Agencies

In global view, it is a known fact that there is an unbalanced statistics between the growth of worldwide consumption of gas and oil and that of solid energy sources which will cause critical problems to our succeeding generations in solving their

energy issues. Currently, the worldwide recoverable reserve of oil and gas is estimated at 25% while that of coal is amounted to 75%, but their consumption figures are in the inverse proportion. Coal consumption has only 8% share of the total amount. If the current scenario is allowed to continue, the recoverable gas and oil reserves will be depleted within 50 years, whereas coal will still be available up-to the year 2200. It is, therefore, obviously crucial to examine the domestic sources of coal with regard to long-term energy use in all individual cases. The same applies to imported coal as well.

For the role of the government, it is important that those suitable basic conditions should be established in order to facilitate a favorable climate for the following:

1) Long-term energy supply security
   - at favorable prices,
   - taking into consideration, both worldwide and domestic reserves.

   At the same time, the supply strategy should be formulated in the way that there will be
   - a low risk by utilizing a combined source of energy production.
   - a low impact on the environment as a result of
     - energy efficiency and
     - energy conservation and
   - incentives in this regard are provided by supporting basic conditions.

2) Provision of basic conditions
   - for import of coal
   - for transport routes of domestic and imported coals
   - for the price structure of domestic and imported coals.
   - for training / upgrading personnel in the coal/energy sector
   - for securing the financial status of imported coal
   - for ensuring a fair competition for all energy sources in the energy market without subsidies from the government
   - for the utilization of secondary fuels (industrial and commercial; residual and waste materials) in selected branches of industry.

3) Governmental executive, advisory and control bodies should be established and/or those existing governmental bodies should be made fit for the forthcoming task.

a) Energy Efficiency

- low specific energy expenditure
- selection of energy source
- supply security
- low impact on environment
- Proof of energy efficiency for every new investment project (Standard should be international state-of-the-art technology).
- Checking those existing processes and plants as well as deriving and realizing measures relating to energy efficiency in order to either reconstruct of plants or shutdown of obsolete plants.
- Installation of metering and controlling equipment for energy consumption as well as monitoring for improving energy efficiency.
- Compilation of specific energy consumption into energy statistics and comparing with international standards.
- Utilization of waste heat
- Use of cogeneration (combined heat and power generation) in industry
- Utilization of both industrial and commercial residual and waste materials in selected branches of industry (cement industry, pig iron production, etc.)

b) Economical Use of Energy

- Basic conditions
  - catalogue of potential savings
  - catalogue of potential losses
  - energy-saving control of equipment and plants
  - catalogue in support of energy-saving measures
  - legal frameworks relating to energy saving
- Inclusion of the issue of economical energy use into training courses

- Inclusion of the subject of economical energy use into advertising by media and firms
- Introduction of energy consulting by EGAT on the economical use of electric energy
- Introduction of energy consulting by independent firms
- Production and sale of energy-saving household appliances
- Offering and installation of metering and control equipment to reduce energy consumption
- Utilization of secondary fuels (industrial residual materials, commercial waste) to meet a share of energy requirements in selected branches of industry.

(3) Economic Arrangements

In the energy market, domestic coal is facing a strong competition with imported coals, oil and gas and, increasingly, with various kinds of energy made from wasted materials (waste oil, petroleum coke, old tires) as regards,

- energy prices
- diversified forms of energy product and handling
- expenditure on processing technology
- environmental conditions in production and processing

For domestic coals, the imported coals should be regarded as competitors in addition to gas and oil. In future, stronger activities will therefore be needed for domestic coal to win new shares and maintain its current shares of the energy market. This means:

- minimizing the costs of coal mining and simultaneously meeting the expenses for environmental protection, and/or mitigation measures.
- examining the commercial usage of by-product materials from the coal mining process
- examining the possibilities of selective mining of high-quality coals from existing opencast mines to be opened up,
- examining possibilities/suitability of coals for pre-used preparation,

- investigations to determine the suitability of coals (powder coals, fluid-bed coals) with regard improving their handling properties and increasing their energy density,
- active market studies by existing and new coal producers to secure market shares in the long term,
- active market studies to be carried out by coal producers with regard to supply and provision of energy-efficient and environmentally compatible technology and technique for the customers,
- ensuring stable quality characteristics of coals and coal products,
- ensuring long-term supply of coals and coal products by the coal industry,
- setting up organizations/associations of the coal industry to protect common interests against the competitors in the energy market,
- setting up service department at coal enterprises to provide advice and service to customers,
- establishing logistics systems for coal transport, handling, storage including lime supply to reduce SO_2 emissions, and return of ashes,
- establishing wholesale enterprise for imported coals and domestic coals,
- supporting plant construction firms for the coal industry (capital goods industry), e.g. for
  - strong facilities for coal, silos for vehicles, pneumatic conveying equipment, powder-coal burners, etc.
  - partial plants (complete plants possibly later on) for coal preparation, drying, grinding
  - partial plants (complete plants possibly later on) for coal use such as small-size boilers up to 1 MW, industrial boilers to 50 MW and above,
  - supporting service firms for maintenance of coal-specific plants,
  - establishing port facilities for receiving and handling of imported coals,
  - establishing a coal-quality control regime for import coals.

(4) Regulations

In the early time of coal resources development, the role of the government has been emphasized only on some particular aspects which are controlling, exploration, and production under the rules and regulations provided in the Mining Law. However, at present, the situations on supply and demand as well as economical consideration of coal have been changed dramatically. It is necessary that the government should review its role as well as those rules and regulations concerning coal development in order to support private sector, who now possessing more capability in technology and investment.

1) Constraints on Development of Coal

Constraints on development of coal in Thailand can be summarized as follows;

a) Delay and unclear process relating to rules and regulations on coal bidding and issuing of prospecting licenses for coal resources.

b) Risk of the mining company concerning land right issue after the discovery of economic coal deposits. This is because the current mining law allows the land owner (or persons who can negotiate with the land owner) to have a legal right to apply for mining licenses without carrying out exploration.

c) It is known by the fact that type of mineral requires a different exploration technique and usually employs a specific mining method. However, most of the contents in the current Mining Law has been issued on the basis of a placer tin mining in the past. Hence, the regulations for coal exploration and mining need to be renovated and improved to facilitate the private sector.

d) Recently, several coal basins have reserved for research purpose by the government under the Sub-clause 6 of the Mining Law. However, until now, there is no clear policy for exploration and development in these coal basins.

e) The privilege granted to a certain state agency in taking the first priority to choose the coal deposit discovered by the DMR should be revoked because the current direction and policy for power generation have been changed. Furthermore, the coal deposits with the large economic potential such as Mae Moh or Saba Yoi are rarely found or may not exist. Such practice is also not complied to the free competition policy of the government.

f) Environmental regulation currently in use is out of date and only applied for small and medium scales mining with conventional technology. These regulations now are not suitable for the modern mining technology and business practices.

g) In the current mining business, the major part of primary investment arises from the troublesome and high expenses in the dealing of land rights purchase. Of course, the government can surrender lands but may not be appropriate in the initial contact because the landowners will feel compelling and will oppose and resist the mine. The government should set up the clear rules and provide the assistance to the mining company step by step.

h) There is no clear policy for the coal deposit which contains other minerals. For example, some economic potentials of kaolin and clay minerals have been discovered in several coal mines. If there is no certain regulation for development of these materials, they will be regarded only as waste product from mining. This is considered as a kind of inefficient utilization of mineral resources of the country.

i) The onshore concession application in each issue will grant the area of 300 rais (48 ha). As the characteristics of coal deposits are layering and widening, the extent of 300 rai-area may not be enough for mine operating such as large dump site. Hence, the area of concession application should not be fixed.

j) Prospecting license can be separated to 2 main types, Special Prospecting License (SPL) and Exclusive Prospecting License (EPL). The exploration period in each type is different. The EPL's period is only one year after granting date and can be extended one time after expire, not longer than one year. It is proposed that the permission time is changed to the fixed three years and cannot be extended anymore, there are some advantages by adding a supplementary regulation. If the applicant does not apply the mining concession on the first year, he will have to return a half of the prospecting area and the second year will be a half of remains. The advantages are to stimulate the prospective investor to conduct the exploration and concession application. Nevertheless, the returned area may be proposed by the other investor.

k) In case the concessionaires can apply the mining rights in large area with not more than 25 years of permission, it should be better if the granted area is relinquished to the government in the proportion of area within a range of mining period instead of returning of all in the last year. This will accelerate the reclamation process and give chance to the others for developing this land.

2) Effective Development of Coal

In conclusion, it is inevitable that, the effective development of coal must require the DMR to;

i) Issuing a suitable Coal Mining Law for the country.

ii) Revise the existing Mining Law.

3 Results of the Study

3.1 Phrae Basin

3.1.1 Geography

The Phrae Basin is located approximately 480 km north of Bangkok. The basin is elliptic with NNW-SSW long axis of 60 km and WNW-ESE short axis of 15 km with a subbasin stretching 20 km toward north. The basin is surrounded by relatively gentle mountain ranges ranging from 500 m to 1,000 m in altitude. The landscape of the basin is mostly flat slope ranging from 200 m at the north to 150 m at the south in altitude. Gentle hilly areas occur in the northeastern area and periphery of the basin. A terrace occur in the western periphery of the sub basin. The Yom River, the main river system, flows in the western side of the basin meandering and gathering tributaries, which flow into the basin from east and west. The river system is utilized for irrigation with dams and canals throughout the basin.

Except the northeastern hilly area, the basin is intensively cultivated and irrigated for paddy field. A total area of paddy field is more than 50% of the agriculture area in the Phrae Province. The northeastern hilly area is mainly utilized for extensive farming of maize, sugar cane, tobacco and stock farming.

Climate of the basin is classified into tropical humid savanna according to Koppen system. Monthly and yearly mean temperature and rainfall for the past eleven years (1986-1996) at Lampang weather station, are shown as follows;

Temperature (°C) : mean 26.2
mean maximum 33.4
mean minimum 20.7

Rainfall (mm) : mean annual 1099.5
monthly 1.2 (January) - 221.9 (August)

3.1.2 Exploration and geological investigation

(1) Exploration

The following exploration was carried out in the Phrae Basin.

Table 3.1-1 Exploration in the Phrae Basin

	1994	1995	1996	1997	Total
Geological mapping		all outcrops			
Drilling (holes) total depth (m)		5 3,551	3 1,779	5 2,954	13 8,284
Geophysical logging (hole) total depth (m)		5 2,994	2 972	3 1,874.5	10 5,840.5
Seismic survey (lines) total length (km)	9* 156			6 30	15 186
Coal analysis (samples)			10		10

* Previously conducted by Petroleum Authority of Thailand (PTT).

1) Almost all the outcrops in the basin were observed. However outcrops occur sporadically only in the northern part and in the periphery.

2) The summary of boreholes conducted by DMR is shown in Table 3.1-1 and 3.1-2. In addition to the DMR boreholes, four short boreholes were drilled in the northern part of the basin by Electricity Generation Authority of Thailand (EGAT).

3) Geophysical logging could not be conducted to some parts of boreholes owing to collapsing of the hole.

4) Seismic survey in 1994 was conducted by Petroleum Authority of Thailand (PTT) along one N-S line and eight E-W lines. Seismic survey by DMR in 1997 was conducted along two N-S lines and four E-W lines

5) The core samples which were collected from the relatively thicker coal beds, were analyzed in Japan.

(2) Geological investigation

All geological data obtained from the above exploration have been investigated by following procedures;

1) Geological mapping

Location of outcrops and measured strikes and dips were plotted on base map of scale 1 : 50,000.

2) Decision f the borehole exploration sites.

The borehole exploration sites were decided through discussion with DMR. The suitable sites were decided to the southern part of the basin as the results of geological mapping and observation of EGAT's borehole cores and interpretation of the seismic profiles.

3) Interpretation of seismic profiles

The remarkable reflectors on each seismic profile were colored and traced so far as recognizable on the profiles, and their travel time were converted into the depth. Correlation between the seismic reflectors and the marker beds is shown in Plate 3.1-1. Structure contour map of C2 coal bed in the southwestern area was drafted by each seismic profile and borehole data.

4) Lithofacies logs

Most of the borehole cores were logged by the Study Team using lithofacies coding method, which was decided to be used for computer data base. The depth of each marker bed was adjusted to the geophysical logs, and the lithology of non-cored interval was presumed from the geophysical logs. Lithofacies logs on a scale of 1 : 500 were drafted at first for detailed investigation in order to correlate to the geophysical logs and the reflectors on the seismic profiles. The depth and thickness of the each coal beds were also adjusted to the geophysical logs. The main coal bed profiles (C2 and C3) were drafted as shown in Fig.3.1-2 and Fig 3.1-3.

5) Correlation and sedimentary facies

The borehole logs on a scale of 1 : 2,000 were drafted and correlated each other referring to the depths of the remarkable reflectors as shown in Plate 3.1-2. For the purpose of correlation, the main sedimentary facies, i.e., lacustrine facies and fan facies, were subdivided and denominated from LA to LD and from FA to FD respectively as shown in Fig.3.1- 4. The comprehensive stratigraphic column is shown in Fig.3.1- 5. Investigation of sedimentary environments has revealed that the coal deposits are understood to be accompanied to lacustrine facies.

Table 3.1-2 Summary of Boreholes in the Phrae Basin, 1995 and 1996

Hole No.	Coordinate	Schedule	Contractor	T.Depth	Geophysical	Coring	
		Started-Finishd	Machine	(m)	Logging(m)	Depth,(Length),m	Ratio(%)
	N: 2,005,597.480	19/10/1995	Siam Tone				
	E: 617,877.570	~	Tone				
PH 1/38	EL. 158.807	19/ 1/1996	(Cap.500m)	622.0	595.0	65~622(557)	89.5
	N: 2,004,881.938	17/11/1995	Siam Tone				
	E: 629,448.870	~	Tone				
PH 2/38	EL. 195.787	6/ 2/1996	(Cap.1000m)	691.0	691.0	19.5~691(671.5)	97.2
	N: 2,002,422.962	10/ 1/1996	Siam Tone				
	E: 625,181.369	~	Tone			240.0~345.0(105.0)	
PH 3/38	EL. 167.651	2/ 5/1996	(Cap.1000m)	738.0	738.0	490.0~643.0(153.0)	35.0
	N: 2,009,637.833	15/ 2/1996	Siam Tone			260.0~334.0(74.0)	
	E: 621,737.863	~	Tone			389.0~428.0(39.0)	
PH 4/38	EL. 152.203	28/ 4/1996	(Cap.500m)	650.0	430.0	512.0~520.0(8.0)	18.7
			EGAT			211.0~285.7(74.7)	
	N: 1,995,019.343	3/ 5/1996	Koken			420.0~447.8(27.8)	
	E: 614,995.535	~	GSR-100A			480.0~490.0(10.0)	
PH 5/38	EL. 149.503	20/ 6/1996	(Cap.2000m)	850.0	565.0	585.0~595.0(10.0)	14.4
Total				3,551.0	2,994.0	1,730.0	48.7
	N: 2,003,155.337	11/ 5/1996	DMR Long year				
	E: 622,088.217	~	A-4				
PH 1/39	EL. 155.700	17/ 7/1996	(Cap.800m)	575.0	---	130~575(445)	77.4
	N: 1,999,888.178	14/ 7/1996	DMR Long year				
	E: 614,794.251	~	A-4				
PH 2/39	EL. 148.563	13/ 8/1996	(Cap.800m)	554.0	322.0	95~554(459)	82.9
	N: 2,011,156.441	6/ 9/1996	DMR Long year				
	E: 622,207.320	~	A-4				
PH 3/39	EL. 157.157	25/10/1996	(Cap.800m)	650.0	650.0	5~650(615)	99.2
Total				1,779.0	972.0	1,549	87.0714

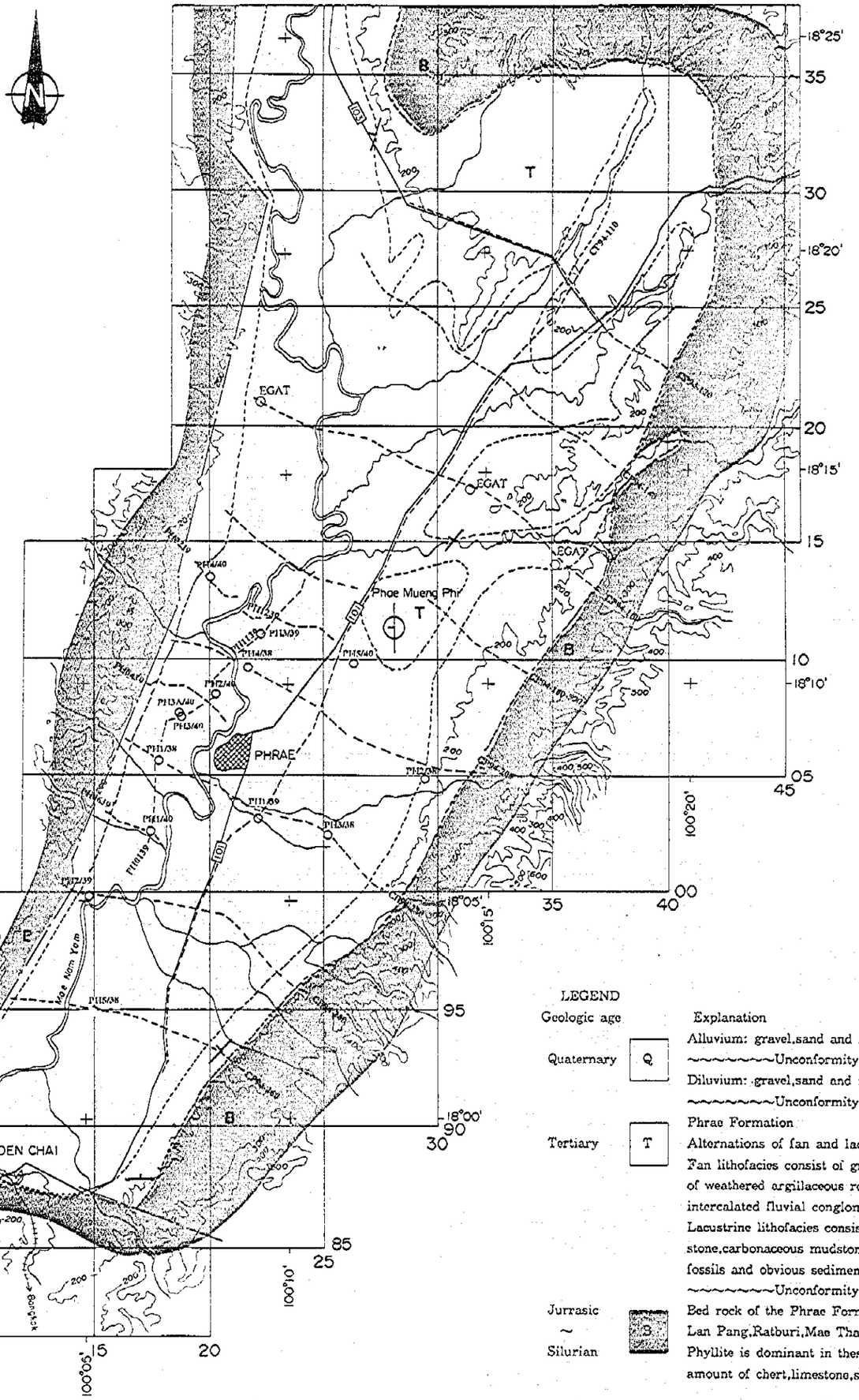
The depth and thickness of each coal bed were adjusted to the geophysical logs.

Table 3.1-3 Summary of Boreholes in the Phrae Basin, 1997

Hole No.	Coordinate	Schedule	Contractor	T.Depth	Geophysical	Coring	
		Started~Finishd	Machine	(m)	Logging(m)	Depth,(Length),m	Ratio(%)
	N: 2,002,590.450	30/11/1996	DMR Long year				
	E: 617,437.249	~	A-4				
PH 1/40	EL. 151.683	22/12/1996	(Cap.800m)	650.0	650.0	81~650(569)	87.5
	N: 2,008,430.324	5/12/1996	DMR Long year			102.0~112.0(10)	
	E: 620,279.654	~	A-4			138.0~181.0(43)	
PH 2/40	EL. 154.718	18/02/1997	(Cap.800m)	445.5	—	184.0~445.5(261.5)	70.6
	N: 2,007,544.031	9/01/1996	DMR Long year				
	E: 618,860.903	~	A-4				
PH 3/40	EL. 157.913	17/01/1997	(Cap.800m)	(103)	—		
	N: 2,007,655.436	24/01/1997	DMR Long year				
	E: 618,739.614	~	A-4			112.0~121.0(9)	
PH 3A/40	EL. 158.817	25/02/1997	(Cap.800m)	650.0	(627.0)	139.0~650.0(511.0)	80.0
	N: 2,013,569.496	23/02/1997	DMR Long year				
	E: 620,008.525	~	A-4				
PH 4/40	EL. 164.541	27/03/1997	(Cap.800m)	597.5	597.5	107.0~597.5(490.5)	82.1
	N: 2,009,871.687	7/03/1997	DMR Long year				
	E: 626,400.847	~	A-4			83.0~164.0(81)	
PH 5/40	EL. 169.646	10/04/1997	(Cap.800m)	611.0	—	173.0~611.0(438.0)	84.9
Total				2,954.0	1,874.5	2,413.0	81.7

The depth and thickness of each coal bed were adjusted to the geophysical logs.

The borehole locations were decided to the southern and western parts of the basin as a result of reconnaissance study of outcrop survey and interpretation of the existing geophysical profiles.



LEGEND

Geologic age		Explanation
Quaternary	Q	Alluvium: gravel,sand and mud. ~~~~~~~~Unconformity Diluvium: gravel,sand and mud.
		~~Unconformity
Tertiary	T	Phrae Formation Alternations of fan and lacustrine lithofacies. Fan lithofacies consist of gritty mudstone (Ftg) of weathered argillaceous rock and occasionally intercalated fluvial conglomerate. Lacustrine lithofacies consist of sandstone,mudstone,carbonaceous mudstone and lignite with fossils and obvious sedimentary structures.
		~~Unconformity
Jurrasic ~ Silurian	B	Bed rock of the Phrae Formation. Lan Pang,Ratburi,Mae Tha and Donchai Groups. Phyllite is dominant in these groups with minor amount of chert,limestone,sandstone and tuff.

—·— Fault
– – – Seismic line
o Borehole
Dip and strike

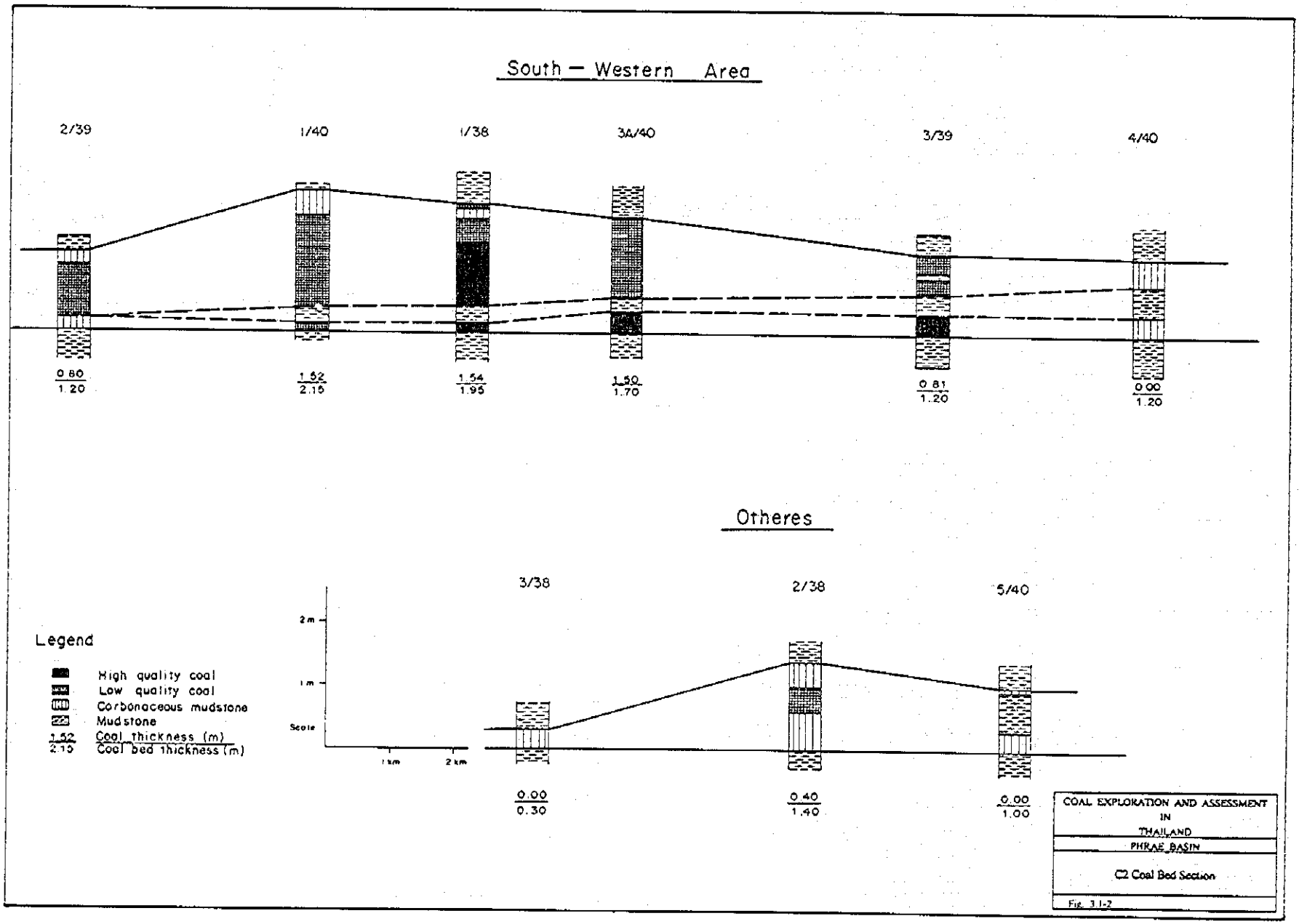
0 5km 10km
Scale

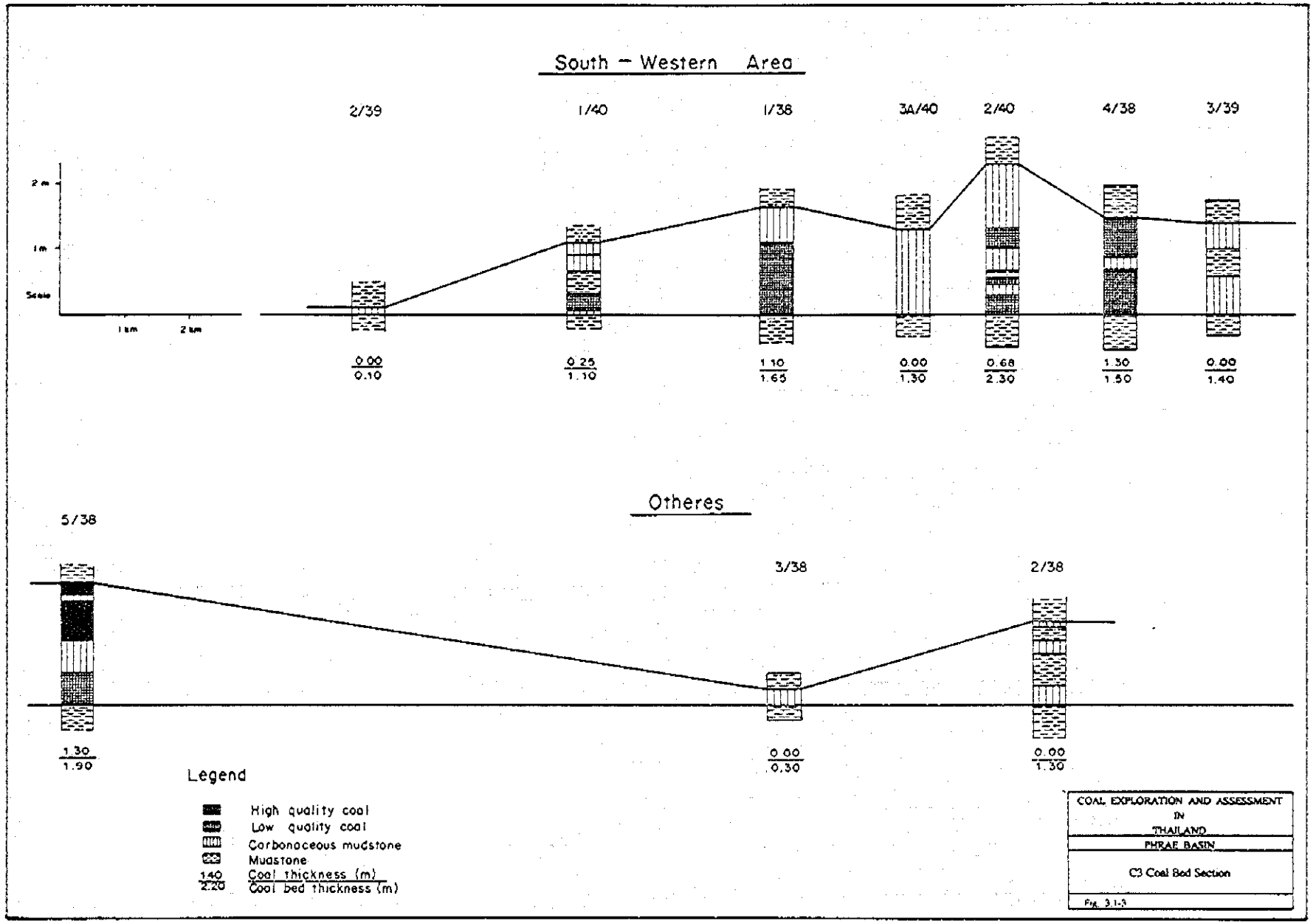
COAL EXPLORATION AND ASSESSMENT IN THAILAND

PHRAE BASIN

Geological Map

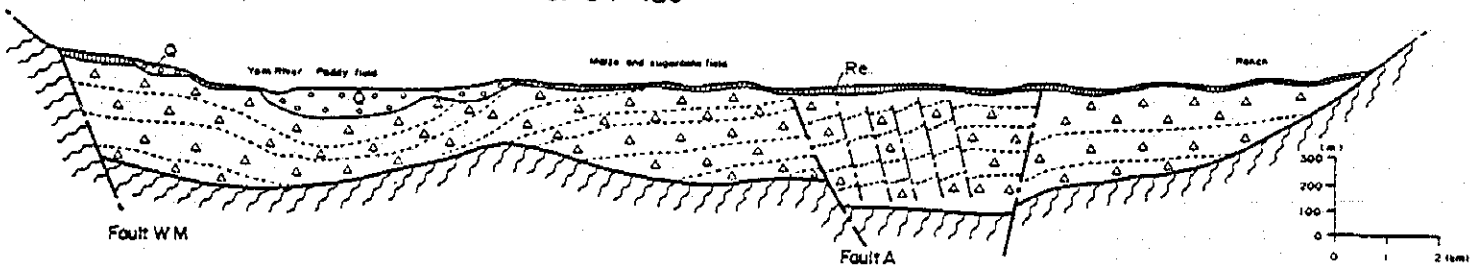
Fig. 3.1-1


South – Western Area
2/39
1/40
1/38
3A/40
3/39
4/40
0.80
1.20
1.52
2.15
1.54
1.95
1.50
1.70
0.81
1.20
0.00
1.20
Otheres
3/38
2/38
5/40
2m
1m
Scale
1km
2km
0.00
0.30
0.40
1.40
0.00
1.00
Legend
High quality coal
Low quality coal
Carbonaceous mudstone
Mudstone
1.52 Coal thickness (m)
2.15 Coal bed thickness (m)
COAL EXPLORATION AND ASSESSMENT IN THAILAND
PHRAE BASIN
C2 Coal Bed Section
Fig. 3.1-2

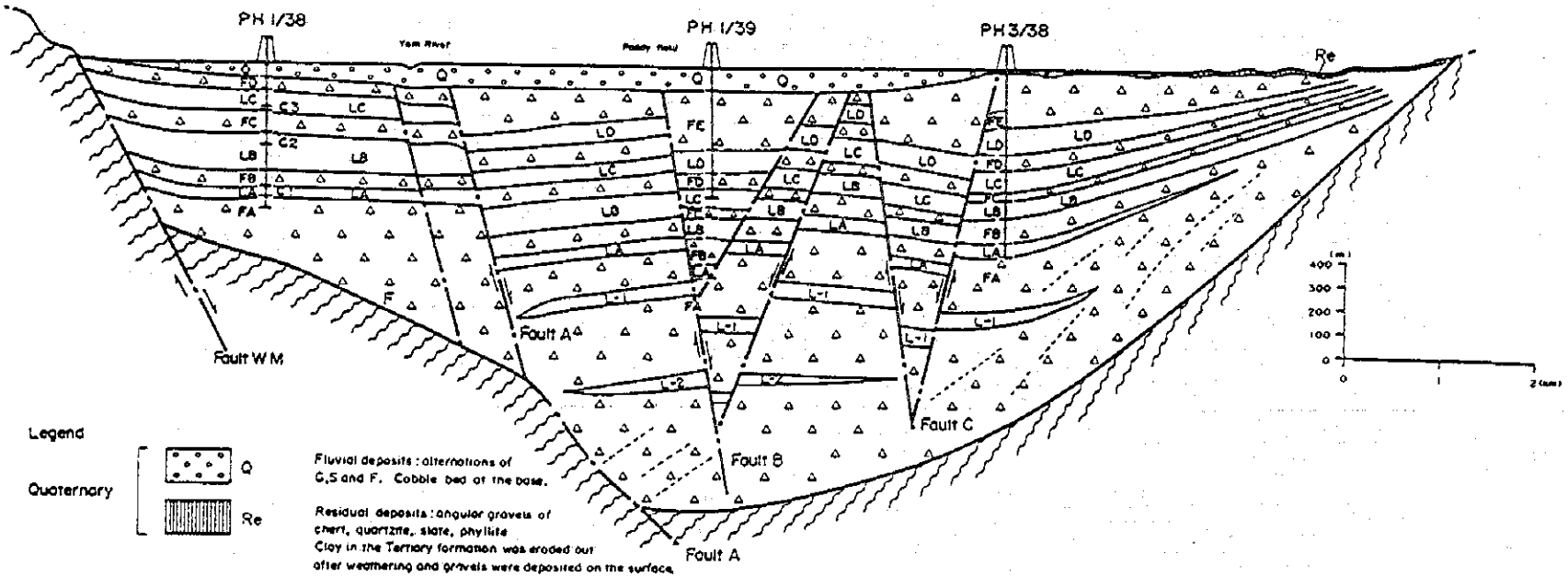

South – Western Area
2/39
1/40
1/38
3A/40
2/40
4/38
3/39
2 m
1 m
Scale
1 km
2 km
0.00 / 0.10
0.25 / 1.10
1.10 / 1.65
0.00 / 1.30
0.68 / 2.30
1.30 / 1.50
0.00 / 1.40
Otheres
5/38
3/38
2/38
1.30 / 1.90
0.00 / 0.30
0.00 / 1.30
Legend
High quality coal
Low quality coal
Carbonaceous mudstone
Mudstone
1.40 / 2.20 Coal thickness (m) / Coal bed thickness (m)
COAL EXPLORATION AND ASSESSMENT IN THAILAND
PHRAE BASIN
C3 Coal Bed Section
Fig. 3.1-3

GEOLOGY OF THE PHRAE BASIN (Conceptual profile)

W ~ E Profile , Northern area CP 94-120



W ~ E Profile , Southern area CP94-220



Legend

Quaternary

Q — Fluvial deposits : alternations of G,S and F. Cobble bed at the base.

Re — Residual deposits : angular gravels of chert, quartzite, slate, phyllite. Clay in the Tertiary formation was eroded out after weathering and gravels were deposited on the surface.

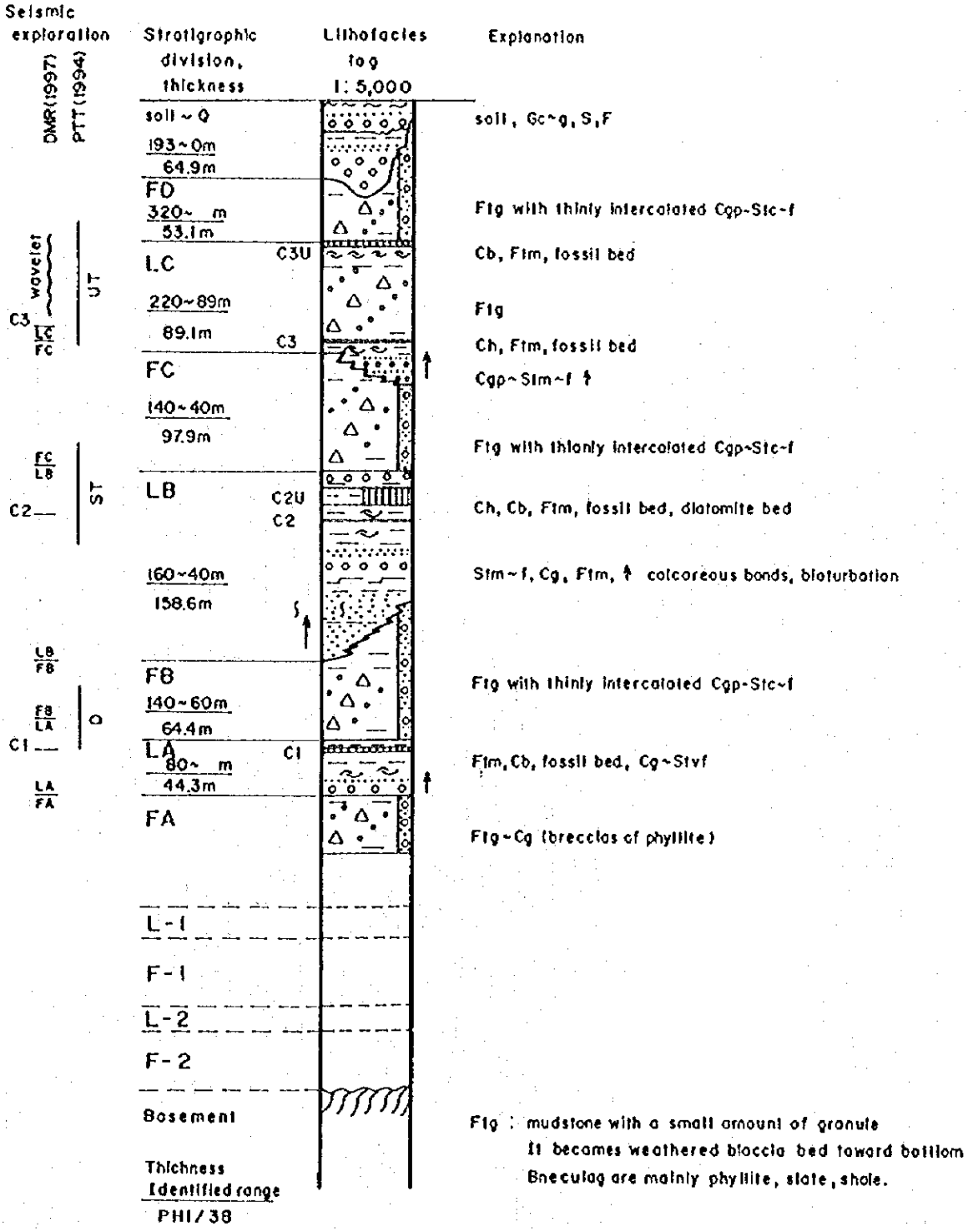
Tertiary (Phrae Formation)

LA ~ LD, L-1, L-2 — Lacustrine, fluvial, small delta deposits ; characterized by massive or laminated Fm, St, Cg, and various lacustrine deposits such as fossil bed, carbonaceous or calcareous beds. Thin fan deposits are included.

FA ~ FE — Fan deposits : Mainly consists of Fig (gritty mudstone) with thin bands of Cg in the upper horizon. This mudstone contains weathered or fresh phyllite breccia in the lower horizon. Therefore this mudstone is understood to be weathered conglomerate.

Triassic Carboniferous — Mainly consists of phyllite and slate. A lesser amount of chert, quartzite and limestone are included.

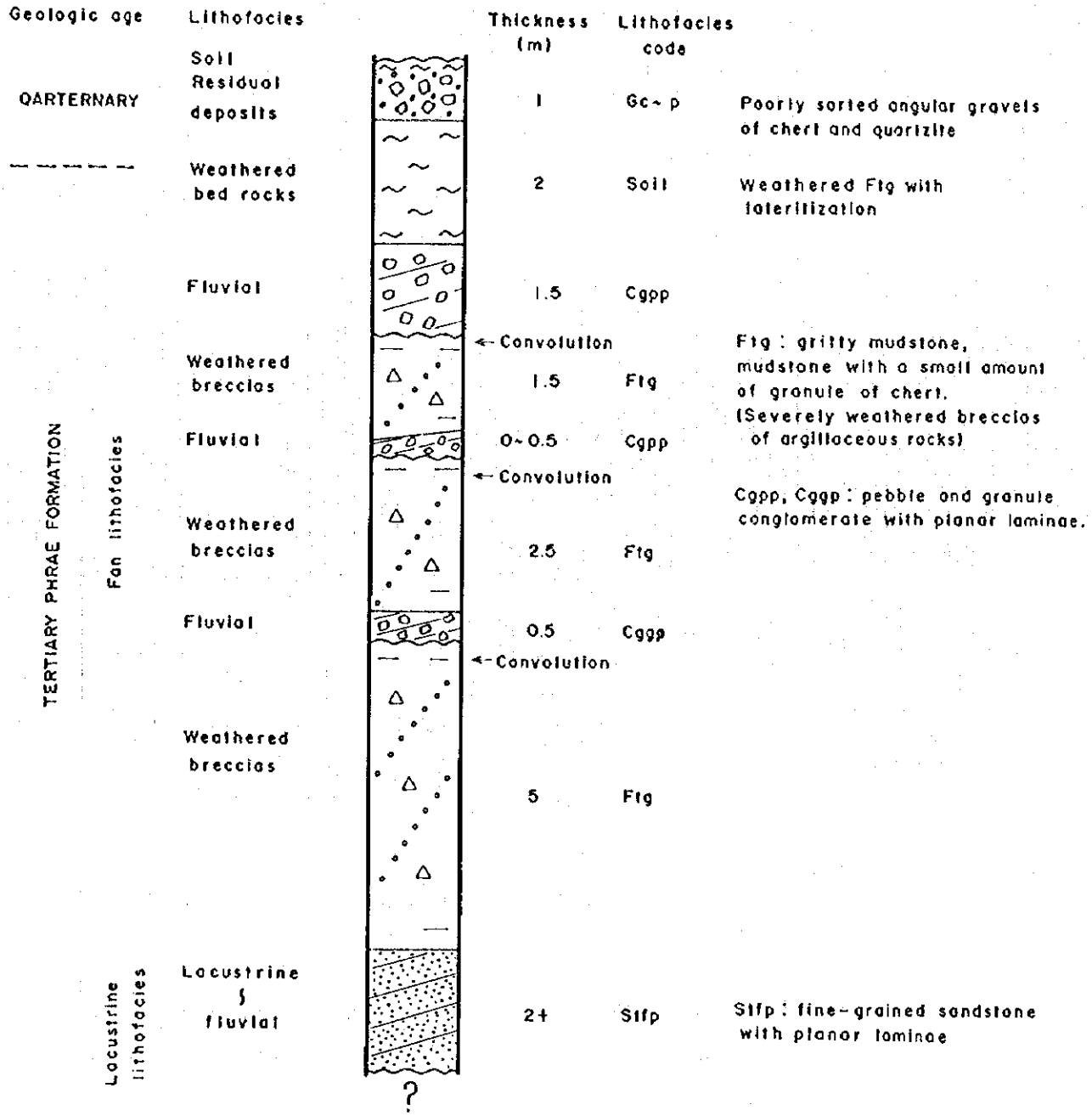
COAL EXPLORATION AND ASSESSMENT IN THAILAND
PHRAE BASIN
Conceptual Profile



Phrae Basin, Stratigraphy

Type : PHI/38

COAL EXPLORATION AND ASSESSMENT IN THAILAND
PHRAE BASIN
Stratigraphic Column
Fig. 3.1-5



Scale 1:100

Lithofacies log of the outcrop in Phae Muang Phi (National park)

COAL EXPLORATION AND ASSESSMENT IN THAILAND
PHRAE BASIN
Lithofacies Log of the Outcrop in Phae Muang Phi(National park)
Fig 3.1-6