2.2 Development Plans in the Southern Regions of Thailand

2.2.1 An Outline of Southern Seaboard Development Program

Overcoming regional differences has always been a primary objective in the Thai Economic Society Development Plan. Although progress until now has been very slow, it is worth nothing that several bottlenecks in the metropolitan area of Bangkok have been identified and that a noticeable movement is occurring toward local regions for the establishment of production bases. This latest trend suggests that the move to develop local regions as industrial nuclei is emerging.

In the southern regions, the "Southern Seaboard Development Concepts" is under way. This plan is designed to shorten the transportation route of crude oil from the Middle East and to construct a petrochemical complex by building ports on the eastern and western sides of the Central Malay Peninsula, connecting these sides with crude oil pipelines. A master plan under the auspices of the World Bank is intended.

A drawback to the southern region is that it is far from domestic markets (Bangkok area); also, educational, medical, and recreational facilities there are insufficiently provided. But, several conveniences available in this region should also be noted, including rich agricultural resources (rubber plantations, marine products), air transportation via the Hatyai Airport, and Songkhla Harbor where large vessels (10,000-ton class) can dock.

Because of the favorable conditions in this region, it will be unnecessary to look only to the metropolitan areas for development. The development of labor-intensive export processing industries in this region by direct transactions with overseas customers is deemed possible.

2.2.2 Southern Seaboard Development Concepts in Retrospect, Objectives and Main Points

(1) Southern Seaboard Development Concept in Retrospect

The Southern Seaboard Development Concept is the second local development plan currently under way. The other is the East Coastal Region Development Plan.

The east region plan is intended to promote petrochemical- or export-oriented industries with the help of natural gas produced in the gulf of Thailand and to facilitate decentralization movements from the metropolitan areas to local regions. The Southern Coastal Region Development Plan is designed to explore an ocean transportation route linking the Middle East and the Far East and, with this in minds to promote local industries and comprehensive local developments.

The Thai government has set up the Southern Seaboard Development Committee, which functions as a decision-making body for this project.

In the same way as the Eastern Coastal Region Development Plan, the committee has established an office for planning and adjusting processes.

For the southern region, several groups once studied the possibility of building canals passing through the Kura Isthmus or of laying pipelines that would replace the existing ordinary canals.

(2) Objectives

The Southern Seaboard Development Program has the following three objectives:

1. To shorten the sea transportation route

   The sea transportation route should be shortened by constructing a land bridge comprised of a highway, a railroad, and a pipeline that connects Krabi on the Andaman Sea and Khanom on the gulf of

Thailand. With this bridge, the current route crossing the Strait of Malacca will be shortened by 835 km, the Sunda route by 1,630 km, and the Ronboku Channel route by 2,780 km.

2. To decentralize the economy to local regions

In the terminal regions along the land bridges, industries should be invited or incentives provided to form new industries, and employment opportunities should be created. All such measures should combine to facilitate decentralization of the economy and distribution of the results of economic development.

3. To maintain stable growth

Stable growth should be maintained and a harmonious relationship maintained with sightseeing, fishery, environment, ecology, and similar issues.

(3) Outline

The outline of the plan consists of construction of a land bridge, construction of crude oil and petroleum products facilities, sea transportation, industrialization, export/import promotion, and urban development.

1. Land bridge construction

- A point-to-point highway of about 180 km linking Krabi on the Strait or Andaman with Khanom on the gulf of Thailand (connecting Krabi and Khanom in two hours)

- Railway (double track, equipped with modern facilities suited for container transfer transportation)

- Pipeline (for transporting crude oil, natural gas, petrochemical products, and fresh water)

- Distribution center for crude oil and petroleum products

2. Construction of crude oil and petroleum-related product facilities

The crude oil transportation route linking the Middle East and the Near East with the Far East should be changed from the current sea route to the new route by using the land bridge. Along with the construction of oil refineries, petroleum product distribution centers, and oil stockpiling bases, it is necessary to promote the growth of gas-related industries and petrochemical industries that use the natural gas produced in the gulf of Thailand.

3. Sea transportation

Besides the introduction of modern cargo-handling and cargo-transfer techniques, the container transportation system should be streamlined by making use of the land bridge, thereby ensuring competitiveness of sea transportation versus the existing sea routes.

4. Industrialization

With the construction of the international transportation route and both Krabi and Khanom terminals, materials and parts can be transported. With these new facilities, such agro-industries as rubber, palm oil, fruits, and marine products should be promoted.

5. Import/export promotion

Both the Krabi and Khanom regions should be organized into centers of international commerce, finance, and business by making use of container transfer systems, crude oil transportation facilities, and overall industrialization.

6. Urban development

Through industrialization of Krabi and Khanom regions, measures should be taken to promote decentralization to local regions from Bangkok, creation of new employment opportunities, and distribution of the results of economic development.

Furthermore, stable growth must be maintained and orderly plans promoted for land utilization and urban development while a harmonious relationship with sightseeing, fishery, and ecology is maintained.

<Krabi Terminal>

The following facilities are planned for construction in the Krabi Terminal.

1. Offshore crude oil terminal: This terminal should be of a scale that allows vessels of up to 250,000 tons to dock. Storage tanks and pump stations should be constructed onshore.

2. Deep sea harbor: A harbor with depth of 14 m should be constructed to allow entry of container ships.

3. Industrial park: Industries related to oil refining, petroleum, and agriculture should be encouraged to operate in the industrial park.

4. Urban development: Urban development should actively be promoted through measures that include land replanning, incidental facilities construction, and infrastructure improvement.

5. Transportation network: A transportation system should be constructed to connect Phuket Airport with neighboring areas.

6. Communications network: A communications system should be laid out to link coasts with vessels and Krabi harbor with Khanom harbor. International radio communication and marine radio communication networks should be replanned and upgraded.

<Khanom Terminal>

The following facilities are planned for construction at the Khanom Terminal:

1. Offshore crude oil terminal

2. Offshore natural gas pipeline: A 170 km pipeline will link the Erawan gas well along the gulf of Thailand with Khanom.

3. Deep-water harbor: A harbor to allow entry of full-sized container ships is planned. It will be equipped with transfer and packing facilities.

4. Industrial park: Gas-separating plants, the petrochemical industry, gas-related industries, petroleum-related industries, storage tanks, and agro-industries should be encouraged to operate in this park.

5. Urban development: Urban development should be actively promoted through measures that include land replanning, incidental facilities construction, and infrastructure improvement.

6. Transportation network: A transportation system should be constructed to link the Srat Thani Airport with neighboring areas.

7. Network Communications: The communications system should be laid out to link coasts with vessels and Krabi harbor with Khanom harbor. International radio communication and marine radio communication networks should be replanned and upgraded.

During these developments, stable growth must be achieved and the environment preserved.

These points must be given special consideration:

1. Preservation and protection of oceanic life

2. Preservation and protection of the diversion between seawater and fresh water, erosion, forests, mangrove woods, and wild life.

3. Quality control of water in relation to water supply, draining, solid wastes, agricultural wastes, and harbor operations

4. Control of the atmosphere and noise

5. Risk management in relation to such things as oil outflow, safety evacuation (or shelter)

2.3 Energy Policy

2.3.1 Outline of Energy Demand and Supply

(1) Energy Demand

The growth of the current energy demand in Thailand increased at an annual average rate of 4.5% in the early years of the 1980s. In 1988, an increase of 8.9% was accomplished over the preceding year.

The gross supply of the first energy demand in Thailand was 32.7 million tons in terms of crude oil in 1988, and the current demand totaled 22.9 million tons (the difference was the loss arising from energy conversion and other factors). The breakdown of the final energy demand by each consumption category was 38.9% for transportation, 29.0% for commercial and household use, 26.7% for manufacturing industries, 3.6% for agriculture, and smaller demands.

(2) Energy Supply

The energy supply structure in Thailand has undergone a big change in recent years. In 1980, more than 50% of it was from imports. Because tremendous development was made in home-produced energies, such as natural gas and lignite, the dependency on imports was reduced to about 40% in 1988.

Although the output of lignite was only 1.5 million tons in 1980, it has increased by about five times, to 7.3 million tons, over the past eight years. With the rapid increase of lignite production and its utilization, a leading role was played by the Electricity Generation Authority of Thailand (EGAT). A total of 5.9 million tons of the total 7.3 available have been consumed by the thermal power stations owned by the EGAT.

The status of the energy supply in 1988 classified in each energy resource was 41.2% by oil, 26.2% by fuel wood and charcoal, 15.9% by natural gas, 6.9% by coal and lignite, 3.9% by bagasse, 3.2% by rice plant straws, and 2.5% by water-power generation.

2.3.2 Basic Guidelines of Energy Policies

The following five policies for the sixth 5-year plan started from 1986 have been presented as the basic guidelines of Thailand's energy strategy:

(1) Along with efforts to reduce its dependency on imported energies, the survey and development of home-available energies should be made to diversify available energy resources and energy supply systems.

(2) To promote effective use of energies, especially those of petroleum products and electric power, their prices should be adjusted to reflect their true costs. With such industrial-use fuels as natural gas, lignite, imported coal, fuel oil, and others, the tax rates for their prices should be kept neutral, no incentives should be given to induce the use of one specific category of energies.

(3) The efforts in energy saving should be encouraged in each category of transportation, manufacturing industries, and commercial buildings for higher efficiency in the use of energy. The efficiency in the use of charcoal and fuel wood should also be increased.

(4) In recognition of the leading role to be taken by private sectors for reducing the government's financial burden in its energy investment, a guideline should be established about each role the government or private sector is responsible for and also about the roles of energy investment by private sectors.

(5) Encouragement should be given to efforts in developing proper energies that are to be used locally.

2.3.3 Energy Administration

The sole responsibility for energy administration resides with the NEPC (National Energy Policy Committee). All important policies relevant to energies are discussed and decided by this Committee. Under this Committee, the NEA (National Energy Administration) and the NESDB (National Economic and Social Development Board) are authorized to administrative rights of planning, developing, and adjusting all aspects of national energies.

The NEA is also responsible for promoting energy conservation and developing new energies. The DMR (Department of Mineral Resources) takes responsibilities for surveying petroleum resources, approving development rights, and approving petroleum refinery companies. Besides, it owns the right to test-dig for lignite intended for use other than power generation. It is also in charge of supervising the Petroleum Authority of Thailand (PAT). Commerce has the right to determine the prices of petroleum products and also the level of petroleum reserves. The Ministry of Finance has the right to control the oil fund, import duties, and others.

Besides the organizations mentioned above are the MEA and PEA, under the supervision of the Ministry of Internal Affairs and the EGAT, under the supervision of the Minister's office.

2.3.4 Production and Consumption of Lignite

(1) Production of Lignite

In Thailand, about 10 lignite mines are in Memo and Lee in the northern Ranpan-Prefecture and in the southern Krabi and elsewhere, a major production site of coal centers around northern regions (especially Memo) of Thailand. The confirmed deposits of lignite total 900 million tons (800 million tons in Memo) in all of Thailand. The deposits that can be mined are estimated at around 1.65 billion tons (1.3 billion tons in Memo).

The output of lignite is increasing each year. It totaled 1.5 million tons in 1980, but jumped to 8.9 million tons in 1989, of which about 6.51 million were produced in Memo.

(2) Consumption of Lignite

Some 75% of the lignite output is presently consumed for power generation and the rest for general manufacturing industries. A power station of the largest scale is the Memo Thermal Power Station. Although the lignite produced in Memo has a low-grade heat quantity of 2,500 kcal/kg, EGAT established a mine mouse thermal power station in Memo with the purpose of saving transportation costs. The total amount of lignite produced in Memo is fully utilized for power generation. The Memo Thermal Power Station now has a generation facility capable of producing 1,425 MW of electricity.

According to the step-by-step expansion plan, the generation capacity will be increased to 2,025 MW by July 1992. EGAT also produces lignite for power generation in Krabi. The capacity of the Krabi power station is 34 MW, and the output of the station was 190,000 tons in 1989. According to the sixth 5-year plan, the 1991 consumption target of lignite intended for use in power generation is set at 9 million tons (equivalent to the generation facility of 1,485 MW) in 1985, it was 5 million tons (equivalent to the generation facility of 735 MW).

The lignite produced in the mines of Lee and other areas is for general industrial use, such as cement factories and tobacco factories. The consumption target of industrial-use lignite is set at 1 million tons for 1991; in 1985 it was 0.5 million.

2.3.5 Electric Power

(1) Power Generation

The gross power generation capacity of EGAT was 6,915 MW in 1989. The breakdown of the total amount; 32.4% by hydroelectric power and 67.6%

by thermal power. Thermal power produces a much larger volume of electricity than hydroelectric power does. In terms of fuels used for power generation, natural gas accounts for 57.7% of the total power generation, lignite for 20.9%, hydroelectricity for 11.6%, and petroleum for 9.8%. Because almost 80% of the total power generation was produced by using petroleum in 1980, we find that petroleum consumption dropped drastically, but the consumption of natural gas and lignite increased remarkably. The gross power generation in 1988 was 32.5 billion kWh. This amount plus 400 million kWh purchased from Laos comprises the total power supply in Thailand, namely, 32.9 billion kWh.

Major hydroelectric power stations include Shinakalin (western Thailand, 540 MW), Pumipon (northern Thailand, 595 MW), Silikit (northern Thailand, 375 MW), Kaolem (western Thailand, 300 MW), and Rajapuraba (southern Thailand, 240 MW).

The thermal power stations using natural gas include Banbakon (eastern Thailand, 1,820 MW) and southern Bangkok (Bangkok, 1,300 MW). The only thermal power station using petroleum is Northern Bangkok (Bangkok, 237.5 MW). The only thermal power station using lignite is at Memo (northern Thailand, 825 MW). The total output of these eight stations reaches as much as 89% of the power generation capacity of Thailand.

The emphasis is placed on power stations using natural gas and lignite in the power source development strategy.

2.4 Environmental Regulation

2.4.1 Outline of Environmental Regulation

Thai thermal power plants must satisfy the environmental protection rules specifying the control of air quality, water quality and solid waste, etc.

(1) Air Quality

The table below shows the environment protection criteria in Thailand. The criteria are expressed in the unit of mg/m^3. The values in ppm are shown for reference.

National Ambient Air Quality Standards

Pollutants	1 hr average value mg/m^3 (ppm)	8 hr average value mg/m^3 (ppm)	24 hr average value mg/m^3 (ppm)	1 yr average value mg/m^3 (ppm)
Carbon Monoxide (CO)	50 (40)	20 (16)	-	-
Nitrogen Dioxide (NO_2)	0.32 (0.16)	-	-	-
Sulfur Dioxide (SO_2)	-	-	0.30 (0.10)	0.10* (0.04)
Suspended Particulate Matter (SPM)	-	-	0.33	0.10*
Photochemical Oxidant (O_3)	0.20 (0.09)	-	-	-
Lead (Pb)	-	-	0.01	-

Note: * = Geometric mean value

For reference, the Japanese environment protection criteria are shown in the table below. As can be seen in the table, the rule is relaxed to allow larger emission of NO_2 and SO_2.

Japanese Ambient Air Quality Standards

Pollutants	Standards
Carbon monooxide (CO)	The daily average of 1-hour value shall not be greater than 10 ppm, and the 8-hour average of 1-hour value shall not be greater than 20 ppm.
Nitrogen dioxide (NO_2)	The daily average of 1-hour value shall be within or less than a range between 0.04 ppm and 0.06 ppm. Sulfur dioxide/ The daily average of 1-hour value shall be within or less than a range between 0.04 ppm and 0.06 ppm.
Sulfur dioxide (SO_2)	The daily average of 1-hour value shall not be greater than 0.04 ppm and the 1-hour value shall not be greater than 0.1 ppm.
Suspended particalate matter (SPM)	The daily average of 1-hour value shall not be greater than 0.10 mg/m^3, and the 1-hour value shall not be greater than 0.20 mg/m^3.
Photochemical oxidant (Os)	The 1-hour value shall not be greater than 0.06 ppm.

(2) Water Quality

The table below shows the discharge control in Thailand.

Items	Units	Standard value	Remarks
BOD (5 day, at 20°C)	mg/l	20-60	Fishery canning Max. 100 Starch Ind. Centrifugal Max. 60 Sedimentation Max. 100 Noodle Ind. Max. 100 Tanning Ind. Max. 100 Pulp Ind. Max. 100 Frozen Food Ind. Max. 100
Suspended Solids	mg/l	Depend on dilution ratios of wastewater and receiving water	Ratio 1/8 to 1/150 Max. 30 1/151 to 1/300 Max. 60 1/301 to 1/500 Max. 150
Dissolved Solids	mg/l	Max. 2,000 or under office's consideration but not more than 5,000	Not higher than receiving water dissolved solids 5,000 mg/l if salinity of receiving water is higher than 2,000 mg/l
pH	-	5-9	
Permaganate value	mg/l	Max. 60	
Sulfide as H S	"	Max. 1.0	
Cyanide as HCN	"	Max. 0.2	
Tar	"	none	
Oil & Grease	"	Max. 5.0	Refinery & Lubricant Oil Industry Max. 15.0
Formaldehyde	"	Max. 1.0	
Phenol & Cresols	"	Max. 1.0	
Free Chlorine	"	Max. 1.0	
Insecticides	"	none	
Radioactivity	Becqurel/l	none	
Heavy metals			
Zinc (Zn)	mg/l	Max. 5.0	Zinc Industry Max. 3.0
Chromium (Cr)	"	Max. 0.5	Zinc Industry Max. 0.2
Arsenic (As)	"	Max. 0.25	
Copper (Cu)	"	Max. 1.0	
Mercury (Hg)	"	Max. 0.005	Zinc Industry Max. 0.002
Cadmium (Cd)	"	Max. 0.03	Zinc Industry Max. 0.1
Barium (Ba)	"	Max. 1.0	
Selenium (Se)	"	Max. 0.02	
Lead (Pb)	"	Max. 0.2	
Nikel (Ni)	"	Max. 0.2	Zinc Industry Max. 0.2
Manganese (Mn)	"	Max. 5.0	
Silver (Ag)	"	-	Zinc Industry Max. 0.02

Temperature: deg. C less than 40
Color and Odor: Not objectionable when mixed in receiving water

(3) Solid Waste

The solid waste to be controlled in Thailand includes paper.cloth, garbage, daily necessaries, ash, carcass, etc. collected from streets and markets, etc. The rule specifies the responsibility of the local governments on the disposal of the above mentioned waste material. That is to say that the rule does not include the control of industrial waste. As for industrial waste, it is interpreted that industrial companies have obligation to dispose such industrial waste at their own risk.

(4) Others

Thai rules provide that such odor, noise and vibration as impairing the health of people should not be generated (no quantitative control is executed).

2.4.2 Trend of Environmental Regulation

New facilities and refurbishment of existing facilities for inercase in capacity will be covered by a new emission control rule "Proposed Industrial Emission Standards by Environmental Division, Ministry of Industry". The proposed plant must satisfy the table below.

No.	Substances	Sources	Proposed Standard Values
1	Particulate	- Boiler & furnance Heavy oil as fuel Coal as fuel - Steel manufacturing - Cement plant and calcium carbide plant - Rock and gravel aggregate plants (production capacity more than 50,000 tons per year) - Other source	 0.3 g/Nm^3 0.5 g/Nm^3 400 mg/Nm^3 400 mg/Nm^3 400 mg/Nm^3 500 mg/Nm^3
2	Smoke capacity	Boiler and Furnace	not exceed 40% Ringlemann scale
3	Aluminium	Furnace or smelter	(dust)300 mg/Nm^3 (Al) 50 mg/Nm^3
4	Alcohol	any source	0.05 lb/min
5	Aldehyde	any source	0.05 lb/min
6	Ammonia	gas plant	25 ppm
7	Antimony	any source	25 mg/Nm^3
8	Aromatics	any source	0.05 lb/min
9	Asbestos	any source	27 µg/Nm^3
10	Arsenic	any source	20 mg/Nm^3
11	Beryllium	any source	10 µg/Nm^3
12	Carbonyls	Burning refuse	25 ppm
13	Chlorine	any source	20 mg/Nm^3
14	Ethylene	from production or by usage	0.03 lb/min
15	Ester	any source	0.05 lb/min
16	Fluorine	any source	0.3 lb/ton P_2O_5
17	Hydrogen Chloride	any source	200 mg/Nm^3
18	Hydrogen Fluoride	any source	10 mg/Nm^3
19	Hydrogen Sulphide	any source	100 ppm
20	Cadmium	any source	1.0 mg/Nm^3
21	Copper	any source	dust 300 mg/Nm^3 (Cu) 20 mg/Nm^3
22	Lead	any source	dust 100 mg/Nm^3 (Pb) 30 mg/Nm^3
23	Mercury	any source	0.1 mg/Nm^3
24	CO	any source	1,000 mg/Nm^3
25	SO_2	H_2SO_4 production Other activities: - Bangkok and its vicinities - other area	500 ppm 400 ppm 700 ppm

No.	Substances	Sources	Proposed Standard Values
26	NO_x	Combustion source HNO_3 production and others	1,000 mg/Nm^3 2,000 mg/Nm^3
27	Nitric acid	any source	70 mg/Nm^3
28	Organic Material	any source	0.01 ld/min
29	Phosphoric acid	any source	3 mg/Nm^3
30	Sulfur trioxide	any source also in combination with H_2SO_4	35 mg/Nm^3 as H_2SO_4
31	Sulfuric acid	any source	35 mg/Nm^3

The proposed plant must pay attention to the terms in the table below.

Substances	Sources	Standard
Particulate	- Boiler coal as fuel	500 mg/m^3N
CO	any source	1,000 mg/m^3N (800 ppm)
SO_2	Other activities: - other area	700 ppm
NOx	Combustion Source	1,000 mg/m^3N (740 ppm)

3. DEMAND FORECAST

CHAPTER 3 DEMAND FORECAST

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3. Demand Forecast

3.1 Demand Forecast in Whole Thailand

3.1.1 Thai Economic Situation

The Thai economy is pursuing stable growth as shown in Table 3-1 in comparison with ASEAN countries. Thailand's growth domestic product per capita already exceeded US$1,000- in 1988 and Thailand enjoys having entered the country group of medium-level income.

Table 3-1 Trend Data of GDP in ASEAN Countries

Country Name	GDP Growth Rate(Annual%)		GDP per Capita as of 1988 (US$)
	1965 - '80	1980 - '88	
Thailand	7.2	6.0	1,000
Malaysia	7.3	4.6	1,940
Indonesia	8.0	5.1	440
Philippines	5.9	0.1	630

Source: World Bank, World Development Report (1990)

The growth rates of GDP in recent years were especially high resulting as 13.2% in 1988, 12.0% in 1989 and 10.0% in 1990. The growth rates are forecasted as still high in future, and the GDP growth rate are estimated to average at 8.2 in the period of 1992 to 1996, 7.5% in the period of 1997 to 2001, and 6.3% in the period of 2002 to 2006 respectively.

One of the major factor of such high economic growth, is the increase of industrial products as seen from the configuration of exports representing the rapid growth rate. This trend will be kept in the future of Thailand. Therefore, the stable electricity supply becomes more and more indispensable to supporting such a high growth.

3.1.2 Power Demand In Thailand

In addition to the favorable economy and rapid industrialization, the electricity supply situation as mentioned above, has recently shown increases due to the large amount of investments including foreign enterprises. The historical trend of peak generation and the energy generation up to 1991 are shown in Table 3-2 provided by EGAT. The table shows the large high average rate growth of 11.22% on the peak and 11.14 % of the energy generation respectively.

Regarding transition of the annual load factor which gradually decreased up to 1989, however recently it began increasing. Generally, the load factor decreases along the behavior of economic development as the experience of foreign countries including Japan. Another view point as daily load variation, daily load curve on peak day are shown in Fig.3-1. It shows that the ratio of bottom to peak was decreased in recent years, which indicates a similar trend of the annual load factor.

3.1.3 Demand Forecast by the Organizations in Thailand

The demand forecast in Thailand is conduced by the Load Forecast Working Group (LFWG) composed of the National Economic & Social Development Board (NESDB), the National Energy Policy Office (NEPO), the National Energy Administration (NEA), the Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA), Electricity Generating Authority of Thailand (EGAT) the National Institute for Development Administration (NIDA) and the Thailand Development Research Institute (TDRI).

The Load Forecast Working Group made the load forecast as the latest one in September 1991. In addition, EGAT also prepared the demand forecast simultaneously as more realistic one for the sensitivity study on the power development planning. The load forecast are shown in Table 3-3 and Table 3-4.

Table 3-2 Total EGAT Generation Requirement Record

	Peak Generation			Energy Generation			
		Increase			Increase		Ld. Fctr
Fscal year	MW	MW	%	GWh	GWh	%	%
1980	2,417.40	162.40	7.20	14,753.73	789.18	5.65	69.67
1981	2,588.70	171.30	7.09	15,959.97	1,206.24	8.18	70.38
1982	2,838.00	249.30	9.63	16,881.95	921.98	5.78	67.91
1983	3,204.30	366.30	12.91	19,066.30	2,184.35	12.94	67.92
1984	3,547.30	343.00	10.70	21,066.44	2,000.14	10.49	67.79
1985	3,878.40	331.10	9.33	23,356.57	2,290.13	10.87	68.75
1986	4,180.90	302.50	7.80	24,779.53	1,422.96	6.09	67.66
1987	4,733.90	553.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.94	3,803.78	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4,460.15	13.94	66.77
1990	7,093.70	861.00	13.81	43,188.19	6,731.10	18.46	69.50
1991	8,045.00	951.30	13.41	49,225.03	6,036.84	13.98	69.85
Average Growth			11.22			11.14	

Fig. 3-1 EGAT Recorded Daily Load Curves on Peak Day
(Fiscal Years 1980-1992)

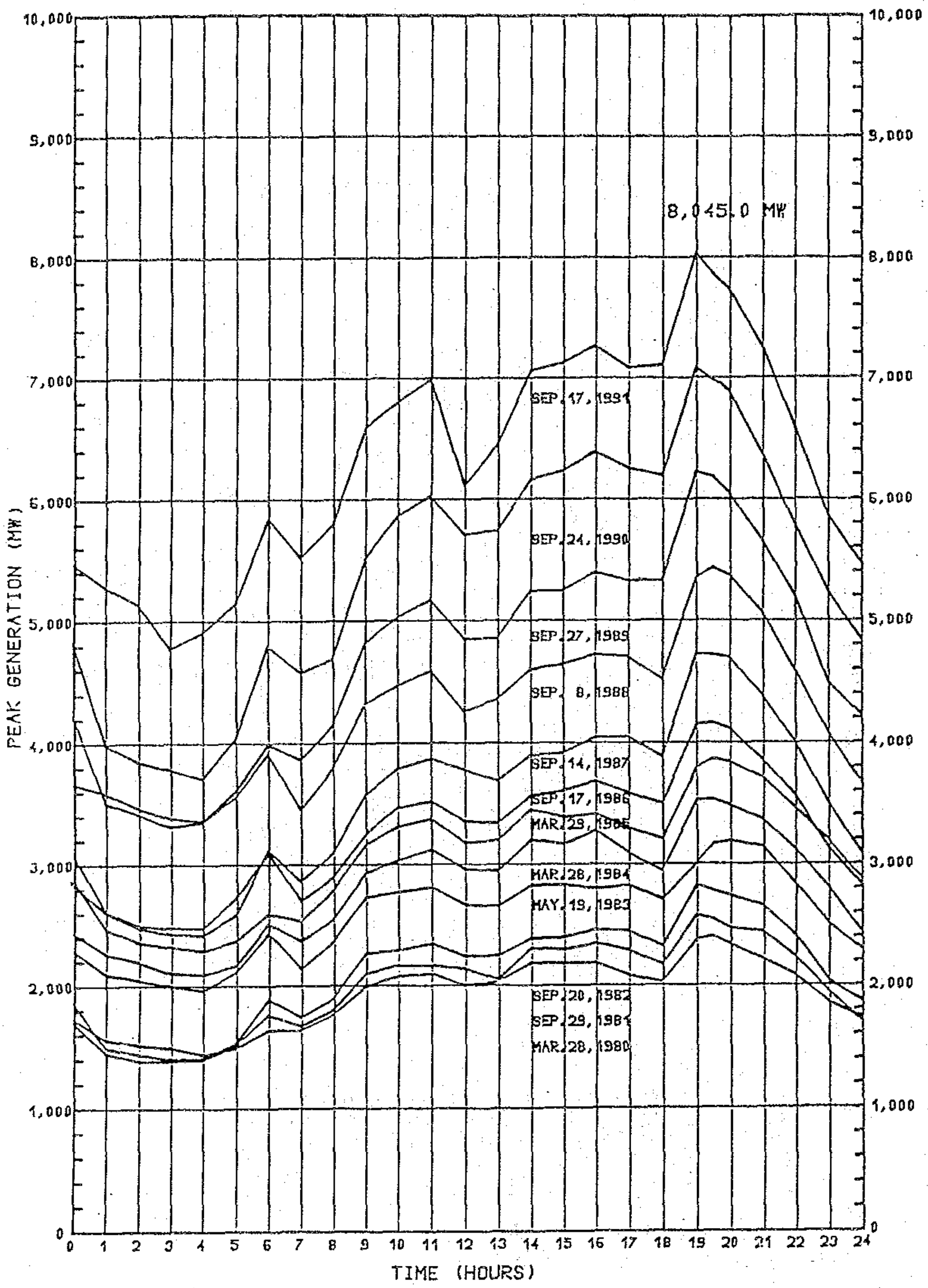


Table 3-3 **Total EGAT Generation Requirement (1991 LFWG Forecast)**

Fiscal Year	Peak Generation MW	Peak Increase MW	Peak Increase %	Energy Generation GWh	Energy Increase GWh	Energy Increase %	Load Factor %
			Actual				
1981	2,588.70	171.30	7.09	15,959.97	1,206.24	8.18	70.38
1982	2,838.00	249.30	9.63	16,881.95	921.98	5.78	67.91
1983	3,204.30	366.30	12.91	19,066.30	2,184.35	12.94	67.92
1984	3,547.30	343.00	10.70	21,066.44	2,000.14	10.49	67.79
1985	3,878.40	331.10	9.33	23,356.57	2,290.13	10.87	68.75
1986	4,180.90	302.50	7.80	24,779.53	1,422.96	6.09	67.66
1987	4,733.90	553.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.94	3,803.78	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4,460.15	13.94	66.77
1990	7,093.70	861.00	13.81	43,188.79	6,731.70	18.46	69.50
1991	8,045.00	951.30	13.41	49,225.03	6,036.24	13.98	69.85
Average Growth 1982-1991	-	545.63	12.01	-	3,326.51	11.92	-
			Forecast				
1992	9,000.00	955.00	11.87	55,475.00	6,249.97	12.70	70.36
1993	9,924 00	924.00	10.27	61,339.00	5,864.00	10.57	70.56
1994	10,892.00	968.00	9.75	67,561.00	6,222.00	10.14	70.81
1995	11,946.00	1,054.00	9.68	74,522.00	6,961.00	10.30	71.21
1996	13,075.00	1,129.00	9.45	81,741.00	7,219.00	9.69	71.37
1997	14,205.00	1,130.00	8.64	89,307.00	7,566.00	9.26	71.77
1998	15,354.00	1,149.00	8.09	96,591.00	7,284.00	8.16	71.81
1999	16,531.00	1,177.00	7.67	104,431.00	7,840.00	8.12	72.12
2000	17,765.00	1,234.00	7.46	112,653.00	8,222.00	7.87	72.39
2001	19,000.00	1,235.00	6.95	121,083.00	8,430.00	7.48	72.75
2002	20,219.00	1,219.00	6.42	129,455.00	8,372.00	6.91	73.09
2003	21,482.00	1,263.00	6.25	138,322 00	8,867.00	6.85	73.50
2004	22,795.00	1,313.00	6.11	147,509.00	9,187.00	6.64	73.87
2005	24,150.00	1,355.00	5.94	157,137.00	9,628.00	6.53	74.28
2006	25,515.00	1,365.00	5.65	166,999.00	9,862.00	6.28	74.72
Average Growth							
1982-1986	-	318.44	10.06	-	1,763.91	9.20	-
1987-1991	-	772.82	13.99	-	4,889.10	14.71	-
1992-1996	-	1,006.00	10.20	-	6,503.19	10.68	-
1997-2001	-	1,185.00	7.76	-	7,868.40	8.18	-
2002-2006	-	1,303.00	6.07	-	9,183.20	6.64	-

Reference : Working Group Load Forecast
September 1991

Table 3-4 **Total EGAT Generation Requirement**
(EGAT Forecast Low Case)

Fiscal Year	Peak Generation MW	Peak Generation Increase MW	Peak Generation Increase %	Energy Generation GWh	Energy Generation Increase GWh	Energy Generation Increase %	Load Factor %
			Actual				
1981	2,588.70	171.30	7.09	15,959.97	1,206.24	8.18	70.38
1982	2,838.00	249.30	9.63	16,881.95	921.98	5.78	67.91
1983	3,204.30	366.30	12.91	19,066.30	2,184.35	12.94	67.92
1984	3,547.30	343.00	10.70	21,066.44	2,000.14	10.49	67.79
1985	3,878.40	331.10	9.33	23,356.57	2,290.13	10.87	68.75
1986	4,180.90	302.50	7.80	24,779.53	1,422.96	6.09	67.66
1987	4,733.90	553.00	13.23	28,193.16	3,413.63	13.78	67.99
1988	5,444.00	710.10	15.00	31,996.94	3,803.78	13.49	67.09
1989	6,232.70	788.70	14.49	36,457.09	4,460.15	13.94	66.77
1990	7,093.70	861.00	13.81	43,188.79	6,731.70	18.46	69.50
1991	8,045.00	951.30	13.41	49,225.03	6,036.24	13.98	69.85
Average Growth 1982-1991	-	545.63	12.01	-	3,326.51	11.92	-
			Forecast				
1992	8,941.00	896.00	11.14	55,106.00	5,880.97	11.95	70.36
1993	9,803 00	862.00	9.64	60,595.00	5,489.00	9.96	70.56
1994	10,734.00	931.00	9.50	66,582.00	5,987.00	9.88	70.81
1995	11,729.00	995.00	9.27	73,054.00	6,472.00	9.72	71.10
1996	12,765.00	1,036.00	8.83	79,863.00	6,809.00	9.32	71.42
1997	13,802.00	1,037.00	8.12	86,747.00	6,884.00	8.62	71.75
1998	14,839.00	1,037.00	7.51	93,279.00	6,532.00	7.53	71.76
1999	15,884.00	1,045.00	7.04	100,042.00	6,763.00	7.25	71.90
2000	16,932.00	1,048.00	6.60	106,765.00	6,723.00	6.72	71.98
2001	17,962.00	1,030.00	6.08	113,288.00	6,523.00	6.11	72.00
2002	19,013.00	1,051.00	5.85	120,085.00	6,797.00	6.00	72.10
2003	20,081.00	1,068.00	5.62	126,954 00	6,869.00	5.72	72.17
2004	21,180.00	1,099.00	5.47	134,013.00	7,059.00	5.56	72.23
2005	22,279.00	1,099.00	5.19	141,183.00	7,170.00	5.35	72.34
2006	23,365.00	1,086.00	4.87	148,186.00	7,003.00	4.96	72.40
Average Growth							
1982-1986	-	318.44	10.06	-	1,763.91	9.20	-
1987-1991	-	772.82	13.99	-	4,889.10	14.71	-
1992-1996	-	945.80	9.67	-	6,127.59	10.16	-
1997-2001	-	1,000.60	7.07	-	6,685.00	7.24	-
2002-2006	-	972.40	5.40	-	6,979.60	5.52	-

Note : Prepared by Systems Planning Department in November 1991 for Sensitivity Study on PDP 92-01.

3.1.4 Demand Forecast by JICA Study Team

JICA Study Team has executed demand forecast independently based on the latest data prepared by Thai organizations. Results of the demand forecast are mentioned below.

(1) The Forecast on the Future Energy Consumption

The growth rate of Thailand's GDP and the growth rate of the energy consumption are strongly correlated to the relation of which are represented by the following expression:

$$Y = -5157.897214 + 52.962689023X + 0.0219479319X^2$$

where

Y = Energy consumption in GWh

X = Amount of GDP in Billion Bahts

The correlation coefficient between actual data of GDP and the energy consumption is shown below.

$$r^2 = 0.9965139651$$

JICA Study Team calculated the future energy consumption with using above mentioned relational expression. In this calculation JICA Study Team adopted conversion factors to GDP of 0.985 for 1992 and 0.775 for 2006 which decreases 0.015 by annual. JICA Study Team expected that future elasticities between GDP growth and energy growth, will be reduced with introduction of high efficiency equipment to be used and improvement of industrial strategies. Furthermore, these conversion factors coordinated to the EGAT estimation for the elasticities.

Finally, in order to evaluate EGAT's forecast, JICA Study Team estimated the energy generation requirement using the overall losses of 14% expected in the future. Table 3-5, Table 3-6, Fig.3-2, Fig. 3-3 and Fig. 3-4 show results of JICA Study Team's estimation.

Table 3-5 Forecast of Energy Consumption in Thailand

Fscl Year	Energy Consumption EStimated by EGAT		EStimated by JICA (1)		GDP in 1972		Cnvrsn Factor	Energy Consumption Per GDP	
	GWh	Growth Rate(%)	GWh	Growth Rate(%)	MBaht	Growth Rate(%)		Wh/Baht	Growth Rate(%)
1980	13,006.97	5.64	13,006.97	5.64	299,472	4.80	1.000	43.43	
1981	13,369.45	2.79	13,369.45	2.79	318,429	6.33	1.000	41.99	-3.33
1982	14,818.16	10.84	14,818.16	10.84	331,357	4.06	1.000	44.72	6.51
1983	16,052.69	8.33	16,052.69	8.33	355,380	7.25	1.000	45.17	1.01
1984	17,602.42	9.65	17,602.42	9.65	380,719	7.13	1.000	46.23	2.36
1985	19,659.62	11.69	19,659.62	11.69	394,082	3.51	1.000	49.89	7.90
1986	21,055.25	7.10	21,055.25	7.10	413,392	4.90	1.000	50.93	2.10
1987	24,235.33	15.10	24,235.33	15.10	452,664	9.50	1.000	53.54	5.12
1988	27,564.80	13.74	27,564.80	13.74	512,416	13.20	1.000	53.79	0.48
1989	31,514.31	14.33	31,514.31	14.33	574,355	12.09	1.000	54.87	2.00
1990	37,085.03	17.68	37,085.03	17.68	633,395	10.28	1.000	58.55	6.71
1991	42,559.03	14.76	42,559.03	14.76	693,558	9.50	1.000	61.36	4.81
1992	47,391.16	11.35	46,519.85	9.31	756,806	9.12	0.985	62.62	2.05
1993	52,111.70	9.96	51,156.84	9.97	823,547	8.82	0.970	63.28	1.05
1994	57,260.52	9.88	56,039.50	9.54	893,781	8.53	0.955	64.07	1.25
1995	62,826.44	9.72	60,802.75	8.50	963,380	7.79	0.940	65.21	1.79
1996	68,682.18	9.32	66,817.27	9.89	1,048,089	8.79	0.925	65.53	0.48
1997	74,602.42	8.62	72,468.37	8.46	1,129,518	7.77	0.910	66.05	0.79
1998	80,219.94	7.53	78,274.27	8.01	1,213,734	7.46	0.895	66.09	0.07
1999	86,036.12	7.25	84,482.92	7.93	1,303,604	7.40	0.880	66.00	-0.14
2000	91,817.90	6.72	91,145.73	7.89	1,399,768	7.38	0.865	65.60	-0.61
2001	97,427.68	6.11	98,314.32	7.86	1,502,868	7.37	0.850	64.83	-1.17
2002	103,273.10	6.00	104,903.11	6.70	1,601,374	6.55	0.835	64.49	-0.52
2003	109,180.44	5.72	111,874.80	6.65	1,705,899	6.53	0.820	64.00	-0.76
2004	115,251.18	5.56	118,786.65	6.18	1,811,911	6.21	0.805	63.61	-0.62
2005	121,417.38	5.35	125,818.96	5.92	1,921,565	6.05	0.790	63.19	-0.66
2006	127,439.96	4.96	133,057.20	5.75	2,036,000	5.96	0.775	62.59	-0.94

Table 3-6 Demand Forecast on Energy and Peak Load for Whole Thai

Fiscal Y.	Estimated by EGAT Energy (GWh)	Load F. (%)	Peak L. (MW)	Growth R. (%)	Estimated by JICA Energy (GWh)	Load F. (%)	Peak L. (MW)	Growth R. (%)
1980	14,753.73	69.67	2,417.40	7.20	14,753.73	69.67	2,417.40	7.20
1981	15,959.97	70.38	2,588.70	7.09	15,959.97	70.38	2,588.70	7.09
1982	16,881.95	67.91	2,838.00	9.63	16,881.95	67.91	2,838.00	9.63
1983	19,066.30	67.92	3,204.30	12.91	19,066.30	67.92	3,204.30	12.91
1984	21,066.44	67.79	3,547.30	10.70	21,066.44	67.79	3,547.30	10.70
1985	23,356.57	68.75	3,878.40	9.33	23,356.57	68.75	3,878.40	9.33
1986	24,779.53	67.66	4,180.90	7.80	24,779.53	67.66	4,180.90	7.80
1987	28,193.16	67.99	4,733.90	13.23	28,193.16	67.99	4,733.90	13.23
1988	31,996.94	67.09	5,444.00	15.00	31,996.94	67.09	5,444.00	15.00
1989	36,457.09	66.77	6,232.70	14.49	36,457.09	66.77	6,232.70	14.49
1990	43,188.19	69.50	7,093.70	13.81	43,188.19	69.50	7,093.70	13.81
1991	49,225.03	69.85	8,045.00	13.41	49,225.03	69.85	8,045.00	13.41
1992	55,106.00	70.36	8,941.00	11.14	54,092.84	70.36	8,941.00	11.14
1993	60,595.00	70.56	9,803.00	9.64	59,484.70	70.56	9,623.38	9.64
1994	66,582.00	70.81	10,734.00	9.50	65,162.21	70.81	10,505.11	9.50
1995	73,054.00	71.10	11,729.00	9.27	70,700.87	71.00	11,367.43	8.21
1996	79,863.00	71.42	12,765.00	8.83	77,694.50	71.00	12,491.88	9.89
1997	86,747.00	71.75	13,802.00	8.12	84,265.55	71.00	13,548.39	8.46
1998	93,279.00	71.76	14,839.00	7.51	91,016.59	71.00	14,633.83	8.01
1999	100,042.00	71.90	15,884.00	7.04	98,235.96	71.00	15,794.58	7.93
2000	106,765.00	71.98	16,932.00	6.60	105,983.40	71.00	17,040.23	7.89
2001	113,288.00	72.00	17,962.00	6.08	114,318.97	71.00	18,380.44	7.86
2002	120,085.00	72.10	19,013.00	5.85	121,980.36	71.00	19,612.25	6.70
2003	126,954.00	72.17	20,081.00	5.62	130,086.97	71.00	20,915.65	6.65
2004	134,013.00	72.23	21,180.00	5.47	138,124.01	71.00	22,207.86	6.18
2005	141,183.00	72.34	22,279.00	5.19	146,301.11	71.00	23,522.59	5.92
2006	148,186.00	72.40	23,365.00	4.87	154,717.67	71.00	24,875.82	5.75

Fig. 3-2 **Energy Consumption for Whole Thai (Estimated by EGAT & JICA)**

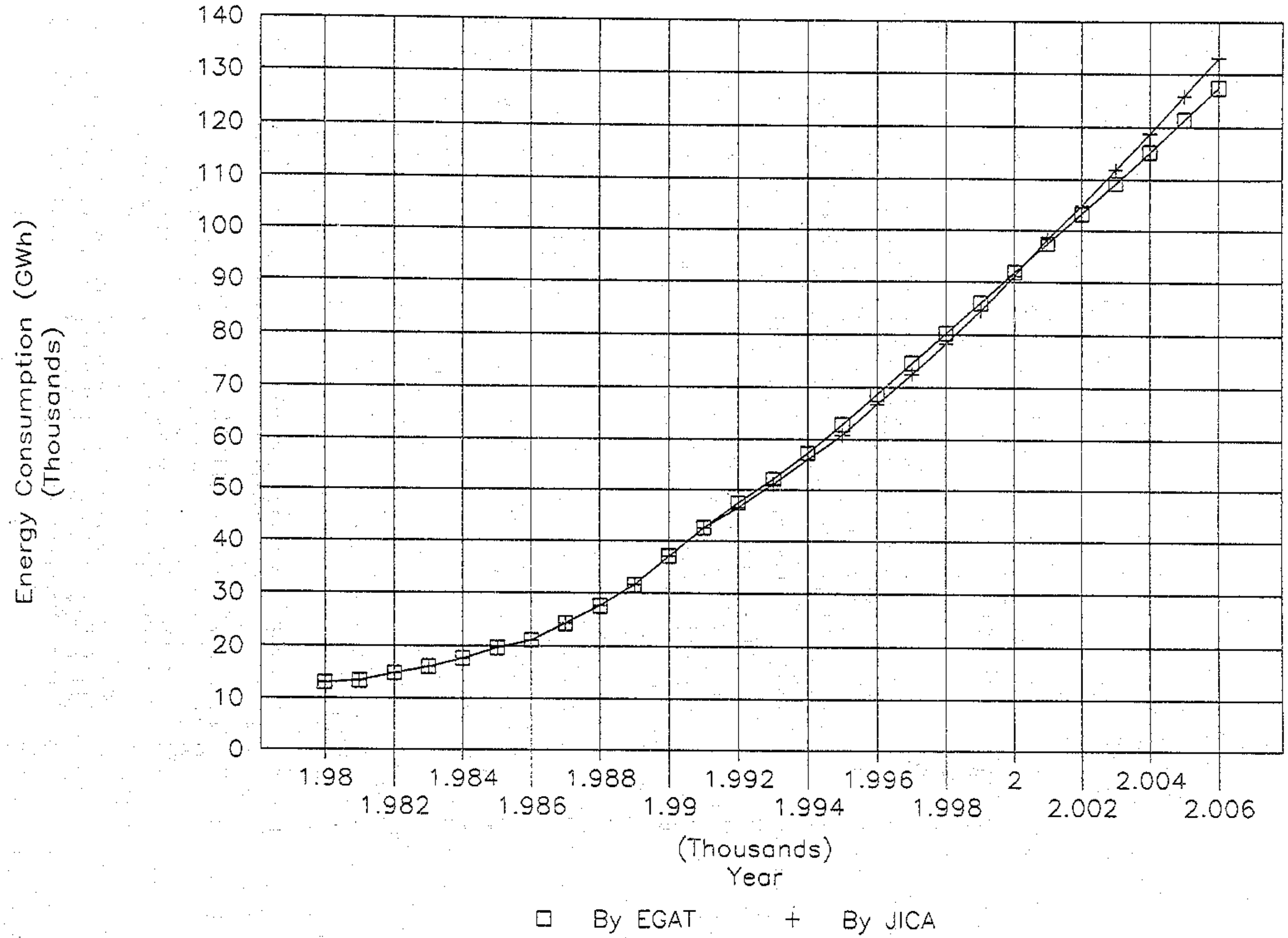


Fig. 3-3 **Energy Generation for Whole Thai**
(Estimated by EGAT & JICA)

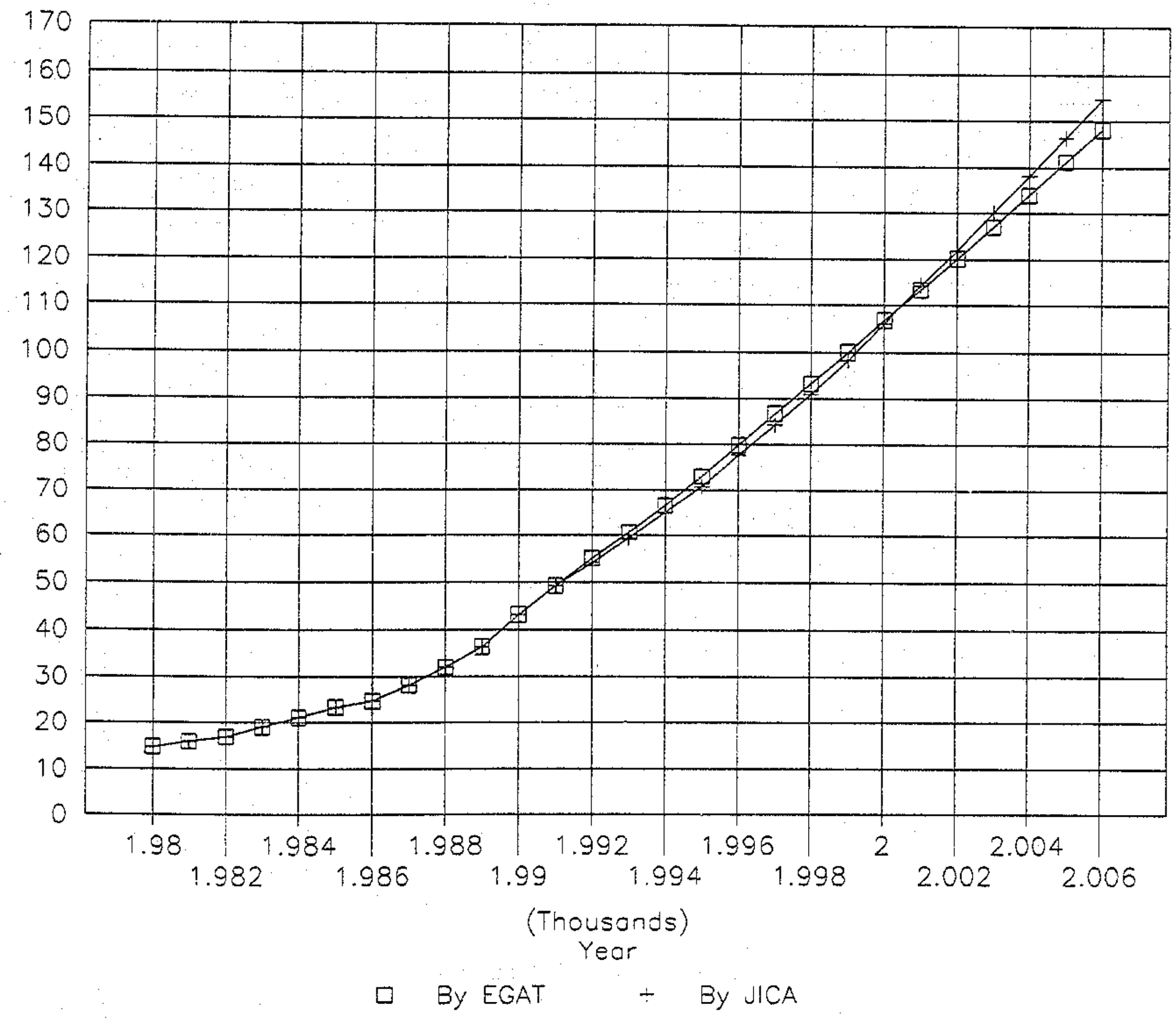
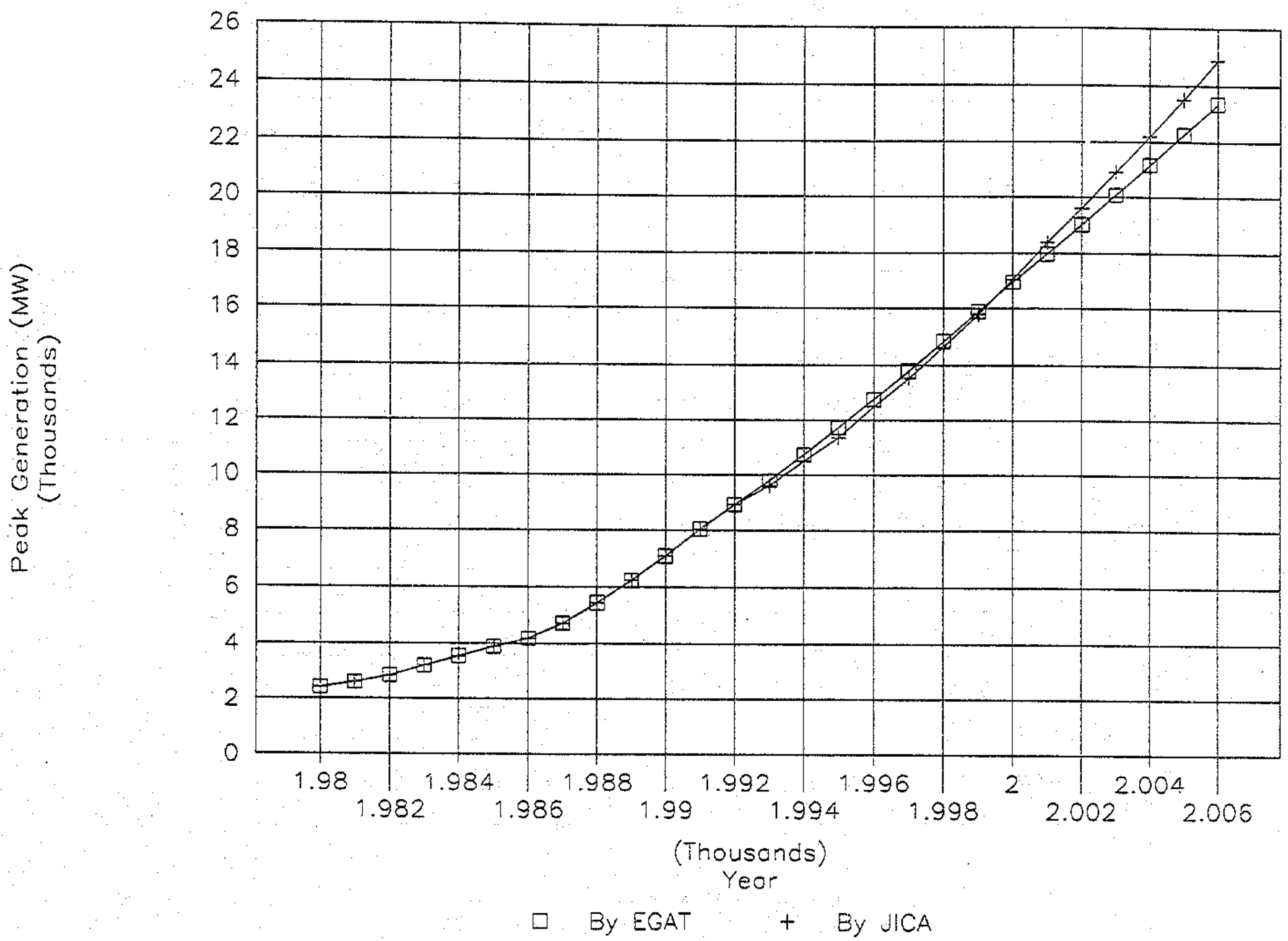


Fig.3-4

Fig. 3-4 **Peak Generation for Whole Thai (Estimated by EGAT & JICA)**



(2) Forecast on the Peak Load

For the peak load forecasting, JICA Study Team estimated that the load factor in the future is lower than the load factor estimated by EGAT. As mentioned above, JICA Study Team compared the load factor in the future estimated by EGAT with the load factor of foreign countries including Japan. In fact, trend data of the load factor has been increased since 1989, however in the future this value will follow the trend value or tendency of foreign countries. With considering the related data, JICA Study Team estimated that the load factor will be saturated at the highest value up to 71% around 1995 as 1 to 1.5% lower to the value estimated by EGAT. Therefore, the result of the calculation by JICA Study Team is slightly higher than EGAT's estimation. The result is shown in Table 3-7 and Fig.3-5.

3.2 Demand Forecast for RegionIII

3.2.1 Power System Situation in RegionIII

The power supply capacity in RegionIII is 610MW as of 1991, which consists of 312MW of hydro power, 214MW of steam power and 84MW of gas turbine plants. On the power demand, the peak load at the sending end is 608MW and the energy generation requirement is 3,922GWh as of 1991. For the both of the peak demand and the energy demand, power supply capability are not satisfied as null reserved margin on the peak load and as the amount of receiving energy is exceeding 1,000GWh more. (Assumption: The plant factor of steam power plant is 0.75, the gas turbine plant is 0.4 and available energy of hydro is 590GWh. The total amount of energy generation is 2,300GWh) Needless to say, power network of this region has been connected to the whole Thai power grid. However, since the length of trunk lines of 230kV is over 500km, power and energy requirements basically should be provided in this region from the view point of system losses reduction and operational practices.

3.2.2 Demand Forecast by EGAT

Demand forecast estimated by EGAT on the peak load and the energy generation is shown in Table 3-8. It shows the large amount of the average growth rate as on the peak generation is 9.01%, on the energy generation is 8.23%

Table 3-7 Demand Forecast on Energy and Peak Load for Region III

Fiscal Y.	Estimated by EGAT Energy (GWh)	Load F. (%)	Peak (MW)	Growth R. (%)	Estimated by JICA Energy (GWh)	Load F. (%)	Peak (MW)	Growth R. (%)
1980	887.96	59.94	169.10	5.65	887.96	59.94	169.10	5.65
1981	1,063.93	61.75	196.70	16.32	1,063.93	61.75	196.70	16.32
1982	1,163.70	61.47	216.10	9.86	1,163.70	61.47	216.10	9.86
1983	1,329.31	63.95	237.30	9.81	1,329.31	63.95	237.30	9.81
1984	1,433.01	58.01	282.00	18.84	1,433.01	58.01	282.00	18.84
1985	1,623.66	62.34	297.30	5.43	1,623.66	62.34	297.30	5.43
1986	1,717.56	61.50	318.80	7.23	1,717.56	61.50	318.80	7.23
1987	1,928.10	60.63	363.00	13.86	1,928.10	60.63	363.00	13.86
1988	2,237.17	61.82	413.10	13.80	2,237.17	61.82	413.10	13.80
1989	2,539.69	61.84	468.80	13.48	2,539.69	61.84	468.80	13.48
1990	2,969.88	63.61	533.00	13.69	2,969.88	63.61	533.00	13.69
1991	3,389.36	63.60	608.40	14.15	3,389.36	63.60	608.40	14.15
1992	3,922.00	62.53	716.00	17.69	3,894.94	62.53	711.06	16.87
1993	4,330.00	61.86	799.00	11.59	4,356.91	61.86	803.97	13.07
1994	4,758.00	61.58	882.00	10.39	4,868.19	61.58	902.43	12.25
1995	5,213.00	61.54	967.00	9.64	5,394.27	61.54	1,000.62	10.88
1996	5,664.00	61.52	1,051.00	8.69	5,954.17	61.52	1,104.84	10.42
1997	6,149.00	61.74	1,137.00	8.18	6,528.69	61.74	1,207.21	9.26
1998	6,674.00	62.24	1,224.00	7.65	7,085.30	62.24	1,299.43	7.64
1999	7,213.00	62.71	1,313.00	7.27	7,668.29	62.71	1,395.88	7.42
2000	7,794.00	63.37	1,404.00	6.93	8,257.04	63.37	1,487.41	6.56
2001	8,422.00	64.27	1,496.00	6.55	8,838.91	64.00	1,576.57	5.99
2002	9,100.00	65.33	1,590.00	6.28	9,451.01	64.00	1,685.75	6.93
2003	9,832.00	66.57	1,686.00	6.04	10,077.76	64.00	1,797.55	6.63
2004	10,623.00	67.97	1,784.00	5.81	10,728.80	64.00	1,913.67	6.46
2005	11,477.00	69.54	1,884.00	5.61	11,398.10	64.00	2,033.05	6.24
2006	12,347.00	70.93	1,987.00	5.47	12,063.14	64.00	2,151.67	5.83

Fig. 3-5 **Energy Generation for Region III (Estimated by EGAT & JICA)**

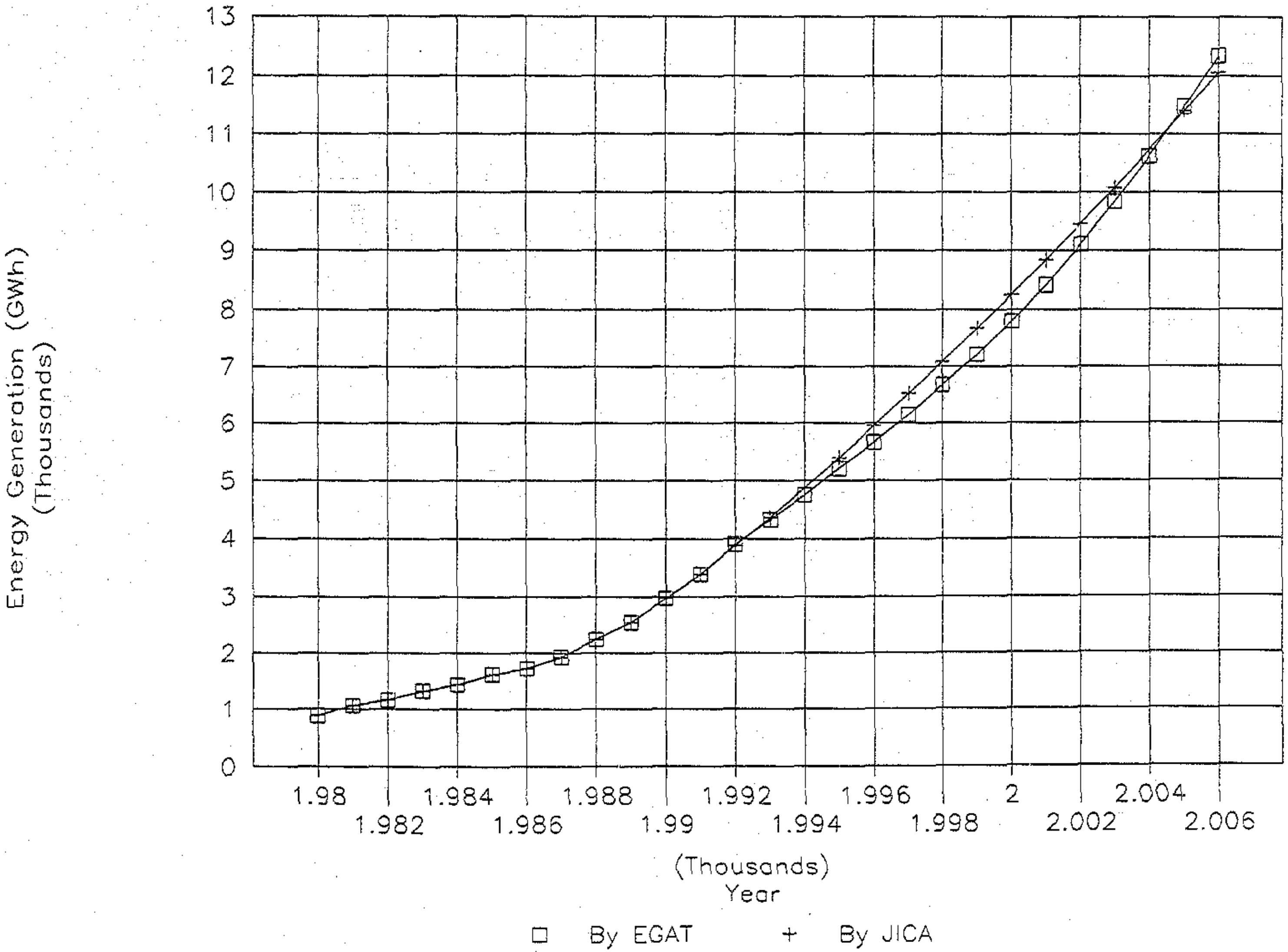


Table 3-8 **Power Plants Located In Region III**

A.Existing Capacity in RegionIII

1.Thermal Power Plant

Plant Name	Capacity Instlld (MW)	Dpndbl (MW)	Retrmnt (Year)	Total as of 1991 (MW)
Barge #1	75	74	2006	
Krabi #1	17	16	1995	
Krabi #2	17	16	1995	
Surat Thani #1	30	29	1998	
Gas Turbine RIII	84	82	1999	
Barge #2	75	74	2013	
				298

2.Hydro Power Plant

Plant Name	Capacity Instlld (MW)	Dpndbl (MW)	Retrmnt (Year)	
Bang Lang #1-3	72	72		
Rajjaprabha#1-3	240	216		
				312

B.Ongoing or Planned Power Plant

1.Thermal Power Plant

Plant Name	Capacity Instlld (MW)	Dpndbl (MW)	Cmmssn (Year)
Khanom C.C	674		
	448		1993
	226		1994
Saba Yoi	600		
	300		2000
	300		2002

2.Hydro Power Plant

Plant Name	Capacity Instlld (MW)	Dpndbl (MW)	Cmmssn (Year)
Kaeng Krung	80		1996

respectively in the period of 1992 to 2006.

3.2.3 Demand Forecast by JICA Study Team

During the site survey for this study, sufficient basic data for demand forecast was not available in this region such as historical GDP growth for RegionIII. Therefore JICA Study Team has executed demand forecast with the relation available between the historical data of whole Thai and RegionIII.

(1) Forecast on The Energy Generation

The growth rate of whole Thai and the growth rate of RegionIII are strongly correlated, and are represented with the following expression.

$$Y = -51.330 + 0.0704756X$$

where

Y = Energy Generation in RegionIII (GWh)

X = Energy Generation of whole Thai (GWh)

In accordance with the energy generation estimation for whole Thai, the elasticities between growth rate of GDP and growth rate of energy generation in RegionIII should be taken into consideration. However, since JICA Study Team calculated the demand forecasting with an indirect method, conversion factors were adopted to the value of energy generation of whole Thai system as a primary value. JICA Study Team estimated that the state of elasticities in RegionIII will be behind with 10 years to the whole Thai system. In order to compensate the error between raw value calculated from above mentioned expression and reasonable value coordinated to the future behavior of the power demand, JICA team used the value of whole Thai energy generation revised with multiplying 1.1 as of 2000 and 1.16 as of 2006. Results of the load forecast for energy generation are shown in Table 3-7 and Fig 3-5.

(2) Forecast on The Peak Load

For the future peak load, JICA Study Team forecasted it in a similar way used for the peak load estimation of whole Thai grid. That is, first JICA Study

Team assumed that the load factor of this region will be saturated with 10 years behind from the whole Thai. And the annual load factor will be increased up to 64% which will be recorded in 1992 as the highest value for this region. Therefore, the results of JICA Study Team are higher than the value estimated by EGAT, and Table 3-7 and Fig 3-6.
show these results.

3.2.4 Power balance in Region III

JICA Study Team also evaluated the power balance in the future based on the estimated peak load and power supply capability in Region III. In this evaluation, JICA Study Team assumed that dependable capacity is taken off the value of the largest unit from the totaling value of installed capacity based on EGAT's PDP. The result is shown in Fig 3-7 and the dependable capacity will be shorted from the year of 1997. Therefore, some additional power plants to EGAT's PDP will be required to secure the basic power system reliability.

3.3 Optimum Power Developing Plan for Region III

In order to prepare the optimum power developing planning, EGAT has already introduced the least cost developing planning program package as WIGPLAN developed by ASEA Brown Boveri (ABB). This software package also provides developing schemes which can provide adequate system reliability corresponding with the target value given by a planner.

In this analysis, EGAT simulates the power system of the assumption that all generators and all load in whole Thailand are connected at one point as called single bus system.

JICA team simulate the power system of the assumption that the power system consists of two power network, one is the Region III and another one is the main power grid including Region I of greater Bangkok.

Furthermore, these two power grids are connected with interconnecting transmission lines of the length approximate 500 km. JICA Team considers that actual Thai power system is similar to two grids rather than single system.

Fig. 3-6 Peak Generation for Region III

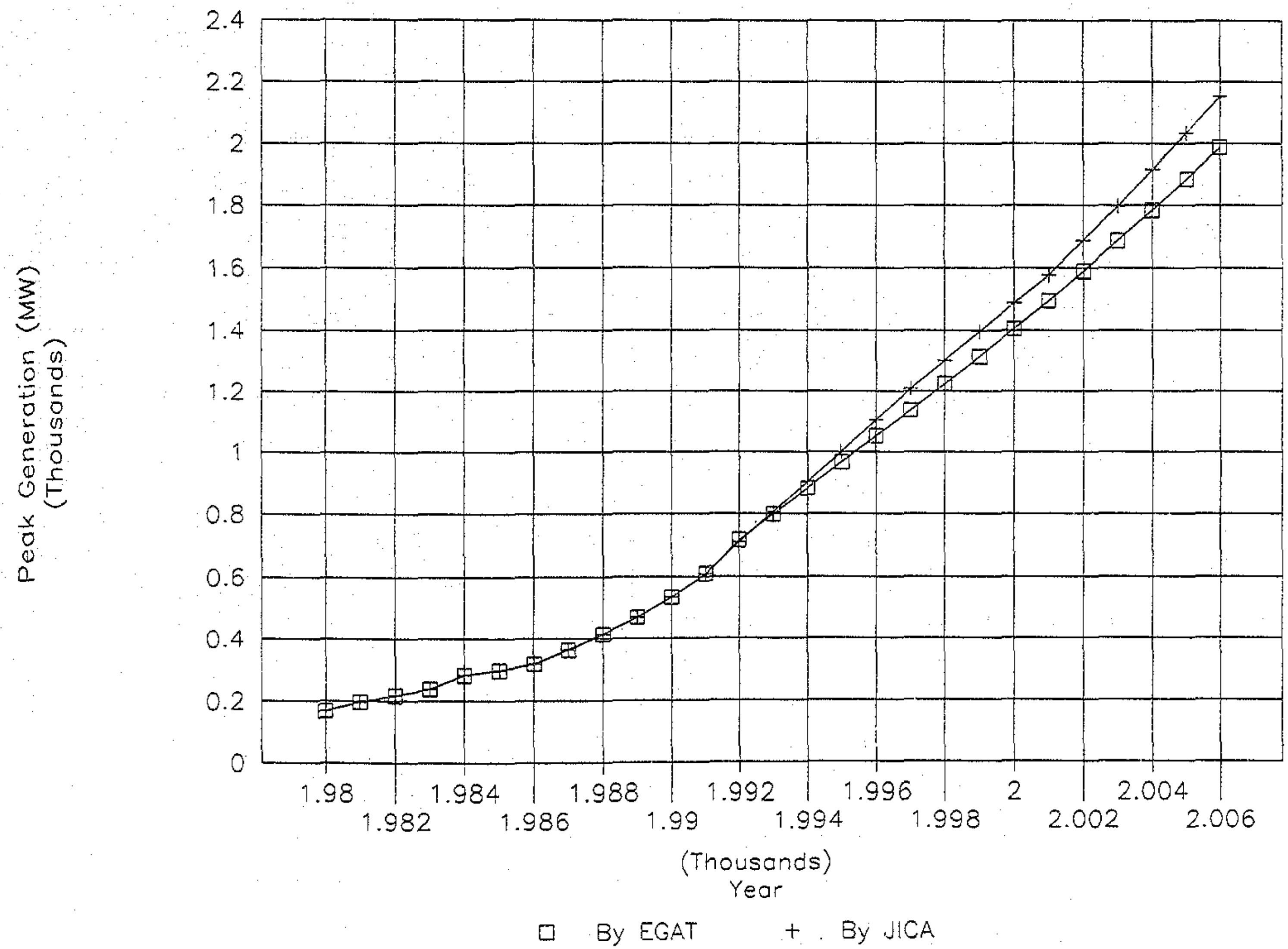
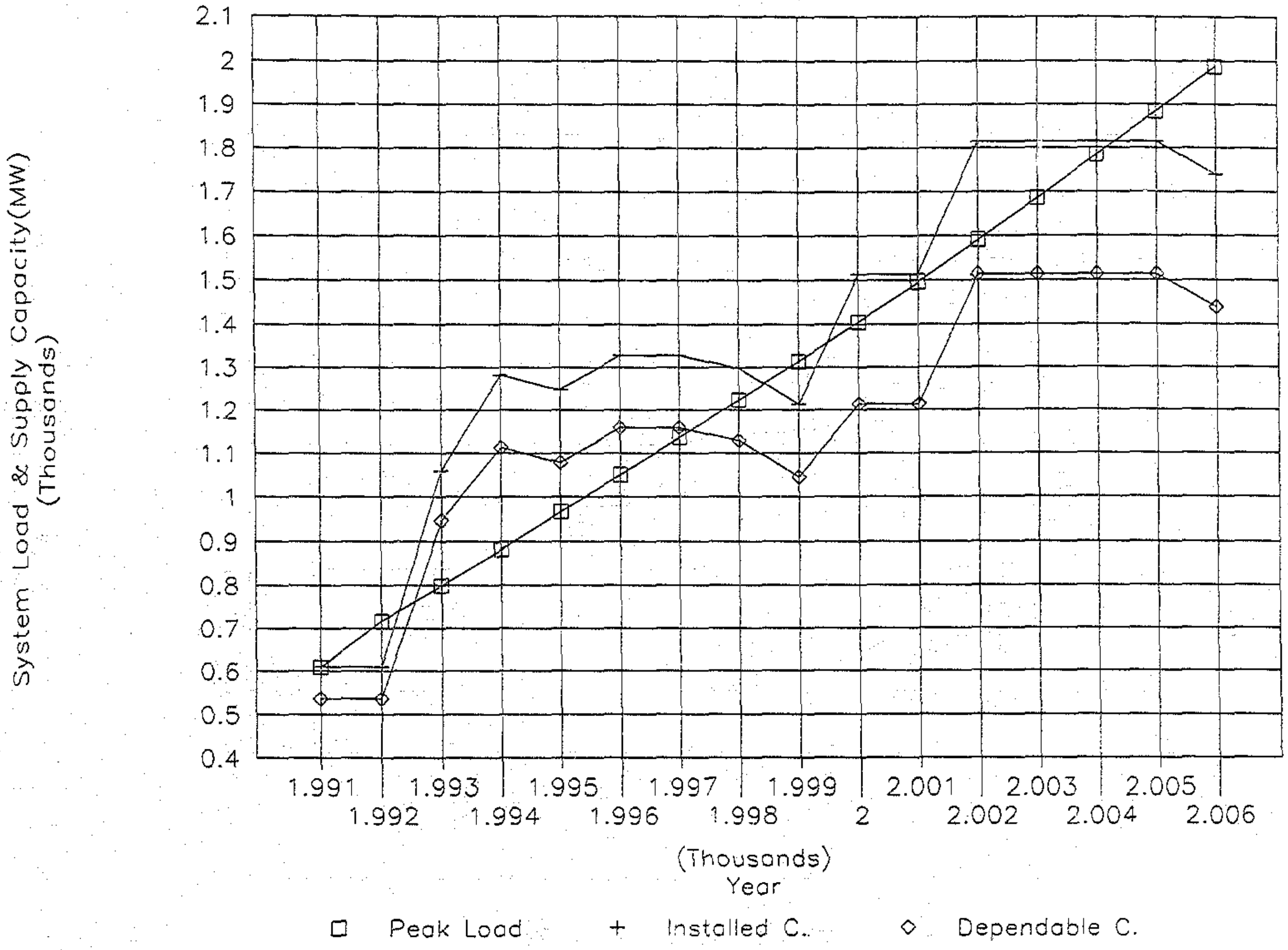


Fig. 3-7 Power Balance in Region III



The least cost planning with targeted system reliability was analysed based on the conditions below.

(1) The targeted system reliability with Loss of Load Probability (LOLP), is less than three days per year in whole study period.

(2) Base load as amount of energy from Region I to Region III, is not expected. However, in order to supply power for the peak portion demand, gas turbine generators are provided especially in forced outage and or scheduled outage of generating units. Therefore, the loading order for these gas turbines are settled as the last group.

(3) In order to make a full use of existing and planned power plants in Region III, minimum reserved margins are not fixed. Power shortage due to forced outage and scheduled outage, should be filled up by the generated power of simulated gas turbines.

All of the candidates used in this study, were also used in PDP 2-01 issued by EGAT.

The results of the least cost developing planning based on the above mentioned condition, accepted that Sin Pun will be completed in year 1996. The capital cost, fixed and variable O&M cost, fuel cost and other costs used in this analysis are same value in which were used in PDP 92-01 of EGAT. The optimum solution of the least cost planning is shown in Table 3-9.

The result shows that the optimum commissioning year for Sin Pun FBC is 1998. However, exchanging power from the Region I to Region III should be reduced in order to reduce system losses. Therefore, it is desirable that Sin Pun Power Plant will be put into operation in available commission year 1997.

Table 3-9 Optimum Solution for Region III

NAME:			KCC1	SAB1	SPN1	HYDR
CAPA.:			337	294	75	80
YEAR	%LOLP	CAP				
1990	0.134	0	0	0	0	0
1991	0.020	0	0	0	0	0
1992	0.164	0	0	0	0	0
1993	0.004	337	1	0	0	0
1994	0.015	337	1	0	0	0
1995	0.038	0	0	0	0	0
1996	0.065	0	0	0	0	0
1997	0.208	0	0	0	0	0
1998	0.044	155	0	0	1	1
1999	0.137	75	0	0	1	0
2000	0.055	294	0	1	0	0
2001	0.099	0	0	0	0	0
2002	0.203	0	0	0	0	0
2003	0.088	294	0	1	0	0
2004	0.170	0	0	0	0	0
2005	0.052	294	0	1	0	0
2006	0.240	0	0	0	0	0
Totals		1786	2	3	2	1

Note:

		Available Commissining Year
KCC1:	Khanom C/C	1994
SPN1:	Sin Pun FBC	1997
SAB1:	Soba Yoi	2000
HYDR:	Kaeng Krung	1994
CAP:	Capacity Added in the each year	

4. SITE SELECTION

CHAPTER 4 SITE SELECTION

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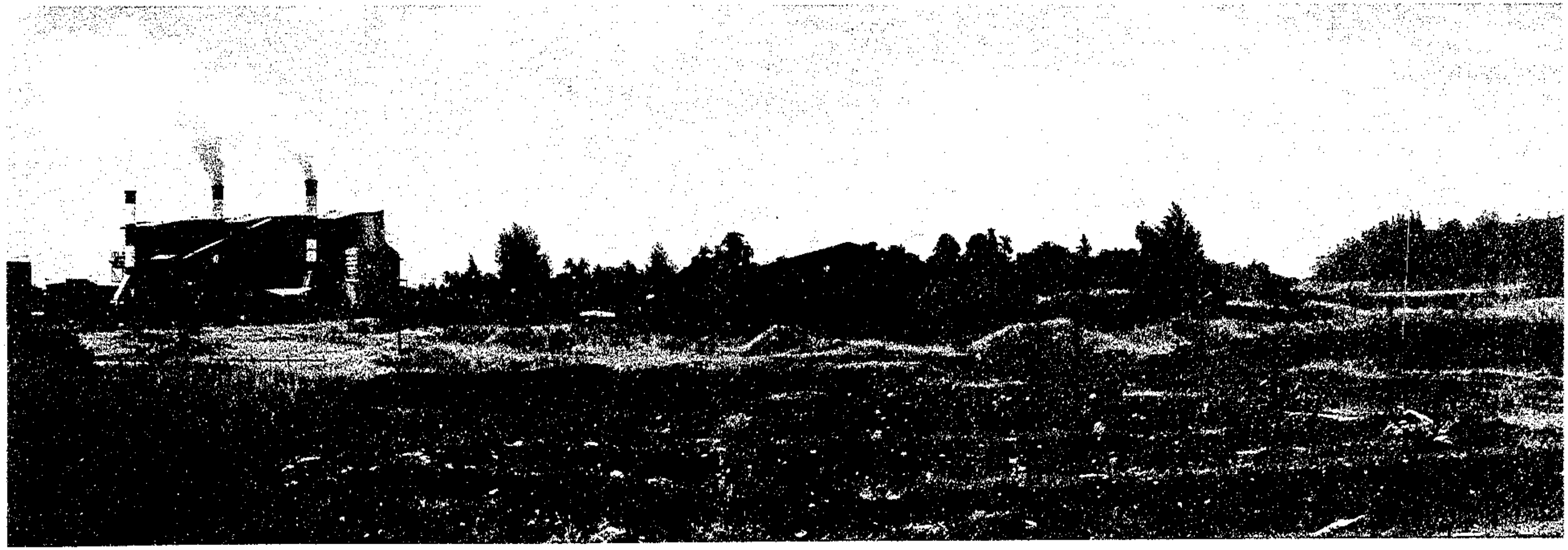
Site No.3 Sin Pun-East of Bang Sai Lignite Resources



Site No.4 Krabi-Existing Krabi Power Station

4. Site Selection

4.1 General

Following points are considered in feasibility study of candidate sites for A-FBC coal-fired power plant.

i) Area should have good topographical and geological condition.
ii) Area should be available the coal and limestone with reasonable cost.
iii) Cooling water and fresh water must be available in vicinity.
iv) Sufficient area should be available with reasonable cost and easy to acquire.
v) Area must be available for large volume of ash disposal in vicinity.
vi) Transmission line route should be selected with minimum cost.
vii) Area must be convenient for securing labors, equipment and materials.
viii) Area must have minimum environmental problems.
ix) Area must be easy to transport large scale equipment with reasonable cost.

These items were examined in the first stage of evaluation of candidate sites.

4.2 Selection of Plant Scale

EGAT plans the generation plant in the power development plan with the scale of 2 × 75 MW as Sin Pun generation project. While, the conceptional mining study report recommends 1 ×100 MW for Sin Pun project because of the economic ratio at the final year of the mining below 10 U$/Gcal. In this study, the economic comparison is carried out among the above two generation scale with the combination of the generation plant and the lignite cost, and resulted that 2 × 75 MW scale is more economical than that of 1 × 100 MW. Table 4-1 shows result of the economic comparison in Krabi site under the respective power plant scale. And Tables 4-2a - 2b show the calculation sheet of the respective cases.

Besides the above economical reason, 2 × 75 MW recommendable with the following reasons.

i) Even selecting 150 MW generation scale, the power demand and supply in the region III is still shortage. The higher generation is preferable in region III.

ii) The more consumption of the domestic lignite is following the policy of Thai Government to save the import of oil.

Table 4-1 Economic Comparison of Power Plant Scale

	2 × 75 MW	1 × 100 MW
Investment Million Baht (excluding IDC)	6119	4273
Levelized Cost (without escalation)	1.71 Baht/kWh	1.76 Baht/kWh
Investment	0.841	0.880
O & M	0.192	0.199
Fuel	0.605	0.611
Limestone	0.072	0.070

Table 4-2a Levelized Cost 2 × 75 MW Krabi Site

	Investment	O & M	Fuel Cost	Limestone	Total	Generation
1	40.00				40.00	
2	748.00				748.00	
3	3593.00				3593.00	
4	1248.00				1248.00	
5	490.00				490.00	
6		91.79	575.35	68.40	735.53	951336
7		104.63	575.35	68.40	748.38	951336
8		118.10	575.35	68.40	761.85	951336
9		130.95	575.35	68.40	774.70	951336
10		144.41	575.35	68.40	788.10	951336
11		157.26	575.35	68.40	801.01	951336
12		270.72	575.35	68.40	814.47	951336
13		183.57	575.35	68.40	827.32	851336
14		196.42	575.35	68.40	840.17	951336
15		209.88	575.35	68.40	853.63	951336
16		222.73	575.35	68.40	866.48	951336
17		236.19	575.35	68.40	879.94	951336
18		249.04	575.35	68.40	892.79	951336
19		262.51	575.35	68.40	906.25	951336
20		275.36	575.35	68.40	919.10	951336
21		275.36	575.35	68.40	959.57	951336
22		275.36	575.35	68.40	959.57	951336
23		275.36	575.35	68.40	959.57	951336
24		275.36	575.35	68.40	959.57	951336
25		275.36	575.35	68.40	959.57	951336
26		275.36	575.35	68.40	959.57	951336
27		275.36	575.35	68.40	959.57	951336
28		275.36	575.35	68.40	959.57	951336
29		275.36	575.35	68.40	959.57	951336
30		275.36	575.35	68.40	919.10	951336
Total	6119.00	5507.10	14383.78	1709.95	27719.83	23783400.00
					9150.7304	5361851.179

Generation: Net Annual Production, Sending End 150 x 0.8 x 24 x 365 x(1-0.095) =	951336	
N.P.V. (DCR=10%) of Total Generation	5361851.1	MW
N.P.V. (DCR=10%) of Total Cost	9150.7304	Million Baht
Production Cost	1.7066364	Baht/kWh
Plant Efficiency	36.4	%
Fuel Consumption (Sin Pun Lignite Only) 128 x 0.8 x 24 x 365 =	897024	
Fuel Price (Sin Pun) B/t (Given Value)	641.4	
Limestone Consumption 61 x 0.8 x 24 x 365 =	427488	
Limestone Price B/t (ref Table 7-3)	160	

Table 4-2b Levelized Cost 100 MW Krabi Site

	Investment	O & M	Fuel Cost	Limestone	Total	Generation
1	0.00				0.00	
2	535.00				535.00	
3	2508.00				2508.00	
4	889.00				889.00	
5	341.00				341.00	
6		64.10	387.47	44.62	496.18	634224
7		73.07	387.47	44.62	505.15	634224
8		82.47	387.47	44.62	514.55	634224
9		91.44	387.47	44.62	523.53	634224
10		100.84	387.47	44.62	532.93	634224
11		109.82	387.47	44.62	541.90	634224
12		119.22	387.47	44.62	551.30	634224
13		128.19	387.47	44.62	560.29	634224
14		137.16	387.47	44.62	569.25	634224
15		146.56	387.47	44.62	578.65	634224
16		155.54	387.47	44.62	587.62	634224
17		164.94	387.47	44.62	597.02	634224
18		173.91	387.47	44.62	606.00	634224
19		183.31	387.47	44.62	615.40	634224
20		192.29	387.47	44.62	624.37	634224
21		192.29	387.47	44.62	650.63	634224
22		192.29	387.47	44.62	650.63	634224
23		192.29	387.47	44.62	650.63	634224
24		192.29	387.47	44.62	650.63	634224
25		192.29	387.47	44.62	650.63	634224
26		192.29	387.47	44.62	650.63	634224
27		192.29	387.47	44.62	650.63	634224
28		192.29	387.47	44.62	650.63	634224
29		192.29	387.47	44.62	650.63	634224
30		192.29	387.47	44.62	624.37	634224
Total	4273.00	3845.70	9686.66	1115.45	18920.82	15855600.00
					6287.2242	3574567.452

Generation: Net Annual Production, Sending End 100 x 0.8 x 24 x 365 x (1-0.095) =	634224	
N.P.V. (DCR=10%) of Total Generation	3574567.4	MW
N.P.V. (DCR=10%) of Total Cost	6287.2242	Million Baht
Production Cost	1.7588769	Baht/kWh
Plant Efficiency	37.2	%
Fuel Consumption (Sin Pun Lignite Only) 138 x 0.8 x 24 x 365 x 100 x 36.4/(150 x 37.2) =	585155.44	
Fuel Price (Sin Pun) B/t (Given Value)	662.16	
Limestone Consumption 61 x 0.8 x 24 x 365 x 100 x 36.9/(150 x 37.8) =	278863.13	
Limestone Price B/t (ref Table 7-3)	160	

4.3 Evaluation of Candidate Site of Power Plant

4.3.1 Candidate Site of Power Plant

Three candidate sites have been studied for the power plant. Two candidate sites are located in Sin Pun mine area and the other site is located in Krabi power station.

Those candidate sites are numbered the site No. 2, the site No. 3 and the site No. 4 respectively following the conventional numbering of EGAT.

The location of each site is shown in Fig. 4-1.

	Description
Site No. 2	West of Bang Sai lignite resource
Site No. 3	East of Bang Sai lignite resource
Site No. 4	Existing Krabi power station

For the site No. 2 and the site No. 3, Sin Pun lignite is applied for the 2 x 75 MW A-FBC, while the Krabi lignite would be mixed with Sin Pun lignite for the site No. 4.

4.3.2 Evaluation Criteria and Basic Condition of Evaluation

Several evaluation criteria are considered in studying feasibility of power plant construction at the selected sites. The plan of development suited to each site must also be examined. The candidate sites were evaluated for feasibility using the following 13 items. The final decision must be made by accessing how each problem can be technically solved and what cost.

i) Meteorological condition.
ii) Suitability of topographic conditions and tentative yard location.
iii) Suitability of geological conditions.
iv) Cost difference for coal procurement involving transportation cost.
v) Cost difference for limestone procurement involving transportation cost.

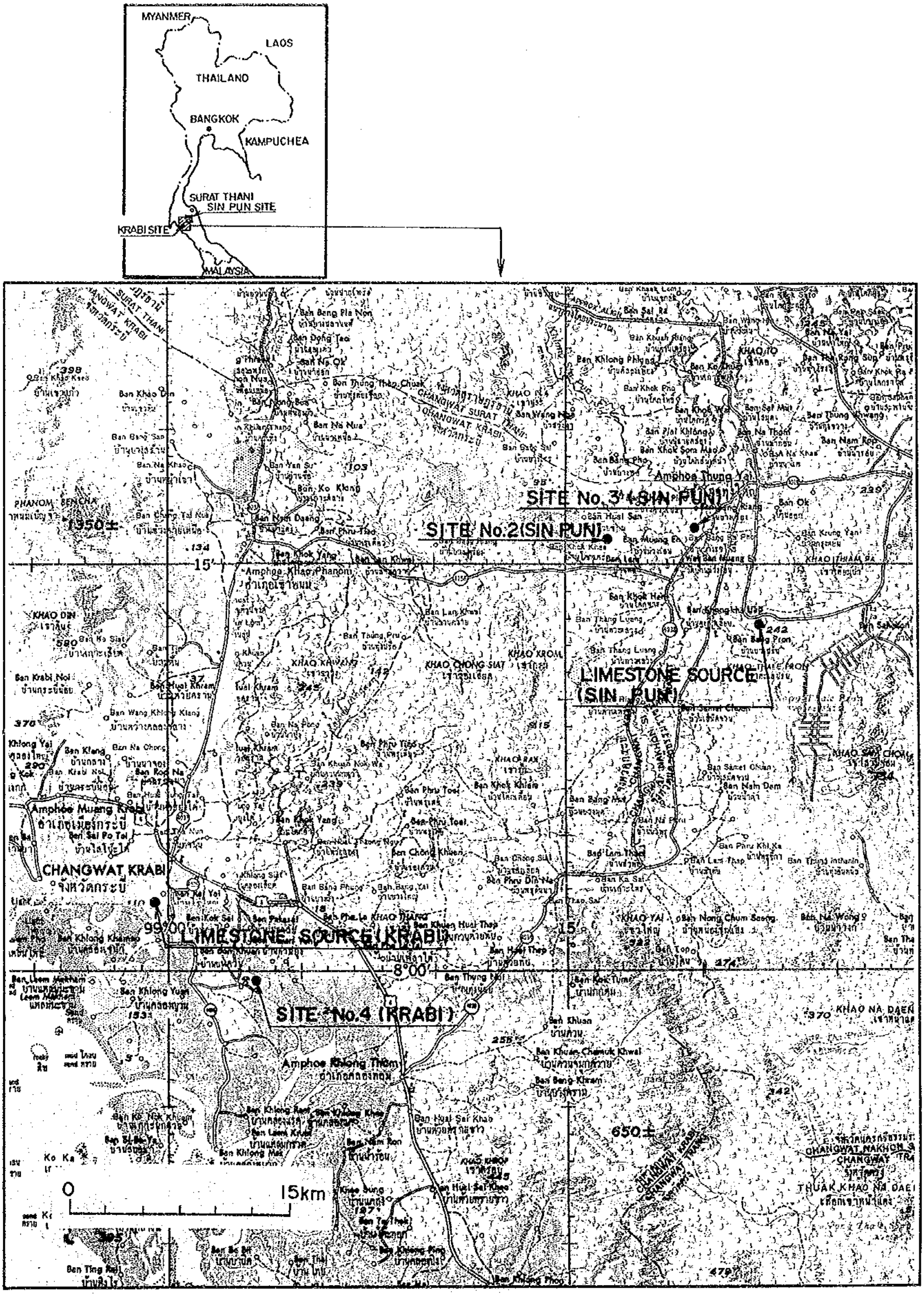


Fig. 4-1 Candidate Site for 2 x 75 MW A-FBC

vi) Stable availability of sufficient condenser cooling water and cost difference.

vii) Availability of sufficient area for power plant with reasonable cost and easy to acquire.

viii) Availability of sufficient area for ash disposal and cost difference.

ix) Selection of transmission line route and cost difference.

x) Selection of access route, new road and cost difference.

xi) Availability to utilize an existing facilities and additional cost.

xii) Impact on the environment caused by plant construction and cost difference.

xiii) Availability of transportation route for constructing material and installing equipment and cost difference.

To evaluate the selected plant sites, the following basic conditions were adopted.

1) Capacity of plant : 2 x 75 MW

2) Annual plant factor : 80 %

3) Operation period : 25 years

4) Annual average heat rate : 2,410 kcal/kWh (η p = 35.7%)

5) Ca/S mol ratio : 2.0

6) Quantity and Quality of coal at each area

		Sin Pun	Krabi
• Quantity (Million ton)	:	25	5
• Heating Value (kcal/kg)	:	2787	1600
• Total Moisture (%)	:	32.7	26.1
• Ash Content (%)	:	21.1	36.4
• Sulfur Content (%)	:	7.0	1.8
• Coal blend ratio in Krabi	:	5.0 M-ton is Krabi coal and the rest is Sin Pun coal with constant ratio during 25 years operation.	

7) Quality of limestone			
$CaCO_3$ Content (%)	:	90	90
8) Lignite consumption			
(ton/day)	:	3072	3336
(10^3 ton/year)	:	897	974
(10^6 ton/25 years)	:	22.4	24.4 (SinPun:Krabi = 4:1)
9) Limestone consumption			
(ton/day)	:	1493	1392
(10^3 ton/year)	:	436	406
(10^3 ton/25years)	:	10.9	10.2
10) Ash disposed			
(ton/day)	:	1890	1930
(10^3 ton/year)	:	552	564
(10^3 ton/25years)	:	13.8	14.1

11) Layout

The plant layout shown in Fig. 4-2 is adopted for the site selection study.

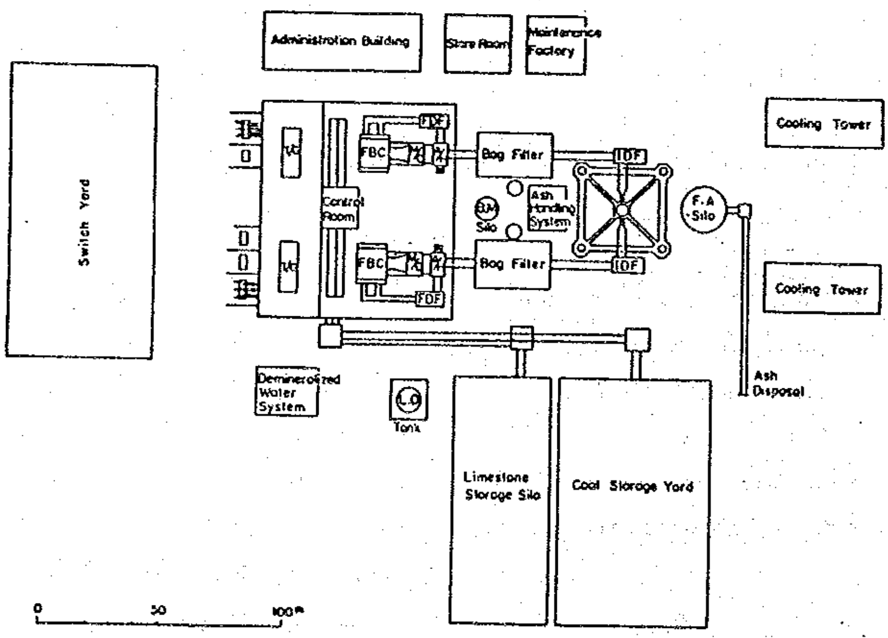


Fig. 4-2 Layout of Sin Pun FBC 2 x 75 MW for Sites Selection Study

4.3.3 Evaluation

The evaluation applies the net present value with discount rate of 10%.

Evaluation result of the study team is summarized in Table 4-3.

Since there are no big difference on the topographic condition and geological condition between Sin Pun sites and Krabi site, the land reclamation does not make the big cost difference among those candidate sites.

The highway routes also run around the candidate sites in vicinity and there are no big cost difference among those sites for the construction of the access road.

The cost difference for the lignite transportation is prominently big among two Sin Pun sites and Krabi site because of the long travel of the Sin Pun coal to Krabi site. The cost calculation is assumed that 20 million tons of lignite are travelling from Sin Pun mine to Krabi site and 5 million tons of them comes from Krabi mine for the site No. 4. This cost difference is only negative to the site No. 4.

The cost difference of the limestone procurement comes from the travelling cost and the difference of required amount of limestone since the sulfur content of Krabi lignite is lower than that of Sin Pun lignite. The impact of the cost difference for the transportation is not big but the cost difference due to the different amount is relatively big.

The cost difference of the cooling water supply system and operation is relatively big because of the different system. The Sin Pun sites apply the cooling tower system due to the shortage of cooling water for the one through cooling system while the Krabi site applies the one-through cooling system from the Phakasai River. Main reason of the cost difference is due to the difference of the power consumption of each system and the cooling tower installation cost.

The cost difference of the ash disposal is due to the sheet pile because Sin Pun sites request the sheet pile for the ash disposal area to prevent an environmental polution of ground water, while Krabi site does not request the sheet pile because none of residents utilize the well water as their drinking water. The impact of this cost difference is relatively big.

The cost difference of transmission line and switch yard cost is coming from the cost difference of transmission line between Sin Pun Sites and the existing network system. Since there is no transmission line running above Sin Pun sites, the new sets of transmission line are requested for the power transmission of 150 MW (2 x 75 MW). On the other side, Krabi site does not request the new set of the transmission lines because of the utilization of the existing lines. The impact of this cost difference is relatively big.

The cost difference of the equipment transportation is due to the inland transportation for Sin Pun sites. The impact of this cost difference is not big.

There are no cost difference on the environmental mitigations because the same emission level is applied to each site.

The land acquisition of Krabi site is not a problem because the site is located in the existing power station while Sin Pun site has no view on the land acquisition for the power station.

The accommodation facilities for the staff in the power station are available in Krabi site with using the existing Krabi power station while the accommodation facilities have to prepare in Sin Pun site.

As a whole, there are small cost benefit on Krabi site with the amount of 3% of the investment. Further to the above cost benefit, Krabi site is selected by EGAT because of the following reasons.

(1) Sin Pun site has unforeseen difficulty and no programmed schedule of the land acquisition, while the Krabi site has land already in the existing power station.

(2) The water pollution in the ash disposal area way effect to the drinking water of the well with the long term period.

Table 4-3 Comparison of Cost Difference (July 1992 Base)

[Million Baht]

In Charge	Item \ Site No.	No. 2 (Sin Pun)	Cost Difference	No. 3 (Sin Pun)	Cost Difference	No. 4 (Krabi)	Cost Difference	Note
EPDC	1. Reclamation of Plant Yard and Access Road	No Pile	+ 6	No Pile	+ 6	No Pile	Base	Discount Rate = 10.0%
	2. Coal Transportation Cost (Involving transportation road)	Sin Pun Coal 23 Million T	△ 456	Sin Pun Coal 23 Million T	△ 456	Sin Pun Coal : Krabi Coal 20 Million T : 5 Million T	Base	
	3. Limestone Transportation Cost and Limestone Cost	Khao Tham Hora	+ 49	Khao Tham Hora	+ 27	Khao Kaew	Base	
	4. Cooling Water Supply and Operation Cost	Cooling Tower Auxiliary Power Consumption Cooling Water Supply	+ 252	Cooling Tower Auxiliary Power Consumption Cooling Water Supply	+ 279	One through cooling water	Base	Exchange Rate 1U$ = 26 Baht = 130 Yen
	5. Ash Disposal Cost	Sheet Pile	+ 77	Sheet Pile	+ 99		Base	Limestone price (Raw material) 123 Baht/ton (1991)
	6. Transmission Line Switch Yard Cost		+ 88		+ 88	The plant operation is restricted due to the transmission line operating condition.	Base	
	7. Equipment Transportation Cost	Krabi to Sin Pun No.2 66km	+ 44	Krabi to Sin Pun No.3 73km	+ 49	Inside Krabi 1km	Base	
	8. Environmental Mitigation Cost	Emission Control	0	Emission Control	0	Emission Control	Base	
	Sub-Total		+ 60		+ 92		Base	
EGAT	1. Cost Difference caused by Coal Price		△ 111		△ 111		Base	
	2. Land Compensation (P/S, Tr Line, Accommodations and Cooling Water Supply Route)	Consideration of the unforeseen difficulty of the land acquisition is not involve in the cost	+ 40	Consideration of the unforeseen difficulty of the land acquisition is not involve in the cost	+ 50		Base	
	3. Accommodations		+ 160		+ 160		Base	
	Total		+ 149		+ 191		Base	
	Specific Evaluation					Earlier implementation of plant because of the land acquisition		
	Final Evaluation						O	

4.3.4 Site No. 2 (West of Bang Sai Lignite Resource)

(1) Meteorological Conditions (Site No. 2)

The site has a tropical monsoon climate and weather patterns are governed by southeast monsoon system. The year can be roughly divided into the rainy season from May through November and the dry season from December through April. The meteorological data observed at stations near the site are shown in Table 4-4.

Table 4-4 Meteorological Data near Site No. 2 & No. 3

1) Temperature

(°C)

	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.
Mean	25.9	26.5	28.3	29.1	28.2	27.7	27.6	26.9	27.1	27.3	26.7	25.7
Max.	32.5	34.8	36.4	36.3	33.3	33.1	33.1	31.8	31.7	32.1	31.3	31.4
Min.	19.3	18.2	20.2	21.9	23.0	22.3	22.0	22.0	22.4	22.6	22.0	19.9

Station: Wat Khong Kha Liap Recording Period: 1986 - 1989

2) Rainfall

(mm)

Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Total
13	12	38	82	207	110	174	262	251	268	187	65	1,669

Station: Wat Khong Kha Liap Recording Period: Oct.1985 - Mar.1990

3) Wind

(knot)

	Jan.	Feb.	Mar.	Apr.	May	Jun.
Prevailing Wind Direction	E	E	E	E	SW	SW
Mean Wind Speed	3.0	3.3	3.2	2.8	3.0	4.2
Max. Wind Speed	40 E	30 E	32 SW	50 S	44 WNW	40 SW, NNW
	Jul.	**Aug.**	**Sep.**	**Oct.**	**Nov.**	**Dec.**
Prevailing Wind Direction	SW	SW	SW	SW	N	N
Mean Wind Speed	3.9	4.2	3.0	2.2	2.4	2.8
Max. Wind Speed	35 SW, WSW	55 WSW	47 SW	50 NW	52 E	30 E

Station: Nakhon Si Thammarat Recording Period: 1956 - 1985
* 1 knot = 0.514 m/sec2

(2) Topographic Conditions and Tentative Yard Location (Site No. 2)

This candidate site is located on the right side of Khlong Bang Kam Prat which runs toward the north. A hill, elevation of which is about +46 m above mean sea level, lies in the western part of the area indicated by EGAT. In contrast with this, the eastern part is comparatively flat and its altitude is +32 m ~ +38 m above mean sea level.

The tentative yard location is shown in Fig. 4-3.

It is recommended tentatively that the plant yard be located on the east part of the hill. The elevation of the plant yard is proposed to be +42 m above mean sea level, taking consideration of the topographic conditions of the site. Since this elevation is higher than the maximum high water level (+32.514 m above mean sea level, 24 Nov. 1988) recorded at Wat Khong Liap gaging station of Khlong Sin Pun, the plant facilities are safe from a flood water inundation.

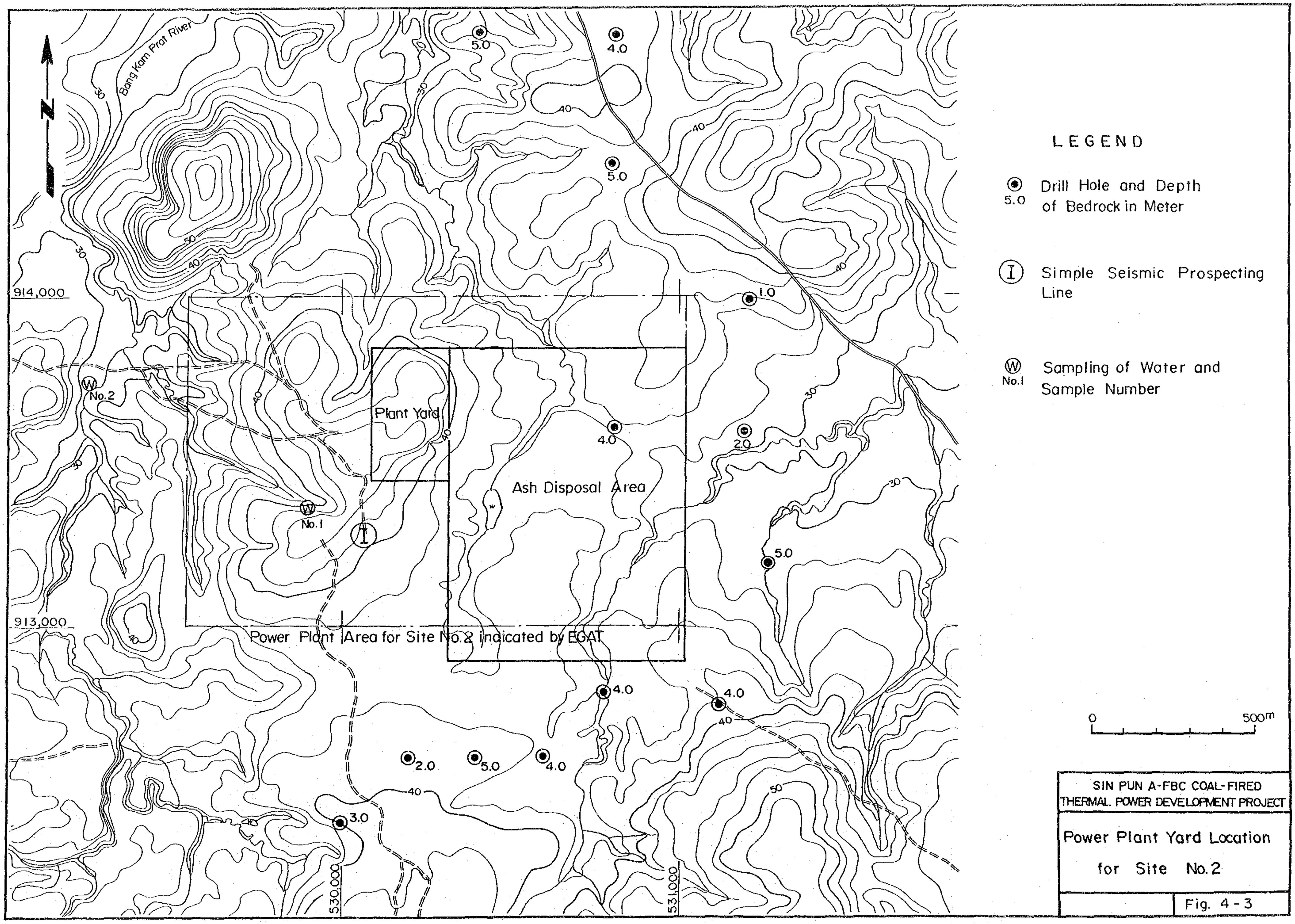
It is recommended tentatively that the ash disposal area be located in a comparatively flat field extending on the east side of the plant yard, although a part of the ash disposal area protrudes from the indicated area, from the viewpoint of making use of the topographic conditions. It is surrounded with an impermeable wall the crest elevation of which is +42.00 m, as high as the plant yard elevation.

(3) Geology (Site No. 2)

1) Outline of Geology of Project Area

The stratigraphy and lithology of the vicinity of the project area are summarized as Table 4-5 according to the Geological Maps of Thailand (1/250,000, published by DMR). The geological map of the project area shown in Fig.4-4 is compiled on the basis of the geological maps of DMR and EGAT.

In Sin Pun area, sedimentary rocks of Permian - Carboniferous period, Mesozoic era and Tertiary period are distributed. The Sin Pun lignite beds are intercalated in the Tertiary group named Sin Pun group, which was deposited mainly in shallow marine and



SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT

Power Plant Yard Location for Site No.2

Fig. 4-3

Table 4-5 Stratigraphy and Lithology in Project Area

Era	Period (Million aged)	Group (Geologic Unit)	Lithology	Distribution	Remarks
Cenozoic	Quaternary (0 – 0.01)	Alluvial deposit	Gravel, sand, silt, caly and beach sand.	No.2 and 3 sites	inffered N-value: less than 50
Cenozoic	Quaternary (0.01 – 1.7)	Terrace and colluvial deposit	Gravel, sand, silt and caly.		
Cenozoic	Tertiary (1.7 – 64)	Krabi group (Sin Pun group)	Shale, calcareous shale, sandstone and siltstone: pale brown, yellowish-brown and white. Limestone, lignite, oil shale and gypsum locally intercalated. Some beds contain gastropods and fossil plants remained.	No.2 site, No.3 site and No.4 site	inffered N-value: more than 50
Mesozoic	Cretaceous–Triassic (64 – 242)	Korat group	Sandstone, siltstone and shale: reddish-brown to brown. Conglomeratic sandstone, conglomerate and dolomitic limestone: with closs-bedding and ripple mark. Occasionally lenses of gray limestone and dolomite intercalated. Fossil plants remains and bivalves in some beds.		
Palaeozoic	Permian–Carboniferous (242-360)	Ratburi group	Limestone: light gray to dark gray, brownish-gray and reddish-gray, thin-bedded to massive, with calcite veins and chert nodules, fossiliferous. Dolomitic limestone and dolomite: gray, brownish-gray and yellowish-brown, thin-bedded to massive, locally brecciated.	Sin Pun and Krabi candidate limestone quarries	
Palaeozoic	Permian–Carboniferous (242-360)		Sandstone: brown and grayish-green, medium- to fine-grained. Chert: white and pale brown, fossiliferous. Siltstone: brown, siliceous. Mudstone: black and gray, thick-bedded, siliceous, fossiliferous. Pebbly mudstone: gray and dark gray, massive.		
Palaeozoic	Carboniferous –Silurian (284-436)	Tanaosi group (Kanchanaburi formation)	Shale, sandy shale, siliceous mudstone, sandstone and slate: yellowish-brown, grayish-brown, greenish-gray to dark gray, well-bedded, abondant drag folds and fossiliferous. Locally siltstone, limestone lenses, calcareous mudstone, calcareous sandstone and chert.		
Palaeozoic	Ordovician (436 – 500)	Thungsong group	Limestone: dark gray, thin-bedded to massive, with argillaceous layers. Shale: brown, with brachiopods.	Thung Song limestone quarries	
Palaeozoic	Cambrian (500 – 564)	Tarutao group	Sandstone, quartzite, shale and phyllite: yellowish-brown and brown.		
Mesozoic –Palaeozoic		Igneous rocks (granite)	Biotite-muscovite granite, biotite-hornblende granite, biotite granite and porphyritic granite.		

Note: This geological map is compiled from Geological Map of Thailand (1/250,000) "CHANGWAT PHANGNGA" (1976), "CHANGWAT NAKHON SI THAMMARAT" (1976), "CHANGWAT PHUKET" (1977) and "CHANGWAT SONGKHLA" (1979) published by Department of Mineral Resources and Geological Map, Sin Pun Area (1/50,000), made by Electricity Generating Authority of Thailand.

SYMBOLS

- Geologic boundary
- Fault
- 10 Strike and dip of bed
- Anticline
- Syncline
- [3] Candidate site and its No.
- ③ Candidate limestone Quarry and i

LEGEND

AGE		GROUP	LITHOLOGY	
Cenozoic	Quaternary	Alluvial deposit	Qa	Gravel, sand, silt, caly and beach sand.
		Terrace and colluvial deposit	Qt	Gravel, sand, silt and caly.
	Tertiary	Krabi group (Sin Pun group)	T	Shale, calcareous shale, sandstone and siltstone. Limestone, lignite, oil shale and gypsum locally intercalated.
Mesozoic	Cretaceous–Triassic	Korat group	CT	Sandstone, siltstone and shale. Conglomeratic sandstone, conglomerate and dolomitic limestone with closs-bedding and ripple mark. Occasionally lenses of limestone and dolomite are intercalated.
Palaeozoic	Permian–Carboniferous	Ratburi group	PCR	Limestone: thin-bedded to massive, with calcite veins and chert nodules. Dolomitic limestone and dolomite: thin-bedded to massive, locally brecciated.
		———	PC	Medium- to fine-grained sandstone. Chert. Siliceous siltstone. Thick-bedded siliceous mudstone. Massive pebbly mudstone.
	Carboniferous–Silurian	Tanaosi group (Kanchanaburi formation)	CS	Shale, sandy shale, siliceous mudstone, sandstone and slate: well-bedded, abundant drag folds. Locally siltstone, limestone lenses, calcareous mudstone, calcareous sandstone and chert.
	Ordovician	Thungsong group	O	Thin-bedded to massive limestone with argillaceous layers, and Shale.
	Cambrian	Tarutao group	C	Sandstone, quartzite, shale and phyllite.
Mesozoic–Palaeozoic		Igneous rocks (granite)	G	Biotite-muscovite granite, biotite-hornblende granite, biotite granite and porphyritic granite.

0 5 10 15km

IANGWAT PHANGNGA" (1976),
SONGKHLA" (1979)
1/50,000), made by

SYMBOLS

- Geologic boundary
- Fault
- 10 Strike and dip of bed
- Anticline
- Syncline
- [3] Candidate site and its No.
- ③ Candidate limestone Quarry and its No.

SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT

Geological Map of Sin Pun and Krabi Area

Fig. 4-4

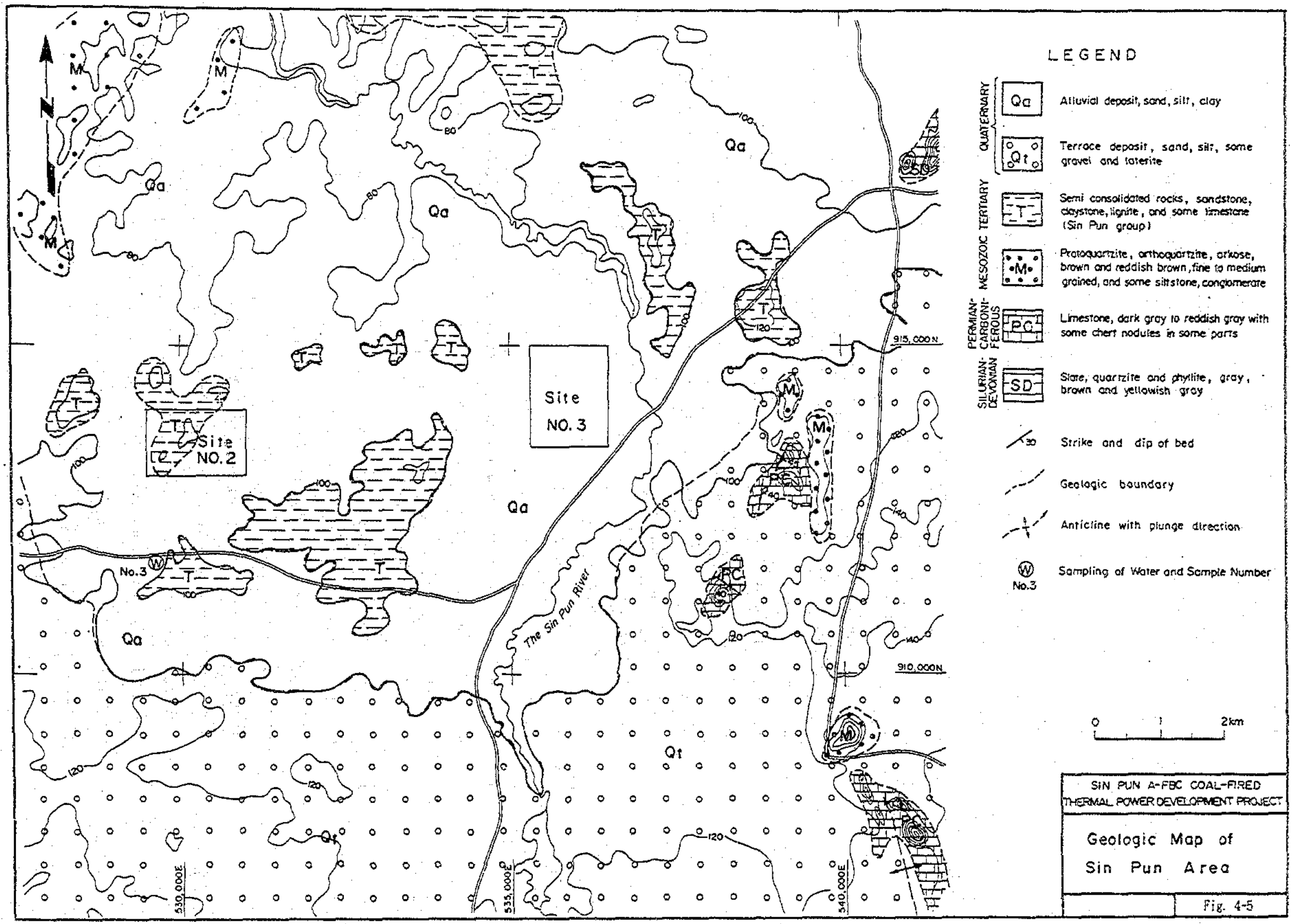
some environment on the coastal area. (In the geological map by DMR, this group is called Krabi group.) The sedimentary rocks in plain region are covered with alluvial deposit of less than 1 m to 10 m thickness or terrace and colluvial deposit (see Fig. 4-5).

Fig. 4-6 shows the Geological map of Sin Pun group. The general strike of beds of Sin Pun group is in east-west direction and their dip is about 10-30°N. There are two major systems of NW-SE and NE-SW normal faults.

2) Geology of Site No. 2

According to the drilling information performed by EGAT, the Sin Pun group can be classified into 3 formations, namely, Muang En formation, Bang Sai formation and Kuan Plea formation in ascending order. The bedrock of the site No. 2 is inferred to be Muang En formation which consists of semiconsolidated and consolidated sedimentary rocks such as claystone, siltstone, mudstone, sandstone, conglomerate and limestone. According to the geologic map made by EGAT (1987), a NE-SW strike normal fault with dip angle about 70-80° exists in the western part of the site. The length of the fault is about 20 km and the displacement is more than several tens of meters. (see Fig.4-6) The accurate location and the geotechnical condition of the shear zone of the fault are not known, however, there will be no big problem about the fault in this project.

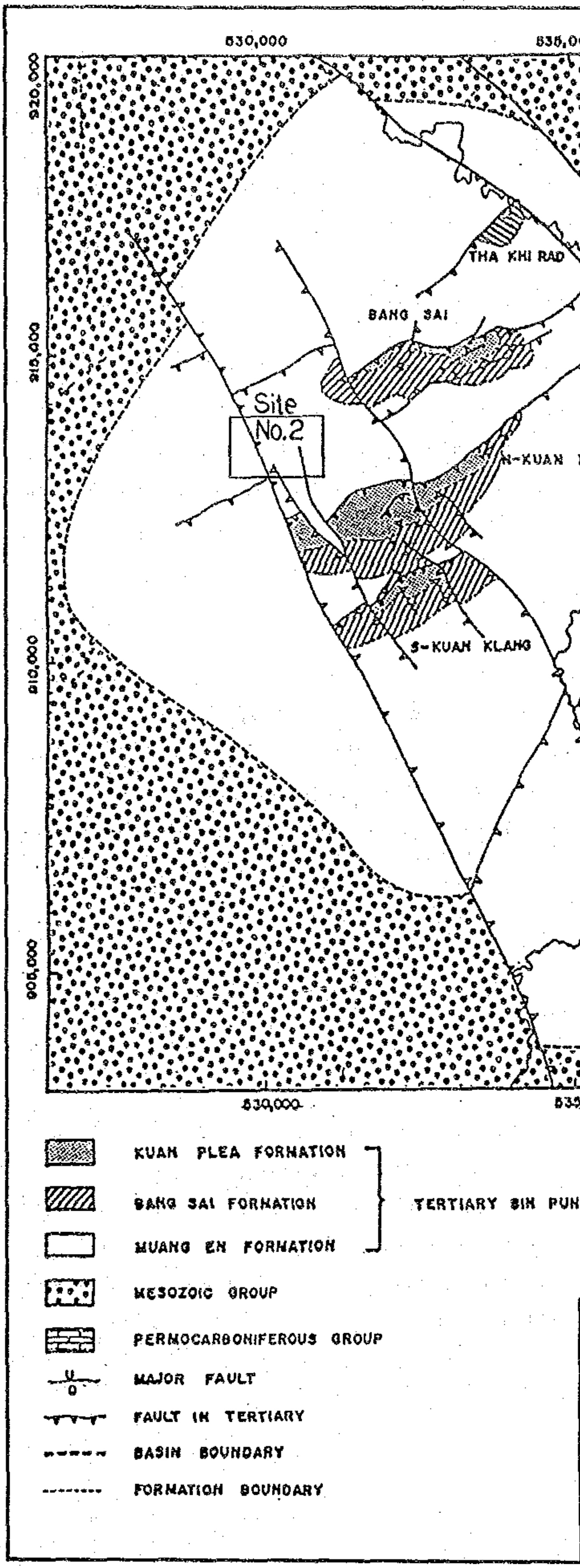
No outcrop except for highly weathered top soil which is composed of brownish-gray sandy silt was found in the area of site No. 2. Alluvial deposit is supposed to be distributed only in the east part of the elevation of which is relatively low and not to be distributed in the proposed plant yard. The thickness of top soil and residual soil of the plant yard will be 2 to 3 m. The bedrock of the plant yard which consists of Tertiary sedimentary rock will be highly weathered near the ground surface, however, it will be possible to use the bedrock for the foundation of the plant by the excavation of several meters depth near the ground



SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT

Geologic Map of Sin Pun Area

Fig. 4-5



SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT

Tertiary Geologic Map of Sin Pun Basin

Fig. 4-6

surface. While the proposed ash disposal area is located in the east part of the area of the site, where the maximum thickness of alluvial deposit is estimated from the drilling data for lignite mine to be about 5 m. (see Fig. 4-3) The geologic conditions of the site are summarized in Table 4-6.

3) Result of Simple Seismic Prospecting

Simple seismic prospecting by hammering method was carried out by JICA team for the purpose of grasping the surface geologic conditions. The prospecting line is located in the south part of the area of the site as shown in Fig. 4-3. The measurement was performed by the use of single channel handy seismograph (Handy Seis, PS-1 Model-1814, made by OYO Corp. (Japan)). The prospecting line was 30 m long.

The data were analyzed by Hagiwara's method as shown in Fig. 4-7. The result shows two velocity layers, 500-600 m/s layer and 1,100 m/s layer. The 1st layer with the thickness of 1 to 2 m will correspond to top soil and extremely weathered bedrock, Muang En formation. The 2nd layer will correspond to the highly weathered bedrock.

4) Hydrogeology of Site No. 2

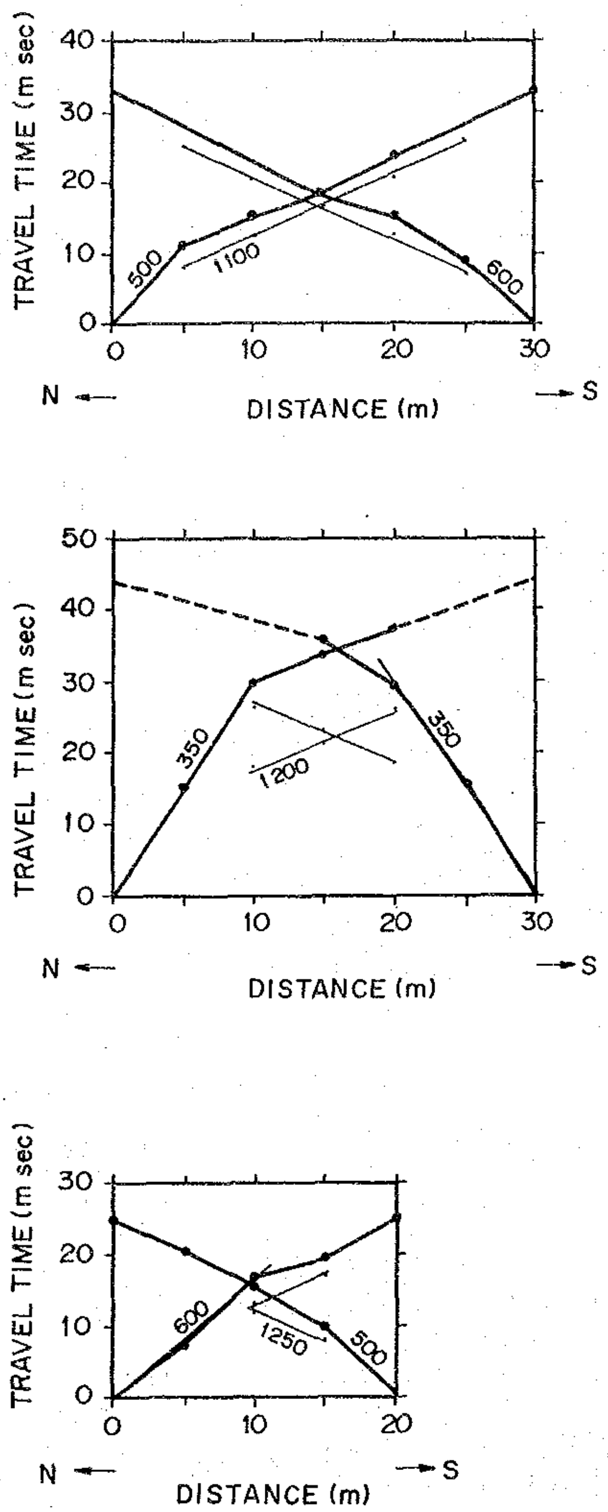
(a) Ground Water Level

The hydrogeological investigations carried out by EGAT indicated that the ground water level of the site is 1-6 m below the ground surface. The ground water levels in the wells observed at the time of field reconnaissance by JICA team were also 4-5 m below the ground surface. Judging from these data, it can be said that the ground water level of the site is rather high.

Table 4-6 Geologic Conditions of Each Candidate Site

Site No.	Sin Pun No.2	Sin Pun No.3	Krabi No.4
Location	4 km to the southwest of Bang Sai lignite area	3 km to the east of Bang Sai lignite area	500m to the north of existing Krabi pawer plant
Topography	gentle hill with the change of elevation in about 14 m	gentle hill with the change of elevation in about 12 m	plain with the change of elevation in about 2 m
Surface Deposits •Name •Age	 Alluvial deposit (unconsolidated) Quarternary Holocene (10,000 years before ~ Present)		
•Component	sand, sandy silt, silt, clay		sandy silt, silt, clay
•Thickness	plant yard : not distributed (residual soil : 2-3m) ash disposal are : 1-5m	plant yard : not distributed (residual soil : 2-3m) ash disposal are : 5-8m	plant yard : 0-1m (residual soil : 0-2m) ash disposal are : 0 m ? (residual soil : 1-2m?)
•Estimated * Wet Density Shear Strength	ρ=2.1 g/cm³ C=0.02 MPa ϕ=26°		ρ=1.9 g/cm³ C=0.02 MPa ϕ=22°
Bedrock •Name •Age •Component	 Sin Pun group, Muang En formation Tertiary sandstone, siltstone, claystone, limestone		 Krabi group, Bang Pu Dum form. Tertiary sandstone, siltstone, claystone
•Thickness	more than 100 m	more than several tens meter	more than several tens meter
•Estimated * Wet Density Shear Strength	ρ=2.2 g/cm³ C=0.04 MPa ϕ=30°		ρ=2.3 g/cm³ C=0.16 MPa ϕ=34°
Permeability	k=10^{-7}~10^{-8}cm/s (mainly), 10^{-5}~10^{-4}cm/s (partly)		
Surface Water	the Bang Kam Prat river flow rate : 0.3 t/s water temperature : 28.7°C date & time: Mar.9 '91, 11:44	the Sin Pun river flow rate : 0.3 t/s water temperature : 30.5°C date & time: Mar.8 '91, 12:25	the Pakasai river distance to the sea: 7 km water temperature : 31.0°C date & time: Mar.15 '91, 10:20
Ground Water Level	1 - 6 m below the ground surface		not more than 2 or 3 m below the ground surface

* Based on SIN PUN COALFIELD GEOTECHNICAL AND HYDROGEOLOGICAL INVESTIGATIONS (EGAT, 1989) and FEASIBILITY STUDY KRABI MINE EXPANSION PROJECT FOR POWER PLANT UNIT 4 (EGAT, 1988)



Sin Pun No.2 Site

velocity of 1st layer

v_1 = 500~600m/s

velocity of 2nd layer

v_2 = 1100 m/s

thickness of 1st layer

h_1 = 1~2m

Sin Pun No.3 Site

v_1 = 350 m/s

v_2 = 1200 m/s

h_1 = 4~5m

Krabi No.4 Site

v_1 = 500 ~ 600 m/s

v_2 1250 m/s

h_1 = 1~3m

Fig. 4-7 Results of Seismic Prospecting (Time-Distance Curve)

(b) Permeability

The Permeability of the bedrock of the site is very low (10^{-6}-10^{-7}cm/s) except for permeable limestone, sandstone and the highly weathered part near the ground surface according to the existing packer test results carried out by EGAT.

(c) Water Chemistry

The results of measurements and analyses of surface water and ground water are indicated in Table 4-7. The high electric conductivity value which means high dissolved ion content is characteristic of the water of the site. The investigation mentioned above was carried out in dry season and the results may be different in rainy season to some extent.

Table 4-7 Chemistry of Surface Water and Ground Water

Sample No.	Site No.	Location	Water Type	In Situ Measurment: Date Time	Water Temp. (°C)	E.C. (μS/cm)	pH	Water Quality Analyses (mg/ℓ) Chemical Composition: Na^+	T-Na	K^+	S-Fe	T-Fe	Cr^{6+}	T-Cr	Cl	SO_4^{2-}	SiO_2	NH_4	M-Alk.	TDS	SS	BOD	Remark
1	2	Well in the middle of the site *	Ground water	Mar.9 '91 12:10	26.5	460	7.5	(not analyzed)															Ground water level: -4.5m
2	2	The Bang Kam Prat river *	River water	Mar.9 '91 11:40	28.7	222	7.6	(not analyzed)															Discharge: 0.3t/s
3	2	Well to the south of the site **	Ground water	Mar.8 '91 14:00	28.2	672	7.2	16	18	4.5	–	3.8	–	0.01	16	6	8.7	1.5	320	380	10	8.6	
4	3	Well in the south of the site ***	Ground water	Mar.8 '91 13:00	27.7	70	6.2	4.5	5.8	1.1	–	0.03	–	–	6	3	5.5	0.9	18	50	4	19	Ground water level: -4.5m
5	3	The Sin Pun river (left bank) ***	River water	Mar.8 '91 12:15	30.7	527	7.8	3.2	6.0	1.7	0.01	0.27	–	0.01	8	42	8.9	1.0	160	380	13	2.0	Discharge: 0.3t/s
5'	3	The Sin Pun river (center of river) ***	River water	Mar.8 '91 12:25	30.5	530	7.8	(not analyzed)															Discharge: 0.3t/s
6	2&3	Bang Kam Prat wier ****	River water	Mar.8 '91 14:50	31.3	271	8.0	3.1	4.9	2.9	0.06	3.4	–	0.01	6	6	8.7	1.1	120	160	14	24	
7	2&3	Bang Kam Prat reservoir ****	River water	Mar.8 '91 15:30	31.8	132	8.7	2.9	3.5	4.5	0.02	0.18	–	–	5	6	7.8	0.9	55	100	7	7.3	
8	2&3	Bang Kam Prat dam outlet ****	River water	Mar.8 '91 15:50	27.6	169	7.6	(not analyzed)															

E.C. : Electric Conductivity
TDS : Total Dissolved Solid
– : less than 0.01 mg/ℓ
T- : Total
SS : Suspended Solid
S- : Soluble (ϕ<0.5-1 μm)
M-Alk. : Methylorange-Alkalinity
BOD : Biochemical Oxygen Demand

* : see Fig. 4-3 ** : see Fig. 4-5 *** : see Fig. 4-14 **** : see Fig. 4-11

(4) Lignite Supply (Site No. 2)

All lignite for the site No. 2 is supplied from Sin Pun deposit for the A-FBC 2 x 75 MW. The lignite is transported by 31.8 ton truck from the mine to the coal storage yard in the site No. 2. The transportation route of the lignite is shown in Fig. 4-8 with the route (A).

The premises for the calculation of the coal transportation cost are taken as shown in Table 4-8 site No. 2 column.

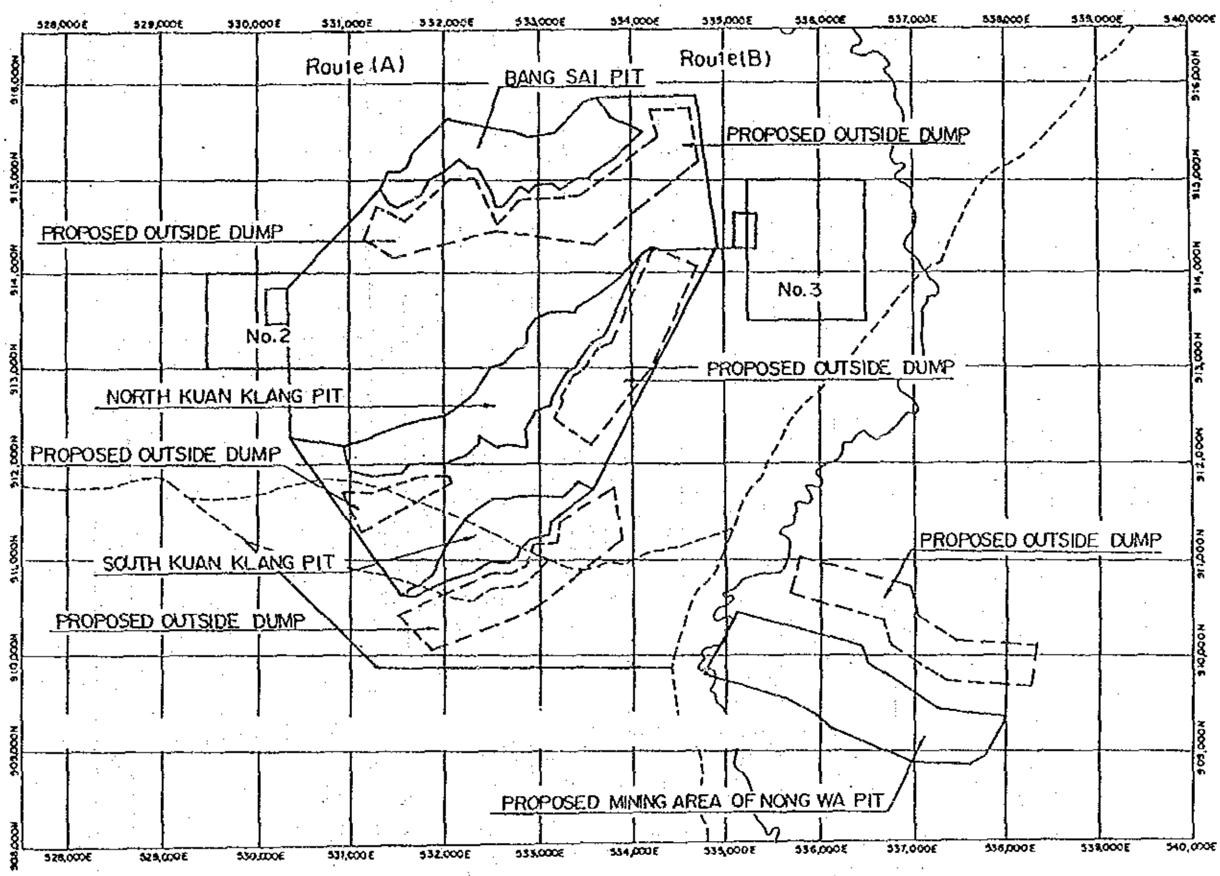
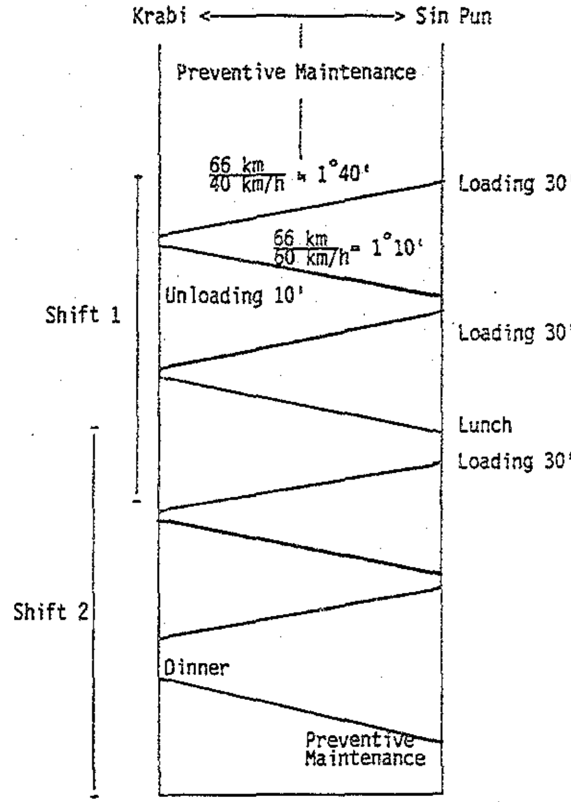


Fig. 4-8 Lignite Supply Route for Site No.2 and Site No.3

Table 4.8 Estimation Premises for Transportation Cost of Lignite

Item	Sin Pun Site No. 2	Sin Pun Site No. 3	Krabi Site No. 4
Amount of Coal Total Annual	22.4 million ton (Sin Pun Ligute) 0.897 Million ton	<---	19.5 Million ton (Sin Pun Lignite) 0.778 Million ton (Sin Pun Lignite) (Plus) 4.9 Million ton (Krabi Lignite) 0.194 Million ton (Krabi Lignite)
Distance from mine to coal storage yard (Average) [km]	3.6 km/ton	3.8 km/ton	Sin Pun mine to Sin Pun coal storage yard - 3.6 km/ Krabi mine to krabi coal storage yard - 3.0 km/
Distance from Sin Pun coal storage yard to Krabi's [km]	-	-	66
Truck Life time	8 years	<---	8 years for 31.8 ton Truck, 10^6 km for 25 ton Truck
Capacity [ton]	31.8 (469 PS)	<---	31.8 from mines to coal storage yard 11 between coal storage yards
Number	9	<---	8 (Sin Pun) + 2 (krabi) = 10 for 31.8 ton truck 30 for 25 ton truck
Fuel Ratio per coal ton	0.063 ℓ/ton.km	<---	0.063 ℓ/ton km for 31.8 ton truck 0.047 ℓ/ton km for 25 ton truck
Oil cost			
Fuel Oil	0.33 U$/ℓ	<---	<---
Other Oil	Fuel Cost x 20%	<---	<---
Truck Cost (Baht)	5,400,000	<---	5,400,000 for 32 ton truck 2,870,000 for 25 ton truck
Maintenance cost/year	Truck cost x 5%	<---	<---
Labour and annual cost Additioned for coal transportation	Base	Base	U$ / K U$ Division chief 1 17,500 17.5 Administration 5 5,500 27.5 Driver 93 4,480 416.64 Electrician 5 5,890 29.45 Fitter 30 7,570 227.1 Welder 20 5,650 113 Rolief 10 4,660 46.6 877.79
Discount Rate %	10.0	<---	<---

Item	Sin Pun Site No. 2	Sin Pun Site No. 3	Krabi Site No. 4
Truck Operation	Base	Base	

(5) Limestone Supply (Site No. 2)

The following four points are investigated for the limestone supply.

i) Khao Tham Hora

ii) Thung Song

iii) Khao Tham Padam

iv) Wat Khao Din

Table 4-9 shows the results of reconnaissance.

Table 4-9 Results of Reconnaissance of Candidate Limestone Quarry for Sin Pun Sites

Site Name	Khao Tham Hora	Thung Song	Khao Tham Padan	Wat Khao Din
No. in Map*	1	2	3	4
Distance from No.2 Site from No.3 Site	12km(to southeast) 9km(to southeast)	40km(to east) 35km(to east)	23km(to southeast) 22km(to southeast)	9km(to east) 4km(to southeast)
Quantity (Mt)	about 13	more than 100	more than 100	about 5
Geology Rock Name	Limestone	Limestone	Dolomitic Limestone	Limestone and Muddy limestone
Age ($x\ 10^6$ years before)	Carboniferous ~ Permian (240~360)	Ordovician (440~500)	Carboniferous ~ Permian (240~360)	Carboniferous ~ Permian (240~360)
Color	Gray	Dark gray	Gray	Gray, Black, Brown
Feature	Massive limestone with many calcite veins and some fault breccia zones cemented by calcite veins	Massive limestone without remarkable intercalated beds or veins	Massive limestone without remarkable intercalated beds or veins (Note: The part observed in field was the very small part of all.)	Partially mudstone and muddy limestone are intercalated. The ratio of pure limestone will be small.
Utilization of Limestone	The site had been used for a quarry before.	There are many quarries under production.	Not used	A cave was being used for a small temple.
Utilization of Nearby Land	There are not any house and field.	There are not any house and field.	There are a house and field.	There are a house and field.
Road Condition	Paved road of 8 m width	Paved road of 8 m width	Unpaved road of 4 m width	Paved road of 8 m width

* See Fig. 4-4

In selecting the candidate limestone, three tests, such as Component Analysis, Difference Thermal Analysis and Reduction Ratio Test, were carried out to check the suitability of limestone for A-FBC.

The results of each test for the above limestone are shown in Table 4-10 together with the reference data for the limestones applied in Wakamatsu A-FBC 50 MW in Japan.

The comments on each test result are as follows;

1) Component Analysis

(a) The content of $CaCO_3$ of the both limestone in Khao Tham Hora and Thung Song is relatively high for the desulferizing materials, while the others, namely Khao Tham Padam and Wat Khao Din are relatively low.

(b) Silica content of Wat Khao Din is very high to wake the erosion problem on the inner tube materials of A-FBC. Silica content of Khao Tham Hora and Thung Song is relatively high but can be available by the suitable drain of the bed materials from the fluidized bed. The limestone of Khao Tham Padam has no problem on the aspect of silica content.

(c) The content of Al, Fe and Na is not high in the limestone from Khao Tham Hora, Thung Song and Khao Tham Padam to make the agglomeration problem in the fluidized bed, while the Wat Khao Din has high content of Al.

(d) From the component analysis, the limestone from Wat Khao Din is not recommendable to apply and the limestones from Khao Tham Hora and Thung Song are preferable to apply.

Table 4-10 Analysis Result of Limestone for Sin Pun Site (Site No. 2 and Site No. 3)

Name of Limestone	Test Result				Reference Data (Limestone applied in Wakamatsu FBC 50 MW)	
	Khao Tham Hora	Thung Song	Khao Tham Padam	Wat Khao Din	Funao	Sekino-yama
Component Analysis						
$CaSO_4$ wt%	-	-	-	-	<0.1	<0.1
$CaCO_3$ wt%	91.6	89.2	66.9	61.5	99.26	98.89
CaO wt%	0.71	0.42	1.74	1.36	<0.1	<0.1
SiO_2 wt%	6.35	3.01	0.12	24.8	0.05	0.03
Al_2O_3 wt%	0.21	0.83	0.03	4.18	-	-
Fe_2O_3 wt%	0.034	0.31	under 0.01	1.75	-	-
$MgCO_3$ wt%	0.61	5.71	28.0	2.82	-	-
MgO wt%	0.036	0.02	0.62	0.05	-	-
Na_2O wt%	0.002	0.001	0.0016	0.006	-	-
Differential Thermal Analysis						
Ignition Loss wt%	40.45	42.18	44.01	30.53	43.1	43.0
Decarboxylation Temp. °C	747.7	750.3	740.2	738.1	782.5	785.9
Reduction Ratio (*)	2.3	0.9	0.8	2.9	5.9	0.6

(*) Reduction Ratio

The test was carried out to check whether the limestone can contribute to the desulfurization before flying out from the fluidized bed.

The test was carried out with the following procedure.

1. To size the diameter of limestone between 1.41 mm to 2.00 mm
2. To burn the limestone three hours with 900°C
3. To pulverize 10 g of the above burn limestone within the capsule 70 mm diameter x 65 mm depth under 479 ~ 483 rpm
4. To screen the pulverized limestone with 0.5 mm sieve
5. To measure the weight of passing limestone through 0.5 mm sieve.

2) Differential Thermal Analysis

The profiles of the differential thermal analysis are shown in Fig. 4-9. The decarboxylation temperature of all limestones are about 30 ~ 40°C lower than that of the limestones applied in Wakamatsu A-FBC. (See Appendix II for the differential thermal analysis)

3) Reduction Ratio

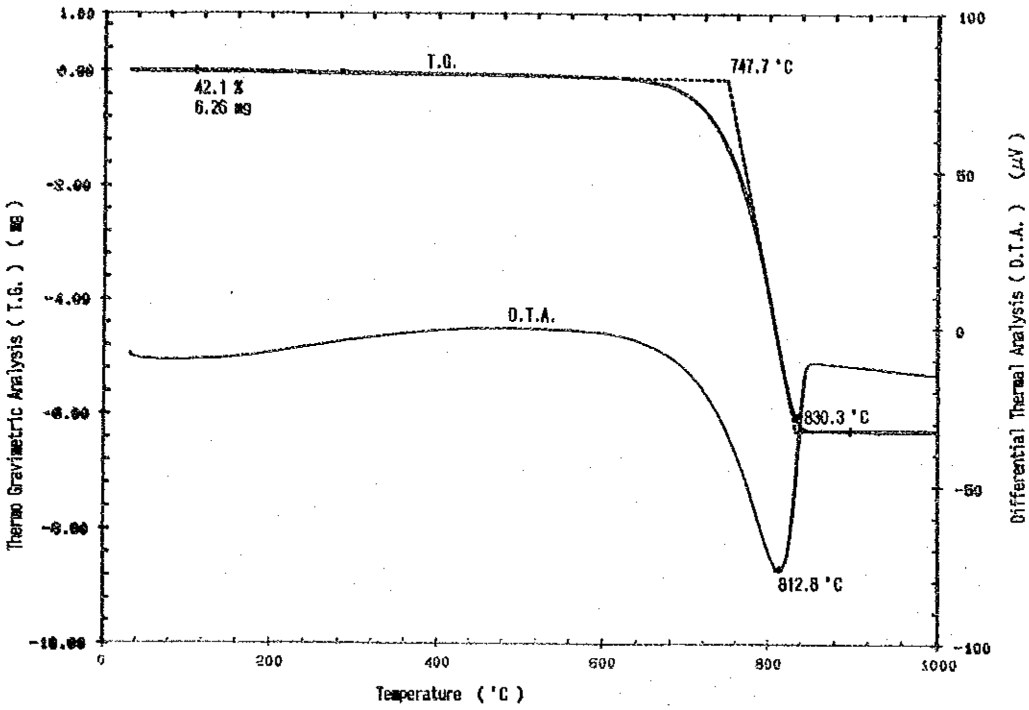
The test was carried out to check whether the limestone can contribute to the desulferization before flying out from the fluidized bed. The passing rate of each limestone is relatively low, therefore the limestones could remain for long period in the fluidized bed with contributing to the desulferization.

From the above points, both limestone of Khao Tham Hora and Thung Song can be judged available for A-FBC desulferizing materials. Since Thung Song is located 50 km far from Sin Pun site and the transportation cost affect on the generating cost of the electricity, the limestone at Khao Tham Hora is recommended to apply for Site No. 2.

The transportation route of this limestone is shown in Fig. 4-10. The premises were taken for the calculation purpose of the transportation for limestone as shown in Table 4-11 Site No. 2 column.

Sample : KHAO THAM HORA

Sampling Time : 1.0 (sec)
Sample Weight : 14.863 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR



Sample : THUNG SONG

Sampling Time : 1.0 (sec)
Sample Weight : 14.960 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR

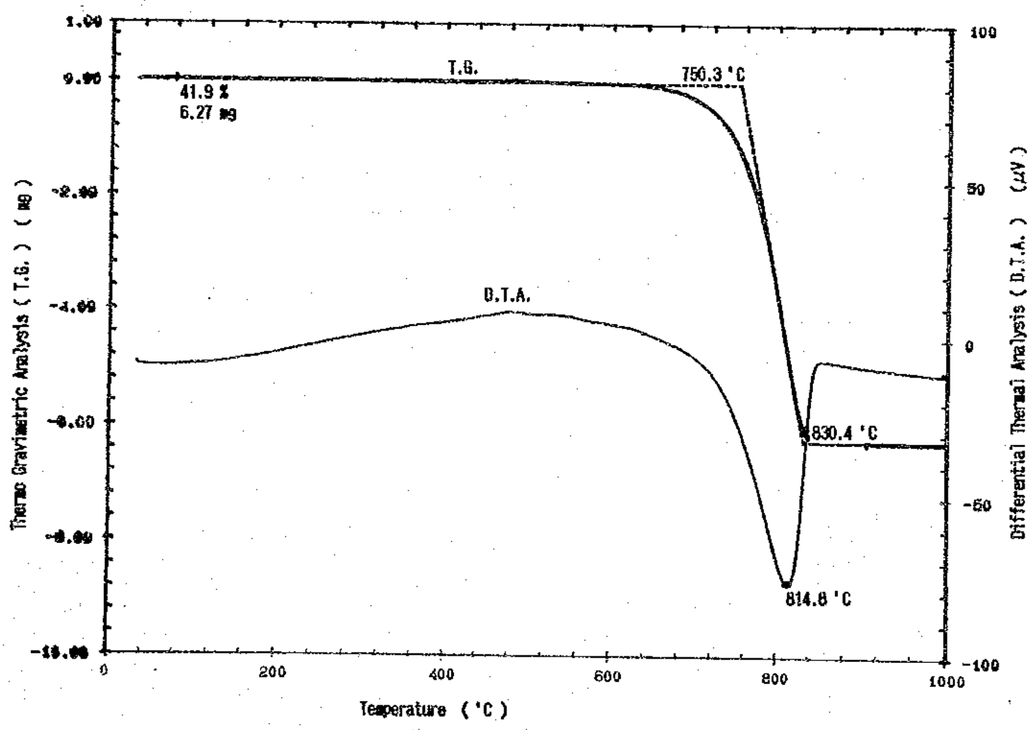
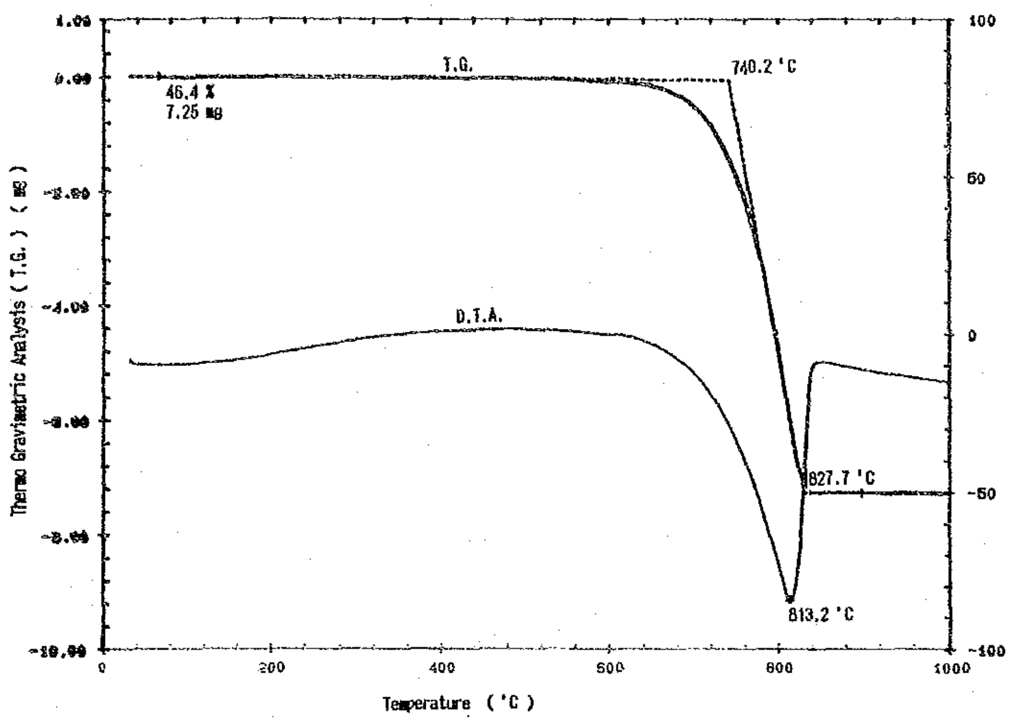


Fig. 4-9 Temperature Profile of Limestone in Sin Pun and Wakamatsu

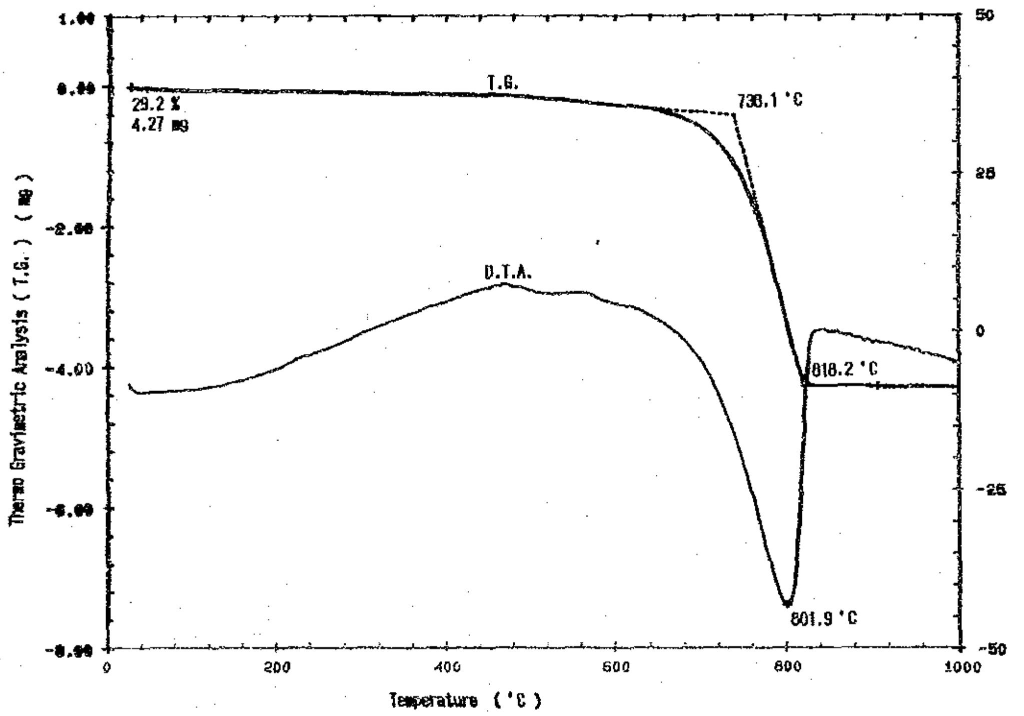
Sample : KHAO THAN PADAN

Sampling Time : 1.0 (sec)
Sample Weight : 15.626 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR



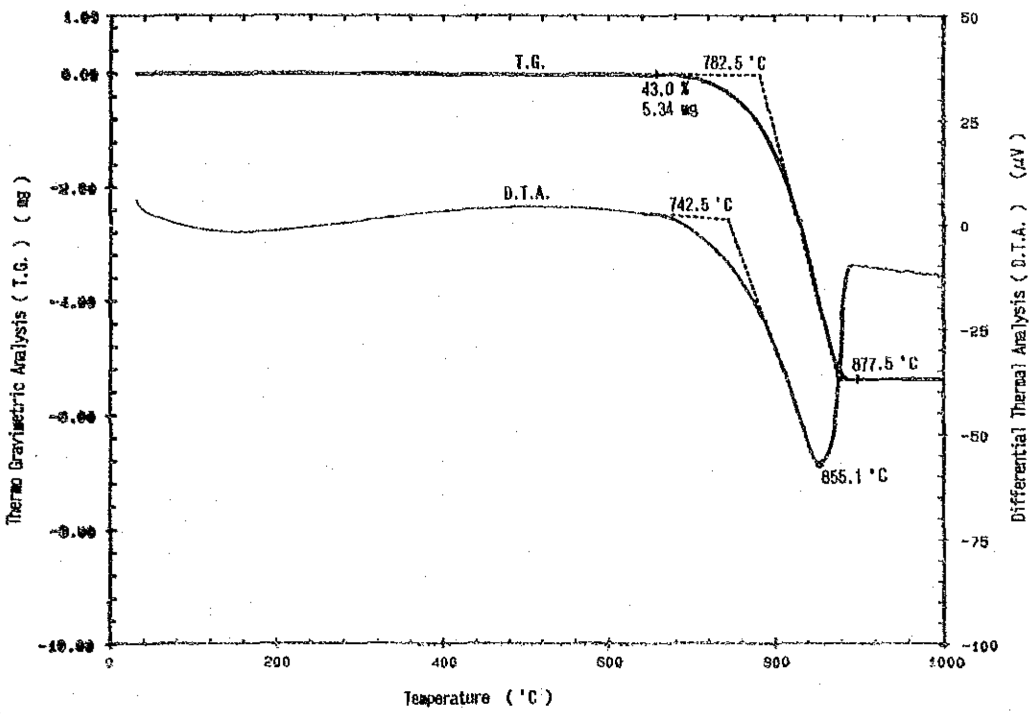
Sample : WAT KHAO DIN

Sampling Time : 1.0 (sec)
Sample Weight : 14.644 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR



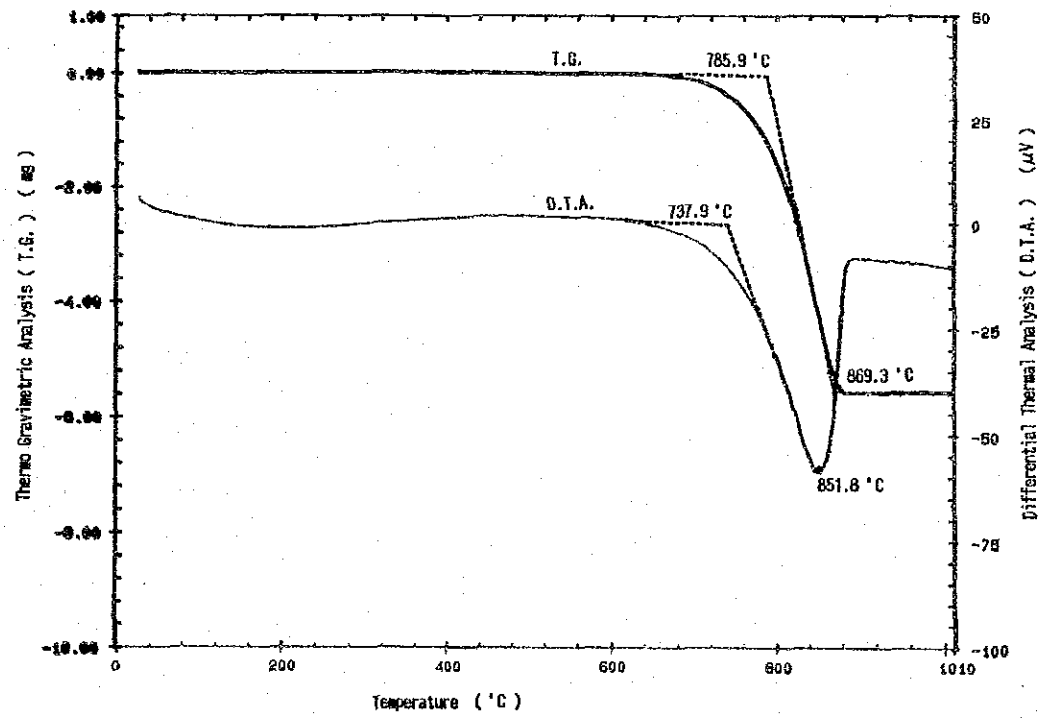
Sample : FUNAO (JAPAN)

Sampling Time : 1.0 (sec)
Sample Weight : 12.432 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR



Sample : SEKINOYAMA (JAPAN)

Sampling Time : 1.0 (sec)
Sample Weight : 12.981 (mg)
Heating Rate : 20.0 ('C/min)
Thermo Couple : PR



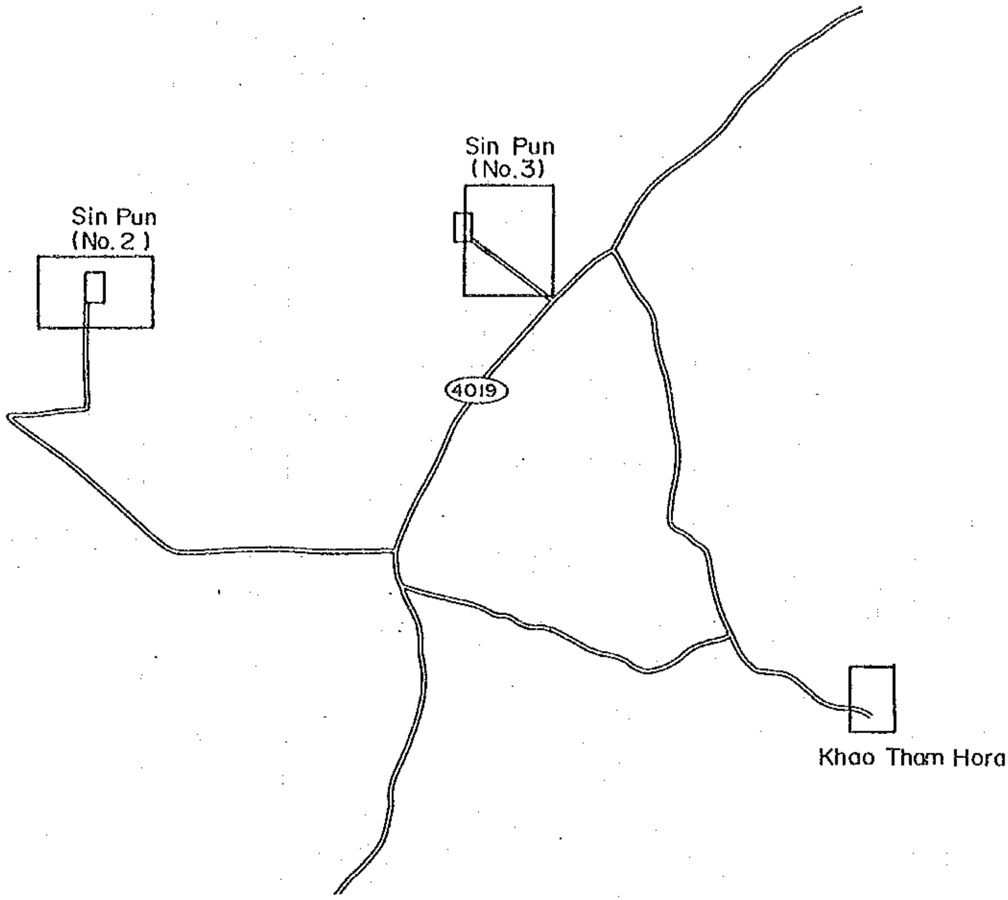


Fig. 4-10 Limestone Transportation Route for Site No.2 and Site No.3