THE KINGDOM OF THAILAND

FEASIBILITY STUDY ON SIN PUN A-FBC COAL-FIRED THERMAL POWER DEVELOPMENT PROJECT

FINAL REPORT

NOVEMBER, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY
ELECTRIC POWER DEVELOPMENT CO., LTD.

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EPDC JICA

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on Sin Pun A-FBC (Atmosphere - Fluidized Bed Combustion) Coal-Fired Thermal Power Development Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr.Hiroshi Isaka of Electric Power Development Company Ltd. 5 times during the period from March 1991 to September 1992.

The team held discussions on the project with officials concern of the Government of Thailand, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

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

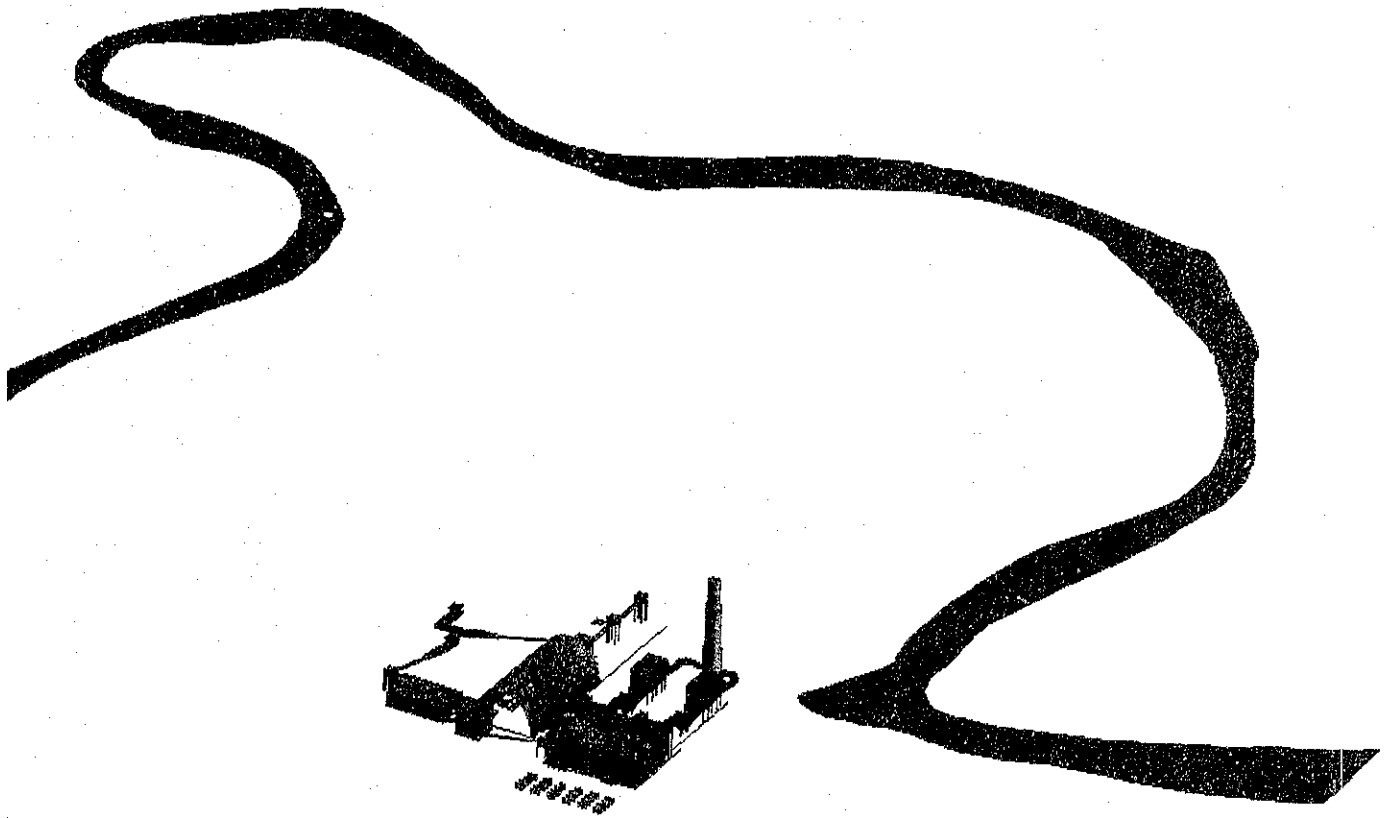
November 1992

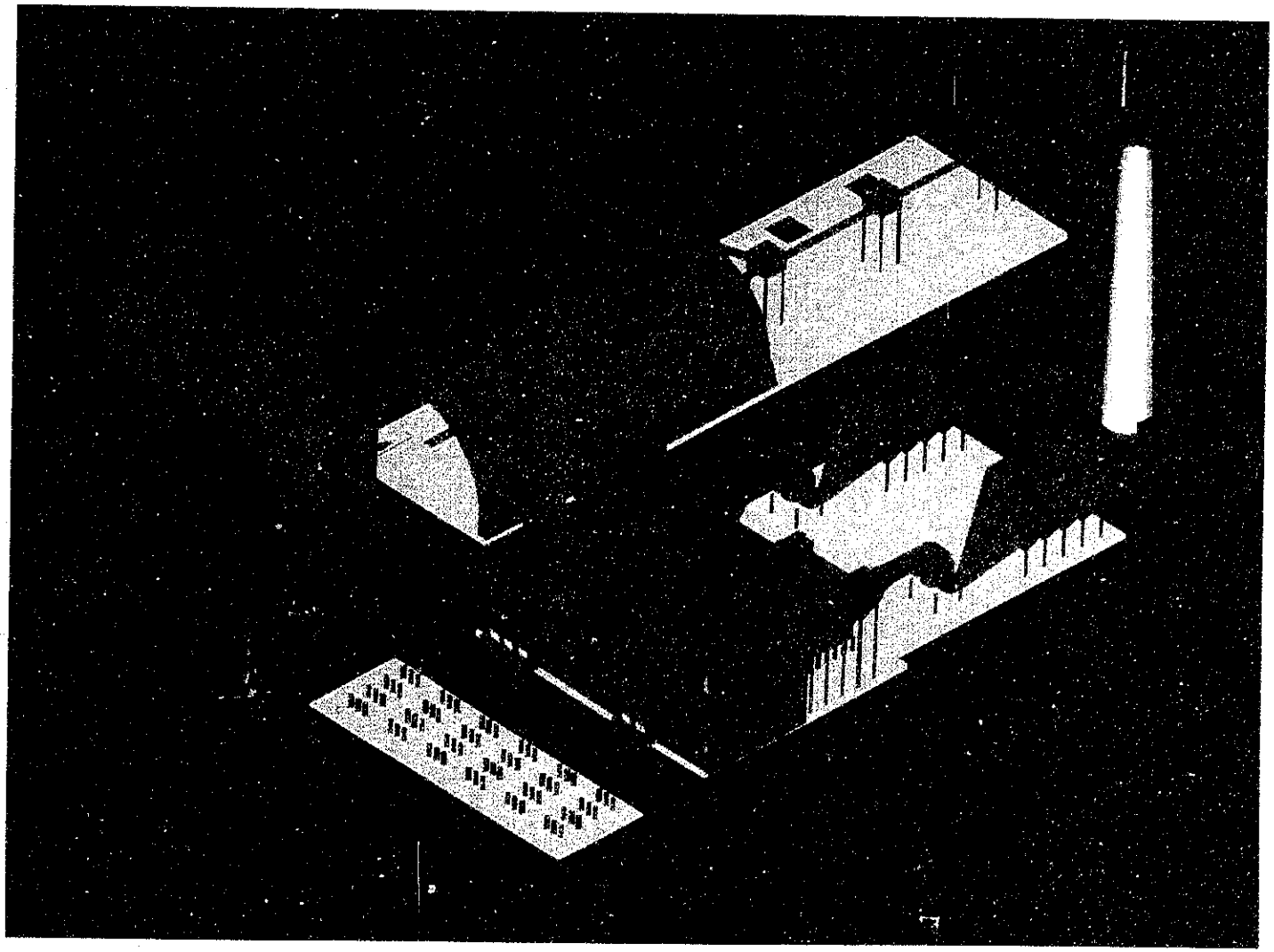
Kensuke Yanagiya

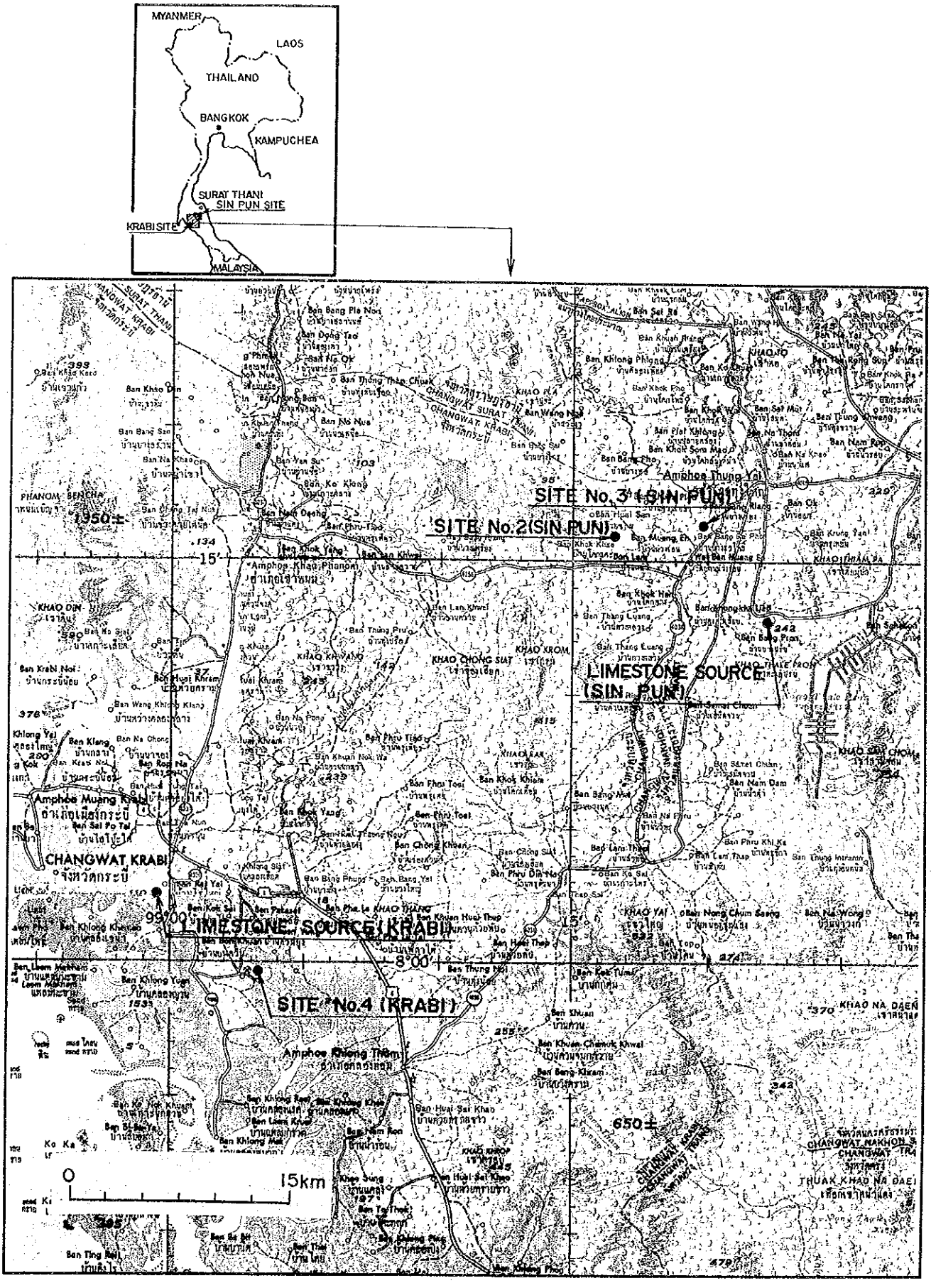
Kensuke Yanagiya

President

Japan International Cooperation Agency

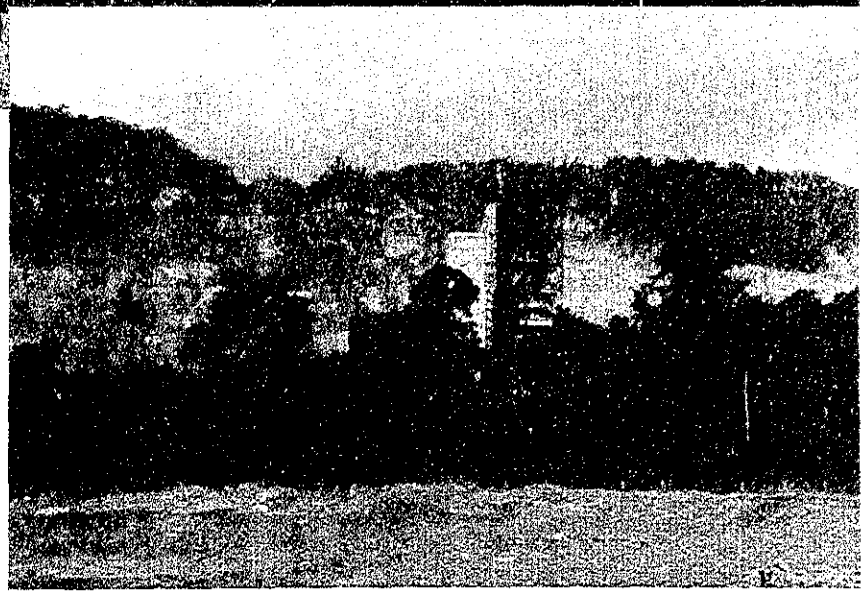





MYANMER
LAOS
THAILAND
BANGKOK
KAMPUCHEA
SURAT THANI
SIN PUN SITE
KRABI SITE
MALAYSIA
SITE No.3 (SIN PUN)
SITE No.2(SIN PUN)
LIMESTONE SOURCE (SIN PUN)
Amphoe Thung Yai
Amphoe Khao Phanom
Amphoe Muang Krabi
CHANGWAT KRABI
LIMESTONE SOURCE (KRABI)
SITE No.4 (KRABI)
Amphoe Khlong Thom
1950±
650±
99°00'
8°00'
15km

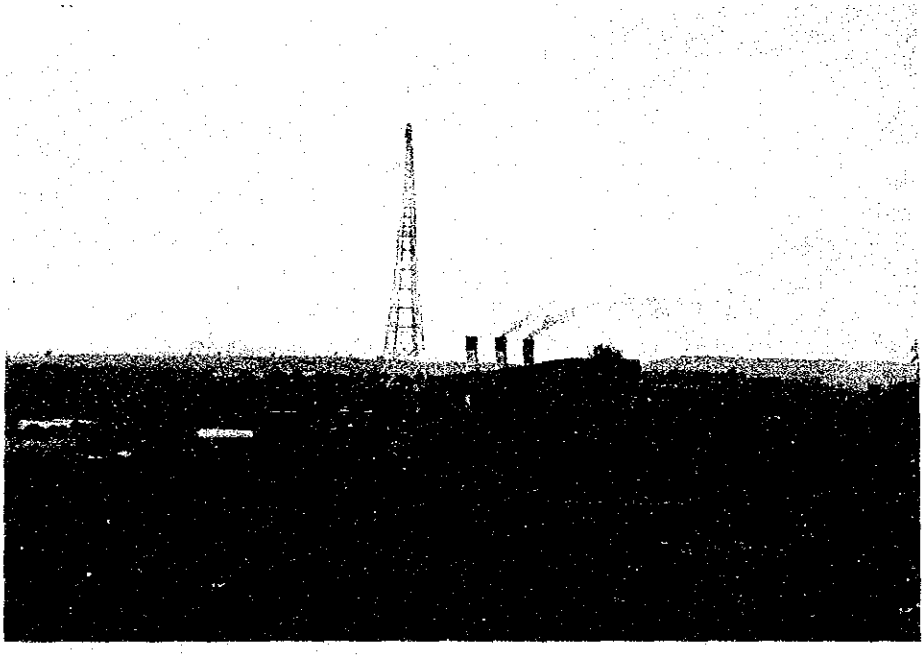
Krabi Site : View From Existing Ash Pond

Limestone Quarry in Sin Pun area

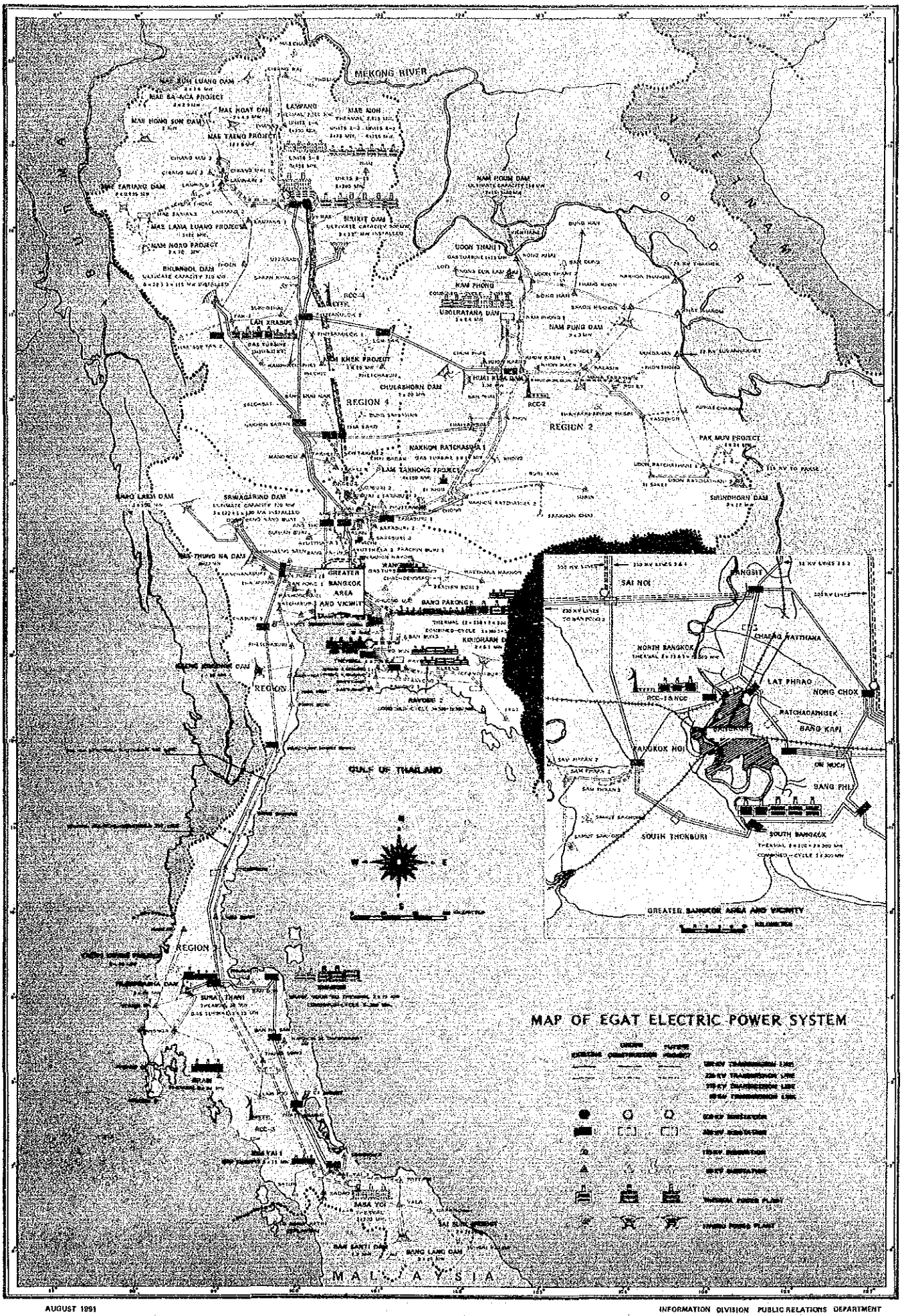


Cement Factory in Thung Song
(50 km from Sin Pun)

Krabi Lignite Mine



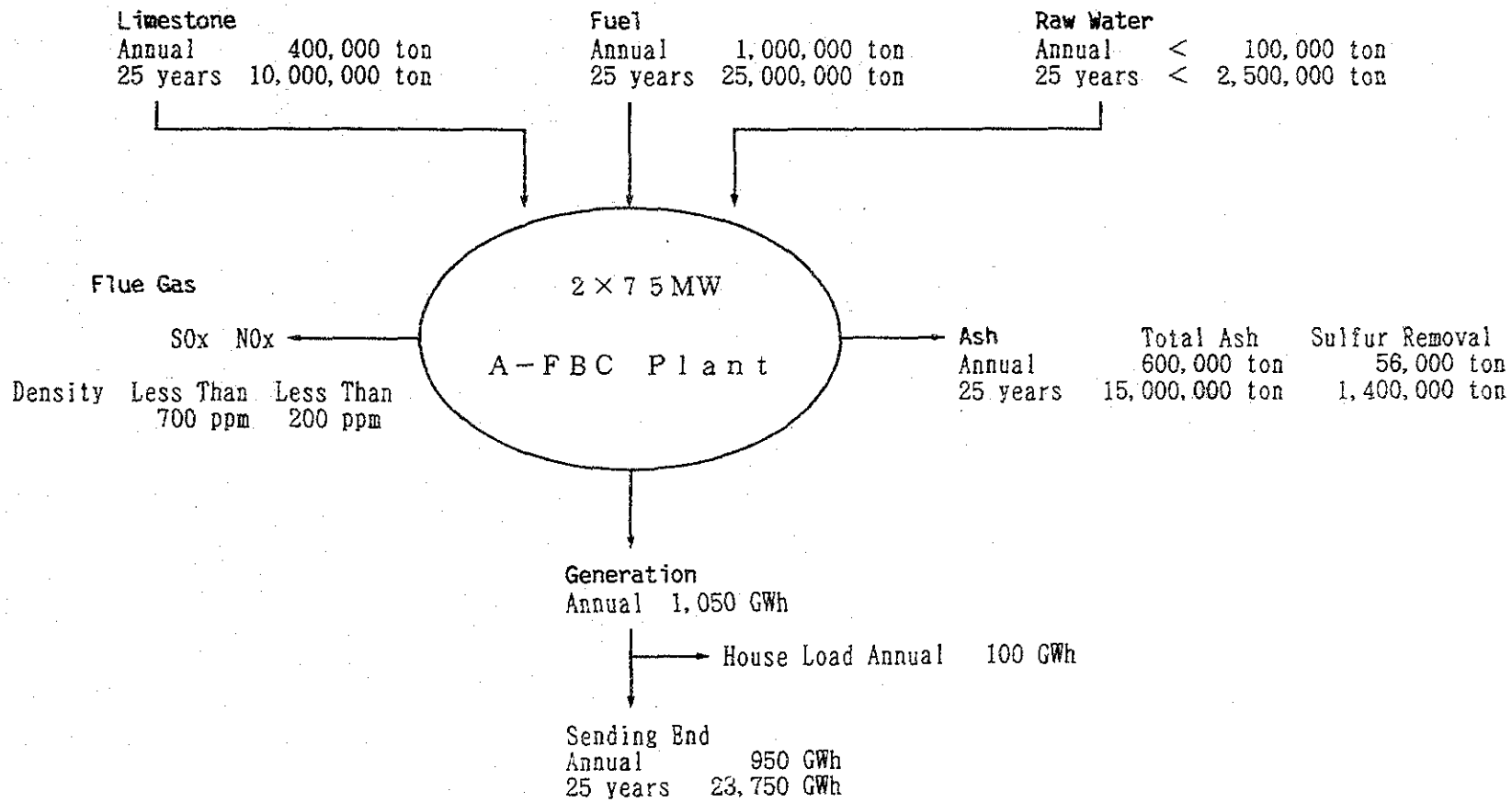
Krabi Power Station



MAP OF EGAT ELECTRIC POWER SYSTEM

AUGUST 1991

INFORMATION DIVISION PUBLIC RELATIONS DEPARTMENT



Material Balance of Sin Pun A-FBC Generating Scheme (Sin Pun + Krabi Lignite Case)

PLAN

E 507, 000

N 883, 500

N 883,000

N 882, 500

N

Existing Ash Sump

Pond

Khlong Pakasai

Khlong Pakasai

E 506, 500

E 506, 500

N882,900

300. 00

E 506,200

+3.50

+7.00

Existing Krabi Power Plant

+3.50

E 506,000

E 506,000

N 884,000

Pond

New Road

0 250m

LEGEND

No.	Facility
①	Stack
②	Turbine House
③	Switch Yard
④	Lignite Storage Yard
⑤	Limestone Storage Yard
⑥	Storehouse
⑦	Office
⑧	PR Building
⑨	Waste Water Treatment
⑩	C.W Intake
⑪	C.W Pump Pit
⑫	Inlet Pipe
⑬	Outlet Pipe
⑭	Outlet Pit
⑮	Discharge Channel

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

GENERAL PLAN

CONTENTS

UNITS AND GLOSSARIES

(1) Units

mm	:	Millimeter
cm	:	Centimeter
m	:	Meter
km	:	Kilometer
cm^2	:	Square centimeter
m^2	:	Square meter
km^2	:	Square kilometer
m^3	:	Cubic meter
MCM	:	Million cubic meter (for development planning)
kg	:	Kilogram
t	:	Metric ton
m^3/s	:	Cubic meter per second
kW	:	Kilowatt
kWh	:	Kilowatt hour
MW	:	Megawatt
GWh	:	Gigawatt hour
kV	:	Kilovolt
kVA	:	Kilovolt-Ampere
MVA	:	Megavolt-Ampere
MCM	:	Thousands of circular mils (for transmission line)
rpm	:	Revolutions per minutes
Hz	:	Hertz (cycles per second)
El.	:	Elevation
^oC	:	Degree in centigrade
mb	:	Millibar
%	:	Percentage
Lu	:	Lugeon value (rate of water loss from a drillhole)
ℓ	:	Liter
1 MW	:	1,000 kW
1 GWh	:	1,000,000 kWh
1 barrel	:	159 ℓ
1 rai	:	1,600 m^2

gal : cm/sec^2 (acceleration of earthquake motion)
kine : cm/sec

(2) Glossaries

(i) Terms

NHWL	:	Normal High Water Level
LWL	:	Low Water Level
TWL	:	Tail Water Level
US$	:	U.S. dollar
฿	:	Baht
M฿	:	Million Baht
hrs	:	Hours
yr	:	Year
ea.	:	Each
Max.	:	Maximum
Min.	:	Minimum
cct	:	Circuit
a.c.	:	Alternative current
ACSR	:	Aluminum Conductor Steel Reinforced
ASTM	:	American Standard for Testing and Materials
CA	:	Catchment Area
FY	:	Fiscal Year
GDP	:	Gross Domestic Product
M_B	:	Body Wave Magnitude
M_S	:	Surface Wave Magnitude
IRR	:	Internal Rate of Return
EDR	:	Equalizing Discount Rate
PMF	:	Probable Maximum Flood
PMP	:	Probable Maximum Precipitation
B-C	:	Net Present Value of Surplus Benefit
B/C	:	Benefit Cost Ratio

(ii) Agencies

AIT	:	Asian Institute of Technology
EGAT	:	Electricity Generating Authority of Thailand
EPDC	:	Electric Power Development Co., Ltd.
JICA	:	Japan International Cooperation Agency
MEA	:	Metropolitan Electricity Authority
NEA	:	National Energy Administration
NEPO	:	National Energy Policy Office
NESDB	:	National Economic and Social Development Board
NIDA	:	National Institute of Development Administration
OPEC	:	Organization of Petroleum Exporting Countries
PEA	:	Provincial Electricity Authority
RID	:	Royal Irrigation Department
TDRI	:	Thailand Development Research Institute
IBRD	:	International Bank for Reconstruction and Development

Summary

Summary

This report is the feasibility study on Sin Pun A-FBC Coal Fired Thermal Power Development Project in Thailand carried out by JICA on the technical corporations by the Japanese government.

This report is submitted to the Thai government and the Electricity Generating Authority of Thailand (EGAT) through the Ministry of Foreign Affairs in Japan.

The feasibility study result is summarized as follows;

(1) Characteristics of Project

Sin Pun A-FBC Coal-Fired Thermal Power Development Project has a characteristics for the environmental protected power development plan by the atmospheric fluidized bed boiler with using the high sulfur low heat valve lignite in Sin Pun on Southern Thailand.

Since Sin Pun Lignite involves high sulfur content up to 7% and has low heat value, the flue gas emits the SO_x with the density up to 10,000 ppm. Furthermore, the project can not be expected the scale merit on the equipment because the economical mining resources reserves 20 million tons in Sin Pun mine and 5 million tons in Krabi mine only and these amounts are just enough for the generation plant 2 x 75 MW scale.

However, since the lignite is a prominent resources in Southern Thailand as mentioned above and the Krabi power station (3 x 20 MW) would retire 1995, the alternate power source is required in these area using Sin Pun and Krabi lignite. It is also required to develop the generation plant as early as possible with keeping the natural resources because the site is located nearby the Krabi terminal which is the center of developing area in the southern Thailand, and also nearby the resort area such as the Phuket island and Krabi. Furthermore, Thailand are going to set the emission regulation on the major air polluted items such as SO_x and NO_x (SO_x 700 ppm, NO_x 1,000 mg/Nm^3 in Southern Thailand), so that the environmental protected power plant is inevitably necessary.

In Thailand, the labour wages are increased rapidly and consequently, rase up the mine development cost which is occupied with the large amount by the labor cost, so that the early mining development is required.

These mining and power plant development will also contributes to accelerate the economic development in this area.

(2) Optimum Power Developing Plan

1) Electric Power Demand in Thailand

In addition to the favorable economy and rapid industrialization in Thailand, the electric power situation, as mentioned above, has recently shown wide increases due to inroads of foreign enterprises.

Whole the power generation capacity of Southern Thailand (Region 3) is 610 MW as of 1991. It consists of 312 MW by hydraulic generation, 214 MW by thermal generation, and 84 MW by gas-turbine.

The peak demand and generated energy of this district in 1991 reached 608 MW, and 3,922 GWh respectively and there is no reserve power at this moment. Furthermore, the generated energy was short more than 1,000 GWh in this year.

Even though the grid system in this region is connected to the whole Tai system, the trunk interconnect line is 500 Km and it is preferable to ballance the demand and supply in this region for the less loss of transmission line and the better operating management.

2) 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. This software package also provides developing schemes which can provide adequate system reliability corresponding with the target value given by a planner.

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 and resulted for the most economical commissioning date to be 1998. However, taking into account of the constant power flow from the central Thai to the region III, it is preferable to implement this project as soon as possible. From this point, it is judged that the optimum commissioning date of the project is 1997 as earliest case.

(3) Site Selection

Following points are considered in feasibility study of candidate sites for 2 x 75 MW A-FBC coal-fired power plant which are economical generating scale for the mining and generation.

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.

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

Evaluation result of the study team is summarized as follows;

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

- 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 poilution 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 be prepared in Sin Pun site.

As a whole, there are small cost benefit on Krabi site within the amount of 3% of the investment as shown in below. In addition 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 may effect to the drinking water of the well with the long term period at Sin Pun site.

MB

	No.2 (Sin Pun)	No.3 (Sin Pun)	No.4 (Krabi)
Cost difference at 1992 Discount Rate 10%	+149	+191	Base

(4) Mining Development

JICA team studied three documents prepared by EGAT. Based on those EGAT studies, JICA team has set up and evaluated the mine development plan. The conception of the plan is interpreted by the fact that 800 thousand tons of

lignite from Sin Pun area and 200 thousand tons of the lignite from Krabi area are supplied yearly to the A-FBC 150MW power plant.

The conclusion is as follows:

1) The basins of Sin Pun and Krabi have enough reserves of lignite to supply to the A-FBC 150MW power plant for 25 years.

2) The quality of the lignite is not so stable. Considering the characteristics of the FBC boiler, the quality variation in the run-of-mine product will be acceptable. However a blending system is recommended for minimizing the quality variation because the lignite is usually supplied from three deposits: two pits in Sin Pun and one in Krabi.

3) EGAT used computers for the purpose of analyzing the geological data in detail to study economic and technical matters and selected three economic deposits (Bang Sai, North Khuan Klang and South Klang Klang) among the five deposits in the Sin Pun Basin. JICA team reviewed the study of EGAT and confirmed its suitability.

4) JICA team recommended the most rational and economic mining sequence for supplying lignite to the 150 MW power plant. This recommendation has been accepted by EGAT.

5) Considering the geological condition, special mining methods or huge mining equipment are not necessary. A shovel and truck operation is the recommendable mining method in most of Sin Pun Area. From a viewpoint of the hydrogeological study, the planned dewatering activities prior to mining are presumed to be effective.

6) Criteria used for the mining plan are based on the experience of EGAT and regarded as realistic.

7) In this Economic evaluation based on the 15% of contingency and 10% of discount rate, Levelized Unit Cost is estimated about US$20 per ton while Average Cost is about US$18 per ton. As Operation Cost is calculated for the lengthy period of 25 years, Levelized Unit Cost will be astringent to the certain figure (US$20). Economic Ratio is lower

than US$10 per Gcal. These evaluations are carried out with estimated parameters for 150 MW on the basis of the 100 MW case.

(5) Limestone Market

Thailand is everywhere affluent in limestone. Especially around the planned plant site are many limestone quarry candidates.

In 1990, the total annual production of limestone in Thailand was about 19 million tons. Cement plants concentrate in the central area of Thailand because of the large demand for cement there, and 1.6 million tons of cement, slightly more than 8% of total production, is produced in the southern area.

The projected 2 x 75 MW class FBC boiler will consume limestone at the rate of 0.4 million tons/year, the limestone market will go through some problem times in the Southern Thailand and users will suffer from price appreciation and the imposition of severer purchase terms. It is recommended that new limestone mines exclusively intended for producing desulfurizer be developed near the planned plant site.

The limestone price is considered 145 Baht/t with the raw material as the market price involving the transportation cost, and it is estimated that the course limestone (3 mm under particle size) for the bubbling type A-FBC is cost about half price of the fine limestone (325 mesh: 40 μm) for the wet type desulfurized facilities.

(6) Combustion Test Result

Sin Pun and Krabi lignite have a particular of the high sulfur content 15 times per heat value compared with the coal utilized in the imported coal fired power plant in Japan as shown in the following table.

	Sin Pun lignite	Krabi Lignite	Imported coal in Japan applied by Utility
Heat Value (LHV: kcal/kg)	2787	1600	around 6000
Moisture Content (%)	32.7	26.1	around 10
Ash Content (%)	21.1	36.4	around 10
Sulfur Content (%)	7.0	1.8	around 1
Fuel Ratio	0.34	0.43	around 2

The limestone nearby Sin Pun area has high purity up to 90% of the lime. The reduction ratio, which indicates the particle size reserving of the limestone in the fluidized bed and is a key indication for the bubbling type fluidized bed combustion, is in the applicable range experienced during the demonstration test in Japan, and consequently is judged suitable as the desulfurizer for the bubbling type fluidized combustion. Furthermore, since the decarbonized temperature, over which the limestone transfers to the quick lime with the decarbonization, is low as 750°C, it is recognized by the sample analysis that Thailand limestone has high activation as the desulfurizer in the fluidized bed.

The combustion test was carried out with two stages using two brands of lignite and the limestones acquired nearby Sin Pun.

Test	Purpose
Bench scale combustion test	Test furnace: Diameter 100 mm Height 2 m Combustion characteristics is grasped under the various operating conditions with using the small amount of the lignite and limestone.
Pilot scale combustion test	Test furnace: Surface 500 mm x 500 mm Height 7m The combustion furnace is simulated with the actual boiler and can combust the actual particle size of lignites and limestone. Based on the combustion characteristics, the F/S level design is carried out and the data for the economical analysis is obtained.

From the above two combustion tests, the confirmed items are as follows;

1) Environmental Characteristics

(a) Desulfurization Performance

(i) The suitable operating conditions for the desulfurization of Sin Pun, Krabi lignite in the fluidized combustion is within the operating range confirmed by the demonstration test in Japan. (Fluidized Bed Temperature 830 or 850°C, Space Velocity 1.5 ~ 2.0 m/s, Air Ratio above 1.2)

(ii) Desulfurized efficiency was increased by applying the recycle system of the fly ash, and could achieve 94% with the calcium-sulfur molar ratio 2 (Ca/S molar ratio 2). This achieves 600 ppm emission which is below the Thailand proposed regulation 700 ppm.

(iii) 30% of unreacted desulfurizer is involved in the ash from the atmospheric fluidized bed boiler and could be utilized

as the desulfurizer again for the future development of the emission regulation. In Japan, there are two kind of the desulfurized system applying the desulfurizer with the ash.

The one is the simplified desulfurized system using the bag filter and the other is the spray dryer system. The demonstration test results of the above could be reflected on this project for the future development of the environmental regulation in Thailand with the detail economical evaluation.

(b) NO_x Emission Performance

(i) The bubbling type fluidized bed boiler applied Sin Pun Krabi lignite can be operated with the NO_x emission 200 ppm under while the Thailand proposed emission regulation is below 1,000 mg/Nm^3 (500 ppm for NO_2)

(ii) Even further development of the emission regulation in future, the additional facilities are not requested in terms of NO_x emission, therefore the boiler is economical design for the NO_x emission.

2) Combustion Characteristics

(a) Fludized Characteristics

The trouble of the fluidized action by the lumpy ash and the agglomeration of the ash are not recognized during the test. Even through the troubles of the lumpy ash shall be confirmed with the thousands hours operation record, it is confirmed by the non-agglomeration during the test period that the troubles are avoided by extracting the fluidized bed ash continuously.

(b) Combustion Efficiency

(i) 98% over combustion efficiency was confirmed even applying the simplified fuel feeding method i.e. the lignite spreader.

(ii) The combustion efficiency 99 ~ 99.5% is achieved by applying the ash recycle system.

(iii) It is confirmed that the economical boiler can be designed because of the high combustion efficiency more than 99% and the non-necessity of the additional facilities for the combustion efficiency such as the unburn carbon burn up cell.

3) Material Balance

(a) The over flow bed material is amounted up to 45% of the total ash with the condition of the limestone particle size 3 mm under and Ca/S molar ratio 2.

(b) It is confirmed under the ash recycle condition that the over flow bed material can be reduced by applying the small particle of the limestone which also increase the desulfurized efficiency.

4) Other Particular

The bag filter is applied for the second stage dust collector. It is confirmed that the emission value of SO_x was reduced up to about 100 ppm at the outlet of the bag filter. It is assumed that the unreacted desulfurizer collected in the bag of the bag filter captures the SO_x in the low velocity flue gas.

It is recommendable to proceed the detail design by getting the test result of the simplified desulfurized equipment using the bag filter which is carried out in Japan.

(7) Environmental Prediction

The environmental prediction for the ambient air was carried out on SO_x and NO_x which are major issues for the generation plan. From the prediction, the maximum ground level density (24 hours value) for SO_x is 128 $\mu g/m^3$ and that (1 hour value) for NO_x is 83 $\mu g/m^3$.

Item	2 x 75 MW A-FBC Emission Condition	Thailand Proposed Emission Regulation
1. SO_x emission	285 g/sec (667 ppm)	700 ppm under (Bangkok 400 ppm below)
2. NO_x emission	113.8 g/sec (350 ppm NO conversion)	1,000 mg/Nm^3 under (NO conversion 750 ppm NO_2 conversion 500 ppm)
3. Stack hight	80 m	
4. Flue gas temperature	130°C	
5. Flue gas velocity	27.3 m/Sec	
6. Diameter of inner stack	2.5 m	
7. Diameter of common stack	3.54 m	

As shown in the table below, the prediction value for the Sin Pun generation project is far below to the proposed regulation in Thailand

	2 x 75 MW Environmental Prediction	Thailand Proposed Emission Regulation
SO_x 24 hours regulation	128 $\mu g/m^3$	300 $\mu g/m^3$
NO_x 1 hour regulation	83 $\mu g/m^3$	320 $\mu g/m^3$

Furthermore, since the other environmental issues are also cleared as shown in below, the project is feasible environmentally also.

- Waste Water from Power Station — Waste water treatment facility is installed in the project and restricted the waste water from the power station within the standard value.

- Penetration of Waste Water in the Ash Disposal Area

The existing mining pit is used as the ash disposal area. The area is located in the existing power station and no inhabitant is living the area. There are no pollution problem occurred in future due to the water penetration to the well water.

- Coal Dust

The lignite from Sin Pun is transported to Krabi by 30 trucks 4 cycle with the distance 66 km.

Since the loading trucks are passing every 8 minutes, the coal dust pollution may be considered. Therefore, the truck shall equip the cover door on the cargo and transport the lignite after water spreading to the lignite for the prevention of flying powder lignite.

(8) Outline of Optimum Development Plan

1) Basic Items

The following items are applied for the design.

Generator Output	:	2 x 75 MW
Boiler Type	:	Atmospheric Bubbling Type Fluidized Bed Combustion Boiler
Annual Load Factor	:	80%
Life Time	:	25 years
Annual Mean Heat Rate (L.H.V.):		2,365kcal/kWh (36.4%) (Bo. Eff. 91.7% x Tb Eff. 41.5% x Ge Eff. 98.5%)x0.97
Main Steam Pressure	:	127 kg/cm^2 g
Steam Temperature	:	538 °C/538 °C
Flue Gas	:	SOx 700ppm, NOx 1,000mg/Nm^3 Dust 500mg/Nm^3

Limestone Consumption (Ca/S Mol Ratio): 2.0

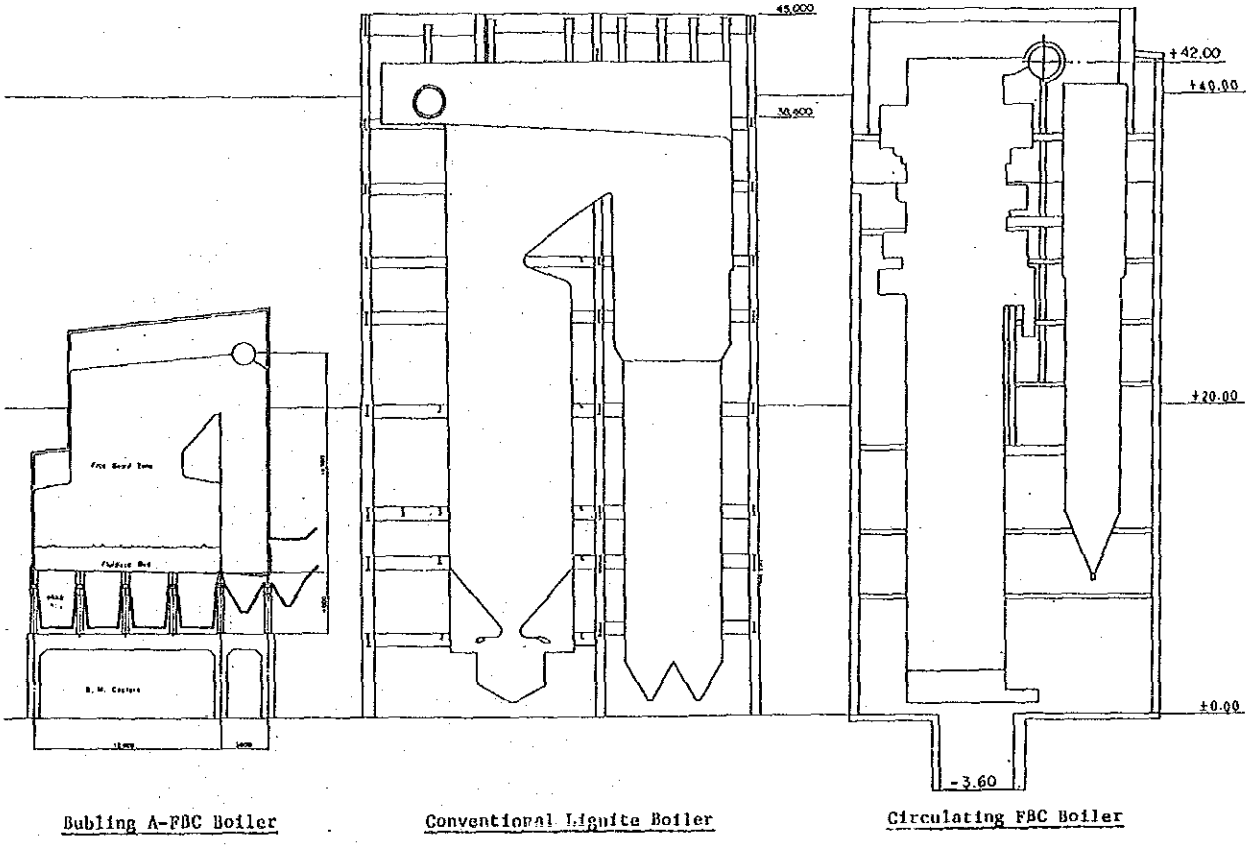
Lignite

	Sin Pun Lignite	Krabi Lignite
Heat Value (LHV) (kcal/kg)	2,795	1,600
Total Moisture (%)	32.7	26.1
Ash Content (%)	21.1	36.4
Sulfur Content (%)	7.0	1.8

Lignite Consumption	:	1,000,000 ton/year (Sin Pun 4, Krabi 1)
Limestone Consumption	:	400,000 t/year
Ash Generation	:	600,000 t/year
Schedule	:	1996 12 Unit 1 Commissioning 1997 6 Unit 2 Commissioning
Sea Water Temp.	:	32 °C
Ambient Temp.	:	34 °C (Max) 27°C (Mean Value)
Wind Velocity Max.	:	30 m/s
Lateral Force	:	V = 0.07 W

2) Outline of Scheme

It is confirmed by the combustion test that the atomospheric bubbling type fluidized bed boiler can conbust the Thailand Sin Pun lignite with the high efficiency and can be designed with the compact and economical boiler. It is also confirmed that the environmental characteristics of this boiler is well friendly in terms of SO_x, NO_x and so on. In the study, it is confirmed that the bubbling type A-FBC can be designed most economical boiler compared with the other type of boiler.



Outline of 75 MW Boiler

Land Preparation

(1) Site Area

Plant yard		:	10 ha
Pump pit and discharge channel		:	3 ha
Ash disposal area	No. 1 area	:	49 ha
	No. 2 area	:	37 ha
Total		:	99 ha

(2) Site Format Level : DL. +7.00 m

(3) Land Preparation Work : Excavation approx. 300,000 m^3

: Filling approx. 20,000 m^3

Lignite and Limestone Preparation System

(1) Lignite Receiving Facility

1) Lignite Receiving Hopper
2) Lignite Receiving Conveyor
   - No. 1 Conveyor (BC1) : 300 T/H
   - No. 2 Conveyor (BC2) : 300 T/H
   - No. 3 Conveyor (BC3) : 300 T/H
   - No. 4 Conveyor (BC4) : 300 T/H

(2) Lignite Dispatching Facility

1) Lignite Dispatching Hopper
2) Lignite Dispatching Feeder : 300 T/H
3) Lignite Dispatching Conveyor
   - No. 5 Conveyor (BC5) : 300 T/H
   - No. 6 Conveyor (BC6) : 300 T/H

(3) Limestone Receiving Facility

1) Limestone Receiving Hopper
2) Limestone Receiving Conveyor
   - No. 1 Conveyor (LBC1) : 150 T/H
   - No. 2 Conveyor (LBC2) : 150 T/H
   - No. 3 Conveyor (LBC3) : 150 T/H

(4) Limestone Dispatching Facility

1) Limestone Dispatching Hopper
2) Limestone Dispatching Feeder : 150 T/H
3) Limestone Dispatching Conveyor
   - No. 4 Conveyor (LBC4) : 150 T/H

(5) Lignite Limestone Crushing Facility

1) Lignite Bucket Elevator : 300 T/H
2) Lignite Distribution Hopper
3) Lignite Feeder : 150 T/H
4) Lignite Crusher : Double Roll Type
   : 150 T/H x 2
5) Lignite Conveyor (LLBC1) : 300 T/H
6) Limestone Bucket Conveyor : 150 T/H

7)	Limestone Crusher	:	H a m m e r Crusher Type
		:	75 T\H x 2
8)	Limestone Conveyor (LLBC2)	:	150 T/H
9)	Lignite-Limestone Conveyor (LLBC3)	:	500 T/H
10)	Lignite-Limestone Bucket Conveyor	:	500 T/H

Oil Storage Tank : 80 m^3

Raw Water Supply System

(1)	Quantity	:	Max. 300 m^3/day
(2)	Water Source	:	R1 and R2 Reservoir
(3)	Intake Pipe Line Length	:	approx. 500 m (R1) approx. 1,500 m (R2)
(4)	Fresh Water Tank	:	1,000 m^3
(5)	Demineralized Water Tank	:	500 m^3
(6)	Demineralization Plant	:	24 m^3/hr

FBC Boiler (Per Unit of 75 MW)

(1)	Boiler 1) Furnace	:	Membrane structure Width : 15 m, Depth : 12 m, Height: 15 m
	Lignite Feeding System		Over spreading system
	Draft System	:	Balance Draft System
	Desulfurized Material	:	Limestone
	Height of Bed	:	1.2 m

Bed Load : 1.2 x 10^6 kcal/m^2h

Heat Exchanger Tube : Economizer, Evaporator, Super, Hater, Re-Heater

2) Boiler Auxiliary

Drum

Super Heater Spray

Re-Heater Spray

Boiler Circulation Pump: 400 t/h

Safety Valves and Silencer

Drum Level Gauge

3) Air Heater Type : Rotative Regeneration Type

Air Side : 270,00 Nm^3/h

47°C Inlet, 277°C Outlet

Gas Side : 310,000 Nm^3/h

330°C Inlet, 130°C Outlet

4) Soot Blower Type : Remote-Auto Control Steam Atomizing Type

5) Continuous Blow Out Facility : Flushing Tank

6) Steel Structure, Boiler Casing Platform and Footstep

7) Cast

(2) Lignite Firing Facility

1) Lignite Bunkere : 150 ton/Hopper (12 hours)

2) Lignite Measuring : 20 t/h (Ca/S Mol Ratio 4, 20% Margin)

3) Lignite Spreader : 20 t/h x 8

4) Auxiliary : Lignite Shoot, Rotary Valve, Screw Conveyor, Gate

(3) Oil Firing Facility

1) Hot Wind Furnace : Light Oil 2,000 kg/h, 550°C

2) Light Oil Pump : 4,000 kg/h

3) Light Oil Intermediate Tank : 20 m^3

4) Strainer Piping and Valves

(4) Air-Gas Draft System

1) Forced Draft Fun : 5,520 m^3/min at 27°C, 2,560 mmH_2O

2) Induced Draft Fan : 8,510 m^2/min at 130°C 600 mmH_2O

3) Wind Duct

4) Gas Duct

(5) Mechanical Cyclone Ash Collecting System

1) Mechanical Cyclone : 312,600 Nm^3/h, 340°C

2) Recycle Blower : 300 m^3/min, 2,650 mmH_2O, 220 kW

3) M/C Ash Storage Hopper : 50 m^3 (3 hours)

4) Auxiliaries
Screw Conveyor
Rotary Valves
Pipes and Valves

(6) Bed Material Handling System

1) B.M. Extraction Valves : 8 per unit

2) B.M. Cooler

3) Auxiliaries
B.M. Shoot

(7) Bag House : 300,000 Nm^3/h Dry 130°C -300 mmH_2O
Inlet Dust 20 g/Nm^3, Outlet Dust 0.5 g/Nm^3
Difference Pressure 100 mmH_2O

(8) Piping and Valves : Main Steam Pipes, Hot Reheat Pipes, Cold Reheat Pipes, High Pressure Turbine Bypass Valves, Low Pressure Turbine Bypass Valves, Main Feed Water Pipes, Spray Pipes, Auxiliary Steam Pipes, Blowdown Pipes, Drain Pipes, Cooling Water Pipes, Chemical Dosing Pipes, Sampling Pipes, Air Pipes, Flush Tank, Blow down Tank, Other Necessary Pipes and Valves

(9) Miscellaneous Equipment

1) Station Air Compressor : 7 kg/cm^2g x 12 m^3/min

2) Chemical Dosing System

3) Sampling Equipment

(10) Control and Instrumentation

1) APC

2) Local Control System

3) Boiler Auxiliary Sequence Control

4) Boiler monitoring System

Boiler Inspection T.V., Drum Level Monitoring T.V., O_2 Monitoring Equipment in Flue Gas, Necessary Transmitter, Indicator and Recorder

5) Instrument Compressor : 7 kg/cm^2g x 10 m^3/min

(11) Electrical : Motors, Cable and Cabling, Earthling

Turbine (Per unit of 75 MW)

(1) Turbine

1) Steam Turbine

Type	:	Tandem Reheat Regeneration Extraction condensing Type
Number	:	1
Rated Output	:	75 MW
Rotation	:	3,000 rpm
Steam Condition		
Main Steam	:	128 kg/cm^2
(Inlet of MSV)		538°C
Reheat Steam	:	30 kg/cm^2
(Inlet of RSV)		538°C
Number of Extraction Steam	:	5
Turbine Efficiency	:	41.5%
Vacuum	:	-693 mmAg
Cooling Water	:	32°C, Sea Water

2) Main Stop valve

3) Reheat Stop Valve

4) Turbine Speed Control Equipment

5) Lubricant Oil Equipment

6) Turning Equipment

7) Grand Steam Pressure Control Equipment

8) Safety and Monitoring Facility

9) Turbine Supervisory Equipment

(2) Condensing Equipment

1) Condenser

Design Vacuum	:	-693 mmAg
Purity Factor	:	75%
Water Velocity in Tube	:	2.0 m/s
Temperature Difference	:	7°C
Electric Cathodic Protection		
Sponge Ball Cleaning Facility		

2) Circulation Water Pump : 6,900 m^3/h, 200 kW

3) Condenser Pump : 220 m3/h x 2 (1 for stand-by), 6.7 kg/cm^2

4) Condenser Booster Pump : 220 m^3/h 2 (1 for stand-by)

(3) Feed Water Heater

1) L.P. No. 1 Heater : 53 kg/s Inlet 90.5°C, Outlet 128°C

2) L.P. No. 2 Heater : 53 kg/s Inlet 44.5°C, Outlet 90.5°C

3) H.P. No. 1 Heater : 64.5 kg/s Inlet 198°C, Outlet 238°C

4) H.P. NO. 2 Heater : 64.5 kg/s Inlet 163.5°C, Outlet 198°C

5) Deareator : Resolving Oxygen under 0.005 cc/ℓ

Storage 60 m^3, 64.5 kg/s
Inlet 128°C, Outlet 161°C

6) Make-up Pump : 80 m^3/h

(4) Boiler Feedwater Pump

1) Motor Derived Type BFP : 250 m^3/h x 2 (1 for stand-by), 3,000 rpm

2) BFP Motor : 1,500 kW x 2 (1 for stand-by), 3,000 rpm

3) BFP Boost up Pump : 250 m^3/h x 2 (1 for stand-by), 3kg/cm^2, 1,500 rpm

(5) Miscellaneous Equipment

1) Auxiliary Cooling Water Pump : 800 m^3/h x 2 (1 for stand-by), 50 m, 1,500 rpm

2) Cooling Water Cooler

3) Auxiliary Cooling Water Stand Pipe and Temperature Control Valve

4) Sailing Crane : Maximum Capacity 40 ton

Cooling Water Facilities

(1) Intake Pump Pit

(2) Inlet Pipe Line 4 lines x 410 m/2 units

(3) Outlet Pipe Line 2 lines x 150 m/2 units

(4) Outlet Pit

(5) Discharge Channel

Electrical Facility

(1) Generator	1)	Generator	:	88.3 MVA 11 kV 4,635 kA 50 Hz, 3,000 rpm p.f. 0.85
		Cooling Method		
		Rotor	:	Air Direct Cooling
		Starter	:	Air Indirect Cooling
		Short Circuit Ratio	:	0.45
		Exciter	:	Brushless Exciter
	2)	Exciter Equipment		
	3)	Automatic Voltage Regulator		
	4)	Nutoral Grounding Resister		
	5)	Electrical Interlock Equipment		
	6)	Isolated Phase Busduct (I.P.B.)		
(2) Transformer	1)	Main Transformer	:	ONAF, 85 MVA, 115 kV/11 kV
	2)	House Transformer	:	ONAF, 10 MVA, 11 kV/6.6 kV
	3)	Starting Transformer	:	ONAF, 10 MVA, 115 kV/6.6 kV
(4) Switch Yard Facility				
	1)	115 kV Switch	:	Air Circuit Breaker 800 A, 2,000 MVA, 120 kV x 6

2) 115 kV Line Switch : Air Drive L.S.
800 A, 115 kV x 18

3) C.T. : 800/5A x 3 x 100 VA x 18

4) P.T and P.D : 110 kV/ $\sqrt{3}$, 500 VA x 18

5) Earth Switch

6) Line Arrester

7) Bus

(5) House Load Facility

1) M/C Circuit Beaker: 6.6 kV A/C
2) P/C Circuit Beaker: 380 V A/C
3) C/C Circuit Beaker: 380 V A/C
4) Distribution Board
5) Direct Current C/C
6) Transformer
Unit P/C Transformer
7) Direct Current Power Supply System
8) Cable and Cabling/Grounding

(6) Control and Instrumentation

1) Central Control and Supervisory Panel
2) Boiler Turbine Generator Control Panel
3) B.T.G Auxiliary Panel
4) Relay Panels
5) Input/Output Panels
6) Steam Turbine and Generator Control Panel
7) All Necessary Sensors
8) Local Control Panels
9) Control CVCF
10) Control Cable and Cabling/Piping
11) Data Acquisition System (Computer)

(7) Emergency Power : 300 kVA

Ash Handling System

(1) FBC, B.M. Transportation Facility: 50 T/H x 2 (Alternate Control)

(2) FBC B.M. Ash Silo : 600 T

(3) FBC, B.M. Transportation Blower

(4) M.C. Transportation Facility

(5) M.C. Ash Silo : 600 T

(6) Bag House Ash Transportation Facility

(7) Bag Ash Silo : 120 T

(8) M.C. Ash, Bag Ash Transportation Blower

Power House Ground floor area: 2,900 m^2, Building volume: 79,000 m^3, Height: 28 m

Stack

(1) Foundation : Reinforced concrete mat

(2) Outer Tube : Reinforced concrete
Height: 80 m
Diameter Top: 8.0 m
Bottom: 13.0 m

(3) Inner Tube : Steel construction
Height: 80 m
Diameter Top: 2.5 m
Mean: 3.5 m

Ancillary Building

(1)	Administration Building	:	Reinforced concrete construction 4 floor 4000 m^2
(2)	Warehouse	:	Reinforced concrete construction 1 floor 2,300 m^2
(2)	Limestone storehouse	:	Reinforced concrete construction 1 floor 1,500 m^2

Environmental Facilities

(1) Flue gas Treatment System

1)	Desulfurization System	:	Non (because of in-situ desulfurization)
2)	Denitrization System	:	Non (because of low NOx combustion in the boiler)

(2) Waste Water Treatment System

Capacity	:	10 m^3/h
Storage Capacity	:	700 m^3

(9) Construction Schedule and Construction Cost

1) Construction Schedule

The lignite production cost is deeply depend on the salary of staffs and the rapid increase of the salary may cause the inflation of the lignite production cost and consequently cause the increase of the power generation cost. Therefore, it is preferable to implement the project as soon as possible. Furthermore, the power demand in the region III would over balance the stable power supply in 1997, therefore the commissioning of the generation plant is set as follows;

Unit 1 End of Dec. 1996

Unit 2 End of June 1997

Since Krabi site is located in the existing power station, the lead time is not requested for the land acquisition. This project has already considered for the environmental reservation. With the above reasons, the project can be implemented earlier than the other project.

2) Construction Cost

The construction cost is based on the product in Japan. The light load steel structure is estimated based on the local material cost to optimize the construction cost.

The total construction cost is shown in the following table.

(Million Baht)

	Foreign	Local	Total
Civil & Structure	145.8	910.2	1,056
Boiler	1,363	466.7	1,829.7
Turbine	1,305	318.7	1,623.7
Miscellaneous	547	312.9	859.9
Administration	0	380.0	380.0
Sub Total	3,360.8	2,388.5	5,749.3 (5,317.3)
Import Duty	0	183	183
Sub Total	3,360.8	2,758.5	6,119.3
IDC	515.3	454.7	970
TOTAL	3,876.1	3,026.2	6,902.3

Note: ( ) portion shows the subtotal without the contingency.

(10) Economical Analysis and Financial Analysis

1) Economical Analysis

(a) The economical analysis of this project applied the alternate equipment aproach method. The comparison is carried out between the economical cost of this proejct (construction cost, fuel cost, limestone cost and operation & Maintenance Cost) and the economical cost for the alternate thermal power plant which can supply the same service with this proejct involving the evironmental aspect.

(b) In detail, the cost for this project is taken as the cost, and that for the alternate thermal power station is taken as the benefit with the condition of the same generation, same fuel and same emission level for the case of the lignite pulverized power plant and FDG, and also with the condition of the same generation, same emission level for the case of the oil power plant.

The compared items are as follows;

(1) Benefit and Cost Ratio (B/C)

(2) Net Present Value [or Benefit Cost difference (B-C)]

(c) As a result, the project was found the economical feasibility as follows;

(i) B/C with pulverized coal fired plant 1.097 ~ 1.101
and with oil fired plant 1.088 ~ 1.135

(ii) NPV with pulverized coal fired plant 864.84 ~ 867.44 Million Baht
with oil fired plant 789.32 ~ 1,156.06 Million Baht

2) Financial Analysis

(a) The financial analysis is carried out with the comparison between the financial cost requested in this project and the financial benefit come out from the electricity tariff in terms of the financial internal rate of return and the tariff variation. As a result, the FIRR of 10% is achieved by increasing the tariff 1.74 B/kWh.

(b) Furthermore, by setting the repayment schedule and financing scheme. The case study was carried out for the above conditions. As a result, the low interest loan can lead this project to be more beneficial.

The case study for the loan condition was carried out to meet the current selling unit price 1.26 B/kWh. As a result, the loan conditions of 0.255% - 2.32% interest on the foreign currency and 65% of the domestic currency and 10% interest on 35% of the domestic currency can achieve the above current selling unit price.

(c) EGAT applies the levelized cost method for the comparison between the project and alternate scheme. With this method, this project is found more beneficial than the alternate scheme.

Conclusion and Recommendation

Conclusion and Recommendation

This project is 2 x 75 MW Sin Pun fluidized bed combustion coal fired power development project with the environmental protected type generation facilities by the fluidized bed combustion boiler using Sin Pun lignite and Krabi lignite in the southern Thailand. The study team carried out the feasibility study with the field survey and the combustion test using two lignite from Sin Pun and Krabi mine, and the limestone nearby the respective candidate site. As a result, the project found the feasibility in terms of the technical, the economical and the environmental aspects.

Conclusion

The following is the content of result.

i) The power demand and supply in Thailand is very tight because of the rapid growth of the economy. Furthermore in Region III, the power generation was short and received the electric power from the central Thailand with the amount of 1,000 GWh in 1991. JICA team carried out the optimum power developing planning and resulted that the most economical developing year of this project is 1998. However, taking into account of that the region III received the electric power from the central Thailand all the time, it is preperable to start this project as soon as possible and it is judged that the optimum date of the completion of commissioning of the project is 1997 as earliest case.

ii) Sin Pun Lignite involves the high sulfur content and emits the SO_x with the density up to 10,000 ppm which would affect strongly on environmental resources. Therefore, the environmental protected power plant is inevitable necessary in this project.

iii) The existing Krabi power station which operated long term as power source in this area is scheduled to retire in 1995 and the alternate power plant is required in these area.

iv) The generation output study was carried out with the case of 1 x 100 MW and 150 MW (2 x 75 MW) and found that 150 MW (2 x 75 MW) case is more economical with the total evaluation of the generation and mining development project.

v) The site selection is carried out among three sites, i.e. two sites for Sin Pun area and one site in the existing Krabi power station. The economical comparison result among three sites shows that there is no big difference among these sites. However, from the unforesean cost in Sin Pun sites for the land acquisition and the mitigation of the affection to the drinking water by the drain in the ash disposal area, the site was decided to Krabi.

vi) The lignite resources of Sin Pun and Krabi is just enough for 2 x 75 MW 25 years and the more consumption of the lignite would exceed the economical ratio of EGAT for the mining.

vii) From the combustion test using Sin Pun and Krabi lignite with the limestone in vicinity of the site, it is confirmed the extremely high combustion characteristics (combustion efficiency 99% above) and environmental characteristics (desulfurized efficiency 94% SO_x emission density 600 ppm, NO_x emission density 200 ppm below).

From the above points, the project is feasible technically.

viii) Compared with the conventional wet $DeSO_x$ facility and the pulverized lignite boiler using Sin Pun lignite and Krabi lignite under the same environmental conditions, the atmospheric bubbling type fluidized bed combustion boiler is more economical due to the compact boiler design which can achieve the high combustion efficiency for the lignite.

Therefore, the atmospheric fluidized boiler is feasible economically also.

ix) This project can be operated within the emission value of the flue gas proposed emission regulation (SO_x 700 ppm under, NO_x 1,000 mg/Nm^3 ≒ 500 ppm NO_2). The current environmental regulation also maintained as shown in the following table. And also the other environmental standard is kept within the value. Therefore the environmental resources are reserved.

	2 x 75 MW Environmental Prediction	Thailand Proposed Emission Regulation
SO_x 24 hours regulation	128 $\mu g/m^3$	300 $\mu g/m^3$
NO_x 1 hour regulation	84 $\mu g/m^3$	320 $\mu g/m^3$

x) The construction cost is estimated based on the available technical design, construction method, material and product in June 1996. The cost is based on the Japanese product cost and the local materials and estimates the import duty and IDC. The construction cost is 19.4 billion yen for the foreign portion and 3.02 billion Baht (equivalent about 15.1 billion yen), totally 34.5 billion yen.

xi) The output of this project 2 x 75 MW is relatively small in the grid of EGAT and does not have a scale merit. Furthermore, due to the additional desulfurizer cost and the additional facility for the environmental protection, the financial feasibility is achieved on the condition of the generating cost above 1.67 Baht/kWh.

xii) This project has several indirect benefits as shown in below. Considering the total economical effect involving the indirect benefits, this project shall be promoted.

- The project will promote the development of new energy sources alternating oil.
- The project will promote the defusion and spread of the bubbling A-FBC technology in the south east asia since the project is the first unit in this area.
- The project will contribute to the development of the project area which is located in the Krabi developing terminal.
- The project will contribute in increasing the quality and reliability of the electricity supply in the region III.

- The project can be implemented earlier than the other project since the site is located in the existing Krabi power station which is scheduled to retire in 1995.

- The project will save the cost related to employment by the utilization of man power in the existing power station to the new power station.

- The project will make the image of the resort area such as Krabi and Phuket better all the more because of the new environmental facility.

Recommendation

Sin Pun fluidized bed combustion coal fired generation project is feasible in technically and economically.

However, the labour cost occupies 30% of the lignite mine developing and the recent rapid increase of the labour cost in Thailand may induce the increase of the lignite mine developing cost when the mine development is delayed and consequently make the generation cost increase. In addition to the above factor, the stable electric supply in southern Thailand would short for the demand in 1997.

With the above points, the project is recommendable to start as soon as possible.

To implement this project with the commissioning date end of 1996 for unit 4, the following items shall be undertaken.

i) To start the detail design at the end of 1992, and to prepare the bid document and other necessary preparation work for the construction in 1993.

ii) To carry out the environmental monitoring and to prepare document for the environmental assessment as soon as possible.

iii) To undertake the mining development project as soon as possible.

iv) To take care of the coal dust pollution on road caused by the damp truck transportation of lignite with applying the cover door on the cargo.

1. INTRODUCTION

CHAPTER 1 INTRODUCTION

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1. INTRODUCTION

1.1 General

Thailand's economic growth rate in 1989 was marked at 11%, being prominent among Asian developing nations. Particularly, the growth of its industrial sector was significant.

The installed capacity of electric power generating facilities in Thailand was 8,314 MW in 1989. Composition of power sources consisted of 2,271 MW in hydro plants (27.3%) and 6,043 MW in thermal plants (72.7%).

The rates of average annual increase of EGAT's power and energy generation for the five years from 1986 to 1990 were 12.9% and 13.2% respectively. The rates increased in 1990 by 13.8% and 18.5% respectively. The rates of increase of future demand will decrease gradually to be 7.6% and 8.3% in 1995, and 6.2% and 7.2% in 2000. After 1995, the annual increase of demand is considered to be about 900 MW and about 6,100 GWh respectively. Therefore, new power plants having a capacity of 900 MW should be implemented every year.

The Thai Government has a policy of utilizing indigenous energy sources such as natural gas, lignite, hydropower etc., while suppressing the increase of oil importation as much as possible.

On the other hand, there is a plan to construct the imported low sulfur coal fired power plant in order to cover the rapid increase of the electric power demand. However as a recent worldwide program for the environmental protection on the SOx emission, the imported low sulfur coal price will rise up gradually, and this tendency will keep the high necessity to apply the indigenous lignite together with the application of the imported coal in Thailand.

In the view of the policy situation mentioned above, EGAT is planning to construct lignite thermal power plants in the southern region of Thailand since the only prominent indigenous energy sources in this region.

Furthermore, following this worldwide tendency for the environmental protection, EGAT has also been pursuing the low polluted emission to keep the environmental resource for humanity, and has been developing its environmental programs which are considered as leading body in the Thailand.

To satisfy the above necessity, EGAT made a preliminary study on the Fluidized-Bed Combustion (FBC) boilered power plant pursuing the following capabilities;

i) Economical design of the boiler for the low SOx and less NOx emission compared with PCF and DeSOx plant

ii) Wider range of coal utilization from the lower grade of the lignite to the high grade of the coal

The study concluded that FBC plant is most feasible boiler for the wider range of the lignite utilization and the low polluted emission boiler.

Following the above preliminary study, the Government of the Kingdom of Thailand requested the Government of Japan to implement the Feasibility Study on Sin Pun A-FBC (Atmosphere-Fluidized Bed Combustion) Coal-Fired Thermal Power Development Project with the capacity of 2 x 75 MW as of November 8, 1990.

1.2 Objective and Scope of the Study

The main objective of the Study is to formulate the optimum development scheme of the Sin Pun A-FBC Coal-Fired Thermal Power Development Project and to assess technical, environmental, financial and economic feasibility of the project.

The Study is divided into two (2) stages, and the scope of work at the respective stages is itemized as follows;

(1) First Stage

1) Collection and review of existing data and information related to the Study.
2) Site reconnaissance
3) Power survey and optimization of development scale
4) Coal and limestone analyses
5) Combustion test (Bench scale)
6) Market research for limestone

(2) Second Stage

1) Environmental investigation
2) Site selection study
3) Combustion test (Pilot scale)
4) Feasibility grade design
5) Coal mine development plan
6) Cost estimation
7) Construction plan
8) Economic and financial analyses of the project

1.3 General Situation of the Kingdom of Thailand

(1) Location and Area

Thailand is situated in between lat. 5° 36' N and 20° 24'N, and in between long. 97° 14' E and 105° 41' E. It is bounded by Lao PDR in the north and the east, by the Cambodia in the east, by the Federation in Malaysia in the south and by the Union of Myanmar in the west.

International rivers forming the boundaries with the neighboring countries are the Mekong river for Laos, the Salamin river and the Moei river for Myanmar.

The total area of the country is 513,115 km^2. The area of the farmland is 199,088 km^2 and accounts for about 40% of the total area. Main rivers and mountain ranges are shown in Fig. 1-1.

(2) Climate

A climate of Thailand is divided into three seasons: a rainy season, cool season and hot season.

The rainy season starts from around the middle of May when the south-west monsoon starts to blow, and ends around the middle of October in the northern region and in November in the southern region. IN the rainy season, there is a shower lasting for one to two hours almost virtually every day. Especially it rains heavily in September.

The season from the middle of November to February is called cold season which is affected by the north-east monsoon blowing in whole of the Thailand. Due to the monsoon the temperature in Bangkok falls to 15°C at night.

The season covering the three months from March to May is called the hot season while it is the hottest time of the year. As the north-east monsoon weakens in this season and the sun moves from the equator to

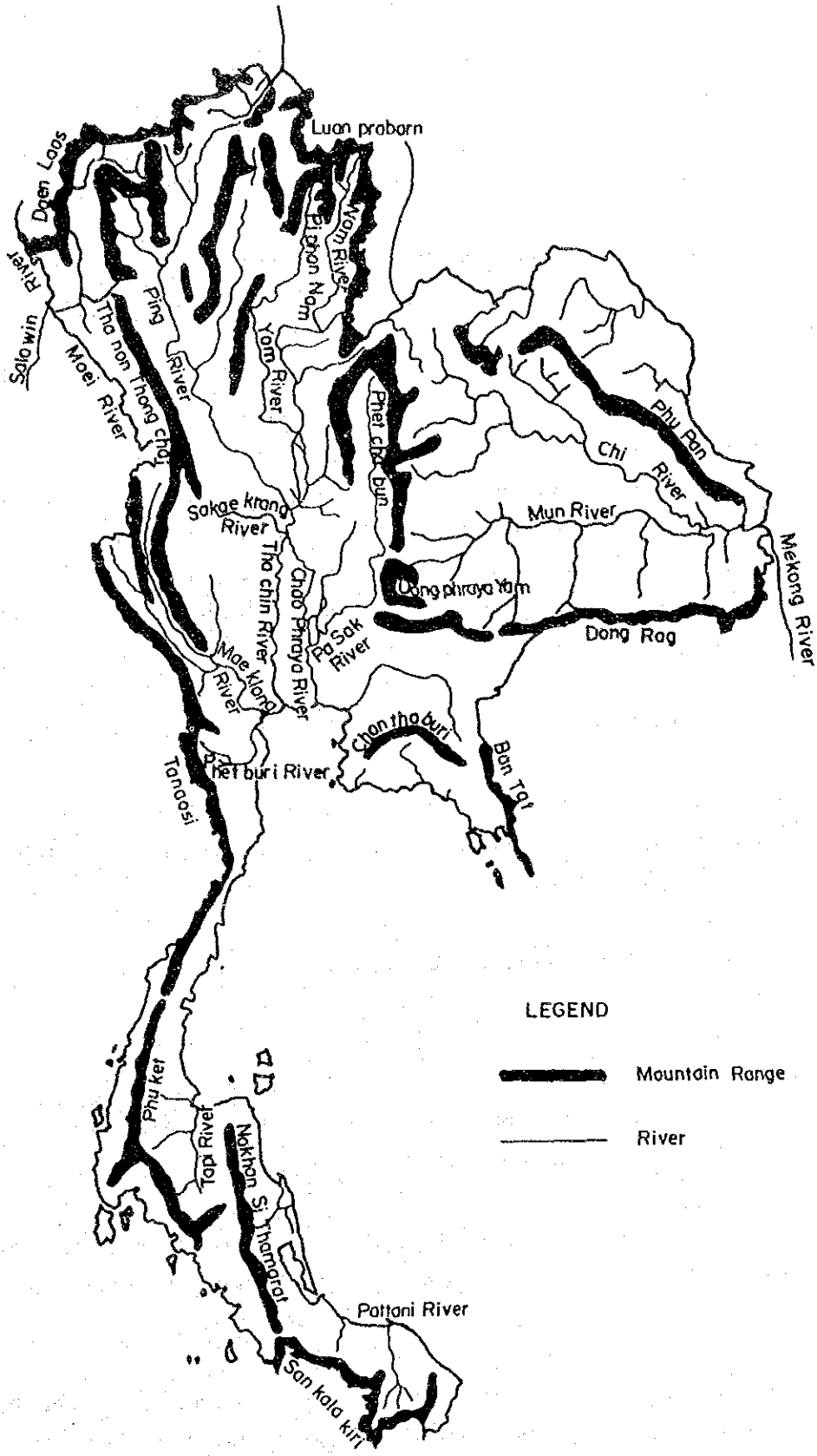


Fig. 1-1 Main Rivers and Mountains Ranges

above Thailand, the temperature rises, becoming especially very high in April. It reaches almost 40°C in April in Bangkok.

Actual rainfall is around 1,300 mm in Bangkok, 1,200 mm in Chiang Mai of the northern part, 1,100 mm in Khon Kaen of the northeastern part and 2,000 mm in Hat Yai of the southern part of Thailand.

(3) Population

The population of Thailand as of December 31, 1989 is 55,888,393 and has increased by 927,000 persons or 1.7% compared with the end of 1988. The population of the Bangkok metropolis is 5,832,843 and has increased by 116,000 persons or 2.03%. The population of the Bangkok metropolis accounts for 10.4% of the total population. The relative density of population is 109 and 3,727 persons/km^2 for the whole of Thailand and Bangkok, respectively.

(4) Government System

Constitutional monarchy has been established in Thailand in 1932. The present constitution was promulgated in December 1978 and its major points are as follows:

- Thailand is a Kingdom having a king as a sovereign.
- Sovereignty rests with the people.
- Freedom of religion, speech, publication, association, formation of political parties and correspondence.
- Support of the democratic form of government and obligation of military service based on the nation, religion, king and constitution.
- Parliament with a two-chamber system (members of the Upper House: appointed, the Lower House: publicly-elected).

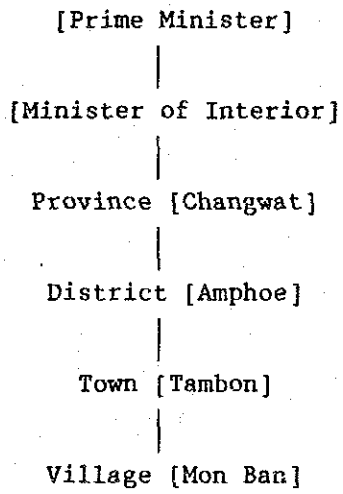
- Promotion of party politics (members of the Lower House must belong to parties).

- Cabinet consisting of a prime minister and ministers of state.

The organization of the government consists of one Prime Minister's office and thirteen Ministries. The organization chart is shown in Fig. 1-2.

The organization of the local government as seen in the figure below mainly consists of "Province (Changwat)", "District (Amphoe)", "Town (Tambon)" and "Village (Mo Ban)". These are under the supervision of the central government. Governors of the provinces are appointed by the Minister of Interior. However, the governor of the Bangkok metropolitan area has been publicly-elected since 1985.

Organization Chart of Local Government



Prime Minister and
Council of Ministers

Office of the Prime Minister	Ministry of Agriculture and Cooperatives	Ministry of Commerce	Ministry of Defence	Ministry of Education	Ministry of Finance	Ministry of Foreign Affairs	Ministry of Industry	Ministry of Interior	Ministry of Justice	Ministry of Public Health	Ministry of Science Technology and Energy	Ministry of Transport and Communications	Ministry of University Affairs	Independent Public Agencies
The Secretariat of the Prime Minister	Office of Permanent Secretary	Office of the Permanent Secretary	Office of the Department Secretary	Office of the Permanent Secretary	Office of the Permanent Secretary	Office of the Permanent Secretary	Office of the Permanent Secretary	Office of the Permanent Secretary	Office of the Permanent Secretary	Office of Permanent Secretary	Office of the Permanent Secretary	Office of the Permanent Secretary	Office of the Permanent Secretary	Office of the Auditor General of Thailand
The Secretariat of the Cabinet	Office of Agricultural Economics	Department of Business Economics	The Supreme Command Headquarters	Department of Curriculum & Instruction Development	The Comptroller General's Department	Department of Asian Affairs	Department of Industrial Promotion	The Office of Accelerated Rural Development	Office of the Judicial Affairs	Department of Communicable Disease Control	Office of Atomic Energy for Peace	Department of Aviation		Bangkok Metropolitan Administration
Office of the Permanent Secretary	Department of Agricultural Extension	Department of Commercial Registration	Royal Thai Army	The Fine Arts Department	The Customs Department	Economic Department	Department of Industrial Works	Community Development Department	Legal Execution Department	Food and Drug Administration	National Energy Administration	Harbour Department		Bank of Thailand
Office of the Board of Investment	Agricultural Land Reform Office	Department of Export Promotion	Royal Thai Navy	Department of General Education	The Excise Department	Department of Information	Department of Mineral Resources	Department of Corrections	Organization of Courts of Justice	Department of Health	Office of the National Environment Board	The Department of Highways		Bureau of the Crown Property
The Bureau of the Budget	Department of Agriculture	Department of Foreign Trade	Royal Thai Air Force	Office of the National Culture Commission	The Fiscal Policy Office	Department of International Organization	Thai Industrial Standards Institute	Department of Labour	The Supreme Court	Department of Medical Sciences	National Research Council	Department of Land Transport		The Office of his Majesty's Principal Private Secretary
Office of the Civil Service Commission	Department of Co-operative Auditing	Insurance Department	The War Veterans Organization of Thailand	Office of the National Primary Education Commission	The Revenue Department	Political Department	Bang Pa-In Paper Mill Industry Co., Ltd.	Department of Lands	The Court of Appeal	Department of Medical Services	Department of Science Service	Office of the Maritime Promotion Commission		The Secretariat of the National Assembly
Office of the Commission of Counter Corruption	Cooperative Promotion Department	Department of Internal Trade	The Battery Organization	Department of Non-Formal Education	The Treasury Department	Protocol Department	The Bankchak Petroleum Co., Ltd.	The Department of Local Administration	The Civil Court	The Government Pharmaceutical Organization	Thailand Institute of Scientific and Technological Research	Meteorological Department		The Privy Council
Office of the Juridical Council	Department of Fisheries	Public Warehouse Organization	The Grass Organization	Department of Physical Education	Bank for Agriculture and Agricultural Cooperatives	Treaties and Legal Affairs Department	Industrial Estate Authority of Thailand	The Royal Thai Police Department	The Criminal Court		National Center for Genetic Engineering and Bictechnology	Port & Telegraph Department		Bureau of the Royal Household
Office of the Narcotics Control Board	Department of Land Development		The Tanning Organization	Office of the Private Education Commission	The Dhipaya Insurance Co., Ltd.		Offshore Mining Organization	Department of Public Prosecution	The Central Juvenile Court			Aeronautical Radio of Thailand Ltd.		The Royal Institute
Office of the National Economic and Social Development Board	Department of Livestock Development			Religious Affairs Department	Government Housing Bank		Sugar Factories, Inc.	Department of Public Welfare	The Central Labour Court			Airports Authority of Thailand		
Office of the National Education Commission	Royal Forest Department			Office of the Teacher Civil Service Commission	The Government Lottery Office		Rubber Estate Organization	Department of Public Works				Bangkok Mass Transit Authority		
National Intelligence Agency	The Royal Irrigation Department			Department of Teacher Education	Government Saving Bank		Thai Plywood Co., Ltd.	Expressway and Rapid Transit Authority of Thailand				The Communications Authority of Thailand		
Office of the National Security Council	Daily Farming Promotion Organization of Thailand			The Vocational Education Department	Krung Thai Bank Ltd.		Petroleum Authority of Thailand	Metropolitan Electricity Authority				Express Transportation Organization of Thailand		
National Statistical Office	Fish Marketing Organization			The Teacher Council of Thailand	Liquor Distillery Organization			Metropolitan Waterworks Authority				Port Authority of Thailand		
National Youth Bureau	Forest Industry Organization			Kurusapa Business Organization	Thailand Tobacco Monopoly			National Housing Authority				State Railway of Thailand		
The Public Relations Department	The Government Cold Storage Organization				Thai Marble Corporation Ltd.			Provincial Electricity Authority				Telephone Organization of Thailand		
Department of Technical & Economic Cooperation	Marketing Organization for Farmers							Provincial Waterworks Authority				Thai Airways International Co., Ltd.		
Electricity Generating Authority of Thailand	Rubber Estate Organization											Thai Marine Navigation Co., Ltd.		
Mass Communication Organization of Thailand	Office of the Rubber Replanting Aid Fund											The Transport Co., Ltd.		
Sport Authority of Thailand														
Tourism Authority of Thailand														
Zoological Park Organization														

Fig. 1-2 Organization Chart of Central Government

1.4 Related Organization

1.4.1 Organizations of Electric Power Sector

The electric power enterprises in Thailand are for the most part under the management of the government, while installed capacity owned by private companies accounts for about 10% of the entire electric power capacity.

The responsibility for comprehensive administration concerning electric power comes under the jurisdiction of the National Energy Administration (NEA) of the Ministry of Science, Technology and Energy.

The responsibility for electric power supply comes under the jurisdiction of EGAT for power generation and transmission to the primary substations and that of the two power distribution organizations, the MEA and the PEA, for on and thereafter.

(1) NEA: National Energy Administration

The NEA is responsible for managing energy policies for all of Thailand. It establishes and adjusts the electric power development plan in addition to being responsible for small scale hydroelectric power projects, etc., which are to be incorporated in the 5-year plan for economic and social development.

(2) EGAT: Electric Generating Authority of Thailand

The EGAT was set up in May 1969 by consolidating 3 organizations: YEA (the Yanhee Electric Authority), NEEA (the North-East Electricity Authority) and LA (the Lignite Authority).

EGAT has been charged, according to the EGAT Act 1968, with responsibility for carrying out the following objectives:

- To generate, acquire, transmit or distribute electric energy to:

  • The Metropolitan Electricity Authority (MEA), the Provincial Electricity Authority (PEA) or other electricity distribution authorities as prescribed;

  • Other electricity consumers as directed by a Royal Decree;

  • Neighbouring countries.

- To undertake various activities concerned with energy sources derived from natural resources e.g. water, wind, natural heat, sunlight, mineral or fuel such as oil, coal or gas and including nuclear energy for the production of electric energy and other activities which will promote the scheme of EGAT.

- To produce and commercialize lignite, and chemicals derived from or utilizing lignite, or join with other bodies for such activities.

To fulfill the aforesaid objectives, the scope of responsibilities entrusted to the Authority by the government are as follows:

- To construct and operate dams and reservoirs or other equipment connected with electric power production and to develop water resources with a view to expanding such opportunities.

- To construct thermal, hydro, nuclear and other types of power plant.

- To improve and expand substation and transmission system including associated equipment for electric power transmission and distribution.

- To specify standard, type and size of substation, transmission system, power plant, lignite chemical plant and fuel for power production as well as associated equipment.

- To formulate policy in connection with the production of power and sales of electricity, lignite and lignite by-products.

To achieve these objectives and responsibilities, EGAT has formed a main policy to ensure that sufficient power is constantly available, the services are reliable, and that power is sold at the lowest possible rates.

The reliability of power supply has been and is being continuously improved and the level of services has become the average in the world. EGAT, as a self-supporting organization, has an independent authority in the management of the organization. Although the decision or power rates is subject to approval of the Cabinet, it draws up the plan independently to cover all costs of power generation.

The financing depends on financing from the government, borrowings from both domestic and international financial organizations in addition to the issuance of bonds which are authorized by the government.

EGAT buys extra electric power from the Nam Ngum Power Plant in Lao PDR, transmitted through power distribution lines in Thakhed and Savannakhet.

Also, Thailand has been interconnected with Malaysia by the transmission lines of 115 kV/132 kV since August 1980, allowing international interchange of electric power.

The organization chart of EGAT is shown on Fig. 1-3.

(3) MEA: The Metropolitan Electricity Authority

The MEA was set up in 1958, combining the Bangkok Electric Power Company which was under the jurisdiction of the Ministry of Interior at that time and the Power Generating Bureau of the government, as an organization fully subsidized by the government.

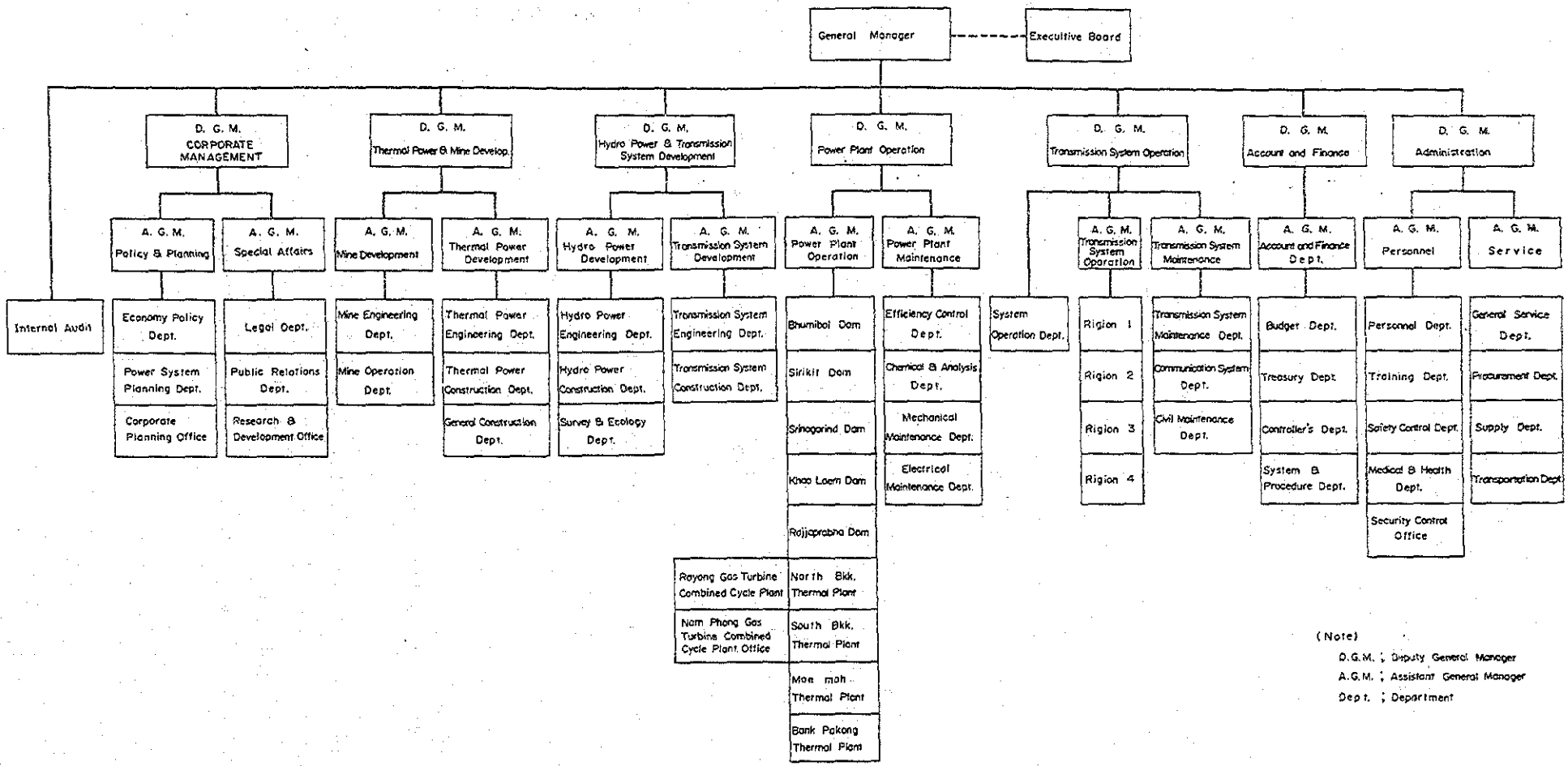


Fig. 1-3 Organization Chart of EGAT

1.4.2 Organization of Environmental Sector

As a result of increasing public concern and wish to create an organization which can effectively protect precious environmental resources, the Thai Government in 1975 promulgated the "Improvement and Conservation of National Environmental Quality Act, (1975)." This Act, among other things, created the National Environment Board (NEB), and the Office of the National Environment Board (ONEB), an executive secretariat and the operational arm of the Board.

(1) NEB: National Environmental Board

Under the Act of 1975, revised in 1978, the NEB is charged with:

- Submitting policy and opinion concerning the improvement and conservation of environmental quality to the Council of Ministers

- Considering guidelines for the implementation of policy in respect of the schemes or projects concerning environmental quality

- Considering and submitting opinion on projects of Government agencies, State enterprises and private organizations, which may have adverse effects on the environmental quality to the Council of Ministers

- Submitting plans for the development, improvement and conservation of environmental quality to the Council of Ministers

- Giving advice to the Prime Minister on matters to be prescribed in the Notification issued under section 17 or the Order issued under section 20 of the Act

- Recommending the standards of environmental quality to Government agencies having the statutory power to prescribe them as well as recommending measures for the prevention and conservation of environmental quality in various respects to the Government agencies concerned

- Recommending any amendment of or improvement to the law concerning the prevention and conservation of environmental quality to the Council of Ministers

- Coordinating works between Government agencies, State enterprises and private organizations on matters concerning the environmental quality

- Submitting opinion to the Prime Minister for consideration and order in the case where any Government agency or State enterprise violates or does not comply with the laws, rules or regulations concerning conservation of environmental quality, which may cause extensive damage.

- Submitting report on the national situation of environmental quality to the Council of Ministers at least once a year

- Considering any other matter concerning the environmental quality as the Council of Ministers or the Prime Minister may request, and

- Performing other functions as may be designated by law to be those of the National Environment Board.

The organization chart of NEB is shown on Fig. 1-4.

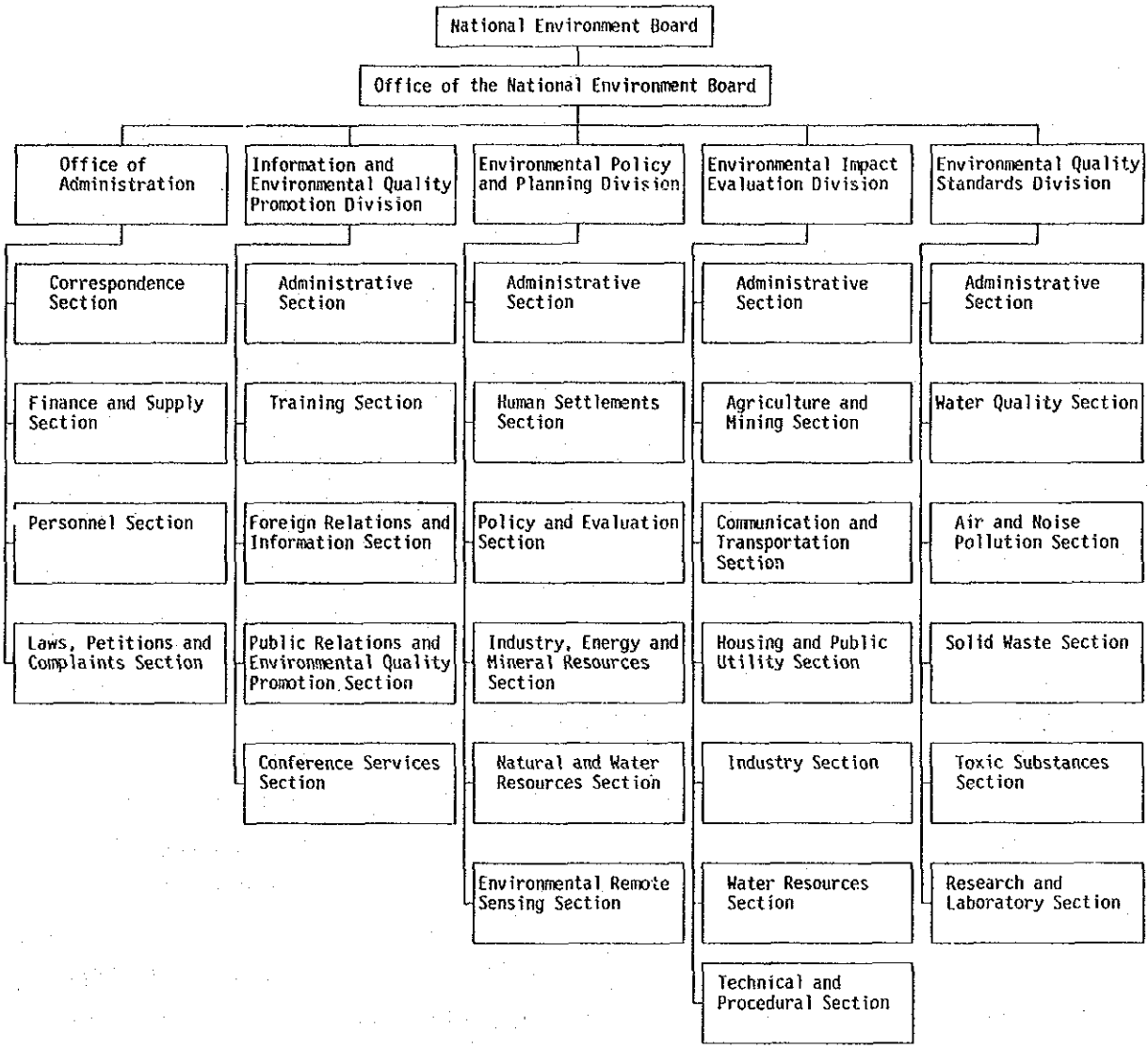


Fig. 1-4 Organization Chart of NEB

1.4.3 Person Related to the Study

The following participants were involved in the study.

EGAT

Name	Position
Mr. Charmon Suthiphongchai	Deputy General Manager Corporate Manager
Mr. Preecha Chungwatana	Deputy General Manager Thermal Power and Mine Development
Mr. Prasart Chumroum	Assistant General Manager Mine Development

(Thermal Power Engineering Dept.)

Dr. Khien Vongsuriya	Director
Mr. Chaya Jivacate	Assitant Director
Dr. Siwanan Na Nakorn	Chief, Special Energy Div.
Mr. Vinit Tangnoi	Chief, Thermal Plant Engineering Div.
Mr. Anuchit Jayaripat	Head, Project Evaluation Sect.
Mr. Somchai Wongpornpuxdee	Head, Fossil Fuel Sect.
Ms. Sriwan Buranachokepisal	Engineer Level 5, Project Evaluation Sect.
Ms. Chulaporn Tamjaijit	Engineer Level 5, Project Co-ordination Sect.

(Mine Engineering Dept.)

Mr. Thongjati Sopondisya	Director
Mr. Chamlong Uchukomol	Assistant Director
Mr. Chumporn Komsartra	Assistant Director
Mr. Nopadol Santipong	Chief, Solid Fuel Geology Div.
Mr. Sittichai Nilkamhaeng	Chief, Mine Planning Div.
Mr. Praphas Wichagul	Assistant Chief, Solid Fuel Geology Div.
*Mr. Weera Wisut	Assistant Head, Mining Project Sect. Mine Planning Div.
Mr. Amnaj Sanguanlosit	Head, Solid Fuel Geology Div. Geological Survey Sect.

Mr. Damri Santativongchai	Engineer Level 4, Mine Planning Div.
Mr. Sakon Srichart	Engineer Level 5, Mine Planning Div.
*Mr. Jirasak Bumrungtrakul	Assitant Head, Mine Planning Div. Mining Project Sect.

(Hydro Power Engineering Dept.)

Mr. Sompol Thieravarut	Engineer Level 9 Water Resources Engineer

(Survey and Ecology Dept.)

Mr. Wuthi Poonudom	Director
Mr. Kitti Kumpeera	Chief, Ecology and Environment Div.
Mr. Sanya Chareonweerakul	Assitant Chief, Ecology and Environment Div.
Dr. Virawan Sombutsiri	Head, Environmental Quality Development Sect.
Mr. Anupan Komkrichwarakool	Head, Environmental Analysis and Evaluation Sect.
Mr. Narumit Kiniman	Scientist Level 6 Ecology and Environmental Division

(System Planning Dept.)

Mr. Smarn Phongprapaphan	Assistant Director
Mr. Prutichai Chonglertvanichkul	Assistant Chief, Power System Planning Div.
Mr. Nophdol Salisdisouk	Head, Power System Technology and EHV Development Sect.

(Region 3 Dept.)

Mr. Uthit Sunthornpradit	Director
Mr. Sumitr Chittchang	Senior Engineer, (Electrical)
Mr. Pibul Visithsiri	Senior Engineer, (Mechanical)

(Mae Moh Power Plant Engineering Project)

Mr. Suporn Hotimavorakul	Superintendent

(Expert)

Mr. Ryuichi Abe

Mr. Kenji Yokokawa

JICA

Name	Position
Mr. Hiroshi Isaka	Team Leader
Mr. Shinichi Tachibana	Mechanical Engineer
Mr. Kazuhiro Nakaoji	Mechanical Engineer (FBC Boiler)
Mr. Yutaka Sugino	Mechanical Engineer
Mr. Yoshiteru Nishie	Electrical Engineer (Power)
Mr. Takehisa Sakai	Electrical Engineer (System)
Mr. Shunsuke Noguchi	Civil Engineer
Mr. Takashi Arai	Engineering Geologist
Mr. Tutomu Ikeda	Mining Engineer
Mr. Ippei Inazu	Architect
Mr. Teruhiko Kusano	Environmental Specialist
Mr. Hiroyuki Seki	Economist

2. BACKGROUND OF THE PROJECT

CHAPTER 2 BACKGROUND OF THE PROJECT

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2. Background of the Project

2.1 Current Economic Situation and National Economic and Social Development Plan

2.1.1 Current Economic Situation

(1) Outline

With plenty of arable land, natural resources and a large labor force, the economy of Thailand in the years following World War II developed steadily achieving a high economic growth rate while diversifying its industrial structure. Till the mid-1950s, its pre-capita GDP was $80, a figure dwarfed by the $1,400 or so of today's GDP per capita. Though the regional variation of income not small, the fact is that Thai economy tided over the oil crisis and other jolts and unwaveringly grew. It is now touted as the most likely country to be a new member of NIES (Newly Industrializing Economies), the group of countries in Asia whose economic status has markedly risen in the recent years.

(2) Major Economic Indicators

The economic performance of Thailand in the recent years after the second oil shock has been on an upward swing, with a 3.5% growth rate for 1985 and 4.9% for 1986 in terms of real GDP (gross domestic product), thanks mainly to the expansion of exports which began in mid-1986. For 1987, 1988 and 1989, real GDP grew by 9.5%, 13.2% and 12.2% respectively and, of the GNE (Gross National Expenditure), both exports and the formation of fixed capital being considerably up from the preceding year. Imports expanded by a large bound, because of increasingly strong domestic demand. Agricultural output grew only a little, however, owing to the drought but manufacturing industry registered a growth of as much as over 10%. Tertiary industries, electric power, water supply, financial business, insurance and services, have all fared well.

Thailand's position in international trade is quite involved. By 1986, the deficit in trade balance had been on the decrease and, as a result

of this, the current account for 1986 turned into the black, though this surplus was small. Since then, imports have increased because of recovery of business at home and exceeded exports to drive both trade balance and current account into the red while capital inflow kept increasing so as to hold the overall balance of payments in favor of Thailand. Therefore its foreign currency reserve has been growing steadily and, moreover, its debt service ratio, once hovering at a high level, shrank to 11.0% at the end of 1989.

Recently for consumer price level is gradually raising and it is over 6% at the present.

Major Economic Indicators and Balance of International Payments from 1983 to 1989 are shown on tables below.

Major Economic Indicators

Indicator	1983	1984	1985	1986	1987	1988	1989
Real GDP growth rate (%)	7.3	7.1	3.5	4.9	9.5	13.2	12.2
Consumer price rise (%)	3.8	0.9	2.4	1.9	2.5	3.8	5.4
Whole price rise (%)	2.0	-3.1	-0.1	-0.4	5.9	8.2	4.6
Foreign currency reserves (US$ billion)	26	27	30	38	52	71	105
Debt to foreign lenders (US$ billion)	9.5	10.8	12.8	14.1	15.7	17.9	19.0
Government finance:							
Balance (Bil. Baht)	-23.7	-34.0	-39.4	-34.2	-8.9	36.1	65.3

Source: Thai Central Bank and NESDB

Balance of International Payments

(Unit: Billion Baht)

Item of Balance	1983	1984	1985	1986	1987	1988	1989
Exports	145.1	173.6	191.7	231.5	298.1	399.2	514.0
Imports	234.3	243.2	253.4	245.7	341.4	501.4	646.8
Balance of trade	-89.2	-69.6	-61.7	-14.2	-43.3	-102.2	-132.8
Current account	66.1	-49.2	-41.9	6.5	9.3	-41.8	-58.0
Overall balance of payments	-18.1	10.6	12.5	33.6	18.2	40.5	111.5
Baht per U.S.$ (average)	22.98	23.61	27.13	26.27	25.71	25.27	25.60

Source: Thai Central Bank and NESDB

Note: Re-exports and similar transactions are not included in the export and import figures.

Coming into 1990, the Thai economy continued to show an expansionary trend to foretell a real growth rate of around 10%. The expected increase in the trade imbalance, which would push up prices and make money supply tighter, because of circulatory factors, has not affected the basic mechanisms of Thai economy enough to signal any negative influence on its current performance, which is good, if not excellent.

2.1.2 Underpinnings of the Economic Growth

The decade of the 1980s opened its door to see the real GDP of Thailand rising rapidly at an annual average of not lower than 5% while the other countries of Asia were compelled to resort to a policy of adjustment in order to avoid increases in overseas debt at the cost of growth rate curtailment. Of the ASEAN countries, Thailand cut an enviable figure with its high growth rate, twice as high as the 2.5% growth rate of world economy during the same period.

The Thai economy, maintaining the high rate of growth we have just noted, is steadfastly supported by eight underpinnings and each will be considered.

The first underpinning is Thai agriculture. Thailand has been one of the major exporters of primary products: rice, rubber, tin and teak have been traditional export items. To these are added the new export items which

surfaced after World War II, namely; cassava, maize, sugar cane, canned fish, frozen shrimp and squid, canned fruit, frozen chicken, etc. Despite the conspicuous changes taking place in the overall export makeup, the share of these agro-aquatic products in the total export volume is at a level of over 50% and signifies the large weight of agro-aquatic industry in the national economy of Thailand.

The second is the diversification of production output. Not only agriculture has been expanding rapidly to take on a new outlook. In addition to such manufactured products as processed foods and textiles, new export products are emerging in increasing quantity from the plants set up by direct investment from overseas or by joint venture of indigenous and foreign capital. Examples of the new export products are IC parts, jewelry, plastic articles, woodwork and furniture. Countries importing these Thai products are diversified; 60% of the total export volume go to OECD countries and the remaining 40% to developing countries.

The third is the government self-restraint on public spending and monetary policy, which improved Thailand's position markedly in regard to fiscal balance and international finance, and helped sustain the stability of domestic economy. Compare Thailand with those developing countries currently struggling under a heavy debt burden, and it will be seen that Thailand is far better circumstanced. This policy of self-restraint is eloquently illustrated by the ceiling that the government imposed on itself during the ongoing 6th economic development plan to limit the annual borrowing from overseas to U.S. $1.5 billion.

The fourth is the innovation worked into the administrative mechanisms, which streamlined administrative decision-making processes. This innovation lies mainly in the introduction of the committee system into governmental organs. Many committees have been instituted to stimulate cooperation between governmental organs and private-sector businesses.

The fifth is the integrity of economic policy. Coming and going of cabinet members in the executive branch do not affect the economic policy once charted. Even the now remote chance of coup d'etat can not swerve or alter

the general tenor of economic policy. This means that a policy once set rolling continues to run on the charted course.

The sixth is the relatively favorable environment for investment. The committee responsible for this area is the government Board of Investment (BOI). the Board has been positive in according generous measures to investors. This attitude, plus several social factors, makes Thailand highly attractive to overseas investors. For one thing, labor is not only plentiful but has high aptitude for technical work. For another, agriculture, as the bedrock of social stability, is steadfast. The land is expansive (513,000 km^2), with a large enough population (55.5 million), to promise a potentially huge domestic market.

The seventh is a large income from tourists of foreign countries. This income in 1989, 96.4 billion Baht, was large than that of apparel which was the top export item.

The eighth is the rapid increase in direct investment of recent years. This increase was triggered in the latter half of 1986 by investors from Japan and Taiwan, and in 1987 the number of applications for investment permits rose considerably. The trend picked up speed in 1988. Obviously, direct investment from overseas is a prominent factor in the continuing growth of Thai economy.

2.1.3 Main Factor of Economic Growth in Thailand

Factors contributing to this success of the Thai economy may be found in its flexibly constituted economic structure, capable of readily adjusting itself to changes, and in the economic policy sustained by the government.

(1) Change in Economic Structure

The basis of Thai economy is agriculture and this fact cannot be ignored in assessing the economic aspect of Thailand today and in weighing the role Thai agriculture has played and is playing. About 60% of the people, who derives their livelihood from agriculture, still

account for a sizable portion of the national output and exports, though their productivity can hardly be said to be high by world standards. Diversification has been taking place to increasingly eclipse the mainstream produce, rice, by such products as maize, cassava, sugar cane, etc., thus paving the way for growth of agro-industry, nurtured by the rich variety of agricultural produce that Thailand is capable of turning out.

The share of agriculture in Thailand's national economy, however, has been shrinking, in relative terms, as manufacturing industry kept steadily expanding to increase its share. In 1989, primary industry accounted for 17% of GDP and manufacturing and construction industries combined accounted for 32%.

In the export area, apparel became the top export item by surpassing rice, and jewelry, gems and personal ornaments took higher places in the list of Thai exports.

Processing and machining services rendered to foreign manufacturers is contributing measurably to Thai export performance. Besides all these, businessmen from Japan, Taiwan and other countries are finding a promising place of business in Thailand. Their high-valued currencies, notably the Japanese Yen, are giving impetus to the inflow of capital in the form of foreign manufacturers setting up plants and shops in Thailand. This trend, often appearing like an inrush of industrial funds, is likely to fuel the industrialization of Thailand for many years to come and to induce a change, if not a radical change, in the economic outlook of Thailand.

(2) Economic Policy

The economic policy long pursued by the Thai government may be viewed as being characterized by enlightened conservatism founded on free enterprise but preferring balanced expansion to high-pitched economic growth. During the period from the first national economic and social development plan (1961-1966) to the current 7th, the government restricted its economic role to that of developing the social capital;

namely, the transportation network, public utilities, housing, etc. It took a cautious stance on the launching of large scale development projects while aiming at fiscal balance and refraining from rash overseas borrowing. Unlike many developing countries, Thailand did not hasten to expand its heavy and chemical industries. Rather, it courted a slow industrialization centered on light industries taking into account the limited levels of technological skill and available funds at home. This traditional policy is still alive, keeping Thailand moving in the direction of industrialization locked into agriculture as one of the NAIC (New Agro-Industrial Countries) and preventing itself from following the footsteps of some countries who ventured on the course of export-oriented high-tech industrialization. Today, Thai economic policy seems to address the problems of how to narrow the development gap existing among regions and to minimize the differences in personal income while maintaining the free play given to the nation's economic engines.

The industrialization policy the government of Thailand has been pushing is built on two policy pillars. One is the economic development plan which started life in 1961 and the other be that which is embodied in the 1962 legislation, "Industrial Investment Promotion Law." It is policy relying on initiatives in the private sector; this is the basic line which has been consistently followed to date. At present, the 7th national and social economic development plan (1991 to 1996) is in progress.

2.1.4 Problems Facing the Thai Economy

Although the overall Thai economy is understood to be in good condition, as explained in the foregoing sections, a great many problems remain unsolved. The primary objectives in Thailand's current economic policies are to reduce regional differentials concerning economic developments, to achieve fair income distribution, and to allow the independent economy of Thailand to take off.

Other problems include slum areas and informal sectors inside big cities; shortcomings in the infrastructure, among them communications; decentralization of industries to reduce an over concentration in the cities; trade deficit problems; an increasing labor force versus decreasing employment opportunities; technical transfer problems; and traffic and flood problems in Bangkok. The Thai government is well aware of these problems and is making efforts to solve them through the 7th national economic and social development plan.

Table 2-1 Targets and Accomplishments of the Development Plans

Growth Item	1st Plan (1961-1966)		2nd Plan (1967-1971)		3rd Plan (1972-1976)		4th Plan (1977-1981)		5th Plan (1982-1986)		6th Plan (1987-1991)	
	Target	Reached	Target	Reached	Target	Reached	Target	Reached	Target	Reached	Target	Reached
Economic Growth Rate (%)	6	8.1	8.5	7.8	7.0	7.1	7.0	7.1	6.6	4.4	5.0	-
Agriculture	4.5	5.0	4.3	4.1	5.1	3.9	5.0	3.5	4.5	2.1	2.9	-
Manufacturing	-	10.5	10.9	9.2	8.0	8.6	9.6	8.7	7.6	5.1	6.6	-
Income per Capita (Baht)	-	2,787	-	3,835	-	7,330	-	17,200	35,700	21,935	27,783	-
Population Increase (%)	3.0	3.3	3.3	3.2	2.5	2.6	2.1	2.2	1.5	1.7	1.3	-
Balance of Trade (Mil. Baht)	-	-2,167	-	-10,484	-	-13,047	-17,940	-45,000	-78,400	-54,000	-35,900	-
Commodity Price Rise (%)	-	-	-	-	10.0	12.0	6.0	11.6	10.6	2.7	2.3	-

Source: NESDB

2.1.5 Outline of the National Economic and Social Development Plan

(1) Targets Set for the 1st through the 6th plans and accomplishments made during the plan periods

The attached table (Table 2-1) shows the planned targets and accomplishments of economic growth rates, GDP per capita, population growth rates, trade balance, and increase rates of consumer prices that resulted from 1961~66 (1st term) through 1992~96 (6th term) of the national economic and social development plan.

(2) Outline of the 7th Plan

Following is an outline of the 7th national economic and social development plan (1992-96), which was approved by the cabinet meeting of August 1990 and started in October 1991.

Objectives

* To maintain an adequate level of economic growth while maintaining the stability of both economy and finance.

* To distribute income and the results of economic developments to local regions.

* To promote further developments of human resources, living standards, environments, and natural resources.

Targets

To achieve these objectives, the following targets in terms of quantity and quality have been established:

1. Economic growth

   * Yearly economic growth rate of 9% on the average

* Increase of income per capita to 75,000 bahts (about US$3,000), in the last year of this plan, from 32,400 bahts in 1989, which means that an average annual growth rate of 7.6% must be achieved.

* Average annual growth rate of more than 2.7% in agricultural production.

* Average annual growth rate of 9.3% in manufacturing production.

* Average annual growth rate of 17% in export revenues and of 12% in export volume on the assumption that the world economy grows at an annual rate of 3%.

2. Targets of economic stability

* Inflation rates should not exceed an annual average of 5.5%.

* Trade deficits should not exceed an annual average of 7% in terms of ratio of GDP.

* The current account should be balanced by the last year of this plan. The deficit ratio of the current account to GDP should not exceed an annual average of 2%.

3. Targets of income distribution

* Target groups for income distribution should clearly be defined for people who belong to these categories: poor farmers, employed farmers, people who run small businesses in city areas, and low-wage workers employed by private enterprises.

* The population ratio of those below the poverty level should be reduced to less than 20% by the last year of this plan, thereby reducing the number of poor people.

* While curtailing the income gap by region and occupation, efforts should be made to raise the income levels of the target groups, especially of poor self-employed farmers and those employed in farming industries.

* Proprietorship of assets should be distributed with special emphases on farmers' income from land and on the housing supply for low-income workers.

4. Targets of human resources, living standards, environments, and natural resources development

* The population growth rate should be lowered to 1.2% annually by the last year of this plan.

* Through the continued efforts to promote and improve lifelong education in the overall education systems (both formal and informal), the quality of the Thai people should be raised to provide them with flexibilities that allow them to cope with changing environments. Also, active participation by the general public in the development programs should be encouraged on a much wider scale, and the profits gained from participation should be protected and secured for the investors.

* Efforts should be made so that all the Thai people can enjoy good health within 10 years.

* To promote the progress of our societies and to preserve and maintain the identity and the precious traditional values of Thailand, it is necessary to bring up the type of people who have a sense of morality and ethics to go along with good health and skills.

* Efficiency concerning the protection of life, properties, and consumer interests should be raised so that people from rural and urban areas alike can benefit from high-quality lifestyles and peaceful societies.

* Living standards should be raised through efforts to reduce the levels of water and air pollution, noise, solid wastes, and harmful wastes and also through efforts to check the worsening situation of environments overall. Recreational areas should be provided. Harmful contaminants in the air, such as sulfur dioxide, carbon monoxide, nitrogen dioxide, and from gasoline, should be reduced to levels that will not harmfully affect people in both city and rural regions.

Primary Policies

To achieve our goals, the following policies have been set forth:

1. To help the economy to grow

To achieve 9% growth during the 7th plan while maintaining a stable economy, it is important to make further advances in the production restructuring program for the agriculture, industry, service, and trading sectors and to solve the problems arising from the deficiency of basic infrastructural services and an insufficient supply of energy. Equally important is the restructuring of money markets and finance and capital markets in line with objectives to promote science and technology policies and to maintain economic growth and stability. As primary policies, developmental guidelines have been proposed for the following nine sectors: Agriculture, manufacturing industries, foreign trading, service industries, infrastructural services, energy industries, science and technologies, new economy zones, and money, finance, and capital markets. The main points proposed:

* To promote diversification of both trading and production structures

* To promote the development of capital markets aiming at creating beneficial investing environments and also to enforce money and

finance policies flexibly in the direction of easing restrictions.

* To open the Thai economic system to the international economy and to enhance productivity with an eye to maintaining Thailand's competitiveness in international markets. to promote the strategy to decentralize production bases to new local economic zones and to create competitive economic environments in Thailand by taking measures to reduce monopoly and protectionism in domestic markets.

* To remove obstructions to economic expansion, to raise the productivity and competitiveness of Thai industries, and to promote the development of science and technology.

* To monitor and control inflation, trade deficits, current account deficits, and foreign liabilities.

* To encourage private-sector participation in national development programs.

2. Income distribution policies

The situation of income gaps in Thailand is becoming much more serious than expected. The population ratio of the below-poverty level dropped to 25.2% in 1988, from 39% in 1969. The tempo for the ratio to drop, however, has dwindled since 1988, reflecting the stagnant market of primary merchandise in the 1990s, which has had a strong influence on poor people in farming regions.

The income gap among households is also increasing. A comparison between the top 20% of the population, the most affluent group, and the bottom 20%, the poorest group, shows the gap has increased 8 to 12 times from 1976 through 1986. A survey by occupation shows that the income level of farmers is still the lowest income category, which is about half the average income level of the total population.

Although the average workers and government employees are paid higher than farmers, those employed by private enterprises are paid much higher, about five times more than government employees are paid.

The economic gap between the metropolitan area and other areas is also increasing. Bangkok produced about 46.3% of total domestic production in 1981. The ratio rose to 48.6% in 1987. However, the production ratios in almost all other areas dropped during the same period.

With the income distribution policies of the 7th plan, therefore, consideration should be given to the above-described income distribution problems and also to the basic problem of property gaps, which forms the root to all these problems. It is also necessary to define underprivileged groups, such as farmers, as a target group of this policy.

Guidelines for the income distribution policies are prepared for seven categories as follows:

- Money/finance policies to facilitate fair income distribution
- Guarantee policies for housing and farmland
- Distribution policies for proprietorships
- Development policies for human resources
- Improvement policies for production and market development systems
- Policies to decentralize social economic services to local areas
- Policies to solve local poverty problems
- Policies to solve city poverty problems

The following main points are proposed in relation to these guidelines:

* To integrate local tax, land tax, and property tax into one general property tax and to study the possibility of introducing an inheritance tax.

* To increase revenues of local areas by means of profits from royalties and to increase power generation by using the natural resources in each local area.

* To increase budgets and to develop education and health services in remote regions and in city slum areas.

* To establish funds for or assign loans to low-income people for purchasing land and houses.

* To improve the production and market development systems for poor people in agriculture

* To decentralize production activities to local regions with emphasis on the movement of small and medium-sized enterprises, which are closely tied to large-scale corporations.

* To enforce fair income policies for underprivileged workers.

* To develop human resources through education, vocational training, and social welfare.

* To accomplish a 100% school attendance rate for six-year compulsory education and to extend the term of compulsory education to nine years by 1995.

* To expand basic infrastructural services to local regions.

* To provide land and housing guarantees to under-privileged people by such means as promotion of land reform, law

enforcement of land rent for agricultural purposes, and housing for low-income classes through the establishment of fair rent charges.

* To provide financial assistance to stall owners and self-employed people who run their own businesses, and to promote fair subcontracting systems and a supply of information with an eye to solving the poverty problems in city areas.

3. Policies for human resources, living standards, and the development of environmental and natural resources

To realize a better living standard for the Thai people during the term of the 7th plan, it is necessary to adjust and improve social, environmental, and natural resource policies and to secure a good balance between these policies and the status of developments on a national scale.

The following development policies are designed to upgrade the living standards of all the Thai people and to enable them to adapt to changes in societies, economies, and technologies.

It is estimated that during the 7th plan, the nation's way of life will be greatly affected by social changes in many sectors throughout Thailand. This country is transforming itself from an old agricultural society to a new society in which urban areas play a key role in economic activities.

The age structure of the population and the family system of Thailand is also going through big changes. Especially in the family system, as one family scale grows smaller because of a decreasing number of children and an increasing number of nuclear families, the number of single-parent households and fatherless families is expected to increase. It is estimated that all these rapid and drastic changes going in the social structures will have a tremendous effect on the Thai people's living standards.

To alleviate these influences, guidelines have been proposed in five categories: human resources development, education and health measures, public health measures, development plans for social ethics and culture, environmental development measures, and development plans for natural resources. These policies are further detailed in the following descriptions:

* To improve the physiques and the mental capabilities of the Thai people so that individuals in any age group can adapt to changes in societies, economies, and technologies. Special emphasis will be placed on reforming the education system into one that can keep abreast of the fast pace of technological innovations and also on reinforcing the job and skill training system.

* To improve the method and the means for more-stable family ties orders. To encourage the private sector and community organizations to establish welfare centers where children and older people can be cared for.

* To ensure social stability and peace with special attention to crime prevention in greater efforts to secure human life and property.

* To encourage the establishment of public mechanisms to promote moral education and to adjust and support the activities of monasteries, religious communities, and religious groups.

* To ensure environmental qualities on the basis of international standards.

* To strictly enforce laws, administrative systems, pollution control, and resource control to prevent air and water pollution, solid waste exhausts harmful wastes, and worsening situations of natural resources.

* To prevent damage caused by acid rain by enforcing proper measures on the use of coal at manufacturing stages.