KINGDOM OF THAILAND

FEASIBILITY STUDY
ON
LAM TA KHONG PUMPED STORAGE DEVELOPMENT PROJECT

FINAL REPORT

NOVEMBER, 1991

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct a feasibility study on Lam Ta Khong Pumped Storage Project and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to Thailand a study team headed by Mr. Tetsuo Nishigori, Deputy Director of Construction and Engineering Office, Construction and Engineering Department, Electric Power Development Company, Ltd., 5 times between February 1990 and November 1991.

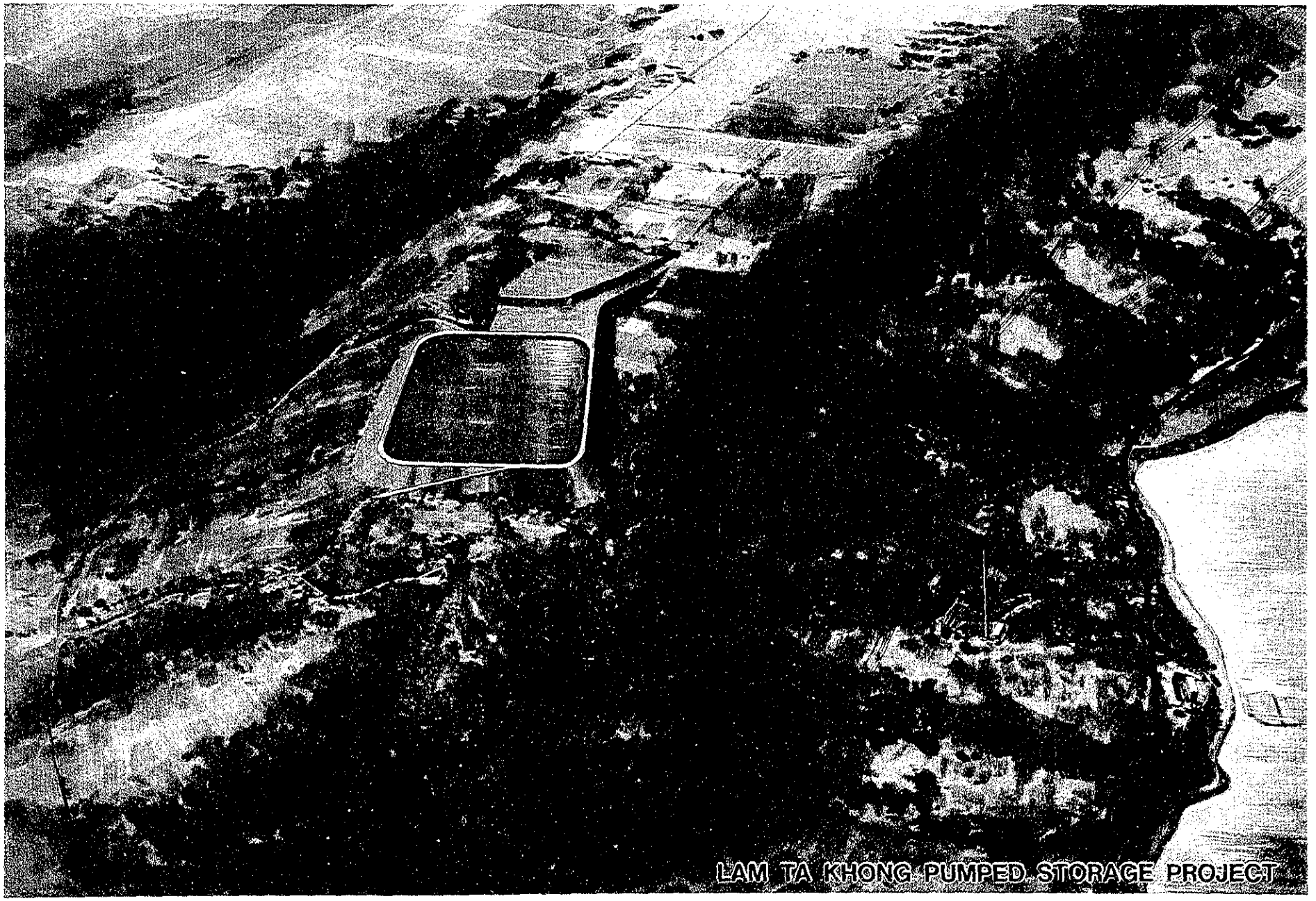
The team held discussions with the officials concerned of the Government of Thailand, and conducted field surveys at the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

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

November 1991

Kensuke Yanagiya
President
Japan International Cooperation Agency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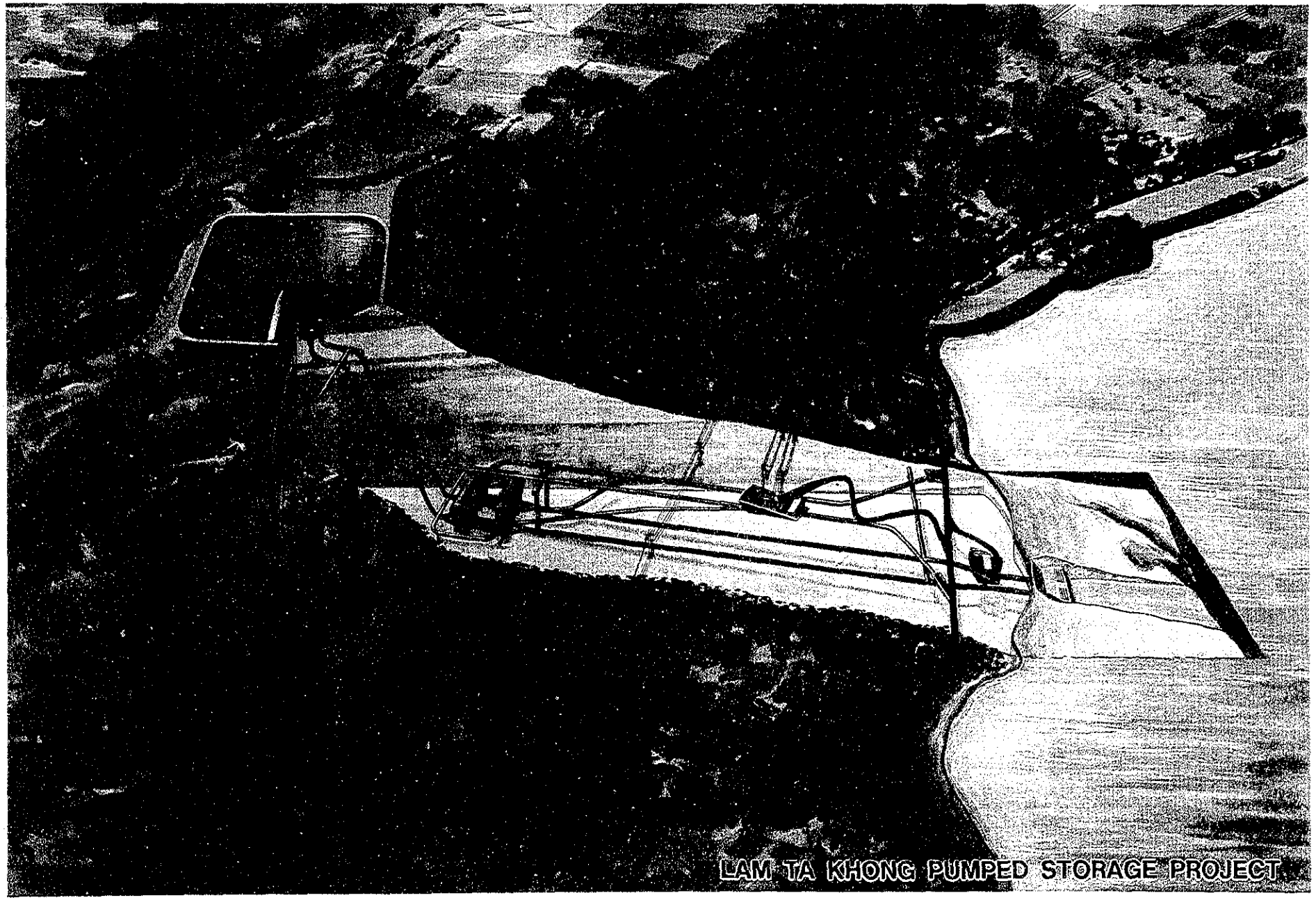
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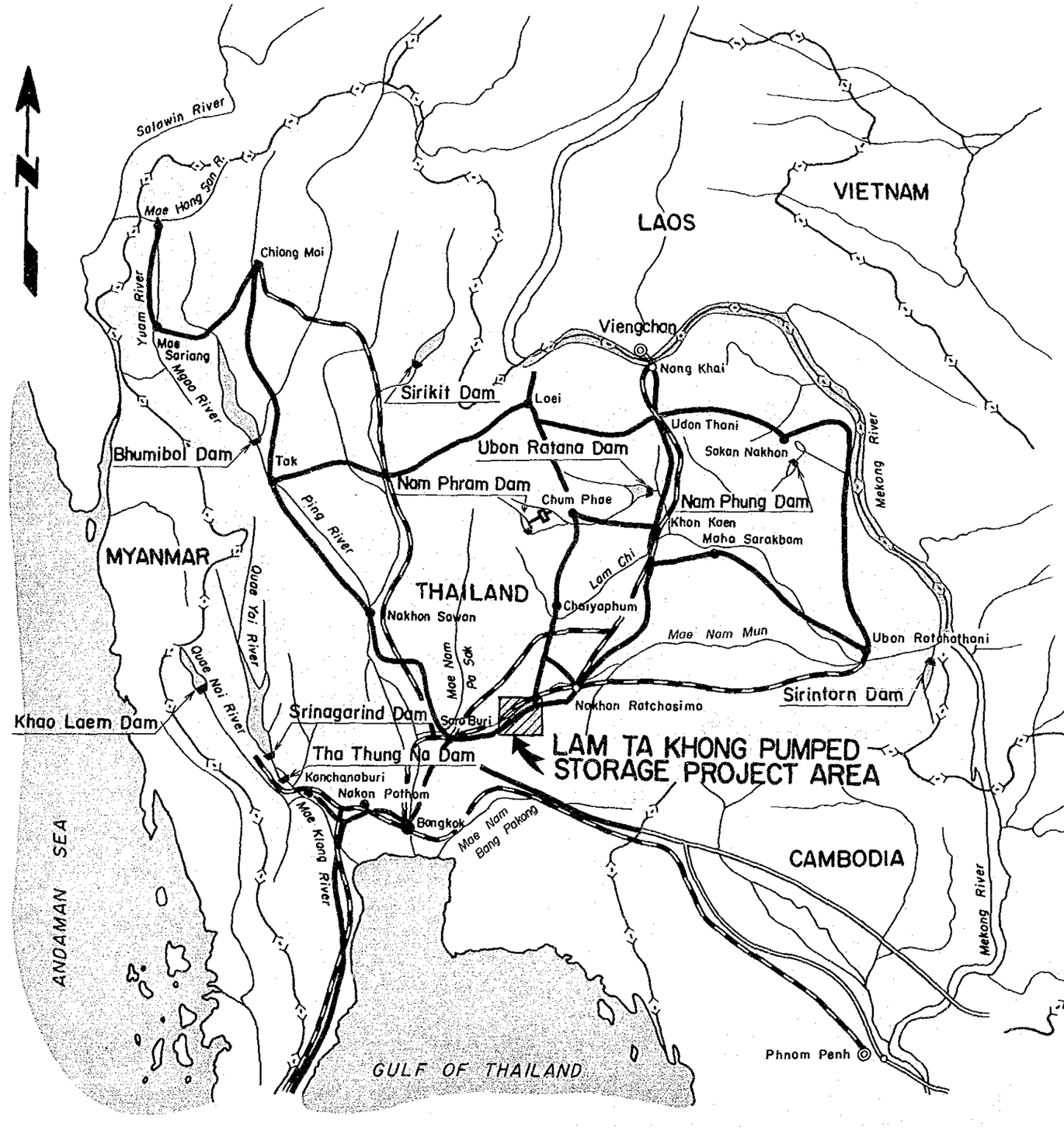

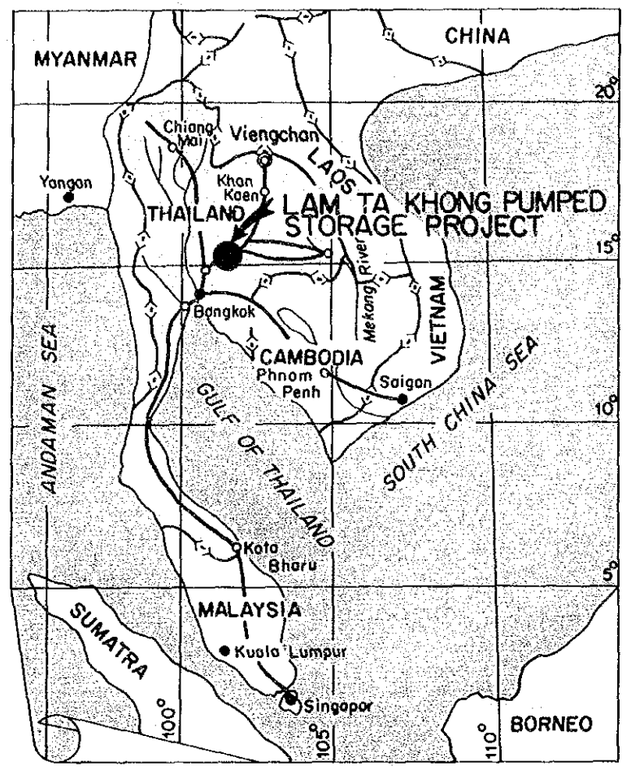

LEGEND

- International boundary
- Railway
- Main road

0 100 200km

LAM TA KHONG
PUMPED STORAGE PROJECT

KEY AND LOCATION MAP

LAM TA KHONG PUMPED STORAGE PROJECT SITE

Lam Ta Khong Reservoir (Existing)

Lam Ta Khong Dam

Amphoe Phatthana Nikhom

Phatthana Nikhom

Amphoe Kaeng Khoi

Kaeng Khoi

Amphoe Pak Chong

Amphoe Muaklek

SARABURI

Bangkok

Lam Phaya Klang

Lam Nam Ta Khong

Mae Nam Pa Sak

Chai Badan

Lam Narai

Lam Buri

R21

R2

15°00'

14°30'

101°30'

0 5 10 15Km.

1:250,000

LAM TA KHONG
PUMPED STORAGE PROJECT

DETAIL LOCATION MAP

Photo-1 Upper Reservoir Site (View from West)

Photo-2 Tailrace Site

Photo-3 Route of Waterway (View from Upper Reservoir)

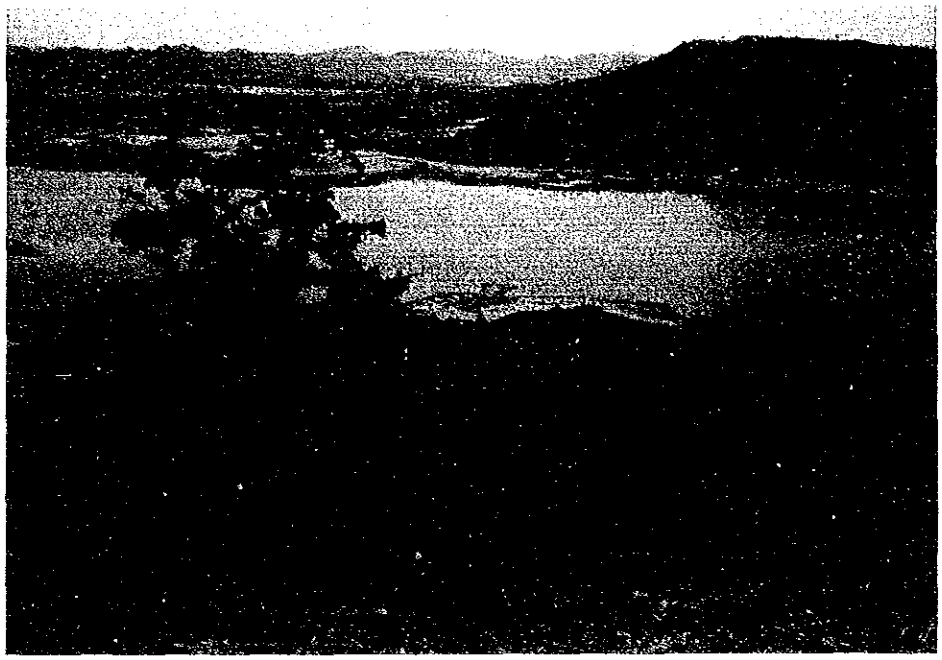

Photo-4 Route of Waterway (View from Tailrace Site)

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Chapter 16 Further Investigation

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
°C	:	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
PAX	:	Private Automatic Exchanger
PMF	:	Probable Maximum Flood
PMP	:	Probable Maximum Precipitation
UHF	:	Ultra High Frequency
VHF	:	Very High Frequency
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
Lao PDR	:	Lao People Democratic Republic
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

CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS AND RECOMMENDATIONS

The Lam Ta Khong Pumped Storage Project is situated on the Lam Ta Khong River, a tributary of the Mun River of the Mekong River system, 200 km northeast of the capital, Bangkok. This Feasibility Study reveals that the project is feasible from technical, environmental and economic points of view. An outline of the conclusions and recommendations are given below.

Conclusions

(1) Electric power demand in Thailand recorded an annual growth rate of 14 percent in 1990 as a result of rapid industrialization. It is predicted that demand will grow at an annual rate of approximately 16 percent in 1991 and 7 percent in 1997. The peak power demand in 1990 of 7,094 MW is estimated to become about 13,000 ~ 14,000 MW in 1997. Therefore, there will be a necessity to construct new facilities of approximately 900 MW every year.

(2) At present, only a few power source exist to meet the rapid increase of peak power demand. In order to supply reliable electric power in the future corresponding to the rapid industrialization of Thailand, it is necessary to develop hydroelectric power plants capable of coping with the peak load. The Lam Ta Khong project is extremely promising as a power source to cope with the above-mentioned increase in demand and as a power source to supply peak loads of Thailand.

(3) The optimum scale of development of the Lam Ta Khong pumped storage power plant is 1,000 MW having the capability of 8 hours' continuous operation (storage capacity of upper reservoir). It is desirable to commence operation of the project at the earliest, and it is considered that this is in the year 1997. In the case that the development of the project is divided into two stages and that the unit 3 and 4 (250 MW x 2 units) are installed later than 1997,

it is recommended that the units 3 and 4 shall be installed by the year of 2002 from an economic point of view.

(4) The power system stability poses a limitation of plant operation. The 1,000 MW generation will be possible in 1997, however, pumping at off-peak time will have to be restricted to 500 MW at most from the stand point of the power system stability.

(5) In addition to the function of power supply capability the Lam Ta Khong power plant will provide the following benefits to EGAT's system. The project will have quick load following characteristics corresponding to load fluctuation, regulating the system frequency and voltage, reserve capacity in case of failure of other power plants, and reducing the frequency of start-and-stop of thermal power plants thereby enabling high efficiency operation of thermal power plants.

(6) Civil structures including surface membrane fill dam for upper reservoir, underground powerhouse, penstock and tailrace tunnel were designed taking into consideration topography, geology, availability of construction materials, earthquakes and environmental aspect.

Bedrock of the upper reservoir, the waterway and the underground powerhouse is composed of sedimentary rock of Mesozoic era, and remarkable faults or other problems were not found judging from the results of in situ rock tests. There are no technical problems which would influence the realization of this project.

(7) The project area is located in an environmental area where development is restricted by the Thai government. Construction of structures on the surface are prohibited in a part of the area. In order to evade the restricted area, underground structures are adopted in this project.

There are no people living in the project area, so there will be no resettlement problem.

Since the project is designed considering the environment, it is feasible from an environmental point of view.

(8) The estimated project cost including import duty, interest during construction and escalation up to 1997 is 16,674 million Baht (US$641 million).

(9) The present value of surplus benefit (B - C), benefit-cost ratio (B/C), and equalizing discount rate (EDR) of the project obtained from economic comparison of the Lam Ta Khong power plant and an alternative thermal plant are 1,504 million Baht, 1.16 and 17.4 percent, respectively. These values indicate that the development of the project is economically feasible.

Recommendations

(1) It is necessary to proceed to the stage of definite study as soon as possible in order that the project is completed and commissioned as scheduled in the year 1997.

(2) The following additional investigations and studies are recommended:

- Exploratory adit should be excavated as soon as possible in order to design the powerhouse and study its construction method. In situ rock tests should be carried out in order to understand the physical properties of the bedrock.

- Along with the definite study of the project development, it is necessary to study reinforcing the power system in future, especially to study installing facilities to supply reactive power for the purpose of holding voltage of 230 kV bus at each substation at the appropriate level. It is particularly important to hold the voltages at Saraburi 2 and Nakhon Ratchasima 2 substations during Lam Ta Khong's pumping.

- In order that the power sources in the northern area can be developed on schedule and the Lam Ta Khong power station and other power stations can be properly operated without limitations it is necessary to reinforce the power system in and after the end of 1990's when power system stability at pumping hours will become critical. The power system reinforcement should be studied including the possibility of pumping by three or four units of the Lam Ta Khong power station.

General Project Description of Lam Ta Khong Pumped Storage Project (1/4)

	Project Name		Lam Ta Khong Pumped Storage	
			Upper Reservoir	Lower Reservoir
1.	LOCATION			Lam Ta Khong River Tributary of Mun River
			District, Pak Chong Sikhiu	District, Pak Chong Sikhiu
			Province: Nakhon Ratchashima	Province: Nakhon Ratchashima
2.	PURPOSE		Power Generation	Multi purpose (Existing)
3.	HYDROLOGY			
	Catchment Area	km^2	0.4	1,430
	Period of Runoff Analysis	yrs.	-	28
	Average Annual Inflow	MCM	-	261
	Design Flood	m^3/sec	-	2,130
4.	RESERVOIR			
	Normal High Water Level (NHWL)	m.MSL.	660.0	277.0
	Low Water Level	m.MSL.	620.0	261.0
	Total Storage Capacity	MCM	10.3	310
	Effective Storage Capacity	MCM	9.9	290
	Surface Area at NHWL	km^2	0.3	44
5.	DAM			
	Type		Rockfill Dam with Asphalt Facing	Homogeneous Earth-fill Dam
	Dam Height	m	60	40.3
	Crest Elevation	m.MSL.	662.50	282.3
	Crest Length	m	2,210	527
	Dam Volume	10^3 m^3	6,190	853
	Upstream Face Slope	-	1 : 2.5	1 : 3.0 - 5.0
	Downstream Face Slope	-	1 : 2.5	1 : 2.5

General Project Description of Lam Ta Khong Pumped Storage Project (2/4)

	Project Name		Lam Ta Khong Pumped Storage	
6.	INTAKE			
	Type		Morning-glory	
	Size	m	$(18.0 - 5.8)^{D}$ x 51	
	Number	set	2	
7.	PENSTOCK			
	Type	-	Inclined Shaft Embedded Steel	
	Number	-	2 - 4	
	Inner Diameter	m	5.8 - 2.6	
	Length	m	690	
8.	TAILRACE TUNNEL			
	Type	-	Concrete Lined Pressure Type	
	Number	-	4 - 2	
	Inner Diameter	m	4.90 - 6.60	
	Length	m	1,470	
9.	SURGE CHAMBER			
	Type	-	Chamber Surge Tank	
	Number	-	2	
	Dimension			
	- Main Body	m	Inside 8.90	Height 107.0
	- Chamber	m	Inside 10.00 x 10.00	Length 35.0
10.	OUTLET			
	Type	-	4 Continuous Box Culvert	
	Number	-	2	
	Size	m	Width 6.6 - 30.0	
		m	Height 6.6 - 10.0	
		m	Length 55.0	

General Project Description of Lam Ta Khong Pumped Storage Project (3/4)

	Project Name		Lam Ta Khong Pumped Storage
11.	POWER HOUSE		
	Type	-	Underground type
	Size (Width x Length x Height)	m	22 x 117 x 45.7
	Draft Gate		
	- Type	-	Bonnet Type Gate
	- Number	set	4
	Tailrace Gate		
	- Type		Roller Gate
	- Number		2
12.	TURBINE/PUMP		
	(Turbine)		
	Type		Vertical Shaft Francis type reversible pump turbine
	Number of Units	unit	4
	Max. Gross Head	m	401
	Rated Intake Water Level	m.MSL.	653
	Rated Tail Water Level	m.MSL.	276
	Gross Head	m	377
	Normal Effective Head	m	357
	Max. Power Discharge	m^3/sec	82.5
	Rated Output	MW	255
	Revolving Speed	rpm	375
	(Pump)		
	Max. Pump Head	m	409
	Max. Pump Input	MW	277
	Max. Pump Discharge	m^3/sec	71.4
	Revolving Speed	rpm	375
13.	GENERATOR/MOTOR		
	Type		3-phase AC Synchronous Generator-Motor
	Number of Units	unit	4
	Rated Output	MVA	278
	Voltage	kV	16.5
	Power Factor	-	Generator 0.9 (Lag) Motor 0.98 (Lead)
	Frequency	Hz	50
	Revolving Speed	rpm	375

General Project Description of Lam Ta Khong Pumped Storage Project (4/4)

	Project Name		Lam Ta Khong Pumped Storage	
14.	MAIN TRANSFORMER			
	Number of Units	unit	4	
	Type	-	Special 3-phase in door forced oil water cooled type with on load tap changer	
	Capacity	MVA	290	
	Voltage	kV	230/16.5	
15.	SWITCHYARD			
	Type	-	SF_6 Gas Insulated Switchgear Type	
	Nominal Voltage	kV	230	
	Number of Circuits	cct	8	
16.	TRANSMISSION LINE			
	Connection	-	To Saraburi 2 - Nakon Rachasima 2 Existing 230 kV Line	To Thalan 3
	Nominal Voltage	kV	230	230
	Number of Circuits	cct	2	2
	Length	km	15	95
17.	POWER GENERATION			
	Max. Power Discharge	m^3/sec	340 (4 units)	
	Normal Effective Head	m	357	
	Installed Capacity	MW	1,000	
	Annual Operating hours	hrs	800	
	Generating Capability of Continuous Operation	hrs	8	
18.	PROJECT COST	MB (MUS$)	16,674 (641)	
19.	ECONOMIC COST	MB (MUS$)	11,254 (433)	
20.	ECONOMICS			
	B - C	MB	1,504	
	B / C	-	1.16	
	EDR	%	17.4	
21.	CONSTRUCTION PERIOD	yrs.	5	
22.	COMMISSIONING		1997	

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

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CHAPTER 1 INTRODUCTION

1.1 Background of Project

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.

In the view of the policy situation mentioned above, hydroelectric power resources development in Thailand has been carried out through large-scale projects such as the Bhumibol Dam (535 MW) on the Ping river, the Sirikit Dam (375 MW) on the Nam river, the Srinagarind Dam (540 MW) on the Quae Yai river, the Khao Laem Dam (300 MW) on the Quae Noi river and the Rajjaprabha Dam (240 MW) on the Khlong Saeng river. As a result of these developments, it may be that the remaining possible large-scale hydroelectric power resources coping with the peak demand are limited mainly to international rivers such as the Mekong river and the Salawin river, existing along the borders.

However, the Mekong river projects include internationally-complicated factors, so that it is very hard to imagine that the development will be realized in the near future.

Under such circumstances, keen attention has been focussed recently on the Lam Ta Khong Pumped Storage Project which is close to Bangkok metropolitan area, the biggest demand area of electricity in Thailand.

In order to cope with the high growth of electricity demand, especially peak demand, a feasibility study on the Lam Ta Khong Pumped Storage Project was requested to the Japanese Government by the Thai Government in 1988.

1.2 Objective and Scope of the Study

1.2.1 Objective of the Study

The feasibility study is designed to develop a basic plan for the Lam Ta Khong Pumped Storage Project, which is feasible and sound in terms of engineering, economy, finance and environment; results of field survey and data analysis in Japan as well as other considerations are compiled to the feasibility study report. In addition, technology transfer is carried out to the Thai side during the study.

1.2.2 Scope of the Study

The feasibility study covers the Lam Ta Khong Pumped Storage Project contemplated by EGAT.

1.2.3 Contents of the Study

The study is carried out in two stages, the Investigation Stage and the Feasibility Design Stage. The stages correspond to the progress of the investigation. The contents of each stage are as follows.

Investigation Stage:

- Collection and review of all relevant existing data, reports and information on the project.

- Formation of alternative development schemes based on the existing data.

Feasibility Design Stage:

- Finalization of the project based on the results of the study in the Investigation Stage and up-to-date information, including environmental data. Confirmation of the project's viability from engineering, economic and environmental points of view.

1.3 Activities of the Team in Thailand and Participants Concerned

1.3.1 Activities of the Team in Thailand

Several activities were carried out in Thailand by the JICA Survey Team during the study period from February 1990 to October 1991 as follows:

(1) First Investigation Work

Period: February 27 - March 28, 1990

(2) First Discussion on Progress of the Project

Period: June 17 - 31, 1990

(3) Second Investigation Work

Period: November 1 - 30, 1990

(4) Second Discussion on Progress of the Project

Period: February 13 - 27, 1991

(5) Discussion on Draft Final Report

Period: August 14 - 28, 1991

1.3.2 List of Participants

The EGAT officials and the member of JICA Team involved in the feasibility study are listed below.

EGAT

Name	Position
Mr. Swarng Champa	Deputy General Manager, Hydro Power and Transmission System Development
Mr. Sommart Boonpiraks	Assist. General Manager, Hydro Power Development
Mr. Taweesak Mahasandana	Director, Hydro Power Engineering Dept.
Mr. Chalermchai Ratnarak	Assist. Director, Hydro Power Engineering Dept.
Mr. Surachai Watanachai	Chief, Project Feasibility Division
Mr. Preecha Chaokasem	Chief, Project Feasibility Division
Mr. Marnit Promboon	Superintendent, Lam Ta Khong Pumped Storage Project
Mr. Nopporn Prapaitrakul	Assist. Superintendent, Lam Ta Khong Pumped Storage Project
Mr. Niwat Kulkanjanatorn	Assist. Chief, Project Feasibility Division
Mr. Sommot Simargool	Chief, Engineering Project Division
Mr. Prakit Pooviboonsuk	Assist. Chief, Engineering Project Division
Mr. Pote Angwatanapanich	Head, Civil Engineering Project Section
Mr. Poolsak Achavananthadith	Assist. Head, Loei-Upper Pasak Project Section
Mr. Sakda Laohadej	Head, Cost Estimate Project Section

Mr. Fuangkiat Bhumichitr	Engineer level 5 Cost Estimate and Schedule Section
Mr. Tripop Linitta	Lawyer level 5, Land Procurement for Project Section
Mr. Pairoj Punuch	Engineer level 5, Mechanical Engineer Section
Mr. Chuchat Leechanawanichpun	Engineer level 5, Electrical Engineer Section
Mrs. Soopawan Klaipongpant	Assist. Chief, Geology & Soil Engineering Division
Mr. Puongpet Uchukomol	Chief, Survey and Analysis Project Division
Mr. Plew Chitrakarn	Assist. Chief, Survey and Analysis Project Division
Mr. Somchai Kokgamhang	Assist. Chief, Geology & Soil Engineering Division
Mr. Patana Asokanan	Head, Geotechnical Survey Project Section
Mr. Punpong Vivattananon	Assistant Head, Geotechnical Survey Project Section
Mr. Teerachai Nopawing	Engineer level 6, Soil Testing Section
Mr. Opat Kiatsirikul	Head, Map & Aerial Survey Section, Survey Division
Mr. Kanit Vitayapiboon	Engineer level 5, Map & Aerial Survey Section, Survey Division
Mr. Kitti Kumpeera	Chief, Environment Project Division

Dr. Virawan Sombatsiri	Assist. Head, Environment Analysis and Evaluation Section, Ecology & Environment Division
Ms. Kamolporn Nakornthap	Assist. Chief, Environment Project Division
Mr. Suchin Potjananapasiri	Head, Physical Resources Project Section
Ms. Karn Ekabut	Head, Ecological Resources Project Section
Mr. Anuchart Palakawongse	Head, Socio-Economic Project Section
Ms. Nonglack Nidhinandana	Head, Sociology Project Section
Mr. Boonsong Peetanonchai	Head, Hydrological Investigation and Analysis Project Section
Mr. Smarn Pongprapapan	Assist. Director, System Planning Department
Mr. Dhanit Suvarnasiri	Chief, Project Management Project Division
Mr. Amornrat Prajyabhorn	Assist. Chief, Project Management Project Division
Mr. Manoon Suwannanimitr	Head, Project Economic Project Section
Ms. Wasana Tantiyaporn	Head, Electrical Equipment Section Design & Tender Document Division
Mr. Chanchai Kitchalern	Engineer level 5, Electrical Equipment Section
Mr. Suwit Kritdam	Engineer level 5, Power System Planning Dept.
Mr. Ryuichi Abe	Expert of Colombo Plan

Mr. Kenji Yokokawa	Expert of Colombo Plan

JICA

Name	Position
Mr. Tetsuo Nishigori	Team Leader
Mr. Yoshihiro Nakazawa	Civil Engineer
Mr. Junichi Tani	Civil Engineer
Mr. Kunio Kitamura	Civil Engineer
Mr. Masahiro Shibata	Geologist
Mr. Torasaburo Motoki	Electrical Engineer
Mr. Mitsuhiro Omori	Electrical Engineer
Mr. Masahide Takaraya	Economist
Mr. Chagard Chumroenprouk	Environmentalist

1.4 Provision of Equipments

To promote the study of the Project the following equipments were provided to the EGAT, and the EGAT carried out the investigation works listed below.

Equipments Provided and Investigation Works

Equipments	Investigation Works
FRP Boat (MODEL W-198F) and Accessories Depth Recorder (MODEL RS-61S)	Sounding survey in the Lam Ta Khong reservoir
Rotary Boring Machine (MODEL YBM-3JES) and Accessories	Drilling at upper pondage, waterway and powerhouse site

1.5 Technology Transfer to the Counterparts

The technology transfer to the counterparts from the EGAT was done during the study period as follows:

- Counterpart
  - Mr. Prakit Pooviboonsuk
    (December 2, 1990 - February 7, 1991)
  - Mr. Pote Angwatanapanich
    (October 7, 1991 - December 4, 1991: Scheduled)
  - Mr. Suvit Kritdum
    (October 7, 1991 - December 4, 1991: Scheduled)

- Schedule
  - Technology transfer and discussions on the feasibility-grade design of the Project
  - Inspections at factories of turbines and generators
  - Inspections at pumped storage power stations under construction or in operation

CHAPTER 2

GENERAL SITUATION OF THE KINGDOM OF THAILAND

CHAPTER 2 GENERAL SITUATION OF THE KINGDOM OF THAILAND

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CHAPTER 2 GENERAL SITUATION OF THE KINGDOM OF THAILAND

2.1 General

(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 Salawin river and the Moei river for Myanmar as shown in Fig. 2-1.

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. 2-1.

(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 the cool season which is affected by the north-east monsoon blowing in whole of the Thailand. Due to the monsoon the temperature in Bangkok falls down 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 above Thailand, the temperature rises, becoming especially very high in April. It reaches almost 40°C in April in Bangkok.

Annual 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, 1987 is 53,873,172 and has increased by 900,000 persons or 1.7% compared with the end of 1986. The population of the Bangkok metropolitan area is 5,609,352 and has increased by 140,000 persons or 2.57%. The population of the Bangkok area accounts for 10.4% of the total population. The relative density of population is 105 and 3,584 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: publicy-elected).

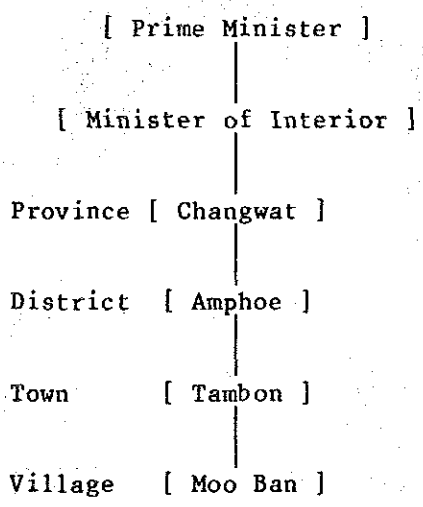
° Promotion of party politics (members of the Lower House must belong to parties).

° 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. 2-2.

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 publicy-elected since 1985.

Organization Chart of Local Government



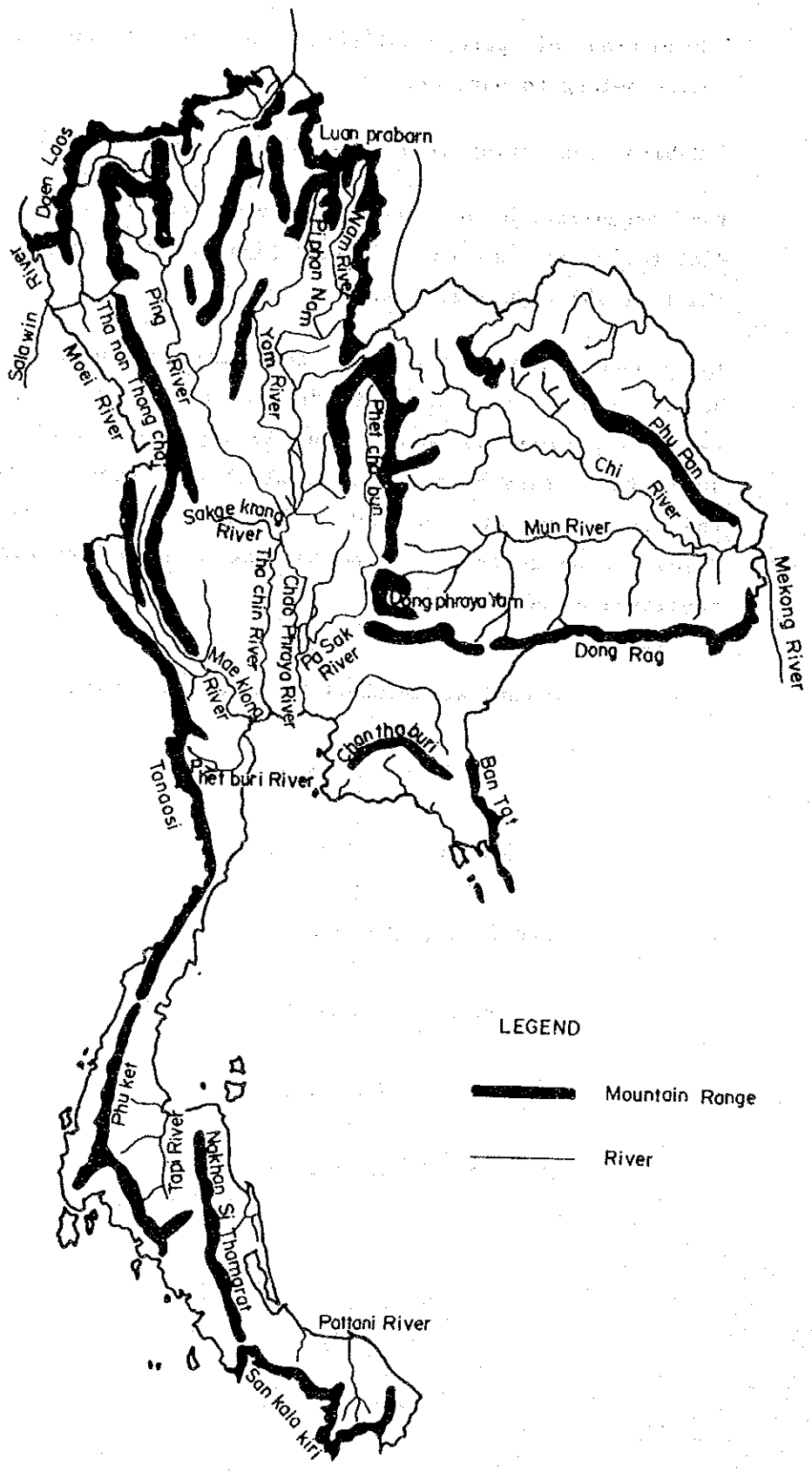


Fig. 2 – 1 MAIN RIVERS AND MOUNTAIN RANGES

Note: [ ] State Enterprise

Fig. 2-2 Organization Chart of Central Government

2.2 Economics

2.2.1 Outline of Economics

(1) 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 per-capita GDP was only $80, a figure dwarfed by the $1,400 or so of today's GDP per capita. Though the income level is still low and 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) 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. 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.

(3) 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 economic development plan (1961-1966) to the current 6th, 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 largescale 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 dif-

ferences in personal income while maintaining the free play given to the nation's economic engines.

(4) The economic performance of Thailand in the recent years 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 the consumer price level is gradually raising and it is over 6% at the present.

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.

Major Economic Indicators and Balance of International Payments 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 Band and NESDB

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

2.2.2 Progress of Industrial Policy

The industrialization policy the government of Thailand has been pushing is built on two policy pillars. One is that which is embodied in the 1962 legislation, "Industrial Investment Promotion Law," and the other be the economic development plan which started life in 1961. 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 6th economic development plan (1987 to 1992) is in progress and this latest plan includes in its features that of welcoming direct investment from overseas enterprises. 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.

2.2.3 Underpinnings of the Economic Growth

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 tex-

tiles, 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. Comings and goings 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 tech-

nical 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. Racial discrimination is practically non-existent as compared to other Asian countries. Ethnic minorities are well assimilated and blended with the Thais.

The seventh is a large income from tourists of foreign countries. This income in 1989, 96.4 billion Baht, was larger 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.

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

2.3 Characteristics of Economics and Electric Power

(1) GDP, Electricity Consumption and Elasticity

The elasticity of the demand for electric power (hereafter, the electricity consumption), in respect to the GDP (Gross Domestic Product) is approximately 1.6.

(2) Electricity Consumption by Categories of Consumers

Table 2-2 shows the electricity consumption by categories of consumers; residential, commercial (offices, government and public offices, leisure, and shops), industrial (factories), agricultural, and others. In the ten-year period from 1980 to 1989, residential use increased by 2.3 times, commercial use by 2.8 times, and industrial use by 2.4 times. The percentage of the total consumption for 1989 accounted for by each category is shown in the following table. Industrial use, primarily factories, accounts for almost 50% of the total.

	(1989) Electricity Consumption (10^6 kWh)	Percentage
Residential	7,025	21%
Commercial	10,108	31%
Industrial	15,431	47%
Agricultural	90	0.3%
Others	180	0.5%
Total	32,834	100%

(3) Electric Consumption per Capita

The population, electric consumption, and electric consumption per capita for the ten year period from 1980 to 1989 is shown in Table 2-3. The figures for 1989 are shown below.

Electric Consumption (10^6 kWh)	32,834
Population (10^3)	55,888
Electric Consumption per Capita (kWh/person)	587

The figures for the 1989 electricity consumption, population, and electricity consumption per capita broken down by area into

Bangkok and environs, Northern Thailand, Northeastern Thailand, Middle Thailand, and Southern Thailand are shown in Table 2-4. The electricity consumption per capita for 1989 is shown below.

Electricity Consumption per Capita (kWh/capita)

Whole Kingdom	587
Bangkok and Environs	2,171
Northern Thailand	219
Northeastern Thailand	122
Middle Thailand	902
Southern Thailand	311

The nationwide electricity consumption per capita is 587 kWh. However the population of Bangkok and its environs, only 13% of the total population, has the highest consumption rate at 2,171 kWh. In Northeastern Thailand, where 35% of the population resides, the average is the lowest at 122 kWh, only 1/18 of the rate for those in the capital and its surrounding areas.

The table below shows the electricity consumption per capita in Thailand compared with that of other ASEAN and NIES countries.

(1985) Country	Electricity Consumption per Capita (kWh/person)	Remarks
Thailand	387	
Philippines	386	
Malaysia	962	
Singapore	3,840	(NIES)
Indonesia	167	
Taiwan	2,520	Electricity Consumption for 1984
South Korea	1,520	
Hong Kong	3,278	

As can be understood from this, the electricity consumption per capita in Thailand falls in about the middle of the range of those of the ASEAN countries, and is closest to that of the

Philippines. Compared with the lowest figure of the NIES nations, South Korea, the figure for Thailand is about 1/3 that for South Korea. As previously indicated, the consumption rate for the Bangkok Area was 2,171 kWh of electricity consumption per person for the year 1989. However, when compared with the capital region in Singapore or in Hong Kong, the Bangkok consumption rate is about two-third.

(4) Electricity Consumption in the Bangkok Area and in the Provinces

The electricity consumption and the percentages for the Bangkok area (MEA) and provincial regions (PEA) for the years 1984 and 1989 are shown below.

	Electricity Consumption (10^6 kWh)	
	1984 (%)	1989 (%)
Capital Region (MEA)	10,123 (55%)	15,829 (48%)
Provincial Region (PEA)	8,449 (45%)	17,005 (52%)

The increase in consumption in the PEA, in other words provincial areas excluding Bangkok and its environs, as evidenced in the above table, is remarkable. The electric consumption for the years 1984 and 1989, broken down by Bangkok area and provincial area are shown in the table below. From this table it is seen that in this five-year period, the rate of increase was greatest in Northern Thailand while the amount of increase was greatest in Bangkok area and the second largest was Central Thailand. In total, the provincial consumption became almost equivalent to the figures for the Bangkok Area (MEA). The economic growth in Central Thailand is thought to have been brought with it a similar economic growth in Bangkok.

Comparison of Electricity Consumption
by Region for 1984 and 1989

	Electricity Consumption (10^6 kWh)		Growth	
	(1) 1984	(2) 1989	(3) Increase (2)-(1)	Times (2)/(1)
Bangkok Area	10,123	15,829	5,706	1.6
Provinces	8,449	17,005	8,556	2.0
Northern Thailand	1,194	2,379	1,185	2.0
Northeastern Thailand	1,431	2,389	958	1.7
Central Thailand	4,636	10,065	5,429	2.2
Southern Thailand	1,189	2,173	984	1.8
Whole Kingdom	18,572	32,834	14,262	1.8

Table 2-2 Electricity Consumption by Categories of Consumers

Year	Residential		Commercial *		Industrial		Agriculture		Street Lighting		Others		Total	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%	GWh	(%)
1980	3,005.3	22.9	3,561.0	27.1	6,454.5	49.1	22.5	0.2	71.2	0.5	34.7	0.3	13,149.2	(100)
1981	3,168.0	22.9	3,468.2	25.1	7,064.2	51.1	20.1	0.1	83.2	0.6	33.5	0.2	13,837.2	(100)
1982	3,630.6	24.1	3,862.4	25.7	7,389.0	49.2	32.5	0.2	90.5	0.6	28.0	0.2	15,033.0	(100)
1983	4,187.7	24.8	4,530.0	26.8	8,013.6	47.4	41.2	0.2	103.2	0.6	30.6	0.2	16,906.3	(100)
1984	4,731.5	25.5	4,912.5	26.5	8,723.5	47.0	47.8	0.3	118.3	0.6	38.6	0.2	18,572.2	(100)
1985	5,164.7	25.8	5,344.1	26.7	9,298.0	46.4	55.0	0.3	127.9	0.6	42.2	0.2	20,031.9	(100)
1986	5,795.1	26.3	5,847.8	26.5	10,162.7	46.1	56.7	0.3	140.9	0.6	31.2	0.1	22,034.4	(100)
1987	6,135.5	24.6	7,331.2	29.4	11,319.4	45.5	61.3	0.2	—	—	46.8	0.2	24,894.2	(100)
1988	6,253.5	22.1	8,847.6	31.3	12,951.8	45.8	67.4	0.2	—	—	132.4	0.5	28,252.7	(100)
1989	7,024.6	21.4	10,108.2	30.8	15,431.0	47.0	89.7	0.3	—	—	180.3	0.5	32,833.8	(100)

* The Values after 1987 Include Street Lighting.

Table 2-3 Trend of Electricity Consumption per Capita

Areas	1981	1982	1983	1984	1985	1986	1987	1988	1989
Whole Kingdom									
1. Electricity Consumption (10^6 kWh)	13,837.1	15,033.0	16,831.8	18,572.2	20,031.9	22,034.4	24,894.2	28,252.7	32,833.8
2. Population (10^3)	47,848.0	48,847.0	49,433.0	50,583.0	51,769.0	52,969.0	53,873.0	54,961.0	55,888.0
3. kWh Per Capita	289.19	307.76	340.50	367.16	386.95	415.99	462.09	514.05	587.49
4. Index (kWh Per Capita)[1/]	208.0	221.0	245.0	264.0	278.0	299.0	332.0	370.0	423.0
MEA Area									
1. Electricity Consumption (10^6 kWh)	7,951.7	8,388.5	9,287.4	10,122.9	10,307.3	10,968.9	12,464.0	13,946.8	15,828.6
2. Population (10^3)	6,625.0	6,817.0	6,456.0	6,660.0	6,915.0	7,086.0	7,338.0	7,538.0	7,290.0
3. kWh Per Capita	1,200.26	1,230.53	1,438.57	1,519.95	1,490.57	1,547.97	1,698.56	1,850.20	2,171.27
4. Index (kWh Per Capita)[1/]	155.0	159.0	186.0	196.0	192.0	200.0	219.0	239.0	280.0
Outside MEA Area									
1. Electricity Consumption (10^6 kWh)	5,885.4	6,644.5	7,544.4	8,449.3	9,724.6	11,065.5	12,430.2	14,305.9	17,005.2
2. Population (10^3)	41,223.0	42,030.0	42,977.0	43,923.0	44,881.0	45,883.0	46,535.0	47,423.0	48,598.0
3. kWh Per Capita	142.77	158.09	175.55	192.37	216.68	241.17	267.12	301.67	349.91
4. Index (kWh Per Capita)[1/]	291.0	323.0	358.0	393.0	442.0	492.0	545.0	616.0	714.0
Northern Area									
1. Electricity Consumption (10^6 kWh)	675.8	761.0	1,044.9	1,194.1	1,537.8	1,719.0	1,948.8	2,115.9	2,378.9
2. Population (10^3)	9,714.0	9,834.0	10,106.0	10,281.0	10,392.0	10,490.0	10,585.0	10,732.0	10,873.0
3. kWh Per Capita	69.57	77.38	103.39	116.15	147.98	163.87	184.11	197.16	218.79
4. Index (kWh Per Capita)[1/]	253.0	281.0	376.0	422.0	598.0	596.0	669.0	717.0	794.0
Northeasten Area									
1. Electricity Consumption (10^6 kWh)	925.6	1,095.1	1,240.0	1,430.6	1,544.8	1,712.5	1,889.7	2,109.2	2,388.5
2. Population (10^3)	16,366.0	16,720.0	17,147.0	17,638.0	18,061.0	18,552.0	18,884.0	19,254.0	19,576.0
3. kWh Per Capita	56.56	65.50	72.32	81.11	85.53	92.31	100.07	109.55	122.01
4. Index (kWh Per Capita)[1/]	283.0	327.0	362.0	406.0	428.0	462.0	500.0	548.0	610.0
Central Area									
1. Electricity Consumption (10^6 kWh)	3,339.4	3,733.9	4,149.7	4,635.6	5,339.7	6,242.9	6,939.8	8,202.3	10,064.5
2. Population (10^3)	9,208.0	9,430.0	9,588.0	9,704.0	9,987.0	10,233.0	10,349.0	10,576.0	11,153.0
3. kWh Per Capita	362.66	395.96	434.16	477.70	534.67	610.08	670.58	775.56	902.4
4. Index (kWh Per Capita)[1/]	279.0	305.0	334.0	367.0	411.0	469.0	516.0	597.00	694.0
Southern Area									
1. Electricity Consumption (10^6 kWh)	944.6	1,054.5	1,019.8	1,189.0	1,302.3	1,391.1	1,651.9	1,878.5	2,173.3
2. Population (10^3)	5,935.0	6,046.0	6,166.0	6,300.0	6,441.0	6,608.0	6,717.0	6,861.0	6,996.0
3. kWh Per Capita	159.16	174.41	179.99	188.73	202.19	210.52	245.93	273.79	310.65
4. Index (kWh Per Capita)[1/]	399.0	371.0	383.0	402.0	430.0	448.0	523.0	583.0	661.0

Sources : EGAT, MEA, PEA, NEA, POF, Department of Local Administration
Note : 1/Base 100 in 1972

CHAPTER 3

PRESENT SITUATION OF ELECTRIC POWER SECTOR

CHAPTER 3 PRESENT SITUATION OF ELECTRIC POWER SECTOR

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CHAPTER 3 PRESENT SITUATION OF ELECTRIC POWER SECTOR

3.1 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 the 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: Electricity 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).

The 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:

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

- o other electricity consumers as directed by a Royal Decree;

- o 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, the 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 considerably higher than before. The 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.

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

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

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

(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.

The MEA does not possess its own power generating facilities, but distributes the electric power supplied by the EGAT to users through its own transmission and distribution facilities. The scope of distribution includes Bangkok, Nonthaburi and Samut Prakan in the area adjacent to Bangkok.

The MEA, together with the PEA, come under the jurisdiction of the PWD (Public Works Department of the Ministry of Interior).

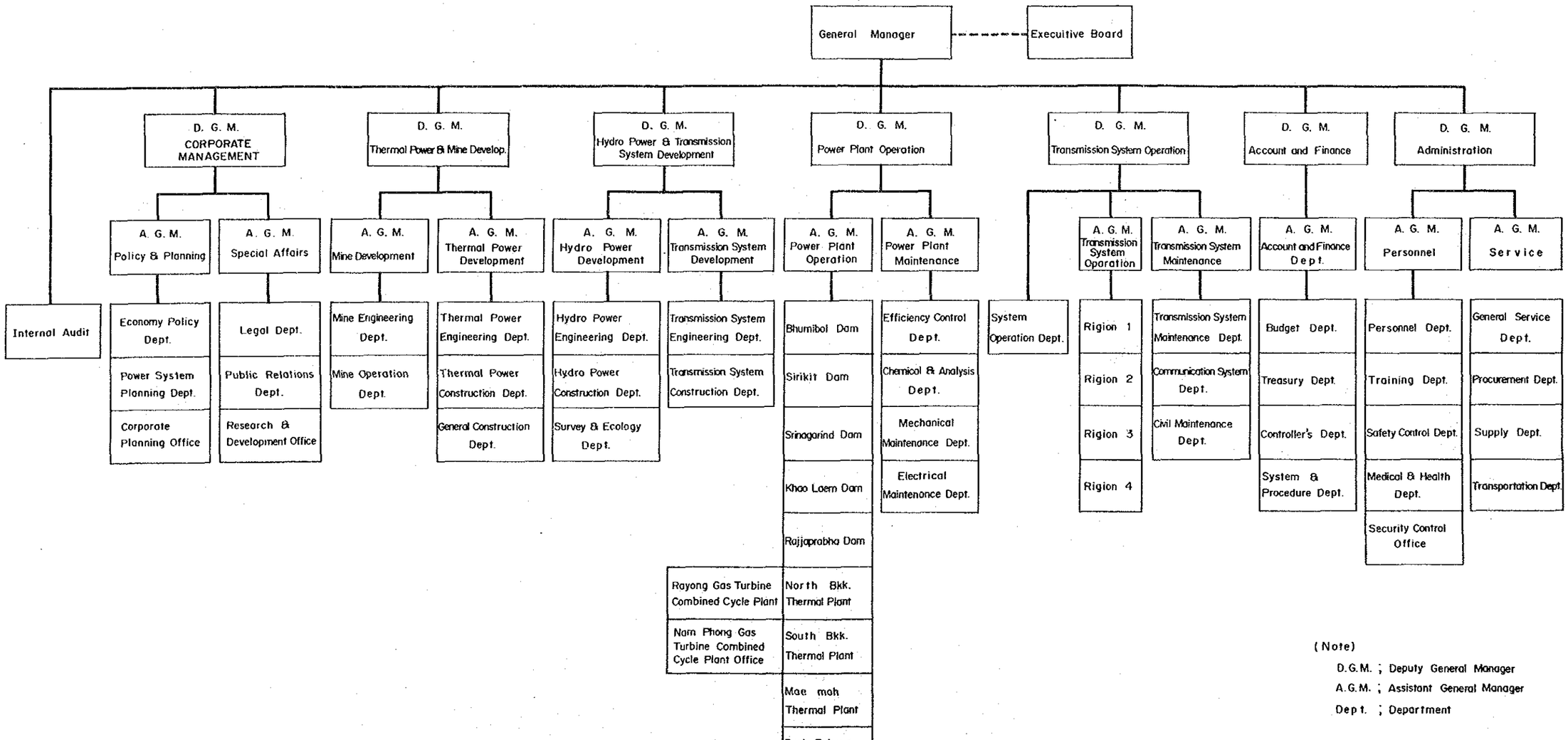
(4) PEA: The Provincial Electricity Authority

The PEA is the public enterprise in charge of distributing electricity to the provinces other than those which come under the jurisdiction of the MEA.

The distribution to users depends mainly on electric power provided by the EGAT, but it owns diesel power generating facilities on a small scale, promoting the electrification of agricultural villages.

(5) OAEP: The Organization of Atomic Energy for Peace

The OAEP comes under the jurisdiction of the Ministry of Science, Technology and Energy, administratively. It executes the promotion of the development of nuclear power, safety management, control business, etc., under the policies established by the Atomic Energy Committee of Thailand.



(Note)

D.G.M. ; Deputy General Manager
A.G.M. ; Assistant General Manager
Dept. ; Department

Fig. 3-1 Organization Chart of EGAT

3.2 Power Supply Facilities

3.2.1 Generating Facilities

(1) Generating Facilities

The total installed capacity of the generating facilities of Thailand is 8,314 MW as of July 1989, and the details of ownership and type of facility are as follows:

(MW)

	EGAT	PEA	NEA	Private	Total
Hydro	2,238	3	30	-	2,271
Steam Turbine	3,982	-	-	593	4,575
Combined Cycle	772	-	-	-	772
Gas Turbine	267	-	-	-	267
Diesel	27	47	-	355	429
Total	7,286	50	30	948	8,314

(Note) 297 MW in Private 948 MW: for standby

The ratio of each facility to total installed capacity is 27% for hydro and 73% for thermal.

(2) Power Supply by EGAT

A list of the EGAT's existing power plants is shown in Table 3-1, and the location of the main power plants and transmission system is shown in Fig. 3-2. The supply area is devided into 4 areas and these are connected by 500 kV, 230 kV and/or 115 kV transmission lines.

The base load generation in Region 1 is mainly provided by the South Bangkok, Bang Pakong oil/gas-fired thermal plants and lignite-fired power plants at Mae Moh supplemented by Bang Pakong combined cycle power plants as an intermediate load plant. For peak generation, capacities are obtained from

Bhumibol, Sirikit, Srinagarind, Kang Krachan, Khao Laem and Tha Thung Na hydroelectric plants.

The power supply for base load in Region 2, the Northeast, is mainly obtained from the interconnection with Region 4 through a 230 kV transmission line and a 115 kV transmission line for interconnection with Region 1. Part of the energy needed for this region has been obtained by the purchase of surplus energy from Nam Ngum power plant in Lao PDR.

The base load generation in Region 3, the South, is provided by the thermal power plant barge at Khanom, the lignite-fired power plant at Krabi and the oil-fired power plant at Surat Thani. The energy is transmitted using the 115 kV Central-Southern transmission line (1st CSTL) which has been in operation since August 1980. Peak power is provided by Bank Lang, Rajjaprabha (Chiew Larn) hydroelectric plants and gas turbines.

The power system in Region 3 is also interconnected with its neighbouring system in Malaysia via a 115/132 kV interconnector, through which part of Region 3 load during peak periods can be supplemented by power import from Malaysia whenever it is considered necessary.

The power supply in Region 4 is supplied by the Mae Moh lignite thermal plant of 1,425 MW.

(3) Hydroelectric Power Plants

Thailand has abundant hydro power resources and the main rivers are located in four areas i.e. the Chao Phraya river and its tributaries, the Quae Yai river and the Quae Noi river basins, the northeast plateau whose rivers pour into tributaries of the Mekong river and the southern isthmus area.

The Bhumibol (535 MW) and Sirikit (375 MW) power plants are located on the Ping river, and the Nan river, tributaries of Chao Phraya river, respectively and represent the large scale hydroelectric power plants of Thailand together with Srinagarind (540 MW).

The Srinagarind power plant is situated on the Quae Yai river, a tributary of the Mae Klong river and has a capacity of 540 MW of which one generator with a capacity of 180 MW is for a pumped storage power plant.

These hydroelectric power plants operate corresponding to the fluctuating peak load of the demand and take into account the supply of irrigation water to the downstream basin.

Table 3-1 shows the existing major hydroelectric power plants.

(4) Thermal Power Plants

The South Bangkok plant (1,330 MW) located in Samut Prakan is one of the largest thermal power plants in Thailand. It uses natural gas produced in the Gulf of Thailand or heavy oil.

The Mae Moh thermal power plant (1,425 MW) near Chiang Mai in the northwest uses lignite obtained from the strip mine nearby as fuel. As of 1990, No. 10 and No. 11 generators (300 MW each) are under construction. It is a large scale plant, which is planned to be expanded to No. 13 generator, eventually.

The North Bangkok thermal power plant started operation in 1960's using heavy oil as fuel, but it is deteriorating with its efficiency being lowered.

3.2.2 Transmission Lines and Substations

The standard voltages for power transmission in the EGAT system are 500, 230, 115 and 69 kV at a frequency of 50 Hertz. Table 3-2 shows the existing facilities of transmission lines and substations as of September 1990. Fig. 3-3 illustrates the total transmission line length classified by voltage levels over the period 1960 - 1995. As of September 1990, the breakdown of the circuit-km of the EGAT's transmission system is: 533 circuit-km of 500 kV, 7,045 circuit-km of 230 kV, 9,598 circuit-km of 115 kV and 600 circuit-km of 69 kV lines.

The 500 kV transmission lines that connect the Mae Moh thermal power plant and Bangkok area (Region 1) have been partially completed at

its full capacity of 500 kV in March 1989.

The following transmission lines form the nucleus of the system.

- o 230 kV transmission lines between substations in the North Bangkok, South Bangkok and Bang Pakong thermal power plant
- o 230 kV transmission lines connecting remote hydroelectric power plants and Region 1
- o 230 kV transmission lines connecting Phitsanulok and Khon Kaen

The power system is formed by the nucleus system linked with the 115 kV transmission lines connecting small hydroelectric power plants scattered in the northeast of Thailand and the 115 kV transmission lines connecting central and southern parts.

As for high voltage substations, there are two 500 kV, thirty-two 230 kV, one-hundred and ten 115 kV and ten 69 kV units, totalling 154 substations. The total installed transformer capacity, excluding station service and generator unit transformers, is 16,902 MVA.

3.2.3 Distribution Facilities

The electric power provided by the EGAT is transmitted to MEA substations at 115 kV and 69 kV, dropped to 24 kV and 12 kV and supplied to households at 220 V and 220/380 V for commercial use.

In the area of jurisdiction under the PEA, distribution lines of 33 kV, 22 kV, 11 kV, etc., are being used and electric power is supplied to general users at 220 V.

Total length of the distribution line in circuit-km as of 1988 is shown below.

Voltage (kV)	Circuit - km	
33	20,819	(PEA)
24/12	6,169	(MEA)
22	105,284	(PEA)
11	55	(PEA)

Table 3-1 EGAT EXISTING INSTALLED GENERATING CAPACITY
(As of 1 September 1990)

	Plant Type	Number of Unit	Capacity (MW)		Average Energy Capability (GWh/Yr)
			Installed	Ultimate	
A.	Hydroelectric Plant				
	Bhumibol	7	535.0	710.0	1,200.0
	Sirikit	3	375.0	500.0	1,000.0
	Ubolratana	3	25.2	25.2	56.0
	Sirindhorn	3	36.0	36.0	86.0
	Chulabhorn	2	40.0	40.0	93.0
	Kang Kracharn	1	17.5	17.5	78.0
	Nam Pung	2	6.0	6.0	15.0
	Srinagarind	4	540.0	720.0	1,140.0
	Bang Lang	3	72.0	72.0	200.0
	Tha Thung Na	2	38.0	38.0	165.0
	Khao Laem	3	300.0	300.0	760.0
	Huai Kum	1	1.06	1.06	2.0
	Ban Santi	1	1.275	1.275 9.0	6.0
	Mae Ngat	2	9.0		29.0
	Kiridharn	2	12.7	12.7	27.0
	Rajjaprabha	3	240.0	240.0	550.0
	Miscellaneous	7	0.428	0.428	1.0
	Total	49	2,249.16	2,729.16	5,408.0
B.	Thermal power Plant				
	North Bangkok	3	237.5		1,250.0
	South Bangkonk	5	1,330.0		9,320.0
	Mae Moh	9	1,425.0		9,360.0
	Krabi	2	34.0		180.0
	Surat Thani	1	30.0		170.0
	Khanom	2	150.0		1,050.0
	Bang Pakong	2	1,100.0		7,710.0
	Total	24	4,306.5		29,040.0
C.	Combined Cycle Power Plant				
	Bang Pakong - Blocks 1 & 2	10	760.0		4,664.0
	- Block 3 & 4 (GT)	4	416.0		2,733.0
	Total	14	1,176.0		7,397.0
D.	Gas Turbine Power Plant				
	Nakhon Ratchasima	1	14.0		31.0
	Udon Thani	1	14.0		31.0
	Hat Yai	3	42.0		92.0
	Surat Thani	3	42.0		92.0
	Lan Krabu	7	126.0		773.0
	Total	15	238.0		1,019.0
	Grand Total	102	7,970.26		42,864.0

Note: a/ Excluding diesel plants of 28.6 MW.

Table 3-2 INSTALLED TRANSMISSION LINES AND SUBSTATIONS
(As of 1 September 1990)

Region and System Voltage	Substations		Transmission Lines (Circuit - Kilometers)		
	Number	Transformer a/ Capacity (MVA)	Double-Circuit	Single-Circuit	Total
Region 1					
500 kV	-	-	26	132	158 b/
230 kV	19	6,860	2,976	18	2,994
115 kV	42	2,505	737	1,480	2,217
69 kV	1	31	-	99	99
Total	62	9,396	3,739	1,729	5,468
Region 2					
500 kV	1	600	519	-	519 c/
115 kV	29	1,126	1,718	1,590	3,308
69 kV	4	47	-	327	327
Total	34	1,773	2,237	1,917	4,154
Region 3					
230 kV	6	1,000	1,274	-	1,274
115 kV	19	1,009	1,173	1,137 d/	2,310
Total	25	2,009	2,447	1,137	3,584
Region 4					
500 kV	2	1,800	-	375	375
230 kV	6	850	2,040	218	2,258
115 kV	20	970	640	1,123	1,763
69 kV	5	104	-	174	174
Total	33	3,724	2,680	1,890	4,570
All Regions					
500 kV	2	1,800	26	507	533
230 kV	32	9,310	6,809	236	7,045
115 kV	110	5,610	4,268	5,330	9,598
69 kV	10	182	-	600	600
Total EGAT	154	16,902	11,103	6,673	17,776

Notes: a/ Station service and generator unit transformers are excluded.
b/ Presently energized at 230 kV and will be upgraded to 500 kV in October 1990.
c/ Presently energized at 115 kV (230 circuit-km).
d/ Including 9 circuit-km of 132 kV transmission line.

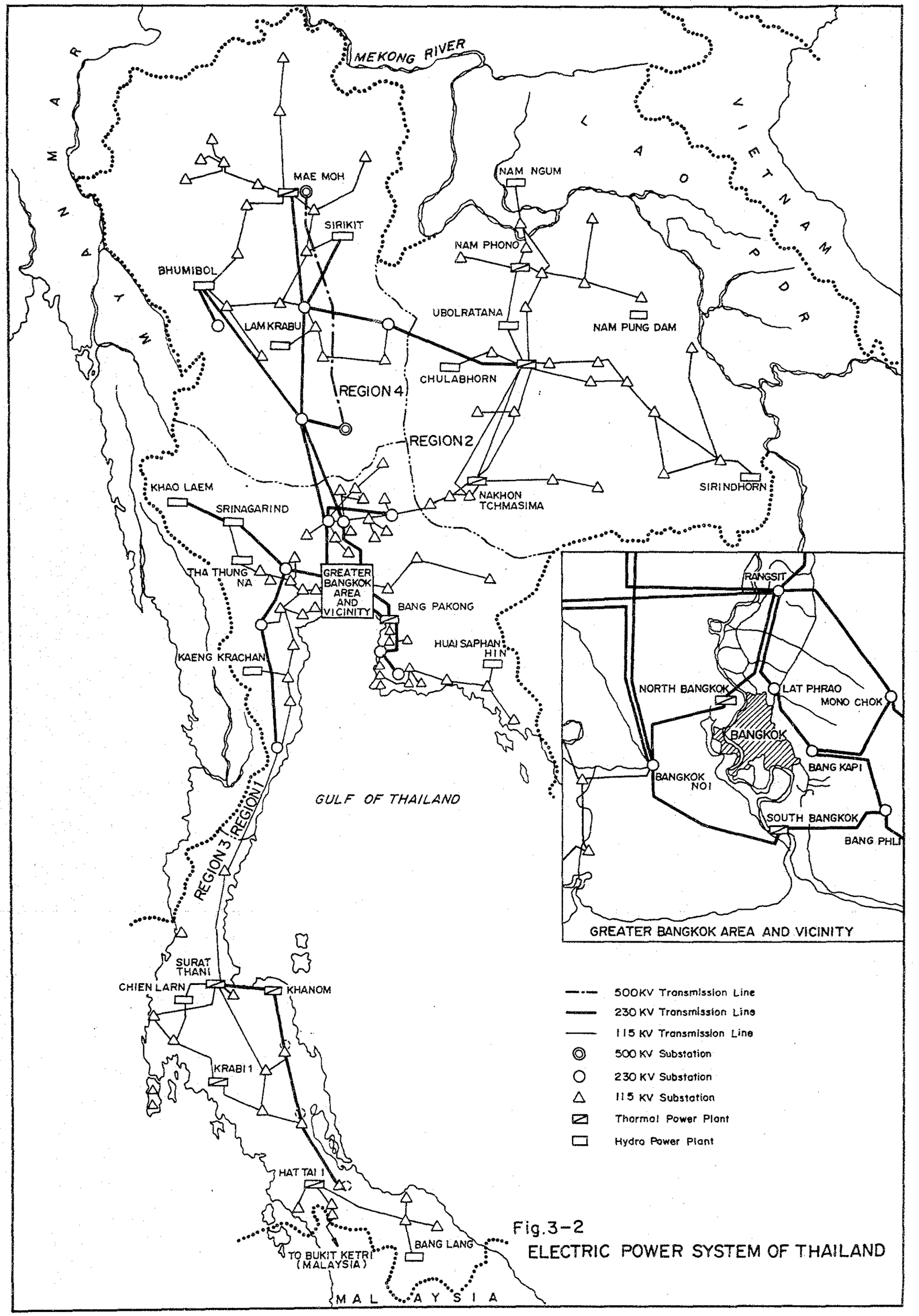


Fig.3-2
ELECTRIC POWER SYSTEM OF THAILAND

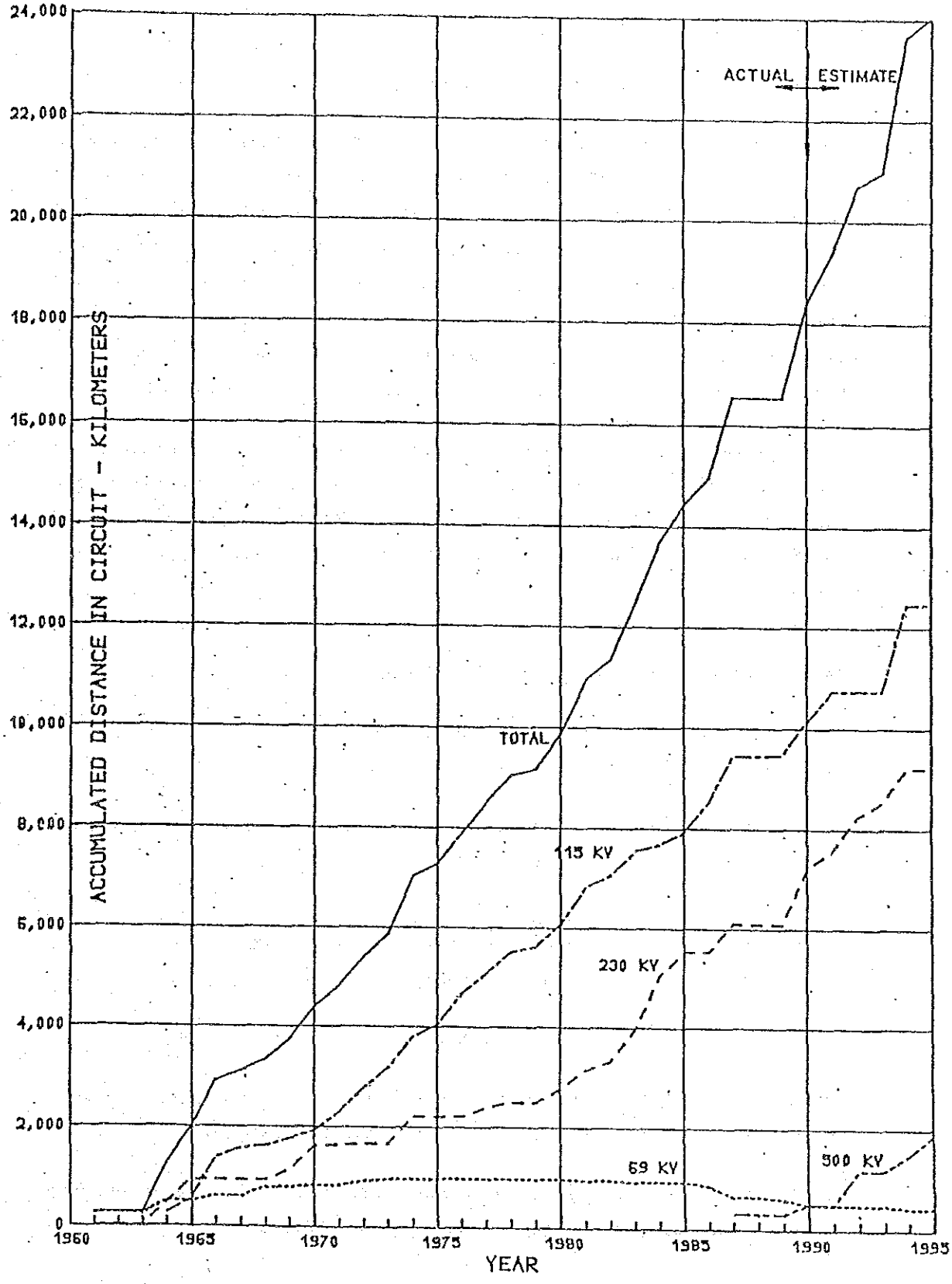


Fig.3-3 GROWTH OF HIGH VOLTAGE AND 500KV TRANSMISSION LINES

3.3 Power Demand and Supply

3.3.1 Trend and Present Situation of Power Demand

The peak demand and energy generation of the EGAT increased from 1,256 MW and 7,259 GWh in FY (Fiscal Year) 1974 to 2,255 MW and 13,969 GWh in FY 1979 at high annual increase rates of 12.4% and 14.0%, respectively. In the first three years of the 1980s the power demand did not show such a rapid increase due to the second oil crisis. However, the power demand resumed its increase from 2,417 MW and 14,754 GWh in FY 1980 to 7,094 MW and 43,189 GWh in FY 1990 at annual increase rate of 11.4% and 11.3%, respectively.

Furthermore, the power demand after FY 1987 was estimated to increase rapidly continuing the same trend as in the late 1970s, the peak generation of the EGAT recorded in FY 1990 was 7,094 MW and 43,189 GWh, being increased by 13.8% and 18.5% respectively, as compared 1989.

3.3.2 Maximum Power Demand and Installed Capacity

Trend of maximum power demand and installed capacity from 1980 to 1989 for the whole Thailand is shown in Table 3-4.

The relation between the installed capacity and maximum power demand is as follows, as of FY 1989:

Installed Capacity (MW)	Dependable Capacity (MW)	Max. Power Demand (MW)	Reserve Capacity (MW)	Margin (%)
7,254	7,408	6,233	1,175	18.9

Further, the figures in Table 3-4 are for calendar year, however, the figure above are for the end of the fiscal year 1989.

The EGAT has used a figure of approximately 25% of reserve margine several years ago, however, it has adopted 15% now.

3.3.3 Energy Balance

The trend of energy balance between energy generation and consumption from 1980 to 1989 is shown in Table 3-5.

The net electric energy supplied as of 1989 amounted to 32,834 GWh. This figure is obtained by adding net imported electric energy of 620 GWh to the total electric energy of 37,406 GWh generated in Thailand and deducting the loss within power plants of 1,464 GWh and the transmission and distribution loss of 3,729 GWh.

The net imported electric energy of 620 GWh was from Nam Ngum hydroelectric power plant in Lao PDR. The transmission and distribution loss is about 10% (transmission lines 4%, distribution lines 6%) of the total electric energy generated.

3.4 Energy Sources

Electric generation by energy sources from 1980 to 1989 is shown in Table 3-6. Comparisons of the figures between 1980 (second oil crises) and 1989 is tabulated below.

(GWh)

	1980	1989
Import	759 (5)	620 (2)
Diesel Oil	391 (3)	23 (0.1)
Hydro	1,273 (8)	5,571 (15)
Fuel Oil	11,352 (75)	4,739 (12)
Lignite	1,410 (9)	7,879 (21)
Natural Gas	0 (0)	19,195 (50)
Total	15,185 (100)	38,026 (100)

(Note) ( ): Percentage to total

The proportion of energy generation using petroleum was 75% in 1980, however it declined sharply to 12% in 1989. On the other hand, energy generation using lignite increased from 9% to 21% and that using natural gas accounted for only 10% in 1981 when the facility was newly installed, but it accounted for 50% in 1989.

As mentioned above the peculiarity of the power source facilities in Thailand can be seen in a diversification of the thermal power plant facilities.

In Thailand, hydropower, natural gas and lignite constitute the main domestic energy resources and the self-sufficiency rate of the generation of electric energy made rapid progress from 17% in 1980 to 86% in 1989.

This is attributable to efforts to reduce the dependency on imported oil and a high powered promotion of the effective use of domestic resources based on the experience of the oil crises in the past.

Table 3-3 TOTAL EGAT GENERATION REQUIREMENT

Fiscal Year	Peak Generation		Energy Generation		Load Factor
	MW	% Increase	GWh	% Increase	%
		Actual			
1974	1,256	4.75	7,259	5.61	65.96
1975	1,407	11.96	8,216	13.13	66.64
1976	1,652	17.45	9,414	14.64	65.05
1977	1,873	13.40	10,951	16.32	66.73
1978	2,101	12.13	12,372	12.98	67.23
1979	2,255	7.35	13,965	12.88	70.69
1980	2,417	7.20	14,754	5.65	69.67
1981	2,589	7.09	15,960	8.18	70.38
1982	2,838	9.63	16,882	5.78	67.91
1983	3,204	12.91	19,066	12.94	67.92
1984	3,547	10.70	21,066	10.49	67.79
1985	3,878	9.33	23,357	10.87	68.75
1986	4,181	7.80	24,780	6.09	67.66
1987	4,734	13.23	28,193	13.78	67.99
1988	5,444	15.00	31,997	13.49	67.09
1989	6,233	14.49	36,457	13.94	66.77
1990	7,094	13.81	43,189	18.47	69.50
Average Growth Rate (%, 1981～1990)	—	11.37	—	11.34	—

Table 3-4 Total Installed Capacity and Peak Generation

Fiscal Year	Installed Capacity (MW)	Peak Generation (MW)
1980	3,448	2,379
1981	4,008	2,561
1982	4,403	2,823
1983	5,032	3,200
1984	6,128	3,545
1985	6,705	3,826
1986	6,785	4,202
1987	6,985	4,842
1988	6,997	5,414
1989	7,336	6,208

SOURCES : EGAT, PEA, NEA, POF

Table 3-5 Electricity Energy Balance

Year	Electricity Supply		Station Service	Transmission and Distribution Line Losses	Electricity Consumption		
	Gross Generation	Net Import			Free Electricity Supply (Official Use, Staff Supply etc.)	Electricity Avalable for Sale	Total
1980	14,426	759	618	1,418	21	13,128	13,149
1981	15,377	731	617	1,654	26	13,811	13,837
1982	16,620	739	681	1,646	28	15,005	15,033
1983	18,857	676	681	1,945	30	16,876	16,906
1984	21,025	688	885	2,256	35	18,537	18,572
1985	23,074	703	1,086	2,660	39	19,993	20,032
1986	24,717	741	1,013	2,411	46	21,988	22,034
1987	28,652	398	1,191	2,965	105	24,789	24,894
1988	32,464	410	1,307	3,314	170	28,083	28,253
1989	37,406	620	1,464	3,729	184	32,650	32,834

Table 3-6 Energy Generation by Sources

Year	Hydro	Fuel Oil	Diesel Oil	Lignite	Natural Gas	Total
1980	1,273	11,352	391	1,410	-	14,426
1981	2,974	8,986	216	1,675	1,526	15,377
1982	3,837	5,857	56	1,859	5,011	16,620
1983	3,660	7,100	124	1,804	6,169	18,857
1984	4,082	6,335	28	2,317	8,263	21,025
1985	3,692	3,380	24	5,313	10,666	23,074
1986	5,554	3,332	34	5,545	10,252	24,717
1987	4,075	2,188	67	6,698	15,624	28,652
1988	3,779	3,142	24	6,800	18,720	32,464
1989	5,571	4,739	23	7,879	19,195	37,406

3.5 Fluctuation in Demand per Day and by Season

Fig. 3-4 shows the transition of the load curve on the day when the maximum demand occurred.

The maximum demand occurred between 7 P.M. - 8 P.M. in all cases, which were greatly affected by the fluctuation in demand in the region supplied by the PEA and can be seen as a typical situation due to demand by household.

After 1980, the difference between the peak demand and off-peak demand has been remarkable due to the promotion of industrialization, which is predicted to continue in the future. Therefore, the future problems will be to control the lowering of the load factor and to secure the reserve margin.

Fig. 3-5 shows the transition of daily load factor and yearly load factor.

Looking at the seasonal fluctuation of the demand, although there were fluctuations in demand month by month, it is clear that the maximum demand tends to increase gradually. At the same time the effect of changes in temperature is remarkable on the energy generated. In other words, the lower the temperature between December and February, the lower the demand, and in March when the temperature starts to become higher, the electric energy generated increases by a large margin. Fig. 3-6 shows the transition of the maximum demand and the electric energy generated in recent years.

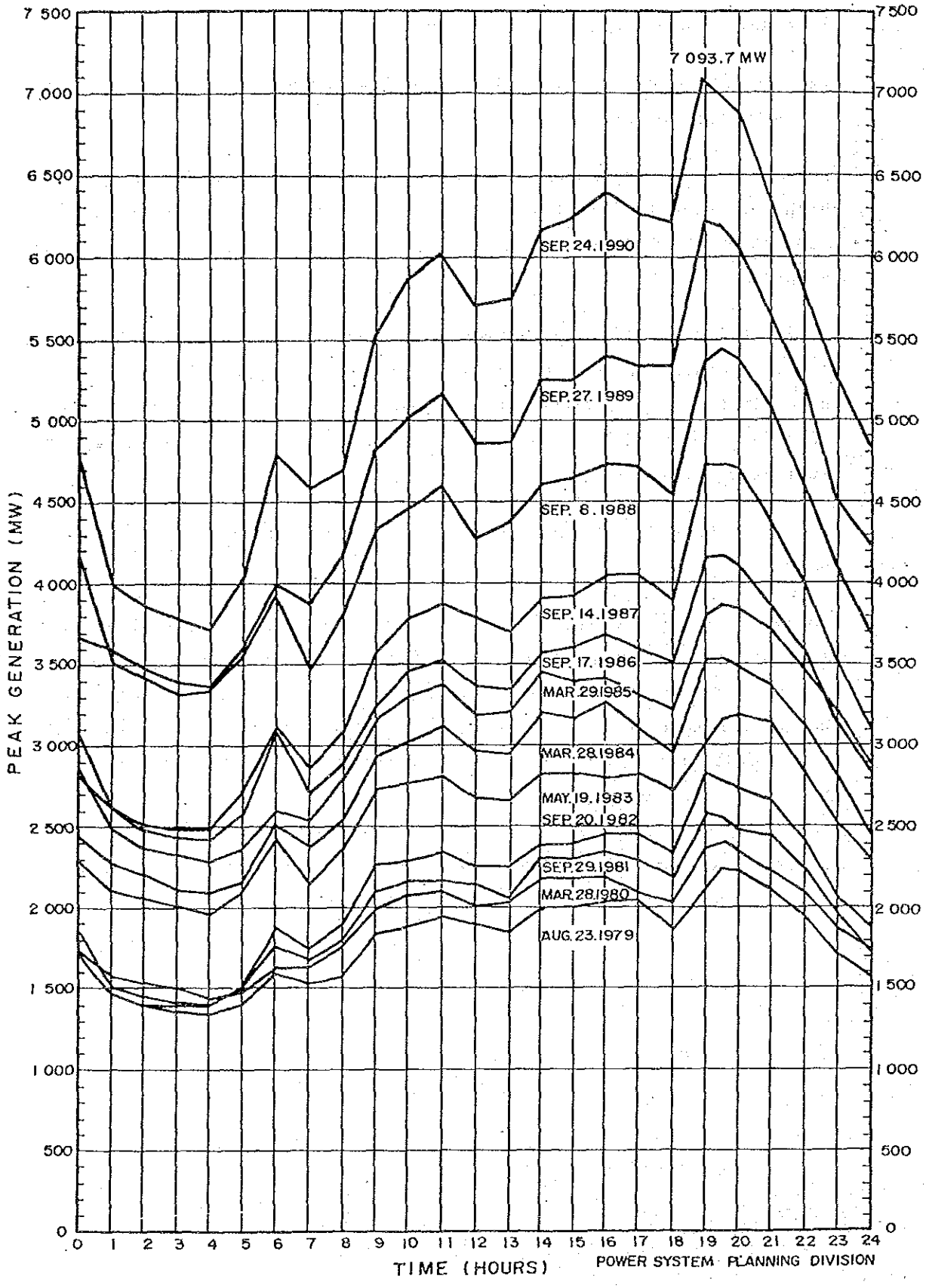


Fig. 3-4 EGAT RECORDED DAILY LOAD CURVES ON HEAVIEST LOAD DAY (FISCAL YEAR 1979-1990)

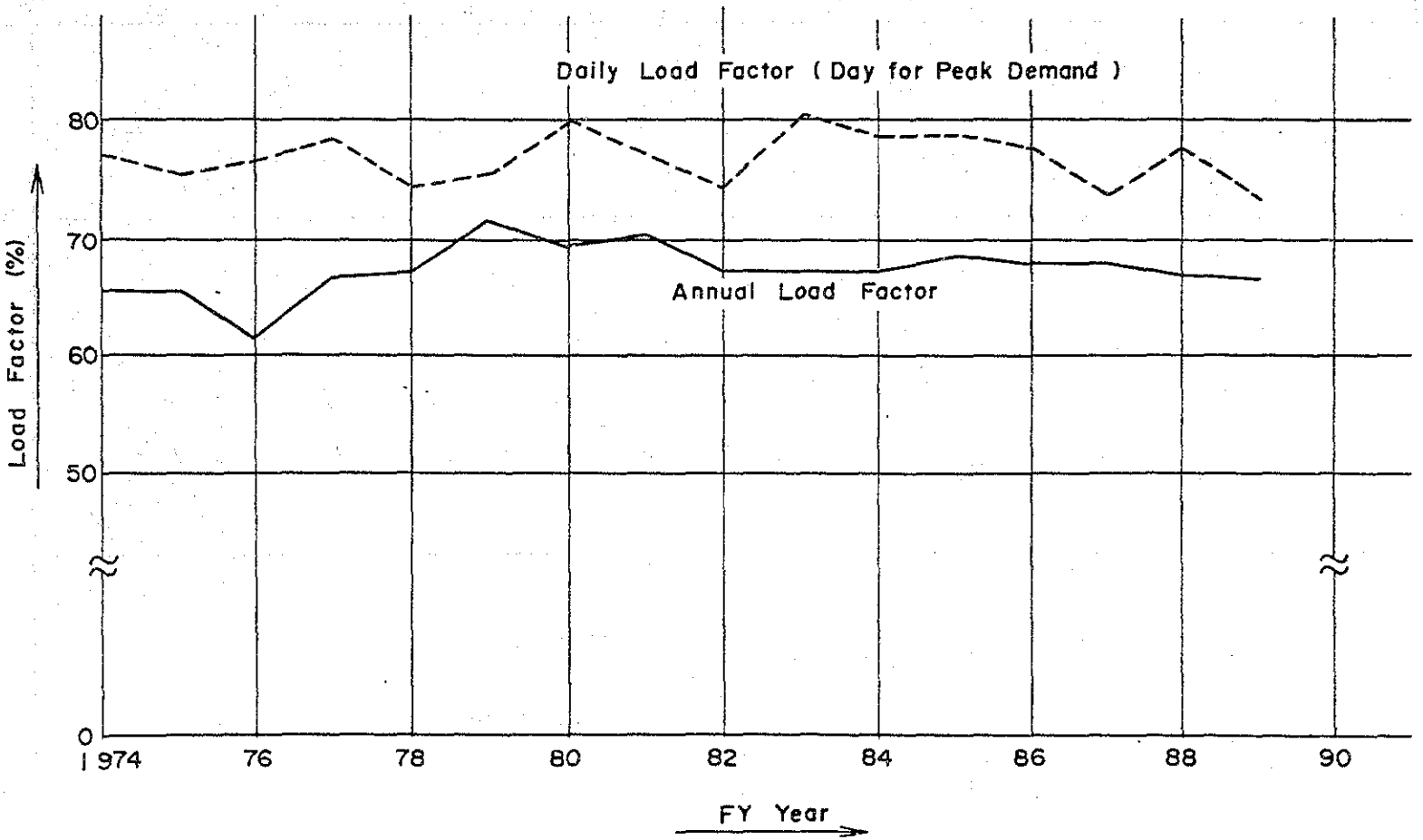


Fig. 3-5 Relation between Annual and Daily Load Factors EGAT Whole System (1974~1989)

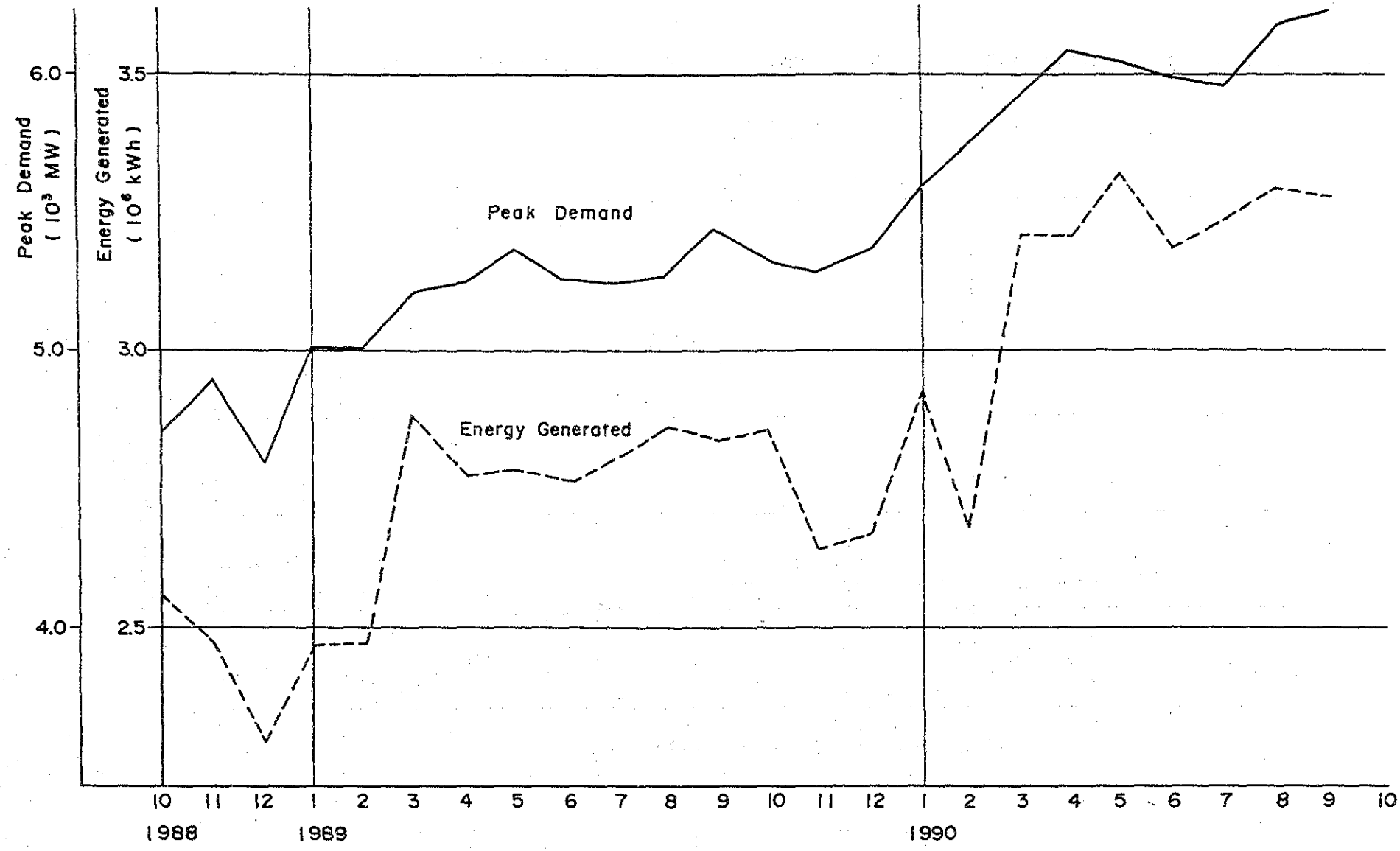


Fig 3-6 Trend of Monthly Peak Demand and Energy Generated