THE KINGDOM OF THAILAND

THE FEASIBILITY STUDY REPORT

ON

DISTRIBUTION SYSTEM DISPATCHING CENTER PROJECT

SUMMARY

JANUARY 1987

JAPAN INTERNATIONAL COOPERATION AGENCY

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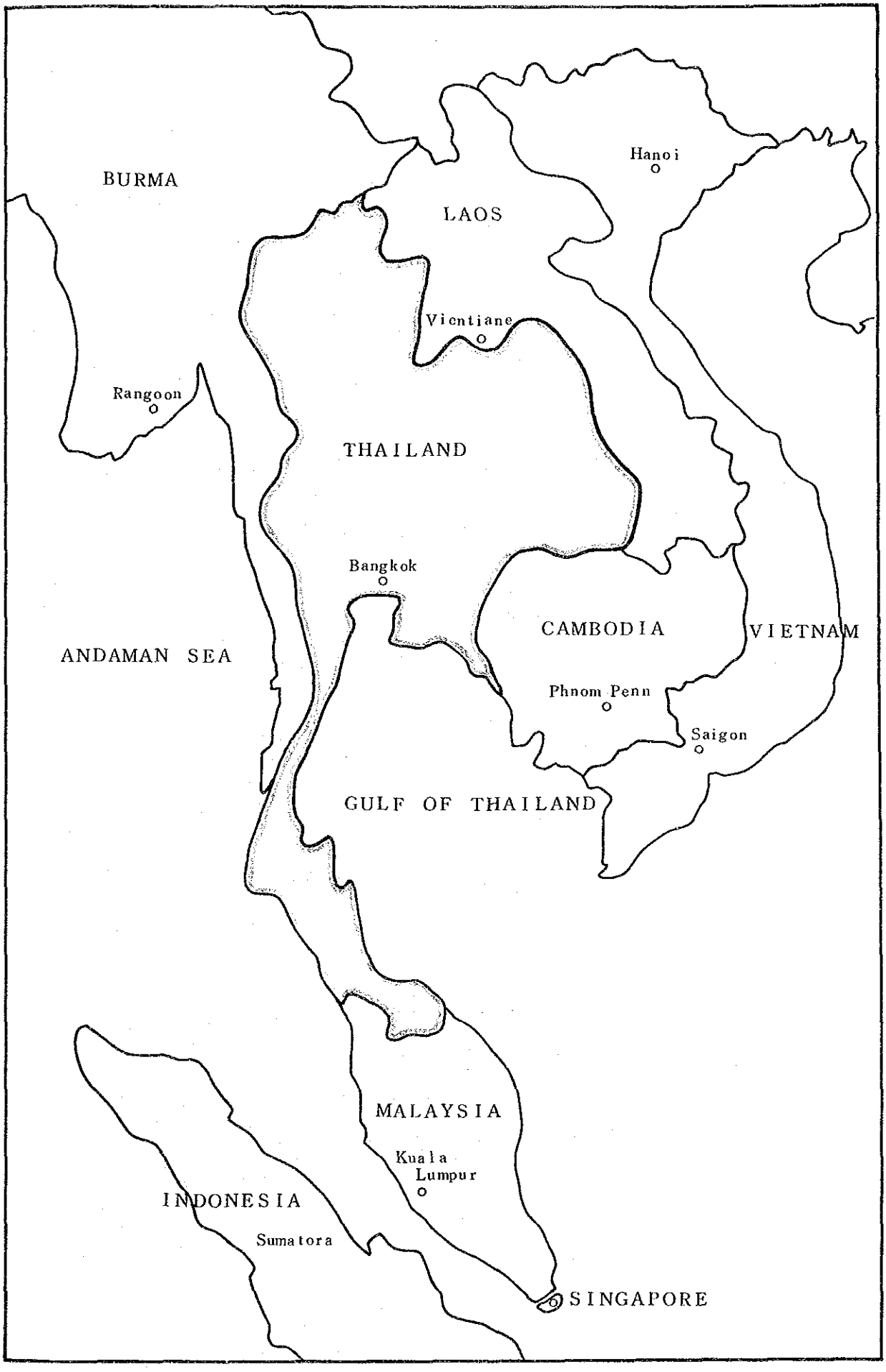
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The following are conclusions and recommendations for the Distribution System Dispatching Center Development Project, for which the study was conducted by the Japan International Cooperation Agency from June 1986 through January 1987 upon the request of the government of the Kingdom of Thailand.

1. Necessity of the Project

The energy sales of PEA is expected to grow at an annual rate of 8.4 percent from 8,557 GWh in FY 1985 to 19,185 GWh in FY 1995, with the share of PEA in the three authorities (EGAT, MEA, PEA) increasing from 42.8 percent to 51.1 percent. Also, the ratio of industrial power demand to the total demand is expected to increase from 44.4 percent in FY 1985 to 46.3 percent in FY 1995. In short, the power demand of PEA will continue to grow at a high growth rate with the ratio of industrial power demand, which requires high supply reliability, continuing to increase steadily.

With the increase of power demand in the future, the power distribution facilities will continue to expand and the configuration of high voltage distribution system will become more complicated.

On the other hand, the faults of high voltage distribution lines are very frequent and the supply interruptions are very long, causing many complaints from customers. The losses of big customers by supply interruptions are estimated at 365 M.Baht in FY 1986, causing the considerable losses to the national economy. The losses of big customers are expected to reach 551 M.Baht in FY 1995 with the increase of industrial power demand.

In spite of the said situation, there is no automated supervisory control equipment provided for the dispatching operations of extensive distribution system, and the dispatching operations are carried out mainly through the voice communication with VHF (partially UHF) radio system. Hence, it is becoming increasingly difficult for PEA to carry out the dispatching operations with the conventional system. Besides, the operation of distribution system will inevitably become more complicated with the growth of power demand and the expansion of power facilities in the future and there will be an increasing social demand for a more reliable power supply.

To cope with the situation, it is essential to promote the automated dispatching operations through the introduction of an advanced distribution dispatching system and the improvement of communication system. It is advisable to carry out these measures as promptly as possible.

2. Distribution System Dispatching Center Development Program

A distribution dispatching center was planned to be constructed in each regional office to supervise and control the substations, sectionalizers and reclosers for the speedy collection of fault information, early detection of fault sections and prompt interchange of power to sound sections, as well as to collect the necessary data for efficient system operation and planning. UHF radio system was adopted for the data transmission.

The proposed distribution dispatching system consists of the following.

Distribution dispatching center	13 centers
Radio repeater station	24 stations
Substation	150 substations
Sectionalizer	871 units
Recloser	420 units

For the number of sectionalizers to be installed, the study was made for the following three cases, of which Case 2 was adopted as the optimum case in terms of the economy.

Case 1: To install one unit for every line

Case 2: To install two units for interconnected line and one unit for radial line

Case 3: To install two units for every line

On completion of the project, the interruption energy in FY 1995 is expected to decrease from 38.7 GWh to 23.3 GWh (60.2 percent), and the interruption energy of big customers is expected to decrease from 10.09 GWh to 5.77 GWh (57.2 percent), resulting in a considerable improvement of supply reliability.

3. Implementation Program of Pilot Distribution System Dispatching Center

Since the automated distribution dispatching system is the first attempt for PEA, the construction of pilot dispatching center and related training unit was planned for the following reasons.

(1) Confirmation, evaluation and improvement of proposed distribution dispatching system and determination of optimum system for the future.

(2) Acquisition of operation and maintenance techniques of automated distribution dispatching system.

(3) Study and training on evaluation, planning, design and construction of automated distribution dispatching system.

(4) Training of engineers/technicians.

The pilot dispatching center was planned to be constructed in Central Region 3 and the training unit in the Training Center.

The proposed pilot distribution dispatching system consists of the following.

Distribution dispatching center	1 center
Radio repeater station	1 station
Substation	12 substations
Sectionalizer	127 units
Recloser	19 units

4. Construction Cost

The construction cost of the project is estimated as follows.

(1,000 US$)

	F.C.	L.C.			Total
		Duties	Others	Sub-Total	
Project Total	66,587	27,290	4,335	31,625	98,212
Pilot Project	8,293	3,395	411	3,806	12,099

5. Implementation Program

The project requires the early implementation and the immediate start of the work as it involves the pilot project.

Accordingly, the study developed the program to implement the pilot project during the period from 1987 to 1989 and the master projects for remaining 11 regions during the five year period from 1990 to 1994. It was also planned to implement the master project in two stages. The project implementation schedule is as shown below.

Stage	Year	Region	Construction Cost (1,000 US$)
1st Stage	1987 - 1989	C3, Training Center	12,099
2nd Stage	1990	C1, C2	19,585
	1991	S1, S2	15,821
	1992	NE3, S3	13,532
3rd Stage	1993	N1, NE1	16,067
	1994	N2, N3, NE2	21,108

The following are recommendations for the implementation of the project.

(1) An appropriate institutional framework for the project implementation must be established.

(2) Particular attention must be paid to the completeness of training.

(3) Assistance of an experienced consultant will be needed.

(4) A package order system is required for the procurement of equipment and materials.

6. Economic Evaluation

The economic internal rate of return (EIRR) of the project was calculated at 11.20 percent for Case 1, 13.44 percent for Case 2 and 11.89 percent for Case 3, and the project may be said to be feasible from the standpoint of national economy. In particular, when the future increase of industrial power demand in the service area of PEA is taken into consideration, the project is expected to have a major effect on the improvement of productivity at customer's factories and activate the industrial investments, thereby contributing greatly to the economic development of Thailand. The effect of the project is not limited to the direct economic effect analyzed by the study but includes,

(1) improvement of power supply reliability,
(2) activation of industrial investment and electric power consumption,
(3) improvement of people's livelihood.

The so-called social rate of return will be considerably higher than EIRR calculated in the study.

The project brings about some benefits on the finance of PEA because the achievement of acceptable degree of reliability and service efficiency requires high investment cost. However a lot of additional benefits which are difficult to measure financially are expected as shown in the followings:-

(1) Effective utilization of system resources through appropriate and timely collection of necessary information.

(2) Improvement of the accuracy of reports used for the operation and planning of distribution system.

(3) Considerable contribution to the efficient implementation of PEA's other projects such as the rural electrification projects, power distribution systems reinforcement projects, etc. with the automated dispatching system and improved communication system.

(4) Reduction in labour works for system operations such as the detection of faulty sections, system operation for the interchange of power to sound sections, etc.

(5) Contribution to meeting the expectations of the publics in terms of safety and better services which will eventually create positive response to PEA and the Government.

Even though the financial burden of the project is estimated to be a considerable amount but it will be soundly managed within the overall balance of PEA by seeking financial support from local or foreign financial institutions.

Chapter 1

BACKGROUND AND OBJECTIVE OF THE PROJECT

Chapter 1 BACKGROUND AND OBJECTIVE OF THE PROJECT

1-1 Background and Objective

The Provincial Electricity Authority (PEA) is under the jurisdiction of the Ministry of Interior, and responsible for the distribution of electricity all over the country, with exception of the metropolitan area where the electricity supply is under the responsibility of the Metropolitan Electricity Authority (MEA).

Since its establishment in 1960, PEA has promoted the extension of electrified area and reinforcement of distribution facilities, and as the result, the annual energy sales amounted to 8,557 GWh and the peak load to 1,956 MW in FY 1985, with the annual average growth rates being 15.0 percent and 14.2 percent, respectively, during the past 10 years. The electrification ratio was 55.2 percent at the end of FY 1985. The power distribution facilities were substantially expanded in the meantime, and the circuit length of high voltage distribution lines reached 89,369 km at the end of FY 1985, with an annual average growth rate being 19.2 percent during the past 10 years.

As for the future forecast, the trend of high growth rate is expected to continue because the government is laying emphasis on the industrial development in the provincial areas, and furthermore the electrification ratio is still low at the present time. Under the circumstances, the power demand is expected to increase to 19,185 GWh in energy sales and 3,877 MW in peak load in FY 1995 at

the annual average growth rates of 8.4 percent and 7.1 percent, respectively. The electrification ratio is expected to be 76.0 percent at the end of FY 1995.

PEA has mainly promoted electrification projects under the Fifth National Economic and Social Development Plan (1982 - 1986), and furthermore another projects consisting mainly of electrification are being planned in succession under the Sixth National Economic and Social Development Plan (1987 - 1991).

It must be kept in mind, however, that the improvement related to the operation and administration of the facilities is lagging behind because thus far PEA has concentrated all of its efforts on the construction of facilities. That being so, there are many problems remaining to be solved, such as the improvement of supply reliability and voltage, the effective utilization of facilities, etc. In particular, referring to the dispatching task of distribution system covering a wide service area, there is no automated supervisory control equipment at all, and the operation is carried out exclusively through the voice communication by VHF (partially UHF) radio system. Under the circumstances, a considerable amount of time and labour have been required for such works as the collection of fault information, detection of faulty sections, interchange of power to sound sections, etc. The frequent complaints have been made by customers because the supply interruptions are long and frequent, and it is becoming increasingly difficult to cope with the situation with the conventional system. Furthermore, it is unquestionable that the operation of distribution system will become more complicated with the increases of both demand and

facilities, and moreover the social requirement for a reliable supply of electricity will become more strict. The promotion of the automation of dispatching task by introducing a modern dispatching system and by improving the communication system is nowadays of urgent need in order to make it possible to cope with the said situation.

The study was carried out in response to the request of technical cooperation made by the Government of the Kingdom of Thailand to the Government of Japan based on the said background.

The objective of the Study is to establish the optimum plan on distribution dispatching and communication systems in the PEA's service area from both economic and technical standpoints, as well as to determine the implementation program for pilot distribution system dispatching center.

1-2 Process of the Study

With the above-mentioned background, the Japan International Cooperation Agency (JICA) organized a study team and sent it to the Kingdom of Thailand. The study team conducted a field survey during the period from June 25 to August 8, 1986. On returning to Japan, the study team reviewed and analyzed the data collected in Thailand and summarized the results of the study in the present Feasibility Study Report on Distribution System Dispatching Center Project.

The work schedule of the study team is as shown in Table 1-1.

1-3 Organization and Itinerary of the Study Team

(1) Organization

The organization of the study team is as follows.

Leader:	FUMINORI SATO,	WEST JEC	- Overall supervision
Member:	YOSHINAO YAHIRO,	WEST JEC	- Communication
Member:	KAZUO CHIJIWA,	WEST JEC	- Substation
Member:	SADAFUMI TOMONAGA,	WEST JEC	- Economic evaluation
Member:	HIROSHI KANEKO,	WEST JEC	- Distribution Dispatching
Member:	KAZUHIRO ABE,	WEST JEC	- Architecture

(2) Itinerary

The itinerary of the study team were as follows.

		Departure	Return
F. SATO	(Field Survey)	Jun. 25, 1986	Aug. 8, 1986
	(Interim Report)	Oct. 12, 1986	Oct. 18, 1986
	(Draft Report)	Dec. 21, 1986	Dec. 27, 1986
Y. YAHIRO	(Field Survey)	Jun. 25, 1986	Aug. 8, 1986
	(Interim Report)	Oct. 12, 1986	Oct. 18, 1986
K. CHIJIWA	(Field Survey)	Jun. 29, 1986	Jul. 28, 1986
S. TOMONAGA	(Field Survey)	Jun. 29, 1986	Jul. 13, 1986
H. KANEKO	(Field Survey)	Jun. 25, 1986	Aug. 8, 1986
K. ABE	(Field Survey)	Jul. 13, 1986	Jul. 22, 1986

(3) Counterparts

The study team discussed and worked with the following counterparts of PEA.

Deputy General Manager	SURASUKDI SENAVONGSE
Assistant General Manager	PRAMUAL KACHATAY
Planning and Civil Works Department	
Director	SAKOL WONGBUDDHA
Project and Planning Division	
Manager	SUNTHORN TANTHAVORN
Deputy Manager	BOONWED CHAROENCHAI
Chief	NARIS SRINUAL
Assistant Chief	CHAIWAT UDOMRATANASIRICHAI
Civil Engineering and Architecture Division	
Deputy Manager	SUBHARP NILVAN
Assistant Manager	PRASERT MANGKALA
Architect	SARANYU UDOMSILPA
Engineer	CHONLATHON SATAVARA
Engineering Department	
Director	CHUTHARAT LEERABHANDH
Electrical and Mechanical Engineering Division	
Manager	PRAVIT CHIRADEJA
Engineer	MANEE PANCHINDAR
Chief	SUWAT IUMCHITKUSOL
Research Division	
Manager	THANU CHINKRUA
Chief	WEERACHAI KOYAKUL
	VORAPOJ PILASLAKSANAKAN
Training Center	
Manager	SOMCHAI SRIRATH
Operation and Maintenance Department	
Director	PRACHA THITATHAN
Distribution System Dispatching Center	
Manager	KAYJORN SONGKAKUL
Deputy Manager	NEETHI BHAVAKUL
Chief	THO KONGSAKUL
Assistant Chief	PASSAKORN CUPTAVANICH
Engineer	SUWAT CHIOCHANCHAI

Table 1-1 IMPLEMENTATION SCHEDULE OF THE STUDY

THE FEASIBILITY STUDY ON DISTRIBUTION SYSTEM DISPATCHING CENTER PROJECT IN THE KINGDOM OF THAILAND (1986)

ITEMS / YEAR & MONTH

OVERALL SCHEDULE

	NAME	ASSIGNMENT	DESCRIPTION OF WORKS
Field study in Thailand and Works in Japan	FUMINORI SATO	Team Leader Overall supervision	Overall supervision of the study Economic and financial evaluation Study of optimum distribution dispatching system Preparation of reports
	YOSHINAO YAHIRO	Communication	Review of present status and future plan of communication system Study of data transmission system Study of improvement plan of general communication system
	KAZUO CHIJIWA	Substation	Review of present status and future plan of substation Review of operation and maintenance system of control station Study of facilities to be supervisory controlled
	SADAFUMI TOMONAGA	Economic analysis	Economic and financial analysis Review of economic situation Review of past record and forecast of electric power demand
	HIROSHI KANEKO	Distribution Dispatching	Review of present status and future plan of distribution system Review of distribution dispatching and maintenance system Study and design of distribution dispatching system
	KAZUHIRO ABE	Architecture	Study of architectural requirements for dispatching center and control station Architectural design
Works in Japan	YASUO WANI	Communication Dispatching	Study of optimum data transmission system Study and design of distribution dispatching system

Chapter 2

GENERAL CONDITION AND ELECTRIC POWER SITUATION IN THAILAND

Chapter 2 GENERAL CONDITIONS AND ELECTRIC POWER SITUATION IN THAILAND

2-1 Economic Situation

The economy of Thailand grew at an annual average growth rate of about 7 percent during the period from 1961 when the First National Economic and Social Development Plan was started, to 1981 when the Fourth Plan was completed.

Tables 2-1 and 2-2 show the main economic indicators and real GDP by industrial origin, respectively. The annual average growth rate of real GDP under the Fifth Plan (October 1981 - September 1986) showed a sign of slowing down owing to the world-wide recessions following the second oil crisis, sluggish world trade and low prices of primary products, indicating 5.0 percent during the period up to September 1985. In 1985, on the list of high rank were agriculture (23.2 percent), manufacturing (20.8 percent), wholesale and retail trade (15.7 percent) and services (11.6 percent), with a favorable growth rate enjoyed by banking, insurance and real estate, electricity and water supply, services, mining and quarrying, and manufacturing.

The trade of Thailand shows the pattern which is common to most of developing countries by exporting such primary products as rice, tapioca, crude rubber, sugar, tin and maize and importing capital goods, including machinery and steel, industrial raw materials and consumer goods. The trade balance of Thailand was constantly in the red, which was covered by the surplus of invisible trade balance and capital balance.

The second oil crisis in 1979 also had a major impact on Thai's commodity prices and the consumer price during the 1979 - 1981 period went up sharply. Thereafter, however, the prices are calming down.

2-2 Energy Situation

The annual average growth rate of energy consumption in Thailand was 11.9 percent during the 1975 - 1980 period but declined to 6 percent during the period from 1980 to 1984. The energy consumption in 1984 was 23,249 Ml of crude oil equivalent, with the share of domestic energy resources being 49.9 percent and the rate of dependence on oil being 54.8 percent. During the period from 1984 to 1992, the energy consumption is expected to increase at an annual average growth rate of 6.5 percent and reach 38,568 Ml (COE) in 1992, with the rate of dependence on oil declining to 48.2 percent.

The present status and future outlooks of domestic energy resources are as follows.

The consumption of domestic petroleum products in 1984 accounted for 9.4 percent of the total consumption of petroleum products. The oil fields are located in the northern region of the country. The oil reserves has not been determined definitely.

The practical use of natural gas started in September 1981 and the consumption of natural gas in 1984 accounted for 9.8 percent of the total energy consumption, which is expected to account for 15.2 percent in 1992. The gas fields are mainly offshore fields located in the Gulf of Thailand, and the confirmed reserves and potential reserves are said to be 4,000 Gft^3 and 10,000 Gft^3, respectively.

The consumption of lignite in 1984 accounted for 3.7 percent of the total energy consumption, which is expected to reach 9.8 percent in 1992. The representative coal mines are located in Mae Moh and Li in the north and Krabi in the south, with the potential reserves of 680 to 1,480 Mt. The greater part of lignite is of low caloric values and the majority is used for the power generation.

The hydro power generation in 1984 accounted for 5.3 percent of the total energy consumption. The potential hydro-energy is said to amount to 27,015 MW, comprising 10,120 MW of domestic rivers and 16,895 MW of international rivers bordering on Laos and Burma.

2-3 Operation of Electric Power Industry in Thailand

The power industry in Thailand is operated by three authorities, EGAT which is responsible for the power generation and transmission, MEA which is responsible for the power distribution in metropolitan area and PEA which is responsible for the power distribution in the areas other than metropolitan area. Besides, NEA owns three small hydro power plants.

NEA is in charge of general administration related to electricity, while NESDB takes charge of the coordination of national power system projects.

2-4 Electric Power Demand

The past records and forecast of power demand in Thailand are shown in Table 2-3.

In FY 1985, the power demand amounted to 19,979 GWh in energy sales and 3,878 MW in peak load, with the annual average growth rates of 9.0 percent and 9.9 percent, respectively, during the past five years. In FY 1995, the energy sales is expected to increase to 37,549 GWh and peak load to 7,128 MW at the annual average growth rates of 6.5 percent and 6.3 percent, respectively. The electrification ratio in Thailand was 59.1 percent in FY 1985 and is expected to reach 79.5 percent in FY 1995. The ratio of industrial power demand to the total demand was 44.9 percent in FY 1985 and is estimated at 42.8 percent in FY 1995.

During the period from FY 1985 to FY 1995, the annual average growth rate of energy sales by authorities is forecast to be 2.6 percent for EGAT, 5.0 percent for MEA and 8.4 percent for PEA. The energy sales of PEA is expected to surpass that of MEA in FY 1989, with the share of PEA in the three Authorities increasing from 42.8 percent in FY 1985 to 51.1 percent in FY 1995.

2-5 Present Status and Future Plans of Power Generation Facilities

The present status and future plans of power generation facilities of EGAT are shown in Table 2-4, and the power system diagram of EGAT is shown in Figure 2-1.

At the end of FY 1985, the total installed capacity of power generation facilities was 6,459.7 MW, with the share of 37.2 percent for natural-gas-fired thermal power plants, 28.1 percent for hydro power plants, 15.2 percent for gas turbine power plants, 13.7 percent for lignite-fired thermal power plants, 5.3 percent for

oil-fired thermal power plants and 0.5 percent for diesel power plants. By region, the Central Region accounted for 63.2 percent, Northern Region 28.9 percent, Southern Region 5.7 percent and Northeastern Region 2.1 percent of the total installed capacity. The Southern and Northeastern Regions have a small share in the total installed capacity.

For the share of energy resources in the total energy generation in FY 1985, natural gas accounted for 43.0 percent, lignite 19.0 percent, oil 18.2 percent, hydro 16.6 percent and purchased power 3.2 percent, indicating the active utilization of domestic energy resources.

The installed capacity is expected to increase to 9,143.1 MW at the end of FY 1995, with the share of 32.8 percent for hydro power plants, 26.2 percent for natural-gas-fired thermal power plants, 22.6 percent for gas turbine power plants, 16.4 percent for lignite-fired thermal power plants and 2.0 percent for oil-fired thermal power plants, thereby reducing the share of oil in the total energy generation to 2.2 percent. For the share of installed capacity by region, the Central Region will account for 52.0 percent, Northern Region 27.0 percent, Southern Region 13.3 percent and Northeastern Region 7.7 percent, with the developments planned also in the Southern and Northeastern Regions.

2-6 Present Status and Future Plans of Transmission and Substation Facilities

The circuit length of transmission lines of EGAT was 14,455 km at the end of FY 1985 and is planned to expand to 21,400 km at the end of FY 1995. The transmission lines are mainly 230 kV and 115 kV lines, with the 230 kV transmission lines forming the trunk lines from the power plants in the Northern and Central Regions to the capital city of Bangkok. The future plans include the construction of 500 kV transmission lines from the Mae Moh power plant in the north to Bangkok, the extension of 230 kV transmission lines to the south, the reinforcement of 230 kV transmission lines to the Northeastern Region and the expansion of 115 kV systems of each Region.

The total installed capacity of substations under EGAT was 10,201.6 MVA at the end of FY 1985, which is planned to reach 24,320 MVA at the end of FY 1995.

Table 2-1 MAIN ECONOMIC INDICATORS

Item		1976	1977	1978	1979	1980	1981	1982	1983	1984
Population (x 1,000)		42,421	43,436	44,463	45,460	46,461	47,490	48,490	49,461	50,397
GDP Growth Rate (Constant Price)	(%)	8.7	7.2	10.1	6.1	5.8	6.3	4.1	5.8	6.2
GDP Growth Rate (Current Price)	(%)	13.0	19.8	21.8	18.4	23.1	14.8	7.6	9.2	7.3
Per Capita GNP	(US$)	389	441	514	589	707	738	735	790	806
Consumer Price Index		100.0	107.6	116.1	127.6	152.7	172.1	181.1	187.9	189.5
	(%)	4.2	7.6	7.9	9.9	19.7	12.7	5.2	3.8	0.9
Balance of International Payment (M. Baht)	Trade	(11,085)	(25,599)	(28,540)	(47,053)	(57,985)	(65,782)	(36,137)	(89,237)	(68,796)
	All Items	(81)	(7,538)	(13,298)	(7,925)	5,179	2,531	3,314	(18,078)	10,588
Foreign Currency Reserves	(M. US$)	1,893	1,915	2,557	3,129	3,026	2,726	2,652	2,555	2,689
Outstanding Foreign Debts (Public Sector)	(M. US$)	816	1,139	1,786	2,713	3,932	5,238	6,032	6,876	8,538
Exchange Rate (to US$)		20.400	20.400	20.336	20.419	20.476	21.820	23.000	23.000	23.639

Table 2-2 GROSS DOMESTIC PRODUCT BY INDUSTRIAL ORIGIN
(1972 Prices)

(Unit: M. Baht)

Industrial Origin	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	%	Annual Growth Rate (%)	
												1976--1981	1981--1985
Argiculture	65,898	65,537	72,513	71,408	72,784	77,701	78,502	81,449	85,902	87,897	23.2	3.4	3.1
Crops	49,013	46,794	53,583	51,804	54,179	58,528	59,904	61,919	65,518	66,696	17.6	3.6	3.3
Livestock	7,622	8,102	8,515	8,931	9,011	9,500	9,897	10,332	10,781	11,088	2.9	4.5	3.9
Fisheries	5,898	7,499	7,414	7,281	6,276	6,777	6,019	6,568	6,862	7,290	1.9	2.8	1.8
Forestry	3,365	3,142	3,001	3,392	3,318	2,896	2,682	2,630	2,741	2,823	0.7	(3.0)	(0.6)
Mining and quarrying	2,906	3,526	4,104	4,531	4,780	4,623	4,431	4,414	5,415	6,012	1.6	9.7	6.8
Manufacturing	42,529	48,071	52,521	57,841	60,597	64,490	67,317	72,252	77,081	78,921	20.8	8.7	5.2
Construction	10,022	11,996	13,583	14,547	16,576	15,500	15,097	15,927	17,680	17,603	4.6	9.1	3.2
Electricity and water supply	3,642	4,144	4,500	5,178	5,560	6,330	6,755	7,348	8,088	8,875	2.3	11.7	8.8
Traisportation and communication	13,366	14,474	16,205	17,663	18,811	20,209	21,715	23,290	24,605	26,242	6.9	8.6	6.7
Wholesale and retaid trade	38,821	41,213	43,658	45,497	48,227	51,103	52,789	55,076	57,430	59,497	15.7	5.7	3.9
Banking, insurance and real estate	10,208	11,574	13,443	15,582	17,419	19,197	21,396	24,238	26,994	29,388	7.8	13.5	11.2
Ownership of dwellings	3,664	3,823	4,052	4,289	4,502	4,723	4,936	5,178	5,369	5,594	1.5	5.2	4.3
Public administration and defence	8,893	9,555	10,166	11,594	12,423	13,192	13,833	14,498	14,106	14,873	3.9	8.2	3.0
Services	21,276	23,260	26,352	28,777	31,173	34,202	37,261	39,276	41,536	43,854	11.6	10.0	6.4
Gross domestic product (GDP)	221,225	237,173	261,097	276,907	292,852	311,270	324,032	342,946	364,206	378,756	100.0	7.1	5.0
Plus: Net factor income payment from the rest of the world	(1,020)	(1,575)	(4,054)	(7,010)	(8,279)	(12,985)	(14,910)	(14,080)	(17,372)	(17,702)		-	-
Gross national product (GNP)	220,205	235,598	257,043	269,897	284,573	298,285	309,122	328,866	346,834	361,054		6.3	4.9
Per capita GNP (BAHT)	5,191	5,424	5,781	5,937	6,125	6,281	6,375	6,649	6,882	7,038		3.9	2.9
Population (x 1,000 capita)	42,421	43,436	44,463	45,460	46,461	47,490	48,490	49,461	50,397	51,301		2.3	1.9

Table 2-3 POWER DEMAND IN THAILAND

Items	Actual											Growth Rate (%/year)
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
ENERGY SALES (GWh)												
Residential	1,373.12	1,540.10	1,880.28	2,221.62	2,627.83	2,884.55	3,128.12	3,461.13	4,091.38	4,572.74	5,091.75	12.0
Small Business	1,022.55	1,182.83	1,401.67	1,656.20	1,833.52	1,636.92	1,583.02	1,627.50	1,822.77	1,946.90	2,155.31	5.7
Large Business	4,072.21	4,736.05	5,466.38	6,054.74	6,830.69	1,904.26	1,906.66	2,084.73	2,236.01	2,420.51	2,726.23	7.4
Small Industrial	-	-	-	-	-	1,883.79	2,054.03	2,185.58	2,390.54	2,571.40	2,687.51	7.4
Large Industrial	-	-	-	-	-	3,746.25	4,243.34	4,436.94	4,554.14	4,894.77	5,371.15	7.5
Others	442.03	442.67	480.56	523.68	567.59	507.47	476.74	481.96	751.07	943.40	1,036.31	15.3
EGAT directly suppl.	430.89	446.35	476.97	488.24	452.68	443.73	500.61	494.33	610.12	689.73	911.00	15.5
Total	7,340.80	8,348.00	9,705.86	10,944.48	12,312.31	13,006.97	13,892.52	14,772.17	16,456.03	18,039.45	19,979.26	9.0
GENERATED ENERGY												
EGAT (GWh)	8,211.57	9,414.48	10,950.62	12,371.67	13,964.56	14,753.73	15,959.97	16,881.95	19,066.30	21,066.44	23,356.74	9.6
PEA (GWh)	110.20	117.90	97.60	84.10	82.10	69.60	44.90	25.00	26.80	20.50	20.70	(21.5)
Total	8,321.77	9,532.38	11,048.22	12,455.77	14,046.66	14,823.33	16,004.87	16,906.95	19,093.10	21,086.94	23,377.44	9.5
PEAK DEMAND (MW)	1,406.60	1,652.10	1,873.40	2,100.60	2,255.00	2,417.40	2,588.70	2,838.00	3,204.30	3,547.30	3,878.40	9.9
LOSS RATIO (%)	11.8	12.4	12.2	12.1	12.3	12.3	13.2	12.6	13.8	14.5	14.5	-
LOAD FACTOR (%)	67.5	65.9	67.3	67.7	71.1	70.0	70.6	68.0	68.0	67.9	68.8	-
ELECTRIFICATION RATIO (%)	21.8	24.6	26.7	30.3	33.0	36.6	41.4	46.3	49.4	53.5	59.1	-

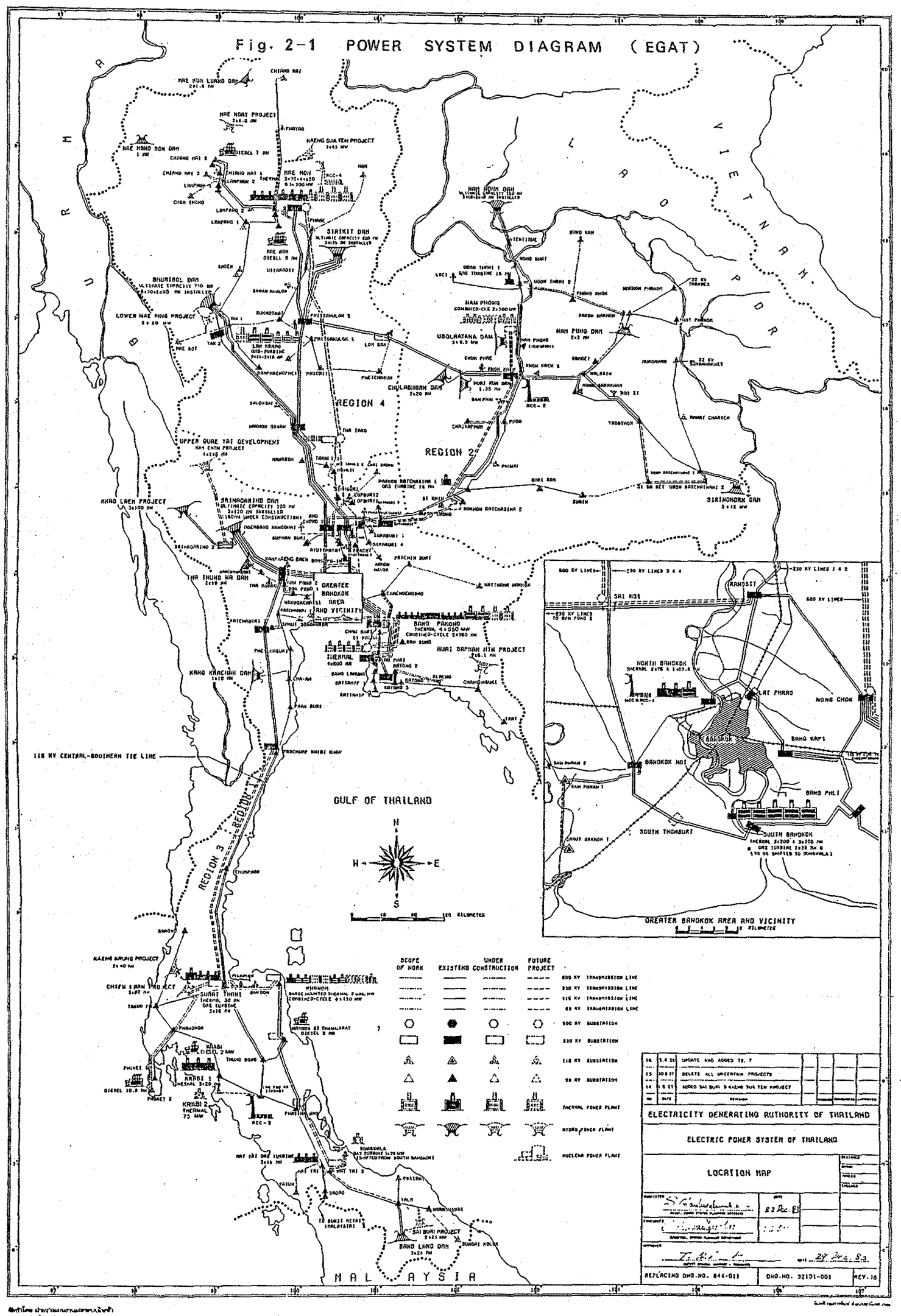
Items	Forecast											Growth Rate (%/year)
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995		
ENERGY SALES (GWh)												
Residential	5,451.08	5,942.34	6,455.71	6,974.43	7,509.61	8,059.03	8,620.01	9,189.75	9,764.93	1,034.77		7.3
Small Business	2,232.96	2,372.42	2,516.54	2,663.80	2,814.00	2,967.04	2,122.61	3,280.62	3,440.76	3,602.95		5.3
Large Business	2,980.02	3,217.75	3,468.35	3,727.99	3,996.56	4,273.76	4,559.40	4,853.27	5,155.17	5,464.81		7.2
Small Industrial	2,799.37	2,945.15	3,093.72	3,243.34	3,394.11	3,546.03	3,699.10	3,853.61	4,009.68	4,167.40		4.5
Large Industrial	5,584.35	6,283.29	7,160.02	8,019.79	8,467.20	8,948.89	9,390.06	9,836.30	10,284.48	10,737.70		7.2
Others	1,192.51	1,320.85	1,409.28	1,501.16	1,595.58	1,686.56	1,775.52	1,866.57	1,959.46	2,054.38		7.1
EGAT directly suppl.	981.35	1,012.22	1,056.73	1,139.81	1,148.87	1,154.77	1,160.84	1,167.06	1,173.50	1,180.15		2.6
Total	21,221.64	23,094.02	25,160.35	27,270.32	28,925.93	30,636.08	32,327.54	34,047.18	35,787.98	37,549.16		6.5
GENERATED ENERGY												
EGAT (GWh)	24,732.00	27,145.00	29,418.00	31,774.00	33,719.00	35,726.00	37,720.00	39,743.00	41,790.00	43,862.00		6.5
PEA (GWh)	27.90	42.60	47.70	49.00	50.30	51.80	49.80	51.30	53.20	55.20		10.3
Total	24,759.90	27,187.60	29,465.70	31,823.00	33,769.30	35,777.80	37,769.80	39,794.30	41,843.20	43,917.20		6.5
PEAK DEMAND (MW)	4,177.00	4,560.00	4,947.00	5,311.0	5,614.00	5,935.00	6,244.00	6,530.00	6,824.00	7,128.00		6.3
LOSS RATIO (%)	14.3	15.1	14.6	14.3	14.3	14.4	14.4	14.4	14.5	14.5		-
LOAD FACTOR (%)	67.7	68.1	68.0	68.4	68.7	68.8	69.1	69.6	70.0	70.3		-
ELECTRIFICATION RATIO (%)	64.2	68.7	71.5	73.1	74.6	76.0	77.1	78.1	78.8	79.5		-

Table 2-4 PRESENT STATUS AND EXPANSION PLAN OF POWER PLANT (EGAT)

(Unit: MW)

Type of Power Plant \ Year / Region		FY 1985						FY 1995					
		Northern	North Eastern	Central	Southern	Total	%	Northern	North Eastern	Central	Southern	Total	%
Hydro		914.8	108.5	698.0	92.3	1,813.6	28.1	919.3	108.5	1,638.0	332.3	2,998.1	32.8
Thermal	Oil			237.5	105.0	342.5	5.3				180.0	180.0	2.0
	Lignite	825.0			60.0	885.0	13.7	1,425.0			75.0	1,500.0	16.4
	Natural Gas			2,400.0		2,400.0	37.2			2,400.0		2,400.0	26.2
	Sub-total	825.0		2,637.5	165.0	3,627.5	56.2	1,425.0		2,400.0	255.0	4,080.0	44.6
Gas Turbine		120.0	30.0	25.0	90.0	265.0	4.1	120.0			25.0	145.0	1.6
Gas Turbine & Combined Cycle				720.0		720.0	11.1		600.0	720.0	600.0	1,920.0	21.0
Diesel		9.0		5.0	19.6	33.6	0.5						
Total		1,868.8	138.5	4,085.5	366.9	6,459.7	100	2,464.3	708.5	4,758.0	1,212.3	9,143.1	100

Fig. 2-1 POWER SYSTEM DIAGRAM (EGAT)



Chapter 3

OUTLINE OF PEA AND ELECTRIC POWER SITUATION

Chapter 3 OUTLINE OF PEA AND ELECTRIC POWER SITUATION

3-1 Profile of PEA

The service area of PEA is approximately 510,000 km^2 (about 1.4 times the area of Japan), accounting for 99.4 percent of the total area of the country, with a population of about 45 million.

Since its establishment in 1960, PEA has promoted the extension of electrified area and the reinforcement of power distribution facilities and has made remarkable accomplishments during the past 10 years from FY 1975 to FY 1985 as shown in Table 3-1. The ratio of introduction of electricity in villages reached 76 percent at the end of FY 1986 and PEA is now promoting the electrification projects to bring this ratio to 95 percent. However, the investment program of PEA under the Sixth National Economic and Social Development Plan (1987 - 1991) indicates the near completion of the electrification projects in FY 1991, though the electrification project still has a large portion in the investment program.

Accordingly, it may be said that PEA is now at the turning point from the stage of quantitative expansion to the stage of qualitative improvement. In its long-term program (1985 - 1991), PEA places emphasis on the reinforcement of facilities, improvement of operation and maintenance, and upgrading of service level.

3-2 Organization of PEA

The organization of PEA consists of a head office, 12 regional offices, 111 electric offices, 158 customer service centers and 1,033 customer service sub-centers. The service areas of regional offices are shown in Fig. 3-1.

The head office carries out mainly project-related works with a total number of about 5,000 employees. The regional offices take charge of the coordination, planning and construction works in responsible areas and have a number of about 3,700 employees. The electric offices are responsible for the construction works, operation and maintenance of facilities and customer services, and are classified into 1st grade to 4th grade offices according to the scale. The customer service centers are responsible for the construction works, maintenance and repair of facilities and customer services in responsible areas. The customer service sub-centers provide mainly customer services. The total number of employees of electric offices and customer service centers/sub-centers is about 13,900.

The offices provided with maintenance function are 111 electric offices and 158 customer service centers, for a total of 269 offices, with a total number of 3,281 maintenance staffs. The service area of each office averages 1,925 km^2, with the average circuit length of high voltage feeders being 331 km. The number of maintenance staffs per 100 circuit-kilometer of high voltage lines is 3.7 persons. Compared with Japan, the average service area per office is 4 times, the average circuit length of high voltage lines

is 0.4 time, and the maintenance staffs per 100 circuit-kilometer of high voltage lines is 3.7 times larger than the corresponding parameters in Japan. Accordingly, it is considered that there is no problem regarding the maintenance.

3-3 Electric Power Demand

The past records and forecast of power demand of PEA are shown in Table 3-2.

In FY 1985, the power demand amounted to 8,557 GWh in energy sales and 1,956 MW in peak load, with the annual average growth rates during the past five years being extremely high at 12.8 percent and 13.4 percent, respectively. In FY 1995, the energy sales is expected to increase to 19,185 MWh and the peak load to 3,877 MW at the annual average growth rates of 8.4 percent and 7.1 percent, respectively. The electrification ratio is expected to reach from 55.2 percent in FY 1985 to 76 percent in FY 1995. The ratio of industrial power demand to the total demand is forecast to increase from 44.4 percent in FY 1985 to 46.3 percent in FY 1995.

The past records and forecast of supply energy by region are shown in Table 3-3. The share of Central Regions is remarkably high. In the future, the growth rates are expected to be particularly high in C2, S3, and N1 Regions.

3-4 Present Status of Power Facilities

(1) Substations

The data related to substations are shown in Table 3-4. The distribution system of PEA is supplied power from 123 substations. All substations are owned by EGAT except for three substations which are owned by PEA. PEA owns only the circuit breakers of high voltage feeders in these substations.

PEA owns control stations adjacent to EGAT substations, and the control stations are operated by one operator in three shifts. There are 67 control stations, with 12 stations being under construction and 26 stations being under plan.

(2) Distribution System

The high-voltage distribution system consists mostly of 33 kV and 22 kV systems. While there are still 11 kV and 3.5 kV systems in part, they are being converted to 22 kV or 33 kV.

The outline of distribution facilities is shown in Table 3-5. There are 564 high voltage feeders with a total circuit length of 89,064 km. The average circuit length per feeder is extremely long, reaching 158 km. In Northeastern Region 2, in particular, the average circuit length per feeder is 327 km.

A total of 423 reclosers are installed on the long distance distribution lines for the protection. The recloser is operated with the current sensing system. There are two types of reclosers, hydraulic type and electronic type, and most of existing reclosers are of hydraulic type. The remote

control of reclosers is not possible for hydraulic type but is possible for electronic type with the addition of control circuit. The switches installed on the high voltage feeders amount to 2,023 units. Most of them are of manual type, but 10 units of sectionalizers are being used for trial. The switches are installed on the high voltage feeders at the rate of one unit for every 30 km of circuit length.

(3) Communication System

The communication system of PEA consists of VHF (150 MHz band), UHF (400 MHz band) and HF (8 MHz band) radio, and is used for the voice communication in simplex operation.

There are 1,859 VHF stations being used in all regions and 108 UHF stations in three regions (N1, C1 and C3). There are 19 VHF repeater stations, of which 11 stations are located at flatlands and 8 stations at highlands such as mountain tops.

Eight (8) VHF waves, 4 UHF waves and 3 HF waves are being used by PEA. Besides, 12 UHF (400 MHz band) waves have been reserved by PEA. By region, only 4 regins use 8 VHF waves (4CH) and 5 regions use only 2 waves (1CH).

The result of field survey showed some radio routes with wrong transmission quality because of the long distance transmission and obstruction by mountains, etc. There were some communication equipment which require the improvement of transmission reliability.

3-5 Present Status of Power Faults

The power faults recorded during the one year period from August 1985 to July 1986 are shown in Table 3-6.

The frequency of faults and duration of supply interruption per feeder were 14 times and 30 hours during the one year period. Compared with Japan, the frequency is 31 times larger and the duration is 100 times longer than those of Japan. The faults lasting for long duration are very frequent and those for three hours or more account for about 20 percent of total faults.

The frequency of faults in one region per year is a maximum of 844 times (S3) and averages 654 times. The frequency of faults in one region per month is a maximum of 142 times (N1) and averages 55 times.

The losses of big customers by supply interruptions are shown in Table 3-7. The supply interruptions of the eight big customers sampled per year were 217 times in frequency, 189 hours in duration and 499 MWh in interruption energy. The losses amounted to 33.1 M.Baht.

The losses per 1 kWh of interruption energy average 66.3 Baht. However, the losses per 1 kWh of interruption energy varies greatly from customer to customer. For the reason, the losses per 1 kWh of interruption energy was calculated at 54.62 Baht from the correlation between the cumulative interruption energy and cumulative losses. The interruption energy for big customers in FY 1986 is estimated at 6,690 MWh, with the losses amounting to 365 M.Baht.

3-6 Present Status of Education and Training

PEA is placing emphasis on the development of human resources with the objective of improving the work efficiency and coping with the new technologies. For the reason, PEA started the construction of Training Center in 1983. The center building is already complete, and the construction of vocational school, dormitories, etc., and the provision of training equipment are being planned. The Training Center is located in Nakhorn Chaisri of Central Region 3, about 40 km west of Bangkok. The site is sized about 81,000 m^2.

There are 32 technical training courses provided, and 50 courses were conducted for 2,067 persons in FY 1985. Of the technical training courses, 6 courses are for distribution dispatching system and 16 courses were conducted for 512 persons in FY 1985.

3-7 Power Tariff

A uniform power tariff is applied throughout Thailand. The power charge increases in proportion to the increase of power consumption. There is a considerable difference in unit price depending on the energy consumption, especially for Residential customers, which ranges from a maximum of 2.11 Baht/kWh to a minimum of 0.7 Baht/kWh.

The unit price is very low for the monthly consumption of less than 35 kWh. The unit price for the monthly consumption of 35 kWh is 0.93 Baht/kWh. The average unit price of sold energy in FY 1985 was 1.69 Baht/kWh.

Table 3-1 TEN YEAR GROWTH STATISTICS

(Unit: Million Baht)

Description	1985	1984	1983	1982	1981	1980	1979	1978	1977	1976	1975	10 Year Increase Amount	10 Year Increase %	Growth Rate
Electric Revenues	14,489.2	12,629.9	11,648.3	10,591.2	8,441.1	4,937.3	3,593.6	3,081.1	2,184.5	1,738.5	1,591.3	12,897.9	810.5	24.7
Other Revenues	1,226.8	1,062.3	1,030.1	1,013.8	740.2	495.9	375.2	340.0	209.9	163.0	114.9	1,111.9	967.7	26.7
Operating Expenses	13,463.4	11,815.6	10,976.3	10,022.4	8,157.0	4,728.7	3,180.7	2,712.7	1,933.0	1,579.1	1,455.5	12,007.9	825.0	24.9
Depreciation	944.8	752.8	607.2	494.1	387.9	292.3	228.9	183.9	149.6	123.2	96.6	848.2	878.0	25.6
Interest on Long-Term Loans	887.3	643.0	597.1	580.3	267.4	131.2	96.7	84.6	68.5	31.4	21.1	866.2	4,105.2	45.3
Foreign Exchange Losses	42.4	12.0	(1.9)	22.1	13.4	18.1	16.9	29.4	12.4	6.1	10.2	32.2	315.6	15.3
Losses on Baht Devaluation	92.3	-	-	95.2	1.8	-	-	-	-	-	-	-	-	-
Net Income	285.8	468.8	499.7	390.9	353.8	262.9	445.6	410.5	230.9	161.7	122.8	163.0	132.7	8.8
Investment	3,660.2	3,584.2	3,015.0	2,979.9	2,451.8	1,527.4	1,320.1	1,051.3	902.4	718.4	399.6	3,260.6	815.9	24.8
Long-Term Loans	14,203.7	10,601.1	9,661.0	7,518.7	6,079.7	3,919.6	2,792.7	2,212.8	1,872.9	1,226.2	460.0	13,743.7	2,987.7	40.9
Net Assets	25,941.1	23,225.8	20,591.1	17,070.2	14,735.2	12,401.6	9,684.1	7,401.1	5,937.6	4,795.5	3,479.3	22,461.8	645.5	22.3
Number of Customers	4,054,200.0	3,619,582.0	3,185,952.0	2,722,534.0	2,270,369.0	1,885,635.0	1,574,039.0	1,349,841.0	1,144,143.0	927,298.0	781,472.0	3,272,728.0	418.7	17.9
Total Sales of Electricity (Million kWh)	8,557.1	7,432.6	6,679.5	5,839.8	5,209.7	4,695.8	4,253.7	3,649.6	3,174.4	2,616.7	2,120.0	6,437.1	303.6	15.0
Average Customer Consumption (kWh)	2,112.7	2,053.4	2,096.6	2,145.0	2,294.6	2,490.3	2,702.4	2,703.7	2,774.5	2,821.6	2,712.8	(600.1)	(22.1)	(2.5)
Average Price of Electricity (Baht/kWh)	1.69	1.7	1.74	1.80	1.62	1.05	0.84	0.84	0.69	0.66	0.75	0.94	125.3	8.5
Total Maximum Demand (MW)	1,953.4	1,703.8	1,555.1	1,336.3	1,180.7	1,040.1	949.1	851.7	740.8	640.1	516.9	1,436.5	277.9	14.2
Purchased Power (MW)	1,932.8	1,682.3	1,533.0	1,308.7	1,151.2	1,005.1	913.2	812.6	700.0	595.0	477.1	1,455.7	305.1	15.0
PEA Generation (MW)	20.6	21.5	22.1	27.6	29.5	35.0	35.9	39.1	40.8	45.1	39.8	(19.2)	(48.2)	(6.4)
Total Electric Energy (Million kWh)	9,440.7	8,242.5	7,411.7	6,453.1	5,806.1	5,200.2	4,760.6	4,120.8	3,513.7	2,875.7	2,309.0	7,131.7	308.8	15.1
Purchased Power(Million kWh)	9,423.9	8,221.9	7,384.9	6,428.1	5,761.2	5,130.6	4,678.5	4,036.7	3,416.1	2,757.8	2,198.8	7,225.1	328.5	15.7
PEA Generation (Million kWh)	16.8	20.6	26.8	25.0	44.9	69.6	82.1	84.1	97.6	117.9	110.2	(93.4)	(84.7)	(17.1)
H.V. Distribution Lines (Circuit-kM)	89,369.0	80,797.0	70,902.0	61,424.0	50,651.0	41,627.0	33,851.0	28,417.0	23,640.0	18,736.0	15,444.0	73,925.0	478.6	19.2
Installed Transformers (MVA)	7,312.3	4,919.8	4,598.9	4,048.7	3,537.9	2,944.5	2,301.7	1,786.9	1,545.1	1,325.5	1,127.3	6,185.0	548.6	20.6
Number of PEA Offices	1,292.0	1,210.0	1,119.0	1,024.0	965.0	927.0	874.0	861.0	835.0	802.0	770.0	522.0	67.7	5.3
Number of Employees	22,584.0	21,382.0	19,605.0	18,188.0	16,262.0	14,310.0	12,274.0	10,594.0	8,883.0	8,028.0	7,502.0	15,082.0	201.0	11.7
Customers/H.V.Distribution Lines	45.4	44.8	44.9	44.3	44.8	45.3	46.5	47.5	48.4	49.5	50.6	(5.2)	(10.2)	(1.1)

Table 3-2 POWER DEMAND OF PEA

Items	Actual											Growth Rate (%/year)
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
ENERGY SALES (GWh)												
Residential	547.20	620.70	804.30	981.30	1,176.60	1,364.20	1,582.12	1,841.75	2,220.83	2,571.50	2,912.00	16.4
Small Business	311.70	427.60	553.70	677.10	795.00	612.50	528.60	519.00	571.80	627.24	684.90	2.3
Large Business	1,145.60	1,438.60	1,676.10	1,844.80	2,121.90	492.80	537.66	597.42	609.14	641.72	710.70	7.6
Small Industrial	-	-	-	-	-	842.70	935.05	1,033.21	1,128.16	1,204.80	1,270.50	8.6
Large Industrial	-	-	-	-	-	1,294.90	1,517.56	1,699.99	1,845.46	1,988.41	2,532.00	14.4
Others	115.50	129.80	140.30	146.40	160.20	88.70	108.72	148.47	304.14	398.89	447.00	38.2
Total	2,120.00	2,616.70	3,174.40	3,649.60	4,253.70	4,695.80	5,209.71	5,839.84	6,679.53	7,432.56	8,557.10	12.8
ENERGY												
Generated (GWh)	110.20	117.90	97.60	84.10	82.10	69.60	44.90	25.00	26.80	20.50	19.60	(22.6)
Purchased (GWh)	2,198.77	2,757.73	3,397.19	4,020.13	4,646.78	5,107.44	5,757.51	6,428.09	7,384.89	8,221.91	9,423.90	13.0
Total	2,308.97	2,875.63	3,494.79	4,104.23	4,728.88	5,177.04	5,802.41	6,353.09	7,411.69	8,242.41	9,443.50	12.8
PEAK DEMAND (MW)	516.9	640.1	740.8	851.7	949.1	1,040.1	1,180.7	1,336.3	1,555.1	1,703.8	1,955.7	13.4
LOSS RATIO (%)	8.2	9.0	9.2	11.1	10.0	9.3	10.2	9.5	9.9	9.8	9.4	-
LOAD FACTOR (%)	51.0	51.3	53.9	55.0	56.9	56.8	56.1	55.1	54.4	55.2	55.1	-
ELECTRIFICATION RATIO (%)	15.9	17.9	20.1	23.3	26.0	30.4	35.7	41.0	44.7	48.9	55.2	-

Items	Forecast											Growth Rate (%/year)
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995		
ENERGY SALES (GWh)												
Residential	3,182.50	3,531.50	3,897.70	4,266.40	4,648.70	5,042.40	5,444.80	5,853.10	6,264.00	6,673.70		8.6
Small Business	737.80	791.60	846.10	901.00	956.10	1,011.30	1,066.30	1,121.00	1,175.10	1,228.50		6.0
Large Business	769.00	829.30	891.60	955.60	1,021.20	1,088.10	1,156.10	1,225.00	1,294.60	1,364.60		6.7
Small Industrial	1,337.90	1,406.80	1,477.30	1,549.40	1,623.20	1,698.70	1,775.90	1,855.10	1,936.40	2,019.90		4.7
Large Industrial	2,866.20	3,436.00	4,180.80	4,909.70	5,227.30	5,580.20	5,893.70	6,213.30	6,535.90	6,864.60		10.5
Others	499.20	554.00	606.30	661.40	718.40	777.70	839.00	902.20	967.30	1,034.10		8.7
Total	9,392.60	10,549.20	11,899.80	13,243.50	14,194.90	15,198.40	16,175.80	17,169.70	18,173.30	19,185.40		8.4
ENERGY												
Generated (GWh)	27.90	42.60	47.70	49.00	50.30	51.80	49.80	51.30	53.20	55.20		10.9
Purchased (GWh)	10,335.90	11,576.00	13,009.10	14,440.90	15,483.20	16,580.10	17,656.40	18,747.50	19,849.30	20,960.40		8.3
Total	10,363.80	11,618.60	13,056.80	14,489.90	15,533.50	16,631.90	17,706.20	18,798.80	19,902.50	21,015.60		8.3
PEAK DEMAND (MW)	2,135.5	2,375.6	2,627.1	2,868.1	3,045.3	3,241.0	3,420.3	3,576.3	3,728.4	3,877.1		7.1
LOSS RATIO (%)	9.4	9.2	8.9	8.6	8.6	8.6	8.6	8.7	8.7	8.7		-
LOAD FACTOR (%)	55.4	55.8	56.7	57.6	58.2	58.6	59.1	60.0	60.9	61.9		-
ELECTRIFICATION RATIO (%)	60.9	65.8	68.6	70.2	71.7	72.9	73.9	74.8	75.4	76.0		-

Table 3-3 ENERGY DEMAND BY REGION

(UNIT: GWh)

REGION	ACTUAL											GROWTH RATE (%/YEAR)
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
N1	122.38	154.00	210.25	248.84	285.73	306.35	339.30	391.72	467.31	524.88	583.94	13.8
N2	88.92	112.49	144.84	179.10	210.45	252.77	302.42	342.97	404.90	459.57	519.89	15.5
N3	133.72	161.87	212.74	249.76	277.37	304.51	338.91	367.05	421.15	459.08	504.29	10.6
SUB-TOTAL	345.03	428.37	567.83	677.70	773.55	863.63	980.63	1,101.73	1,293.35	1,443.53	1,608.12	13.2
NE1	161.57	186.84	215.34	257.40	282.48	309.43	365.10	438.91	502.62	561.78	609.44	14.5
NE2	71.16	88.84	113.07	142.40	160.44	184.02	225.36	253.16	307.91	359.73	406.18	17.2
NE3	172.50	209.65	250.90	294.62	337.93	383.39	433.13	472.52	543.77	622.98	682.69	12.2
SUB-TOTAL	405.23	485.33	579.31	694.43	780.85	876.84	1,023.60	1,164.60	1,354.30	1,544.49	1,698.31	14.1
C1	285.52	370.68	475.45	540.88	571.50	642.79	739.20	864.34	1,111.93	1,292.20	1,762.19	22.3
C2	221.79	278.24	339.34	442.89	505.24	571.53	650.16	712.38	863.11	979.52	1,113.03	14.3
C3	464.06	608.22	709.13	808.09	972.73	1,022.61	1,082.78	1,136.66	1,275.71	1,386.51	1,505.24	8.0
SUB-TOTAL	971.38	1,257.14	1,523.92	1,791.85	2,049.47	2,236.93	2,472.14	2,713.38	3,250.75	3,658.23	4,380.46	14.4
S1	179.60	207.22	246.84	274.56	342.76	328.22	372.62	429.77	479.06	511.58	567.38	11.6
S2	164.50	188.60	230.99	272.89	318.03	354.30	391.84	417.88	471.05	513.74	580.61	10.4
S3	81.15	109.13	166.29	212.11	271.24	315.79	362.28	412.01	481.04	528.86	577.46	12.8
SUB-TOTAL	425.24	504.95	644.12	759.56	932.03	998.30	1,126.74	1,259.66	1,431.16	1,554.19	1,725.45	11.6
GRAND TOTAL	2,146.87	2,675.78	3,315.18	3,923.54	4,535.90	4,975.70	5,603.11	6,239.37	7,329.56	8,200.44	9,412.34	13.6

REGION	FORECAST											GROWTH RATE (%/YEAR)
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995		
N1	635.97	707.76	773.56	850.09	936.72	1,035.28	1,138.12	1,241.78	1,344.01	1,447.94		9.5
N2	542.30	600.39	653.02	707.28	763.89	821.28	879.00	936.40	993.35	1,049.47		7.3
N3	548.76	607.07	651.69	698.11	747.19	796.79	846.59	895.96	944.86	993.02		7.0
SUB-TOTAL	1,727.02	1,915.22	2,078.28	2,255.47	2,447.80	2,653.36	2,863.70	3,074.14	3,282.22	3,490.42		8.1
NE1	654.75	721.05	781.96	844.30	909.21	974.66	1,040.09	1,104.54	1,167.79	1,229.36		7.3
NE2	439.66	492.86	543.42	596.38	652.11	709.46	769.85	831.26	893.53	957.08		8.9
NE3	719.44	786.49	845.23	904.67	966.24	1,027.58	1,088.46	1,147.97	1,206.11	1,262.25		6.3
SUB-TOTAL	1,813.85	2,000.41	2,170.61	2,345.35	2,527.55	2,711.70	2,898.40	3,083.76	3,267.44	3,448.70		7.3
C1	2,110.74	2,415.86	2,956.06	3,128.46	3,266.71	3,410.00	3,558.71	3,713.61	3,874.66	4,041.93		8.7
C2	1,218.52	1,405.87	1,565.01	2,098.79	2,234.31	2,391.41	2,525.56	2,661.74	2,799.69	2,938.61		10.2
C3	1,616.25	1,776.46	1,924.63	2,078.91	2,243.15	2,413.12	2,588.29	2,767.05	2,949.28	3,134.04		7.6
SUB-TOTAL	4,945.50	5,598.19	6,445.70	7,306.16	7,744.16	8,214.53	8,672.56	9,142.40	9,623.63	10,114.58		8.7
S1	596.09	661.62	781.55	845.37	912.63	982.50	1,054.40	1,127.85	1,202.32	1,277.24		8.5
S2	618.73	677.57	736.42	796.08	858.57	922.42	987.25	1,052.24	1,117.18	1,181.59		7.4
S3	633.90	723.00	796.54	892.47	992.40	1,095.60	1,180.10	1,267.11	1,356.50	1,447.87		9.6
SUB-TOTAL	1,848.73	2,062.18	2,314.51	2,533.92	2,763.60	3,000.52	3,221.75	3,447.20	3,676.00	3,906.70		8.5
GRAND TOTAL	10,335.10	11,576.00	13,009.10	14,440.89	15,483.12	16,580.10	17,656.40	18,747.50	19,849.29	20,960.40		8.3

Table 3-4 SUBSTATION DATA (SUMMARY)

Region	No. of Substation	No. of Transformer	Power Transformer Capacity (MVA)	C B	Recloser		No. of Control Room										No. of Staff at Control Station		No. of Feeder	No. of Recloser on Distribution Line	
							Existing				Under Const.				Future Plan						
							Type				Type				Type						
					Hydraulic	Electronic	1	2	3	4	1	2	3	4	1	2	3	4	Present	Futuer Plan		Hydraulic	Electronic
N1	14	30	310.80	36	9	10	5	0	0	0	0	0	0	0	0	4	0	0	17	13	56	27	9
N2	11	14	236.50	31	3	3	6	0	0	0	0	0	0	0	1	1	0	1	22	9	39	34	3
N3	7	11	223.75	22	2	3	4	0	0	0	1	0	0	0	0	2	0	0	13	10	34	32	1
NE1	12	17	292.65	41	4	3	6	0	0	0	2	0	0	0	0	3	0	0	20	15	47	73	0
NE2	9	14	289.50	26	3	3	4	0	0	0	1	0	0	0	0	1	0	1	14	10	36	58	1
NE3	8	12	270.50	48	1	0	8	0	0	0	0	0	0	0	0	0	0	0	29	0	50	40	2
C1	13	19	546.00	92	6	3	5	0	2	1	0	1	0	0	3	0	0	0	33	13	75	20	2
C2	11	19	510.00	56	3	2	5	1	0	0	2	1	0	0	0	1	0	0	23	13	58	21	3
C3	10	17	470.00	55	1	5	7	0	0	0	1	0	0	0	0	2	0	0	27	9	67	18	1
S1	9	12	250.00	33	1	2	6	0	0	0	0	0	0	0	0	2	0	0	19	6	34	26	0
S2	11	18	314.00	31	2	4	3	0	0	0	2	0	0	0	0	2	0	0	11	13	35	16	6
S3	8	11	261.50	28	0	5	4	0	0	0	1	0	0	0	0	2	0	0	14	10	33	23	7
Total	123	194	3,975.20	499	35	43	63	1	2	1	10	2	0	0	4	20	0	2	242	121	564	388	35

Table 3-5 DISTRIBUTION FACILITIES

Region	Area (km^2)	No. of Substation	No. of H.V. Feeder	cct Length of H.V. Line (km)	No. of Recloser on D/L	No. of Switch on D/L	Average H.V. cct Length per Feeder (km)	Average No. of Recloser per Feeder	Average No. of Switch per Feeder	Average H.V. cct Length per Section (Recloser) (km)	Average H.V. cct Length per Section (Recloser & Switch) (km)
N1	71,946	14	56	7,624	36	201	136	0.64	3.6	83	26
N2	74,147	11	39	7,256	37	209	186	0.95	5.4	95	25
N3	40,655	7	34	6,616	33	192	195	0.97	5.6	99	26
NE1	61,034	12	47	11,824	73	267	252	1.55	5.7	99	31
NE2	57,640	9	36	11,768	59	153	327	1.64	4.3	124	47
NE3	49,475	8	50	7,363	42	268	147	0.84	5.4	80	20
C1	22,644	13	75	7,087	22	113	94	0.29	1.5	73	34
C2	21,963	11	58	6,084	24	166	105	0.41	2.9	74	25
C3	27,864	10	67	8,566	19	134	128	0.28	2.0	100	39
S1	28,145	9	34	4,200	26	145	124	0.76	4.3	70	20
S2	37,349	11	35	5,626	22	76	161	0.63	2.2	99	42
S3	24,830	8	33	5,050	30	99	153	0.91	3.0	80	31
Total	517,692	123	564	89,064	423	2,023	158	0.75	3.6	90	30

Table 3-6 SUMMARY OF FAULT RECORD (1985/8--1986/7)

Regions	Frequency (Times)	Duration (Hrs.)	No. of H.V. Feeders	Frequency / Feeder (Times)	Duration / Feeder (Hrs.)	Duration / Frequency (Hrs.)	H.V. cct Length / Feeder (km)	Energy Sales / Feeder (GWh)
NORTHERN								
Region 1	634	1,061	56	11.34	20.73	1.83	136	9.41
Region 2	471	1,061	39	12.08	27.21	2.25	186	11.45
Region 3	360	783	34	13.53	23.03	1.70	195	12.57
NORTHEASTERN								
Region 1	743	1,132	47	15.81	66.64	4.22	252	11.62
Region 2	468	928	36	13.00	35.17	2.71	327	9.66
Region 3	629	911	50	12.58	18.22	1.45	147	12.44
CENTRAL								
Region 1	806	1,132	75	10.75	15.09	1.40	94	22.03
Region 2	602	928	58	10.38	16.00	1.54	105	17.50
Region 3	807	1,021	67	12.04	15.24	1.27	128	21.31
SOUTHERN								
Region 1	704	1,552	34	20.71	45.65	2.20	124	14.13
Region 2	677	1,931	35	19.34	55.17	2.85	161	14.90
Region 3	844	2,035	33	25.58	61.67	2.41	153	16.47
TOTAL	7,846	16,918	564	13.91	30.00	2.16	158	15.17

Table 3-7 INFLUENCE OF SUPPLY INTERRUPTION ON BIG CUSTOMERS

Customer		Maximum Demand (kW)	Annual Consump. (MWh)	Annual Revenue (1,000 Baht)	Interrup. Freguency (Times)	Interrup. Duration (Hrs.)	Interrup. Energy (A) (MWh)	Damage & Loss (B) (1,000 Baht)	(B/A) (Baht/kWh)	Cumulative Interrup. Energy (MWh)	Cumulative Damage & Loss (1,000 Baht)
Thai Otsuka	(C3)	800	1,700	100,000	32	32.00	6.21	1,120	180.35	6.21	1,120
Pun Chaphol Fiber	(C3)	14,000	49,056	1,500,000	24	5.00	28.00	5,000	178.57	34.21	6,120
Thai Bridgestone	(C1)	3,600	13,620	-	8	18.55	28.84	1,500	52.01	63.05	7,620
Thai Kurabo	(C1)	4,240	27,419	500,000	29	17.28	54.09	500	9.24	117.14	8,120
Bangkok Glass	(C1)	4,500	24,500	-	54	22.00	61.53	3,800	61.76	178.67	11,920
Thai Teijin	(C1)	10,260	41,790	-	28	21.47	102.42	2,000	19.53	281.09	13,920
Bangkok Carbide	(C3)	4,500	26,829	-	12	34.00	104.13	1,128	10.83	385.22	15,048
Thai Toray	(C3)	4,020	25,996	575,555	30	38.46	114.13	18,057	158.21	499.35	33,105
Total		45,920	210,910	-	217	188.76	499.35	33,105	66.30	499.35	33,105
Average		5,740	26,364	-	27	23.60	62.42	4,138	66.30	-	-

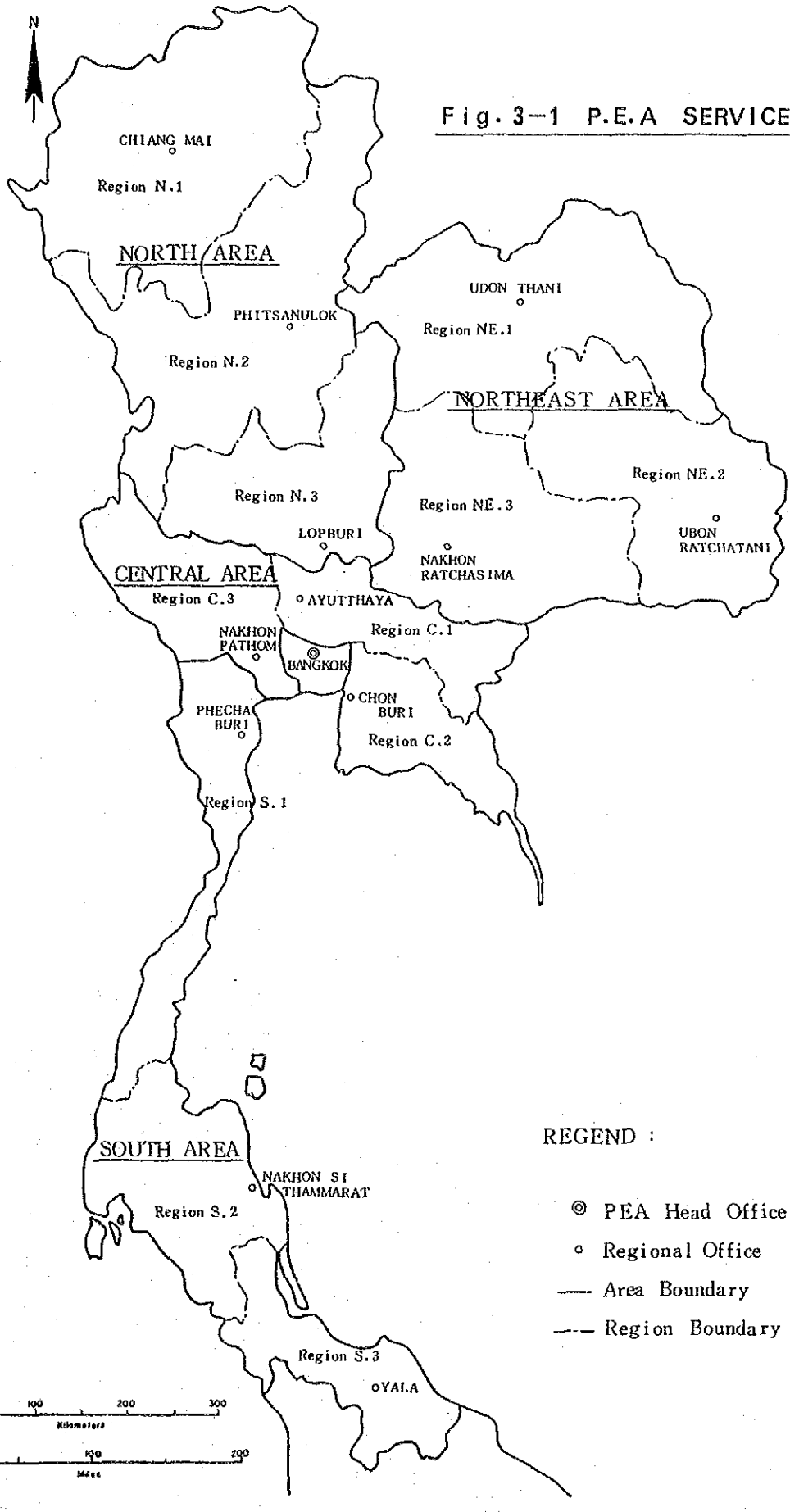


Fig. 3-1 P.E.A SERVICE AREA

Chapter 4

PRESENT STATUS AND PROBLEMS OF DISTRIBUTION DISPATCHING SYSTEM

Chapter 4

PRESENT STATUS AND PROBLEMS OF DISTRIBUTION DISPATCHING SYSTEM

The existing distribution dispatching system of PEA consists of a central dispatching center and 12 regional dispatching centers. The central dispatching center is responsible for overall planning and coordination, while the regional dispatching centers perform the distribution dispatching operations in their service areas, with each center being operated by two operators in three shifts. The facilities under the control of one regional dispatching center include 13 substations and 75 high voltage feeders in the case of Central Region 1 which has the largest scale.

The results of the evaluation of present status and problems of distribution dispatching system are as described in the followings.

(1) The present system, in which the regional dispatching center carry out the dispatching operations in their service areas, is considered appropriate in view of the scale of distribution system.

(2) As the maintenance crews are distributed to the electric offices and customer service centers in each region, there is no problem for the maintenance.

(3) When the circuit breaker at the substation where no control station is installed or the recloser is tripped, it takes a lot of time for the regional dispatching center to collect the fault information and confirm the operation of devices.

(4) As the detection of fault sections and the system operation for the interchange of power to sound sections are carried out manually on commands from the regional dispatching center, a lot of time is also required for the said works.

(5) Because of the problems mentioned in the proceeding items (3) and (4), the supply interruption per fault lasts longer, causing the frequent complaints from customers and the considerable losses to big customers.