CHAPTER 17

ELECTRIC POWER

CHAPTER 17

ELECTRIC POWER

17.1 Introduction

17.1.1 Background

Thailand is a very important country in Southeast Asia. It has a land area of 513 thousand square-km and a population of 61.8 million in 1999. The 1999 annual GDP per capita was about US$ 2,000 (maximum of US$ 2,943 in 1996), From being a developing country, Thailand is poised to become a medium-developed country. However, the economic activities of the country have been concentrated in the Metropolitan Bangkok area, and the four provinces of the Study Area in the northeastern region are far behind the national average in economic development.

17.1.2 Strategies for Power System Development

As of the year 2000, the Eighth National Economic and Social Development Plan (1997-2001) of the Royal Thai Government (RTG) is in progress. The recent financial crisis in Asia including Thailand has had a direct impact on EGAT's operations and its investment plans. Whereas, at the international level, there are more distinctive trends concerning various aspects of a changing electric power utility, such as investment, technology and management, which also caused some impact on EGAT's operations.

A power development program needs to be prepared so as to provide an adequate amount of energy to satisfy demand for various economic activities at reasonable prices, while ensuring quality (maintaining rated voltage and frequency) and security of supply (less frequency and duration of supply interruptions). The reserve capacity of the power generation system needs to be maintained at not less than 25% of the

maximum power demand to ensure supply capability under all actual operating conditions. The increase in power generation capacity shall be attained not only by the development of power plants of EGAT but also by power purchase from IPPs (Independent Power Producer) and SPPs (Small Power Producer) using non-conventional energy or cogeneration system. The large power import from Lao PDR of 313 MW (IPP projects of Theun Hinboun and Houay Ho) was commenced in 1998 and 1999.

In carrying out the power system development, indigenous sources of energy shall be utilized as far as applicable. In Thailand, the available indigenous sources of energy are mainly the offshore natural gas and lignite. Any deficiency in power supply quantity is to be supplemented by import of power energy from neighboring countries, Lao PDR, Myanmar, Yunnan province of PRC, etc.; therefore it is required to speed up negotiations and cooperation to power development with neighboring countries. The power import will also contribute to diversification of energy sources of the country. The interconnection of the transmission system between Thailand and neighboring countries, especially the six countries in the Mekong Basin sub-regional group, shall also be developed and improved to create mutual economic benefit and reliability of the power system.

As the available indigenous sources of energy in Thailand are limited, methods for efficient and economical use of energy shall be sought in every respect. Consumption of energy sources and electric power shall be reduced through energy conservation and DSM activities.

Competitions in power supply activities in various fields covering generation, transmission and distribution, and increasing the role of the private sector need to be promoted. The power purchase from IPPs and SPPs is to be increased.

Environmental problems resulting from energy development and utilization need to be prevented and solved to execute desired targets and to avoid conflicts with the public.

17.2 Power Sector Organization

17.2.1 National Organization

The Electricity Generating Authority of Thailand (EGAT) is responsible for the generation, acquisition, transmission and bulk supply of electric energy to distribution authorities: the Metropolitan Electricity Authority (MEA) for distribution in the metropolitan Bangkok area and Provincial Electricity Authorities (PEA) for the other areas of the country. EGAT is authorized to sell power directly to large consumers, and as well as to perform international power trade with neighboring countries. EGAT

is operated under control of the Office of the Prime Minister, while MEA and PEA are attached to the Ministry of Interior. General flow of electric power among related authorities is shown in Figure 17.1.

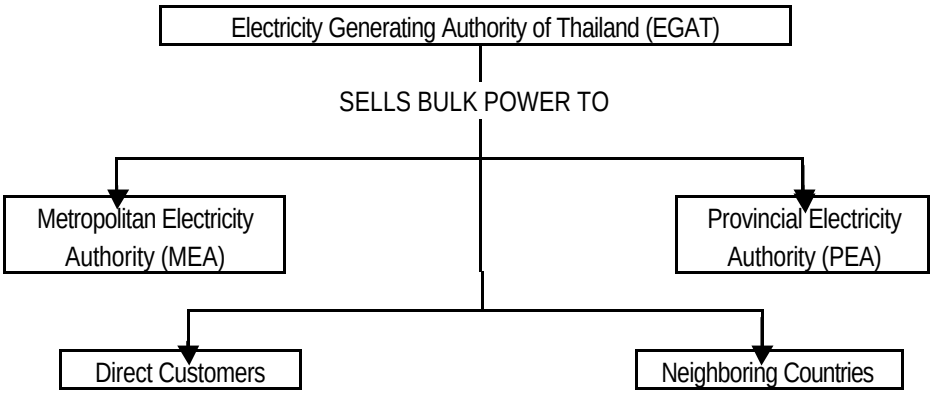

Figure 17.1 Power Utilities in Thailand

EGAT is responsible for the generation and transmission development planning, while MEA and PEA have similar roles for the distribution systems (including 115 kV transmission when required) in their concession areas. EGAT basically carries out long-term development planning for the period of 12-15 years into the future with occasional revision according to the condition of the country's economy and energy demand. Social and environmental impacts shall be reviewed to avoid any trouble with the public.

To achieve its objectives, EGAT is granted to carry out construction of dams, reservoirs, power plants, transmission systems and related facilities as well as to establish regulatory policies on the generation, transmission and distribution of electric energy. EGAT is also allowed to undertake other businesses related to electric energy and other businesses concerning or for continuity of the operation of EGAT. The organizational chart of EGAT is shown in Figure 17.2.

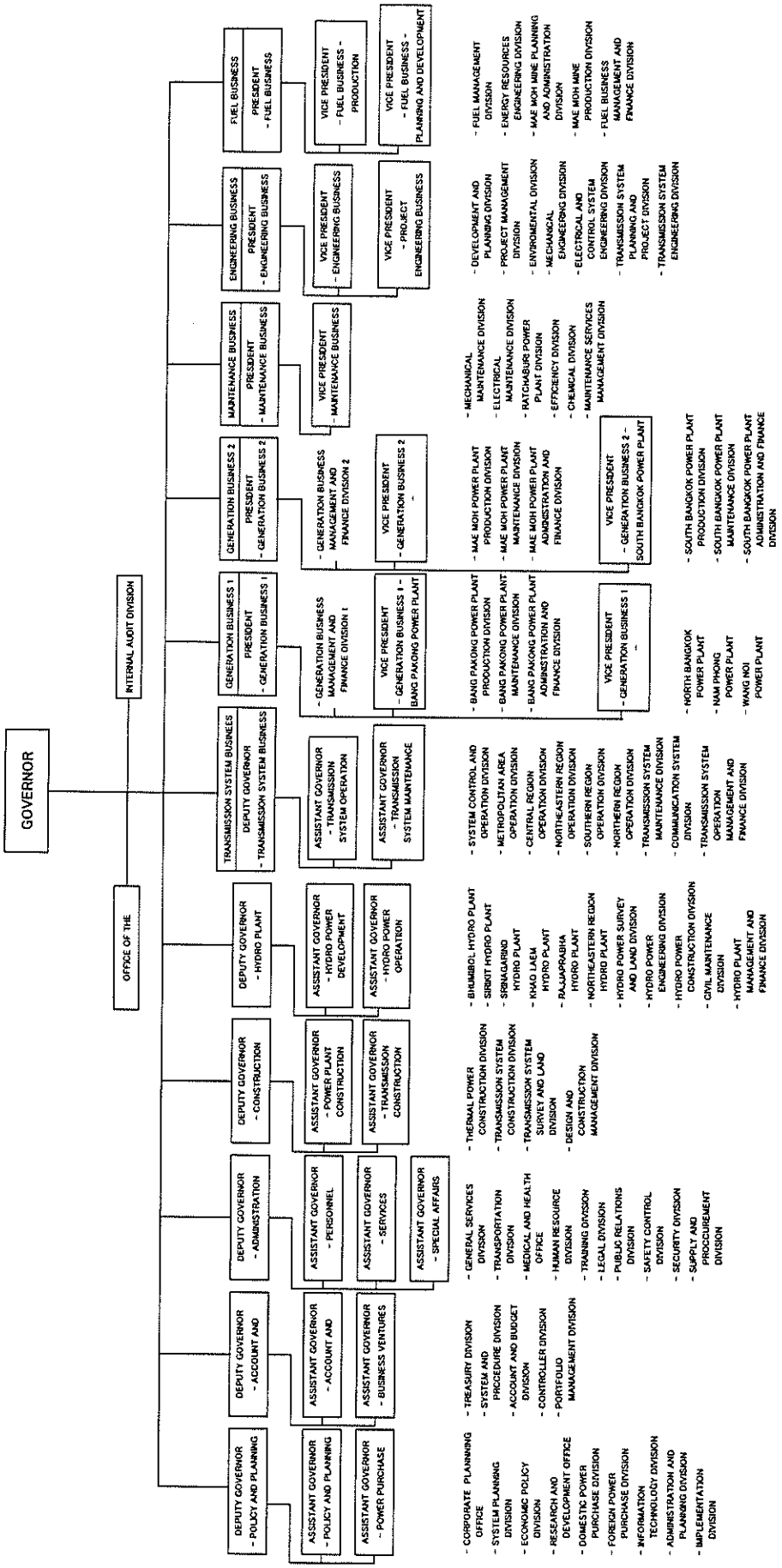

Figure 17.2 Organization of EGAT

The preparation of policies on the energy planning, management and utilization at the national level is under the responsibility of the National Energy Policy Council (NEPC) appointed by RTG. There are a number of other government organizations involved in the energy management of the country; they are the National Economic and Social Development Board (NESDB), the Office of the Environment Policy and Planning (OEPP), the National Energy Policy Office (NEPO), the Ministry of Finance, the Bureau of Budget and other ministries. These organizations are to direct the respective power utilities.

17.2.2 Local Power Supply Organizations

(1) EGAT

EGAT has a regional office in each of the five areas and regions as mentioned below:

Metropolitan Area: Greater Bangkok including Nonthaburi and Samut Prakan provinces.

- Central Region (Region 1): 22 provinces in the Central area.
- Northeastern Region (Region 2): 19 provinces in the Northeast.
- Southern Region (Region 3): 14 provinces in the South.
- Northern Region (Region 4): 18 provinces in the North and upper part of the Central area.

Each office looks after the operation and maintenance of the transmission system and medium to small power stations including regional load dispatching in the region. Transmission system planning is the responsibility of the head office. The regional office of Northeastern (N-E) Region for Northeastern Thailand is located in Khon Kaen. The four provinces in the Study Area, Mukdahan, Nakhon Phanom, Sakon Nakhon and Kalasin, are in N-E Region (Region 2).

(2) PEA and MEA

The power distribution activities in all the provinces, which include secondary transmission and local power generation, are under control of PEA, which has its head office in Bangkok. For the Bangkok municipality area, similar activities are undertaken by MEA.

PEA grouped its service area into four regions (Central, Northeastern, Northern and Southern), just the same as that of EGAT. In the N-E Region area, there are 3

Administration Area offices: Area NE.1 at Udon Thani, Area NE.2 at Ubon Ratchathani and Area NE.3 at Nakhon Ratchasima. Of the four provinces in the Study Area, Nakhon Phanom and Sakon Nakhon belong to Area NE.1 and Mukdahan and Kalasin, to NE.2.

PEA purchases electric energy from EGAT on bulk supply basis and retails it to consumers, and is in charge of planning, designing, constructing and maintaining distribution facilities in its concession area. The 115 kV branch extension from the main system of EGAT is also to be undertaken by PEA.

The overall management of distribution system in the area is the responsibility of PEA's Area Offices (NE.1 and NE.2 offices for the 4 provinces), while the operation and maintenance and construction of distribution facilities is taken care of by the Provincial Branch Offices, one office in each province.

17.2.3 "Corporatization" and Privatization

RTG has initiated a deregulation and privatization policy to enhance competition, to improve operational efficiency of the entities so as to improve the quality of public services and to reduce the investment expenditure and debt burden of the government. Under this policy the electric power supply industries are going to be separated into three categories of generation, transmission (probably including power dispatching) and distribution businesses. This plan is under review and will be realized step by step.

RTG intends to achieve structural reform of power utilities toward "corporatization" and privatization step by step. The concept of a more business-like approach has been adopted by giving more autonomy to each utility in managing its operations. After reform, the operation of power utilities will be performed in a business-oriented manner.

17.2.4 Participation of Private Sector in Power Development, etc.

The power system of Thailand has become quite large (total installed capacity is 18,951.2 MW as of April 2000), and the government alone is not possible to support all the enormous investment necessary for power system development. RTG has a policy to promote private sector participation to the power generation industry and to endeavor to supplement deficiency in development fund by utilizing private funds. Thus, the construction and O&M activities will be executed in more efficient ways by IPPs and SPPs.

In addition to the generation development activities, there are also cases to transfer completed power plants to private parties for management of plants including operation and maintenance. In this case, EGAT sells completed power plants, which are under operation or newly constructed, to private parties at reasonable prices, and after the transfer buys the generated energy from these private enterprises. At present Electricity Generating Public Company Limited (EGCO), a subsidiary company of EGAT, is the largest company undertaking this business.

17.3 Power Tariff System

RTG takes charge of deciding the electricity tariffs. The tariff structure must be approved by NEPC and the Cabinet, who base their decision on the supporting information provided by the Working Group consisting of representatives from various organizations including EGAT.

The energy development strategies envisage the establishment of a tariff system reflecting actual costs. In the Thai power system there are two categories of power rates: one is applied to the bulk supply from EGAT to MEA and PEA and the other is retail sale from the power distribution authorities to consumers.

(1) Bulk Supply Tariffs

The monthly electricity rates are set for five classes of receiving voltage, 230-115-69-33-22 kV, and the rates are higher for the lower voltage. The 22-kV rate for peak time is about 16% higher than the 230-kV rate. Power bills are charged on the received energy only and no capacity charges are applied. The bulk supply electricity tariffs to MEA and PEA effective from 1 March 2000 are presented in Table 17.1.

Table 17.1 Bulk Supply Electricity Tariffs to MEA and PEA

(Effective Date : 1 March 2000) Unit: Baht/kWh

1. Monthly Electricity Rates			
Voltage Level (kV)	Monday - Saturday		Sunday 09:00-24:00 Hr.
	09:00-22:00 Hr.	22:00-09:00 Hr.	
230	1.5349	0.6671	0.6062
115	1.5697	0.6697	0.6088
69	1.6292	0.6769	0.6153
33	1.7720	0.6857	0.6232
22	1.7751	0.6864	0.6238
2. Monthly Surcharge / Discount Payments			
Surcharge for MEA		0.2277 Baht/kWh	
Discount for PEA		0.1005 Baht/kWh	

Note: 1. Should there be any change in expenses beyond control by utility such as the fluctuations of fuel costs, etc., adjustments will be made to increase or decrease the electricity charge in the electricity bills.

The bulk supply rates are based on the figures, the retail consumer power tariffs (uniform throughout the country) minus actual distribution costs, which are lower for large or concentrated systems. For the MEA rates a certain surcharge (14%-15%) is added on the average costs and some discount (around 6%) is applied to the PEA rates. This means cross subsidy from MEA to PEA to attain the uniform consumer tariffs.

Sixty-one percent (61%) of energy was sold to PEA and 37%, to MEA in 1999, and the average bulk supply rate in 1999 was 1.59 baht/kWh, while the remaining 2% of energy was sold to direct consumers and Lao PDR, etc. Value-added tax has been excluded from the bulk supply tariff.

The operation of EGAT is based on financial balance with the power sales income, and a certain amount of profit is transferred yearly to the national budget.

(2) Tariffs for Retail Sales to Consumers

One uniform tariff system is applied to the whole country regardless of difference in actual cost of delivery: low in large systems and high in small systems. The tariff system is established with seven schedules for Residential (sub-divided to Small and Large), Small General Service, Medium General Service, Large General Service, Specific Business, Government Institutions and Non-Profit Organizations, and Agricultural Pumping Service as shown in Table 17.2. Specific features of the present tariff system are mentioned below:

Table 17.2 Electricity Tariffs Schedule of Thailand

(Effective Date: 1 January 1997)

Schedule 1: Residential

1.1 Small (≤ 150 kWh/month)	Baht/kWh	**1.2 Large (> 150 kWh/month)**	Baht/kWh
First 5 kWh	4.96 (Baht)	First 35 kWh	82.51 (Baht)
Next 10 kWh (6th - 15th)	0.7124	Next 115 kWh (36th - 150th)	1.1236
Next 10 kWh (16th - 25th)	0.8993	Next 250 kWh (151st - 400th)	2.1329
Next 10 kWh (26th - 35th)	1.1516	Over 400 kWh (401st - up)	2.4226
Next 65 kWh (36th - 100th)	1.5348		
Next 50 kWh (101st - 150th)	1.6282		
Next 250 kWh (151st - 400th)	2.1329		
Over 400 kWh (401st - up)	2.4226		
Minimum charge: Baht 4.67		Minimum charge: Baht 83.18	

Schedule 2: Small General Service (Demand < 30 kW)

kWh/month	Baht/kWh
First 35 kWh	89.39 (Baht)
Next 115 kWh (36th - 150th)	1.1236
Next 250 kWh (151st - 400th)	2.1329
Over 400 kWh (401st - up)	2.4226

Minimum charge: Baht 87.85

Schedule 3: Medium General Service (Demand 30-1,999 kW and 355,000 kWh/month)

3.1 Normal Rate	Demand Charge (Baht/kW)	Energy Charge (Baht/kWh)
3.1.1 69 kV and above	175.50	1.0208
3.1.2 12-33 kV	196.26	1.0582
3.1.3 Below 12 kV	221.50	1.0862

3.2 Time of Use (TOU) Rate (> 250,000 kWh/month)	Demand Charge (Baht/kW) Monday-Saturday 09:00-22:00 hr	Energy Charge (Baht/kWh)			Service Charge (Baht)
		Monday-Saturday		Sunday	
		09:00-22:00 hr	22:00-09:00 hr	00:00-24:00 hr	
3.2.1 115 kV and above	102.80	1.5349	0.6671	0.6062	400
3.2.2 69 kV	158.88	1.6292	0.6769	0.6153	400
3.2.3 12-33 kV	200.93	1.7736	0.6861	0.6236	850
3.2.4 Below 12kV	214.95	1.8891	0.7283	0.6616	850

Minimum Charge: The minimum charge will be computed as 70% of the total amount of maximum demand charge of the last 12 month period ending with the current month.

Schedule 4: Large General Service (Demand ≥ 2,000 kW or Energy > 355,000 kWh/month)

4.2 Time of Day (TOD) Rate	Demand Charge (Baht/kW)			Energy Charge (Baht/kWh)
	18:30-21:30 hr	08:00-18:30 hr *	21:30-8:00 hr	
4.1.1 69 kV and above	224.30	29.91	0	1.0208
4.2.3 12-33 kV	285.05	58.88	0	1.0582
4.2.4 Below 12kV	332.71	68.22	0	1.0862

***** For excess demand from18:30-21:30 hr. period only.

4.2 Time of Use (TOU) Rate	Demand Charge (Baht/kW) Monday-Saturday 09:00-22:00 hr	Energy Charge (Baht/kWh)			Service Charge (Baht)
		Monday-Saturday		Sunday	
		09:00-22:00 hr	22:00-09:00 hr	09:00-24:00 hr	
4.2.1 115 kV and above	102.80	1.5349	0.6671	0.6062	400
4.2.2 69 kV	158.88	1.6292	0.6769	0.6153	400
4.2.3 12-33 kV	200.93	1.7736	0.6861	0.6236	850
4.2.4 Below 12kV	214.95	1.8891	0.7283	0.6616	850

Minimum Charge: The minimum charge will be computed as 70% of the total amount of maximum demand charge of the last 12 month period ending with the current month.

Schedule 5: Specific Business (Demand ≥ 30 kW)

5.1 Normal Rate	Demand Charge (Baht/kW)	Energy Charge (Baht/kWh)
5.1.1 69 kV and above	220.56	1.0208
5.1.2 12-33 kV	256.07	1.0582
5.1.3 Below 12 kV	276.64	1.0862

The optional rate for energy consumption of more than 250,000 kWh/month and since October 1997 the consumption of more than 355,000 kWh/month will be classified under Schedule 5.2.

5.2 Time of Use (TOU) Rate (> 250,000 kWh/month)	Demand Charge (Baht/kW) Monday-Saturday 09:00-22:00 hr	Energy Charge (Baht/kWh)			Service Charge (Baht)
		Monday-Saturday		Sunday	
		09:00-22:00 hr	22:00-09:00 hr	00:00-24:00 hr	
5.2.1 115 kV and above	102.80	1.5349	0.6671	0.6062	400
5.2.2 69 kV	158.88	1.6292	0.6769	0.6153	400
5.2.3 12-33 kV	200.93	1.7736	0.6861	0.6236	850
5.2.4 Below 12kV	214.95	1.8891	0.7283	0.6616	850

Minimum Charge: The minimum charge will be computed as 70% of the total amount of maximum demand charge of the last 12 month period ending with the current month.

Schedule 6: Government Institutions and Non-Profit Organizations

(For energy consumption of < 250,000 kWh/month, the Government Institution Consumption of ≥ 250,000 kWh/month will be reclassified in Sub-clause 3.2 or 4.2 depending on the case since October 1997)

KWh/month	< 12 kV	12 - 33 kV	≥ 69 kV
First 10 kWh Over 10 kWh (11st - up)	18.06 (Baht) 1.8058 (B/kWh)		
First 10 kWh Over 10 kWh (11st - up)		480.06 (Baht) 1.6002 (B/kWh)	
First 10 kWh Over 10 kWh (11st - up)			14,413.31 (Baht) 1.4413 (B/kWh)
Minimum Charge:	17.48 (Baht)	462.62 (Baht)	13,831.78 (Baht)

Schedule 7: Agricultural Pumping Service

First 100 kWh Over 100 kWh (101st - up)	115.16 1.1516	Baht Baht/kWh

Minimum Charge: Baht 109.35

Note: 1. Should there be any change in expenses beyond control by the utility such as the fluctuations of fuel costs, etc., adjustments will be made to increase or decrease the electricity charge in the electricity bills.
2. The Value Added Tax should be added.
3. The TOU rate is an optional rate for customer before 1 October, 1997 and will be applied new customers beyond 1 October, 1997. Once a customer is reclassified into the TOU rate, the customer cannot be rescheduled to Normal rate again.

- Tariff levels are generally low for the small residential loads (1/3 of the average for the smallest category) and agricultural loads (little over half of the average), which represents cross subsidy.
- Only energy charge is applied to small consumers, and both demand and energy charges to large consumers.
- The time-of-day-differential system to charge high energy rates during the peak time (9:00-22:00 of weekday) and low rates for the off-peak time (22:00-9:00 of weekday and Sunday) is applied to large consumers.
- Tariffs to large consumers are lower for those receiving a higher voltage and higher for those receiving a lower voltage, reflecting actual cost of services.
- Special arrangement involving tariff adjustment based on power factor is not found in the tariff system. However, the installation of static capacitors is requested for large consumers.

The present tariff system has been effective for a relatively long time, since 1 January 1997. Should there be any change in expenses beyond control by the utility such as fluctuation of fuel costs, etc., adjustment will be made to increase and decrease the electricity charge in electricity bills. The Value Added Tax should be added to the bills.

The overall average power tariff in 1999 was 2.1143 baht/kWh for the country (5.62 USc/kWh), 2.0418 for PEA and 2.2403 for MEA.

17.4 Historical Power Demand and Load Forecast

Power demand data of Thailand are prepared for fiscal years (FY), starting from October of the previous year and ending in September. FY 1999 started from October 1998 and ended in September 1999.

17.4.1 Historical Power Demand

The historical record of electricity generation and consumption for the period of 1987 to 1999 is shown in Table 17.3, and electricity losses in generation, transmission and distribution systems are presented in Table 17.4.

Table 17.3 Historical Record of Electricity Generation and Consumption

Fiscal Year	Generation				Consmption		GDP Growth Rate	Electrification Ratio 2/	Number of Consumers
	Peak Demand (MW)	Growth Rate (%)	Energy (GWh)	Growth Rate (%)	Energy (GWh)	Growth Rate (%)	(% p.a.)	(%)	
1987	4,733.9	13.23	28,193.16	13.78	24,235.33	15.10	9.5	63.51	6,121,371
1988	5,444.0	15.00	31,996.94	13.49	27,564.93	13.74	13.3	67.18	6,668,078
1989	6,232.7	14.49	36,457.09	13.94	31,514.19	14.33	12.2	68.67	7,258,174
1990	7,093.7	13.81	43,188.78	18.46	37,084.54	17.68	11.2	73.61	7,859,316
1991	8,045.0	13.41	49,225.03	13.98	42,308.64	14.09	8.6	73.16	8,459,316
1992	8,876.9	10.34	56,006.44	13.78	48,199.56	13.92	8.1	75.14	9,043,842
1993	9,730.0	9.61	62,179.73	11.02	54,661.06	13.41	8.4	73.71	9,651,511
1994	10,708.8	10.06	69,651.14	12.02	60,692.36	11.03	8.9	74.29	10,159,850
1995	12,267.9	14.56	78,880.37	13.25	69,354.66	14.27	8.8	74.89	10,853,680
1996	13,310.9	8.50	85,924.66	8.93	75,920.98	9.47	5.5	76.20	11,462,175
1997	14,506.3	8.98	92,724.66	7.91	81,548.62	7.41	-0.4	80.00	12,144,282
1998	14,179.9	-2.25	92,134.44	-0.64	80,775.58	-0.95	-10.0	80.32	12,628,532
1999	13,712.4	-3.30	90,413.99	-1.87	79,848.28	-1.15	1/ 3.5	82.00	12,996,922
Average Growth Rate(%) 1887-1999		9.27		10.20		10.45			

Note: 1/: Preliminary data, 2/: Population electrified as a percentage of total population

Source: EGAT Power Development Plan, PDP 99-02

Table 17.4 Historical Record of Generation, Transmission and Distribution Losses

Fiscal Year	Energy Generated	Pumping Energy for Pumped Storage plant		Energy Losses							
				Generation Losses *1		Transmission and Substation Losses *2		Distribution Losses (MEA and PEA) *3		Total Losses (EGAT, MEA and PEA)	
	(GWh)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)	(GWh)	(%)
1987	28,193.16	35.71	0.13	1,186.58	4.21	1,142.63	4.05	1,592.91	5.65	3,922.12	13.91
1988	31,996.94	140.62	0.44	1,296.81	4.05	1,065.96	3.33	1,928.62	6.03	4,291.39	13.41
1989	36,457.09	131.37	0.36	1,430.90	3.92	1,283.61	3.52	2,097.02	5.75	4,811.53	13.20
1990	43,188.79	434.74	1.01	1,736.59	4.02	1,648.67	3.82	2,284.25	5.29	5,669.51	13.13
1991	49,225.03	528.14	1.07	1,898.67	3.86	2,036.18	4.14	2,453.09	4.98	6,388.25	12.98
1992	56,006.44	397.48	0.71	2,270.24	4.05	2,567.35	4.58	2,571.81	4.59	7,409.40	13.23
1993	62,179.73	435.43	0.70	2,523.65	4.06	2,662.42	4.28	1,897.17	3.05	7,083.24	11.39
1994	69,651.14	772.90	1.11	2,650.36	3.81	2,584.53	3.71	2,950.99	4.24	8,185.88	11.75
1995	78,880.37	822.98	1.04	2,778.41	3.52	2,499.39	3.17	3,424.93	4.34	8,702.73	11.03
1996	85,924.13	734.87	0.86	3,003.12	3.50	2,735.18	3.18	3,529.98	4.11	9,268.28	10.79
1997	92,724.66	616.24	0.66	3,297.92	3.56	2,911.93	3.14	4,349.95	4.69	10,559.80	11.39
1998	92,134.44	620.84	0.67	3,462.64	3.76	2,453.36	2.66	4,822.02	5.23	10,738.02	11.65
1999	90,413.99	264.65	0.29	3,325.42	3.68	2,311.91	2.56	4,663.73	5.16	10,301.06	11.39

Note: *1: Including mining, construction uses and cooling towers.

*2: Including street lights in 1987

*3: Including MEA and PEA sub-transmission losses

The growth of power consumption is graphically shown in Figure 17.3.

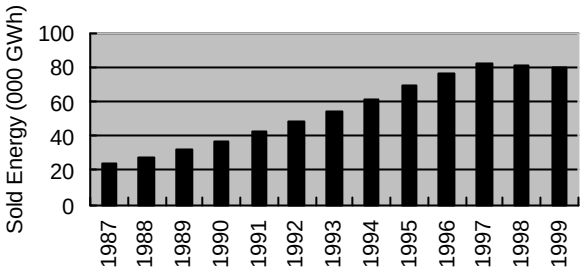

Figure 17.3 Record of Energy Sales

The past largest peak demand of the country was recorded on 5 April 2000, registering 14,918.3 MW, which was lower than the projected 15,254 MW in the latest TLFS forecast based on the Moderate Economic Recovery scenario.

According to Table 17.3, the growth of power demand was very high up to 1995, the 8-year average rate being 14%, reflecting the high economic growth in this period. The rate went down to less than 10% in 1996 and 1997, and after 1997 the growth was further stagnated due to the recent economic recession. The minus growth (around 1% per annum), not experienced in decades, was experienced in 1998 and 1999. Such decrease was recorded mainly in the Bangkok area and the influence to the northeastern demand was less; minor decrease was recorded only in 1999. But the economy picked up toward the end of 1999, and the peak demand of 2000 corresponds to increase of 8.8% over that of 1999.

Electricity loss in Thailand (the sum of EGAT, MEA and PEA) posted continually decreasing rates up to 1995, and after 1995 the loss factor has remained at almost the same level. In 1999, the total loss factor including generation loss was 11.39% and T&D loss factor was 7.72%. The loss factor of N-E Region was calculated at 6.32%. A significant decrease from this loss factor will be very difficult.

The major parameters of the power demand of the country, N-E Region and the four provinces in the Study Area are shown in Table (Table 17.5) below:

Table 17.5 Major Parameters of the Power Demand in 1999

No	Item	Country	N-E Region	4 Provinces
1	Population (million)	61.8	21.4	3.13
2	GDP per capita *1 (US$)	2004	699	605
3	Installed capacity, (MW)	18,951	1,266	6
4	Peak power, (MW)	13,712	1,602	162 *2
5	Annual energy requirement, (GWh)	90,414	8,019	788
6	Annual consumption, (GWh)	79,848	7,512	728
7	Average growth rate of consumption for recent 10 years, (%)	9.74	11.18	11.27
8	Per-capita consumption *2, (kWh)	1,292	351	233
9	Annual load factor, (%)	75.3	52.2	----
10	T&D loss factor, (%)	7.72	6.32	7.61 *3

Source: EGAT and PEA

Note: *1: 1998 data.

*2: Sum of non-coincidental substation loads. Actual peak was not recorded.

*3: PEA portion only. Rough estimation; substation supply areas do not always coincide with provincial boundaries.

With regard to total consumption in 1999, the Central Region comprising metropolitan Bangkok accounted for 75.2% of the total for the country and N-E Region consumed only 9.4%, while the consumption of the four provinces in the Study Area was 9.7% of the region's total (less than 1% that of the country). The per capita energy consumption of N-E Region and the four provinces, at 27% and 18% respectively, was considerably lower than the national average. Economic activities of the four provinces are predominantly agricultural and there are no power-consuming heavy industries, and this seems to explain the low power consumption.

For the country the industrial sector consumed the largest share of 50.7% in 1999. The consumption was 22.6% in the residential sector, 21.9% in the commercial sector and the remaining 4.8% in other consumer groups. While in the N-E Region the residential sector recorded the largest share of 43.9% in 1999. The category-wise power sales data of the country, N-E region and the four provinces are shown in Table 17.6.

In addition to the sales in the country, EGAT and PEA is exporting power to the neighboring countries, Lao PDR, Cambodia and Myanmar. The major export is the power supply to Lao PDR with peak demand of around 30 MW by EGAT, which corresponds to only 0.2% of the peak demand of the country. The EGAT's export to Lao PDR is made from the N-E region and the export from Mukdahan and Nakhon Phanom with a 1999 peak of 25.5 MW occupies the largest portion. Other export by PEA to Lao PDR, Myanmar and Cambodia is of minor scale.

The annual peak demand is usually recorded in April or May, the hottest month of the year, due to the increase in air-conditioning demand.

Table 17.6 Category-wise Energy Consumption in Recent Years

Fiscal Year: 1997

Area	Residential		Small General	Medium General	Large General	Specific Business	Gov. & Nonprofit	Agriculture Pumping	Temporary	Standby Rate	Total
	< 150	> 150									
Country	17,129.3		8,764.6	18,943.5	29,407.6	2,577.1	4726.58 *				76,822.0
N-E Region	1,743.2	892.1	829.2	1,143.3	802.7	139.2	549.0	41.7	102.5	1.4	6,244.3
Mukdahan	24.3	16.5	12.0	11.3		4.4	8.3	0.9	0.6		78.2
Nakon Phanom	53.3	21.4	21.6	9.4	1.3	2.1	15.0	1.2	1.7		127.0
Sakon Nakon	82.4	34.4	33.7	20.7		2.2	26.0	2.7	2.3		204.3
Kalasin	82.3	25.6	29.0	26.3	68.0	3.1	15.7	1.8	2.1		253.9

Fiscal Year: 1998

Area	Residential		Small General	Medium General	Large General	Specific Business	Gov. & Nonprofit	Agriculture Pumping	Temporary	Standby Rate	Total
	< 150	> 150									
Country	18,865.0		8,633.9	16,516.5	29,910.3	2,664.0	4185.78 *				76,589.8
N-E Region	1,944.9	1,039.8	870.4	1,028.6	1,022.8	133.1	470.7	68.8	77.3	1.4	6,657.7
Mukdahan	26.5	18.3	12.6	10.9		4.0	8.7	1.7	0.5		83.2
Nakon Phanom	60.4	25.0	23.1	10.4	2.0	1.9	14.8	3.4	1.4		142.4
Sakon Nakon	91.7	40.2	35.0	28.6		2.4	26.0	4.2	1.9		230.0
Kalasin	93.1	30.4	32.4	27.8	62.8	2.9	16.8	2.9	3.5		272.5

Fiscal Year: 1999

Area	Residential		Small General	Medium General	Large General	Specific Business	Gov. & Nonprofit	Agriculture Pumping	Temporary	Stanby Rate	Total
	< 150	> 150									
Country	18,093.6		8,329.9	16,267.9	30,735.5	2,612.6	3,177.1	185.5	246.3	199.9	79,848.3
N-E Region	1,917.9	970.0	837.2	1,020.8	1,083.3	131.3	473.3	72.6	62.6	2.2	6,571.2
Mukdahan	26.6	17.1	12.2	10.4		3.9	8.9	1.4	0.9		81.4
Nakon Phanom	60.1	24.4	22.7	9.5	2.9	2.8	15.3	3.2	1.3		142.1
Sakon Nakon	92.7	39.3	33.6	20.1		2.9	26.8	3.4	2.0		220.8
Kalasin	91.6	28.9	31.7	26.7	69.6	2.8	17.2	3.5	2.2		274.1

*Included in category, “Others” up to 1998.

Source: EGAT and PEA

The daily consumption pattern of Thailand changed from evening peak to day-time peak in 1994 as shown in Figure 17.4, reflecting the progress in economic activities of the country. However, the difference between day peak and evening peak is not much and this makes the equivalent peak time long. In the power tariff system the daily peak time is taken as 9:00 in the morning to 22:00 at night. While the daily load pattern of N-E Region is shown in Figure 17.5. A typical evening peak pattern, with daily peak at 19:00 to 20:00, is observed.

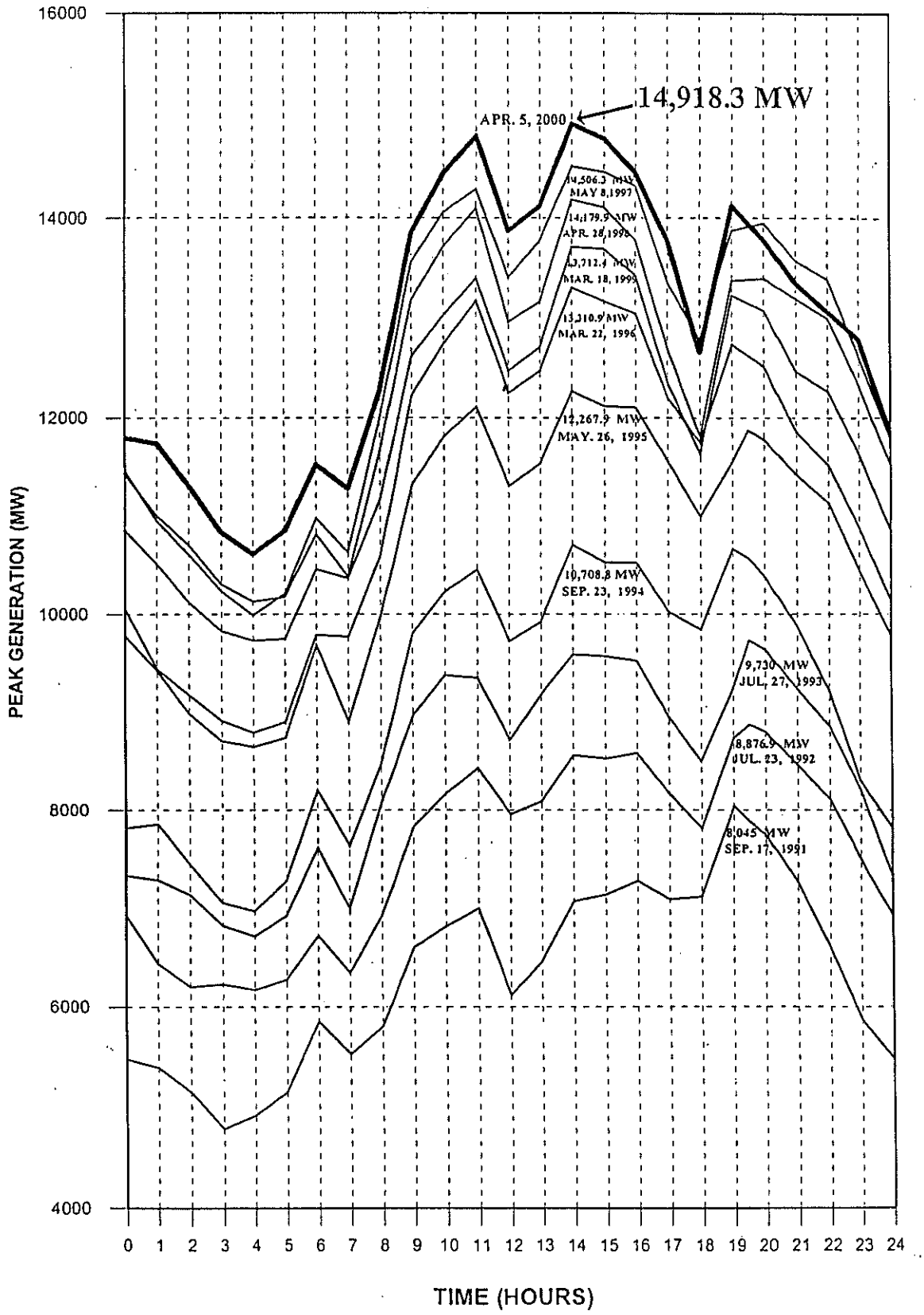

Figure 17.4 Daily Load Curve on Peak Days of EGAT System

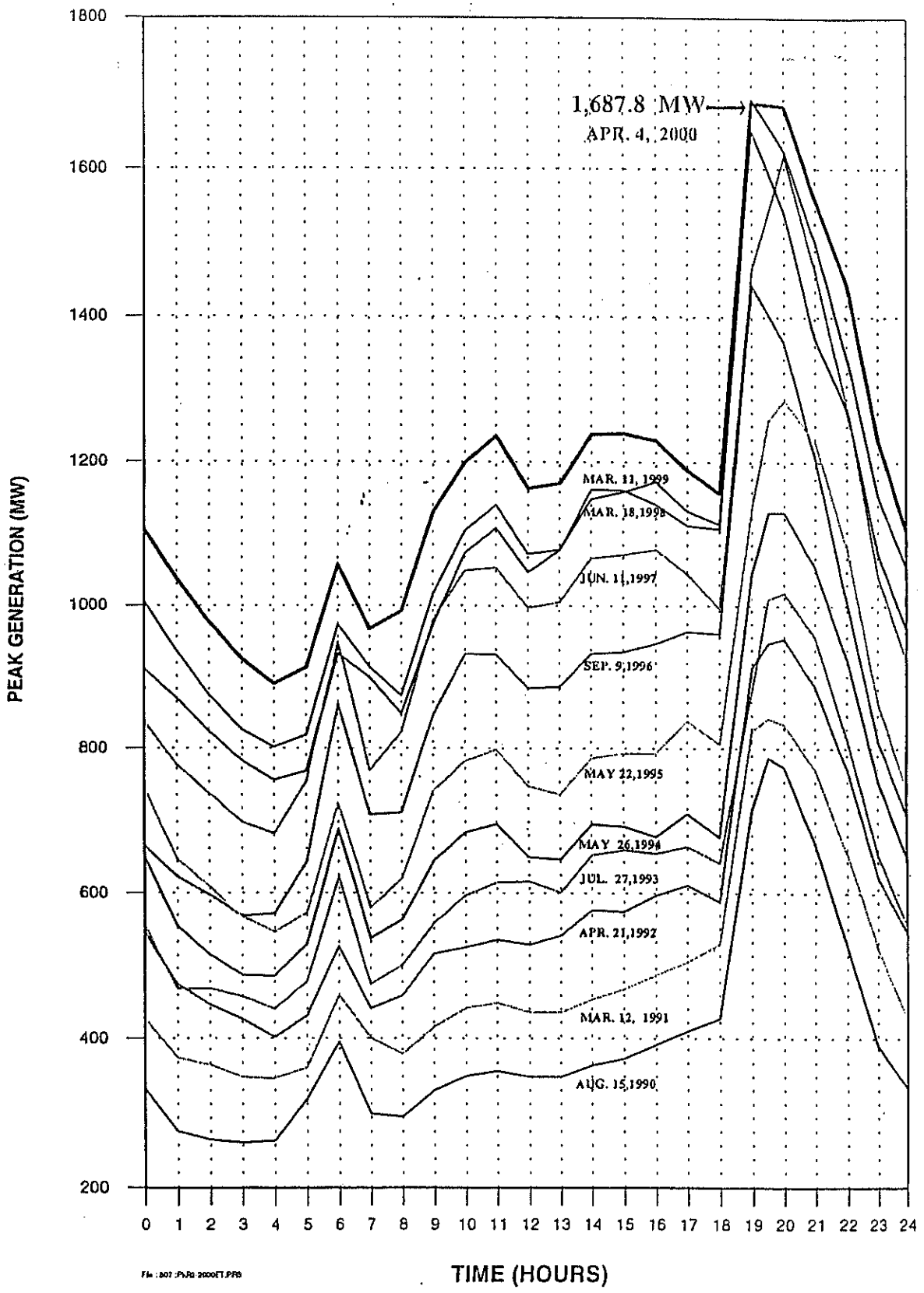

Figure 17.5 Daily Load Curves on Peak Days of Northeastern Region

The power system of Thailand has made remarkable system reinforcement and improvement in quality and reliability of supply in recent years, and is entering a status of medium-developed country.

The electrification of rural villages has progressed much in recent years and the effort for village electrification has almost been completed as seen in Table 17.7 below:

Table 17.7 List of Electrification Rates

Unit: %

	All PEA	N-E Region	Mukdahan	Nakhon Phanom	Sakon Nakhon	Kalasin
Village	99.0	99.9	100	100	100	100
Household	95.8	97.0	94.0	98.4	96.6	98.0

Source: PEA

With the progress of the recent Rural Household Electrification Project, 2nd stage, the village electrification of N-E Region is completed except for several villages in national forests, and all villages in the four provinces are supplied. While the household electrification ratio is 97%. This rate will never reach 100%. There are remotely separated houses, and some time is required from completion of houses till its connection to the power grid. Connection charge is considerable for poor people.

17.4.2 Load Forecast

(1) Official Long-Term Forecast

As well as the Thai economy the Thai power system seems to have graduated from one of a developing country into that of a medium-developed country. EGAT can arrange fund necessary for implementation of projects and complete their construction as scheduled. In case that an unexpected situation like the recent economic recession happens and all ongoing projects are completed as scheduled, the result would be excessive capability of the system. Therefore, a demand forecast needs to be accurately prepared so as to avoid a wide gap from the actual demand.

The recent long-term load forecast of the Thai power system for the period up to the year 2011 was issued in September 1998 by a working group known as the Thailand Load Forecast Subcommittee (TLFS), which was formed by the National Energy Policy Formulation Committee. In spite of the recent changes in economic situation, TLFS judged that the 1998 forecast is still applicable to future development planning and decided not to issue any new projection in the mean time. The recent power development plan, PDP 99-02, was prepared based on the 1998 TLFS forecast.

In this forecast the future demand was forecasted based on three possibilities of economic recovery: Rapid Economic Recovery (RER), Moderate Economic Recovery (MER) and Low Economic Recovery (LER), for the period of up to the year 2011. This forecast is available on the national level (refer to Table 17.8 for peak load and Table 17.9 for energy requirement) and for the peak demand and energy requirement based on MER of N-E Region (refer to Table 17.10). The averages of growth rates of power consumption for the period of 1999 to 2011 based on MER are 6.70% for the country and 7.09% for N-E Region. Comparing the figures in Tables 17.8 and 17.9, the recent forecast demand is much lower than the very low case forecast for the year 1997.

Power development plans of EGAT and PEA are prepared for demand based on MER, and sensitivity of the plans is checked referring to the cases based on RER and LER.

It is considered that the 1998 TLFS forecast is in a reasonable range according to past examples of similar countries.

Table 17.8 Comparison of Load Forecast of the Country (1), Peak Demand

Fiscal Year	Very Low Case Sept. 1997	Load Forecast								
		Moderate Recovery Case			Relatively Rapid Recovery Case			Low Recovery Case		
	(MW)	(MW)	Difference	(%)	(MW)	Difference	(%)	(MW)	Difference	(%)
1999	15,989	14,499	-1,490	-9.32	14,972	-1,017	-6.36	14,287	-1,702	-10.64
2000	17,481	15,254	-2,227	-12.74	16,037	-1,444	-8.26	14,762	-2,719	-15.55
2001	19,049	16,214	-2,835	-14.88	17,286	-1,763	-9.26	15,398	-3,651	-19.17
2002	20,566	17,308	-3,258	-15.84	18,678	-1,888	-9.18	16,150	-4,416	-21.47
2003	22,093	18,399	-3,694	-16.72	20,042	-2,051	-9.28	16,892	-5,201	-23.54
2004	23,685	19,611	-4,074	-17.20	21,597	-2,088	-8.82	17,746	-5,939	-25.07
2005	25,347	20,818	-4,529	-17.87	23,223	-2,124	-8.38	18,588	-6,759	-26.67
2006	27,076	22,168	-4,908	-18.13	24,958	-2,118	-7.82	19,467	-7,609	-28.10
2007	28,918	23,728	-5,190	-17.95	26,950	-1,968	-6.81	20,575	-8,343	-28.85
2008	30,834	25,450	-5,384	-17.46	29,021	-1,813	-5.88	21,861	-8,973	-29.10
2009	32,809	27,232	-5,577	-17.00	31,090	-1,719	-5.24	23,286	-9,523	-29.03
2010	34,883	28,912	-5,971	-17.12	33,132	-1,751	-5.02	24,671	-10,212	-29.28
2011	37,047	30,587	-6,460	-17.44	35,216	-1,831	-4.94	25,951	-11,096	-29.95
Average Growth Rate (%)										
1997-2001	7.43	4.02	-3.41		5.37	-2.07		2.96	-4.47	
2001-2006	7.29	6.46	-0.83		7.62	0.34		4.80	-2.48	
2007-2011	6.47	6.65	0.18		7.13	0.66		5.92	-0.55	

Note: Prepared by Thailand Load Forecast Subcommittee in September 1999.

Table 17.9 Comparison of Load Forecast of the Country (2), Energy Requirement

Note: Prepared by Thailand Load Forecast Subcommittee in September 1999.

Fiscal Year	Very Low Case Sept. 1997	Load Forecast								
		Moderate Recovery Case			Relatively Rapid Recovery Case			Low Recovery Case		
	(MW)	(MW)	Difference	(%)	(MW)	Difference	(%)	(MW)	Difference	(%)
1999	104,067	93,178	-10,889	-10.46	96,904	-7,163	-6.88	91,834	-12,233	-11.75
2000	113,704	97,858	-15,846	-13.94	103,709	-9,995	-8.79	94,570	-19,134	-16.83
2001	124,233	103,685	-20,548	-16.54	111,475	-12,758	-10.27	98,108	-26,125	-21.03
2002	134,360	110,436	-23,924	-17.81	120,148	-14,212	-10.58	102,429	-31,931	-23.77
2003	145,168	117,341	-27,827	-19.17	129,080	-16,088	-11.08	106,947	-38,221	-26.33
2004	157,228	124,532	-32,696	-20.80	138,647	-18,581	-11.82	111,736	-45,492	-28.93
2005	169,415	132,228	-37,187	-21.95	149,439	-19,976	-11.79	116,980	-52,435	-30.95
2006	181,232	141,300	-39,932	-22.03	161,378	-19,854	-10.96	122,756	-58,476	-32.27
2007	194,045	151,322	-42,723	-22.02	174,490	-19,555	-10.08	129,738	-64,307	-33.14
2008	207,902	162,438	-45,464	-21.87	188,005	-19,897	-9.57	137,996	-69,906	-33.62
2009	221,014	173,532	-47,482	-21.48	200,949	-20,065	-9.08	146,979	-74,035	-33.50
2010	234,743	184,213	-50,530	-21.53	214,215	-20,528	-8.74	156,032	-78,711	-33.53
2011	249,045	194,930	-54,115	-21.73	227,993	-21,052	-8.45	164,381	-84,664	-34.00
Average Growth Rate (%)										
1997-2001	7.65	3.83	-3.82		5.34	-2.31		2.68	-4.97	
2001-2006	7.84	6.39	-1.46		7.68	-0.17		4.58	-3.26	
2006-2011	6.56	6.65	0.08		7.16	0.59		6.01	-0.55	

Table 17.10 Load Forecast of the Northeast Region Based on MER, Peak Power and Energy Requirement

Fiscal Year	Peak Power			Energy Requirement			Annual Load Factor (%)
	Peak Power (MW)	Difference (MW)	Gr. Rate (%)	Energy (GWh)	Difference (GWh)	Gr. Rate (%)	
1998	1,511			7,443			56.23
1999	1,551	40	2.65	7,863	420	5.64	57.87
2000	1,678	127	8.19	8,435	572	7.27	57.38
2001	1,812	134	7.99	9,053	618	7.33	57.03
2002	1,952	140	7.73	9,711	658	7.27	56.79
2003	2,099	147	7.53	10,411	700	7.21	56.62
2004	2,254	155	7.38	11,153	742	7.13	56.49
2005	2,417	163	7.23	11,947	794	7.12	56.43
2006	2,591	174	7.20	12,799	852	7.13	56.39
2007	2,775	184	7.10	13,695	896	7.00	56.34
2008	2,968	193	6.95	14,637	942	6.88	56.30
2009	3,172	204	6.87	15,631	994	6.79	56.25
2010	3,389	217	6.84	16,682	1,051	6.72	56.19
2011	3,618	229	6.76	17,794	1,112	6.67	56.14
Average Growth Rate (%)							
1998-2001	6.24			6.75			
2001-2006	7.41			7.17			
2006-2011	6.91			6.81			

Source: PEA

(2) Extension of Forecast up to 2020

The TLFS load forecasts for the country and N-E Region for the period up to 2011 were extended to 2020 by the Study Team only for MER, as only forecasts based on MER are referred for power development planning. The growth rates of energy requirement in 2011 were assumed to decrease gradually to the final rate of around 5.5% toward 2020. The load forecast was carried out in the following process:

- Estimation of energy requirement as mentioned above and calculation of energy demand.
- Estimation of annual load factor: According to past examples of developed countries, the annual load factor of developing country goes up with progress of economy reaching the maximum when day peak becomes comparable to evening peak. In most cases the maximum factor is 70% to 75%. After that the load factor goes down gradually, and the present load factors of developed countries are around 60%. Assumed annual load factors for Thailand in 2020 are 65% for the country and 58% for N-E Region.
- Calculation of peak power and its growth rate.

The estimated growth rates for energy requirement of the country and N-E Region are summarized in Table 17.11.

Table 17.11 Summary of Forecasted Growth Rates

Unit in %

Year	Country		Northeastern Region	
	Peak Power	Energy	Peak Power	Energy
2000	11.25	8.23	8.14	7.27
2005	6.15	6.18	7.25	7.12
2010	6.17	6.16	6.82	6.67
2015	6.99	5.68	5.76	6.15
2020	6.90	5.50	5.12	5.50

The results of forecast for the country and N-E Region are shown in Table

The forecast peak demand of the country and N-E region—TLFS's forecast up to 2011 and its extension up to 2020 by the Study Team—is presented in Figure 17.6.

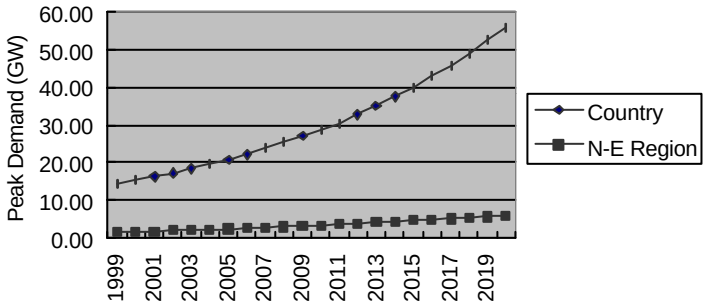

Figure 17.6 Forecast Peak Demand

Table 17.12 Load Forecast to 2020 of the Country and Northeastern Region, Peak Power and Energy Requirement

Fiscal Year	Country					Northeastern Region				
	Peak Power		Energy		Load	Peak Power		Energy		Load
	Peak Power (MW)	Gr. Rate (%)	Energy (GWh)	Gr. Rate (%)	Factor (%)	Peak Power (MW)	Gr. Rate (%)	Energy (GWh)	Gr. Rate (%)	Factor (%)
2007	23,728		151,322		72.80	2,775		13,695		56.34
2008	25,450	7.26	162,438	7.35	72.86	2,968	6.95	14,637	6.88	56.30
2009	27,232	7.00	173,532	6.83	72.74	3,172	6.87	15,631	6.79	56.25
2010	28,912	6.17	184,213	6.16	72.73	3,389	6.84	16,682	6.72	56.19
2011	30,587	5.79	194,930	5.82	72.75	3,618	6.76	17,794	6.67	56.14
2012	32,743	7.05	206,201	5.78	71.89	3,840	6.15	18,957	6.54	56.35
2013	35,045	7.03	218,051	5.75	71.03	4,071	6.02	20,171	6.41	56.56
2014	37,501	7.01	230,504	5.71	70.17	4,311	5.89	21,437	6.28	56.76
2015	40,121	6.99	243,586	5.68	69.31	4,560	5.76	22,755	6.15	56.97
2016	42,917	6.97	257,324	5.64	68.45	4,816	5.63	24,124	6.02	57.18
2017	45,900	6.95	271,746	5.60	67.58	5,081	5.50	25,544	5.89	57.38
2018	49,082	6.93	286,879	5.57	66.72	5,355	5.38	27,014	5.76	57.59
2019	52,475	6.91	302,752	5.53	65.86	5,636	5.25	28,534	5.63	57.80
2020	56,093	6.90	319,397	5.50	65.00	5,924	5.12	30,102	5.50	58.00
Average Growth Rate (%)										
2007-2010	6.81		6.78			6.89		6.80		
2010-2015	6.77		5.75			6.11		6.41		
2015-2020	6.93		5.57			5.38		5.76		

Note: 1: 2007 to 2010 figures are based on the TLFS and PEA forecast and this forecast was extended to 2020.

2: Forecast was prepared in the following step:

- Growth rate of energy will gradually go down to 5.5% in 2020.
- Annual load factor is assumed to go down to 65% in 2020 for the country and go up to 58% for the Northeastern Region with progress of economy.
- Peak power is calculated using the above-obtained energy and load factor.

17.5 Existing Power System

17.5.1 Generation System

The total generating capacity of the country as of April 2000 is 18,951.2 MW (not including 0.534 MW of renewable energy), which comprises facilities listed in Table 17.13.

Table 17.13 Summary of Existing Power Plants

Type of Plants	Total Output		Percentage
Hydro Power Plants	2,880.0	MW	(15.2%)
Thermal Power Plants	6,492.5	MW	(34.2%)
Combined Cycle Power Plants	5,074.6	MW	(26.8%)
Peaking Plants	662.0	MW	(3.5%)
Power Purchases*	3,842.1	MW	(20.3%)
Total	18,951.2	MW	(100%)

*Comprising EGCO, SPPs, Lao PDR power plants, and IPPs including plants in Lao PDR.

Source: EGAT, PDP 99-02

Reference is made to Table 17.14 regarding the particulars of facilities. Since 1995 the category 'Power Purchase' has been increasing at a very high rate in accordance

with government policy to promote private party participation to generation activities. The largest source of purchase in the country is EGCO. The diversity of energy source mix is aimed at according to government policy, and the energy source for power generation of EGAT in 1999 comprised 36.2% indigenous natural gas, 17.6% imported heavy oil, 17.2% lignite, 3.8% hydro, 0.8% diesel oil and 24.3% power purchase. The 24.3% power purchase comprises 15.4% from EGCO, 6.7% from SPPs and 2.1% from Laos.

In 1998 and 1999 the import from Lao PDR increased much by the commissioning of 2 IPP plants, the Theun Hinboun project with guaranteed supply of 187 MW at the border and the Houay Ho project of 126 MW. The agreed overall average power rates of these two projects are 4.8 US cents/kWh and 4.6 cents/kWh respectively. The surplus energy of the Lao power system has been imported through 115 kV transmission lines since 1971.

Some support from Malaysia is available in emergency cases through a 115/132 kV transmission system interconnection.

Table 17.14 Existing Installed Generating Capacity (As of April 2000)

	Type of Plant		Type of Fuel	Installed capacity (MW)	Total Capacity (MW)		Average Energy Generated (GWh)
A.	**Hydroelectric Plant**						
	Bhumibol		---	(5x76.3)+(1x70)+115+171	737.5		1,062.0
	Sirikit		---	4x125	500.0		670.0
	Ubolratana		---	3x8.4	25.2		26.0
	Sirindhorn		---	3x12	36.0		52.0
	Chulabhorn		---	2x20	40.0		59.0
	Kang Kracharn		---	1x17.5	17.5		57.0
	Nam Pung		---	2x3	6.0		10.0
	Srinagarind		---	(3x120)+(2x180)	720.0		953.0
	Bang Lang		---	3x24	72.0		119.0
	Tha Tung Na		---	2x19	38.0		94.0
	Khao Laem		---	3x100	300.0		460.0
	Pak Mun		---	4x34	136.0		251.0
	Huai Kum		---	1x1.06	1.06		0.0
	Ban Santi		---	1x1.275	1.275		0.0
	Mae Ngat		---	2x4.5	9.0		19.0
	Rajjaprabha		---	3x80	240.0		351.0
	Miscellaneous		---	0.429	0.429		12.0
		Total			2,879.964		4,195.0
B.	**Thermal Power Plant**						
	North Bangkok		Oil	(2x75)+(1x87.5)	237.5		1,250.0
	South Bangkok		Oil/Gas	(2x200)+(3x310)	1,330.0		9,320.0
	Mae Moh		Lignite	(3x75)+(4x150)+(6x300)	2,625.0		18,396.0
	Bang Pakong		Oil/Gas	(2x550)+(3x600)	2,300.0		16,118.0
					6492.5		45,084.0
C.	**Combined Cycle Power Plant**						
	Bang Pakong	Blocks 1&2	Gas	2x[(4x60.7)+(137.5)]	760.6		5,330.0
		Blocks 3&4	Gas	(4x104)+(2x99)	614.0		4,303.0
	Nam Phong	Blocks 1&2	Gas	(4x121)+(2x113)	710.0		4,976.0
	South Bangkok	Block 1	Gas	(2x110)+(1x115)	335.0		2,348.0
		Block 2	Gas	(2x202)+(1x220)	624.0		4,373.0
	Wang Noi	Block 1	Gas	(2x223)+(1x205)	651.0		4,562.0
		Block 2	Gas	(2x223)+(1x205)	651.0		4,562.0
		Block 3	Gas	(2x236)+(1x257)	729.0		5,109.0
					5,074.6		35,563.0
D.	**Gas Turbine Power Plant**						
	Lan Krab		Gas	(4x14)+(2x16)+(4x20)	168.0		986.0
	Nong Chok 1-4		Diesel	4x122	488.0		1,070.0
		Total			656.0		2,056.0
E.	**Diesel Power Plant**						
	Mae Hong Son		Diesel	1x6	6.0		42.0
		Total			6.0		42.0
F.	**Purchased Power**						
	Kiridharn Hydro		---	2x6.35	12.7		22.0
	EGCO						
	- Rayong CC	Blocks 1&4	Gas	(8x103)+(4x102)	1,232.0		8,634.0
	- Kanom TH		Oil/Gas	2x75	150.0		1,050.0
	- Khanom CC		Gas	(4x112)+(1x226)	674.0		4,723.0
	SPP		Oil/Gas/Coal	1,433.4	1,433.4		10,045.0
	Theun Hinboun Hydro		---	2x115	214.0	*1	1,570.0
	Houay Ho Hydro		---	2x75	126.0	*1	570.0
		Total			3,842.0		26,614.0
		Grand Total			18,951.164	*2	113,554.0

Note: *1: Capacity at border.

*2: Not including alternative energy of 534 kW.

17.5.2 Transmission and Distribution System

The nationwide transmission network of EGAT comprises 500, 230 and 115/69 kV systems. The 500/230 kV system functions as the main transmission system and the 115/69 kV system as the secondary system. In the near future the secondary transmission system will be unified to 115 kV, and the 69 kV system being partly used at present will be phased out eventually. Both of the 500/230 kV system and 115 kV system are in principle operated in loop formation to ensure stability of the power system. However, in the metropolitan area 115 kV interconnection is opened at many points to limit the system fault level and to avoid miss-operation of the relaying system.

The national transmission network diagram of EGAT is depicted in Figure 17.7 and the region-wise quantities of transmission facilities, in Table 17.15.

The 500-kV system of EGAT is in operation between the Mae Moh lignite thermal power station (2,625 MW) and the Bangkok area, which has several interconnections with the major 230 kV systems including connection with the northeastern system. At present this 500-kV system is being extended around the metropolitan area to transmit very large power. The 230-kV system forms the major transmission system, connecting all major power stations and load centers in every part of the country. Local cities and towns are normally fed with electric power through the 115-kV secondary system. The 115/22-kV substations are operated as standard distribution substations.

In the past, all 115-kV transmission lines and 115/22 kV substations were constructed by EGAT and power to PEA was supplied at the 22-kV side of the 115/22-kV substations. However, this principle is being changed. In the future, EGAT will construct 115-kV main system only and basically not construct additional 115/22-kV substations. In case that PEA sees the necessity of additional substations to meet the growing demand in the area, PEA is to install its own 115-kV transmission lines and 115/22-kV substations.

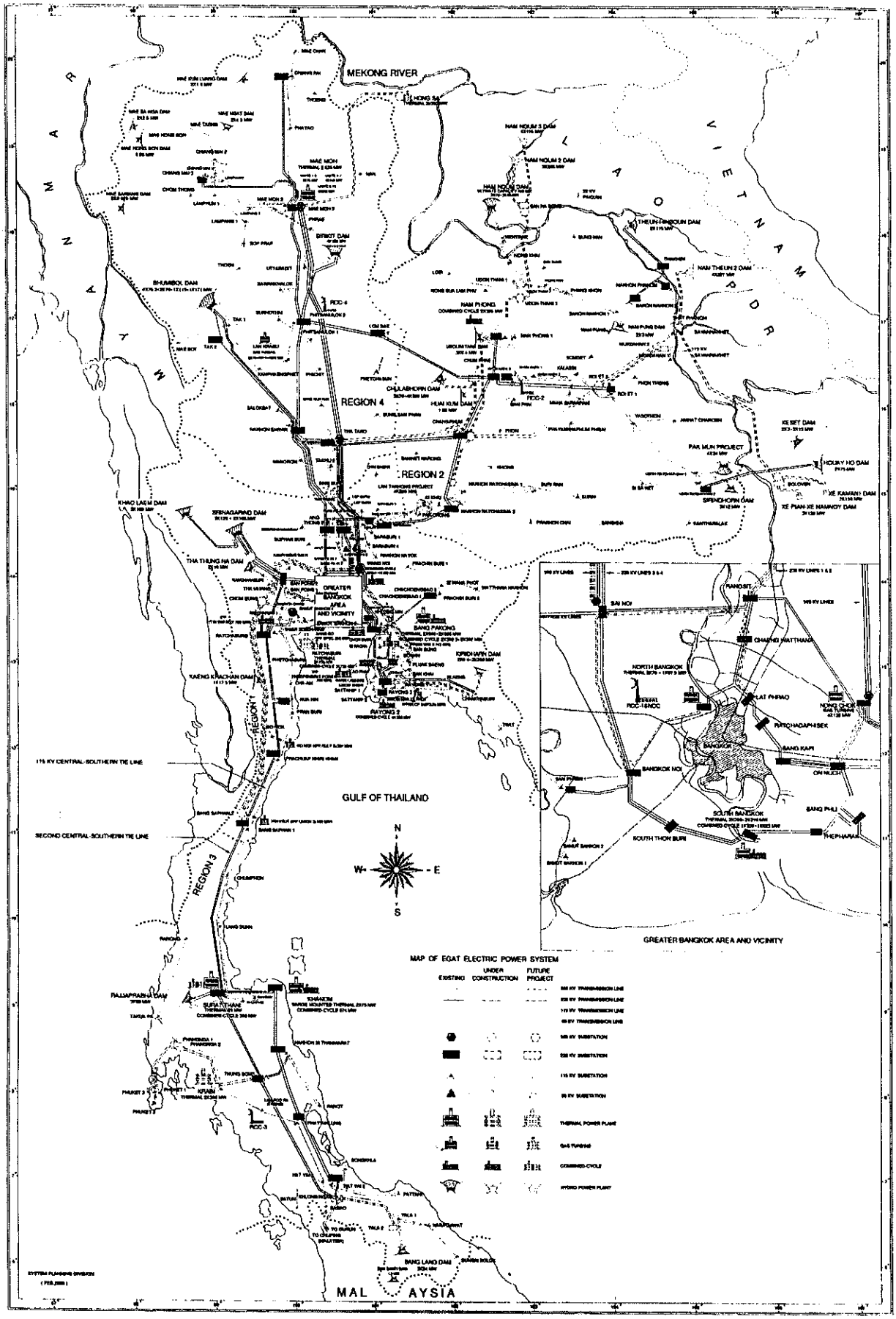

Figure 17.7 Transmission Network of Overall EGAT System

Table 17.15 Existing Transmission Lines and Substations (As of April 2000)

Region And System Voltage	Substations		Transmission Lines (circuit-km)
	Number	Transformer Capacity (MVA)	
Metropolitan Area			
500 kV	2	3,450	328
230 kV	12	13,333	674
Total	14	16,783	1,002
Central Region			
500 kV	2	3,000	453
230 kV	19	10,393	3,321
115 kV	44	4,938	2,833
69 kV	2	96	52
22 kV	--	2	--
Total	67	18,429	6,659
Northeastern Region			
230 kV	9	3,600	1,571
115 kV	36	3,158	5,088
69 kV	--	7	--
Total	45	6,765	6,659
Southern Region			
230 kV	6	2,500	1,577
132 kV	1	133	9
115 kV	19	1,919	2,893
Total	26	4,552	4,479
Northern Region			
500 kV	2	2,400	1,143
230 kV	7	3,133	3,295
115 kV	30	2,573	2,739
	39	8,106	7,177
All Regions			
500 kV	6	8,850	1,924
230 kV	53	32,960	10,438
132 kV	1	133	9
115 kV	129	12,587	13,553
69 kV	2	104	52
22 kV	--	2	--
Total EGAT	191	54,636	25,976

Source: EGAT

The load dispatching system of EGAT comprises the National Control Center (NCC) located in the EGAT headquarters in Bangkok, and Regional Control Centers (RCC), one each at regional centers for Metropolitan Area, and Central, Northeastern, Northern and Southern Regions. NCC is responsible for energy management and continuous power supply to all areas in the country all year round including control of major power stations. While, RCC monitors and controls the transmission system and medium to small power stations in the region. It is told that EGAT developed its own computer software for its load dispatching system.

To improve quality management system EGAT obtained ISO 9001 for its transmission system design and provision of construction and procurement management. New technologies, such as updated Combined Cycle Plants, Gas Insulated Switchgear (GIS), Computer Control System (CCS), Remote Substation Control (RSC), etc., have been introduced to actual use.

The standard medium voltage (MV) distribution system voltage of the country is 22 kV, but 33 kV is also used in most of Southern Region and a part of Northern Region. All MV distribution systems of N-E Region are rated at 22 kV. The low voltage (LV) distribution system is of 380/220 V and 3-phase/ 4-wire.

For power consumption billing purpose, the computer software, Point Of Service (POS) system of the USA, is applied throughout the country.

17.5.3 Power Supply in the Four Provinces of the Study Area

(1) Power Source Facilities

The available power sources in the N-E Region are listed in Table 17.16.

Table 17.16 Available Power Generation in Northeastern Region

No.	Power Station	Location	Units x MW	Total Capacity (MW)
1.	Pak Mun	Ubon Ratchathani	4 x 34	136
2.	Chulaborn	Chaiyaphum	2 x 20	40
3.	Sirindhorn	Ubon Ratchathani	3 x 12	36
4.	Ubol Ratana	Khon Kaen	3 x 8.4	25.2
5.	Nam Pung	Sakon Nakhon	2 x 3	6
6.	Nam Phong *1	Khon Kaen	2 x 365	730
7.	Theun Hinbuon	Lao PDR	2 x 105	187 *2
8.	Houay Ho	Lao PDR	2 x 75	126 *2
	Total			1,286.2

Source: EGAT

Note:*1 The Nam Phong power station is a combined cycle power plant with natural gas, and all the others are hydroelectric plants.

*2 Guaranteed capacity at the Thai-Lao border.

Power supplies for base load in N-E Region are mainly from the Nam Phong combined-cycle power plant and the interconnections with the Central and Northern regions through 230-kV and 115-kV tie lines. The power source in the four provinces is negligibly small - a mere 6 MW. Hydroelectric power plants are operated mainly for peak support.

A part of energy needed for this region is supplemented with the two recently commissioned IPP's hydro power plants in Lao PDR, Theun Hinbuon and Houay Ho. The Theun Hinboun power station is for base supply with partial operation in dry season. While the annual peak operation time of the Houay Ho power station is about 4,100 hours and the energy generation decreases in dry season. The surplus power of the EdL plants of Nam Ngum, Nam Leuk and Xeset is also supplied to Thailand. Power supply of Theun Hinboun and Houay Ho from the east of the region is contributing to improve regional balance of power sources as other major sources are located in the west of the region.

The electric power requirement of N-E Region in 1999 was 1,551 MW in peak power and 7,849 GWh in energy, while the imported energy from Lao PDR was 1,726 GWh, or 22% of energy. For the region the imported power from Lao PDR occupies an important portion, and in the future its importance will increase more and more.

(2) Transmission and Distribution Facilities

There is no existing 500-kV system in the N-E Region. A 230-kV main transmission line runs from the Nam Phong power station in the northwest to the Nakhon Ratchsima 2 substation in the southwest. This transmission line runs in the western part of the region, outside the Study Area. This system has three 230-kV interconnections with the main 500-kV network in the Central and Northern Regions at the Khon Kaen 3 substation, Chayaphum and Nakhon Ratchasima 2 substation. To the Roi Et substation located just south of Kalasin in the Study Area, one double circuit, 230-kV line, is extended from the Khon Kaen 3 substation. In addition, there is a 230-kV line to import power from the Theun Hinboun power station in Lao PDR. This line is feeding to the two 230/115-kV substations in the Study Area, Nakhon Phanom (1 x 200 MVA) and Sakon Nakhon 2 (3 x 200 MVA), to transmit the imported power to the 115-kV system in the region. Another power importing 230-kV line from the Houay Ho power station is terminated at the Ubon Ratchathani 2 substation to the south of the Study Area.

At present in the N-E Region there are 45 EGAT substations of 115/22 kV, while PEA has 115-kV transmission lines of 503 km in length and eight 115/22-kV substations. While, there is no PEA substation in the four provinces. Several of EGAT's 115-kV lines are in operation in the four provinces of the Study Area. There are two 115-kV double-circuit lines, one from Kalasin to Sakon Nakhon with 2 intermediate stations and the other from Udon Thani to Sakon Nakhon with one substation in the Study Area. A 115-kV single-circuit line (double-circuit partly) runs along the Mekong River connecting Nakhon Phanom and Ubon Ratchathani with 2 intermediate substations in the Study Area. In total there are 8 EGAT distribution substations in the Study Area, and their capacity and maximum loads are as given below.

Mukdahan			
- Mukdahan substation	2 x 50	100 MVA	Max. 17.8 MW
Nakhon Phanom			
- Nakhon Phanom substation	2 x 25	50 MVA	Max. 19.7 MW
- That Phanom substation	1 x 25	25 MVA	Max. 11.5 MW
Sakon Nakhon			
- Sakon Nakhon 1 substation	2 x 25	50 MVA	Max. 33.7 MW
- Nam Pung substation	1 x 10	10 MVA	Max. 3.6 MW
- Phang Khon substation	25 + 50	75 MVA	Max. 26.2 MW
Kalasin			
Kalasin substation	2 x 50	100 MVA	Max. 36.0 MW
Somdet substation	2 x 50	100 MVA	Max. 31.5 MW

Some substations have a lot of reserve capacity as demand has stagnated in recent years due to the recent economic recession. This is significant at substations around which vigorous economic activities including industries are expected. Transmission lines of 115 kV firmly connect these substations. The transmission system diagram of N-E Region is presented in Figure 17.8.

According to the available EGAT's power flow diagrams of the existing northeastern transmission system, it is understood that the present system is operated with considerable allowance in capacity. It is also noted that system development plans are being prepared with enough allowance. It is considered that some contingency is taken into account to improve the system's reliability.

Spacing between substations is long, therefore length of distribution lines is generally long; maximum length is around 50km. However, the consumer service voltage is maintained at a reasonable level by installing static capacitors on lines (both PEA and large consumers) and automatic line voltage adjusters of autotransformer type at line midpoints. Addition of substations by PEA is surely needed with increase of area demand.

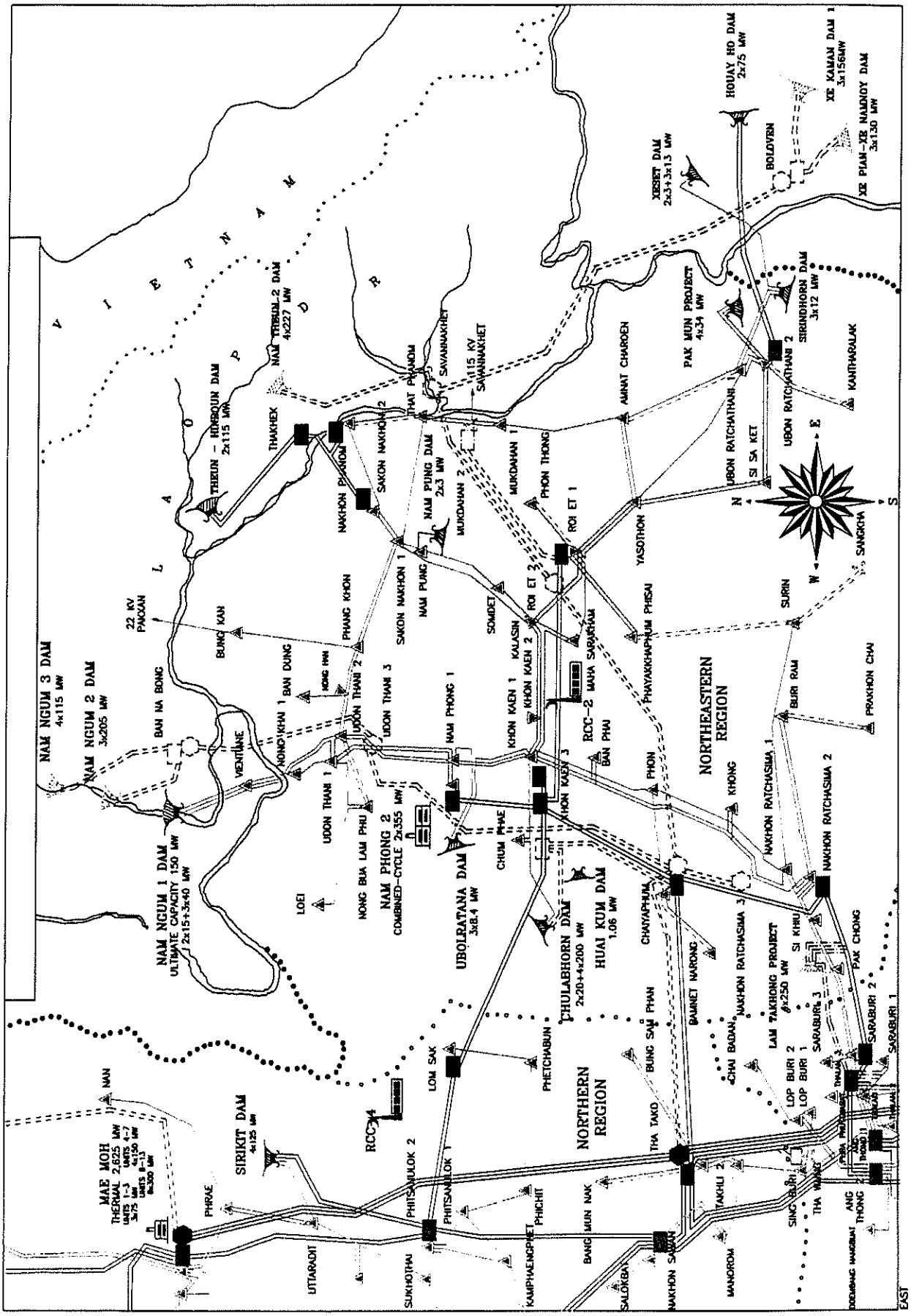

Figure 17.8 Transmission System in the Northeastern Region

Bare conductors are mostly used for overhead 22-kV distribution lines; however insulated wires and cables are also installed to improve reliability of service in urban areas and where a lot of trees interfere with the lines. Insulated wires are used for LV lines.

The 22-kV distribution system is well stretched in the Study Area, which is widely covered with farmlands. Main lines are running along major roads and branch lines are extended to wide farm areas. As mentioned in Section 17.4.1, the rural electrification activities in the N-E Region have been almost completed. In the region, there are still five villages still un-electrified in the national park area. For electrification of these villages, solar energy and other means are under study.

For management of the distribution system in the command area, PEA uses the PSS series software of PTI of USA. One system is installed in each of the administration office areas, for NE.1 (Udon Thani), NE.2 (Ubon Ratchathani) and NE.3 (Nakhon Ratchasima) in the N-E region. All technical data of area distribution system are incorporated in the computer programs, PSS/U and PSS/ADEPT, and technical performances under all the operating conditions can be examined by operating these computer programs.

The prime target for supply of sufficient energy has been satisfied. As the next target of the power system, PEA is trying to improve the service quality, maintaining consumer supply voltage and reduction of frequency and duration of supply interruption. For this purpose, the computer program in each area office is essential.

The overall quantities of transmission and distribution facilities in the N-E Region are given in Table 17.17 below:

Table 17.17 Overall Quantities of the Existing Transmission and Distribution Facilities in the Northeastern Region

Voltage	Line Length (circuit-km)			Transformer Capacity (MVA)		
	EGAT	PEA	Total	EGAT	PEA	Total
230 kV	1,571	---	1,571	3,600	---	3,600
115 kV	5,051	504	5,555	3,158	175	3,333
69 kV	7	---	7	---	---	---
22 kV	---	26,753	26,753	---	6,115	6,115
0.4 kV	---	37,340	37,340	---	---	---

Source: EGAT and PEA

17.6 Power Development Plans

The recent EGAT power development plan under execution as of mid-2000 is PDP 99-02 of May 2000, which is a revision of PDP 99-01 of January 1999 and updated referring to the recent recovery of Thai economy and the increase in power demand.

This power development plan was based on the MER scenario mentioned in Section 17.4.2, which forecasted the load growth at a rate of almost double in 10 years time. PDP 99-2 plans to meet this growth of demand with the generation in the country and the import of electric energy from neighboring countries, and the latter will occupy a considerable portion in future development.

17.6.1 Generation Development

(1) Energy Source Option

With regard to available energy sources for future power generation in Thailand, the following are noted:

1) Hydroelectric potential

The hydroelectric potential in Thailand is estimated at about 15,155 MW. Of this capacity, 2,893 MW (19%) has been in operation and a 1,000-MW pumped storage plant is under construction at Lam Thakhon. Further large-scale development will be environmentally difficult except for pumped storage projects

2) Natural gas

The natural gas generation is environmentally benign, and the combined cycle generation with natural gas is highly efficient and relatively cheap in generation cost. However, the availability of offshore natural gas of Thailand is limited and will not be sufficient to meet the future increasing demand. The first pipeline to import natural gas from Myanmar has been constructed, and import will be commenced on completion of the Ratchaburi power station scheduled in 2000. The import of liquefied natural gas (LNG) is under review; however, some cost increase will be inevitable.

3) Lignite

Lignite reserves are scattered throughout the country. The largest reserve is existing at Mae Moh and a lignite-fired power plant of 2,625-MW capacity was constructed

there. Though the country's potential is estimated at 5,925 MW, lignite-fired projects are not incorporated in PDP 99-2 due to environmental restrictions and possible opposition from local inhabitants.

4) Oil

Any recoverable reserve of oil has not been identified in the country, and all the oil in use is imported. The government has a policy to reduce oil consumption as far as possible.

5) Imported coal

The imported coal is an important source that can be considered in long-term generation planning from its availability in the international market at a reasonable energy rate. The major problems in burning coal are environmental issues due to emission of carbon dioxide and sulfur dioxide gases.

6) Hydroelectric power in neighboring countries

A considerable amount of hydroelectric potential compared to the expected demand is existing in countries surrounding Thailand. They are Lao PDR, Myanmar and Yunnan province of People's Republic of China (PRC). For execution of large development in these countries, collaboration in various phases comprising financial and technical assistance from Thailand will be essential.

In order to secure electricity supply without aggravating the environmental situation of the country by the considerable amount of thermal generation, the import of considerable amount of power from its neighboring countries will need to be taken into account.

(2) Generation Development Plan

Total capacity of the existing generating plants as of April 2000 is 18,951 MW, and this capacity is planned to be increased to 39,297 MW by the end of 2011 according to PDP 99-02 as summarized below:

- Existing capacity as of April 2000 18,951.2 MW
- Total added capacity up to 2011 22,298.8 MW
- Additional purchase from SPPs 525.0 MW
- Plant retirement - 2,478.1 MW
- Grand total capacity at end-2011 39,296.9 MW

Of the total added capacity, development of 11,494.8 MW is ongoing for completion up to 2007 and the remaining 10,560 MW that is not started yet will be completed during the period of 2003 to 2011. The composition of development plans is shown in Table 17.18.

Table 17.18 Summary of Generation Development Plans up to 2011

Plant Type	Ongoing Up to 2007	Planned 2003 to 2011	Total Up to 2011
Hydro	1,006.3	660	1,666.3
Thermal	2,070	---	2,070
Combined Cycle	2,419	100	2,519
IPP	5,943.5	6,500	12,443.5
TNB Cooperate.	300	---	300
From Lao PDR	---	3,300	3,300
Total	11,738.8	10,560	22,298.8

Source: EGAT, PDP 99-02

The hydroelectric development is limited to the 2 pumped storage plants, Lam Takhong (4 x 250 MW) in the N-E Region and Kiridarn (3 x 220 MW) in the Central Region. These hydroelectric plants will be constructed by EGAT. During this period the increase in Purchase Category from IPP, SPP and neighboring countries is significant. Except for the ongoing projects, the thermal plant addition by EGAT will be stopped and all thermal additions are planned as IPP projects. After 2001 the total capacity of the EGAT plants will not increase and remain almost unchanged, and in 2011 only about 30% of energy will be generated in EGAT's plants. The planned addition of generating capacity up to 2011 derives mainly from the development of thermal power plants, with gas, oil or imported coal.

Though the present importing power rate from Lao PDR is relatively low, this rate will tend to become higher in the future. Up to now the hydro development in Lao PDR has been executed at very favorable sites; however, such top favorable sites will run out in the near future and development costs will become higher.

(3) Power Import from Neighboring Countries

In 1999 the power import from Lao PDR occupied 2.1% of the energy requirement of the country. From the reasons mentioned in the above Item (2), the power import will significantly increase in the future. According to PDP 99-02, with regard to the power import in 2011 comprising the hydroelectric power from Lao PDR, the generation based on imported natural gas from Myanmar and the cooperation with Malaysia will amount to about 13% of the total installed capacity.

Following several meetings in the past with Lao PDR, Myanmar, Yunnan Province of PRC and TNB of Malaysia, only the three items mentioned above have been incorporated in PDP 99-02. Summary of various power importing arrangements from the these countries is given below:

1) Lao PDR: According to PDP 99-02, the import of 1,600-MW hydroelectric power is scheduled by 2006 and further 1,700 MW by 2008. Hydroelectric projects for supply to Thailand are all IPP projects for exclusive use for power export by international consortiums. Surplus energy from the EdL power stations for domestic supply can also be exported to Thailand, but quantity is subject to the demand in Lao PDR and the season. The Nam Theun 2 project by IPP with border capacity of 920 MW is in its most advanced stage and scheduled for commissioning in 2006. In addition to projects scheduled up to 2008, many projects have been studied to confirm their feasibility. Lao PDR with abundant hydroelectric potential can be a favorable source for power import in the long run.

2) Myanmar: In the past many hydroelectric and natural gas power projects have been raised as projects suitable for power supply to Thailand. However, their execution for development has not progressed due to political instability of the country and other constraints. Myanmar can be a good source for power import in the long run, as a lot of hydroelectric potential is existing in the eastern mountains and the country has offshore natural gas reserves. From Myanmar import of natural gas was also agreed on and a pipeline has already been constructed. The gas import will be commenced on completion of the first stage of the Ratchaburi combined cycle power station (2,275 MW in total capacity) scheduled in 2000.

3) Yunnan Province of China: In 1998, it was agreed to import 3,000 MW of power by 2017 including the generated power of the Jinghong hydroelectric power station (1,500 MW).

4) Collaboration with Malaysia: The power exchange with Malaysia is intended for emergency power needs. A HVDC transmission system is under construction to strengthen the link between the two countries. After its completion additional power exchange of 300 MW will become possible.

After 2011 further increase of power import will be essential, and RTG and EGAT will need to proceed with necessary investigation and negotiations for new arrangements. These countries have not financial sources and technical expertise necessary for large development. Therefore, various cooperation efforts from Thailand and IPP parties will be required to proceed with development.

(4) Proper Reserve Capacity

Due to recent stagnant demand growth, several power projects have been cancelled or postponed. However it is not possible to stop or slow down the projects under execution, and completion of ongoing projects will cause the increase in reserve margin exceeding a reasonable level. It is planned that the highest level of 44% in 2002 will go down to a normal level of 25% by 2006.

To secure the Loss of Load Probability (LOLP) of less than 1 day in a year, a reserve margin of generating capacity shall be a minimum of 25% of the largest power demand.

17.6.2 Extension of Transmission and Distribution System

From its nature, the extension of transmission system is dependent on the generation development and regional distribution of load growth, and is to be planned to meet the increased demand optimally, sustaining the rated voltage and reducing the frequency and duration of supply interruptions. For system reliability EGAT applies the single contingency (N-1) criterion. The consumer power supply shall not be seriously affected by separation of any one component of the power network such as generator, transformer, line, etc.

The transmission system needs to be step by step reinforced and improved taking into account the position of power sources and forecasted loads, referring to the results of network analysis on power flow and fault disturbance. In Thailand the PSS/E software of PTI of the USA is used for this purpose.

17.6.3 Power System Development in the Study Area

(1) Coming Large Demand

The main economic activities in the area are in agriculture, and significant growth of demand will not take place. However, relatively large growth is assumed by EGAT for industrial areas between Roi Et, Kalasin and Som Det. In the Mukdahan area, vigorous economic activities will emerge related to the construction of the Mekong crossing bridge and commencement of the East-West Corridor project.

(2) Development of Power Sources

The power development planned in PDP 99-2 up to 2011 in N-E Region is only the Lam Takhong pumped storage project of 1,000-MW capacity in Nakhon Ratchasima province. This project is at present under construction and will be developed in two stages, with commissioning of a 2 x 250 MW each in 2001 and 2007. Though this project is located in N-E Region the power station is not far from Bangkok and will be operated according to the peak requirement of the Bangkok area. The outgoing transmission line from this power station will be connected to the Saraburi substation in Central Region. Thus the project will not contribute much to the rural power supply of N-E Region.

Land is generally flat in the N-E region, and therefore there are no significant hydroelectric generation sites. No remarkable hydrocarbon resources are found, and the area is not suitable for construction of large thermal plants with foreign fuels. Thus in the period up to 2011, there is no power development plan except for the Lam Thakong project. The additional power requirement in the plan period of up to 2020 will be met predominantly by the increase in power import from Lao PDR.

The additional power source requirement in N-E Region up to 2011 is roughly estimated at about 1,800 MW. While the revised timetable for power import from IPP projects in Lao PDR envisages a power receiving of 3,300 MW by 2008. This 3,300 MW will be more than enough to meet the demand of the region, and the surplus power needs to be transmitted to the central system through the region.

(3) Extension of Transmission and Distribution System

The 3,300-MW power from Lao PDR will be imported through two 500-kV transmission lines. Therefore, the 500-kV transmission system need to be reinforced for smooth flow of power between the importing points from Lao PDR and the demand center of the Bangkok area and for necessary tapping in the region. Reinforcement of the 230- and 115-kV system is also needed for delivery of increased power to load centers.

The 230-kV transmission system development plan up to 2011 for N-E Region in PDP 99-02 comprises a line from the Lam Thakong pumped storage power station to the Saraburi substation in Central Region. As for extension of the 115 kV system by EGAT, the system reinforcements in the Udon Thani area and in the southern part of the region are mentioned. No 115-kV system extension is planned by EGAT in the four provinces in the Study Area. The conceived transmission system of EGAT is shown in dotted lines on the transmission system diagram depicted in Figure 17.7.

Only the plans in PDP 99-2, the 115-kV system will not be adequate to fully meet the increase in power demand, more than doubling in the plan period. In addition to transformer-capacity addition at the existing substations, considerable addition of new 115-kV lines and 115/22-kV substations by PEA will be needed. The EGAT's load forecast of substations in the Study Area up to 2011 on the assumption that there are no changes in the present supply areas is presented in Table 17.19. At present, 16 substations are under construction and 12 substations are planned in the region by PEA. In the four provinces, the Sri Songkharam substation is under construction by PEA in Nakhon Phanom province.

According to medium-term, area-wise forecast of demand, operating conditions of the transmission and distribution systems shall be monitored using computer software and the 115-kV system reinforcement plan shall be worked out. To meet the increasing power demand in the Mukdahan area related to the East - West Corridor Project, EGAT is considering extension of its 230-kV transmission system from Roi Et to Mukdahan. So far as the power flow calculation results of EGAT are reviewed, the existing transmission system has some allowance at present and fundamental modification of system will not be required until around 2011.

Table 17.19 Load Forecast of Substations in the Study Area

1. Peak Power

Province	Substation	Voltage (kV)	Forecast Demand (Non-Coincident MW)											
			2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mukdahan	Mukdahan	22	35.31	37.50	40.15	43.50	46.79	50.59	54.38	58.36	62.55	66.98	71.66	76.61
Nakhon Phanom	Nakhon Phanom	22	9.02	9.42	9.89	10.50	11.11	11.75	12.41	13.09	13.79	14.53	15.30	16.09
	That Phanom	22	17.68	18.62	19.77	21.23	22.75	24.32	25.95	27.66	29.45	31.33	33.31	35.38
Sakon Nakhon	Sakon Nakhon	22	18.23	19.43	20.69	22.02	23.42	24.90	26.46	28.11	29.85	31.70	33.65	35.72
	Phang Khon	22	26.46	28.47	30.68	33.11	35.62	38.24	40.97	43.84	46.85	50.02	53.36	56.90
		115	43.08	45.81	48.76	52.01	55.37	58.87	62.52	66.35	70.37	74.58	79.02	83.70
	Nam Phung	22	4.27	4.57	4.88	5.19	5.51	5.84	6.18	6.54	6.90	7.28	7.67	8.08
Kalasin	Kakasin	22	46.23	47.76	50.12	53.80	57.61	61.58	65.72	70.05	74.60	79.38	84.41	89.72
	Somedet	22	33.20	34.89	37.14	40.32	43.65	47.15	50.86	54.78	58.94	63.36	68.06	73.06

2. Energy Requirement

Province	Substation	Forecast Demand (GWh)											
		2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011
Mukdahan	Mukdahan	140.9	152.4	165.6	179.3	194.8	210.9	225.2	245.0	265.8	293.3	319.6	346.2
Nakhon Phanom	Nakhon Phanom	37.0	39.3	41.9	44.4	47.3	50.3	52.8	56.4	60.2	65.3	70.0	74.7
	That Phanom	61.2	65.7	70.8	76.0	81.9	88.0	93.3	100.8	108.6	119.1	128.9	139.8
Sakon Nakhon	Sakon Nakhon	71.7	77.8	84.1	89.5	95.7	102.3	108.0	116.3	125.0	136.8	147.9	159.0
	Phang Khon	328.9	357.4	387.6	414.5	445.3	477.2	504.8	544.4	585.6	641.2	693.2	745.4
	Nam Phung	13.1	14.3	15.5	16.4	17.6	18.7	19.7	21.1	22.5	24.5	26.3	28.1
Kalasin	Kalasin	188.2	198.0	211.0	226.3	243.8	261.9	277.7	300.1	323.4	354.7	384.1	413.7
	Somedet	137.1	146.7	158.6	172.0	187.4	203.5	218.0	238.0	259.1	287.2	314.1	341.7

Source: EGAT

The transmission and distribution system extension and reinforcement by PEA is being performed periodically under the following two categories:

1) Transmission System Development (TSD) Project

- From 115-kV power purchasing points from EGAT to connection to the 22-kV bus of PEA substations; including 115-kV lines, 115-kV receiving circuits and 115/22-kV transformers.
- Prepared by PEA head office from the medium-term viewpoint of 5 to 6 years based on computer analysis results on the transmission system.
- Bilateral fund from Japan, Germany, etc. is mainly utilized.

2) Power System Reinforcement (PSR) Project

- 22-kV buses and feeder facilities in substations, 22-kV switching stations, 22-kV distribution lines including static capacitors, etc.
- Prepared by PEA area offices from the viewpoint of immediate requirements based on computer analysis results on the distribution system.
- Main fund sources are ADB, PEA's own fund, domestic commercial borrowing, etc.

At present the Transmission System and Substation Development Project, 7th Stage, and the Power Distribution System Reinforcement Project, 7th Stage, are in progress in the N-E Region. The Rural Household Electrification Project, 2nd Stage, is also ongoing.

PEA also uses the PSS/E software of PTI for transmission system analysis. All the technical information of area distribution system in each area is incorporated in the computer program, PSS/U and PSS/ADEPT of PTI, in the area office. All the operating conditions, which need immediate reinforcement, can be examined by operating these computer programs.

Necessity for system reinforcement of the current distribution system can be technically examined using these computer programs, and the distribution system has already covered the whole area. Therefore, distribution reinforcement plans are prepared mainly from a technical point of view, which take into account coming of large loads.

The fund for construction of distribution system is provided mainly by PEA's own arrangement, including borrowing from foreign sources, and partly by arrangement of RTG. From fund sources, the foreign fund occupies around half and the remaining

half is composed of comparable amounts coming from PEA's own fund and domestic borrowing.

To handle the 3,300-MW power from Lao PDR from 2 directions, the 500-kV transmission system will be necessary. The mutually agreed power interchanging points of the two countries are as given below:

Nam Ngum area: Banna Bon on Lao side and Udon Thani on Thai side
Central Lao area: Savannakhet on Lao side and Roi Et on Thai side

On the Lao side all the scheduled IPP power stations on the Nam Ngum, Nam Theun and Sekong river systems will be interconnected through new 500-kV double circuit lines to improve security of supply, and the power will be exported to Thailand from the above 2 points. On the Thai side, both 500-kV Udon Thani and Roi Et substations will be connected with the Chiyaphum substation, and further to the Tha Tako substation on the 500-kV Mae Moh - Bangkok main system. This 500-kV system needs to be interconnected with the 230/115-kV transmission system of N-E Region to tap off power for supply in the region. Reference is made to the transmission system diagram of EGAT in Figure 17.7. Thus the imported power will be fed to the northeastern demand and available surplus will be transferred to the central system. All the planned 500-kV transmission lines in Thailand will be of double circuit construction.

17.7 Demand-Side Management and Environmental Considerations

17.7.1 Demand-Side Management (DSM)

Together with the economic growth, the power demand in Thailand has grown steadily except for the period of recent economic recession. Thailand is by far the largest power consumer among the countries in Southeast Asia, and has already joined the medium-developed group of countries. The indigenous energy sources in Thailand suitable for power generation is limited, and Thailand must import either fuel or electric power to meet the power demand in the country. The import requirement is increasing rapidly.

Under such a situation, comprehensive DSM initiatives were introduced in the beginning of the 1990s to slow down the growth in power generation requirement. In 1992 RTG approved legislation establishing the Energy Conservation Promotion Act, which increased the commitment and resources necessary to implement a comprehensive energy efficiency program. The Thai DSM project has two main objectives:

- To build sufficient institutional capability in the Thai electric power sector and the energy-related private sector to deliver cost-effective energy services throughout the economy; and
- To pursue policies and actions that will lead to the development, manufacture and adoption of energy-efficient equipment and processes within the country.

Typical DSM activities for energy conservation taken at present are given below:

- Production side measures to manufacture energy-efficient appliances such as lamps, motors, etc.;
- Energy-efficiency labeling on refrigerators and air conditioners;
- Customer-oriented program to monitor electricity consumption at key locations for energy efficiency and shifting non-critical loads to off-peak hours. This is called as "Green Building Program."

17.7.2 Environmental Considerations

The past 5-year National and Economic and Social Development Plan (1992-96) clearly addressed the improvement of quality of life and enhancement of environmental and natural resources.

For sustainable power development, utmost care shall be taken to environmental conservation to avoid trouble with the public. Environmental Impact Assessment (EIA) is being carried out based on the Environmental Policy in parallel with execution of development project.

Global warming due to the emission of CO_2 gas is of great concern worldwide. The power sector is a very large consumer of energy, and CO_2 gas emission shall be minimized by reducing use of fossil fuel and using materials that emit less CO_2.

The lignite-fired Mae Moh Power Plant sometimes causes widespread air pollution problems and also health problems in villages within the plant vicinity. EGAT is installing high cost desulphurisation plant in the flue gas systems to mitigate the air pollution problems. Also for other thermal power stations, air-cleaning plants will be needed.

To avoid environmental problems associated with the thermal power generation, use of clean fuel is preferred. Natural gas is regarded as the cleanest fuel as this does not contain sulfur and emits less carbon dioxide gas compared with other fuels.

The implementation of new transmission line construction projects has become more and more difficult due to its complex problems related to land acquisition and compensation, environmental constraints, and so forth.