Chapter 3

OUTLINE OF PEA AND ELECTRIC POWER SITUATION

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3-1 Profile of PEA

The service area of PEA is approximately 510,000 km^2 (approximately 1.4 times the area of Japan), accounting for 99.4 percent of the total area of the country. There are 70 Provinces, 688 Districts, 5,990 Tambons and 54,492 Villages in PEA's service area, with approximately 45 million of population.

The projects shown in the table below were implemented by PEA under the First to the Fifth National Economic and Social Development Plan, with the following objectives.

- Extension of the electrified areas
- Reinforcement of the facilities and improvement of the reliability
- Reduction of operation cost

Project	Completed projects	Projects under way	Investment cost (M.Baht)
Electrification project	10	3	16,500
Distribution system reinforcement project	16	2	7,340
Project for extension of distribution line to diesel power plants	2	1	930
Total	28	6	24,770

Making a comparison of the scales of PEA at the epoch of the establishment and 1985, the energy sales increased from 26.4 GWh to 8,557.1 GWh (324 times), and the assets increased from 87 M.Baht to 25,941.1 M.Baht (298 times). The growth accomplished during the 10-year period from 1975 to 1985 is shown in Table 3-1. Data shown in this table give a clear idea of the remarkable growth accomplished during the past 10 years.

The ratio of introduction of electricity in villages was 76 percent at the end of FY 1986, and PEA is implementing electrification projects with the target of increasing this ratio to 95 percent. The investment program planned by PEA under the Sixth National Economic and Social Development Plan (1987 - 1991) is shown in Table 3-2, and as can be seen, the electrification projects are expected to be almost completed in FY 1991.

Such being the case, it may be said that the PEA is facing a turning point from the stage of quantitative expansion to qualitative improvement, and in the long-term plan (1985 - 1991), importance is being attached to the reinforcement of the facilities, improvement of the operation and maintenance, and upgrading of the service level.

3-2 Organization of PEA

The organization of PEA consists of head office, regional offices, electric offices, customer service centers and customer service sub-centers.

The organization of head office is shown in Table 3-3. The technical body consists of 5 departments, planning and civil works,

engineering, operation and maintenance, service and construction, which are divided further into 13 divisions, the distribution system dispatching center and the training center. The administrative body consists of 4 departments, administration and personnel, economics and finance, accounting and procurement, which are divided further into 10 divisions, the data processing center and the medical service center. The head office of PEA is located in Bangkok. Most of the work done at head office is related to the projects, with a total number of approximately 5,000 employees.

The regional organization is shown in Table 3-4.

There are 3 regional offices in each one of 4 Areas, the Northern Area, Northeastern Area, Central Area and Southern Area, totalling 12 regional offices. These regional offices are located in the main cities of each region. The service areas of each regional office are shown in Fig. 3-1. The regional offices take charge of the coordination, planning and construction in responsible areas, with a total number of approximately 3,700 employees.

The electric offices take charge of the construction work, operation, maintenance and repair of the facilities, and customer service, and are classified into 1st grade to 4th grade electric offices according to the scale. The customer service centers take charge of the construction works, maintenance and operation of the facilities and customer service in responsible areas, and the customer service sub-centers are mainly in charge of customer service.

The existing number of offices, staffs and maintenance staffs are shown in the following table. The breakdown of each region is shown in Annexes 3-1 to 3-3.

Offices	No. of Offices	No. of Staffs	No. of Maintenance Staffs
Electric Offices	111	9,251	1,756
1st Grade	6	925	187
2nd Grade	34	3,838	738
3rd Grade	54	3,867	714
4th Grade	17	621	117
Customer S.C.	158	2,767	1,525
Customer S. Sub-C	1,033	1,893	1,893
Total	1,302	13,911	5,174

The number of staffs of each office averages 83 persons for electric offices (154 for 1st grade, 113 for 2nd grade, 72 for 3rd grade and 37 for 4th grade), 18 persons for customer service centers and 2 persons for customer service sub-centers. On the other hand, the number of maintenance staffs of each office averages 16 persons for electric offices (31 for 1st grade, 22 for 2nd grade, 13 for 3rd grade and 7 for 4th grade), 10 persons for customer service centers and 2 persons for customer service sub-centers.

As for the vehicles, 490 units are allotted to regional offices, 1,502 units to electric offices, 362 units to customer service centers and 43 units to customer service sub-centers, totalling 2,397 units, as shown in Annex 3-4. And as can be seen, the customer service sub-centers are provided with practically no vehicle at all. As for the types of vehicles, the existing cars consist of 750 units of construction cars, 961 units of maintenance cars and 686 units for other uses (service cars, etc.).

The offices provided with maintenance function consist of 111 electric offices and 158 customer service centers, totalling 269 offices, with a total number of 3,281 maintenance staffs. The service area of each office averages 1,925 km^2, and the average circuit length of high-voltage lines is of the order of 331 km. On the other hand, the maintenance staff per 100 circuit-kilometer of high-voltage lines is of the order of 3.7 persons. Making a comparison of these indexes with the corresponding ones of Japan, the average service area of each office is 4 times, the average circuit length of high-voltage lines is 0.4 times, and the maintenance staff per 100 circuit-kilometer of high-voltage lines is 3.7 times larger than that in Japan, respectively, and it is considered that there is no problem regarding the maintenance.

3-3 Electric Power Demand

(1) Past Records of Power Demand

The past records of power demand of PEA are shown in Table 3-5.

In FY 1985, the power demand amounted to 8,557 GWh in energy sales and 1,956 MW in peak load, with very high annual average growth rates being 12.8 percent and 13.4 percent, respectively, during the past 5 years. As for the energy sales by customer classifications, Residential accounted for 34.0 percent of the total energy sales, Business 16.3 percent, Industrial 44.4 percent and Others 5.2 percent in FY 1985. As for the annual average growth rate, Residential and Large

Industrial increased at particularly high rates of 16.4 percent and 14.4 percent, respectively. Making a comparison of the proportion by customer classifications with that of whole Thailand, it is observed that the proportion is almost same as that of whole Thailand for Industrial, while higher for Residential and lower for Business. The electrification ratio was 55.2 percent.

In FY 1985, the supply energy totalled 9,443.5 GWh, consisting of 9,423.9 GWh (99.79 percent) of purchased energy and 19.6 GWh (0.21 percent) of generated energy by PEA. The purchased energy consists of 9.391.0 GWh (99.44 percent) from EGAT, 17.5 GWh (0.19 percent) from MEA and 15.4 GWh (0.16 percent) from NEA. The loss ratio was 9.4 percent, and the annual load factor was 55.1 percent. PEA owns small-scale diesel power plants, with a total installed capacity being 72.9 MW. PEA has implemented projects to renounce diesel power plants by extending distribution lines for the sake of cost saving, and as a result more than 200 plants have been renounced so far, and 21 plants are in operation at the present time.

The past records of the number of customers served by PEA are shown in Table 3-6. At the end of FY 1985, the number of customers amounted to 4,054,200, of which 3,990,533 (98.4 percent) are residential customers. The annual average growth rate showed a very high rate of 16.5 percent during the past 5 years.

The energy sales by region in FY 1985 is shown in Annex 3-5. The Central Region accounted for 47.8 percent of the

total sales, 79.7 percent of Large Industrial sales and 48.5 percent of Small Industrial sales.

The daily load curves of substations are shown in Annexes 3-6-1 to 3-6-4. Annexes 3-6-1 and 3-6-2 show the daily load curves in dry season and rainy season of Samut Sakhon 1 Substation, which supplies power to industrial areas, on the other hand, Annexes 3-6-3 and 3-6-4 show the daily load curves in dry season and rainy season of Suphan Buri Substation which supplies power to rural areas. As can be seen, in Samut Sakhon 1 Substation the daily load curve is relatively flat, but in Suphan Buri Substation there are two peaks in the morning and evening, with the peak load recorded in the morning. The annual load factor by region is shown in Annex 3-7. The annual load factor is relatively low, with the highest record of 64.2 percent in Central Region 3 and the lowest record of 38.4 percent in Northeastern Region 2 in FY 1985.

(2) Power Demand Forecast

The forecast is made of the whole demand and each substation demand. The forecast of the whole demand is made for the energy sales by customer classifications, supply energy and peak load, and the forecast of each substation demand for the supply energy and peak load. The forecast is calculated on the basis of past trends, taking into consideration such factors as the electrification plans, economic situation, trends of big customers, etc.

The results of the forecast of whole demand are shown in Table 3-5. In FY 1995, the power demand is expected to amount to 19,185 GWh in energy sales and 3,877 MW in peak load, with the annual average growth rates being 8.4 percent and 7.1 percent, respectively. As for the annual average growth rate, Large Industrial and Residential are expected to increase at particularly high rates of 10.5 percent and 8.6 percent, respectively. The electrification ratio is expected to reach 76.0 percent.

In FY 1995, the supply energy is expected to total 21,015.6 GWh, consisting of 20,960.4 GWh (99.74 percent) of purchased energy and 55.2 GWh (0.26 percent) of generated energy by PEA. The increase of generated energy is attributable to the projects for the development of small-scale power plants to supply power in remote areas. The construction of solar energy power plants was completed in July, 1986 with the aid of the Government of Japan, and furthermore the development of small-scale hydro power and wind power plants are also being planned.

The forecast of the number of customers is shown in Table 3-6. The number of customers is expected to reach 6,432,540 at the end of FY 1995, with the annual average growth rate being 4.7 percent. The annual average growth rate of residential customers is expected to slow down to 4.7 percent.

The results of the forecast of substation demand by region are shown in Annexes 3-8-1 and 3-8-2. The growth rates are expected to be relatively high in Central Region 2,

Southern Region 3 and Northern Region 1. The development of the Central Region 2 is being carried out under the Eastern Seaboard Development Project, and it is expected to become the future industrial and economic center of the country, as well as the gateway for the international trade. As for the Southern Region 3, the urban development projects of Hat Yai and Song Khla are being planned. On the other hand, the Northern Region 1 comprises the second largest city of the country, and is listed atop the main urban development projects of the Kingdom of Thailand. The Northern Region Industrial Estate Project is being planned therein. Importance is being attached to the tourism development as well.

3-4 Present Status of Power Facilities

(1) Substations

The data related to substations, sorted by region, are shown in Table 3-7. Detailed data of each substation are shown in Annexes 3-9-1 to 3-9-12, and the locations of various substations are shown in Annexes 3-10-1 to 3-10-12.

The distribution system of PEA is supplied power from 123 substations, with 194 units of transformers and the installed capacity of 3,975 MVA. All substations are owned by EGAT, with exception of 3 substations owned by PEA. PEA owns only the circuit breakers of high-voltage feeders. As for the capacities of units, 22 kinds ranging from 1 MVA to 50 MVA are used, with the most common units being 25 and 40 MVA. The number of installed circuit breakers amounts to 499 units.

PEA has control stations adjacent to the substations of EGAT, and the control stations are operated with one operator working in 3 shifts. At the control stations the circuit breakers of the high-voltage feeders are installed outdoors, and on the other hand the switchboard, power supply equipment, radio equipment, etc., are installed in the control room. There are 4 types of control rooms, with Type 1 sized 7 x 12 m, Type 2 sized 7 x 15 m, Type 3 sized 7 x 21 m, and Type 4 sized 14 x 14 m. Type 3 and Type 4 control rooms are for 115 kV and 69 kV substations. As things now stand, there are 67 control stations, and for the remaining 56 substations the reclosers are mostly installed at the outgoing feeders. PEA has established the policy to install control stations for all substations, and as a matter of fact there are 12 of them under construction, and 26 more being planned.

The protective equipment consists of the overcurrent relays, grounding relays and reclosing relays.

(2) Distribution System

The high-voltage distribution system has 4 voltage classes, 33 kV, 22 kV, 11 kV and 3.5 kV, consisting of 14.6 percent of 33 kV, 84.4 percent of 22 kV, and 1.0 percent of 11 kV. The 33 kV system, with the 3-phase 4-wire multiple grounding system, is being used in Southern Regions 2 and 3, in part of Southern Region 1 (Ranong), and in part of Northern Region 1 (Chiang Rai and Phayao). The 22 kV system, with the 3-phase 3-wire solidly grounding system, is being used in the

other regions. The 11 kV and 3.5 kV systems are being converted to 22 kV and 33 kV. The outline of distribution facilities is shown in Table 3-8.

There are 564 feeders of high-voltage distribution lines totaling 89,064 circuit-kilometers, and the average circuit length per feeder is very long, reaching 158 km. The distribution lines are particularly long in Northeastern Region 2, with the average circuit length per feeder being 327 km. The conductors are of bare aluminum and ACSR, with the latter one being used for long spans. The conductor sizes being used are 240 mm^2 (transmission capacity of 23.8 MVA at 22 kV), 185 mm^2 (19.8 MVA), 120 mm^2 (14.8 MVA), 95 mm^2 (12.9 MVA), 70 mm^2 (10.2 MVA), 50 mm^2 (8.5 MVA), 35 mm^2 (6.8 MVA) and 25 mm^2 (5.5 MVA). The aerial cables are used in part of the outgoing lines of substations where many feeders are installed side by side. There is practically no use of underground cables. Most of the supporting structures consist of concrete poles, and the cross arms are also made of concrete.

The installed capacity of pole-mounted transformers reaches 7,312 MVA. As for the unit capacities, there are 13 varieties of transformers currently in use, with the single phase ones having 10, 20 and 30 kVA and the three-phase ones ranging from 50 kVA to 2,000 kVA.

The number of reclosers installed on the long-distance distribution lines for the sake of protection amounts to 423 units. There are two types of reclosers being used, hydraulic type and electronic type, and most of the existing units are of hydraulic type. The remote control of reclosers is impossible for the hydraulic type, and is possible for the

electronic type with the addition of control circuit. The number of switches installed on the high-voltage distribution lines amounts to 2,023 units. Most of these switches are of manual type, and 10 units of sectionalizers are being used for trial purpose. The switches are installed at the rate of 1 unit for every 30 km of circuit length. Moreover, 30,137 sets of fuses are installed on the spur lines.

There are 85 units of automatic voltage regulators installed on the long-distance distribution lines. The present status of voltage is by no means satisfactory, and the future implementation of the measures to improve the voltage is regarded as indispensable. The voltage regulation is operated with a permissible voltage drop ratio of 10 percent.

(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 being used for voice communication in simplex operation.

The present status of radio stations is shown in Table 3-9. There are 1,859 VHF stations being used in all regions, and 108 UHF stations being used in 3 regions (N1, C1 and C3). HF radio is used for the communication between head office and regional offices, and between regional offices and remote offices of each Region. There are 19 VHF repeater stations, with 11 stations located at flatlands and 8 stations located atop mountains. Two-frequencies carrier system is used in repeater stations, and there is no tandem repeater stations.

Eight (8) VHF waves, 4 UHF waves and 3 HF waves are used as shown in Table 3-10. Besides the said waves, the PEA has

already reserved 12 UHF waves (400 MHz band). The information on the present status of radio frequencies used in Thailand can not be available officially, but according to the unofficial information there is some room for additional waves in 400 MHz and 900 MHz bands, and a considerable room in 2,000 MHz band.

The present status of frequency being used in each Region is shown in Table 3-11. For the VHF radio, 8 waves (4CH), 6 wave (3CH), 4 waves (2H) and 2 waves (1CH) are being used in 4 Regions, 1 Region, 2 Regions and 5 Regions, respectively. For the UHF radio, 2 waves (1CH) are being used in 3 Regions.

As things now stand, PEA is carrying out the data transmission between Head Office and Central Region 1 Office (Ayuttaya) by leasing a communication channel of TOT (Telephone Organization of Thailand), but PEA has no plan to lease more channels in the future because the lease charge is expensive.

The results of investigation of radio routes carried out during the field survey are shown in Table 3-12. The radio wave test was carried out in Central Region 3, on the other hand the survey of repeater station sites and the merit evaluation by voice communication were carried out in Northern Region 1, Northeastern Region 1, Central Region 1 and Southern Region 2. It was found as a result of investigation that there are some routes with wrong transmission quality because of the long-distance transmission, obstruction by mountains, etc. Furthermore, the improvement of reliability is also necessary in connection with the facilities.

3-5 Present Status of Power Faults

The record of power faults occurred during the one-year period from August, 1985 to July, 1986 is shown in Table 3-13, and the details are shown in Annexes 3-11-1 to 3-11-4.

The frequency of faults and duration of supply interruption per feeder are very frequent and long, amounting to 14 times and 30 hours during the one year period. Making a comparison of these records with the corresponding ones of Japan, the frequency is 31 times larger and the duration is 100 times longer. The energy sales per feeder is 1.6 times larger. The high frequency of faults per feeder in Southern Region is attributable to the frequent faults caused by the contact of lines with trees, and on the other hand the long duration per feeder in Northeastern Regions 1 and 2 is attributable to the long distance of high voltage distribution lines. The average duration per fault is 2.16 hours. As for the duration of each fault, the duration of less than 1 hour accounts for 49.3 percent of total faults, 1 hour - less than 3 hours 31.0 percent, 3 hours - less than 5 hours 9.9 percent, 5 hours - less than 10 hours 6.9 percent and 10 hours or more 2.9 percent.

The frequency of faults in one Region per year ranges from a maximum of 844 times (S3) to a minimum of 460 times (N3), and averages 654 times. The frequency of faults in one Region per month ranges from a maximum of 142 times (N1) to a minimum of 10 times (N2), and averages 55 times, representing a very large fluctuation from month to month. The frequency of fault is lowest during the month from December to February.

As for the causes of faults, the facilities account for 22.8 percent, trees 16.7 percent, birds and animals 9.1 percent, unknown causes 24.9 percent and other causes 26.5 percent. The faults caused by lightning, wind and flood are included in the classification "other causes".

Table 3-14 shows the survey result of the losses of big customers by supply interruptions. The data were obtained from the eight customers out of 11 customers surveyed. During the one year period, the eight customers experienced a total of 217 supply interruptions, with 189 hours in duration, 499 MWh in interruption energy and 33.1 M.Baht in losses. The losses of these customers by supply interruptions average 66.3 Baht per 1 kWh of interruption energy. However, the losses of each customer per 1 kWh of interruption energy differs greatly from customer to customer. For the reason, the losses of big customers was determined to be 54.62 Baht/kWh from the correlation between the cumulative interruption energy and cumulative losses shown in Fig. 3-2. The interruption energy for big customers in FY 1986 is estimated at 6,690 MWh (see Annex 9-2), with the total losses amounting to 365 M. Baht.

Of the eight big customers, Thai Toray (textile factory) suffered most with its loss amounting to 18.1 M.Baht, of which 13.9 M.Baht was the loss suffered in the dyeing process.

3-6 Present Status of Education and Training

PEA is laying special emphasis on the development of human resources with the objective of coping with the new technologies

and improving the work efficiency. In this connection, the construction of Training Center was started 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 in succession. The Training Center is located in Nakhorn Chaisri, Nakhorn Pathom Province, approximately 40 km to the west of Bangkok, and the site is sized approximately 81,000 m^2.

There are 32 training courses in the technical field, as shown in Table 3-15. Fifty (50) technical training courses were conducted in FY 1985 for 2,067 persons. Of the said courses there are 6 courses related to distribution dispatching system, and 16 courses for 512 persons were conducted in FY 1985. The curricula of courses related to the distribution dispatching system are shown in Annexes 3-12-1 to 3-12-6.

3-7 Power Tariff

The power tariff structure of PEA is shown in Table 3-16. An uniform power tariff is enforced all over the country. There is no demand charge for Residential and Small Business (under 30 kW), and only energy charge is applied for these customers. The larger the energy consumption the more expensive the unit energy price. In the case of Residential customers there are considerable differences in the unit price according to the energy consumption, ranging from a maximum of 2.11 Baht/kWh to a minimum of 0.7 Baht/kWh. The power charge is especially cheap when the monthly consumption does not exceed 35 kWh, with the unit price being 0.93 Baht/kWh for the consumption of 35 kWh. The average unit price of sold energy amounted to 1.69 Baht/kWh in FY 1985.

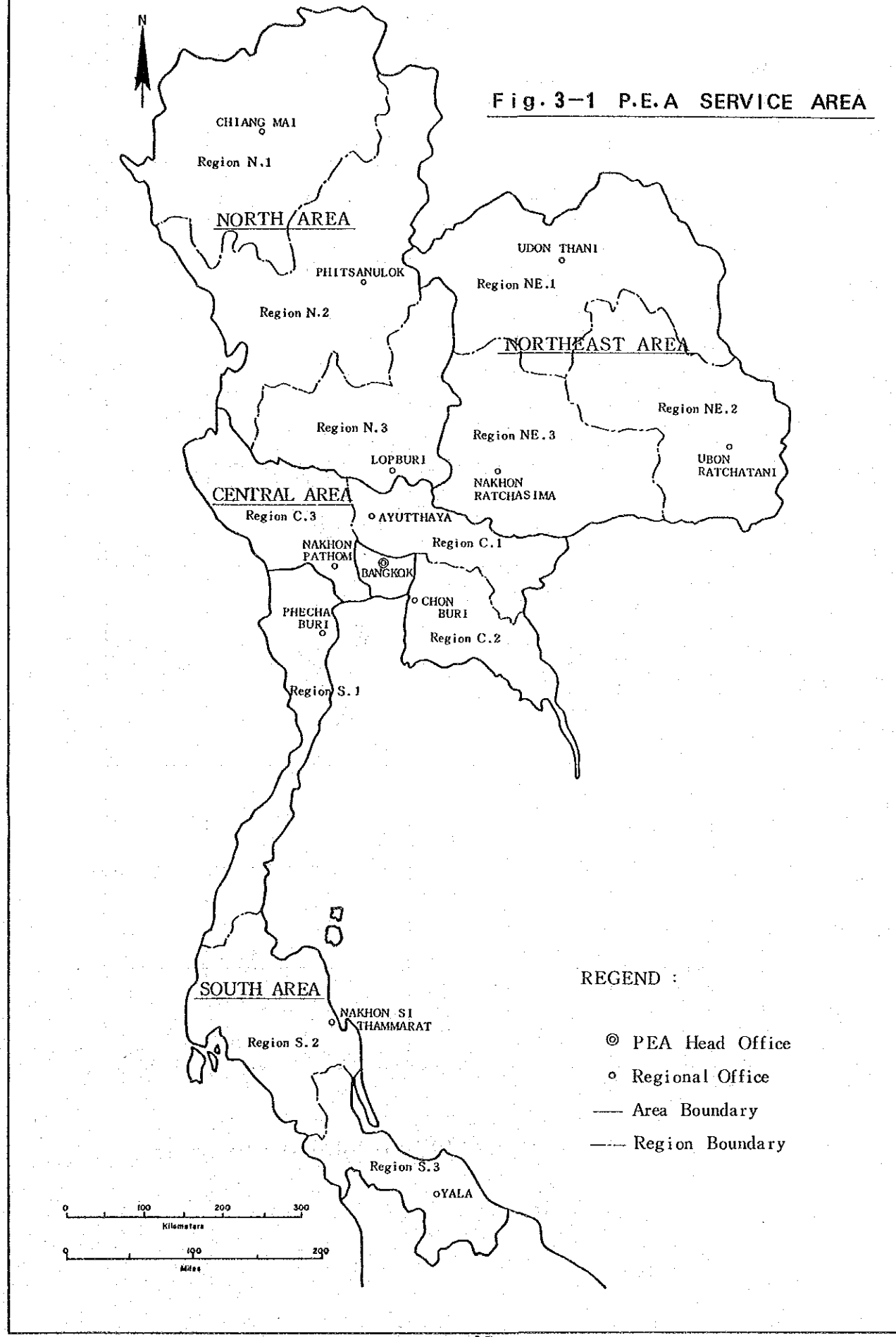


Fig. 3-1 P.E.A SERVICE AREA

Fig 3-2 INTERRUPTION ENERGY DAMAGE & LOSS CURVE

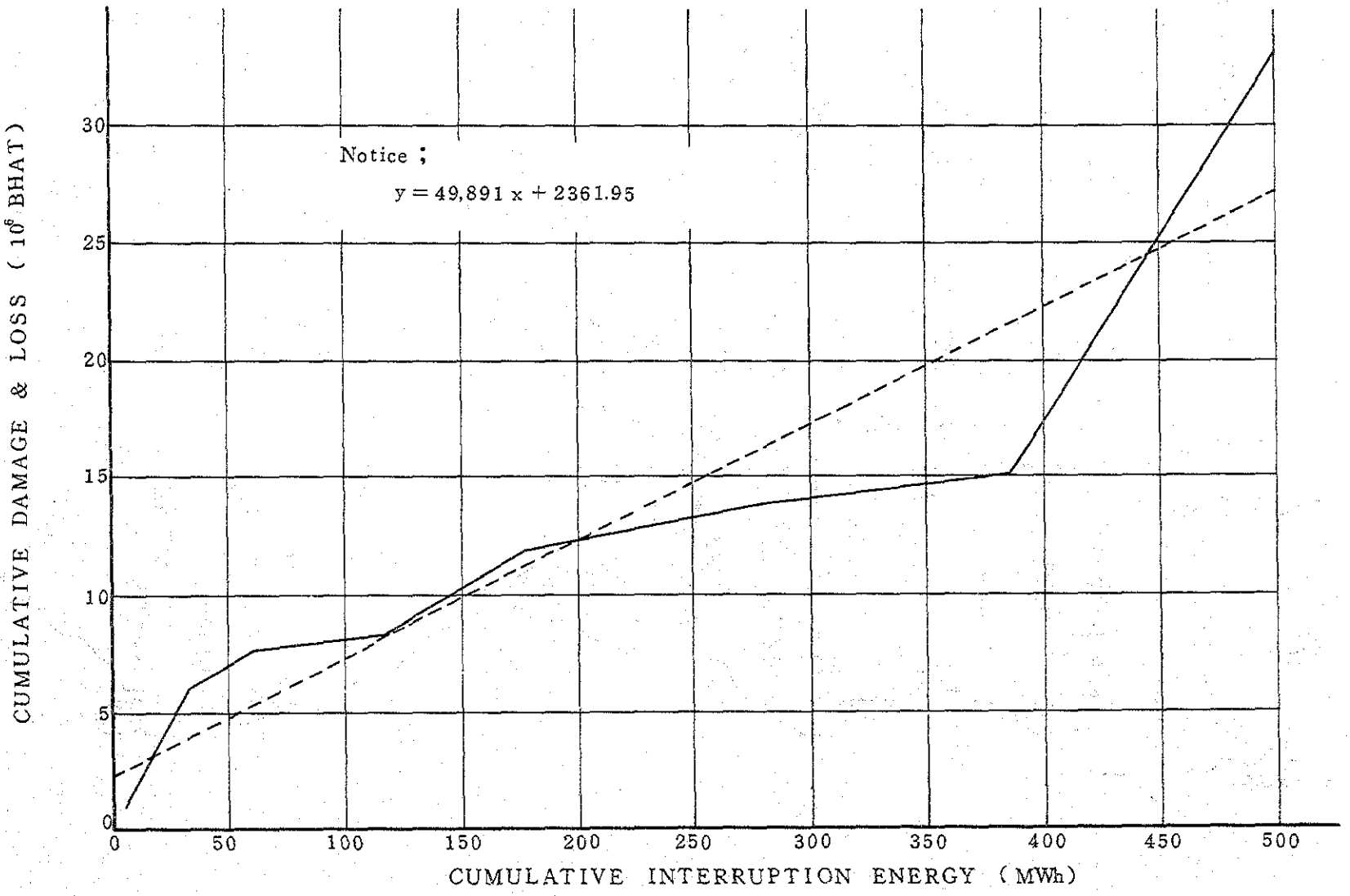


Table 3-1 TEN YEAR GROWTH STATISTICS

(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 INVESTMENT PROGRAM OF PEA

(Unit: M.Bahts)

Projects	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
Projects under the fifth National development plan										
Power distribution system reinforcement project, 3rd stage					307.9	429.6	827.3	805.1	556.8	
Village electrification project, 1st & 2nd stage					433.4	270.0	355.3			
Accelerated rural electrification project, 2nd stage					1,068.0	475.5	194.3			
Normal rural electrification project, 1st stage					809.7	472.8				
Mini-hydro project					145.7	62.0	127.5	211.5	70.0	
Other projects					254.3					
Projects under the sixth National development plan										
Power distribution system reinforcement project, 4th stage							405.5	1,415.0	1,995.0	540.0
Village electrification project, 3rd stage							642.0	796.0	676.0	
Normal rural electrification project, 2nd stage							172.0	671.0	385.0	312.0
Other projects						10.0	51.0	56.0	3.0	
Total	2,979.9	3,015.0	3,584.2	3,660.2	3,019.0	1,719.9	2,909.4	3,954.6	3,685.8	852.0

Table 3-3 ORGANIZATION · CHART

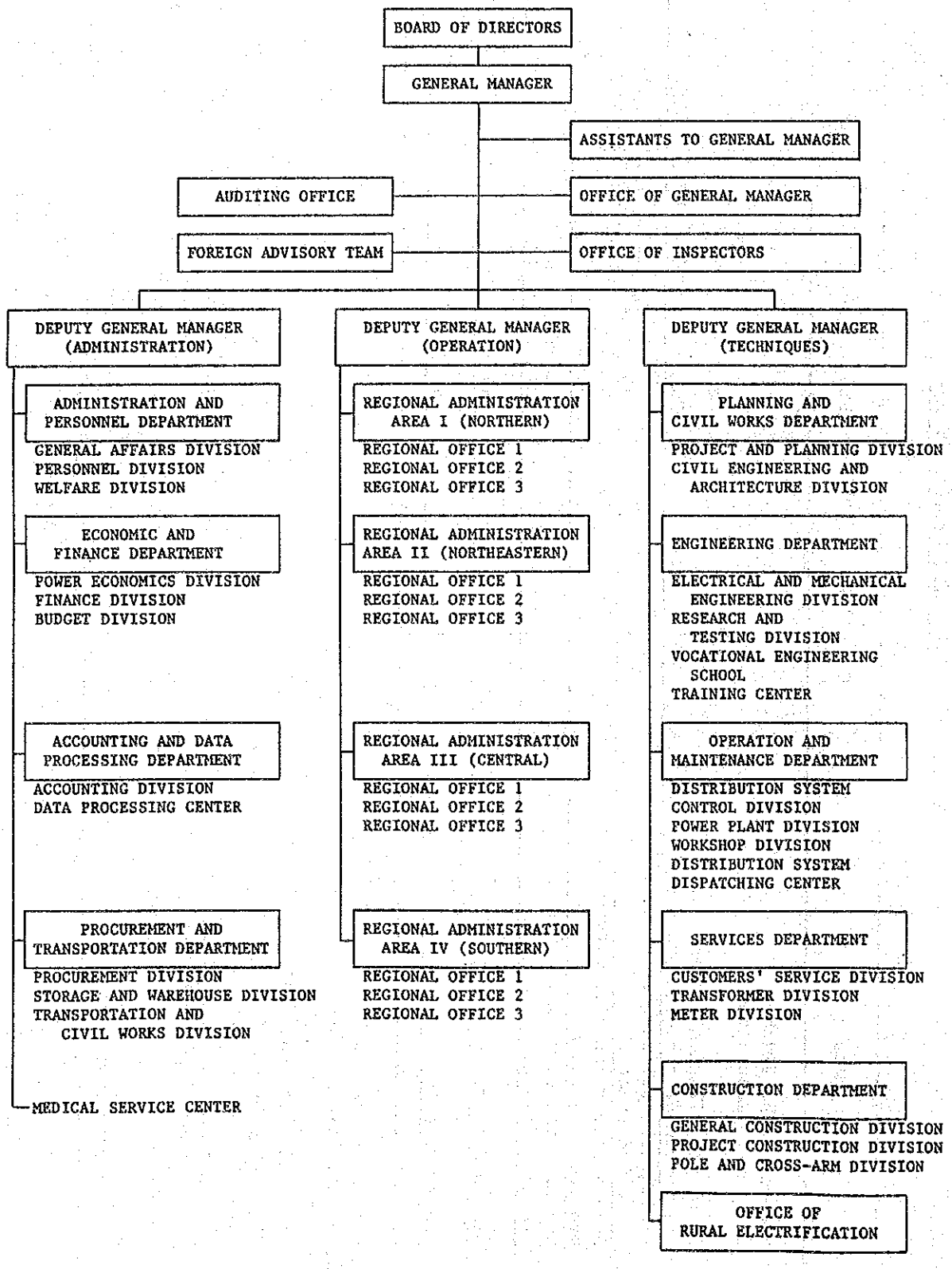


Table 3-4 REGIONAL ORGANIZATION CHART

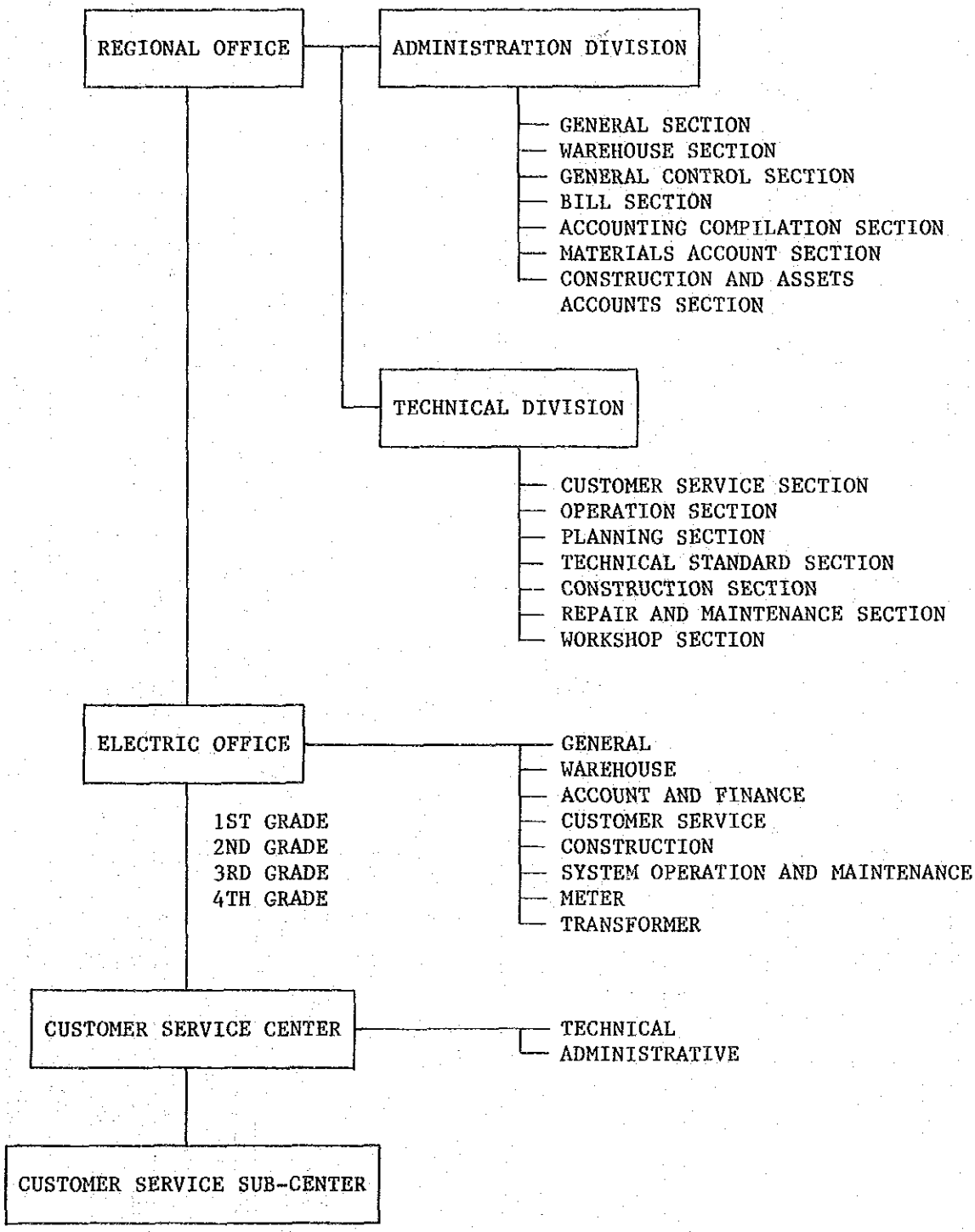


Table 3-5 POWER DEMAND OF PEA

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 3-6 NUMBER OF CUSTOMERS OF PEA

Items	Actual											Growth Rate (%/year)
	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	
Residential	768,160	911,751	1,123,927	1,324,245	1,542,308	1,849,911	2,230,216	2,678,925	3,135,647	3,562,977	3,990,533	16.6
Small Business	8,455	10,465	14,579	18,496	22,166	25,168	28,060	31,201	35,460	39,883	45,297	12.5
Large Business	602	770	871	962	1,123	1,406	1,586	1,702	1,537	1,718	1,977	7.1
Small Industrial	-	-	-	-	-	1,548	1,897	2,163	2,321	2,572	2,820	12.7
Large Industrial	-	-	-	-	-	187	196	221	237	273	309	10.6
Others	4,255	4,412	4,766	6,138	8,442	7,415	8,414	8,322	10,750	12,159	13,264	12.3
Total	781,472	927,398	1,144,143	1,349,841	1,574,039	1,885,635	2,270,369	2,722,534	3,185,952	3,619,582	4,054,200	16.5

Items	Forecast											Growth Rate (%/year)
	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995		
Residential	4,383,608	4,840,380	5,214,541	5,486,219	5,716,640	5,933,300	6,049,000	6,148,808	6,228,743	6,294,767		4.7
Small Business	50,196	55,202	60,418	65,805	71,393	77,175	83,123	89,223	95,443	101,764		8.4
Large Business	2,144	2,316	2,495	2,678	2,866	3,060	3,256	3,456	3,659	3,864		6.9
Small Industrial	3,023	3,229	3,441	3,660	3,888	4,122	4,364	4,614	4,872	5,140		6.2
Large Industrial	398	451	488	524	559	596	633	670	708	745		9.2
Others	14,378	15,541	16,748	17,996	19,282	20,607	21,968	23,364	24,796	26,260		7.1
Total	4,453,747	4,917,119	5,298,131	5,576,882	5,814,628	6,038,860	6,162,344	6,270,135	6,358,221	6,432,540		4.7

Table 3-7 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 3-8 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 3-9 COMMUNICATION FACILITIES

Regions	VHF Station				UHF Station				HF St.
	Master Station	Sub Station	Mobile Station	Repeater	Master Station	Sub Station	Mobile Station	Repeater	
Northern									
Region 1	45	55	74	4	1	11	11		4
Region 2	35	66	60	2					4
Region 3	27	54	55	3					3
Sub-Total	107	175	189	9	1	11	11	0	11
Northeastern									
Region 1	41	96	63	2					6
Region 2	26	89	60	1					2
Region 3	16	71	66	1					2
Sub-Total	83	256	189	4	0	0	0	0	10
Central									
Region 1	23	72	71		1	19	19		
Region 2	12	54	92	1					
Region 3	11	48	46		1	24	19		
Sub-Total	46	174	209	1	2	43	38	0	0
Southern									
Region 1	25	47	58	2					3
Region 2	42	55	64	1					5
Region 3	9	57	52	2					3
Sub-Total	76	159	174	5	0	0	0	0	11
Head office	3					2			2
TOTAL	315	764	761	19	3	56	49	0	34

Table 3-10 RADIO FREQUENCY

System		Channel	Frequency (MHz)		Remarks
			Tx	Rx	
VHF	Master	CH 1 CH 2 CH 3 CH 4	171.250 171.300 171.350 171.400	165.500 165.550 165.600 165.650	
	Repeater Sub. Mobile	CH 1 CH 2 CH 3 CH 4	165.500 165.550 165.600 165.650	171.250 171.300 171.350 171.400	
UHF I	Master	CH 1	457.025	460.175	
	Sub. Mobile	CH 1 CH 1	460.175 457.025	457.025 457.025	
UHF II	Master	CH 2	457.125	460.275	
	Sub. Mobile	CH 2 CH 2	460.275 457.125	457.125 457.125	
UHF III			450.650 450.675 450.750 450.725 470.300 470.325	460.150 460.200 460.225 460.250 475.300 475.325	Reserved
HF		CH 1 CH 2 CH 3	7.541 7.960 8.145	7.541 7.960 8.145	

Table 3-11 PRESENT STATUS OF FREQUENCIES USED IN EACH REGION

Region \ Frequency Band	150 MHz	400 MHz
N1	CH 1, 2, 3, 4	CH 2
N2	CH 1, 2, 3, 4	
N3	CH 2	
NE1	CH 1, 2, 3, 4	
NE2	CH 1	
NE3	CH 1, 2	
C1	CH 2, 3	CH 1
C2	CH 2	
C3	CH 2	CH 2
S1	CH 1, 2, 3, 4	
S2	CH 1, 2, 3	
S3	CH 2	

Table 3-12 INVESTIGATION RESULTS OF RADIO WAVE ROUTES

Region	Route	Field Strength		Remarks
CENTRAL Region 3	KHAO PHU LIAB - REGIONAL OFFICE	26 dB/uV	OK	*1 Additional repeater station at Suphanburi SS will be required *2 Direct transmission from Regional Office will be possible
	KHAO PHU LIAB - NONG RI	30	OK	
	KHAO PHU LIAB - SAI YOK	23	OK	
	KHAO PHU LIAB - SUPHANBURI SS	16	OK	
	KHAO PHU LIAB - SAM CHUK	6	*1 NG	
	KHAO PHU LIAB - SAMUT SAKHON SS	-	*2 NG	

Region	Route	Evaluation		Remarks
CENTRAL Region 1	RANGSIT - NAKHON NAYOK	M-4	OK	*1 Field strength fluctuation was found to be 5-8 dB/uV
	REGIONAL OFFICE - NAKHON NAYOK	M-4	OK	
	PRACHIN BURI - KHAO YAI - RANGSIT	M-5	OK	
	PRACHIN BURI - KHAO YAI - REGIONAL OFFICE	M-5	OK	
	PRACHIN BURI - RANGSIT	M-4	*1	
NORTHERN Region 1	DOI INTANON - REGIONAL OFFICE	M-4	OK	*1 Improvement is expected by means of antenna *2 Additional repeater station will be required
	DOI INTANON - CHIANG RAI	M-3	*1	
	DOI INTANON - LAMPANG	M-3	*1	
	DOI INTANON - FANG	M-3	*1	
	DOI INTANON - PHAYAO	M-2	*2 NG	
	DOI INTANON - LAMPHUN	M-4	OK	
	NGAO - DOI INTANON - LAMPHUN	M-3	*1	
	NGAO - DOI INTANON - REGIONAL OFFICE	M-3	*1	
	NGAO - PHAYAO	M-2	NG	
NORTHEASTERN Region 1	KHAO PHU PHAN - REGIONAL OFFICE	M-5	OK	*1 Improvement is expected by means of antenna
	KHAO PHU PHAN - NAKHON PHANOM	M-5	OK	
	KHAO NUM NAO - LOEI	M-5	OK	
	KHAO NUM NAO - KNON KAEN	M-4	OK	
	KHAO NUM NAO - REGIONAL OFFICE	M-3	*1	
	KHAO NUM NAO - NONG KHAI	M-4	OK	
SOUTHERN Region 2	KHAO THAN PHO - REGIONAL OFFICE	M-4	OK	
	KHAO THAN PHO - SURAT THANI	M-4	OK	
	KHAO THAN PHO - TRANG	M-4	OK	
	KHAO THAN PHO - KRABI	M-2	NG	
	KHAO THAN PHO - PHUKET	M-2	NG	
	REGIONAL OFFICE - KRABI	M-4	OK	
	REGIONAL OFFICE - KRABI - PHUKET	M-4	OK	
	REGIONAL OFFICE - KRABI - TRANG	M-3		
	REGIONAL OFFICE - TRANG	-	NG	
	REGIONAL OFFICE - KANCHANADIT - SURAT THANI	M-3		

Table 3-13 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 3-14 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	-	-

Table 3-15 TRAINING COURSE

1. Lineman
2. Distribution System Construction
3. Distribution System Operation and Maintenance
4. Customer Service
5. Technician for Customer Service Center
6. Technician for Customer Service Sub-Center
7. Energy Metering
8. Recloser
9. Switchgear
10. Transformer Installation and Maintenance
11. Voltage Regulator
12. Capacitor
13. Distribution Control Station Operators
14. Distribution Control Station Operation (on-Site)
15. Substation Operation
16. Distribution System Dispatching Center Operator
17. Distribution System Dispatching Center Operation for Engineers
18. Hotlineman
19. Chief Hotlineman
20. Hydraulic Crane Truck for Driver
21. Hydraulic Crane Truck for Supervisor
22. Hydraulic Crane Maintenance and Repair
23. Trailer Truck for Driver
24. Forklift Truck for Driver

25. Heavy Truck for Driver

26. Automobile Tachograph Analysis

27. Diesel Generating Set Maintenance

28. Safety Inspector

29. Safety Engineer

30. Safety for Distribution System Construction Supervisor

31. Fuel Oil and Lubricant

32. Train-the-Trainer

Table 3-16 TARIFF STRUCTURE OF ELECTRICITY DISTRIBUTORS (MEA, PEA)

1. Residential Service

Energy Charge:	First	5 kWh or less	5.00 Baht
	Next	10 kWh	0.70 Baht/kWh
	Next	10 kWh	0.90 Baht/kWh
	Next	10 kWh	1.17 Baht/kWh
	Next	65 kWh	1.65 Baht/kWh
	Next	50 kWh	1.75 Baht/kWh
	Next	150 kWh	1.83 Baht/kWh
	Next	100 kWh	2.04 Baht/kWh
	Over	400 kWh	2.11 Baht/kWh

Minimum Charge: Baht 5.00 per month

2. Small Business (Under 30 kW)

Energy Charge:	First	40 kWh or less	89.72 Baht
	Next	260 kWh	1.81 Baht/kWh
	Next	700 kWh	1.92 Baht/kWh
	Next	2,000 kWh	2.04 Baht/kWh
	Over	3,000 kWh	2.21 Baht/kWh

Minimum Charge: Baht 89.72 per month

3. Large Business (Over 30 kW)

Demand Charge:			98.00 Baht/kW
Energy Charge:			1.52 Baht/kWh

4. Small Industrial (30-499 kW)

Demand Charge:			98.00 Baht/kW
Energy Charge:	First	50 kWh	1.46 Baht/kWh
	Next	150 kWh	1.45 Baht/kWh
	Next	200 kWh	1.44 Baht/kWh
	Over	400 kWh	1.43 Baht/kWh

5. Large Industrial (Over 500 kW)

Demand Charge:			90.00 Baht/kW
Energy Charge:	First	200 kWh	1.44 Baht/kWh
	Next	280 kWh	1.43 Baht/kWh
	Over	480 kWh	1.41 Baht/kWh

6. Large Industrial (OFF-PEAK)

OFF-PEAK		
Demand Charge:		65.00 Baht/kW
Energy Charge:		1.40 Baht/kW
ON-PEAK		
Demand Charge:		115.00 Baht/kW
Energy Charge:		1.40 Baht/kW

7. Temporary

Demand Charge:	30.00 Baht/kW

8. Special Rate

Demand Charge:		87.00 Baht/kW
Energy Charge:		0.9361 Baht/kW

9. Water Work and Irrigation

Energy Charge:	First	100 kWh or less	117.00 Baht/kW
	Over	100 kWh	1.17 Baht/kW

Minimum Charge: Baht 117.00 per month

Note: Effective April, 1983

Chapter 4

PRESENT STATUS AND PROBLEMS OF DISTRIBUTION DISPATCHING SYSTEM

Chapter 4

PRESENT STATUS AND PROBLEMS OF DISTRIBUTION DISPATCHING SYSTEM

4-1 Organization of Distribution Dispatching System

The distribution system dispatching center of PEA consists of a central distribution system dispatching center and 12 regional distribution system dispatching centers.

The central distribution system dispatching center belongs to the operation and maintenance department of head office, as shown in Table 3-3, and takes charge of the following duties.

- Establishment of the regulations and standards of distribution dispatching system
- Analysis and planning of distribution dispatching system
- Study of the operation of distribution dispatching system
- Study and application of new techniques and equipment
- Education and training

The regional distribution system dispatching center is under the control of the operation section of regional office, as shown in Table 3-4, and takes charge of the dispatching duties in responsible area of regional office, with 2 operators working in 3 shifts. The number of substations and high-voltage feeders under the control of regional distribution system dispatching centers are shown in Table 3-7. In Central Region 1, which has the largest scale, there are 13 substations and 75 feeders.

4-2 Dispatching Operation System

The issue of dispatching commands and the exchange of information within the area under the control of regional office are carried out directly by radio between the regional distribution system dispatching center and the control stations, electric offices, customer service centers, customer service sub-centers, mobile radio stations, as shown in Table 4-1.

4-3 Fault Handling Procedure

The Fault handling procedure of distribution lines is shown in Table 4-2. The outline of the procedure is summarized in the followings.

(1) Collection of Fault Information

There are 3 routes for the regional distribution system dispatching center to collect the fault information.

(a) Control station -- Regional distribution system dispatching center
(When the circuit breaker of control station is tripped.)

(b) Office / service center -- Regional distribution system dispatching center
(When the circuit breaker of substation without control station is tripped or when the recloser is tripped.)

(c) Customer -- Office / service center -- Regional distribution system dispatching center

(Same as Case (b))

The notifications of customer to the office / service center are done either by telephone or directly in person. The notifications between the PEA organs concerned are done by radio.

(2) Fault Handling Procedure

The procedures to be taken after the regional distribution system dispatching center receives the fault information are described in the followings.

(a) The regional distribution system dispatching center examines the fault information, and give the commands to maintenance crews of the offices / service centers to investigate the faulty point. The command issuing route is as mentioned in Clause 4-2. The maintenance crews and vehicles are distributed to the offices / service centers as mentioned in Clause 3-2.

(b) The maintenance crews patrol the service area by mobiles, and when they discover the faulty point they take the emergency countermeasures and inform the regional distribution system dispatching center of the situation.

(c) The regional distribution system dispatching center directs the system operation and restoration works to maintenance crews.

(d) The maintenance crews restore the system by carrying out the restoration works. When the restoration works are difficult, the maintenance crews inform the regional distribution system dispatching center of the fact once again.

4-4 Evaluation of Present Status and Problems of Distribution Dispatching System

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 distribution system dispatching center takes charge of distribution dispatching task in the service area of regional office, is regarded as appropriate in view of the following reasons.

(a) The scale of distribution system in Central Region 1, which is the largest one, consists of 13 substations and 75 high voltage feeders, and therefore it is possible to be covered from a single dispatching center.

(b) The maintenance crews are distributed throughout the electric offices and customer service centers, and there is no problem regarding the maintenance.

(2) The following problems are identified in connection with the collection of fault information.

(a) When the circuit breaker of substation where the control station is not installed is tripped, the fault information is collected from the offices / service centers, or from customers via the offices / service centers. In this case it is necessary to confirm the operation of circuit breakers, requiring rather long time for the confirmation of fault. In particular, the notifications from customers take very long time in the areas where the public telephone service is not available.

(b) When the recloser is tripped, the operation of recloser is detected very rarely at the control station. Therefore, the collection of the fault information is done in the same way as in (a) above. Furthermore, it is necessary to confirm the operation of recloser, requiring considerably long time for the confirmation of fault.

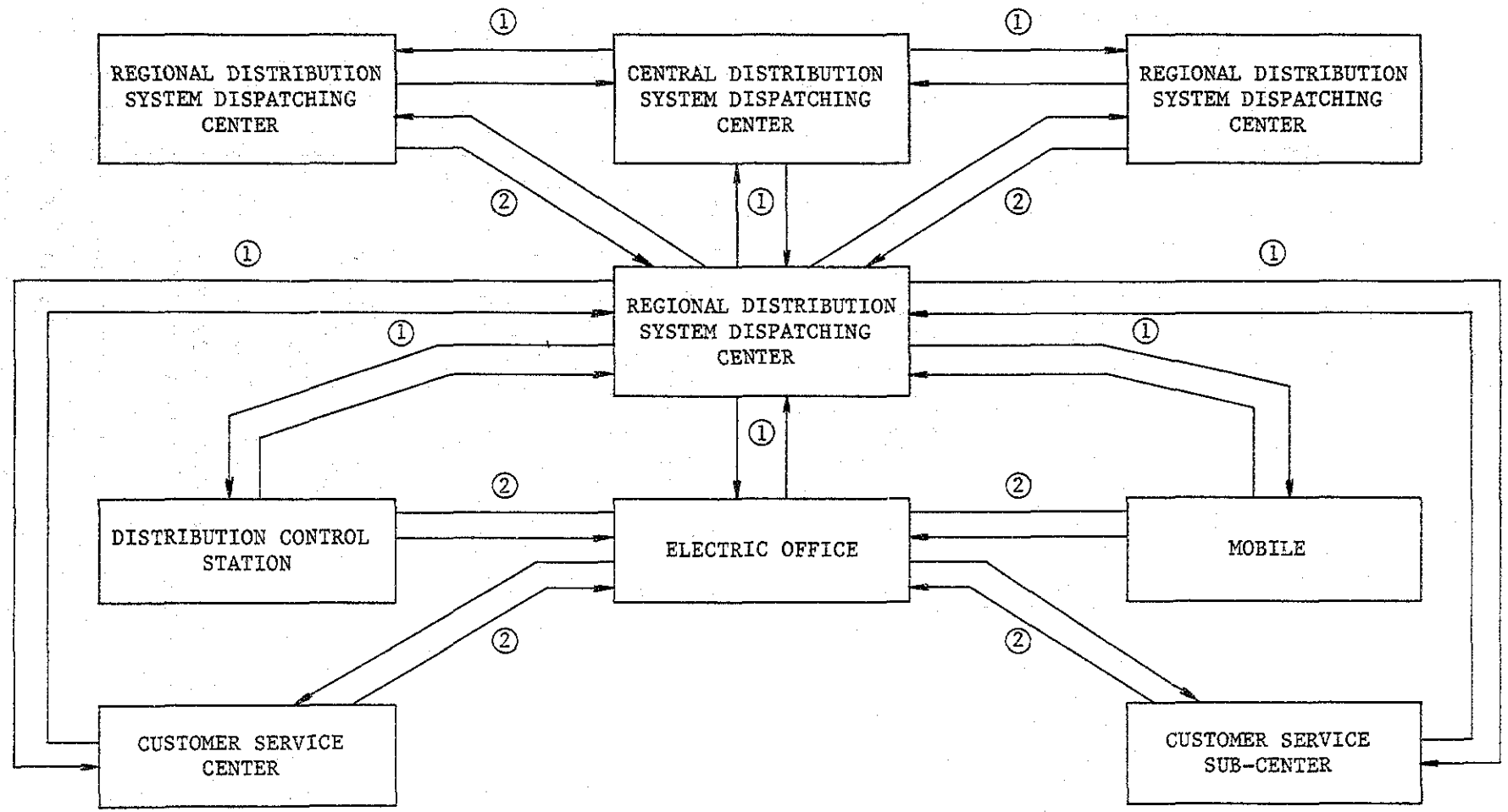
(3) The investigation of faulty section, and the system operation for interchanging power to sound section are carried out manually according to the commands issued at the distribution system dispatching center. That being so, long time is

required for the detection of faulty section and system switchover.

(4) As a consequence of the said situation, the supply interruption becomes long whenever a fault occurs in the system, in addition, the faults occur frequently, causing the frequent complaints from customers.

(5) Results of survey of big customers indicate that the damages/losses attributable to supply interruption amount to huge sums, as described in Clause 3-5, causing the considerable losses to the national economy.

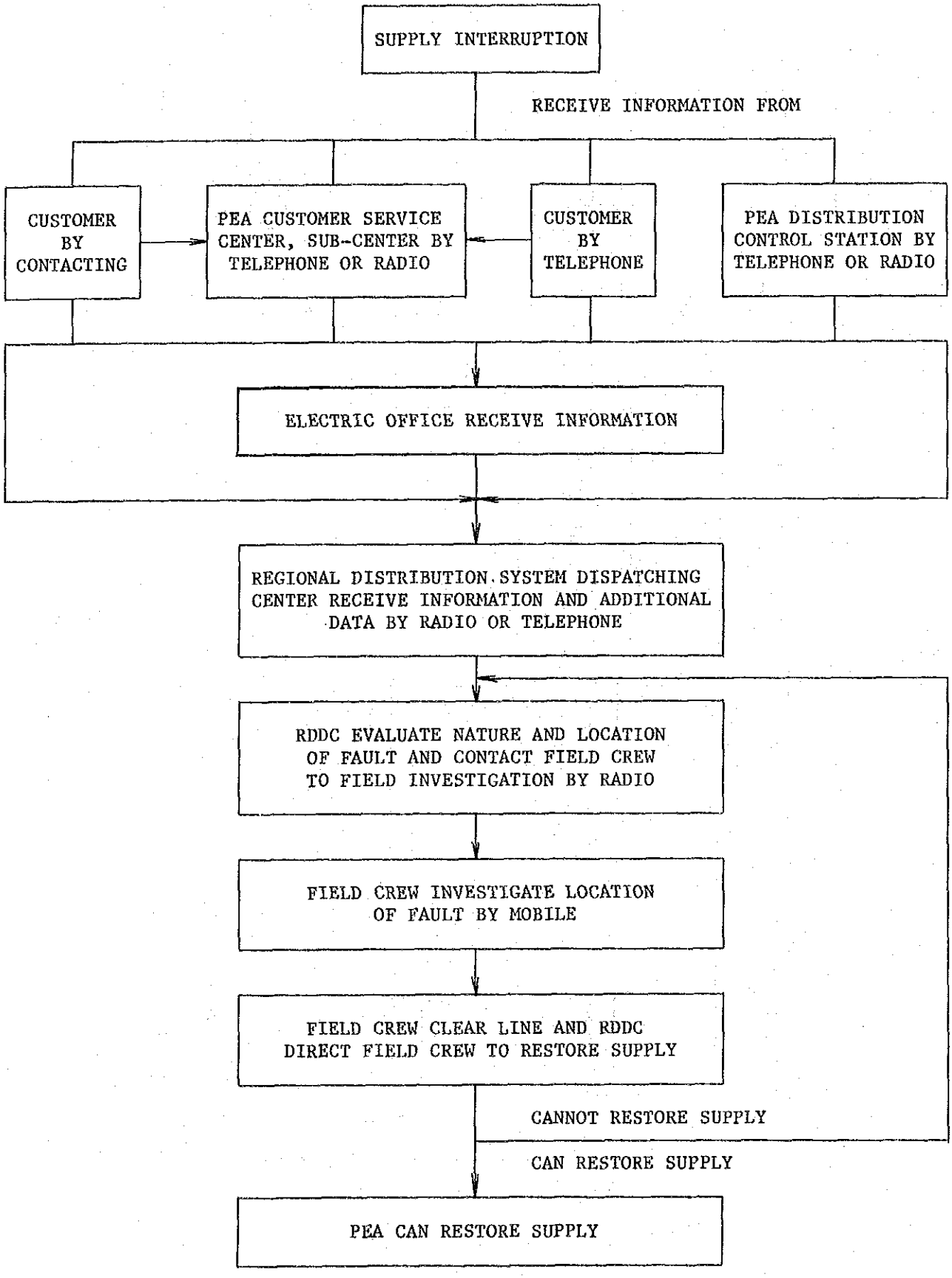
Table 4-1 OPERATIONAL SYSTEM OF PEA DISTRIBUTION DISPATCHING



NOTE: ① FORMAL COMMUNICATION

② INFORMAL COMMUNICATION

Table 4-2 FAULT HANDLING PROCEDURE



Chapter 5

DISTRIBUTION SYSTEM DISPATCHING CENTER DEVELOPMENT PROGRAM

Chapter 5 DISTRIBUTION SYSTEM DISPATCHING CENTER DEVELOPMENT PROGRAM

5-1 Necessity of Distribution System Dispatching Center Development

During the period from FY 1985 to FY 1995, the energy sales of three authorities (EGAT, MEA and PEA) in Thailand is expected to grow at an annual rate of 6.5 percent from 19,979 GWh to 37,549 GWh. During the same period, the energy sales of PEA is expected to grow at an annual rate of 8.4 percent from 8,557 GWh to 19,185 GWh, with the share of PEA in the three Authorities increasing from 42.8 percent to 51.1 percent. While the ratio of industrial power demand to total demand for the three Authorities will decrease from 44.9 percent (8,970 GWh) in FY 1985 to 42.8 percent (16,085 GWh) in FY 1995, that for PEA is expected to increase from 44.4 percent (3,802 GWh) in FY 1985 to 46.3 percent (8,885 GWh) 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.

The circuit length of high voltage lines increased at an annual rate of 19.2 percent during the past 10 years, reaching 89,369 km at the end of FY 1985. This trend of increase is expected to continue in the future, though the increase rate may decline somewhat.

The number of high voltage feeders is planned to increase from 564 in FY 1985 to 811 in FY 1995. With these expansions, the configuration of high voltage distribution system will become increasingly complicated.

On the other hand, the faults of high voltage distribution lines totaled 7,846 times, with the supply interruption of 16,918 hours during the one year period from August 1985 to July 1986. The frequency of faults per feeder was 14 times, with the supply interruption of 30 hours, indicating an extremely high level of power faults. The average duration of supply interruption per fault is 2.16 hours and the supply interruption lasting more than three hours account for about 20 percent of the total faults. The losses of big customers by supply interruption in FY 1986 is estimated at 365 M.Baht, causing the great losses to the national economy. The losses of big customers is expected to increase in the future with the growth of industrial power demand and is estimated to reach 551 M.Baht in FY 1995.

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 being carried out mainly through the voice communication with VHF (partially UHF) radio system. As a result, a considerable amount of time and labor have been required for the collection of fault information, detection of fault sections, and interchange of power to sound sections, and it is becoming increasingly difficult for PEA to cope with the situation with the conventional system. Moreover, the operation of distribution system is expected to become more complicated and difficult with the growth of power demand and expansion of facilities in the future, and the social demand for a more reliable power supply will become more strict.

To cope with the situation, it is essential to promote the automated distribution 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.

5-2 Facilities to be Supervisory Controlled

The studies were made of the substation expansion plan, high voltage feeder expansion plan and the criteria for the installation of sectionalizers, to estimate the quantities of facilities to be supervisory controlled and the data quantities to be transmitted through the distribution dispatching system.

(1) Substation Expansion Plan

The substation expansion plan is summarized by regions in Table 5-1. The detailed data of each substation are shown in Annexes 5-1-1 to 5-1-12. In FY 2000, a total number of substations is expected to reach 156 substations, with 270 transformers having a total capacity of 7,734 MVA. The number of substations of one region will range from a maximum of 19 substations (C1) to a minimum of 10 substations (NE2, NE3), averaging 13 substations. The most common unit capacities of transformers to be installed are 25, 40 and 50 MVA. The utilization factor of transformers is expected to reach 67.0 percent in 2000, as shown in Table 5-2.

(2) High Voltage Feeder Expansion Plan

The high voltage feeder expansion plan is summarized by regions in Table 5-3. The detailed data of each substation are shown in Annexes 5-2-1 to 5-2-12. In FY 2000, a total number of high voltage feeders is expected to reach 841 feeders, with the number of feeders of one region ranging from a maximum of 116 feeders (C1) to a minimum of 48 feeders (S1), averaging 70 feeders. The average number of feeders per substation is expected to be 5.4 feeders, with an average load of 6.2 MW per feeder.

(3) Reclosers

No long-term plan regarding the reclosers has been made by PEA. With more substations added, no long-distance distribution line is expected to increase. Therefore, for the reclosers, the existing number of units was considered to be left.

(4) Criteria for Installation of Sectionalizers

As mentioned in Clause 3-4-(2), only 10 units of sectionalizers are now being used for trial purpose. Therefore, the supply reliability would be improved remarkably, if the sectionalizers are installed and the detection of faulty sections, interchange of power into sound sections are effected by the remote control from the distribution system dispatching centers.

The effect of the improvement of supply reliability by the installation of sectionalizers may be analyzed as follows. The expressions below are used to calculate the interruption reduction ratio which is defined as the ratio of reduced interruption by sectionalizers to the interruption in the case that no sectionalizer is installed. It is assumed that "n" units of sectionalizers are installed for one line and the load of each section is uniform.

(a) For Radial Line

$$D_r = \frac{n}{2(n+1)}$$

(b) For Interconnected Line

$$D_i = \frac{n}{n+1}$$

where,

D_r: Interruption reduction ratio for radial line

D_i: Interruption reduction ratio for interconnected line

n : No. of sectionalizers installed per line

A fixed relationship exists between D_r and D_i: $D_i = 2D_r$. That is, the interruption reduction ratio for the interconnected line is twice that for the radial line. The table below shows D_r and D_i with "n" as the parameter.

D \ n	1	2	3	4	5
D_r	0.250	0.333	0.375	0.400	0.417
D_i	0.500	0.667	0.750	0.800	0.833

The table below shows d_r and d_i, the incremental interruption reduction ratio for each additional unit with "nth" as the parameter.

d \ nth	1st	2nd	3rd	4th	5th
d_r	0.250	0.083	0.042	0.025	0.017
d_i	0.500	0.167	0.083	0.050	0.033

The table above indicates that the first unit installed contributes most to the interruption reduction. The rate of contribution by the second and subsequent unit added is reduced successively. For the sectionalizer, the following three cases were studied based on the analysis above.

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

The table below shows the interruption reduction ratio for the three cases, with the interconnection ratio of high voltage lines "i" (supply energy of interconnected lines/total supply energy) used as the parameter.

D / i	Case 1 $\frac{1+i}{4}$	Case 2 $\frac{3+5i}{12}$	Case 3 $\frac{1+i}{3}$
0	0.250	0.250	0.333
0.1	0.275	0.292	0.367
0.2	0.300	0.333	0.400
0.3	0.325	0.375	0.433
0.4	0.350	0.417	0.467
0.5	0.375	0.458	0.500
0.6	0.400	0.500	0.533
0.7	0.425	0.542	0.567
0.8	0.450	0.583	0.600
0.9	0.475	0.625	0.633
1.0	0.500	0.667	0.667

The interconnection ratios of high voltage lines for each region are shown in Table 5-4. The ratios were estimated for the substations that can be interconnected by distribution lines. The detailed data for each substation are shown in Annex 5-3. The average interconnection ratio is estimated at 40 percent.

Table 5-5 shows the number of units of sectionalizers to be required for the above three cases in 1994 and 2000. The required number of sectionalizers was calculated by reducing the number of existing reclosers on main lines from that for the abovementined criteria. Annex 5-4 shows the installation status of reclosers, and Annexes 5-5-1 and 5-5-2 show the calculation method of the required number of sectionalizers. The total required number of units is as shown in the following table.

Case / FY	Case 1	Case 2	Case 3
1994	691	871	1,400
2000	730	912	1,477

(5) Quantity of the Facilities to be Supervisory Controlled

Table 5-6 shows the quantities of the facilities to be supervisory controlled in 1994 in each region. These facilities were estimated to reach 150 substations, 794 circuit breakers, 420 reclosers, and 691, 871 and 1,400 sectionalizers for Case 1, 2 and 3, respectively. The detailed data for each region are shown in Annex 5-6.

5-3 Organization of Distribution System Dispatching Center

As a rule, a single distribution system dispatching center is to be constructed at each regional office for the reasons described below. In Southern Region 1, however, two dispatching centers are to be constructed because of the restricted condition of radio routes.

(1) The scale of high voltage distribution system is expected to be in the range of being covered from a single distribution system dispatching center in the future. As mentioned in Clause 5-2, the number of substations of one region is expected to range from a maximum of 19 substations to a minimum

of 10 substations, averaging 13 substations. And the number of high voltage feeders of one region is expected to range from a maximum of 116 feeders to a minimum of 48 feeders, averaging 70 feeders.

(2) Because the regional office is the coordinative organ of distribution system planning and operation, the distribution system dispatching center is most suitable to be located at each regional office from the organizational and operational viewpoints.

(3) There are many cases in which the high voltage distribution lines of a single substation are extended ranging from offices to offices. Therefore, it is considered that the centralized dispatching from the regional office makes the system operation easier.

(4) As mentioned in Clause 3-2, there is no problem regarding the present maintenance system, because the maintenance staffs are distributed throughout the electric offices and customer service centers.

(5) By the installation of repeater stations, the data transmission system is possible to cover almost all areas of each region.

(6) If the distribution system dispatching center are not centralized but distributed, an increasing number of radio waves for dispatching system will be needed, along with the re-structure of the existing communication system. With more center facilities required, the construction cost will be much higher.

5-4 Function of Distribution Dispatching System

To solve the problems of existing distribution dispatching system described in Chapter 4, the measures such as the early collection of fault information, speedy detection of the faulty section, quick interchange of power to sound sections, and fast system reconfiguration, etc. are necessary. Also needed is the acquisition of data for the interchange of power in case of faults as well as for the efficient system operation and planning.

With the above system requirements taken into account, the following functions were determined for the distribution dispatching system.

(1) Supervisory Functions

(a) Normal Supervision

The master terminal unit polls the remote terminal units one by one to supervise their status. The data to be collected include:

- Open-close status of control station breakers, distribution line reclosers and sectionalizers (hereinafter referred to as "switching devices")

- Operation status of control station relays
- Bus voltage at control stations
- Active power and reactive power of high voltage feeders

(b) Detection of Status Changes

Besides the normal supervision, the master terminal unit transmits the status change detection signal simultaneously to all its remote terminal units at fixed intervals (every n units) to supervise their status changes. If the multiple remote terminal units transmit the status change signal at the same time, the detection is made for each group divided beforehand. The status change detection is made for the switching devices.

(2) Control Functions

(a) Individual Control

In the individual control mode, the master terminal unit selects a specific remote terminal and open or close the switching device.

(b) Concurrent Control

In the concurrent control mode, the master terminal unit closes all the switching devices concurrently.

(3) Display Function

The master terminal unit displays the open-close status of switching devices, status changes and measured data on the CRTs.

(4) System Diagnostic Function

The function to diagnose faults, malfunction of the master terminal units, power supply units and other equipment is to be included.

(5) Maintenance Function

The maintenance of the data base following the addition, removal or replacement of switching devices is to be readily carried out through the use of man-machine interface devices.

(6) Data Collection, Processing and Compilation

The function to collect, process and compile the data for the operation and planning of distribution system is to be included.

(a) Bus Voltage at Control Station and Current, Active Power and Reactive Power of High Voltage Feeder

The data are to be collected hourly.

(b) System Operation Logs

Table 5-7 summarized the required data quantities to be transmitted in each region in FY 2000 estimated based on the above functions. The detailed data are shown in Annexes 5-7-1 to 5-7-12. The data quantities to be transmitted in one region for case 3 are estimated at 630 measured values and 1,459 status indications for the largest region (C1), 267 measured values and 631 status indications for the smallest region (S1), and 379 measured values and 899 status indications on the average.

Table 5-8 shows the calculation results of the polling cycles (required duration for collecting data from every remote terminal unit) for each region in 2000. The polling cycles were calculated for the normal polling and hourly polling. In case 3, the polling cycles of the largest region (C1) is estimated at 5.2 min. for the normal polling and 6.1 min. for the hourly polling at the signaling rate of 200 bauds.

5-5 Structure of Distribution Dispatching System

The block diagram of distribution dispatching system is shown in Fig. 5-1.

This distribution dispatching system consists of the master terminal units (MTU), remote terminal units (RTU) and feeder remote terminal units (FRU). The MTU and RTU/FRU are linked by UHF radio via the repeater stations. The MTU is connected with the computer system via the front end processor (FEP). The man-machine interface devices comprise the CRT units, printer and loggers.

Recent trends are in favor of concentrating all indications of the open-close status of switching devices onto the CRT, discontinuing the use of mimic board for status display. Therefore, it was planned to utilize the CRT for the status display, with the mimic board used to have a overview of the total distribution system. Two CRTs are provided to each series of the dual system. One of them may be used exclusively for the status display.

The data transmission is performed by the polling method in which the master terminal unit polls its remote terminal units for the data collection or control. It is considered that an 11-bit format is to be used for the data transmission and the word configuration is to be variable depending on the data quantities. With the polling cycles and transmission characteristics taken into account, the signaling rate of 200 bauds is considered to be preferable.

5-6 Data Transmission System

(1) Data Transmission Media

There are three types of data transmission media, namely, radio wave, communication line and power line. The communication lines are widely used for the supervisory control of the short-distance distribution system with the circuit length of 10 km or less. However, the use of communication lines for the supervisory control of the long-distance distribution system such as that of PEA involves the following problems.

(a) Because of the high transmission loss, the repeater stations are required to be installed at the intervals of 20 to 30 km, causing the deterioration of transmission characteristics and high cost.

(b) The transmission characteristics are worsened by the noise induced by distribution lines.

(c) The data transmission is affected by distribution line fault or by lightning.

(d) The damaged cable sheaths tend to absorb moisture, deteriorating the insulation.

(e) The extended communication cables increase the overall costs.

The power line carrier system is widely used for the transmission system. For the distribution system, however, there are so many equipment connected and many spur lines involved that the high frequency transmission characteristics are complicated with the resulting high transmission loss and high line noise.

The distribution line carrier is only partially used on the trial basis for the supervisory control of the short-distance distribution system with the circuit length of 10 km or less. However, the said system is yet to be field-proven and it is considered to be a technologically incomplete system.

Another kind of distribution line carrier with the low frequencies of less than 300 Hz is also used for the supervisory control of distribution system. This system is not suitable for the supervisory control of a large number of facilities because of its low signaling rate.

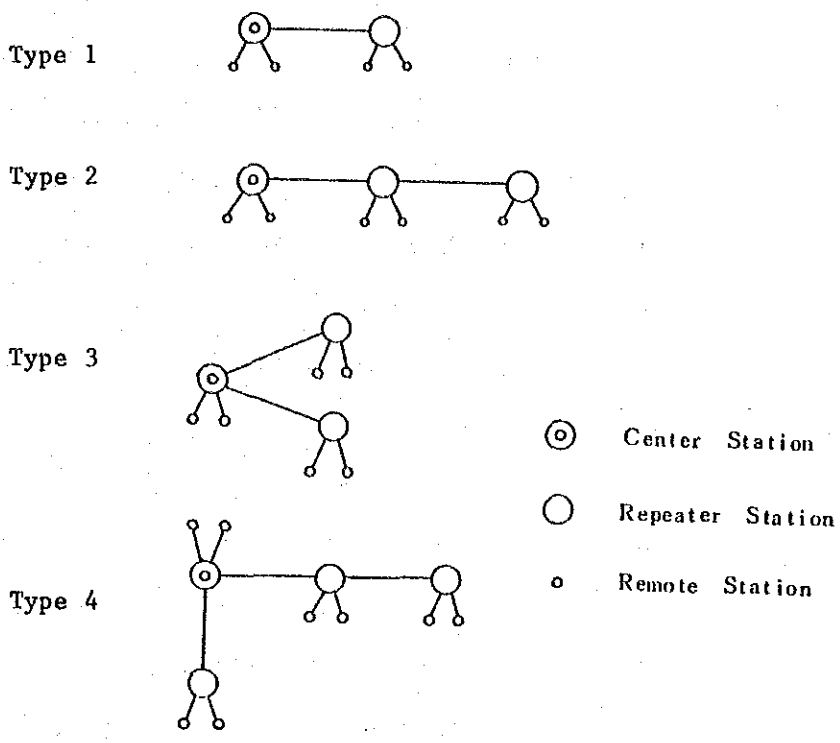
For the reasons, the radio wave was adopted as the data transmission medium.

(2) Selection of Radio Routes

The selected radio routes are summarized in Fig. 5-2. The details for each region are shown in Annexes 5-8-1 to 5-8-12. The routes were selected on the map based on the results of field surveys. The special consideration was given to cover the all areas of each region with a minimum number of repeater stations. Because the service area is extensive, the repeater stations are required throughout all regions. A total of twenty-four repeater stations were planned, with three regions having one station, six regions having two stations and three regions having three stations.

In Southern Region 1, six repeater stations are required in series to cover the Ranong substation in the southern district from the regional office. For the reason, two distribution system dispatching centers were planned to be constructed in Southern Region 1, one at regional office and the other at Chum Phon electric office.

The radio routes may be grouped into four types as shown below.



The transmission characteristics were studied regarding each repeater station and remote station (substation, recloser) with the target value being a S/N of 25 dB or more (in the standard status), a field strength of -95 dBm, and a utilization factor of 95%.

In the standard status, S/N was 30 dB or more for each station. In terms of the field strength, only a few stations turned out to be hardly covered, but these stations are recloser remote stations, which are likely to be covered through the relocation.

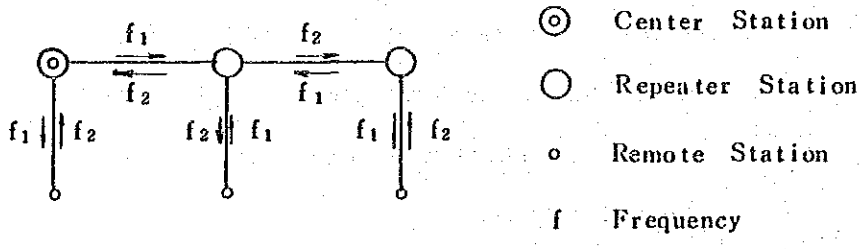
It is considered that the radio interference can be prevented by the several measures, appropriate allocation of frequencies to each region, employment of directional antennas, adjustment of receiver sensitivity, etc.

Because the maps with a scale of 1/250,000 were used for the study of transmission characteristics, there were some places where the intervals of contour lines were so wide that the detailed topography could not be recognized. Prior to the construction works, it will be necessary to grasp the topography on the maps with a scale of 1/50,000 and to perform the propagation tests.

(3) Radio Frequencies

The data transmission in the distribution dispatching system is performed by the polling method, in which the remote stations are polled one by one. In this case, there are two patterns of transmitter operation. The required number of frequencies is different for each pattern as described below.

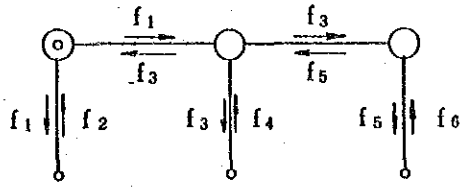
(a) The transmitters at center stations, repeater stations and remote stations are turned on only at the time of data transmission.



For this pattern, only two waves are required regardless of the number of repeater stations. The obvious advantage is the simple equipment configuration.

However, this kind of pattern is not practical because it takes 0.5 seconds to turn on its transmitter every time a station transmits data, resulting in the prolonged polling cycle.

(b) The transmitters at center and repeater stations are kept turned on, while the transmitters at remote stations are turned on only at the time of data transmission.



The equipment configuration is complicated, and 4 waves are required in case of one repeater station, 6 waves in case of 2 repeater stations, and 8 waves in case of 3 repeater stations. But the turning on time of transmitters is required only for the remote stations, resulting in the short polling cycle. This operation pattern was adopted in the distribution dispatching system. The polling cycles mentioned in Clause 5-4 were calculated based on this operation pattern.

The table below shows the number of central and repeater stations as well as the number of frequencies required for each region.

Region	No. of Center Stations	No. of Repeater Stations	No. of Frequencies
N1	1	2	6
N2	1	3	8
N3	1	2	6
NE1	1	3	8
NE2	1	2	6
NE3	1	2	6
C1	1	1	4
C2	1	1	4
C3	1	1	4
S1	2	3	10
S2	1	2	6
S3	1	2	6

For the number of frequencies for all regions, approximately 12 waves would be required.

UHF (400 MHz band) radio were adopted for the distribution dispatching system with the foregoing and the following factors taken into account:

(a) PEA has already reserved 12 UHF waves (400 MHz band).

(b) In Thailand, there are some room in 400 MHz band and it is considered that the required number of frequencies for the distribution dispatching system is possible to be secured in the future.

(c) Based on the results of field propagation tests and the study in Japan, it is concluded that the data transmission is technically feasible by using the 400 MHz radio.

(4) Improvement of Existing Communication System

As mentioned in Clause 3-4-(3), the existing communication system has such problems as the low transmission quality due to the long distance propagation and obstruction by mountains, and inadequate number of channels for the required information quantities.

To improve these problems, the multi-channel radio system was planned for the trunk communication system between the distribution system dispatching center and the repeater stations. This system consists of six channels, with one channel used for the data transmission, one channel for the dispatching communication and the rest for the general communication. While there seems to be little necessity for using the multi-channel radio system for the distribution dispatching system, the adoption of this improvement measure will result in the improvement of transmission quality and the increase of the number of channels for the existing communication system. For the dispatching communication, the proposed system provides the direct communication from the distribution dispatching center to almost all areas of each region.

As the additional equipment for the improvement measure, the multi-channel transmitters-receivers and the single-channel transmitters-receivers for the dispatching communication were considered at the distribution system dispatching

centers and repeater stations. The additional construction cost for the improvement measure is estimated at 2.8 M.US$.

(5) Structure of Equipment

The structure of major equipment is as shown in the followings.

(a) Center and Repeater Stations

- Multi-channel UHF transmitter-receiver with standby
  Duplex operation
  Transmitter output: 10W
- Single-channel UHF transmitter-receiver with standby
  Duplex operation
  Transmitter output: 10 W
- Single-channel UHF transmitter-receiver
  Simplex operation
  Transmitter output: 10 W
- Remote supervisory equipment
- Grid parabolic antenna
- Eight-stages co-linear antenna

(b) Substation Remote Stations

- Single-channel UHF transmitter-receiver with standby

  Simplex operation

  Transmitter output: 10 W

- Remote supervisory equipment

- Five-elements Yagi antenna

(c) Feeder Remote Stations

- Single-channel UHF transmitter-receiver

  Simplex operation

  Transmitter output: 10 W

- Five-elements Yagi antenna

The required number of transmitters and receivers in FY 1994 is shown in the following table.

Station		No. of Stations	No. of Transmitters	No. of Receivers
Center Station		13	36	36
Repeater Station		24	78	78
Substation Remote Station		150	150	150
Feeder Remote Station	Case 1	1,111	1,111	1,111
	Case 2	1,291	1,291	1,291
	Case 3	1,820	1,820	1,820

5-7 Evaluation of Supply Reliability

Table 5-9 shows the estimated frequency of power faults and interruption energy in FY 1995. The frequency of faults was estimated on the assumption that the frequency of faults per feeder will decrease at an annual rate of 5 percent. For the interruption energy, the decremental interruption energy was calculated by multiplying the interruption energy prior to the project by the interruption reduction ratio mentioned in Clause 5-2-(4) (see Annexes 9-1 and 9-2).

The frequency of power faults is expected to decrease from 7,846 in FY 1985 to 7,143 in FY 1995.

The interruption energy in FY 1995 is expected to decrease from 30.0 GWh in FY 1985 to 25.6 GWh for Case 1, 23.3 GWh for Case 2 and 21.2 GWh for Case 3, and to decrease to 66.1 percent, 60.2 percent and 54.8 percent, respectively, compared with 38.7 GWh which is the estimated interruption energy prior to the project. The share of interruption energy in the energy sales is expected to decrease from 0.319 percent in FY 1985 to 0.133 percent for Case 1, 0.121 percent for Case 2 and 0.111 percent for Case 3, respectively.

The interruption energy of big customers in FY 1995 is expected to decrease from 6.69 GWh in FY 1985 to 6.49 GWh for Case 1, 5.77 GWh for Case 2 and 5.29 GWh for Case 3, and to decrease to 64.3 percent, 57.2 percent and 52.4 percent, respectively, compared with 10.09 GWh which is the estimated interruption energy for big customers prior to the project. The share of interruption energy

in the energy sales for big customers is expected to decrease from 0.233 percent in FY 1985 to 0.095 percent for Case 1, 0.084 percent for Case 2, and 0.07 percent for Case 3, respectively.

5-8 Architectural Requirements

The architectural requirements were studied with the new regional office building of Central Region 3, which was selected for the site of pilot distribution dispatching center, for a model.

(1) Buildings

The distribution system dispatching center will consist of a control room, computer room and staff office as shown in Annex 5-9.

The dispatching center is most desirable to be located on the top floor (4th floor) in consideration of the relation with radio antennas to be installed on the roof top and the ease of installation of airconditioning system.

There is no problem for the space as shown in Annex 5-9, but the columns on 2 line and C - F lines are not desirable for the efficient operation of the dispatching center and should not be provided. Without these columns, the column span will be 9,250 mm, which is not considered to pose any design problem structurally.

For the floor structure, the double floor structure (free access H = 250 mm) should be employed for the maintenance of cables.

The floor height of the fourth floor of this building is 3,300 mm and the ceiling height, after deduction of the depth of 500 mm for roof girder, is 2,800 mm. With the requirement for increasing the depth of roof girder for longer column span and the employment of the double floor structure taken into account, the floor height should be increased by about 800 mm to 4,100 mm.

For the structure of the building, the study was made only in outline, as the detailed structural calculations for the building were not available. The floor of the fourth floor seems to be constructed with the pre-stressed concrete panels but the concrete strength, and the tensile strength and yield strength of reinforcing bars are not known. As the live load of computer room is estimated to be about 300 kg/m^2, it will be necessary to reinforce the floor by providing steel members between the existing beams.

While the strength of existing beams is considered to be structurally safe, the detailed structural study will be required prior to the start of construction work.

(2) Airconditioning system

For the design condition, the outdoor temperature of 34°C and relative humidity of 53.1 percent and the design room temperature of 25°C and relative humidity of 50 percent were considered. Also, the heat generation of equipment was considered to be 9,500 kcal/h in the computer room and 1,700 kcal/h in the control room.

For the type of airconditioning system, the type shown in Annex 5-10 is recommended for the following reasons.

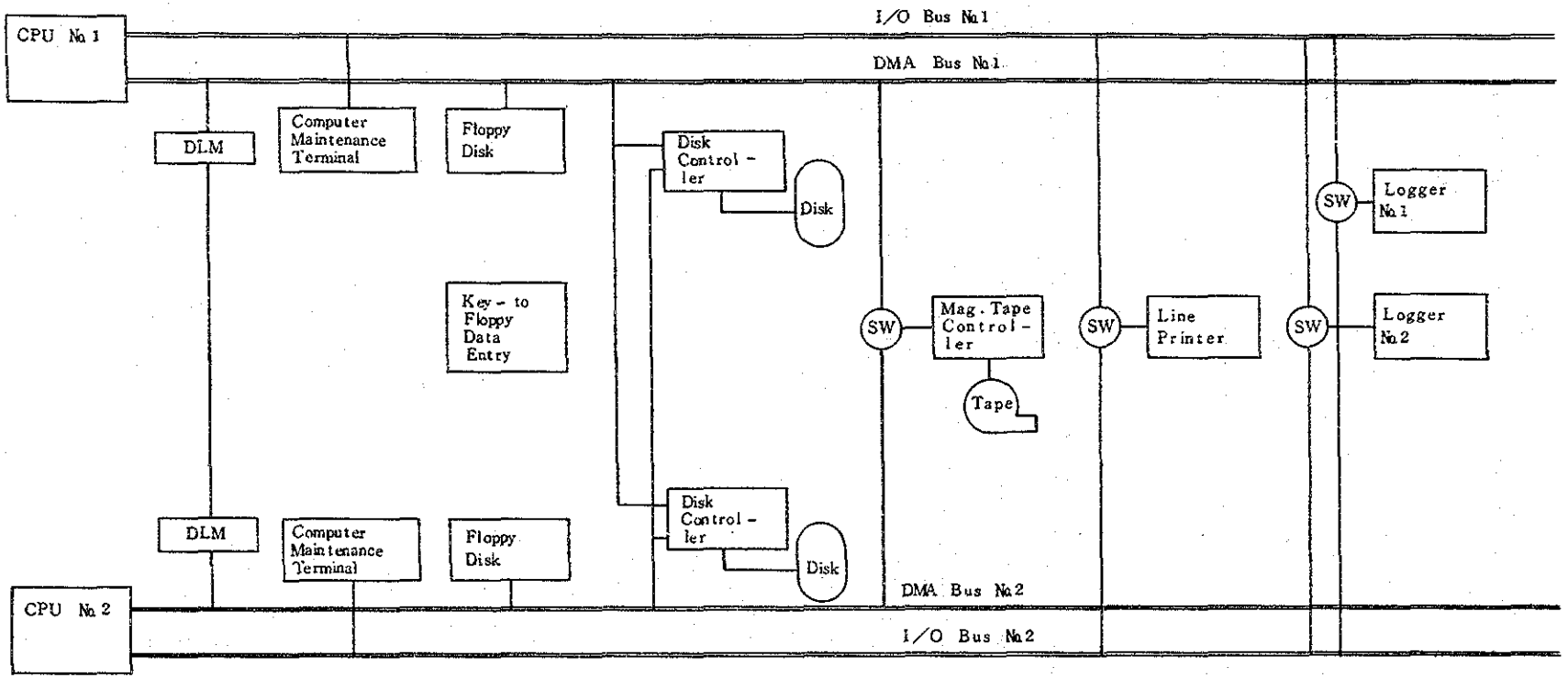
- Ease of room temperature control
- Ease of operation
- Installation work is simple and fast
- Equipment is in wide use and relatively low in price.

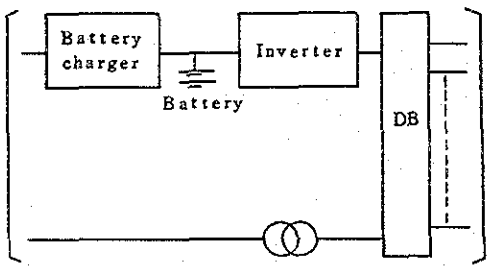
(3) Illumination

For the design condition, the illuminance of 1,000 lx for the control room and computer room, 500 lx for the staff office and 200 lx for the corridors were considered.

The layout (tentative) of illumination equipment is shown in Annex 5-11.

Fig 5-1 DISTRIBUTION DISPATCHING SYSTEM BLOCK DIAGRAM (1)





UPS Configuration

Regend

A-KB	:	Alphanumeric Keyboard
CON	:	Controller
DLM	:	Data link Module
F-KB	:	Function Keyboard
FRU	:	Feeder Remote Terminal Unit
FEP	:	Front End Processor
INF	:	Interface
MTU	:	Master Telecontrol Unit
SCC	:	Supervisory and Control of System Configuration
UHF	:	Ultra High Frequency
DB	:	Distribution Board

Fig 5-1 DISTRIBUTION DISPATCHING SYSTEM BLOCK DIAGRAM (2)

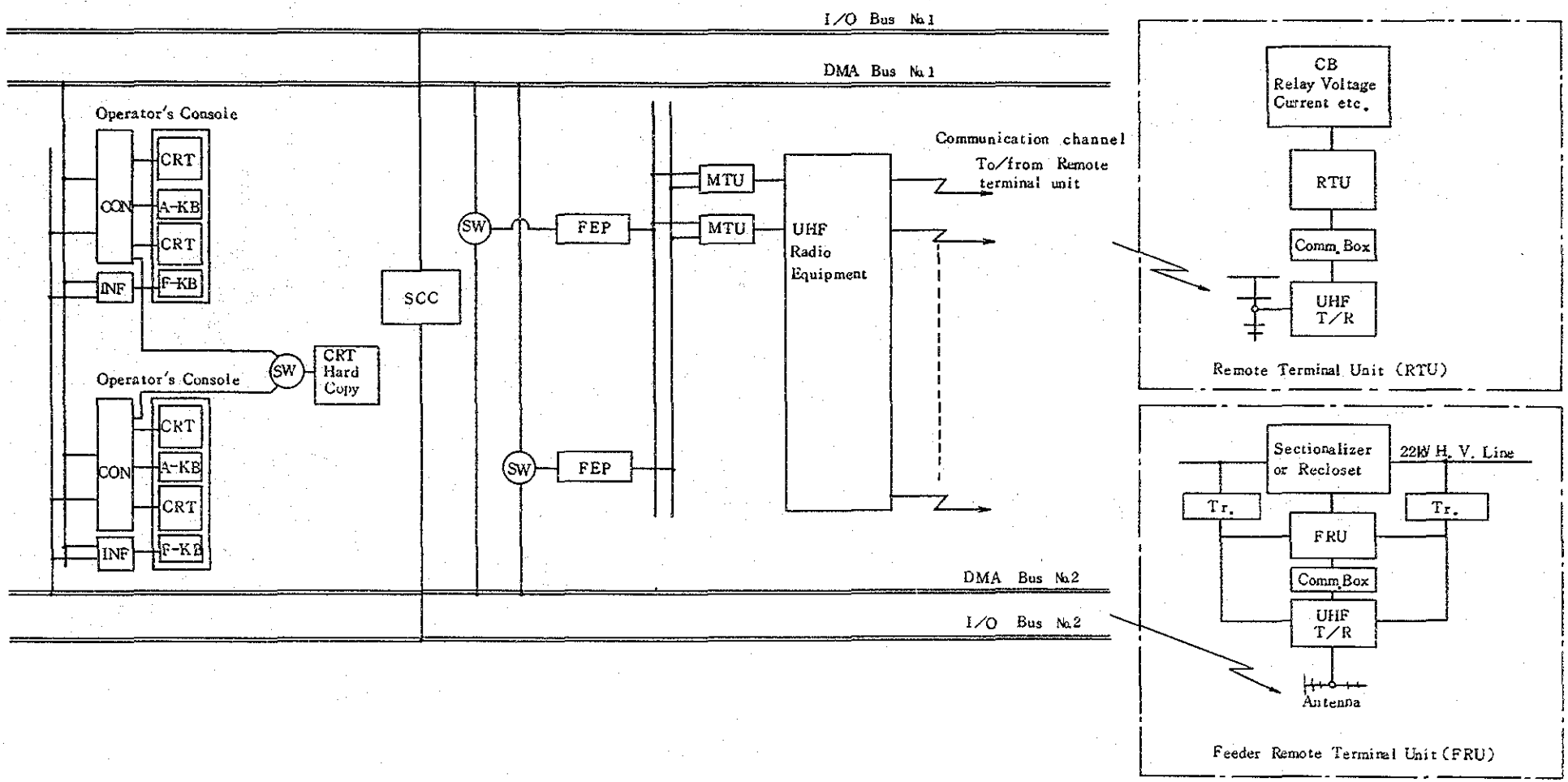


Fig. 5-2 RADIO ROUTE DIAGRAM

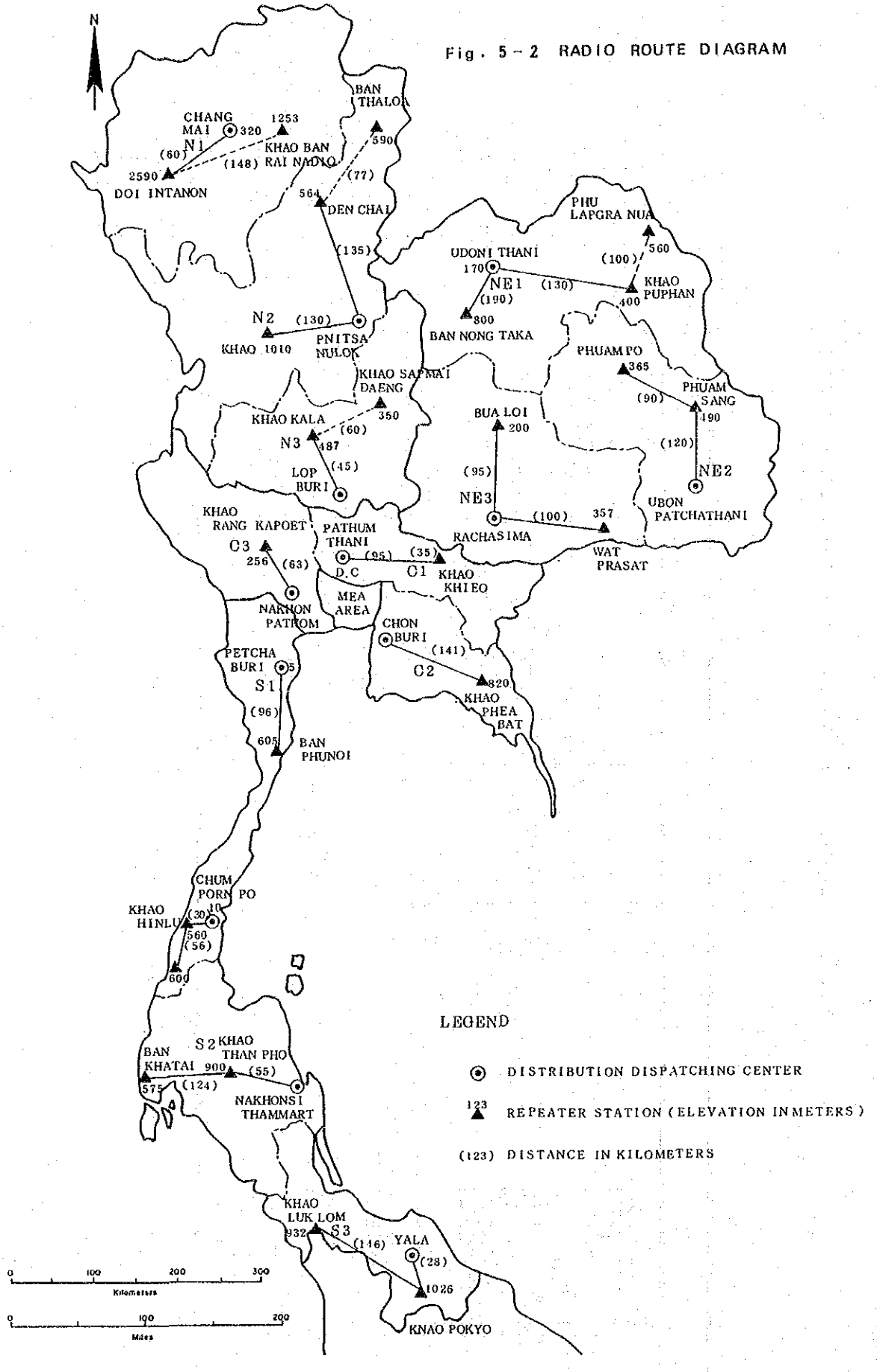


Table 5-1 SUBSTATION EXPANSION PLAN (SUMMARY)

(Unit: MVA)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Capacity (MVA)															
N1	310.8	422.0	492.0	492.0	618.8	618.8	618.8	618.8	652.1	652.1	672.1	672.1	672.1	672.1	672.1
N2	236.5	322.5	397.5	397.5	462.5	487.5	487.5	487.5	525.0	525.0	525.0	532.5	532.5	532.5	532.5
N3	223.75	305.0	305.0	355.0	380.0	417.5	460.0	460.0	460.0	460.0	460.0	460.0	460.0	460.0	460.0
NE1	292.65	380.95	399.65	474.65	474.65	474.65	502.15	502.15	502.15	554.40	604.40	629.40	629.40	644.55	644.55
NE2	289.5	289.5	314.5	439.5	489.5	489.5	489.5	501.5	501.5	556.5	556.5	556.5	571.5	593.0	593.0
NE3	270.5	320.5	320.5	460.5	485.5	485.5	510.5	534.5	553.0	553.0	553.0	553.0	553.0	553.0	553.0
C1	546.0	711.0	761.0	811.0	876.0	876.0	916.0	956.0	956.0	971.0	971.0	971.0	1,026.0	1,026.0	1,026.0
C2	510.0	615.0	655.0	707.5	732.5	757.5	757.5	787.5	817.5	832.5	877.5	920.0	935.0	935.0	935.0
C3	500.0	565.0	565.0	670.0	670.0	670.0	795.0	795.0	795.0	835.0	835.0	835.0	835.0	850.0	850.0
S1	250.0	250.0	250.0	250.0	275.0	350.0	365.0	365.0	377.5	377.5	377.5	377.5	377.5	377.5	377.5
S2	314.0	333.0	333.0	358.0	358.0	358.0	375.5	390.5	390.5	469.5	469.5	469.6	499.0	499.0	499.0
S3	261.5	354.0	354.0	379.0	404.0	429.0	429.0	444.0	469.0	469.0	551.5	556.5	591.5	591.5	591.5
Total	4,005.20	4,868.45	5,147.15	5,794.65	6,226.45	6,413.95	6,706.45	6,842.45	6,999.25	7,255.50	7,452.00	7,543.00	7,682.50	7,734.15	7,734.15
No. of Substations															
N1	14	16	16	16	16	16	16	16	16	16	16	16	16	16	16
N2	11	11	11	11	12	13	13	13	13	13	13	13	13	13	13
N3	7	9	9	11	12	12	12	12	12	12	12	12	12	12	12
NE1	12	14	14	15	15	15	15	15	15	15	15	15	15	15	15
NE2	9	9	9	9	10	10	10	10	10	10	10	10	10	10	10
NE3	8	8	8	9	10	10	10	10	10	10	10	10	10	10	10
C1	13	15	15	17	19	19	19	19	19	19	19	19	19	19	19
C2	11	12	12	12	13	14	14	14	14	14	14	14	14	14	14
C3	10	10	10	12	12	12	12	12	12	12	12	12	12	12	12
S1	9	9	9	9	9	12	12	12	12	12	12	12	12	12	12
S2	11	11	11	12	12	12	12	12	12	12	12	12	12	12	12
S3	8	10	10	10	10	11	11	11	11	11	11	11	11	11	11
Total	123	134	134	143	150	156	156	156	156	156	156	156	156	156	156

(Continued Table 5-1)

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
No. of Banks															
N1	22	24	24	24	25	25	25	25	25	25	25	25	25	25	25
N2	13	15	17	17	19	20	20	20	21	21	21	21	21	21	21
N3	9	12	12	14	15	16	16	16	16	16	16	16	16	16	16
NE1	14	18	18	21	21	21	21	21	21	22	23	24	24	24	24
NE2	13	13	14	17	19	19	19	19	19	21	21	21	21	21	21
NE3	10	11	11	15	16	16	17	18	18	18	18	18	18	18	18
C1	19	23	25	27	29	29	30	31	31	31	31	31	32	32	32
C2	18	21	22	24	25	26	26	26	26	26	26	26	26	26	26
C3	17	19	19	21	21	21	24	24	24	25	25	25	25	25	25
S1	10	10	10	10	11	14	14	14	15	15	15	15	15	15	15
S2	14	14	14	15	15	15	16	16	16	18	18	18	19	19	19
S3	11	14	14	15	15	16	16	16	16	16	17	17	18	18	18
Total	170	194	200	220	231	238	244	246	248	254	256	257	260	260	260
No. of Transformers															
N1	30	33	33	33	32	32	32	32	32	32	32	32	32	32	32
N2	14	16	18	18	19	20	20	20	21	21	21	21	21	21	21
N3	11	13	13	15	16	16	16	16	16	16	16	16	16	16	16
NE1	17	21	21	24	24	24	24	24	24	24	25	26	26	26	26
NE2	14	14	15	18	20	20	20	20	20	21	21	21	21	21	21
NE3	12	13	13	16	17	17	18	18	18	18	18	18	18	18	18
C1	19	23	25	27	29	29	30	31	31	31	31	31	32	32	32
C2	19	22	23	24	25	26	26	26	26	26	26	26	26	26	26
C3	17	19	19	21	21	21	24	24	24	25	25	25	25	25	25
S1	12	12	12	12	12	15	15	15	15	15	15	15	15	15	15
S2	18	18	18	19	19	19	19	19	19	20	20	20	20	20	20
S3	11	14	14	15	15	16	16	16	16	16	17	17	18	18	18
Total	194	218	224	242	249	255	260	261	262	265	267	268	270	270	270

Table 5-2 ESTIMATED UTILIZATION FACTOR OF SUBSTATION TRNASFORMERS

Region	Items	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N1	Inst. cap. (MVA)	310.8	422.0	492.0	492.0	618.8	618.8	618.8	618.8	652.1	652.1	672.1	672.1	672.1	672.1	672.1
	Demand (MW)	164.17	180.60	195.62	214.04	234.75	258.46	282.01	304.62	325.66	346.48	368.62	392.17	412.23	443.90	472.26
	Utily. fac. (%)	52.8	42.8	39.8	43.5	37.9	41.8	45.6	49.2	49.9	53.1	54.8	58.3	61.3	66.0	70.3
N2	Inst. cap. (MVA)	236.5	322.5	397.5	397.5	462.5	487.5	487.5	487.5	525.0	525.0	525.0	532.5	532.5	532.5	532.5
	Demand (MW)	131.39	144.39	155.87	167.60	179.72	191.85	203.89	215.70	227.25	238.46	250.22	262.55	275.50	289.08	303.33
	Utily. fac. (%)	55.6	44.8	39.2	42.2	38.9	39.4	41.8	44.2	43.3	45.4	47.7	49.3	51.7	54.3	57.0
N3	Inst. cap. (MVA)	223.75	305.0	305.0	355.0	380.0	417.5	460.0	460.0	460.0	460.0	460.0	460.0	460.0	460.0	460.0
	Demand (MW)	120.98	132.93	141.69	150.72	160.20	169.65	178.99	188.12	197.00	205.60	214.58	223.96	233.75	243.96	254.63
	Utily. fac. (%)	54.1	43.6	46.5	42.5	42.2	40.6	38.9	40.9	42.8	44.7	46.6	48.7	50.8	53.0	55.4
NE1	Inst. cap. (MVA)	292.65	380.95	399.65	474.65	474.65	474.65	502.15	502.15	502.15	554.40	604.40	629.40	629.40	644.55	644.55
	Demand (MW)	172.13	188.02	202.19	216.48	231.17	245.74	260.06	273.88	287.20	299.89	313.15	226.99	341.44	356.53	372.29
	Utily. fac. (%)	58.8	49.4	50.6	45.6	48.7	51.8	51.8	54.5	57.2	54.1	51.8	52.0	54.2	55.3	57.8
NE2	Inst. cap. (MVA)	289.5	289.5	314.5	439.5	489.5	489.5	489.5	501.5	501.5	556.5	556.5	556.5	571.5	593.0	593.0
	Demand (MW)	140.17	139.50	152.29	165.48	179.14	192.95	207.31	221.65	235.93	250.27	265.49	281.63	298.75	316.91	336.18
	Utily. fac. (%)	48.4	48.2	48.4	37.7	36.6	39.4	42.4	44.2	47.0	45.0	47.7	50.6	52.3	53.4	56.7
NE3	Inst. cap. (MVA)	270.5	320.5	320.5	460.5	485.5	485.5	510.5	534.5	553.0	553.0	553.0	553.0	553.0	553.0	553.0
	Demand (MW)	158.08	171.45	182.85	194.21	205.85	217.27	228.43	239.14	249.40	259.10	269.18	279.65	290.53	301.83	313.57
	Utily. fac. (%)	58.4	53.5	57.1	42.2	42.4	44.8	44.7	44.7	45.1	46.9	48.7	50.6	52.5	54.6	56.7

(Continued Table 5-2)

Region	Items	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
C1	Inst. cap. (MVA)	546.0	711.0	761.0	811.0	876.0	876.0	916.0	956.0	956.0	971.0	971.0	971.0	1,026.0	1,026.0	1,026.0
	Demand (MW)	360.42	419.58	508.41	529.43	551.53	574.29	597.81	622.12	647.21	673.07	699.99	727.99	757.11	787.40	818.89
	Utily. fac. (%)	66.0	59.0	66.8	65.3	63.0	65.6	65.3	65.1	67.7	69.3	72.1	75.0	73.8	76.7	79.8
C2	Inst. cap. (MVA)	510.0	615.0	655.0	707.5	732.5	757.5	757.5	787.5	817.5	832.5	877.5	920.0	935.0	935.0	935.0
	Demand (MW)	235.68	259.15	289.99	388.75	413.10	442.18	464.51	486.92	509.36	531.67	554.96	579.26	604.64	631.12	658.76
	Utily. fac. (%)	46.2	42.1	44.3	54.9	56.4	58.4	61.3	61.8	62.3	63.9	63.2	63.0	64.7	67.5	70.5
C3	Inst. cap. (MVA)	500.0	565.0	565.0	670.0	670.0	670.0	795.0	795.0	795.0	835.0	835.0	835.0	835.0	850.0	850.0
	Demand (MW)	302.14	314.30	338.75	363.92	390.46	417.58	445.25	473.15	501.26	529.42	559.17	590.60	623.79	658.85	695.87
	Utily. fac. (%)	60.4	55.6	60.0	54.3	58.3	62.3	56.0	59.5	63.1	63.4	67.0	70.7	74.7	77.5	81.9
S1	Inst. cap. (MVA)	250.0	250.0	250.0	250.0	275.0	350.0	365.0	365.0	377.5	377.5	377.5	377.5	377.5	377.5	377.5
	Demand (MW)	116.08	127.81	148.38	159.40	170.89	182.69	194.68	206.75	218.82	230.77	243.37	256.66	270.67	285.45	301.04
	Utily. fac. (%)	46.4	51.1	59.4	63.8	62.1	52.2	53.3	56.6	58.0	61.1	64.5	68.0	71.7	75.6	79.7
S2	Inst. cap. (MVA)	314.0	333.0	333.0	358.0	358.0	358.0	375.5	390.5	390.5	469.5	469.5	469.5	499.0	499.0	499.0
	Demand (MW)	122.96	132.34	142.98	153.36	164.22	175.18	186.16	197.00	207.67	218.09	229.04	240.54	252.61	265.29	278.61
	Utily. fac. (%)	39.2	39.7	42.9	42.8	45.9	48.9	49.6	50.4	53.2	46.5	48.8	51.2	50.6	53.2	55.8
S3	Inst. cap. (MVA)	261.5	354.0	354.0	379.0	404.0	429.0	429.0	444.0	469.0	469.0	551.5	566.5	591.5	591.5	591.5
	Demand (MW)	154.13	151.39	165.51	184.07	203.31	222.92	237.86	252.99	268.29	283.65	299.90	317.09	335.26	354.47	374.78
	Utily. fac. (%)	58.9	42.8	46.8	48.6	50.3	52.0	55.4	57.0	57.2	60.5	54.4	56.0	56.7	59.9	63.4
Total	Inst. cap. (MVA)	4,005.20	4,868.45	5,147.15	5,794.65	6,226.45	6,413.95	6,706.45	6,842.45	6,999.25	7,255.50	7,453.00	7,543.00	7,682.50	7,734.15	7,734.15
	Demand (MW)	2,178.32	2,361.46	2,624.53	2,887.45	3,084.34	3,290.76	3,486.95	3,682.05	3,875.04	4,066.46	4,267.67	4,479.09	4,696.28	4,934.79	5,180.21
	Utily. fac. (%)	54.4	48.5	51.0	49.8	49.5	51.3	52.0	53.8	55.4	56.0	57.3	59.4	61.1	63.8	67.0

Table 5-3 H.V. FEEDER EXPANSION PLAN (SUMMARY)

(Unit: cct)

Region	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
N1	56	62	62	62	66	66	66	66	66	66	66	68	71	71	71
N2	39	39	39	39	52	56	56	56	59	59	59	60	60	62	62
N3	34	42	42	50	54	60	60	60	60	60	60	60	60	60	60
NE1	47	55	55	59	69	69	69	69	69	69	73	75	75	79	79
NE2	36	36	40	40	47	47	47	47	47	54	54	55	55	55	55
NE3	50	50	50	59	63	63	64	64	64	64	64	64	64	64	64
C1	75	87	89	97	107	107	111	115	115	115	115	116	116	116	116
C2	58	62	66	70	82	86	86	89	90	90	90	90	90	90	90
C3	67	69	69	80	80	80	86	86	86	87	87	88	88	88	88
S1	34	34	34	34	36	48	48	48	48	48	48	48	48	48	48
S2	35	35	35	39	43	44	44	45	45	45	46	47	50	50	51
S3	33	42	42	42	46	50	50	51	54	54	57	57	57	57	57
Total	564	613	623	671	745	776	787	796	803	811	819	828	834	840	841

Table 5-4 ESTIMATED INTERCONNECTION RATIO OF H.V. LINE

Region		1986		1987		1988		1989		1990		1991		1992		1993		1994		1995	
		cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)
N1	A	20	335.9	20	356.4	20	388.8	20	428.4	20	474.5	20	529.1	20	586.5	20	644.5	20	701.5	20	759.9
	T	56	636.0	62	707.8	62	773.6	62	850.1	66	936.7	66	1,035.3	66	1,138.1	66	1,241.8	66	1,344.0	66	1,447.9
	R	36	53	32	50	32	50	32	50	30	51	30	51	30	52	30	52	30	52	30	52
N2	A	4	79.4	4	86.8	4	93.5	4	100.4	8	152.6	8	163.3	8	173.9	8	184.3	10	206.3	10	216.8
	T	39	542.3	39	600.4	39	653.0	39	707.3	52	763.9	56	821.3	56	879.0	56	936.4	59	993.4	59	1,049.5
	R	10	15	10	14	10	14	10	14	15	20	14	20	14	20	14	20	17	21	17	21
N3	A	6	124.5	6	138.0	6	139.7	10	266.8	10	284.4	14	334.9	14	354.6	14	374.0	14	393.4	14	412.4
	T	34	548.8	42	607.1	42	651.7	50	698.1	54	747.2	60	796.8	60	846.6	60	896.0	60	944.9	60	993.0
	R	18	23	14	23	14	21	20	38	19	38	23	42	23	42	23	42	23	42	23	42
NE1	A	4	106.9	8	220.7	8	238.2	8	256.1	10	300.4	10	320.6	10	340.7	10	360.1	10	379.0	10	397.1
	T	47	654.8	55	721.1	55	782.0	59	844.3	69	909.2	69	974.7	69	1,040.1	69	1,104.5	69	1,167.8	69	1,229.4
	R	9	16	15	31	15	30	14	30	14	33	14	33	14	33	14	33	14	32	14	32
NE2	A	4	76.8	4	90.0	6	109.1	6	120.9	6	133.3	6	146.1	6	159.6	6	173.3	6	187.5	8	219.3
	T	36	439.7	36	492.9	40	543.4	40	596.4	47	652.1	47	709.5	47	769.9	47	831.3	47	893.5	54	957.1
	R	11	17	11	18	15	20	15	20	13	20	13	21	13	21	13	21	13	21	15	23
NE3	A	8	196.3	8	212.8	8	226.4	8	240.3	8	254.7	8	268.9	8	283.0	8	296.5	8	309.5	8	321.8
	T	50	719.4	50	786.5	50	845.2	59	904.7	63	966.2	63	1,027.6	64	1,088.5	64	1,148.0	64	1,206.1	64	1,262.3
	R	16	27	16	27	16	27	14	27	13	26	13	26	13	26	13	26	13	26	13	25
C1	A	22	1,038.0	26	1,209.1	28	1,563.6	28	1,650.2	32	1,811.9	32	1,886.3	34	1,966.9	36	2,051.2	36	2,136.5	36	2,225.8
	T	75	2,110.7	87	2,415.9	89	2,956.1	97	3,128.5	107	3,266.7	107	3,410.0	111	3,558.7	115	3,713.6	115	3,874.7	115	4,041.9
	R	29	49	30	50	31	53	29	53	30	55	30	55	31	55	31	55	31	55	31	55
C2	A	14	401.7	14	468.9	14	485.0	16	785.4	16	792.0	16	798.7	16	832.8	16	868.0	16	904.4	16	941.8
	T	58	1,218.5	62	1,405.9	66	1,565.0	70	2,098.8	82	2,234.3	86	2,391.4	86	2,525.6	89	2,661.7	90	2,799.7	90	2,938.6
	R	24	33	23	33	21	31	23	37	20	35	19	33	19	33	18	33	18	32	18	32
C3	A	26	919.7	26	973.0	26	1,051.8	28	1,103.6	28	1,189.8	28	1,279.4	32	1,415.8	32	1,513.6	32	1,613.9	32	1,699.3
	T	67	1,616.3	69	1,776.5	69	1,924.6	80	2,078.9	80	2,243.2	80	2,413.1	86	2,588.3	86	2,767.1	86	2,949.3	87	3,134.0
	R	39	57	38	55	38	55	35	53	35	53	35	53	37	55	37	55	37	55	37	54

(Continued Table 5-4)

Region		1986		1987		1988		1989		1990		1991		1992		1993		1994		1995	
		cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)	cct	Energy (GWh)
S1	A	6	170.2	6	188.3	6	234.6	6	253.1	8	313.4	14	450.2	14	483.4	14	517.5	14	552.2	14	587.3
	T	34	596.1	34	661.6	34	781.6	34	845.4	36	912.6	48	982.5	48	1,054.4	48	1,127.9	48	1,202.3	48	1,277.2
	R	18	29	18	28	18	30	18	30	22	34	29	46	29	46	29	46	29	46	29	46
S2	A	4	77.0	4	84.1	4	89.4	8	209.8	8	224.0	8	229.6	8	243.7	8	248.7	8	262.3	8	275.8
	T	35	618.7	35	677.6	35	736.4	39	796.1	43	858.6	44	922.4	44	987.3	45	1,052.2	45	1,117.2	45	1,181.6
	R	11	12	11	12	11	12	21	26	19	26	18	25	18	25	18	24	18	23	18	23
S3	A	6	186.8	6	192.5	6	211.5	6	230.0	6	249.5	6	270.3	6	292.3	6	301.4	6	324.2	6	347.9
	T	33	633.9	42	723.0	42	796.5	42	892.5	46	992.4	50	1,095.6	50	1,180.1	51	1,267.1	54	1,356.5	54	1,447.9
	R	18	29	14	27	14	27	14	26	13	25	12	25	12	25	12	24	11	24	11	24
Total	A	124	3,713.2	132	4,220.6	136	4,831.6	148	5,645.0	160	6,180.5	170	6,677.4	176	7,133.2	178	7,533.1	180	7,970.7	182	8,405.2
	T	564	10,335.2	613	11,576.3	623	13,009.1	671	14,441.1	745	15,483.1	776	16,580.2	787	17,656.6	796	18,747.6	803	19,849.4	811	20,960.4
	R	22	36	22	36	22	37	22	39	21	40	22	40	22	40	22	40	22	40	22	40

Note: A: Interconnected Feeder T: Total Feeder R: Interconnection Ratio (%)

Table 5-5 REQUIRED NUMBER OF SECTIONALIZERS (1994 and 2000)

(Unit: sets)

Region	1994			2000		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
N1	57	77	108	62	82	118
N2	44	54	96	47	57	102
N3	51	65	102	51	65	102
NE1	45	55	96	55	65	116
NE2	23	29	59	32	40	76
NE3	45	53	97	45	53	97
C1	123	159	234	124	160	236
C2	85	101	174	85	101	174
C3	95	127	179	97	129	183
S1	43	57	87	43	57	87
S2	35	43	75	41	49	87
S3	45	51	93	48	54	99
Total	691	871	1,400	730	912	1,477

Table 5-6 FACILITIES TO BE SUPERVISORY CONTROLLED (1994)

Region	No. of Substation	No. of Banks	No. of Circuit	No. of Sectionalizer			No. of Recloser
				Case 1	Case 2	Case 3	
N1	12	25	59	57	77	108	34
N2	12	21	58	44	54	96	37
N3	12	16	60	51	65	102	33
NE1	14	21	68	45	55	96	72
NE2	10	19	47	23	29	59	59
NE3	10	18	64	45	53	97	42
C1	19	31	115	123	159	234	22
C2	14	26	90	85	101	174	24
C3	12	24	86	95	127	179	19
S1	12	15	48	43	57	87	26
S2	12	16	45	35	43	75	22
S3	11	16	54	45	51	93	30
Total	150	248	794	691	871	1,400	420

Table 5-7 ESTIMATED DATA QUANTITIES TO BE TRANSMITTED (2000)

Region	No. of SS	Remote Terminal		No. of Units	Measured Value					Status Indication							
					Current	Active Power	Reactive Power	Voltage	Total	On/Off	OCR		G.R.		Re.Ry Lock	Local Control	Total
											Inst.	Delay	Inst.	Delay			
N1	12	CB		64	192	64	64	33	353	64	192	192	64	64	64	12	652
		Sectionalizer	Case 1	62						62							62
			Case 2	82						82							82
			Case 3	118						118							118
		Recloser		34						34					34		68
N2	12	CB		61	183	61	61	31	336	61	183	183	61	61	61	12	622
		Sectionalizer	Case 1	47						47							47
			Case 2	57						57							57
			Case 3	102						102							102
		Recloser		37						37					37		74
N3	12	CB		60	180	60	60	28	328	60	180	180	60	60	60	12	612
		Sectionalizer	Case 1	51						55							51
			Case 2	65						65							65
			Case 3	102						102							116
		Recloser		33						33					33		66
NE1	14	CB		78	234	78	78	34	424	78	234	234	78	78	78	14	794
		Sectionalizer	Case 1	55						55							55
			Case 2	65						65							65
			Case 3	116						116							116
		Recloser		72						72					72		144
NE2	10	CB		55	165	55	55	29	304	55	165	165	55	55	55	10	560
		Sectionalizer	Case 1	32						32							32
			Case 2	40						40							40
			Case 3	76						76							76
		Recloser		59						59					59		118
NE3	10	CB		64	192	64	64	28	348	64	192	192	64	64	64	10	650
		Sectionalizer	Case 1	45						45							45
			Case 2	53						53							53
			Case 3	97						97							97
		Recloser		42						42					42		84

(Continued Table 5-7)

Region	No. of SS	Remote Terminal		No. of Recloser	Measured Value					Status Indication							
					Current	Active Power	Reactive Power	Voltage	Total	On/Off	OCR		G.R.		Re.Ry Lock	Local Control	Total
											Inst.	Delay	Inst.	Delay			
C1	19	CB		116	348	116	116	50	630	116	348	348	116	116	116	19	1,179
		Sectionalizer	Case 1	124						124							124
			Case 2	160						160							160
			Case 3	236						236							236
		Recloser		22						22					22		44
C2	14	CB		90	270	90	90	40	490	90	270	270	90	90	90	14	914
		Sectionalizer	Case 1	85						85							85
			Case 2	101						101							101
			Case 3	174						174							174
		Recloser		24						24					24		48
C3	12	CB		88	264	88	88	37	477	88	264	264	88	88	88	12	892
		Sectionalizer	Case 1	97						97							97
			Case 2	129						129							129
			Case 3	183						183							183
		Recloser		19						19					19		38
S1	12	CB		48	144	48	48	27	267	48	144	144	48	48	48	12	492
		Sectionalizer	Case 1	43						43							43
			Case 2	57						57							57
			Case 3	87						87							87
		Recloser		26						26					26		52
S2	12	CB		51	153	51	51	27	282	51	153	153	51	51	51	12	522
		Sectionalizer	Case 1	41						41							41
			Case 2	49						49							49
			Case 3	87						87							87
		Recloser		22						22					22		44
S3	11	CB		57	171	57	57	27	312	57	171	171	57	57	57	11	581
		Sectionalizer	Case 1	48						48							48
			Case 2	54						54							54
			Case 3	99						99							99
		Recloser		30						30					30		60
Total	150	CB		832	2,496	832	832	391	4,551	832	2,496	2,496	832	832	832	150	8,470
		Sectionalizer	Case 1	730						730							730
			Case 2	912						912							912
			Case 3	1,477						1,477							1,477
		Recloser		420						420					420		840

Table 5-8 ESTIMATED POLLING CYCLE (2000)

Region	200 B						600 B					
	Normal Polling			Hourly Polling			Normal Polling			Hourly Polling		
	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3	Case 1	Case 2	Case 3
N1	2.11	2.46	3.09	2.58	2.93	3.56	1.30	1.53	1.94	1.46	1.69	2.10
N2	1.89	2.06	2.85	2.33	2.51	3.30	1.16	1.27	1.79	1.31	1.42	1.93
N3	1.87	2.12	2.77	2.31	2.56	3.21	1.16	1.31	1.74	1.30	1.46	1.88
NE1	2.73	2.91	3.80	3.30	3.48	4.37	1.69	1.80	2.39	1.88	2.00	2.58
NE2	1.96	2.10	2.73	2.36	2.50	3.13	1.21	1.30	1.71	1.35	1.44	1.85
NE3	1.91	2.05	2.82	2.38	2.52	3.29	1.17	1.26	1.77	1.33	1.42	1.92
C1	3.28	3.91	5.24	4.13	4.76	6.09	2.01	2.42	3.28	2.29	2.70	3.57
C2	2.46	2.74	4.02	3.12	3.40	4.68	1.50	1.68	2.51	1.72	1.90	2.73
C3	2.54	3.10	4.05	3.19	3.75	4.69	1.56	1.92	2.53	1.77	2.13	2.75
S1	1.57	1.82	2.34	1.92	2.17	2.69	0.97	1.13	1.47	1.09	1.25	1.59
S2	1.48	1.62	2.29	1.86	2.00	2.66	0.91	1.00	1.43	1.03	1.12	1.56
S3	1.75	1.85	2.64	2.17	2.27	3.06	1.07	1.14	1.65	1.21	1.28	1.79
Average	2.13	2.40	3.22	2.64	2.90	3.73	1.31	1.48	2.02	1.48	1.65	2.19

Table 5-9 ESTIMATED FREQUENCY OF FAULTS AND INTERRUPTION ENERGY

Item			1986	1995			
				Before Project	After Project		
					Case 1	Case 2	Case 3
Frequency of Faults			7,846	7,143	7,143	7,143	7,143
Total	Interruption Energy (GWh)	A	30.0	38.7	25.6	23.3	21.2
		%	-	100	66.1	60.2	54.8
	Energy Sales (GWh)	B	9,392.6	19,185.4	19,185.4	19,185.4	19,185.4
	A/B (%)		0.319	0.202	0.133	0.121	0.111
Large Industrial	Interruption Energy (GWh)	A	6.69	10.09	6.49	5.77	5.29
		%	-	100	64.3	57.2	52.4
	Energy Sales (GWh)	B	2,866.2	6,864.6	6,864.6	6,864.6	6,864.6
	A/B (%)		0.233	0.147	0.095	0.084	0.077