Chapter 5

DISTRIBUTION SYSTEM DISPATCHING CENTER DEVELOPMENT PROGRAM

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5-1 Necessity of Distribution System Dispatching Center Development

During the period from FY 1985 to FY 1995, the energy sales of PEA is forecast to increase at an annual average growth rate of 8.4 percent from 8,557 GWh in FY 1985 to 19,185 GWh in FY 1995, with the share of PEA in the three authorities (EGAT, MEA and PEA) increasing from 42.8 percent to 51.1 percent. Also, the ratio of industrial power demand to the total demand is expected to increase from 44.4 percent (3,802 GWh) to 46.3 percent (8,885 GWh) during the same period. In short, the power demand of PEA will continue to grow at a high growth rate in the future, and there is a sign of continuous growth of industrial power demand which requires high supply reliability.

The circuit length of high voltage lines, in the meanwhile, has increased at an annual rate of 19.2 percent during the past 10 years and is expected to continue to increase in the future, though the increase rate may decline somewhat. The number of high voltage feeders is scheduled to increase from 564 in FY 1986 to 811 in FY 1995. With these expansions, the configuration of high voltage distribution system is expected to become increasingly complicated.

On the other hand, the faults of high voltage distribution lines are very frequent and the supply interruptions are very long, with a record of 14 times and 30 hours per feeder during the one year period. Also, the losses of big customers by supply interruption are estimated at 365 M.Baht in FY 1986, causing the great losses to the national economy. The losses of big customers are expected to increase further in the future with the growth of industrial power demand and are estimated at 551 M.Baht in FY 1995.

Under these situations, no automated supervisory control equipment are provided for the dispatching operations of extensive distribution system, and the dispatching operations are being carried out through the voice communications with VHF (partially UHF) radio system. As a result, tremendous time and labor have been required for the collection of fault information, detection of fault sections and interchange of power to sound sections, indicating the increasing difficulty of coping with the situation with the conventional system. In the future, the operation of power distribution system will inevitably become more complicated with the increase of power demand and the expansion of facilities, and the social demand for a more reliable power supply will become more strict.

To cope with the situation, it is essential for PEA to promote the automated dispatching operations through the introduction of an advanced distribution dispatching system and the improvement of existing communication system as early as possible.

5-2 Facilities to be Supervisory Controlled

The facilities to be supervisory controlled by the proposed distribution dispatching system were determined based on the substation expansion plan, high voltage feeder expansion plan, criteria for the installation of sectionalizers, etc. For the reclosers, the existing number of units was considered to be left in the future as the long distance high voltage lines is not likely to increase because of the construction of additional substations. For the sectionalizers, the study was made on the following three cases. The number of sectionalizers required was determined after subtracting the number of existing reclosers installed on main lines.

Case 1: To install one unit for every line

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

Case 3: To install two units for every line

Based on the foregoing study, the facilities to be supervisory controlled were determined to be 150 substations, 794 circuit breakers, 420 reclosers and 691 sectionalizers (Case 1), 871 sectionalizers (Case 2) and 1,400 sectionalizers (Case 3). The breakdown of these facilities by region is shown in Table 5-1.

5-3 Organization of Distribution System Dispatching Center

One distribution dispatching center was determined to be constructed at each regional office for the reasons described below. However, two dispatching centers were required for Southern region 1 because of the restrictions on radio routes (see Fig. 5-2).

(1) The scale of future high voltage distribution system is expected to be in the range that can be adequately covered from one dispatching center. In Central Region 1 where the distribution system is expected to become the largest scale, the number of substations and high voltage feeders is expected to be 19 and 116, respectively, in the year 2000.

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

(3) As there are many cases in which the high voltage lines of one substation are extended ranging from offices to offices, the centralized dispatching operation from the regional office is more efficient and easier.

(4) There is no problem for the maintenance as the maintenance staffs of distribution lines are distributed to electric offices and customer service centers.

(5) Almost all areas of each region may be covered by the data transmission system with the installation of repeater stations.

(6) The distribution, rather than the centralization, of distribution system dispatching centers will result in the increase of the number of radio frequencies for the dispatching system, along with the re-structure of existing communication system. In addition, with more center facilities required, the construction cost will be much higher.

5-4 Function of Distribution Dispatching System

The functions of the proposed distribution dispatching system were determined to be as follows based on the system requirements.

(1) Supervisory Functions

(a) Normal Supervision

- Open-close status of circuit breakers, sectionalizers and reclosers
- Operation status of control station relays
- Bus voltage, active power and reactive power of high voltage feeders

(b) Detection of Status Changes

- Circuit breakers, sectionalizers and reclosers

(2) Control Functions

(a) Individual Control

- Open-close operations of circuit breakers, sectionalizers and reclosers

(b) Concurrent Control

- Closing operation of circuit breakers, sectionalizers and reclosers

(3) Display Function

(4) System Diagnostic Function

(5) Maintenance Function

(6) Data Collection, Processing and Compilation

With the above mentioned functions, the required data quantities to be transmitted in Central Region 1, where the distribution system will be the largest scale, in the year 2000 will amount to 630 measured values and 1,459 status indications for Case 3. The polling cycles (required duration for collecting data from every remote terminal unit) were calculated at 5.2 minutes for the normal polling and 6.1 minutes for the hourly polling at the signaling rate of 200 bauds.

5-5 Structure of Distribution Dispatching System

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

The distribution dispatching system consists of the master terminal units (MTU), substation 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 are connected with the computer system via the front end processor (FEP). The man-machine interface devices comprise the CRT units, printer and loggers.

The data transmission is performed by the polling method in which the master terminal unit polls remote terminal units one by one for the data collection or control. The 11-bit format was considered for the data transmission, with the word configuration being variable depending on the data quantities. For the signaling rate, 200 bauds is considered to be preferable in consideration of the polling cycle and transmission characteristics.

5-6 Data Transmission System

(1) Selection of Radio Routes

The selected radio routes are summarized in Fig. 5-2. The radio routes were selected on the map based on the results of field surveys and the special consideration was given to cover the all areas of each region with a minimum number of repeater stations. A total number of 24 repeater stations were planned.

As the study of transmission characteristics was made using the maps with a scale of 1/250,000, there were same cases where the intervals of contour lines were so wide that the detailed topography could not be recognized. Prior to the construction works, the detailed study of topography on the maps with a scale of 1/50,000 and the propagation tests will be required.

(2) Radio Frequencies

For the operation patterns of transmitters, the duplex operation system was adopted for the center stations and repeater stations and the simplex operation system was adopted for the remote stations in consideration of the polling cycles. Based on this operation pattern and the selected radio routes mentioned in the proceeding item (1), about 12 radio frequencies are considered to be required for all regions.

The radio frequency to be used for the proposed distribution dispatching system was determined to be 400 MHz band in consideration of the results of field propagation tests, availability of radio frequencies in Thailand, the frequencies used and reserved by PEA and the required number of frequencies for the proposed distribution dispatching system.

(3) Improvement of Existing Communication System

As the improvement measure for the existing communication system, the multi-channel radio system was planned for the trunk communication system between the distribution system dispatching center and 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 the proposed distribution dispatching system does not require the multi-channel radio system, this improvement measure will contribute to the improvement of transmission quality of the existing communication system, with the possibility of increasing the number of channels. Also for the dispatching communication, the direct communications from the dispatching center to almost all areas of each region will be possible.

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

(4) Structure of Equipment

Based on the foregoing study, the number of radio stations and transmitter-receiver sets required for the proposed data transmission system were determined to be 13 center stations/36 sets, 24 repeater stations/78 sets, 150 substation remote stations/150 sets and 1,111 feeder remote stations/1,111 sets (Case 1), 1,291 feeder remote stations/1,291 sets (Case 2) and 1,820 feeder remote stations/1,820 sets (Case 3).

5-7 Evaluation of Supply Reliability

Table 5-2 shows the estimated frequency of power faults and interruption energy in FY 1995.

With the completion of the project, the interruption energy is expected to decrease from 38.7 GWh to 23.3 GWh (60.2%) in FY 1995, and the interruption energy of Large Industrial customers is expected to decrease from 10.09 GWh to 5.77 GWh (57.2%), thereby improving drastically the power supply reliability.

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 Fig. 5-3.

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 Fig. 5-3, but the columns on ② line and Ⓒ ~ Ⓕ lines are not desirable for the efficient operation of the dispatching center and should not be provided. Without this column, 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% and the design room temperature of 25°C and relative humidity of 50% 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 Fig. 5-4 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 Fig. 5-5.

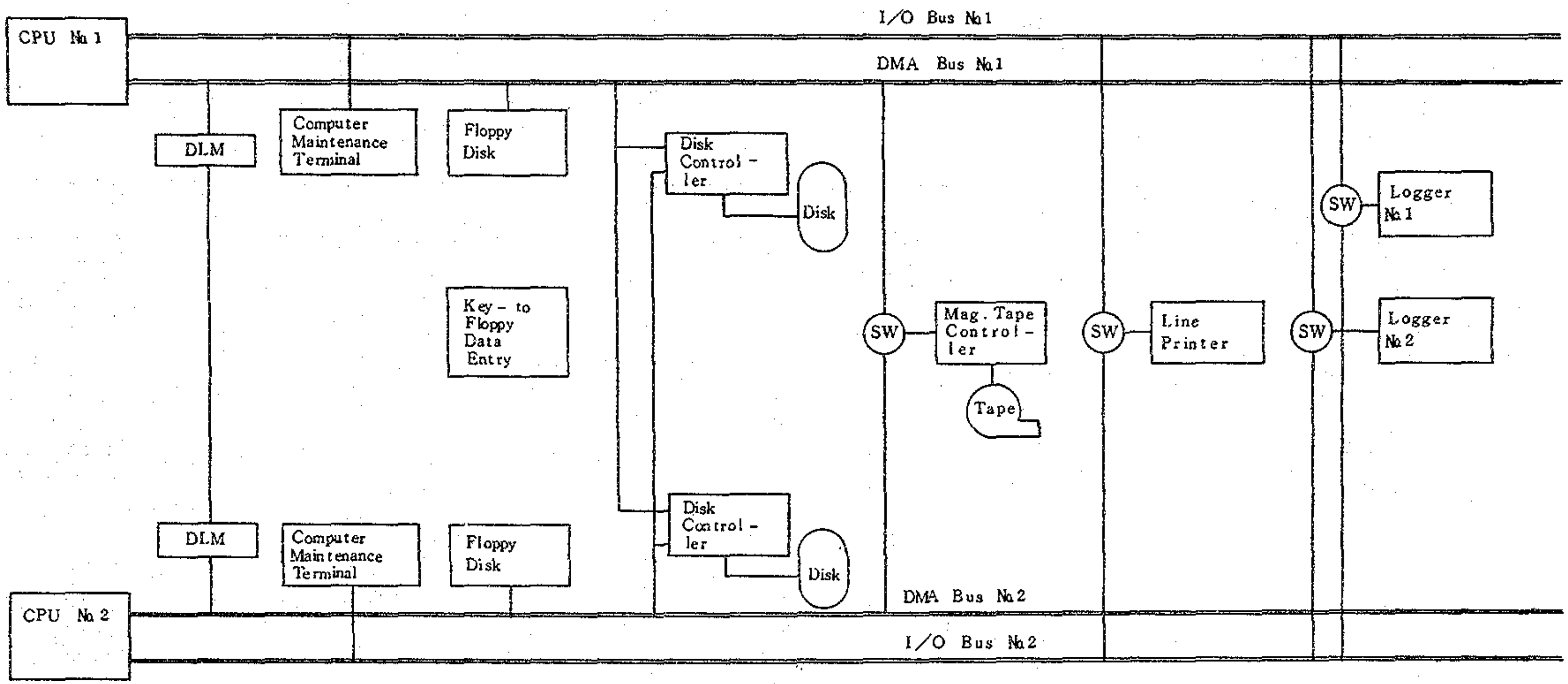
Table 5-1 FACILITIES TO BE SUPERVISORY CONTROLLED (1994)

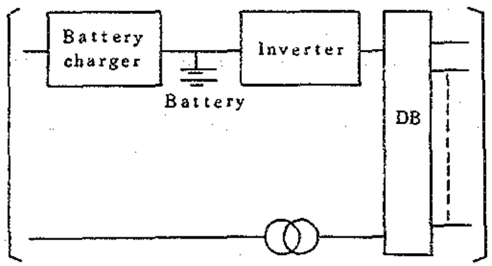
Region	No. of Substation	No. of Banks	No. of Circuit	No. of Sectionalizer			No. of Recloser
				Case 1	Case 2	Case 3	
N1	12	25	59	57	77	108	34
N2	12	21	58	44	54	96	37
N3	12	16	60	51	65	102	33
NE1	14	21	68	45	55	96	72
NE2	10	19	47	23	29	59	59
NE3	10	18	64	45	53	97	42
C1	19	31	115	123	159	234	22
C2	14	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 5-2 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

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



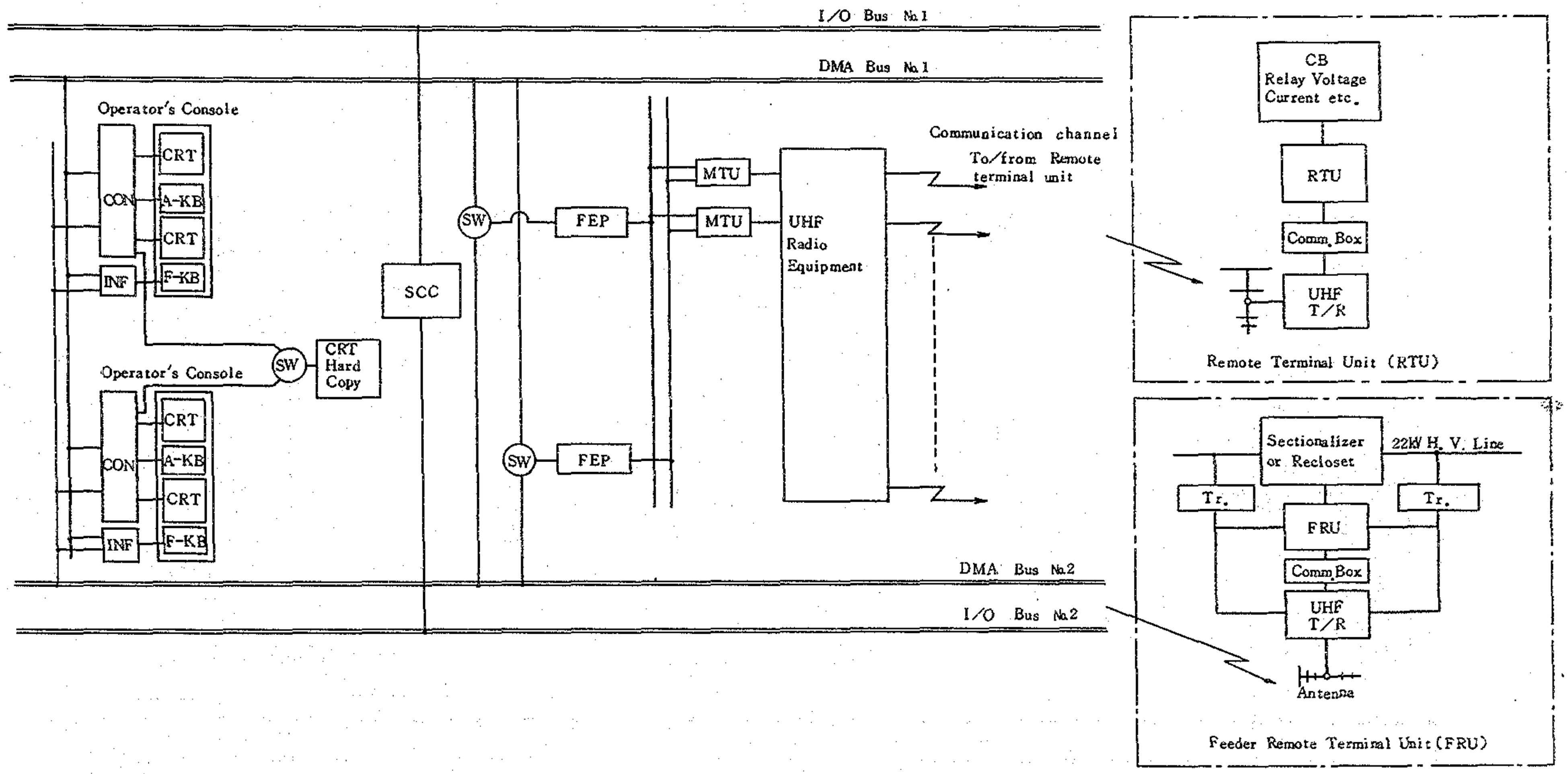


UPS Configuration

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)



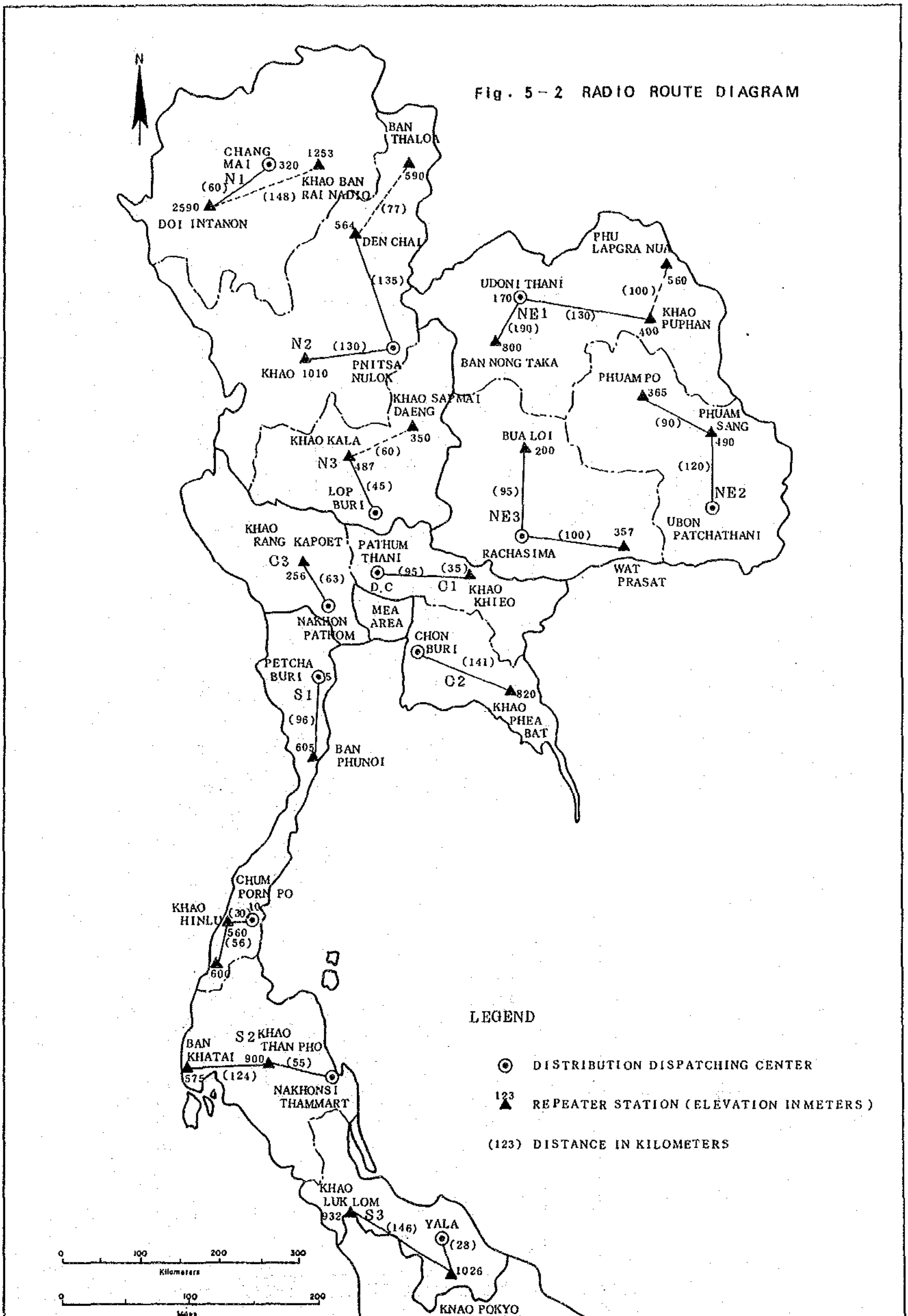


Fig. 5-2 RADIO ROUTE DIAGRAM

Fig. 5-3 TENTATIVE LAYOUT OF DISTRIBUTION DISPATCHING CENTER (C3)

WEIGHT OF EQUIPMENT

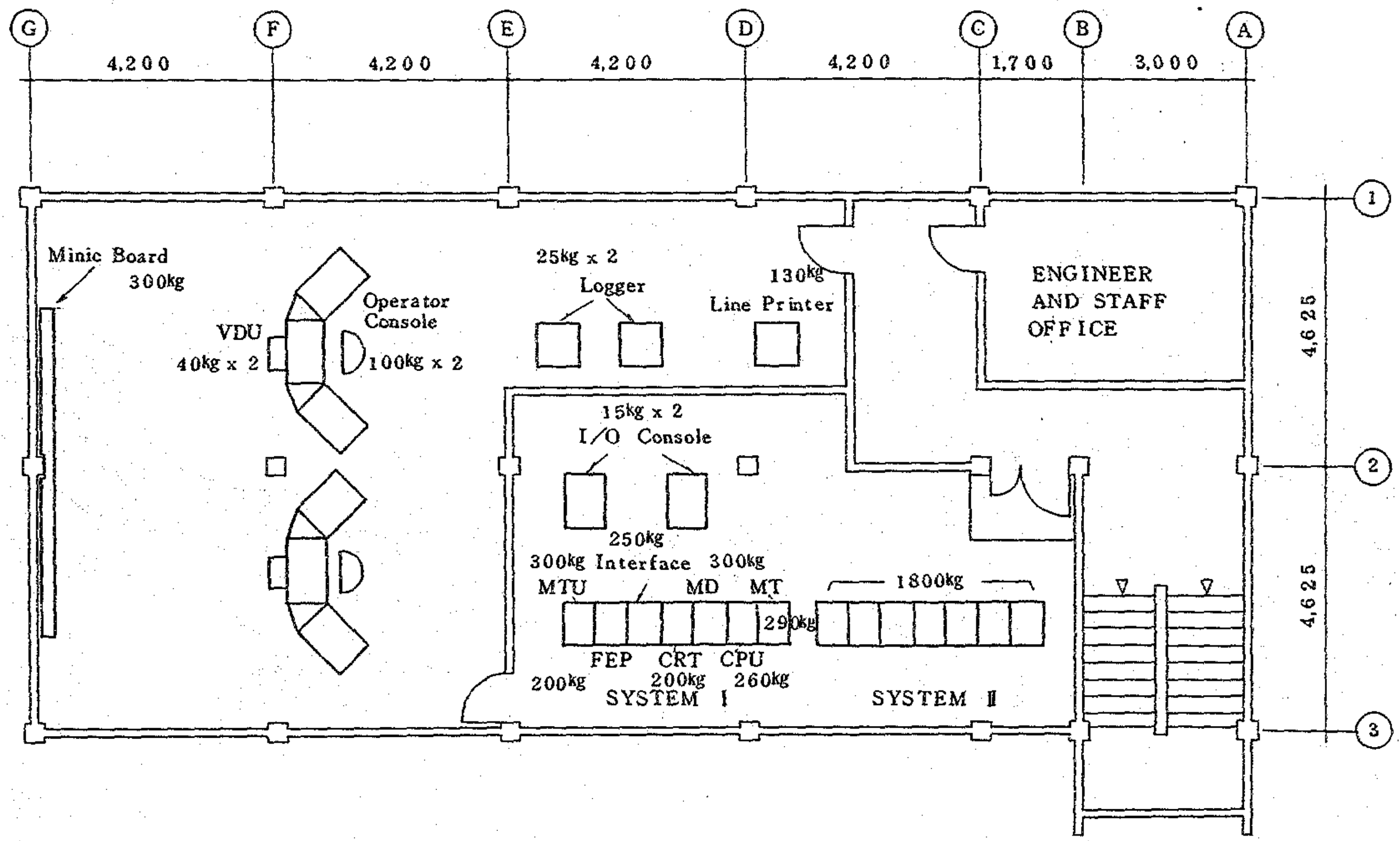
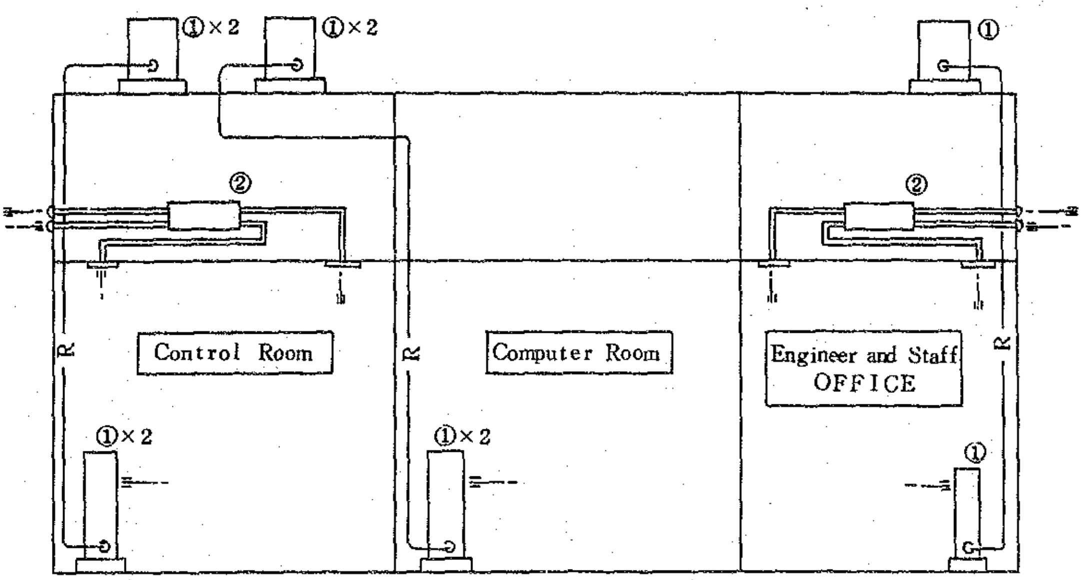


Fig. 5-4 AIR CONDITIONING SYSTEM

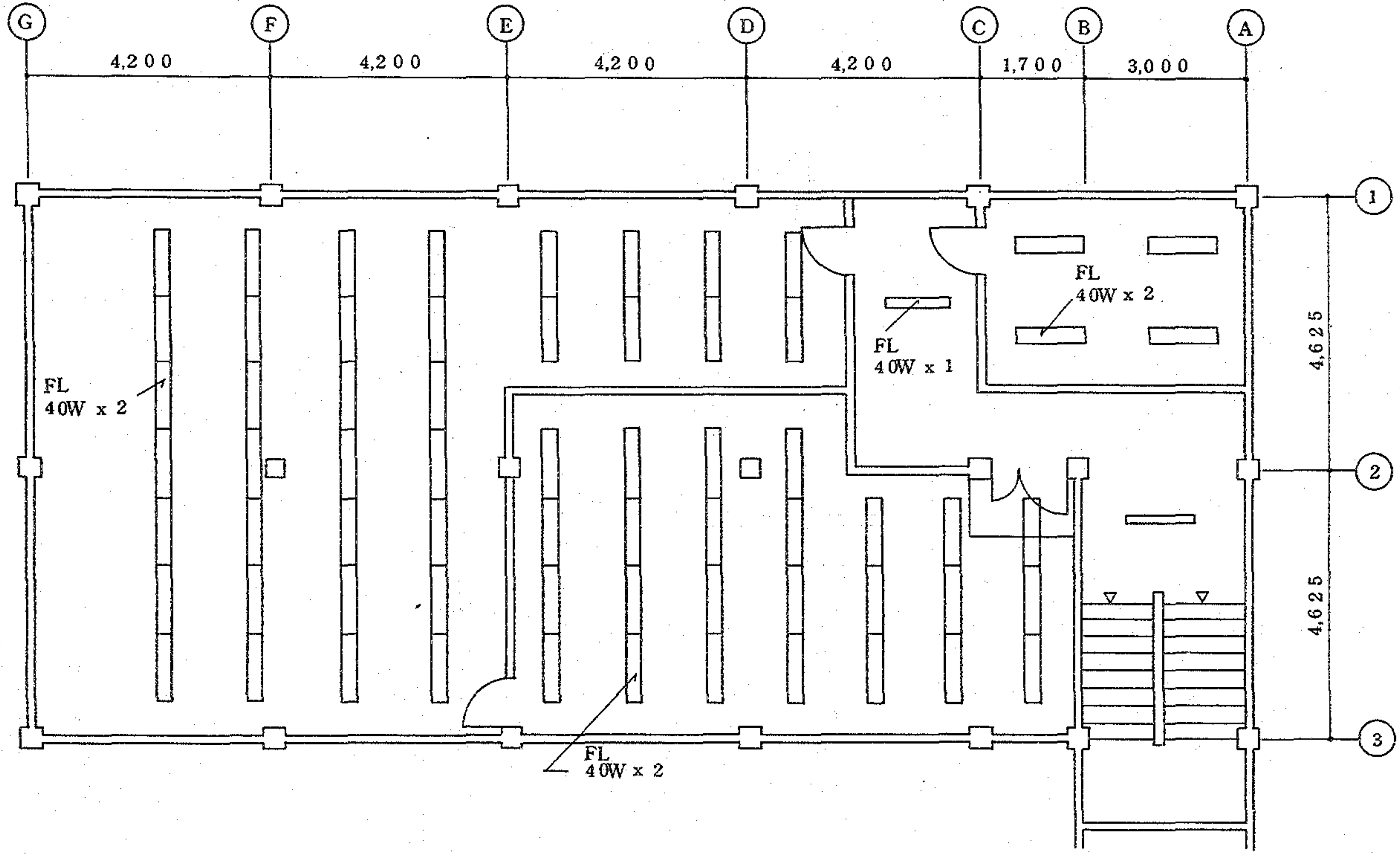


Legend

① : AIR COOLED PACKAGE

② : HEAT EXCHANGE TYPE VENTIRATING UNIT

Fig. 5-5 TENTATIVE LIGHITING LAYOUT OF DISTRIBUTION DISPATCHIND CENTER (C3)



Chapter 6

IMPLEMENTATION PROGRAM OF PILOT DISTRIBUTION SYSTEM DISPATCHING CENTER

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6-1 Necessity of Pilot Distribution System Dispatching Center

As the automated distribution dispatching system is the first attempt for PEA, the construction of pilot distribution dispatching center and the provision of training unit were planned for the following reasons.

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

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

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

(4) Training of engineers/technicians.

6-2 Selection of Sites of Pilot Distribution Dispatching Center

As the same system may be applied to all regions, the construction of one pilot dispatching center was considered sufficient.

For the site of pilot dispatching center, Central Region 3 was selected in consideration of its advantageous location for the system confirmation, evaluation and training, its importance with respect to the amount and quality of power demand, availability of the building and the status of control stations installed.

6-3 Facilities to be Supervisory Controlled

The facilities to be supervisory controlled were determined to be 12 substations, 86 circuit breakers, 19 reclosers and 95 units of sectionalizer (Case 1), 127 units (Case 2) and 179 units (Case 3). Fig. 6-1 shows the distribution system diagram of Central Region 3.

6-4 Function and Structure of Distribution Dispatching System

The functions and structure of the distribution dispatching system are as described in Clause 5-4 and 5-5, respectively. The pilot dispatching center will be located on the fourth floor of the new regional office building. The equipment layout (tentative) of the pilot dispatching center is shown in Fig. 6-2.

6-5 Data Transmission System

The proposed radio route diagram in Central Region 3 is shown in Fig. 6-3. During the field survey, the propagation test was conducted from Khao Phu Liab (a repeater station is being constructed by TOT) located about 18 km west of Kanchanaburi. As the construction of repeater station in this location requires the construction of an additional repeater station around Suphauburi, Khao Rang Kapoet was selected for the site of repeater station.

The radio stations and transmitters-receivers required for the data transmission system include one center station / 3 sets of transmitter-receivers, one repeater station / 3 sets, 12 substation remote stations / 12 sets and 114 feeder remote stations / 114 sets (Case 1), 146 stations / 146 sets (Case 2) and 198 stations / 198 sets (Case 3).

6-6 Education and Training Program and Training Unit

The education and training are very important and indispensable for the smooth execution of the project and the optimum operation of the distribution dispatching system. The training under the project is divided into the training for the trainers of PEA, training for the pilot project and training for the master project as described below.

(1) Training for the Trainers of PEA

This training will be conducted in Japan for two system engineers, two operation engineers and one communication engineer. The training duration will be approximately three months.

(2) Training for the pilot project

This training will be conducted by the trainers at the Training Center and the pilot dispatching center for the staffs of central distribution dispatching center, and dispatching operators and related staffs of Central Region 3. The training period will be approximately three months prior to the commissioning of the pilot dispatching center. The On-the-Job training or follow-up training will be required after the commissioning of pilot dispatching center. The training course (tentative) for distribution dispatching system are shown in Table 6-1.

(3) Training for the Master Project

This training will be conducted by the trainers at the Training Center and the pilot dispatching center for the dispatching operators and related staffs of each region. As there is no restriction on the timing and duration for this training, the training may be conducted systematically throughout the year.

Since the pilot dispatching center will be operated in the live power system, the practical training on the operation and maintenance will naturally be limited. Besides, the project requires the training for a large number of personnel and the use of the training unit is indispensable for the substantial training. For the reason, the provision of training unit equipped with the minimum requirement such as the computer, master terminal unit, operator console and others, was planned for the Training Center so that the simulation training on the operation and maintenance can be conducted.

Table 6-1 DISTRIBUTION DISPATCHING SYSTEM TRAINING COURSE (DRAFT)

1. Objective

To promote the working knowledge of PEA's personnel concerning the distribution dispatching system operations and maintenances.

2. Training Subjects

2.1 Structure and equipments of dispatching system

(1) Data transmission devices

. Master terminal unit

. Substation terminal unit

. Feeder remote terminal unit

(2) Man-machine interface devices

. Dispatching console

. CRT

. Typewriter, etc.

(3) Computer

(4) Communication system

. Transmitter ad receiver

. communication control unit

(5) Power source

(6) Circuit breaker

(7) Recloser

(8) Sectionalizer

2.2 Functions of dispatching system

(1) Data aquisition

(2) Data processing

(3) Data logging

(4) Display

(5) Supervisory control

(6) Fault detection and isolation

(7) Service restoration

2.3 Operation procedure

2.4 Maintenance procedure

3. Training Methodologies

3.1 Lecture in the classroom with texts, manuals and visual aids such as

- Overhead projector
- Slide projector
- Video tape

3.2 Practice

- at training center by means of training unit
- at pilot dispatching center
- at control station
- at working site

4. Trainees

Engineers and technicians

5. Number of trainees per course

about 30 persons

6. Duration of training

Ten (10) days

Fig 6-1 DISTRIBUTION SYSTEM DIAGRAM (C3)

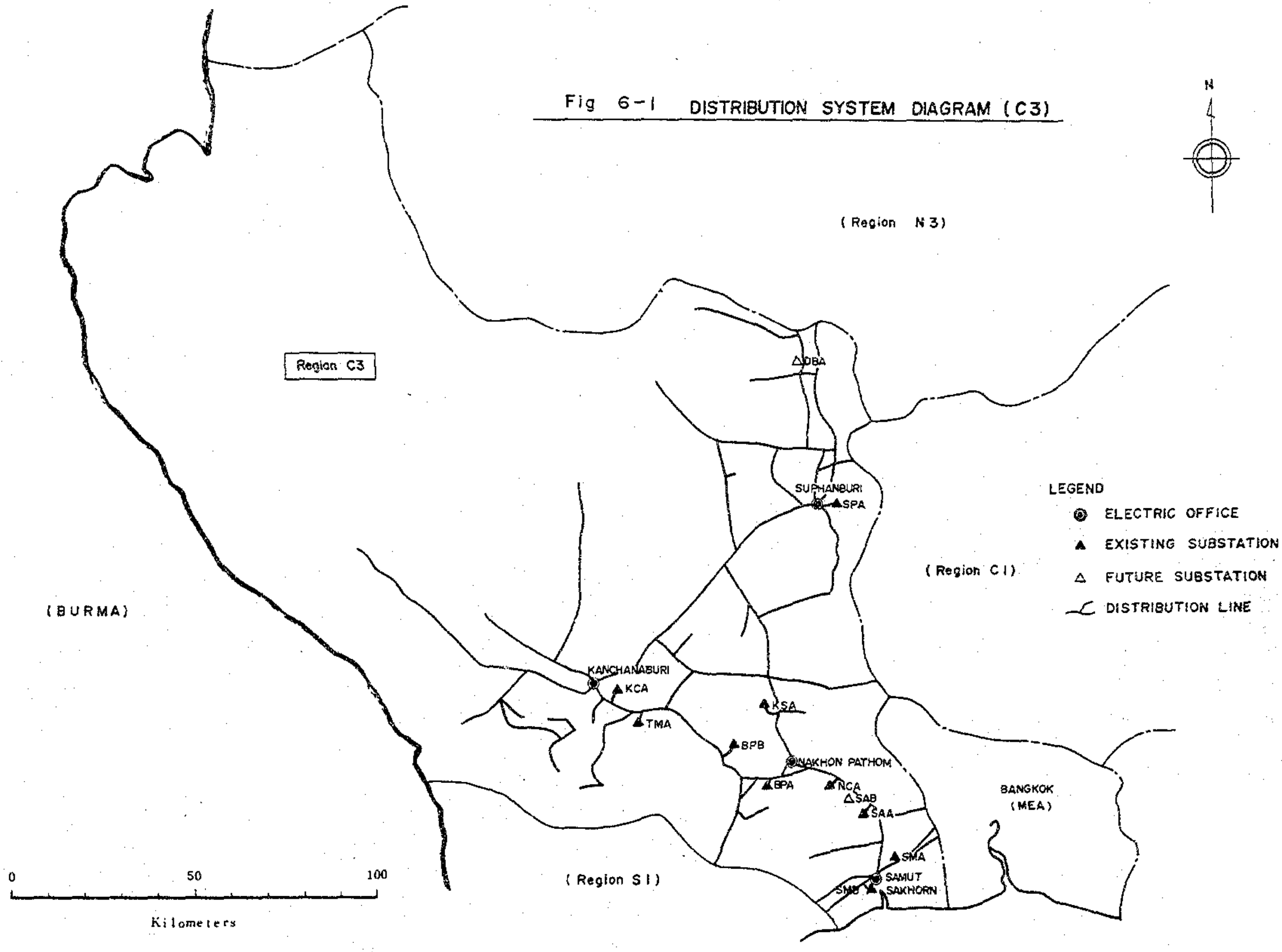


Fig 6 — 2 TENTATIVE LAYOUT OF DISTRIBUTION DISPATCHING CENTER (C3)

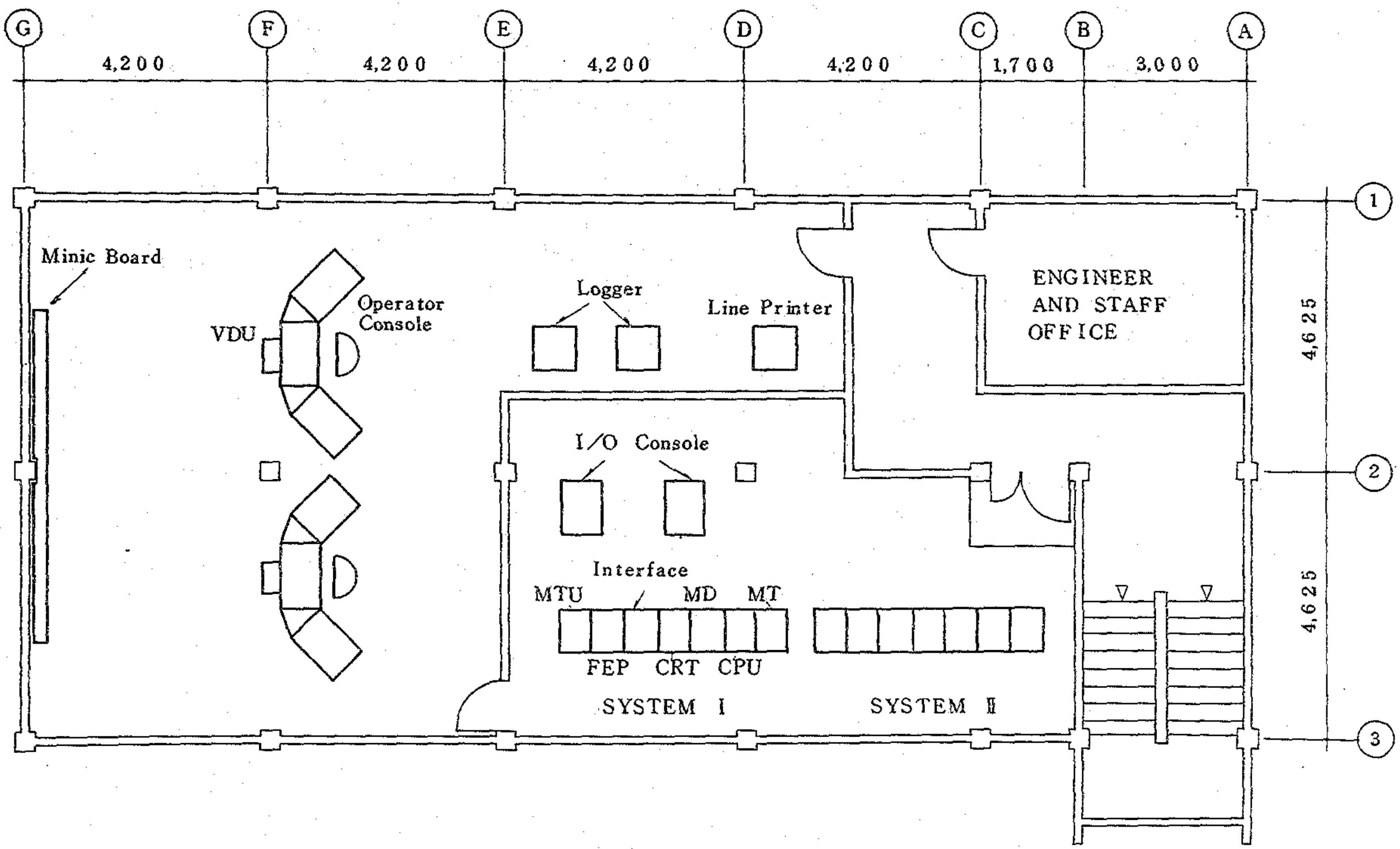
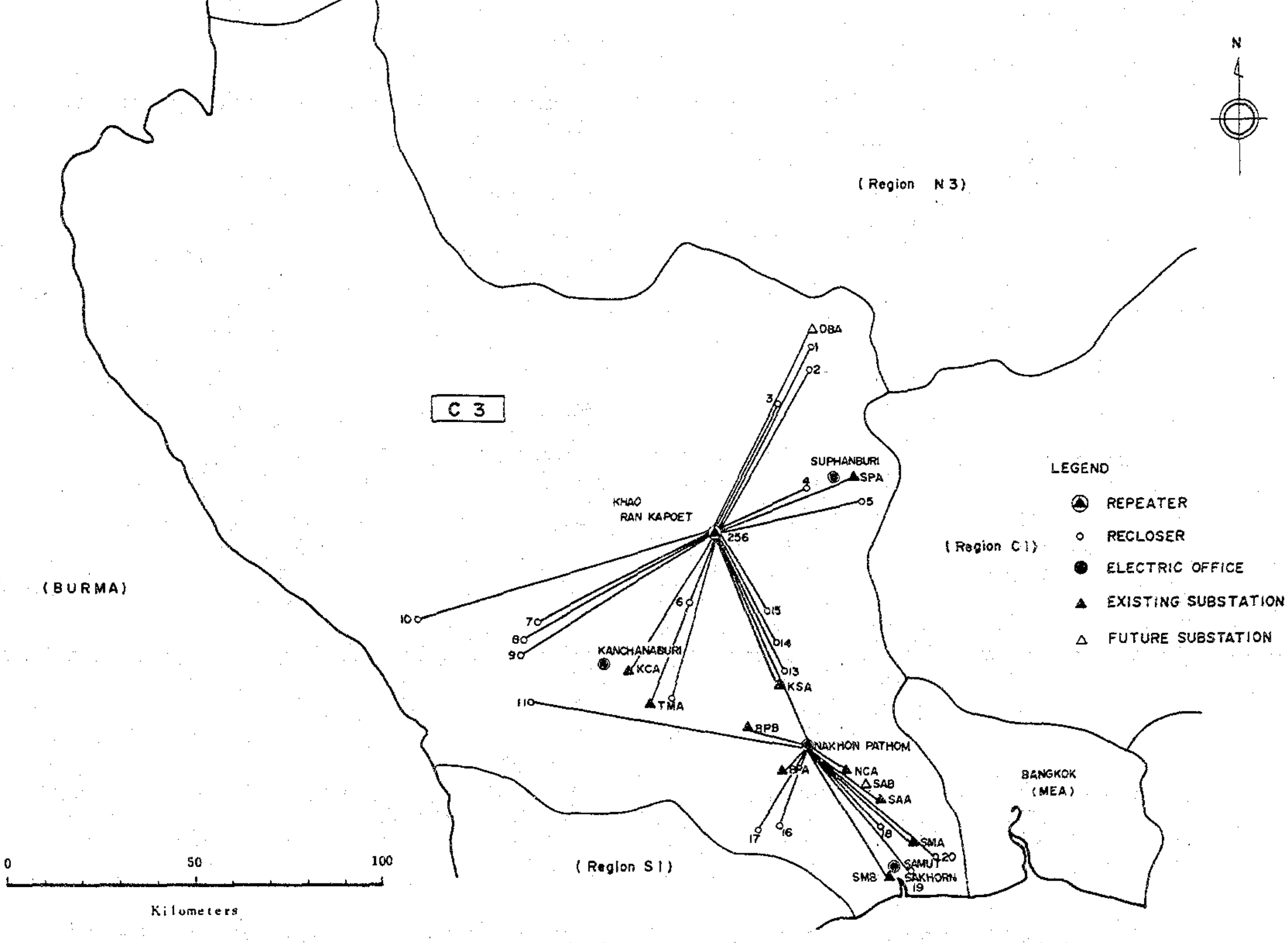


Fig 6-3 RADIO ROUTE DIAGRM (REGION C3)



Chapter 7

CONSTRUCTION COST

Chapter 7 CONSTRUCTION COST

The construction costs for the project and pilot project are shown in Tables 7-1 and 7-2, respectively. The construction cost of pilot project is included in the construction cost shown in Table 7-1.

The exchange rates as of September 22, 1986 used for the conversion are 1 US$ = 25.936 Baht and 1 US$ = 153.80 Yen.

The breakdown of construction cost by region is shown in Tables 7-3-1 to 7-3-3.

Table 7-1 CONSTRUCTION COST OF THE PROJECT

(Unit: 1,000 US$)

Item	Case 1				Case 2				Case 3			
	F.C.	L.C.		Total	F.C.	L.C.		Total	F.C.	L.C.		Total
		Duties	Others			Duties	Others			Duties	Others	
Center Terminal Unit	20,417	8,062	1,899	30,378	20,417	8,062	1,899	30,378	20,417	8,062	1,899	30,378
Substation Remote Terminal Unit	6,920	3,598	147	10,665	6,920	3,598	147	10,665	6,920	3,598	147	10,665
Feeder Remote Terminal Unit	11,972	6,228	581	18,781	14,510	7,543	741	22,794	21,967	11,423	1,015	34,405
Data Transmission System	17,348	5,206	1,064	23,618	18,687	5,606	1,154	25,447	22,615	6,785	1,416	30,816
Sub-total (CIF)	56,657	23,094	3,691	83,422	60,534	24,809	3,941	89,284	71,919	29,868	4,477	106,264
Contingency (incl. Eng. Fee)	5,666	2,309	369	8,344	6,053	2,481	394	8,928	7,192	2,987	448	10,627
Total	62,323	25,403	4,060	91,786	66,587	27,290	4,335	98,212	79,111	32,855	4,925	116,891

Table 7-2 CONSTRUCTION COST OF THE PILOT PROJECT

(Unit: 1,000 US$)

Item	Case 1				Case 2				Case 3			
	F.C.	L.C.		Total	F.C.	L.C.		Total	F.C.	L.C.		Total
		Duties	Others			Duties	Others			Duties	Others	
Pilot Distribution Dispatching Center	6,275	2,562	328	9,165	6,964	2,867	373	10,204	8,083	3,364	426	11,873
Training Unit	575	219	1	795	575	219	1	795	575	219	1	795
Sub-total (CIF)	6,850	2,781	329	9,960	7,539	3,086	374	10,999	8,658	3,583	427	12,668
Contingency (incl. Eng. Fee)	685	278	33	996	754	309	37	1,100	866	358	43	1,267
Total	7,535	3,059	362	10,956	8,293	3,395	411	12,099	9,524	3,941	470	13,935

Table 7-3-1 CONSTRUCTION COST BY REGION (CASE 1)

(Unit: 1,000 US$)

Region	Center Terminal Unit		Substation Remote Terminal Unit		Feeder Remote Terminal Unit		Data Transmission System		Total		
										L.C.	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	Duties	Others
N1	1,419	146	545	12	984	50	1,393	61	4,341	1,777	269
N2	1,419	146	543	11	817	40	1,529	88	4,308	1,730	285
N3	1,419	146	546	12	894	44	1,375	109	4,234	1,726	311
NE1	1,419	146	633	13	1,017	50	1,857	131	4,926	1,979	340
NE2	1,419	146	451	10	638	32	1,299	107	3,807	1,521	295
NE3	1,419	146	483	10	857	40	1,336	86	4,095	1,662	282
C1	1,419	146	904	19	1,851	90	1,832	85	6,006	2,547	340
C2	1,419	146	678	14	1,326	60	1,447	93	4,870	2,041	313
C3	2,814	146	598	13	1,440	73	1,423	96	6,275	2,562	328
S1	2,838	292	523	11	744	38	1,440	85	5,545	2,219	426
S2	1,419	146	517	11	610	28	1,174	71	3,720	1,502	256
S3	1,419	146	499	11	794	36	1,243	52	3,955	1,609	245
Training Center	575	1	-	-	-	-	-	-	575	219	1
Total	20,417	1,899	6,920	147	11,972	581	17,348	1,064	56,657	23,094	3,691

Table 7-3-2 CONSTRUCTION COST BY REGION (CASE 2)

(Unit: 1,000 US$)

Region	Center Terminal Unit		Substation Remote Terminal Unit		Feeder Remote Terminal Unit		Data Transmission System		Total		
										L.C.	
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	Duties	Others
N1	1,419	146	545	12	1,266	69	1,541	71	4,771	1,967	298
N2	1,419	146	543	11	958	48	1,603	93	4,523	1,825	298
N3	1,419	146	546	12	1,091	57	1,479	116	4,535	1,859	331
NE1	1,419	146	633	13	1,158	59	1,932	136	5,142	2,075	354
NE2	1,419	146	451	10	723	38	1,343	110	3,936	1,578	304
NE3	1,419	146	483	10	970	47	1,396	90	4,268	1,738	293
C1	1,419	146	904	19	2,358	122	2,100	103	6,781	2,890	390
C2	1,419	146	678	14	1,552	74	1,566	101	5,215	2,194	335
C3	2,814	146	598	13	1,891	102	1,661	112	6,964	2,867	373
S1	2,838	292	523	11	941	50	1,544	92	5,846	2,352	445
S2	1,419	146	517	11	723	35	1,234	75	3,893	1,579	267
S3	1,419	146	499	11	879	40	1,288	55	4,085	1,666	252
Training Center	575	1	-	-	-	-	-	-	575	219	1
Total	20,417	1,899	6,920	147	14,510	741	18,687	1,154	60,534	24,809	3,941

Table 7-3-3 CONSTRUCTION COST BY REGION (CASE 3)

(Unit: 1,000 US$)

Region	Center Terminal Unit		Substation Remote Terminal Unit		Feeder Remote Terminal Unit		Data Transmission System		Total		
	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C.	F.C.	L.C. Duties	L.C. Others
N1	1,419	146	545	12	1,703	85	1,772	86	5,439	2,265	329
N2	1,419	146	543	11	1,550	70	1,915	114	5,427	2,227	341
N3	1,419	146	546	12	1,613	76	1,754	134	5,332	2,213	368
NE1	1,419	146	633	13	1,736	80	2,236	156	6,024	2,467	395
NE2	1,419	146	451	10	1,146	52	1,566	125	4,582	1,865	333
NE3	1,419	146	483	10	1,590	69	1,723	112	5,215	2,159	337
C1	1,419	146	904	19	3,415	161	2,657	140	8,395	3,607	466
C2	1,419	146	678	14	2,581	111	2,108	137	6,786	2,891	408
C3	2,814	146	598	13	2,624	129	2,047	138	8,083	3,364	426
S1	2,838	292	523	11	1,364	66	1,766	107	6,491	2,639	476
S2	1,419	146	517	11	1,174	53	1,471	91	4,581	1,884	301
S3	1,419	146	499	11	1,471	63	1,600	76	4,989	2,068	296
Training Center	575	1	-	-	-	-	-	-	575	219	1
Total	20,417	1,899	6,920	147	21,967	1,015	22,615	1,416	71,919	29,868	4,477

Chapter 8

IMPLEMENTATION PROGRAM OF THE PROJECT

Chapter 8 IMPLEMENTATION PROGRAM OF THE PROJECT

8-1 General Concept of Project Implementation

As already mentioned in Clause 5-1, the project is required to be implemented as early as possible as it involves the pilot project described in Chapter 6.

For the implementation, the project is divided into the pilot project and the master project for the remaining 11 regions. For the implementation of master project, the following two alternatives were considered.

(1) Alternative 1

The project will be implemented region by region. The ranking of implementation is shown in Table 8-1.

(2) Alternative 2

Each region will be divided into A-zone (urban and industrial areas) and B-zone (rural area), and the project will be implemented in A-zone first and then in B-zone.

8-2 Implementation Program

The study of these alternatives was made for Case 2, which was adopted as the optimum case. Table 8-2 shows the names of regions/zones to be implemented and the construction costs by year. Tables

8-3 and 8-4 show the facilities to be supervisory controlled and construction costs by regin and by zone, respectively.

Alternative 1 is superior for the ease of project implementation. In Alternative 1, the project planning, construction work and the application of software may be executed at one time for each region, while Alternative 2 requires to divide these works. With respect to the operation of distribution dispatching system, Alternative 2 is superior as it provides dispatching centers in all regions in three years and also gives the priority to urban and industrial areas.

Since the automated distribution dispatching system is the first attempt for PEA, the priority was given to the efficiency of project implementation and Alternative 1 was selected for the project.

Based on the foregoing study, the project was scheduled to be executed in the following three stages.

(a) First Stage (1987 - 1989)

Pilot distribution dispatching center (Central Region 3) and training unit (Training Center)

(b) Second Stage (1990 - 1992)

Distribution dispatching centers in six regions (C1, C2, S1, S2, S3, NE3)

(c) Third Stage (1993 - 1994)

Distribution dispatching centers in five regions (N1, N2, N3, NE1, NE2)

In each stage of the project, the detailed survey of the sites of repeater stations and radio routes, the study on the optimum arrangement of sectionalizers based on the future plan of distribution system, detailed design, preparation of detailed specifications for various equipment and training, etc. will be required. For the efficient execution of the project including aforementioned associated works, it is essential to establish an appropriate institutional framework for the project implementation and the assistance of an experienced consultant will also be needed.

As the equipment of the proposed distribution dispatching system, including the equipment for dispatching centers, repeater stations, substations and distribution lines, are required to be designed and manufactured as an intergrated system, a package order system is essential for the procurement of equipment and materials.

8-3 Implementation Schedule

The implementation schedule of the project is shown in Table 8-5.

Table 8-1 IMPLEMENTATION RANKING BY REGIONS

Region	Construction Cost A (1,000 US$)	Benefit (1995)								Supply Energy (1995) (Gwh)	Ranking
		Reduction of Interruption Energy		Reduction of C/S Operators		Reduction of Big Customer's Losses		Total B (1,000 US$)	B/A (%)		
		Energy (MWh)	Amount (1,000 US$)	Operators	Amount (1,000 US$)	Energy (MWh)	Amount (1,000 US$)				
N1	7,740	924.1	15	12	34	14.1	30	79	1.0	1,448	9
N2	7,311	632.2	10	16	46	20.7	43	99	1.4	1,049	11
N3	7,397	636.5	10	9	26	18.0	38	74	1.0	993	12
NE1	8,327	2,071.8	33	14	40	230.5	485	558	6.7	1,229	8
NE2	6,400	765.7	12	10	28	31.4	65	106	1.7	957	10
NE3	6,929	538.7	9	21	60	212.6	448	517	7.5	1,262	7
C1	11,067	1,925.7	31	23	65	1,567.3	3,301	3,397	30.7	4,042	2
C2	8,518	1,187.0	19	17	48	363.7	766	833	9.8	2,939	3
C3	11,224	1,491.4	24	20	57	851.2	1,793	1,874	16.7	3,134	1
S1	9,508	1,693.5	27	13	37	402.0	847	911	9.6	1,277	5
S2	6,313	1,489.6	24	8	23	372.9	785	832	13.2	1,182	4
S3	6,603	2,058.6	33	10	28	238.2	502	563	8.5	1,448	6
Total	97,337	15,414.8	247	173	492	4,322.6	9,104	9,843	10.1	20,960	

Table 8-2 IMPLEMENTATION SCHEDULE FOR 11 REGIONS

Alternatives	Year	Regions or Zones to be Implemented						Construction Cost (1,000 US$)
Alternative 1	1990	C1	C2					19,585
	1991	S1	S2					15,821
	1992	NE3	S3					13,532
	1993	NE1	N1					16,067
	1994	N2	N3	NE2				21,108
Alternative 2	1990	C1-A	C2-A	S1-A				18,434
	1991	S2-A	S3-A	NE1-A	NE3-A			17,488
	1992	NE2-A	N1-A	N2-A	N3-A			17,503
	1993	C1-B	C2-B	S1-B	S2-B	NE1-B		16,382
	1994	S3-B	NE2-B	NE3-B	N1-B	N2-B	N3-B	16,306

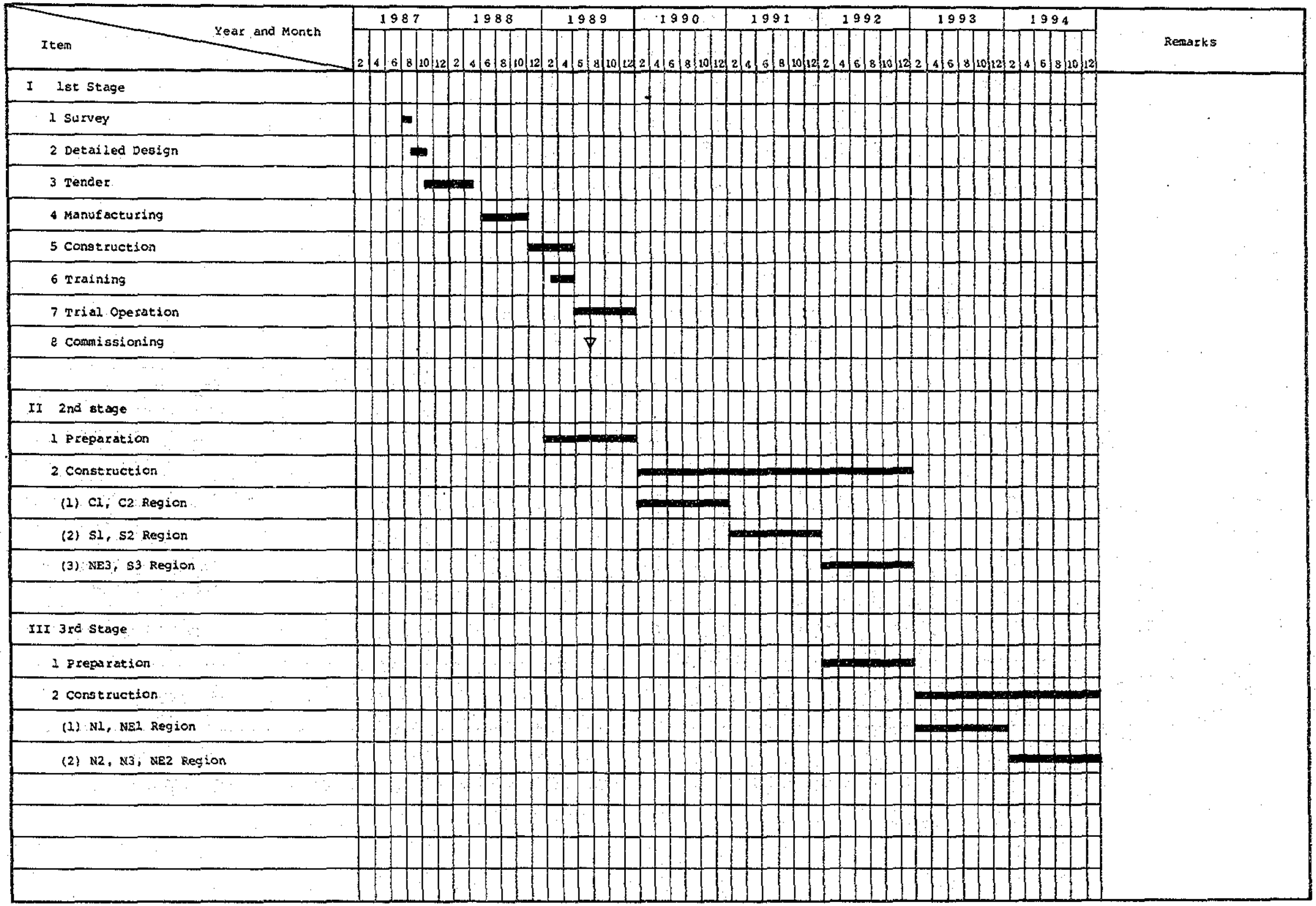
Table 8-3 FACILITIES TO BE SUPERVISORY CONTROLLED AND CONSTRUCTION COST BY REGIONS (1994)

Region	Supply Energy (GWh)	No. of Dispatching Center	No. of Repeater Station	No. of Substation	No. of Bank	No. of Feeder	No. of Sectionalizer	No. of Recloser	Construction Cost (1,000 US$)
N1	1,344	1	2	12	19	59	77	34	7,740
N2	993	1	3	12	20	58	54	37	7,311
N3	945	1	2	12	16	60	65	33	7,397
NE1	1,168	1	3	14	20	68	55	72	8,327
NE2	893	1	2	10	19	47	29	59	6,400
NE3	1,206	1	2	10	18	64	53	42	6,929
C1	3,875	1	1	19	31	115	159	22	11,067
C2	2,800	1	1	14	26	90	101	24	8,518
C3	-	-	-	-	-	-	-	-	-
S1	1,202	2	3	12	15	48	57	26	9,508
S2	1,117	1	2	12	16	45	43	22	6,313
S3	1,357	1	2	11	16	54	51	30	6,603
Total	16,900	12	23	138	216	708	744	401	86,113

Table 8-4 FACILITIES TO BE SUPERVISORY CONTROLLED AND CONSTRUCTION COST BY ZONES (1994)

Zone	Substation	Supply Energy (GWh)	No. of Dispatching Center	No. of Repeater Station	No. of Substation	No. of Bank	No. of Feeder	No. of Sectionalizer	No. of Recloser	Construction Cost (1,000 US$)
N1-A	CMA, CMB, CMC, CRA	779	1	2	4	8	24	33	18	4,895
N2-A	PLA, PIA, UTA	485	1	1	3	6	19	17	18	3,142
N3-A	LPA, LPB, SBA, NSA	588	1	1	3	7	26	32	19	4,677
NE1-A	UDA, UDB, KKA, KKB	606	1	1	4	6	22	29	25	4,789
NE2-A	UBA, SJA, YTA	442	1	1	3	8	16	4	26	3,789
NE3-A	NRA, NRB	544	1	-	2	5	20	23	15	3,940
C1-A	BKA, BMA, PQA, TYA, NVA, SRB, SRC	2,570	1	1	7	12	49	79	5	6,411
C2-A	CBA, CCA, BLA, RAA, RAC	1,976	1	1	5	14	45	52	10	5,405
S1-A	PBA, SSA, CAA, CPA	734	2	-	4	6	20	24	17	6,618
S2-A	NTA, PPA, SNA, LRA	625	1	1	4	7	20	19	12	4,128
S3-A	HYA, HYB, SLA, PTA	887	1	2	4	7	27	34	3	4,631
Total		10,236	12	11	43	86	288	346	168	53,425
N1-B		565	-	-	8	11	35	44	16	2,845
N2-B		509	-	2	9	14	39	37	19	3,169
N3-B		357	-	1	9	9	34	33	14	2,720
NE1-B		562	-	2	10	14	46	26	47	3,538
NE2-B		451	-	1	7	11	31	25	33	2,611
NE3-B		662	-	2	8	13	44	30	27	2,989
C1-B		1,305	-	-	12	19	66	80	17	4,656
C2-B		824	-	-	9	12	45	49	14	3,113
S1-B		468	-	3	8	9	28	33	9	2,890
S2-B		492	-	1	8	9	25	24	10	2,185
S3-B		469	-	-	7	9	27	17	27	1,972
Total		6,664	-	12	95	130	420	398	233	32,688

Table 8-5 IMPLEMENTATION SCHEDULE



Chapter 9

ECONOMIC EVALUATION

Chapter 9 ECONOMIC EVALUATION

9-1 Methodology of Economic Evaluation

The economic evaluation of the project was made with the internal rate of return (IRR). However, the project has no direct economic effect on the finance of PEA, and the evaluation was made with the economic internal rate of return (EIRR), including the benefit of big customers derived from the reduction of supply interruption.

9-2 Economic Evaluation

(1) Cost

The construction cost excluding import duties was considered, and the balance of depreciation cost after the calculation period was converted to the present value and subtracted from the amount of investment (see Table 9-1). The investment schedule is described in Chapter 8.

The operation cost was determined to be 1 percent of the total investment cost in consideration of the past records of PEA.

(2) Benefit

The benefit of PEA derived from the reduction of supply interruption, the benefit of PEA derived from the reduction of control station operators, and the benefit of big customers derived from the reduction of supply interruption were considered (see Table 9-1).

(3) EIRR

Table 9-2 shows net in-flow, while Table 9-3 and Fig. 9-1 show net present value.

EIRR was calculated at 11.20 percent for Case 1, 13.44 percent for Case 2 and 11.89 percent for Case 3, with Case 2 considered as the optimum case.

9-3 Financial Analysis

The financial analysis was made for Case 2.

The annual interest rate and repayment term were considered as follows in consideration of the past borrowings of PEA and others.

	Annual Interest Rate	Repayment Term (Grace Period)
Foreign currency	3.0%	20 years (10 years)
Local currency	12.0%	15 years (5 years)

The amortization schedule and the cash flow of PEA are shown in Tables 9-4 and 9-5, respectively.

The cash balance of PEA will be in the red, with the deficit amounting to 119.3 M.US$, during the period from 1988 to 2007, which is equivalent to 0.40 percent of the electric revenue of PEA during the same period. By year, the deficit will continue to increase in the amount up to the year 2004 but will decline gradually after reaching the maximum amount of 8.7 M.US$ in the year 2004.

9-4 Sensitivity Analysis

(1) EIRR

EIRR is influenced largely by the number of sectionalizers to be installed and the benefit of big customers. Accordingly, the sensitivity analysis was made on these two factors.

(a) Effect of the Number of Sectionalizers to be Installed

The analysis was made to check the effect of the number of sectionalizes to be installed on EIRR for Case 4 and Case 5 in addition to the three cases already studied. The result of the analysis is as shown in the following table, which may be summarized as follows.

. The first one unit has the greatest effect.

. EIRR is highest in Case 2 (2 units for interconnected line and one unit for radial line).

. EIRR decreases when the number of sectionalizers is increased from that in Case 2.

Case	No. of Sectionalizers	EIRR (%)	Installation Criteria	
			Interconnected Line	Radial Line
Case 1	691	11.20	1	1
Case 2	871	13.44	2	1
Case 3	1,400	11.89	2	2
Case 4	1,580	12.18	3	2
Case 5	2,164	10.06	3	3

(b) Effect of the Benefit of Big Customers

The analysis was made to check the effect of the losses of big customers per 1 kWh of interruption energy on EIRR for Case 2. The result of the analysis is as shown below.

Losses/1 kWh of Interruption Energy	EIRR
54.62 Baht/kWh (Base Case)	13.44%
60.08 (10% up)	15.51%
49.16 (10% down)	11.35%
43.70 (20% down)	9.26%
38.23 (30% down)	7.13%

(2) FIRR

As the benefit of PEA derived from the project is extremely small as compared with the required construction cost, it is not possible to calculate the financial internal rate of return (FIRR). Accordingly, the analysis was made on the relation between FIRR and the required incremental revenue. The study was made for Case 2 and the required incremental revenue was expressed by the percentage of electric revenue. The result of analysis is shown in the following table.

FIRR (%)	5	10	15
Required Incremental Revenue (% of Electric Revenue)	0.306	0.419	0.522

9-5 Conclusion

On the basis of the foregoing studies, Case 2 was selected as the optimum case.

There is no doubt that the project is feasible from a national economic point of view. When the necessity of the project mentioned in Clause 5-1, particularly the future growth of industrial power demand in the service area of PEA, is taken into consideration, the project is considered to have a major effect on the improvement of productivity of customer's factories and activate the industrial investments, thereby contributing greatly to the economic development of Thailand. The effect of the project is not limited to the direct economic effect analyzed by the study but includes,

(1) improvement of power supply reliability,

(2) activation of industrial investment and electric power consumption,

(3) improvement of people's livelihood.

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

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

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

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

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

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

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

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

Table 9-1-1 COST AND BENEFIT (CASE 1)

(Unit: 1,000 US$)

Year	Implementation Schedule	Investment Cost			Benefit						Remarks
					Decremental Interruption Energy		Reduction of C/S Operators		Reduction of Big Customer's Losses		
		F.C.	L.C.	Total	Energy (MWh)	Amount	Operators	Amount	Energy (MWh)	Amount	
1986		-	-	-	0	0	0	0	0	0	
1987		-	-	-	0	0	0	0	0	0	Exchange Rate:
1988	C3, Training C	7,535	362	7,897	0	0	0	0	0	0	$1.00
1989					1,085	17	20	57	666	1,402	= 25.9359 Baht
1990	C1, C2	11,964	718	12,682	1,110	18	20	57	673	1,418	$1.00
1991	S1, S2	10,192	751	10,943	3,787	61	60	171	2,265	4,771	= 153.8 Yen
1992	NE3, S3	8,854	580	9,434	6,462	103	82	233	2,947	6,206	
1993	NE1, N1	10,194	670	10,864	8,738	140	104	296	2,347	7,050	Estimated Rate
1994	N2, N3, NE2	13,584	979	14,563	11,306	181	138	393	3,553	7,483	of Interrupted
1995					13,121	210	173	492	3,603	7,588	Energy:
1996					13,190	211	173	492	3,595	7,571	0.016 $/kWh
1997					13,264	212	173	492	3,587	7,554	
1998					13,324	213	173	492	3,579	7,538	Salaries &
1999					13,396	214	173	492	3,572	7,522	Wages:
2000					13,464	215	173	492	3,563	7,505	2,845
2001					13,534	217	173	492	3,555	7,487	$/Operator
2002					13,609	218	173	492	3,548	7,471	
2003					13,682	219	173	492	3,539	7,454	Big Customer's
2004					13,761	220	173	492	3,532	7,438	Losses:
2005					13,831	221	173	492	3,524	7,422	2.106 $/kWh
2006					13,910	223	173	492	3,516	7,405	
2007					13,987	224	173	492	3,508	7,389	

Table 9-1-2 COST AND BENEFIT (CASE 2)

(Unit: 1,000 US$)

Year	Implementation Schedule	Investment Cost			Benefit						Remarks
					Decremental Interruption Energy		Reduction of C/S Operators		Reduction of Big Customer's Losses		
		F.C.	L.C.	Total	Energy (MWh)	Amount	Operators	Amount	Energy (MWh)	Amount	
1986		-	-	-	0	0	0	0	0	0	
1987		-	-	-	0	0	0	0	0	0	Exchange Rate:
1988	C3, Training C	8,293	411	8,704	0	0	0	0	0	0	$1.00
1989					1,336	21	20	57	820	1,727	= 25.9359 Baht
1990	C1, C2	13,195	798	13,994	1,367	22	20	57	829	1,746	$1.00
1991	S1, S2	10,713	784	11,497	4,606	74	60	171	2,777	5,848	= 153.8 Yen
1992	NE3, S3	9,189	599	9,788	7,744	124	82	233	3,578	7,535	
1993	NE1, N1	10,904	717	11,621	10,310	165	104	296	4,030	8,486	Estimated Rate
1994	N2, N3, NE2	14,293	1,026	15,319	13,344	214	138	393	4,187	8,819	of Interrupted
1995					15,415	247	173	492	4,323	9,104	Energy:
1996					15,495	248	173	492	4,313	9,084	0.016 $/kWh
1997					15,581	249	173	492	4,304	9,064	
1998					15,651	250	173	492	4,295	9,044	Salaries &
1999					15,734	252	173	492	4,285	9,025	Wages:
2000					15,814	253	173	492	4,276	9,004	2,845
2001					15,895	254	173	492	4,266	8,983	$/Operator
2002					15,982	256	173	492	4,257	8,964	
2003					16,068	257	173	492	4,247	8,943	Big Customer's
2004					16,159	259	173	492	4,237	8,924	Losses:
2005					16,241	260	173	492	4,229	8,905	2.106 $/kWh
2006					16,333	261	173	492	4,218	8,884	
2007					16,423	263	173	492	4,209	8,865	

Table 9-1-3 COST AND BENEFIT (CASE 3)

(Unit: 1,000 US$)

Year	Implementation Schedule	Investment Cost			Benefit						Remarks
					Decremental Interruption Energy		Reduction of C/S Operators		Reduction of Big Customer's Losses		
		F.C.	L.C.	Total	Energy (MWh)	Amount	Operators	Amount	Energy (MWh)	Amount	
1986		-	-	-	0	0	0	0	0	0	
1987		-	-	-	0	0	0	0	0	0	Exchange Rate:
1988	C3, Training C	9,524	470	9,994	0	0	0	0	0	0	$1.00
1989					1,447	23	20	57	888	1,870	= 25.9359 Baht
1990	C1, C2	16,699	961	17,660	1,480	24	20	57	898	1,891	$1.00
1991	S1, S2	12,179	854	13,033	5,050	81	60	171	3,021	6,361	= 153.8 Yen
1992	NE3, S3	11,225	697	11,922	8,616	138	82	233	3,929	8,275	
1993	NE1, N1	12,609	797	13,406	11,650	186	104	296	4,463	9,399	Estimated Rate
1994	N2, N3, NE2	16,875	1,146	18,021	15,075	241	138	393	4,737	9,977	of Interrupted
1995					17,495	280	173	492	4,804	10,117	Energy:
1996					17,587	281	173	492	4,793	10,095	0.016 $/kWh
1997					17,686	283	173	492	4,783	10,072	
1998					17,765	284	173	492	4,772	10,051	Salaries &
1999					17,861	286	173	492	4,762	10,029	Wages:
2000					17,952	287	173	492	4,751	10,006	2,845
2001					18,045	289	173	492	4,740	9,983	$/Operator
2002					18,146	290	173	492	4,730	9,962	
2003					18,243	292	173	492	4,719	9,939	Big Customer's
2004					18,348	294	173	492	4,709	9,917	Losses:
2005					18,442	295	173	492	4,699	9,896	2.106 $/kWh
2006					18,546	297	173	492	4,688	9,873	
2007					18,650	298	173	492	4,678	9,852	

Table 9-2-1 NET IN-FLOW (CASE 1)

(Unit: 1,000 US$)

Year	Cost			Benefit				Net In-Flow
	Investment	Operating	Total (1)	Decremental Int. Energy	Reduction C. Center Operator	Reduction Customer's Losses	Total (2)	(2) - (1)
1986	-	0	0	0	0	0	0	0
1987	-	0	0	0	0	0	0	0
1988	7,897	0	7,897	0	0	0	0	(7,897)
1989		79	79	17	57	1,402	1,476	1,397
1990	12,682	79	12,761	18	57	1,418	1,493	(11,268)
1991	10,943	206	11,149	61	171	4,771	5,003	(6,146)
1992	9,434	315	9,749	103	233	6,206	6,542	(3,207)
1993	10,864	409	11,273	140	296	7,050	7,486	(3,787)
1994	14,563	518	15,081	181	393	7,483	8,057	(7,024)
1995		664	664	210	492	7,588	8,290	7,626
1996		664	664	211	492	7,571	8,274	7,610
1997		664	664	212	492	7,554	8,258	7,594
1998		664	664	213	492	7,538	8,243	7,579
1999		664	664	214	492	7,522	8,228	7,564
2000		664	664	215	492	7,505	8,212	7,548
2001		664	664	217	492	7,487	8,196	7,532
2002		664	664	218	492	7,471	8,181	7,517
2003		664	664	219	492	7,454	8,165	7,501
2004		664	664	220	492	7,438	8,150	7,486
2005		664	664	221	492	7,422	8,135	7,471
2006		664	664	223	492	7,405	8,120	7,456
2007	(11,881)	664	(11,217)	224	492	7,389	8,105	19,322
	54,502	10,238	64,740	3,337	7,603	125,674	136,614	71,874

Table 9-2-2 NET IN-FLOW (CASE 2)

(Unit: 1,000 US$)

Year	Cost			Benefit				Net In-Flow
	Investment	Operating	Total (1)	Decremental Int. Energy	Reduction C. Center Operator	Reduction Customer's Losses	Total (2)	(2) - (1)
1986	-	0	0	0	0	0	0	0
1987	-	0	0	0	0	0	0	0
1988	8,704	0	8,704	0	0	0	0	(8,704)
1989		87	87	21	57	1,727	1,805	1,718
1990	13,993	87	14,080	22	57	1,746	1,825	(12,255)
1991	11,497	227	11,724	74	171	5,848	6,093	(5,631)
1992	9,788	342	10,130	124	233	7,535	7,892	(2,238)
1993	11,621	440	12,061	165	296	8,486	8,947	(3,114)
1994	15,319	556	15,875	214	393	8,819	9,426	(6,449)
1995		709	709	247	492	9,104	9,843	9,134
1996		709	709	248	492	9,084	9,824	9,115
1997		709	709	249	492	9,064	9,805	9,096
1998		709	709	250	492	9,044	9,786	9,077
1999		709	709	252	492	9,025	9,769	9,060
2000		709	709	253	492	9,004	9,749	9,040
2001		709	709	254	492	8,983	9,729	9,020
2002		709	709	256	492	8,964	9,712	9,003
2003		709	709	257	492	8,943	9,692	8,983
2004		709	709	259	492	8,924	9,675	8,966
2005		709	709	260	492	8,905	9,657	8,948
2006		709	709	261	492	8,884	9,637	8,928
2007	(12,582)	709	(11,873)	263	492	8,865	9,620	21,493
	58,340	10,956	69,296	3,929	7,603	150,954	162,486	93,190

Table 9-2-3 NET IN-FLOW (CASE 3)

(Unit: 1,000 US$)

Year	Cost			Benefit				Net In-Flow
	Investment	Operating	Total (1)	Decremental Int. Energy	Reduction C. Center Operator	Reduction Customer's Losses	Total (2)	(2) - (1)
1986	-	0	0	0	0	0	0	0
1987	-	0	0	0	0	0	0	0
1988	9,994	0	9,994	0	0	0	0	(9,994)
1989		100	100	23	57	1,870	1,950	1,850
1990	17,660	100	17,760	24	57	1,891	1,972	(15,788)
1991	13,033	277	13,310	81	171	6,361	6,613	(6,697)
1992	11,922	407	12,329	138	233	8,275	8,646	(3,683)
1993	13,406	526	13,932	186	296	9,399	9,881	(4,051)
1994	18,021	660	18,681	241	393	9,977	10,611	(8,070)
1995		840	840	280	492	10,117	10,889	10,049
1996		840	840	281	492	10,095	10,868	10,028
1997		840	840	283	492	10,072	10,847	10,007
1998		840	840	284	492	10,051	10,827	9,987
1999		840	840	286	492	10,029	10,807	9,967
2000		840	840	287	492	10,006	10,785	9,945
2001		840	840	289	492	9,983	10,764	9,924
2002		840	840	290	492	9,962	10,744	9,904
2003		840	840	292	492	9,939	10,723	9,883
2004		840	840	294	492	9,917	10,703	9,863
2005		840	840	295	492	9,896	10,683	9,843
2006		840	840	297	492	9,873	10,662	9,822
2007	(14,863)	840	(14,023)	298	492	9,852	10,642	24,665
	69,173	12,990	82,163	4,449	7,603	167,565	179,617	97,454

Table 9-3 NET PRESENT VALUE

(Unit: 1,000 US$)

Items		Discount Rate (%)							
		5	6	7	8	9	10	11	12
Net Present Value (1986 Price)	Case 1	22,344	16,843	12,263	8,443	5,263	2,616	408	(1,424)
	Case 2	32,803	25,978	20,260	15,458	11,425	8,037	5,189	2,798
	Case 3	31,734	24,386	18,248	13,120	8,836	5,251	2,261	(234)

Items		Discount Rate (%)							
		13	14	15	16	17	18	19	20
Net Present Value (1986 Price)	Case 1	(2,937)	(4,191)	(5,224)	(6,071)	(6,758)	(7,315)	(7,758)	(8,108)
	Case 2	789	(895)	(2,306)	(3,484)	(4,470)	(5,284)	(5,957)	(6,513)
	Case 3	(2,316)	(4,044)	(5,476)	(6,661)	(7,633)	(8,424)	(9,065)	(9,578)

Table 9-4 AMORTIZATION SCHEDULE (CASE 2)

(Unit: 1,000 US$)

Year	Loan Schedule			Amortization Schedule								
				Principal			Balance			Interest		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
1986												
1987												
1988	8,293	3,806	12,099				8,293	3,806	12,099	249	457	706
1989							8,293	3,806	12,099	249	457	706
1990	13,195	6,390	19,585				21,488	10,196	31,684	645	1,223	1,868
1991	10,713	5,108	15,821				32,201	15,304	47,505	966	1,836	2,802
1992	9,189	4,343	13,532				41,390	19,647	61,037	1,242	2,358	3,600
1993	10,904	5,163	16,067		254	254	52,294	24,556	76,850	1,569	2,947	4,516
1994	14,293	6,815	21,108		254	254	66,587	31,117	97,704	1,998	3,734	5,732
1995					680	680	66,587	30,437	97,024	1,998	3,652	5,650
1996					1,021	1,021	66,587	29,416	96,003	1,998	3,530	5,528
1997					1,311	1,311	66,587	28,105	94,692	1,998	3,373	5,371
1998				415	1,655	2,070	66,172	26,450	92,622	1,985	3,174	5,159
1999				415	2,109	2,524	65,757	24,341	90,098	1,972	2,921	4,893
2000				1,075	2,109	3,184	64,682	22,232	86,914	1,940	2,668	4,608
2001				1,611	2,109	3,724	63,071	20,123	83,194	1,892	2,415	4,370
2002				2,070	2,109	4,179	61,001	18,014	79,015	1,830	2,162	3,992
2003				2,615	2,109	4,724	58,386	15,905	74,291	1,751	1,909	3,660
2004				3,330	2,109	5,439	55,056	13,796	68,852	1,651	1,655	3,306
2005				3,330	2,109	5,439	51,726	11,687	63,413	1,552	1,402	2,954
2006				3,330	2,109	5,439	48,396	9,578	57,974	1,452	1,149	2,601
2007				3,330	2,105	5,435	45,066	7,473	52,539	1,352	897	2,249
Sub-Total	66,587	31,625	98,212	21,521	24,152	45,673	-	-	-	30,289	43,919	74,208

Table 9-4 AMORTIZATION SCHEDULE (CASE 2)

(Continued) (Unit: 1,000 US$)

Year	Loan Schedule			Amortization Schedule								
				Principal			Balance			Interest		
	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total	F.C.	L.C.	Total
2008				3,330	1,855	5,185	41,736	5,618	47,354	1,252	674	1,926
2009				3,330	1,855	5,185	38,406	3,763	42,169	1,152	452	1,604
2010				3,330	1,422	4,752	35,076	2,341	37,417	1,052	281	1,333
2011				3,330	1,081	4,411	31,746	1,260	33,006	952	151	1,103
2012				3,330	801	4,131	28,416	459	28,875	853	55	908
2013				3,330	459	3,789	25,086	0	25,086	753	0	753
2014				3,330		3,330	21,756		21,756	653		653
2015				3,330		3,330	18,426		18,426	553		553
2016				3,330		3,330	15,096		15,096	453		453
2017				3,323		3,323	11,773		11,773	353		353
2018				2,915		2,915	8,858		8,858	266		266
2019				2,910		2,910	5,948		5,948	178		178
2020				2,248		2,248	3,700		3,700	111		111
2021				1,728		1,728	1,972		1,972	59		59
2022				1,264		1,264	708		708	21		21
2023				708		708	0		0	0		0
Sub-Total				45,066	7,473	52,539	-	-	-	8,661	1,613	10,274
Total	66,587	31,625	98,212	66,587	31,625	98,212	-	-	-	38,950	45,532	84,482

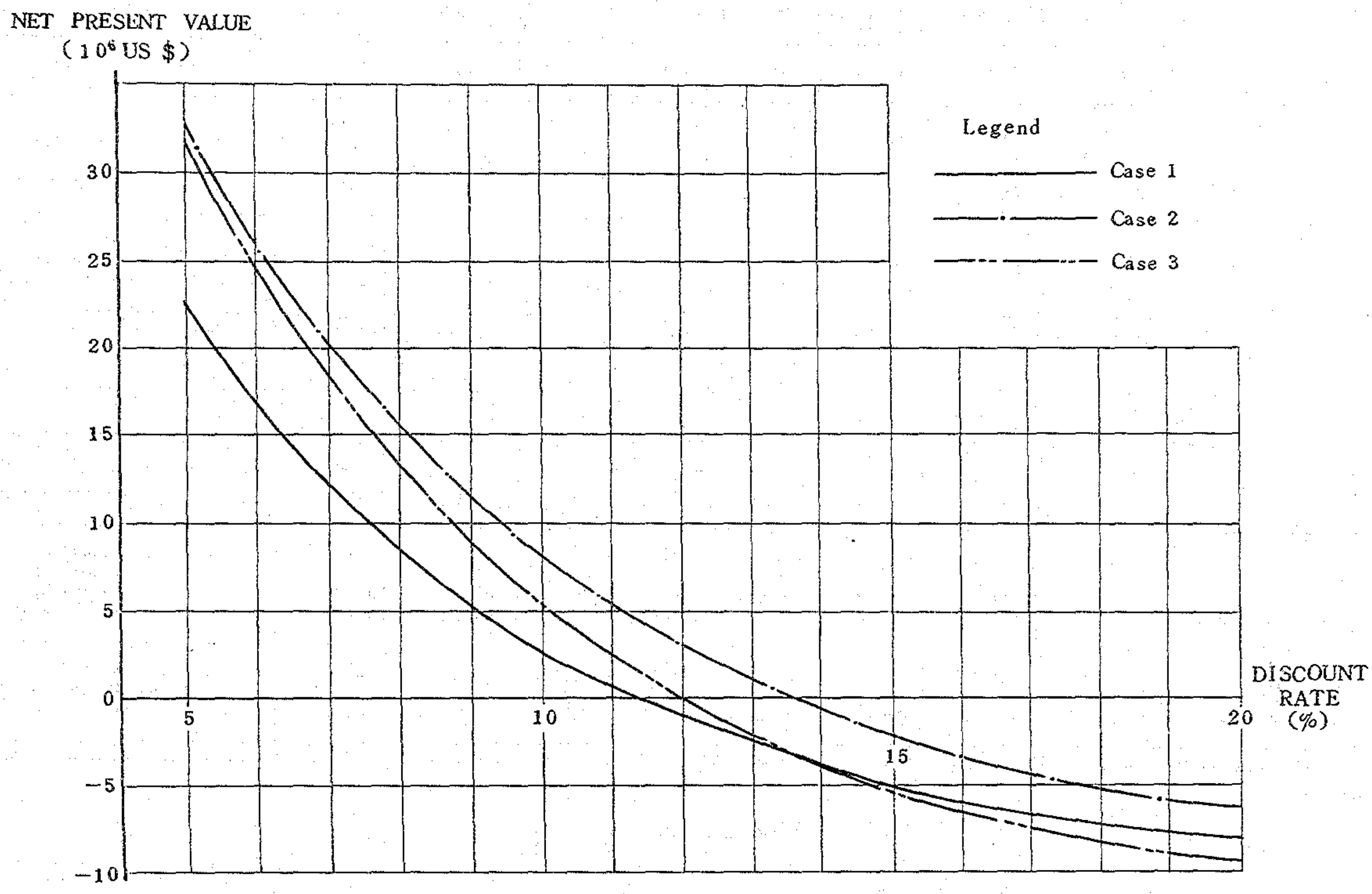
Table 9-5 CASH FLOW STATEMENT (CASE 2)

(Unit: 1,000 US$)

Item		1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
1. Sources of Funds		12,099	(9)	19,577	15,839	13,547	16,088	21,159	30	31	32	33
Operating Profit		-	(9)	(8)	18	15	21	51	30	31	32	33
Long Term Debt		12,099	-	19,585	15,821	13,532	16,067	21,108	-	-	-	-
2. Uses of Funds		12,805	706	21,453	18,623	17,132	20,837	27,094	6,330	6,549	6,682	7,229
Investment		12,099	-	19,585	15,821	13,532	16,067	21,108	-	-	-	-
Repayment		-	-	-	-	-	254	254	680	1,021	1,311	2,070
Interest		706	706	1,868	2,802	3,600	4,516	5,732	5,650	5,528	5,371	5,159
3. Cash Balance	(1)	(706)	(715)	(1,876)	(2,784)	(3,585)	(4,749)	(5,935)	(6,300)	(6,518)	(6,650)	(7,196)
Electric Revenues	(2)	775,398	862,954	924,948	990,336	1,054,024	1,118,787	1,184,209	1,250,132	1,319,723	1,393,192	1,470,746
(1)/(2)	(%)	(0.09)	(0.08)	(0.20)	(0.28)	(0.34)	(0.42)	(0.50)	(0.50)	(0.49)	(0.48)	(0.49)

Item		1999	2000	2001	2002	2003	2004	2005	2006	2007		Total
1. Sources of Funds		35	36	37	39	40	42	43	44	46		98,788
Operating Profit		35	36	37	39	40	42	43	44	46		576
Long Term Debt		-	-	-	-	-	-	-	-	-		98,212
2. Uses of Funds		7,417	7,792	8,027	8,171	8,384	8,745	8,393	8,040	7,684		218,093
Investment		-	-	-	-	-	-	-	-	-		98,212
Repayment		2,524	3,184	3,720	4,179	4,724	5,439	5,439	5,439	5,435		45,673
Interest		4,893	4,608	4,307	3,992	3,660	3,306	2,954	2,601	2,249		74,208
3. Cash Balance	(1)	(7,382)	(7,756)	(7,990)	(8,132)	(8,344)	(8,703)	(8,350)	(7,996)	(7,638)		(119,305)
Electric Revenues	(2)	1,552,620	1,639,056	1,730,300	1,826,620	1,928,304	2,035,649	2,148,970	2,268,605	2,394,893		29,869,466
(1)/(2)	(%)	(0.48)	(0.47)	(0.46)	(0.45)	(0.43)	(0.43)	(0.39)	(0.35)	(0.32)		(0.40)

Fig 9-1 NET PRESENT VALUE CURVE



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