6.3.4 Short-Term expansion plan of distribution substations (FY1997～2001)

The short-term expansion plan for distribution substations in FY 1997 through 2001 will be formulated by reviewing a new five-year plan obtained from MEA. An outline of the short-term expansion plan of MEA is presented in Table 6.3-9 and its development by the respective substations in Appendix 6.3-3.

Table 6.3-9 Construct Plan of Distribution Substation(MEA Original Plan)

FY		1996	1997	1998	1999	2000	2001
Planning Load	[MVA]	6,856.23	7,456.16	8,002.55	8,586.20	9,243.01	9,916.55
Additional Load per annum	[MVA]	-	599.93	546.39	583.65	656.81	673.54
Increase Rate per annum	[%]	-	8.75	7.33	7.29	7.65	7.29
Number of Substations		124	134	139	140	144	151
Number of Banks		257	282	295	304	319	343
Installed Capacity	[MVA]	11,645	13,065	13,905	14,565	15,465	17,625
Average Utilization Factor	[%]	58.9	57.1	57.6	59.0	59.8	56.3
Bank Configuration Ratio		2.07	2.10	2.12	2.17	2.22	2.27
Number of New Substations		-	10	5	1	4	7
Capacity of New Substations	[MVA]	-	540	440	120	460	800
Number of Expanded Substations		-	19	8	9	8	21
Expanded Capacity	[MVA]	-	880	340	400	420	980
Increment	[MVA]	-	1,420	780	520	880	1,780

The bank configuration ratio indicates as low a value ranging roughly from 2.1 to 2.2, since the share of substation of one-bank configuration is high according to the short-term expansion plan of MEA in FY 1997 through 2001. As the electric power demand has increased at an annual average rate of 7% level for the past five years, such a low bank configuration ratio is deemed to have been caused by construction of a number of substations of one-bank configuration to cover the rapid increasing demand.

Another presumable reason is that the next five years will be a peak period of the voltage boosting project from 12 kV to 24 kV. In other words, 24 kV substations will be constructed by replacing existing 12 kV transformers with 24 kV transformers since it is easier to promote the work of replacing existing transformers after constructing 24 kV substations and reducing the load by absorbing 12 kV load. Therefore, early implementation of substation construction projects is also deemed to have been required.

The one-bank configuration of substation is not desirable in view of supply

reliability since there is no relief method of load at the time of one bank fault by other than switching the load over to another substation. However, it is to have been inevitable to adopt the one-bank configuration during the process of voltage boosting projects to 24 kV to meet rapid increase of demand as mentioned above.

According to the five-year plan formulated by MEA, it is found that many substations have been operated with exceeding the utilization factor specified in the planning criteria of MEA described below as well as that specified in the expansion plan in Clauses 6.3.2 and 6.3.3 without taking appropriate remedial countermeasures in the respective fiscal years.

- 2-bank configuration substation with the utilization factor exceeding by 75%
- 3-bank configuration substation with the utilization factor exceeding by 80%
- [1×60 + 1×40]MVA configuration substation with the utilization factor exceeding by 65% (in excess of 65 MVA)
- [1×60 + 2×40]MVA configuration substation with the utilization factor exceeding by 79.3% (in excess of 111 MVA)
- [1×40 + 2×20]MVA configuration substation with the utilization factor exceeding by 78.3% (in excess of 63 MVA)
- [2×60 + 1×20]MVA configuration substation with the utilization factor exceeding by 79.3% (in excess of 111 MVA)

According to the short-term plan of MEA, substations are scheduled to be constructed concentratedly in FY 1997 and 2000. Judging from the work execution capability, it is deemed essential to average this over-concentration of substation construction in these two years.

In consideration of the above situations, the MEA's extension plan shall be reviewed to relax the concentrated work period by preferentially postponing the commissioning years of the substations with a utilization factor of less than 40%. Meanwhile, switching-over of load between mutual substations has been studied based on the method described in Clause 6.3.2. Since it is impossible to switch over load freely between the substations in the area where 12 kV and 24 kV systems coexist, the load switching-over procedure is planned based on the following conditions as described in Clause 6.3.2.

- Switching-over of load should be executed preferentially between the same voltage substations.

- Switching of load over to 12 kV area to 24 kV area should not be executed.
- Switching of load over to 24 kV area to 12 kV area is evaluated possible after upgrading the voltage rating of distribution equipment to 24 kV.

The results of review are presented in Tables 6.3-10, 6.3.11, Figs. 6.3-7, 6.3-8, 6.3-9 and 6.3-10 and Appendix 6.3-4.

Table 6.3-10 Construct Plan of Distribution Substation(JICA Study Team Plan)

FY		1996	1997	1998	1999	2000	2001
Planning Load	[MVA]	6,856.23	7,456.16	8,002.55	8,586.21	9,243.01	9,916.55
Additional Load per annum	[MVA]	-	599.93	546.39	583.66	656.80	673.54
Increase Rate per annum	[%]	-	8.75	7.33	7.29	7.65	7.29
Number of Substations		124	130	135	139	144	151
Number of Banks		257	277	289	302	318	341
Installed Capacity	[MVA]	11,645	12,825	13,585	14,425	15,405	17,545
Average Utilization Factor	[%]	58.9	58.1	58.9	59.5	60.0	56.5
Bank Configuration Ratio		2.07	2.13	2.14	2.17	2.21	2.26
Number of New Substations		-	6	5	4	5	7
Capacity of New Substations	[MVA]	-	300	340	340	580	800
Number of Expanded Substations		-	18	10	8	7	23
Expanded Capacity	[MVA]	-	920	360	360	380	960
Increment	[MVA]	-	1,220	700	700	960	1,760

The construction work of substations concentrated in particular years is deemed to have generally been averaged in the substation expansion plan. Although the bank capacity expansion plan tends to be concentrated still in FY 1997 and 2001, however, this plan has not been reviewed particularly since even the distribution voltage boosting plan to 24 kV being studied by MEA should also be reviewed when the bank capacity expansion plan is to be reviewed.

Should a bank fault or other major trouble occurs in either of the isolated substation in the 12 kV or 24 kV area, it is found some cases which would be impossible to release the load from the other surrounding substations and a problem be raised in several substations during the short-term period in FY 1997 through to 2001. However, such situations are deemed inevitable during the process of progress of such a large scale voltage boosting project to 24 kV.

Table 6.3-11 Target for Distribution Substation System Program (1/4)

Description	Installation Capacity [MVA]				
	1997	1998	1999	2000	2001
Construction of Substation					
Taiban (TN)	1×60				
Dindaeng (DD)	1×(40)				
Klongkum (KG)	1×60				
Muangthong 4 (M4)	1×60				
Samyarn (YN)	1×(40)				
Trokchan (TC)	1×(40)				
Jatujag (JJ)		2×(40)			
Kaset (KE)		1×(40)+ 1×60			
Shimplee (HP)		1×60			
Tubyao (TY)		1×60			
Watkampaeng (WK)		1×40			
Muangthong 5 (M5)			2×60		
Patanakarn (TA)			1×60		
Sriwiang (SW)			2×(40)		
Tha-kwian (TI)			2×(40)		
Muangthong 6 (M6)				2×60	
Prawes (PW)				2×60	
Prompong (RP)				2×60	
Suwintawong (WW)				2×60	
Wuttakart (WR)				1×(40)+ 1×60	
Bannai (MI)					2×60
Muangthong 7 (M7)					2×60
Nanglerng (NL)					2×40
Plubpla (PL)					2×60
Sainoi (SI)					2×60
Satorn (SH)					2×60

Table 6.3-11 Target for Distribution Substation System Program (2/4)

Description	Installation Capacity (MVA)				
	1997	1998	1999	2000	2001
Suanyai (YI)					2×60
Addition of Substation					
Bangchalong (BN)	1×60 to 2×60				
Bangkhaen (KA)			1×60 to 2×60		
Bangkok noi (BO)	2×40 to 1×40+ 1×60				
Bangmod (BM)			2×(40) to 2×(40)+ 1×60		
Bangpongpang (PG)			1×40+ 1×60 to 2×60		
Donmuang (DM)		2×40+ 1×60 to 2×60			
Huaykwang (HK)					2×60 to 3×60
Klongmai (KM)				1×40 to 2×60	
Klongsanamchai (SC)	1×40 to 1×40+ 1×(40)				
Lardprao (LP)	2×20 to 2×(40)				1×(40)+ 1×60 to 2×(40)+ 1×60
Lumpini (LN)					4×40 to 3×40+ 1×60
Mahamek (MM)					2×40+ 1×(40) to 3×60
Makasan (MS)	2×40 to 2×40+ 1×(40)				
Muangthong 1 (M1)	1×60 to 2×60				
Nongkham (NH)		1×40+ 1×60 to 2×60			
Nonthaburi (NR)		2×20+ 1×40 to 1×40+ 1×60			1×40+ 1×60 to 2×60
Pakkred (PE)	2×40+ 1×60 to 1×40+ 2×60			1×40+ 2×60 to 3×60	
Paknam (PN)					2×40 to 2×60
Phaisingto (PI)					1×40+ 2×60 to 3×60
Prachachuen (PC)					2×40 to 1×40+ 1×60
Samrong (SR)			2×40+ 1×60 to 1×40+ 2×60		1×40+ 2×60 to 3×60
South Bangkok (SK)					2×20 to 1×60
Suanson (SO)					2×40 to 2×60

Table 6.3-11 Target for Distribution Substation System Program

Description	Installation Capacity [MVA]				
	1997	1998	1999	2000	2001
Surawong (SU)					3×40 to 1×40+ 2×60
Thanontok (TT)		1×40 to 1×40+ 1×(40)			1×40+ 1×(40) to 2×60
Wangpetchaboon (WB)			2×40 to 2×40+ 1×(40)		2×40+ 1×(40) to 3×60
Bangkae (BE)			1×40 to 2×(40)		
Bangson (BZ)	1×(40) to 2×(40)				
Bearing (RI)	1×60 to 2×60				
Ekamai (EM)	1×(40) to 2×(40)+ 1×60				
Ekburi (EB)				1×60 to 2×60	
Huamak (HA)					1×40 to 1×60
Khotor (KO)	1×60 to 2×60				2×60 to 3×60
Muangthong 3 (M3)	1×60 to 2×60				
Sainamtip (SA)	1×60 to 1×(40)+ 1×60				2×60 to 3×60
South Bangplee (OB)	1×60 to 2×60				
Srieiam (SE)					2×60 to 3×60
Surasak (UK)	1×(40) to 2×(40)				
Taiban (TN)				1×60 to 2×60	
Taweewattana (TW)		1×60 to 2×60			
Thonburirom (TR)		1×(40) to 2×(40)			
Bangbor (AB)	1×60 to 2×60				
Bangjak (JK)				1×(40) to 1×(40)+ 1×60	
Bangkradee (KD)			1×(40) to 2×60		
Bangshan (BH)		1×60 to 2×60			
Dindaeng (DD)				1×(40) to 2×(40)	
Ekachai (EC)					1×60 to 2×60
Ghoaklang (GK)	1×60 to 2×60				
Jangwatana (JW)	1×60 to 2×60				
Klongkum (KG)			1×60 to 2×60		

Table 6.3-11 Target for Distribution Substation System Program (4／4)

Description	Installation Capacity [MVA]				
	1997	1998	1999	2000	2001
Klongprapa (NL)					1×60 to 2×60
Muangthong 4 (M4)		1×60 to 2×60			
Patanakarn (TA)					1×60 to 2×60
Samyarn (YN)		1×(40) to 2×(40)			
Shimplee (HP)				1×60 to 2×60	
Trokchan (TC)		1×(40) to 2×(40)			
Tubyao (TY)					1×60 to 2×60
Watkampaeng (WK)					1×40 to 2×60

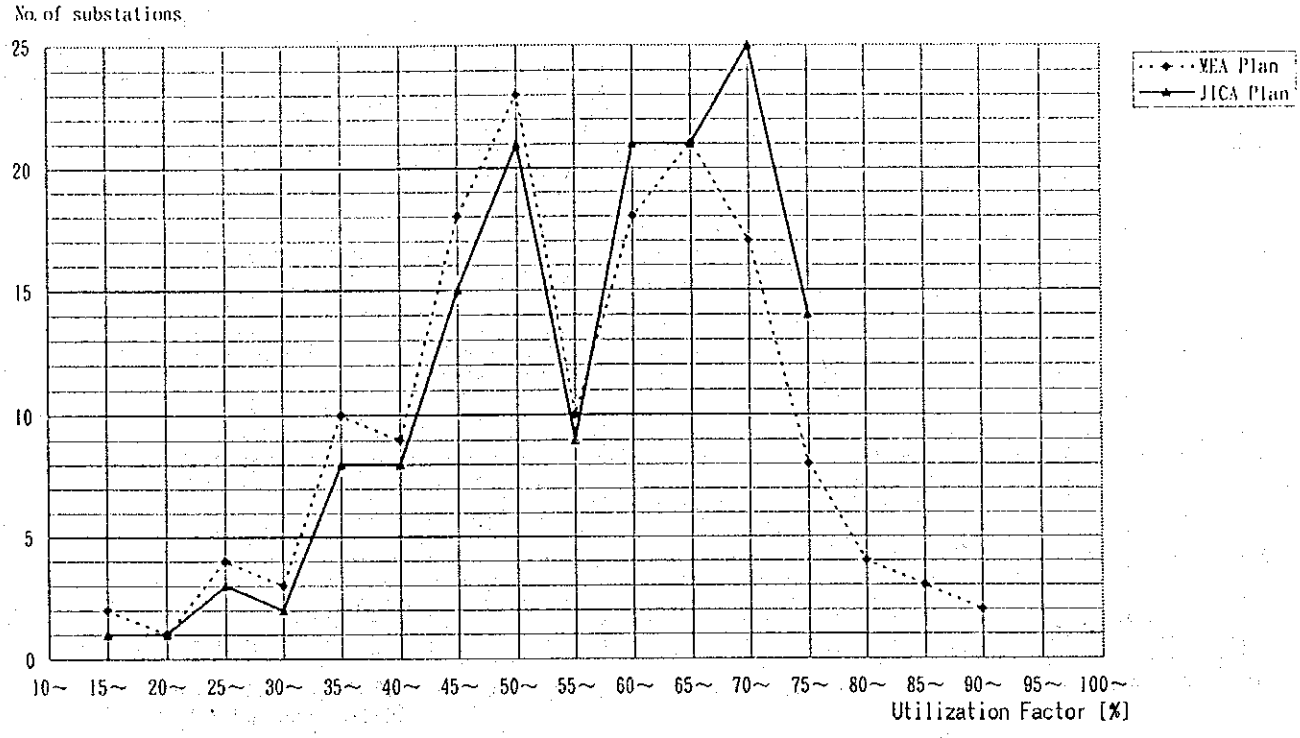


Fig 6.3-7 Distribution Substation Utilization Factor (Planning Year=1997)

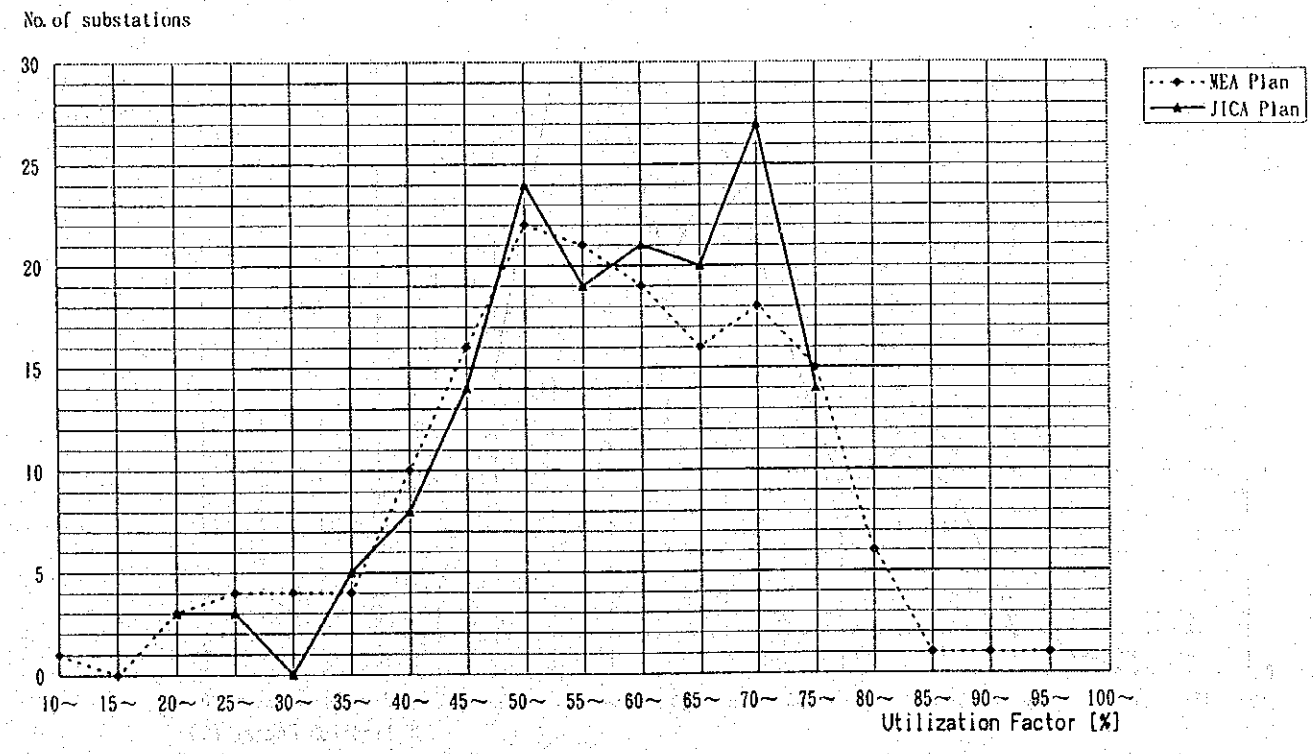


Fig 6.3-8 Distribution Substation Utilization Factor (Planning Year=1998)

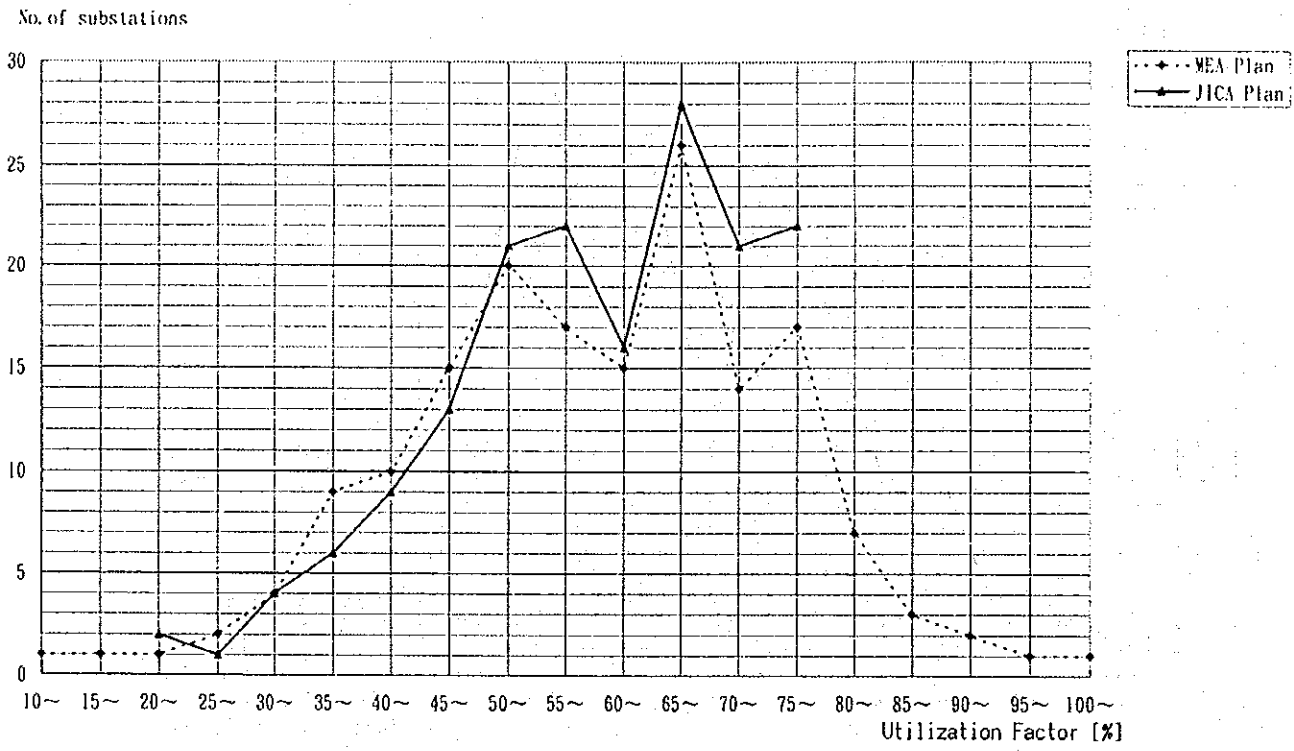


Fig 6.3-9 Distribution Substation Utilization Factor (Planning Year=1999)

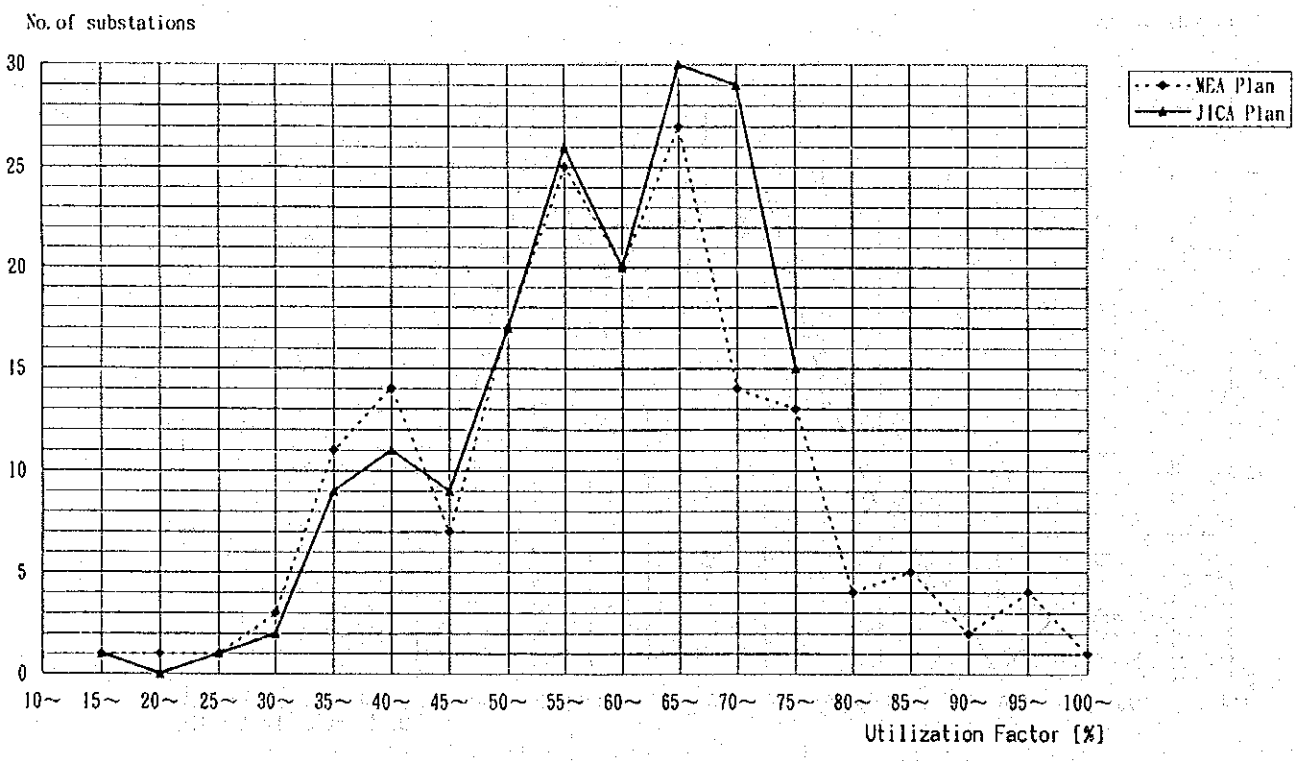


Fig 6.3-10 Distribution Substation Utilization Factor (Planning Year=2000)

6.4 Subtransmission Line and Terminal Station System Plan

6.4.1 Methodology of Planning

The study on the long-term subtransmission line and terminal station system (hereinafter referred to as "the subtransmission system") plan up to FY 2016 has been carried out based on the distribution substation expansion plan formulated by the JICA Study Team as discussed in Section 6.3.
In formulating the long-term optimum plan, the subtransmission system should be planned in such manner that it can supply power efficiently and be in conformity with the planning criteria.

(1) Approach to the subtransmission system planning

First, the study on the basic system configuration at FY 2016 which is the final target in this Study was carried out based on the MEA's draft long-term plan up to FY 2011, taking into account the distribution substation expansion plan at FY 2016 formulated by the JICA Study Team.

After formulating the long-term optimum plan at FY 2016, the study on the optimum subtransmission system plan at each target year during the period of FY 1997-2011 has been carried out by expanding the necessary subtransmission system facilities in chronological order toward the FY 2016's plan.

Power flow analyses and fault current calculation have been carried out to define the necessity for subtransmission system improvement and expansion.

(2) Criteria for the subtransmission system planning

The criteria adopted for the subtransmission system planning in this Study are based on the MEA's planning criteria as presented in Section 5.2.

If load flow through the subtransmission system facilities such as subtransmission lines and transformer banks is probable to exceed the maximum loading level as defined in MEA's planning criteria, countermeasures for system improvement and expansion shall be taken to solve the problem.

6.4.2 FY 2016's Plan

Based on the MEA's power demand forecast by the JICA Study Team as discussed in Section 4.3, the maximum power demand is estimated to be increased by 2,346 MW at the average annual growth rate of 3.3% for the periods of FY 2011-2016. The improvement and expansion of the subtransmission system facilities such as subtransmission lines and terminal stations as well as the distribution substations has been planned according to the increasing demand. The study of the subtransmission system plan at FY 2016 has been carried out based on the system configuration at FY 2011 prepared by MEA, taking into the long-term distribution substation plan at FY 2016.

Fig. 6.4-1 and Fig. 6.4-2 show the system configuration at FY 2016 planned by the JICA Study Team.

(1) Terminal station improvement and expansion

Since the terminal station is the large power supply source, planning of the terminal station system, therefore, requires the efficient capability of power distribution to the MEA's distribution substations. That means each distribution substation must be able to supply sufficient power either in normal case or emergency case with high reliability and keep the voltage level within the criteria.

If any of the terminal stations are unable to cope with the increasing load, the following countermeasures should be considered:

- Load reduction by transferring the distribution substations to be supplied from one terminal station to the other.
- Addition of terminal station capacity to be able to supply the increasing load.
- Construction of new terminal station to share load from adjacent terminal stations.

Table 6.4-1 shows the terminal station expansion plan at FY 2016 formulated by the JICA Study Team, including countermeasures such as load to be switched over to other terminal stations. The two new terminal stations with total capacity 1,800 MVA will be constructed and 11

existing terminal stations will have capacity added totally 2,900 MVA compared with the JICA plan at FY 2011, as discussed in the following Clause 6.4.3. The total increasing capacity, therefore, will be 4,700 MVA, of which 1,200 MVA is invested by MEA and 3,500 MVA is invested by EGAT.

The two new terminal stations planned by the JICA Study Team can be summarized as follows:

(a) Construction of a new terminal station as countermeasures against overloading of Nonjok T/S and Onnuj T/S.

The installation of 2 x 300 MVA 230/115 kV transformers are proposed. As one of the candidate sites, a place around Ramintra area will be selected by reason of:

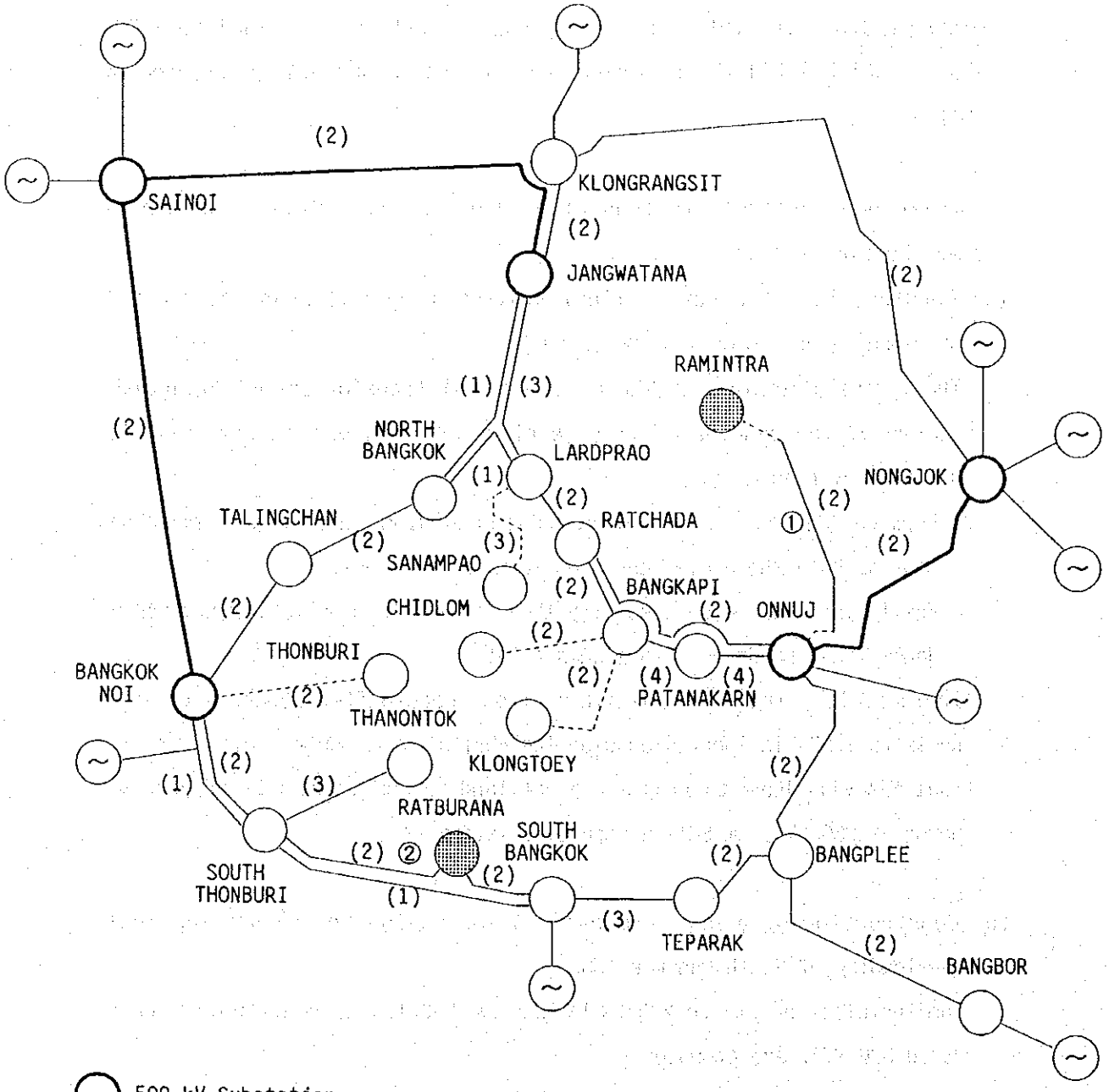
- Located adjacent to the 115 kV subtransmission lines on the secondary side of both the above-mentioned terminal stations.
- Easily interconnected also with the northern terminal stations such as Jangwatana, Lardprao, Klongrangsit, etc.

Incidentally, the new terminal station (hereinafter referred to as " Ramintra T/S") is located outside the EGAT's 230 kV outer ring lines, so that MEA will have to find a plot of land to construct T/S and receive power at 230 kV from EGAT at nearby existing T/S.

(b) Construction of a new terminal station as countermeasures against overloading of South Bangkok T/S.

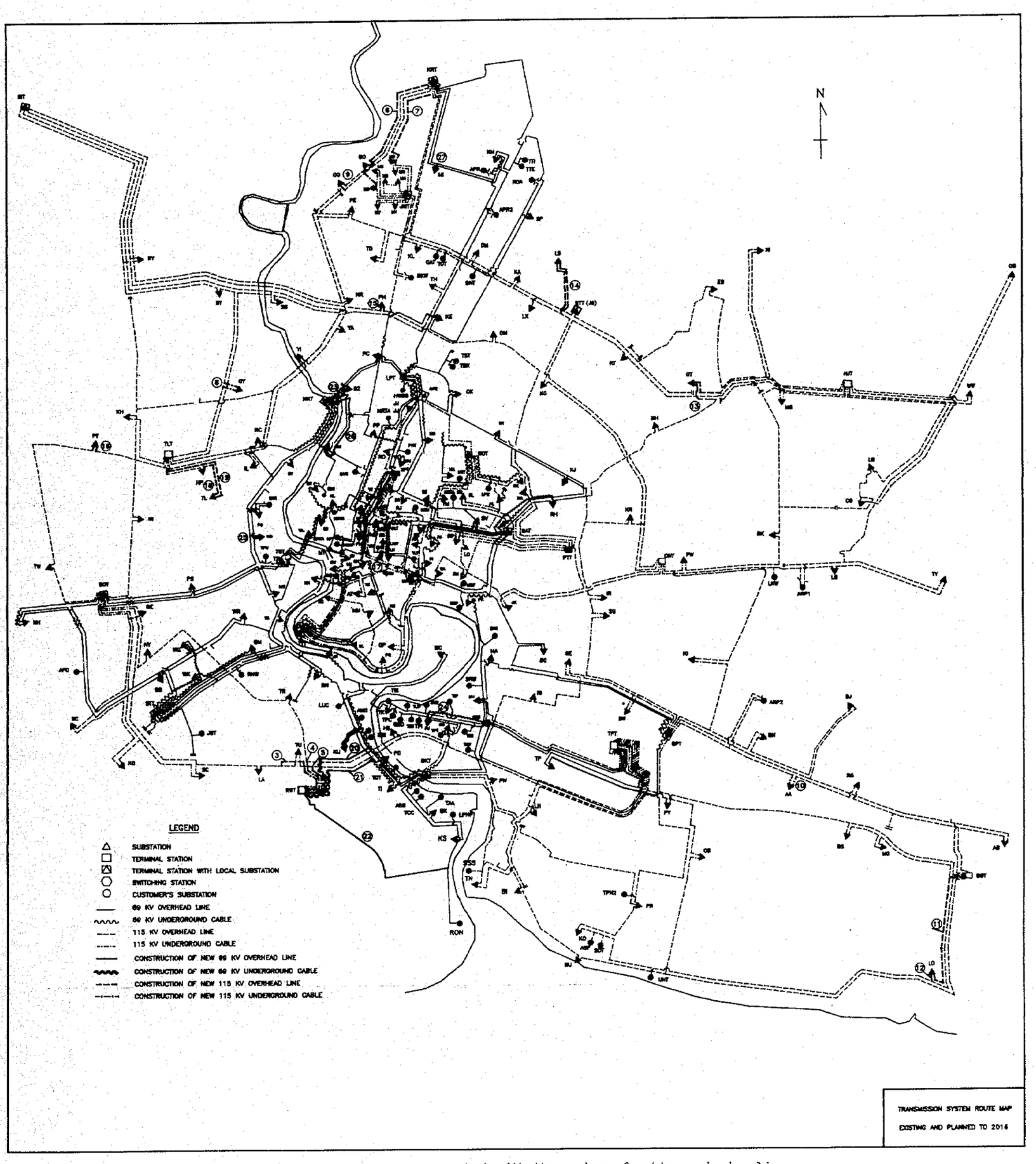
The installation of two 230/69 kV and two 230/115 kV transformers, each rated 300 MVA, are proposed.

As the 69 kV load at South Bangkok T/S is distributed widely also in the area along the west side of the Chau Phraya River, it is desirable that the new terminal station should be constructed around Ratburana area, located on the west side of the river, by terminating the double circuit of the EGAT's existing three circuit 230 kV South Thonburi - South Bangkok line at the new terminal station (hereinafter referred to as "Ratburana T/S").



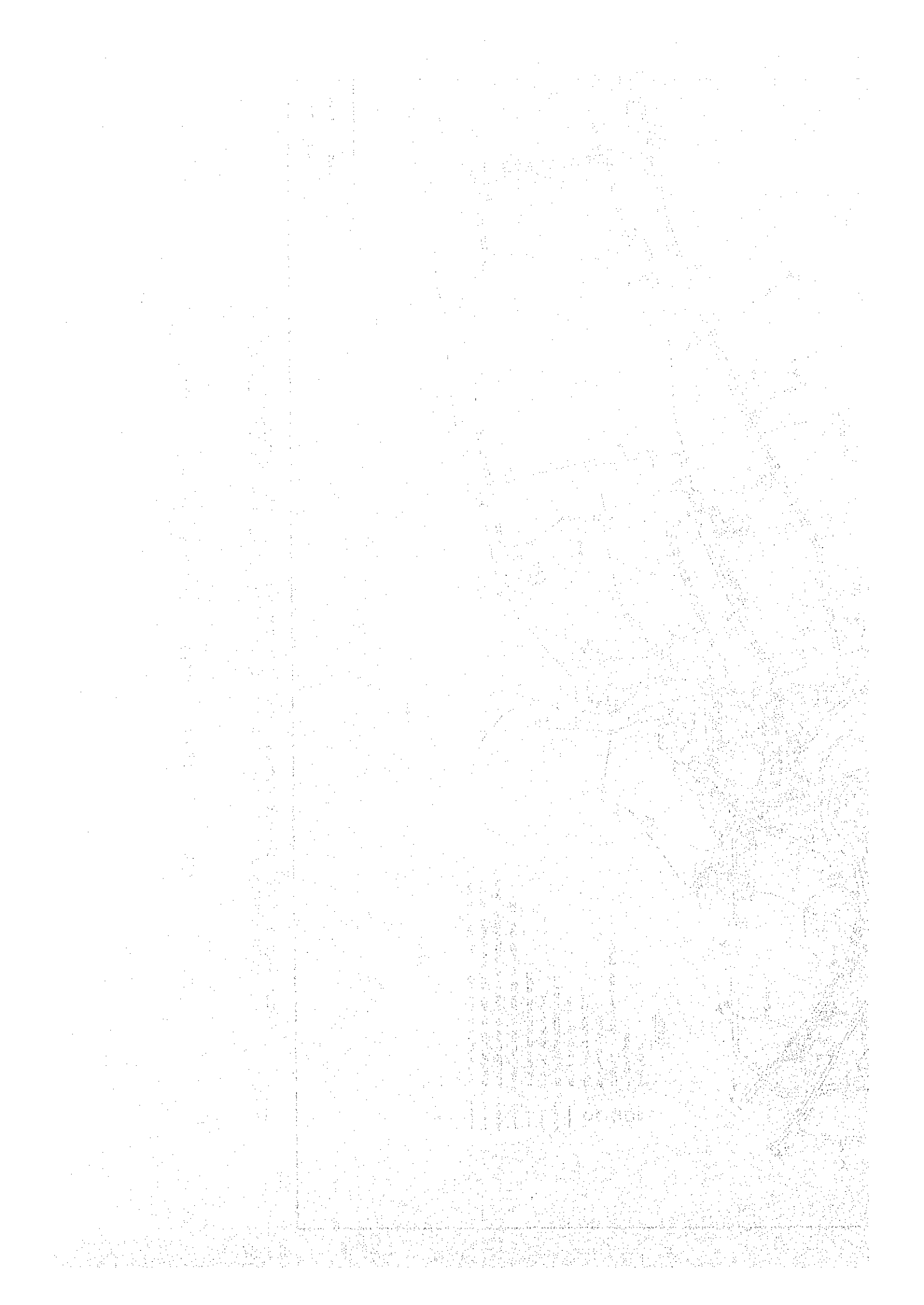
Note: Figures in circle are correspondent with the number of subtransmission line to be constructed during the period of FY 2012-2016 as shown in Table 6.4-2.

Fig. 6.4-1 230 kV System Configuration at FY 2016



Note: Figures in circle are correspondent with the number of subtransmission line to be constructed during the period of FY 2012-2016 as shown in Table 6.4-2.

Fig. 6.4-2 115 kV and 69 kV System Configuration at FY 2016



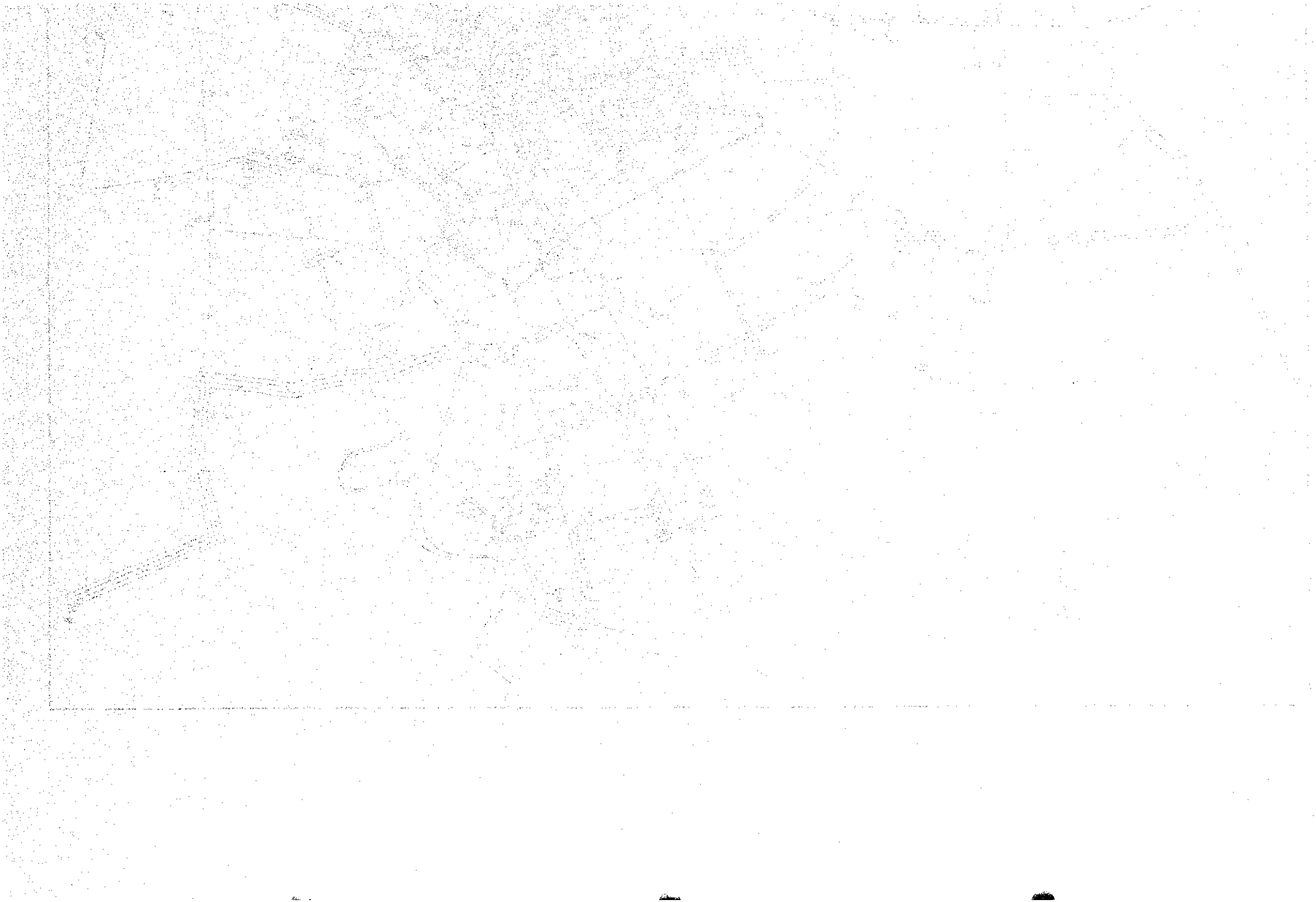


Table 6.4-1 Terminal Station Expansion Plan at FY 2016
(a) 115kV System

Terminal Station	2011 Plan		2016					For each Terminal Stations					Countermeasure		
	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utilizing Factor	Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %			
1. Bangplee A	2*200	400	294.20	171.60	340.59	384.86	96.22			2*200*					
Bangplee B	2*200	400	320.20	177.60	366.16	413.76	103.44	998.28	200	2*300	1000	79.86			
2. Klongrangsit(MEA) (MEA+PEA)	3*200 -	600	501.60	268.80	569.08	643.06	107.18	803.83	200	4*200	800	80.38	From On-nuj To Ramintra	107.8MW 104.7	
3. Nongjok A	2*300	600	471.80	177.80	504.19	569.74	94.96	1,131.86		4*300	1200	75.46	To Ramintra	186.3	
Nongjok B	2*300	600	273.80	115.40	297.13	335.75	55.96								
4. South Bangkok	3*200	600	255.30	124.20	283.91	320.82	53.47	401.02		3*200	600	53.47	To Ratburana	148.3	
5. Bangkoknoi A	2*300	600	318.20	127.40	342.76	387.31	64.55								
Bangkoknoi B	1*300	300	184.80	83.60	202.83	229.20	76.40	770.64	300	4*300	1200	51.38	To Ratburana	103.7	
6. Jangwatana A	2*300	600	407.20	234.20	469.75	530.81	88.47								
Jangwatana B	2*300	600	336.00	188.20	385.12	435.18	72.53	1,207.49		4*300	1200	80.50			
7. Sainoi	2*300	600	461.10	266.40	532.52	601.75	100.29	752.19	300	3*300	900	66.86			
8. Teparak	2*300	600	341.60	181.80	386.96	437.27	72.88	546.59		2*300	600	72.88	To Ratburana	68.2	
9. Bangbor A	2*300	600	337.60	190.60	387.69	438.09	73.01								
Bangbor B	1*300	300	180.20	99.70	205.94	232.71	77.57	838.50		3*300	900	74.53			
10. On-nuj A	2*300	600	444.00	186.80	481.70	544.32	90.72								
On-nuj B	2*300	600	271.20	151.00	310.40	350.76	58.46	1,118.84		4*300	1200	74.59	To Ramintra To K.Rangsit	111.1 107.8	
11. Ratchada	2*300	600	319.60	152.00	353.90	399.91	66.65	499.89		2*300	600	66.65			
12. Sanampao	2*300	600	402.90	204.90	452.01	510.77	85.13	638.46	300	3*300	900	56.75			
13. Thanontok	2*300	600	377.60	109.80	393.24	444.36	74.06	555.45		2*300	600	74.06			
14. Klongtoei	2*300	600	436.20	211.80	484.90	547.94	91.32	684.92	300	3*300	900	60.88			
15. Patanakarn A	2*300	600	437.80	199.40	481.07	543.61	90.60								
Patanakarn B	1*300	300	212.00	85.60	228.63	258.35	86.12	1,002.45	300	4*300	1200	66.83			
16. Talingchan A	2*300	600	429.60	135.60	450.49	509.06	84.84								
Talingchan B	1*300	300	379.00	127.40	399.84	451.82	150.61	1,201.09	300	4*300	1200	80.07			
17. New terminal St. (Ramintra)			403.20	195.00	447.88	506.10		632.63	600	2*300	600	84.35	From On-nuj Nongjok K.Rangsit	111.1MW 186.3 104.7	
18. New terminal St. (Ratburana)			321.60	194.60	375.89	424.76		530.95	600	2*300	600	70.79	From Bangkoknoi S.Bangkok Teparak	103.7 148.3 68.2	
Total	12800	12800	9,118.30	4,361.20	10,134.58	11,452.07	89.47	14,315.09	3400	16200	16200	70.69			

Table 6.4-1 Terminal Station Expansion Plan at FY 2016
(b) 69kV System

Terminal Station	2011 Plan		2016										Countermeasure
	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor %	For each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	
1. Bangkapi A	2*300	600	465.00	113.40	478.63	525.05	87.51						
Bangkapi B	2*200	400	306.40	130.80	333.15	365.47	91.37	1,113.15	200	4*300	1200	74.21	
2. Bangkok Noi A	2*200	400	254.80	120.20	281.73	309.06	77.26						
Bangkok Noi B	1*200	200	192.80	63.20	202.89	222.58	111.29						
Bangkok Noi C	1*200	200	92.60	34.60	98.85	108.44	54.22	800.09		4*200	800	80.01	
3. Bangplee	2*200	400	243.00	140.40	280.64	307.87	76.97	384.83		2*200	400	76.97	
4. Chidlom	2*250	500	345.80	157.00	379.77	416.61	83.32	520.76		2*250	500	83.32	
5. Klongrangsit (MEA) (MEA)+(PEA)	3*200	600	394.80	144.90	420.55	461.34	76.89	576.68		3*200	600	76.89	
6. Lardprao A	2*300	600	412.40	196.00	457.47	501.84	83.64						
Lardprao B	2*300	600	340.60	132.00	365.28	400.72	66.79	1,128.20		4*300	1200	75.21	
7. North Bangkok A	2*200	400	267.20	122.00	293.73	322.23	80.56			2*200+			
North Bangkok B	2*300	600	383.20	195.80	430.33	472.07	78.68	992.87		2*300	1000	79.43	
8. South Bangkok A	2*300	600	355.00	210.00	412.46	452.47	75.41						
South Bangkok B	2*300	600	286.20	154.60	325.29	356.84	59.47	1,011.64		4*300	1200	67.44	To Ratburana 305.3MW
9. South Thonburi A	2*200	400	354.40	122.80	375.07	411.45	102.86			2*200+			
South Thonburi B	2*200	400	282.00	127.60	309.53	339.55	84.89	938.75	200	2*300	1000	75.10	
10. Ratchada	2*300	600	432.30	223.20	486.52	533.71	88.95	667.14	300	3*300	900	59.30	
11. Teparak	2*300	600	244.20	139.40	281.19	308.46	51.41	385.58		2*300	600	51.41	
12. Thanontok	2*250	500	323.80	113.40	343.08	376.36	75.27	470.45		2*250	500	75.27	
13. Sanampao	2*300	600	371.60	127.60	392.90	431.01	71.83	538.76		2*300	600	71.83	
14. Thonburi	2*300	600	317.60	120.40	339.66	372.60	62.10	465.75		2*300	600	62.10	
15. New terminal St (Ratburana)			305.60	106.40	323.59	354.98		443.73	600	2*300	600	59.16	From South Bangkok 305.3MW
Total	10400	10400	6,971.30	2,997.70	7,288.72	7,995.73	76.88	10,438.39	1300	11700	11700	68.34	

(2) Subtransmission line improvement and expansion

In planning subtransmission line system, the system reliability must be considered. That is to say in case of interruption in any line single contingency must be able to relieve the situation so that the distribution system will not be affected. In other words, power must be delivered in either normal or emergency case.

Table 6.4-2 shows the subtransmission line expansion plan during the period of FY 2012-2016 formulated by the JICA Study Team. The total length of subtransmission line to be constructed will be 109.3 ckt-km, of which 79.0 ckt-km is overhead line and 30.3 ckt-km is underground cable. These can be briefly summarized as follows:

(a) Construction of 230 kV double circuit subtransmission line from Onnuj T/S to the new Ramintra T/S, a distance of 19.0 km, of which 13.0 km is overhead line and 6.0 km is underground cable.

(b) Construction of the outgoing 115 kV and 69 kV subtransmission line from the new Ratburana T/S, the total length of 24.7 ckt-km.

(c) Construction of 115 kV subtransmission line to be linked the 11 new distribution substations such as Klongdan D/S, Lumpagshe D/S, etc., the total length of 26.0 ckt-km.

(d) Construction of the incoming 69 kV subtransmission line to be linked distribution substations with the installation of the third transformer such as Samsen D/S, Bangson D/S, etc. to modify the system configuration to "Tapped-tie normally open (3 incomings)", the total length of 6.1 ckt-km.

(e) Construction of 115 kV subtransmission line to transfer the load at Maungthong-3 D/S and Maungthong-9 D/S from Jangwatana T/S to Klongrangsit T/S as countermeasures for the overloading Jangwatana T/S, the total length of 14.5 ckt-km.

Incidentally, 230 kV subtransmission line to be linked the new Ratburana T/S will be constructed by EGAT, since the new terminal station is located under the existing EGAT's 230 kV South Thonburi - South Bangkok line.

Table 6.4-2 Subtransmission Line Expansion Plan (FY 2012-2016)

OH : Overhead Line
UG : Underground Cable

No.	Description	Line Length (ckt-km)			Remarks
		OH.	UG.		
		2x400mm²	2x800mm²	2x1200mm²	
	Construction of 230kV Subtransmission Line				
1	Onnuj T/S - Ramintra T/S (2ckt)	26.0	—	12.0	Supply line for the new Ramintra T/S
2	Link Ratburana T/S (4ckt)	(2.0) 2x1272MCM	—	—	2 pi connection at the new Ratburana T/S to be constructed by EGAT
	Subtotal	26.0	—	12.0	
	Construction of 115kV Subtransmission Line				
3	Ratburana T/S - No.340 Rd. (1ckt)	1.0	1.8	—	Outgoing line from the new Ratburana T/S
4	Ratburana T/S - No.340 Rd. (1ckt)	—	1.7	—	Outgoing line from the new Ratburana T/S
5	Ratburana T/S - No.340 Rd. (1ckt)	—	1.5	—	Outgoing line from the new Ratburana T/S
6	Klongrangsit T/S - Maungthong3 D/S (1ckt)	6.0	2.5	—	Countermeares for overloading Jangwatana T/S
7	Klongrangsit T/S - Maungthong9 D/S (1ckt)	4.5	1.5	—	Countermeares for overloading Jangwatana T/S
8	Link Bangkruay D/S (2ckt) *	—	0.1	—	Supply line for the new Bangkruay D/S
9	Link Bangpang D/S (2ckt) *	—	0.1	—	Supply line for the new Bangpang D/S
10	Link Bangpla D/S (2ckt) *	—	0.1	—	Supply line for the new Bangpla D/S
11	Bangbor T/S - Klongdan D/S (1ckt) *	6.0	0.3	—	Supply line for the new Klongdan D/S
12	Link Klongdan D/S (1ckt) *	—	0.3	—	Supply line for the new Klongdan D/S
13	Link Klonggratiam D/S (2ckt) *	1.0	0.1	—	Supply line for the new Klonggratiam D/S
14	Lumpagshe D/S - Ram Inthra Rd. (2ckt) *	6.7	0.1	—	Supply line for the new Lumpagshe D/S
15	Link Pongpetch D/S (2ckt) *	—	0.1	—	Supply line for the new Pongpetch D/S
16	Link Puttamonton D/S (2ckt) *	—	0.1	—	Supply line for the new Puttamonton D/S
17	Rajdamri D/S - Rama 4 Rd. (2ckt) *	—	2.4	—	Supply line for the new Rajdamri D/S
18	The front of Shimplee D/S - Talingchan D/S (1ckt) *	3.4	0.1	—	Supply line for the new Talingchan D/S
19	Talingchan T/S - Talingchan D/S (1ckt) *	4.8	0.3	—	Supply line for the new Talingchan D/S
	Subtotal	33.4	13.1	—	

Note: * MEA's draft long-term plan at FY 2011

Table 6.4-2 Subtransmission Line Expansion Plan (FY 2012-2016) (Cont.)

OH : Overhead Line
UG : Underground Cable

No.	Description	Line Length (ckt-km)			Remarks
		OH.	UG.		
		2x400mm²	2x800mm²	2x1200mm²	
	Construction of 69kV Subtransmission Line				
20	Ratburana T/S - Suksawat Rd. (1ckt)	2.0	1.7	—	Outgoing line from the new Ratburana T/S
21	Ratburana T/S - Suksawat Rd. (1ckt)	2.0	1.5	—	Outgoing line from the new Ratburana T/S
22	Ratburana T/S - Suksawat Rd. (1ckt)	11.0	0.5	—	Outgoing line from the new Ratburana T/S
23	Link Bangson D/S (1ckt) *	0.1	0.6	—	Addition of incoming line at Bangson D/S
24	Link Poojao D/S (1ckt)	—	0.1	—	Addition of incoming line at Poojao D/S
25	Link Watdeedod D/S (1ckt)	—	0.1	—	Addition of incoming line at Watdeedod D/S
26	North Bangkok T/S - Samsen D/S (1ckt)	4.5	0.6	—	Addition of incoming line at Samsen D/S
27	Link Banmai D/S (1ckt) *	—	0.1	—	Addition of incoming line at Banmai D/S
	Subtotal	19.6	5.2	—	
	Total	79.0	18.3	12.0	

Note: * MEA's draft long-term plan at FY 2011

6.4.3 FY 1997-2011's Plan

Based on the draft long-term plan up to FY 2011 prepared by MEA, the study of the subtransmission system expansion plan at each target year during the period of FY 1997-2011 has been carried out according to the distribution substation expansion plan formulated by the JICA Study Team.

(1) Terminal station improvement and expansion

Table 6.4-3 to 6.4-9 show the terminal station expansion plan at each target year during the period of FY 1997-2011 formulated by the JICA Study Team, including countermeasures such as load to be switched over to other terminal stations.

Table 6.4-10 shows the target for terminal station programme up to FY 2016. The total increasing capacity up to FY 2011 will be 12,915 MVA, of which 3,000 MVA is constructed by MEA's own investment and 9,915 MVA is constructed by EGAT's own investment.

These can be briefly summarized as follows:

(a) Construction of terminal station

The nine new terminal stations with total capacity 4,800 MVA will be constructed. Among these, the following four terminal stations which are located outside the EGAT's 230 kV outer ring lines will be constructed with the total capacity of 2,400 MVA by MEA's own investment.

FY 1999:	Thanontok T/S	230/115 kV, 2x300 MVA
FY 2000:	Sanampao T/S	230/115 kV, 1x300 MVA
		230/69 kV, 1x300 MVA
FY 2006:	Klongtoey T/S	230/115 kV, 2x300 MVA
	Thonburi T/S	230/69 kV, 1x300 MVA

(b) Addition of terminal station

The 18 existing terminal stations will have capacity added totally 8,115 MVA. Among these, the following two terminal stations will have capacity added totally 900 MVA by MEA's own investment.

FY 2006: Sanampao T/S 230/69 kV, 1x300 MVA to 2x300 MVA

FY 2011: Sanampao T/S 230/115 kV, 1x300 MVA to 2x300 MVA
Thonburi T/S 230/69 kV, 1x300 MVA to 2x300 MVA

The installed capacity of terminal stations at each target year up to FY 2016 is as shown in Table 6.4-11.

Table 6.4-3 Terminal Station Expansion Plan at FY1997
(a) 115kV System

Terminal Station	1991 Bank Capacity (MVA)	1996 Bank Capacity (MVA)	1997 Plan Bank Capacity (MVA)	1997 Plan Total (MVA)	1997 JICA Plan Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor	For Each Terminal Stations Required (MVA)	Adding (MVA)	Config. (MVA)	Total (MVA)	U.F. %	Countermeasure
1. Bangplee A	2*200	3*200	3*200	600	412.80	81.90	420.85	475.56	79.26						
Bangplee B	-	-	-							594.45		3*200	600	79.26	
2. Klongrangsit(MEA)	-	-	2*200	400	23.80	2.00	23.88	26.99	6.75	33.74	-200	2*200	400	6.75	
(MEA+PEA)	2*200	3*200	-												
3. Nongjok A	1*200	2*200	2*200	400	254.40	112.00	277.96	314.10	78.52	579.70	300	2*200+	700	66.25	
Nongjok B	-	-	1*300	300	121.20	53.40	132.44	149.66	49.89			1*300			
4. South Bangkok	2*200	2*200	2*200	400	298.60	68.80	306.42	346.26	86.56	432.82		2*200	400	86.56	Switch over some load to Teparak
5. Bangkoknoi A	-	1*200	1*300	300	-7.00	9.90	12.12	13.70	4.57						
Bangkoknoi B	-	-	-							17.13	100	1*300	300	4.57	
6. Jangwatana A	-	2*300	2*300	600	293.60	47.40	297.40	336.06	56.01						
Jangwatana B	-	-								420.08		2*300	600	56.01	
7. Sainoi	-	1*200	1*300	300	93.90	27.50	97.84	110.56	36.85	138.20	100	1*300	300	36.85	
8. Teparak	-	1*300	1*300	300	149.80	30.20	152.81	172.68	57.56	215.85		1*300	300	57.56	
9. Bangbor A	-	-													
Bangbor B	-	-													
10. On-nuj A	-	-													
On-nuj B	-	-													
11. Ratchada	-	-													
12. Sanampao	-	-													
13. Thanontok	-	-													
14. Klongtoei	-	-													
15. Patanakarn A	-	-													
Patanakarn B	-	-													
16. Talingchan A	-	-													
Talingchan B	-	-													
Total	1400	3300	3600	3600	1,641.10	433.10	1,721.74	1,945.57	54.04	2,431.96	300	3600	3600	54.04	

Table 6.4-3 Terminal Station Expansion Plan at FY 1997
(b) 69 kV System

Terminal Station	1991 Bank Capacity (MVA)	1996 Bank Capacity (MVA)	1997 Plan Bank Capacity (MVA)	1997 Plan Total (MVA)	1997 JICA Plan Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor %	For each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	Countermeasure
1. Bangkapi A	2*200	2*200	2*200	400	299.40	44.20	302.65	332.00	83.00			2*200+			
Bangkapi B	2*200	2*200	2*200	400	258.20	32.20	260.20	285.44	71.36	771.80		2*200	800	77.18	
2. Bangkok Noi A	2*200	2*200	2*200	400	261.00	89.80	276.02	302.79	75.70						
Bangkok Noi B	1*200	1*200	1*200	200	89.00	37.60	96.62	105.99	52.99						
Bangkok Noi C	-	1*200	1*200	200	87.40	41.10	96.58	105.95	52.97	643.41		4*200	800	64.34	
3. Bangplee	2*200	2*200	2*200	400	199.40	31.00	201.80	221.37	55.34	276.71		2*200	400	55.34	
4. Chidlom	2*50+2*200	2*50+2*200	2*50+2*200	500	400.10	185.40	440.97	483.74	96.75	604.68		2*250	500	96.75	
5. Klongrangsit (MEA)	-	-	2*200	400	218.00	23.60	219.27	240.54	60.14	300.68	-200	2*200	400	60.14	
(MEA)+(PEA)	3*200	3*200													
6. Lardprao A	2*200	2*200	2*200	400	217.80	12.60	218.16	239.33	59.83			2*200+			
Lardprao B	1*200	2*200	2*200	400	341.40	77.80	350.15	384.12	96.03	779.30		2*200	800	77.93	
7. North Bangkok A	1*200+1*285	1*200+1*285	1*200+1*285	485	283.60	77.60	294.03	322.55	66.50			200+285+			
North Bangkok B	1*200	1*200	1*200	200	228.80	59.00	236.28	259.20	129.60	727.19		1*200	685	84.93	
8. South Bangkok A	2*200	2*200	2*200	400	275.60	71.20	284.65	312.26	78.06			2*200+			
South Bangkok B	2*200	2*200	2*200	400	292.60	78.80	303.03	332.42	83.10	805.85		2*200	800	80.58	
9. South Thonburi A	2*200	2*200	2*200	400	308.20	68.80	315.79	346.42	86.60						
South Thonburi B	-	1*200	2*200	400	248.80	34.60	251.19	275.56	68.89	777.47	200	4*200	800	77.75	
10. Ratchada	-	2*300	2*300	600	357.80	60.60	362.90	398.10	66.35	497.62		2*300	600	66.35	
11. Teparak	-	1*300	1*300	300	142.50	30.00	145.62	159.75	53.25	199.69		1*300	300	53.25	
12. Thanontok	-	2*250	2*250	500	168.80	19.80	169.96	186.44	37.29	233.05		2*250	500	37.29	
13. Sanampao	-	-	-												
14. Thonburi	-	-	-												
Total	5385	7385	7385	7385	4,678.40	1,075.70	4,825.85	5,293.96	71.69	6,617.45	0	7385	7385	71.69	

Table 6.4-4 Terminal Station Expansion Plan at FY1998
(a) 115 kV System

Terminal Station	1991 Bank Capacity (MVA)	1996 Bank Capacity (MVA)	1997 Bank Capacity (MVA)	1998 Plan Bank Capacity (MVA)	1998 Plan Total (MVA)	1998 JICA Plan Coincident Load (MW)	(MVAR)	(MVA)	Peak Lond (MVA)	Utiliz Factor	For Each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	Countermeasure
1. Bangplee A	2*200	3*200	3*200	3*200	600	435.30	84.00	443.33	500.96	83.49						
Bangplee B	-	-	-	-							626.20		3*200	600	83.49	Switch over some load to Teparak
2. Klongrangsit(MEA)	-	-	2*200	2*200	400	173.20	67.20	185.78	209.93	52.48	262.41		2*200	400	52.48	
(MEA+PEA)	2*200	3*200	-	-												
3. Nongjok A	1*200	2*200	2*200	2*200	400	205.40	68.40	216.49	244.63	61.16	451.59		2*200	700	51.61	
Nongjok B	-	-	1*300	1*300	300	97.90	32.70	103.22	116.63	38.88			1*300			
4. South Bangkok	2*200	2*200	2*200	2*200	400	285.00	71.00	293.71	331.89	82.97	414.87		2*200	400	82.97	Switch over some load to Teparak
5. Bangkoknoi A	-	1*200	1*300	1*300	300	66.20	13.20	67.50	76.28	25.43						
Bangkoknoi B	-	-	-	-							95.35		1*300	300	25.43	
6. Jangwatana A	-	2*300	2*300	2*300	600	322.20	62.80	328.26	370.94	61.82						
Jangwatana B	-	-		1*300	300	29.80	7.30	30.68	34.67	11.56	507.01	300	3*300	900	45.07	
7. Sainoi	-	1*200	1*300	1*300	300	98.90	57.30	114.30	129.16	43.05	161.45		1*300	300	43.05	
8. Teparak	-	1*300	1*300	2*300	600	188.20	28.00	190.27	215.01	35.83	268.76	300	2*300	600	35.83	
9. Bangbor A	-	-														
Bangbor B	-	-		-												
10. On-nuj A	-	-		2*300	600	105.20	21.80	107.44	121.40	20.23						
On-nuj B	-	-		-							151.75	600	2*300	600	20.23	
11. Ratchada	-	-														
12. Sanampao	-	-														
13. Thanontok	-	-														
14. Klongtoei	-	-														
15. Patanakarn A	-	-														
Patanakarn B	-	-														
16. Talingchan A	-	-														
Talingchan B	-	-														
Total	1400	3300	3600	4800	4800	2,007.30	513.70	2,080.98	2,351.51	48.99	2,939.39	1200	4800	4800	48.99	

Table 6.4-4 Terminal Station Expansion Plan at FY1998
(b) 69 kV System

Terminal Station	1991 Bank Capacity (MVA)	1996 Bank Capacity (MVA)	1997 Bank Capacity (MVA)	1998 Plan Bank Capacity (MVA)	1998 Plan Total (MVA)	1998 JICA Plan Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor %	For each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	Countermeasure
1. Bangkapi A	2*200	2*200	2*200	2*200	400	302.20	89.00	315.03	345.59	86.40			2*200+			
Bangkapi B	2*200	2*200	2*200	2*200	400	260.00	61.00	267.06	292.96	73.24	798.20		2*200	800	79.82	
2. Bangkok Noi A	2*200	2*200	2*200	2*200	400	319.00	58.20	324.27	355.72	88.93						
Bangkok Noi B	1*200	1*200	1*200	1*200	200	73.60	5.70	73.82	80.98	40.49						
Bangkok Noi C	-	1*200	1*200	1*200	200	79.00	8.40	79.45	87.15	43.58	654.81		4*200	800	65.48	
3. Bangplee	2*200	2*200	2*200	2*200	400	185.80	35.00	189.07	207.41	51.85	259.26		2*200	400	51.85	
4. Chidlom	2*50+2*200	2*50+2*200	2*50+2*200	2*50+2*200	500	358.30	177.70	399.95	438.74	87.75	548.42		2*250	500	87.75	
5. Klongrangsit (MEA)	-	-	2*200	2*200	400	118.40	27.00	121.44	133.22	33.30	166.52		2*200	400	33.30	
(MEA)+(PEA)	3*200	3*200														
6. Lardprao A	2*200	2*200	2*200	2*200	400	302.60	28.40	303.93	333.41	83.35			2*200+			
Lardprao B	1*200	2*200	2*200	2*200	400	327.60	51.00	331.55	363.71	90.93	871.40		2*200	800	87.14	
7. North Bangkok A	1*200+1*285	1*200+1*285	1*200+1*285	1*200+1*285	485	309.60	53.80	314.24	344.72	71.08			200+285+			
North Bangkok B	1*200	1*200	1*200	1*200	200	220.30	49.70	225.84	247.74	123.87	740.58		1*200	685	86.49	
8. South Bangkok A	2*200	2*200	2*200	2*200	400	317.40	85.20	328.64	360.51	90.13			2*200+			
South Bangkok B	2*200	2*200	2*200	2*200	400	250.40	60.80	257.68	282.67	70.67	803.98		2*200	800	80.40	
9. South Thonburi A	2*200	2*200	2*200	2*200	400	312.40	63.40	318.77	349.69	87.42						
South Thonburi B	-	1*200	2*200	2*200	400	406.60	59.80	410.97	450.84	112.71	1,000.66		4*200	800	100.07	
10. Ratchada	-	2*300	2*300	2*300	600	369.50	77.20	377.48	414.09	69.02	517.62		2*300	600	69.02	
11. Teparak	-	1*300	1*300	2*300	600	252.00	49.60	256.83	281.75	46.96	352.18	300	2*300	600	46.96	
12. Thanontok	-	2*250	2*250	2*250	500	43.40	6.00	43.81	48.06	9.61	60.08		2*250	500	9.61	
13. Sanampao	-	-	-	-												
14. Thonburi	-	-	-	-												
Total	5385	7385	7385	7685	7685	4,808.10	1,046.90	4,939.81	5,418.97	70.51	6,773.71	300	7685	7685	70.51	

Table 6.4-5 Terminal Station Expansion Plan at FY1999
(a) 115 kV System

Terminal Station	1991 Bank Capacity (MVA)	1996 Bank Capacity (MVA)	1997 Bank Capacity (MVA)	1998 Bank Capacity (MVA)	1999 Plan Bank Capacity (MVA)	1999 Plan Total (MVA)	1999 JICA Plan Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz. Factor	For Each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	Countermeasure
1. Bangplee A	2*200	3*200	3*200	3*200	3*200	600	433.80	75.60	440.34	497.58	82.93						
Bangplee B	-	-	-	-	-							621.98		3*200	600	82.93	Switch over some load to Teparak
2. Klongrangsit (MEA)	-	-	2*200	2*200	2*200	400	206.20	87.20	223.88	252.98	63.25	316.23		2*200	400	63.25	
(MEA+PEA)	2*200	3*200	-	-	-												
3. Nongjok A	1*200	2*200	2*200	2*200	2*200	400	219.40	98.60	240.54	271.81	67.95	508.95		2*200+	700	58.17	
Nongjok B	-	-	1*300	1*300	1*300	300	109.70	48.10	119.78	135.35	45.12			1*300			
4. South Bangkok	2*200	2*200	2*200	2*200	2*200	400	271.80	32.40	273.72	309.31	77.33	386.64		2*200	400	77.33	
5. Bangkoknoi A	-	1*200	1*300	1*300	1*300	300	152.50	48.20	159.94	180.73	60.24						
Bangkoknoi B	-	-	-	-	-							225.91		1*300	300	60.24	
6. Jangwatana A	-	2*300	2*300	2*300	2*300	600	359.00	83.00	368.47	416.37	69.40						
Jangwatana B	-	-		1*300	1*300	300	57.00	25.30	62.36	70.47	23.49	608.55		3*300	900	54.09	
7. Sainoi	-	1*200	1*300	1*300	2*300	600	152.80	73.20	169.43	191.45	31.91	239.32	300	2*300	600	31.91	
8. Teparak	-	1*300	1*300	2*300	2*300	600	220.60	32.80	223.03	252.02	42.00	315.02		2*300	600	42.00	
9. Bangbor A	-	-															
Bangbor B	-	-		-	-												
10. On-nuj A	-	-		2*300	2*300	600	138.20	51.00	147.31	166.46	27.74						
On-nuj B	-	-		-	-							208.08		2*300	600	27.74	
11. Ratchada	-	-															
12. Sanampao	-	-															
13. Thanontok	-	-			2*300	600	213.40	10.80	213.67	241.45	40.24	301.81	600	2*300	600	40.24	
14. Klongtoei	-	-			-												
15. Patanakarn A	-	-			-												
Patanakarn B	-	-			-												
16. Talingchan A	-	-			-												
Talingchan B	-	-			-												
Total	1400	3300	3600	4800	5700	5700	2,534.40	666.20	2,642.47	2,985.99	52.39	3,732.49	900	5700	5700	52.39	

Table 6.4-5 Terminal Station Expansion Plan at FY1999
(b) 69 kV System

Terminal Station	1995 Bank Capacity (MVA)	1996 Bank Capacity (MVA)	1997 Bank Capacity (MVA)	1998 Bank Capacity (MVA)	1999 Plan Bank Capacity (MVA)	1999 Plan Total (MVA)	1999 JICA Plan Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor %	For each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	Countermeasure
1. Bangkapi A	2*200	2*200	2*200	2*200	2*200	400	314.80	43.80	317.83	348.66	87.17			2*200+			
Bangkapi B	2*200	2*200	2*200	2*200	2*200	400	272.20	35.80	274.54	301.17	75.29	812.30		2*200	800	81.23	
2. Bangkok Noi A	2*200	2*200	2*200	2*200	2*200	400	315.20	35.60	317.20	347.97	86.99						
Bangkok Noi B	1*200	1*200	1*200	1*200	1*200	200	73.50	4.80	73.66	80.80	40.40						
Bangkok Noi C	-	1*200	1*200	1*200	1*200	200	78.30	5.70	78.51	86.12	43.06	643.62		4*200	800	64.36	
3. Bangplee	2*200	2*200	2*200	2*200	2*200	400	197.60	30.20	199.89	219.28	54.82	274.11		2*200	400	54.82	
4. Chidlom	2*50+2*200	2*50+2*200	2*50+2*200	2*50+2*200	2*50+2*200	500	351.00	208.00	408.00	447.58	89.52	559.47		2*250	500	89.52	
5. Klongrangsit(MEA)	-	-	2*200	2*200	2*200	400	123.00	59.20	136.51	149.75	37.44	187.18		2*200	400	37.44	
(MEA)+(PEA)	3*200	3*200															
6. Lardprao A	2*200	2*200	2*200	2*200	2*200	400	292.00	15.20	292.40	320.76	80.19			2*200+			
Lardprao B	1*200	2*200	2*200	2*200	2*200	400	320.00	25.40	321.01	352.14	88.04	841.13		2*200	800	84.11	
7. North Bangkok A	1*200+1*285	1*200+1*285	1*200+1*285	1*200+1*285	1*200+1*285	485	279.20	21.00	279.99	307.15	63.33			200+285+			
North Bangkok B	1*200	1*200	1*200	1*200	1*200	200	249.60	36.70	252.28	276.76	138.38	729.88		1*200	685	85.24	
8. South Bangkok A	2*200	2*200	2*200	2*200	2*200	400	308.10	47.60	311.76	342.00	85.50			2*200+			
South Bangkok B	2*200	2*200	2*200	2*200	2*200	400	277.80	46.20	281.62	308.93	77.23	813.66		2*200	800	81.37	
9. South Thonburi A	2*200	2*200	2*200	2*200	2*200	400	308.20	37.40	310.46	340.58	85.14						
South Thonburi B	-	1*200	2*200	2*200	2*200	400	108.80	8.60	109.14	119.73	29.93	575.38		4*200	800	57.54	
10. Ratchada	-	2*300	2*300	2*300	2*300	600	393.00	52.60	396.50	434.97	72.49	543.71		2*300	600	72.49	
11. Teparak	-	1*300	1*300	2*300	2*300	600	282.80	47.80	286.81	314.63	52.44	393.29		2*300	600	52.44	
12. Thanontok	-	2*250	2*250	2*250	2*250	500	299.80	21.20	300.55	329.70	65.94	412.13		2*250	500	65.94	
13. Sanampao	-	-	-	-	-												
14. Thonburi	-	-	-	-	-												
Total	5385	7385	7385	7685	7685	7685	4,844.90	782.80	4,948.65	5,428.67	70.64	6,785.84	0	7685	7685	70.64	

Table 6.4-6 Terminal Station Expansion Plan at FT2000
(a) 115 kV System

Terminal Station	1991	1996	1997	1998	1999	2000 Plan		2000 JICA Plan									Countermeasure
	Bank Capacity (MVA)	Bank Capacity (MVA)	Bank Capacity (MVA)	Bank Capacity (MVA)	Bank Capacity (MVA)	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor	For Each Terminal Stations Required (MVA)	Adding (MVA)	Confign. (MVA)	Total (MVA)	U.F. %	
1. Bangplee A	2*200	3*200	3*200	3*200	3*200	3*200	600	365.10	80.70	373.91	422.52	70.42						
Bangplee B	-	-	-	-	-	-							528.15		3*200	600	70.42	
2. Klongrangsit (MEA)	-	-	2*200	2*200	2*200	2*200	400	218.20	78.80	231.99	262.15	65.54	327.69		2*200	400	65.54	
(MEA+PEA)	2*200	3*200	-	-	-	-												
3. Nongjok A	1*200	2*200	2*200	2*200	2*200	2*200	400	249.60	59.20	256.52	289.87	72.47	541.71		2*200+	700	61.91	
Nongjok B	-	-	1*300	1*300	1*300	1*300	300	123.70	28.70	126.99	143.49	47.83			1*300			
4. South Bangkok	2*200	2*200	2*200	2*200	2*200	2*200	400	195.20	50.00	201.50	227.70	56.92	284.62		2*200	400	56.92	
5. Bangkoknoi A	-	1*200	1*300	1*300	1*300	2*300	600	195.20	17.40	195.97	221.45	36.91						
Bangkoknoi B	-	-	-	-	-	-							276.81	300	2*300	600	36.91	
6. Jangwatana A	-	2*300	2*300	2*300	2*300	2*300	600	374.40	122.40	393.90	445.11	74.18						
Jangwatana B	-	-		1*300	1*300	1*300	300	122.20	48.90	131.62	148.73	49.58	742.30		3*300	900	65.98	
7. Sainoi	-	1*200	1*300	1*300	2*300	2*300	600	129.40	59.00	142.22	160.70	26.78	200.88		2*300	600	26.78	
8. Teparak	-	1*300	1*300	2*300	2*300	2*300	600	326.40	77.40	335.45	379.06	63.18	473.83		2*300	600	63.18	
9. Bangbor A	-	-																
Bangbor B	-	-		-	-													
10. On-nuj A	-	-		2*300	2*300	2*300	600	285.80	41.20	288.75	326.29	54.38						
On-nuj B	-	-		-	-	-							407.87		2*300	600	54.38	
11. Ratchada	-	-				1*300	300	48.10	4.10	48.27	54.55	18.18	68.19	300	1*300	300	18.18	
12. Sanampao	-	-				1*300	300	40.20	2.30	40.27	45.50	15.17	56.88	300	1*300	300	15.17	
13. Thanontok	-	-			2*300	2*300	600	209.80	17.60	210.54	237.91	39.65	297.38		2*300	600	39.65	
14. Klongtoei	-	-			-	-												
15. Patanakarn A	-	-			-	-												
Patanakarn B	-	-			-	-												
16. Talingchan A	-	-			-	-												
Talingchan B	-	-			-	-												
Total	1400	3300	3600	4800	5700	6600	6600	2,883.30	687.70	2,977.91	3,365.04	50.99	4,206.30	900	6600	6600	50.99	

Table 6.4-6 Terminal Station Expansion Plan at FY2000
(b) 69 kVSystem

Terminal Station	1991 Bank Capacity (MVA)	1996 Bank Capacity (MVA)	1997 Bank Capacity (MVA)	1998 Bank Capacity (MVA)	1999 Bank Capacity (MVA)	2000 Plan Bank Capacity (MVA)	2000 Plan Total (MVA)	2000 JICA Plan Coincident Load (MW)	Coincident Load (MVAR)	Coincident Load (MVA)	Peak Load (MVA)	Utiliz Factor %	For each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	Countermeasure
1. Bangkapi A	2*200	2*200	2*200	2*200	2*200	2*200	400	331.00	80.80	340.72	373.77	93.44			2*200+			
Bangkapi B	2*200	2*200	2*200	2*200	2*200	2*200	400	299.00	61.00	305.16	334.76	83.69	885.66		2*200	800	88.57	
2. Bangkok Noi A	2*200	2*200	2*200	2*200	2*200	2*200	400	264.80	48.60	269.22	295.34	73.83						
Bangkok Noi B	1*200	1*200	1*200	1*200	1*200	1*200	200	102.40	13.40	103.27	113.29	56.65						
Bangkok Noi C	-	1*200	1*200	1*200	1*200	1*200	200	56.90	11.20	57.99	63.62	31.81	590.31		4*200	800	59.03	
3. Bangplee	2*200	2*200	2*200	2*200	2*200	2*200	400	199.00	44.20	203.85	223.62	55.91	279.53		2*200	400	55.91	
4. Chidlom	2*50+2*200	2*50+2*200	2*50+2*200	2*50+2*200	2*50+2*200	2*50+2*200	500	288.80	173.00	336.65	369.31	73.86	461.63		2*250	500	73.86	
5. Klongrangsit(MEA)	-	-	2*200	2*200	2*200	2*200	400	137.20	66.20	152.34	167.11	41.78	208.89		2*200	400	41.78	
(MEA)+(PEA)	3*200	3*200																
6. Lardprao A	2*200	2*200	2*200	2*200	2*200	2*200	400	236.80	36.00	239.52	262.75	65.69			2*200+			
Lardprao B	1*200	2*200	2*200	2*200	2*200	2*200	400	269.00	28.20	270.47	296.71	74.18	699.33		2*200	800	69.93	
7. North Bangkok A	1*200+1*285	1*200+1*285	1*200+1*285	1*200+1*285	1*200+1*285	1*200+1*285	485	267.80	55.80	273.55	300.09	61.87			200+285+			
North Bangkok B	1*200	1*200	1*200	1*200	1*200	1*200	200	264.80	92.70	280.56	307.77	153.89	759.82		1*200	685	88.74	
8. South Bangkok A	2*200	2*200	2*200	2*200	2*200	2*200	400	334.40	81.20	344.12	377.50	94.37			2*200+			
South Bangkok B	2*200	2*200	2*200	2*200	2*200	2*200	400	280.80	79.40	291.81	320.12	80.03	872.02		2*200	800	87.20	
9. South Thonburi A	2*200	2*200	2*200	2*200	2*200	2*200	400	279.20	67.20	287.17	315.03	78.76						
South Thonburi B	-	1*200	2*200	2*200	2*200	2*200	400	166.60	13.00	167.11	183.32	45.83	622.93		4*200	800	62.29	
10. Ratchada	-	2*300	2*300	2*300	2*300	2*300	600	380.40	69.40	386.68	424.19	70.70	530.23		2*300	600	70.70	
11. Teparak	-	1*300	1*300	2*300	2*300	2*300	600	310.60	88.00	322.83	354.14	59.02	442.67		2*300	600	59.02	
12. Thanontok	-	2*250	2*250	2*250	2*250	2*250	500	303.80	34.00	305.70	335.35	67.07	419.19		2*250	500	67.07	
13. Sanampao	-	-	-	-	-	1*300	300	167.30	36.30	171.19	187.80	62.60	234.75		1*300	300	62.60	
14. Thonburi	-	-	-	-	-	-												
Total	5385	7385	7385	7685	7685	7985	7985	4,940.60	1,179.60	5,109.91	5,605.57	70.20	7,006.96	0	7985	7985	70.20	

Table 6.4-7 Terminal Station Expansion Plan at FY2001
(a) 115kV System

Terminal Station	2000 Plan		2001 JICA Plan									Countermeasure
	Bank Capacity (MVA)	Total (MVA)	Coincident Lond (MW)	(MVAR)	(MVA)	Peak Lond (MVA)	Utilizing Factor	For Each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	
1. Bangplee A Bangplee B	3*200	600	311.10	120.90	333.77	377.16	62.86	471.45		3*200	600	62.86	
2. Klongrangsit(MEA) (MEA+PEA)	2*200	400	238.00	161.00	287.34	324.70	81.17	405.87		2*200	400	81.17	
3. Nongjok A Nongjok B	2*200 1*300	400 300	256.60 122.20	129.80 63.90	287.56 137.90	324.94 155.83	81.24 51.94	600.96		2*200+ 1*300	700	68.68	
4. South Bangkok	2*200	400	205.20	59.00	213.51	241.27	60.32	301.59		2*200	400	60.32	
5. Bangkoknoi A Bangkoknoi B	2*300	600	249.60	43.20	253.31	286.24	47.71	357.80		2*300	600	47.71	
6. Jangwatana A Jangwatana B	2*300 1*300	600 300	276.60 274.40	134.00 132.00	307.35 304.50	347.30 344.08	57.88 114.69	864.23		3*300	900	76.82	
7. Sainoi	2*300	600	214.20	51.60	220.33	248.97	41.50	311.21		2*300	600	41.50	
8. Teparak	2*300	600	339.60	98.20	353.51	399.47	66.58	499.34		2*300	600	66.58	
9. Bangbor A Bangbor B			100.30	47.20	110.85	125.26	#DIV/0!	156.58	300	1*300	300	41.75	
10. On-nuj A On-nuj B	2*300	600	269.20	115.20	292.81	330.88	55.15	413.60		2*300	600	55.15	
11. Ratchada	1*300	300	76.50	10.90	77.27	87.32	29.11	109.15		1*300	300	29.11	
12. Sanampao	1*300	300	45.40	1.20	45.42	51.32	17.11	64.15		1*300	300	17.11	
13. Thanontok	2*300	600	269.20	51.40	274.06	309.69	51.62	387.11		2*300	600	51.62	
14. Klongtoei													
15. Patanakarn A Patanakarn B													
16. Talingchan A Talingchan B													
Total	6600	6600	3,248.10	1,219.50	3,499.50	3,954.43	59.92	4,943.04	300	6900	6900	57.31	

Table 6.4-7 Terminal Station Expansion Plan at FY2001
(b) 69kV System

Terminal Station	2000 Plan		2001 JICA Plan										Countermeasure
	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor %	For each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	
1. Bangkapi A	2*200	400	332.00	101.80	347.26	380.94	95.24			2*300+			
Bangkapi B	2*200	400	289.20	111.40	309.91	339.98	84.99	901.15	200	2*200	1000	72.09	
2. Bangkok Noi A	2*200	400	239.80	50.00	244.96	268.72	67.18						
Bangkok Noi B	1*200	200	108.80	17.00	110.12	120.80	60.40						
Bangkok Noi C	1*200	200	64.40	15.00	66.12	72.54	36.27	577.57		4*200	800	57.76	
3. Bangplee	2*200	400	192.00	76.20	206.57	226.61	56.65	283.26		2*200	400	56.65	
4. Chidlom	2*50+2*20(	500	291.90	144.30	325.62	357.20	71.44	446.51		2*250	500	71.44	
5. Klongrangsit (MEA) (MEA)+(PEA)	2*200	400	183.20	84.20	201.62	221.18	55.30	276.48		2*200	400	55.30	
6. Lardprao A	2*200	400	231.60	32.60	233.88	256.57	64.14			2*200+			
Lardprao B	2*200	400	329.20	60.80	334.77	367.24	91.81	779.76		2*200	800	77.98	
7. North Bangkok A	2*200	400	304.40	66.00	311.47	341.69	85.42			2*300+			
North Bangkok B	1*285	285	271.80	60.40	278.43	305.44	107.17	808.90	315	2*200	1000	64.71	
8. South Bangkok A	2*200	400	345.60	106.60	361.67	396.75	99.19			2*300+			
South Bangkok B	2*200	400	270.80	101.00	289.02	317.06	79.26	892.26	200	2*200	1000	71.38	
9. South Thonburi A	2*200	400	276.00	67.80	284.21	311.77	77.94						
South Thonburi B	2*200	400	183.60	52.20	190.88	209.39	52.35	651.46		4*200	800	65.15	
10. Ratchada	2*300	600	429.80	139.80	451.96	495.81	82.63	619.76		2*300	600	82.63	
11. Teparak	2*300	600	320.80	97.00	335.14	367.65	61.28	459.57		2*300	600	61.28	
12. Thanontok	2*250	500	302.60	47.00	306.23	335.93	67.19	419.92		2*250	500	67.19	
13. Sanampao	1*300	300	186.60	47.40	192.53	211.20	70.40	264.00		1*300	300	70.40	
14. Thonburi	-												
Total	8100	7985	5,154.10	1,478.50	5,382.37	5,904.46	73.94	7,380.58	715	8700	8700	67.87	

Table 6.4-8 Terminal Station Expansion Plan at FY 2006
(a) 115kV System

Terminal Station	2001 Plan		2006 JICA Plan									Countermeasure
	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utilizing Factor	For Each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	
1. Bangplee A	2*200	400	274.60	42.60	277.88	314.01	78.50			2*200+			
Bangplee B	1*200	200	233.40	37.40	236.38	267.11	133.55	726.40	200	2*200	800	72.64	
2. Klongrangsit(MEA) (MEA+PEA)	2*200	400	223.00	75.80	235.53	266.15	66.54	332.69		2*200	400	66.54	
3. Nongjok A	2*200	400	259.80	131.60	291.23	329.09	82.27	670.59		2*200+	700	76.64	
Nongjok B	1*300	300	177.30	47.40	183.53	207.39	69.13			1*300			
4. South Bangkok	2*200	400	274.50	119.10	299.22	338.12	84.53	422.65	200	3*200	600	56.35	
5. Bangkoknoi A	2*300	600	305.80	65.40	312.72	353.37	58.89						
Bangkoknoi B								441.71		2*300	600	58.89	
6. Jangwatana A	2*300	600	431.40	73.40	437.60	494.49	82.41						
Jangwatana B	1*300	300	416.20	71.00	422.21	477.10	159.03	1,214.48	300	4*300	1200	80.97	
7. Sainoi	2*300	600	233.80	121.80	263.62	297.90	49.65	372.37		2*300	600	49.65	
8. Teparak	2*300	600	261.40	47.80	265.73	300.28	50.05	375.35		2*300	600	50.05	
9. Bangbor A	1*300	300	326.20	72.60	334.18	377.62	125.87						
Bangbor B								472.03	300	2*300	600	62.94	
10. On-nuj A	1*300	300	266.40	54.80	271.98	307.34	102.45						
On-nuj B	1*300	300	110.20	33.80	115.27	130.25	43.42	546.98	300	3*300	900	48.62	
11. Ratchada	1*300	300	134.40	27.90	137.27	155.11	51.70	193.89		1*300	300	51.70	
12. Sanampao	1*300	300	196.40	28.30	198.43	224.22	74.74	280.28		1*300	300	74.74	
13. Thanontok	2*300	600	300.40	51.60	304.80	344.42	57.40	430.53		2*300	600	57.40	
14. Klongtoei			235.60	54.00	241.71	273.13		341.41	600	2*300	600	45.52	
15. Patanakarn A			302.20	70.60	310.34	350.68							
Patanakarn B			188.50	37.90	192.27	217.27		709.94	900	3*300	900	63.11	
16. Talingchan A			333.60	68.20	340.50	384.76							
Talingchan B								480.96	600	2*300	600	64.13	
Total	6900	6900	5,485.10	1,333.00	5,672.40	6,409.81	92.90	8,012.26	3400	10300	10300	62.23	

Table 6.4-8 Terminal Station Expansion Plan at FY 2006
(b) 69kV System

Terminal Station	2001 Plan		2006 JICA Plan										Countermeasure
	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor %	For Each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	
1. Bangkapi A	2*300	600	338.40	59.20	343.54	376.86	62.81			2*300+			
Bangkapi B	2*200	400	237.80	38.20	240.85	264.21	66.05	801.34		2*200	1000	64.11	
2. Bangkok Noi A	2*200	400	207.40	57.80	215.30	236.19	59.05						
Bangkok Noi B	1*200	200	141.20	25.90	143.56	157.48	78.74						
Bangkok Noi C	1*200	200	82.50	14.50	83.76	91.89	45.94	606.95		4*200	800	60.69	
3. Bangplee	2*200	400	199.60	27.80	201.53	221.07	55.27	276.34		2*200	400	55.27	
4. Chidlom	2*50+2*20(	500	299.60	49.00	303.58	333.03	66.61	416.28		2*250	500	66.61	
5. Klongrangsit (MEA) (MEA)+(PEA)	2*200	400	286.50	138.30	318.13	348.99	87.25	436.24	200	3*200	600	58.17	
6. Lardprao A	2*200	400	322.40	54.20	326.92	358.64	89.66			2*300+			
Lardprao B	2*200	400	307.60	60.80	313.55	343.97	85.99	878.25	200	2*200	1000	70.26	
7. North Bangkok A	2*300	600	229.20	49.80	234.55	257.30	42.88			2*300+			
North Bangkok B	2*200	400	268.00	54.60	273.51	300.04	75.01	696.67		2*200	1000	55.73	
8. South Bangkok A	2*200	400	409.20	102.60	421.87	462.79	115.70			2*300+			
South Bangkok B	2*200	400	363.40	95.00	375.61	412.05	103.01	1,093.54	200	2*200	1000	87.48	
9. South Thonburi A	2*200	400	222.40	40.60	226.08	248.00	62.00						
South Thonburi B	2*200	400	238.40	60.80	246.03	269.90	67.47	647.38		4*200	800	64.74	
10. Ratchada	2*300	600	329.80	53.60	334.13	366.54	61.09	458.17		2*300	600	61.09	
11. Teparak	2*300	600	194.00	30.00	196.31	215.35	35.89	269.18		2*300	600	35.89	
12. Thanontok	2*250	500	281.20	57.60	287.04	314.88	62.98	393.60		2*250	500	62.98	
13. Sanampao	1*300	300	246.20	35.20	248.70	272.83	90.94	341.03	300	2*300	600	45.47	
14. Thonburi	-		199.50	37.70	203.03	222.72		278.41	300	1*300	300	74.24	
Total	8500	8500	5,404.30	1,143.20	5,537.57	6,074.72	71.47	7,593.40	1200	9700	9700	62.63	

Table 6.4-9 Terminal Station Expansion Plan at FY2011
(a) 115kV System

Terminal Station	2006 Plan		2011 JICA Plan									Countermeasure
	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utilizing Factor	For each Terminal Stations: Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	
1. Bangplee A	2*200	400	271.60	152.40	311.44	351.92	87.98			2*200+			
Bangplee B	2*200	400	225.60	108.80	250.65	283.23	70.81	793.94		2*200	800	79.39	
2. Klongrangsit (MEA) (MEA+PEA)	2*200	400	296.40	152.10	333.15	376.46	94.11	470.57	200	3*200	600	62.74	
3. Nongjok A	2*200	400	309.80	135.20	338.02	381.96	95.49	1,016.07	500	4*300	1200	67.74	
Nongjok B	1*300	300	357.60	132.40	381.32	430.90	143.63						
4. South Bangkok	3*200	600	373.80	135.00	397.43	449.10	74.85	561.37		3*200	600	74.85	
5. Bangkoknoi A	1*300	300	362.60	117.40	381.13	430.68	143.56						
Bangkoknoi B	1*300	300	155.70	40.10	160.78	181.68	60.56	765.45	300	3*300	900	68.04	
6. Jangwatana A	2*300	600	353.20	192.40	402.20	454.49	75.75						
Jangwatana B	2*300	600	434.80	230.20	491.98	555.94	92.66	1,263.03		4*300	1200	84.20	
7. Sainoi	2*300	600	357.80	216.60	418.25	472.63	78.77	590.78		2*300	600	78.77	
8. Teparak	2*300	600	381.80	104.60	395.87	447.33	74.56	559.17		2*300	600	74.56	
9. Bangbor A	1*300	300	364.60	217.20	424.39	479.56	159.85						
Bangbor B	1*300	300	122.30	65.80	138.88	156.93	52.31	795.62	300	3*300	900	70.72	
10. On-nuj A	2*300	600	338.80	162.60	375.80	424.65	70.78						
On-nuj B	1*300	300	339.40	156.60	373.79	422.38	140.79	1,058.79	300	4*300	1200	70.59	
11. Ratchada	1*300	300	280.20	119.00	304.42	344.00	114.67	430.00	300	2*300	600	57.33	
12. Sanampao	1*300	300	370.40	179.00	411.38	464.86	154.95	581.08	300	2*300	600	77.48	
13. Thanontok	2*300	600	325.80	82.80	336.16	379.86	63.31	474.82		2*300	600	63.31	
14. Klongtoei	2*300	600	308.60	144.00	340.54	384.81	64.14	481.02		2*300	600	64.14	
15. Patanakarn A	2*300	600	367.40	150.40	396.99	448.60	74.77						
Patanakarn B	1*300	300	183.30	81.30	200.52	226.59	75.53	843.99		3*300	900	75.02	
16. Talingchan A	1*300	300	359.80	108.80	375.89	424.76	141.59						
Talingchan B	1*300	300	213.50	58.30	221.32	250.09	83.36	843.56	300	3*300	900	74.98	
17. New terminal St. (Jorakabuo)													
Total	10300	10300	7,455.00	3,243.00	8,162.30	9,223.40	89.55	11,529.25	2500	12800	12800	72.06	

Table 6.4-9 Terminal Station Expansion Plan at FY 2011
(b) 69kV System

Terminal Station	2006 Plan		2011 JICA Plan									Countermeasure
	Bank Capacity (MVA)	Total (MVA)	Coincident Load (MW)	(MVAR)	(MVA)	Peak Load (MVA)	Utiliz Factor %	For each Terminal Stations Required (MVA)	Adding (MVA)	Configu. (MVA)	Total (MVA)	U.F. %	
1. Bangkapi A	2*300	600	420.80	146.80	445.67	488.90	81.48			2*300+			
Bangkapi B	2*200	400	268.20	83.00	280.75	307.98	77.00	996.10		2*200	1000	79.69	
2. Bangkok Noi A	2*200	400	231.20	94.80	249.88	274.12	68.53						
Bangkok Noi B	1*200	200	163.40	42.90	168.94	185.32	92.66						
Bangkok Noi C	1*200	200	86.80	23.70	89.98	98.71	49.35	697.69		4*200	800	69.77	
3. Bangplee	2*200	400	217.60	119.60	248.30	272.39	68.10	340.48		2*200	400	68.10	
4. Chidlom	2*250	500	341.60	54.40	345.90	379.46	75.89	474.32		2*250	500	75.89	
5. Klongrangsit (MEA) (MEA)+(PEA)	3*200	600	336.90	161.40	373.57	409.80	68.30	512.25		3*200	600	68.30	
6. Lardprao A	2*300	600	443.60	198.80	486.11	533.26	88.88			2*300+			
Lardprao B	2*200	400	293.00	104.40	311.04	341.22	85.30	1,093.10	200	2*300	1200	72.87	
7. North Bangkok A	2*200	400	236.20	95.80	254.89	279.61	69.90			2*200+			
North Bangkok B	2*300	600	248.60	131.20	281.10	308.36	51.39	734.97		2*300	1000	58.80	
8. South Bangkok A	2*300	600	464.80	165.60	493.42	541.28	90.21						
South Bangkok B	2*200	400	410.60	179.60	448.16	491.63	122.91	1,291.14	200	4*300	1200	86.08	
9. South Thonburi A	2*200	400	277.40	88.00	291.02	319.25	79.81						
South Thonburi B	2*200	400	249.60	88.40	264.79	290.48	72.62	762.16		4*200	800	76.22	
10. Ratchada	2*300	600	377.20	169.20	413.41	453.51	75.59	566.89		2*300	600	75.59	
11. Teparak	2*300	600	215.60	58.20	223.32	244.98	40.83	306.22		2*300	600	40.83	
12. Thanontok	2*250	500	309.80	80.40	320.06	351.11	70.22	438.89		2*250	500	70.22	
13. Sanampao	2*300	600	326.80	105.40	343.38	376.68	62.78	470.85		2*300	600	62.78	
14. Thonburi	1*300	300	313.40	87.00	325.25	356.80	118.93	446.00	300	2*300	600	59.47	
Total	9700	9700	6,233.10	2,278.60	6,658.94	7,304.86	75.31	9,131.08	700	10400	10400	70.24	

Table 6.4-10 Target for Terminal Station System Program

Name of Terminal Station	System Voltage (kV)	Installation Capacity (MVA)							
		1997	1998	1999	2000	2001	2006	2011	2016
Construction									
1. Onnuj	230-115		2x300						
2. Thanontok *	230-115			2x300					
3. Sanampao *	230-115				1x300				
	230- 69				1x300				
4. Ratchada	230-115				1x300				
5. Bangbor	230-115					1x300			
6. Klongtoey *	230-115						2x300		
7. Patanakarn	230-115						3x300		
8. Talingchan	230-115						2x300		
9. Thonburi *	230- 69						1x300		
10. Ramintra *	230-115								2x300
11. Ratburana	230-115								2x300
	230- 69								2x300
Subtotal		—	600	600	900	300	2,400	—	1,800
Addition									
1. South Thonburi	230- 69	3x200 to 4x200							
2. Klongrangsit	230-115	1x200 to 2x200							
3. Nongjok	230-115	2x200 to 2x200 + 1x300							
4. Teparak	230-115		1x300 to 2x300						
	230- 69		1x300 to 2x300						
5. Jangwatana	230-115		2x300 to 3x300						
6. Sainoi	230-115			1x300 to 2x300					
7. Bangkoknoi	230-115				1x300 to 2x300				
8. Bangkapi	230- 69					4x200 to 2x200 + 2x300			
9. North Bangkok	230- 69					2x200 + 1x285 to 2x200 + 2x300			
10. South Bangkok	230- 69					4x200 to 2x200 + 2x300			
11. Bangplee	230-115						3x200 to 4x200		
12. South Bangkok	230-115						2x200 to 3x200		
13. Jangwatana	230-115						3x300 to 4x300		
14. Bangbor	230-115						1x300 to 2x300		
15. Onnuj	230-115						2x300 to 3x300		

Note: * MEA's Terminal Station

Table 6.4-10 Target for Terminal Station System Program (Cont.)

Name of Terminal Station	System Voltage (kV)	Installation Capacity (MVA)							
		1997	1998	1999	2000	2001	2006	2011	2016
16. Klongrangsit	230- 69						2x200 to 3x200		
17. Lardprao	230- 69						4x200 to 2x200 + 2x300		
18. Sanampao *	230- 69						1x300 to 2x300		
19. Klongrangsit	230-115							2x200 to 3x200	
20. Nonjok	230-115							2x200 + 1x300 to 4x300	
21. Bangkoknoi	230-115							2x300 to 3x300	
22. Bangbor	230-115							2x300 to 3x300	
23. Onnuj	230-115							3x300 to 4x300	
24. Ratchada	230-115							1x300 to 2x300	
25. Sanampao *	230-115							1x300 to 2x300	
26. Talingchan	230-115							2x300 to 3x300	
27. Lardprao	230- 69							2x200 + 2x300 to 4x300	
28. South Bangkok	230- 69							2x200 + 2x300 to 4x300	
29. Thonburi *	230- 69							1x300 to 2x300	
30. Bangplee	230-115								4x200 to 2x200 + 2x300
31. Klongrangsit	230-115								3x200 to 4x200
32. Bangkoknoi	230-115								3x300 to 4x300
33. Sainoi	230-115								2x300 to 3x300
34. Sanampao *	230-115								2x300 to 3x300
35. Klongtoey *	230-115								2x300 to 3x300
36. Patanakarn	230-115								3x300 to 4x300
37. Talingchan	230-115								3x300 to 4x300
38. Bangkapi	230- 69								2x200 + 2x300 to 4x300
39. South Thonburi	230- 69								4x200 to 2x200 + 2x300
40. Ratchada	230- 69								2x300 to 3x300
Subtotal		700	900	300	300	715	2,000	3,200	2,900
Total		700	1,500	900	1,200	1,015	4,400	3,200	4,700

Note: * MEA's Terminal Station

Table 6.4-11 Installed Capacity of Terminal Stations

(Unit: MVA)

Name of Terminal Station	Actual	7th Plan	Planning Period							
	1995	1996	1997	1998	1999	2000	2001	2006	2011	2016
115kV System										
1. Bangplee	2x200	3x200	3x200	3x200	3x200	3x200	3x200	4x200	4x200	2x200 + 2x300
2. Klongrangsit	2x200	3x200	2x200	2x200	2x200	2x200	2x200	2x200	3x200	4x200
3. Nongjok	1x200	2x200	2x200 + 1x300	2x200 + 1x300	2x200 + 1x300	2x200 + 1x300	2x200 + 1x300	2x200 + 1x300	4x300	4x300
4. South Bangkok	2x200	2x200	2x200	2x200	2x200	2x200	2x200	3x200	3x200	3x200
5. Bangkoknoi	—	1x200	1x300	1x300	1x300	2x300	2x300	2x300	3x300	4x300
6. Jangwatana	—	2x300	2x300	3x300	3x300	3x300	3x300	4x300	4x300	4x300
7. Sainoi	—	1x200	1x300	1x300	2x300	2x300	2x300	2x300	2x300	3x300
8. Teparak	—	1x300	1x300	2x300	2x300	2x300	2x300	2x300	2x300	2x300
9. Bangbor	—	—	—	—	—	—	1x300	2x300	3x300	3x300
10. Onnuj	—	—	—	2x300	2x300	2x300	2x300	3x300	4x300	4x300
11. Ratchada	—	—	—	—	—	1x300	1x300	1x300	2x300	2x300
12. Sanampao *	—	—	—	—	—	1x300	1x300	1x300	2x300	3x300
13. Thanontok *	—	—	—	—	2x300	2x300	2x300	2x300	2x300	2x300
14. Klongtoey *	—	—	—	—	—	—	—	2x300	2x300	3x300
15. Patanakarn	—	—	—	—	—	—	—	3x300	3x300	4x300
16. Talingchan	—	—	—	—	—	—	—	2x300	3x300	4x300
17. Ramintra *	—	—	—	—	—	—	—	—	—	2x300
18. Ratburana	—	—	—	—	—	—	—	—	—	2x300
Subtotal	1,400	3,300	3,600	4,800	5,700	6,600	6,900	10,300	12,800	16,200
69kV System										
1. Bangkapi	4x200	4x200	4x200	4x200	4x200	4x200	2x200 + 2x300	2x200 + 2x300	2x200 + 2x300	4x300
2. Bangkoknoi	3x200	4x200	4x200	4x200	4x200	4x200	4x200	4x200	4x200	4x200
3. Bangplee	2x200	2x200	2x200	2x200	2x200	2x200	2x200	2x200	2x200	2x200
4. Chidlom *	2x250	2x250	2x250	2x250	2x250	2x250	2x250	2x250	2x250	2x250
5. Klongrangsit	3x200	3x200	2x200	2x200	2x200	2x200	2x200	3x200	3x200	3x200
6. Lardprao	4x200	4x200	4x200	4x200	4x200	4x200	4x200	2x200 + 2x300	4x300	4x300
7. North Bangkok	2x200 + 1x285	2x200 + 1x285	2x200 + 1x285	2x200 + 1x285	2x200 + 1x285	2x200 + 1x285	2x200 + 2x300	2x200 + 2x300	2x200 + 2x300	2x200 + 2x300
8. South Bangkok	4x200	4x200	4x200	4x200	4x200	4x200	2x200 + 2x300	2x200 + 2x300	4x300	4x300
9. South Thonburi	2x200	3x200	4x200	4x200	4x200	4x200	4x200	4x200	4x200	2x200 + 2x300
10. Ratchada	—	2x300	2x300	2x300	2x300	2x300	2x300	2x300	2x300	3x300
11. Teparak	—	1x300	1x300	2x300	2x300	2x300	2x300	2x300	2x300	2x300
12. Thanontok *	—	2x250	2x250	2x250	2x250	2x250	2x250	2x250	2x250	2x250
13. Sanampao *	—	—	—	—	—	1x300	1x300	2x300	2x300	2x300
14. Thonburi *	—	—	—	—	—	—	—	1x300	2x300	2x300
15. Ratburana	—	—	—	—	—	—	—	—	—	2x300
Subtotal	5,585	7,385	7,385	7,685	7,685	7,985	8,700	9,700	10,400	11,700
Total	6,985	10,685	10,985	12,485	13,385	14,585	15,600	20,000	23,200	27,900

Note: * MEA's Terminal Station

(2) Subtransmission line improvement and expansion

(a) 230 kV subtransmission line

There will be three new 230 kV double circuit subtransmission line construction to receive power from EGAT's 230 kV terminal stations, using underground cable, a total distance 25.9 km.

Furthermore, there will be 230 kV single circuit subtransmission line addition at the total distance of 16.4 km, of which 8.0 km is overhead line and 8.4 km is underground cable.

Table 6.4-12 shows the 230 kV subtransmission line system expansion plan.

Table 6.4-12 230 kV Subtransmission Line System Expansion Plan
(FY 1997-2011)

Name of Subtransmission Line	Distance (km)	Circuit (No.)	Conductor Size (mm^2)	Commissioning Date (Fiscal Year)
Construction				
1. Lardprao - Sanampao T/S	7.8	2	2x1,200	2000
2. Bangkapi - Klongtoey T/S	7.7	2	2x1,200	2006
3. Bangkoknoi - Thonburi T/S	10.4	2	2x1,200	2006
Addition				
1. South Thonburi - Thanontok T/S	8.0 0.6	1 1	2x400 2x1,200	1997
2. Lardprao - Sanampao T/S	7.8	1	2x1,200	2006

(b) 115 kV and 69 kV subtransmission line

The total length of 115 kV and 69 kV subtransmission line to be constructed and improved up to FY 2011 will be 1,034.1 km, of which 779.1 km is overhead line and 255.0 km is underground cable, as is shown in Table 6.4-13.

Table 6.4-13 115 kV and 69 kV Subtransmission Line System Expansion Plan (FY 1997-2011)

(Unit: ckt-km)

FY	Overhead Line			Underground Cable		
	115 kV	69 kV	Total	115 kV	69 kV	Total
1997	53.4	6.7	60.1	9.0	11.0	20.0
1998	111.3	12.7	124.0	4.7	4.5	9.2
1999	94.5	4.3	98.8	23.5	7.7	31.2
2000	75.6	23.2	98.8	22.7	14.5	37.2
2001	9.5	8.4	17.9	11.5	2.1	13.6
1997-2001	344.3	55.3	399.6	71.4	39.8	111.2
2006	232.8	42.8	275.6	67.0	30.4	97.4
2011	89.0	14.9	103.9	29.6	16.8	46.4
Total	666.1	113.0	779.1	168.0	87.0	255.0

6.5 Design of Protective Relay System

To attain further high reliability of 230 kV subtransmission line, the following protection system shall be applied under this plan on the basis of two main protection groups and one backup protection group.

Meanwhile, the protection systems of 115 kV and 69 kV subtransmission lines, substations, etc. will be determined in accordance with the relevant criteria of MEA with necessary modifications.

Incidentally, the optical fiber should be used as a telecommunication line of the differential relays.

Protective Relay Scheme

Main protection	Group 1 ; Digital current differential scheme
	Group 2 ; Distance relaying scheme
Backup protection	Distance relaying scheme

6.6 Telecommunication Equipment Related to Power Distribution Facilities

6.6.1 Optical Fiber Telecommunication Network

(1) Optical fiber telecommunication network between district offices

A telecommunication network formation plan is being formulated by MEA (Refer to Figs. 6.6-1 and 6.6-2) for the purpose of forming an optical fiber telecommunication network by FY 1998 between the Head Office adjacent to the Chidlom T/S and 14 district offices (existing 13 offices including one office scheduled to be constructed). As this plan is effective in view of the following points, the MEA is recommended to promote the plan for implementation:

(a) Since it will be made possible to form a perfectly privately-owned optical fiber telephone communication network between the above district offices which are formed at present by public telephone network and voice radio communication systems, the telecommunication means will become much more convenient and the traffic of voice radio communication system be relaxed.

(b) It will be possible to make effective utilization of the SCADA system as interconnection channels.

(c) The optical fiber network can be used as interconnection channels of computers installed in the head office and district offices.

(d) The new network can be used as interconnection channels for Automatic Distribution System between the Chidlom Load Dispatching center and individual district offices.

(e) The new network can also be used effectively as video transmission circuit between the head office and district offices.

(f) The network can be used also as protective relay telecommunication channels of subtransmission line.

(g) By making use of a large capacity of optical fiber telecommunication network, the network can be expanded for multiple purpose telecommunication channels between substations as a backbone network of MEA.

In consideration that the optical fiber telecommunication network will be formed mainly by overhead optical fiber cables (mounted on distribution

line), any cable route should be so selected as to eliminate the necessity of relocation resulting from the change of distribution line route in the future. From this viewpoint, it is desirable to lay the optical fiber cable by making use of 69 kV and 115 kV subtransmission line routes which are relatively more stable than distribution lines.

An optical fiber cable route plan is presented in Fig. 6.6-3. And construction plan is presented in Table 6.6-1.

(2) Optical fiber telecommunication network for protection of subtransmission line

The subtransmission lines (230 kV) requiring protection scheduled to be constructed and the commissioning period thereof (fiscal year) are as listed below:

Route	Commissioning FY	Length
1. Lardprao (EGAT)-- Sanampao (MEA)	2000	7.8 km (UG)
2. Bangkapi (EGAT)-- Klongtoey(MEA)	2006	7.7 km (UG)
3. Bangkoknoi(EGAT)-- Thonburi (MEA)	2006	10.4 km (UG)
4. Onnuj (EGAT)-- Ramintra (MEA)	2016	13.0 km (OH) 6.0 km (UG)

As any telecommunication channel for protection of subtransmission line should be highly reliable, the microwave radio systems, optical fiber systems or power line carrier systems are generally used. Since underground cable is scheduled to be used under this subtransmission line construction project, application of the power line carrier wave system would be difficult. Therefore, it will be appropriate to form the telecommunication systems for protection of subtransmission line by adopting microwave radio system or optical fiber system. In preparation for selecting the microwave system or optical fiber system, studies should be carried out on a case-by-case basis regarding whether or not the microwave radio frequency can be allocated by the relevant authority as well as in view of the topographic conditions and situations of urbanization.

To improve the reliability, moreover, the telecommunication line should be of a two-route (diversity) configuration.

Since these 230 kV subtransmission lines are comprised of terminal

stations of EGAT at one end and those of MEA at another end, the telecommunication system for protection of subtransmission lines should be selected based on an agreement between both EGAT and MEA.

As mentioned above, there are a number of uncertain factors regarding the method of forming telecommunication systems for protection of subtransmission lines associated with this subtransmission line construction project. In this study, it is assumed for example to make effective use of optical fiber telecommunication network between the districts offices in Item 6.6.1(1) above, and the route plans of optical fiber cable telecommunication systems for protection of subtransmission line are as presented below: (For detail refer to Fig. 6.6-4)

(a) Lardprao--Sanampao

1st route: Lardprao T/S - Sanampao T/S

2nd route: Lardprao T/S - Bangkhen D/O - Nonthaburi D/O - Bangyai D/O - Thonburi D/O - Watlieb D/O - Samen D/O - Sanampao T/S

(b) Bangkapi-- Klongtoey

1st route: Bangkapi T/S - Chidlom T/S - Klongtoey T/S

2nd route: Bangkapi T/S - Bankapi D/O - Minburi D/O - Bangplee D/O - Paknam D/O - Klongtoey T/S

(c) Bangkoknoi--Thonburi

1st route: Bangkoknoi T/S - Thonburi T/S

2nd route: Bangkoknoi T/S - Bangkhunthin D/O - Yanawa D/O - Rasburana D/O- Klongtoey D/O - Chidlom H/O - Watlieb D/O - Thonburi T/S

(d) Onnuj--Rasburana

1st route: Onnuj T/S - Rasburana T/S

2nd route: Onnuj T/S - Minburi D/O - Rasburana T/S

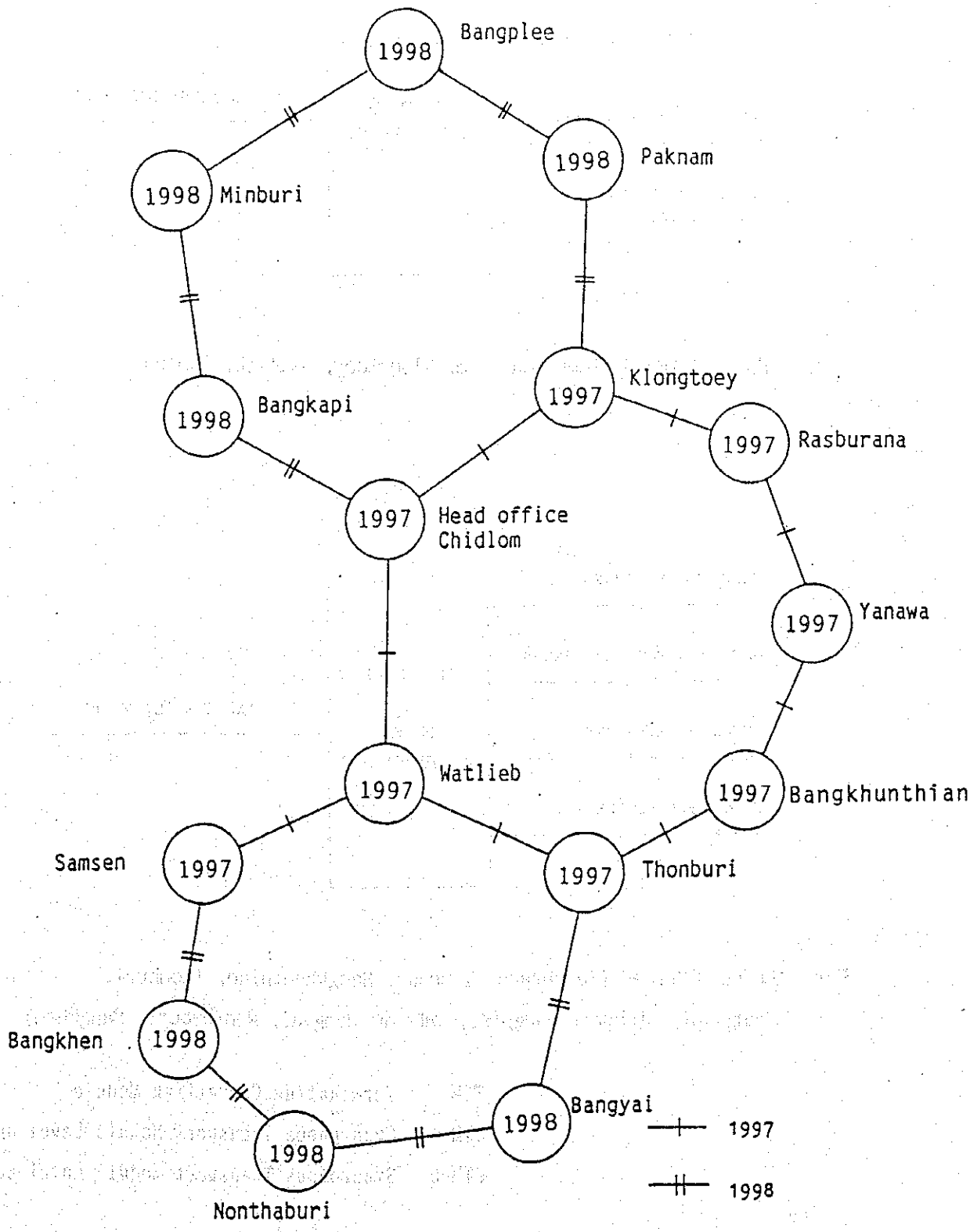
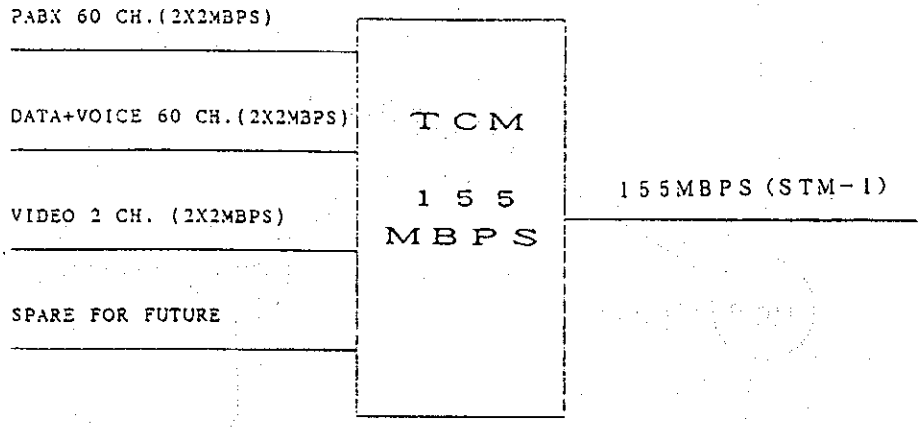
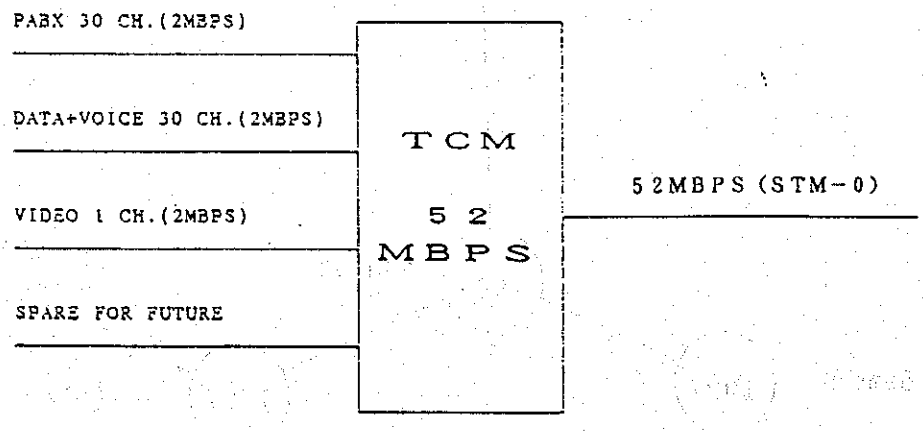


Fig. 6.6-1 MEA Fiber Optic Transmission Configuration Network



For : 4 MEA Offices (Chidlom, Klongtoey, Watlieb, Samsen)



For : 11 MEA Offices (Rasburana, Yannawa, Bangkhunthian, Thonburi, Bangkapi, Minburi, Bangplee, Paknam, Bangyai, Nonthaburi, Bangkhen)

TCM : Terminating Converting Module
STM-1 : Syncronous Transport Module Level one
STM-0 : Syncronous Transport Module Level zero

Fig. 6.6-2 MEA Fiber Optic Transmission Equipment

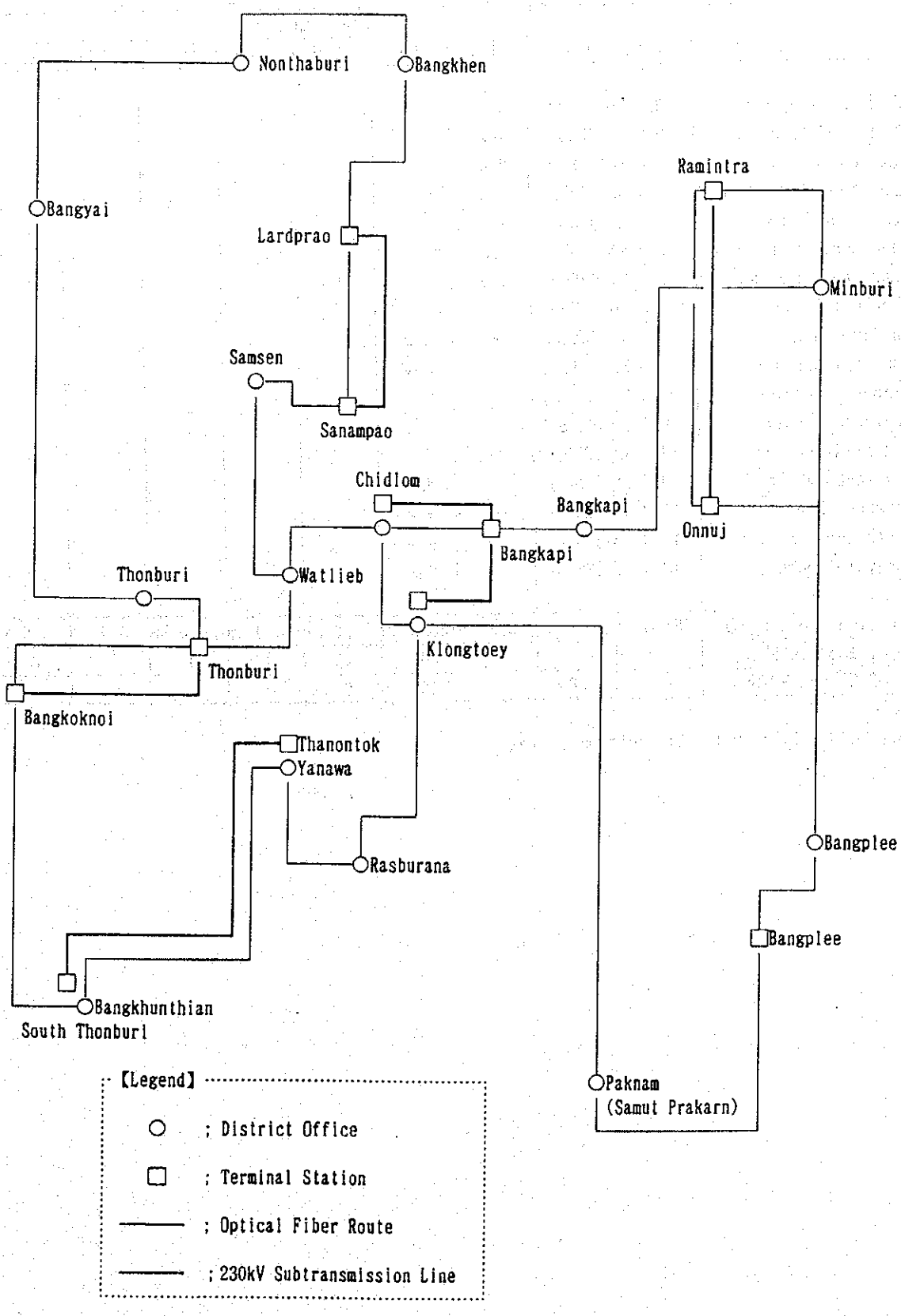


Fig. 6.6-3 Optical Fiber Route

Table 6.6-1 Optical Fiber Network Construction Plan amoung District Offices

No.	Section	Length	Capacity	Planning Period 1997	1998	1999	2000	2001	2006	2011	2016
1	Chidlom-Klongtoey	3.9 Km	155Mbps	New							
2	Chidlom-Watlieb	9.6 Km	155Mbps	New							
3	Watlieb-Samsen	8.4 Km	155Mbps	New							
4	Klongtoey-Rasburana	11.4 Km	52Mbps	New							
5	Rasburana-Yanawa	3.5 Km	52Mbps	New							
6	Yanawa-Bangkhunthian	9.2 Km	52Mbps	New							
7	Bangkhunthian-Thonburi	26.9 Km	52Mbps	New							
8	Thonburi-Watlieb	3.3 Km	52Mbps	New							
9	Chidlom-Bangkapi	7.5 Km	52Mbps	—	New						
10	Bangkapi-Minburi	18.1 Km	52Mbps	—	New						
11	Minburi-Bangplee	25.6 Km	52Mbps	—	New						
12	Bangplee-Paknam	20.5 Km	52Mbps	—	New						
13	Paknam-Klongtoey	18.6 Km	52Mbps	—	New						
14	Samsen-Bangkhen	19.5 Km	52Mbps	—	New						
15	Bangkhen-Nontaburi	16.8 Km	52Mbps	—	New						
16	Nonthaburi-Bangyai	15.0 Km	52Mbps	—	New						
17	Bangyai-Thonburi	18.0 Km	52Mbps	—	New						
Construction Cable Length		235.8 Km	—	76.2 km	159.6 km	0.0 km	0.0 km	0.0 km	0.0 km	0.0 km	0.0 km
Number of 155Mbps FOTS		—	6	6	0	0	0	0	0	0	0
Number of 52Mbps FOTS		—	28	10	18	0	0	0	0	0	0

Note FOTS ; Fiber Optic Transmition System

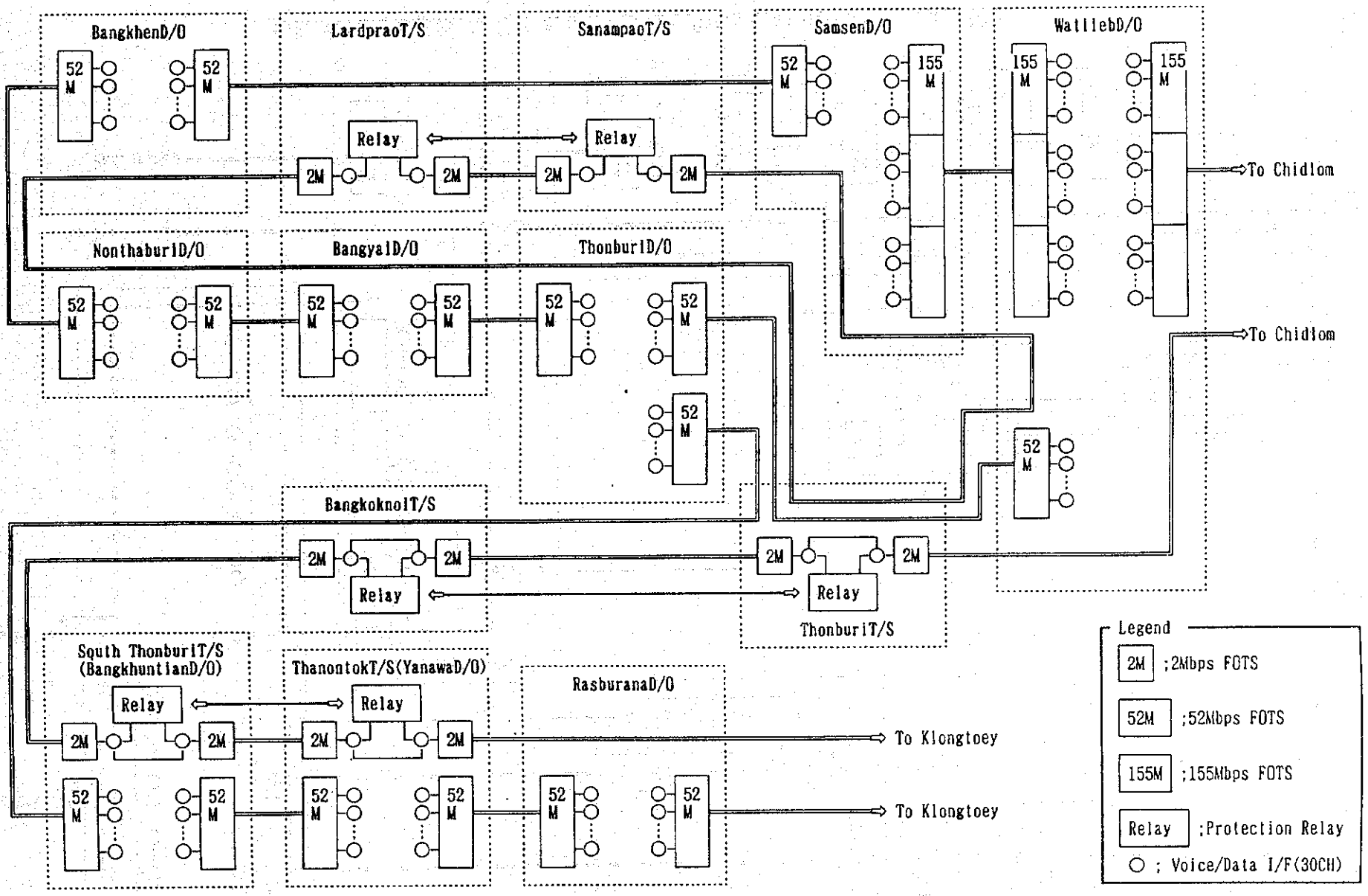


Fig. 6.6-4 System Configulation of Fiber Optic Transmission System (1/2)

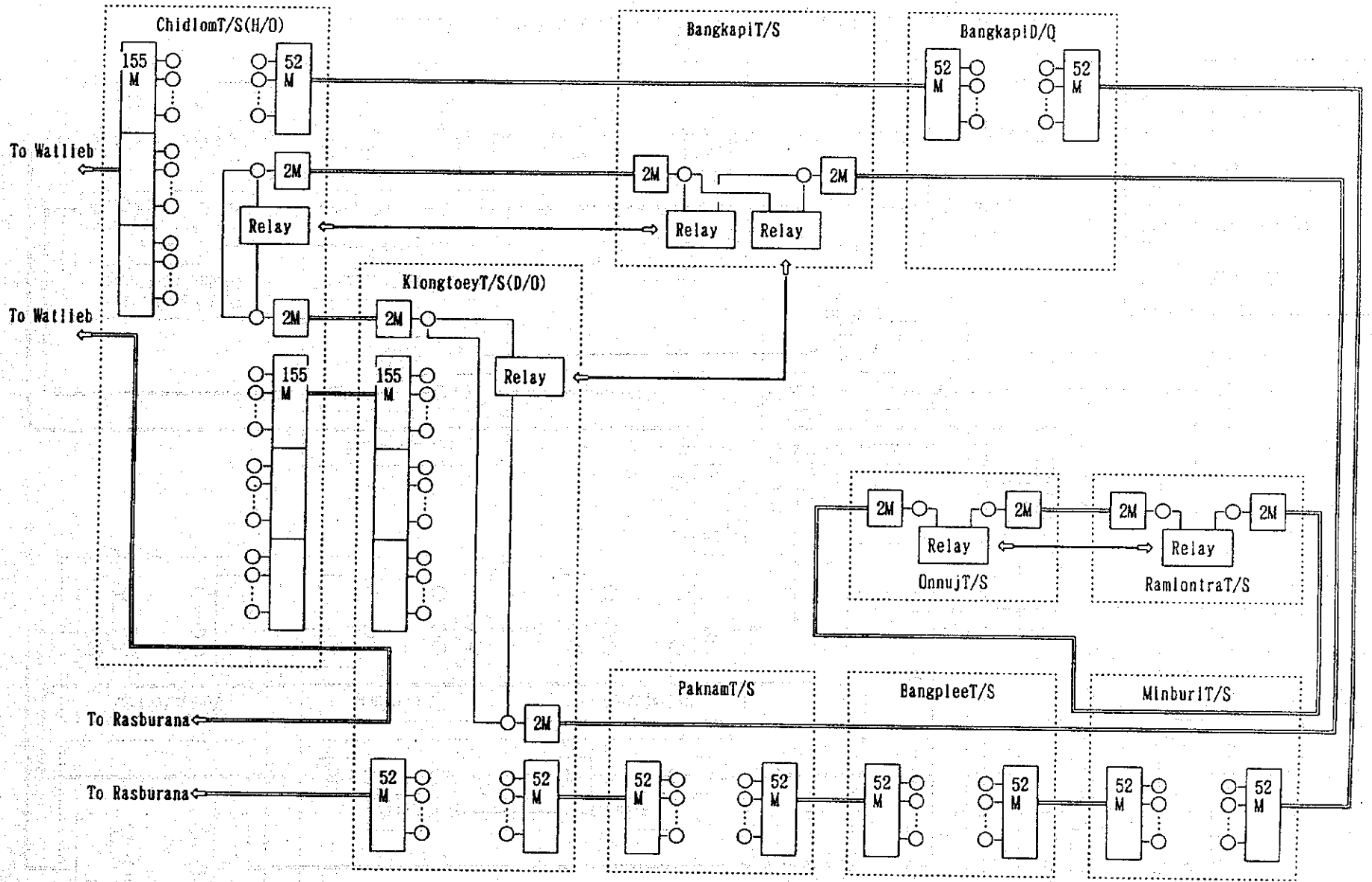


Fig. 6.6-4 System Configulation of Fiber Optic Transmission System (2/2)

6.6.2 VHF and UHF Telecommunication Network

(1) Trunk radio system

At present, the MEA is promoting introduction of a trunk radio system of 800 MHz band, and the number of voice communication channels are 15 [extension to 28 channels is possible in maximum in view of the system]. Thereby, the channel shortage problem in contrast to the number of subscriber units (about 1,800 sets) will be settled after completion of this Project. The relationship between the number of channels and that of subscriber unit for the trunk radio system is presented in Fig. 6.6-5 (This diagram shows the number of subscriber units which can be accommodated by the number of channels).

Along with the extension of substations and subtransmission lines, the number of subscriber units accommodated in the trunk radio system is expected to be increased after FY 1997. Considering that the telecommunication means among district offices will be changed over to the optical fiber telecommunication network subsequent to construction of the optical fiber telecommunication network as mentioned previously, however, the trend of increase in the number of subscriber units for the trunk radio system is expected to become moderate. As the number of voice channels of trunk radio system can be extended to 28 channels in the future, it will be possible to accommodate roughly 3,000 sets of subscriber units ultimately in the future.

By increasing the number of voice channels (repeater units) in proportion to the increase in the number of subscriber units, the trunk radio system is evaluated to be sufficient to meet the needs of MEA for radio telecommunication network in the future as well.

(2) SCADA telecommunication systems

(a) Installation plan of RTU for SCADA

The plan for installing RTU for SCADA according to the transmission line and substation equipment extension project of MEA is as follows:

1) RTU installation plan in terminal and switching stations

With regard to the terminal and switching stations, the RTU

installation plan has been formulated based on the following prerequisites:

a) The RTU shall be accommodated in the SCADA system when the terminal and switching stations are to be constructed.

b) With regard to the Banbor and Patanakarn T/Ss, the RTU shall be installed at the time of constructing the distribution station, and be used commonly after construction of the terminal stations.

Meanwhile, the RTU installation plan in this case is presented in the Table 6.6-2.

2) RTU installation plan in distribution stations

With regard to the terminal station, the RTU installation plan has been formulated based on the following prerequisites:

a) The RTU will be installed only when the number of banks has been two or more. Therefore, any RTU will not be installed when the number of bank is one.

b) In case the terminal stations and distribution substations are constructed in combination, the RTU will be used commonly for both of them.

The RTU installation plan in this case is presented in the table 6.6-3.

3) Number of installed RTU

The number of RTU to be installed in the respective fiscal years according to the substation extension plan is as listed below:

Item	7th	Planning Period							
	1996	1997	1998	1999	2000	2001	2006	2011	2016
Number of RTUs for T/S	6	5	5	5	6	5	5	5	4
Number of RTUs for D/S	82	93	101	109	120	130	149	164	171
Number of common use RTUs for T/S and D/S	10	11	12	12	12	14	18	18	21
Total number of RTUs	98	109	118	126	138	149	172	187	196

(b) Acquisition of radio channels for SCADA system

Whereas, the capacity of the existing two SCADA systems is as follows:

Contract	Maximum Capacity	Radio Channel
MEA-PSD-207/REPEAT (1981)	80 RTUs	16CH (Actual 16CH) (800MHz) 5 RTUs/CH
PM4-0532-WBA (1991)	120 RTUs	24CH (Actual 8CH) (2.2GHz) 5 RTUs/CH

The system installed at FY 1991 is in replacement of that at FY 1981. Since the number of existing radio channels is 24 channels in total including sixteen 800 MHz band channels and eight 2,200 MHz band channels, the maximum number of RTU which can be accommodated will become 120 (5 RTUs/channel x 24 channels) judging from the number of radio channels.

When the RTU installation plan is taken into account, therefore, the number of existing radio channels (120 RTUs can be accommodated) will be fully occupied in FY 1999. Consequently, it will be required to extend the 2,200 MHz band radio channels by FY 1999.

(c) Countermeasures for preventing radio wave interference with high-rise buildings in the central part of Bangkok

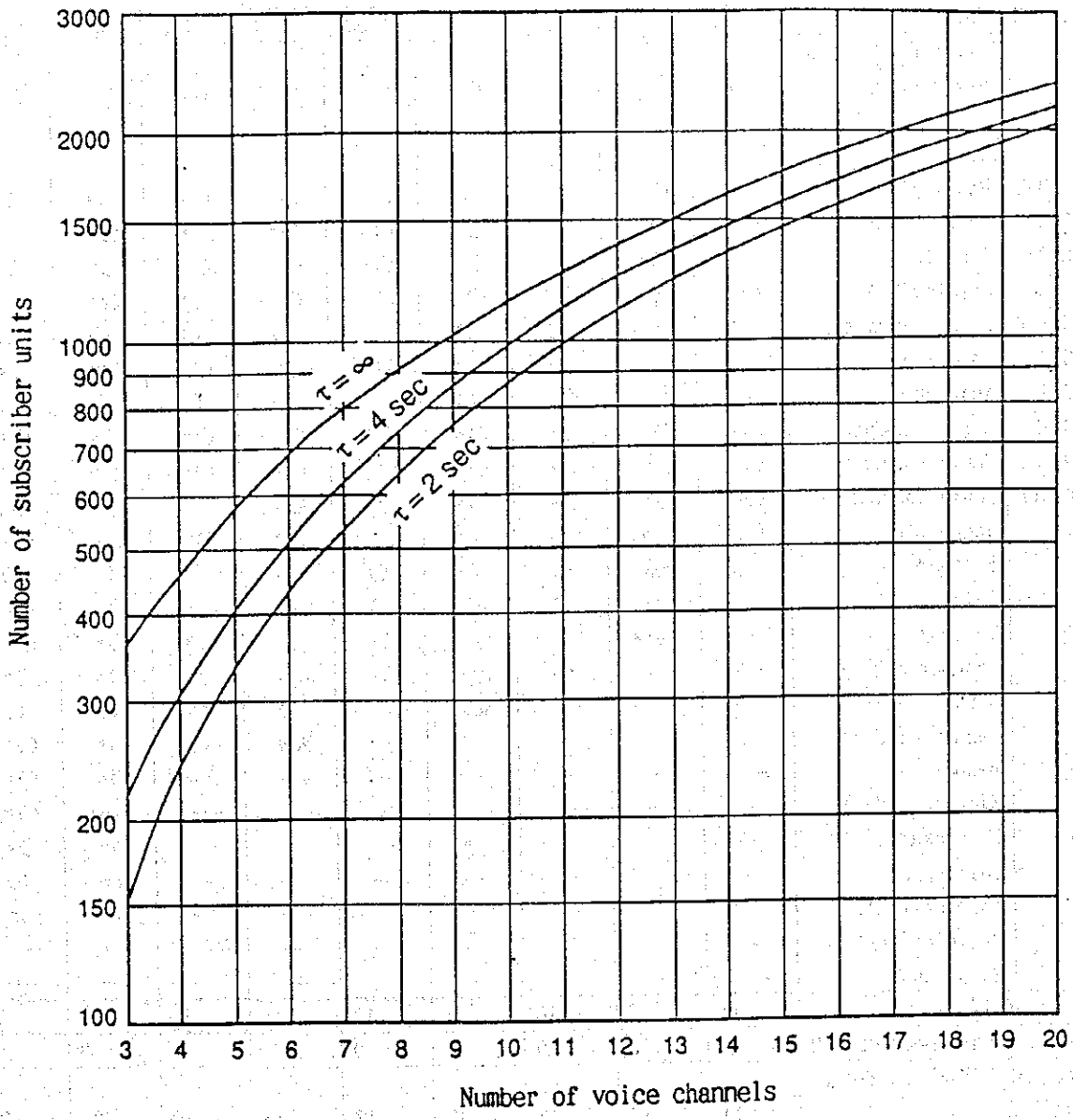
The propagation interference of the SCADA radio channels is predicted to become severe further in the future in proportion to increase in the number of high-rise buildings along with the progress of development in the central part of Bangkok. As the shadow loss per unit shielding area is greater in the case of 2,200 MHz band radio channels than in the case of 800 MHz band radio channels, moreover, the propagation interference due to high-rise buildings will be so much severe.

As a countermeasure, it considered effective to make positive use of optical fiber cable network being planned by MEA at present. Meanwhile, the SCADA radio wave channels have been formed so far at the respective substations from the two HUB radio stations at Chidlom and Watlieb (the section between Chidlom and Watlieb has already been linked through optical fiber cable). By extending this system and increasing the number of HUB radio stations, it will be possible to avoid the shadow loss due to high-rise buildings (In case the radio propagation conditions between a number of substations in the northern direction

example, it is considered possible to link the section between Samsen and Chidlom through optical fiber cable network on the basis of the Samsen and other district offices as HUB radio stations.).

To prevent propagation interference in a particular substation, it will also be effective to use radio and cable in combination or make effective use of radio relay and other systems as adopted at present by MEA.

In preparation for coping with intensification of high-rise buildings in the central part of Bangkok in the future, it will also be necessary to study replacement of the SCADA telecommunication channels to substations in the relevant area with metal cable or optical fiber cable. (For detail refer to Clause 9.9.4)



Note τ : Average access time (include mean waiting time cause to busy)

Condition of traffic

-Average number of calling per 1 unit 1.8 times / 1 hour

-Average holding time : 16 sec.

Fig. 6.6-5 Trunk Radio System (Relationship between voice channels and subscriber units)

Table 6.6-2 SCADA RTU Installation Plan of Terminal Stations and Switching Station

No.	ABB.	Name of Terminal Station	Actual 1995	7th Plan 1996	Planning Period 1997	1998	1999	2000	2001	2006	2011	2016
		Switching Station										
1	SRS	Samrong(MEA)	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
		Terminal Station										
1	BAT	Bangkapi	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
2	BOT	Bangkok Noi	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
3	BPT	Bangplee	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
4	CLT	Chidlom(MEA)	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
5	KRT	Klong Rangsit	O	O	O	O	O	O	O	O	O	O
6	LPT	Lard Prao	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
7	NJT	Nongjok	O	O	O	O	O	O	O	O	O	O
8	NKT	North Bangkok	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
9	SKT	South Bangkok	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
10	STT	South Thonburi	O*	O*	O*	O*	O*	O*	O*	O*	O*	O*
11		Jangwattna	—	New	O*	O*	O*	O*	O*	O*	O*	O*
12		Ratchada	—	New	O	O	O	O	O	O	O	O
13		Sainoi	—	New	O	O	O	O	O*	O*	O*	O*
14		Teparak	—	New*	O*	O*	O*	O*	O*	O*	O*	O*
15		Thanontok(MEA)	—	New	O	O*	O*	O*	O*	O*	O*	O*
16		Onnuj	—	—	—	New	O	O	O	O	O	O
17		Sanampao(MEA)	—	—	—	—	—	New	O	O*	O*	O*
18		Banbor	—	—	—	—	—	—	O*	O*	O*	O*
19		Klongtoey(MEA)	—	—	—	—	—	—	—	New*	O*	O*
20		Patanakarn	—	—	—	—	—	—	—	O*	O*	O*
21		Talingchan	—	—	—	—	—	—	—	New	O	O*
22		Thonburi(MEA)	—	—	—	—	—	—	—	New*	O*	O*
23		Ramintra(MEA)	—	—	—	—	—	—	—	—	—	New*
24		Ratburana	—	—	—	—	—	—	—	—	—	New*
Number of T/S			11	16	16	17	17	18	19	23	23	25
Construction Number of RTU				5	0	1	0	1	0	3	0	2
Number of T/S where RTU is installed			11	16	16	17	17	18	19	23	23	25
Number of T/S where RTU is used commonly with D/S			9	10	11	12	12	12	14	18	18	21

Note ;" * " mark shows Terminal Station where the RTU is used commonly with MEA's Distribution Station.

Table 6.6-3 SCADA RTU Installation Plan of Distribution Stations

No.	ABB.	Name of Distribution Station	Actual 1995	7th Plan 1996	Planning Period 1997	1998	1999	2000	2001	2006	2011	2016
1	BB	Bangbon	○	○	○	○	○	○	○	○	○	○
2	BN	Bangchalong	×1Bank	New	○	○	○	○	○	○	○	○
3	BA	Bangkapi(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
4	KA	Bangkhaen	—	×1Bank	×1Bank	×1Bank	New	○	○	○	○	○
5	BR	Bangkhunprom	○	○	○	○	○	○	○	○	○	○
6	BL	Bangklo	○	○	○	○	○	○	○	○	○	○
7	BO	Bangkok Noi(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
8	BC	Bangkrachao	○	○	○	○	○	○	○	○	○	○
9	BM	Bangmod	×1Bank	New	○	○	○	○	○	○	○	○
10	BG	Bangna	○	○	○	○	○	○	○	○	○	○
11	BJ	Bangnamjued	×1Bank	New	○	○	○	○	○	○	○	○
12	BI	Bangping	○	○	○	○	○	○	○	○	○	○
13	BK	Bangplakod	×	New	○	○	○	○	○	○	○	○
14	BP	Bangplee(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
15	PG	Bangpongpang	×1Bank	New	○	○	○	○	○	○	○	○
16	BD	Bangpood	○	○	○	○	○	○	○	○	○	○
17	BU	Bangpu	○	○	○	○	○	○	○	○	○	○
18	RY	Bangrakyai	×1Bank	New	○	○	○	○	○	○	○	○
19	BS	Bangsaothong	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○
20	BY	Bangyeekhan	○	○	○	○	○	○	○	○	○	○
21	CG	Chalongkrung	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○
22	CK	Chankasem	○	○	○	○	○	○	○	○	○	○
23	CL	Chidlom(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
24	DM	Donmuang	○	○	○	○	○	○	○	○	○	○
25	HK	Huaykwang	○	○	○	○	○	○	○	○	○	○
26	KP	Kingpetch	○	○	○	○	○	○	○	○	○	○
27	KJ	Klongjan	○	○	○	○	○	○	○	○	○	○
28	KM	Klongmai	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○	○	○
29	SC	Klongsanamchai	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○	○	○	○
30	KS	Klongsanpasamit	○	○	○	○	○	○	○	○	○	○
31	KN	Klongsarn	○	○	○	○	○	○	○	○	○	○
32	KT	Klongtoey(TS)	○	○	○	○	○	○	○	○*	○*	○*
33	WG	Klongwatsing	×1Bank	New	○	○	○	○	○	○	○	○
34	KU	Krunai	×1Bank	New	○	○	○	○	○	○	○	○
35	LK	Lardplakao	○1Bank	○1Bank	○1Bank	○1Bank	○1Bank	○1Bank	○1Bank	○	○	○
36	LP	Lardprao(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
37	LN	Lumpini	○	○	○	○	○	○	○	○	○	○
38	MN	Mahaisawan	○	○	○	○	○	○	○	○	○	○
39	MM	Mahamek	○	○	○	○	○	○	○	○	○	○
40	MA	Maiad	○	○	○	○	○	○	○	○	○	○
41	MS	Makasan	○	○	○	○	○	○	○	○	○	○
42	MB	Minburi	○	○	○	○	○	○	○	○	○	○
43	MC	Mochit	○	○	○	○	○	○	○	○	○	○
44	MG	Muangmai	○	○	○	○	○	○	○	○	○	○
45	M1	Muangthong 1	×1Bank	×1Bank	New	○	○	○	○	○	○	○
46	NN	Nana	×1Bank	New	○	○	○	○	○	○	○	○
47	NH	Nongkham	×	New	○	○	○	○	○	○	○	○
48	NR	Nonthaburi	○	○	○	○	○	○	○	○	○	○

Table 6.6-3 SCADA RTU Installation Plan of Distribution Stations

No.	ABB.	Name of Distribution Station	Actual	7th Plan	Planning Period							
			1995	1996	1997	1998	1999	2000	2001	2006	2011	2016
49	NK	North Bangkok(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
50	PE	Pakkred	○	○	○	○	○	○	○	○	○	○
51	PN	Paknam	○	○	○	○	○	○	○	○	○	○
52	PS	Petchkasem	○	○	○	○	○	○	○	○	○	○
53	PI	Phaisingto	○	○	○	○	○	○	○	○	○	○
54	PJ	Poojao	○	○	○	○	○	○	○	○	○	○
55	PC	Prachachuen	○	○	○	○	○	○	○	○	○	○
56	PK	Prakanong	○	○	○	○	○	○	○	○	○	○
57	PR	Prakasa	○	○	○	○	○	○	○	○	○	○
58	PO	Prannok	○	○	○	○	○	○	○	○	○	○
59	PD	Prapradaeng	○	○	○	○	○	○	○	○	○	○
60	PA	Prasanmit	○	○	○	○	○	○	○	○	○	○
61	PM	Prathumwan	○	○	○	○	○	○	○	○	○	○
62	RT	Ramintra(TS)	○	○	○	○	○	○	○	○	○	○*
63	RH	Ramkhamhaeng	○	○	○	○	○	○	○	○	○	○
64	RN	Rasburana(TS)	○	○	○	○	○	○	○	○	○	○*
65	RK	Romklao	○	○	○	○	○	○	○	○	○	○
66	RC	Rungpracha	○	○	○	○	○	○	○	○	○	○
67	SM	Sailom	○	○	○	○	○	○	○	○	○	○
68	SR	Samrong(SS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
69	SN	Samsen	○	○	○	○	○	○	○	○	○	○
70	SS	Sansab	○	○	○	○	○	○	○	○	○	○
71	SD	Sapandam	○	○	○	○	○	○	○	○	○	○
72	SP	Sapanmai	×1Bank	New	○	○	○	○	○	○	○	○
73	SL	Silom	○	○	○	○	○	○	○	○	○	○
74	SY	Sipraya	○	○	○	○	○	○	○	○	○	○
75	SV	Soonvijai	○	○	○	○	○	○	○	○	○	○
76	SK	South Bangkok(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
77	ST	South Thonburi(TS)	○*	○*	○*	○*	○*	○*	○*	○*	○*	○*
78	YA	Srithanya	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○
79	SO	Suansom	×1Bank	New	○	○	○	○	○	○	○	○
80	SU	Surawong	×	New	○	○	○	○	○	○	○	○
81	TS	Taksin	○	○	○	○	○	○	○	○	○	○
82	TP	Teparak(TS)	—	○*	○*	○*	○*	○*	○*	○*	○*	○*
83	TT	Thanontok(TS)	×1Bank	×1Bank	×1Bank	○*	○*	○*	○*	○*	○*	○*
84	TB	Thonburi(TS)	○	○	○	○	○	○	○	○*	○*	○*
85	TK	Tongkung	○	○	○	○	○	○	○	○	○	○
86	WB	Wangpetchboon	×1Bank	New	○	○	○	○	○	○	○	○
87	WT	Wangthonglang	○	○	○	○	○	○	○	○	○	○
88	WL	Watlieb	○	○	○	○	○	○	○	○	○	○
89	YT	Yothee	○	○	○	○	○	○	○	○	○	○
90	BE	Bangkae	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○	○	○	○
91	BZ	Bangson	—	×1Bank	New	○	○	○	○	○	○	○
92	RI	Bearing	—	×1Bank	New	○	○	○	○	○	○	○
93	EM	Ekamai	—	×1Bank	New	○	○	○	○	○	○	○
94	EB	Ekuburi	—	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○	○	○
95	HA	Huamak	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○
96	IN	Intamara	—	New	○	○	○	○	○	○	○	○

Table 6.6-3 SCADA RTU Installation Plan of Distribution Stations

No.	ABB.	Name of Distribution Station	Actual	7th Plan	Planning Period							
			1995	1996	1997	1998	1999	2000	2001	2006	2011	2016
97	JR	Jangron	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○
98	KO	Khortor	×1Bank	×1Bank	New	○	○	○	○	○	○	○
99	KI	Kingkaew	×1Bank	New	○	○	○	○	○	○	○	○
100	KH	Klongmahasawad	—	New	○	○	○	○	○	○	○	○
101	LB	Lardkrabang	○	○	○	○	○	○	○	○	○	○
102	M3	Muangthong 3	×1Bank	×1Bank	New	○	○	○	○	○	○	○
103	NS	Nonsee	—	New	○	○	○	○	○	○	○	○
104	PP	Prandipat	—	New	○	○	○	○	○	○	○	○
105	SA	Sainamtip	—	×1Bank	New	○	○	○	○	○	○	○
106	SB	Sanambinnam	—	New	○	○	○	○	○	○	○	○
107	RG	Saorahong	—	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○
108	OB	South Bangplee	—	×1Bank	New	○	○	○	○	○	○	○
109	SE	Srieiam	×1Bank	New	○	○	○	○	○	○	○	○
110	SG	Suanluang	×1Bank	New	○	○	○	○	○	○	○	○
111	UK	Surasak	×1Bank	×1Bank	New	○	○	○	○	○	○	○
112	TN	Taiban	—	—	×1Bank	×1Bank	×1Bank	New	○	○	○	○
113	TW	Taweewattana	×1Bank	×1Bank	×1Bank	New	○	○	○	○	○	○
114	TR	Thonburirom	—	×1Bank	×1Bank	New	○	○	○	○	○	○
115	TH	Tungsonghong	—	New	○	○	○	○	○	○	○	○
116	YK	Yenarkart	×1Bank	New	○	○	○	○	○	○	○	○
117	AB	Bangbor(TS)	—	×1Bank	New	○	○	○	○*	○*	○*	○*
118	JK	Bangjak	—	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○	○	○
119	KD	Bangkradee	—	×1Bank	×1Bank	×1Bank	New	○	○	○	○	○
120	BH	Bangshan	—	×1Bank	×1Bank	New	○	○	○	○	○	○
121	MI	Banmai	—	—	—	—	—	—	New	○	○	○
122	DD	Dindaeng	—	—	×1Bank	×1Bank	×1Bank	New	○	○	○	○
123	EC	Ekachai	—	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○	○
124	GK	Ghoaklang	—	×1Bank	New	○	○	○	○	○	○	○
125	JW	Jangwatana(TS)	—	×1Bank	○*	○*	○*	○*	○*	○*	○*	○*
126	JJ	Jatujag	—	—	—	New	○	○	○	○	○	○
127	KE	Kaset	—	—	—	New	○	○	○	○	○	○
128	KG	Klongkum	—	—	×1Bank	×1Bank	New	○	○	○	○	○
129	KL	Klongprapa	—	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○	○
130	MU	Mitrudom	—	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	×1Bank	New	○	○
131	M4	Muangthong 4	—	—	×1Bank	New	○	○	○	○	○	○
132	M5	Muangthong 5	—	—	—	—	New	○	○	○	○	○
133	M6	Muangthong 6	—	—	—	—	—	New	○	○	○	○
134	M7	Muangthong 7	—	—	—	—	—	—	New	○	○	○
135	NL	Nanglerng	—	—	—	—	—	—	New	○	○	○
136	TA	Patanakarn(TS)	—	—	—	—	×1Bank	×1Bank	New	○*	○*	○*
137	PL	Plubpla	—	—	—	—	—	—	New	○	○	○
138	PW	Prawes	—	—	—	—	—	New	○	○	○	○
139	RP	Prompong	—	—	—	—	—	New	○	○	○	○
140	SI	Sainoi(TS)	—	—	—	—	—	—	○*	○*	○*	○*
141	YN	Samyarn	—	—	×1Bank	New	○	○	○	○	○	○
142	SH	Satorn	—	—	—	—	—	—	New	○	○	○
143	HP	Shimplee	—	—	—	×1Bank	×1Bank	New	○	○	○	○
144	SW	Sriwiang	—	—	—	—	New	○	○	○	○	○

Table 6.6-3 SCADA RTU Installation Plan of Distribution Stations

No.	ABB.	Name of Distribution Station	Actual	7th Plan	Planning Period							
			1995	1996	1997	1998	1999	2000	2001	2006	2011	2016
145	YI	Suanyai	—	—	—	—	—	—	New	○	○	○
146	WW	Suwintawong	—	—	—	—	—	New	○	○	○	○
147	TI	Thakwian	—	—	—	—	New	○	○	○	○	○
148	TC	Trokchan	—	—	×1Bank	New	○	○	○	○	○	○
149	TY	Tubyao	—	—	—	×1Bank	×1Bank	×1Bank	New	○	○	○
150	WK	Watkampaeng	—	—	—	×1Bank	×1Bank	×1Bank	New	○	○	○
151	WR	Wuttakart	—	—	—	—	—	New	○	○	○	○
152	AK	Asoke	—	—	—	—	—	—	—	New	○	○
153	BT	Bangbuotong	—	—	—	—	—	—	—	—	New	○
154	HS	Banghuasae	—	—	—	—	—	—	—	New	○	○
155	BW	Bangkaew	—	—	—	—	—	—	—	New	○	○
156	PY	Bangpleeyai	—	—	—	—	—	—	—	—	New	○
157	TD	Bangtalard	—	—	—	—	—	—	—	New	○	○
158	JB	Jorakabuo	—	—	—	—	—	—	—	New	○	○
159	KB	Klongbangpi	—	—	—	—	—	—	—	—	New	○
160	LA	Klongna	—	—	—	—	—	—	—	New	○	○
161	GP	Klongpume	—	—	—	—	—	—	—	—	New	○
162	KR	Krungtepkreeta	—	—	—	—	—	—	—	—	New	○
163	KH	Land & House	—	—	—	—	—	—	—	New	○	○
164	M8	Muangthong 8	—	—	—	—	—	—	—	New	○	○
165	M9	Muangthong 9	—	—	—	—	—	—	—	New	○	○
166	RL	Praramkao	—	—	—	—	—	—	—	New	○	○
167	RJ	Rajchaprarop	—	—	—	—	—	—	—	New	○	○
168	NP	Sanampao(TS)	—	—	—	—	—	—	—	○*	○*	○*
169	OM	Sananikom	—	—	—	—	—	—	—	New	○	○
170	OS	Songsunikom	—	—	—	—	—	—	—	New	○	○
171	IR	Srinakarin	—	—	—	—	—	—	—	New	○	○
172	LO	Thonglor	—	—	—	—	—	—	—	—	New	○
173	TU	Tungkru	—	—	—	—	—	—	—	—	New	○
174	WD	Watdeedod	—	—	—	—	—	—	—	New	○	○
175	GY	Bangkruay	—	—	—	—	—	—	—	—	—	New
176	GG	Bangpang	—	—	—	—	—	—	—	—	—	New
177	AA	Bangpla	—	—	—	—	—	—	—	—	—	New
178	LD	Klongdan	—	—	—	—	—	—	—	—	—	New
179	GT	Klonggratiam	—	—	—	—	—	—	—	—	—	New
180	LG	Luangpang	—	—	—	—	—	—	—	—	New	○
181	LS	Lumpagshe	—	—	—	—	—	—	—	—	—	New
182	NI	Nimitmai	—	—	—	—	—	—	—	—	New	○
183	NY	Nongyai	—	—	—	—	—	—	—	—	New	○
184	IL	Pinklao	—	—	—	—	—	—	—	—	New	○
185	PH	Pongpetch	—	—	—	—	—	—	—	—	—	New
186	PT	Puttamonton	—	—	—	—	—	—	—	—	—	New
187	RO	Rajchakru	—	—	—	—	—	—	—	—	New	○
188	RR	Rajdamri	—	—	—	—	—	—	—	—	—	New
189	AT	Satorntai	—	—	—	—	—	—	—	—	New	○
190	TL	Talingchan(TS)	—	—	—	—	—	—	—	—	—	○*
191	TM	Tiamruammit	—	—	—	—	—	—	—	—	New	○
192	RM	Trimit	—	—	—	—	—	—	—	—	New	○

Table 6.6-3 SCADA RTU Installation Plan of Distribution Stations

No.	ABB.	Name of Distribution Station	Actual 1995	7th Plan 1996	Planning Period 1997	1998	1999	2000	2001	2006	2011	2016
Number of D/S			99	124	130	135	139	144	151	167	182	192
Number of D/S with two or more banks			30	33	27	23	19	13	8	0	0	0
Number of D/S with one bank			69	91	103	112	120	131	143	167	182	192
Construction Number of RTU				24	11	8	8	11	11	22	15	9
Number of D/S where RTU is installed			67	92	104	113	121	132	144	167	182	192
Number of D/S where RTU is commonly used with T/S			9	10	11	12	12	12	14	18	18	21

Note;"*" mark shows Distribution Station where the RTU is commonly used with Terminal Stataion.
"○" mark shows Distribution station where RTU is installed.
"×" mark shows Distribution Station where RTU is not installed.
"×1Bank" mark shows Distribution Station with one bank where RTU is not installed.

CHAPTER 7

POWER SYSTEM ANALYSIS

CHAPTER 7 POWER SYSTEM ANALYSIS

7.1 General

The power system analysis studies are carried out parametrically in the planning stage for each year through the study of load flow, short circuit fault current and single line ground fault current.

(1) Load flow study

The objective of load flow study is to simulate power distribution system in order to know the power flow, power loss in subtransmission line system and transformers, as well as voltages at various buses in either normal or emergency cases. In addition, load flow study can help plan and arrange configuration suitable for the existing and new terminal and distribution substations. It also helps locate sites and fix ratings of new substations.

(2) 3 Phase Short Circuit (SC) and Single Line Ground (SLG) fault current study

The SC and SLG fault current studies are essential as they are the distribution system analysis when there occurs SC or SLG fault which will have impact on voltage and current of each bus. The results of SC and SLG fault current studies will be used in setting interrupting capacity of electrical equipment such as rating of circuit breaker etc. In addition, they will help choose protective relay for efficient control of protection system as well as arrange suitable power distribution configuration of SC and SLG fault current level within the criteria.

Incidentally, judging from the result of "Feasibility Study (F/S) on Bulk Power Supply Project for the Greater Bangkok Area" issued by JICA in 1993, EGAT bulk power transmission system up to FY 2011 can be steady from the point of view of system stability, so that MEA system may well be stable. Furthermore, with appropriate reinforcement after FY 2011, MEA system in FY 2016 can be expected to be stable as within the same criteria.

7.2 Conditions of Analysis

The power system analysis studies have to be carried out by simulating the EGAT bulk power transmission system and the whole MEA power distribution system under the following conditions:

(1) Fiscal year under Study

(a) Short-term plan

FY 1997, 1998, 1999, 2000, 2001

(b) Long-term plan

FY 2006, 2011, 2016

(2) System configuration of planned years

(a) Short-term plan

The latest EGAT power Development Plan (PDP) has been taking into consideration in the system configuration of EGAT's 500 kV and 230 kV transmission systems which transmit the power to the MEA power system . Meanwhile, the MEA power system during the period FY 1997-2001 is based on the assumed FY 1996's system, the last year of the Revised 7th Plan.

(b) Long-term plan

In FY 2006, the EGAT power system followed the latest PDP as well as Short-term plan. However, in FY 2011 and 2016, EGAT and MEA systems are based on the result of First and Second Field Investigation by the Study Team, "Feasibility Study on Bulk Power Supply Project for the Greater Bangkok Area" issued by JICA in 1993, and the draft long-term plan up to FY 2011 prepared by MEA.

(3) Load forecast at each distribution substation

Load forecast at each distribution substation is based on the system peak (coincident) load at each distribution substation according to the distribution substation expansion plan formulated by this JICA Study Team as discussed in Section 6.3.

The power factor of system peak is assumed to be 95% at the secondary voltage side according to the MEA's planning criteria.

(4) Planning criteria

Planning criteria used for the system analysis is based on the MEA's planning criteria as presented in Section 5.2.

7.3 Results of Load Flow Study

The following are the summarized results of the load flow studies for the cases considered as the appropriate plans for the power distribution system improvement and expansion in the Metropolitan Area as presented in Section 6.4.

7.3.1 FY 2016's System

Fig.7.3-1 shows the result of load flow study for FY 2016's system under normal conditions.

The busbar-voltage at each substation can be maintained within the target operating voltage criteria under normal conditions as presented in Clause 5.2.1 by appropriate reactive power compensation installed at some substations.

Some terminal stations undergo overloading of 3-4% against the target loading (80%). However, satisfactory system performance can be achieved by taking countermeasures such as switching the load to other terminal stations as presented in Clause 6.4.2.

7.3.2 FY 1997-2001's System

Fig.7.3-2 to 7.3-6 show the results of load flow studies for FY 1997-2001's system under normal conditions.

The busbar-voltage at each substation can be maintained within the target operating voltage criteria under normal conditions as presented in Clause 5.2.1 by appropriate reactive power compensation installed at some substations.

Some terminal stations are still several % overloading against the target

loading (80%). However, satisfactory system performance can be achieved by taking countermeasures such as switching load to other terminal stations as presented in Clause 6.4.3.

7.3.3 FY 2006's System

Fig.7.3-7 shows the result of load flow study for FY 2006's system under normal conditions.
The busbar-voltage at each substation can be maintained within target operating voltage criteria under normal condition as presented in Clause 5.2.1 by appropriate reactive power compensation installed at some substations.
Some terminal substations are still several % overloading against the target loading (80%). However, satisfactory system performance can be achieved by taking countermeasures such as switching load to other terminal stations as presented in Clause 6.4.3.

7.3.4 FY 2011's System

Fig.7.3-8 shows the result of load flow study for FY 2011's system under normal conditions.
The busbar-voltage at each substation can be maintained within target operating voltage criteria under normal condition as presented in Clause 5.2.1 by appropriate reactive power compensation installed at some substations.
Some terminal stations are still several % overloading against the target loading (80%). However, satisfactory system performance can be achieved by taking countermeasures such as switching load to other terminal stations as presented in Clause 6.4.3.

7.4 Results of 3 Phase Short Circuit (SC) Fault Current Study

The SC fault current analysis has been carried out at each terminal station only for FY 2006 and FY 2016.

Results of the SLG fault current studies are shown in Fig.7.4-1 and 7.4-2.

The SC fault current levels at all busbars are within the MEA's planning criteria as presented in Clause 5.2.4.

Incidentally, the generator data used for the SC fault current study is subtransient reactance (Xd").

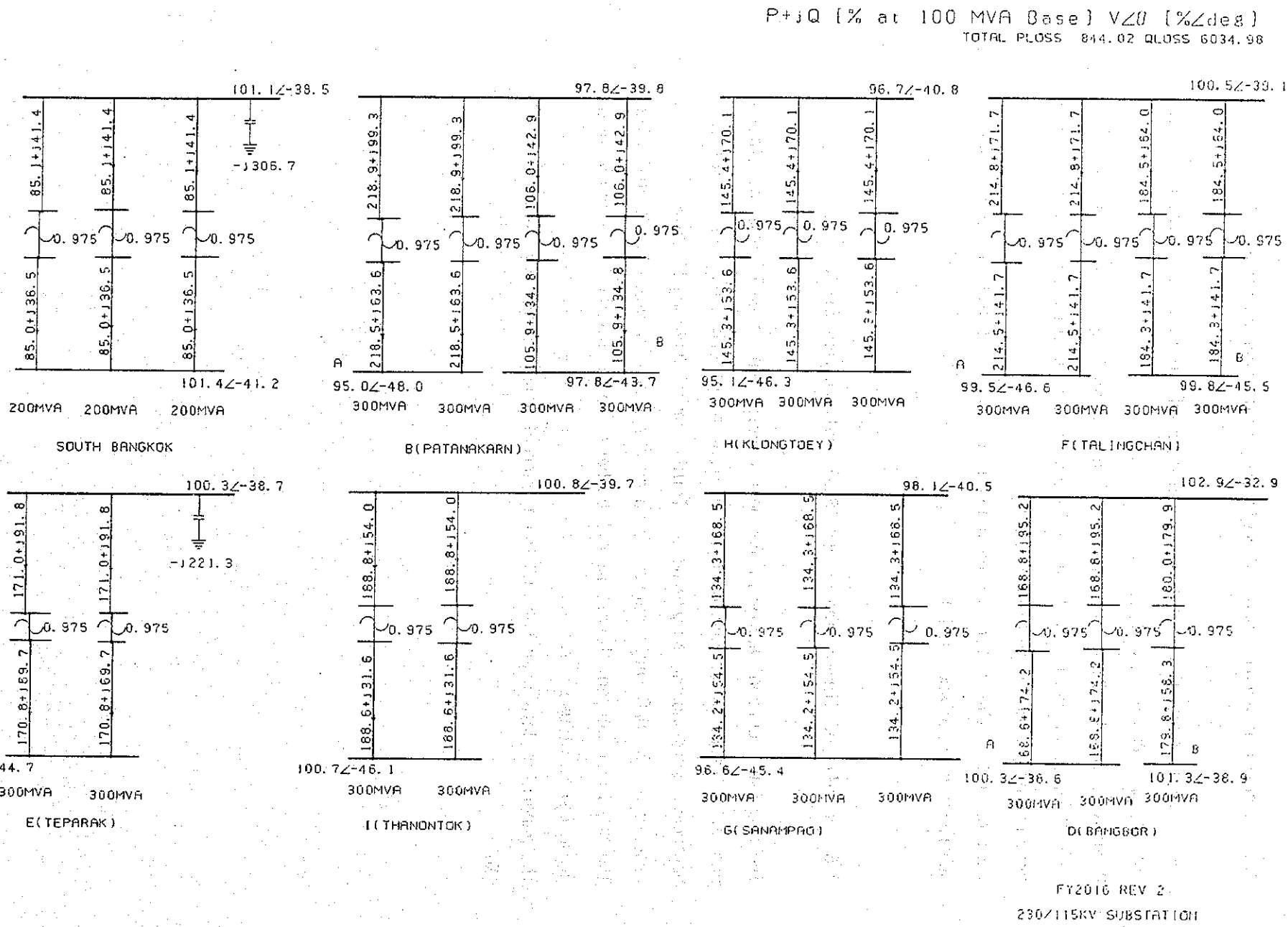
7.5 Results of Single Line Ground (SLG) Fault Current Study

The SLG fault current analysis has been carried out at each terminal station and some distribution substations located in network area such as Watlieb, Sapandam, Banghunprom, Nanglerng and Trimit for FY 2006 and FY 2016.

Results of the SLG fault current studies are shown in Table 7.5-1 and 7.5-2.

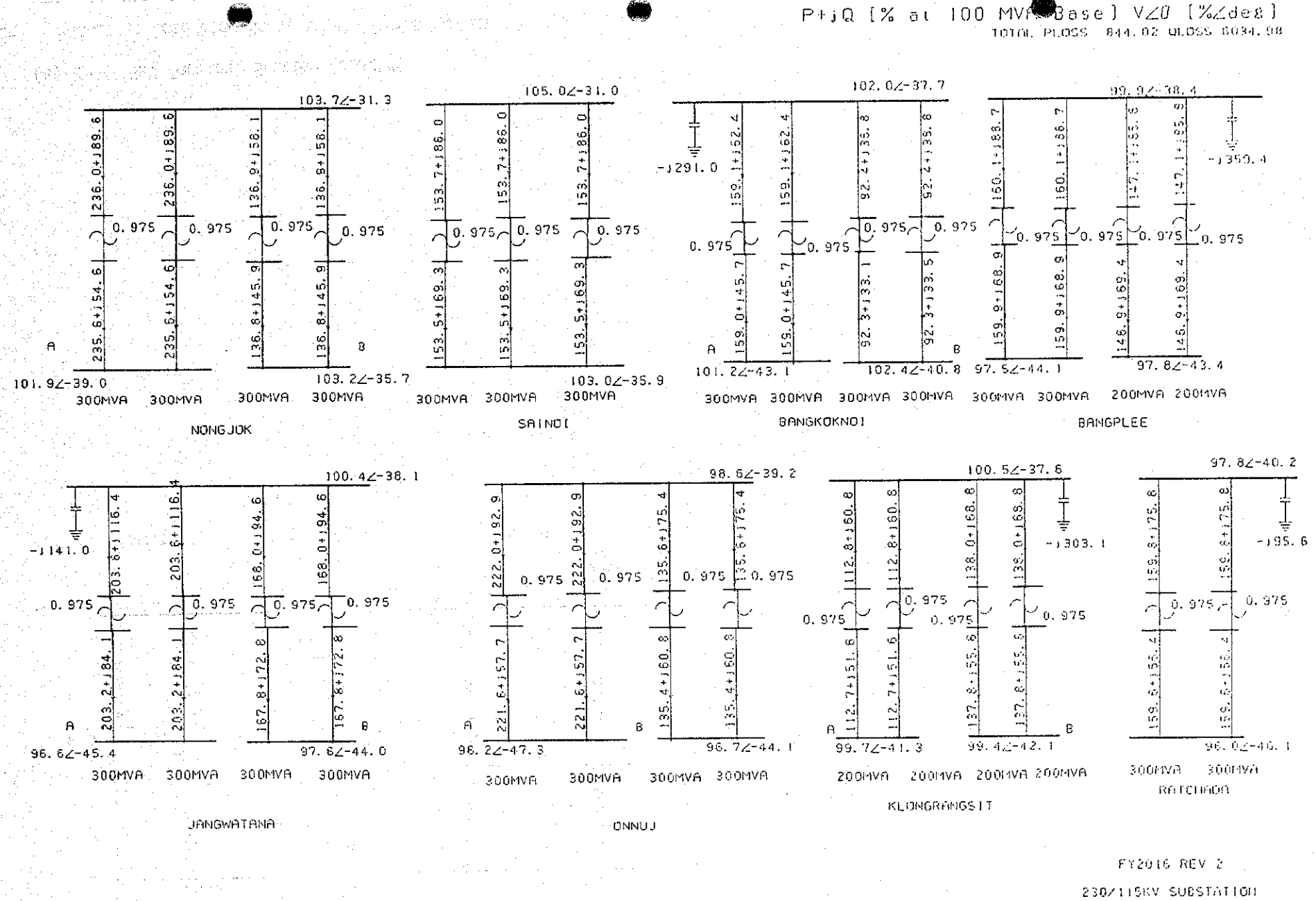
The SLG fault current levels at all busbars are within the MEA's criteria as presented in Clause 5.2.4.

The generator data used for SLG fault current study is subtransient reactance (Xd").



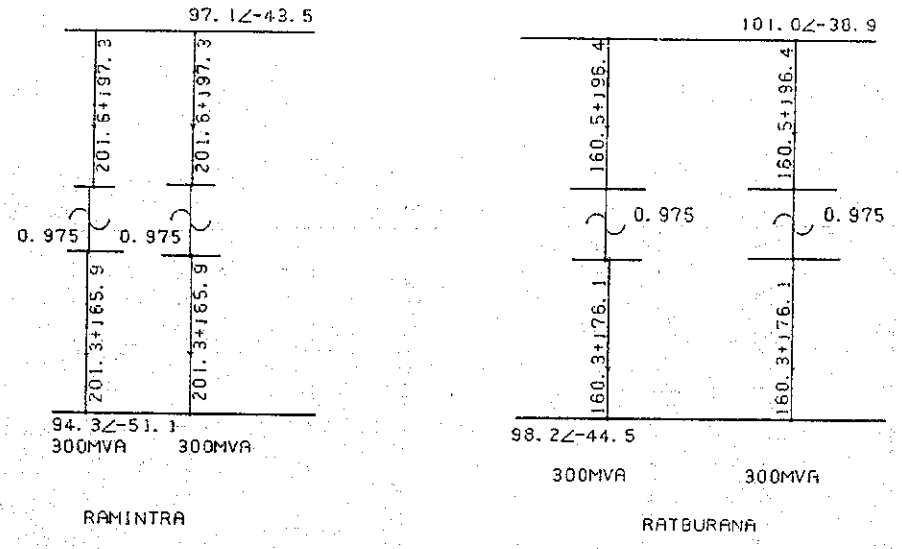
(a) 230/115kV Terminal Station

Fig.7.3-1 Result of Load Flow Study in FY 2016's System



(a) 230/115kV Terminal Station (cont'd)

Fig.7.3-1 Result of Load Flow Study in FY 2016's System



FY2016 REV 2
230/115KV SUBSTATION

(a) 230/115kV Terminal Station (cont'd)

Fig.7.3-1 Result of Load Flow Study in FY 2016's System