CHAPTER 9

FEASIBILITY DESIGN

CHAPTER 9 FEASIBILITY DESIGN

9.1 General

The feasibility design is to be carried out for the purpose of efficiently realizing formation of the power supply facilities to the densely populated areas in accordance with the short and long term distribution system improvement and expansion plan described in CHAPTER 6. In other words, this feasibility design shall be carried out according to the following standards and criteria of MEA primarily for selecting the overhead and underground transmission line routes as well as the substation sites so as to match the local situations while reflecting the results of the first and second site survey, and those of detailed survey of the model districts carried out simultaneously. Meanwhile, any advanced equipment shall designed according to the relevant international standards (ISO):

- Basic Criteria for Power System Planning
- Overhead Subtransmission Construction Standards
- Underground (Transmission Line/Cable) Construction Standards

Before discussing on the feasibility design of the respective equipment and facilities, let us first of all describe herein on the results of studying the transformer capacity of distribution substations, voltage of related transmission and distribution systems and size of distribution line conductor in the model zones and surrounding areas.

9.2 Selection of Model Districts

The model districts of which detailed feasibility studies are to be carried out have been selected through the discussions between MEA and the Study Team, bearing in mind the large-scale demand areas in the center of cities and taking into account the industrial and geographical elements as follows:

- Sathorn Area (high load density area)
- Phahol Yothin Area (commercial area)
- Jomthong Area (industrial area)

(1) Feature of the model districts

(a) Sathorn Area

This area is located in the southeastern part of the city center near by Silom street, one of the most busy streets, as is shown in Fig. 9.2-1(a). There are many high-rise buildings in the district and also buildings under construction on both sides of the Sathorn street. The load demand tends to increase rapidly.

(b) Phahol Yothin Area

This area is located in the northern part of the Victory Monument, as is shown in Fig. 9.2-1(b). There are many commercial and business high-rise buildings adjacent to commercial and residential areas and some buildings under construction on both sides of the Phahol Yothin street. This street is also expected to install the outgoing subtransmission lines from new Sanampao T/S

(c) Jomthong Area

This area is located in the western part of the Chao Phraya River and along with Klong Daokhanong River, as is shown in Fig. 9.2-1(c). This area has been prospering as a small industry area. There are many small industry shops on both sides of the street and narrow area. Electric power for this area has been supplied from Klongwatsing and Taksin distribution substations. As MEA plan to install new distribution substation in this area, they are now seeking the land for the substation.

(2) Load forecast of each district

Load densities of each district are listed below, based on the results of load forecast by MEA.

Area	FY 1993 MVA/km²	FY 2001 MVA/km²	FY 2001 aai (%)	FY 2006 MVA/km²	FY 2006 aai (%)
(a) Sathorn	25.11	44.86	7.5	55.39	4.3
(b) Phahol Yothin	7.36	16.03	10.2	21.30	5.8
(c) Jomthong	6.42	15.11	11.3	20.73	6.5

(3) Load demand for buildings

The load demand for each high-rise building located in Sathorn and Phahol Yothin Area are as shown in the table below:

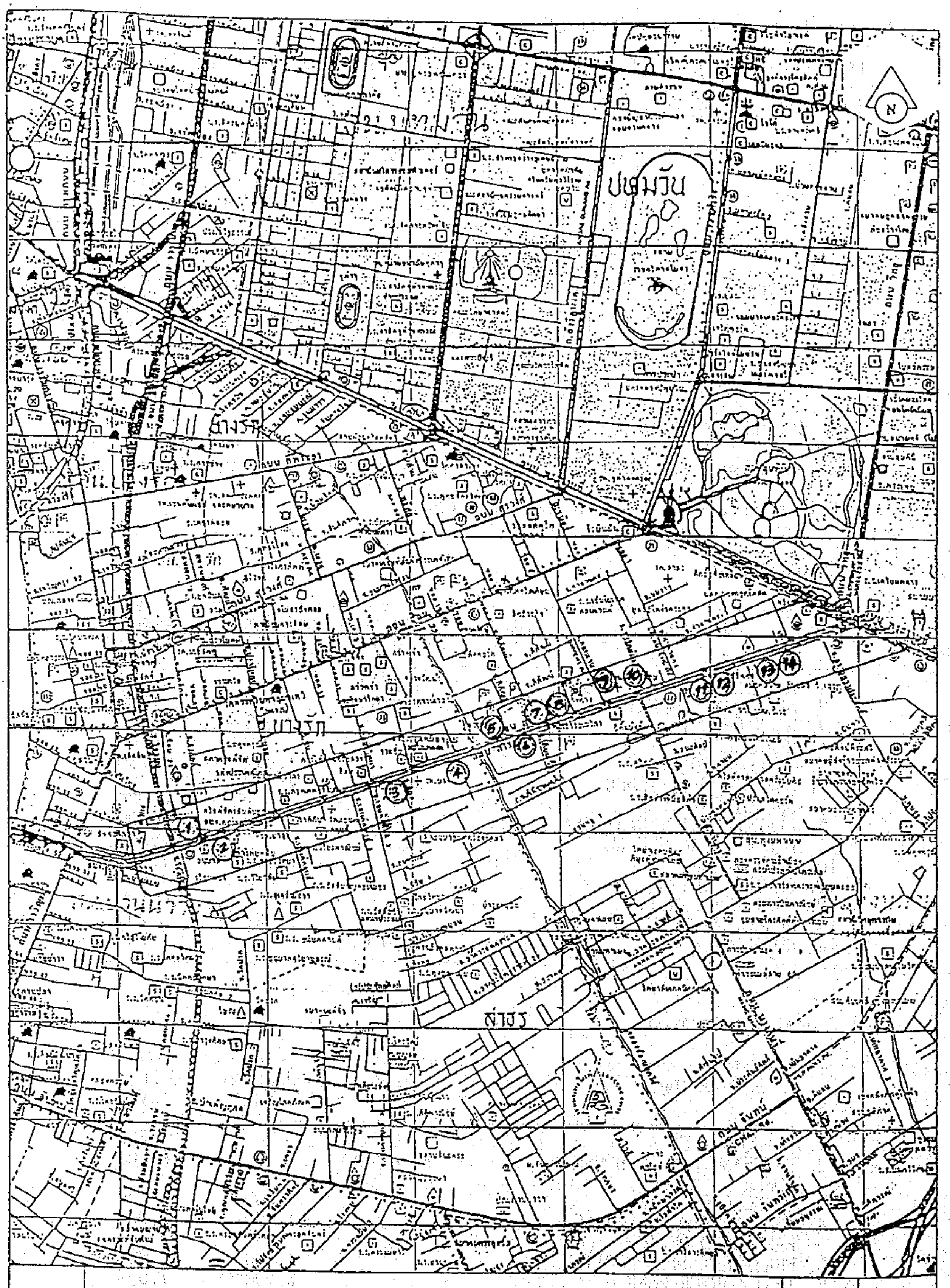
(a) Sathorn Area

Building	Storey	Area (m^2)	Load Demand (kVA)	Connect (kVA)
1. ATM INTERNATIONAL HOTEL	27	40,749	-	7,250
2. SRI-SIAM PROPERTY	33	73,169	862	8,900
3. BANK OF ASIA	-	-	2,000	-
4. RAJANAKARN	32	-	-	9,600
5. SATHORN THANI	-	-	1,847	4,050
6. SATHORN CITY TOWER	31	50,000	2,382	10,400
7. SAENGTHONG THANI	-	-	-	8,000
8. EVERGREEN INTERNATIONAL	14	-	899	3,000
9. BNH MEDICAL CENTRE	12	27,215	-	4,000
10. HARINTHORN	20	-	2,632	7,200
11. CENTRAL INTER	-	-	440	4,000
12. THAIVA TOWER II	-	-	-	10,500
13. SUKHOTHAI HOTEL	-	-	1,467	3,200
14. ROYAL SATHORN	19	20,000	-	4,200

(b) Phahol Yothin Area

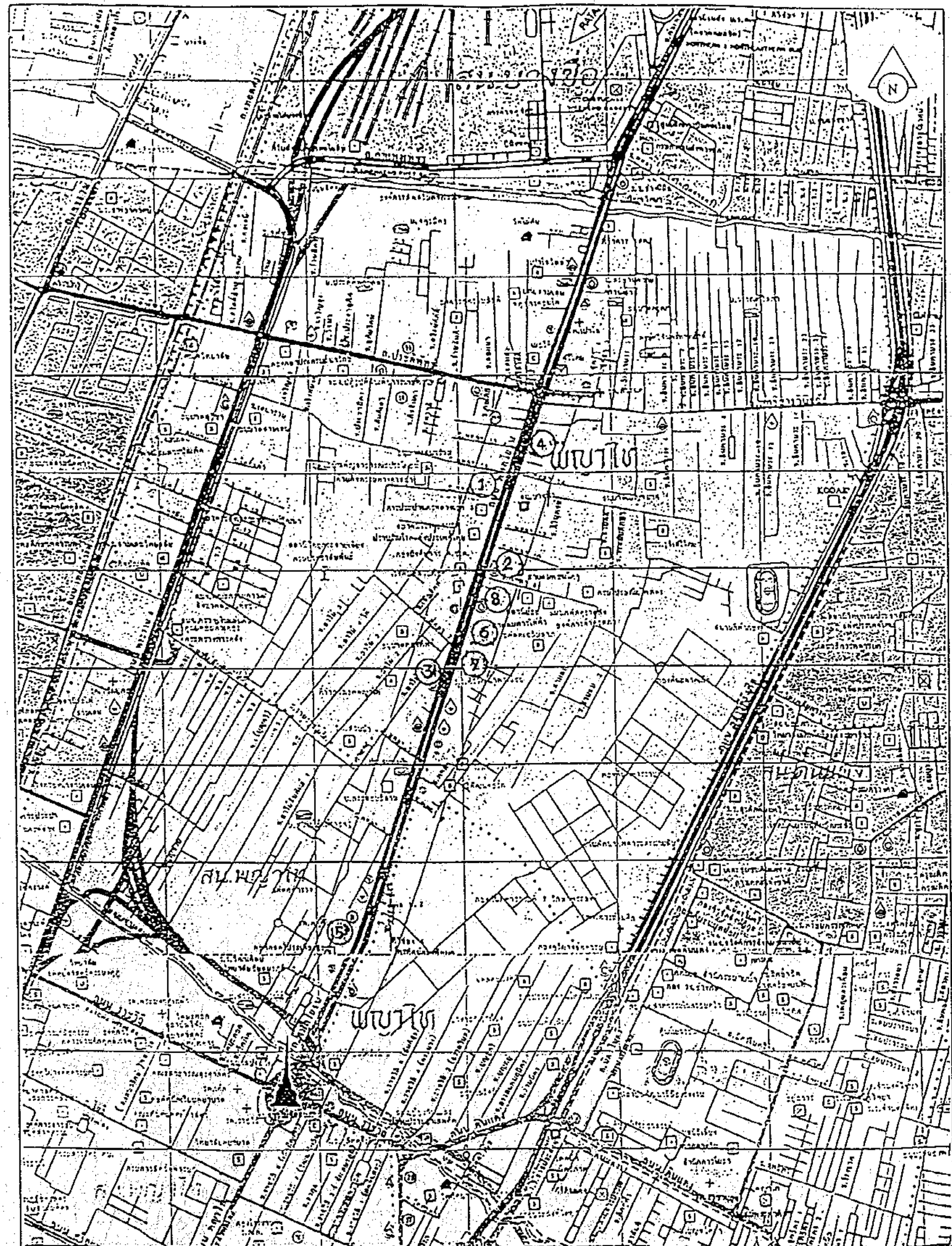
Building	Storey	Area	Load Demand (kVA)	Connect (kVA)
1. MAISON MANEEYA	-	-	-	2,500
2. BANCHANG LAND & HOUSE TOWER	-	$1^1/_4$ Rai*	-	6,000
3. BONPONG BUILDING	-	-	2,000	3,200
4. THE GOVERNMENT SAVING BANK HEAD OFFICE	-	-	1,400	2,000
5. PHAYATHAI II, HOSPITAL	-	-	1,600	4,000
6. THAI FARMER BANK, HEAD OFFICE	-	-	5,600	7,500
7. S.P. BUILDING (IBM)	-	-	-	7,200
8. PHAHOLYATHIN	-	-	900	13,200

Note: * 400Rai=650ha

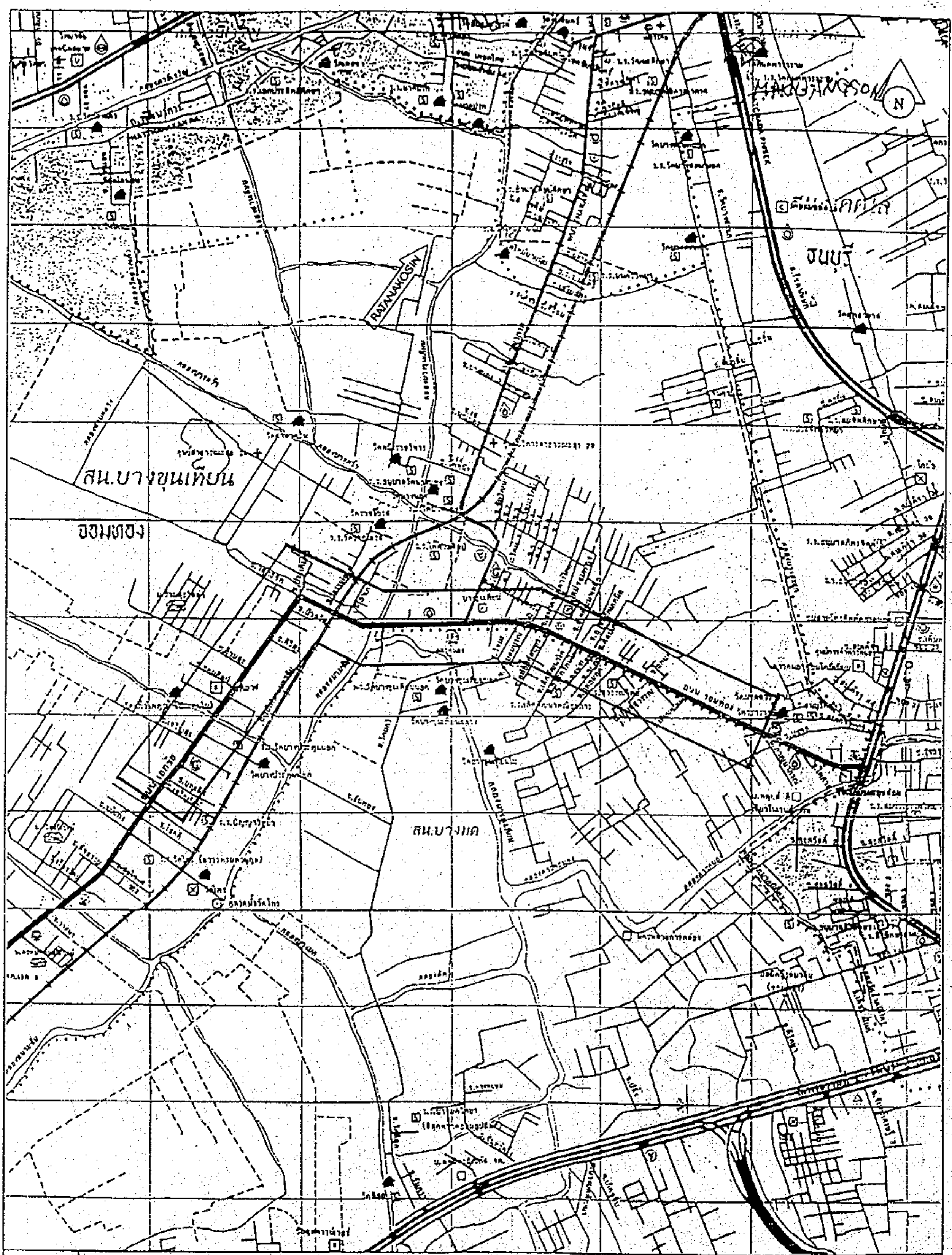


REV.NO.	DESCRIPTION OF REVISIONS	BY	DATE

DISTRIBUTION PLANNING FEEDER SECTION	METROPOLITAN ELECTRICITY AUTHORITY	SCALE
DR. / CHK.	Fig.9.2-1 Map of Model Districts	SUPERSEDING
CHF. OF SECT.	(a) Sathorn Area	SH.NO. OF
DATE		DWG. NO.



REV.NO.	DESCRIPTION OF REVISIONS	BY	DATE
DISTRIBUTION FEEDER PLANNING SECTION	METROPOLITAN ELECTRICITY AUTHORITY	SCALE 1 : 20,000	
DR. / CHK.	Fig.9.2-1 Map of Model Districts	SUPERSEDING	
CHF. OF SECT.	(b) Phahol Yothin Area	SH.NO. OF	
DATE		DWG. NO.	



REV.NO.	DESCRIPTION OF REVISIONS	BY	DATE
DISTRIBUTION FEEDER PLANNING SECTION	METROPOLITAN ELECTRICITY AUTHORITY	SCALE 1 : 20,000	
DR. / CHK.	Fig.9.2-1 Map of Model Districts	SUPERSEDING	
		SH.NO.	OF
CHF. OF SECT.	(c) Jomthong Area	DWG. NO.	
DATE			

9.3 Study of Model Districts

9.3.1 Study of Distribution System and Capacity of Distribution Substation in the Model Districts

For executing detailed feasibility design, the following model districts have been selected as described in Section 9.2.

- Sathorn zone (High density commercial area)
- Paphol Yothin zone (Commercial area)
- Jomthong zone (Industrial area)

With regard to these model districts, subtransmission lines and distribution substations in the surrounding areas, optimum systems of distribution system and distribution substation are studied on the basis of the following items as parameters:

Substation capacity

- Case 1 : 3 × 40 MVA
- Case 2 : 4 × 40 MVA
- Case 3 : 3 × 60 MVA
- Case 4 : 3 × 80 MVA

(1) Prerequisite conditions of distribution substation

The respective cases of expansion plans are formulated by optimum system study, based on the following prerequisite conditions:

(a) The power demand in the model districts and surrounding areas are studied based on the power demand obtained in Section 6.3.

(b) The distribution voltage, size of distribution conductor and number of distribution lines per one bank are all based on the same conditions as those described below in the respective cases because of the following reasons:

Namely, when the portions of feeders downstream of substation transformer are studied based on individual parameters, then the parameters become too many and complex to promote further study.

The distribution voltage, size of distribution conductor and number of distribution lines per one bank subsequent to feeders are studied in Clause 9.3.3.

· Distribution voltage : 24 kV

· Conductor size : 185 mm^2

· Maximum number of distribution conductors per one bank : seven feeders(c) The capacity of substations will be so planned as to become roughly equal in the respective cases.

(d) The extension plan of the substations in the respective cases is formulated based on the planning policy described in Section 6.3.

Meanwhile, the 3 x 80 MVA configuration is studied for the model districts, an additional bank configuration.
For this purpose, the planning policy for this configuration should also be set in advance similarly as described in Section 6.3.

· At the time of 2-bank configuration
  Normal : 75%, Emergency : 125%
  Switching-over by distribution line : 20 MVA in maximum
  Although the load to be switched over by distribution line is 15 MVA in maximum in the case of 60 MVA bank, the load is 20 MVA in the case of 80 MVA.

· At the time of 3-bank configuration
  Normal : 80%, Emergency : 120%
  Switching-over by distribution line : None

The level at the time of dissimilar capacity bank configuration at the execution stage of the substation expansion project is studied below.

· At the time of 1 x 80 MVA + 1 x 40 MVA configuration

	BAY 1	BAY 2
Normal:		
Capacity	80 MVA	40 MVA
Load	60 MVA	30 MVA
Utilization Factor	75%	75%
Emergency:		
Load	40 MVA	50 MVA
Utilization Factor	—	125%

In this case, 40 MVA is left over as a residual load. Out of this much load, 20 MVA can be switched over by distribution line, but 20 MVA is left over without being switched over.

Therefore, the substation should be operated by lowering the normal load by 10 MVA.

The normal load and availability factor of the substation at this time, are 70 MVA and 58.3%, respectively.

- At the time of 1 x 80 MVA + 2 x 40 MVA configuration

	BAY 1	BAY 2	BAY 3
Normal:			
Capacity	80 MVA	40 MVA	40 MVA
Load	64 MVA	32 MVA	32 MVA
Utilization Factor	80%	80%	80%
Emergency:			
Load	32 MVA	48 MVA	48 MVA
Utilization Factor	—	120%	120%

In this case, 32 MVA is left over as a residual load. Out of this much load, 20 MVA can be switched over by distribution line, but 12 MVA is left over without being switched over.

In this case, therefore, the substation should be operated by lowering the normal load by 12 MVA.

At this time, the normal load and availability factor of the substation are 116 MVA and 72.5%, respectively.

・At the time of 2 x 80 MVA + 1 x 40 MVA

	BAY 1	BAY 2	BAY 3
Normal:			
Capacity	80 MVA	80 MVA	40 MVA
Load	64 MVA	64 MVA	32 MVA
Utilization Factor	80%	80%	80%
Emergency:			
Load	16 MVA	96 MVA	48 MVA
Utilization Factor	—	120%	120%

Although 16 MVA is left over as residual load in this case, all of the load can be switched over by distribution line so that there will be no particular problem.

(2) Power distribution plan to model districts

A study has been carried out regarding the 115 kV and 69 kV system configurations for power supply to distribution substations in the model districts and surrounding areas.

Since the supply capacity of distribution substations is different in the respective cases, a policy of system configuration to be applied in all of the respective cases has been studied, and an expansion plan has been formulated based on the policy. The policy of system configuration studied herein is presented in Table 9.3-1.

The expansion plan in the respective cases mentioned above has been formulated on the basis of the subtransmission line expansion plan described in Section 6.4 taking into account effective utilization of the existing systems around the respective model districts and surrounding areas as well as the transmission line expansion plan constituting the basis of this study. Case 3 is almost the same as the base plan in Section 6.4.

The system configurations used in this study are outlined in Fig. 9.3-1.

(3) Advantage and disadvantage of system configurations to be applied

The results of formulating the expansion plans of distribution systems and distribution substations in the respective cases based on the prerequisite conditions mentioned previously are presented in Table 9.3-2(a),(b),(c) and Fig. 9.3-2, and the construction cost therefore in Table 9.3-3(a),(b),(c).

(a) Evaluation of the respective cases

The construction cost in the respective cases is as completed in the tables below.

The number of substations to be constructed in Case 1 is largest among the respective cases followed by Case 2. Since the modification cost of GIS for adding to four banks is high, the construction cost in the respective model districts is apparently higher in both of the cases than the other cases.

The 3 x 60 MVA and 3 x 80 MVA plans with the smallest number of substations to be constructed are advantageous, since the substation construction cost dominates over the other cost when the construction is economically evaluated.

Total Cost (Unit : Million Baht)

Name of Area	Case 1	Case 2	Case 3	Case 4
Sathorn	1,915.8	1,518.1	1,244.7	1,341.6
Phahol Yothin	1,355.2	1,140.0	1,036.2	923.2
Jomthong	799.4	624.8	473.2	457.1
Total	4,070.4	3,282.9	2,754.1	2,721.9

Present Value (Unit : Million Baht)

Name of Area	Case 1	Case 2	Case 3	Case 4
Sathorn	1,338.7	1,107.0	970.8	978.1
Phahol Yothin	874.7	768.7	743.6	692.9
Jomthong	629.5	505.0	401.6	363.2
Total	2,842.9	2,380.7	2,116.0	2,034.2

(b) Economic comparison of Cases 3 and 4

In Cases 3 and 4, the substation capacity to be expanded in the respective model districts is roughly equal. However, while the number of substations to be constructed in Case 4 is slightly lower than in Case 3 so that the substation expansion cost of Case 4 is advantageous over Case 3 on one hand, the capacity of transmission lines to be expanded along with expansion of substations in Case 4 is greater than that in Case 3 and therefore disadvantageous over Case 3. The results of study are individually outlined below:

i) Although the substation expansion cost in the Sathorn area is lower in Case 4 than that in Case 3, the total construction cost is higher in Case 4 than that in Case 3 since the transmission expansion cost is higher in Case 4.

ii) In the Paphol Yothin area, the substation expansion cost is lower in Case 4, and although the expansion cost of transmission line is slightly increased, the total construction cost is advantageous in Case 4 over Case 3.

iii) In the Jomthong area, the substation expansion cost in Case 4 is lowered by half that in Case 3, and although the transmission line expansion cost in Case4 is roughly twice that in Case 3, the total construction cost in Case 4 is advantageous over that in Case 3.

As mentioned above, the difference in the total construction cost results from the relationship between the scales of substation and transmission line expansion work in the respective model areas. In other words, the difference in the total construction cost is caused by the extent of the possibility of reusing the existing distribution systems in individual areas.

From this study, it is impossible to indiscriminately evaluate the advantages and disadvantages of the cases of 3 x 60 MVA and 3 x 80 MVA because of actual situations inherent to the respective model districts. However, the above two cases are substantially advantageous economically over the other cases of 3 x 40 MVA and 4 x 40 MVA, and the extent of this advantage over these cases is roughly equal as conceptionally presented below:

3 × 40 MVA > 4 × 40 MVA ≫ 3 × 60 MVA and 3 × 80 MVA

Table 9.3-1 Relation of Substation Capacity and System Configuration

Case	Substation No. of Tr. x Capacity (MVA)	Maximum Load (MVA)	Standard Transmission Line			System configuration : Number of connecting substations in single subtransmission line with both end terminal station
			Voltage (kV)	Transmission Capacity (MVA)	Allowable Connecting substation	
1	3x40	96	115	288	3	3
			69	192	2	2
2	4x40	144	115	288	2	2
			69	192	1+1/3	2 but spare line for 2bank is required
3	3x60	144	115	288	2	2
			69	192	1+1/3	2 but spare line for 2bank is required
4	3x80	192	115	288	1+1/2	2 but spare line for 2bank is required
			69	192	1	1

Maximum load is assumed at 80% loading or 120% load on sound bank when 1 transformer shuts down

Refer to Fig. 9.3-3 and Fig. 9.3-4

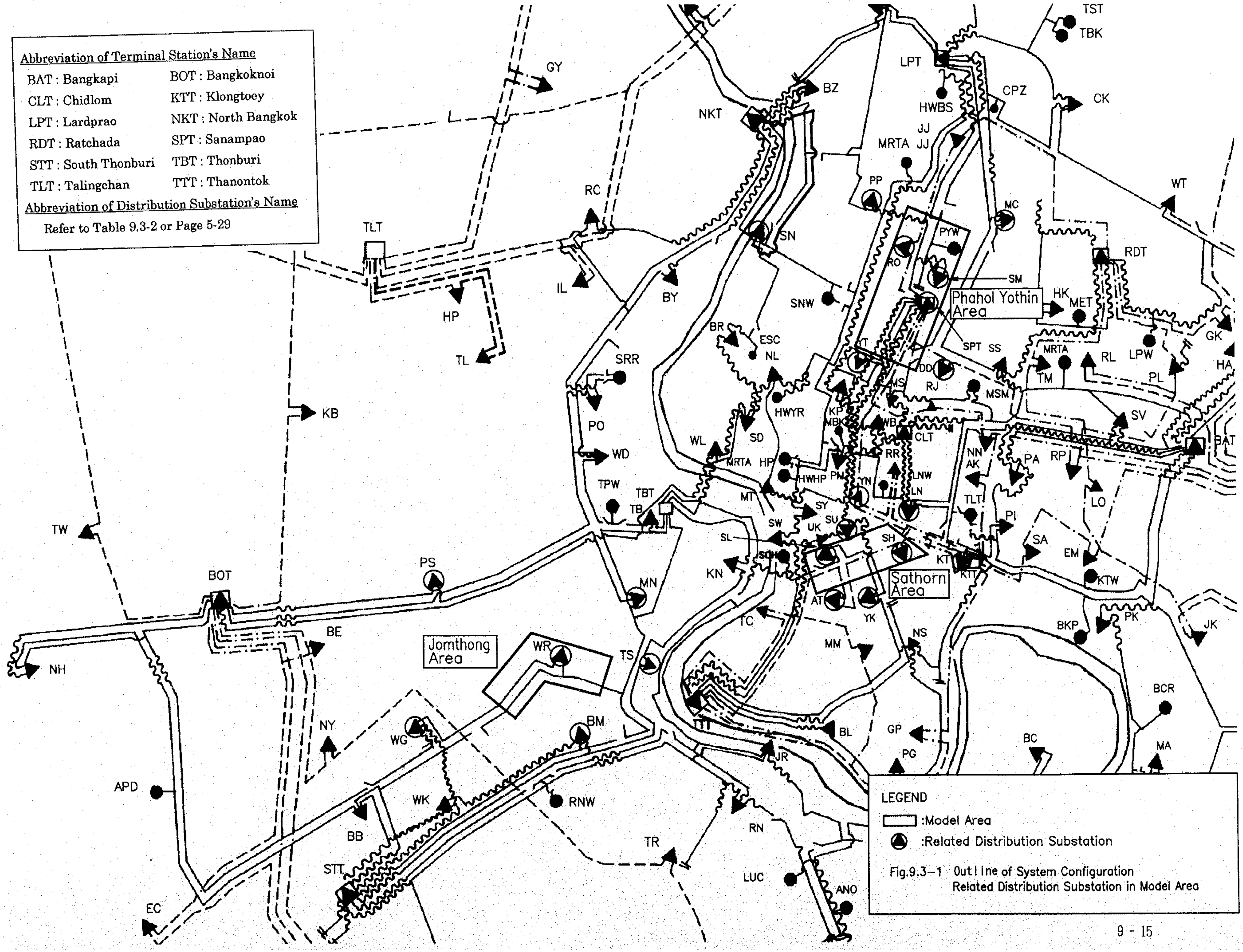


Fig.9.3-1 Outline of System Configuration
Related Distribution Substation in Model Area

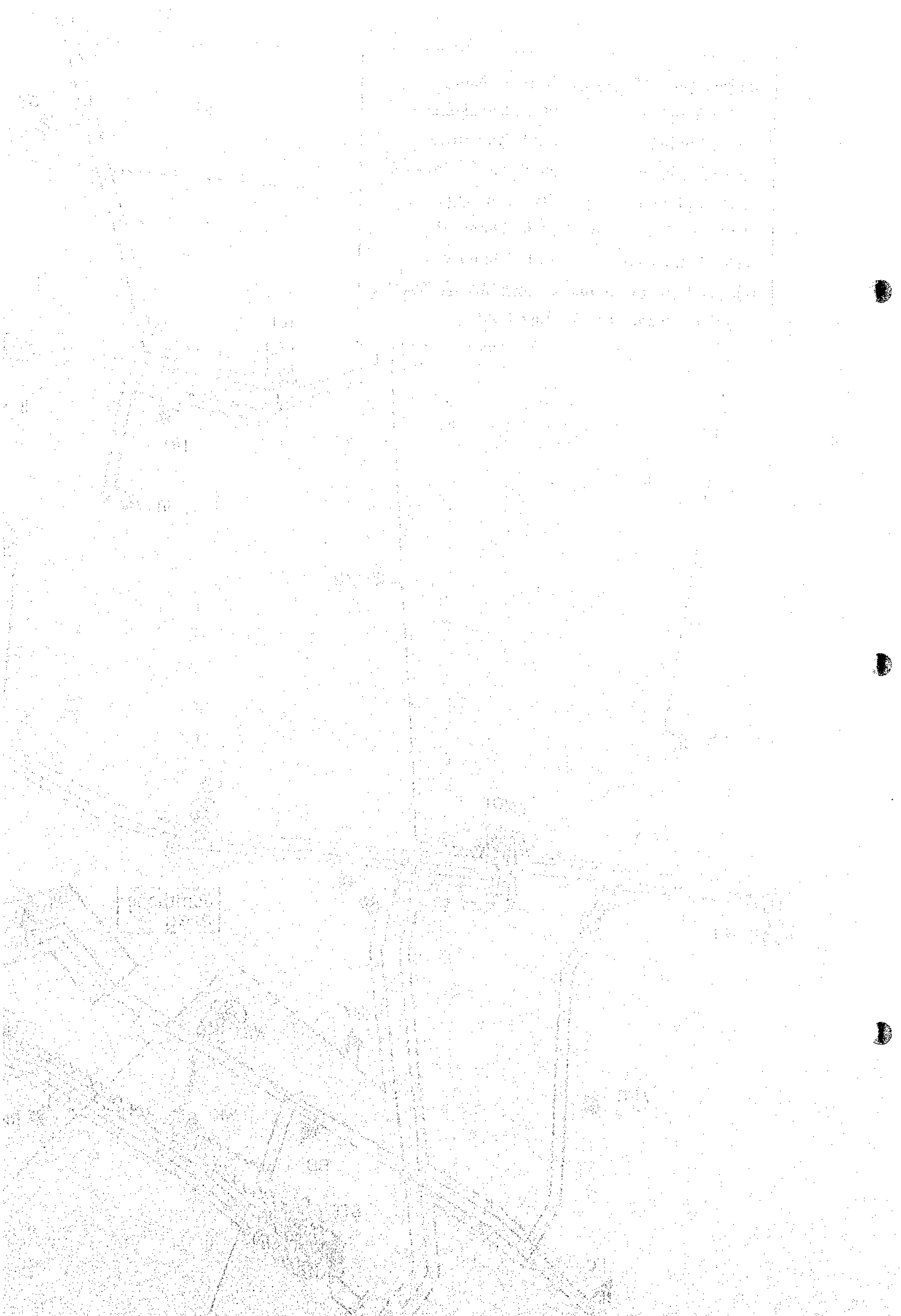


Table 9.3-2 (a) Case Study of Substation (Sathorn Area)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.29	51.14	63.9	2 × 40 ×	80	38.00	49.16	61.5
37	LN	Lumpini	4 × 40 ×	160	85.39	111.14	69.5	3 × 40 1 × 60	180	94.07	121.71	67.6
73	SL	Silom	2 × 40 ×	80	42.44	55.24	69.1	2 × 40 ×	80	37.10	48.00	60.0
80	SU	Surawong	3 × 40 ×	120	60.74	79.06	65.9	1 × 40 2 × 60	160	69.71	90.19	56.4
116	YK	Yenarkart	2 × (40) ×	80	45.60	59.35	74.2	2 × 60 ×	120	44.81	57.98	48.3
141	YN	Samyarn	× ×	0	0.00		0.0	2 × (40) ×	80	42.50	54.99	68.7
142	SH	Satorn	× ×	0	0.00		0.0	2 × 60 ×	120	53.35	69.02	57.5
189	AT	Satorntai	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		520	273.46	355.93	68.4		820	379.54	491.05	59.9

No	ABB	Substation	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.96	51.51	64.4	3 × 60 ×	180	92.15	118.50	65.8	3 × 60 ×	180	85.69	109.63	60.9
37	LN	Lumpini	3 × 40 1 × 60	180	97.01	125.05	69.5	3 × 40 1 × 60	180	103.19	132.70	73.7	3 × 40 1 × 60	180	106.56	136.34	75.7
73	SL	Silom	2 × 40 ×	80	43.26	55.76	69.7	2 × 40 ×	80	44.46	57.17	71.5	1 × 40 1 × 60	100	47.77	61.12	61.1
80	SU	Surawong	3 × 60 ×	180	61.58	79.38	44.1	3 × 60 ×	180	71.64	92.13	51.2	3 × 60 ×	180	76.97	98.48	54.7
116	YK	Yenarkart	3 × 60 ×	180	86.47	111.46	61.9	3 × 60 ×	180	96.42	123.99	68.9	3 × 60 ×	180	81.65	104.46	58.0
141	YN	Samyarn	2 × 60 ×	120	61.47	79.23	66.0	3 × 60 ×	180	101.07	129.97	72.2	3 × 60 ×	180	90.96	116.38	64.7
142	SH	Satorn	2 × 60 ×	120	61.32	79.04	65.9	3 × 60 ×	180	95.22	122.45	68.0	3 × 60 ×	180	102.31	130.90	72.7
189	AT	Satorntai	× ×	0	0.00		0.0	3 × 60 ×	180	77.51	99.68	55.4	3 × 60 ×	180	83.28	106.55	59.2
		Total		940	451.07	581.43	61.9		1340	681.66	876.59	65.4		1360	675.19	863.86	63.5

Case-1 (3 × 40MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.29	51.14	63.9	2 × 40 ×	80	38.00	49.16	61.5
37	LN	Lumpini	4 × 40 ×	160	85.39	111.14	69.5	4 × 40 ×	160	94.07	121.71	76.1
73	SL	Silom	2 × 40 ×	80	42.44	55.24	69.1	2 × 40 ×	80	37.10	48.00	60.0
80	SU	Surawong	3 × 40 ×	120	60.74	79.06	65.9	3 × 40 ×	120	69.71	90.19	75.2
116	YK	Yenarkart	2 × 40 ×	80	45.60	59.35	74.2	2 × 40 ×	80	44.81	57.98	72.5
141	YN	Samyarn	× ×	0	0.00		0.0	2 × 40 ×	80	42.50	54.99	68.7
142	SH	Satorn	× ×	0	0.00		0.0	3 × 40 ×	120	53.35	69.02	57.5
189	AT	Satorntai	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		New-sub 1	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		New-sub 2	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		New-sub 3	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		New-sub 4	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		520	273.46	355.93	68.4		720	379.54	491.05	68.2

No	ABB	Substation	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.96	51.51	64.4	3 × 40 ×	120	59.82	76.92	64.1	3 × 40 ×	120	64.27	82.23	68.5
37	LN	Lumpini	4 × 40 ×	160	97.01	125.05	78.2	4 × 40 ×	160	90.80	116.76	73.0	4 × 40 ×	160	93.25	119.30	74.6
73	SL	Silom	2 × 40 ×	80	21.58	27.82	34.8	2 × 40 ×	80	44.46	57.17	71.5	2 × 40 ×	80	23.89	30.56	38.2
80	SU	Surawong	3 × 40 ×	120	61.58	79.38	66.2	3 × 40 ×	120	71.64	92.13	76.8	3 × 40 ×	120	51.13	65.42	54.5
116	YK	Yenarkart	3 × 40 ×	120	68.82	88.71	73.9	3 × 40 ×	120	68.86	88.55	73.8	3 × 40 ×	120	65.31	83.56	69.6
141	YN	Samyarn	3 × 40 ×	120	61.47	79.23	66.0	3 × 40 ×	120	67.21	86.43	72.0	3 × 40 ×	120	72.77	93.10	77.6
142	SH	Satorn	3 × 40 ×	120	71.54	92.21	76.8	3 × 40 ×	120	71.41	91.83	76.5	3 × 40 ×	120	63.95	81.82	68.2
189	AT	Satorntai	2 × 40 ×	80	29.11	37.52	46.9	3 × 40 ×	120	45.65	58.70	48.9	3 × 40 ×	120	65.52	83.83	69.9
		New-sub 1	× ×	0	0.00		0.0	2 × 40 ×	80	44.73	57.52	71.9	2 × 40 ×	80	34.73	44.44	55.6
		New-sub 2	× ×	0	0.00		0.0	2 × 40 ×	80	32.57	41.89	52.4	2 × 40 ×	80	41.91	53.62	67.0
		New-sub 3	× ×	0	0.00		0.0	2 × 40 ×	80	45.76	58.85	73.6	3 × 40 ×	120	56.82	72.70	60.6
		New-sub 4	× ×	0	0.00		0.0	2 × 40 ×	80	38.76	49.84	62.3	2 × 40 ×	80	41.64	53.28	66.6
		Total		880	451.07	581.43	66.1		1280	681.67	876.59	68.5		1320	675.19	863.86	65.4

Case-2 (4 × 40MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.29	51.14	63.9	2 × 40 ×	80	38.00	49.16	61.5
37	LN	Lumpini	4 × 40 ×	160	85.39	111.14	69.5	4 × 40 ×	160	94.07	121.71	76.1
73	SL	Silom	2 × 40 ×	80	42.44	55.24	69.1	2 × 40 ×	80	37.10	48.00	60.0
80	SU	Surawong	3 × 40 ×	120	60.74	79.06	65.9	3 × 40 ×	120	69.71	90.19	75.2
116	YK	Yenarkart	2 × 40 ×	80	45.60	59.35	74.2	2 × 40 ×	80	44.81	57.98	72.5
141	YN	Samyarn	× ×	0	0.00		0.0	2 × 40 ×	80	42.50	54.99	68.7
142	SH	Satorn	× ×	0	0.00		0.0	3 × 40 ×	120	53.35	69.02	57.5
189	AT	Satorntai	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		New-sub 1	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		520	273.46	355.93	68.4		720	379.54	491.05	68.2

No	ABB	Substation	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.96	51.51	64.4	4 × 40 ×	160	92.15	118.50	74.1	4 × 40 ×	160	99.01	126.67	79.2
37	LN	Lumpini	4 × 40 ×	160	97.01	125.05	78.2	4 × 40 ×	160	90.80	116.76	73.0	4 × 40 ×	160	98.12	125.54	78.5
73	SL	Silom	2 × 40 ×	80	43.26	55.76	69.7	2 × 40 ×	80	44.46	57.17	71.5	2 × 40 ×	80	23.89	30.56	38.2
80	SU	Surawong	3 × 40 ×	120	61.58	79.38	66.2	3 × 40 ×	120	71.64	92.13	76.8	3 × 40 ×	120	38.49	49.24	41.0
116	YK	Yenarkart	4 × 40 ×	160	86.47	111.46	69.7	4 × 40 ×	160	96.42	123.99	77.5	4 × 40 ×	160	81.65	104.46	65.3
141	YN	Samyarn	3 × 40 ×	120	61.47	79.23	66.0	4 × 40 ×	160	84.14	108.20	67.6	4 × 40 ×	160	93.06	119.06	74.4
142	SH	Satorn	3 × 40 ×	120	61.32	79.04	65.9	4 × 40 ×	160	64.53	82.98	51.9	4 × 40 ×	160	98.22	125.66	78.5
189	AT	Satorntai	× ×	0	0.00		0.0	4 × 40 ×	160	77.51	99.68	62.3	4 × 40 ×	160	65.52	83.83	52.4
		New-sub 1	× ×	0	0.00		0.0	3 × 40 ×	120	60.02	77.18	64.3	4 × 40 ×	160	77.25	98.84	61.8
		Total		840	451.07	581.43	69.2		1280	681.67	876.59	68.5		1320	675.21	863.86	65.4

Case-3 (3 × 60MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.29	51.14	63.9	2 × 40 ×	80	38.00	49.16	61.5
37	LN	Lumpini	4 × 40 ×	160	85.39	111.14	69.5	4 × 40 ×	160	94.07	121.71	76.1
73	SL	Silom	2 × 40 ×	80	42.44	55.24	69.1	2 × 40 ×	80	37.10	48.00	60.0
80	SU	Surawong	3 × 40 ×	120	60.74	79.06	65.9	3 × 40 ×	120	69.71	90.19	75.2
116	YK	Yenarkart	2 × 40 ×	80	45.60	59.35	74.2	2 × 40 ×	80	44.81	57.98	72.5
141	YN	Samyarn	× ×	0	0.00		0.0	2 × 60 ×	120	42.50	54.99	45.8
142	SH	Satorn	× ×	0	0.00		0.0	2 × 60 ×	120	53.35	69.02	57.5
189	AT	Satorntai	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		520	273.46	355.93	68.4		760	379.54	491.05	64.6

No	ABB	Substation	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.96	51.51	64.4	3 × 60 ×	180	92.15	118.50	65.8	3 × 60 ×	180	85.69	109.63	60.9
37	LN	Lumpini	4 × 40 ×	160	97.01	125.05	78.2	3 × 40 1 × 60	180	103.19	132.70	73.7	3 × 40 1 × 60	180	106.56	136.34	75.7
73	SL	Silom	2 × 40 ×	80	43.26	55.76	69.7	2 × 40 ×	80	44.46	57.17	71.5	1 × 40 1 × 60	100	47.77	61.12	61.1
80	SU	Surawong	3 × 40 ×	120	61.58	79.38	66.2	3 × 40 ×	120	71.64	92.13	76.8	2 × 40 1 × 60	140	76.97	98.48	70.3
116	YK	Yenarkart	3 × 60 ×	180	86.47	111.46	61.9	3 × 60 ×	180	96.42	123.99	68.9	3 × 60 ×	180	81.65	104.46	58.0
141	YN	Samyarn	2 × 60 ×	120	61.47	79.23	66.0	3 × 60 ×	180	101.07	129.97	72.2	3 × 60 ×	180	90.96	116.38	64.7
142	SH	Satorn	2 × 60 ×	120	61.32	79.04	65.9	3 × 60 ×	180	95.22	122.45	68.0	3 × 60 ×	180	102.31	130.90	72.7
189	AT	Satorntai	× ×	0	0.00		0.0	3 × 60 ×	180	77.51	99.68	55.4	3 × 60 ×	180	83.28	106.55	59.2
		Total		860	451.07	581.43	67.6		1280	681.66	876.59	68.5		1320	675.19	863.86	65.4

Case-4 (3 × 80MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.29	51.14	63.9	2 × 40 ×	80	38.00	49.16	61.5
37	LN	Lumpini	4 × 40 ×	160	85.39	111.14	69.5	4 × 40 ×	160	98.41	127.32	79.6
73	SL	Silom	2 × 40 ×	80	42.44	55.24	69.1	2 × 40 ×	80	37.10	48.00	60.0
80	SU	Surawong	3 × 40 ×	120	60.74	79.06	65.9	3 × 40 ×	120	69.71	90.19	75.2
116	YK	Yenarkart	2 × 40 ×	80	45.60	59.35	74.2	2 × 40 ×	80	44.81	57.98	72.5
141	YN	Samyarn	× ×	0	0.00		0.0	2 × 80 ×	160	91.52	118.40	74.0
142	SH	Satorn	× ×	0	0.00		0.0	× ×	0	0.00		0.0
189	AT	Satorntai	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		520	273.46	355.93	68.4		680	379.55	491.05	72.2

No	ABB	Substation	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
32	KT	Klongtoey	2 × 40 ×	80	39.96	51.51	64.4	2 × 80 ×	160	92.15	118.50	74.1	2 × 80 ×	160	85.69	109.63	68.5
37	LN	Lumpini	4 × 40 ×	160	97.01	125.05	78.2	3 × 40 1 × 80	200	103.19	132.70	66.4	3 × 40 1 × 80	200	106.56	136.34	68.2
73	SL	Silom	2 × 40 ×	80	43.26	55.76	69.7	2 × 40 ×	80	44.46	57.17	71.5	1 × 40 1 × 80	120	47.77	61.12	50.9
80	SU	Surawong	3 × 40 ×	120	61.58	79.38	66.2	3 × 40 ×	120	71.64	92.13	76.8	3 × 40 ×	120	38.49	49.24	41.0
116	YK	Yenarkart	2 × 80 ×	160	86.47	111.46	69.7	3 × 80 ×	240	135.17	173.83	72.4	3 × 80 ×	240	123.28	157.73	65.7
141	YN	Samyarn	2 × 80 ×	160	61.47	79.23	49.5	3 × 80 ×	240	101.07	129.97	54.2	3 × 80 ×	240	129.45	165.62	69.0
142	SH	Satorn	2 × 80 ×	160	61.32	79.04	49.4	3 × 80 ×	240	133.98	172.29	71.8	3 × 80 ×	240	143.96	184.18	76.7
189	AT	Satorntai	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		920	451.07	581.43	63.2		1280	681.66	876.59	68.5		1320	675.20	863.86	65.4

Indoor type substation : Klongtoey(KT), Silom(SL), Surawong(SU)

Load-1 : Coincident load
Load-2 : Non-coincident load

	1996	2001	2006	2011	2016
Diversity factor	1.1805	1.1825	1.1820	1.1818	1.1818
Power factor	0.9070	0.9140	0.9170	0.9190	0.9237

Table 9.3-2 (b) Case Study of Substation (Phahol Yothin Area)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)
43	MC	Mochit	2 × 40 1 × (40)	120	44.52	57.95	48.3	2 × 40 1 × (40)	120	65.63	84.91	70.8	2 × 40 1 × 60	140	58.64	75.59	54.0
67	SM	Sailom	2 × 40 ×	80	45.29	58.95	73.7	2 × 40 ×	80	45.87	59.34	74.2	2 × 40 ×	80	40.54	52.26	65.3
69	SN	Samsen	3 × 40 ×	120	59.22	77.08	64.2	3 × 40 ×	120	64.56	83.52	69.6	3 × 40 ×	120	63.79	82.22	68.5
89	YT	Yothee	2 × 40 ×	80	34.63	45.07	56.3	2 × 40 ×	80	44.10	57.05	71.3	2 × 40 ×	80	42.16	54.34	67.9
104	PP	Pradipat	2 × (40) ×	80	37.76	49.15	61.4	1 × (40) 1 × 60	100	53.33	68.99	69.0	2 × 60 ×	120	64.06	82.57	68.8
122	DD	Dindaeng	× ×	0	0.00		0.0	2 × (40) ×	80	45.40	58.74	73.4	2 × 60 ×	120	62.44	80.48	67.1
168	NP	Sanampao	× ×	0	0.00		0.0	× ×	0	0.00		0.0	2 × 60 ×	120	63.80	82.24	68.5
187	RO	Rajchakru	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		480	221.42	288.20	60.0		580	318.89	412.55	71.1		780	395.43	509.70	65.3

No	ABB	Substation	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
43	MC	Mochit	2 × 40 1 × 60	140	73.06	93.95	67.1	2 × 40 1 × 60	140	80.14	102.53	73.2
67	SM	Sailom	2 × 40 ×	80	41.28	53.09	66.4	1 × 40 1 × 60	100	50.76	64.94	64.9
69	SN	Samsen	3 × 40 ×	120	68.45	88.02	73.4	2 × 40 1 × 60	140	84.16	107.68	76.9
89	YT	Yothee	2 × 40 ×	80	43.27	55.64	69.6	2 × 40 ×	80	46.49	59.48	74.4
104	PP	Pradipat	3 × 60 ×	180	87.95	113.10	62.8	3 × 60 ×	180	108.13	138.35	76.9
122	DD	Dindaeng	3 × 60 ×	180	70.75	90.98	50.5	3 × 60 ×	180	81.85	104.72	58.2
168	NP	Sanampao	2 × 60 ×	120	54.13	69.61	58.0	2 × 60 ×	120	66.55	85.15	71.0
187	RO	Rajchakru	2 × 60 ×	120	55.48	71.35	59.5	2 × 60 ×	120	68.22	87.28	72.7
		Total		1020	494.37	635.74	62.3		1060	586.30	750.13	70.8

Case-1 (3 × 40MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	44.52	57.95	48.3	3 × 40 ×	120	65.63	84.91	70.8	3 × 40 ×	120	58.64	75.59	63.0
67	SM	Sailom	2 × 40 ×	80	45.29	58.95	73.7	2 × 40 ×	80	45.87	59.34	74.2	2 × 40 ×	80	40.54	52.26	65.3
69	SN	Samsen	3 × 40 ×	120	59.22	77.08	64.2	3 × 40 ×	120	64.56	83.52	69.6	3 × 40 ×	120	63.79	82.22	68.5
89	YT	Yothee	2 × 40 ×	80	34.63	45.07	56.3	2 × 40 ×	80	44.10	57.05	71.3	2 × 40 ×	80	42.16	54.34	67.9
104	PP	Pradipat	2 × 40 ×	80	37.76	49.15	61.4	3 × 40 ×	120	53.33	68.99	57.5	3 × 40 ×	120	64.06	82.57	68.8
122	DD	Dindaeng	× ×	0	0.00		0.0	2 × 40 ×	80	45.40	58.74	73.4	3 × 40 ×	120	62.44	80.48	67.1
168	NP	Sanampao	× ×	0	0.00		0.0	× ×	0	0.00		0.0	3 × 40 ×	120	63.80	82.24	68.5
187	RO	Rajchakru	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		New-sub 1	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		New-sub 2	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		480	221.42	288.20	60.0		600	318.89	412.55	68.8		760	395.43	509.70	67.1

No	ABB	Substation	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	73.06	93.95	78.3	3 × 40 ×	120	68.11	87.14	72.6
67	SM	Sailom	2 × 40 ×	80	41.28	53.09	66.4	2 × 40 ×	80	45.11	57.72	72.2
69	SN	Samsen	3 × 40 ×	120	58.68	75.46	62.9	3 × 40 ×	120	72.13	92.28	76.9
89	YT	Yothee	2 × 40 ×	80	43.27	55.64	69.6	2 × 40 ×	80	46.49	59.48	74.4
104	PP	Pradipat	3 × 40 ×	120	72.24	92.90	77.4	3 × 40 ×	120	73.38	93.89	78.2
122	DD	Dindaeng	3 × 40 ×	120	70.75	90.98	75.8	3 × 40 ×	120	58.46	74.80	62.3
168	NP	Sanampao	3 × 40 ×	120	54.13	69.61	58.0	3 × 40 ×	120	66.55	85.15	71.0
187	RO	Rajchakru	3 × 40 ×	120	55.48	71.35	59.5	3 × 40 ×	120	68.22	87.28	72.7
		New-sub 1	2 × 40 ×	80	25.48	32.76	41.0	3 × 40 ×	120	46.79	59.86	49.9
		New-sub 2	× ×	0	0.00		0.0	2 × 40 ×	80	41.06	52.53	65.7
		Total		960	494.37	635.74	66.2		1080	586.30	750.13	69.5

Case-2 (4 × 40MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	44.52	57.95	48.3	3 × 40 ×	120	65.63	84.91	70.8	3 × 40 ×	120	58.64	75.59	63.0
67	SM	Sailom	2 × 40 ×	80	45.29	58.95	73.7	2 × 40 ×	80	45.87	59.34	74.2	2 × 40 ×	80	40.54	52.26	65.3
69	SN	Samsen	3 × 40 ×	120	59.22	77.08	64.2	3 × 40 ×	120	64.56	83.52	69.6	3 × 40 ×	120	63.79	82.22	68.5
89	YT	Yothee	2 × 40 ×	80	34.63	45.07	56.3	2 × 40 ×	80	44.10	57.05	71.3	2 × 40 ×	80	42.16	54.34	67.9
104	PP	Pradipat	2 × 40 ×	80	37.76	49.15	61.4	3 × 40 ×	120	53.33	68.99	57.5	3 × 40 ×	120	64.06	82.57	68.8
122	DD	Dindaeng	× ×	0	0.00		0.0	2 × 40 ×	80	45.40	58.74	73.4	3 × 40 ×	120	62.44	80.48	67.1
168	NP	Sanampao	× ×	0	0.00		0.0	× ×	0	0.00		0.0	3 × 40 ×	120	63.80	82.24	68.5
187	RO	Rajchakru	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		480	221.42	288.20	60.0		600	318.89	412.55	68.8		760	395.43	509.70	67.1

No	ABB	Substation	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	73.06	93.95	78.3	4 × 40 ×	160	80.14	102.53	64.1
67	SM	Sailom	2 × 40 ×	80	41.28	53.09	66.4	2 × 40 ×	80	45.11	57.72	72.2
69	SN	Samsen	3 × 40 ×	120	68.45	88.02	73.4	4 × 40 ×	160	84.16	107.68	67.3
89	YT	Yothee	2 × 40 ×	80	43.27	55.64	69.6	2 × 40 ×	80	46.49	59.48	74.4
104	PP	Pradipat	4 × 40 ×	160	87.95	113.10	70.7	4 × 40 ×	160	96.55	123.53	77.2
122	DD	Dindaeng	3 × 40 ×	120	70.75	90.98	75.8	4 × 40 ×	160	81.85	104.72	65.5
168	NP	Sanampao	3 × 40 ×	120	54.13	69.61	58.0	3 × 40 ×	120	66.55	85.15	71.0
187	RO	Rajchakru	3 × 40 ×	120	55.48	71.35	59.5	4 × 40 ×	160	85.44	109.32	68.3
		Total		920	494.37	635.74	69.1		1080	586.29	750.13	69.5

Case-3 (3 × 60MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	44.52	57.95	48.3	3 × 40 ×	120	65.63	84.91	70.8	3 × 40 ×	120	58.64	75.59	63.0
67	SM	Sailom	2 × 40 ×	80	45.29	58.95	73.7	2 × 40 ×	80	45.87	59.34	74.2	2 × 40 ×	80	40.54	52.26	65.3
69	SN	Samsen	3 × 40 ×	120	59.22	77.08	64.2	3 × 40 ×	120	64.56	83.52	69.6	3 × 40 ×	120	63.79	82.22	68.5
89	YT	Yothee	2 × 40 ×	80	34.63	45.07	56.3	2 × 40 ×	80	44.10	57.05	71.3	2 × 40 ×	80	42.16	54.34	67.9
104	PP	Pradipat	2 × 40 ×	80	37.76	49.15	61.4	2 × 60 ×	120	53.33	68.99	57.5	2 × 60 ×	120	64.06	82.57	68.8
122	DD	Dindaeng	× ×	0	0.00		0.0	2 × 60 ×	120	45.40	58.74	49.0	2 × 60 ×	120	62.44	80.48	67.1
168	NP	Sanampao	× ×	0	0.00		0.0	× ×	0	0.00		0.0	2 × 60 ×	120	63.80	82.24	68.5
187	RO	Rajchakru	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		480	221.42	288.20	60.0		640	318.89	412.55	64.5		760	395.43	509.70	67.1

No	ABB	Substation	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	73.06	93.95	78.3	2 × 40 1 × 60	140	80.14	102.53	73.2
67	SM	Sailom	2 × 40 ×	80	41.28	53.09	66.4	1 × 40 1 × 60	100	50.76	64.94	64.9
69	SN	Samsen	3 × 40 ×	120	68.45	88.02	73.4	2 × 40 1 × 60	140	84.16	107.68	76.9
89	YT	Yothee	2 × 40 ×	80	43.27	55.64	69.6	2 × 40 ×	80	46.49	59.48	74.4
104	PP	Pradipat	3 × 60 ×	180	87.95	113.10	62.8	3 × 60 ×	180	108.13	138.35	76.9
122	DD	Dindaeng	3 × 60 ×	180	70.75	90.98	50.5	3 × 60 ×	180	81.85	104.72	58.2
168	NP	Sanampao	2 × 60 ×	120	54.13	69.61	58.0	2 × 60 ×	120	66.55	85.15	71.0
187	RO	Rajchakru	2 × 60 ×	120	55.48	71.35	59.5	2 × 60 ×	120	68.22	87.28	72.7
		Total		1000	494.37	635.74	63.6		1060	586.30	750.13	70.8

Case-4 (3 × 80MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	44.52	57.95	48.3	3 × 40 ×	120	65.63	84.91	70.8	3 × 40 ×	120	58.64	75.59	63.0
67	SM	Sailom	2 × 40 ×	80	45.29	58.95	73.7	2 × 40 ×	80	41.21	53.31	66.6	2 × 40 ×	80	40.54	52.26	65.3
69	SN	Samsen	3 × 40 ×	120	59.22	77.08	64.2	3 × 40 ×	120	64.56	83.52	69.6	3 × 40 ×	120	63.79	82.22	68.5
89	YT	Yothee	2 × 40 ×	80	34.63	45.07	56.3	2 × 40 ×	80	44.10	57.05	71.3	2 × 40 ×	80	42.16	54.34	67.9
104	PP	Pradipat	2 × 40 ×	80	37.76	49.15	61.4	2 × 40 ×	80	41.92	54.23	67.8	2 × 80 ×	160	64.06	82.57	51.6
122	DD	Dindaeng	× ×	0	0.00		0.0	2 × 80 ×	160	61.47	79.53	49.7	2 × 80 ×	160	62.44	80.48	50.3
168	NP	Sanampao	× ×	0	0.00		0.0	× ×	0	0.00		0.0	2 × 80 ×	160	63.80	82.24	51.4
187	RO	Rajchakru	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		480	221.42	288.20	60.0		640	318.89	412.55	64.5		880	395.43	509.70	57.9

No	ABB	Substation	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
43	MC	Mochit	3 × 40 ×	120	73.06	93.95	78.3	2 × 40 1 × 80	160	80.14	102.53	64.1
67	SM	Sailom	2 × 40 ×	80	41.28	53.09	66.4	1 × 40 1 × 80	120	50.76	64.94	54.1
69	SN	Samsen	3 × 40 ×	120	68.45	88.02	73.4	2 × 40 1 × 80	160	84.16	107.68	67.3
89	YT	Yothee	2 × 40 ×	80	43.27	55.64	69.6	2 × 40 ×	80	46.49	59.48	74.4
104	PP	Pradipat	3 × 80 ×	240	115.70	148.78	62.0	3 × 80 ×	240	142.24	181.99	75.8
122	DD	Dindaeng	2 × 80 ×	160	70.75	90.98	56.9	2 × 80 ×	160	89.24	114.18	71.4
168	NP	Sanampao	2 × 80 ×	160	81.87	105.28	65.8	2 × 80 ×	160	93.27	119.33	74.6
187	RO	Rajchakru	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		960	494.38	635.74	66.2		1080	586.30	750.13	69.5

Indoor type substation : Sailom(SM), Yothee(YT)

Load-1 : Coincident load
Load-2 : Non-coincident load

	1996	2001	2006	2011	2016
Diversity factor	1.1805	1.1825	1.1820	1.1818	1.1818
Power factor	0.9070	0.9140	0.9170	0.9190	0.9237

Table 9.3-2 (c) Case Study of Substation (Jomthong Area)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
9	BM	Bangmod	2 × (40) ×	80	39.40	51.28	64.1	2 × (40) 1 × 60	140	71.30	92.24	65.9	3 × 60 ×	180	76.79	98.98	55.0	3 × 60 ×	180	84.49	108.65	60.4	3 × 60 ×	180	86.78	111.03	61.7
33	WC	Klongwatsing	2 × (40) ×	80	29.39	38.25	47.8	2 × 60 ×	120	43.20	55.89	46.6	2 × 60 ×	120	56.41	72.71	60.6	3 × 60 ×	180	76.38	98.22	54.6	3 × 60 ×	180	97.36	124.56	69.2
38	MN	Mahaisawan	2 × 40 1 × 60	140	36.14	47.04	33.6	2 × 40 1 × 60	140	62.04	80.27	57.3	2 × 40 1 × 60	140	59.00	76.05	54.3	2 × 40 1 × 60	140	73.36	94.34	67.4	2 × 40 1 × 60	140	75.35	96.40	68.9
52	PS	Petchkasem	1 × 40 2 × 22.4	84.8	44.76	58.26	68.7	1 × 40 2 × 22.4	84.8	42.58	55.09	65.0	1 × 40 1 × 60	100	44.25	57.04	57.0	1 × 40 1 × 60	100	50.41	64.82	64.8	2 × 60 ×	120	62.00	79.33	66.1
81	TS	Taksin	2 × 40 ×	80	34.68	45.14	56.4	2 × 40 ×	80	37.47	48.48	60.6	2 × 40 ×	80	42.08	54.24	67.8	2 × 40 ×	80	42.58	54.76	68.5	2 × 40 ×	80	43.73	55.95	69.9
151	WR	Wuttakart	× ×	0	0.00		0.0	2 × 60 ×	120	33.32	43.11	35.9	2 × 60 ×	120	44.09	56.83	47.4	2 × 60 ×	120	50.74	65.25	54.4	2 × 60 ×	120	53.78	68.81	57.3
		Total		464.8	184.37	239.97	51.6		684.8	289.91	375.08	54.8		740	322.62	415.85	56.2		800	377.96	486.04	60.8		820	419.00	536.08	65.4

Case-1 (3 × 40MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
9	BM	Bangmod	2 × 40 ×	80	39.40	51.28	64.1	3 × 40 ×	120	71.30	92.24	76.9	3 × 40 ×	120	70.78	91.23	76.0	3 × 40 ×	120	63.37	81.49	67.9	3 × 40 ×	120	65.06	83.24	69.4
33	WC	Klongwatsing	2 × 40 ×	80	29.39	38.25	47.8	2 × 40 ×	80	43.20	55.89	69.9	3 × 40 ×	120	56.41	72.71	60.6	3 × 40 ×	120	69.33	89.16	74.3	3 × 40 ×	120	73.03	93.44	77.9
38	MN	Mahaisawan	3 × 40 ×	120	36.14	47.04	39.2	3 × 40 ×	120	62.04	80.27	66.9	3 × 40 ×	120	59.00	76.05	63.4	3 × 40 ×	120	73.36	94.34	78.6	3 × 40 ×	120	46.02	58.88	49.1
52	PS	Petchkasem	1 × 40 2 × 22.4	84.8	44.76	58.26	68.7	1 × 40 2 × 22.4	84.8	42.58	55.09	65.0	2 × 40 ×	80	44.25	57.04	71.3	3 × 40 ×	120	50.41	64.82	54.0	3 × 40 ×	120	62.00	79.33	66.1
81	TS	Taksin	2 × 40 ×	80	34.68	45.14	56.4	2 × 40 ×	80	37.47	48.48	60.6	2 × 40 ×	80	42.08	54.24	67.8	2 × 40 ×	80	42.58	54.76	68.5	2 × 40 ×	80	43.73	55.95	69.9
151	WR	Wuttakart	× ×	0	0.00		0.0	2 × 40 ×	80	33.32	43.11	53.9	3 × 40 ×	120	50.10	64.58	53.8	3 × 40 ×	120	50.74	65.25	54.4	3 × 40 ×	120	53.78	68.81	57.3
		New-sub 1	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0	2 × 40 ×	80	28.17	36.22	45.3	2 × 40 ×	80	46.04	58.91	73.6
		New-sub 2	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0	2 × 40 ×	80	29.33	37.52	46.9
		Total		444.8	184.37	239.97	54.0		564.8	289.91	375.08	66.4		640	322.62	415.85	65.0		760	377.96	486.04	64.0		840	418.99	536.08	63.8

Case-2 (4 × 40MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
9	BM	Bangmod	2 × 40 ×	80	39.40	51.28	64.1	3 × 40 ×	120	71.30	92.24	76.9	3 × 40 ×	120	70.78	91.23	76.0	4 × 40 ×	160	84.49	108.65	67.9	4 × 40 ×	160	86.78	111.03	69.4
33	WC	Klongwatsing	2 × 40 ×	80	29.39	38.25	47.8	2 × 40 ×	80	43.20	55.89	69.9	3 × 40 ×	120	56.41	72.71	60.6	4 × 40 ×	160	76.38	98.22	61.4	4 × 40 ×	160	85.19	109.00	68.1
38	MN	Mahaisawan	3 × 40 ×	120	36.14	47.04	39.2	3 × 40 ×	120	62.04	80.27	66.9	3 × 40 ×	120	59.00	76.05	63.4	3 × 40 ×	120	73.36	94.34	78.6	3 × 40 ×	120	46.02	58.88	49.1
52	PS	Petchkasem	1 × 40 2 × 22.4	84.8	44.76	58.26	68.7	1 × 40 2 × 22.4	84.8	42.58	55.09	65.0	2 × 40 ×	80	44.25	57.04	71.3	3 × 40 ×	120	50.41	64.82	54.0	4 × 40 ×	160	74.17	94.89	59.3
81	TS	Taksin	2 × 40 ×	80	34.68	45.14	56.4	2 × 40 ×	80	37.47	48.48	60.6	2 × 40 ×	80	42.08	54.24	67.8	2 × 40 ×	80	42.58	54.76	68.5	2 × 40 ×	80	43.73	55.95	69.9
151	WR	Wuttakart	× ×	0	0.00		0.0	2 × 40 ×	80	33.32	43.11	53.9	3 × 40 ×	120	50.10	64.58	53.8	3 × 40 ×	120	50.74	65.25	54.4	4 × 40 ×	160	83.11	106.33	66.5
		Total		444.8	184.37	239.97	54.0		564.8	289.91	375.08	66.4		640	322.62	415.85	65.0		760	377.96	486.04	64.0		840	419.00	536.08	63.8

Case-3 (3 × 60MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
9	BM	Bangmod	2 × 40 ×	80	39.40	51.28	64.1	2 × 40 1 × 60	140	71.30	92.24	65.9	3 × 60 ×	180	76.79	98.98	55.0	3 × 60 ×	180	84.49	108.65	60.4	3 × 60 ×	180	86.78	111.03	61.7
33	WC	Klongwatsing	2 × 40 ×	80	29.39	38.25	47.8	2 × 40 ×	80	43.20	55.89	69.9	2 × 60 ×	120	56.41	72.71	60.6	3 × 60 ×	180	76.38	98.22	54.6	3 × 60 ×	180	97.36	124.56	69.2
38	MN	Mahaisawan	3 × 40 ×	120	36.14	47.04	39.2	3 × 40 ×	120	62.04	80.27	66.9	3 × 40 ×	120	59.00	76.05	63.4	2 × 40 1 × 60	140	73.36	94.34	67.4	2 × 40 1 × 60	140	75.35	96.40	68.9
52	PS	Petchkasem	1 × 40 2 × 22.4	84.8	44.76	58.26	68.7	1 × 40 2 × 22.4	84.8	42.58	55.09	65.0	1 × 40 1 × 60	100	44.25	57.04	57.0	1 × 40 1 × 60	100	50.41	64.82	64.8	2 × 60 ×	120	62.00	79.33	66.1
81	TS	Taksin	2 × 40 ×	80	34.68	45.14	56.4	2 × 40 ×	80	37.47	48.48	60.6	2 × 40 ×	80	42.08	54.24	67.8	2 × 40 ×	80	42.58	54.76	68.5	2 × 40 ×	80	43.73	55.95	69.9
151	WR	Wuttakart	× ×	0	0.00		0.0	2 × 60 ×	120	33.32	43.11	35.9	2 × 60 ×	120	44.09	56.83	47.4	2 × 60 ×	120	50.74	65.25	54.4	2 × 60 ×	120	53.78	68.81	57.3
		Total		444.8	184.37	239.97	54.0		624.8	289.91	375.08	60.0		720	322.62	415.85	57.8		800	377.96	486.04	60.8		820	419.00	536.08	65.4

Case-4 (3 × 80MVA)

No	ABB	Substation	1996 Bank configuration	1996 Capacity (MVA)	1996 Load-1 (MW)	1996 Load-2 (MVA)	1996 Utilization factor (%)	2001 Bank configuration	2001 Capacity (MVA)	2001 Load-1 (MW)	2001 Load-2 (MVA)	2001 Utilization factor (%)	2006 Bank configuration	2006 Capacity (MVA)	2006 Load-1 (MW)	2006 Load-2 (MVA)	2006 Utilization factor (%)	2011 Bank configuration	2011 Capacity (MVA)	2011 Load-1 (MW)	2011 Load-2 (MVA)	2011 Utilization factor (%)	2016 Bank configuration	2016 Capacity (MVA)	2016 Load-1 (MW)	2016 Load-2 (MVA)	2016 Utilization factor (%)
9	BM	Bangmod	2 × 40 ×	80	39.40	51.28	64.1	2 × 40 1 × 80	160	71.30	92.24	57.7	1 × 40 2 × 80	200	104.64	134.88	67.4	1 × 40 2 × 80	200	111.05	142.80	71.4	3 × 80 ×	240	114.12	146.01	60.8
33	WC	Klongwatsing	2 × 40 ×	80	29.39	38.25	47.8	2 × 80 ×	160	71.26	92.19	57.6	2 × 80 ×	160	68.01	87.66	54.8	3 × 80 ×	240	100.56	129.32	53.9	3 × 80 ×	240	132.01	168.89	70.4
38	MN	Mahaisawan	3 × 40 ×	120	36.14	47.04	39.2	2 × 40 1 × 80	160	67.31	87.08	54.4	2 × 40 1 × 80	160	63.64	82.03	51.3	2 × 40 1 × 80	160	73.36	94.34	59.0	2 × 40 1 × 80	160	78.63	100.60	62.9
52	PS	Petchkasem	1 × 40 2 × 22.4	84.8	44.76	58.26	68.7	1 × 40 2 × 22.4	84.8	42.58	55.09	65.0	1 × 40 1 × 80	120	44.25	57.04	47.5	1 × 40 1 × 80	120	50.41	64.82	54.0	1 × 40 1 × 80	120	50.52	64.63	53.9
81	TS	Taksin	2 × 40 ×	80	34.68	45.14	56.4	2 × 40 ×	80	37.47	48.48	60.6	2 × 40 ×	80	42.08	54.24	67.8	2 × 40 ×	80	42.58	54.76	68.5	2 × 40 ×	80	43.73	55.95	69.9
151	WR	Wuttakart	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0	× ×	0	0.00		0.0
		Total		444.8	184.37	239.97	54.0		644.8	289.92	375.08	58.2		720	322.62	415.85	57.8		800	377.96	486.04	60.8		840	419.01	536.08	63.8

Indoor type substation : Mahaisawan(MN), Taksin(TS)

Load-1 : Coincident load
Load-2 : Non-coincident load

	1996	2001	2006	2011	2016
Diversity factor	1.1805	1.1825	1.1820	1.1818	1.1818
Power factor	0.9070	0.9140	0.9170	0.9190	0.9237

Figures indicated in parentheses are correspond to the expansion work numbers in Table 9.3-3.
Figures underneath symbol of substation mean the maximum load in MVA

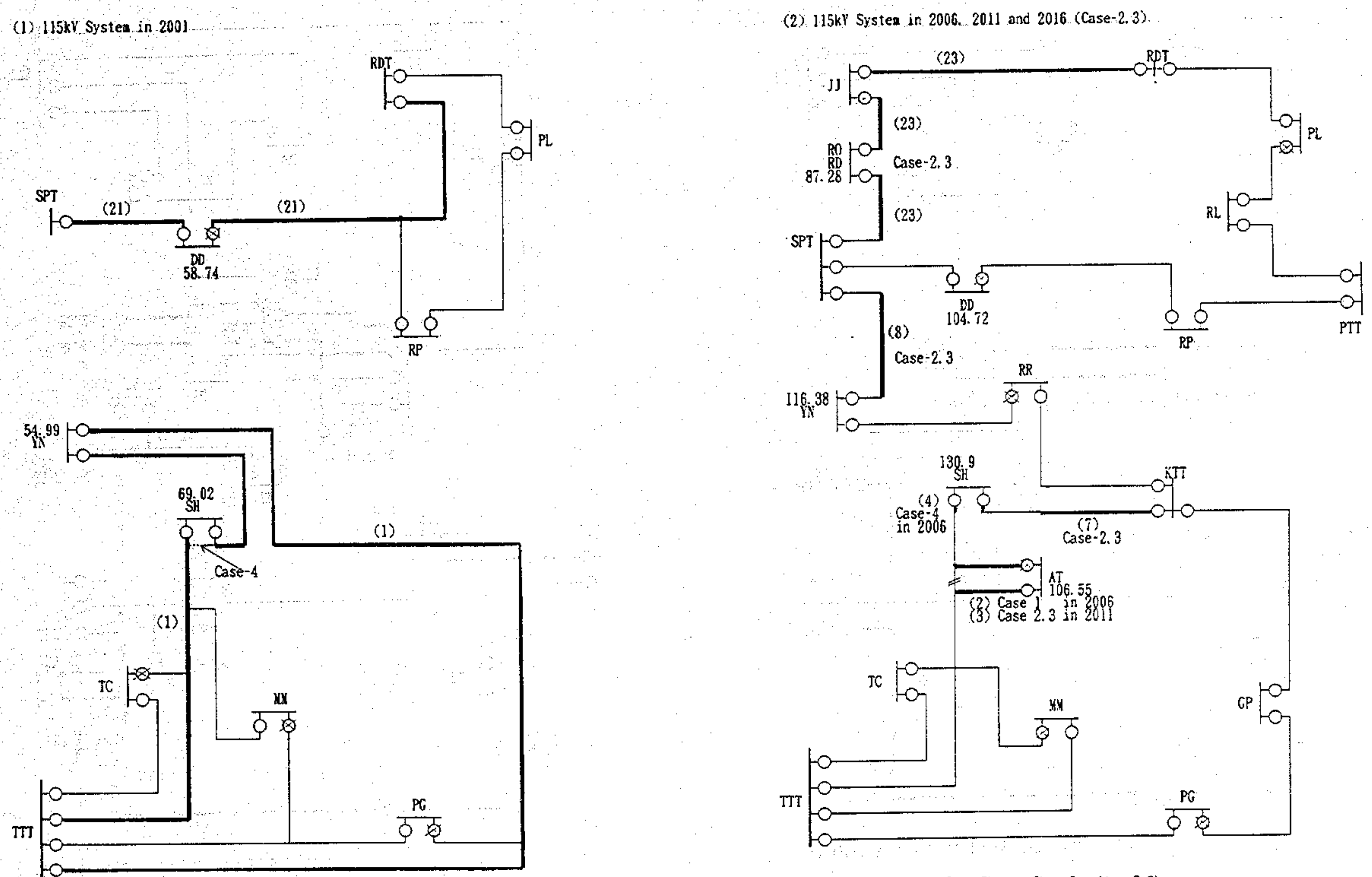
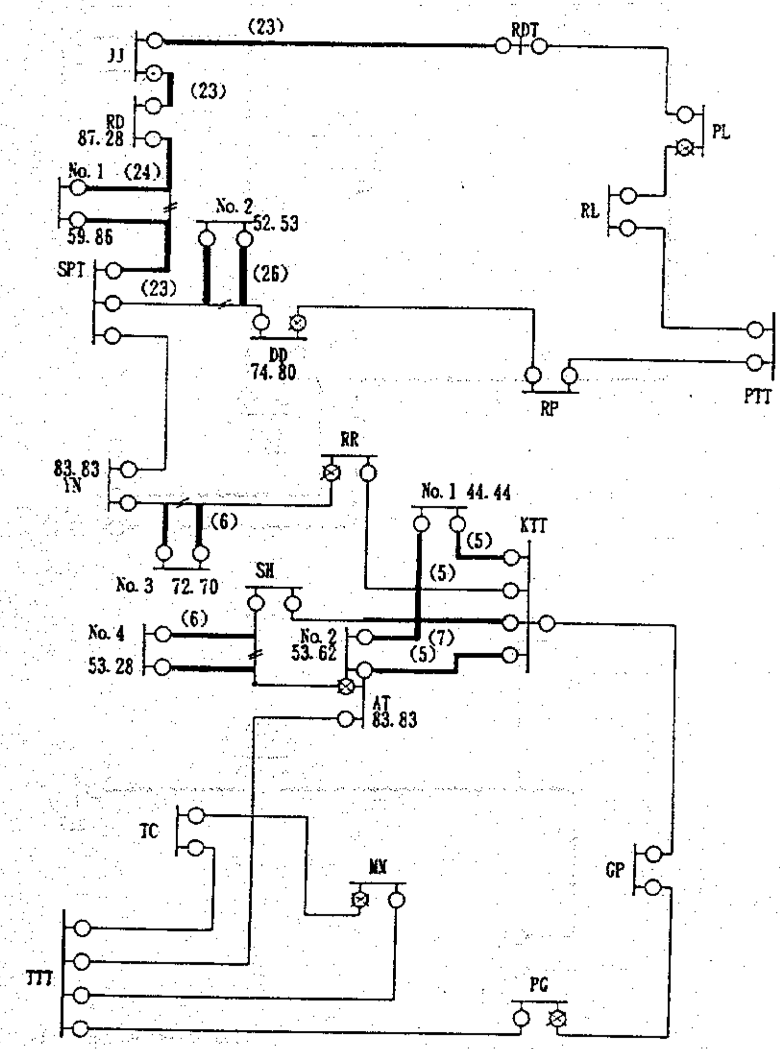


Fig. 9.3-2 System Configuration for Case Study (1 of 6)

(3) 115kV System in 2011 and 2016 (Case-1)



(4) 115kV System in 2011 and 2016 (Case-4)

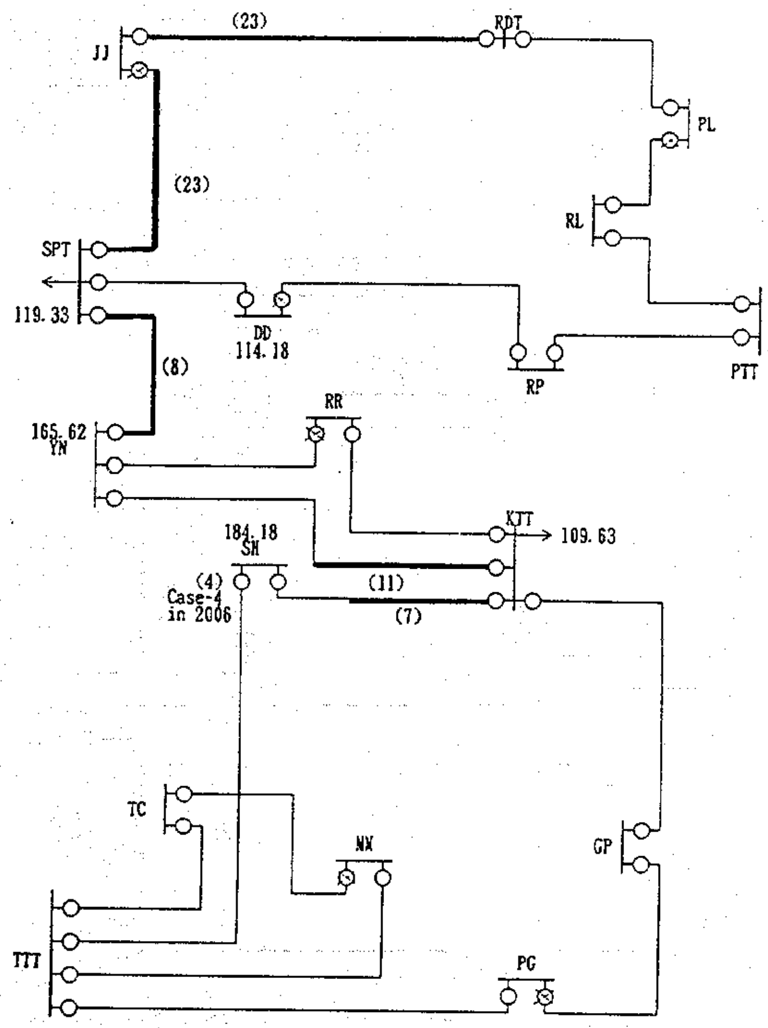
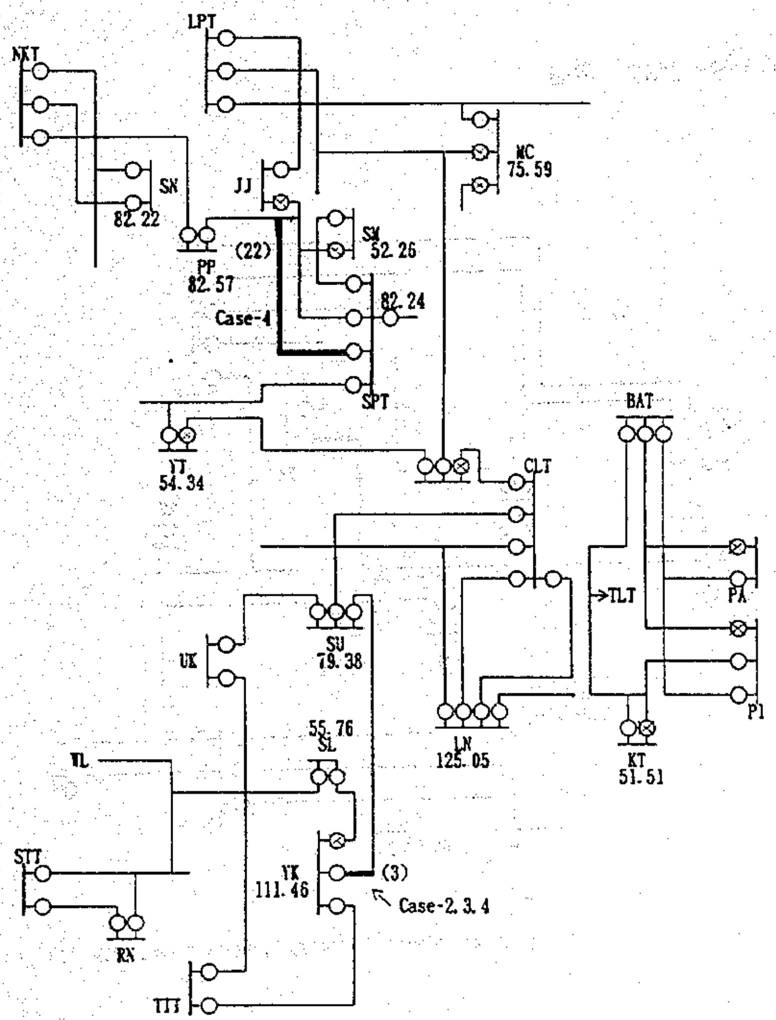


Fig. 9.3-2 System Configuration for Case Study (2 of 6)

(5) 69kV System in 2006 (Sathorn and Phahol Yothin)



(6) 69kV System in 2011 and 2016. (Satohrn and Phahol Yothin)

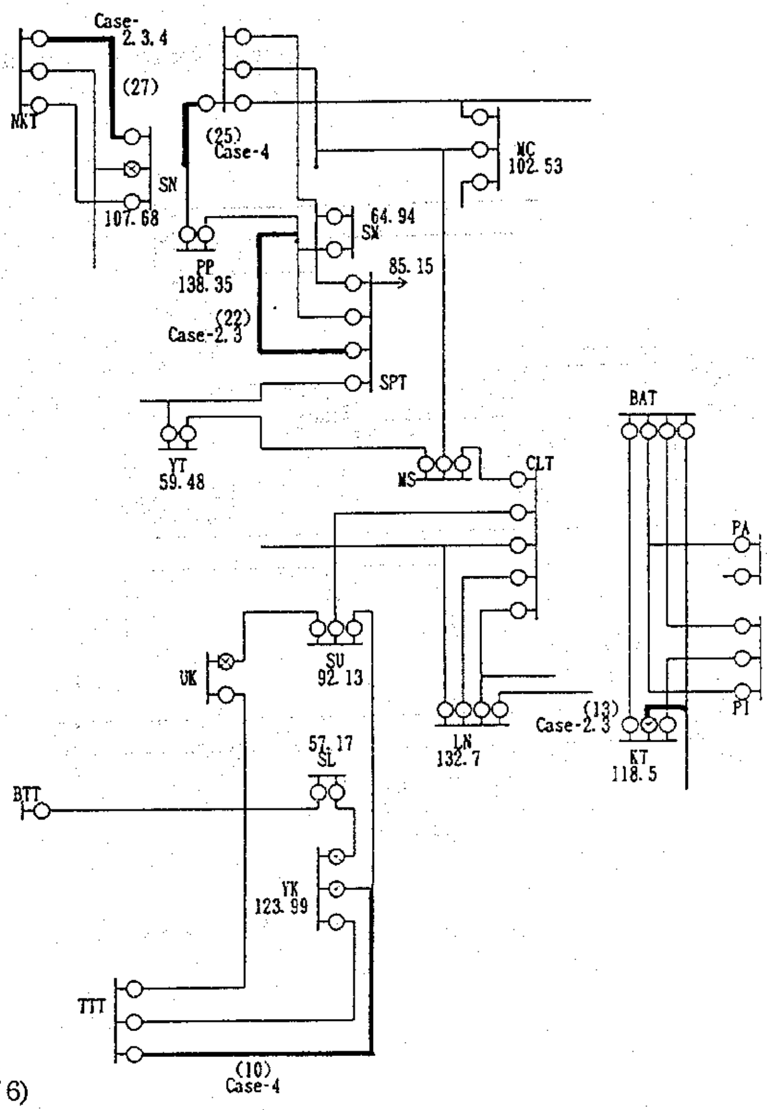
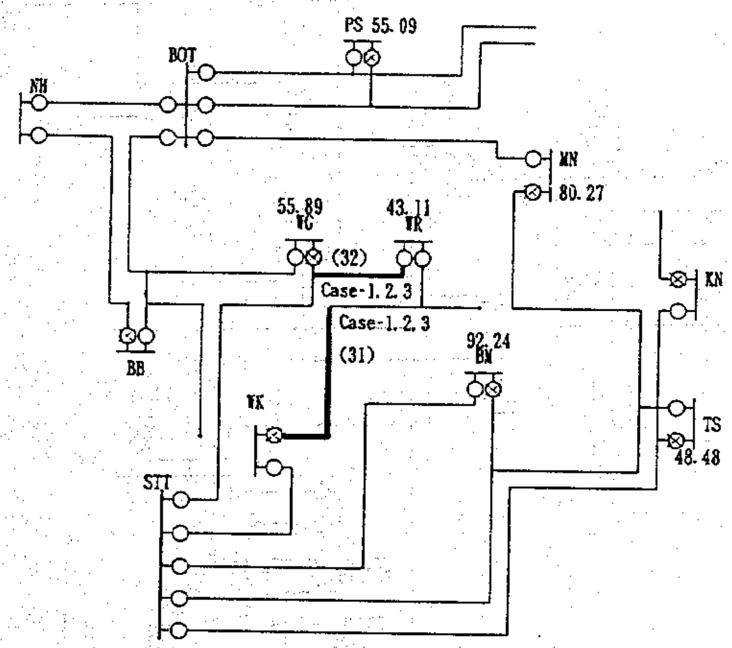


Fig. 9.3-2 System Configuration for Case Study (3 of 6)

(7) 69kV System in 2001 (Joathong Area) (Case-1, 2, 3)



(8) 69kV System in 2006 (Joathong Area) (Case-1, 2, 3)

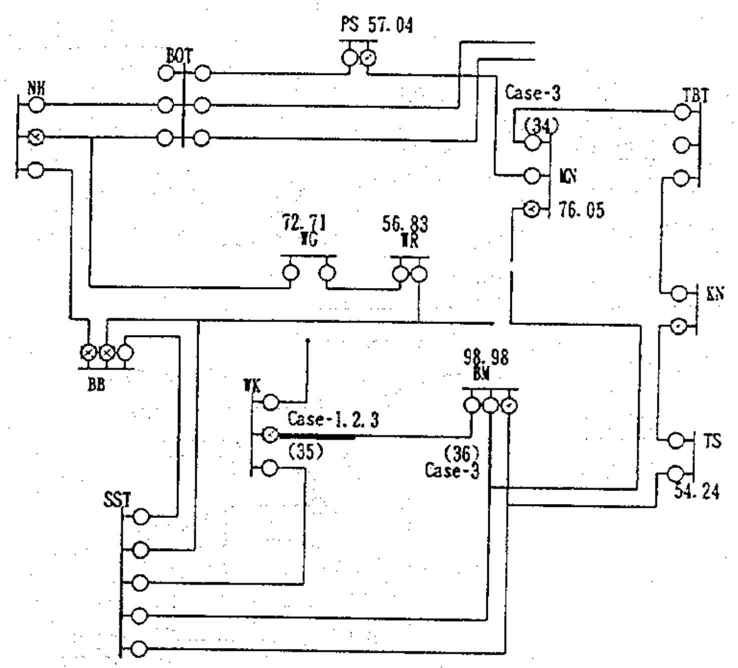
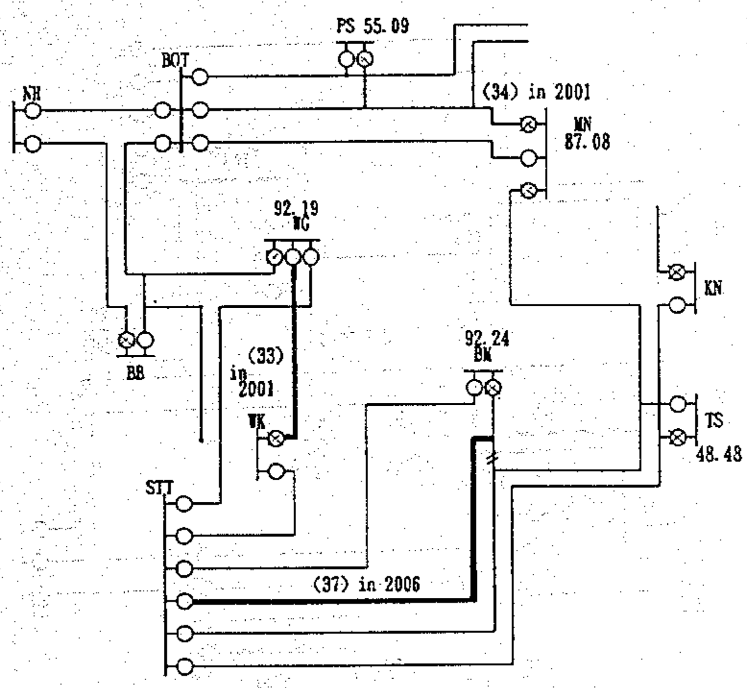


Fig. 9.3-2 System Configuration for Case Study (4 of 6)

(9) 69kV System in 2001 and 2006 (Jomthong Area) (Case-4)



(10) 69kV System in 2011 and 2016 (Jomthong Area) (Case-1)

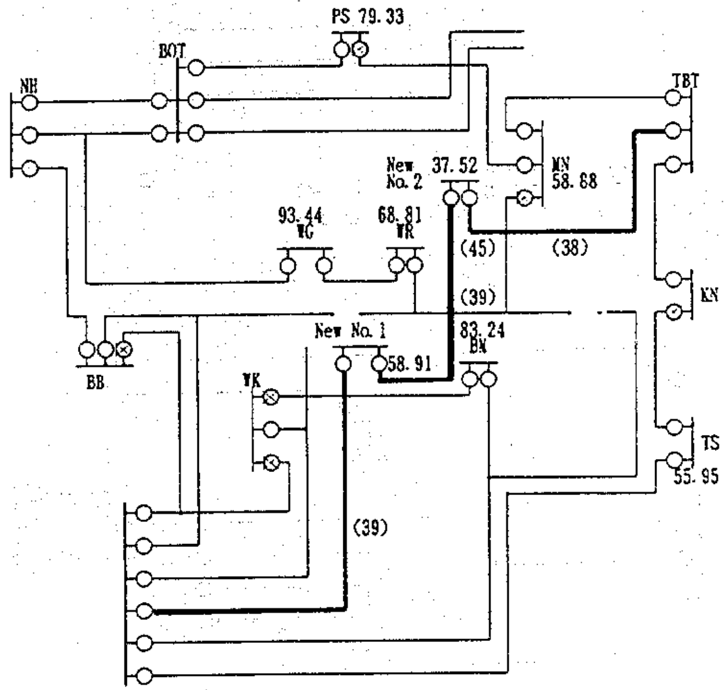
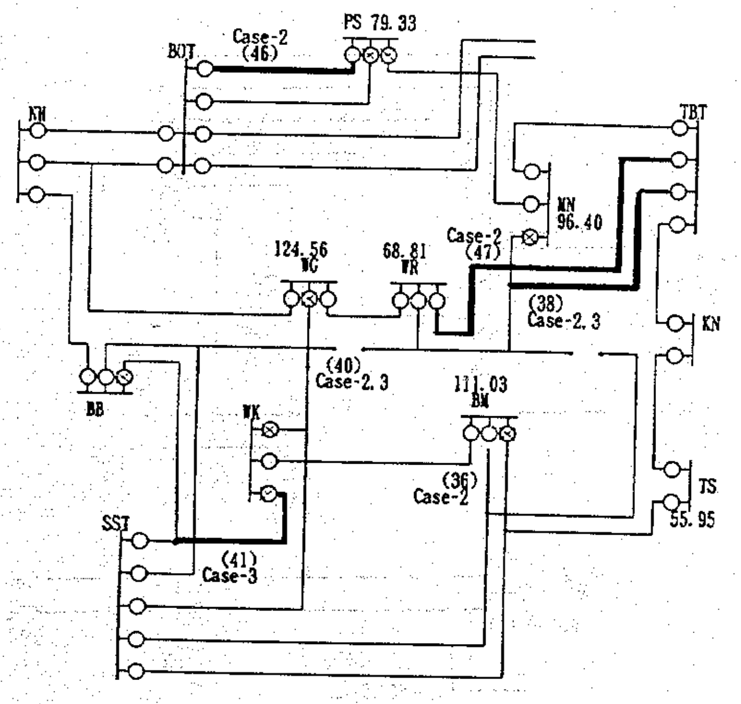


Fig. 9.3-2 System Configuration for Case Study (5 of 6)

(11) 69kV System in 2011 and 2016 (Joothong Area) (Case-2, 3)



(12) 69kV System in 2011 and 2016 (Joothong Area) (Case-4)

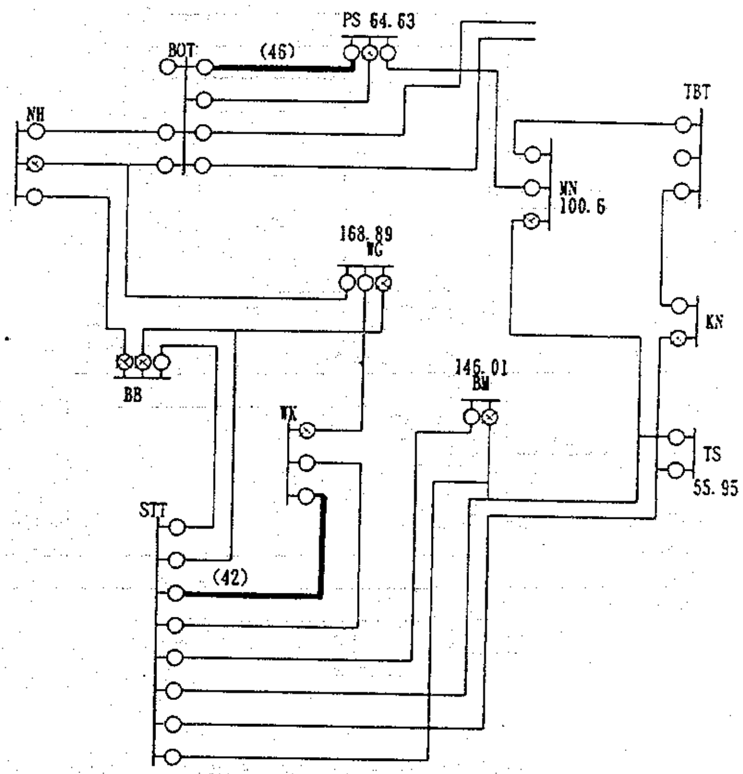


Fig. 9.3-2 System Configuration for Case Study (6 of 6)

Table 9.3-3 (a) Cost of Case Study (Sathorn Area)

		2001		2006		2011		2016		Total	
		Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)
Case-1	Substation	New Samyarn(YN) : 2×40 (115kV) Satorn(SH) : 3×40 (115kV)	152,200 170,600	New Satorntai(AT) : 2×40 (115kV) Addition of capacity Yenarkart(YK) : 2×40 to 3×40 Samyarn(YN) : 2×40 to 3×40	152,200 17,300 18,400	New New-substation 1 : 2×40 New-substation 2 : 2×40 New-substation 3 : 2×40 New-substation 4 : 2×40 Addition of capacity Klongtoey(KT) : 2×40 to 3×40 Satorntai(AT) : 2×40 to 3×40	152,200 152,200 152,200 152,200 17,300 18,400	Addition of capacity New-substation 3 : 2×40 to 3×40	18,400	New 7 substations 600 MVA Addition of capacity 5 substations 200 MVA	1,083,800 89,800
		Sub-Amount	(322,800) 322,800	Sub-Amount	(133,970) 187,900	Sub-Amount	(327,630) 644,500	Sub-Amount	(6,670) 18,400	Sub-Amount	(791,070) 1,173,600
	Line	(1) Thanontok-YN-SH-Thanontok 2*400 14.7km, 2*800 12.5km	284,500 52,553	(2) Link Satorntai 2*800 1.0km	22,760	(5) New-ss 1,2 Klongtoey loop 2*800 7km (6) New-ss 3,4 Branch near YN and SH 2*800 4km (7) Klongtoey-Sat.Rd. 2*800 1.2km (8) Sanampao-YN 2*800 4.6km	159,320 91,040 27,312 104,696				
		Sub-Amount	(337,053) 337,053	Sub-Amount	(16,230) 22,760	Sub-Amount	(194,380) 382,368	Sub-Amount	()	Sub-Amount	(547,663) 742,181
		Amount	(659,853) 659,853	Amount	(150,200) 210,660	Amount	(522,010) 1,026,868	Amount	(6,670) 18,400	Amount	(1,338,733) 1,915,781
Case-2	Substation	New Samyarn(YN) : 2×40 (115kV) Satorn(SH) : 3×40 (115kV)	152,200 170,600	Addition of capacity Yenarkart(YK) : 2×40 to 4×40(69kV) Samyarn(YN) : 2×40 to 3×40	61,300 18,400	New Satorntai(AT) : 4×40 New-substation 1 : 3×40 Addition of capacity Klongtoey(KT) : 2×40 to 4×40 Samyarn(YN) : 3×40 to 4×40 Satorn(SH) : 3×40 to 4×40	211,200 170,600 61,300 40,600 40,600	Addition of capacity New-substation 1 : 3×40 to 4×40	40,600	New 4 substations 480 MVA Addition of capacity 6 substations 320 MVA	701,600 262,800
		Sub-Amount	(322,800) 322,800	Sub-Amount	(56,820) 79,700	Sub-Amount	(266,530) 524,300	Sub-Amount	(14,720) 40,600	Sub-Amount	(660,870) 967,400
	Line	(1) Thanontok-YN-SH-Thanontok 2*400 14.7km, 2*800 12.5km	284,500 52,553	(3) Link Yenarkart 2*800 0.1km	2,003	(9) Klontoey-New-ss1 Branch SH 2*800 2.0km (10) Link Satorntai 2*800 1.0km (11) Klongtoey-Sat.Rd. 2*800 1.2km (12) Sanampao-YN 2*800 4.6km (13) Link Klongtoey 2*800 0.5km	45,520 22,760 27,312 104,696 11,380				
		Sub-Amount	(337,053) 337,053	Sub-Amount	(1,430) 2,003	Sub-Amount	(107,600) 211,668	Sub-Amount	()	Sub-Amount	(446,083) 550,724
		Amount	(659,853) 659,853	Amount	(58,250) 81,703	Amount	(374,130) 735,968	Amount	(14,720) 40,600	Amount	(1,106,953) 1,518,124
Case-3	Substation	New Samyarn(YN) : 2×60 (115kV) Satorn(SH) : 2×60 (115kV)	167,000 167,000	Addition of capacity Yenarkart(YK) : 2×40 to 3×60	61,800	New Satorntai(AT) : 3×60 Addition of capacity Klongtoey(KT) : 2×40 to 3×60 Lumpini(LN) : 4×40 to 3×40+1×60 Samyarn(YN) : 2×60 to 3×60 Satorn(SH) : 2×60 to 3×60	188,300 61,800 17,000 21,300 21,300	Addition of capacity Silom(SL) : 2×40 to 1×40 + 1×60 Surawong(SU) : 3×40 to 2×40 + 1×60	17,000 17,000	New 3 substations 420 MVA Addition of capacity 7 substations 380 MVA	522,300 217,200
		Sub-Amount	(334,000) 334,000	Sub-Amount	(44,060) 61,800	Sub-Amount	(157,440) 309,700	Sub-Amount	(12,320) 34,000	Sub-Amount	(547,820) 739,500
	Line	(1) Thanontok-YN-SH-Thanontok 2*400 14.7km, 2*800 12.5km	284,500 52,553	(3) Link Yenarkart 2*800 0.1km	2,003	(2) Link Satorntai 2*800 1.0km (7) Klongtoey-Sat.Rd. 2*800 1.2km (8) Sanampao-YN 2*800 4.6km (13) Link Klongtoey 2*800 0.5km	22,760 27,312 104,696 11,380				
		Sub-Amount	(337,053) 337,053	Sub-Amount	(1,430) 2,003	Sub-Amount	(84,460) 166,148	Sub-Amount	()	Sub-Amount	(422,943) 505,204
		Amount	(671,053) 671,053	Amount	(45,490) 63,803	Amount	(241,900) 475,848	Amount	(12,320) 34,000	Amount	(970,763) 1,244,704
Case-4	Substation	New Samyarn(YN) : 2×80 (115kV)	181,000	New Satorn(SH) : 2×80 Addition of capacity Yenarkart(YK) : 2×40 to 2×80	181,000 39,000	Addition of capacity Klongtoey(KT) : 2×40to115kV 2×80 Lumpini(LN) : 4×40 to 3×40+1×80 Yenarkart(YK) : 2×80 to 3×80 Samyarn(YN) : 2×80 to 3×80 Satorn(SH) : 2×80 to 3×80	146,000 19,500 22,800 34,800 34,800	Addition of capacity Silom(SL) : 2×40 to 1×40 + 1×80	19,500	New 2 substations 320 MVA Addition of capacity 7 substations 480 MVA	362,000 316,400
		Sub-Amount	(181,000) 181,000	Sub-Amount	(156,860) 220,000	Sub-Amount	(131,100) 257,900	Sub-Amount	(7,070) 19,500	Sub-Amount	(476,030) 678,400
	Line	(1) Thanontok-YN-Thanontok 2*400 14.7km, 2*800 12.3km	279,948 52,553	(4) Link Satorn 2*800 0.2km (3) Link Yenarkart 2*800 0.1km	5,452 2,003	(10) Thanontok-YK 2*800 7.5km (11) Klongtoey-Satorn Rd. link YN 115kV 2*800 1.8km (7) Klongtoey-Sat.Rd. 2*800 1.2km (8) Sanampao-YN 2*800 4.6km	150,225 40,968 27,312 104,696				
		Sub-Amount	(332,501) 332,501	Sub-Amount	(5,320) 7,455	Sub-Amount	(164,300) 323,201	Sub-Amount	()	Sub-Amount	(502,121) 663,157
		Amount	(513,501) 513,501	Amount	(162,170) 227,455	Amount	(295,400) 581,101	Amount	(7,070) 19,500	Amount	(978,141) 1,341,557

( ) : Present value of cost at 2001
Interest : 7%

Table 9.3-3 (b) Cost of Case Study (Phahol Yothin Area)

		2001 Construction	2001 Cost (1000 Baht)	2006 Construction	2006 Cost (1000 Baht)	2011 Construction	2011 Cost (1000 Baht)	2016 Construction	2016 Cost (1000 Baht)	Total Construction	Total Cost (1000 Baht)
Case-1	Substation	New Dindaeng(DD) : 2×40 Addition of capacity Pradipat(PP) : 2×40 to 3×40	152,200 17,300	New Sanampao(NP) : 3×40 Addition of capacity Dindaeng(DD) : 2×40 to 3×40	170,600 18,400	New Rajchakru(RO) : 3×40 New-substation 1 : 2×40	170,600 152,200	New New-substation 2 : 2×40 Addition of capacity New-substation 1 : 2×40 to 3×40	152,200 18,400	New 5 substations 480 MVA Addition of capacity 3 substations 120 MVA	 797,800 54,100
		Sub-Amount	(169,500) 169,500	Sub-Amount	(134,750) 189,000	Sub-Amount	(164,100) 322,800	Sub-Amount	(61,830) 170,600	Sub-Amount	(530,180) 851,900
	Line	115kV loop for Dindaeng (21) Ratchada-DD-Sanampao 2*400 2.0km, 2*800 8.2km	 186,632 7,150			(23) Sanampao-RO-JJ-Ratchada 115kV 2*800 6.6km (24) New-ss 1 Branch near RO 2*800 5km	150,216 113,800	(26) New-ss 2 Branch near DD 2*800 2km	45,520		
		Sub-Amount	(193,782) 193,782	Sub-Amount	()	Sub-Amount	(134,210) 264,016	Sub-Amount	(16,500) 45,520	Sub-Amount	(344,492) 503,318
		Amount	(363,282) 363,282	Amount	(134,750) 189,000	Amount	(298,310) 586,816	Amount	(78,330) 216,120	Amount	(874,672) 1,355,218
Case-2	Substation	New Dindaeng(DD) : 2×40 Addition of capacity Pradipat(PP) : 2×40 to 3×40	152,200 17,300	New Sanampao(NP) : 3×40 Addition of capacity Dindaeng(DD) : 2×40 to 3×40	170,600 18,400	New Rajchakru(RO) : 3×40 Addition of capacity Pradipat(PP) : 3×40 to 4×40	170,600 44,000	Addition of capacity Mochit(MC) : 3×40 to 4×40 Samsen(SN) : 3×40 to 4×40 Dindaeng(DD) : 3×40 to 4×40 Rajachakru(RO) : 3×40 to 4×40	 40,600 44,000 40,600 40,600	New 3 substations 320 MVA Addition of capacity 7 substations 280 MVA	 493,400 245,500
		Sub-Amount	(169,500) 169,500	Sub-Amount	(134,750) 189,000	Sub-Amount	(109,090) 214,600	Sub-Amount	(60,090) 165,800	Sub-Amount	(473,430) 738,900
	Line	115kV loop for Dindaeng (21) Ratchada-DD-Sanampao 2*400 2.0km, 2*800 8.2km	 186,632 7,150			(23) Sanampao-RO-JJ-Ratchada 115kV 2*800 6.6km (22) Sanampao-PP branch near Sailom 2*800 1.5km	150,216 30,045	(27) N.Bangkok-Samsen 2*400 4.5km, 2*800 0.6km	12,018 15,025		
		Sub-Amount	(193,782) 193,782	Sub-Amount	()	Sub-Amount	(91,640) 180,261	Sub-Amount	(9,800) 27,043	Sub-Amount	(295,222) 401,086
		Amount	(363,282) 363,282	Amount	(134,750) 189,000	Amount	(200,730) 394,861	Amount	(69,900) 192,843	Amount	(768,662) 1,139,986
Case-3	Substation	New Dindaeng(DD) : 2×60 Addition of capacity Pradipat(PP) : 2×40 to 2×60	167,000 34,000	New Sanampao(NP) : 2×60	167,000	New Rajchakru(RO) : 2×60 Addition of capacity Pradipat(PP) : 2×60 to 3×60 Dindaeng(DD) : 2×60 to 3×60	167,000 27,800 21,300	Addition of capacity Mochit(MC) : 3×40 to 2×40 + 1×60 Sailom(SM) : 2×40 to 1×40 + 1×60 Samsen(SN) : 3×40 to 2×40 + 1×60	 17,000 17,000 17,000	New 3 substations 360 MVA Addition of capacity 6 substations 220 MVA	 501,000 134,100
		Sub-Amount	(201,000) 201,000	Sub-Amount	(119,070) 167,000	Sub-Amount	(109,850) 216,100	Sub-Amount	(18,480) 51,000	Sub-Amount	(448,400) 635,100
	Line	115kV loop for Dindaeng (21) Ratchada-DD-Sanampao 2*400 2.0km, 2*800 8.2km	 186,632 7,150			(23) Sanampao-RO-JJ-Ratchada 115kV 2*800 6.6km (22) Sanampao-PP branch near Sailom 2*800 1.5km	150,216 30,045	(27) N.Bangkok-Samsen 2*400 4.5km, 2*800 0.6km	12,018 15,025		
		Sub-Amount	(193,782) 193,782	Sub-Amount	()	Sub-Amount	(91,640) 180,261	Sub-Amount	(9,800) 27,043	Sub-Amount	(295,222) 401,086
		Amount	(394,782) 394,782	Amount	(119,070) 167,000	Amount	(201,490) 396,361	Amount	(28,290) 78,043	Amount	(743,632) 1,036,186
Case-4	Substation	New Dindaeng(DD) : 2×80	181,000	New Sanampao(NP) : 2×80 Addition of capacity Pradipat(PP) : 2×40 to 2×80	181,000 41,000	Addition of capacity Pradipat(PP) : 2×80 to 3×80	22,800	Addition of capacity Mochit(MC) : 3×40 to 2×40 + 1×80 Sailom(SM) : 2×40 to 1×40 + 1×80 Samsen(SN) : 3×40 to 2×40 + 1×80	 19,500 19,500 19,500	New 2 substations 320 MVA Addition of capacity 5 substations 280 MVA	 362,000 122,300
		Sub-Amount	(181,000) 181,000	Sub-Amount	(158,280) 222,000	Sub-Amount	(11,590) 22,800	Sub-Amount	(21,200) 58,500	Sub-Amount	(372,070) 484,300
	Line	115kV loop for Dindaeng (21) Ratchada-DD-Sanampao 2*400 2.0km, 2*800 8.2km	 186,632 7,150	(12) Sanampao-PP branch near Sailom 2*800 1.5km	30,045	(23) Sanampao-JJ-Ratchada 115kV 2*800 6.5km (25) Lardprao-PP branch near Prachacuen 2*800 2.1km	147,940 42,063	(27) N.Bangkok-Samsen 2*400 4.5km, 2*800 0.6km	10,015 15,025		
		Sub-Amount	(193,782) 193,782	Sub-Amount	(21,420) 30,045	Sub-Amount	(96,590) 190,003	Sub-Amount	(9,080) 25,040	Sub-Amount	(320,872) 438,870
		Amount	(374,782) 374,782	Amount	(179,700) 252,045	Amount	(108,180) 212,803	Amount	(30,280) 83,540	Amount	(692,942) 923,170

( ) : Present value of cost at 2001
Interest : 7%

Table 9.3-3 (c) Cost of Case Study (Jomthong Area)

		2001		2006		2011		2016		Total	
		Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)	Construction	Cost (1000 Baht)
Case-1	Substation	New Wuttakart(WR) : 2×40	136,500			New New-substation 1 : 2×40	136,500	New New-substation 2 : 2×40	136,500	New 3 substations 240 MVA	409,500
		Addition of capacity Bangmod(BM) : 2×40 to 3×40	17,300	Addition of capacity Klongwatsing(WG) : 2×40 to 3×40 Petchkasem(PS) : 1×40 + 2×22.4 to 2×40 Wuttakart(WR) : 2×40 to 3×40	17,300 14,000 17,300	Addition of capacity Petchkasem(PS) : 2×40 to 3×40	17,300			Addition of capacity 5 substations 155 MVA	83,200
		Sub-Amount	(153,800) 153,800	Sub-Amount	(34,650) 48,600	Sub-Amount	(109,660) 153,800	Sub-Amount	(97,320) 136,500	Sub-Amount	(395,430) 492,700
	Line	(31) Watkampaeng-Ekachai 2*800 1.5km (32) Link Wuttakalt 2*400 4.0km 2*800 0.5km	30,045 13,380 10,015	(35) Link Watkampaeng 2*800 0.2km	4,006	Thonburi-New-ss 1 ・(38) Thonburi-Mahaisawan Rd. 2*400 2.1km, 2*800 1.0km ・(39) Mahaisawan Rd.-New-ss(Ekachai) -S.Thonburi 2*400 6km, 2*800 6km	20,030 7,025 120,180 20,070	(45) Interconnect New-ss 1 and ss 2 Brabch line 2*800 2ckt 2km	81,984		
		Sub-Amount	(53,440) 53,440	Sub-Amount	(2,860) 4,006	Sub-Amount	(119,290) 167,305	Sub-Amount	(58,450) 81,984	Sub-Amount	(234,040) 306,735
		Amount	(207,240) 207,240	Amount	(37,510) 52,606	Amount	(228,940) 321,105	Amount	(155,780) 218,484	Amount	(629,470) 799,435
Case-2	Substation	New Wuttakart(WR) : 2×40	136,500							New 1 substations 80 MVA	136,500
		Addition of capacity Bangmod(BM) : 2×40 to 3×40	17,300	Addition of capacity Klongwatsing(WG) : 2×40 to 3×40 Petchkasem(PS) : 1×40 + 2×22.4 to 2×40 Wuttakart(WR) : 2×40 to 3×40	17,300 14,000 17,300	Addition of capacity Bangmod(BM) : 3×40 to 4×40 Klongwatsing(WG) : 3×40 to 4×40 Petchkasem(PS) : 2×40 to 3×40	44,000 44,000 17,300	Addition of capacity Petchkasem(PS) : 3×40 to 4×40 Wuttakart(WR) : 3×40 to 4×40	44,000 44,000	Addition of capacity 9 substations 315 MVA	259,200
		Sub-Amount	(153,800) 153,800	Sub-Amount	(34,650) 48,600	Sub-Amount	(75,080) 105,300	Sub-Amount	(62,740) 88,000	Sub-Amount	(326,270) 395,700
	Line	(31) Watkampaeng-Ekachai 2*800 1.5km (32) Link Wuttakalt 2*400 4.0km 2*800 0.5km	30,045 13,380 10,015	(35) Link Watkampaeng 2*800 0.2km	4,006	(38) Thonburi-Mahaisawan Rd. 2*400 2.1km, 2*800 1.0km (36) Link Bangmod 2*800 0.5km (40) Link K.watsing 2*800 0.3km	20,030 7,025 10,015 6,009	(46) Bangkoknoi-Petchkasem 2*400 2.5Km, 2*800 2.5km (47) Thonburi-Wuttakart 2*400 3km, 2*800 3.0km	50,075 8,363 60,090 10,035		
		Sub-Amount	(53,440) 53,440	Sub-Amount	(2,860) 4,006	Sub-Amount	(30,710) 43,079	Sub-Amount	(91,660) 128,563	Sub-Amount	(178,670) 229,088
		Amount	(207,240) 207,240	Amount	(37,510) 52,606	Amount	(105,790) 148,379	Amount	(154,410) 216,563	Amount	(504,950) 624,788
Case-3	Substation	New Wuttakart(WR) : 2×60	150,000							New 1 substations 120 MVA	150,000
		Addition of capacity Bangmod(BM) : 2×40 to 2×40 + 1×60	20,300	Addition of capacity Bangmod(BM) : 2×40 + 1×60 to 3×60 Klongwatsing(WG) : 2×40 to 2×60 Petchkasem(PS) :1x40 + 2x22.4 to 1x40+1x60	41,500 34,000 17,000	Addition of capacity Klongwatsing(WG) : 2×60 to 3×60 Mahaisawan(MN) : 3x40 to 2x40 + 1x60	27,800 17,000	Addition of capacity Petchkasem(PS) : 1×40 + 1×60 to 2×60	17,000	Addition of capacity 7 substations 255 MVA	174,600
		Sub-Amount	(170,300) 170,300	Sub-Amount	(65,950) 92,500	Sub-Amount	(31,940) 44,800	Sub-Amount	(12,120) 17,000	Sub-Amount	(280,310) 324,600
	Line	(31) Watkampaeng-Ekachai 2*800 1.5km (32) Link Wuttakalt 2*400 4.0km 2*800 0.5km	30,045 13,380 10,015	(34) Mahaisawan-Tapra intersection 2*400 1.4km, 2*800 0.2kM (35) Link Watkampaeng 2*800 0.2km (36) Link Bangmod 2*800 2 to 3ckt 0.5km	4,006 3,345 4,683 10,015	(38) Thonburi-Mahaisawan Rd. 2*400 2.1km, 2*800 1.0km (40) Link K.watsing 2*800 0.3km (41) Watkampeang-Bangkhavntian Rd. 2*800 2.0km	20,030 7,025 6,009 40,060				
		Sub-Amount	(53,440) 53,440	Sub-Amount	(15,720) 22,049	Sub-Amount	(52,140) 73,124	Sub-Amount	()	Sub-Amount	(121,300) 148,613
		Amount	(223,740) 223,740	Amount	(81,670) 114,549	Amount	(84,080) 117,924	Amount	(12,120) 17,000	Amount	(401,610) 473,213
Case-4	Substation									New 0 substations 0 MVA	
		Addition of capacity Bangmod(BM) : 2×40 to 2×40 + 1×80 Klongwatsing(WG) : 2×40 to 2×80 Mahaisawan(MN) : 3×40 to 2×40 + 1×80	22,800 39,000 19,500	Addition of capacity Bangmod(BM) : 2×40 + 1×80 to 1×40 + 2×80 Petchkasem(PS) : 1×40 + 2×22.4 to 1x40 + 1x80	19,500 19,500	Addition of capacity Klongwatsing(WG) : 2×80 to 3×80	22,800	Addition of capacity Petchkasem(PS) : 1×40 + 2×80 to 3×80	19,500	Addition of capacity 7 substations 395 MVA	162,600
		Sub-Amount	(81,300) 81,300	Sub-Amount	(27,810) 39,000	Sub-Amount	(16,260) 22,800	Sub-Amount	(13,900) 19,500	Sub-Amount	(139,270) 162,600
	Line	(33) Watkampaeng-K.watsing 2*800 2.0km (34) Mahaisawan-Tapra intersection 2*400 1.4km, 2*800 0.2kM	40,060 4,683 4,006	(37) S.thonburi-Bangmod 2*800 6.5km	130,195	(42) Souththonburi-Watkanpeang 2*800 2.6km	52,078	(46) Bangkoknoi-Petchkasem 2*400 2.5km, 2*800 2.5km	55,075 8,363		
		Sub-Amount	(48,749) 48,749	Sub-Amount	(92,830) 130,195	Sub-Amount	(37,130) 52,078	Sub-Amount	(45,230) 63,438	Sub-Amount	(223,939) 294,460
		Amount	(130,049) 130,049	Amount	(120,630) 169,195	Amount	(53,390) 74,878	Amount	(59,130) 82,938	Amount	(363,199) 457,060

( ) : Present value of cost at 2001
Interest : 7%

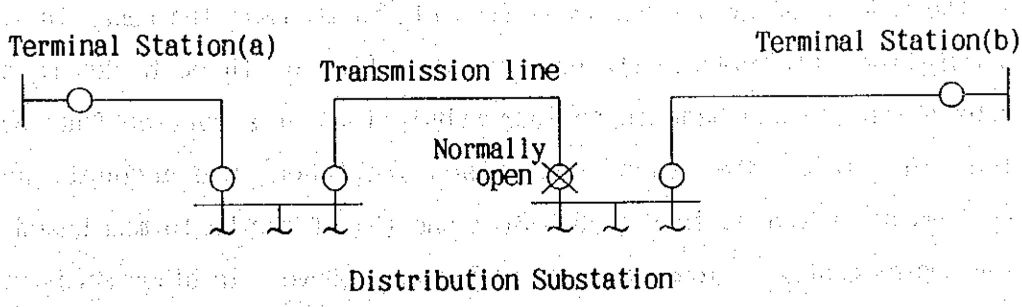
9.3.2 Economical Comparison of System Voltages using 115 kV and 69 kV System

The power is transmitted at 69 kV around the city center area and at 115 kV in the surrounding areas according to the patterns of the MEA's power system, but the 115 kV system tends to be further increased.

Therefore, the conditions of system configuration and operation, construction cost, economic and other conditions are compared in the cases of adopting 69 kV and 115 kV system configurations.

(1) Configuration of system models

Adopted in this comparison according to the planning criteria of MEA are the distribution substation consisting of three 60 MVA transformer banks and a so-called "tapped-tie normally open" as is shown Fig. 5.2-1(a) wherein the subtransmission line is connected from a terminal station to another terminal station through two distribution substations.



(2) Capacity of subtransmission line

The subtransmission line with a capacity satisfying the MEA's planning criteria is assumed to be constructed.

Capacity of subtransmission line (MVA)
(using double conductor)

	69 kV		115 kV	
	Normal	Emergency	Normal	Emergency
Overhead	192	212	288	308
Underground	192	212	288	308

(3) Load conditions

The normal allowable loads in the respective substations are assumed as follows where the utilization factor is 80%:

Distribution substation : 3 x 60 MVA x 0.8 = 144 MVA

Terminal station : 4 x 300 MVA x 0.8 = 960 MVA

Since the allowable load in two terminal stations is 1,920 MVA, it is possible to transmit the power to about 14 distribution substations.

(4) Overall system configuration

2 substations are installed directly to the respective terminal stations out of the 14 distribution substations, and the remaining 12 substations are received the power through subtransmission lines.

Judging from the capacity of subtransmission line, it is possible to transmit the power to two distribution substations through one circuit in the case of 115 kV system.

In the case of 69 kV system, it is possible to transmit the power in 1.33 substations (192/144 MVA), namely, a portion of three banks in one substation and one bank in another substation, or a portion four bank load in total. When these conditions are taken into account, such systems as indicated in Fig. 9.3-3(a) and (b) of can be formed based on the system configuration presented in Item (1) above. In other words, the outgoing line from terminal station shall be of double conductor, and line between distribution substations can be connected through single conductor in the case of 115 kV system. In the case of 69 kV system, however, a standby line is required in either one of the substations when shutdown of single side subtransmission line is taken into account. The capacity of the standby line should be sufficient to transmit a portion of two banks as indicated in Fig. 9.3-4. As a result, such a system as indicated in Fig. 9.3-3(b) of has been formed.

Although the standby line consisting of single conductor will be sufficient, the double conductor standby line should be adopted for coping with future changes of system conditions with flexibility.

(5) Unit construction cost

Based on the data obtained during the First Field Investigation, the following unit construction costs are used:

(Unit: 1,000Baht)

	69 kV	115 kV
Distribution substation		
60 MVA 2 banks	150,000	167,000
1 bank addition	20,300	21,300
Subtransmission line		
(overhead)		
1 ckt/km double conductor	3,344	3,575
(underground)		
1 ckt/km double conductor	20,024	22,757
Subtransmission line outlet CB	9,100	11,400

(6) Distance of subtransmission line

Although the actual system may undergo progress along with lapse of time, the construction cost of the entire model systems is compared herein. In other words, how the construction cost would vary between the 69 kV and 115 kV systems is examined by using the distance between the terminal station and distribution substation and that between mutual distribution substations as parameters. The shorter the transmission distance, the more advantageous in case the substation equipment cost is lower for the 69 kV system. However, the longer the transmission distance, the more advantageous in the case of 115 kV system requiring no standby line. In addition, the 115 kV system is further advantageous in view of the transmission loss as well.

Meanwhile, the construction cost and transmission loss are calculated on the assumption that the respective substations are arranged at an equal distance.

(7) Comparison between construction cost and annual expenses including transmission loss

As shown in Table 9.3-4(a), in case of underground cable line, the longer the distance between any two distribution substations is than 2.7 km, as a border in terms of construction cost, the more advantageous is the 115 kV system, but the shorter this distance is than this border, the more advantageous is the 69 kV system.

If compared in terms of annual expenses including transmission loss, the border of advantage in distance is roughly 2.0 km. As a sensitivity test, the cost of substation outlet circuit breakers is calculated where the cost on the 115 kV system is assumed to be raised further by 10% (from 11.4 million Baht to 12.54 million Baht). As a result of comparing the construction cost based on this calculation, the border of construction cost is about 3 km, and about 2.3 km when the transmission loss is included, as is presented in Table 9.3-4(b).

In the case of overhead line, the border of line distance becomes longer since the construction cost of subtransmission line becomes relatively lower. As a result of comparing the annual expenses including transmission loss, about 2.1 km is a border distance, as is presented in Table 9.3-4(c). Detail comparison is presented in Table 9.3-5(a) and (b).

(8) Results of study

The reinforcement of the 115 kV system is deemed to be the most advantageous in attaining simplification of the system, reduction of the number of subtransmission line circuits, saving of transmission loss and so forth, taking into account the various economic effects incurred from the unit construction costs and the choice between overhead and underground conductors. However, the 69 kV system can not necessarily be disregarded altogether, as the 69 kV network has already been widely equipped in the central area of Bangkok, and the road conditions are so diverse that in some places only 69 kV overhead line is possible instead of 115 kV overhead line.

(9) Comparison between 230 kV and 115 kV distribution substations

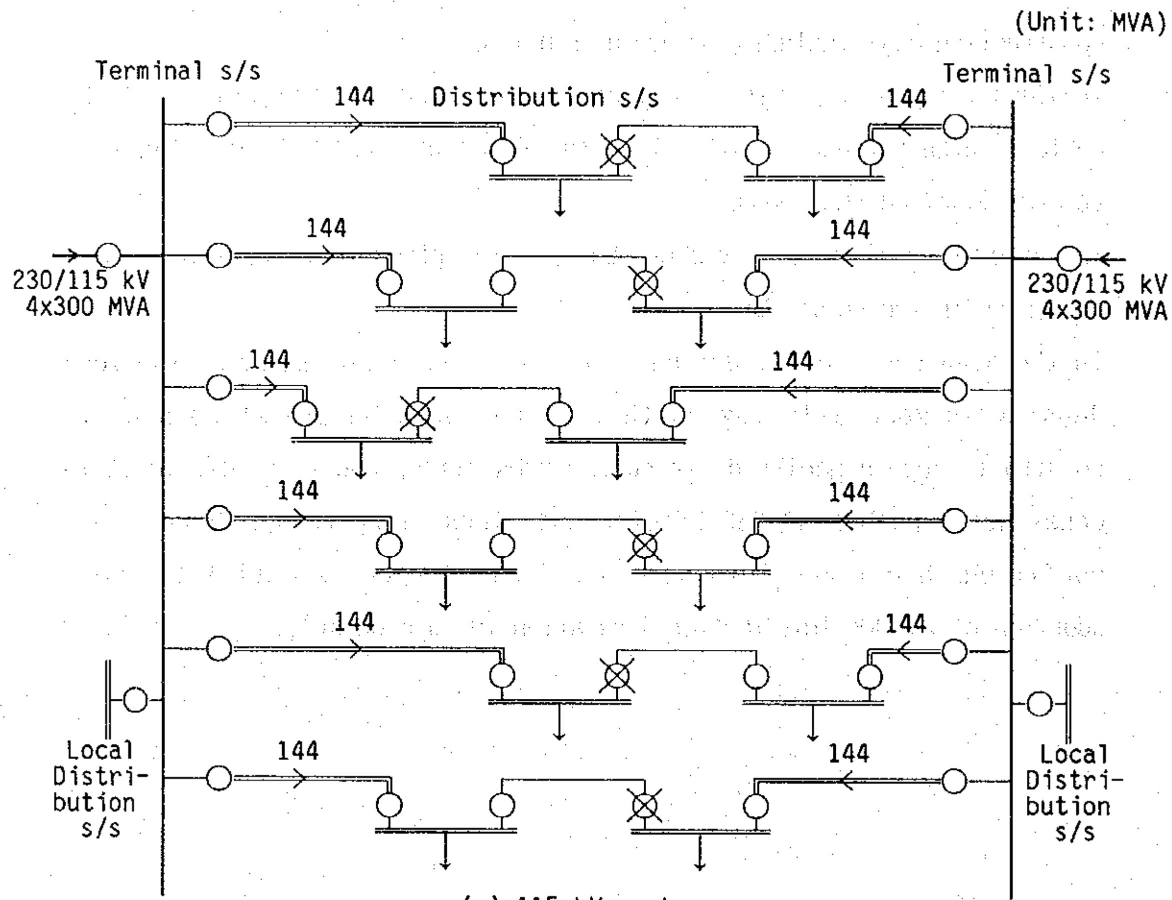
Comparisons have been made in constructing distribution substations of 80 MVA x 3 for several sites with 230 kV and with 115 kV systems respectively in the similar method as above-mentioned. When constructing 230 kV distribution substations, it will be possible to decrease the transformer capacity of terminal substation, but the unit cost of individual distribution substations will become higher than in the case of 115 kV substation.

Therefore, the 115 kV plan will be advantageous in view of the construction cost including transmission line.

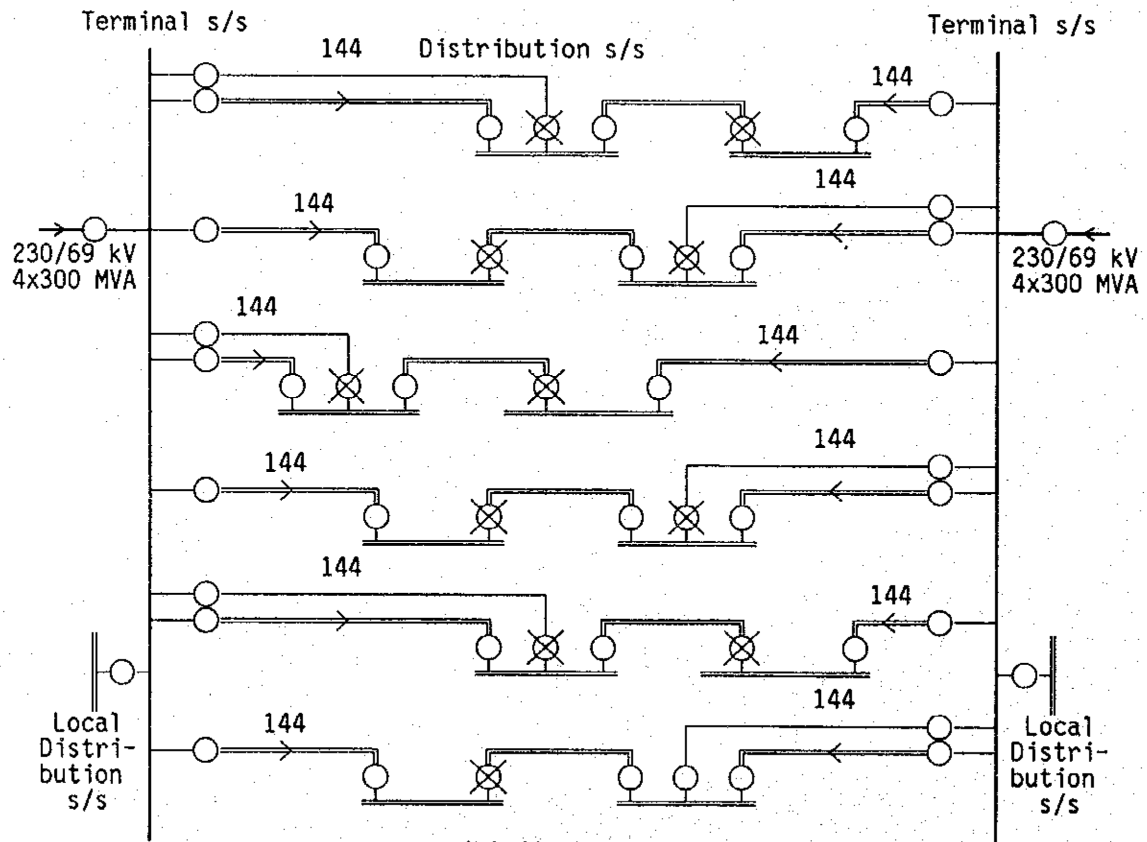
In the underground cable supply area, the construction cost of 230 kV cable is higher than that of 115 kV cable so that the 230 kV cable plan is apparently disadvantageous.

In the overhead line supply area, both of the plans indicate nearly equal values as indicated in Table 9.3-6.

In the area where construction of overhead line is possible, the load density is generally low so that there would be almost no need to construct large capacity distribution substation, and it is difficult to construct a number of 230 kV overhead lines along roads. When there conditions are taken into account, it is judged essential to avoid adoption of 230 kV distribution substation in such an area.



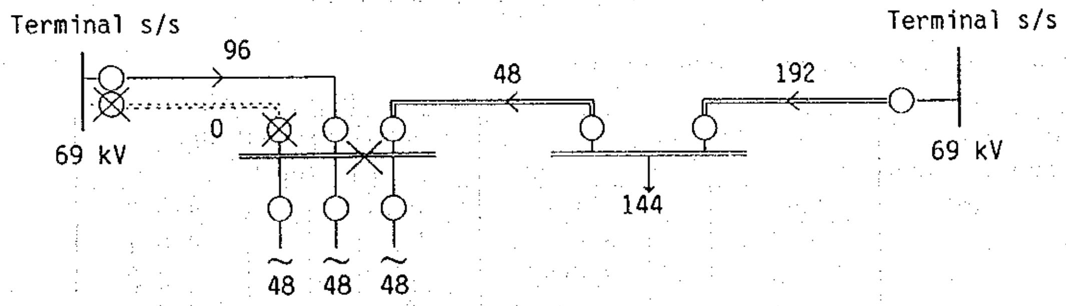
(a) 115 kV system



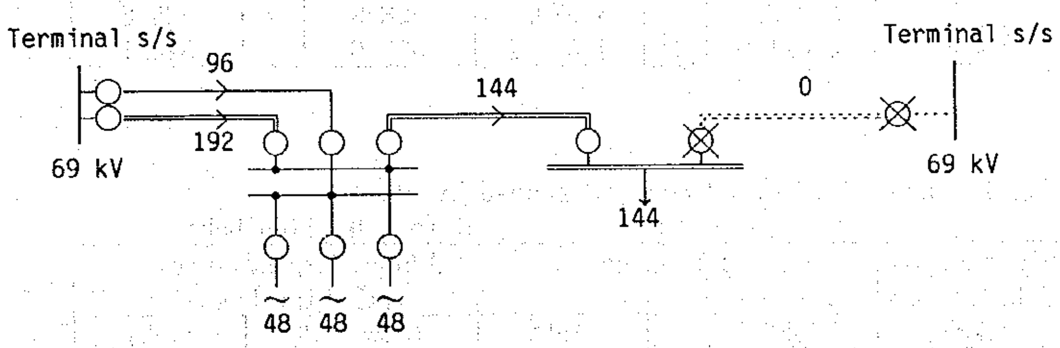
(b) 69 kV system

Fig. 9.3-3 Model System Configuration

(Unit: MVA)



(a) At the time of one of single line shut down of two lines



(b) At the time of single line shut down

Fig. 9.3-4 Load Flow at the time of single line shut down in Model System

Table 9.3-4 Cost Comparison Analysis

(a) In case of Underground Cable Line

Unit : Million Baht

Distance of Substations (km)	Construction cost			Annual Expenditure with Line Loss		
	69kV		115kV	69kV		115kV
1.9	3,588.5	<	3,642.5	475.2	<	476.7
2.0	3,636.6	<	3,683.5	481.9	<	482.2
2.1	3,684.6	<	3,724.4	488.7	>	487.6
2.2	3,732.7	<	3,765.4	495.4	>	493.1
2.6	3,924.9	<	3,929.2	522.2	>	515.1
2.7	3,972.0	>	3,970.2	528.9	>	520.6
2.8	4,021.0	>	4,011.2	535.6	>	526.1

(b) In case of 115kV CB cost increased by 10%

Unit : Million Baht

Distance of Substations (km)	Construction cost			Annual Expenditure with Line Loss		
	69kV		115kV	69kV		115kV
2.2	3,732.7	<	3,788.2	495.4	<	496.1
2.3	3,780.7	<	3,829.1	502.1	>	501.6
2.4	3,828.8	<	3,870.1	508.8	>	507.1
2.5	3,876.8	<	3,911.1	515.5	>	512.6
2.9	4,069.1	<	4,074.9	542.3	>	534.5
3.0	4,117.1	>	4,115.9	549.0	>	540.0
3.1	4,165.2	>	4,156.8	555.7	>	545.5
3.2	4,213.2	>	4,197.8	562.4	>	551.0

(c) In case of Overhead Line

Unit : Million Baht

Distance of Substations (km)	Construction cost			Annual Expenditure with Line Loss		
	69kV		115kV	69kV		115kV
2.0	2,835.9	<	2,992.9	398.5	<	399.8
2.1	2,843.9	<	2,999.3	401.0	<	401.2
2.2	2,852.0	<	3,005.8	403.6	>	402.6
2.3	2,860.0	<	3,012.2	406.1	>	403.9
11.0	3,558.2	<	3,572.1	626.6	>	523.4
12.0	3,638.5	>	3,636.4	651.9	>	537.1
13.0	3,718.7	>	3,700.8	677.3	>	550.9
14.0	3,799.0	>	3,765.1	702.6	>	564.6

Table 9.3-5 Detailed Cost Data

(a) In case of Underground Cable Line on the assumption that distance between each substation is 2 km

	In Case of 69kV				In case of 115 kV			
	No. of Unit	Unit Cost	Length km	Cost 1000 BT	No. of Unit	Unit Cost	Length km	Cost 1000 BT
Terminal SS	2				2			
Main Tr 2ry CB	8	9,100		72,800	8	11,400		91,200
Out going CB	12	9,100		109,200	12	11,400		136,800
Spare Line CB	12	9,100		109,200				
Distribution SS	14	170,300		2,384,200	14	188,300		2,636,200
Subtotal				2,675,400				2,864,200
Transmission Line	18	20,024	2	720,864	12	22,757	2	546,168
Transmission Line	6	20,024	2	240,288	6	22,757	2	273,084
Subtotal				961,152		45,514		819,252
Total cost				3,636,552				3,683,452
Annual Expenditure								
13% to Cost of SS				347,802				372,346
of Cable				124,950				106,503
Total Line Loss	kWh/km			3,011,608				1,084,179
1.526 BT/kWh	1.526		2	9,191			2	3,309
Total Expenditure				481,943				482,158

Loss Calculation
r at 20°C =0.0224 ohm : r at 60°C =0.02631 ohm for 800 sq.mm cable / km
Loss factor=0.5

	In Case of 69 kV	In case of 115 kV
Base Loss/double conductor	57.30	20.63
Total line Loss kW/km	687.58	247.53
Total Line Loss kWh/km	3,011,608	1,084,179

(b) In case of Overhead Line on the assumption that distance between each substation is 2.1 km

	In Case of 69kV				In case of 115 kV			
	No. of Unit	Unit Cost	Length km	Cost 1000 BT	No. of Unit	Unit Cost	Length km	Cost 1000 BT
Terminal SS	2				2			
Main Tr 2ry CB	8	9,100		72,800	8	11,400		91,200
Out going CB	12	9,100		109,200	12	11,400		136,800
Spare Line CB	12	9,100		109,200				
Distribution SS	14	170,300		2,384,200	14	188,300		2,636,200
Subtotal				2,675,400				2,864,200
Transmission Line	18	3,344	2.1	126,403	18	3,575	2.1	135,135
Transmission Line	6	3,344	2.1	42,134			2.1	0
Subtotal				168,538				135,135
Total				2,843,938				2,999,335
Annual Expenditure								
13% to Cost of SS				347,802				372,346
of Cable				21,910				17,568
Total Line Loss	kWh/km			9,770,843				3,517,504
1.526BT/kWh	1.526		2.1	31,312			2.1	11,272
Total Expenditure				401,024				401,186

Loss Calculation
r at 20°C =0.0726 ohm : r at 60°C =0.08536 ohm for 400 sq.mm AAC conductor / km
Loss factor=0.5

	In Case of 69 kV	In case of 115 kV
Base Loss	185.90	66.92
Total line Loss kW/km	2,230.79	803.08
Total Line Loss kWh/km	9,770,843	3,517,504

Table 9.3-6 Cost Comparison between 230 and 115kV System

Installation capacity : 230/24kV 3*80MVA and 115/24kV 3*80 MVA
In case of Overhead Line on the assumption that distance between each substation is 3.7 km
Equivalent capacity of 10 distribution SS 3*80MVA *10=2400MVA is added to 115kV side transformer capacity for Terminal stations

	In Case of 230kV				In case of 115 kV			
	No. of Unit	Unit Cost	Length km	Cost 1000 BT	No. of Unit	Unit Cost	Length km	Cost 1000 BT
Terminal SS	2				2			
Main trans 1*300MVA	0				8	47,500		380,000
Main Tr. 1ry CB	0				8	32,900		263,200
Main Tr. 2ry CB	0			0	8	11,400		91,200
Out going CB	8	32,900		263,200	8	11,400		91,200
Spare Line CB	0	32,900		0	8	11,400		91,200
Distribution SS	10	269,000		2,690,000	10	188,300		1,883,000
Subtotal				2,953,200				2,799,800
Transmission Line	12	4,422	3.7	196,337	12	3,575	3.7	158,730
Transmission Line	0	4,422	3.7	0	4	3,575	3.7	52,910
Subtotal				196,337		7,150		211,640
Total				3,149,537				3,011,440
Annual Expenditure								
13% to Cost of SS				383,916				363,974
of Cable				25,524				27,513
Total Line Loss	kWh/km			1,042,223				4,168,893
1.526 BT/kWh	1.526		3.7	5,885			3.7	23,538
Total Expenditure				415,324				415,026

Loss Calculation
r at 20 ℃ =0.0726 ohm : r at 60 ℃ =0.08536 ohm for 400 sq.mm AAC conductor / km
Loss factor=0.5

	In Case of 230 kV	In case of 115 kV
Base Loss/double conductor	29.74	118.98
Total line Loss kW/km	237.95	951.80
Total Line Loss kWh/km	1,042,223	4,168,893

Cost Comparison by Substation Distance

Distance of Substations (km)	Construction Cost			Annual Expenditure with Loss		
	230kV	Comp.	115KV	230kV	Comp.	115kV
4.0	3,165.5	>	3,028.6	417.8	<	419.2
3.9	3,160.2	>	3,022.9	417.0	<	417.8
3.8	3,154.8	>	3,017.2	416.2	<	416.4
3.7	3,149.5	>	3,011.4	415.3	>	415.0
3.6	3,144.2	>	3,005.7	414.5	>	413.6