CHAPTER 4

REVIEW OF POWER DEMAND FORECAST

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4.1 General

In Thailand, the country's overall power demand has recently been increasing rapidly along with activity on economy, penetration of overseas enterprises, industrial plants, and so forth.
Both the peak power demand and electric energy consumption have been undergoing a high increase rate exceeding 10% per year for the past several years in spite of slight drop in FY 1993.

In recent years, the power demand in the Bangkok Metropolitan area has been growing at the high rate. This is primarily because an increase of population resulting from migration of people from local areas, development of commercial and manufacturing industries, construction of a large number of high-rise building complexes mainly for hotels and condominiums, improvement in living standard, and so forth. Meanwhile, industrial condominiums and other electric energy consumption-intensive industries have also been located increasingly in the surrounding PEA's supply area, so that the share of MEA's received energy from EGAT fell from 55% in FY 1983 to 44% in FY 1993.

4.2 Power Demand Forecast by MEA

4.2.1 Power Demand Forecast in Thailand

In Thailand, power demand forecast has been carried out by the Load Forecast Subcommittee of the National Energy Policy Formulation Committee. This group (subcommittee) is organized by experts in electricity consumption representing the government agencies in charge of energy policy planning, electricity generation and distribution. These government agencies include the National Energy Policy Office (NEPO), EGAT, PEA and MEA.

The power demand forecast during the period from FY 1993 through FY 2011 was announced in June 1993.

This forecast was carried out by classifying customers of the MEA and PEA and EGAT's direct customers, as well as into residential, business (small, large and specific businesses) and industrial load (small, medium, large scales and so forth) by categories of electricity consumers.

On the basis of these forecast values, the EGAT's generation requirements are estimated by adding transmission loss, station service power and so forth. Moreover, the peak load is forecast based on the past trend of peak load taking into account the daily load curves and load factors.

The total generation requirement of EGAT by FY 2011 based on the results of power demand forecast is presented in Table 4.2-1 "Total EGAT's Generation Requirement". From this, the peak generation and energy generation are respectively forecast to increase roughly to 3.8 times and 4 times by FY 2011 from FY 1992.

4.2.2 Power Demand Forecast in the MEA's Area

The methodology and results of power demand forecast of MEA announced by the above-mentioned National Energy Policy Formulation Committee have been reviewed as outlined below.

(1) Residential power demand

The residential power demand occupies about 19% of the MEA's sold energy in FY 1992.

The methodology of residential power demand forecast is based primarily on the population and dwelling forecast and secondly on the following respective items:

(a) Share of dwelling by income level.
(The growth of household income is related to the GRP)

(b) Share by dwelling types.

(c) Diffusion of electrical home appliances by types.

(d) Household income levels and dwelling types.

(e) Effect of improvement in equipment efficiency.

(f) Classifying customers into residential and non-residential customers by residential electricity rate classes.

The diffusion of air conditioner, the largest electricity consuming equipment among electrical home appliances, is predicted to be roughly doubled in FY 2006 from 0.5 per household in FY 1992.

The share of electricity consumption by air conditioners is expected to increase to 39% in FY 2006 from 30% in FY 1992.

The electricity consumption by air conditioners, refrigerators and desk fans is predicted to share two-third (2/3) the total dwelling electricity consumption in FY 2006.

The effect of improving the efficiency of electrical home appliances incorporated in this forecast is studied regarding the three kinds of home appliances: air conditioner, refrigerator and electric light. Where any efficiency improvement is not taken into account, the dwelling power demand is forecast to increase by about 12% greater to 12,052 GWh from 10,744 GWh in FY 2006.

Fiscal Year	1991 (GWh)	1996 (GWh)	(%aai)	2001 (GWh)	(%aai)	2006 (GWh)	(%aai)
Improved Efficiency	3,810	5,720	8.47	8,150	7.34	10,744	5.68
No Improved Efficiency	3,810	6,072	9.77	8,935	8.03	12,052	6.17

aai: average annual increase

(2) Business power demand

(a) Power demand for small business

The power demand for small business (less than 30 kW) occupies about 13% of the MEA's sold energy in FY 1992.

This power demand forecast is carried out with a regression equation using GRP (gross regional product) and electricity rate for small business as functions. The reason that the floor space end-use approach applied for forecasting large scale business power demand is not used for forecasting power demand for small business is that the electricity consumption pattern of this sector is less homogeneous than that of large scale business sector and many other factors than floor space would affect the power demand increase rate.

(b) Short-term power demand forecast for large and specific (hotel) business.

The power demand in this category respectively shares about 19% and 2% of the MEA's sold electrical energy in FY 1992.

For short-term forecast in the MEA region, the Load Forecast Subcommittee has established an end-use approach using floor area increment. According to this approach, the information of building construction permits for the next three years is obtained together with other general information from the Bangkok Metropolitan Administration(BMA). Although it is difficult in this case to obtain the floor areas of existing buildings and the information of 500 kW or smaller loads, this approach has contributed significantly for improving the power forecast methodology in the MEA region where large commercial buildings are constructed one after another. Furthermore, the construction period is set by business categories (in the case of hotels, for example, two, three and four year construction periods are set as 50%, 30% and 20%, respectively), and it is reflected in the load forecast that 10% of building construction projects would be canceled.

The energy consumption data per unit floor area referred for load forecast are presented in Table 4.2-2.

(c) Long-term power demand forecast for large business

The "electricity intensity" approach methodology is used for long-term power demand forecast from FY 1994 through FY 2006. The electricity consumption per unit GRP by major business sectors is calculated and the ratio of electricity consumption is estimated based on the past consumption trend.

Since this method is a tentative one, the Subcommittee intends to establish a long-term power demand forecast methodology based on the floor areas by building types.

(d) Long-term power demand forecast for specific (hotel) business

The long-term specific business power demand is forecast by calculation from the relationship between the sold electrical energy and GRP in the service sector.

(e) Results of power demand forecast for business

While the power demand for small business is forecast to increase to about 2.7 times at an annual average increase rate of 7.3% from FY 1992 through FY 2006, the power demand for large business is forecast to expand remarkably to about four times at an average annual rate of as high as 10.6% during the same period.

The results of forecast are presented in Table 4.2-3.

(3) Industrial power demand

The industrial power demand shares about 36% of the MEA's sold electrical energy in FY 1992.

(a) Short-term forecast

Although basic information is basically obtained from the study of initial information from relevant parties and that based on the information from the Board of Investment (BOI), further accurate information is obtained from applications for electricity supply by MEA. The early information from BOI is very useful.

Moreover, the information of future projects is heard directly from 500 kW or greater peak power demand customers.

(b) Long-term forecast

The long-term power demand by industrial categories is forecast by using the same energy intensity ratio as that for long-term large business energy demand forecast. In MEA's supply area, the textile industry is the largest electricity consuming sector and expected to continue to be a high consuming sector in the future. This industry is followed by the machinery, petrochemical industries.

Considering that there is no plan to introduce any new large-scale industrial park in MEA's supply area, and there are some industrial plants relocated to the surrounding areas from the metropolitan center, the growth of industrial power demand has been lowered when compared with that of the business power demand.

The results of forecasting the energy sales by categories of industrial customers exceeding 30 kW are presented in Table 4.2-4.

Although the ratio of industrial energy sales to business sales was 60:40 in FY 1991, this ratio is forecast to become roughly 50:50 in FY 2006.

(4) Other power demand

The customers in this category are government institutions, nonprofit organizations, street lighting, farming pumps, waterworks, temporary construction and free-of-charge portion.

The power demand for these customers are basically calculated using the respective regression equations.

(5) Consolidated forecasts

For calculating the consolidated peak power demand of MEA, the following equation is used to accumulate the load curves by the respective power demand classes and number of customers into an overall load curve.

$$P = \sum_{i}^{n} [C_i L_i]$$

P : System annual load curve
Ci : Number of customers in the i^{th} category
Li : Daily load curve of the i^{th} customer category
Pmax : Annual system peak load

The overall load curve is based on the daily load curves surveyed in FY 1985 through FY 1988. The number of customers by the respective power demand classes is obtained from regression equations based on the population forecast and GRP. The rate of energy loss at peak load is obtained from a correlation with load factors. The 30-minutes peak load is calculated by multiplying the obtained peak load with a certain ratio, the value obtained thus is used as a peak load.

Table 4.2-5 shows MEA's load forecast up to FY 2016.

(6) Improvement of forecast methodology

For forecasting the power demand in FY 1993, the Load Forecast Subcommittee had directed its efforts to the improvement of forecasting methodology.

(a) The effects of improving the efficiency of air conditioner, refrigerator and electric light among electrical home appliances have been incorporated in this power demand forecast. To survey such improvement in efficiency, utilities have interviewed electrical home appliance manufacturers, and studied literatures.

(b) PEA has conducted a 10,000 sample survey. The results of this survey will be reflecting in the next forecast.

(c) The peak load calculation method of EGAT has been improved based on the records in the past four years.

(d) MEA carried out study of the relationship between the peak load and atmospheric temperature and concluded that the load will be changed by 100 MW where the temperature goes up or down by 1℃.

(e) Studies have been extended continuously for incorporating various improvement countermeasures into the next power demand forecast.

As mentioned above, the organization for power demand forecast in Thailand has been established highly excellently, and every possible effort has been directed incessantly for improving the methodology of review as well.

Table 4.2-1 Total EGAT's Generation Requirement
(Including Station Service)

Fiscal Year	Peak Demand		Energy Load			Annual
	(MW)	(%) Increase	(Average MW)	(GWh)	(%) Increase	Load Factor (%)
Historic						
1982	2,838	9.6	1,927	16,882	5.8	67.9
1983	3,204	12.9	2,177	19,066	12.9	67.9
1984	3,547	10.7	2,405	21,066	10.5	67.8
1985	3,878	9.3	2,666	23,357	10.9	68.7
1986	4,181	7.8	2,829	24,780	6.1	67.7
1987	4,734	13.2	3,218	28,193	13.8	68.0
1988	5,444	15.0	3,653	31,997	13.5	67.1
1989	6,233	14.5	4,162	36,457	13.9	66.8
1990	7,094	13.8	4,930	43,189	18.5	69.5
1991	8,045	13.4	5,619	49,225	14.0	69.8
1992	8,877	10.3	6,393	56,006	13.8	72.0
Forecast						
1993	9,978	12.4	7,169	62,797	12.1	71.8
1994	10,975	10.0	7,923	69,407	10.5	72.2
1995	11,993	9.3	8,720	76,388	10.1	72.7
1996	13,103	9.3	9,577	83,896	9.8	73.1
1997	14,193	8.3	10,408	91,178	8.7	73.3
1998	15,315	7.9	11,339	99,334	8.9	74.0
1999	16,446	7.4	12,202	106,891	7.6	74.2
2000	17,685	7.5	13,143	115,136	7.7	74.3
2001	19,029	7.6	14,173	124,158	7.8	74.5
2002	20,237	6.3	15,106	132,330	6.6	74.6
2003	21,440	5.9	16,112	141,138	6.7	75.1
2004	22,690	5.8	17,156	150,283	6.5	75.6
2005	23,997	5.8	18,227	159,668	6.2	76.0
2006	25,371	5.7	19,354	169,545	6.2	76.3
2007	26,835	5.8	20,495	179,533	5.9	76.4
2008	28,409	5.9	21,733	190,380	6.0	76.5
2009	30,044	5.8	23,018	201,642	5.9	76.6
2010	31,749	5.7	24,360	213,395	5.8	76.7
2011	33,532	5.6	25,765	225,702	5.8	76.8
Average Annual Increase (%)						
1982-1986		10.06			9.20	
1987-1991		13.99			14.71	
1992-1996		10.25			11.25	
1997-2001		7.75			8.16	
2002-2006		5.92			6.43	
2007-2011		5.74			5.89	

Source: Thailand Load Forecast Subcommittee, June 1993.

Table 4.2-2 Electricity Use per Square Meter in Commercial Enterprises

Unit:kWh/Sq.Metre/Year

	MEA (1989)	MEA/CEC (1987)	J.R.Busch (JR)1990	Valued Used
Offices		200	125-260	200
Banks	377			
Insurance Offices	270			
Office Buildings	170			
Office Condos	106			
Rented Office Towers	220			
Hotels	450	250	180-420	300
Department Stores	395	330	320-460	400
Wholesale Trade	-	-	-	200
Warehouses and Showroom	-	-	-	10
Health Services	-	118-300	-	300
School and Universities	-	130*	-	40
Recreational and Cultural	-	160**	-	-
Others				20

* Based on college libraries only

** Except theatres which are more than 200

Table 4.2-3 Business Sales Forecast Result

	Fiscal Year				Increase during 1992→2006	
	1992	1996	2001	2006	Times	aai(%)
Small Business						
Customers(×1000)	269	336	412	481	1.8	4.2
Sales(GWh)	2,947	4,231	5,931	7,945	2.7	7.3
aai in Customers (%)		5.7	4.2	3.1 a		
ai in Sales (%)		9.5	7.0	6.0		
Large and Specific Business						
Customers	9,475	13,346	19,281	25,795		
Sales(GWh)	4,617	8,304	13,466	18,814	2.7	7.4
					4.1	10.6
aai in Customer (%)		8.9	7.6	6.0		
aai in Sales (%)		15.8	10.2	6.9		

Note : aai means average annual increase

Table 4.2-4 Forecast of Energy Sales for Over 30kW

Unit GWh

Sector	1991	Component ratio	1992	1996	2001	2006	Component ratio	aai (%) 1991→2006
1. Agriculture	13.38	0.10	14.94	24.22	39.59	57.67	0.14	10.23
2. Mining	5.07	0.04	5.78	8.87	13.21	19.96	0.05	9.57
3. Other Food Processing	971.08	7.23	1,048.47	1,411.18	1,729.75	2,079.12	4.98	5.21
4. Textile	2,136.38	15.90	2,354.53	3,476.06	4,400.28	4,862.24	11.65	5.64
5. Paper & Printing	487.17	3.63	522.62	687.51	924.63	1,188.22	2.85	6.12
6. Chemical & Petroleum	1,664.96	12.39	1,786.11	2,087.19	2,610.80	3,202.73	7.67	4.46
7. Cement & Product	92.26	0.69	102.22	146.74	224.60	303.68	0.73	8.27
8. Other Heavey	299.28	2.23	328.12	446.23	556.48	729.90	1.75	6.12
9. Iron & Steel	771.29	5.74	786.43	850.80	944.63	1,025.68	2.46	1.92
10. Machinery	1,337.06	9.95	1,463.54	2,342.13	4,182.57	5,890.56	14.11	10.39
11. Construction	142.01	1.06	171.31	335.83	713.35	1,190.32	2.85	15.23
12. Electricity & Water Supply	291.19	2.17	317.15	375.48	426.64	473.20	1.13	3.29
13. Transport	526.15	3.92	594.06	1,077.57	1,721.86	2,404.62	5.76	10.66
14. Trade	1,041.39	7.75	1,179.56	2,114.65	3,407.22	4,426.49	10.60	10.13
15. Banking & Etc	666.83	4.96	807.10	1,673.22	3,209.24	4,653.67	11.15	13.83
16. Hotel & Restaurant	1,123.29	8.36	1,174.12	1,427.62	1,886.72	2,552.21	6.11	5.62
17. Other Market Service	1,663.94	12.39	1,798.31	2,885.84	4,396.15	6,174.60	14.79	9.14
18. Non-Market Service	201.79	1.50	212.25	295.65	377.39	508.09	1.22	6.35
Total	13,434.52	100.00	14,666.62	21,666.79	31,765.11	41,742.96	100.00	7.85
Total Industrial	7,932.06	59.04	8,596.66	11,831.49	16,357.02	20,569.20	49.28	6.56
Total Business	5,257.76	39.14	5,783.08	9,496.88	15,008.59	20,732.49	49.67	9.58

Table 4.2-5 MEA's Electricity Demand Forecast

MEA'S FORECAST OF MAXIMUM POWER DEMAND, ENERGY RECIEVED FROM EGAT, ENERGY SALES, % ENERGY LOSS AND LOAD FACTOR.

FISCAL YEAR	MAX. POWER DEMAND		ENERGY RECIEVED		ENERGY SALES (GWH)	% ENERGY LOSS	% LOAD FACTOR
	MW	% INC	GWH	% INC			
ACTUAL 1993	4,346	8.84	24,873	8.40	23,849	4.11	65.33
FORECAST 1994	4,791	10.24	27,879	12.09	26,568	4.70	66.43
1995	5,231	9.18	30,387	9.00	28,959	4.70	66.31
1996	5,723	9.41	33,226	9.34	31,664	4.70	66.28
1997	6,205	8.42	35,881	7.99	34,194	4.70	66.01
1998	6,670	7.49	38,632	7.67	36,817	4.70	66.12
1999	7,174	7.56	41,573	7.61	39,619	4.70	66.15
2000	7,701	7.35	44,644	7.39	42,546	4.70	66.18
2001	8,290	7.65	48,085	7.71	45,825	4.70	66.21
2002	8,805	6.21	51,085	6.24	48,684	4.70	66.23
2003	9,245	5.00	54,009	5.72	51,471	4.70	66.69
2004	9,703	4.95	57,066	5.66	54,384	4.70	67.14
2005	10,173	4.84	60,181	5.46	57,353	4.70	67.53
2006	10,653	4.72	63,345	5.26	60,367	4.70	67.88
2007	11,192	5.06	66,549	5.06	63,421	4.70	67.88
2008	11,737	4.87	69,794	4.88	66,514	4.70	67.88
2009	12,290	4.71	73,080	4.71	69,646	4.70	67.88
2010	12,850	4.56	76,407	4.55	72,816	4.70	67.88
2011	13,416	4.40	79,775	4.41	76,026	4.70	67.88
2012	13,889	3.52	82,587	3.52	78,705	4.70	67.88
2013	14,362	3.40	85,398	3.40	81,385	4.70	67.88
2014	14,835	3.29	88,210	3.29	84,064	4.70	67.88
2015	15,307	3.19	91,021	3.19	86,743	4.70	67.88
2016	15,780	3.09	93,833	3.09	89,423	4.70	67.88

Note: Presented by MEA at 1st Field Investigation.

4.3 Review of the MEA's Power Demand Forecast by the Study Team

4.3.1 Methodology of Review

(1) Available data

(a) The study team obtained a document pertaining to the MEA's load forecast published in June 1993 by the Thailand Load Forecast Subcommittee. Described in this document are detailed forecast methodology and results by FY 2006. Also, the forecast peak load values (energy received from EGAT) by FY 2011 are given therein.

(b) The peak load values, received and sold electric energy, loss ratio and load factors by FY 2016 were obtained from the MEA. (Table 4.2-5)

(c) The 1972 constant price values by FY 2006 published by the Thailand Development Research Institute were obtained as predicted values of GRP. Any data subsequent thereto was reported to be unavailable. Moreover, various economic reports were obtained.

(d) In addition, the road project maps and other city development information centering on Bangkok were obtained.

(e) An outline of the Muang Thong Thani Project being under implementation about 20 km north of the city center of Bangkok was obtained as large scale city development project information.

(2) Key points of review

(a) The power demand forecast methodology will be clarified after reviewing the data in Item (a) above. For further details, refer to Section 4.2.

(b) The recent trend indicates that the power demand in PEA region is growing more rapidly than that in MEA region. While large scale industrial estate have been introduced in PEA region, there is reported to be not big industrial estate project in MEA Region. Therefore, it can be confirmed from the past data that MEA's share of load has been decreased and this trend is particularly remarkable in the industrial sales.

(c) It is confirmed that the correlation between the power demand and GRP tends to be closer in the regions with many electricity consumption-intensive industries are located whereas such correlation tends to be weakened in active business regions.

(d) After extending the predicted value of GRP by FY 2006 to those by FY 2016 on a curve, the correlation with MEA's predicted power demand is studied on the curve.

(e) The electric power demand in Southeast Asian countries has been studied in view of the position of Thailand in terms of power demand.

4.3.2 Results of Review

(1) Share of MEA's power demand to overall power demand in Thailand

Obtained as a means of examining the share of MEA's power demand is the ratio of electric energy received by MEA from EGAT to EGAT's sold electric energy (obtained by deducting station service energy, pumping-up energy and transmission loss from generated electric energy). As the results are presented in Table 4.3-1, the MEA's share has been lowered consistently for the past twelve years even from the past records and is confirmed to undergo a similar trend from the power demand forecast by FY 2011.

(2) Comparison of power demand configuration and trend of load increase in MEA's Region and Central Region of PEA

The trend of increase in various categories of energy sales in MEA region and that in the Central Region adjacent to MEA region among PEA Region are compared based on this historical records of energy sales as the results are indicated in Table 4.3-2.

Although the number of residential customers is roughly equal to each other as seen in the table, the energy consumption is much greater in MEA Region than that in PEA Region (2.5 times the energy consumption per customer in FY 1991).

In the case of business sales energy, both the number of customers and energy consumption are extremely greater in MEA region. Although the increase rate in the Central Region is high, there is a substantial difference quantitatively, which apparently indicates a difference in the regional characteristics.

Speaking of industrial sales energy, the number of customers in MEA Region, which was as much as 3.6 times that in the Central Region in FY 1981 was decreased to only 1.6 times in FY 1991. The energy consumption in the Central Region became greater than that in MEA region reversely from 2.1 times that in the latter region.

The number of large industrial customers in the Central Region increased substantially from 16 to 130 in contrast to the increase from 60 to 104 in MEA Region.

The energy consumption of large industrial customers in MEA Region, which was 2.8 times that in the Central Region in FY 1981, was lowered to a nearly equal level in FY 1986 and 0.6 times in FY 1991 (The consumption in the Central Region is 1.7 times that in MEA Region). Thus, the large industrial energy consumption is increasing at a much higher rate in the Central Region than that in MEA Region.

This realistically indicates that large industrial plant location sites have been exhausted in MEA Region. Such a past trend is also reflected in the long-term forecast based on regression equations.

(3) Study based on elastic values

To examine the past elastic values, the annual average increase rate of electric energy sold and that of GRP in FY 1988 through FY 1992, and the average values of elastic values [(Increase rate of electric energy sales)/(GRP increase rate)] based on the above annual average increase rates are obtained.

As the calculation results are presented in Table 4.3-3, the elastic values vary extensively from 1.95 in maximum to 0.76 in minimum with the average value being 1.05.

By examining the trend of the relationship between the load and GRP predicted by FY 2006, it has been confirmed that although the elastic values exceed 1.0 as a whole in Thailand, that in MEA region tends to undergo a downward trend, as is shown in Table 4.3-4.

Since the GRP by FY 2006 has been given, this GRP is extended to a trend curve by FY 2016, and after plotting this curve and a load forecast curve on a same graph, the similarity between the GRP and load forecast curves have been studied, as is shown in Fig. 4.3-1.

To clarify the future trend of elastic values, such a trend has been expressed on a logarithmic curve based on the elastic values in 1982 through to 1995. As a result, this curve indicates that the elastic values are decreased gradually as indicated in Fig. 4.3-2.

On the basis of this curve, the electric power demand has been obtained from the GRP and elastic values forecast through to 2016. The results are presented in Table 4.3-5. and Fig. 4.3-3.

Meanwhile, the power demand in 1995 has been forecast on the assumption that the average increase rate would be 10.9% continuously by the end of the year as in the previous seven months.

The electric power demand in 1996 and thereafter has been calculated by applying the above elastic values. In addition, lower and higher curves are drawn with a yearly allowance of 0.5% in the increase rate of GRP (so that a gap of about ±10% would appear in twenty years), and these curves are compared with the forecast curve of the MEA. As seen from the curves, the MEA's forecast curve are included roughly halfway between both of these curves.

(4) Increase of power demand in ASEAN countries

When the transition of power demand in the ASEAN (Association of Southeast Asian Nations) countries is viewed in terms of peak load, the growth of power demand in Thailand is highest among other countries as presented in Table 4.3-6 and Fig. 4.3-4. (Source: January 1995 Issue of Overseas Electric Power, the Japan Electric Power Information Center, Inc. (JEPIC))

As the economic growth has been indicating a saturation trend in Indonesia, some observes predict that the economic situations in Thailand would also undergo a slowdown trend unless the traffic conditions in Bangkok should be improved. However, the infrastructure projects including replenishment of road networks, development of mass transportation system and other projects have been promoted steadily for development of economy in the country.

In consideration that the power demand forecast values to be used in this study will be applied for the improvement and expansion plans of transmission line and distribution facilities, excessively conservative forecast should be avoided so as not to cause any trouble to smooth electricity supply in the future.

(5) Recent trend of demand

With regard to the recent trend of MEA's electric power demand, the past records by May 1995 were compared with the demand forecast in FY 1993. As a result, although the actual records fell a little short of the forecast values in FY 1993 and 1994, the load increased substantially, and the peak load exceeded the forecast value by 2% in the earlier half of FY 1995. The energy sales also increased by 10.9% over the previous year. Should this trend prevail, the demand in FY 1995 is predicted to slightly exceed the forecast value.

(6) Conclusion

The source of the demand figures used in this power Distribution System Improvement and Expansion Plan is the forecast values established by MEA basing on the demand forecast issued by the Load Forecast Subcommittee of Thailand.

Considering from an overall point of view, however, it is recommended that this demand forecast should be reviewed by this Committee at adequate intervals. Although the importance of forecasting in the MW unit is justifiable on a facility planning, this method is more prone to errors and difficult than the MWh forecasting method considering the possible declines of load factor in case of changes in the demand composition. Therefore, a constant observation on its tendency is also recommended.

Table 4.3-1 Peak and Energy Share of MEA

Fiscal Year	Generation by EGAT				MEA's Load Received from EGAT					
	Peak		Sales		Peak			Energy		
	MW	Inc.%	GWh	Inc.%	MW	Inc.%	Share %	GWh	Inc.%	Share %
1982	2,838.0	9.6	15,402.7	5.7	1,498.8	8.0	52.8	8,718.7	2.6	56.6
1983	3,204.3	12.9	17,590.1	14.2	1,630.6	8.8	50.9	9,665.7	10.9	54.9
1984	3,547.3	10.7	19,381.9	10.2	1,775.8	8.9	50.1	10,497.5	8.6	54.2
1985	3,878.4	9.3	21,299.1	9.9	1,822.9	2.6	47.0	10,909.6	3.9	51.2
1986	4,180.9	7.8	22,617.8	6.2	1,982.6	8.8	47.4	11,390.6	4.4	50.4
1987	4,733.9	13.2	25,844.8	14.3	2,178.1	9.9	46.0	12,929.7	13.5	50.0
1988	5,444.0	15.0	29,403.5	13.8	2,432.2	11.7	44.7	14,564.1	12.6	49.5
1989	6,232.7	14.5	33,611.2	14.3	2,714.5	11.6	43.6	16,143.8	10.8	48.0
1990	7,093.7	13.8	39,368.8	17.1	3,123.5	15.1	44.0	18,622.5	15.4	47.3
1991	8,045.0	10.4	44,773.2	13.7	3,519.4	12.7	43.7	20,776.8	11.6	46.4
1992	8,876.9	10.3	50,770.9	13.4	3,992.6	13.4	45.0	22,945.5	10.4	45.2
1993	9,730.0	9.6	56,558.2	11.4	4,346.0	8.9	44.7	24,872.7	8.4	44.0
Actual Increase % 1983-1993		11.7		12.4		10.3			9.9	
Actual in 1994	(10,709)				(4,755)			(27,525)		
Forecast										
1994	11,395	17.1	63,490	12.1	4,791	10.2	42.0	27,879	12.1	43.9
1995	12,459	9.3	69,971	10.2	5,231	9.2	42.0	30,387	9.0	43.4
1996	13,616	9.3	76,836	9.8	5,723	9.4	42.0	33,226	9.3	43.2
1997	14,763	8.4	83,564	8.8	6,205	8.4	42.0	35,881	8.0	42.9
1998	15,933	7.9	90,638	8.5	6,670	7.5	41.9	38,632	7.7	42.6
1999	17,095	7.3	97,669	7.8	7,174	7.6	42.0	41,573	7.6	42.6
2000	18,372	7.5	105,410	7.9	7,701	7.3	41.9	44,644	7.4	42.4
2001	19,775	7.6	113,853	8.0	8,290	7.6	41.9	48,085	7.7	42.2
2002	21,035	6.4	121,525	6.7	8,805	6.2	41.9	51,085	6.2	42.0
2003	22,301	6.0	129,572	6.6	9,245	5.0	41.5	54,009	5.7	41.7
2004	23,614	5.9	137,930	6.5	9,703	5.0	41.1	57,066	5.7	41.4
2005	24,983	5.8	146,621	6.3	10,173	4.8	40.7	60,181	5.5	41.0
2006	26,429	5.8	155,766	6.2	10,653	4.7	40.3	63,345	5.3	40.7
2007	27,933	5.7	165,014	5.9	11,192	5.1	40.1	66,549	5.1	40.3
2008	29,576	5.9	175,057	6.1	11,737	4.9	39.7	69,794	4.9	39.9
2009	31,278	5.8	185,486	6.0	12,290	4.7	39.3	73,080	4.7	39.4
2010	33,052	5.7	196,368	5.9	12,850	4.6	38.9	76,407	4.6	38.9
2011	34,908	5.6	207,763	5.8	13,416	4.4	38.4	79,775	4.4	38.4
Average Increase %										
1994-2001		8.2		8.7		8.1			8.1	
2001-2011		5.8		8.2		7.7			7.7	

Table 4.3-2 Historical record of Sales Energy by Main Category
(Comparison Between MEA and Central Region of PEA)

Description		Fiscal Year 1981	1986	1991	1992
Residential					
MEA	Customers(x1000)	619.8	792.3	1,101.0	1,200.1
	Sales GWh	1,450.4	2,107.6	3,809.6	4,212.4
	aai in Customers %		5.0	6.8	
	aai in Sales %		7.8	12.6	10.6
	kWh/Customer	2,340.1	2,660.1	3,460.1	3,510.0
Central	Customers(x1000)	475.0	828.3	1,179.0	
	Sales GWh	398.2	720.0	1,492.0	1,707.0
	aai in Customers %		11.8	7.3	
	aai in Sales %		12.6	15.7	14.4
	kWh/Customer	838.3	869.3	1,265.5	
Ratio (MEA/Central)	Customers	1.3	1.0	0.9	
	Sales	3.6	2.9	2.6	2.5
	kWh/Customer	2.8	3.1	2.7	
Small Business					
MEA	Customers(x1000)	157.6	189.6	249.2	269.1
	Sales GWh	1,098.0	1,530.0	2,730.2	2,946.8
	aai in Customers %		3.8	5.6	
	aai in Sales %		6.9	12.3	7.9
Central	Customers(x1000)	34.6	60.2	104.6	
	Sales GWh	208.8	378.1	813.5	987.2
	aai in Customers %		11.7	11.7	
	aai in Sales %		12.6	16.6	21.4
Ratio (MEA/Central)	Customers	4.6	3.1	2.4	
	Sales	5.3	4.0	3.4	3.0
Large Business					
MEA	Customers	2,853	3,855	8,539	9,412
	Sales GWh	861.3	1,522.8	3,772.9	4,226.0
	aai in Customers %		6.2	17.2	
	aai in Sales %		12.1	19.9	12.0
Central	Customers	280	486	1,573	
	Sales GWh	66.0	119.7	605.0	788.2
	aai in Customers %		11.7	26.5	
	aai in Sales %		12.6	38.3	30.3
Ratio (MEA/Central)	Customers	10.2	7.9	5.4	
	Sales	13.1	12.7	6.2	5.4

Note : aai means average annual increase

Description		Fiscal Year 1981	1986	1991	1992
Small Industry					
MEA	Customers	3,307	4,095	5,143	5,508
	Sales GWh	1,080.0	1,446.4	2,279.4	2,586.2
	aai in Customers %		4.4	4.7	7.1
	aai in Sales %		6.0	9.5	13.5
Central	Customers	873	1,435	3,016	
	Sales GWh	453.1	672.6	1,474.3	
	aai in Customers %		10.5	16.0	
	aai in Sales %		8.2	17.0	
Ratio (MEA/Central)	Customers	3.8	2.9	1.7	
	Sales	2.4	2.2	1.5	
Medium Industry					
MEA	Customers	213	309	534	571
	Sales GWh	857.2	1,047.0	2,250.7	2,553.7
	aai in Customers %		7.7	11.6	6.9
	aai in Sales %		4.1	16.5	13.5
Central	Customers	112	170	462	
	Sales GWh	635.1	848.6	1,922.6	
	aai in Customers %		8.7	22.1	
	aai in Sales %		6.0	17.8	
Ratio (MEA/Central)	Customers	1.9	1.8	1.2	
	Sales	1.3	1.2	1.2	
Large Industry					
MEA	Customers	60	62	104	120
	Sales GWh	1,270.9	1,480.3	2,627.6	2,871.9
	aai in Customers %		0.7	10.9	15.4
	aai in Sales %		3.1	12.2	9.3
Central	Customers	16	49	130	
	Sales GWh	454.9	1,427.7	4,511.5	
	aai in Customers %		25.1	21.5	
	aai in Sales %		25.7	25.9	
Ratio (MEA/Central)	Customers	3.8	1.3	0.8	
	Sales	2.8	1.0	0.6	
Total of Above Industry					
MEA	Customers	3,580	4,466	5,781	6,199
	Sales GWh	3,208	3,974	7,158	8,012
	aai in Customers %		4.5	5.3	7.2
	aai in Sales %		4.4	12.5	11.9
Central	Customers	1,001	1,654	3,608	
	Sales GWh	1,543	2,949	7,908	
	aai in Customers %		10.6	16.9	
	aai in Sales %		13.8	21.8	
Ratio (MEA/Central)	Customers	3.6	2.7	1.6	
	Sales	2.1	1.3	0.9	

Table 4.3-3 Elasticity of Sold Energy to GRP

Growth rate of Sold Energy Ave. : 10.17

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1983	8.63									
1984	8.41	8.19								
1985	6.97	6.16	4.16							
1986	6.05	5.20	3.74	3.32						
1987	7.48	7.20	6.87	8.25	13.42					
1988	8.38	8.34	8.37	9.81	13.21	13.01				
1989	8.82	8.85	8.98	10.22	12.63	12.24	11.47			
1990	9.72	9.88	10.16	11.40	13.52	13.56	13.83	16.25		
1991	9.97	10.14	10.42	11.50	13.22	13.17	13.22	14.10	12.00	
1992	10.04	10.20	10.45	11.38	12.79	12.66	12.57	12.94	11.33	10.66

Groowth rate of GRP Ave. : 10.26

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1983	10.78									
1984	7.46	4.23								
1985	5.64	3.16	2.10							
1986	5.40	3.66	3.38	4.67						
1987	7.37	6.54	7.32	10.02	15.66					
1988	8.95	8.59	9.71	12.37	16.43	17.21				
1989	9.64	9.46	10.53	12.74	15.57	15.53	13.88			
1990	9.95	9.83	10.79	12.62	14.69	14.38	12.98	12.10		
1991	9.94	9.83	10.65	12.15	13.71	13.22	11.92	10.96	9.83	
1992	9.85	9.74	10.45	11.70	12.92	12.38	11.20	10.32	9.44	9.05

Elasticity Ave. : 1.05

Year	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991
1983	0.80									
1984	1.13	1.93								
1985	1.24	1.95	1.98							
1986	1.12	1.42	1.11	0.71						
1987	1.01	1.10	0.94	0.82	0.86					
1988	0.94	0.97	0.86	0.79	0.80	0.76				
1989	0.91	0.94	0.85	0.80	0.81	0.79	0.83			
1990	0.98	1.00	0.94	0.90	0.92	0.94	1.07	1.34		
1991	1.00	1.03	0.98	0.95	0.96	1.00	1.11	1.29	1.22	
1992	1.02	1.05	1.00	0.97	0.99	1.02	1.12	1.25	1.20	1.18

Table 4.3-4 Relation Between Energy Requirement and Gross Regional Product

F.Y	1992	1996	2001	2006	2011
Energy (GWh)					
MEA	22946	33226	48085	63345	79775
aai %		9.70	7.67	5.67	4.72
PEA					
-North	3658	5615	8179	11307	15566
-Northeast	3753	5737	8301	11433	15683
-Central	14358	23065	36866	53690	76380
-South	4380	6491	9422	12805	17194
-Total	26150	40908	62768	89235	124822
aai %		11.84	8.94	7.29	6.94
EGAT's Direct Customers	1693	2703	3000	3186	3165
EGAT+PEA Customers	27843	43611	65768	92421	127987
aai %		11.87	8.56	7.04	6.73
Total	50789	76837	113853	155766	207762
aai in Total %		10.90	8.18	6.47	5.93
Total Energy Generation	56006	83896	124158	169545	225702
aai in Total Generation %		10.63	8.16	6.43	5.89
Gross Regional Product (BBT)					
MEA	324.5	445.7	654.5	889.3	
aai %		8.26	7.98	6.33	
PEA	423.0	575.0	837.1	1,137.2	
aai %		7.98	7.80	6.32	
Whole Kingdom	747.5	1,020.8	1,491.6	2,026.5	
aai %		8.10	7.88	6.32	
Elasticity (Ene.aai/GRP aai)	aai/GRP aai)				
MEA		1.17	0.96	0.90	
EGAT+PEA		1.49	1.10	1.11	
Whole Kingdom		1.35	1.04	1.02	

Note : aai means average annual increase

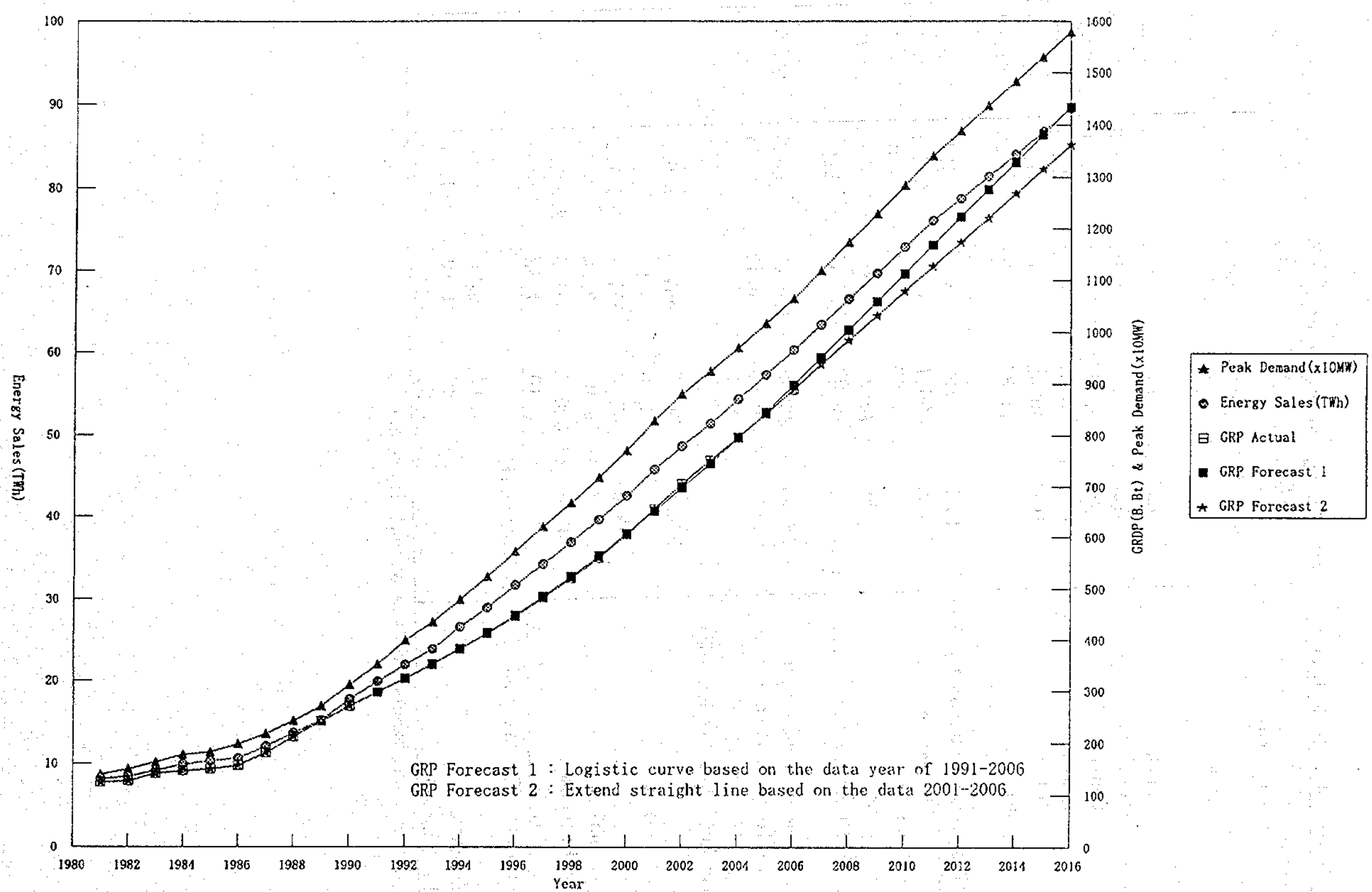


Fig. 4.3-1 Energy Sales, Peak Demand, GRP Relation

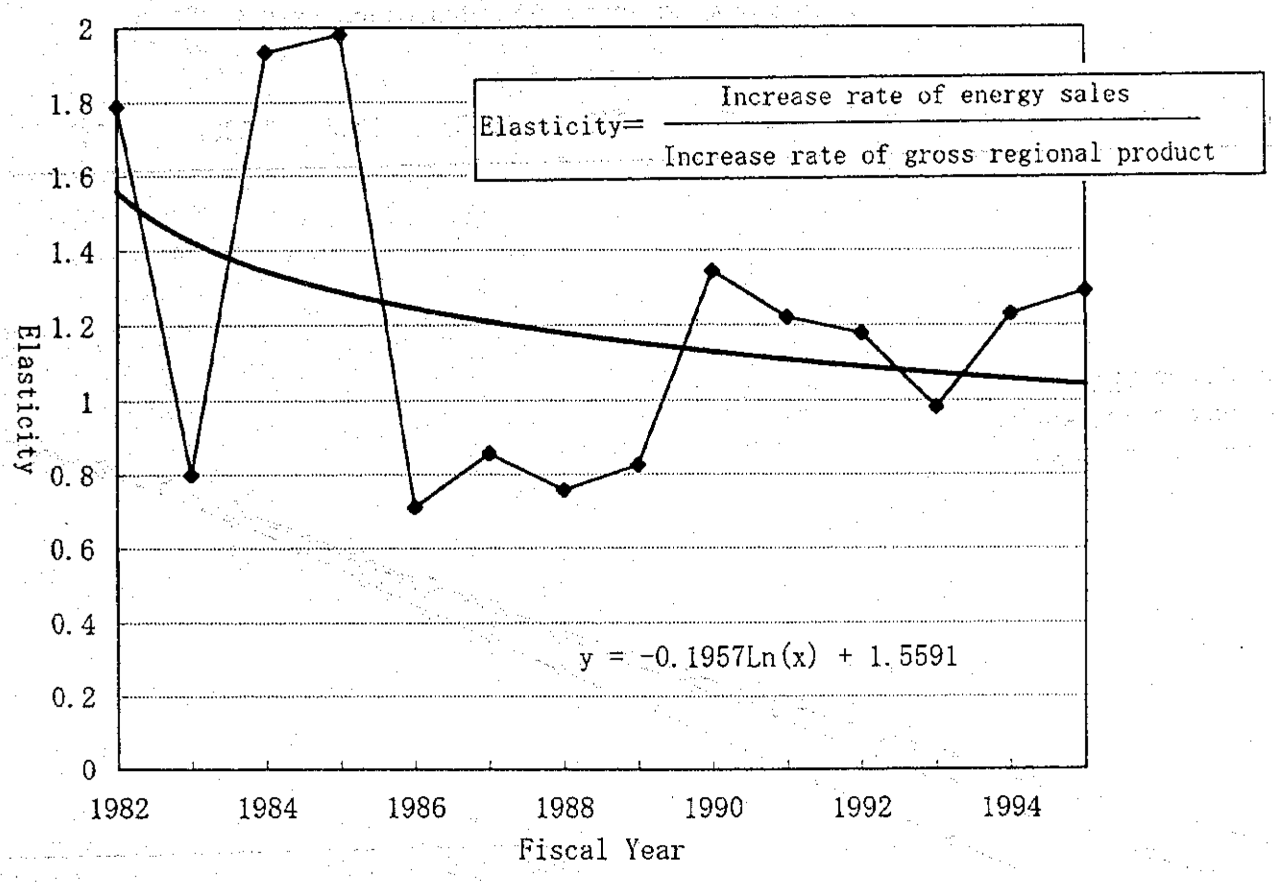


Fig. 4.3-2 Elasticity Curve of MEA

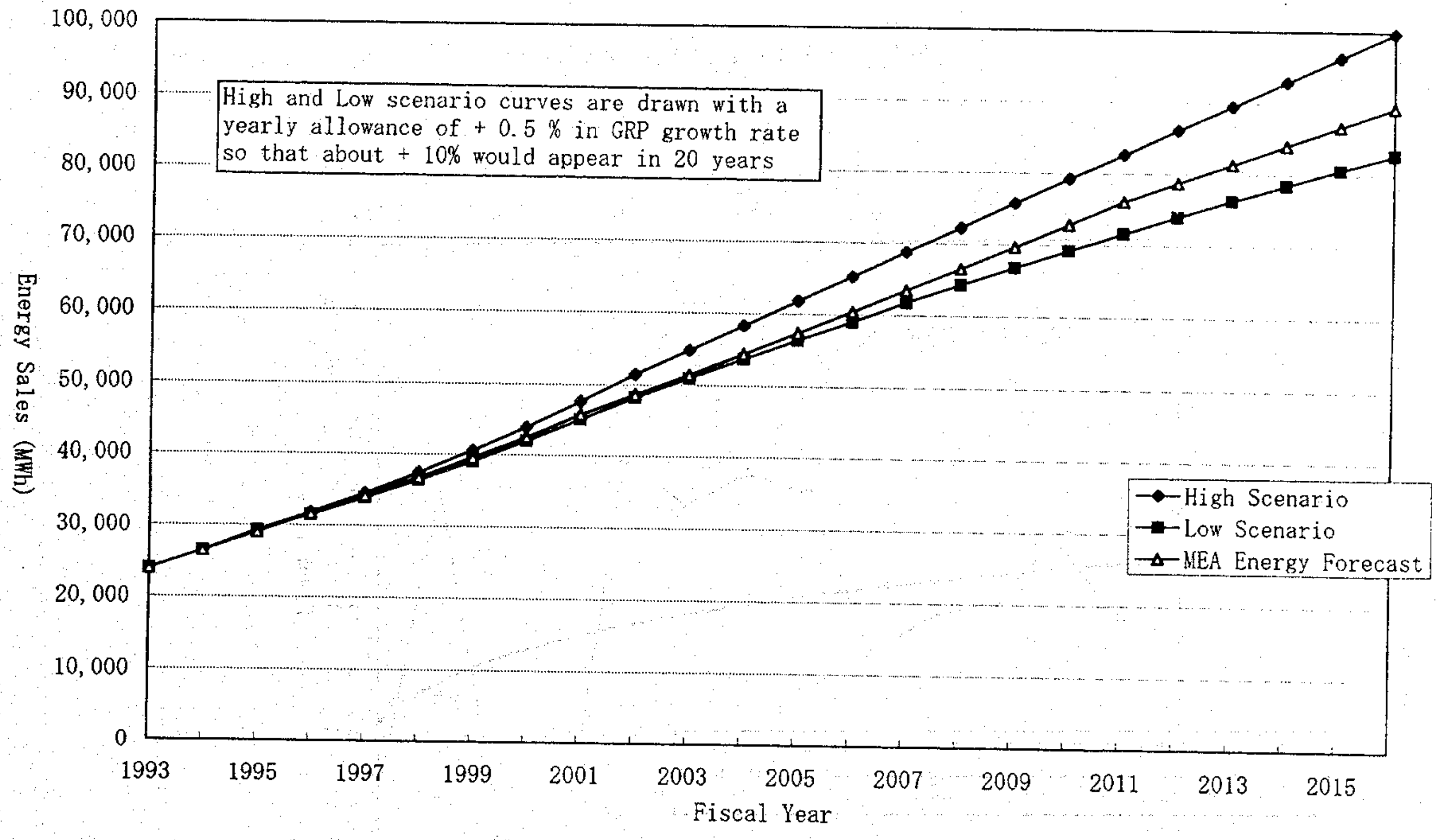


Fig. 4.3-3 Macro Forecast Study by Elasticity

Table 4.3-5 Macro Forecast Study by Elasticity

(GWh)

Year	GRP Forecast at '72 const price B.Bt)	Elasticity	Energy Forecast by Elasticity			MEA Energy Forecast
			Medium scenario	High scenario	Low scenario	
1993	352.50	0.98	23,849	23,849	23,849	23,849
1994	382.28	1.21	26,370	26,370	26,370	26,370
1995	412.55	1.27	29,244	29,244	29,244	28,959
1996	445.74	1.03	31,665	31,816	31,515	31,664
1997	481.87	1.02	34,274	34,599	33,951	34,194
1998	519.93	1.00	36,994	37,518	36,475	36,817
1999	560.23	0.99	39,843	40,594	39,102	39,619
2000	604.80	0.98	42,958	43,967	41,968	42,546
2001	654.47	0.97	46,390	47,694	45,117	45,825
2002	705.05	0.96	49,844	51,474	48,258	48,648
2003	750.62	0.95	52,918	54,894	51,004	51,471
2004	796.38	0.95	55,968	58,318	53,703	54,384
2005	842.89	0.94	59,031	61,783	56,390	57,353
2006	889.34	0.93	62,054	65,234	59,016	60,367
2007	937.91	0.92	65,177	68,817	61,714	63,421
2008	985.11	0.91	68,175	72,298	64,271	66,514
2009	1,032.32	0.91	71,139	75,768	66,773	69,646
2010	1,079.53	0.90	74,067	79,228	69,221	72,816
2011	1,126.73	0.89	76,960	82,677	71,616	76,026
2012	1,173.94	0.89	79,821	86,117	73,960	78,705
2013	1,221.15	0.88	82,648	89,546	76,255	81,385
2014	1,268.35	0.87	85,443	92,966	78,500	84,064
2015	1,315.56	0.87	88,207	96,377	80,698	86,743
2016	1,362.77	0.86	90,940	99,779	82,849	89,423

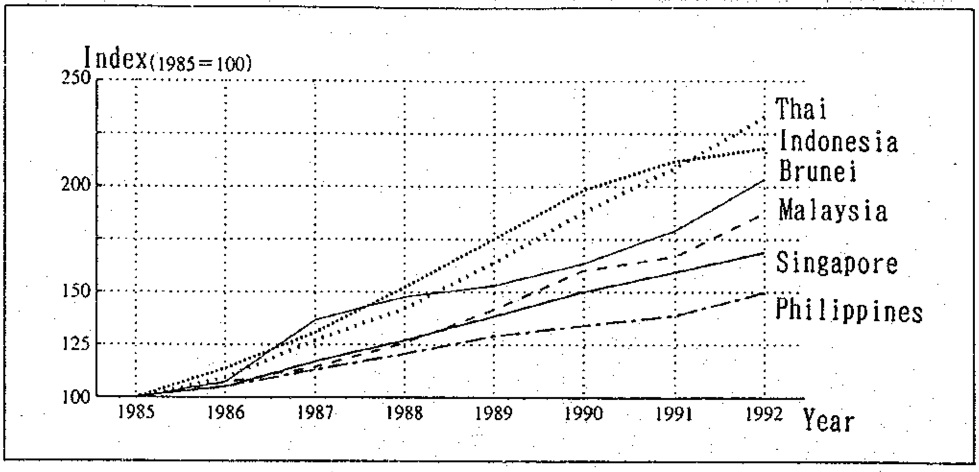
Table.4.3-6 Transition of Electric Peak Load in ASEAN Countries

Unit:MW

Year	Brunei	Indonesia	Malaysia	Philippines	Singapore	Thai
1985	108	2,966	2,421	3,037	1,665	3,826
1996	117	3,404	2,557	3,203	1,764	4,202
1987	147	3,890	2,750	3,432	1,939	4,842
1988	158	4,497	3,049	3,684	2,118	5,414
1989	164	5,168	3,380	3,909	2,286	6,208
1990	174	5,898	3,840	3,974	2,488	7,167
1991	194	6,304	3,990	4,088	2,631	7,990
1992	221	6,414	4,498	4,588	2,790	8,828
	(10.7%)	(11.8%)	(9.3%)	(6.1%)	(7.7%)	(12.7%)

Note : (   ) shows average annual increas rate from 1985 to 1992

Fig.4.3-4 Transition of Electric Peak Load in ASEAN Countries



Source : Overseas Electric Power : No.1 in 1995
Published by Japan Electric Power Information Center, Inc.

Table 4.3-7 Comparison of Actual and Forecasted Load

Year	Item	Max. Power Demand MW	Increase %	Received from EGAT GWh	Increase %	Energy Sales GWh	Increase %	Load Factor %
1992	Actual	3,992.60		22,945.54		21,967.62		65.43
1993	Forecast	4,392.22	10.01	25,463.34	10.97	24,266.56	10.47	66.18
	Actual	4,346.00	8.85	24,872.66	8.40	23,849.41	8.57	65.33
	Differ.%	-1.05		-2.32		-1.72		-1.28
1994	Forecast	4,791.45	9.09	27,878.56	9.49	26,568.27	9.49	66.42
	Actual	4,754.75	9.41	27,525.27	10.66	26,369.83	10.57	66.08
	Differ.%	-0.77		-1.27		-0.75		-0.51
1995	Forecast	5,231.30	9.18	30,387.33	9.00	28,959.13	9.00	66.31
	* Actual	5,336.70	12.24	30,525.52	10.90	29,244.10	10.90	65.30
	Differ.%	2.01		0.45		0.98		-1.52
	Note	* Actual as of May		* Assumed from half year's record				

CHAPTER 5

MEA's SHORT- AND LONG-TERM POWER DISTRIBUTION SYSTEM IMPROVEMENT AND EXPANSION PLAN

CHAPTER 5 MEA's SHORT- AND LONG-TERM POWER DISTRIBUTION SYSTEM IMPROVEMENT AND EXPANSION PLAN

5.1 General

MEA has formulated year-on-year plan for improving and expanding its power distribution system in order to cope with the increasing power demand and performed the implementation.

In this chapter, firstly, the outline of the MEA's planning criteria for power distribution system based on the system planning and the MEA's basic policy to formulate the Revised Seventh Power Distribution System Improvement and Expansion Plan FY 1992-1996 (hereinafter referred to as "the Revised 7th Plan") are described. Secondly, the progress situation and problems of the Revised 7th Plan are discussed. Thirdly, the outline of the MEA's short- and long-term plan after FY 1997 and EGAT's power development plan are described.

5.2 MEA's Planning Criteria

5.2.1 Target Operating Voltage

Target operating voltages of the MEA system are controlled according to the following table.

(unit: volt)

Nominal Voltage	Normal Max.	Normal Min.	Emergency Max.	Emergency Min.
230,000	231,000	209,000	242,000	198,000
115,000	117,600	106,400	123,000	96,012
69,000	70,350	63,650	72,500	57,335
24,000	23,600	21,800	24,000	21,600
12,000	11,800	10,900	12,000	10,800
380	400	371	414	362
220	231	214	239	209

5.2.2 Maximum Loading of Subtransmission Line

Maximum loading of subtransmission line is as shown in the table below.

Voltage	Normal	Emergency (4h/day)
230 kV (a)	267 MVA (670 A)	400 MVA (1,000 A)
(b)	320 MVA (803 A)	480 MVA (1,205 A)
115 kV	288 MVA (1,450 A)	308 MVA (1,550 A)
69 kV	192 MVA (1,610 A)	212 MVA (1,770 A)

Note: (a) Transmission from 4x250 MVA terminal station
(b) Transmission from 4x300 MVA terminal station

Incidentally, transmission capacity of EGAT 230 kV single-circuit overhead transmission line is as shown in the table below.

Conductor MCM ACSR	Transmission Capacity (MVA)
1 x 1,272	429
2 x 1,272	858
4 x 795	1,303
4 x 1,272	1,716

In case of the n circuits, transmission capacity should be (n-1) times the capacity of a single-circuit line with the same conductor size.

5.2.3 Capacity and Maximum Loading of Substation

(1) Capacity

Installed capacity of terminal and distribution substations is as shown in the table below.

	Existing (if expansible)	New
Terminal Station (EGAT)	4x200 MVA	4x300 MVA
(MEA)	———	4x250 or 4x300 MVA
Distribution Station	3x40 or 3x60 MVA	3x60 MVA

(2) Maximum Loading of Substation

Maximum loading of terminal and distribution substations is as shown in the table below.

	Ratio to Transformer Rating	
	Normal	Emergency (4h/day)
Terminal Station (EGAT)	80%	107%
(MEA)	80%	107%
Distribution Station (2 bays)	75%	125%
(3 bays)	80%	120%

5.2.4 Maximum Fault Level

Maximum fault level is as shown in the table below.

Voltage	Maximum fault level
230 kV	50 kA
115 kV	31.5 kA
69 kV	40 kA

5.2.5 System Configuration

Proper system configurations should be determined for each of distribution area, load flow, fault level and right of way for transmission and distribution lines along the route.

(1) 230 kV system

230 kV subtransmission line configuration is radial with at least three circuits.

(2) 115-69 kV system

The 115 kV or 69 kV subtransmission line configuration can be classified into four systems as follows:

(a) Radial

In order to improve system reliability each end of transmission line is connected together so that it can be switched to other terminal stations. This configuration is called "Tapped tie normally open", as is shown in Fig. 5.2-1(a) and (b).

(b) Tapped-tie

This configuration renders high reliability as well as high fault level. So it is applied in the area where the distribution substation is located considerably far from the terminal station or in the area where the fault level is within the criteria.

The tapped-tie configuration is shown in Fig. 5.2-1(c).

(c) Loop

This configuration is the same as the tapped-tie except that both ends of subtransmission lines are supplied from the same terminal station. It renders high system reliability and fault level is moderate.

Loop configuration is shown in Fig. 5.2-1(d).

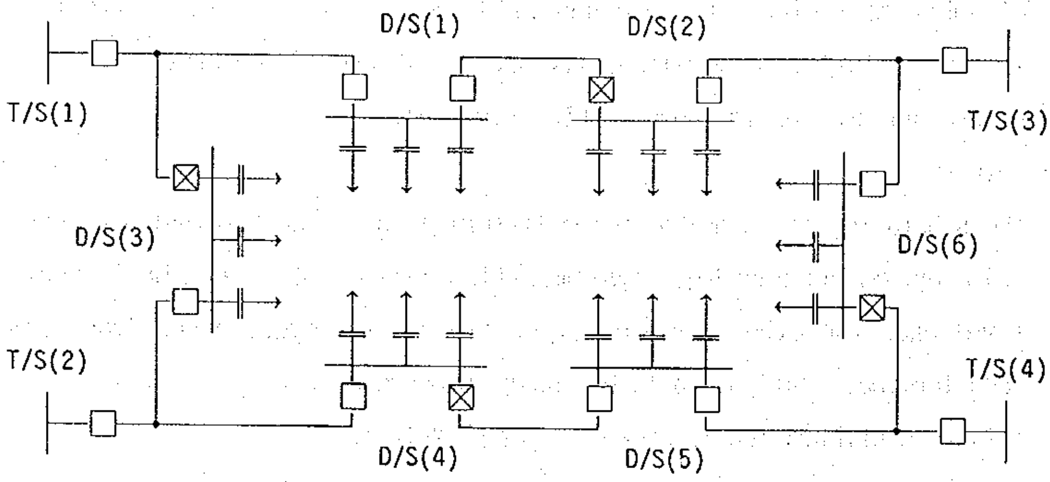
(d) Network

The substation is to be connected from at least three terminal stations. This system renders high system reliability as well as higher fault level than the other three configurations. Moreover, power flow from each terminal station should be taken into account.

Network configuration is shown in Fig. 5.2-1(e).

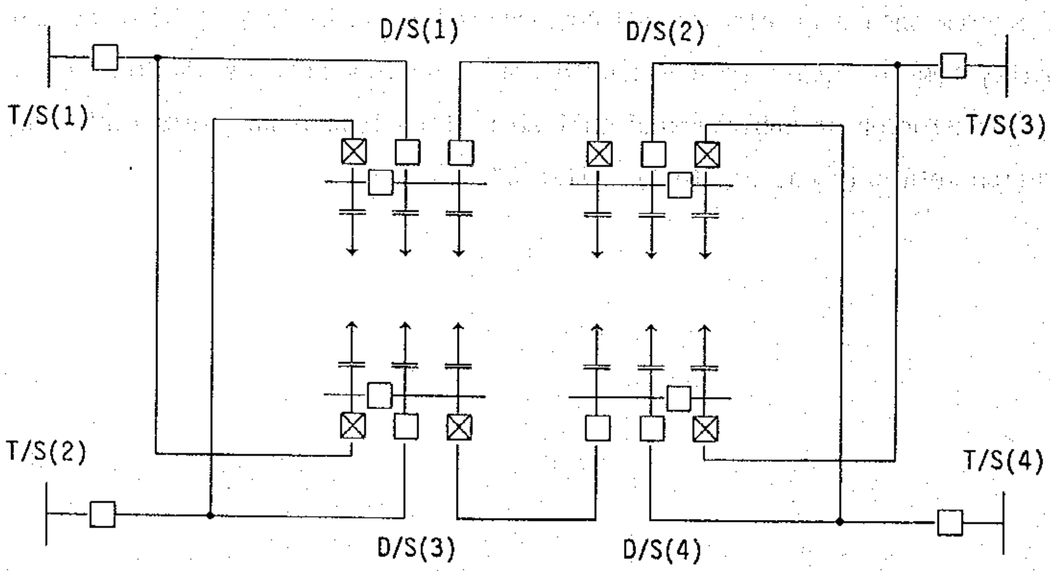
5.2.6 Reliability

In planning subtransmission line system, reliability must be considered. MEA power system should be planned and constructed in such a manner that it can generally remain intact at any single contingencies such as the loss of a single transformer or subtransmission line with no loss load. This worldwide evaluation method is called "(n-1) criteria".



Note: Maximum installed capacity at each 69-24 kV D/S is not more than 120 MVA

(a) Tapped-tie normally open (2 incomings)
(for 69-12/24 kV and 115-24 kV distribution substation)



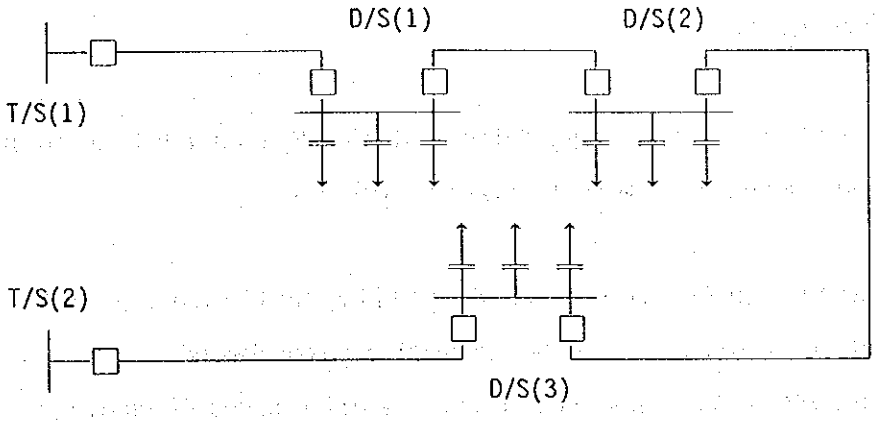
Note: Maximum installed capacity at each D/S is more than 120MVA

(b) Tapped-tie normally open (3 incomings)
(for 69-24 kV and 115/24 kV distribution substation only)

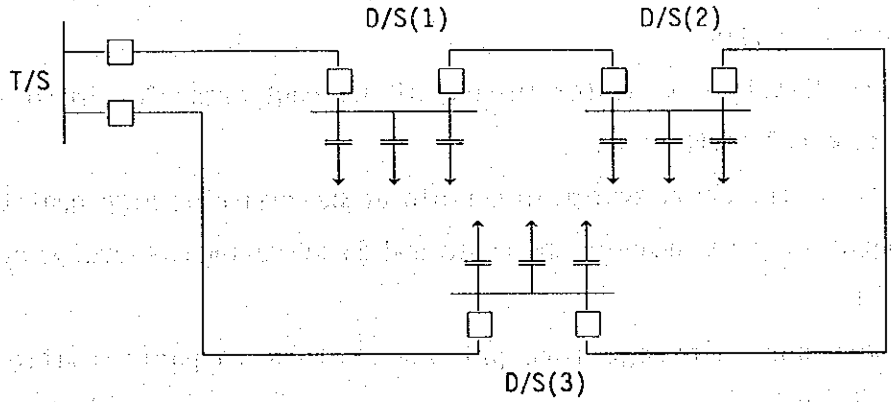
T/S : Terminal Station
D/S : Distribution Substation

□ : CB Normally Close
⊠ : CB Normally Open

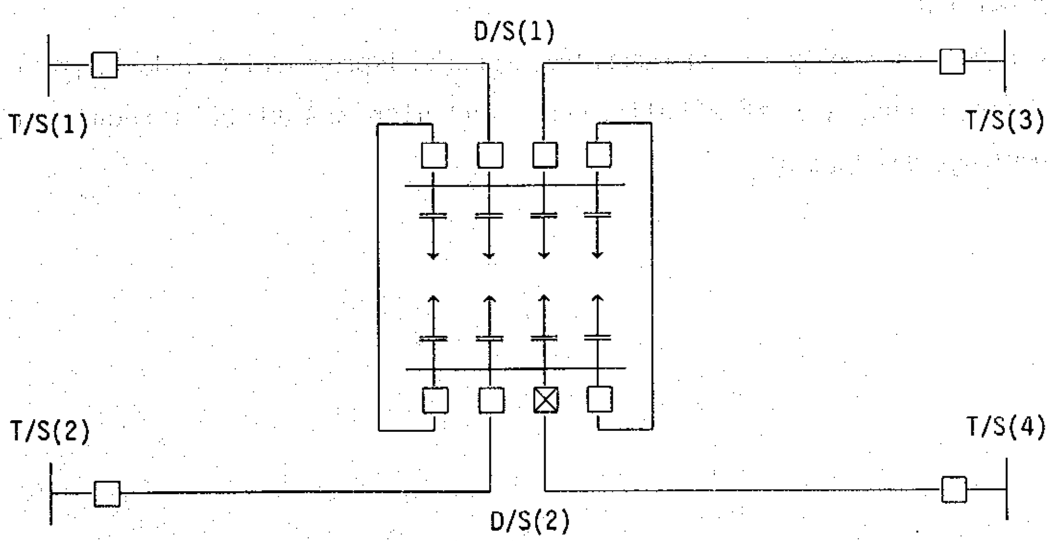
Fig. 5.2-1 Subtransmission Line Configuration



(c) Tapped-tie



(d) Loop



(e) Network

Fig. 5.2-1 Subtransmission Line Configuration (cont'd)

5.3 The Revised 7th Plan

5.3.1 Policy Guidelines

MEA has set a series of policy guidelines of the Revised 7th Plan to improve the power distribution system reliability as follows:

(1) To construct sufficiently good quality, reliable and safe power distribution system to serve the increasing power demand.

(2) To promote and provide services to satisfy all classes of customers and to encourage efficient, safe and economical electricity utilization.

(3) To improve quality of distribution system in business and industrial areas for more reliability.

(4) To improve distribution system in some significant areas for improvement of landscape and environment.

(5) To improve distribution system in certain areas requiring high quality of power supply by using underground cable and 24 kV voltage regarding system reliability.

(6) To promote and encourage more private sectors in participation in implementation.

(7) To control the tariff rate in line with economic and investment principles.

(8) To study and employ modern technology for the improvement and development of power supply system reliability and also MEA staff's technical knowledge development.

5.3.2 Outline of the Revised 7th Plan

MEA formulated the Revised 7th Plan in line with the above mentioned policy and has performed its implementation to cope with the rapid increasing demand. Brief description of the Revised 7th Plan concerning this Study is as follows:

(1) Terminal Station

Six new terminal stations (Thanontok, Sainoi, Jangwatana, Ratchada, Bangkoknoi and Teparak) are to be constructed with the total capacity of 2,700 MVA, of which Thanontok is to be invested by MEA.

Besides seven existing terminal stations will be boosted by 1,400 MVA and the total increasing capacity will be 4,100 MVA.

(2) Distribution Substation

Forty-two new distribution substations with total capacity of 4,400 MVA will be constructed; 16 existing substations will be boosted by 800 MVA in total, and 22 temporary or small substations will be dismantled resulting in reduction of 1,060 MVA. The total increasing capacity will be 4,140 MVA. In addition, there will be modification of two more existing substations.

(3) Subtransmission Line System

The total length of subtransmission line to be constructed will be 377.7 ckt-km of which 281 ckt-km is overhead line and 96.7 ckt-km is underground cable. Moreover, there will be subtransmission line addition at the total length of 35.3 ckt-km, of which 26.6 ckt-km is overhead line and 8.7 ckt-km is underground cable.

5.4 Progress Situation and Problems

5.4.1 Load Forecast and Actual Records

Based on the load forecast for FY 1991, the 7th Plan was revised and placed into execution. As the actual load exceeded the forecast value (by approximately 2.6%) later in FY 1992, the load forecast was revised accordingly in FY 1993.

The difference between actual value and the forecast value at each year of FY 1993, 1994 and 1995 (98.9% in FY 1993, 99.2% in FY 1994 and 102.0% in FY 1995) was very small. It is judged justifiable to use the revised forecast values in FY 1993 for this study. However, it is time to review the whole load forecast as the next step, taking the latest trend of increasing load into account.

Forecast values according to the Revised 7th Plan and actual values of load in the past are as shown in the table below.

Fiscal Year		1991	1992	1993	1994	1995	1996
Revised 7th Plan Forecast in FY 1991	(MW)	3591.4	3890.4	4264.7	4656.1	5110.9	5610.7
	(%/a)	12.7	10.5	9.6	9.2	9.8	9.8
Actual	(MW)	3591.4	3992.6	4346.0	4754.8	5336.7	
	(%/a)	12.7	13.4	8.9	9.4	12.2	
Forecast in FY 1993	(MW)			4392.0	4791.0	5231.0	5723.0
	(%/a)			10.0	9.1	9.2	9.4

5.4.2 Progress of Substation Expansion Plan

According to the Revised 7th Plan, most of the substation expansion work has been considerably behind schedule. As a countermeasure to cover power supply, therefore, temporary one-bank substation has been installed in many cases. Table 5.4-1 shows the commissioning date of the respective substations based on the initial substation expansion plan and the outlook for commissioning of such substations as of the stage of the First Field Investigation. In this table, the modified outlook of the commissioning period is marked by arrows. Although 12 substations among the 73 projects in total have been commissioned as temporary substations in advance along with rapid increase of power demand, the construction work of many other substations has been by two or three years behind schedule. However, the majority of substations are scheduled to be commissioned by FY 1997, except five substations which are postponed to FY 1998.

On the other hand, 16 substations with a total output of 680 MVA, which had not been allocated in the Revised 7th Plan, were constructed or expanded in FY 1993. These substations are deemed to have been constructed or expanded as a result of delay in the commissioning period based on the Sixth Five-Year Plan or as an emergency countermeasure to cover short power supply.

The particularly serious problem under the Revised 7th Plan is that the commissioning period of the Thanontok T/S (230/69 kV, 2x250 MVA) proposed to be constructed as a terminal substation might be postponed from FY 1993 to FY 1998.

Although a standby one bank has been proposed to be installed in the Chidlom T/S (230/69 kV, 2x250 MVA) located comparatively close to the Thanontok T/S, the delay in commissioning of the Thanontok T/S is considered to cause a substantial effect upon stable power supply in the future. Such an effect is studied in the following Clause 5.4.3.

Description		Annual Installation Capacity (MVA)					Additional Fiscal Year		Total Installation Capacity (MVA)	Remarks
		1992	1993	1994	1995	1996	1997	1998		
Construction of Transmission Substation										
Thanontok	230-69 kV		2x250 →							
Sainoi	230-115 kV		1x200 →							
Jangwatana	230-115 kV			2x300 →						
Ratchada	230-69 kV				2x300 →					
Bangkoknoi	230-115 kV				1x200					
Teparak	230-69 kV					1x300 →				
	230-115 kV					1x300 →				
Subtotal		-	700 (0)	600 (0)	800 (200)	600 (800)	(1200)	(500)	2700 (2700)	
Addition of Transmission Substation										Chidlom 1 ×250 in 1995 as a stand by transformer
Lardprao	230-69 kV	3x200 to 4x200 →								
South Bangkok	230-115 kV	1x200 to 2x200 →								
Bangkoknoi	230-69 kV			2x100+ 2x200 to 4x200 →						
Bangplee	230-115 kV			2x200 to 3x200 →						
Klongrangsit	230-115 kV			2x200 to 3x200 →						
South Thonburi	230-69 kV				2x200 to 3x200					
Nongjok	230-115 kV				1x200 to 2x200					
Subtotal		400 (0)	- (200)	600 (200)	400 (800)	-	(200)		1400 (1400)	
Total		400 (0)	700 (200)	1200 (200)	1200 (1000)	600 (800)	(1400)	(500)	4100 (4100)	

Description		Annual Installation Capacity (MVA)					Additional Fiscal Year		Total Installation Capacity (MVA)	Remarks
		1992	1993	1994	1995	1996	1997	1998		
Construction of Distribution Substation										
Nongbon (Suanluana)	115-12/24 kV	1x40+2x60 →		(1x60)						
Rungpracha (Talingchan)	69-12 kV	2x40 (1x40) →		(2x60)						
South Thonburi	69-12 kV	2x40 →	(2x60)							
Bangplakod	69-12 kV	2x40 →								
Sapanmai	69-12/24 kV	1x40+1x60 →	(1x40→1x60)							
Soonvijai	69-12/24 kV	2x40+1x60 →		(1x40) (1x60)						
Ekamai	69-12 kV	3x40 →								
Pradipat	69-12 kV		2x40 →							
Nanlinchi(Yanarkart)	69-12 kV		3x40 →	(1x60)						
Bangnamjued	115-24 kV		2x60+1x20 →							
Bangmod	69-12 kV	(1x40) ←	2x40 →							
Wangpetchaboon	69-12 kV	(1x40) ←	2x40 →							
Tungsonghong	69-24 kV		2x60 →							
Jomthong	69-12 kV		2x40 →							
Bangrakyai	115-24 kV		(1x60) ←	2x60 →						
Suansom	69-12 kV	(1x40) ←		2x40 (1x60) →						
Krunai(Suksawad)	69-12 kV	(1x40) ←		2x40						
Kaset	69-12/24 kV			1x40+1x60 →						
Kingkaew	115-24 kV			2x60 (1x40) →						
Nonsee	69-12 kV			2x40 →						
Nana(Sansab 2)	69-12 kV			2x40 →						
Muangthong I	115-24 kV	(1x60) ←		2x60 →						
Bangpongpang	69-24 kV			2x60 (1x60) →						
Bangchalong	115-24 kV		(1x60) ←	2x60 →						
Inthamara	69-24 kV				2x60 →					
Sanambinnam (Watkalang)	115-12 kV			(1x60) ←	2x40 →					
Klongsanamchai (Chaithalae)	69-12/24 kV				1x40+1x60 →					
Bangrak(Surasak)	69-12/24 kV			(1x60) ←	1x40+1x60 →					
South Bangplee (Bang tumrhu)	115-24 kV			(1x40) ←	2x60 →					
Bangchan	115-24 kV				2x60 →					

Description		Annual Installation Capacity (MVA)					Additional Fiscal Year		Total Installation Capacity (MVA)	Remarks
		1992	1993	1994	1995	1996	1997	1998		
Muangthong 3	115-24 kV			(1x60)←	2x60 →	→	→			
Sri-eiam*	69-24 kV			(2x60)←	2x60					
Sainamtip	69-12 kV				2x40 →	→	→			
Bangsai	115-24 kV				2x60					
Tungkru	69-12 kV					2x40 →	→	→		
Nanglerng	69-12 kV					2x40 →	→	→		
Bangson	69-12/24 kV					1x40+1x60 →	→			
Thanontok	69-12/24 kV					1x40+1x60 →	→	→		
Ghoaklang(Thepleela)	69-24 kV					2x60 →	→			1x40 at 1990
Khortor	115-24 kV			(1x60)←	←	2x60 →	→			
Jangwatana	115-24 kV					2x60 →	→			
Bering	69-24 kV					2x60 →	→			
Bangkae				(1x40)						
Taweewattana				(1x40)						
Subtotal		760 (260)	700 (340)	1020 (1040)	1080 (460)	840 (560)	(1360)	(340)	4400 (4360)	
Addition of Distribution Substation										
Bangpood	69-12 kV	2x20 to 2x40 →	→(2x60)							
Lardplakao	115-24 kV	1x40 to 1x60 →	→							
Chankasem	69-12/24		2x40 to 2x40+60 →	→	→					
Kingpetch	69-12 kV		(1x60)←	←2x40 to 3x40 →	→					
Ramkamhaeng	69-12/24 kV			2x40 to 2x40+ 1x60 →	→	→				
Rungpracha (Talingchan)	69-12/24 kV			2x40 to 2x40+ 1x60 →	→					
Bangplakod	69-12 kV		(2x60)←	←	←2x40 to 3x40					
Pakkred	69-12/24 kV		←	←	←2x40 to 2x40+1x60					

Description	Voltage	Annual Installation Capacity (MVA) Revieed 7th Plan					Additional Fiscal Year		Total Installation Capacity (MVA)	Remarks
		1992	1993	1994	1995	1996	1997	1998		
Wangthonglang	69-24 kV				←	2x60 to 3x60				
Nana(Sansab 2)	69-12/24 kV					1x40+60 to 1x40+2x60				
Subtotal		60 (0)	60 (260)	160 (0)	100 (160)	120 (120)			500 (540)	
Addition and Modification of Distribution Substation										
Donmuang	69-12/24 kV	2x40 to 2x40+60 →	→	→	→	→				
Mahamek	69-12 kV		2x40 to 3x40 →	→	→	→				
Thonburi	69-12 kV		2x40 to 3x40 →	→	→	→				
Mochit	69-12 kV			2x40 to 3x40 →	→	→				
Bangkapi	69-12/24 kV			2x40 to 2x40+60 →	→					
Makasan	69-12/24 kV				2x40 to 2x40+60					
Subtotal		60 (0)	80 (0)	100 (0)	60 (120)	- (180)			300 (300)	
Total		880 (260)	840 (600)	1280 (1040)	1240 (740)	960 (860)	(1360)	(340)	5200 (5200)	

Note : There are 2 new substations(each 60 MVA) and 14 expanded substations in 1993
These are not included in 7th plan and in this Table : Total increasing capacity 680 MVA
( ) shows annual increasing capacity of actual condition

5.4.3 Effect of Delay of Thanontok Substation Construction

According to the outlook at the time of the First Field Investigation, the Thanontok Substation was scheduled to be commissioned in FY 1998. However, this substation was scheduled to have been commissioned in FY 1993 in the Revised 7th Plan.

Therefore, a brief study is made on the basis of a power flow diagram on the situations in the surrounding substation loads in case the Thanontok T/S is not commissioned in FY 1996, the final fiscal year of the Revised 7th Plan.

(1) Study conditions

- All of the substations other than the Thanontok T/S are assumed to be completed on schedule (as indicated in the power flow diagram).
- Switchover to surrounding substations is to be made by making and breaking of the transmission line side circuit breakers in distribution substations.
- In case the load to be switched over is large, the load is also switched over mutually between the surrounding substations.
- Although transmission loss may vary depending on switching-over of load, such a loss is negligibly small so that it is disregarded in this outline study.

(2) Results of study

Studies have been made to switch the loads in the Thanontok T/S over to the surrounding Childlom, Lardprao, South Bangkok and South Thonburi T/Ss as a countermeasure, but it is concluded difficult to switch over all of the loads due to the shortage of the capacity (transmission capacity: approximately 107 MVA; estimated load after switching-over: 117-153 MVA) of the transmission line consisting of only three single core cables on the 69 kV side Childlom T/S. The load in the Childlom T/S, which is estimated to become nearly 640 MVA, may also substantially exceed the bank capacity of 2x250 MVA. The portion of changeover to the other terminal stations (Lardprao, South Bangkok and South Thonburi) is not deemed to cause any problem, since the transmission line will be free from excessively heavy load, and the load in the terminal station is remaining within a range of 80% utilization factor.

In case Thanontok T/S does not exist, the Childlom T/S and its secondary system will be exposed to excessively heavy load, and stable power supply can be disturbed. Therefore, an urgent countermeasure will be required, as is shown in Table 5.4-2 and Fig. 5.4-1.

Table 5.4-2 Load Flow Condition of Surrounding Thanontok T/S in case of Load Switching to Another Substations

Total Load of Thanontok T/S at FY 1996: 376.78 MW+j174.02 MVAR

Substation and Customer received from Thanontok			Sending-out Load		Terminal Station to be switched	Switching Load		Line Load Flow				Condition of Surrounding Substation						
Name	Load							Before Switching		After Switching		Name and Bank Capacity	Sending-out Load					
													Before Switching			After Switching		
	MW	MVAR	MW	MVAR		MW	MVAR	MW	MVAR	MW	MVAR	MVA	MW	MVAR	(MVA)	MW	MVAR	(MVA)
Sipraya	41.05	15.74	41.22	16.18	Lardprao	41.22	16.18	Sending from Lardprao 60.90	23.82	102.12 (109.7 MVA)	40	Lardprao 400 400	259.15 269.8	70.23 41.34	(268.5) (272.9)	300.37 269.8	86.41 41.34	(312.6) (272.9)
Bangrak	22.22 12.12	8.36 6.04						Sending from Chidlom										
Surawong	44.70 16.04	16.45 8.19	89.23	40.46	Chidlom	96.26	53.29→	28.56	12.64	124.82** (141.2 MVA)	65.93							
Mahamek	54.16	17.76	61.19	30.59	Chidlom	54.16	17.76					Chidlom						
Saladaeng	45.6	17.2	45.82	20.46	Chidlom	45.82	20.46	49.66 (42.44	21.49 13.44)*	107.20** (116.8 MVA)	46.27	500	327.42	140.17	(356.20)	557.63	269.23	(619.2)
Bangpongpang	42.52	25.49	76.41	50.99	Chidlom	76.41	50.99→	50.52	34.74	126.93** (153.2 MVA)	85.73	250(spare)						
Bangklo	33.55	17.82																
Bangkrajao	6.34	2.32						Sending from South Bangkok										
Jaengron	11.33	6.07	28.82	8.83	South Bangkok	28.82	8.83→	55.89	36.40	84.71 (96.0 MVA)	45.23→	South Bangkok 400 400	295.14 283.15	56.52 62.32	(300.5) (289.9)	323.96 283.15	65.35 62.32	(330.5) (289.9)
Ajinomoto	11.1	3.1																
Local	17.61 16.0	8.10 7.36	33.61	15.46	South Thonburi	33.61	15.46→	Sending from South Thonburi 43.50	23.40	77.11 (86.3 MVA)	38.86	South Thonburi 400 200	221.58 111.64	72.22 42.36	(233.1) (119.4)	297.63 111.64	101.12 42.36	(314.3) (119.4)
Subtotal	374.34	160.00																
Loss	2.44	14.02																
Total	376.78	174.02	376.3	182.97														
* Second step Switching of Silom Load	42.44	13.44	Sending from Chidlom 42.44	13.44	Chidlom to South Thonburi	42.44	13.44→	Sending from South Thonburi 53.35	26.74	95.79 (103.9 MVA)	40.18							

Note: * 2nd step switching
** Transmission line capacity 107 MVA (Single core 800 sq.mm)

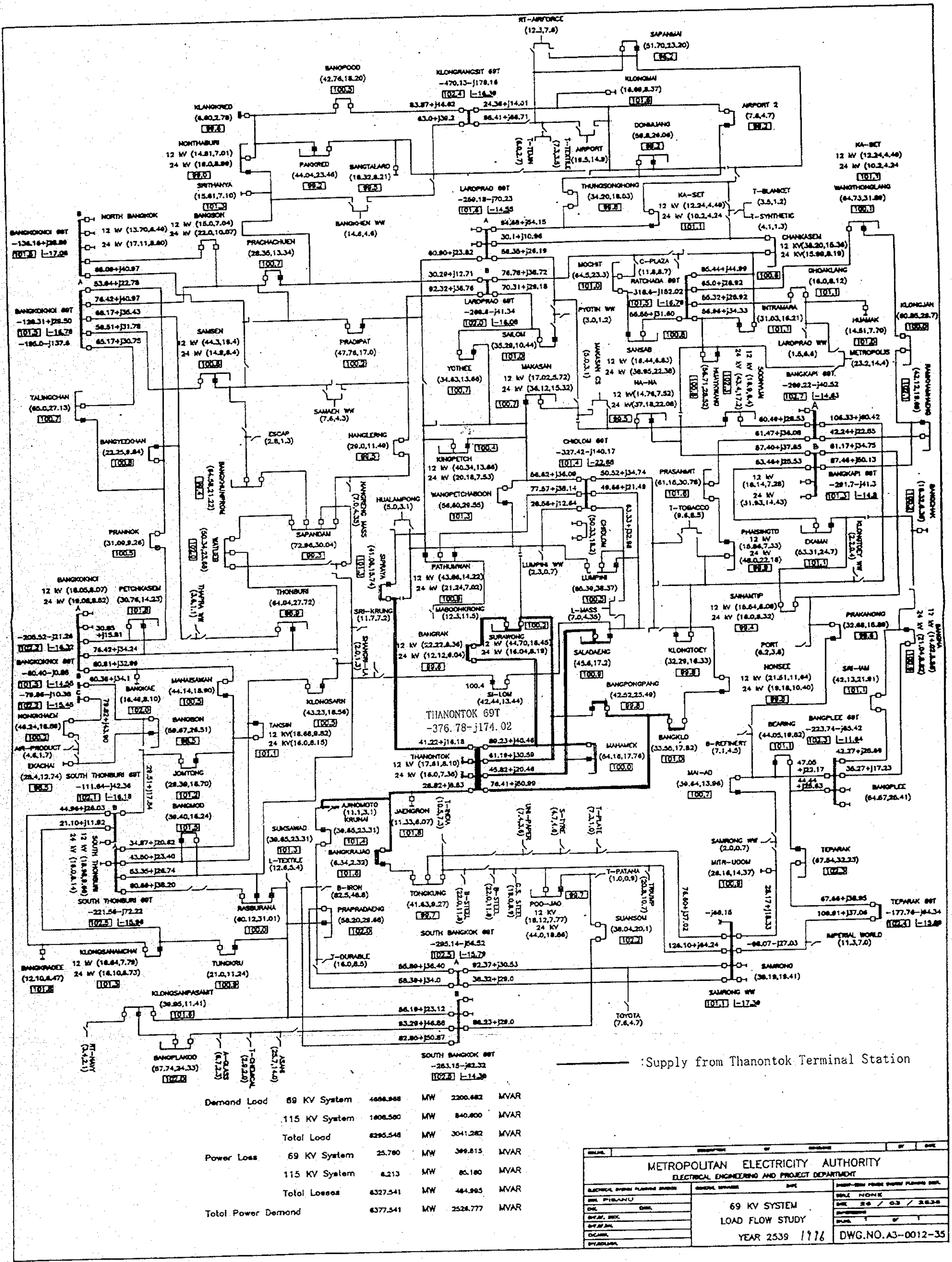
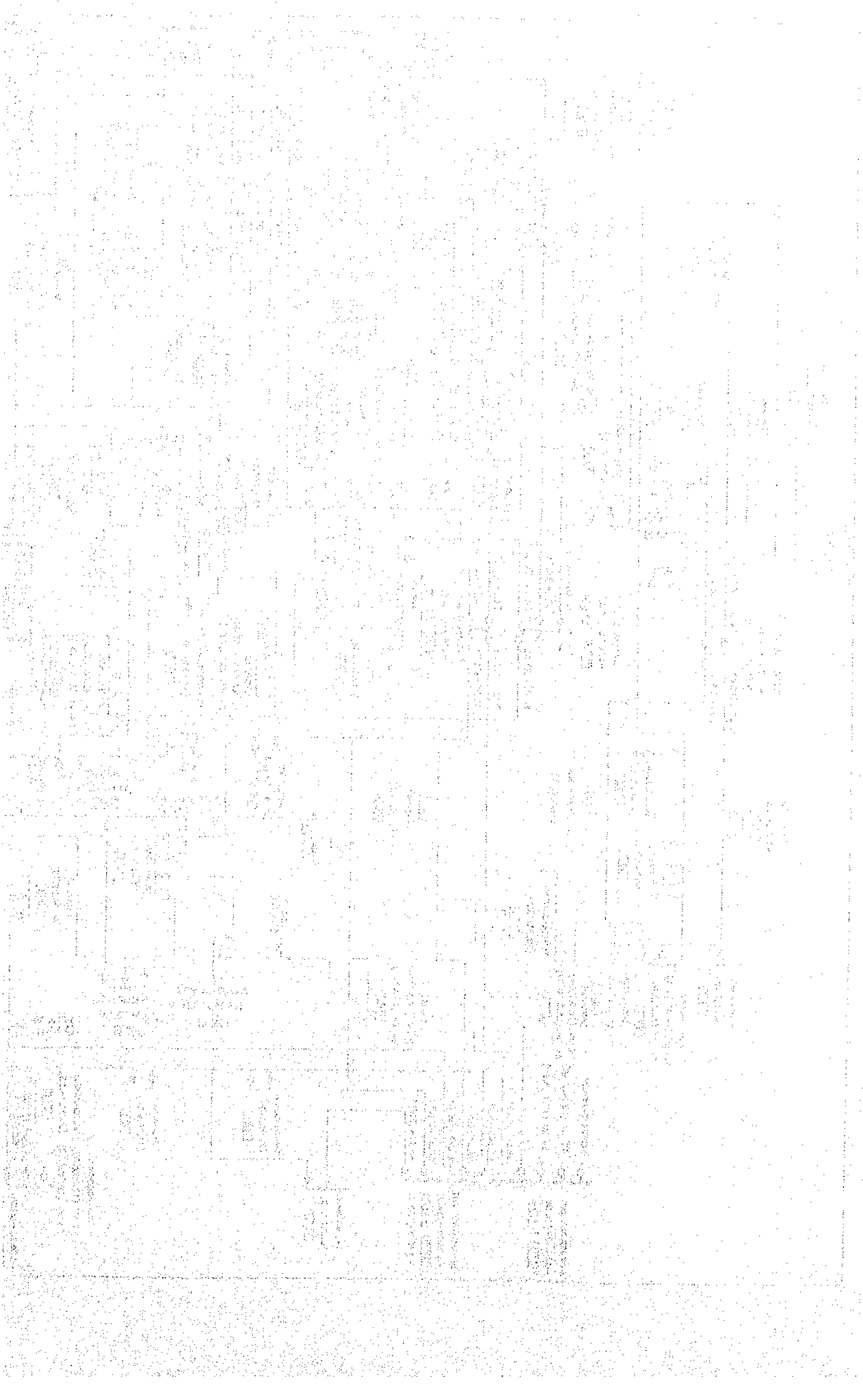


Fig. 5.4-1 Load Flow Study for 69 kV System in 1996 by MEA



5.4.4 Utilization Factor of Distribution Substation

According to the design criteria of MEA, the maximum load in a distribution substation is specified as presented in the table below based on the rated capacity of the respective transformers at normal and emergency load conditions. However, the conditions of the prevailing reliability have been confirmed by examining the actual load situations.

MEA's Design Criteria of Distribution Substation

	Maximum loading against transformer rating (%)		Load factor in remaining bank at one bank shut down (%)	Load to be switched over (%)
	Normal	Emergency		
2-bank substation	75	125	150	25 *
3-bank substation	80	120	120	0

Note: * In case of 2x60 MVA, the load of 15 MVA should be switched over.

(1) Utilization factor of distribution substation

Utilization factor of distribution substations was checked by looking up the actual record of distribution substation peak load in September 1994, as is shown in the Table below:

Utilization Factor (%)	Number of related substations	Share
95 - 100	1	31%
90 - 94.9	6	
85 - 89.9	3	
80 - 84.9	8	
75 - 79.9	14	
30 - 74.9	62	60%
20 - 29.9	4	9%
10 - 19.9	2	
1 - 9.9	3	
Total	103	100%

The extent of load which should be switched over to other substations at the time of shutdown at one bank was examined while paying attention to the utilization factor exceeding 80% among the above, as is shown in Table 5.4-3.
The load equivalent to 25% of one-bank capacity in maximum is allowed to be switched over to another substation in the case of 2-bank substation according to the design criteria, but many substations are operated at much higher load than the above. In the case of substation with different bank capacity, the capacity which should be changed over at the time of shutdown of larger capacity bank has become particularly large. The largest capacity requiring switchover is 95% in the Prakasa Substation, where about 43% of the total load should be switched over.

(2) Expansion plan of excessively loaded substations
Examined herein is what kind of countermeasures for extending excessively loaded substations have been incorporated in the expansion plan according to the Revised 7th Plan, as is shown in Table 5.4-4.
Such an excessively heavy load is deemed to have been reduced in many substations, should the corresponding or adjacent substations have been extended on schedule. Whereas, no extension plan has been worked out for the excessively loaded Muang Mai Substation and Bangsaotong Substation adjacent to each other in the southeastern region.
On the other hand, the utilization factor is low particularly in many substations commissioned in FY 1994. The temporary one-bank substations (designed for Power supply to large scale residential condominiums) adjacent to the Muangtong-1 and -3 Substation are operated respectively at an extremely low utilization factor of lower than 10% at the stage of site survey. Under such situations as mentioned above, it would be necessary to study future countermeasures while observing the load conditions in the surrounding areas.

Table 5.4-3 Necessary Switching Load to Other Substation on High Utilization Substation

No.	Code No.*	Name of D/S	Utilization factor (%)	Capacity (MVA)	Bank config.	Maximum load(MVA) (a)	At the time of 1 bank stop: Allowable capacity (MVA) (b)	Necessary load switching to other D/S (c)=(a-b)	Switching ratio to maximum load (d)=(c/a)×100%	Sound capacity (MVA) (e)	Switching ratio to sound capacity (f)=(c/d)×100%
1	1	Bangkapi	81.1	80	2×40	64.9	50	14.9	22.9	40	37.3
2	2	Bangbon	83.6	120	3×40	100.4	96	4.4	4.4	80	5.5
3	9	Bangplee	83	120	2×60	99.6	75	24.6	24.7	60	41
4	12	Chankasem	91.2	80	2×40	72.9	50	22.9	31.4	40	57.3
5	15	Klongjan	87.9	160	2×60 1×40	140.6	125	15.6	11.1	100	15.6**
6	32	Prakanong	84.7	80	2×40	67.8	50	17.8	26.3	40	29.7
7	33	Prakasa	87.2	100	1×40 1×60	87.2	50	37.2	42.7	40	93
8	36	Paknam	94	80	2×40	75.2	50	25.2	33.5	40	63
9	39	Rasburana	90.1	120	3×40	108.1	96	12.1	11.2	80	15.1
10	51	Watlieb	82.5	80	2×40	66	50	16	24.2	40	40
11	52	Yothee	81.4	80	2×40	65.2	50	15.2	23.3	40	38
12	54	Ramkhamhaeng	95	80	2×40	76	50	26	24.2	40	65
13	56	Muangmai	93	120	2×60	111.6	75	36.6	32.8	60	61
14	63	Bangsaotong	90.8	60	1×60	54.5	0	54.5	100	—	100
15	64	Bangmod	89.7	40	1×40	35.9	0	35.9	100	—	100
16	69	Bangrakyai	92.1	60	1×60	55.3	0	53.5	100	—	100
17	70	Bangnamjued	81.4	60	1×60	48.8	0	48.8	100	—	100
18	97	Suanluang	83.8	60	1×60	50.3	0	50.3	100	—	100

Note: * Code No. means arrangement number of substation in MEA's Monthly Report
** As Klongjan D/S has 2x60 MVA for 24 kV and 1x40 MVA for 12 kV, the maximum load shall be considered separately

Table 5.4-4 Heavy Load Substation and Expansion Plan in the Revised 7th Plan

(unit : MVA)

No.	Code No.	Name of D/S	Adjacent D/S and Expansion Plan
1	1	Bangkapi	Soonvijai 1×40+1×60→+1×40(1994 → ?)
2	2	Bangbon	South Thonburi
3	9	Bangplee	King kaew 2×60(1994 →1995)
4	12	Chankasem	+1×60(1993 →1995)
5	15	Klongjam	Ramkhamhaeng +1×60(1994 →1996)
6	32	Parakanong	Ekamai 3×40(1992 →1996)
7	33	Prakasa	Khotor 1×60 at 1994→2×60(1995 →1997)
			Bangtumuru 1×40 at 1994→2×60(1995 →1997)
8	36	Paknam	Suansom 1×60 at 1994→2×40(1994 →1995)
9	39	Rasburana	Kurunai 1×40 at 1992←2×40(1994 →1996)
10	51	Watlieb	Nanglerng 2×40(1996 →1998)
11	52	Yothee	Kingpetch 2×40→3×40(1994 →1995)
			Makasan 2×40→+60(1995)
12	54	Ramkhamhaeng	2×40→+1×60(1994 →1996)
13	56	Muangmai	Bangsaotong
14	63	Bangsaotong	Muangmai
15	64	Bangmod	1×40→2×40(1993 →1996)
16	69	Bangrakyai	1×60→2×60(1994 →1995)
17	70	Bangnamjued	1×60→2×60+1×20(1993 →1994→ ?)
18	97	Suanluang	1×60→1×40+2×60(1992 →1995)