JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

METROPOLITAN ELECTRICITY AUTHORITY (MEA)
THE KINGDOM OF THAILAND

FEASIBILITY STUDY
ON
POWER DISTRIBUTION SYSTEM
IMPROVEMENT AND EXPANSION PLAN
IN THE METROPOLITAN AREA
IN
THE KINGDOM OF THAILAND

FINAL REPORT

SUMMARY

NOVEMBER 1995

TOKYO ELECTRIC POWER SERVICES CO., LTD.
ELECTRIC POWER DEVELOPMENT CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

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Conclusions

1. Power Demand in the Metropolitan Area

In Thailand, the majority of electric power is generated by the Electricity Generating Authority of Thailand (EGAT) and the peak generation and annual energy production in fiscal year (FY) 1994 were recorded at 10,709 MW and 69,651 GWh, respectively. The power is being supplied to the customers in the metropolitan area by the Metropolitan Electricity Authority (MEA) and the maximum power demand forecasts used in the Study are as follows:

FY	Max. Demand
1994 (actual)	4,755 MW
1997	6,205 MW
1998	6,670 MW
1999	7,174 MW
2000	7,701 MW
2001	8,290 MW
2006	10,653 MW
2011	13,416 MW
2016	15,780 MW

2. Present Situations and Problems of Power Distribution System Facilities

Electric power in the MEA's distribution area is supplied by the 230 kV EGAT's transmission network surrounding Bangkok.

The mushroom growth of the metropolitan area, however, has resulted in rapid increasing electric demand and difficulty in acquiring land for substation, escalation of land price, and so forth.

At present, the Seventh Power Distribution System Improvement and Expansion Plan (FY 1992-1996) is being implemented by MEA.

Under these circumstances, MEA has realized the needs of the feasibility study on long-term power distribution system improvement and expansion plan in the metropolitan area, and requested this study to the Japanese Government through Thai Government, and the Study has been carried out by this Japan International Cooperation Agency (JICA) Study Team.

3. Basic Assumptions of the Feasibility Study

(1) System Planning

Based on the MEA's planning criteria.

(2) Implementation of the Plan

(a) Subtransmission lines

The present right of way is assumed to be available in the future as well. Overhead line will be mainly used taking economy into account, underground cable line will be used only the route where overhead line cannot be constructed by physical or environmental restrictions.

(b) Substations

Transformers will be installed outdoor and the switching equipment will be installed indoor according to the MEA's standard. Underground type substation will be applied at such a site where it is difficult to acquire a sufficient space particularly in high load density areas.

(3) Environmental Issues

Only those issues predictable at present are considered within the framework of the present environmental restrictions.

(4) Cost Estimation

Based on the latest MEA's standard unit construction cost.

4. Outline of the Plan

Quantity of construction work, completion date and construction cost of the Plan are as follows:

FY	Construction and Addition of T/S (MVA)	Construction and Addition of D/S (MVA)	Construction and Modification of Subtransmission Line (ckt-km)	Construction Cost (Million Baht)
1997	700	1,220	88.7	4,352.9
1998	1,500	700	133.2	3,126.3
1999	900 (600)	700	130.0	2,993.4
2000	1,200 (600)	960	151.6	6,474.1
2001	1,015	1,760	31.5	4,719.2
Sub-total	5,315 (1,200)	5,340	535.0	21,666.0
			(Million US$	866.64)
2006	4,400 (1,200)	4,195	417.0	18,204.7
2011	3,200 (600)	4,360	150.3	8,146.5
2016	4,700 (1,200)	2,540	109.3	7,781.5
Total	17,615 (4,200)	16,435	1,211.6	55,798.7
			(Million US$	2,231.95)

Notes: 1. Figures in parenthesis in T/S column represent the MEA's own investment.

2. Construction cost is estimated in FY 1995 price level, involving VAT and Import Duty.

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

5. Economic Evaluation

The results of integration of the construction cost for this plan have been evaluated to be economically justifiable.

6. Financial Analysis

The financial analysis has been carried out by comparing the cost-flow of the construction cost and the cost of operation and maintenance of the facilities incurred from the execution of this plan, with the benefit-flow of the rate proceeds obtained from the increase of power consumption resulting from the completion of this plan.

The analysis has proved this plan to be financially sound.

Recommendations

(1) The Study has been carried out from a global point of view on the improvement and expansion of the metropolitan power distribution system. It is necessary, therefore, to study this plan in detail in advance to the actual implementation. When better alternatives are found, it is advisable that the plan will be reviewed on each occasion taking long range views into consideration.

(2) This is a feasibility study, prepared basing itself on the results of initial basic desk study carried out taking into account the present situation. This plan, therefore, has to be reviewed as required whenever there is any change in the power supply, social environment, basic assumptions and so forth.
Furthermore, terminal stations which supply power to the MEA's distribution area are connected to the 230 kV EGAT's transmission network, based on the latest Power Development Plan (PDP). Therefore, if there is any change in the EGAT's system, this plan has to be reviewed accordingly.

(3) At present, MEA is promoting use of insulated wire instead of bare wire in its 24 kV and 12 kV primary line systems. This will contribute greatly to eliminating faults judging from the past experience in Japan. At the same time, countermeasures for preventing burn-out of line due to lightning surge should also be steadily promoted together with the use of insulated wire.
Next, appropriate countermeasures should be taken in view of system configuration by installing line switches on the 24 kV and 12 kV primary line systems to improve the reliability at the time of fault in distribution substation as well as of fault in primary line. At the same time, research should be carried out for introducing the distribution automation system including automatic and remote control of line switches for the purpose of realizing automatic separation of a section of distribution line in fault and early restoration in sound section. In addition, introduction of underground primary line systems should also be systematically promoted in the high load density areas.

To ensure the reliability of integrated power distribution system as mentioned above, it would be of an urgent necessity to execute feasibility study for the 24 kV and 12 kV primary line systems subsequent to implementation of this plan.

(4) The topographic maps of the line routes, longitudinal sections should be prepared urgently as required for formulation of work execution plan and calculation of the volume of work, by executing site survey for selecting the locations of subtransmission lines and substations under this plan.

(5) The fund procurement plan for the work will be formulated by preparing a fund plan for each category of work schedule and a cash flow plan by each fiscal year for this plan at the same time. Meanwhile, the fund procurement plan should be formulated taking into account allocation of local fund and loan from third countries.

(6) The work schedule for this plan should be so formulated as to average the work volume per each fiscal year and match the best timing for power demand. It is preferable, therefore, to start preparatory actions one or two years before commencement of the corresponding work in anticipation of the necessity of a long time period for procurement of fund, field survey, detailed design and negotiations for land acquisition for the respective work categories.

(7) Expansion of scope of work and reinforcements of the existing sector in charge of land acquisition should be performed to acquire the land timely for proceeding the power distribution facilities construction just as planned. In addition, establishment of new organization in charge of implementing an important substation/subtransmission line construction project, like a comprehensive construction center, is recommended to promote the construction work intensively.

(8) To maintain the power distribution system facilities under this plan, it is essential to realize modernization of protective relay system and telecommunication facilities, mobilization of transportation of equipment and materials for patrol inspections, mechanization of maintenance work, modification of work method, and so forth as promptly as possible.

(9) Power cable of MEA is buried as an independent work separately from the other buried works (water supply, sewage and other system) in a same section, an environmental problem can be raised due repetition of road excavation. To avoid such a problem, therefore, Common Duct plans are under feasibility study for several routes in central part of Bangkok. In any case, early implementation of such project is desired also for effective utilization of underground space for common uses.
Also it will become essential to adopt underground substation in the overpopulated center area of Bangkok in future. Since the ground is soft and the groundwater level is high in the area, the design and execution of civil, architectural and structural work for underground room will require extensive and high level know-how and technology.
It is recommended to construct a pilot scale underground substation in as early period as possible and accumulate data and information to contribute for dissemination of such an underground type substation in future.

(10) In consideration of the necessity to prior advance training of technical experts as the staff in charge of executing management of this plan, it is essential to let these engineers take part positively in the Colombo Plan and other expert training programs of JICA to transfer technical knowledge to the engineers.
Moreover, training of the MEA's maintenance and management staff should also be provided at the same time to sustain maintenance of the power distribution system facilities under this plan.

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Metropolitan Electricity Authority (MEA) supplies electric power to a total area of 3,192 km^2 of Bangkok and its adjoining cities of Nonthaburi and Samut Prakan. Maximum power demand in fiscal year (FY) 1994 was recorded on September 23, 1994 at 4,755 MW, marking an increase of 409 MW or 9.4% over FY 1993, which accounts for about 45% of the total power demand of the whole Kingdom of Thailand.

The electric power demand was estimated as 5,723 MW for FY 1996, 8,290 MW for FY 2001, 10,653 MW for FY 2006, 13,416 MW for FY 2011 and 15,780 MW for FY 2016. The maximum power demand in the next 20 years, therefore, is expected to grow about three times as much of the present figure, however, the construction of new distribution system facilities is facing difficulties on account of the recent increasing density of land use in the center of Bangkok.

In order to meet with the increasing power demand under these circumstances, and to stabilize the supply of electric power, the Government of Kingdom of Thailand recognized the necessity of an urgent preparation of the power distribution system improvement and expansion plan, and submitted to the Japanese Government in July 1993 a request for the implementation of a feasibility study on this Project.

The Government of Japan decided to conduct a feasibility study on the Project, and assigned this work to JICA.

1.2 Contents of the Study

1.2.1 Objective of the Study

The objective of this study is to conduct the feasibility study on the various aspects of technology, economy, financing, society, organization and environment for the preparation of the power distribution system improvement and expansion plan, and at the same time, to transfer the technology to the Siamese counterparts concerning the feasibility of power distribution system during this study period.

1.2.2 Scope of the Study

The Objective Areas of the Study are Bangkok, Nonthaburi and Samut Prakan where MEA is supplying electric power. The Scope of the Study covers, however, the subtransmission lines and substations from the receiving point of EGAT to the distribution substations where the power is stepped down to 24 kV or 12 kV. Besides, the detailed studies have been carried out on the following model districts selected through the discussions between MEA and the Study Team, bearing in mind the high load density areas in the center of cities and taking into account the industrial and geographical elements.

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

The years up to FY 2001 were defined as short-term target years. The FY 2006, FY 2011, and FY 2016 (20 years from FY 1997) were defined as long-term target years, and the detailed studies have been conducted per each target year.

1.2.3 Study Items

The characteristic of this study consists firstly in the review of the existing MEA's short-term plan concerning the distribution system facilities in the Metropolitan Area which holds the densely populated area, and secondly in the preparation of a power distribution system improvement and expansion plan covering the short- and long-terms from FY 1997 onwards.

As for the high load density areas, the main items to have been studied under severe environmental conditions are as follows:

(1) Method of land acquisition for the substations.

(2) Possibilities of distribution system facilities making use of underground spaces.

(3) Application of the advanced technology to the distribution system facilities, including an attempt to make them compact.

(4) Detailed study for feasibility design on the model districts in the high load density area.

(5) Forecast on the environmental impact, and on the necessity of its

assessment.

Besides, seminars were held in Thailand two times during this study period. Also for the MEA engineers visiting Japan, the technology transfer of preparing plans regarding the Metropolitan Area was held as one of important themes of the Study.

The Study Team has provided technical suggestions and/or recommendations especially for the method of underground power distribution for 24/12 kV distribution line systems, based on the technology and experience accumulated in the densely populated areas in Japan.

Study items in the Study consists of:

a) Collection and evaluation of existing data and information.
b) Field investigation.
c) Study of current status of power system.
d) Identification of existing power system facilities.
e) Review of power demand forecast.
f) Review of existing short-term power distribution system improvement and expansion plan.
g) Formulation of short- and long-term power distribution system improvement and expansion plan.
h) Preliminary study of environmental impact.
i) Feasibility design.
j) Cost estimation and construction schedule.
k) Economic and financial analysis.
l) Technology transfer.

1.3 Activities of the Team in Thailand and Participants Concerned

1.3.1 Activities of the Team in Thailand

During the period from November 1994 to October 1995, the JICA Study Team performed the following activities in Thailand.

First : November 16th to December 17th, 1994.
Second: May 17th to June 15th, 1995.
Third : September 21th to October 5th, 1995.

1.3.2 JICA Study Team

Mr. Hiroyuki Imoto	JICA Study Planner
Mr. Kunio Okawara	Study Team Leader/ General Management
Mr. Masao Koike	Study Team Sub Leader/ Overhead Transmission Line
Mr. Shinji Sakurai	Underground Transmission Line
Mr. Shinichi Funabashi	System Planning
Mr. Toshio Wada	Substation
Mr. Katsuhiro Mukai	Protective Relay System
Mr. Ryuichi Abe	System Analysis
Mr. Katsunori Hoshi	Telecommunication
Mr. Yoshihiro Shishikura	Economics
Mr. Hiroaki Komuro	Distribution Substation Planning
Mr. Satoru Kitano	Assistance for System Analysis
Mr. Masahiro Sekita	Assistance for System Analysis

1.4 Provision of Equipment

The Study Team purchased a personal computer in Bangkok during the Second Field Investigation, and used it for system analyses, transfer of technical knowledge to MEA's engineers and other purposes.
Incidentally, this computer was provided by JICA to MEA on October 3, 1995 after completion of the Third Field Investigation.

1.5 Training for Counterpart

The training for power distribution system to the MEA's counterparts was carried out in Japan during this study period as follows:

(1) Name : Mr. Nipon CHIRATAWEEWOOT (at the expense of JICA)
Period : June 20 to July 19, 1995 (30 days)

(2) Name : Mr. Napadol PUTARUNGSI (at the expense of MEA)
Period : June 25 to July 19, 1995 (25 days)

1.6 Seminar

The Seminars for the purpose of technology transfer to MEA were held in Thailand two times during this study period as follows:

(1) First Seminar (May 25, 1995)
The first seminar was held by the JICA study team in one day during the Second Field Investigation concerning examples of Tokyo Electric Power Company (TEPCO)'s experience in power supply for the high load density areas, other topics such as the new technology of TEPCO.

(2) Second Seminar (September 28, 1995)
The second seminar was held by JICA in one day during the Third Field Investigation concerning summery of feasibility study of this project.

CHAPTER 2

GROWTH OF THE KINGDOM OF THAILAND AND THE METROPOLITAN AREA

2.1 Economic Growth of the Kingdom of Thailand

The National Economic and Social Development Board (NESDB) predicted the annual average real economic growth rate by 2000, namely, 8.0% during the earlier half of 1990s and 7.7% during the latter half of 1990s. Particularly in the case of the MEA's supply area, the economic growth rate is predicted to undergo a moderate downward trend from 8% to 6% by 2006.

Table 2.1-1 Targets of Economic Growth and Achievements

	1990 - 95	1995 - 00	2000 - 06
[Estimation of whole Country]			
NESDB	8.0%	7.7%	
MEA's Load Forecast Results FY 1993	8.4%	7.8%	6.6%
Actual (1990-92)	8.8%		
[Estimation of MEA's Area]			
MEA's Load Forecast Results FY 1993	8.8%	8.0%	6.6%
Actual (1990-92)	9.4%		
[Estimation of PEA's Area]			
MEA's Load Forecast Results FY 1993	8.1%	7.7%	6.6%
Actual (1990-92)	8.3%		

2.2 Major Development Projects around Bangkok

The major development projects around Bangkok are as presented below:

(1) Second international airport construction project

The second Bangkok international airport will be constructed in Samut Prakan Province about 30 km east of Bangkok by 2000.

Along with construction of this new airport, international business parks and science garden park are scheduled to be constructed around Nong Ngu Hao. Moreover, these projects are expected to offer employment opportunities for as many as 3.50 million people as an economic benefit by 2010.

(2) Government Center development project

Fifty percent of the government agencies and state-owned enterprises which are not directly involved in the services to the people will be relocated to the Government Center New Town scheduled to be developed around Thatakieb and Sanam Chai Khet of Chachoengsao about 120 km east of Bangkok. In this area, about one million people are predicted to live here in the future.

(3) Development of mass transportation systems

Development of mass transportation systems in Bangkok so far, the following projects have been proposed:

(a) Hopewell Project

This project is intended to construct an elevated railway line and a highway by using the land along the existing line route of the State Railway of Thailand (SRT). The route consists of a 25.9 km section between Taling Chan and Hua Mak and a 34.2 km section between Ponimit and Rangsit running respectively in the east - west and north - south directions crossing on the center of Bangkok. Meanwhile, this project is scheduled to be completed by 1999.

(b) Thanayong Project

Two lines consisting of a Sukumvit Line and a Victory Line totally 23.7 km are scheduled to be constructed according to a BOT agreement signed by and between the Bangkok Metropolitan Authority (BMA) and Thanayong and scheduled to be opened in 1998.

(c) MRTA Project

This project has been proposed by the Metropolitan Rapid Transit Authority (MRTA) to form a loop railway line with the existing line of SRT through connection between Bangsu and Hua Lum Pong. Although this project was planned initially on the basis of elevated line, it is now being reviewed taking into account the necessity of adopting subway in the city center area.

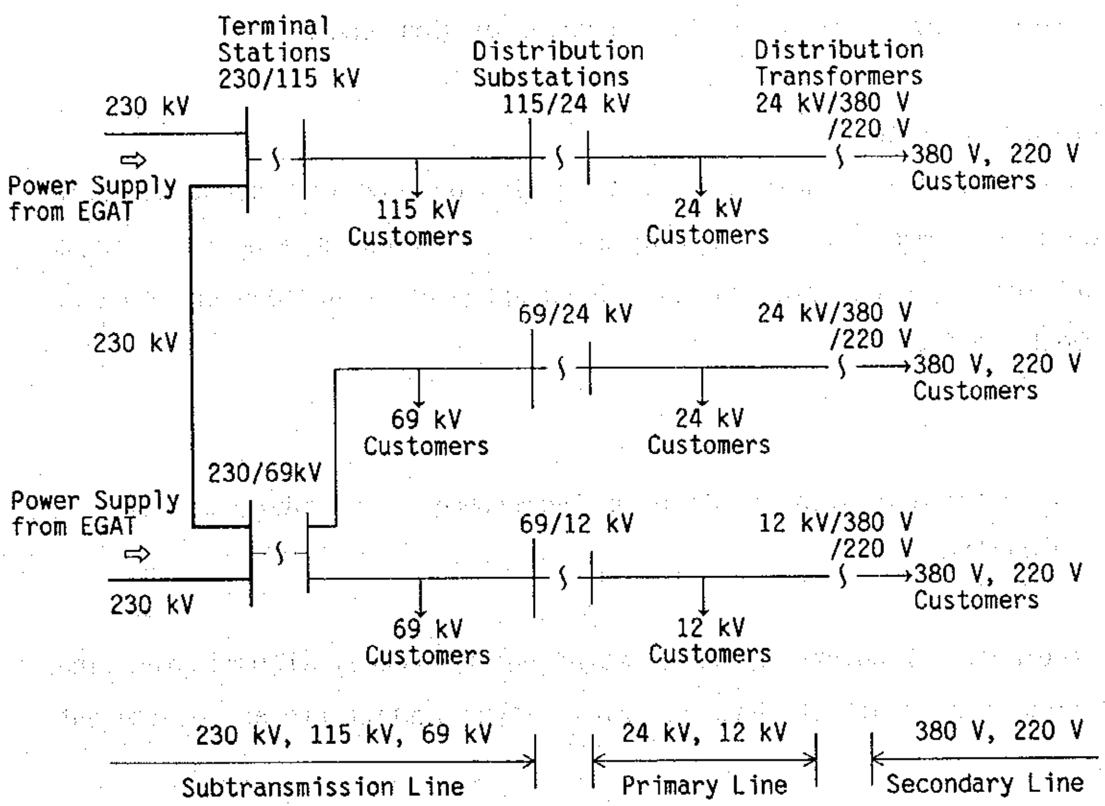
CHAPTER 3

PRESENT SITUATIONS AND PROBLEMS
OF
EXISTING POWER DISTRIBUTION SYSTEM
FACILITIES IN THE METROPOLITAN AREA

CHAPTER 3 PRESENT SITUATIONS AND PROBLEMS OF EXISTING POWER DISTRIBUTION SYSTEM FACILITIES IN THE METROPOLITAN AREA

3.1 Power System Configuration

The standard voltages for power distribution in MEA's system are 230 kV, 115 kV, 69 kV, 24 kV, 12 kV, 380V and 220V at the frequency of 50Hz as shown in the schematic diagram below.



As per the end of FY 1994, MEA received electric power from EGAT at voltage level 230, 115 and 69 kV through 10 terminal stations located within 230 kV outer ring transmission system surrounding Bangkok. The power was fed from each terminal station to 103 distribution substations scattering throughout the service area through MEA's subtransmission lines.

N.B.

The 230 kV substations of EGAT and MEA mentioned in this Report are hereinafter referred to as the "terminal stations" or "T/S".

3.2 Problematical Points of Existing Overhead Subtransmission Line Facilities

The problematical points in the existing overhead subtransmission line clarified as a result of the First Field Investigation are as pointed out below:

(1) Clearance

As the city development projects have been promoted at a rapid tempo in the old city, the lack of clearance is raising a problem as more new buildings have to be built closer subtransmission lines.

(2) Ground clearance

As the support structure of subtransmission line is made of concrete columns in many cases, the routes of subtransmission line requiring a sufficient ground clearance, such as speedways and elevated bridges, should be detoured.

3.3 Problematical Points of Existing Underground Subtransmission Line Facilities

The problematical points in the existing underground subtransmission line clarified as a result of the First Field Investigation are as pointed out below:

(1) Asbestos cement duct

The duct bank is bound over its entire length for reinforcement with concrete as asbestos cement duct is used as a duct bank for underground subtransmission line causing the duct installation work period to become longer and traffic congestion particularly when such work is carried out by an open-cut method.

Thus, it is recommended to adopt the polyester concrete fiberglass reinforced plastic pipe in order to curtail work period.

(2) Combined use of overhead line and underground line

The existing underground cable is used partly among the overhead line sections in many cases. Since there is no fault section locating detector installed as an auxiliary device, it is impossible to readily judge whether a fault has occurred in the overhead section or underground section. Therefore, execution of reclosing (re-transmission) at the time of fault in the underground cable section might possibly cause spread of cable damage due to fault current.

3.4 Problematical Points of Existing Distribution Substation

As a countermeasure for meeting rapid increase of load in recent years, it has been inevitable to construct temporary one bank substations which can be installed within a short period of time. Such situations would have made it inevitable to consume the valuable time and labor forces uselessly for planning, design and construction of the temporary substations and could possibly cause delay in construction of permanent substations in the future. Since various problems can probably be raised in view of supply reliability as well, it is urgently required to strengthen and improve the capabilities of planning, land acquisition, design and construction work.

3.5 Problematical Points of Protective Relay System

(1) Success ratio of automatic reclosing

The success ratio of automatic reclosing in FY 1994 was 28.2% for subtransmission line and 68.5% for distribution line as indicated in the table below:

Success ratio of automatic reclosing

Subtransmission lines			Feeders			
Instant. reclose	Fail to reclose	Total	Instant. reclose	Reclose in time	Fail to reclose	Total
134 (28.2 %)	341 (71.8 %)	475 (100.0%)	3,141 (51.3 %)	1,055 (17.2 %)	1,930 (31.5 %)	6,126 (100.0%)

Generally, the success ratio of automatic reclosing is reported to be 90% or above for overhead subtransmission line and 70-80% for overhead distribution line. Although the success ratio of automatic reclosing for feeders in the case of MEA is roughly equal to the above, that of subtransmission line has been worsened substantially.

Therefore, it is considered necessary to investigate the causes of frequent failure in automatic reclosing of subtransmission line and take appropriate preventive countermeasures. It would also be one of the options to temporarily suspend automatic reclosing until completion of the investigations.

According to this study result of cause of subtransmission line trip, the 13 cases or 16.9% of automatic reclosing are deemed undesirable in view of public safety. In this respect, it would be one of the options to lock automatic reclosing of subtransmission line.

(2) Improvement of the reliability of protective relay

(a) Installation of automatic oscillograph

About 60% of protective relay operation has so far occurred by unknown causes and maloperation, but this value will be reduced substantially and the reliability of protective relays be improved remarkably through appropriate countermeasures for promoting analysis of the above relationship after installing automatic oscillograph.

(b) Prevention of recurrence of maloperation

Should many similar maloperation phenomena be observed, it will be necessary to take appropriate countermeasures after investigating and clarifying the causes of such maloperation. In the case of maloperation occurring at the time of charging subtransmission line, maloperation of DZR and OCGR due to inrush current can also be considered. Meanwhile, the automatic oscilloscope also ensures easy analysis of inrush current.

(c) The relay configuration should be modified to a combination of instantaneously acting relay and timer.

The standard protective relay being applied by MEA has an inverse time lag characteristics. This relay does not allow appropriate timely coordination with the other relays and can possibly cause maloperation of protective relays. By modifying the configuration of protective relays into a combination of instantaneously acting relay and timer, it will be possible to ensure easy timely coordination with other relays and expect reduction of maloperation.

CHAPTER 4

REVIEW OF POWER DEMAND FORECAST

CHAPTER 4 REVIEW OF POWER DEMAND FORECAST

4.1 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.

The total generation requirement of EGAT by FY 2011 based on the results of power demand forecast is presented in Table 4.1-1 "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. The results of power demand forecast by FY 2016 in MEA's area are presented in Table 4.1-2.

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

(1) Study based on elastic values

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. 4.2-1.

To clarify the future trend of elastic values, such a trend has been expressed on a logarithmic curve based on the elastic values in FY 1982 through to FY 1995. As a result, this curve indicates that the elastic values are decreased gradually as indicated in Fig. 4.2-2.

On the basis of this curve, the electric power demand has been obtained from the GRP and elastic values forecast through to FY 2016. The result is presented in Fig. 4.2-3.

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.

(2) Recent trend of demand

With regard to the recent trend of electric power demand, the past records by May 1995 were compared with the demand forecast in FY 1993.

As is shown in Table 4.2-1, although the actual records fell a little short of the forecast values in FY 1993 and FY 1994, the load increased substantially, and the peak load exceeded the forecast value by 2% in the earlier half of 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.

(3) Conclusion

The source of 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 4.1-1 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 4.1-2 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	% ENERGY	% LOAD
	MW	% INC	GWH	% INC	SALES (GWH)	LOSS	FACTOR
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.

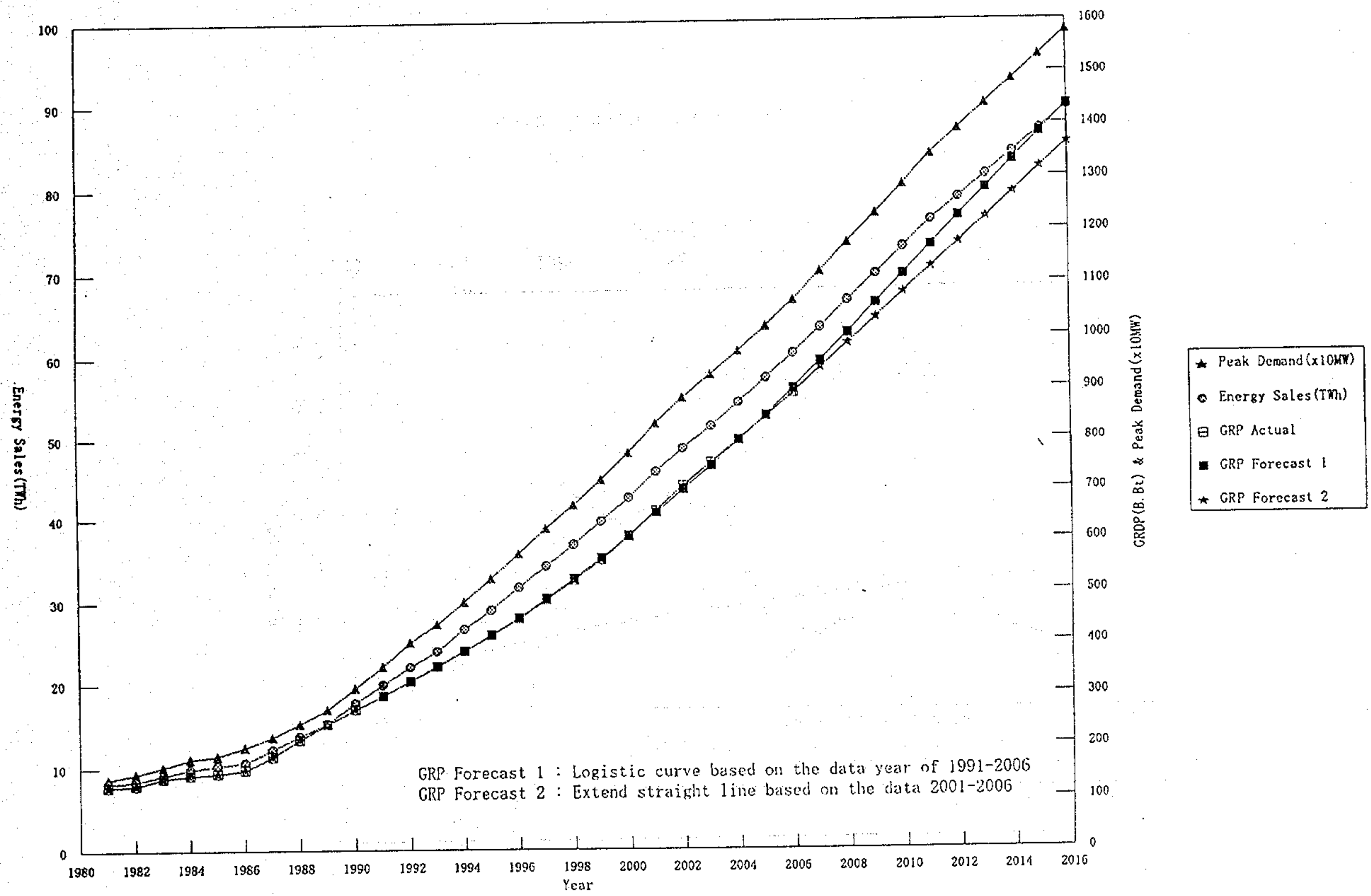


Fig 4.2-1 Energy Sales, Peak Demand, GRP Relation

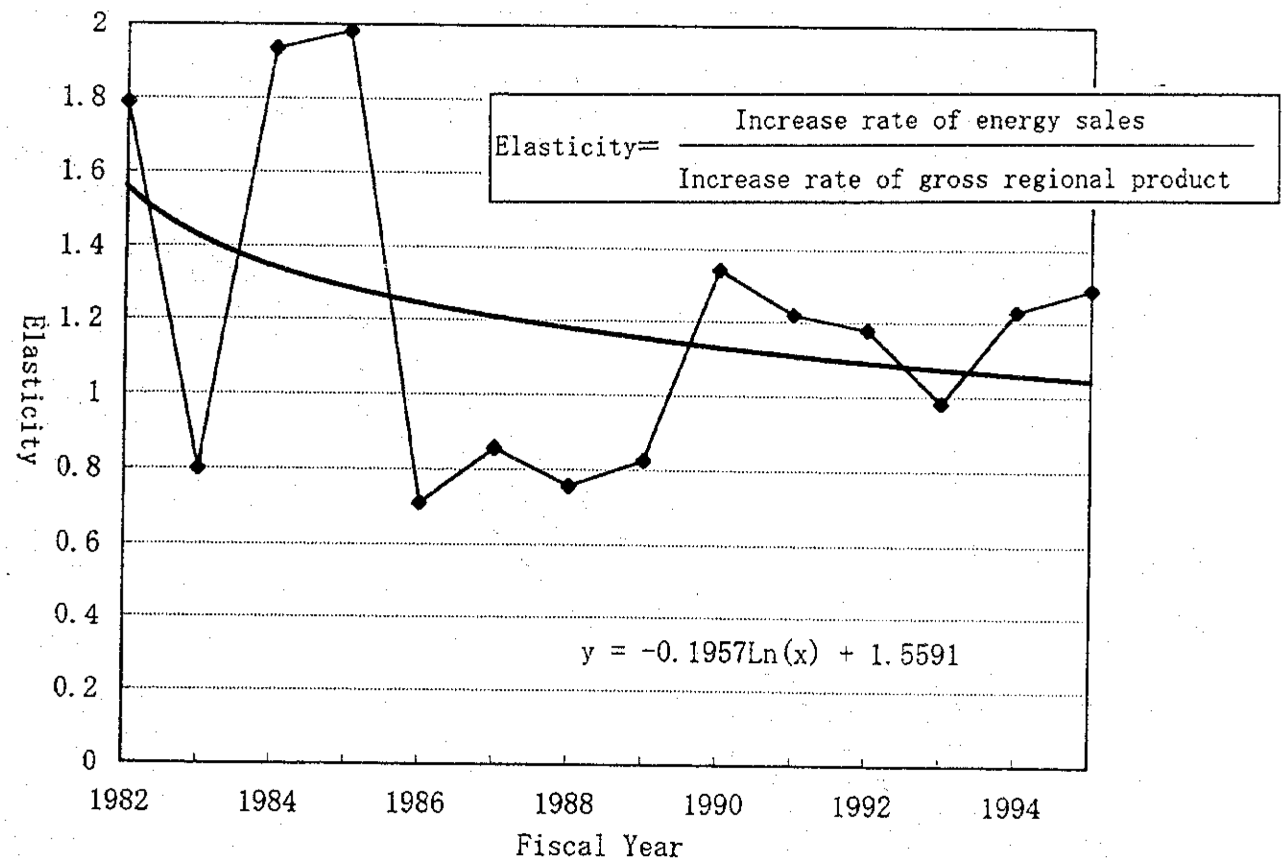


Fig. 4.2-2 Elasticity Curve of MEA

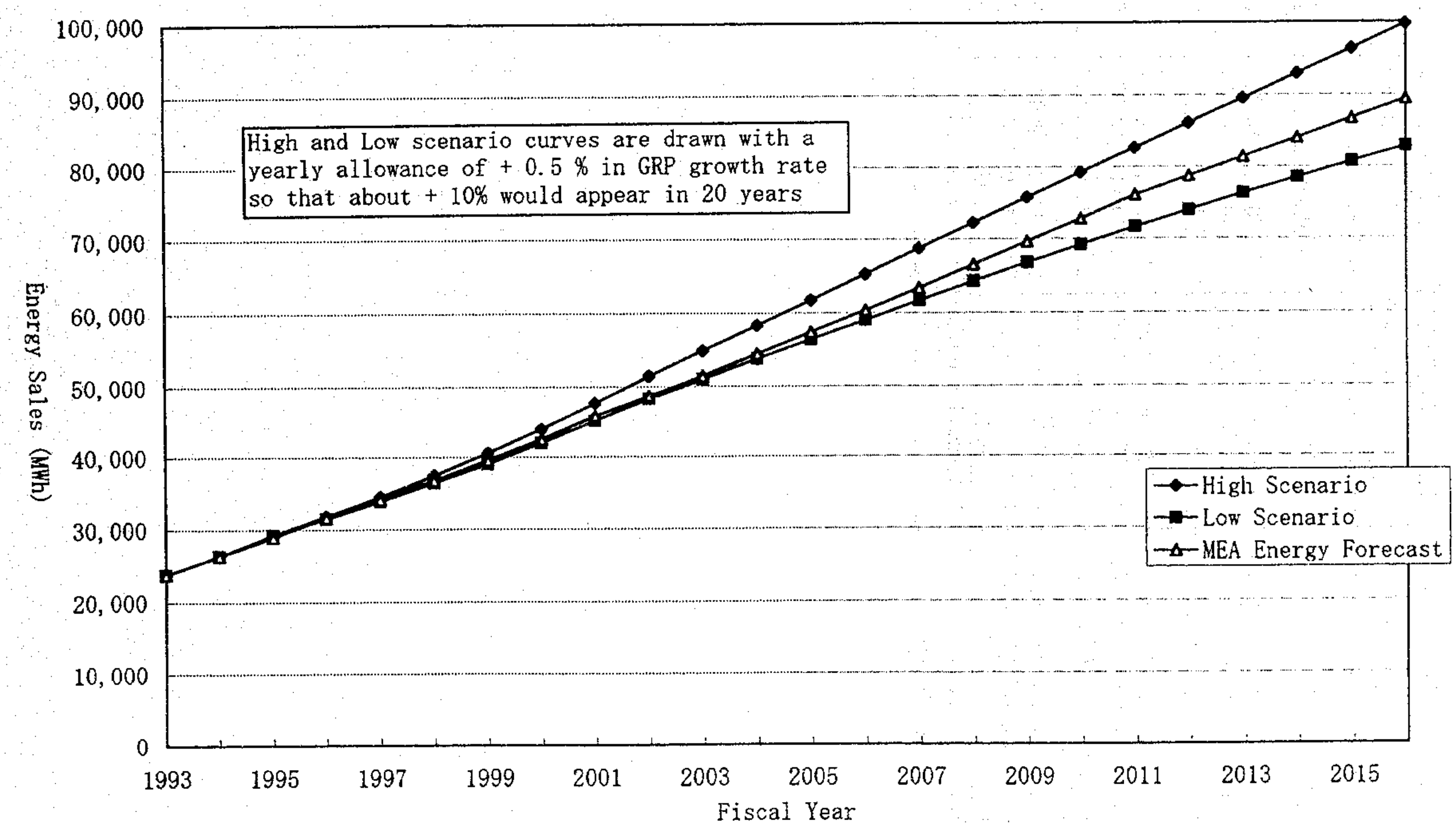


Fig. 4.2-3 Macro Forecast by Elasticity

Table 4.2-1 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				