

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)  
METROPOLITAN ELECTRICITY AUTHORITY (MEA)  
THE KINGDOM OF THAILAND

No. 56

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

NOVEMBER 1995

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

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## PREFACE

In response to a request from the Government of the Kingdom of Thailand, the Government of Japan decided to conduct the Feasibility Study on Power Distribution System Improvement and Expansion Plan in the Metropolitan Area in the Kingdom of Thailand and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team, led by Mr. Kunio Okawara of the Tokyo Electric Power Services Co., Ltd. (TEPSCO) and organized by TEPSCO and Electric Power Development Co., Ltd. to the Kingdom of Thailand three times from November 1994 to October 1995.

The team held discussion with the officials concerned of the Government of the Kingdom of Thailand and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

I hope this report will contribute to the promotion of the plan and to the enhancement of friendly relations between our two countries.

I wish to express my sincere appreciation to the officials concerned of the Government of the Kingdom of Thailand for their close cooperation throughout the study.

November 1995



Kimio Fujita

President

Japan International Cooperation Agency

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November 1995

Mr. Kimio Fujita  
President  
Japan International Cooperation Agency  
Tokyo, Japan

Dear Mr. Fujita

### Letter of Transmittal

We are pleased to submit you the final report on the Feasibility Study on Power Distribution System Improvement and Expansion Plan in the Metropolitan Area in the Kingdom of Thailand. This study was conducted by a joint consultant consisting of Tokyo Electric Power Services Co., Ltd. and Electric Power Development Co., Ltd. under the contract with JICA, during the period from November 1994 to November 1995. In conducting the study, we have made effort to formulate most appropriate system plan reflecting the results of technical discussions we had with the officials concerned of Metropolitan Electricity Authority (MEA) and Electricity Generating Authority of Thailand (EGAT), which were held during our stay in Bangkok.

This report presents a plan for short and long term power distribution system improvement and expansion in the Bangkok metropolitan area at the 230 kV and lower voltage levels. Due to the recent extremely rapid growth of the urban area of Bangkok, construction of power distribution system facilities in the area has become increasingly difficult. Therefore, electric power supply to the area is one of the important problems in the Kingdom of Thailand. After completion of these short and long term plans which foresee the year of 2016, electric power will be steadily secured.

In view of the urgency of expansion of power distribution system and of the need for socio-economic development of the Kingdom of Thailand as a whole, we recommend that His Majesty's government implements this Project as a top priority.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of International Trade and Industry and Ministry of Finance. We also wish to express our deep gratitude to the authorities concerned of the Government of Thailand, the JICA Thailand office and the Embassy of Japan in Thailand for cooperation and assistance throughout our study.

Very truly yours,

K. Okawara

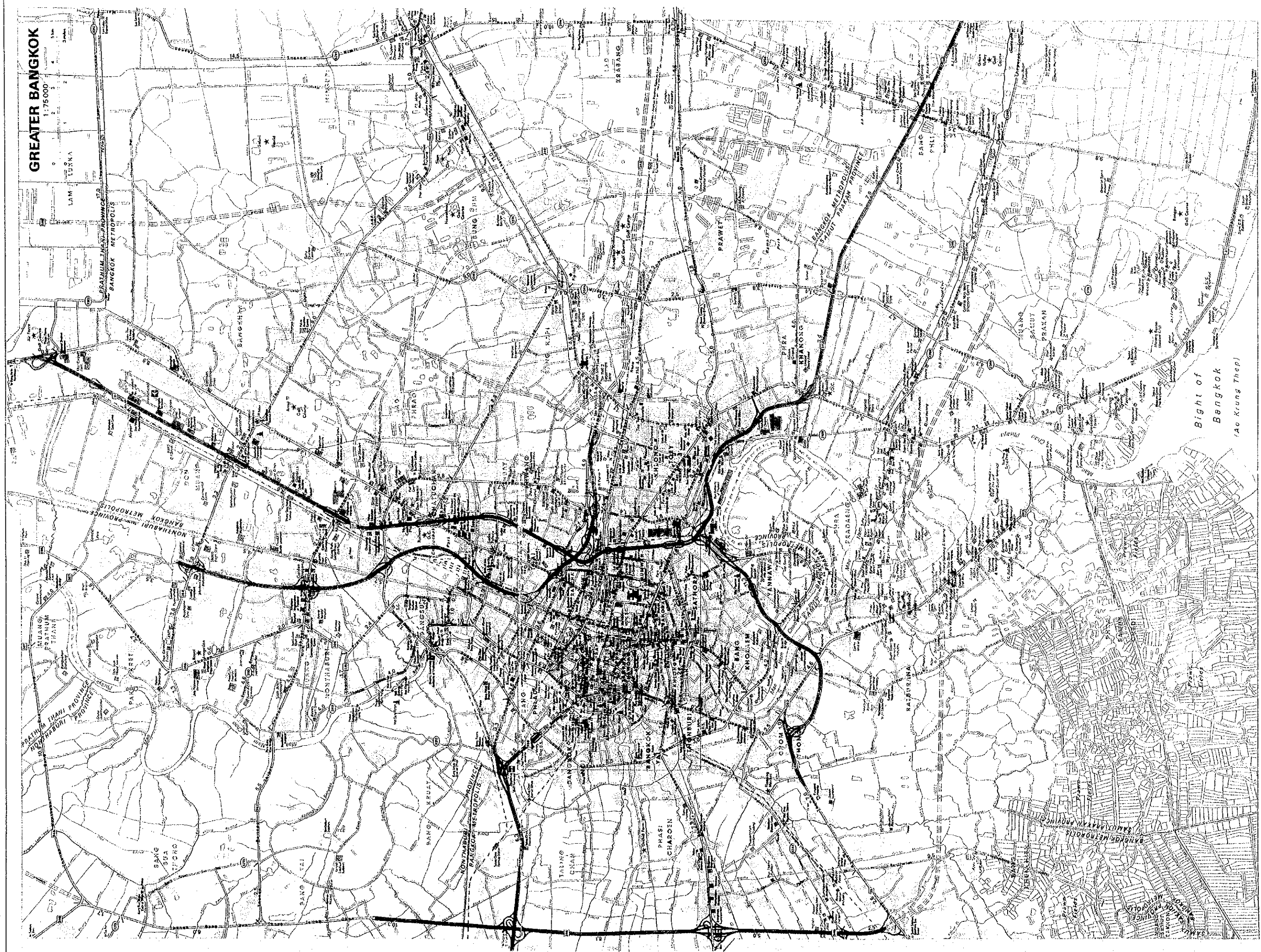
Kunio Okawara

Team Leader,

Feasibility Study on Power Distribution System

Improvement and Expansion Plan

in the Metropolitan Area in the Kingdom of Thailand



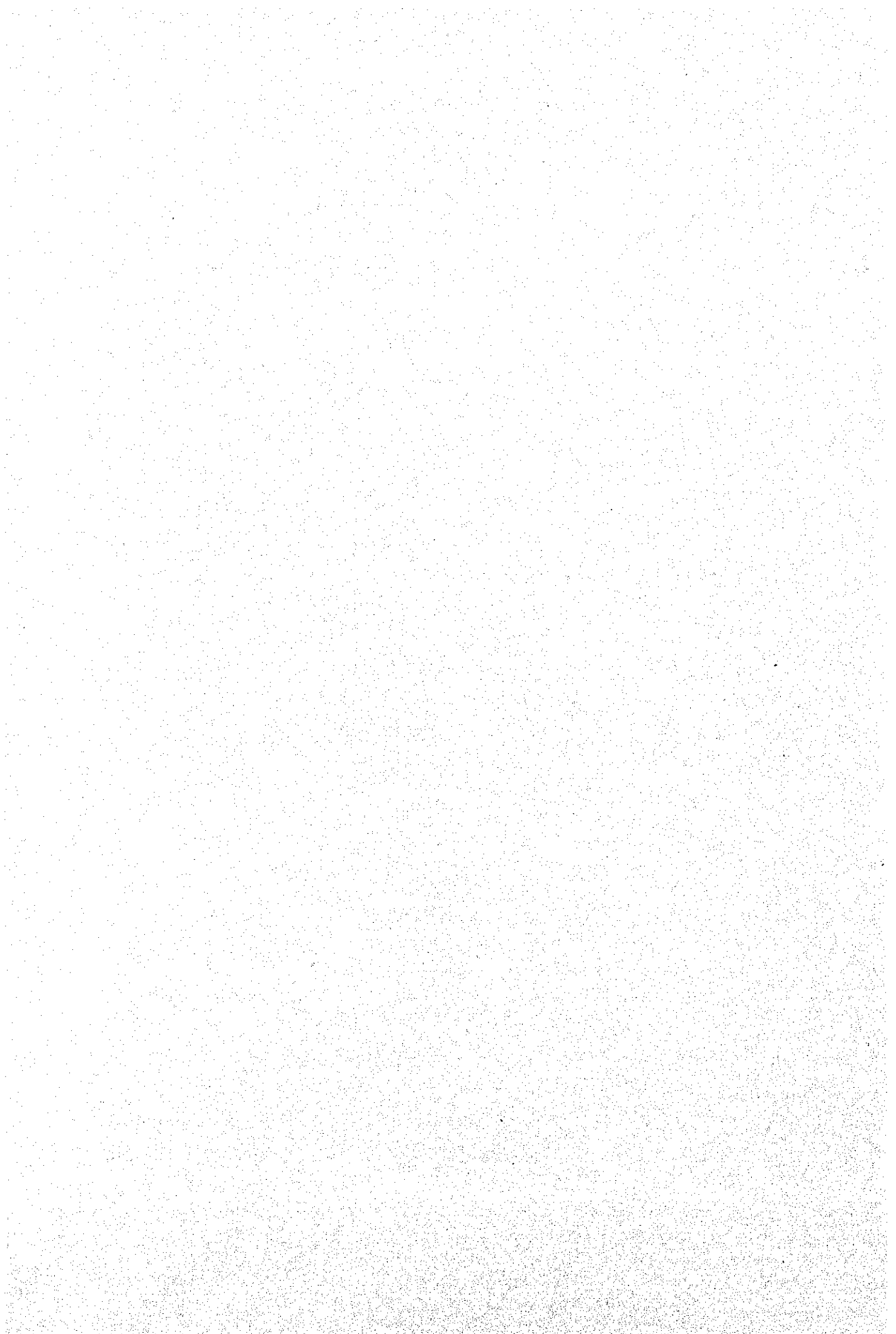
GREATER BANGKOK

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# CONTENTS

	<u>Page</u>
CONCLUSION AND RECOMMENDATION	1
CHAPTER 1 INTRODUCTION	
1.1 Background of the Study . . . . .	1 - 1
1.2 Contents of the Study . . . . .	1 - 2
1.2.1 Objective of the Study . . . . .	1 - 2
1.2.2 Scope of the Study . . . . .	1 - 2
1.2.3 Study Items . . . . .	1 - 3
1.3 Activities of the Team in Thailand and Participants Concerned . . . . .	1 - 4
1.3.1 Activities of the Team in Thailand . . . . .	1 - 4
1.3.2 List of Participants . . . . .	1 - 5
1.4 Provision of Equipment . . . . .	1 - 10
1.5 Training for Counterpart . . . . .	1 - 10
1.6 Seminar . . . . .	1 - 10
CHAPTER 2 OVERVIEW OF THE KINGDOM OF THAILAND AND THE METROPOLITAN AREA	
2.1 General . . . . .	2 - 1
2.2 Economics . . . . .	2 - 8
2.2.1 Economics of the Kingdom of Thailand . . . . .	2 - 8
2.2.2 Economics of the Metropolitan Area . . . . .	2 - 21
2.2.3 Economics Growth of the Kingdom of Thailand . . . . .	2 - 24
2.3 Population Increasing Ratio of the Metropolitan Area . . . . .	2 - 27
2.4 Development Situation of the Metropolitan Area . . . . .	2 - 30
CHAPTER 3 PRESENT SITUATIONS OF ELECTRIC POWER UTILITY INDUSTRY	
3.1 General . . . . .	3 - 1

3.2	Power Sector of the Kingdom of Thailand . . . . .	3 - 9
3.2.1	National Energy Policy Office (NEPO) . . . . .	3 - 9
3.2.2	Electricity Generating Authority of Thailand (EGAT) . . . . .	3 - 9
3.2.3	Metropolitan Electricity Authority (MEA) . . . . .	3 - 14
3.2.4	Provincial Electricity Authority (PEA) . . . . .	3 - 16
3.3	Present Situations and Problems of Existing Power Distribution System Facilities in the Metropolitan Area . . . . .	3 - 20
3.3.1	Power System Configuration . . . . .	3 - 20
3.3.2	Power Subtransmission Line Facilities . . . . .	3 - 23
3.3.3	Substation Facilities . . . . .	3 - 34
3.3.4	Distribution System Facilities . . . . .	3 - 42
3.3.5	Protective Relay System . . . . .	3 - 53
3.3.6	Telecommunication Equipment . . . . .	3 - 76
3.4	Power Demand and Supply in the Metropolitan Area . . . . .	3 - 84
3.4.1	Power Demand . . . . .	3 - 84
3.4.2	Power Supply . . . . .	3 - 87
3.4.3	Power Demand and Supply Balance . . . . .	3 - 89
3.5	Electric Rate in the Metropolitan Area . . . . .	3 - 91

#### CHAPTER 4 REVIEW OF POWER DEMAND FORECAST

4.1	General . . . . .	4 - 1
4.2	Power Demand Forecast by MEA . . . . .	4 - 2
4.2.1	Power Demand Forecast in Thailand . . . . .	4 - 2
4.2.2	Power Demand Forecast in the MEA's Area . . . . .	4 - 2
4.3	Review of the MEA's Power Demand Forecast by the Study Team . . . . .	4 - 12
4.3.1	Methodology of Review . . . . .	4 - 12
4.3.2	Results of Review . . . . .	4 - 13

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

5.1	General . . . . .	5 - 1
5.2	MEA's Planning Criteria . . . . .	5 - 2

5.2.1	Target Operating Voltage . . . . .	5 - 2
5.2.2	Maximum Loading of Subtransmission Line . . . . .	5 - 2
5.2.3	Capacity and Maximum Loading of Substation . . . . .	5 - 3
5.2.4	Maximum Fault Level . . . . .	5 - 4
5.2.5	System Configuration . . . . .	5 - 4
5.2.6	Reliability . . . . .	5 - 5
5.3	The Revised 7th Plan . . . . .	5 - 8
5.3.1	Policy Guidelines . . . . .	5 - 8
5.3.2	Outline of the Revised 7th Plan . . . . .	5 - 9
5.4	Progress Situation and Problems . . . . .	5 - 10
5.4.1	Load Forecast and Actual Records . . . . .	5 - 10
5.4.2	Progress of Substation Expansion Plan . . . . .	5 - 11
5.4.3	Effect of Delay of Thanontok Substation Construction . . . . .	5 - 16
5.4.4	Utilization Factor of Distribution Substation . . . . .	5 - 21
5.5	MEA's Draft Long-Term Plan during FY 1997-2011 . . . . .	5 - 25
5.6	EGAT's Power Development Plan . . . . .	5 - 35

## CHAPTER 6 FORMULATION OF OPTIMUM SHORT- AND LONG-TERM POWER DISTRIBUTION SYSTEM IMPROVEMENT AND EXPANSION PLAN

6.1	General . . . . .	6 - 1
6.2	Regional Load Forecast . . . . .	6 - 2
6.2.1	Regional Load Forecast by MEA . . . . .	6 - 2
6.2.2	Regional Load Forecast in FY 2016 by the JICA Study Team . . . . .	6 - 2
6.3	Distribution Substation Plan . . . . .	6 - 11
6.3.1	Formulation Policy of Distribution Substation Plan . . . . .	6 - 11
6.3.2	Long-Term Expansion Plan of Distribution Substations (FY 2016) . . . . .	6 - 21
6.3.3	Long-Term Expansion Plan of Distribution Substations (FY 2001-2011) . . . . .	6 - 30
6.3.4	Short-Term expansion plan of distribution substations (FY 1997-2001) . . . . .	6 - 44
6.4	Subtransmission Line and Terminal Station System Plan . . . . .	6 - 53

6.4.1	Methodology of Planning . . . . .	6 - 53
6.4.2	FY 2016's Plan . . . . .	6 - 54
6.4.3	FY 1997-2011's Plan . . . . .	6 - 64
6.5	Design of Protective Relay System . . . . .	6 - 85
6.6	Telecommunication Equipment Related to Power Distribution Facilities . . . . .	6 - 86
6.6.1	Optical Fiber Telecommunication Network . . . . .	6 - 86
6.6.2	VHF and UHF Telecommunication Network . . . . .	6 - 95

## CHAPTER 7 POWER SYSTEM ANALYSIS

7.1	General . . . . .	7 - 1
7.2	Conditions of Analysis . . . . .	7 - 2
7.3	Results of Load Flow Study . . . . .	7 - 3
7.3.1	FY 2016's System . . . . .	7 - 3
7.3.2	FY 1997-2001's System . . . . .	7 - 3
7.3.3	FY 2006's System . . . . .	7 - 4
7.3.4	FY 2011's System . . . . .	7 - 4
7.4	Results of 3 Phase Short Circuit (SC) Fault Current Study . . . . .	7 - 5
7.5	Results of Single Line Ground (SLG) Fault Current Study . . . . .	7 - 5

## CHAPTER 8 PRELIMINARY STUDY OF ENVIRONMENTAL IMPACT ASSESSMENT

8.1	General . . . . .	8 - 1
8.1.1	Countermeasures for Enhancement and Conservation of Environment in Thailand . . . . .	8 - 1
8.1.2	Environmental Impact on Transmission Line and Substation Facilities . . . . .	8 - 2
8.2	Environmental Impact Assessment Study Pertaining to Overhead Subtransmission . . . . .	8 - 5
8.2.1	Environment Impact Pertaining to Overhead Subtransmission Line in MEA . . . . .	8 - 5
8.2.2	Present Situations of Environmental Impact Assessment Study Pertaining to Overhead Subtransmission Line in Japan . . . . .	8 - 13

8.3	Electromagnetic Induction . . . . .	8 - 16
8.4	Environmental Countermeasures Pertaining to Substation . . .	8 - 21

## CHAPTER 9 FEASIBILITY DESIGN

9.1	General . . . . .	9 - 1
9.2	Selection of Model Districts . . . . .	9 - 2
9.3	Study of Model Districts . . . . .	9 - 7
9.3.1	Study of Distribution System and Capacity of Distribution Substation in the Model Districts . . . . .	9 - 7
9.3.2	Economical Comparison of System Voltages using 115kV and 69kV System . . . . .	9 - 35
9.3.3	Study of Distribution Voltage, Conductor Size and Bank Configuration . . . . .	9 - 45
9.3.4	Future Plan for Model Districts . . . . .	9 - 56
9.4	Overhead Subtransmission Line Facilities . . . . .	9 - 75
9.4.1	Selection of Overhead Subtransmission Line Route . . .	9 - 75
9.4.2	Basic Design . . . . .	9 - 78
9.5	Underground Subtransmission Line Facilities . . . . .	9 - 87
9.5.1	Selection of Underground Subtransmission Line Route . .	9 - 87
9.5.2	Basic Design . . . . .	9 - 90
9.6	Substation . . . . .	9 - 96
9.6.1	Selection of Substation Sites . . . . .	9 - 96
9.6.2	Basic Design . . . . .	9 - 97
9.7	Land Acquisition Plan for Subtransmission Line and Substation Facilities . . . . .	9 - 103
9.7.1	Features and Problematical Points . . . . .	9 - 103
9.7.2	Method of Promoting Land Acquisition . . . . .	9 - 105
9.8	Underground Distribution System Facilities . . . . .	9 - 114
9.8.1	Underground Substation . . . . .	9 - 114
9.8.2	Utility Tunnel . . . . .	9 - 119
9.9	Application of Advanced technology for Distribution System . .	9 - 122
9.9.1	Composite and Compact Type Substation Equipment . . .	9 - 122

9.9.2	New Technology for Constructing Underground Transmission Line . . . . .	9 - 126
9.9.3	New Technology for Protection and Control . . . . .	9 - 131
9.9.4	New Technology for Telecommunication Equipment . . . . .	9 - 134

## CHAPTER 10 CONSTRUCTION SCHEDULE AND COST ESTIMATION

10.1	General . . . . .	10 - 1
10.2	Construction Schedule . . . . .	10 - 1
10.2.1	Subtransmission Lines . . . . .	10 - 1
10.2.2	Substation . . . . .	10 - 9
10.3	Method of Estimating the Construction Cost . . . . .	10 - 15
10.3.1	Subtransmission Line Facilities . . . . .	10 - 15
10.3.2	Substation . . . . .	10 - 18
10.4	Rates of Taxes and Other Expenses . . . . .	10 - 28
10.4.1	Taxes . . . . .	10 - 28
10.4.2	Rates of the Other Cost Expenses . . . . .	10 - 28
10.4.3	Material Transportation Cost . . . . .	10 - 29
10.5	Construction Cost and Expenditure . . . . .	10 - 31
10.5.1	Subtransmission Line Facility . . . . .	10 - 32
10.5.2	Construction Cost of Substations . . . . .	10 - 37
10.5.3	Telecommunication Equipment . . . . .	10 - 59

## CHAPTER 11 ECONOMIC EVALUATION

11.1	General . . . . .	11 - 1
11.2	Premises Conditions for Economic Evaluation . . . . .	11 - 1
11.3	Benefit Evaluation . . . . .	11 - 3
11.4	Economic Assessment . . . . .	11 - 5
11.4.1	Cost . . . . .	11 - 5
11.4.2	Benefit . . . . .	11 - 5
11.4.3	Economic Assessment Result . . . . .	11 - 6

## CHAPTER 12 FINANCIAL ANALYSIS

12.1	General . . . . .	12 - 1
12.2	Analytical Method . . . . .	12 - 1
12.3	Premises Conditions for Economic Evaluation . . . . .	12 - 2
12.3.1	Financial Internal Rate of Return (FIRR) . . . . .	12 - 2
12.3.2	Debt Service Ratio . . . . .	12 - 3
12.4	Financial Internal Rate of Return (FIRR) . . . . .	12 - 4
12.5	Calculation of Debt Service Ratio . . . . .	12 - 5
12.6	Revision of Electric Fee . . . . .	12 - 5

## CHAPTER 13 TECHNOLOGY TRANSFER . . . . . 13 - 1

## CHAPTER 14 FUTURE STUDIES . . . . . 14 - 1



## LIST OF TABLES

Table	Description
Table 2.1-1	Population Increase Rate of ASEAN Member Countries
Table 2.2-1	Real GDP Growth Rate of ASEAN Member Countries in Terms of US Dollar
Table 2.2-2	Trend of the Shares of Agricultural and Manufacturing Industries to Nominal GDP
Table 2.2-3	Trend of Shares in Export Amount
Table 2.2-4	Trend in the Amount of Trade in Thailand
Table 2.2-5	Trend in the Share of Imported Goods
Table 2.2-6	Trend in International Balance
Table 2.2-7	Trend in the Balance of Foreign Debts
Table 2.2-8	Comparison of the Respective Industrial Sectors to GDP and Working Population (1992)
Table 2.2-9	Trend of Income Distribution by Brackets
Table 2.2-10	Percentage of Age Group Enrolled in Education (1988)
Table 2.2-11	Outline of the First-Seventh National Economic Development Plans
Table 2.2-12	Nominal GDP by Industries and Regions in FY 1989
Table 2.2-13	Targets of Economic Growth and Achievements
Table 2.2-14	Targets of Economic Growth
Table 2.3-1	Comparison of Regional Population
Table 2.3-2	Prediction of Population Increase
Table 2.4-1	Incentives for Investment in Local Regions
Table 2.4-2	Industrial Parks and Dead Stocks by Zone
Table 3.2-1	New Generating Capacity (1995-2011)
Table 3.3-1	Current Carrying Capacity of Overhead Subtransmission Line
Table 3.3-2	Current Carrying Capacity of Underground Subtransmission Line
Table 3.3-3	Subtransmission Line Utilizing Factor
Table 3.3-4	Current Carrying Capacity of Overhead Distribution Line
Table 3.3-5	Current Carrying Capacity of Underground Distribution Line
Table 3.3-6	Tripped CB and Operation State
Table 4.2-1	Total EGAT's Generation Requirement
Table 4.2-2	Electricity Use per Square Meter in Commercial Enterprises
Table 4.2-3	Business Sales Forecast Result
Table 4.2-4	Forecast of Energy Sales for Over 30 kW

Table 4.2-5	MEA's Electricity Demand Forecast
Table 4.3-1	Peak and Energy Share of MEA
Table 4.3-2	Historical Record of Sales Energy by Main Category
Table 4.3-3	Elasticity of Sold Energy to GRP
Table 4.3-4	Relation between Energy Requirement and Gross Regional Product
Table 4.3-5	Macro Forecast Study by Elasticity
Table 4.3-6	Transition of Electric Peak Load in ASEAN Countries
Table 4.3-7	Comparison of Actual and Forecast Load
Table 5.4-1	Target and Actual Condition of Substation Commissioning Date
Table 5.4-2	Load Flow Condition of Surrounding Thanontok T/S in case of Load Switching to Another Substations
Table 5.4-3	Necessary Switching Load to Other Substation on High Utilization Substation
Table 5.4-4	Heavy Load Substation and Expansion Plan in the Revised 7th Plan
Table 6.2-1	MEA's Forecast of Maximum Power Demand & 2016' Forecast of Planning Load
Table 6.2-2	Block Load of Distribution Substation Planning
Table 6.3-1	Diversity Factor of Distribution Feeder
Table 6.3-2	Standard Bank Capacity ( $V_s=12kV$ )
Table 6.3-3	Standard Bank Capacity ( $V_s=24kV$ )
Table 6.3-4	Equivalent Resistance
Table 6.3-5	Length Corresponding to Specified Voltage Drop Limit
Table 6.3-6	Expansion of Distribution Substation
Table 6.3-7	Construct Plan of Distribution Substation
Table 6.3-8	Target for Distribution Substation System Program
Table 6.3-9	Construct Plan of Distribution Substation
Table 6.3-10	Construct Plan of Distribution Substation (JICA Study Team Plan)
Table 6.3-11	Target for Distribution Substation System Program
Table 6.4-1	Terminal Station Expansion Plan at FY 2016
Table 6.4-2	Subtransmission Line Expansion Plan (FY 2012-2016)
Table 6.4-3	Terminal Station Expansion Plan at FY 1997
Table 6.4-4	Terminal Station Expansion Plan at FY 1998
Table 6.4-5	Terminal Station Expansion Plan at FY 1999
Table 6.4-6	Terminal Station Expansion Plan at FY 2000
Table 6.4-7	Terminal Station Expansion Plan at FY 2001

Table 6.4-8	Terminal Station Expansion Plan at FY 2006
Table 6.4-9	Terminal Station Expansion Plan at FY 2011
Table 6.4-10	Target for Terminal Station System Program
Table 6.4-11	Installed Capacity of Terminal Stations
Table 6.4-12	230kV Subtransmission Line System Expansion Plan (FY 1997-2011)
Table 6.4-13	115kV and 69kV Subtransmission Line System Expansion Plan (FY 1997-2011)
Table 6.6-1	Optical Fiber Network Construction Plan among District Offices
Table 6.6-2	SCADA RTU Installation Plan of Terminal Stations and Switching Station
Table 6.6-3	SCADA RTU Installation Plan of Distribution Stations
Table 7.5-1	Result of SLG Study in FY 2006's System
Table 7.5-2	Result of SLG Study in FY 2016's System
Table 8.3-1	Present limit Value of Electromagnetic Induction Voltage in Major Countries
Table 9.3-1	Relation of Substation Capacity and System Configuration
Table 9.3-2	Case Study of Substation
Table 9.3-3	Cost of Case Study
Table 9.3-4	Cost Comparison Analysis
Table 9.3-5	Detailed Cost Data
Table 9.3-6	Cost Comparison between 230 and 115kv system
Table 9.3-7	Number of Feeders
Table 9.3-8	Supply Area of Substation
Table 9.3-9	Cost of Model Case
Table 9.3-10	Power Demand of Sathorn Area
Table 9.3-11	Power Demand of Phahol Yothin Area
Table 9.3-12	Power Demand of Jomthong Area
Table 9.9-1	Typical Types and Features of Cooling Systems
Table 10.2-1	Construction Work Schedule in Short-term Expansion Plan
Table 10.2-2	Time Schedule for Various Type of Substation Construction
Table 10.3-1	Land Price for Distribution Substations
Table 10.3-2	Standard Unit Cost for D/S Construction
Table 10.3-3	Standard Unit Cost for Temporary S/S Construction
Table 10.3-4	Standard Unit Cost for D/S Addition
Table 10.3-5	Standard Unit Cost for T/S Construction

Table 10.3-6	Standard Unit Cost for T/S Addition
Table 10.5-1	Construction Cost Disbursement for Terminal Stations
Table 10.5-2	Construction Cost Disbursement for Distribution Substations
Table 11.3-1	Estimation for Energy Purchase and Energy Sales
Table 11.3-2	Incremental Electric Energy Purchase and Sales in MEA Area, which become available by this Project
Table 11.3-3	Total Energy Losses
Table 11.4-1	Construction Cost for Economic Analysis
Table 11.4-2	Operation and Maintenance Cost
Table 11.4-3	MEA's Average Energy Purchase and Sales Price
Table 11.4-4	Energy Purchase, Sales and Environmental Pollution Prevention Cost
Table 11.4-5	Benefit Flow and Cost Flow of the Project
Table 11.4-6	Calculation of EIRR
Table 12.3-1	Construction and Reimbursement Period
Table 12.4-1	Construction Cost for Financial Analysis
Table 12.4-2	Calculation of FIRR
Table 12.5-1	Construction Cost divided into Foreign and Local Currency Portion
Table 12.5-2	Calculation of Interest during Construction
Table 12.5-3	Operation and Maintenance Cost
Table 12.5-4	Energy Purchase and Sales
Table 12.5-5	Repayment Schedule of Debt (Loan Supplied 1996-1997)
Table 12.5-6	Repayment Schedule of Debt (Loan Supplied 1997-1998)
Table 12.5-7	Repayment Schedule of Debt (Loan Supplied 1998-1999)
Table 12.5-8	Repayment Schedule of Debt (Loan Supplied 1999-2000)
Table 12.5-9	Repayment Schedule of Debt (Loan Supplied 2000-2001)
Table 12.5-10	Repayment Schedule of Debt (Loan Supplied 2005-2006)
Table 12.5-11	Repayment Schedule of Debt (Loan Supplied 2010-2011)
Table 12.5-12	Repayment Schedule of Debt (Loan Supplied 2015-2016)
Table 12.5-13	Statement of Profit and Loss
Table 12.5-14	Cash Flow
Table 12.5-15	Calculation of Debt Service Ratio

## LIST OF FIGURES

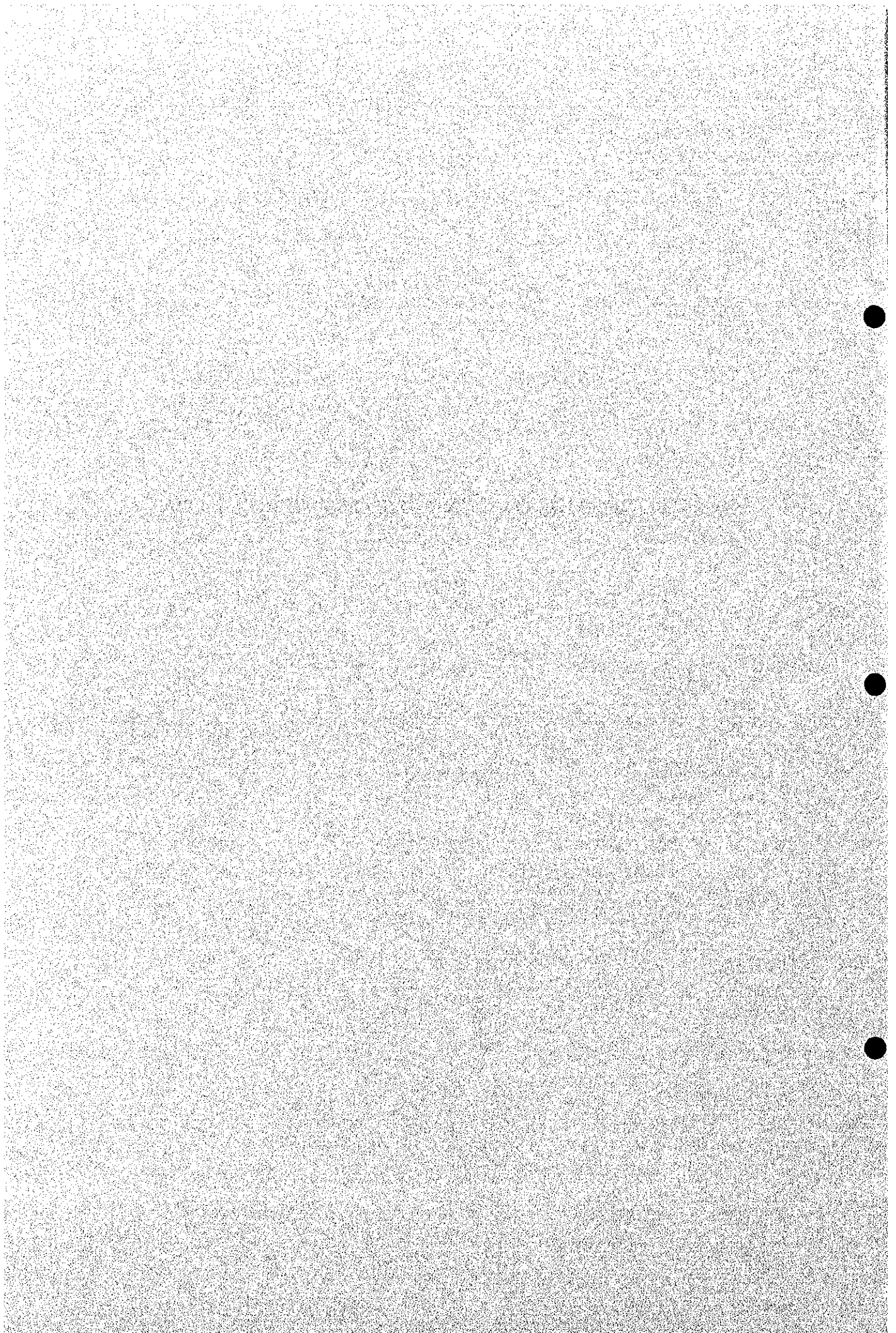
Figure	Description
Fig. 2.1-1	Temperature (Degree Celsius)
Fig. 2.1-2	Rain Fall
Fig. 2.1-3	Relative Humidity
Fig. 2.1-4	Trend of Population Growth and its Rate
Fig. 2.2-1	Real GDP Growth and Growth rate at 1972 Constant Prices
Fig. 2.2-2	Growth Rate of Real GDP per Capita at 1972 Constant Prices
Fig. 2.2-3	Consumer Price Index and Wholesale Price Index
Fig. 2.2-4	Comparison of Nominal GDP per Capita by Region
Fig. 2.2-5	Regional Share in Nominal 1989 GDP
Fig. 2.2-6	Regional Share of Population in FY 1989
Fig. 2.2-7	Growth Rate of Nominal GDP by Region
Fig. 2.2-8	Nominal GDP by Region in FY 1989
Fig. 2.2-9	Nominal GDP's Share by Industries and Region in FY 1989
Fig. 2.3-1	Population of Bangkok and it's Share
Fig. 2.3-2	Share of Population in MEA's Area
Fig. 2.3-3	Regional Population Density
Fig. 3.1-1	Energy Consumptions by MEA's and PEA's Regions included EGAT's Direct Customers
Fig. 3.1-2	Growth Rate of Energy Consumptions by MEA's and PEA's Regions Included EGAT's Direct Customers
Fig. 3.1-3	Energy Consumption by MEA's and PEA's Regions per Capita
Fig. 3.1-4	Energy Consumptions Growth Rate per Capita by Regions Included EGAT's Direct Customers
Fig. 3.1-5	Energy Consumption to GDP Elasticity by Regions
Fig. 3.1-6	Comparison of Regional Energy Consumptions Excluded EGAT's Direct Customers
Fig. 3.1-7	Comparison of Regional Customers Excluded EGAT's Direct Customers
Fig. 3.1-8	Comparison of Regional Energy Consumption Per Customer
Fig. 3.1-9	Comparison of Energy Sales by Category in MEA's Area
Fig. 3.1-10	Comparison of Energy Sales by Category in PEA's North Area
Fig. 3.1-11	Comparison of Energy Sales by Category in PEA's Northeast Area
Fig. 3.1-12	Comparison of Energy Sales by Category in PEA's Central Area

- Fig. 3.1-13 Comparison of Energy Sales by Category in PEA's South Area
- Fig. 3.3-1 Common Duct Plan in Central Part of Bangkok
- Fig. 3.3-2 Basic Facility Reduction Methods
- Fig. 3.3-3 Effects of Space Reduction
- Fig. 3.3-4 Radial with Emergency Tie
- Fig. 3.3-5 Radial with Automatic Reclosing Sectionalizer
- Fig. 3.3-6 Underground Loop
- Fig. 3.3-7 Underground Primary Selection
- Fig. 3.3-8 Secondary Network
- Fig. 3.3-9 Underground Special Spare Line
- Fig. 3.3-10 Outline of DAS (Distribution Automation System)  
Pole-Top RTU Installation Diagram
- Fig. 3.3-11 Outline of DAS (Distribution Automation System)  
Hardware Configuration
- Fig. 3.4-1 Trend of kWh Sales
- Fig. 3.4-2 Energy Sales by Customer Classification
- Fig. 3.4-3 Maximum 30-Minutes Power Demand and Annual Load Factor
- Fig. 3.4-4 Daily Load Curves on Peak Day
- Fig. 3.4-5 Monthly System Peak Load
- Fig. 3.4-6 EGAT Energy Generation by Type of Fuel
- Fig. 3.4-7 EGAT Energy Sales for FY 1993
- Fig. 3.4-8 System Annual Reserve Margin (at the time of load peak)
- Fig. 3.4-9 Distribution Substation Annual Reserve Margin  
(on the maximum demand peak day)
- 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
- Fig. 4.3-4 Transition of Electric Peak Load in ASEAN Countries
- Fig. 5.2-1 Subtransmission Line Configuration
- Fig. 5.4-1 Load Flow Study for 69 kV System in 1996 by MEA
- Fig. 5.5-1 230 kV Subtransmission System Route Map in FY 2011
- Fig. 5.5-2 69 kV and 115 kV Subtransmission System Route Map in FY 2011
- Fig. 5.5-3 Result of MEA's Load Flow Study in FY 2011's System (115 kV)
- Fig. 5.5-4 Result of MEA's Load Flow Study in FY 2011's System (69 kV)
- Fig. 5.6-1 Future Trend of Total Generating Capacity

- Fig. 5.6-2 Forecast of Energy Generation by Types of Fuel
- Fig. 5.6-3 EGAT Power System in Future
- Fig. 6.2-1 Planning Load
- Fig. 6.2-2 Distribution Substation Planning Load
- Fig. 6.2-3 Block Area
- Fig. 6.3-1 Distribution Substation Utilization Factor (Planning Year=2016)
- Fig. 6.3-2 Distribution Substation Utilization Factor (Compare with 1996)
- Fig. 6.3-3 Distribution Substation Utilization Factor (Planning Year=2001)
- Fig. 6.3-4 Distribution Substation Utilization Factor (Planning Year=2006)
- Fig. 6.3-5 Distribution Substation Utilization Factor (Planning Year=2011)
- Fig. 6.3-6 Distribution Substation Utilization Factor (Planning Year=2016)
- Fig. 6.3-7 Distribution Substation Utilization Factor (Planning Year=1997)
- Fig. 6.3-8 Distribution Substation Utilization Factor (Planning Year=1998)
- Fig. 6.3-9 Distribution Substation Utilization Factor (Planning Year=1999)
- Fig. 6.3-10 Distribution Substation Utilization Factor (Planning Year=2000)
- Fig. 6.4-1 230kV System Configuration at FY 2016
- Fig. 6.4-2 115kV and 69kV System Configuration at FY 2016
- Fig. 6.6-1 MEA Fiber Optic Transmission Configuration Network
- Fig. 6.6-2 MEA Fiber Optic Transmission Equipment
- Fig. 6.6-3 Optical Fiber Route
- Fig. 6.6-4 System Configuration of Fiber Optic Transmission System
- Fig. 6.6-5 Trunk Radio System  
(Relationship between voice channels and subscriber units)
- Fig. 7.3-1 Result of Load Flow Study in FY 2016's System
- Fig. 7.3-2 Result of Load Flow Study in FY 1997's System
- Fig. 7.3-3 Result of Load Flow Study in FY 1998's System
- Fig. 7.3-4 Result of Load Flow Study in FY 1999's System
- Fig. 7.3-5 Result of Load Flow Study in FY 2000's System
- Fig. 7.3-6 Result of Load Flow Study in FY 2001's System
- Fig. 7.3-7 Result of Load Flow Study in FY 2006's System
- Fig. 7.3-8 Result of Load Flow Study in FY 2011's System
- Fig. 7.4-1 Result of Short Circuit Study in FY 2006's System
- Fig. 7.4-2 Result of Short Circuit Study in FY 2016's System
- Fig. 8.2-1 Electrostatic Induction Analysis of Overhead Transmission Line  
(115kV 1ckt)

- Fig. 8.2-2 Electrostatic Induction Analysis of Overhead Transmission Line  
(115kV 2ckt)
- Fig. 8.2-3 Electrostatic Induction Analysis of Overhead Transmission Line  
(69kV 1ckt)
- Fig. 8.2-4 Electrostatic Induction Analysis of Overhead Transmission Line  
(69kV 2ckt)
- Fig. 9.2-1 Map of Model Districts
- Fig. 9.3-1 OutLine of System Configuration Related Distribution Substation  
in Model Area
- Fig. 9.3-2 System Configuration for Case Study
- Fig. 9.3.3 Model System Configuration
- Fig. 9.3-4 Load Flow at the Time of Single Line Shut Down in Model System
- Fig. 9.3-5 Model of Feeder Rising Point
- Fig. 9.3-6 Load Density of Sathorn Area
- Fig. 9.3-7 Future Conceptual Diagram of Sathorn Area
- Fig. 9.3-8 Load Density of Phahol Yothin Area
- Fig. 9.3-9 Future Conceptual Diagram of Phahol Yothin Area
- Fig. 9.3-10 Load Density of Jomthong Area
- Fig. 9.3-11 Future Conceptual Diagram of Jomthong Area
- Fig. 9.4-1 Principal Dimension of Single Circuit Steel Pole
- Fig. 9.4-2 Structure Foundation
- Fig. 9.7-1 Flow of Equipment Planning and Land Acquisition Planning
- Fig. 9.8-1 Concept of Utility Tunnel
- Fig. 9.8-2 Installation Sections by the Respective Kinds

## **CONCLUSION AND RECOMMENDATION**



## CONCLUSION AND RECOMMENDATION

### 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 (Million US\$)	21,666.0 866.64)
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 (Million US\$)	55,798.7 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.

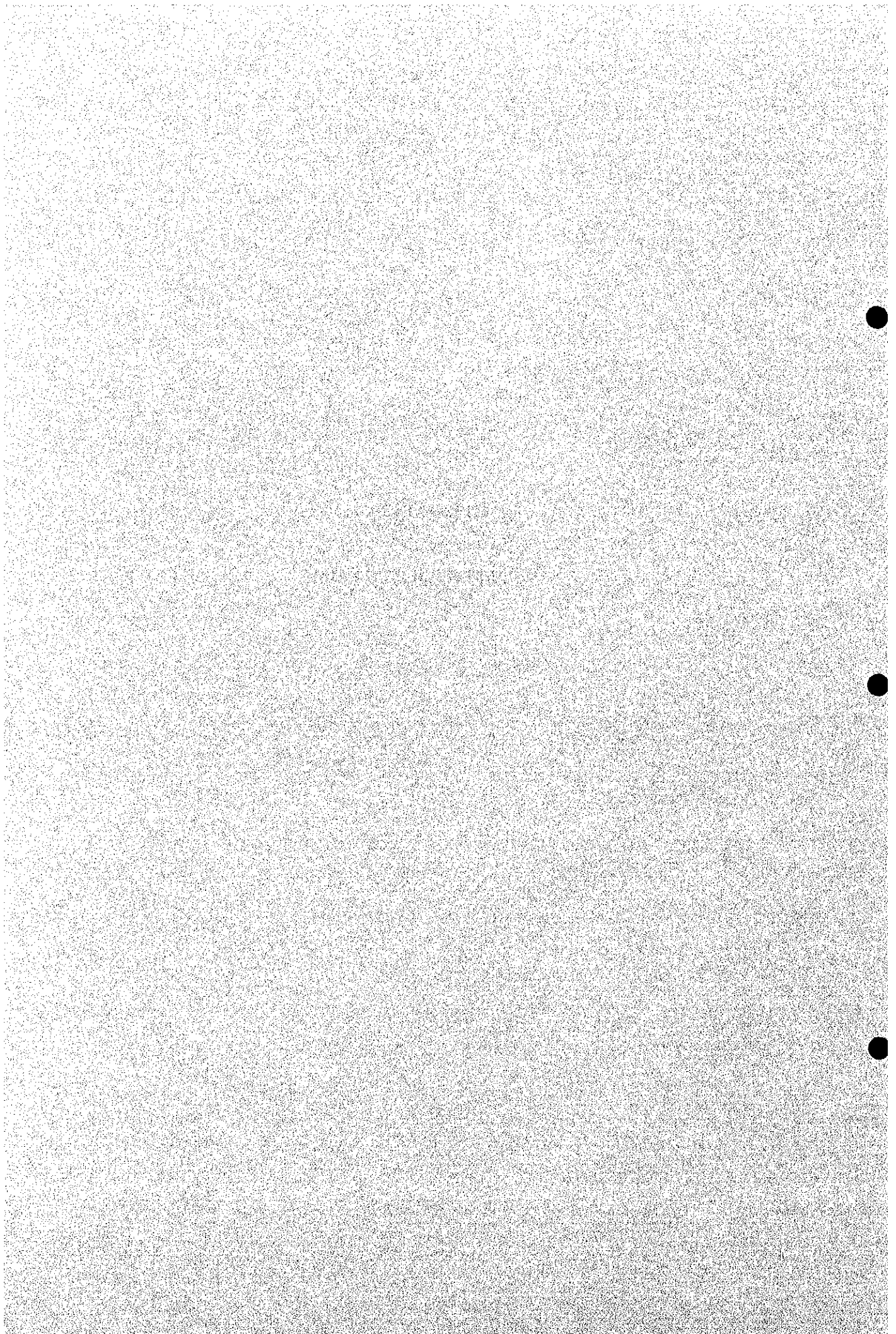
It is recommended to construct a pilot scale underground substation in as early period as possible and accumulate data and information to contribute for dissemination of such an underground type substation in future.

(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<sup>2</sup> 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 which was announced by the Load Forecast Subcommittee of Thailand in June 1993 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. Recently, in Bangkok metropolitan area electric power demand has increased steeply by rapid growth of population (many country people have come into the city), development of commerce and industry, increasing high-rise buildings construction for big hotels and condominiums and rising the standard of living, etc. Therefore, average annual growth rate of power demand has been considerably increasing for 11.9% in the past five years.

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.

In response to this request, the Government of Japan had the Japan International Cooperation Agency (JICA) dispatched the Preliminary Study Mission to Thailand in March 1994, and the Mission surveyed the background of the request, performed site surveys, collected information and data, and made a preliminary study in the future policies and other relevant matters. On March 29, 1994, the Preliminary Study Team of JICA and MEA reached an

agreement on "the Scope of Work for Feasibility Study on Power Distribution System Improvement and Expansion Plan in the Metropolitan Area in the Kingdom of Thailand".

Based on the Agreement, 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 its 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. However, as regards the short-term five years (from FY 1997 through FY 2001) a specific implementation schedule have been prepared for each 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) Reviewing 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 17, 1994

- Presentation and discussion on Inception Report
- Field survey for the related areas
- Collection of the study data
- Selection and determination of model districts for detailed study
- Discussion of the seminar etc.

Second: May 17th to June 15, 1995

- Presentation and discussion on Interim Report
- First seminar for technology transfer
- Detail study for feasibility design on model districts
- Field survey for additional items

Third : September 21 to October 5, 1995

- Presentation and discussion on Draft Final Report
- Second seminar for technology transfer

### 1.3.2 List of Participants

The MEA with Electricity Generating Authority of Thailand (EGAT) people, and the JICA Study Team involved in this study are as listed below.

#### MEA

Mr. Wannawit Thamwanich	Deputy Governor, Finance
Dr. Kasem Chaihongsa	Deputy Governor, Technical & Planning
Mr. Sombhop Khamala	Assistant Governor

#### Electrical Engineering and Project Department

Mr. Jari Kamklai	Director
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Mr. Sutep Intharaha	Deputy Chief, Distribution Feeder Planning Section, Electrical System Planning Division
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Power System Control Department
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Mr. Sahust Pratuknukul	Asst. Chief, Transmission System Planning Division, Systems Planning Department
Mr. Rangsan Athamanolap	Asst. Chief, Relay Division, Transmission Maintenance Department
Mr. Kittipon Chuangaroon	Head, R1+R4 Analysis and Planning Section, Transmission System Planning Division, Systems Planning Department
Mr. Kijja Sripatthangkura	Head, Transmission System Project Section, Transmission System Planning Division, Systems Planning Department
Mr. Thanat Thirachit	Telecommunication System Engineering Section, Communication Planning and Engineering Division, Communication System Department
Mr. Paisarn Omailertpongsa	Communication Planning and Engineering Division, Communication System Department

JICA Study Team
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Mr. Hiroyuki Imoto	JICA Study Planner
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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. Katsuhiko 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 summary of feasibility study of this project.