THE REPUBLIC OF THE PHILIPPINES

MASTER PLAN STUDY

ON

REHABILITATION/RENOVATION AND

OPERATION/MAINTENANCE IMPROVEMENT

OF

POWER FACILITIES IN LUZON GRID

FINAL REPORT

(SUMMARY)

MAY, 1992

JAPAN INTERNATIONAL COOPERATION AGENCY

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PREFACE

In response to the request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct a Master Plan Study on Rehabilitation/Renovation and Operation/Maintenance Improvement of Power Facilities in Luzon Grid and entrusted the study to the Japan International Cooperation Agency (JICA).

JICA sent to the Philippines a study team headed by Mr. Teruaki Ogawa of West Japan Engineering Consultants, Inc. three times during the period from July 1991 to April 1992.

The team held discussions on the project with officials concerned of the Government of the Republic of the Philippines, and conducted field surveys in the study area. After the team returned to Japan, further studies were made and the present report was prepared.

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

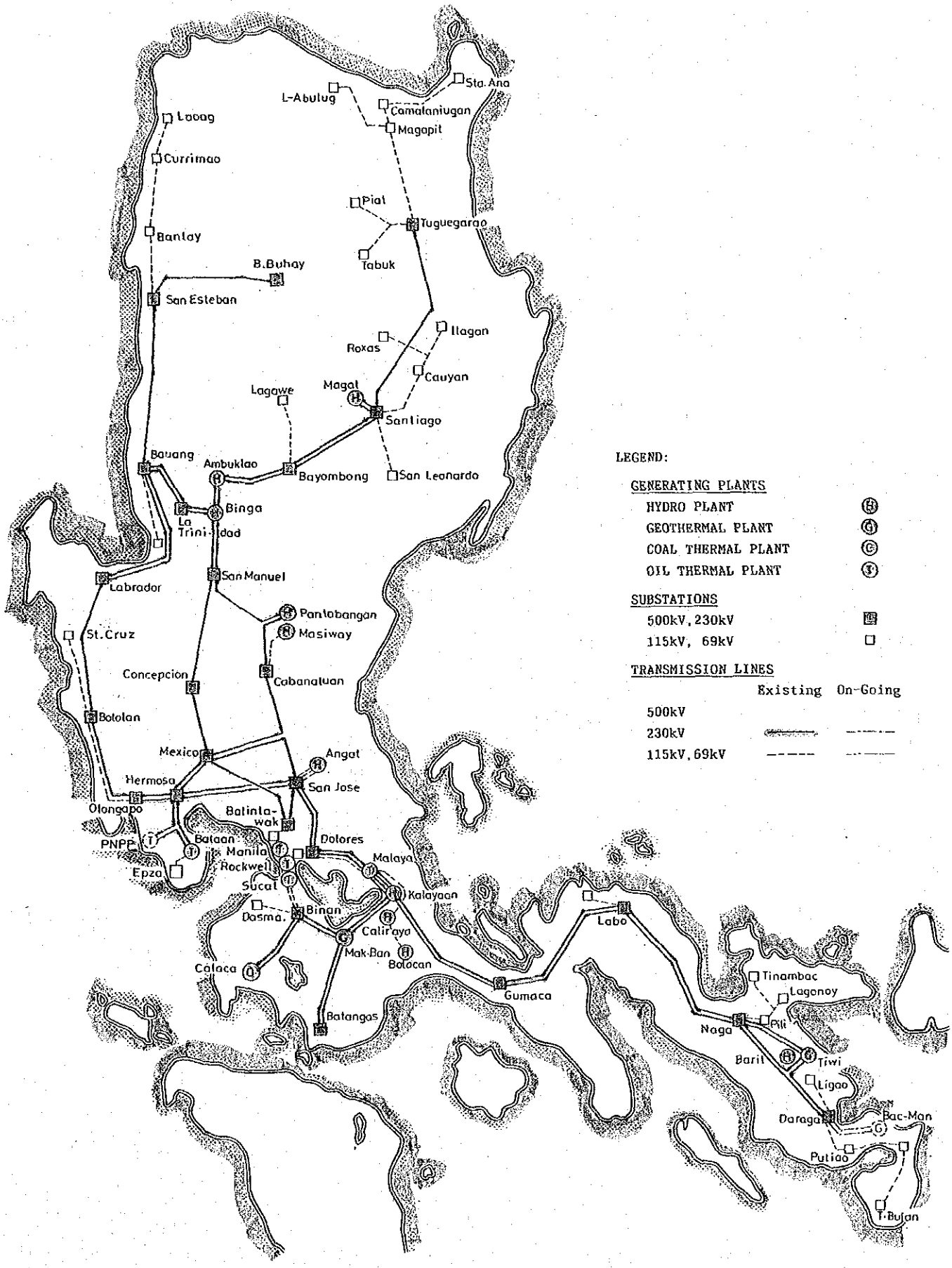
I wish to express my sincere appreciation to the officials concerned of the Government of the Republic of the Philippines for their close cooperation extended to the team.

May 1992

Kensuke Yanagiya

Kensuke Yanagiya
President
Japan International Cooperation Agency

LUZON GRID POWER SYSTEM DIAGRAM



LEGEND:

GENERATING PLANTS

HYDRO PLANT	Ⓗ
GEOTHERMAL PLANT	Ⓖ
COAL THERMAL PLANT	Ⓒ
OIL THERMAL PLANT	Ⓣ

SUBSTATIONS

500kV, 230kV	▣
115kV, 69kV	□

TRANSMISSION LINES

	Existing	On-Going
500kV		
230kV	———	——·——
115kV, 69kV	– – – –	··——

CONTENTS

(SUMMARY)

CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background and Progress of Study

The total installed capacity of the power generating facilities in the Luzon grid was 4,321 MW in 1990, which accounted for 71.6% of 6,037 MW of installed capacity in the whole Philippines. The peak demand in the Luzon grid was 2,973 MW and it appears from the above figures, that there is sufficient supply capability. However, supply interruptions and/or load sheddings have been frequently experienced in Luzon Grid, because of faults due to deterioration of facilities and degraded performances of power generation, transmission, and substation due to insufficient repair and maintenance, aggravated by the natural disasters. Therefore, steady electric power supply is given a high priority in the national policy. With the above background, the National Power Corporation (hereinafter referred to as "NAPOCOR") requested the study on the rehabilitation of power generating facilities, improvement of operation/maintenance of the power facilities, and renovation of transmission lines and substations.

In response to the request, Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched a preliminary study team in March 1991 and agreed upon and signed the "IMPLEMENTING ARRANGEMENT" for the Study with NAPOCOR.

JICA dispatched the survey team two times to Manila and other areas in the Republic of the Philippines, and carried out the field survey of thermal, geothermal and hydro power plants and transmission lines and substation facilities, held discussions with NAPOCOR, and collected necessary data and information.

This Final Report is the compilation of the results of analyses and studies made by the study team based on not only the materials collected by the surveys but discussion with NAPOCOR and in line with the purpose of this study after performing the presentation of the Draft Final Report to NAPOCOR.

In the meantime, the study team prepared the Interim Report compiling the results of the first stage field survey, and submitted it to NAPOCOR during the period of the second stage field survey in November 1991.

1.2 Objectives of the Study

The objectives of this study are to formulate and compile in the report (1) 5-year rehabilitation plan for the power plant facilities, and 5-year renovation plan for transmission lines and substations, (2) operation and maintenance improvement plan for power facilities and (3) environmental countermeasures related to the operation of power facilities.

Technology transfer was made to NAPOCOR engineers during the study period.

1.3 Objective Areas and Power Facilities for the Study

Thermal, geothermal and hydro power plants and transmission lines and substations connected to the Luzon Grid in the Philippines.

1.4 Contents and Procedures of the Study

JICA dispatched to the Philippines the experts suited for the study to formulate the 5-year master plan of Rehabilitation/Renovation and operation and maintenance improvement plan of power facilities, and carried out the field survey of thermal, geothermal and hydro power plants, and transmission lines and substations. They collected necessary data and informations and held consultations with the NAPOCOR Task Force members.

The study was carried out in two years, from 1991 through 1992. The field survey was carried out in two times, 1st Stage and 2nd Stage, in 1991, and the studies in Table 1-1 were carried out in the process shown in the flow chart in Fig. 1-1. The schedule of the study is as shown in Table 1-2. On the occasion of the 2nd Stage during the field survey and reporting on the Draft Final Report, JICA held seminars for which JICA Headquarters dispatched additional experts.

The seminars were attended by many engineers of NAPOCOR Task Force and others, and discussions were made on the problems of the facilities and the operation and maintenance based on the Interim Report, when the practices in the Japanese power companies were also explained. In the second seminar, explanation was made on the Implementation Program in Chapter 9 and Economic, Financial Evaluation, etc.

The presentation of the Draft Final Report to NAPOCOR was carried out during the third visit from April 21 to May 5, 1992.

As for the improvement of operation/maintenance, the Quality Assurance Department (QA) of NAPOCOR had pointed out the problems in the annual audit report of 1990, and added that the same problems were repeated without improvement. As the improvement of operation/maintenance involves complicated problems difficult to solve, necessary follow-up should be continued further into future.

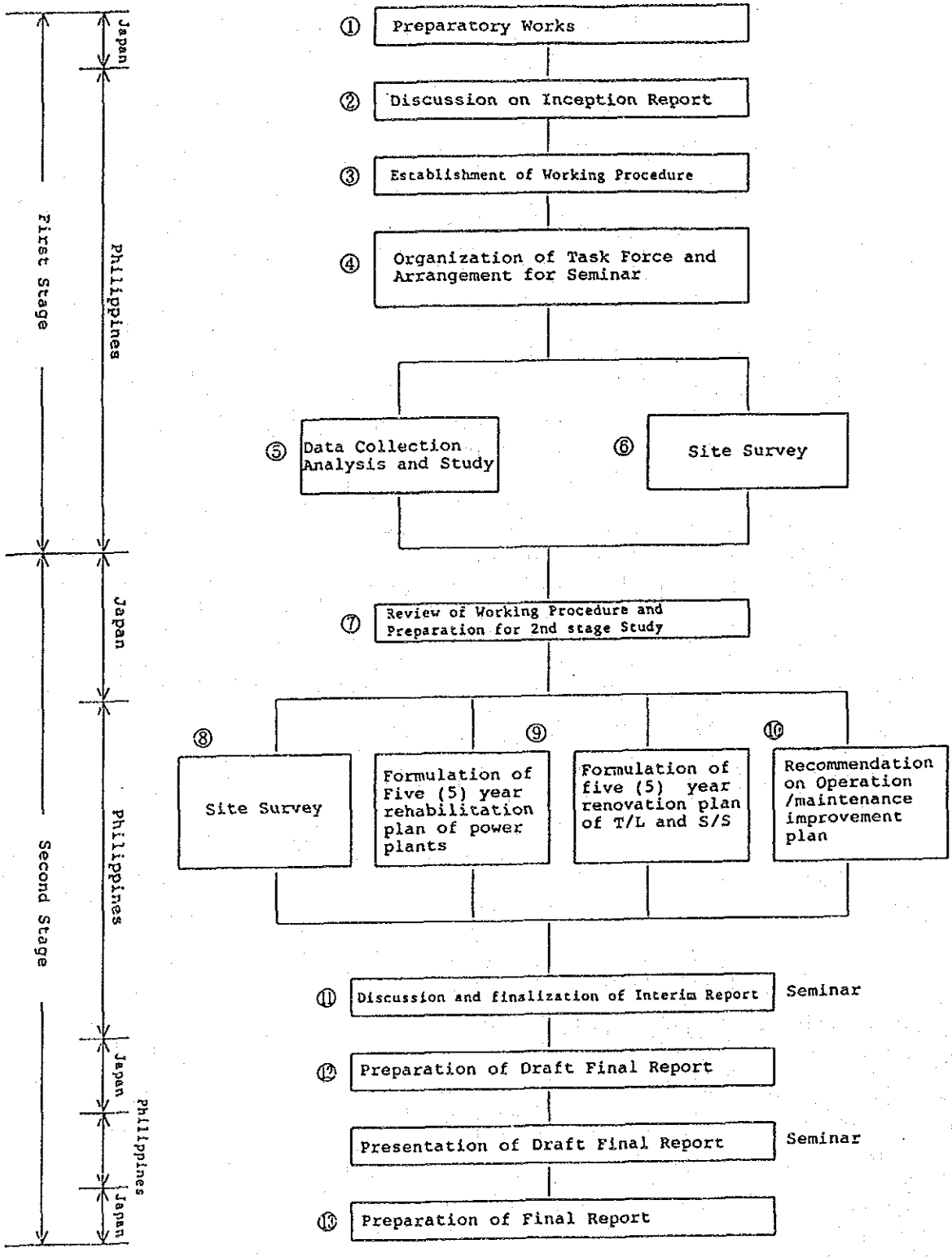
With the full cooperation of the Head Office, regional centers and power plants through the first and the second field survey periods, the study team was able to carry out studies and the collection of data and information.

Table 1-1 Contents of Study

Requirement	Service Items	1st Stage	2nd Stage
1. Preparatory Works	1) Preparation of Inception Report	o	-
	2) Consultation on IC/R and eatablishment of working procedure including organization of NAPOCOR Task Force and arrangement for seminar	o	-
	3) Review, consultation and finalization of working procedures	-	o
	4) Submittal of implementation plan of seminars	-	o
2. Formulation of 5-year Power Facilities Rehabilization/Renovation Plan (Master Plan)	1) Collection of data and information	o	o
	2) Analysis and study of collected data and information, and determination of power facilities rehabilitation/renovation work items	o	o
	3) Field survey of power facilities and collection and reconfirmation of data and information	o	o
	4) Study of causes of aged deterioration/defects and recommendation on rehabilitation/renovation measures	o	o
	5) Establishment of criteria for prioritization of rehabilitation/renovation work items	o	o
	6) Formulation of rehabilitation/renovation project schedule	o	o
	7) Study and recommendation on spare parts control	o	o
	8) Construction cost and disbursement plan	-	o
	9) Economic and financial evaluation	-	o

Requirement	Service Items	1st Stage	2nd Stage
3. Proposal of Operation and Maintenance Improvement Plan	1) Collection of data and information	o	o
	2) Analysis and study of collected data and information, identification of problems, and proposal of improvement plan	o	o
	3) Study of effective coordination of operation and maintenance systems on the power plant and area levels	o	o
	4) Proposal of administrative and technical procedures of operation and maintenance	o	o
	5) Standardization of maintenance manuals	-	o
	6) Establishment of information feedback system	-	o
	7) Standardization of test instruments, repair tools and facilities	-	o
4. Proposal of Environmental Countermeasures	1) Collection of data and information, and environmental laws and regulations in the Philippines	o	o
	2) Method of handling of equipment using PCB Proposal on control of equipment using PCB	o Field Survey	o
	3) Proposal on environmental monitoring system and cost estimate	o	o
5. Seminars	1) Thermal/geothermal/environmental groups	-	o
	2) Hydro/transmission and substation groups	-	o

Fig. 1-1 Flow Chart of the Study



1.5 Members of Study Team and Their Assignment

Name	Assignment	Service Items
Teruaki Ogawa	Team Leader	. Overall supervision . Coordination on the Study
Yoshiyuki Niihara	Hydro power plant facilities (civil)	. Survey and analysis of the present conditions of civil structures of hydro power plants. . Formulation of 5-year rehabilitation plan of civil structures of hydro power plants.
Toshinori Ishii	Hydro power plant facilities (Electrical)	. Survey and analysis of the present conditions and investigation of causes of decline of functions of electrical equipment of hydro power plants. . Formulation of 5-year rehabilitation plan of electrical equipment of hydro power plants.
Yukio Shimoda	Thermal power plant facilities	. Survey and analysis of the present conditions and investigation of causes of decline of functions of thermal power plant facilities. . Formulation of 5-year rehabilitation plan of thermal power plant facilities.
Kowashi Aosaki*	Geothermal power plant facilities	. Survey and analysis of the present conditions and investigation of causes of decline of functions of geothermal power plant facilities. . Formulation of 5-year rehabilitation plan of geothermal power plant facilities.

Name	Assignment	Service Items
Fuminori Sato	Transmission lines	. Survey and analysis of the present conditions of investigation of causes of decline of functions of transmission line facilities. . Formulation 5-year renovation plan of T/L facilities.
Hideo Yabusa	Substations	. Survey and analysis of the present conditions and investigation of causes of decline of functions of substations. . Formulation 5-year renovation plan of substations.
Toshikazu Simojo	Operation/Maintenance of hydro power plant, T/L and S/S.	. Survey and analysis of the present situation of operation/maintenance of hydro power plants, T/L and S/S. . Investigation and analysis of causes of defects in the operation/maintenance systems. . Formulation of the operation/maintenance management improvement plan.
Kazutoshi Ariyoshi	Operation/Maintenance of thermal power plant.	. Survey and analysis of the present situation of operation/maintenance of thermal power plants. . Investigation and analysis of causes of defects in the operation/maintenance systems. . Formulation of the operation/maintenance management improvement plan.

Name	Assignment	Service Items
Tadanori Aoki	Environment	. Survey and analysis of the environmental problems. . Recommendation on the environmental counter-measures.
Ginjiro Matsuo	Geothermal Power Plant Facilities, Economist	. Survey and analysis of the present conditions and investigation of causes of decline of functions of geothermal power plant facilities Economic survey and evaluation

* Joined in 1st Stage Field Survey only.

1.6 Survey Schedule

The period of field survey of each member of the study team was as tabulated in the following.

Name	1st Stage		2nd Stage	
	Departed from Japan	Returned to Japan	Departed from Japan	Returned to Japan
* Teruaki Ogawa	Jul. 16, 1991	Aug. 14, 1991	Nov. 5, 1991	Dec. 4, 1991
* Yoshiyuki Niihara	"	"	"	"
Toshinori Ishii	"	"	"	"
Yukio Shimoda	"	"	"	"
Kowashi Aosaki	"	Aug. 5, 1991	-	-
* Ginjiro Matsuo	"	Aug. 14, 1991	Nov. 5, 1991	Dec. 4, 1991
* Fuminori Sato	"	"	"	"
* Hideo Yabusa	"	"	"	"
* Toshikazu Shimojo	"	"	"	"
Kazutoshi Ariyoshi	"	"	"	"
* Tadanori Aoki	"	Aug. 5, 1991	"	Nov. 19, 1991

*-marked members visited the Philippines for explanation of the Draft Final Report in the 2nd Stage. Period: Departed from Japan on April 21, 1992 and returned to Japan on May 5, 1992.

1.7 Study Schedule

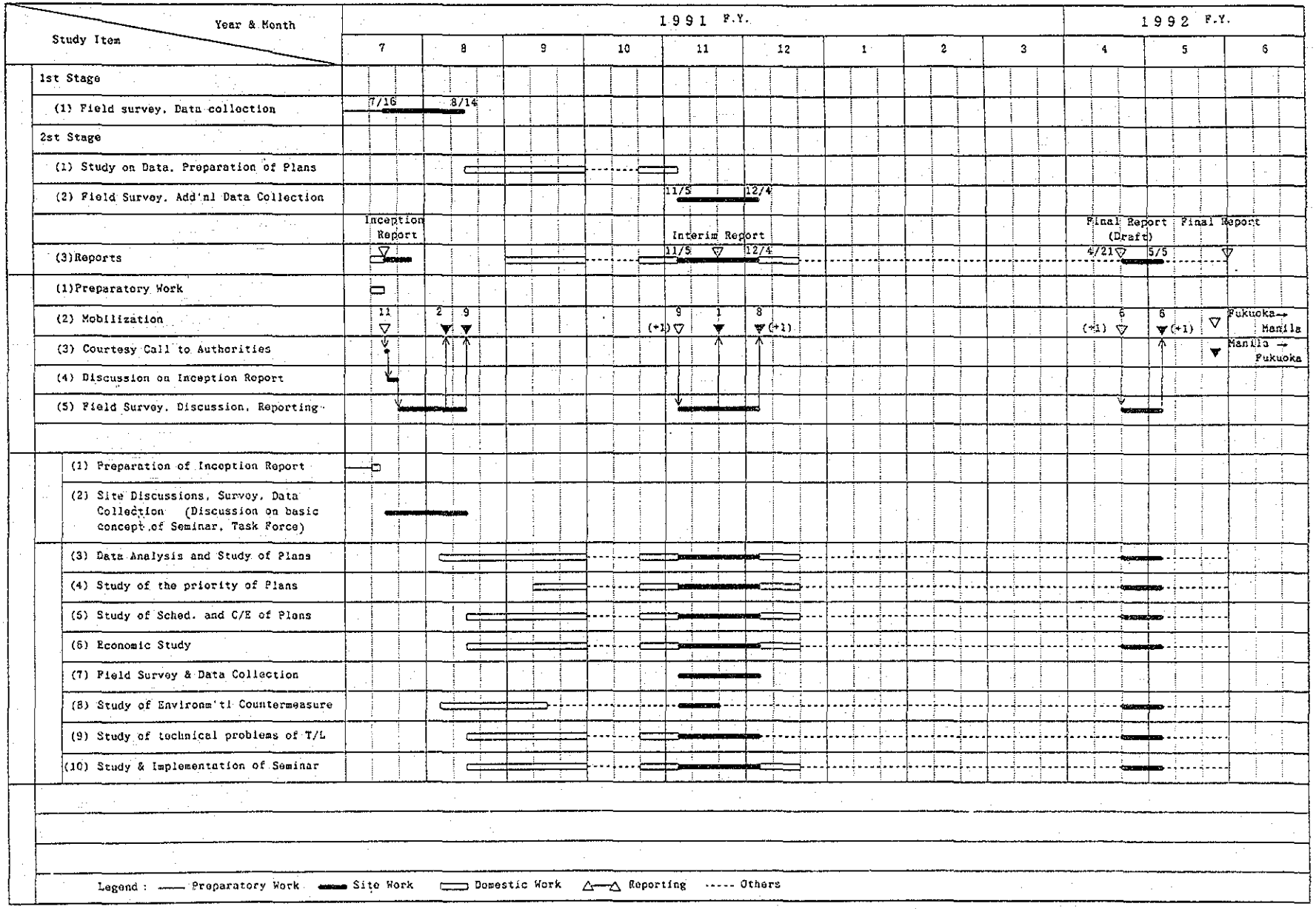
The Master Plan Study Schedule is on following Table 1-2.

1.8 Field Survey

During the survey period the study team visited the Head Office, regional centers and power plants of NAPOCOR. At the commencement of the 1st Stage Survey, the team visited NEDA.

Table 1-2 Study Schedule

Master Plan Study Schedule
Rehabilitation/Renovation and Operation/Maintenance Improvement
of Power Facilities in Luzon Grid.



CHAPTER 2

CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 2 CONCLUSIONS AND RECOMMENDATIONS

The conclusions of the present study for, and recommendations on the 5 year rehabilitation/renovation and operation/maintenance improvement plans of power facilities and the environmental management, are as described in the following.

2.1 5-year Rehabilitation/Renovation Plans of Power Facilities

With regard to the problems of respective facilities, the following rehabilitation/renovation plans which would be effective for improvement of supply reliability and rationalization of maintenance works have been formulated.

Since the facilities are suffering from frequent faults, it will be necessary to push forward strongly the fault reduction countermeasures separately from the above plans.

2.1.1 Rehabilitation/Renovation Plans

1. Thermal Power Plants

(1) Manila Thermal Power Plant Units No. 1 and No. 2 Rehabilitation

No. 1 Unit: 100 MW, No. 2 Unit: 100 MW

[Major Items]

a. Boiler and boiler auxiliary equipment

(a) Detailed inspection and replacement of major pressure parts of boiler

(b) Replacement/repair of major boiler auxiliaries

b. turbine and turbine auxiliary equipment

(a) Inspection of major parts of turbine proper
Replacement of HP and IP turbine inner casings and rotors/blades, replacement of LP turbine casing, and replacement of main stop valves

(b) Replacement/repair of major turbine auxiliaries

c. Electrical equipment

(a) Diagnosis of remaining life and replacement/repair of generator stators and rotors

(b) Replacement of major motors, switchgears, cables, etc.

d. Instruments and control

(a) Replacement/improvement of automatic boiler control system

(b) Provision of spare parts for instruments and control devices

(c) Replacement/improvement of local control systems

(2) Bataan Thermal Power Plant Units No. 1 and No. 2 Rehabilitation

No. 1 Unit: 75 MW No. 2 Unit: 150 MW

[Major Items]

a. Boiler and boiler auxiliary equipment

(a) Detailed inspection and replacement of major pressure parts of boiler

(b) Replacement/repair of major boiler auxiliaries

b. Turbine and turbine auxiliary equipment

(a) Inspection of major parts of turbine proper
Diagnosis of remaining life of HP, IP, and LP rotors

(b) Replacement/repair of major turbine auxiliaries
Replacement/repair of boiler feed pumps, etc.

c. Electrical equipment

(a) Replacement/repair of generator stators and rotors

(b) Replacement/repair of motors, power cables, and switchyard equipment

d. Instruments and control

(a) Replacement/repair of control board recorders and meters, and automatic boiler control system

(b) Provision of spare parts for instruments and control devices

(c) Replacement/repair of local control systems (No. 1 Unit only)

Besides, Sucat Thermal Power Plant No. 2 and No. 3 Units rehabilitation project is in progress.

- Sucat No. 2 Unit (200 MW) rehabilitation

Rehabilitation works scheduled to be started from May 1993.

- Sucat No. 3 Unit (200 MW) rehabilitation

  Rehabilitation works scheduled to be started from July 1992.

2. Geothermal Power Plants

(1) Tiwi Geothermal Power Plant Units No. 1 - No. 6 Rehabilitation
No. 1 - No. 6 Units (55 MW x 6, 330 MW)

[Major Items]

a. Mechanical part

(a) Procurement of turbine spare rotor, nozzle, and diaphragm

(b) Installation of turbine water washing equipment

(c) Main cooling water pipe inner lining and addition of electrolytic protection system

(d) Installation of automatic tube cleaner for generator H_2 gas cooler

(e) Additional steam production well drilling

(f) Procurement of automobiles for transport of operators and maintenance works

b. Electrical part

(a) Inspection of generator stator windings and retaining rings

(b) Rewedging of generator stator windings

(c) Replacement of AVR

c. Instruments and control

(a) Replacement of recorders, indicating meters, transmitters, etc.

(b) Repair or replacement of air conditioners

(2) Mak-Ban Geothermal Power Plant Unit No. 1 - No. 6 Rehabilitation

No. 1 - No. 6 Units (55 MW x 6, 330 MW)

[Major Items]

a. Mechanical part

(a) Procurement of turbine spare rotor, nozzle, and diaphragm

(b) Installation of turbine water washing equipment

(c) Main cooling water pipe inner lining with stainless steel and addition of electrolytic protection system

(d) Installation of automatic tube cleaner for generator H_2 gas cooler

(e) Addition of after-condenser to steam air ejector and extension of gas exhaust line to outlet of cooling tower fans

(f) Procurement of automobiles for transport of operators and maintenance works

b. Electrical part

(a) Inspection of generator stator windings and retaining rings

(b) Rewedging of generator stator windings

(c) Replacement of AVR

c. Instruments and control

(a) Replacement of turbine supervisory instrument sensors

(b) Replacement of control board recorders, meters and transmitters

3. Hydro Power Plants

(1) Reconstruction of Ambuklao Power Plant intake

(2) Replacement of Magat Power Plant excitation transformer

4. Transmission Lines and Substations

(1) Replacement of overhead ground wires

(2) Replacement of circuit breakers

(3) Adoption of steel towers for river and road crossings

(4) Rerouting of transmission line section where restoration works are difficult

(5) Provision of defective insulator detectors

(6) Replacement of disconnecting switches

(7) Provision of spare circuit breakers

2.1.2 Rehabilitation/Renovation Cost

Unit: US$1,000

Facilities	F.C.	L.C.	Total
Thermal power plants	165,700	29,200	194,900
Geothermal power plants	94,908	2,830	97,738
Hydro power plants	12,714	6,840	19,554
Transmission lines and substations	15,901	1,340	17,241
Total	289,223	40,210	329,433

2.1.3 Annual disbursement Schedule

Unit: US$1,000

Facilities		Previous year	First year	Second year	Third year	Forth year	Fifth year
Thermal power plants	F.C.	26,365	36,644	44,228	50,673	7,790	-
	L.C.	2,089	3,884	8,108	11,776	3,343	-
	Total	28,454	40,528	52,336	62,450	11,133	-
Geothermal power plants	F.C.	-	7,016	17,046	30,342	26,202	14,302
	L.C.	-	201	504	903	790	432
	Total	-	7,217	17,550	31,245	26,992	14,734
Hydro power plants	F.C.	-	663	6,332	3,479	2,240	-
	L.C.	-	1,711	3,305	1,284	540	-
	Total	-	2,374	9,637	4,763	2,780	-
Transmission lines and substations	F.C.	-	3,147	2,996	3,468	3,440	2,850
	L.C.	-	228	324	445	230	113
	Total	-	3,375	3,320	3,913	3,670	2,963
Total	F.C.	26,365	47,470	70,601	87,962	39,672	17,152
	L.C.	2,089	6,024	12,241	14,408	4,903	545
	Total	28,454	53,494	82,842	102,370	44,575	17,697

2.2 Operation/Maintenance Improvement Plans

The study and implementation of the following improvement plans is recommended for solving the problems in operation and maintenance.

2.2.1 Head Office

1. Organization

   (1) Reinforcement of planning department

   (2) Establishment of maintenance department

2. Equipment and Materials Procurement System

   (1) Systematic advance arrangement for procurement of important proprietary equipment and materials (especially imported goods)

   (2) Enlargement of authority of local offices in procurement (including in emergency case)

   (3) Expediting of procurement processes

3. Personnel Plan

   (1) Formulation of short-term/long-term personnel plans

   (2) Systematic movement of personnel

4. Education and Training

   (1) Reinforcement of education and training system for new employees and middle-level employees
   (especially for operations and maintenance group)

5. Enhancement of Employees' Morale

(1) Continued appeal to authorities concerned for improvement of salary and fringe benefits.

(2) Increased and impartial opportunities for education and training (within country and overseas)

(3) Impartial opportunities for promotion

(4) Introduction of group proposal system on cost saving and improvement of working efficiency

(5) Improvement of environment/conditions of employees' work places

(6) Enforcement of safety measures for employees' works

(7) Adoption of other measures to incite personnel to work

2.2.2 Thermal Power Plants

1. Operation and Maintenance Management System

(1) Efficiency Control Group

a. Preparation of technical manual embodying the works

b. Coordination among divisions and sections in the power plant, such as periodical liaison and consultations

c. Handling of environmental works

(2) Maintenance Groups

a. Preparation of maintenance manual covering the works of newly formed planning and scheduling groups

b. Securing of necessary personnel and strategic assignment

(3) Periodical Overhaul Management

a. Clarification of responsible manager and scopes of responsibility of divisions and sections concerned for periodical overhaul

b. Study on the possibility of shifting from direct working system into contract working system

2. Performance of Operation and Maintenance

(1) Improvement of daily operation management

(2) Improvement of daily maintenance management

(3) Revision of operation and maintenance manuals

(4) Enhancement of MMP functions

3. Training and Safety Education

(1) Enlargement of scope of selection of trainees

(2) Reinforcement of basic education for new employees and education and training for middle-level employees, and introduction of job rotation system for operators to get versed in all operation positions and for maintenance/technical support personnel

(3) Early implementation of the training center and introduction of operation simulator

(4) Diffusion of TQC concept

(5) Opening of meetings for root-cause analysis and discussion of accidents and troubles, and training in countermeasures against troubles related

(6) Personnel rotations within a power plant and with other plants/organizations related

4. Procurement and Management of Equipment and Materials

(1) Improvement of procurement system for spare parts, parts and consumables

(2) Improvement of acceptance system

(3) Improvement of inventory management (including material handling/storing)

(4) Improvement of as-received coal quality

5. Other Recommended Items

(1) Earlier implementation of items pointed out by Quality Assurance Department of Head Office (All thermal power plants)

(2) Improvement and reinforcement of communication systems (All thermal power plants)

(3) Inspection and repair of bottom plates of oil storage tanks and water tanks (All thermal power plants and NAPOCOR depots)

(4) Installation and/or improvement and reinforcement of waste water treatment equipment and sedimentation ponds (All thermal power plants)

(5) Inspection and dredging of cooling water intake (All thermal power plants, especially Batangas Power Plant and Bataan

marine intake pipe replacement)

(6) Maintenance of analyzing equipment and tools in chemical laboratory (All thermal power plants)

6. Special Remarks

Investigation of countermeasures against avalanche of sand and stone into Malaya Power Plant/PPC common trend.

2.2.3 Geothermal Power Plants

1. Operation and Maintenance Organization

(1) Reinforcement of organization for periodical overhaul, and study on shifting from direct working system into contract working system

2. Performance of Operation and Maintenance

(1) Improvement of daily operation management

(2) Improvement of daily maintenance management

(3) Improvement of periodical overhaul management

(4) Revision of operation and maintenance manuals

3. Training and Safety Education

Same as for thermal power plant

4. Improvement of Procurement and Management of Equipment and Materials

Same as for thermal power plant

2.2.4 Hydro Power Plants, Transmission Lines and Substations

1. Operation and Maintenance System

   (1) Division of NLRC into two regional centers, and relocation of office

   (2) Establishment of organizational units in charge of maintenance in the regional centers

2. Operation and Maintenance Procedure

   (1) Review of the frequency of preventive maintenance and test items by Technical Services (TS)

   (2) Review of recording frequency of operation logs at hydro power plants and substations

   (3) Review of the frequency of patrol checks at hydro power plants and substations

   (4) Carrying out of periodic inspection of civil structures

      a. Measurement of deposits in the reservoirs

      b. Measurement of wall thickness of penstocks

      c. Inspection of races

   (5) Review of patrol check procedure for transmission lines

   (6) Contracting out of simple works

   (7) Promotion of fault reduction countermeasures

3. Operation and Maintenance Manuals

(1) Review of hydro power plant preventive maintenance guide, substation patrol checklist guideline and transmission line patrol checklist guideline

(2) Preparation of civil structure inspection manual

4. Operation and Maintenance Records, Reports, and Reporting System

(1) Review of forced outage report

a. Standardization of the classification of causes on the Corporation-wide level

b. Review of the forms of monthly and annual reports

(2) Preparation of maintenance work reports

(3) Preparation of civil structure inspection report

(4) Submission of the above reports to the regional centers and the Head Office

5. Spare Parts Inventory Level and Management System

(1) Arrangement of basic data, and study of procurement procedure, management system, etc.

- Arrangement of statistics of parts used in the past
- Arrangement of equipment fault statistics
- Investigation of the availability of parts
- Review of the standard inventory level of spare parts
- Standardization of specifications
- Adequate lead time and ordering time
- Simplification of procurement procedure
- Strengthening of the spare parts management system in the Head Office and regional centers

(2) Storing of spare equipment for substation equipment

6. Custody of Technical Documents and Drawings

(1) Establishment of the rule for retaining the specifications, drawings, design calculations, etc. at the time of construction, and arrangement of the above documents and drawings for the existing facilities

(2) Standardization of single line diagrams, and establishment of the rule for periodic updating

7 Test Instruments, Workshop Facilities, and Repair Tools

(1) Provision of the devices for measuring deposits in the reservoirs and wall thickness of the penstocks

(2) Utilization of Maintenance Engineering Center (MEC) for the repairing of parts at the hydro power plants and for the overhaul of GCBs.

8. Training of Operation and Maintenance Staff

(1) To increase the staff of Technical Training Division to improve the training quality, enrich the curriculum, and increase the frequency of training courses.

(2) To promote the early implementation of the Training Center Project to enrich and improve the quality of training.

2.3 Environmental Management

1. Complete Storage Control and Management of PCB

(1) Dissemination of knowledge of method of storing and handling of PCB

(2) Selection of person in charge of storing and control of PCB

2. Monitoring of Air Pollution

(1) Observation of meteorological data at power plants and measurement of SO_2, NOx and dust at emission source (stack inlet)

(2) Measurement of ground level concentration (Installation of monitoring station or purchase of observation buses)

3. Measures for Reduction of Hydrogen Sulfide from Geothermal Power Plants

(1) Introduction of ejector exhaust gas to cooling towers

4. Reinforcement of Environmental Management System

(1) Assignment of persons in charge of environmental problems to regional centers and thermal power plants

(2) Fostering of affiliate company specializing in environmental investigation

CHAPTER 3

GENERAL SITUATION OF THE REPUBLIC OF THE PHILIPPINES

CHAPTER 3 GENERAL SITUATION OF THE REPUBLIC OF THE PHILIPPINES

3.1 Outline of the Philippines

The Republic of the Philippines consists of approximately 7,100 islands of various sizes, spread over an area extending 1,855 km from north to south and 1,108 km from east to west, and has a total land area of 299,765 square kilometers. The largest island is Luzon (104,686 km^2) lying in the north, followed by Mindanao (94,630 km^2) situated in the southernmost. Between the two islands, there are nine relatively large islands, including Samar (13,079 km^2), with a total land area of 85,451 km^2.

The population, which was 48,098,000 in the 1980 census, is estimated at 61,980,000 in 1990, with an annual growth rate of 2.57 percent. The population of Luzon was 26,081,000 (54 percent of total population) in 1980 and is estimated at 33,746,000 (growth rate of 2.64%) in 1990.

The island of Luzon is politically divided into one special district and 71 provinces, which are placed under administrative control of 12 Regions and Metro Manila Area. The island of Luzon together with the island of Masbate, is generally called "Luzon", while the island of Mindanao is referred to as "Mindanao" and all other islands between "Luzon" and "Mindanao" are called "Visayas". (excluding Mindoro and Palawan)

3.2 Politics and Economy

3.2.1 Politics

(1) General

Since the turnover of the administration from Mr. Marcos to Mrs. Aquino by the revolution in February 1986, the new administration has exerted its best efforts to normalize the domestic situations and to reconstruct the economy under the new Constitution promulgated on February 2, 1987. As for the diplomatic policy, the Republic of the Philippines is now seeking for and positively proceeding to the new direction of peaceful international relationship with independence not covered by any umbrella of particular international powers.

(2) Energy Policy

As to the energy policy in the Philippines, the Medium Term Development Plan (1987-1992) was started by the New Regime, and severe reconsideration of the energy plans was undertaken. According to the Plan, the dependence upon oil should be lessened for the purpose of stabilizing the energy supply, for which the comprehensive energy policy was set up such as; the diversification of the oil supply sources and oil products; the adjustment of infrastructures for effective utilization of energy; diffusion of energy saving technology and furthering of energy storage. Moreover, in 1987, the participation of private sectors into the electric power enterprises was permitted for promotion of the economic development. (Executive Order 215).

(3) Electric Power Policy

As to the electric enterprises in the Philippines, the state owned NAPOCOR, since its establishment has been in charge of the development of the electric power sources, and Manila Electric Company (MERALCO), a private power distribution company, has been engaged in the supply of electricity mainly to Metro Manila area.

In 1969, the National Electrification Administration (NEA) was established to supply electricity through the electrification cooperatives organized all over the Philippines, except for Metro Manila.

NAPOCOR has been directly controlled by the Office of the President instead of the former Ministry of Energy, since the New Regime started, and has been under the administration of the Energy Regulatory Board (ERB) as well as the National Power Board (NPB).

Consequently, NAPOCOR is in the similar position as NEDA which controls the development plans of the country.

On the other hand, the National Electrification Administration (NEA), taking charge of rural electrifications is under the control of the Department of Environmental and Natural Resources (DENR).

3.2.2 Philippine Economy

(1) General

The economic system of the Philippines is that of private system modeled after the United States economic system. However, the role of the government in the national economy has become increasingly important in recent years through successive implementation of powerful infrastructure improvement programs.

To characterize the economic environment of the Philippines, the "economy based on excess labor" is often pointed out.

In the Philippines, the unemployment ratio is constantly at high levels, which was 4.6 percent in 1982, 5.5 percent in 1987, and 4.2 percent in 1988, making a major source of social unrest.

(2) Economic Indicators

a. General

The Philippines came through a difficult economic struggle in the past; the economic instability as a result of the oil crisis, inflationary and recessive pressures, and the deterioration of world market prices for the country's export products.

Until 1984, the country's economy was in a decline. Prices of basic goods and services almost doubled from the 1980 prices. Inflation rate was recorded at 50.3 percent, and the consumer price index was 306.20 against the previous year's 137.10. The Peso-Dollar exchange rate increased to ₱16.70 from ₱11.10 in 1983.

In 1986, the government under the new leadership managed to improve the economy and provided more job opportunities for its people. As a result, the country's Gross National Product (GNP) at constant 1972 prices improved by 15.4 percent. During the year, gross value added of the agriculture, fishery and forestry sector and services sector increased by 3.74 percent and 2.32 percent, respectively, while the industrial sector registered a negative growth of 2.74 percent. Prices continued to increase but at a much lesser rate of 0.8 percent.

The country's economic performance was more encouraging in 1987. The increase in GNP was 5.05 percent and gross value added of all three sectors likewise increased 0.72 percent for agriculture, fishery and forestry sector, 7.90 percent for the industrial sector, and 4.85 percent for the services sector.

Foreign trade is another important factor in the development of economy. The country's export of products is increasing the dollar reserve available for the purchase of equipment and other goods from other countries.

Through the years, the Philippines' premier trading partners are the United States and Japan. Total trade of both countries increased from 1985 to 1986; the United States from 2.89 to 2.90 billion U.S. Dollars and Japan from 1.61 to 1.72 billion U.S. Dollars. Hong Kong, the Federal Republic of Germany and Taiwan complete the list of top five countries which have trade relations with the Philippines. Although all five countries recorded increases in their total trade, it was only with the United States and the Federal Republic of Germany that the Philippines registered a favorable balance of trade.

b. Bases of demand forecast

Various economic and demographic variables were used in projecting of energy sales to different customers.

NEDA's latest official medium-term forecast was adopted for economic indicators for the period 1990-1992. For 1993-2010, three Gross Domestic Product (GDP) scenarios (low, medium, and high) were considered in obtaining the upper and lower limits of demand growth. The resulting absolute GDP levels were then allocated to the different sectoral components of GDP based on their historical percentage shares to total GDP.

The following Table 3-1 summarizes these economic variables.

Table 3-1 Luzon Grid Economic Indicators

Item	Average Annual Growth Rate (%)			
	1989-1992	1993-2000	2001-2010	1989-2010
Low Scenario				
Gross Domestic Product (NAT.)	6.4	6.1	4.8	5.6
GDP MFG. (NAT.)	7.8	7.1	4.4	6.0
GDP Services (NAT.)	6.0	6.3	4.8	5.6
PCE (Metro Manila)	4.5	5.4	4.4	4.8
Medium Scenario				
Gross Domestic Product (NAT.)	6.4	6.5	6.5	6.5
GDP MFG. (NAT.)	7.8	7.5	6.1	7.0
GDP Services (NAT.)	6.0	6.7	6.6	6.5
PCE (Metro Manila)	4.5	5.8	6.1	5.7
High Scenario				
Gross Domestic Product (NAT.)	6.4	6.0	9.0	8.5
GDP MFG. (NAT.)	7.8	10.1	8.6	9.0
GDP Services (NAT.)	6.0	9.2	9.1	8.6
PCE (Metro Manila)	4.5	8.2	8.6	7.7

Note : PCE = Personal Consumption Expenditure

CHAPTER 4

CURRENT POWER SITUATION IN LUZON GRID

CHAPTER 4 CURRENT POWER SITUATION IN LUZON GRID

4.1 Forecast of Power Demand and Peak Load

(1) Capacity and Annual Generation of Generating Facilities

The total installed capacity of the entire Philippines as of the end of 1990 was 6,037 MW, out of which 4,321 MW (corresponding to 72%) beloved to the Luzon Grid, whereas the Visayas Grid had 663 MW, and the Mindanao Grid 1,053 MW. The power generation in 1990 totaled 24,800 GWH, out of which the Luzon Grid had 18,800 GWH (corresponding to 76%). The energy sold in 1990 was 22,900 GWH in the entire grids, and 17,400 GWH (76%) in the Luzon Grid.

The population serviced in 1988 was 53,850,000 in the total grids, and 29,690,000 (corresponding to its 55%) in the Luzon Grid. The electric energy consumption per person was 542 KWH in the Luzon Grid against 393 KWH in the entire grids. The energy sold in 1988 was 21,200 GWH in the entire grids, and 16,100 GWH in the Luzon Grid. (Refer to Table 4-1 - 4-3)

(2) Composition of Generating Facilities

The power sources are composed of 2,612 MW of the oil-fired thermal power plants (corresponding 43% of the total), and 405 MW of the coal-fired power plants (7%), thus the thermal power plants accounting for 50% of the total.

The Hydro power generating capacity is 2,132 MW corresponding to 35% of the total, including 300 MW of Kalayaan Pumped-storage Power Plant, and the remaining 15% is 888 MW by the geothermal power plants.

The Luzon Grid has the generating capacity of 4,321 MW, corresponding to 72% of the total capacity, which is broken down to 2,135 MW (50%) of the oil-fired thermal power plants, 300 MW (7%) of the coal-fired thermal power plant, 1,226 MW (28%), of the hydro power plants and 660 MW (15%) of the geothermal power plants. It is a peculiarity of the structure of power sources of the Philippines that the share of the geothermal power generation is large as compared with those in the other countries. (Refer to Table 4-1)

(3) Power Demand Forecast

As for the power demand forecast, NAPOCOR made its own demand forecast based on the forecast in the power development study report prepared by Bechtel Corporation in March 1988, and formulated the electric power development program for the entire systems in the Philippines for 15 years from 1991 through 2005.

According to this program, the maximum power demand in 2005 is estimated at 11,428 MW, approximately 2.8 times 4,075 MW estimated for 1991 (demand in 1990 was recorded at 3,974 MW). In the Luzon Grid, the maximum power demand in 2005 is estimated at 8,647 MW or 2.9 times 3,013 MW estimated for 1991 (demand in 1990 was recorded at 2,973 MW).

These values are a little lower than the estimate based on the high economic growth of 9% by Bechtel Corporation, and is fairly higher than the standard forecast based on 6% of the economic growth, which is judged to be a forecast with some margin.
(Refer to Table 4-3)

Note: The values of installed capacity, GWH, etc. of the power sources in the text were taken from 1990 Annual Report.

Table 4-1. SUMMARY OF INSTALLED CAPACITY
1991 POWER DEVELOPMENT PROGRAM

GRID/ PLANT TYPE	CAPACITY (MW)					AVE. YEARLY INCREASE (MW)			GROWTH RATE (PERCENT)		
	1990	1990 AR	1995	2000	2005	1991-1995	1996-2000	2001-2005	1991-1995	1996-2000	2001-2005
PHILIPPINES	6108	6037	8539	10675	15543	486	427	974	6.9	4.6	7.8
OIL-BASED	2683	2612	3644	3682	3698	192	8	3	6.3	0.2	0.1
HYDRO	2132	2132	2217	2485	3437	17	54	190	0.8	2.3	6.7
GEO	888	888	1323	1603	1803	87	56	40	8.3	3.9	2.4
COAL	405	405	1355	2905	6605	190	310	740	27.3	16.5	17.9
LUZON	4391	4321	6236	8114	12014	369	376	780	7.3	5.4	8.2
OIL-BASED 1/	2205	2135	2805	2805	2805	120	0	0	4.9	0.0	0.0
HYDRO	1226	1226	1226	1494	1794	0	54	60	0.0	4.0	3.7
GEO	660	660	955	1015	1015	59	12	0	7.7	1.2	0.0
COAL 1/	300	300	1250	2800	6400	190	310	720	33.0	17.5	18.0
VISAYAS	664	663	778	856	1172	23	16	63	3.2	1.9	6.5
OIL-BASED	329	328	358	396	412	6	8	3	1.7	2.0	0.8
HYDRO	2	2	7	7	7	1	0	0	28.5	0.0	0.0
GEO	228	228	308	348	548	16	8	40	6.2	2.5	9.5
COAL	105	105	105	105	205	0	0	20	0.0	0.0	14.3
CEBU	334		289	289	389	-9	0	20	-2.9	0.0	6.1
OIL-BASED	229		184	184	184	-9	0	0	-4.3	0.0	0.0
COAL	105		105	105	205	0	0	20	0.0	0.0	14.3
NEGROS	116		196	268	308	16	14	8	11.1	6.5	2.8
OIL-BASED				32	32	0	6	0	-	-	0.0
HYDRO	1		1	1	1	0	0	0	0.0	0.0	0.0
GEO	115		195	235	275	16	8	8	11.1	3.8	3.2
PANAY	80		80	80	80	0	0	0	0.0	0.0	0.0
OIL-BASED	80		80	80	80	0	0	0	0.0	0.0	0.0
HYDRO	0		0	0	0	0	0	0	-	-	-
LEYTE-SAMAR	113		176	176	336	13	0	32	9.3	0.0	13.9
OIL-BASED			63	63	63	13	0	0	-	0.0	0.0
GEO	113		113	113	273	0	0	32	0.0	0.0	19.4
BOHOL	21		37	43	59	3	1	3	12.0	3.1	6.5
OIL-BASED	20		31	37	53	2	1	3	9.2	3.6	7.5
HYDRO 1/	1		6	6	6	1	0	0	43.1	0.0	0.0
MINDANAO	1053	1053	1525	1705	2357	94	36	130	7.7	2.3	6.7
OIL-BASED	149	149	481	481	481	66	0	0	26.4	0.0	0.0
HYDRO	904	904	984	984	1636	16	0	130	1.7	0.0	10.7
GEO			60	240	240	12	36	0	-	32.0	0.0

CAP_TOT2.XLS

1/ Includes non-NPC plants.

AR= Annual Report

Table 4-2 SYSTEM ENERGY GENERATION MIX
1991 POWER DEVELOPMENT PROGRAM

GRID/FUEL TYPE	ACTUAL 1990		PROJECTED 1991		1995		2000		2005	
	GWH	%	GWH	%	GWH	%	GWH	%	GWH	%
PHILIPPINES	24800	100	26270	100	36633	100	53404	100	75992	100
OIL-BASED	11541	47	12342	47	13582	37	9988	19	6854	9
HYDRO	6047	24	5806	22	6600	18	7643	14	10084	13
GEO	5470	22	5916	23	9282	25	17060	32	18537	24
COAL	1742	7	2206	8	7169	20	18713	35	40517	53
LUZON	16823	100	20035	100	27192	100	40257	100	57860	100
OIL-BASED	10328	55	11061	55	11450	42	6405	16	3962	7
HYDRO	2370	13	2369	12	2369	9	3412	8	3412	6
GEO	4495	24	4650	23	6826	25	12347	31	10446	18
COAL	1630	9	1955	10	6547	24	18093	45	40040	69
VISAYAS	2051	100	2371	100	3675	100	5184	100	7633	100
OIL-BASED	955	47	841	35	1006	27	1638	32	1463	19
HYDRO	9	0	13	1	34	1	34	1	34	0
GEO	975	48	1266	53	2013	55	2892	56	5659	74
COAL	112	5	251	11	622	17	620	12	477	6
MINDANAO	3926	100	3864	100	5766	100	7963	100	10499	100
OIL-BASED	258	7	440	11	1126	20	1945	24	1429	14
HYDRO	3668	93	3424	89	4197	73	4197	53	6638	63
GEO	0	0	0	0	443	8	1821	23	2432	23

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Table 4-3 ENERGY SALES AND DEMAND FORECAST SUMMARY

1991 POWER DEVELOPMENT PROGRAM

YEAR	ENERGY SALES (GWH)				DEMAND (MW) 1/			
	LUZ	VIS	MIN	PHIL	LUZ	VIS	MIN	PHIL
ACTUAL								
1986	13535	1355	2948	17838	2311	283	484	3078
1990	17601	1926	3756	23283	2888	356	621	3865
1990 AR	17368	1818	3729	22915	2973	380	621	3974
GROWTH RATE (%) (1987-1990)	6.8	9.2	6.2	6.9	5.7	5.9	6.4	5.9
FORECAST								
1991	18402	2120	3941	24463	3013	407	655	4075
1995	24868	3300	5456	33624	4072	592	907	5571
GROWTH RATE (%) (1991-1995)	7.2	11.4	7.8	7.6	7.1	10.7	7.9	7.6
1996	26898	3529	5811	36238	4405	633	966	6004
2000	36815	4631	7475	48921	6029	812	1243	8084
GROWTH RATE (%) (1996-2000)	8.2	7.0	6.5	7.8	8.2	6.5	6.5	7.7
2001	39569	4959	7793	52321	6480	860	1296	8636
2005	52807	6537	9904	69248	8647	1134	1647	11428
GROWTH RATE (%) (2001-2005)	7.5	7.1	5.8	7.2	7.5	6.9	5.8	7.2
(1991-2000)	7.7	9.2	7.1	7.7	7.6	8.6	7.2	7.7
(1991-2005)	7.6	8.5	6.7	7.5	7.6	8.0	6.7	7.5

1/ Net of Station use and non-coincident demand for Visayas and Philippines.

AR= Annual Report

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4.2 Power Development Plan

(1) Composition of Future Generating Facilities

The power development program up to 2005 by NAPOCOR is made on the basis of 11,428 MW (8,647 MW in the Luzon Grid) of the peak power demand forecast for 2005.

This program follows the plan by Bechtel Corporation in which the installed capacity in 2005 of the entire systems in the Philippines will reach 15,543 MW with a reserve rate of 36%. The power sources will be composed of 3,698 MW (24%) of oil-fired thermal power, 3,437 MW (22%) of hydro power, 1,803 MW (12%) of geothermal power, and 6,605 MW (42%) of coal-fired thermal power, and it is characterized by a drastic increase of coal-fired thermal power generation.

With regard to the Luzon Grid, the total installed capacity will be 12,014 MW with 39% reserve in 2005, composed of 2,805 MW (23%) of oil-fired thermal power, 1,794 MW (15%) of hydro power, 1,015 MW (9%) of geothermal power, and 6,400 MW (53%) of coal-fired thermal power.

This power source configuration is characterized by the higher share of coal-fired thermal power and lower share of hydro power, and less flexibility of system regulation is feared. (Refer to Table 4-1)

(2) Outline of Power Development Program

The power development program by NAPOCOR for the Luzon Grid is based on the Bechtel concept that the new hydro power development is not economical, and the development of geothermal and coal-fired thermal power plants are emphasized.

Especially, since an extreme shortage of power is foreseen in 1994, new construction of gas turbine generators of 210 MW in 1989 and 436 MW in 1991 is planned.

Interconnection of the Luzon Grid with the Leyte Grid is planned to introduce the geothermal power of 880 MW from Tongonan, Leyte to Luzon from 1997 through 1999, which will necessitate the construction of interconnecting lines of Leyte - Samar - Luzon in 1997.
The Calaca II Power Plant is planned to be commissioned in 1994, and the bidding documents are now under review. There may be 2 to 3 years delay in its implementation.

The coal-fired thermal power plant III scheduled to be commissioned in 1995 is already decided, together with the BOT scheme of construction.

The coal-fired thermal power plant (Masinloc) scheduled for 1995 is projected in Zambales. For coal-fired thermal power plant B, the feasibility study is expected to be made soon including the selection of an appropriate site. (Refer to Table 4-4, Fig.4-1 - 4-2)

(3) Review of the Components of Future Generating Facilities

In view of the tendency of too much dependence upon the imported coal, reconsideration for the use of indigenous energy sources has been pointed out. In connection with the commencement of the study of hydro power plants for the regulating power sources, the restudy of the utilization of hydro power potential of 5,000 MW in Luzon is undertaken as well as the expansion of Kalayaan Pumped-storage Power Plant.

The Rockwell Thermal Power Plant in Makati has become an urgent issue for its aged deterioration and environmental pollution, and its earlier rehabilitation or removal out of the city is a pending problem.

An agreement was signed in September 1989 on USAID grant for the feasibility study of the above. The power plant has 3 units of 60 MW and 5 units of 25 MW, totaling 305 MW, but only 2 units of 60 MW are in operation after 25 to 38 years after commissioning.

(4) Promotion of Power Sources Development Program

The electric power demand and supply balance in the Luzon Grid is in a very tight condition caused by the abortage of supply power, and the planned supply curtailment (or brown-out) is made as a matter of daily routine.

The main reason of the above situation lies in the fact that the capabilities of the existing power plants have declined largely, and the reserve power which appears to be 30% or more is actually nearly zero or on the minus side.

The decrease of the reserve power is due to;

* Decrease of output of hydro power plants due to drought,
* Output limitation and unit shutdown due to aged deterioration of equipment and troubles,
* Unit shutdown for maintenance,

Where the former two reasons are largely responsible. Consequently, the new power sources development projects do not proceed as planned initially, and the delays add again to the supply power shortage.

Therefore, as the countermeasure for the power shortage, it would be essential (1) to see that there would be no further delay of the power sources development program, and (2) to carry out the rehabilitation, repair and maintenance of existing power generating facilities regularly in defiance of inevitable unit shutdowns.

LVMLN97R/PDPSUMM

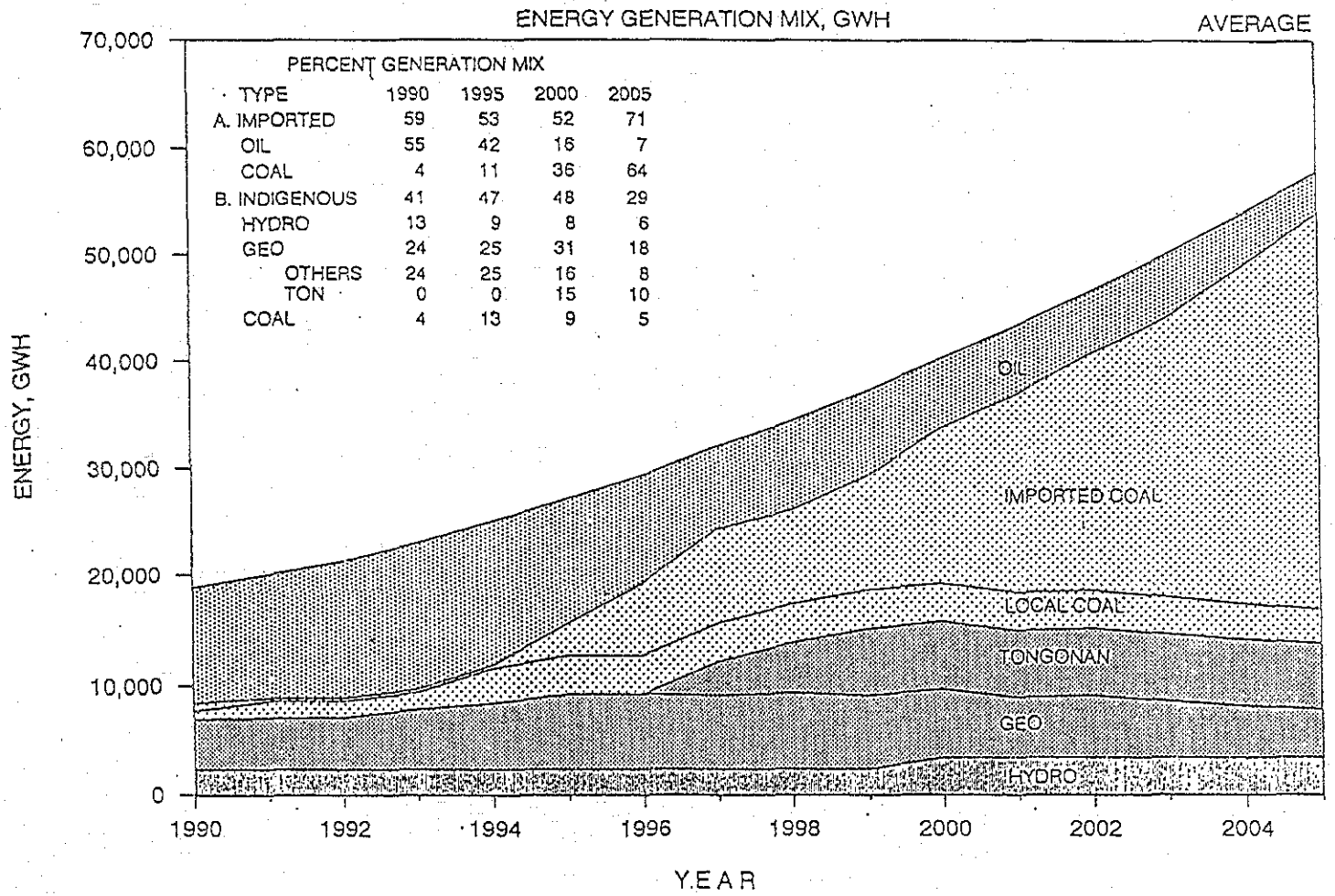
08 SEP 1991

Table 4-4 1991 POWER DEVELOPMENT PROGRAM

YEAR	LUZON MO.	POWER PLANT	TYPE	MW	VISAYAS MO.	POWER PLANT	TYPE	MW	MINDANAO MO.	POWER PLANT	TYPE	MW	TOTAL
1991	JAN	HOPEWELL GT #2	GT	70	FEB	ABB-LBGT#1	GT	28	FEB	PBGT-MT#8	GT	30	447
	JAN	PBGT-JB#1	GT	30	FEB	PBGT-MT#7	GT	30	MAR	PBGT-MT#9	GT	30	
	MAR	HOPEWELL GT #3	GT	70	APR	ABB-LBGT#2	GT	28	AUG	PBGT-JB#2	GT	30	
	MAR	PBGT-JB#3	GT	30	OCT	BDPP Unit 5	DSL	6					
	JUN	PBGT-JB #4	GT	30	DEC	JANOPOL MH	HYDRO	5					
	OCT	PBGT-JB #5	GT	30									
1992	JUL	LBGT - SUCAT	GT	30	OCT	CDPP II-U4	DSL	19	JUL	AGUS I	HYDRO	80	165
									JUL	SMPB-12	DSL	36	
1993	JAN	BATAAN CC-STAGE 1	CC	210	JAN	CEBU-NEGROS INTERCONNECTION			FEB	DAVAO CC STAGE 1	CC	140	755
	MAR	MAKBAN BINARY	GEO	12	JUL	PALINPINON II - 1	GEO	20	NOV	DAVAO CC STAGE 2	CC	70	
	MAY	BACMAN II	GEO	40	SEP	PALINPINON II - 2	GEO	20					
	JUN	BACMAN I	GEO	110	NOV	PALINPINON II - 3	GEO	20					
	SEP	BATAAN CC-STAGE 2	CC	100									
	OCT	MAIBARARA BINARY	GEO	13									
1994	MAR	CALACA II	COAL	300	JAN	PALINPINON II - 4	GEO	20					326
					JAN	BOHOL DIESEL	DSL	6					
1995	JAN	DEL GALLEGO	GEO	120					JAN	MT. APO A	GEO	60	830
	MAY	MASINLOC I	COAL	300									
	JUN	HOPEWELL I-BOT	COAL	350									
1996	JAN	MASINLOC II	COAL	300	JAN	MAMBUCAL A	GEO	40	JAN	MT. APO B	GEO	60	460
	JAN	BULUSAN	GEO	60									
1997	JAN	LUZON-LEYTE INTERCONNECTION			JAN	LEYTE-CEBU INTERCONNECTION			JAN	LEYTE-MINDANAO INTERCONNECTION			790
	JAN	HOPEWELL II-BOT	COAL	350	JAN	LEYTE A	GEO	440					
1998					JAN	LEYTE B1	GEO	220	JAN	MT. APO C	GEO	120	346
					JAN	BOHOL DIESEL	DSL	6					
1999	JAN	COAL	COAL	300	JAN	LEYTE B2	GEO	220					520
2000	JAN	COAL	COAL	600									868
	JAN	CASECNAN	HYDRO	268									
2001	JAN	LUZON-MINDORO INTERCONNECTION			JAN	CEBU-BOHOL INTERCONNECTION							770
	JAN	COAL	COAL	600	JAN	MAMBUCAL B1	GEO	20					
	JAN	KALAYAAN	HYDRO	150									
2002	JAN	COAL	COAL	600	JAN	MAMBUCAL B2	GEO	20	JAN	AGUS III	HYDRO	223	863
					JAN	LEYTE C1	GEO	20					
2003	JAN	COAL	COAL	600	JAN	LEYTE C2	GEO	20	JAN	SMALL HYDRO STAGE 1	HYDRO	105	875
	JAN	KALAYAAN	HYDRO	150									
2004	JAN	COAL	COAL	900	JAN	LEYTE C3 - 5	GEO	60	JAN	SMALL HYDRO STAGE 2	HYDRO	106	1134
										SMALL HYDRO STAGE 3	HYDRO	68	
2005	JAN	COAL	COAL	900	JAN	LEYTE C6 - 8	GEO	60	JAN	BULANOG-BATANG	HYDRO	150	1110
TOTAL				7623				1328				1308	10259

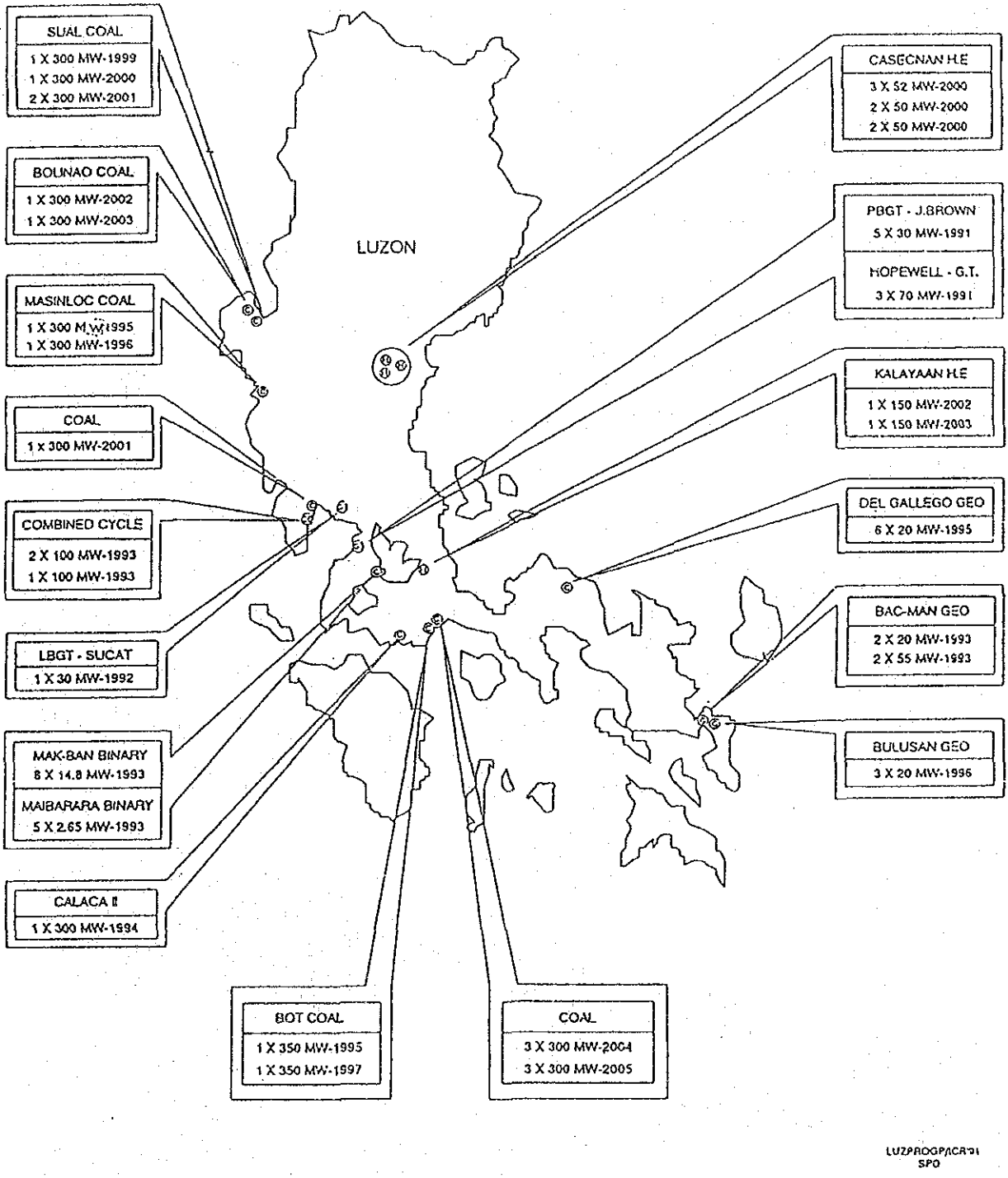
Fig. 4-1

LUZON GRID



LUZON GRID

Fig. 4-2 PROPOSED GENERATION PROJECTS
1991 POWER DEVELOPMENT PROGRAM



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CHAPTER 5

OUTLINE OF NATIONAL POWER CORPORATION

CHAPTER 5 OUTLINE OF NATIONAL POWER CORPORATION

5.1 History of National Power Corporation

National Power Corporation (NAPOCOR) was established in 1936 as a public corporation fully owned by the Philippine Government. NAPOCOR is in charge of the construction and operation of power generation, transmission and substation facilities, and sells electric power wholesale to Manila Electric Company (MERALCO), other power distribution companies and electric cooperatives, and also sells power directly to some large customers.

NAPOCOR was originally organized to develop hydroelectric power and electric power from other natural resources. NAPOCOR expanded the scope of operation in 1972, and purchased thermal power plants from MERALCO in 1978, and ever since, has been carrying out the operation of power generation, transmission and substation facilities.

5.2 Organization Structure of NAPOCOR

NAPOCOR is under the jurisdiction of the Office of Energy Affairs (OEA), which is under the direct control of the President, and the Energy Regulatory Board (ERB). The highest decision-making organ for NAPOCOR is the National Power Board (NPB).

In the Head Office, the technical organization consists of Engineering, Luzon Operations, and Visayas/Mindanao Operations, while the administrative organization consists of Administration, Finance, Human Resources, Planning Services, Controller, and the Office of the General Counsel.

As for the local organizations, NAPOCOR has 5 regional centers, the Northern Luzon Regional Center (NLRC), Southern Luzon Regional Center (SLRC) and Metro Manila Regional Center (MMRC), all on Luzon Island, and the Visayas Regional Center (VRC) in the Visayas area, and the Mindanao Regional Center (MRC) on Mindanao Island.

In an effort to rationalize and integrate job functions, NAPOCOR is implementing the organizational reform which includes the "early retirement incentive program". Although substantial reform was carried out in November 1991, the complete transition to the new organizations has not yet been finished.

5.3 Manpower and Training

According to the manpower trend in the past 10 years, the number of employees generally decreased between 1981 and 1985, but it turned to the increasing trend after 1985. In 1990, the number of employees reached 16,056.

The allocation of manpower in 1990 was 74% for Operations, 15% for Engineering, and 11% for Administration, which indicates that operation and maintenance staff account for a large portion of the manpower. In 1990, the number of employees for Engineering and Operations were increased by 1,469 and 1,633, respectively, to cope with the increasing projects and strengthen operation and maintenance.

Human Resources is in charge of manpower training, and is endeavoring to develop the capabilities and technical skill of the employees. According to the five-year records between 1986 and 1990, the annual average number of training course attendants was 4,071, with 875 (21.5%) attending the manager and supervisor courses, 717 (17.6%) the operation and maintenance courses, 1,104 (27.1%) the engineering and computer courses, and 1,375 (33.8%) the administration courses.

Technical training is under the responsibility of the Technical Training Division (TTD) of the Human Resources & Organizational Development Department. However, TTD, with the limited training staff, has not provided sufficient training. Therefore, it will be essential to increase the staff of TTD in order to improve the training quality, enrich the curriculum and increase the frequency of training courses.

The training center project, which was scheduled for implementation by the ADB loan, was canceled in October 1991. The bidding documents for the project have already been prepared. The proposed location is the NAPOCOR's Housing Compound in Bagac, Bataan Province. Early implementation of this project is imperative for the enrichment and improvement of training.

5.4 Financial Situation

In 1990, the energy sales was 22,915 GWh, an increase of 3.02% over the previous year. However, because of the power rate increases, the operating revenue amounted to 25,779 million Pesos, an increase of 25.08% over the previous year.

On the other hand, due to the rise of crude oil prices and other costs caused by the Gulf Crisis, the operating expenses amounted to 21,660 million Pesos, an increase of 41.47% over the previous year, resulting in the net income loss of 65 million Pesos.

In 1991, it is anticipated that the financial situation will become even worse due to the rise in oil prices caused by the Gulf War and the devaluation of Peso. A provisional calculation shows that the net income loss will be 2,941 million Pesos, the return on rate base 3.5%, and the debt service ratio 0.6.

NAPOCOR plans the financial improvement by raising the power rates and enhancing the operational efficiency, to fulfill the loan requirements of the World Bank and other financial institutions of the return on rate base of 8% and the debt service ratio of 1.5.

5.5 Power Rates

The power rates of NAPOCOR are determined by the National Power Board. The automatic adjustment system, that will automatically adjust the power rates with the changes in fuel prices and the exchange rate, is scheduled to be approved in 1992.

As the power rates are determined based on the generating costs, the rates vary with each grid, reflecting the differences in power source structure by grid. The average power rate in the Mindanao Grid, where power is mostly generated by hydro power plants, is approximately 58% of that in the Luzon and Visayas Grids where power is mainly generated by thermal power plants.

In addition, the power rates vary depending on the customers. The rates for electric cooperatives are set fairly low to encourage electrification in the rural areas.

After 1986, the average power rates showed a decreasing tendency, however, in 1990, power rates were raised due to the rise of crude oil prices, resulting in an increase of 20.1% in the average power rates. The rate increases in 1990 was 41.4% for the Luzon Grid, 39.4% for the Visayas Grid, 16.9% for the Mindanao Grid and 38.5% for the whole Philippines. Yet, since the rate increases were implemented seven times through the year, the effects are to be realized in both 1990 and 1991.

NAPOCOR plans to increase the power rates at an annual average rate of 12.1% between 1992 and 1994.

CHAPTER 6

MASTER PLAN OF 5-YEAR REHABILITATION/RENOVATION OF POWER FACILITIES

CHAPTER 6 MASTER PLAN OF 5-YEAR REHABILITATION/RENOVATION OF POWER FACILITIES

6.1 Thermal Power Plants

6.1.1 Current Status, including Problems, of Thermal Power Facilities

1. Outline of Thermal Power Plants

(1) Number of Thermal Power Plants and Total Installed Capacity (Number of units)

All thermal power plants in the Luzon Grid are under the jurisdiction of the Metro Manila Regional Center (MMRC). The status as of August 1991 is as follows:

Steam power plant	5 plants	2,225 MW (11 units)
Gas turbine power plant	2 plants	210 MW (7 units)
Total	7 plants	2,435 MW (18 units)

The breakdown of the above is given in Table 6-1-1.

Table 6-1-1 List of Thermal Power Plants (As of Aug. 1991)

Power Plant	Location	Installed Capacity (MW)	Unit No.	Unit Cap. (MW)	Year of Commission	Running Years
Bataan	Limay, Bataan	225	1	75	1972	19
			2	150	1977	14
Sucat	Muntinglupa Metro Manila	850	1	150	1968	23 *1)
			2	200	1970	21 *2)
			3	200	1971	20 *2)
			4	300	1972	19 *1)
Manila	Ermita, Manila	200	1	100	1965	26
			2	100	1966	25
Malaya	Pililla, Rizal	650	1	300	1975	16 *3)
			2	350	1979	12 *4)
Subtotal Oil-fired		1,925MW	10 units			
Batangas	Calaca. Batangas	300	1	300	1984	7
Subtotal Coal-fired		300MW	1 unit			
Bataan Gas Turbine	Limay, Bataan	120	1	30	1989	2
			2	30	1989	2
			3	30	1989	2
			4	30	1989	2
Malaya Gas Turbine	Pililla, Rizal	90	1	30	1989	2
			2	30	1989	2
			3	30	1989	2
Subtotal Gas Turbine		210MW	7 units			
Total Thermal		2,435MW	18 units			

Note: Rehabilitation Project
*1) Implemented in 1990
*2) To be implemented in 1992 and 1993
*3) Implemented in 1987
*4) Implemented in 1986

(2) Outline of Thermal Power Plant Facilities

The outline is shown in Table 6-1-5, "Summary of Thermal Power Plant Facilities."

2. Current Status of Thermal Power Plants

(1) Reduced Output of Thermal Power Plants

As shown in Table 6-1-2, the present total capability of thermal power plants as of November, 1991 is roughly 83% of the total rated capacity.

Large output drops are seen with the Bataan No. 1, Sucat No. 2, and Malaya No. 1 Units.

Table 6-1-2 Rated Capacity VS Present Capability (As of Nov. 1991)

	Power Plant Unit No.	Rated Capacity A(MW)	Present Capability B(MW)	B/A (%)	Year of Commission (Running Years)	Total Operating Hours (Hr)
Oil-Fired	Bataan No.1	75	*50	67	1972 (19)	120,772 *5)
	Bataan No.2	150	*130	87	1977 (14)	91,305
	Manila No.1	100	90	90	1965 (26)	200,505
	Manila No.2	100	95	95	1966 (25)	185,935
	Sucat No.1 *1)	150	120	80	1968 (23)	149,739
	Sucat No.2 *2)	200	*150	75	1970 (21)	121,946
	Sucat No.3 *2)	200	160	80	1971 (20)	118,427
	Sucat No.4 *1)	300	300	100	1972 (19)	96,634
	Malaya No.1 *3)	300	210	70	1975 (16)	96,954
	Malaya No.2 *4)	350	290	83	1979 (12)	83,405
Coal-Fired	Batangas No.1	300	260	87	1984 (7)	43,301
	Total	2,225	1,855	83	-	-

Note: Rehabilitation Project

* Capability prior to overhauling

*1) Implemented in 1990
*2) To be implemented in 1992 and 1993
*3) Implemented in 1987
*4) Implemented in 1986
*5) As of Dec. 1990

(2) Increased Heat Rate of Thermal Power Plants (lowered plant efficiency)

Fig. 6-1-1 shows the thermal efficiency plotted from Table 6-1-3 Comparative Gross Heat Rate and Thermal Efficiency.

With all units, the heat rates (or thermal efficiency) have fallen below the design or guaranteed heat rates owing to the deterioration caused by age. (refer to Table 6-1-3 c/a; c = current heat rate, a = designed or guaranteed heat rate)

The worst three are the Sucat No. 3 (c/a = 1.483), Bataan No. 1 (c/a = 1.226) and Sucat No. 2 (c/a = 1.214).

Fig. 6-1-1 Present Status of Thermal Efficiency at Thermal Power Plants (As of June, 1991)

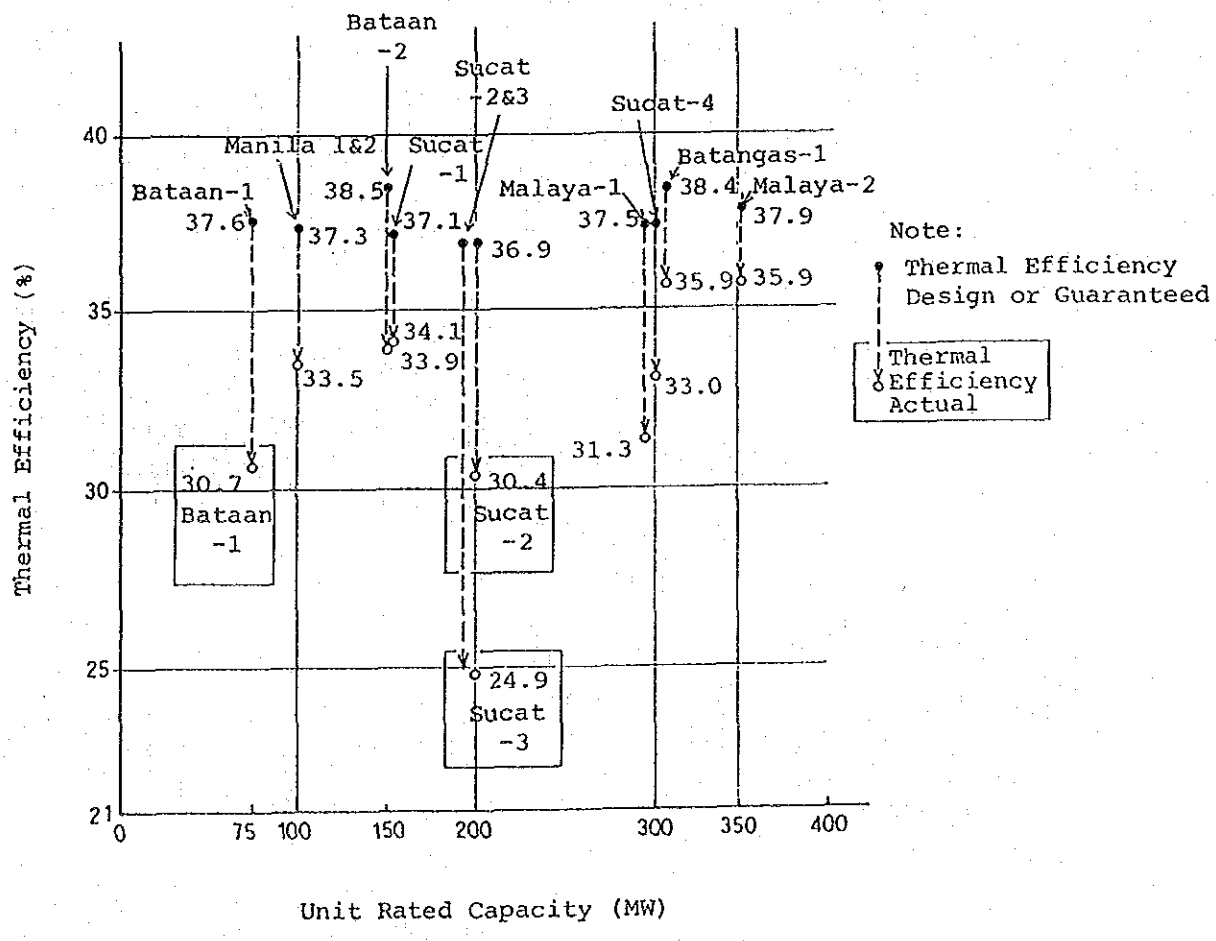


Table 6-1-3 Comparative Gross Heat Rate and Thermal Efficiency (As of Jun.1991)

Power Plant Unit No.	Rated Capacity (MW)	Gross Heat Rate(BTU/KWH) • Thermal Efficiency (%)					
		Design/ Guaranteed (a)	Acceptance test (b)	Before O/H (c)	After O/H expected (d)	(c/a)	(d/a)
Bataan No.1	75	37.6% 9,070	37.1% 9,190	30.7% 11,120	33.4% 10,200	1.226	1.125
Bataan No.2	150	38.5% 8,850	38.6% 8,840	33.9% 10,070	35.5% 9,620	1.138	1.087
Manila No.1	100	37.3% 9,138	37.6% 9,060	33.5% 10,185	34.9% 9,775	1.115	1.070
Manila No.2	100	37.3% 9,138	38.1% 8,955	33.5% 10,190	34.8% 9,800	1.115	1.072
Sucat No.1	150	37.1% 9,190	* 37.1% (1990)	34.1% 9,990	34.9% 9,770	1.087	1.063
Sucat No.2	200	36.9% 9,239	* 36.9% (predicted)	30.4% 11,220	32.0% 10,650	1.214	1.153
Sucat No.3	200	36.9% 9,239	* 36.9% (predicted)	24.9% 13,700	29.1% 11,725	1.483	1.269
Sucat No.4	300	37.5% 9,104	* 37.2% (1990)	33.0% 10,320	33.8% 10,095	1.134	1.109
Malaya No.1	300	37.5% 9,104	* 35.9% (1987)	31.3% 10,885	32.5% 10,505	1.196	1.154
Malaya No.2	350	37.9% 8,998	* 37.4% (1986)	35.9% 9,490	36.6% 9,330	1.055	1.037
Batangas No.1	300	38.4% 8,876	39.0% 8,760	35.9% 9,520	37.0% 9,220	1.073	1.039

Note:

*-Based on acceptance test after rehabilitaion

a-Based on manufacturers design/guaranteed performance

b-Based on acceptance test after construction

c-Actual performance for the month of May 1991

d-Expected performance after overhauling

• Thermal efficiency is calculated from Gross Heat Rate, by the following conversion rates.

1 kcal = 3.96832 BTU

860 kcal ≒ 3,413 BTU

(3) Number of Forced Outages at Thermal Power Plants

The number of forced outages in the previous 5 years (1986-1990) is graphed out in Fig. 6-1-2. The distinctive findings are as follows:

a. The power plants where annual forced outages were relatively numerous throughout the previous 5 years:

. Oil-fired thermal power plant - Bataan No. 1 & 2, Malaya No. 1 & 2.

With the Malaya No. 1 Unit, forced outages occurred frequently after rehabilitation, while with Malaya No. 2 Unit, frequent forced outages occurred in 1990 through 1991.

. Coal-fired thermal power plant - Batangas No. 1

The number of forced outages with coal-fired thermal power plants is higher than with oil-fired thermal power plants. This is considered to be due to the difference in fuel, and should be treated separately from the problem of aged deterioration.

b. The power plants which suffered relatively few annual forced outages throughout the previous 5 years:

. Oil-fired thermal power plants - Sucat No. 1 & 2

c. In 1990, the annual forced outages in the power plant units, except for the Manila No. 1 & 2, were higher than in previous years.

(4) Maintenance Outage Hours of Thermal Power Plants

The maintenance outage hours (including planned outages) in the previous 5 years are converted into months and shown in Fig. 6-1-2.

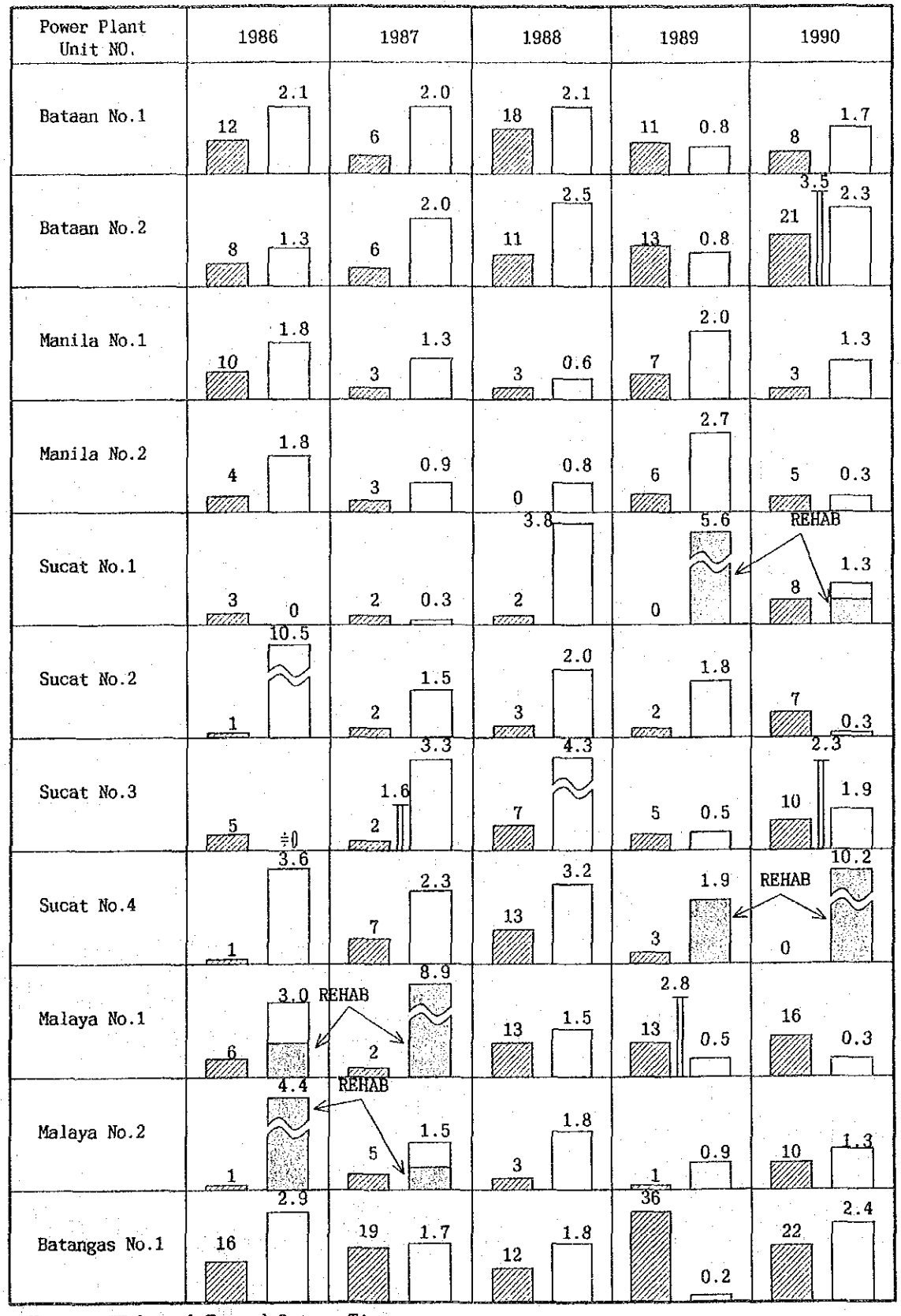
According to the NAPOCOR plan, the average length of a periodic inspection & repair (once a year) is 40 days for conventional unit (Drum type), 60 days for once-through unit and coal-fired unit. Therefore, if the annual maintenance outage period is somewhere between 1.3--2.0 months in the Figure, it should not be regarded as abnormal in view of the running years of the respective units. It may be that the units with an annual maintenance outage exceeding the above-mentioned length needed repairs due to accidents or aged deterioration.

The distinctive findings from the Figure are as follows:

a. With Bataan No. 2, an increasing tendency is noted in the number of forced outages and in the length of maintenance outages.

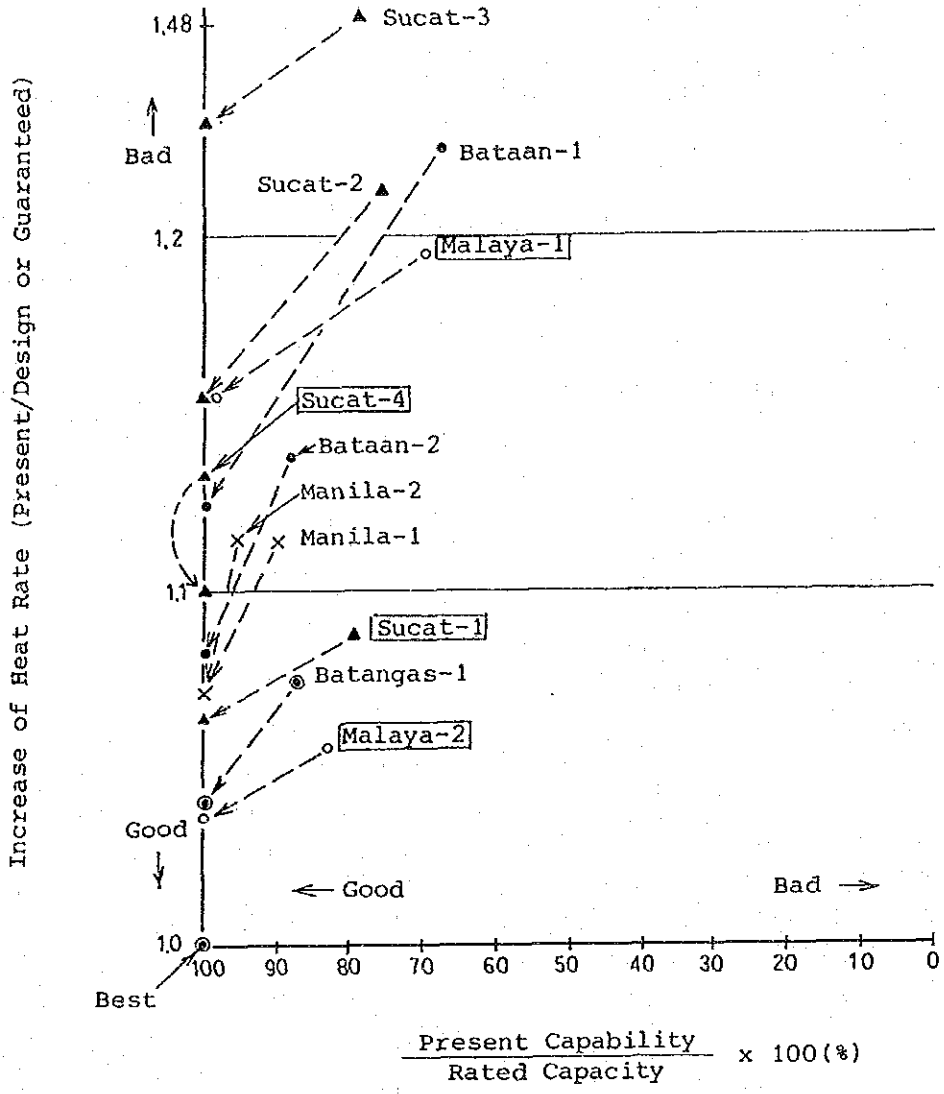
b. With Sucat No. 2 & 3, the annual maintenance outage period exceeded 3 months in some different years. Also, an increasing tendency is observed in their numbers of annual forced outages, which had been relatively small previously.

Fig. 6-1-2 Annual Forced Outage Times and Annual Maintenance Outage Hours



Note: ▨ Annual Forced Outage Times
□ Annual Maintenance Outage Hours (In Months)
▩ Rehabilitation
Annual Forced Outage Hours (In Months)

Fig. 6-1-3 Present Conditions of Thermal Power Plants
(Capacity and heat rate)



Note: ▭ Rehabilitated unit

●<-- Heat rate after overhaul (Predicted)

(5) Summary of Present Status of Thermal Power Plant Units

a. Generally, the service life of a thermal power unit is said to be 30 years. According to this scale, the existing units are generally in the middle-age, and some are approaching the retirement age.

Except for Batangas No. 1 Unit of 7 years in operation, all units have exceeded 10 years. Every unit at Manila and Sucat Power Plants has 19-26 running years. More specifically, 6 units out of 11 units have exceeded one hundred thousand running hours. Most of all, the running hours of Manila No. 1 Unit have surpassed two hundred thousand hours.

As the aged deterioration with these units is advanced, appropriate rehabilitation or planned maintenance is called for.

b. Fig. 6-1-3 is the macroscopic illustration of the present status of each unit indicated by both the aforementioned factors of reduced output and increased heat rate.

Before deciding the order of implementation of the rehabilitation or planned maintenance, consideration should be given to the expected results for each power plant to be obtained through the implementation of the rehabilitation or planned maintenance (discussed in detail in Clause 6.1.3).

c. In addition to the findings from Fig. 6-1-3, the recent 5-year results of the annual number of forced outages and maintenance outage lengths with each power plant unit are recapitulated below.

(a) Sucat No. 2 & No. 3 Units should be given the priority for rehabilitation. In fact, their rehabilitation work is scheduled for 1992 and 1993

respectively. The contractors for the work have been appointed, and the check and review by the consultant of the drawings submitted by the manufacturers is in progress.

(b) Malaya No. 2 Unit and Sucat No. 1 Unit are in relatively good condition when compared with other units, regardless of the fact that their last rehabilitations were made roughly 5 years ago with the former unit and one year ago with the latter.

(c) Batangas No. 1 Unit (coal-fired) is in relatively good condition, although it has been confronted to a number of inevitable problems due to the designated fuel of low grade coal.

(d) Both Manila No. 1 and No. 2 Units are in relatively good condition, considering they have been running for over 25 years. Therefore, if it is imperative to maintain their generating capacity of 200 MW in full for the coming 10 years, rehabilitation is recommended for implementation before their service life expires (that is, within the coming 5-6 years). (refer to Fig. 6-1-4)

Fig. 6-1-4 Summary of Present Status of Thermal Power Plant Units

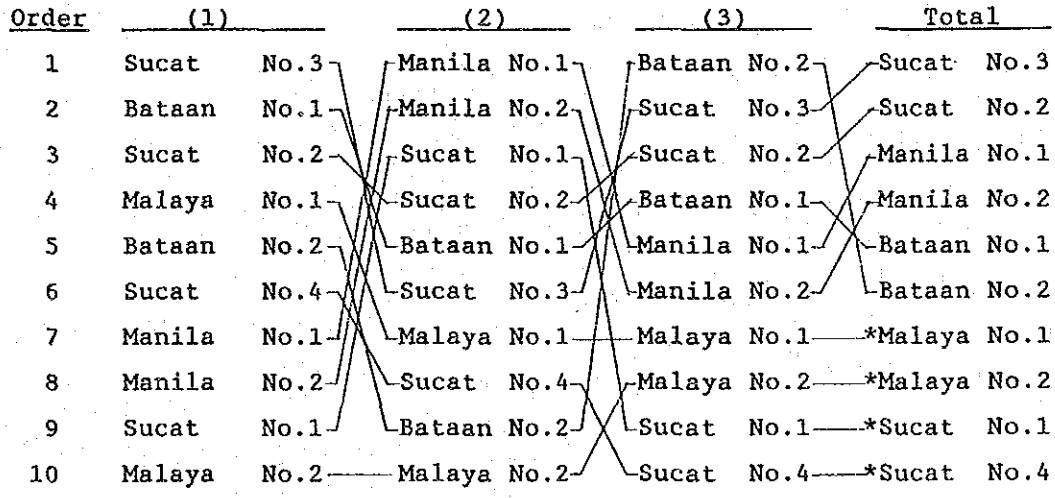
. The following three elements were evaluated in summarizing the present status of the power plant units microscopically. For the final judgment, other factors such as the specific deteriorated conditions of the major equipment of the respective units should be considered as well.

(1) Output decrease and heat reat increase (See Fig. 6-1-3)

(2) Total operating hous (See Table 6-1-2)

(3) Annual maintenance outage hours (See Fig. 6-1-2)

. The power plant units are listed in the order from the worst for each of (1), (2) and (3) factors.



(Batangas P.P. is excluded because it is a coal-fired thermal power plant.)

(Note) * With Sucat No. 1 and No. 4 Units, one year has passed since the completion of rehabilitation.

With Malaya No. 1 and No. 2 Units, four years have passed since the completion of rehabilitation.

3. Problems of Thermal Power Plant Units and Countermeasures

(1) Causes of Reduced Output and Countermeasures

The causes of the reduced output and the countermeasures are listed in Table 6-1-4.

(2) Problems with Equipment and Countermeasures

The problems with the equipment in the power plant units and the basic countermeasures were surveyed.

The problems collected during the site survey are classified into Turbine (T), Boiler (B), Electric (E), Instrument & Control (IC), and other Miscellaneous facilities (M).

The number of problems falling under each category is totaled as shown below.

Plant	Unit	Major Problems					
		T	B	E	IC	M	Total
Bataan	No. 1	10	15	17	12	3	57
	No. 2	11	11	8	13	3	46
Manila	No. 1	8	16	9	14	5	52
	No. 2	8	16	9	14	5	52
Sucat	No. 1	2	1	-	-	-	3
	No. 2	9	19	10	39	8	85
	No. 3	10	18	9	39	8	84
	No. 4	3	2	2	1	-	8
Malaya	No. 1	6	5	4	11	2	28
	No. 2	5	5	2	10	2	24
Batangas	No. 1	4	22	3	-	-	29

T : Turbine
B : Boiler
E : Electrical Equip.
IC: Instrument & Control
M : Miscellaneous and Chemical Equip.

Table 6-1-4 Rated Capacity VS Present Capability

(As of Nov. 1991)

Plant • Unit	Rated Capacity A (MW)	Present Capability B(MW)	B/A ×100 (%)	Reason for Derating/Load Limitation	Action Plan/Corrective Measures
Bataan No.1	75	*50	67	Insufficient combustion air due to deteriorated and corroded AH elements, and gas ducts leak	Presently undergoing (75 days) Major Overhauling from Oct. 5, 1991 to Dec. 18, 1991.
Bataan No.2	150	*130	87	Low steam pressure, high silica in feedwater, deteriorated AH elements/seals	As excessive vibration occurred during the test operation after the repair of the generator rotor, the test operation will be repeated after repairing.
Manila No.1	100	90	90	Low condenser vacuum due to dirty condenser tubes	Scheduled for (40 days) Annual Overhauling from Jan. 13, 1992 to Feb. 21, 1992.
Manila No.2	100	95	95	Low condenser vacuum due to dirty condenser tubes	Scheduled for (40days) Annual Overhauling from May 30, 1992 to Jul. 8, 1992.
Sucat No.1	150	120	80 *1	AH seal leakage and turbine control valve problem	Maintenance scheduled for Jan. 1992.
Sucat No.2	200	*150	75 *2	Unit operating at reduced pressure due to weak boiler tubes. Imsufficient air flow due to derated capacity of FDF 2A caused by heating of motor inboard bearing. Excessive number of plugged main condenser tubes. High boiler make-up due to continuous operation of main and hogging ejectors.	Presently undergoing Annual Overhauling and main condenser retubing from Aug. 16, 1991 to Dec. 5, 1991. Expected to recover rated capacity after rehabilitation schedule to begin in May 1993.
Sucat No.3	200	160	80 *2	Unit operating at reduced pressure due to weak boiler tubes. High turbine thrust bearing temp.	Annual Overhauling (75 days) and AH rehabilitation finished in May 26, 1991 through Aug. 7, 1991. Expected to recover rated capacity after rehabilitation scheduled to begin in July 1992.
Sucat No.4	300	300	100 *1		Unit rehabilitated in 1990.
Malaya No.1	300	210	70 *3	Capability limited due to heating of generator stator core.	Generator stator core end inspection to be made during the Overhauling in 1992.
Malaya No.2	350	290	83 *4	Operating at reduced pressure due to weak boiler tubes. (W/W, SH and RH)	Annual Overhauling (90 days) scheduled for Aug. 30, 1992 to Nov. 27, 1992.
Batangas No.1	300	260	87	Operating at reduced pressure due to weak boiler tubes and simmering V1 drum safty valve. Decrease in primary air supply capacity due to excessive clearances caused by erosion of coal pulverizer air port rings. Main condenser tube leak suspected as evident by high chloride concentration in condensate water.	Annual Overhauling (60 days) scheduled for Feb. 20, 1992 to Apr. 19, 1992.

Note : Rehabilitation Project

*1 implemented in 1990.
*2 to be implemented in 1992 and 1993.
*3 implemented in 1987.
*4 implemented in 1986.

* Capability prior to overhauling

Table 6-1-5 (1)

SUMMARY OF THERMAL POWER PLANT FACILITIES

POWER PLANT	PLANT OUTPUT kW	UNIT No.	BOILER						TURBINE							GENERATOR				
			TYPE	EVAPORATION t/h	STEAM PRESSURE kg/cm2	STEAM TEMPERATURE °C	FUEL	MANUFACTURER	TYPE	RATED OUTPUT kW	STEAM PRESSURE kg/cm2	STEAM TEMPERATURE °C	VACUUM mmHg	SPEED rpm	MANUFACTURER	RATED CAPACITY kVA	VOLTAGE kV	FREQUENCY Hz	MANUFACTURER	COMMISSIONING
BATAAN	225,000	1	NATURAL CIRCULATION	240.0	133.0	541/541	H.O	MITSUBISHI HEAVY INDUSTRY	TANDEM-COMPOUND REHEAT CONDENSING	75,000	127.0	538/538	700.0	3,600	MITSUBISHI HEAVY INDUSTRY	93,750	13.8	60	MITSUBISHI ELECTRIC	MAY 1972
		2	DO	490.0	147.0	541/541	H.O	DO	DO	150,000	140.0	538/538	704.8	3,600	FUJI ELECTRIC	187,500	13.8	60	FUJI ELECTRIC	FEB 1977
MANILA	200,000	1	NATURAL CIRCULATION	326.6	134.1	541/541	H.O	BABCOCK-HITACHI	DO	100,000	126.8	538/538	709.2	3,600	HITACHI	128,000	13.8	60	HITACHI	SEP 1965
		2	DO	326.6	134.1	541/541	H.O	DO	DO	100,000	126.8	538/538	709.2	3,600	DO	128,000	13.8	60	DO	OCT 1966
SUCAT	850,000	1	NATURAL CIRCULATION	483.1	153.3	541/541	H.O	BABCOCK-HITACHI	DO	150,000	126.8	538/538	709.2	3,600	GE	188,000	18.0	60	GE	JUL 1968
		2	ONCE-THROUGH BENSON	760.0	194.8	541/541	H.O	DO	DO	200,000	190.2	538/538	709.2	3,600	SIEMENS	245,000	14.4	60	SIEMENS	OCT 1970
		3	DO	760.0	194.8	541/541	H.O	DO	DO	200,000	190.2	538/538	709.2	3,600	DO	245,000	14.4	60	DO	APR 1971
		4	DO	1,031.6	194.8	541/541	H.O	DO	DO	300,000	189.8	538/538	709.2	3,600	DO	370,000	21.0	60	DO	JUN 1972
MALAYA	650,000	1	ONCE-THROUGH BENSON	1,033.7	194.8	541/541	H.O	BABCOCK-HITACHI	DO	300,000	189.8	538/538	709.2	3,600	SIEMENS	370,000	21.0	60	SIEMENS	DEC 1974
		2	NATURAL CIRCULATION	1,305.4	204.6	541/541	H.O	DO	DO	350,000	168.7	538/538	700.3	3,600	HITACHI	438,000	21.0	60	HITACHI	MAR 1979
BATANGAS	300,000	1	NATURAL CIRCULATION	1,033.2	200.4	541/541	P.C H.O	FOSTER WHEELER	DO	300,000	169.0	538/538	696.5	3,600	TOSHIBA	355,000	22.0	60	TOSHIBA	NOV 1984

Table 6-1-5 (2)
SUMMARY OF GASTURBINE POWER PLANT FACILITIES

POWER PLANT	PLANT OUTPUT kW	GASTURBINE								GENERATOR					COMMISS-IONING
		UNIT No.	TYPE	RATED OUTPUT kW	TURBINE INLET PRESSURE ata	TURBINE INLET TEMPERA-TURE C	SPEED rpm	FUEL	MANUFAC-TURER	RATED CAPACITY kVA	VOL-TAGE kV	FREQU-ENCY Hz	SPEED rpm	MANUFAC-TURER	
BATAAN	120,000	1	OPEN CYCLE	30,000	9.41	360	5,100	DISTI-LLATE	ALSTHOM	38,600	13.8	60	3,600	ALSTHOM	NOV 1989
		2	DO	30,000	9.64	360	5,100	DO	DO	38,600	13.8	60	3,600	DO	NOV 1989
		3	DO	30,000	9.92	360	5,100	DO	DO	38,600	13.8	60	3,600	DO	NOV 1989
		4	DO	30,000	9.41	360	5,100	DO	DO	38,600	13.8	60	3,600	DO	NOV 1989
MALAYA	90,000	1	OPEN CYCLE	30,000	9.70	356	5,100	DISTI-LLATE	HITACHI	38,740	13.8	60	3,600	HITACHI	AUG 1989
		2	DO	30,000	9.70	356	5,100	DO	DO	38,740	13.8	60	3,600	DO	AUG 1989
		3	DO	30,000	9.70	356	5,100	DO	DO	38,740	13.8	60	3,600	DO	AUG 1989

6.1.2 Planning of 5-year Rehabilitation Project for Thermal Power Plant Units (Master Plan)

1. Rehabilitation in Progress

NAPOCOR is now carrying out the rehabilitation of Sucat No. 2 and No. 3 units, and the execution period is scheduled as follows (Refer to the Fig. 6-1-5 Work Schedule):

Sucat No. 2	(May 1993 - April 1994)
Sucat No. 3	(July 1992 - May 1993)

2. Criteria for Selection of Rehabilitation Items

The selection criteria are as follows:

(1) Renovation of the equipment for which the service life will expire within next few years

(2) Advance renewal of the equipment which, in the event of breakdown or stoppage, would create major problems, incur large expenses, and require extended time in restoration.

(3) Improvements required for pollution prevention and environmental improvement.

(4) Advance renewal of old facilities, vital for safe operation, for which acquisition of spare parts is already difficult or will become difficult in the future.

(5) Renewal or supply of the parts which, if maintenance is postponed, would entail large costs and extended outage time in the future.

3. Effect or Purpose of Rehabilitation

(1) Restoration of full power plant output,

(2) Restoration or improvement of thermal efficiency,

(3) Extension of service life or confirmation of remaining service life,

(4) Restoration or improvement of operational reliability,

(5) Improvement of environmental safeguards (prevention of pollution, environmental protection), etc.

4. Selection of Rehabilitation Items

ANNEX 1. shows the results of selection of the rehabilitation items.

5. Problems with Batangas Power Plant No. 1 Unit and Countermeasures

(1) Pending Problems

There are problems of clogging of coal bunkers and coal transfer tower hoppers. These are the problems pending with the improvement works already finished, and are not taken up in the present rehabilitation program.
The remaining one is the countermeasure against flying dust at the coal stockyard, and it is advisable that this work be carried out in the construction works of No. 2 Unit in the future.

(2) Measure for Recovery of Rated Output

The output of the Unit is down from the rated 300 MW to 260 MW (as of November 1991) for reasons described in Table 6-1-4. Especially, if the weak boiler tubes are caused by erosion and such causes due to the low quality of coal, there would be no other means of coping with this problems than to tackle these in the periodical overhauls. It is considered that the other problems also can be solved by periodical overhauls, for the time being.

(3) Fundamental Countermeasure

a. It seems that the power plant is suffering from frequent troubles even after the improvement works of the coal-related facilities, because of the domestic coal (Run of Mine) of extremely poor quality. The power plant is seized with the dilemma between the national policy for increased consumption of domestic coal (Run of Mine) and various problems and increased volume of maintenance works due to the poor quality of the coal.

b. Many problems arising with the boiler facilities and the environmental measures can be said to be due to the problems of the domestic coal. As the fundamental countermeasure, it would be important to have the quality of domestic coal improved and to suppress the use of domestic coal (blending ratio with imported coal) below a reasonable level. The proposal submitted by JICA in 1988 was the guideline to this purpose.

6. Work Schedule in 5-year Master Plan

The work schedule in the 5-year master plan is provided in Fig. 6-1-5, which is based on the consideration of the priority of rehabilitation items discussed in 6.1.3.

Fig 6-1-5 Schedule for Master Plan on 5-Year Rehabilitation

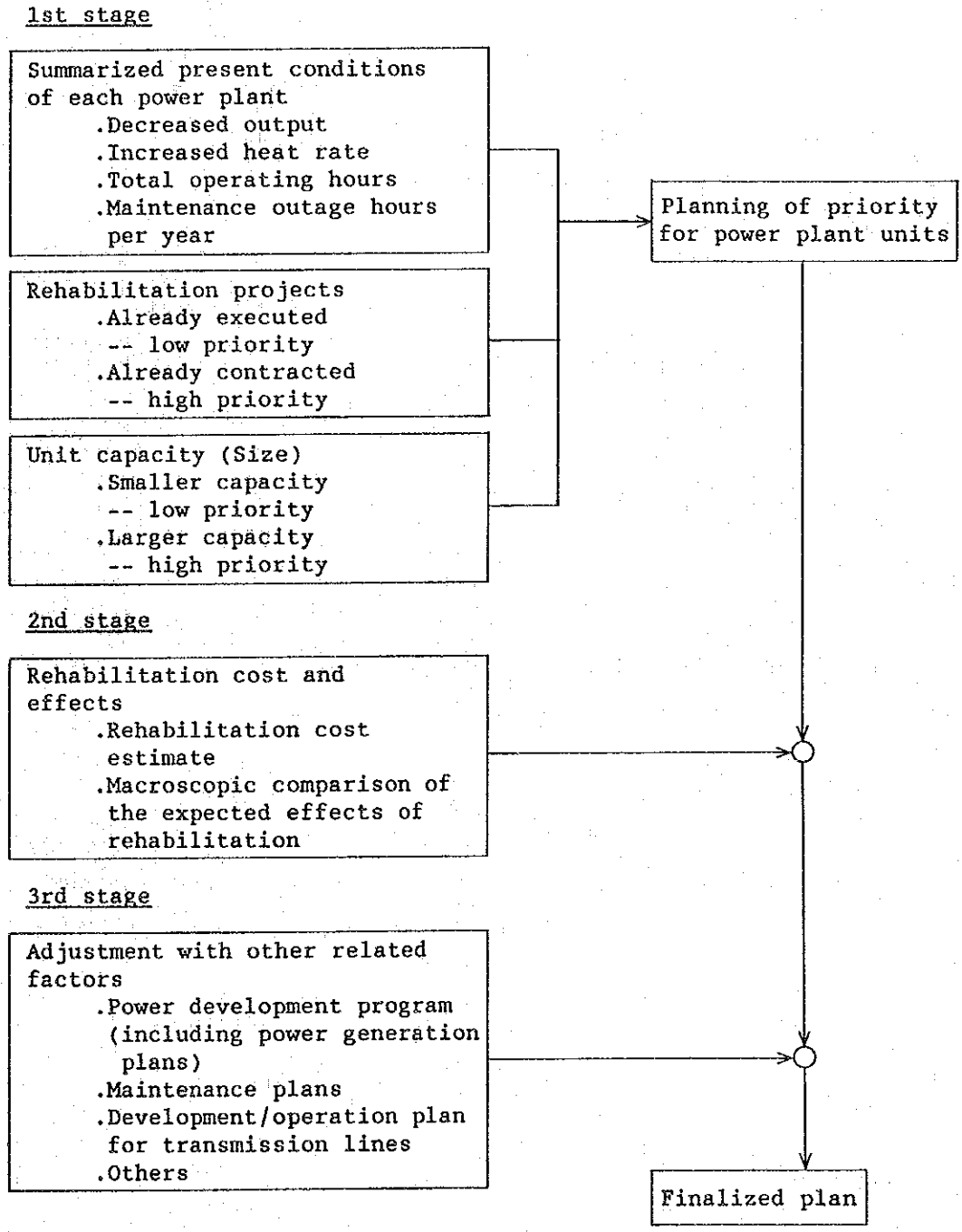
PLANT	UNIT	COMMISSIONING	RATED CAPACITY (MW)	1991	1992	1993	1994	1995	1996	1997
BATAAN	1	1972	75	(19) 75 M.OH	(20) INTAKE BASIN CLEANING	40 PO (21)	40 PO (22)	40 PO (23)	(24) (6M) REHAB	(25) 50 INSP.AFTER REHAB
BATAAN	2	1977	150	PO (14) GEN. RP. GEN.RP.	(15) INTAKE BASIN CLEANING	30 PO (16)	30 PO (17)	30 PO (18)	(19) PO	(6M) REHAB (20)
MALAYA	1	1975	300	35 PO (16)	(17) 50 PO	(18) 90 M.OH	(19) PO	(20) PO	(21) PO	PO (22)
MALAYA	2	1979	350	70 PO (12)	(13) 90 PO	(14) 40 PO	(15) PO	(16) PO	(17) PO	PO (18) PO
MANILA	1	1965	100	(26)	40 PO (27)	40 PO (28) 40 PO	(29) (10M) REHAB	(30)	(31) 50 INSP.AFTER REHAB	(32) PO
MANILA	2	1966	100	45 PO (25)	(26) 40 PO	(27) 40 PO	28 40 PO (10M) REHAB	(29)	(30)	50 INSP.AFTER REHAB (31)
SUCAT	1	1968	150	(23) INSP.AFTER REHAB	40 PO (24)	(25) PO	(26) MAJOR MAINT	(27)	PO (28)	PO (29)
SUCAT	2	1970	200	(21) 75 CONDENSER RETUBING	(22) 40 PO	(23) (10.5M) REHAB	(24)	(25) 50 INSP.AFTER REHAB	(26) 40 PO	(27) PO
SUCAT	3	1971	200	(20) 75 AH REHAB	(21) (10.5M) REHAB	(22)	(23) 50 INSP.AFTER REHAB	(24) PO	(25) PO	(26) PO
SUCAT	4	1972	300	(19)	50 INSP.AFTER REHAB (20)	(21) 40 PO	(22) 40 PO	(23) MAJOR MAINT	(24) PO	(25)
BATANGAS	1	1984	300	(7)	60 PO (8)	40 PO (9)	(10) 60 PLANNED INSP.	(11) PO	(12) PO	(13) PO

Note: PO=PLANNED OUTAGE
M.OH=MAJOR OVERHAUL

6.1.3 Order of Priority for Rehabilitation

1. Method of Priority Evaluation for Power Plants and Units

The order of priority will be examined in the following procedure:



2. Result of Evaluation Priority

(1) Result of 1st Stage Evaluation

Given below is the result of the 1st stage evaluation, which shows the same order of priority as Fig. 6-1-4 Summary of Present Status of Thermal Power Plant Units.

Order	Power plant . unit	Output	Remarks
1.	Sucat No. 3	200 MW	Rehabilitation project in progress
2.	Sucat No. 2	200 MW	
3.	Manila No. 1	100 MW	Based on the 30-year service life, rehabilitation should be completed by April 1996
4.	Manila No. 2	100 MW	
5.	Bataan No. 1	75 MW	Total operating hours: 120,772 Hr.
6.	Bataan No. 2	150 MW	91,305 Hr.
7.	* Malaya No. 1	300 MW	96,954 Hr.
8.	* Malaya No. 2	350 MW	83,405 Hr.
9.	* Sucat No. 1	150 MW	149,739 Hr.
10.	* Sucat No. 4	300 MW	96,634 Hr.

Note: * marked units have already been rehabilitated. For these units, it is suggested that the existing problems be corrected systematically during the periodic overhaul work.

(2) Result of 2nd Stage Evaluation

a. Rehabilitation Cost Estimate

The estimated rehabilitation costs for Manila No. 1 & No. 2 Units and Bataan No. 1 & No. 2 Units are shown below. For Sucat No. 2 & No. 3 Units, rounded figures are given based on the amounts in the already executed rehabilitation contract.

Power plant unit	Rehabilitation cost (including consultant fees)	
Manila No. 1 Manila No. 2	US$110,000 x 10^3	
Bataan No. 1	US$ 37,500 x 10^3	
Bataan No. 2	US$ 79,500 x 10^3	
Sucat No. 2	US$ 74,468 x 10^3	(¥10,500 x 10^6) (exch. rate ¥141/US$1)
Sucat No. 3	US$ 92,624 x 10^3	(¥13,060 x 10^6) (exch. rate ¥141/US$1)

b. Macroscopic Comparison of Rehabilitation Effects

(a) Method of Macroscopic Comparison of Rehabilitation Effects

As a result of rehabilitation, the plant efficiency will be restored. Such restoration is illustrated in Fig. 6-1-6.

By calculation of the balance between the estimated fuel savings obtained through the restored plant efficiency and the rehabilitation cost per kWh, a macroscopic comparison of the rehabilitation effects was attempted.

. The macroscopic comparison of the rehabilitation effects revealed the following order of effects in a descending scale.

Results of Calculation of rehabilitation effects	Priority in the 1st Stage
Sucat No. 3	Sucat No. 3
Sucat No. 2	Sucat No. 2
Bataan No. 1	Manila No. 1
Manila No. 1	Manila No. 2
Manila No. 2	Bataan No. 1
Bataan No. 2	Bataan No. 2

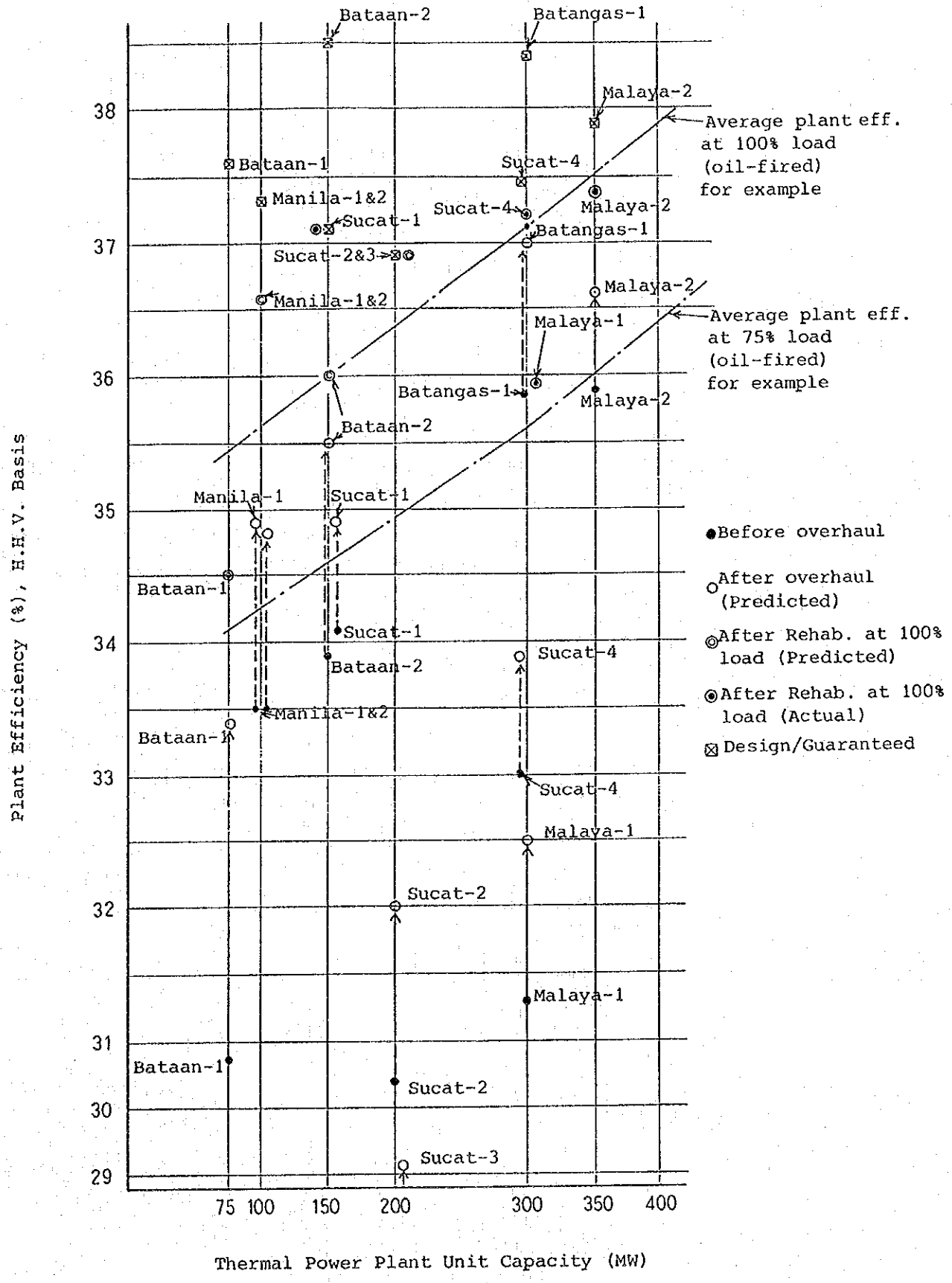
c. Result of the 2nd Stage Evaluation

Comprehensively considering the 1st stage result and the above result, it was decided that the priority order given in the 1st stage evaluation should be maintained for the following reasons:

(a) Bataan No. 1 and No. 2 Units should be rehabilitated consecutively to optimize mobilization of personnel and equipment and dispatching foreign technicians and consultants.

(b) Unless Manila No. 1 & No. 2 Units are rehabilitated immediately after the completion of Sucat No. 2 Unit rehabilitation, the running years of these two units will exceed 30 years.

Fig. 6-1-6 Recovery of Efficiency by Rehabilitation or Overhaul
(June 1991)



(3) Results of 3rd Stage Evaluation

a. Adjustment with Power Development Plan (including Power Generation Plan)

The term of the 5-year Master Plan for power plant rehabilitation is set to be 1994 to 1998. The power development plan and power generation plan up to 2005 are shown in Tables 4-1 -- 4-4, Table 6-1-6 and Fig. 6-1-7. As is clearly indicated in these tables, it is estimated that the existing thermal power plants need to be operated at the annual capacity factor of 70% on an average.

b. Adjustment with Maintenance Plan

The implementation period for rehabilitation of Sucat No. 2 & No. 3 Units is scheduled as shown in Fig. 6-1-5. Therefore, in reference to the 2nd stage evaluation results, the rehabilitation schedule was arranged for the other power plant units.

The periodic overhaul for each power plant should be scheduled, in principle, for once a year. Also, periodic overhaul should be coordinated to minimize the overlapping periods between the power plants and, in addition, not to increase shutdown capacity during the overlapping period. The final rehabilitation work schedule was drawn up as shown in Fig. 6-1-5 after discussions with NAPOCOR during the 2nd stage field investigation.

Table 6-1-6 POWER DEVELOPMENT AND PEAK LOAD IN LUZON GRID

	OIL THERMAL		COMBINED CYCLE		GAS TURBINE		COAL THERMAL		GEO THERMAL		HYDROPOWER		TOTAL		PEAK LOAD FORECAST (MW)
	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	NEW PLANT (MW)	INSTALLED CAPACITY (MW)	
1989		1,925		0		210		300		660		1,226	0	4,321	2,782
1990		1,925		0	70 (HOPEWELL #1: 70 X 1)	280		300		660		1,226	70	4,391	2,888
1991		1,925		0	260 (HOPEWELL #2, 3: 70 x 2) (PBT(JB) #1, 3, 4, 5: 30 x 4)	540		300		660		1,226	260	4,651	3,013
1992		1,925		0	30 (SUCAT:30x1)	570		300		660		1,226	30	4,681	3,218
1993		1,925	310 (BATAAN CC #1, 2: 210 + 100)	310		570		300	175 (MAKBAN--BINARY: 12) (MAIBARARA BINARY: 13) (BACMAN I #1, 2: 55 x 2) (BACMAN II #1, 2: 20 x 2)	835		1,226	485	5,166	3,481
1994		1,925		310		570		300		835		1,226	0	5,166	3,765
1995		1,925		310		570	300 (CALACA #2:300)	600	120 (DEL GALLEGO GEO: 120)	955		1,226	420	5,586	4,072
1996		1,925		310		570	650 (MASINLOC #1: 300) (HOPEWELL #1: 350)	1,250	60 (BULUSAN GEO: 60)	1,015		1,226	710	6,296	4,405
1997	(LUZON -- LEYTE INTERCONNECTION) 1,925			310		570	300 (MASINLOC #2: 300)	1,550	440 (TONGONAN A: 440)	1,455		1,226	740	7,036	4,764
1998		1,925		310		570	350 (HOPEWELL #2: 350)	1,900	220 (TONGONAN B1: 220)	1,675		1,226	570	7,606	5,153
1999		1,925		310		570	300 (COAL A: 300)	2,200	220 (TONGONAN B2: 220)	1,895		1,226	520	8,126	5,874
2000		1,925		310		570	600 (COAL B: 600)	2,800		1,895	268 (CASECNAN)	1,494	868	8,994	6,029
2001		1,925		310		570	600 (COAL C: 600)	3,400		1,895	150 (KALAYAAN)	1,644	750	9,744	6,460
2002		1,925		310		570	600 (COAL D: 600)	4,000		1,895		1,644	600	10,344	6,965
2003		1,925		310		570	600 (COAL E: 600)	4,600		1,895	150 (KALAYAAN)	1,794	750	11,094	7,485
2004		1,925		310		570	900 (COAL F: 900)	5,500		1,895		1,794	900	11,994	8,045
2005		1,925		310		570	900 (COAL G: 900)	6,400		1,895		1,794	900	12,894	8,647

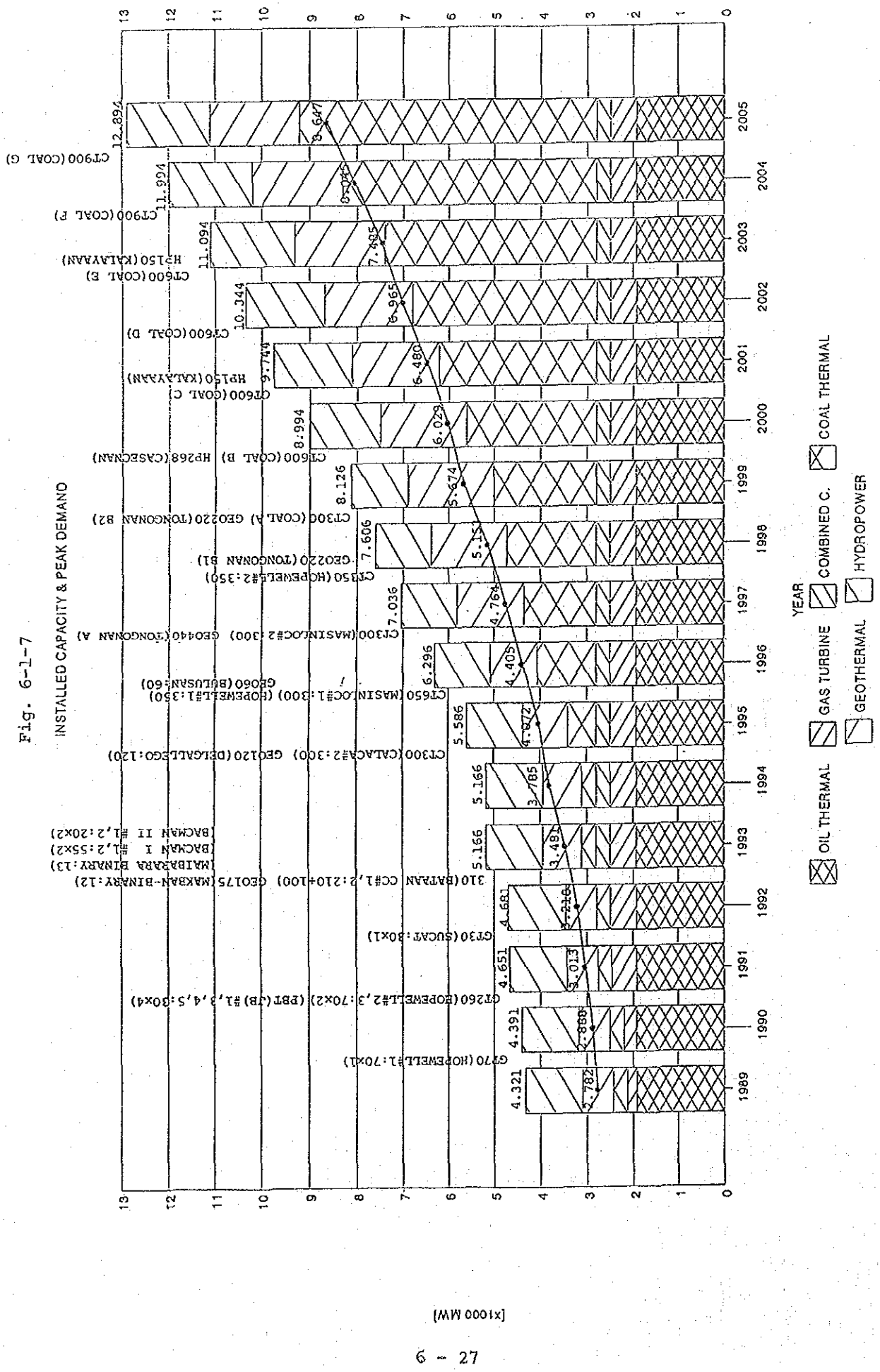

INSTALLED CAPACITY & PEAK DEMAND
[x1000 MW]
YEAR
OIL THERMAL
GAS TURBINE
GEOTHERMAL
COAL THERMAL
COMBINED C.
HYDROPOWER
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
4.321
4.391
4.651
4.681
5.166
5.166
5.586
6.296
7.036
7.606
8.126
8.994
9.744
10.344
11.094
11.994
12.894
7.782
7.868
8.013
7.216
7.785
3.481
4.872
4.405
4.764
5.13
5.674
6.029
6.480
6.965
7.485
8.045
8.647
G270(HOPEWELL#1:70x1)
G260(HOPEWELL#2,3:70x2) (PBT(JB)#1,3,4,5:30x4)
GT30(SUCAT:30x1)
310(BATAAN CC#1,2:210+100) GEO175(MAKBAN-BINARY:12)
[MAIBARARA BINARY:13)
[BACMAN I #1,2:55x2)
[BACMAN II #1,2:20x2)
CT300(CALACA#2:300) GEO120(DELGALLEGO:120)
CT650(MASINLOC#1:300) (HOPEWELL#1:350)
GEO60(BULUSAN:60)
CT300(MASINLOC#2:300) GEO440(TONGONAN A)
CT350(HOPEWELL#2:350)
GEO220(TONGONAN B1)
CT300(COAL A) GEO220(TONGONAN B2)
CT600(COAL B) HP268(CASECNAN)
CT600(COAL C)
HP150(KALAYAAN)
CT600(COAL D)
CT600(COAL E)
HP150(KALAYAAN)
CT900(COAL F)
CT900(COAL G)

Fig. 6-1-7

ANNEX 1. SUMMARY OF MAJOR REHABILITATION WORKS

ANNEX 1. SUMMARY OF MAJOR REHABILITATION WORKS

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Boiler													
a. Superheater	Detailed inspection of SH tubes	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	☆ 1992	
	Replacement of SSH tube	◉ ☆ Partial, 1992	◉ ☆ Partial, 1992	◉ Partial	◉	◎	◎	◎	◎	◎	◎		
	Replacement of roof SH tube	◉ Partial			◉							* ☆ 1992	*Primary SH
	Replacement of deteriorated/ thinning tube	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	☆ 1992	
b. Reheater	Detailed inspection of RH tubes	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	☆ 1992	
	Replacement of RH tube	◉ Partial	☆ 1992	◉ Partial	◉	◎	◎	◎ Partial	◎ Partial	◎	◎	☆ 1992	
	Replacement of deteriorated/ thinning tube	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	☆ 1992	
c. Water Wall	Detailed inspection of W/W tube	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of W/W tube	◉ Partial	◉ ☆ Partial, 1992	◉	◉ ☆ 1992	◎	◎						
d. Boiler Casing & Gas, Air Duct	Repair of leaking boiler casing and gas, air duct	◉ ☆ 1993	◉	◉	◉	◎	◎	◎	◎	◎		☆ 1992	
e. Attemperator	Replacement of SH and RH attemperator spray nozzle	◉		◉	◉	◎	◎	◎	◎	◎	◎		
f. Burner	Modification of steam atomizing burner system	◉	◉	◉	◉	◎	◎					* ☆ 1992	*Coal Burner
g. Bottom Hopper	Repair of bottom ash hopper					◎	◎						
h. Safety valve	Replacement/repair of safety valve			◉ SH-3						☆	☆		
Boiler Auxiliaries													
a. Forced Draft Fan /Gas Recirculation Fan	Replacement/repair of FDF/GRF	◉ FDF	◉ FDF					* ◎ FDF	* ◎ FDF		☆ GRF		*Transfer of FDF
b. Air Heater	Replacement of heating elements and parts	◉ ☆ 1992	◉ ☆ 1992	◉	◉	◎	◎	◎	◎	◎	◎	☆ 1992	

LEGEND: ◉-Implemented ◎-1st Priority ◯-2nd Priority ☆-To be implemented in overhaul

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
c. Steam Coil Air Heater	Replacement of heating elements	◉		◉	◉	◎	◎	* ◎	* ◎	◎	◉		* Additional of SCAH
	Modification of SCAH drain system	◉	◉	◉	◉	◎	◎	◎	◎	◎	◉		
d. Fuel Oil Firing System	Replacement/repair of fuel oil heater	◉	◉	☆ 1993	◉	◎	◎	◎	◎	◎	◎		
	Modification of light oil firing system	◉	◉	◉	◉	◎	◎						
e. Ash Handling System	Replacement of ash handling system	◉	◉	◉	◉	◎	◎	◎	◎			☆ 1992	
	Replacement/repair of dust collector	◉	◉	◉	◉	◎	◎	◎	◎			* ☆ 1992	* EP
f. Auxiliary Steam System	Repair/modification of auxiliary steam line and auxiliary boiler	◉ Aux. B		◉	◉	◎	◎	◎	◎				
g. Soot Blower	Replacement/repair of soot blower	◉ ☆ 1992	◉	◉	◉	◎	◎	◎	◎	◎	◎	☆ 1992	
h. Piping System	Inspection and repair of pipe line	◉	◉	◉	* ◉	* ◎	* ◎	◎	◎	◎	◎		* Inspection of main steam pipe
i. Smoke stack	Guniting for smoke stack	☆ 1993	☆ 1992		◉	◎		○	○	☆			
j. Stacker and Reclaimer	Realignment of the rail											☆ 1992	
k. Cool Yard	Cement all stockpile flooring											☆	
l. Conveyor	Replacement/repair of conveyor											☆ 1992	
m. Transfer Tower	Rehabilitation of transfer tower											☆ 1993	
n. Mill	Replacement/repair of mill											☆ 1992	

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Turbine a. HP Turbine	Major inspection	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of inner casing				◉	◎	◎	◎	◎				
	Replacement of turbine rotor		☆ Blade 1992	◉ Blade	◉	◎	◎	◎	◎	* ◎	* ◎		*Diagnosis of remaining life
b. IP Turbine	Major inspection	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of inner casing	◉			◉	◎	◎	◎	◎				
	Replacement of turbine rotor	☆ 1993		◉ Blade	◉ Blade	◎	◎	◎	◎	* ◎	* ◎		*Diagnosis of remaining life
c. LP Turbine	Major inspection	◉	◉	◉	◉	* ◎	* ◎	◎	◎	◎	◎		
	Replacement of turbine rotor	◉ ☆ Blade 1993	☆ Blade 1992	◉	◉	◉ Blade 1990	◎ Blade			* ◎	* ◎		*Diagnosis of remaining life
	Replacement of casing				☆ 1994								
d. Main Stop Valve	Replacement of turbine main valve							◎ MSV	◎ MSV		◎ Parts		
e. BFP Turbine	Reblading of BFP turbine	☆ 1993											
Turbine Auxiliaries a. Condenser	Replacement of tubes	◉ ☆ Aux 1992	◉ 1983	◉ Partial	◉	◉ 1991	◎ Partial	* ◉ ◎ 1986	◉ 1991	☆ 1993	☆ 1993	☆ 1992	*Air cooling zone only
	Installation of on-line cleaning and Debris filter system							☆ 1993	☆ 1993	◉ 1992	☆ 1993		
b. Low Pressure Feed Water Heater	Replacement of LP heater	◉ ☆ #3 #3 1993	☆ #2,3 1992				◎ #3		◎ #3				
c. High Pressure Feed Water Heater	Replacement of HP heater	◉ ☆ #5A, #5A #5B #5B 1993		☆ #6 1992	◉ #5A,5B #6A,6B	◎ #5A,5B	◉ ◎ #6A,#6B 1991	◉ #5,1983 #6,1981	◉ ◎ #5, #6 1983	◎ · ☆ HP#1,#2	◉ HP#1,2		
	Installation of HP heaters by-pass line	◉				◉	◉						

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
d. Deaerator	Modification of deaerator		◉		☆ 1994					☆ 1993			
e. Turbine Oil Pump	Replacement/repair of oil pump	◉ JOP		◉	◉								
f. Turbine Lube Oil System	Modification of lube. oil purifying system	◉											
g. Air ejector	Replacement of air ejector					◎	◎						
h. Extraction Steam line	Additional non-return valve at the extraction steam to deaerator	◉			◉								
i. House Service Closed Cycle Heat Exchanger	Replacement of HSCC heat exchanger			☆ 1993	◉	◎	◉	○	○	◎ Tube			
	Additional installation of heat exchanger	◉ ☆ 1993								◉ 1991			
j. Boiler Feed Water Pump	Replacement/repair of BFP	◉		◉	◉					◎	* ◎	☆ 1992	*BFP Outlet valve
k. Circulating Water Pump	Replacement/repair of CWP				◉			☆ 1993	☆ 1993	◎ Parts	◎ Parts		
l. Condensate Water Pump	Replacement/repair of CP							☆	☆		☆ Parts 1992		
m. Piping System	Repair of damaged pipe insulation	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
n. Others	Installation of travelling crane			◉									
	Replacement of passenger elevator				* ◉					☆	☆		*Additional installation
	Repair/replacement of power house ventilation fans	◉ ☆ 1993	◉	◉	◉	◉	◉	◎	◎				
o. Cooperation with manufacturer	Invitation of Manufacturers supervisor for the above checking/improvement/replacement	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	◎	

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Electrical Equipment a. Generator	Replacement/repair of generator stator	* ☆ 1992	☆ Bushing 1992		◉			* ◎	* ◎	◎	◎		*Diagnosis of remaining life
	Replacement/repair of generator rotor	◉	* ◉	◉	◉			◎	◎	◎	◉ ◎ 1991		*Diagnosis of remaining life
b. Exciter	Replacement/repair of exciter	◉ ☆ 1992			◉	◎	◎						
	Replacement/repair of AVR				◉	◎	◎			◎	◎		
c. Gas and Seal oil	Replacement/repair of generator gas and seal oil equipment									◎	◎		
d. Batteries and CVCF/UPS	Additional/replacement of batteries	* ◉	* ◉					☆	☆				*Additional silicon dropper
	Additional of CVCF/UPS set				◉	◎	◎			☆			
e. Emergency Diesel Generator	Automatic start and cabling of emergency diesel generator	◉ ☆ 1993	◉										
f. Motor	Replacement of 4,160V/480V motor		☆ CWP 1992	◉ RWP	◉ RWP ☆ CWP			○ CP,BFP CWP	○ CP,BFP CWP		◎ AOP		
g. Switchgear	Replacement of 4,160V switch-gear							○ P/C,Tr	○ P/C,Tr	☆ VCB			
	Additional/replacement of MCC	◉ E				◎ B,T,SS	◎ B,T,SS, VF			☆ P/C			
h. Power Cable	Replacement of power cable			◉	◉	◎ 4.16kV 480V	◎ 4.16kV 480V	○ 4.16kV	○ 4.16kV	◎ 15kV			
i. Switchyard	Replacement/repair of switch-yard equipment				☆ GCB	◎ GCB,DS	◎ GCB,DS			◎ GCB,LA	◎ GCB,LA		
j Communication Facilities	Additional communication facilities	☆	◉			☆		☆		☆		☆	
k. Others	Replacement of fire protection system	◉											
	Replacement of sootblower electrical control system					◎	◎	○	○	◎		☆ 1992	

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Instrument and Control	Additional recorder for condensate flow, turbine speed/cam position, condenser vacuum & generator output	◉	◉	◉	◉	◎	◎						
	Replacement of local gauge and meter	◉	◉	◉	◉	◎	◎						
	Replacement of control board recorder and indicator	☆ 1993	☆ 1993	◉	◉	◎	◎	○	○	◎	◎		
	Replacement/modification of ABC and start-up system	◉ N-90	☆ N-90	◉ N-90	◉ N-90	◎ N-90	◎ N-90	◎ N-90	◎ N-90	◎ N-90	◎ N-90		
	Spare parts	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement/modification of fuel oil control system		◉ Burner			◎	◎						
	Installation of furnace/smoke monitoring TV	◉	◉	◉	◉	◎	◎	◎ Smoke	◎ Smoke	☆	☆		
	Replacement of boiler metal temperature measurement	◉ ☆ 1992	☆ 1993	◉	◉	◎	◎						
	ABC and start up control overhaul/calibration and fine tuning	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement/repair of local control: Deaerator, Heater & condensate drain control	◉		◉	◉	◎	◎	○	○	◎			
	Replacement/repair of local control: Aux. steam and AH temp. control	◉	◉ ☆ 1992	◉	◉	◎	◎	○	○	◎			
	Replacement/repair of local control: Others	◉ ☆ 1992	◉ ☆ 1992	◉	◉	◎	◎	○	○	◎			
	Replacement/repair of EHG	◉			◉	◎	◎				◎		
	Replacement of relay for plant interlock	◉	◉		◉	◎	◎	○	○				
	Inprovement of central control room air conditioner	◉ ☆ 1992								* ☆ 1992			* Repair
	Additional control/station service air compressor and modification of piping	◉ CONT ☆ CONT 1992		◉	◉					☆ SWYD		☆ SS 1992	

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Instrument and Control	Additional first out indicator	◉	◉										
	Modification of alarm system	◉	◉										
	Additional alarm and annunciator	◉	◉	◉	◉	◎	◎				◎		
	Modification for load run-back	◉ FDF,CWP	◉ FDF,CWP	◉ FDF,CWP	◉ FDF,CWP	◎ FDF,CWP	◎ FDF,CWP						
	Additional/replacement of protective relay	◉ GEN				◎ GEN							
	Replacement of fuel oil flow meter	◉	◉	◉	◉	◎	◎	○	○	○	☆		
	Replacement of drum level transmitter/indicator		◉	◉				☆	☆	☆	☆		
	Replacement of mercury type float, temp. & press. switches	☆ 1992				◎	◎	○	○				
	Replacement of BFP minimum flow and control valve			◉		◎	◎	☆	☆				
	Additional sequence of event recorder			◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of flue gas O_2 measurement			◉	◉	◎	◎	◎	◎	◎	◎		
	Replacement of turbine supervisory instruments	◉ ☆ 1993			◉	◎	◎			◎	◎		
	Additional generator H_2 purity meter	◉		◉	◉	◎	◎	○	○	☆	☆		
	Replacement of turbine wall stress evaluator					◎	◎						

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Demineralizer	Additional demineralizing plant	◉ 1986			◉ 1984	◎ 1993				* ◎			*Replacement of HCl tank
	Additonal pre-water treatment plant	◉ 1986			◉ 1991								
	Overhauling and resin make-up	☆				◎ 1992		☆		☆		☆	
	Using of Laguna Lake Water	◉			◉			—		—		—	
	Neutralizing equipment	☆ 1992			◉			☆		◉		◉	
	Replacement of demineralizer instruments							☆ PH, Conductivity		☆ PH, Conductivity Silica		☆ Silica	
Condensate Polishing Plant	Replacement of control panel including instruments	◉	—	—	◉	◎	◎	—	—	—	—	—	
	Repair/replacement of control system for automatic operation	◉	—	—	◉	◎	◎	—	—	—	—	—	
	Using of higher quality caustic soda of rayon grade	◉	—	—	◉	◉	◉	—	—	—	—	—	
	Overhauling, and resin make-up	☆	—	—	☆	◎	◎	—	—	—	—	—	
	Adjustment of resin level	—	—	—	—	◎	◎	—	—	—	—	—	
	Installation of condensate magnetic filter	—	—	—	◉	◎	◎	—	—	—	—	—	
Oil Water Separator	Installation of oil water separator									☆ 1992			

ITEM		MALAYA -1	MALAYA -2	SUCAT -1	SUCAT -4	SUCAT -2	SUCAT -3	MANILA -1	MANILA -2	BATAAN -1	BATAAN -2	BATANGAS CF-1	REMARKS
Secondary Water Treatment a. Chemical Feed System b. Chemical Feed Control	Replacement of chemical feed system	◉	☆ 1992	◉	◉	◎	◎	◎	◎			◉	
	Determination of NH3 injection by the measurement of conductivity	◉	☆	◉	◉	◎	◎					◉	
	Automatic pH control	◉	☆	◉	◉	◎	◎					◉	
Sampling Rack	Replacement of sampling rack	◉	◉	◉	◉	◎	◎	◎	◎	☆ 1992	☆ 1992	☆	
Monitoring Instrument	Additional of chemical monitoring instruments	◉	◉	◉	◉	◎	◎	○	○	☆	☆	☆	
Cooling Water a. House Service Closed Cycle Heat Exchanger	Change of water quality analysis item	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	◉	
	Injection of chemicals	◉	◉	◉	◉	◉	◉	◎	◎	◎	◎	◉	
	Check of sacrifical zinc plate	◉	◉	◉	◉	◎	◎	◎	◎	◎	◎	◉	
b. Condenser Cooling Water	Replacement/repair of cathodic protection equipment	◉	◉		◉	◎	◎	○	○	○	○	◉	
	Replacement of travelling water screen				◉			◎ Wash P	◎ Wash P	○	○		
	Replacement of raw water pump		☆ 1992		☆ 1992								
	Reinstallation of gantry crane											☆ 1992	
	Replacement/repair of circulating water pipe line									* ◎	* ◎	* ☆ 1992	*Including marine pipe

6.2 Geothermal Power Plant

There are two geothermal power plants in the Luzon Grid, Tiwi and Mak-Ban. The installed capacity of each power plant is 330 MW, or 55 MW x 6 Units (660 MW in total). The installed capacity of these power plants has the share of 15% of the system total and the annual generation 24% in 1990. The capacity factor in 1990 recorded 68% in Tiwi and 88% in Mak-Ban.

The reason why the capacity factor of Tiwi was conspicuously lower than that of Mak-Ban is the insufficient steam supply in the Tiwi geothermal area. If the necessary quantity of steam supply is available, Tiwi may be operated with a capacity factor higher than 85%.

6.2.1 Present Situation and Problems in Tiwi Geothermal Power Plant

1. Geothermal Steam Supply

The steam supply necessary for operation at the installed capacity of 330 MW (55 MW x 6 Units) is 3,125 t/hr, and the geothermal steam available from PGI, the steam supplier, is 2,360 t/hr as of the end of July 1991. Thus, it is short of the steam requirement by 765 t/hr, or 80 MW equivalent.

2. Present Status of Steam Supply and Power Plant Facilities

The total number of shutdowns of Units 1 to 6 in Tiwi Geothermal Power Plant in 5 years from 1986 to 1990 was 325 and the total shutdown period was 1,476 days, which is equivalent to 13.5% of the total operating days.