No. 5

JAPAN INTERNATIONAL COOPERATION AGENCY(JICA)

NATIONAL POWER CORPORATION
THE REPUBLIC OF THE PHILIPPINES

FEASIBILITY STUDY
ON
MALAYA POWER PLANT
RELIABILITY IMPROVEMENT PROJECT

FINAL REPORT
MAIN REPORT

MARCH 1995

West Japan Engineering Consultants, Inc.

MPN
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PREFACE

In response to a request from the Government of the Republic of the Philippines, the Government of Japan decided to conduct the Feasibility Study on Malaya Power Plant Reliability Improvement Project in the Republic of the Philippines and entrusted the study to the Japan International Cooperation Agency (JICA).

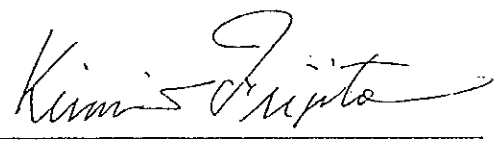
JICA sent to the Republic of the Philippines a study team headed by Mr. Teruaki OGAWA of WEST JEC Inc., three times during the period from August 1994 to March 1995.

The team held discussions on the project with officials concerned of the Government of the Republic of Philippines and conducted the survey. After the team returned 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 two countries.

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

March 1995



Kimio Fujita
President
Japan International Cooperation Agency

March 1995

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

Dear Mr. Fujita,

Letter of Transmittal

We are pleased to submit to you the report of the Feasibility Study on Malaya Power Plant Reliability Improvement Project in the Republic of the Philippines. The improvement plan in this report includes suggestions of the authorities concerned of the Government of Japan and your Agency. Also, included are comments made by the Department of Energy and the National Power Corporation of the Philippines during technical discussions on the draft report held in Manila.

The improvement plan of power plant reliability presented in this report is a combination of hardware (plant facilities) rehabilitation and software (operation and maintenance management) improvement, and to be carried out for five (5) years concurrently. The plan consists of three (3) programs; I) Rehabilitation & regular annual overhauls of power plant facilities including life expectancy analysis, II) Improvement of method/system for periodic overhaul and safe/reliable operation, and III) Improvement of hiring, education and training of personnel and Enhancement of morale.

Not only hardware rehabilitation but also software improvement is essential for reliable power plant operation. Thus, the programs mentioned above have to be carried out simultaneously. The program-I will be executed similarly as the other conventional rehabilitation projects conducted by contractor(s). For the programs-II & III, we recommend that National Power Corporation organize promptly task forces for the detail study and implementation of the programs. A Feasibility Study of Program-II is also recommended to figure out definite size and scope of the project.

We wish to take this opportunity to express our sincere gratitude to your Agency, the Ministry of Foreign Affairs, the Ministry of International Trade and Industry and other authorities concerned of Japan. We also wish to express our deep gratitude to National Power Corporation, the Department of Energy, National Economic and Development Authority and other authorities concerned of the Republic of the Philippines for close cooperation and assistance extended to us during our survey and study.

Very truly yours,

T. Ogawa

Teruaki Ogawa
Team Leader
Feasibility Study on
Malaya Power Plant
Reliability Improvement Project

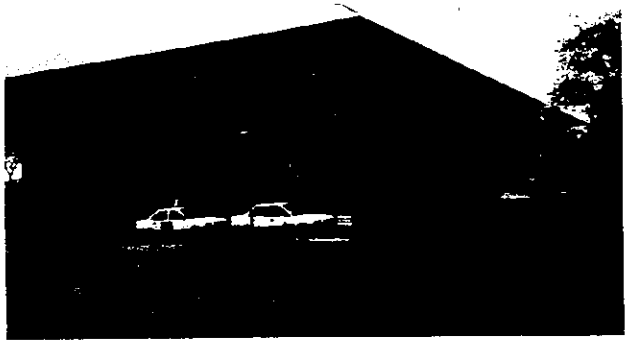


Photo-1 NPC Head Office

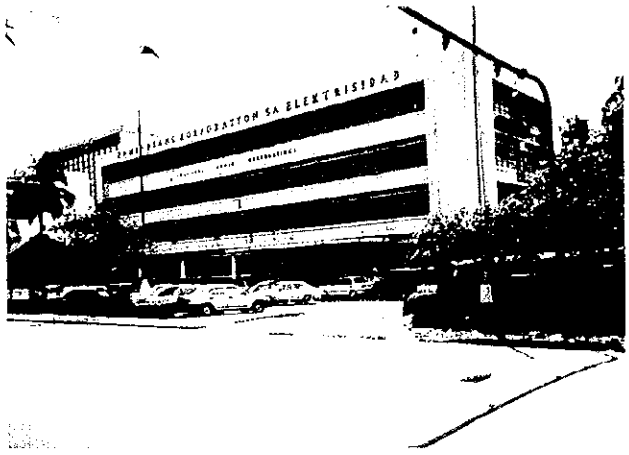
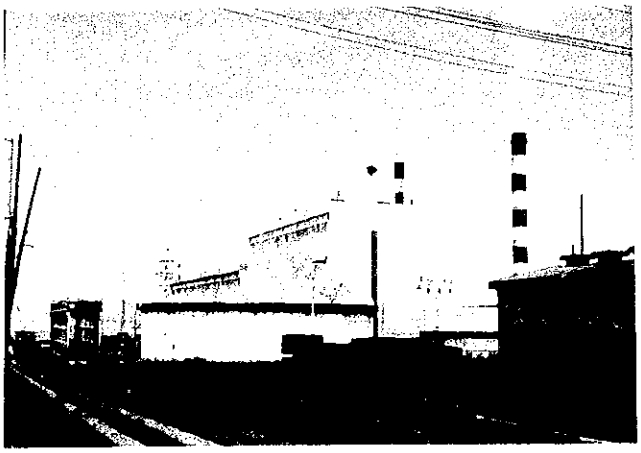


Photo-2 NPC Metro Manila Regional Center (MMRC)



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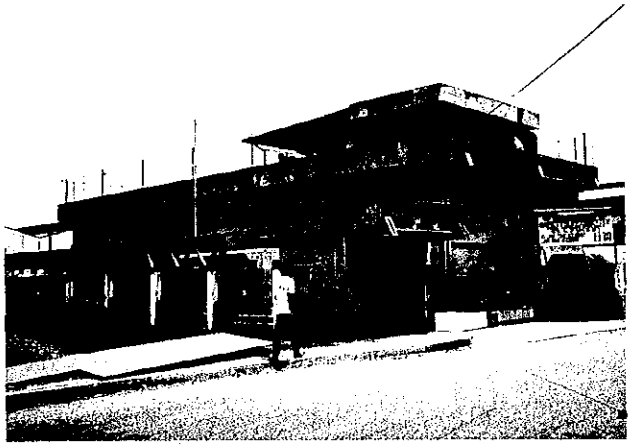

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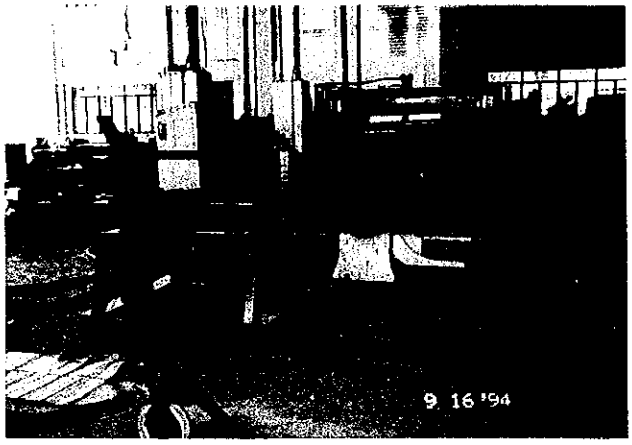

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Photo-8 MEC Workshop,
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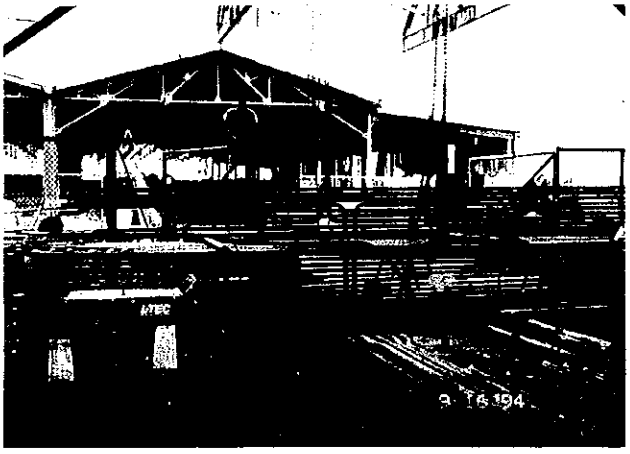

Photo-9 MEC Workshop,
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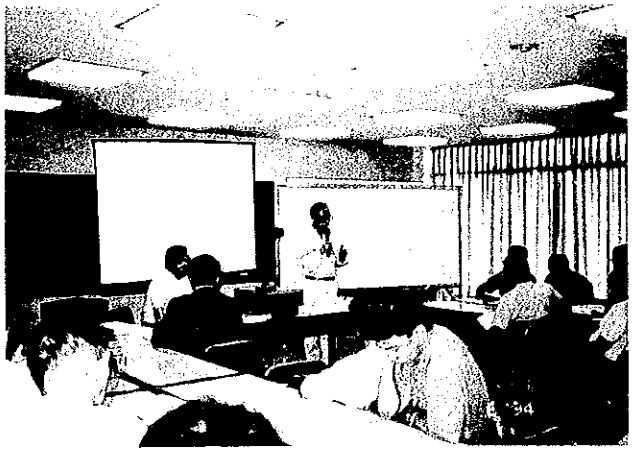

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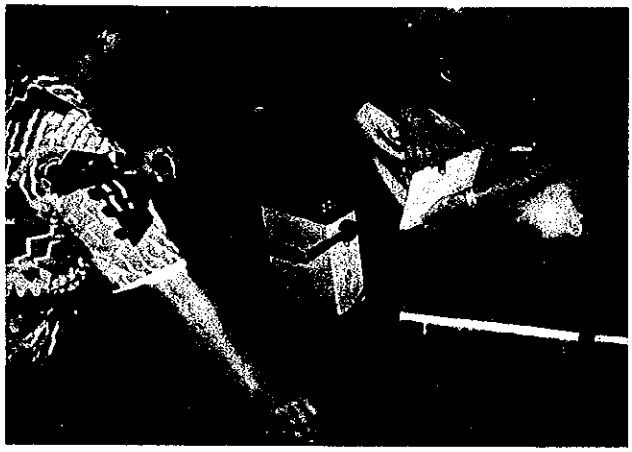
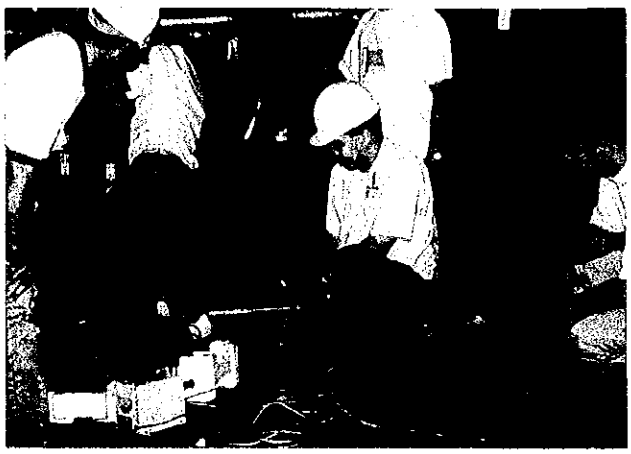


Photo-16 Ultra Sonic Flaw Detector at Work Field



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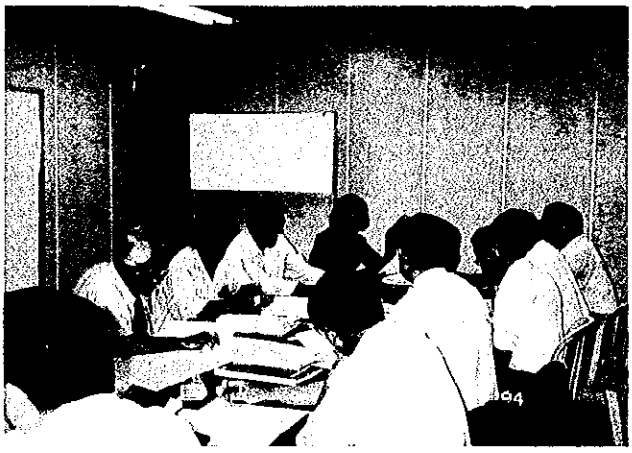

Photo-19 Discussion with NPC Counterpart at MMRC, Mr. A. O. Nerona, Task Force Manager (Second from Left)

Photo-20 Discussion with NPC Counterpart at Malaya Power Plant, Mr. O. P. Mendoza, Plant Manager (Forth from Left)

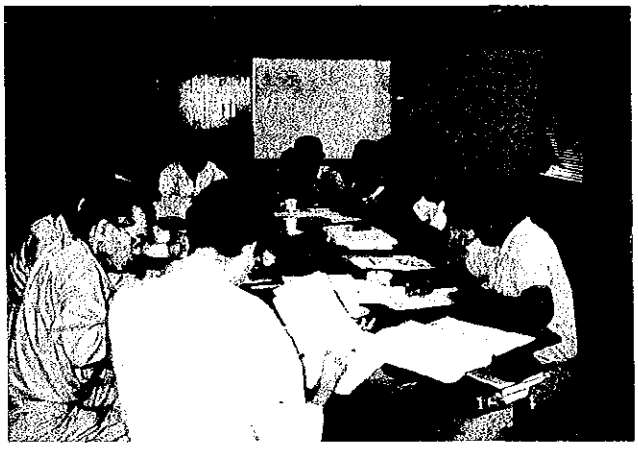

Photo-21 Discussion with NPC Counterpart at MEC,
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(First from Right)

Photo-22 Discussion with NPC Counterpart at MSD, Mr. V. C. Almazan, MSD Manager
(Forth from Left)

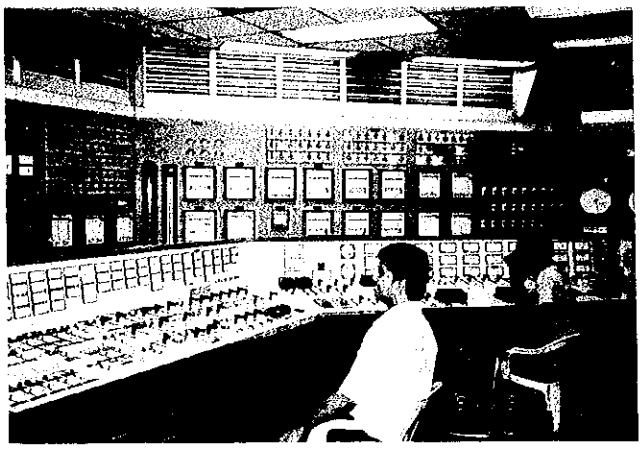
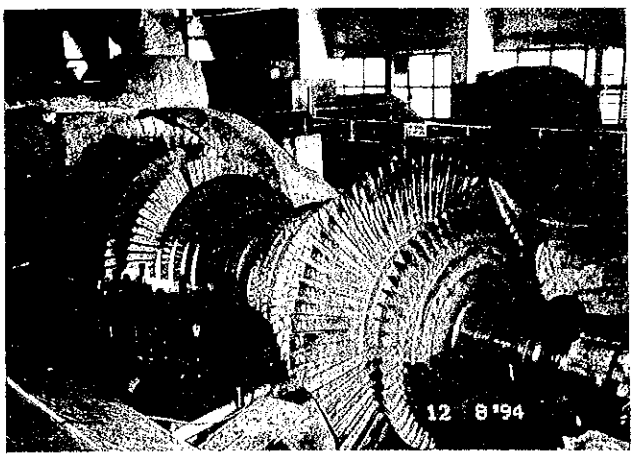


Photo-23 Central Control Board of Malaya Unit No. 2



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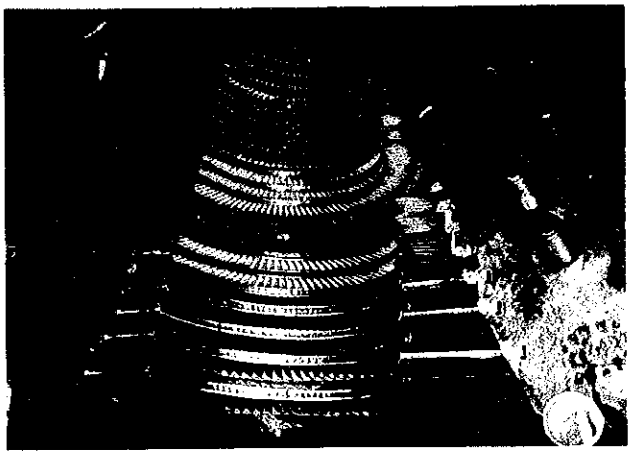
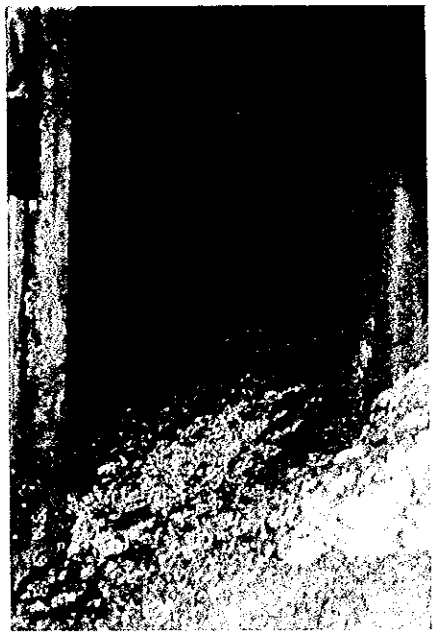


Photo-25 Lower Half Casing of Boiler Feed Pump Turbine of Malaya Unit No. 1, under Overhauling



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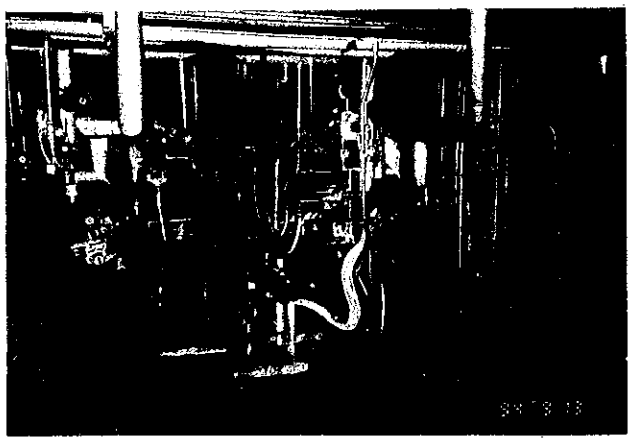
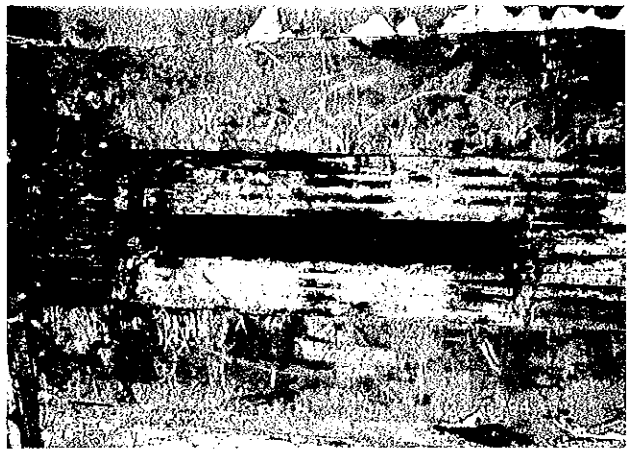


Photo-27 Burner Enclosure of Malaya Unit No. 1 Boiler



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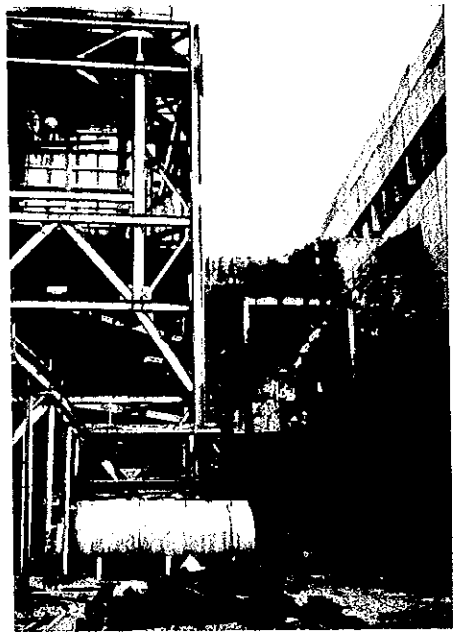

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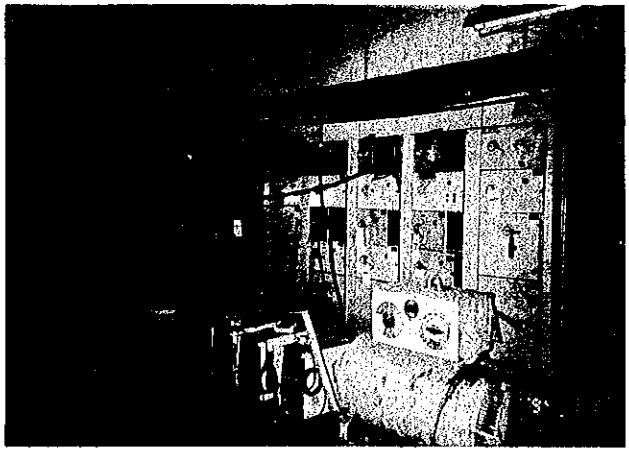

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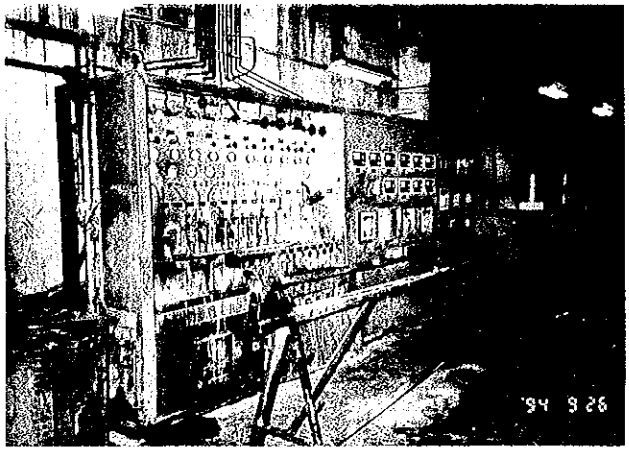

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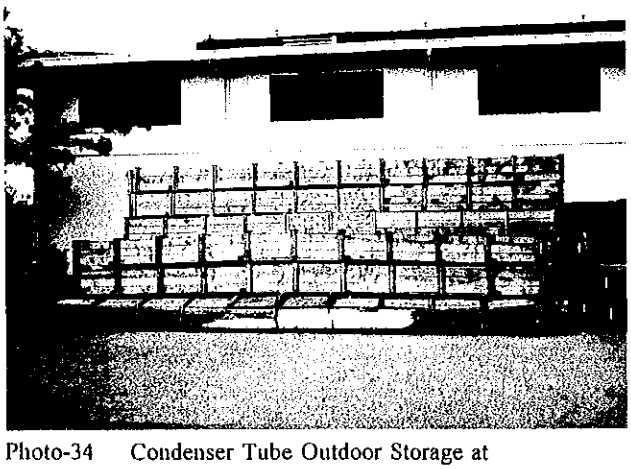

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GENERAL

CHAPTER 1 GENERAL

1.1 Background of the Study

At present in the year of 1994, the power supply situation in the Luzon Grid is being greatly improved by consistent effort exerted by National Power Corporation (referred to as NPC hereinafter) and the Philippine government. But, back in the year of 1991 to 1993, the Luzon Grid suffered from chronic power supply shortage and daily brownouts. There are two (2) major reasons for this power situation, namely the delay of the power development program and the deterioration of existing power generating facilities. The delay of the power development program, one (1) of the major reasons for the power shortage, has been made up for by the implementation of the fast track projects. But, the other reason, namely, the problems residing in the present operation and maintenance practices (software) of the generating facilities are still to be solved despite of continuous diligent efforts for improvement by NPC.

Malaya Thermal Power Plant (referred to as Malaya TPP hereinafter) was rehabilitated in 1986 and 1987, but serious troubles were consecutively encountered in 1991 and 1992 for both units, 4 years after the rehabilitation. Repair works for the damages by these troubles have already been carried out, however, new problems might be being generated within the power plant equipment/materials (hardware) due to the annual deterioration.

In order to formulate the Improvement Plans for both hardware and software problems mentioned above, the Philippine government made request to the Japanese government on the technical cooperation for the study of the rehabilitation of Malaya TPP (Phase II) and improvement plan for operation and maintenance.

In response to this request, the Japan International Cooperation Agency (referred to as JICA hereinafter) dispatched the Preparatory Study Team in February 1994 and signed the Implementing Arrangement on March 1, 1994.

On the basis of this Implementing Arrangement, JICA has dispatched the Main Study Team (referred to as Team hereinafter), three (3) times, in September 1994, December 1994 and February 1995.

1.2 Objective of the Study

The objective of this study is to formulate the following improvement plans in order to upgrade the reliability of the Malaya TPP.

- Formulation of the rehabilitation project of the existing power plant facilities optimum in view of technical, economical and financial aspects.

- Formulation of improvement plan for operation and maintenance and good technology transfer to NPC counterpart.

1.3 Objective Area and Facilities

This study shall cover such areas and offices/facilities as Malaya TPP, Metro Manila Regional Center (MMRC), NPC Head Office, Maintenance and Department of Energy (DOE).

1.4 Scope of the Study and Study Methodology

JICA dispatched experts to the Luzon island of the Republic of the Philippines, conducted the detailed survey and collected relevant data and information with close cooperation of NPC. On the basis of the detailed analysis of the data and information, recommendations are presented to NPC as for the formulation of the rehabilitation program of the power plant (hardware) and the improvement plan of operation & maintenance (software).

1.4.1. Scope of the Study

Scope of the Study is as described in the following;

1) Power Plant Facilities (Hardware)

The detailed study on previous plant operations shown in various records such as troubles/fault records, inspection/maintenance records, performance test records, etc. is carried out. The power plant facilities are also inspected with the overhauled condition, and from the point of view of the preventive maintenance, the conditions of power plant facilities are evaluated to identify the following items:

a. Repair or replacement of the equipment/parts including major equipment, which are deemed essential for the restoration of plant output.

b. Repair or replacement of the equipment/parts which have severely deteriorated or which are difficult to repair or replace during normal maintenance, and which are essential for the restoration of reliability.

After the detailed review of the above, an optimum rehabilitation program of the power plant facilities is formulated in the five (5) year overhaul plan followed by the economic and financial evaluation.

2) Operation & Maintenance (Software)

The study on such software matters as listed in the following is carried out to propose the measures that would keep the facilities from unexpected forced outage as well as the points to be improved for good operation & maintenance:

a. Operation & maintenance procedures

b. Daily patrol & check methods

c. Planning & budgeting methods for periodic and preventive maintenance

d. Periodic maintenance procedures and organization structure

e. Management procedure for drawings and data

f. Management and storage methods for spare parts

g. Organization of the power plant personnel
Manpower and skilled personnel for operation and maintenance including technical/engineering functions for preparation of technical specifications for procurement

h. Establishment of procurement concept for proprietary items of power plant equipment or parts for maintenance or overhaul

i. System for authority and responsibility

j. Sub-contracting method for periodic and other maintenance

k. Operation & maintenance management system at head office and MMRC

l. Hiring and education/training of employees

Problems found through the above study are analyzed, relevant root causes are identified and concrete software improvement plans are formulated.

3) Technology Transfer

Technology transfer to NPC counterpart of task force members is made by means of the joint surveys during the first site survey in the Philippines and seminars are held at the time of the second and the third Study in the Philippines.

1.4.2 Study Methodology

1) Study Implementing Procedure

a. Preparation in Japan

a) Arrangement and review of available reports, documents and data related to the Study
b) Preparation of the Inception Report
c) Preparation of questionnaire and data sheets for the site survey

b. First Study in the Philippines

a) Explanation of the Inception Report and discussion on the study procedure
b) Survey on the present conditions of power plant facilities of Malaya No. 1 & No. 2 units, and collection of related data and information
c) Survey on the present conditions of power plant operation and maintenance (software), and collection of related data and information
d) Survey on environmental conditions
e) Collection of data and information related to economic and financial evaluation

c. First Study in Japan

a) Analysis of collected data and information and study of improvement plans for power plant facilities
b) Analysis of collected data and information and study of improvement plans for operation and maintenance of power plant
c) Analysis of collected data and information and study of countermeasure for environmental impact
d) Analysis and study of collected data and information for economic and financial evaluation
e) Preparation of the Interim Report
f) Preparation of implementation program of the first seminar

d. Second Study in the Philippines

a) Explanation and discussion on the Interim Report
b) Implementation of the first seminar (introduction of operation and maintenance management of a Japanese electric power company)
c) Additional survey and data collection

e. Second Study in Japan

a) Analysis of additional data and formulation of Improvement Plans based on the discussion with the Interim Report
b) Revision of economic and financial evaluation
c) Preparation of the Draft Final Report
d) Preparation of implementation program of the second seminar

f. Third Study in the Philippines

a) Explanation and discussion with the Draft Final Report
b) Implementation of the second seminar (Improvement plans of operation and maintenance)

g. Preparation and Submission of Final Report (in Japan)

2) Study Flow Chart

Figure 1-2 "Study Flow Chart" shows the sequence of the Study mentioned above.

3) NPC Task Force

The improvement plans formulated through the Study are to meet the actual conditions in the Philippines and must be realized. From this point of view, one of the most important factors for the success of this Study is that NPC staffs study the root causes of problems and to formulate the improvement plans by themselves. The Team assists, making best use of the experience in Japan, NPC in taking the initiative to formulate the improvement plans through the mutual discussions. In order to materialize the scheme, NPC has organized the Task Force throughout the Study period, to establish a project group as a firm organization directly connected to the vice president, MMRC for materialization of the Improvement Plans of operation and maintenance even after completion of the JICA Study.

Figure 1-1 Luzon Grid Power System Diagram

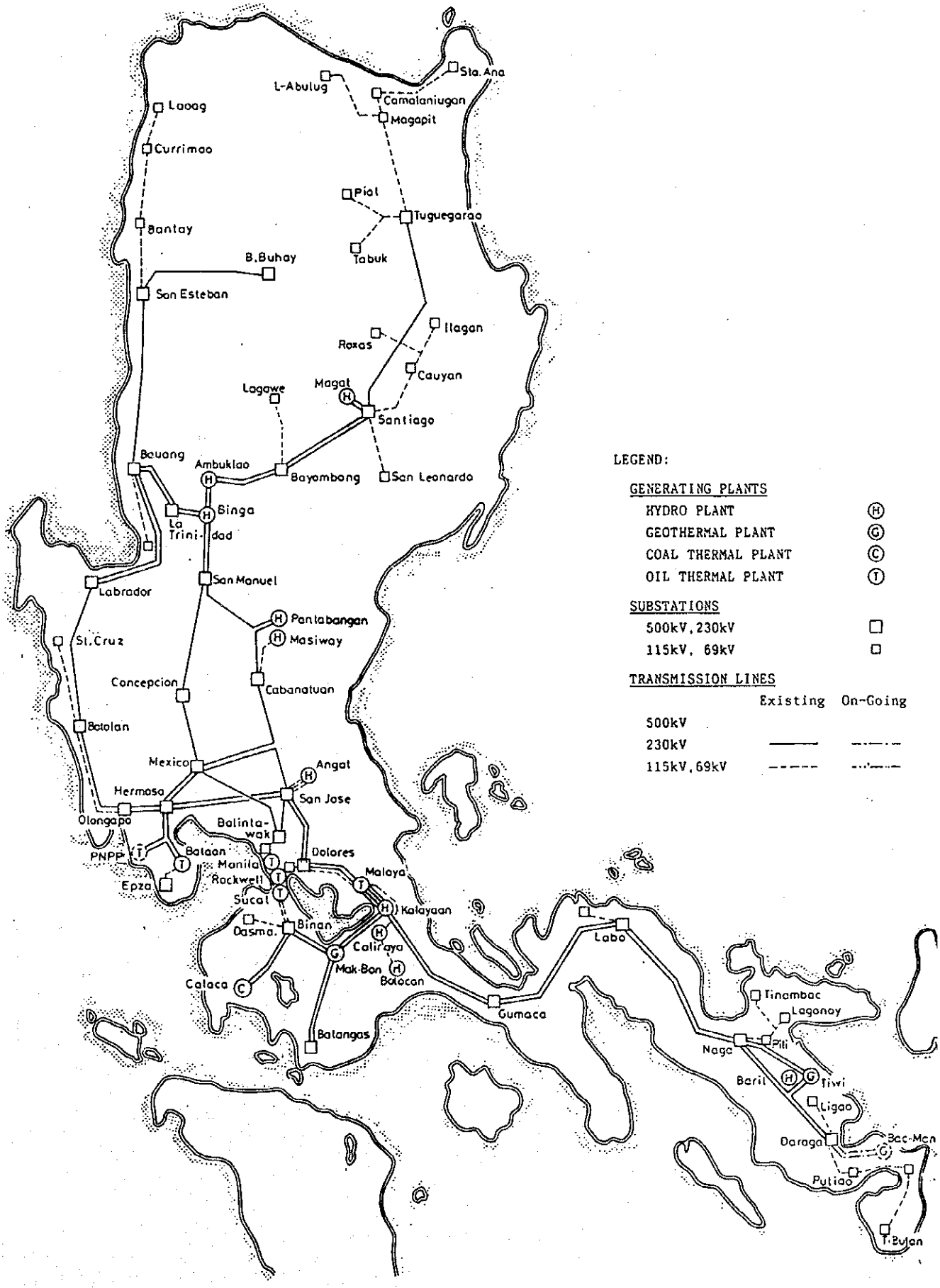
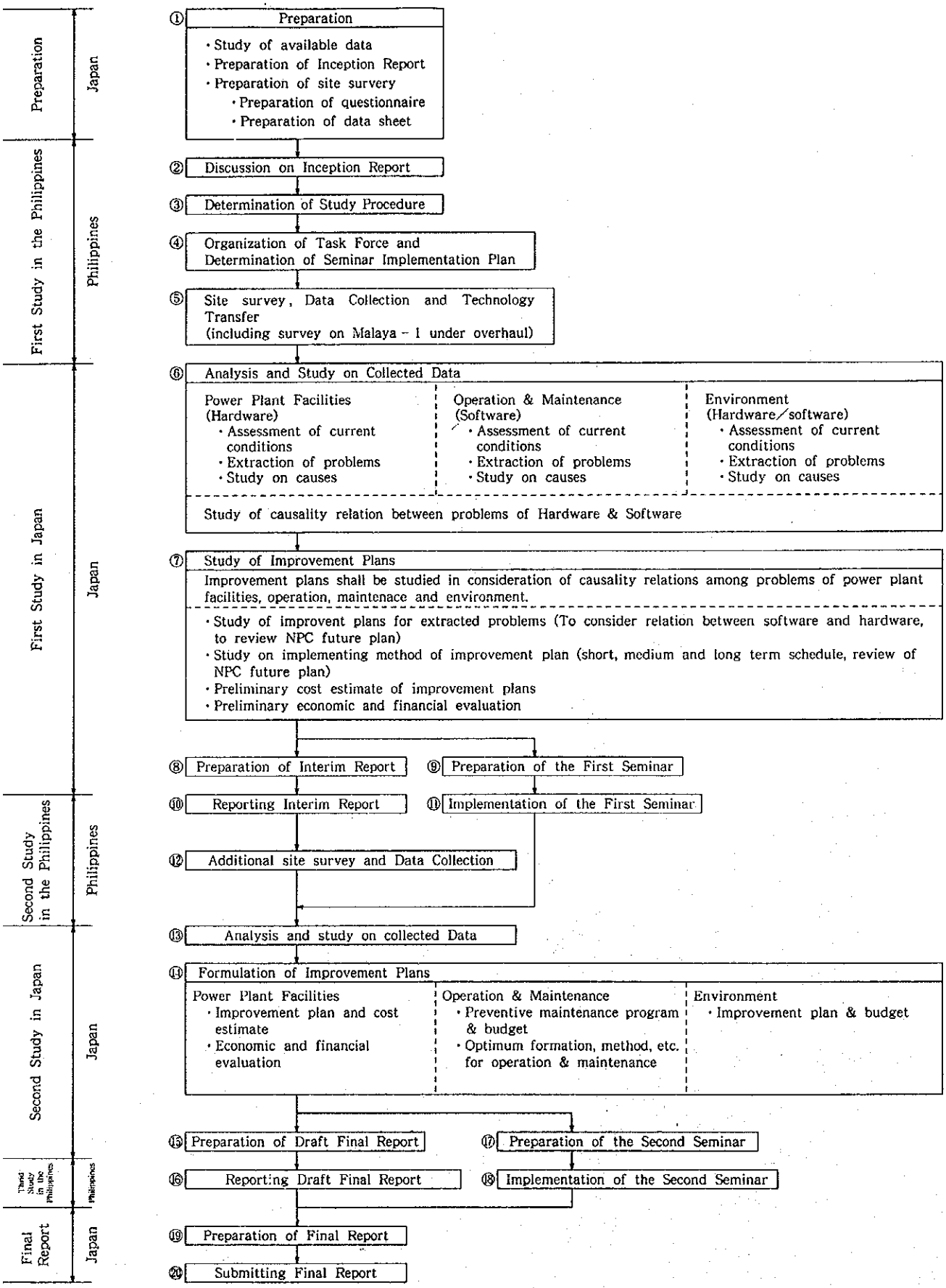


Figure 1-2 Study Flow Chart



1.5 Study Team Members

Name	Assignment	Service Items
Teruaki OGAWA	Team Leader	- General management - Engineering supervision
Kenji TOMOKIYO	Organization & Management	- Study on the organization and management - Formulation of Improvement Plan
Yoshimi FUNAKOSHI	Power Plant Facilities (Mechanical)	- Site survey on mechanical equipment - Study on the data and analysis - Formulation of Improvement Plan
Ginjiro MATSUO	Power Plant Facilities (Electrical)	- Site survey on electric and control equipment - Study on the data and analysis - Formulation of Improvement Plan
Yukio SHIMODA	Operation	- Site survey on plant operation - Study on the data and analysis - Formulation of Improvement Plan
Hirofumi GOTO	Maintenance	- Site survey on maintenance management and spare parts control - Study on the data and analysis - Formulation of Improvement Plan
Yoshihiro EGUCHI	Maintenance	- Site survey on maintenance management and spare parts control - Formulation of Improvement Plan
Nobuhiro HARAGUCHI	Environment	- Site survey on environment and power plant chemical facilities - Study on the data and analysis - Formulation of Improvement Plan

Kenji FUJII	Economic Evaluation	- Economic and Financial Evaluation
Katsumi OTANI	Assistant	- Assistance and arrangement for efficient work

1.6 NPC Task Force of Counterpart

1) Organization of Task Force of Counterpart

NPC organized Task Force of Counterpart to facilitate the effective transfer of technology and know-how during the Study, and also to execute continuously the realization of the Improvement Plan after the Study.

2) Organization and Structure of Task Force of Counterpart

The organizational structure of Task-Force of Counterpart is shown in the following Figure 1-3 and Table 1-1.

a. Mr. Maño, Vice President, MMRC, who is the signatory of the Minutes of Meeting of the Preparatory Study, is the top responsible person (Chairman) of the Task Force of Counterpart.

b. Task Force Manager as a leader of the Task Force of Counterpart including both Divisions of Hardware Study and Software Study is positioned under Chairman.

c. Both Divisions and Groups are respectively formed in accordance with fields and items of the Study. Each Group has a Group Coordinator as a leader of the Group, and the other members of each Group are assigned from manager and chief class of NPC.

d. Each Group of Task Force of Counterpart frequently communicates each other through Chairman, Task Force Manager and Coordinators. On communication between The Team and Task Force of Counterpart, the same way is applied.

Figure 1-3 Organization of NPC Task Force of Counterpart

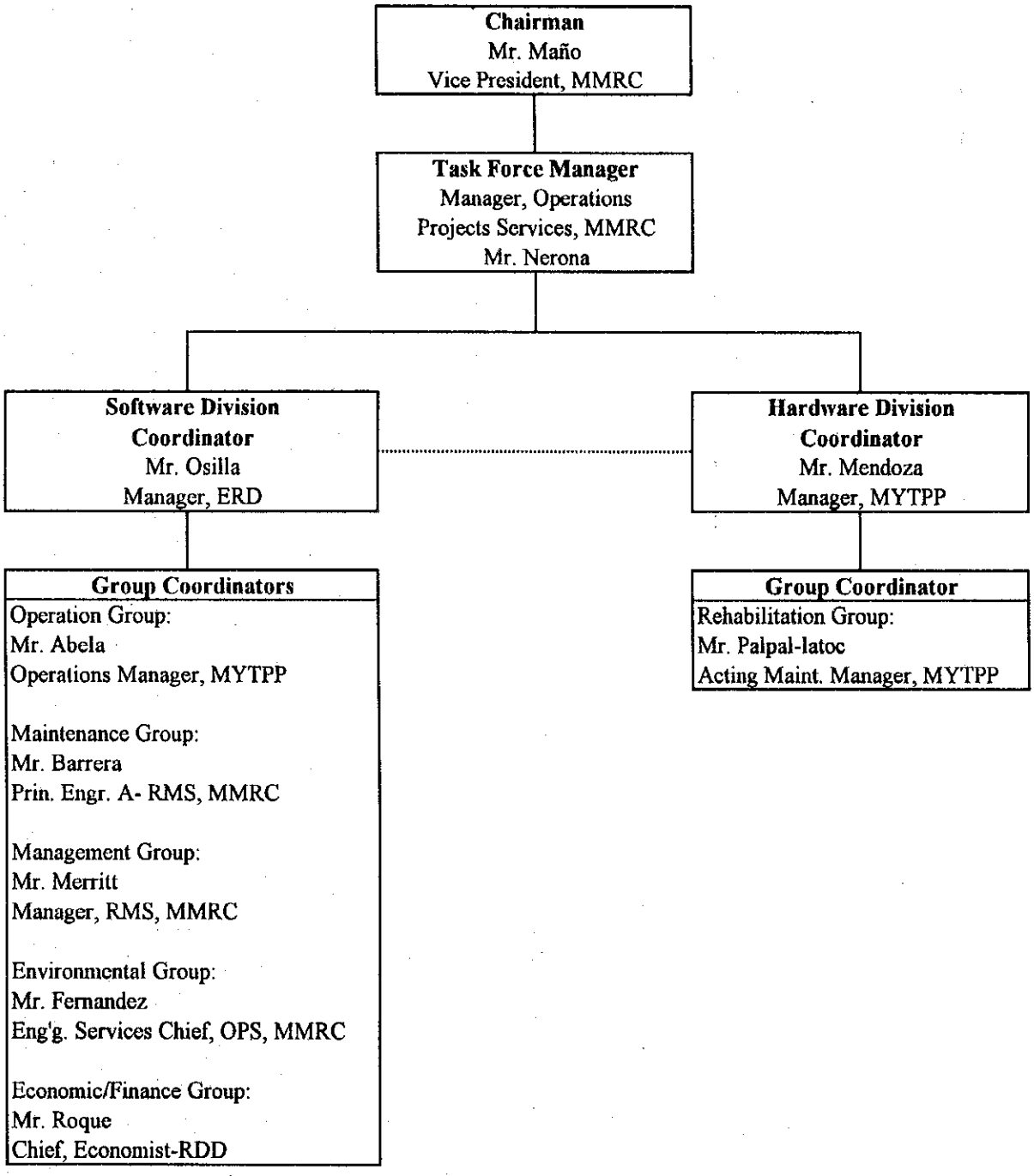


Table 1-1 Member of NPC Task Force of Counterpart

Field	Group	Member	
1. Hardware Division	Rehabilitation Plan	Division Coordinator	Mr. Mendoza (Group Manager, MYTPP)
a) Power Plant Facilities	Rehabilitation Plan - Study of present conditions of power plant facilities - Study of overhaul activities - Rehabilitation plan	Group Coordinator Members	Mr. Palpal-latoc (Acting Maint Manager, MYTPP) Mr. Marte (Mech. Maint. Supt., MYTPP) Mr. Galingan (I & C Maint. Supt., MYTPP) Mr. Flores (Chemical Supt., MYTPP)
2. Software Division	Improvement Plan for Operation & Maintenance	Division Coordinator	Mr. Osilla (Manager, ERD)
b) Operation/Maintenance	[I] Operation - Operation procedure - Daily patrol & check - Education / training of operator	Group Coordinator Members	Mr. Abela (Operations Manager, MYTPP) Mr. Lumawag (Eng'g Services Chief, OPS, MMRC) Mr. Labadan (Operations Supt., MYTPP) Mr. Flores (Chemical Supt., MYTPP)
	[II] Maintenance - Daily maintenance procedure - Daily patrol & check - Plan, procedure & organization of periodic maintenance - Management of drawings & spare parts - Organization of power station personnel - Procurement of goods / materials	Group Coordinator Members	Mr. Barrera (Prin. Engr. A-RMS, MMRC) Mr. Fajardo (Eff. Control Supt., MYTPP) Mr. Dela Cruz (Maint. Supt., Sucat TPP) Mr. Villona (Sched/Planning Supt., MYTPP) Mr. Ortañez (MSD Supt., MMRC)
	[III] Management - Organization of Head Office & MMRC - Responsibility and competence - Hiring of employees - Education / training of employees	Group Coordinator Members	Mr. Merritt (Manager, RMS, MMRC) Mr. Guarin (Manager, ECD-ERD, NPC H.O.) Mr. Ramos (Prin. Engr. A-QA/Operation,) Ms. Delos Reyes (Admin. Manager, MMRC)
c) Environment	[IV] Environment Group - Study of present conditions of Malaya TPP - Formulation of improvement plan	Group Coordinator Members	Mr. Fernandez (Eng'g Services Chief, OPS, MMRC) Mr. Dannang (RMS, MMRC) Mr. Flores (Chemical Supt., MYTPP)
d) Economy / Finance	[V] Economic & Financial Evaluation (Rehabilitation)	Group Coordinator	Mr. Roque (Chief Economist - RDD)

1.7 Study Schedule

The study is conducted for seven (7) months started with the first work in the Philippines from August 31, 1994, and completed with the submission of the Final Report in March 1995. Refer to Figure 1-4.

1) Preparatory Work in Japan

Prior to the site survey, the following preparatory works were performed in Japan for a smooth progress and efficient results of the site survey.

- Study on available data and information prior to the survey
- Preparation of the Inception Report
- Preparation of data sheets and questionnaires

2) First Work in the Philippines (one (1) month from August 31, 1994)

The first site survey was done in the period of the annual overhaul of Malaya-1. The Team (9 persons, except the economist) and NPC discussed the Inception Report, and mutually confirmed the course of the study, establishment of the task force, procedure of the seminars and plan of the counterpart training. Figure 1-5 shows the detailed schedule of the first work in the Philippines.

3) First Work in Japan

Data and information collected at the first work in the Philippines were studied, and problems on both hardware and software were identified. The causes of the problems were analyzed, and the draft Improvement Plans for the problem were studied. The Interim Report was prepared as a summary of the study up to this stage. Materials for the first seminar were also prepared.

4) Second Work in the Philippines (half months, from November 30, 1994)

The Team (7 persons) and NPC discussed the Interim Report, and made a mutual consensus of the Improvement Plan. Preliminary economic and financial evaluation also was discussed. An additional field survey was conducted for further data and information. The first Seminar was held at NPC training center on operation and maintenance

management.

5) Second Work in Japan

The Improvement Plan was revised on the basis of the discussion results on the Interim Report and the study of the additional data and information. The Draft Final Report was prepared. Preparation for the second Seminar was done.

6) Third Work in the Philippines.

The Team (4 persons) discusses the Draft Final Report with NPC, and the Improvement Plan is finalized. The second Seminar is held.

7) Final Report

The Final Report is completed on the basis of the discussion on the Draft Final Report, and is submitted to NPC in April 1995.

Figure 1-4 Study Schedule

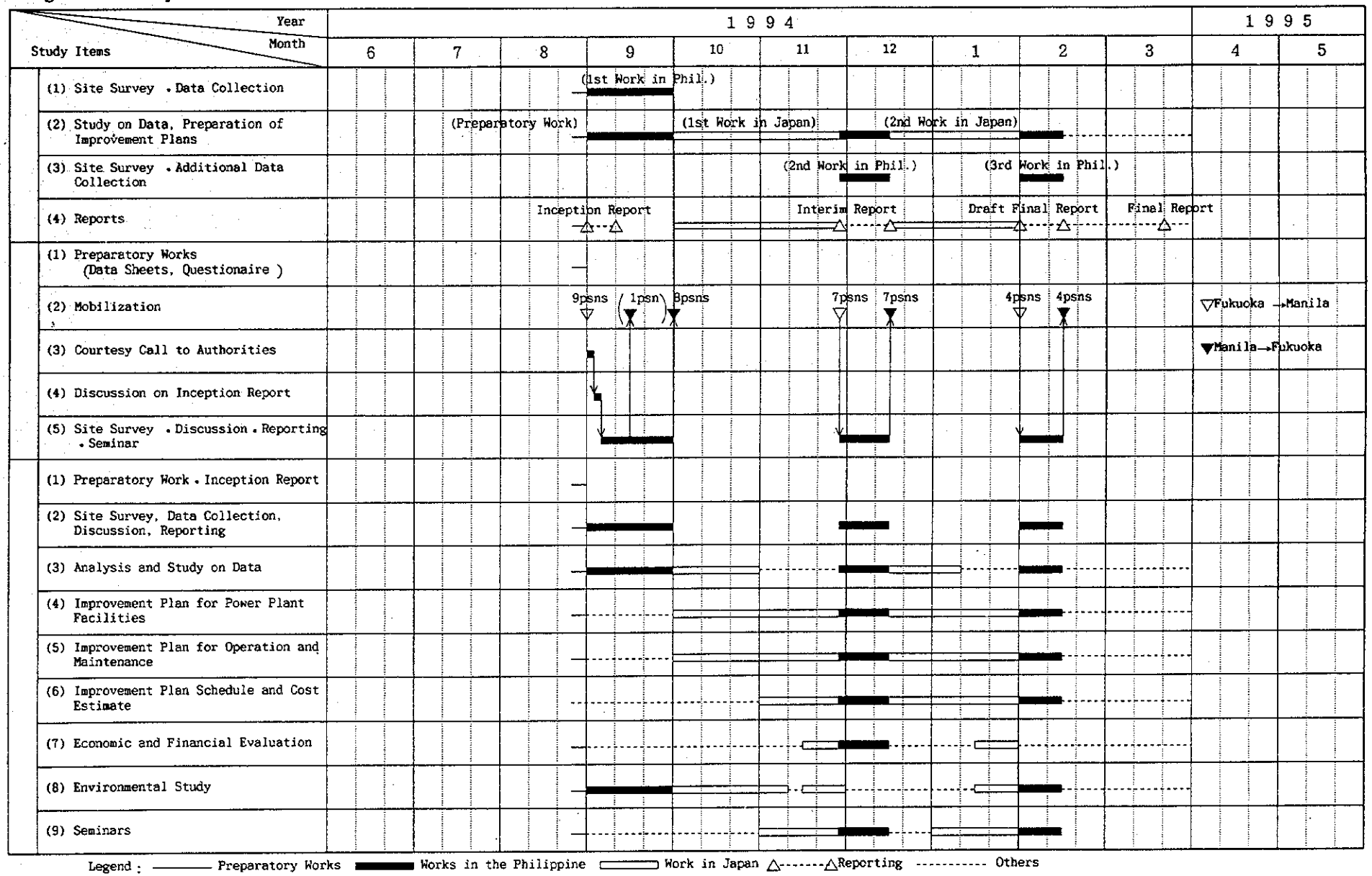


Figure 1-5 Detailed Schedule of the First Work in the Philippines

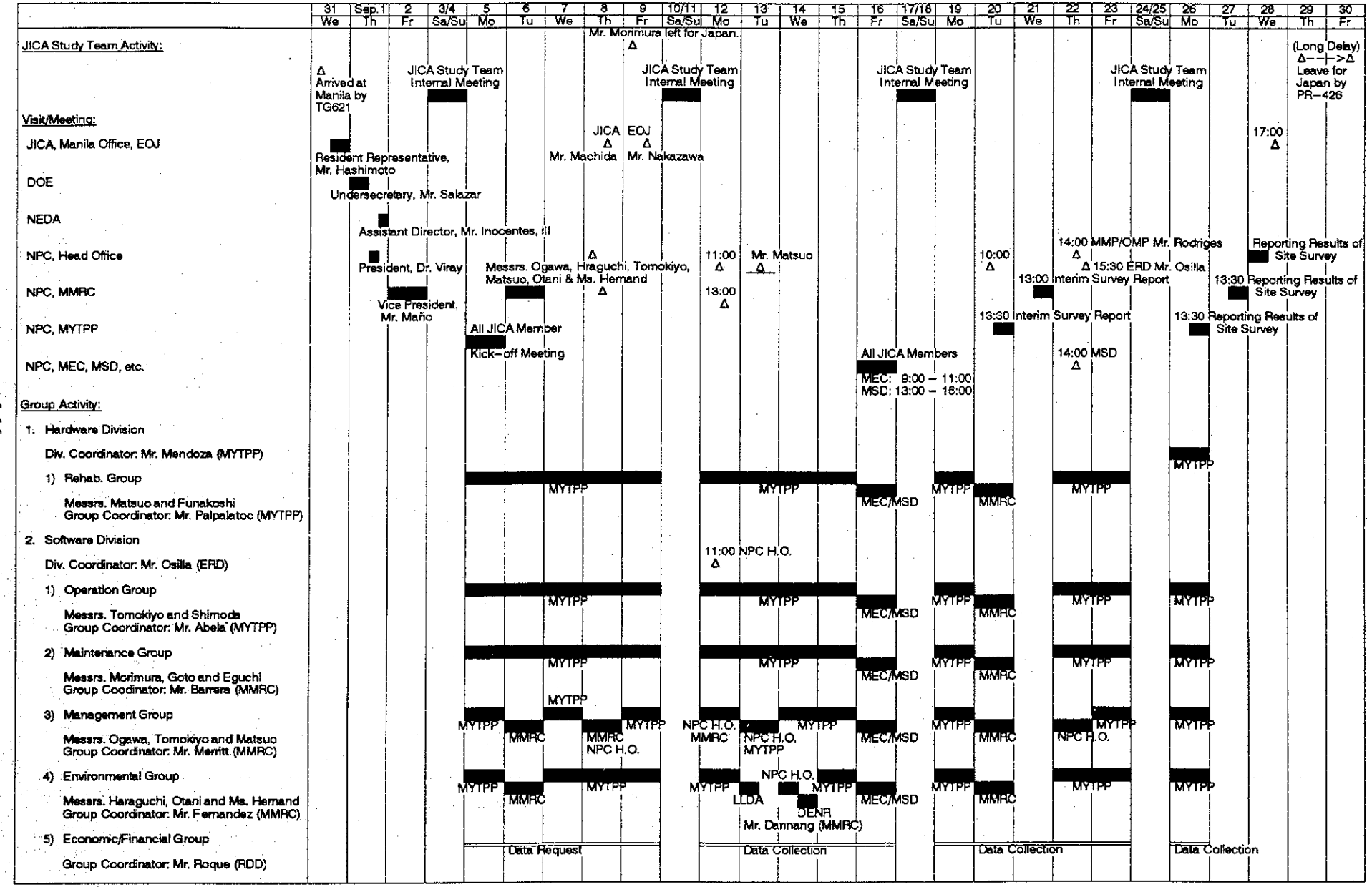


Figure 1-6 Detailed Schedule of the Second Work in the Philippines

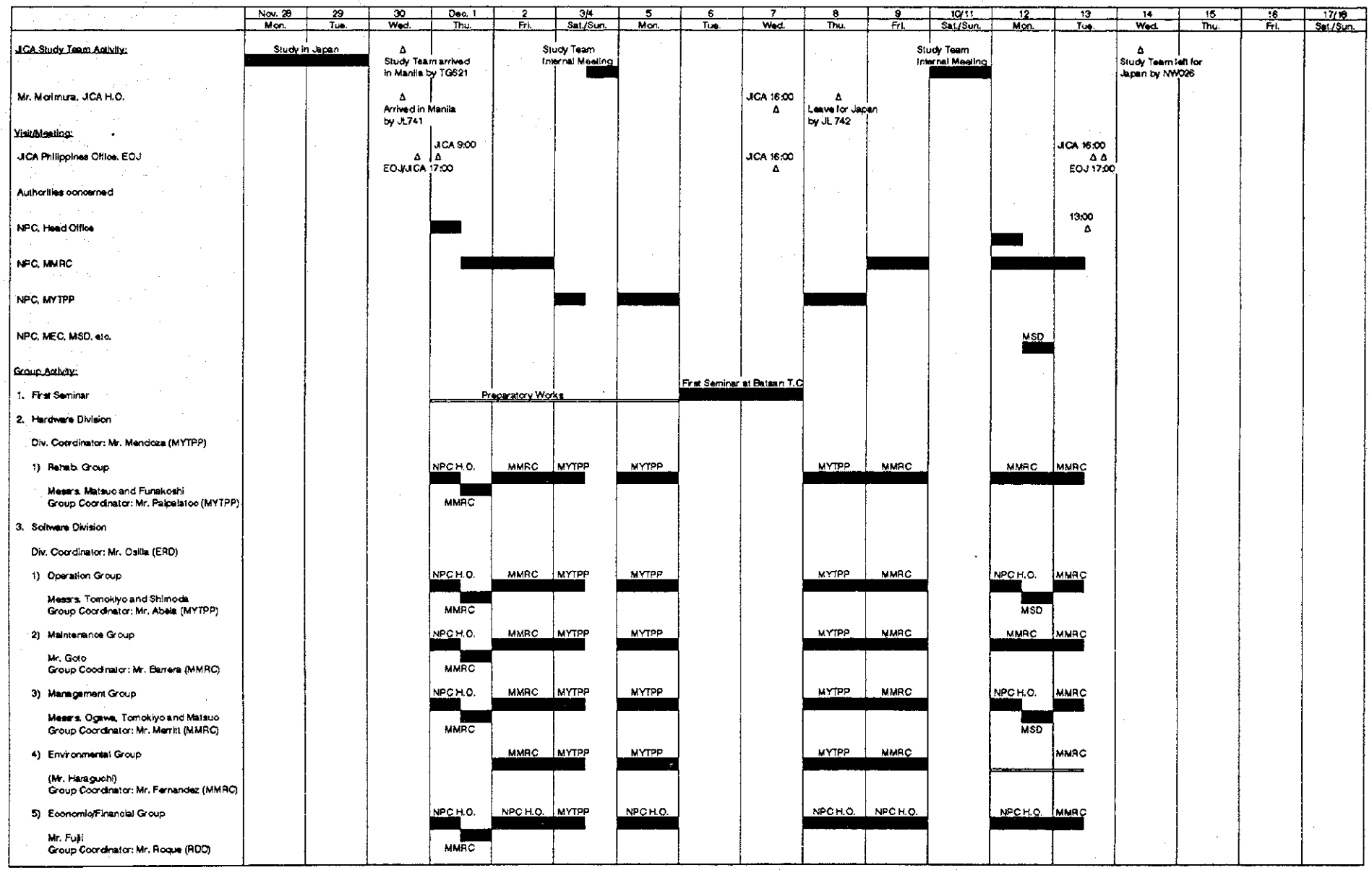
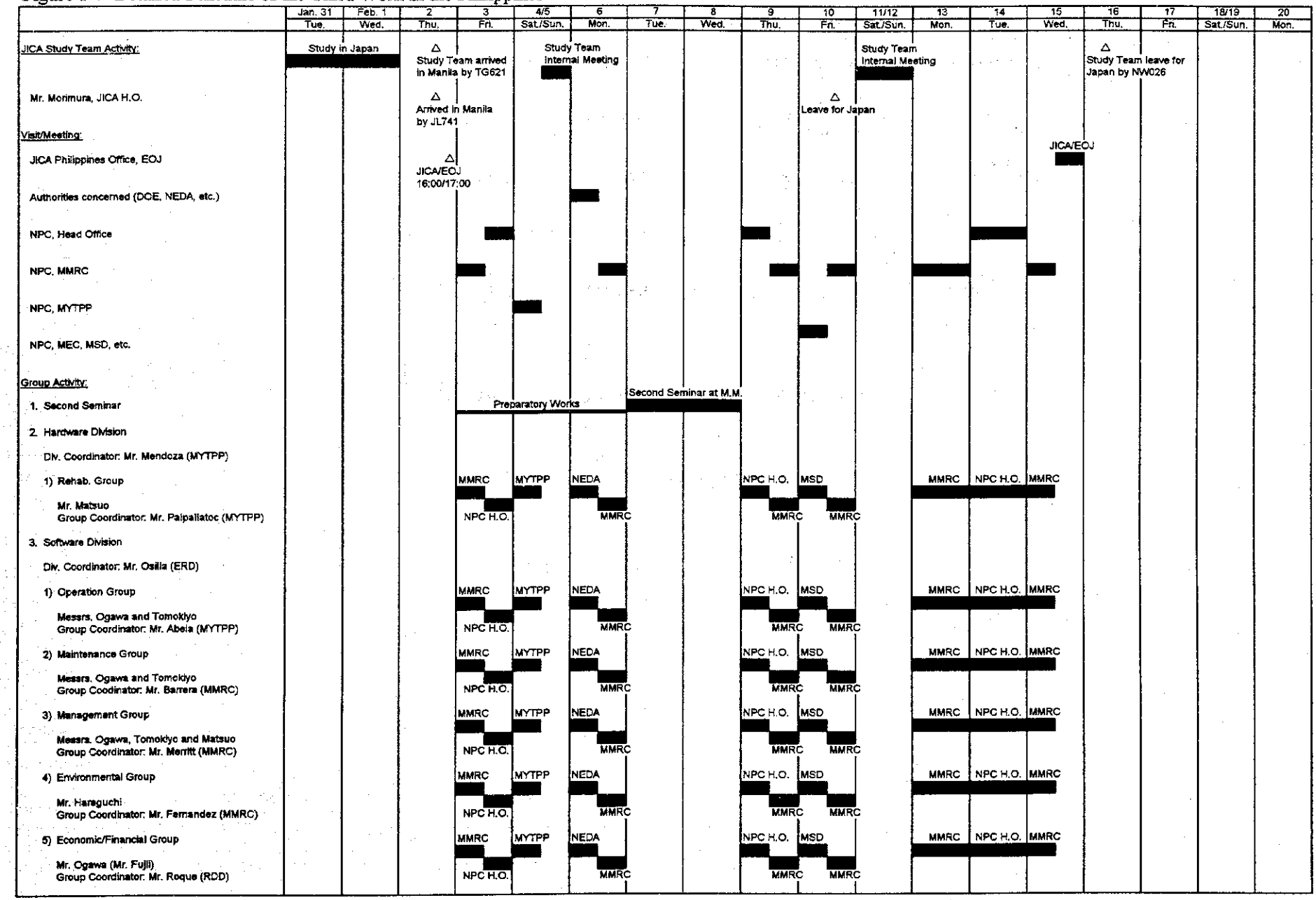


Figure 1-7 Detailed Schedule of the Third Work in the Philippines



1.8 Place and Person Visited

1) Embassy of Japan, Philippines	Mr. Norio Nakazawa First Secretary
2) JICA Philippine Office	Mr. Akihiko Hashimoto Resident Representative
	Mr. Satoshi Machida Deputy Resident Representative
	Mr. Nobuyuki Kobayashi Assistant Resident Representative
	Mr. Kazutoshi Ariyoshi JICA Expert
	Mr. Fumitada Mizuno JICA Expert
3) Department of Energy (DOE)	Mr. Mariano S. Salazar Under Secretary
4) National Economic and Development Authority (NEDA)	Mr. Eugenio B. Inocentes, III Assistant Director Public Investment Staff
	Mr. August Pagkalinawan Infrastructure Engineer
	Ms. Alley A. Bernardo Chief Economic Development Specialist, ASPAC Division
	Ms. Cristina C. Santiago Economic Development Specialist ASPAC Division

5) Department of Environment & Natural Resource (DENR)	Mr. Sixto E. Tolentino, Jr. Ph. D Regional Technical Director Environmental Management and Protected Areas Services, Region IV-A
6) Laguna Lake Development Authority (LLDA)	Mr. Alejandro E. Santiago General Manager Mr. Floro R. Francisco Assistant General Manager Ms. Adelina C. Santos Borja, M. Sc. Freshwater Biologist Limrologist Mr. Ceazar H. Natividad Civil/Sanitary Engineer
7) National Power Corporation (NPC)	
a. NPC Head Office	Dr. Francisco L. Viray Former President, Secretary of DOE Mr. Guido A. Delgado President Ms. P. A. Segovia Vice President, Human Resource Mr. A. Macalintal Vice President, Administration Mr. L. F. Osilla Manager, Efficiency and Reliability Dept. (ERD) Ms. Petel Manager, Environmental Management Dept. Mr. L. F. Ramos Manager, Fuel, Corplan

	Mr. P. B. Anido Manager, Operation & Maintenance, Corplan
	Mr. M. L. Marcelo, Jr. OIC, Reliability & Availability Improvement, ERD
	Mr. R. V. Guarin Efficiency Control Division, ERD
	Mr. M. M. Austria Office of the President
	Mr. J. Alcantara Operation Training Division
	Mr. G. Feliciano Operation Training Division
	Mr. R. Plan Operation Training Division
	Mr. H. T. Roque Chief, Economist, RDD
b. Metro Manila Regional Center (MMRC)	Mr. M. E. Maño Vice President, Metro Manila Regional Center
	Mr. A. O. Nerona Manager, Operations Project Services (OPS)
	Mr. P. L. Merritt Jr. Manager, Regional Management Services
	Ms. E. S. Delos Reyes Manager, Administration
	Mr. I. E. Barrera Regional Management Services

	Mr. R. L. Dannang Regional Management Services
	Mr. A. B. Lumawag Jr. Chief, Engineering Services, MEDTD, OPS
	Mr. P. R. Fernandez Chief, Engineering Services, Chemical OPS
	Mr. J. B. Enriquez Operations Project Dept.
	Ms. E. C. Tapia Administration Dept.
c. Malaya Thermal Power Plant (Malaya TPP)	Mr. O. P. Mendoza Plant Manager
	Mr. J. T. Abela Operations Manager
	Mr. A. S. Palpal-latoc Acting Maintenance Manager
	Mr. J. A. Marte Mechanical Maintenance Superintendent
	Mr. J. R. Galingan Instrument & Control Maintenance Superintendent
	Mr. F. R. Flores Chemical Superintendent
	Mr. E. T. Labadan Operations Superintendent
	Mr. W. Fajardo Efficiency Control Superintendent

	Mr. T. Villona Schedule/Planning Superintendent
d. Maintenance Engineering Center (MEC)	Mr. E. L. Ampat Manager, MEC
	Mr. Eduardo D. Ligayo Manager, Engineering Dept.
	Mr. Mannuel Espeleta Manager, Machine Shop
	Mr. Rogelio L. Panlilio Manager, Metal Forming & Welding Div.
	Mr. Chamberlain F. Nagma Manager, Production Engineering Div.
	Mr. L. Tuazon Quality Control
	Mr. Constantino J. Castillo Chemical Laboratory
	Ms. Cordelia Rodriguez Materials Laboratory
e. Maintenance Service Department (MSD)	Mr. V. C. Almazan Manager, MSD
	Mr. R. S. Volante Manager, Mechanical
	Mr. R. F. Conocono Manager, Electrical
	Mr. R. R. Ortañez Superintendent, Boiler
	Mr. E. D. Vergara Superintendent, Turbine

Mr. A. T. Delos Santos
Superintendent, Auxiliary

Mr. N. N. Gensoli
Superintendent, Generator

Mr. A. M. Rivera
Superintendent, Relay Services

Mr. R. R. Mabaylan
Superintendent, Test/Meter Services

CHAPTER 2

CONCLUSION AND RECOMMENDATIONS

CHAPTER 2. CONCLUSIONS AND RECOMMENDATIONS

The following sections describe the conclusions of the survey and our recommendations concerning the reliability improvement plan for the existing power plant facilities (hardware) and the improvement plan for operation and maintenance management (software).

2.1 Outline

1) It is no exaggeration to say that reliability of power plant facilities depends on implementation of complete periodic overhaul. It bears repeating: implementation of periodic overhaul, complete in every aspect, is critically important and absolutely required. This is the first of our conclusions.

   Like all of us, power plant facilities incur some problems naturally as they age. As we require periodic health examinations followed by treatment, so do power plant facilities. Getting aged requires special inspections and treatment that is "rehabilitation".

   How the power plant has handled facility (hardware) problems and how it will cope with facility problems in the future determine reliability of the power plant. "What is the complete periodic overhaul maintenance ?" is a theme which not only the NPC task force, but everyone concerned are expected to consider.

   The periodic overhaul discussed here is the general term for the standardized annual overhaul work accompanied by regular inspections.

2) In order to assure complete overhaul, establishment of overhaul regulations and overhaul planning/preparation system and reinforcement of Maintenance Services Department (MSD) are considered essential.

   Support systems of MSD such as those for spare parts supply, supply of construction machines and overhaul tools, transportation, communications, lodging facilities, etc. are also indispensable. Above items are basically regarded as the software issues, however, hardware such as spare parts, construction machines, tools, transportation, etc. relevant to the above software items are also discussed. As well as the solution of the software issues mentioned above improvement of such personnel related matter as the education/training of power plant operators as well as systems for job rotation and personnel promotion/pay hike are also the matters of significance in view of the brush-up of skills and morale enhancement.

3) Most of the software problems are not so simple as those of hardware which can be solved by replacement or repair of defective parts. Software problems are difficult, require time and effort to solve, and related to not only Malaya TPP but also all thermal power plants. Therefore, from the beginning, a campaign appealing to all concerned to make efforts to realize the improvement should be launched.

Our proposal for the goal and slogan of the campaign is "No Forced Outages and No Accidents."

4) After all, the hardware and software improvement must be carried out concurrently so that the plant reliability could be attained. Taking into the lead time for implementation of the hardware improvement, the implementation will be the 3rd or 4th year after this study. Accordingly, the implementation plan of the reliability improvement program, or Overall Schedule, is set as follows:

a. Implementation year : From 1995 to 1999

b. Duration : 5 years

c. Hardware Improvement

a) Program-I

- Rehabilitation Project : 10 months for Unit No. 1 from 1979 to 1998
  3 months for Unit No. 2 in 1997

b) Periodic Overhaul : Once a year from 1995 to 1999
  In the year when the rehabilitation is carried out, the periodic overhaul shall be carried out at the same time.

d. Software Improvement

a) Program-II

- Improvement of procedure and organization for planning of periodic overhaul
- Improvement of procedure and organization for implementation of periodic overhaul
- Measures for safe and reliable operation

b) Program-III

- Improvement related to education and training of employee
- Morale enhancement

e. "No Forced Outage and No Accident" Movement

- Through 5 years

2.2 Improvement Plan

2.2.1 Reliability Improvement of Power Plant Facilities (Hardware)

We provide a improvement plan which is a combination of rehabilitation; Program-I and periodic overhauls.

1) Effects of Project

a. Recovery of Rated Output

The unit output will be recovered to 300 MW for Unit No. 1 and 350 MW for Unit No. 2.

b. Recovery of Plant Efficiency

The efficiency will be recovered to a 1988 value after the previous rehabilitation project.

c. Improvement of Reliability

The reliability will be improved, and the units can be operated with a higher capacity factor in 1988 after the previous rehabilitation project.

d. Service Life

Both the units will be operated until the originally scheduled retirement year, 2005 for Unit No. 1 and 2009 for Unit No. 2.

2) Major Work Items

In order to obtain the project effects mentioned above, the following major works should be carried out in addition to the comprehensive overhaul work of the power plant facilities.

a. Malaya Unit No. 1

Plant Facilities	Major Work Items
Boiler	- Replacement of whole water wall tubes. - Boiler chemical cleaning - Examination of secondary superheater - Complete repair of boiler casing and gas duct - Replacement of heating elements of air pre-heater - Improvement of dust collector and ash handling system - Rehabilitation of smoke stack inner lining - Study on fuel additive injection - Installation of additional sootblower at secondary superheater section
Turbine	- Life expectancy analysis (HP-, IP- & LP-turbines, Major Valves, Main steam pipe, Reheat steam pipe) - Comprehensive overhaul of HP-turbine or replacement with higher efficiency HP turbine - Comprehensive overhaul of IP-turbine - Replacement of IP-turbine rotor - Comprehensive overhaul of LP-turbine and replacement of cut blades - Eddy current test of condenser tubes - Replacement of tube handle of LP feedwater heater or replacement of complete assembly - Replacement of condensate distributor of deaerator or replacement with spray type deaerator - Replacement of circulating water pump - Installation of additional plate type heat exchanger
Electrical Facilities	- Repair of generator stator core end - Installation of spare 4160V switchgear cubicle - Installation of spare 480 control center
Instrument & Control Facilities	- Replacement of boiler metal temperature recorder, etc. - Replacement of control valves and instruments - Improvement of minimum flow control of boiler feed pumps

a. Malaya Unit No. 1 (cont'd)

Plant Facilities	Major Work Items
Chemical Facilities	- Recovery of automatic operation of condensate polishing plant and comprehensive overhaul - Installation of magnetic filter - Establishment of steady raw water supply system to demineralizing plant - Replenishment of chemical apparatus for laboratory

b. Malaya Unit No. 2

Plant Facilities	Major Work Items
Boiler	- Replacement of boiler hopper tubes - Replacement of superheater spray nozzles - Replacement of feedwater stop valve at economizer inlet - Complete repair of boiler casing and gas duct - Replacement of GRF rotor - Replacement of heating elements of air pre-heater - Replacement of defective sections of steam coil air heater - Improvement of dust collector and ash handling system - Rehabilitation of smoke stack inner lining - Study on fuel additive injection - Life expectancy analysis of main steam pipe and reheat steam pipe
Turbine	- Comprehensive overhaul of HP-, IP- & LP-turbines and life expectancy analysis - Eddy current test of condenser tubes - Replacement of raw water pump for heat exchanger
Electrical Facilities	- Replacement of whole 480V motor control center and others
Instruments and Control Facilities	- Replacement of GRF damper controller - Replacement of automatic boiler control (ABC) and others
Chemical Facilities	- Replacement of whole sampling rack

b. Malaya Unit No. 2 (cont'd)

Plant Facilities	Major Work Items
Common Facilities	- Replacement of auxiliary boiler tubes and countermeasure for corrosion - Installation of concrete sheet pile at intake channel - Additional installation and repair of lighting fixtures of powerhouse and boiler house.

3) Implementation Plan (See Figure 2-1)

a. First Year

- A Major Overhaul will be carried out for both the Units No. 1 and No. 2
- Remaining service life of boilers, turbines, and generators will be diagnosed.

Based on the results of the above work, implementation plans for overhauls and rehabilitation work for the 2nd and subsequent years will be drawn up.

b. Second Year

- An annual overhaul will be carried out for both the Units No. 1 and No. 2. Work periods will be relatively short.
- Sections left uninspected during the Major Overhaul in the first year will be inspected to determine the degree of deterioration. The results will be reflected in the plans for rehabilitation.

c. Third Year

- Rehabilitation and overhaul will be executed.
- For rehabilitation work items, refer to the foregoing clause 2) and Chapter 4, Clause 4.3 in detail.

d. Fourth Year

- One year after completion of rehabilitation, a simplified annual overhaul will be conducted to check the sections repaired, replaced or improved during the

rehabilitation. Items left uncorrected during the 3rd overhaul (Rehabilitation), if any, will be properly rectified.

- All defective sections will be completely rectified by the rehabilitation and four periodic overhauls.

e. Fifth Year

- In the second year after completion of rehabilitation, a Major Overhaul will be carried out.
- In accordance with the inspection results, standards for future overhauls and deterioration surveys will be formulated.
- If this 5th Major Overhaul does not fit within the planned time-frame of 5 years, the 4th annual overhaul will be conducted as this Major Overhaul.

4) Implementation Method

a. Rehabilitation

- Rehabilitation of major equipment will be subcontracted to individual contractors including the original manufacturers. Their responsibilities will be made clear by a 'turnkey' contract.
- Supervision over the entire job will be conducted with assistance of a consultant.

b. Overhauls

- Overhauls will be executed by the NPC.
- Planning and supervision of the remaining life and deterioration surveys will be conducted with assistance of a consultant. Actual surveys and work will be subcontracted.

c. Costs

- Funds for rehabilitation and post-rehabilitation overhauls (construction costs) will be procured through a loan.

5) Costs of Work

[UNIT: x 1,000 US$]

Items	UNIT NO. 1			UNIT NO. 2			UNIT NOS. 1 & 2		
	F. C.	L. C.	TOTAL	F. C.	L. C.	TOTAL	F. C.	L. C.	TOTAL
1. Rehabilitation cost	96,134	5,161	101,295	36,817	1,977	38,794	132,951	7,138	140,089
2. Consultant fee	3,580	188	3,768	1,170	62	1,232	4,750	250	5,000
3. Total project cost	99,714	5,349	105,063	37,987	2,039	40,026	137,701	7,388	145,089

6) Projected Disbursement Schedule

Unit: Thousand US $

	No. 1 Unit	No. 2 Unit	Total
1995	1,815	1,586	3,401
1996	15,746	5,862	21,608
1997	55,316	30,464	85,779
1998	30,373	1,057	31,430
1999	1,814	1,057	2,870
Total	105,063	40,026	145,089

2.2.2 Improvement Plan for Operations and Maintenance Management (Software)

In order to solve the various problems concerning operations and maintenance, we recommend that the following improvement plan be studied and implemented.

PRIORITY ITEMS OF IMPLEMENTATION:

Program-II

I. Formulation of complete periodic overhaul plan
II. Implementation of complete periodic overhaul
III. Safe and reliable operations

Program-III

IV. Hiring, education and training of personnel
V. Improvement of morale

The essential points of the improvement plan for the respective priority items are given below. For Program-II, further detailed survey (F/S) is deemed necessary. For other recommendations not included in the improvement plan, refer to Chapter 5.2.

1) Formulation of Complete Periodic Overhaul Plan (Priority Item I)

a. Preparation and Establishment of Periodic Overhaul Standards

a) Establishment of the standards for periodic inspection categories and intervals
Annual implementation plan should be strictly observed.
Particularly, work schedule and period should never be arbitrarily changed without satisfactory or proper justification.

b) Standardization of the items and scope of inspection and repair work to be repeated with overhauls.

b. Establishment of Days for Standard Periodic Overhaul for Each Power Plant Unit.

c. Reinforcement of Periodic Overhaul Plan Formulating Function

a) Clarification of departments or sections, in power plant and MSD, in charge of periodic overhaul planning and the scope of their responsibilities

b) Plan for diagnosis of the life-span of important equipment and deterioration survey.

2) Complete Implementation of Periodic Overhaul (Priority Item II)

a. Mandatory Implementation of Periodic Overhaul in Conformity to the Periodic Overhaul Standards

a) Establishment of company guidelines stipulating mandatory implementation of periodic inspections

b) Study of legal measures applicable in support of these company guidelines

b. Capability Improvement Plan for MSD's Work Implementation

a) Required Staff Size and Supplementing Measures
- Estimate of required number of MSD staff
- Recruitment from both in-house and outside sources
- Measures for in-house recruitment

b) Arrangement of Support System for Overhaul Works
- Supply of spare parts for overhaul
- Procurement of machines and tools for overhaul works (lacking and short items)
- Procurement of vehicles for transportation of personnel and equipment/materials
- Construction of lodging facilities for overhaul workers at site, MSD site offices at power plants, equipment/material center, training center, etc.
- Preparation of communication systems

c) Nurturing and Training of Subcontractors

- Supplementing of staff from outside sources will be made through subcontracting.

c. Establishment of Organized Work Implementation System and Lines of Responsibility for Periodic Overhauls

a) Promotion of work schedule and quality control

b) Expediting (following-up) of ordered items

c) Implementation of diagnosis of the life-span of important equipment as well as deterioration survey

3) Safe and Reliable Operations (Priority Item III)

Points

1. Prevention of operational error, early detection of abnormal symptoms or such section during operation
2. Establishment of operating system being cognizant that some operations will be conducted by young inexperienced operators

a. Complete Preparation of Operational Procedures and Manuals
Manuals should be prepared to meet the purpose of OMP project.

b. Daily patrol and inspections, and routine work should be strictly carried out.

a) Daily patrol inspections

b) Periodic routine operations including spare equipment switching tests

- Preparation of routine operation check sheet, etc. for prevention of operational error and for recording

c. Review of Shift Operations System

a) Operation staff, and rotation staff structure

- Since the present full strength staff size needs to be examined for its adequateness for all power plants and MSD, the full strength of rotation staff will also be examined.

b) Increase of Shuttle Bus Operations

- Increase of shuttle bus service

4) Hiring, Education and Training of Personnel (Priority Item IV)

Points

1. Since people solve problems, the reliability improvement for the Malaya TPP cannot be expected without addressing those issues relating to human resources.
2. In recognition of the importance of this issue, the NPC has been studying the improvement measures including the educational and training programs prepared for new employees.
3. Improvement measures to complement and reinforce NPC's own efforts need to be put into practice as soon as possible.
4. Improvement of morale

a. Hiring of Personnel

a) Review of Full Strength

- In order to promote efficient job operation based on the management policy of the company, without increasing the total staff size, the present staff size allocated for each power station, MSD, etc. should be re-examined.
- Estimates should be made for changes in staff size accompanying the projected construction/addition or abolition of power plants.

b) Drawing Up a Long-term Staff Plan

- In reference to the results of above-mentioned review and estimation, long-term staff plan should be drawn up, and based on the plan, the annual number of new employees should be stabilized.

c) Review of Hiring System

- Current system of hiring irregularly only when vacancies need to be filled should be replaced by annual hiring of all new employees together at a time based on the long-term hiring plan.

b. Education and Training

a) Education of New Employees

- Newly employed power plant staff and newly employed MMRC engineers will be educated collectively.

  Linked with periodic once-a-year employment, this will be implemented at the NPC training center.
- After collective education at the training center, the new members allocated to each station will be given orientation and training.

b) Education of Staff Members with Some Years of Experience

- Operation training by simulator for operators

  Operation training by simulator shall be implemented systematically every year for all operators after their 1st year of employment including the younger employees and seasoned staff and leaders.
- Position training for operators

  Position training shall be implemented systematically, irrelevant to the necessity of transfer to fill retired operator's or other vacancies.

  All shall undergo training to acquire skill and knowledge for multiple positions.

c) Personnel Transfer, Job Rotation and Position Training

- Multiple position training facilitates job rotation.
- By giving higher priority for promotion to those who have acquired skill and knowledge for multiple positions, the opportunities of transfer of personnel and promotion will increase.

d) Overseas Training for Seasoned Operators and Maintenance/Repair Engineers

e) Retaining Operations and Maintenance/Repair Consultants

Schedule	Duration and number of consultants	
	First phase	Second phase
Before rehabilitation	2 years, 2 people	-
After rehabilitation	-	2 years, 2 people

5) Improvement of Morale (Priority Item V)

a. Feasibility Study of Qualification System

- Qualification system to evaluate the knowledge and skill of the individual achieved through education, training or voluntary self enhancing efforts (OJT) will be adopted.
- For seasoned technical personnel, periodic examinations on academic subjects and practical job performance (or practical skill) will be conducted, for which a minimum number of years in a certain position will be a requirement.
  Those who have passed the examination will be rated and given a certain qualification and will be given priority for promotion.
  (Qualification for operators is currently under study at the NPC.)

b. Implementation of Education and Training for Morale Improvement
  All personnel in every power plant shall take the course by turns.

c. Study of Adoption of Periodic Personnel Transfer System
  Rotation of personnel between different sections within the power plant, and where possible, between different power plants and/or MMRC, will be systematized to prevent employee burnout.

d. Implementation of an Incentive System
  The system seems to exist, therefore the applicable range should be expanded.

- Activities of quality control and/or other similar groups to make voluntary proposals should be encouraged. In combination with an incentive system, support shall be provided to these activities to encourage and motivate all members to exercise their originality and ingenuity in the workplace.

2.2.3 Implementation Method

Reliability improvement plan for the Malaya TPP, as explained previously, has to be executed in parallel with rehabilitation of power plant facilities and improvement of operations and maintenance procedures. The following are recommended in coordination with this principle:

1) Classification of Implementation Plan

For actual implementation, the above-stated priority items shall be categorized into the following 3 programs.

Program-I	:	Power plant facility rehabilitation project
Program-II	:	a. Improvement of periodic overhaul plan methods and system
		b. Reinforcement of periodic overhaul implementation methods and system
		c. Measures for safe and reliable operation
Program-III	:	a. Hiring, education and training of personnel
		b. Morale enhancement

2) Project Implementation

a. Implementation Methods

a) Program-I

Like other conventional rehabilitation projects for the power plant facilities, this program shall be executed by contracted work to contractors.

b) Program-II

Task forces will be organized with the operations and maintenance staff members from NPC Head Office, MMRC, power plants, MSD and MEC. The program shall be carried out in cooperation with OMP and MMP groups.

Like the study for MSD reinforcement versatile review in detail of hardware and software is required for this program.

Therefore, along with the review of the software for the other two important items, 'Complete Periodic Overhaul Plan' and 'Safe and Reliable Operation,' one study project shall be formed and an immediate Feasibility Study (F/S) shall be conducted.

However, there are items in Program-II, which need to be implemented at once and can also be implemented as soon as the NPC system has been ready, such as those related to 'Safe and Reliable Operation.' They include:

- Preparation of operations manuals and procedures
- Review of daily patrol and inspections, and routine work
- Review of operational shift system, etc.

We recommend that these be categorized under Program-II/Phase-I, and to be carried out in parallel with the aforementioned F/S led by the NPC task forces and supported by consultants.

c) Program-III

Task forces shall be organized, involving power plant staff, led mainly by NPC Head Office Human Resources and MMRC Human Resources Section. Then the concrete improvement plan shall be studied and executed by referring to the advice given in this study report.

b. Implementation Schedule

The implementation schedule for these three types of programs are as shown in Figure 2-1 Malaya TPP Reliability Improvement Plan, Implementation Schedule.

Figure 2-1 Improvement Plan Overall Schedule

	1st year 1995	2nd year 1996	3rd year 1997	4th year 1998	5th year 1999
1. Program-I					
Rehabilitation (Hardware) Unit No.1	Major Overhaul	Annual Overhaul		Major Overhaul REHABILITATION	Major Overhaul
Unit No.2	Major Overhaul	Annual Overhaul	Major Overhaul REHABILITATION	Annual Overhaul	Major Overhaul
2. Program-II					
1) Feasibility Study on Program-II					
2) Implementation of Program-II	Phase-I		Phase-II		
a. Improvement of Planning system of Overhaul	Taskforce	Detailed Study	Implementation		
b. Reinforcement of Implementation System of Overhaul					
a) Regulations of Overhaul, etc.	Taskforce	Detailed Study	Implementation		
b) Reinforcement of MSD					
• Personnel&System	Taskforce	Detailed Study Peparation	Addition of Personnel & training		
• Procurement of tools, machines, vehicles, etc. for overhaul		Peparation	Procurement		
• Construction of Facilities.		Peparation	Construction		
·Site offices at P/S.					
·Material Centre					
·Training Centre, etc.					
c) Preparation of various Manuals	Preparation		Implementation		
c. Countermeasures for Safe and Reliable operation	Taskforce	Detailed Study	Implementation		
3. Program-III					
1) Improvement of Hiring, Education and Training System	Taskforce	Detailed study	Implementation		
2) Improvement of Morale	Taskforce	Detailed study	Implementation		

2.2.4 Economic and Financial Evaluation

1) Economic Evaluation

The study team concluded through technical study that there are merits of the rehabilitation project; output recovery, reliability improvement, etc. Based on these merits, the economic evaluation will be done to check if the Project would economically benefit to the society as compared with the alternatives that can provide with the same services by Malaya TPP after rehabilitation (With Project). The economic internal rate of return, EIRR, will be calculated and compared with the discount rate set forth for this type of Project in the Philippines. The study team applied the alternative for the economic evaluation this time; namely the cost of the With project is taken as *Cost* (project cost plus fuel cost) and the cost of Without as *Benefit* (fuel cost plus expenses for supplementary power supply/purchase). The operation and maintenance cost, interest expenses, other overhead costs are disregarded because these costs will be necessary for both With and Without cases.

It is recommended that the rehabilitation items, cost estimate of the equipment, and these assumed operating conditions be reviewed in collation with the actual operating conditions whenever the management will be required decision making concerning this rehabilitation project.

2) Result of Economic Evaluation

a. Energy Generated and Unit Generating Cost

The following table shows comparisons of energy generated and average generating cost per kWh between With and Without cases. The generating cost of the With cases considers the levelized investment for rehabilitation works with a discount rate of 15% and both the generating costs are average values for the respective operating years.

	M-1		M-2	
	With	Without	With	Without
Energy Production in GWh	12,877	8,032	25,754	18,172
Unit Gen. Cost in P/kWh*	1.3108	1.2249	1.0224	1.0383

Concerning the comparison of energy generated, the capacity factor decline greatly influence on the energy production of the Without case as a matter of course. The energy production of the Without cases will be about 62% for M-1 and 70% for M-2 as against the With case. Since the insufficiency in energy production should rely on purchase of the energy, the economic impact of the With case in this point of view is significant.

In the other hand, the unit generating cost of the With case become higher than that of the Without case because of a large amount of investment to the rehabilitation works. The generating cost of the With case, however, is still lower than the average power rate in Luzon Grid at 1.8505 peso per kWh and that of other Non-NPC power supply sources.

b. EIRR of Base Case

Each EIRR value depending on the supplementary power sources at the base case (the capacity factor at 70% at With case and fuel oil cost at US$15/bbl) is calculated. Also EIRRs of M-1 only, M-2 only and combination thereof are calculated as summarized below.

EIRR of the Project

Supplementary Power Source	M-1 Only	M-2 Only	M-1 & M-2 Combined
LUZON GRID Average	2.27%	26.65%	12.32%
Oil based	1.34%	25.47%	11.35%
Coal	3.74%	28.52%	13.86%
Geothermal	1.39%	25.53%	11.40%
Gas turbine	25.46%	58.77%	37.40%
NON NPC PLANTS Average	21.57%	52.97%	33.06%
Oil based	17.60%	47.23%	28.69%
Coal	15.29%	43.97%	26.17%

Gas Turbine	32.65%	69.94%	45.59%

c. Conclusion

Shorter economic benefit recovery period compared with the investment to M-1, seven years only, greatly gave the adverse effect to the overall economic evaluation while M-2 rehabilitation with smaller investment and the longer recovery period became competitive with most of the alternative cases except only NPC's geothermal power supply. In consideration of the fact that the republic is now concentrating the development of large scale coal-fired thermal power plant comparable to these objective units in term of output capacity, the competition with the coal-fired power units, probably combination of NPC's own source and non-NPC source, is the most probable case. In this case, the project EIRR became 13.86%, which is below NEDA's 15% but exceeds current discount rate of the Philippines at 12%. So, the report concludes that the project is economically feasible from the stand point of NPC.

As a result of sensitivity analysis, too, the sensitivity to the capacity factor is very high and a few drops of the capacity factor may jeopardize the project economy even the coal-fired thermal is selected as an alternative. From the economic view point, maintenance of the plant dependability and availability is crucial if this project should be pursued. As to the project total cost, the estimated cost still have a few margins if the first contender is considered as the coal-thermal. Should the supplementary energy in the case of Without be supplied through purchase of Non-NPC plants, this project is highly worth to pursue economically. Namely, the implementation of this rehabilitation project is much better for NPC rather than that NPC increases the purchase from Non-NPC power sources.

3) Financial Evaluation

Financial soundness of Malaya thermal power station after rehabilitation, or operation of these units by NPC, will be analyzed by an internal rate of return method, and then FIRR will be compared with the opportunity cost of capital for the project. The benefit of the project will be the balance of energy production and sales between With and Without cases. In addition, the financial statements; cash flow balance, income statement and repayment schedule, will be prepared.

4) Result of Financial Evaluation

Financial internal rates of return of the project stand at 16.06% for M-1, 46.67% for M-2 and 29.74% for the combined. As these figures well cleared the opportunity cost of capital at 5.8% and even the rate base of NPC at 8%, the project is concluded financially feasible. Those financial evaluations this time compared the balance of energy production between the With and Without cases, the financial evaluation with the actual cases taking the benefit as power sale by With case only may result in similar FIRR values since the depreciation and interest portions in the power rate were deducted in the With/Without FIRR calculations.

Should the technical and physical restoration of the equipment and facilities be attained as engineered, the project is concluded financially feasible.

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Table 2-1 Economic Internal Rate of Return

No. 1 & No. 2 Combined EIRR =	12.32%	11.35%	13.86%	11.40%	37.40%	33.06%	28.69%	26.17%	45.59%
EIRR =	2.27%	1.34%	3.73%	1.39%	25.46%	21.57%	17.60%	15.29%	32.65%

No. 1 Unit

	Year	WITH REHABILITATION								WITHOUT REHABILITATION							Supply by Other Power Sources (P/kWh)									
		Project Cost	M-1 WITH Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump.	Fuel Cost	With Total Cost	M-1 W/O Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump.	Fuel Cost	Supple-mental Energy	Luzon Grid Average	Oil Based	Coal	Geo-thermal	Gas Turbine	Non Average	NPC Non Oil	NPC Non Coal	NPC Non Gas T.	
		Thous $	MW	%	GWh	%	Mil. lit.	Thous $	Thous $	MW	%	GWh	%	Mil. lit.	Thous $	GWh	1.0797	1.051	1.1264	1.0525	2.068	1.878	1.6809	1.5742	2.5209	P/kWh
0	1994	0							0								0	0	0	0	0	0	0	0	0	
1	1995	1,815							1,815								-1,815	-1,815	-1,815	-1,815	-1,815	-1,815	-1,815	-1,815	-1,815	
2	1996	15,746							15,746								-15,746	-15,746	-15,746	-15,746	-15,746	-15,746	-15,746	-15,746	-15,746	
3	1997	55,315							55,315								-55,315	-55,315	-55,315	-55,315	-55,315	-55,315	-55,315	-55,315	-55,315	
4	1998	30,373							30,373								-30,373	-30,373	-30,373	-30,373	-30,373	-30,373	-30,373	-30,373	-30,373	
5	1999	1,814	300	70%	1,839.60	33.27%	488.30	48,216	50,030	300	47.50%	1,248.30	29.69%	371.30	36,663	591.30	11,188	10,535	12,250	10,569	34,119	29,343	24,861	22,434	43,964	
6	2000	0	300	70%	1,839.60	33.19%	489.48	48,332	48,332	300	46.16%	1,213.08	28.85%	371.33	36,666	626.52	14,351	13,660	15,477	13,696	38,648	33,568	28,839	26,267	49,080	
7	2001	0	300	70%	1,839.60	33.11%	490.66	48,449	48,449	300	44.86%	1,178.92	28.04%	371.30	36,663	660.68	15,650	14,921	16,837	14,959	41,272	35,935	30,927	28,216	52,272	
8	2002	0	300	70%	1,839.60	33.03%	491.85	48,566	48,566	300	43.59%	1,145.55	27.25%	371.25	36,658	694.05	16,914	16,148	18,160	16,188	43,830	38,224	32,962	30,114	55,385	
9	2003	0	300	70%	1,839.60	32.95%	493.04	48,684	48,684	300	42.36%	1,113.22	26.48%	371.26	36,659	726.38	18,139	17,338	19,444	17,379	46,309	40,442	34,935	31,955	58,403	
10	2004	0	300	70%	1,839.60	32.87%	494.24	48,802	48,802	300	41.17%	1,081.95	25.73%	371.35	36,668	757.65	19,329	18,493	20,690	18,536	48,711	42,592	36,848	33,739	61,326	
11	2005	0	300	70%	1,839.60	32.79%	495.45	48,922	48,922	300	40.01%	1,051.46	25.00%	371.42	36,675	788.14	20,482	19,612	21,898	19,658	51,047	44,681	38,706	35,472	64,169	
12	2006	0																								
13	2007	0																								
14	2008	0																								
15	2009	0																								
Total		105,063			12,877.20		3,443	339,971	445,034			8032.48		2599.21	256,652	4,844.72	12,804	7,458	21,507	7,736	200,687	161,556	124,829	104,948	281,350	

EIRR =	26.65%	25.47%	28.52%	25.53%	58.77%	52.97%	47.23%	43.97%	69.94%

No. 2 Unit

	Year	WITH REHABILITATION								WITHOUT REHABILITATION							Supply by Other Power Sources (P/kWh)									
		Project Cost	M-2 WITH Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump.	Fuel Cost	With Total Cost	M-2 W/O Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump.	Fuel Cost	Supple-mental Energy	Luzon Grid Average	Oil Based	Coal	Geo-thermal	Gas Turbine	Non Average	NPC Non Oil	NPC Non Coal	NPC Non Gas T.	
		Thous $	MW	%	GWh	%	Mil. lit.	Thous $	Thous $	MW	%	GWh	%	Mil. lit.	Thous $	GWh	1.0797	1.051	1.1264	1.0525	2.068	1.878	1.6809	1.5742	2.5209	P/kWh
0	1994	0							0								0	0	0	0	0	0	0	0	0	
1	1995	1,586							1586								-1,586	-1,586	-1,586	-1,586	-1,586	-1,586	-1,586	-1,586	-1,586	
2	1996	5,862							5862								-5,862	-5,862	-5,862	-5,862	-5,862	-5,862	-5,862	-5,862	-5,862	
3	1997	30,464							30464								-30,464	-30,464	-30,464	-30,464	-30,464	-30,464	-30,464	-30,464	-30,464	
4	1998	1,057	350	70%	2,146.20	34.90%	543.08	53,625	54,682	350	60.00%	1,839.60	32.33%	502.50	49,618	306.60	7,668	7,330	8,219	7,347	19,558	17,082	14,758	13,499	24,663	
5	1999	1,057	350	70%	2,146.20	34.82%	544.33	53,748	54,805	350	57.83%	1,773.07	32.11%	487.64	48,151	373.13	8,841	8,429	9,511	8,451	23,311	20,297	17,469	15,938	29,524	
6	2000	0	350	70%	2,146.20	34.74%	545.58	53,872	53,872	350	55.74%	1,708.99	31.89%	473.26	46,731	437.21	11,015	10,532	11,800	10,558	27,970	24,439	21,125	19,330	35,250	
7	2001	0	350	70%	2,146.20	34.66%	546.84	53,996	53,996	350	53.72%	1,647.06	31.67%	459.28	45,350	499.14	12,082	11,531	12,978	11,560	31,439	27,407	23,623	21,575	39,749	
8	2002	0	350	70%	2,146.20	34.58%	548.10	54,121	54,121	350	51.78%	1,587.57	31.45%	445.79	44,018	558.63	13,095	12,479	14,099	12,511	34,759	30,247	26,012	23,720	44,080	
9	2003	0	350	70%	2,146.20	34.50%	549.38	54,247	54,247	350	49.91%	1,530.24	31.24%	432.58	42,714	615.96	14,046	13,366	15,152	13,402	37,933	32,958	28,289	25,761	48,189	
10	2004	0	350	70%	2,146.20	34.42%	550.65	54,372	54,372	350	48.10%	1,474.75	31.03%	419.72	41,444	671.45	14,955	14,214	16,161	14,253	40,995	35,571	30,481	27,726	52,174	
11	2005	0	350	70%	2,146.20	34.34%	551.93	54,499	54,499	350	46.36%	1,421.40	30.82%	407.29	40,217	724.80	15,817	15,017	17,119	15,056	43,925	38,071	32,576	29,602	55,993	
12	2006	0	350	70%	2,146.20	34.26%	553.22	54,626	54,626	350	44.68%	1,369.89	30.61%	395.22	39,025	776.31	16,637	15,780	18,031	15,825	46,743	40,472	34,587	31,402	59,668	
13	2007	0	350	70%	2,146.20	34.18%	554.52	54,754	54,754	350	43.06%	1,320.22	30.40%	383.52	37,870	825.98	17,418	16,505	18,900	16,552	49,449	42,777	36,516	33,126	63,201	
14	2008	0	350	70%	2,146.20	34.10%	555.82	54,883	54,883	350	41.50%	1,272.39	30.19%	372.20	36,752	873.81	18,156	17,191	19,725	17,242	52,043	44,965	38,361	34,775	66,592	
15	2009	0	350	70%	2,146.20	34.02%	557.13	55,012	55,012	350	40.00%	1,226.40	29.98%	361.26	35,672	919.80	18,856	17,841	20,509	17,894	54,527	47,098	40,125	36,350	69,842	
Total		40,026			25,754.40		6,600.58	651,755	691,781			18,171.58		5140.26	507,562	7,583	130,672	122,303	144,292	122,741	424,740	363,492	306,010	274,892	550,993	

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Table 2-2 FIRR Calculations

M-1 & M-2 Combined FIRR = 29.74%

No. 1 Unit

FIRR = 16.06%

	Year	WITH REHABILITATION								WITHOUT REHABILITATION										
		Project Cost	M-1 WITH Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump	Fuel Cost	With Total Cost	M-1 W/O Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump	Fuel Cost	Benefit Energy With	Balance of Fuel Cost	Energy Sale Benefit	Cost Balance
		Thous $	MW	%	GWh	%	Mil. lit.	Thous $	Thous $	MW	%	GWh	%	Mil. lit.	Thous $	GWh	Thous $	Thous $	Thous $
0	1994																		
1	1995	1,815							1,815										-1,815
2	1996	15,746							15,746										-15,746
3	1997	55,315							55,315										-55,315
4	1998	30,373							30,373										-30,373
5	1999	1,814	300	70%	1,839.60	33.27%	488.30	44,346	46,160	300	47.50%	1248.3	29.69%	371.30	33,721	591.30	-10,625	35,765	23,326
6	2000		300	70%	1,839.60	33.19%	489.48	44,453	44,453	300	46.16%	1213.08	28.85%	371.33	33,723	626.52	-10,730	37,895	27,165
7	2001		300	70%	1,839.60	33.11%	490.66	44,561	44,561	300	44.86%	1178.92	28.04%	371.30	33,721	660.68	-10,840	39,961	29,121
8	2002		300	70%	1,839.60	33.03%	491.85	44,669	44,669	300	43.59%	1145.55	27.25%	371.25	33,716	694.05	-10,953	41,979	31,026
9	2003		300	70%	1,839.60	32.95%	493.04	44,777	44,777	300	42.36%	1113.22	26.48%	371.26	33,717	726.38	-11,060	43,935	32,875
10	2004		300	70%	1,839.60	32.87%	494.24	44,886	44,886	300	41.17%	1081.95	25.73%	371.35	33,725	757.65	-11,161	45,826	34,665
11	2005		300	70%	1,839.60	32.79%	495.45	44,996	44,996	300	40.01%	1051.46	25.00%	371.42	33,731	788.14	-11,265	47,670	36,405
12	2006																		
13	2007																		
14	2008																		
15	2009																		
Total		105,063			12,877.20		3,443	312,688	417,751			8032.48		2599.21	236,054	4844.72	-76,634	293,031	111,334

No. 2 Unit

FIRR = 46.67%

	Year	WITH REHABILITATION								WITHOUT REHABILITATION										
		Project Cost	M-2 WITH Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump	Fuel Cost	With Total Cost	M-2 W/O Capability	Capacity Factor	Annual Energy	Effici-ency	Fuel Consump	Fuel Cost	Benefit Energy With	Balance of Fuel Cost	Energy Sale Benefit	Cost Balance
		Thous $	MW	%	GWh	%	Mil. lit.	Thous $	Thous $	MW	%	GWh	%	Mil. lit.	Thous $	GWh	Thous $	Thous $	Thous $
0	1994																		
1	1995	1,586							1,586										-1586
2	1996	5,862							5,862										-5862
3	1997	30,464							30,464										-30,464
4	1998	1,057	350	70%	2,146.20	34.90%	543.08	49,321	50,378	350	60.00%	1,839.60	32.33%	502.50	45,636	306.6	-3,685	18,545	13,803
5	1999	1,057	350	70%	2,146.20	34.82%	544.33	49,435	50,492	350	57.83%	1,773.07	32.11%	487.64	44,286	373.13	-5,149	22,569	16,363
6	2000		350	70%	2,146.20	34.74%	545.58	49,548	49,548	350	55.74%	1,708.99	31.89%	473.26	42,980	437.21	-6,568	26,444	19,876
7	2001		350	70%	2,146.20	34.66%	546.84	49,663	49,663	350	53.72%	1,647.06	31.67%	459.28	41,711	499.14	-7,952	30,190	22,238
8	2002		350	70%	2,146.20	34.58%	548.10	49,777	49,777	350	51.78%	1,587.57	31.45%	445.79	40,486	558.63	-9,291	33,789	24,498
9	2003		350	70%	2,146.20	34.50%	549.38	49,893	49,893	350	49.91%	1,530.24	31.24%	432.58	39,286	615.96	-10,607	37,256	26,649
10	2004		350	70%	2,146.20	34.42%	550.65	50,009	50,009	350	48.10%	1,474.75	31.03%	419.72	38,118	671.45	-11,891	40,612	28,721
11	2005		350	70%	2,146.20	34.34%	551.93	50,125	50,125	350	46.36%	1,421.40	30.82%	407.29	36,989	724.80	-13,136	43,839	30,703
12	2006		350	70%	2,146.20	34.26%	553.22	50,242	50,242	350	44.68%	1,369.89	30.61%	395.22	35,893	776.31	-14,349	46,955	32,606
13	2007		350	70%	2,146.20	34.18%	554.52	50,360	50,360	350	43.06%	1,320.22	30.40%	383.52	34,830	825.98	-15,530	49,959	34,429
14	2008		350	70%	2,146.20	34.10%	555.82	50,478	50,478	350	41.50%	1,272.39	30.19%	372.20	33,802	873.81	-16,676	52,852	36,176
15	2009		350	70%	2,146.20	34.02%	557.13	50,597	50,597	350	40.00%	1,226.40	29.98%	361.26	32,809	919.80	-17,788	55,634	37,846
Total		40,026			25,754.40		6,601	599,448	639,474			18,172		5140.26	466,826	7582.82	-132,622	458,644	285,996

2.2.5 Recommendation on Environmental Improvement

1) Air Pollution

a. Procurement of Fuel Oil Sulfur Meter

The sulfur content in fuel which is restricted by national regulations can be controlled and the SO_2 content in stack gas can be calculated.

b. Measurement of NO_x Content in Flue Gas

NO_x in the power plant stack gas is not measured. Since a standard value for NO_x emission has been established by national regulations, measurement should be implemented by all means.

c. Procurement of Anemometer with Continuous Recorder

In the Environmental Impact Assessment for existing courses and new sources, the Philippine government requires an atmospheric diffusion forecast calculation. However, forecast calculation is not possible due to the unavailability of meteorological data (wind direction and velocity data, in particular) for the area. It is necessary for the NPC to purchase one or two sets of anemometers and consecutively take meteorological data for one year for each existing thermal power plant as well as for the planned sites for new thermal power plants.

2) Water Contamination

a. Relocation of the Waste Water Neutralization Tank, and Installation of Neutralization Vessel

Current neutralization method of adding caustic soda cannot ensure satisfactory neutralization. It is necessary to install a neutralization vessel in a position immediately before the waste water outlet so that the waste water will be completely neutralized at this point before being discharged.

b. Installation of Waste Water Clarifier

Highly-concentrated unburnt carbon ash is in the waste water discharged into Laguna Lake. A waste water clarifier should be installed to prevent contamination.

c. Prevention of Oil Spill from the API Oil-water Separator

Oil detectors should be installed and patrol frequency should be increased as measures to prevent oil spillage due to accidents, floods and/or other natural/man made disasters or incidents.

3) Noise

Noise at the north boundary and in the surrounding area of the power plant should be measured.

4) Measures to Reduce Unburnt Carbon Ash

Due to use of inferior quality heavy oil for fuel, a large volume of unburnt carbon ash is generated at the Malaya TPP. The following measures should be considered.

- The unburnt carbon must be reduced by improving the combustion method.
- Use of superior fuel oil of lower viscosity, use of additives or agents and other measures need to be studied.
- Detail study on the causes of high unburnt carbon content in the ash must be made to prepare appropriate countermeasures.