6.4 Recommendations on Environmental Improvement Plan

6.4.1 Air Pollution

1) Procurement of Fuel Oil Sulfur Meter (roughly 4 million yen)

The fuel oil sulfur meter (Fluorescent X-ray analytical instrument for sulfur) can measure the sulfur content in heavy fuel oil in 3 to 5 minutes, and thereby:

a. the sulfur content in fuel on which restrictions are imposed by national regulation can be controlled; and

b. the sulfur dioxide (SO_2) concentration in flue gas can be calculated by using the measured value. (Calculated value is almost identical to actually measured value.) The calculation formula is:

$$SO_2\ ppm = \frac{0.7S}{Vd + (m-1)\ A_0} \times 10^6$$

$$m = \frac{21}{21-(O_2)}$$

S : sulfur content in fuel oil (wt %)

Vd : amount of combustion gas per 1 kg of heavy oil
m^3N = 10.0 m^3N/1 kg fuel

(O_2) : oxygen (vol. %) in air preheater outlet

A_0 : theoretical amount of air per 1 kg of heavy oil
m^3N = 10.6 m^3N/1 kg fuel

m : air ratio

We recommend that one sulfur meter be purchased by the NPC, and used to measure sulfur content in fuel oil for the Malaya, Manila and Sucat power plants.

2) Measurement of NOx in Stack Gas

The SO_2 emission and particulate concentration in the stack gas have been measured annually by MMRC, but NOx measurement has not been conducted. Now that a standard value for NOx has been stipulated by national regulation, it should certainly be included among the annual measurement items. NOx concentration cannot be easily predicted as it is the total of fuel NOx and thermal NOx values.

3) Procurement of Wind Vane Anemometer with a 10-m Pole and Continuous Recorder

In the EIA (Environmental Impact Assessment) for existing sources and new sources, the Philippine government requires an atmospheric diffusion forecast calculation. However, due to the unavailability of meteorological data (wind direction and velocity data, in particular) for the area, an accurate forecast calculation cannot be obtained. It is necessary for the NPC to purchase one or two sets of wind vane 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 stations.

6.4.2 Water Contamination

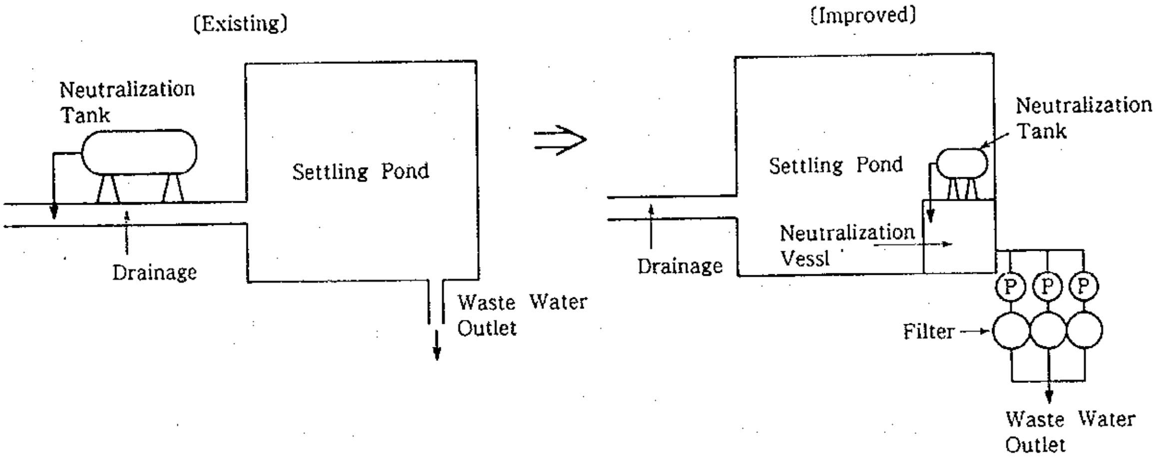
1) Relocation of the Waste Water Neutralization Tank, and Installation of Neutralization Vessel

Presently, at the Malaya TPP, the waste water from unburnt carbon ash treatment is neutralized while draining by adding caustic soda (NaOH) before reaching the settling pond. This method cannot ensure satisfactory neutralization, as is evident with the value, pH 5.29, measured at the outlet during the survey, which is lower than the effluent standard 6.0. This should be rectified by relocating the neutralization tank to a position immediately before the outlet as illustrated in Figure 6-27, so that the waste water will be completely neutralized at this point.

2) 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. To cut costs, use of the existing Permutit demineralization plant (with filters replacing the ion-exchange resin) as the clarifying system should be considered.

Figure 6-27 An Example of a Recommended Waste Water Treatment Process



3) Prevention of Oil Spill from the API Oil-Water Separator

Oil spill can cause severe contamination of Laguna Lake. Oil detectors should be installed or patrol frequency should be increased as measures to prevent spillage due to accident or flood.

6.4.3 Noise

Noise should be measured at the northern boundary and in the surrounding area (Residential area within 500 m of the property line) with the following conditions.

Measuring Conditions:

1) Night-time during normal operation of Malaya Units No. 1 and No. 2 (at the northern boundary)
2) During start-up (at the northern boundary and in the surrounding area)

6.4.4 Unburnt Carbon Ash

As described in 6.3.4, a large amount of unburnt carbon ash is generated due to poor fuel quality. Table 5-26 and Table 5-27 show that viscosity of the fuel oil used at Malaya TPP is much higher than that usually used in Japan (Malaya TPP: 483.6 cSt (50°C), Japan: 81 to 138 cSt (50°C)).

To reduce unburnt carbon ash, it is important to keep combustion condition good through fine combustion control, for example:

- Fuel oil temperature should be high enough to keep low viscosity.
- Pressure and temperature of atomizing steam should be kept properly.
- Maintenance and management of burner tips should be done securely.
- Defected diffuser cones should be repaired or replaced during an overhaul.

High quality fuel oil with low viscosity may improve combustion in the boiler, and reduce unburnt carbon ash. It's low sulfur consistency may reduce concentration of SO_2 in flue gas as well.

Some additive into fuel oil will be another method to improve combustion and reduce unburnt carbon ash. The cost of fuel additive should be considered in this case.

6.5 Improvement Proposals for Safety and Antidisaster Management

6.5.1 Necessity of Safety and Antidisaster Management

We believe that the measures for environmental management and safety & antidisaster management should be drawn up separately. The former is to study influences of actions which may cause some unfavorable effects to the surrounding environment of power plants and to formulate countermeasures if deemed necessary. Such serious or unfavorable actions would include continuous contaminant emission to the atmosphere and effluent of the same to lakes or the sea. While, the latter, safety & antidisaster management, is to prevent reprehensible incidents or situations, such as accidents resulting in injury or death, fires, explosions, or oil leakage, which must never be allowed to occur. In the event of some unforeseen accident or situation, utmost efforts should be made to minimize the damage. The unfortunate oil leak accident that recently occurred at the Malaya TPP should be considered as basically a Safety & Antidisaster Management problem which transformed into an environmental problem affecting the environment surrounding the power plant.

In the event of a major accident, e.g. fire, explosion or oil leakage, and others which may lead to injury and/or loss of life, suspended power supply, repair costs, compensation for environmental problems, it is a loss of precious human life as well as a tremendous financial waste. Therefore, we feel strongly that accident prevention through safety & antidisaster management is as important as the power generating operations themselves, and should be treated with equal concern and emphasis.

NPC has a corporate-wide, Safety and Antidisaster committee with counterparts in the regional and plant levels. At this opportunity, we suggest to reaffirm items shown in 6.5.2, and make safety & antidisaster management understood and implemented by all personnel.

6.5.2 Concrete Improvement Proposals

We suggest following items to be done for safety & antidisaster management.

1) Establishment of Safety & Antidisaster Management Committee Headquarters (either at the NPC Head Office or MMRC)

   a. The Committee Headquarters will have a chairman to be selected from among the NPC management and some exclusively designated members (or those who concurrently hold another post).

b. Main duties

a) Committee Headquarters will gather reports of the safety & antidisaster management status at each power plant, and submit them to upper management. It will also inform power plants of conditions at other power stations and relay instructions from upper management.

b) Committee Headquarters will witness safety & antidisaster drills carried out at power plants, and visit and observe the safety & antidisaster management of each power plant.

c) A safety & antidisaster seminar will be held jointly for members of the Safety & Antidisaster Management Committee from each power plant.

d) Committee Headquarters will investigate and analyze domestic and foreign disasters or accidents and provide each power plant with the information and request them to study the possible occurrence of a similar disaster or accident at their facility.

e) Committee Headquarters will study the procurement and installation request of safety & antidisaster facility or equipment (e.g. oil fence, oil leak detector, fire extinguish equipment, and fire alarm) respectively submitted by each power plant.

f) Committee Headquarters will study the support system at the time of accident occurrence.

g) Others

2) Establishment of Thermal Power Plant Safety & Antidisaster Committee (at each thermal power plant)

a. The Committee will consist of the power plant manager as chairman, all superintendents, and 1 or 2 personnel selected from each section.

b. Main duties

a) The Committee will study the safety & antidisaster patrol routes, sections to be checked[1], patrol frequency[2], patrol team[3], check sheet form, etc. These will be implemented upon approval of the Safety & Antidisaster Management Committee Headquarters.

[1] The Committee will select probable sections where accidents causing injury or death, fire, explosion, oil leaks, or other hazardous chemical leaks may occur.
The committee will also select sections to be checked during unit operation and periodic overhaul work respectively (including supervision of hazardous or dangerous work).

[2] Patrol frequency will be increased after typhoons or earthquakes.

[3] It is recommended that the patrol team include the power plant manager and superintendents.

b) The Committee will plan safety & antidisaster drills (e.g. oil leak and fire) (1 ~ 2 times annually)

c) The Committee members will attend the seminar offered by the Safety & Antidisaster Management Committee Headquarters and make presentations concerning their own plant's safety and antidisaster status.

d) Based on the information and material provided by the Safety & Antidisaster Management Committee Headquarters, the Committee will study and submit a report on the possible occurrence of similar accidents, disasters or potentially dangerous situations at their own power plant.

e) The Committee will study the necessity of procuring and installing antidisaster facility/equipment, and send requests to Committee Headquarters if deemed necessary.

f) In the even of an accident, the Committee will immediately notify Committee Headquarters and request support, etc.

g) Others

CHAPTER 7

MALAYA THERMAL POWER PLANT RELIABILITY IMPROVEMENT PLAN

CHAPTER 7. MALAYA THERMAL POWER PLANT RELIABILITY IMPROVEMENT PLAN

Based on the aforementioned survey results on hardware and software, improvement plans for both aspects will be formulated in this chapter.

7.1 General

1) Reliability Improvement Plan for Power Generating Facilities (Hardware) - Basic Concept

It is wrong to believe that the reliability of the power plant can be improved by rehabilitation of hardware only. Firstly, reliability is maintained by periodic inspection and repair, or overhaul, (hereinafter called periodic overhaul) which are conducted systematically and thoroughly. However, reliability gradually lessens after many years of operation. The reliability of the power generating facilities, which has been unavoidably lowered, can be restored by rehabilitation as a measure against deterioration.

Figure 7-1 shows the conceptual relationship of deterioration with periodic overhaul and rehabilitation. This diagram explains how the periodic overhaul is important and economically advantageous in maintaining the reliability of hardware.

As a result of this Study, we have formulated an improvement plan which includes periodic overhauls in addition to rehabilitation.

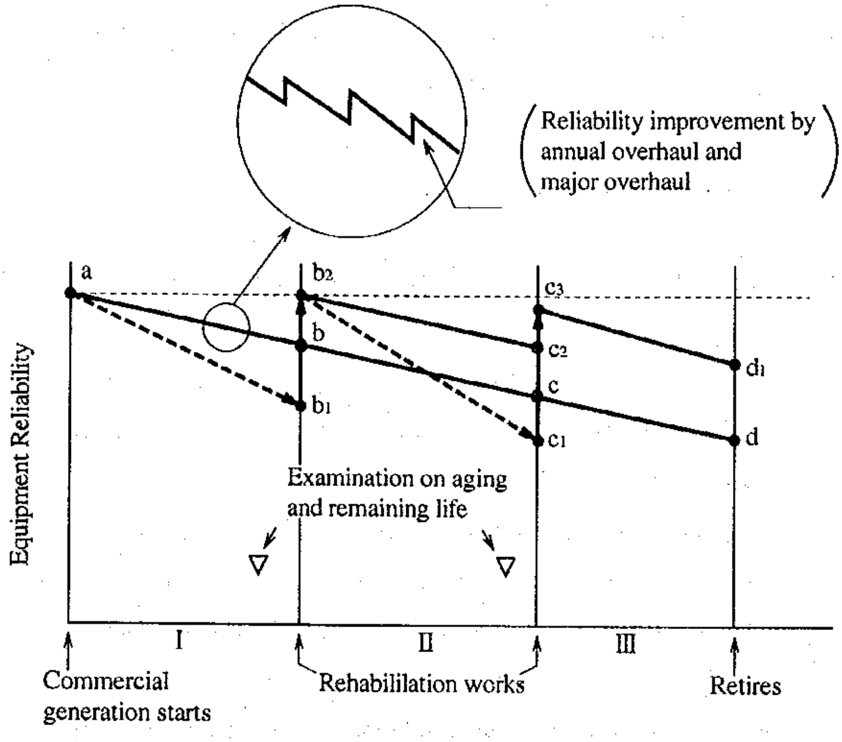
a. Time-frame for Improvement Plan and Rehabilitation

For this Study, the period of the improvement plan shall be 5 years on condition that the periodic overhaul for Units No. 1 and No. 2 is annually executed. Considering the time required for equipment/material delivery and commissioning, rehabilitation work shall commence in the third year and be completed by the end of fourth year. Refer to Figure 4-7, Rehabilitation & 5-Year Overhaul.

b. Rehabilitation Items and Periodic Overhaul Items

The NPC's periodic overhaul items shall be excluded from the rehabilitation work items. New items not included in the rehabilitation items shall be carried out during the periodic overhauls within the planned period even if they are not included among the NPC's periodic overhaul items. (The periodic overhaul work: repair cost, the rehabilitation work: facilities cost.)

Figure 7-1 Equipment Reliability-Aging and Remaining Life



a - b - c - d	:	Normal deterioration due to age even under good maintenance
b → b_2 and c_2 → c_3	:	Improvement through rehabilitation
a → b_1 and b_2 → c_1	:	With lack of steady and proper maintenance, the equipment rapidly deteriorates.
b_1 → b_2 and c_1 → c_3	:	Rehabilitation in this case requires considerably more expense and time than in normal cases, i.e. b → b_2 or c_2 → c_3 This is especially so in case c_1 → c_3

2) Basic Concept of Improvement Plan for the Software

The software is solely responsible for improvement and maintenance of hardware reliability of the power plant facilities. From the recommendations regarding the improvement plan for the software in Chapter 5, the improvement plan shall be formulated by selecting priority items that are necessary in achieving the project goal of "No Forced Outages and No Accident".

a. Time-frame and Time of Commencement

The time-frame for improvement is 5 years, the same as for hardware. Although it varies depending on items, preparations should be finished in 1 or 2 years, to be commenced in the 2nd or 3rd year, and be completed by the end of 5th year. Refer to Figure 7-7, Improvement Plan Overall Schedule.

b. Priority Items

a) The following 5 items are priority items:

I. Formulation of complete periodic overhaul plan
II. Implementation of complete periodic overhaul
III. Safe and reliable operation
IV. Hiring, education and training of personnel
V. Improvement of morale

b) Contents of Individual priority Items

Regarding software and human factors, the Study led us to find many issues which need to be solved behind each problem.

- Figure 7-2 provides easy understanding of the current problems of the power plant and their direct causes, and the situation surrounding the problems.
- Table 7-1 is a summary of issues behind the problems on software and human factors, and their measures by priority items.

Figure 7-2 Current Condition of Power Plant and Cause of Problems

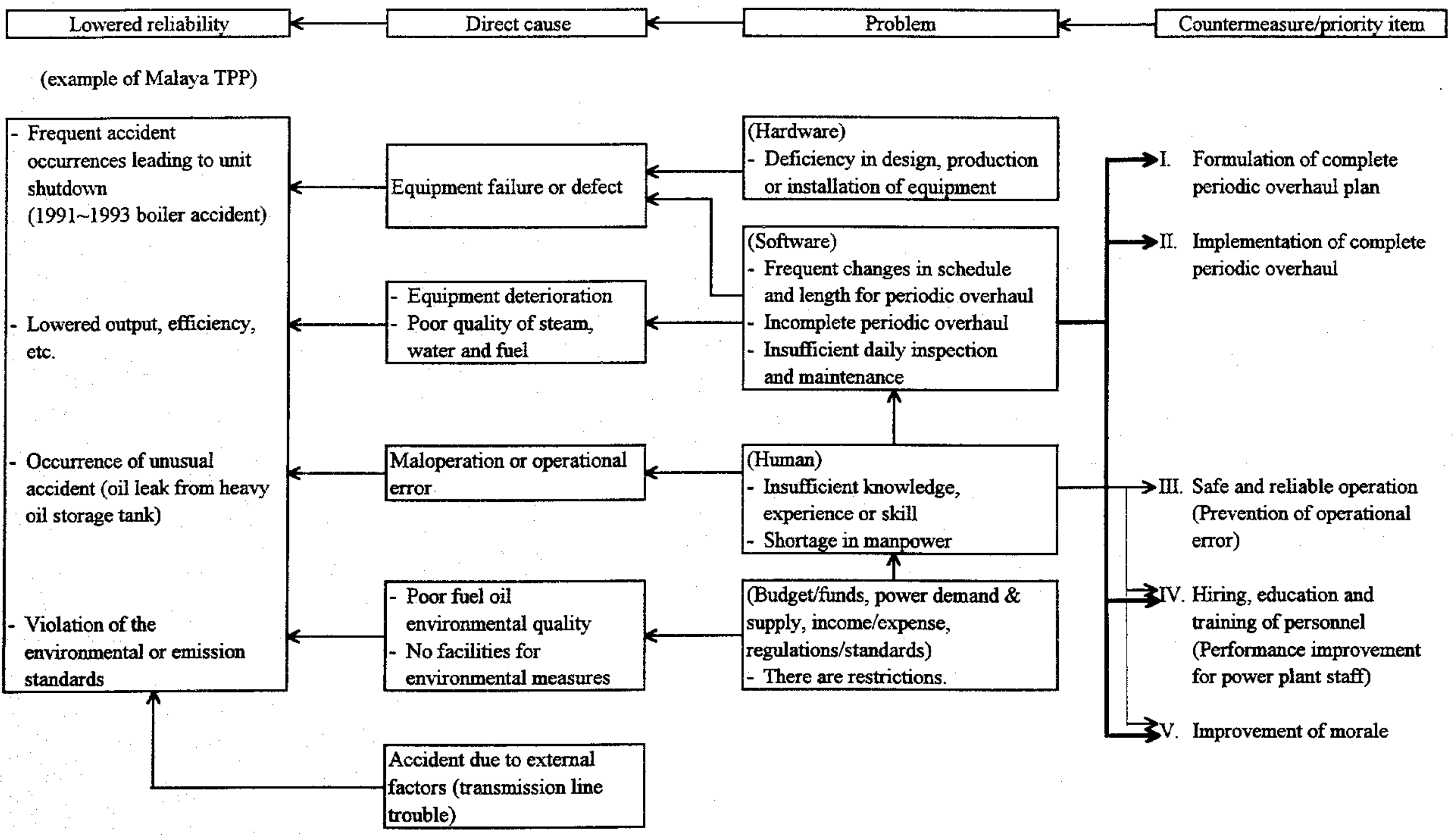


Table 7-1 Software Improvement Plan (Priority Items)

I. Formulation of Complete Periodic Overhaul Plan

(Issues)	(Measures)
1) No standards for periodic inspection items and their intervals	1) Repletion of contents for periodic overhaul plan a. Formulation/establishment of periodic inspection items and intervals b. In relation to the above, study required periodic overhaul length and interval for each power plant unit.
2) Section in charge of periodic overhaul and its range of responsibility should be clarified. Strengthening of its capability should be necessary, including formulation of the standards mentioned in 1).	2) Strengthening of function to formulate periodic overhaul plan - Further study of power plant organization, division of work, education, training
3) Acquisition of know-how to formulate a complete periodic overhaul plan.	

II. Implementation of Complete Periodic Overhaul

(Issues)	(Measures)
1) Periodic overhaul time and length are frequently changed, which almost becomes a normal practice.	1) Company policy should be established that the scheduled time and length of periodic overhaul should not be changed without a specific reason.
2) There are no legal regulations regarding the periodic inspection items and their intervals.	2) Legalization of requirements regarding the periodic overhaul, such as periodic inspection items and their intervals.
3) Insufficient capacity for work implementation	3) System improvement for periodic overhaul work implementation
4) Preparation of equipment disassembly/ inspection manuals, and check sheets.	4) Should be prepared by MSD.
5) Delay in delivery of spare parts and other parts for periodic overhaul	5, 6 & 7) - Responsibility system for the periodic overhaul work should be clarified. - Expediting (following-up) of ordered items - Work schedule control - Implementation of inspections and test, and preparation of records and reports
6) Work schedule is often extended. Improvement in care of work.	

Table 7-1 Software Improvement Plan (Priority Items)

II. Implementation of Complete Periodic Overhaul (cont'd)

7) Certain implementation of inspections & tests during overhaul and at the time of completion of work, and preparation of records and reports (to be reflected in the periodic overhaul plan or safe and proper operation)	
8) Improvement of daily inspection and maintenance	8) Preparation of maintenance manuals.

III. Safe and Reliable Operation

(Issues)	(Measures)
1) Preparation of operation manuals is necessary. These manuals should be used as text for training.	1) Preparation of operation manuals The operation manuals under preparation at OMP of NPC Head Office can be used as models.
2) Sound implementation of operator routine work	2) Implementation of the same
3) Review of organization of operation shift	3) Implementation of the same

IV. Hiring, Education and Training of Personnel

(Issues)	(Measures)
1) The fill-the-vacancy or occasional hiring system is problematic.	1) Improvement of hiring system Periodic hiring based on a long-term staff plan is imperative.
2) Collective education of new employees is not conducted.	2) & 3) New employee education, position education, and job rotation are necessary.
3) Operators stay in the same position for a long time. Promotion opportunities are limited.	
4) OJT only for operator training	4) Training of operators with simulator

V. Improvement of Morale

(Issues)	(Measures)
1) There are hardly any job rotations within MMRC or power plant, or between them.	1) Systematic implementation of job rotation
2) Evaluation of education/training results and a qualification system for promotion need to be studied.	2) Implementation of the same
3) Proposal and reward system needs to be studied.	3) Implementation of the same

7.2 Reliability Improvement Plan for Power Plant Facilities (Hardware)

- Rehabilitation period shall be the 5 years after completion of the JICA Study.
- Rehabilitation shall be effectively combined with Annual Overhaul before and after rehabilitation.
- Rehabilitation work shall be completed by the end of the fourth year of the above said rehabilitation period.

1) Implementation Plan

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 Chapter 4, Clause 4.3.

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.

c. 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.

2) General Work Schedule

Overall work schedule is given in Figure 4-9.

3) 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 contracted.

c. Costs

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

4) Scope of Implementation

a. Rehabilitation

a) Scope of Work

The scope of work is described in detail in the following tables:
Table 4-18 for the Malaya Thermal Power Plant No. 1 Unit
Table 4-19 for the Malaya Thermal Power Plant No. 2 Unit
Table 4-20 for the Malaya Thermal Power Plant Common Facilities

b) Costs of Work

Unit:Thousand US $

	No. 1 Unit	No. 2 Unit	Total
Project costs	101,295	38,794	140,089
Consultant fee	3,768	1,232	5,000
Total	105,063	40,026	145,089

c) 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

7.3 Improvement Plan for Operations and Maintenance Management (Software)

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

1) Approach to Improvement Plan

In order to make a complete periodic overhaul plan, exact and accurate conditions of hardware (defective parts and sections) must be grasped, first of all. Figures 7-3 and 7-4 explain the periodic overhaul plan and the detailed work-flow up to the finalization of periodic overhaul budget in the case of Japan.

The Study results of this time show that standards for periodic overhauls of the thermal power plant hardware have not yet been established. Therefore, along with the preparation of a list of defective sections of hardware (Figure 7-3, Item No.①), the completion of the following three standards is necessary.

- Periodic Overhaul Standards (Figure 7-3, Item No.②)
- Deterioration Examination Standards (Figure 7-3, Item No. ③)
- Routine Maintenance Standards (Figure 7-3, Item No.④)

In this improvement plan, the following three items, including the first among the three standards, are chosen as the most important items. The numbers given for the items correspond to those in "Measure" column of Table 7-1.

I, 1) a. Preparation and establishment of periodic overhaul standards
I, 1) b. Review of required duration and interval of periodic overhauls for each power plant unit
I, 2) Reinforcement of formulating function of periodic overhaul plan

The approach to these is given in the following clauses.

Figure 7 – 3 Periodic Overhaul Plan (Work-flow up to the Finalization of Periodic Overhaul Budget)

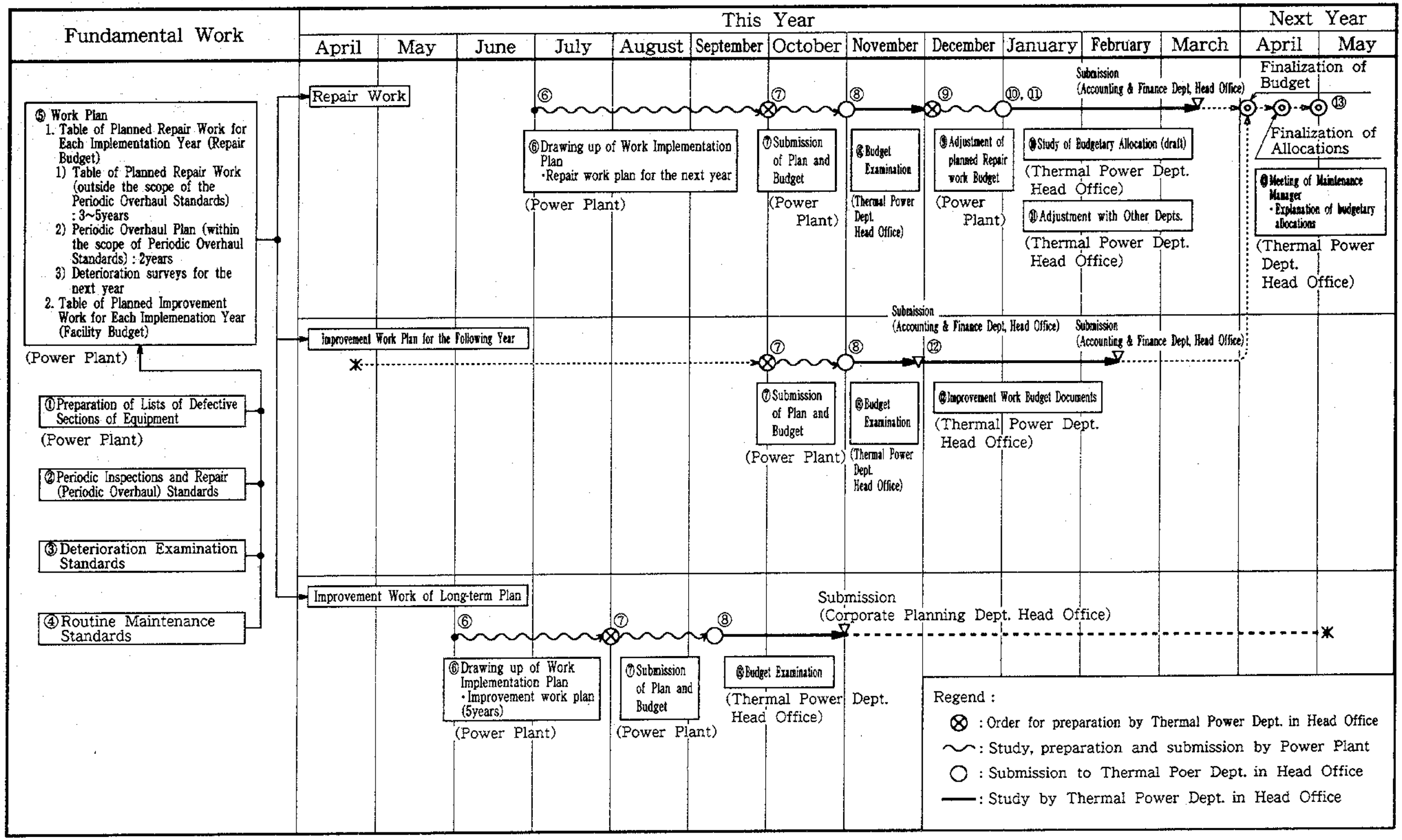
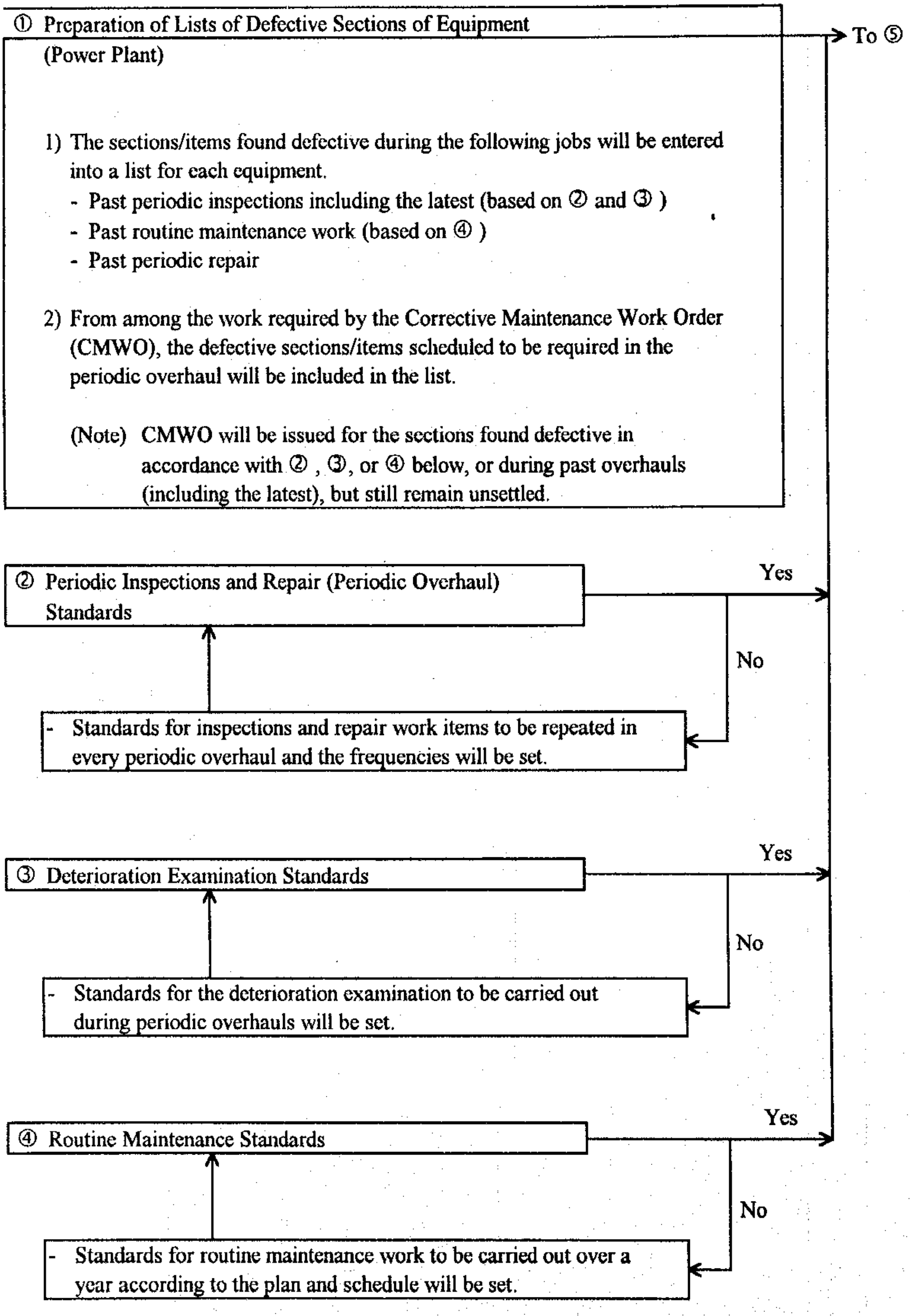


Figure 7- 4 Detailed Work-flow up to the Finalization of Periodic Overhaul Budget (1/6)



① Preparation of Lists of Defective Sections of Equipment
(Power Plant)

1) The sections/items found defective during the following jobs will be entered into a list for each equipment.
   - Past periodic inspections including the latest (based on ② and ③)
   - Past routine maintenance work (based on ④)
   - Past periodic repair

2) From among the work required by the Corrective Maintenance Work Order (CMWO), the defective sections/items scheduled to be required in the periodic overhaul will be included in the list.

(Note) CMWO will be issued for the sections found defective in accordance with ② , ③, or ④ below, or during past overhauls (including the latest), but still remain unsettled.

② Periodic Inspections and Repair (Periodic Overhaul) Standards

- Standards for inspections and repair work items to be repeated in every periodic overhaul and the frequencies will be set.

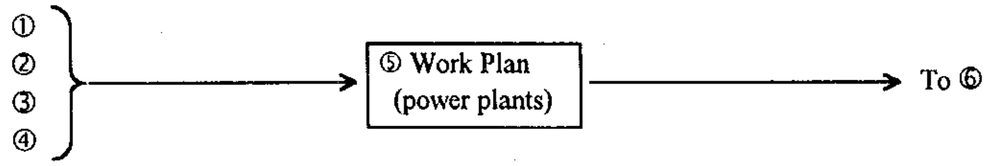
③ Deterioration Examination Standards

- Standards for the deterioration examination to be carried out during periodic overhauls will be set.

④ Routine Maintenance Standards

- Standards for routine maintenance work to be carried out over a year according to the plan and schedule will be set.

7- 4 Detailed Work-flow up to the Finalization of Periodic Overhaul Budget (2/6)



1. A Table of Planned Repair Work for each implementation year will be prepared.
   (Repair budget)

   1) Table of Planned Repair Work (outside the scope of the Periodic Overhaul Standards.)
      The table will be prepared for the coming three to five years. The sections and items for repair will be selected from among those listed in the aforementioned List of Defective Sections ①.

      From among repair work to be conducted during periodic overhauls, those which are not included in the scope of Periodic Overhaul Standards or Routine Maintenance Standards will be called special repair work.

   2) Periodic Overhaul Plan (within the scope of Periodic Overhaul Standards)
      - The Thermal Power Department of the Head Office has made the schedule of periodic overhauls for two years starting next year.
      - The power plants will formulate the periodic overhaul plan for the next year in accordance with aforementioned Periodic Overhaul Standards ②.

   3) Deterioration examination for the next year
      A plan will be made in accordance with the aforementioned Deterioration Examination Standards ③.

   4) Routine maintenance work plan
      Annual plan will have been made in the aforementioned Routine Maintenance Standards ④.

2. A table of planned improvement work for each implementation year will be prepared. (Facility budget)
   The table will be made out for the coming 5 years.
   The sections and items to be improved will be selected from among those listed in the aforementioned List of Defective Parts ①.

Figure 7- 4 Detailed Work-flow up to the Finalization of Periodic Overhaul Budget (3/6)

From ⑤ → ⑥ Drawing Up of Work Implementation Plan (Power Plant) To ⑦

1. Items to be studied

1) Selection of a work title for each repair or improvement to be implemented in the next year or thereafter

2) For each title,
   a. The reason for the work (and effect - in case of improvement work)
   b. Outline of work
   c. Delivery term for major materials
   d. Work period (the time and duration of work execution)
   e. Work budget (rough estimate)
   f. Relevant laws and standards
   g. To whom the order should be given

2. Preparation of documents to be submitted

2-1 Repair work plan for the next year → To ⑦-1
1) A breakdown table of special repair work budget
2) Outline of special repair work plan for each title name (a ~ g)
3) A breakdown table of repair work budget (concerning electric work and mechanical work)
4) Explanation on repair work budget

2-2 Improvement work plan → To ⑦-3
1) A summary table of planned improvement work for the next five years
2) A table of planned improvement work titles for the next five years
3) Outline of improvement work plan for each work title (a ~ g)

Figure 7- 4 Detailed Work-flow up to the Finalization of Periodic Overhaul Budget (4/6)

From ⑥

⑦ Submission of Plan and Budget
(Power Plant)

To ⑧

From ⑥-2-1

1. Repair work plan for the next year
   1) Order for preparation shall be given by Thermal Power Dept. in the Head Office. (End of September)
   2) Plan shall be studied and prepared by the power plant.
      - Deadline: End of October
   3) Submission of documents
      - Deadline: End of October
      - Submit to: Thermal Power Dept. in the Head Office

2. Improvement work plan for the next year
   1) Order for plan preparation shall be given by the Thermal Power Dept.. in Head Office. (Beginning of October)
   2) Plan shall be prepared by the power plant. (To be collected and put together by Engineering Section)
      - Deadline: End of October
      (Collected and put together by Engineering Section in the power plant)
   3) Submission of documents
      - Deadline: End of October
      - Submit to: Accounting & Finance Dept. in the Head Office

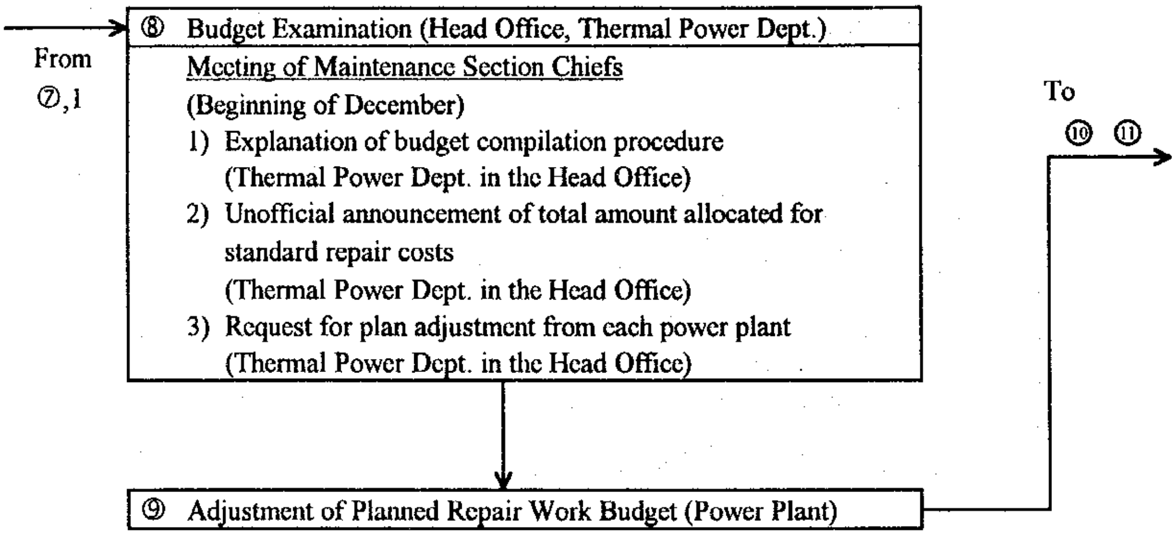
To ⑧

From ⑥-2-2

3. Improvement work plan
   1) Order for plan preparation shall be given by Thermal Power Dept. in Head Office. (End of July)
   2) Plan shall be studied and prepared by the power plant.
      - Deadline: September 15
      (Collected and put together by Engineering Section in the power plant)
   3) Submission of documents
      - Deadline: September 15
      - Submit to: Thermal Power Dept. in Head Office

To ⑧

Figure 7- 4 Detailed Work-flow up to the Finalization of Periodic Overhaul Budget (5/6)

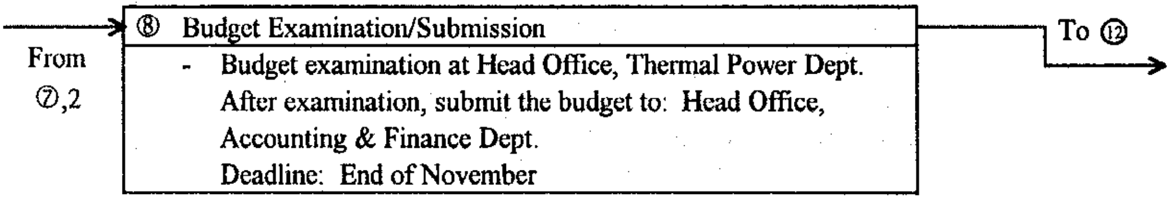


⑧ Budget Examination (Head Office, Thermal Power Dept.)

Meeting of Maintenance Section Chiefs
(Beginning of December)

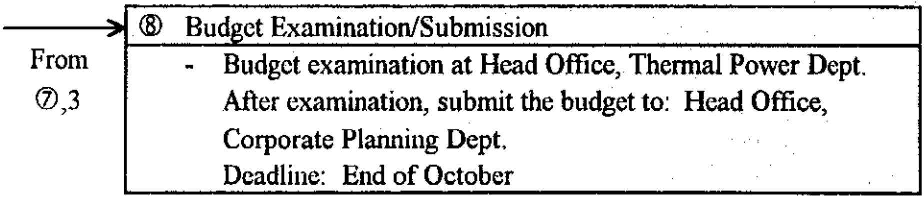
1) Explanation of budget compilation procedure
   (Thermal Power Dept. in the Head Office)
2) Unofficial announcement of total amount allocated for standard repair costs
   (Thermal Power Dept. in the Head Office)
3) Request for plan adjustment from each power plant
   (Thermal Power Dept. in the Head Office)

⑨ Adjustment of Planned Repair Work Budget (Power Plant)



⑧ Budget Examination/Submission

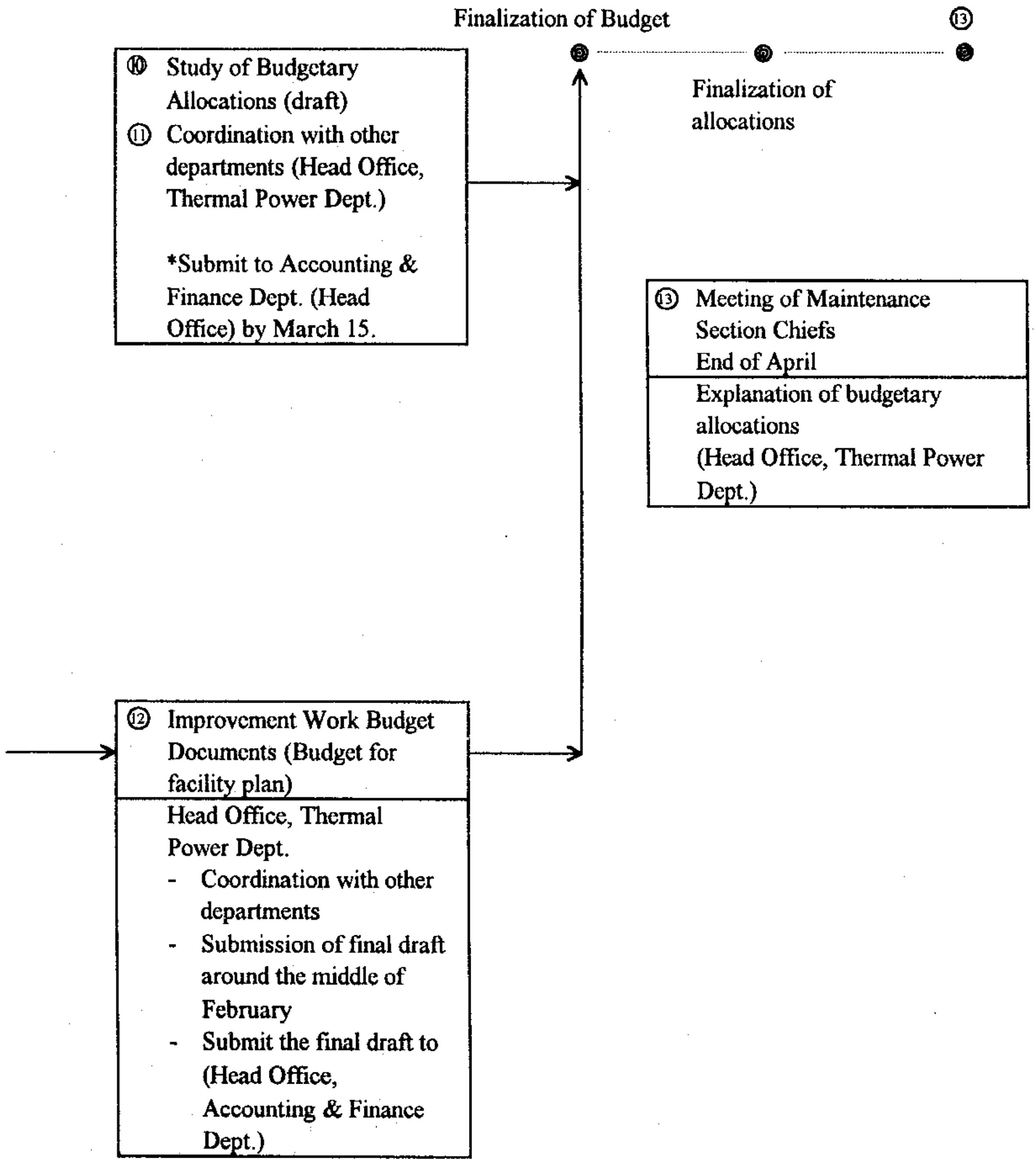
- Budget examination at Head Office, Thermal Power Dept.
  After examination, submit the budget to: Head Office, Accounting & Finance Dept.
  Deadline: End of November



⑧ Budget Examination/Submission

- Budget examination at Head Office, Thermal Power Dept.
  After examination, submit the budget to: Head Office, Corporate Planning Dept.
  Deadline: End of October

Figure 7- 4 Detailed Work-flow up to the Finalization of Periodic Overhaul Budget (6/6)



Note: 1. This chart is an example from Japan.
1. MMRC of NPC seems to correspond to the Thermal Power Dept., Corporate Planning Dept. and Accounting & Finance Dept. in the Head Office in Japan.

2) Preparation and Establishment of Periodic Overhaul Standards (Priority Item I-1)-a.)

a. Purpose

- To set standards for the kinds and intervals of periodic inspections; and
- To set inspection and repair work items to be repeatedly carried out at every periodic overhaul, and to set execution intervals for them.

b. Effects

- Periodic overhauls correspond to the periodic health check of humans. Vital sections will be regularly and successively inspected, and the collected data will be stored and accumulated. This will enable a grasp of current conditions and tendencies and encourage appropriate, economical, and timely repair.
- Establishment of Periodic Overhaul Standards will make it possible to computerize estimates of periodic overhaul costs and preparation of budgets, allowing for rationalization of job operation.

c. Contents of Work and Sections in Charge

- Preparation and Establishment of "Guidelines for Preparing Periodic Overhaul Standards"

Sections in charge	ERD and QA in the Head Office
Person(s) in charge	Designated manager(s) of ERD or QA
Responsibilities	- Drawing up of the guideline draft - Appointment of staff for the task - Supervision and control of the task operation - Coordination with the power plants and MMRC/MSD - Authorization of guideline draft - Notification, distribution and explanation of the guideline, after authorization, to the respective sections and departments concerned.

- Preparation and Establishment of Periodic Overhaul Standards for Each Power Plant

Section in charge	Power Plant	MSD	MMRC
Person(s) in charge	Manager of Maintenance & Repair Dept.	Manager designated by UP	Manager designated by VP
Responsibilities	- Preparation of standards for equipment to be inspected under the power plant's responsibility - All items related to the above	- Preparation of standards for equipment to be inspected under MSD's responsibility - All items related to the above	- Monitoring and steering of preparation - To obtain cooperation of ERD and QA of the Head Office, as occasion demands

Note:
1. Power plants and MSD will prepare the Periodic overhaul Standards (Draft) respectively in accordance with the aforementioned guidelines.
2. Each power plant will put together what has been prepared, including those made by the MSD, into their Periodic Overhaul Standards (Draft).
3. The MMRC will examine each power plant's Periodic Overhaul Standards (Draft) and authorize them.

d. Suggested Periodic Overhaul Standards

a) Categories and intervals of periodic overhauls

In order to help preparation of Periodic Overhaul Standards, a suggestion on the categories and intervals of periodic overhauls is provided in Table 7-2 for reference.

When this table is applied to the Units No. 1 and No. 2 of the Malaya TPP as of the end of 1993, both the units fall under the category of Special Precise Inspection on Long-term Running Unit (S-inspection) because the total operating hours after the initial commissioning exceed 100,000 hours, as mentioned below.

	Total Operating Hours (Hr.)	Total No. of Start-up
No. 1 Unit	116,089.01	359
No. 2 Unit	101,510.93	213

Table 7-2 A Draft of Standards for Periodic Overhaul Categories (for Reference)

Periodic Overhaul Categories	Levels of Inspection*[1]
Periodic Inspection for Standard Use Period*[2]	A-inspection
	B-inspection
	C-inspection
Periodic Inspection for Prolonged Use Period *[3]	A or B, plus S-inspection

Notes: *[1] Levels of inspection

A-inspection; Level of inspection which allows 4 years continuous operation for turbine and 2 years for boiler before coming overhaul.

B-inspection; Level of inspection which allows 3 years continuous operation for turbine and 1.5 years for boiler before coming overhaul.

C-inspection; Level of inspection which allows 2 years continuous operation for turbine and 1 year operation for boiler before coming overhaul.

S-inspection; Inspection to be added which is included in "Periodical inspection after long-term operation" shown in Appendix 5-4.

*[2] The period from the 2nd year after initial operation up to 100,000 hours (total operation hours after commissioning) or up to 2500 times (total number of start-ups after commissioning) is categorized as normal stage, and standard-type periodic inspections (A or B or C) will be conducted.

However, during the initial periodic inspection, detailed inspections shall be conducted in addition to the standard-type periodic inspections so that initial stage troubles and problems particular to the facility will be identified.

*[3] The period exceeding that of the 'Periodic Inspection for Standard Use Period' is categorized as the prolonged use period and, in addition to the standard-type periodic inspections (A or B), detailed inspections (S-inspection) will be conducted so that the state of deterioration will be grasped and data necessary for taking measures for future operations will be collected.

b) Combination of Periodic Inspection Categories

Diverse patterns are conceivable for the order and combination of periodic inspections. Those in charge of facility management must consider the execution schedule of periodic inspections in accordance with the operating conditions of facilities such as turbines and boilers, and plan the order and combination properly.

The order of the periodic inspections shall be based on the following rule:

- As a principle, A-and B-inspections shall be conducted alternately.
- The first periodic inspection shall be A-inspection.
- The inspection immediately after an extended interval of periodic inspections shall not be C-inspection.
- Consecutive implementation of C-inspections shall not be allowed.
- The periodic inspection either before or after C-inspection shall be A-inspection.

Examples of the combination concept based on the above-stated rule are provided in Table 7-3 and 7-4.

Table 7-3 Periodic Inspection for Standard Use Period (Example)

	Year	0	1	2	3	4	5	6	7	8	9
Basic	Boiler	A	B	A	B	A	B	A	B	A	B
	Turbine	A		B		A		B		A	
Application example 1	Boiler	A	···B		···A	···B		···A	···B		···A
	Turbine	A			···B			···A			···B
Application example 2	Boiler	A	C	B	C	A	C	B	C	A	
	Turbine	A		C		B			C	A	
Application example 3	Boiler	A	C	A	C	A	C	A	C	A	
	Turbine	A		C		A		C		A	

Note: In this table, the starting point is the year when A-inspection is conducted for both boiler and steam turbine.

Table 7-4 Periodic Inspection for Prolonged Use Period (Example)

The basic combination is the same as for the standard use period. Special inspections (S-inspection) under the Deterioration Examination Standards shall be conducted in addition to A- or B-inspections.

Year		0	1	2	3	4	5	6	7	8	9
Basic	Boiler	A	B	A	B	A	B	A	B	A	B
	Turbine	A		B		A		B		A	
Application example 1	Boiler	A	B		A	B		A	B		A
	Turbine	A	B		A	B		A	B		A

Note: In this table, the starting point is the year when A-inspection is implemented for both boiler and steam turbine.

c) Periodic Inspection Work Items

- Periodic inspections are divided into three large types of A, B, and C. Standards for the work items for each of these three inspection types and those for S-inspection shall be prepared.
- A draft of the standards shall be prepared for boiler facilities and turbine facilities.
- For ease and convenience in preparation of a draft of standards, utilize the standards which have been actually used. Such a sample is provided in Appendix 5-4. (Source: Guidelines of Periodic Inspections for Commercial Thermal Power Plants, December 1987, issued by Association of Thermal & Nuclear Power Generating Engineering, Japan)

d) Periodic Inspection Work Procedures (Reference)

Concerning the standard work items discussed in the previous paragraphs, inspection procedures, including the frequency and degree of disassembly, contents of inspection, and work procedures, are described in the aforementioned guidelines.

3) Days Required for Standardized Periodic Overhaul for Each Unit (Priority Item I-1-b)

a. Purpose

- Along with the establishment of standards for periodic overhauls, the appropriate number of days required for such standardized periodic overhauls shall be determined.
- The days needed for a standardized periodic overhaul shall be determined in accordance with unit capacity, type of main equipment (boilers, turbines) and fuel variety, and also with the periodic inspection category and the combination of inspection types.

b. Effects

- Once the basic schedules of standardized periodic overhauls (Days of SPO) have been established, the power plant and the MSD will be able to make long-term periodic overhaul plans more easily. Further, the MMRC will be able to collectively grasp the overhaul plans of the power plants, and will be able to manage the comprehensive program.
- Establishment of the SPO duration requires, as a basis, the standardization of SPO processes. This will enable the man-hours to be established for each work item of the standardized periodic overhaul, which will pave the way for a standardized and computerized budget.

c. Sections in Charge and Responsibilities

Sections in charge	Power Plant	MSD	MMRC
Person(s) in charge	Manager designated by plant manager	Manager designated by VP	Manager designated by VP
Responsibilities	- All items relevant to this task - In consultation with the MSD, each power plant shall formulate their own standardized periodic overhaul processes and determine the number of days required. - Rendering cooperation to the MMRC by joining MMRC-hosted conferences and other activities.		- See below

Responsibilities of the MMRC

- To present a policy on this project to the concerned sections in the Head Office and the respective power plants for internal confirmation.
- To set the launching date and completion target date of the task for each power plant, and to notify them of the schedule.
- To monitor the progress of each power plant, and give necessary advice.
- To study the drafts submitted by the respective power plants and prepare the standards (draft) as a whole.
- To adjust and coordinate the standards (draft) within the MMRC as well as with the concerned sections in the Head Office.
- To authorize the adjusted and coordinated draft in-house and put the standards into practice under the name of the VP.

d. Determining the Days Required for Standardized Periodic Overhauls

- Based on the standards for periodic overhauls (standardized periodic overhaul work items and periodic inspection categories), days required for standardized periodic overhauls, i.e. standard number of days and processes, shall be studied.
- The points to which attention must be paid are:

a) When records of processes or number of days needed for past periodic overhauls are referred to, work other than standardized periodic overhauls, such as special repair work or improvement work, should be excluded. In addition, extensions of work schedules due to delay in delivery of purchased parts should not be taken into consideration.

b) The periodic overhaul plan of the MSD and power plant maintenance repair group who take charge of the work, as well as work executing capability and efficiency, should be taken into consideration. The reason is that these are vitally important factors which may determine the issue of the number of days needed.

- Table 7-5 gives an example of s standardized number of days for periodic overhauls in Japan. This can be used as a reference for the NPC study.

Table 7-5 Days Needed for Standardized Periodic Overhauls in Japan (for Reference)

Thermal Power Plant		Periodic Inspection Categories		
Output (MW)	Fuel	a-A	a-B	b-B
500	Heavy Oil	53	45	36
375	Heavy Oil	50	42	32
250	Heavy Oil	48	37	27
700	Coal	70	70	55

Note: Periodic Inspection Categories

a; Boiler - A-inspection A; Turbine - A-inspection

b; Boiler - B-inspection B; Turbine - B-inspection

Refer to Table 7-2 for definition of A- and B-inspections.

Days are working days, not including holidays.

e. Days Needed for Standardized Periodic Overhauls (Suggestion)

a) MMRC Annual Periodic Overhaul Schedule

The NPC has prepared the periodic overhaul schedule for 1995 (dated December 6, 1994). (Refer to Figure 4-8) According to this schedule:

- 90 days are required for standardized periodic overhauls for existing thermal power plants, regardless of the capacity of the power plant unit.
- Between periodic overhauls, maintenance outages of 6 days are scheduled twice.
- Total yearly outage per unit comes to 102 days, leaving availability at 72%.
- The 90 days decided upon for periodic overhaul is assumed to have been arrived at through past experience as the longest commonly applicable period.

b) Days Needed for Standardized Periodic Overhaul (Suggestion)

The standardized periodic inspection items are considered to be about the same as those in Japan. As a suggestion for the (targeted) days for standardized periodic overhaul to be applicable when the periodic overhaul plan in the MSD and power plants as well as the improvement of the execution capabilities proposed in this report have been implemented, we propose the following Table 7-6.

Table 7-6 Days Needed for Standardized Periodic Overhauls (suggested targets)

Thermal Power Plant		Periodic Inspection Categories		
Output (MW)	Fuel	a-A	a-B	b-B
350	Heavy Oil	55	41	36
300	Heavy Oil	50 (85)	37	35
200	Heavy Oil	45 (85)	32	30
300	Coal	60	50	40

Note: The Figures in parentheses are for Siemens turbine.

a-A; Boiler A inspection Turbine A inspection

a-B; Boiler A inspection Turbine B inspection

b-B; Boiler B inspection Turbine B inspection

Table 7-7 Breakdown of Required Number of Days of Disassembled Inspection

	GE, WH type Turbine (375 MW)	Siemens Turbine
Cooling down	5	5
Disassembling	10	30
Inspections	7	7
Assembling	15	30
Oil flushing until start-up	13	13
Total	50	85

4) Reinforcement of Formulating Function of Periodic Overhaul Plan (Priority Items, I-2)

a. Purpose

- To clarify the section in charge of periodic overhaul and the scope of responsibility at Power Plant and MSD.
- To review organization and allocation of personnel which are deemed to be necessary in connection with the above mentioned item, and to set the improvement.

b. Effects

- To promote formulation of perfect periodic overhaul plan

c. Section in Charge of Review of Work and Items in Charge

Sections in Charge	Power Plant	MSD	MMRC
Person(s) in Charge	Manager designated by Plant Manager	Manager designated by VP	Manager designated by VP
Responsibilities	1. Review of Statement of Function - From a viewpoint of implementation of perfect periodic overhauls, on the periodic overhaul plan (Contents of Work, Work Schedule, Budget, etc., Everything), to review the scope of work in charge of each section and to adjust it. - Based on the results of the work mentioned above, to draw up a draft of revision for the existing statement of function. 2. To study on the necessary organization and allocation of personnel in connection with the revision mentioned above. 3. Regarding works aforementioned, to participate in the meeting sponsored by MMRC. 4. To cooperate with MMRC on putting works together		Items described below:

Items in charge of MMRC:

- To show the policy of the work to relevant sections in Head Office, MSD and each power plant and to confirm it in NPC
- To set the starting date and scheduled completion date of works at each power plant, to indicate them to MSD and each power plant
- To monitor progress conditions of the works above mentioned and to give necessary advice.
- To study on the proposals submitted by each power plant and to draw up a corporate-wide revised draft plan.
- To adjust the plan with relevant sections of MMRC and those of Head Office
- To authorize the draft plan and to make public and implement under the name of VP.

d. Review of Statement of Function

Power Plant:

P & S (Planning & Scheduling), which is one section of maintenance groups, must take responsibility for essential role on implementation of perfect periodic overhaul plan. The role is to be clarified in the statement of function.

a) Present Function of P & S

Present Functions	Points of Review
1. Planning & scheduling of predictive, preventive maintenance, minor and major overhaul.	1. The present function is sound, however, the following are to be considered. (1) Drawing up individual work plan and schedule is not P & S's duty, but the responsibility of the sections concerned. P & S is rather to act as coordinator of maintenance groups of Power Plant and each section of MSD, and to monitor the progress of their work, from the stand point of overall Power Plant. (2) Section Chief of P & S is able to make a request necessary for execution of the duty to maintenance groups of Power Plant and MSD's each section. Each section shall follow the request.
2. Adjustment of the plans and schedules with other sections in power plant	2. To conduct adjustment among power plants and MSD as well as among other sections in a power plant
3. Monitoring and follow-up after procedures for placing order of spare parts, materials	3. P & S should not be responsible for follow-up of requisitioned materials and parts. It is the responsibility of the requisitioning sections to follow up these requisitions. P & S should, however, monitor the status of these requisitioned items.

b) Division of Functions among P & S and Each Maintenance Section

- From the stand point of implementing perfect periodic overhaul plan, each group is to clarify the respective duty in detail referring to Table 7-8 "Division of Duties in Connection with Periodic Overhauls".
- Based on the results mentioned above, to draw up drafts of Statement of Function and Statement of Duties.

c. Study on Organization and Allocation of Personnel

In connection with the review of assignment of duties aforementioned, organization and allocation of necessary personnel will also be studied.

Existing allocation of personnel of the power plant is as follows;

Superintendent A	1 person	(Section Manager)
Principal Engineer B	1 person	(Assistant Section Manager)
Principal Engineer C	3 persons	Engineer(s) in charge of each assigned duty
Senior Engineer	1 person	
Senior Draft-man	1 person	(Person in charge of drawing)
Data Controller/encoder	1 person	(Person in charge of documents)

Table 7-8 Division of Duties in Connection with Periodic Overhauls (referred to Figure 5-3 and Table 5-7)

Duties	P & S	Each Section of Maintenance Groups
1. Planning - Work item, scope and contents - Schedule - Budget - Purchase plan of parts and materials - Engineering	- To request drawing up the plan, informing the planning policy to each section of power plant and MSD. - To adjust and arrange the items drawn up by each section - To arrange and coordinate the plan as for power plant including items prepared by MSD. - Prepare Bar charts, PERT-CPM for overall works - Addresses concerned groups of changes to plans and schedules	Each section is to implement the respective items in charge. - Mechanical Maintenance - Electrical maintenance - Instrument & Control Maintenance - Chemical

2. Requisitioning
- Drawing up purchase specifications
- Drawing up a written estimate
- Drawing up documents of application for approval by relevant sections and departments
- Drawing up and submission of Purchase Requisition
  - Spare parts, materials, equipment, etc.
  - Items relevant to maintenance work
	- To monitor status of inventory of spare parts and materials needed for preventive maintenance and periodic OH.
	- To initiate necessary PRs including preparation
		Each section is to implement the respective items in charge.
		- Mechanical Maintenance
		- Electrical maintenance
		- Instrument & Control Maintenance
		- Chemical

Duties	P & S	Each Section of Maintenance Groups
3. Implementation		
- Preparation for maintenance work	NA	Each section of power plant and MSD is to implement the respective items in charge. - Receiving should be joint responsibility of end user and Q. C.
- Receiving procured parts and components - Testing - Certificate of acceptance	NA	
- Overall implementation plan - Implementation of maintenance work	Coordination among all groups is to be responsibility of P & S including tagging out and isolation of system to be worked out by concerned maintenance sections	
- Management of work schedule	P & S is to be responsible for monitoring overall progress of the work and revision/updating of Bar chart, PERT-CPM as necessary.	Each section is to conduct schedule control of the work in charge. The progress condition is to be submitted to P & S.
- Performance test planning, implementation and preparation of reports	Efficiency & Control has the responsibility and other sections groups will cooperate with the items.	Same as the Left
4. Management of reports and documents		
- Preparation of reports	- NA	- Preparation of reports is to be implement by each section of power plant and MSD.
- Collection and arrangement of records such as measurements, tests during periodic overhaul	- To arrange and collate all reports drawn up by each section.	- The records are submitted to P & S.

7.3.2 Complete Implementation of Periodic Overhaul (Priority Item II)

1) Approach to Improvement Plan

The measures deemed necessary for complete implementation of periodic overhauls are given in Table 7-1. The following three items will be particularly essential:

1 To make mandatory, implementation of periodic overhauls in conformity with periodic overhaul standards

2 To review MSD's insufficient logistic for work implementation and to formulate an improvement plan

3 To review and improve the existing organized implementation system and clearly define the lines of responsibility for periodic overhauls

Approach concerning these items will be outlined below:

2) To make mandatory, implementation of periodic overhaul in conformity with periodic overhaul standards

a. Purpose

- Company guidelines which stipulate mandatory implementation of periodic inspections will be formulated and enacted.
- Legal measures, if possible, supporting said guidelines will be studied and made into a proposal to submit to superior officers or upper management

b. Effect

- Ensured complete implementation of periodic inspection for facilities by the facility owners will contribute to the improvement of power plant reliability, thereby stabilizing electric power supply.
- Now that the balance between supply and demand of power has finally been improved by development of a new power source and brown-outs have been almost eliminated, it is high time to implement complete periodic overhauls. If this opportunity is missed, the effects cannot be completely predicted nor should they be underestimated.

c. Sections in Charge of Work and Responsibilities (Suggestion)

Sections in charge	Head Office ERD/QA	MMRC
Person in charge	Manager designated by VP in charge of ERD/QA	Manager designated by VP
Responsibilities	- Preparation of company regulations (draft) stipulating mandatory implementation of periodic inspections - Study of legal measures supporting said company guidelines and preparation of the proposal	- To extend cooperation to the Head Office sections in charge of carrying out the work

d. Contents of the Company Regulations Stipulating Mandatory Implementation of Periodic Inspections (for reference)

a) Power plant facilities and their scope or sections to be subjected to the periodic inspections shall be specified.

b) Standards for implementation period and interval of periodic inspections

c) Persons in charge of inspections (e.g. to be selected from MMRC or ERD)

e. Study of Legal Measures Concerning Periodic Inspections, and Preparation of the Proposal

a) Research and review of the examples implemented in other countries

b) Preparation of proposal and submission to superior officers

3) Review of the MSD's Insufficient Capability for Work Implementation, and Proposal of Improvement Plan

a. Purpose

- Preparation of improvement proposal on MSD's capability for work implementation

b. Effect

- To contribute to complete implementation of periodic overhaul

c. Sections in Charge of Work and Responsibilities (suggestion)

Sections in charge	Head Office, Personnel Dept. Human Resources	MMRC/MSD/Power Plant
Person in charge	Manager designated by VP	Manager designated by VP
Responsibilities	1. Review of the recommendations and improvement plans given in this report concerning power plant/MSD staff size and education/training	1. Same as 1. left. In addition, collection and sorting of review results and submission to the Head Office (Personnel Dept.)
	2. Completion of NPC's Improvement plan concerning MSD staff size and their education & training by taking the results of the MMRC's review, and submission to superior officers	2. Review of recommendations and improvement plans given in this report concerning facilities and equipment necessary for MSD's capability improvement. Completion of review results and submission to superior officers

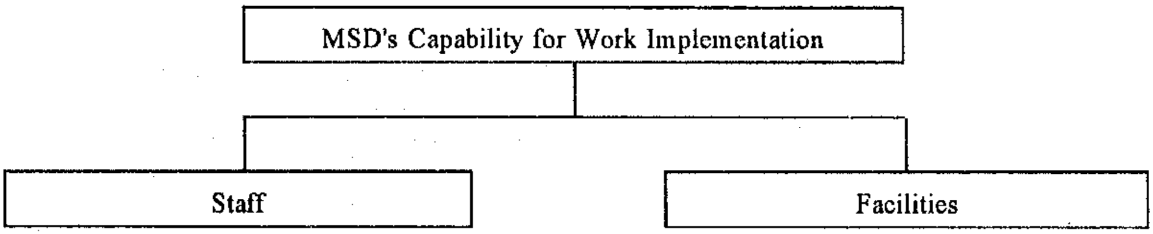
Note: For review of the improvement plans provided hereinafter, task forces will be organized and led by a manager designated by the VP. Each task force shall prepare respective work schedule and establish the general work schedule in the joint meeting.

d. Improvement Plan of MSD's Capability for Work Implementation

a) Improvement fields and issues to be examined

Improvement of capability requires a number of issues to be considered as listed below. The task forces will address these issues and prepare the improvement plans.

Figure 7-5 Improvement of MSD's Capability for Work Implementation



- Review of necessary number of staff and sufficiency
- Implementation of education and training
- Nurturing or training subcontractors
- Improvement of work procedure manuals

- Sufficiency of equipment and tools for work
- Preparation of transporting and carrying vehicles
- Preparation of site office and accommodations
- Preparation of facilities for skill education and training

b) Re-examination of Required Number of Staff, and Sufficiency

- Annual Periodic Overhaul schedule, 1995

  Figure 4-8 (signed) is the annual maintenance schedule for 1995 gathered by the MMRC for thermal power plants.

  - The schedule is so prepared that two or more power plants will not concurrently undergo a major overhaul. This matches the general estimation on the current capability of MSD that they cannot effectively implement more than one major and one minor overhaul at the same time.
  - The schedule also suggests that they make it a policy to conduct the periodic overhaul once every year for each unit. However, it has periodic overhauls for many power plant units in January, when there deems to be practical problems.

- Necessary number of MSD staff

  Based on the aforementioned annual maintenance schedule, we estimated the necessary number of overhaul staff throughout the year from a broad perspective. The result is provided in Figure 5-22. In this figure, periodic overhauls for gas turbines are included.

  This Figure 5-22 indicates that the hatching section requiring more than the total 189 MSD engineers (as per Figure 5-11 MSD Organization Chart) requires staff supplement.

- Total number of required supplement of staff for MSD (estimate)

Peak period	roughly 200 skilled workers and craftsmen	[3 units (350 MW, 250 MW & 100 MW) and gas turbines]
Intermediate period	roughly 100 skilled workers and craftsmen	[2 units (including a 350 MW unit) and gas turbines]
Off-peak period	roughly 20 skilled workers and craftsmen	[2 units (100 MW & 150 MW) and gas turbines]

Conventionally, such personnel shortages were supplemented by temporary employment from outside in addition to assistance from maintenance & repair staff and operators of power plant.

(Policy for re-examination)

- Out of the schedule over a year, the peak period is rather short (roughly one month). Therefore, the targeted number of supplemental staff members shall be 100 (maximum), and for the first stage half will be necessary (roughly 50). Proceeding on to the second stage will be done only after reviewing the results of the first stage.
- The remaining shortage of staff for the peak and intermediate periods will be supplemented with temporary employment from outside.

- In-house MSD staff supplementation method

  It is practical to replenish the staff shortage with personnel from power plants within the NPC. A suggestion of the procedure for this is provided below:

1 Re-examine the required number of operators per shift for each power plant.

2 As a result of 1 above, several operators may be transferred to maintenance & repair group.

3 After the increase in maintenance & repair group engineers, an equivalent number will be allocated to MSD.

4 For those transferred from operations to maintenance & repair group, education and training will be implemented systematically.

5 Those maintenance engineers allocated to MSD will, during the periodic overhaul at the power plant to which they currently belong, be engaged in the periodic overhaul there, and will be assigned to other power plants for the periodic overhaul as required.

- Details Concerning 1 and 2 above

1 Re-examination of the Required Number of Operators Per Shift at Power Plant

The current full strength of shift operators/shift is as follows:

Power plant	Malaya No. 1 & No. 2 Units	
Shift operators total number/number per shift	105 / 20	
Operations Superintendent A	1	3
Operations Principal Engineer B	2 (1 + 1)	
Boiler	6 (3 + 3)	8
Auxiliary	2	
Turbine	4 (2 + 2)	6
Auxiliary	2	
Electrical control	3	3

The number in brackets indicate the number of operators per unit. Those for chemical service are excluded.

The full strength for shift operations shall be reviewed so that it will correspond to the present conditions at Malaya Power Plant.

	Present	After review	Surplus
Boiler operators	3 + 3 = 6	(2 + 2) + 1 = 5	1
Turbine operators	2 + 2 = 4	(1 + 1) + 1 = 3	1
Chemical operators	3	2	1

Similar number of reduction in average may be expected for power plants other than Malaya TPP after review. This will allow for total reduction per power plant of: 3 operators x 5 shifts = 15 operators. Necessary measures shall be studied in efforts toward this goal.

2 Transfer to Maintenance & Repair Group

Each power plant shall study the transfer of these 15 operators to another group including maintenance & repair group.
The number of operators to be transferred to maintenance & repair group is assumed to be 10, not including the operator for chemical.

3 Selection of Engineers to be Allocated to MSD

From among the engineers in the MSD (excluding those operators to be transferred from shift operations), those to be assigned to MSD shall be selected. Targeted number is 10 (5 in the first stage and 5 in the second stage).

4 Implementation of Education/Training

- Scheduled training will be given to those personnels transferred from operations group to maintenance group by each job group.
- The human resources group at Head Office will also let them participate the education and training program to cooperate the above mentioned education and training.

5 The maintenance personnel of MSD stationed at a particular power plant will join the overhaul work of his plant during the overhaul period, however, he will work for the overhaul of other plant while his plant is under operation.

Reinforcement of MSD personnel by the above scheme will be completed within 5 years.

4) Fostering of Subcontractors

a. Purpose

Subcontractors shall be fostered for efficient and economic supplement of the capability of MSD.

b. Effect

- Since the NPC supervisor can control the overhaul work through the supervisors of the subcontractors, he can avail himself of ease of schedule and quality control of the various works simultaneously conducted.
- Specifying the work by the contract specifications, the scope of the responsibility of the contractor can be easily clarified to enable less MSD personnel should the contract include the procurement of the equipment and materials for the work and required labor.

c. Fostering Plan of Subcontractors

a) A section in charge of fostering of subcontractors will be created within MSD.

b) That section of MSD will prepare the fostering plan through the coordination with relevant departments and sections of MMRC.
  - Short listing of Candidate Subcontractors
    Subcontractors (in plural number) and their respective area of the work will be decided on the basis of their experience on the overhaul and inspection works of power plant equipment or similar.
  - The selected subcontractors will be constantly given some particular portion of the overhaul works to let them obtain skills and know-how of the overhaul work for the fostering purposes.

c) Their capability shall gradually be strengthened and scope of works expanded of subcontractors.

7.3.3 Safe and Reliable Operation (Priority Item III)

1) General

Even if the rehabilitation of power generating facilities (hardware) and improvement of maintenance and periodic overhauls, explained in Clause 7.2, are implemented, reliability of a power plant cannot be maintained if the power generating facility is not operated properly or is damaged by misoperation.

Since operations are not always in the hands of experienced operators, it is necessary to establish a system that ensures safe and proper operation even when the operation is conducted by inexperienced young operators.

Concrete measures are explained below.

2) Measures

a. Complete Preparation of Operation Manuals

As referred to in Chapter 5, the operation manuals currently used in the power plants are insufficient. More comprehensive operation manuals should be prepared, in which the contents can be thoroughly understood by all operators. These manuals should be prepared by effectively utilizing the OMP (Operations Management Program) organization and under the cooperation of power plant personnel.

b. Daily Patrol and Inspections, and Routine Work

a) Daily Patrol and Inspection by Operators

At the Malaya TPP, in view of its superannuated facilities with insufficient monitoring instruments and alarm devices, hourly patrol and inspections are indispensable for early detection of abnormalities. However, selective patrol with rationalized patrol items is possible.

For safe and proper patrol and inspections, the patrol passages and lighting equipment must be improved and gas or steam leaking sections must be repaired.

Efforts should be made to avoid leaving troubled sections un-repaired for an extended period.

b) Stand-by Equipment Change-over Test and Other Routine Operations

No problem seems to exist in the current intervals of spare equipment switching tests for auxiliary equipment and turbine routine tests.

To prevent operational errors and to record the results of the operational performance during switching, a routine operation check-sheet needs to be prepared. In addition, for comprehensive management of routine work, a monthly routine table should be prepared to ensure accurate implementation of prescribed routine operations.

c. Operational Rotation System

a) Operation Staff and Rotation Staff Structure

Although the Malaya TPP has a central control system, the power generating facilities are old and, therefore, not designed for automation and labor-saving. An effective means for improvement of the power plant reliability would be to reduce the number of operators through automation of the facilities, and reinforce the maintenance and repair system by sending the freed staff to maintenance and repair, thereby securing them for periodic overhauls.

b) Shift Categories and Shuttle Bus Service

Since traffic congestion in Metro Manila has become aggravated and a reduced commuting time cannot be expected, it is imperative to lessen the commuting drag by increasing bus operations and improving road conditions. As a fundamental measure, we also recommend that company houses and dormitories be constructed in the vicinity of the Malaya TPP.

Example of Increased Bus operations: Total 3 buses by adding one bus

	Quezon	MYTPP		Quezon		MYTPP		Manila
No. 1	Lv.	Arr.	LV.	Arr.	Lv.	Arr.	Lv.	Arr.
bus	5:50	7:30	8:00	9:30	1:30	3:00	4:30	6:00
	a.m.	a.m.	a.m.	a.m.	p.m.	p.m.	p.m.	p.m.

	Manila	MYTPP		MYTPP	Manila
No. 2	Lv.	Arr.		Lv.	Arr.
bus	5:50	7:30		4:30	6:00
	a.m.	a.m.		p.m.	p.m.

The No. 3 bus runs on the same schedule as the No. 2 bus.

	Manila	MYTPP		MYTPP	Manila
No. 3	Lv.	Arr.		Lv.	Arr.
bus	5:50	7:30		4:30	6:00
	a.m.	a.m.		p.m.	p.m.

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

1) General

The current lowered reliability of the Malay TPP is caused by a tangle of diverse factors. Comprehensive improvement measures to eliminate all these factors are called for. Moreover, since it is people, after all, who really solve problems, improvement of power plant reliability cannot be expected without dealing with the human issues. Recently the NPC has been well aware of the importance of this issue, and a variety of improvement measures have been studied, including the Cadetship Program, Apprenticeship Program, and Student Traineeship Program and education & training plan of experienced personnel.

To reinforce and supplement these improvement measures at the NPC, the following improvements concerning the hiring system and education and training methods of NPC personnel should be implemented as soon as possible.

2) Measure

a. Hiring System

a) Review of Staff Complement

Whether the current complement is appropriate or not shall be reviewed in detail for each section and department in the power plant organization and MMRC.

b) Formulation of Long-term Hiring Plan

A long-term hiring plan shall be formulated by forecasting future vacancies and increasing staff (vacancies from retirement on or before retirement age, and increases based on the power development plan).

c) Hiring System

The current practice of hiring whenever there is an opening shall be replaced by a hiring system in which all necessary personnel will be recruited from graduating classes at a predetermined time every year based on the above-mentioned long-term hiring plan.
As one (1) of the measures to materialize this regular hiring, the study on the conversion of the positions prepared for cadetship program into those for regular employee will be conducted by NPC.

b. Education and Training

Education and training should be implemented separately for new employees and employees with some experience.

a) Education of New Employees

- Collective education of new employees

  In tandem with annual periodic hiring, collective education for newly employed power plant personnel and MMRC engineers shall be implemented in the NPC Training Center. (It would be even better if this could be a join education program including technical staff from the Head Office.)

  The following are possible subjects of education:

- Basic education

- Consciousness and attitude:	Along with aiding in a smooth transfer form student life to adult life, this education can help them enhance their consciousness as a member of society and a member of an organization.
- Knowledge and skill:	Help them acquire knowledge about the power supply industry and basic skills as to how a job should be conducted.

- Professional education

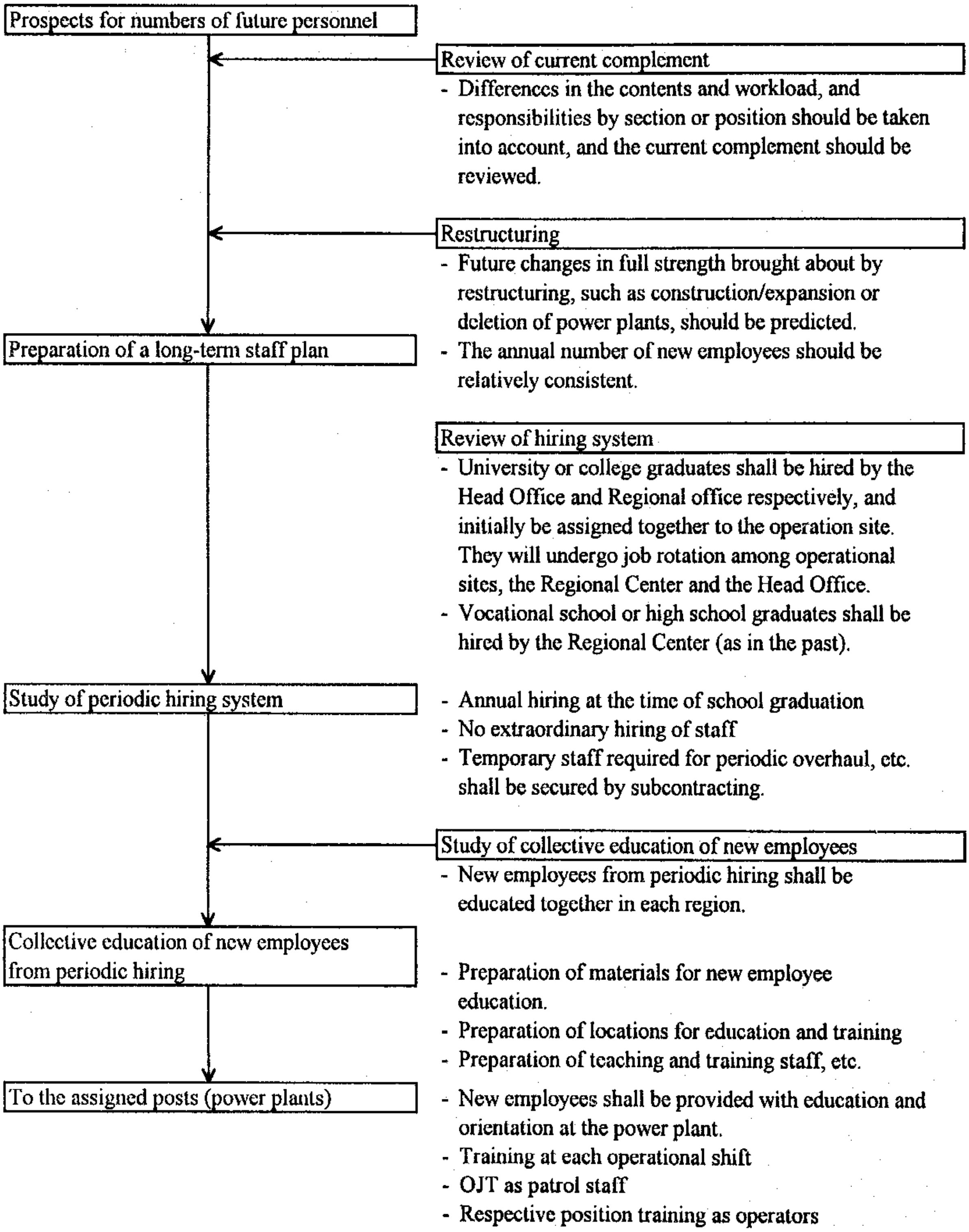
  Provides them with the broad technical knowledge and skill necessary for fulfillment of their job, based on actual work procedure.

- Education at the power plants
  - After the above-explained collective education at the Training Center, all new technical staff will be sent to their respective power plants to undergo orientation.
  - Thereafter, they will be respectively allocated to operational shifts as operator trainees to undergo on-the-job training (OJT) for roughly 6 months.
  - After completion of the above training, they will be officially logged into shifts to work as a member of a patrol staff for three months. Then, they will be assigned to respective positions as operators to carry out the OJT for their position for a year.
  - Operator education will be carried out using the simulator.
  - Thereafter, they will be sent to sections in the power plants or to MMRC.

c. Implementing Procedure of Hiring and Education of New Employee

The procedure to implement the hiring system as well as the education and training of new employees explained in 1) and 2) above are summarized in the flow chart of Figure 7-6.

Figure 7-6 Employment of a Periodic Hiring System and Implementation of New Employees' Collective Education



Prospects for numbers of future personnel

Review of current complement

- Differences in the contents and workload, and responsibilities by section or position should be taken into account, and the current complement should be reviewed.

Restructuring

- Future changes in full strength brought about by restructuring, such as construction/expansion or deletion of power plants, should be predicted.
- The annual number of new employees should be relatively consistent.

Preparation of a long-term staff plan

Review of hiring system

- University or college graduates shall be hired by the Head Office and Regional office respectively, and initially be assigned together to the operation site. They will undergo job rotation among operational sites, the Regional Center and the Head Office.
- Vocational school or high school graduates shall be hired by the Regional Center (as in the past).

Study of periodic hiring system

- Annual hiring at the time of school graduation
- No extraordinary hiring of staff
- Temporary staff required for periodic overhaul, etc. shall be secured by subcontracting.

Study of collective education of new employees

- New employees from periodic hiring shall be educated together in each region.

Collective education of new employees from periodic hiring

- Preparation of materials for new employee education.
- Preparation of locations for education and training
- Preparation of teaching and training staff, etc.

To the assigned posts (power plants)

- New employees shall be provided with education and orientation at the power plant.
- Training at each operational shift
- OJT as patrol staff
- Respective position training as operators

d. Education of Experienced Personnel

a) Special Skill Education

Education and training for special skills required in each section of the power plant shall be provided for an adequate length of time at the training center, at the manufacturers' or at varieties of research institutions, etc.

b) Position Training of Operators

Regardless of transfers to fill vacancies opened through retirement of an operator, position training shall be planned and implemented systematically as a part of the plan. The implementation plan shall be particularly designed to educate younger operators.

c) Operator Training with a Simulator

- Training shall be conducted by using the simulator to be constructed with the No. 2 Unit of the Batangas Power Plant (expected to start operation by the third quarter of 1995)
- In accordance with years of experience, operation personnel will take the following courses (reference)

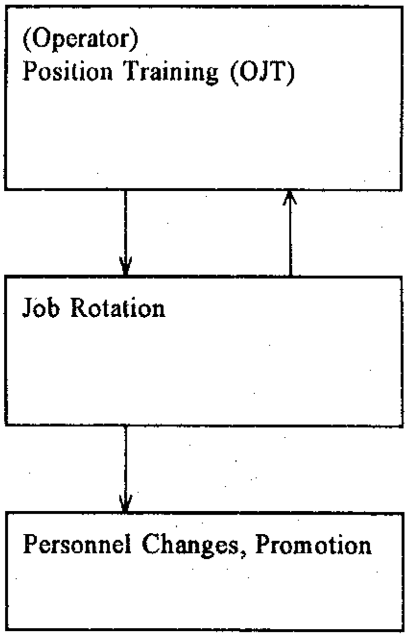
Basic course	2nd year of employment	5 days/session	6 people/session*[1]
Middle-standing course	3rd to 5th year of employment	3 days/session	6 people/session*[1]
Leaders course	Chief operators	4 days/session	4 people/session*[1]
Work place course	Shift operations superintendents and operators	3 days/session	6 people/session*[2]

Note) Malaya TPP operation staff: 105 operators = 21 operators/shift x 5 shifts

*[1] Inclusive of operators from outside of the Malaya TPP

*[2] Limited to the Malaya TPP personnel

d) Personnel Transfer, Job Rotation and Position Training



- Training for 2 positions or more
- To be regularly conducted regardless of vacancy
- Freshmen are out of complement in the shift during this training.

- Experience further on the acquired position
- 2 positions are targeted to be acquired for 2 years.

- Study on the scheduled personnel changes
- Study on the scheduled promotion system

e) Overseas Training of Middle-ranking Operators and Maintenance Engineers

- Schedule of training	Operators:	during a long-term outage of the power plant, such as during rehabilitation work
	Repair staff:	before rehabilitation work
- Duration	(e.g.)	2 months
- Place of training	(e.g.)	Heavy electric machinery manufacturer

e. Employment of Operations and Maintenance Consultants

Schedule	Duration and number of consultants	
	1st phase	2nd phase
Before rehabilitation	2 years, 2 people	-
After rehabilitation	-	2 years, 2 people

- Instructors Combination of consultants and expert engineers (manufacturers, etc.)

- Consultants will join the NPC's managers in charge in providing effective instructions concerning all matters necessary for complete implementation of periodic overhauls
- Consultancy fees will be included in the rehabilitation budget.

7.3.5 Improvement of Morale (Priority Item V)

1) General

One of the issues raised by the NPC during our survey was the lowered morale of the employees. The Personnel Dept. of the NPC has also been well aware of this issue and has been making a variety of efforts. Among the probable causes of lowered morale, the following are prominent:

a. Promotion cannot be effected unless a superior position becomes vacant.

b. Education and training to improve morale of power plant personnel is not yet sufficient.

c. Particularly in the power plant, continuous assignment to one job or section is causing employee burnout.

d. A proposal and reward system which encourages individual contributions and ideas is not effectively functioning.

e. Bureaucracy in the government services in the processing papers and other procedures.

2) Measure

For elimination of the causes given in 1) above, the following measures are considered necessary.

a. The current personnel management system shall incorporate a qualification system to identify those who have passed both the academic and practical skill tests as competent and qualified for promotion. (Qualification system is currently under study in the NPC, aiming towards early implementation.)

b. Periodic education and training for morale improvement shall be implemented to be attended by all employees of the power plant in shifts.

c. To prevent employee burnout, there shall be rotation of personnel between different sections within the power plant, or, where possible, between different power plants and/or the MMRC.

d. Quality control circles and/or other similar groups of employees to make voluntary proposals shall be organized at each work place to, in combination with a reward system, encourage and motivate all members to exercise their originality and ingenuity in the work place.

3) "No Forced Outage & No Accident" Campaign

As with all other businesses and industries, the key to success is "human resources."

In Chapters 4, 5 and 6, improvement proposals are explained regarding hardware and software. However, actual implementation needs involvement of all staffs from the power plant executives to ordinary employees. Therefore, the management should appraise the operational efforts, and initiate a campaign to encourage and support involvement in improvement.

As a target of this campaign, we recommend the "No forced outage and No accident."

When the JICA visited the Philippines for the first site survey, they proposed "No forced outages" to the NPC's task force as a target in the reliability improvement plan. This means that no unit trip attributable to the power plant should occur before the next annual overhaul.

Also, during the first site survey, it was found that there had been a recent oil leak accident in the fuel tank. Thus, in addition to the prevention of unit trips, the prevention of accidents which may lead to pollution should be targeted.

a. Details and Term of Campaign

Towards the goal of "No Forced Outage & No Accident," each power plant will develop individual campaigns of their own. For the coming 5 years, each power plant will independently set up their own slogan every year to conduct the campaign. The following slogans are provided only for reference:

(Operations Section)
- Steady and diligent execution of patrol inspections
- Prevention of operational errors
  Let's make it a practice to call out each step aloud as we go through procedures, and physically point to each check item.
- Be sure to use safety protection and danger warning tags.

(Maintenance Section)
- Ensure Communications before and after each work.
- Be sure to hold a meeting before work.
- Steadily carry out routine check and maintenance work.

b. Plan for Campaign Promotion

The results of the campaign shall be evaluated for reduced forced outages and accidents, etc. and achievements will be the subject of commendation. The method of commendation will be discussed later in this paper within the framework of the incentive system.

7.4 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 have been formulated in coordination with this principle:

7.4.1 Contents of the Plan

1) Priority Items included in the Plan

a. Rehabilitation Project of Power Plant Facilities

b. Improvement of Operations and Maintenance Procedures

   a) Formulation of complete periodic overhaul plan
   b) Implementation of complete periodic overhaul
   c) Safe and reliable operation
   d) Hiring, education and training of personnel
   e) Improvement of morale

2) 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. Improvement of morale

3) Purposes of Individual Programs

a. Program-I

The concept of this program is the same as that of the rehabilitation projects of power plant facilities as have been executed by NPC. The purpose is to restore the original output, performance, and reliability of the facilities.

b. Program-II

This is to improve operations and maintenance management, which is imperative so that once recovered output, performance and reliability of the power plant facilities through Program-I will not rapidly drop again. This program must be carried out immediately and in a short time.

c. Program-III

This is an essential program for the success of Program-II. Its purpose is to solve the problems of the items which involve human factors (hiring, education and training of personnel, and improvement of morale). Immediate implementation is a must, however, it will take quite a long time before its effects can be seen.

7.4.2 Project Implementation

1) Implementation Methods

a. Program-I

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

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.

Reinforced MSD is a prerequisite for complete implementation of periodic overhaul. In parallel with reinforcement of the human factor, versatile review in detail of hardware and software is required. A review of the hardware includes procurement of tools/instruments, welding machines, scaffolding materials, and cranes and other machines, transportation vehicles, and construction of offices affiliated to power plants, lodging quarters for workers during periodic overhaul, materials center, and training center. Software review includes preparation of periodic overhaul standards and a variety of manuals and procedures.

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

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.

2) Implementation Schedule

The implementation schedule for these three types of programs are as shown in Figure 7-7 Malaya TPP Reliability Improvement Plan, Implementation Schedule.

7.4.3 Disbursement Schedule

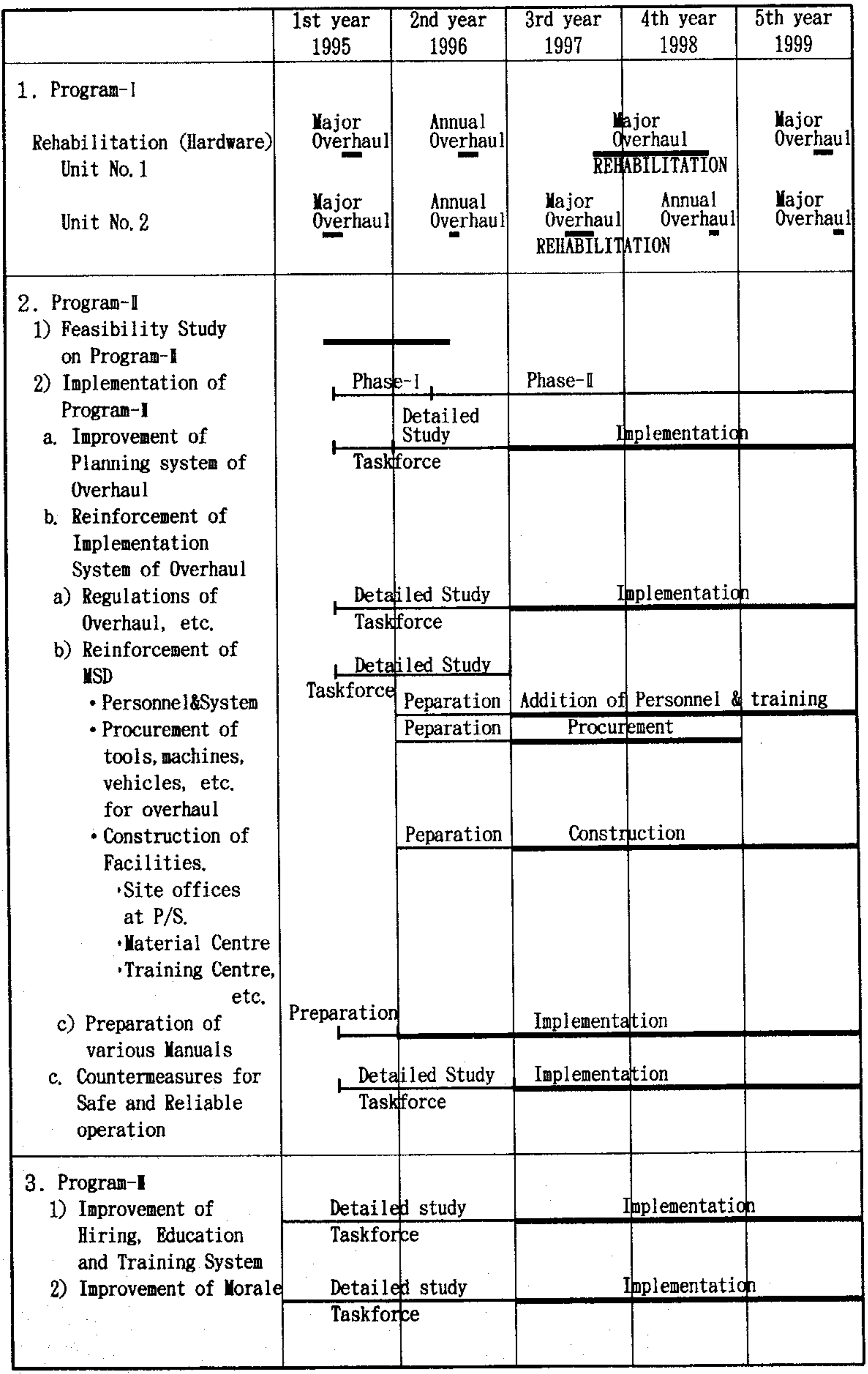
Cost has been calculated for only the rehabilitation project of power plant facilities (hardware). The cost needed for software improvement is mainly for Program-II, an estimate is difficult to obtain without F/S. Thus, the calculation was not done.

Table 7-9 Disbursement Schedule

[Unit: Thousand US$]

	1995	1996	1997	1998	1999	Total
Unit No. 1	1,815	15,746	55,316	30,373	1,814	105,063
Unit No. 2	1,586	5,862	30,464	1,057	1,067	40,026
Total	3,401	21,608	85,779	31,430	2,871	145,089

Figure 7-7 Improvement Plan Overall Schedule



CHAPTER 8

ECONOMIC EVALUATION

CHAPTER 8 ECONOMIC EVALUATION

8.1 Economic Evaluation

8.1.1 Evaluation Method

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.

It is noted, however, that the engineering survey this time was not sufficient, in particular in term of time and timing allowed for the detailed site survey. There are difficulties to detect the defective parts or equipment of the plant under operation (M-2), and moreover to predict how both the units will be when the rehabilitation projects would start in 1997. Based on experience in a similar type of rehabilitation projects in the study team's own country and in the Philippines, the study team assumed the most probable operating conditions of the Malaya TPP, both the cases if the rehabilitation would be implemented (WITH) and not implemented (WITHOUT). 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.

To help do so with ease, the study team made efforts in preparation of the electric spread sheets for financial and economic calculations so that any change of important parameters such as project cost, capacity factor, efficiency, fuel cost, etc. may instantly give the target figures, i.e., EIRRs or FIRRs. These calculation files were submitted to an NPC counterpart in a diskette together with the Interim Report.

8.1.2 Operating Conditions of Malaya TPP

The most fundamental assumptions are that the Luzon power system would demand operation or output of Malaya TPP at fullest possible performance until the project life, and without rehabilitation or even if the deterioration should advance, both the units would terminate their lives in the scheduled retirement years. With respect to the operating conditions and operating cost as referred to Tables 8-1 and 8-2, the following basic features are assumed:

1) With Project Case

- The derated unit capacities can be restored to the original ones.
- Both the units will be operated at a 70% capacity factor for those project lives (up to the respective retirement year).
- The efficiency will be restored to 1988 levels, 33.27% for M-1 and 34.90% for M-2.
- Even after rehabilitation, the natural decline of the efficiency is unavoidable and so an annual decline rate of 0.08% is assumed.

2) Without Project Case

- Both the capability and efficiency will deteriorate unless rehabilitation should be carried out.
- When the rehabilitation works will be carried out in 1997 and 1998, capability and efficiency of both the units are assumed to decline 1992 levels.
- Although the deterioration will further advance, the units will be operated at the scheduled retirement year, 2005 for M-1 and 2009 for M-2.

The assumed operating conditions of both the units when the rehabilitation works should have been completed are summarized in the Table 8-1.

8.1.3 Alternatives

1) 1st Alternative

The first alternative among others is a without project case and the insufficient energy production may be supplemented by additional production by the other power units or purchase from the private sectors.

2) Other Alternatives

As long as Malaya TPP without rehabilitation would be operable, the insufficient energy may be supplemented by purchase or supply by the other power plants. But after the retirement of Malaya TPP, an additional power supply source may be necessary. The study team considers it impractical, mathematically possible though, to evaluate the With project as compared with the assumed newly constructed power supply source because the remaining life of the units is not so long enough to compete with the new ones. Moreover, NPC has prepared the detailed generating cost of several types of power generating sources not only for NPC's but for private supply sources. Thus, the study team considered it more practical to use these data as alternative power source.

3) Applied Alternative

Taking into account the above, the study team applied the mixture of the above for 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.

8.1.4 Evaluation Conditions/Assumptions

1) Hurdle Rate

The hurdle rate for the economic analysis shall be the discount rate at 15% set forth by NEDA for this type of project in the Philippines. Owing to the favorable economic activities with inflow of the foreign investment, the discount rate in the Philippines stays around 12% in these days.

2) Fuel Cost and Data

The fuel cost used for the economic evaluation shall be a border price instead of the actual cost at which NPC purchases. In the Philippines, as most of the fossil fuel will be imported from abroad, the international average price for oil and coal will be used.

The current international crude oil price at 15 US$ will be used as a base case and the variation of the price will be tested with a sensitivity analysis. The data of oil used for the economic evaluation are as follows:

Type	Cost	HV	Density
Bunker-C*	15 US$/bbl.	10,240 kcal/kg**	0.951**
Imported Coal***	44.268 US$/ton	6,825 kcal/kg	-

Note: * : Used for Malaya TPP and alternative combined cycle PP.
** : Sampled at Malaya TPP and analyzed by JICA
*** : Reference purpose only

3) Other Operation Cost

For the With/Without analysis this time, the operating costs other than fuel will incur equally both the case and so was not considered for IRR calculations. As for comparison with the generating costs of NPC's and Non-NPC's several power sources, which may supplement the deficiency in power supply in the Without case, Table 8-2 shows the generating costs of Malaya TPP for the past five years and the average.

4) Energy Cost for Supplementary Supply

The purchase source of energy to supplement the deficiency between With and Without will be NPC's own source and private power plants. To equalize the conditions at Malaya TPP, the power supply cost (transmission and substation) is deducted. Because usually the IRR calculation will not consider the interest payment, both the cases (With and Without) does not consider the interest payment. The generating costs of the alternative power sources are shown below:

[Unit Peso/kWh] as of June 1994

Type	Gross Cost A	Power Supply B	Interest C	Net Cost D=A-(B+C)
LUZON GRID Average	1.3483	0.0640	0.2046	1.0797
Oil based	1.2991	0.0826	0.1655	1.0510
Coal	1.6390	-	0.5126	1.1264
Geothermal	1.2271	0.0010	0.1736	1.0525
Gas turbine	2.3889	0.1567	0.1442	2.0880
NON NPC PLANTS Average	1.8780	-	-	1.8780
Oil based	1.6809	-	-	1.6809
Coal	1.5742	-	-	1.5742
Gas Turbine	2.5209	-	-	2.5209

Source: NPC Head Office

8.1.5 Result of Evaluation

1) 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

Note: See Table 8-3, Malaya TPP Operating Conditions

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 becomes 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.

2) EIRR of Base Case

Table 8-3 shows the result of the calculation*. 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.

Note: The study team used EXCEL Ver.5.0 for all calculations.

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%

3) Sensitivity Analysis

The sensitivity of the EIRR value to capacity factor of With case and to total project cost was tested. Concerning that to the fuel cost, Bunker-C oil, it was found that the higher the fuel unit cost will be, the lower the EIRR value becomes. This is reason why the With case produce much more energy with fuel than the Without case. If an efficiency factor for fuel consumption could be incorporated into the calculation, the EIRR against Oil base and Gas turbine will become higher than the base case while that against Coal will become lower owing to the relatively lower coal cost than the Oil.

The EIRR sensitivity to the capacity factor of With case in a range from 70% to 45% and to the total project cost from 1.4 times to 0.85 times was tested and the tables and figures are given in Table 8-4 and Figures 8-1 and 8-2.

4) 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.

Project	Malaya Reliability Improvement Project
Subject	MTTP Operating Conditions CY 1989 to 1993
File Name	ope_con/Sheet1
Date	21/11/94
Rev.	18/01/95

Table 8-1 Malaya TPP Operating Record

No. 1 Unit — Up to Aug. 1994

Code	Description	Unit	1989	1990	1991	1992	1993	*1994	Average up to 1993
A	Rated Output	MW	300	300	300	300	300	300	300
B	Average Load	MW	250	268	243	209	177	84	229
C	Total Power Production	GWh	1,567.67	2,106.00	1,581.00	1,245.00	1,159.04	329.94	1,531.74
D	Service Hours	Hr	6,265.34	7,863.42	6,521.29	5,949.17	6,553.54	3,960.46	6,630.55
E	Outage Hours	Hr	2,494.66	896.58	2,238.71	2,834.83	2,206.46	1,895.54	2,134.25
	a. Planned outage	Hr	0.00	212.75	837.73	1,216.97	0.00	0.00	453.49
	b. Forced outage (within)	Hr	2,429.33	683.83	1,400.98	1,617.86	2,206.46	1,895.54	1,667.69
	c. Forced outage (outside)	Hr	65.33	0.00	0.00	0.00	0.00	0.00	13.07
	d. Maint. outage	Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F	Aux. Power Ratio	%	3.00	3.00	3.19	3.62	3.26	n/a	3.21
G	Utilization factor	%	71.52	89.77	74.44	67.91	74.81	67.63	75.69
H	Capacity factor	%	59.65	80.14	60.16	47.37	44.10	18.78	58.29
I	Heat Rate	BTU/kWh	10,431	10,883	10,934	11,494	11,575	16,787	11,063.40
J	Frequency of Start/Shutdown		22	19	15	19	16	9	18.2
K	Fuel Consumption	Mil. lit	409.08	573.37	432.45	357.99	335.62	138.56	421.70
	a. Bunker-C	Lit/kWh	0.2609	0.2723	0.2735	0.2875	0.2896	0.4200	0.2768
	b. Light Oil	Lit/kWh	N/A	N/A	N/A	N/A	N/A	N/A	

No. 2 Unit

Code	Description	Unit	1989	1990	1991	1992	1993	1994	Average
A	Rated Output	MW	350	350	350	350	350	350	350
B	Average Load	MW	280	292	287	222	131	271	242
C	Total Power Production	GWh	2,209.31	2,197.69	1,897.06	1,828.97	440.50	701.48	1,714.71
D	Service Hours	Hr	7,883.75	7,533.16	6,604.13	8,229.64	3,360.98	2,612.30	6,722.33
E	Outage Hours	Hr	876.25	1,226.84	2,155.87	554.36	5,399.02	3,243.70	2,042.47
	a. Planned outage	Hr	750.97	694.21	1,658.20	0.00	4,524.42	2,113.18	1,525.56
	b. Forced outage (within)	Hr	113.85	532.63	497.67	554.36	874.60	1,130.52	514.62
	c. Forced outage (outside)	Hr	11.43	0.00	0.00	0.00	0.00	0.00	2.29
	d. Maint. outage	Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F	Aux. Power Ratio	%	2.50	2.50	2.70	3.45	7.63	n/a	3.76
G	Utilization factor	%	90.00	85.99	75.39	93.95	38.37	44.61	76.74
H	Capacity factor	%	72.06	71.68	61.87	59.65	14.37	34.23	55.93
I	Heat Rate	BTU/kWh	9,909	10,021	9,945	10,554	11,321	16,787	10,350.00
J	Frequency of Start/Shutdown		7	10	7	8	9	9	8.2
K	Fuel Consumption	Mil. lit	547.67	550.94	471.97	482.89	124.76	294.59	435.65
	a. Bunker-C	Lit/kWh	0.2479	0.2507	0.2488	0.264	0.2832	0.4200	0.25892
	b. Light Oil	Lit/kWh	N/A	N/A	N/A	N/A	N/A	N/A	

No. 1 & 2 Units

Code	Description	Unit	1989	1990	1991	1992	1993		Average
A	Rated Output	MW	650	650	650	650	650	650	650
B	Average Load	MW	530	560	530	431	308	355	472
C	Total Power Production	GWh	3,777	4,304	3,478	3,074	1,600	1,031	3,246
D	Service Hours	Hr	14,149.09	15,396.58	13,125.42	14,178.81	9,914.52	6,572.76	13,352.88
E	Outage Hours	Hr	3,370.91	2,123.42	4,394.58	3,389.19	7,605.48	5,139.24	4,176.72
	a. Planned outage	Hr	750.97	906.96	2,495.93	1,216.97	4,524.42	2,113.18	1,979.05
	b. Forced outage (within)	Hr	2,543.18	1,216.46	1,898.65	2,172.22	3,081.06	3,026.06	2,182.31
	c. Forced outage (outside)	Hr	76.76	0.00	0.00	0.00	0.00	0.00	15.35
	d. Maint. outage	Hr	0.00	0.00	0.00	0.00	0.00	0.00	0.00
F	Aux. Power Ratio	%	-	-	-	-	-	-	-
G	Utilization factor	%	80.76	87.88	74.92	80.71	56.59	56.12	76.17
H	Capacity factor	%	66.33	75.58	61.08	53.84	28.09	27.10	56.99
I	Heat Rate	BTU/kWh	-	-	-	-	-	-	-
J	Frequency of Start/Shutdown		29	29	22	27	25	18	26.4
K	Fuel Consumption	Mil. lit	956.75	1124.31	904.42	840.88	460.38	433.15	857.35
	a. Bunker-C	Lit/kWh	-	-	-	-	-	-	-
	b. Light Oil	Lit/kWh	-	-	-	-	-	-	-

Source: Malaya Thermal Power Plant

GENERATING COST

Total Operating Cost	Thou P.	2064.52	3895.26	4385.9	2974.34	1764.45		3,016.89
Capital Expenditure	Thou P.	53.58	2.96	6.34	4.03	2.34		13.85
Total Cost	Thou P.	2118.1	3898.22	4392.24	2978.37	1766.79		3,030.74
Generating Cost	Peso/kWh	0.54661	0.9051	1.26102	0.96759	1.1031		0.9567

Project	Malaya Reliability Improvement Project
Subject	MTTP Operating Conditions CY 1989 to 1993
File Name	ope_con Sheet2
Date	11/21/94
Rev.	1/18/95

Table 8-2 Malaya TPP Operating Cost

No. 1 & 2 Units

Description	1989	1990	1991	1992	1993	Average up to 1993	RATIO
OPERATING EXPENSES							
ADMINISTRATIVE & GENERAL EXPENSES	48,024	51,137	66,184	67,630	63,008	59,197	2.00%
MAN POWER RERATED	35,969	35,930	40,971	48,026	39,409	40,061	
O & M GENERAL PLANT EQT	-	1,479	1,529	1,546	1,687	1,248	
OTHERS	12,055	13,728	23,684	18,058	21,912	17,887	
OPERATION AND MAINTENANCE	35,592	31,944	108,382	45,440	63,175	56,907	1.90%
OPERATION	24,914	26,601	96,003	37,527	43,342	45,677	
MAINTENANCE	10,678	5,343	12,379	7,913	19,833	11,229	
TAX & INSURANCE	33,053	14,611	35,727	56,558	42,939	36,578	1.20%
TAXES & DUTIES	4,966	9,469	5,125	17,693	204	7,491	
INSURANCE	28,087	5,142	30,602	12,874	16,194	18,580	
FRANCHISE TAX	-	-	-	25,725	26,141	10,373	
REALITY TAX	-	-	-	266	400	133	
FUEL & ADDITIVES	1,735,094	3,328,836	3,647,726	2,088,050	806,998	2,321,341	76.60%
DEPRECIATION	212,761	468,550	527,878	716,660	788,326	542,835	17.90%
TOTAL OPERATING EXPENSES	2,064,524	3,895,078	4,385,897	2,974,338	1,764,446	3,016,857	99.50%
GENERAL PLANT EQUIPMENT	81	1,601	1,037	1,965	1,546	1,246	
CONSTRUCTION WORK IN PROGRESS	53,499	1,361	5,300	2,063	1,192	12,683	
TOTAL CAPITAL EXPENDITURE	53,580	2,962	6,337	4,028	2,738	13,929	0.50%
GRAND TOTAL	2,118,104	3,898,040	4,392,234	2,978,366	1,767,184	3,030,786	100.00%
POWER GENERATION (GWh)	3,777	4,304	3,478	3,074	1,600	3,246	
							GROWTH
GENERATING COST (P/kWh)	0.5608	0.9058	1.2629	0.9689	1.1047	0.9606	18.47%
ADMINISTRATIVE & GENERAL EXP.	0.0127	0.0119	0.019	0.022	0.0394	0.0210	32.72%
OPERATION & MAINTENANCE	0.0094	0.0074	0.0312	0.0148	0.0395	0.0205	43.18%
TAX & INSURANCE	0.0088	0.0034	0.0103	0.0184	0.0268	0.0135	32.10%
FUEL	0.4594	0.7735	1.0488	0.6793	0.5045	0.6931	2.37%
DEPRECIATION	0.0563	0.1089	0.1518	0.2331	0.4928	0.2086	72.00%
CAPITAL EXPENDITURE	0.0142	0.0007	0.0018	0.0013	0.0017	0.0039	-41.18%

Source: NPC/MMRC

Project	Malaya Reliability Improvement Project
Subject	Operation Data
File Name	Basic.xls/Ope_con
Date	11/15/94
Rev.	1/16/95

Table 8-3 Malaya TPP Operating Conditions

			With Project		Without Project	
ITEM		Unit	No. 1	No. 2	No. 1	No. 2
	No. of Unit	No.	1	1	1	1
	Date of Commissioning	Date	Aug-1975	Apr-1979	Aug-1975	Apr-1979
	Economic life	mm/yyyy	30	30	30	30
	Retirement year	mm/yyyy	Aug-2005	Apr-2009	Aug-2005	Apr-2009
	Years after 1994		11	15	11	15
OPERATING CONDITIONS						
	Unit Capacity	MW	300	350	300	350
	Dependable Capacity	MW	300	350	300	350
	Fuel Type		Bunker-C	Bunker-C	Bunker-C	Bunker-C
	Plant efficiency	%	33.27%	34.90%	29.69%	32.33%
	Station use	%	6%	6%	6%	6%
	Capacity factor	%	70%	70%	47.50%	60%
	Annual Generation	GWh	1839.6	2146.2	1248.3	1839.6
	Salable Energy	GWh	1729.22	2017.43	1173.4	1729.22
	Fuel Consumption	Mil. lit.	488.30	543.08	371.30	502.50
REHABILITATION PROJECT						
	Total Inv. Cost	M$	115.793	37.862	0	0
	Rehab. start		Mar-1998	Aug-1997	-	-
	Rehab. period	months	7	3	-	-
	Life/Life after rehab.	Years	7	12	7	12
WITH REHABILITATION						
	Efficiency decline	%/annum	-0.08%	-0.08%	-	-
WITHOUT REHABILITATION						
	Efficiency decline	%	-	-	-2.82%	-0.68%
	Capacity factor decline	%	-	-	-2.82%	-3.62%
UNIT COST						
	Administrative Cost	P/kW	91			
	O & M	P/kW	88			
	Depreciation	P/kW	835			
		Total	1014	Thousand Peso/kW		
	O & M Cost	P/kWh	0.0205	0.0205	0.0302	0.0239
	Administration Cost*	P/kWh	0.0210	0.0210	0.0309	0.0245
	Tax & Insurance	P/kWh	0.0135	0.0135	0.0199	0.0158
	Interest Cost*	P/kWh	0.2125	0.2125	0.3132	0.2479
	Subtotal	P/kWh	0.2675	0.2675	0.3942	0.3121
	Fuel Cost*	P/kWh	0.6864	0.658	0.8307	0.7262
	Levelized Rehab. Investment	P/kWh	0.3569	0.0895	0	0
	Unit generating cost	P/kWh	1.3108	1.0150	1.2249	1.0383

Note* : Average for respective operating years
The current average power rate at 1.8505 P/kWh

Project Malaya Reliability Improvement Project
Subject EIRR
File Name Basic.xls/eirr_2
Date 11/24/94
Rev. 1/18/95

Table 8 - 4 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%	45.50%
EIRR =	2.27%	1.34%	3.73%	1.39%	25.46%	21.57%	17.60%	15.29%	32.65%

No. 1 Unit

		WITH REHABILITATION								WITHOUT REHABILITATION							Supply by Other Power Sources (P/kWh)									
	Year	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 NPC Average	Non NPC Oil	Non NPC Coal	Non NPC Gas T.	
		Thous $	MW	%	GWh	%	Mil. lt.	Thous $	Thous $	MW	%	GWh	%	Mil. lt.	Thous $	GWh	1.0797	1.051	1.1264	1.0525	2.088	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	33,588	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

		WITH REHABILITATION								WITHOUT REHABILITATION							Supply by Other Power Sources (P/kWh)									
	Year	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 NPC Average	Non NPC Oil	Non NPC Coal	Non NPC Gas T.	
		Thous $	MW	%	GWh	%	Mil. lt.	Thous $	Thous $	MW	%	GWh	%	Mil. lt.	Thous $	GWh	1.0797	1.051	1.1264	1.0525	2.088	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	44,060	
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	15,058	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	17,416	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	44,985	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	

Project	Malaya Reliability Improvement Project
Subject	Sensitivity
File Name	Basic.xls/sensitivity
Date	11/25/94
Rev.	1/16/95

Table 8 - 5 Sensitivity to Capacity Factor and Project Cost

To Capacity Factor

	EIRR of M-1/M-2					
Capacity Facotr	Luzon Grid Average	Oil Based	Coal	Geo-thermal	Gas Turbine	Non NPC Average
70%	12.32%	11.35%	13.86%	11.40%	37.40%	33.06%
68%	10.64%	9.74%	12.05%	9.79%	33.50%	29.57%
65%	8.90%	8.09%	10.18%	8.13%	29.49%	25.98%
63%	7.10%	6.37%	8.24%	6.41%	25.36%	22.28%
60%	5.23%	4.59%	6.23%	4.62%	21.09%	18.44%
58%	3.27%	2.72%	4.12%	2.75%	16.65%	14.44%
55%	1.20%	0.76%	1.89%	0.79%	11.99%	10.23%
53%	-0.98%	-1.31%	-0.47%	-1.29%	7.04%	5.75%
50%	-3.33%	-3.53%	-3.00%	-3.52%	1.69%	0.89%
48%	-5.87%	-5.93%	-5.77%	-5.93%	-4.26%	-4.52%
45%	-8.68%	-8.58%	-8.84%	-8.58%		

To Project Cost

	EIRR of M-1/M-2					
Project Cost	Luzon Grid Average	Oil Based	Coal	Geo-thermal	Gas Turbine	Non NPC Average
140%	5.86%	5.01%	7.20%	5.05%	27.31%	23.65%
135%	6.52%	5.65%	7.88%	5.70%	28.32%	24.59%
130%	7.21%	6.33%	8.59%	6.38%	29.38%	25.59%
125%	7.94%	7.05%	9.34%	7.09%	30.51%	26.64%
120%	8.71%	7.80%	10.13%	7.85%	31.71%	27.76%
115%	9.53%	8.61%	10.97%	8.65%	32.99%	28.96%
110%	10.40%	9.46%	11.87%	9.51%	34.36%	30.23%
105%	11.33%	10.37%	12.83%	10.42%	35.83%	31.59%
100%	12.32%	11.35%	13.86%	11.40%	37.40%	33.06%
95%	13.39%	12.40%	14.96%	12.45%	39.11%	34.65%
90%	14.55%	13.53%	16.15%	13.58%	40.96%	36.36%
85%	15.80%	14.75%	17.45%	14.81%	42.97%	38.24%

Sensitivity

Figure 8 - 1 EIRR Sensitivity to Cap. Factor

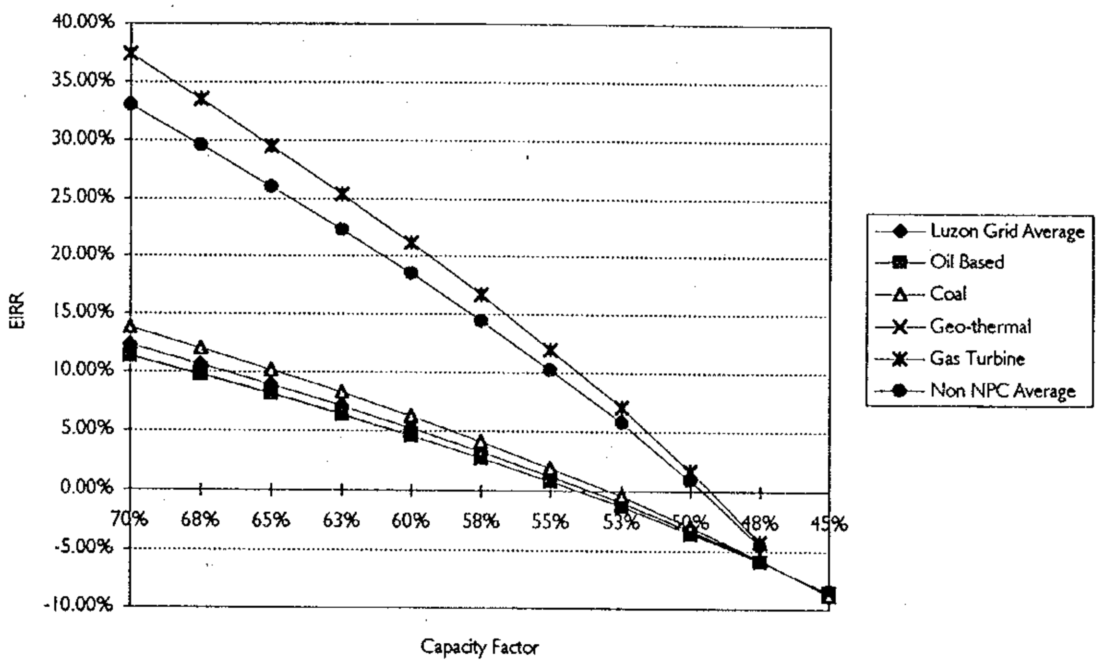
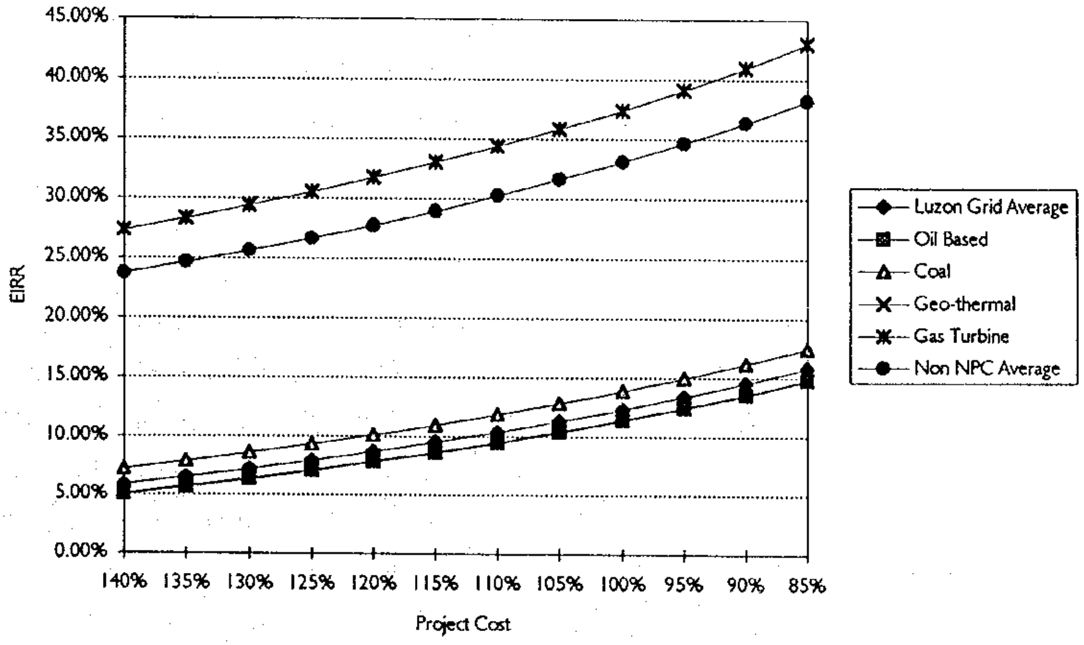


Figure 8 - 2 EIRR Sensitivity to Project Cost



8.2 Financial Evaluation

8.2.1 Evaluation Method

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.

8.2.2 Evaluation Conditions/Assumptions

1) Opportunity Cost of Capital

Assuming that NPC will procure finance from the Export and Import Bank of Japan (EXIM Japan) as same as preceding rehabilitation project, the interest rate of EXIM Japan at 5.80% will be the opportunity capital of this Project.

2) Project Life

The project is assumed to start with the Consulting Services in 1995 as soon as the Loan Agreement with EXIM Japan would have been concluded. After preparation of specifications for rehabilitation works followed by tendering for selection of the contractors, the rehabilitation works will be carried out in 1997 for M-2 and in 1998 for M-1. In 1999, post-rehabilitation services by Consultant will be carried out. M-1 and M-2 will accomplish 30-year life, both With and Without cases, in 2005 for M-1 and in 2009 for M-2.

3) Benefit

The operating conditions similar to those assumed in the economic evaluation are applied. In comparing with the Without Project, the benefit of the With Project, increased revenue owing to the recovered outputs, will be calculated. The power rate for energy sale uses a 1993 average power rate in Luzon Grid at 1.5726 peso per kWh after deduction of depreciation cost at 0.2086 P/kWh and interest cost at 0.0693 P/kWh, which are considered to belong to the original plant construction and off set in both the cases.

4) Out-flow

a. Project Cost

The project cost estimated in Chapter 4 is applied and the project will be implemented for five years. The disbursement schedule of the cost is as follows:

Unit: Thousand US$

Year	M-1	M-2	M-1 & M-2
1995	1,815	1,586	3,401
1996	15,746	5,862	21,608
1997	55,315	30,464	85,779
1998	30,373	1,057	31,430
1999	1,814	1,057	2,871
Total	106,063	40,026	145,089

b. Fuel Price

The fuel price used for the financial evaluation is actual price as of July 1994 and the high calorific value is one which the study team sampled at Malaya TPP during site survey and analyzed in Japan

Type	Cost	HV	Density
Bunker-C*	2.3610 P/lit.	10,240 kcal/kg**	0.951**

Note: * : Used for Malaya TPP and obtained at Malaya TPP (As of July 1994)
** : Data of Bunker-C sampled at Malaya TPP for detailed analysis by JICA

c. Operation and Maintenance Cost

Both the cases will incur the operation and maintenance cost, administration cost, tax and duties, depreciation and others no matter which the rehabilitation would be carried out or not. In FIRR calculation, these costs are disregarded as these costs will off set.

5) Loan Term

The loan term will be an interest rate of 5.8% per annum, a commitment fee of 0.5% and repayment of 10 years without a grace period. The repayment schedule will be prepared accordingly. The commitment fee is considered for the not-disbursed portion of the loan.

6) Sensitivity Analysis

The following items are tested on sensitivity to FIRR

a. Capacity factor of With case
b. Project cost
c. Fuel cost
d. Power rate

8.2.3 Result of Evaluation

1) FIRR

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

2) Sensitivity Analysis

a. To Capacity Factor

Similar to the economic analysis, maintenance of a certain rate of the capacity factor is essential to attain the financial viability of the project after rehabilitation works, M-1 in particular. In the case of M-1, if the capacity factor should decline by 10% from the planned value, the FIRR value would become below the opportunity cost of capital while M-2 has a certain margin in the capacity factor decline.

b. To Project Cost

Also, because the M-1 has a shorter operation period after rehabilitation with larger investment, the investment to M-1 must be careful and should not increase by 40% from the planned value if the M-1 rehabilitation is considered independently.

c. To Fuel Cost

As far as this evaluation method concerned taking into account the benefit as balance of the energy sale between With and Without cases, the variation of fuel costs gives an adverse effect to the FIRRs. The more With case generates the power, the more With cases consume the fuel. Therefore, the higher the fuel price is assumed, the lower the FIRR becomes. Even the fuel cost become 20 $/bbl. FIRR is maintained at more than a 10% level.

d. To Power Rate

Naturally, the higher the power rate is, the higher the revenue can be expected. The sensitivity to power rate in a range of plus and minus 25% is tested. All the cases are in favor of the financial feasibility as shown in Figure 8-6.

3) Financial Statement

Repayment schedule, income statement and cash-flow statement as against investment and benefit for M-1 and M-2 combined were prepared for this rehabilitation project only. When the project will terminate in 2009, retirement year of M-2, the net income will stand at about 289 million US$ after repayment of the loan for the project. The detail are shown in Tables 8-7, 8-8 and 8-9.

firr - 1

Project Malaya Reliability Improvement Project
Subject FIRR
File Name firr.xls
Date 11/24/94
Rev. 1/18/95

Table 8 - 6 Financial Internal Rate of Return

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

No. 1 Unit

FIRR = 16.06%

		WITH REHABILITATION								WITHOUT REHABILITATION									
	Year	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 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%

		WITH REHABILITATION								WITHOUT REHABILITATION									
	Year	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 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

Project Malaya Reliability Improvement Project
Subject Sensitivity
File Name firr.xls
Date 11/25/94
Rev. 1/18/95

Sensitivity to Capacity Factor

	FIRR		
Capacity Factor	M-1	M-2	M-1/M-2
70%	16.06%	46.67%	29.74%
67.50%	13.56%	44.17%	27.24%
65.00%	11.06%	41.67%	24.74%
62.50%	8.56%	39.17%	22.24%
60.00%	6.06%	36.67%	19.74%
57.50%	3.56%	34.17%	17.24%
55.00%	1.06%	31.67%	14.74%
52.50%	-1.44%	29.17%	12.24%
50.00%	-3.94%	26.67%	9.74%
47.50%	-6.44%	24.17%	7.24%
45.00%	-8.94%	21.67%	4.74%

Investment to FIRR

Project Cost	M-1	M-2	M-1/M-2
140%	8.07%	36.50%	21.83%
135%	8.89%	37.50%	22.63%
130%	9.75%	38.55%	23.48%
125%	10.66%	39.68%	24.37%
120%	11.61%	40.88%	25.32%
115%	12.62%	42.17%	26.32%
110%	13.70%	43.55%	27.38%
105%	14.84%	45.05%	28.52%
100%	16.06%	46.67%	29.74%
95%	17.37%	48.45%	31.05%
90%	18.77%	50.38%	32.48%
85%	20.29%	52.52%	34.02%

Figure 8-3 Sensitivity to Capacity Factor

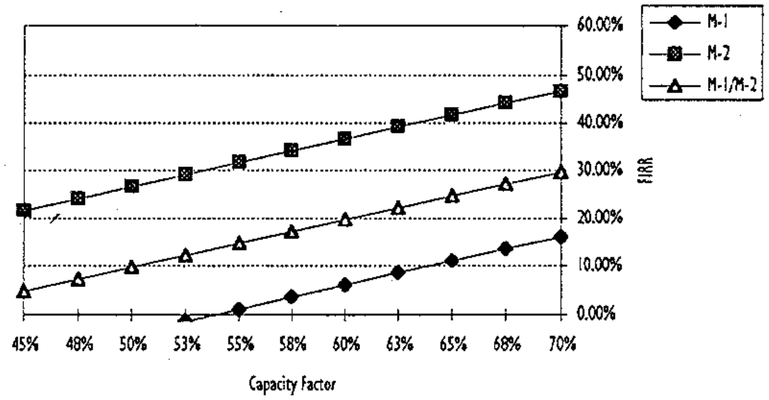
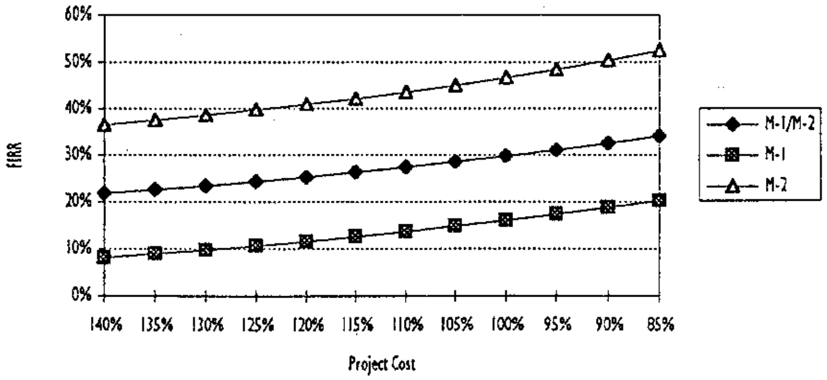


Figure 8-4 Sensitivity of FIRR to Project Cost



Sensitivity to Fuel Cost

FIRR

Fuel Cost [$/bbl.]	M-1	M-2	M-1/M-2
20	12.37%	42.14%	26.01%
19	13.06%	42.99%	26.71%
18	13.73%	43.82%	27.40%
17	14.40%	44.63%	28.07%
16	15.06%	45.44%	28.73%
15	15.70%	46.23%	29.38%
14	16.34%	47.02%	30.02%
13	16.97%	47.79%	30.65%
12	17.59%	48.56%	31.27%
11	18.21%	49.32%	31.89%
10	18.81%	50.07%	32.49%

Sensitivity to Power Rate

FIRR

Power Rate	M-1	M-2	M-1/M-2
125%	23.92%	57.44%	37.74%
120%	22.46%	55.36%	36.23%
115%	20.94%	53.25%	34.67%
110%	19.37%	51.10%	33.08%
105%	17.75%	48.91%	31.44%
100%	16.06%	46.67%	29.74%
95%	14.30%	44.39%	27.98%
90%	12.46%	42.04%	26.14%
85%	10.53%	39.62%	24.22%
80%	8.50%	37.11%	22.19%
75%	6.35%	34.50%	20.01%

Figure 8- 5 Sensitivity to Fuel Cost

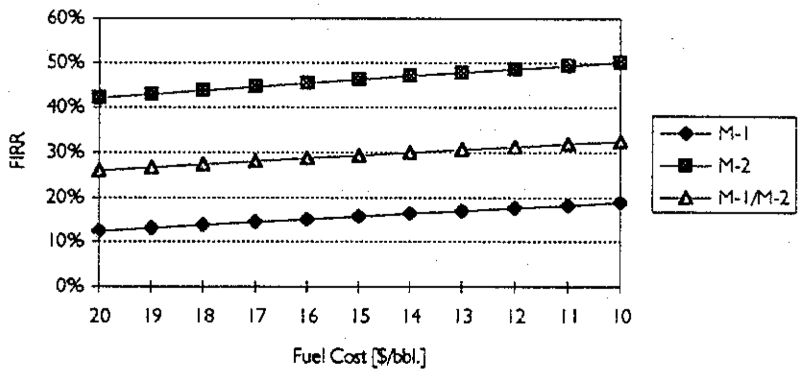
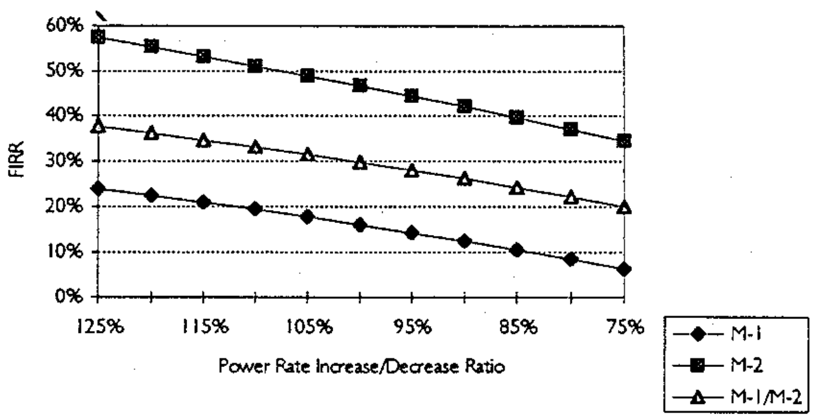


Figure 8-6 Sensitivity to Power Rate



frr - 2

Table 8 - 7 Repayment Schedule

			1995 loan				1996 loan				1997 loan				1998 loan				1999 loan			
	Year	Loan	Principal	Interest	Repay-ment	Outstand-ing Balance	Principal	Interest	Repay-ment	Outstand-ing Balance	Principal	Interest	Repay-ment	Outstand-ing Balance	Principal	Interest	Repay-ment	Outstand-ing Balance	Principal	Interest	Repay-ment	Outstand-ing Balance
0	1994	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	1995	3,401	0	0	0	3,401	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	1996	21,608	261	197	458	3,140	0	0	0	21,608	0	0	0	0	0	0	0	0	0	0	0	0
3	1997	85,779	276	182	458	2,865	1,655	1253	2,908	19,953	0	0	0	85,779	0	0	0	0	0	0	0	0
4	1998	31,430	292	166	458	2,573	1,751	1157	2,908	18,202	6,569	4975	11,544	79,210	0	0	0	31,430	0	0	0	0
5	1999	2,871	309	149	458	2,264	1,852	1056	2,908	16,350	6,950	4594	11,544	72,259	2,407	1823	4,230	29,023	0	0	0	2,871
6	2000	0	327	131	458	1,937	1,960	948	2,908	14,390	7,353	4191	11,544	64,906	2,547	1683	4,230	26,476	219	167	386	2,652
7	2001	0	346	112	458	1,592	2,073	835	2,908	12,317	7,779	3765	11,544	57,126	2,694	1536	4,230	23,782	232	154	386	2,419
8	2002	0	366	92	458	1,226	2,194	714	2,908	10,123	8,231	3313	11,544	48,895	2,851	1379	4,230	20,931	246	140	386	2,173
9	2003	0	387	71	458	839	2,321	587	2,908	7,801	8,708	2836	11,544	40,186	3,016	1214	4,230	17,915	260	126	386	1,912
10	2004	0	409	49	458	431	2,456	452	2,908	5,345	9,213	2331	11,544	30,973	3,191	1039	4,230	14,724	275	111	386	1,637
11	2005	0	431	25	456	0	2,598	310	2,908	2,747	9,748	1796	11,544	21,225	3,376	854	4,230	11,348	291	95	386	1,346
12	2006	0	0	0	0	0	2,747	159	2,906	0	10,313	1231	11,544	10,911	3,572	658	4,230	7,776	308	78	386	1,037
13	2007	0	0	0	0	0	0	0	0	0	10,911	633	11,544	0	3,779	451	4,230	3,997	326	60	386	711
14	2008	0	0	0	0	0	0	0	0	0	0	0	0	0	3,997	232	4,229	0	345	41	386	365
15	2009	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	365	21	386	0
Total		145,089	3,401	1,174	4,575		21,608	7,471	29,079		85,779	29,665	115,444		31,430	10,869	42,299		2,871	993	3,864	

		TOTAL				
	Year	Principal	Interest	Repay-ment	Outstand-ing Balance	Commit-ment Fee
0	1994	0	0	0	0	725
1	1995	0	0	0	3,401	708
2	1996	261	197	458	24,748	600
3	1997	1,931	1,435	3,366	108,596	172
4	1998	8,612	6,298	14,910	131,414	14
5	1999	11,518	7,622	19,140	122,767	0
6	2000	12,407	7,120	19,527	110,360	0
7	2001	13,125	6,402	19,527	97,236	0
8	2002	13,889	5,638	19,527	83,347	0
9	2003	14,693	4,834	19,527	68,655	0
10	2004	15,545	3,982	19,527	53,110	0
11	2005	16,444	3,080	19,524	36,666	0
12	2006	16,941	2,126	19,067	19,725	0
13	2007	15,016	1,144	16,160	4,708	0
14	2008	4,343	273	4,616	365	0
15	2009	365	21	386	0	0
Total		145,089	50,172	195,261		2,219

LOAN TERM		
Interest	%	5.80%
Commitment fee	%	0.50%
Grace P.	Year	0
Repayment	Years	10

Table 8 - 8 Income Statement

						OPERATING COST							PROFIT	FINANCIAL COST		NET INCOME
Year		Benefit Energy			With Revenue	Add. Fuel Cost			Depreic. Cost			With Total Cost		Commit. Fee	Interest	
		M-1	M2	Total		M-1	M-2	Total	M-1	M-2	Total					
		GWH	GWH	GWH	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $
0	1994	0	0	0	0	0	0	0			0	0	0	0	0	0
1	1995	0	0	0	0	0	0	0			0	0	0	725	0	-725
2	1996	0	0	0	0	0	0	0			0	0	0	708	197	-905
3	1997	0	0	0	0	0	0	0			0	0	0	600	1,435	-2,035
4	1998	0	306.60	306.60	18,545	3,385	3,685	7,370		3,336	3,336	10706	7839	172	6,298	1,369
5	1999	591.30	373.13	964.43	58,333	5,149	5,149	10,298	15,009	3,336	18,345	28643	29690	14	7,622	22,054
6	2000	626.52	437.21	1,063.73	64,339	6,568	6,568	13,136	15,009	3,336	18,345	31481	32858	0	7,120	25,738
7	2001	660.68	499.14	1,159.82	70,151	7,952	7,952	15,904	15,009	3,336	18,345	34249	35902	0	6,402	29,500
8	2002	694.05	558.63	1,252.68	75,768	9,291	9,291	18,582	15,009	3,336	18,345	36927	38841	0	5,638	33,203
9	2003	726.38	615.96	1,342.34	81,191	10,607	10,607	21,214	15,009	3,336	18,345	39559	41632	0	4,834	36,798
10	2004	757.65	671.45	1,429.10	86,439	11,891	11,891	23,782	15,009	3,336	18,345	42127	44312	0	3,982	40,330
11	2005	788.14	724.80	1,512.94	91,510	13,136	13,136	26,272	15,009	3,336	18,345	44617	46893	0	3,080	43,813
12	2006	0	776.31	776.31	46,955	14,349	14,349	28,698		3,336	3,336	32034	14921	0	2,126	12,795
13	2007	0	825.98	825.98	49,959	15,530	15,530	31,060		3,336	3,336	34396	15563	0	1,144	14,419
14	2008	0	873.81	873.81	52,852	16,676	16,676	33,352		3,336	3,336	36688	16164	0	273	15,891
15	2009	0	919.80	919.80	55,634	17,788	17,788	35,576		3,330	3,330	38906	16728	0	21	16,707
Total		4,844.72	7,582.82	12,428	751,676	132,622	132,622	265,244	105,063	40,026	145,089	410,333	341,343	2,219	50,172	288,952

Table 8 - 9 Cash-flow Statement

			CASH INFLOW			CASH OUTFLOW			BALANCE	
Year		Loan	Net Income	Depreciation	Total	Rehab. Cost	Repay (Principal)	Total	Annual Balance	Accumu. Balance
		Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $	Thous $
0	1994	0	0	0	0	0	0	0	0	0
1	1995	3,401	-725	0	2,676	3,401	0	3,401	-725	-725
2	1996	21,608	-905	0	20,703	21,608	261	21,869	-1,166	-1,891
3	1997	85,779	-2,035	0	83,744	85,779	1,931	87,710	-3,966	-5,857
4	1998	31,430	1,369	3,336	36,135	31,430	8,612	40,042	-3,907	-9,764
5	1999	2,871	22,054	18,345	43,270	2,871	11,518	14,389	28,881	19,117
6	2000		25,738	18,345	44,083		12,407	12,407	31,676	50,793
7	2001		29,500	18,345	47,845		13,125	13,125	34,720	85,514
8	2002		33,203	18,345	51,548		13,889	13,889	37,659	123,173
9	2003		36,798	18,345	55,143		14,693	14,693	40,450	163,624
10	2004		40,330	18,345	58,675		15,545	15,545	43,130	206,754
11	2005		43,813	18,345	62,158		16,444	16,444	45,714	252,468
12	2006		12,795	3,336	16,131		16,941	16,941	-810	251,658
13	2007		14,419	3,336	17,755		15,016	15,016	2,739	254,396
14	2008		15,891	3,336	19,227		4,343	4,343	14,884	269,280
15	2009		16,707	3,330	20,037		365	365	19,672	288,952
Total		145,089	288,952	145,089	579,130	145,089	145,089	290,178	288,952	

APPENDICES

Appendix 4-1

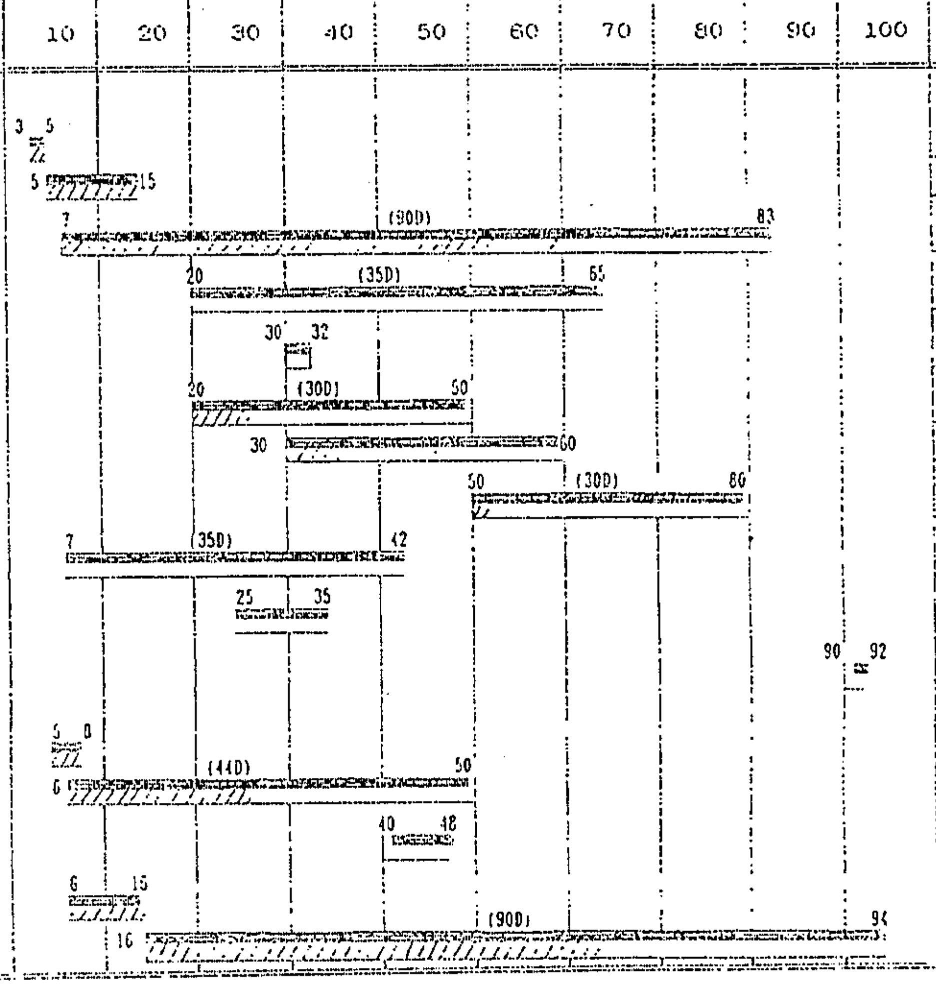
NATIONAL POWER CORPORATION

MALAYA 1 ANNUAL OVERHAUL ACTIVITIES (REV. 3)

October 1, 1994 - January 10, 1995

As of [illegible]

Sheet 1 of 4



A C T I V I T I E S	RESP. MAINT.	DAYS	R E M A R K S
1.0 BOILER			
1.1 Cooling Down			1.1 FINISHED
1.2 Cleaning of Boiler Tubes/Washing	MSD		1.2 100% COMPLETE
1.3 Replacement of Sec SH tubes 37 panels	MEC/MSD		1.3 70 % COMPLETE
1.4 Non-destructive Test of Boiler Tubes	MEC		1.4
1.5 Sampling of W/W Tubes (2.0 M)	MSD		1.5
1.6 Repair of Casing Leak	MSD		1.6 20% COMPLETE
1.7 Inspection/Repair of Burner/Air Register	MSD		1.7 55 % COMPLETE
1.8 Inspection/Overhaul of Sootblowers.	MM/EM		1.8 10 % COMPLETE
1.9 Inspection/Repair of Boiler Valves	MM		1.9
1.10 Replacement of Reheat Spray CV	IC/MM		1.10
1.11 Hydrostatic Test	OPN/ECS		1.11
2.0 BOILER AUXILIARIES			
2.1 AH Washing	EC/GS/OP		2.1 100% COMPLETE
2.2 Replacement of AH Elements & Repair of Rotor	MSD		2.2 95 % COMPLETE .
2.3 Replacement/Adjustment of Circumferential Seal	MSD		2.3
2.4 Cleaning of Gas Duct	GS		2.4 100% COMPLETE
2.5 Insp./Repair of Air & Gas Duct Dampers	MSD/GS		2.5 6[illegible]% COMPLETE

Appendix 4-1

NATIONAL POWER CORPORATION

MALAYA 1 ANNUAL OVERHAUL ACTIVITIES (REV. 3)

October 1. 1994 - January 10, 1994

As of ______________

Sheet 2 of 4

ACTIVITIES	RESP. MAINT.	DAYS	10	20	30	40	50	60	70	80	90	100	REMARKS
2.6 Repair of Gas Duct/ Dust Hopper	MSD			11			48						2.6 47% COMPLETE
2.7 Inspection of Smoke-stack Inner Liner	MEC/MSD			0			(600)		70				2.7
2.8 Replacement of Dust Co-llector Conveying Line	MSD				20 (200)	40							2.8
2.9 Re-blading of T-BFP (Stationary & Rotating)	MEC/MSD		5				(900)				95		2.9 40% COMPLETE
2.10 Installation of T-BFP Turning Gear	MSD							65	70				2.10
2.11 Overhaul of T-BFP	MSD		6		(440)		50						2.11 –
2.12 Overhaul of M-BFP	MM				30				(600)		90		2.12 [illegible] COMPLETE
2.13 Overhaul of FDF 1A & 1B	MM/EM		10		(250)	35							2.13 55% COMPLETE
2.14 Replacement of FDF Dis-charge Dampers Assy.	MM/EM		6		21								2.14
2.15 Inspection/Overhaul of GRF	MM/EM				25	(150)	40						2.15 5% COMPLETE
2.16 Replacement of GRF Con-trol Drive	IC/MM					40	(100)	50					2.16
2.17 Overhaul of MFOP 1A, 1B	MM				20 (200)	40							2.17 100% COMPLETE
2.18 Cleaning/Hydro of FOH	GS/EC		6	(100) 16									2.18
2.19 Cleaning/Hydro of SCAH	GS/EC				22 (150)	37							2.19
2.20 Replacement of Drain Line (A.H. and S.B.)	MSD							60	(100)	70			2.20 REPAIR OF AH DRAIN [illegible]%
2.21 Repair of Auxiliary Boiler	MEC/MSD			0				(900)				100	2.21
2.22 Inspection of Flash Tank	MM				30	35							2.22
2.23 Overhaul of Relief Valve	MM						40 (200)	60					2.23 20% COMPLETE

Appendix 4-1

NATIONAL POWER CORPORATION

MALAYA 1 ANNUAL OVERHAUL ACTIVITIES (REV. 3)

October 1. 1994 - January 10. 1995

As of ____________

Sheet 3 of 4

ACTIVITIES	RESP. MAINT.	DAYS	10	20	30	40	50	60	70	80	90	100	REMARKS
3.0 TURBINE/GENERATOR													
3.1 Cooling Down			3 8										3.1 FINISHED
3.2 Purging of Generator	EC		10										3.2 100% COMPLETE
3.3 Disassembly of Exciter	EM			(15D) 25									3.3 [illegible] COMPLETE
3.4 Re-assembly of Exciter	MSD/EM/ Contr.					30 (25D) 55							3.4
3.5 Simulation Test of Generator Control Devices	IC/EM							50 60					3.5
3.6 Charging of Generator	EC/EM											95 96	3.6
3.7 Re-blading of LP Turbine Blades 8th Stage	MSD/MEC			10 (80D) 90									3.7 10% COMPLETE
3.8 Collection of Turbine Blade Scale (LP)	MSD					30 (20D) 50							3.8 100% COMPLETE
3.9 Bearing Inspection	MSD					35 (50D) 85							3.9
3.10 Inspection/Overhauling of Turbine Valves	MSD			10 (30D) 40									3.10 25% COMPLETE
3.11 Inspection of Gland Steam Bellows	MSD			10 (15D) 25									3.11
3.12 Replacement of Drain Station Lines	MM				25 (10D) 35								3.12
3.13 Overhaul of Drain Station Valves	MM			15 (20D) 35									3.13 5% COMPLETE
3.14 Cleaning of TOT	OPTN								60 65				3.14
3.15 Turbine Oil Flushing	OPTN								65 (20D) 85				3.15
3.16 Turbine Oil Filtering (Vacuum-Dyne)	OPTN								65 85				3.16

Appendix 4-1

NATIONAL POWER CORPORATION

MALAYA 1 ANNUAL OVERHAUL ACTIVITIES (REV. 3)

October 1. 1994 - January 10. 1995

As of ____________

Sheet 4 of 4

ACTIVITIES	RESP. MAINT.	DAYS	10	20	30	40	50	60	70	80	90	100	REMARKS
4.0 TURBINE AUXILIARIES													
4.1 Replacement of LPH 3	MSD/MEC							55		(45D)	90		4.1 55% COMPLETE
4.2 Hydrotest of LPHs and HPHs	EC/OPTN			15 (10D)	25								4.2
4.3 Installation of Strainers at Extraction Line to HPH 5	MSD							50	(20D) 70				4.3
4.4 Cleaning/Leak Test of Main Condenser	GS/ECS			10		(45D)		55					4.4 20% COMPLETE
4.5 Sampling of Main Condenser Tubes	MSD				30	35							4.5
4.6 Partial Re-tubing of Auxiliary Condenser	MSD				20 (15D)	35							4.6
4.7 Epoxy Cladding of Tube Sheet (MSC & Aux. Cdsr)	Contr.						45		(40D)		85		4.7
4.8 Inspection/Cleaning of H.E. (Tubular & Plate Type)	GS/MM/EC			10 (15D)	25								4.8 40 % COMPLETE
4.9 Overhaul of Turbine Gland Steam Seal	MM/IC				25 (10D)	35							4.9
4.10 Inspection/Repair of Auxiliary Valves	MM			10	(35D)		45						4.10 20 % COMPLETE
4.11 Overhaul of CWP 1A & 1B	MM			10		(60D)			70				4.11 70% COMPLETE
4.12 Overhaul of CP 1A & 1B	MM/EM		10							0			4.12 60% COMPLETE
4.13 Overhaul of RWP 1A & 1B	MM/EM		10			25							4.13 40% COMPLETE
4.14 Overhaul of HSCCP A,B,C	MM/EM				25		0						4.14
4.15 Inspection/Cleaning of CWP Suction Area	SCUBA/OPTN						50		(25D)	75			4.15
4.16 Deferred Jobs	MM/EM/IC												4.16

Prepared by: wOlby

MC OBLEPIAS/TM VILLONA, JR.

P & S Section

Reviewed by:

AS PALPAL-LATOC

Acting Maint. Manager

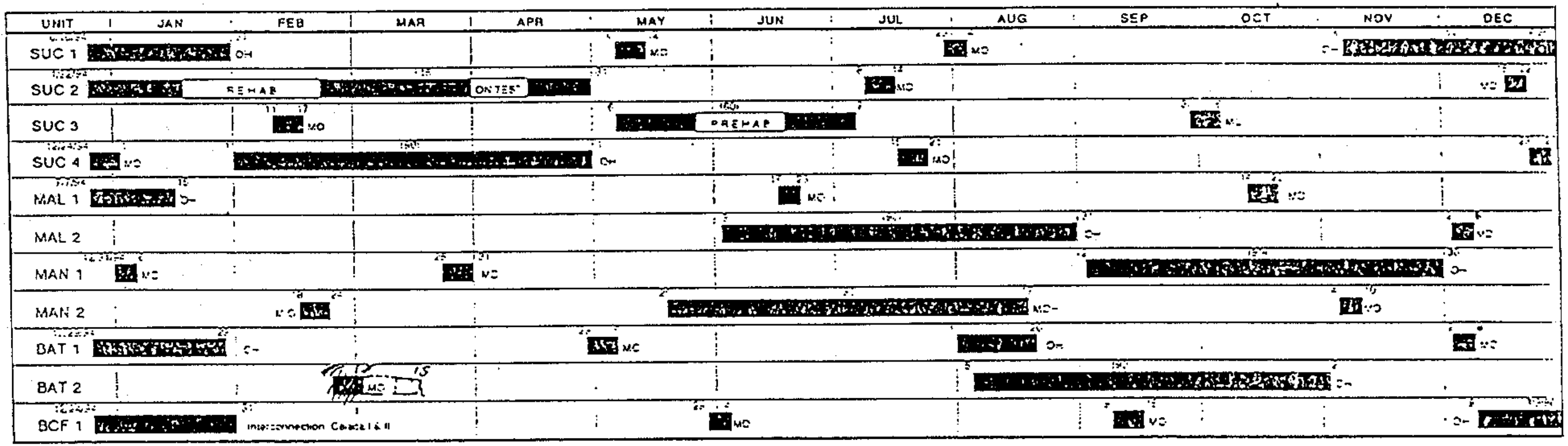
Approved by:

O.P. MENDOZA

Plant Manager

Appendix 4-2

MAINTENANCE SCHEDULE
MMRC PLANTS
TARGET
1995



Legend :

MO - Maintenance Outage
OH - Annual Overhauling
MOH - Major Overhauling

L. S. ACAPULCO
BCFTP Manager

C. C. CANDELARIA
Bataan TP Manager

V. C. DE GUZMAN
Manila TP, OIC

O. P. MENDOZA
Malaya TP Manager

V. P. ESTACIO
Sucat TP Manager

V. C. ALMAZAN
MSD Manager

Dec. 06, 1994

1994/12/08 Received
at Malaya P/S

Appendix 4-3

FIVE-YEAR PLANT MAINTENANCE PROGRAM

Regional Center : MMRC
Plant : MALAYA THERMAL PLANT
Unit : UNIT #1

ACTIVITIES	EQUIPMENT/PARTS/ COMPONENTS AND MATERIALS	DATE NEEDED	ESTIMATED COST	REMARKS STATUS
1.0 REPLACEMENT OF STAND-BY TUBE TYPE HEAT EXCHANGER W/ PLATE TYPE	ONE (1) SET PLATE TYPE HEAT EXCHANGER	1995 (4TH QTR)		FOR P.R.
2.0 INSTALLATION OF REVERSED INSULATION AT GAS DUCTS	FOR CONTRACT	1995 (4TH QTR)		FOR P.R.
3.0 OVERHAUL OF FDF/GRF	CONSUMABLE MATERIALS AND SPARE PARTS	1995 (4TH QTR)		FOR P.R.
4.0 INSTALLATION OF ON LINE VIBRATION MONITORING SYSTEM OF MAJOR EQPT.	FOR INQUIRY/CONTRACT	1995 (4TH QTR)		FOR P.R.
5.0 REPLACEMENT OF OBSOLETE RECORDERS AND GAUGES	RECORDERS AND GAUGES	1995 (4TH QTR)		FOR P.R.
6.0 INSTALLATION OF BOILER PROBE	MOTORIZED BOILER PROBE	1995		FOR P.R.
7.0 REHABILITATION OF AMMONEX REGENERATION SYSTEM	FOR CONTRACT	1995		FOR P.R.

Appendix 4-3

FIVE-YEAR PLANT MAINTENANCE PROGRAM

Regional Center : MMRC
Plant : MALAYA THERMAL PLANT
Unit : UNIT #1

ACTIVITIES	EQUIPMENT/PARTS/ COMPONENTS AND MATERIALS	DATE NEEDED	ESTIMATED COST	REMARKS STATUS
1.0 REPLACEMENT OF WEAK BOILER W/W TUBES (BURNER ZONE)	W/W PANELS	1996 (4TH QTR)		FOR P.R.
2.0 INSTALLATION OF RSB'S AT SEC SH TUBES	RSB ASSEMBLY (6 SETS)	1996 (4TH QTR)		FOR P.R.
3.0 REHABILITATION OF FWH DRIPS SYSTEM CV	FWH DRIPS CV PARTS	1996		FOR P.R.
4.0 PROCUREMENT OF SPARE MOTOR FOR GRF	SPARE MOTOR ASSEMBLY	1996		FOR P.R.
5.0 PROCUREMENT OF SPARE MOTOR FOR FDF	SPARE MOTOR ASSEMBLY	1996		FOR P.R.
6.0 REPLACEMENT OF NEW AVR	FOR CONTRACT	1996		FOR P.R.

FIVE-YEAR PLANT MAINTENANCE PROGRAM

Regional Center : MMRC
Plant : MALAYA THERMAL PLANT
Unit : UNIT #2

ACTIVITIES	EQUIPMENT/PARTS/ COMPONENTS AND MATERIALS	DATE NEEDED	ESTIMATED COST	REMARKS STATUS
1.0 COMPLETE RETUBING OF MAIN CONDENSER	CONDENSER TUBES	1995 (3RD QTR)		WITH P.R.
2.0 REPLACEMENT OF WEAK FURNACE HOPPER TUBES	FURNACE HOPPER TUBE PANELS	1995 (3RD QTR)		FOR P.R.
3.0 REPAIR OF REVERSED INSULATION	FOR CONTRACT	1995 (3RD QTR)		FOR P.R.
4.0 REPLACEMENT OF DETERIORATED DC CYCLONE SEPARATOR	D.C. CYCLONE PIPES	1995 (3RD QTR)		FOR P.R.
5.0 REPLACEMENT OF OBSOLETE RECORDERS & PRESSURE GAUGES	RECORDERS AND PRESSURE GAUGES SET	1995 (3RD QTR)		WITH P.R. #2MAL93-00565, 2MAL93-00728
6.0 REPLACEMENT OF DRUM LEVEL LOCAL INDICATION	DRUM LEVEL INDICATOR ASSEMBLY	1995 (3RD QTR)		FOR P.R.
7.0 REPLACEMENT OF GRF CONTROL DRIVE	CONTROL DRIVE ASSEMBLY	1995 (3RD QTR)		FOR P.R.
8.0 INSTALLATION OF ON LINE VIBRATION MONITORING SYSTEM ON MAJOR EQPT.	FOR CONTRACT	1995 (3RD QTR)		FOR P.R.
9.0 INSTALLATION OF BOILER THERMO PROBE	MOTORIZED THERMO PROBE	1995 (3RD QTR)		FOR P.R.
10.0 REPLACEMENT OF CWP 2A MOTOR	MOTOR ASSEMBLY	1995 (3RD QTR)		WITH P.R.

Appendix 4-3

FIVE-YEAR PLANT MAINTENANCE PROGRAM

Regional Center : MMRC
Plant : MALAYA THERMAL PLANT
Unit : UNIT #2

ACTIVITIES	EQUIPMENT/PARTS/ COMPONENTS AND MATERIALS	DATE NEEDED	ESTIMATED COST	REMARKS STATUS
11.0 REPLACEMENT OF OBSOLETE SAMPLING RACK	FOR CONTRACT - NEW DESIGN SAMPLING RACK	1995 (3RD QTR)		WITH P.R. BUT NO SUPPLIER QUOTED FOR RE-P.R.

Appendix 4-3

FIVE-YEAR PLANT MAINTENANCE PROGRAM

Regional Center : MMRC
Plant : MALAYA THERMAL PLANT
Unit : UNIT #2

ACTIVITIES	EQUIPMENT/PARTS/ COMPONENTS AND MATERIALS	DATE NEEDED	ESTIMATED COST	REMARKS STATUS
1:0 REPLACEMENT OF RWP	TURBINE TYPE PUMP ASSEMBLY	1996 (2ND QTR)		FOR P.R.
2.0 OVERHAUL OF FDF/GRF	CONSUMABLE PARTS & MATERIALS	1996 (2ND QTR)		FOR P.R.
3.0 REPLACEMENT OF THE EXISTING PNEUMATIC TYPE TO AUTOMATIC BOILER CONTROL AND AUXILIARIES TO BAILEY INF 1-90 SYSTEM (MICROPROCESSOR BASE PROGRAMMABLE CONTROL)	FOR CONTRACT	1996 (2ND QTR)		FOR P.R.
4.0 PROCUREMENT OF GRF SPARE MOTOR	SPARE MOTOR ASSEMBLY	1996 (2ND QTR)		FOR P.R.
5.0 PROCUREMENT OF FDF SPARE MOTOR	SPARE MOTOR ASSEMBLY	1996 (2ND QTR)		FOR P.R.

FIVE-YEAR PLANT MAINTENANCE PROGRAM

Regional Center : MMRC
Plant : MALAYA THERMAL PLANT
Unit : COMMON FACILITIES

ACTIVITIES	EQUIPMENTS/PARTS/ COMPONENTS AND MATERIALS	DATE NEEDED	ESTIMATED COST	REMARKS STATUS
1.0 INSTALLATION OF FUEL OIL METERING TO FUEL OIL STORAGE TANKS	F.O. METERS	1994 (3RD QTR)		WITH P.R. UNDER PROCESS
2.0 REPLACEMENT OF EXISTING FLAMMABLE MINERAL OIL AT EMERGNCY TRANSFORMER	FOR CONTRACT	1995 (4TH QTR)		FOR P.R.
3.0 REPLACEMENT OF AGING HOIST WIRE ROPE OF CWP OVERHEAD CRANE	SPARE WIRE ROPE	1995 (4TH QTR)		FOR P.R.
4.0 REHABILITATION OF IN-TAKE CHANNEL SHEET FILES	FOR CONTRACT	1995		FOR P.R.
5.0 DREDGING OF SETTLING BASIN	FOR CONTRACT	1995		FOR P.R.
6.0 REPLACEMENT OF STORAGE BATTERY - 60 CELLS SET	60 CELLS BATTERY SET	1996 (2ND QTR)		FOR P.R.