The causes of shutdown are classified in the following:
(Ratio is shown in the percentage of shutdown days.)

Cause of the Plant Shutdown	Ratio
Plant overhaul/maintenance	57.4%
Power System faults	12.4%
Troubles of PGI steam supply system	10.2%
Cleaning of steam strainers	7.1%
Sticking of MSV and CV, and governor troubles	4.4%
Hotwater pump troubles	3.0%
Plant electrical system faults	1.6%
Cooling water pipeline troubles and others	3.7%
Spark of generator slip ring carbon brushes	0.2%

3. Problems with Steam Supply System and Power Plant Facilities and Countermeasures

(1) Mechanical Facilities

a. Overhaul

The frequency of overhauling and the length of shutdown periods increase as the quality of steam gets poorer.

The steam quality at Tiwi Geothermal Power Plant has been improved since the commissioning, and further in 1990, the steam scrubbing system was added and good results are obtained. Based on the operation records to date, it is judged that the safety of the plant will be maintained with the overhaul once or twice a year.

A maximum of 13 weeks of the period of plant shutdown for the plant overhaul was recorded. However, if one set of spare rotor is available in stock, the period required for the overhaul would be less than 3 weeks even in the worst case. From the above viewpoint, procurement of one set of spare turbine rotor, nozzle and diaphragm is recommended.

b. Installation of Water Washing Equipment

Recently, the water washing system was developed, and it became possible to remove the scale deposited on the turbine nozzles and blades without shutting down the unit.

As a means of protection of the plant, the water washing system should be added for the extension of the continuous operation time, prevention of decline of the output and prevention of rubbing of the rotor due to scaling.

c. Lining of Main Cooling Water Pipes

The corrosion of the main cooling water pipes and hot water pipes are conspicuous, and in the extreme case, as much as 75% of the tube wall thickness is corroded. These pipes are buried underground, over which the hybrid type gas compressors are located. Therefore, if the corrosion progresses at the present rate, it is feared that the pipes may collapse under the earth pressure and heavy loads.

It is necessary to line the pipes with stainless steel (SUS 304) pipes of wall thicknesses corresponding to the lost thicknesses and prevent the collapsing and the progress of corrosion.

d. Installation of H_2 Gas Cooler Tube Cleaner

Algae growth and mud deposit in the generator hydrogen gas cooler tubes decrease the coefficient of overall heat transmission. To recover this, tube cleaning is carried out with a decreased output or unit shutdown.

The H_2 gas cooler will be equipped with cleaning brushes so that the interior of the tubes may be cleaned automatically and continuously.

e. Installation of Hybrid Type Gas Extractors including H_2S Gas Diffusion System

The installation of the hybrid type gas extractors for No. 1, No. 2, No. 5 and No. 6 Units is under way, by which an increase of the output (approx. 29 MW), lowered ground concentration of H_2S gas and prevention of corrosion due to scattered steam condensate, etc. are expected.

For the same reasons as above, one (1) set of hybrid type gas extractor for common use should be added to No. 3 and No. 4 Units also, or an increase of the output (approx. 11 MW).

f. Procurement of Vehicles

At Tiwi Power Plant, there are 255 employees composed of 123 operators, 70 maintenance crew and 62 others. And the power plant has one mobile allocated to Plants A, B and C combined.

The working mode of operators is by the 4 group 3 shift system, but the shift changes are difficult to be made regularly because of difficult transportation.

In some cases, operators cannot help working two shifts continuously. This is a serious problem in the operation of the power plant.

Since the power plant and the residential quarters of the employees are located in the remote area, there is no public transportation available.

And the number of vehicles assigned to the power plants is short, and they are all dilapidated by age and need to be replaced.

For smooth transportation of shift operators and speedy transportation of maintenance crew and security personnel in care of power plant troubles and emergency.

It is advisable to purchase one small bus (capacity: 29 persons) and a jeep (capacity: 7 persons) equipped with a winch.

(2) Electric Facilities

a. Electric Facilities within Powerhouse

(a) Generator equipment

No problem was found with both the stators and the rotors of the generators proper so far. However, as it is more than 10 years already since the commissioning of No. 1 to 4 units, the detailed study on the necessity of the rewedging of stator windings is essential and study on rewinding of rotors, and detail inspection of retaining rings are necessary. Repair of the slip rings, and replacement of the brush holders and brushes are necessary. The H_2 gas seal at the generator stator temperature sensor terminals should be thoroughly inspected. Parts of the AVR also have been corroded to the degree needing replacement.

(b) 4.16 kV and 480 V switchgears and 480 V motor control centers

The central air conditioners are now out of order and the doors of the electric room are left open, the air of the powerhouse containing H_2S gas enters and gives adverse effects of corrosion and deterioration of the electric equipment, relays, instruments, etc. The repair of the air conditioners is imperative.

(c) Addition of generator circuit breaker

As there occur frequent plant trips due to the power system faults, it is advisable to install the generator circuit breakers to facilitate the operation of the plant with the station service load only and to raise the flexibility in the plant operation.

b. Electric Facilities in Switchyard

As mentioned before, the steam and H_2S gas in the ejector exhaust cause corrosion, insulation drop, and malfunctioning of the electric facilities in the switchyard, especially the exposed parts of conductors, insulators, disconnecting switches, overhead ground wires, circuit breakers, control equipment, etc.

As a fundamental measures, the more effective means of diffusion of the ejector exhaust should be established.

(3) Instrumentation and Control Equipment

Because the H_2S containing NCG discharged from the condenser is not dispersed in the air satisfactorily, several problems have occurred on the control and instrumentation facilities. Especially, the windows of the central control room are kept open to take in the outside air, because all the air conditioners of Plant A, B and C are out of order. Thus, the air contaminated with H_2S comes into the room and causes adverse effects of corrosion and insulation deterioration on the instruments and control equipment in the room. The restoration of the air conditioners is urgently needed. The major rehabilitation work items on instrumentation and control equipment are described in the following.

a. Repair of Hotwell Level Control System

b. Replacement of Control Board Recorders

c. Repair and Replacement of Control Board Indicators and Transmitters

d. Inspection and Repair of Control Air Supply System and Additional Installation of Air compressors (3 sets)

e. Installation of Automatic Chemical Dosing System

6.2.2 Present Situation and Problems in Mak-Ban Geothermal Power Plant

1. Geothermal Steam Supply

There is no indication of shortage of geothermal steam supply.

2. Present Status of Power Plant Facilities

The frequency of shutdowns of Units No. 1 to 6 of Mak-Ban Geothermal Power Plant in 5 years from 1986 to 1990 was 239 times and the total shutdown days were 839, which is equivalent to 7.7% of the total operating days.

The causes of shutdowns are classified in the following:

Cause of the Plant Shutdown	Ratio
Plant overhaul/maintenance	58.8%
Plant electrical system faults	16.3%
Cooling water pipeline troubles	8.3%
Hydrogen gas cooler cleaning	5.5%
Troubles of PGI steam supply system	4.2%
Condenser vacuum low	3.9%
Spark of generator slip ring carbon brushes	1.3%
Governor system troubles	1.3%
Power System faults	0.5%

3. Problems with Power Plant Facilities and Countermeasures

(1) Mechanical Facilities

a. Overhaul

The frequency of overhauling and the total number of shutdown days increase as the quality of steam gets poorer.

The steam quality at Mak-Ban Geothermal Power Plant has been improved since the commissioning, and further in 1990, the steam scrubbing system was added and good results are obtained. Based on the operation records to date, it is judged that the safety of the plant will be maintained with the overhaul once or twice a year.

It was recorded that 12 weeks of plant shutdown was needed at the maximum for the plant overhaul. However, if one set of spare rotor is available in stocks, the period required for the overhaul would be less than 3 weeks even in the worst case. From this viewpoint, procurement of one set of spare turbine rotor, nozzle and diaphragm is recommended.

b. Installation of Water Washing Equipment

Recently, the water washing system was developed, and it became possible to remove the scale deposited on the turbine nozzles and blades without shutting the unit down.

As a means of protection of the plant, the water washing system should be added for extension of the continuous operation time, prevention of decline of the output and prevention of rubbing of the rotor due to scaling.

c. Lining of Main Cooling Water Pipes

The main cooling water pipes and hot water pipes are severely corroded, and in the extreme case, as much as 75% of the tube wall thickness is corroded. These pipes are buried underground. Therefore, if the corrosion progresses at the present rate, it is feared that the pipes may collapse under the earth pressure.

It is necessary to line the pipes with stainless steel (SUS 304) pipes of wall thicknesses corresponding to the lost thicknesses and prevent collapsing and further progress of corrosion.

d. Installation of H_2 Gas Cooler Tubes Cleaner

Algae growth and mud deposited in the generator hydrogen gas cooler tubes decrease the coefficient of overall heat transmission. To recover this, tube cleaning is carried out with a decreased output or unit shutdown.

The H_2 gas cooler will be equipped with cleaning brushes so that the interior of the tubes may be cleaned automatically and continuously.

e. Diffusion of H_2S gas and Addition of After-condenser

With No. 1 Unit through No. 4 Unit, the steam ejectors are in normal use and the gas compressors are kept on standby.

At present, the gas compressors suffer surging and corrosion has progressed extensibly. Thus, it is judged that the gas compressors cannot be used any longer.

For the steam ejectors to be used normally without troubles, it is advisable to add after-condensers to the steam ejectors and protect the surrounding equipment from corrosion due to the discharged steam condensate. And further it is advised that the discharge from the ejectors be led to the outlet of forced draft of the cooling towers to effect better diffusion and decrease the ground concentration of H_2S gas.

f. Procurement of Vehicles

At this Mak-Ban Power Plant, there are 271 employees composed of 135 operators, 63 maintenance crew and 73 others. And the power plant has one mobile allocated to Plants A, B and C combined.

The working mode of operators is by the 4 group 3 shift system, but the shift changes are difficult to be made regularly because of difficult transportation.

In some cases, operators cannot help working two shifts continuously. This is a serious problem in the operation of the power plant.

Since the power plant and the residential quarters of the employees are located in the mountains, there is no public transportation available.

And the number of vehicles assigned to the power plants is short, and they are all dilapidated by age and need to be replaced.

For smooth transportation of shift operators and speedy transportation of maintenance crew and security personnel in case of power plant troubles and emergency.

It is advisable to purchase one small bus (capacity: 29 persons) and a jeep (capacity: 7 persons) equipped with a winch.

(2) Electric Facilities

a. Electric Facilities within Powerhouse

(a) Generator equipment

No problem was found with both the stators and the rotors of the generators proper so far. However, as it is more than 10 years already since the commissioning of No. 1 to 4 units, a detailed study on the necessity of the rewedging of stator windings is essential, and rewinding of the rotor and detail inspection of retaining rings seems essential. Repair of the slip rings, and replacement of the brush holders and brushes are necessary. The H_2 gas seal at the generator stator temperature sensor terminals should be thoroughly inspected. Parts of the AVR also have been corroded to the degree needing replacement.

(b) 4.16 kV and 480 V switchgears and 480 V motor control centers

The centralized air conditioning system gets out of order once in a while, and the doors of the electric room are opened, when the air of the powerhouse containing H_2S gas enters and gives adverse effects of corrosion and deterioration to the electric equipment, relays, instruments, etc. It is necessary to install the H_2S gas diffusion device and maintain the air conditioners.

As for the magneblast circuit breakers for the generator, heating due to increased contact resistance once caused the burnt circuit breaker. Thus, the circuit breakers for No.2, 3 and 4 Unit have been replaced with gas circuit breakers. It would be necessary to consider the replacement of the circuit breaker for No.1 Unit.

The 480 V motor control center has a problem in its design. When one of the cooling fan motors on the cooling tower is grounded, all the cooling fans are tripped, leading to the plant trip. Therefore, it is necessary to consider the selective tripping at grounding faults of this system.

And as there frequently occur the grounding faults and burns of the cooling fan motors, it is necessary to make a detailed investigation of the causes.

b. Electric Facilities in Switchyard

As mentioned before, the steam and H_2S gas in the ejector exhaust cause corrosion, insulation drop, and malfunctioning of the electric facilities in the switchyard, especially the exposed parts of conductors, insulators, disconnecting switches, overhead ground wires, circuit breakers, control equipment, etc.

As a fundamental measures, the more effective means of diffusion of the ejector exhaust should be established. Some obsolete type OCB should also be replaced with SF6 type circuit breakers.

(3) Instrumentation and Control Equipment

Unlike Tiwi Power Plant, the air conditioning system for the central control room of Mak-Ban Power Plant are operating normally, and such corrosion and deterioration of the equipment and instruments as experienced in Tiwi Power Plant have not occurred. However, the instrumentation and control equipment installed at locations exposed to the atmosphere have been corroded by H_2S gas.

The major rehabilitation work items with instrumentation and control equipment are described in the following.

a. Repair of Hotwell Level Control System

b. Replacement of Control Board Recorders (obsolete type)

c. Repair and Replacement of Control Board Indicators and Transmitters

d. Replacement of Turbine Supervisory Instruments

e. Inspection and Repair of Control Air Supply

f. Installation of Automatic Chemical Dosing System

6.2.3 Formulation of Rehabilitation Plan

1. Criteria for Selection of Rehabilitation Items

The rehabilitation work items and the priority are determined based on the site survey on the causes of shutdowns in 5 years, the overhauling report and the following fundamental concepts for the rehabilitation.

(1) Improvement and repair items aiming at eliminating the causes of faults which resulted in long forced shutdowns.

(2) Replacement or improvement items against troubles or failures which may not only lead to serious plant troubles but also need a long time and excessive expenses for restoration.

(3) Improvement items which are necessary for prevention of pollution or environmental preservation.

(4) Advance replacement of obsolete equipment which are indispensable for proper operation of the plant and spare parts which are or will become unavailable.

(5) Items which are, if adopted in the rehabilitation program, economically advantageous for increase of generated energy

with less overhaul frequency and shorter overhaul period.

(6) Improvement items which will economize the operation and maintenance expenses largely.

(7) Replacement or supply of parts which may need a considerable time and expenses if the maintenance is deferred.

2. Rehabilitation Work Items for Tiwi Geothermal Power Plant

The rehabilitation items for the mechanical, electrical and instrumentation and control facilities of the power plant and their priority are described in Table 6-2-1.

3. Rehabilitation Work Items for Mak-Ban Geothermal Power Plant

The rehabilitation items for the mechanical, electrical, and instrumentation and control facilities of the power plant and their priority are described in Table 6-2-2.

Table 6-2-1 Power Plant Rehabilitation Items and Priority

Power Plant: Tiwi

No.	Rehabilitation Item	Unit No.						Priority			Remarks
		1	2	3	4	5	6	1st	2nd	3rd	
Mechanical part											
M- 1	Procurement of turbine spare rotor, nozzle and diaphragm	-	-	-	-	o	-	o	-	-	
M- 2	Installation of water washing equipment	o	o	o	o	o	o	o	-	-	
M- 3	Main cooling water pipe inner lining with stainless steel and addition of electrolytic protection system	o	o	o	o	o	o	o	-	-	
M- 4	Replacement of aux. cooling water pipeline including the headers	o	o	o	o	o	o	o	-	-	
M- 5	Installation of hybrid type gas extraction system including removal of ejector steams discharge point to downstream of cooling tower fans	-	-	o	o	-	-	o	-	-	
M- 6	Partial replacement of cooling tower materials	o	o	o	o	o	o	o	-	-	
M- 7	Installation of automatic tube cleaner for generator H_2 gas cooler	o	o	o	o	o	o	o	-	-	
M- 8	Procurement of vehicle	o	-	-	-	-	-	o	-	-	
M- 9	Procurement of honing machine	-	o	-	-	-	-	o	-	-	
M-10	Additional steam production wells	o	o	o	o	o	o	o	-	-	Scope of PGI, steam supplier
M-11	Installation of steam scrubber system	-	-	o	o	-	-	o	-	-	ditto
M-12	Modification of rupture disk blowout line	o	o	o	o	o	o	o	-	-	ditto
Electrical part											
E- 1	Inspection of generator rotor windings	o	o	o	o	o	o	o	-	-	*Detail study is needed*
E- 2	Inspection of retaining ring of generator rotor	o	o	o	o	o	o	o	-	-	
E- 3	Rewedging of generator stator windings	o	o	o	o	o	o	o	-	-	
E- 4	AVR replacement	o	o	o	o	o	o	o	-	-	
E- 5	Adoption of selective tripping for CTF motor control center ground faults	o	o	o	o	o	o	o	-	-	
I & C part											
IC-1	Replacement of control board recorders	o	o	o	o	o	o	o	-	-	
IC-2	Repair or replacement of air conditioning system	o	o	o	o	o	o	o	-	-	
IC-3	Repair or replacement of control board indicators /transmitters	o	o	o	o	o	o	o	-	-	
IC-4	Replacement of TSI	o	o	o	o	o	o	o	-	-	
IC-5	Replacement of automatic chemical dosing system	o	o	o	o	o	o	-	o	-	
IC-6	Additional installation of control air compressor	o	-	o	-	o	-	o	-	-	3 sets

Table 6-2-2 Power Plant Rehabilitation Items and Priority

Power Plant: Mak-Ban

No.	Rehabilitation Item	Unit No.						Priority			Remarks
		1	2	3	4	5	6	1st	2nd	3rd	
Mechanical part											
M- 1	Procurement of turbine spare rotor, nozzle and diaphragm	o	-	-	-	-	-	o	-	-	
M- 2	Installation of water washing system	o	o	o	o	o	o	o	-	-	
M- 3	Main cooling water pipe inner lining with stainless steel and addition of electrolytic protection system	o	-	o	o	o	o	o	-	-	
M- 4	Replacement of aux. cooling water pipeline including the headers	o	o	o	o	o	o	o	-	-	
M- 5	Installation of automatic tube cleaner for generator H_2 gas cooler	o	o	o	o	o	o	o	-	-	
M- 6	Installation of after-condenser including removal of ejector steam discharge point to downstream of cooling tower fans	o	o	o	o	-	-	o	-	-	
M- 7	Partial replacement of cooling tower materials	o	o	o	o	o	o	o	-	-	
M- 8	Remodeling of main stop valve	o	o	o	o	o	o	o	-	-	
M- 9	Procurement of vehicles	o	-	-	-	-	-	o	-	-	
M-10	Procurement of honing machine	-	o	-	-	-	-	o	-	-	
M-11	Installation of steam scrubber system	-	-	o	o	-	-	o	-	-	Scope of PGI, steam supplier
M-12	Modification of rupture disk line	o	o	o	o	o	o	o	-	-	ditto
Electrical part											
E- 1	Inspection of generator rotor windings	o	o	o	o	o	o	o	-	-	
E- 2	Inspection of retaining ring of generator rotor	o	o	o	o	o	o	o	-	-	
E- 3	Rewedging of generator stator windings	o	o	o	o	o	o	o	-	-	
E- 4	AVR replacement	o	o	o	o	o	o	o	-	-	
E- 5	Replacement of generator stator temperature sensor terminal board	o	o	o	o	o	o	o	-	-	
E- 6	Replacement of defective disconnecting switches in switchyard	o	o	o	o	-	-	o	-	-	
E- 7	Replacement of switchyard circuit breakers	o	o	o	o	o	o	o	-	-	6 sets
E- 8	Adoption of selective tripping for CTF motor control center ground faults	o	o	o	o	o	o	o	-	-	
I & C part											
IC-1	Replacement TSI sensors/parts	o	o	o	o	-	-	o	-	-	
IC-2	Replacement of control board recorders	o	o	o	o	-	-	o	-	-	
IC-3	Replacement of control board indicators/transmitters	o	o	o	o	-	-	o	-	-	
IC-4	Replacement of chemical dosing system	o	o	o	o	-	-	-	o	-	

Table 6-2-3

SUMMARY OF GEOTHERMAL POWER PLANT FACILITIES

POWER PLANT	PLANT OUTPUT kW	GEOTHERMAL WELL: PRODUCTION WELL: NUMBER	GEOTHERMAL WELL: PRODUCTION WELL: TOTAL DEPTH m	GEOTHERMAL WELL: PRODUCTION WELL: MAX.MIN DEPTHS m	GEOTHERMAL WELL: REINJ. WELL NUMBER	GEOTHERMAL WELL: TOTAL STEAM FLOW t/h	GEOTHERMAL WELL: TOAL HOT-WATER FLOW t/h	PLANT CYCLE	COOLING TOWER	TURBINE: UNIT No.	TURBINE: TYPE	TURBINE: RATED OUTPUT kW	TURBINE: STEAM PRESSURE kg/cm2	TURBINE: STEAM TEMPERA-TURE C	TURBINE: EXHAUST PRESSURE mmHg.abs	TURBINE: SPEED rpm	TURBINE: MANUFAC-TURER	GENERATOR: RATED CAPACITY kVA	GENERATOR: VOL-TAGE kV	GENERATOR: FREQU-ENCY Hz	GENERATOR: MANUFAC-TURER	COMMISS-IONING
MAK-BAN	330,000	58		MAX. 3,141 MIN. 655	21	3,249		SINGLE FLASH	CROSS FLOW INDUCED DRAFT	1	DOUBLE FLOW	55,000	5.68	162.3	101.6	3,600	M.H.I.	68,750	13.8	60	MITSU-BISHI ELECTRIC	SEP 1979
								DO	DO	2	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	NOV 1979
								DO	DO	3	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	AUG 1980
								DO	DO	4	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	OCT 1980
								DO	DO	5	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	SEP 1984
		(SEP) (1991)						DO	DO	6	DO	55,000	5.68	162.3	101.6	3,600	DO	68,750	13.8	60	DO	DEC 1984
TIWI	330,000	77		MAX. 2,970 MIN. 457	7	2,360		SINGLE FLASH	CROSS FLOW INDUCED DRAFT	1	DOUBLE FLOW	55,000	6.10	160.6	101.6	3,600	TOSHIBA	69,000	13.8	60	TOSHIBA	JAN 1979
								DO	DO	2	DO	55,000	6.10	160.6	101.6	3,600	DO	69,000	13.8	60	DO	MAY 1979
								DO	DO	3	DO	55,000	6.10	160.6	101.6	3,600	DO	69,000	13.8	60	DO	JAN 1980
								DO	DO	4	DO	55,000	6.10	160.6	101.6	3,600	DO	69,000	13.8	60	DO	APR 1980
								DO	DO	5	DO	55,000	6.00	164.4	101.6	3,600	DO	69,000	13.8	60	DO	DEC 1981
								DO	DO	6	DO	55,000	6.00	164.4	101.6	3,600	DO	69,000	13.8	60	DO	MAR 1982

6.3 Hydro Power Plants

6.3.1 Current Status and Problems of Hydro Power Plants

The current status and problems of hydro power plants revealed in the present study are as follows:

1. Outline of Hydro Power Plants in the Luzon Grid

There are 11 hydro power plants with a total capacity of 1,226.16 MW in the Luzon Grid (refer to Table 6-3-1). In the grid, the generated energy by hydro power plants reached 2,369 GWh in 1990, and the percentage of hydro power generation to the total generation was 28.4% in the plant capacity and 12.6% in the generated energy.

Most hydro power plant dams are owned by NIA (National Irrigation Administration) and used for irrigation. Some of them are also used for water supply, and accordingly the plant capacity factor is low, particularly in the dry season between April and June.

Ambuklao Power Plant is currently undergoing rehabilitation because the silt deposit overreached the level of the intake, and in addition, the civil structures were damaged and the generator room was flooded by the earthquake in July 1990. The rehabilitation is scheduled to be completed in 1995.

All other hydro power plants were in operation, excepting Botocan Power Plant which was out of operation for replacement of circuit breakers.

2. Civil Structures of Hydro Power Plants

(1) Dams

Out of NAPOCOR owned dams, namely, Ambuklao, Binga, Caliraya and Botocan Dams, the dams which have problems are under rehabilitation. A particularly prominent problem discovered

Table 6-3-1 HYDRO POWER PLANT DATA

Regional Center	Power Plant	Installed Capacity (MW)	Unit Nos.	Unit Capacity (MW)	Date Of Commis.	Remarks
NLRC	Magat	360	1	90	1983	
			2	90	1983	
			3	90	1983	
			4	90	1983	
	Ambuklao	75	1	25	1956	
			2	25	1956	
			3	25	1957	
	Binga	100	1	25	1960	
			2	25	1960	
			3	25	1960	
			4	25	1960	
	Pantabangan	100	1	50	1977	
			2	50	1977	
	Masiway	12	1	12	1981	
	Angat	228	1	50	1967	
			2	50	1967	
			3	50	1968	
			4	50	1968	
			Aux1	6	1967	
			Aux2	6	1967	
			Aux3	6	1978	
			Aux4	10	1986	
	Sub Total	875	22			
SLRC	Kalayaan	300	1	150	1982	Pumped Strage Power Plant
			2	150	1982	
	Caliraya	32	1	10	1945	
			2	10	1945	
			3	10	1947	
			4	10	1950	
	Botocan	16.96	1	8	1948	
			2	8	1948	
			3	0.96	1960	
	Barit	1.8	1	1.8	1957	
	Cawayan	0.4	1	0.4	1959	
	Sub Total	351.16	11			
Total		1,226.16	33			

in the study is the silt deposit in Ambuklao and Binga Dams. The volume of deposits has already exceeded 45% of the reservoir capacity in both dams.

The annual deposits inflow into Ambuklao reservoir amounts to 3,600,000 m^3 and fine silt is concentratedly deposited around the intake. The silt level has overreached the level of the intake, and the power plant has been out of service since 1990. Although NAPOCOR plans to dredge around the intake, the dredging work entails many problems such as the location of the power plant, disposal of dredged silt, road condition, etc. Therefore, the Ambuklao Power Plant intake should be reconstructed so that the intake level may be raised with the rising level of silt deposit.

At the Binga Power Plant, since the silt deposit reached the level of the intake in 1991, rehabilitation is under way. Since the volume of deposits inflow into the Binga reservoir is less than that into the Ambuklao reservoir, it is likely that the dredging work will maintain the intake operation for some time. However, reconstruction of the intake will be needed in the long run.

Water leakage from the service spillway at the Caliraya Dam has drastically increased since August 1991, and countermeasures are being studied by NAPOCOR.

(2) Other Structures

For the other structures, water leakage around water turbines, water leakage from headrace, etc. were found at some power plants, but they are not so serious as to hinder the operation immediately.

3. Electrical Equipment of Hydro Power Plants

(1) Water Turbines and Generators

a. The frequency of forced outages in 1990 was 89, and the duration of outages was 777.46 hours. The longest outage was 143.60 hours, caused by the air cooler failure of No. 1 generator at Masiway Power Plant.

b. It is noted that the same kind of water turbine and generator faults have occurred repeatedly. In 1990, 16 times of faults related to the exciters occurred at Magat Power Plant, and 21 times of breaking element troubles of water turbine guide vanes occurred at Binga Power Plant.

It is necessary to thoroughly identify the causes of faults in order to prevent further occurrence of faults. For this purpose, it is essential to record the details of faults and the operating conditions. Based on the detailed records by type of equipment and type of causes, the causes of faults must be fully studied and the results of study should be reflected on the equipment and maintenance improvements.

(2) Other Equipment

Water leakage around water turbine covers, etc. were observed at some power plants in operation, but they were not so serious as to hinder their operation immediately. It is impossible to draw a conclusion on the conditions of all the equipment by this short-term survey, but it seemed that power plants were maintained relatively well, without serious vibration and other harmful phenomena.

Switchyard equipment are described in Item 3 of Sub-clause 6.4.1.

6.3.2 Formulation of Rehabilitation Plan

Reconstruction of Ambuklao Power Plant intake and replacement of Magat Power Plant excitation transformer have been planned.

1. Civil Structures

Regarding the countermeasures against the silt deposit in the Ambuklao reservoir, the JICA conducted the study and prepared the report in March 1988. In this report, the following five alternatives were studied and alternative "e", Vertical Intake Tower, was recommended in consideration of construction costs, duration of plant outages, construction methods, maintenance costs, and other economic factors.

a. Large Scale Dredging
b. Raising of Intake Tower
c. Sediment Discharge Tunnel
d. Inclined Intake Tower
e. Vertical Intake Tower

In the present study, the JICA report was reviewed based on the results of the survey, and the same conclusion was reached. The presently progressing Ambuklao Power Plant rehabilitation is scheduled to be completed in 1995 and thus, the earliest commencement of this reconstruction project is recommended.

2. Electrical Equipment

The dry-type transformers for the static exciters of the Magat Power Plant have had frequent failures. As it is suspected that the transformers have problems in the design and structure, replacement with molded transformers has been planned.

Switchyard equipment are described in Item 2 of Sub-clause 6.4.2.

6.3.3 Priority Criteria and Priority

The order of priority is (1) the reconstruction of Ambuklao Power Plant intake, and (2) the replacement of Magat Power Plant excitation transformer.

6.4 Transmission Lines and Substations

6.4.1 Current Status and Problems of Transmission and Substation Facilities

The current status and problems of transmission and substation facilities revealed in the present study are as follows:

1. Outline of the Luzon Grid

As shown in Fig. 6-4-1, the Luzon Grid consists mainly of 230 kV system which runs through the island from north to south, with 115 kV system used in some parts of the island. The secondary transmission voltage is 69 kV.

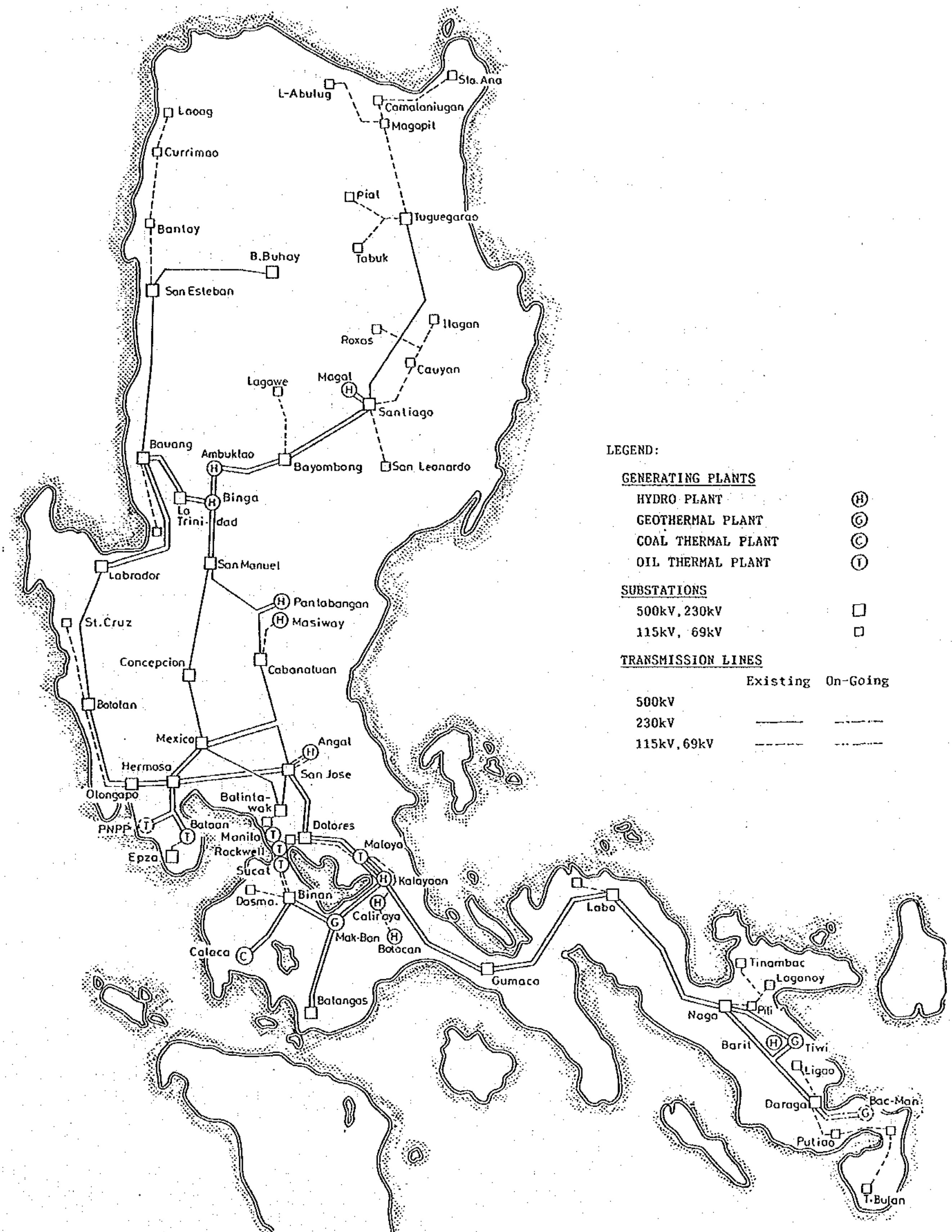
As for the power sources, hydro power plants are located mainly in the north of the island, thermal, geothermal and pumped storage power plants in and around Manila, and a geothermal power plant is located in the south.

The 230 kV system is divided into the following five systems.

- Northern System, which extends from Magat Power Plant to Bauang Substation through Ambuklao and Binga Power Plants
- Central System, which extends from Binga Power Plant to San Jose and Balintawak Substations through Mexico Substation
- Midwest System, which extends from Bauang Substation to San Jose Substation through Hermosa Substation
- Manila Outer Link System, which extends from San Jose Substation to Sucat Power Plant through Kalayaan Power Plant and Binan Substation
- Southern System, which extends from Tiwi Power Plant to Kalayaan Power Plant.

The Midwest System was commissioned in December 1991.

Fig. 6-4-1 LUZON GRID POWER SYSTEM DIAGRAM



Most of the 230 kV lines are in loop configuration with one or two circuits per route, but some of the lines are in radial configuration with a single circuit per route. All of the lines are supported by steel towers, with single, double and four conductors of ACSR 795 MCM.

For the 115 kV lines, steel towers and wooden poles are used for supports. Steel tower lines have two circuits per route, while wooden pole lines have a single circuit per route, with the conductors of ACSR 795 MCM and 336.4 MCM.

The MERALCO system in and around Manila is formed with 115 kV transmission lines which are supplied from Balintawak, San Jose, Dolores and Binan substations, and Malaya and Sucat power plants.

The 69 kV lines are mostly supported by wooden poles and are in radial configuration with a single circuit per route, with the conductors of ACSR 336.4 MCM and 4/0.

The circuit lengths of transmission lines and the number and capacity of substations in the Luzon Grid as of the end of 1990 are shown below.

	Transmission Line	Substation	
	Circuit Length (km)	Number	Capacity (MVA)
230 kV	3,232	22	3,485
115 kV	442	6	310
69 kV	2,976	46	467
34.5 kV & below	524		
Total	7,174	74	4,262

2. Transmission Facilities

(1) 230 kV System

a. For the 230 kV system, line faults have occurred frequently, posing problems as described below. However, there is no big problem concerning the system formation.

b. In the Northern System, separation of the hydro power plants from the grid caused by transmission line faults and voltage drop during the dry season are the problems of the system. In the Southern System, separation of the Tiwi Power Plant from the grid occurred due to broken ground wires.

The problems of the Northern System will be eliminated by completion of the Midwest System. With regard to the Southern System, the overhead ground wires need to be replaced with aluminum-clad steel wires.

c. The average frequency of line faults per 100 km was 5.6 in 1990, which is roughly 6 times larger than the frequency in Japan. The maximum frequency was 24.8 for the Binga - San Manuel Line. As described in Clause 7.5, it is imperative to investigate the causes of the faults and to push forward the countermeasures for fault reduction.

d. Corrosion of Overhead Ground Wires in the Southern System

Galvanized steel wire is used for the overhead ground wire, but in some places, the corrosion has occurred in just a few years, causing broken wires.

Corroded overhead ground wires are being partly replaced. However, scheduled replacement with aluminum-clad steel wire should be carried out.

Zinc coating of a new galvanized steel wire obtained during the survey was significantly smaller than the specified value. The standardization of specifications and distribution of the specifications to all related organizations and departments, as well as strict testing of purchased materials are necessary.

e. Corrosion of Insulator Pins in the Southern System

As with the overhead ground wires, corrosion of insulator pins is widespread. This is the galvanic corrosion caused by the direct current component of the leakage current.

Replacement of corroded insulators is conducted in accordance with the annual preventive maintenance program. However, composite insulators are partly used, despite the fact that the zinc sleeved insulator is specified as the standard.

f. Steel Tower Failures by Typhoons

According to meteorological observation records, maximum gust wind velocities of more than 200 km/hour have been recorded many times.

The Naga - Tiwi Line (failed in 1987) and Santiago - Bayombong Line (failed in 1989) have the design wind velocity of 165 km/hour and, accordingly, lack sufficient strength.

There are two possible countermeasures. One is to reinforce the steel towers with additional members and reinforce the foundations, and the other is to reinforce by the use of guy wires. As the former is not considered technically and economically feasible, the reinforcement with guy wires is deemed advisable.

g. Problems with the Design and Construction of Steel Towers

Misapplication of strain towers and suspension towers was observed. In some cases, suspension towers are used where strain towers should be used. More attention must be paid to the clearance in consideration of the local conditions such as frequent typhoons and high IKL (Iso-keraunic Level).

h. Arcing Horns

Considering the high IKL, arcing horns should be installed.

(2) 115 kV System

a. 115 kV lines supported by wooden poles have a single circuit per route and have had frequent faults, but cause no major problems as the lengths of the lines are limited.

b. In 1990, the average frequency of line faults per 100 km was 5.2 with steel tower lines, 20.9 with wooden pole lines and 14.1 as a total of 115 kV lines. This is roughly 5 times larger than the frequency in Japan.

(3) 69 kV System

a. There have been numerous faults, causing very long outages. The average frequency of line faults per 100 km in 1990 was 58.5, which is roughly 12 times larger than the frequency in Japan, with the average duration of 7.0 hours per fault. As mentioned in Clause 7.5, the causes of the faults must be investigated, and the measures for fault reduction should be promoted.

b. There are lines interrupted for extremely long durations at the time of typhoons. Among them, there are some sections where the restoration works were delayed due to difficulties in transporting the wooden poles. For these sections, rerouting will be necessary.

c. There is a line interrupted for long duration due to broken conductors caused by drifting logs during floods. This is attributable to lack of the clearance, and therefore, conversion to steel towers will be necessary.

d. There were insulators damaged by flash-over. As the arcing horn is not used, insulators are apt to be damaged. Hot-line detection of defective insulators should be adopted.

e. There were a large number of wooden poles felled by typhoons and other accidents. Preventive maintenance of the wooden poles should be promoted.

3. Substation and Hydro Power Plant Switchyard Equipment

(1) 230 kV Substations and Hydro Power Plant Switchyards

a. The frequency of the faults at 230 kV substations and hydro power plant switchyards in 1990 was 25, and the duration of outage was 10.5 hours per fault.

The frequency is not so large as compared with faults of other facilities, in consideration of the fact that there are many aged equipment at the 230 kV substations and hydro power plant switchyards. However, there are no detailed records of the faults and their causes. It is necessary to identify the causes of these faults based on detailed records classified by the type of equipment and causes, and to reflect them on the equipment and maintenance improvements.

b. Power Transformers

Oil leakage from the cooling system and transformer proper was observed at some of the substations and power plants, but it was not so serious as to hinder the operation immediately.

c. Circuit Breakers and Disconnecting Switches

The 230 kV bus system employs the 1-1/2 breaker system. Therefore, there are more circuit breakers and disconnecting switches per circuit.

At the 230 kV substations and hydro power plants, there are 211 units of 230 kV circuit breakers, 47 units of 115 kV circuit breakers and 103 units of 69 kV circuit breakers, or a total of 361 circuit breakers. These circuit breakers classified by the years of manufacture are shown in the tables below. There are many aged OCBs (oil circuit breakers) and ACBs (air circuit breakers). Most of the 69kV circuit breakers are OCBs.

Number of 230 kV Circuit Breakers by Years of Manufacture

Mfg. Years	-1960	1961-70	1971-80	1981-	Total (%)
OCB	9	11	17	0	37 (17.5)
ACB	0	9	7	0	16 (7.6)
GCB	0	0	87	71	158 (74.9)
Total	9	20	111	71	211 (100)

Number of 115 kV Circuit Breakers by Years of Manufacture

Mfg. Years	-1960	1961-70	1971-80	1981-	Total (%)
OCB	1	3	11	0	15 (31.9)
ACB	0	10	3	0	13 (27.7)
GCB	0	0	15	4	19 (40.4)
Total	1	13	29	4	47 (100)

Number of 69 kV Circuit Breakers by Years of Manufacture

Mfg. Years	-1960	1961-70	1971-80	1981-	Total (%)
OCB	1	14	57	16	88 (85.5)
ACB	0	2	7	0	9 (8.7)
GCB	0	0	4	2	6 (5.8)
Total	1	16	68	18	103 (100)

Number of Circuit Breakers by Years of Manufacture (Total)

Mfg. Years	-1960	1961-70	1971-80	1981-	Total (%)
OCB	11	28	85	16	140 (38.8)
ACB	0	21	17	0	38 (10.5)
GCB	0	0	106	77	183 (50.7)
Total	11	49	208	93	361 (100)

There are some circuit breakers with oil or gas leakage. Since there are some circuit breakers which will lack breaking capacity in the near future, replacement of circuit breakers is in progress at some of the substations.

Most disconnecting switches are of the manual operation type, and some are difficult to open and close due to tight operating mechanism, and there are some with pin insulators.

d. Other Equipment

Bolted type connectors are used for the branch connections of 230 kV bus bars at some substations with which discoloration due to overheating was observed. Compression type connectors should be used.

(2) 69 kV Substations

The equipment of NAPOCOR's 69 kV substations could not be inspected during the present survey, but they have small installed capacities of 3 to 10 MVA and are equipped with minimal equipment. Consequently, it seems that they pose no problem.

The NAPOCOR's 69 kV substations have been transferred to cooperatives one by one.

(3) Provision of Spare Parts

The equipment of substations were purchased from various manufacturers in various countries. Consequently, it is difficult to keep the many types of spare parts needed for all the equipment. In many cases, the parts for old equipment are not manufactured any longer.

In addition, a high-level of skill is required in the replacement of the inner parts (such as moving and fixed contacts) of GCB. Since the skill of replacement affects the performance of the equipment after replacement, the guidance of expert engineers will be required even if spare parts are available at hand. Therefore, with 230 kV breakers, which are the most important for system operation, it is recommended that spare equipment of standard specifications be kept in strategic locations and that the whole of the equipment be replaced in case of emergency.

6.4.2 Formulation of Renovation Plan

For the problems described in Sub-clause 6.4.1, the following renovation plans which would be effective for improvement of supply reliability and rationalization of maintenance works have been formulated. With the respective site, the detailed survey should be made during the feasibility study.

1. Transmission Facilities

(1) Replacement of Overhead Ground Wires

Replacement of 566 km of overhead ground wires of the 230 kV transmission lines with aluminum-clad steel wires has been planned.

(2) Adoption of Steel Towers for River or Road Crossings (69 kV line)

Adoption of steel towers for 20 river crossings and 9 road crossings, which were requested by the area offices, has been planned.

(3) Rerouting of the Section of 69 kV line where Restoration Works are Difficult

Rerouting of the section between the structure Nos. #307 and #345, 10 km, of the Tuguegarao - Camalaniugan Line has been planned.

(4) Provision of Defective Insulator Detectors

Provision of defective insulator detectors, one set for each power transmission line maintenance group, totaling 22 sets, has been planned.

2. Substation and Hydro Power Plant Switchyard Equipment

(1) Replacement of Circuit Breakers

The respective circuit breaker replacement plans are as explained below. It has been planned to replace circuit breakers with GCBs (gas circuit breakers) which are the most reliable and effective for rationalization of maintenance works.

a. Replacement Plan of Circuit Breakers which will Lack Breaking Capacity in the Near Future

Replacement of 11 circuit breakers which will lack breaking capacity by 1995 has been planned.

b. Replacement Plan of 230 kV OCBs and ACBs

There are 211 sets of 230 kV circuit breakers, comprising 158 GCBs, 37 OCBs and 16 ACBs. Of these, as the OCBs and ACBs have deteriorated and have maintenance problems, the replacement of 33 circuit breakers has been planned, except for the 20 circuit breakers which are now being replaced.

c. Replacement Plan of GCBs with Structural Problems

Replacement of 4 sets of 230 kV GCBs which have structural problems such as gas leakage, etc. has been planned.

d. Replacement Plan of 115 kV and 69 kV Circuit Breakers

There are 150 sets of 115 kV and 69 kV circuit breakers, comprising 25 GCBs, 103 OCBs and 22 ACBs. Of these, replacement of 19 OCBs and 14 ACBs has been planned as requested by the area offices and power plants.

(2) Replacement of Disconnecting Switches

Most of the disconnecting switches connected in series with the foregoing circuit breakers to be replaced are difficult to open and close, use pin insulators, or have structural problems due to extreme deterioration through years of use. Thus, replacement of these disconnecting switches has been planned. The respective replacement plans will be reviewed further during the feasibility study.

(3) Provision of Spare Circuit Breakers

230 kV 40 kA GCB 3 sets (two for NLRC, one for SLRC)

6.4.3 Priority Criteria and Priority

In consideration of the influence of faults, safety, and operation and maintenance problems, the priority is set as follows.

1. Replacement of overhead ground wires

2. Replacement of circuit breakers which will lack breaking capacity in the near future

3. Replacement of 230 kV circuit breakers

4. Adoption of steel towers for river or road crossings

5. Rerouting of transmission line section where restoration works are difficult

6. Provision of defective insulator detectors

7. Replacement of 115 kV and 69 kV circuit breakers

8. Replacement of disconnecting switches

9. Provision of spare circuit breakers

CHAPTER 7

OPERATION/MAINTENANCE IMPROVEMENT PLAN

CHAPTER 7 OPERATION/MAINTENANCE IMPROVEMENT PLAN

7.1 General

7.1.1 Present Status and Problems

1. Significance of Operation/maintenance Improvement Plan

In this study, Operation/Maintenance Improvement was taken up as the main theme. This is based on the following reasons and recognition.

(1) After the implementation of the Rehabilitation/Renovation and maintenance works, the effect would not last long and the effect of the investment would not be satisfactorily achieved, if the operation and maintenance management is inadequate. In other words, it is necessary to improve the efficiency of maintenance.

(2) The sections in charge of operation and maintenance carry out the most important works supporting the reliability and efficiency of electric power supply, even though their works are not conspicuous. The work efforts of these sections should be esteemed highly, and their challenge to improvement of their works should be encouraged and assisted.

2. Present Status and Problems

The present status of the electric power facilities in the Luzon Grid is symbolized by the following two phenomena.

- Low reliability of power supply
  - Frequent brownouts and forced outages

- Low quality of power supply
  - Low voltage and unstable frequency

Fig. 7-1-1 is the compilation of the "live voices" the Study Team came by at places visited.

It is clear that the supply capability is lacking basically.

Basic cause		Countermeasure
‖ Supply power shortage		
Delay of development of new power sources No new power sources after Batangas P.P. No. 1 Unit (300 MW) commissioned in 1984	→	Promotion of development of new power sources
Existing power plants are not working fully. Reserve power 31% --> nearly 0%	→	Implementation of rehabilitation works

Reserve power as of 1990

Installed capacity - Max. power = Reserve power

(4,321 MW (100%)) (2,973 MW (69%)) (1,348 MW (31%))

Countermeasures

- Promotion of development of new power sources

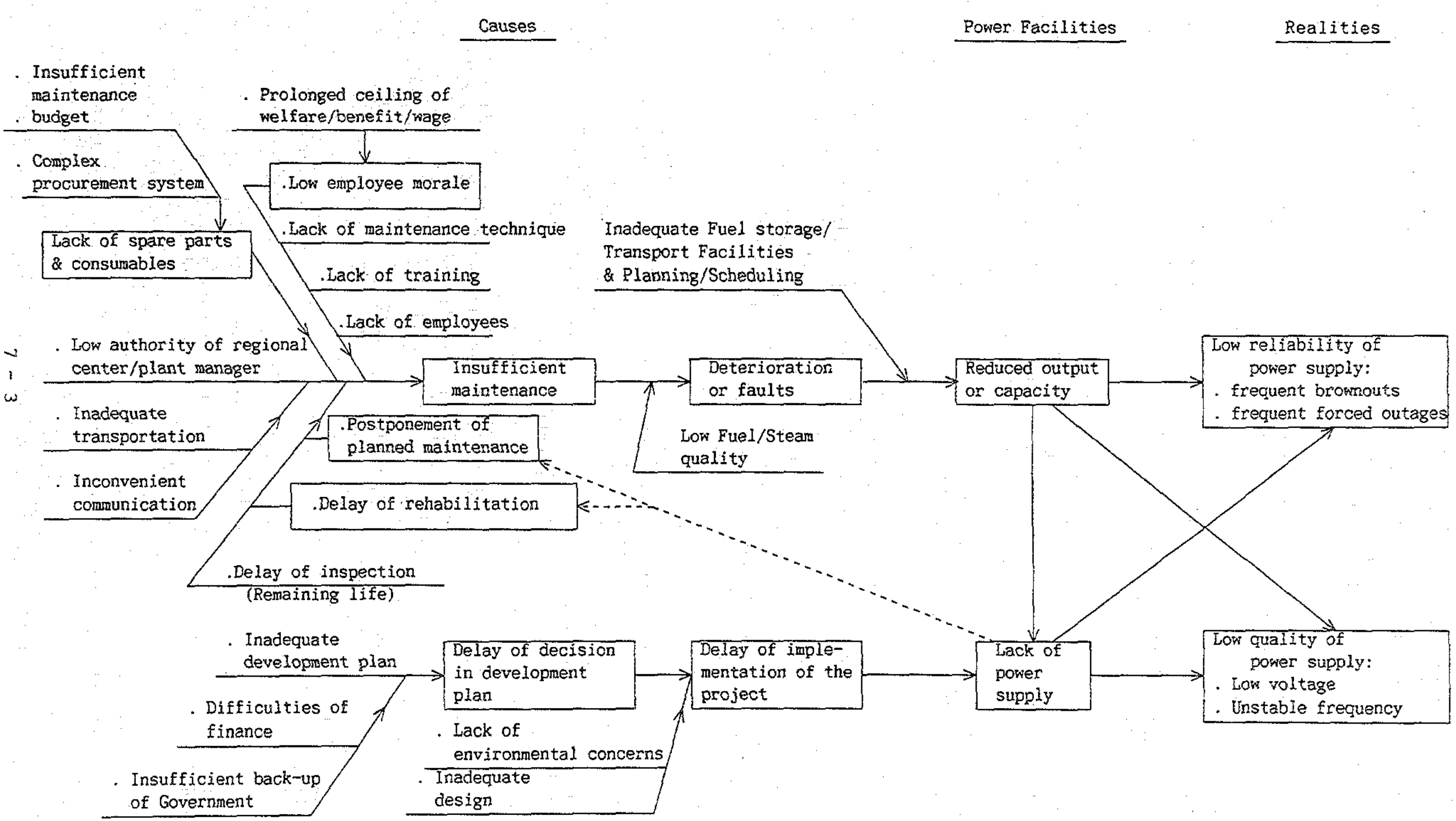
- Rehabilitation of existing power sources

  Rehabilitation of the existing power sources should be advanced in view of their quick effect and economy.

- Improvement of operation and maintenance

  The investment effect of the new facilities and rehabilitation depends on the operation and maintenance. Therefore, the problems relating to the improvement of operation and maintenance will be dealt with first.

Fig. 7-1-1 Analysis chart of Causes



(1) Problems and Approach to the Remedy

a. Clues for approach

The clues for the approach to the problems are as follows.

. Data and information collected.

. 1990 Annual Audit Report by the Quality Assurance Department (QA) of NAPOCOR Head Office.

. Operation and Maintenance Management Survey Report of 1987 by ADB.

b. Management and administration system

One of the problems advised to the Study Team during the present study was the "delay in the procurement of goods".

To cope with these problems, it is necessary to study the management and administration system. In the "Implementing Arrangement" agreed upon between JICA Preparatory Study Team and NAPOCOR, it is stated that "The study shall also cover the improvement of efficiency of maintenance through improvement of the NAPOCOR's management and administration systems...".

c. Study items for improvement planning

The problems related with NAPOCOR as a whole are treated in this Section 7.1 General, and those related with the regional centers, power plants, etc. are treated in Section 7.2 and the following sections.

The following were taken up as the problems related to NAPOCOR as a whole.

- Organization of NAPOCOR Head Office
- Equipment and materials procurement system
- Personnel plan
- Education and training plan
- Morale of employees

(2) Organization of NAPOCOR Head Office

a. Present Status

NAPOCOR carried out the review of the organization of the corporation as a whole in the period from August through November 1991, which coincided with the survey period of the Study Team.
In August 1991, reshuffle of the top management, including the President, was made. And under the new management, the organization of the Head Office was altered.
As compared with the former organization, the new organization is more functional and well defined.
(Refer to *Table* 7-1-1.)

Major alterations related to the operation and maintenance are as described in the following.

Engineering Department

(a) Plant Betterment Services Department was proposed.

(b) The Quality Assurance Departments which were formerly a part of the Operation Department and the

Engineering Department respectively, were combined in the Engineering Department, and these two departments and the formerly independent Safety & Security Department were made into one new department.

(c) The Hydro Power, Thermal Power and Transmission Departments which were formerly separate departments were reorganized into the Development/Design Department and the Construction Department.

Operation Department

(a) Formerly there was one senior vice president, but two senior vice presidents were newly instituted, one in charge of Luzon and the other in charge of Visayas and Mindanao, and the operation department was divided into two independent systems.

(b) There was a reorganization within the System Operation Department, and the formerly independent Efficiency & Reliability Department has been absorbed by the System Operation Department.

Others

The Planning Services, Finance, Controllers, Administration and Human Resources Departments which were under the Senior Vice President of Corporate Affairs were made independent departments directly under the President.

b. Problems

(a) Reinforcement of Planning Services Department

Speaking from the viewpoint of the operation and maintenance improvement planning, the plans of improvement, repair and or abolishment of the existing power plants and transmission and substation facilities must be studied in relation with the power sources development plans and the generating plans.

To carry out these important duties, it is necessary that the staff of the Planning Services Department is reinforced.

(b) Establishment of operation and maintenance management control department

Improvements on the various problems described in Section 7.2 and the following sections should be made in accordance with the policy and plan on the corporation-wide level and the so-called "headquarters" to control the implementation should be established in the Head Office.

(3) Equipment and Materials Procurement System

a. Present status

The process of procurement is presented schematically in the following.

Step	Responsible section	No of days required
Filling in of Purchase Requisition (PR), and authorization in the power plant, etc.	Power plant, and other offices (End user)	(A)
Check and registration of PR. and check of possibility of manufacturing by MEC	Regional Center(RC) Maintenance Engineering Center (MEC)	(B)
	Head Office <u>Material Management Dept</u>	
Check of PR, and check of supplier	. Spare Parts Adjustment Dept. . Materials Planning/ Investigation Dept.	8-12 (15)
Bidding and evaluation	. Procurement Dept.	34-63
Technical evaluation	. Quality Assurance/ Ordering organization (End user)	7-10
		(C) Total 52-93 Days (Standard)
Ordering Procedure/ ordering	. Procurement Dept/ Budgetary Control Dept . Authorization	11-20 (D)
Delivery	. Supplier	

b. Problems

(a) According to the voices from sites and the opinion of the QA, the problems seem to lie in the following.

- Shortage of maintenance budget

- Shortage of spare parts and consumables
  - Equipment and materials (mainly imported goods) desired by the site cannot be procured.

It seemed that these problems are all dependent on the policy and the system of procurement of the Head Office. Therefore, the Study Team made the investigation and exchange of opinions at the departments concerned in the Head Office.

(b) Results of investigation

The results of investigation are summarized in the following.

i) Problems with the origin of purchase requisition

- The delivery period entered in the purchase requisition sometimes dose not meet the necessary time (Ⓐ+Ⓑ+Ⓒ+Ⓓ).

- The procurement specifications are sometimes incomplete and it takes time in the adjustment between the Procurement Department and the origin of P.R.

- The authority of the power plant manager and such local managers in the procurement is very limited.

ii) Problems with regional centers

. The regional centers are too busy in processing of many P.R.'s submitted from the power plants and others. The staffs are relatively short in number and it takes time in the processing.

. The engineering sections of the regional centers and the end users should be able to check the problems with manufacturer's design.

iii) Problems with departments concerned in the Head Office.

. There are many offices concerned with the procurement in the Head Office, and it takes time in processing through them.

. As the equipment and materials that can be purchased by the power plants, etc. for them selves are so limited that the procurement is made mostly in Manila, and it takes time in processing many P.R.'s submitted from all the organizations in NAPOCOR.

iv) Problems related to the policy and authorization of procurement

. In the procurement of equipment and materials and the works necessary for rehabilitation/ maintenance of the existing facilities, it seems that even the important procurement is made on the cheapest price basis from suppliers different from the original suppliers, and large losses are incurred because of poor quality in some cases.

- As the approval of procurement of the equipment and materials and the works are subjected to the top management, it takes time in the procurement.

The Study Team could not pursue these problems in sufficient detail, and cannot propose concrete improvement plans. Therefore, the Team would submit the plans as reference opinions.

(4) Personnel Program

a. Present status

The change of the number of personnel in the past 10 years and the formation by the department are shown in the figures below. It is noted that the number of personnel increased conspicuously in two years, 1989-1990, mostly in the Operation and Maintenance Departments.

On the other hand, resignation of medium-level operators and maintenance crew members from NAPOCOR (actually, moving to other companies) is increasing.

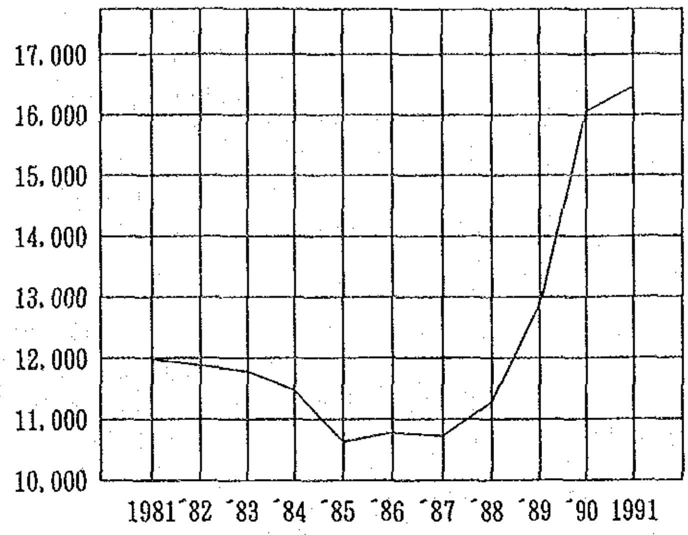
This is due to the ceiling limit on the salary of NAPOCOR employees by the Salary Standardization Law, Republic Act No 6758 of August 1989, and the fact that the demand for experienced operators and maintenance personnel is high as a result of the participation of private enterprises in the electric utilities by BOT. And this tendency would last into the future.

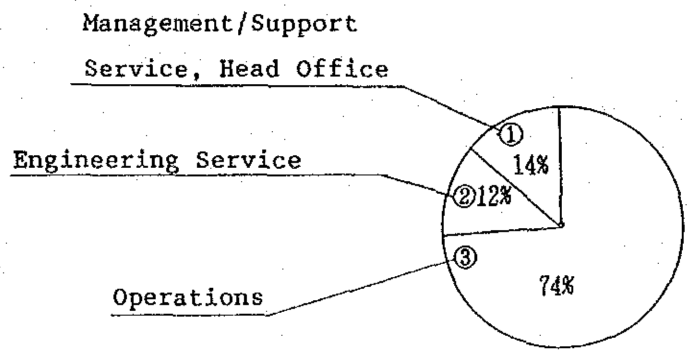
b. Problems

The above situation means that less experienced operators and maintenance personnel would increase and experts would decrease, which is an important problem that cannot be neglected. In the future, as the electric power sources development progresses, the necessary number of operators and maintenance personnel will increase further, and it is necessary to secure these personnel systematically through employment of new employees and other means, and at the same time the prevention of resignation of personnel of the existing power plants and other institutions should be considered seriously.

Changes of Personnel

(incl. laborers in casual employment)





Number of Regular Employees as of June 30, 1991

①	Management/Support Service......	1,404 (14%)
②	Engineering Service.............	1,186 (12%)
③	Operations......................	7,389 (74%)
	Total	9,979 (100%)

(5) Education and Training Program

a. Problems

In the situation described in the foregoing Personnel Program, the education and training is one of the important problems for the future.

b. Measures to be taken

. To increase the knowledge, ability and experience of the medium-level personnel and also increase the number of medium-level operators and maintenance personnel.

. To reinforce the education and training of new employees.

It is advisable to review the present education and training program with the above two points in view.

(6) Morale of Personnel

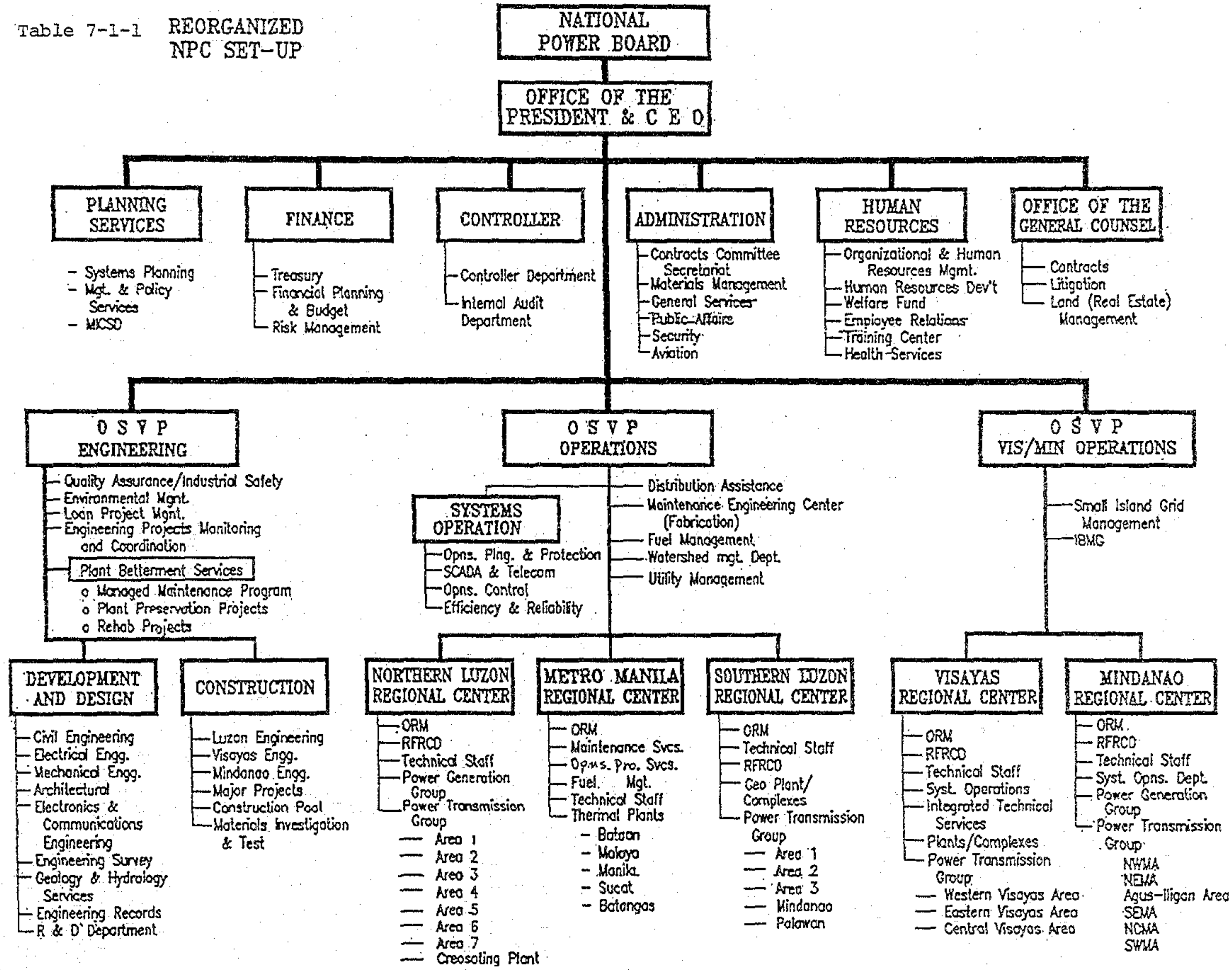
a. Problems

Employees look dissatisfied at their salaries which have been frozen nearly 10 years pursuant to the Salary Standardization Law. Under this Law, they are faced with the grim reality that even though they are promoted in position, their salaries would remain unraised. It may not be helped under these conditions that the willingness of the employees to work looks very low.

b. Countermeasure

It is impossible to evade the Law by the power of NAPOCOR itself, and therefore, it would be the only way for NAPOCOR to seek measures to raise the morale of the employees by some method which are in the hand of NAPOCOR.

Table 7-1-1 REORGANIZED NPC SET-UP



7.1.2. Proposals on Organization and System of Head Office

1. Organization of Head Office

(1) Reinforcement of Planning Department

a. The NAPOCOR-wide management policy and basic plan (excluding personnel affairs) should be compiled by the Planning Department.

b. The authority and the staff of the Planning Department should be reinforced adequately for discharging the above responsibility.

(2) Establishment of Maintenance Department

a. A department to make the overall control of the maintenance of power plant facilities, which are in the charge of the regional centers, should be established in the Operations Group.

b. With regard to the procurement items to be approved by the Head Office, this Department can make preliminary adjustment, in place of the end users, with the Materials Management Department (MMD) prior to the issuance of the Purchase Requisition (PR). Further this Department can check the progress of processing of PR's submitted to MMD.

2. Equipment and Materials Procurement System

(1) Systematic Preparation for Procurement of Important Equipment and Materials (Especially imported items)

a. Power plants and such end users should make the following preparations prior to the issuance of PR's on the basis of the approved maintenance program.

- Reconfirmation of delivery period.
- Setting of delivery period and timing of issuance of PR's.
- Preparation of procurement specifications, attached drawings, reference drawings, and data.
- Preparation of explanatory statement of the reasons, if procurement from the original manufactures is necessary.

b. The issuance of PR's should be made promptly, not later than the set date.

(2) Enlargement of Authority of End Users on Procurement

a. The procurement procedures for regional center and end users are all handled in the Head Office under the new organization.

b. However, the authority on the procurement of the managers of power plants and regional centers should be reconsidered into the direction of enlargement, for the following reasons.

(a) To enable the managers to carry out the periodical and routine maintenance works on their responsibilities.

(b) To expedite the procurement procedures (including request for works and emergency case)

(3) Expediting of Procurement Procedure

a. In connection with the foregoing Item (2), the following processes should be simplified positively for increased efficiency.

(a) Processing of procurement procedure (especially in the Head Office) for the procurement made on the responsibility of the power plant managers.

(b) Processing of procurement procedure (especially in the Head Office) for the procurement made on the responsibility of the managers of regional centers.

b. With the procurement items which must be approved by the Head Office, the processing of PR's, when received by MMD, should be expedited by the work of the Maintenance Department in the Head Office.

3. Personnel Plan

(1) Formulation of Short-term/Long-term Personnel Plans

Especially with the Operation and Maintenance Departments, the unbalance between the personnel requirements under the new organization and the present number of personnel should be checked. And also, the age structure and experiences of the personnel in the field will be reviewed to check any unbalance that may exist. Based on these check data, the short-term and the long-term personnel plans should be formulated.

(2) Systematic Movement of Personnel

With the age structure and experiences of the operation and maintenance personnel at the work places taken as the reference, adequate changes of personnel among the work places to raise the capability of the work places.

4. Education and Training

(1) Especially in the operation and maintenance departments, the education and training system for the medium-level personnel and the new employees and less experienced personnel should be established.

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

(3) Reinforcement of Human Resources Staff.

5. Enhancement of Morale

The following are considered for the enhancement of the morale of the personnel.

(1) To continue to appeal to the authorities concerned for the improvement of the salary and the fringe benefit.

(2) To give opportunities of education and training, within the country and overseas, to the personnel (especially technical personnel) impartially.

(3) To give the opportunities of promotion to the personnel impartially based on the years of service, experience and other conditions.

(4) To implement the group proposal system to encourage the job units to submit practicable proposals of cost saving, improvement of work efficiency, etc.

(5) To improve the environment and conditions of the work places.

(6) To enforce the safety measures necessary for the works of personnel.

(7) To adopt other measures to incite the personnel to action.

7.2 Thermal Power Plants

7.2.1 Present Status and Problems of Operation and Maintenance

1. Operation and Maintenance Organization

(1) Metro Manila Regional Center (MMRC)

At present, five thermal power plants are in operation in Luzon Island, and the operation and maintenance of these power plants, including Batangas Power Plant located in the Southern Luzon Regional Center (SLRC) area, are under the jurisdiction of MMRC. The organization of MMRC is shown in Tables 7-2-1.

a. Major changes

(a) The former Central Maintenance/Technical Service Division (CM/TS) was reorganized into the Operation Project Services and the Maintenance Services.

b. Merits of the reorganization

(a) MMRC has come to have the organization to effect the overall control of the engineering problems.

(b) The Maintenance Services has unified the Central Maintenance Division and the Technical Services Division into a concise and more efficient organization.

(c) All the procurement activities have been transferred to the Head Office and the procurement system has been rationalized.

c. Problems

(a) Problems with the former organization and the reorganization

The Study Team stated in the Interim Report that it seemed necessary to establish an integrated department in NAPOCOR Head Office which handles the maintenance management.

The present reorganization gives the impression to the Team that the opinion of the Team has been half realized, because the general headquarters was established in MMRC, not in the Head Office.

(b) Future problems

- It is desired that the operating procedures under the new organization be established quickly.

- It is necessary to secure the necessary personnel and to assign them strategically.

(2) Thermal Power Plants

The organizations of individual thermal power plants have also been reformed. Examples of the new organizations are shown in Tables 7-2-2 and 7-2-3.

a. Major Changes

The six sections in the old organization have been reorganized as follows and each division is headed by the manager who is in full charge of the division.

Old Organization	New Organization
. Operation (1 section.) →	. Operation (1 div.)
. Chemical (1 section.) → (Operation)	
. Plant Eng. and Control (1 section.) →	. Eff. Control (1 group) (newly organized)
. Mech./Elect. Maint. (2 sections) →	. Maintenance (1 div.) (Including planning & scheduling group (newly organized))
. MMP (ad hoc) → (Maintenance)	
. Support Services (1 section.) →	. Support Services (1 section.)
Total 6 sections	2 divisions + 1 section + 1 group

b. Features of the Reform

(a) The organization has been reformed functionally and simplified.

(b) New organization defines the line of command and directions and the division of responsibility.

(c) In the new organization is observed the intention to strengthen the staff of the maintenance department to carry out the maintenance works by the power plant's own staff.

c. Present reorganization and problems

The present reorganization is esteemed as the solution of the problems with the old organization. However, the part to handle the environmental problems is not clear yet.

- To establish the work management procedure under the new organization.

- To secure necessary personnel and assign them strategically.

(3) Maintenance Engineering Center (MEC)

a. The Maintenance Engineering Center (MEC) is playing an important role in the maintenance system of NAPOCOR. The organization of the MEC is shown on Table 7-2-4.

(4) Organization for Periodical Overhaul

a. Organization after the reorganization

As stated before, the Maintenance Services of MMRC and the Maintenance Divisions of thermal power plants were reorganized, while there has been no fundamental change in the periodical overhaul in the sense that the overhaul is carried out by these two groups at the plant and with the cooperation of the other related parties. However, it is expected that some new effect, for example smoother progress of the overhaul schedule, more precise execution of the overhauling works, etc., will be realized as a result of the reorganization.

b. Future Problems

Under the new organization, it would be necessary to review the organization for the periodical overhaul. Shifting from the present direct working system into the contract working system would be worth considering.

Table 7-2-1

METRO MANILA REGIONAL CENTER

TABLE OF ORGANIZATION

SUMMARY:

OVP	- 4
TECHNICAL STAFF	- 8
RFRCD	- 19
MAINT. SVCS.	-197
OPERATIONS PROJECT SVCS.	- 41
FUEL MGMT.	- 74
OFFICE OF THE RES. MGR.	- 4
FINANCE	- 36
ADMINISTRATION	- 36
ORLC	- 3
BATAAN TPP	-268
MALAYA TPP	-287
MANILA TPP	-221
SUCAT TPP	-404
BATANGAS CFTPP	-340

TOTAL	1942

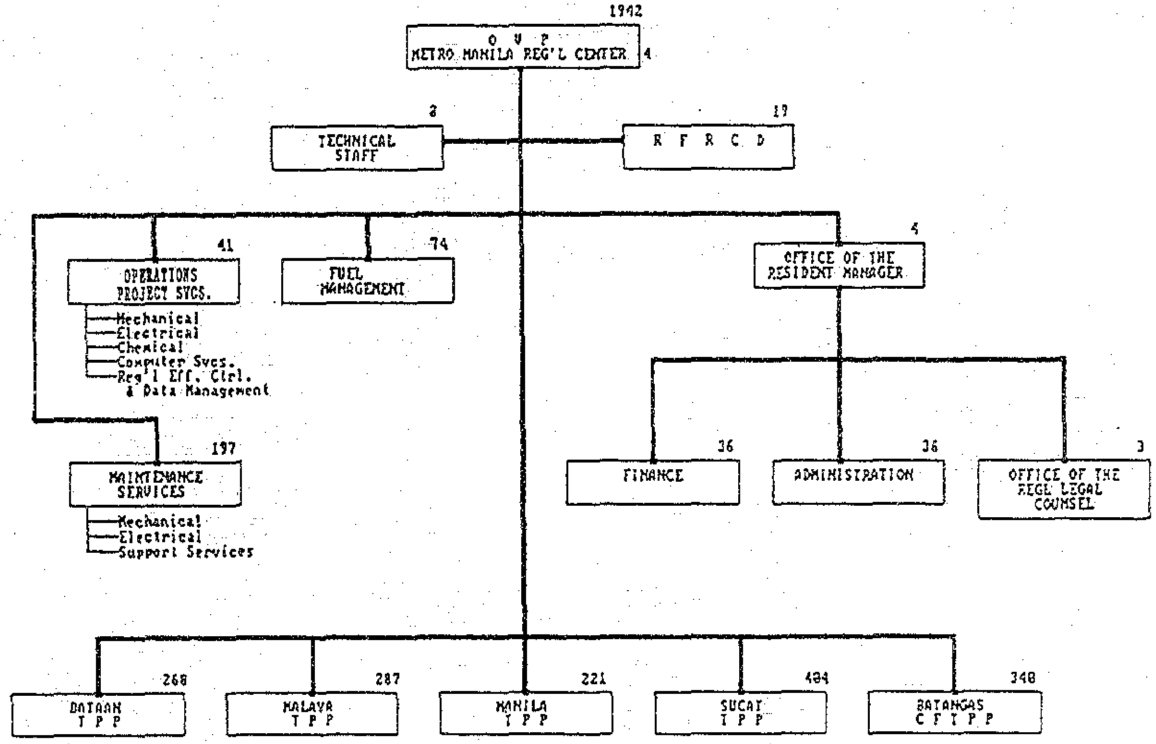
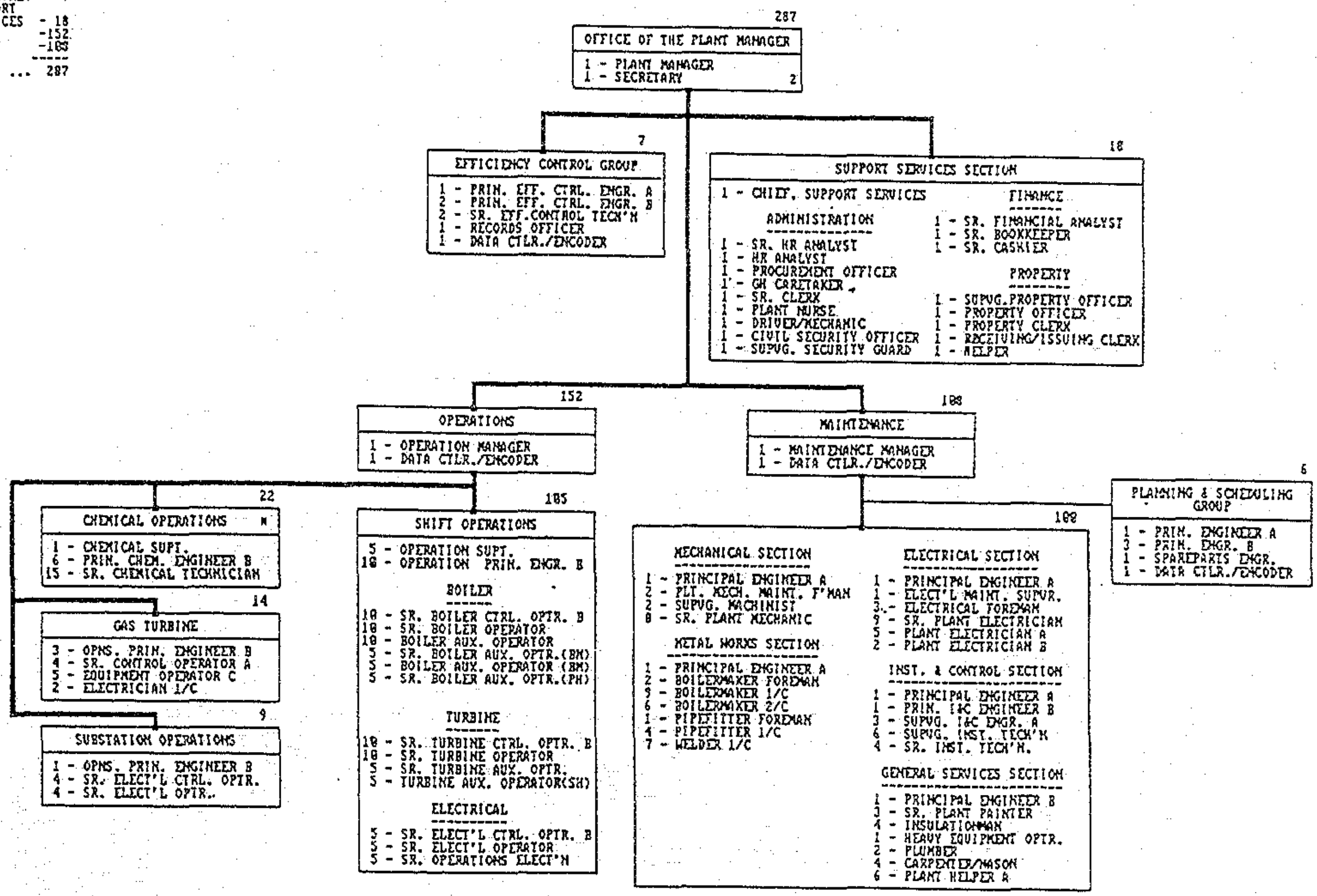


Table 7-2-2 MALAYA THERMAL-POWER PLANT

TABLE OF ORGANIZATION

SUMMARY:

OM - 2
EFF CTRL. - 7
SUPPORT SERVICES - 18
OPPNS -152
MAINT -108
Total ... 287



* Chemical Operations personnel assigned in shift work shall report to the Shift Superintendent.

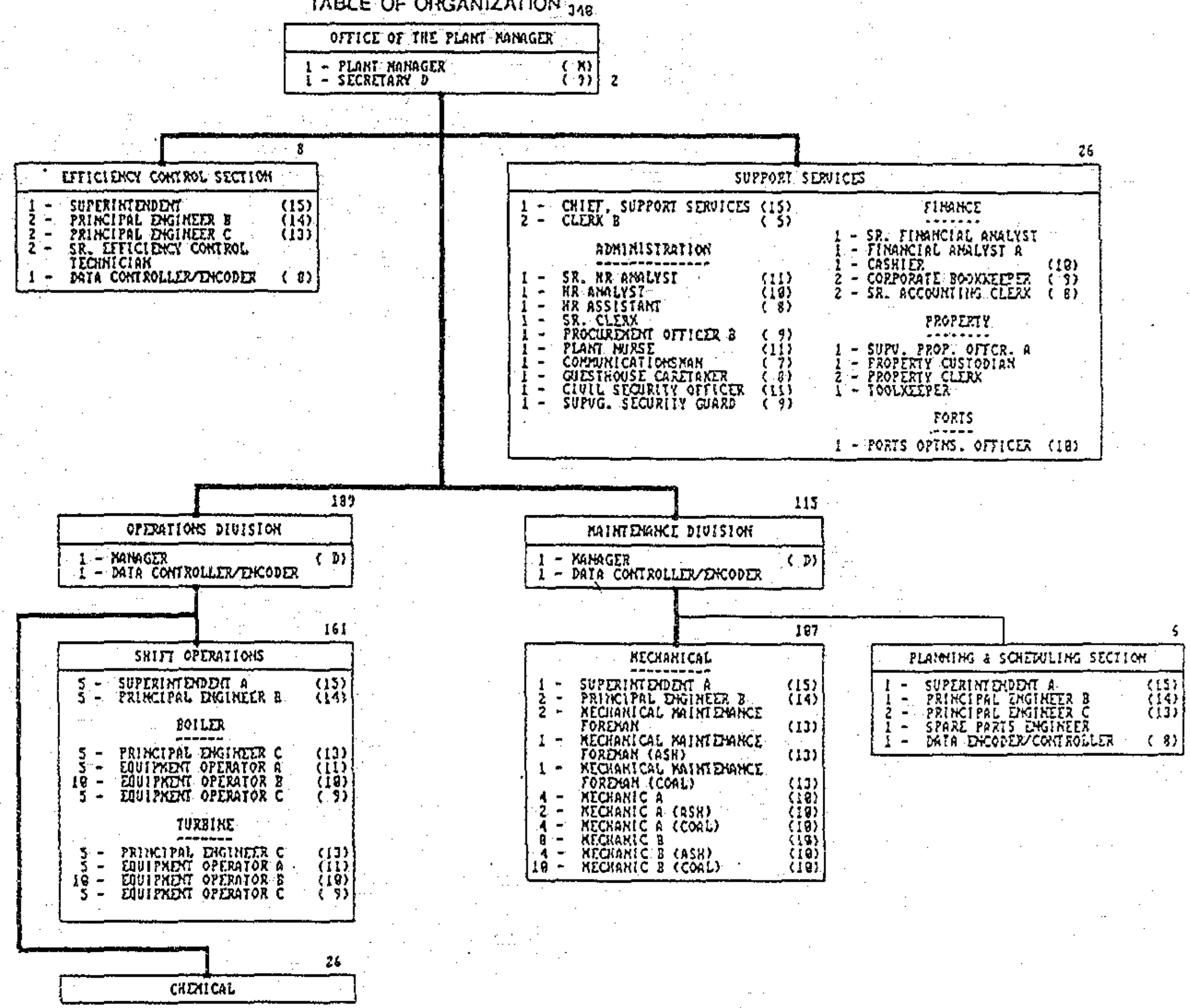
SUMMARY:

Office of the Plant Manager - 2
Efficiency Control - 8
Support - 26
Operations Division -189
Maintenance Division -115

T o t a l..............348

Table 7-2-3 BATANGAS COAL-FIRED THERMAL POWER PLANT

TABLE OF ORGANIZATION



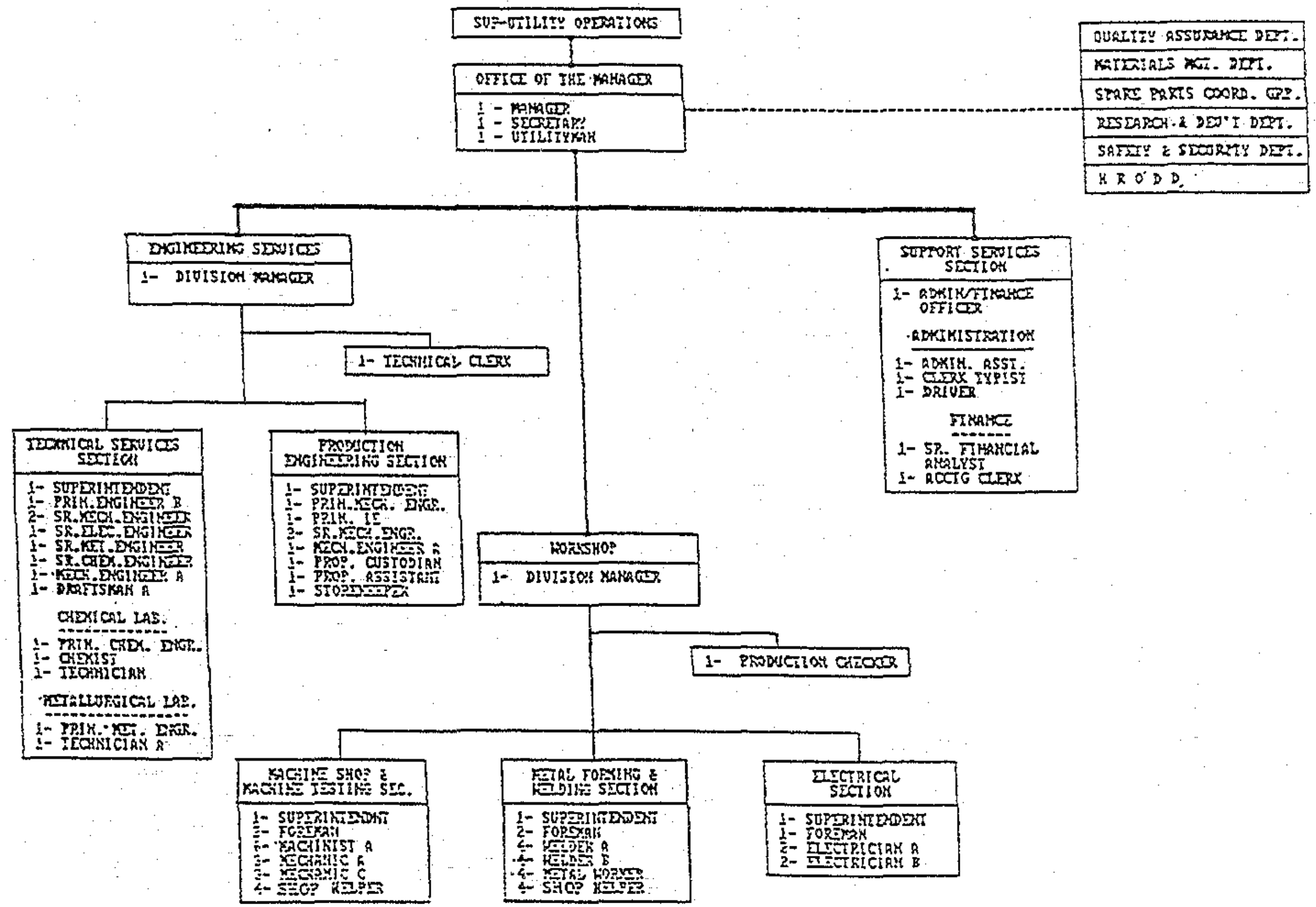
SUMMARY

OFFICE OF THE MGR.	3
SUPPORT SVCS.	6
ENG'G SVCS.	25
WORKSHOP	45
TOTAL	[illegible]

Table 7-2-4 MAINTENANCE ENGINEERING CENTER

1985–1992 TRANSITIONAL

TABLE OF ORGANIZATION



NOTE ALL POSITION TITLES & JOB LEVELS ARE SUBJECT TO FINAL EVALUATION BY THE JOB EVALUATION COMMITTEE

2. Operation and Maintenance Works (Problems)

(1) Operation

The established works with the patrol, inspection checklists, routine tests, maintenance request slips, and chemical works should be carried out reliably.

(2) Maintenance

The most prominent cause of the decline of power plant output is incomplete maintenance. The major problems in the performance of the maintenance works are listed below:

a. Daily maintenance

b. Disposition of maintenance request slips

c. Periodical equipment diagnosis

The operating conditions of the equipment are diagnosed by the examination of the data of vibration, pressure, temperature, noise, flow, etc. measured periodically.

The activities of the periodical equipment diagnosis do not seem to be carried out strictly.

The improvement of the above situation should be made through the review of the organization and the education.

d. Periodical overhaul

The periodical overhaul is the most important of the maintenance works for the continuous and reliable operation of the power plant. Sufficient preparation and flawless execution of the works are necessary for successful overhauls.

3. Training and Education

(1) The Head Office prepares the training and education program for the operation and maintenance staff of thermal power plants, but the confirmation of the effect of the training and education is not made.

(2) It is observed that the basic education for the operators and maintenance crew and also the education/training in the basic technique for their coping with the faults and trouble shooting are not sufficient.

(3) Safety Control and Education

There is a section in charge of safety in the Head Office, where the basic safety manual and education materials are prepared, but actually no practical results have been achieved for lack of the budget, staff and education aids.

4. Procurement and Management of Equipment and Materials

(1) Procurement of Equipment and Materials

a. Delay of delivery to power plants

The most important problem in the maintenance of the power plants is the procurement of equipment and materials.

b. Future problems

The above problem is not of the nature that can be remedied by the recent reorganization, and seems to be caused by the following.

(a) Slipshod procurement plan

(b) The sections in charge of engineering and maintenance are not strong enough.

(2) Procurement of Fuel

a. Major reform

By the recent reorganization, the Fuel Management Department was created in MMRC.

b. Features of the reform

(a) Fuel Management Department takes the charge of and controls the heavy oil, light oil, and coal used in the thermal power plants, from the procurement to the receiving and transportation.

(b) The personnel engaged in the receiving and storing of the fuel belong to this Fuel Management Department.

c. Future problems

The deterioration of the domestic run-of-mine coal quality and foreign matters mixed in the coal at Batangas Power Plant make the obstacles in the operation and the cause of environmental pollution.

(3) Management of Equipment and Materials

a. Inventory control

The Planning and Scheduling Group of the power plant is in charge of the inventory control. The confirmation of inventory of the goods in store is not made sufficiently, and the responsibility of inventory is not clearly defined.

b. Spare parts procurement plan

It would be necessary to review and readjust the kinds and quantity of the spare parts in stock based on the record of past use, and it would be necessary also to readjust the stock of common spare parts with the other power plants.

c. Responsibility of inspection and acceptance

Who has the responsibility for the inspection and acceptance of the delivered goods does not seem to be clearly stipulated.

d. Method of storing

There are many cases where the spare parts, equipment and materials in store, especially the special materials, precision instruments, chemicals, etc. become unusable because of poor method of storing. Sometimes used/defective or rejected parts are stored together with unused/ready spares.

e. Procurement

The authorization of procurement is classified into the following.

Power Plant	Less than 20,000 pesos (Less than ¥100,000.-)
MMRC	20,000 to 1 million pesos (¥100,000.- to ¥5 million)
Head Office	More than 1 million pesos (More than ¥5 million including all foreign purchase

The authority delegated to the power plant manager is extremely small.

Even though the practical disposition of the procurement is carried out in the Head Office, the authorization of decision making had better be reviewed and readjusted.

5. Performance and Efficiency Management

Before and after the periodical overhaul, or periodically once a year, the performance test of the plant should be carried out to grasp the conditions of the plant correctly. At present, neither the routine management of the plant performance nor accurate efficiency management is considered to be made sufficiently.

7.2.2 Recommendations of Maintenance Management and Operation and Maintenance Improvement Program

With a view to solving the problems in the operation and maintenance discussed in Sub-clause 7.2.1 and to effect improvement, the Survey Team recommends basically the following program for each item.

1. Organization for Operation and Maintenance Management

(1) MMRC

a. The operating procedures for the Operations Project Services and the Maintenance Services under the new organization should be established quickly.

b. The necessary personnel should be secured and assigned strategically.

(2) Power Plants

a. Efficiency Control Group

This group should work positively, as the organ to promote the improvement of the operation and maintenance of the power plant, and for this the following are recommended.

(a) To prepare the technical manual with definite job descriptions of the group.

(b) Periodical liaison and consultation should be made not only between the Operations and Maintenance Divisions but also with the Support Services in the power plant.

(c) It may be advisable to assign the handling of environmental problems to this group.

b. Maintenance Division

The maintenance manual covering the works of the newly formed planning and scheduling group should be prepared.

c. Necessary personnel should be secured and assigned strategically.

2. Performance of Operation and Maintenance

(1) Improvement of Daily Operation Management

a. To carry out the daily, weekly and monthly patrol inspections strictly.

b. To carry out the daily, weekly and monthly routine tests strictly.

c. To communicate on and report the abnormalities of the plant speedily when discovered.

d. To take early and appropriate countermeasures.

e. To issue the maintenance request slips timely.

(2) Improvement of Daily Maintenance Management

a. To put the marking of the limit values and allowable ranges on the supervisory instruments and meters.

b. To mark the recorder papers and check sheets with the limit values.

c. To attach name plates or put the names on all the equipment, piping and valves.

d. To take the measurements of the equipment data periodically.

e. To make the statistical management of the data and diagnosis.

f. To dispose of the maintenance request slips quickly.

(3) Improvement of Periodical Overhaul Management

a. Review of responsibility in overhaul organization

b. Close coordination between MMRC and QA and defining of the responsibility

c. Sufficient preparation for the overhaul

d. Prompt and right judgment on the results of inspections and tests.

e. Joint confirmation by the responsible supervisor and the representative of the maintenance executing party at appropriate times.

f. Preparation of working environment.

g. Effective utilization of MEC and close cooperation with BHPI and other contractors.

h. Establishment of inspection organizations and improvement of reliability of inspection.

i. Improvement of the equipment and materials procurement system.

(4) Operation and Maintenance Manuals

The manuals should be revised with the changes of equipment and system and the experiences incorporated.

(5) Enhancement of MMP Functions

Establishment of the MMP is very effective. The functions should be enlarged and in case abnormal conditions occur, the MMP should detect the cause promptly and take the initiative for the countermeasures. The Survey Team recommends more effective utilization of the MMP.

3. Training and Education

(1) The training and education should be given not only to operating and maintenance technical staff but to the administrative staff with well-defined educational curricula and schedules.

(2) Further, the education and training program should be utilized for reeducation to raise the levels of the employees already in service.

(3) It is desired that the training center plan be promoted for basic education and technical training of the operation and maintenance staff with certification program. Especially the installation of the simulator for training of operators of thermal power plants should be expedited.

(4) It is necessary to formulate an education program to introduce the management officers including the top management to the newly developed technology and quality control concepts.

(5) It would make an effective means of training to hold meetings for analysis and discussions of accidents and troubles in the power plant and make the field training in the countermeasure against troubles.

(6) Personnel rotations within and between power plants, from the operation section to the maintenance section for example, is also recommended for further consideration.

4. Procurement and Management of Equipment and Materials

(1) Improvement of Procurement System for Spare Parts, Parts and Consumables

a. The purchase authority of the power plant manager should be increased so that the period of delivery may be minimized.

b. Preparation of standard purchase specifications must also be taken up as the study item.

c. The registered supplier system should be adopted for the procurement of the equipment and materials, and the supplier qualification criteria should be prepared.

d. For the procurement of special equipment and parts and for the emergency procurement, the nominated or preferred ordering should be permitted more flexibly if a strong economic justification/evaluation is presented.

(2) Improvement of Acceptance System

The section in charge of the inspection and acceptance of the delivered equipment and materials and the responsibility of acceptance should be defined clearly in the framework of the procurement system.

(3) Improvement of Inventory Management

a. The computer data of inventory should be verified periodically with the actual stock.

b. The method of storing of the spare parts common to the power plants and installation of central/regional warehouses should be studied.

c. The method of storing of the special materials, precision equipments, chemicals, etc. will be improved.

For the improvement of the above, the manual stipulating the practical actions should be prepared and used in the actual acceptance work.

(4) Improvement of As-received Coal Quality

Foreign matters are often mixed in the domestic coal delivered to Batangas Coal-fired Power Plant. Strict request for assurance of the coal quality should be made to the coal supplier.

5. Other Recommended Items

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

(2) Improvement and reinforcement of communication systems. (All thermal power plants/fuel management department)

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

(4) Improvement and reinforcement or installation of waste water treatment equipment and sedimentation pond. (All thermal power plants)

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

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

6. Requests to Other Organizations

(1) The coal supplier should be requested to assure the coal quality.

(2) The coal supplier should be requested to use larger coal carriers.

7. Special Remark

In 1989, the JICA Afforestation Project Study Report was submitted to the Department of Environment and Material Resources of the Philippine Government. The report forecasted the danger of avalanche of sand and stone with Malaya Power Plant located near Lake Laguna, and proposed the countermeasure.

Detailed investigation should be carried out at an early date and the countermeasure should be taken in consultation with the Government.

7.3 Geothermal Power Plants

7.3.1 Present Status and Problems of Operation and Maintenance

1. Operation and Maintenance Organization

(1) Southern Luzon Regional Center (SLRC)

There are now 2 geothermal power plants in operation in Luzon Island. Both Tiwi and Mak-Ban Power Plants are under the control of SLRC. The new organization of SLRC is shown in Table 7-3-2.

a. Major change

Discontinuation of CM/TS in SLRC.

b. Features of the change

The geothermal power plants used to carry out the maintenance and periodical overhaul for themselves and, if necessary, got the cooperation of CM/TS. And there would be no problem posed by the discontinuation of CM/TS by the recent reorganization. The maintenance and periodical overhaul will be made by the reorganized maintenance division with the assistance of MEC as before.

(2) Geothermal Power Plants

The organizations of the geothermal power plants have also been reorganized. An example of the new organizations is shown in Table 7-3-2.

a. Major changes

The four sections in the old organization have been reorganized as follows.

Each division is headed by the manager who assumes the full responsibility of the division. The organization is basically similar to that of the thermal power plant.

Old Organization	New Organization
. Operation (1 section) (incl. chemical) →	. Operation (1 division) (incl. chemical)
. Maintenance (1 section) →	. Maintenance (1 division) (Including scheduling group (new))
. Engineering & Chemical (1 section) (incl. environmental) →	. Efficiency & Environmental Control Group (1 group) (new)
. Support Services (1 section) →	. Support Services (1 section)
	. Watershed Area Team (1 team)
Total 4 sections	2 divisions + 1 section + 1 group + 1 team

b. Features of the changes

The remarks similar to those on the thermal power plants apply generally to the geothermal power plants.

c. Future problems

The same remarks as to the thermal power plants apply.

2. Performance of Operation and Maintenance

Same as with the thermal power plants.

3. Training and Safety Education

Same as with the thermal power plants.

4. Procurement and Management of Equipment and Materials

Same as with the thermal power plants.

5. Performance and Efficiency Management

Same as with the thermal power plants.

Table 7-3-1

SOUTHERN LUZON REGIONAL CENTER

TABLE OF ORGANIZATION

SUMMARY:

OVP	-	8
TECHNICAL STAFF	-	11
RFRCD	-	26
ORM	-	88
PLANTS	-	691
POWER TRANSMISSION GROUP	-	534
TOTAL		1358

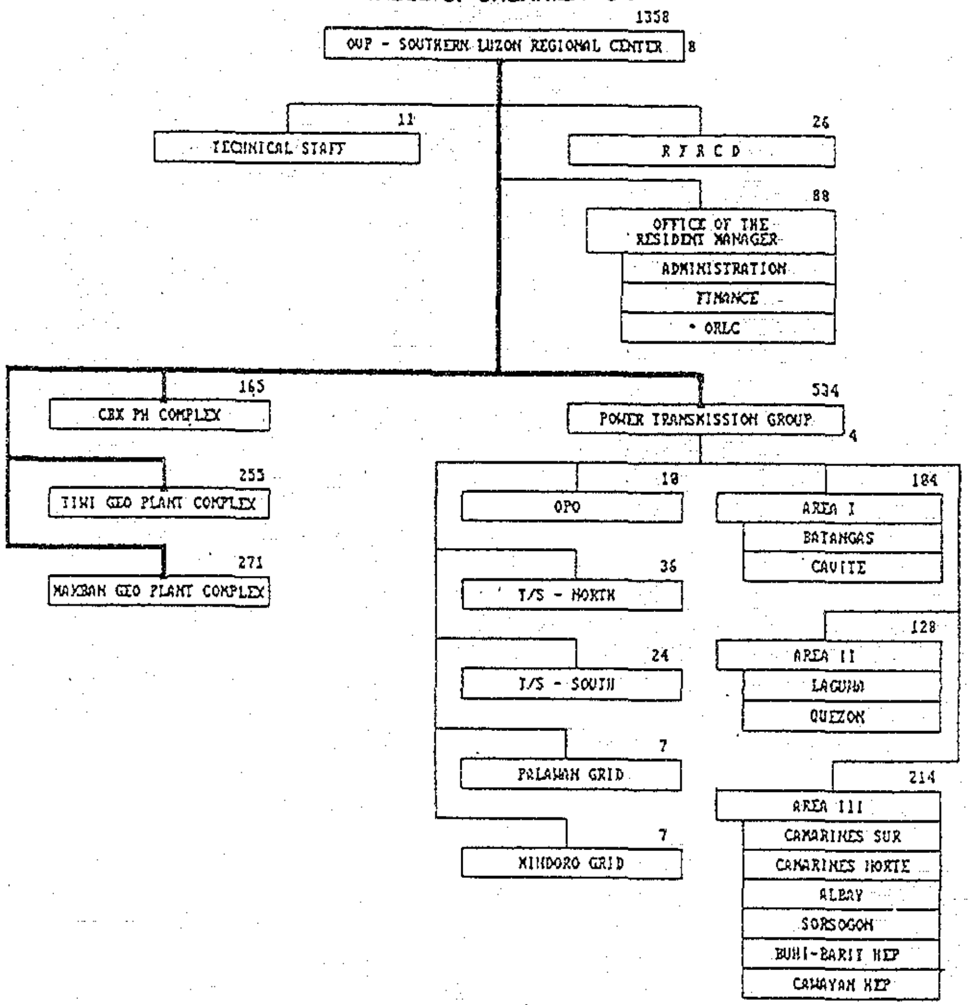


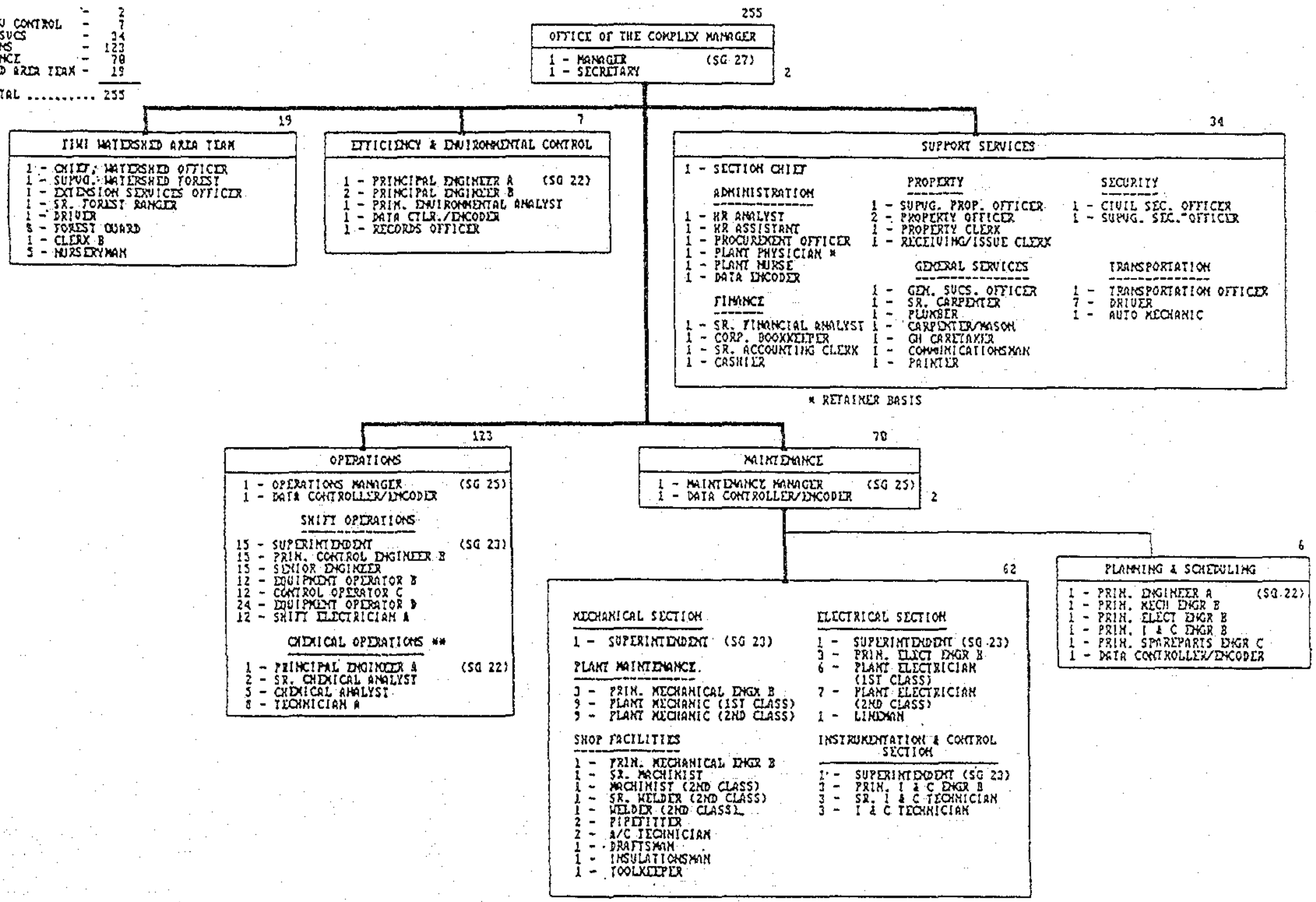
Table 7-3-2

TIWI GEOTHERMAL POWER PLANT

TABLE OF ORGANIZATION

SUMMARY:

OCM	- 2
EFF & ENV CONTROL	- 7
SUPPORT SVCS	- 34
OPERATIONS	- 123
MAINTENANCE	- 70
WATERSHED AREA TEAM	- 19
TOTAL	255



7.3.2 Recommendation of Maintenance Management and Operation and Maintenance Improvement Program

With a view to solving the foregoing problems and effecting improvement, the Study Team recommends the following.

1. Operation and Maintenance Management System

(1) Review of Jurisdiction

At the geothermal power plants, as the special geothermal maintenance forces have been established, there is no technical reason to transfer the jurisdiction to MMRC now. And it would be more advantageous to leave the geothermal power plants under the jurisdiction of SLRC.

(2) Reinforcement of Organization

There are already 12 geothermal power generating units, and assuming that the periodical overhaul of the units will be carried out once a year, it would be necessary to continue periodical overhauls one after another all through the year.

In consideration of the expansion project of Mak-Ban Power Plant and other expansion projects in the future on top of the above situation, it is imperative to reinforce the maintenance organization and the staff of the power plants and provide additional maintenance equipment, tools and vehicles.

Switching of the present direct working system into the contract working system should be taken up as a subject of study.

2. Performance of Operation and Maintenance

Same as for the thermal power plant.

3. Training and Safety Education

Same as for the thermal power plant.

4. Procurement and Management of Equipment and Materials

Same as for the thermal power plant.

7.4 Hydro Power Plants

7.4.1 Present Status and Problems of Operation and Maintenance

1. Operation and Maintenance System

(1) In the Luzon Grid, the Northern Luzon Regional Center (NLRC) and the Southern Luzon Regional Center (SLRC) take charge of operation and maintenance of hydro power plants, geothermal power plants, transmission lines, and substations.

(2) The present organization and staffing of NLRC and SLRC are as illustrated in Tables 7-4-1 and 7-4-2. Both organizations were reorganized in November 1991, during the course of the study.

In NLRC, the organization for operation and maintenance is largely divided into the Power Generation Group (PGG) and the Power Transmission Group (PTG). PGG controls and manages the power plants, while PTG does the Operations Project Office, Technical Services, and area offices. Both PGG and PTG were established by the reorganization, but, there are no PGG and PTG in SLRC. In addition, the Vice-President is supported by the technical staff.

Administration and Finance, which are responsible for procurement and control of materials, budgeting, etc., were reinforced by the reorganization.

(3) Regional Centers

In the regional centers, the engineers responsible for operation and maintenance of the hydro power plants, transmission lines and substations number as few as 10, and no civil engineers are assigned. In order to substantiate and improve upon the facility management, maintenance planning, and maintenance implementation management in the future, the present structure is not enough, and it will be necessary to

Table 7-4-1 ORGANIZATION STRUCTURE OF NLRC (1)

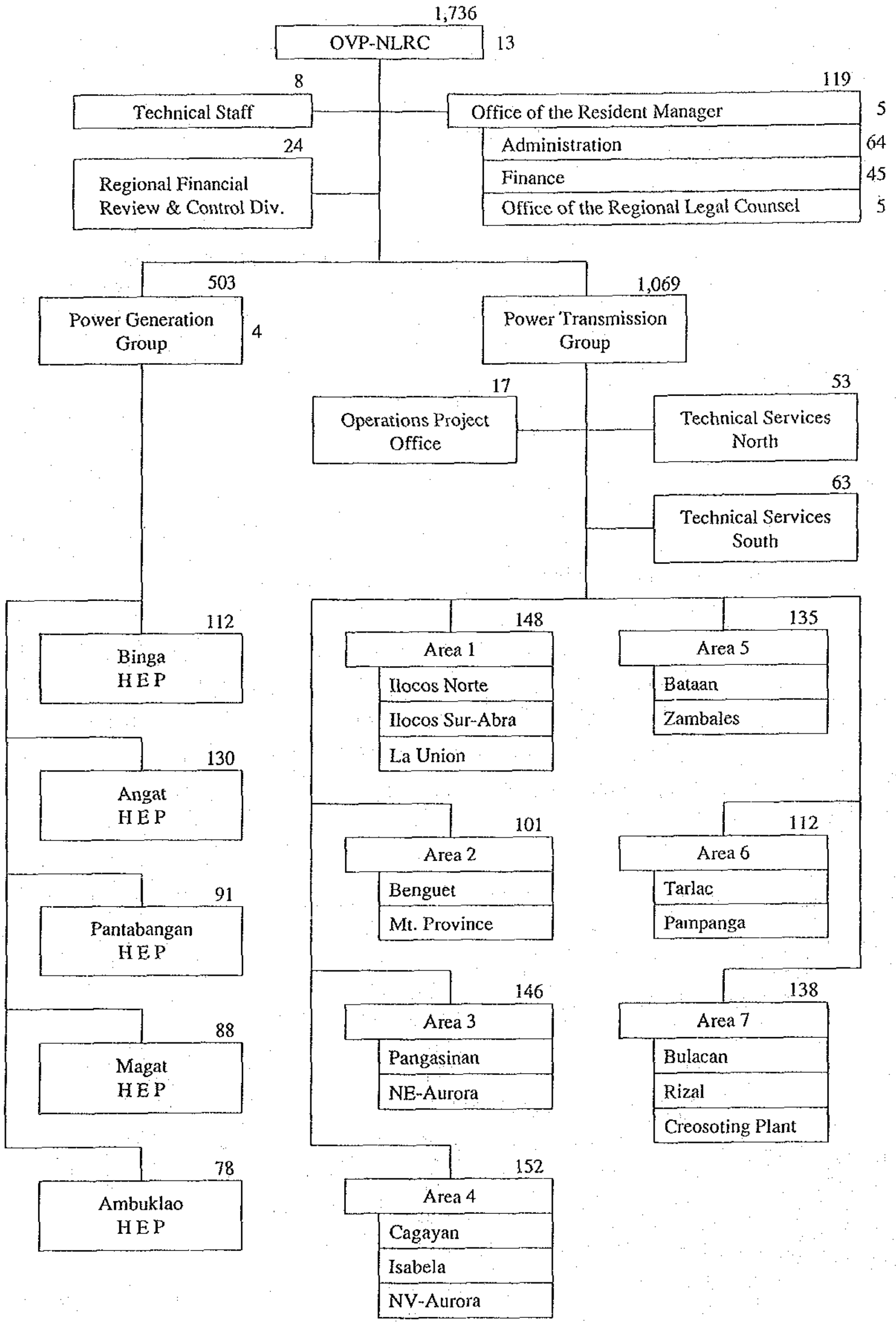


Table 7-4-1 ORGANIZATION STRUCTURE OF NLRC (2)

Technical Services		Manager Office		Relay Section	Meter Section	Test Section	Communication Section	Mechanical Test	Satelite Section
		Manager	Staff						
North	53	1	1	9	9	9	9	9	6
South	63	1	1	17	13	13	9	9	—

Area Offices		Manager Office		Substation			Transmission Line		Support Services	Creosoting Plant
		Manager	Staff	Manager	Operation	Maintenance	Manager	Maintenance		
Area 1	148	1	2	1	32	13	1	70	28	—
Area 2	101	1	2	1	19	13	1	44	20	—
Area 3	146	1	2	1	35	13	1	68	25	—
Area 4	152	1	2	1	35	15	1	70	27	—
Area 5	135	1	2	1	35	13	1	60	22	—
Area 6	112	1	2	1	22	11	1	52	22	—
Area 7	138	1	2	1	20	13	1	60	22	18
Total	932	7	14	7	198	91	7	424	166	18

Power Plants		Manager Office			Operation	Maintenance	ECPS	Watershed	Support Services
		Manager	Asst. Mgr.	Staff					
Binga	112	1	1	1	30	35	4	21	19
Angat	130	1	1	1	34	41	4	29	19
Pantabangan	91	1	1	1	34	32	4	—	18
Magat	88	1	1	1	26	38	4	—	17
Ambuklao	78	1	—	1	13	19	—	33	11
Total	499	5	4	5	137	165	16	83	84

ECPS : Efficiency Control & Planning & Scheduling

Table 7-4-2 ORGANIZATION STRUCTURE OF SLRC (1)

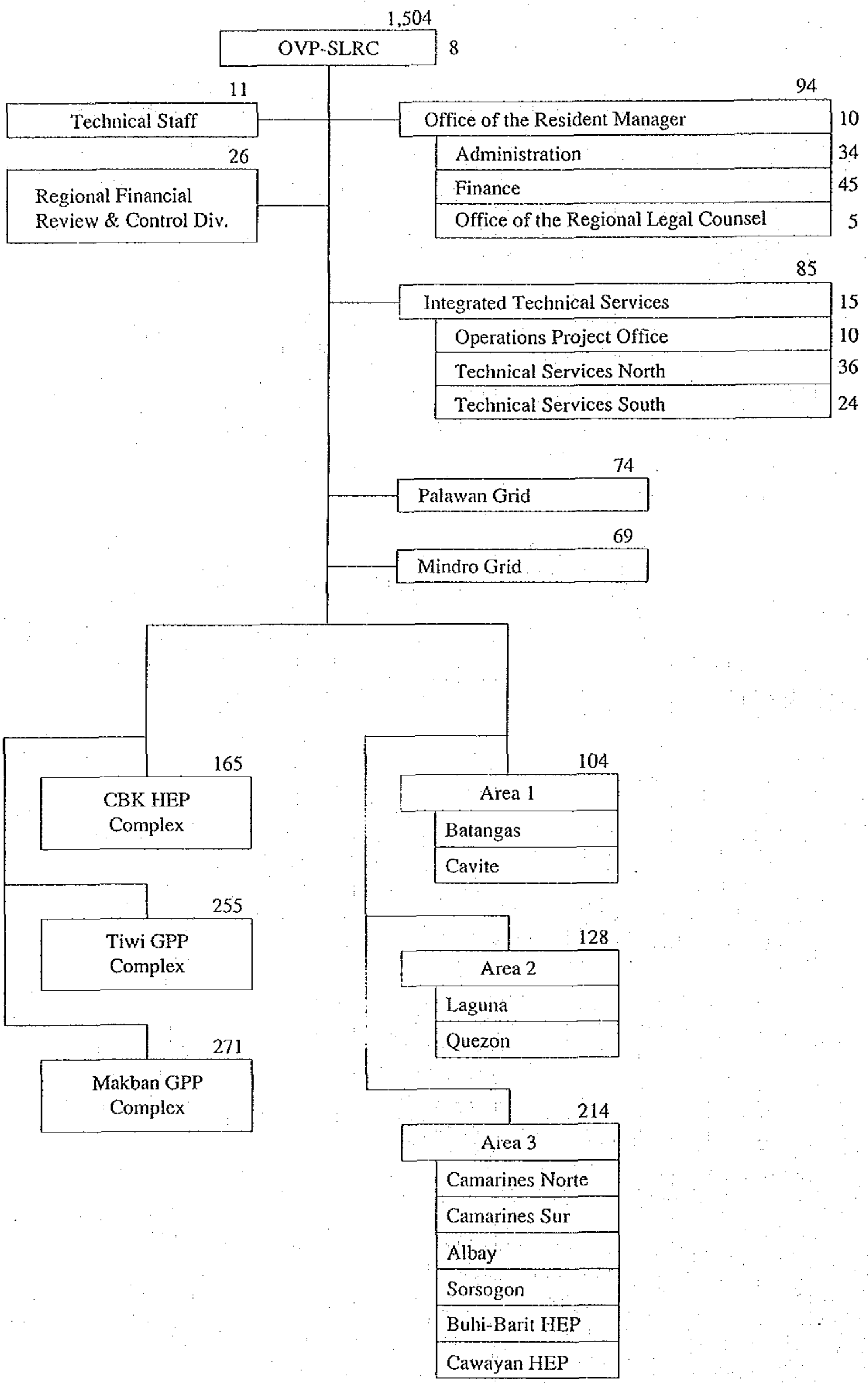


Table 7-4-2 ORGANIZATION STRUCTURE OF SLRC (2)

Technical Services		Manager Office		Relay Section	Meter Section	Test Section	Communication Section
		Manager	Staff				
North	36	1	3	9	9	9	5
South	24	1	3	5	5	5	5

Area Offices		Manager Office		Substation			Transmission Line		Barit & Cawayan HEP			Support Services
		Manager	Staff	Manager	Operation	Maintenance	Manager	Maintenance	Operation	Maintenance	Watershed	
Area 1	104	1	2	1	26	15	1	34	—	—	—	24
Area 2	128	1	2	1	18	13	1	68	—	—	—	24
Area 3	214	1	2	1	31	14	2	95	9	10	12	37
Total	446	3	6	3	75	42	4	197	9	10	12	85

Power Plants		Manager Office		Operation		Maintenance		ECPS	EEC	Watershed	Support Services
		Manager	Staff	Manager	Staff	Manager	Staff				
CBK	165	1	1	1	55	1	49	4	—	20	33
Tiwi	255	1	1	1	122	1	69	—	7	19	34
Makban	271	1	1	1	134	1	62	—	7	30	34
Total	691	3	3	3	311	3	180	4	14	69	101

ECPS : Efficiency Control & Planning & Scheduling
EEC : Efficiency & Environmental Control

set up the organizational units to take charge of maintenance in the regional centers.

The management span of NLRC is excessively large, with almost twice the size of SLRC. In addition, Baguio, where NLRC office is located, is unfavorable for office location as the roads are often closed due to typhoons.

The Operations Project Office (OPO) is another office set up by the reorganization, and is responsible for engineering task for the transmission and substation facilities. OPO is staffed with electrical, mechanical, civil and geological engineers.

(4) Technical Services

Technical Services (TS) has the respective sections of Relay, Meter, Test, Communication, Mechanical Test (only in NLRC), and Satellite (only in TS-North-NLRC), and makes the rounds of power plants and substations to conduct preventive maintenance (test, calibration, repair, trouble shooting) of protective relays, meters (including billing meters), power equipment, and communication equipment. The Mechanical Test Section took over the tests which used to be conducted by Central Maintenance (CM), and the Satellite Section was set up to carry out tests in the Cagayan Region.

(5) Hydro Power Plants

The organization of the hydro power plants consists of Operation Section, Maintenance Section, Watershed Area Team, Efficiency Control & Planning & Scheduling Group (ECPS), and Support Services Section, under the control of a manager and an assistant manager. The organization of Kalayaan, Caliraya and Botocan Power Plants is called the Caliraya-Botocan-Kalayaan Plant Complex, and these power plants are controlled by a plant manager, an operation manager, and a maintenance manager.

The following are the major changes made by the reorganization.

. CM staff were transferred to power plants.

. ECPS was set up to improve upon the maintenance planning, spare parts planning, and operational efficiency of power plants.

. The Watershed Area Teams were transferred from the Head Office to the power plants.

. The Property Unit was reinforced for improving the management of materials and assets.

By the above changes, improvements of maintenance planning, maintenance implementation, and spare parts management are expected.

2. Operation and Maintenance Procedures

(1) Operation

Operation of hydro power plants is carried out by the 4-group 3-shift system with 5 to 8 operators in each shift. Operators perform the operation in accordance with the instruction of the Power Management Center and the established operation manual.

The operation log is made up of several sheets on which each operator records hourly data for many items. The frequency of recording is considered reducible. It is especially desired that the night shift work be simplified as much as possible.

(2) Maintenance

The maintenance sections of hydro power plants take charge of the maintenance of power plants, and TS's carry out the preventive maintenance of protective relays, meters, power equipment, and communication equipment.

In the hydro power plants, operators perform patrol checks. The frequency of checks is divided into each shift, daily, semi-weekly, weekly, semi-monthly, monthly, quarterly, semi-annual, and annual checks. It will be necessary to review the necessity of the said patrol checks and reduce the frequency of checks.

As for the maintenance planning, the power plants prepare the annual preventive maintenance program upon consultation with TS and submit the budget to the Head Office through the regional centers.

The same kinds of faults are recurring in the power plants. Future maintenance should simplify the recording of operation logs and the routine inspections, and emphasize the investigation of the causes of faults, arrangement of the various data on faults, and study of proper improvement measures, so as to facilitate effective maintenance of the facilities.

Regarding the civil structures, though routine maintenance is performed by the power plants, no periodical inspection is carried out. It is necessary to carry out the periodical measurement of deposits in the reservoirs and wall thickness of the penstocks, and the periodical inspection of the races.

3. Operation and Maintenance Manuals

(1) Operation Manual

For operation of the power plants, the corporation-wide standardized manual, "Start-up/Shutdown Procedure", has been established. Each power plant has the operation manual that is applicable to its own plants.

(2) Maintenance Manual

a. Preventive Maintenance Guide

Items, descriptions, and frequency of checks for each equipment, as well as the form of patrol checklist, are specified in the guide. As mentioned in the previous Item 2, it will be necessary to review the frequency of checks.

b. Civil Structures Inspection Manual

It is necessary to prepare the inspection manual for the measurement of deposits in the reservoirs and wall thickness of the penstocks as well as for the inspection of the races.

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

(1) Operation Records

Various data covering generated energy, water turbines and generators including auxiliaries, oil pressure, water pressure, switchyard equipment, transmission lines, etc., are recorded every hour. The operation log is made up of several sheets.

(2) Forced Outage Reports

The hydro power plants submit daily and monthly reports to the regional centers and the Head Office. These reports contain the name of equipment, date and time of occurrences, duration of outages, operation of protective devices, causes, etc.

For the causes, the names of failed parts are often recorded instead. Primary causes should be investigated and reflected on the maintenance of the equipment. Though the monthly reports are enumerated in sequence of date, these should be summarized by units and by causes. Also, annual reports which are summarized by units and by causes should be prepared and utilized as the management data for maintenance of the equipment.

(3) Trouble Report, Maintenance Order, and Turnover Report

The trouble report is issued by the operation section, while the maintenance order and the turnover report are issued by the maintenance section. Since the turnover report contains work descriptions, working hours, used materials, etc., these data should be summarized and utilized as the management data for maintenance works.

5. Spare Parts Inventory Level and Management System

In the hydro power plants, some spare parts have been stored for a long time and some fall short of the standard requirement levels. And also, insufficient specifications, inadequate lead time, time-consuming bidding procedures, etc. are causing delay in the delivery of parts.

6. Custody of Technical Documents and Drawings

Specifications and drawings at the time of plant construction are not kept in old power plants. Drawings needed for overhaul of water turbines and generators, and equipment specifications, drawings, manuals, etc. prepared by the manufacturers are kept for the purpose of operation and maintenance.

Though the single line diagrams have been prepared, the contents differ at each power plant, and the diagrams have not been updated periodically.

7. Test Instruments, Workshop Facilities, and Repair Tools

The test instruments are maintained at TS, and the power plants are provided with the instruments which are needed for maintenance of the equipment. Each power plant has a workshop and is provided repair tools.

In recent years, parts for the hydro power plants have been partially repaired at the MEC (Maintenance Engineering Center), and it will be necessary in the future to fully utilize the MEC for efficient repairing of parts.

8. Training of Operation and Maintenance Staff for Hydro Power Plants, Transmission Lines, and Substations

Technical training has been provided through seminars and OJT. Since NAPOCOR has no training center, facilities such as guest houses are used for the seminars. Because there are no appropriate training facilities, the training quality is not sufficient and the frequency is also not enough. According to the statistics on the operation and maintenance training courses for hydro power plants, transmission lines, and substations, some courses have not actually been carried out, and most are not given continuously.

As described in Clause 5.3, it will be necessary to strengthen the technical training system and promote effective training.

7.4.2 Recommendations on the Operation/Maintenance Improvement Plan

The study and implementation of the following improvement plan is recommended for solving the problems of operation and maintenance mentioned in Sub-clause 7.4.1.

1. *Operation and Maintenance System*

    (1) Division of NLRC into Two Regional Centers and Relocation of Office

    (2) Establishment of Organizational Units in Charge of Maintenance in Regional Centers

2. Operation and Maintenance Procedures

    (1) Preventive Maintenance by TS

    Described in Item 2 of Sub-clause 7.5.2.

    (2) Reduction of Recording Frequency of Operation Log

    (3) Reduction of the Frequency of Patrol Checks

    (4) Periodic Inspection of Civil Structures

    a. To measure the deposits in the reservoirs once a year for Ambuklao and Binga reservoirs, and once every three years for other reservoirs.

    b. To measure the wall thickness of penstocks, which have exceeded 30 years of service, about once every 5 years.

    c. To inspect the races roughly once every two years

(5) Promotion of Fault Reduction Countermeasures

To prepare the fault reduction program based on the fault statistics, and effectively push forward the fault reduction countermeasures by setting the priority of respective countermeasures.

3. Operation and Maintenance Manuals

(1) Revision of Preventive Maintenance Guide

To review the frequency of checks and revise the guide.

(2) Preparation of Civil Structure Inspection Manual

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

(1) Review of Forced Outage Reports

a. To standardize the classification of causes on the corporation-wide level.

b. To prepare monthly and annual reports classified by units, causes, and damaged equipment, and submit them to the regional centers and the Head Office.

(2) Preparation of Maintenance Work Reports

(3) Preparation of Periodic Inspection Report of Civil Structures

5. Spare Parts Inventory Level and Management System

The following study should be pushed forward.

- Arrangement of statistics of parts used in the past
- Arrangement of equipment fault statistics

- Review of the availability of parts

- Review of standard inventory level of spare parts

- Standardization of specifications

- Adequate lead time and ordering points

- Simplification of procurement procedures such as bidding procedures, delegation of procurement authorities to lower organizations, etc.

- Strengthening of the spare parts management system in the Head Office and the regional centers

Subsequent to the above, to study the adoption of the computerized management system.

6. Custody of Technical Documents and Drawings

(1) To establish the rule for keeping the specifications and drawings at the time of construction. For the existing power plants, to arrange the above documents and drawings.

(2) To standardize the single line diagram and establish the rule for periodic updating.

7. Test Instruments, Workshop Facilities, and Repair Tools

(1) To provide the devices for measuring deposits in the reservoirs and wall thickness of the penstocks.

(2) To make the best use of the MEC to execute repair works efficiently.

8. Training of Operation and Maintenance Staff for Hydro Power Plants, Transmission Lines and Substations

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

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

7.5 Transmission Lines and Substations

7.5.1 Present Status and Problems of Operation and Maintenance

1. Operation and Maintenance System

(1) Regional Centers and TS

As explained in Sub-clause 7.4.1.

(2) Area Offices

The area offices are responsible for the operation and maintenance of substations and transmission lines. The organizational structure is divided into the Substation Operation and Maintenance Section, the Transmission Line Maintenance Section, and the Support Services Section, under the control of the respective area manager, substation manager, and transmission manager. In NLRC and SLRC, 10 area offices, 7 in NLRC and 3 in SLRC, cover 26 provinces (refer to Tables 7-4-1 and 7-4-2).

The major changes effected by the reorganization are:

- 6 area offices and 24 sub-area offices in the former structure were integrated into 10 area offices. This integration has facilitated efficient execution of maintenance works.
- The posts of substation manager and transmission manager were established, and the management system of these two sections has been reinforced.
- The number of the substation operators was reduced and the Substation Maintenance Section and the Transmission Line Maintenance Section have been reinforced.

By the above changes, maintenance planning and implementation are expected to be improved hereafter.

2. Operation and Maintenance Procedures

(1) Operation of Substations

Operation of the major substations (230 kV and 115 kV) is performed by the 4-group 3-shift system, with 2 operators at the 230 kV substation and 1 operator at the 115 kV substation for each shift. Operators perform the operation in accordance with the instruction from the load dispatching office and the established operation manual.

The operation log is recorded with hourly data every day, but the frequency of recording is considered reducible.

(2) Maintenance of Substations

Maintenance of the substations is taken care of by the substation maintenance sections of the area offices, and preventive maintenance of major equipment by TS.

In the substations, the operators conduct patrol checks and the maintenance staff perform maintenance works. Patrol checks are conducted in each shift. The results are recorded into the patrol checklist and kept. The frequency of patrol checks could be reduced.

As for the maintenance planning, the area offices prepare the annual preventive maintenance program upon consultation with TS, and submit the budget including the TS portion to the Head Office through the regional centers.

Frequency of preventive maintenance conducted by TS is considered generally higher than needed. It is necessary to check the test results and review the frequency.

(3) Maintenance of Transmission Lines

Maintenance of the transmission lines is taken care of by the transmission line maintenance sections of the area offices. These sections are divided into 1 to 3 groups, respectively consisting of 2 to 5 maintenance crews. In general, each province is provided with one group. Each maintenance crew is staffed by 8 members, namely, 1 foreman, 6 linemen and 1 driver. In NLRC and SLRC, there are 11 transmission line maintenance sections, 22 groups and 72 maintenance crews. Each maintenance crew is provided with a working vehicle and each group a truck with crane.

The maintenance crews perform patrol checks and maintenance works of transmission lines. For the patrol checks, patrol and inspection are usually performed at the same time, and some area offices conduct right of way (ROW) clearing at the same time as well. The results of each patrol check are recorded into the patrol checklist and kept.

For the maintenance planning, the area offices prepare the annual preventive maintenance program and submit the budget to the Head Office through the regional centers.

An effective way to perform patrol checks of transmission lines would be to divide the works into the patrol for visual observation of ROW and facilities, and the inspection of steel towers, wooden poles, insulators, conductors, etc. Also, hot-line detection of defective insulators should be conducted to reduce the faults caused by defective insulators.

Since many faults have occurred in the transmission system, it is necessary to investigate the causes of the faults and push forward the countermeasures for fault reduction.

ROW clearing accounts for a large portion of the maintenance works. Such simple works as ROW clearing should be delegated to common laborers, and the maintenance crews should devote themselves to the maintenance of facilities.

3. Operation and Maintenance Manuals

(1) Operation Manual

For the operation of substations, the corporation-wide standardized manual, "Lines and Substation Energizing/Shutdown Procedure", has been established. In addition, each substation has its own operation manual that is applicable to the substation.

(2) Maintenance Manual

a. Substation patrol checklist guideline

Check items and checking frequency for each equipment in the substations and the form of the patrol checklist have been specified. Review of checking frequency is necessary as mentioned in Item 2 above. Since the battery check item (4.1.b of substation patrol checklist guideline) contains technical problem, this item should be reviewed.

b. Transmission line patrol checklist guideline

Though the check items for the steel towers, wooden poles, etc. and the form of the patrol checklist are defined, the checking frequency is not specified. It is necessary to review the patrol check procedures, check items, and checking frequency as mentioned in Item 2 above.

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

(1) Substation Operation Log

Voltage, power, reactive power, and phase current, etc. by lines are recorded every hour.

(2) Forced Outage Report

The area offices submit daily reports to the regional centers and monthly reports to the regional centers and TS. These reports contain the name of the lines, date, duration, lost energy, causes, etc.

The forced outage report contains the following problems:

a. There are many "unknown" and "transient" recorded in the cause column. Primary causes such as lightning, wind, rain, etc. should be recorded.

b. In some cases, the damaged facilities themselves are inadvertently in the cause column.

c. Classification of causes differs by area offices.

d. Forced outage, scheduled outage, and unscheduled outage are enumerated in the monthly report in sequence of date. The report should be classified by the kind of outage, by lines, and by causes.

(3) Maintenance Work Schedule and Accomplishment Reports

These reports are prepared on a weekly basis. The reports contain the date, structure No., work descriptions, name of linemen, etc. The accomplishment reports should be utilized as the management data for the maintenance works by summarizing the work descriptions and man-months.

5. Spare Parts Inventory Level and Management System

(1) Transmission Lines

Since there were some transmission lines interrupted for long durations due to typhoons and others, it will be necessary to estimate the quantity of unplanned materials based on the past records of materials and store the spare materials in the regional centers or the area offices.

(2) Substations

In the substations, there are some cases of lacking spare parts for the following reasons.

- A variety of equipment have been purchased from various manufacturers of different countries.

- Parts for old equipment are no longer manufactured.

- Procurement of parts requires considerable time.

- Insufficient specifications, inadequate lead time, time-consuming bidding procedures, etc. have caused delay in the delivery of parts.

On the other hand, repairs requiring high-skilled technique, such as overhauls of GCBs, are likely to increase in the future.

Spare parts should be stored in the future, and in addition, the spare equipment of standard specifications should also be stored for the above-stated reasons.

6. Custody of Technical Documents and Drawings

Specifications and drawings at the time of construction are not kept in the area offices, but kept by the engineering department of the Head Office. Some of them for old facilities are missing.

In the substations, specifications, drawings and operation manuals prepared by manufacturers are kept. Though the single line diagrams have been prepared, the forms and recorded items differ at each substation, and the diagrams have not been updated periodically.

As for the transmission lines, the route plans and sectional profile drawings, steel tower drawings, clearance diagrams, etc. are rarely maintained in the area offices. In some area offices, technical data containing details of structures, span length, etc. for wooden pole lines have been prepared.

7. Test Instruments, Workshop Facilities, and Repair Tools

The test instruments are maintained by TS, and the area offices are provided with instruments necessary for routine maintenance.

In the workshops of the area offices, only repair tools such as grinders, welding machines, soldering guns, hand drills, wrenches, power saws, etc. are provided, but this poses no problem for the time being.

8. Training of Operation and Maintenance Staff

As described in Item 8 of Sub-clause 7.4.1.

9. Load Dispatching System and Communication System

(1) Load Dispatching System

Operation of power plants, transmission lines and substations is conducted by instruction from the Power Management Center. Information for the system operation is, in part, automatically transmitted through telemeters. However, most of the information is collected by telephone. Also, all load dispatching instruction is issued through telephone.

Computers are provided for supporting the load dispatching task, however, due to the incomplete communication system, instantaneous information collection from each station is insufficient and the computer system is far from functioning satisfactorily.

Frequency fluctuation is quite large, and further improvement seems to be impossible with the present power system capacity and regulating capability of NAPOCOR. It will be necessary to fully investigate the conditions of load fluctuation, review the regulating capacity of generators, and study the optimal method.

As for the voltage regulation, due to the insufficient capacity of the reactive power control equipment, the voltage in the metropolitan area drops drastically during thermal power plants shutdowns. And also, the voltage in the northern system similarly drops when hydro power plants in the northern system are stopped. It will be necessary to study and implement the installation of power capacitors as quickly as possible. For maintaining the voltage in the metropolitan area, the extent of responsibility should be clarified with MERALCO and phase modifying equipment should be installed, as needed by both parties.

As for the emergency procedures in case of faults, it seems impossible to adequately handle complicated faults with any reasonable speed by the use of the existing communication system. Therefore, the establishment of effective system operation procedures in case of faults and the improvement of the communication system are strongly urged.

(2) Communication System

The existing communication system for load dispatching consists mainly of micro-wave and power line carrier systems. Since both are equipped with small capacity equipment, the number of channels is insufficient and satisfactory load dispatching is impossible.

The RTU's (Remote Terminal Unit) for collection of site information for load dispatching are also insufficient, and the reinforcement of the RTU's as well as the communication system is necessary.

In addition, since the load dispatching has priority in the use of communication channels, the channels available for other business are insufficient. It will be necessary in the future to further strengthen the communication system to realize computerization and rationalization of business activities.

7.5.2 Recommendations on the Operation/Maintenance Improvement Plan

The study and implementation of the following improvement plan is recommended for solving the problems of operation and maintenance mentioned in Sub-clause 7.5.1.

1. Operation and Maintenance System

As described in Item 1 of Sub-clause 7.4.2.

2. Operation and Maintenance Procedures

(1) Review of Preventive Maintenance by TS

The adequate frequency of the preventive maintenance will be roughly once every three years with the power equipment, once every six years with GCB's, once a year with the billing meters, once every two years with the integrating meters, and as the necessity arises with the indicating meters. Among the test items, the turn ratio, winding resistance, and exciting current tests are considered unnecessary.

(2) Reduction of Recording Frequency of Substation Operation Log

It will be sufficient to record every hour during the peak load duration and two to three times for the rest of the day.

(3) Reduction of the Frequency of Substation Patrol Checks

In view of the current conditions of the equipment, once a week during the day shift will be sufficient.

(4) Review of Patrol Check Procedures of Transmission Lines

a. To divide the transmission line patrol checks into the patrol and the inspection. It is advisable to perform minor maintenance works during the patrol and conduct the inspection separately. The standard frequency could be

2 or 3 times a year for the patrol and once every 2 or 3 years for the inspection.

b. To adopt the hot-line detection of defective insulators so as to minimize the faults caused by defective insulators.

(5) Contracting out of Simple Works

(6) Promotion of Fault Reduction Countermeasures

To prepare the fault reduction program based on the fault statistics, and effectively push forward the fault reduction countermeasures by setting the priority of respective countermeasures.

3. Operation and Maintenance Manuals

(1) Revision of Substation Patrol Checklist Guideline

To review the checking frequency and check items, and revise the guideline.

(2) Revision of Transmission Line Patrol Checklist Guideline

To review the patrol check procedures, checking frequency and check items, and revise the guideline.

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

(1) Review of Forced Outage Reports

a. To standardize the classification of causes on the corporation-wide level.

b. To prepare monthly and annual reports classified by lines, by causes, and by damaged facilities, and submit them to the regional centers and the Head Office.

(2) Preparation of Maintenance Work Reports

5. Spare Parts Inventory Level and Management System

(1) Transmission Lines

a. To divide the materials used for the transmission lines into planned and unplanned materials and record them.

b. To study the spare materials storing system at the regional center or the area office level by estimating the required quantity of unplanned materials.

(2) Substations

The following study should be pushed forward.

- Arrangement of statistics of parts used in the past
- Arrangement of equipment fault statistics
- Review of the availability of parts
- Review of the standard inventory level of spare parts and spare equipment
- Standardization of specifications
- Adequate lead time and ordering points
- Simplification of procurement procedures such as bidding procedures, delegation of procurement authorities to lower organizations, etc.
- Strengthening of the spare parts management system in the Head Office and the regional centers

6. Custody of Technical Documents and Drawings

(1) Transmission Lines

a. For the steel tower lines, to establish the rules for maintaining the route plans and sectional profile drawings, steel tower drawings (including foundation), clearance diagrams, etc. at the time of construction. For the existing lines, to arrange the above documents and drawings.

b. For the wooden pole lines, to maintain the technical data and the route maps in all area offices.

(2) Substations

a. To establish the rule for maintaining the specifications and drawings at the time of construction. For the existing substations, to arrange the above documents and drawings.

b. To standardize the single line diagram and establish the rule for periodic updating.

7. Test Instruments, Workshop Facilities, and Repair Tools

(1) To study the methods of inspection and repair requiring highly skilled technique such as the overhaul of GCB, and study the improvement of the workshops.

(2) To utilize the MEC for the overhaul of GCB.

8. Training of Operation and Maintenance Staff

As described in Item 8 of Sub-clause 7.4.2.

CHAPTER 8

ENVIRONMENTAL MANAGEMENT

CHAPTER 8 ENVIRONMENTAL MANAGEMENT

8.1 Environmental Management in the Republic of the Philippines

8.1.1 Environmental Administration in the Philippines

The environmental affairs are administrated in accordance with the rules and regulations for the prevention of environmental pollution promulgated by the National Pollution Control Commission (NPCC) in 1978.

It specifies the standards and regulations for air quality, water quality and noise.

In 1979, the application of the Environmental Impact Statement (EIS) was promulgated.

In 1987, as the Aquino Regime started, NPCC was reorganized under DENR.

In 1990, the Water Quality Criteria and Effluent Regulations for the prevention of water pollution were revised.

8.1.2 Present State of the Environment

Metro Manila now has many problems accompanying its industrialization and population growth.

1. Solid Waste

   The present amount of solid waste discharge is 3,600 t/day. However, it is estimated that, in the year 2000, the amount will reach 5,000 t/day. Therefore, disposal of waste along with the treatment of toxic and harmful matters is now being studied.

2. Air Pollution

   Sixty percent of the air pollution is believed to be caused by the transport facilities while the other 40% is caused by the factories. The SO_2 concentration within Metro Manila is 0.05 ppm, which is less than the NPCC's control value of 0.14 ppm. The exhaust from diesel engine automobiles is considered as a major pollution source.

3. Sewage Disposal

Only about 12% of the Manila population uses the sewage collection system. As a large amount of waste and sewage is disposed of in rivers and canals, the contamination of the river water has been aggravated.

4. Nature Conservation

For the conservation of the natural environment, the Philippine Government is striving to conserve the national parks by preventing illegal settlement of people and felling of trees.

Also, the preservation of animals indigenous to the Philippines, such as flying lemurs, Philippine eagles and Philippine crocodiles, is also a consideration.

8.1.3 Present State of Environmental Management at Power Plants and Recommendation

1. Air Quality

(1) Exhaust gas from stack

As the oil-fired thermal power plants (Sucat, Malaya, Manila and Bataan) use heavy oil with the sulfur content of 2.5 -- 4.0%, the SO_2 discharged from the stack is 1,500 -- 2,500 ppm, far exceeding the control value of 250 mg/scm. (SO_2 = 87.5 ppm)

In order to meet the emission standard of 250 mg/scm, a heavy oil with low sulfur content of 0.16% must be used.

Currently, the measurement of exhaust gas (SO_2, SO_3, NOx and dust) is not being conducted on a regular basis. The flue gas measuring instrument should be installed on the flue in the future.

(2) Ambient Sulfur Dioxide (SO_2) concentration

The recent record of measurements shows that the NPCC's limit value of SO_2 concentration of 369 micrograms/scm (0.14 ppm) (24 hours) and 850 micrograms/scm (0.3 ppm) (1 hour) have not been exceeded.

(3) Meteorological observation

There is a meteorological observation tower at Batangas Coal-fired Thermal Power Plant, and observations were made. However, the instruments have been out of order and the repair of the instruments is programmed at present.
It is recommended that first the surface meteorological observation be conducted at each power plant and, then the environmental impact investigation for the exhaust gas diffusion be implemented.

2. Water Quality

The condenser cooling water used for the Sucat and Malaya Thermal Power Plants is taken from Laguna Lake.

Thermal power plants discharge a great volume of acid and alkaline waste water consisting of regeneration waste water from the demineralizing plant and the condensate polisher (Ammonex), air heater wash waste water, etc.

Each power plant should be equipped with the waste water neutralization equipment to satisfy the Effluent Standard of DENR Administrative Order.

3. Noise

The limit values set by NPCC for class D which is reserved as a heavy industrial area are 75 dB for the daytime, 70 dB for the morning and evening, and 65 dB for the night.

According to recorded measurements at the thermal and geothermal power plants, the noise at the plant boundary does not exceed the limit values.

Recommendations are as follows.

In accordance with the NPCC standards, the noise levels at plant boundary should be measured and recorded for each time period - daytime, morning, evening and night.

The noise levels of the major noise sources at the power plant should be measured and recorded, and the decreasing rates as they reach the plant boundary should be determined.

An isopleth of noise level inside the plant yard should be prepared.

8.2 Recommendation on Improvement of Environmental Measures

8.2.1 Control Technology and Removal Methods of PCB

1. Present Status of PCB Control

Polychlorinated biphenyl (PCB) is a homolog of compounds containing chlorine, and usually oily liquid compound. As PCB has superior characteristics in stability, electric insulation, etc. it has been used for electrical equipment including transformers.

However, since its toxicity was confirmed, the Ministry of International Trade and Industry of Japan has enforced stringent storage control regulations on the handling of electrical equipment using PCB since 1984.

The Environmental Service Department (ESD) of NAPOCOR drew up the "Progress Report on the Survey of PCB", which describes health damages and handling and control methods, and includes a list of electrical equipment containing PCB.
This is an indication of their serious effort in solving the PCB problem.

However, the present condition of PCB control at the power plants are not always satisfactory. At one power plant, PCB containing oil was left outside in drum cans and new operators did not understand the toxicity of PCB. Also, there were no labels pasted on the drum cans containing PCB.

In consideration of the conditions in NAPOCOR, the following are proposed.

2. Recommendations for PCB Control

In consideration of the condition in NAPOCOR, the following are proposed.

(1) Storage control

A warehouse should be specified to collectively store the small equipment and oil (in drum cans) containing PCB.
The large equipment should be stored in the power plant.

The history of the equipment, etc. should be recorded in a control ledger.
The PCB containing equipment in use and in storage should be labeled. The labels should be made collectively at the Head Office and distributed to each power plant.

(2) Person in charge of control

In order to prevent oil leakage accidents, a person in charge of the control should be appointed to attend to transfer and removal of the equipment and oil containing PCB, as well as to conduct regular inspections.

(3) PCB detection methods

The measuring method should be studied with the gaschromatograph owned by NAPOCOR.
Refer to JIS K 0093.

(4) Handling

PCB should be handled with special attention paid to prevention of leakage, and also to its potential harm to the living things.
It should be handled in specified work clothes and gloves.

8.2.2 Air Pollution Monitoring Method at Thermal Power Plants

1. Present Status of Air Pollution Monitoring

At the four oil-fired thermal power plants of Sucat, Malaya, Manila and Bataan, the concentrations of SO_2, SO_3 and NOx in exhaust gas at the stack entrance are not measured. Air pollution monitoring for SO_2, NOx and dust in the vicinity of the power plants is not regularly conducted, either.

2. Predictive Calculation of Exhaust Gas Diffusion

Predictive calculation of the diffusion of exhaust gas was made with the sulfur content in the fuel oil in 1989 and technical information from the boiler manufacturers.

Table 8-2-1 Predictive Calculation of Exhaust Gas Diffusion

Plant	Unit	Max. SO_2 ground concentration C max. (ppm)	Distance Xmax. (m)
Sucat	No.1 & 2 No.3 & 4 Total	0.0389 0.0424 0.0805	11,703 13,609 approx. 13 km
Malaya	No.1 No.2 Total	0.068 0.064 0.1315	9,308 10,515 approx. 10 km
Manila	No.1 No.2 Total	0.047 0.047 0.094	5,817 5,817 approx. 6 km
Bataan	No.1 No.2 Total	0.0576 0.0745 0.1285	4,879 6,261 approx. 6 km
Batangas	No.1	0.00451	8 km

3. Monitoring Methods

The following methods are recommended for the monitoring at thermal power plants.

(1) Meteorological observation

At each power plant, wind direction and speed and stability should be observed.

(2) Measurement of SO_2, NOx and dust at emission source (stack)

(3) Measurement of the ground level concentration
A monitoring stations or with mobil observation buses

The aim of the installation of monitoring stations is to collect the measured data in the central control station by telemeter, so that the data may be integrally controlled to meet the NPCC control values. Therefore, it is advisable to add the telemeter system in the future.

8.2.3 Measures for Reduction of Hydrogen Sulfide from Geothermal Power Plants

1. Present Status of the Environment

The concentration of hydrogen sulfide currently emitted from Tiwi Power Plant, obtained by using the noncondensable gas ratio and component gas proportion in the steam used in Plants A, B and C, is as follows:

Plant A	1,748 ppm
Plant B	884 ppm
Plant C	1,203 ppm

The hydrogen sulfide emission standard of NPCC dated June 23, 1978 stipulates roughly 10 ppm.

2. Hydrogen Sulfide Concentration Reduction Measures

The method currently developed by plant manufacturers in the method of introducing the hydrogen sulfide [H_2S] emitted from the ejector to the cooling tower, and this method is considered the most effective measure.

Mak-Ban and Tiwi Geothermal Power Plants are compared with Japanese geothermal power plants in Table 8-2-2. The H_2S concentration (ppm) emitted from these two Philippine plants is similar in values to those at Hatchobaru Geothermal Power Plant, and judging from the results of the wind tunnel test for Hatchobaru, similar reduction in H_2S concentration at the outlets of cooling towers may be expected when the said method is adopted at Mak-Ban and Tiwi Power Plants. This indicates that sufficient reduction can be expected.

Table 8-2-2 Comparison of H_2S Concentration

		Hatchobaru G.P.P.		Mori G.P.P.		Mak-Ban G.P.P.	Tiwi G.P.P.
Output	MW	55		50		55	55
Fans in operation		4	3	4	2	6	6
Exhaust humid air volume	10^3 Nm^3 /h	8,159	6,344	8,100	4,100	12,391	12,391
Exhaust humid air temperature	℃	38.5	27.5	39.2	36.6	36	36
Humid air exhaust speed	m/s	11.2	11.2	7.5	7.5	9.5	9.5
Height of exhaust port	m	17.7	17.7	24	24	19.9	19.9
Diameter of exhaust port	m	9	9	10.8	10.8	9.75	9.75
Hydrogen sulfide exhaust volume	Nm^3 /h	65	65	267	267	148	116
H_2S	ppm	8	10.3	33	66	11.9	9.4
Wind tunnel experiment result							
Longest landing distance	km	0.1	0.1	W 0.3 NE 0.25 SW 0.35	0.25 0.1	——	——
Highest concentration on ground H_2S	ppm	0.0048	0.0051	W 0.003 NE 0.099 SW 0.007	0.03 0.326	——	——
Wind speed	m/s	6	6	6	6		