Table 4-4

SUMMARY OF CAPACITY ADDITIONS (MW)
1991 POWER DEVELOPMENT PROGRAM

YEAR	PLANT TYPE						TOTAL
	HYDRO	GEO	COAL	DIESEL	GT	CC	
1991	5	-	-	6	436	-	447
1992	80	-	-	55	30	-	165
1993	-	235	-	-	-	520	755
1994	-	20	300	6	-	-	326
1995	-	180	650	-	-	-	830
1996	-	160	300	-	-	-	460
1997	-	440	350	-	-	-	790
1998	-	340	-	6	-	-	346
1999	-	220	300	-	-	-	520
2000	268	-	600	-	-	-	868
2001	150	20	600	-	-	-	770
2002	223	40	600	-	-	-	863
2003	255	20	600	-	-	-	875
2004	174	60	900	-	-	-	1134
2005	150	60	900	-	-	-	1110
TOTAL	1305	1795	6100	73	466	520	10259

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Table 4-5

1991 POWER DEVELOPMENT PROGRAM

YEAR	LUZON				VISAYAS				MINDANAO				TOTAL
	MO.	POWER PLANT	TYPE	MW	MO.	POWER PLANT	TYPE	MW	MO.	POWER PLANT	TYPE	MW	
1991	JAN	HOPEWELL GT #2	GT	70	FEB	ABB-LBGT#1	GT	28	FEB	PBGT-MT#8	GT	30	447
	JAN	PBGT-JB#1	GT	30	FEB	PBGT-MT#7	GT	30	MAR	PBGT-MT#9	GT	30	
	MAR	HOPEWELL GT #3	GT	70	APR	ABB-LBGT#2	GT	28	AUG	PBGT-JB#2	GT	30	
	MAR	PBGT-JB#3	GT	30	OCT	BDPP Unit 5	DSL	6					
	JUN	PBGT-JB #4	GT	30	DEC	JANOPOL MH	HYDRO	5					
	OCT	PBGT-JB #5	GT	30									
1992	JUL	LBGT - SUCAT	GT	30	OCT	CDPP II-U4	DSL	19	JUL	AGUS I	HYDRO	80	155
									JUL	SMPB-12	DSL	36	
1993	JAN	BATAAN CC-STAGE 1	CC	210	JAN	CEBU-NEGROS INTERCONNECTION			FEB	DAVAO CC STAGE 1	CC	140	755
	MAR	MAKBAN BINARY	GEO	12	JUL	PALINPINON II - 1	GEO	20	NOV	DAVAO CC STAGE 2	CC	70	
	MAY	BACMAN II	GEO	40	SEP	PALINPINON II - 2	GEO	20					
	JUN	BACMAN I	GEO	110	NOV	PALINPINON II - 3	GEO	20					
	SEP	BATAAN CC-STAGE 2	CC	100									
	OCT	MAIBARARA BINARY	GEO	13									
1994	MAR	CALACA II	COAL	300	JAN	PALINPINON II - 4	GEO	20					326
					JAN	BOHOL DIESEL	DSL	6					
1995	JAN	DEL GALLEGO	GEO	120					JAN	MT. APO A	GEO	60	830
	MAY	MASINLOC I	COAL	300									
	JUN	HOPEWELL I-BOT	COAL	350									
1996	JAN	MASINLOC II	COAL	300	JAN	MAMBUCAL A	GEO	40	JAN	MT. APO B	GEO	60	460
	JAN	BULUSAN	GEO	60									
1997	JAN	LUZON-LEYTE INTERCONNECTION			JAN	LEYTE-CEBU INTERCONNECTION			JAN	LEYTE-MINDANAO INTERCONNECTION			790
	JAN	HOPEWELL II-BOT	COAL	350	JAN	LEYTE-A	GEO	440					
1998					JAN	LEYTE B1	GEO	220	JAN	MT. APO C	GEO	120	346
					JAN	BOHOL DIESEL	DSL	6					
1999	JAN	COAL	COAL	300	JAN	LEYTE B2	GEO	220					520
2000	JAN	COAL	COAL	600									868
	JAN	CASECNAN	HYDRO	268									
2001	JAN	LUZON-MINDORO INTERCONNECTION			JAN	CEBU-BOHOL INTERCONNECTION							770
	JAN	COAL	COAL	600	JAN	MAMBUCAL B1	GEO	20					
	JAN	KALAYAAN	HYDRO	150									
2002	JAN	COAL	COAL	600	JAN	MAMBUCAL B2	GEO	20	JAN	AGUS III	HYDRO	223	863
					JAN	LEYTE C1	GEO	20					
2003	JAN	COAL	COAL	600	JAN	LEYTE C2	GEO	20	JAN	SMALL HYDRO STAGE 1	HYDRO	105	875
	JAN	KALAYAAN	HYDRO	150									
2004	JAN	COAL	COAL	900	JAN	LEYTE C3 - 5	GEO	60	JAN	SMALL HYDRO STAGE 2	HYDRO	106	1134
										SMALL HYDRO STAGE 3	HYDRO	68	
2005	JAN	COAL	COAL	900	JAN	LEYTE C6 - 8	GEO	60	JAN	BULANOG-BATANG	HYDRO	150	1110
TOTAL				7623				1328				1308	10259

Fig. 4-1

PHILIPPINES

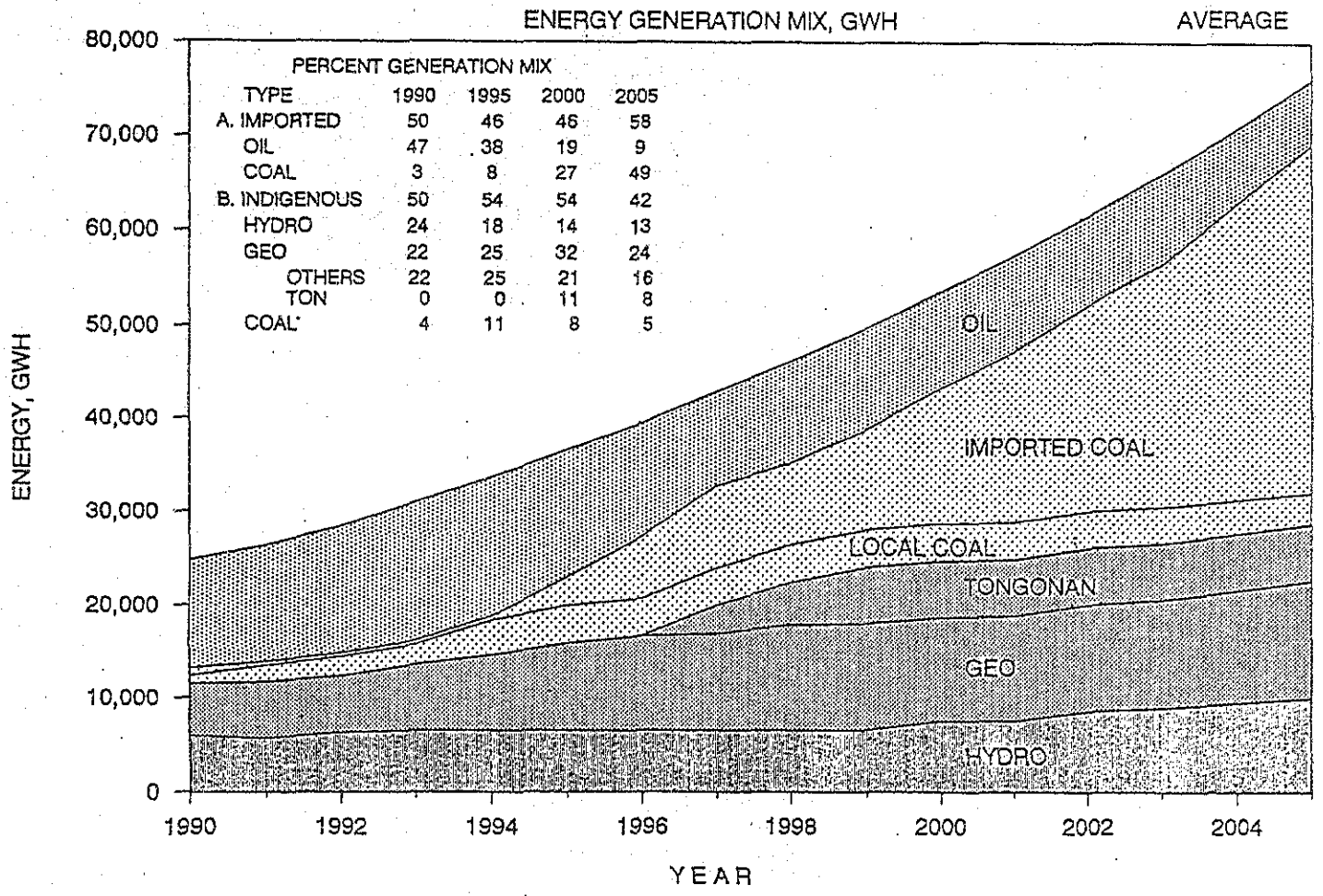

Fig. 4-2

LUZON GRID

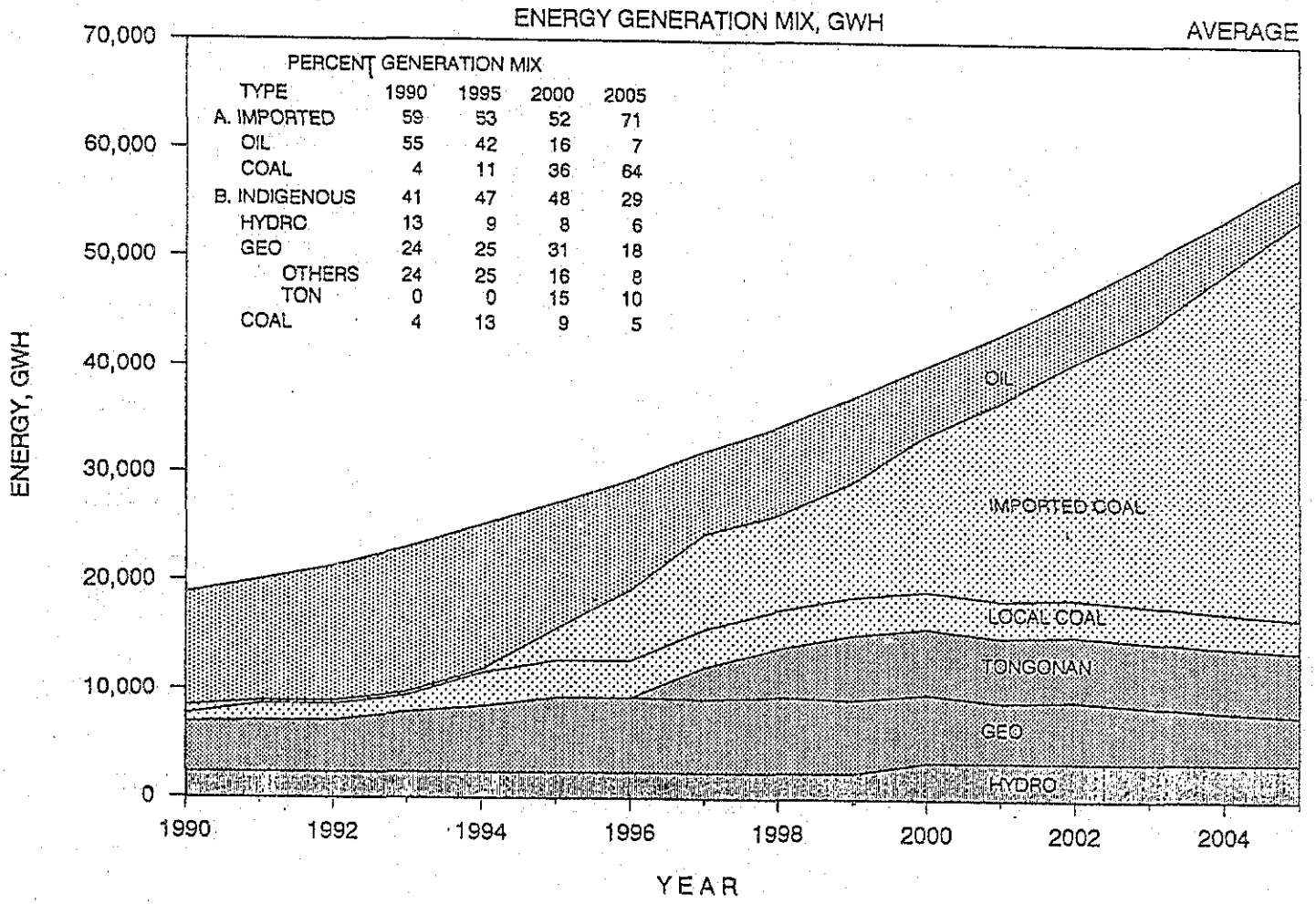

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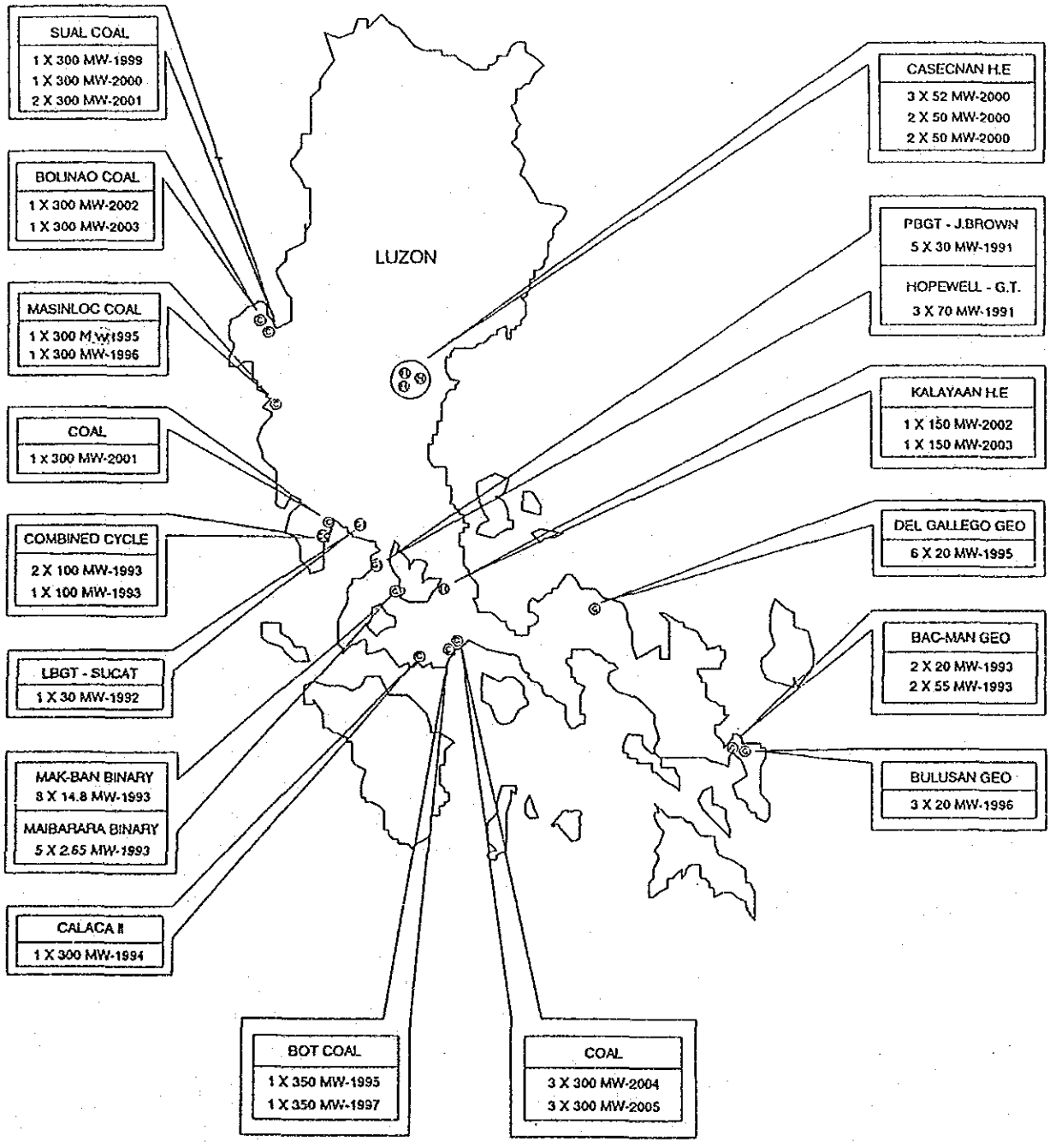
Fig. 4-3

LUZON GRID

PROPOSED GENERATION PROJECTS
1991 POWER DEVELOPMENT PROGRAM



CHAPTER 5

OUTLINE OF NATIONAL POWER CORPORATION

CHAPTER 5 OUTLINE OF NATIONAL POWER CORPORATION

5.1 History of National Power Corporation

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

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

Development of the scale of NAPOCOR's operation is as shown in the followings.

	1966	1976	1980	1985	1990
Energy Generation GWh	1,425	3,140	15,086	18,757	24,799
Energy Sales GWh	1,310	2,966	14,033	17,140	22,915
Peak Demand MW	674	1,787	2,414	3,037	3,974
Generating Capacity MW	270	663	3,821	5,549	6,037
Transmission Line Length km	2,398	3,682	7,152	11,832	14,060
Substation Capacity MVA	916	2,180	7,598	13,307	14,381

5.2 Organization Structure of NAPOCOR

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

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

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

In an effort to rationalize and integrate job functions, NAPOCOR is implementing the organizational reform which includes the "early retirement incentive program". Although substantial reform was carried out in November 1991, the complete transition to the new organizations has not yet been finished. The new and old organizations are shown in Tables 5-1 and 5-2, respectively. A comparison of these two indicates that the integration of job functions has rationalized and simplified the organizational structure.

The organization related to the operation and maintenance is described in Chapter 7.

5.3 Manpower and Training

According to the manpower trend in the past 10 years, the number of employees generally decreased between 1981 and 1985, but it turned to the increasing trend after 1985. In 1990, the number of employees increased by 3,102. The transition of employees from 1981 to 1990 is shown below:

Year	No. of Employees	Year	No. of Employees
1981	12,062	1986	10,821
1982	11,978	1987	10,819
1983	11,837	1988	11,294
1984	11,523	1989	12,954
1985	10,564	1990	16,056

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

Human Resources is in charge of manpower training, and is endeavoring to develop the capabilities and technical skill of the employees. According to the five-year records between 1986 and 1990, the annual average number of training course attendants was 4,071, with 875 (21.5%) attending the manager and supervisor courses, 717 (17.6%) the operation and maintenance courses, 1,104 (27.1%) the engineering and computer courses, and 1,375 (33.8%) the administration courses. The training for the operation and maintenance staff is described in Chapter 7. However, it is pointed out that the above-mentioned 717 attendants are far too few, considering the operation and maintenance staff of more than 12,000.

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

The training center project, which was scheduled for implementation by the ADB loan, was canceled in October 1991. This was due to the escalated construction costs for the Bac-Man Geothermal Power Plant which was also included in the said loan. The bidding documents for the project have already been prepared. The proposed location is the NAPOCOR's Housing Compound in Bagac, Bataan Province. This compound, which was used during the construction of the PNPP, is spacious and fully equipped with a hotel, apartments, housing, athletic facilities, etc. Presently, a part of the training, mainly lectures, are carried out at this compound. Early implementation of this project is imperative for the enrichment and improvement of training.

5.4 Financial Situation

The outline of financial performance in 1990 is shown in Table 5-3.

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

On the other hand, due to the rise of crude oil prices and other costs caused by the Gulf Crisis, the operating expenses amounted to 21,660 million Pesos, an increase of 41.47% over the previous year. In particular, the generating cost increased by 56.17% and the oil cost per kWh 98.32% over the previous year.

Consequently, the operating income decreased by 22.27% to 4,119 million Pesos, and the net income loss was 65 million Pesos.

Total assets were 160,460 million Pesos with the net utility plants of 78,144 million Pesos, or increases of 17.14% and 19.10% over the previous year, respectively. The assets, which had not been revalued since 1987, were revalued in 1991.

Although the return on rate base was 6.02%, it has been reported that it would be 2.7% after the revaluation. The debt service ratio was 1.4, and the self-financing ratio was 0.3%.

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

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

5.5 Power Rates

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

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

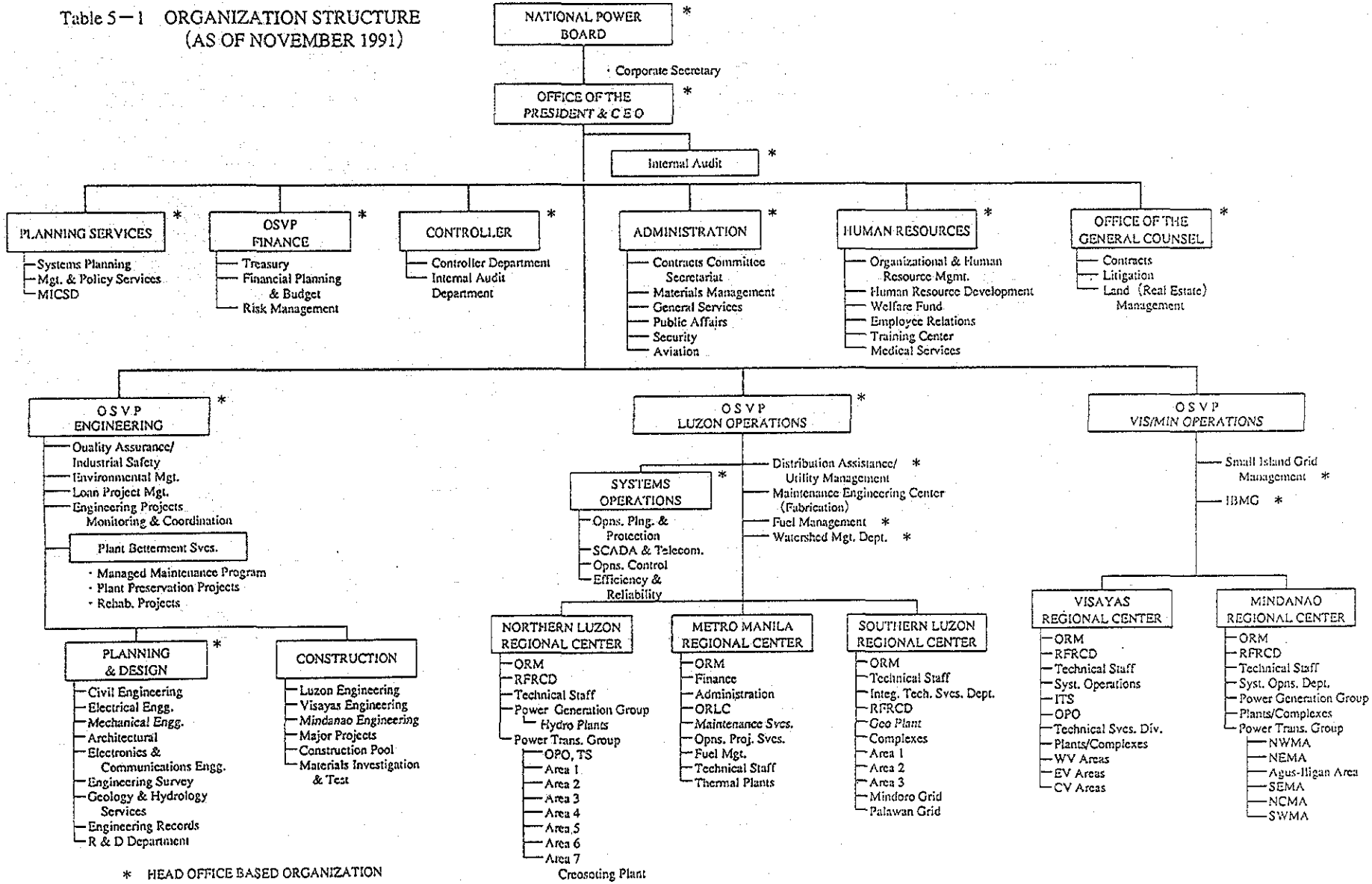
In addition, the power rates vary depending on the customers. The rates for electric cooperatives are set fairly low to encourage electrification in the rural areas.

Table 5-4 shows the past transition and estimation of average power rates.

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

As stated in Clause 5.4, the purpose of rate increases after 1992 is to improve the financial situation. An annual average increase rate of 12.1% is planned between 1992 and 1994.

Table 5－1 ORGANIZATION STRUCTURE
(AS OF NOVEMBER 1991)



* HEAD OFFICE BASED ORGANIZATION

Table 5－2　ORGANIZATION STRUCTURE
(AS OF FEBRUARY 1991)

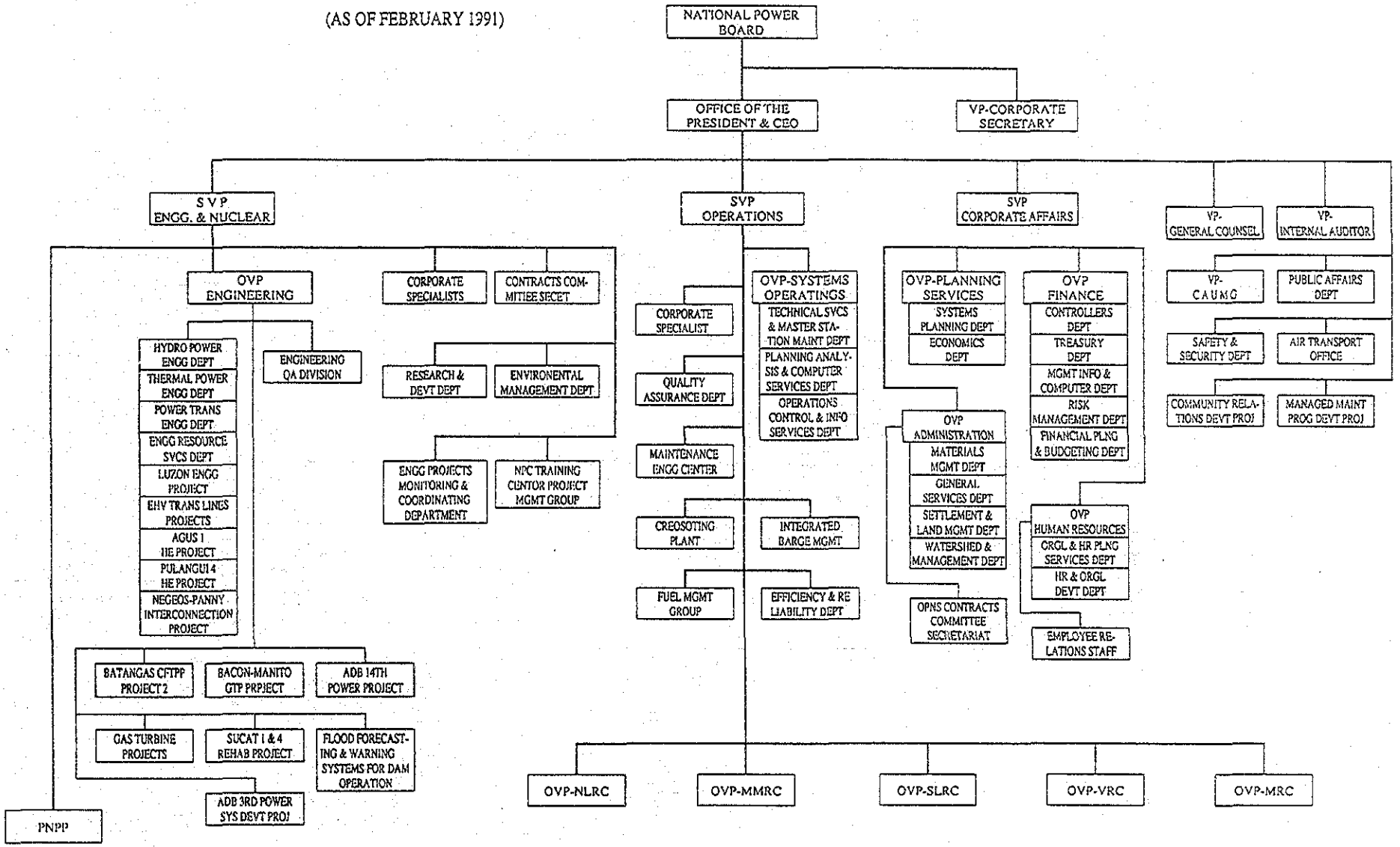


Table 5-3 FINANCIAL PERFORMANCE IN 1990

Items			Unit	1990	1989	Inc(Dec) %
Energy Sales			GWh	22,915	22,244	3.02
Average Power Rate			P/kWh	1.1263	0.9381	20.06
Net Operating Revenue			P Mn	25,779	20,610	25.08
Operating Expenses			〃	21,660	15,311	41.47
Generation			〃	15,141	9,695	56.17
Transmission and Distribution			〃	489	382	28.01
Administrative and General			〃	538	434	23.96
Depreciation			〃	4,613	3,856	19.63
Depletion			〃	489	492	(0.61)
Provision			〃	30	109	(72.48)
Other Operating Expenses			〃	360	343	4.96
Operating Income			〃	4,119	5,299	(22.27)
Net Income			〃	(65)	1,661	(103.91)
Rate Base			〃	68,409	66,901	2.25
Return on Rate Base			%	6.02	7.92	(23.99)
Cost of Service			P/kWh Sold	1.1263	0.9381	20.06
Fuel Cost			〃	0.4248	0.2142	98.32
Steam Cost			〃	0.1326	0.1252	5.91
Coal Cost			〃	0.0482	0.0522	(7.66)
Depreciation and Depletion			〃	0.2229	0.1979	12.63
Manpower Related Expenses			〃	0.0535	0.0543	(1.47)
Other Operating Expenses			〃	0.0643	0.0531	21.09
Non-Other Operating Expenses			〃	0.1828	0.1655	10.45
Net Income			〃	(0.0028)	0.0757	(100.37)
Assets	Total		P Mn	160,460	136,976	17.14
	Utility Plant	Under Construction	〃	22,151	17,027	30.09
		Operating(Net)	〃	78,144	65,660	19.01
Proprietary Capital			〃	32,912	35,537	(7.39)
Long Term Debt			〃	69,108	52,740	31.04
Capital Expenditures			〃	11,182	6,609	69.19
Funding Sources	Foreign Loans		〃	7,735	3,789	104.14
	Net Internal Cash Generation		〃	4,239	1,890	124.28
	Equity Advance from the National Goverment		〃	598	0	-
	Others		〃	(1,390)	930	(249.46)

Table 5-4 AVERAGE POWER RATES

(Unit:P/kWh)

Year	Luzon	Visayas	Mindanao	Phillipines	Annual Increase Rate(%)
1980	0.3641	0.4078	0.1644	0.3423	
1981	0.4480	0.4982	0.1800	0.4166	21.7
1982	0.4670	0.5444	0.1859	0.4299	3.2
1983	0.6152	0.7244	0.2966	0.5790	34.7
1984	0.9740	0.9980	0.3740	0.8754	51.2
1985	1.2082	1.0401	0.5205	1.0835	23.8
1986	1.0552	0.9063	0.5086	0.9548	-11.9
1987	0.9793	0.8671	0.5657	0.9038	-5.3
1988	1.0031	0.9252	0.6252	0.9354	3.5
1989	0.9877	1.0385	0.6669	0.9381	0.3
1990	1.2049	1.2424	0.7043	1.1263	20.1
1991				1.3900	23.4
1992				1.6600	19.4
1993				1.8800	13.3
1994				1.9600	4.3

CHAPTER 6

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

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

6.1 Thermal Power Plants

6.1.1 Current Status, including Problems, of Thermal Power Facilities

1. Outline of Thermal Power Plants

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

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

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

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

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

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

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

(2) Outline of Thermal Power Plant Facilities

The outline is shown in Table 6-1-12, "Summary of Thermal Power Plant Facilities."

2. Current Status of Thermal Power Plants

(1) Reduced Output of Thermal Power Plants

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

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

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

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

Note: Rehabilitation Project

* Capability prior to overhauling

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

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

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

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

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

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

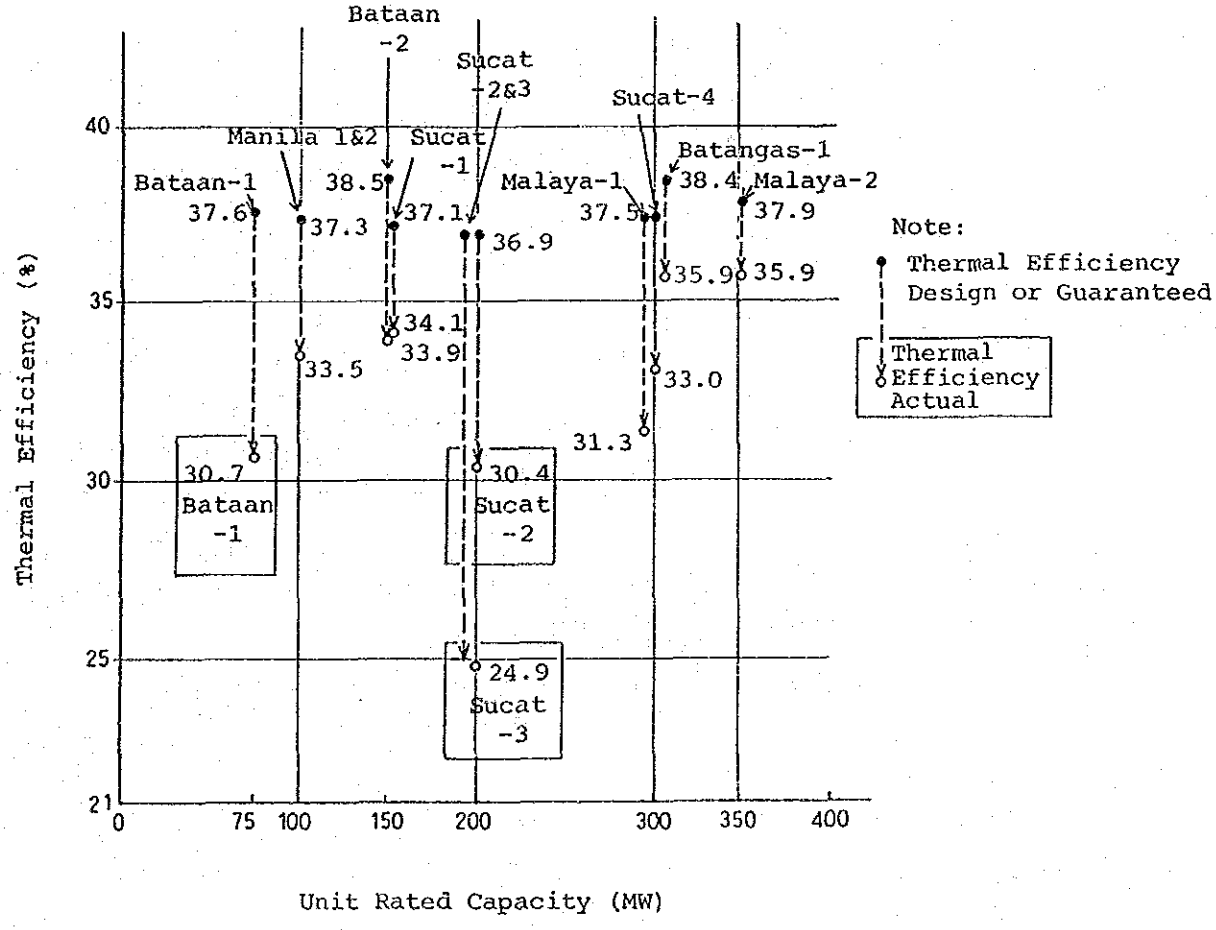


Table 6-1-3 Comparative Gross Heat Rate and Thermal Efficiency (As of Jun.1991)

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

Note:

*-Based on acceptance test after rehabilitaion

a-Based on manufacturers design/guaranteed performance

b-Based on acceptance test after construction

c-Actual performance for the month of May 1991

d-Expected performance after overhauling

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

1 kcal = 3.96832 BTU

860 kcal ≒ 3,413 BTU

(3) Number of Forced Outages at Thermal Power Plants

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

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

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

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

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

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

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

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

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

(4) Maintenance Outage Hours of Thermal Power Plants

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

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

The distinctive findings from the Figure are as follows:

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

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

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

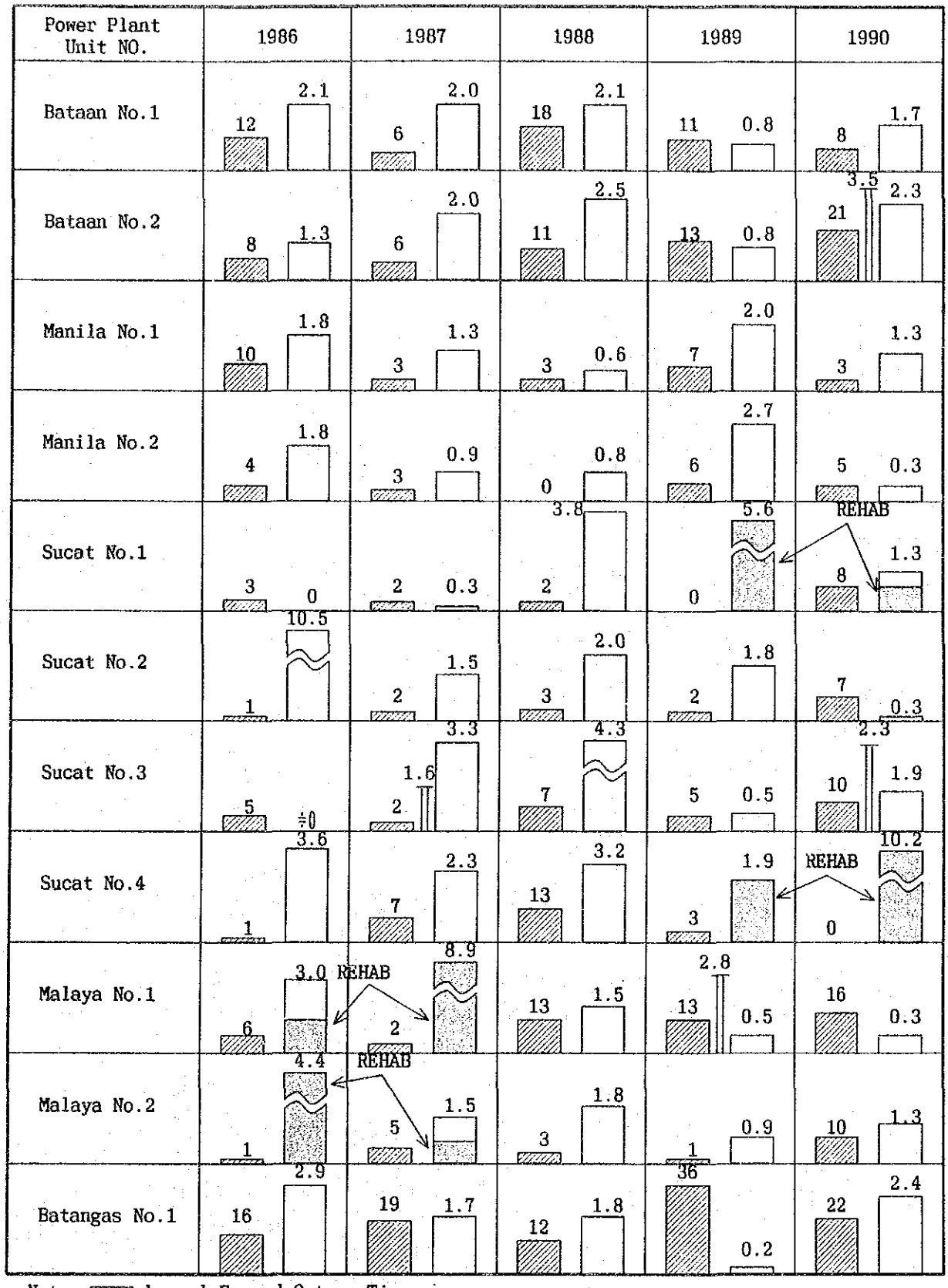
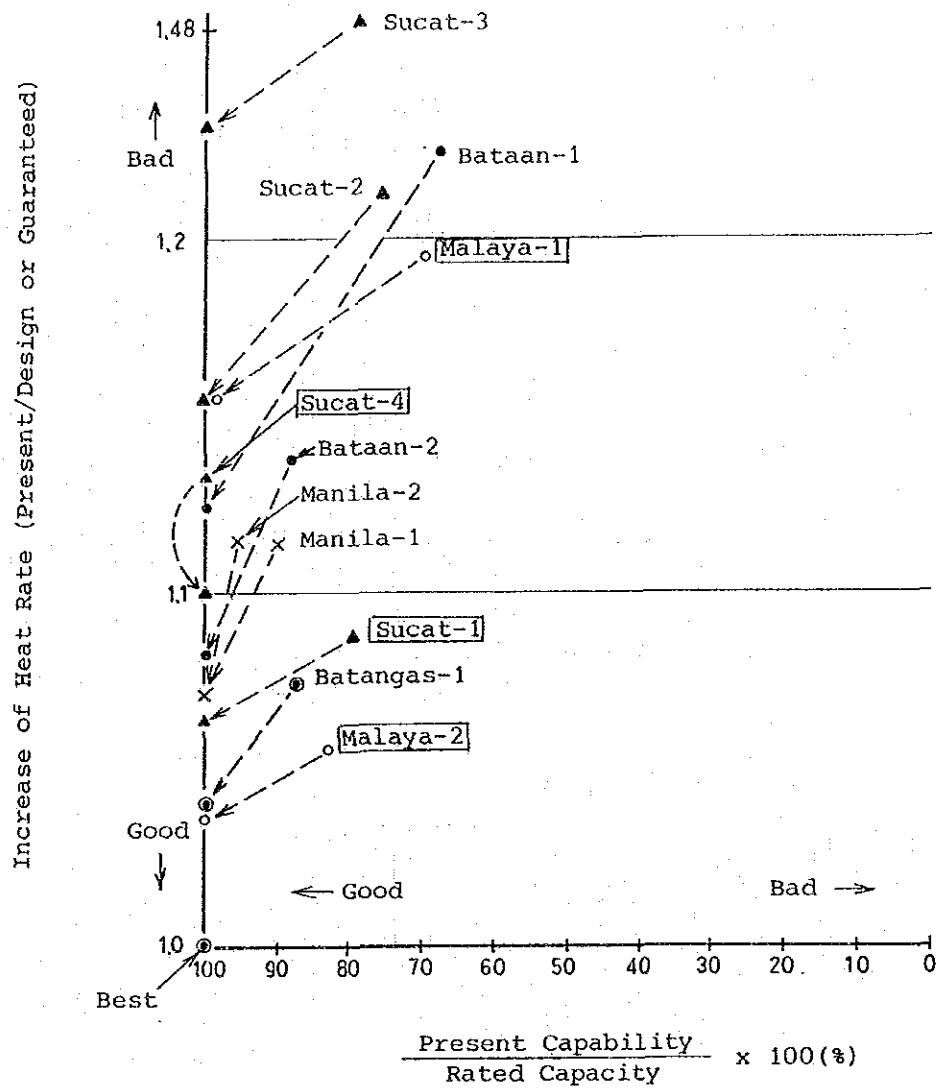


Fig. 6-1-3 Present Conditions of Thermal Power Plants
(Capacity and heat rate)



Note: ▭ Rehabilitated unit

●<--- Heat rate after overhaul (Predicted)

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

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

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

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

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

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

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

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

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

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

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

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

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

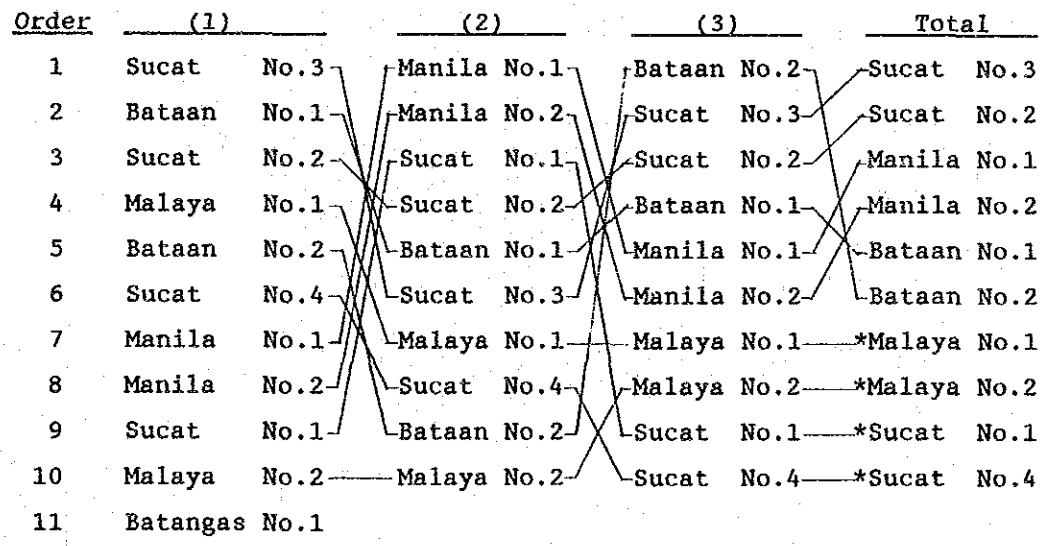
. The following three elements were evaluated in summarizing the present status of the power plant units microscopically. For the final judgment, other factors such as the specific deteriorated conditions of the major equipment of the respective units should be considered as well.

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

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

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

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



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

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

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

3. Problems of Thermal Power Plant Units and Countermeasures

(1) Causes of Reduced Output and Countermeasures

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

(2) Problems with Equipment and Countermeasures

The problems with the equipment in the power plant units and the countermeasures are shown in Tables 6-1-5 - 6-1-11.

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

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

Plant	Unit	Table	Major Problems					
			T	B	E	IC	M	Total
Bataan	No. 1	6-1- 5	10	15	17	12	3	57
	No. 2	6-1- 6	11	11	8	13	3	46
Manila	No. 1	6-1- 7	8	16	9	14	5	52
	No. 2	6-1- 7	8	16	9	14	5	52
Sucat	No. 1	6-1- 8	2	1	-	-	-	3
	No. 2	6-1- 8	9	19	10	39	8	85
	No. 3	6-1- 8	10	18	9	39	8	84
	No. 4	6-1- 8	3	2	2	1	-	8
Malaya	No. 1	6-1- 9	6	5	4	11	2	28
	No. 2	6-1-10	5	5	2	10	2	24
Batangas	No. 1	6-1-11	4	22	3	-	-	29

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

Table 6-1-4 Rated Capacity VS Present Capability

(As of Nov. 1991)

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

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

* Capability prior to overhauling

Table 6-1-5 Problem and Basic Countermeasure

Plant : Bataan Unit No. 1 (1/5)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	HIP Turbine Rotor - Aged deterioration	. Non-destructive inspection to confirm the reliability and remaining life	1	o	
2	LP Turbine Rotor - Aged deterioration	. Non-destructive inspection to confirm the reliability and remaining life	1	o	
3	Condenser Tubes Leaking	. Complete replacement of condenser tubes			o 1993
4	HP #1 Feed Water Heater Leaking	. Complete replacement of HP #1 feed water heater	1	o	
5	HP #2 Feed Water Heater Leaking	. Complete replacement of HP #2 feed water heater			o 1996
6	Deaerator Tray	. Replacement of tray			o 1993
7	Boiler Feed Pump - Water emulsifies with oil passing through bearing standby period - Pump does not build-up pressure	. Replacement of pump rotor with floating mechanical seal . Replacement of hydraulic coupling	1	o	
8	Circulating Water Pump - Aged deterioration	. Replacement of circulating water pump parts	1	o	
9	HSCC Heat Exchanger - Heat exchanger leaking - Pump vibration	. Replacement of - Heat exchanger tubes - Pump shaft and impeller - Butterfly valves	1	o	
10	Intake Marine Pipe - Intake steel pipe is corroded. - Common used for No. 1 and No. 2 units	. Additional installation of marine pipes Length: 2.4 mø x 500 m - 2 lines	1	o	

Note: T = Turbine, B = Boiler, E = Elect. Equip, IC = Instrument/Control, M = Misc. and Chemical
Prty = Priority, Reh = Rehabilitation, OH = Overhaul

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Boiler and Boiler Auxiliary Equipment				
B1	Boiler Pressure Part - Aged deterioration	. Overhaul, inspection of remaining - Boiler drum, header, furnace wall tubes, economizer tubes, SH tubes, RH tubes	1	o	
2	Secondary SH Tubes - Deterioration of tubes	. Complete replacement of secondary SH tubes	1	o	
3	Reheater Tubes - Deterioration of tubes	. Complete replacement of reheater tubes	1	o	
4	SH and RH Attemperator Spray Nozzles	. Replacement of spray nozzles	1	o	
5	Safety Valves for Drum, SH, RH	. Replacement/overhaul of safety valves			o 1993
6	Boiler Casing - Aged deterioration and leaking	. Replacement/repair of boiler casing	1	o	
7	Gas and Air Ducts - Aged deterioration and leaking	. Replacement/repair of gas and air ducts	1	o	
8	Gas and Air Duct Expansion Joints - Leaking & corrosion	. Replacement of gas and air duct expansion joints			o
9	Gas and Air Duct Dampers - Sticking & corrosion	. Replacement/repair of gas and air duct dampers			o
10	Fuel Oil Firing System	. Replacement/repair of FO burners, ignitors, FO tanks, FO pumps, FO heaters, etc.	1	o	
11	Sootblower - Aged deterioration	. Replacement of the existing sootblowers with new type	1	o	
12	Smoke stack	. Inspection and repair of smoke stack			o
13	Steam Coil Air Heater - Aged deterioration	. Replacement of existing SCAH with new ones	1	o	
14	Air Preheater - Fire inside the rotor 2 times in 1990 and low temp. part in bad alignment.	. Complete replacement of heating elements, seals, diaphragms and others	1	o	
15	Insulation and refractory - Aged deterioration	. Replacement/repair of insulation and refractory	1	o	

Plant : Bataan Unit No. 1 (3/5)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Electrical Equipment				
E1	Generator Stator Coil - Aged deterioration	. Replacement of stator coil	1	o	
2	Generator Rotor - Aged deterioration	. Replacement of rotor with new rotor	1	o	
3	Generator Stator Terminal Board - Aged deterioration	. Replacement of terminal board with new type	1	o	
4	Generator Lead Bushing - Aged deterioration	. Replacement of lead bushing with dry type condenser bushing	1	o	
5	Generator Brush Holder	. Improvement of slip ring brush holder with cartridge type	1	o	
6	Seal Oil Vacuum Pump - Vacuum pump overheat and oil leakage	. Replacement of seal oil vacuum pump	1	o	
7	Generator H2 Gas Dryer - Aged deterioration	. Replacement of H2 gas dryer	1	o	
8	Generator Gas Supply System - Aged deterioration	. Replacement of H2 and CO2 gas supply system	1	o	
9	Generator AVR - Aged deterioration	. Replacement of AVR from magnetic amplifier type to thyristor type AVR	1	o	
10	15 kV Cable - Aged deterioration	. Replacement of 15 kV cable and pothead for Gen. bus to Unit Aux. Tr.	1	o	
11	69 kV Switchyard Equipment - Deterioration of ACB and OCB	. Replacement of 69 kV switchyard equipment - 69 kV Gas circuit breaker, 10 sets	1	o	
12	Lightning Arrester - Aged deterioration	. Replacement of 69 kV and 230 kV LA			o
13	4,160 V Switchgear - Aged deterioration of ASGEN's latch	. Replacement of 3 sets with VCB			o 1993
14	480 V Power Center - Corrosion of terminal board and relay due to HCl pipe leakage	. Replacement of corroded terminal, wire and relay			o 1993
15	UPS (Uninterruptible Power System)	. Replacement of MG set with UPS			o
16	Substation Air Compressor	. Replacement of air compressor ATLAS: 1 set			o 1992
17	Communication Facilities	. Additional installation and improvement of communication facilities			o

No.	Problem	Basic Countermeasure	Prty	Reh	OH
IC	Instrument and Control				
1	Drum Water Level Gauge and Indicator - Out of order	. Replacement of drum water level gauge and remote indicator			o
2	Furnace Monitoring TV	. Replacement of furnace monitoring TV			o
3	Smoke Monitoring TV	. Installation of smoke monitoring TV			o
4	Furnace Gas Temperature Measurement	. Replacement of furnace gas temperature measuring equipment			o
5	Generator H2 Purity Meter	. Replacement of generator H2 purity meter			o 1993
6	Automatic Boiler Control - Obsolete, no more spare parts	. Replacement/modification of boiler control system - Pneumatic control into digital control system	1	o	
7	Flue Gas O2 Meter - Out of order and no spare parts due to old type	. Replacement of the existing meter with new type	1	o	
8	Chemical Monitoring Instrument	. Replacement of chemical monitoring instrument - pH, Conductivity, instrument for Demi-plant			o 1993
9	Fuel Oil Flow Meter - Out of order - Aged deterioration	. Replacement of the existing meter with new type	2	o	
10	Turbine Supervisory Instruments - Aged deterioration	. Replacement of turbine supervisory instruments with new model	1	o	
11	Control Room Board Recorders - Aged deterioration - No spare parts due to old type	. Replacement of control room board recorders with new model	1	o	
12	Local Control System - Aged deterioration	. Replacement of local control system - Steam temp. control - SCAH control - FO flow control, FO heater control - FDF air flow contorl - Sootblower steam press. control - Deaerator water level control - Condenser level control - HP, LP Heater level control	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Miscellaneous and Chemical Equipment				
M1	Elevator - Out of order and obsolete	. Replacement of elevator			o
2	Control Room Air Conditioner - 3 sets of 10 sets are out of order (15 T)	. Overhauling/repair of air conditioner			o 1992
3	Oil Water Separator - Not existing	. Installation of new facilities			o 1992

Table 6-1-6 Problem and Basic Countermeasure

Plant : Bataan Unit No. 2 (1/5)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	HP Turbine Rotor, Blade, and Casing - Aged deterioration	. Non-destructive inspection to confirm the reliability and remaining life	1	o	
2	IP Turbine Rotor, Blade, and Casing - Aged deterioration	. Non-destructive inspection to confirm the reliability and remaining life	1	o	
3	LP Turbine Rotor, Blade - Aged deterioration	. Non-destructive inspection to confirm the reliability and remaining life	1	o	
4	Turbine Bearing	. Replacement of #2 bearing bush	1	o	
5	Turbine Main Valves (MSV/MCV & RSV/ICV) - Aged deterioration	. Non-destructive inspection to confirm the reliability and remaining life . Replacement of main valve parts	1	o	
6	Turbine Control and Protection Device	. Replacement of electrical parts for EH Governor	1	o	
7	Condenser Tubes Leaking	. Complete replacement of condenser tubes			o 1993
7A	Condenser, no device for backwashing the tubes	. Installation of on-line tube cleaning and debris filter system			o 1993
8	CWP Outlet Valve - Actuator driven by oil piston	. Modification of actuator from oil piston type to motor-operated type			o
9	BFP Outlet Valve - Packing gland leaking	. Replacement of BFP outlet valve (Motor-operated type)	1	o	
10	HSCC Heat Exchanger - 2 pumps & 2 heat exchangers have to be operated in summer	. Installation of additional plate type heat exchanger for No. 1 and 2 units			o
11	Circulating Water Pump - Aged deterioration	. Replacement of circulating water pump parts	1	o	

Note: T = Turbine, B = Boiler, E = Elect. Equip, IC = Instrument/Control, M = Misc. and Chemical
Prty = Priority, Reh = Rehabilitation, OH = Overhaul

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Boiler and Boiler Auxiliary Equipment				
B1	Boiler Pressure Part - Aged deterioration	. Overhaul, inspection of - Boiler drum, header, furnace wall tubes, SH tubes, RH tubes	1	o	
2	Secondary SH Tubes - Deterioration of tubes	. Complete replacement of secondary SH panels	1	o	
3	Reheater Tubes - Deterioration of tubes	. Complete replacement of reheater panels	1	o	
4	SH Attemperator Spray Nozzles	. Replacement of spray nozzles	1	o	
5	Safety Valves for Drum, SH, RH	. Replacement/overhaul of safety valves			o
6	Boiler Casing - Aged deterioration and leaking	. Replacement/repair of boiler casing including insulation and refractory	1	o	
7	Gas and Air Ducts - Aged deterioration and leaking	. Replacement/repair of gas and air ducts including expansion joints and dampers	1	o	
8	Fuel Oil Firing System	. Replacement/repair of FO burners, torchs, FO pumps, FO heaters, FO tanks, etc.	1	o	
9	Sootblower - Aged deterioration	. Replacement of the existing sootblowers with new type	1	o	
10	Gas Recirculation Fan - Bearing damaged - Bearing cooling system defective design - Rotor and shaft sealing insufficient	. Improvement of bearing cooling system and sealing system			o
11	Air Preheater - Erosion/corrosion of elements and parts - Guide bearing is overheating.	. Replacement of heating elements, rotor seal plates, and guide bearings	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Electrical Equipment				
E1	Generator Stator Coil - Aged deterioration	. Replacement of stator coil	1	o	
2	Generator Rotor	. Replacement of rotor with new rotor	1	o	
3	Generator Bearing	. Replacement of generator bearing metal	1	o	
4	Generator Gas Supply System - Aged deterioration	. Replacement of H2 and CO2 gas supply system	1	o	
5	Generator AVR - Aged deterioration	. Replacement of generator AVR with new model	1	o	
6	AOP Motor	. Rewinding of AOP motor	1	o	
7	230 kV Switchyard Equipment - Deterioration of ACB and OCB	. Replacement of 230 kV switchyard equipment - 230 kV Gas circuit breaker, 5 sets	1	o	
8	Lightning Arrester - Aged deterioration	. Replacement of LA - MT 2A & MT 2B of 230 kV switchyard	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Instrument and Control				
IC					
1	Drum Water Level Gauge and Indicator - Out of order	. Replacement of drum water level gauge and remote indicator			o 1992
2	Furnace Monitoring TV	. Replacement of furnace monitoring TV			o
3	Smoke Monitoring TV	. Installation of smoke monitoring TV			o
4	Furnace Gas Temperature Measurement	. Replacement of furnace gas temperature measuring equipment			o
5	Generator H2 Purity Meter	. Replacement of generator H2 purity meter	1	o	
6	Generator H2 Gas Control Panel	. Replacement of H2 gas control panel including switches and instruments	1	o	
7	Automatic Boiler Control - Obsolete, no more spare parts	. Replacement/modification of boiler control system - Electrical control into digital control system	1	o	
8	Flue Gas O2 Meter - Out of order and no spare parts due to old type	. Replacement of the existing meter with new type	1	o	
9	Chemical Monitoring Instruments - Out of order and obsolete	. Replacement of chemical monitoring instruments - Silica, pH, Conductivity meter			o 1993
10	Turbine Supervisory Instruments - Aged deterioration	. Replacement of turbine supervisory instruments with new model	1	o	
11	Light Oil Flow Meter - Aged deterioration	. Replacement of the existing meter with new type			o 1993
12	Control Room Board Recorders - Aged deterioration - No spare parts due to old type	. Replacement of control room board recorders with new model	1	o	
13	Alarm and Annunciator	. Modification of - First cause annunciator - Event sequence monitoring system	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Miscellaneous and Chemical Equipment				
M1	Elevator - Out of order and obsolete	. Replacement of elevator			o
2	Sampling Rack System - Aged deterioration	. Replacement of sampling rack system	1	o	
3	Hydrochloric Acid Tank (HCl Tank) - Aged deterioration	. Replacement of HCl tank for Demi-plant	1	o	

Table 6-1-7 Problem and Basic Countermeasure

Plant : Manila Unit No. 1 & 2 (1/5)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	HIP Turbine Rotor and Blades - Aged deterioration	.Replacement of HIP turbine rotor and blades	1	o	
2	HP, IP Turbine Inner-Casing - Aged deterioration	.Replacement of HP, IP turbine inner-casing	1	o	
3	Main Condenser Retubing - Air cooling zone ammonia attack	.Replacement of condenser tubes (No. 1 unit)	1	o	
3A	Condenser, no device for backwashing the tubes	.Installation of on-line tube cleaning and debris filter system			o 1993
4	Feed Water Heaters				
	. #3 LP Heater - Tube leaking	.Replacement of #3 LP heater (No. 2 Unit)	1	o	
	. #6 HP Heater - Tube leaking	.Replacement of #6 HP heater (No. 2 Unit)	1	o	
5	HSCC Heat Exchanger - Corrosion and poor heat transfer	.Replacement of HSCC heat exchanger	2	o	
6	Circulating Water Pump - Aging Errosion/corrosion	.Replacement of parts			o 1993
7	Travelling Screen	.Replacement/overhauling	1	o	
8	Valves, Pipes and Hangers				
	1) Hanger	.Inspection and adjustment	1	o	
	2) Valves	.Replacement - Turbine main stop valves	1	o	
	3) Piping	.Inspection and Repair - Main steam, RH steam - Condensate, FW - CWP line - HSCC line	1	o	
9	Condensate Water Pump				
	- Casing crack No. 1 A	.Replacement of pump			o
	- Casing crack No. 2 A	.Replacement of pump			o

Note: T = Turbine, B = Boiler, E = Elect. Equip, IC = Instrument/Control, M = Misc. and Chemical
Prty = Priority, Reh = Rehabilitation, OH = Overhaul

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Boiler and Boiler Auxiliary Equipment				
B1	High Pressure/Temperature Part of Boiler - Aged deterioration	1) Inspection and overhaul of drum	1	o	
		2) Inspection of waterwall tubes - Cutting of tube sample & inspection	1	o	
		3) Inspection of economizer tubes - Cutting of tube sample & inspection	1	o	
		4) Inspection of primary superheater tubes - Cutting of tube sample & inspection	1	o	
		5) Hydrostatic pressure test of boiler			o
2	Secondary Superheater - Aged deterioration	1) Replacement of 2nd. SH tubes (except SUS tube banks) and tube support 100%	1	o	
		2) Inspection of 2nd. SH tubes			o
3	Reheater - Aged deterioration	1) Replacement of reheater tubes (inlet bank only) and tube supports 100%	1	o	
		2) Inspection of reheater tubes			o
4	Gas and Air Ducts	. Repair/replacement of gas and air ducts	1	o	
5	Gas Duct Dampers - Very bad condition	1) Replacement 11 sets	1	o	
		2) Repair others	1	o	
6	Gas and Air Duct Expansion Joints - Leakage & corrosion	. Replacement all sets	1	o	
7	SH and RH Attemperator Spray Nozzles	. Replacement of spray nozzles	1	o	
8	Fuel Oil Firing System	. Replacement/repair of FO burners, FO heaters, FO pumps	1	o	
9	Air Preheater - Erosion/corrosion of cold end element and seal	. Replacement of cold end element and seals	1	o	
10	SCAH - Not installed	. Additional installation of SCAH (No. 1 & No. 2 Units)	1	o	
11	Sootblower - Reliabilty down with sticky motion	. Overhauling of retractable soot blowers	1	o	
12	FDF and Air Duct - Vibration	. Transfer/replacement of FDF and modification of air duct	1	o	
13	Smoke Stack - Damage of gunite lining	. Inspection and repair	2	o	
14	Dust Collector and Hoppers - Erosion/corrosion	. Repair/replacement of dust collector and hoppers	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
B15	Ash Handling System - Aged deterioration	.Modification/replacement of ash handling system	1	o	
16	Auxiliary Steam System - Aged deterioration	.Modification/replacement of auxiliary steam system	1	o	
	Electrical Equipement				
E1	Generator Rotor - Generator rotor winding insulation deteriorated	.Replacement of generator rotor	1	o	
2	Generator Stator - Generator stator winding insulation deteriorated	.Inspection of generator stator	1	o	
3	BFP Motor - Aged deterioration	.Rewinding	1	o	
4	CWP Motor - Aged deterioration	.Rewinding	1	o	
5	Condensate Water Pump Motor - Aged deterioration	.Rewinding for No. 1 unit 2 sets .Rewinding for No. 2 unit 2 sets	1 1	o o	
6	Power Cables - Aged deterioration	.Replacement of 4,160 V power cables	2	o	
7	Battery - Aged deterioration	.Replacement of battery			o 1993
8	4,160 V/480 V Transformer	.Replacement of 4,160 V/480 V transformer (From PCB oil to mineral oil)	2	o	
9	Communication Facilities	.Additional installation and improvement of communication facilities			o

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Instrument and Control				
IC 1	Automatic Boiler Control - Obsolete, no more spare parts	.Replacement/modification of boiler control system - Pneumatic control into micro processor control system	1	o	
2	Smoke Stack Monitiring TV	.Addition of smoke stack monitoring TV	1	o	
3	Flue Gas O2 Meter	.Replacement of flue gas O2 meter	1	o	
4	Turbine Aux. Level Controls	.Replacement/overhaul of level control for deaerator, condenser hotwell, feedwater heater drain and LTR drain	2	o	
5	Mercury Type Float, Temp. and Pressure Switches - No more spare parts due to obsoleteness	.Replacement of mercury type float, temp. and pressure switches	2	o	
6	Draft Gauges	.Total replacement of draft gauges	2	o	
7	Interlock Relay	.Addition of interlock relay	2	o	
8	Sootblower Control System	.Replacement of sootblower control system	2	o	
9	Control Room Board Recorders	.Replacement of control room board recorders	2	o	
10	Hydrogen Purity Meter	.Replacement of generator hydrogen purity meter	2	o	
11	Boiler Drum Level Gauge	.Installation of BAILEY boiler drum level gauge (Bi-color, YARWAY to be replaced)			o 1993
12	Checmical Monitoring Instruments	.Additional of chemical monitoring instruments	2	o	
13	Fuel Oil Flow Meter and Integrator	.Replacement of fuel oil flow meter and integrator			o 1993
14	Feedwater Control Valve	.Replacement of feedwater control valve			o 1993

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Miscellaneous and Chemical Equipment				
M1	Chemical Injection System - Aged deterioration	.Replacement of chemical injection system	1	o	
2	Screen Wash Pump - Aged deterioration	.Replacement of wash pump (3 sets) for travelling water screen	1	o	
3	Ventilation Fan - Aged deterioration	.Repair/overhaul of ventilation fans for boiler/turbine buildings	1	o	o
4	Boiler Building Roof	.Repair of waterproof for boiler building roof			o 1992
5	Sampling Rack System - Aged deterioration	.Replacement of sampling rack system	2	o	

Table 6-1-8 Problem and Basic Countermeasure

Plant : Sucat Unit No. 1 (1/10)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	Feed Water Heater - HPH #6 Tube leaking	.Replacement of tubes for HPH #6			o 1992
2	HSCC Heat Exchanger - Tube leaking	.Replacement with plate type heat exchangers (2 sets)			o 1993
	Boiler and Boiler Auxiliary Equipment				
B1	Fuel Oil Heater - Tube leaking	.Replacement of fuel oil heaters (3 sets)			o 1993

Note: T = Turbine, B = Boiler, E = Elect. Equip, IC = Instrument/Control,
M = Misc. and Chemical
Prty = Priority, Reh = Rehabilitation, OH = Overhaul

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	HP Turbine Rotor and Blades - Aged deterioration	.Replacement of HP turbine rotor and blades	1	o	
2	IP Turbine Rotor and Blades - Aged deterioration	.Replacement of IP turbine rotor and blades	1	o	
3	HP and IP Turbine Inner Casing - Aged deterioration	.Replacement of HP and IP turbine inner casing	1	o	
4	LP Turbine Blades - Aged deterioration	.Reblading of LP turbine blades (No. 3 Unit)	1	o	
5	Main Steam Condenser - Tube leaking	.Retubing of main steam condenser (No. 2 Unit)			o 1991
		.Partial retubing of main steam condenser (No. 3 Unit)	1	o	
6	Air Ejector - Aged deterioration	.Replacement of air ejectors (2 sets for main condenser and 2 sets for auxiliary condenser)	1	o	
7	Condensate Pump	.Overhaul of condensate pumps			o
8	Circulating Water Pump	.Overhaul of circulating water pumps			o
9	Feed Water Heater and Drain Cooler - Tube leaking	.Replacement of feed water heater and drain cooler			
		- HPH #6A and #6B (No. 3 Unit)	1	o	
		- HPH #5A and #5B (No. 2 Unit)	1	o	
		- LPH #3 (No. 3 Unit)			o 1992
		- Drain cooler (No. 3 Unit)	1	o	
10	HSCC Heat Exchanger - Tube leaking	.Replacement of plate type heat exchanger (2 sets)(No. 2 Unit)	1	o	
		.Overhaul of plate type heat exchanger (No. 3 Unit)			o 1992

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Boiler and Boiler Auxiliary Equipment				
B1	Water Wall Tubes - Deterioration of tubes	.Replacement of all front and rear walls, side walls, burner zone panels, and corner tubes.	1	o	
2	Secondary SH Panels - Deterioration of tubes	.Replacement of 60 panels of secondary SH	1	o	
3	Pendant RH Panels - Deterioration of tubes	.Dismantling/removal of all pendant RH panels .Installation of new pendant RH panels	1	o	
4	SH and RH Attemperator Spray Nozzles	.Replacement of spray nozzles SH ... 2 pcs RH ... 1 pc	1	o	
5	Boiler Casing - Aged deterioration and leaking	.Replacement/repair of boiler casing	1	o	
6	Gas and Air Ducts - Aged deterioration and leaking	.Replacement/repair of gas and air ducts	1	o	
7	Boiler Bottom Ash Hopper - Aged deterioration	.Comprehensive repair of bottom ash hoppers	1	o	
8	Air Preheater - Erosion/corrosion of elements and parts	.Replacement of heating elements and parts	1	o	
9	Steam Coil Air Heater - Aged deterioration	.Replacement of existing SCAH with new ones	1	o	
10	Dust Collector and Ash Handling System - Aged deterioration	.Replacement of dust collector hoppers and ash handling system	1	o	
11	Gas Recriculation Fan	.Overhaul of gas recirculation fans			o
12	Forced Draft Fan	.Overhaul of forced draft fans			o
13	Motor Driven Boiler Feed Pump	.Overhaul of motor driven boiler feed pumps			o
14	Turbine Driven Boiler Feed Pump	.Overhaul of turbine driven boiler feed pumps			o
15	Sootblower System - Unreliable due to sticky motion	.Replacement/rehabilitation of sootblower system	1	o	
16	Fuel Oil Firing System and Fuel Oil Heater	.Replacement of fuel oil burners with the new design steam atomizing Y-jet burners .Replacement of fuel oil heaters (2 sets)	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
B17	Light Oil Firing System	.Modification of light oil firing system	1	o	
18	Smoke Stack - Damage of inner steel lining & insulation	.Rehabilitation of smoke stack (Common for Sucat 1 and Sucat 2)	1	o	
19	Boiler Piping	.Replacement of start-up bypass target pipes and supports .Modification of auxiliary steam system	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Electrical Equipment				
E1	Generator Stator and Rotor	.Overhaul of generator stator and rotor			o
2	Exciter and AVR	.Replacement of exciter and AVR - Brushless exciter to Static exciter (ABB) (No. 2 Unit)	1	o	
		.Repair of exciter (No. 3 Unit) - Replacement of AVR	1	o	
3	480 V Switchgear and MCC	.Overhaul of existing 480 V SWGR			o
		.Replacement of motor control centers with new ones - Turbine MCC - Boiler MCC - Station service MCC - Vent fan MCC (No. 3 Unit only) - Power receptacle panel	1	o	
		.Replacement of 480 V power cables	1	o	
4	4,160 V Motor	.Overhaul of all 4,160 V motors			o
5	4,160 V Power Cable	.Replacement of 4,160 V power cables - MBFP, FDF, P/C Tr	1	o	
6	CVCF	.Additional installation of CVCF	1	o	
7	Sootblower Electrical Control System	.Replacement of sootblower electrical control system	1	o	
8	Protective Relay	.Replacement of reverse power relay (No. 2 Unit only)	1	o	
9	115 kV Switchyard Equipment - Deterioration of DS and OCB	.Replacement of 115 kV switchyard equipment - 115 kV disconnecting switch, 2 sets - 115 kV gas circuit breaker, 2 sets	1	o	
10	Communication Facilities	.Additional installation and improvement of communication facilities			o

No.	Problem	Basic Countermeasure	Prty	Reh	OH
IC	Instrument and Control				
1	Auxiliary Steam System	. Modification of auxiliary steam system . Replacement of control valve	1	o	
2	SCAH Control System	. Replacement/modification of SCAH control system	1	o	
3	Fuel Oil Heater Control	. Replacement/modification of fuel oil heater control system	1	o	
4	Fuel Oil Control	. Replacement/modification of fuel oil control system - Fuel oil pressure control - Atomizing pressure/temperature control	1	o	
5	Fuel Oil Flow Meter and Integrator	. Replacement of fuel oil flow meter	1	o	
6	Light Oil Control	. Replacement/overhaul of light oil control system - Light oil pressure control - Ignitor control system	1	o	o
7	Control Air Back-up Valve	. Installation of control air back-up valve	1	o	
8	Dust Collector By-Pass Control	. Replacement of dust collector by-pass control system	1	o	
9	GRF Control System	. Replacement of GRF control system - GRF cooling and sealing air damper control - GRF outlet damper control - GRF inlet damper cotnrol	1	o	
10	FDF Control System	. Replacement of FDF control system - FDF flow control from Siemens motor type to Bailey pneumatic type - FDF cooling and sealing air damper control	1	o	
11	AH Gas Inlet Damper Control	. Replacement of AH gas inlet damper control from Siemens motor type to Bailey pneumatic type	1	o	
12	Automatic Boiler Control - Obsolete, no more spare parts	. Replacement/modification of automatic boiler control system with Bailey Network-90 for reliable operation	1	o	
13	Steam Temperature Control	. Replacement of steam temperature control system - SH and RH spray control valve - SH and RH spray shut-off valve	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
IC 14	Start-up By-Pass System	.Replacement of start-up by-pass system including transmitter, H/A station and control valve	1	o	
15	Boiler Metal Temp. Measurement	.Replacement of temperature rocorder and sensors	1	o	
16	Furnace Gas Temp. Measurement	.Replacement of probe tube and sensors	1	o	
17	Closed Circuit Television System	.Replacement of closed circuit television system for boiler furnace flame monitoring and smoke stack monitoring	1	o	
18	Sootblower Control System	.Replacement of sootblower steam pressure control and AH sootblower shut-off valve	1	o	
19	Flue Gas Oxygen Measurement	.Replacement of flue gas oxygen analyzer and recorder	1	o	
20	Deaerator Control System	.Replacement of deaerator control system - Deaerator pressure control - Deaerator storage tank level control	1	o	
21	Turbine Local Control System	.Replacement of turbine local control system - Hotwell level and condensate recirculation control - HPH #6A and #6B drain control - HPH #5A and #5B drain control - LPH #3 drain control - LPH #2 drain control - LPH #1 drain control - House service closed cycle cooling water control	1	o	
22	Low Temperature Cold Reheat Drainer	.Replacement of low temperature cold reheat drainer	1	o	
23	Sequence of Event Recorder	.Addition of sequence of event recorder (36 points)	1	o	
24	Condenser Recorder	.Addition of recorder for condensate make-up, condensate flow and vacuum measuring system	1	o	
25	Local Gauges	.Replacement of local gauges - Pressure gauge 103 + 33 pcs - Temp. gauge 63 + 19 pcs	1	o	
26	Mercury Type Float, Temp. and Press. Switches	.Replacement of mercury type float, temp. and press. switches	1	o	

Plant : Sucat Unit No. 2 & 3 (8/10)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
IC 27	Draft Gauge Indication	. Replacement of draft gauge indication with Bailey multi-pointer gauge type PG	1	o	
28	Interlock Relay	. Replacement/modification of interlock relay with new model	1	o	
29	Control Board Recorder	. Replacement of control board recorder for boiler air/gas, boiler steam/ water, condensate, feed water, T/G bearing and turbine metal casing temperature	1	o	
30	B/T Board Indicator and Transmitter	. Replacement of B/T board pressure/ temperature indicators and trans- mitters	1	o	
31	Alarm and Annunciator	. Addition of alarm and annunciator	1	o	
32	TBFP Recorder	. Replacement of TBFP recorder for bearing temperature and other operating parameters	1	o	
33	Turbine Hydraulic Control and Steam Seal Control	. Complete replacement of Electro- hydraulic (EHG) control system and steam seal control	1	o	
34	Turbine Supervisory Instruments	. Replacement of turbine supervisory instruments with new model	1	o	
35	Turbine Valve Position Indication	. Replacement of the position transducer for control valve and extraction valves including indicators	1	o	
36	Minimum Flow Valve for BFP	. Modification of minimum flow valve control system	1	o	
37	Hydrogen Purity Meter	. Replacement of hydrogen purity meter	1	o	
38	TBFP Hydraulic Control	. Replacement/overhaul of TBFP hydraulic control	1	o	
39	Turbine Wall Stress Evaluator	. Replacement of turbine wall stress evaluator with new hardware system	1	o	

Plant : Sucat Unit No. 2 & 3 (9/10)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Miscellaneous and Chemical Equipment				
M1	Chemical Feed System	. Replacement of chemical feed system	1	o	
2	Condensate Polishing Plant	. Replacement/overhaul of condensate polishing plant	1	o	o
3	Condensate Magnetic Filter	. Additional installation of condensate magnetic filter	1	o	
4	Flushing Lines	. Rehabilitation of preboiler flushing lines for start-up purpose of unit	1	o	
5	Demineralizing Plant	. Replacement/overhaul of existing demineralizing plant	1	o	o
6	New Demineralizing Plant	. Additional installation of new Organo demineralizing plant (54 t/h, 1 train)	1	o	
7	Sampling Rack	. Replacement of sampling rack	1	o	
8	Chemical Preservation System for Sucat 2 and 3	. Additional installation of boiler preservation system	1	o	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	LP Turbine Casing - Casing crack	. Replacement of LP turbine casing			o 1994
2	Deaerator	. Modification of deaerator from Siemens type to Tray type			o 1994
3	Raw Water Pump	. Replacement of raw water pump			o 1992
	Boiler and Boiler Auxiliary Equipment				
B1	Water Wall Tubes - Deterioration of tubes	. Replacement of boiler corner tubes			o 1992
2	FDF Suction Silencer	. Replacement of expansion joint			o 1994
	Electrical Equipment				
E1	CWP Motor - Aged deterioration	. Replacement of 4A CWP motor			o
2	115 kV Switchyard Equipment - Deterioration of OCB	. Replacement of 115 kV switchyard equipment - 115 kV gas circuit breaker, 2 sets (For generator CB)			o 1994
	Instrument and Control				
IC 1	Boiler Control Valve - Aged deterioration	. Replacement of boiler control valves (CV-107, CV-109, MV-1)			o 1994

Table 6-1-9 Problem and Basic Countermeasure

Plant : Malaya Unit No. 1 (1/5)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	IP Turbine Rotor - Many balancing weight	.Replacement of IP rotor			o 1993 (MO)
2	Aux. Condenser - Plugged tubes 6.18%	.Retubing (Replacement with tubes that are already available)			o 1992
3	Feed Water Heater . HPH #5A & 5B - Plugged tubes 1.96% for 5B . LPH#3 - Plugged tubes over 35%, bypass operation due to tube leaking	.Installation of strainer* along the extraction steam line to HPH #5A & #5B. * Fabricated by MEC. .Replacement of tubes* for HPH #5A & #5B and LPH #3. * Fabricated by MEC.			o 1992 o 1993
4	House Service Cooling Water Heat Exchanger - Tube leakage 9.46% with #A 10.64% with #B	.Replacement of #B cooling water heat exchanger with plate type heat exchanger (Additional) Note: 1) Existing H.S. cooling water heat exchangers #A and #B are tube type. 2) In the last 1991 overhaul, the new plate type heat exchanger was installed.			o 1993
5	Weak T-BFP Turbine Blades - Deterioration of blades	.Reblading of T-BFP turbine			o 1993
6	LP Turbine Rotor - Deterioration of blades	.Reblading of LP turbine rotor for generator side only			o 1993

Note: T = Turbine, B = Boiler, E = Elect. Equip, IC = Instrument/Control,
M = Misc. and Chemical
Prty = Priority, Reh = Rehabilitation, OH = Overhaul

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Boiler and Boiler Auxiliary Equipment				
B1	Air Preheater - Excessive corrosion of heating elements and parts	. Replacement of heating elements* and parts * Intermediate temperature elements fabricated by manufacturer: 1 lot . If found the fule oil additive was effective, no replacement of elements will be necessary in 1992.			o 1992 or 1993
2	Secondary SH Tubes - Sec. SH tube panels are misaligned	. Adjustment/realignment of tubes and panels. . Installation of tube-clamps			o 1992
3	Stack - Inner plate Lining is corroded	. Inspection and partinal repair			o 1993
4	Gas Duct - Gas duct is leaking due to excessive corrosion	. Modification of gas duct between boiler and stack, as same as NO.2 unit (Insulation inside the duct)			o 1993
5	Retractable Soot Blowers for Secondary SH - Not operable due to deterioration	. Replacement/repair of retractable soot blowers ... 2 sets			o 1993

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Electrical Equipment				
E1	Generator Stator - Core end temperature high (287 °F = 142 °C)	.Generator core end inspection by "ELCID" test to be done during the OH.			o 1992
		.Depending on the result of test by "ELCID", repair/replace of generator core end similar Sucat-4 will be evaluated.			o 1993
2	Exciter - Exciter failure, burned stator winding (2-times)	.Replacement of exciter from Brushless type to Static type (Refinement under ABB Contract)			o 1992
3	Emergency Diesel Generator - Obsolete, no more spare parts - Insufficient generating capacity	.Replacement of emergency diesel generator Existing 300 KW to 500-600 KW new one			o 1993 (MO)
4	Communication Facilities	.Additional installation and improvement of communication facilities			o

No.	Problem	Basic Countermeasure	Prty	Reh	OH
IC	Instrument and Control				
1	GRF Inlet/Outlet Damper Control - Pneumatic actuators are already old and spare parts are obsolete.	. Replacement with new type actuators			o 1993
2	Boiler Metal Temp. Measurement - Malfunction of sensors	. Replacement of defective sensors			o 1992
3	Control Air Compressor - Insufficient control air system	. Installation of additional control air compressor (ATLAS)			o 1992
4	Low Temp. Reheater Drain Control - Defective and used in manual only	. Improvement of hammering of pipes . Replacement of spare parts			o 1992
5	Boiler Metal Temp. Measurement - Recorder is obsolete and difficult to buy spare parts	. Replacement of existing old and obsolete recorder with new model. (Electronic type) . Replacement of defective sensors.			o 1993
6	Mercury Type; Float, Temp. and Press. Switch - Aged deterioration	. Replacement of defective switches with new model (Micro switch type)			o 1992
7	Control Room Board Recorder - Difficult to buy spare parts	. Replacement of existing old, obsolete model with new model. (Electronic type)			o 1993
8	Boiler/Turbine Board Indicator & Transmitter - Difficult to buy spare parts	. Replacement of existing old, obsolete model with new model. (Electronic type)			o 1993
9	Turbine valve Position Indicator - Transmitter is deteriorated	. Replacement of defective transmitter with new one; more durable one			o 1993
10	Air Conditioner for Control Room - Existing package type system is not enough.	. Replacement with redesigned centeralized air conditioning system.			o 1992
11	Manual Burner Firing System	. Modification of burner firing system to automatic operation at control room			o 1993

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Micellaneous and Chemical Equipment				
M1	Boiler Room Ventilation (Roof Fans) - Not operable due to deterioration - Difficult to do maintenance and repairing during operation of the boiler	.Modification/repair of ventilation facilities - Modification of ventilation penthouse : 6 sets - Removal of existing fans and motors : 6 sets - Installation of new ventilation fans and ducts : 6 sets			o 1992 or 1993 (MO)
2	Sewage Treatment Plant	.Rehabilitation of sewage treatment plant			o 1992

Table 6-1-10 Problem and Countermeasure

Plant : Malaya Unit No. 2 (1/4)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	HP Turbine Rotor - 6th. stage blades, cracked	.Replacement of 6th. stage blades. - 96 blades and 96 sets of shrouds of HP turbine, 6th stage.			o 1992
2	LP Turbine Rotor - 16 th. stage blades, cracked	.Replacement of 16th. stage blades. - 9 blades and 9 sets of shrouds of LP turbine, 16th. stage.			o 1992
3	Feed Water Heater . LPH #2 . LPH #3 - Plugged tubes - Cracked tubes at desuperheating zone	.Replacement of tubes.			o 1992
4	Cold Reheat Steam Line - A hanger is out of order	.Modification of hangers			o 1992
5	Raw Water Pump - Errosion of pump rotor/ casing due to deterioration	.Replacement with a new pump vertical type ... 1 set only			o 1992

Note: T = Turbine, B = Boiler, E = Elect. Equip, IC = Instrument/Control,
M = Misc. and Chemical
Prty = Priority, Reh = Rehabilitation, OH = Overhaul

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Boiler and Boiler Auxiliary Equipment				
B1	Water Wall Tubes - Deteriaration of tubes - Steam pressure derated from 169 kg/cm2 to 140 kg/cm2 to preclude tube failure forced outages	. Complete retubing of all front and rear walls, and partial retubing of side walls			o 1992
2	Secondary SH Tubes - Deterionation of tubes	. Partial replacement of thinned tubes			o 1992
3	Reheater Tubes - Deterioration of tubes	. Complete replacement of inlet coil			o 1992
4	Air Preheater - Excessive corrosion of heating elements and parts	. Replacement of heating elements* and parts * Intermediate temperature elements fabricated by MEC.: 1 lot			o 1992
5	Smoke Stack - Inner plate lining is corroded.	. Inspection and partial plate repair			o 1992
	Electrical Equipment				
E1	Generator Neutral Bushing - Neutral bushing heating	. Inspection/repair/replacement of generator neutral bushing			o 1992
2	Circulating Water Pump Motor - Pump vibration due to damaged cutless bearing	. Replacement of motor with the spare motor: 1 set			o 1992

No.	Problem	Basic Countermeasure	Prty	Reh	OH
IC	Instrument and Control				
1	Aux. Steam Control system - C.V. is not used, but bypassed in operation due to high press. drop.	. Replacement of control valve (C.V.)			o 1992
2	SCAH Control - C.V. response is sometimes slow; C.V. positioner is of old model.	. Replacement of control valve (C.V.) positioner.			o 1993
3	FDF Air Flow Control - Malfunction always happens in changing control mode from auto to manual. - No spare parts due to obsolete model.	. Replacement/modificaiton of control system; - Pneumatic to micro processor base control			o 1993
4	GRF Inlet/outlet Damper Control - Operable only in manual mode. - High vibration in auto mode.	. Replacement of control system or possible replacement of obsolete components			o 1993
5	Automatic Boiler Control - Slow response, and can not follows auto frequency control.	. Replacement/modification of boiler control system; - Pneumatic contorl into micro processor control system (NETWORK-90 system)			o 1993
6	Condenser Recorder - Some sensors are defective.	. Replacement of thermocouple, R.T.D and sensors.			o 1993
7	Boiler Metal Temp. Measurement - Recorder is obsolete and difficult to buy spare parts.	. Replacement of existing old and obsolete recorder with new model.			o 1993
8	Control Room Board Recorder - Difficult to buy spare parts.	. Replacement of old and obsolete model with new model.			o 1993
9	Boiler/Turbine Board Indicator & Transmitter - Difficult to buy spare parts.	. Replacement of existing old, obsolete ones with new model.			o 1993
10	Turbine Governor Control System	. Modification of turbine governor control system (Mechanical governor to Electro hydraulic governor)			o 1992

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Miscellaneous and Chemical Equipment				
M1	Chemical Injection System	. Installation of automatic chemical injection of boiler water system			o 1992
2	Sampling Rack - Aged deterioration	. Replacement of sampling rack			o 1992

Table 6-1-11 Problem and Basic Countermeasure

Plant : Batangas Unit No. 1 (1/4)

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Turbine and Turbine Auxiliary Equipment				
T1	Condenser Tubes - Tube leaking	.Total replacement of Al-Cu tubes .Replacement of failed titanium tubes			o 1992
2	Condenser Discharge Pipe - Damaged rubber lining - Corrosion of steel pipe	.Inspection and repair of condenser discharge pipe			o 1992
3	Condensate Pump - Low performance	.Replacement of pump parts			o 1992
4	Gantry Crane for CWP - Crashed by typhoon	.Reinstallation of the crane			o 1992

Note T = Turbine, B = Boiler, E = Elect. Equip, IC = Instrument/Control,
M = Misc. and Chemical
Prty = Priority, Reh = Rehabilitation, OH = Overhaul

No.	Problem	Basic Countermeasure	Prty	Reh	OH
	Boiler and Boiler Auxiliary Equipment				
B1	Primary SH Tubes - Sootblowing steam erodes tube wall.	. Inspection/testing of tubes wall thickness by ultrasonic thickness indicator (UTI) . Replacement of tubes, if found below allowable thickness			o 1992
2	Reheater Tubes - Sootblowing steam erodes tube wall.	. Inspection/testing of tubes wall thickness by UTI . Replacement of tubes, if found below allowable thickness			o 1992
3	Poor Performance of Mills - Wear of mill internal components, speed reducer bearing, burner shut-off valves, dampers, etc.	. Replacement/repair of worn out components . To conduct periodic inspection every 2,500--3,000 hrs.			o 1992
4	Coal Burners and Coal Conduits - Erosion by pulverized coal flow	. Replacement/repair of coal burners and coal conduits			o 1992
5	Gas and Air Ducts - Aged deterioration and leaking	. Replacement of gas and air ducts and expansion joints			o 1992
6	Air Preheater - Erosion and leaking	. Replacement/repair of heating elements and parts			o 1992
7	Primary Air Insufficient - AH and air ducts leaking	. Repair of AH and air ducts . Repair of mill, primary air fans, dampers, controls			o 1992
8	Sootblower - Several SB out of commission	. Repair/replacement of damaged parts			o 1992
9	Coal Silos Clogging - Sticky Semirara coal	. Final acceptance still pending . Under study by contractor	1	o 1990	
10	Transfer Tower Hopper Clogging - Sticky Semirara coal	. Provisional acceptance still pending . Still under discussion with contractor	1	o 1990	

No.	Problem	Basic Countermeasure	Prty	Reh	OH
B					
11	Spontaneous Combustion at Coal Stockyard - Semirara coal prone to spontaneous combustion due to high VCM moisture moisture	.Control of coal inventory at coal yard - Stock of pile height limited to 10 m			o
		.Compaction of coal stockpile - Two new bulldozers already delivered			
		.Use of heavy equipment to remove, transfer and cool hot coal at the stockyard			o
12	Conveyor System - Rapid deterioration of conveyor system components	.Replacement of all deteriorated system components and worn out conveyors			1992
13	Flying Dust at Coal Stockyard - Strong winds	.Installation of windbreak fence (No. 2 Unit construction stage)	1	o No2U	
14	Flooded Coal Yard during Heavy Downpour - Uncemented coal yard floor absorbs water. Coal saturated with water covers drainage canal making it difficult to restore water flow to the sedimentation pond.	.Cementing of all stockpipe floor and enlargement of drainage canals. Each 3 stockpile coal yard has an area of 50 x 250 meters. (Under study)			o
15	Transfer Tower Structure Deteriorated - Constant contact with coal and water	.Rehabilitation of transfer tower structure			o 1993
16	Boiler Feed Pump - Low performance	.Replacement of worn out pump components			o 1992
17	Station Service Air Compressor - Deterioration/breakdown of air compressor	.Repair of existing station service air compressor			o 1992
		.Additional installation of station service air compressor			
18	Pressure Blower for Transfer of Ash - Inadequate air	.Additional installation of new pressure blower			o
		.Overhaul of old pressure blower			o 1992
19	Ash Handling Plant - Erosion/corrosion of plant components	.Replacement/repair of worn out components			o 1992
20	Stacker and Reclaimer Rails	.Realignment of the rails			

No.	Problem	Basic Countermeasure	Prty	Reh	OH
B					
21	Stacker and Reclaimer Water Spray	. Installation of coal dust water spray			o 1991
22	Unloader Water Spray	. Installation of coal dust water spray			o 1991
	Electrical Equipment				
E1	Electrostatic Precipitator (EP) - Erosion/corrosion of parts	. Overhaul/repair of EP			o 1992
2	Sootblower Control system - PLC breakdown	. Repair of PLC (Programmable Logic Controller)			o
3	Communication Facilities	. Additional installation and improvement of communication facilities			o

Table 6-1-12 (1)

SUMMARY OF THERMAL POWER PLANT FACILITIES

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

Table 6-1-12 (2)

SUMMARY OF GASTURBINE POWER PLANT FACILITIES

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

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

1. Rehabilitation in Progress

NAPOCOR is now carrying out the rehabilitation of Sucat No. 2 and No. 3 units. The rehabilitation items are outlined in Table 6-1-8 and the execution period is scheduled as follows (Refer to the Fig. 6-1-5 Work Schedule):

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

For the following power plant units, the rehabilitation was completed:

Power plant unit	Rehabilitation period
Malaya No. 1	Nov. 7, 1986 - Oct. 19, 1987
Malaya No. 2	July 7, 1986 - Jan. 29, 1987
Sucat No. 1	July 16, 1989 - Jan. 26, 1990
Sucat No. 4	Oct. 1, 1989 - Dec. 3, 1990

2. Criteria for Selection of Rehabilitation Items

Rehabilitation items will be selected from the problems listed in Tables 6-1-5 - 6-1-11.

The selection criteria are as follows:

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

In this case, it is desirable to examine the remaining service life (service life is roughly 30 years according to past records) of the main equipment, such as boiler pressure parts, turbine generator proper, main transformer, and to match the life of rehabilitated equipment to the remaining life of the main equipment.

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

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

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

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

3. Effect or Purpose of Rehabilitation

Rehabilitation of the items selected pursuant to this criteria will certainly contribute to the solution of the aforementioned problems, and, consequently, the following effects will be realized:

(1) Restoration of full power plant output,

(2) Restoration or improvement of thermal efficiency,

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

(4) Restoration or improvement of operational reliability,

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

4. Selection of Rehabilitation Items

Table 6-1-5 ~ Table 6-1-11 show the results of selection (proposal) of the rehabilitation items, being divided into tasks to be performed during the rehabilitation project and those to be done during ordinary overhaul. The final selection of the rehabilitation items will be made in consideration of the rehabilitation costs, also.

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

(1) Pending Problems

There are 3 rehabilitation items with this unit as listed in Table 6-1-11. As all the items are the pending problems with the coal reclaiming and handling facilities, these 3 items are not taken up in the present rehabilitation program. Two of these are the problems pending with the improvement works already finished, and the remaining one is the countermeasure against flying dust at the coal stockyard, and it is advisable that this work be carried out in the construction works of No. 2 Unit in the future.

(2) Measure for Recovery of Rated Output

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

(3) Fundamental Countermeasure

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

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

6. Work Schedule in 5-year Master Plan

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

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

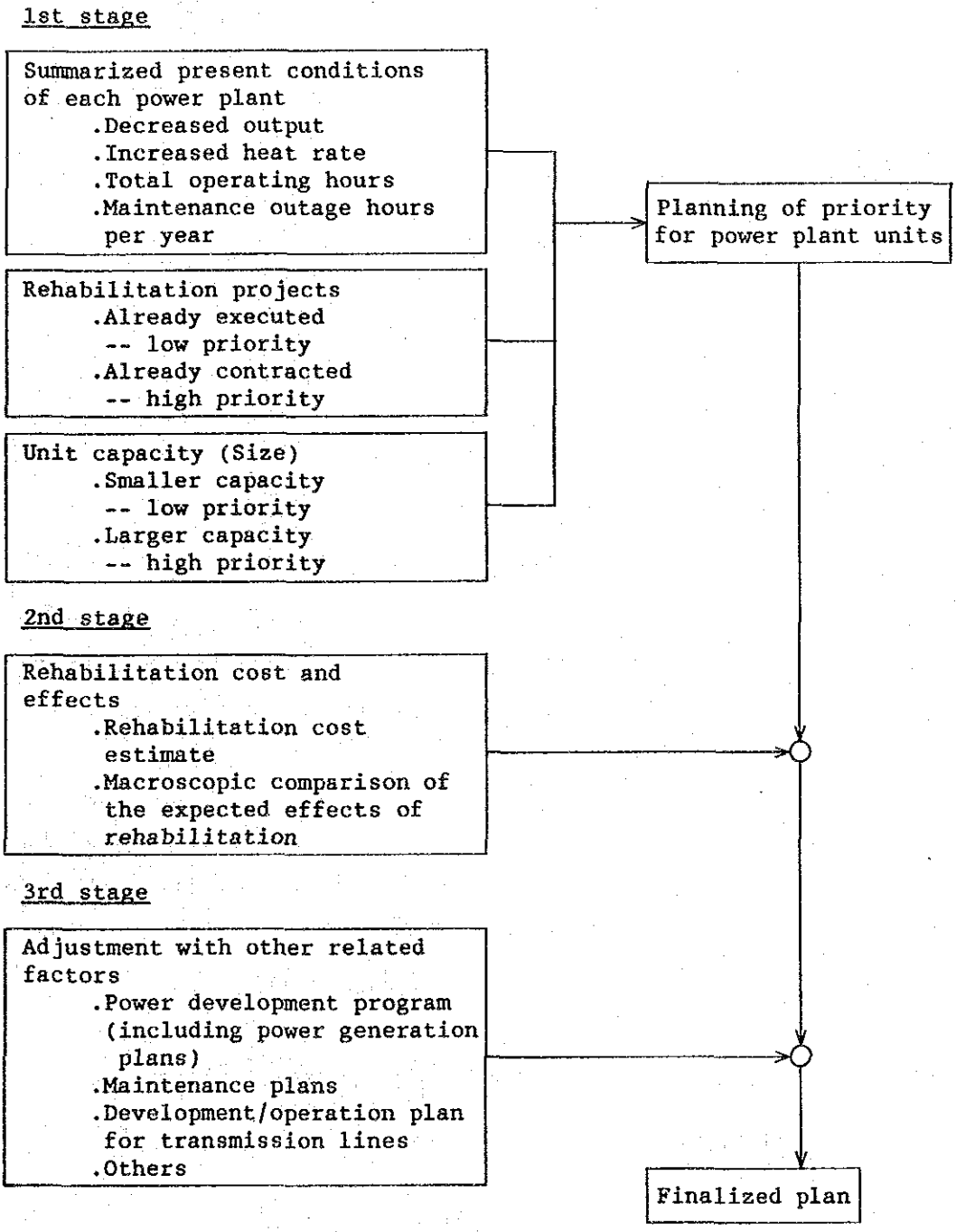
PLANT	UNIT	COMMISSIONING	RATED CAPACITY (MW)	1991	1992	1993	1994	1995	1996	1997
BATAAN	1	1972	75	⑲ 75 M.OH	⑳ INTAKE BASIN CLEANING	40 PO ㉑	40 PO ㉒	40 PO ㉓	㉔ (6M) REHAB	㉕ 50 INSP.AFTER REHAB
BATAAN	2	1977	150	PO ⑭ GEN. RP. GEN.RP.	⑮ INTAKE BASIN CLEANING	30 PO ⑯	30 PO ⑰	30 PO ⑱	⑲ PO (6M) REHAB	⑳
MALAYA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

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

6.1.3 Order of Priority for Rehabilitation

1. Method of Priority Evaluation for Power Plants and Units

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



2. Result of Evaluation Priority

(1) Result of 1st Stage Evaluation

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

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

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

(2) Result of 2nd Stage Evaluation

a. Rehabilitation Cost Estimate

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

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

[Reference]

Rehabilitation costs of the already implemented projects (rough figures) (including consultant fees)

Power plant unit	Rehabilitation cost (including consultant fees)	
Malaya No. 1	US$ 36,525 x 10^3	(¥ 9,131 x 10^6) (exch. rate ¥250/US$1)
Malaya No. 2	US$ 12,647 x 10^3	(¥ 3,162 x 10^6) (exch. rate ¥250/US$1)
Sucat No. 1	US$ 46,747 x 10^3	(¥ 6,077 x 10^6) (exch. rate ¥130/US$1)
Sucat No. 4	US$ 83,693 x 10^3	(¥10,880 x 10^6) (exch. rate ¥130/US$1)

(a) Method of Rehabilitation Cost Estimation

The rehabilitation cost per kWh for Manila No. 1 & No. 2 Units and Bataan No. 1 & No. 2 Units is roughly estimated in Fig. 6-1-6, which is prepared in the following manner:

(i) Divide the rehabilitation costs (including consultant fees) for the Sucat No. 1 & No. 4 Units by the projected annual average power generation in the three post-rehabilitation years (with 70% and 60% capacity factor) and, at thus obtained value (US$/kWh), draw a line parallel to the axis of abscissa . Also, divide the rehabilitation costs by output (MW), and, at thus obtained value (US$/MW), draw a line parallel to the axis of ordinates. Then plot and . mark at the point of intersection.

(ii) In the same manner, plot the values for Sucat No. 2 & 3 Units and Malaya No. 1 & No. 2 Units in the graph.

(iii) These points plotted in the graph are generally in a straight diagonal line.

. The rehabilitation of Sucat No. 1 & No. 4 Units were made simultaneously.

. Since there is an interval of 3 years between the rehabilitation of Sucat No. 1 & No. 4 Units and that of No. 2 & No. 3 Units, the rehabilitation costs for the latter two units are higher than those for the former two units.

. The rehabilitation costs per kWh for Malaya No. 1 & No. 2 Units are relatively low as these units were rehabilitated three years before Sucat No. 1 & No. 4 Units.

. The differences in rehabilitation costs between units rehabilitated at the same time are due to the differences in the project scopes.

(b) Rehabilitation Cost Estimate for Manila No. 1 & No. 2 Units

Rehabilitation of these two units will commence 2 - 3 years after Sucat No. 3 Unit, and consequently, the rehabilitation cost will fall on the extension of the line in Fig. 6-1-6. If the cost per kWh is assumed to be US$0.9 x 10^{-2}/kWh, the cost per MW would be US$550/MW, and the total rehabilitation cost for the 2 Units would amount to US$110,000 x 10^3.

Because they are approaching 30 years of use, Manila No. 1 & No. 2 Units rehabilitation must include major replacements of main equipment, which will raise the rehabilitation cost per kWh.

For an estimate for these two units, the results of the feasibility study (projected construction costs) were referred to as well.

(c) Rehabilitation Cost Estimates for Bataan No. 1 & No. 2 Units

The commencement of the rehabilitation of Bataan No. 1 Unit and No. 2 Unit is expected to be 4 years and 5 years respectively after Sucat No. 3 Unit.

Assuming that the scope of the work will be similar to the rehabilitation of Sucat No. 2 and No. 3 Units, and with adjustment made for the differences in the unit capacities, the costs were tentatively calculated in the following.

No. 1 Unit (75 MW):

Cost/MW adjustment : *1 US$460 x 10^3/MW x $(\frac{75}{200})^{3/4}$ ≃ US$220 x 10^3/MW

Cost/kWh adjustment : *2 $0.36 \times 10^{-2} \times (\frac{200}{75})^{3/4}$

$= 0.75 \times 10^{-2}$ US$/kwh

Rehabilitation projected cost escalation for future : $0.75 \times 10^{-2} \times (1 + 0.03)^4$ ≃ 0.84×10^{-2} US$/kWh

Cost/MW : US$500 x 10^3/MW

Grand total of rehabilitation costs : US$500 x 10^3/MW x 75 MW = <u>US$37,500 x 10^3</u>

No. 2 Unit (150 MW):

Cost/MW adjustment : US$460 x 10^3/MW x $(\frac{150}{200})^{3/4}$ ≃ US$371 x 10^3/MW

Cost/kWh adjustment : *3 $0.62 \times 10^{-2} \times (\frac{200}{150})^{3/4}$ ≃ 0.77×10^{-2} US$/kWh

Rehabilitation projected cost escalation for future : $0.77 \times 10^{-2} \times (1 + 0.03)^5$ = 0.89×10^{-2} US$/kWh

Cost/MW : US$530 x 10^3/MW

Grand total of rehabilitation costs : US$530 x 10^3/MW x 150 MW = <u>US$79,500 x 10^3</u>

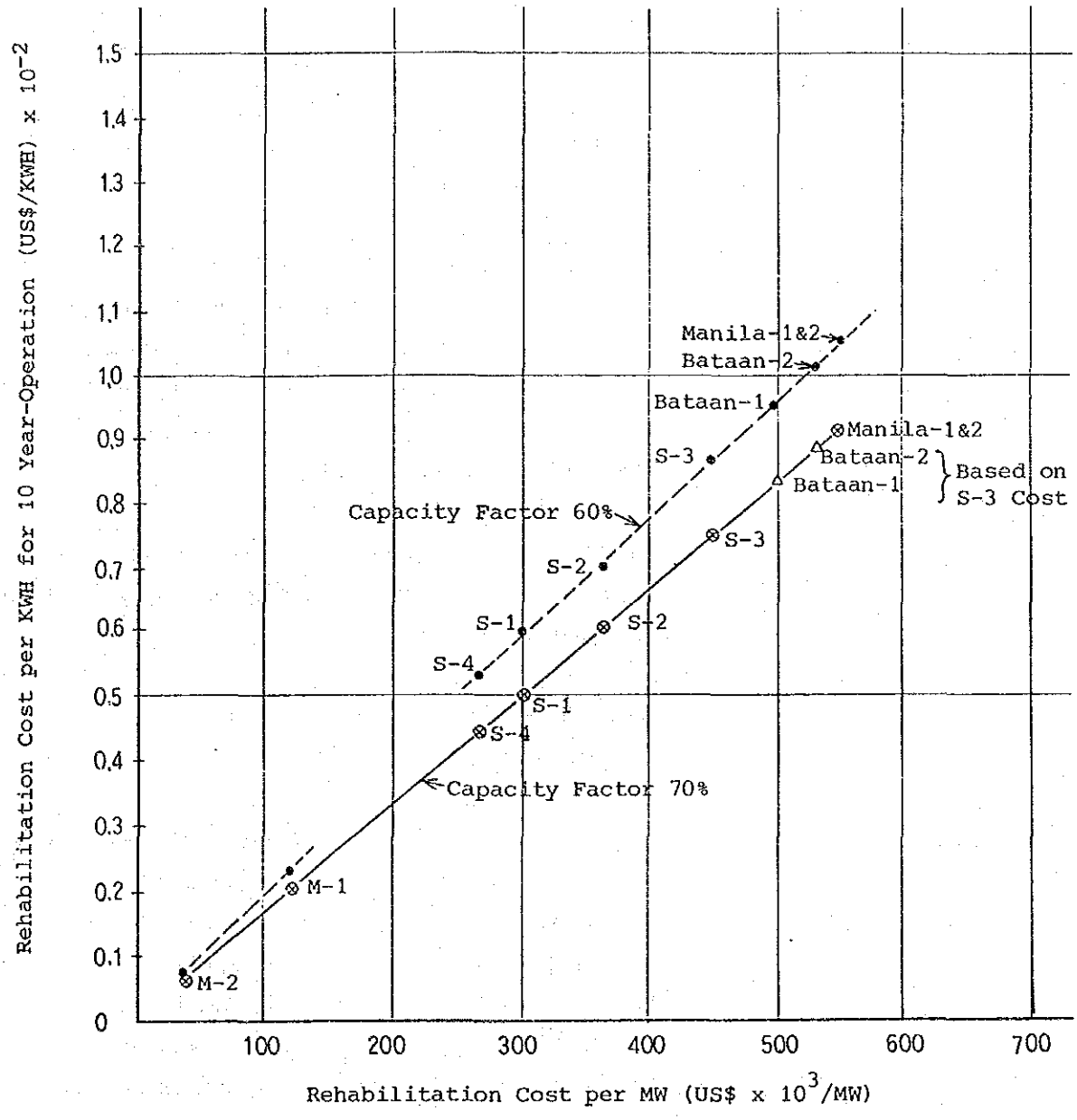
Note)

*1: US$460 x 10^3/MW is taken from the unit cost/MW of Sucat Unit No. 3 Rehabilitation

*2: 0.36 means cost/kWh against US$220 x 10^3/MW.

*3: 0.62 means cost/kWh against US$371 x 10^3/MW.

Fig. 6-1-6 Rehabilitation Cost Estimation



(Note) M-1, 2 : Malaya No. 1 & No. 2 Unit
S-1, 2, 3 & 4: Sucat No. 1 - No. 4 Unit

b. Macroscopic Comparison of Rehabilitation Effects

(a) Method of Macroscopic Comparison of Rehabilitation Effects

. As a result of rehabilitation, the plant efficiency will be restored. Such restoration is illustrated in Fig. 6-1-7.

By calculation of the balance between the estimated fuel savings obtained through the restored plant efficiency and the rehabilitation cost per kWh, a macroscopic comparison of the rehabilitation effects was attempted, and the results are given in Table 6-1-13.

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

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

c. Result of the 2nd Stage Evaluation

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

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

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

Fig. 6-1-7 Recovery of Efficiency by Rehabilitation or Overhaul
(June 1991)

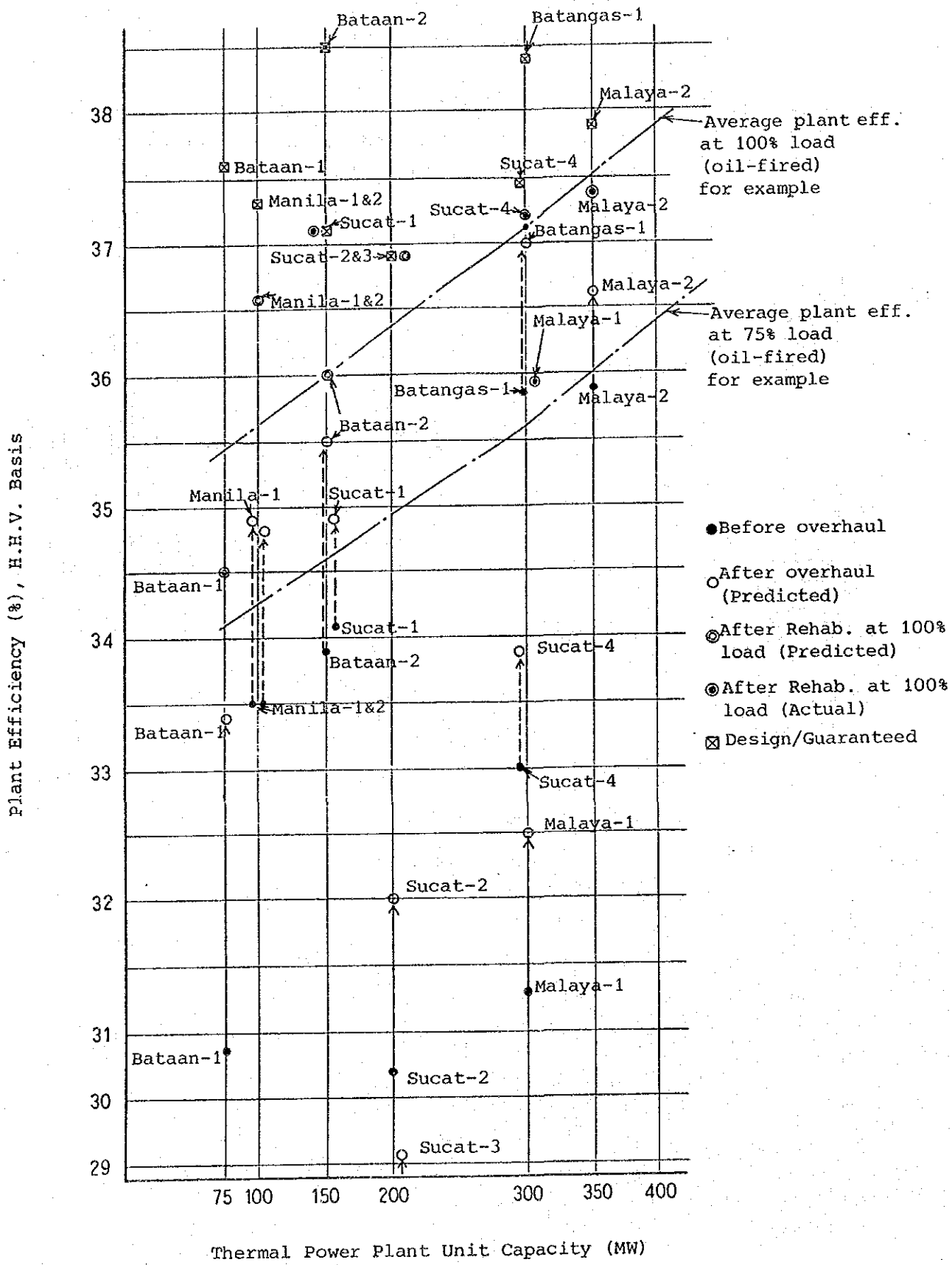


Table 6-1-13 Calculation of Improvement in Fuel Cost

Power Plant	Unit No.	Rated Cap. (MW)	Plant Efficiency η_P Before O/H a (%)	Plant Efficiency η_P After O/H b (%)	Plant Efficiency η_P After Rehab. c (%)	Calorific value of fuel (H.H.V.) Hh (Kcal/ℓ)	Fuel consumption $F=\frac{860}{d}$ (ℓ/kWh) Before O/H a′	Fuel consumption After O/H b′	Fuel consumption After Rehab. c′		Improvement in Fuel consumption e (ℓ/kWh) (b′or c′) − a′	Saving in Fuel Cost f (¥/kWh) ex Fuel Unit Price (¥18.87/ℓ)	Rehabilitation Effects Rehab. Cost D_2 − Saving in Fuel Cost. f (¥/kWh) ± 0 : Good − : Very good	Order
Bataan	1	75	30.7	33.4	34.5	10,190	0.275	0.253	0.2446	b′—a′ c′—a′	-0.022 -0.0304	0.415 0.574	1.06 − 0.415 = 0.645 1.06 − 0.574 = 0.486	3
Bataan	2	150	33.9	35.5	36.0	10,190	0.249	0.238	0.2344	b′—a′ c′—a′	-0.011 -0.0146	0.208 0.276	1.12 − 0.208 = 0.912 1.12 − 0.276 = 0.844	6
Manila	1	100	33.5	34.9	36.6	10,190	0.252	0.242	0.2306	b′—a′ c′—a′	-0.01 -0.0214	0.189 0.404	1.17 − 0.189 = 0.981 1.17 − 0.404 = 0.766	4
Manila	2	100	33.5	34.8	36.6	10,190	0.252	0.243	0.2306	b′—a′ c′—a′	-0.009 -0.0214	0.170 0.404	1.17 − 0.170 = 1.00 1.17 − 0.404 = 0.766	5
Sucat	1	150	34.1	34.9	*37.1	10,190	0.247	0.242	—	b′—a′	-0.005	0.094	0.66 − 0.094 = 0.566	
Sucat	2	200	30.4	32.0	36.9	10,190	0.2776	0.264	0.229	b′—a′ c′—a′	-0.0136 -0.0486	0.257 0.917	0.85 − 0.257 = 0.593 0.85 − 0.917 = -0.067	2
Sucat	3	200	24.9	29.1	36.9	10,190	0.339	0.290	0.229	b′—a′ c′—a′	-0.049 -0.11	0.925 2.075	1.06 − 0.925 = 0.135 1.06 − 2.075 = -1.015	1
Sucat	4	300	33.0	33.8	*37.2	10.190	0.2557	0.250	—	b′—a′	-0.0057	0.107	0.59 − 0.107 = 0.483	
Malaya	1	300	31.3	32.5	*35.9	10,190	0.2696	0.260	—	b′—a′	-0.0096	0.181	0.5 − 0.181 = 0.319	
Malaya	2	350	35.9	36.6	*37.4	10,190	0.235	0.2306	—	b′—a′	-0.0044	0.083	0.15 − 0.083 = 0.067	
Batangas	1	300	35.9	37.0	—	10,190	0.235	0.228	—	b′—a′	-0.007	0.132		

Note : Plant Efficiency Refer to Table 6-1-3

$$d=\frac{\eta_P}{100}\times Hh$$

* : Based on Acceptance Test after Rehabilitation

Fuel Unit Price
US$23/BL. ≒¥18.87 / ℓ

Table 6-1-14 Rehabilitation Cost per kWH

Power Plant	Unit No.	Rated Cap. (MW)	Rehabilitation Period (Actual months/contract Months)	Total Rehab. Cost A ¥ $\times 10^6$	Total Rehab. Cost A < ¥/Ex.Rate > US$ $\times 10^3$	Annual Ave. Energy Generation B (GWH/Year)	Capacity Factor (B/Rated capacity $\times 8760 \times 100$ (%))	Rehabilitation Cost D=Total Rehab. Cost A/(B$\times 10^6$) $\times$10Years D_1 (US$/kWH) $\times 10^{-2}$	Rehabilitation Cost D=Total Rehab. Cost A/(B$\times 10^6$) $\times$10Years D_2 (¥/kWH)
Malaya	1	300	NOV. 7,1986 ~OCT. 19,1987 (11.3/6.5 months)	(74.3%) ¥.8,913 *1 ¥.218 >	(¥.9,131$\times 10^6$/250) ≒US$.36,525	1988...1,884 1989...1,568 1990...2,106 } 1,853	$\frac{1,853}{2,628}\times 100$ ≒70 60	0.2 0.23	0.5 (¥250/US$1)
Malaya	2	350	JUL. 7,1986 ~JAN. 29,1987 (6.5 /7.0 months)	(25.7%) ¥.3,087 *1 ¥.75 >	(¥.3,162$\times 10^6$/250) ≒US$.12,647	1987...2,029 1988...2,122 1989...2,209 1990...2,197 } 2,139	$\frac{2,139}{3,066}\times 100$ ≒70 60	0.06 0.07	0.15
Sucat	1	150	JUL. 16,1989~JAN. 26,1990 (6.3/5.5 months)	(35.8%)) ¥.5,962 *1 ¥.115 >	(¥.6,077$\times 10^6$/130) ≒US$.46,747	1991... 920 1992... 935 1993... 894 } 916	$\frac{916}{1,314}\times 100$ ≒70 60	0.51 0.60	0.66(¥130/US$1) 0.77
Sucat	4	300	OCT. 1,1989~DEC. 3,1990 (14.1/8.0 months)	(64.2%)) ¥.10,674 *1 ¥.206 >	(¥.10,880$\times 10^6$/130) ≒US$.83,693	1991...2,078 1992...2,003 1993...2,066 } 2,049	$\frac{2,049}{2,628}\times 100$ 60 ≒78 70	0.525 0.41 0.45	0.68(¥130/US$1) 0.53 0.59
Sucat	2	200	MAY 1993 ~ APR. 1994 (—/10.5 months)	¥.10,500	US$74,468	1987~1990... 772 (44%) (4 Years) 1994~ ...1,226 (70%)	$\frac{1,226}{1,752}\times 100$ ≒70 60	0.6 0.7	0.85(¥141/US$1) 0.99
Sucat	3	200	JUL.1992 ~ MAY. 1993 (—/10.5 months)	¥.13,060	US$92,624	1986~1990... 679 (39%) (5 Years) 1993~ ...1,226 (70%)	$\frac{1,226}{1,752}\times 100$ ≒70 60	0.75 0.87	1.06 1.23
Bataan	1	75	Refer to Fig. 6-1-5 (6 months)		US$37,500	460	$\frac{460}{657}\times 100$ =70	0.815	1.06(¥130/US$1)
Bataan	2	150			US$79,500	394	$\frac{394}{657}\times 100$ =60	0.95	1.24
						920	$\frac{920}{1,314}\times 100$ =70	0.86	1.12
						788	$\frac{788}{1,314}\times 100$ =60	1.01	1.31
Manila	1	100	Refer to Fig. 6-1-5 (10 months)		Total US$110,000 for 2 units US$ 55,000 for 1 unit	613	$\frac{613}{876}\times 100$ =70	0.9	1.17(¥130/US$1)
Manila	2	100				525	$\frac{525}{876}\times 100$ =60	1.05	1.36

Note : *1 Consulant Fee was calculated by the proportional rate to the tortal rehabilitation cost after the example of Rehabilitation works for Malaya P.P.

Malaya (Total) ¥293,033. $\times 10^3$