JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

THE SOCIALIST REPUBLIC OF VIET NAM
THE MINISTRY OF ENERGY

FEASIBILTY STUDY
ON
REHABILITATION OF DA NHIM POWER SYSTEM
IN
THE SOCIALIST REPUBLIC OF VIET NAM

FINAL REPORT

JUNE 1995

NIPPON KOEI CO., LTD.
TOKYO, JAPAN

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PREFACE

In response to a request from the Government of the Socialist Republic of Viet Nam, the Government of Japan decided to conduct the Feasibility Study on Rehabilitation of Da Nhim Power System in Viet Nam and entrusted the study to Japan International Cooperation Agency (JICA).

JICA sent a study team led by Mr. Masatoshi Kanda of Nippon Koei Co., Ltd. to the Socialist Republic of Viet Nam three times from June 1994 to March 1995.

The team held discussions with the officials concerned of the Government of the Socialist Republic of Viet Nam, and conducted related field surveys. After returning to Japan, the team conducted further studies and compiled the final results in this report.

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

I wish to express my sincere appreciation to the officials concerned of the Government of the Socialist Republic of Viet Nam for their close cooperation throughout the study.

June 1995

Kimio Fujita
President
Japan International Cooperation Agency

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CHAPTER 1

INTRODUCTION

CHAPTER 1 INTRODUCTION

1.1 Background of the Study

The Da Nhim 230 kV power system consisting of the Da Nhim power station, Saigon substation and a 230 kV transmission line running between both stations was constructed under the reparations and financing of the Government of Japan (GOJ). The construction of the system commenced in 1960 and was completed in 1964.

Four units of 40 MW turbine and generator set were installed in the power station. The Saigon substation was installed with 7 units of 230 kV single-phase 28 MVA main transformer, 2 units of 19 MVar synchronous condensers, static condensers of 40 MVA in total, and other related facilities. The 230 kV transmission line 257 km in length connecting the power station and the substation was structured using Aluminium Conductor Steel Reinforced (ACSR) of a total 410 sq.mm, on 729 galvanized steel towers. The major purpose of the power system was to deliver energy generated at the Da Nhim power station to Ho Chi Minh City. Thereafter, Viet Nam constructed two midway 230 kV substations at Bao Loc and Long Binh between the Da Nhim power station and the Saigon substation for supplying electricity to the rural areas.

For supplying power generated by the Da Nhim power station to the towns of Phan Rang (Thap Cham substation) and Cam Ranh (Cam Ranh substation) on the east coast and the Dalat town (Dalat substation) in the northwest area of the Da Nhim power station, a 66 kV power system was constructed in 1974 under financial assistance from Japan.

After the conflict, Viet Nam extended the Da Nhim power system for delivering power from the Da Nhim power station. In 1989, a 66 kV transmission line system was constructed southwards from the Thap Cham substation to the Phan Thiet substation via the Phan Ri substation. Another 66 kV transmission system was extended from the Cam Ranh substation to a town north of it called Dien Khanh, in 1975. Furthermore, a 110 kV transmission line was completed in 1989, extending from the Da Nhim power station to the Nha Trang substation.

The Da Nhim 230 kV power facilities have been operating for over 30 years since it was commissioned. However, the condition of the facilities is declining because of tentative repairs to the damaged facilities, shortage of genuine spare parts, and insufficient testing apparatus. Despite these conditions, this system still plays an important role in providing the country with a stable power supply. The restoration and renovation of the facilities are now urgently required.

Power demand in the Cam Ranh, Phan Rang, Phan Ri, and Phan Thiet areas has increased rapidly, and reinforcement of the Da Nhim 66 kV power system is urgently required.

Regarding this situation, the Government of Viet Nam (GOV) requested GOJ to undertake the study for the rehabilitation of the facilities in the Da Nhim 230 kV power system and upgrade the existing 66 kV power system. GOJ sent Japan International Cooperation Agency's (JICA) preinvestigation team to Viet Nam in October 1993, in order to discuss the scope of the study to be undertaken by Japan and the facilitates to be extended by GOV to the Japanese Study Team.

The Study has been carried out in order to conduct a detailed investigation of the facilities, to formulate the specific plans for the rehabilitation and upgrade of the facilities agreed upon by both Governments, and to prepare the related reports for submitting to both Governments.

GOV will request GOJ to provide a loan for the implementation of the rehabilitation and upgrade of the power facilities. The Study, therefore, should include the preparation of documents in order to procure the necessary equipment and materials for immediate implementation, after the Study is completed.

1.2 Objective and Scope of the Study

1.2.1 Objective of the Study

During the 30 years after their commissioning, the Da Nhim dam and power station, the Saigon substation, the 230 kV transmission line and their incidental facilities have been operating despite the various problems which have arisen. Recently, many technical faults with the needle valves of the water turbines, turbine control gears, exciters, communitators, bearings, transformers, gates and penstocks, dam mechanical structures, and others in the Da Nhim power station, have occurred. Similar faults have been observed with facilities such as transformers, switch-gears, arresters, control boards, and panels, in the Saigon substation and the 230 kV transmission line facilities.

The existing 66 kV power facilities extending from the Da Nhim power station are deteriorating as a result of the insufficient capacity due to the rapid increase of power demand in the Thap Cham, Cam Ranh, Phan Ri, and Phan Thiet areas. Viet Nam intends to upgrade the voltage of the system in order to increase the transmission capacity of these facilities.

The major purpose of the Study is to formulate the optimum plan for the urgent and long term rehabilitation of the 230 kV power system and for the upgrade of the 66 kV transmission system extending from the Da Nhim power station. Another purpose of the Study was to transfer technology concerning various technical fields to the counterparts of the Study Team throughout the duration of the Study.

1.2.2 Scope of the Study

The study covers the following facilities for the Da Nhim power system:

(1) Da Nhim power station

Dam, headrace tunnels, tailrace, gates, penstocks, valves, turbines, generators, transformers, switchgear, control boards, hydrological data acquisition system, etc.

(2) Saigon substation and 230 kV transmission line

Substation equipment such as transformers, switchgear, rotary condensers, switchboards, control boards, and 230 kV transmission line between the Da Nhim power station and the Saigon substation.

(3) Existing 66 kV transmission lines and new substations

New substations to be located near the existing substations at Thap Cham, Phan Ri, Phan Thiet and Cam Ranh, and the existing 66 kV transmission lines connecting those substations with the Da Nhim power station.

It is noted that the Dien Khanh substation and 66 kV transmission line between Cam Ranh and Dien Khanh substation were added to the Study.

After the detailed examination to each facility and formulation of the rehabilitation and upgrade of the facilities, the formulated plan is economically and financially to be evaluated.

1.3 Outline of the Study

Figure 1.1 shows the flow chart of the Study. The Study was conducted in the following 7 stages:

(1) Preparatory study stage in Japan
(2) Field investigation stage
(3) First study stage in Japan (preparation of the Interim Report)
(4) Interim report stage in Viet Nam
(5) Second study stage in Japan (preparation of the Draft Final Report)
(6) Draft final report stage in Viet Nam
(7) Third study stage in Japan (preparation of the Final Report)

The specific works in each stage were as follows:

1.3.1 Preparatory Study Stage in Japan

Prior to the field investigation and study, the Study Team examined all the materials and information relating to the Project provided by JICA and in hand with the Study Team. On the basis of the examination, the Study Team prepared the detailed scope of the study, procedure of the plan formulation, establishment of work allocation and the work policy of each working group, study schedule, etc. The results of these examinations were summarized in the Inception Report and submitted to both Governments.

1.3.2 Field Investigation Stage

This investigation was achieved using the following 9 working groups classified in the technical speciality. The study schedule of these groups are summarized in Figure 1.2.

(1) Turbine group
(2) Generator group
(3) Waterway group
(4) Dam and civil group
(5) Hydrological data collection group
(6) Substation and switch-gear group
(7) 230 kV transmission line group
(8) System upgrade study group
(9) Socioeconomic and financial study group

The Study for the upgrade of the systems was covered by the (f) and (g) groups mentioned above.

Members of the Study Team visited Viet Nam in several parties. The first party arrived at Ho Chi Minh City on June 27, 1994. This party submitted and explained the Inception Report to PC-2 and the Ministry of Energy, and requested PC-2 to cooperate with the Study Team in the collection of the necessary records and information for the Project. Subsequently, the party arranged residence and vehicles for the Study Team, made the preparatory arrangements for the field investigation, received cargoes of equipment and materials for the field investigation, and conducted the prior study on the collected records and information. Two members of the Study Team visited Hanoi in order to report the arrival of the Study Team and scope of the study to the State Planning Committee, the Ministry of Energy, and the Japanese Embassy.

The second party of the Study Team arrived in Ho Chi Minh City on July 12, 1994, and immediately moved to Song Pha in order to implement the field investigation.

Each study group investigated its related facilities in the operative condition and under dewatering and deenergizing conditions. The results of the investigation are stated in the following Chapters.

1.3.3 First Study Stage in Japan

The Study Team examined and analyzed the results obtained through the field investigation stage immediately after returning to Japan. On the basis of the examination and analysis, the Study Team prepared the Interim Report regarding the recommendable rehabilitation and reinforcement plan for each facility.

1.3.4 Interim Report Stage in Viet Nam

Five members of the Team visited Viet Nam for around two weeks in November 1994 for submitting and explaining the Interim Report to the authorities concerned. During the period, the recommended rehabilitation and reinforcement plans were discussed between Vietnamese authorities and the Team. The results of the discussions are stated in the minutes of meeting compiled in the Annex to this report.

1.3.5 Second Study Stage in Japan

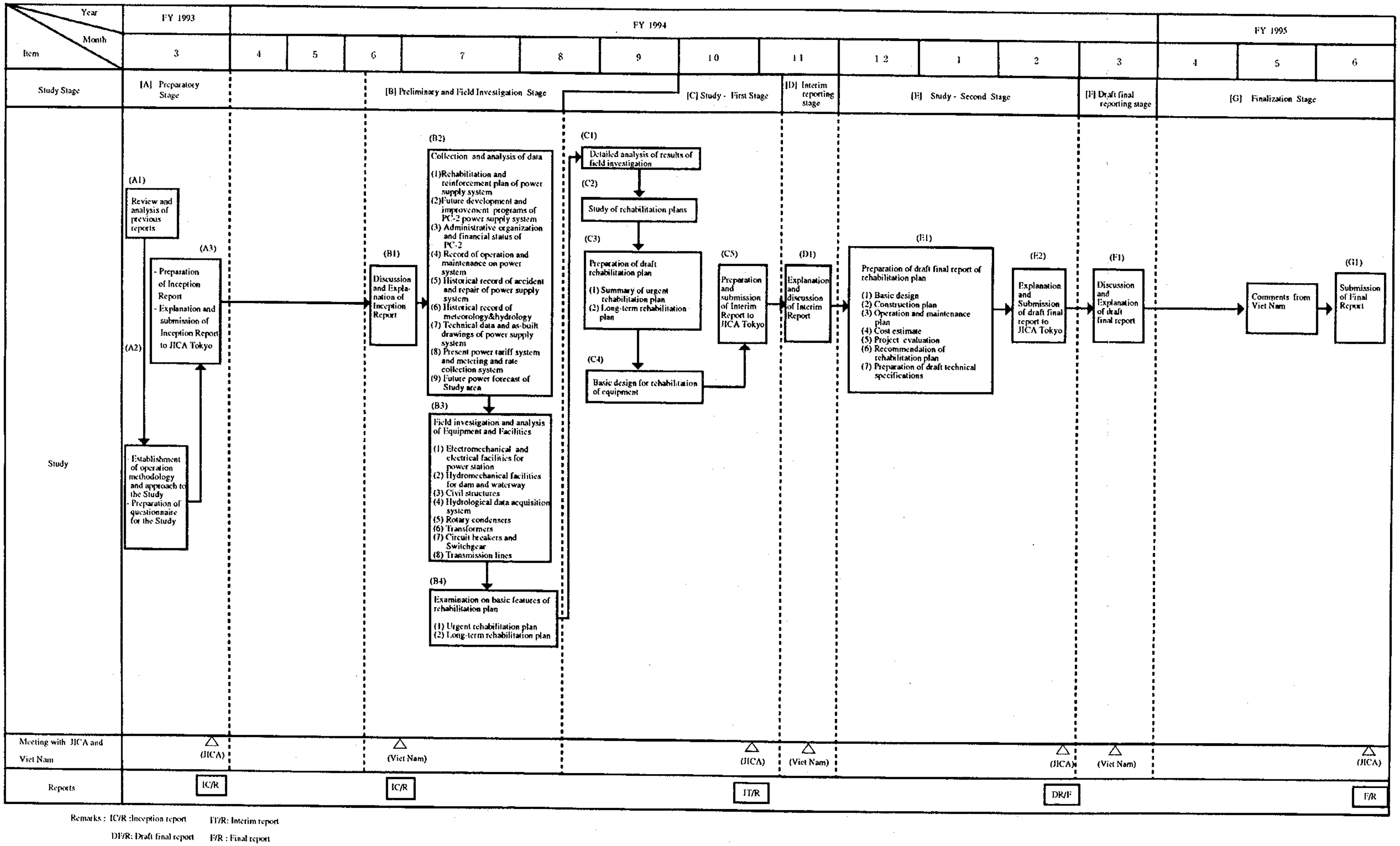
The Team continued its study to prepare a draft final report for the specific plans including the implementation program and the project cost estimate for rehabilitation and reinforcement of the existing facilities as well as for upgrading plan of the 66 kV facilities to 110 kV facilities. Items discussed during the interim report stage have been fully incorporated to the draft final report.

1.3.6 Draft Final Report Stage in Viet Nam

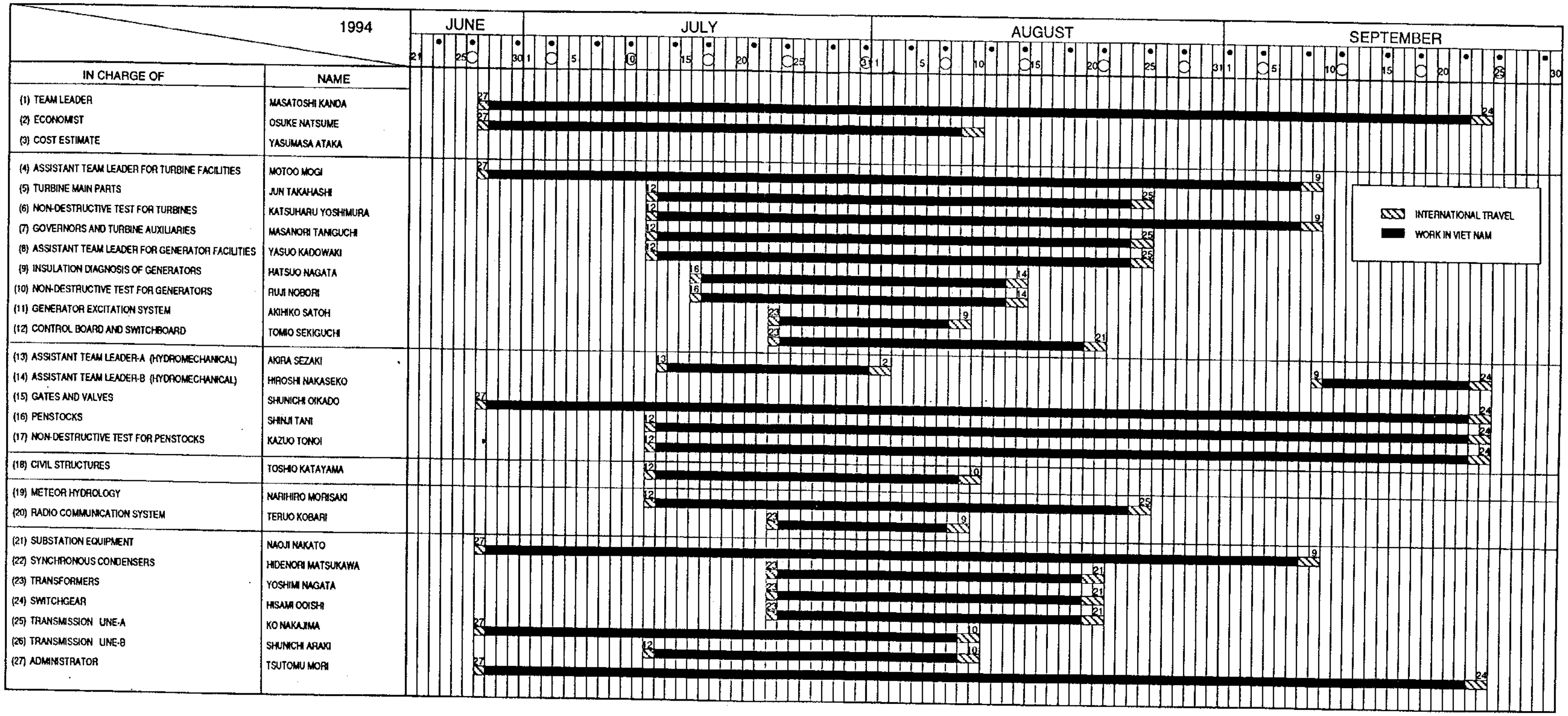
Four members of the Team visited Viet Nam for submitting and explaining the draft final report to the authorities concerned for about 2 weeks in March 1995. Through the discussions on the report, all the plans and programs concluded in the report were examined and discussed in detail among PC-2, PC-3, the Ministry of Energy and the Team.

1.3.7 Third Study Stage in Japan

On the basis of the final comments given by PC-2 and PC-3 during the end of May 1995, the Team prepared the final report and the technical documents for the materials and equipment required for implementing the concluded plans. The final report with its summary and technical documents were submitted to JICA head office in June 1995.

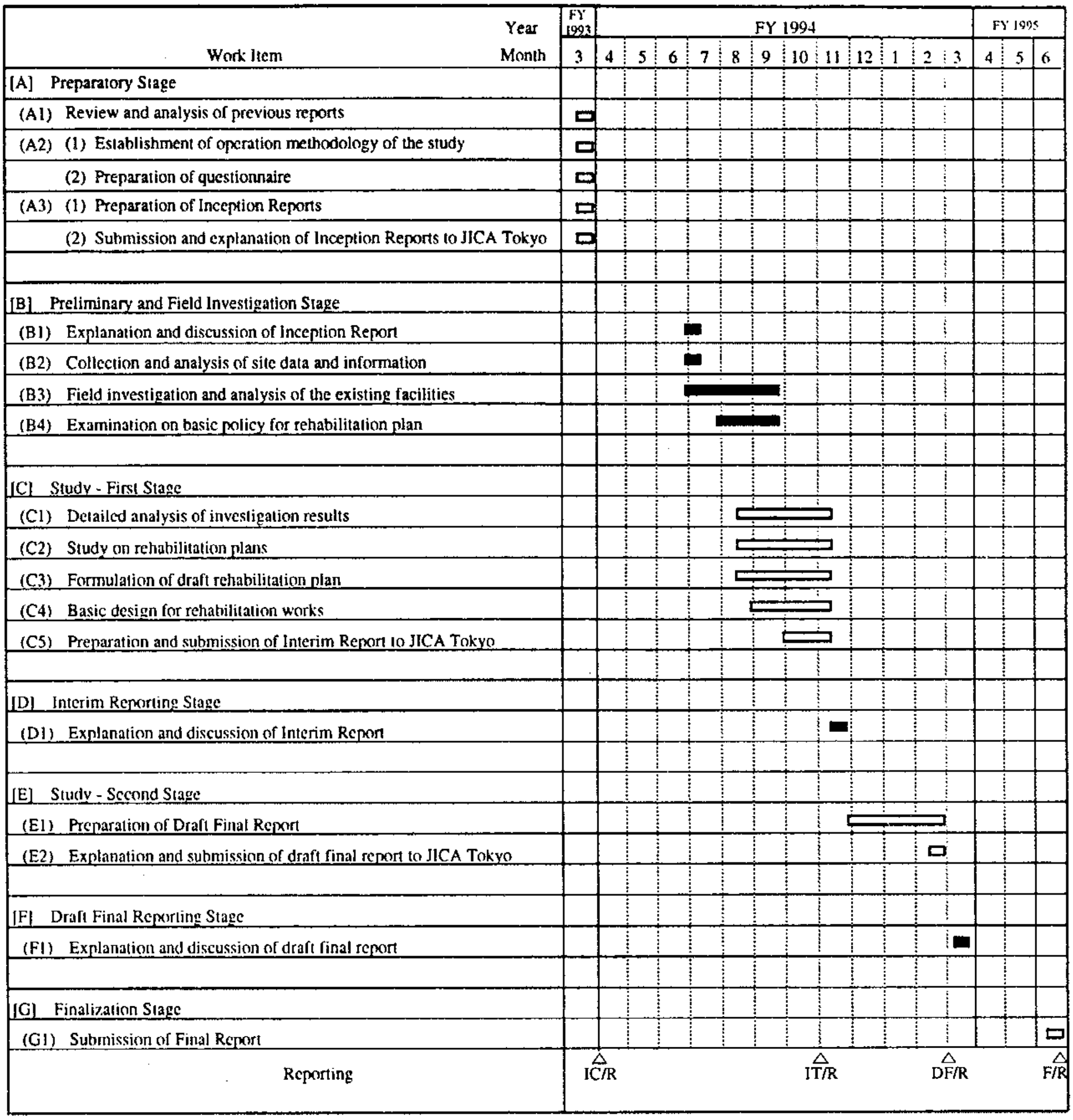


FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 1.1 General Work Flow



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 1.2 Schedule of Field Investigation

Figure 1.2 Schedule of Field Investigation



Note : ▬ Field Study ▭ Home Study

△ IC/R Inception Report △ IT/R Interim Report
△ DF/R Draft Final Report △ F/R Final Report

FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 1.3 Study Schedule

CHAPTER 2

PROFILE OF THE STUDY AREA

CHAPTER 2 PROFILE OF THE STUDY AREA

2.1 Geographical Features

2.1.1 Land

Viet Nam is geographically a long, narrow country locating at the east edge of Indochina region of about 331,033 km^2. Neighboring countries are China, Laos and Cambodia. The coastline borders the South China Sea on the east and the Gulf of Thailand on the south, the length of which is about 3,260 km.

Viet Nam has two big productive agricultural land, i.e. Red River Delta in its north and Mekong River Delta in its south where the population is concentrated. Most of the border areas are mountainous and relatively sparsely populated.

2.1.2 Population

Viet Nam's population, estimated at about 69.3 million people in 1992, is growing at an average annual rate of 2.0 percent. Twenty-two per cent of the population live in urban areas. The two largest cities, Ho Chi Minh City (4.1 million) and Hanoi (2.1 million), account for about 44 per cent of the urban population. Viet Nam has been successful in achieving a relatively high level of social development. According to UNDP report, an adult literacy rate of 88 per cent and life expectancy at 62.7 years in 1990 are well above those of all least developing countries' average, 45 percent and 51.0 years respectively.

2.1.3 Climate

The climate is predominantly sub-tropical monsoon type, however, having it's long shape from north to south, the average annual temperature has notable variations. The average annual temperature in Hanoi is 23.5°C, while that of Ho Chi Minh is 27.1°C. Winter in Hanoi (January) experiences cool weather of 16.5°C in average. Annual rainfall over the greater part of Vietnam's territory is around 1,600 mm, while in places where the mountain slopes are open to the winds, precipitation may exceed 2,500 - 3,600 mm and even reach 4,000 mm per year.

2.2 Socioeconomy

2.2.1 Structure of Economy

The structure of Gross Domestic Products (GDP) is remaining stable these years i.e. agriculture slightly less than 40%, industry 25% and services less than 40%. However, according to the development forecast provided by Institute of Energy, structural conversion is expected along with the economic growth. It is forecasted that by 2000, agriculture 25%, industry 27% and services 48% will be the share of GDP. GDP of Viet Nam is estimated as 110,535 billion Dong in 1992 and 136,571 billion Dong in 1993. Average economic growth rate from 1986 to 1990 is estimated as 3.9%, and has been growing rapidly, in 1992, it recorded 8.3% and in 1993, target growth rate 7.5% seems to be well achieved. GNP per capita is estimated by UNDP at US$220 in 1992.

2.2.2 Trade

Trade with non-CMEA (Council for Mutual Economic Assistance) countries is expanding significantly. Exports to non-CMEA countries reached $2.48 billion in 1992 compared with only $0.47 billion in 1988. Imports increased at a slower rate from $0.60 billion in 1988 to about $2.48 billion in 1992. Balance of trade payments in convertible currency in 1992 is estimated at a deficit of US$40 million amounting from exports US$40 million in US$2.47 billion and imports in US$2.51. Principal exported goods are, crude oil, rice, marine products, coffee, coal, rubber, handicrafts, wood products, etc., and principal imported goods are, fuel, fertilizers, vehicles, capital equipment, etc.

2.2.3 Development Plan

The Seventh National Congress of the Communist Party, which met in June 1991, adopted the Socio-Economic Stabilization and Development Strategy to the Year 2000 aiming at double the Viet Nam's GDP in the ten-year period.

Macroeconomic objectives include:

(1) reduction of macroeconomic instability while maintaining a moderate rate of economic growth, (2) promotion of strong export growth, (3) increase of the rate of capital formation with a particular emphasis on encouraging increased private investment, (4) the development of infrastructure and strong service sector and (5) the adoption of improved technology and improvement of technical skills.

Social development objectives include:

(1) increase and more stable nutrition levels, (2) reduction of unemployment, (3) more appropriate education (4) diffusion of preventative health, (5) reduction of population growth and (6) more equitable distribution of income and public services. Priority is also given to developing the institutional, administrative and legal framework consistent with the new system of economic management.

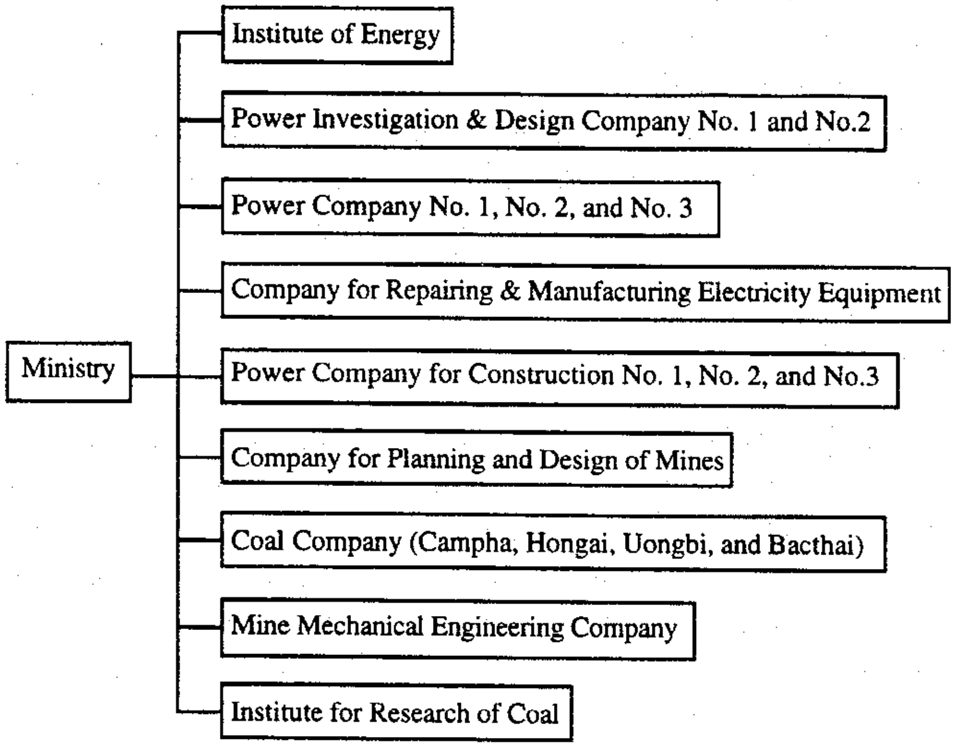
2.2.4 Foreign Investment

The Socio-Economic Stabilization and Development Strategy to the Year 2000 also emphasizes the attracting foreign capital, both official development assistance (ODA) and foreign direct investment (FDI). To promote foreign investment, Foreign Investment Code was enacted in 1987 followed by by-laws and regulations. State Committee for Cooperation and Investment (SCCI) was also established in the same year to assess and approve each investment plan. Foreign investment has increased since the code and SCCI's establishment. In 1988, SCCI approved 37 projects, US$362 million, in 1992, 192 projects, US$1,905 million and in 1993, 339 projects US$3,873 million.

2.3 Power Sector

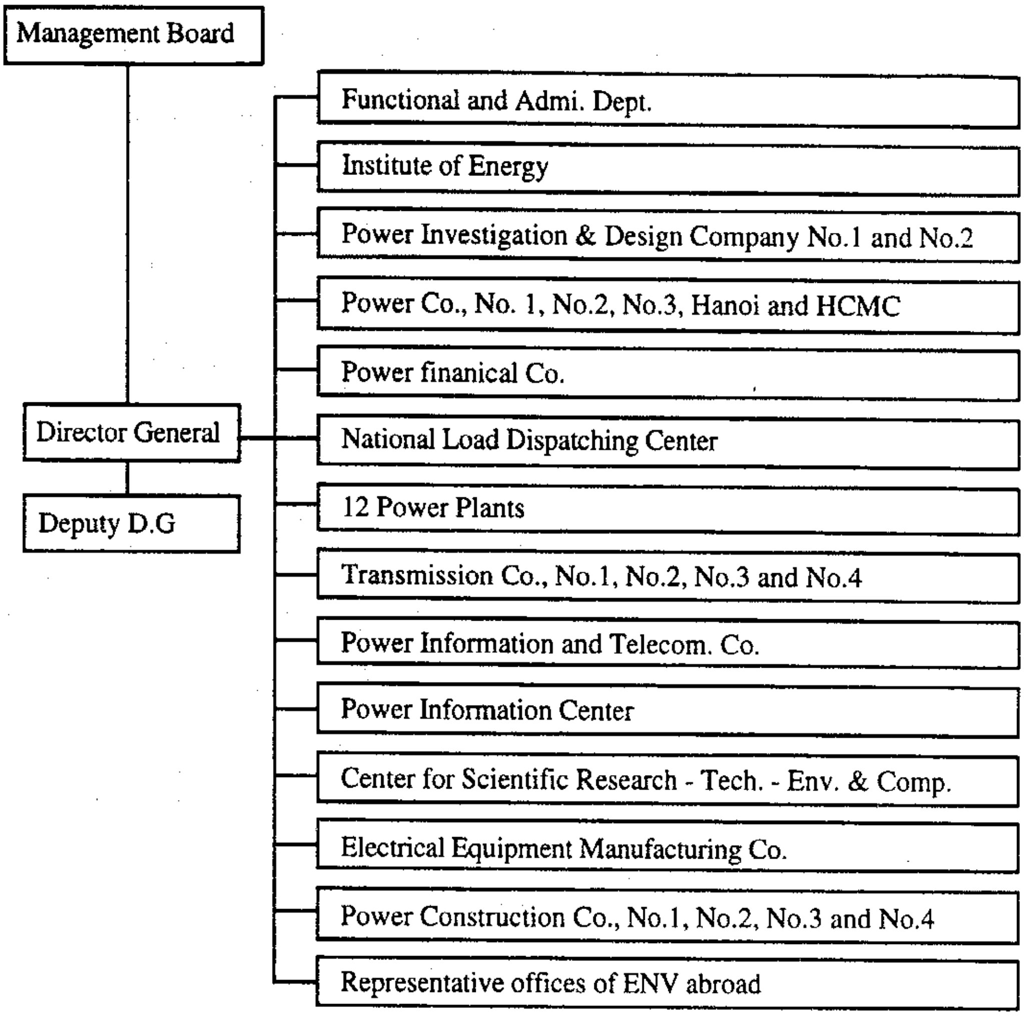
2.3.1 Administration of the Power Sector

The power sector in Viet Nam is at present managed by the Ministry of Energy. Under the ministry, various institutes and companies are related to the country's energy sector and are organized as below:

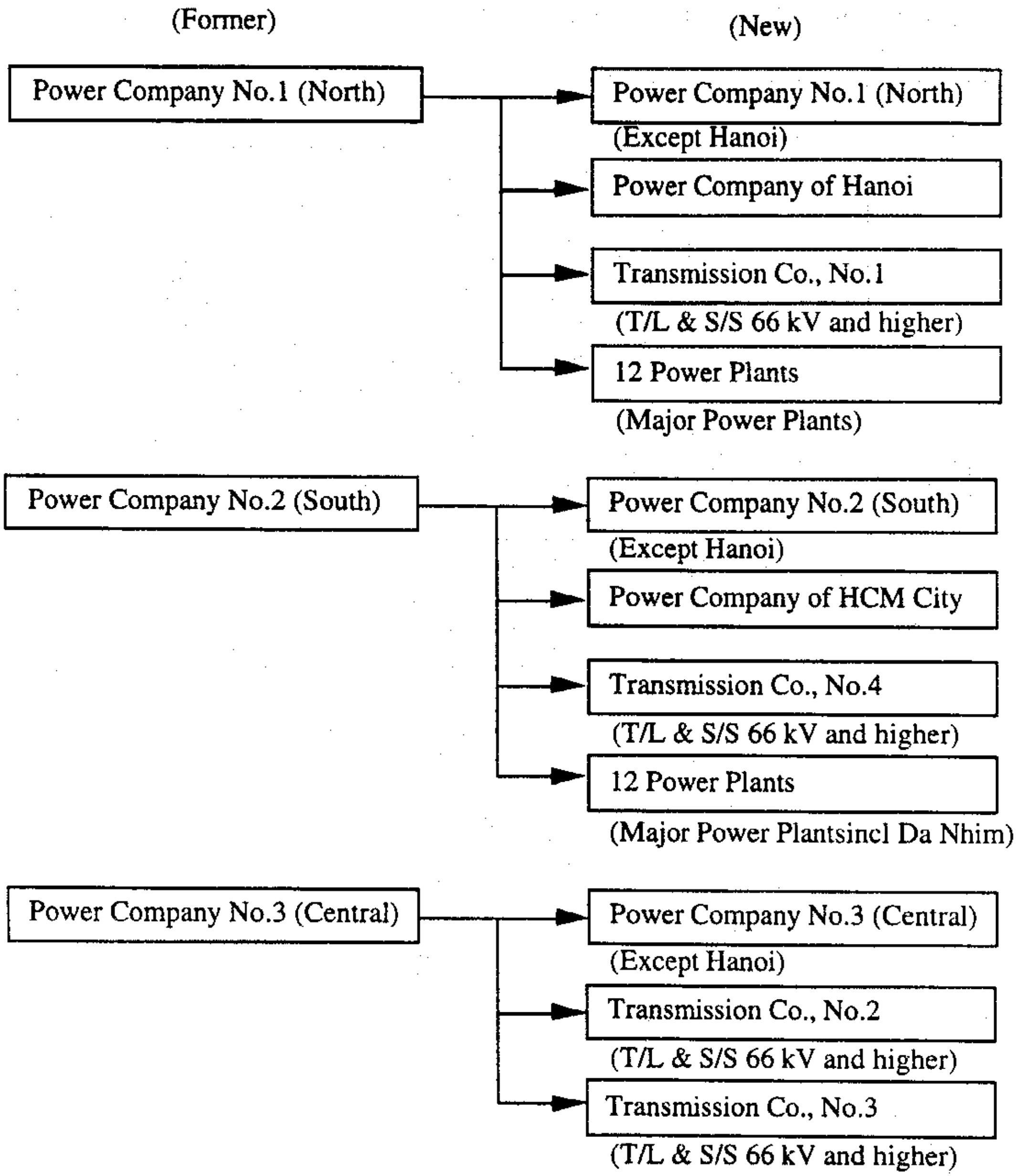


The power section in Viet Nam was reorganized and the General Power Company of Electricity of Viet Nam (EVN) was established on 1st April 1995, in integration of various institutes, power companies and other companies related to the power sector under the ministry of energy.

General Company of Electricity of Viet Nam (EVN)



By this reorganization, each former power company which has a closed relation to the Study was divided into several companies as below.



The reorganization is now in progress. The Study was executed under the former organization of the power sector in Viet Nam. Accordingly, the study report was prepared basing on the former organization as of the end of December 1994 .

The following presents an outline of the organizations related to the power sector (Institute of Energy, Power Investigation and Design Company, Power Company, and Power Company for Construction) as of the end of December 1994.

(1) Institute of Energy

The Institute of Energy is the special research institute responsible for the energy sector in the country and the following activities:

1) Formation of an energy development plan for the country and research of projects related to energy as the national energy organization

2) Formation of the master plan of power development in the country and execution of the research and investigation of the development and promotion of the energy field

3) Basic and practical research of science and technology, transfer of knowledge in the power sector, and research of new energy and energy renewal

4) Investigation and research of the energy economy

The institute exchanges various information concerning energy with foreign organizations such as ESCAP (Economic and Social Commission for Asia and the Pacific), UNDP (United Nations Development Program), UNICEF (United Nations International Children's Emergency Fund), FAO (Food and Agriculture Organization), SIDA (Swedish International Development Authority), EDF (Electricite du France), IEEJ(Institute of Electrical Engineers of Japan), USSR, etc.

(2) Power Investigation and Design Company

The company implements investigation plans and feasibility studies, detailed design and supervision of new projects with regard to power plants, transmission lines, as well as communications facilities related to the power projects. Principally, the company is not to participate in renewal, improvement or extension of the existing power facilities.

(3) Power Company

The power company is responsible for managing, operating, and maintaining all the power facilities and distribution networks in each region and selling energy to the customers. The company is also responsible for investigation, design, and construction of the power facilities below 66 kV.

(3-1) Power Company No.1 (PC-1)

The company manages the power system in the northern region of the country, which incorporates the following 23 provinces:

Hanoi	Quang Ninh	Than Hoa	Hai Hung
Lang Son	Nghe An	Hai Phong	Bac Thai
Ha Tinh	Thai Binh	Cao Bang	Nam Ha
Tuyen Quang	Ninh Binh	HA Giang	Hoa Binh
Yen Bai	Ha Tay	Lao Cai	Vinh Phu
Son La	Ha Bac	Lai Chau	

In order to meet the increasing power demand in the region, PC-1 plans to develop the following power facilities aiming for 8,600 GWh in 1995 and 20,000 GWh in the year 2000:

1) completion of four additional units of generating sets at the Hoa Binh hydropower station in order to increase annual energy production to 8,400 GWh,

2) construction of the Son La hydropower station of 3,600 MW, which will result in the annual energy of 16,000 GWh being produced,

3) addition of 840 MW generating sets to the Phan Lai thermal power station,

4) rehabilitation of the Nih Binh and Uong Bi thermal power stations,

5) construction of new transmission line facilities, a 220 kV line over 940 km and a 110 kV line over 1,360 km, between 1990-1995,

6) construction of new 220 kV substations with a total capacity of 1,300 MVA and 110 kV substations with a total capacity of 1,495 MVA, and

7) construction of an additional substation on the Hoa Binh-Phu Lam 500 kV transmission line at Vinh.

(3-2) Power Company No.2 (PC-2)

The PC-2 is responsible for managing the whole power system in the following 19 southern provinces. The Da Nhim power system is in the PC-2 region.

Ho Chi Minh	Dong Nai	Ninh Thuan	Bing Thuan
Lam Dong	Song Be	Tay Ninh	Ba Ria Vun Tau
Long An	Vinh Long	Tra Vinh	Dong Thap
An Gian	Can Tho	Soc Trang	Ben Tre
Tien Giang	Ming Hai	Kien Giang	

The economy in the southern region of the country is expanding rapidly. Due to the economy expanding, PC-2 is faced with an imbalance of power and energy.

Even if the Tri An hydropower station (400 MW) is in operation, the power and energy supply in this region does not meet the demand for it. The Ministry of Energy plans to construct a new gas turbine station and to shift PC-1's existing diesel generating sets of a total 8 MW into the PC-2 region beside other new development programs. In addition, the region receives energy generated in the Hoa Binh hydropower plant in the PC-1 through 500 kV transmission line. The organization of PC-2 is outlined in Figure 2.1.

(3-3) Power Company No.3 (PC-3)

PC-3 manages the power system of the following 11 provinces in the central region of the country:

Quang Binh	Quang Tri	Thua Thien-Hue	Quang Nam-Da Nang
Quang Ngai	Binh Dinh	Phu Yen	Khan Hoa
Gia Lai	Kon Tum	Dak Lak	

The power system and facilities in this region are under development. Since 1976, the development of new power sources and system expansion have been achieved, however, the scale of these projects was rather small. The total installed capacity of the existing generating facilities which comprise diesel generator units, a gas turbine generating station, and 3 small hydropower stations in this region is only 19.4 MW. Similarly to the PC-2, energy from the Hoa Binh hydropower plant is supplied for the demand in this region through 500 kV transmission line.

The Da Nhim power system supplies the southern district of the region with power through the existing 110 kV transmission line which extends to the Nha Trang substation and through to the 66 kV Cam Ranh substation. Figure 2.2 shows the management organization of PC-3.

(4) Power Company for Construction

The company (PCC) will construct all the power plants, transmission lines, and substations above 110 kV including communication systems related to the power sector. The company has experience in the construction of the 500 kV transmission system, which extends from the Hoa Binh power station to the Phu Lam substation. The PCC-2 also manages a tower factory and a concrete pole factory.

2.3.2 Power System

In the country, trunk transmission lines of 230 kV or 220 kV connect the major demand centers. A 500 kV transmission line was completed in 1994 and operates between the Hoa Binh hydropower station in the PC-1 region and the Phu Lam substation in the PC-2 region, via the PC-3 region. Additional 500 kV substation is functioning at Da Nang and Play Cu (PC-3). These will deliver energy from Hoa Binh to the major demand centers in the country. This line enables power to be exchanged throughout the whole country.

There is a 220 kV interconnecting line extending from the Vinh substation in PC-1 to the Dong Hoi substation in PC-3. Other interconnecting lines operate between PC-2 and PC-3 a 110 kV line extending from the Da Nhim power station in PC-2 to the Nha Trang substation in PC-3 and a 66 kV transmission line extending from the Thap Cham substation in PC-2 to the Cam Ranh substation in PC-3. These will deliver the power from the Da Nhim power station.

Major power systems in the country are shown in Figures 2.3 to 2.6.

2.3.3 Existing Power Facilities

(1) Generating facilities

The following are the generating facilities which were installed in the country as of the end of 1994.

unit : MW

Region	Hydro	Thermal		Diesel	Gas Turbine	Total
		Oil	Coal			
PC-1	2,028	-	645	-	-	2,673
PC-2	564	205	-	204	383	1,356
PC-3	20	-	-	230	-	250
Total	2,612	205	645	434	383	4,279

Hydropower facilities shares 61% of the total the generating facilities in the country, while thermal power facilities shares 20% which is observed in the table above. The regional generating facilities are detailed in Table 2.1.

Regionally, the PC-1 and PC-2 share 62% and 32% of the total generating facilities. Installation of the generating facilities per capita of each power company is 87 kW in PC-1, 46 kW in PC-2, and 25 kW in PC-3.

1) PC-1

There are 5 power stations operating in this region consisting of 3 thermal power stations and 2 hydropower stations, which are presented as follows:

Thermal	Pha Lai	4 x 110 = 440 MW
	Uong Bi	1 x 50 + 1 x 55 = 105 MW
	Ninh Binh	4 x 25 = 100 MW
Hydro	Hoa Binh	8 x 240 = 1,920 MW
	Thac Ba	3 x 36 = 108 MW
Total		2,673 MW

The Hoa Binh hydropower station has been designed and constructed, with the assistance of the ex-Soviet Union, since 1979 and the operation of its first unit started at the end of 1988. Four units of 240 MW were completed by the end of 1992. The final installation capacity of the power station is planned to be 1,920 MW with a total number of 8 units and the remaining four units of 240 MW were also completed by the end of 1994.

2) PC-2

The following are the generating facilities (1,356 MW in total) operating in the PC-2 region as of the end of 1994. The Da Nhim hydropower station which was commissioned in 1963, is provided with 4 units of 40 MW (160 MW in total) and delivers its energy mainly to Ho Chi Minh City, the largest demand center in the region.

Thermal	Thu Duc	1 x 33 = 33 MW
		2 x 66 = 132 MW
	Can Tho	1 x 33 = 33 MW
	Cogido	7 MW
Hydro	Da Nhim	4 x 40 = 160 MW
	Tri An	4 x 100 = 400 MW
	Suoi Vang	4 MW
Gas Turbine	Thu Duc	125 MW
	Can Tho	24 MW
	Ba Ria	234 MW
Diesel		204 MW
Total		1,356 MW

(Source : Institute of Energy)

The Thu Duc oil-fired thermal power station was commissioned in 1966 and increased to 165 MW, with additional units being installed in 1972. The Can Tho (Tra Noc) oil thermal power station was commissioned in 1975 for supplying power to the Mekong delta area. The Tri An hydropower station was constructed under the assistance of the ex-Soviet Union and the operation of it started with an installed capacity of 400 MW, in 1988. Diesel generating sets, which were scattered in the region as of the end of 1993, operate in the remote areas with a total installed capacity of 204 MW (possible output of 65 MW).

The hydropower and thermal power shares in the region are 42% and 15%, respectively.

The energy production at the Da Nhim power station since 1977 shows in the tables below.

Year	Hydro				Thermal	Gas & Diesel	Total	Share of Da Nhim
	Da Nhim	Tri An	Other	Total				
1977	761	-	15	776	642		1,418	53.7%
78	867	-	15	882	617		1,499	57.8%
79	928	-	15	943	509		1,452	63.9%
80	1,095	-	15	1,110	435		1,545	70.9%
81	1,021	-	15	1,036	539		1,575	64.8%
82	1,081	-	15	1,096	599		1,695	63.8%
83	814	-	15	829	904		1,733	47.0%
84	1,142	-	15	1,157	743		1,900	60.1%
85	1,068	-	14	1,081	717	61	1,858	57.5%
86	903	-	-	903	971	151	2,026	44.6%
87	998	-	-	998	1,071	170	2,239	44.6%
88	841	633	15	1,489	994	109	2,592	32.4%
89	781	1,437	8	2,226	740	103	3,069	25.4%
90	774	1,697	13	2,484	841	128	3,453	22.4%
91	800	1,738	12	2,550	1,059	184	3,793	21.1%
92	918	1,685	16	2,619	1,036	358	4,013	22.9%
93	958	1,832	17	2,807	1,139	716	4,662	20.5%

This table shows that the annual average energy production of the Da Nhim power station is estimated at 1,000 x 10^6 kWh.

3) PC-3

The total installed generating capacity is 250 MW only at present, consisting of diesel generating sets scattered over the region 3, hydropower stations. At present the power stations in the region are not wholly interconnected. A new 220 kV transmission line in PC-1 was extended to PC-3 in 1990 and supplies PC-1's power to the five northern provinces in the PC-3 region. The energy of the Da Nhim power station is also transmitted to its southern area as stated above. The following are the generating facilities of PC-3:

Hydro	Drayling	12 MW
	An Diem	6 MW
	Phu Ninh	2 MW
Diesel		230 MW
Total		250 MW

(Source: Institute of Energy)

(2) Transmission line and substation facilities

The transmission line and substation facilities in the country, as of the end of 1993, are as follows. Figure 2.3 shows the major facilities of these transmission lines and substations.

	Country	PC-1	PC-2	PC-3
Line facilities (km)				
230 - 220 kV	1,790	960	630	200
110 - 66 kV	5,257	2,621	1,587	1,049
35-6 kV	31,777	17,953	9,743	4,081
low voltage lines	16,645	10,000	5,655	990
Substations (MVA)				
230 - 220 kV	2,796	1,376	1,294	126
110 - 66 kV	3,630	1,885	1,534	211
35 - 6 kV	2,208	2,000	81	127
distribution network	5,587	2,907	2,131	549

(Source: Institute of Energy)

2.3.4 Power Demand and Demand Forecast

(1) Power Demand

The power records in the country covering the last 9 years from 1986 to 1994 are summarized in Table 2.3. From the table the following facts were intelligible:

1) Energy production

The total energy production for the whole country reached 12,200 GWh in 1994 with an average annual growth rate of 10.4%. The rate is much higher than the average rate of 4% recorded in non-OECD (Organization for Economic Cooperation and Development) countries. It shows that power consumption in

Viet Nam is increasing very rapidly. Since the per capita consumption in Viet Nam is, however, extremely low, it is anticipated that power demand will continuously grow at a high rate.

In 1994 PC-1's share of production was 59%, PC-2's 39%, and PC-3's 2%. Owing to the shortage of its own generating plants, PC-3 is obliged to import from PC-1 and PC-2 so much energy as to be equal to 305% of self-production.

About 73 % of the total electricity in the country is produced by the hydropower plants which utilize indigenous and abundant water resources. This trend will further continue according to the development program.

2) Energy consumption

The annual average growth rate of energy consumption in the country was 10.4% for the last 9 years, as observed in Table 2.4. In particular, the high agricultural and domestic demand growth rates were recorded to be 19.0% and 13.4%.

Although energy consumed by the agricultural sector in the PC-1 region shares only 28% of the total amount of energy consumed, its average growth rate is about 20%. On the contrary, the growth rate of the industrial sector is as low as 2.5%, but energy consumption reached 37% of the total regional amount. The peak demand, which has grown at an average annual rate of 9.0%, reached 1,080 MW in 1993. The peak demand of the PC-1 region shares about 50% of that for the whole country.

In the PC-2 region, the high industrial, agricultural, and general demand growth rates were recorded to be from 12 to 17%. The industrial and domestic sectors have consumed 86% of the total amount of energy consumed in the region. The peak demand in 1993 reached 870 MW with an annual average growth rate of 14.4%. Therefore, new power sources are urgently required for meeting such a rapid increase.

The growth rate in the PC-3 region was 12.9% greater than the average rate for the 3 regions. In particular, the growth rate of the domestic sector was 17.8%. This is caused by the decrease of power shortages due to the increase of supplies from PC-1 and PC-2. The increase of power supply will result in the increase of the amount of energy consumed in the region.

(2) Power Demand Forecast

The power demand forecasts in the country are authorized through the following procedures:

- Each power company prepares its own forecast in its region.
- The Institute of Energy examines the forecasts submitted by the power companies.
- Upon the approval of the Ministry of Energy, the official forecast will be issued.

The latest forecasts were issued in January 1995. The forecasts will be prepared by the year 2010. Table 2.5 show the forecasts of high growth and base growth scenarios according to the region. An outline of the forecasts is presented in the tables below.

	1995 Planned	2000		2005		2010	
		High	Base	High	Base	High	Base
PC-1							
1. Consumption (GWh)	4,440	8,362	7,948	13,825	12,783	23,763	21,281
Industry	1,595	3,872	3,757	7,661	7,099	15,160	13,413
Agriculture	1,269	403	388	530	510	697	670
Services	270	513	513	949	949	1,755	1,755
Domestic	1,306	3,574	3,290	4,685	4,225	6,151	5,443
2. Energy Loss (GWh)	1,340	2,025	1,793	2,594	2,399	3,240	2,902
3. Energy Required (GWh)	5,780	10,387	9,741	16,419	15,182	27,003	24,183
4. Peak Demand (MW)	1,100	1,907	1,744	2,840	2,626	4,533	4,060
PC-2							
1.Consumption (GWh)	5,254	11,056	10,395	20,011	18,615	37,118	34,249
Industry	2,674	6,547	6,137	13,169	12,344	26,485	24,829
Agriculture	160	139	137	175	175	223	223
Services	600	1,145	1,100	2,192	2,006	4,197	3,657
Domestic	1,820	3,225	3,021	4,475	4,090	6,213	5,540
2. Energy Loss (GWh)	1,478	2,493	2,266	3,670	3,414	5,061	4,669
3. Energy Required (GWh)	6,732	13,549	12,661	23,681	22,029	42,179	38,918
4. Peak Demand (MW)	1,200	2,343	2,190	4,035	3,753	7,081	6,534
PC-3							
1.Consumption (GWh)	943.7	1,710	1,618	3,011	2,718	5,284	4,624
Industry	319	557	523	1,060	902	2,019	1,554
Agriculture	104	103	103	138	138	185	185
Services	117	197	197	417	417	881	881
Domestic	403	853	795	1,396	1,261	2,202	2,004
2. Energy Loss (GWh)	295	401	391	601	565	734	642
3. Energy Required (GWh)	1,238.7	2,111	2,009	3,612	3,283	6,021	5,266
4. Peak Demand (MW)	277	455	432	723	658	1.146	1,002
Country (Total of 3 PCs)							
1.Consumption (GWh)	10,637	21,128	19,961	36,847	34,116	66,168	60,154
Industry	4,588	10,976	10,417	21,890	20,345	43,664	39,796
Agriculture	1,533	645	628	843	823	1,105	1,078
Services	1,810	2,320	1,855	3,558	3,372	6,833	6,293
Domestic	3,529	7,652	7,106	10,556	9,576	14,566	12,987
2. Energy Loss (GWh)	3,113	4,919	4,450	6,865	6,378	9,035	8,213
3. Energy Required (GWh)	13,750	26,047	24,411	43,712	40,494	75,203	68,367

(Source: Institute of Energy)

As observed in the table, the average growth rates of energy consumed up until the year 2010 over the country, is assumed at 12.1% for the high growth scenario and 11.7% for the basic growth scenario. These rates are deemed to be reasonable considering the past power trend. The forecast for the whole country shows the following:

- Growth rate will gradually decline.

- The amount of energy consumed by the industrial sector was 43% of the total amount consumed in 1994. Since industrialization of the country will further accelerate in the future, the above is forecasted to increase to around 63%.
- Growth rate of the domestic sector is assumed at 9% to 10% per annum against the rate of 13.4% recorded for the last 9 years. In the future the total amount of energy consumed by the domestic sector is, however, forecasted to be around 22%,in the year 2010, decreasing from 33%, which was recorded for the last 9 years.
- Peak load in the country will grow by 10% to 11% (a similar rate to the past actual growth).

The forecast for each power company is analyzed below:

1) PC-1

The average growth rate of the energy consumed was 6.9% per annum for the last 9 years. The results of the forecast for the energy consumed showed that it will grow at the same level in total. Although the growth of energy consumed by the industrial sector was only 2.5% in the past, the forecast assumes that by the year 2010 it will be 15% per annum and will share more than 60% of the total amount of energy consumed in the region, which reflects the industrialization policy. The growth of energy consumed by the domestic sector is assumed to decrease up to around 5.5% after the year 2000. Growth of the agricultural sector is forecasted to decline from the past 20% annual growth rate, since the sector might become electrified.

The peak demand is forecasted to increase at the rate of 9.0% per annum along the past trend.

2) PC-2

It is anticipated that industrialization in the region will accelerate and the energy consumed, after the year 2000, will increase to 60% to 70% compared to 50% in 1994. Its annual growth rate will be 15.0%. The percent growth rate of energy consumed by the advanced domestic and public demand will decrease up to around 6.5% after the year 2000 and the share will be about 17% of the total amount of energy consumed in the region. The peak demand in the region will slightly decline from 14.4%, recorded for the past 9 years, to 12% . However, both the energy consumed and the peak load in the region will overtake those in the PC-1 region, after the year 1995.

3) PC-3

Although the growth of electricity demand in the PC-3 region has been restricted due to the serious shortage of power sources, it will increase owing to the increase of power supplies from PC-1 through the 500 kV system and development of new hydropower plants in the region. Accordingly, the growth rate of power demand in the region is assumed to be high rate. It is forecasted that the total amount of energy consumed will increase at 11.2% per annum and domestic consumption will grow at an average annual rate of 12.0% and will share more than 42% of the total amount of energy consumed in the region. This high growth rate is understandable in considering the future electrification of the region after power sources have been made available.

2.3.5 Development Program and Power Balance

(1) Power Development Program

For meeting the rapidly growing power and energy demand in the country, the Government of Viet Nam and the power companies have plans of extension and rehabilitation of the existing power facilities and development of new power facilities. The country aims to develop indigenous and abundant hydro potential for hydropower plants in the long term program.

Following generating plants are programmed to be developed by the year 2010 in the fourth power development master plan.

Year	Type	Name of Plant	Capacity (MW)	Region
1995	HP	Thac Mo	150	South
	HP	Vinh Son	66	Central
1996	G.T	Ba Ria (F6)	35	South
1997	G.T	Ba Ria steam part	2 x 56	South
	CC	C.C Nos. 1 & 2 gas turbine part	4 x 100	South
1998	HP	Song Hinh	70	Central
		C.C Nos. 1 & 2 steam part	2 x 100	South
1999	TP(C)	Pha Lai 2, No.1	1 x 300	North
	TP(O)	Phu My, No.1	1 x 200	South
	HP	Yaly, Nos. 1 & 2	2 x 180	Central
2000	TP(C)	Pha Lai 2, No.2	1 x 300	North
	TP(O)	Phu My, Nos.2 & 3	2 x 200	South
	HP	Yaly, Nos. 3 & 4	2 x 180	Central
2001	HP	Ham Thuan	300	South
2002	HP	Da Mi	172	South
	HP	Se San	220	Central
	HP	Buon Cuop	85	Central
2003	HP	Dai Ninh	300	South
	CC	CC No.3	300	South
2004	HP	Thuong Kontum	260	Central
	CC	CC No.4	300	South
2005	HP	Ban Mai	350	North
	HP	Pleikrong	120	Central
	CC	CC No.5	300	South
2006	TP	Quang Ninh, No.2	300	South
	TP	Western TP, No.1	300	South
2007	HP	Son La, No.1 & 2	2 x 300	North
	TP	Western TP, No.2	1 x 300	South
	GT	GT Nos. 1 & 2	2 x 100	South
2008	HP	Son La, Nos. 3 & 4	2 x 300	North
	TP	Western TP, No.3	300	South
	GT	GT No.3	100	South
2009	HP	Son La, Nos. 5 & 6	2 x 300	North
	TP	Southern TP, No.1	300	South
	GT	GT. No.4	100	South
2010	HP	Son La, Nos. 7 & 8	2 x 300	North
	TP	Southern TP, Nos. 2 & 3	2 x 300	South
	GT	GT Nos. 5 & 6	2 x 100	South

(Source: Institute of Energy)

Note :
- HP : Hydropower
- GT : Gas Turbine
- CC : Combined Cycle
- TP(C)(O) : Thermal Power (coal) (oil)

(2) Power Balance of Country

(2.1) Whole country

The master plan of fourth power development presents the forecast for peak demand and required energy as well as the power balance up to the year 2010. Since there are no large scale power sources to be completed in the PC-2 and PC-3 region in the very near future, and PC-1 has some surplus power from the Hoa Binh hydropower station at present, the plan intends energy delivery from the Hoa Binh power station in PC-1 to PC-2 and PC-3 through the new 500kV transmission line and substations for supplementing energy shortage in the two regions. The balance is examined under the following conditions.

1) Power and energy balances in the period of 1995-2010 are estimated from differences between the forecasted demand with the system reservation and the sum of total supply capacity of the existing facilities and additional capacity of the new generating facilities programmed as above.

2) The system reservation is estimated at 10% to 20% of the system peak load depending on the size of system, which seems reasonable.

3) Maximum output of the Hoa Binh power plant is rated at 1,920 MW.

4) PC-1 will accommodate its surplus electricity to PC-2 up to the year 2010 and PC-3 up to the year 1998. After completion of unit Nos. 1 and 2 of the Yaly power station in 1999, PC-3 will accommodate its surplus electricity to PC-2 up to the year 2010. Only in the year 1988, PC-2 will accommodate its electricity of 74 MW to PC-3.

Following are power balances under the high growth scenario. Details are shown in Table 2-6.

	1995	1996	1997	1998	1999	2000	2005	2010
PC-1								
Power Balance (MW)	790 (250)	742 (250)	639 (300)	633 (300)	635 (300)	611 (300)	340 (500)	360 (700)
PC-2								
Power Balance (MW)	41 (300)	-221 (300)	-189 (350)	-256 (350)	-22 (400)	265 (450)	14 (600)	-116 (800)
PC-3								
Power Balance (MW)	35 (0)	40 (0)	40 (0)	50 (0)	50 (0)	166 (0)	613 (0)	302 (0)

(Remark) Figures in bracket (system reserve power). Plus figures and minus (-) figures show surplus and shortage, respectively. System reserve power is included in the required power demand.

In the high growth scenario the power shortage of PC-2 in the years up to 2010 will be covered by the estimated surplus of PC-1 and PC-3 (central) and system reserves in the years.

(2.2) Power balance of PC-2

Following are the energy and power balances in the PC-2 region (high growth scenario) extracted from Tables 2.7 and 2.8.

	1995	1996	1997	1998	1999	2000	2005	2010
Energy Required (GWh)	6770	7865	9138	10616	12333	14328	23681	42179
Possible Supply Energy (GWh)								
(Hydro)	3305	3305	3305	3305	3305	3305	6073	6073
(Thermal)	468	615	959	981	120	132	132	80
(Gas Turbine)	913	1450	2976	5047	6492	6051	11597	28113
(Diesel)	123	134	111	217	40	40	-	-
(from 500kV Line)	1961	2361	1787	1066	2376	4800	5879	7913
Balance of Requirement and Supply (GWh)	0	0	0	0	0	0	0	0
Peak Load (MW)	1220	1400	1607	1844	2116	2428	3954	6939
Possible Supply (MW)	1561	1479	1768	1938	2494	3093	4568	7623
(Hydro)	710	710	710	710	710	710	1482	1482
(Thermal)	194	194	194	194	38	38	38	38
(Gas Turbine)	190	222	634	934	1354	1724	2624	5324
(Diesel)	174	174	174	174	110	50	-	-
(from 500kV Line)	293	179	56	-74	282	571	424	779
Reservation (MW)	300	300	350	350	400	400	600	800
Balance of Power (MW)	+41	-221	-189	-256	-22	+265	+14	-116

(Source: Institute of Energy

(Remark) Plus figures and minus (-) figures show surplus and shortage, respectively.

The balances above mentioned are estimated taking account of the supply reservation equal to 11% to 20% of the total supply capacity and expecting power import from the Hoa Binh power plant in the PC-1 region and Yaly in the PC-3 (Central) region in the future.

PC-2 plans increase of production of thermal, gas turbine and diesel plants for covering decrease of production of the hydropower plants in dry season. However it is noted that the Da Nhim power plant will be able to produce constant energy through whole the year.

Suppliable energy will to meet the requirement through the period of 1995 to 2010.

2.3.6 Power Tariff

(1) Power Tariff System

The power tariff is to be finally determined by the committee of the cabinet ministers after examination on the tariff drafted jointly by the ministry of finance, the state planning committee, the price committee, the ministry of labour and the ministry of energy. The draft is to be made in examination on information submitted by each power company.

Information submitted by the power companies are those relating to the production costs spent in the previous year only.

(2) Present Power Tariff

The same tariff system is applied for the whole country. The power tariff was amended several times since 1987. The present tariff was regulated on August 1, 1994 as outlined below.

Industries & Administrative Offices	20kV and above	normal hours	:	450 Dong/kWh
		peak hours	:	710 Dong/kWh
		off-peak hours	:	280 Dong/kWh
	6kV to 20kV	normal hours	:	500 Dong/kWh
		peak hours	:	800 Dong/kWh
		off-peak hours	:	300 Dong/kWh
	lower than 6kV	normal hours	:	550 Dong/kWh
		peak hours	:	800 Dong/kWh
		off-peak hours	:	320 Dong/kWh
Agriculture	6kV and above	off-peak hours	:	180 Dong/kWh
		other hours	:	450 Dong/kWh
	lower than 6kV	off-peak hours	:	190 Dong/kWh
		other hours	:	480 Dong/kWh
Street Lighting			:	450 Dong/kWh

Domestic-use		up to 150 kWh	: 450 Dong/kWh
		151 to 250 kWh	: 600 Dong/kWh
		more than 251 kWh	: 800 Dong/kWh
Wholesale	general	at substation in rural area	: 360 Dong/kWh
	residential use	at private substation	: 400 Dong/kWh
	residential use	at service substation	: 420 Dong/kWh
Business, Service & Trading			: 850 Dong/kWh
Foreigner	production	20kV and over	: 0.070 US$/kWh
		6kV to 20kV	: 0.075 US$/kWh
		lower than 6kV	: 0.080 US$/kWh
	business, service & trading	20kV and over	: 0.090 US$/kWh
		6kV to 20kV	: 0.100 US$/kWh
		lower than 6kV	: 0.110 US$/kWh
	residential	20kV and over	: 0.080 US$/kWh
		6kV to 20kV	: 0.085 US$/kWh
		lower than 6kV	: 0.090 US$/kWh

Normal hours	:	4 am - 6 pm
Peak hours	:	6 pm - 10 pm
Off-peak hours	:	10 pm - 4 am

Table 2.1 Existing Power Plants (as of the end of 1994)

(MW)

	Hydro	Thermal(Oil)	Thermal(Coal)	Diesel	Gas Turbine	Total
PC-1	2,028	-	645	-	-	2,673
PC-2	564	205	-	204	383	1,356
PC-3	20	-	-	230	-	250
Total	2,612	205	645	434	383	4,279

(Source : Institute of Energy)

PC-1	Hydropower	Hoa Binh	8 x 240 = 1,920 MW
		Thac Ba	3 x 36 = 108 MW
	Coal Thermal	Pha Lai	4 x 110 = 440 MW
		Uong Bi	1 x 50 + 1 x 55 = 105 MW
		Ninh Binh	4 x 25 = 100 MW
	Total		2,673 MW
PC-2	Hydropower	Da Nhim	4 x 40 = 160 MW
		Tri An	4 x 100 = 400 MW
		Khac (Suoi Vang)	3.7 MW
	Oil Thermal	Thu Duc	2 x 66 + 1 x 33 = 165 MW
		Can Tho	1 x 33 = 33 MW
		Cogido	1 x 7.3 = 7.3 MW
	Gas Turbine	Thu Duc	23.4 + 12.5 + 14.7 + 2 x 37.5 = 125.6 MW
		Ba Ria	2 x 23.4 + 5 x 37.5 = 234.3 MW
		Can Tho	2 x 12 = 24 MW
	Diesel Engine	Cho Quan	33.0 MW
		Bien Hoa	33.0 MW
		Hoa An	14.3 MW
		Cho Lon	11.2 MW
		Ba Queo	30.0 MW
		Tan Son Nhat	5.0 MW
		Other Rural Area	77.0 MW
	Total		1,356.4 MW
PC-3	Hydropower	Drayling	12.0 MW
		An Diem	5.4 MW
		Phu Ninh	2.0 MW
	Diesel Engine		230 MW
	Total		249.4 MW

(Source : Institute of Energy)

Table 2.2 Existing Transmission Lines and Substations (as of the end of 1994)

(1) Transmission Lines

(circuit - km)

Voltage	Country	PC-1	PC-2	PC-3
230 kV & 220 kV	1,790	960	630	200
110 kV	4,183	2,621	581	981
66 kV	1,074	-	1,006	68
35 kV - 6 kV	31,777	17,953	9,743	4,081
Low Tension Lines	16,645	10,000	5,655	990

(Source : Institute of Energy)

(Details of PC-2's Facilities)

Line Section	Circuit - km	Power Conductor
230kV & 220 kV Lines		
Da Nhim - Long Binh	238.6	ACSR 410 mm^2
Long Binh - Saigon	18.4	ACSR 410 mm^2
Long Binh - Ba Ria	65.0	ACSR 400 mm^2
Tri An - Long Binh	22.9	ACSR 300 mm^2
Tri An - Hoc Mon	104.6	ACSR 400 mm^2
Saigon - Hoc Mon	14.6	ACSR 400 mm^2
Hoc Mon - Phu Lam - Tra Noc	166.4	ACSR 400 mm^2
Total	630.5	
110 kV Lines		
Hoc Mon - Hoa Xa	29.4	ACSR 200 mm^2
Long Binh - Vung Tau	81.5	ACSR 185 mm^2
Long Binh - Bien Hoa	13.8	ACSR 240 mm^2
Long Binh - Xuan Loc	44.8	ACSR 185 mm^2
Tri An - Dong Xoai	45.0	ACSR 185 mm^2
Tra Noc - Long Xuyen	63.0	ACSR 160 mm^2
Long Xuyen - Rach Gia	58.9	ACSR 160 mm^2
Rach Gia - Kien Luong	69.0	ACSR 185 mm^2
Long Xuyen - Chau Doc	54.0	ACSR 185 mm^2
Total	516.9	
66 kV Lines		
Da Nhim - Cam Ranh	30.0	ACSR 336.4 MCM
Thu Duc No.1 P/S - Saigon S/S	0.5	ACSR 795 MCM
Thu Duc No.2 & No.3 - Saigon S/S	1.0	ACSR 795 MCM
Saigon - Cat Lai	11.0	ACSR 795 MCM
Cat Lai - Xa Lo 1	3.2	ACSR 795 MCM
Cat Lai - Chanh Hung	9.3	ACSR 795 MCM
Saigon - Xa Lo 2	13.8	ACSR 795 MCM
Xa Loi - Hung Vuong	6.4	ACSR 795 MCM
Hung Vuong - Cholon	3.1	ACSR 795 MCM
Cholon - Chanh Hung	7.1	ACSR 795 MCM
Saigon - Dong Nai	15.5	ACSR 185 mm^2
Dong Nai - Vicasa	1.3	ACSR 147 mm^2
Saigon - Phu Hoa Dong	34.0	ACSR 336 MCM
Phu Hoa Dong - Trang Bang	23.0	ACSR 336 MCM
Trang Bang - Tay Ninh	46.0	ACSR 336 MCM

Line Section	Circuit - km	Power Conductor
Cholon - My Tho	60.0	ACSR 147 mm^2
My Tho - Go Cong	35.0	ACSR 147 mm^2
My Tho - Cai Lay	25.3	ACSR 147 mm^2
My Tho - Ben Tre	18.0	ACSR 185 mm^2
Tra Noc - Can Tho	14.6	ACSR 160 mm^2
Tra Noc - Soc Trang	83.5	ACSR 185 mm^2
Soc Trang - Bac Lieu	55.0	ACSR 185 mm^2
Bac Lieu - Ca Mau	70.0	ACSR 185 mm^2
Tra Noc - Sadec	31.6	ACSR 160 mm^2
Sadec - Vinh Long	23.4	ACSR 160 mm^2
Vinh Long - Tra Vinh	64.2	ACSR 185 mm^2
Da Nhim - Thap Cham	41.3	ACSR 336 MCM
Thap Cham - Cam Ranh 1	30.2	ACSR 336 MCM
Thap Cham - Phan Thiet	137.0	ACSR 185 mm^2
Vinh Long - My Thuan	3.4	ACSR 400 mm^2
My Thuan - Cao Lanh	30.5	ACSR 185 mm^2
Cao Lanh - An long		ACSR 185 mm^2
Nha Be - An Nghia	24.9	ACSR 185 mm^2
Total	953.1	

(Source : Institute of Energy)

(2) Substation Facilities

(MVA)

Voltage	Country	PC-1	PC-2	PC-3
230 kV & 220 kV	2,976	1,376	1,294	126
110 kV	2,992	1,885	902	205
66 kV	638	-	632	6
35 kV - 6 kV	2,208	2,000	81	127
Low Tension Network	5,587	2,907	2,131	549

(Source : Institute of Energy)

(Details of PC-2's Facilities)

Substation	Voltage (kV)	Transformer (MVA)
230kV & 220 kV Substation		
Saigon	230/66/11	2 x 3 x 28
Tra Noc	220/110/66	1 x 100
Hoc Mon	220/110/10	2 x 125
Long Binh	220/110/10	2 x 125
Tri An	220/110/6	1 x 63
Bao Loc	220/35	1 x 25
Da Nhim	220/110/10	1 x 63
Total		919
110 kV Substation		
Ho Xa	110/15/10	2 x 40
Cholon	110/15/10	2 x 40
Ba Queo	110/15/10	2 x 40

Substation	Voltage (kV)	Transformer (MVA)
Long Binh	110/15/10	1 x 40
Bien Hoa	110/15/10	1 x 40
Binh Trieu	110/15/10	1 x 40
Vung Tau	110/15/10	1 x 40
Phan Lan (L. Thanh)	110/6	1 x 10
Xuan Loc	110/35/10	1 x 16
Dong Xoai	110/35/10	1 x 16
Chau Doc	110/35/10	1 x 16
Long Xuyen	110/15	2 x 11.5
Rach Gia	110/15	1 x 11.5
Kien Luong	110/6	2 x 30
Chung Su	110/35	1 x 20
Total		572.5
66 kV Substation		
Saigon	66/15	2 x 20
Xa Lo	66/15	20 + 33
Hung Vuong	66/15	1 x 33
Chanh Hung	66/15	2 x 30
Viet Thanh	66/15	1 x 33
Phu Hoa Dong	66/15	1 x 10
Binh Chanh	66/15	1 x 5
An Nghia	66/15	1 x 2
Go Dau	66/15	1 x 20
Trang Bang	66/15	1 x 10
Tay Ninh	66/15	1 x 15
Vicasa	66/15	1 x 12.5
Dong Nai	66/15	1 x 33
Tan Mai	66/15	20 + 25
Dalat	66/6	1 x 12
Thap Cham	66/15	1 x 12
Ninh Son	66/15	1 x 1
Phan Ri	66/15	1 x 1
Phan Thiet	66/15	1 x 10
Ben Luc	66/15	1 x 6.25
Tan An	66/15	1 x 12.5
My Tho	66/15	1 x 20
Go Cong	66/15	2 x 2
Cai Lay	66/15	1 x 10
My Thuan	66/15	1 x 2
Cao lanh	66/15	1 x 10
Sadec	66/15	1 x 15
Ben Tre	66/15	1 x 10
Can Tho	66/15	1 x 20
Binh Thuy	66/15	1 x 6
Vinh Long	66/15	1 x 20
Soc Trang	66/15	1 x 10
Tra Vinh	66/15	1 x 10
Bac Lieu	66/15	1 x 6
Ca Mau	66/15	1 x 12.5
Thoi Son	66/15	1 x 0.5
Total		549.25

(Source : PC-2, Energy Center)

Table 2.3 Generation Record (1986 - 1994)

(GWh)

	1986	1987	1988	1989	1990	1991	1992	1993	1994
Country									
Generation	5,525	6,050	6,784	7,792	8,678	9,152	9,652	10,661	12,200
Growth Rate (%)	-	9.50	12.13	14.86	11.37	5.46	5.46	10.55	14.44
Hydropower	1,400	1,373	1,785	3,825	5,369	6,317	7,228	7,965	8,872
Growth Rate (%)	-	-1.93	30.00	114.28	40.37	17.66	14.42	10.20	11.39
Thermal	3,656	4,174	4,433	3,662	2,841	2,425	1,887	1,776	2,248
Growth Rate (%)	-	14.17	6.20	-17.39	-22.42	-14.64	-22.18	-5.88	26.58
Diesel/Gas	469	498	566	505	468	411	537	920	1,080
Growth Rate (%)	-	6.18	13.65	-10.78	-7.33	-12.18	30.66	75.60	17.39
PC-1									
Generation	3,237	3,537	3,873	4,359	4,869	5,122	5,415	5,750	7,147
Growth Rate (%)	-	9.27	9.50	12.55	11.70	5.20	5.72	6.20	24.30
Hydropower	487	355	293	1,590	2,859	3,710	4,549	5,090	5,834
Growth Rate (%)	-	- 27.10	- 17.46	442.66	79.81	29.77	22.61	11.89	14.62
Thermal	2,684	3,108	3,439	2,723	2,000	1,365	851	637	1,288
Growth Rate (%)	-	15.80	10.65	- 20.82	- 26.55	- 31.75	- 37.66	- 25.15	102.20
Diesel/Gas	75	74	141	46	12	47	15	23	25
Growth Rate (%)	-	0	90.54	- 67.38	- 73.91	291.67	- 68.09	53.33	8.70
PC-2									
Generation	2,026	2,239	2,592	3,069	3,453	3,793	4,013	4,662	4,800
Growth Rate (%)	-	10.51	15.76	18.40	12.51	9.85	5.80	16.19	2.96
Hydropower	903	998	1,489	2,226	2,484	2,550	2,619	2,807	2,930
Growth Rate (%)	-	10.52	49.20	49.50	11.59	2.66	2.71	7.18	4.38
Thermal	972	1.071	994	740	841	1,059	1,036	1,139	960
Growth Rate (%)	-	10.19	- 7.19	- 25.55	13.65	25.92	- 2.17	9.94	-15.72
Diesel/Gas	151	170	109	103	128	184	358	716	910
Growth Rate (%)	-	12.58	- 35.88	- 0.55	24.27	43.75	94.57	100.00	27.09
PC-3									
Generation	262	274	319	365	357	237	225	249	253
Growth Rate (%)	-	4.58	16.42	14.42	- 2.19	- 33.61	- 5.06	10.67	1.61
From PC-1	-	-	-	-	68	261	350	443	552
Growth Rate (%)	-	-	-	-	-	283.82	34.1	26.57	24.60
From PC-2	81	92	111	120	138	142	145	159	220
Growth Rate (%)	-	13.58	20.65	8.11	15.00	2.90	2.11	9.66	38.36

(Source : Institute of Energy)

Table 2.4 Electricity Consumption (1986-1994)

Unit : GWh

	1986	1987	1988	1989	1990	1991	1992	1993	1994	Average Annual Growth (%)
Country										
Industry (GWh)	2,197	2,384	2,590	2,622	2,845	3,080	3,197	3,477	3,904	8.6
Agriculture *1 (GWh)	332	387	441	463	587	806	975	1,147	1,336	19.0
Household (GWh)	1,101	1,244	1,356	1,882	2,035	2,052	2,153	2,518	3,019	13.4
Others *2 (GWh)	521	585	639	698	718	645	604	697	823	5.9
Sales (GWh)	4,151	4,600	5,026	5,665	6,185	6,583	6,929	7,839	9,082	10.3
Losses (GWh)	1,374	1,450	1,758	2,127	2,493	2,569	2,723	2,822	3,118	10.8
Total Consumption	5,525	6,050	6,784	7,792	8,678	9,152	9,652	10,661	12,200	10.4
Max. Load (MW)								2,162		
PC-1										
Industry (GWh)	1,244	1,344	1,465	1,385	1,468	1,445	1,466	1,514	1,513	2.5
Agriculture 1* (GWh)	263	308	344	355	467	672	827	979	1,124	19.9
Household (GWh)	520	611	646	979	856	885	898	995	1,172	10.7
Others *2 (GWh)	358	370	370	380	371	288	232	226	251	-4.3
Sales (GWh)	2,385	2,633	2,825	2,999	3,162	3,290	3,423	3,714	4,060	6.9
Losses (GWh)	852	904	1,048	1,360	1,639	1,571	1,642	1,593	1,625	8.4
Total Consumption	3,237	3,537	3,873	4,359	4,801	4,861	5,065	5,310	5,685	7.3
Transfer to PC-3	-	-	-	-	68	261	350	441		
Peak Load (MW)	591	598	707	827	878	991	1,050	1,080		
PC-2										
Industry (GWh)	820	895	959	1,055	1,198	1,448	1,535	1,740	2,133	12.7
Agriculture *1 (GWh)	35	42	52	66	71	79	87	95	125	17.2
Household (GWh)	493	540	607	869	1,017	992	1,036	1,260	1,520	15.1
Others *2 (GWh)	129	181	231	278	303	305	316	392	480	17.9
Sales (GWh)	1,477	1,658	1,849	2,268	2,589	2,824	2,973	3,487	4,258	14.2
Losses (GWh)	468	489	632	681	724	831	895	1,016	1,232	12.9
Total Consumption	1,945	2,147	2,481	2,949	3,313	3,655	3,868	4,507	5,490	13.8
Transfer to PC-3	81	92	111	120	138	142	145	161	210	12.6
Peak Load (MW)	339	390	481	580	647	711	790	870		
PC-3										
Industry (GWh)	133	145	166	182	179	187	196	224	258	8.6
Agriculture *1 (GWh)	34	37	45	42	49	55	61	73	87	12.5
Household (GWh)	88	93	103	134	162	175	220	263	327	17.8
Others *2 (GWh)	34	34	38	40	44	52	58	78	92	13.3
Sales (GWh)	289	309	352	398	434	469	535	638	764	12.9
Losses (GWh)	54	57	78	87	129	171	185	213	261	21.8
Total Consumption	343	366	430	485	563	640	720	849	1,025	14.7
Peak Load (MW)								212		

(Source : Institute of Energy)

(*1) including households in villages
(*2) including nonindustrial, tansportation, and commercial loads

Table 2.5 Demand Forecast

	1995	2000		2005		2010	
	Planned	High	Base	High	Base	High	Base
PC-1							
1. Consumption (GWh)	4,440	8,362	7,948	13,825	12,783	23,763	21,281
Industry	1,595	3,872	3,757	7,661	7,099	15,160	13,413
Agriculture	1,269	403	388	530	510	697	670
Services	270	513	513	949	949	1,755	1,755
Domestic	1,306	3,574	3,290	4,685	4,225	6,151	5,443
2. E	1,340	2,025	1,793	2,594	2,399	3,240	2,902
nergy Loss (GWh)							
3. Energy Required (GWh)	5,780	10,387	9,741	16,419	15,182	27,003	24,183
4. Peak Demand (MW)	1,100	1,907	1,744	2,840	2,626	4,533	4,060
PC-2							
1.Consumption (GWh)	5,254	11,056	10,395	20,011	18,615	37,118	34,249
Industry	2,674	6,547	6,137	13,169	12,344	26,485	24,829
Agriculture	160	139	137	175	175	223	223
Services	600	1,145	1,100	2,192	2,006	4,197	3,657
Domestic	1,820	3,225	3,021	4,475	4,090	6,213	5,540
2. Energy Loss (GWh)	1,478	2,493	2,266	3,670	3,414	5,061	4,669
3. Energy Required (GWh)	6,732	13,549	12,661	23,681	22,029	42,179	38,918
4. Peak Demand (MW)	1,200	2,343	2,190	4,035	3,753	7,081	6,534
PC-3							
1.Consumption (GWh)	943.7	1,710	1,618	3,011	2,718	5,284	4,624
Industry	319	557	523	1,060	902	2,019	1,554
Agriculture	104	103	103	138	138	185	185
Services	117	197	197	417	417	881	881
Domestic	403	853	795	1,396	1,261	2,202	2,004
2. Energy Loss (GWh)	295	401	391	601	565	734	642
3. Energy Required (GWh)	1,238.7	2,111	2,009	3,612	3,283	6,021	5,266
4. Peak Demand (MW)	277	455	432	723	658	1.146	1,002
Country (Total of 3 PCs)							
1.Consumption (GWh)	10,637	21,128	19,961	36,847	34,116	66,168	60,154
Industry	4,588	10,976	10,417	21,890	20,345	43,664	39,796
Agriculture	1,533	645	628	843	823	1,105	1,078
Services	1,810	2,320	1,855	3,558	3,372	6,833	6,293
Domestic	3,529	7,652	7,106	10,556	9,576	14,566	12,987
2. Energy Loss (GWh)	3,113	4,919	4,450	6,865	6,378	9,035	8,213
3. Energy Required (GWh)	13,750	26,047	24,411	43,712	40,494	75,203	68,367

(Source: Institute of Energy)

Table 2.6 Power Balance of Each Power Company (high scenario)

	1995	1996	1997	1998	1999	2000	2005	2010
PC-1								
Maximum Demand (MW)	1081	1210	1353	1514	1693	1894	2820	4501
To PC-2 and PC-3 (MW)	507	426	336	181	300	423	218	717
Reservation (MW)	250	250	300	300	300	300	500	700
Maximum Power Required (MW)	1838	1886	1989	1995	2293	2617	3538	5918
Suppliable Power (MW)	2628	2628	2628	2628	2928	3228	3878	6278
Power Balance (MW)*1	790	742	639	633	635	611	340	360
PC-2								
Maximum Demand (MW)	1220	1400	1607	1844	2116	2428	3954	6939
Reservation (MW)	300	300	350	350	400	400	600	800
Maximum Power Required (MW)	1520	1700	1957	2194	2516	2828	4554	7739
Trade with PC-1/PC-3 (MW)	293	179	56	-74	282	571	424	779
Suppliable Power (MW)	1268	1300	1712	2012	2212	2522	4144	6844
Maximum Possible Supply (MW)	1561	1479	1768	1938	2494	3093	4568	7623
Power Balance (MW)*1	41	-221	-189	-256	-22	265	14	-116
PC-3								
Maximum Demand (MW)	275	313	356	404	460	523	718	1138
Power from PC-1 & PC-2 (MW)	175	218	261	249	-5	-186	-229	-120
Suppliable Power (MW)	135	135	135	205	515	875	1560	1560
Power Balance (MW)*1	35	40	40	50	50	166	613	302

(Source : Institute of Energy)

Note : (+) surplus, (-) shortage

Table 2.7 Power Balance of PC-2 (high growth scenario)

	1995	1996	1997	1998	1999	2000	2005	2010
Maximum Demand (MW)	1220	1400	1607	1844	2116	2428	3954	6939
Suppliable Power (MW)	1561	1479	1768	1938	2494	3093	4568	7623
(Hydro)-Da Nhim	(160)	(160)	(160)	(160)	(160)	(160)	(160)	(160)
(Hydro)-Tri An	(400)	(400)	(400)	(400)	(400)	(400)	(400)	(400)
(Hydro)-Thac Mo	(150)	(150)	(150)	(150)	(150)	(150)	(150)	(150)
(Hydro)-Ham Thuan, Da Mi	-	-	-	-	-	-	(472)	(472)
(Hydro)-Dai Ninh	-	-	-	-	-	-	(300)	(300)
(Hydro)-Subtotal	(710)	(710)	(710)	(710)	(710)	(710)	(1482)	(1482)
(Thermal)-Thu Duc	(156)	(156)	(156)	(156)	(156)	(156)	(156)	(156)
(Thermal)-Can Tho Cogido	(38)	(38)	(38)	(38)	(38)	(38)	(38)	(38)
(Thermal)-Phu My	-	-	-	-	(200)	(600)	(600)	(600)
(Gas & Comb.)-New Thu Duc	-	-	-	-	(64)	(64)	(64)	(64)
(Gas & Comb.)-Ba Ria - Old	(30)	(30)	(30)	(30)	(30)	-	-	-
(Gas & Comb.) New Ba Ria	(160)	(192)	(304)	(304)	(304)	(304)	(304)	(304)
(Gas & Comb.)-New	-	-	(300)	(600)	(600)	(600)	(1500)	(3600)
(Gas)-New	-	-	-	-	-	-	-	(600)
(Diesel)-Total	(174)	(174)	(174)	(174)	(110)	(50)	-	-
(Thermal)-Subtotal	(558)	(590)	(1002)	(1302)	(1502)	(1812)	(2662)	(5362)
(500kV Delivery)	293	179	56	-74	282	571	424	779
Reservation Needed (MW)	300	300	350	350	400	400	600	800
Power Balance (MW) *1	41	-221	-189	-256	-22	265	14	-116

(Source : Institute of Energy)

*1 : (+) : surplus, (-) : shortage

Table 2.8 Energy Balance of PC-2 (high growth scenario)

	1995	1996	1997	1998	1999	2000	2005	2010
Maximum Demand (GWh)	(6770)	(7865)	(9138)	(10616)	(12333)	(14328)	(23681)	(42179)
Suppliable Energy (GWh)								
(Hydro)-Da Nhim	(1061)	(1061)	(1061)	(1061)	(1061)	(1061)	(1061)	(1061)
(Hydro)-Tri An	(1640)	(1640)	(1640)	(1640)	(1640)	(1640)	(1640)	(1640)
(Hydro)-Thac Mo	(604)	(604)	(604)	(604)	(604)	(604)	(604)	(604)
(Hydro)-Ham Thuan, Da Mi	-	-	-	-	-	-	(1550)	(1550)
(Hydro)-Dai Ninh	-	-	-	-	-	-	(1218)	(1218)
(Hydro)-Subtotal	(3305)	(3305)	(3305)	(3305)	(3305)	(3305)	(6073)	(6073)
(Thermal)-Thu Duc	(364)	(740)	(782)	(792)	(490)	(350)	(350)	(350)
(Thermal)-Can Tho	(104)	(146)	(177)	(189)	(120)	(132)	(132)	(80)
(Thermal)-Phu My	-	-	-	(133)	(1428)	(2205)	(2593)	(2399)
(Gas & Comb.) - New Thu Duc.	-	(47)	(125)	(289)	(121)	(103)	(100)	(73)
(Gas & Comb.) - Ba Ria-Old	(73)	(110)	(91)	(88)	(56)	-	-	-
(Gas & Comb.) - New Ba Ria	(840)	(1022)	(1988)	(1997)	(1200)	(701)	(780)	(755)
(Gas & Comb.) -New	-	-	(772)	(2540)	(3197)	(2692)	(7774)	(24192)
(Gas)-New	-	-	-	-	-	-	-	(344)
(Diesel)-Total	(123)	(134)	(111)	(217)	(40)	(40)	(0)	(0)
(Thermal) - Subtotal	(1504)	(2199)	(4046)	(6245)	(6652)	(6223)	(11729)	(28193)
(500kV Delivery)	(1961)	(2361)	(1787)	(1066)	(2376)	(4800)	(5879)	(7913)

(Sorce : Institule of Energy)

BOARD OF MANAGEMENT

TRADE UNION

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1. General service Dept.
2. Planning Dept.
3. Personnel Dept.
4. External Economic Activities
5. Investigation & Security Dept.
6. Technical Dept.
7. Occupational Safety Dept.
8. Construction Project Dept.
9. Logistics Dept.
10. Accounting &Finance Dept.
11. Statistics Dept.
12. Commercial Dept.
13. Public Relations

POWER PLANTS

14. Thu Duc Thermal P/P.
15. Can Tho Thermal P/P.
16. Da Nhim Hydro P/P.
17. Tri An Hydro P/P.
18. Cho Quan Diesel P/P.

19. Transmission Dept.

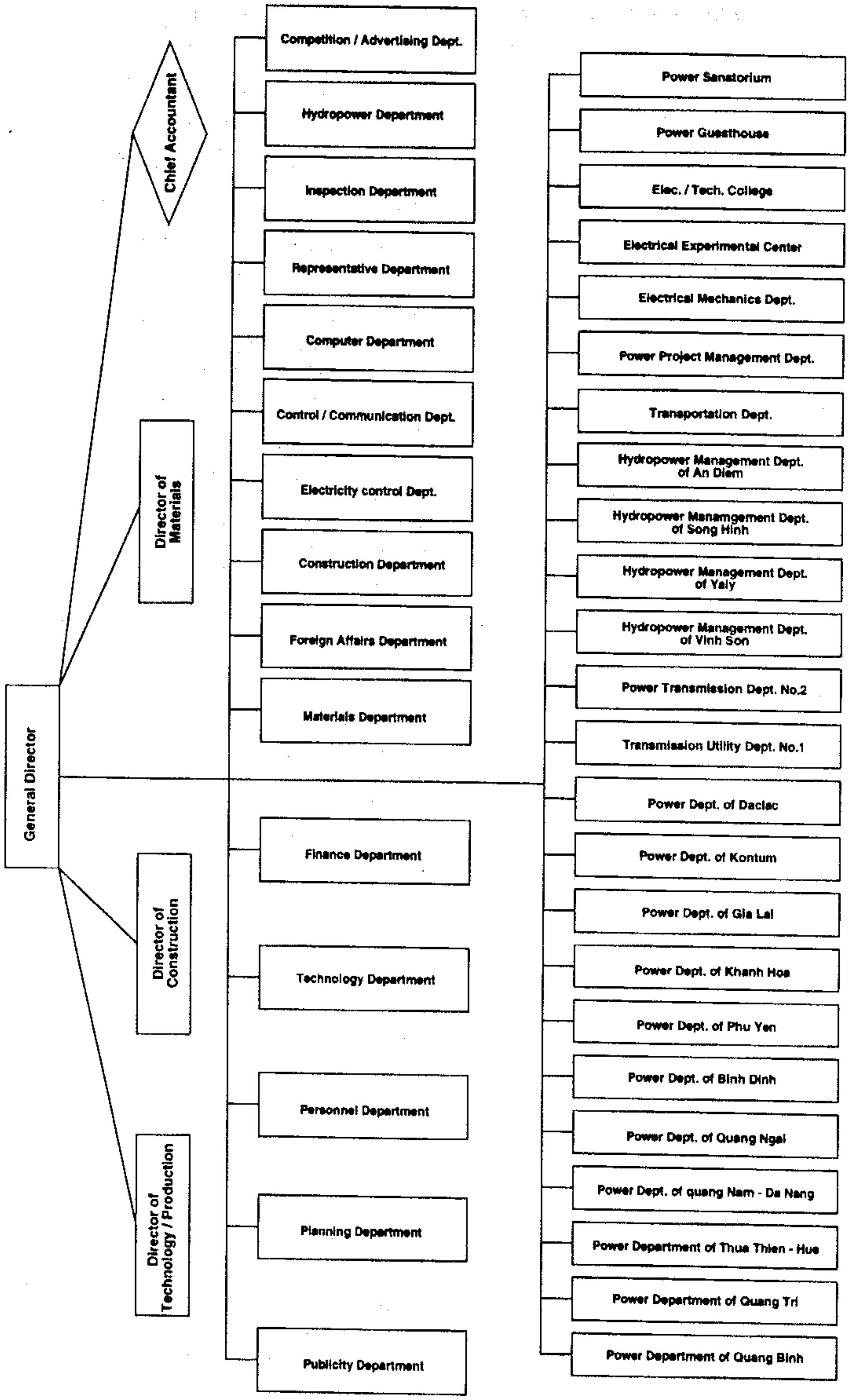
DISTRIBUTION DEPARTMENTS

20. Ho Chi Minh Region
21. Dong Nai Region
22. Ninh Thuan Region
23. Binh Thuan Region
24. Lam Dong Region
25. Song Be Region
26. Tay Ninh Region
27. Ba Ria Vung Tau Region
28. Long An Region
29. Vinh Long Region
30. Tra Vinh Region
31. Dong Thap Region
32. An Giang Region
33. Can Tho Region
34. Soc Trang Region
35. Ben Tre Region
36. Tien Giang Region
37. Minh Hai Region
38. Kien Giang Region

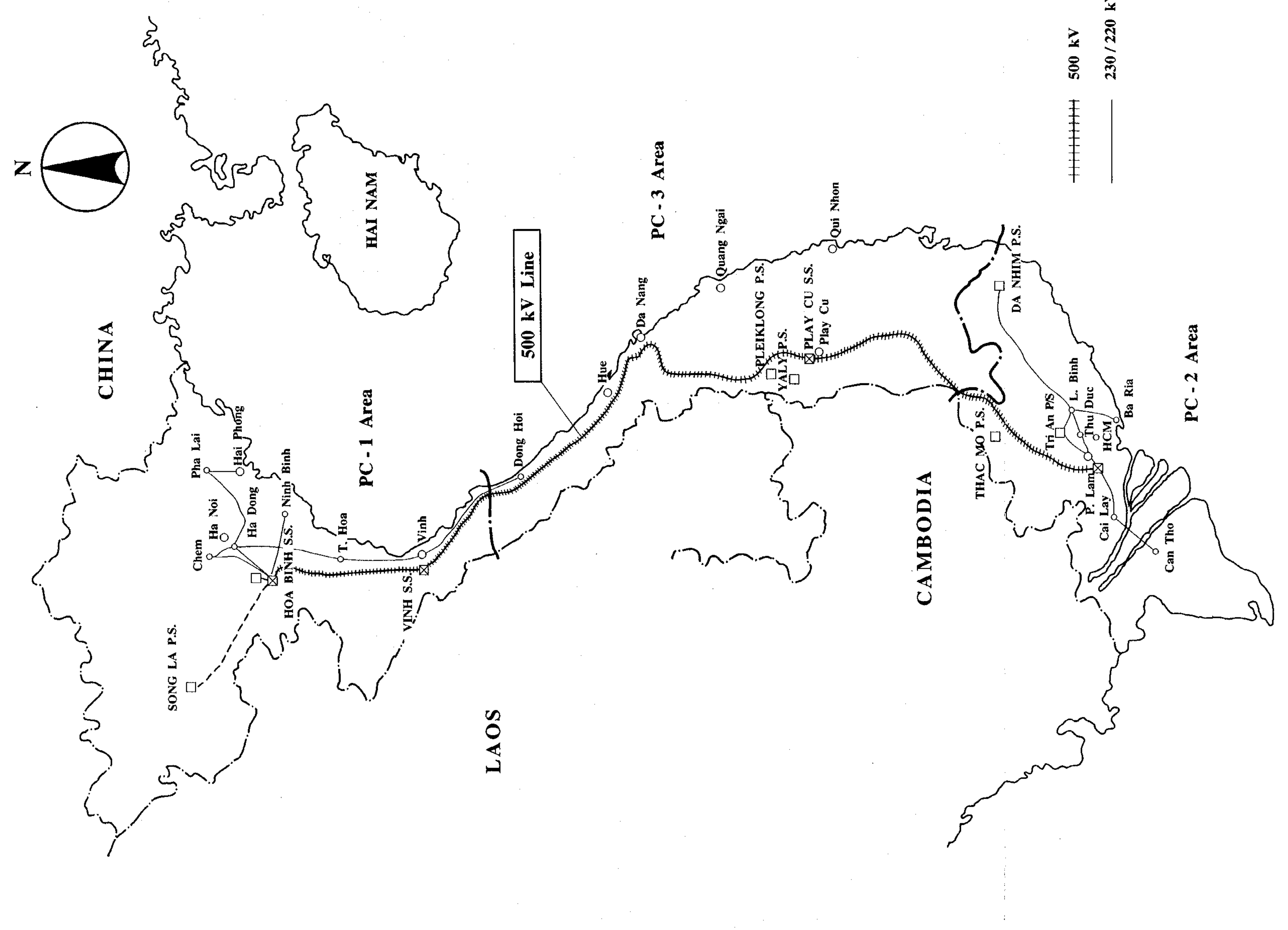
SUBSIDIARIES

39. Electrical Testing Center
40. Power System Control Center
41. Energy Center
42. Data Processing Center
43. Network Construction Division
44. Transportation and Warehouse Division
45. Central Workshop
46. Technical College
47. Ham Thuan/Thac Mo Project Management
48. Power Project Management

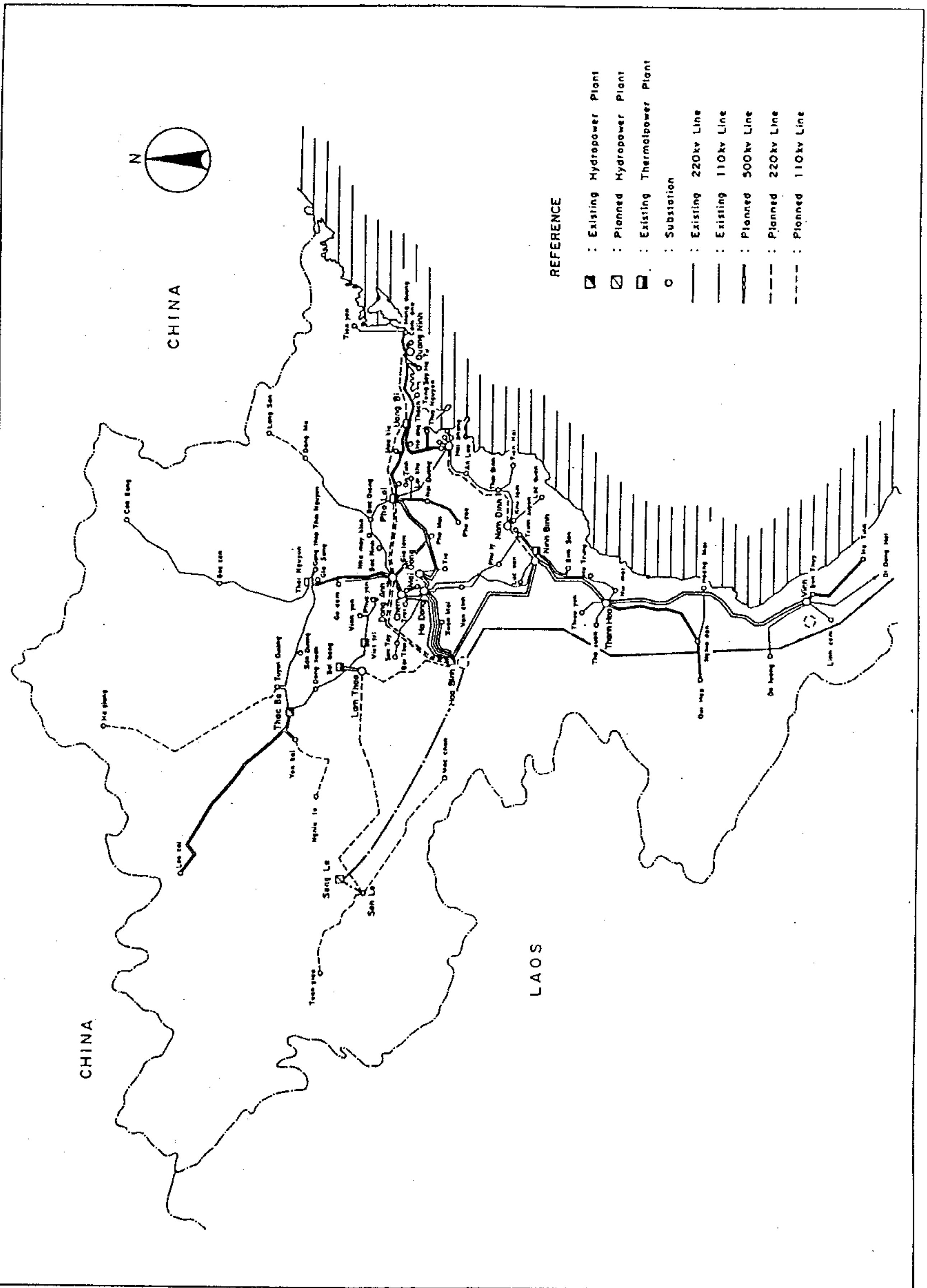
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.1 Organization Chart of PC-2



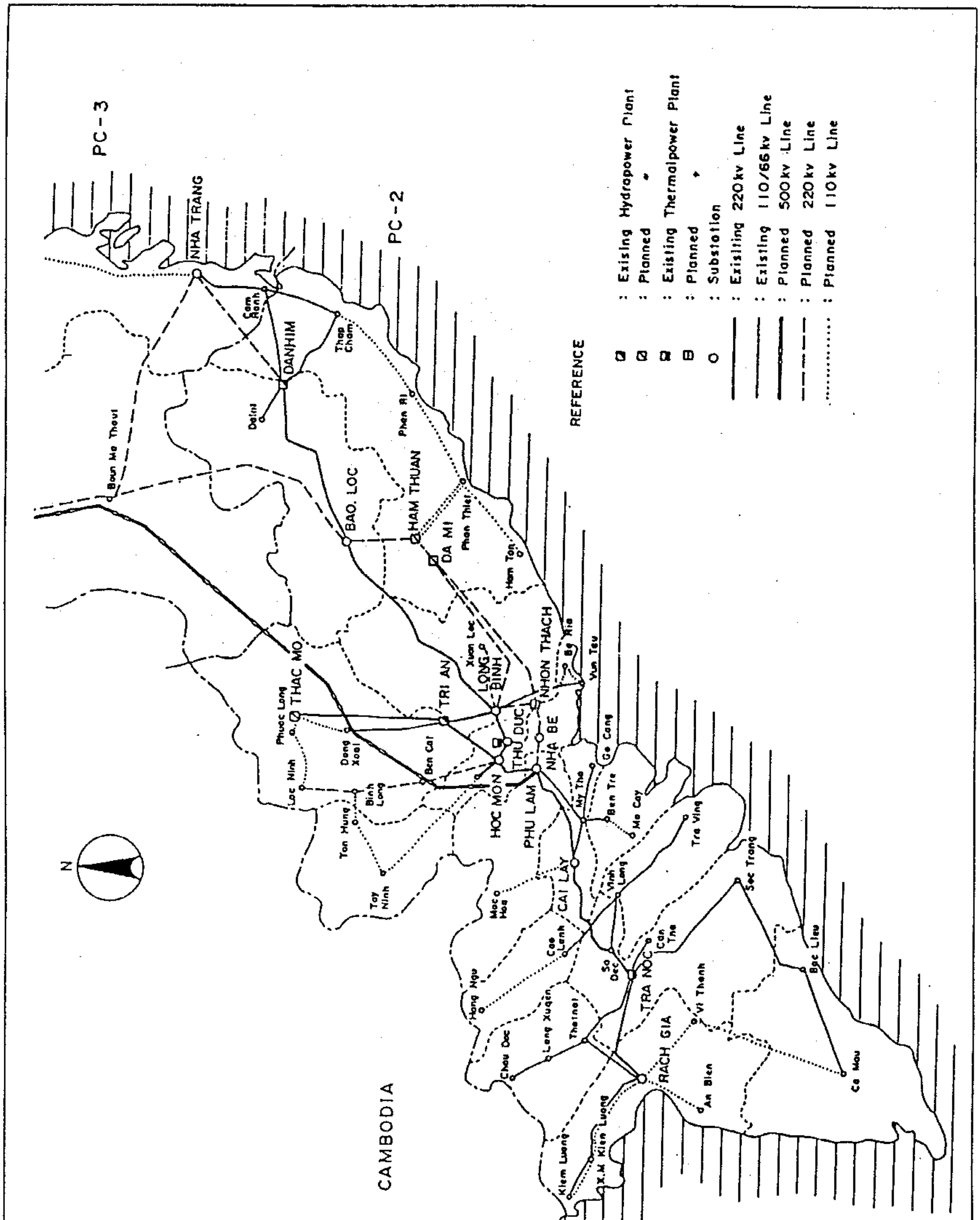
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.2 Organization Chart of PC-3



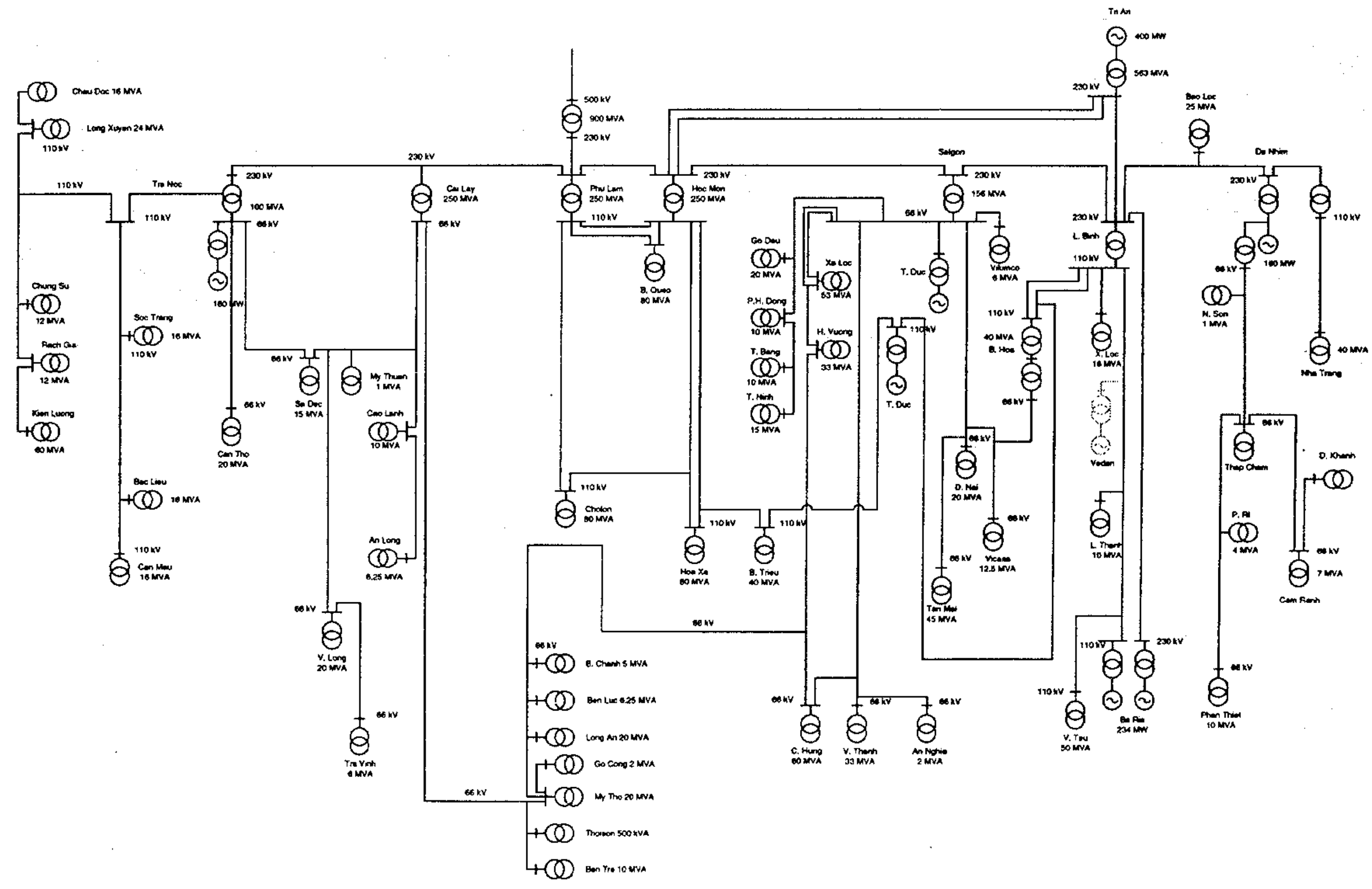
FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.3 Major Power System in Country



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.4 Major Power System in PC-1 Region



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.5 (1) Major Power System in PC-2 Region

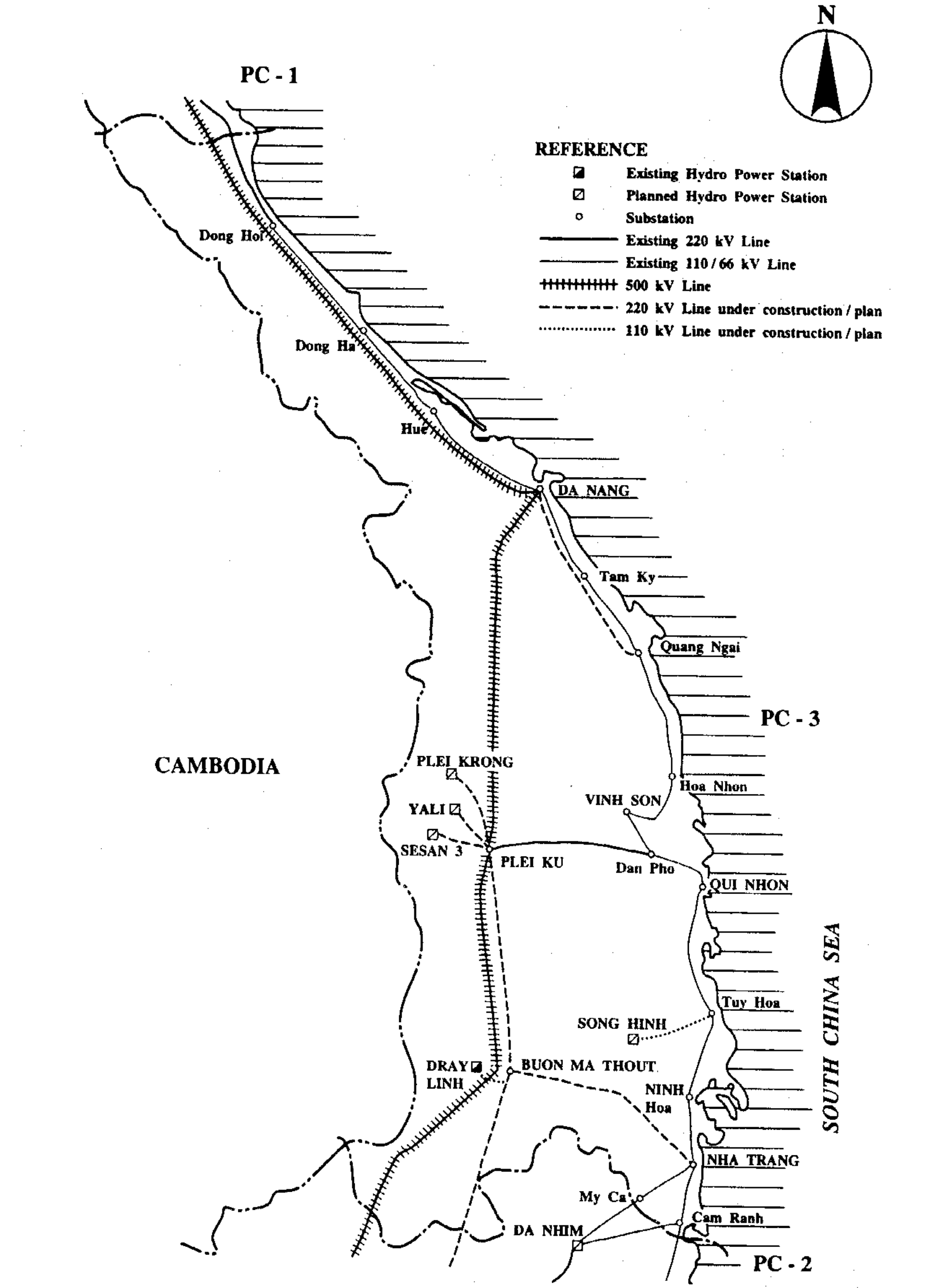


FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM

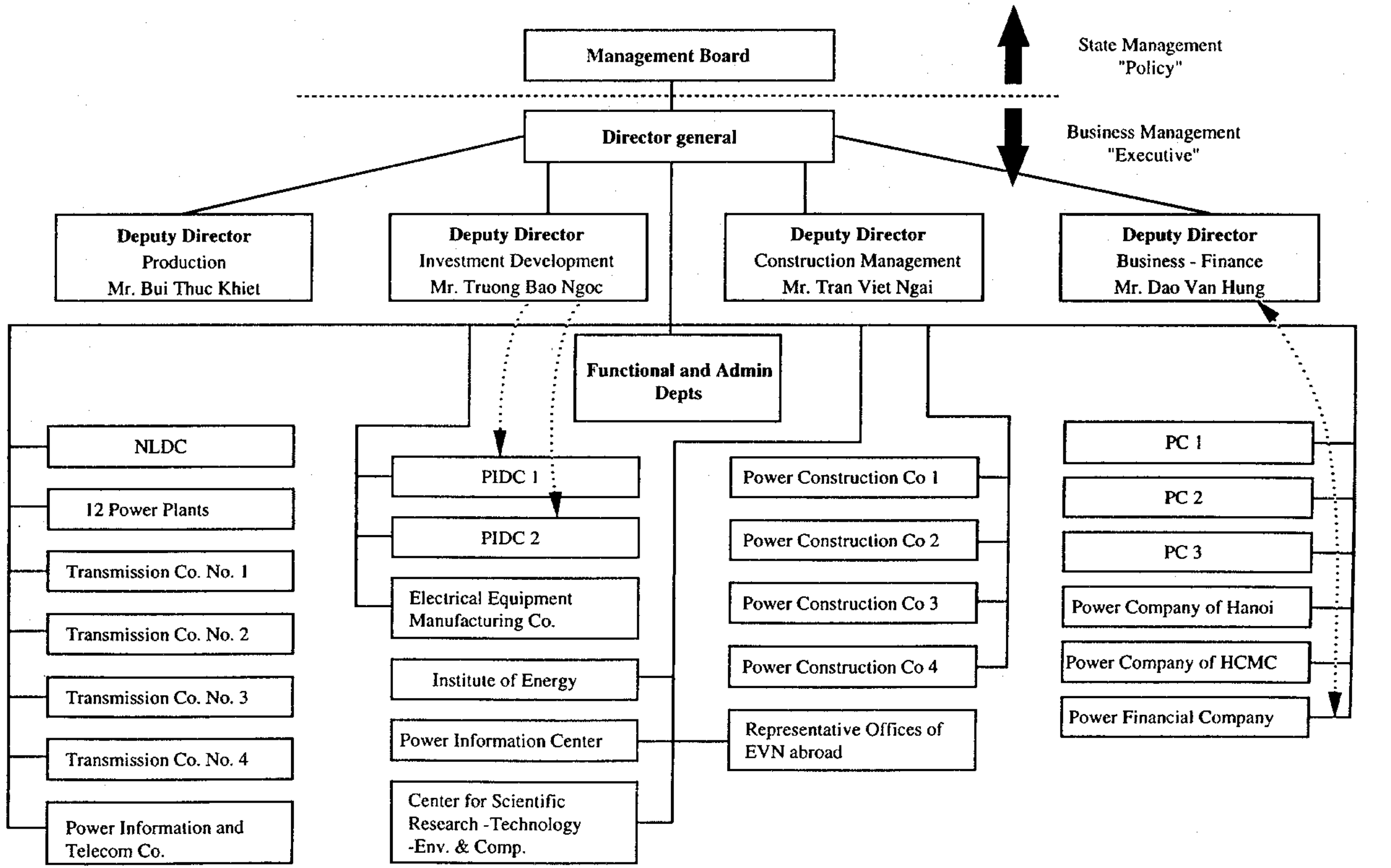
MINISTRY OF ENERGY

JAPAN INTERNATIONAL COOPERATION AGENCY

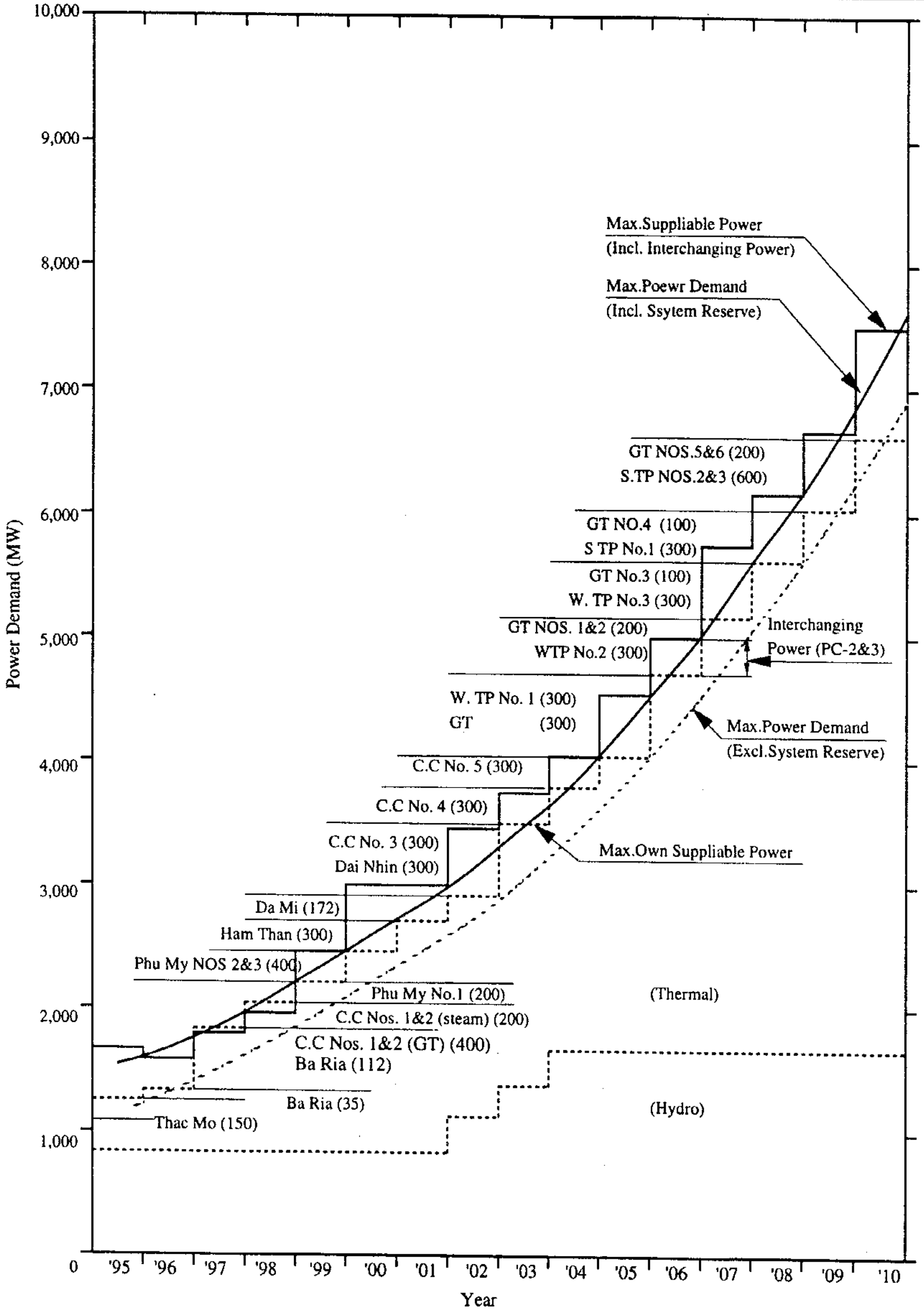
Figure 2.5 (2)
Single Line Diagram of PC-2 System



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.6 Major Power System in PC-3 Region



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.7 General Company of Electricity of Vietnam (EVN)



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 2.8 Power Balance in South Power System (High Growth Senario)

CHAPTER 3

WATER TURBINE AND ANCILLARY FACILITIES

CHAPTER 3 WATER TURBINE AND ANCILLARY FACILITIES

3.1 Approach and Results of Study

This clause covers ways of approach, procedure and results of the field investigation of the Study Team to the water turbines and ancillary facilities.

Ratings of the existing turbines are as follow;

Number of Units	:	4
Type and Form	:	HP-1R2N
Rated Output	:	42,000 kW
Rated Net head	:	720 m
Rated Flow	:	6.65 cub m/s
Normal Speed	:	500 rpm
Runaway Speed	:	920 rpm
Standard	:	JEC 151 (1960)
Manufacturer	:	Tokyo Shibaura Electric Co., Ltd.
Year of Manufacture	:	1962 and 1963

3.1.1 Field Investigation

Prior to the field investigation, the Study Team explained to PC-2 the way of approach of the investigation, its procedure and results of the preliminary study on the basis of the descriptions in the Inception Report.

The field investigation was conducted by the Study Team in cooperation with the counterpart personnel from the maintenance and workshop group of the PC-2 Da Nhim hydropower station.

Major items of the turbines were inspected during the periods of dewatering of penstocks. The dewatering was scheduled in a very short period taking account of the present tight power supply situation in the country. The allowed dewatering periods were as below;

- Pressure tunnel between the intake and the penstock valves was scheduled for dewatering 3 days on July 18, 19 and 20, 1994, but actually it was for only 1.5 days on July 18 and 19 (half day).
- No.1 penstock line (right line) for No.1 and No.2 turbine and generator units; 14 days from July 18 to July 31, 1994.

- No.2 penstock line (left line) for No.3 and No.4 turbine and generator units; 14 days from August 1 to August 14, 1994.

(1) Scope of investigation

Prior to the actual field investigation, the Study Team and the PC-2 counterpart had discussed in the frequent meetings and agreed on the following main inspection items through the site examination on the facilities. Disassembling of the turbines under the dewatering condition was tried to be minimized by the efficient inspection work in the limited period.

1) Running condition of facilities

- measurement of vibration and noise level
- visual inspection (hereinafter referred to as VT) of each unit
- VT of auxiliary equipment including governors

2) Turbine and inlet valve

- VT of housing
- VT of needles and nozzle tips
- VT of nozzles
- VT of inlet valves
- VT of water supply pipes

3) Auxiliary equipment

- VT of governors
- VT of deflector servomotors
- VT of control cabinets
- VT of oil pump sets
- VT of air compressor system
- VT of inlet valve control cabinets
- VT of water supply system
- VT of instrument and others

4) Nondestructive examination of bucket

- VT of buckets
- liquid penetrant examination (hereinafter referred to as PT) of buckets

- magnetic particle examination (hereinafter referred to as MT) of buckets
- ultrasonic examination (hereinafter referred to as UT) of buckets
- micro structure observation (hereinafter referred to as SUMP) of buckets

(2) Procedure of investigation

The PC-2's counterparts and the Study Team's members of each working group for civil work and building, metal work, turbine, generator, control system, switchgear and communication equipment had daily and weekly meetings for mutual understanding on inspection carried out, inspection schedule, safety measure taken, assignment schedule of the counterparts, etc., and also for transfer of knowledge.

Each unit of turbines in the running condition was investigated measuring of vibration and noise level (scale A) on loads varied from 40% to 100% in 20% step before and after disassembling the turbines for the comparative examination.

Main parts of the running turbines, governors, and other control system were also investigated.

Following safety measures were applied through the investigation period.

i) Provision of scaffolds and steps around the turbines and inside the housing
ii) Provision of cover to the anticipated parts to prevent scattering of liquid during nondestructive examination
iii) Use of goggle and mask by both engineers and technicians
iv) Performance of inlet valve operation test in combination with the penstock investigation schedule
v) Provision of safety ropes and tapes around the energized parts & testing area

The Study Team conducted the investigation to the facilities with the following procedure.

i) Hearing from and confirmation with the counterparts of the records of maintenance, repairing process about damages, used materials for the repair, number of the replaced parts, materials locally procured, and others

ii) Investigation of operational condition of turbines under normal running and starting or stopping conditions

iii) Inspection of the storaged spare parts, materials, and tools for maintenance of the turbines

iv) Investigation of the damaged and incomplete repaired parts of the facilities , and confirmation on the parts to be urgently rectified

v) Discussion with the counterparts about materials to be urgently procured on the basis of the list provided by the Da Nhim maintenance and workshop group

vii) Examination the malfunctional instrument and relays

viii) Hearing from and discussion with the counterparts about maintenance manuals, check list and task sheet for maintenance

ix) Examination on the records of maintenance and operation

3.1.2 Results of Field Investigation

This clause states the results of the Study Team's investigation to the existing facilities. The Study Team observed that the turbines and their related facilities have been generally well operated and maintained by all the working staffs of the power station.

Meanwhile, the Study Team observed at the same time a lot of parts and materials seriously damaged on the facilities. Those damaged portions may shorten the life of the facilities. Followings are such damaged portions found out during the investigation.

i) Erosion and damage due to high water pressure
ii) Wear and tear due to continuos movement or revolution for a long period
iii) Repeated repair at the same portion
iv) Reduction of capacity on the oil pressure pump, air compressor and cooling water pumps due to the leakage or worn out
v) Excessive water leakage from a balance piston of the upper needle servomotor at the full load running time of No.1 unit. The damage on the shaft was repaired during this investigation period.
vi) Malfunctioned instrument and control device such as oil level control of oil pressure system

(1) Noise level and vibration

Noise level and vibration were measured twice. The first measurement was carried out in the original operation before shut down of the turbines and the second measurement was done in the normal operation after reassembly of the turbines.

1) Noise level

Noise level of each unit was measured as 109 db, 107 db, 107 db and 110 db in unit No.1, No.2, No.3 and No.4 respectively at four (4) units full load operation. Difference of noise levels among four units, is little and the noise of No.2 unit did not indicate high level against the pre-information.

2) Vibration

High vibration was measured at the top and both sides (point 1, 2 and 5 on Figure 3.1) of the upper housing of all units. Maximum measured vibration at each unit reaches 0.5 mm, 1.0 mm, 0.9 mm and 0.6 mm on the top and upper parts of the housing for unit No.1, No.2, No.3 and No.4, respectively.

Tables 3.1 and 3.2 and Figure 3.1 show the detailed measurement of noise level and vibration of each turbine.

(2) Turbine and inlet valve

1) Runner bucket

The runner buckets have been maintained well, but cavitation erosion and a lot of damages were found out by nondestructive examination on all units.

2) Turbine housing and baffles

Damages were found on baffle plates on the inside of the housings of No.1, No.3 and No.4 units. The damages exist on the right wing viewing from the lower nozzle of each unit. Baffle portions of lower nozzle in all units were also corroded. The most serious corrosion was observed on the baffle plate of No.1 unit, where the plate of 30 mm thickness is bored through.

3) Needle tip and deflector tip

Corrosion was observed on the lower and upper needle tips of all units. Maximum 5 mm depth on the upper needle of No.1 unit was measured. Corrosion was also observed on deflector tips of all units.

4) Inlet valve

The inlet valve was visually inspected in the operating condition. Inspection to the valve was carried out in the penstock at the half open position of the valve during the dewatering period. Erosions on valve body seat, valve body and valve rotor were observed on all units. An eroded hole on the disc of No.2 unit was found, and the hole was welded to repair by the maintenance staffs during the investigation period.

5) Bypass valve , drain valve and pipe

High pressured water leaks out from the bypass and penstock drain valves on all units due to erosion. Thickness of pipes of the above mentioned valves were measured by the ultrasonic instrument. As seen in Table 3.3, decrease caused by corrosion and erosion of pipe thickness is remarkable.

(3) Auxiliaries

1) Governor

Following abnormal conditions were observed on the governors.

a) Wear and tear of the pendulums of all units. Its maximum depth of 13/1000 mm was measured on the governor of No.1 unit.
b) Rust and traces of excessive defects on part of pilot valves of all units
c) Malfunctions of the distributing valves
d) Excessive oil leakage from pilot valves for needle control

2) Deflector servomotor

Following damages were found on the deflector servomotors.

a) Damage on piston rods of all units
b) Excessive oil leakage from the gland of No.3 unit

3) Control cabinet

Pressure switches (63W) for the branch pipes were locked in all units.

4) Oil pump set

Following defects were observed.

a) Discharging capacity of the oil pumps were much less than the rated capacity (280 l/min). Measured capacity was 88% (No.3 unit) to 84% (No.4 unit) only of their ratings.
b) Oil level controls of all units were out of function.
c) Flow detecting relays (69WQ) of all units were out of function.

5) Air compressor

Discharge of air compressors was reduced to one third of its rated capacity (1000 l/min).

6) Inlet valve control cabinet

Excessive water leakage was observed on the distributing valve for the seat valve of all units.

7) Water supply system

Noise from motor bearing was generated.

8) Others

Malfunctions or oil leakage were observed on the following apparatus.

a) Flow detecting relays
b) Oil level indicator of sump tank
c) Auxiliary multi-contact relays (77LX and 63Q1X)
d) Oil leakage from copper tube or pipe fitting of all units

(4) Nondestructive examination of runner

Runners have been well operated and maintained by PC-2 although cavitation erosion and some damages which were induced unavoidably due to long term operational condition of water turbines were found on the runners.

Each runner has been operated for a long period by June 1994 since its installation, as seen in the attached Figure 3.5.

No.1 unit : 8 years and 4 months since March 1986
No.2 unit : 6 years and 3 months since April 1988
No.3 unit : 3 years and 3 months since April 1991

No.4 unit : 12 years since July 1982

Nondestructive examination disclosed the serious damages on all runners caused by cavitation erosion and intermittent welding for repair.

Tables 3.6 to 3.12 show the existing defects on the runner buckets in the operation and spares of the Da Nhim power station.

As a result of the manufacturer's analyses to the similar models to the runner bucket of the Da Nhim power station mentioned on Table 3.13, the life of the runner buckets was estimated at less than 8 years after occurrence of crack if the crack on the root of the bucket is extended over approximate 3.0 mm in length.

The Study Team considered from the general technical practice of welding that repair of the runners having such cracks is not quite reliable by the normal welding method at the site. Therefore, it is recommended that all runner buckets in the present operation should be replaced with new buckets in the urgent rehabilitation stage.

3.2 Situation of Operation & Maintenance and Countermeasures

3.2.1 Operation

The Study Team examined the organization of operation group in the power station. Operation of the power station is performed in the structure of four (4) shifts. A shift consists of five (5) in total, one (1) shift engineer, two (2) electricians in the control room, and two (2) mechanicians in the machine room.

3.2.2 Maintenance

The Study Team observed that persons in charge of the operation and maintenance for the turbines in the power station have been generally well trained and acquired adequate technical knowledge for the existing facilities. Check lists, work sheets and other necessary documents are provided in the power station for safe operation of the facilities.

Meanwhile, the Study Team observed the following conditions to be improved by PC-2.

i) Maintenance staffs have difficulty in finding out the real troubles or abnormal condition of water turbine early, since the faulted or malfunctioned instruments and relays are provided in the existing control panel.

ii) The space for storing the maintenence equipment of water turbines is not enough. Rust-proof treatment is also not applied to in the storing room.

iii) The instruction manuals, documents, drawings, and operation records are well kept with the related lists or indexes. On the other hand, some maintenance records actually executed in the past are personally kept and can not be reviewed by other staffs.

It is reported that the power station has approximately 20 skillful persons well-trained for maintenance and repair of the existing turbines.

3.2.3 Countermeasure

In advance of the urgent rehabilitation under this study, the Da Nhim power station needs the following materials and parts in the great urgency for maintaining the existing turbine facilities. Attached Table 3.4 is a list of spare parts requested by the maintenance group and workshop of the Da Nhim hydro power station. Main materials requested are as follows.

- nozzle and needle tips
- gasket for intake valve
- vibration disc and pendulum motor for governor
- distribution and control valves
- bend pipes of bypass valves
- bronze electrode for repair work

3.3 Plan of Urgent Rehabilitation

This clause covers the plan of rehabilitation works of each facility for the turbine. The plan was prepared on the basis of the Study Team's investigation to the facilities and discussions with the maintenance staffs of the Da Nhim hydropower station.

Running hours of the turbines from the commencement of operation to the end of June 1994 were recorded as follows:

No.1 unit : 156,481 hours
No.2 unit : 169,444 hours
No.3 unit : 146,554 hours
No.4 unit : 158,480 hours

Considering that no radical replacement of major parts have been made in the past, it is understood that the running hours recorded are extremely long. It is also understood that no serious trouble of water turbines have occurred in the past due to proper maintenance work of PC-2 staff while many wear and tear induced from the long operation period are observed on the facilities.

Rehabilitation of the turbines and their auxiliary facilities will be achieved by means of either replacement of the damaged parts with new products or repair to the damaged parts. Replacement will be conducted on those portions, if the replacement will be more economical than the repair, no spare parts are available any more, or newly developed facilities are recommended for the efficient operation. Rehabilitation in other cases will be planned by repair of the existing defects.

The urgent rehabilitation plan was formulated mainly for the following facilities:

(1) Parts or materials subjected to the high water pressure

(2) Small or slight damage which may cause the system trouble

(3) Parts which are frequently used in operation and are difficult or impossible to procure at the present

(4) An effective step, at the chance of rehabilitation, to modernization of the station

(5) Facilities urgently required for the overall development of PC-2

(6) Additional devices necessary to response the existing complexed and expanded power system

(7) Facilities to contribute toward to the economical system operation coping with the peak load or the system response

(8) Facilities based on the standing point of humanity

3.4 Basic Design for Urgent Rehabilitation Plan

The basic design for urgent rehabilitation plan was conducted on the turbine, inlet valve, governor, oil pressure system and water supply system.

As the basic criteria, it was preconditioned that the fundamental rating and dimensions of the facilities to be rehabilitated should be same as those of the existing facilities or those in the original design of the facilities. Through the field investigation after dismantling the turbines, dangerous or serious defects caused by the erosion on the seat valve of No.2 Unit inlet valve were found out. These defects could not be detected out or conjectured by the investigation from the outside. From the facts found, and running and repairing records of the turbines, the Study Team recommended to replace the existing parts and materials related with the high water pressure with new parts and materials.

Also, for the parts of the governors which have been operated for the long period and are difficult or impossible to procure at the present, the Study Team recommended renewal by the parts with the modernized types of the governors and such control devices as solenoid valves.

Recommended parts to be replaced or repaired are as follows and shown in Figures 3.2 to 3.3.

3.4.1 Turbine

(1) Replacement

- runner bucket and reamer bolts concerned
- upper and lower nozzle
- needles and deflectors

(2) Repair at the site

- baffle plate
- deflector servomotor
- operating mechanism for deflector

3.4.2 Inlet Valve and Bypass Valve

(1) Replacement

- inlet valve with application of a new seal method
- survomotor and auxiliary parts for inlet valve
- bypass valve with the related servomoter and pipes
- distributing valve for the above
- distributing system of seat valve

(2) As spare

- two (2) of drain valve

3.4.3 Governor

Following equipments are recommended to be replaced.

- pressure relays
- solenoid valves
- protection relays for auxiliaries
- instrument (wattmeter, position indicator tachometer, and thermometer)
- digital type regulator with cabinets
- signal indicator
- transducer for position indication
- switches
- copper pipes and fitting concerned
- turbine rotation detecting devices (be installed on the end of excitor shaft)

3.4.4 Oil Pressure System

The following equipment and parts are recommended to be replaced.

- motor driven oil pump set
- unloader
- oil level control devices
- level indicator of sump tank
- switch box for the above
- pipes

3.4.5 Air Compressor

Following equipment is recommended to be replaced.

- motor driven air compressor (one set for four units)
- switch box for the above

3.4.6 Water Supply System

Following equipment is recommended to be replaced.

- motor driven pump set
- switch box for the above
- strainer and sand separator for seat valve and needle balance piston

- strainer for cooling water pumps
- valves for above mentions

3.5 Implementation Program of Urgent Rehabilitation Plan

Equipment and materials required for the urgent rehabilitation works for the water turbines and the ancillary facilities are anticipated to be manufactured and delivered to the site in one (1) year including manufacturing design, inspection and test before shipment after the conclusion of the contract.

The rehabilitation works in the power station will be mainly carried out by the work forces of PC-2 under the technical assistance of the consulting engineers as well as the experts dispatched from the manufacturers.

The site works for the water turbines should be executed in accordance with the program well coordinated with the programs of the works for generators, pentocks, transformers, switchgear, civil and building, and others. As seen in the program compiled in Chapter 4, the comprehensive rehabilitation work program of water turbine is seriously related with those of the generators. Thus, the rehabilitation works for the water turbines is recommended to be carried out in accordance with the program of the generators and be performed unit by unit in the series sequence in order to keep the continuous operation of the power station.

Table 3.5 shows the program of the site rehabilitation works to be required for one unit of the water turbine. All the works of the turbine should start after disassembly of the generator concerned and the dewatering of the related penstock. During the dewatering, the inlet valve for the turbine will be disassembled and the penstock to the turbine will be completely closed by a solid blind plate. Then, the penstock will be watered again for operation of another turbine connected to the penstock. Thus, operation of two units of turbine-generator set will be stopped at the same time for disassembling of an inlet valve and provision of a blind plate. The period of such stoppage of two units is estimated at about three (3) days. Following those preparatory works, main works of the rehabilitation of the turbine will be commenced. After completion of the various works for the turbine, the next dewatering of the penstock is required for disassembly of the blind plate and installation of the inlet valve for about three (3) days. All the turbine works should be completed sufficiently before the reassembly of the generator. The estimated work period per one unit at the site is about two (2) months, which will never disturb the works and program of the generator as seen in the comprehensive program. The same procedure will be repeated for the rehabilitation works of other units.

It is strongly advised to further investigate and examine the following items in advance of commencement of the local works.

(1) Further detailed investigation of the parts and portions to be rehabilitated for preparation of the specific work program and schedule.

(2) Check on items, sizes, and quantities of such small parts as bolts, nuts, cable terminals, etc. required for the rehabilitation, in both the present storage and the packing lists submitted by the contractor.

(3) Confirmation of availability of the stored and procured tools to be used for the rehabilitation works.

(4) Confirmation of availability of the stored and procured instrument to be used for the rehabilitation works.

(5) Confirmation of power supply availability for the comprehensive rehabilitation works.

(6) Confirmation of water supply availability for the comprehensive rehabilitation works.

(7) Preparation of the schedule of the crane and hoist to be used by other works.

(8) Detailed investigation of the inland transportation route between the Saigon port and the Da Nhim power station of the equipment and materials for the rehabilitation works.

(9) Detailed investigation of the load capacity of the bridges along the transportation route.

(10) Arrangement of the warehouse for the spare materials and the facilities replaced.

(11) Security arrangement of the warehouse.

(12) Strength and structural check of the wire ropes in hands.

(13) Pr-education and training of the persons for the works.

3.6 Long Term Rehabilitation Plan

Following the completion of the urgent rehabilitation works, a long term rehabilitation program will be examined and formulated for the water turbines and the ancillaries for further improvement.

The Study Team recommends the following items for the turbines to be examined.

(1) Repair of turbine runners

Repair to the cracked turbine runners will be effectively done in the manufacturer's factory by the welding with heat-treatment.

(2) Renovation for the existing grease lubricating bearings

In view of unavoidable deterioration of lubrication oil and easy maintenance work, utilization of the oil-less bearing is recommendable.

(3) New application on the needle tip

The water turbines are continuously subjected to the erosion issues caused by high velocity water.

Recently, new materials such as ceramics are developed to strongly resist against erosion, and to increase the mechanical strength in comparison with other casting iron. Therefore, the existing needle tips will be replaced with those made from the new materials.

(4) Motor-motor driven oil pressure pump system

A motor driven pump is continuously working in the normal condition, and a small turbine driven pump is to be operated in an emergency case in the present oil pressure pump system of the power station.

The Study Team recommends to change the present motor-turbine system to the motor-motor pump system.

The recommended system is to be provided with two (2) motor-pump sets; one set is for the normal operation and another set is of stand-by set for the emergency condition of the oil pressure system. Both motor driven pumps are alternatively used either for the normal operation or for the stand-by unit.

Such new system will make the maintenance work easy and prolong their lives.

(5) Turbine housing

Renewal of the turbine housings may be examined to reduce the noise and vibration.

However, in this case, the present layout of four (4) units of turbine-generator sets in the building might be required substantially to be rearranged. Thus, the renewal of housings will be realized at the time when the facilities will be completely replaced with new models of the facilities.

3.7 Recommendation of Operation and Maintenance

The Study team observed that persons in change of the operation and maintenance for the turbines have been generally well trained and acquired the adequate technical knowledge and engineering for the existing facilities. Work or mission sheets for the operation, check or confirmation list and other necessary documents are efficiently provided in the power station for safe operation and maintenance of the facilities.

Meanwhile, the Study Team recommends following items to be continuously studied for keeping the power station in the sound condition and keeping up with the expanding power systems in the country.

(1) In order not to fall into the mannerism of the operation and maintenance of the facilities, PC-2 should amend the present work sheets and others and also educate new technology to stimulate the working staffs.

(2) The present stores should be improved so as to be:

- expanded for more space,
- kept in the neat situation,
- kept in the well-ordered condition, and
- protected by the rust-proof provision.

(3) Instruction manuals, necessary documents, and facility drawings should be put in order for the quick offering to the requirement of the staffs. All records of the maintenance, operation, and repair should be displayed in the opened place for reference of the staffs. Due to such an easy reference of the materials, the operators will be able to produce the advanced conception for more efficient or stable operation and maintenance of the facilities.

(4) The Study Team examined and inspected the water turbines and their ancillary facilities at the field investigation stage in accordance with the inspection method which is applied by an electric power company in Japan. On completion of the urgent rehabilitation to the facilities, PC-2 is recommended to be inspected the rehabilitated

facilities at the same level of investigation method applied by the Study Team and to be established the following periodical inspection schedule.

1) Initial inspection

The inspection should be carried out within one (1) year to the facilities related after the new installation of the facilities or after the additional installation of facilities. This inspection is to be performed apart from those inspections stated in the following 2) and 3).

2) Ordinary inspection

The ordinary inspection is scheduled once a year to the facilities from the outside.

3) Precise inspection

The inspection is to be carried out once ten (10) years to the facilities after disassembling of the structures.

4) Extra inspection

The inspection should be carried out on following occasions.

a) When any abnormal state is recognized on any part of the facilities, or
b) When the inspection finds any trouble on any part of the facilities.

Table 3.1 Noise & Vibration Measurement (1)

DATE : 7/17/94
TIME : 13:00 to 16:00

Noise measurement (before disassembly)
Unit : dB A Scale

Unit. No.	Output			
	40% (16MW)	60% (24MW)	80% (32MW)	100% (40MW)
#1	101...102	102...103	103...105	107...109
#2	101	102	103...104	105...109
#3	101	101...103	104...105	105...107
#4	103...104	103...104	104...105	108...110

Vibration measurement (before disassembly)
(1/1000mm)

Unit No.	Measurement Point	Output			
		40% (16MW)	60% (24MW)	80% (32MW)	100% (40MW)
#1	1	20...34	40...60	80...400	100...300/max 500
	2	48...60	70...80	130...180	200...300
	3	28...34	40...50	65...80	80...100
	4	4...5	7...9	18...28	28...32
	5	40...60	70...100	120...150	180...220
	6	17...22	28...36	44...60	60
#2	1	30...40	60...80	100...200	500...800/max1000
	2	50...80	90...120	150...200	300...500
	3	30...40	50...70	90...110	140...200
	4	4...5	7...8	15...25	32...38
	5	60...80	110...150	160...220	400...600/max1000
	6	24...30	50...60	70...90	90...120
	7	5...6	9...10	30...34	70...80
#3	1	40...56	70...100	120...160	120...160
	2	50...70	110...160	180...250	300...600
	3	40...50	50...80	80...100	100...140
	4	4...5	7...9	20...38	20...40
	5	70...100	110...150	200...360	300...900
	6	20...25	30...38	40...56	60...70
#4	1	26...42	50...80	90...140	150...220
	2	90...150	110...140	150...240	200...450
	3	34...46	52...62	70...90	100...140
	4	90...120	7...10	10...12	17...25
	5	54..80/max90	90...120	140...200	200...450
	6	17...24	32...42	46...60	60...80

Table 3.2 Noise & Vibration Measurement (2)

DATE : 8/17/94
TIME : 8:00 to 11:00

Noise measurement (after reassembly)
Unit : dB A Scale

Unit. No.	Output			
	40% (16MW)	60% (24MW)	80% (32MW)	100% (40MW)
#1	101	102	103	104
#2	103	103	105	107
#3	103	103	105	106
#4	105	105	106	109

Vibration measurement (after reassembly)
(1/1000mm)

Unit No.	Measurement Point	Output			
		40% (16MW)	60% (24MW)	80% (32MW)	100% (40MW)
#1	1	20...30	40...50	110...130	110...140
	2	50...60	80...100	130...150	200...300
	3	30	48...56	80...90	90...110
	4	6	8...10	18...24	28...36
	5	50...60	90...120	110...150	160...240
	6	21...25	36...40	54...64	80...90
#2	1	40...50	70...90	120...180	300...400/max 800
	2	50...60	90...110.	150...200	500...800/max 1000
	3	30	60...70	100...130	140...160
	4	5	8...10	17...20	36...44
	5	70...80	130...160	160...210	300...500/max 800
	6	25	50...62	80...100	100...300
	7	6	14...18	50...60	90...100
#3	1	40...50	70...80	100...130	120...140/max 400
	2	60...70	100...130	170...220	260...360/max 600
	3	40...50	60...80	90...110	110...150
	4	5	8...9	16...24	16...24
	5	70...85	110...140	150...230	200...300
	6	24...28	34...44	50...60	60...80
#4	1	30...40	50...70	90...120	150...200
	2	70...110	100...160	150...200	200...400
	3	30...40	50...60	70...90	90...130
	4	4...5	7...9	15...20	20...30
	5	60...80	100...130	150...200	260...400/max 600
	6	22...28	40...50	60...70	80...100

Table 3.3 Thickness Measurement of Pipe

	Thickness (mm)				Remarks
Date	7/22/94	7/29/94	8/5/94	8/10/94	
Unit No.	#1	#2	#3	#4	
Position					
1	5.5		5.5		
2	5.5		5.5		
3	4.5	4.0	4.5	4.5	
4	6.5	5.5	6.5	6.0	
5	4.0	4.0	5.0	4.25	
6	28.0	26.0	28.5	24.0	Discharge-Penstock pipe
7	5.5	5.0	7.0	6.0	By-pass pipe
8	6.5	9.0	9.3	9.5	
9	8.5	8.5	9.0	8.5	
10	5.5	4.0	4.0	3.5	
11	4.0	4.0	5.5	6.0	
12	4.0	3.5	4.0	4.25	
13	8.5	7.0	8.5	8.5	
14	4.5	4.5	4.5	4.5	
15	6.0				

Measurement Points of Pipe Thickness

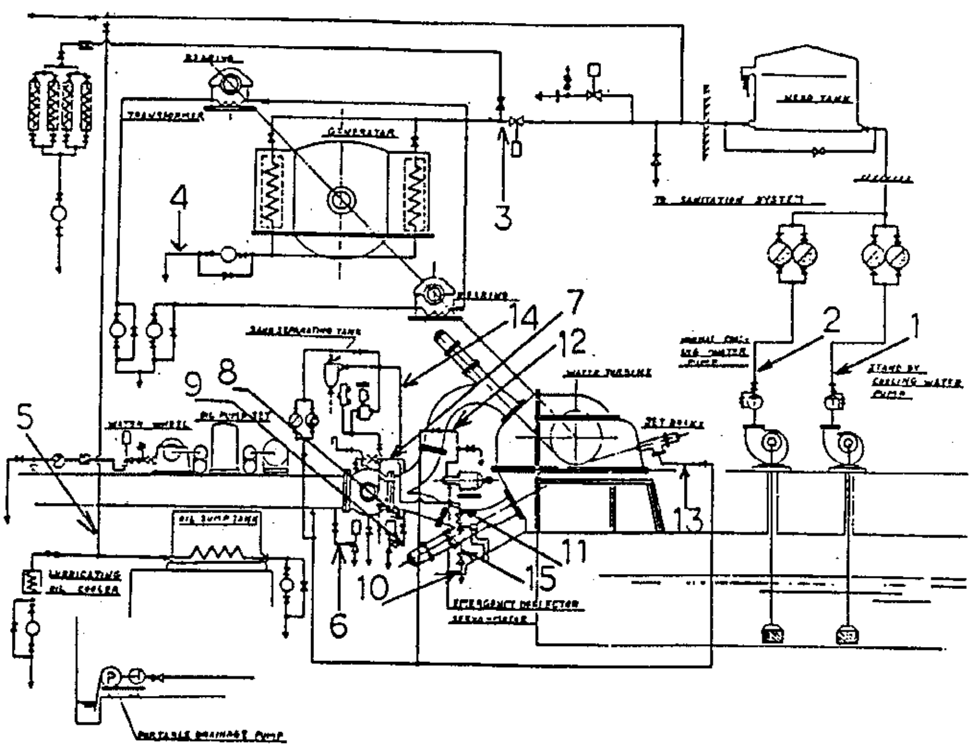


Table 3.4 List of Spare Parts

(For Turbine & Ancillaries)

Turbine			
1.	Nozzle tip	8	sets
2.	Needle tip	4	sets
3.	Shaft & piston of needle servo.	1	set
4.	Shaft & piston of deflector servo.	2	sets
5.	Sluice valve for penstock drain	1	set
6.	Sluice valve for branch pipe	2	sets
7.	Non-grease seal for deflector shaft	10	sets
Inlet Valve			
8.	Delta gasket for inlet valve	5	sets
9.	Bronze electrode ct-3	100	kgs
10.	Distributing valve for main valve	4	sets
11.	Distributing valve for seat valve	4	sets
12.	Bend pipe of bypass valve	4	sets
Pressure Oil System			
13.	Pressure oil pump (motor side)	2	sets
14.	Air supply valve for pressure oil tank	4	sets
Governor			
15.	Vibrator disk for governor	10	sets
16.	Pendulum motor	2	sets
Tools			
17.	Centrifugal lub.oil filter, 2000 l/hr..	1	set

Table 3.5 Rehabilitation Work Schedule of Turbine Per Unit

	Item
1	Check of Procured Materials
2	Measure of Existing System gap. distance, elevation etc.
3	DisAss of TB, IV
4	DisAss, Ass of Runner
5	Rep. of Housing
6	Ren. of Needle, Deflector
7	Ren. of IV
8	Ren. of Bypass V
9	Ren. of DistV, Distributor
10	Ren. of High-Press Piping
11	Ren. of Cooling W. Supply System
12	Ren. of Gov. Cont, Cubicle
13	Ren. of TB Operating Cubicle
14	Ren. of Oil Press Supply System
15	Ren. of Aux Panel
16	Ass of IV
17	Ass of Needle, Deflector
18	Check, Adj of Needle, Deflector Mechanism
19	Run Out Check of Runner with Gen Coupling
20	Piping, Wiring
21	Final Ass. painting
22	Dry Test
23	Wet Test
24	Technical Guidance
25	S.V of Welding
26	SV of Panel Ass
27	SV of TB Cont. Adj
28	SV of Testing
29	SV of TB Ass
30	SV of TB Cont

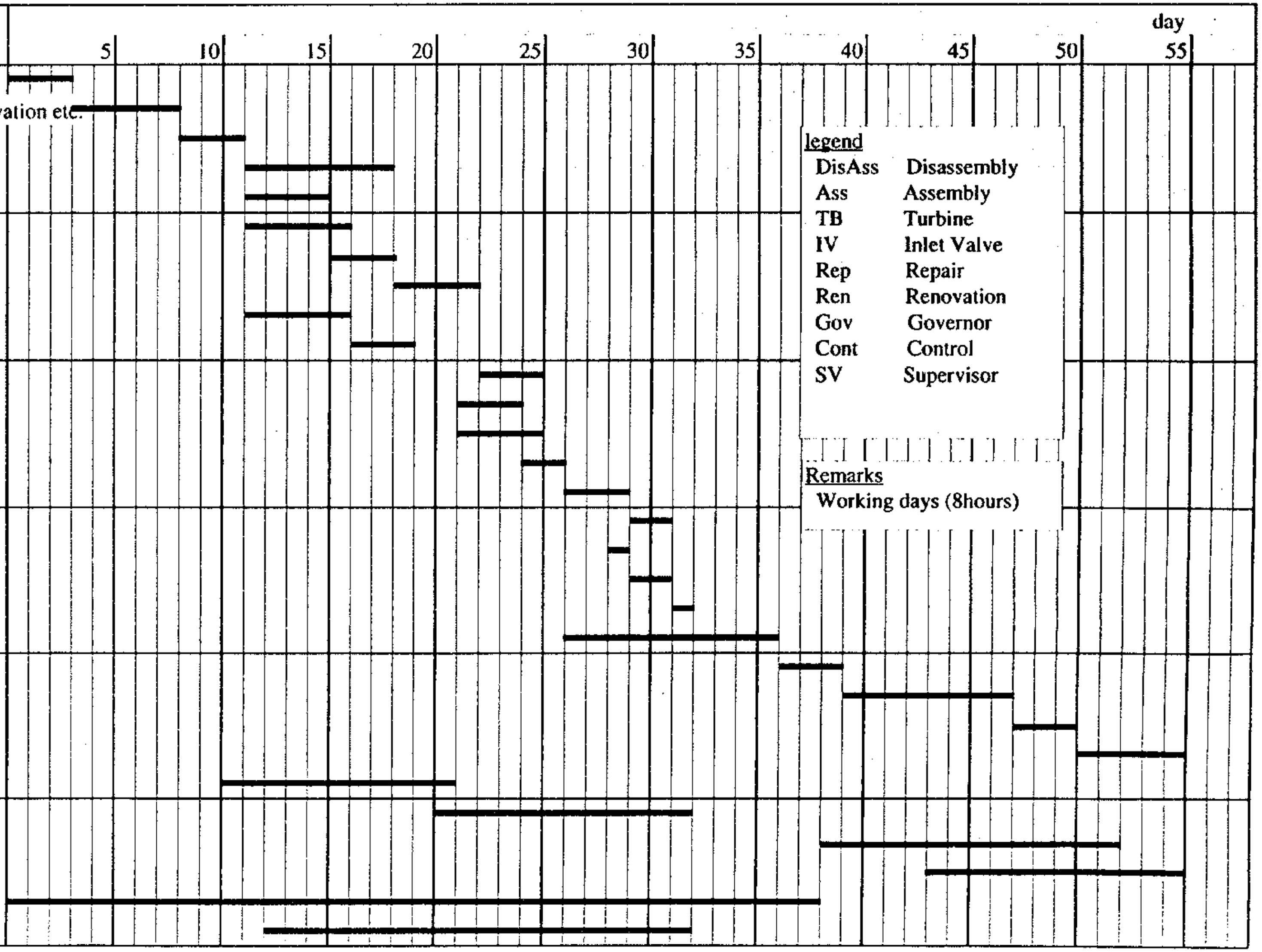
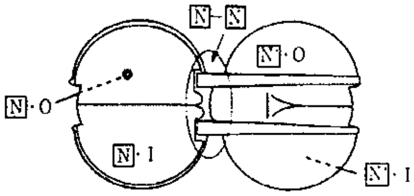


Table 3.6 Remarkable Defects of Buckets

Runner	Manufactured	Operating hour as of June 1994	Weld Repair	Nondestructive Examinations			
				VT	PT	MT	UT
TH7316 (No.1U)	1985	61.629	exist	Cavi Max. 5 mmd	#1 defective welding blow hole #11 defective welding 3 mml	#15 1.5 mml #18 2 mml	#1 2 mmd #11 4 mmd #15 1 mmd #18 1 mmd
V70311A (No.2U)	1987	46.622	none	Cavi Max. 3 mmd	#5 1.5 mml #11 1 mml #20 1 mml	#5 4 mml #11 1 mml #20 2 mml	#5 2 mmd #11 1 mmd #20 1 mmd
TH7397 (No.3U)	1985	42.984	none	Cavi Max. 2.5 mmd	#19 2 mml	#10 3 mml #13 1.5 mml #19 3 mml	#10 1 mmd #13 1 mmd #19 1 mmd
TH0549 (No.4U)	1980	97.775	none	Cavi Max. 3 mmd	#1 2 mml #2 1 mml #5 1 mml #8 2 mml #9 2 mml #13 4 mml	#1 2.5 mml #2 1 mml #6 5 mml #8 2 mml #13 9 mml	#1 2 mmd #2 1 mmd #5 4 mmd #6 2 mmd #8 1 mmd #9 1 mmd #13 4 mmd
TM576A (Spare)	1963	75.701	exist	Cavi Max. 2 mmd	defective casting #15 18 mml cracked	#12 2 mml #15 1 mml #17 5 mml #20 2 mml	#12 1 mmd #15 10 mmd 18 mmd #17 2 mmd #20 1 mmd
TM796A (Spare)	1963	77.328	exist	Cavi Max. 5 mmd	All bucked defective welding cracked Max. 50 mml, crack counted defects 73 points	#1,2,3,4,5,6,8,9 #12,14,15,19 defected Max. 50 mml	#1,2,3,7,8,10,11 #12,13,14,15,17,19 defected Max. 30 mm (throughout)

Table 3.7 Examination of Bucket

No.1 Unit (TH7316)



× ; damage found

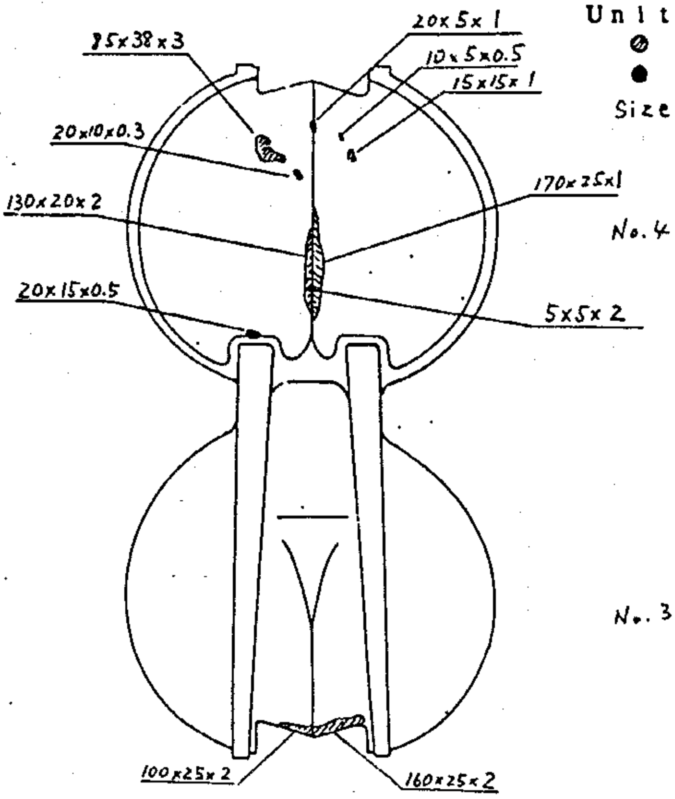
Bucket No.	VT	PT	MT	UT	SUMP	Bucket No.	VT	PT	MT	UT	SUMP
1・I	×				×	11・I	× 1U-11V	×	1U-11P		×
1・O	×	×		×	×	11・O	×	×		×	×
1－2	×	1U-1P				11－12	×				
2・I	×					12・I	×				
2・O	×	×				12・O	×	×			
2－3	×					12－13	×				
3・I	×					13・I	×				
3・O	×	×				13・O	×	×			
3－4	×	1U-3V				13－14	×				
4・I	×					14・I	×				
4・O	×	×				14・O	×	×	1U-15M		
4－5	×					14－15	－		×		
5・I	×					15・I	×			×	
5・O	×	×				15・O	×	×		×	×
5－6	×	1U-5V				15－16	×				
6・I	×					16・I	×				
6・O	×	×				16・O	×	×			
6－7	×					16－17	－				
7・I	×					17・I	×				
7・O	×	×				17・O	×	×	1U-18M		
7－8	×					17－18	×		×		
8・I	×					18・I	×				
8・O	×	×				18・O	×	×		×	
8－9	×					18－19	×				
9・I	×					19・I	×				
9・O	×	×				19・O	×	×			
9－10	×					19－20	×				
10・I	×					20・I	×				
10・O	×	×				20・O	×	×			
10－11	×					20－1	－				

Visual Inspection Record

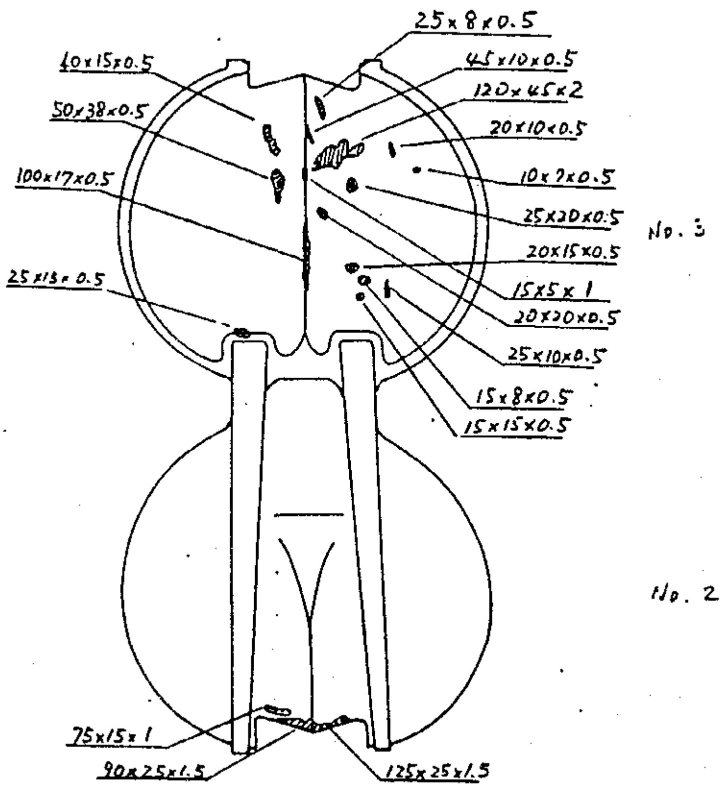
No. TH7316

Unit : mm
⊘ : Cavitation
● : Dimple
Size : Length x Wide x Depth

No. 3&4



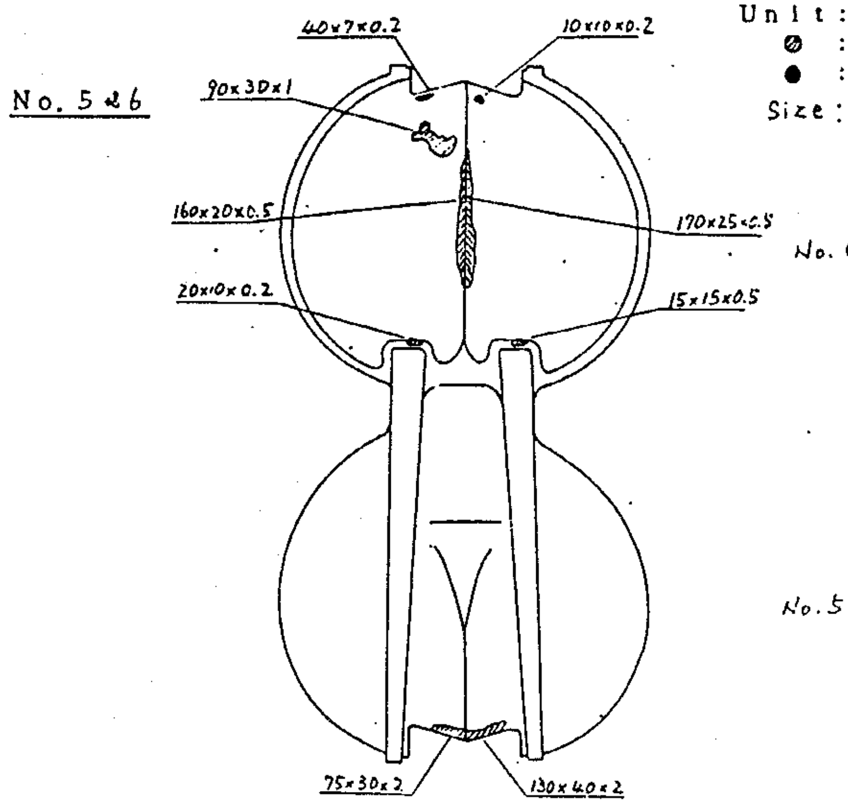
No. 2&3

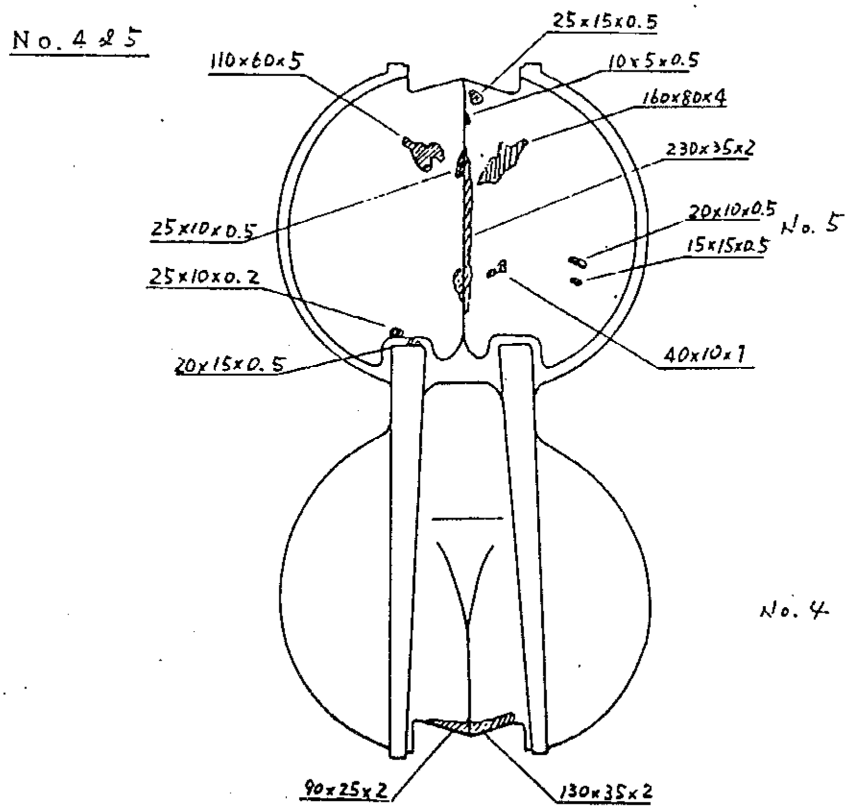


Visual Inspection Record

No. TH7316

Unit : mm
⊘ : Cavitation
● : Dimple
Size : Length x Wide x Depth

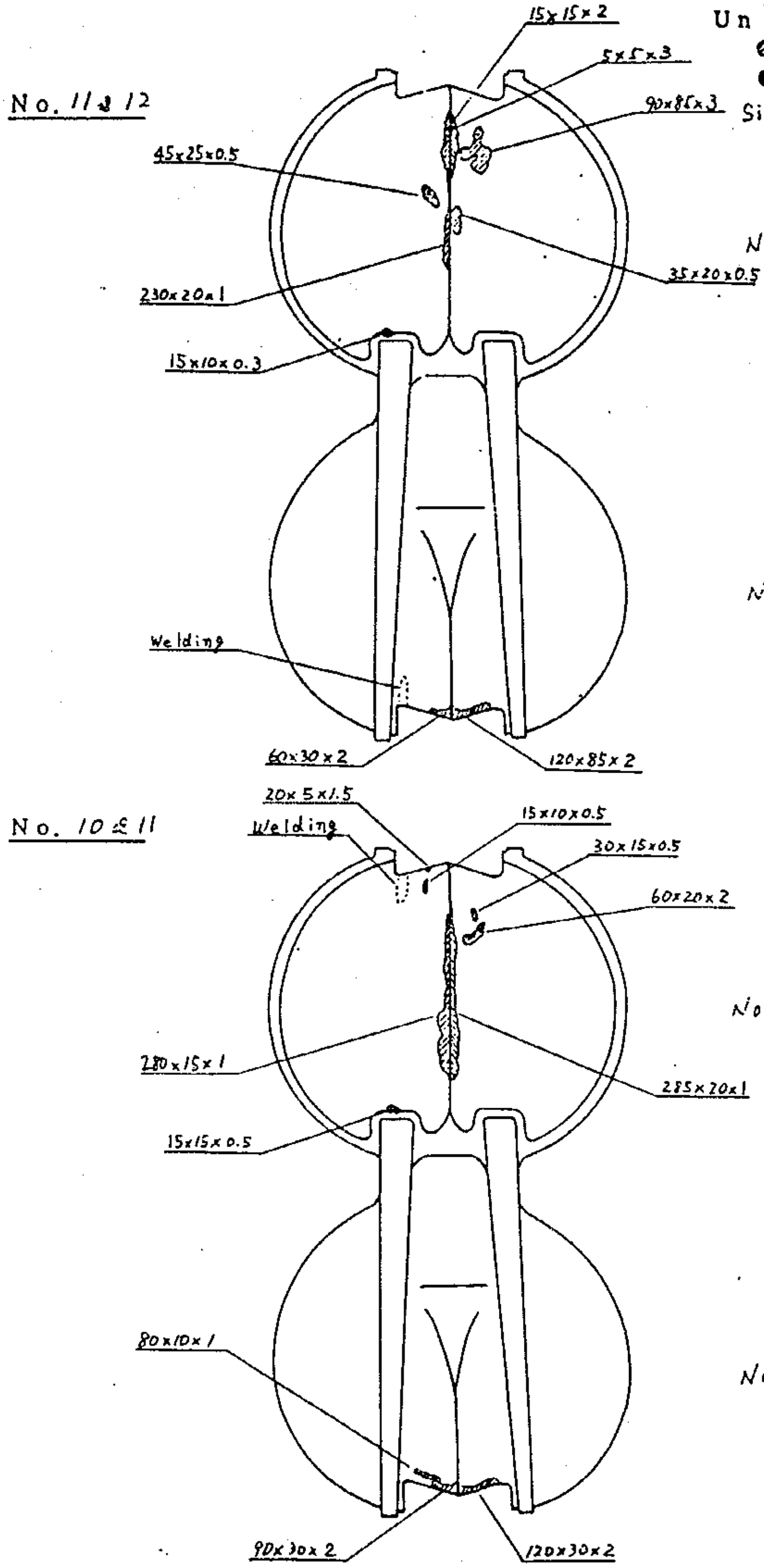




Visual Inspection Record

No. TH7316

Unit : mm
⊘ : Cavitation
● : Dimple
Size : Length x Wide x Depth



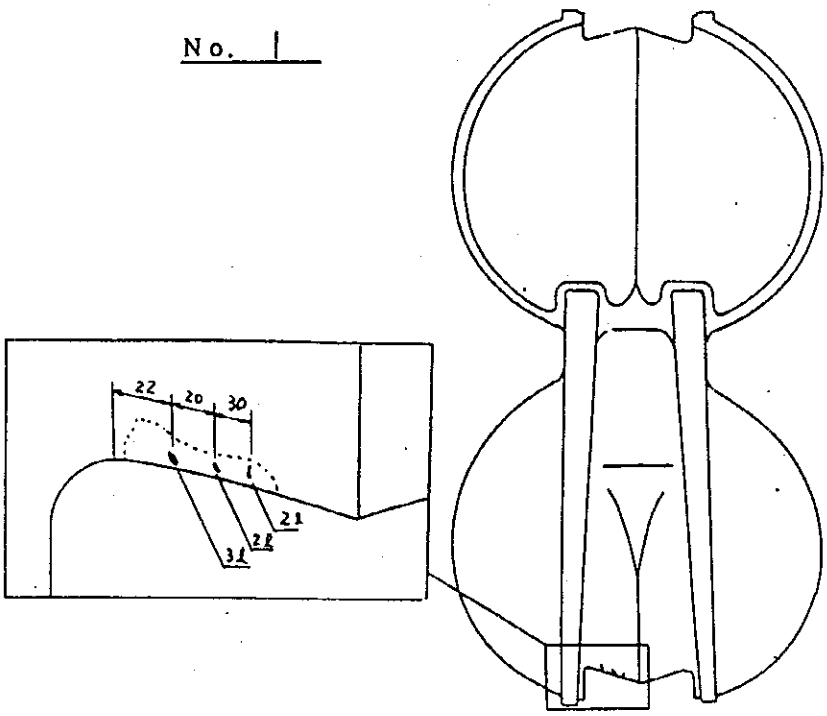
1U-1P
1U-11P

Penetrant Examination Record

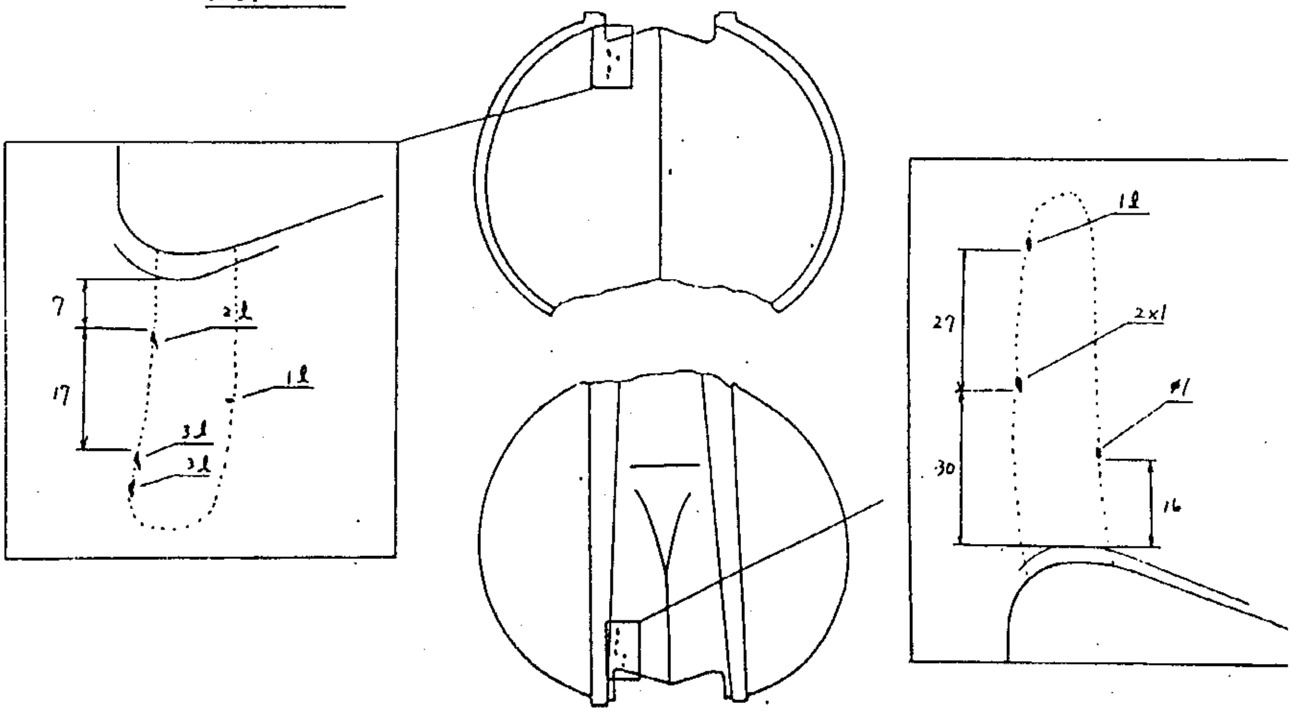
*1 No. TH7316

Unit : mm
ℓ : Linear Indication
φ : Rounded Indication

No. 1



No. 11



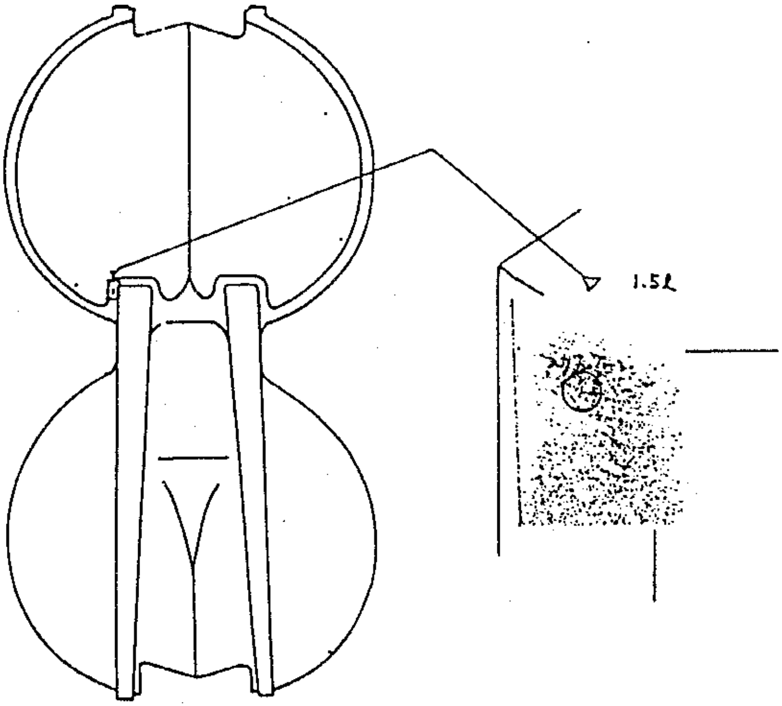
Magnetic Particle Examination Record

#1 No. TH 73/6

Unit : mm

No. 15

14



No. 18

17

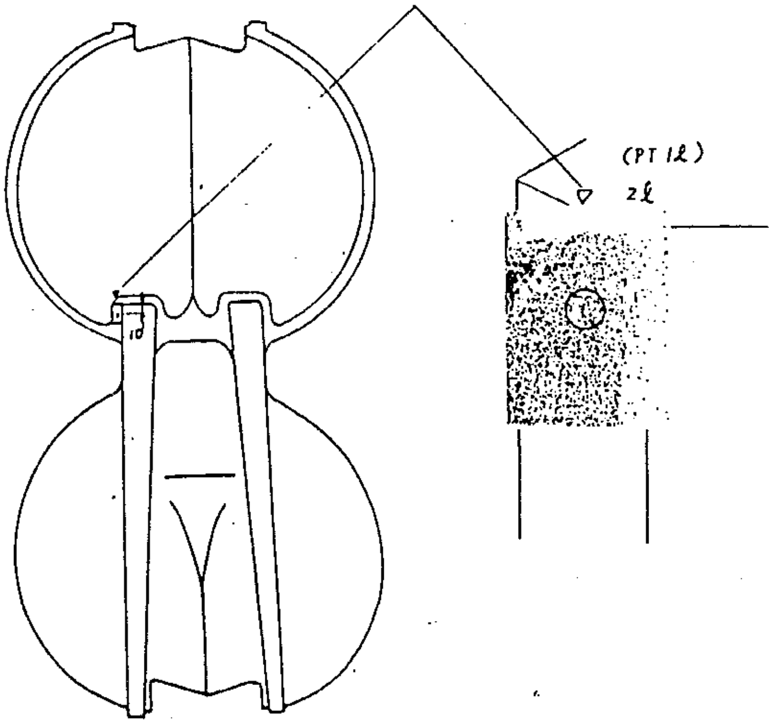
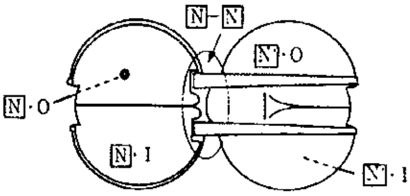


Table 3.8 Examination of Bucket

No.2 Unit (V70311A)



× ; damage found

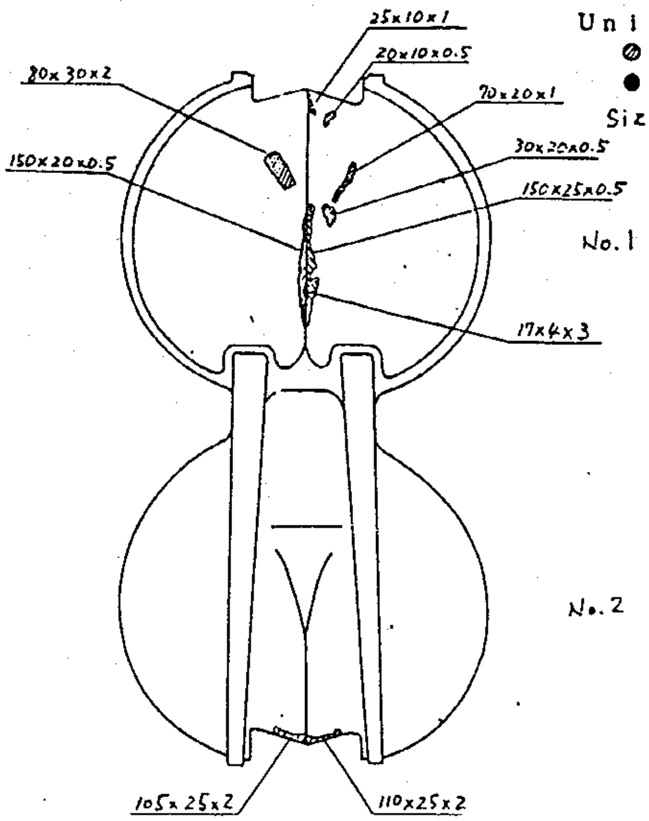
Bucket No.	VT	PT	MT	UT	SUMP	Bucket No.	VT	PT	MT	UT	SUMP
1 · I	×					11 · I	×				
1 · O	×	×				11 · O	×	×		×	
1 − 2	−	2U-1V				11 − 12	−				
2 · I	×					12 · I	×				
2 · O	×	×				12 · O	×	×			
2 − 3	−					12 − 13	−				
3 · I	×					13 · I	×				
3 · O	×	×				13 · O	×	×			
3 − 4	×					13 − 14	×				
4 · I	×					14 · I	×				
4 · O	×	×				14 · O	×	×			
4 − 5	×	×	2U-5M ×	×	×	14 − 15	×				
5 · I	×					15 · I	×				
5 · O	×	×				15 · O	×	×			
5 − 6	×					15 − 16	×				
6 · I	×					16 · I	×				
6 · O	×	×				16 · O	×	×			
6 − 7	×					16 − 17	×				
7 · I	×					17 · I	×				
7 · O	×	×				17 · O	×	×			
7 − 8	×					17 − 18	−				
8 · I	×					18 · I	×				
8 · O	×	×				18 · O	×	×			
8 − 9	×					18 − 19	×				
9 · I	×					19 · I	×				
9 · O	×	×				19 · O	×	×			
9 − 10	−	2U-9V				19 − 20	−	2U-19P ×	2U-19M ×		×
10 · I	×					20 · I	×			×	
10 · O	×	×				20 · O	×	×			
10 − 11	×	2U-10P ×	2U-10M ×			20 − 1	−				

Visual Inspection Record

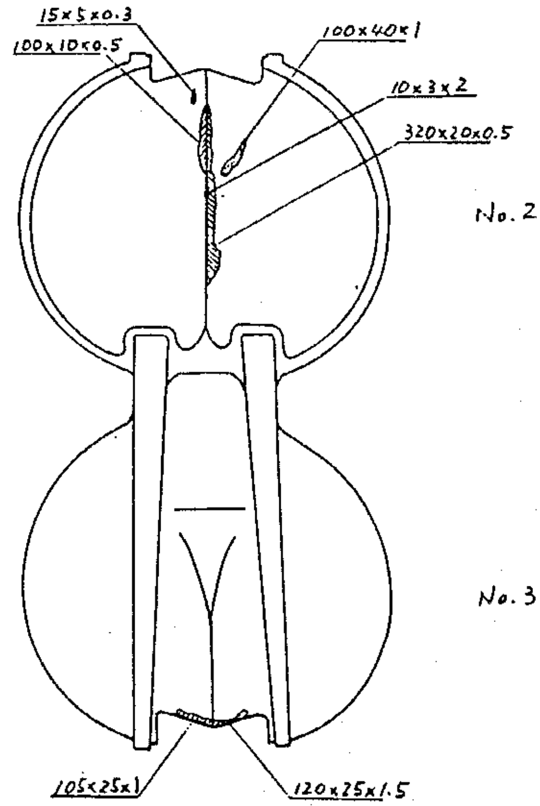
#2 No. 86-36347-0
V 70311-A

Unit : mm
⊘ : Cavitation
● : Dimple
Size : Length x Wide x Depth

No. 1 & 2



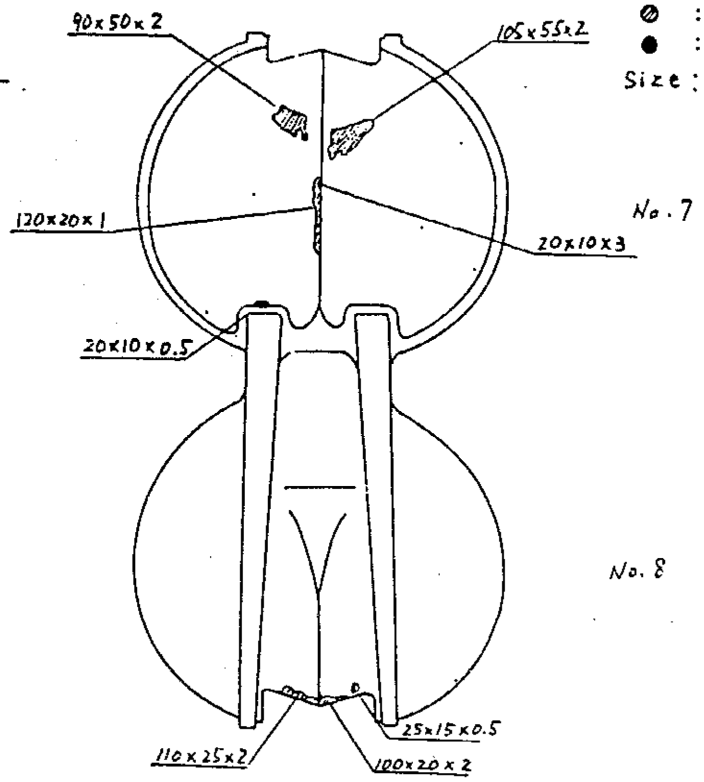
No. 2 & 3



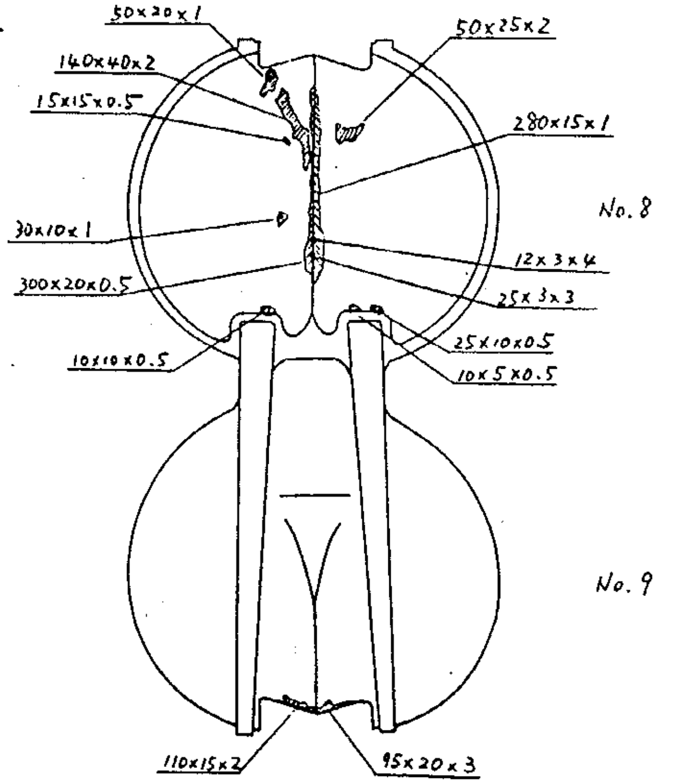
Visual Inspection Record

*2 No.86-36347-0
∇ 70311-A
Unit : mm
⊘ : Cavitation
● : Dimple
Size : Length x Wide x Depth

No. 7 & 8



No. 8 & 9

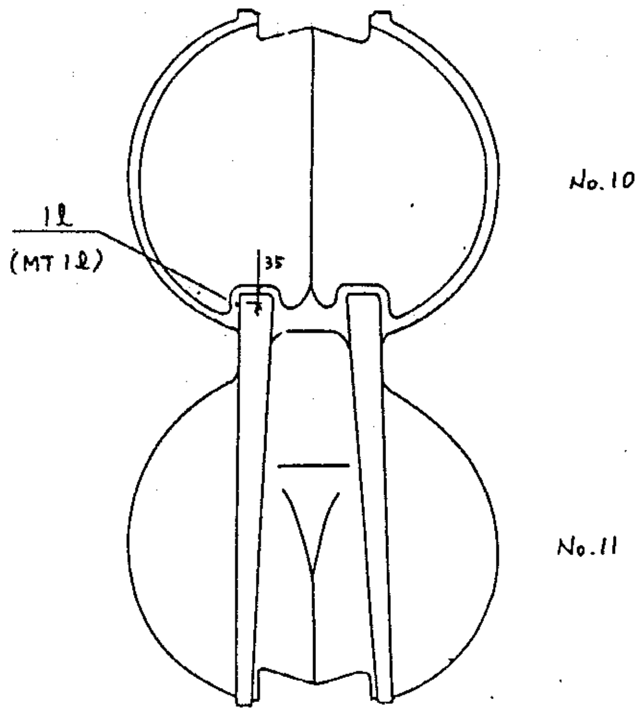


Penetrant Examination Record

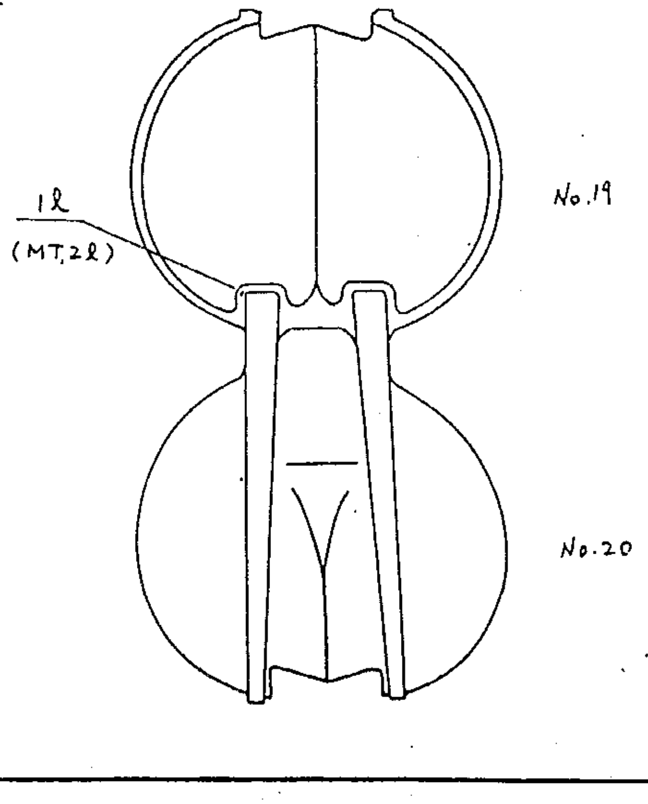
#2 No. V70311-A

Unit : mm
ℓ : Linear Indication
φ : Rounded Indication

No. 11



No. 20



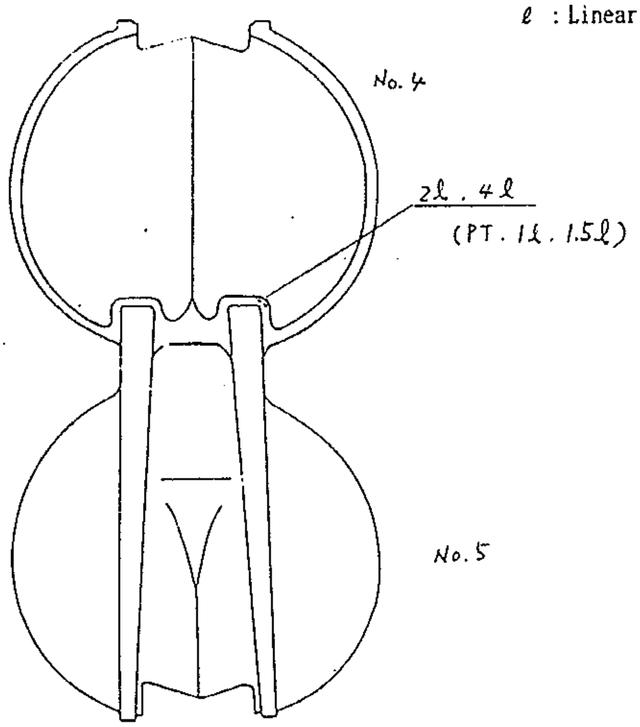
Magnetic Particle Examination Record

#2 No. ▽ 70311-A

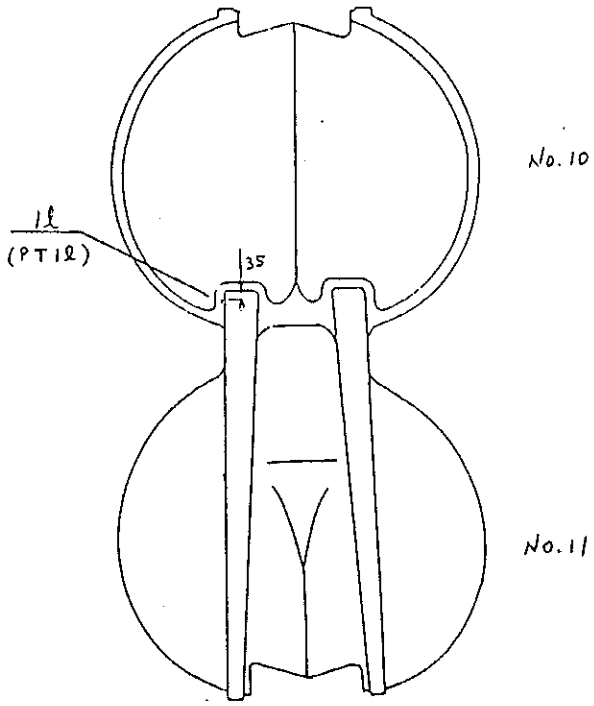
Unit : mm

ℓ : Linear Indication

No. 5



No. 11



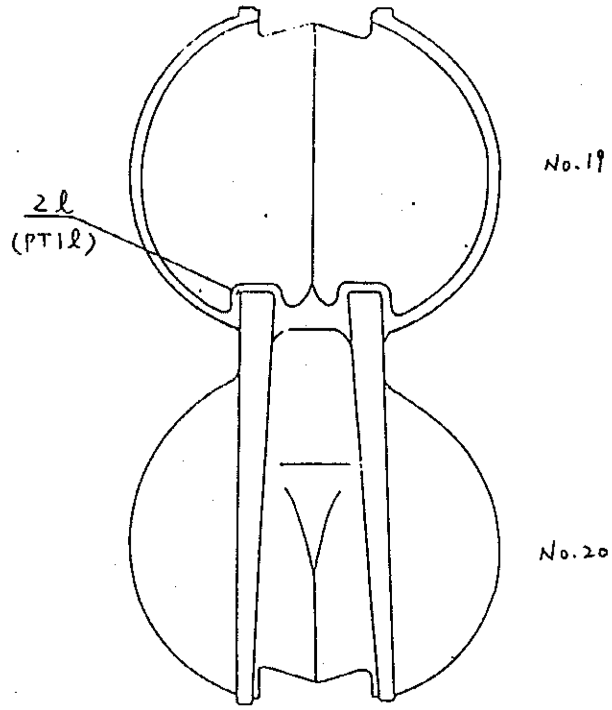
Magnetic Particle Examination Record

#2 No. V-70311-A

Unit : mm

ℓ : Linear Indication

No. 20



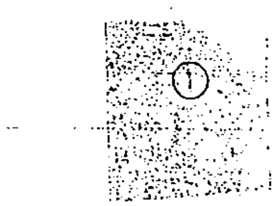
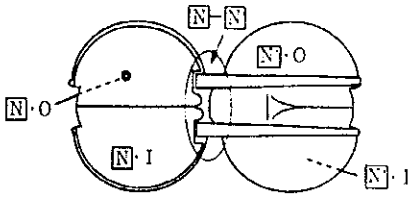


Table 3.9 Examination of Bucket

No.3 Unit (TH7397)



× ; damage found

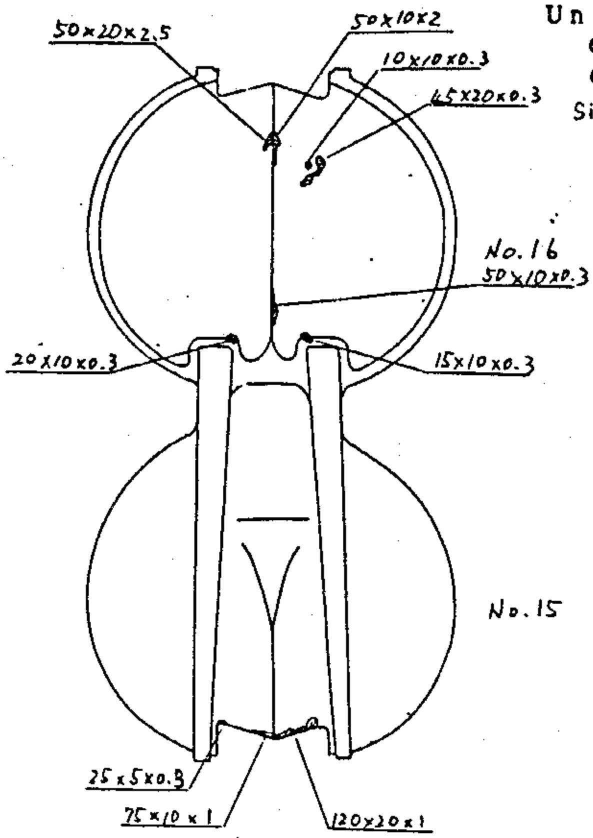
Bucket No.	VT	PT	MT	UT	SUMP	Bucket No.	VT	PT	MT	UT	SUMP
1 · I	×					11 · I	×				
1 · O	×	×				11 · O	×	×			
1 − 2	×					11−12	×				
2 · I	×					12 · I	×				
2 · O	×	×				12 · O	×	×			
2 − 3	×					12−13	×				
3 · I	×					13 · I	×				
3 · O	×	×				13 · O	×	×	3U-13M		
3 − 4	×					13−14	−		×	×	×
4 · I	×					14 · I	×				
4 · O	×	×				14 · O	×	×			
4 − 5	−					14−15	×				
5 · I	×					15 · I	×	3U-16V			
5 · O	×	×				15 · O	×	×			
5 − 6	×					15−16	×				
6 · I	×					16 · I	×				
6 · O	×	×				16 · O	×	×			
6 − 7	×					16−17	×				
7 · I	×					17 · I	×				
7 · O	×	×				17 · O	×	×			
7 − 8	×					17−18	×				
8 · I	×					18 · I	×				
8 · O	×	×				18 · O	×	×			
8 − 9	×					18−19	×				
9 · I	×					19 · I	×				
9 · O	×	×	3U-9M			19 · O	×	×		3U-19M	
9 −10	×		×			19−20	−		×		×
10 · I	×					20 · I	×				
10 · O	×	×		×		20 · O	×	×			
10−11	−					20− 1	−				

Visual Inspection Record

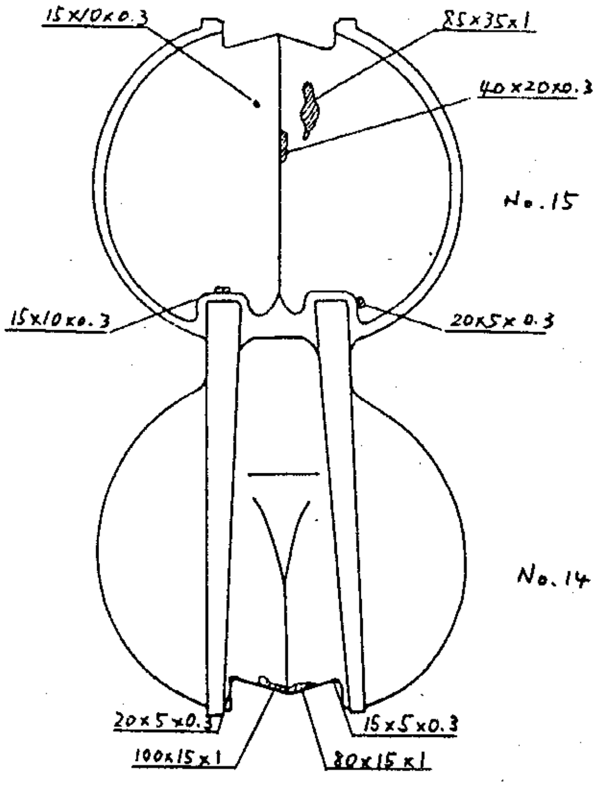
#3 No. TH 7397

Unit : mm
⊘ : Cavitation
● : Dimple
Size : Length x Wide x Depth

No.15 & 16



No.14 & 15



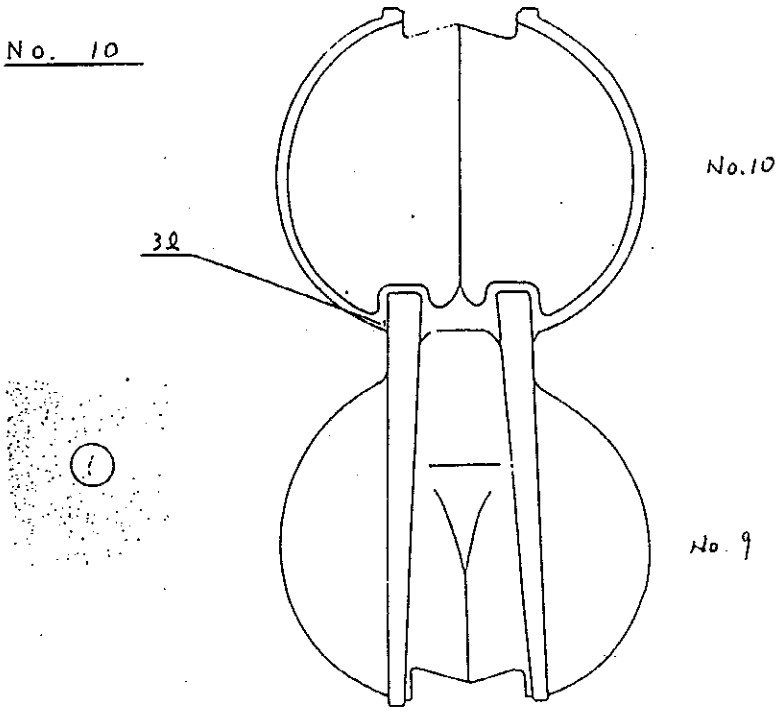
3U-9M
3U-13M

Magnetic Particle Examination Record #3 No. TH7397

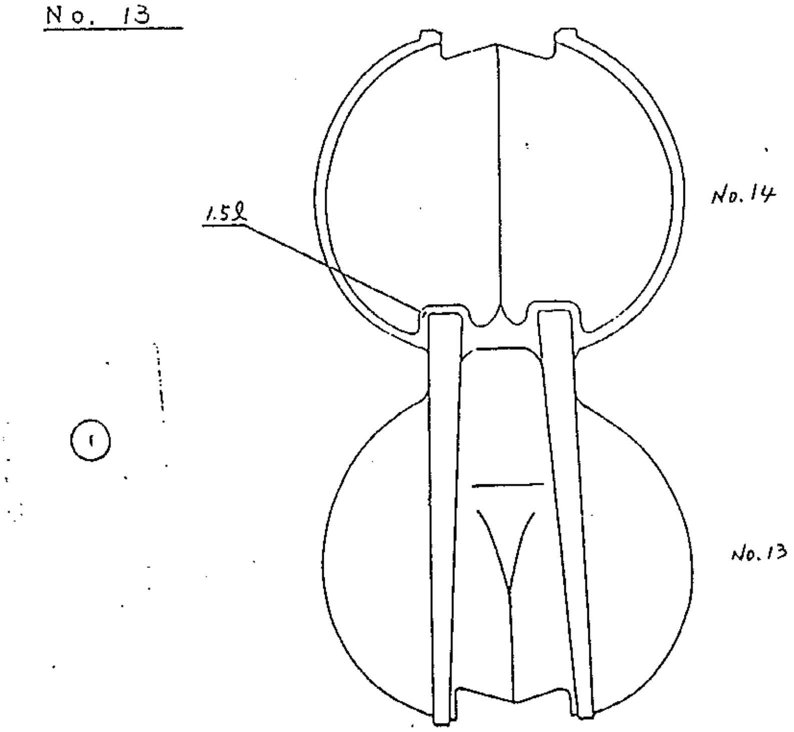
Unit : mm

ℓ : Linear Indication

No. 10



No. 13



Magnetic Particle Examination Record

#3 No. TH7397

Unit : mm

ℓ : Linear Indication

No. 19

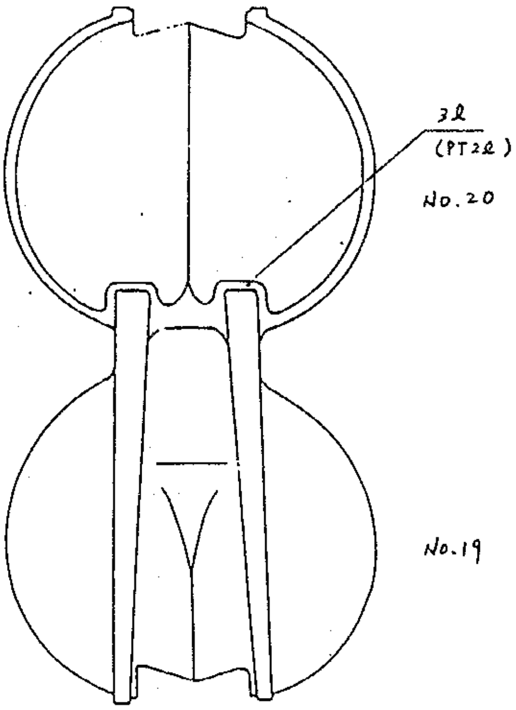
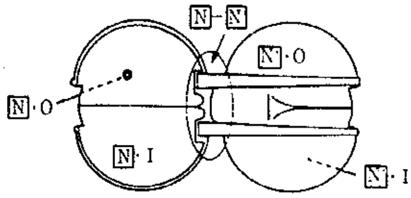


Table 3.10 Examination of Bucket

No.4 Unit (TH0594)



× ; damage found

Bucket No.	VT	PT	MT	UT	SUMP	Bucket No.	VT	PT	MT	UT	SUMP
1 · I	×					11 · I	×				
1 · O	×	×				11 · O	×	×			
1 − 2	−		×	×		11 − 12	−				
2 · I	×					12 · I	×				
2 · O	×	×				12 · O	×	×			
2 − 3	−			×		12 − 13	−				
3 · I	×					13 · I	×				
3 · O	×	×				13 · O	×	×			
3 − 4	−					13 − 14	−	×	×	×	×
4 · I	×					14 · I	×				
4 · O	×	×				14 · O	×	×			
4 − 5	−		×			14 − 15	−				
5 · I	×					15 · I	×				
5 · O	×	×				15 · O	×	×			
5 − 6	−	×	×	×		15 − 16	−				
6 · I	×					16 · I	×				
6 · O	×	×				16 · O	×	×			
6 − 7	−			×		16 − 17	−				
7 · I	×					17 · I	×				
7 · O	×	×				17 · O	×	×			
7 − 8	−					17 − 18	−				
8 · I	×					18 · I	×				
8 · O	×	×				18 · O	×	×			
8 − 9	−	×	×	×		18 − 19	×				
9 · I	×					19 · I	×				
9 · O	×	×				19 · O	×	×			
9 − 10	−	×		×		19 − 20	−				
10 · I	×					20 · I	×				
10 · O	×	×				20 · O	×	×			
10 − 11	−	4U-10V				20 − 1	−	×	×		

Visual Inspection Record #4 No. TH0549

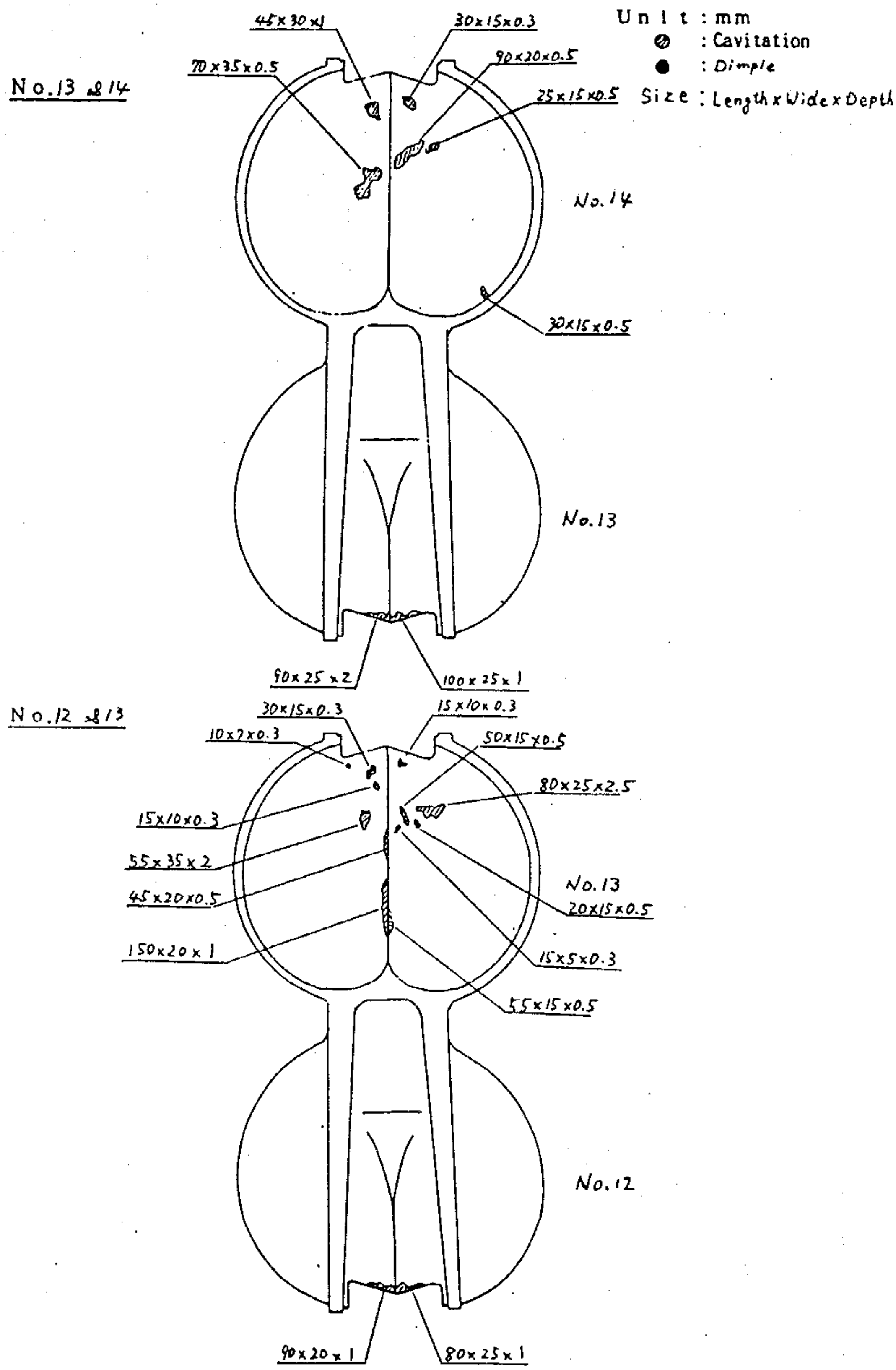
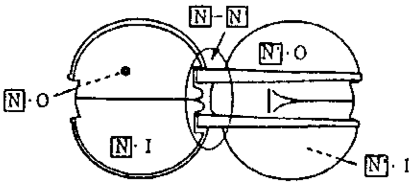


Table 3.11 Examination of Bucket

Spare 1 (TM576A)

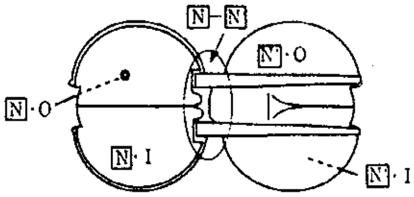


× ; damage found

Bucket No.	VT	PT	MT	UT	SUMP	Bucket No.	VT	PT	MT	UT	SUMP
1 · I	×					11 · I	×				
1 · O	×	×				11 · O	×	×			
1 − 2	×					11−12	−		×		
2 · I	×					12 · I	×			×	
2 · O	×	×				12 · O	×	×			
2 − 3	×					12−13	−				
3 · I	×					13 · I	×				
3 · O	×	×				13 · O	×	×			
3 − 4	×					13−14	−				
4 · I	×					14 · I	×				
4 · O	×	×				14 · O	×	×			
4 − 5	×					14−15	−		×		
5 · I	×					15 · I	×	×		×	×
5 · O	×	×				15 · O	×	×			
5 − 6	−					15−16	×				
6 · I	×					16 · I	×				
6 · O	×	×				16 · O	×	×			
6 − 7	−					16−17	−		×		
7 · I	×					17 · I	×			×	
7 · O	×	×				17 · O	×	×			
7 − 8	−					17−18	−				
8 · I	×					18 · I	×				
8 · O	×	×				18 · O	×	×			
8 − 9	−					18−19	−				
9 · I	×					19 · I	×				
9 · O	×	×				19 · O	×				
9 −10	×					19−20	−		×		
10 · I	×					20 · I	×			×	
10 · O	×	×				20 · O	×	×			
10−11	×					20− 1	−				

Table 3.12 Examination of Bucket

Spare 2 (TH796A)



× ; damage found

Bucket No.	VT	PT	MT	UT	SUMP	Bucket No.	VT	PT	MT	UT	SUMP
1 · I	×	×	×	×		11 · I	×	×		×	
1 · O	×	×	×			11 · O	×	×			
1 − 2	×					11−12	−				
2 · I	×	×	×	×		12 · I	×	×	×	×	×
2 · O	×	×	×			12 · O	×	×			
2 − 3	−					12−13	−				
3 · I	×	×	×	×		13 · I	×	×	×	×	
3 · O	×	×				13 · O	×	×			
3 − 4	−					13−14	−				
4 · I	×	×	×	×		14 · I	×	×	×	×	
4 · O	×	×				14 · O	×	×			
4 − 5	−					14−15	−				
5 · I	×	×	×	×		15 · I	×	×	×	×	×
5 · O	×	×				15 · O	×	×			
5 − 6	−					15−16	−				
6 · I	×	×	×	×		16 · I	×	×		×	
6 · O	×	×				16 · O	×	×	×		
6 − 7	−					16−17	×				
7 · I	×	×	×	×		17 · I	×	×		×	
7 · O	×	×	×			17 · O	×	×			
7 − 8	−					17−18	×				
8 · I	×	×	×	×		18 · I	×	×	×	×	
8 · O	×	×	×			18 · O	×	×			
8 − 9	−					18−19	−				
9 · I	×	×	×	×		19 · I	×	×	×	×	
9 · O	×	×				19 · O	×	×			
9 −10	−					19−20	−				
10 · I	×	×		×		20 · I	×	×	×	×	
10 · O	×	×	×			20 · O	×	×			
10−11	−					20− 1	×				