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

SUMMARY

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

FEASIBILITY STUDY
ON
REHABILITATION OF DA NHIM POWER SYSTEM
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SUMMARY

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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 the 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 seriously 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 of 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, covered the preparation of documents in order to procure the necessary equipment and materials for immediate implementation, after the Study was 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 have been deteriorated due to shortage of spare parts, and the rapid increase of power demand in the Thap Cham, Cam Ranh, Phan Ri, and Phan Thiet areas is reaching to the limit of the

transmission capacity. 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 was 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 covered 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 was economically and financially 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:

(a) Preparatory study stage in Japan
(b) Field investigation stage
(c) First study stage in Japan (preparation of the Interim Report)
(d) Interim report stage in Viet Nam
(e) Second study stage in Japan (preparation of the Draft Final Report)
(f) Draft final report stage in Viet Nam
(g) 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.

(a) Turbine group
(b) Generator group
(c) Waterway group
(d) Dam and civil group
(e) Hydrological data collection group
(f) Substation and switch-gear group
(g) 230 kV transmission line group
(h) System upgrade study group
(i) 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 the 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 the 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

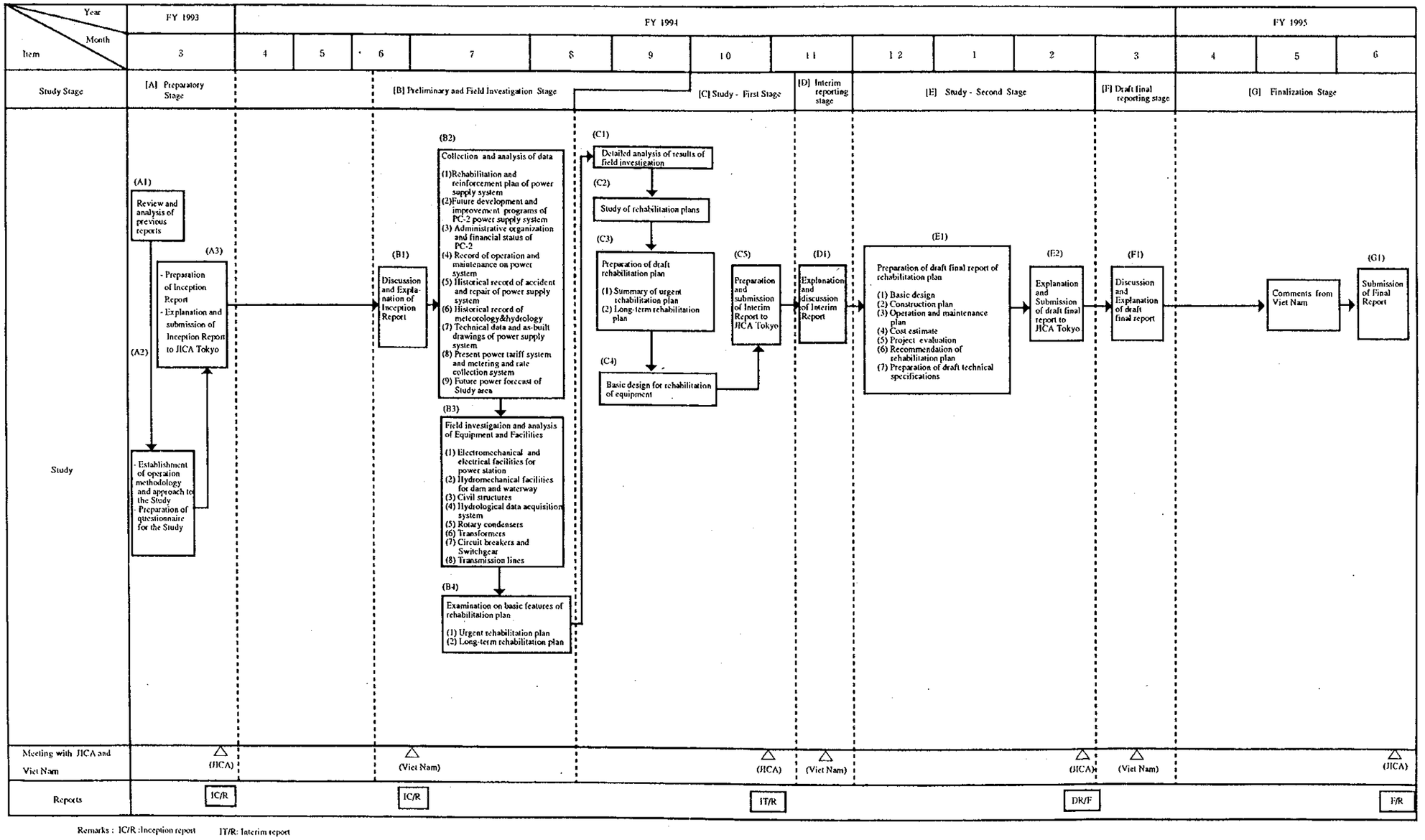
of the existing facilities as well as for upgrading plan of the 66 kV facilities to 110 kV facilities. Items discussed through the study have been fully incorporated to the draft final report.

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

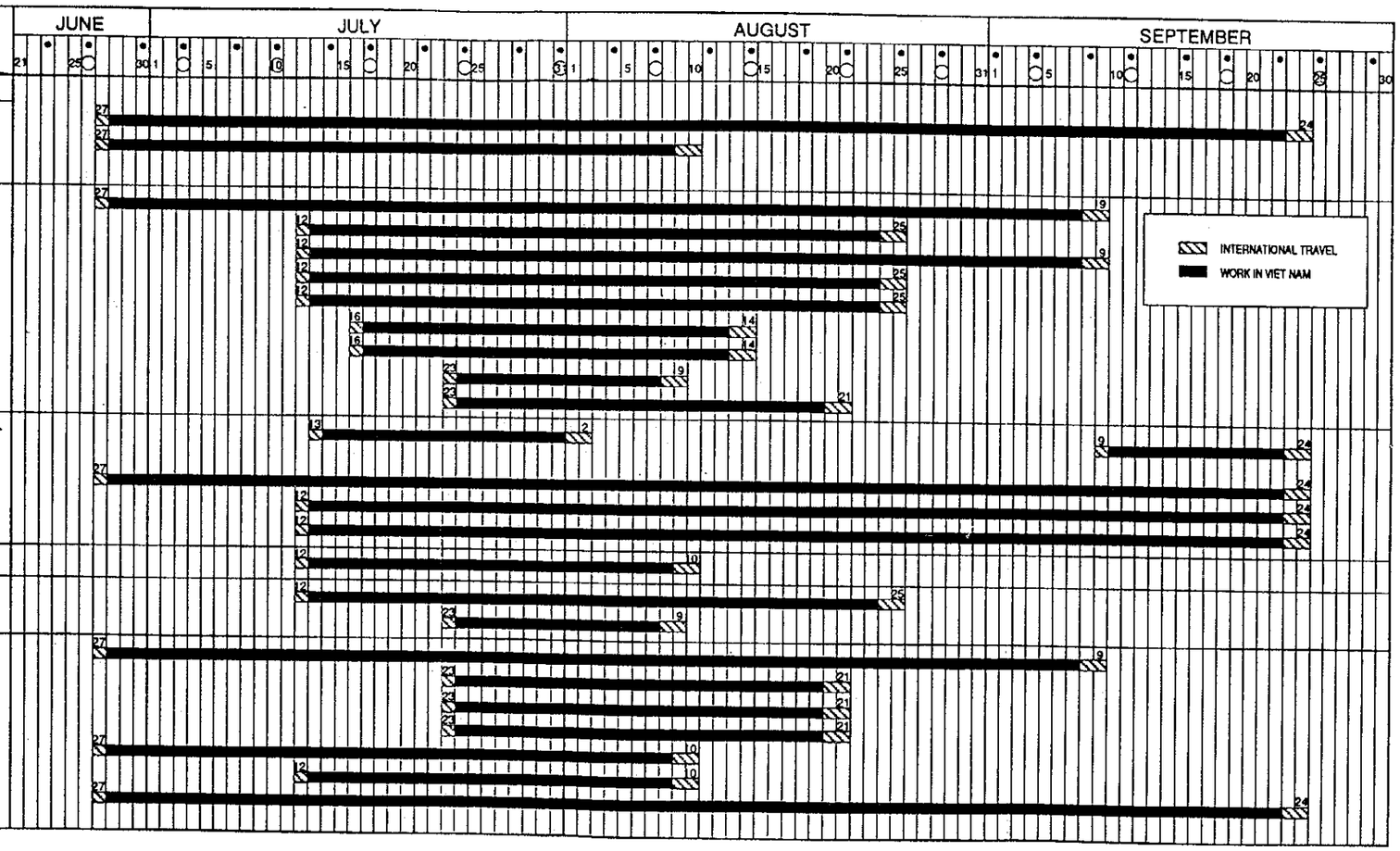
On the basis of the final comments given by PC-2 and PC-3 during the end of May 1995, the Team prepared the final report and the technical documents for the materials and equipment required for implementing the concluded plans. The final report with its summary and technical documents were submitted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



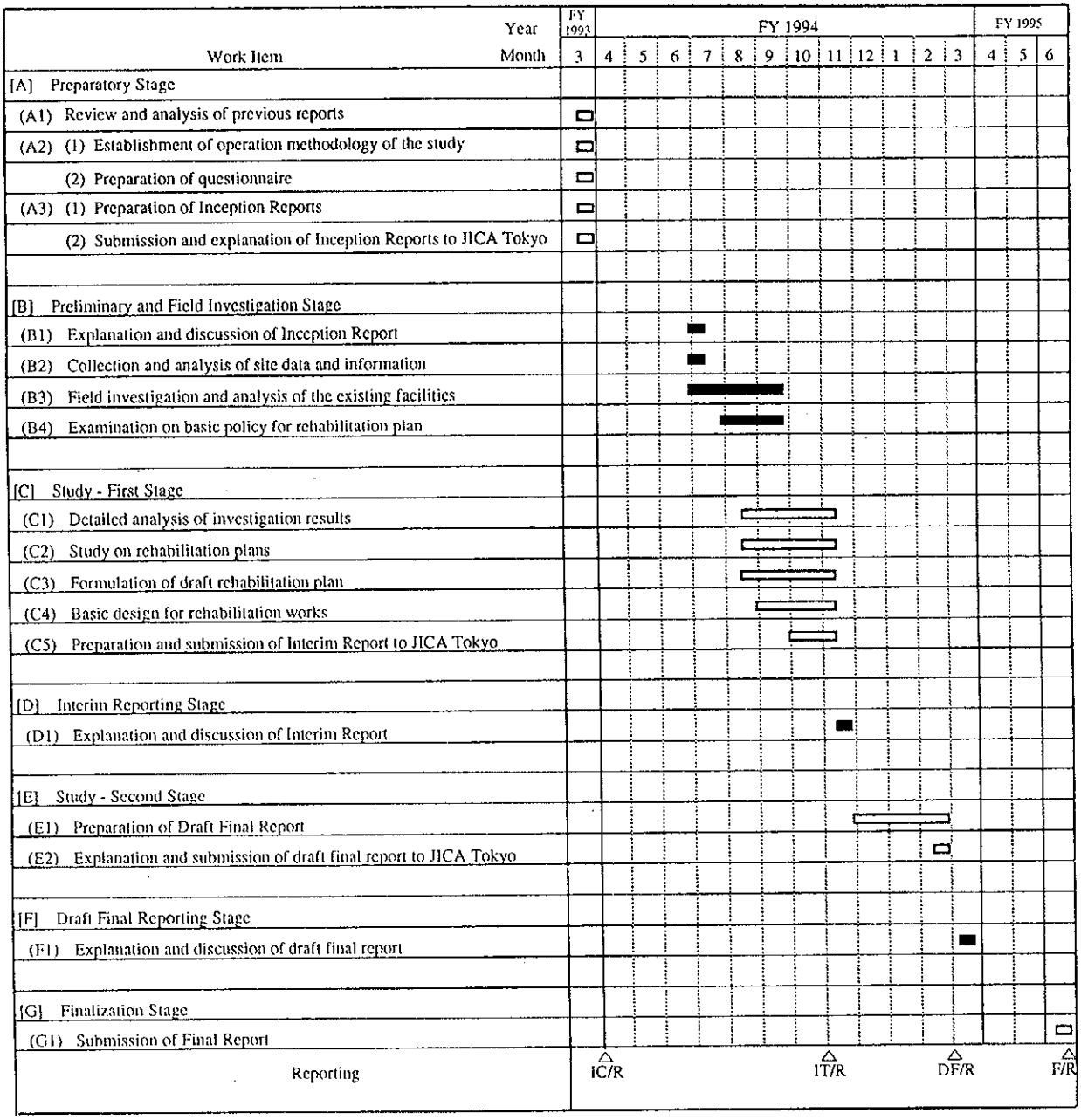
Remarks : IC/R :Inception report IT/R: Interim report
DF/R: Draft final report F/R : Final report

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

1994	IN CHARGE OF	NAME
	(1) TEAM LEADER	MASATOSHI KANDA
	(2) ECONOMIST	OSUKE NATSUME
	(3) COST ESTIMATE	YASUMASA ATAKA
	(4) ASSISTANT TEAM LEADER FOR TURBINE FACILITIES	MOTOO MOGI
	(5) TURBINE MAIN PARTS	JUN TAKAHASHI
	(6) NON-DESTRUCTIVE TEST FOR TURBINES	KATSUHARU YOSHIMURA
	(7) GOVERNORS AND TURBINE AUXILIARIES	MASANORI TANIGUCHI
	(8) ASSISTANT TEAM LEADER FOR GENERATOR FACILITIES	YASUO KADOWAKI
	(9) INSULATION DIAGNOSIS OF GENERATORS	HATSUO NAGATA
	(10) NON-DESTRUCTIVE TEST FOR GENERATORS	RUJI NOBORI
	(11) GENERATOR EXCITATION SYSTEM	AKIHIKO SATOH
	(12) CONTROL BOARD AND SWITCHBOARD	TOMIO SEKIGUCHI
	(13) ASSISTANT TEAM LEADER-A (HYDROMECHANICAL)	AKIRA SEZAKI
	(14) ASSISTANT TEAM LEADER-B (HYDROMECHANICAL)	HIROSHI NAKASEKO
	(15) GATES AND VALVES	SHUNICHI OIKADO
	(16) PENSTOCKS	SHINJI TANI
	(17) NON-DESTRUCTIVE TEST FOR PENSTOCKS	KAZUO TONOI
	(18) CIVIL STRUCTURES	TOSHIO KATAYAMA
	(19) METEOR HYDROLOGY	NARIHIRO MORISAKI
	(20) RADIO COMMUNICATION SYSTEM	TERUO KOBARI
	(21) SUBSTATION EQUIPMENT	NAOJI NAKATO
	(22) SYNCHRONOUS CONDENSERS	HIDENORI MATSUKAWA
	(23) TRANSFORMERS	YOSHIMI NAGATA
	(24) SWITCHGEAR	HISAMI OOISHI
	(25) TRANSMISSION LINE-A	KO NAKAJIMA
	(26) TRANSMISSION LINE-B	SHUNICHI ARAKI
	(27) ADMINISTRATOR	TSUTOMU MORI



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	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

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'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, the Ho Chi Minh City (4.1 million) and Hanoi City (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.

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. 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.

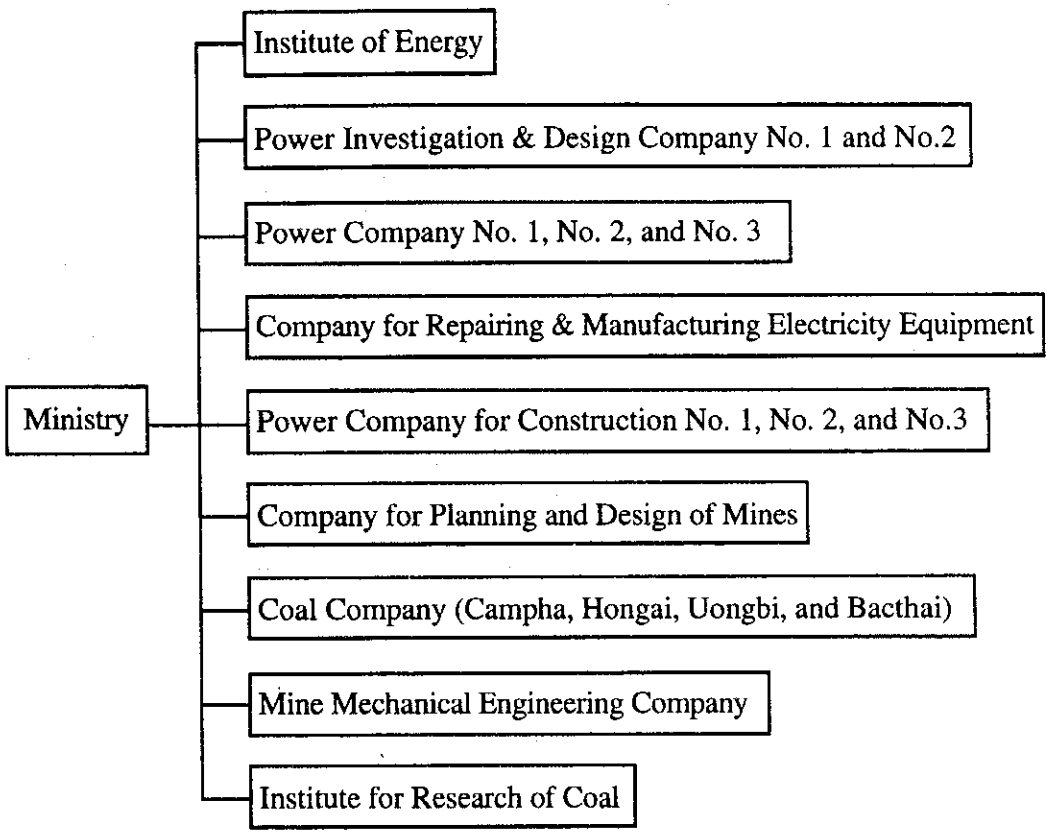
2.2.4 Foreign Investment

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

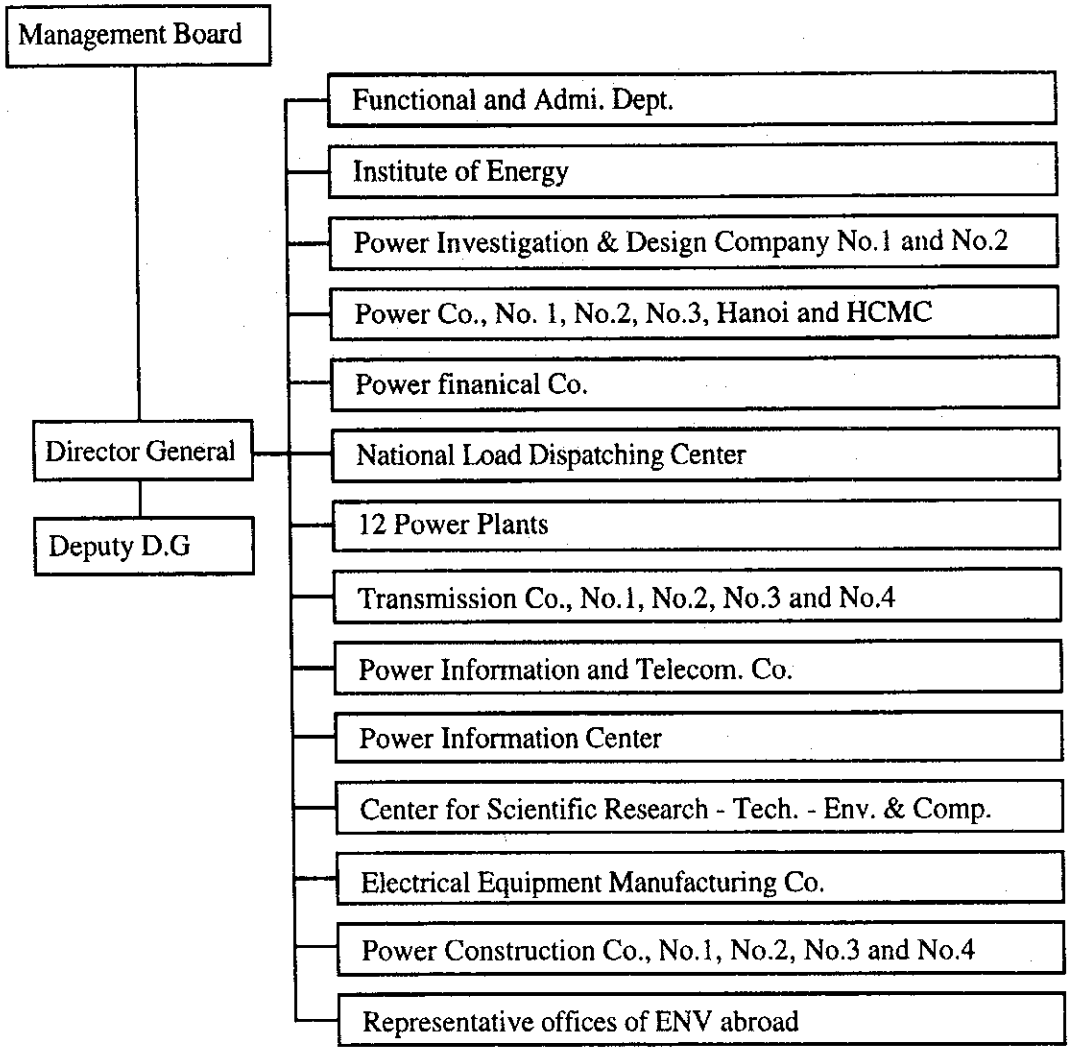
2.3.1 Administration of the Power Sector

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:

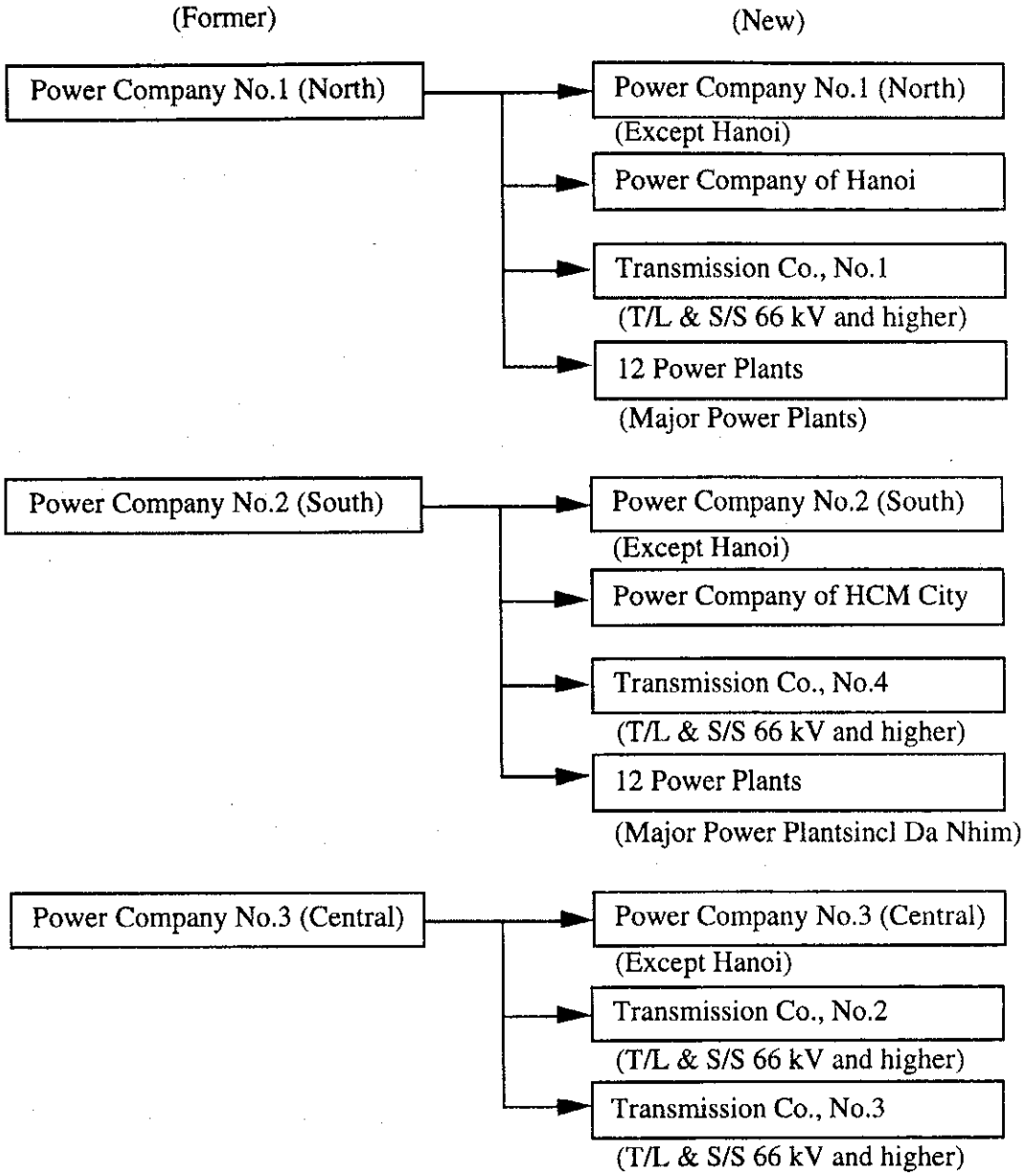


The power section in Viet Nam was reorganized and the General Power Company of Electricity of Viet Nam (EVN) was established on 1st April 1995, in integration of various institutes, power companies and other companies related to the power sector under the ministry of energy.

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 .

(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.

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

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

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

The economy in the southern region of the country is expanding rapidly. Due to the economy expanding, PC-2 faces 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 is critical to meet the demand. 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.

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

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

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 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 also through to the 66 kV Cam Ranh substation.

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 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 power delivery is made between PC-2 and PC-3 through 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 deliver the power from the Da Nhim power station.

2.3.3 Existing Power Facilities

The following were 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 shared 61% of the total generating facilities in the country, while thermal power facilities shared 20% which is observed in the table above.

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

2.3.4 Power Demand and Demand Forecast

(1) Power Demand

The power records in the country covering the last 8 years from 1986 to 1994 show the following tendency.

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 was 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 was 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.

2) Energy consumption

The annual average growth rate of energy consumption in the country was 10.4% for the last 9 years. 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 shared only 28% of the total amount of energy consumed, its average growth rate was about 20%. On the contrary, the growth rate of the industrial sector was as low as 2.5%, but energy consumption reached 37% of the total regional amount. The peak demand, which had grown at an average annual rate of 9.0%, reached 1,080 MW in 1994. The peak demand of the PC-1 region shared 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% being greater than the average rate for the 3 regions. In particular, the growth rate of the domestic sector was 17.8%. This was 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 latest forecasts were issued in January 1995. The forecasts were prepared by the year 2010.

The average growth rates of energy consumption 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).

Following are major features of the demand forecast for each region.

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 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 facilities, 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 higher 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 demands 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 (MV)	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 & 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

Year	Type	Name of Plant	Capacity (MV)	Region
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(C)	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 500 kV transmission line and substations for supplementing energy shortage in the two regions.

Following are power balances under the high growth scenario.

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

(Remarks) Figures in bracket (system reserve power). Plus figures and minus (-) figures show surplus and shortage, respectively. System reserve power is not included in the power balance.

In the high growth scenario the power shortage of PC-2 in the years upto 2010 will be covered by the estimated surplus of PC-1 and PC-3 in the years.

(2.2) Power balance of PC-2

Following are the energy and power balances under the high growth senario in the PC-2 region.

	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)	203	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.

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.

CHAPTER 3

RESULTS OF THE FIELD STUDY

CHAPTER 3 RESULTS OF THE FIELD STUDY

3.1 General

The field investigation was carried out during a period of three months from the end of July to the end of September 1994, taking account of stop of the Da Nhim Power station and Saigon substation.

In accordance with the Agreement between GOJ and GOV, the field investigation was achieved in cooperation with the Study team and PC-2. Prior to the investigation, the Study team explained PC-2 about the method, items and schedule of the field investigation based on the inception report.

The operation and maintenance records were collected and analyzed to grasp the present condition of the objective facilities.

The field investigation of the facilities was conducted under normal operation and dewatered, stopped or deenergized conditions. Facilities under water at the reservoir and intake were visually investigated by divers.

Period of field investigation: June 27 - Sep. 24, 1994

Da Nhim Power station

Full stop:	Jul. 18 - Jul. 19
Stop of No. 1 Penstock (Unit Nos. 1& 2):	Jul. 18 - Jul. 31
Stop of No. 2 Penstock (Unit Nos. 3 & 4):	Aug. 1 - Aug. 13

Saigon substation

Stop of M. Tr No. 1 bank:	Aug. 9 - Aug. 10
Stop of M. Tr No. 2 bank:	Aug. 11 - Aug. 12
Stop of Syn. Condensers:	Aug. 8 - Aug. 17

Objective facilities of the Study were as follows:

(1) Da Nhim Power Station

1) Water turbines

2) Generators
3) Main, local and house service transformers
4) 230 kV, 66 kV, 31.5 kV switchgears and control boards
5) Spillway gates, intake gate, penstock pipes
6) Dam, spillway, intake, waterway and powerhouse
7) Hydrological data acquisition equipment

(2) Saigon substation

1) Synchronous condensers
2) Main, local and house service transformers
3) 230 kV, 66 kV, 15 kV switchgears and control boards

(3) Saigon 230 kV transmission line

230 kV, 1-circuit, 257 km in route length, 730 towers

(4) 66 kV transmission lines (upgrading)

1) Da Nhim - Thap Cham line (41 km)
2) Thap Cham - Phan Ri - Than Tiet line (137 km)
3) Thap Cham - Cam Ranh line (46 km)
4) Cam Ranh - Dien Khanh line (46 km)

(5) 66 kV substations (upgraing)

1) Da Nhim power station
2) Thap Cham substation
3) Phan Ri substation
4) Phan Tiet substation
5) Cam Ranh substation
6) Dien Khanh substation

3.2 Water Turbine and Ancillary Facilities

The scope of the detailed investigation by dismantling of the turbine was limited corresponding to the dewatering period of the penstock pipe by discussion with PC-2.

(1) Investigation under operation

Visual inspection and measurement of noise and vibration were conducted at four units full load operation. The values of noise level measured were in a range between 107 dB and 110 dB. Maximum vibration was observed at the top and sides of turbine housing and measured values of each unit were 0.5 mm, 1.0 mm, 0.9 mm and 0.6 mm for unit No. 1, No. 2, No. 3 and No. 4 respectively.

(2) Detailed investigation

1) Runner bucket

Visual inspection and nondestructive examination were conducted to all runners.

2) Turbine housing and baffle

Damages were found on baffle plates on the inside of the housings of No. 1, No. 3 and No. 4 units.

3) Needle tip and deflector tip

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

4) Inlet valve

Erosion on the valve body seat was observed on all units. An eroded hole on the rotor of No. 2 unit was found.

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 was decreased remarkably.

6) Governor

Wear, tear, rust and excessive oil leakage were observed and decrease of proper governing function was remarkable.

7) Other ancillary facilities

Damages, defects and excessive decrease of capacity were found on the meters, relays, oil pumps, air compressor and water pumps.

(3) Non destructive examination of runner

Visual inspection, liquid penetrate examination, magnetic particle test and SUMP test were conducted to four operating and two used spare runners. Nondestructive examination disclosed the serious damages on all runners caused by cavitation and intermittent welding for repair. It is suggested that the used spare runners don't use due to serious damages.

3.3 Generator and Ancillary Facilities

The field investigation was carried out in cooperation with turbine work. Due to the short stopping period, the detailed investigation was carried out mainly to No. 2 and No. 4 units which have never been overhauled and have not been replaced the main shafts.

(1) Investigation under operation

Shaft voltage, vibration of bearing, noise and temperatures of stator winding and bearing metal were measured at four units full load operation. Temperature of stator winding was increased about 10% from the initial operation time of the generators.

Oil leakage of about 10 cc/day was observed around turbine side bearing pedestal of No. 1 and No. 2 units. Water leakage of about 10 liters/hour also observed from the air cooler installed on the penstock side of No. 1 unit.

No sparks on the brushes of all the units were observed. But chattering sound were audible.

(2) Detailed investigation

1) Stator core

Some local over-heating was on the core end of each one-block at both turbine and exciter sides of the all generator units, and the over heated parts are

discolored to blue. Detachment of the surface vanish was also observed. This local over-heating seems to be caused by an eddy current.

Remodeling of end portion of the core with newly designed cores will be required to prevent this local over-heating.

2) Stator winding

As a result of insulation diagnosis, the desiccation condition and values of insulation resistance of the windings were normal. But the values of $\Delta \tan \delta$ of all units exceed the reference value, and insulation aging of the stator winding is recognized.

At the slot ends of the stator cores, the white corona traces were found on both ends of the turbine side and exciter side of all the units.

Almost all the stator slot wedges on all units were loose and lost their proper function.

The slot liners placed between the core slot of the stator and stator coil had broken and dropped out. Broken-down pieces of the liners are burnt out.

3) Rotor winding

Surface of the pole coils of all the units were stained with oil vapor and dust. The insulation resistance of the rotor windings of No. 2 and No. 3 units are not quite satisfactory. No abnormalities on the layer insulation are recognized.

4) Generator shaft (for No. 2 and No. 4 units)

There were no developing cracks observed on the main shafts of No. 2 and No. 4 units by magnetic particular test and confirmed by liquid penetrate examination.

5) Main bearing metal (only for No. 2 and No. 4 units)

Some slight streaks were observed on the inner sliding surfaces of the white metals of No. 2 and No. 4 units.

6) Exciter

The large raggedness and a lot of streaks were found on the surface of the commutators of all the units. The brushes of exciters have been held loosely due to the remarkable wear.

7) Others

The air coolers for all the units have superannuated and remarkably quaking. The inspection found considerable development of erosion on the inside surfaces of cooling water pipes. All dial thermometers and cooling water flow relays for all units were almost not working properly. The cables for the meters and relays have been superannuated.

3.4 Waterway and Ancillary Facilities

The detailed investigation of the equipment and facilities were carried out under the deenergizing and dewatering condition of the power station to inspect accurately the degree of the deterioration and damages of the facilities. The intake facilities were inspected visually by divers.

The results of the field investigation are as follows.

(1) Spillway radial gates and hoists

The occurrence of the corrosion due to removal of the paint material were observed on the surfaces of skin plate and gate girders and the some seal rubbers damaged due to aging and deterioration were also observed.

It was also observed that the remote control panel, local control panels, auxiliary mechanical and electrical parts were remarkably aged and deteriorated.

(2) Spillway irrigation outlet facilities

The Study Team observed that the valve chamber was completely submerged at the moment and thus the detailed inspection required for the irrigation outlet valve was impossible.

(3) Intake fixed trash racks

The detailed investigation for the submerged portion of trash rack was visually carried out by divers.

It was observed that the thickness of screen bars was deducted at an average 3 mm from the original one.

(4) Intake movable trash rack and hoist

The screen panels were damaged several times in the past, due to vibration of screen panel and renewed at two (2) times by PC-2.

As a result of the visual inspection by divers, the large breakage of secondary concrete was observed at left side of a front guide frame for the downstream screen panel.

The control panel and auxiliary electrical parts of the hoist were remarkably aged and deteriorated.

(5) Intake Caterpillar gate and hoist

The operation test was attempted to confirm the operational condition of gate leaf and hoist and the satisfactory operation condition was confirmed.

(6) Surge tank and penstock tunnel drain facilities

The operation conditions of valves and conduit were in satisfactory and no water leakage form valve seat was also observed.

(7) Butterfly valves

No leakage from No.1 butterfly valve and minor leakage from No.2 butterfly valve were confirmed.

The aging of the seat rubbers quality of butterfly valve disk and air valves was in progress and the deterioration of the over velocity tripping devices due to occurrence of corrosion was remarkable.

The No.2 butterfly valve was confirmed the difficulty smooth operation of valve closure by the counter-weight due to increased friction load of seat rubber.

(8) Penstocks

1) Appearance inspection

a) Inner surface

The paint condition of the shell surface for the No. 1 line was effectively maintained. But the present paint condition of the shell surface for the No. 2 line was not effect for corrosion protection and the serious corrosion were also observed on the shell surface.

b) Outer surfaces

The paint condition on the both penstock lines was effectively maintained at the moment.

2) Shell thickness inspection

The thickness of pipe shell was within allowable design valve.

3) Welding quality inspection

The quality of the field welding joints on both penstock lines were within acceptable range.

4) Inspection of penstock portions repaired by Viet Nam

The penstock portions repaired by Viet Nam after an end of war were located between BL. No.2 and No.3 of the penstock No.2 line and No.8 unit pipe between BL. No.4 and BL. No.5 of the penstock No.2 line, respectively.

The safety of penstock was confirmed with comparison between the design information from the PC-2 report and the results of the penstock stress to be estimated from the analysis as a result of the SUMP test and chemical analysis of material.

3.5 Dam and Civil Structure

The field investigation carried out for about one month from the middle of July to the middle of August 1994. The reservoir water level was constant at around EL. 1,025 throughout the field investigation period, which is about 17 m lower than the reservoir high water level of EL. 1,042 m.

Major investigation items and their results are as follows.

(1). Present condition of sediment deposit in the reservoir

1) Reservoir cross section survey

The reservoir cross section survey was conducted mainly with a set of echo sounder brought from Japan. The cross section survey in the upstream reaches was done by leveling on the Da Nhim river and Krong Klet river.

The concrete-made base points were installed on the both banks of each survey line for permanently utilizing.

2) Present silt sedimentation space

The present silt sedimentation space is derived to be about 50% of the originally secured volume of 2 million m^3 and the estimated value is considered to be in a reliable range.

(2) Seepage through the dam

There seem to be no issues concerning the total seepage volume through the dam.

(3) Settlement of the dam crest

The comparison of the dam crest elevation in 1972, 1992 and 1993 clarifies that no significant settlement of the dam body has occurred as a whole for these 20 years.

(4) Main defects and issues identified concerning civil structures

1) Dam: Occurrence of muddy flow along spillway channel on the condition of spillout of discharge through spillway at the reservoir water level higher than the HWL

2) Spillway: Occurrence of cracks in concrete of overflow weir, clogging of drain holes in the valve chamber of irrigation outlet and river bank erosion in the downstream portion of spillway.

3) Intake structure: Partial loss of concrete in guide frame of movable trash racks and cracks in concrete of partition wall in intake shaft

4) Headrace tunnel: High water leakage from the surrounding rock zones of tunnel under the dewatered condition (no survey was conducted in this time)

5) Penstock line: Drainage of rain water and erosion of foundation in the steep-sloped portion

6) Power house: Repair of cracked concrete wall of powerhouse

3.6 Hydrological Data Acquisition System

The field investigation of hydrological data acquisition system was carried out by method of collection of data, hearing from the concerned persons, examination of documents and field survey.

(1) Existing facilities

The existing rainfall gauging stations were designed, manufactured and constructed by the Army Academy of Technology in 1983. After that, an extensive modification of the system was made under the responsibility of the power station in 1989 and the system has been operating until now as it is.

The rainfall gauging stations were located at three places, i.e. Xuan Tho, Da Sa and Da Chay. The central station was in the dam control house near the spillway of the main dam, and the water level gauging station was located at the right side the spillway gates

of the dam. The data transmission between the central station and power station were executed with voice by telephone.

(2) Results of field survey

1) Data acquisition system

The present "Event Reporting System" may be applicable to the present system having three gauging stations. However, when the number of the gauging stations increases more than 10, the polling system is recommendable.

2) Location of gauging station

All of the present three rainfall gauging stations were located on the west side of catchment area of the Da Nhim reservoir due to easy access. Two or three of new rainfall gauging stations on the east side of catchment area and two new water level gauging stations on the upstream of Da Nhim and Krong Klet rivers are required to be additionally installed from the meteo-hydrological point of view, for estimating the inflow to the reservoir.

3) Hardware

The existing facilities had no serious problems, However, they were so aged that extension of the ganging system and modification of the data acquisition system would not be applied to them.

4) Radio wave propagation

Judging from the examination on the profile of communication route of the existing stations, the reliability of the radio circuit was judged to be very low.

3.7 Substation Facilities

The field investigation was carried out on the substation facilities at the Da Nhim Power station and Saigon substation, and also carried out on the main transformers for the Thap Cham and Phan Thiet substations which are planned to be upgraded.

(1) Da Nhim power station

1) Transformers

The laboratory analysis of the insulating oil was performed to nine (9) transformers to diagnose the deterioration of the transformer insulation. As a result of the analysis, it is certain that the main transformer No. 1 unit was subject to local heat problem due to imperfect contact and leakage current. Also, there was a great possibility of local heat inside of 31.5 kV 2 MVA transformer due to imperfect contact or other causes.

Deterioration of bushings, improper operation of Buchholtz and other relays were found on almost all transformers.

2) Switchgear

The outdoor switchgear incurred discoloration on the conductive parts and terminals, and rust on many steel members. Many air-blast circuit breakers and current transformers had a little oil leakage. However, these defects and abnormalities were not so serious to interfere the operation of the switchgear under the present conditions.

3) Control board

There were no serious defects and rust on the panel, cables and terminals and that almost all the wiring and terminal connections were still in good condition. However, since almost all the instruments and relays were used exceeding their standard service life, it is expected that such problems as mechanical troubles, imperfect contact, accuracy degradation and wrong operating characteristics will be arisen increasingly in the future.

(2) Saigon substation

1) Synchronous condensers

The synchronous condensers were damaged by the fire accident on the 11 kV circuits, the burning-out of the main bearing metals and other troubles. Also, it was reported that the synchronous condensers have not been overhauled at all and are bad condition.

a) Stator

The stator windings for both units were covered with heavy dust and their insulation resistance was too low. Judging from the DC current absorption test, which indicated the index of porosity (PI) was about 1.0, the stator windings were in hygroscope condition. The result of the tan δ measurement also showed that the stator windings were absorbing moisture abnormally.

Some spacers for the stator windings for both units were slided out a little from the slots. As for the stator core, it was observed that the fastening bolts for the stator core for Unit 1 was loosen a little. No other special abnormalities were observed on the stator core.

b) Rotor

The rotor coils for both units were covered with heavy dusts. The insulation resistance of the rotor coils for both units was too low.

The threads of the slip rings for both unitswere worn down a lot especially at the center.

c) Main shafts

The fretting corrosion was observed on the main shaft at the PMG side of unit No. 1.

d) Main bearings

Almost all the babbit metal lining of the bearing metals for both units were detached and some of them be separated deeply.

Excessive oil leakage was observed on the oil circulating pumps, oil lift pumps and heavy rust and corrosion were also observed on the cooling water pumps.

e) Exciters

The main and pilot exciters for both units were covered with heavy dust. Some brushes did not work smoothly. The field pole terminals, lead wires, etc. have been deteriorated remarkably.

The AVR units are unusable since 1985 due to the trouble.

2) Transformers

The laboratory analysis of the insulating oil was performed to nine (9) transformers to diagnose the deterioration of the transformer insulation. As a result of the analysis, there was a great possibility of partial discharge being appeared in the main transformer B-phase of No. 1 bank and local heat in the main transformer C-phase of No. 2 bank. Also, there was a great possibility of burning of solid insulation material in two 66 kV, 20 MVA transformers.

Deterioration of the bushings, improper operation of buchholtz and other relays were found on almost all the transformers.

3) Switchgear

The outdoor switchgear incurred discoloration on the conductive parts and terminals, and rust on many steel members. Many air circuit breakers and current transformer had a little oil leakage. However, there detects and abnormalities were not so serious to interfere with the operation of the switchgear under the present condition.

4) Control board

Each board partly rusted and damaged. The inside of each board was very dirty with dusts and spider's webs. However, there are no serious defects and abnormalities to interfere with the ordinary operation. Since almost all the instruments and relays were used exceeding their standard service life. The troubles due to improper operation of relays and low accuracy of meters will be arisen increasingly in the near future.

The transmission line fault locator for 230 kV Saigon line were long out of use.

(3) Thap Cham and Phan Thiet substations

The laboratory analysis of the insulating oil was performed to each main transformer of Thap Cham and Phan Thiet substation. From the result of the analysis, it is recommended that both transformers should be not diverted to other substation after upgrading of the substations without internal inspection and repair.

3.8 230 kV Transmission Line

The Study Team conducted the investigation of the facilities through the discussion held with the counterparts,

The results of investigation are as follows.

(1) Steel Towers

The Study Team found the following conditions and confirmed the necessity for urgent rehabilitation.

1) Existing tower members having a small sectional area due to damage caused by bullets
2) Many missing members from the designed structures
3) Members different from the designed quality and size
4) Deformed members due to serious rust
5) Deformed members due to their improper fabrication
6) Rust on most of the members used for the tentative repairs due to the members not being galvanized but only painted.

(2) Power conductors and overhead earthwires

It was necessary to use different size of conductors and earthwires for tentative repair due tot he shortage of materials. The joints of these conductors and earthwires were not made using the proper joint sleeves, but by using temporary materials such as clips or aluminium tapes. These temporary joints have not yet been replaced with proper joints.

(3) Insulators

Much fog on the high land and artificial pollution from factories are very serious problem in the area of the Bao Loc and Saigon-Long Binh substations. The Study Team recommends PC-2 to utilize fog type insulator in the polluted areas.

(4) Tools for rehabilitation and maintenance

The Study Team confirmed that the amount of tools stored in warehouse in the Saigon substation and Don Duong office is very small. The tools stored are mainly tools which were supplied 30 years ago are in a state of disrepair.

(5) Maintenance works and manuals

The maintenance organization of 230 kV Saigon line consist of 9 groups with 17 linemen and two radio equipped vehicles per group.

The present maintenance manuals are commonly prepared for the lines from 1 kV to 230 kV. The Study Team presented the maintenance manuals for the Da Nhim ~ Saigon 230 kV transmission line, which were prepared during the construction period of the line.

3.9 Upgraded 66 kV Facilities

Prior to the field investigation. The Study Team confirmed the request by Viet Nam.

Through the discussion, it was disclosed that the existing Cam Ranh substation and the line extending from the Thap Cham substation to the Cam Ranh substation are now under the management of PC-3.

If the Cam Ranh substation and the related transmission line are upgraded, the upgrade of the 66 kV transmission line from the Cam Ranh substation to the Dien Khanh substation which locate in the middle place of the Cam Ranh-Nha Trang line, as well as the Dien Khanh substation is necessary. The director of PC-3 requested the Study Team to study these facilities together with the Cam Ranh substation and the Thap Cham - Cam Ranh line. It investigated these facilities on the way to the office of the PC-3 in the Nha Trang City.

(1) Power records and power demand forecasts

Average annual growth rates in the area planned for the upgrade were recorded at such high levels as 20% for energy consumption and 17% for the maximum power demand, over the last 4 years.

An official demand forecast is issued by the Ministry of Energy after the ministry has approved the draft demand forecast prepared by each power company. An average annual growth rates in the area were forecasted as 24.5% for energy consumption and 18.4% for the maximum power demand for the year up to 2000.

(2) Transmission line

1) Overhead earthwires and power conductors

All the existing power conductors can be applied to the 110 kV transmission lines as they are.

The existing overhead earthwires and power conductors are believed to be in good condition except for the individual wires which were partially broken complete wires, which were broken and then tentative repaired.

2) Supports

All the existing supports can be used for the upgraded power system without modification. But the tarpainted timber poles in the Cam Ranh-Dien Khanh section are planed to be replaced with concrete poles by PC-3.

3) Insulators and hardware

Since the facilities were designed and constructed for 110 kV - 132 kV lines, no modification is required for upgrading the line voltage.

In Cam Ranh-Dien Khanh section, most of the insulator sets have only 6 units per set for the operation of the 66 kV system. It is necessary to increase the number of insulator units for the 110 kV system.

4) Tools and devices for repair and maintenance

Tools and devices required are the same as those used by the 230 kV transmission line, however, they should be procured separately because of the different areas to be covered.

(3) Substations

1) Existing 66 kV substation facilities

After upgraded the 66 kV line to 110 kV, the usable 66 kV existing facilities will be transferred to other 66 kV system.

2) Sites of new 110 kV substations

The sites for new 110 kV substation have been prepared by PC-2 and PC-3 in the neighbour of existing 66 kV substation.

CHAPTER 4

URGENT REHABILITATION PLAN

CHAPTER 4 URGENT REHABILITATION PLAN

4.1 General of Plan

The plan is formulated for prevention of the further deterioration of the facilities and restoration and improvement of the proper functions of the facilities for the Da Nhim power station, Saigon substation and 230 kV transmission line.

The plan is also formulated for maintenance of the proper function for ten (10) years after the urgent rehabilitation by regular repair without large scale rehabilitation.

The plan is formulated not only for restoration but also improvement and modernization of the facilities and capacity up of equipment in considering the future demand.

As a result of the field survey, the Study Team recommended that some rehabilitation works should be carried out by PC-2 themselves without delay as the special urgent rehabilitation works. The Study Team also recommended an additional study on rehabilitation of civil structures and flood control plan which is to be carried out in a separate study.

(1) Special urgent rehabilitation

1) Da Nhim power station

a) Generator
- replacement of stator slot wedges of all units extremely loosed at their ends
- repair of air cooler for unit No. 1
- renewal of the oil lift pump on the exciter side of No. 2 unit
- finishing of surfaces of commutators of the exciters for No. 4 unit
- repair of the defected parts of blades of fans of No. 1 unit
- liquid penetration examination of main bearing metal of No. 1 and No. 3 units

b) Transformer
- internal inspection of main transformer No. 1 bank.

2) Saigon substation

Detailed overhaul inspection and cleaning of synchronous condensers and replacement of air filters for synchronous condensers.

(2) Urgent rehabilitation plan

The urgent rehabilitation plans of each facility is summarized as follows.

1) Water turbine and ancillary facilities

a) Replacement of runner bucket and reamer bolts, upper and lower nozzles, needle and deflector, and repair of baffle plate, deflector servo motor and operating mechanism

b) Replacement of inlet valve, bypass valve and related valves.

c) Replacement of governor to digital type regulator with cabinet, solenoids, relays and other devices

d) Replacement of motor driven oil pump, air compressor, and their accessories

2) Generator and ancillary facilities

a) Renewal of the stator cores and coils
b) Replacement of the existing exciters with static thyristor exciter
c) Improvement of lifting method of the rotor
d) Remodeling of air housing and prevention of noise
e) Renewal of main bearing metals
f) Renewal of air coolers
g) Renewal of oil cooler, lubricating oil pump and oil lifter
h) Renewal of dial type thermometers, relays
i) Renewal of oil seals and air seals
j) Replacement of wiring in the housing, oil and water pipes
k) Repair painting

3) Waterway and ancillary facilities

a) Renewal of seal rubber and seal clamps for gates and valves

b) Repair painting work of gates and penstock
c) Replacement of control panel of gates and valves
d) Renewal of mechanical and electrical parts of gates and valves
e) Repairing of damaged ring girders
f) Renewal of irrigation valves
g) Renewal of water supply pump
h) Renewal of movable trash rack panel
i) Renovation of rope haulage of penstock
j) Provision of spare parts and maintenance equipment

4) Dam and civil structure

a) Spillway
- V-cut and filling mortal in cracked portion of overflow weir
- Provision of drain holes for valve chamber of irrigation outlet by core drilling

b) Intake structure
- Concrete placement in the deteriorated portions of guide frame for movable trash racks
- V-cut and filling of mortal in cracked portions of partition wall of intake shaft

c) Penstock line
- Compacted backfill with sand and gravel
- Check boring in the foundation
- Construction of new drainage channel
- Slope protection works

d) Power house
- V-cut and filling of mortal and/or other plastic materials in cracked portion of down stream wall and other cracked concrete portions.

5) Hydrological data acquisition system

a) To comprehend overall rainfall in the catchment area of the Da Nhim reservoir by the effective distribution of the rainfall gauging stations.

b) To comprehend inflow and outflow of the Da Nhim reservoir by some additional water level gauging station.

c) To provide the function of real time data acquisition by improvement of the radio transmission characteristics including relocation of the central station.

d) To provide the function of water management at the central station.

e) To monitor the water management status in the powerhouse by additional installation of data transmission circuit and water management leased telephone circuit between the central station and the powerhouse.

f) To provide the warning facilities for safety of inhabitant in the down stream.

6) Substation facilities

For Da Nhim power station

a) Transformers

- Replacement of the defective and obsolescent components for the main transformer Nos. 1, 2, 3 and 4 units
- Replacement of all the house-service transformers
- Replacement of the 31.5 kV transformers by a new transformer with 10 MVA
- Removal of three 66 kV, 16 MVA transformers after the 66 kV Thap Cham line is upgraded to 110 kV
  (These 66 kV transformers will be relocated to the other substations)
- Replacement of the defective and obsolescent components for the 66 kV, 22.5 MVA transformer

b) Switchgear

- Replacement of 230 kV voltage transformers
- Replacement and repair of the defective and obsolescent components for 230 kV and 66 kV switchgear
- Replacement of the A.C. motor driven type air compressors for the air-blast circuit breakers

c) Control and relay boards

- Replacement of all the control and relay boards and introduction of the supervisory computer system for modernization of the control system

For Saigon Substation

a) Synchronous condensers

- The urgent rehabilitation was cancelled by the opinion of PC-2 that the synchronous condensers at Saigon substation are now not so important for the power system control.

b) Transformers

- Replacement of the main transformer No. 2 unit by a three-phase, 125 MVA transformer
- Overhaul and replacement of the defective and obsolescent components for the four single-phase main transformers which are composed as the main transformer No. 1 unit
- Replacement of the house-service transformers with new ones whose capacity will be increased to 400 kVA respectively
- Replacement of two 66 kV, 20 MVA transformers with new ones whose capacity will be increased to 31.5 MVA
- Replacement of three single-phase 66 kV transformers by a three-phase, 12.5 MVA transformer

c) Switchgear

- Replacement of the 66 kV switchgear; four current transformers, three voltage transformers, eleven lightning arresters
- Additional installation of the 66 kV lightning arresters
- Replacement of the defective and obsolescent components for 66 kV switchgear
- Replacement of the A.C. motor driven type air compressor for the 66 kV air blast circuit breakers
- Additional installation of one 66 kV static condenser bank with 10 MVA

d) Control and relay boards

- Replacement of all the control and relay boards and introduction of the data logging and event recording system for modernization of the control system
- Renewal of the fault locator for the 230 kV transmission line. The fault locator will be installed at the Long Binh substation and at the Da Nhim power station

e) PLC system

- Modification of PLC terminal equipment from 1-ch to 4-ch for sections between the Saigon substation and the Long Binh substation and between the Long Binh substation and the Da Nhim power station.

7) 230 kV transmission

a) Rehabilitation of the towers

- Tower foundations and the surrounding areas
- Superstructures of the towers

b) Rehabilitation of the overhead earthwires and power conductors

- Preparatory investigation
- Rehabilitation of the overhead earthwires
- Rehabilitation of the power conductors

c) Rehabilitation of the insulators and insulator sets

- Replacement of the insulator units or fittings
- Replacement of the insulators with power conductors

8) 66 kV substations to be upgraded

Construction of the five new 110 kV substations of Thap Cham, Phan Ri , Phan Thiet, Cam Ranh and Dien Khanh and extension of 110 kV substation equipment of the Da Nhim power station.

(3) Additional study on rehabilitation of civil strictures and flood control plan

1) Field investigations and analysis to clarify the cause of occurrence of muddy flow in the reservoir during release of a large-scale flood discharge from spillway, and preparation of rehabilitation plan if any defect are found out in the dam body.

2) Study on conservation of the upper Da Nhim river basin of the Dran dam.

3) Feasibility study on the flood mitigation in the downstream area of the Dran dam site.

4.2 Basic Design

The Basic design condition of the rehabilitation plan is as follow;

(1) General condition

The materials and equipment to be used for the rehabilitation work will comply with the latest revision of the International Standards and the Japanese Standards.

The components to be used for the partial rehabilitation of the respective equipment essentially required to have the same dimensions and performance as the original ones, to insure that the rehabilitated equipment could be operated with the same performance as the new one.

The parts and equipment to be renewed should be designed and fabricated in compliance with the specified rating and requirements and should be tested in the approved manner.

(2) Basic condition for each facility

1) Turbine
- The replacement parts for the turbine main portion shall have equivalent and/or higher quality of existing ones.
- The new speed governor shall be of cabinet type digital regulator.
- The specifications for the auxiliary equipment shall be the same as original ones.

2) Generators
- The overall performances of the generator after rehabilitation shall be not less than those at the initial operation.
- The new excitation system shall be of static thyristor exciter.
- The generator shall be modified so that the rotor could be drawn out without splitting the stator.
- The specifications for the auxiliary equipment shall be the same as original ones unless otherwise specified.

3) Gates Valves
- The basic design shall conform to the latest Japanese Engineering Standards.
- The specifications for the parts and equipment shall be the same as original ones.
- The new local control panels for the pillway gates shall be two panels, each for two gates.
- The control panels for the gates and valves shall incorporate the necessary provisions for the central supervisory system in the future.

4) Civil works
- Repair concrete work for the spillway shall be carried out in the dry season and at low water level to insure enough time for concrete curing.
- Repair concrete work for the intake shall be carried out under no water condition.
- Grouting for the foundation of the penstock lines shall be depend on the result of boaring.

5) Hydrological data acquisition system
- The hydrological data acquisition system shall be designed and established for effective water management on the basis of the wave propagation characteristics.
- All data shall be collected by polling method.
- The system shall be composed of the rainfall and water level gauging stations, the warning stations, the central station, the powerhouse remote station and repeater stations.

6) Substation equipment

- The replacement components shall be new, equivalent specifications and suitably fitted to the original structures in case the design of the components is modified.
- The new equipment shall be designed and fabricated in compliance with the specified rating and requirements.
- In principle, electrical equipment and apparatus shall comply with IEC standard.
- Power cables shall be of cross-linked polyethylene insulated cables.
- The excitation system for the synchronous condensers shall be of static thyristor type one.

7) 230 kV Transmission line

- Preventive measures around the tower foundation shall be taken depending on the actual situation.
- The materials for tower shall conform to JIS-SS-41 and SS-51 or equivalent.
- The overhead eathwire shall be of JIS-G-3537 of 88 mm^2, 12 mm or equivalent.
- The power conductor shall be of JIS-C-3110 ACSR 410 mm^2 or equivalent.
- The insulator shall be of porcelain-wade 254 mm x 146 mm, cap and pin type with ball and socket.

4.3 Implementation Program

The overall implementation programme of the urgent rehabilitation plan is shown on Figure 4.1.

(1) Implementation form of urgent rehabilitation work

Following formation is recommended to implement the urgent rehabilitation works.

1) Design, preparation of the specifications of the equipment and materials to be procured from the outside of Viet Nam, and the supervision of the works will be carried out by the Consultant.

2) Supply of equipment, parts and materials from the outside of Viet Nam including technical services of erection at site and training of Vietnamese engineers and technicians in the manufacturer's works will be made by the manufacturer(s) selected in the international competitive bid or a tender by the limited bidders.

3) The civil work will be carried out by the Vietnamese erection team mainly organized from the maintenance group of the Da Nhim Power Station on the basis of the design of the Consultant.

4) The rehabilitation work at site including dismantling, reassembling, repairing or renewal of equipment will be carried out by the Vietnamese erection team mainly organized from the maintenance group of the Da Nhim Power Station.

(2) Construction plan

The rehabilitation work of the generators should be conducted urgently, efficiently and economically in co-operation with other related rehabilitation works such as for water turbines, transformers, switchgear, penstocks and civil structures.

The urgent rehabilitation works should be planned so minimize the interruption of to the power supply and the spill out of the water from the reservoir.

(3) Construction method

Disassembling and reassembling works of the generator and turbine will be carried out at the same time in the machine room. In addition, it is conceivable that in a certain period, the works for transformers, switchgear equipment will also be carried out in the erection bay. Accordingly, non-essential equipment, parts and materials should be moved from the machine room for keeping necessary spaces for each work. Especially, the inside of erection pit shall be kept clean to disassemble and reassemble the stator cores and coils. The floor space to set the dismantled equipment and parts should be shown on the drawings for the every work stage.

The civil work for the dam, intake and penstock will be carried out in principle during the dry season. It is recommendable to carry out the concrete work of the intake at the water level less than EL. 1,016.5 m and under the inflow of less than 5 m3/sec after

the provision of stoplog at the existing stoplog slot. The period of the work is estimated at ten (10) days.

The hydrological data acquisition system will be installed after confirmation of final design of data acquisition, transmission method and management system as a result of field survey and map survey.

Disassembling and reassembling works of the distribution panel at the power house and the sub-station will be planned and carried out to be minimized the interruption of the power supply.

The rehabilitation of 230 kV transmission line will be carried out under the normal operational condition of line, except for replacement of the main steel structure of the tower. The repair of the overhead earthwires, power conductors, and insulators will be executed by the organization of 19 gangs for repairing and completed for 8 to 10 days.

4.4 Recommendation of Operation and Maintenance

It is recommended the following operation and maintenance plan for Da Nhim power supply system.

(1) Water Turbine, Generator, Waterway and ancillary facilities and Switchgear

1) Systems Operation and Maintenance Manual with regulation and time schedule.

2) Make up the filing system for drawings, records and other documents for easy reference.

3) Perform the periodical in inspection and take necessary action according to the O&M Manual.

4) Purchase non destructive and insulation resistance testing facility including operator training.

5) Restudy the regulation of using the water in the dam.

6) Operate the power house with high efficiency.

7) Train the staff with advanced technology.

8) Store proper quality and gratuity of spare parts.

9) Modify the parts and material control system at the stone.

(2) Dam and Civil

1) When the water level increasing, do not try to keep the level max. in order to avoid sudden water release from the dam.

2) It is recommended to monitor settlement of dam crest in the contract portion of dam and spillway.

3) It is recommended to monitor the condition of sediment deposit in the reservoir at an interval of five (5) years.

(3) 230 kV Transmission Line

1) Keep the maintenance staff as it is (17 staffs/gang x 9 gangs).

2) Erect additional 230 kV T/L from Da Nhim to Bao Loc

3) Perform overall inspection to the existing T/L

4.5 Implementation Schedule and Cost Estimate of Project

4.5.1 General

This Chapter summarizes the estimated implementation schedule of the Project and the cost estimate for the project implementation of the urgent rehabilitation of the Da Nhim 230 kV power system and the upgrading of the Da Nhim 66 kV transmission system recommended in the foregoing chapters.

The project implementation schedule is prepared for the preparatory stage and the project implementation stage. The preparatory stage covers the period from the detailed design to the conclusion of the supply contracts for the various facilities. The works will be carried

out by the executing agencies and the consultants. The works in the implementation stage are for manufacturer's design, manufacturing, fabrication and procurement of the equipment and materials as well as for the site erection works. The period is estimated from the actual experience of the similar projects and in consideration of the working capacity of the executing agencies.

The cost is estimated on the assumption that almost all the major equipment and materials required for the Project will be imported into Viet Nam while all the local works required at the site will be executed mainly by the working forces of PC-2 or PC-3 under assistance of expatriate experts. The costs of the imported equipment and materials are estimated for the costs in 1997 referring to the recent international competitive bid prices of the similar projects. The costs for the local works to be executed by PC-2 and PC-3 are estimated by the Study Team in accordance with information collected during its field investigation stage. New substation buildings for the 110 kV substations for the upgrading project are assumed to be constructed by PC-2 and PC-3 using locally available materials.

It is also assumed that all taxes, duties and other levies are exempted by the Vietnamese Government for the imported goods and the expatriate experts for the Project.

4.5.2 Implementation Schedule

The estimated time schedule of the Project is shown in Figure 4.1. The schedule is prepared for the preparatory works, the urgent rehabilitation works, the upgrading works, and the additional study for the civil structures.

The preparatory works are for the detailed design of the facilities to be rehabilitated, preparation of tender documents for procurement of the equipment and materials, tender floating, tender evaluation, negotiation with successful tenderers, and conclusion of contracts as well as review of the design, documents, evaluation and contracts by the project executing agencies of Viet Nam and the fund source. The period of the preparatory stage is estimated to be 12 months. The consulting engineers will perform all the works in this stage together with the executing agencies.

After the conclusion of the contracts, each contractor will carry out his manufacturing design and fabrication of the contracted equipment and materials. Upon site arrival of the fabricated equipment and materials, the executing agencies will start the rehabilitation works with assistance of the consulting engineers. The critical path of the project execution will be on the rehabilitation of the generators and their ancillary facilities. Four units of the turbine

generator sets will be completed within 3 years after the contracts. While, the rehabilitation of the Saigon substation, 230 kV transmission line, and the hydrological acquisition system is expected within 23 months after the contracts.

The upgrading works of the existing 66 kV system will be completed within 21 months after the contracts under the assumption that construction of all the new 110 kV substations and works for the transmission lines will be executed in parallel at the same time by the executing agencies.

The additional detailed study for the civil structures related to the Da Nhim dam will immediately start after the project fund will become available. It will take about 18 months to submit the final report to the agency of the project.

4.5.3 Summary of Project Cost

The project cost includes the cost of the imported goods, the local works, the expatriate experts, the engineering services for detailed design and construction supervision and the provisional sums and is summarized below. The Foreign Currency covers the C.I.F. price of the imported goods and the cost of the expatriate experts and the engineering services, while the Local Currency covers the cost of the inland transportation of the imported goods and the direct and indirect cost for the local works executed under the responsibilities of PC-2 and PC-3. The provisional sum is assumed at 5 % of the total amount for the foreign currency portion and 10 % of the total amount for the local currency portion.

Exchange rate between Japanese Yen and US Dollars is assumed at Yen 100 per US$ 1.00.

Further details for the estimated cost of each work are shown in Tables 4.1 to 4.11.

(1) Rehabilitation Works of Da Nhim Power Station, Saigon Substation and 230 kV Line

	Work Items	Cost Estimate		
		Foreign Portion (J.¥ 1,000)	Local Portion (J.¥ 1,000)	Total (J.¥ 1,000)
1.	Water Turbines and Ancillaries	1,510,000	7,000	1,517,000
2.	Generators and Ancillaries	1,596,000	20,000	1,616,000
3.	Waterway and Ancillaries	497,000	23,000	520,000
4.	Dam and Civil Structures	0	46,000	46,000
5.	Hydrological Data Acquisition	363,000	34,000	397,000
6.	Da Nhim Substation	741,000	8,000	749,000
7.	Saigon Substation	850,000	36,000	886,000
8.	230 kV Transmission Line (*)	163,000	16,000	179,000
9.	Sub-total of Items 1 to 8	5,720,000	190,000	5,910,000
10.	Engineering Service	351,000	0	351,000
11.	Sub-total of Items 9 and 10	6,071,000	190,000	6,261,000
12.	Price Contingency (5% & 10%)	303,000	19,000	322,000
	Total for Rehabilitation	6,374,000	209,000	6,583,000

(*) Including tools and appliances for maintenance works

(2) Upgrading Works of 66 kV Transmission System

	Work Items	Cost Estimate		
		Foreign Portion (J.¥ 1,000)	Local Portion (J.¥ 1,000)	Total (J.¥ 1,000)
1.	Da Nhim 110 kV Switchyard	183,000	2,000	185,000
2.	Thap Cham Substation (*)	256,000	46,000	302,000
3.	Phan Ri Substation (*)	212,000	46,000	258,000
4.	Phan Thiet Substation (*)	193,000	46,000	239,000
5.	Transmission Lines (*)	67,000	17,000	84,000
6.	Sub-total of Items 1 to 5	911,000	157,000	1,068,000
7.	Engineering Service	69,000	0	69,000
8.	Sub-total of Items 6 and 7	980,000	157,000	1,137,000
9.	Price Contingency (5% & 10%)	49,000	16,000	65,000
	Total for Upgrading in PC-2	1,029,000	173,000	1,202,000
10.	Cam Ranh Substation	301,000	47,000	348,000
11.	Dien Khanh Substation	251,000	46,000	297,000
12.	Testing Equipment	78,000	1,000	79,000
13.	Transmission Lines (*)	249,000	78,000	327,000
14.	Sub-total of Items 10 to 13	879,000	172,000	1,051,000
15.	Engineering Service	69,000	0	69,000
16.	Sub-total of Items 14 and 15	948,000	172,000	1,120,000
17.	Price Contingency (5% & 10%)	47,000	17,000	64,000
	Total for Upgrading in PC-3	995,000	189,000	1,184,000
	Grand Total for Upgrading Plan	2,024,000	362,000	2,386,000

(*) Including tools and appliance for maintenance works

(3) Additional Study for Dam and Civil Structures

Work Items	Cost Estimate		
	Foreign Portion (J.¥ 1,000)	Local Portion (J.¥ 1,000)	Total (J.¥ 1,000)
Additional Study	282,000	104,000	386,000

(4) Total Project Cost

	Work Items	Cost Estimate		
		Foreign Portion (J.¥ 1,000)	Local Portion (J.¥ 1,000)	Total (J.¥ 1,000)
1.	Rehabilitation Works	5,720,000	190,000	5,910,000
2.	Upgrading Works	1,790,000	329,000	2,119,000
3.	Engineering Service	489,000	0	489,000
4.	Price Contingency	399,000	52,000	451,000
5.	Add. Study for Civil Structures	282,000	104,000	386,000
	Total Project Cost	8,680,000	675,000	9,355,000

4.5.4 Project Phasing

As shown in the above cost estimates, the total project cost will amount approximately to Japanese ¥ 9,355,000,000. This total project cost is estimated for all the recommended works for the urgent rehabilitation plan and the upgrading plan. As seen in the total project cost, the project scale is rather big for the rehabilitation project and it may be difficult to finance the total amount of the project cost for implementation of all the works at once. Therefore it is proposed that the Project should be implemented by phasing into two stages for smooth financing of the project fund.

(1) Criteria for project phasing

A plan of the project phasing is formulated in accordance with the following criteria.

1) The urgent rehabilitation of the facilities that were seriously deteriorated and aged should be given top priority and should be carried out in the first phase.
2) In case the deterioration and ageing were not so serious and will not cause the fatal damage to the facilities even though they will be left as they are for the time being, the urgent rehabilitation of such facilities should be carried out in the second stage.

3) The urgent rehabilitation of the facilities, such as the urgent rehabilitation of the hydrological data acquisition system and the modernization of the control system, which are not essential to the operation of the Da Nhim Power Station and the Saigon Substation, should be carried out in the second stage.

4) The upgrading plan of the existing 66 kV power system should be implemented in the second stage.

5) In order to avoid unnecessary complications due to the phased implementation of the Project, all the works in the same facilities should in principle be done in the same phase.

(2) Plan of Project Phasing

Referring to the above criteria, the project phasing is proposed as follows:

1) <u>First Phase</u>

a) Urgent rehabilitation of water turbines, generators and substation facilities for the Da Nhim Power Station (except substation facilities listed for second phase)
b) Urgent rehabilitation of substation facilities for the Saigon Substation (except substation facilities listed for second phase)

c) Urgent rehabilitation of 230 kV transmission line

2) Second Phase

a) Urgent rehabilitation of water way, dam and civil structures, hydrological data acquisition system and the following substation facilities for the Da Nhim Power Station

i) Rehabilitation of 230 kV circuit breakers and disconnecting switches
ii) Rehabilitation of 13.2 kV switchgear
iii) Rehabilitation of 6.6 kV switchgear
iv) Introduction of supervisory computer system to power station control system
iii) Rehabilitation of surge tank water level measuring equipment

b) Urgent rehabilitation of the following substation facilities for the Saigon Substation

i) Rehabilitation of 66 kV circuit breakers and disconnecting switches
ii) Additional installation of 66 kV static condenser bank
iii) Introduction of computer system to substation control system

c) Upgrading of the existing 66 kV power system

d) Additional study for dam and civil structures

(3) Cost Estimate for Project Phasing

On the basis of the above proposed plan of the project phasing, the project cost for each phase is as tabulated below.

	Work Items	Cost Estimate		
		Foreign Portion (J.¥ 1,000)	Local Portion (J.¥ 1,000)	Total (J.¥ 1,000)
	FIRST PHASE			
1.	Da Nhim Power Station			
	(a) Water Turbines and Ancillaries	1,510,000	7,000	1,517,000
	(b) Generators and Ancillaries	1,596,000	20,000	1,616,000
	(c) Substation Facilities	487,000	5,000	492,000
	Sub-total	3,593,000	32,000	3,625,000
2.	Saigon Substation	661,000	35,000	696,000
3.	230 kV Transmission Line	163,000	16,000	179,000
4.	Engineering Service	212,000	0	212,000
5.	Price Contingency (5% & 10%)	229,000	9,000	238,000
	Total for First Phase	4,858,000	92,000	4,950,000
	SECOND PHASE			
1.	Da Nhim Power Station			
	(a) Waterway and Ancillaries	497,000	23,000	520,000
	(b) Dam and Civil Structures	0	46,000	46,000
	(c) Hydrological Data Acquisition	363,000	34,000	397,000
	(d) Substation Facilities	254,000	3,000	257,000
	Sub-total	1,114,000	106,000	1,220,000
2.	Saigon Substation	189,000	1,000	190,000
3.	Upgrading of 66 kV power system	1,790,000	329,000	2,119,000
4.	Engineering Service	277,000	0	277,000
5.	Price Contingency (5% & 10%)	170,000	43,000	213,000
6.	Add. Study of Civil Structures	282,000	104,000	386,000
	Total for Second Phase	3,822,000	583,000	4,405,000

Table 4.1 Cost Estimate for Water Turbines and Ancillaries

(Unit: ¥1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Replacement of Runners (4 sets)	400,000	23,200	-	-	423,200
Rehabilitation of Housings (4 sets)	18,720	1,080	-	-	19,800
Rehabilitation of Turbine Main Parts (4 sets)	147,420	8,540	-	-	155,960
Rehabilitation of Jet Brakes (4 sets)	20,000	1,160	-	-	21,160
Rehabilitation of Deflector Servomotors (4 sets)	5,940	340	-	-	6,280
Replacement of Inlet Valves (4 sets)	320,000	18,560	-	-	338,560
Replacement of High Pressure Valves and Pipes	59,300	3,440	-	-	62,740
Replacement of Drain Valves and Pipes	4,320	240	-	-	4,560
Replacement of Copper Pipes	360	20	-	-	380
Rehabilitation of Water Supply System	7,640	440	-	-	8,080
Replacement of Water Supply Valves	2,880	160	-	-	3,040
Replacement of Governor Actuators (4 sets)	186,200	10,800	-	-	197,000
Replacement of Regulators (4 sets)	98,460	5,700	-	-	104,160
Replacement of Speed Sensing Devices (4 sets)	11,240	640	-	-	11,880
Replacement of Turbine Control Panels (4 sets)	37,260	2,160	-	-	39,420
Instruments for Main Control Boards	800	40	-	-	840
Replacement of Oil Pressure Pump-Motors	10,000	580	-	-	10,580
Replacement of Unloader Pilot Valves	25,640	1,480	-	-	27,120
Instruments for Oil Tanks	9,440	540	-	-	9,980
Replacement of Air Compressors	7,920	460	-	-	8,380
Other Materials	40,000	2,320	-	-	42,320
Inland Tranportation and Local Works	-	-	3,000	4,000	7,000
(Sub-total)	(1,413,540)	(81,900)	(3,000)	(4,000)	(1,502,440)
Expatriate Specialists	15,000	-	-	-	15,000
Total	1,428,540	81,900	3,000	4,000	1,517,440

Total Foreign Currency	1,510,440
Total Local Currency	7,000
Total	1,517,440

Table 4.2 Cost Estimate for Generators and Ancillaries

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Renewal of Stators (4 sets)	617,550	37,050	-	-	654,600
Renewal of Excitation System with AVR (4 sets)	258,940	16,060	-	-	275,000
Renewal of Bearing Metals (4 sets)	110,920	6,680	-	-	117,600
Renewal of Air Coolers (4 sets)	70,280	4,220	-	-	74,500
Renewal of Oil Coolers (4 sets)	19,520	1,180	-	-	20,700
Renewal of Oil Pumps (4 sets)	3,120	180	-	-	3,300
Renewal of Oil Lifting Pumps (4 sets)	2,360	140	-	-	2,500
Renewal of Cooling Water Pipes (4 sets)	13,680	820	-	-	14,500
Renewal of Pipes for Lubricating Oil (4 sets)	9,340	560	-	-	9,900
Renewal of Pipes for Oil Lift (4 sets)	7,840	460	-	-	8,300
Rehabilitation of Air Housing and End-bells	56,200	3,400	-	-	59,600
Improvement of Lifting Device of Rotor	11,330	670	-	-	12,000
Renewal of Electrical Equipment and Wiring	48,000	2,900	-	-	50,900
Renewal of Oil Seals for Bearings (4 sets)	46,880	2,820	-	-	49,700
Renewal of Air Seals (4 sets)	6,240	360	-	-	6,600
Spare Parts and Other Materials	78,300	4,700	-	-	83,000
Inland Tranport and Local Works	-	-	5,000	15,000	20,000
(Sub-total)	(1,360,500)	(82,200)	(5,000)	(15,000)	(1,462,700)
Expatriate Specialists	153,300	-	-	-	153,300
Total	1,513,800	82,200	5,000	15,000	1,616,000

Total Foreign Currency	1,596,000
Total Local Currency	20,000
Total	1,616,000

Table 4.3 Cost Estimate for Waterway and Ancillaries

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Spillway Radial Gates & Gates					
Wire Rope Hangers	19,368	65	30	85	19,548
Repair Painting of Skin Plates	6,259	380	211	360	7,210
Seal Rubbers with Clamps	4,352	148	68	420	4,988
E & M Parts of Hoists	406	51	50	35	542
Control Panel & Cables	14,000	358	133	100	14,591
(Sub-total)	(44,385)	(1,002)	(492)	(1,000)	(46,879)
Spillway Irrigation Outlet					
Outlet Valves and Control	17,383	428	209	100	18,120
Water Supply Pump	3,300	104	96	35	3,535
(Sub-total)	(20,683)	(532)	(305)	(135)	(21,655)
Movable Trash Rack					
Upstream Trash Rack	1,000	51	192	500	1,743
E & M Parts of Hoist	3,633	14	10	30	3,687
Control Panel & Cables	4,394	35	20	15	4,464
(Sub-total)	(9,027)	(100)	(222)	(545)	(9,894)
Intake Caterpillar Gate & Hoist					
Seal Rubbers with Clamps	933	78	44	110	1,165
Repair Painting of Skin Plate	265	22	12	36	335
E & M Parts of Hoist	605	20	10	5	640
Control Panel & Cables	4,000	35	20	10	4,065
(Sub-total)	(5,803)	(155)	(86)	(161)	(6,205)
Surge Tank Drain Facilities	5,205	150	85	300	5,740
(Sub-total)	(5,205)	(150)	(85)	(300)	(5,740)
Butterfly Valves					
Seal Rubbers with Clamps	1,654	30	20	165	1,869
Auxiliary Facilities	4,041	42	17	50	4,150
Control Panel, Oil Pipes & Cables	16,500	255	106	225	17,086
Detailed Inspection of Valves	-	-	-	160	160
(Sub-total)	(22,195)	(327)	(143)	(600)	(23,265)
Penstocks					
Painting at Upstream of Butterfly Valves	52,045	3,182	1,800	5,000	62,027
Penstock Maintenance Equipment	210,000	8,637	5,000	5,910	229,547
Painting & Repair of No. 1 Penstock	3,535	155	74	650	4,414
Painting & Repair of No. 2 Penstock	3,535	155	74	650	4,414
(Sub-total)	(269,115)	(12,129)	(6,948)	(12,210)	(300,402)

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Spare Parts & Tools	5,000	155	150	-	5,305
Expatriate Specialists	101,125	-	-	-	101,125
Total	482,538	14,550	8,431	14,951	520,470

Total Foreign Currency	497,088
Total Local Currency	23,382
Total	520,470

Table 4.4 Cost Estimate for Dam and Civil Structures

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Preparatory Works	-	-	-	9,200	9,200
Rehabilitation of Spillway	-	-	-	500	500
Repair of Intake Structures	-	-	-	1,100	1,100
Repair of Civil Structures along Penstocks	-	-	-	34,900	34,900
Repair of Powerhouse	-	-	-	300	300
Total	0	0	0	46,000	46,000

Total Foreign Currency	0
Total Local Currency	46,000
Total	46,000

Table 4.5 Cost Estimate for Hydrogical Data Aquisition System

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Rainfall Gauging Stations	28,996	2,029	289	2,899	34,213
Water Level Gauging Stations	19,830	1,388	198	1,983	23,399
Warning Stations	18,772	1,314	187	1,877	22,150
Central Station	94,031	6,582	940	9,403	110,956
Repeater Stations	59,024	4,131	590	5,902	69,647
Central Radio Station in Power Station	56,280	3,939	562	5,628	66,409
Spare Parts	27,693	1,938	276	2,769	32,676
Radio Propagation Test	10,660	-	-	-	10,660
Expatriate Specialists for Installation and Tests	22,200	-	-	-	22,200
Expartiate Specialists for O&M Instruction	3,900	-	-	-	3,900
Total	341,386	21,321	3,042	30,461	396,210

Total Foreign Currency	362,707
Total Local Currency	33,503
Total	396,210

Table 4.6 Cost Estimate for Da Nhim Switchyard

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Transformers					
Rehabilitation of Main Transformers	89,677	6,277	897	866	97,717
Renewal of House-Service Transformers	6,360	445	64	70	6,939
Renewal of 31.5 kV Transformer	12,300	861	123	186	13,470
Rehabilitation of 66 kV Transformer	1,220	85	12	5	1,322
(Sub-total)	(109,557)	(7,668)	(1,096)	(1,127)	(119,448)
Switchgear					
Rehabilitation of 230 kV Switchgear	12,000	840	120	15	12,975
Repair of 13.2 kV & 6.6 kV Switchgear	70	5	1	1	77
Replacement of Air Compressors	11,750	823	118	34	12,725
Spare Parts & Miscellaneous Materials	1,150	81	12	0	1,243
(Sub-total)	(24,970)	(1,749)	(251)	(50)	(27,020)
Control and Protection Equipment					
Main Control Board	58,000	4,060	580	41	62,681
Protective Relay Board	85,000	5,950	850	55	91,855
Supervisory Computer System	200,000	14,000	2,000	81	216,081
Others	147,900	10,353	1,479	200	159,932
(Sub-total)	(490,900)	(34,363)	(4,909)	(377)	(530,549)
Surge Tank Water Level Measuring Equipment	3,500	245	35	87	3,867
(Sub-total)	(3,500)	(245)	(35)	(87)	(3,867)
Expatriate Specialists	68,340	-	-	-	68,340
Total	697,267	44,025	6,291	1,641	749,224

Total Foreign Currency	741,292
Total Local Currency	7,932
Total	749,224

Table 4.7 Cost Estimate for Saigon Substation

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Transformers					
Rehabilitation of Main Transformer 1T	30,792	2,155	154	388	33,489
Renewal of Main Transformer 2T	115,000	8,050	575	321	123,946
Renewal of House-Service Transformers	2,520	176	13	181	2,890
Renewal of 66 kV Transformers	102,180	7,153	511	355	110,199
(Sub-total)	(250,492)	(17,534)	(1,253)	(1,245)	(270,524)
Switchgear					
Rehabilitation of 66 kV Switchgear	28,500	1,995	143	55	30,693
Replacement of 15 kV Switchgear	1,980	139	10	11	2,140
Replacement of Air Compressors	3,000	210	15	3	3,228
Renewal of Static Condenser Bank	36,400	2,548	182	57	39,187
Foundation Works	-	-	-	399	399
Others	2,740	192	14	-	2,946
(Sub-total)	(72,620)	(5,084)	(364)	(525)	(78,593)
Control and Protection Equipment					
Main Control Board	88,000	6,160	440	64	94,664
Protective Relay Board	101,000	7,070	505	64	108,639
Supervisory Computer System	100,000	7,000	500	87	107,587
Others for Saigon Substation	71,200	4,984	357	30,253	106,794
Long Binh Substation	29,400	2,058	147	27	31,632
(Sub-total)	(389,600)	(27,272)	(1,949)	(30,495)	(449,316)
Overhead Traveling Crane	900	63	5	14	982
(Sub-total)	(900)	(63)	(5)	(14)	(982)
PLC Telephone System					
Modification in Saigon Substation	9,360	655	48	23	10,086
Modification in Long Binh Substation	19,560	1,369	98	46	21,073
Modification in Da Nhim Power Station	10,560	739	54	23	11,376
(Sub-total)	(39,480)	(2,763)	(200)	(92)	(42,535)
Expatriate Specialists	44,640	-	-	-	44,640
Total	797,732	52,716	3,771	32,371	886,590

Total Foreign Currency	850,448
Total Local Currency	36,142
Total	886,590

Table 4.8 Cost Estimate for 230 kV Transmission Line

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Conductors and Overhead Earthwires	38,285	2,488	900	5,340	47,013
Insulators and Accessories	44,400	2,886	420	-	47,706
Towers	11,755	764	900	7,480	20,899
Tools and Appliances	58,290	3,789	600	-	62,679
Total	152,730	9,927	2,820	12,820	178,297

Total Foreign Currency	162,657
Total Local Currency	15,640
Total	178,297

Note:

Cost of the local works for the insulator replacement is included in the cost for the conductors and overhead earthwires.

Table 4.9 Cost Estimate for Upgrading of Substations

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Da Nhim Power Station					
Transformer	115,000	8,050	1,150	103	124,303
Switchgear	25,700	1,799	257	307	28,063
PLC Telephone System	22,693	1,585	227	37	24,542
Expatriate Specialists	7,860	-	-	-	7,860
(Sub-total)	(171,253)	(11,434)	(1,634)	(447)	(184,768)
Thap Cham Substation					
Transformer	30,700	2,149	308	65	33,222
110 kV Switchgear	56,330	3,946	566	107	60,949
22 kV Switchgear	23,100	1,617	231	18	24,966
Control and Protection Equipment	65,930	4,615	659	131	71,335
PLC Telephone System	33,420	2,340	334	90	36,184
Miscellaneous Materials	10,470	733	105	62	11,370
Civil and Building Works	-	-	-	43,500	43,500
Expatriate Specialist	20,760	-	-	-	20,760
(Sub-total)	(240,710)	(15,400)	(2,203)	(43,973)	(302,286)
Phan Ri Substation					
Transformer	30,700	2,149	308	65	33,222
110 kV Switchgear	43,940	3,077	441	81	47,539
22 kV Switchgear	18,380	1,287	184	15	19,866
Control and Protection Equipment	58,210	4,075	582	128	62,995
PLC Telephone System	21,870	1,531	219	62	23,682
Miscellaneous Materials	8,660	606	87	62	9,415
Civil and Building Works	-	-	-	43,500	43,500
Expatriate Specialist	17,850	-	-	-	17,850
(Sub-total)	(199,610)	(12,725)	(1,821)	(43,913)	(258,069)
Phan Thiet Substation					
Transformer	36,360	2,545	363	65	39,333
110 kV Switchgear	29,660	2,078	298	53	32,089
22 kV Switchgear	19,010	1,331	190	15	20,546
Control and Protection Equipment	50,490	3,534	505	125	54,654
PLC Telephone System	15,600	1,092	156	34	16,882
Miscellaneous Materials	15,110	1,058	151	62	16,381
Civil and Building Works	-	-	-	43,500	43,500
Expatriate Specialist	15,120	-	-	-	15,120
(Sub-total)	(181,350)	(11,638)	(1,663)	(43,854)	(238,505)

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Cam Ranh Substation					
Transformer	30,700	2,149	308	65	33,222
110 kV Switchgear	72,560	5,082	729	151	78,522
22 kV Switchgear	23,940	1,676	239	15	25,870
Static Condenser	12,000	840	120	19	12,979
Control and Protection Equipment	81,920	5,734	819	141	88,614
PLC Telephone System	26,490	1,855	265	65	28,675
Miscellaneous Materials	12,380	867	124	62	13,433
Civil and Building Works	-	-	-	43,500	43,500
Expatriate Specialist	22,860	-	-	-	22,860
(Sub-total)	(282,850)	(18,203)	(2,604)	(44,018)	(347,675)
Dien Khanh Substation					
Transformer	30,700	2,149	308	65	33,222
110 kV Switchgear	57,280	4,011	574	119	61,984
22 kV Switchgear	23,940	1,676	239	15	25,870
Static Condenser	12,000	840	120	19	12,979
Control and Protection Equipment	65,380	4,577	654	131	70,742
PLC Telephone System	17,250	1,208	173	37	18,668
Miscellaneous Materials	10,330	723	103	62	11,218
Civil and Building Works	-	-	-	43,500	43,500
Expatriate Specialist	18,900	-	-	-	18,900
(Sub-total)	(235,780)	(15,184)	(2,171)	(43,948)	(297,083)
Testing Equipment for Substations	73,299	5,132	733	0	79,164
Total	1,384,852	89,716	12,829	220,153	1,707,550

Total Foreign Currency	1,474,568
Total Local Currency	232,982
Total	1,707,550

Table 4.10 Cost Estimate for Upgrading to 110 kV Transmission Lines

(Unit: ¥ 1,000)

Particulars	FOB	Insurance & Freight	Inland Transport	Local Works	Total Amount
Da Nhim - Thap Cham - Phan Thiet (PC-2)					
Conductors and Overhead Earthwires	4,108	267	180	6,436	10,991
Insulators and Accessories	14,500	943	240	0	15,683
Poles and Accessories	6,959	452	1,800	6,436	15,647
Tools and Appliances	37,522	2,439	1,800	0	41,761
(Sub-total)	(63,089)	(4,101)	(4,020)	(12,872)	(84,082)
Thap Cham - Cam Ranh (PC-3)					
Conductors and Overhead Earthwires	30,600	1,989	1,800	2,547	36,936
Insulators and Accessories	26,500	1,723	720	0	28,943
Poles and Accessories	4,490	292	240	637	5,659
Tools and Appliances	47,057	3,059	900	0	51,016
(Sub-total)	(108,647)	(7,063)	(3,660)	(3,184)	(122,554)
Cam Ranh - Dien Khanh (PC-3)					
Conductors and Overhead Earthwires	32,951	2,142	1,800	17,726	54,619
Insulators and Accessories	44,500	2,893	720	0	48,113
Poles and Accessories	640	42	240	49,302	50,224
Tools and Appliances	47,057	3,059	900	0	51,016
(Sub-total)	(125,148)	(8,136)	(3,660)	(67,028)	(203,972)
Total	296,884	19,300	11,340	83,084	410,608

Total Foreign Currency	316,184
Total Local Currency	94,424
Total	410,608

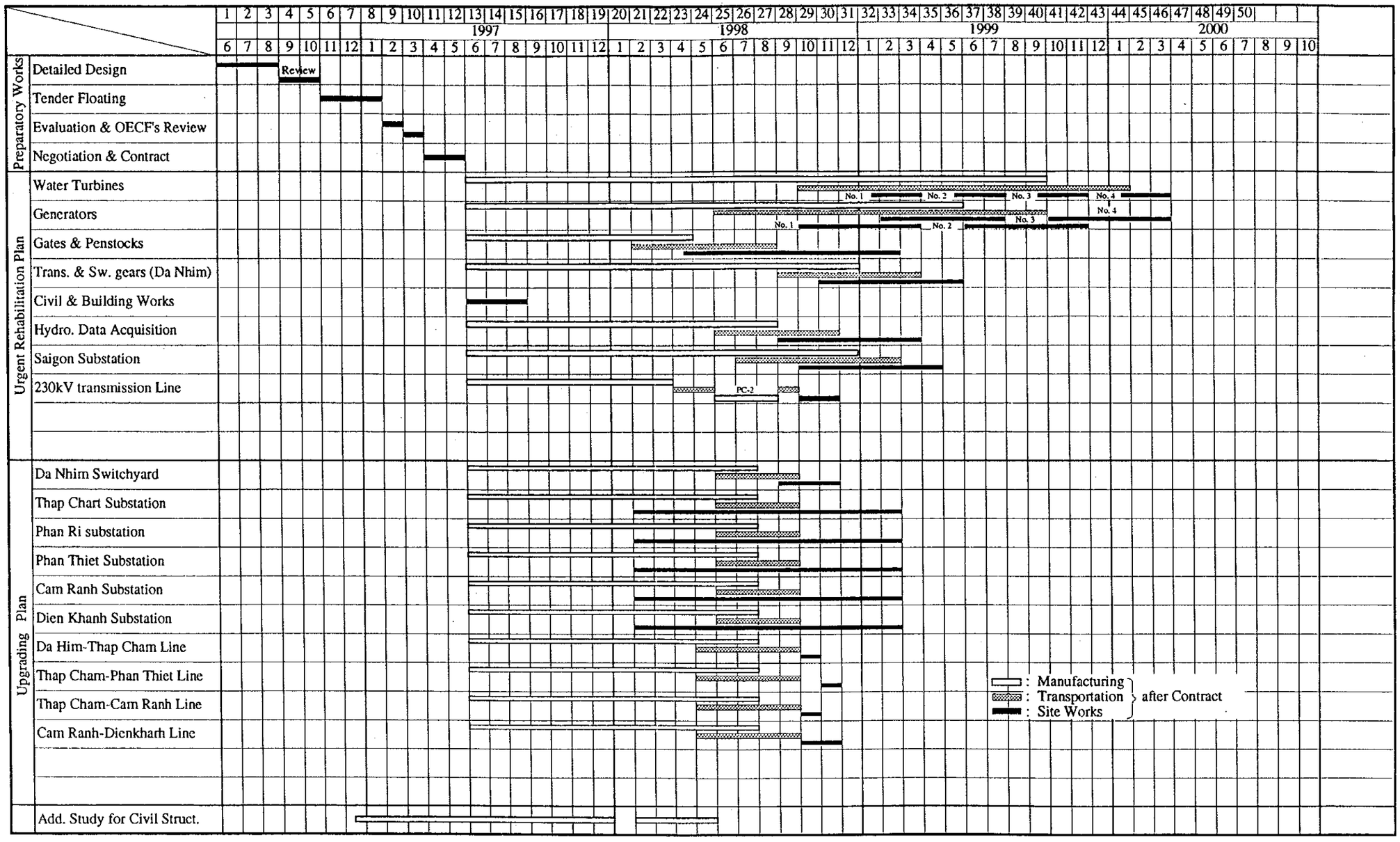
Note:
Cost for the local works for insulators are included in the cost for the conductors and overhead earthwires.

Table 4.11 Cost Estimate for Additional Study for Dam and Civil Structures

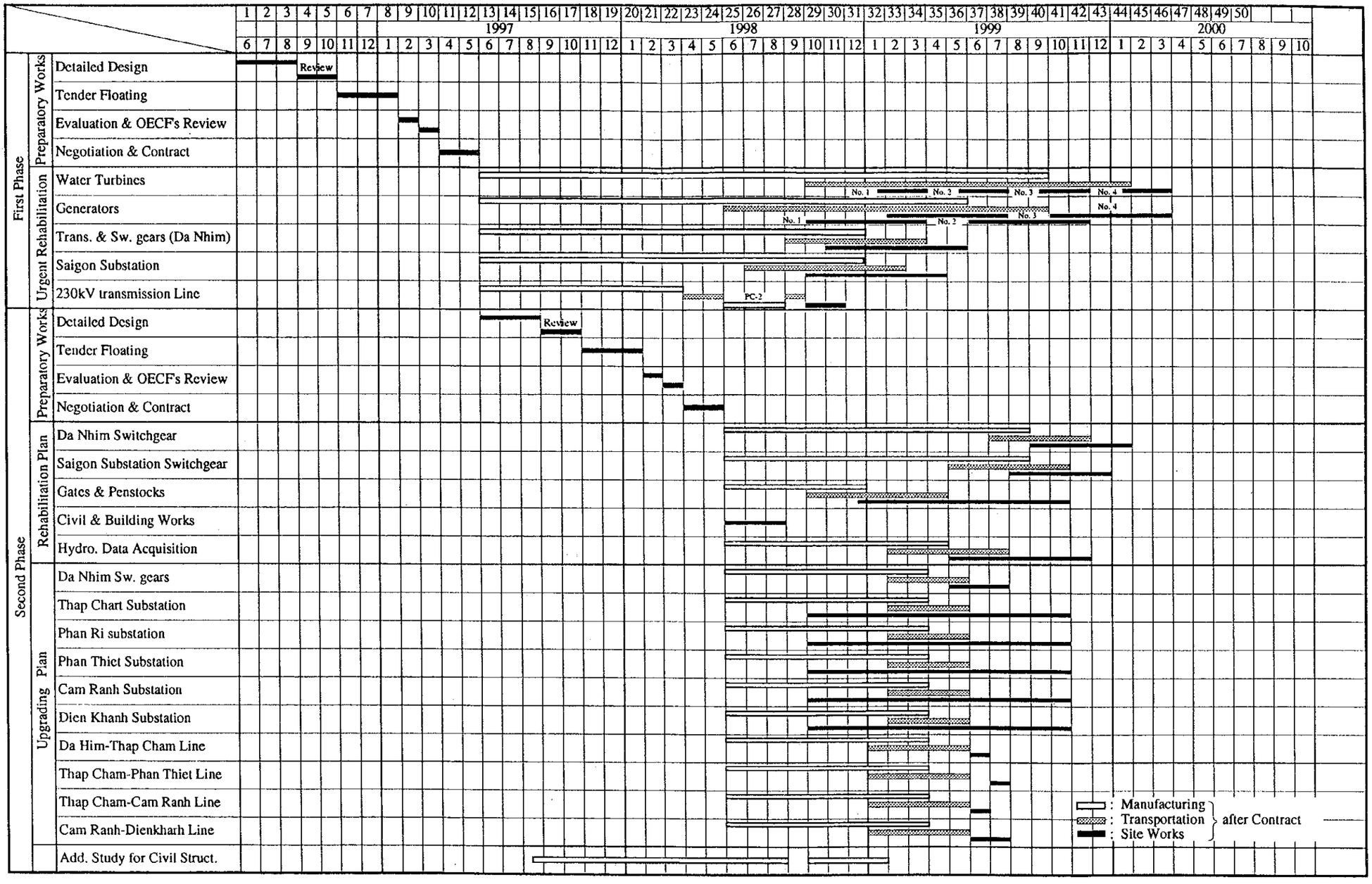
(Unit: ¥ 1,000)

Particulars	Unit	Q'ty	Foreign Currency	Local Currency	Total Amount
Study on Dam and A Part of Spillway	Lot	1	9,382	3,668	13,050
Study on Conservation of Upper Da Nhim	Lot	1	25,000	3,200	28,200
Study on Flood Mitigation and Enviroment	Lot	1	900	44,910	45,810
Cost of Instrument for Investigation	Lot	1	25,982	0	25,982
Cost of Vehicles	Lot	1	0	22,116	22,116
Personnel Expenses	Lot	1	219,780	29,260	249,040
Traveling Expenses	Lot	1	1,008	600	1,608
Printing of Reports	Lot	1	0	565	565
Total			282,052	104,319	386,371

Total Foreign Currency	282,052
Total Local Currency	104,319
Total	386,371



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.1 (1) Implementation Schedule of Rehabilitation of Da Nhim Power System



FEASIBILITY STUDY ON REHABILITATION OF DA NHIM POWER SYSTEM	MINISTRY OF ENERGY JAPAN INTERNATIONAL COOPERATION AGENCY	Figure 4.1 (2) Implementation Schedule of Rehabilitation of Da Nhim Power System (Alternative)

CHAPTER 5

LONG TERM REHABILITATION PLAN

CHAPTER 5 LONG TERM REHABILITATION PLAN

5.1 General

The long term rehabilitation plan is formulated for such facilities that no urgent rehabilitation is required, but replacement, repair or modernization will be needed in the near future due to deterioration or declination of the original functions. However, the plan excludes the maintenance repair of the facilities.

Following are the formulated plans for the long term rehabilitation.

(1) Water turbines and ancillaries

1) replacement of the existing bearings to the oilless bearings,
2) adoption of the ceramic filmed needle tips,
3) modification of the oil pressure pumps from the existing turbine-motor system to motor-motor system, and
4) improvement of the existing turbine housings.

(2) Generators and ancillaries

1) renewal of the existing pole coils for the generator rotors,
2) replacement of the existing main shafts for No. 2 and No.4 units, and
3) automation of the power plant.

(3) Waterways and ancillaries

1) improvement of the intake fixed trash racks,
2) removal of the existing intake movable trash racks,
c) renewal of the hoist of the intake movable trash racks,
3) replacement of the existing tubes located between No.2 and No.3 blocks as well as No.8 block along the No.2 penstock,
4) renewal of cooling water pipes, and
5) renewal of the trash racks for irrigation purpose.

(4) Dam and civil structures

1) slope protection of the river bank downstream of spillway,
2) slope protection for land slopes upstream and downstream of the intake structure,
3) construction of coffer dam in front of the fixed trash racks, and
4) repair of the water leaking portion the pressure tunnel.

(5) Hydrological data acquisition system

1) analyses of the collected and stored hydrological data,
2) establishment of the rules for the optimum water management, and
3) provision of the program and necessary equipment for the management.

(6) Substation facilities

1) renewal of other transformers than those replaced in the urgent rehabilitation plan,
2) replacement of switchgear for the 230kV system when their rated short circuit capacities will be insufficient for the expanded power system in future, and
3) provision of the GIS equipment when the existing 66kV switchgear in the Saigon substation would be upgraded to 110 kV system.

5.2 Implementation Program

The rehabilitated facilities after the urgent plan will be operated and maintained in accordance with the new manuals. Times of and measures for rehabilitation of those facilities recommended for the long term rehabilitation plan will be determined by observation through the periodical inspection to the facilities.

Implementation program for the long term rehabilitation plan should be decided in consideration of the affect of dewatering of the penstocks, interruption of generation and transmission, energy loss due to power interruption to the PC-2 power system.

CHAPTER 6

UPGRADE PLAN OF EXISTING 66 KV FACILITIES

CHAPTER 6 UPGRADE PLAN FOR THE EXISTING 66 KV FACILITIES

6.1 General Plan

(1) Background of the Plan

Energy consumption and the peak load of the areas supplied power by the Da Nhim power station through the 66 kV transmission line, have grown at the annual average rates of more than 20% and 16% over the past 4 years. According to the forecasts regarding PC-2 and PC-3, the average annual growth rates of energy consumed and the peak load in the areas will further increase to 31% and 22%, respectively, due to the regional development, promotion of industrialization, and increase of electrification in the areas.

Since the existing 66 kV transmission facilities will not be capable of meeting the forecasted power demand for the year 1996, the areas will require additional 66 kV transmission facilities or the upgrade of the existing facilities in order to increase the transmission capacity. In consolidation of the standard voltages of the power system, the country intends to eliminate 66 kV systems and upgrade all the existing 66 kV power facilities to higher voltage facilities. Therefore, the existing Da Nhim 66 kV facilities will have to be upgraded to 110 kV systems. As discussed in Chapter 8, the upgrade plan is economically and financially justified.

(2) Upgrade Plan

The following 66 kV transmission lines will be upgraded under the Project:

1) Da Nhim-Thap Cham line over 41 km
2) Thap Cham-Phan Ri-Phan Thiet line over 137 km
3) Thap Cham-Cam Ranh line over 46 km
4) Cam Ranh-Dien Khanh over 46 km

These transmission lines are constructed in design to be facilities of the 110 kV systems, considering of the future voltage upgrade. Therefore, the existing facilities are suitable for 110 kV systems without any modification to their structures. The existing facilities damaged during the war, have been improperly restored due to the serious shortage of spare parts and there are still many portions which need to be restored, improved, and replaced with new materials. These portions should be urgently restored regardless of the upgrade plan.

Existing supports for the Cam Ranh-Dien Khanh line in the PC-3 region are creosote-painted timber poles. They have rotted over the last 20 years and have been reinforced with additional timber poles or concrete poles. Therefore, PC-3 intends to replace all the existing timber poles with local-made concrete poles.

Substations to be upgraded under the Project are as follows:

1) Da Nhim outdoor switchyard (PC-2)
2) Thap Cham substation (PC-2)
3) Phan Ri substation (PC-2)
4) Phan Thiet substation (PC-2)
5) Cam Ranh substation (PC-3)
6) Dien Khanh substation (PC-3)

The Ninh Son 66 kV substation operating between the Da Nhim power station and the Thap Cham substation will be eliminated from the upgrade plan of PC-2 because the future power demand is low. Power will be supplied to this area by the Da Nhim power station through the existing 35 kV distribution line.

The capacity of each new 110 kV substation is determined for the future demand of each substation forecasted by PC-2 and PC-3. Premises required for the new substations are available on the land annexed to the existing 66 kV substations. Therefore, it is easy to modify the connections of the transmission lines from the existing 66 kV substations to the new 110 kV substations.

After the implementation of the upgrade plan, equipment and facilities in the existing substations will be removed to and utilized by other existing 66 kV substations in the PC-2 and PC-3 regions for the time being depending on their technical functions.

(3) Assessment of Plan

PC-2's and PC-3's upgrade plans are appropriate from the view points of not only the technical and economical examinations but also the regional development program, promotion of industrialization, and the country's policy concerning the consolidation of the voltage of the power system.

6.2 Implementation Program

New 110 kV substations can be constructed while the existing 66 kV substations are supplying power to the demand areas. Accordingly, the supply of power does not need to be interrupted for construction of the new substations.

The replacement of damaged supports and crossarms of the power conductors, repair of power conductor joints, and replacement and supplement of insulators are major rehabilitation works which should be carried out prior to the upgrading of the line voltage of the Da Nhim-Thap Cham, Thap Cham-Phan Ri- Phan Thiet, and Thap Cham-Cam Ranh-Dien Khanh lines. For these works to be carried out, the supply of power, on the lines does have to be interrupted. There are no other alternative lines for supplying power to the demand areas. The interruption of the supply of power for a long period will seriously affect the daily life of the inhabitants and also the social and economic activities in the areas.

Since the peak demand hours in these areas are in the evening, the interruption of the supply of power for the works should be scheduled in order to avoid the hours between be 4:00PM - 8:00AM so as to minimize disturbance of people's daily life. Assuming that the rehabilitation of the transmission lines will be completed within 10 days, the following work forces will be required for each line section:

	Working Group	Total Workers	PC in Charge
(a) Da Nhim-Thap Cham	9 groups	108 persons	PC-2
(b) Thap Cham-Phan Ri-Phan Thiet	25 groups	175 persons	PC-2
(c) Thap Cham-Cam Ranh	8 groups	96 persons	PC-3

In order to shorten the power interruption period as much possible, the works of each section should be executed all at once on the same days. Considering the scale of the work force of the construction and maintenance groups, it will be not difficult for PC-2 and PC-3 to arrange 283 workers and 96 workers for each day of the 10 day period.

The rehabilitation and replacement works of the Cam Ranh-Dien Khanh line will be carried out without the supply of power being interrupted, since there is an alternative line for supplying power to the demand area.

The rehabilitation of the lines, replacement of the timber supports, and construction of the new 110 kV substations will be carried out by PC-2 and PC-3 themselves. However, it is recommended that some experts and specialists participate with the PC-2 and PC-3 working

groups in the substation works so that the works may be implemented smoothly and properly.

All the equipment and materials for the rehabilitation and reconstruction of the lines and for the 110 kV substations are available in the world market, accordingly, it is advised to procure the equipment and materials under international competitive bidding.

6.3 Operation, Maintenance and Management of the Facilities

Both PC-2 and PC-3 have abundant experience in the rehabilitation, construction, operation, maintenance, and management of the facilities and power system. It is understood that the facilities having been upgraded will be well operated, maintained and managed by PC-2 and PC-3, provided that the necessary spare parts and tools would be available and the proper manuals for the facilities would be provided.

6.4 Cost Estimate of the Project

The following are the cost estimates for the rehabilitation and improvement of the existing transmission line facilities and the construction of the 110 kV substations. The items and quantities of materials and tools required for the works, maintenance of the transmission lines, and the design of the new substations were determined on the basis of discussions held between PC-2/PC-3 and the Study Team. The prices used for the estimate are those of the international market prices in 1994.

	Work Items	Cost Estimate		
		Foreign Portion (J.¥ 1,000)	Local Portion (J.¥ 1,000)	Total (J.¥ 1,000)
1.	Da Nhim Switchyard	183,000	2,000	185,000
2.	Thap Cham Substation (*)	256,000	46,000	302,000
3.	Phan Ri Substation (*)	212,000	46,000	258,000
4.	Phan Thiet Substation (*)	193,000	46,000	239,000
5.	Transmission Lines (*)	67,000	17,000	84,000
6.	Engineering Service	69,000	0	69,000
7.	Price Contingency (5 & 10%)	49,000	16,000	65,000
	Total of Upgrade in PC-2	1,029,000	173,000	1,202,000
8.	Cam Ranh Substation	301,000	47,000	348,000
9.	Dien Khan Substation	251,000	46,000	297,000
10.	Testing Equipment	78,000	1,000	79,000
11.	Transmission Lines (*)	249,000	78,000	327,000
12.	Engineering Service	69,000	0	69,000
13.	Price Contingency (5 & 10%)	47,000	17,000	64,000
	Total of Upgrade in PC-3	995,000	189,000	1,184,000
	Total for Upgrading Plan	2,024,000	362,000	2,386,000

(*) Including tools and appliances for maintenance works.

CHAPTER 7

PROJECT ASSESSMENT

CHAPTER 7 PROJECT ASSESSMENT

7.1 General

Both the urgent rehabilitation and the 66 kV system voltage upgrade plans formulated in the foregoing chapters were evaluated in the method of Economic and Financial Internal Rate of Return (FIRR and EIRR). The economic viability of the plans was analyzed from the point of view of the whole national economy, while the financial analysis was made from the point of view of the project executing agency.

The project evaluations were conducted under the following criteria.

(1) The project costs are allocated in the foreign currency and the local currency. The foreign currency is for the procurement of materials and equipment and the engineering services together with the project contingency. While, the local currency is for procurement of some items of the materials and equipment, inland transportation of the materials and equipment and erection costs as well as the project contingency.

(2) The foreign currency for the project implementation is assumed to be funded by a loan. Conditions of the loan are assumed as follow:

1) Repayment period to be 30 years including the grace period of 5 years
2) Annual interest to be 2 %

(3) Energy cost for the financial evaluation is assumed at 0.07 US$/kWh, which is referred to the Long Run Marginal Cost in the least cost expansion plan of the Vietnamese electricity system mentioned in the Report No.1084-VN "Viet Nam Energy Sector Investment and Policy Review" June 18, 1993 of the World Bank and based on instruction of EVN.

(4) Energy cost for economic evaluation is also assumed at 0.07 US$/kWh for the Long Run Marginal Cost in the least cost expansion plan of the Vietnamese electricity system, which is analyzed in the same report as the above World Bank.

7.2 The Urgent Rehabilitation Project and The 66 kV System Voltage Upgrade Project

7.2.1 Generated Energy and Outage Factor of Generating Facilities

Table 7.1 shows the operation records of generation, availability and outage factors of the facilities in the period of 1979 to 1993. The availability factor is the ratio of the actual operating hours of the facilities to the whole hours in a year regardless of the production of the generating facilities of four (4) units. While, the outage factor is the ratio of total hours of outage of the facilities to whole hours in a year. It is understood from the 15 years' records such tendency that the energy production is decreasing and the outage factor is increasing.

The outage of the facilities is originated from the system operation condition, the water level of the reservoir, the facility trouble, the scheduled periodical inspection to the facilities, or the scheduled repairing of the facilities. However, the definite outage hours caused by each origin are not obtained because of no available records in the power station and shortage of the site investigation period. The energy production may be seasonally variable due to the system operational condition and the periodical inspection for the facilities, but the total annual energy production will not be normally affected by those origins. It is rather influenced by the water level on the beginning of the year (1st January) and the water inflow into the reservoir in the year.

The relation of the annual energy production against the outage factor is obtained from analyses of the available data and shown as the scatter diagram and the regression line in Figure 7.1. The correlation coefficient is high as much as 0.84. On the other hand, Figure 7.1.(4) shows the scattered diagram of the energy production to the water inflow into the reservoir. The correlation coefficient obtained from the diagram is 0.19. These two coefficients disclose that the declining tendency of energy production in the Da Nhim power station is not caused by the water inflow but more by the outage of the generating facilities.

As seen in Figure 7.1 (2), the outage factor of the generating facilities has increased year by year. An approximate equation mentioned in the Figure is formed in a slower rise of the outage factor due to an influence of the sharply jumped factor (23.3%) recorded in 1983 than the actual rise. The jumped factor was not caused by troubles or repairing works of the generating facilities, but mainly by the low water level reaching to the lowest level in the period of January to July in 1983. Precipitation in the rainy seasons in 1982 and 1983 was extremely less. Such less precipitation was easily understood from such a fact that most of the reservoirs in Indonesia were empty in the same years. However, in this examination, the slower rise of the outage factor is adopted for safer evaluation.

7.2.2 Cost of the Project

Costs of the urgent rehabilitation project and the 66 kV system voltage upgrade project include those (CIF, ocean freight, and insurance) for procurement of the equipment and materials, rehabilitation cost (inland transportation, engineering services, civil and building works, and personnel expenses), minus benefit due to reduction of energy production caused by outage of the facility operation, cost of operation and maintenance of the facilities, etc.

(1) Cost of rehabilitation

Costs for the rehabilitation works are estimated in Chapter 7, and the following is its summary of those subjected to the evaluation.

(Unit : J ¥ 1,000)

Particulars	Rehabilitation			Renewal		
	Foreign Portion	Local Portion	Total	Foreign Portion	Local Portion	Total
a) Power station	3,847,000	35,000	3,882,000	5,131,000	40,000	5,171,000
b) Waterways	497,000	23,000	520,000	497,000	23,000	520,000
c) Civil & Building	0	46,000	46,000	0	46,000	46,000
d) Hydro. Data Acqu.	363,000	34,000	397,000	363,000	34,000	397,000
e) 230kV Line	163,000	16,000	179,000	163,000	16,000	179,000
f) Saigon Substation	850,000	36,000	886,000	1,795,000	36,000	1,831,000
g) Eng. Services	351,000	0	351,000	351,000	0	351,000
h) Contingency	303,000	19,000	322,000	415,000	20,000	435,000
Total	6,374,000	209,000	6,583,000	8,715,000	215,000	8,930,000

It is noted that costs for renewal of the waterways, civil and building works, and 230 kV transmission line are appropriated with the same amount for the rehabilitation works, since the facility is technically judged unnecessary to be renewed.

(2) Energy loss due to outage of generating facilities for rehabilitation and upgrade

Operation of the turbine and generator set related should be stopped for the rehabilitation or renewal, which is to reduce energy production of the power station. The following energy reduction due to the stoppage is considered for the evaluation purpose.

1) Reduction of energy due to the implementation of the rehabilitation project is estimated at 100.61 GWh (=943.3 GWh x 8% / 0.75) in the year 1999 considering the following conditions.

i) Minimum possible annual operating ratio (AP1) for annual production energy of 943.3 GWh in the past 15 years of 1979 to 1993

- Annual capacity factor of power station : 67.3%
- Minimum rate of operation of generating unit required to produce the energy of 943.3 GWh : 67.3 %

Therefore, AP1 = 67.3 % x 10% (allowance) = approx. 75%

ii) Average annual possible operating ratio (AP2) during the rehabilitation

As a result of the calculation based on total stoppage duration of the generating units of the year 1999 shown in Figure 7.1, (AP2) is assumed to be approx.67 %.

iii) Reduction of energy (AP) due to the rehabilitation

(AP) = 943.3 GWh x ((AP1) - (AP2))

= 943.3 GWh x 8 % / 0.75 = 100.62 GWh

2) Energy loss production due to the implementation of the 66 kV system voltage upgrade project is estimated at 64 GWh for 2 months power interruption in the year 1998 referring to Table 7.5.

(3) Operation and maintenance cost

The cost for operation and maintenance of the rehabilitated or renewed facilities is assumed at 2% of the cost for the rehabilitation or renewal of the facilities as the value adopted generally for the hydropower plants. However, that for the facilities not rehabilitated or renewed is assumed at 5% in consideration of more frequent maintenance works.

The cost for operation and maintenance of the upgraded facilities is also assumed at 2% of the cost for the construction of the facilities.

(4) Adjustment of cost for economical evaluation

For the economical evaluation, all the cost for the rehabilitation or renewal of the facilities will be converted into the economical cost with opportunity cost or the cost of the actual resources. Adjustment of the economical cost of goods is done considering increase of import, decrease of export, increase of the domestic production or diversion from others. Normally, the financial cost is converted into the economical cost at the rate determined for group of the goods or category of the works. In this evaluation, the standard conversion factors are assumed at 1.0 for both foreign currency and the local currency portions on the basis of the instruction of EVN.

7.2.3 Benefit

(1) Increase of energy due to improvement of the generating facilities

Energy production of the power station is to increase by improvement of the outage factor due to rehabilitation or renewal of the facilities. The increase of energy production is one of the benefits of the project. The possible energy production on the basis of calculation of the increased energy production after the project is considered to be 1,070 GWh/year recorded in the period of 1980 to 1982 or more, while an average annual energy production is assumed as 943.3 GWh.

The increased energy production after rehabilitation or renewal of the facilities is obtained as follow:

1) The outage factor (I) in the year (i) is calculated applying an approximate equation of the outage factor stated in the aforementioned Subsection 7.2.1.

2) The energy (Wi) in the year (i) is obtained from the regression equation noted in Figure 7.1(2).

3) Then, the energy additionally generated (Wi) in the year (i) is obtained from the equation below.

$$\Delta Wi = 943.3 - Wi \text{ (GWh)}$$

The additional energy is assumed to be 50% in the year 1999 in the progressing of the works and 100% thereafter.

(2) Additional energy sales due to 66 kV system voltage upgrade project are estimated from the balance between the transmission capacities of the upgraded 66kV system and

the existing 66kV system. The transmission line capacities of the 110kV and 66kV systems are computed as 695 GWh/year and 417 GWh/year from the power conductors used. The energy additionally sold will be constant after the year when the total energy demand in the system will reach the 695 GWh/year of the maximum capacity of the upgraded facilities.

Since the demand forecasts of the project area were conducted by PC-2 and PC-3 till the year 2000, those after the year were prepared by the Study Team as seen in Table 7.5.

(3) Units of benefits

The following unit cost is adopted to examination of the benefit from the rehabilitation or renewal of the facilities

1) 0.07 US$/kWh of the energy unit cost stated in the foregoing Section 7.1 is considered 19% of energy loss and adopted to economic evaluation of the Project.

2) 0.07 US$/kWh of the energy unit cost stated in the foregoing Section 7.1 is considered 19 % of energy loss, 2% of water resource tax and 8% of sales tax of revenue and adopted to financial evaluation of the Project.

(4) Costs of operation and maintenance of the existing facilities

Without rehabilitation or renewal, the cost required for the operation and maintenance of the existing facilities should be more than that for the normal hydropower plants. It is obviously understood that the continuous operation of the system will cause the technical troubles without improvement of the generators, synchronous condensers, and others. Since the partial improvement of the facilities is not the project purpose, such condition will not be considered in the evaluation. The cost for operation and maintenance of the existing facilities without the project is assumed to be 5% equivalent to 2.5 times the cost for the improved facilities.

(5) Complete renewal of the facilities

The existing facilities should become inoperative condition sometime in the future without any improvement even if the minimum repairing works would be done. It is assumed that the complete renewal of the facilities concerned will be carried out in the year 2010 when the outage factor of the facilities will come down to 25%.

7.2.4 Economic Evaluation

The economic evaluation was made provided that both cases of the rehabilitation plan and the 66 kV system upgrade plan will be implemented at the same time.

The annual disbursement of investment due to the rehabilitation plan and the 66 kV system upgrade plan is assumed as below.

(unit :J¥ 1,000)

	Rehabilitation Plan			66 kV System Upgrade Plan			
Year	Foreign Portion	Local Portion	Total Amount	Foreign Portion	Local Portion	Total Amount	(Total)
1996	110,100	0	110,100	45,000	0	45,000	(155,100)
1997	856,300	59,000	915,300	212,600	59,000	271,600	(1,186,900)
1998	4,166,900	125,000	4,291,900	1,766,400	303,000	2,069,400	(6,361,300)
1999	1,240,700	25,000	1,265,700	0	0	0	(1,265,700)
Total	6,374,000	209,000	6,583,000	2,024,000	362,000	2,386,000	(8,969,000)

The annual disbursement of investment due to the complete renewal of the facilities is assumed as below.

(unit : J¥ 1,000)

Year	Foreign Portion	Local Portion	Total Amount
1 st	76,500	0	76,500
2 nd	1,998,000	46,900	2,044,900
3 rd	6,467,000	130,400	6,597,400
4 th	150,300	33,400	183,700
5 th	23,200	4,300	27,500
Total	8,715,000	215,000	8,930,000

Table 7.3 shows the result of the economic evaluation. The EIRR of the project is calculated as 21.69 %. The EIRR is further analyzed for the sensitivity for variation of the components in the evaluation. The EIRRs in the sensitivity analyses are as follows;

(Variation)	- 10 %	+ 10 %	+ 15 %	+ 20 %
Project Costs	23.57 %	20.05 %	19.31 %	18.60 %
Energy Rate	20.13 %	23.19 %	23.92 %	24.64 %
O & M Cost	22.17 %	21.22 %	20.99 %	20.77 %

The economic evaluation results that the project is appropriate, because the EIRR is much above the assumed interest of the fund and the opportunity cost of capital (generally 8 to 10%).

In addition to the above, economic sensitive analyses (EIRR) was made on the basis of the project phasing proposed in Subsection 4.5.4 (2) and assumptions of implementation time of second phase.

As seen in the following table, the EIRRs for each assumption show that the project is recommendable to implement second phase after one (1) year of commencement of the first phase as the EIRR is 22.82%.

Time Delay of Implementation of Second Phase	0 year	1 year	2 years	3 years	4 years
EIRR	21.69 %	22.82 %	22.20 %	21.64 %	21.15 %

7.2.5 Financial Evaluation

Similarly to the economic evaluation, the financial evaluation was also made provided that both cases of the rehabilitation plan and the 66 kV system upgrade plan will be implemented at the same time.

The annual disbursement of investment due to the rehabilitation plan and the 66 kV system upgrade plan is assumed as below.

(unit :J¥ 1,000)

	Rehabilitation Plan			66kV System Upgrade Plan			
Year	Foreign Portion	Local Portion	Total Amount	Foreign Portion	Local Portion	Total Amount	(Total)
1996	110,100	0	110,100	45,000	0	45,000	(155,100)
1997	856,300	59,000	915,300	212,600	59,000	271,600	(1,186,900)
1998	4,166,900	125,000	4,291,900	1,766,400	303,000	2,069,400	(6,361,300)
1999	1,240,700	25,000	1,265,700	0	0	0	(1,265,700)
Total	6,374,000	209,000	6,583,000	2,024,000	362,000	2,386,000	(8,969,000)

The annual disbursement of investment due to the complete renewal of the facilities is assumed as below.

(unit : J¥ 1,000)

Year	Foreign Portion	Local Portion	Total Amount
1 st	76,500	0	76,500
2 nd	1,998,000	46,900	2,044,900
3 rd	6,467,000	130,400	6,597,400
4 th	150,300	33,400	183,700
5 th	23,200	4,300	27,500
Total	8,715,000	215,000	8,930,000

Table 7.4 shows the result of the financial evaluation. The FIRR of the project is calculated as 20.13 %. The FIRR is also further analyzed for the sensitivity for variation of the components in the evaluation. The FIRRs in the sensitivity analyses are as follows;

(Variation)	- 10 %	+ 10 %	+ 15 %	+ 20 %
Project Costs	21.93 %	18.56 %	17.84 %	17.16 %
Energy Rate	18.67 %	21.54 %	22.22 %	22.90 %
O & M Cost	20.60 %	19.68 %	19.45 %	19.23 %

The financial evaluation results that the project is appropriate, because the FIRR is much above the assumed interest of the fund and the opportunity cost of capital.

In addition to the above, financial sensitive analyses (FIRR) is also made on the basis of the project phasing proposed in Subsection 4.5.4 (2) and assumptions for implementation of time delay of second phase.

As seen in the following table, the EIRRs for each assumption show that the project is recommendable to implement second phase after one (1) year of commencement of the first phase as the FIRR is 21.12%.

Time Delay of Implementation of Second Phase	0 year	1 year	2 years	3 years	4 years
FIRR	20.13%	21.12 %	20.59 %	20.11 %	19.68 %

Table 7.1 Operating Data in Da Nhim Power Station

YEAR	GENERATED ENERGY (GWh)	AVAILABILITIES FACTOR (%)	OUTAGE FACTOR (%)	WATER INFLOW (10^6m3)
1979	926.5	95.4	4.6	592.2
1980	1,094.2	99.1	0.9	702.6
1981	1,022.1	92.9	7.1	742.0
1982	1,098.3	94.9	5.1	484.1
1983	815.7	76.7	23.3	704.2
1984	1,145.3	96.3	3.7	658.4
1985	1,067.6	92.6	7.4	554.7
1986	902.5	89.0	11.0	585.6
1987	998.4	92.3	7.7	473.4
1988	839.9	88.3	11.7	587.2
1989	781.1	83.0	17.0	626.6
1990	774.4	86.2	13.8	642.4
1991	806.8	82.0	18.0	382.8
1992	917.7	90.7	9.3	663.1
1993	958.3	90.5	9.5	746.5
Average	943.3	90.0	10.0	609.7