JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ELECTRICITY OF VIETNAM
THE SOCIALIST REPUBLIC OF VIETNAM

FEASIBILITY STUDY
ON
DONG NAI NO.3 AND NO.4 COMBINED HYDROPOWER PROJECT
IN
THE MIDDLE REACHES OF THE DONG NAI RIVER
IN
THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT

VOLUME I
EXECUTIVE SUMMARY

MARCH 2000

NIPPON KOEI CO., LTD.
TOKYO ELECTRIC POWER SERVICES CO., LTD.

JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ELECTRICITY OF VIETNAM
THE SOCIALIST REPUBLIC OF VIETNAM

FEASIBILITY STUDY
ON
DONG NAI NO.3 AND NO.4 COMBINED HYDROPOWER PROJECT
IN
THE MIDDLE REACHES OF THE DONG NAI RIVER
IN
THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT

VOLUME I

EXECUTIVE SUMMARY

MARCH 2000

NIPPON KOEI CO., LTD.
TOKYO ELECTRIC POWER SERVICES CO., LTD

Composition of the Final Report

Volume I : Executive Summary

Volume II : Main Report

Volume III-1: Supporting Report

Appendix A : Geological Investigation

Volume III-2: Supporting Report

Appendix B : Topographic Survey

Appendix C : Hydrological Investigation

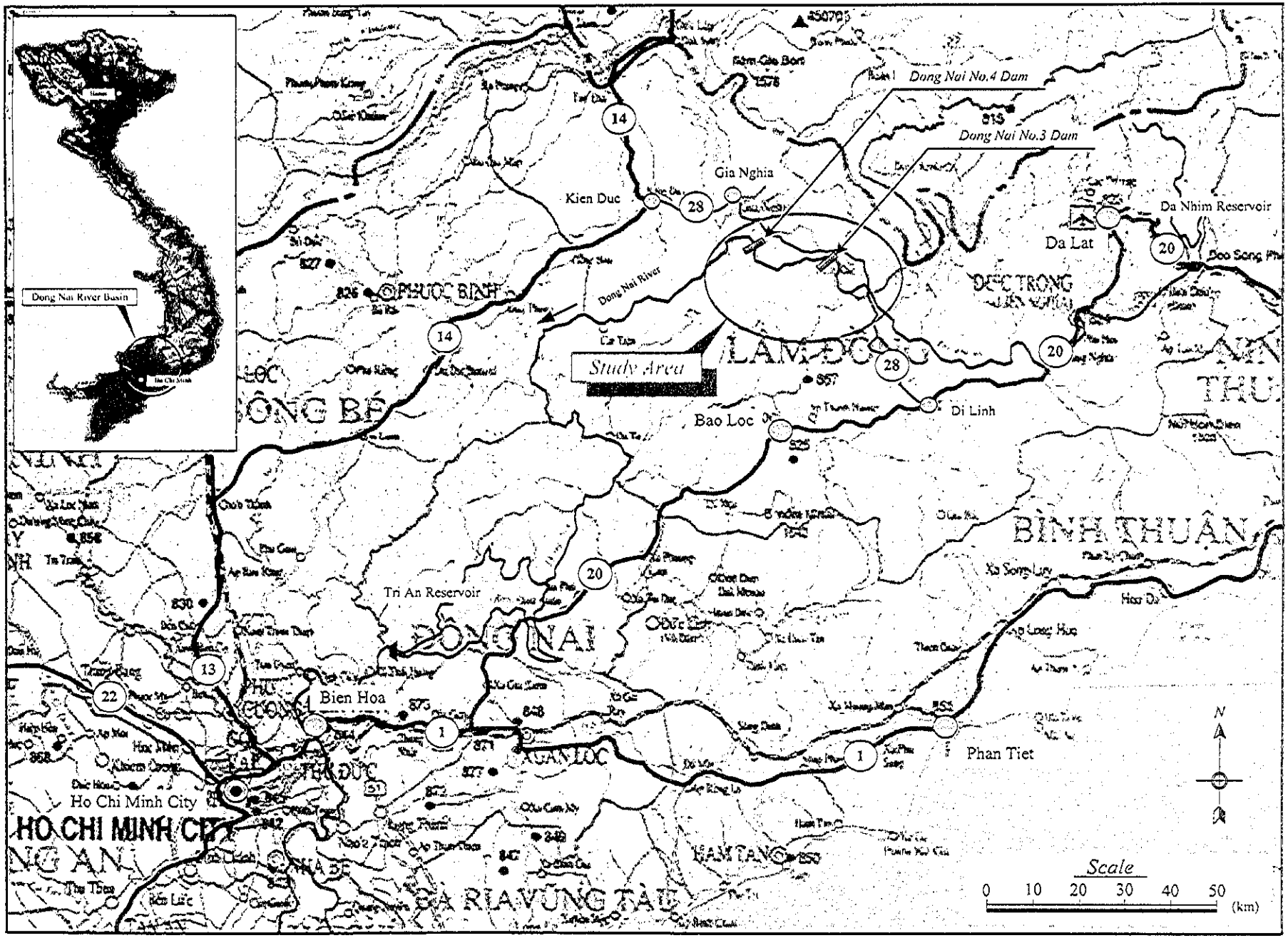
Appendix D : Environmental Survey

Appendix E : Examination of Project Layout Plan

Appendix F : Data Related to Power Transmission System and Explanation of EGEAS

Currency Exchange Rates Adopted for the Study

US$1.00 = VND 13,870
VND 1.00= ¥ 0.008219
(in March 1999)



Location Map of Dong Nai No.3 and No.4 Combined Hydropower Project

MAIN FEATURES OF DONG NAI NO.3 PROJECT

1. Dam and Reservoir

1.1 Hydrology

• Catchment Area (C.A.)	2,441 km^2*
• Basin Average Rainfall	1,950 mm
• Annual Mean Discharge	75.20 m^3/sec

Note: *; excludes C.A. of existing Dran Dam (Da Nhim HPP) and C.A. of on-going Dai Ninh HPP Project

1.2 Reservoir

• Full Supply Level (FSL)	El.590 m
• Minimum Operation Level (MOL)	El.560 m
• Flood Water Level for PMF	El.596.8 m
• Gross Storage Capacity	1,856 million m^3
• Effective Storage Capacity	1,248 million m^3
• Reservoir Surface Area at FSL	56 km^2

1.3 Dam

• Type	Concrete Face Rockfill Dam (CFRD)
• Crest Elevation	El.597.5 m
• Crest Length	470 m
• Crest Width	10 m
• Height above Riverbed	108.5 m
• Upstream Embankment Slope	1:1.4
• Downstream Embankment Slope	1:1.5
• Total Embankment Volume	4.73 million m^3

1.4 Spillway

• Design Flood (1,000-year probable flood)	7,240 m^3/sec
• Check Flood (Probable Maximum Flood)	12,480 m^3/sec
• Type	Gated Weir and Open Chuteway with Flip Bucket
• Gated Weir Portion	
- Crest Elevation	El.574 m
- Crest Width	52 m
- Gate	15 m wide ×16 m high ×3 gates (radial gates)
• Chuteway Portion	
- Width	52 m
- Length	158.3 m
• Energy Dissipation	Flip Bucket type

1.5 River Diversion

(1) General

• Design Flood (20-year probable flood)	2,590 m^3/sec
• Check Flood (30-year probable flood)	2,800 m^3/sec

(2) Main Coffer Dam

• Type	Rockfill Dam
• Crest Elevation	El.519 m
• Embankment Volume	0.38 million m^3

(3) Diversion Tunnel

• Type	Concrete Lined Circular Tunnel
• Number of Tunnel	2
• Diameter	11.5 m
• Length	780 m and 980 m

2. Hydropower Generating Facilities

2.1 Intake

• Inlet Dimension	15.1 m width ×17.0 m high ×1 no
• Sill Elevation	El.543 m
• Gate	8.4 m width ×8.4 m high ×1 gate

2.2 Headrace Tunnel

• Type	Concrete Lined Circular Tunnel
• Number of Tunnel	1
• Diameter	8.4 m
• Length	6,960 m

2.3 Surge Tank

• Type	Restricted Orifice type
• Shaft	
- Diameter	20.9 m
- Height	85 m
• Diameter of Orifice	3.5 m
• Upper Surging Water Level	El.615.0 m
• Lower Surging Water Level	El.540.7 m

2.4 Penstock

• Type	Inclined/Horizontal Pressure Tunnel, Steel Lined
• Upper Portion (before branch)	
- Number of Tunnel	1
- Diameter	6.5 m
- Length	226 m
• Lower Portion (after branch)	
- Number of Branch	2
- Diameter	4.6 m
- Length	55 m

2.5 Powerhouse

• Type	Outdoor type
• Building Dimension	25.2 m width × 63 m long
• Overhead Travel Crane	165 ton × 2 no

2.6 Generating Equipment

(1) Turbine

• Type	Vertical Shaft Francis type
• Number of Units	2
• Rated Output	126 MW
• Rated Speed	200 rpm

(2) Generator

• Type	Semi-umbrella type
• Number of Units	2
• Rated Capacity	137 MVA
• Frequency	50 Hz
• Power factor	0.9

(3) Main Transformer

• Type	3-phase, Outdoor-type
• Number of Units	2
• Voltage Ratio	16.5 kV / 500 kV
• Capacity	140 MVA

2.7 Transmission Line and Switchyard

(1) Transmission Line

• Length	12 km
• Number of Circuits	Double Circuit
• Voltage	500 kV
• Conductor	ACSR 330mm^2 × 4

(2) Switchyard

• Site Dimension	150 m width × 170 m long
• Number of Circuit Breaker	5

3. Power and Energy

3.1 Discharge

• Firm Discharge	66.6 m^3/sec
• Maximum Plant Discharge	213.1 m^3/sec

3.2 Head

• Maximum Gross Head	150 m
• Rated Effective Head	130 m

3.3 Power and Energy Outputs

• Installed Capacity	240 MW
• Firm Capacity	83 MW
• Dependable Capacity	218 MW
• Annual Energy	
- Primary	636 GWh
- Secondary	100 GWh
- Total	736 GWh

MAIN FEATURES OF DONG NAI NO.4 PROJECT

1. Dam and Reservoir

1.1 Hydrology

• Catchment Area (C.A.)	149 km^2*
• Basin Average Rainfall	2,657 mm
• Average Runoff	6.54 m^3/sec

Note: *; Residual C.A. between Dong Nai No.3 and No.4 dam sites

1.2 Reservoir

• Full Supply Level (FSL)	El.440 m
• Minimum Operating Level (MOL)	El.430 m
• Flood Water Level for PMF	El.447.1 m
• Gross Storage Capacity	124 million m^3
• Effective Storage Capacity	37 million m^3
• Reservoir Surface Area at FSL	4 km^2

1.3 Dam

• Type	Rockfill Dam with Center Earth Core
• Crest Elevation	El.448.5 m
• Crest Length	240 m
• Crest Width	10 m
• Height above riverbed	96 m
• Upstream Embankment Slope	1:2.2
• Downstream Embankment Slope	1:1.8
• Embankment Volume	2.2 million m^3

1.4 Spillway

• Design Flood (1,000-year probable flood)	6,430 m^3/sec*
• Check Flood (Probable Maximum Flood)	9,960 m^3/sec*

Note: *; Flood for Dong Nai No.4 = (Flood from the residual C.A. mentioned above)+ (Regulated outflow from Dong Nai No.3 dam/spillway)

• Type	Gated Weir and Open Chuteway with Flip Bucket
• Gated Weir Portion	
- Crest Elevation	El.424 m
- Crest Width	52 m
- Gate	15 m wide ×16 m high ×3 gates (radial gates)
• Chuteway Portion	
- Width	52 m
- Length	106.6 m
• Energy Dissipation	Flip Bucket type

1.5 River Diversion

(1) General

• Design Flood (20-year probable flood)	2,630 m^3/sec*
• Check Flood (30-year probable flood)	2,850 m^3/sec*

Note: *: Flood for Dong Nai No.4 = (Flood from the residual C.A. mentioned above)+ (Regulated outflow from Dong Nai No.3 dam/spillway)

(2) Main Coffer Dam

• Type	Rockfill Dam
• Crest Elevation	El.395 m
• Embankment Volume	391,000 m^3

(3) Diversion Tunnel

• Type	Concrete Lined Circular Tunnel
• Number of Tunnel	2
• Diameter	10.9 m
• Length	690 m and 800 m

2. Hydropower Generating Facilities

2.1 Intake

• Inlet Dimension	15.7 m width ×17.0 m high ×1 no
• Sill Elevation	El.413 m
• Gate	8.6 m width ×8.6 m high ×1 gate

2.2 Headrace Tunnel

• Type	Concrete Lined Circular Tunnel
• Number of Tunnel	1
• Diameter	8.6 m
• Length	5,320 m

2.3 Surge Tank

• Type	Restricted Orifice type
• Shaft	
- Diameter	17 m
- Height	69 m
• Diameter of Orifice	3.5 m
• Upper Surging Water Level	El.466.7 m
• Lower Surging Water Level	El.409.1 m

2.4 Penstock

• Type	Inclined/Horizontal Pressure Tunnel, Steel Lined
• Upper Portion (before branch)	
- Number of Tunnel	1
- Diameter	6.7 m
- Length	377 m
• Lower Portion (after branch)	

- Number of Branch	3
- Diameter	3.9 m
- Length	57 m

2.5 Powerhouse

• Type	Outdoor type
• Building Dimension	24 m width × 78 m long
• Overhead Travel Crane	250 ton × 1 no

2.6 Generating Equipment

(1) Turbine

• Type	Vertical Shaft Francis type
• Number of Units	3
• Rated Output	94 MW
• Rated Speed	214 rpm

(2) Generator

• Type	Semi-umbrella type
• Number of Units	3
• Rated Capacity	101 MVA
• Frequency	50 Hz
• Power factor	0.9

(3) Main Transformer

• Type	3-phase, Outdoor type
• Number of Units	3
• Voltage Ratio	16.5 kV / 500 kV
• Capacity	110 MVA

2.7 Transmission Line and Switchyard

(1) Transmission Line

• Length	13 km
• Number of Circuits	Double Circuit
• Voltage	500 kV
• Conductor	ACSR330mm^2 × 4

(2) Switchyard

• Site Dimension	150 m width × 200 m long
• Number of Circuit Breaker	6

3. Power and Energy

3.1 Discharge

• Firm Discharge	69.9 m^3/sec
• Maximum Plant Discharge	223.7 m^3/sec

3.2 Head

• Maximum Gross Head	150 m
• Rated Effective Head	138m

3.3 Power and Energy Outputs

• Installed Capacity	270 MW

- Firm Capacity 89 MW
- Dependable Capacity 256 MW
- Annual Energy
  - Primary 721 GWh
  - Secondary 120 GWh
  - Total 841 GWh

Estimated Total Project Cost for Dong Nai No.3 and No.4 Combined Hydropower Project

Estimated Total Project Cost (1)

(Unit: million US$)

Description	FC	LC	Total
I. Base Cost	368.4	270.4	638.8
Construction Cost	333.4	219.6	553.0
Engineering Service	31.1	10.4	41.5
Administration	0.0	3.9	3.9
Land compensation and resettlement	3.9	6.7	10.6
Tax	0.0	29.8	29.8
II. Contingency	55.0	43.3	98.3
Price contingency	26.0	17.9	43.9
Physical contingency	29.0	25.4	54.4
Total Project Cost	423.4	313.7	737.1

Estimated Total Project Cost (2)

(Unit: million US$)

Description	No.3	No.4	Total
I. Base Cost	343.9	294.9	638.8
Construction Cost	293.4	259.6	553.0
Engineering Service	22.0	19.5	41.5
Administration	2.1	1.8	3.9
Land compensation and resettlement	10.6	0.0	10.6
Tax	15.8	14.0	29.8
II. Contingency	52.6	45.7	98.3
Price contingency	22.6	21.3	43.9
Physical contingency	30.0	24.4	54.4
Total Project Cost	396.5	340.6	737.1

FEASIBILITY STUDY
ON
DONG NAI NO.3 AND NO.4 COMBINED HYDROPOWER PROJECT
ON
THE MIDDLE REACHES OF THE DONG NAI RIVER
IN
THE SOCIALIST REPUBLIC OF VIETNAM

FINAL REPORT

VOLUME I

EXECUTIVE SUMMARY

Table of Contents

List of Tables

List of Figures

Abbreviations

1. Organization

ADB	: Asian Development Bank
DSI	: Development Strategy Institute
CTNP Office	: Cat Tien National Park Office
EPRI	: Electric Power Research Institute
EVN	: Electricity of Vietnam
IBRD	: International Bank for Reconstruction and Development
IOE	: Institute of Energy
JICA	: Japan International Cooperation Agency
MoARD	: Ministry of Agriculture and Rural Development
MPI	: Ministry of Planning and Investment
PC	: Power Company
PECC2	: Power Engineering and Consulting Company No.2
WB	: World Bank (International Bank for Reconstruction and Development)
WWF	: World Wide Fund for Nature

2. Water Level of Reservoir and Tailrace

FSL	: Full Supply level
MOL	: Minimum Operation Level
RWL	: Rated Water Level
FWL	: Flood Water Level
TWL	: Tail Water level

3. Chemical Element

pH	: pH value
BOD	: Biochemical oxygen demand
DO	: Dissolved oxygen

4. Unit

MW	: mega-watt	km	: kilometer
kW	: kilowatt	km^2	: square kilometer
MWh	: mega-watt hour	ha	: hectare
kWh	: kilo-watt hour	$mile^2$	: square mile
GWh	: giga-watt	m^3	: cubic meter
GWh/yr	: giga-watt per year	m^3/year	: cubic meter per year
kV	: kilovolt	m^3/sec	: cubic meter per second
MVA	: mega-volt ampere	$m^3/sec/km^2$	: cubic meter per second per square kilometer
mm	: millimeter	$feet^3/sec/miles^2$	: cubic feet per second per square mile
mm/day	: millimeter per day	g	: gram
mm/year	: millimeter per year	mg/l	: milligram per liter
m	: meter		
m/s or m/sec	: meter per second		
m/sec^2	: meter per square second		

5. Currency

VND	: Vietnamese Dong
US$	: US Dollar
USc or US ¢	: US Cent

6. Others

AC	: Alternating Current
ASEAN	: Association of Southeast Asian Nations
C.A.	: Catchment Area
C-Cycle	: Combined Cycle
CPI	: Consumer Price Index
DP	: Dynamic Programming
EGEAS	: Electric Generation Expansion Analysis System
EIA	: Environmental Impact Assessment
EIRR	: Economic Internal Rate of Return
FC	: Foreign Currency
FDI	: Foreign Direct Investment
F.M.	: Finess Modulus
FIRR	: Financial Internal Rate of Return
GDP	: Gross Domestic Products
GNP	: Gross National Products
GRDP	: Gross Regional Domestic Products
HCM	: Ho Chi Minh
HCMC	: Ho Chi Minh City
HPP	: Hydropower Project
ICB	: International Competitive Bid
IPP	: Independent Power Producer
LC	: Local Currency
LCB	: Local Competitive Bid
LOLP	: Loss of Load Probability
LRMC	: Long Run Marginal Cost
MDD	: Maximum Dry Density
MIT	: Massachusetts Institute of Technology
ODA	: Official Development Aid
OMC	: Optimum Moisture Content
PMP	: Probable Maximum Precipitation
RAC	: Resettlement Action Committee
RAP	: Resettlement Action Plan
ROE	: Return on Equity
SGS	: Streamflow Gauging Station
SME	: Small and Medium Enterprises
SRMC	: Short-Run Marginal Cost
VAT	: Value Added Tax
WASP	: Wien Automatic System Planning Package

EXECUTIVE SUMMARY

I. THE STUDY

Background of the Study

1 The electrical power demand in Vietnam has been increasing steadily from 7,792 GWh in 1989 to 12,283 GWh in 1994 and 20,850 GWh in 1998. The average annual growth rate of the total power demand during 1993 to 1998 was as high as 17.2%.

Furthermore, the power generation and peak load forecast for future development are in the order of 68,000 GWh in 2010 and 105,000 GWh in 2015, and 11,000 MW in 2010 and 17,000 MW in 2015, respectively, although the growth rates are projected to be far smaller than experienced so far.

Under such circumstances, EVN has prepared the long-term power source development plans. Among the various candidate development plans, the Dong Nai No.3 and No.4 Combined Hydropower Project was identified as an attractive development plan through such studies as the JICA master plan study in 1996 and pre-feasibility study by EVN in 1998 in order to meet the deficiency of electric power that was foreseen to take place before 2010.

After a series of arrangements between the Government of Japan and the Government of the Socialist Republic of Vietnam, this Feasibility Study started in December 1998 and the field investigations were carried out four times to date to work out the optimum development plan after a full review of the previous studies.

This Final Report presents the optimum development of the Project that has been formulated through incorporating the results of the studies/investigations done so far, as well as the comments on the Interim Report from the organizations concerned including EVN.

Objectives of the Study

2 The Study aims at formulating the optimum development plan of the Project by assessing technical, economic, financial, and environmental aspects of the Project. Further, the Study aims at finding out the most suitable timing of commissioning the optimized development plan, to make various arrangements to be required for putting the Project into execution.

The outcomes of the Study should be compiled to be acceptable to the international

lending agencies for financial arrangement to implement the Project as well as various requirements of the Government of Vietnam as much as possible.

It is also one of the main objectives to achieve transfer of technology to and training of the counterpart personnel of the Government of Vietnam in the course of the Study.

The Study Stages and Schedule

3. The Study was conducted in three stages, namely, Preliminary Investigation Stage, Detailed Investigation Stage, and Feasibility-Grade Design stage, with phases of home preparatory work, five field investigations and two home office works during the period of approximately 16 months from mid-December 1998 to March 2000. The overall work schedule is summarized below:

Study Stages and Reports

Study Stage	Work Period	Report Submitted
- Home Preparatory work	December 1998	Inception Report
- First Field Investigation	January - March 1999	Progress Report No.1
- Second Field Investigation	May - July 1999	Progress Report No.2
- Third Field Investigation	August - September 1999	-
- First Home Office Work	October - November 1999	-
- Fourth Field Investigation	December 1999	Interim Report
- Second Home Office Work	January - February 2000	-
- Fifth Field Investigation	February 2000	Draft Final Report

Composition of Final Report

4. This Final Report presents the results of all the investigation and studies carried out by the JICA Study Team from December 1998 to February 2000, comprising the following volumes:

Volume I	Executive Summary
Volume II	Main Report
Volume III-1	Supporting Report
	Appendix A : Geological Investigation
Volume III-2	Supporting Report
	Appendix B : Topographical Survey

Appendix C : Hydrological Investigation

Appendix D : Environmental Survey

Appendix E : Examination of Project Layout Plan

Appendix F : Data Related to Power Transmission System and Explanation of EGEAS

II. SOCIO-ECONOMIC SITUATION

Geographic Features

5 The Dong Nai River Basin lies in the Central Highlands Region and Southeast Region. The Dong Nai mainstream which originates in an eastern part of Lam Dong Province flows down to the west as a whole, forming a boundary between the Lam Dong Province and Dac Lac Province in the middle reach where the Dong Nai No.3 and No.4 dam sites are located. Near Cat Tien, it starts meandering largely to change the flow direction from west to east. In the large meandering portion, the river course forms a boundary of Lam Dong Province with the Binh Phuoc Province and Dong Nai Province in the downstream direction. Thereafter, it changes the flow direction almost to the south to join the existing Tri An reservoir situated about 220km downstream of Dong Nai No.4 dam site. Lam Dong Province and Dac Lac Province are within the Central Highlands Region while the Binh Phuoc Province and Dong Nai Province within the Southeast Region as shown in Figure S.1.

Administrative Structure

6. The Socialist Republic of Vietnam is divided into eight regions mainly based on their geographical conditions, which are further administratively divided into sixty-one provinces. The stratum administrative structure is depicted in Figure S.2. As shown in the figure, the administrative stratum is structured by four levels:

i) Central level,

ii) Provincial level: Provinces and 4 Centrally Administered Cities,

iii) District level : Urban Districts, Rural Districts, Cities and Towns, and

iv) Commune level: Communes, Wards and Towns.

The Four Centrally Administered Cities are Hanoi, Hai Phong, Danang and Ho Chi Minh.

Population

7. The total population in 1998 was 78 million, which was the second largest in Southeast Asia following Indonesia. Out of the total population, a majority of 78% people live in rural villages and the remaining 21% live in urban areas in 1998. The growth rate of the total population is decreasing for these two decades and reached 1.8% per year in 1997 which was the target rate to be attained in 2000 in the sixth Five-year National Development Plan for 1996-2000.

The total number of labor force in 1997 was 37 million, which corresponded to 48.2%

of the total population. The annual average growth rate was 3.5% in 1996 and 3.4 % in 1997. The agriculture and forestry provide the largest share of labor force of 67.1% in 1997, though it is gradually decreasing recently. Manufacturing is the second largest source of labor force with 8.9% of the total.

GDP and External Trade

8. After declaration of an economic renewal program called " Doi Moi" in 1986 and the subsequent open-market policy adoption, an continuous economic development has been recorded. Especially GDP growth during the period from 1992 to 1997 was remarkable. Annual average GDP growth for these five years reached as high as 9.8%. The sector structure of the economy shows the drastic decrease in agriculture sector from 44% of the total GDP in 1985 to 24% of the total GDP in 1998. While the same share of industry has increased from 22% of the total GDP in 1985 to 31% of the total GDP in 1998.

Export of Vietnam recorded US$ 9 billion corresponding to 46% of GDP in 1997. Average growth rate of exports for the period of 1990-1997 was 32% per year. The high economic growth in 1990's can be naturally attributed to this remarkable increase in export. As for the export destination in 1997, 66% of the total exports of Vietnam was forwarded to Asian countries among which Japan occupied the largest share of 18%, following by Singapore (13%) and Taiwan (9%).

Import of Vietnam recorded US$ 10 billion corresponding to 54% of GDP in 1997. Average growth rate of imports for the period of 1990-1997 was 36% per year.

National Development Plan

9. The Sixth Five-Year Plan for Socio-economic Development of Vietnam for the period of 1996-2000 shows favorable achievement in general as briefed below, although having been affected much by the Asian Economic Crisis risen in the mid-1997. The per-capita GDP target set for 2000 in the Plan was easily attained in 1998 already owing to the high growth rate in 1995 and 1996 with more than 12% in the respective year.

The target for Consumer Price Index (CPI) set at a level less than 10% per year in the Plan was also attained with average annual increase of 5.9% per year. The food production target of 30 million tons in 2000 was also attained in 1997(30.561 million tons). However, the target of electricity supply set at 30,000GWh in 2000 in the Plan was not attained yet with the power supply at 20,850 GWh in 1998.

Regional Development Plan

10. Regional Development Plan being actually compiled by planning agencies for each Five-year plan period still requires certain improvement by providing the standard criteria for regional planning in Vietnam. Such being the case, only an outline of regions is presented through briefing the regional development plan for 1999.

i) The Red River Delta Region: agricultural growth rate at 4,4% in 1999 while that in industry at 11.6%.

ii) Regions in Central area: Upgrading and building of irrigation systems and speeding up of shifting plant and animal structure and extension of afforestation acreage in upward areas. As for industrial production, intensification of offshore fishing projects and exploitation of 50,000 coastal hectares to farm aqua-products.

iii) The Southeast Region: an important role in the development of national economy with its potential of industrial growth, accounting for 52% of the country's industrial production, more than 50% of the export and import turnover, more than 57% of the national budget revenues.

iv) The region comprising HCM City- Binh Duong-Ba Ria-Vung Tau: Top priority to be placed on oil exploitation industry, energy, fertilizer, steel, building materials, electronics, garments, etc., in the strategy of regional development.

v) The Mekong River Delta Region: agricultural growth rate at 4.6% in 1999 at least with a food output of 15.5-16.6 million tons while industry at 10%, services at 8%, import and export turnover 9.1% and employment creation for 160,000 people.

Impact of East-Asian Economic Crisis

11. In 1998, the foreign direct investment (FDI) inflows have dropped sharply in the first six months, FDI inflows having totaled only US$ 1.0 billion compared to US$ 1.7 billion in 1997. The primary reason has been the sharp decline of economic activity in Asian regions as a result of the crisis.

Recovery from the current recession will depend to a large extent on the economic recovery of other surrounding Asian countries to which Vietnam exported 66% of the total export in 1997. Fortunately to Vietnam, Asian economies have been gradually improving in these several months.

Socio-Economic Projection

12. A socio-economic projection up to the year 2015 was conducted for the limited purpose of providing a macro-framework for the electric power demand projection. Most of the projected macro indices were primarily those projections made by the Government of Vietnam and/or World Bank where data and information are accumulated. The following GDP forecast by MPI for 1999 and 2000 and thereafter by the Institute of Energy in Hanoi was adopted for this Study:

Projected GDP Growth Rates of the Whole Vietnam

Period in Year	1999	2000	2001-2005	2006-2010	2011-2020
GDP growth rate	5.0% p.a	6.0 % p.a	7.2 % p.a	7.2 % p.a	6.5 % p.a

The consequent per-capita GDP in 2015 was projected at US$ 1,744 at current price level which is approaching to the per-capita GNP level of " middle income group (US$ 1,890 in 1997) defined by World Bank.

III. SITE CONDITIONS

Present River System and Topography

13. The mainstream of the Dong Nai River originates from the hilly areas with elevation of 1,000 m to 2,000m in the northern part of Lam Dong Province where the city Da Lat is situated. The Dong Nai River originating from the northern hills joins three large tributaries, the La Nga River, Be River and Saigon River in the order from upstream to downstream and it finally debauches into the Sea. The gross catchment area of the Dong Nai River including those of the three major tributaries is about 31,000 km2. The Dong Nai mainstream flows into the existing Dran reservoir created under Da Nhim hydropower project completed in 1964. Most of the river flow is diverted to the neighboring eastern basin (the Phan Rang River basin) except large-scale floods through the spillway.

The Dai Ninh HPP with two dams; one on the Dong Nai mainstream and the other on its tributary, the Da Queyon River, are proposed to be constructed in near future. Most of the river flow into those two reservoirs are also planned to be diverted to the neighboring eastern basin except large-scale floods through the spillway. Therefore, only the river flow downstream of the Dai Ninh HPP is essentially usable for this Project.

The Dong Nai River reaches the proposed Dong Nai No.3 dam after flowing for a river course of about 80 km downstream of the Dai Ninh HPP. The Dong Nai No.4 dam site is selected at the location about 20km downstream of the Dong Nai No.3 dam site. The river system in the middle and upper reaches of the Dong Nai mainstream is shown in Figure S.3.

The Dong Nai No.3 and No.4 Combined HPP site is dominantly composed of hilly areas covered with basalt. The river channel becomes wider upstream of the Dong Nai No.3 dam site to secure a large-scale reservoir storage capacity.

The topographic survey done at this stage shows the river bed width on the Dong Nai No.3 dam axis is about 120m with the lowest river bed elevation at approximately El. 490. While the river bed at the Dong Nai No.4 dam site is as narrow as about 40m near the river bed.

Meteorology and Hydrology

14. There were no streamflow gauging stations in the vicinity of the proposed Dong Nai No.3 and No.4 dam sites on the Dong Nai mainstream until a new streamflow gauging station was installed at the Dong Nai No.3 dam site during the Second Field Investigation. Although the new streamflow gauging station has been in operation

since the end of June 1999, the period of the water level records at the new station are as short-term as less than one year, so it is premature to carry out the runoff analysis for estimating the long-term runoff at the proposed Dong Nai No.3 and No.4 dam sites based on the limited records only. Therefore, the runoff data at other streamflow gauging station had to be transposed to the Project catchment in carrying out the runoff analysis. For this purpose, the existing Ta Lai streamflow gauging station that is located about 220 km downstream of the proposed Dong Nai No.4 dam site was selected through the following cross-checks to verify the consistency of observed runoff data:

i) The annual runoff depths at Ta Lai streamflow gauging station are consistently correlated with its annual basin average rainfalls throughout the entire observation period of 20 years from 1979 to 1988,

ii) The mean annual runoff coefficient at Ta Lai streaflow gauging station is derived to be 0.50, which is in an adequate range in comparison with the values at other streamflow gauging stations situated in the middle reach of the Dong Nai River basin.

The runoff data at Ta Lai SGS with an effective catchment of 8,850 km^2 were transposed to the proposed Dong Nai No.3 and No.4 dam sites in consideration of the differences in their catchment areas as well as annual average rainfalls. Consequently, the mean discharge at the Don Nai No.3 dam site was estimated at 75.2 m^3/sec, while the mean runoff yielded from the catchment area of 149 km^2, intervening between the Dong Nai No.3 and No.4 dam sites, was derived to be 6.54 m^3/sec. The estimated mean runoff at the Dong Nai No.3 dam site is assessed to be consistent in comparison with such runoff factors as specific discharge and runoff coefficient of neighboring basins as shown in Figure S.4. To further verify the consistency of the estimated runoff data at the Dong Nai No.3 dam site, the correlation analysis was made for the concurrent mean 5-day discharges at Ta Lai SGS and the new SGS at the Dong Nai No.3 dam site. The correlation analysis clarifies that the estimated Dong Nai No.3 inflow data are in a consistent range. Meanwhile, it is recommended that further runoff analysis would need to be performed in the subsequent detailed design stage after the runoff data of more than 2 years at the new SGS will become available.

15. In the Project catchment, the unusual rainstorms took place mainly due to the passage of typhoon at a frequency of one in 10 to 20 years, which comes from the Vietnam Sea. Since the runoff data were not sufficiently available for making the flood frequency analysis, the probable floods at the proposed Dong Nai No.3 were estimated by means of applying the probable basin average rainfalls to a unitgraph that was derived from the typical flood hydrograph at Ta Lai SGS through the dimensionless unitgraph method. The 1,000-year probable daily rainfalls were estimated at 395 mm. Besides, the probable maximum precipitation (PMP) was derived to be 687 mm/day in

accordance with the procedures of the WMO for the Mekong River basin. As a result, the 1,000-year probable flood and PMF at the Dong Nai No.3 dam site were estimated at 7,240 m3/sec and 12,500 m3/sec, respectively. Figure S.5 shows hydrographs of estimated probable floods and PMF at the Dong Nai No.3 dam site.

In the present feasibility-grade design, the estimated 1,000-year probable flood and PMF are adopted as the design flood and check flood for the spillway. The adequacy of the estimated floods were cross-checked through the comparison with the design floods in other dam projects in the Dong Nai River basin in terms of the Creager's coefficient as shown in figure S.6. As seen in the Figure, the estimated design flood and PMF falls in an adequate range as compared with the design floods and PMF adopted in other dam projects in the Dong Nai river Basin.

16. The sediment analysis was carried out based on the suspended concentration records measured at Ta Lai SGS in order to estimate the annual sediment volumes to be deposited in the planned Dong Nai No.3 and No.4 reservoirs. The denudation rate of the middle reach of the Dong Nai River was estimated at about 0.2 mm/year, which almost coincides with the values estimated in the Ham Thuan HPP in the La Nga River basin situated adjacent to the Project catchemnt, as shown in Figure S.7. The annual sediment volumes deposited by the planned Dong Nai No.3 and No.4 reservoirs were estimated at 0.85 and 0.06 million m^3, respectively, taking into account the reservoir trap efficiencies derived from the empirical curve. The Study contemplates the Dong Nai No.3 and No.4 reservoirs to have sufficient dead storage capacities to store the sediment inflow for 100 years.

Geology

17. The bedrock of the Project area, both the Dong Nai No.3 and No.4 dam sites and the reservoirs, is composed of sandstone, shale and siltstone of the Jurassic La Nga Formation. The bedding planes show almost constantly similar strikes around N45°E and dip northwest or southeast, reflecting folds. The sedimentary rock of La Nga Formation is covered by the Plio-Pleistocene Tuc Trung Basalt, which generally lies higher than the reservoir level. The geological maps of Dong Nai No.3 and No.4 dam sites are presented in Figures S.8 and S.9, resepectively.

The sandstone with shale and siltstone is well-cemented hard rock in the fresh or only slightly weathered condition, but very soft when highly weathered. The slightly weathered or fresh rock at the Dong Nai No.3 dam site indicates that the bulk density is around 2.7 g/cm^3 and that the uniaxial (unconfined) compressive strength is over 1,000 kgf/cm^2 except a few weak samples. While the uniaxial compressive strength of the rock at the Dong Nai No.4 dam site is lower than that at the Dong Nai No.3 dam site, with the laboratory test data scattering between 350 kgf/cm^2 and 1,300 kgf/cm^2.

Concrete gravity dams or the impervious earth core of fill-dams have to found on the slightly weathered rock, which is encountered at the depth of 30 to 35 metres at the Dong Nai No.3 dam site and 25 to 30 metres at the Dong Nai No.4 dam site.

For both dam sites, the seepage potential is fairly low and it is easy to treat it as long as the dams are founded on the slightly weathered rock.

The headrace tunnels of both Dong Nai No.3 and No.4 will for the most part be driven in the hard and fresh rock, except for the fault zone and highly weathered rock near the portals.

The reservoir areas of the Dong Nai No.3 and No.4 show no sign of either harmful sliding or water loss.

Seismicity

18. The land of Vietnam, except its farthest northern part, is situated on a crater or a stabilized continental mass called Sunda Shelf. This area is characterized by low seismicity and little earthquake. The probable maximum accelerations at the project site were derived to be 0.009g for 100-year return period and 0.014g for 200-year return period through the probabilistic calculation made based on 16 events of earthquakes at the dam sites.

The earthquake factor is 0.035 for rock-base structures in the Ham Thuan-Da Mi Hydropower Project and 0.07 for earth-base structures, while a value of 0.1was proposed in the study of design criteria for the Dai Ninh Hydropower Project. The value of 0.1 is taken as a conservative minimum value for the design of this Project.

Construction Materials

19. Earth core material is taken from the residual soil over the plateau near the Dong Nai No.3 and No.4 dam sites, and rock material is to be taken around the Tuc Trung Basalt escarpments at the edge of the plateau within 4 km from those dam sites

On the other hand, sands for concrete and dam filters will have to be mechanically crushed at sites or acquired from potential sources more than 120 km from the Project site. Coarse aggregates for concrete will have to be mechanically produced with rocks obtained from the quarry sites adjacent to the Project site.

IV. ENVIRONMENTAL ASSESSMENT

Approach Adopted for Environmental Assessment and Resettlement Plan

20. The initial environmental examination (IEE) in the First Field Investigation framed the key environmental items as briefed below:

i) Impacts to inundation area due to Dong Nai No.3 reservoir and its mitigation/compensation,

ii) Impacts to natural environment due to the creation of both Dong Nai No.3 and No.4 reservoirs,

iii) Impacts to downstream areas including the Cat Tien National Park and even its downstream areas due to the Project,

iv) Feasibility of fishery development for utilization of reservoir,

v) Consideration of environmental management and monitoring system, and

vi) Costs of compensation and environmental mitigation

The environmental survey focussed on these items. It was subcontracted to the local contractor (PECC2) on a local contract basis during the Second and Third Field Investigations. The environmental survey was also deployed to satisfy requirements of the relevant laws and regulations of Vietnam as well as guidelines of international lending agencies.

Reservoir Population and Resettlement Action Plan

21. The surveys revealed that the land of 8 communes would be affected by impounding the Dong Nai No.3. However, resettlement is only required in relation to impounding the Dong Nai No.3 reservoir. Impounding the Dong Nai No.4 reservoir would not cause any commune or household to loose land or homes.

In case of the Dong Nai No.3 reservoir, a total of 257 households (representing 1,383 persons) would loose homes and fields and would need to be resettled. A total of 127 households (representing 763 persons) would loose fields but not homes.

Over 95% of the commune households belong to the Ma ethnic minority tribe. The tribe originates from the central highlands plateau area and immigrated into the Dong Nai No.3 and No.4 regions after 1975. They are certainly not indigenous to the project area. The communes are poor to very poor by the Vietnamese standards and have an economy based on agriculture. The vast majority live in homes built from

wood or bamboo.

From an opinion poll and later a Rapid Rural Appraisal (RRA) conducted within the affected communes, the households reported that they were not opposed to resettlement as long as they would be compensated for any lost assets on a like-for-like basis or cash equivalent value. They would like to have better constructed homes and improved medical, educational and market place facilities and transport routes in the resettlement areas. The Resettlement Action Plan (RAP) prepared under the Study considers their aspirations in some detail and the corresponding range of permitted and regulated compensation measures.

The main budgeted items in the RAP are: (a) land registration fees; (b) compensation for impounded farm lands, homes, cemeteries, and commune facilities such as schools, health centers and roads; (d) leveling and clearing the resettlement areas and constructing its roads, water wells and providing electrification; (e) the Resettlement Action Committee (RAC); and (f) the independent ("watchdog") external monitoring agency. Compensation would be provided to replace fields, crops, homes, graveyards, commune facilities and roads. The content of the RAP and the scale and the range of the compensation measures are prescribed within the national and provincial legislation. The RAP would be implemented through a constituted Resettlement Action Committee (RAC), which itself would be monitored by an external independent ("watchdog") monitoring agency. Acting together, these two agencies would ensure that all of the RAP's provisions are implemented expediently.

Two resettlement areas are proposed in the RAP: one for the Dak Plao/Dak Som households, and the other for the Dinh Trang Thuong households. Both areas provide more than three times the area of land formerly available to the households for development. The households are opposed to adopting a livelihood based on fish farming and wish to retain their agricultural lifestyles, which are consistent with their ethnic origins and culture. The proposed resettlement areas are shown in Figure S.10.

There are no archaeological, historical or cultural assets within the proposed impoundment areas of Dong Nai No.3 and No.4 or at the locations of the dams and powerhouses.

Natural Reservoir Environment

22. The reconnaissance and detailed field investigation surveys of the areas around the proposed Dong Nai No.3 and No. 4 reservoir areas revealed very contrasting conditions.

The proposed Dong Nai No.3 reservoir area is currently severely impacted through the

clearance of forest to meet the expanding agricultural needs of the growing communes. Vast areas of once densely forested land are now covered in sparse bamboo or laying fallow. The trees were cut to provide timber to construct homes and furniture. The Dong Nai No. 3 area has very little natural forest remaining alongside the Dong Nai River, and this too is under current exploitation for timber and for growing crops. Bamboo vegetation comprises more than 90% of the unmanaged vegetation within the Dong Nai No.3 reservoir area. It has replaced the former hardwood forests. It is a very low value commodity, and is not important to wildlife. Animal surveys in this area did not reveal the presence of any important species. Most of the natural wildlife has fled from the area or been killed by hunters. Consequently, the Dong Nai No.3 reservoir area is severely impoverished in terms of natural animal and plant species.

The proposed impoundment area of the Dong Nai No.4 reservoir area lies within a narrow (40 meter wide) steep-sided gorge. The steep sides of this gorge have a relatively sparse cover of bamboo and hardwood vegetation. However, thick virgin forest, especially on the left bank of the Dong Nai River, extends outwards from the gorge. Because of the rugged and steep topography, the absence of roads, and the dense forest alongside the gorge, access into the forest was very difficult and it was not possible to study the animals living there in much detail. Owing to the extreme difficulties presented in penetrating the forest, it has no significant human settlements. It is in fact "virgin forest". This forest is likely to be the home for diverse kinds of animals, many of which would be protected or endangered species.

The World Wide Fund for Nature (WWF) commented that access roads to the structure sites of the Dong Nai No.4 plant, and later developments, could facilitate human settlements in this thick forest. Thus any access roads must be planned and sited carefully, to minimize possible future threats arising from exploitation of this forest from immigrants. Furthermore there would need to be strict policing on these roads to prevent illegal hunters and settlers from entering the forest during and after construction of the hydropower plants.

Effects to Downstream Areas of the Project Site

23. The downstream hydrological impacts would comprise:

i) Changes in water flow between the dams and the powerhouses;

ii) Mode and frequency of water discharged from the powerhouses;

iii) River channel and river-bed erosion;

iv) Changes in the availability of water to meet the needs of others through abstraction; and

v) Changes in the availability of water required by sensitive ecosystems such as national parks.

Analyses indicate that for aesthetic rather than for ecological reasons, it would be beneficial to restore the aquatic habitat immediately downstream of the dam up to the confluence of the next tributary discharging into the Dong Nai River. This could be achieved by allowing a small discharge from the dam. However, any such restoration would be of minor ecological value.

The riverbed of the Dong Nai is hard sandstone/siltstone and it is highly resistant to mechanical erosion in general. The "with project" maximum discharge of 200 m^3 per second from the Dong Nai No.4 powerhouse would be smaller than the average discharge rate of 250 m^3 per second "without the project" during the flood season. The water discharged from the powerhouse would not erode the river channel.

Between the Dong Nai No.4 planned powerhouse and the Tri An reservoir there are no significant points of water abstraction to meet the needs of irrigation, drinking and industrial manufacture. Very occasionally, water is abstracted from two locations about 150 km downstream from the planned powerhouse to supply some paddies. Detailed analyses indicate that the dam operations would reduce the monthly flood peak discharge of the Dong Nai River, where it passes the northeastern boundary of Nam Cat Tien (the southern sector of the Cat Tien National Park) by 20 to 30%. The comparatively small reduction is due to a recharge of the Dong Nai River from the catchment extending from the Dong Nai No.4 powerhouse to Nam Cat Tien. The catchment contributes to a significant amount of flow in the River (by as much as 30%). Consequently the development of the Project will not pose unacceptable environmental concerns for potable, irrigation, and industrial needs where presently such limited abstraction occurs.

The Cat Tien National Park is at a higher elevation than the mean elevation of flow in the Dong Nai River, and consequently the parkland drains into the Dong Nai throughout the year. The Dong Nai River does not recharge the Cat Tien National Park. There is one exception, namely at the Bau Sau wetland in Nam Cat Tien. During the peak flood period in the monsoon season (June through to September) part of the Dong Nai River flow reverses into a stream (the Dak Lua stream) and floods the Bau Sau wetland. According to information obtained from the local inhabitants, this lasts for about 10 to 15 days a year. The phenomenon was investigated during the 1999 monsoon season through a hydrological investigation. The 1999 monsoon was one of a particularly high severity, which has a return period of about 25 years. The hydrological survey indicated that the reverse flow into the wetland, lasting in total for about 10 days, is a seasonal monsoon phenomenon. The reverse flow is unlikely to have significance in supporting the wetland for the remaining part of the year.

Impacts to the single-horned rhinoceros in the Cat Tien National Park and the buffer zone surrounding the Park which were serious concerns before commencement of this Study have been confirmed at this stage to be negligible.

A key issue is whether longer continuous release from the Dong Nai No.4 powerhouse would be required to mitigate any impacts resulting from the envisaged peak power operational mode (daily 7.5 hours cycle on; and 16.5 hours off). An option of maintaining longer hours of continuous release could be employed through providing three power units in the Dong Nai No.4 powerhouse. For the flexibility of coping with any unforeseeable environmental difficulties, provision of three power units in the Dong Nai No.4 power station is recommended.

Fisheries Development for Utilization of Reservoirs

24. The survey of the Dong Nai River water quality and of the aquatic animals revealed about 70 species of fish, belonging mostly to the carp family. Most of these fish species would survive impoundment and live equally as well in reservoirs. The analyzed water samples showed water of good to high quality, with no detectable concentrations of pollutants.

Most of these species could be farmed in reservoirs. However, the communes are opposed to adopting a livelihood based on fish farming and would prefer to retain their agricultural lifestyle, which is consistent with their ethnic heritage and cultural values. Fish farming might, however, appeal to a commercial organization with capital to construct the outlay. The possibility to develop fish farming could be reviewed with the District and Provincial Fishery Departments during the detailed design stage of the Project.

Environment Management and Monitoring

25. Environmental management and monitoring with respect to resettlement action planning and compensation measures would be done by the Resettlement Action Committee and the approved independent external monitoring organization in accordance with the relevant regulations in Vietnam. The costs to be incurred for their activities are included in the Project cost.

All aspects of environmental monitoring would be undertaken through the EVN environmental departments, which would tender some studies, such as water quality monitoring and ecological surveys, to local contractors.

Costs of Land Compensation and Environmental Mitigation

26. The costs for resettlement compensation and land acquisition were estimated at about US$ 11 million (VND 147billion) during the field investigation stage by the local contractor under the contract from the JICA Study Team. Major items surveyed at this stage including relocation of the National Highway Road No.28 of 50km comprise farm products, land, buildings, preparation of resettlement areas and other costs such as for Resettlement Action Committee and the approved independent external monitoring organization for monitoring the RAP. The costs derived here should be subject to future review from time to time.

V. POWER SURVEY

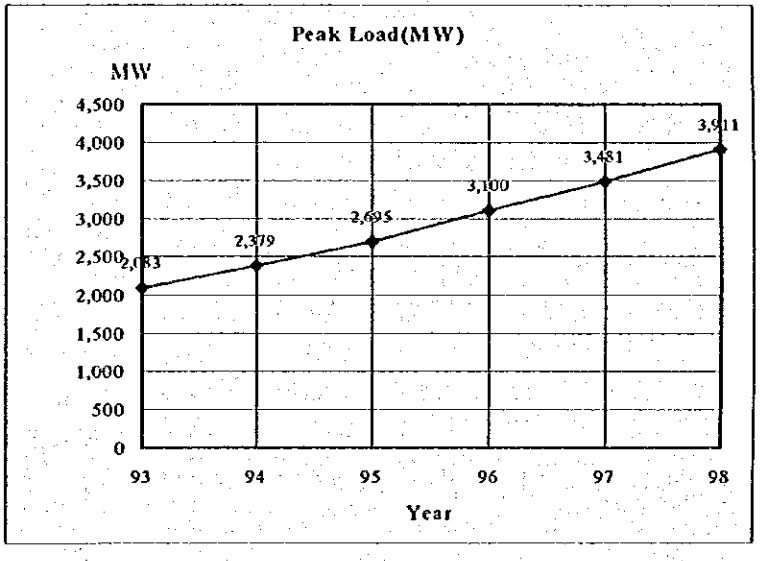
Power Sector Organization

27. In January 1995, the Government established a holding company, the Electricity of Vietnam (EVN), for the entire power sector. EVN is the State Corporation established under the State Enterprise Law and the EVN's Board of Management is authorized to perform the ownership function on behalf of the State.

With the creation of EVN, the operations in the power sector are managed by the entities as shown in Figure S.11.

Historical Power Demand and Existing Power System

28. The electric power demand is increasing steadily from 5,661 GWh in 1994 to 17,739 GWh in 1998. The average growth rate per annum of total demand during 1993-1998 was 17.2 %. The peak power demand has increased at annual average growth rate of 13.4 %, attaining 2,083MW in 1993 and 3,911MW in 1998 as shown below:



Existing installed capacity of power stations in the country is 5,055 MW as of the end of 1998 and the compositions are as follows:

List of Existing Power Plants in Vietnam

Power Plant	Total Installed Capacity	Share
Hydro	2,854 MW	56.5 %
Thermal(coal)	645 MW	12.8 %
Thermal (fuel oil)	198 MW	3.9 %
Gas Turbine	711 MW	14.1 %
Diesel	397 MW	7.9 %
IPP	250 MW	4.9 %
Total	5,055 MW	100 %

The transmission system of Vietnam is composed of 500 kV trunk transmission system and 220 kV major transmission system. The present power system diagram of the 500 kV and 220 kV systems of the whole country is shown in Figure S.12. The existing 500 kV and 220 kV transmission lines and substations are as follows:

- The total circuit lengths of transmission lines:

  500 kV 1,487 km
  220 kV 2,435 km

- The total capacity of substations:

  500 kV 2,700 MVA
  220 kV 4,410 MVA

Power Demand Forecast

29. The JICA Study Team carried out the power demand forecast up to 2015 by applying two methods, namely, the macro method and demand-plus method, to compare with the demand forecast by EVN.

Since it was found that there hardly exists any difference between results of the two methods in the period of roughly 10 years up to 2010, the JICA Study Team has decided to adopt figures estimated using the macro method.

The demand forecast by the JICA Study Team is estimated to grow slower by approximately 2 years than that by EVN. The results of energy generation and peak load forecast are shown in Figures S.13 and S.14.

The peak demand for all Vietnam in 1998 was 3,911 MW. Assuming an annual rate of 7.7 %, this will rise to 6,579 MW by 2005, which is roughly 1.7 times greater than the same value in 1998. The peak power demand is projected to reach 10,148 MW in 2010 at an annual increase rate of 9.1 % between 2005 and 2010, that is equivalent approximately to 2.6 times the same value in 1998.

Concerning the energy generation, which stood at 21,654 GWh in 1998, it is forecast that this will increase to 39,072 GWh in 2005 at an annual average growth rate of

8.8 % and to reach 61,337 GWh in 2010 at an annual average growth rate of 9.4 %. These values are 1.8 times and 2.8 times greater than the 1998 figure, respectively.

VI. PLAN FORMULATION

Procedures Applied to Optimization Study

30. In the First Field Investigation which lasted about two months from the middle of January to middle of March 1999, a preliminary optimization study was carried out to select the optimum Project layout plan formed by the definite locations of the Dong Nai No.3 and No.4 dam sites and powerhouse sites. The five alternative Project layout plans were worked out as shown in Figure S.15, of which the Alternative 2 was selected as the optimum layout plan as discussed in Appendix E of Supporting Report. In the subsequent Second and Third Field Investigations, the detailed field investigations including geological investigation and topographic survey such as preparation of 1 to 1,000 scaled topographic maps were performed for the optimum layout plan. To formulate the optimum development plan of the Project, the optimization study was carried out with regard to the following items:

i) Selection of type of the Dong Nai No.3 and No.4 dams

ii) Development scale of the Project on a full supply level (FSL) of the Dong Nai No.3 reservoir and installed capacities of the Dong Nai No.3 and No.4 power stations

iii) Daily minimum plant factor (daily peak operation hour) of the Dong Nai No.3 and No.4

iv) Installation timing of the Dong Nai No.3 and No.4 power plants

To select the most favorable dam type for the Dong Nai No.3 and No.4 schemes, a cost comparison was made among the promising dam types conceived. The optimum dam types for the Dong Nai No.3 and No.4 schemes were finally selected as explained in the following Item No. 31, taking into consideration not only the economic advantage, but also the construction periods that may affect the realization of the power Development Plan Phase V prepared recently by the Government of Vietnam.

Since the operation mode of the Dong Nai No.4 power plants is dependent on the flow regulated by and released from the comparatively large-scale Dong Nai No.3 reservoir, the optimization study for determining the optimum development scale of the Project was made on a premise that the Dong Nai No.3 and No.4 schemes are developed as a combined project. The net benefit maximization criteria was introduced to find out the optimum development scale.

The optimum installation timing as well as the peak operation hours of the Dong Nai No.3 and No.4 power plants were determined using the software package, EGEAS, so that the total capital and operation cost of the whole power system of Vietnam until the year 2015 is minimized.

Development Alternatives for Optimization Study Use

31. Through the studies at the stages of Progress Report, No.1 (Jan.-Mar. 1999) and Interim Report (Dec.1999), the feasibility-grade design for this Project has been elaborated. The design elaboration has been focused on the two following major items:

i) Type of the main dams

ii) Project layouts for No.3 and No.4 project components.

The following types of dam were compared to find out the most proper type of dams for No.3 and No.4 sites in terms of technical and economic views:

i) Rock-fill type

ii) Concrete face rock-fill type

iii) Conventional concrete gravity type

iv) Combined type of concrete gravity dam and rock-fill dam for No.3 site

In addition to the above four alternative types, possibility of RCC dam application was considered, but it was discarded at this stage because stable supply of pozzolans (ground-granulated blast-furnace slag, high-lime fly-ash and limestone powder) was not able to be ensured on local market.

The economical comparison of the type of dams was made on the basis of FSL at El.590, which is very likely to be the optimum FSL from the optimization study done so far.

The conventional earth core rockfill dam (ECRD) and concrete face rockfill dam (CFRD) at No.3 dam site are more economical than other type of dams and the cost difference between conventional rock-fill dam and concrete face rock-fill dam is estimated to be approximately 10 million US$ in favor to conventional ECRD. However the concrete face rockfill dam has an advantage of shortening the construction period against the rockfill dam by about one year. These two dam types for Dong Nia No.3 is compared from the economic and financial aspects as described below:

(i) As described in Section 6.5 of Main Report, the best commissioning year of Dong Nai No.3 Project which can save the capital and O&M costs of whole power system of Vietnam most effectively is selected to be the year 2007 through the economic analysis using the software EGEAS. This conclusion is still valid, even though the project cost of Dong Nai No.3 would increase or decrease by 10 to 15 million US$. This shows that the CFRD which can be commissioned in 2007 is more economically advantageous than ECRD for Dong Nai No.3 Project from the economic viewpoint.

(ii) To compare the advantages of the CFRD and ECRD for Dong Nai No.3 from the

financial aspect, FIRR of Dong Nai No.3 Project was estimated for each of these two cases applying the same criteria. Consequently, FIRRs of the Dong Nai No.3 Project is derived to be about 6.0% and 5.9% in case of CFRD and ECRD for the Dong Nai No.3 dam, respectively. For Dong Nai No.3 dam, accordingly, the CFRD is slightly more advantageous than ECRD, although there is no large difference the two FIRR values.

In this Feasibility Study, in conclusion, the concrete face rockfill dam type is recommended for Dong Nai No.3 dam.

Concerning Dong Nai No.4 dam, both rock-fill dam and concrete face rock-fill dam are also more economical than other type of dams and their cost differences will amount to approximately 10 million US$ between rock-fill dam and concrete face rock-fill dam in favour to rock-fill dam. There is also a possibility to shorten the construction period for concrete face rock-fill dam as discussed for Dong Nai No.3 dam. However the critical path is construction of the waterway rather than the dam construction because it is unavoidable to layout the waterway through widely spread hill side which requires provision of very expensive lengthy construction adits to shorten the construction period for the waterway.

Therefore the least cost alternative of rock-fill dam is recommended for the type of Dong Nai No.4 dam.

In reality, no CFRD type dams have been provided in Vietnam up to now. However, the CFRD is now an established type of rockfill dam in technology. In many feasibility studies, it is selected over other types of dams including earth core rockfill dam (ECRD) because of shorter construction period and/or lower cost. Further, many CFRD type dams have been successfully completed as can be seen in Table 7.1 in Main Report, which shows a part of the actual examples in the world. Therefore, it is highly recommended to adopt the CFRD for Dong Nai No.3 dam in order to develop the dam design and construction technologies in Vietnam from now on.

The project layouts both for No.3 and No.4 dam sites have been confirmed to be kept as worked out at the stage of Interim Report, subject to minor adjustment at the stage of the detailed design.

i) Dam axis

ii) Location of diversion tunnels

iii) Location of spillway

iv) Location of power intake, headrace and power station

Based on the selected type of dams and the confirmed layouts at No.3 and No.4 dam sites, alternative development scales with cost were worked out for the optimization study.

Optimum Development Scale of the Project

32. The regulated discharge from the Dong Nai No.3 accounts for a large part of available discharge for the Dong Nai No.4 power station. Taking into account the characteristic of the Dong Nai No.4 scheme, 8 alternative development cases for the confirmed dam types and layouts that are explained in Item No. 31 are set up by varying the full supply level of the Dong Nai No.3 reservoir from El.575m at a 5 m interval. The economic benefits accrued from the Project were measured by means of the two different methods, namely the least cost alternative method and the long-run marginal cost.

In case the long-run marginal cost method is used to estimate the economic benefit, the economic annual net benefit is apparently maximized when a FSL of the Dong Nai No.3 is set at El.590m as shown in Figure S.16. While, in case of the least cost alternative method, the economic net benefit reveals the comparatively constant value for the development cases with FSL higher than El.585m, although the development case with a FSL of El.590m shows the highest economic viability among the examined development cases. Based on the results of the economic comparison study with the long-run marginal cost method as well as the least cost alternative method, it is determined that a FSL of the Dong Nai No.3 reservoir is set at El.590m. It is verified through the reservoir operation study that about 98% of the total inflow to the Dong Nai No.3 reservoir could be effectively utilized for the hydropower generation in case of the selected development case with a FSL of El.590m.

Optimum Daily Peak Operation Hour

33. To determine the peak operation hours of the Dong Nai No.3 and No.4 power plants, the capital and operation cost of the whole power system of Vietnam were attempted to be estimated with the Software package, EGEAS, for 5 alternative cases of 6-hours to 8-hours peak operation at a half hour intervals. The comparative study clarified that the case of 7.5-hours peak operation could save the whole power system cost among the alternative cases as shown in Figure S.16, although there is no significant difference between the costs of the two cases of 7.5-hour to 8-hour peak operation. In general, the hydropower project is planned to cope with 6 to 8 hours peak operation, rarely 4 to 5 hours peak operation, depending the portion in the daily load duration curve which is born by the Project in the future. Taking into account the uncertainty associated with the projection of the peak load increase in the future, the Study recommended to formulate the Project with 7.5-hour peak operation, which corresponds to a minimum daily plant factor of about 31%.

Optimum Commissioning Year for Dong Nai No.3 and No. Power Plants

34. In order to find the optimum commissioning year of the Dong Nai No.3 and No.4 hydropower plants, the JICA Study Team examined the long-term power source development plan covering the period up to 2015 using the software EGEAS (Electric Generation Expansion Analysis System).

EGEAS was utilized to find the least cost sequence of power plants added to the power system applying the following basic criteria:

i) 25% of the total power demand in the power system is maintained as the reserve capacity throughout the evaluation period.

ii) The candidate power plants put into operation during the evaluation period as well as their commissioning years are determined to meet the power demand of the power system so that the present worth of all capital and O&M costs of the power system is minimized.

As a result of the study, EGEAS found out that the Dong Nai No.3 and No.4 hydropower plants are best installed in the year 2007 and 2008, respectively.

VII. FEASIBILITY-GRADE DESIGN

VII-1 Dong Nai No.3 Project

Main Dam

35. In the feasibility-grade design, the main structures involved in the Dong Nai No.3 and No.4 Combined Hydropower Project are illustrated on 1 to 1,000 and 1 to 10,000 scaled topographic maps produced through the topographic survey performed during the field investigation as shown in Figures S.17 to S.28.

36. For the Dong Nai No.3 dam, Concrete Face Rockfill Dam (CFRD) was the most appropriate dam type through examination and comparison with other types as mentioned above. The dam is 108.5m high and total embankment volume is around 4.56 million m^3 with the upstream and downstream slopes of 1:1.4 and 1:1.5, respectively.

River Diversion

37. The tunnel type river diversion was designed with two lanes. The design flood for the diversion scheme consists of the design flood of 20-year probable flood and the check flood of 30-year probable flood. The peak inflow of the respective floods are 2,590 m^3/sec for the design flood and 2,800 m^3/sec for the check flood.

The diversion tunnels are 11.5m in diameter, and 780 m and 980 m long, respectively, both being laid out on the right bank. A 30 m high cofferdam, which is decided as the maximum height to be embanked within 4 months of dry time, is laid out.

Spillway

38. The designed spillway was laid out on the left abutment to suit the topography and consists of fore-bay, headworks with 3 sets of radial gates, each with 15 m wide and 16 m high, chute and flip bucket. Plunge pool was designed as non pre-excavated pool to allow for certain erosion of the river bed and both river banks due to flipped jet flows to some extent because the eroded materials are considered not to reach the No.3 power station, subject to future elaboration with suitable hydraulic model test at the detailed design stage.

The design flood for the spillway is a 1,000-year probable flood (7,240 m^3/sec) and further the adequate spillway capacity is examined against the check flood (PMF :12,480 m^3/sec).

Waterway and Power House

39. A power intake, an intake gate shaft, a headrace tunnel, a surge tank, embedded type of penstock, outdoor type of powerhouse and an open switchyard were laid out on the right abutment. The comparative study on the powerhouse type, which is either an outdoor type or an underground type, resulted in selecting an outdoor type powerhouse because of the economical advantage.

The optimization study led to a conclusion of the headrace tunnel diameter of 8.4 m and penstock of 6.5 m. The restricted orifice type surge tank was designed, of which the shaft diameter is 20.9 m with a 85 m height.

River Outlet

40. No river outlet facilities are adopted for this Project for the following reasons:

i) Based on the field investigation at this stage, the reservoir areas of Dong Nai No.3 and No.4 dams are practically water-tight and free from any major harmful slope. Therefore the provision for emergency case would be too redundant for this Project.

ii) Releasing water to the downstream during impounding of Dong Nai No.3 reservoir after closing the last diversion tunnel would not be seriously required for the following reason.

- The last closure of the diversion tunnel must be carried out during the rainy season.
- While the residual catchment area of Dong Nai No.4 dam is as wide as approximately 5,000 km2 at and around Cat Tien National Park and therefore ample river water would be made available to the downstream of the Park from the residual catchment area.
- Further the upstream area of the Park is least populated without any water take from the Dong Nai River.

iii) After commencement of the power commissioning, regular water supply through both power stations will be very reliable because number of power units is more than two and therefore simultaneous shut-down of the units would be very remote.

iv) Tributaries downstream of each dam would function as useful water supply sources particularly at the sections between each dam and each power station.

Power Facilities

41. The Dong Nai No.3 power station was planned as a peaking station with daily peak duration of approximately 7.5 hours. The total installed capacity of the power station is 240 MW with two units of water turbine generator. The water turbine will be 94 MW vertical shaft Francis turbines operated directly coupled with 101 MVA AC synchronous generators. The generated power will be stepped up to the transmission voltage of 500 KV with main transformers (16.5kV/500kV) near the powerhouse, and transferred to the open outdoor switchyard near the surge tank to send out to the 500 KV transmission system through the Dong Nai No.4 power station. The powerhouse will accommodate a 250 ton overhead travel crane.

VII-2 Dong Nai No.4 Project

42. The same design concept was applied to carry out the feasibility-grade design for most of the major structural components for the Dong Nai No.4 project. The major differences are as follows:

i) Type of main dam

ii) Number of units of turbine generator

iii) Location of the waterway and power station on the left bank

The reasons for difference between types of the Dong Nai No.3 and No.4 main dams are explained in Item No.31 (VI Plan Formulation) above.

Number of units of turbine generator for No.4 power station was determined to be three units from a conservative viewpoint to increase the flexibility for unforeseeable environmental impacts to downstream areas.

Location of the waterway and power station was laid out on the left bank from the topographic views.

The main features of the Project components at No.3 and No.4 project sites are shown in "Main Features of Dong Nai No.3 Project and Main Features of No.4 Projects which are presented at the head of this Executive Summary.

Transmission System

43. With regard to the transmission method for the Dong Nai No.3 and No.4 power stations, the following three alternatives were set up and assessed from the technical and economical aspects:

i) Alternative 1: Construct a new transmission line consisting of two 220 kV circuits along one route leading from Dong Nai No. 4 switchyard,

through Dong Nai No. 3 switchyard, and up to the 500/220 kV Di Linh substation. Install one more 500/220 kV 450 MVA transformer in Di Linh substation.

ii) Alternative 2: Install step-up transformers (220 kV to 500 kV) to serve both Dong Nai No. 3 and No. 4 in the Dong Nai No. 4 switchyard, and newly lay a single route of 500 kV two circuits transmission line from this substation to the existing 500 kV transmission line between Pleik and Phu Lam. Connect Dong Nai No. 3 and Dong Nai No. 4 by a single route of 220 kV two circuits transmission line.

iii) Alternative 3: Directly step-up to 500 kV at each power station of Dong Nai No. 3 and Dong Nai No. 4, and connect Dong Nai No. 4 to the existing 500 kV transmission line between Pleik and Phu Lam by means of a single route of 500 kV two circuits transmission line.

The general assessment was made in view of economy, and technical problems regarding power flow, voltage and stability although the transmission stability is hardly expressed in quantitative terms. The economical comparison was made in terms of sum of annual cost, and economic value lost by power loss that is measured in kWh and kW values.

Based on the general assessment, the JICA Study Team recommends the Alternative 3 as the best of the three alternatives, based on the results of the evaluation from all aspects such as economy, stability, reliability, transmission loss, and so on.

VIII. CONSTRUCTION PLAN AND COST ESTIMATES

Construction Plan

44. River diversion during dam construction will be achieved applying diversion tunnel method with fill type cofferdams and 30-year probable flood of 2,800 m^3/sec for both of the Dong Nai No.3 and No.4 projects. Integrated cofferdam is adopted for the Dong Nai No.4.

All the fill materials can be obtained in the vicinity of the dam sites within 10 km hauling distance. Quarry site developed in each project is a main source of rock embankment. Re-use materials from foundation excavation are also intended by about 10% for No. 3 and 25% for No.4 project. Three dry seasons will be required for embankment work of No.4 center core rockfill dam due to intensive rainfall in wet season, while less rainfall effect is anticipated for No.3 concrete face rockfill dam. Face slab concrete will be placed with 15 m-wide slip forms after completion of embankment work in No.3 project. About one year construction period will be required.

In order to minimize the overall construction schedule, the diversion tunnel construction is planned to be advanced prior to the main civil work contract for both Dong Nai No. 3 and No.4 projects. Overall schedule is so arranged that riverbed excavation can be commenced in the beginning of the dry season when the diversion tunnel is completed.

Construction of headrace tunnels is also large scaled works forming subcritical path in both projects.

Since provision of intermediate work adit seems not to be practicable in view of topographical condition of No. 4 project site, longer construction time than No.3 case will be required.

Construction Schedule

45. The construction of main works will be commenced from beginning of 2003 as shown in Figure S.29 after financial arrangement, detailed design and procurement process of contractors. The commissioning of generating units will be achieved at the end of 2007 in Dong Nai No.3 after a 5-year construction period, and at the end of 2008 in Dong Nai No.4 after a 6 year construction period as indicated in Figure S31.

The following activities will constitute a critical path in the overall time schedule:

Critical Path Work of Dong Nai No.3 Project

No.	Activity/Event	Timing
1)	Loan request	July 2000
2)	Loan agreement	March 2001
3)	Selection of consultant	April - June 2001
4)	Detailed design and bid document preparation	From July 2001
5)	Procurement procedures - preparatory	From January 2002
6)	Procurement procedures - diversion tunnel	From January 2002
7)	Procurement procedures - civil work	From October 2002
8)	Commencement of work - preparatory works	From July 2002
9)	Commencement of work - diversion tunnel	From January 2003
10)	Commencement of work - civil work	From January 2004
11)	River diversion	December 2004
12)	Dam Construction (from cofferdam)	34 moths
13)	Reservoir impounding	From October 2007
14)	Wet test of generating equipment	December 2007
15)	Commissioning of power plant	End of December 2007

Critical Path Work of Dong Nai No.4 Project

No.	Activity/Event	Timing
1)	Loan request	July 2000
2)	Loan agreement	March 2001
3)	Selection of consultant	April - June 2001
4)	Detailed design and bid document preparation	From July 2001
5)	Procurement procedures - preparatory	From January 2002
6)	Procurement procedures - diversion tunnel	From January 2002
7)	Procurement procedures - civil work	From October 2002
8)	Commencement of work - preparatory works	From July 2002
9)	Commencement of work - diversion tunnel	From January 2003
10)	Commencement of work - civil work	From January 2004
11)	Headrace tunnel construction	54 months
12)	Reservoir impounding	From August 2008
13)	Wet test of generating equipment	December 2008
14)	Commissioning of power plant	End of December 2008

Cost Estimate

46. The Project cost was estimated with use of unit price estimate method basically, taking into account of existing site conditions, prevailing market prices of various construction resources, proposed construction method and work quantities derived from the feasibility-grade design.

The total project cost is estimated at 737.1 million US$ comprising foreign currency portion of 423.4 million US$ and local currency portion of 313.7 million US$ as summarized below and detailed in Table S.1.

Estimate of Total Project Cost (1)

(Unit: million US$)

Description	F.C.	L.C.	Total
I. Base Cost	368.4	270.4	638.8
Construction Cost	333.4	219.6	553.0
Engineering Service	31.1	10.4	41.5
Administration	0.0	3.9	3.9
Land compensation and resettlement	3.9	6.7	10.6
Tax	0.0	29.8	29.8
II. Contingency	55.0	43.3	98.3
Price contingency	26.0	17.9	43.9
Physical contingency	29.0	25.4	54.4
Total Project Cost	423.4	313.7	737.1

Estimate of Total Project Cost (2)

(Unit: million US$)

Description	No.3	No.4	Total
I. Base Cost	343.9	294.9	638.8
Construction Cost	293.4	259.6	553.0
Engineering Service	22.0	19.5	41.5
Administration	2.1	1.8	3.9
Land compensation and resettlement	10.6	0.0	10.6
Tax	15.8	14.0	29.8
II. Contingency	52.6	45.7	98.3
Price contingency	22.6	21.3	43.9
Physical contingency	30.0	24.4	54.4
Total Project Cost	396.5	340.6	737.1

This estimate totaling 737.1 million US$ consists of 396.5 million US$ (or 54%) for Dong Nai No.3 and 340.6 million US$ (or 46%) for Dong Nai No.4.

IX. PROJECT EVALUATION

Economic Evaluation

47. The total capital cost of the Project (at 1999 prices) is estimated at US$ 737.0 million with the breakdown of foreign currency portion of US$ 423.4 million and the local currency portion of US$ 313.6 million (VND 4,349.6 billion equivalent). Besides this capital cost, the interest to be accrued during the construction period is estimated at US$ 35.0 million that is scheduled to be paid after the commissioning.

The viability of the Project is examined through economic evaluation and financial analysis. The economic evaluation is conducted from the point of view of the entire society as a whole based on the comparison of economic cost and economic benefit. The economic cost is derived by the Project cost (financial cost) deducted by transfer payment (tax) and price contingency. Shadow pricing is applied to unskilled labor wage and the economic value of land is considered nil.

48. The economic benefit is estimated through two criteria: one is the conventional alternative-thermal (Case A) and another is the long-run marginal cost (LRMC) (Case B).

Case A assumes that the least-cost alternative thermal project will be substituted for the present Project in case the present Project is not implemented. The cost to be saved, i.e. the cost of the alternative thermal, is considered as the benefit of the present Project. This Study assumes a hypothetical thermal alternative plant as a composite of coal fired thermal plant and combined cycle gas turbine plant. It takes into consideration the current power development situation in Vietnam and various environmental problems inherent in thermal power plants. It also assumes the combined cycle gas turbine supplying peak power demand while the coal fired thermal plant supplying base load and/or intermediate portion of power demand. The unit cost of the hypothetical thermal alternative is derived at US$182.3/kW and US¢1.92/kWh. The economic benefit is derived by the capacity cost multiplied by the installed capacity (474 MW in 90% peak power) and by the energy cost multiplied by the Project's output (1,657 GWh/year in routine operation).

In Case B, the economic benefit of power to be generated by the Project is evaluated by a unit power price determined based on the LRMC. The LRMC is broadly defined as the incremental cost of all adjustments in the system expansion plan attributable to an incremental increase in demand that is sustained into the future and is widely recognized as the most reasonable base of electricity pricing. As imagined from this definition, the LRMC is in many cases estimated when a long-term power development plan is newly established. This time in Vietnam, it was calculated at US¢ 7.43 /kWh in the EVN's Power Development Master Plan Phase V (the Master Plan Phase V). The economic benefit is derived by this LRMC value multiplied by

the Project's output.

49. The economic benefit also includes the river-flow enhancement benefit downstream of the Dong Nai reservoirs. The incremental power generation at Tri An hydropower plant is incorporated in the analysis.

The economic internal rate of return (EIRR) is computed at 13.1% for Case A and 13.5% for Case B as shown in Table S.2. Comparing to the opportunity cost of capital that is assumed at 10% in this Study, these EIRR values prove that the Project is economically viable.

The sensitivity test of EIRR is carried out for Case A. The change of EIRR value is examined by varying the determinant of benefit and cost of the Project in two ways. One is to examine the EIRR by varying the Project's construction cost and the fuel cost of the alternative thermal. Another is to examine the EIRR by varying the Project's construction cost and the Project's total benefit. Both results prove that, even under the worst cases, EIRR values exceeding the opportunity cost of capital is secured.

Financial Evaluation

50. The financial analysis is conducted from the point of view of the executing agency of the Project i.e. EVN. The Project cost adopted for the financial analysis was derived by excluding the transmission line cost from the Project cost, because the transfer-point of electricity was set in this analysis at the switchyard of the power station. The total capital cost (at 1999 constant prices) applied for the financial analysis is US$ 727.2 million with the breakdown of foreign currency portion of US$ 417.5 million and the local currency portion of US$ 309.7 million (VND 4,295.5 billion equivalent).

The financial revenue is estimated based on the power rate by which EVN sells the electricity to Power Company. Two (2) alternative power rates are assumed: US¢4.5/kWh and US¢5.0/kWh. Accordingly, two (2) financial internal rates of return (FIRR) are calculated based on these two power rates. The FIRR for the power rate of US¢4.5/kWh is derived at 6.5% as shown in Table S.3 and that for US¢5.0/kWh is derived at 7.4%. The FIRR value is dependent on the power rate by which EVN sells the electricity to Power Company.

51. The sensitivity test of FIRR indicates an FIRR of 5.0% under the worst case of cost increase with 10% and benefit decrease with 10%. Twelve (12) alternative cases are worked out as shown in the table below combining major three (3) determinants of financial viability as follows:

	FC:LC = 85:15			FC:LC=70:30		
FC interest rate: (% p.a.)	3.5%	5.0%	8.5%	3.5%	5.0%	8.5%
Power rate=4.5 c/kWh	Case 1-1	Case 1-2	Case 1-3	Case 2-1	Case 2-2	Case 2-3
Power rate=5.0 c/kWh	Case 3-1	Case 3-2	Case 3-3	Case 4-1	Case 4-2	Case 4-3

The loans repayability of the Project was examined for each of these 12 cases through preparation of sources-and-uses-of-funds statements as discussed in Chapter 9 of Main Report (See Table 9.9 in Main Report). Table S.4 shows the repayability of Project loans for the Case 1-1.

i) Composition of financing sources i.e. percentage share of foreign and local currency loans to total loan requirement: Foreign loan: domestic loan = 85:15 for Cases 1 and Cases 3; 70:30 for Cases 2 and Cases 4,

ii) Interest rate of foreign currency loans that may vary according to foreign financial agencies: 3.5%, 5.0% and 8.5% per annum, and

iii) EVN's power rate to sell electricity to Power Company: US¢4.5/kWh and US¢5.0/kWh.

The interest rate of foreign loans is assumed to be the total of the interest rate of foreign financial agency and the surcharge of Vietnamese National Bank. The repayment period is assumed at 30 years for foreign loans and 10 years for domestic loans with grace period throughout the construction period. The interest rate of domestic loans is assumed at 13% per annum commonly to all the cases. As shown in Table S.4, the outstanding loan principal will reach its peak at the end of the construction period and will reduce year by year thereafter to become zero in the end of the year 2039. The financial result is presented in the column of "surplus after tax" for each year and is accumulated in the right-most column. The result of loan repayability examination is summarized in the following two tables.

52. The loan repayability of the 12 cases are assessed based on the two tables shown below.

i) Number of years with cumulative deficit:

	FC:LC=85:15			FC:LC=70:30		
FC interest rate: (% p.a.)	3.5%	5.0%	8.5%	3.5%	5.0%	8.5%
Power rate=4.5 c/kWh	0	0	28	7	12	27
Power rate=5.0 c/kWh	0	0	17	0	6	18

The table shown above indicates the number of years with cumulative deficit. In the cases with tariff rate of US¢4.5/ kWh, two (2) cases show no cumulative deficit years throughout the evaluation period. In cases where the cumulative deficit are recorded, some measures such as issuing bond and/or borrowing money is required to make up the deficit for operation, which may cause additional cost for the Project. And long years of cumulative deficit may affect the smooth payment of interest and principal of

loans. In this context, Case 1-1 and Case 1-2 are desirable having no deficit years at all. While, some difficulties in repayment may be anticipated in Case 1-3 and Case 2-3 of which interest rate of foreign loan is the highest among all cases.

In the cases with tariff rate of US¢5.0/ kWh, betterment is naturally observed and the number of cases with zero year of cumulative deficit increase to three (3) cases including Case 3-1, Case 3-2 and Case 4-1.

ii) Debt Service Coverage Ratio (in times)

FC interest rate: (% p.a.)	Year	FC:LC=85:15			FC:LC=70:30		
		3.5%	5.0%	8.5%	3.5%	5.0%	8.5%
Power rate=4.5 c/kWh	2015	0.9	0.8	0.6	0.7	0.6	0.5
	2025	1.7	1.6	1.3	2.2	2.0	1.6
	2035	2.2	2.1	1.9	2.8	2.7	2.4
Power rate=5.0 c/kWh	2015	1.0	0.9	0.7	0.8	0.7	0.6
	2025	1.9	1.7	1.4	2.4	2.1	1.7
	2035	2.4	2.3	2.1	3.1	2.9	2.7

The debt service coverage ratio (DSCR) is defined as the sum of income after tax, depreciation and interest paid divided by the sum of interest paid and loan repayment. The DSCR is calculated and shown in the table above for each case for the three (3) years of 2015, 2025 and 2035 based on Table S.4. Taking an example of Case 1-1, DSCR of 2.2 in 2035 means that the net income plus depreciation plus interest paid can drop by nearly half for EVN still to meet its debt obligation. In general public investment, this ratio is usually considered appropriate when it falls in 1.5 times and higher. DSCR in 2015 is rather low of 0.9, which is caused by the heavier loan repayment than other years with the repayment of both the foreign and domestic loans. The DSCR is improved in the years of 2025 and 2035 when the repayment of domestic loans is already finished with the foreign loans' repayment only remaining. Excluding the ten-year period after the commissioning when the burden of financing expenditure of both the foreign and domestic loans exists, the DSCR may be considered to assure the repayability of loans with the exception of the cases with high interest rate of 8.5% per annum. In order to reduce the loan repayment burden in the initial stage of the operation, domestic loans with a longer repayment period than ten (10) years assumed in this Study should desirably be arranged in the next stage.

53. Judging from the above-mentioned two (2) indices comprising the number of cumulative deficit years and the DSCR, the following can be concluded for the loan repayability:

i) Case 1-1 is most desirable and

ii) the four (4) cases with zero cumulative deficit years are recommendable following the Case 1-1.

As for the other cases than these five (5), some financial arrangements will have to be made to sustain the Project during the years with cumulative deficit.