MEKONG ENERGY COMPANY LTD
Ho Chi Minh City / Vietnam

E521
Volume 3

Environmental Assessment Report
for
Build Operate and Transfer (BOT) Project
PHU MY 2.2
715 MW Combined Cycle Power Plant

January 2002

THE CONSORTIUM

COLENCO / FICHTNER

Baden, Switzerland   Stuttgart, Germany

CONTENT OF THE ENVIRONMENTAL ASSESSMENT REPORT

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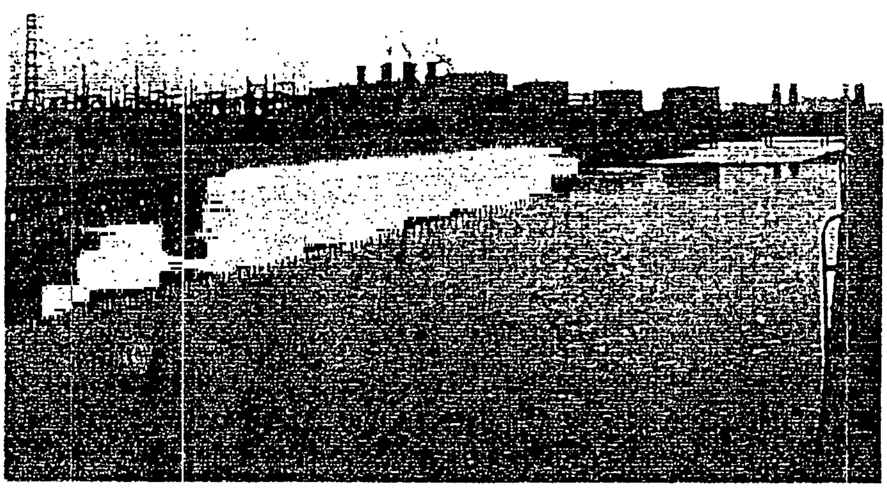

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CONTENT OF THE ENVIRONMENTAL ASSESSMENT REPORT

SECTION A	EXECUTIVE SUMMARY
SECTION B	POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORKS
SECTION C	PROJECT DESCRIPTION
SECTION D	BASELINE DATA
SECTION E	ENVIRONMENTAL IMPACTS
SECTION F	ANALYSIS OF ALTERNATIVES
SECTION G	ENVIRONMENTAL MANAGEMENT PLANT
SECTION H	PUBLIC CONSULTATION
SECTION I	APPENDICES

SECTION C: PROJECT DESCRIPTION

SECTION D: BASELINE DATA

LIST OF TABLES

LIST OF FIGURES

ABBREVIATIONS

AAS	Atomic Absorption Spectrophotometer
ASS	Acid Sulphate Soil
BOD	Biochemical Oxygen Demand
BOT	Build Operate Transfer
CC	Combined Cycle
CO, NO_x, SO_2	Formulas of chemical compounds
COD	Chemical Oxygen Demand
dB(A)	Decibel (A)
DOSTE	Department of Science, Technology and Environment
EA	Environmental Assessment
EC	Electrical Conductivity
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EPC	Engineering Procurement Contract
EVN	General Electric Company of Vietnam
F/S	Feasibility Study
GOV	Government of Vietnam
g/s	Gram per second
GSA	Gas Supply Agreement
ITB	Institute of Tropical Biology
LLA	Land Lease Agreement
MECO	Mekong Energy Co. Ltd.
MOI	Ministry of Industry
MOSTE	Ministry of Science, Technology and Environment
MPI	Ministry of Planning and Investment
MW	Mega Watt
NEMS	National Environmental Monitoring System

NGO	Non-Government Organisation
NH 51	National Highway 51
PECC-2	Power Engineering Consulting Company N2
PM	Particulate Matter
PMU	Project Management Unit
PPA	Power Purchase Agreement
ppmv	Part per million per Volume
SC	Single Cycle
SS	Suspended Solids
THC	Total Hydrocarbons
TPM	Total Particulate Matters
TPP	Thermal Power Plant
TSP	Total Suspended Particulate
UDEC	Urban Development & Construction Company (of Bia Rai Vung Tau Province)
USD	United States Dollars
UV-VIS	Ultraviolet-Visual
VACNE	Vietnam Association for the Conservation of Nature and Environment
VESDEC	Vietnam Environment and Sustainable Development Center South Branch
VND	Vietnam Dong
VOC	Volatile Organic Compounds
WB	World Bank
WHO	World Health Organisation

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SECTION A

EXECUTIVE SUMMARY

SECTION A EXECUTIVE SUMMARY

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

As an important basis for developing the industrial sector and infrastructure, and ultimately increasing the quality of life of the people in Vietnam, the Vietnamese Government has set the expansion of the power generation sector as a high priority.

Vietnam's power sector has achieved a fairly high growth rate thus far. The total installed capacity of the power generation system has increased from 4,013 MW at the end of 1993 to 5,765 MW at the end of 1999. The average growth rate during this period was 15.5% per annum. Based on the Master Plan for Power Development N°.5, the development policy of the Vietnamese power source for the period 1996 - 2010 contains the following main key points regarding the thermal power energy development:

- The use of national natural gas reserves as an important basis for power generation.
- Natural gas, as a clean and economical fuel, shall be utilised as the primary fuel source for the latest power generation technology (combined cycle technology).
- The combined cycle power plants shall be predominantly located in the vicinity of the gas pipelines, such as the Phu My and Ba Ria sites.

Based on this governmental policy, the Phu My Power Generation Centre (PMPGC) has been approved for the installation of 5 different combined cycle power projects, which was approved by the Government of Vietnam (Approval No. 1177/QD – KHDT Issued by the Ministry of Industry on 31/07/1997) in order to increase the power generation capacity and fulfil the future power demands of Vietnam.

On October 28, 1997 the Ministry of Industry (MOI) of Vietnam issued a Request for a Proposal for the right to develop the Phu My 2.2 Power Project at PMPGC site under a build, operate and transfer (BOT) investment structure. The Project was awarded to the Consortium comprising of EDF International, Sumitomo Corporation and TOKYO Electric Power Co, Inc. in January 1999.

The Phu My 2.2 Project is a 715 MW combined cycled power plant. The design operating life of the plant is 30 years. The term of the Project will be 20 years from the Commercial Operation Date (COD) after which the plant will be overhauled and transferred at no cost to the MOI.

Upon receipt of the Investment License the Consortium established the Mekong Energy Company Ltd. (MECO) as a limited liability company in Vietnam. MECO will subsequently implement the Phu My 2.2 Project on behalf of the Shareholders.

The original Environmental Impact Assessment (EIA) Report of Phu My 2.2 had been prepared by a team of foreign and local experts. This EIA report was finalised in April 2001 and submitted to the Ministry of Science, Technology and Environment (MOSTE) for approval. With the letter of May 25, 2001, MOSTE approved the Phu My 2.2 Project.

The EIA report on hand which is based on the EIA report of April 2001 has been prepared upon the requirements of the lenders by a team of experts of the Consortium Colenco Power Engineering Ltd in Baden, Switzerland and Fichtner GmbH & Co. KG in Stuttgart, Germany.

2 BACKGROUND OF THE ENVIRONMENTAL IMPACT ASSESSEMENT REPORT

2.1 LEGAL AND TECHNICAL BACKGROUND

The following legal documents were used as a basis for the preparation of this EIA report:

- Law on Environmental Protection approved by the National Assembly of the Socialist Republic of Vietnam on 27 December 1993; issued according to the order 29-L/CTN 10 January 1994 of the State Chairman
- Decree N° 175/CP on 18 October 1994 issued by the Government of Vietnam (GOV) for the guidelines on implementation of the Law on Environmental Protection
- Vietnamese Standard of Environment, issued by the Ministry of Science, Technology and Environment (MOSTE) in 1995
- Circular N° 490/1998/TT-KHCNMT issued on 29th April 1998 by MOSTE requiring content of an EIA study.
- Decree N22/CP April 1998 of the GOV on policy of Resettlement
- World Bank Operational Policies (OP) 4.01 and Bank Procedures (BP) 4.01, 1999

The main technical documents have been used for the preparation of this EIA report are the following:

- Master Plan #5 of Phu My Power Generation Complex prepared by PECC2, in 1997
- Power Market Analysis of Vietnam prepared by PECC2, in 1999 based on Master Plan # 5 of the Energy Institute, was approved by the Vietnamese Government by Decree 95/2001/QD-TTg dated July 22nd 2001.
- Feasibility Study Report of the Phu My 2.2 Project, prepared by the PECC2 (January 2001)
- Thematic reports on the environmental conditions at the project area and Ba Ria -Vung Tau implemented by the Team of Dr. Le Trinh in 1995, 1996 and December 1999
- Data on the present socio-economic state of Tan Thanh district and Phu My town provided by district People Committee
- World Bank Guidelines for New Thermal Power Plant, 1999
- Scope of work and performance guarantee of Phu My 2.2 EPC contract

2.2 ENVIRONMENTAL REQUIREMENTS

Considering the Vietnamese and World Bank Standards and Regulations for construction of the new power plants, the applicable environmental requirements for Phu My 2.2 Power Project are summarized in Table A1. The table consists of the requirements on stack emissions, ambient air quality, wastewater discharge, cooling water discharge and noise.

Table A1: Main Environmental Requirements for Phu My 2.2 Power Project			
Items	**Dimension**	**Vietnamese Standards**	**World Bank Guidelines**
Emission			
NO_2	mg/Nm^3	1000	125 (gas)/ 165 (oil)
	t/day	-	-
SO_2	mg/Nm^3	500	2000
	t/day	-	122 (for 715 MW)
Particulate	mg/Nm^3	400	50
Ambient Air Quality			
NO_2			
- 1 hr Average	mg/Nm^3	0.4	-
- 24 hrs Average	mg/Nm^3	0.1	0.15
- Annual Average	mg/Nm^3	-	0.10
SO_2			
- 1 hr Average	mg/Nm^3	0.5	-
- 24 hrs Average	mg/Nm^3	0.3	0.15
- Annual Average	mg/Nm^3	-	0.08
Particulate			
- 1 hr Average	mg/Nm^3	0.3	-
- 24 hrs Average	mg/Nm^3	0.2	0.23
- Annual Average	mg/Nm^3	-	0.08
Wastewater Discharge			
Temperature	°C	40	-
pH	-	5.5 – 9	6-9
BOD_5	mg/l	50	-
COD	mg/l	100	-
TSS	mg/l	100	50
Oil and Grease	mg/l	1	10
Residual Chlorine	mg/l	2	0.2
Coliform	MPN/100 ml	10000	-
Cooling water Discharge Temperature	°C	< 40	Increase at mixing zone < 3
Noise			
Day Time (6 h – 22 h)	dB(A)	70	70
Night Time (22 h – 6 h)	dB(A)	50	70

3 PROJECT DESCRIPTION

The Phu My 2.2 Power Project with a power generation capacity of 715 MW shall be installed at the Phu My Power Generation Centre (PMPGC). The implementation of the Phu My Power Generation Centre (PMPGC), with its five individual power generation projects, belongs to the most important development programs of the Vietnamese Government.

The PMPGC is located near the town of Phu My in the district Tan Thanh in Ba Ria–Vung Tau province, approximately 75 km southeast of Ho Chi Minh City. The site is approximately 40 km from the port of Vung Tau, in the industrial corridor between Ho Chi Minh City and Vung Tau, and is linked by a major highway (National Road 51), running from Vung Tau port to the proximity of the site. The PMPGC is about 2 km from National Road 51.

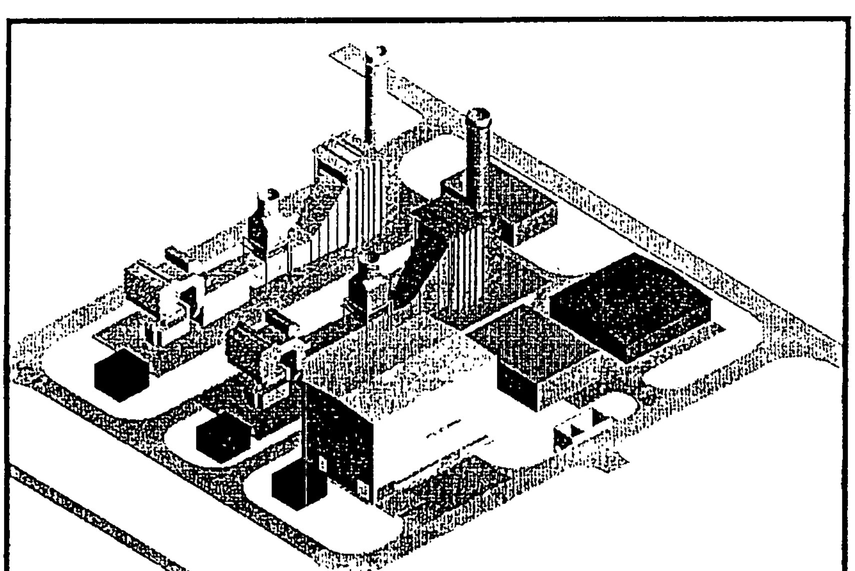
The development schedule of PMPGC depends, to a large extent, on availability of finance and growth rate of power demand. As can be seen on the Table A2, at the final development stage the PMPGC will consist of five individual power plant projects (all based on combined cycle technology) with a total generation capacity of 3,815 MW.

Table A2: Power Generation Plants located at the PMPGC

	Power Plant Project	Final Capacity (MW)	Project Status
1	Phu My 1	1,090	700 MW in operation
2	Phu My 2.1	860	550 MW in operation
3	Phu My 2.2	715	In implementation
4	Phu My 3	720	In implementation
5	Phu My 4	430	In implementation

All common required infrastructure systems (roads, cooling water supply, power transmission, etc.) have been mainly implemented. With the Phu My 2.2 Project, the PMPGC will be further extended with additional power generation units, which are based on combined cycle technology with natural gas as primary fuel (see Figure A1).

Figure A1: Phu My 2.2 Combined Cycle Power Project



The Phu My 2.2 Power Plant will mainly consist of 2 gas turbine-generator units, 2 heat recovery steam generators and one steam turbine-generator set. The main design and operational data of this plant are summarized in Table A3.

Table A3: The Main Design and Operational Data of the Phu My 2.2 Power Plant

	Dimension	Data
Plant location	-	Phu My Industrial Zone
Completion schedule		
- Commercial operation	-	September 2004
- Construction period	-	24 Months
Annual operational time	h/a	7,884
Annual average plant load factor	%	75
Annual equivalent full load operation	h/a	6,570
Plant thermal efficiency	%	54.7
Net heat	kJ/kWh	6,580
Net power generation capacity	MW	715
Annual net power generation	GWh	4,698
Plant concept:		
- Technology	-	Combined cycle system
- No. of gas turbines	-	2
- No. of steam turbines	-	1
- No. of heat recovery systems	-	2
- No. of stacks (main and by-pass)	-	4
Type of fuel		
- Main fuel	-	Natural gas from Nam Cin Son
- Emergency fuel	-	Distillate oil max. 5 days per year
Cooling water:		
- Demand	m^3/s	17
- Maximum temperature rise	°C	7
- Intake	-	Sao River
- outtake	-	Thi Vai River
Emissions:		
NO_x		
- Natural gas	mg/Nm^3	52
- Distillate oil (max. 5 days/year)	mg/Nm^3	119
SO_2 (dist. oil; max. 5 days/year)	mg/Nm^3	376
CO (gas / oil)	mg/Nm^3	20 / 30
Noise level:		
- Phu My Complex boundary	dB(A)	70
- Equipment (1 m distance)	dB(A)	90

PMPGC covers a total area of approximately 128 ha of land, in which only 8 ha will be utilised by the Phu My 2.2 BOT Power Project. Site preparation for the installation of the Phu My 2.2 will be particularly restricted to this area. Other areas within the PMPGC may have connection to the Phu My 2.2 Project but are not considered to be a part of this project (i.e. cooling water supply/discharge systems and main transmission line). These common areas belong to EVN, which are in the main already complete.

4 BASELINE DATA

Phu My town belongs to Tan Thanh district, Ba Ria - Vung Tau province. It lies on both sides of National Road 51 from Km 44 (My Xuan commune) to Km 47 (Phuoc Hoa commune). It is located on the left bank of the Thi Vai River, which is the border between Phu My town and Can Gio district of Ho Chi Minh City. Phu My was upgraded to a town in August 1994. It is the administrative centre for the district and also a centre for the industrial parks of the province. Its area is approximately 3,173 ha and the population in 1999 was 10,020 (It was 8,651 in 1998). The main baseline data of the Phu My area are summarized in the following table.

Climate	
Average temperature	Hottest months (April and May): approx. 29 °C Coldest month (December and January): approx. 25°C
Average pressure	Dry season: 1008 and 1012 mbar Rainy season: 1008 and 1010 mbar
Average humidity	Dry season: 75 to 84 % Rainy season: 79 to 86 %
Average rainfall	Period May to October: about 230 to 319 mm per month Period December to April: 9 to 35 mm per month
Average wind velocity	West-Southwest wind (mostly in rainy season): 2 to 3.2 m/s East-Northeast (mainly in dry season): 2.4 to 4.7 m/s
Hydrological characteristic	
Sao River	Origin: Trinh Mountain at the Northeast of the project site (a branch of the Thi Vai River) Cooling water supply source for PMPGC (approx. 90 m^3/s)
Thi Vai River	Length approx. 40 km; width approx. 700 to 800 m; depth approx. 10 to 15 m (depending on semi-diurnal tide) Water flow 0 to 10000 m^3/s (depending on tide) Tidal average amplitude: 310 cm (max. 465 cm ; min. 151 cm) Cooling water outtake point of PMPGC
Ambient air quality	
SO_2 concentration	1 hour average between 0.056 and 0.303 mg/Nm^3
NO_2 concentration	1 hour average between 0.033 and 0.297 mg/Nm^3
Particulate concentration	1 hour average between 0.26 and 1.45 mg/Nm^3
Noise pollution	Measurement 1999: L_{EQA} value 54.6 to 63.4 dB(A) Measurement 2000: L_{EQA} value 62.0 to 68.1 dB(A)

The Phu My Power Generation Centre (PMPGC) is scheduled to be developed into a complex that will ultimately provide about 3,800 MW of electrical energy. This complex occupies a space of approximately 128 ha of Phu My area. Only 8 ha of this occupied area will be utilised by the Phu My 2.2 BOT Power Project. At the final development stage, the PMPGC will consist of 5 individual power plant complex (Phu My 1, 2.1, 2.2, 3 and 4). Currently only two power plants (Phu My 1 and gas turbines of Phu My 2.1) with a total capacity of approximately 1640 MW are in operation.

The construction of the Phu My 2.2 Combined Cycle Power Plant will have positive long-term benefits on the Phu My region, providing direct/indirect employment opportunities for the local populace. It is predicted that during the construction phase of Phu My 2.2 it will provide short-term employment opportunities for approximately 1000 construction workers, and once the plant enters commercial operation it will provide high quality long-term employment for approximately 45 persons.

5 PROJECT IMPACTS AND MITIGATION MEASURES

5.1 INTRODUCTION

The Project, including the construction and operation of the Phu My 2.2 Power Plant will play a very important role in the development of the Vietnam Energy Sector, particularly in the Southern part of Vietnam. It will promote the policy of industrialization and modernization of the Government of Vietnam in the coming decades as well as create a great opportunity for urbanization, proper change in land-use and overall socio-economic development of the Southern Economic Focal Zone.

Beside significant beneficial impacts, and despite the use of a modern combined cycle technology and the use of natural gas as primary fuel, the project may cause minor negative effects on the environment (see Figure A9). But the design and approach of the implementation are intended to minimise such negative effects as much as possible.

It has to be taken into consideration that the Phu My 2.2 Project is part of the total PMPGC with a final generation capacity of approximately 3,800 MW. Phu My 2.2 Project (715 MW) will contribute approximately 19% of the total output of the final situation. The site has already been developed for the total PMPGC including Phu My 2.2 Project. For example, the fuel oil jetty and the cooling water intake and discharge systems are already constructed, and only the interconnection to the new power generation unit will have to be completed. No agricultural or forested land had to be removed due to Phu My 2.2 addition to the complex.

5.2 CONSTRUCTION PHASE

Table A4 summarises the main impacts of the Phu My 2.2 Power Project during the construction phase of Phu My 2.2. In addition, the table contains a short assessment of each individual impact and the applied mitigation measures. As an overall assessment, it can be stated that there are no serious impacts during the construction period. Since at the PMPGC site two power plants have already been constructed (Phu My 1 and Phu My 2.1), giving sufficient experience to the local authorities, local people and workers which will be available.

Table A4: The main Project Impacts and Mitigation Measures during Construction Phas

No.	Impact	Possible Effects	Assessment / Mitigation Measures
1	Land clearing of local people	Resettlement and compensation of people	All required activities have already been performed in connection with PMPGC construction
2	Land used	Space requirement	Approx. 8 ha of total 128 ha of the Phu My Site is required
3	Traffic / transportation	Increase in traffic volume	Temporarily affects. Transport of main plants and equipment by water way Keep the traffic slow for safety
4	Construction labour and activities	Increase in air pollution, noise and waste quantity	Temporarily affects. Avoiding of dust pollution by periodic watering of site during civil works. Avoiding of noisy activities during the night. Wastewater and solid waste disposal according to the local regulations
5	Socio-economic	Employment aspects	Positive effects on temporary employment for local workers

5.3 OPERATION PHASE

The main energy and mass balances as well as emissions of the Phu My 2.2 Power Plants are shown in Figure A2. This plant will only be one of the five power plants, which will be located at the PMPGC. All these power plants are installed in close proximity to each other on the same site. Several of the required supply and disposal systems (e.g. cooling water supply and discharge) belong to PMPGC (EVN) and will be used by all five power plants. Considering the closed locality of the plants and the common supply and disposal systems of PMPGC, the operational impacts can be divided in the following two groups:

1st Group: impacts, which can directly be controlled by each individual power plant:

- Flue gas emissions into the atmosphere (e. g. NO_x, SO_2, CO)
- Cooling water supply and discharge within plant boundary
- Natural gas supply within plant boundary
- Distillate oil supply with in plant boundary
- Noise within plant boundary and closed area located to each plant
- Waste water discharge within plant boundary
- Solid waste disposal

2nd Group: impacts, which are collective and cannot directly be controlled by each individual power plant (impact of whole PMPGC):

- Ambient air quality
- Cooling water supply from the Sao river
- Cooling water discharge to the Thi Vai river
- Waste water discharge to the Thi Vai river
- Sanitary water discharge to the Thi Vai river
- Natural gas supply system
- Distillate oil supply system
- Noise outside of the PMPGC

Considering the above mentioned aspects, in the Table A5 the main operational impacts of the Phu My 2.2 Project are summarized.

As an overall assessment the following can be stated:

- Due to the selected technology (combined cycle) and fuel (natural gas) the environmental impact of the plant will be minimized to an acceptable level (see Figure A9).

- The project full fills all relevant Vietnamese and WB Standards and Regulations. In particular, the pollutant emissions of the plant will be very low in comparison to Vietnamese and WB Standards (see Figures A3 and A4).

- The socio-economic benefits of the project for the development of local region as well as for the Vietnam is very high

Figure A2: The Main Energy and Mass Balances of the Phu My 2.2 Power Plant

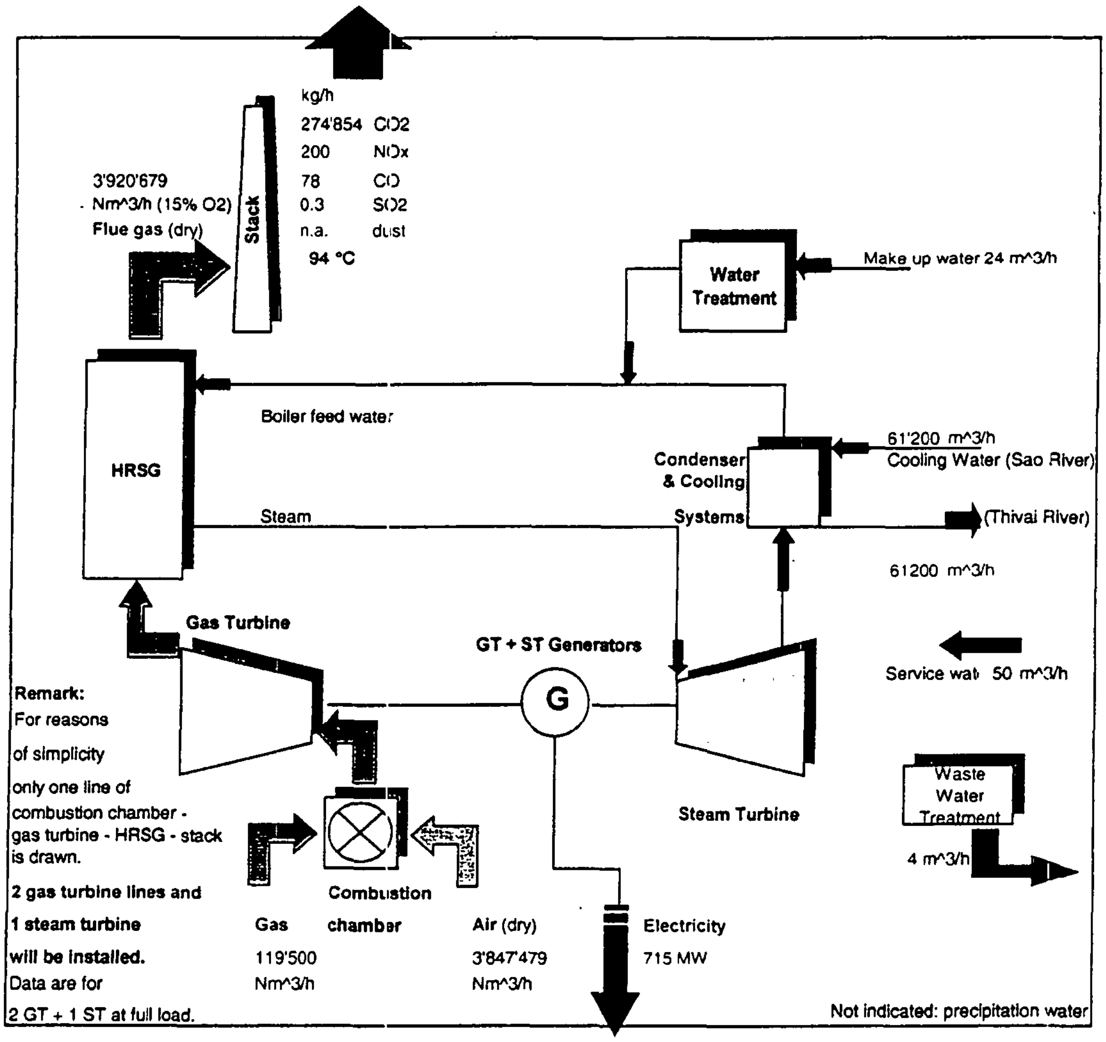


Table A5: The Main Project Impacts and Mitigation Measures during Operation Phase

No.	Impact	Possible Effects	Assessment / Mitigation Measures
1	Climate	Greenhouse effect	Minimising of specific CO_2 emissions by high plant efficiency and natural gas as fuel (384 kg/MWh)
2	Emissions	NO_x and SO_2 pollutions	Limitation of NO_x emission by applying of modern combustion technology (gas 52 / oil 119 mg/Nm^3). Limitation of SO_2 emission by using of oil for max. 5 days/year
3	Ambient air quality	Increasing of pollutant concentration	Impact minimised because all plants at PMPGC are based on combined cycle system with gas as main fuel (relatively low emissions). Stack height supports good dispersion.
4	Noise	Plant surrounding	Appling noise protection measures in order to meet the required standard
5	Fresh water demand	Water availability	Fresh water demand of 30 to 50 m^3/h which will be supplied by Ba Ria Vung Tau Water Company via existing PMPGC water pipe system
6	Cooling water demand	Water availability	Limited demand because of combined cycle technology. About 70 % of power will be generated by gas turbines which do not need cooling water. Maximum demand for Phu My 2.2 about 17 m^3/s, for total PMPGC about 90 m^3/s
7	Wastewater discharge	River pollution	Appling of wastewater treatment in order to meet the required standards
8	Cooling water discharge	Temperature increase of river water. Effects on fish species and mangroves	Limitation of cooling water temperature increase to max 7 °C. Using of suitable discharge system for appropriate temperature distribution in Thi Via River. Temperature increase near surrounding of discharge point of max. 2.6 °C will decrease quickly to lower than 1 °C. This temperature increase in a closed area will not affect the fish species and mangroves seriously.
9	Cooling water intake	Reduction of fish species	The cooling water intake will be designed for a low velocity of about 0.3 m/s at which fish can escape easily
10	Solid waste disposal	Pollution of rivers and near area	The solid waste will be disposed by an authorised local disposal company (similar to PMPGC) according to local regulations
11	Socio-economic	Country and future development	The impact of the project on the local and Vietnamese socio-economic development can be assessed as very high

Figure A3: SO_2 Emissions in % of the Relevant Standards

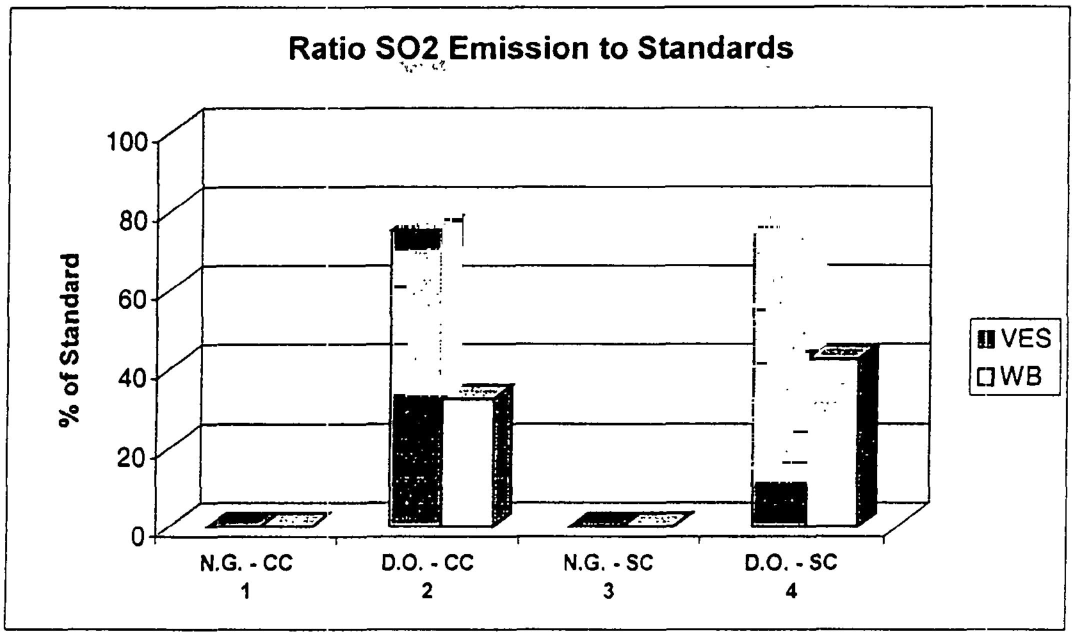
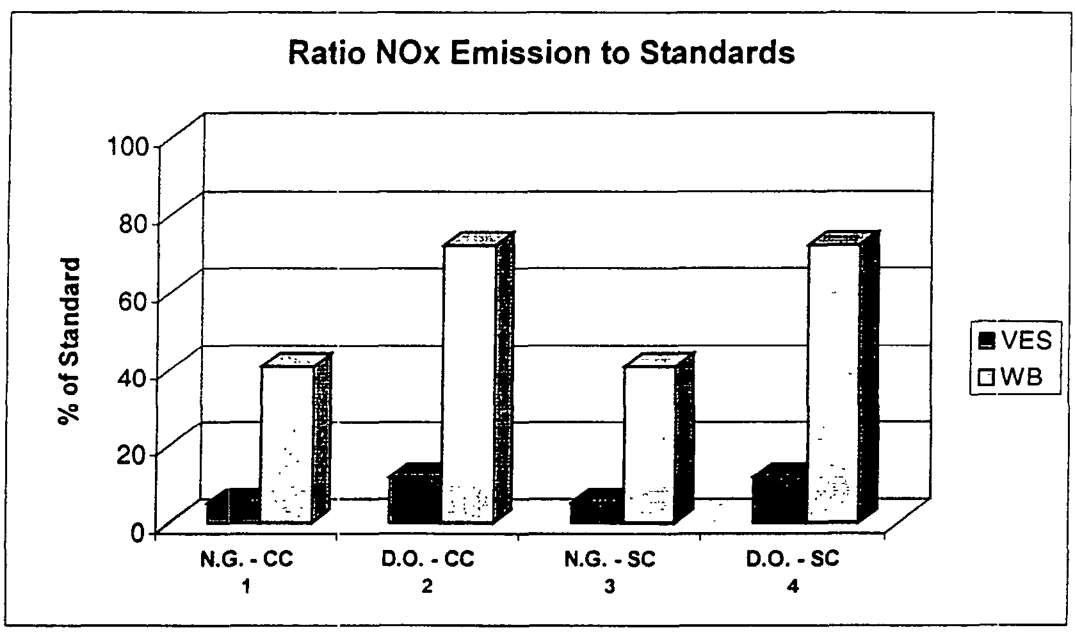


Figure A4: NO_X Emissions in % of the Relevant Standards



1 - Natural gas as fuel – combined cycle	(N.G. – CC)
2 - Distillate Oil as fuel – combined cycle	(D.O. – CC)
3 - Natural gas as fuel – single cycle	(N.G. – SC)
4 - Distillate oil as fuel – single cycle	(N.G. – CC)

6 PROJECT ALTERNATIVES

In order to assess the selected technology of Phu My 2.2 Project regarding the environmental impacts, the following two power generation alternatives (including flue gas desulphurisation) have been investigated:

- Generation of 715 MW by a fuel oil-fired conventional power plant.
- Generation of 715 MW by a coal-fired conventional power plant

The results of this investigation show that the negative environmental impacts of these alternatives are much higher than of the Phu My 2.2 plant concept:

- Higher CO_2 emission
- Higher NO_X emission
- Higher SO_2 emission
- Higher cooling water demand
- Additional consumables for flue gas cleaning
- Additional residues to be treated and to be disposed
- Higher disposal problems (ash, gypsum, etc.)
- Higher burden to waterway due to transport of high amounts of fuel by ship
- Higher risks of oil spill and fire
- Higher space requirement and land used

Figures A5 to A7 show the comparison between Phu My 2.2 main emissions and the investingated alternatives.

Considering all the above gained results, it can be assessed that the plant concept of Phu My 2.2 is the most suitable technology selection for generation of 715 MW power at the Phu My site. This plant concept is based on modern combined cycle technology with high thermal efficiency and relatively low environmental impact.

Figure A5: Comparison of CO_2 Emissions of the Alternatives

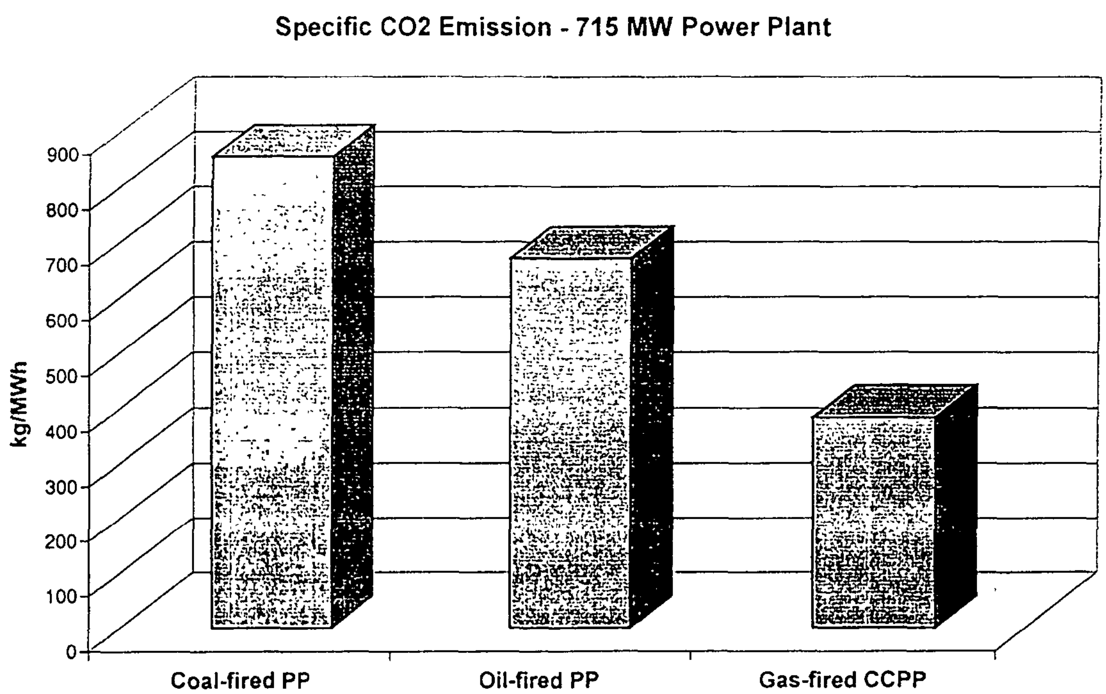


Figure A6: Comparison of SO_2 and NO_X Emissions of Alternatives considering FGD for Coal- and Oil-fired Power Plants

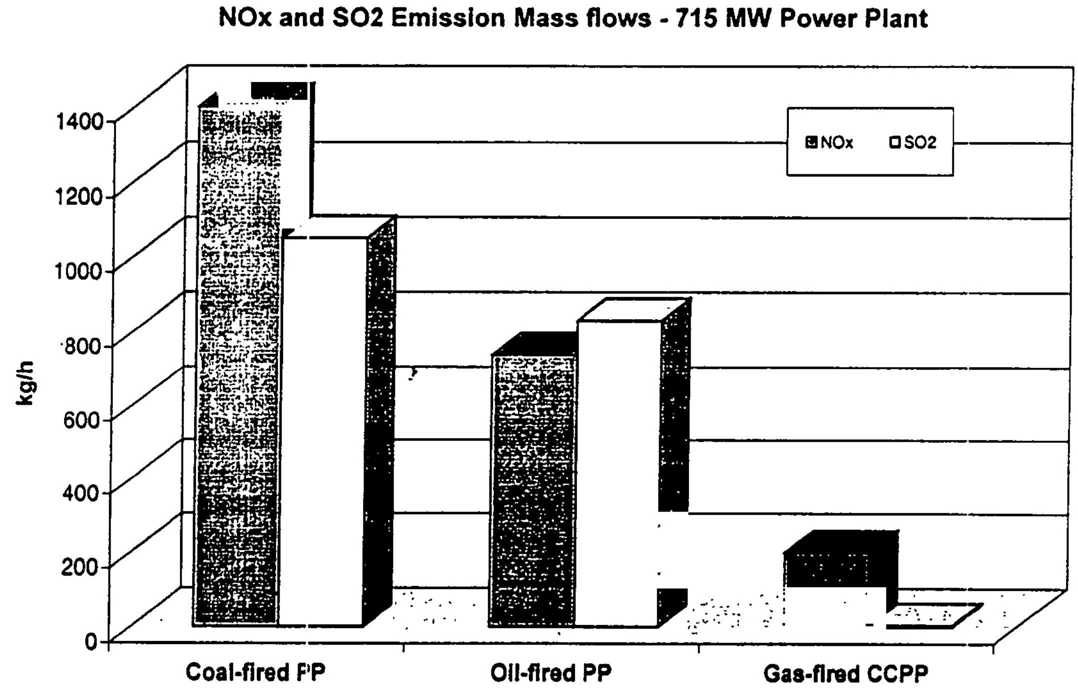
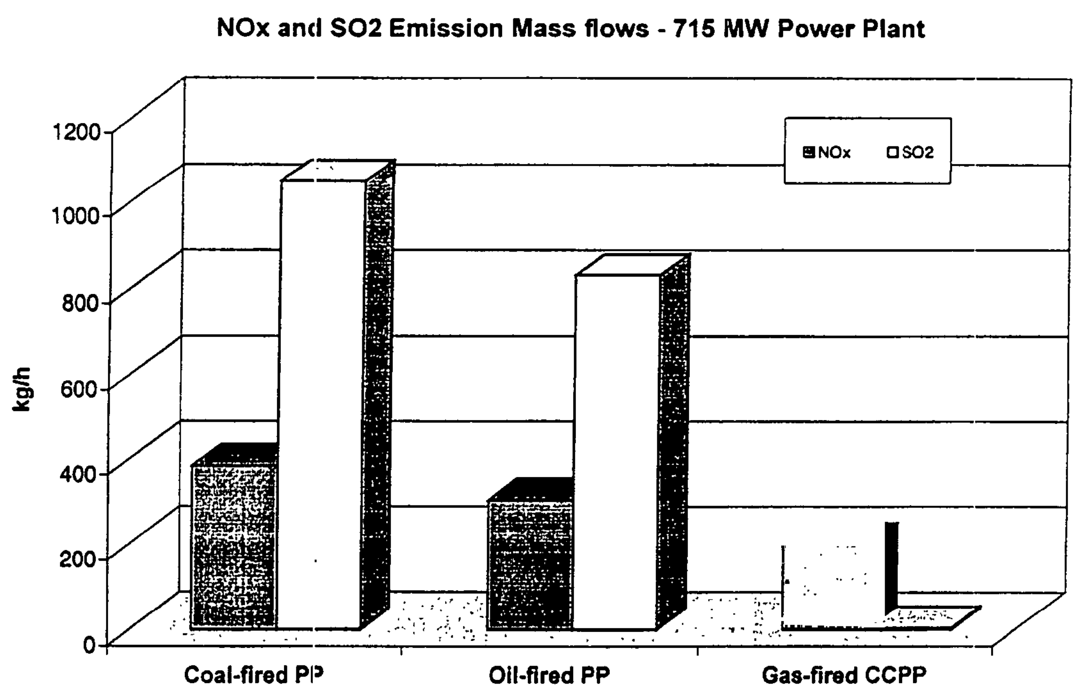


Figure A7: Comparison of SO_2 and NO_X Emissions of Alternatives considering De-NO_X and FGD for Coal- and Oil-fired Power Plants



7 ENVIRONMENTAL MANAGEMENT AND MONITORING

In order to properly assess environmental impacts of the Phu My 2.2 Thermal Power Plant as well as evaluate effectiveness of mitigation measures applied for abatement of environmental pollution a program of monitoring and oversight of the project will be implemented.

The Phu My 2.2 Power Plant (715 MW) will be only a part of the whole PMPGC, which include four other power plants with a (total capacity 3800 MW) Since several environmental impacts (e.g. ambient air concentrations) cannot be divided to each individual plant, a suitable monitoring program for Phu My 2.2 as well as whole PMPGC have to be considered.

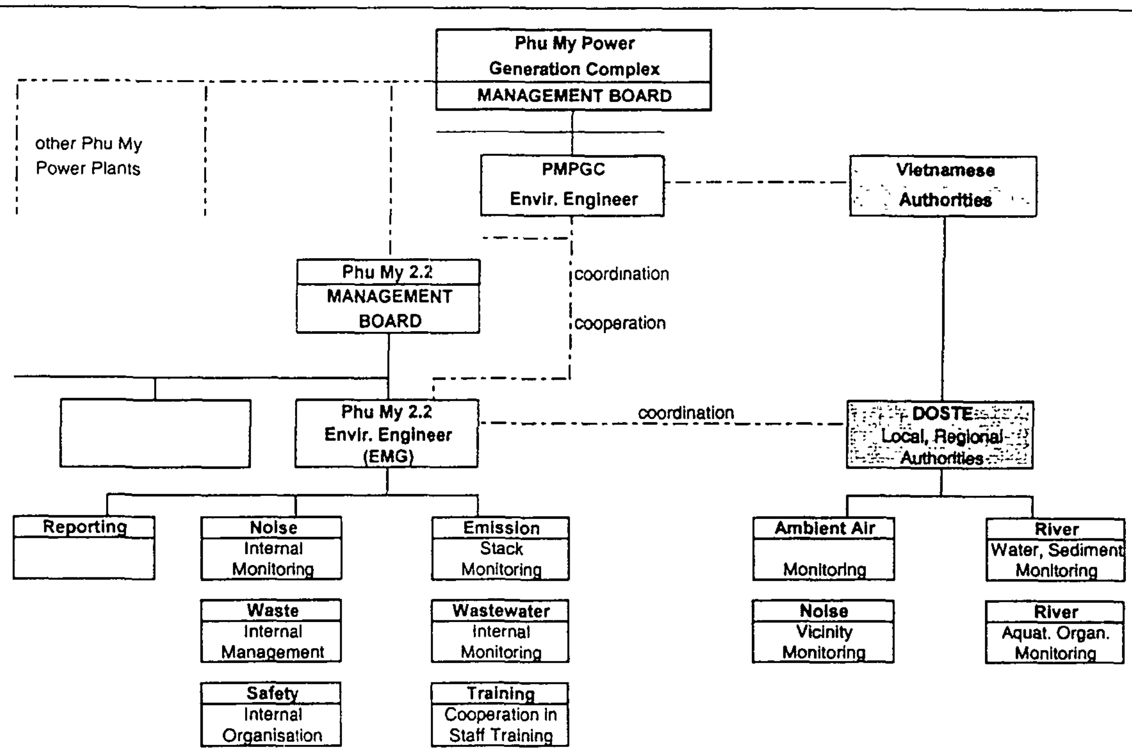
Figure A8 shows a recommendation for the organisation of the environmental management and monitoring of the Phu My 2.2 and the whole PMPGC.

The Phu My 2.2 Management Board shall be responsible for the internal environmental management and monitoring of the plant. For this purpose, the board shall appoint an Environmental Engineer as head of an environmental management group (EMG) who shall be responsible for the execution of environmental related issues of Phu My 2.2 plant.

Additionally, it is also considered to establish for the PMPGC an authority/environmental engineer with responsibility for environmental matters common to the whole PMPGC (e.g. ambient air and noise monitoring).

The organisation of the environmental management in Phu My 2.2 shall be set about early in order to commence working already during construction phase.

Fig A8: ORGANISATION OF ENVIRONMENTAL MANAGEMENT FOR PHU MY 2.2 POWER PLANT



8 PUBLIC CONSULTATION

The public consultation process for the Phu My 2.2 Power Project was performed in the following two phases:

- The first phase of public consultation was performed from April to August 2001
- The second phase was initiated in November 2001 in order to complete the procedure and to comply with World Bank's requirement to hold two meetings for a category A project. The second phase has been performed with consent of World Bank's representative in Hanoi.

The first phase of the public consultation process was organised and conducted mainly by VESDEC and PECC2. A booklet in Vietnamese language, summarising the project's description and particularly, environmental and social impacts, was prepared and sent to interested agencies (total of 8 agencies).

On July 31, 2001, after 2 months spent for project communication, the official meeting between the representatives of the project, the province, district and town, and the representatives of project affected households was held in an office of Tan Thanh People's Committee.

After presentation of the project, the participants in the meeting gave their comments, evaluation and requirements to the project, comprising:

- Importance of the Project
- Relocation of the Affected Households
- The Main Concerns of the Local People to the Project
- The Main Suggestions and Requirements of the Local People

In the meeting, various proposals to the project were given by the local participants, mainly concentrating on issues like:
- the project should carry out suitable measures for the prevention of dust, noise, traffic jam during transport of construction materials
- the project or EVN should well design and operate water intake system to minimise loss of fish, shrimps created by river water intake.
- a monitoring program on aquatic species, particularly fish and shrimp source in the Thi Vai river should be performed now and in the operation phase.
- the project should thoroughly design, install and operate system for prevention of risks by fire
- the project should create positive socio-economic effect on the local people
- the project should be responsible for all impacts created by project construction and operation. In case of damage on aquaculture, fishery, public health etc., the project should give adequate compensation for affected households.

The Project Proponent has confirmed that in the design and construction phases, emphasis will be given to all environmental issues.

In conclusion of the meeting, the Vice-Chairman of Tan Thanh District People's Committee has greatly evaluated the democratic way of the Project in the Public Consultation process. He has also promised that the people in Phu My town and Tan Thanh district will support and cooperate with the project in the construction and operation phases. He has emphasized that the project should pay attention to possible environmental and social negative impacts and implement appropriate measures to meet the suggestions and requirements given by the representatives of local people in this meeting.

The second phase of public consultation process took place on Thursday 20 December 2001 from 9:30 a.m. at the Tan Thanh People's Committee Headquarters. For one week in advance, two facilities were available to display various documents/diagrams relating to the Phu My 2.2 project for the interested parties to view:

- Tan Thanh People's Committee Headquarters
- Phu My People's Committee Headquarters.

Following preparatory activities were executed in connection with this second public consultation phase:

- Invitation of all interested persons from several Governmental and Non Governmental institutions and organisations: (Phu My Town, Tan Thanh District, Ba Ria – Vung Tau Province, Ho Chi Minh City Polytechnics University, UNDP Ho Chi Minh Rep. Office, NGO World Vision, Non Government Organization (NGO) ENDA, UNESCO Ho Chi Minh City)

- Public announcements regarding the document viewing and public consultation meeting in TV, radio and newspaper

- Documentation viewing facilities in each showroom (e. g. project booklet, pictures and diagrams, notebook for write down the questions). An responsible engineer of PECC2 was available to answer the questions

- Preparation of the Agenda of the consultation meeting, introduction, project description, technical and environmental project impacts

- Performance of the consultation meeting: the meeting commenced at 09:30 h a.m. and was concluded at 12:00 h noon, followed by a visit to the document viewing facilities.

During the meeting the questions were mainly focused on following issues:

- How does MECO intend to maintain discipline, order and prevent negative anti-social behaviour arising in the local community during the construction phase of the project when a large influx of workers (up to 1000) will be concentrated in the area?

- What other impacts besides slightly raising the temperature of the river (Thi Vai) will occur by the cooling water discharge? And what effect will this have on the local aquaculture industry (shrimp farms)?

- How does MECO propose to dispose of other pollutants such as chemicals, solid wastes etc?

- What employment prospects and training opportunities will be available to the local residents?

Answers may be summarised as follows:

- MECO will develop and maintain, a close relationship with the local authorities implement security control measures should the need arise. Furthermore MECO will insist that their sub-contractors, especially local vendors (civil constructors) implement, and where applicable enforce strict internal regulations to adequately control the labor force

- The wastewater discharged into the Thi Vai River will not pose any risk to the environment, but will maintain a stable temperature, which will have no impact on the local aquaculture industry. The area around the discharge channel does not contain residential properties, nor as per the PMPGC master plan, is there any intention to use the land for residential purposes

- As Phu My 2.2 is a Gas-fired Combined Cycle Power Plant, it will only discharge cooling water (containing negligible amounts of chemical compositions, the flue gas will contain such pollutant substances as dust, NO_x, SO_x but these will be well within the guidelines stipulated by WB and Vietnamese Standards). The cooling water, which is discharged into the Thi Vai River, will have no impact on the local environment

- Mekong is committed to do their utmost to offer/provide employment opportunities to the local residents. 10% of staff during the operation phase shall be employed from the local community. Furthermore MECO is to offer skill training/scholarship opportunities to local residents with a view to offering long-term employment at the plant. MECO is to commence a study, to locate where such training facilities are available in Vietnam. During the construction phase of the project a large proportion of the site workers will be drawn from the local community to maximize employment opportunities during the construction period.

Statements have been given from the following organisations:

- Non Government Organisation ENDA (Environment and Development in Action)
- Phu My Town
- Tan Thanh District

The main important issues of these statements may be summarized as follows:

- Supervision of the work force during the construction phase shall be implemented to prevent possible civil unrest.
- MECO should cooperate with the local authorities to provide funds for the local technical institutes to provide training to the local residents.
- Phu My 2.2 will significantly contribute to developing the local community and will have negligible impacts on the environment.
- All measures to mitigate the impacts on the local community and environment should be implemented stringently to alleviate possible negative impacts.
- MECO should undertake a survey during the construction phase of the project to ascertain what impacts (positive/negative) the project will have on the local community and what mitigating measures can be undertaken to negate the negative impacts
- The access roads should be watered down at regular intervals to prevent the dust becoming airborne.
- Traffic – speed, reducing measures should be undertaken to protect the local residents.
- Management of Phu My 2.2 should contact local community leaders and authorities to implement measures to prevent social unrest developing within the local community
- During the construction/operation periods MECO should contact local community authorities regarding the implementing the suggested training program
- Air, dust, noise and vibration should be monitored and adequate measures should be implemented to control the effects of such impacts

9 CONCLUSIONS

Considering all investigation results, the Phu My 2.2 Power Project can be assessed as follows:

- The project will help to meet the rapid growth in electricity demand in Ho Chi Minh City and the Vung Tau industrial zone
- The project will strengthen the regional power supply system, stimulate industrial development and improve the living standards of local residents
- The project is an integral part of the natural gas utilisation chain that will enable the commercialisation of the Nam Con Basin, natural gas resources.
- The project will create employment for many workers during the construction and operation phase, and numerous indirect jobs in the supporting local services and supply industry.
- As one of the first BOT projects in Vietnam the project will help Vietnam attract additional foreign investment. The know how transfer and personnel training may also be considered as important benefits of this projects
- The selected technology of the project "combined cycle principle" is currently representing the most technically and environmentally appropriate power generation system
- The design and construction of the plant will consider and meet the Vietnamese Standards and WB Standards.
- The project will use natural gas as fuel (distillate oil max. 5 days/year) which is, environmentally, the most suitable fossil fuel for power generation
- Considering the importance of this power project for Vietnam, the environmental impacts of the plant are in an acceptable range. The main impacts can be assessed as slight to intermediate (see Figure A9).

Figure A9: Summarising Assessment of Environmental Impacts

Impact	slight		inter-mediate		high		Remark
Impacts During Construction Phase							only temporary
Land clearing							already done
Air pollution	■	■					mainly dust
Water pollution	■	■					sanitary water
Noise	■	■	■				construction equipment
Land used							no additional land needed
Impacts During Operation Phase							
Particulate emission							neglectible
CO emission	■						< standards (VN)
SO2 emission	■						< standards (VN, WB), max 5 days/a
NOx emission	■	■					< standards (VN, WB)
Impact on ambient air	■	■					< standards (VN, WB)
Noise	■	■					
Impact on water (by wastewater discharge)	■	■					
Thermal impact by cooling water discharge	■	■	■				< standards (VN, WB), total Phu My
Impact on climate (CO2)	■	■					
Impact on Flora & Fauna	■	■	■				biodiversity, ingestion by CW intake
Impact on fish	■						ingestion by CW intake
Impact on Mangroves	■						

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SECTION B

PROJECT BACKGROUND, POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORKS

SECTION B PROJECT BACKGROUND, POLICY, LEGAL AND ADMINISTRATIVE FRAMEWORKS

TABLE OF CONTENTS

LIST OF TABLES

1 POLICY AND PROJECT BACKGROUND

1.1 POWER DEVELOPMENT POLICY

As an important basis for developing the industrial sector and infrastructure, and ultimately increasing the quality of life of the people in Vietnam, the Vietnamese Government has set a high priority for the expansion of the power generation sector.

During the previous years, Vietnam's power sector has achieved a relatively high growth rate (Appendix B1). As can be determined from the following Table B1, the total power sale of electricity of Vietnam (EVN) has been lifted to about 19'600 GWh in 1999 from 6'185 GWh in 1990 (total increase of about 320 %). The average growth rate of power sales in this period was approximately 13 % per year. The total power generation in Vietnam increased in this period from 8'680 GWh in 1990 to 23'739 GWh in 1999. The average growth rate amounts to about 11.9 % per year. In the same period the power system losses decreased from a total of 25.4 % in 1990 to 16.1% in 1999 due to the improvement of power generation and transmission efficiency.

Table B1: Main Data of Power Generation and Sales in Vietnam in the Period of 1990-1999

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Power generation (GWh)	8680	9152	9654	10665	12284	14636	16945	19152	21665	23739
Growth rate (%)	11.4	5 5	5.5	10.4	15.2	19.2	15.8	13.0	13.0	9.6
Power sales (GWh)	6185	6583	6931	7839	9284	11185	13374	15303	17725	19592
Growth rate	11.9	6.4	5.3	13.1	18.4	20.6	19.2	14.8	15.7	10.5
Power loses	25.4	25.5	25.6	24.0	22.5	21.7	19.3	18.2	16.1	15.5
Consumption per capita kWh/person)	93	97	100	110	128	151	177	200	233	255

Despite this relatively fast track power development, the specific power consumption per capita in Vietnam is still very low. This value increased from 93 kW in 1990 to 255 kW in 1999, averaging about 270 %. In comparison with other countries in the Asian region (and the rest of the world) however, Vietnam has one of the lowest specific power consumption per person per annum. Table B2 shows a comparison between power consumption and GDP of Vietnam and some other selected countries (Appendix B1).

Table B2: Comparison of Specific Power Consumption and GDP of Vietnam and Some other Countries (Data of 1996)

	Consumption kWh/Capita	GDP USD/Capita	Comparison Consumption	Comparison GDP
Vietnam	225	178.2	*Basis*	*Basis*
Pakistan	418	395.4	1.85	2.22
China	780	602.0	4.64	3.38
Myanmar	55	584.8	0.24	3.28
Philippines	399	746.5	1.77	4.19
Indonesia	315	889.0	1.4	4.99
Thailand	1294	2262.9	5.75	12.69
Malaysia	2032	3327.3	9.03	18.67
Singapore	7196	19857.2	31.98	111.94
USA	12711	24686.1	56.5	138.54

According to this table, the specific power consumption for Vietnam in 1996 was about 1.4 to 56.5 times lower, and the GDP was about 2.2 to 138.5 times lower than the other countries the comparisons were drawn against.

Considering this very poor situation in the power sector, and the governmental efforts for the industrialisation of the country, the Master Plan for Power Development No 5 has prepared a power demand forecast for the period to 2020. This forecast is shown in the Table B3.

Table B3: Electricity Demand Forecast in Period 1995 to 2020

	1995	2000	2005	2010	2015	2020	Increasing
Scenario 1:Basis GWh	14'636	26'000	46'459	70'437	109'439	167'000	10.2 %/a
Consumption: kWh/capita	198	306	560	734	1'087	1'560	
Scenario 2: High	14'636	26'475	49'000	78'466	126'949	201'67	
Consumption: kWh/capita	198	343	591	817	1'261	1'881	11.0 %/a

According to this forecast for the power demand an annual increase of approximately 10 to 11 % per year can be expected. In order to satisfy the forecast power demand, the power generation capacity of Vietnam has to increase accordingly within the next two decades.

Vietnam's power sector has achieved a fairly high growth rate thus far. The total installed capacity of the power generation system has increased from 4,013 MW at the end of 1993 to 5,765 MW at the end of 1999. The average growth rate during this period was 15.5% per annum. Table B4 shows the established and available power capacity of the existing power plants up to the end 1999.

Table B4: Existing Installed and Available Power Generation Capacity of Vietnam

Type of Power Plants	Installed Capacity MW	Available Capacity MW
Hydropower Plant	2'854	2'866
Thermal Power Plant	1'218	1'168
Gas Turbine	1'174	1'100
Diesel Generator	519	245
Total	5'765	5'384

Based on the Master Plan for Power Development N°.5, the development policy of the power source for the whole of Vietnam for the period 1996-2010 contains the following key points:

➢ First priority is given to the development of hydropower with sources at three main river basins:

1) Da river basin houses the most important project - Son La hydropower plant project with a capacity of 2,400 MW or 3,600 MW. It is relatively large project and is not scheduled for completion and operational service until the years 2012-2016 respectively.

2) Sesan river basin houses the Yaly hydropower plant that is under construction and is scheduled to be commissioned and in operational service by 2001. Apart from this, there are also another two planned projects, Sesan 3 and Pleikrong.

3) Dong Nai river basin houses the following projects: Ham Thuan - Da Mi scheduled to be commissioned and in operational service by 2001; Dai Ninh by 2006; Dong Nai 4, Dong Nai 8 and other projects which are yet to be determined.

4) Apart from the three main river basins as mentioned above, there are other projects such as: Ban Mai, Buon Cuop, Can Don, Rao Quan, Cua Dat etc. to be considered for future construction.

- The use of natural gas (associated and non-associated) to generate power. The Nam Con Son Gas quantity and reserves have recently been estimated at 1,300 billion m^3. Gas will be extracted and transported at 2.1 billion m^3 per year by the beginning of 2003, which is scheduled to increase to 2.7 billion m^3/year by 2005-2010.

  Natural gas is a clean and economical fuel, and the most appropriate fuel to utilise as the primary fuel source for the latest combined cycle technology. Therefore the Vietnamese Government has a policy to develop combined cycle power plants in the vicinity of the gas pipelines, such as the Phu My and Ba Ria sites.

- To develop coal fired thermal power generating Centres next to the coal-mines, such as Quang Ninh, Na Duong, etc.

With such a power development program, power supply may satisfy power demand, developed by a basic scenario or scenario's which indicate a higher growth rate for the period after year 2000.

The Phu My Power Generation Centre has been approved for the installation of 5 different combined cycle power projects by the Government of Vietnam (Approval No. 1177/QD – KHDT Issued by the Ministry of Industry on 31/07/1997) in order to increase the power generation capacity and full fill the future power demands of Vietnam.

1.2 PROJECT BACKGROUND

On October 28, 1997 the Ministry of Industry (MOI) of Vietnam issued a Request for a Proposal for the right to develop the Phu My 2.2 Power Project at Ba Ria – Vung Tau Province under a build, operate and transfer (BOT) investment structure. The Project will be one of the first private sector electricity generation plants to be undertaken in Vietnam and the Government of Vietnam intends to use this project to establish a viable BOT framework for use in future private sector infrastructure developments in Vietnam.

The Phu My 2.2 Project was awarded to the Consortium comprising of EDF International, Sumitomo Corporation and TOKYO Electric Power Co, Inc. in January 1999. In the subsequent period the Consortium negotiated the terms of the BOT Contract with the MOI, the Power Purchase Agreement (PPA) with Electricity of Vietnam (EVN), the Gas Supply Agreement (GSA) with oil and Gas Corporation of Vietnam (PetroVietnam), the Land Lease Agreement (LLA) with the Urban Development & Construction Company of Bia Ria – Vung Tau Province (UDEC) and the Government Guarantee with the Ministry of Planning and Investment (MPI) and the State Bank of Vietnam (SBV). Documentation was initialled in the first half of 2001 and the Consortium submitted a formal application for an Investment License on 8 June to the Ministry of Planning and Investment (MPI). The Investment License was issued in September 2001.

Upon receipt of the Investment License the Consortium established the Mekong Energy Company Ltd. (MECO) as a limited liability company in Vietnam. MECO will subsequently implement the Phu My 2.2 Project on behalf of the Shareholders.

The Phu My 2.2 Project is a 715 MW combined cycled power plant. The design operating life of the plant is 30 years. The term of the Project will be 20 years from the Commercial Operation Date (COD) after which the plant will be overhauled and transferred at no cost to the MOI.

Power output from the plant will help to meet rapid growth in electricity demand in Ho Chi Minh City and the Vung Tau industrial zone. Phu My 2.2 Power Project will be part of the Phu My Generation Centre (PMPGC). This complex is a core component of EVN's strategy to meet future requirements in an area where EVN estimate that electricity demand will grow at approx. 16 % per annum.

The main objectives of the power project can be summarised as follows:

➢ To strengthen the regional power supply system, upgrade the general physical infrastructure, stimulate industrial development and improve the living standard of local residents and associated stakeholders

➢ To efficiently use the indigenous natural gas from the Nam Con Son resource area. The project is an integral part of the natural gas utilisation chain that will enable the commercialisation of the Nam Con Basin, natural gas resources.

➢ To create long term, stable, high quality direct employment for approximately 1'000 skilled and unskilled workers during the construction phase, and numerous indirect jobs in the supporting local services and supply industry.

➢ To stimulate additional direct foreign investment into Vietnam. As one of the first major infrastructure projects in Vietnam to be structured under BOT commercial terms, legal and commercial precedents have been set during the development of the project which will help Vietnam attract additional foreign investment.

➢ To transfer the best available technology, and management technique and expertise, through the installation of an advanced technological power plant using power equipment and technology, and the implementation of long-term advanced level multidisciplinary skill training.

2 LEGAL FRAMEWORK

2.1 OBJECTIVES

The original Environmental Impact Assessment (EIA) Report of Phu My 2.2 was prepared by a team consisting of:

- Experts of "Vietnam Association for the Conservation of Natural and Environment" (VESDEC)
- Experts of "Power Engineering Consulting Company" (PECC2)
- Experts of EDFI Consortium

This EIA report was finalised in April 2001 and submitted to the Ministry of Science, Technology and Environment (MOSTE) for approval.

With the letter of May 25, 2001, MOSTE had approved the Phu My 2.2 Project. This Approval Letter is in Appendix B2.

The EIA report in hand is based on the EIA report of April 2001 and is prepared on the requirements of the lenders. The main objectives of this EIA are as follows:

- To submit a report according to the lenders requirements
- To justify the results of the existing EIA report of April 25, 2001
- To provide the additional information and data, if require

2.2 LEGAL BACKGROUND

This EIA report in hand is based on the following legal documents.

- Law on Environmental Protection approved by the National Assembly of the Socialist Republic of Vietnam on 27 December 1993; issued according to the order 29-L/CTN 10 January 1994 of the State Chairman [1]

- Decree No 175/CP on 18 October 1994 issued by the Government of Vietnam (GOV) for the guidelines on implementation of the Law on Environmental Protection[2]

- Vietnamese Standard of Environment [3], issued by the Ministry of Science, Technology and Environment (MOSTE) in 1995

- Circular No 490/1998/TT-KHCNMT issued on 29th April 1998 by MOSTE[4] requiring content of an EIA study.

- Decree N22/CP April 1998 of the GOV on policy of Resettlement [5]

- World Bank Guidelines for New Thermal Power Plant, 1999 [6]

2.3 TECHNICAL BACKGROUND

The technical documents have been used for the preparation of this EIA report are the following:

- Feasibility Study Report of the Phu My 2.2 Project, prepared by the PECC2 (January 2001 [7]
- Master Plan #5 of Phu My Power Generation Complex prepared by PECC2, in 1997 [8].
- Power Market Analysis of Vietnam prepared by PECC2 in 1999 [9].
- Thematic reports on the environmental conditions at the project area and Ba Ria -Vung Tau implemented by the Team of Dr. Le Trinh in 1995, 1996 and December 1999 [10-13]
- EIA Reports of Phu My Projects [14-16]
- Data on the present socio-economic state of Tan Thanh district and Phu My town provided by district People Committee [17]
- Guidelines of the World Bank for EIA [18-19]
- Books, Technical papers of Vietnam on EIA[20-22]
- Scope of work and performance guarantee of Phu My 2.2 EPC contract

3 ADMINISTRATIVE FRAMEWORK

3.1 PROJECT TEAM

As already mentioned in Chapter 2.1 the original EIA Report was prepared by a team of local and foreign experts.

This report in hand has been prepared by a team of experts of the Consortium Colenco Power Engineering Ltd in Baden, Switzerland and Fichtner in Stuttgart, Germany.

The main expert team is composed of:
Dr. Mehdi H. Javad
Dr. Ludwig Raible
Mr. David Green

The expert team was supported by the local Engineering Company "PECC2" which was also involved in the preparation of the original EIA report.

3.2 APPLIED METHODOLOGY

3.2.1 Assessment Methods

Assessment of the possible impacts of the Phu My Project on the environment was based on the following methods:

Judgement:
Based on international literature and experience, judgement was used for preliminary assessment of the impacts of the project on the environment.

Checklist:
Based on engineering features, as well as the environmental status, various checklists were set up for identification of the impacts and recommendation of mitigation measures.

Rapid Assessment:
Rapid assessment suggested by WHO [22] was used in assessment of pollution loads (air emission and wastewater) from the project.

Environmental Modelling:
Environmental modelling was applied for computation and assessment of possible water and air pollution created by the project.
- SO_2, NO_x dispersion modelling
- Thermal pollution dispersion modelling
- Oil spill, dispersion created by fuel transport on the Thi Vai River.

Methodology of Identification and Classification of Potential Impacts:
Potential environmental impacts of the project were identified based on a series of field surveys of the existing natural environmental conditions within the Project area and meeting the provincial environmental management agencies and possible affected households.

In this study, the anticipated negative environmental impacts are classified into 4 categories *"High" "Intermediate", "Slight"* and *"negligible"*

- A *hight* can destroy an element of the environment or create a strong environmental modification. Such an impact can greatly affect an environmental component if it is impossible to adopt adequate mitigation measures.

- An *intermediate impact* may partially reduce a value or use of an environmental component and have an affect on a limited portion of the population.

- A *slight impact* may slightly reduce the value or use of an environmental component and slightly affect a small group of the population.

- Some activities of the project may not create evident negative impacts on the environment. In such cases, the assessment will not be detailed but some commentaries will be given. This type of impacts is identified as *"negligible"*

3.2.2 Measurement of Ambient Air Quality

The existing air quality (background concentration) at the Phu My Site has been measured in ten monitoring points around the project area (see Section D). The following items have been measured:

- Microclimatic data (temperature, humidity, wind direction and velocity)
- Total suspended particulate (TSP)
- SO_2 concentration
- NO_2 concentration

The measurements of the air pollutants based on the following methods/equipment:

- TSP: Whatman paper / High Volume Sampler (SIBATA HVC-500, from Japan)
- SO_2, NO_2: Sampling by DESAGA from Germany and analysis based colorimetry method

3.2.3 Measurement of Noise Emission

Noise emission at the project site has been measured in the same locations as for the air quality monitoring. The measurement has been performed through Quest-1900 Noise Analyser (USA)

3.2.4 Study on Aquatic Organisms

Fish collection:
Fish and juvenile fish species were collected by a net with a width of 50 cm, length of 250 cm and net size of 150 μm. Each sampling was taken every 15 minutes.

Fish species identification:
The collected fish species were stored in 10% formaldehyde and species identification following the standard method use in the Vietnam National Centre of Science and Technology.

Study on Fishery:
Collecting of data from the Peoples Committee of Tan Thanh District and interviewing the local fishermen.

Sampling and Analysis of Planktons:
Phytoplanktons and zooplanktons were sampled by a cone-shaped sampling net with a surface diameter of 40 cm, the length of water filter is 80 cm, and the length of the net is 100 cm. In phytoplankton sampling the net N 70 and for zooplankton sampling the net N 49 was used. Biological samples were stored by addition of 4 % formaline solution.

Planktons were sampled at 10 river monitoring sites along the Thi Vai River at the same, locations as the water quality samples were collected. All plankton samples were examined and species were classified by the standard methods, applied in the ITB (National Centre for Natural Sciences and Technology).

Sampling and Analysis of Benthic Animals:
Benthic animals were collected at 10 points (at the same locations as the water quality were collected) by a Petersen dredger with a dredging area of 0.025 m^2 for quantitative analysis and by a specific net for benthic organism collection, which is a triangular shaped net, frame length on each side is 20 cm, length of the net is 70 cm. Benthic animals were stabilised by a 8% formaline solution. Analysis of benthic animals was undertaken according to the standard methods, applied in the ITB.

3.2.5 Study on Flora

Vegetation species were identified by observation at the downstream sector of the Thi Vai basin (from Phu My to Go Dau River). Distribution and density of the major vegetation species were recorded.

3.5.6 Study on Wild Animal

The biologists of the study team performed the wild animal study by observing the area, including West Bank (Can Gio district) and East Bank (Tan Thanh district) of the Thi Vai River and interviewing local people who have lived in the area for many years.

3.5.7 Study on Socio-Economic Conditions

A Socio-economic study was conducted by interviewing the leaders and staff of the Phu My People's Committee.

4 ENVIRONMENTAL REQUIREMENTS

4.1 EMISSION STANDARDS

For the assessment of the impact of the flue gas emission from the Phu My 2.2 plant the following standards will be considered:

- Vietnam Emission Standard (VES) for new thermal power plants (TCVN 5939-1995)
- The World Bank Emission Guideline for thermal power plants from 1998

The relevant emission limits of Vietnamese and WB Standards are summarised in Table B5.

Table B5: Emissions Standards of Vietnam and World Bank

	Load (t/day)	Concentration in Flue Gas (mg/Nm^3)			
	SO_2	SO_2	NO_x(as NO_2)	CO	Particulate
Vietnamese Standard	No requirements	500[a)]	1000[a)]	500[a)]	400[a)]
World Bank Standard	0.2 tons per day up to 500 MWe plus 0.1 ton per day for each additional MWe over 500 MWe	> 2000	Gaseous fuels: > 125 Liquid fuels: > 165		For all fuels: 50 mg/ Nm^3

a) mg/Nm^3 according to dry flue gas and 298°K

4.2 AMBIENT AIR QUALITY STANDARDS

For the assessment of the ambient air quality of the Phu My project site the following standards will be considered:

- Vietnamese Ambient Air Quality Standard TCVN 5937-1995
- World Bank Guideline of Air Quality Standards

The relevant ambient air quality requirements of the above mentioned documents are shown in Table B6.

Table B6: Ambient Air Quality Standards of Vietnam and World Bank			
	1hr average mg/Nm^3	24 hrs average mg/Nm^3	Annual Average mg/Nm^3
Vietnamese Standard[(a)]			
SO_2	0.5	0.3	
NO_2	0.4	0.1	
Particulates (TSP)	0.3	0.2	
WB Standard[(b)]			
SO_2	-	0.15	0.08
NO_2	-	0.15	0.10
TSP	-	0.23	0.08
PM_{10}	-	0.15	0.05
(a) Vietnamese Standard - TCVN 5937-1995 (b) WB Standards for Thermal Power Plants – Guideline for new Plants/1999.			

4.3 WATER QUALITY STANDARDS

Table B7 shows the Vietnamese Standards for industrial wastewater (TCVN 5945 – 1995). The Vietnamese Standards for ground water quality (TCVN 5944 – 1995) and surface water quality (TCVN 5942 – 1995) are shown in Tables B8 and B9. The WB's Guideline for effluents from thermal power plants is shown in Table B10.

Pollutant values from industrial wastewater have to meet at least one of three categories shown in Table B8 depending on the receptor. According to current conditions of Thi Vai River surface water near the Site the Standards of category B have to be applied for Phu My 2.2 Project.

Relating to the Phu My 2.2 Project with natural gas as fuel, in particular the limit of oil and grease in wastewater will be important. The source of oil and grease mixed in discharge wastewater from the Phu My power plant will come mainly from miscellaneous equipment

Table B7: Vietnamese Wastewater Discharge Standard (TCVN 5945 – 1995)					
N°	Parameter	Unit	Limitation Value		
			A	B	C
1	Temperature	°C	40	40	45
2	pH value	-	6 – 9	5,5 – 9	5 – 9
3	BOD_5 (20°C)	mg/l	20	50	100
4	COD	mg/l	50	100	400
5	SS	mg/l	50	100	200
6	Arsenic	mg/l	0,05	0,1	0,5
7	Cadmium	mg/l	0,01	0,02	0,5
8	Lead	mg/l	0,1	0,5	1
9	Residual Chlorine	mg/l	1	2	2
10	Chromium (VI)	mg/l	0,05	0,1	0,5
11	Chromium (III)	mg/l	0,2	1	2
12	Mineral oils and fat	mg/l	ND	1	5
13	Animal-Vegetable fat and oil	mg/l	5	10	30
14	Copper	mg/l	0,2	1	5

Table B7: Vietnamese Wastewater Discharge Standard (TCVN 5945 – 1995)					
N°	Parameter	Unit	Limitation Value		
			A	B	C
15	Zinc	mg/l	1	2	5
16	Manganese	mg/l	0,2	1	5
17	Nickel	mg/l	0,2	1	2
18	Organic Phosphorus	mg/l	0,2	0,5	1
19	Total Phosphorus	mg/l	4	6	8
20	Iron	mg/l	1	5	10
21	Tetrachloethylene	mg/l	0,02	0,1	0,1
22	Tin	mg/l	0,2	1	5
23	Mercury	mg/l	0,005	0,005	0,01
24	Total nitrogen	mg/l	30	60	60
25	Trichloethylene	mg/l	0,05	0,3	0,3
26	Ammonia (as N)	mg/l	0,1	1	10
27	Fluoride	mg/l	1	2	5
28	Phenol	mg/l	0,001	0,05	1
29	Sulphide	mg/l	0,2	0,5	1
30	Cyanide	mg/l	0,05	0,1	0,2
31	Coliform	MPN/100 ml	5.000	10.000	-
32	Gross α activity	Bq/l	0,1	0,1	-
33	Gross β activity	Bq/l	1,0	1,0	-

Table B8: Vietnamese Ground Water Quality Standard (TCVN 5944 – 1995)			
No	Parameter	Unit	Limitation Value
1	pH value	-	6.5 – 8.5
2	Colour	Pt-Co	5 -50
3	Hardness (as CaCO3)	mg/l	300 – 500
4	Total solids	mg/l	750 – 1500
5	Arsenic	mg/l	0.05
6	Cadmium	mg/l	0.01
7	Chloride	mg/l	200 – 600
8	Lead	mg/l	0.05
9	Chromium (VI)	mg/l	0.05
10	Cyanide	mg/l	0.01
11	Copper	mg/l	1.0
12	Fluoride	mg/l	1.0
13	Zinc	mg/l	5.0
14	Manganese	mg/l	0.1 – 0.5
15	Nitrate	mg/l	45
16	Phenols compound	mg/l	0.001
17	Iron	mg/l	1 – 5
18	Sulphate	mg/l	200 – 400
19	Mercury	mg/l	0.001
20	Selenium	mg/l	0.01
21	Feacal coli	MPN/100 mg/l	Not detectable
22	Coliform	MPN/100 mg/l	3
No	Parameter and Substance	Unit	Limitation value

Table B9: Vietnamese Surface Water Quality Standard (TCVN 5942 – 1995)

No	Parameter	Unit	Limitation Value	
			A	B
1	pH value	mg/l	6 - 8,5	5.5 – 9
2	BODs (20oC	mg/l	< 4	< 25
3	COD	mg/l	< 10	< 35
4	DO	mg/l	> 6	> 2
5	SS	mg/l	20	80
6	Arsenic	mg/l	0.05	0.1
7	Barium	mg/l	1	4
8	Cadmium	mg/l	0.01	0.02
9	Lead	mg/l	0.05	0.1
10	Chromium, Hexavalent	mg/l	0.05	0.05
11	Chromium, Trivalent	mg/l	0.1	1
12	Copper	mg/l	0.1	1
13	Zinc	mg/l	1	2
14	Manganese	mg/l	0.1	0.8
15	Nickel	mg/l	0.1	1
16	Iron	mg/l	1	2
17	Mercury	mg/l	0.001	0.002
18	Tin	mg/l	1	2
19	Amonia (as N)	mg/l	0.05	1
20	Flouride	mg/l	1	1.5
21	Nitrate (as N)	mg/l	10	15
22	Nitrite (as N)	mg/l	0.01	0.05
23	Cyanide	mg/l	0.01	0.05
24	Phenol compounds	mg/l	0.001	0.02
25	Oil and Grease	mg/l	ND	0.3
26	Detergent	mg/l	0.5	0.5
27	Coliform	MPN/100 ml	5.000	10.000
28	Total pesticide (Except DDT)	mg/l	0.15	0.15
29	DDT	mg/l	0.01	0.01
30	Gross a activity	Bq/l	0.1	0.1
31	Gross b activity	Bq/l	1.0	1.0

A: Water source used for domestic purpose after treatment
B: Water source used for other purposes

Table B10: WB's Guideline for Effluents from Thermal Power Plants

Parameter	Maximum value (mg/l)
pH	6-9
TSS	50
Oil and grease	10
Total residual chlorine	0.2
Chromium (total)	0.5
Copper	0.5
Iron	1.0
Zinc	1.0
Temperature increase at the edge of the mixing zone	less than or equal 3°C

Source: Thermal Power – Guideline for New Plant (1999)

4.4 NOISE STANDARDS

The Vietnam Noise Standards (TCVN 5949-1995) for Public and Residential areas are shown in Table B10. The recommended WB Guidelines for noise emissions for new plants are summarized in Table B11. Comparisons between WB guidelines and Vietnam Noise Standard, shows that for the same norm (commercial area) Vietnamese Standard is more stringent. Using these standards will adequately meet the WB guidelines.

Table B11: Vietnamese Permissible Noise Level in Public and Residential Area

No	Area	Permissible Noise (LEG Value) dB(A)		
		6h-18h	18h-22h	22h-6h
1	Areas needed special low noise: (hospitals, libraries, sanatoria kindergartens, schools)	50	45	40
2	Residential area: Hotels, administration offices, houses, apartment houses, etc	60	55	45
3	Commercial and service areas	70	70	50
4	Small industrial factories in residential areas	75	70	50

Source: MOSTE, Vietnam Standards on the Environment TCVN 5949-1995

Table B12: World Bank Guideline for Noise Emission

Receptor	Maximum Allowable Level dB(A)	
	Day Time (7:00 – 22:00)	Night Time (22:00 – 7:00)
Residential, Institutional Educational	55	45
Industrial commercial	70	70

Source: WB. Thermal Power – Guideline for New Plant, 1999

4.5 INTERNATIONAL ENVIRONMENTAL AGREEMENT

The following information have been provided by the Ministry of Science, Technology and Environment (MOSTE) of Vietnam:

- Vietnam is committed to be involved and take part in any Organization in efforts to reduce the CO2 emissions, which includes the Kyoto Protocol, Rio conference, concerning the greenhouse effect on the environment.

- Vietnam is an active member of the following:
  - Vietnam is the member of Agreement at Vienna in 1995 relating to ozone protection on 26/4/1994
  - Vietnam agreed the Montreal Protocol about pollution control having effecting the ozone layer 26-1-1984
  - Vietnam took part in frame level of United Nation about weather changes in 1992
  - Vietnam is not sign in Kyoto Protocol.

SECTION C

PROJECT DESCRIPTION

SECTION C: PROJECT DESCRIPTION

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The implementation of the Phu My Power Generation Centre (PMPGC) with its five individual power generation projects belongs to the most important development program of the Vietnamese Government. The PMPGC has already been approved by the Vietnamese Government in Approval No 1177/QD – KHDT issued by the MOI on 31/07/1997.

Over the previous five years the Phu My Site has been prepared by the Electricity of Vietnam (EVN) as a location for the installation of the PMPGC, with a total output capacity of approximately 3'800 MW. The site is already connected to the national power grid and main gas supply pipeline. Also the required common infrastructure (e. g. access roads etc) to all the power projects is mainly finalized. In general the following works are already complete or in the final implementation stage:

- Connection to the Vietnamese National Power Grid (Approval No 1729/QD – KHDT issued by the MOI on 30/07/2001)
- Connection to the natural gas supply system from the Nam Con Son gas field
- Cooling water supply system including intake and discharge channels (Approval No. 443/TTg on 03/07/1996 issued by Prime Minister for Investment of Phu My 1)
- Connecting road between main road and PMPGC
- Roads within the PMPGC

In Figure C1 the existing power generation units located in the PMPGC are shown (status December 2001). The situation after completion of all planned power projects is shown in Figure C2. The main data and information about all individual Phu My Power Projects is summarised in Table C1.

Currently at the site only the Phu My 1 Power Project and 4 gas turbines of Phu My 2.1 Project are completed. The current net power generation capacity is about 1'250 MW. After completion of all the projects (scheduled end of 2004) the total net generation capacity of the whole PMPGC will amount to approximately 3'815 MW.

All power projects are based on advanced combined cycle technology with high thermal efficiency more than 50 %. After completion of all the planned projects the PMPGC should totally consist of 13 combined cycle generation units (one unit consists of 2 or 3 gas turbines plus one steam turbine).

Currently not only natural gas but also distillate oil is used by the existing power generation units of PMPGC because of natural gas deficit. At the beginning of the operation period the Phu My 2.2 will be supplied with natural gas originating from the Bach Ho gas fields, located in Bach Ho province. The main gas pipeline is now under construction and is scheduled for completion by January 2003. The supplied gas quantity will be sufficient for the operation of all existing and planned power plant units at the PMPGC. On completion of the natural gas connection, all the power generation units on the PMPGC will operate with natural gas as the primary fuel. Distillate fuel oil with a sulphur content of 0.7% will be used in emergencies only, and further restricted to a maximum of 5 days per year.

The Phu My 2.2 Power Project with a net generation capacity of about 715 MW (approx. 19 % of total generation capacity) represents an important part of the PMPGC. This project is based on a BOT Contract (Build, Operate and Transfer) between MOI and Mekong Energy Company Ltd. (Mekong) and supports the liberalisation and privatisation objectives of the Vietnamese Government in the field of electricity generation and supply.

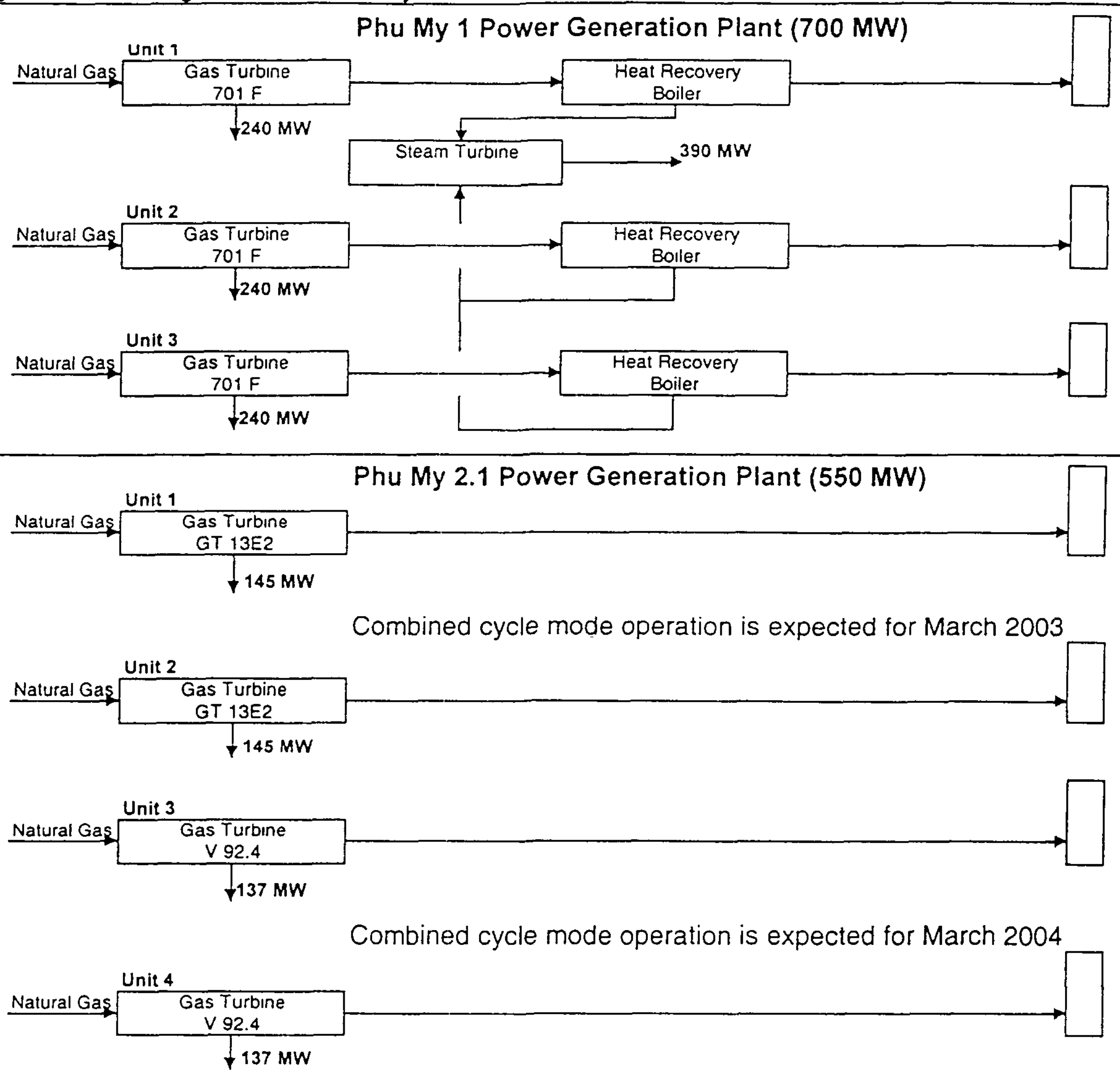
The Phu My 2.2 BOT Project was reviewed and approved by the Vietnamese Government on 18/09/2001 (Approval No. 2226/GP – KHDT Issued by MOI). The Environmental Impact Assessment Report for this project has been performed in 2001 and has also been approved by the Vietnamese Government (see Appendix B2, Approval No 864/QD - BKHCNMT, Issued by MOSTE on 25/5/2001).

Appendix C1 shows the photos of the different parts of the Phu My Power Generation Complex.

Table C1: Main Data of Phu My Power Generation Centre

Project	Phu My 1	Phu My 2.1	Phu My 2.2	Phu My 3	Phu My 4
Status of project: - Project approved - Project in implementation - Project in operation	 Yes Yes Yes	 Yes Yes Yes	 Yes	 Yes	 Yes
Power generation capacity: - Current (Nov. 2001) - Final (expected End of 2004)	 700 1'090	 550 860	 715	 720	 430
No. of main equipment: - Gas turbines - Steam turbines - Heat recovery boilers	 3 1 3	 4 2 4	 2 1 2	 2 1 2	 2 1 2
Start up of operation: - Open cycle mode - Combined cycle mode			Estimated 9/2004 9/2004	Estimated 2004	To be determined
Fuel supply: - Main fuel - Emergency fuel	 Natural gas Distillate oil				
Cooling system: - Type - Cooling water temp. increase	 Once through cooling water system Maximum 7 °C				
Cooling water demand	23..2	22	17	16	11.5

Figure C1: Existing Situation of Phu My Power Generation Centre on December 2001



Phu My 2.2 Power Generation Plant (715 MW)

The plant is scheduled for operation mid of 2004

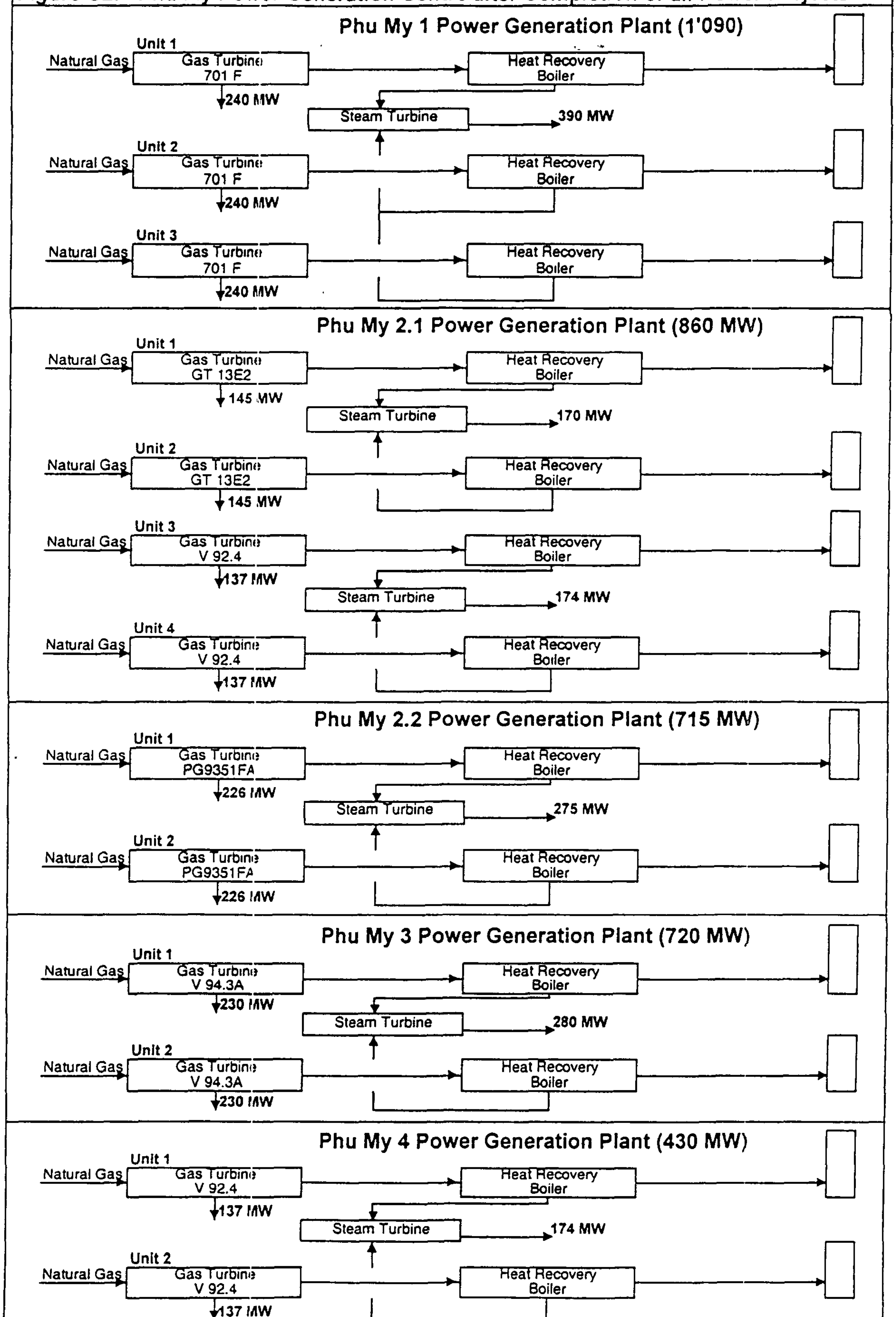
Phu My 3 Power Generation Plant (720 MW)

The plant is scheduled for operation end of 2003

Phu My 4 Power Generation Plant (430 MW)

The plant is scheduled for operation end of 2004

Figure C2: Phu My Power Generation Centre after Completion of all Power Projects



2 PROJECT LOCATION AND PLANT LAYOUT

2.1 LOCATION AND PROJECT BOUNDARIES

The Phu My 2.2 Power Plant will be installed within the boundary of the EVN PMPGC (see Figure C3), which is approximately 75 km southeast of Ho Chi Minh City and is located near the town of Phu My in the district Tan Thanh in Ba Ria–Vung Tau province. The site is approximately 40 km from the port of Vung Tau, in the industrial corridor between Ho Chi Minh City and Vung Tau, and is linked by a major highway, running from Vung Tau port to the proximity of the site. The Phu My Power Plant Centre (PMPGC) is about two km from National Road 51.

The location of Phu My for constructing the PMPGC, consisting of several thermal power projects, was approved by the Vietnamese Government on the 12/09/1995 (Approval No. 560/TTg) consequently approving the transfer of the land, to EVN, to build PMPGC.

The approval was granted due to the following reasons:

- Sound infrastructure, there is an established system of roads and waterways which provide a convenient and accessible transport system: Water supply and electrical power lines which are readily available and can easily be reached from the plant plus a major natural gas supply system which is currently under implementation.
- Excellent possibility for utilising the local rivers (Sau and Thi Vai) as a source of water, and cooling water supply/discharge for the whole PMPGC.
- Interconnection with the national electricity network and close proximity to the largest power consumption centres of Vietnam (Ho Chi Minh City, Dong Nai, Binh Duong and Vung Tau).
- There is no evident topographical hindrance for air emission dispersion.
- The PMPGC has been planned to be close to an industrial zone. Various industrial production plants have already been established in this zone. Sufficient qualified labour for constructing and operating the power plant projects are readily available in the area
- The resettlement of the affected households in the project area has already been successfully completed. Therefore, a Resettlement Action Plan (RAP) is no longer necessary.

2.2 TRAFFIC SYSTEM

Presently, the PMPGC can be reached by Road N1 from National Road N51. This road is about 2 km long and consists of gravel and asphalt concrete.

Inside the PMPGC a road system was constructed/completed by EVN for common use of all the power projects. For the Phu My 2.2 project only the connecting roads within the considered boundary of the project will require constructing. The new roads will be constructed of asphalt concrete overlaying a compacted aggregate base. According to the function and designed loading capacity, internal roads will be classified as A, B, C categories with a width of 8 m, 6 m and 4 m, respectively.

2.3 PLANT LAYOUT

The Phu My 2.2 Plant will be installed in the centre of the PMPGC between existing Phu My 2.1 and projected Phu My 4 (see Figure C3). Three principal areas, the power block, the high voltage switchyard, and the fuel storage and water treatment facilities will be constructed on the project site.

The 500 kV switchyard will be installed to the West of the plant. Transmission lines will be located at the Northwest side to be connected to the EVN grid.

The fuel oil storage tanks will be located to the West, adjacent to the existing fuel oil storage tanks of Phu My 1.

The Phu My 2.2 Power Plant will mainly consist of 2 gas turbine-generator units, 2 heat recovery steam generators and one steam turbine-generator set. Accordingly, the following main principles have been taken into account (general layout is shown in Figure C4):

- The gas Turbine-Generator sets are arranged longitudinally outdoor.
- The exhaust ducts are each fitted with blanking plates.
- The duct and the bypass stacks are supported by steel structures.
- The steam turbine-generator set is installed longitudinally, in parallel with the gas turbines. It is set up on a compact type foundation pedestal.
- The steam turbine generator set is housed in a steel-frame building located between the two gas turbine generator sets. An overhead travelling crane is provided for maintenance purposes.
- The heat recovery boilers (HRSG's) are arranged outdoors in the prolongation of the gas turbine exhaust ducts. They are supported by a steel structure.
- A pipe rack provides overhead routing for main steam and water pipes between the HRSG's and the steam turbine hall.

2.4 MAIN CONSTRUCTION ISSUES

2.4.1 Site Preparation

The project area consists of land that will be required for the construction and operation of the project. PMPGC covers a total area of approximately 128 ha of land, in which only 8 ha will be utilised by the Phu My 2.2 BOT Power Project. Site preparation for the installation of the power units will be restricted to this area.

Other areas within the PMPGC may have connection to the Phu My 2.2 Project but are not considered to be a part of this project (i.e. cooling water supply/discharge systems and main transmission line). These common areas belong to EVN, which are not in the scope of Phu My 2.2 project and have been separately reviewed and approved by the appropriate agencies and in the main already complete.

2.4.2 Man Power Requirement

Current estimation of manpower requirements indicates that the construction labour force for Phu My 2.2 will peak at about 1000 workers on site. During routine operations in the operation phase the labour force will be about 45 persons, with additional skilled labour on site as required during annual maintenance periods.

During the construction period most of the local workers originate from the surrounding area of Phu My Town and will be accommodated in their own houses. Several other workers will be accommodated in the nearby hotels. Since already two similar power plant projects have been successfully constructed (Phu My 1 and Phu My 2.1) at the PMPGC, the hotels and restaurants in this area have sufficient accommodation and catering facilities. Only a limited number of the workers will be staying at the construction site. These workers will be accommodated in camps which the EPC contractor will provide according to the local regulations. The Ba Ria Vung Tau Water Supply Company will supply the water requirements via a existing piping system at PMPGC. The sanitary waste disposal of the camps will be performed by Ba Ria-Vung Tau Environmental Company. Toilets will be connected to the central sewage system of PMPGC. For locations which are not possible, mobile toilets will be used.

Creation of long term, stable, high quality direct employment for approximately 45 people, who will operate the plant, temporary jobs for approximately 1000 skilled and unskilled people during the construction phase, and numerous indirect jobs in the supporting local service and supply industry are some of the main objectives of this project

Figure C3: Plant Layout of Phu My Power Generation Centre at the Phu My Site

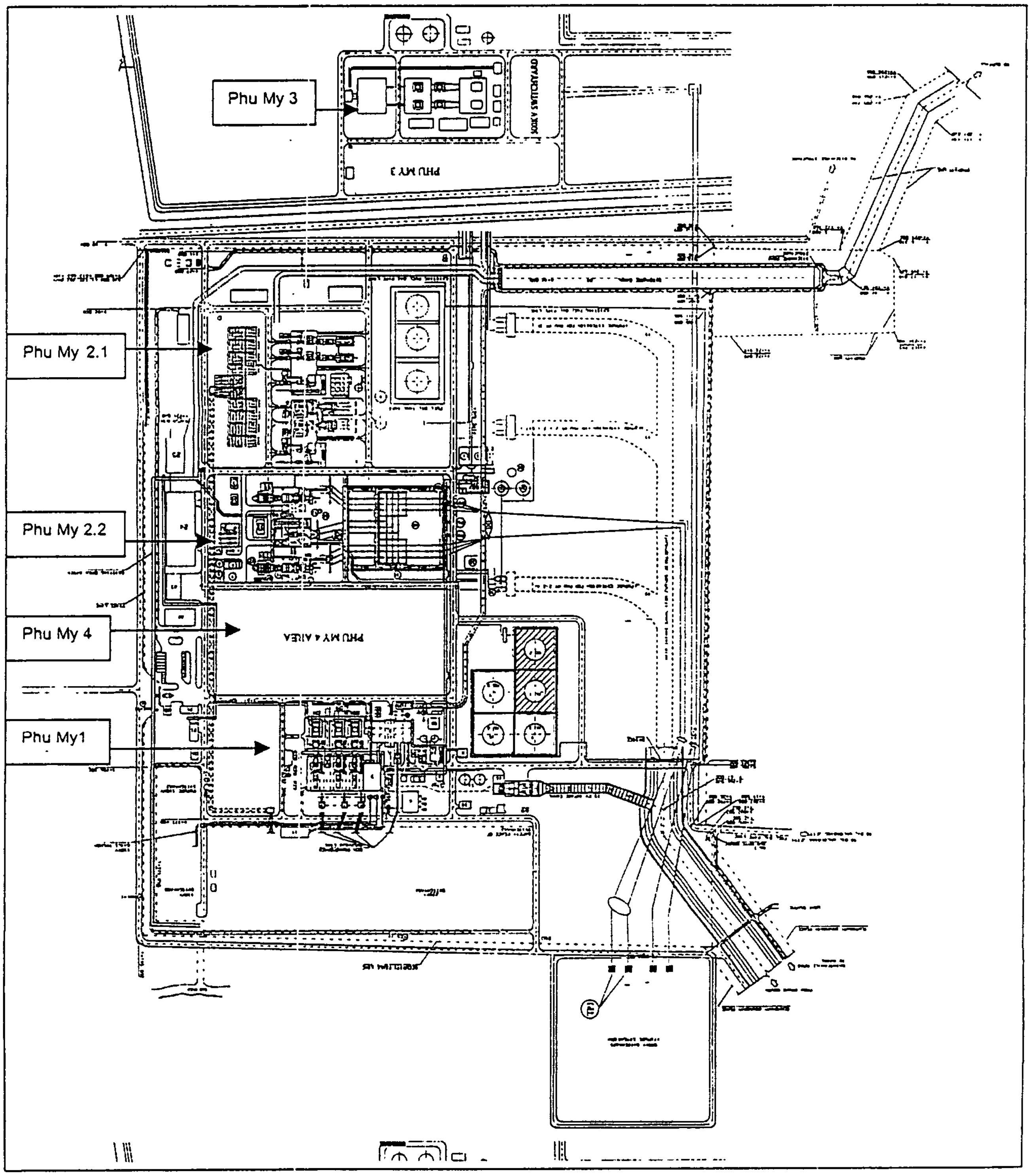
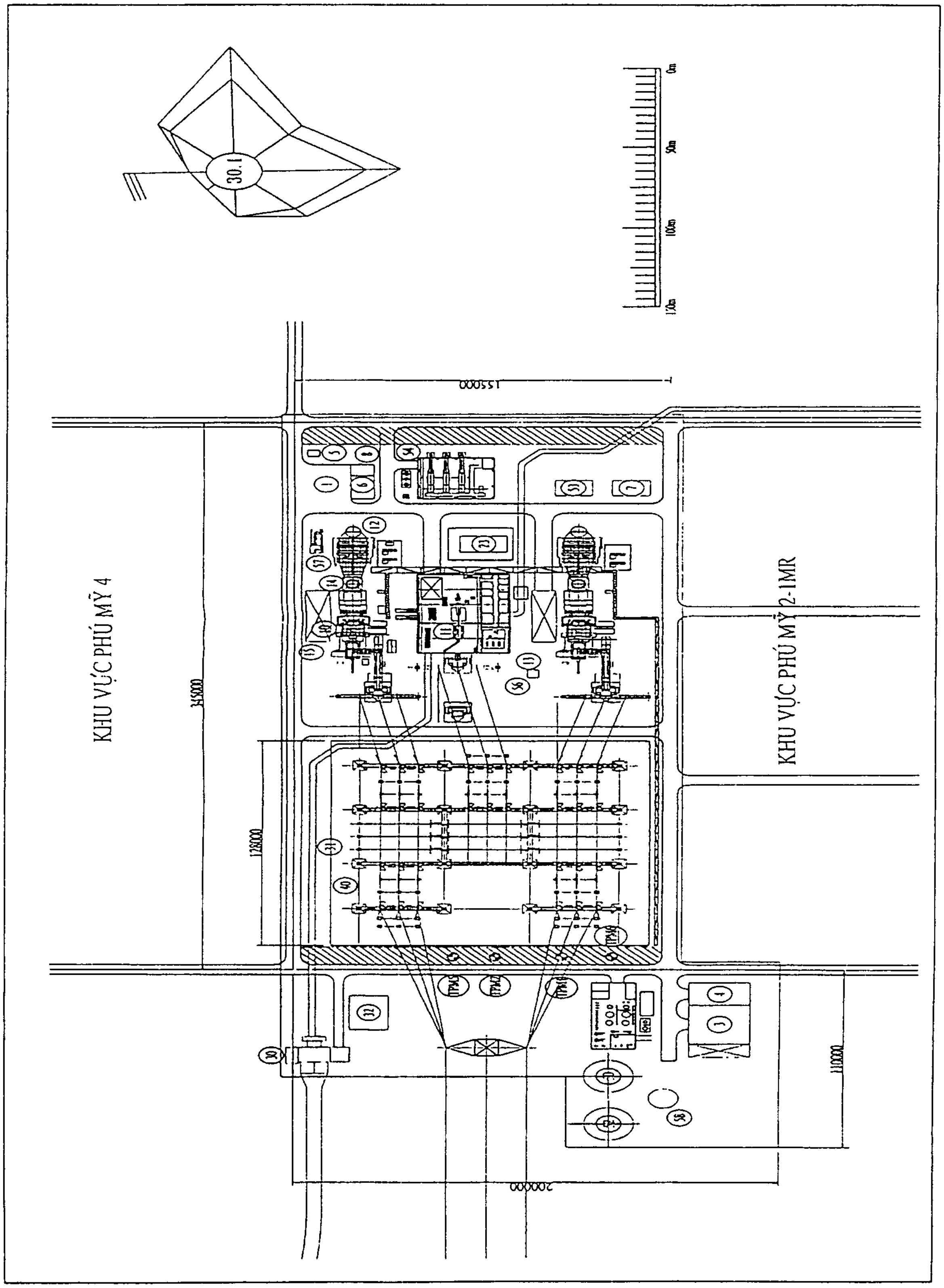


Figure C4: General Plant Layout



3 PLANT CONCEPT

In the following sections the main concepts and data of the Phu My 2.2 Power Project will be presented.

3.1 FUEL SUPPLY

3.1.1 Natural Gas

Natural gas will be the primary fuel for Phu My 2.2 as well as the other power plants located at PMPGC. The power plant will be supplied from the Nam Con Son, offshore basin gas fields by PetroVietnam. PetroVietnam will also provide and operate a gas pre-treatment plant near the PMPGC. A common gas distribution station will be provided to supply natural gas to Phu My 2.2 and other local power plants.

Natural gas will be delivered through a submarine pipeline system to be constructed by a consortium of BP Amoco and PetroVietnam.

The Feasibility Study relating to the gas pipeline construction from Nam Con Son to on-shore was completed and approved by the Government on 23rd March 2000. BP Amoco Consortium contracted with PetroVietnam to buy natural gas from te Nam Con Son on 15th December 2001. Gas from Nam Con Son will reach the shore in the beginning of 2003.

Properties of natural gas:	
Gross Calorific Value:	37 to 47 MJ/Nm^3
Total sulphur content:	< 36 vppm

3.1.2 Distillate Fuel Oil

Distillate fuel oil is considered only an emergency fuel in case the gas supply is unexpectedly interrupted or for emergency reasons e.g. the gas supply has to be disconnected. The quality complies with criteria of the GT supplier specification. The GT systems will be designed to automatically switch from gas firing to oil firing. However, the plant is restricted to operating on distillate fuel oil to maximum 5 days per year.

Distillate oil will be transported to the existing jetty of EVN by waterway and from here it will be transported via a pipeline to storage tanks located on the different Phu My projects (Phu My 1 to 4). The two storage tanks of Phu My 2.2 will have sufficient capacity for seven days continuous operation at full load.

Properties of distillate oil:	
Gross Calorific Value:	44.8 to 46.1 MJ/kg
Sulphur content:	0.7 %
Ash content:	0.01 %

3.2 WATER SUPPLY AND TREATMENT

3.2.1 Fresh Water

The Phu My 2.2 Power Plant will require in average 30 to 50 m^3/h of fresh water as service water, potable water and demineralised water, which all have different quality requirements (maximum 160 m^3/h considering water injection during distillate oil firing for NO_x reduction). The Ba Ria/Vung Tau Water Company will supply fresh water for the Phu-My 2.2 project and the other power plants located on the PMPGC. The common fresh water supply system for the whole PMPGC has already been completed by EVN.

The considered water treatment trains (two) consist of activated carbon filter, cation exchanger, anion exchanger, mixed bed polisher, chemical storage, chemical unloading, preparation, dosing system for regeneration. The system will be changed according to the actual site water characteristics. Demineralised water will be stored in a storage tank which will be designed with the capacity to store sufficient water to provide 24 hours of continuous supply during plant operation including gas turbine water injection for NO_x control while operating on distillate oil.

3.2.2 Cooling Water

The cooling water will be taken from the existing EVN cooling water channel, which is supplied by water from the Sao River. The cooling water pipe runs along the northern side of the switchyard, turns right at the North-East corner of the switchyard, then transits the eastern boundary and turns into the steam turbine hall. After the cooling process the Phu My 2.2 cooling water will be mixed with the cooling water of all other located power plants in the PMPGC and discharged via existing EVN channel into the Thi Vai River.

The whole PMPGC has a cooling water demand of about 90 m^3/s (approx. 324,000 m^3/h) at 100 % load of all generating units. Considering an overall load factor of 80 % for the whole PMPGC (5 generating plants), the total cooling water demand will normally amount to about 70 m^3/s.

The cooling water demand of Phu My 2.2 plant for 100 % plant load amounts to about 17 m^3/s (approx. 61,000 m^3/h), which is about 19 % of the whole cooling water demand of the PMPGC.
The cooling water will be treated in a circulation water chlorination plant. The active chlorine concentration of intake water will be 2 ppm in normal operation and 3 ppm for shock dosing The dosing rate is to be selectable by local control system. The circulating water system will be designed according to requirements of the Thi Vai River Water Standard from 16/02/1995).
The chlorination system will be provided to avoid bacterial and other marine growth in the circulating water system and water treatment system. The Hypochlorite will be generated by the electrolysis of the cooling water. The Hypochlorite will be injected to the circulating water supply line by continuous dosing pumps.

3.3 GAS TURBINE SYSTEM

The considered two GT's of Phu My 2.2 are based on advanced combustion technology with a low NOx emission of 25 vppm (about 52 mg/Nm^3). The gas turbine generator will be directly coupled with the gas turbine. It will be a horizontal, three phases, synchronous, hydrogen gas cooled, totally enclosed type machine.

The main data of the GT's are summarised as follows:

Type:	PG9351FA Outdoor
Number:	2
Capacity:	226 MW (gas fired)
Fuel consumption at 100 % load:	
- Natural gas	119'500 Nm^3/h
- Distillate oil (only emergency)	120'500 kg/h
Exhaust system:	Bypass stack, silencer, and blanking plate. Stack is 30 m high and 6,9 m in diameter
Rotation speed:	3000 rpm
Air compressor + IGV:	18 stages
GT	3 stages
NO_x Emissions control:	
Natural gas	Dry Low NO_x Burner system
Distillate oil	Water injection system
NO_x emission:	
Natural gas	52 mg/Nm^3 based of dry flue gas and 15%O_2
Distillate oil	119 mg/Nm^3 based of dry flue gas and 15%O_2

3.4 STEAM TURBINE SYSTEM

The steam turbine with two casings, combined HP/IP and double-flow LP and reheat is designed to operate in combined-cycle mode with the gas turbine. The steam turbine generator will be directly coupled with the steam turbine. It shall be a horizontal, three phase, synchronous, hydrogen gas cooled, totally enclosed type machine.

The main data of the steam turbine are shown in the following Table:

.Type:	Indoor
Number:	1
Capacity:	275.3 MW
Configuration	Dual casing,
Steam inlet conditions	127 kg/cm^2 at 566°C
Rotation speed:	3000 rpm
Exhaust flow	Down
Back pressure	45.6 mm HgA
Short circuit ratio	0.44
Cooling system	Hydrogen gas cooled
Excitation system	Static excitation

3.5 HEAT RECOVERY SYSTEM

The Heat Recovery Steam Generator (HRSG) is specifically designed to match the operating characteristics of the gas turbine.

The HRSG is designed to be fully integrated into the combined cycle system and includes required inlet/outlet ductwork, structural supports and accessories.

The HRSG is a three-pressure level, reheat, duct-fired, natural circulation type with horizontal gas turbine exhaust gas flow through vertical tube heat transfer sections.

Type:	Outdoor, natural circulation, vertical or horizontal gas flow
Number:	2
Pressure levels	3 level with reheat
Steam generation	637 t/h
Stack:	
- Height	60 m
- Diameter	6.9 m

3.6 FLUE GAS SYSTEM

The flue gases from each heat recovery boiler will be discharged to the atmosphere by a 60 m high stack. The flue gas temperature will be about 95 °C. Stack (by-pass and main stack) test ports will be provided in order to continually monitor the exhaust gas emissions. Stack test port locations will conform to guidelines per U.S. EPA Method 1. The results of the flue gas measurement can be directly monitored in the control room of the plant.

The main data of the flow gas systems and flue gas data of Phu My 2.2 plant for 100 % plant load operation are shown in the Table C2.

Table C2: The main Data of the Flue Gas System and Flue Gas Data

	Dimension	Natural Gas	Distillate Oil
Stack:			
- Number	-	2	
- Height	m	60	
- Inner diameter	m	6.9	
Flue gas flow (air ratio 3.1 and full load)			
- Wet flow gas	10^6 Nm^3/h	4.10	4.37
- Dry flow gas	10^6 Nm^3/h	3.72	4.06
Flue gas composition:			
- H_2O	Vol %	9.15	7.07
- CO_2	Vol %	3.40	4.39
- N_2	Vol %	74.11	75.02
- O_2	Vol %	13.34	13.51
Flue gas pollutant concentration (According to dry flue gas, 15 % O_2):			
- NO_x	mg/Nm^3	52	119
- SO_2	mg/Nm^3	0	376
- CO	mg/Nm^3	20	30
- Particles	mg/Nm^3	Negligible	Negligible
Flue gas temperature	°C	94	139
Continuous flue gas measurement (per units):		NO_x, SO_x, CO, O_2 and Temperature	
Comment: Distillate oil only as emergency fuel, maximum operation 5 days per year			

3.7 WASTE WATER TREATMENT

Wastewater of different quality will be produced from the operation of the Phu My 2.2 Power Plant. All the produced wastewater, including oil contaminated water, chemical contaminated water, and sanitary wastewater will be treated in a treatment plant in accordance with the Vietnamese and World Bank requirements. The treated wastewater will be discharged into the Thi Vai River, located on the South side of the PMPGC.

Waste streams directed off-site are as follows:

- Sanitary waste will be collected to a septic tank and treated. The treated water will be discharged into the cooling water discharge channel.
- Drain systems, including plant drains, oily drains after passing through an adequate wastewater treatment system including such as an oil/water separator, neutralisation tank, coagulation and filtration equipment, discharge to the cooling water discharge channel

Since the wastewater is treated before release into the discharge channel, the quality of these complies with the Vietnamese Effluent Standards (TCVN 5945-1995.

3.9 SOLID WASTE DISPOSAL

Because natural gas is the primary fuel there will be no solid wastes (e. g. fly ash) produced in connection with the operation of Phu My 2.2 Power Plant. Some solid waste is created during the maintenance activities. such as air filter elements.

The Oily waste collected after oil/water separation as well as the other municipal and special wastes will be collected and transported by an external disposal contractor (Ba Ria-Vung Tau Environmental Company) for recycling purposes or special disposal depending on provincial disposal requirements.

3.10 ELECTRICAL SYSTEM

3.10.1 Switchyard

Electrical power will be generated at 15.75 kV and 50 Hz, by two gas turbine generators and one steam turbine generator and will be transmitted to the 500 kV System via main unit step-up transformers. Within each gas turbine unit, there is a unit auxiliary transformer, which is connected to the Isolated Bus duct and supplies power to the auxiliary circuits. During start-up, auxiliary power is supplied from 500 kV via unit transformers.

The Phu My 2.2 500 kV switchyard will be an open terminal design configured in a single busbar system, two bays of gas turbine-generator units, 1 bay of steam-turbine generator unit and two feeders connected to the EVN 500 kV switchyard.

3.10.2 Auxiliary Electrical System

The auxiliary electrical system of the power plant is designed to provide station power through unit transformers fed from the primary (16 kV) unit bus. The power for the unit auxiliaries is taken from the primary unit bus during normal on-line operation or back-fed from the 500 kV switchyard via the unit step up transformers, when the Facility is off-line.

The proposed auxiliary system voltages are 6.6 kV for main auxiliary electrical cubical and 0.4 kV for the low voltage auxiliaries.

3.10.3 Power Control System

The control systems will enable remote control and supervision of generating plant operations from the Central Control Room.

3.10.4 Power Transmission System

Phu My 2.2 will be connected to the grid via the EVN 500 kV switchyard at the North of Phu My 1 Power Plant. There is one 220 kV outgoing double circuit transmission line, which is located at the right East boundary of the PM2.2. The conductor size is AC185.

3.10.5 Fire Protection System

The fire protection system designed in accordance with NFPA and Vietnamese standards consists of an underground/overhead distribution system extending around all operating areas with a looped configuration to provide multi-directional fire water supply to maintain high reliability. CO_2 fire protection system will be applied for gas turbine enclosures and bearings. Fire hydrants will be provided along the distribution system at approximately 80 meter intervals. Each hydrant will be provided with an individual curb box valve. Auxiliary equipment and tools will be provided in an equipment hose house located adjacent to each fire hydrant. Portable fire extinguishers will be provided throughout the plant.

One electrical motor driven fire water pump, one diesel driven fire water pump and one jockey pump supply the fire water to fire ring main and take suction from the service water tank.

Smoke detectors will be installed for offices and electrical/switchgear rooms. Heat detectors will be installed for workshop building. Rate of rise heat detectors will be installed for lube oil unit, transformer area, H_2 generating plant building.

A fire detection and alarm system will be provided to monitor the various areas throughout the combined-cycle facility. The system includes a main fire control panel in the central control room that monitors the status of various detectors and pull boxes. The fire detection and alarm system will be designed in accordance with NFPA 70, 72 and 72^{E} and Vietnamese standards.

4 OPERATIONAL CONCEPT

The scheduled total operational time of Phu Power Plant is 20 years. The two units of the plant will be operated and controlled automatically from the central control room of the plant. Remote operational philosophy for start-up, shutdown and automatic operation under load will be applied.

The annual average plant load factor will amount to approx. 75 %, corresponding to 6'570 equivalent full load operation. About 45 persons will be required for the operation of the plant. An external maintenance contractor will provide the main maintenance services.

Table C3 summarises the main operational data of the Phu My 2.2 Power Project.

Table C3: The main Operational Data of the Phu My 2.2 Power plant

	Dimension	Natural Gas	Distillate Oil
Annual operational time	h/a	7'884	Max. 120
Annual average plant load factor	%	75	only
Annual equivalent full load operation	h/a	6'570	emergency
Plant thermal efficiency	%	54.7	51.2
Net heat	kJ/kWh	6,580	7,038
	kW/kWh	1.83	1.95
Net power generation capacity	MW	715	724
Annual net power generation	GWh	4,698	
Fuel consumption at 100 % load	Nm^3/h	119,500	
	t/h		120.5
Cooling water demand	m^3/s	17	
Maximum circulating water temperature rise	°C	7	
Emissions:			
NOx	mg/Nm^3	52	119
CO	mg/Nm^3	20	25
Noise emission levels (guaranteed values of BOT Contract):			
PMPGC site boundaries	dB(A)	70	
- Night	dB(A)	70	
- day			
	dB(A)	90	
1 m distance equipment			

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SECTION D

BASELINE DATA

SECTION D: BASELINE DATA

TABLE OF CONTENT

LIST OF TABLES

LIST OF FIGURES

1 ASSESSMENT OF THE STUDY AREA

Phu My town belongs to Tan Thanh district, Ba Ria - Vung Tau province. It lies on both sides of National Road 51 from Km 44 (My Xuan commune) to Km 47 (Phuoc Hoa commune). It is located on the left bank of the Thi Vai River, which is the border between Phu My town and Can Gio district of Ho Chi Minh City.

Phu My was upgraded to a town in August 1994. It is the administrative centre for the district and also a centre for the industrial parks of the province. Its area is approximately 3,173 ha and the population in 1999 was 10,020 (It was 8,651 in 1998).

The Phu My Power Generation Centre (PMPGC) is approximately 75 km southeast of Ho Chi Minh City and 40 km from the port of Vung Tau, it is located near the town of Phu My (formerly Phu My commune) in the district Tan Thanh in Ba Ria–Vung Tau province (see Figure D1). The site is in the industrial corridor between Ho Chi Minh City and Vung Tau, and is conveniently linked by a major highway (National Road 51), running from Vung Tau port to the proximity of the site. The Phu My Power Generation Centre (PMPGC) is located about two km from National Road 51.

The PMPGC project site (see Figure D2) occupies an area of approximately 128 ha of land, in which only 8 ha will be utilised by the Phu My 2.2 BOT Power Project.

Figure D1: Location of the Phu My Power Generation Centre

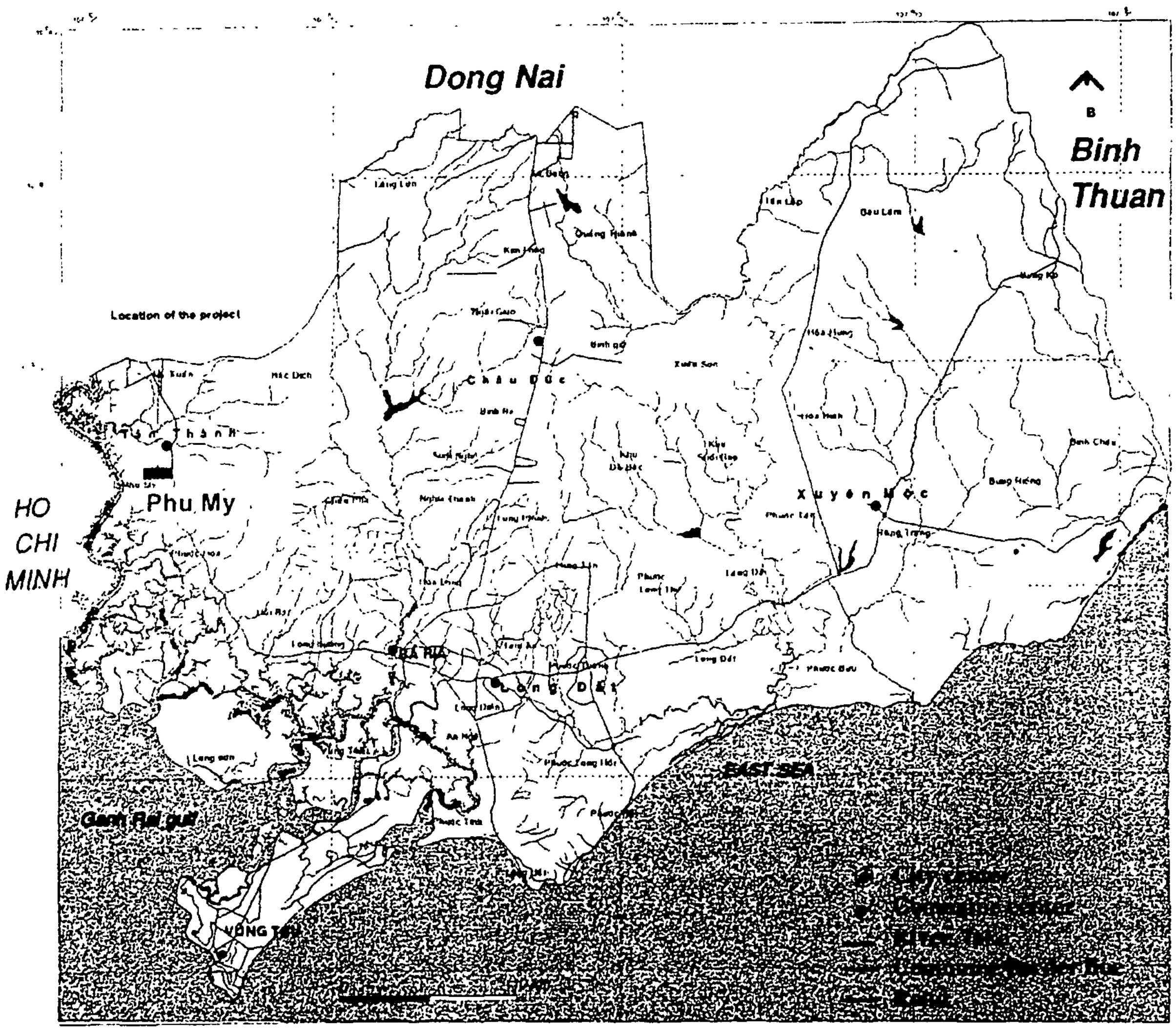
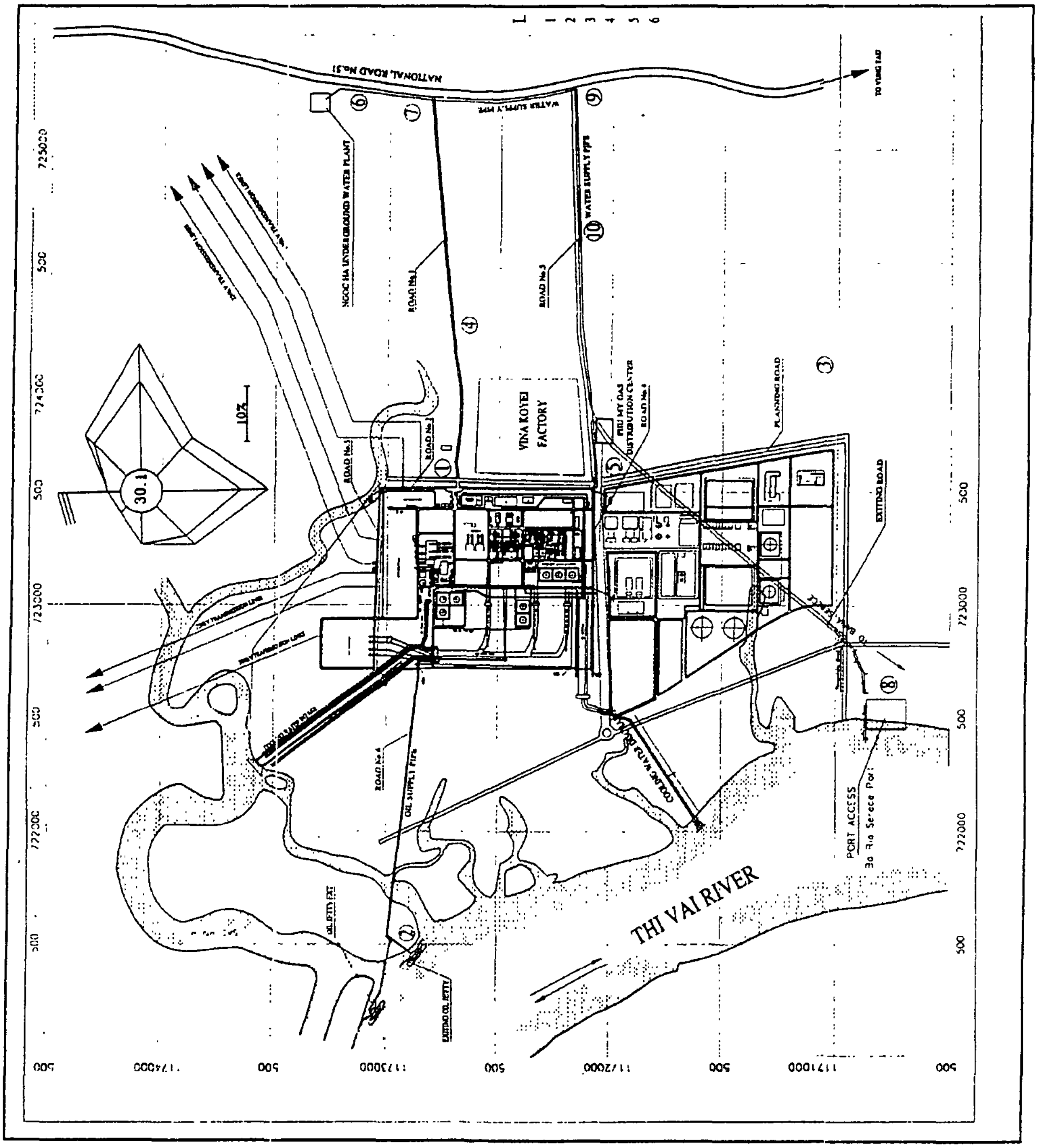


Figure D2: Location of the Phu My 2.2 Power Project



2 DESCRIPTION OF THE RELEVANT PHYSICAL CONDITIONS

2.1 TOPOGRAPHY AND GEOLOGY

The town of Phu My (formerly Phu My commune) of Tan Thanh district (Ba Ria-Vung Tau province) is located in a flat area with an altitude sloping from the East (near the foot of Thi Vai Mountain) 50-60m to the West (the riverside of the Thi Vai River). Although Thi Vai Mountain is about 470 m high, it will not obstruct or impact on the dispersion of the flue gas from the power plant because it is approximately 5 km from the project site and occupies a very small area.

Although the site is adjacent to an area of rocky mountain terrain, the soil in the southeast area of Phu My is primarily red–yellow soil on granite. The area north of the general site location is primarily grey soil on granite and the project site itself is grey soil over an ancient alluvial substructure. The riverside of the Thi Vai area consists of a saline soil and potential acidic sulphate soil in deep layers.

The grey soil on granite and ancient alluvia has a low content of organic matter and moisture. The foundation of the plant is based on an area of sandy clay having a low water-retention capacity. Historically the land was utilized for agricultural purposes, the primary crops being cashew and eucalyptus trees. The Thi Vai and Sao riversides/banks mainly consist of mangrove forest where the soil contains sulphate, chloride, sodium, and potassium compounds at significant levels of concentration. The naturally occurring composition of the native soil completely inhibits any significant potential for agricultural development in this area and the site in specific. It is impossible to cultivate rice on any significant portion of the project site. Therefore, only cashew, eucalyptus and comrnon indigenous shrubs could sustain reliable growth; only those specific vegetation species with high salinity tolerance can be developed in the area along the Thi Vai and Sao Rivers.

2.2 CLIMATE

According to a data study on the Ba Ria – Vung Tau environment [25], the expected climatic characteristics at the project area are summarized in the following sub-sections.

2.2.1 Atmospheric Temperature

Ba Ria-Vung Tau province has a high and stable atmospheric temperature (Table D.1). The average annual temperature varies between 24.8 (January) and 29.1°C (May). In the hottest months (April, May), the monthly average temperature is about 29°C and in the coldest month (December in mainland, January offshore) the monthly average temperature is about 25°C. The annual amplitude of temperature is narrow, about 3 – 4°C as for both the sea and mainland.

Table D1: Air Temperature at Vung Tau Station (October 1996-September 1997)

	1996				1997							
	X	XI	XII	I/	II/	III	IV	V	VI	VII	VIII	IX
Max (°C)	32.1	31.3	30.7	29.4	30.8	31.8	32.6	34.3	34.2	32.3	32.9	32.8
Average (°C)	27.1	26.9	25.6	24.8	26.6	27.0	28.8	29.1	28.9	27.5	27.6	27.9
Min (°C)	23.3	23.3	19.0	20.2	23.5	22.2	25.5	22.9	24.2	22.7	23.4	23.0

2.2.2 Solar Radiation

The annual average of total radiation in Ba Ria – Vung Tau varies between 155 and 165 kcal/cm^2, and the annual average of radiation balance varies between 80 and 90 kcal/cm^2. The monthly maximum radiation is 17.6 kcal/cm^2 (in March) and monthly minimum radiation is 11.2 kcal/cm^2 (in November).

The maximum radiation occurs in March, which is also usually the driest and least cloudy period during any year. The minimum radiation falls in November because it is the transitional period between the rainy season and the dry season (at the same time, from the hot season to the cold season). The temperature decreases, as does solar radiation although the sky is generally still very cloudy and frequently rainy.

Ba Ria-Vung Tau is one of the provinces receiving the most sunlight of any area in Vietnam. The average of sunny hours in a year there is about 2300 – 2800 with the maximum of 300 hours in March (average 9.7 sunny hours per day) and the minimum of 127 (average 4.1 sunny hours per day) in December (Table D2).

Table D2: Sunny Hours at Vung Tau Station (October 1996- September 1997)

	1996			1997								
	X	XI	XII	I/	II/	III	IV	V	VI	VII	VIII	IX
Total Sunny Hours	158.1	144.0	127.1	282.1	232.5	300.7	275.9	207.7	244.9	186	176	193.2
Daily Maximum	10.7	10.6	10.3	10.2	10.6	11.1	11.3	10.7	11.2	10.5	10	10.5

2.2.3 Atmospheric Pressure

The atmospheric pressure varies a little between seasons of a year. It's average is between 1008 and 1012 mbar in the dry season and between 1008 and 1010 mb in the rainy season. The maximum can reach 1016 mbar and the minimum 1003 mbar (Table D3).

Table D3: Atmospheric Pressure at Vung Tau Station (October 1996- September 1997)

	1996			1997								
	X	XI	XII	I/	II/	III	IV	V	VI	VII	VIII	IX
Max (mbar)	1012.1	1012.4	1014.6	1015.5	1013.6	1015.2	1012.9	1011.8	1013.4	1010	1013	1014.2
Average (mbar)	1008.7	1008.7	1010.5	1012.4	1010.3	1011.8	1010.5	1008.3	1008.7	1008	1008	1008.7
Min (mbar)	1005.4	1003.5	1007.1	1007.6	1007.1	1009.0	1008.0	1004.5	1003.5	1005	1003	1003.5

2.2.4 Evaporation

The evaporation rate in Ba Ria-Vung Tau is considered to be the highest in Vietnam. That indicates that the area is very rich in radiant heat, energy and wind.

The annual average of evaporation has been recorded for many years at Dai Tung Lam (Phu My) station (adjacent to the project site), where the highest evaporation (140 - 160 mm) falls in

March, and the lowest (49 - 62 mm) in September. The annual total of evaporation is over 1,100 mm.

2.2.5 Humidity

Because of great differentiation in radiation between the dry season and the rainy season, the difference in humidity between the two seasons is very large. In the rainy season, the monthly average of relative humidity varies between 79 and 86%. In the dry season this value varies between 75 and 84% (Table D4). The annual variation of humidity, the high record falls in October-December, the low record in April or March. In this variation, the relative humidity is lowest from 12 a. m. to 2 PM (when the temperature is highest in the day) and the highest from 5 to 6 a.m.

Table D4: Monthly Relative Humidity at Vung Tau Station (October 1996 – September 1997)

	1996			1997								
	X	XI	XII	I/	II/	III	IV	V	VI	VII	VIII	IX
Max (%)	97	97	97	97	94	91	96	97	93	96	94	98
Average (%)	86	84	82	77	76	75	76	79	79	83	83	83
Min (%)	62	64	43	46	51	54	53	49	52	62	60	62

2.2.6 Rainfall

In Ba Ria – Vung Tau province, there is an intensive differentiation between the rainy season and the dry season. Rainfall in 6 months of the rainy season accounts for 85 to 90 % of the total rainfall in a year. In the period from May to October, the monthly average of rainfall at Phu My is 230 to 319 mm and in the period from December to April, it is only to 9-35 mm, and even lower than 5 mm per month in some regions (e.g. Long Thanh) in the period from January to March (Table D5). The middle of the dry season (January - March) is in fact a period of drought during which water for domestic use and agriculture is a problem for the province.

Table D5: Annual Average of Rainfall in the Region (in mm)

Location	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Vung Tau	2.2	0.6	4.6	33.0	188.1	206.1	213.4	172.6	214.3	215.4	68.8	22.7	1346.8
Dai Tung Lam	12	9	14	47	230	249	261	258	249	319	87	35	1770
Long Thanh	9	5	10	67	222	289	317	323	335	287	117	43	2007

During the rainy season (May to October) there are 15 to 20 rainy days in a month. The rainfall in the area of Vung Tau City is less than that of the mainland. However, as Vung Tau is a peninsula projecting into the sea, the number of rainy days there is higher.

2.2.7 Wind

At Vung Tau station, wind velocity varies continuously in a year with an average of between 2.0 to 4.6 m/s (Table D6).

Table D6: Annual Average Wind Velocity (1997)

Location	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Vung Tau	3.2	4.6	4.7	3.8	2.7	3.2	2.8	2.9	2.3	2.0	2.4	2.9	3.2
Ganh Rai Bay	4.5	4.8	5.6	5.4	4.3	4.8	5.2	5.4	4.4	4.4	5.0	5.2	4.9
Thi Vai	3.9	4.0	4.4	3.2	2.5	2.8	2.7	3.6	2.7	3.0	2.8	2.9	3.2

The project site is influenced by two kind of monsoon:

- The Southwest, West – Southwest wind mostly appears in the rainy season (May October) with an average speed of 2.0 to 3.2 m/s. It usually brings rain.
- The East, East – Northeast wind mainly appears in the period from November to April with an average speed of 2.4– 4.7 m/s.

It is not an area characterized by a high frequency of typhoons or tropical storms but low intensity tempests are common.

2.2.8 Storm and Tropical Low Pressure

High-grade storms resulting from extreme tropical low, pressure zones rarely occur in Southern Vietnam or the Ba Ria – Vung Tau area. Storms together with wind having a grade velocity of 9 - 10 m/s are very rare. Storm and tropical low pressure, occasionally occur in the September to December period, most frequently in November. The major storm direction is South or West - Southwest moving. Most storms appear in offshore areas.

Thirty five to forty tempest days in a year are recorded in Ba Ria-Vung Tau, out of which the period from May to October (the rainy season) observes most tempests (strong wind, heavy rain, thunder, and lightning), which could cause damage to people and capital material assets, especially antennas and multi-storey buildings.

The season of north/easterly winds lasts from December to April with the strongest winds occur in the period from December to February. The wind speed in the peak north/easterly wind season is usually over 10 m/s (frequency over 50%) offshore. Notably offshore, strong winds obstruct fishery and transportation between mainland and derricks.

2.3 HYDROLOGY AND WATER QUALITY

2.3.1 Hydrological Characteristics

The Sao River:
The Sao River including the Muong stream runs across the project site. The Sao River originates from Trinh Mountain at the Northeast of the project site. It runs across National Road 51 at the Ngoc Ha Bridge then joins the Thi Vai River, Northeast of the site. The Sao River provides the Phu My Power Generation Complex with cooling water. The real flow rate of the Sao River is about 5.0 m^3/s in the rainy season and 3.0 m^3/s in the dry season. Sao River can be considered as a branch of the Thi Vai River. To supply enough cooling water for Phu My power complex, The Electricity of Vietnam (EVN) has commenced a project of dredging the Sao River. The project is ongoing, and scheduled to be completed by the end of 2002. The designed capacity of the Sao River after dredging is complete will be at least 90 m^3/s.

The Thi Vai River:
The Thi Vai River is the waterway for transporting fuel to the Phu My Power Generation Centre. It will also receive the heated cooling water from the cooling water systems of all the existing and proposed power plants (Phu My 1, 2.1, 2.2, 3 and 4). With a length of approximately 40 km, the River originates from Long Thanh (Dong Nai province), running through the districts of Tan Thanh and Chau Thanh of Ba Ria – Vung Tau province, discharging the water into the East Sea through the Ganh Rai gulf. Downstream, the Thi Vai River has tributaries linking with the Saigon – Dong Nai River systems.

The river basin is small (77 km^2) and its length is short. The width of the river reaches 700 to 800 m at the estuary. The riverbed is deep with a U-shape cross-section. The depth nearby the power plant is about 10 – 15 m. The hydrological regime of the Thi Vai River significantly depends on a regime of semi-diurnal tide.

The Thi Vai River, water flow rate varies from 0 (at the transition period) to a maximum level of 10,000 m^3/s. The flow rate is predominantly tidal, the river flow rate itself only accounts for 5-10 % of the total flow. The water flow from the river is definitely large enough for PMPGC cooling demand (totally 90 m^3/s for all units and 100 % plants load) using the direct flow cooling method that is the most economical.

The readings of the water level monitoring station at Go Dau indicate that the average water level in the dry season is higher than in the rainy season. The tidal amplitude has an average at 310 cm, maximum is 465 cm, and minimum is 151cm (Table D7). The readings recorded within the past decades indicate the maximum tidal height of + 2.20 m and the minimum of – 3.50 m. Tidal movement primarily produces the flow. When the rising tide, changes to ebb tide or vice versa, the speed of the water flow reaches 0 (v = 0) but this phenomenon does not last long and usually coincides with tidal peaks.

Table D7: Monthly Tidal Level at Phu My on the Thi Vai River (April 1990/March 1991)

Tidal Level (cm)	1990									1991			Annual
	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	
Mean	296	297	307	296	284	284	279	291	286	296	279	285	290
Max	407	425	445	432	399	373	392	443	433	426	388	369	445
Min	201	213	188	195	180	187	188	169	145	172	175	175	145

Source: DOSTE Ba Ria – Vung Tau Province, 1991

In the dry season (6th April 2000) at the Phu My site, water levels of 89–380 cm were recorded. On this particular day the maximum flow speed recorded on the Thi Vai River was 1.06 m/s and the maximum flow was 2,198 m^3/s (Table D8)

Table D8: Tidal Level and Discharge of the Thi Vai River at Phu My (6th April 2000)						
Hour	Water Level	Area of Wet Cross Section (m^2)	Average Velocity (m/s)	Discharge (m^3/s)		Flow Direction
				In (-)	Out (+)	
9	89	1,439	0.078		112	Out
10	113	1,503	- 0.277	- 416		In
12	230	1,829	- 0.359	- 657		In
15	380	2,254	- 0.184	- 415		In
18	315	2,068	1.063		2,198	Out
21	74	1,399	0.171		239	Out
24	188	1,706	- 0.457	- 810		In
Source: VESDEC, 2000						

2.3.2 Water Quality

The results of several investigations of water quality of the Thi Vai River carried out by VESDEC are summarized in Tables D9 to D11. The investigations were performed at several locations along this river according to Figure D3.

Considering the results of these investigations the Thi Thi Vai River is only lightly polluted. The primary, pollution sources have identified is the industrial parks at Go Dau upstream of the PMPGC, plus to a certain extent transportation (shipping) and the fishing vessels of the local residents also contribute to the pollution. The Phu My Power Generation Centre with natural gas as main fuel does not significantly contribute to this pollution.

The concentration of bacteria (coliform, E.coli) in water of the Thi Vai River (Go Dau Port area: 15,000 MPN/100 ml, Tac Nha Phuong area: 43,000 MPN/100 ml) is higher than the Vietnamese Standard (TCVN 5942-1995: maximum allowable concentration of bacteria in surface water is 10,000 MPN/100 ml for water source of B class (see Section B, Table B8). This is most likely the result of the river directly receiving effluent from the canals running across residential areas.

The concentration of pollutions at the Sao River (cooling water intake of PMPGC) is similar to that of the Thi Vai River at the Phu My port (see Table D8, sites M4, M5, M5a).

Table D9: Water Quality of the Thi Vai River at Phu My port (measured 1996-1997)						
Parameter	Unit	Mar 96	June 96	Sep 96	Dec 96	Mar 97
Temperature	T C	29	28.7	28.6	28.6	28
PH	-	7.1	7.8	6.9	6.8	7.1
EC	(µS/cm)	46,000	39,950	30,000	38,000	39,600
Turbidity	(NTU)	2	3	19	12	8
SS	(mg/l)	5	6	20	60	5
NH_4^+ (as N)	(mg/l)	0.03	1.9	1.3	0.21	0.29
NO_3^- (as N)	(mg/l)	0.5	0.22	0.15	0.09	1.4
PO_4^{3-} (as P)	(mg/l)	0.03	0.05	0.09	0.02	0.03
DO	(mg/l)	4.1	5.6	6.7	5.6	5.6
BOD_5	(mg/l)	9	13	12	13	3
$\sum$ soluble Fe	(mg/l)	0.07	0.35	0.43	0.1	0.35
Pb	(mg/l)	0	0	0.039	0.019	0.005
Hg	(mg/l)	<0.2	0.5	0.3	<0.2	0.3
$\sum$ Coliform	MPN/100ml	460	2400	2400	64	72

Table D10: Water Quality of the Thi Vai River (measured August 2000)

Parameter	Unit	L1	L2	L3	L4	L5
PH		6,4	6,5	6,4	7,6	6,8
Turbidity	NTU	72	65	76	37	22
SS	mg/l	38	31	35	16	8
DO	mg/l	6.2	5.8	5.6	5.9	4.3
BOD_5	mg/l	6	5	6,0	3	4
N-NH_4	mg/l	0	0	0.26	0.01	2.56
N-NO_3	mg/l	0.33	0.40	0.13	0.20	0.11
P-PO_4	mg/l	0.04	0.04	<0.01	0.03	0.02
Cr	mg/l	<0.01	<0.01	0.10	<0.01	<0.01
Oils	mg/l	0.12	0.16	<0.01	0.08	0.12
Cd	mg/l	<0.01	<0.01	<0.2	<0.01	<0.01
Hg	mg/l	<0.2	<0.2	0	<0.2	<0.2
Phenol	mg/l	0	0	8.27	0	0
Total Fe	mg/l	4.53	3.17		1.02	0.18

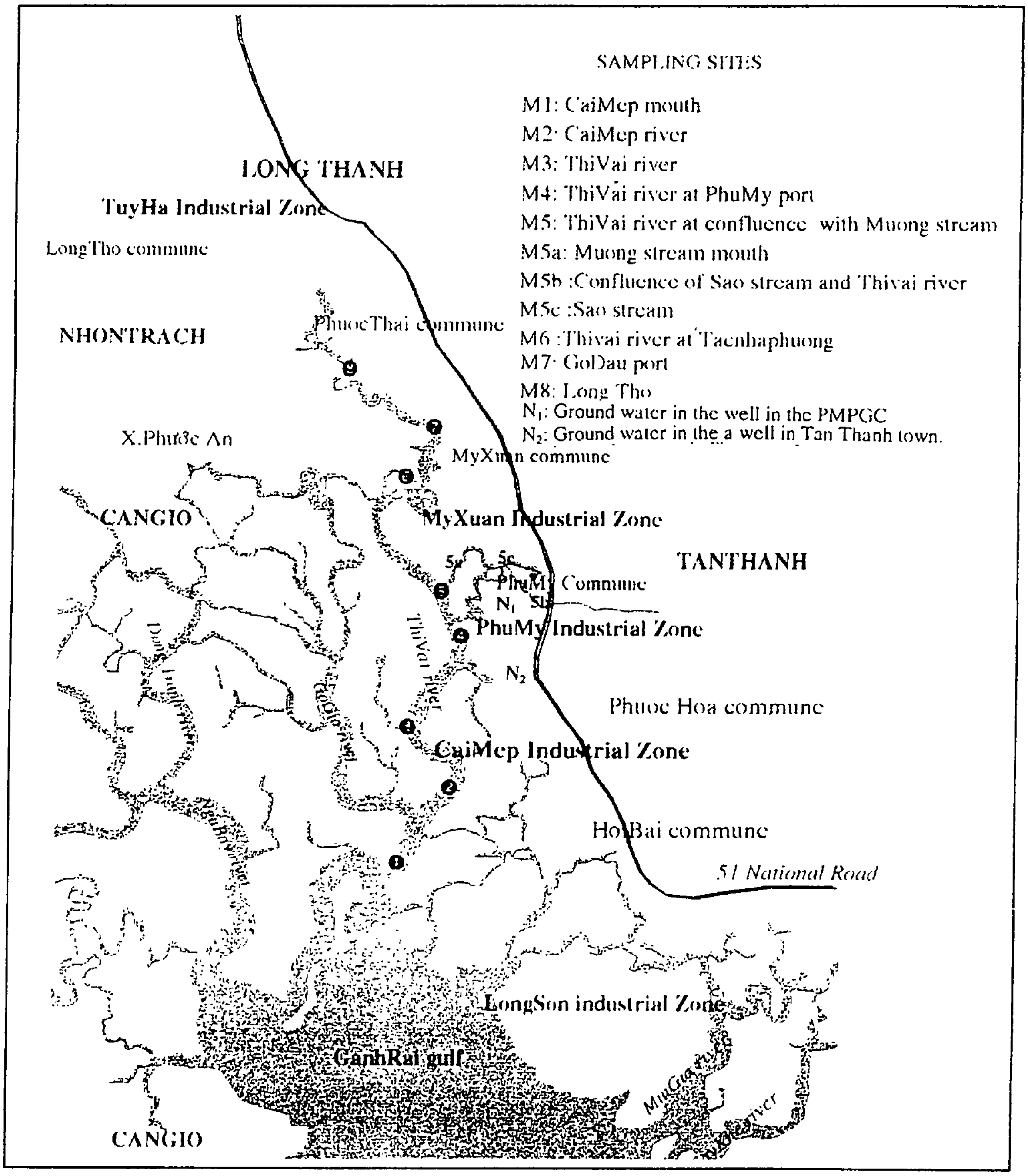
a) Sources: VESDEC
b) Location of monitoring sites:
L1: Phuockhanh
L2: Binhkhanh
L3: Vamsat
L4 Thienglieng
L5: Vedan (Thivai river)

Table D11: Results of Water Quality Monitoring at the Thi Via River (January 2000)

No	Parameter	Unit	M1	M3	M4	M5	M5a	M5b	M5c	M6	M7	M8
1	PH		7.9	7.2	7.3	7.2	6.8	7.6	7.1	6.8	7.1	6.7
2	Temperature	^oC	28.5	29.0	29.0	29.0	29.5	29.2	29.2	29.5	28.5	29.0
3	SS	mg/l	55	60	52	65	60	70	62	95	120	125
4	DO	mg/l	5.2	5.5	5.5	5.2	4.5	5.0	4.5	3.8	3.5	3.0
5	EC	$10^3\mu S/cm$	50.2	45.2	42	38	35	37	36	32	31.5	28.0
6	NO_3^- (as N)	mg/l	0.15	0.16	0.24	0.20	0.19	0.26	0.17	0.22	0.25	0.31
7	PO_4^{3-} (as P)	mg/l	0.10	0.11	0.08	0.07	0.07	0.05	0.07	0.07	0.09	0.11
8	Fe	mg/l	0.20	0.17	0.13	0.17	0.14	0.24	0.31	0.22	0.24	0.13
9	BOD_5	mg/l	5	7	6	6	7	3	5	4	4	5
10	Grease+Oil	mg/l	0.04	0.04	0.05	0.08	0.06	0.10	0.06	0.08	0.08	0.06
11	Phenols	mg/l	0	0	0	0	0	0	0	0	0	0
12	Pb	µg/l	1.7	2.1	1.8	1.2	2.8	1.0	1.6	2.7	2.0	2.4
13	Zn	µg/l	6.8	8.5	7.3	9.0	7.8	8.2	8.8	6.2	5.4	9.4
14	T-Coli	MPN/ 100ml	240	1400	900	2300	3900	15000	43000	21000	93000	4000
15	F-Coli	MPN/ 100Ml	30	400	0	900	1400	15000	7000	15000	43000	4000
16	NH_4^+ (as N)	mg/l	0.01	0.15	0.20	0.15	0.15	0.20	0.35	0.55	0.85	0.75
17	Hg	µg/l	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2
18	Cd	µg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
19	Cr	µg/l	<1	10	10	20	15	20	10	20	20	10
20	As	µg/l	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1

a) Spurces: VESDEC
b) No 1 to 15 monitored in January 2000
No 16 to 20 monitored in May 2000
c) Location of monitoring sites:
M1: Cai Mep mouth (Thi Vai River mouth)
M3: Thi Vai River at Caimep
M4: Thi Vai River at Phu My port
M5: Thi Vai River at confluence with Muong stream
M5a: Muong stream mouth (Sao River at the project site)
M5b: Confluence of Sao Stream and Thi Vai River
M5c: Sao stream
M6: Thi Vai River at Tac Nha Phuong
M7: Thi Vai River at Go Dau port
M8: Thi Vai River at Long Tho

Figure D3: Locations of Water Sampling Points at Thi Via River



2.3.4 Groundwater Quality

The results of analyses of ground water of a well in PMPGC and of a well in Tan Thanh town are summarized in Table D12. Comparing the measured data with the Vietnamese allowable limits in ground water (see Section B, Table B9), only the pH value do not meet the standard requirements (pH: 4.4 to 5.2 in comparison to 6.5 to 8.5).

Table D12: Quality of Groundwater in Phu My Site (measured February 2000)

Parameter	Unit	N1	N2
PH		4.4	5.2
EC	µS/cm	250	320
SS	mg/l	0	0
Turbidity	NTU	1	2
NH_4^+ (as N)	mg/l	0.26	0.35
NO_3^- (as N)	mg/l	0.03	0 05
NO_2^- (as N)	mg/l	< 0.01	0 02
ΣP	mg/l	0.008	0.015
Cl^-	mg/l	< 5	15
ΣFe	mg/l	0.99	1.25
Hardness (as $CaCO_3$)	Meq/l	0.07	0.12
HCO_3^-	mg/l	6.1	5.2
Ca	mg/l	0.26	0.35
Mg	mg/l	0.12	0.20

a) VESDEC EIA Team, February 2000
b) Location of monitoring sites (see Figure D3):
N1: ground water of a well in the Phu My Power Generation Complex
N2: ground water of a well in Tan Thanh town

2.4 AMBIENT AIR QUALITY

The Phu My 2.2 Project will be implemented within the PMPGC which is located in the Tan Thanh district of the Ba Ria – Vung Tau province. Some units of PMPGC Projects (Phu My 1 and Phu My 2.1) are already in operation. In the surrounding area of the PMPGC some other factories are in operation, such as Vina Kyoei Steel Mill, Ba Ria Serece port, Food Processing factories and My LPG station.

In January 2000 the ambient air quality at PMPGC and some other near locations were investigated by VESDEC. The results of these investigations are summarized in Table D13.

Based on the results shown in Table D13, the existing ambient air quality can be evaluated as follows:

Particulate Concentration:
Concentration of total suspended particulate (TSP) has been measured in a range between 0.26 and 1.45 mg/Nm^3. At the monitoring sites, 4 points observed a dust concentration lower than 0.30 mg/Nm^3, meeting the Vietnamese Environmental Standards (see Section B, Table B7) while 6 sites exceed the Vietnamese standard. The high concentration of particulate in this area is mainly caused by traffic, transportation and construction activities. The WB standard for

particulate based on 24 hours average and can not be directly compared with the measured data.

The operation of the power generation units of PMPGC does not cause any particulate emission problems since these units are based on natural gas as fuel.

Table D13: Results of Ambient Air Quality Measurement in January 2000

Sample Location	Concentration of Pollutants 1 Hour Average Values (mg/Nm^3)		
	Particulate (TSP)	SO_2	NO_2
K_1	0.49	0.127	0.236
K_2	0.26	0.095	0.119
K_3	1.45	0.185	0.239
K_4	0.54	0.196	0.145
K_5	0.74	0.303	0.297
K_6	0.28	0.066	0.033
K_7	0.30	0.056	0.042
K_8	0.42	0.115	0.097
K_9	0.55	0.136	0.103
K_{10}	0.28	0.063	0.035
Vietnamese Standard (1 hr average)	0.30	0.50	0.40
WB Standard (24 hr average)	0.23	0.150	0.15

a) Source: VESDEC, January 2000
b) Monitoring location:
K_1: Out site of fence, about 160 m from the stack of Phu My 2.1
K_2: The oil jetty under construction
K_3: Office of the Phu My 2.1Power Plant
K_4: About 1.5 km from the project site to the National Road 51
K_5: T-junction of the power plant, the steel company and Ba Ria port, about 400 m from the project site
K_6: Hue Lam pagoda, about 2.5 km from the project site
K_7: Xom Dinh hamlet, My Xuan commune , Long Thanh district, about 2 km from the project site
K_8: Gate of BaRia Serece port, about 1.3 km from the project site
K_9: An area near the Phu My Concrete Factory
K_{10}: House of Mr. Nguyen Van Nhan in Quang Phu commune, 3.5 km from the project site

SO_2 Pollution:
The 1 hour SO_2 concentration values varied between 0.056 and 0.303 mg/Nm^3, meeting the Vietnamese Standard of 0.5 mg/Nm^3. Since the existing power generation units at PMPGC (Phu My 1 and 2.1) had only burnt natural gas, they have not contributed to this SO_2 ground level concentration. This SO_2 ground level concentration is in particular due to the activities of local traffic, small-scale industry and households.

NO_2 Pollution:
The NO_x ground level concentration in this area varied between 0.033 and 0.297mg/Nm^3. All measured NO_x concentrations meet the Vietnamese Standard of 0.4 mg/Nm^3. The main sources of NO_x pollution in this area are traffic, PMPGC (Phu My 1 and 2.1) and small-scale industry. NO_x will also be the main emission from the Phu My Power Plant (maximum 52 mg/Nm^3, according to dry flue gas and 15 % Oxygen). It can be expected that this plant will also contribute in increasing of the NO_x ground level concentration in this area in the future.

2.5 NOISE POLLUTION

The results of noise measurement performed by VESDEC in December 1999 and in May 2000 are summarized in Table D14. According to the gained results the background of noise level meets the Vietnamese Standard for industrial area.

Table D14: Results of Noise Measurement in December 1999 and May 2000

	December 1999			May 2000		
	Average of Integral Noise pressure dB(A)			Average of Integral Noise pressure dB(A)		
	Max	L_{50}	L_{EQA}	Max	L_{50}	L_{EQA}
K1	72.6	58.5	58.9			
K2	70.8	54.8	56.3	85.2	61.9	64.8
K3	64.7	54.1	54.6			
K4	73.8	57.3	60.1	80.5	66.3	68.1
K5	72.0	60.5	63.4	80.9	52.0	62.0
Vietnamese Standard for the Industrial Area						70
WB's Standard for Industrial, Commercial Area (day and night time, LEQ hourly)						70

a) Source: VESDEC, January 2000
b) Monitoring location:
K1: Out site of fence, about 160 m from the stack of Phu My 2.1
K2: Office of the Phu My 2.1Power Plant
K3: The oil jetty under construction
K4: T-junction of the power plant, the steel company and Ba Ria port, about 400 m from the project site
K5: Gate of BaRia Serece port, about 1.3 km from the project site
c) Measuring time period:
December 24, 1999 at 9.27 AM to 3.18 PM
May 18, 2000 at 9.52 AM to 12.29 PM

3 DESCRIPTION OF THE RELEVANT BIOLOGICAL CONDITIONS

Due to the fact that the majority of the vegetation was removed from the Phu My Power Generation Centre (PMPGC) project area, there are no valuable natural biological resources. The following information indicates the biological resources covering the Thi Vai River area, which is located out-side the project area, but which could be impacted by the project operation.

3.1 VEGETATION

The majority of the Eastern bank of the Thi Vai River is integrated into an agricultural ecosystem. The basic characteristics of this agricultural ecosystem, is the combination of fresh water and brackish water in the whole Thi Vai basin, caused by tidal currents in the estuarine area.

On arable land the dominant trees are cashew (*Anacardium*) and eucalyptus (*Eucaliptus*) upland crops (tapioca, corn, green beans, soy beans etc) and fruit trees (longan, orange, banana, coconut) planted on the higher elevated fields. In the flat lower fields, rice is the main produce. Other kinds of wild vegetation are grass and mangrove trees (*Rhizophora, Phoenix fruiticans, Avicennia* etc.).

The flora broadly distributed in the area is not very rich in terms of species composition or variety.

In the Western part of the Thi Vai River belonging to Can Gio district, a dense mangrove forest is found. The main mangrove trees are Nipa palm, Rhizophora, Sonneratia, Avicennia etc.

The mangrove forests between Vung Tau and Ha Tien are the largest and richest in the country due to the area's low topography; numerous rivers and canals, abundant alluvium and a favorable tropical climate. The mangrove forests of Can Gio and Minh Hai, found within this area, play a significant role in regulating the ecosystems of South Vietnam. Both of these areas were severely damaged by chemicals during the war, but have been restored through reforestation programs.

UNESCO has recognised the Can Gio mangrove forest of Ho Chi Minh as Vietnam's first Biosphere reserve zone. The mangrove forest has saved more than 200 animal species and 72 salt-marsh plant species from extinction, according to Asia Pulse. It has also helped promote economic development in the region by raising local income through forestation, aquaculture and ecological tourism.

3.2 TERRESTRIAL FAUNA

Bird:

The recovery of the Can Gio mangrove forest in the west bank has attracted numerous aquatic birds, in 1996, 36 bird species were observed in/or around the mangrove forests adjacent to the project. The birds were observed congregating in flocks to seek food and shelter in the tidal estuarine mud flats along the rivers of Thi Vai and Go Gia.

There are 6 species, which are particularly common to the area (+++) such as areola (*Ardea bacchus*), spotted dove (*Streptopelia chinensis*), flowerpecker (*Dicaeum concolor*), hirundo (*Hirundo rustica*), red-whiskered bulbul (*Pycnonotus jocosus*) and munia (*Munia*). In addition there are 16 species living primarily on the riverside, in the mangrove forest which have an average number distributed throughout the area (++) and there are 14 other species which have a limited presence in the area (+).

Mammals:
There are 11 recorded mammal species which have been observed in the mangrove forest on the West Bank of the Thi Vai river, including wild boar, squirrel, wild cat, rabbit, monkey, otter, etc (Appendix D1). They mainly congregate under the canopy of *Rhizophora* and *Phoenix Paludosa* on mounds inside the mangrove forest. There are numerous signs of wild boar activity in the mangrove forest. These species belong to the list of wild animals to be strictly conserved, which is a requirement of the GOV (Appendix D2) are *Lutra lutra* (otter), *Felis spp.*

Amphibian and Reptile:
Eight species of amphibians and reptiles have been observed in the area. These are especially common in wetland areas. The most significant species is *Rana tigrina* – (field frog). The 4 species having a high distribution level (+++) are frog, toad, bullfrog and tree frog (Appendix D1).

At present, the animal species mentioned above are observed in the mangrove forest on the West Bank of the Thi Vai River. They are not present in the Project area.

3.3 AQUATIC ECOSYSTEM OF THE THI VAI AND SAO RIVERS

From results of the field surveys carried out by VESDEC in December 1999 shown in Tables D15-D16 and Appendices D3 to D6, the following evaluation on the present aquatic ecosystem in the Thi Vai River can be established.

Phytoplankton:
The number and percentage of phytoplankton species recorded at various times in 1999 are listed in Table D15.

Table D15: Phytoplankton Species in Thi Vai River (1999)

	December 1999		September 1999		April 1999	
	Species	%	Species	%	Species	%
Cyanophyta	9	7.7	9	11.7	10	10.3
Chrysophyta	1	0.9	-		1	1.0
Bacillariophyta	90	77.6	42	54.4	70	72.2

Source: VESDEC, 1999

In the study in December 1999, 3 species of Euglenophyta were observed, including *Trachelomonas volvocina* in the Thi Vai River. *Euglena acus* and *Strombomas australica* only appear in the Sao River at high tide.

The species indicating mesosaprobic environment appear in almost all sampling sites. They include *Oscillatoria geitleriana, Oscillatoria limosa, Coscinodiscus jonessianus, Coscinodiscus subtilis, Skeletonema costatum, Chaetoceros decipiens, Chaetoceros subtilis, Ditylum sol, and Thalassiothrix frauenfeldii.* These have multiplied significantly and become the dominant species, since effluent from the Vedan factories, at Go Dau (located about 15 km upstream of the project site) has been discharged directly into the Thi Vai River.

The species indicating that the existing environment is polluted and acidified in brackish water of the Sao River include *Euglena acus, Enteromorpha tubulosa, Eunotia tautoensis, Eunotia zygodon, Phormidium tenue, Oscillatoria princeps,*

The number of phytoplankton species is decreasing from the estuary (49 - 53 species) to upstream (Long Tho, 24 - 38 species). Therefore in areas of poor water movement (the gate of Nha Phuong – Long Tho), the industrial effluent from the Vedan factories significantly reduces the number of phytoplankton species.

The quantity of phytoplankton is very high in the main flow and tributaries of the Sao River, from 153,000,000 to 684,450,000 cells/m^3. *Oscillatoria geitleriana* is totally dominant in the whole system. The quantity of phytoplankton increases from the estuary to the middle of the River section (Phu My port, Go Dau port, Muong canal) and reduces in the upstream section (Long Tho).

Since 1997 *Oscillatoria geileriana* has been the dominant species recorded at sampling sites in the Thi Vai River. This expresses the stability at mesosaprobic level of the aquatic environment of the Thi Vai River, after extended periods of receiving effluent from Go Dau and Vedan industrial park (from August 1994).

Zooplankton:
Number and percentage of zooplankton species in the Thi Vai River are listed in Table D16.

Table D16: Zooplanktons Species in the Thi Vai River, 1999

	December 1999		September 1999		April 1999	
	Species	%	Species	%	Species	%
Copepoda	13	61.9	15	65.2	17	60.7
Cladocera	1	4.7	-	-	-	-
Rotatoria	1	4.7	3	13.0	3	10.7
Coelenterata	1	4.7	-	-	2	7.1
Chaetognatha	-	-	-	-	1	3.6
Larve	5	23.9	5	21.7	5	18.5
Total	21		23		28	

Source: VESDEC, 1999

The phenomenon in which Ciliata appears in large numbers of species and quantity in the Thi Vai River was initially observed in 1995, at that time suspended organic solids existed at high concentration. Ciliata species play a pivotal role in the decomposition and purification of the environment thanks to their heterotropic and necrotic lifestyle.

Only one species of fresh water, *Diaphanosoma excisum* is observed in the Sao River– near the discharge pipe of the Phu My town.

The species of Layer Ciliata such as *Oithona similis, Ergasilus sp., Brachionus plicatilis* are considered indicators of an organically polluted aquatic environment in the Thi Vai River.

Other species are adaptable to organic pollution. Larvae of shrimp (Zoe, Mysis) and young fish only migrate up to Phu My port, which is less polluted than the area where the Sao and Thi Vai Rivers converge at Long Tho.

The number of zooplankton species reduces from the estuary to Go Dau port and increases in Long Tho.

The quantity of zooplankton recorded at the various sampling points has indicated a large disparity, ranging from 7,000 to 115,300 individuals/m^3. It is low in the estuary and increases from Phu My port to the gate of the Sao River, then decreases at Go Dau port and once more increases at Long Tho.

The dominant species include *Oithona similis*, Ciliata and larvae of *Nauplius copepoda, etc.* As there is not a lot of Ciliata species, the quantity of zooplankton in the Thi Vai River in this study period is medium and comparable with the study period of September 1999.

Zoobenthos:
Benthic animals in the Thi Vai River in 1999 are listed in Table D17.

Table D17: Variation of Benthic Animals in the Thi Vai River

	December 1999		September 1999		April 1999	
	Species	%	Species	%	Species	%
Nemertini	1	2.8			1	3.4
Polychaeta	24	68.6	20	83.3	19	65.5
Crustacea	7	20.0	4	16.7	6	20.7
Mollusca	2	5.7			2	6.9
Echinodermata	1	2.8			1	3.4
Total	32			24	29	

Source: VESDEC, 1999

Four additional Polychaeta species were observed when comparisons were drawn against the results of the monitoring activity conducted in September 1999. In total, 5 additional Polychaeta species were recorded when comparisons were drawn against these results and the results recorded in April 1999.

Structure of species is as follows:

	April 1999	September 1999	December 1999
$\frac{\textit{Errantia species}}{\textit{Sedentaria species}}$	$\frac{11}{7}=1.57$	$\frac{6}{9}=0.6$	$\frac{12}{12}=1$

Therefore, the change of the species structure of Polychaeta in the Thi Vai River is continuous and dependant on the distribution of settled waste matter in the bottom sediment. At site 7 (Go Dau port) near the discharge source, the mud is black, decayed and exhausted and all zoobenthos are killed. At other points such as the gate of Muong canal, Sao River and Long Tho, the industrial constituents from Go Dau effluent is diluted and the concentration of precipitates is lower. That stimulates Polychaeta as the number of species increases from 11 – 17, and the quantity rises (1,110 – 2,770 individuals/m^2), of which *Sedentaria* is the dominant species in both number of species and quantity. Consequently, the growth of Polychaeta is an important parameter to assess the impacts of effluent on the ecosystem of brackish water.

Crustacean species only appear at sites, which are far away from discharge sources.

The bulk of the Mollusc species are dead and the individuals that are alive are collected only from points far away from the point of the discharge source.

Recently, there has been a significant difference noted at the monitoring sites in the quantity of zoobenthos recorded. Except at Go Dau port site, where all the zoobenthos were killed in 1995, the remaining sites recorded the zoobenthos quantity at 40 to 2,770 individuals/m^2 with the dominant species being *Sedentaria*.

Similarity:
On the basis of the phytoplankton – zooplankton similarity, it is possible to divide the study area into 3 ecological zones, to correspond with the quality of aquatic environment as follows:

- Zone I: from Cai Mep estuary to the gate of Sao River.
- Zone II: from the confluence of the Sao and Thi Vai Rivers to upstream (Nha Phuong)
- Zone III: from Nhap Huong barge gate to Long Tho (sites 6, 7, 8).

The similarity of zoobenthos indicates the significant difference of the riverbed (bottom) mud between sampling points.

Sites in the zone I have a higher general composition, equivalent to relatively similar quality of riverbed (bottom) mud. The mud is grey, covered by a layer of alga. The sites in zone II differentiate from sites in zone I as the riverbed is sand. The quality of mud in the estuary is greatly different from that of zone I.

Diversity:
The distribution and diversity of the three 3 groups of aquatic organisms also indicates the environmental quality of the three waters zones:

- From the gate of the Sao River to Long Tho: the diversity is low, corresponding to the long-term and direct impacts of the effluent from Go Dau industrial park.

- The Sao River is less polluted because it is only impacted by effluent during the periods of high tide. In this zone, the biological diversity is higher.

- From the estuary to the project site, under compelling influence of sea water, the Thi Vai River is less polluted than the above 2 zones consequently the diversity of aquatic creatures is far greater.

Fish Species Composition:
According to various studies conducted by our team since 1995, the distribution of the fish species differentiates between the downstream and up-stream sections of the river. The downstream – estuarine zone observes the most diversified composition with sea fish being the dominant species. The number of species in the zones of the Phu My Power Generation Complex and the upstream zone is lower and not significantly different. The list of sea fish species observed in the study area is shown in Appendices D7 and D8.

Of the aquatic species, found in the Thi Vai River there are over 20 fish species, 11 species of shrimp and crab and over 20 other aquatic species, which are considered to be economically viable. Valuable fish species include *Crinidens sarissophorus*, Pama croaker, whitegoby, tassel fish, mullet etc. However, shrimp species (*Penaeus monodon and P. merguiensis*) are the most valuable product of the coastal zone in the basin. Sea products are the main economic sources of coastal and estuarine inhabitants in Ba Ria-Vung Tau and Ho Chi Minh City.

4 DESCRIPTION OF SOCIO-ECONOMIC CONDITIONS

4.1 OVERALL SITUATION

The town's people committee an official government administration agency governs Phu My town. As other towns in Vietnam, in Phu My town there are political social organizations, e.g. Communist Party, Youth Communist Union, Women Union, Vietnam Fatherland Frontier, etc. These organizations are responsible for development of socio-economy of the town.

Evaluation of the area around the Phu My 2.2 plant (Phu My Town) was created by urbanisation and industrialization process of the Tan Thanh district. The Phu My Energy Complex only partly contributed in this process, but it will significantly impact on socio-economic development of the town in the future.

Evaluation of the area around the Phu My 2.2 plant (Phu My Town) was created by urbanisation and industrialization process of the Tan Thanh district. The Phu My Energy Complex only partly contributed in this process, but it will significantly impact on socio-economic development of the town in the future

Buddhism and Catholicism are prevailing in the town with 70 % of the population being followers. Almost opposite the People's Committee office of Tan Thanh district, is an area called "Dai Tung Lam" which has a pagoda, with a main temple and many small pagodas adjacent, there are also many small pagodas scattered around the residential areas, which has attracted numerous tourists and Buddhists. In addition, there is also a Cao Dai Temple for Cao Dai followers and Churches for Catholics and Christians.

The main occupations of the local inhabitants include farming, husbandry, aquaculture, fishing, salt making and forestry. A small number of local inhabitants earn their living by trading, services and handicrafts. In the previous years economic growth in the town has increased significantly. The total production of the town was VND12.73 billion in 1995 which increased by 305 % to VND 51.6 billion in 1999, marking a year-to-year average growth rate of 46.8 % [17]

4.2 PRESENT LAND USE

Phu My town has a total area of 3,173 ha. Table D18 indicates a rapid change in the structure of land use at Phu My town in the period from 1995 to 1998. In particular the portion of land used for agricultural activities increased in the last few years.

The Phu My Power Generation Centre (PMPGC) occupies an area of approximately 128 ha of Phu My Town. About 8 ha of this land will be used for the installation of Phu My 2.2 Power Project.

Table D18: Structure of Land used in Phu My Town for period of 1995-1998

Type of land	1995		1998	
	Area (ha)	%	Area (ha)	%
Total area	3,173	100	3,173	100
Agricultural land	1,420.65	44.77	1,791.2	56.42
1. Land for annual crop	200	14.08	183.2	10.23
- Rice field	185		117.9	
- Others	15		65.3	

2. Gardens	55.9	3.93	49.4	2.76
3. Land for perennial crop	690	4.86	1065.4	59. 51
4. Land for aquaculture and others	474.75	33.42	493.2	27.55
Forested land	363.96	11.47	331.9	10.46
Others	1,388.39	43.76	1,049.9	33.12
Source: People Committee of Phu My Town, 1999				

4.3 TOURISM

Tourist potentials of Ba Ria - Vung Tau province:
Vung Tau has a large potential for tourism with its preserved forests, Binh Chau- Phuoc Buu forests next to the sea, the Binh Chau hot-water mineral spring, with beauty spots such as Coc Lake, Tram Lake, Long Son island, Con Dao National park, and its 305.40 km seashore (including Con Dao island district) which has many beautiful beaches.

The seaside districts (Xuyen Moc, Long Dat) and the city of Vung Tau have seashore of over 100 km, of which 72 km has a gradual incline of 3° to 8° and can therefore be utilized as excellent beach resorts. Furthermore with its mild weather and abundant sunlight and the seawater being relatively warm (average temperature: 27.9 °C) the beaches in Vung Tau draw a large number of holidaymakers all year round.

Vung Tau and its surrounding areas also have historical relics such as Dinh Mountain and Minh Mountain, plus numerous famous temples and pagodas, which attract a large number of tourists, especially after the Lunar New Year.

According to statistics in 1994, the tourist sector of Ba Ria – Vung Tau province gained revenue of VND 320 billion, by receiving approximately 2 million visitors, of which 181,000 were foreigners. The figures for the subsequent years were 2.96 million tourists and VND 700 billion sales in 1997, 3.1 million tourists and VND 800 billion sales in 1998, respectively.

In particular, Vung Tau tourist sector had a turnover of VND 800 billion with 250,000 overseas tourists, with the local hotels reaching an occupancy rate of 40 % in 1998. There are 86 travel agencies, of which 22 are joint ventures with foreign partners. The infrastructure for tourism (roads, hotel rooms and information) has quickly developed from 29 hotels and 68 villas in 1993 to the current 71 hotels and 41 villas in addition to 84 guesthouses in other provinces.

In the provincial socio-economic development strategy from 2000 to 2010, authorities are determined to boost its tourist sector towards the focal economy of the province. The master plan for the development of tourist beaches is one of the pivotal contents of this strategy.

On the basis of potentials for tourist beaches and territorial development orientation, the following tourist complexes will take shape with the beaches acting as a nucleus.

- Complex of Vung Tau City and its surroundings
- Complex of Long Hai – Phuoc Hai – Minh Dam
- Complex of Phuoc Buu – Binh Chau

From the above indicated tourist sites, the project area of the Phu My 2.2 Plant, including an area of a 2.0km diameter around the plant will not have an impact on the tourism industry.

Tourism of Phu My Town:
The town is not a focal tourism area of the province but in the town there are several temples of Buddhism which attract ten thousands of visitors annually.

Table D19: Prediction of Tourists Coming to Vung Tau City (2000 and 2010)

Tourist	Item	2000	2010
Foreigners	Man-tirnes (thousand)	594	1,393
	Average duration of residence	2.2	3.5
	Day – man (thousand)	1009	4,875
Local	Man-tirnes (thousand)	3,707	8,003
	Average duration of residence	2.0	3.0
	Day – man (thousand)	7,414	24,009

Source: Tourist Development Master Plan of Ba Ria – Vung Tau province (1995-2010)

4.4 AGRICULTURE

Determining the important role of agriculture, Phu My town changed the structure of cultivation and husbandry to intensive production methods, and at the same time, developed an area specifically for vegetables with higher value and improved output. The turnover of agriculture increased by 74 % within five years (1994-1999) with an annual growth rate of 19.6 %. The density of husbandry accounted for 47% in the overall growth.

4.5 FISHERY - AQUACULTURE

Under the influence of brackish and saline water, intensive shrimp farming is the prevailing method of aquaculture along the Thi Vai River. The most valuable shrimp species are *Penaeus merguiensis* and *p. monodon*. There are also other kinds of fish and crab. The area of shrimp culture was 50 ha in 1995 and only 29 ha in 1999 although the area planned for aquaculture is 493.2 ha.

Fishing output:
The fishing output in 1994 in the zone from the project site (Phu My) to the Thi Vai estuary was highest (1495.7 tons) whilst that of the zone from the project site to Go Dau was lower (1105.6 tons). Due to the reduction of the fish resources, fishing output of Phu My town was over 100 tons in 1995 and it was reduced to less than 50 tons in 1999.

Reduction of fishing output at the Thi Vai basin is evident, but the main reasons are water pollution caused by the food processing plants situated upstream, and the reduction of aqua-cultural area, but the existing and future thermal power plants in the Phu My Power Generation Centre will have no further impact on the current situation

Reproduction season of fish species:
Concerning the fish species composition in the aforementioned zones, it is possible to classify seafood species in two groups:

- Brackish fish species live permanently in the estuary, rarely migrating offshore or to fresh water, including families such as *Eleotridae*, *Gobiidae*, *Apocryptidae*, *Centropomidae*, *Scatophagidae*, *Sparidae* ...

- Sea fish species live in the sea, migrating to this area for certain periods in their life cycle. The main families in this group include *Engraulidae*, *Ariidae*, *Sciaenidae*, *Mugilidae*, etc.

- Other seawater creatures such as *Penaeidae* (shrimp), *Portunidae* (crab), *Octopusidae* (cuttlefish) are included in this group.

Migratory sea fish species can reproduce here or elsewhere but brackish fish species certainly reproduce and grow in the Thi Vai River. They can be severely impacted by environmental changes and find it difficult to recover even when the environment is improved.

4.6 TRADING

Trading activities and services of Phu My town have been encouraged to develop, and expand business to meet the increasing demand of local inhabitants. The earning of this sector was VND 1.95 billion in 1994 and VND 29.5 billion in 1999, increasing by 15 times, with an average growth rate of 46.2 % per annum, accounting for 56.8 % in GDP. However, the variety of businesses and goods produced are not sufficiently diversified or abundant enough, with the majority of businesses being involved with small trading/services or the food industry.

4.7 HANDICRAFT PRODUCTION:

This sector was stabilized and governed for the development of potential careers such as mechanical processing and food processing and new careers such as overhaul and repair of cars, electronic appliances and refrigerators. The turnover of this sector in the town is VND 540 million in 1994, increasing by 19.57 times to VND 8.950 billion in 1999 with an average growth rate of 52 % per annum, accounting for 18.22 % of GDP. However, due to the small scale of production and the lack of advanced technology, its products are still crude and cheap, and as yet do not meet the international standards for export.

4.8 INFRASTRUCTURE

Transportation:
Apart from the improvement of National Road 51, Phu My town has built 4.2 km of new road. At the same time, the town has annually carried out the maintenance of the internal roads, 4 km of which were upgraded with direct investment from the district.

As the Thi Vai River is deep and its bottom is solid, many deep river ports such as Go Dau port, Phu My port, Ba Ria-Serece port have been situated here. In the future, Cai Mep port (at Thi Vai estuary) and Sao Mai – Ben Dinh port (at Vung Tau) will be constructed. Consequently, the density of waterway transportation in the river will increase rapidly, serving factories and industrial parks on the riverside.

It is reasonable to state that the transportation system of Phu My is very convenient for the economic development in this area.

Electricity Supply:
Due to efforts to increase the capacity of electricity supply and expand the electricity distribution network, there are now 1,325 households using electricity, accounting for 76 % of the total households in the town.

Rural water supply:
In 1998, there were 37 UNICEF wells, 335 drilled wells and 1,198 dug wells. Most of them have a relatively low pH (high acidity) in the dry season.

4.9 HEALTH CARE, CULTURAL AND SOCIAL WELFARE

Health care:
Local authorities have implemented health care for the inhabitants, with vaccination programs effectively carried out (97 % of the population), and the spread of epidemic diseases has been stopped.

Due to the proficient performance of the population control program and the associated propaganda, the natural population growth rate was reduced (annual population growth rate was 1.75 % in 1999 in comparing with 2.10 % in 1990). In 1999 the rate of infant malnutrition reduced to 21 % from 30 % in 1997.

Education:
14 classrooms and auxiliary facilities of primary schools and kindergartens were built. The town also allocated an adequate budget to repair available classrooms, and is able to meet the demand for education and educational progress in the region.

Authorities also pay attention and cooperate with the educational sector to improve the quality of learning and teaching. The number of pupils is increasing at an average rate of 5 % per annum. One hundred per cent of 6-year-old children go to schools. 100 % and 83 % of pupils pass the graduation exam of primary school and secondary school, respectively.

Archaeology:
There are no archaeological sites in the project area, but according to the Department of Science, Technology and Environment of Dong Nai province, there are cultural relics of the Bronze Age in Hac Dinh village, 5 km far from the project site to the northeast.

4.10 SOCIO-ECONOMIC DEVELOPMENT OF PHU MY TOWN

Advantages and disadvantages of Phu My town in socio-economic development are as follows:

- As the master plan and the concrete plans are not available, investment in socio-economic development is faced with numerous difficulties.
- A major part of the current labor force is not skilled and therefore fails to meet the requirements of industrial parks. Most of labourers are from other regions.

Plan and solution for socio-economic development of Phu My Town in the year 2000 can be summarized as follows:

Growth Rate:
The economic growth in the year 2000 is expected at 20.97 %, with a GDP of VND 69.2 billion.

Agriculture
As a result of planning for industrial development, the cultivated area will be reduced. At present, the area of perennial crops is 1065.4 ha and the land for annual crops is 183.2 ha. Therefore, agriculture will be developed toward intensive production of commercial goods with Suoi Sao (Ngoc Ha hamlet) as a zone specializing in rice production and zone 1 (Van Hanh

hamlet) as a zone specializing in vegetable. Family-scale animal husbandry is expected to account for 55-60 % of total value of agricultural production.

Agricultural development and urban construction will be coordinated together with environmental protection. People will be encouraged to perform their economic role, creating more jobs and manufacturing more products for the society. The production value is expected at VND 14.2 billion, increasing by 7 %, of which cultivation will be VND5.2 billion, husbandry VND 7.1 billion (393 MT of pork, 259 MT of poultry) and the per capita income is expected to be VND 1.6 million per year.

Fishery:
As a result of industrial planning, the area of land for aquaculture reduced to 29 ha, 33 households earn their living on the local waterways, fishing with 18 boats and 8 junks. Fishing-incentives include the application of advanced techniques in farming tiger-shrimp and fresh water fish to meet the current demand of the market. The town has a plan to achieve the fishing output of 50 tons, farming output of 22 tons, a total production of VND 2 billion.

Handicrafts and Small Industries:
The town has the conditions and potential to develop handicraft and small industries with the potential involvement of 365 households producing VND17 billion, increasing by 29 %. The town will concentrate on cultivating a business environment conducive to the development of economic components. Local industries will be bound with central industries such as repair of mechanical products, electro-mechanics, refrigerators, food processing and industrial garment to meet the demand for production, and trades in the town and its surrounding areas. The per capita income in this sector is expected to be about VND3 million per year.

Trading and Service:
Trading and service are expected to develop to match the calibre of the town and meet growing local demand. The total sales relating to trading and service is estimated at VND 34.3 billion, increasing by 22 %:

- Trading: 140 households, sales: VND 27.7 billion
- Service: 183 households, sales: VND 6.6 billion

To attain the development targets of trading and service, the town will encourage economic components to invest in trading and service, stabilize and rearrange the market place in Ngoc Ha and kiosks near Dai Tung Lam pagoda. State management of this sector will be consolidated to ensure that its development is on the right track. The per capita income in this sector is expected to be VND 9.1 million per year.

Construction and Infrastructure:
As a new city in the future, the town should develop its infrastructure based on the master plan prepared by authorities of the province and the central government. In 1999, the town invested in some items of infrastructure as follows:

Roads: 36 km; of which 9.5 km, is main road, 8.4 km rural road, and 18.1 km pathway. In addition, the master plan was prepared to receive the investment from the province in infrastructure facilities of Ngoc Ha village. The town also had roads built and maintained with the investment mobilized from people.

Schools: To serve the progress of education in 1999, the town called on the contributions of enterprises and local inhabitants in construction of the works as follows:

- Building 2 classroom of the kindergarten in Van Hanh hamlet with an expenditure of VND100 million.

- Building fences and upgrading the kindergarten (kindergarten combine) with an investment of VND100 million.

- Upgrading the primary school in Phu My and building 10 classrooms in Quang Trung school.

Electricity: The town has managed an electricity network of 30.160 km, of which low-voltage lines are 24.620 km and medium-voltage lines are 5.540 km. 85 % of inhabitants use electricity. In the year 2000, the town will expand the network of low-voltage electricity through the lines as follows:

- Low-voltage line of Chinh Phong,
- Low-voltage line to Galaxy, 600 m long
- Low-voltage line of Road 81, 700 m long
- Low-voltage line of zone 7, Ngoc Ha, 500m long.

The aim of this sector by the end of 2000 is 90 % of inhabitants using electricity.

Culture and Society:
Education: With 1 senior high school, 1 junior high school, 3 primary schools and 3 kindergartens with 3,827 pupils (1617, 890, 1320 and 203 pupils, respectively) in the school year of 1999-2000. Compulsory education was accomplished at primary level. The targets of the year 2000 include 100 % of children going to schools, 100 % and 98 % of pupils passing primary and secondary graduation exams, respectively. The quality of education and the interaction between the schools, families and the society are subject to consolidating. Movements of the youth corps will be enhanced to emulate the good performance of education.

Health care: The town will implement the task of initial health care for inhabitants. National programs of health care will be accomplished. The town will also control the birth rate under 1.37 %, reducing it further to 0.08%. The current rate of infant malnutrition of 17.57 % is subject to reduction to 13 %.
Welfare for families of war invalids, martyrs and people having served the revolution will be ensured. There are 19 households (100 people) subject to hunger eradication and poverty alleviation (at the criteria of 25 kg). In fact, the survey in 1999 indicated that the real figure was 28 households (125 people). To reduce that rate to the minimum, the town will continue mobilizing possible sources, calling for the assistance of the bank for the poor and promote the public movement of helping each other.

Labour and Job creation: A survey revealed that there are 472 jobless people, of which 80 had graduated from senior high schools. The town plans to open more training courses and career centres and introduce labourers into industrial parks and works under construction will be prioritised for female labourers.

4.11 REACTIONS OF LOCAL HOUSEHOLDS

Basically, local people and leaders of Phu My town clearly support the projects of industrial development, particularly the Thermal Power Plant projects in Phu My with high expectations for jobs and improvements of their way of life. However, the local people and the People's Committee of Phu My town want to receive adequate support from the proposed industrial projects intended for the town, including the power generation projects, as a way to improving the current employment situation, and to improve the local infrastructure facilities.

5 CHANGES ANTICIPATED BEFORE THE PROJECT COMMENCES

The construction of the Phu My 2.2 Combined Cycle Power Plant will have positive long-term benefits on the Phu My region, providing direct/indirect employment opportunities for the local populace. Therefore the expected positive benefits far outweigh the short-term negative impacts, which may occur during the construction phase of the project.

It is anticipated that during the construction phase of the project, that road traffic to/from the site will increase in the short term period, this may have a negative impact on the local environment (exhaust fumes, dust, noise etc), however as the Phu My 2.2 power Plant is to be located within the boundaries of the Phu My Power Generation Centre, and there are comparatively few inhabitants on the road from Highway 51 to site, these possible negative impacts will pose a negligible risk to the local community and once the plant enters the operation phase these will no longer apply.

On the positive side it is predicted that during the construction phase of Phu My 2.2 it will provide short-term employment opportunities for approximately 1000 construction workers, and once the plant enters commercial operation it will provide high quality long-term employment for approximately 45 persons.

Furthermore the plant should provide the local engineering and service industries with opportunities to develop and expand, which will provide additional indirect employment

As Vietnam will require 70 to 80 billion kWh per year by 2010 this plant is required to assist in providing this target (source Vietnam News 30/11/01).

6 CURRENT AND PROPOSED DEVELOPMENT ACTIVITIES WITHIN THE PROJECT AREA

The Phu My Power Generation Centre (PMPGC) is scheduled to be developed into a complex that will ultimately provide about 3,800 MW of electrical energy. To achieve this output the complex will consist of the following power projects:

Phu My 1	with a generation capacity of 1,090 MW
Phu My 2.1	with a generation capacity of 860 MW
Phu My 2.2	with a generation capacity of 715 MW
Phu My 3	with a generation capacity of 720 MW
Phu My 4	with a generation capacity of 430 MW

The current status of the PMPGC and the proposed development activities to be completed are as follows:

Current Status:
The current status at the PMPGC is (see Figure C1):

Phu My 1 Power Plant (1,090 MW):
- Construction of the combined cycle power plant is complete and the plant is currently entering the commissioning phase.
- The plant is scheduled to enter commercial operation in April 2002

Phu My 2.1 Power plants (550 MW):
- Phu My 2.1 simple cycle plant (two ABB GT's) entered commercial operation in March 1997
- Phu My 2.1 Extension simple cycle power plant (two Siemens GT's) entered commercial operation in March 1999

Proposed Development Activities:
The future development at the PMPGC is (see Figure C2):

Extension of Phu My 2.1 simple cycle to combined cycle mode:
- EPC contract for the extension of two ABB GT's has already awarded. The commercial operation based on combined cycle mode is scheduled for March 2003
- EPC contract for the extension of two Siemens GT's is under negotiation. The commercial operation based on combined cycle mode is expected for March 2004

Phu My 2.2 combined cycle power plant:
- Commercial operation is scheduled for End of 2004

Phu My 3 combined cycle power plant:
- The groundbreaking ceremony was held on 29/11/01 and site preparation is ongoing.
- Commercial operation is scheduled for December 2003

Phu My 4 Combined Cycle Power Plant:
- Commercial operation is scheduled for December 2003

SECTION E

ENVIRONMENTAL IMPACTS

SECTION E: ENVIRONMENTAL IMPACTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

The Project, including the construction and operation of the thermal power plant of 715 MW will play a very important role in the development of the Vietnam Energy Sector, particularly in the Southern part of Vietnam. It will promote the policy of industrialization and modernization of the Government of Vietnam in the coming decades as well as create a great opportunity for urbanization, proper change in land-use and overall socio-economic development of the Southern Economic Focal Zone. In this section of the EIA Report the impact of the Phu My 2.2 Power Project on the environment will be investigated. All relevant types of emissions and influences are considered in the study, particularly those that may have an impact on the physical and biological resources in the vicinity of the project, as well as those that could affect humans and their quality of life.

Beside significant beneficial impacts, and despite the use of a modern, clean technology and the use of natural gas as the primary fuel, the project may have minor negative effects on the environment. But the design, approach and implementation are intended to minimise such negative effects as much as possible.

Additionally, it has to be taken into consideration that the Phu My 2.2 Project is part of the total Phu My power generation complex with a final generation capacity of 3,800 MW, i.e. Phu My 2.2 project will contribute approximately 19% of the total output of the final situation. The site is already developed for the total Phu My power generation complex including Phu My 2.2. For example, the fuel oil jetty and the cooling water intake and discharge systems are already constructed, and only the interconnection to the new power generation unit will have to be completed. No agricultural or forested land has to be removed additionally due to Phu My 2.2 addition to the PMPGC because the site has been already levelled.

In the following sections the impacts during the construction phase and especially during the long lasting operation phase, as well as socio-economic aspects will be investigated and assessed in more detail.

2 IMPACTS DURING THE CONSTRUCTION PHASE

Possible impacts during design and construction phase are

- Impacts of land clearing on local people
- Impact on land used
- Impacts by traffic and transportation
- Impacts caused by labour concentration
- Impacts by civil works and construction of the power plant.

2.1 IMPACTS OF LAND CLEARING ON LOCAL PEOPLE

The Phu My 2.2 Power Project will be installed within the PMPGC area. The land clearing activities have been performed already for the whole PMPGC, so that no additional impacts will arise regarding this issue.

By interviewing all existing households in February of 1995 it was recognized that all the families agreed to transfer their land to the PMPGC, if the proposed compensation rate was reasonable. Based on this achieved agreements all the families living in this area were compensated and have been resettled. Consequently there is no need for further resettlement in connection with Phu My 2.2 Power Project.

The power plant will be constructed in the planned area, on which all-residential sites, economic units have already been removed; encroachment on agricultural, aquaculture and residential lands is not expected.

2.2 LAND USED

The Phu My 2.2 combined cycle power plant, as part of PMPGC will only utilise 8 ha of the total 128 ha of the Phu My site, which is already developed. Over the previous five years the Phu My Site has been prepared by the Electricity of Vietnam (EVN) as a location for the installation of the PMPGC, with a total output capacity of almost 3,800 MW. The site is already connected to the national power grid and main gas supply pipeline. Also the required common infrastructure (e. g. access roads etc) to all the power projects is mainly finalized.

No additional land will be required. No further encroachment on agricultural, aquaculture and residential land is needed. No additional impact on land use is expected.

2.3 IMPACTS BY TRAFFIC AND TRANSPORTATION

Presently the, Phu My Power Generation Centre (PMPGC) can be reached by Roads N1 and N5 from National Highway N51. These link roads are about 2 km long and consist of gravel and asphalt concrete. Inside the PMPGC a road system has been constructed/completed by EVN for the common use of all the power projects. A further transport possibility is given by the adjacent waterways. It is expected that the transportation of the main materials and equipment will be as follows:

Material / Equipment	Method of transportation
Civil construction material (stone, cement, brick, rock, etc.)	Truck transport to site by the National Highway NH51
Plants and equipment (gas and steam turbines, heat recovery boiler, steel structure, etc.)	Ship transport to site by the water way

Due to transportation of construction materials, plant equipment and labour, the traffic volume in the area, especially on the National Highway NH51 may increase slightly but only for a temporary period during the construction phase. It is expected that the major impact will be on the road, which links NH51 to the site. The emission of dust and exhaust gases of cars and trucks will reach an increased level which will be directly attributable to the civil and construction activities. In order to reduce the impact of traffic, the main plants and equipment will be transported by water way to the Phu My site.

Many people have established over previous years (in the course of development and construction of PMPGC) small restaurants and shops along the connecting road to PMPGC, and as such are making a living on these services they provide to the workers on site. In general the region around the Phu My site is not heavily populated and these effects will only be temporary and are concentrated mainly on the aforementioned link road and therefore can be assessed as not serious.

The increase of traffic may cause traffic accident. It will be one of main concern of local people, therefore to maintain the traffic safety it is considered to keep the traffic slow which pass through residential areas by appropriate measures such as giving a safety education to the drivers.

2.4 IMPACTS CAUSED BY LABOUR CONCENTRATION

During the construction phase, which will constitute the highest levels of activity, with up to 1,000 construction workers concentrated onto the project site. Thus the following impacts may be considered.

Most of the local workers originate from the surrounding area of Phu My Town and will be accommodated in their own houses. Several other workers will be accommodated in the nearby hotels. Since already two similar power plant projects have been successfully constructed (Phu My 1 and Phu My 2.1) at the PMPGC, the hotels and restaurants in this area have accommodation and catering facilities. Only a limited number of the workers will be staying at the construction site. These workers will be accommodated in camps, which the EPC contractor will provide according to the local regulations.

Sanitary waste:
The average daily amount of sanitary waste produced by a group of 1000 workers is estimated to reach 30 to 50 m^3. Standards request a concentration of oxygen higher than 50 % saturated concentration, i.e., higher than 3.8 mg/l. The sanitary effluent is usually treated by a biological method. The appropriate method is selected depending on flow rate, collection method and condition of land surface. In the case where it is not possible to build a wastewater treatment plant to treat all of wastewater from the site, the most effective treatment method would be to use a septic tank system. The function of a septic tank is to settle solid waste, digests in an-

aerobic process and produces residue with a treatment efficiency of more than 70 - 80 % BOD. The achievable waste water discharge quality will comply with the Vietnamese standards.

With the increase of the construction activities, the amount of the daily domestic solid waste will also increase. Depending on the intensity of the activities, the amount of domestic wastes may reach up to 500 to 1,000 kg, containing 60-70 % organic matter and 30-40 % others (plastic, papers etc). These wastes will be disposed according to the local regulations by an external authorized disposal company (same way as by construction of Phu My 1and Phu My 2.1)

Possible Transmission of Infections Diseases from Workers to Local Population and vice-versa:
In Phu My communicable diseases, such as water-born diseases (diarrhoea, dysentery, typhoid fever), vector-born diseases (Dengue fever) are still common. In the circumstance of low sanitary conditions and daily contact between local people and construction workers, infectious diseases cannot be excluded. Effective mitigation and prevention measures shall be taken into consideration.

2.5 IMPACTS BY CIVIL WORKS AND CONSTRUCTION OF THE POWER PLANT

During construction phase of Phu My 2.2 Thermal Power Plant and associated civil works, the following impacts are to be expected:

- Temporary increase in air pollution from the construction site, from construction materials utilised on site and from the transportation of construction materials
- Temporary noise and vibration pollution produced by construction equipment

Impacts on air quality:
In the construction phase air pollution is predominately produced by dust and exhaust gas from trucks and construction machinery. It is indicated that during site preparation, the following construction equipment will cause adverse impacts on air quality: trucks, compactors, pile drivers, jackhammer and drills, generators, asphalt heating equipment, concrete processing stations. Because most of this equipment uses gasoline or diesel, they will emit particulate matter, SO_2, NO_X, VOC and lead into the air.

According to various monitoring data at various construction sites in Vietnam under normal weather conditions, this impact on air quality is only local (could only be classed as serious at or nearby the construction sites) and temporary (only during the construction period).

The major air pollutant during the construction phase will be dust produced by earth works (digging, excavation, filling, levelling), particularly during the dry season. Receptors, which can be affected, are areas surrounding the construction sites, as well as houses and buildings located at a distance of approximately 200 m from the construction site. At this distance in the dry season and at the peak of construction hours, ambient air quality may be degraded. However, at this distance within the construction area there is no residential building, so the impact of air pollution on these types of receptors is not relevant. As described in Section G, water down shall be appropriately used to minimise possible impacts.

Noise impact:
According to data monitored and indicated in Section D, the present noise levels in populated areas in the Town of Phu My and in the project site area are low, and meet the Vietnam Noise Standards (TCVN 5949-1995) for commercial areas. Comparison with World Bank guidelines shows that for the same norm (commercial area) TCVN is the more stringent of the two, i. e. TCVN will adequately meet the WB Guideline (see Section B, Tables B10 and 11):

Noise standards for Commercial areas:

Vietnamese Standard		WB Standard	
6 h to 22 h	22 h to 6 h	7 h to 22 h	22 h to 7 h
70 dB(A)	50 dB(A)	70 dB(A)	70 dB(A)

During the construction phase temporary noise emissions may be caused by:
- Construction equipment
- Concrete mixing plant
- Pile driving for construction
- Rock blasting and drilling
- Earth moving activity
- Generators
- Vehicles used for material transport.

For most of the above, mentioned construction equipment the noise level in 15 m distance will be in a range of 70 to 90 dB(A). The noise level at further distance can be determined using – 6 dB(A) every time distance is doubled and there is no obstacle. Thus, the maximum level will be 84 dB(A) at 30 m, 78 dBA at 60 m, 72 dB(A) at 120 m, 66 dB(A) at 240 m and 60 dB(A) at 440 m. Since the residential areas are located in about 500 m distance to the construction site, the noise impact will be within an acceptable level.

Vibration Impact:
During construction phase, the major potential vibration sources are pile driving. The main types of construction pile driving are presented below:

- Linked sheet piles of 7.5 to 5 meters length with U-shape cross section are hammered to the desired depth to form a linked steel panel, an 8-ton drop hammer with energy input of 48 KJ can produce vibration of 12.9 mm/s at a distance of 10 m.

- Sheet piling operation silt bed at an energy input of 30 KJ may produce vibration of 4.30 mm/s at a distance of 10 m.

- Diesel hammer on clay bed can produce vibration of 7 mm/s at a distance of 10 m.

Piling using hammers will be reduced as much as possible. Boring will be performed if the adjacent operational gas turbines of Phu My 2.1 are affected by vibration seriously.

All protected areas such as Buddhist pagodas are located far enough away (more than 3 km) from the project site, so that vibration from the construction site will not affect them.

Concerning the above, mentioned environmental impacts that may occur during the construction phase, it can be stated that:

- They are mainly restricted to the Phu My Power Generation Centre.
- Most of the construction work, e.g. site access roads, fuel oil jetty, cooling water intake and discharge channels, buildings, preparation of the site, have already been completed in accordance with the approvals of the Vietnamese and local authorities
- The construction period at the site will be ongoing until the total Phu My Power Generation Centre is completed and in commercial operation (PM 1 and PM2.1 add-on works are ongoing; PM 2.2, PM 3 and PM 4 are scheduled to be erected).
- The impacts can be classed as only local and temporary

3 IMPACTS DURING THE OPERATION PHASE

The environmental impacts that the operation of a thermal power plant may have are:

- Climate (greenhouse effect)
- Air quality
- Noise
- Water
- Flora and Fauna
- Socio-economic effects

These impacts will be discussed in more detail in the following sub-sections.

Generally, it has to be stated that a combined cycle power plant (CCPP) with natural gas as the primary fuel ranks with the cleanest processes to produce electricity from fossil resources. After burning the fuel in the gas turbine (GT), the hot flue gas of the GT produces steam in a heat recovery steam generator (HRSG), which feeds a steam turbine (ST). GT and ST are coupled to generators for power generation.

Phu My 2.2 power plant will use natural gas as the primary fuel. Distillate oil will only be used when natural gas is not available, and restricted to a maximum of 5 days per year. Also the simple cycle operation mode has to be regarded as an exception.

The impacts, which have to be considered during the operational phase of a gas-fired CCPP, are mainly caused by gaseous NO_X emissions and thermal cooling water discharge. A schematic diagram of CCPP Phu My 2.2 with main balance data is shown as Figure E1.

Combustion calculations have been performed with the expected compositions of natural gas and distillate oil, and for different operational scenarios. The results of these calculations give detailed data on flue gas volume flows, flue gas composition etc.

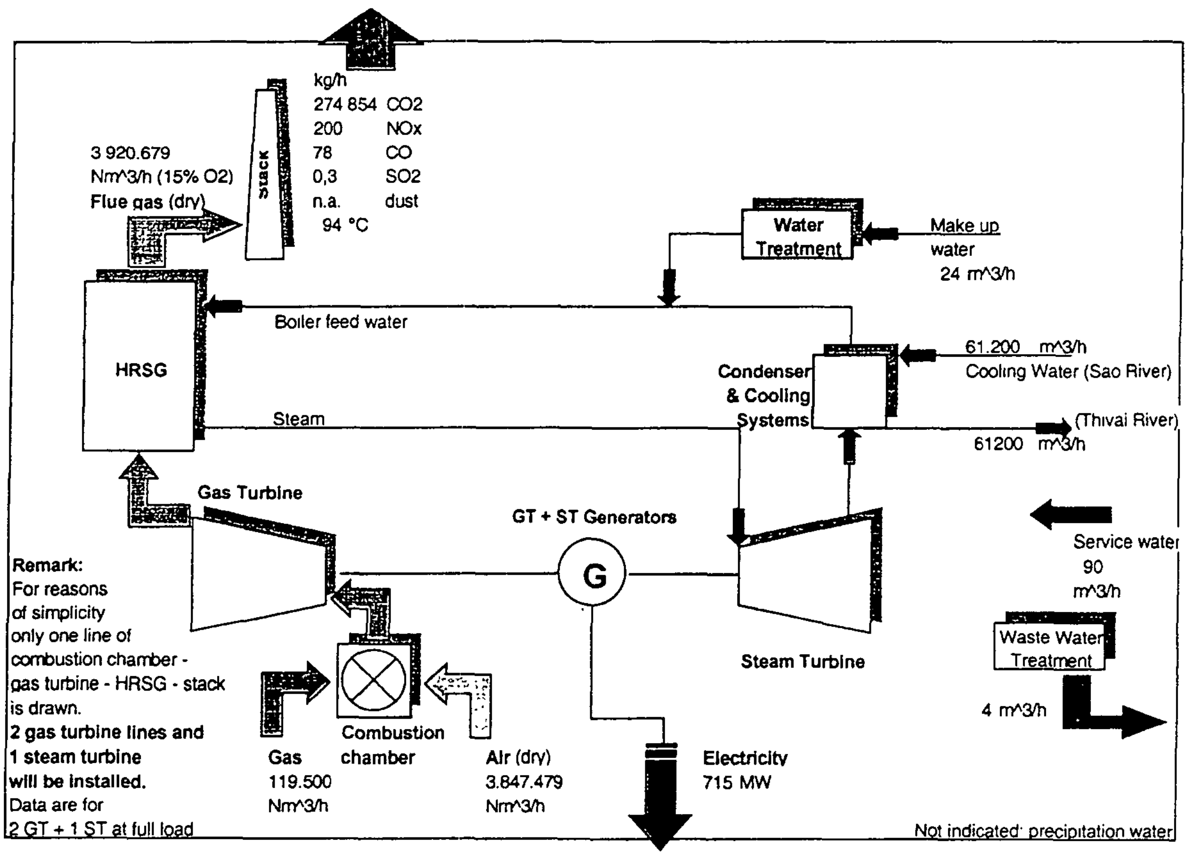
In Appendix E1, the detailed results of the combustion calculations for the combined cycle operation with natural gas and distillate oil (cases 1 and 2), as well as for single cycle operation (cases 3 and 4) are summarised and a compilation of the emission data is provided. The main results of these calculations are summarized in Table E1.

Table E1: Main Results of Combustion Calculation of Phu My 2.2 Power Plant				
CASE	1 normal case	2	3	4
PLANT OPERATION DATA:				
Fuel	**Gas**	Dist. Oil	Gas	Dist. Oil
power MW el.	**715**	724	450	466
efficiency %	**54.71**	51.15	34.58	32.98
mode	**comb. cycle**	comb. cycle	single cycle	single cycle
Gas consumption Nm3/h	**119'500**		119'500	
Dist. Oil consumption kg/h		120500		120500
Equival. full load hours per year *)	**6570**	120		
Annual power generation GWh/a	**4698**			
EMISSION DATA:				
CO carbon monoxide				
mg/Nm3 (dry, 15% O2)	**20**	30	20	30
g/s	**22**	36	22	36
kg/h	**78**	131	78	131
t/day	**1.9**	3.2	1.9	3.2
t/a	**515**	16		
kg/MWh	**0.11**	0.18	0.17	0.28
CO2 carbone dioxide				
kg/Nm3 for Gas kg/kg for D.O.	**2.30**	3.15	2.30	3.15
t/h	**275**	380	275	380
t/a	**1'805'793**	45'597		
kg/MWh	**384**	525	611	815
SO2 Sulfur dioxide				
mg/Nm3 (dry, 15% O2)	**0**	376	0	376
g/s	**0.09**	458	0.09	458
kg/h	**0.34**	1648	0	1648
t/day	**0.0**	39.5	0.0	39.5
t/a	**2.2**	198		
kg/MWh	**0.00**	2.28	0.00	3.54
NOx (as NO2) nitrogen oxides				
mg/Nm3 (dry, 15% O2)	**52**	119	52	119
g/s	**56**	145	56	145
kg/h	**200**	521	200	521
t/day	**4.8**	12.5	4.8	12.5
t/a	**1314**	63		
kg/MWh	**0.28**	0.72	0.44	1.12
Flue Gas Data				
Nm3/h (wet, act. O2 with a = 3,1)	**4'102'055**	4'373'616	4'102'055	4'373'616
Nm3/h (dry, 15% O2)	**3'920'679**	4'378'893	3'920'679	4'378'893
Nm3/s (dry, 15% O2)	**1'089**	1'216	1'089	1'216
Temperature at stack exit °C	**94**	139	623	618
Temperature at stack exit K	**367**	412	896	891
Stack height m	**60**	60	30	30
Number of stacks	**2**	2	2	2
FG velocity at stack exit m/s	**20.5**	24.5	50.0	53.0

*) 75% of 365 x 24 h/a for case 1; case 2 max. 120 h/a

Fig. E1: SCHEMATIC DIAGRAM AND BALANCE OF PHU MY 2.2 POWER PLANT

Fuel: Natural Gas Mode: Combined Cycle (normal operation, case 1)



3.1 IMPACT ON CLIMATE

Each combustion process, burning fossil fuels containing carbon material produces carbon dioxide, CO_2 according to the carbon content in the fuel. Carbon dioxide is the major gaseous combustion product. It is not poisonous, but it causes the undesirable greenhouse effect, which will probably lead to an increase in the average temperature and other detrimental disturbances of the global climate. There is no practical way of disposing of large quantities of carbon dioxide other than to release them into the atmosphere. The only measures that can be taken to limit CO_2 emissions is to use fuels with low specific CO_2 values and to increase the plant efficiency in order to keep the carbon dioxide emission per produced electric energy unit as low as possible.

In the proposed project a great deal of effort was taken to select the most efficient thermal plant cycle. At normal operation condition the thermal efficiency of the plant will be about 55 %.

The following Table E2 shows the CO_2 emission data of Phu My 2.2 power plant for different operation mode.

Table E2: Emission Data for CO_2

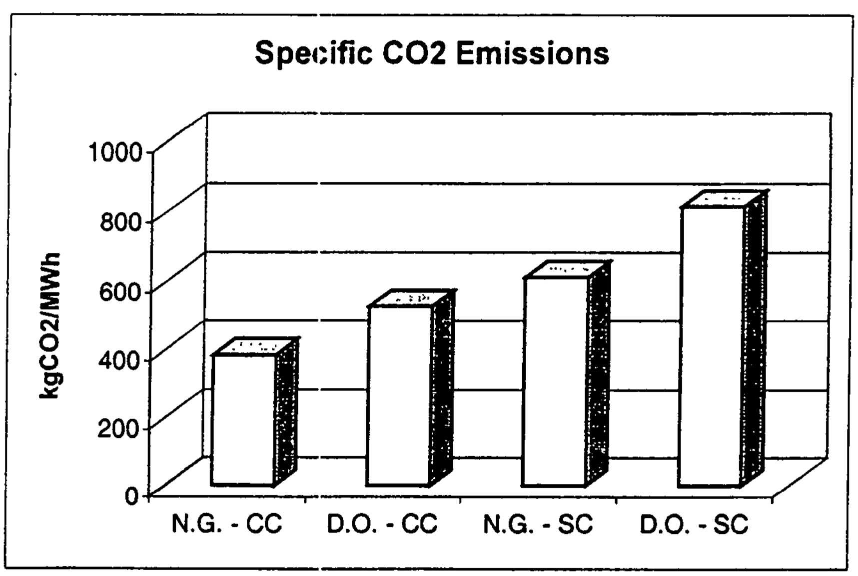
CASE	1 normal case	2	3	4
Fuel	Gas	Dist. Oil	Gas	Dist. Oil
Power MW el.	715	724	450	466
Efficiency %	54.71	51.15	34.58	32.98
Mode	Combined cycle	Combined cycle	Single cycle	Single cycle
Gas consumption Nm^3/h	119.500		119,500	
Distillate oil consumption kg/h		120,500		120,500
Equivalent full load hours per year *)	6,570	120		
CO_2 Emission:				
Kg/Nm^3 natural gas	2.30		2.30	
Kg/kg distillate oil		3,15		3,15
t/h	275	380	275	380
t/a	1,805,793	45,597		
kg/MWh	384	525	611	815

*) 75% of 365 x 24 h/a for case 1; case 2 max. 120 h/a

Figure E2 shows the specific CO_2 emissions of the four investigated cases

- 1 - Natural gas as fuel – combined cycle (N.G. – CC)
- 2 - Distillate Oil as fuel – combined cycle (D.O. – CC)
- 3 - Natural gas as fuel – single cycle (N.G. – SC)
- 4 - Distillate oil as fuel – single cycle (N.G. – CC)

Figure E2: Specific CO_2 Emissions of four Operational Modes (4 Cases)



The lowest specific CO_2 emission rate is achieved with the combined cycle operation and natural gas as fuel (case 1), which is the normal operation mode of the Phu My 2.2 power plant. In this case, the CO_2 emission rate is 275 t/h. With 6,570 equivalent full load hours per year, this is equivalent to:

Yearly CO_2 emission of Phu My 2.2 Power Plant: 1.8 million tons

The plant concept (combined cycle of high efficiency and with gas as primary fuel) ensures that this project has minimal contribution to Vietnam's total CO_2 emissions and to the annual industrial global burden.

3.2 IMPACTS ON THE AIR

The following sections deal with the evaluation of the emissions of Phu My 2.2 project as well as with the impacts on ambient air quality.

As a basis for the calculation of the emission rates and for the estimation of the ground level concentration, combustion calculations were performed as mentioned above (see Appendix E1). The results of these calculations give the required information on flue gas volume flows and flue gas data as well as on flue gas composition. For NO_X and CO which cannot be calculated, guaranteed data, is taken from the Contractor's figures, has been used.

3.2.1 Emissions

In the following the emission concentrations and emission rates are calculated or estimated on a reliable data basis and compared with the valid Vietnamese standards and with World Bank standards in order to assess the environmental impact caused by the emission of pollutants with flue gas.

3.2.1.1 CO Emissions

CO emissions concentrations (see Table E1) will not exceed 20 mg/Nm^3 (specific: 0.11 kg/MWh) when firing gas and 30 mg/Nm^3 (specific: 0.18 kg/MWh) when firing oil. These values are much below the standard of 500 mg/Nm^3 (TCVN 5939-1995).

3.2.1.2 Dust Emissions

Phu My 2.2 is a combined cycle power plant with natural gas as the primary fuel and a limitation of using distillate oil to max. 5 days a year. With gas as fuel, there are no particulate emissions. Even when firing distillate oil, the particulate emission with flue gas will be low (max. 27 mg/Nm^3) due to the negligible ash content of the fuel oil (max. 0.1 %).

3.2.1.3 SO_2 Emissions

Table E3 summarises the main relevant SO_2 emission data of Phu My Power Plant. The SO_2 emission concentration amounts to 376 mg/Nm^3 (dry flue gas at 15 % O_2) when the plant is operated on distillate fuel oil. But this fuel shall be restricted to 5 days per year, as a consequence the maximum expected annual SO_2 emission rate is in the range of 0 to 200 t/a. During distillate oil operation, for 1 MWh electricity produced 2.28 kg SO_2 will be emitted. The daily emission rate during oil operation amounts to 39.5 t.

For normal operation with natural gas as fuel the SO_2 concentration in the flue gas is negligible.

Table E3: SO_2 Emission Data.				
CASE	1 Normal case	2	3	4
Fuel	Gas	Dist. Oil	Gas	Dist. Oil
Power MW el.	715	724	450	466
Mode	Combined Cycle	Combined Cycle	Single cycle	Single cycle
Gas consumption Nm3/h	119,500		119,500	
Dist. Oil consumption kg/h		120,500		120,500
Equivalent full load hours per year *)	6,570	120		
SO2 Emission:				
mg/Nm3 (dry, 15% O2)	0	376	0	376
g/s	0.09	458	0.09	458
kg/h	0.34	1,648	0	1,648
t/day	0	39.5	0	39.5
t/a	2.2	198		
kg/MWh	0	2.28	0	3.54

*) 75% of 365 x 24 h/a for case 1; case 2 max. 120 h/a

3.2.1.4 NO_x Emissions

Phu My 2.2 will install GE9FA gas turbines which is equipped with dry low NO_x combustors to achieve low NO_x emission level. The NO_X emission concentration is guaranteed to 52 mg/Nm^3 (dry, 15 % O_2) when the plant is operated on natural gas and to 119 mg/Nm^3 (dry, 15% O_2) when firing distillate oil. The corresponding specific NO_X emission factors are 0.28 kg/MWh with gas and 0.72 kg/MWh with oil. The NO_X concentration is a guaranteed figure and insofar can be assessed as a maximum value.

The NO_X emission data are compiled in Table E4 below. The annual NO_X emission rate of Phu My 2.2 (combined cycle, gas-fired) is expected to be approx. 1300 t/a.

Table E4: NOx Emission Data				
CASE	1 Normal case	2	3	4
Fuel	Gas	Dist. Oil	Gas	Dist. Oil
Power MW el.	715	724	450	466
Mode	Combined Cycle	Combined Cycle	Single cycle	Single cycle
Gas consumption Nm3/h	119,500		119,500	
Dist. Oil consumption kg/h		120,500		120,500
Equivalent full load hours per year *)	6,570	120		
NOx (as NO2) Emission:				
mg/Nm3 (dry, 15% O2)	52	119	52	119
g/s	56	145	56	145
kg/h	200	521	200	521
t/day	4.8	12.5	4.8	12.5
t/a	1,314	63		
kg/MWh	0.28	0.72	0.44	1.12

*) 75% of 365 x 24 h/a for case 1; case 2 max. 120 h/a

3.2.1.5 Comparison of Emissions with Standards

In the following, the emission concentrations or emission rates respectively, for the only important potential gaseous pollutants NO_X and SO_2 are compared with the valid Vietnamese standards (see Section B, Table B5) and with World Bank standards (see Section B, Table B6) in order to assess the environmental impact caused by the emission of pollutants with flue gas.

For comparison the following emission standards have to be considered:

	SO_2 Emission	NO_x Emission
Vietnamese Standard:	500 mg/Nm^3	1000 mg/Nm^3
Word Bank Standard:		
- Emission load	121.5 t/d (for 715 MW)	
- max. Concentration	2000 mg/Nm^3	125 (gas) / 165 (oil) mg/Nm^3

The Vietnamese Standard is in terms of emission concentration (mg/Nm^3). The applicable World Bank Standards is for SO_2 depending on the generating capacity, but with a maximum in terms of concentration. For approx. 715 MW the standard comes up to approx. 122 t/day. For NO_X different values in terms of concentration apply for both gas and oil.

The emission of particulate matter is negligible for Phu My 2.2. Only with distillate oil as fuel (max. 5 days/a) can a dust emission of max. 27 mg/Nm^3 arise. This emission will be much lower than Vietnamese Standard (400 mg/Nm^3) and WB Standard (50 mg/Nm^3).

The CO emission values may reach only approx. 6 % of the standard (500 mg/Nm^3).

As the main emissions are NO_X which is relevant to both gas and oil as fuel, and SO_2 which is relevant only when firing oil.

Figure E3 shows the comparison between SO_2 emission of Phu My 2.2 plant and the Vietnamese Standard and WB' Standard.

As can be seen, SO_2 emissions will only occur during oil firing (cases 2 and 4) which will be restricted to 5 days per year. Even during these short times whilst using distillate oil the emissions will be within a safe margin and below the values set in the standards.

The SO_2 emission during firing distillate oil is 75 % of the Vietnamese (VES) standard (500 mg/Nm^3) and 32 % of the World Bank (WB) standard (122 t/day) for combined cycle operation (case 2). For single cycle operation, the SO_2 emission amounts to 75 % of the Vietnamese (VES) standard (500 mg/Nm^3) and 42 % of the World Bank (WB) standard (93 t/day) (case 4).

During normal operation SO_2 emissions will not pose a problem.

Figure E4 shows the comparison of NO_X emission. The NO_X emissions when firing natural gas is 5 % of the Vietnamese (VES) standard (1000 mg/Nm^3) and 41 % of the World Bank (WB) standard (125 mg/Nm^3).

The corresponding values when firing distillate oil are 12 % of the Vietnamese (VES) standard (1000 mg/Nm^3) and 72 % of the World Bank (WB) standard (165 mg/Nm^3).

Figure E3: SO_2 Emissions in % of the Relevant Standards

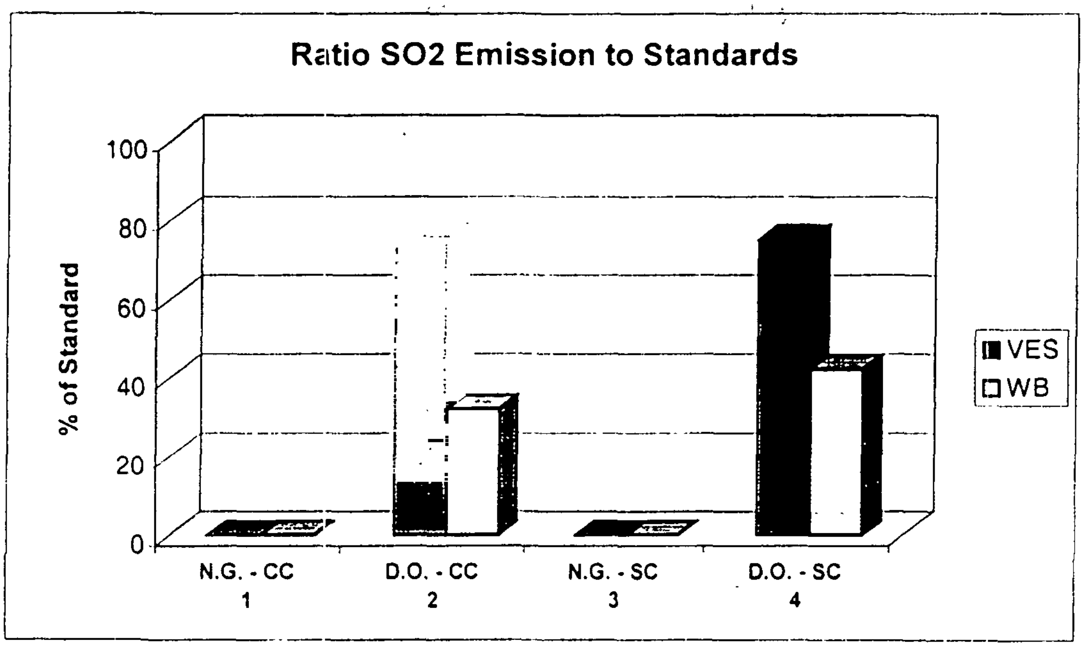
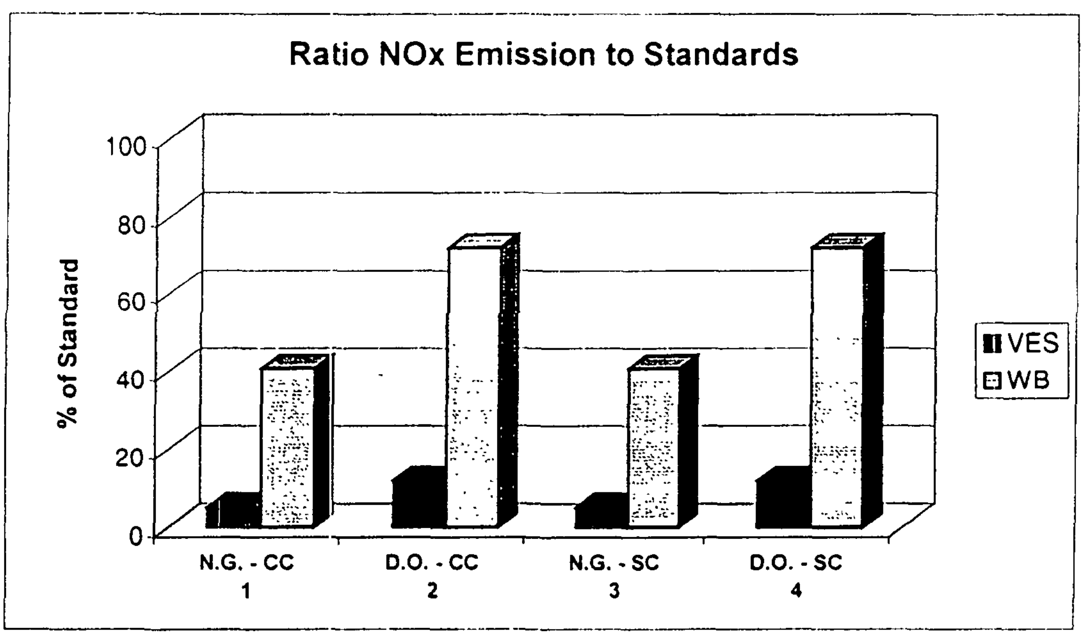


Figure E4: NO_X Emissions in % of the Relevant Standards



Summarising it can be stated that

- Each possible operational scenario falls within the margins of the applicable emission standards.
- For the normal operation of Phu My 2.2 (N.G. – CC; case 1) the margin for NO_X emission is very comfortable and SO_2 emission does not occur.

Upon complete implementation of the whole Phu My Power Generation Centre all plants will operate under normal conditions according the combined cycle process and with the same natural gas. That means Phu My 2.2's contribution to the total emission of Phu My Power Generation Centre is in a range about 18 % (which also applies to percentage of the total generation capacity).

3.2.1.6 Remarks on Reliability of Emission Data

The calculated emission data is mainly based on fuel composition and combustion calculations. The combustion calculations are particularly accurate and deliver flue gas flow data and composition of flue gas. The NO_X emissions however cannot be calculated. They have been taken from the Contractor's guarantee sheet and can be assessed insofar as being "on the safe side" and are in a range, which is the norm for the specified plant. Summarising, it can be stated that the above-mentioned emission data is reliable and forms a good basis for the environmental assessment.

3.2.2 Ambient Air Quality

To assess the impact of Phu My 2.2 on the ambient air quality the contribution of the plant to the ground level concentrations of pollutant gases shall be estimated. The distribution of the emitted gases is determined mainly by:

- The emitted mass flow (flue gas flow, mass concentration)
- Stack height and flue gas temperature (effective stack height)
- Meteorological conditions, especially wind velocity, direction and distribution (wind-rose)
- Properties of the land surface (flat, mountains).

The pollutant gas SO_2 can only be relevant when distillate oil is fired, i.e. for a maximum of 5 days a year. The emissions of dust can be neglected because gas is the primary fuel.

The NO_X emission has to be considered for both gas and oil as fuel. The emission rates for oil are higher but the higher flue gas temperature improves the effective stack height and the dispersion, and oil is restricted to a max. 5 days per year. During the simple cycle operation the flue gas temperature is very high with the consequence of a corresponding high effective stack height and very low ground level values in the area around the site.

3.2.2.1 Estimated Cases

Taking into account these considerations, the estimation of the impact on ambient air quality shall be based on:

- For NO_X during the normal operation with natural gas-fired combined cycle process; N.G. – CC (case 1)

- For SO_2 on distillate oil-fired combined cycle process D.O. – CC; (case 2).

The flue gas and emission data, which determine the dispersion into the ambient air, are summarized in Table E5.

Table E5: Data Relevant for Dispersion

CASE	1 Normal case	2
Fuel	Gas	Dist. Oil
Power MW el.	715	724
Mode	Combined Cycle	Combined Cycle
Relevant emission	NO_x	SO_2
EMISSION DATA:		
SO_2		
mg/Nm³ (dry, 15 % O_2)	0	376
g/s	0.09	458
NO_x (as NO_2)		
mg/Nm³ (dry, 15 % O_2)	52	119
g/s	56	145
Flue Gas Data (full load, both stacks, air ratio = 3.1)		
Flow Nm³/h (wet, act. O_2 with a = 3,1)	4,102,055	4,373,616
Flow Nm³/h (dry, 15 % O_2)	3,920,679	4,378,893
Temperature at stack exit °C	94	139
Temperature at stack exit K	367	412
Stack height m	60	60
Velocity at stack exit m/s	20.5	24.5

3.2.2.2 Meteorological Conditions

There are two main meteorological seasons, which are characterised by differing wind directions and velocity (measured at a height of 10 m):

- Dry season: with wind direction east velocity 2.8 m/s
- Wet season: with wind direction south velocity 1.5 m/s

For dispersion calculations the wind velocity was recalculated for a height of 60 m using an empirical formula.

Ambient temperatures: average dry and wet season: 27°C
Atmospheric pressure: 1013 mb
Topographic condition: plain/flat in rural area

3.2.2.3 Dispersion Calculation Results

Previously performed dispersion calculations (for the EIA Report approved by MOSTE) used a relatively simple model and the above-mentioned meteorological input data, which is not very detailed. Consequently, the results may have only limited evidence.

The input data and results of the existing dispersion calculations have been checked and were found to contain conflicting input data, especially pertaining to the follow:

- The NO_X mass flows were somewhat low (approx. 10 %) obviously due to calculating from the flue gas flow and concentration without using consistent figures for both dimensions (i.e. the same O_2 content, e. g. 15 %)
- The SO_2 mass flows have been taken approx. 100 % too high.

Consequently the figures have been revised and corrected by hand taking into consideration that changing mass flow input data by a certain percentage will result in the corresponding changes of the calculated maximum ground level concentration.

After these corrections, the main results are as follows.

- The calculated maximum ground level concentrations for SO_2 and NO_X are all below the applicable standards (Vietnam and WB).

- The maximum average of NO_X ground level concentrations may be expected at a distance of approx. 2,300 m west from the source for dry season and approx. 4,300 north for wet season.

- The maximum average of SO_2 ground level concentrations may be expected at a distance of approx. 5,000 m west from the source at dry season and approx. 10,000 m north for wet season.

Table E6 shows the estimated ground level concentrations of Phu My 2.2 in comparison with the relevant standards for ambient air quality.

Table E6: Ambient Air Quality Standards in Comparison with Estimated Ground Level Concentrations caused by Phu My 2.2

Standard:	1 h average	24 h average	Annual average
Vietnamese TCVN 5937-1995			
NO_X	0.40	0.10	
SO_2	0.50	0.30	
World Bank			
NO_X		0.15	0.10
SO_2		0.15	0.08
Estimated by dispersion calculation:			
NO_X dry season	0.047	0.024	
NO_X wet season	0.031	0.015	
SO_2 dry season	0.11	0.056	
SO_2 wet season	0.064	0.032	

3.2.2.4 Comparison with Background:

An assessment of the existing ambient air quality around the Phu My site has been given in Section D, Chapter 2.4. According to the results of ambient air quality measurements performed at the beginning 2000 (see Table D13), the background pollutant concentrations in the surroundings of the Phu My complex were in the following range (1 h average value):

Dust 0.26 to 1.45 mg/Nm^3
SO_2 0.056 to 0.303 mg/Nm^3
NO_x 0.033 to 0.297 mg/Nm^3

The addition of the highest calculated hourly average of NO_x or SO_2 to the highest measured 1 h average would result in values, which are still below the Vietnamese standards. But such a consideration is only a very theoretical, worst case approach because it adds concentrations, which have been calculated for a point of maximum impact to measured concentrations at a different location.

But the considerations indicate that during normal operation of Phu My 2.2, a safe margin to the ambient air standards can be expected.

3.2.2.5 Considerations on total Phu My Power Generation Centre

In the course of an EIA study for the whole Phu My Power Generation Centre dispersion calculations have been performed, taking into consideration all existing and future power generation plants of Phu My Complex.

Four different alternatives have been considered:

1. All CC power plants of Phu My Power Generation Centre are gas-fired
2. PM 2.1 plants are gas-fired, all other are oil-fired
3. All plants of Phu My Power Generation Centre are oil-fired
4. PM 2.1 is oil-fired and the rest is gas-fired

The first alternative represents the normal operation of the combined cycle power plants using natural gas as fuel. Alternative 3 represents the absolute "Worst case scenario" when all plants of Phu My Power Generation Centre would be fired with oil. The results are summarised in Table E7.

Table E7: Estimated max. Ground Level Concentrations of Total PMPGC (mg/Nm^3)

Alternative	1		2		3		4	
	Total PM NG		PM2.1 NG rest: DO		total PM DO		PM2.1 DO rest: NG	
Dry Season	1h	24h	1h	24h	1h	24h	1h	24h
- NO_x	0.07	0.03	0.42	**0.21**	0.80	**0.40**	0.40	**0.20**
- SO_2			0.37	**0.18**	0.56	**0.28**	0.14	0.07
Wet Season	1h	24h	1h	24h	1h	24h	1h	24h
- NO_x	0.11	0.05	0.52	**0.26**	0.95	**0.48**	0.40	**0.21**
- SO_2	0.00	0.00	0.45	**0.22**	0.68	**0.34**	0.18	0.09

Vietnamese Standard		1h	24h
- NO_x		0.40	0.10
- SO_2		0.50	0.30
Worl Bank Standard		1h	24h
- NO_x			**0.15**
- SO_2			**0.15**

NG = Natural Gas, DO = Distillate Oil

The data have been corrected by hand, because in the original study similar mistakes have been found as mentioned above for the case regarding Phu My 2.2. For 2 plants (PM 2.2 and PM 3) the SO_2 concentration with oil firing has been taken approx. 100 % too high. Because the contribution of PM 2.2 and PM 3 in the 3rd alternative is almost 40 % to the power generation, approx. the same share applies to the SO_2 mass flow (same process, same fuel, similar efficiency). Appropriate considerations apply for the 2nd alternative of the table. To correct, the SO_2 values they had to be reduced by 20 % for the 3rd alternative and by 27 % for the 2nd alternative.

These corrections were relevant for 2nd and 3rd alternative, which include PM 2.2 and PM 3 with oil firing. The data in Table E7 are the revised figures.

The ambient air quality standards are additionally presented in the lower part of the table. Highlighted values indicate that the estimated ground level concentrations could reach or exceed the Vietnamese standards; bold values indicate that the estimated ground level concentrations could reach or exceed the WB standards.

- It is clear that for **normal operation** (alt. 1; all plants combined cycle with natural gas) of total PMPGC there will remain a safe margin to the relevant standards.
- If in **worst case** (alt. 3) all power plants of PMPGC would be fired with oil the estimated ground level concentrations would exceed the standards. But this alternative is rather theoretical because normal fuel is gas and oil will only be used if no gas would be available, and for limited times.
- For alternatives 2 it may be expected that in some cases the standards may be reached or exceeded, depending mainly on the amount of oil.

It has to be pointed out that the majority of the time the power plants of PMPGC will be operated with natural gas as fuel source, and that cases which could possibly exceed the ground level concentrations will be rare. In addition, the applied dispersion model is quite simple and only limited suitability to represent the situation of the total PMPGC.

3.3 NOISE IMPACT

During the operation of the plant, turbines, ventilators, and air compressors may create high noise emissions, impacting on the workers and surrounding residents. If noise exceeds permissible levels, they will have a negative impact on human health. Noise can reduce labour productivity and can lead to worker attention being distracted, which could lead to safety incidents.

The requirements for noise emission are based on the TCVN 5949-1995, which is shown in Table B10 (see Section B). The necessary measures such as installing silencers to the noisy equipment for the reduction of noise emission and achieving the Vietnamese Noise Standard has been considered and guaranteed by the EPC contractor of Phu My 2.2 project. Furthermore the EPC contractor will perform a detail noise level study at site boundary.

Since the residential area is relatively far away from the location of Phu My 2.2 plant, the noise generated from the plant will mainly impact the plant working areas and not the surrounding area.

3.4 IMPACTS ON WATER

The impact of Phu My 2.2 power plant on water can be divided in the following three aspects:

- Water consumption (fresh water and cooling water)
- Waste water discharge
- Cooling water discharge

3.4.1 Water Consumption

The Phu My 2.2 power plant will consume an average of 30, tö 50 m^3/h fresh water as service water, potable water and demineralised water. The fresh water will be supplied via the existing water pipe system, of PMPGC by the Ba Ria/Vung Tau Water Company.

The cooling water requirement of the Phu My 2.2 plant at 100 % plant load is 17 m^3/s (approx. 61,000 m^3/h). The cooling water will be taken from the EVN cooling channel, which is supplied by water from the Sao River. This channel provides cooling water for all other power plants of PMPGC (Phu My 1, 2.1, 3, and 4). The maximum cooling water requirements of all plants at 100 % load will be about 90 m^3/s (approx. 324,000 m^3/h). Considering an overall load factor of 80 % for all 5 power plants projects (due to maintenance and power demand load schedule all units will not simultaneously be operated at 100 % load), the average total cooling water demand will be normally about 70 m^3/s (252,000 m^3/h).

Cooling water from Sao River represent the main water consumption of the Phu My 2.2 plant. But, practically, the total amount of this water will be discharged to the Thi Vai River after cooling process (evaporation losses negligible).

It should be mentioned that in comparison to the conventional coal-, oil- or gas-fired power plants (cooling water demand for approx. 3,800 MW power generation approx. 190 m^3/s) the cooling water consumption of PMPGC is more than 50 % lower. The main reason for this is that due to combined cycle technology only about 30 % of PMPGC power output is generated by the steam turbines, which require cooling water. The rest 70 % power output is generated in gas turbines, which do not require cooling water.

3.4.2 Wastewater Discharge

In general, a thermal power plant can have an impact on the surface water and ground water in the surrounding area. The ground water will not be directly impacted by Phu My 2.2 project since this plant does not use ground water and does not discharge any wastewater in the ground. But the plant will directly impact the surface water. The impact can be caused by the following sources:

- Wastewater from various chemical processes, such as demineralised water treatment
- Wastewater from washing and cleaning of plant and equipment
- Rainwater
- Sanitary wastewater

The process wastewater will only rise from the demi-water treatment plant. The demi-water quantity for normal plant operation (for blow down) will be about 20 m^3/h. The wastewater flow of this plant will be in a range of 3 to 5 m^3/h. This wastewater will be treated (e.g. neutralisation) in order to meet the requirements of the Vietnamese Discharge Standard (see Section B, Table B7). Also other produced wastewater, including oil contaminated water will be treated by adequate wastewater treatment system including such as oil separation pit, coagulation and filtration equipment to meet the 1 mg/l standard for oil and grease (TCVN5945-1995). Treated wastewater will be monitored (see Section G) and together discharged to the Thi Vai River via the cooling discharge channel of PMPGC. The rainwater will also be collected and discharged via cooling water channel to the Thi Vai River. As natural gas will be used as main fuel (there are no desulphurisation plant and ash storage area which could produce waste water), it can be expected that the concentration of heavy metals in wastewater will be very low (mainly originate from input water).

The Phu My 2.2 project will build a rainwater drainage system. Its design will be based on the data of rainfall over the previous ten years to ensure adequate/rapid drainage. Areas with high potential to be contaminated by oil and grease will have a separate collection system. The drainage system of Phu My 2.2 will be connected to the existing drainage system of PMPGC. The two trunk lines for discharging storm water, which is in the scope of works of Phu My 1 Power Project, are already complete and in operation. Its total capacity is designed to discharge the storm water of the whole PMPGC area with 10% return period.

The sanitary wastewater of the Phu My 2.2 power plant (for about 50 operational staff and 50 temporary workers) will be about 5 m^3/h. The most common method in Vietnam for treatment of sanitary domestic wastewater is the anaerobic biological digester or self-decomposition tank commonly called a "Septic Tank". The septic tank precipitates solids, flocculates and enhances the separation and dissolution of oil, grease and associated hydrolysed organic emulsions, and accelerates the anaerobic decomposition of organic waste and associated sludge. This conventional method is applicable to the whole PMPGC and will also apply to the Phu My 2.2 Power Project.

The sanitary effluent of all located plants in PMPGC will be collected by underground pipelines and routed to the central treatment tank where it will be treated in the anaerobic process. After settling solids and residues, treatment water will be taken from the central treatment tank by a discharge pipeline to the final treatment. Effluent will be disinfected by chlorine or calcium chlorine to the common waste system before discharging to the Thi Vai River. After treatment the BOD will be reduced by more than 80%. Wastewater quality will be in compliance with Vietnamese standards.

3.4.3 Cooling Water Discharge

Water discharged from the cooling system will have a high flow rate and slightly elevated temperature and will contain low concentrations of chlorine. The active chlorine concentration of intake water will be 2 ppm in normal operation and 3 ppm for shock dosing. Chlorine in the form of hypochlorite is an active oxidiser and dissipates quickly and harmlessly in the discharge stream. Concentrations of residual chlorine will be lower than the permissible effluent standards of Vietnam, which is 2.0 mg/l for water source B, and also be lower than the WB guideline, which is 0.2 mg/l (24-hour average) due to the long distance of the discharge channel. In conclusion we assess the impact of residual chlorine will be negligible and harmless.

Cooling water Phu My 2.2 will be taken from the common cooling water channel of PMPGC (see Section C, Chapter 3.2.2). After passing through the cooling system of the plant, the cooling water will be discharged via common PMPGC discharge channel to the Thi Vai River. The temperature increase of cooling water at the outlet of the condenser is not allowed to be higher than 7 °C.

The discharged cooling water will amount to:

- 17 m^3/s for Phu My 2.2
- Maximum 90 m^3/s for all plants at PMPGC considering 100 % overall plant load
- Average approx. 70 m^3/s for all plants at PMPGC considering 80 % overall plant load

The Thi Vai River with a width of 700 to 800 m (depth near PMPGC about 10 to 15 m) has an ambient temperature of 27 °C and is subject to tidal currents (see Section D, Chapter 2.3.1). Depending on the tidal the water flow rate of this river varies from 0 to 10,000 m^3/s.

A previous study on cooling water discharges (included in the EIA approved by MOSTE) indicated that depending on the tidal condition, the water temperature of the river could increase by 1 °C. This temperature increase could be in a range of 2 to 2.5 km for only Phu My 2.2 and of 3 to 3.5 km for all PMPGC, respectively. Only near the cooling water outlet the water temperature in an area of 30 to 60 m may reach higher temperature about 2 – 3 °C.

The mathematical model was based on continuity equations, motion equations and heat transfer – dispersion equations using finite method. The two-dimensional model was developed by VESDEC for computation of cooling water dispersion.

In order to assess this impact aspect in more detail additional investigations and tests on the effects of the cooling water discharge have been performed in the Fluid Dynamics Laboratories of Mitsubishi Heavy Industries. These investigations have been performed for the whole PMPGC, in order to select the optimal discharging system. The Report on these investigations is summarized in Appendix E1. The investigations were performed on 3-dimensional bases and also took into consideration possible scouring of the riverbed. Two cases have been investigated for two somewhat different proposals on the arrangement of the 6 cooling water discharge pipes. The case 1 with the better results will be realised at the PMPGC. Figures E5 to E7 give an impression on temperature profiles and riverbed erosion.

The main results of this investigation for the case 1 which will be realised are as follows:

Velocity (density flow)
The maximum surface velocity is 0.57 m/s, recorded at approx. 108 m from the Under Water Pipe discharge point. Considering the relationship with the sides of the river, the maximum velocity of the discharged cooling water occurred on the North side of the cooling water inflow. This is due to the greater cooling influence from the deeper water on the southern side of the discharge, compared to the minimal cooling effect from the shallow water on the northern side, resulting in the North Westerly flow.

Temperature (hot water diffusion)
The temperature profiles on the Thi Vai river surface follow a similar pattern to the velocity profiles. The maximum surface temperature is approx. 29.6 °C (+2.6 °C) near the location of maximum velocity.

Scouring in the river bed (erosion)
The results indicate that scouring phenomenon on the Thi Vai riverbed is not a serious problem, and that additional protection is not required.

Considering the results of performed investigations as well as the Vietnamese Standard and WB Guideline for cooling water discharge, the following assessment can be made:

- The cooling water discharge of whole PMPGC will meet the Vietnamese Standards, which requires that the discharge temperature must be less than 40 °C. Depending on the cooling water intake temperature (similar to river water temperature in average about 27 -29 °C), the cooling water discharge temperature will be in a range of 34 to 36 °C.

- Regarding the WB guidelines, effluence temperature increase from thermal power plant at the edge of the mixing zone should be less than or equal to 3 °C. Even in cases where the whole PMPGC plants are operating at maximum capacity, increase of the water temperature complies with WB Guidelines

- The temperature increase of the river water is relatively low and in an acceptable range. In the area near the cooling water discharge (approx. 30 to 60 m), the temperature increase may reach 2 to 3 °C. In longer distance to the discharge point, the temperature increase will fall very quickly to lower than 1 °C. The reason for this is the huge water volume and water exchange rate of the river. The minimum water volume for 100 m river length (width 800 m, depth 10 m) is estimated to be about 800,000 m^3, corresponding to the cooling water discharge volume for approximately 3, hour full load operation of whole PMPGC.

Figure E5: Temperature at Water Surface

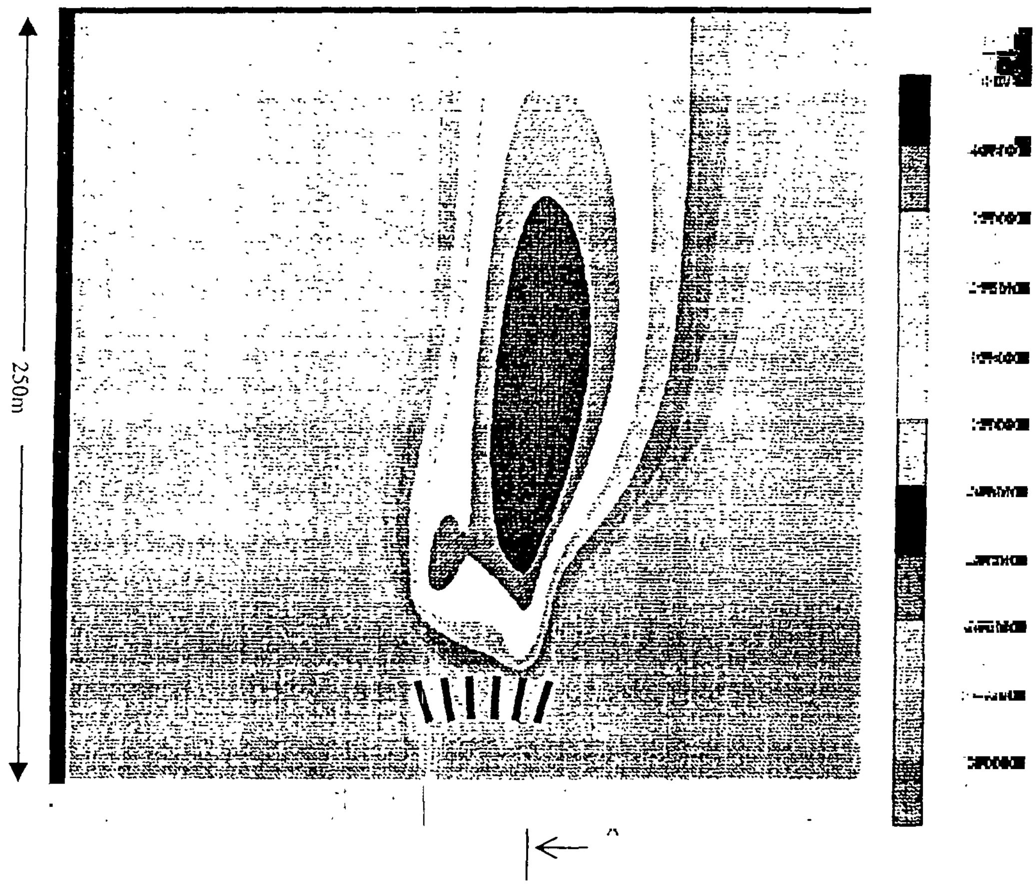


Figure E6: Temperature at Mainstream of Vertical Direction

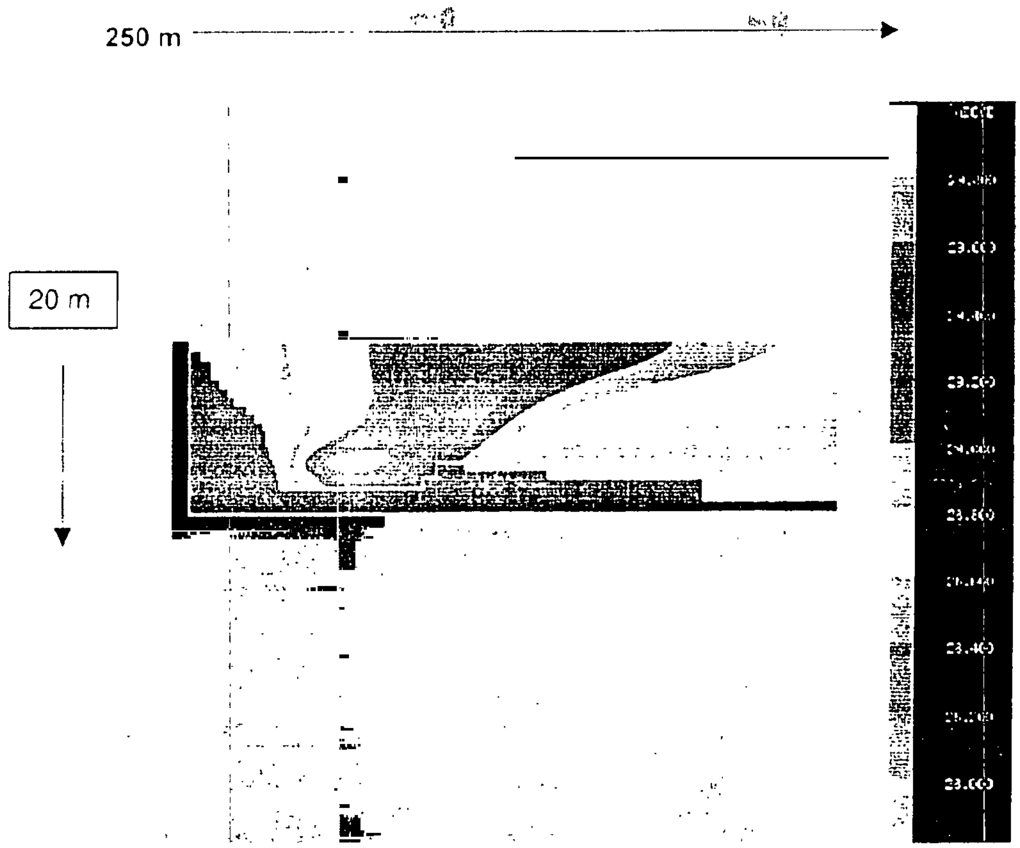
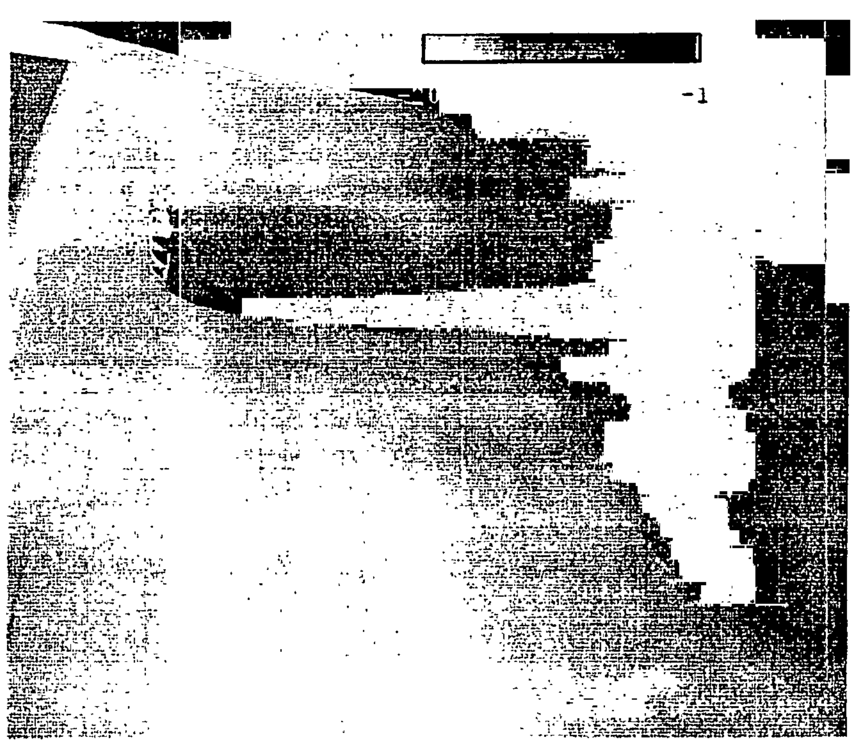


Figure E7: Scouring of the River Bed



3.5 IMPACTS ON FLORA AND FAUNA

3.5.1 Fish Species

For aquatic animal species, the body temperature is usually only 0.5-1 °C different from the external temperature. Therefore, water temperature strongly and directly influences metabolism. The fish easily adapt to the seasonal changes of temperature even when temperature difference between winter and summer is 0 – 30 °C. However, the fish will be affected when put into a medium with sudden change, warmer or colder 8-12 °C, depending on species. In such cases, the fish may die due to respiratory symptoms or heart muscle paralysis. For young fish, this can occur when the water temperature suddenly varies in a range of 1.5 – 3 °C.

A study on direct or indirect effects of water temperature on aquatic bio-resources as well as particularly concentrated on aquatic animal species have been carried out by Kennedy, and J. Mihursky, (1967), and E. Raney, and B. Menzel, (1967). However, almost all studies made were on fresh water fish such as *Cyprinus carpio, Carssius, Tinca tinca, Rutilus rutilus, Ctepharyngodon idella, Hypothalmichthys molitrix, Perca fluviatilis, Exoslucius....*

For the Thi Vai River, most aquatic animal species are brackish or saline water species and have not been mentioned in any document yet.

When temperature of river water increases, respiration and pulse rate of the fish will increase accordingly for suitable oxygen adsorption in order to satisfy the increase of metabolism.

Since the max. temperature increase, due to whole Phu My complex, of 2 – 3 °C is limited to a small area, and more far away the increase will be below 1 °C, no substantial adverse impact on fish is expected.

3.5.2 Benthic Animals

The average water temperature of Thi Vai River is 27 – 29 °C (the maximum observed temperature is 31.5 °C). If the, discharge of cooling water of the Phu My thermal power plant causes a water temperature river increase of 1 °C, the temperature will be 28 – 30 °C (the highest temperature will be therefore 32.5 °C). This would not be a considerably impact on benthic animals in the whole area. According to the experiments done at the Institute of Tropical Biology in Ho Chi Minh City on some aquatic species such as *Artermis salina, Metapecnacus eusis, Macrobrachium rosenbergii, Mytilus smargadimus*, the temperature threshold lethal to tropical aquatic animals is in the range of 40 °C – 42 °C. In fact, the amplitude of temperature for reproduction of tropical aquatic animals in nature is 20 °C – 34 °C, the optimum temperature for their reproduction aquatic is 25 – 28. It is necessary to notice the development of species, which live adhering to and causing damage to hydraulic work include *Balamu amphitrite, Ostresa sp, Limnoperna siamense*. The temperature at their metabolism decreases in 35 °C. From 37 °C up, the intensity of metabolism decreases considerably. They could be seriously affected at 40–42 °C. No serious effect may be expected by the conditions of the present project.

3.5.3 Micro-Organisms

The increase in temperature impacts the development of micro-organisms. At 16–19 °C, the bio-diversity of micro-organism is the highest. The bio-diversity is reduced according to the increase in temperature but on the other hand there is expected to be a considerable increase of individual number.

3.5.4 Impact of Water Intake on Aquatic Ecosystem

The water intake structure for the entire Phu My Power Generation Centre is a concrete structure including the water intake gate and drainage canal designed to support the total planned generation capacity of about 3,800 MW.

The flow rate of water necessary for the cooling system of whole PMPGC will be about 83 m^3/s in the final phase (for all 5 Thermal Power Plants). Against such huge amount of the flow rate, the cooling water intake will be designed for a low velocity of about 0.3 m/s at which fish can escape easily.

Therefore the impact of water intake on aquatic ecosystem will be an acceptable level.

3.5.5 Mangroves

Mangrove forests are one type of tropical forest supplying important habitat for a lot of species (world-wide) of fish, invertebrates (e.g. crustaceans and molluscs) and plants. They are at least as productive as good farmland. They are under threat worldwide. The worst destruction of Mangroves has taken place in Asia. As the mangroves disappear, catches of fish, crustaceans and molluscs decline accordingly because these animals lose their spawning grounds and nursery areas. Mangroves stabilise shorelines, they also trap silt washed off the land and they filter out pollutants from the water.

Can Gio Biosphere is the first biosphere reserve (UNESCO) in Vietnam. It covers 75,740 ha mangrove-dominated area with a high conservation value for its biological diversity? More than 200 species of fauna and 52 species of flora have been identified in this interplay area between Ho Chi Minh City and the sea, the "green lungs' for the largest urban area of Vietnam. What is most remarkable is that Can Gio is an ecosystem destroyed during the war but restored by the tireless effort of Vietnamese people over the last three decades. Can Gio has demonstrated that, once committed, how much environmental improvement can be achieved in a developing country. It was the first time that an entirely rehabilitated ecosystem designated as a Biosphere Reserve. Can Gio thus ear-marked a new development for the World Network of Biosphere Reserves.

In the first stage of PMPGC some mangrove forest had been, but no more mangrove forest will be cleared. As already discussed in Chapter 3.4.3 the increase in river water temperature is negligible. Only for a limited area the river water temperature increase may reach 1 °C. Considering the normal annual temperature changes of the river water (average 27 to 29 °C, maximum measured 31.5 °C) this low temperature increase will have no adverse effect on mangroves. It is anticipated that the Phu My 2.2 Project and the Phu My Power Generation Centre will have no substantial adverse effects on the Can Gio mangroves biosphere reserve.

3.6 SOCIO-ECONOMICAL IMPACTS

Direct effect:
The project will promote industrialisation and urbanisation in the Southern Focal Economic Zone (SFEZ). It will provide energy for industrial parks and population centres as well as for the Vietnamese National Power Grid. Consequently, this will promote socio-economic growth in the zone, and indirectly of Vietnam. With this positive impact, the life of the majority of local residents will be improved. Particularly, for Ba Ria/Vung Tau province, this project will play a huge role in the development of, not only local energy and industrial sectors, but also local education and culture.

Indirect effects:
The Project will also have indirect positive socio-economic impacts. One of the indirect impacts of the project is the increase of land value. The cost of land along the National Highway N51, particularly in Phu My Town will continue to increase.

Promotion of industrialization:
Industrialization process in the Southern Focal Economic Zone will be strongly promoted. All planned industrial parks in the zone will have an excellent chance of developing.

Population changes:
Population changes will result from land use modification in Phu My Town. Agricultural, aquaculture and forestry populations will decline, but at the same time other sectors of Industry will increase such as services and industry.

Changes in employment opportunity:
Construction of the plant will provide significant temporary employment for local labourers and construction workers. There are many village surveys showing that job opportunities will be increased.

Therefore, it may be concluded that the positive impact the project will have on the area is expected to be much higher than any potential losses caused by the negative impacts on local socio-economy and environment.

4 RISKS

In connection to the Phu My 2.2 Project, the following environmental risks could be considered:
Water and soil contamination from oil supply system:
Oil supply system belongs to PMPGC (EVN). This system consist of oil jetty, oil pumping system and oil pipeline. EVN is responsible for the operation of these systems according to the relevant Vietnamese Regulations. From the result of the water quality monitoring (Table D11), which meets Vietnamese Standards (TCVN 5942 – 1995), it is expected that there is no significant impact of oil spill from oil supply system due to the successful pollution control described . Section G 2.3.

Water and soil contamination from oil storage tanks:
Phu My 2.2 plant has two tanks with a total capacity of about 27,200 tonnes, sufficient for approximately 7 days full load operation. In order to limit the contamination risks the tanks will be installed in an area surrounded by a bund wall. The total volume that the bund wall can retain will be 110% of the volume of tanks. Therefore this risk is negligible.

Problems in connection with natural gas supply:
In case the natural gas will not be available for a long period, the plant could operate with distillate oil. This would increase the emission of pollutions, in particular SO_2 emission and consequently impact the quality of ambient air. But this is not possible since operation with oil only for maximum 5 days per year is allowed.

Fire accident:
In case of a fire accident, the surrounding environment of the Phu My plant could be affected. In order to prevent this accident the Phu My 2.2 plant will be designed, constructed and operated according to the requirements of the Vietnamese Fire Fighting Police. The fire protection system is designed in accordance with NFPA and Vietnamese standards and consists of an underground/overhead distribution system extending around all operating areas with a looped configuration to provide multi-directional fire water supply to maintain high reliability.

5 OVERALL ASSESSMENT OF ENVIRONMENTAL IMPACTS

Based on the results gained in the forgoing Chapters, the Figure E8 has been prepared to show the main environmental impact of the Phu My 2.2 Project. The impacts are divided into impacts during construction phase and impacts during operation phase. Considering this Figure the environmental impacts of the Phu My 2.2 power plant can be stated as follows:

Construction phase:

- The impacts are only temporary
- The impacts can be assessed as slight
- For implementation of such an important project, the impact can be stated as acceptable

Operation Phase:

- In general the applied combined cycle technology represents, environmentally, the best available power generation system
- The considered main fuel, natural gas, is also environmentally representing the best possibility for power generation
- Because of the above mentioned aspects, the overall environmental impact of the plant can be assessed as slight or intermediate
- The positive impact of the project on the local and Vietnamese socio-economical development can be assessed as relatively high

The design and construction of the plant will consider the Vietnamese Standards and WB Standards.

Figure E8: Overall Environmental Assessment of the Phu My 2.2 Power Project

Impact	slight		inter-mediate		high		Remark
Impacts During Construction Phase							only temporary
Land clearing							already done
Air pollution	■	■					mainly dust
Water pollution	■	■					sanitary water
Noise	■	■	■				construction equipment
Land used							no additional land needed
Impacts During Operation Phase							
Particulate emission							neglectible
CO emission	■						< standards (VN)
SO_2 emission	■						< standards (VN, WB), max 5 days/a
NO_x emission	■	■					< standards (VN, WB)
Impact on ambient air	■	■					< standards (VN, WB)
Noise	■	■					
Impact on water (by wastewater discharge)	■	■					
Thermal impact by cooling water discharge	■	■	■				< standards (VN, WB), total Phu My
Impact on climate (CO_2)	■	■					
Impact on Flora & Fauna	■	■	■				biodiversity, ingestion by CW intake
Impact on fish	■						ingestion by CW intake
Impact on Mangroves	■						

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Environmental Assessment Report
of PHU MY 2 Phase 2

SECTION F

ANALYSIS OF ALTERNATIVES

SECTION F: ANALYSIS OF ALTERNATIVES

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION

In this section alternatives to the Phu My 2.2 Power Project shall be compared, concerning site and especially technology and design, with respect to their potential environmental impacts and suitability under local conditions.

First some remarks will be given on the situation without Phu My 2.2 Project and on alternative sites. Then feasible alternatives in technology for power generation from fossil fuels will be discussed and compared with the 715 MW Phu My 2.2 Combined Cycle Power Project, namely:

- 715 MW oil-fired conventional power plant
- 715 MW coal-fired conventional power plant

The objective is to prove that the proposed Phu My plant technology is the most feasible alternative, giving the lowest environmental impact, and therefore, the most suitable solution.

2 SITUATION WITHOUT THE PROJECT

In case the Phu My 2.2 Project is not realised, the negative environmental impacts of the whole Phu My Power Generation Centre (PMPGC) would decrease accordingly. But, also the positive socio-economic effects would be reduced.

The emissions to the air and to the river as described and assessed in Section E would be reduced accordingly. Taking into account that Phu My 2.2 contributes only approximately 19 % to the total output of PMPGC, the situation without the Phu My 2.2 Plant would not be considerably better than with this plant. Many of the negative impacts were caused during the preparation of the site and developing the basic site infrastructure on the whole PMPGC, which is essentially complete, and therefore would not be changed or reduced by not erecting Phu My 2.2.

At present, the Southern Focal Economic Zone (SFEZ) including Ho Chi Minh City, Binh Duong, Dong Nai and Ba Ria-Vung Tau province, contributes over 60% of the industrial output, 30% of fishery output and 60% of export output for the whole of Vietnam. This zone is also the highest urbanized zone in Vietnam with a population of over 8.5 million, 70% of which live in urban areas. However, shortage of electricity is a huge problem in this zone, particularly in the dry season, when hydropower production is curtailed due to lack of rainfall and low river flow. Shortage of electricity causes significant limitations in economic development, education, culture and health care in the zone. As forecasted by EVN, in the period 2000-2010 energy shortages will increase every year. This will be a major obstacle for socio-economic growth of Vietnam, particularly of the SFEZ. If the situation is not rapidly overcome, the planned economic growth rate of the whole of Vietnam as well as Ba Ria – Vung Tau province and Phu My town will not be achieved.

Without the project, the chances of increasing the income of the various households in the province, particularly in the Phu My town area, as well as the aforementioned other positive socio-economic effects, would be reduced. Lower overall development of the economy in the province, as well as in the whole SFEZ, would be created by the shortages of energy supply, which will be the main reason for this limitation in socio-economic development.

The implementation of the PMPGC, with its five individual power generation projects, belongs to the most important development program of the Vietnamese Government. The PMPGC has already been approved by the Vietnamese Government in Approval No. 1177/QD – KHDT, issued by the Ministry of Industry on 31/07/1997. Phu My 2.2 is part of PMPGC, which will reach a generation capacity after implementation of all power projects of approximately 3800 MW. Therefore the situation without Phu My 2.2 cannot be considered as a suitable alternative.

3 CONSIDERED ALTERNATIVES

3.1 ALTERNATIVES TO SITE

Phu My 2.2 Combined Cycle Power Plant (CCPP) will be implemented on the existing site of Phu My Power Generation Centre. The site has been selected and approved in the course of the development of PMPGC.

Advantages of the Phu My site, which proved to be the most suitable are:

- Sound infrastructure with system of roads and waterways which provide a convenient and accessible transport system
- Near to the gas field and a major natural gas supply system which is currently under implementation
- Excellent possibility for utilising the local rivers (Sau and Thi Vai) as a source of water, and cooling water supply/discharge for the whole PMPGC
- Interconnection with the national electricity network
- Close proximity to the largest power consumption centres of Vietnam (Ho Chi Minh City, Dong Nai, Binh Duong and Vung Tau).
- PMPGC is close to an industrial zone. Various industrial production plants have already been established in this zone. Sufficient qualified labour for constructing and operating the power plant projects are readily available in the area.

Over the previous five years, the Phu My Site has been prepared by the Electricity of Vietnam (EVN) as a location for the installation of the PMPGC. The site is already connected to the national power grid and main gas supply pipeline. Also the required common infrastructure (e. g. access roads etc) to all the power projects is in the main complete. Insofar as an alternative site for Phu My 2.2 Power Project, this is out of question.

3.2 ALTERNATIVES TO TECHNOLOGY

Following, two alternative technologies for power generation from fossil fuels will be discussed and compared with the Phu My 2.2 plant concept, particularly in connection to the environmental impact aspects:

- Generation of 715 MW by an oil-fired conventional power plant
- Generation of 715 MW by a coal-fired conventional power plant

For these power plant concepts, flue gas treatment equipment (flue gas desulphurisation, FGD) has also to be taken into consideration in order to fulfil the Vietnamese Emission Standard.

3.2.1 Oil-Fired Power Plant

Design

A conventional power plant has been considered using fuel oil with the same composition as foreseen for PM 2.2 Project. For the environmental comparison with the Phu My 2.2 Project, the relevant plant data are as follows:

- Efficiency 40 %
- Low calorific value (LHV) 42.3 MJ/kg
- Sulphur content 0.7 %
- Fuel consumption 152 t/h

The plant will be fitted with a flue gas desulphurisation plant (FGD) in order to meet the Vietnamese Standard of 500 mg/Nm^3 for SO_2. Additional expenditure will arise due to the higher capacities in fuel storage, transport and handling systems and residue disposal.

Since the total power generation will only be produced by steam turbine, the cooling water demand of this alternative will be approximately 50 % higher than for the Phu My 2.2 Project (approximately 70 % of power will be produced by gas turbines).

The installation of a FGD will cause additional consumption (limestone, process water) and produce additional residues (gypsum, FGD wastewater). The installation of a De-NO_X system for reduction of NO_X emissions is not considered because the Vietnamese Standard of 1000 mg/Nm^3 can be achieved without this measure (in Chapter 4 the comparison will additionally include figures with De-NO_X).

Potential Environmental Impacts

The potential environmental impacts are higher than for the Phu My 2.2 plant concept (see also Chapter 4), because of:

- Higher CO_2 emission
- Higher NO_X emission
- Higher SO_2 emission
- Higher cooling water demand
- Additional consumables
- Additional residues to be treated and to be disposed
- Higher burden to waterway due to transport of high amounts of fuel by ship
- Higher risks of oil spill and fire.

Taking all these scenarios collectively clearly indicates that the potential environmental impacts to be considered regarding an oil-fired power plant of the same generation capacity have to be assessed clearly higher than those for Phu My 2.2 project which is based on gas-fired combined cycle technology.

Suitability and Economic Aspects

Considering the above-mentioned higher expenditure, which will be incurred for the flue gas treatment, fuel transport, consumables, residue disposal etc. in connection with lower efficiency, it can also be expected that, from an economical point of view, this concept clearly falls below the Phu My 2.2 plant concept and, as such, should not be considered for implementation.

Furthermore, the actual situation at Phu My site also has to be taken into consideration. PMPGC is developed and the site and associated infrastructure are designed and mainly complete for installation of combined cycle plants. The considered space for Phu My 2.2 would not be sufficient for installation of an oil-fired power plant with flue gas desulphurisation system.

3.2.2 Coal-Fired Power Plant

Design

A conventional coal-fired power plant is considered for the comparison with Phu My 2.2. An import quality of coal is assumed as fuel, with the following composition:

Analysis	% (as received)
C	69.80
H	4.10
O	4.65
N	1.30
S	1.00
Cl	0.05
Ash	10.50
Water	8.60

For the environmental comparison with the Phu My 2.2 Project, the relevant plant data are as follows:

- Efficiency 39 %
- Low caloric value 27.6 MJ/kg
- Sulphur content 1 %
- Coal consumption 239 t/h

The plant will be fitted with an electrostatic precipitator for fly ash removal and a flue gas desulphurisation plant (FGD) in order to meet the Vietnamese SO_2 Standard of 500 mg/Nm^3.

Additional expenditure will arise due to coal unloading, storage and transportation facilities and due to bottom ash and fly ash handling and disposal. The cooling water demand of the coal-fired plant will also be about 50 % higher than for the Phu my 2.2 concept.

The installation of an FGD will cause additional consumption (limestone, process water) and produce additional residues (gypsum, wastewater and slag). The installation of a De-NO_X system is not considered because the Vietnamese standard of 1000 mg/Nm3 does not require it (in Chapter 4, the comparison will additionally include figures with De-NO_X).

Potential Environmental Impacts

The potential environmental impacts are higher than for the Phu My 2.2 plant concept (see also Chapter 4), because of:

- Higher CO_2 emission
- Higher NO_X emission
- Higher SO_2 emission
- Higher cooling water demand

- Additional consumables for FGD
- Bottom ash and fly ash to be disposed
- FGD residues to be treated and to be disposed
- Higher burden to waterway due to transport of coal by ship
- Higher burden to traffic due to ash transport
- Additional land requirements for coal yard and ash disposal site.

The operation of an ash disposal site will have adverse impacts on the local environment such as air pollution created by ash disposal activity and river, pond water pollution due to receiving run-off water containing heavy metals and solids from the ash disposal site. Consequently, this may adversely influence the natural eco-systems in the surrounding area.

Taking all these scenarios collectively clearly indicates that the potential environmental impacts to be considered regarding a coal-fired power plant of the same generation capacity have to be assessed clearly higher than those for Phu My 2.2 project which is based on gas-fired combined cycle technology.

Suitability and Economical Aspects

Due to economical aspects, a coal-fired power plant could be taken into consideration. Concerning the suitability, similar aspects as for the oil-fired plant apply, i. e. with the actual situation at PMPGC, an implementation of a coal-fired plant is not possible at the available space for Phu My 2.2 Power Project.

4 COMPARISON AND CONCLUSION

In Table F1 the main plant characteristics and data of the investigated alternatives are compiled and compared with those of the Phu My 2.2 Combined Cycle Project. The comparison of the main emissions between these alternatives and Phu My 2.2 concept are shown in the following Figures:

- Figure F1 shows the comparison of the greenhouse gas CO_2
- Figure F2 shows the comparison of the mass flows for the pollutant gases NO_X and SO_2. For oil and coal-fired alternatives, an FGD is considered but not a De-NO_X plant.
- Figure F3 shows the same as Figure F2 but additionally considering a De-NO_X system for oil and coal-fired plants.

Considering all above gained results, it can be assessed that the plant concept of Phu My 2.2 is the most suitable technology selection for generation of 715 MW power at the Phu My site. This plant concept is based on modern combined cycle technology with high thermal efficiency and relatively low environmental impact.

Table F1: Comparison of Power Plant Alternatives and Phu My Plant Concept

Plant Data	Conventional Coal-fired PP	Conventional Oil-fired PP	Phu My Gas-fired CCPP
Fuel	Coal *)	Oil **)	Natural gas ***)
Power generation capacity MW	715	715	715
Efficiency %	39	40	54
Lower heating value MJ/kg / MJ/Nm^3	27.6	42.3	39.4
Fuel consumption kg/h, Nm^3/h	239,000	152,200	119,500
Reference O_2 %	6	3	15
Flue Gas Data			
Nm^3/h (dry, ref. O_2)	2,330,942	1,843,617	3,920,704
NO_x mg/Nm^3 (dry, ref. O_2)	600	400	52
SO_2 mg/Nm^3 (dry, ref. O_2)	1,903	1,129	<1
SO_2 mg/Nm^3 (dry, ref. O_2) with FGD	450	450	
CO_2 kg/kg fuel, kg/Nm^3 gas	2.56	3.15	2.30
Emissions			
Mass flows:			
NOx kg/h	1,399	737	200
SO_2 kg/h (with FGD for coal and oil fired plants)	1,049	830	<1
CO_2 t/h	612	480	275
Specific emissions:			
NO_x kg/MWh	1.96	1.03	0.28
SO_2 kg/MWh	1.47	1.16	0
CO_2 kg/MWh	855	671	384
Additional Consumption			
Limestone (FGD) kg/h	6,000	2,200	-
Process water (FGD) m^3/h	120	90	-
Additional Residues			
Ash (to be disposed) kg/h	20,554	neglectible	-
Gypsum (FGD) kg/h	10,400	3,900	-
Wastewater (FGD) m^3/h	4	1	-
Other Aspects			
Land for coal yard/ash disposal	yes	no	-
Impact by ash transport and disposal	yes	no	-
Influence on waterway by fuel transport	yes	yes	-
Cooling water demand/discharge	50 % higher	50 % higher	-
Risks (e.g. oil spill, shipping accident)	increased	higher	-

*) 1 % S, LHV = 27,6 MJ/kg
**) 0,7 % S, LHV = 42,3 MJ/kg
***) LHV = 39,4 MJ/Nm3

Figure F1: Comparison of CO_2 Emissions of the Alternatives

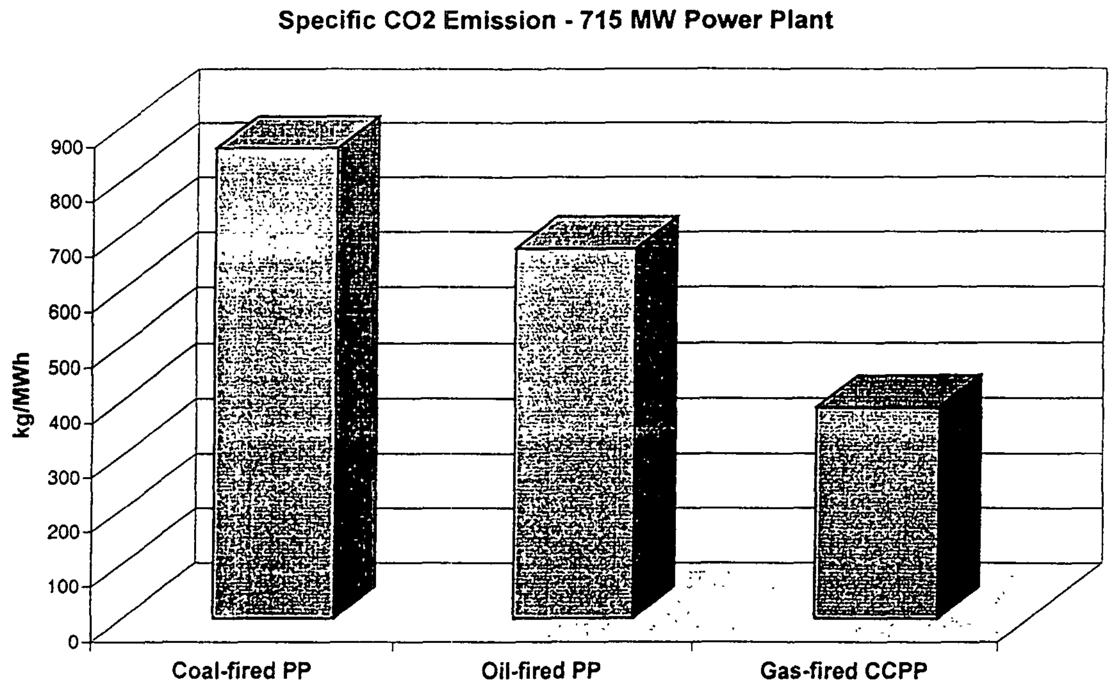


Figure F2: Comparison of SO_2 and NO_X Emissions of Alternatives considering FGD for coal- and oil-fired Power Plants

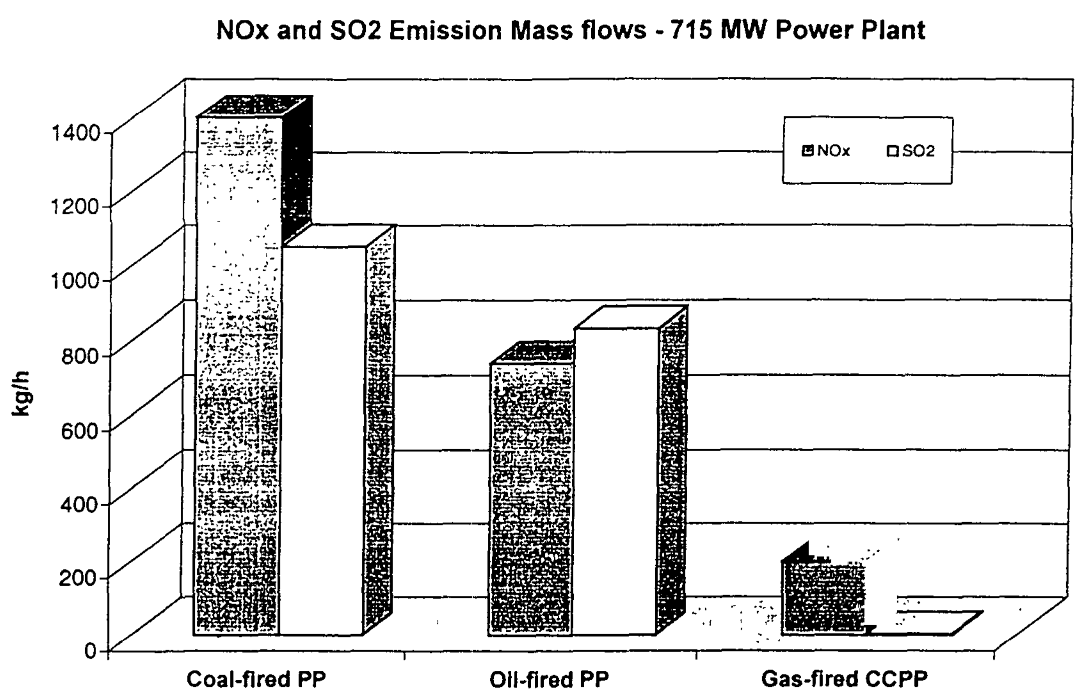
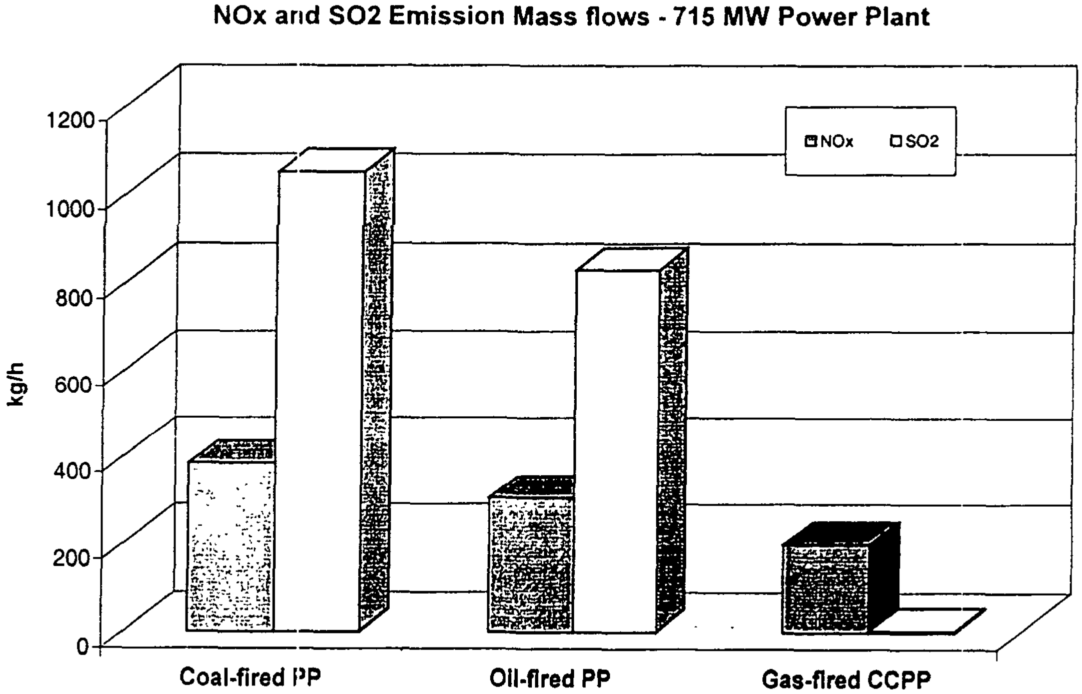


Figure F3: **Comparison of SO_2 and NO_X Emissions of Alternatives considering De-NO_X and FGD for coal- and oil-fired Power Plants**



SECTION G

ENVIRONMENTAL MANAGEMENT PLAN

SECTION G: ENVIRONMENTAL MANAGEMENT PLAN

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1 INTRODUCTION AND INSTITUTIONAL REQUIREMENTS

1.1 INTRODUCTION

The Phu My 2.2 Thermal Power Project with a capacity of 715 MW will be implemented at Phu My Power Centre (PMPGC) in Tan Thanh district, Ba Ria – Vung Tau province. After its final completion the PMPGC will include 5 different power plant projects with a total generation capacity of about 3,800 MW. All common infrastructure systems (roads, cooling water supply, power transmission, etc.) have in the main been completed. With the Phu My 2.2 Project, the PMPGC will be extended with two additional power generation units, which are based on combined cycle technology with natural gas as the primary fuel. The development is designated a "Category A" project, for which the EIA report shall include an Environmental Management Plan (EMP). According to the World Bank Operational Policies (OP.4.01, January, 1999) the EMP shall describe mitigation, monitoring and institutional measures to be taken during implementation and operation of the project to eliminate adverse environmental and social impacts, or reduce them to acceptable levels.

1.2 LEGAL DOCUMENTS

Monitoring the project during the implementation period is also a requirement of the Government of Vietnam. The main legal documents relating to the requirements of environmental monitoring are indicated as follows.

- Environmental Protection Law of Vietnam, issued on 10th January 1994 by Order of the President.
- Decree N175/CP on 18th October 1994 issued by the Government, guiding implementation of the Environmental Protection Law,
- Circular N276-TT/Mtg on 6th March 1997 issued by the Ministry of Science, Technology and Environment (MOSTE) guiding implementation of pollution control and environmental monitoring after approval of EIA report.
- Guideline of World Bank (OD 4.00, October 1989; OD 4.30, OP 4.01, January 1999).

1.3 MONITORING AGENCIES

In Vietnam, NEA within MOSTE is responsible for nation wide environmental management, including environmental monitoring. A National Monitoring System, which was set up by NEA in 1994 includes various environmental research centres. These centres monitor the air and water quality in selected areas, and reports the results directly to NEA.

According to Vietnamese law, projects and/or companies, which could pose a risk to the environment, can perform/implement suitable monitoring procedures during the construction and operational phases ("internal monitoring").

At provincial level, DOSTE of Ba Ria – Vung Tau is responsible for environmental management at Phu My Town, including the Phu My 2.2 Thermal Power Plant. However, external environmental monitoring should be conducted by an independent environmental research agency.

2 MITIGATION MEASURES

2.1 DESIGN PHASE

There are no churches, temples, pagodas, natural forests, or wildlife sanctuaries in the project area that could be encroached upon by the construction or operation of the Phu My 2.2 plant. Therefore, measures for encroachment limitation of populated, cultural and protected sites are not necessary. The Phu-My Complex has a jetty to receive fuel oil from tankers. Therefore, during its design phase, the protection of mangrove forest and wetland along the Thi Vai River was considered, so that the impacted areas are minimised, particularly on the left bank of the river. The scope of works within Phu My 2.2 does not contemplate any additional jetty or any construction works which would encroach upon the waterway. This plant will be located in the existing PMPGC area, where all households have been removed and compensation settled some years ago. Therefore, a Resettlement Action Plan is also not required for this project.

The Design of the combined cycle power plant Phu My 2.2 is characterised by high efficiency and natural gas as fuel for normal operation, which ensures that:

- The emissions of CO, dust, SO_2 and NO_x are minimised and will meet the Vietnamese and World Bank standards.
- The requirements of the Vietnamese and World Bank Noise regulations will be respected.
- The wastewater treatment systems and cooling water system will be completed according to the requirements of the Vietnam Standard and World Bank guidelines.
- The distillate oil storage tanks will be installed according to Vietnamese regulations.
- All required safety measures (fire prevention with adequate control measures, workers health and safety) will be in accordance with the Vietnamese Standards and the guidelines of the Fire Control Agencies of the Ministry of the Fire Police and Ba Ria – Vung Tau Fire Police Administration.

2.2 CONSTRUCTION PHASE

The following measures will be considered during the construction phase of the Phu My 2.2 Power Plant:

Protection of water quality and aquatic ecosystems:

- Disposal of solid waste (construction waste, sand, stone etc.) and waste grease and oil from construction equipment to the local water source will be prevented. All the waste will be collected and transported to the approved provincial disposal sites
- The project will install adequate sanitation systems (for example mobile toilet facilities) for workers to prevent untreated or inappropriate domestic waste discharge
- Discharge and disposal of domestic waste from the construction camps into water sources will be avoided. Domestic solid wastes will be collected and transported to the disposal sites of Ba Ria-Vung Tau. The Ba Ria-Vung Tau Environmental Companies, through an Agreement with the Constructors, can implement solid waste collection and treatment.

Protection of air quality:

Air pollution during the construction phase (mainly during civil work activities) may occur mainly due to dust emission. The following mitigation measure will be performed:

- During the dry season, periodic watering of the construction sites access

- Contractors will be required to implement and apply the following measure to mitigate dust and prevent traffic accidents:
  - Limit the speed within the construction site, and the access road leading to the site.
  - Regularly water down the site and access roads
  - Wash down the vehicles, which are leaving site.
  - Vehicles transporting open loads of construction materials such as sand, clay shall be covered where necessary

Noise:

To reduce noise during the construction phase appropriate measures shall be taken to comply with local regulations:

- Prohibition of noisy activities during the night.
- Speed restrictions to be applied to heavy/articulated vehicles, which pass through residential areas.

Impact by Traffic:

To maintain the traffic safety it is considered to keep the traffic slow which pass through residential areas by appropriate measures such as giving a safety education to the drivers.

A summary of all important impacts during the construction phase and the applied mitigation measures are given in the following table:

The main Project Impacts and Mitigation Measures during Construction Phase

No.	Impact	Possible Effects	Assessment / Mitigation Measures
1	Land clearing of local people	Resettlement and compensation of people	All required activities have already been performed in connection with PMPGC construction
2	Land used	Space requirement	Approx. 8 ha of total 128 ha of the Phu My Site is required
3	Traffic / transportation	Increase in traffic volume	Temporarily affects. Transport of main plants and equipment by water way Keep the traffic slow for safety
4	Construction labour and activities	Increase in air pollution, noise and waste quantity	Temporarily affects. Avoiding of dust pollution by periodic watering of site during civil works. Avoiding of noisy activities during the night. Wastewater and solid waste disposal according to the local regulations
5	Socio-economic	Employment aspects	Positive effects on temporary employment for local workers

2.3 OPERATION PHASE

The Phu My 2.2 power plant will be one of the five power plants, which will be located at the PMPGC. All these power plants are installed in close proximity to each other on the same site. Several of the required supply and disposal systems (e.g. cooling water supply and discharge) belong to PMPGC (EVN) and will be utilised by all five power plants. Considering the close proximity of the plants and the common supply and disposal systems of PMPGC, the operational impacts can be divided into the following two groups:

1st Group: Impacts, which can be directly controlled by each individual power plant:

- Flue gas emissions into the atmosphere (e. g. NO_x, SO_2, CO)
- Cooling water supply and discharge within the plant boundary
- Natural gas supply within the plant boundary
- Distillate oil supply within the plant boundary
- Noise within the plant boundary
- Waste water discharge within the plant boundary
- Solid waste disposal

2nd Group: Impacts, which are collective and cannot directly be controlled by each individual power plant (impact of whole PMPGC):

- Ambient air quality
- Cooling water supply from the Sao river
- Cooling water discharge to the Thi Vai river
- Waste water discharge to the Thi Vai river
- Sanitary water discharge to the Thi Vai river
- Natural gas supply system
- Distillate oil supply system
- Noise outside of the PMPGC

Air Pollution:

As investigated in Section E, the NO_x and SO_2 emissions of Phu My 2.2 power plant will be below the Vietnamese and World Bank Emission Standards with natural gas as the primary fuel and distillate oil as secondary emergency fuel (see Table G1).

No special mitigation measures to control air emissions are required during the operation of Phu My 2.2 power plant. The mitigation measures to minimise air pollution are found in the technology and design of the power plant, such as:

- Combined cycle concept high efficiency
- Natural gas as normal fuel
- Dry low NO_x system (gas as fuel)
- Limitation of distillate oil as emergency fuel (max. 5 days/a)
- Water injection system to reduce NO_x emission when firing oil.

In combined cycle mode the flue gas will be discharged to the atmosphere by stacks of 60 m in height to ensure sufficient dispersion of the pollutants.

Table G1: Comparison between Phu My 2.2 Emissions and Standards			
	Phu My 2.2 Emissions mg/Nm^3	**Vietnamese Standard mg/Nm^3**	**World Bank Standard mg/Nm^3**
Dust	Negligible	400	50
NO_x - Main fuel natural gas - Emergency fuel distillate oil (Max. 5 days/a)	 52 119	 1000 1000	 125 165
SO_2 - Main fuel "natural gas" - Emergency fuel "distillate oil" (Max. 5 days/a)	 Negligible 376 mg/Nm^3 39.5 t/day	 500 500	 122 - 122 t/day

According to the impact on ambient air quality, the NO_X emission is the most important aspect of pollution of the Phu My 2.2 project, as well as the whole PMPGC, since natural gas will be used as the primary fuel (distillate oil max. 5 days/a). Considering the existing background concentration and the normal operation of all plants at 100 % load, the estimated maximum ground level NO_X concentrations caused by Phu My 2.2 and by the whole PMPGC will be below the applicable standards of Vietnam and WB (see Table G2).

Table G2: Estimated Maximum NO_X Concentration in Ambient Air			
NO_X Concentration	**Background** mg/Nm^3	**Phu My 2.2** mg/Nm^3	**PMPGC** mg/Nm^3
1 h average: - Dry season - Wet season	0.033 to 0.297	 0.047 0.031	 0.07 0.11
24 h average: - Dry season - Wet season		 0.024 0.015	 0.03 0.05
Vietnamese Standard: - 1 h average - 24 h average		 0.40 0.10	 0.40 0.10
WB Standard: - 24 h average - Annual average		 0.15 0.10	 0.15 0.10

Noise

The Phu My 2.2 power plant as part of PMPGC is located at least 400 m from the nearest residential areas. To reduce noise level in the neighbourhood and to protect workers in the plant, Phu My 2.2 will be designed so that the equipment will meet the requirements of the Vietnamese

Noise Standards and WB Guidelines (e. g. installing silencers). Since the residential area is relatively far away from the power plant, the generated noise will have no impact on this area. The Vietnamese noise standard for commercial and service area (70 / 50 dB(A): day time / night time) as well as the WB Guideline (70 dB(A)) will be met.

Wastewater pollution

Rainwater drainage:
The Phu My 2.2 project will build a rainwater drainage system. Areas with high potential to be contaminated by oil and grease will have a separate collection system. The drainage system of Phu My 2.2 will be connected to the existing drainage system of PMPGC.

Sanitary wastewater:
The sanitary wastewater will be treated in an anaerobic biological digester or self-decomposition tank commonly called a "Septic Tank". After treatment the BOD will be reduced by more than 80%. Wastewater quality will be in compliance with Vietnamese standards.

Avoiding water pollution due to oil spills:
The Oil Jetty belongs to EVN, and is operated by PMPGC management board and is not in the scope of Phu My 2.2. In order to control pollution caused by the activities of ships, lighters and barges at the jetty, the following measures have been considered by PMPGC:

- Prohibition of any discharge of oil contaminated water waste to the river by any marine vessel or barge. The pumping of any contaminated water into the River is forbidden. Waste oil and dredged material are to be discharged, properly treated and disposed on land, any such disposal or treatment area is to be located no less than 2 km from any recognized and legally established aqua-cultural area.

- The harbour authority should regulate and inspect marine safety systems and equipment both shipboard and onshore, regulate and oversee any control and treatment systems and procedures for oil or any other contamination leaked or spilled from ships or other marine vessels within the regulatory jurisdiction and control of the port authority

- Require that all marine vessels, transient or otherwise have suitable systems and equipment installed and in service to prevent, mitigate, control and recover from safety and environmental incidents such as fire, explosion, oil spill or other events of similar scope and nature.

The common distillate oil supply system is operated and is the responsibility of PMPGC management board. These existing systems are implemented and operated according to the requirements of the Vietnamese regulations and standards.

In order to avoid oil pollution within the boundary of the Phu My 2.2 power plant, all appropriate measures according to the Vietnamese Standards will be taken into consideration. For example, the fuel oil tanks will be constructed as bunded tanks (impermeable pad, surrounded by dykes). The bund may hold the total volume of the tank, plus 10%. In areas with the possibility of oil spills (workshops, garage, oil forwarding pumps, etc.), oil separators will be installed before water from those areas is drained off.

Cooling water intake / discharge

The cooling water intake will be designed for a low velocity of about 0.3 m/s at which fish can escape easily. The cooling water discharge point on the Thi Vai River has been selected to ensure adequate/thorough mixing in the initial contact and dissemination zone. And also the design of the cooling water discharge pipes has decided to optimise the thermal diffusion.

Industrial and sanitary solid wastes

Sanitary Waste:
In the operation phase the quantity of sanitary waste from the workers is minimal and will be collected and transported to an appropriate place for disposal in accordance with local requirements.

Industrial Waste:
Industrial solid waste such as packs, cloths saturated with oil and/or grease and sludge extracted from a treatment system will be gathered and treated or transported to an appropriate place for disposal in accordance with local requirements.

Fire prevention

Fire prevention and control at the Phu My 2.2 CCPP will be designed in accordance with Vietnamese Standards. In addition, fire prevention system will strictly follow the guidelines of the Fire Control Agencies of Ministry of Fire Police and Ba Ria – Vung Tau Fire Police Administration. The design of the projects fire prevention, and control systems, will be approved by the Vietnam Authority.

A summary of all important impacts during the operation phase and the applied mitigation measures are given in the following table:

The Main Project Impacts and Mitigation Measures during Operation Phase

No.	Impact	Possible Effects	Assessment / Mitigation Measures
1	Climate	Greenhouse effect	Minimising of specific CO_2 emissions by high plant efficiency and natural gas as fuel (384 kg/MWh)
2	Emissions	NO_x and SO_2 pollutions	Limitation of NO_x emission by applying of modern combustion technology (gas 52 / oil 119 mg/Nm^3). Limitation of SO_2 emission by using of oil for max. 5 days/year
3	Ambient air quality	Increasing of pollutant concentration	Impact minimised because all plants at PMPGC are based on combined cycle system with gas as main fuel (relatively low emissions). Stack height supports good dispersion.
4	Noise	Plant surrounding	Appling noise protection measures in order to meet the required standard
5	Fresh water demand	Water availability	Fresh water demand of 30 to 50 m^3/h which will be supplied by Ba Ria Vung Tau Water Company via existing PMPGC water pipe system
6	Cooling water demand	Water availability	Limited demand because of combined cycle technology. About 70 % of power will be generated by gas turbines which do not need cooling water. Maximum demand for Phu My 2.2 about 17 m^3/s, for total PMPGC about 90 m^3/s

7	Wastewater discharge	River pollution	Appling of wastewater treatment in order to meet the required standards
8	Cooling water discharge	Temperature increase of river water. Effects on fish species and mangroves	Limitation of cooling water temperature increase to max. 7 °C. Using of suitable discharge system for appropriate temperature distribution in Thi Via River. Temperature increase near surrounding of discharge point of max. 2.6 °C will decrease quickly to lower than 1 °C. This temperature increase in a closed area will not affect the fish species and mangroves seriously.
9	Cooling water intake	Reduction of fish species	The cooling water intake will be designed for a low velocity of about 0.3 m/s at which fish can escape easily
10	Solid waste disposal	Pollution of rivers and near area	The solid waste will be disposed by an authorised local disposal company (similar to PMPGC) according to local regulations
11	Socio-economic	Country and future development	The impact of the project on the local and Vietnamese socio-economic development can be assessed as very high

3 MONITORING

3.1 ORGANISATION OF ENVIRONMENTAL MANAGEMENT

In order to properly assess environmental impacts of the Phu My 2.2 Thermal Power Plant as well as evaluate the effectiveness of mitigation measures applied for the abatement of environmental pollution a program of monitoring and oversight of the project will be implemented. This oversight program will be implemented by the Department of Science, Technology and Environment (DOSTE) of Ba Ria - Vung Tau province in cooperation with the Phu My 2.2 Plant Management Board.

As already discussed in Chapter 2.3, the Phu My 2.2 Power Plant (715 MW) will only be a part of the whole PMPGC which includes four other power plants (PMPGC total capacity approx. 3800 MW). Since several environmental impacts (e.g. ambient air concentrations) cannot be divided and associated to each individual plant, a suitable monitoring program for Phu My 2.2 as well as whole PMPGC has to be considered.

Figure G1 indicates the organisation of the environmental management and monitoring of the Phu My 2.2 and the whole PMPGC.

The Phu My 2.2 Management Board will be responsible for the internal environmental management and monitoring of the plant. For this purpose, the board shall nominate and appoint an Environmental Engineer as head of an environmental management group (EMG) who shall be responsible for the execution of environmental related issues such as:

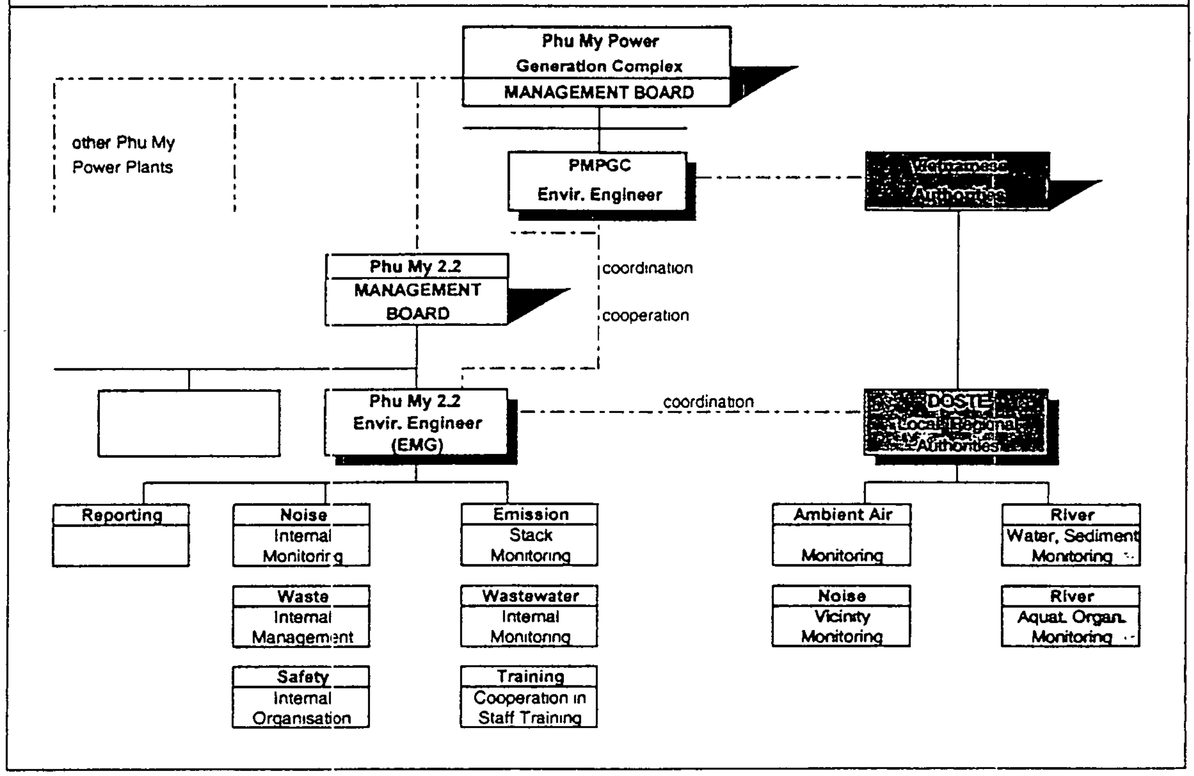
- Stack emission monitoring
- Internal noise monitoring
- Internal waste management
- Waste water monitoring
- Labour safety
- Coordination with local and regional authorities (DOSTE)
- Coordination with environmental management unit of PMPGC
- Power plant related reporting.
- Cooperation in performing labour/staff training

Additionally, an authority/environmental engineer will be responsible for the environmental issues common for the whole PMPGC. Main responsibilities of the central environmental engineer shall be

- Ambient air monitoring
- Noise monitoring at residential area
- Waste water discharge to Thi Via River
- Cooling water discharge to Thi Vai river
- Waste management for the total complex
- Coordination of activities between all located power plants
- Standardising of procedures and equipment to be applied by all plants
- Preparing reports for the whole PMPGC
- Coordination with Vietnamese authorities
- Organisation of labour/staff training

The organisation of the environmental management of Phu My 2.2 shall be set in place early in order to commence work during the construction phase.

Fig. G1: ORGANISATION OF ENVIRONMENTAL MANAGEMENT FOR PHU MY 2.2 POWER PLANT



3.2 Atmospheric Pollution Monitoring

Impacts on air quality shall be monitored, by measuring the emissions of the Phu My 2.2 power plant as well as by monitoring the ambient air quality and meteorological parameters in the area around the PMPGC site.

The Environmental Management Group (EMG) of Phu My 2.2 power plant shall be responsible for the execution and evaluation of the emission measurements at the stacks of the plant. EMG of PMPGC shall be responsible for the ambient air quality monitoring. The measurement and monitoring activities shall be performed by the Department of Science, Technology and Environment (DOSTE) according to the Vietnams regulations. All monitoring activities shall be coordinated between the parties involved.

The following Table G3 summarises the recommended scope and plan of air pollution monitoring:

Table G3: Atmospheric Pollution Monitoring Plan			
	Parameter to be monitored	**Location / Method /Frequency**	**Responsibility Estimated Cost**
Construction Phase:	Ambient Air: Dust	- Phu My 2.2 site and surrounding - Approx. monthly during civil work activities (apprx. 5 times)	EMG of Phu My 2.2 Measurement cost: 10000 USD
Operational Phase	Emissions: NO_x, SO_2, CO, O_2 Temperature	- Stack - Analysers with evaluation unit - Automatic, continuously	EMG of Phu My 2.2 Cost of instruments: Approx. 150000 USD
Operational Phase	Ambient Air: NO_x, SO_2	- Site surroundings - Ambient air monitoring stations - 2 times per year (rainy and dry season)	EMG of PMPGC/DOSTE Measurement cost: approx. 15000 USD/year
Operational Phase	Meteorological Parameters: Wind velocity and direction, Temperature, pressure, humidity	- Site surroundings - Ambient air monitoring stations - 2 times per year (rainy and dry season)	EMG of PMPGC/DOSTE Cost included in above position

3.3 NOISE MONITORING

During operation phase, noise measurements shall be performed in order to monitor the noise level within the boundary of the Phu My 2.2 plant as well as the residential area outside of the PMPGC. The EMG of Phu My 2.2 shall record the measurements at the plant boundary. The responsibility for measuring/recording the noise levels outside the plant boundaries shall be within the scope of the EMG of the PMPGC. The measurements should be performed by DOSTE according to the Vietnamese regulations. Table G4 summarises the noise monitoring plan.

Table G4: Noise Monitoring Plan			
	Parameter to be monitored	**Location / Method /Frequency**	**Responsibility**
Construction Phase	Noise levels (LEG)	- site boundary, close to nearest residential area - Portable acoustimeter - During peak hours of construction	EMG of Phu My 2.2 Measurement cost:: approx. 2000 USD
Main equipment of Phu My 2.2 (e. g. turbines, generators)	Noise levels (LEG)	- 1 m from equipment - Portable acoustimeter - 1 time per month	EMG of Phu My 2.2 Measurement cost:: approx. 3000 USD
Noise at surroundings of site	Noise level	- Outside Phu My site, close to nearest residential area - Portable acoustimeter - 2 times a year	EMG of PMPGC DOSTE Measurement cost:: approx. 3000 USD

3.4 WATER POLLUTION MONITORING

The discharge of wastewaters, from within the Phu My 2.2 power plant boundary shall be monitored regularly by the EMG of Phu My 2.2.

Water quality of the Thi Vai and Sao Rivers, shall be monitored regularly by the EMG of PMPGC, since the water quality can be affected by all the power plants located at PMPGC. The implementation of the water, monitoring program shall commence during the construction phase and will continue during plant operation. The measurement and monitoring shall be performed by DOSTE according to the Vietnamese requirements.

The water monitoring plan is summarised in Table G5.

Table G5: Water Pollution Monitoring Plan

Item	Parameter to be monitored	Location / Frequency	Responsibility
Construction Phase: Thi Vai River water	pH, susp. solids, oil/grease, COD, BOD_5, coliforms, temperature	- Upstream of Thi Vai River - at jetty - Downstream on Thi Vai river - 2 times (1 each season)	EMG of Phu My 2.2 Measurement cost:: approx. 2000 USD
Operation Phase: Effluent discharge Phu My 2.2:	pH, susp. solids, oil/grease, BOD_5 temperature	- At boundary of Phu My 2.2 plant, before discharge point to common PMPGC discharge channel - 1 times/month	EMG of Phu My 2.2 Measurement in power plant laboratory
Operation Phase: Effluent discharge PMPGC	pH, susp. solids, oil/grease, COD, BOD_5, coliforms temperature	- Common PMPGC discharge channel - 2 times per year (1 each season)	EMG of PMPGC DOSTE Measurement cost:: approx. 2000 USD/a
Operation Phase: Sao River water	pH, susp. solids, oil/grease, COD, BOD_5, coliforms temperature	- Upstream of Thi Vai River - at jetty - Downstream on Thi Vai river - 2 times per year (1 each season)	EMG of PMPGC DOSTE Measurement cost:: approx. 2000 USD/a
Operation Phase: Thi Vai River water	pH, susp. solids, oil/grease, COD, BOD_5, coliforms, temperature	- Upstream of Thi Vai River - at jetty - Downstream on Thi Vai river - 2 times per year (1 each season)	EMG of PMPGC DOSTE Measurement cost:: approx. 2000 USD/a

3.5 AQUATIC ORGANISMS MONITORING

Additionally river water and sediment, aquatic organisms shall be collected, stored and examined following proven/standard methods widely applied by ecological research institutes in Vietnam and overseas. These monitoring program shall commence at the end of the construction phase and be performed for 3 years of operation as outlined in Table G6.

Table G6: Aquatic Organisms Monitoring Plan

Item	Parameter to be monitored	Location / Frequency	Phase Responsibility
Construction Phase: Aquatic organisms	phytoplankton, zooplankton, benthic organisms, fish juvenile and eggs	- Upstream on Thi Vai river - Downstream on Thi Vai river - 2 times (1 each season)	EMG of Phu My 2.2 Measurement cost:: approx. 5000 USD
Aquatic organisms	phytoplankton, zooplankton, benthic organisms, fish juvenile and eggs	- Upstream on Thi Vai river - Downstream on Thi Vai river - 2 times/year (1 each season), 3 years operation	EMG of PMPGC Measurement cost:: approx. 5000 USD/a

4 TRAINING PROGRAM

It is recommended to conduct a consulting and training program for lead personnel of Phu My 2.2 power plant and PMPGC. This will ensure that highly qualified staff will take over the responsibility and will work on environmental management and monitoring. The training program should be performed in coordination with the responsible local authorities.

The consulting and training program should commence towards the end of the construction period and be completed in the first few months of operation. The detailed scope and schedule may be established later, an initial brief outline of a possible scope is given in the following Table G7.

Table G7: Brief Summary of Consultant / Training Services

Activity	Subject	Specialist	Duration Months	Staff-Months	Cost USD
Consulting	Preparation of training program	Environmental Engineer	2	1 foreign 2 local	30000
Consulting	Support in establishing environmental management group and management program	Environmental Engineer	3	1 foreign 3 local	50000
Training	Environmental monitoring of thermal power plants and potential mitigation measures	Environmental Engineer	2	1 foreign 1 local	25000
Training	Emission monitoring equipment: - Requirements - Specification - Operation - Maintenance -	1 Environmental Engineer of Phu My 2.2	1		15000
Training	Wastewater analysis and, waste management	1 Environmental Engineer of Phu My 2.2	1		15000
Training	Worker safety and health aspects	1 Environmental Engineer of Phu My 2.2	1		15000

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SECTION H

PUBLIC CONSULTATION

SECTION H: PUBLIC CONSULTATION

TABLE OF CONTENTS

LIST OF TABLES

1 INTRODUCTION

The Phu My 2.2 Thermal Power Plant is a BOT project, proposed by Mekong Energy Company (MECO), a Consortium of EdF, TEPCO and Sumitomo. The Project is part of the Phu My Power Generation Complex, where land clearing, relocation of houses, preparing of infrastructure facilities have been completely done before 1996. The project has a capacity of 715 MW; the main fuel to be used is natural gas.

An EIA report of the project has been prepared on behalf of MECO (PECC2, VESDEC) and the Project has been approved by the Vietnamese Government in May 2001.

Phu My 2.2 is a category A project (World Bank classification) and needs a Public Consultation Process.

World Bank policy directs the borrower to publicly solicit, hear and consider the concerns of the local community, other affected groups and local NGOs (non-governmental organisations) and to fully incorporate into the design and implementation of the project and the Environmental Assessment (EA). The rationale for consideration and incorporation of the concerns of the affected parties is to assure community acceptance and enhance the viability of the project.

Also according the basic principles of the Socialist Republic of Vietnam, all policies, programs or projects of the Government, private and/or foreign investors should be disclosed and discussed with the people in the affected areas so that the reasonable comments and concerns of project affected people (PAP) are fully considered and incorporated.

2 REPORT ON PUBLIC CONSULTATION

The public consultation process for the Phu My 2.2 power plant project was performed in two phases.

A first phase was from April to August 2001

A second phase was initiated in November 2001 in order to complete the procedure and to comply with World Bank's requirement to hold two meetings for a category A project. The second phase has been performed with regular information of World Bank's Services in Hanoi.

2.1 FIRST PHASE OF PUBLIC CONSULTATION

The first phase of the public consultation process was organised and conducted mainly by VESDEC and PECC2. The main activities are summarised in Table H1.

Table H1: Activities of First Phase of Public Consultation Process			
Activities	Location	Duration	Conducted by
1. Discussion with the provincial environmental agency (DOSTE)	Vungtau town	April, May 2001	VESDEC
2. Presentation of the EIA Report to MOSTE	MOSTE, Hanoi	April 2001	MECO
3. Receiving environmental approval paper given by the Government Environmental Agency (MOSTE)	MOSTE, Hanoi	May 2001	MECO
4. Informing to the People Committee of Baria-Vungtau Province, Tanthanh District and related agencies, representatives of Project Affected Households (PAHs) on the Public Consultation Process	Vungtau, Phumy town	May 2001	MECO / PECC2
5. Preparation of booklets and materials to be distributed to the related agencies/people	Baria-Vungtau, HCM City	May, June 2001	PECC2, VESDEC
6. Organisation of official meeting with the related agencies and representatives of the PAHs	Phumy town	July 31, 2001	MECO / PECC2, VESDEC
7. Hearing from governmental agencies, research institutes, scientists, PAHs	Baria-Vungtau; HCM City	July-August 2001	MECO
8. Preparation and submission a report on Public Consultation for WB and MOSTE	Baria-Vungtau; HCM City	August 2001	MECO & related consultants

2.1.1 Material for Public Consultation Meeting

A booklet in Vietnamese language, summarising the project's technology and particularly, environmental and social impacts, had been prepared and distributed 2 months before the meeting to the following agencies:

- People Committee of Baria-Vungtau Province
- DOSTE Baria-Vung tau
- People Committee of Tanthanh district
- People Committee of Phumy town
- Departments of Planning & Investment; Industry, Public Health, Tourism, Agriculture & Rural Development, Fishery of the province
- Associations of Vietnamese Women, Vietnamese Veterans, Vietnamese Farmers of the province and Tan Thanh district
- Scientific and research institutions: VACNE, environmental faculties of the Ho Chi Minh National Universities, Institute of Tropical Biology...
- Fatherland Front of Tan Thanh district and Phu My town.

2.1.2 Public Consultation Meeting

On July 31, 2001, after 2 months spent for project communication, the official meeting between the representatives of the project, the province, district and town, and the representatives of project affected households was held in an office of Tan Thanh People's Committee.

Participants in the meeting were the representatives of

- MECO,
- PECC2, VESDEC (who prepared the EIA)
- 25 representatives of local people and
- environmental faculty of the University of Technology, HCM City and
- Reporters from Tan Thanh Radio Station.

The list of participants is shown in Appendix H1. The program of the meeting is shown in Appendix H2.

Mr. Nguyen Xuan Xuong, Vice Chairman of People's Committee of Tan Thanh district was chairman of the meeting.

- The project representatives reported on the main characteristics of the project (technology, location, construction, operation, etc.) and main environmental impacts of the project.
- It was also presented that the project followed the relevant Vietnamese and WB guidelines for EIA study and that the project has received an approval document on the EIA report given by the Vietnamese Environmental Authority (MOSTE)
- PECC2 presented the main data on the project technology and discussed alternatives as well as the impacts of the project on air quality
- VESDEC presented the main adverse impacts of the project on the local environment and socio-economy and also various effective technical and management measures to be applied by the project to mitigate the potential impacts.

After presentation of information on the project, the participants in the meeting gave their comments, evaluation and requirements to the project, comprising:

Importance of the Project
Representatives of the People's Committee, People Council of the district and the town and most of participants have highly evaluated the importance of the Phu My 2.2 as well as the Phu My Power Generation Complex in socio-economic development of the town. Therefore, local people and administrative organisations of the district and town strongly support the project.

Relocation of the Affected Households
The representatives of the Project Affected Households (PAHs) and People's Committee have confirmed that before 1996 the Phu My Energy Complex planned by EVN has fairly solved the resettlement problems and compensation for the loss of land, houses, trees for the PAH before 1996. All PAHs were satisfied with the relocation policy conducted by EVN.

The Main Concerns of the Local People to the Project
Most of participants were concerned on possible adverse impacts of the projects like
- water intake for cooling system, which may negatively influence fish source of the Thi Vai river, and consequently influence fishing households,
- dust and noise pollution and damage of local road created by material transport during the construction phase,
- environmental pollution created by waste of thousands workers during the construction phase,

- environmental risks, mainly gas burning, explosion and oil leakage, which may influence to human life and fish sources.

The Main Suggestions and Requirements of the Local People
In the meeting, various proposals to the project were given by the local participants, mainly concentrating on issues like:

- the project should carry out suitable measures for the prevention of dust, noise, traffic jam during transport of construction materials
- the project or EVN should well design and operate water intake system to minimise loss of fish, shrimps created by river water intake.
- a monitoring program on aquatic species, particularly fish and shrimp source in the Thi Vai river should be performed now and in the operation phase.
- the project should thoroughly design, install and operate system for prevention of risks by fire
- the project should create positive socio-economic effect on the local people
- the project should be responsible for all impacts created by project construction and operation. In case of damage on aquaculture, fishery, public health etc., the project should give adequate compensation for affected households.

The Project Proponent has promised to obtain all comments and suggestion of the representatives of local people and will report to the project managers. He confirmed that in the design and tender documents, emphasis will be given to environmental issues.

In conclusion of the meeting, the Vice-Chairman of Tan Thanh District People's Committee has greatly evaluated the democratic way of the Project in Public Consultation process. He has also promised that people in Phu My town and Tan Thanh district will support and cooperate with the project in the construction and operation phase. He has emphasised that the project should pay attention on possible environmental and social negative impacts and implement appropriate measures to meet the suggestions and requirements given by the representatives of local people in this meeting.

2.2 SECOND PHASE OF PUBLIC CONSULTATION

The second meeting for public consultation was scheduled and took place on Thursday 20 December 2001 from 9:30 h am at the Tan Thanh People's Committee Headquarters. For one week in advance, two facilities were available to display various documents/diagrams relating to the Phu My 2.2 project for the interested parties to view:

- Tan Thanh People's Committee Headquarters
- Phu My People's Committee Headquarters.

2.2.1 Preparation of the Second Meeting

Invited Persons
The invited persons are listed in Appendix H3.

Public Announcements
Information regarding the document viewing facilities and Public Consultation Meeting have been announced on:

- Ba Ria - Vung Tau TV Station (BRT1) on the $17^{th}/18^{th}$ December 2001, at 20:00hrs until 20:15hrs, following the Daily News..

- A radio Broadcast in the Tan Thanh District and Phu My Town will air every lunchtime from the 14th to the 20th of December 2001.
- An article published in the Ba Ria – Vung Tau Newspaper on the 13th of December 2001.

Document viewing facilities

- In each showroom a notebook was available for the visitors to write down their questions and concerns, which will be addressed at the Public Consultation Meeting.
- Diagrams and pictures have been posted on the walls of the showrooms to give a visual representation of the technological aspects of the project and the environmental impacts.
- A booklet (see Appendix H4) was available to all visitors which explains the fundamental aspects of the project in text and visually.
- An engineer from PECC2 was available to welcome the visitors, and answer, and note, all concerns and questions.
  The showroom at Phu My Town received 85 visitors and 8 comments were left in the Note Book (opinions contributed, questions and intention to work for the Project.).
  The showroom at Tan Thanh District got around 30 visitors, as it is not the Site for Phu My 2.2 plant. 2 comments were written in the Note Book for recommendation to the Owner of Phu My 2.2, and one idea to expect to get job in the Power Plant.

Agenda of the Second Public Consultation Meeting

The agenda was established to comprise

- Introduction by the chairman of the public consultation meeting, Mr. Le Van Xuong/Vice Chairman of Tan Thanh District
- Introduction by MECO on the Project and on the consortium who will implement the project and operate the plant
- Overview by PECC2 on technical aspects of the project and by an environmental expert on potential environmental impacts of the project
- Questions and Answer session
- Conclusion and closing.

2.2.3 Second Public Consultation Meeting-

The second public consultation meeting was held the 20th December 2001 in Tan THanh People's Commitee Head Quarters. The meeting commenced at 09:30 h am and was concluded at 12:00 h noon, followed by a visit to the document viewing facilities (Photos see Appendix H5).

Participants

- Ms Vo Thi Quyen Quyen/Secretary of UNDP, Ho Chi Minh City Office
- Mr Tran Viet Phu/Area Development Team Leader of World Vision (NGO)
- Mr. Cat Van Thanh/Vice Manager of Management Board of Can Gio Forest Preservation Program
- Mr. Phan Xuan Thanh/Ho Chi Minh City Polytechnic University – Faculty of Environment
- Mr. Nguyen Cong Nhan/Farmer, Phu My Town
- Ms. Doan Thi Bich Nga/House Wife, Phu My Town
- Ms. Pham Thi Thom/Union of Women, Phu My Town
- Mr. Doan Van Khai/Project coordinator of ENDA (NGO)
- Mr. Phan Xuan Thanh/Ho Chi Minh City Polytechnic University – Faculty of Environment
- Mr. Tran Dinh Dao/Phu My People's Committee
- Mr. Le Dinh Luan/Phu My People's Committee
- Mr. Vo Van Xeo/Phu My People's Committee
- Mr. Dao Quoc Thinh/Vice Director of Tan Thanh Radio Station
- Mr. Nguyen Manh Kha/Tan Thanh Radio Station

- Mr. Duong Van Son/Union of Veteran
- Mr. Ngo Hong Phat/Union of Veteran
- Mr. Trinh Van Dang/Dept. of Labor – Tan Thanh District
- Mr. Nguyen Dinh Hoang/Youth Union of Tan Thanh District
- Ms. Pham Binh Yen/Union of Veteran
- Mr. Doan Vu Cong Hoan/Union of Youth – Tan Thanh District
- Mr. Vu Minh Chanh/Tan Thanh People's Committee
- Mr. Le Van Cong/Tan Thanh Union of Farmers
- Ms. Tran Thi Ai Ha/Tan Thanh Union of Women
- Mr. Le Van Xuong/Vice Chairman of Tan Thanh District
- Mr. Le Phuc Hien/Vice Manager of Administration Dept -Tan Thanh District
- Mr. Trinh Van Mat/Economic Dept – Tan Thanh District
- Mr. Nguyen Van Thuan/Office of Tan Thanh People's Committee
- Mr. Tran Van Sy/Office of Tan Thanh People's Committee
- Mr. Trinh Tu Kha/Director of IPIDCO
- Ms. Nguyen Thi Mai/Communist Party Cell of Tan Thanh
- Mr. Nguyen Thanh Hung/ Office of Tan Thanh People's Committee
- Mr. To Van Qua/Vice Manager of Office of Tan Thanh People's Committee
- Mr. Pham Van Khoa/Ba Ria – Vung Tau Service of Planning & Investment
- Mr. Nguyen Quoc Luan/Socio-economic and Environment Expert from VESDEC
- Mr. Tran Xuan Huong/ Chairman of Phu My Town
- Mr. Le Dinh Luan/Vice Chairman of Phu My Town
- Several residents from the Phu My area, whose primary business is aquaculture farming (shrimp rearing).
- Journalists from Ba Ria Vung Tau Newspaper, Reporters from BR – VT TV Station and from Tan Thanh Radio Station

Introduction
The general introduction to the public consultation meeting was given by Mr. Le Van Xuong, Vice Chairman of Tan Thanh District. Mr. Richard Perrier, General Manager of MECO, gave a brief presentation of the Project.

- What is Phu My 2.2 BOT and who are the Investors (EDF, TEPCO and Sumitomo)
- The size of the Project, the phases of construction and of operation , time schedule, impact
- Environment Management of Phu My 2.2, part of Phu My Complex

Technical Project Information
Mr. Nguyen Tai Anh, Manager of PECC2, gave an in depth technical overview of the project and of the impact of the Project (see also the Booklet, Appendix H4).

Project Impacts
Mr. Nguyen Quoc Luan, Socio-economic and Environment Expert from VESDEC., informed about potential environmental impacts and socio-economic impacts of the project. Summarising, he stated, that there would be no major impacts on the local environment and that the project would provide long term positive benefits to the local community and surrounding areas.

Question & Answer Session
After the presentations about the Phu My 2.2 combined cycle power plant project the question and answer session followed.

Questions:
The questions were mainly focused on following issues:

- How does MECO intend to maintain discipline, order and prevent negative anti-social behavior arising in the local community during the construction phase of the project when a large influx of workers (up to 1000) will be concentrated in the area? The local community has already experienced Works for PM 1 and PM 2.1 power plant, the previous civil works brought social troubles in the Town
- What other impacts besides slightly raising the temperature of the river (Thi Vai) will occur by the cooling water discharge? If inhabitants are near the water discharge channel, is it dangerous ? And what effect will this have on the local aquaculture industry (shrimp farms)?
- How does MECO propose to dispose of waste water, solid wastes and will there be by-products that contain chemicals or other pollutants? Reference was made to an MSG plant which illegally disposed of some type of byproduct and apparently damaged some farmland. In the region some industries have closed without clean-up or forgot the regulations and the waste pollution increase the years passing by
- What employment prospects and training opportunities will be available to the local residents? ? In the existing plants the members of the local community have only found a few non-skilled jobs like laborer and security guards.
- The speed of the trucks on the main streets of Phu My town is a major concern. The dust which comes from the truck traffic during the civil construction is of great concern and should be held down as much as possible.

Answers:
Answers to the questions were provided by Mr. Perrier (MECO) and Mr.Tai Anh (PECC2). Answers may be summarised as follows:

- MECO will develop and maintain, a close relationship with the local authorities implement security control measures should the need arise. Furthermore MECO will insist that their sub-contractors, especially local vendors (civil constructors) implement, and where applicable enforce strict internal regulations to adequately control the labor force

- The wastewater discharged into the Thi Vai River will not pose any risk to the environment, but will maintain a stable temperature, which will have no impact on the local aquaculture industry. The area around the discharge channel does not contain residential properties, nor as per the PMPGC master plan, is there any intention to use the land for residential purposes

- As Phu My 2.2 is a Gas-fired Combined Cycle Power Plant, it will only discharge cooling water (containing negligible amounts of chemical compositions, the flue gas will contain such pollutant substances as dust, NOx, SOx but these will be well within the guidelines stipulated by WB and Vietnamese Standards). The cooling water, which is discharged into the Thi Vai River, will have no impact on the local environment

- Mekong is committed to do their utmost to offer/provide employment opportunities to the local residents. 10% of staff during the operation phase shall be employed from the local community. Furthermore MECO is to offer skill training/scholarship opportunities to local residents with a view to offering long-term employment at the plant. MECO is to commence a study, to locate where such training facilities are available in Vietnam. During the construction phase of the project MECO will strongly promote and encourage the employment of people from the local community during the construction phase by their Contractor and sub-contractors.

Statement of Non Government Organisation:
As representative of Non Government Organisation, Mr. Doan Van Khai, Project Coordinator of ENDA, Environment and Development in Action, expressed that he was honored to be invited to the public consultation meeting by MECO and stated his opinion as follows:

- The building of the power plant will have a limited impact on the local environment

- The expert explanation delivered by PECC2 (Mr. Tai Ánh) was deemed satisfactory and dealt with issues that were of concern.
- SOx / NOx are within the guidelines of both the WB and Vietnamese standards.
- Solid waste, wastewater will be treated adequately.
- Noise, vibration, air and water quality shall have adequate mitigating measures applied.
- Supervision of the work force during the construction phase shall be implemented to prevent possible civil unrest.
- In order to alleviate impacts on the environment, consultation with the local residents should be encouraged and implemented.
- Phu My 2.2 will assist in developing the local industrial sector and provide a suitable platform for transferring skills to local residents.
- During the construction phase the project will provide employment opportunities for approximately 1000 skilled and un-skilled workers and provide long term high quality employment for 45 persons during the operational phase.
- MECO should cooperate with the local authorities to provide funds for the local technical institutes to provide training to the local residents.
- Phu My 2.2 will significantly contribute to developing the local community and will have negligible impacts on the environment.
- All measures to mitigate the impacts on the local community and environment should be implemented stringently to alleviate possible negative impacts.

Statement of Phu My Town:
The speech was given by Mr. Le Dinh Luan, Vice Chairman of Phu My Town.

- Suggested MECO to undertake a survey during the construction phase of the project to ascertain what impacts (positive/negative) the project will have on the local community and what mitigating measures can be undertaken to negate the negative impacts. What mitigating measures can be undertaken to resolve such impacts as:
  - Increase in traffic on the access roads (N1 & N5) to PMPGC from highway 51, which will/could have the following negative impacts:
    - Traffic accidents
    - Dust
  - Social disorder caused by large numbers of workers concentrated in the local area.
  - Training program for local residents.
  - All of the measures proposed to mitigate the impacts on the local community and environment must be implemented actually and stringently.

Statement of Tan Thanh District:
Speech was given by Mr. Le Van Xuong, Vice Chairman of Tan Thanh District. He reiterated that his concerns matched those of Mr. Le Dinh Luan, and went on to say that this was the second public consultation meeting held at the Tan Thanh peoples committee headquarters and went on to say that he hopes that the project would be completed successfully and stated that the project will offer only positive impacts on the local community.
However he did add that the management of all concerned contractors should be adequate to perform and implement strict measures to limit the impacts that the workforce could have on the local community, which could lead to civil unrest.
Furthermore he suggested that during the construction phase that the following measures should be stringently implemented to negate the negative impacts:

- Dust – the access roads should be watered down at regular intervals to prevent the dust becoming airborne.
- Traffic – speed, reducing measures should be undertaken to protect the local residents.
- Management – should contact local community leaders and authorities to implement measures to prevent social unrest developing within the local community.
- MECO – During the construction/operation periods to contact local community authorities regarding the implementing the suggested training program.

Air, Dust, Noise, Vibration – to be monitored and adequate measures implemented to control the effects of such impacts.

Closing:
The closing speech was given by Mr. Richard Perrier, MECO.
He expressed his thanks to the People's Committees of Tan Thanh Dist and Phu My Town.
MECO confirms its commitment to effectively apply the mitigation measures, to cooperate with local authorities for the social impact and to start a scholarship program.
MECO proposes to meet with the EPC Contractor the 2 People's Committee early next year to finalize details of the cooperation plans with the local authorities as mentioned above..

3 MECO SHORT TERM ACTION PLAN

The action plan has to be design in close relation with the local Authorities , but the following actions are already planned

- **MECO and the main Contractor** will contact with the People Committee of Phu My Townlet and Tan Thanh District by early January 2002, to set up a MOU (Memorandum of Understanding). The MOU shall cover the followings:

    - A liaison channel for the local Authorities to MECO's person-in-charge (for immediate information on social trouble linked to the workers population, traffic accidents, dust, disposed waste etc.).

    - MECO relation with the Police of Phu My Townlet under the witnesses of the People's Committee for security maintenance during construction phase.

    - MECO and EPC Contractor action to ensure daily watering on the 2 local roads (No.1 and No. 5) leading to the construction site from National Highway No. 51

    - MECO shall with the Contractor and the local Authorities to work out a Personnel Management Plan with Sub-contractors (especially with the local Vendors - Civil Construction companies). There should be clauses and conditions on labor force's living condition on site and outside the fence. This should lead the Sub-contractors to have "Rules of Conducts" (on and off-site) .

    - MECO and the Contractor should work with EVN and the local Authority to ensure the transportation Subcontractors fully comply with the speed limits and traffic rules. Contractors should establish a program of/on-site dust control to mitigate the adverse health impacts on workers and equipment (expected to finish before September 2002).

- **MECO as Power Company** ,by early January 2001 will work with Phu My and Tan Thanh's People's Commitees for a scholarships programme . MECO shall locate shortly suitable technical schools in Hochiminh City for a training course of at least two years (latest by end Quarter 1 of 2002). The graduating students will be recruited by MECO (aiming at aminimum of five positions)

- **MECO will strongly promote** and encourage the employment of local people during the construction phase by its Contractor and sub-contractors (to be done from June 2002 up to September 2004).

SECTION I

APPENDICES

SECTION I APPENDICES

LIST OF APPENDICES

Environmental Assessment Report
of PHU MY 2 Phase 2

APPENDIX B1

POWER MARKET ANALYSIS

ANNEX 2

POWER MARKET ANALYSIS

TABLE OF CONTENTS

1. POWER DEMAND IN VIETNAM

In this section the power market of Vietnam will be analysed. The main source of data for the section is Master Plan for Power Development of Vietnam

1.1. POWER CONSUMPTION AND GENERATION OF VIETNAM IN THE PERIOD OF 1990-1999

During past years, Vietnam's power sector has achieved a fairly high growth rate. Total sale of electricity of Vietnam has been lifted to 19,592 GWh in 1999 from 6,185GWh in 1990. Average growth rate in this period was 13% per annum. In which, the industry represents 10,9%, agriculture 18,6%, non-industry 7,5%, transportation 12,9% and residential consumption 18%.

The power electricity consumption in Vietnam in the period of 1990 – 1999 is shown in table 2-1.

As illustrated in table 2-1 and figures 2-1, 2-2, Vietnam's electricity consumption structure has been becoming worse. The percentage ratio of industry consumption fell from 46% in 1990 down to 38.7% in 1999 , when residential consumption was increased from 32.9 to 51.1% in the period. That means the P_{max}/P_{min} ratio (maximum capacity/minimum capacity) is very high, about more than 2 times, which is causing many difficulties to ensure safety and reliability for power supply system.

Table 2-1: Consumption of Vietnam power system in the period of 1990-1999

Unit: GWh

No.	Consumption	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	**Total sale of electricity**	6,185	6,583	6,931	7,839	9,284	11,185	13,374	15,303	17,725	19,592
	Growth rate (%)	11.9	6.4	5.3	13.1	18.4	20.6	19.2	14.8	15.7	10.5
2	**KWh per capital (kWh/person)**	93	97	100	110	128	151	177	200	233	255
3	**Industry consumption**	2,845	3,080	3,197	3,477	3,944	4,614	5,503	6,163	6,781	7,590
	Ratio (%)	46.0	46.8	46.1	44.4	42.5	41.3	41.1	40.3	38.4	38.7
4	**Agriculture consumption**	587	806	975	1147	1359	632	643	691	715	582
	Ratio (%)	9.5	12.2	14.1	14.6	14.6	5.6	4.8	4.5	4.0	3.0
5	**Civil consumption**	2,035	2,052	2,153	2,518	3,131	4,929	6,136	7,221	8,849	10,020

No.	Consumption	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Ratio (%)	32.9	31.2	31.1	32.1	33.7	44.1	45.9	47.2	49.7	51.1
6	**Other consumption (Non-industry, service, transportation,...)**	**718**	**645**	**606**	**697**	**850**	**1,010**	**1,092**	**1,228**	**1,380**	**1,400**
	Ratio (%)	11.6	9.8	8.7	8.9	9.15	9.0	8.2	8.0	7.9	7.2
7	**Total of loss (%)**	**25.4**	**25.5**	**25.6**	**24.0**	**22.5**	**21.7**	**19.3**	**18.2**	**16.1**	**15.53**

Figure 2-1: Power consumption of Vietnam in the period of 1990-1999

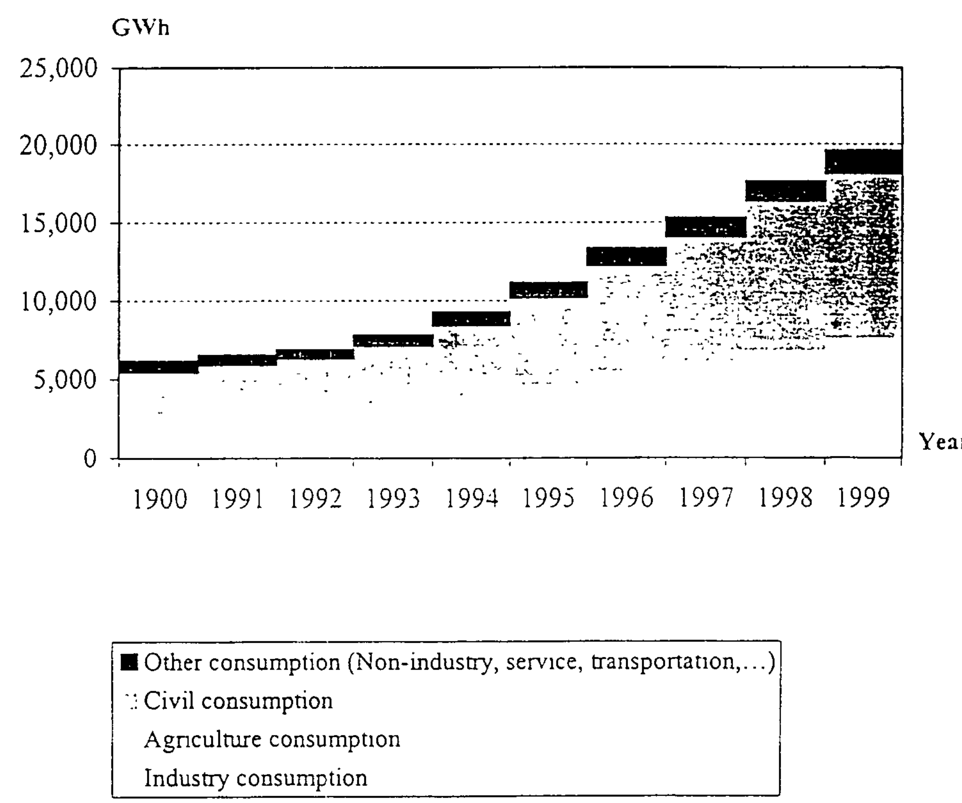
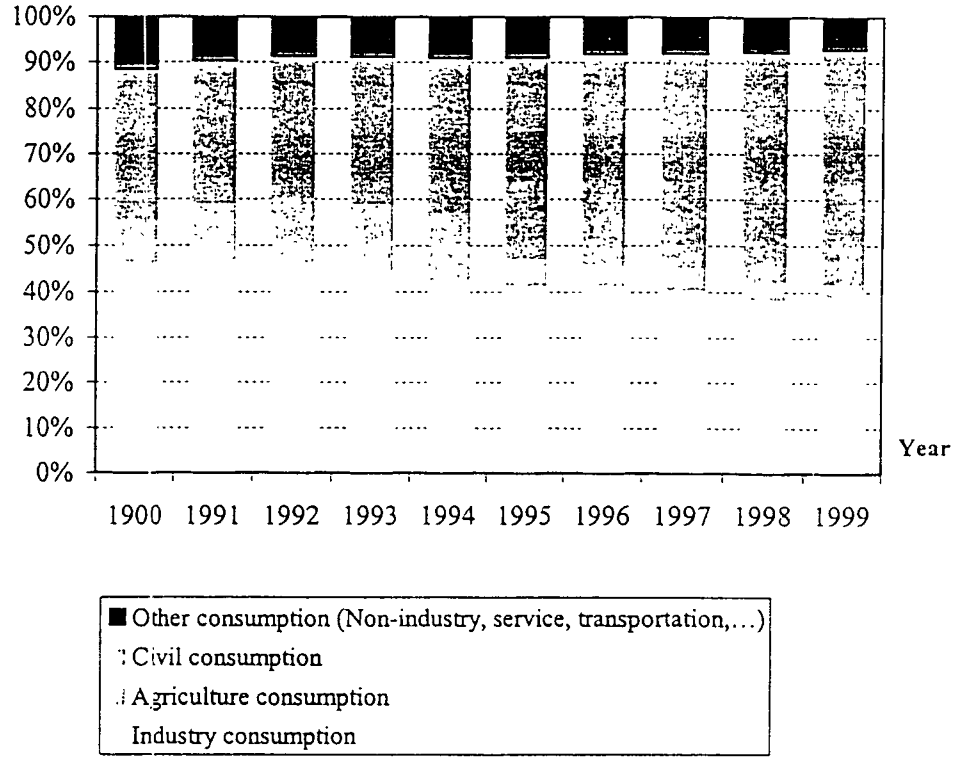


Figure 2-2: Power consumption percentage ratio for Vietnam in the period of 1990-1999



Power consumption in 1999 was 19,592GWh, which represents an increase of 10.5% from the previous year compared to the 13% average growth rate over the period 1990-1999. In 1999, the power consumption has slightly risen in comparison with the average due to decreasing number of large consumers together with impact of economic crisis in Asia and over the world and of natural disasters (floods, storms) in some places. The difference between power demand and power generation is shown in the table 2-2.

Table 2-2: Comparison between power generation and load demand for period of 1995-2000

Unit: GWh

	Target	1995	1996	1997	1998	1999	2000	G.R. (%)
Sale power	Forecast	11459	13467	15778	18368	21290	24535	16.4%
	Sale	11185	13374	15303	17725	19592	21403	13.9%
Generation power	Forecast	14571	16980	19732	22800	26235	30006	15.5%
	Generation	14636	16945	19151	21665	23739	26000	12.2%

Notes:

* Sale power:

  + Forecast: Sale power forecast

  + Sale: Total of sale power of Vietnam power system

* Generation power:

  + Forecast: Power demand forecast

  + Generation: Total of power generation of power system. It includes sale and loss of the Vietnam power system. The loss of power system includes "Technical loss" and "Non-technical loss".

* Figures of 2000 are approximate only (because there are statistics only for first 10 months of 2000)

According to the above table, for the period 1995-2000 the power generation is less than the forecast one as expected in the Master Plan for Power Development N°.4 of Vietnam. However, based on the Master plan for Power Development N°.5 of Vietnam, the load demand in 2000 is estimated to be about 26 billion kWh, which is lower than the 30 billion kWh estimated by the Master Plan for Power Development N°.4.

Along with the growth of consumption demand, the electricity generation sources and transmission system also have been substantially developed to meet the requirements of economic development. Total installed capacity of the power system was 5,765MW by the end of 1999 . The electricity energy production has been increased respectively from 8,680GWh in 1990 to 23,739 in 1999 , which represents an average growth rate of 11.86% per annum. However, due to a lack of power source in Vietnam in the years 1997, 1998 and 1999, some consumers had to be interrupted.

The power generation of Vietnam in the period of 1990 – 1999 is detailed in table 2-3

Table 2-3: Power-energy generation in the period of 1990-1999

Unit: GWh

TT	Power generation	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
	Total of power generation	**8,680**	**9,152**	**9,654**	**10,665**	**12,284**	**14,636**	**16,945**	**19,152**	**21,665**	**23,739**
	Growth rate (%)	11.4	5.5	5.5	10.4	15.2	19.2	15.8	13.0	13.0	9.6
	KWh per capita (kWh/person)	131	135	139	150	169	198	225	250	285	309
	Pmax (MW)	1,660	1,850	2,005	2,143	2,408	2,796	3,177	3,595	3,875	4,329
1	**Hydro power**	5,374	6,317	7,228	7,946	9,239	10,582	12,008	11,677	11,092	13,937
	Ratio (%)	61.9	69.0	74.9	74.5	75.2	72.3	70.8	61.0	51.0	58.7
2	**Thermal power**	2,841	2,425	1,889	1,776	2,113	2,929	3,279	4,333	5,616	5,386
	Ratio (%)	32.7	26.9	19.6	16.6	17.2	20.0	19.4	22.6	25.9	22.7
3	**Diesel-Gas turbine**	465	410	537	943	932	1,125	1,658	3,142	4,957	4,416
	Ratio (%)	5.4	4.1	5.5	8.1	7.6	7.7	9.8	16.4	23.0	18.6
4	**Auxiliary power (%)**	4.4	3.5	3.5	3.3	2.48	2.31	2.56	2.25	2.59	2.3

As shown in the above tables, power generation was increased from 8,680GWh in 1990, to 23,739GWh in 1999 (average: 11.86%/year) and Vietnamese power system losses decreased from 25% in 1990 to 16.1% in 1998 and 15.8% in 1999 (average: 1.5%/year). The energy consumed by power plants auxiliaries was improved from 4.4% in 1990 down to 2.3 % in1999 . For this reason, in the period 1990-1999, the growth rate of sale power-energy is actually greater than the figure given in the table.

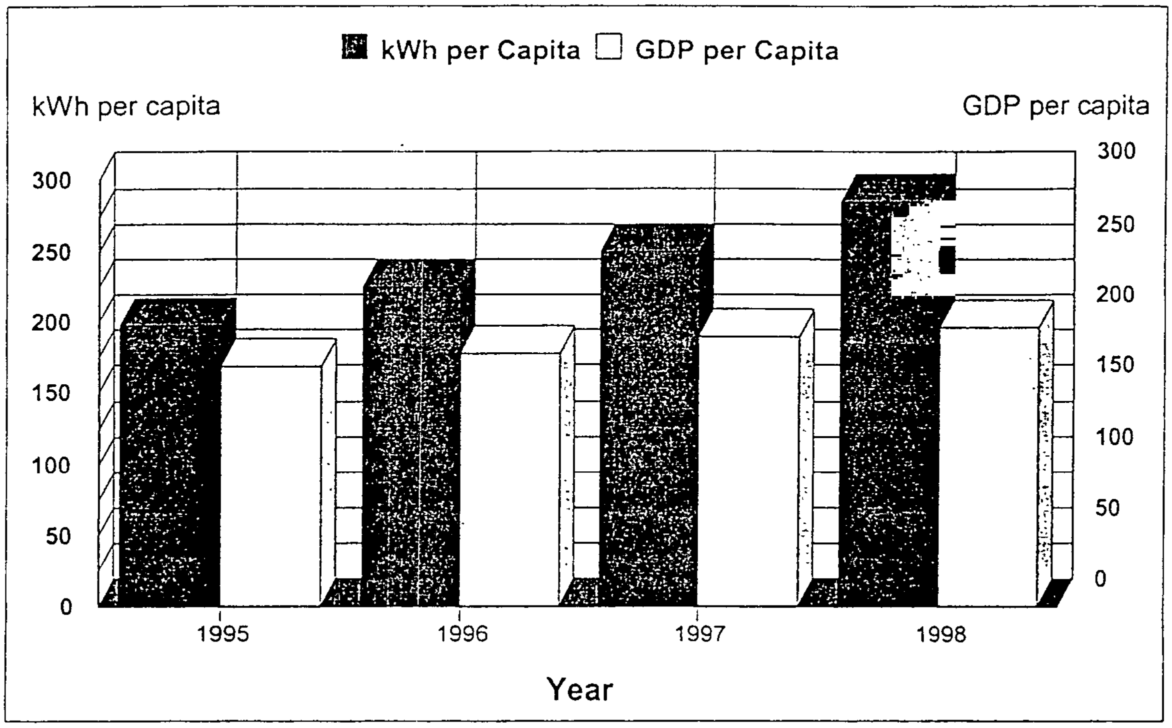
1.2. POWER DEMAND IN VIETNAM (INCLUDING COMPARISON WITH OTHER COUNTRIES)

GDP per capita of Vietnam has been up from 169.35US$ in 1995 to 196.6US$ in 1998, which represents a growth rate of 5% per annum. The electricity consumption per capita has been respectively increased from 198kWh in 1995 to 285kWh in 1998; which represents a growth rate of 12.9% per annum. The electricity consumption and GDP of Vietnam in the period 1995-1998 is shown in table 2-4 and figure 2-3.

Table 2-4: kWh and GDP per capita of Vietnam in the period of 1995-1998

Year	1995	1996	1997	1998
GDP/capita (US$)	169.35	178.18	189.76	196.6
KWh/capita	198	225	250	285

Figure 2-3: kWh and GDP per capita of Vietnam in the period of 1995-1998



However, Vietnam has one of lowest annual electricity consumption per capita figures in Asian area and in the world. The comparison table is shown in table 2-5

Table: 2-5: kWh and GDP per capita of Asian and United States in 1996

	kWh/Capita	GDP/Capita (US$)	Comp. With Vietnam (kWh/capita)	Comp. With Vietnam (GDP/capita)
Vietnam	225	178.18	Basic	Basic
Pakistan	418	395.4	1.85	2.22
Myanmar	55	584.8	0.24	3.28
China	780	602	4.64	3.38
Philippines	399	746.45	1.77	4.19
Indonesia	315	889.04	1.4	4.99
Thailand	1294	2262.87	5.75	12.69
Malaysia	2032	3327.32	9.03	18.67
Korea	4174	8517.7	18.55	47.80
Singapore	7196	19857.21	31.98	111.94
United States	12711	24686.14	56.5	138.54

According to above table, the electricity consumption (kWh per capita) of Vietnam is less than Asian region and in the world from 1.4 to 56.5 times and GDP per capita of Vietnam is less than from 2.2 to 138.5 times in the year of 1996, respectively.

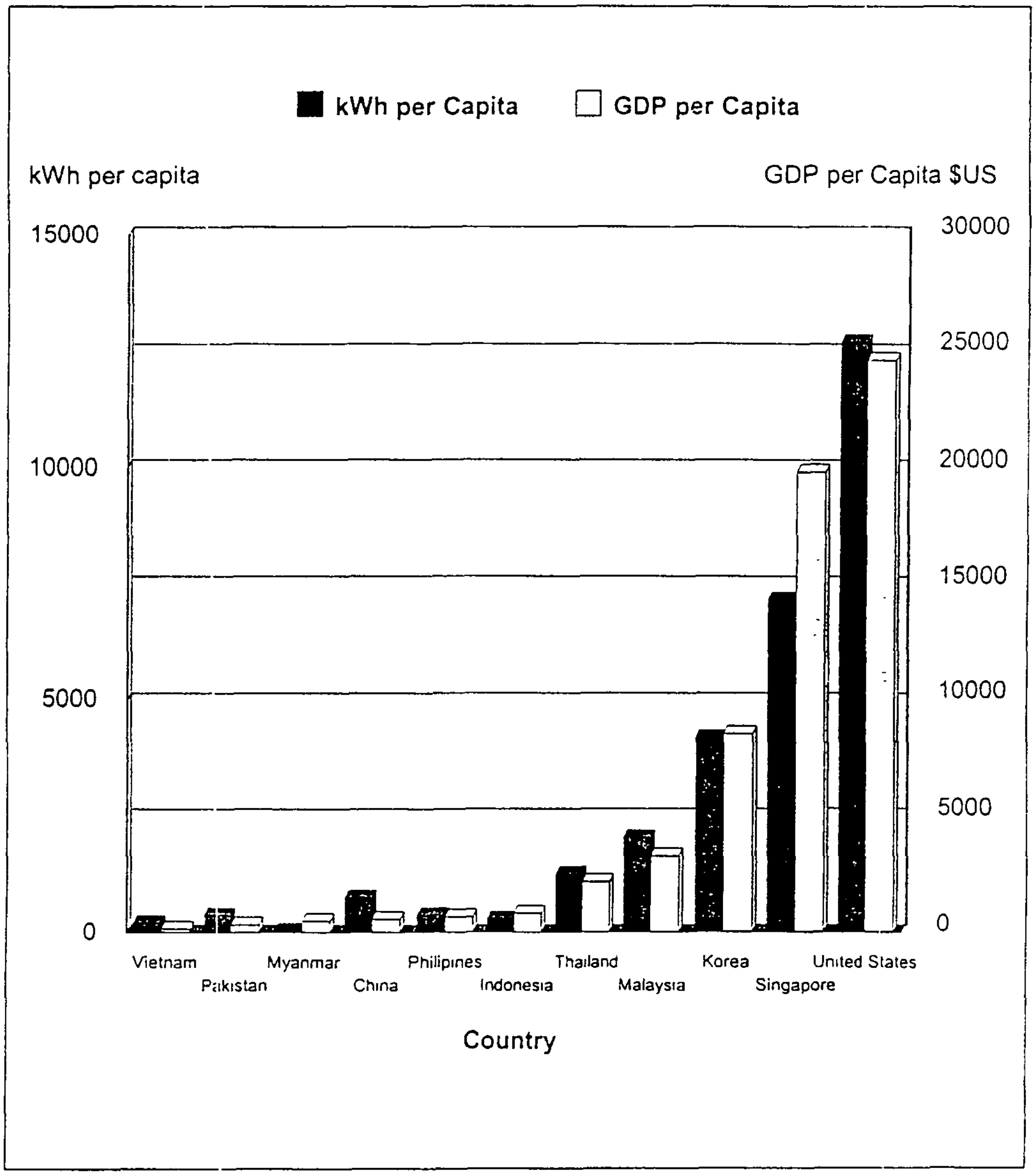


Figure 2-4: Electrical consumption and GDP per Capita in Asia and United States in 1996.

The Institute of Energy has provided the electricity consumption forecast with the two scenarios currently being used for power system planning purposes in Vietnam. They are summarised in Table 2-6. To meet market needs, the base case assumes a generation growth of 10.2% per annum out to the year 2020, by which total consumption will be in the order of magnitude of 167,002GWh.

Table 2-6: Electricity demand forecasts in period 1995 to 2020

Unit: GWh

Case	Generation						Growt h
	1995	2000	2005	2010	2015	2020	
Base	14,636	26,000	46,459	70,437	109,439	167,002	10.2%
KWh/ capita	198	306	560	734	1,087	1,560	
High	14,636	26,475	49,009	78,466	126,949	201,367	11.0%
KWh/ capita	198	343	591	817	1,261	1,881	

Note: 1995 figure is actual

As a result of table 2-6, electricity consumption per capita of Vietnam is expected to be 1,560kWh in 2020, when average electricity consumption per capita in the world in 1990 was of about 2,000 kWh. In 1999, average electricity consumption was 1,500kWh in Thailand and 2,500kWh in Malaysia (according to Master Plan for Power Development N^{o}.5). That means the electricity demand of Vietnam will be well short of the one of any Asian country for 20 years and any developed country over the world for 30 years.

1.3. POWER DEMAND FORECAST

Power demand is forecast from two scenarios as base case and high case as set up in accordance with Master Plan for power Development No5 (2000-2010, taking into account for 2020 year).

A) SELECTION OF FORECAST METHODS

Power demand forecast is the most important, because the power growth rate will affect the economic growth rate. Therefore, power demand forecast with adequate accuracy and reliability is necessary.

Selection of forecast methods will depend on the following matters:

1) The National economic growth rate,
2) The plan as well as strategy for development of Vietnam,
3) Technological science,
4) Forecast period of time, etc.

The power demand forecast can be estimated based on the following methods:

- Elastic Coefficient Method
- Direct method
- Method of extrapolation on time
- Equivalent method
- Experience method, etc.

Each method has its own pros and cons that have been considered.

Forecast period of time is one of most important matters, because it will affect correctness and error level allowed for the power demand forecast. So, the choice of the forecast period of time will be based on the following items:

- A too long time period would lead to a significant error,
- A too short time period would not meet the requirements,
- A reasonable forecast period of time would help to choose the right method for power demand forecast.

In this report, the forecast period of time which was selected is 11 years (2000-2010)

As the Vietnamese economy has a stable development, a planned economy, small number of economic crisis, etc. and above items, we chose the Elastic Coefficient Method for power demand forecast method. Elastic Coefficient Method is suitable for a forecast period of time from 10 to 15 years and conditions of the economic growth rate in Vietnam.

Elastic Coefficient Method:

- Based on the economic growth rate (GDP), the economic elastic coefficient (EC_E) will be calculated.

$$EC_E = \frac{\sum_{i=1}^{n} \frac{CGR_i}{EGR_i}}{n}$$

Where,

+ CGR: The consumption growth rate of the last years
+ EGR: The economic growth rate of the last years
+ i: The i year
+ n: Number of year for calculation

Based on the industrial economic growth rate (GDP), the industrial economic elastic coefficient (EC_I) will be calculated.

$$EC_I = \frac{\sum_{i=1}^{n} \frac{CGR_i}{IGR_i}}{n}$$

Where,

+ CGR: The consumption growth rate of the last years
+ IGR: The industrial growth rate of the last years
+ i: The i year
+ n: Number of year for calculation

- Elastic Coefficient will be reselected according to conditions of power growth rate to present expectation of Vietnam power growth rate, experience and Master Plan for Power Development N°.5 in Vietnam. And Elastic Coefficient (EC) is selected, coordinated between EC_E and EC_I.
- Based on the EC, power demand forecast will be calculated as follows:
  + The first year of power demand forecast = Forecast result based on the last years
  + Next year = EC x The increasing GDP per annum x Forecast result of the last year

B) POWER DEMAND FORECAST BY ELASTIC COEFFICIENT METHOD

- Operation of Vietnam power system during the period 1990-1999.
- The growth of economic (GDP) for period 1990-1999.
- Elastic coefficient between economic growth and power demand growth.
- Forecast for economic growth in the future
- Elastic coefficient is used to power demand forecast in the future
- Selection of elastic coefficient:
  + Based on ratio between power generation growth rate and the economic growth rate (the most important one is the industrial growth rate) in the last period of years,
  + And based on experience of other countries in the world, the experience of countries in Asian region is the most appropriate.
- Elastic coefficient is selected at 1.4 to 1.5, which are based on Master plan for Power Development N°.5 for Vietnam.
- Power demand forecast will be implemented in the period of 2001-2010.

C) CONDITION OF ECONOMICAL DEVELOPMENT IN THE YEARS OF 1990-1999

The economy of Vietnam had greatly increased in the years of 1991-1999, of 7.7% in average. About 9% was achieved for six years (1992-1997). Due to effects of economic crisis in 1998, Vietnam economy has slowed down the increasing but still achieved 5.8% in 1998 and 4.8% in 1999.

Table 2-7: Growth rate of GDP over the period of 1990-1999

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999
Growth rate GDP (%)	6.0	8.6	8.1	9.3	9.54	9.34	8.15	5.8	4.8

Growth organization in different fields of activity is as follows:

In industry, value of GDP increased 12.6% for 1991-1999, in which, it increased 10.5% in 1998 and 7.7% in 1999 due to effects of economic crisis in region.

Before 1990, oil and gas output only achieved 40 thousand tons in 1986. Up to 1997, achieved 10.2 million tons, 12.4 million tons in 1998 and continuously increasing, obtained 15 million tons in 1999. Fired gas output reached 1.1 billion m^3.

Rice output for exporting has increased from 1 to 4.5 million tons from the year 1991 to 1999, respectively, of more 20% average increased rate per annum.

D) SELECTION OF ELASTIC COEFFICIENT

In accordance with formula to determine the above elastic coefficient, it is calculated by the ratio between economic growth rate and power generation growth rate in the past years. Based on value of the economic growth rate and power generation growth, the elastic coefficient is as follows:

Table 2-8: Elastic coefficient between economic growth and power consumption growth

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg.
Growth rate GDP (%)	6.0	8.6	8.1	9.3	9.54	9.34	8.15	5.8	4.8	7.7
The Growth of sale power (%)	6.4	5.3	13.1	18.4	20.6	19.2	14.8	15.7	10.5	14,6
Elastic	1.07	0.62	1.62	1.98	2.16	2.06	1.82	2.71	2.19	1.89

Year	1991	1992	1993	1994	1995	1996	1997	1998	1999	Avg.
coefficient										

Thus, average of elastic coefficient is 1.89 in years 1991-1999. This result means that the rate of power generation growth is nearly the double in comparison with the economic growth.

Besides, it should be based on experience of other countries in the world and especially the experience of Asian countries. The elastic coefficient of Asian countries is as follows:

Table 2-9: Elastic coefficient in Asian countries

Name of country	**Elastic coefficient**		
	GDP growth (%)	The Growth of sale power (%)	Power/GDP
Thailand	8.72	13.4	1.54
Malaysia	9.06	13.6	1.50
Indonesia	7.19	14.0	1.94

Based on database mentioned in table 2-9, simultaneous consideration with elastic coefficient of countries in the region, it is recommended to select an elastic coefficient in order to forecast the demand in Vietnam in years 2001-2010 of 1.5 to 1.6.

E) FORECAST FOR GDP GROWTH RATE

Table 2-10: The growth rate of economic in Vietnam for period of 1996-2010

Unit: %/year

	High scenario			Basic scenario		
Economics	1996-2000	2001-2010	2011-2020	1996-2000	2001-2010	2011-2020
GDP	**6.9**	**7.2**	**6.5**	**6.9**	**8.0**	**7.0**
Industry	10.8	9.0	8.0	10.8	9.5	8.1
Agriculture	3.6	3.1	3.1	3.6	3.1	3.0
Service	5.7	7.4	6.2	5.7	8.8	7.0

F) BASIC SCENARIO

This scenario corresponds to a high growth rate of economy, as the result of positive influences from objective and subjective factors. This scenario has a high occurrence probability, so as it is selected for consideration. The growth of GDP for period of 2000-2010 is about 7.2%.

Power demand forecast in base case

Table 2-11: Power demand forecast in base case

YEAR	2000		2005		2010		2015		2020	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%
Industry	8,488	41.6	17,359	44.6	30,289	49.2	51,298	53.6	83,268	56.8
Agriculture	715	3.6	935	2.6	1,163	1.9	1,422	1.5	1,738	1.2
Lighting and living	10,670	47.6	17,400	44.8	24,659	40	34,094	35.6	46,931	32
Service and sale	1,579	7.2	3,103	8.0	5,461	8.9	8,932	9.3	14,618	10
Total of power sale	**21,452**	**100**	**38,797**	**100**	**61,572**	**100**	**95,746**	**100**	**146,555**	**100**
Power generation	**26,000**		**46,459**		**70,437**		**109,439**		**167,022**	
Capacity	4,487		7,802		11,653		17,487		26,854	
KWh per capital kWh/person/year	306		560		734		1,087		1,560	

G) HIGH SCENARIO

This scenario corresponds to a higher development of economy. The GDP growth rate for period of 2000 - 2010 years is estimated as 8.0% per annum.

Power demand forecast in high case

Table 2-12: Power demand forecast in high case

YEAR	2000		2005		2010		2015		2020	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%
Industry	8,743	41.6	18,229	46.8	36,310	52.9	64,272	57.9	108,723	61.5
Agriculture	735	3.6	996	2.4	1,163	1.7	1,394	1.3	1,671	0.9
Lighting and living	10,980	47.6	18,404	42.5	24,690	36.0	34,423	31.0	47,550	26.9
Service and sale	1,624	7.2	3,271	8.3	6,429	9.4	10,977	9.9	18,753	10.6

YEAR	2000		2005		2010		2015		2020	
	GWh	%	GWh	%	GWh	%	GWh	%	GWh	%
Total of power sale	**22,082**	**100**	**40,900**	**100**	**68,592**	**100**	**111,067**	**100**	**176,696**	**100**
Power generation	**26,475**		**49,009**		**78,466**		**126,949**		**201,367**	
Capacity	4,615		8,230		12,982		20,703		32,376	
KWh per capital kWh/person/year	343		591		817		1,261		1,881	

According to this expectation, Vietnam will not reach the figure of 1000kWh/person/year by the year of 2010. If compared with Thailand (at present: 1500kWh/person/year), Vietnam is now 20 years lagged behind.

H) DETAILED POWER DEMAND FORECAST IS GIVEN IN TABLES A.2-1 TO A.2-4 IN APPENDIX A2.

1.4. DEVELOPMENT POLICY OF POWER SOURCE FOR VIETNAM

Based on the Master Plan for Power Development N°.5, the development policy of the power source for the whole Vietnam for the period 1996-2010 contains the following main points:

1. First priority is given to the development of hydropower source on three main river basins:
   i. Da river basin houses the most important project - Son La hydropower plant project with a capacity of 2,400 MW or 3,600 MW. It is quite a big project therefore it can only be put into operation in the years 2012-2016.
   ii. Sesan river basin houses the Yaly hydropower plant that is under construction and will be commissioned in 2001. Apart from this, there are two planned projects, Sesan 3 and Pleikrong.
   iii. Dong Nai river basin houses the following projects: Ham Thuan - Da Mi to be commissioned in 2001; Dai Ninh in 2006; Dong Nai 4, Dong Nai 8 and some other projects.
   iv. Apart from the three main river basins as mentioned above, there are some other projects such as: Ban Mai, Buon Cuop, Can Don, Rao Quan, Cua Dat etc. to be considered for construction.
2. To use natural gas (associated and non-associated) to generate power. Gas quantity and reserve as recently estimated are very important. Gas will be extracted and transported at 2.1 billion m^3 per year by the end of 2002 and 6 billion m^3/year in 2005-2010.

Natural gas is a clean and economical fuel. The most suitable technology to utilize natural gas as primary fuel is combined cycle. Therefore the Government has a policy to develop combined cycle power plants near to gas pipeline, such as at Phu My and Ba Ria sites.

3. To develop coal fired thermal power generating Centres next to the coal-mines such as Quang Ninh, Na Duong, etc.

With such a power development plan, power supply may satisfy power demand, developed by basic scenario or scenario with higher growth rate for period after year 2000. However, it is difficult to balance power supply and power demand for the period 1996-2000 because of the high growth rate of power demand.

1.5. POWER BALANCE

A) PRINCIPLES OF POWER BALANCE

Capacity of the Vietnam power system will be balanced according to two scenarios; there are basic and high scenarios, according to the following principles:

- Rated capacity of power plants in the Vietnam power system.
- Availability capacity of power plants in the Vietnam power system.
- Maximum load demand (P_{max})
- Power generation and load demand
- The reserved capacity depends on total capacity of the system and relevant reserve percentage.
- Alternatives of source comprise high case of sources and base case of sources. The high case of sources alternative is based on a new power plants fast tracking implementation, the base case of sources alternative is based on a normal one.

B) DETAILED POWER BALANCE

The detailed power balance is given in tables of A.2-5 to A.2-8 (by base case of sources) and A.2-15 to A.2-18 (by high case of sources) in the appendix A2.

1.6. ENERGY BALANCE

A) PRINCIPLES OF ENERGY BALANCE

- Each scenario of power development will be balanced according to two alternatives of water incoming frequency.
  - The available power-energy of hydro power plants by a frequency of 90% and 50%

  - Alternative of very low water coming of 90% frequency: This is a very special alternative, it is a situation that may happen. In such a year, it is necessary to mobilise all existing power sources including low efficiency, regardless of economy to cover power shortages.
  - Alternative of average water coming of 50% frequency. Based on this, the typical operation regime will be determined. It is an important hypothesis for carrying out economical evaluation and financial analysis.
- Hydropower sources characteristics are based on feasibility study and/ or in accordance with Master Plan for Power Development N^{o}.5.
- The thermal power characteristics sources are considered in the following order:
  - If the feasibility study of a project has been prepared, the scale and schedule of the project will be followed as in F/S.
  - If the feasibility study of a project is under preparation, the scale and schedule of the project will be studied to determine suitability.
  - The capacity of Phu My 3 power plant is considered of 720MW.
  - Other thermal power plants characteristics are considered as mentioned in Master Plan for Power Development No5.
- The existing power plants will be considered based on the use of available capability, including rehabilitation or upgrade proposal. Particularly three coal fired power plants namely Ninh Binh, Pha Lai, Uong Bi are considered for rehabilitation.

B) ENERGY GENERATION OF POWER PLANTS

Energy generation of Power Plants is given in tables of A.2-9, A.2-12 (by base case of sources) and A.2-19, A.2-22 (by high case of sources) in the appendix A2.

C) ENERGY BALANCE IN BASIC SCENARIO

The energy balance results according to water incoming frequency of 90%, 50% are given in tables of A.2-10, A.2-13, (by basic case of sources) and A.2-20, A.2-23 (by high case of sources) in the appendix A2.

Based on above results, conclusions are made as follows:

- Alternative of basic source:
  - With the frequency of 50% of water, Viet Nam power plant will help enough electricity reserve by the 2001-2010.
  - With the frequency of 90% of water, the lack of electricity reserve would take place in the years of 2001, 2002, and 2003.
- Alternative of high source:

- With the frequency of 50% of water, Viet Nam power plant will help enough electricity reserve by the 2001-2010.
- With the frequency of 90% of water, the lack of electricity reserve would take place in the years of 2001. 2002 and 2003.

D) ENERGY BALANCE IN HIGH SCENARIO

The energy balance results according to water incoming frequency of 90%, 50% are given in tables of A.2-11, A.2-14 (by basic case of sources) and A.2-21, A.2-24 (by base case of sources) in the appendix A2.

Based on above results, conclusions are made as follows:

- Alternative of basic source:
  - With the frequency of 50% of water, the lack of electricity reserve would take place in the years of 2002, 2007, 2008, 2009 and 2010.
  - With the frequency of 90% of water, the lack of electricity reserve would take place in the 2001-2010.
- Alternative of high source:
  - With the frequency of 50% of water, the lack of electricity reserve would take place in the years of 2001 and 2002.
  - With the frequency of 90% of water, the lack of electricity reserve would take place in the years of 2001, 2002, 2003, 2004, 2005, 2008, 2009 and 2010.

1.7. THE NECESSITY AND SCALE OF PHU MY 2-2 POWER PLANT PROJECT

1. The energy balance results according to water incoming frequency of 90%, 50% are given in tables A.2.10, and A.2.11, correspondingly.
2. In all load demand scenarios, the existing of Phu My 2-2 power plant is indispensable to meet the increasing load demand in period 2001-2010 and next period.
3. The capacity is required to be 715MW because of the load demand for 2001-2010 period and based on the result of capacity as well as energy balance in Vietnam (as mentioned in appendix A2).
4. Based on the load demand growth, it is proposed to select capacity and time schedule of Phu My 2-2 as following:
   i. Available capacity: 715 MW
   ii. Progress: March 2004
5. The period of 2004-2010, based on the load demand growth and the result of capacity as well as energy balance in Vietnam (as mentioned in appendix A2), generation demand of Phu My 2-2 as follows:
   + High case of source: From 3,000,000 to 4,000,000 (MWh)
   + Basic case of source: From 4,000,000 to 5,000,000 (MWh)

+ Detailed generation demand of Phu My 2-2 will be included in the typical daily diagram.

1.8. TYPICAL DAILY LOAD DIAGRAM OF VIETNAM POWER SYSTEM

Typical daily load of Vietnam power system is given in tables of A.2-25 to A.2-48 and diagrams of A.2-1 to A.2-36 in the appendix A2.

The period of 2001-2010, based on results of capacity and energy balance and based on typical daily load diagrams with the frequencies of 50% (dry reason) and 90% (rainy reason) of water, so the following MWh per year of Phu My 2-2 will be required.

1. High case of source
   - Basic case of load demand
     + 2004 year: 3,000,000 (MWh)
     + 2005 year: 4,000,000 (MWh)
     + 2006 year: 4,000,000 (MWh)
     + 2007 year: 4,000,000 (MWh)
     + 2008 year: 3,500,000 (MWh)
     + 2009 year: 3,000,000 (MWh)
     + 2010 year: 4,000,000 (MWh)
   - High case of load demand
     + 2004 year: 3,000,000 (MWh)
     + 2005 year: 4,500,000 (MWh)
     + 2006 year: 4,500,000 (MWh)
     + 2007 year: 4,500,000 (MWh)
     + 2008 year: 4,500,000 (MWh)
     + 2009 year: 4,500,000 (MWh)
     + 2010 year: 4,500,000 (MWh)
2. Basic case of source
   - Basic case of load demand
     + 2004 year: 3,000,000 (MWh)
     + 2005 year: 4,000,000 (MWh)
     + 2006 year: 4,000,000 (MWh)
     + 2007 year: 4,000,000 (MWh)
     + 2008 year: 4,000,000 (MWh)
     + 2009 year: 4,000,000 (MWh)
     + 2010 year: 4,000,000 (MWh)
   - High case of load demand
     + 2004 year: 3,000,000 (MWh)
     + 2005 year: 5,000,000 (MWh)
     + 2006 year: 5,000,000 (MWh)

+ 2007 year: 5,000,000 (MWh)
+ 2008 year: 5,000,000 (MWh)
+ 2009 year: 5,000,000 (MWh)
+ 2010 year: 5,000,000 (MWh)

3. Based on above conditions, final of generation demand for Phu My 2-2 power plant as follows:

   + 2004 year: 3,000,000 (MWh)
   + 2005 year: 4,000,000 (MWh)
   + 2006 year: 4,000,000 (MWh)
   + 2007 year: 4,000,000 (MWh)
   + 2008 year: 4,000,000 (MWh)
   + 2009 year: 4,000,000 (MWh)
   + 2010 year: 4,000,000 (MWh)

In the period of 2011-2020, generation of Phu My 2-2 power plant will be required to 4,000,000MWh/year.

2. POWER SYSTEM ANALYSIS

2.1. THE GROWTH OF POWER GENERATION SOURCES

Vietnam's power sector has achieved a fairly high growth rate so far. Total installed capacity of the power system increased from 4,013MW at the end of 1993 to 5,765MW at the end of 1999. The electricity energy production had been up respectively from 10,665 million kWh to 23,739 million kWh. Average growth rate during this period was 15.5% per annum. Electricity sale also grew by 17.16% per annum. As a result, Vietnam's electricity consumption per capita was also lifted to 255kWh in 1999 from 110kWh in 1993. According to statistics at the end of 1999, the national power network was able to supply electricity to all provinces and cities in Viet Nam, in which, 69.7% of households, 6958/8896 (78.2%) of villages and 470/491 (95.7%) of districts in rural area of the country.

According to the Master Plan for Power Development N°.4, 2000 power demand is expected to reach 30.11 billion kWh, in which electricity sales will be 24,54 million kWh. Further on, if GDP grows annually by 9%/year, 2005 power consumption will only be able to reach 53 billion kWh.

However, reality in 1999 was somewhat different from what had been forecast. Power consumption was only 19,592GWh, which was 14% up compared to the previous year. In 1999, power consumption has only risen by 10.5%, due to a decreasing demand of large consumers together with impacts of natural disasters (floods, storms) in some places. EVN has recommended to adjust the 2001-2010 electricity production plan. From current situation, electricity energy demand for 2000 is expected to be 26 billion kWh only. This is different from World Bank's forecast.

According to World Bank analyses, electricity demand in Vietnam in 2000 will be 5 times the level of 1995, with growth rate of 15% to 20% per annum. As a consequence, estimated investment of USS 6.9 billions will be needed for the development of electricity, coal, fuel oil and gas sectors.

Installed and available capacity (MW) of existing power plants up to the end 1999 are detailed in table 2-10.

Table 2-13: Installed and available capacity

No.	Name of power plant	Installed (MW)	Capacity (MW)
I	**Hydropower**	**2.854**	**2.866**
	Thac Ba	108	120
	Hoa Binh	1.920	1.920
	Vinh Son	66	66
	Da Nhim	160	160
	Tri An	400	400

No.	Name of power plant	Installed (MW)	Capacity (MW)
	Thac Mo	150	150
	Small hydropower	50	50
II	**Thermal power**	**1.218**	**1.168**
	Uong Bi (Fired coal)	105	105
	Ninh Binh (Fired coal)	100	100
	Pha Lai (Fired coal)	440	400
	Thu duc (Fired oil)	165	156
	Tra Noc (Fired oil)	33	32
	Hiep Phuoc (Independent power plant)	375	375
III	**Gas turbine**	1.174	1.100
	Thu Duc	128	100
	Ba Ria	328	296
	Phu My	568	568
	Tra Noc	150	136
IV	**Diesel**	**519**	**245**
	Nomura Hai Phong (Independent power plant)	50	50
	Central region	190	65
	Southern region	199	50
	Industry group of Singapore (Binh Duong province)	8	8
	Amarta (Bien Hoa City-Dong Nai province)	12	12
	Vedan (Dong Nai)	60	60
	Total	**5.765**	**5.384**

Notes:

- Installed capacity: The rated capacity of power plants in Vietnam power system.
- Available capacity: Present available capacity of power plants for which the degradation has been taken into account.

It can be seen from the table that a major share of electricity generation from hydro sources has resulted in more economical operation of the power system. However, it has brought alone some technical drawbacks. Because of its hydro-meteorological conditions, Vietnam has more than 60% of the water flow of the rivers concentrated in 5 months, during the rainy season (from June to November). During this period of the year, hydro power plants cover the lower part of load curve (running at base load), while the thermal power plants are operated to support network frequency which is not suitable with their technical characteristics and design. In contrast, during months of dry season, as a result of restricted available power generating capacity due to low water flows, the thermal power plants have to be over operated to cope with power demand, which results in higher outage rate and load rejections.

2.2. OVERVIEW OF THE EXITNG HYDROPOWER PLANTS IN THE VIET NAM POWER SYSTEM

Total installed capacity of large and medium scale hydropower plants is 2,854MW. Except of some new hydropower plants such as Thac Mo, Vinh Son, all other hydropower plants have been in operation for more than 10 years. However, those plants with their equipment still being in good condition are reliably operated to bring economic benefits as well as to meet the Vietnam's electricity demand.

Table 2-14: Generation of the exiting hydropower plants

Unit: GWh

No.	Name of plants	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	Thac Ba	457	386	345	327	405	455	484	483	379	286
2	Hoa Binh	2.400	3.306	4.188	4.744	5.660	6.860	7.206	7.026	6.912	8.112
3	Da Nhim	774	800	918	958	1.033	936	1.162	1.122	1.160	1.368
4	Tri An	1.697	1.738	1.685	1.832	1.994	1.440	1.856	1.773	1.615	2.550
5	Thac Mo	-	-	-	-	-	511	787	800	601	1.041
6	Vinh Son	-	-	-	-	34	239	338	286	211	414

According to above table, hydropower plants, such as Tri An, Thac Mo and Vinh Son, operated with the installed capacity which is more than 6,000 hours (T_{max}>6,000 hours) in 1999. The special case, Da Nhim hydropower plant operated with the installed capacity over 8,000 hours (T_{max}>8,000 hours), its mean operated with the installed capacity during year.

As the above actual data, generation of hydropower plants has the satisfactory signals. However, this will cause difficulty if it happens in the years of 90% water frequency (the year of very low water incoming frequency).

2.3. OVERVIEW OF THE EXISTING THERMAL POWER PLANTS IN VIET NAM POWER SYSTEM

Installed capacity of existing diesel, thermal and gas turbine power plants is 2,911MW, out of which 2,513MW are available. 605MW are coal fired plants; 188MW oil-fired plants; 1100MW combustion turbine plants; and 375MW Hiep Phuoc independence power plant. For the location of the plants please refer to the attached map. Hereafter is some brief information about these thermal and gas turbine power plants so far:

Ninh Binh: The plant capacity is 100MW comprising four (4) units 25MW each. The plant is using coal from Hon Gai as main fuel. Commercial operation started in 1976. Since the plant has been excessively exploited (6000 hours/year) from 1976 to 1983, technical and economical merits are deteriorated. In addition, it causes a serious environmental impact. Current auxiliary consumption is greater than 12%, while the designed value was 8.4%. In 1997, the 80m old stack of plant replaced with the 130m new stack, and precipitators replaced with electro static precipitators for all 4 IP boilers. Thus, environment situation of Ninh Binh town area has been considerably improved (precipitator efficient of 99%). In 2000, 4 IP boilers have been maintained and upgraded with the exist igniter which is replaced by type of UD igniter,... The purpose of this works falls on the following targets: Efficient of plant is 602g standard coal per kWh, precipitator efficient of 99% and auxiliary power consumption of 10%.

Uong Bi: includes 4 medium pressure units (4 x 12MW), operation started from 1964 and 2 high pressure units of 50MW and 55MW started in 1975 and 1977. Due to obsolete technology and equipment, all medium pressure units have been used for reactive power generation only. The two remaining high pressure units are planned for upgrading so that they can be operated reliably in long term with a newly installed 300MW unit which is scheduled for installation after the year 2000. The fuel consumption of existing high-pressure unit is 647g Standard Coal per kWh with auxiliary power consumption of 12%.

Pha Lai: So far the plant is the largest thermal power station in Vietnam with a total installed capacity of 440MW (4x110MW). Units were put in commercial operation in 1983, 1984, 1985 and 1987 Plant equipment was supplied by former Soviet Union. During the past years, the plant has been maintained and upgraded and therefore it has been highly and reliably operated to supply power to the network during dry seasons. Fuel consumption is 458g Standard Coal per kWh and auxiliary consumption is 10.9%.

Thu Duc: The plant has an installed capacity of 165MW comprising one unit of 33MW and two units of 66MW. The plant has been operating since 1966. The United States supplied its equipment. Despite it is more than 30 years old the plant, with a well applied maintenance, overhaul and upgrade program, is still able to run well with available capacity of 156MW. Fuel consumption is 280g FO per kWh along with auxiliary power consumption of 6.5%. In addition to the oil-fired steam units, there are also some small gas turbines with total installed capacity of 125MW, from which 100MW is available. Among those gas turbines, two gas turbines with 37.5MW each were installed in 1992 and are properly running. Economic and technical merits of the remaining gas turbines have been deteriorated.

Tra Noc: Installed capacity of the plant is 186MW consisting of a 35MW oil-fired steam unit with 32MW available capacity. 2 x 37.5MW gas turbines have been operated since 1996 and 2 x 39 MW since 1999. All units are still operating accurately.

Baria: There are 8 units with a total of 326MW capacity consisting of 6 x 37,5MW and 2x23.4MW units that have available capacity of only 300MW. Associated gas from Bach Ho field (White Tiger) is currently used for power plant as main fuel. An additional add-on steam unit has been installed and was put in operation in 1999. A second add-on steam unit will be installed in 2001 so that plant will have two combined cycle blocks (3-3-1), which will generate a total of 300MW fuelled by gas.

Phu My 2-1: Two 144MW-combustion turbines were supplied by ABB. They were installed and put into operation in 1997. The combustion turbines are designed to run on gas as main fuel while distillate oil is used as stand by fuel. Installation of an add-on steam cycle with an additional output of 143MW will bring the output of the whole block to 431MW. The add-on cycle will be available by mid 2002.

Phu My 2-1 Extension: The plant has two units with a capacity of 140MW each. The combustion turbines, which were manufactured by Siemens were installed and put into operation by 1999. The associated gas from Bach Ho is used as main fuel.

Table 2-15: Generation of the exiting thermal-power plant

Unit: GWh

No.	Name of plants	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
1	Ninh Binh (coal)	268	256	182	189	216	133	350	520	492	257
2	Uong Bi (coal)	239	104	50	51	118	223	376	541	601	574
3	Pha Lai (coal)	1493	1005	619	397	737	1666	1651	2264	2387	2080
4	Thu Duc (FO)	665	852	794	928	870	721	719	800	1082	804
5	Tra Noc (FO)	176	207	242	204	172	185	184	208	247	187
	Gas turbine (DO)	-	-	-	-	-	-	32	220	428	277
6	Ba Ria (Gas-DO)	-	-	150	296	350	748	1097	1350	1636	1312
7	Phu My 2-1 (Gas-	-	-	-	-	-	-	-	1081	2076	2242

3. ELECTRICITY END USERS AND TARIFFS

According to World Bank estimates, Vietnam average electricity tariff has been around 4.8 UScent/kWh so far. This tariff has been based on electricity production and distribution costs evaluated and submitted by Electricity of Vietnam to Government's Goods Pricing Committee. However, this tariff does not reflect adequately all the costs in reality. The under-valuation of fixed assets and extremely low depreciation rate are main reasons that do not allow investors to get back their investment capitals and cover the capital cost.

Additionally, the tariff structure also needs to be improved. Some improvements have been made when tariff was increased in May 1997, i.e. the difference between peak hours and off peak hours. However, there are still some problems. For example whole price to Distribution Company is still too low, whilst some retailed price items are too high. There are big differences in retailed tariff, especially between consumers in urban and rural areas. The progressive price varies in wide range as well.

The above mentioned issues need to be improved by structural changes of electricity tariff so that it can reflect more accurately the long term marginal costs of electricity generation, transmission and distribution at different voltages.

According to Government's Goods Price Committee's decision letter No 87/1999/QD-BVGCP of dated September 23, 1999 on electricity tariff and the letter No 46/1999/QD-BVGCP, dated June 16, 1999 on the electricity tariff, which are applicable to foreign investment enterprises, the electricity tariff, from October 1, 1999 is as follows: (Source: Saigon Giai Phong newspaper, September 1999)

Table 2-17: Electricity price

Unit: VND/kWh

User Tariffs	Electricity price without VAT	Electricity price including VAT
I/ Electricity price for production:		
1/ Electricity price at voltage level of 110kV and above		
- Off peak hours	700	770
- Off off peak hours	340	374
- Peak hours	1240	1364
2/ Electricity price at voltage level from 22kV to under 110kV		
- Off peak hours	730	803
- Off off peak hours	360	396
- Peak hours	1290	1419
3/ Electricity price at voltage level from 6,6kV to under 22kV:		
- Off peak hours	770	847

User Tariffs	Electricity price without VAT	Electricity price including VAT
- Off off peak hours	390	429
- Peak hours	1340	1474
4/ Electricity price at voltage level under 6,6kV:		
- Off peak hours	800	880
- Off off peak hours	410	451
- Peak hours	1390	1529
II/ Electricity price for rice crops and irrigation water pump, southern industrial crops		
1. Electricity price at voltage level of 6.6kV and above		
- Off peak hours	572.72	630
- Off off peak hours	227.27	250
- Peak hours	900.00	990
2. Electricity price at voltage level under 6.6kV		
- Off peak hours	600.00	660
- Off off peak hours	236.36	260
- Peak hours	950.00	1045
III/ Electricity price for fresh water, urban drain water		
1/ Electricity price at voltage level of 6.6kV and above		
- Off peak hours	710.00	781
- Off off peak hours	350.00	385
- Peak hours	1250.00	1375
2/ Electricity price at voltage level under 6.6kV		
- Off peak hours	750.00	825
- Off off peak hours	360.00	396
- Peak hours	1330.00	1463
VI/ : Electricity price for hospital, school		
1/ Electricity price at voltage level of 6.6kV and above	700.00	770
2/ Electricity price at voltage level under 6.6kV	736.36	810
V/ Electricity price for public lighting		
1/ Electricity price at voltage level of 6.6kV and above	770.00	847
2/ Electricity price at voltage level under 6.6kV	800.00	880
VI/ Electricity price for administration office		

User Tariffs	Electricity price without VAT	Electricity price including VAT
1/ Electricity price at voltage level of 6.6kV and above		
2/ Electricity price at voltage level under 6.6kV	790.00	869
	820.00	902
VII/ Electricity price for the living		
- With the first 100kWh,	454.54	500
- Next 50kWh,	640.00	704
- Next 50kWh,	870.00	957
- Next 100kWh,	1060.00	1166
- Over 301kWh	1270.00	1397
VIII/ The wholesale prices		
1/ Electricity price for the land		
a/ The living	327.27	360
b/ Others	650.00	715
2/ Electricity price for the resident area:		
a/ Service		
- At output of transformer of customer	450.00	495
- At output of transformer of power branch	460.00	506
b/ Electricity price for other items	690.00	759
XI/ Electricity price for business, service, travel and trade:		
1/ Electricity price at voltage level of 6.6kV and above		
- Off peak hours	1220.00	1342
- Off off peak hours	660.00	726
- Peak hours	2060.00	2266
2/ Electricity price at voltage level under 6.6kV		
- Off peak hours	1270.00	1397
- Off off peak hours	680.00	748
- Peak hours	2170.00	2387
X/ Electricity price for the business with foreign investment and foreign person		
1/ Electricity price for production		
a/ Electricity price at voltage level of 110kV and above		
- Off peak hours	830.00	913
- Off off peak hours	440.00	484
- Peak hours	1410.00	1551
b/ Electricity price at voltage level from		

User Tariffs	Electricity price without VAT	Electricity price including VAT
6.6kV to under 110kV		
- Off peak hours	890.00	979
- Off off peak hours	480.00	528
- Peak hours	1510.00	1661
c/ Electricity price at voltage level from 6.6kV to under 22kV		
- Off peak hours	950.00	1045
- Off off peak hours	520.00	572
- Peak hours	1600.00	1760
d/ Electricity price at voltage level under 6.6kV		
- Off peak hours	1020.00	1122
- Off off peak hours	560.00	616
- Peak hours	1710.00	1881
2/ Electricity price for business service, travel and trade:		
a/ Electricity price at voltage level of 22kV and above		
- Off peak hours	1260.00	1386
- Off off peak hours	690.00	759
- Peak hours	2110.00	2321
b/ Electricity price at voltage level from 6.6kV to under 22kV		
- Off peak hours	1400.00	1540
- Off off peak hours	760.00	836
- Peak hours	2360.00	2596
c/ Electricity price at voltage level under 6.6kV		
- Off peak hours	1530.00	1683
- Off off peak hours	850.00	935
- Peak hours	2550.00	2805
3/ Electricity price for the living of foreign person		
a/ Electricity price at voltage level of 22kV and above	1200.00	1320
b/ Electricity price at voltage level from 6.6kV to under 22kV	1330.00	1463
c/ Electricity price at voltage level under 6.6kV	1470.00	1617

Notes:

+ Off peak hours: From 4 o'clock to 17 o'clock (14 hours). In this time, power consumption demand is at normal level.
+ Peak hours: From 18 o'clock to 21 o'clock (4 hours). In this time, power consumption demand is at high level.
+ Off off Peak hours: From 22 o'clock to 3 o'clock (6 hours). In this time, power consumption demand is at low level.

Since 1990, the power sector has increased its electricity tariff six times. The average tariff at that time was 360 VND/kWh. From January 1, 1999 the average tariff was 703 VND/kWh and is currently standing at 728 VND/kWh (about 5.2 US cents/kWh), which is still lower than those in neighbouring countries.

The electricity sales tariff needs to be structured in the way that reflects adequately all financial aspects as well as marginal cost of demand, which is normally in long term. Therefore, the tariff needs to be increased gradually to economically feasible level. The level of about 8 US cents per kWh is determined by long-term marginal cost that includes cost for electricity generation, transmission and distribution. On the other hand, the tariff increase will also help to control the electricity demand. Lack of tariff increase would result in higher demand and in turn it would require increasing financing for investment of newly installed capacity and also would not encourage people for electricity saving.

APPENDIX B2

APPROVAL LETTER
DATED MAY 25, 2001

MINISTRY OF SCIENCE, TECHNOLOGY AND ENVIRONMENT

REPUBLIC SOCIALIST OF VIETNAM
Independence-Freedom-Happiness

No.: 864/QD-BKHCNMT

Hanoi, 25 May 2001

DECISION OF THE MINISTER OF SCIENCE, TECHNOLOGY AND ENVIRONMENT
Approving the Environmental Impact Assessment Report of the Phu My 2-2 Thermal Power Plant Project in Ba Ria-Vung Tau

THE MINISTER
OF SCIENCE, TECHNOLOGY AND ENVIRONMENT

- Pursuant to the Law on Environmental Protection approved by the National Assembly of the Republic Socialist of Viet Nam on 27 December 1993,
- Pursuant to Decree175/CP dated 18 October 1994 of the Government for the Guidelines on implementation of the Law on Environmental Protection,
- Pursuant to Decree 22/CP dated 22 May 1993 of the Government on the functions, duties, powers and organizational structure of the Ministry of Science, Technology and Environment,
- Having considered the Application for the Environmental Impact Assessment Report Review of the Project Director of Phu My 2-2 Thermal Power Plant Project on 12 March 2001,
- Having considered the Minutes of meeting of the Evaluation Council on Environmental Impact Assessment Report of Phu My 2-2 Thermal Power Plant Project on 3 April 2001 and the Presentation on amendments and additions of the Environmental Impact Assessment Report of the Phu My 2-2 of Project Director on 26 April 2001,

DECIDES

Article 1: To approve the Environmental Impact Assessment Report of the Phu My 2-2 Thermal Power Plant Project of EDFI Consortium after it has been amended and added as requested by the Evaluation Council on 3 April 2001,

Article 2: The Sponsors of Project shall be responsible for the right implementation of the contents as described in the Environmental Impact Assessment Report and all the compulsory requirements as follows:

2.1 To construct, install equipment and operate the waste treatment system in order to ensure that:

- The waste air sources from the Plant must be treated to meet the VN standards (TCVN 1995-5937 and TCVN 1995-5939) before discharging into the environment.

- The industrial waste water, the life waste water, the waste water from the cooling system and the overflow rainwater must be collected and treated to meet the Vietnamese standards (TCVN 5945-1995)-class B before discharging into the Thi Vai River.

- The waste sludge, oil contaminated water collected from the settling tanks and all solid waste types from the Plant must be collected and treated to ensure the environmental sanitation.

2.2 To take appropriate measures in cooling water intake in order to ensure not to adversely affect the aquatic eco-system of the Sao River.

2.3 Green trees must be appropriately planted in the area of the Plant with at least 15% of the land area for this purpose.

2.4 During the construction phase, all preventive measures must be planned to avoid the inundation in time. The sludge, soil, and waster stone must be collected and treated to ensure the environmental sanitation.

2.5 To ensure the sufficient costs for the environmental protection activities and seriously implement the program for environmental surveys as stated on the Environmental Impact Assessment Report. The survey and observation data must be updated and filed at the Company.

2.6 To report in writing the changes in comparison with the content of the approved Environmental Impact Assessment Report and with the consent of the Governmental bodies in charge of the environmental protection, such amendments shall be made

Article 3: The Environmental Impact Assessment Report and the above-mentioned compulsory requirements shall be a basis for the Governmental bodies in charge of environmental protection to verify the implementation of environmental protection of the Plant.

Article 4: After completion of the construction works in respect of environment, the Sponsors shall have to submit a writing report to Governmental environmental bodies for verification and supervision.

Article 5: The Department of Science, Technology and Environment of Ba Ria-Vung Tau is authorized to follow up and supervise the environmental activities of the Plant.

Article 6 : This Decision shall take effect from the date of its signing.

FOR THE MINISTRY OF SCIENCE,
TECHNOLOGY AND ENVIRONMENT
VICE-MINISTER
(Signed and sealed)

PHAM NGUYEN KHOI

CC:
- Phu My 2-2 Thermal Power Plant,
- Ministry of Industry (to report),
- People's Committee of Ba Ria – Vung Tau province (to report),
- Department of Science, Technology and Environment of Ba Ria -Vung Tau (to coordinate)
- For filing: HS, VT.

1651 Mỹ

BỘ KHOA HỌC CÔNG NGHỆ
VÀ MÔI TRƯỜNG

Số: 864 / QĐ - BKHCNMT

CỘNG HOÀ XÃ HỘI CHỦ NGHĨA VIỆT NAM
Độc lập - Tự do - Hạnh phúc

Hà Nội, ngày 25 tháng 5 năm 2001

QUYẾT ĐỊNH CỦA BỘ TRƯỞNG
BỘ KHOA HỌC CÔNG NGHỆ VÀ MÔI TRƯỜNG

Về việc phê chuẩn Báo cáo đánh giá tác động môi trường
dự án Nhiệt điện Phú Mỹ 2 -2 tại Bà Rịa - Vũng tàu

BỘ TRƯỞNG
BỘ KHOA HỌC, CÔNG NGHỆ VÀ MÔI TRƯỜNG

- Căn cứ Luật Bảo vệ môi trường được Quốc Hội Nước Cộng Hoà Xã Hội Chủ Nghĩa Việt Nam thông qua ngày 27 tháng 12 năm 1993;
- Căn cứ Nghị định số 175/CP ngày 18 tháng 10 năm 1994 của Chính phủ về Hướng dẫn thi hành Luật Bảo vệ môi trường;
- Căn cứ Nghị định số 22/CP ngày 22 tháng 05 năm 1993 của Chính phủ về nhiệm vụ, quyền hạn và tổ chức bộ máy của Bộ Khoa học, Công nghệ và Môi trường;
- Xét Đơn xin thẩm định Báo cáo đánh giá tác động môi trường, ngày 12/03/2001 của Giám đốc dự án Nhiệt điện Phú Mỹ 2 -2;
- Xét Biên bản họp Hội đồng thẩm định Báo cáo đánh giá tác động môi trường dự án Nhiệt điện Phú Mỹ 2-2, ngày 03 tháng 04 năm 2001 và Tờ trình về việc sửa đổi, bổ sung Báo cáo đánh giá tác động môi trường dự án Phú Mỹ 2 -2 của Giám đốc dự án, ngày 26 tháng 4 năm 2001,

QUYẾT ĐỊNH

Điều 1. Phê chuẩn nội dung Báo cáo đánh giá tác động môi trường dự án Nhiệt điện Phú Mỹ 2 -2 của Tập đoàn EDFI sau khi đã được bổ sung, chỉnh sửa theo yêu cầu của Hội đồng thẩm định họp ngày 03 tháng 04 năm 2001.

Điều 2. Chủ dự án có trách nhiệm thực hiện đúng những nội dung đã được nêu trong Báo cáo đánh giá tác động môi trường và những yêu cầu bắt buộc sau đây:

2.1. Xây dựng, lắp đặt thiết bị và vận hành hệ thống xử lý chất thải đảm bảo:

+ Các nguồn khí thải của Nhà máy phải được xử lý đạt các tiêu chuẩn TCVN 1995-5937 và TCVN 1995-5939 trước khi thải ra môi trường;

+ Các nguồn nước thải sản xuất, nước thải sinh hoạt, nước thải từ hệ thống làm mát và nước mưa chảy tràn phải được thu gom và xử lý đạt tiêu chuẩn loại B, TCVN 5945-1995 trước khi thải vào hệ thống sông Thị Vải;

+ Bùn thải, váng dầu thu được từ các bể lắng và các loại chất thải rắn khác của Nhà máy phải được thu gom và xử lý đảm bảo vệ sinh môi trường;

2.2. Có các biện pháp thích hợp trong việc lấy nước làm mát, đảm bảo không gây ảnh hưởng xấu đến hệ thuỷ sinh sông Sao.

2.3. Trong khuôn viên Nhà máy phải được quy hoạch trồng cây xanh hợp lý với ít nhất 15% diện tích đất dành cho mục đích này.

2.4. Trong quá trình thi công phải có các biện pháp phòng chống ngập úng kịp thời; các loại bùn, đất đá thải phải được thu gom, xử lý đảm bảo vệ sinh môi trường.

2.5. Đảm bảo đầy đủ kinh phí cho các hoạt động bảo vệ môi trường và thực hiện nghiêm túc chương trình quan trắc môi trường như đã nêu trong Báo cáo đánh giá tác động môi trường. Số liệu quan trắc, giám sát phải được cập nhật và lưu giữ tại Công ty;

2.6. Báo cáo bằng văn bản những thay đổi so với nội dung Báo cáo đánh giá tác động môi trường đã được phê duyệt và chỉ được thực hiện khi có sự đồng ý bằng văn bản của các cơ quan quản lý Nhà nước về bảo vệ môi trường.

Điều 3. Báo cáo đánh giá tác động môi trường của dự án và những yêu cầu bắt buộc nêu trên là cơ sở để các cơ quan quản lý Nhà nước về bảo vệ môi trường kiểm tra việc thực hiện bảo vệ môi trường của Nhà máy.

Điều 4. Sau khi hoàn thành các hạng mục công trình về môi trường, Chủ dự án phải có báo cáo bằng văn bản gửi cơ quan quản lý Nhà nước về bảo vệ môi trường để kiểm tra và theo dõi.

Điều 5. Ủy nhiệm Sở Khoa học Công nghệ và Môi trường Tp. Bà Rịa - Vũng Tàu theo dõi, giám sát hoạt động bảo vệ môi trường của Nhà máy.

Điều 6. Quyết định này có hiệu lực thi hành kể từ ngày ký quyết định.

Nơi nhận :
- Nhà máy Nhiệt điện Phú Mỹ 2-2;
- Bộ Công nghiệp (để thông báo);
- UBND Tp. Bà Rịa - Vũng Tàu (để thông báo);
- Sở KHCNMT Tp. Bà Rịa - Vũng Tàu (để phối hợp);
- Lưu HS, VT.

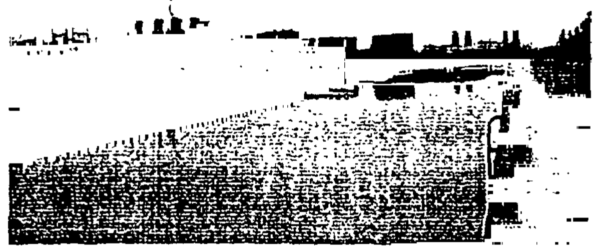
K/T BỘ TRƯỞNG
BỘ KHOA HỌC, CÔNG NGHỆ VÀ MÔI TRƯỜNG
THỨ TRƯỞNG

Phạm Khôi Nguyên

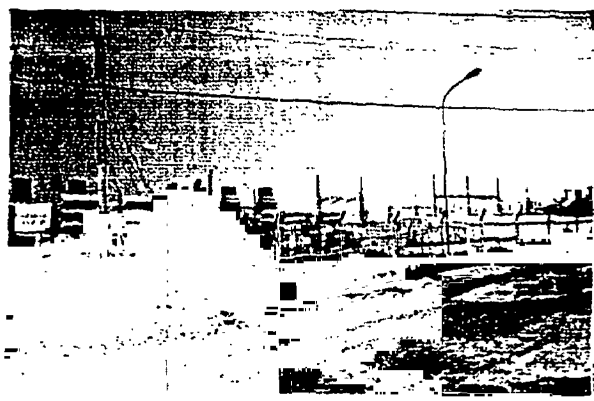
APPENDIX C1

PHOTOS OF
PHU MY POWER GENERATION COMPLEX

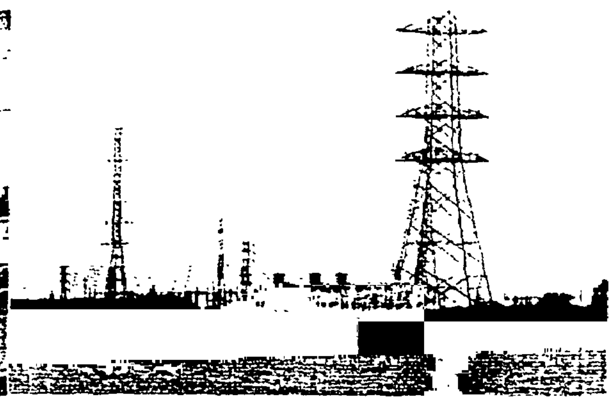
Intake canal looking towards the plant



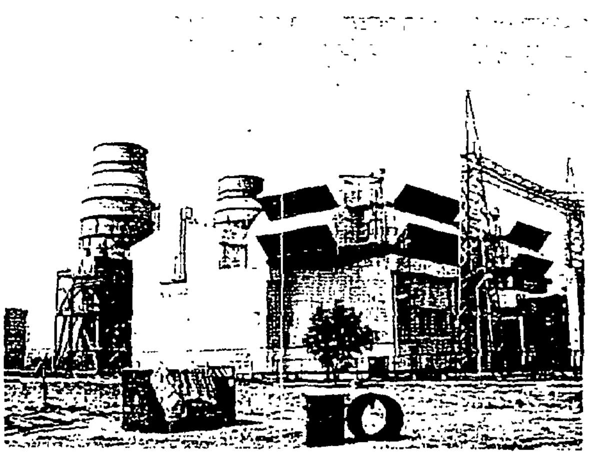
Intake canal looking towards the plant 2



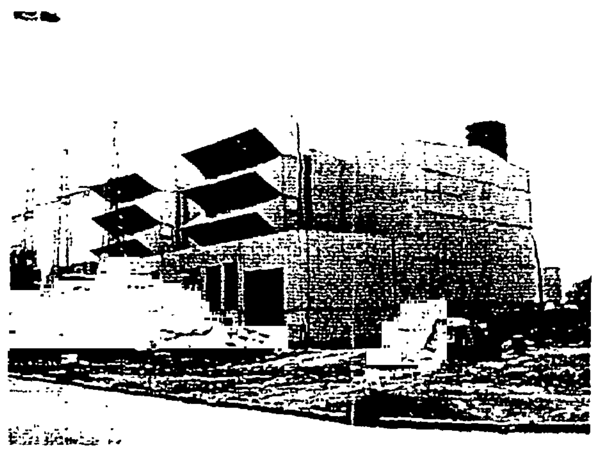
Phu My Power Generation Complex



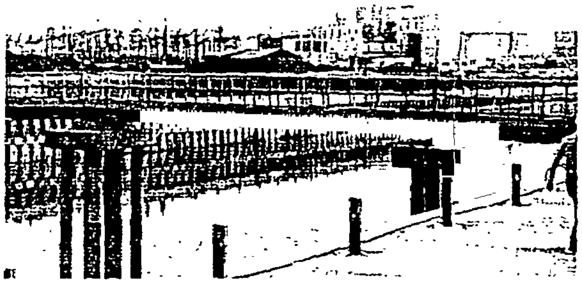
220 kV Phu My Transmission Lines



Phu My 2-1 Extension

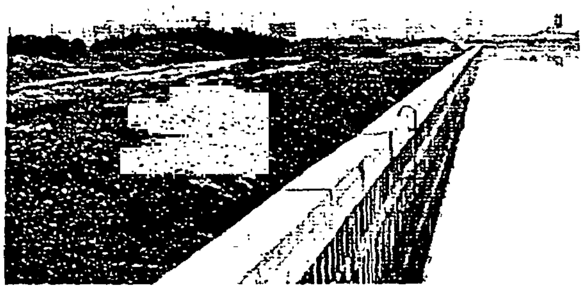


Phu My 2-1

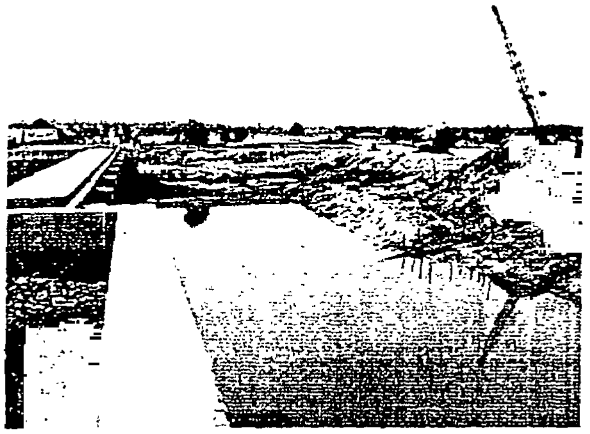


Phu My 1 from Sao River

Intake canal towards Sao River

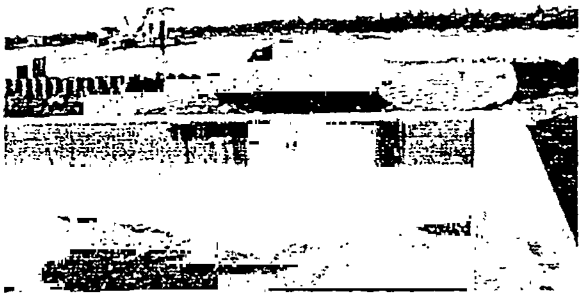


Intake Canal 2

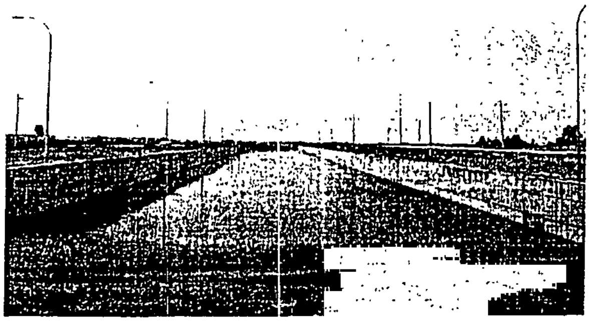


Intake Canal 3

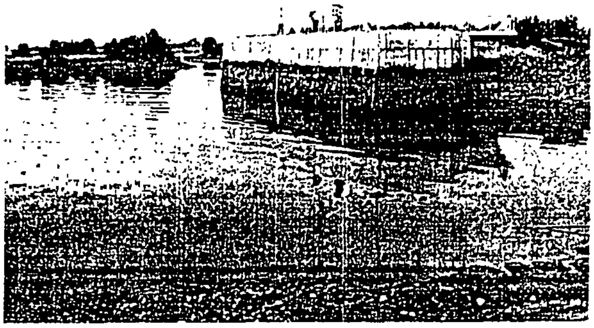
Intake Canal, downstream Sao River



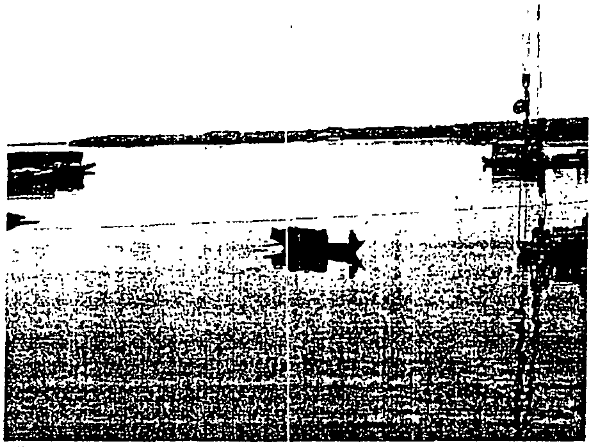
Intake Canal, upstream Sao River



Discharge Canal



End of Discharge Canal

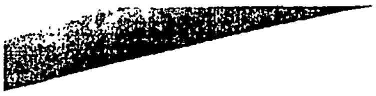


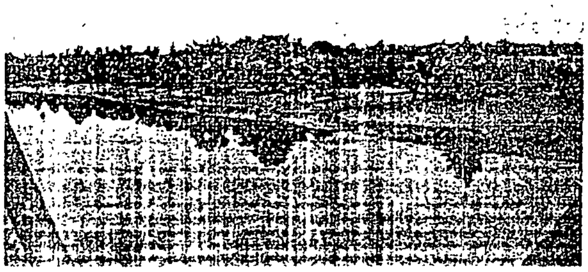
View downstream Thi Vai River from discharge canal

View of site from the Thi Vai River end of discharge canal

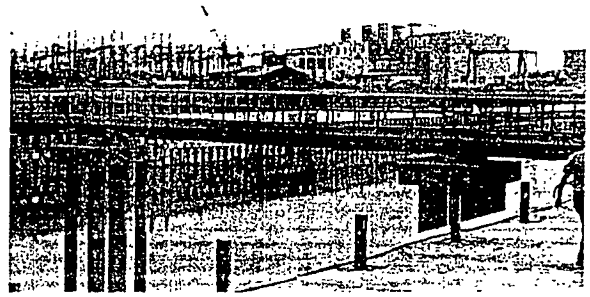
Mangroves, intake canal 2

Mangroves, intake canal

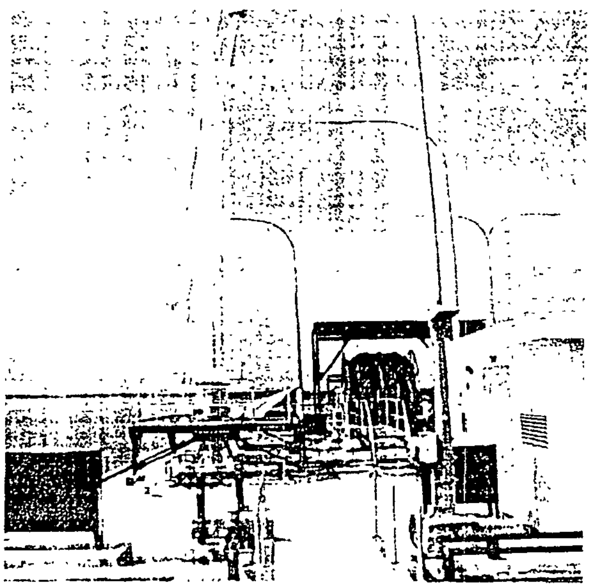




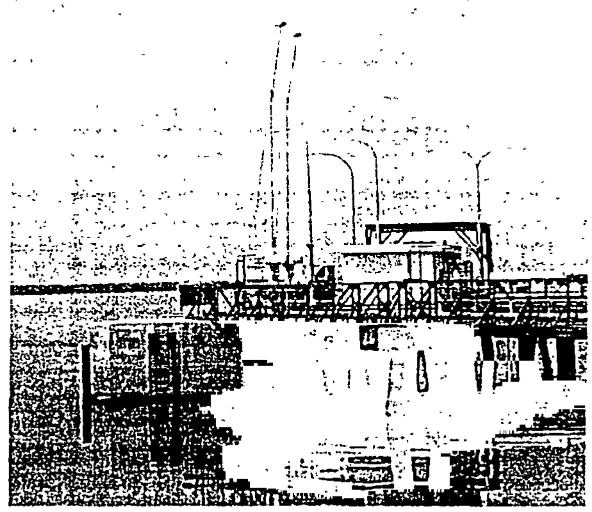
Mangroves near oil terminal



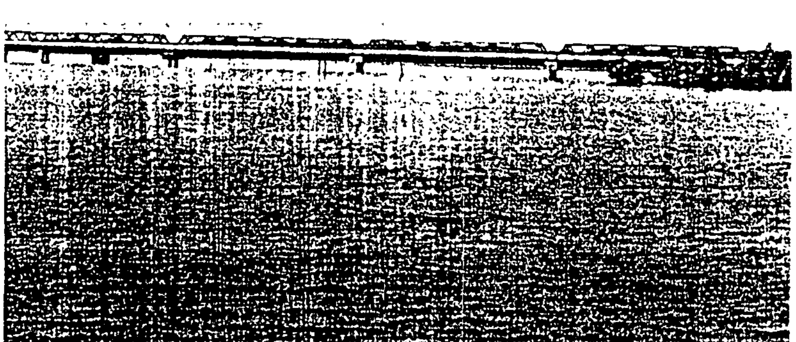
Phu My 1 from Sao River



Oil Terminal on the Thi Vaı River 1



Oil Terminal on the Thi Vai River 2



Oil Pipeline from Oil Jetty to Phu My Power Plant

Environmental Assessment Report
of PHU MY 2 Phase 2

APPENDIX D1

LIST OF ANIMALS OBSERVED INTHE THI VAI RIVER

Appendix 3.8

List of animals observed in the Thivai river basin

No	SPECIES NAME	VIETNAMESE NAME	COVERING LEVEL
	AMPHIBIANS	**ẾCH NHÁI**	
01	Bufo melanosticus	Cóc nhà	+++
02	Rana limnocharis	Ngoé	+++
03	Rana cancrivosa	Ếch cua	+
04	Rana macrodactyla	Nhái cây	++
05	Rana tigriaa	Ếch đồng	+++
06	Kaloula pulchra	Ếch ương	+++
07	Rhacophorus leucomystax	Nhái bám	++
08	Ooedozyga limna	Cóc nước	+

No	SPECIES NAME	VIETNAMESE NAME	COVERING LEVEL
	REPTILES	**BÒ SÁT**	
01	Python molurus	Trăn mốc	+
02	Cerberus rhynchops	Rắn cá	++
03	Xenochrophis piscator	Rắn nước	+++
04	Elaphe radiata	Rắn sọc dưa	+
05	Trimaresurus papeorum	Rắn lục	++
06	Naja naja	Rắn hổ mang	++
07	Bungarus fasciatus	Rắn cạp long	++
08	Xenopeltis unicolor	Rắn mòng	+
09	Hemidactylus frenatus	Thạch sùng	+++
10	Varanus sp.	Kỳ đà	++
11	Mabuya multifasciata	thằn lằn bóng	++
12	Malayemys subtrijuga	Ruà	++
13	Cuora sp	Ruà	+
14	Gerko gerko	Tắc kè	+
15	Calotes versicolor	Cắké đầu xanh	++
16	Ptyas korros	Rắn ráo	++
16	Calotes calotes	Cắc ké nâu	+

	BIRDS	CHIM	
01	Dendrocygna javanica	Le nâu	++
02	Ardea cinerea	Diệc xám	+
03	Ardea purpurea	Diệc lụa	+
04	Ardeola bacchus	Cò bợ	+++
05	Butorides striatus	Cò xanh	+
06	Egretta alba	Cò ngang lớn	++
07	Ixobrychus sinensis	Cò lụa nhỏ	+
08	Ibis leucocephalus	Giang sen	+
09	Ciconia episcopus	Hạc khoang cổ	+
10	Plegadis falcinelus	Quắm đen	+
11	Streskiornis chinensis	Cu gáy	+++
12	Streptopelia tranqueharica	Cu ngói	++
13	Cuculus merulinus	Tìm vịt	++
14	Centropus sinensis	Bìm bịp	++
15	Eudinamys scolopacea	Tu hú	+
16	Haeliatus sp.	Diều	++
17	Haeliatus indus	Diều lụa	+
18	Polihierax insignis	Cát hồng trắng	+
19	Dicacum concolor	Chim sâu	+++
20	Hirunda rustica	Nhạn bụng trắng	++
21	Sterna sp.	Nhạn biển	+++
22	Picnonotus jocosus	Chào mào	+++
23	Acridotheres fuscus	Sáo nâu	++
24	Motaciila alba	Chìa vôi	+
25	Anhinga malanogester	Điêng điểng	+
26	Phalacrocorax carbo	Cốc đế	++
27	Picoides macei	Gõ kiến nâu	++
28	Gallicrex cinerea	Gà nước	++
29	Rallus striatus	Gà nước	++
30	Pelecanus sp.	Bồ nông	+
31	Alcedo atthis pengalensis	Bồng chanh(bói cá)	++
32	Halcyon pileata	Sả đầu đen	++
33	Lonchura punctulata	Chim ri đá	+++
34	Ampeliceps coronatus	Sáo đầu vàng	++
35	Pycnonotus atriceps	Bông lau	+
36	Aethopyga siparaja	Chim hút mật nâu	++

No	SPECIES NAME	VIETNAMESE NAME	COVERING LEVEL
	MAMMALS	**ĐỘNG VẬT CÓ VÚ**	
01	Lutra lutra	Rái cá	+
02	Viverra zibetha	Cầy giông	+
03	Felis sp.	Mèo rừng	+
04	Bandicota indica	Chuột đất	+++
05	Rattus argentiveater	Chuột đồng	+++
06	Callosciurus pyheythur	Sóc bụng xám	++
07	Sus scora	Lợn rừng	++
08	Cervus unicolor	Nai	+
09	Maccacus cynomelgus	Khỉ	++
10	Lepus indicus	Thỏ rừng	++
11	Melogale moscata	Chồn	++

Source : VESDC/ITB December 1999

Environmental Assessment Report
of PHU MY 2 Phase 2

APPENDIX D2

LIST OF RARE VEGETATION SPECIES AND ANIMALS

Appendix 3.9 List of rare vegetation species and animals
(Issued following Decree No 18/HDBT dated 17.1.1992)

The group one

IA - Vegetation species

No	Vietnamese names	Scientific names	Mark
1	2	3	4
1	Bách xanh	Calocedrus macrolepis	
2	Thông đỏ	Taxus chinensis	
3	Phỉ 3 mũi	Cephalotaxus fortunei	
4	Thông tre	Podocarpus neriifolius	
5	Thông Pà cò	Pinus kwangtugensis	
6	Thông Đà Lạt	Pinus dalatensis	
7	Thông nước	Glyptostrobus pensilis	
8	Hinh đá vôi	Keteleeria calcarea	
9	Sam bông	Amentotaxus argotenia	
10	Sam lạnh	Abies nukiangensis	
11	Trầm (gió bầu)	Aquilaria crassna	
12	Hoàng đàn	Copressus torulosa	
13	Thông 2 lá dẹt	Ducampopinus krepfii	

IB - Animals

No	Vietnamese names	Scientific names	Mark
1	2	3	4
1	Tê giác 1 sừng	Rhinoceros Sondaicus	
2	Bò tót	Bos gaurus	
3	Bò xám	Bos sauveli	
4	Bò rừng	Bos bangteng	
5	Trâu rừng	Bubalus bubalis	
6	Voi	Elephas maximus	
7	Cà tong	Cervus eldi	
8	Hươu vàng	Cervus porcirus	
9	Hươu sạ	Moschus moschiferus	
10	Hổ	Panthera tigris	
11	Báo hoa mai	Panthera pardus	
12	Báo Gấm	Neofelis nebulosa	
13	Gấu chó	Helarctos malayanus	
14	Voọc xám	Trachipithecus phayrei	
15	Voọc mũi hếch	Rhinopithecus avunculus	
16	Voọc ngũ sắc:		
	-Voọc ngũ sắc Trung Bộ	Pygathrix nemaeus	
	-Voọc ngũ sắc Nam Bộ	Pygathrix nigripes	
17	Voọc đen:		
	-Voọc đen má trắng	Presbytis francoisi francoisi	
	-Voọc đầu trắng	Presbytis francoisi poliocephalus	
	-Voọc mông trắng	Presbytis francoisi delacouri	
	-Voọc Hà Tĩnh	Presbytis francoisi hatinensis	
	-Voọc đen Tây Bắc	Presbytis francoisi ap	
18	Vượn đen:		
	- Vượn đen	Hylobates concolor concolor	
	- Vượn đen má trắng	Hylobates concolor leucogensis	
	- Vượn tay trắng	Hylobatas lar	
	- Vượn đen má trắng Nam Bộ	Hylobates concolor gabrienlae	
19	Chồn mực	Arctictis binturong	
20	Cầy vằn	Chrotogale owstoni	
21	Cầy gấm	Prionodon pardicolor	
22	Chồi dơi	Galeopithecus temminski	
23	Cầy vàng	Martes flavigula	
24	Culi lùn	Nycticebus pigmaeus	

IIB - Animals

No	Vietnamese names	Scientific names	Mark
1	2	3	4
1	Khỉ:		
	- Khỉ cộc	Macaca arctoides	
	- Khỉ vàng	Macaca mulatta	
	- Khỉ mốc	Macaca assamensis	
	- Khỉ duôi lợn	Macaca nemestrina	
2	Sơn dương	Capricornis sumatraensis	
3	Mèo rừng	Felis bengalensis	
		Felis marmorata	
		Felis temmiskii	
4	Rái cá	Lutra lutra	
5	Gấu ngựa	Selenartos thibethanus	
6	Sói dỏ	Cuon alpinua	
7	Sóc den	Ratuta bicolor	
8	Phượng hoàng dất	Buceros bicornis	
9	Rùa núi vàng	Indotestudo elongata	
10	Giải	Pelochelys bubroni	

No	Vietnamese names	Scientific names	Mark
25	Sóc bay:		
	- Sóc bay sao	Petaurista elegans	
	- Sóc bay trâu	Petaurista lylei	
26	Sóc bay:		
	- Sóc bay nhỏ	Belomys	
	- Sóc bay lông tai	Belomys pearsoni	
27	Sói Tây Nguyên	Canis aureus	
28	Công	Pavo muticus imperatir	
29	Gà lôi:		
	- Gà lôi	Lophura diardi diardi	
	- Gà lôi lam mào đen	Lophura imperialis Delacouri	
	- Gà lôi lam mào trắng	Lophura diardi Bonoparte	
30	Gà tiền:		
	- Gà tiền	Polyplectron bicalcaratum	
	- Gà tiền mặt đỏ	Polyplectron germaini	
31	Trĩ sao	Rheinarctia ocellata	
32	Sếu cổ trụi	Grus antigol	
33	Cá sấu nước lợ	Crocodylus porosus	
34	Cá sấu nước ngọt	Crocodylus Siamensis	
35	Hổ mang chúa	Ophiogus hannah	
36	Cá cóc Tam đảo	Paramesotriton deloustan	

The group two

IIA - Vegetation species

No	Vietnamese names	Scientific names	Mark
1	Cẩm lai	Dalbergia oliverrii Gamble	
	Cẩm lai Bà Rịa	Dalbergia bariaensis	
	Cẩm lai	Dalbergia oliverrii Gamble	
	Cẩm lai Đồng Nai	Dalbergia dongnaiensis	
2	Gà te (Gõ đỏ)	Afzelia xylocarpa	
3	Gụ		
	Gụ mật	Sindora cochinchinensis	Gõ mật
	Gụ lau	Sindora tonkinensis-A.Chev	Gõ lau
4	Giáng hương		
	Giáng hương	Pterocarpus pedatus Pierre	
	Giáng hương Cambốt	Pterocarpus cambodianus Pierre	
	Giáng hương mắt chim	Pterocarpus indicus Willd	
5	Lát		
	Lát hoa	Chukrasia tabularis A.juss	
	Lát da đồng	Chukrasia sp	
	Lát chun	Chukrasia sp	
6	Trắc		
	Trắc	Dalbergia cochinchinensis Pierre	
	Trắc dây	Dalbergia annamensis	
	Trắc cambốt	Dalbergia combodiana Pierre	
7	Pơ mu	Fokienia hodginsii A.Henry et Thomas	
8	Mun		
	Mun	Diospyros mun H.lec	
	Mun sọc	Dyospyros sp	
9	Đinh	Markhamia pierrei	
10	Sến mật	Madhuca pasquieri	
11	Nghiến	Burretiodendron hsienmu	
12	Lim xanh	Erythophloeum fordii	
13	Kim giao	Padocarpus fleuryi	
14	Ba gạc	Rauwolfia verticillata	
15	Ba kích	Morinda officinalis	
16	Bách hợp	Lilium brownii	
17	Sâm ngọc linh	Panax vietnammensis	
18	Sa nhân	Amomum longgiligulare	
19	Thảo quả	Amomum tsaoko	

APPENDIX D3

COMPOSITION AND DENSITY OF BENTHIC ANIMALS INTHE THI VAI RIVER
December 1999

Appendix 3.11 **Composition and density of benthic animals in the Thivai river, December 1999**

No	Scientific names	Sampling point								
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*8*
	A. NEMERTINI									
01	Genus sp.	3								
	B. POLYCHAETA									
	I_ Errantia									
	Aphroditidae									
02	Harmothoe sp.				2	4				
	Nephthydidae									
03	Nephthys polybranchia (Southern)		2	1				19		
	Nereidae									
04	Nereis sp.		1					1	3	3
05	Neanthes meggitti Monro			3		4		3		
	Lumbrinereidae									
06	Lumbrinereis heterpoda (Marenzeller)					11				
	Syllidae									
07	Pionosyllis compacta Malmgren					16	1	2		
08	Odontosyllis gibba Malmgren			1						
09	Ehlersia sp.						1			
	Hesionidae									
10	Ophiodromus sp.									1
	Spintheridae									
11	Euphrosyne sp.				2					1

No	Scientific names	Sampling point								
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*8*
	Phyllodocidae									
12	Eteone sp.					4		8		3
	Eunicidae									
13	Diopatra neapolitana Delle Chiaje			1	15	13		2	4	
	II_ Sedentaria									
	Spionidae									
14	Aonides oxycephala (Sars)		3	1	2					2
15	Polydora malmgreni Claparède				8	135		3	5	93
16	Parapolydora pinnata Ehlers		10		91			22	11	
	Disomidae									
17	Disoma carica Birula			2	11	2			17	2
	Cirratulidae									
18	Cirratulus sp.			1	1	10				
19	Cossura longicirrata Webster et Benedict					13				
	Capitellidae									
20	Capitella capitata (Fabricius)		1	1						
21	Notomatus sp.					1				
	Sternaspidae									
22	Sternaspis scutata (Ranzani)	1	6							
	Maldanidae									

No	Scientific names	Sampling point								
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*8*
23	Maldane sarsi Malmgren		2				2			
	Terebellidae									
24	Pista sp.								5	2
	Sabellidae									
25	Bispira polymorpha Johnson		1		5	5		5		3
	C. CRUSTACEA									
	I_ Amphipoda									
	Gammaridae									
26	Melita sp.					4		15		
27	Grandidierella lignorum Barnard				14	35		16	2	
	Hyalidae									
28	Hyale hawaiensis (Dana)	2	2					5		
	II_ Tanaidacea									
	Apseudidae									
29	Apseudes vietnamensis Dang									32
	III_ Decapoda - Brachyura									
30	Cua non					1				
	IV_ Mysidacea									
	Mysidae									
31	Mesopodopsis slabberi		5							1
	V_ Cumacea									
32	Genus sp.		2							

No	Scientific names	Sampling point								
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*8*
	D. MOLLUSCA									
	I_ Gastropoda									
	Cerithridae									
33	Cerithium sp.	C		C			C	C	C	C
	II_ Bivalvia									
	Aloidae									
34	Aloidis sp.			2		1	C	C	C	
	E. ECHINODERMATA									
	I_ Ophiuroidae									
	Amphiuridae									
35	Amphioplus laevis (Koehler)	3			11	18				
	Number of species (Số loài)	5	11	10	11	17	5	14	9	12
	Individual in sample (Số lượng)	9	35	13	156	277	4	111	47	143
	Individuals/m²	**90**	**350**	**130**	**1.560**	**2.770**	**40**	**1.110**	**470**	**1.430**

Source: VESDC, Dec. 1999

No	Scientific names	Sampling point								
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*8*
	D. MOLLUSCA									
	I_ Gastropoda									
	Cerithridae									
33	Cerithium sp.	C		C			C	C	C	C
	II_ Bivalvia									
	Aloidae									
34	Aloidis sp.			2		1	C	C	C	
	E. ECHINODERMATA									
	I_ Ophiuroidae									
	Amphiuridae									
35	Amphioplus laevis (Koehler)	3			11	18				
	Number of species (Số loài)	5	11	10	11	17	5	14	9	12
	Individual in sample (Số lượng)	9	35	13	156	277	4	111	47	143
	Individuals/m^2	**90**	**350**	**130**	**1.560**	**2.770**	**40**	**1.110**	**470**	**1.430**

Source: VESDC, Dec. 1999

Appendix 3.12 **Composition and density of zooplanktons species in the Thivai river, December 1999**

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
	COPEPODA										
	Paracalanidae										
1.	Paracalanus parvus (Claus)	5	3	1	1					1	
2.	Paracalanus aculeatus Giesbrècht	1	1	1							
3.	Acrocalanus gracilis Chen et Zhang	2	1								
	Pseudodiaptomidae										
4.	Schmackeria speciosa Dang		2		1			5		1	1
	Acartiidae										
5.	Acartia clausi Giesbrecht		1			1	1	5		1	1
	Oithonidae										
6.	Oithona similis Claus	18	21	9	4		2		14	4	6
7.	Oithona brevicornis (Giesbrecht)			1						1	
8.	Oithona rigida Rosendorn	2	1	1							
	Corycaeidae										
9.	Corycaeus speciosus Dana	1									
	Cyclopidae										
10.	Halicyclops sp.									1	
	Macrosetellidae										
11.	Macrosetella gracilis Dana	1									
	Canuellidae										
12.	Canuella perplexa T. et A.Scott								2	1	

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
	Ergasilidae										
13.	Ergasilus sp.										1
	CLADOCERA										
	Sididae										
14.	Diaphanosoma excisum Sars							1			
	ROTATORIA										
	Brachionidae										
15.	Brachionus plicatilis Muller		1								12
	COELENTERATA										
	Thaunantiadae										
16.	Obelia sp.		2	2	1		1	4		1	2
	PROTOZOA										
17.	Ciliata			620	1.100	345	226	150	950	78	174
	LARVA										
18.	Nauplius copepoda	141	32	27	46	73	11	129	20	24	27
19.	Zoe	3	2					1	1		
20.	Mysis	1	1								
21.	Polychaeta	2	1	1							11
22.	Young fish		1								
	Number	**11**	**14**	**9**	**6**	**3**	**5**	**7**	**5**	**10**	**9**
	Quantity /m^3	**17.700**	**7.000**	**66.300**	**115.300**	**41.900**	**24.100**	**29.500**	**98.700**	**11.200**	**23.500**

Source: VESDC, December 1999

Environmental Assessment Report
of PHU MY 2 Phase 2

APPENDIX D4

COMPOSITION AND DENSITY OF ZOOPLANKTONS SPECIES IN THE THI VAI RIVER
December 1999

Appendix 3.12 **Composition and density of zooplanktons species in the Thivai river, December 1999**

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
	COPEPODA										
	Paracalanidae										
1.	Paracalanus parvus (Claus)	5	3	1	1					1	
2.	Paracalanus aculeatus Giesbrècht	1	1	1							
3.	Acrocalanus gracilis Chen et Zhang	2	1								
	Pseudodiaptomidae										
4.	Schmackeria speciosa Dang		2		1			5		1	1
	Acartiidae										
5.	Acartia clausi Giesbrecht		1			1	1	5		1	1
	Oithonidae										
6.	Oithona similis Claus	18	21	9	4		2		14	4	6
7.	Oithona brevicornis (Giesbrecht)			1						1	
8.	Oithona rigida Rosendorn	2	1	1							
	Corycaeidae										
9.	Corycaeus speciosus Dana	1									
	Cyclopidae										
10.	Halicyclops sp.									1	
	Macrosetellidae										
11.	Macrosetella gracilis Dana	1									
	Canuellidae										
12.	Canuella perplexa T. et A.Scott								2	1	

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
	Ergasilidae										
13.	Ergasilus sp.										1
	CLADOCERA										
	Sididae										
14.	Diaphanosoma excisum Sars							1			
	ROTATORIA										
	Brachionidae										
15.	Brachionus plicatilis Muller		1								12
	COELENTERATA										
	Thaunantiadae										
16.	Obelia sp.		2	2	1		1	4		1	2
	PROTOZOA										
17.	Ciliata			620	1.100	345	226	150	950	78	174
	LARVA										
18.	Nauplius copepoda	141	32	27	46	73	11	129	20	24	27
19.	Zoe	3	2					1	1		
20.	Mysis	1	1								
21.	Polychaeta	2	1	1							11
22.	Young fish		1								
	Number	**11**	**14**	**9**	**6**	**3**	**5**	**7**	**5**	**10**	**9**
	Quantity /m^3	**17.700**	**7.000**	**66.300**	**115.300**	**41.900**	**24.100**	**29.500**	**98.700**	**11.200**	**23.500**

Source: VESDC, December 1999

Appendix 3.13 Density of phytoplanktons in Thivai river, December, 1999

Sampling point	Quantity (tb/m^3)	Dominant species	Quantity Dominant species (tb/m^3)
1	173.250.000	Oscillatoria geitleriana	133.500.000
3	355.650.000	Oscillatoria geitleriana	314.100.000
4	599.700.000	Oscillatoria geitleriana	561.000.000
5	684.450.000	Oscillatoria geitleriana	650.550.000
5A	439.500.000	Oscillatoria geitleriana	412.950.000
5B	410.000.000	Oscillatoria geitleriana	371.250.000
5C	362.250.000	Oscillatoria geitleriana	345.750.000
6	544.800.000	Oscillatoria geitleriana	523.200.000
7	488.400.000	Oscillatoria geitleriana	459.400.000
8	153.000.000	Oscillatoria geitleriana	136.800.000

APPENDIX D5

DENSITY OF PHYTOPLANKTONS IN THE THI VAI RIVER

December 1999

Appendix 3.10 **Composition of Phytoplankton species in the Thivai river, December 1999**

No	Scientific names	Sampling points									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
	CYANOPHYTA										
1.	Oscillatoria acuta	+	+	+	+	+	+	+	+	+	
2.	O. geitleriana	+	+	+	+	+	+	+	+	+	+
3.	O. limosa		+	+		+	+	+	+	+	+
4.	O. princeps	+					+	+			
5.	O. salina							+			+
6.	O. subbrevis	+									
7.	Trichodesmium erythraeum						+				
8.	Spirulina major	+	+	+	+				+	+	
9.	Phormidium tenue			+	+	+	+		+		+
	CHRYSOPHYTA										
10.	Dictyocha fibula	+	+		+						
	BACILLARIOPHYTA										
11.	Melosira sulcata	+	+	+	+	+			+		
12.	Cyclotella comta	+	+	+	+	+	+	+	+	+	+
13.	C. striata	+	+	+	+	+	+	+	+	+	
14.	Coscinodiscus asteromphalus	+	+	+	+	+			+		+
15.	C. bipartitus	+	+	+		+	+				
16.	C. jonesianus	+	+	+	+	+	+	+	+	+	+
17.	C. lineatus	+	+	+	+				+		
18.	C. perforatus v. pavillardi				+						
19.	C. radiatus	+	+			+					

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
20.	C. subtilis	+	+	+	+	+	+		+	+	+
21.	Actinoptychus annulatus	+	+								
22.	Thalassiosira pacifica			+	+	+			+	+	+
23.	Guinardia flaccida		+	+							
24.	Skeletonema costatum	+	+	+	+	+	+		+	+	
25.	Rhizosolenia imbricata		+								
26.	R. setigera	+	+			+				+	
27.	Corethron hystrix		+								
28.	Chaetoceros abnormis	+	+	+	+						
29.	C. compactum			+	+	+	+	+	+	+	
30.	C. decipiens	+	+	+	+	+	+		+	+	+
31.	C. pseudocurvisetus		+								
32.	C. subtilis		+	+	+	+	+	+	+	+	
33.	Biddulphia mobiliensis	+	+		+						
34.	B. obtusa								+	+	
35.	B. reticulum	+	+			+					
36.	B. sinensis		+	+							
37.	Triceratium dubium								+		
38.	T. favus								+		
39.	Hemiaulus sinensis	+									
40.	Cerataulina bergonii			+							
41.	C. compacta										+

No.	Scientific names	Sampling point									
		1	3	4	5	5A	5B	5C	6	7	8
42.	Ditylum sol	+	+	+	+	+	+		+	+	
43.	Streptotheca thamesis	+									
44.	Asterionella japonica	+			+						
45.	Synedra demerarae							+			
46.	S. tabulata							+			
47.	S. ulna						+		+	+	
48.	Thalassionema nitzschioides	+	+	+		+	+		+		
49.	Thalassiothrix frauenfeldii	+	+	+	+	+	+			+	+
50.	Grammatophora marina							+			
51.	Licmophora abbreviata		+		+					+	
52.	Eunotia tautoniensis						+	+		+	
53.	E. zygodon						+				
54.	Achnanthes brevipes										+
55.	Cocconeis costata v. kerguelensis	+									
56.	Tryblioptychus cocconeisformis	+	+	+	+						
57.	Navicula cancellata				+	+	+	+	+	+	+
58.	N. digito-radiata						+	+			
59.	N. gracilis							+			
60.	N. membranacea			+							
61.	N. palpebralis					+	+	+	+		+
62.	N. sp.							+			

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
63.	Pinnularia microstauron						+				
64.	Trachyneis aspera	+	+		+		+		+	+	
65.	Diploneis elliptica	+	+			+		+			
66.	D. gruendlerii	+	+				+				
67.	Frustulia interposita			+			+	+	+	+	
68.	Gyrosigma balticum	+	+	+	+	+	+	+	+	+	+
69.	G. eximium							+			
70.	G. littorale						+				
71.	G. sinensis	+	+	+	+		+	+		+	
72.	G. spenceri				+						
73.	G. strigile			+			+	+	+		
74.	G. wansbeckii						+	+		+	
75.	Pleurosigma aestuarii				+						
76.	P. affine	+	+								
77.	P. angulatum	+	+	+	+		+	+	+	+	+
78.	P. elongatum				+		+	+			+
79.	P. fasciola	+	+	+	+	+	+	+	+	+	
80.	P. naviculaceum								+		
81.	P. pelagicum	+	+	+	+	+	+		+	+	
82.	P. sp.	+									
83.	Amphiprora alata	+	+	+	+	+					

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
84.	Cymbella ventricosa				+	+		+	+		
85.	Gomphonema acuminatum		+								
86.	Rhopalodia gibberula						+				
87.	Nitzschia closterium		+	+	+	+	+	+	+	+	+
88.	N. filiformis					+					
89.	N. longissima					+					
90.	N. longissima v. reversa				+	+	+	+			+
91.	N. lorenziana					+	+		+	+	
92.	N. navicularis									+	
93.	N. paradoxa	+	+	+					+	+	
94.	N. panduriformis		+								
95.	N. sigma		+		+			+	+		
96.	N. sigma v. intercedens		+	+	+		+	+		+	
97.	N. vitrea	+				+					
98.	Pseudonitzschia sp.		+	+	+			+	+		
99.	Surirella ovata	+									
100.	S. striatula	+	+	+	+	+		+	+	+	
	CHLOROPHYTA										
101.	Schroediria setigera				+	+	+	+		+	
102.	Scenedesmus arcuatus							+			
103.	Enteromorpha tubulosa					+		+	+	+	
104.	Schizomeris leibleinii						+				

No	Scientific names	Sampling point									
		1	*3*	*4*	*5*	*5A*	*5B*	*5C*	*6*	*7*	*8*
	EUGLENOPHYTA										
105	Euglena acus							+			
106	Trachelomonas volvocina				+						
107	Strombomonas australica							+			
	DINOPHYTA										
108	Ceratium furca	+	+	+							
109	Gonyaulax scrippsae		+								
110	G. spinifera						+				
111	G. verior			+	+	+			+		+
112	Glenodinium lenticula					+			+		+
113	Pyrophacus horologium	+		+					+	+	+
114	P. steinii					+					+
115	Peridinium pallidum	+		+							
116	P. sp.			+			+	+			
	Total	49	53	45	46	42	46	42	44	38	24

Source: VESDC, Dec. 1999

APPENDIX D6

LIST OF FISH SPECIES COLLECTED IN THE THI VAI RIVER

Appendix 3.14

List of fish species collected in Thivai river

No	Species name	Vietnamese name	English name	Section I	Section II	Section III
I	DASYATIDAE					
1	Dasyatis sp.	Caù ñuoâi	Ray			X
II	OPHICHTIDAE					
2	Pisoodonophis boro (Hamilton)***	Lich cu		X		
III	MURAENIDAE					
3	Muraenesox cinereus (Forsskal)***	Ca Lat	Pike conger			X
IV	CLUPEIDAE					
4	Kowala coval (Cuvier)	Ca Mai	Silag			X
5	Sardinella sp.	Trich	Sardine			X
6	Anodontostoma charcanda (H-B)	Moi				X
V	ENGRAULIDAE					
7	Thryssa mystax Bloch & Schneider	Lep	Anchovy			X
8	Thryssa sp.	Lep so	Anchovy			X
9	Coilia clupeoides (Lacepede)	Mao Ga	Anchovy		X	X
10	Colia sp.	Mao Ga	Anchovy		X	
11	Stoiephorus tri (Bleeker)	Com soc	Anchovy			X
12	Stolephorus commersonii (Lacepede)	Com thuong	Anchovy			X
13	Setipinna taty (Valenciennes)	Calep	Anchovy		X	X
VI	GADIDAE					
14	Bregmaceros sp.	Ca Tuyet	Gadus			X
VII	BAGRIDAE					
15	Mystus gulio (Hamilton)	Chot trau	Catfish, bagrid			
VIII	ARIIDAE					
16	Arius sagor (H&B)*	Vo cho	Sea catfish			X
17	Arius sp.	Uc	Sea catfish			X
IX	PLOTOSIDAE					
18	Plotosus canius (Hamilton)**	Ca ngat	Catfish	X	X	X
X	HEMIRHAMPHIDAE					
19	Hemirhamphus quoyi (C&V)	Lim kim	Half beak	X		X
XI	BELONIDAE					
20	Tylosurus leiurus (Bleeker)	Nhai	Garfish			X
21	Strongyiurus strongyiurus (van Hasselt)	Nhai duoi cham	Garfish			X
XII	PLATICEPHALIDAE					
22	Platicephalus macracanthus Bleeker	Chai	Flat head	X	X	X
23	Platycephalus scaber Day**	Chai	Flat head		X	X
XIII	CENTROPOMIDAE					
24	Chanda gymnocephala (Lacepede)	Son xuong	Perchiet	X	X	X
25	Lates calcarifer (Bloch)***	Chem	Sea bass	X		X

Appendix 3.14 (cont)

No	Species name	Vietnamese name	English name	Section I	Section II	Section III
XIV	SILLAGINIDAE					
26	Sillago sihama (Forskal)*	Duc	Silver sillage	X	X	X
XV	LEIOGNATHIDAE					
27	Leiognathus brevirostris (C&V)	Liet	Ponyfish	X	X	X
XVI	GERREIDAE					
28	Gerres macracanthus (Bleeker)	Mom	Silver biddy	X	X	X
XVII	THERAPONIDAE					
29	Therapon jarbua (Forsskai)*	Cang	Therapon			X
XVIII	LUTJANIDAE					
30	Lutjanus sp.	Ca hong	Snapper			X
XIX	SCIAENIDAE					
31	Nibea soldado (Lacepede)***	Suu	Soldier croaker	X		
32	Otolithoides pama (H&B)***	Duong	Pama croaker		X	X
33	Protononea sp.	Du	Croaker			X
34	Dendrophysa russelli Cuvier*	Du	Croaker			X
35	Johnieops sina (Cuvier)*	Du	Croaker			X
XX	SCATOPHAGIDAE					
36	Scatophagus argus (Linnaeus)	Ngau		X	X	X
XXI	MUGILIDAE					
37	Liza subviridis (Valenciennes)**	Doi	Mullet	X	X	X
38	Liza sp. ***	Doi	Mullet			X
XXII	POLYNEMIDAE					
39	Eleutharonama tetradactylum Shaw***	Chet	Tassel fish			X
XXIII	SYNODONTIDAE					
40	Harpodon nehereus (H&B)**	Khoai	Bummalow			X
41	Saurida elongata T & S **	Moi	Lizard fish			X
XXIV	SPARIDAE					
42	Crinidens sarissophorus Cantor)***	Chia voi				X
XXV	ELEOTRIDAE					
43	Eleotris fuscus (Hamilton)**	Bong trung	Goby	X		
44	Butis butis Hamilton	Bong cau	Goby		X	
XXVI	GOBIIDA					
45	Acentrogobius canius C & V	Bong cham	Goby	X	X	X
46	Acentrogobius atripinnatus Smith	Bong tron	Goby			X
47	Acentrogobius sp.	Bong la tre	Goby	X		
48	Glossogobius sparsipapillus Akihito & Meguro **	Bong cat	White goby	X	X	X
49	Pogonogobius planifrons (Day)	Bong rau	Goby		X	
XXVII	APOCRYPTEIDAE					
50	Pseudapocryptes lanceolatus(Bloch)**	Bong keo	Goby	X		X
51	Boleophthalmus boddardi (pallas)	Bong sao	Mud skipper	X		X

Appendix 3.14 (cont)

No	Species name	Vietnamese name	English name	Section		
				I	II	III
XXVIII	TAENOIDIDAE					
52	Taenoides nigrimarginatus Hora	Bong re cau	Goby			X
XXIX	TRYPAUCHENIDAE					
53	Trypauchen vagina (Bloch)	Bong lo Keo do		X	X	X
XXX	CYNOGLOSSIDAE					
54	Cynoglossus punticeps (Richardson)*	Luoi trau	Tongue		X	X
55	Cynoglossus macrolepidotus (Bleeker)*	Luoi trau	sole		X	X
56	Cynogiossus macrostomus Normal*	Luoi trau	Tongue		X	X
57	Cynoglossus sp.	Luoi trau	sole Tongue sole Tongue sole	X	X	X
XXXI	SOLEIDAE					
58	Synaptura spp.	Luoi meo	Sole			
XXXII	PSETTODIDAE					
59	Psettodes erumel (Bloch&Schneider)	Ca ngo				X
XXXIII	SPHYRAENIDAE					
60	Sphyraena jello (C&V)**	Nhong	Barracuda			X
XXXIV	BATRACHOIDEA					
61	Batrachus grunieus (linaeus)**	Mang ech		X	X	X
XXXV	TETRAODONTIDAE					
62	Chelonodon fluviatilis (Hamilton)	Noc	Global fish		X	X
	Total			21	25	52

Note:

- Section I: Upper river of electicity plant
- Section II: Vicinity of electricity plant
- Section III: Lower river of electricity plant

* Low commercial value fish

** Mean commercial value fish

*** High commercial value fish

Source : Aquacultural Research Institute N°2 (1995)

APPENDIX D7

LIST OF SHRIMPS AND CEPHALOPOD OBSERVED IN THE THI VAI RIVER

Appendix 3.15

List of shrimp and cephalopod observed in Thivai river

No	Species name	Vietnamese name	English name	Section		
				I	II	III
I	PENAEIDAE					
1	M. gracillima Mobili**	Tom sat	Cat prawn			X
2	M. hardwichii Miero **	Tom sat	Cat prawn			X
3	M. affinis H. Milne - Ewards **	Tom sat	Pink prawn			X
4	Meta penaeus brevicornis H. Milne - Ewards**	Tom sat	Cat prawn			X
5	Metapenaeus ensis (De Haan)**	Tom dat	Endeavour	X	X	X
6	Metapenaeus lysianassa De Man**	Tom bac song		X	X	X
7	Parapenaeopsis sculptilis Heller **	Tom sat		X	X	X
8	Penaeus merguiensis H. Milne-Edwards***	Tom the	White shrimp	X	X	X
9	Penaeus monodon Fabricus***	Tom su	Tiger shrimp			
II	PALAEMONIDAE					
10	Macrobrachium rosenbergii De Man***	Tom cang xanh	Giant prawn	X		
11	M. equidens Dana	Tep trung		X		
12	M. mamilodactylus Thailwitz	Tep trung		X		
13	Exopalaemon styliferus H. Milne Edwards	Tom gai		X		
14	Exopalaemon sp.	Tom gai		X		
15	Palaemonetes sp1.	Tep gao		X		
III	SERGESTIDAE					
16	Acetes sp.	Ruoc	Acetes	X	X	X
IV	SQUILLIDAE					
17	Squilla mantis	Tom tich		X	X	X
V	PORTUNIDAE					
18	Sylla serrata ***	Cua	Mud crab	X	X	X
19	Portunus pelagicus**	Ghe	Swimming crab			X
VI	OCTOPUSIDAE					
20	Octopus sp.	Muc tuot	Octopus		X	X
				13	8	13

Note:

- Section I: Upper river of the NPK plant
- Section II: Vicinity of the NPK plant
- Section III: Lower river of the NPK plant

* Low commercial value fish
** Mean commercial value fish
*** High commercial value fish

Source : Aquacultural Research Institute N°2 (1995)

Environmental Assessment Report
of PHU MY 2 Phase 2

APPENDIX E1

COMBUSTION CALCULATIONS

COMBUSTION CALCULATION FOR GASEOUS FUELS

RABLE

Project:	**Phu My 2.2**	MW el.	715
Combustion calculation for		efficiency	54.7%
Fuel:	**Gas 715 MW**	LHV in MJ/Nm³	39.37
with following composition		Input MW th. (MJ/s)	1307

		% vol			% vol
Methan	CH_4	89.42	Hydrogen	H_2	
Acetylen	C_2H_2		Oxygen	O_2	
Ethylen	C_2H_4		Nitrogen	N_2	0.34
Ethan	C_2H_6	4.26	Carbon oxide	CO	
Propen	C_3H_6		Carbon dioxide	CO_2	1.88
Propan	C_3H_8	2.38		H_2S	0.00
Buten	C_4H_8				
Butan	C_4H_{10}	1.12			
Pentan	C_5H_{12}	0.35	Hexan	C_6H_{14}	0.250
	Summe	100 0			

air ratio:	3.1	H2O in air:	0.020	O2 in air	21%
Fuel (Nm³/h)	119'500		kg/kg dry air	density dry air:	1.2933

RESULTS of combustion calculation

		Nm³ / Nm³ Gas	kg / Nm³ Gas	Nm³/h
Min. demand O2		2.181	3.117	260'636
Min. demand air	dry	10.386	13.433	1'241'122
Act. demand air	dry	32.196	41.641	3'847'479
Act. demand air	wet	33.233		3'971'328
Min. flue gas volume	dry	9.374		1'120'194
Min. flue gas volume	wet	11.814		1'411'801
Actual flue gas volume	**dry**	**31.185**		3'726'551
Actual flue gas volume	**wet**	**34.327**		4'102'055
spec. CO2-value		1.166	2.300	
spec. SO2-value		0.0000	0.0000	

Flue gas composition related to wet flue gas			**Flue gas composition** related to dry flue gas		
H2O	9.15	% vol			
N2	74.11	% vol	N2	81.57	% vol
CO2	3.40	% vol	CO2	3.74	% vol
O2	13.34	% vol	O2	14.69	% vol
SO2	0	ppm	SO2	0	ppm
SO2	0 08	mg / Nm³	SO2	0.09	mg / Nm³

Flue gas volume flow at fuel throughput of

119'500	Nm³ Gas / h			3'726'551	Nm³ / h	dry
				4'102'055	Nm³ / h	wet
ralated to	15		% Ref.-O2:	3'920'679	Nm³ / h	dry

COMBUSTION CALCULATION FOR SOLID AND LIQUID FUELS

RAIBLE

Project:	**Phu My 2.2**	MW el.	724
Combustion calculation for		efficiency	51.2%
Fuel:	**Dist. Oil - 724 MW**	LHV in MJ/kg	**42.30**
with following composition		Input MW th.	1416

		i. raw	
Carbon	C	86.00	mass %
Hydrogen	H	13.10	mass %
Oxygen	O	0.10	mass %
Nitrogen	N	0.10	mass %
Sulphur	S	0.70	mass %
Chlorine	Cl		mass %
			mass %
Ash	a		mass %
Water	w		mass %
	Sum	100 00	

Air ratio:	3.1	H2O in air:	0.020	O2 in air:	21%
Fuel (kg/h)	120'500		kg/kg dry air	Density dry air:	1.2933

RESULTS of combustion calculation

		Nm^3 / kg fuel	kg / kg fuel	Nm^3/h
Min. demand O2		2.335	3.337	281'342
Min. demand air	dry	11.118	14.379	1'339'724
Act. demand air	dry	34.466	44.576	4'153'145
Act. demand air	wet	35.575		4'286'834
Min. flue gas volume	dry	10.383		1'251'112
Min. flue gas volume	wet	12.196		1'469'632
Actual flue gas volume	**dry**	**33.731**		**4'064'533**
Actual flue gas volume	**wet**	**36.296**		**4'373'616**
spec. CO2-value		1.594	3 153	
spec. SO2-value		0.00478	0.01400	
spec. HCl-value				

Flue gas composition related to wet flue gas			**Flue gas composition** related to dry flue gas		
H2O	7.07	% vol			
N2	75.02	% vol	N2	80.72	% vol
CO2	4.39	% vol	CO2	4.73	% vol
O2	13.51	% vol	O2	14.54	% vol
SO2	132	ppm	SO2	142	ppm
HCl		ppm	HCl		ppm
SO2	377	mg / Nm^3	SO2	405	mg / Nm^3
HCl		mg / Nm^3	HCl		mg / Nm^3

Flue gas volume flow at fuel throughput of

120'500	kg / h:		4'064'533	Nm^3 / h	dry
			4'373'616	Nm^3 / h	wet
related to	15	% Ref.-O2:	4'378'893	Nm^3 / h	dry

Appendix E1-3

COMBUSTION CALCULATION FOR GASEOUS FUELS

RA/BLE

Project:	**Phu My 2.2**			MW el.	452
Combustion calculation for				efficiency	34.6%
Fuel:	**Gas - 450 MW**			LHV in MJ/Nm³	39.37
with following composition				Input MW th. (MJ/s)	1307

		% vol			% vol
Methan	CH4	89.42	Hydrogen	H2	
Acetylen	C2H2		Oxygen	O2	
Ethylen	C2H4		Nitrogen	N2	0.34
Ethan	C2H6	4.26	Carbon oxide	CO	
Propen	C3H6		Carbon dioxide	CO2	1.88
Propan	C3H8	2.38		H2S	0.00
Buten	C4H8				
Butan	C4H10	1.12			
Pentan	C5H12	0.35	Hexan	C6H14	0.250
	Summe	100 0			

air ratio:	3.1	H2O in air:	0.020	O2 in air	21%
Fuel (Nm³/h)	119'500		kg/kg dry air	density dry air:	1.2933

RESULTS of combustion calculation

		Nm³ / Nm³ Gas	kg / Nm³ Gas	Nm³/h
Min. demand O2		2.181	3.117	260'636
Min. demand air	dry	10.386	13.433	1'241'122
Act. demand air	dry	32.196	41.641	3'847'479
Act. demand air	wet	33.233		3'971'328
Min. flue gas volume	dry	9.374		1'120'194
Min. flue gas volume	wet	11.814		1'411'801
Actual flue gas volume	**dry**	**31.185**		3'726'551
Actual flue gas volume	**wet**	**34.327**		4'102'055
spec. CO2-value		1.166	2.300	
spec. SO2-value		0.0000	0.0000	

Flue gas composition related to wet flue gas			**Flue gas composition** related to dry flue gas		
H2O	9.15	% vol			
N2	74.11	% vol	N2	81.57	% vol
CO2	3.40	% vol	CO2	3.74	% vol
O2	13.34	% vol	O2	14.69	% vol
SO2	0	ppm	SO2	0	ppm
SO2	0.08	mg / Nm³	SO2	0 09	mg / Nm³

Flue gas volume flow at fuel throughput of

119'500	Nm³ Gas / h		3'726'551	Nm³ / h	dry
			4'102'055	Nm³ / h	wet
ralated to	15	% Ref.-O2:	3'920'679	Nm³ / h	dry

COMBUSTION CALCULATION FOR SOLID AND LIQUID FUELS

RAIBLE

Project:	**Phu My 2.2**			MW el.	467
Combustion calculation for				efficiency	33.0%
Fuel:	**Dist. Oil - 466 MW**			LHV in MJ/kg	**42.30**
with following composition				Input MW th.	1416

		i. raw	
Carbon	C	86.00	mass %
Hydrogen	H	13.10	mass %
Oxygen	O	0.10	mass %
Nitrogen	N	0.10	mass %
Sulphur	S	0.70	mass %
Chlorine	Cl		mass %
			mass %
Ash	a		mass %
Water	w		mass %
	Sum	100.00	

Air ratio:	3.1	H2O in air:	0.020	O2 in air:	21%
Fuel (kg/h)	120'500		kg/kg dry air	Density dry air:	1.2933

RESULTS of combustion calculation

		Nm^3 / kg fuel	kg / kg fuel	Nm^3/h
Min. demand O2		2.335	3.337	281'342
Min. demand air	dry	11.118	14.379	1'339'724
Act. demand air	dry	34.466	44.576	4'153'145
Act. demand air	wet	35.575		4'286'834
Min. flue gas volume	dry	10.383		1'251'112
Min. flue gas volume	wet	12.196		1'469'632
Actual flue gas volume	**dry**	**33.731**		4'064'533
Actual flue gas volume	**wet**	**36.296**		4'373'616
spec. CO2-value		1.594	3.153	
spec. SO2-value		0.00478	0.01400	
spec. HCl-value				

Flue gas composition related to wet flue gas			**Flue gas composition** related to dry flue gas		
H2O	7.07	% vol			
N2	75.02	% vol	N2	80.72	% vol
CO2	4.39	% vol	CO2	4.73	% vol
O2	13.51	% vol	O2	14.54	% vol
SO2	132	ppm	SO2	142	ppm
HCl		ppm	HCl		ppm
SO2	377	mg / Nm^3	SO2	405	mg / Nm^3
HCl		mg / Nm^3	HCl		mg / Nm^3

Flue gas volume flow at fuel throughput of

120'500	kg / h:		4'064'533	Nm^3 / h	dry
			4'373'616	Nm^3 / h	wet
related to	15	% Ref.-O2:	4'378'893	Nm^3 / h	dry

Compilation of Emission Data of Phu My 2.2

CASE	1 normal case	2	3	4
Fuel	**Gas**	Dist. Oil	Gas	Dist. Oil
power MW el.	**715**	724	450	466
efficiency %	**54.71**	51.15	34.58	32.98
mode	**comb. cycle**	comb. cycle	single cycle	single cycle
Gas consumption Nm3/h	**119'500**		119'500	
Dist. Oil consumption kg/h		120500		120500
Equival. full load hours per year *)	**6570**	120		
EMISSION DATA				
CO carbon monoxide				
mg/Nm3 (dry, 15% O2)	**20**	30	20	30
g/s	**22**	36	22	36
kg/h	**78**	131	78	131
t/day	**1.9**	3.2	1.9	3.2
t/a	**515**	16		
kg/MWh	**0.11**	0.18	0.17	0.28
CO2 carbon dioxide				
kg/Nm3 for Gas kg/kg for D.O.	**2.30**	3.15	2.30	3.15
t/h	**275**	380	275	380
t/a	**1'805'793**	45'597		
kg/MWh	**384**	525	611	815
SO2 Sulfur dioxide				
mg/Nm3 (dry, 15% O2)	**0**	376	0	376
g/s	**0.09**	458	0.09	458
kg/h	**0.34**	1648	0	1648
t/day	**0.0**	39.5	0.0	39.5
t/a	**2.2**	198		
kg/MWh	**0.00**	2.28	0.00	3.54
NOx (as NO2) nitrogen oxides				
mg/Nm3 (dry, 15% O2)	**51**	119	51	119
g/s	**56**	145	56	145
kg/h	**200**	521	200	521
t/day	**4.8**	12.5	4.8	12.5
t/a	**1314**	63		
kg/MWh	**0.28**	0.72	0.44	1.12
Flue Gas Data				
Nm3/h (wet, act. O2 with a = 3,1)	**4'102'055**	4'373'616	4'102'055	4'373'616
Nm3/h (dry, 15% O2)	**3'920'679**	4'378'893	3'920'679	4'378'893
Nm3/s (dry, 15% O2)	**1'089**	1'216	1'089	1'216
Temperature at stack exit °C	**94**	139	623	618
Temperature at stack exit K	**367**	412	896	891
Stack height m	**60**	60	30	30
Number of stacks	**2**	2	2	2
FG velocity at stack exit m/s	**20.5**	24.5	50.0	53.0

*) 75% of 365 x 24 h/a for case 1; case 2 max. 120 h/a

APPENDIX E2

REPORT
on the Results of Investigation of Cooling Water Discharge for Phu My Power Generation Centre

Fluid Dynamics Laboratory of Takasago R&D Center
Mitsubishi Heavy Industries, Ltd.

1. General

This document presents the numerical results of the simulation tests performed to ascertain the diffusion of the heated cooling water from Phu My Power Plant, returning into the Thi Vai River through the submerged Cooling Water return pipe lines in accordance with the agreement reached with EVN/C during the 3rd progress meeting held on March 29, 1999. These tests were performed in the Fluid Dynamics Laboratory of Takasago R&D Center, Mitsubishi Heavy Industries, Ltd.

The main purpose of the test were to clarify the following.

(1) To examine the velocity profile around the Under Water Pipes

(2) To examine the temperature profile around the Under Water Pipes

(3) To examine the expected effect of scouring around the Under Water Pipes

Two types of simulation were investigated to compare the MHI recommended pipe arrangement with Clients proposed pipe arrangement.

The detailed results are as follows.

2. Calculation Conditions

2.1 Simulation Condition

The Simulation Condition is described in the following table-1 in accordance with the Clients Specification, Part-2, clause 6.11.8.13.

Table-1 Calculation Conditions

Case	1	2
Flow Rate **	83 m^3/s	
Velocity of Discharge Flow **	3.1 m/s	
Number of Under Water Pipe **	6 pipes	
Depth of Under Water Pipe bottom **	EL - 17 m	
Depth of Under Water Pipe outlet center **	EL - 13 m	
Width of EVN property area in the Thi Vai river **	50 m	
Width of Under Water Pipe Arrangement **	40 m	
Distance between pipe discharge points	8.5 m	9.0 m
Angle of each Under Water Pipe	7^o	12^o
Ambient Water Temperature **	27 .	
Ambient Water Salinity	2.7 %	
Thi Vai river Water Level	EL ± 0 m	
Thi Vai river Current Velocity	0 m/s	

** Specified by Clients Specification.

2.2 Simulation Cases

Two types of Under Water Pipe arrangements as follows

Case -1 : MHI recommended pipe arrangement (DWG No. 76700 - 0123, Attachment-1)

Case -2 : Clients preferred pipe arrangement (DWG No. None, Attachment-2)

2.3 Simulation Sediment

The Simulation Sediment was described following tables in accordance our simulation experience.

The expected Sediment is shown in the Fig-1.1 and Fig-1.2 in next page.

Table - 2.1.1 : Direction of Flow L for Case - 1 (total 250 m , 68 mesh)

	Number of Mesh	Width of Mesh
Shore Line - CW Discharge	20	0.5 - 4.5 m
CW Discharge - up to 250 m	48	0.5 - 19.2 m

Table - 2.1.2 : Direction of Flow L for Case - 2 (total 250 m , 63 mesh)

	Number of Mesh	Width of Mesh
Shore Line - CW Discharge	27	1.0 - 4.5 m
CW Discharge - up to 250 m	36	1.1 - 19.2 m

Table - 2.2.1 : Direction of Width W for Case - 1 (total 400 m , 108 mesh)

	Number of Mesh	Width of Mesh
CW Discharge Under Water Pipe	2	Approx. 1.06 m
Under Water Pipe - Under Water Pipe	6	1.0 - 1.1 m
Under Water Pipe - 200 m	33	1.0 - 15.5 m

Table - 2.2.2 : Direction of Width W for Case - 2 (total 400 m , 103 mesh)

	Number of Mesh	Width of Mesh
CW Discharge Under Water Pipe	2	Approx. 1.06 m
Under Water Pipe - Under Water Pipe	5	Approx. 1.2 m
Under Water Pipe - 200 m	33	1.2 - 15.8 m

Table - 2.3 : Direction of Depth H (total 20 m , 20 mesh)

	Number of Mesh	Width of Mesh
River Bed - Under Water Pipe	5	0.8 - 1.5 m
Under Water Pipe	3	Approx. 0.71 m

Under Water Pipe - Water Surface	12	0.9 - 1.1 m

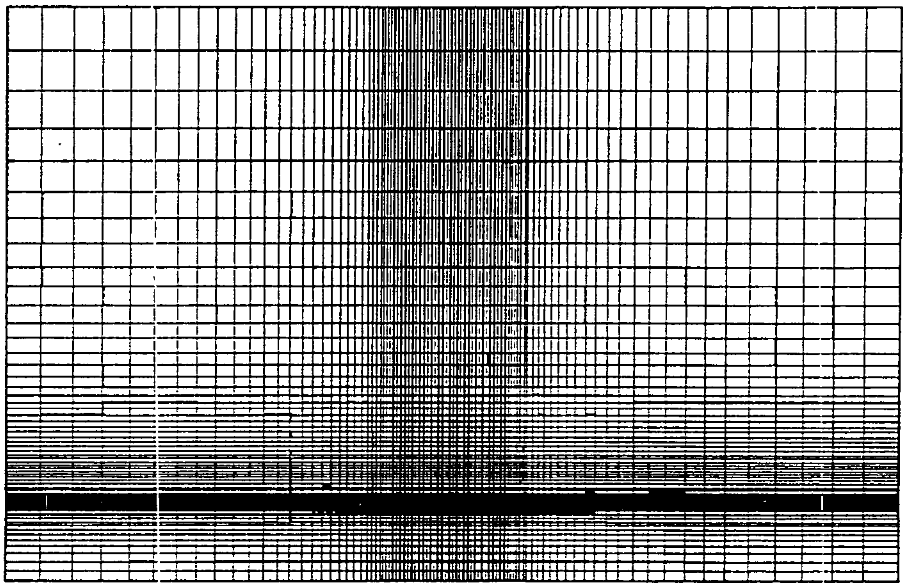


Fig.-1.1 Horizontal Segments

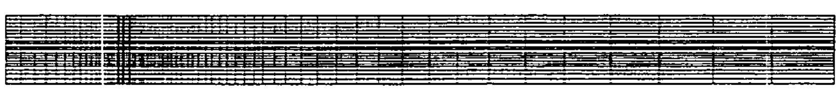


Fig.-1.2 Vertical Segments

3. Calculation Result

The simulation results are shown in Attachment-3 and the Thi Vai river bed condition is shown in Attachment-4.

3.1 Velocity (Density Flow)

The Velocity profile at the water surface of Thi Vai river, for Case-1 is shown in Fig.2.1.1, and for Case-2 is shown in Fig.2.1.3.

The maximum surface velocity in both cases was 0.57 m/s, recorded at approx. 108 m from the Under Water Pipe discharge point in Case-1, and at approx. 73 m from the discharge point in Case-2.

Considering the relationship with the sides of the river, the maximum velocity of the discharged cooling water occurred on the North side of the cooling water inflow. This is due to the greater cooling influence from the deeper water on the southern side of the discharge, compared to the minimal cooling effect from the shallow water on the northern side, resulting in the North Westerly flow.

Reviewing Fig.2.1.3, it can be seem that in a limited area near top of the cooling water inflow a velocity of 0.66 m/s occurs, and this is attributed to the flow being disrupted in this area by the flow and an increase in temperature due to forced recirculation with the discharge from the 12 degree angled Under Water Pipe discharge.

This local 0.66 m/s velocity is in a North Easterly direction, which is contrary to the main direction of the heated water flow.

Please refer to Figs.2.2.1 and 2.2.3 which respectively describe the main heated water stream of Case-1 and Case-2.

3.2 Temperature (hot water diffusion)

The Temperature profiles on the Thi Vai river surface are described in Fig. 2.1.2 (for Case-1) and in Fig.2.1.4 (for Case-2). These profiles follow a similar pattern to the Velocity profile.

The maximum surface temperatures are approx. 29.6 degC (+2.6 degC for Case-1) and approx. 29.8 degC (+2.8 degC for Case-2) near the location of maximum velocity.

The Case-2 result, indicates a lack of heated water diffusion due to the above change in velocity and heated water recirculation around the Under Water Pipe discharge.

For your relevance the sectional temperature profile of the main heated water steam are shown in Fig.2.2.2 (for Case-1) and in Fig.2.2.4 (for Case-2).

3.2 Scouring in the river bed (erosion)

The Scouring phenomenon on the Thi Vai river bed is described in Fig. 2.3.1 (for Case-1) and in Fig.2.3.2 (for Case-2).

The results of both simulation tests indicate that the scouring phenomenon is not a serious problem, and that additional protection is not required.

4. Conclusion

The numerical simulation was performed for the two selected cases the following data was obtained.

	Case-1	Case-2
Maximum Velocity at water surface	0.57 m/s	0.57 (0.66) m/s
Maximum Temperature at water surface	29.6 degC (+2.6)	29.8 degC (+2.8)

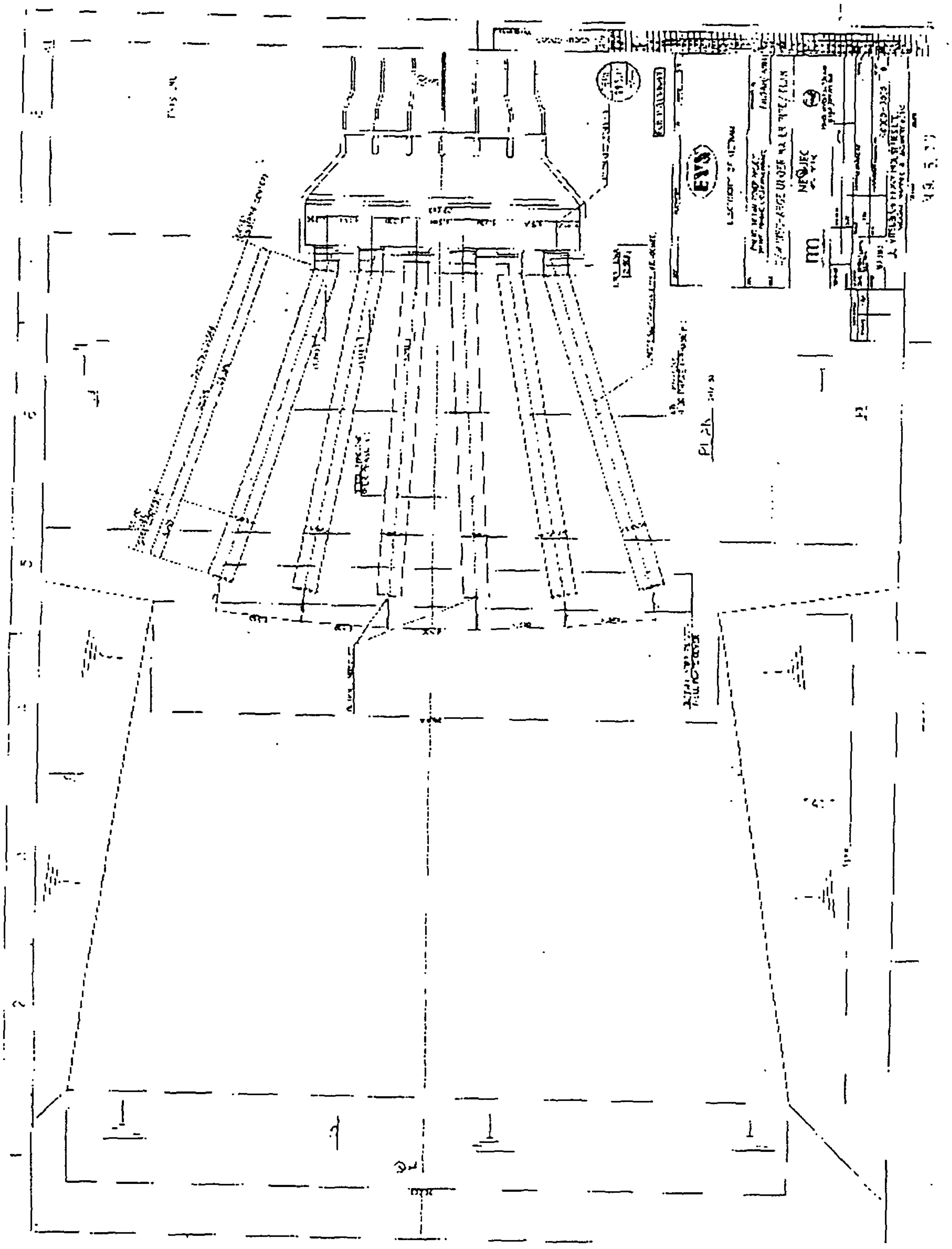
In the velocity profiles, Case-1 shows a more smooth distribution of the heated water into the Thi Vai river, than Case-2. The Case-1 arrangement also provides a more constant velocity.

In the temperature profiles, Case-1 provides better diffusion than Case-2, and the Maximum temperature recorded is lower than Case-2. Another concern with Case-2 is that the simulation test indicates the possibility of hot water recirculation which shows be avoided in this kind of Submerged CW discharge.

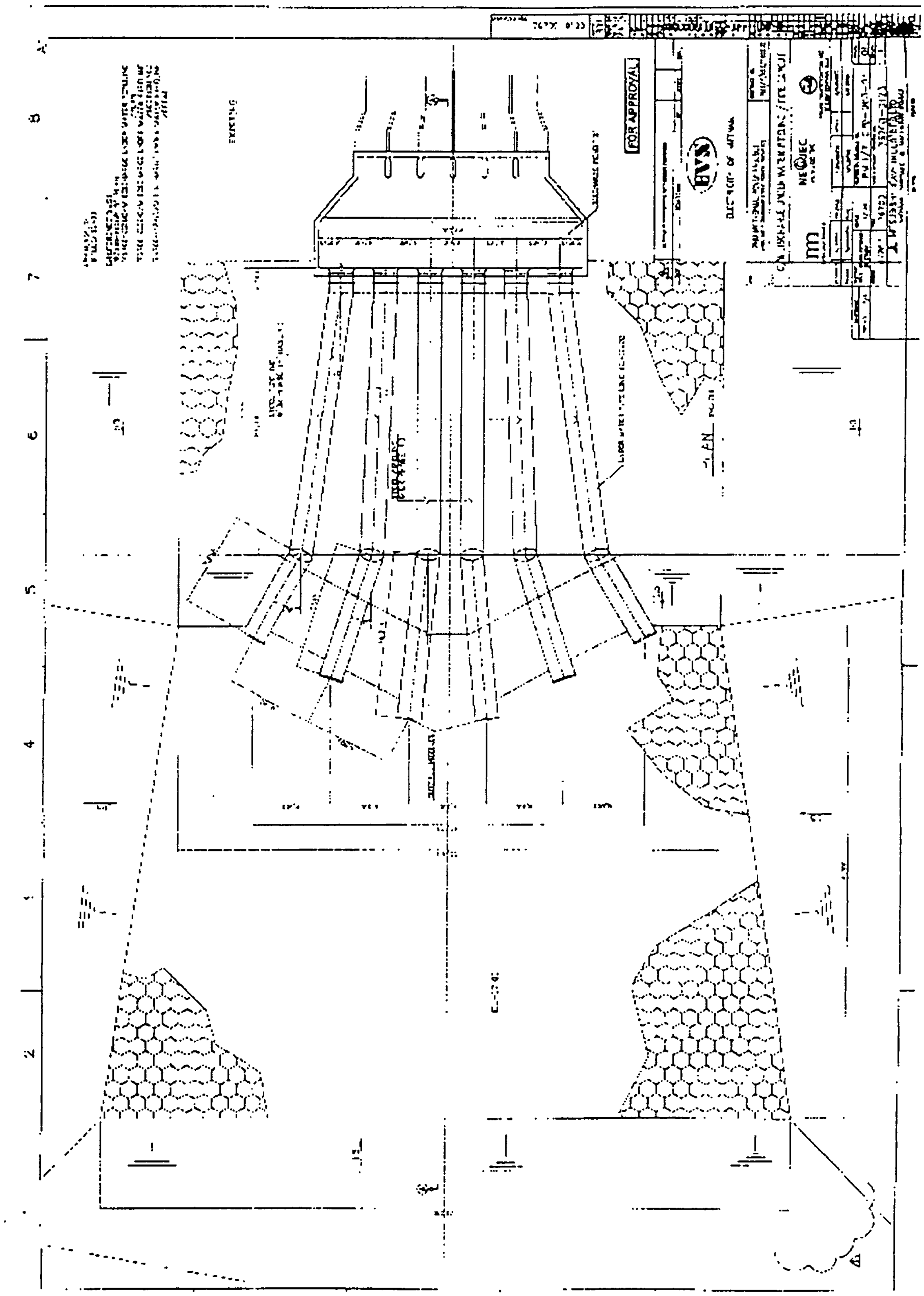
Therefore in our opinion, Case-1 is the preferred solution as the submerged CW Pipe arrangement for the Phu My Power Station and is in accordance with the Clients Specification.

Remark:

Case-1 shall be realised.



Case-1 Under Water Pipe Arrangement Drawing



Case-2 Under Water Pipe Arrangement Drawing

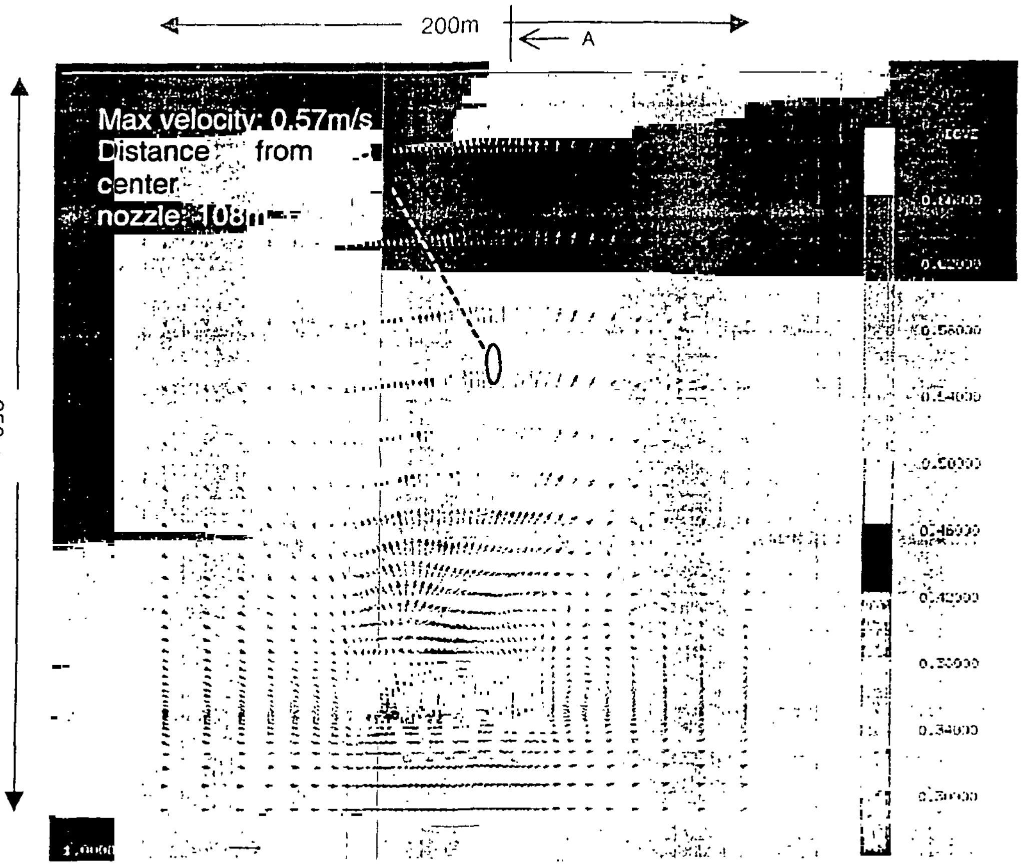


Fig. 2.1.1 Velocity vector at water surface (Case-1)

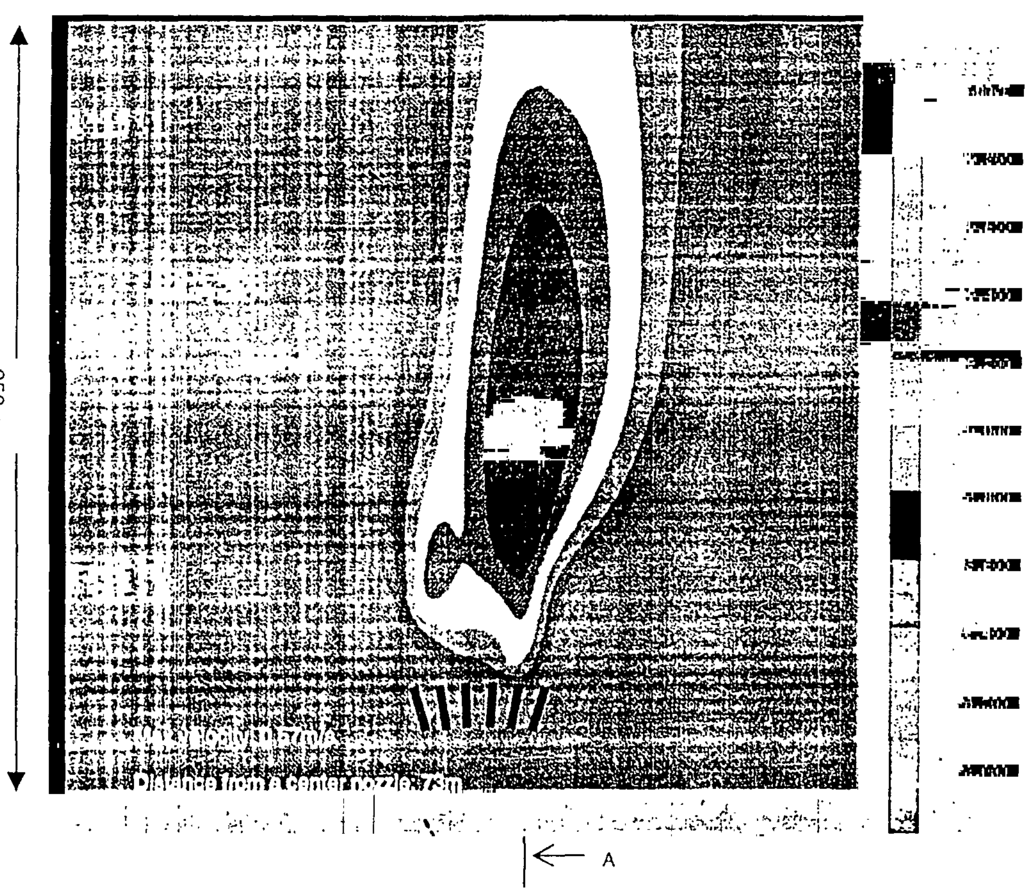


Fig. 2.1.2 Temperature at water surface (Case-1)

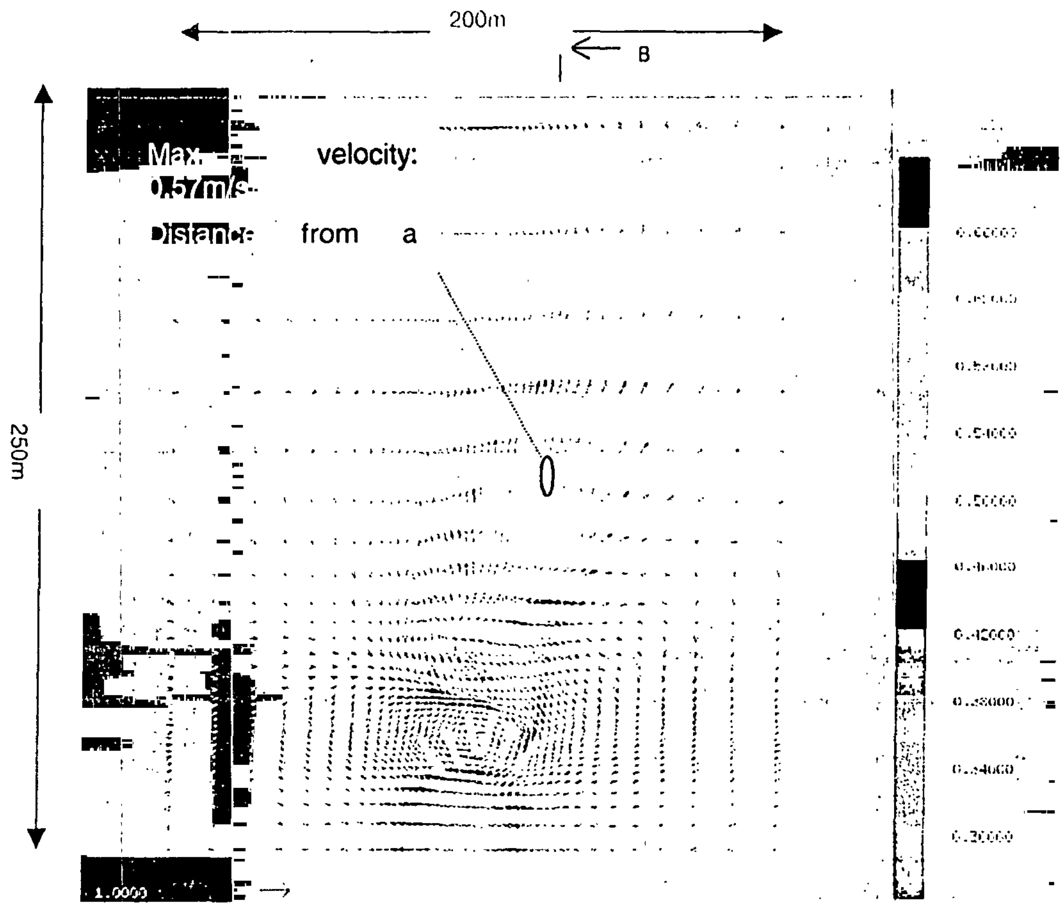


Fig. 2.1.3 Velocity vector at water surface (Case-2)

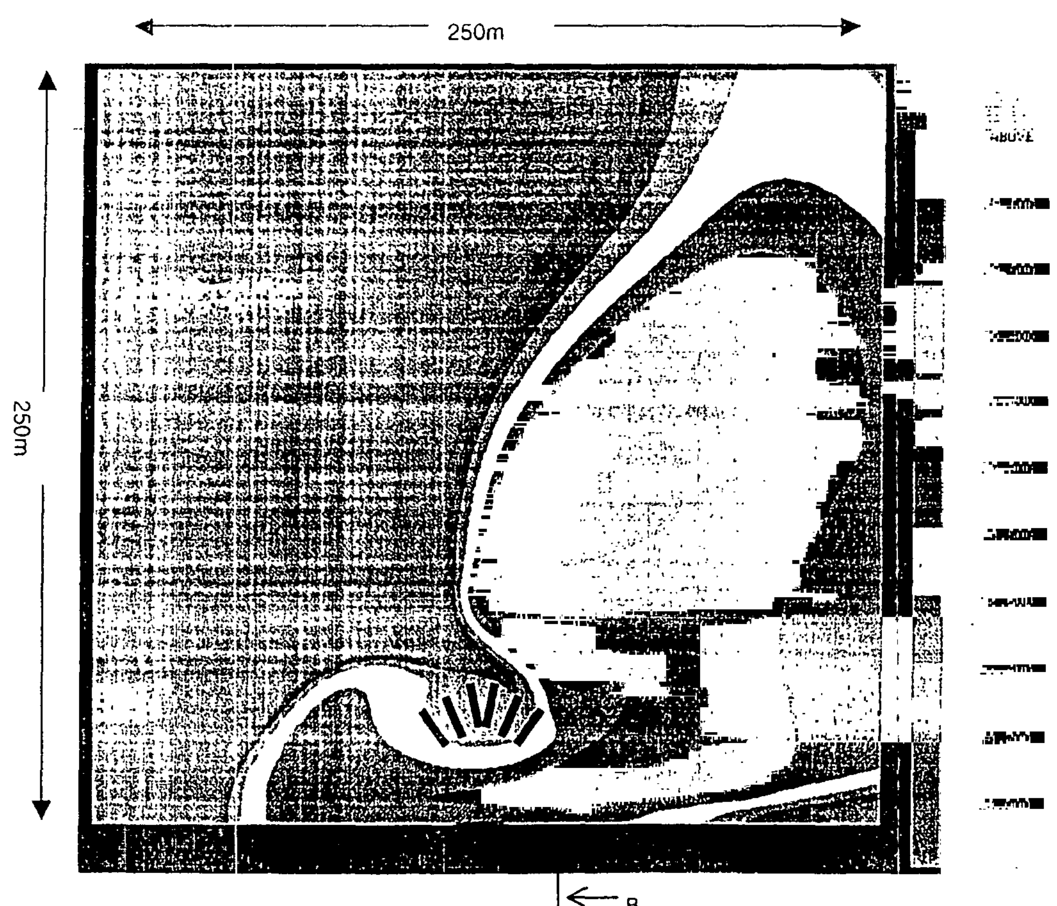


Fig. 2.1.4 Temperature at water surface (Case-2)

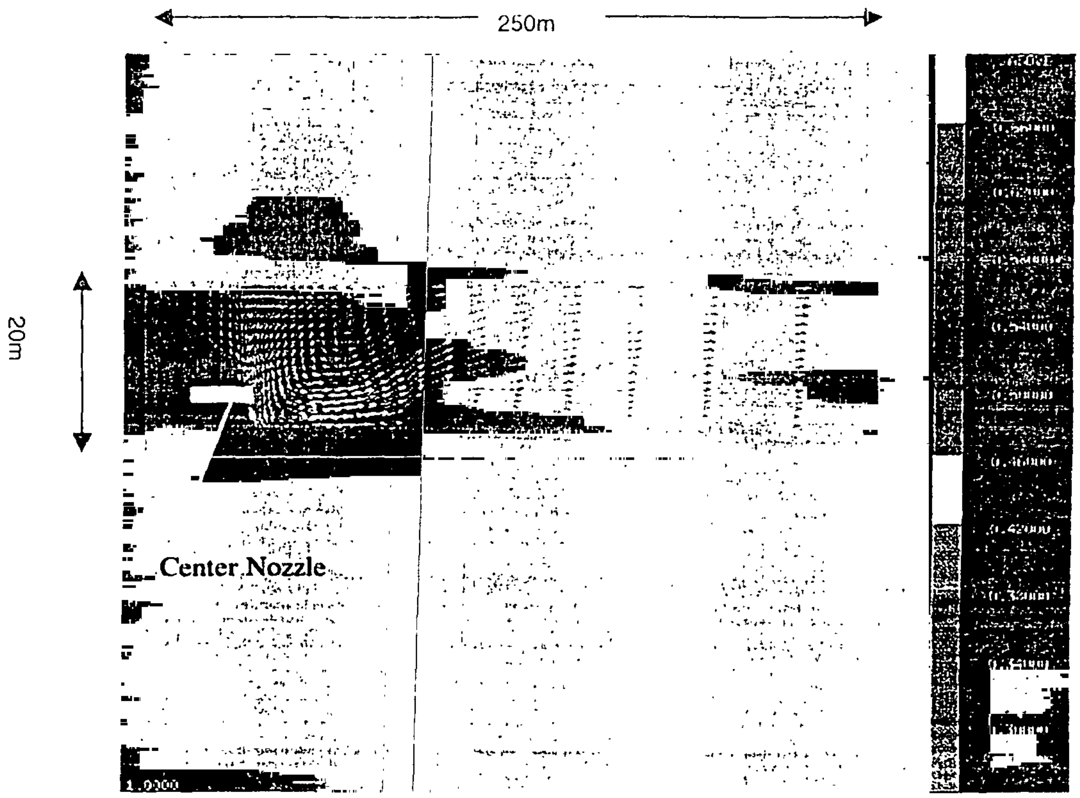


Fig. 2.2.1 velocity vector at the mainstream of vertical direction (Case-1 Section A)

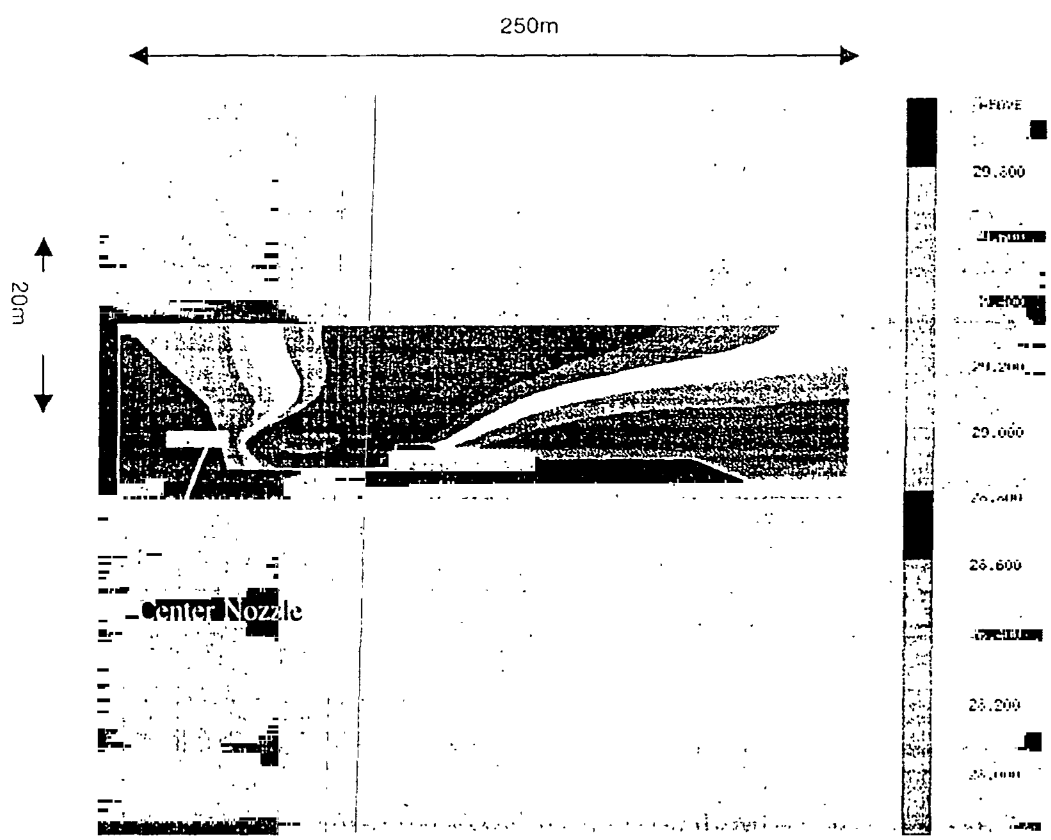


Fig. 2.2.2 Temperature at the mainstream of vertical direction (Case-1 Section A-A)

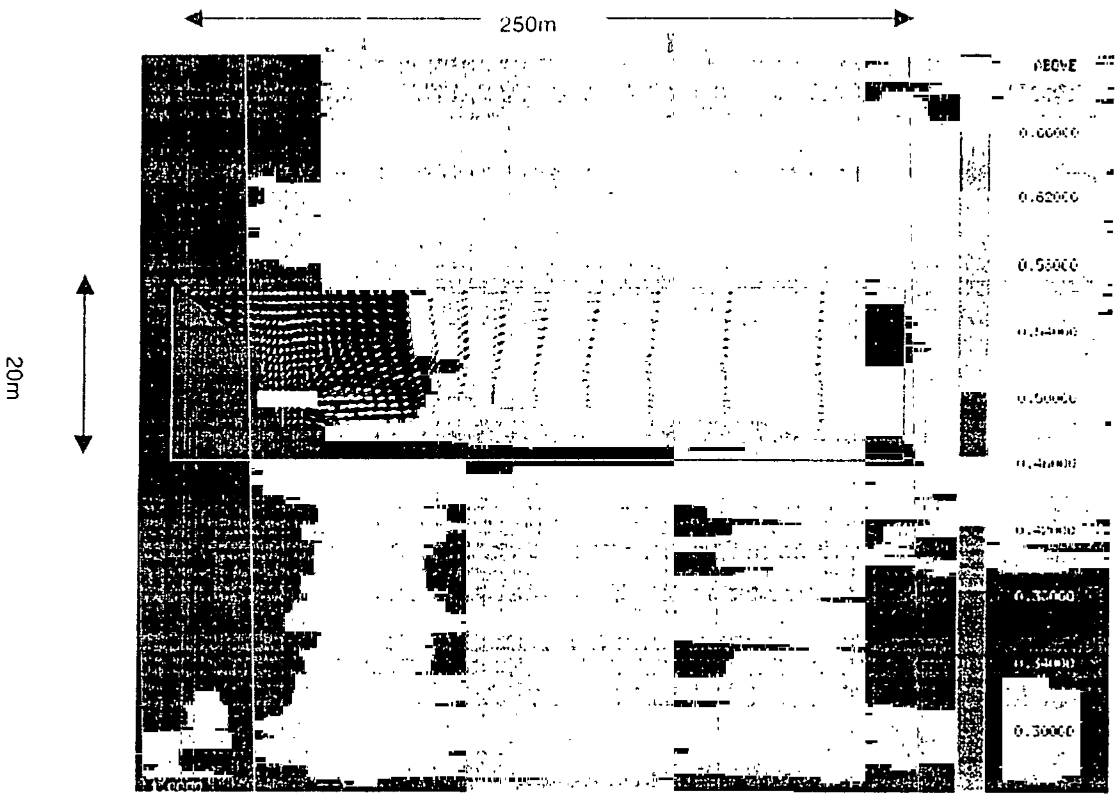


Fig. 2.2.3 velocity vector at the mainstream of vertical direction (Case-2 Section B-B)

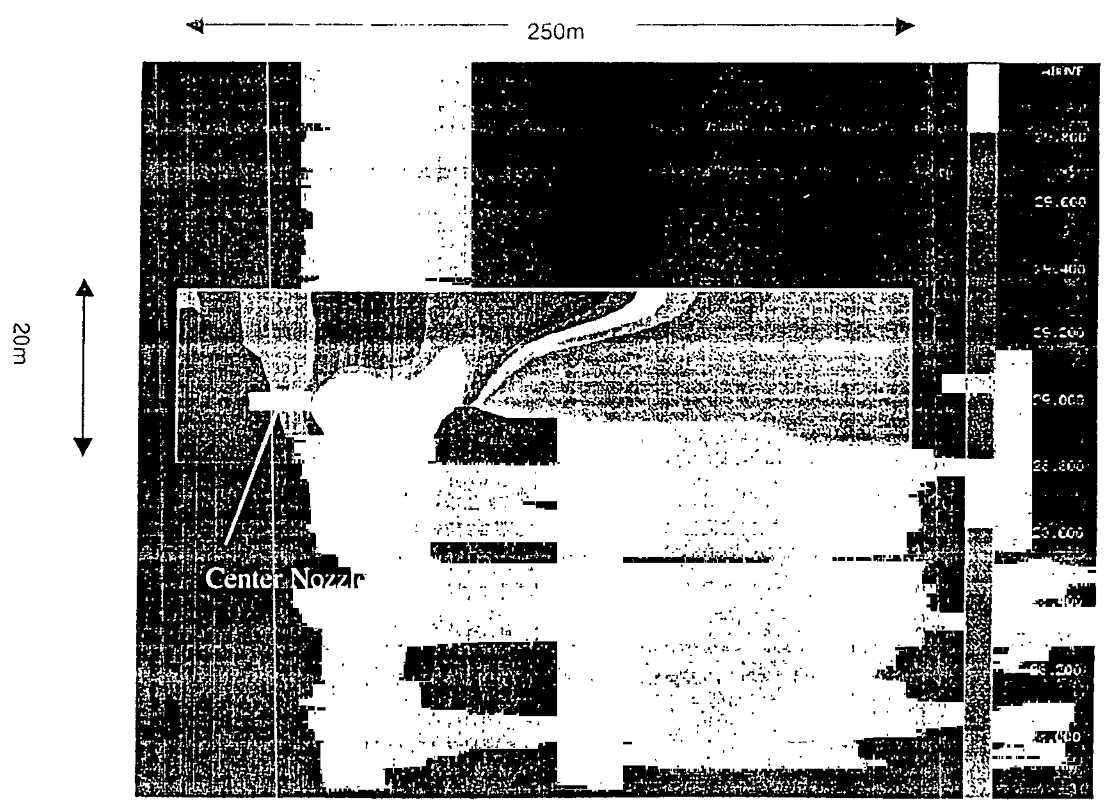


Fig. 2.2.4 Temperature at the mainstream of vertical direction (Case-2 Section B-B)

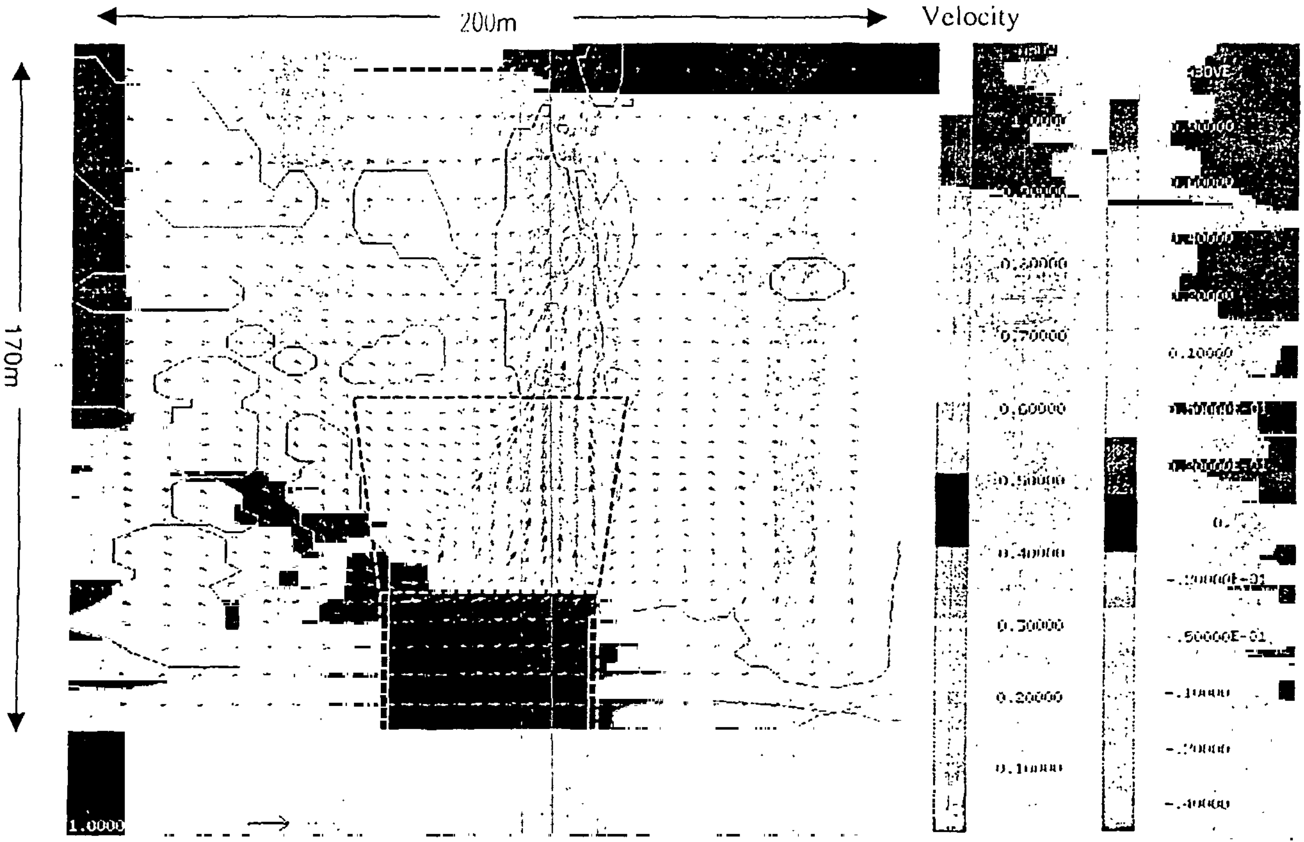


Fig. 2.3.1 River Bed selective excavation / Sediment distribution (Case-1)

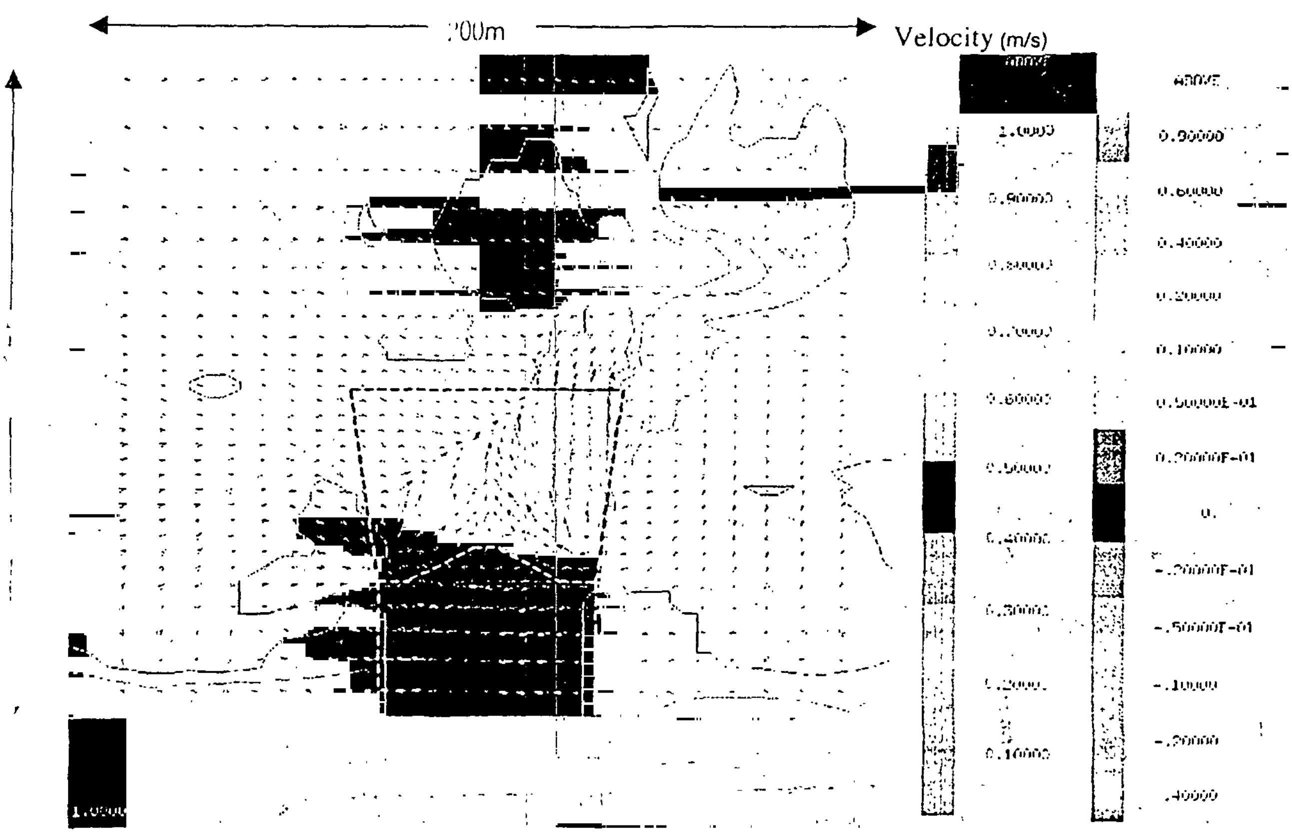
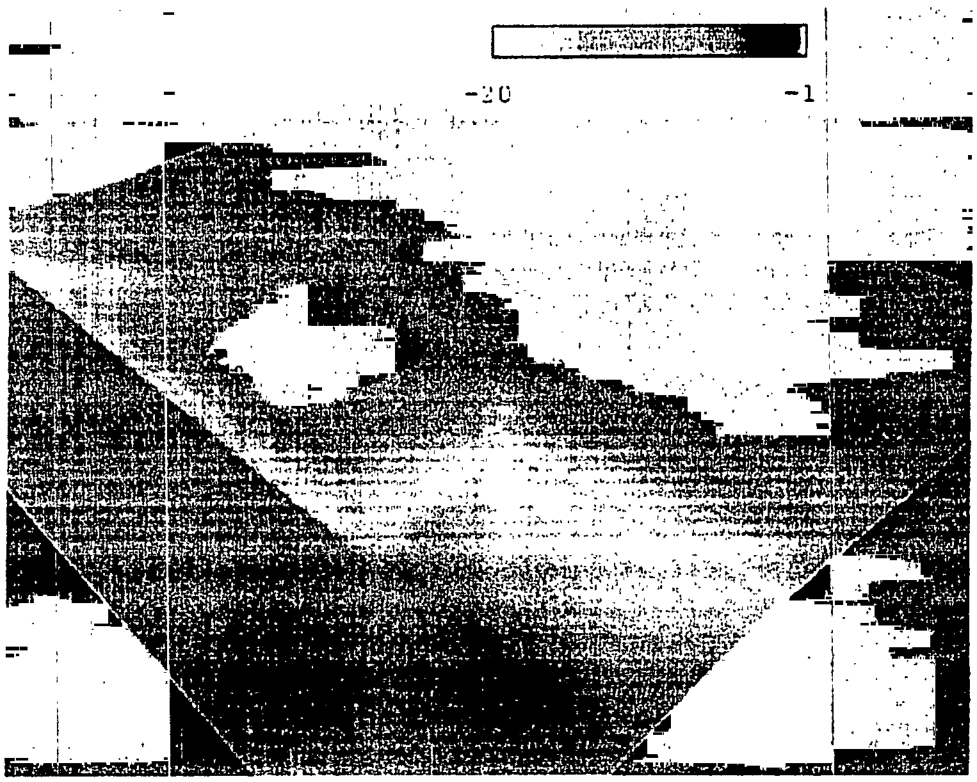
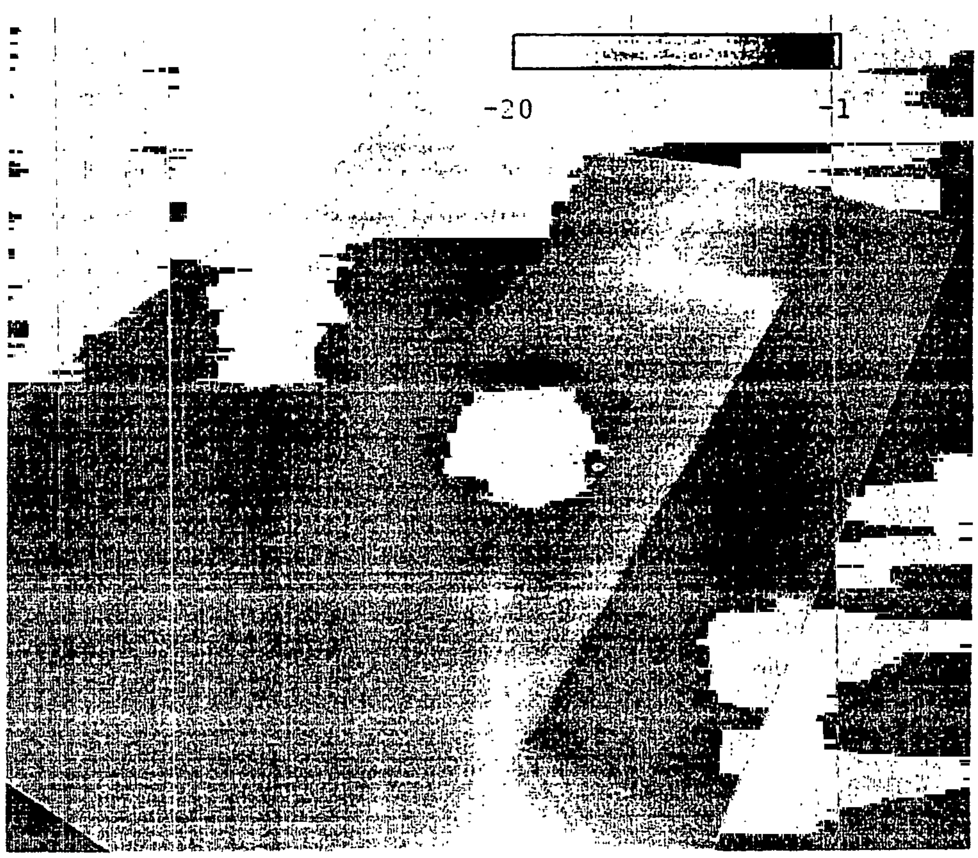


Fig. 2.3.2 River Bed selective excavation / Sediment distribution (Case-2)

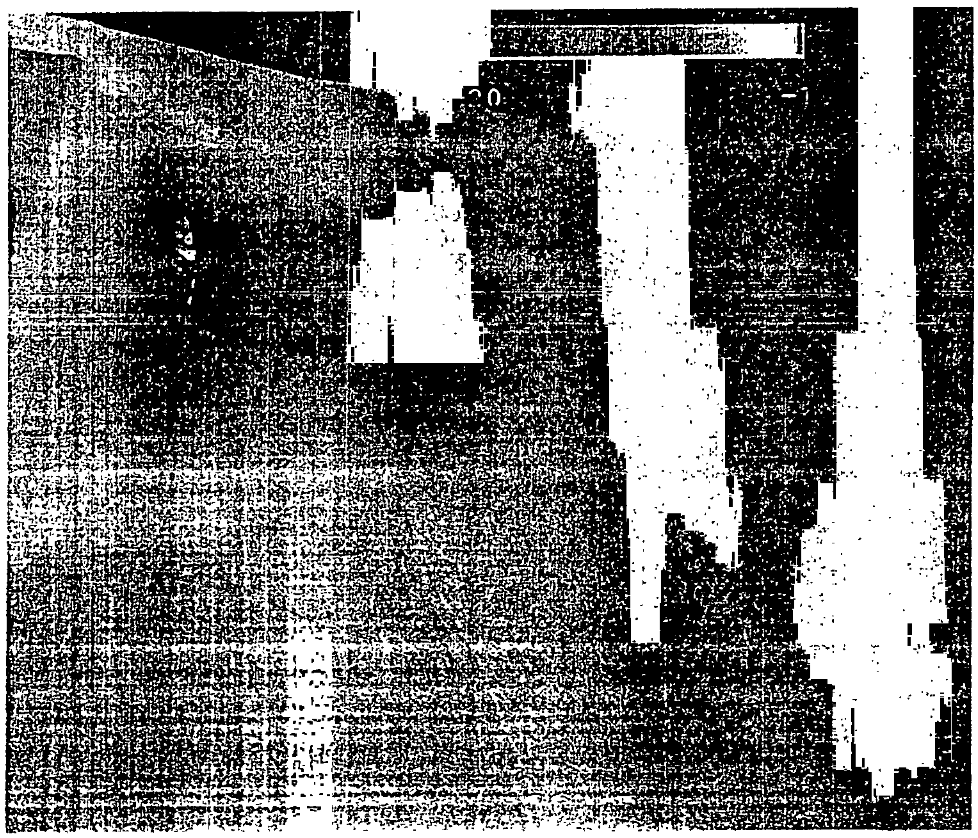
Riverbed-1



Riverbed 2



Riverbed-3



Riverbed-4

APPENDIX H1

LISTS OF PARTICIPANTS OF THE MEETING OF JULY 31, 2001

DANH SÁCH HỘI THẢO
SỰ THAM GIA Ý KIẾN CỦA CỘNG ĐỒNG
TẠI UBND HUYỆN TÂN THÀNH
(Dự án Phú Mỹ 2-2)

UBND huyện Tân Thành ngày [illegible]

Số TT	Họ và tên	Đơn vị	
1	Nguyễn Văn Chung	Văn phòng [illegible]	
2	Nguyễn Tài Anh	Công ty tư vấn xây dựng [illegible]	
3	Nguyễn Thuý Hà	"	
4	Lê [illegible]	Viện [illegible]	
5	Phạm Văn [illegible]	"	
6	[illegible]	[illegible]	
7	[illegible]	Viện [illegible]	
8	Nguyễn Văn [illegible]	[illegible] Phú Mỹ	
9	[illegible]	[illegible]	
10	[illegible]	PCT: HĐND [illegible] Phú Mỹ	
11	[illegible]	[illegible] Tân Thành	
12	Nguyễn Văn Chính	[illegible] Tân Thành	
13	[illegible] Hùng	CT. UBND TT. Phú Mỹ	
14	[illegible]	[illegible]	
15	NGUYỄN VĂN NINH	C.T [illegible]	
16	NGUYỄN [illegible]	[illegible]	
17	[illegible]	[illegible]	
18	LÊ XUÂN [illegible]	[illegible]	
19	[illegible]	[illegible]	
20	[illegible]	[illegible]	
21	TRẦN [illegible]	[illegible]	
22	[illegible]	[illegible]	
23	Đào Quốc Thịnh	[illegible] huyện Tân Thành	
24			
25			
26			
27			

APPENDIX H1a

LISTS OF PARTICIPANTS
OF THE MEETING OF DECEMBER 20, 2001

DANH SÁCH ĐẠI BIỂU THAM DỰ HỘI NGHỊ
THAM VẤN CỘNG ĐỒNG - DỰ ÁN PHÚ MỸ 2-3

STT	Họ và Tên	Đơn Vị	Ký tên
1	Võ Thị Quyên Quyên	UNDP	
2	Trần Viết Ngữ	World Vision (Tầm nhìn Thế giới)	
3	Cao Văn Thoại	UBND Huyện Cần Giờ TP HCM	
4	Nguyễn Công Nhân	BT. TT Phú Mỹ	
5	Đoàn T Bích Ngà	TT Phú Mỹ	
6	Phan Tấn Thuận	P.N TT Phú Mỹ	
7	Đoàn Văn Khả	Enda vietnam	
8	Phan Xuân Thanh	Khoa Môi Trường Trường ĐHBK	
9	Trần Đình Thọ	UBNDTT Phú mỹ	
10	Lê Đình Liêm	"	
11	Võ Văn Xéc	"	
12	Đào quốc Thịnh	[illegible]	
13	Ng Mạnh [illegible]	[illegible]	
14	Dương Văn Sơn	CCB huyện	
15	Ngô [illegible] Phát	[illegible]	
16	[illegible] Văn Tăng	P. Lao động - TB. XH. H. Tân Thành	
17	Nguyễn Đình Hoàng	Huyện Đoàn Tân Thành	
18	Phan [illegible]	Hội CCB	
19	Đoàn Văn Công Hoà	Huyện Đoàn TT	
20	Võ Anh Chánh	Huyện Tân Thành - UBND	
21	Lê Thị Công	Hội nông dân - Huyện	
22	Trần Thị Ái Hà	Hội LHPN Huyện	
23	[illegible]	phó chủ tịch UBND Huyện	
24	Lê Phúc Hiền	phó V/p. UBND Huyện	
25	[illegible]	[illegible]	
26	[illegible]	[illegible]	
27	Trần Trọng Sỹ	V/p UBND Huyện	
28	Trịnh Tú Kha	G. đốc CTY IPIDCO	
29	Nguyễn Thị [illegible]	Huyện ủy	
30	Nguyễn Đình Huy	V/p UB N.D Huyện	
31	Võ Văn Quá	phó văn phòng UBND Huyện	
32	Phạm Văn Khoa	Sở KH và Đầu Tư	

APPENDIX H2

PROGRAM OF THE MEETING
OF JULY 31,2001

The program of the Public Consultation meeting on 31/07/2001

1/ Mr. Le Van Xuong— Vice Chairman of the People's Committee of Tan Thanh District will preside the meeting and will introduce the purpose of the meeting.

2/ Mr. Nguyen Van Chung — Representative of the Investor will express the meaning, purpose, and the size of the Project.

3/ PECC 2, Representative for EVN shall give a short description and the fundamental of the Project, chiefly engaging in the Environment Impact and the Impact on natural, social and economical situation.

4/ Questions from the public

5/ Answers from PECC 2 and VESDEC .

6/ Suggestions from the public and from the Non-Governmental Organization regarding job creation, strict relation between the Investors and the local residents during construction and operation period of the Project.

7/ Representative of the Investor will receive the opinions from the public and promise to make an action plan.

8/ Mr. Le Van Xuong — Vice Chairman of Tan Thanh District will conclude and close the meeting.

The program of the Public Consultation Meeting 20/12/2001

a) The chairman of the public consultation meeting will be either:

   The Peoples Committee Chairman of Tan Thanh district.

   The chairman will introduce and explain the purpose of the meeting to all the concerned parties.

b) Representatives of the owner will describe the organization chart and the purpose and benefits of the project to the public.

c) A power engineering consulting company (PECC 2) spokesman, representing the Electricity of Vietnam (EVN), shall explain the technological aspects of the project and discuss the impacts the project will have on the:

   - Natural environment
   - Socio-economic

d) Question and answer session

e) PECC 2 and VESDEC shall precisely explain/address the relevant issues that concern the participants of the public consultation meeting, and answer the questions that were entered in the notebooks that were made available in the showrooms.

f) Comments from the representative of Non Government Organization (NGO) and Government Body regarding local employment.

g) The representatives of the owner will consider the comments and respond where necessary.

h) The Peoples committee Chairman of Tan Thanh District will bring the meeting to a close.

APPENDIX H2a

PROGRAM OF THE MEETING OF DECEMBER 20,2001

APPENDIX H3

LISTS OF INVITED PERSONS TO THE MEETING OF DECEMBER 20, 2001

LISTS OF INVITED PERSONS

1. **Phu My Town.**

- Representative for the People's Committee
- Representative for the People's Council
- Representative for Union of Women
- Member of the Party
- Head of Hamlet
- Official in charge of Environment
- Representative for the Father Front
- Official in charge of Agriculture
- Representative for Union of Farmers
- Representative for Land Management Service
- Representative for Association of Ex- Soldiers
- Representative for Youth Union
- Representative for Budhism Association
- Representative for Catholics Association
- Around 10 families living on Shrimp farming.
- Representative for Vinakoyei
- Representative for Phu My Port
- Representative for the People's Committee of Can Gio District
- Representative for Management Board of Can Gio Forest Preservation.

2. **Tan Thanh District.**

- Representative for the People's Committee
- Representative for the People's Council
- Representative for Union of Women
- Financing Department
- Economics Department
- Agriculture Department
- Land Department
- Representative for the Fatherland Front
- Representative for Union of Farmers
- Representative for Association of Ex- Soldiers
- Representative for Youth Union
- Representative for Budhism Association
- Representative for Catholics Association
- Police Headquarter
- Taân Thaønh TV Station

3. **Ba Ria – Vung Tau Province**

- The People's Committee
- Department of Science – Technology – Environment
- Department of Land
- Department of Planning - Investment
- Department of Financing - Pricing
- Department of Industry
- Ba Ria – Vung Tau Newspaper

4. **Ho Chi Minh City Polytechnics University**

Mr. Nguyen Van Phuoc / Head of Environment Faculty
Add: Ho Chi Minh City Polytechnics / Environment Faculty.
268 Ly Thuong Kiet St., Dist. 10, Ho Chi Minh City
Fax: 088639682. Tel: 088639682

5. UNDP Ho Chi Minh Rep. Office

Mr. Vo Thi Quyen Quyen / Secretary
Add: 2 Phung Khac Khoan, Q1, Ho Chi Minh City
Fax: 088231834. Tel: 088295821

6. NGO World Vision

Mr. Tran Van Thanh / Project Officer
Add: 42 Nguyen Dinh Chieu, Dist. 4, Ho Chi Minh City
Fax: 088241718. Tel: 088299225

7. Non Government Organization (NGO) ENDA

Mr. Bang Anh Tuan / Director
Add: C2, Buu Long St., Bac Hai Residental Complex (Cu Xa Bac Hai), Ho Chi Minh City
Fax: 089703273. Tel: 089700243

8. UNESCO Ho Chi Minh City (in charge of Can Gio Forest Preservation Programme)

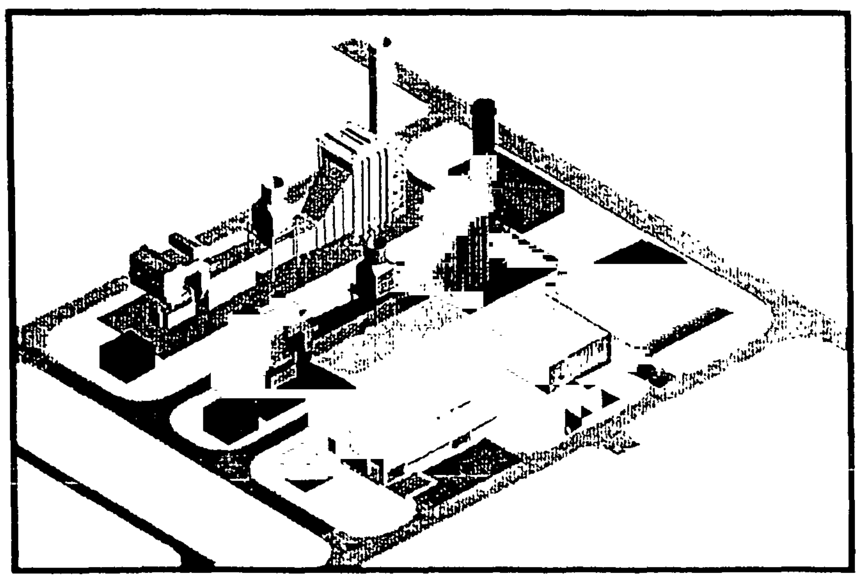
Mr. Le Duc Tuan / Manager
Add: 176 Hai Ba Trung St., Dist. 1, Ho Chi Minh City
Tel: 8291383
Mr. Cat Van Thanh / Can Gio District, Manager of Mangrove Preservation Plan (sponsored by Unesco)

APPENDIX H4

BOOKLET ON THE TECHNICAL OVERVIEW OF THE PROJECT

PHU-MY 2.2 BOT POWER PROJECT

MEKONG ENERGY COMPANY (MECO)



1 INTRODUCTION

Phu-My 2, Phase 2 Power Station will be built inside the Phu My Power Generation Complex which is located in Ba Ria Vung Tau Province. The Power Plant will be finance ,built and operate for the first 20 years by Mekong Energy Company according to the terms of a **Build-Operate-Transfer (BOT)** contract with the Ministry of Industry (MOI).This project is the result of an International Bid Competition where the Sponsors of this Project offered the lowest price and best terms to the MOI.

In a BOT Project, the Power Station is built and operate by the Private Investor and after 20 years is given free of charge to the Vietnamese Authorities after a complete major overhall.

The Power Plant is located within the boundaries of **Phu My Power Generation Centre (PMPGC)**

The implementation of the Phu My Power Generation Centre, with its six individual power generation projects belongs to the most important development program of the Vietnamese Government. The PMPGC has been approved by the Vietnamese Government on 31/07/1997.

The PMPGC has been developed by Electricity of Vietnam (EVN) with a total output capacity of 3800 MW and is already connected to the national power grid and main gas supply pipeline. The primary common infrastructure including access roads and water channels to all the power projects are basically in place. The following works are already completed or are in the final implementation stage:

- Connection to the Vietnamese National Power Grid (Approval No. 1729/QD - KHDT Issued by the Ministry of Industry on 30/07/2001.

- Connection to the natural gas supply system
- Cooling water supply system including intake and discharge channels (Approval No. 443/TTg on 03/07/1996 Issued by Prime minister for investment of Phu My 1)
- Connecting road between main road and PMPGC
- Roads within the PMPGC

The Phu My 2.2 Power Project will have a power output capability of 715 MW which is about one fifth of totalComplex generation).

This BOT project is executed between MOI and Mekong Energy Company Ltd. (Meco) and supports objectives of the Vietnamese Government in the field of electricity generation.

Mekong Energy Company Ltd is owned by three investors, EDF International (EDFI), Tokyo Electric Power International (TEPCI) and Sumitomo Corporation (SUMITOMO) .

EDFI is completely owned by Electricité de France, the electric power utility owned by the government of France TEPCI is is completely owned by TEPCO the Utility in charge of Generation, Transmission and Distribution of TOKYO Japan and Sumitomo is a major integrated Japanese Trading Company with extensive long term activities in Vietnamimportant activities in Vietnam.

The total estimated project cost is US $ 400 million ,the Sponsors will provide at least 20% equity and financing will be provide byWB, ADB, and, Japanese and French bilateral development agencies, export credit agencies and commercial and financial institutions.

The primary fuel supply will be natural gas supplied by PetroVietnam Gas Company ("PVGC").Use of secondary fuel (Distillate oil) is restricted to a maximum of 5 days per year.

Electricity generated will be sold to Electricity of Vietnam (EVN).

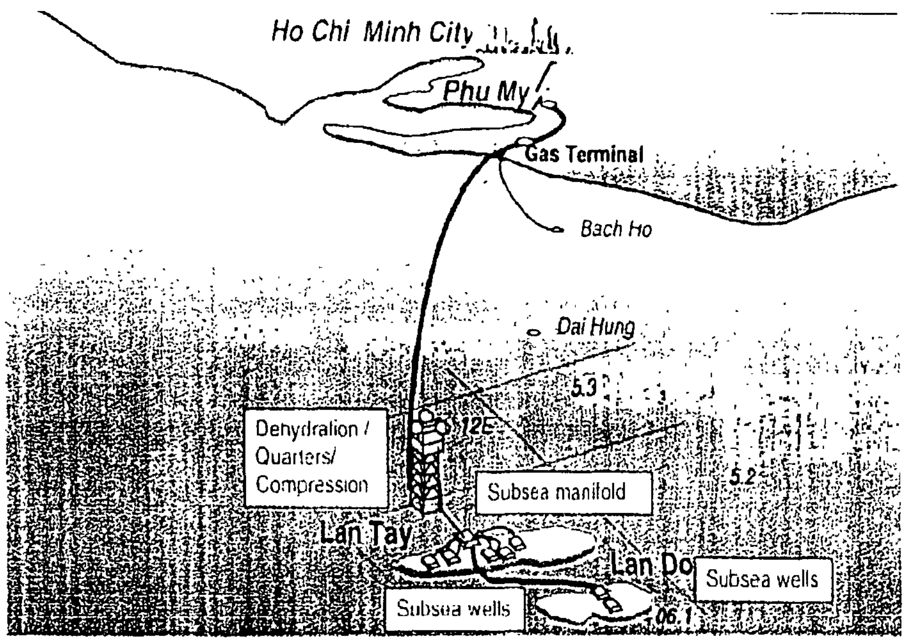
The Phu My 2.2 BOT Project was reviewed and approved by the Vietnamese Government on 18/09/2001 (Approval No. 2226/GP – KHDT Issued by MPI). The Environmental Impact Assessment Report base on a comprehensive study performed in 2001 and has also been approved by the Vietnamese Government (Approval No 864/QD - BKHCNMT, Issued by MOSTE on 25/5/2001).

Letter No1174/QD-KHDT approved the project's Feasibility Study report prepared by the Consortium June 04th 2001.

Vietnamese Government granted the Investment License to the Consortium on September 18th, 2001.

2 DEVELOPMENT SCHEDULE of PHU MY POWER GENERATION COMPLEX

Phu My Complex is the key element of the development and valorisation of the natural gas resources of Vietnam .



Using finance from World Bank, Phu My 2-1 was constructed in 1995. The project was implemented on a fast track scheme in order to meet the increasing power demands. The plant is currently in commercial operation.

. PM2-1 extension, comprising of 2 new gas turbines, was constructed and put into commercial operation in 1998.

Phu My 1 is a significant project, since a large part of the PMPGC infrastructure systems were included its scope of works. The project is under construction and as planned, is available for operation in simple cycle in 2001, the steam cycle will be ready for operation and the plant converted to combined cycle mode by April, 2002.

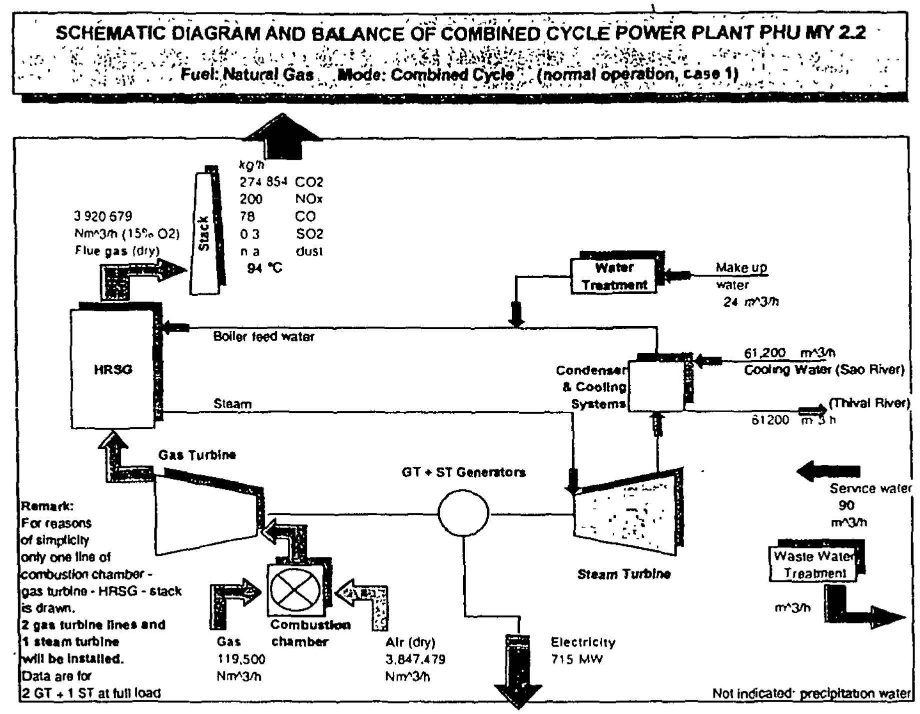
The current schedule for the power plants now under construction ,is as follows::

- Phu My 2-1 add on
  Commercial operation: End of January 2003
- Phu My 2-1 extension add on
  Commercial operation: Mid of October 2003
- Phu My 3 BOT
  Commercial operation End of December 2003
- Phu My 2-2 BOT
  - Commercial Operation Date End of 2004

3 PROJECT DESCRIPTION

Combined Cycle Power Plant (CCPP) technology has proven to be the most efficient means of producing power, and is the most environmentally friendly technology available to date. Refer to Figure PM.1, for the basic details of the CCPP operating philosophy

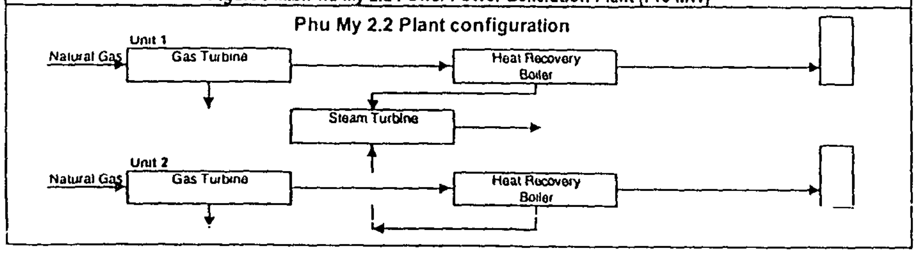
Figure PM.1



The Phu My 2-2 Project is a combined cycle power plant with a total output capacity of 715MW in a 2-2-1 configuration (Fig PM.2).

Fig PM.2

Figure PM.2:Phu My 2.2 Power Power Generation Plant (715 MW)



Power from Phu My 2-2 will be delivered to the national power grid. The power plant is scheduled to be operating in combined cycle mode by September 2004.

The technology used in Phu My 2.2 is proven technology characterised by proven reliability, outstanding, high cycle efficiency and high environmental performance standards.

Table PM.1: Project summary

Item	Phu My 2-2
Location	Phu My Industrial Zone, Vung Tau – Ba Ria
Net Capacity	715 MW
Generated energy annually	About 4,8 billion kWh
Gas Supply	Nam Con Son
Average Daily Gas Consumption	2,343 million m^3/d
EPC Contractors.	CNET (EDF)

Item	Phu My 2-2
Commercial Operation Date (C.O.D)	September 2004
Construction Period	24 Months
Project Capital Cost	US $400 Million

The plant will use natural gas supplied from the Nam Con Son gas field as the primary fuel and distillate oil as an alternative standby fuel during 5 days per year maximum. Distillate oil may be delivered to the power plant through common facility of the site by barge into two storage oil tanks.

Power and energy generated at Phu My 2-2 will be delivered via 500kV switchgear and a short overhead transmission lines to the EVN 500 kV Phu My substation.

Cooling water originating from the Sao River will be supplied to the pump house via a subsidiary supply line from the main intake channel.

The Ba Ria Vung Tau Water Supply Company will supply fresh water via a piping system.

As part of the Phu My Power Generation Centre development scheme, Phu My 2-2 will share common infrastructure systems like cooling water intake/discharge channels, D.O. fuel supply, fresh water, 500kV switchyard, etc.

Table PM.2.: Performance guarantee (fuel: natural gas, net power output: 100%)

Description	Unit	Simple Cycle	Combined Cycle
Gas Turbine Output (Gross)	MW	2x225	2x224
Steam Turbine Output (Gross)	MW	NA	281
Auxiliary Loads, Including Auxiliary Transformers Losses (Estimated)	MW	2	10.7
Step-up Transformer Losses (estimated)	MW	2	3.3
Total Losses	MW	4	14
Guaranteed Net Power Output at 500 kV bus bar	MW	446	715
Contracted Heat Rate (based on LHV)	kJ/kWh	10410	6580
Guaranteed Noise Level	db (A) @ PHU MY Complex boundary	* Day 70 * Night 70	* Day 70 * Night 70
	Equipment db (A) @ 1 meter	90	90
Guaranteed NOx Emissions for gaseous fuel @ 15% O_2	mg/Nm^3	52	52
SO2 Emissions for gaseous fuel @ 15% O_2	mg/Nm^3	Negligible	Negligible

* At site reference conditions

4 POWER PLANT IMPACTS

4.1 Assessment of the Potential Environmental Impacts of the Phu My 2.2

The Project during construction and operation of this power plant will play an important role in the development of the Vietnam Energy Sector, particularly in the Southern region of Vietnam. It will facilitate the Government of Vietnam's policy of industrialisation and modernisation , and provide the opportunity for overall socio-economic development of the Southern Economic Focal Zone. These positive socio-economic values of the project are clearly indicated in the EIA and in the Feasibility Study approved by the Authorities.

Beside the significant beneficial impacts, and despite the use of a modern and clean technology and the use of natural gas as primary fuel, the project may produce negative local impacts on the environment. However, the project will not result in the occupation of any additional land resources for the construction of the plant, but will use only the existing planned area, on which there are no residential or commercial sites. The potential environmental impacts are identified and assessed by various methods (checklist, matrix, network and modelling). Conclusions from this assessment are given as follows.

4.1.1 Impacts Associated With the Project's Design and Pre-Construction Phase

The new thermal power plant will be constructed within the boundaries, and in the planned area, of the existing Phu My Power

Generation Centre. There are no residential properties or economic units within the site, these were removed some years ago; encroachment on agricultural, aquaculture and residential lands is not expected.

4.1.2 Impacts generally Associated With a Construction Phase

As for any important industrial facilities, the Phu My 2.2 Combined Cycle Power Plant will involve civil works during the construction process, which may have the following impacts to the environment:

- A temporary increase in the volume of transportation activities in the area due to transportation of construction materials, plant equipment and operation of construction equipment. This may obstruct normal traffic on the National Highway 51 and on the road connecting the Energy Complex with the Highway.

- Possible air pollution from the construction site and from the transportation of construction materials

- Noise and vibration pollution produced by construction equipment.

- Soil and water pollution by oil and grease leaking from construction equipment.

- River water pollution created by erosion at the construction site; spoil disposal area and waste handling facilities.

- Water and soil pollution created by wastes from construction camps and work sites.

These impacts can be assessed and are described as temporary and localised. These impacts can be minimised by using effective mitigation measures during construction . Local regulations (concerning noise, dust control, material transport and traffic management) will be complied with in order to mitigate potential impacts.

Detailed assessment of the above impacts was given in the detailed EIA Report.

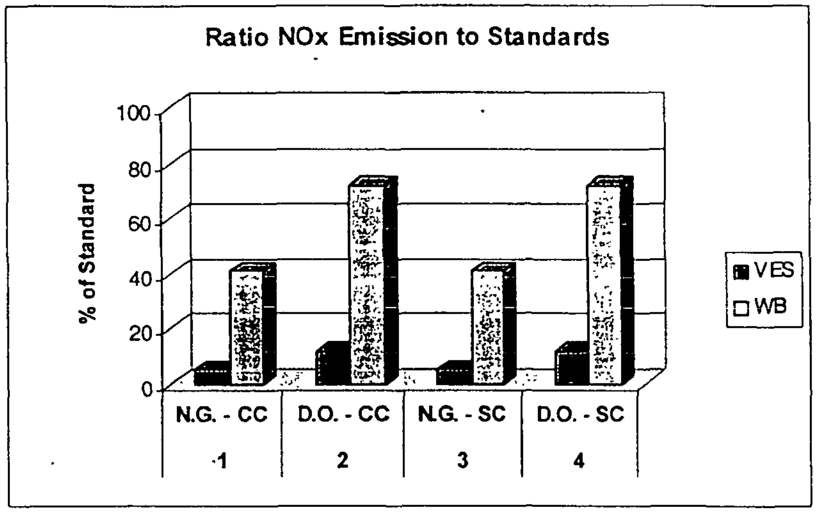
4.1.3 Impacts Associated With Operation Phase

- **Air Pollution**

Natural gas is used as the primary fuel. Distillate Oil will be the secondary fuel, however Phu My 2.2 will be restricted operating on D.O to a maximum of 5 days per year. Air pollution will be limited because natural gas is an inherently clean fuel, which contains very little sulphur and produces very low levels of nitrogen oxides due to the GT design, which incorporates a dry low NOx combustion process.

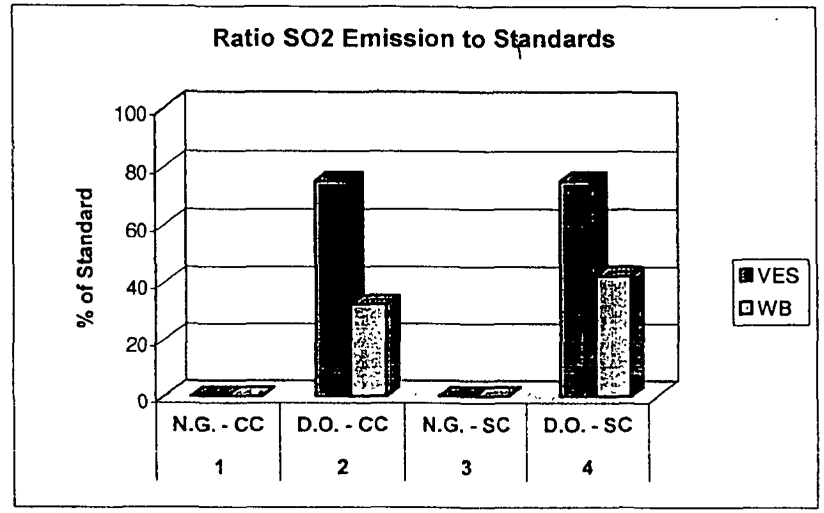
Using an air quality model, a study showed that ground concentrations of SO_2, NO_x and dust adequately meets the Vietnam Standard and WB guideline for ambient air (refer to Fig PM.3 and Fig PM4).

Fig PM.3



VES: Vietnamese Standard WB: World Bank Standard

Fig PM.4



- **Water And Soil Pollution**

Pollution created by possible fuel leakage from the fuel storage tanks and from fuel delivery tankers will be limited because tanks are installed within an adequately sized, impermeably sealed retention area. Discharge of treated wastewater and solid waste will be strictly controlled and will comply with all applicable regulations.

River water may be thermally polluted by heated flume from cooling water discharge but the increase in temperature between the inlet and outlet of the condenser will be no more than 7°C.

Using a thermal pollution dispersion model, the study indicated in cases of water intake of 17 m^3s (when PHU MY 2-2 is only in operation) to $80m^3s$ (when the entire projected PHU MY complex is in operation) that **the river temperature at the mixing zone** will be increased by only 1-2^{0}C, which will not significantly damage the local aquatic ecosystem.

The threat to aquatic organisms in the Sau Vai River by the cooling water intake may be considered. This impact cannot be avoided, but it is minimised by implementing appropriate technical mitigation measures.

- **Noise And Vibration Pollution**

Noise and vibration pollution generated from the plant will impact the plant working areas but the noise transmitted to the surrounding area will be minimal and will remain in compliance with all applicable regulations.

SUMMARISING ASSESSMENT OF ENVIRONMENTAL IMPACTS

Summarising the considerations on environmental impacts of the Phu My 2.2 power plant, it can be stated that

- Some of the impacts are negligible.
- Most of the impacts can be assessed as slight
- Only a few may reach an intermediate level.

  Power generation with a natural gas-fired combined cycle process, as in the present Project, is one of the most environmentally friendly possibilities to produce electricity

  from fossil fuels. Additionally it has to be taken into consideration that Phu My 2.2 will only be one part of the whole Phu My Power Generation Centre. The site is already developed, and concerning some impacts there will be no additional burden by the implementation of Phu My 2.2.

- As intermadiate impacts are assessed the impacts on fish and micro-organisms, due to thermal cooling water discharge and of the mecanical impact of the cooling water intake are considered. Only the localized effects are considered only in connection with the operation of the whole Phu My Power Generation Centre.
- The impact of gaseous pollutant emissions is only slight during normal operation. Wastewaters shall be treated according to the applicable standards to limit their possible impact.

Regarding Phu My 2.2 Project in connection with the entire Phu My Power Generation Centre, the contribution of Phu My 2.2 may be estimated at approx. 18 %. This estimation is allowed, because after total implementation of Phu My Power Generation Centre all power plants will be operated with the same fuelandin compliance with the same standard.

Figure E.8 shall illustrate the summarising assessment of the main environmental impacts.

Figure PM6: Summarising Assessment of Environmental Impacts				
Impact	slight	inter-mediat	high	Remark
Impacts During Construction Phase				only temporary
Land clearing				already done
Air pollution				mainly dust
Water pollution				sanitary water
Noise				construction equipment
Land used				no additional land needed
Impacts During Operation Phase				
Particulate emission				neglectible
CO emission				< standards (VN)
SO_2 emission				< standards (VN, WB), max 5 days/a
NO_x *emission*				< standards (VN, WB)
Impact on ambient air				< standards (VN, WB)
Noise				
Impact on water (by wastewater discharge)				
Thermal impact by cooling water discharge				< standards (VN, WB), total Phu My
Impact on climate (CO_2)				
Impact on Flora & Fauna				biodiversity, ingestion by CW intake
Impact on fish				*ingestion by CW intake*
Impact on Mangroves				

ALTERNATIVES TO TECHNOLOGY

The 715 MW Phu My 2.2 combined cycle Power Plant Phu My 2.2 represents a modern power generation concept with high efficiency and low environmental impacts. As alternative technologies for power generation from fossil fuels will be discussed and compared

- generation of 715 MW by a coal-fired conventional power plant

- generation of 715 MW by a fuel oil-fired conventional power plant.

Vietnamese emission standards would require flue gas treatment equipment to be installed

Table PM.4. Shows a comparison between NOx and SO_2 Emission Mass Flow between Coal-fired, Oil-fired and Gas-fired Combined Cycle Power Plant.

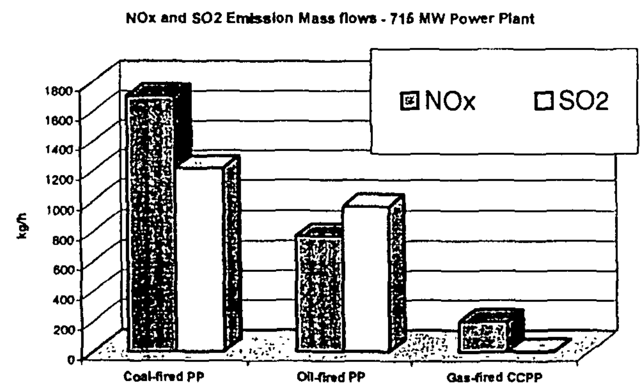
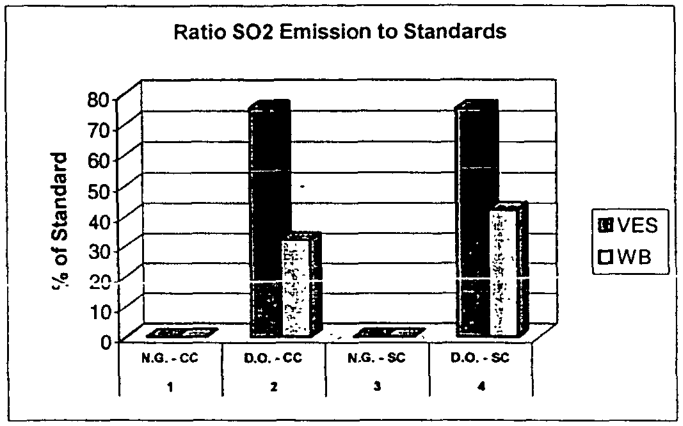


Table PM.5. Comparison on Nox and SO_2 Emission between Oil-fired and Gas-fired Combined Cycle Power Plant.



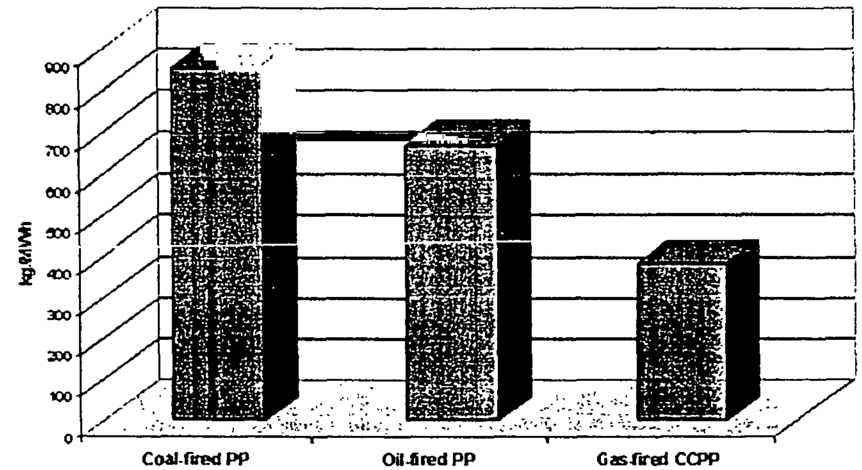
NG Natural Gas, DO Oil

CC Combine Cycle, SC Single Cycle

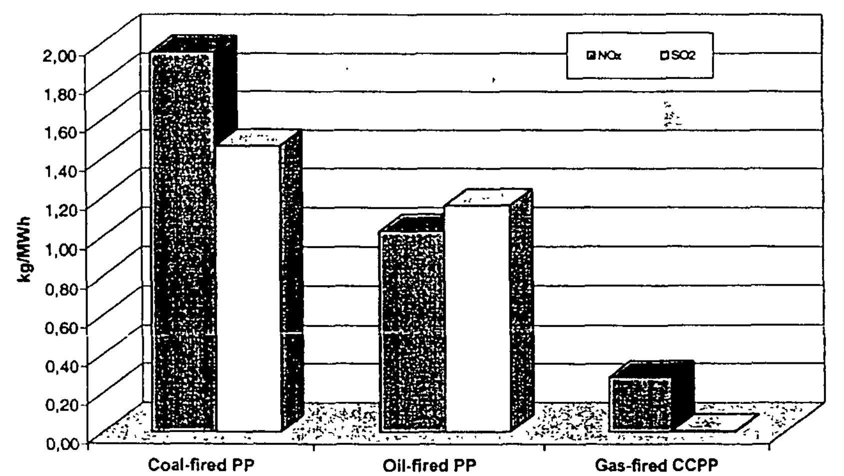
Table F.1: Comparison of different Power Plant Concepts

Plant Data	Conventional Coal-fired PP	Conventional Oil-fired PP	Gas-fired CCPP
Fuel	Coal *)	Oil **)	Natural gas ***)
power MW el.	715	715	715
efficiency %	39	40	54
Emissions			
NOx kg/MWh	1,96	1,03	0,28
SO2 kg/MWh	1,47	1,16	0,01
CO2 kg/MWh	855	671	384
Additional Consumption			
Limestone (FGD) kg/h	6.000	2.200	no
Processwater (FGD) m3/h	120	90	no
Additional Residues			
Ash (to be disposed) kg/h	20.554	neglectible	no
Gypsum (FGD) kg/h	10.400	3.900	no
Wastewater (FGD) m3/h	4	1	no

Specific CO2 Emission - 715 MW Power Plant



Specific NOx and SO2 Emissions - 715 MW Power Plant



5 BENEFITS TO VIETNAM

The development of Phu My 2-2 will provide substantial benefits to Vietnam, and will be a catalyst for development of the Vietnamese gas industry and national industrialization.

- Phu My 2-2 is an important part of the natural gas consumption project that will enable the development of Nam Con Son gas field and of the neighbouring Vietnamese natural gas resources.
- The project will enhance the capital flow into Vietnam, thereby leaving scarce national financial resources for other projects, which may have limited access to private foreign capital.
- This Facility will add 715 MW of power generation capacity in the Phu My area before 2005.
- The project will also support industrial development of the Ba Ria- Vung Tau area and Southern Vietnam.
- The success of Phu My 2-2 will attract additional foreign investment.

The following additional benefits can be mentioned:

- A significant transfer of sophisticated technology, long term high value skill development through training and the transfer of a complete operational and management team to Vietnam at the end of the BOT period.
- Employment of up to 1,500 Vietnamese workers during construction.

- Direct permanent employment for some 40 Vietnamese workers.
- On-going indirect employment in supporting service and industries.
- Enhancement of local educational and cultural opportunities.

- The plant will be 100% Vietnamese owned upon transfer.
- The project Operator will implement an O&M program designed to maximize the life of the plant consistent with EVN dispatch requirements within the limits of good engineering practice and project economics.

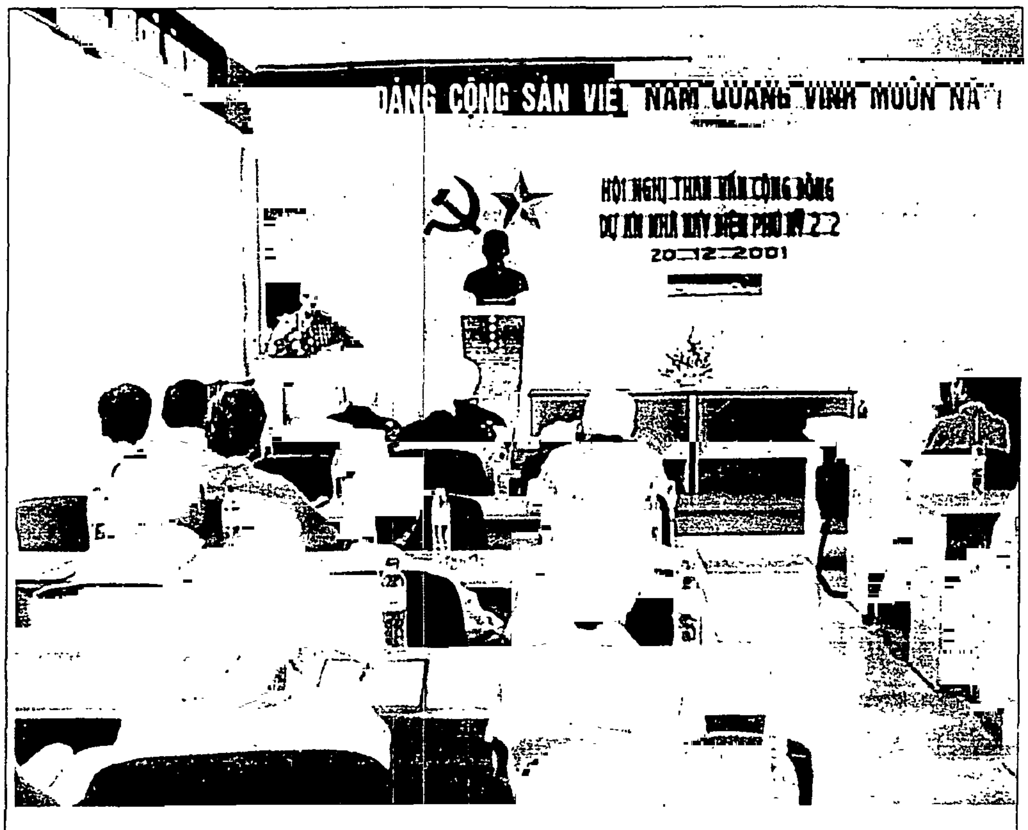
Environmental Assessment Report
of PHU MY 2 Phase 2

APPENDIX H5

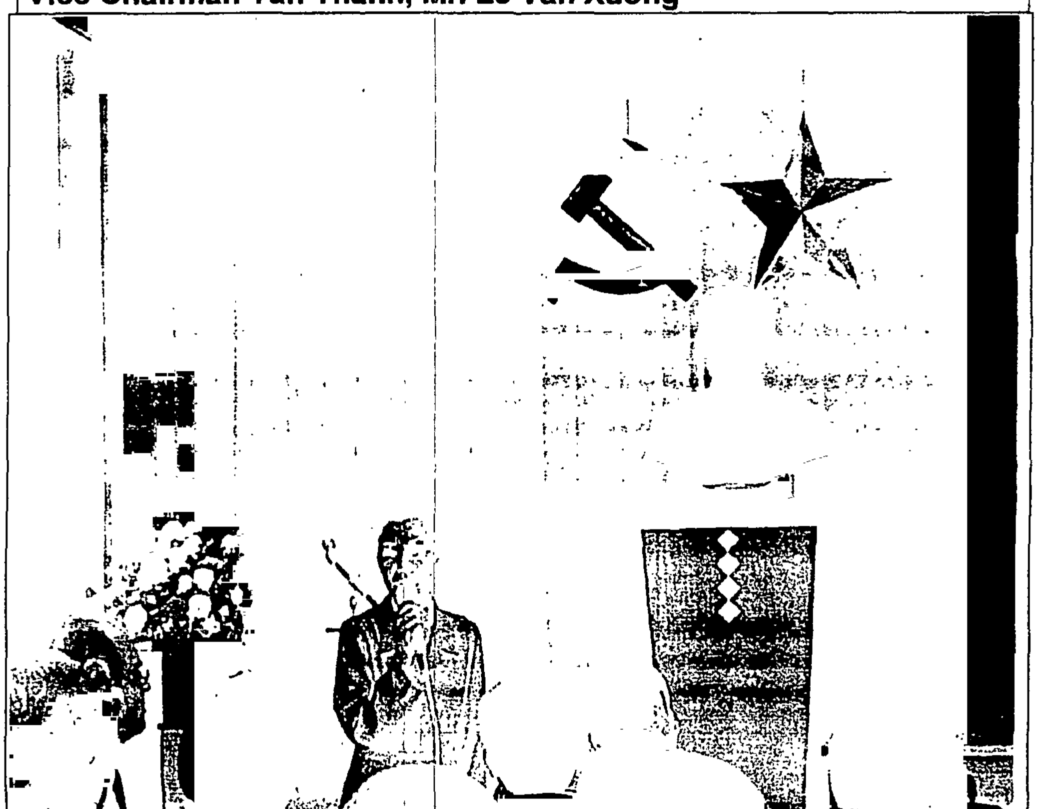
PHOTOS OF THE PUBLIC CONSULTATION MEETING

Tan Thanh People's Committee Building

Mr. Richard Perrier – Introduction



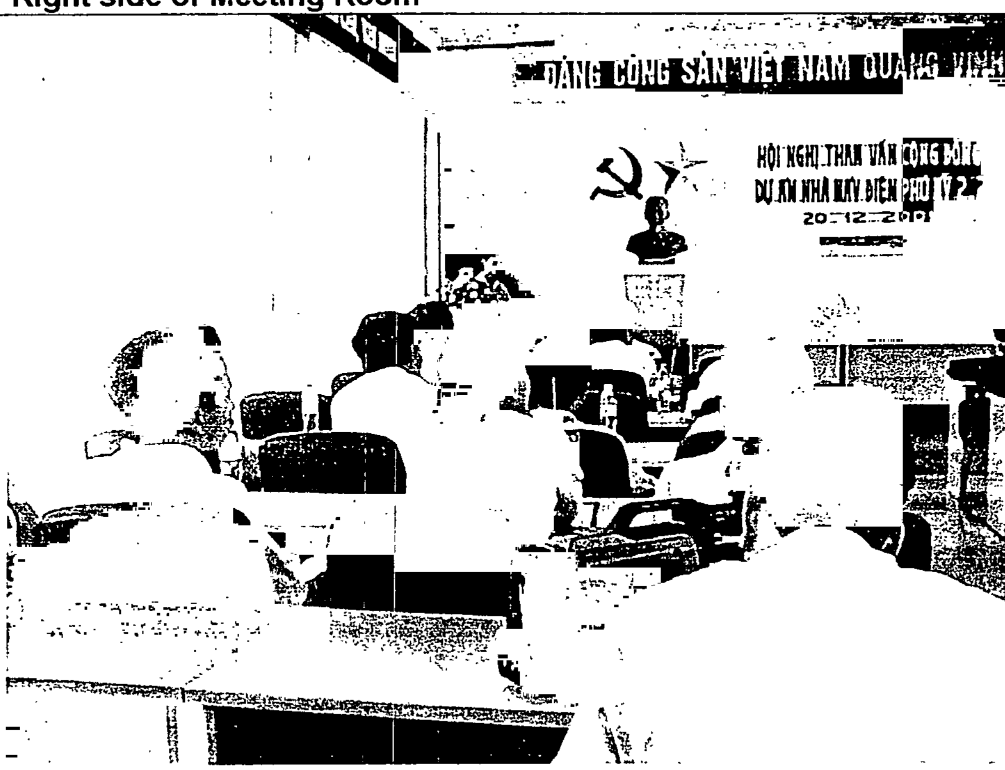
Vice Chairman Tan Thanh, Mr. Le Van Xuong



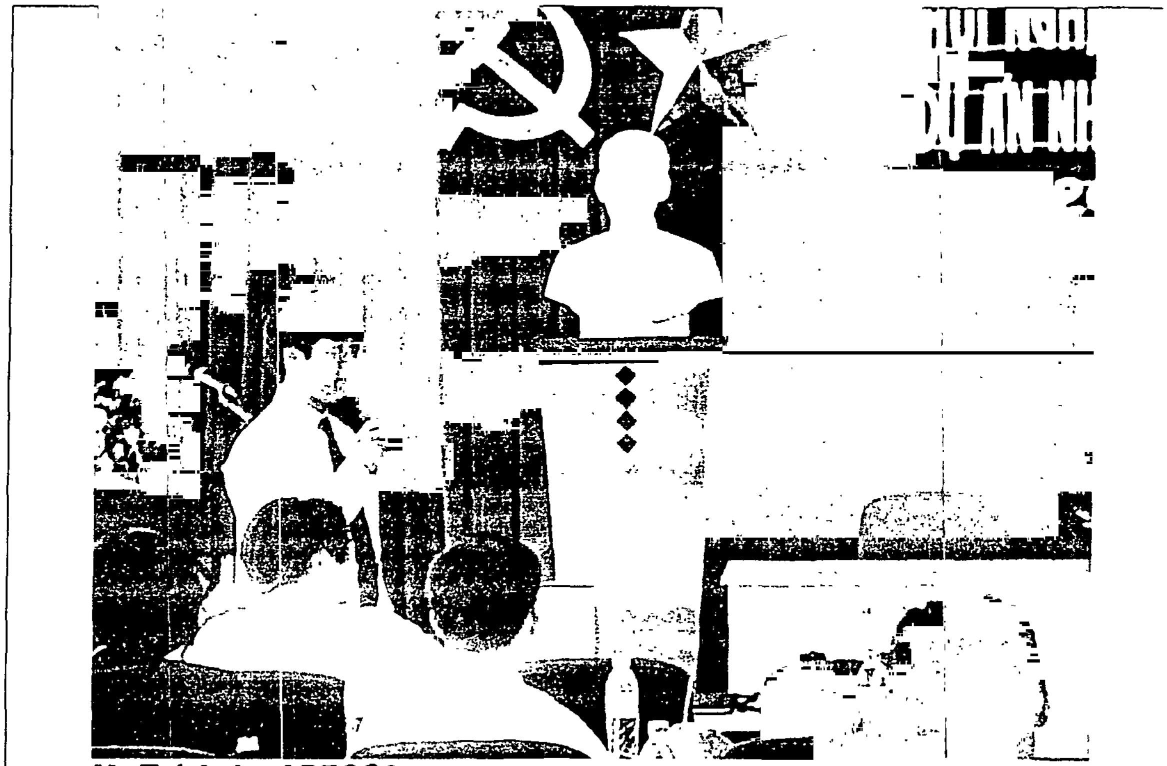
Member of the public asking questions

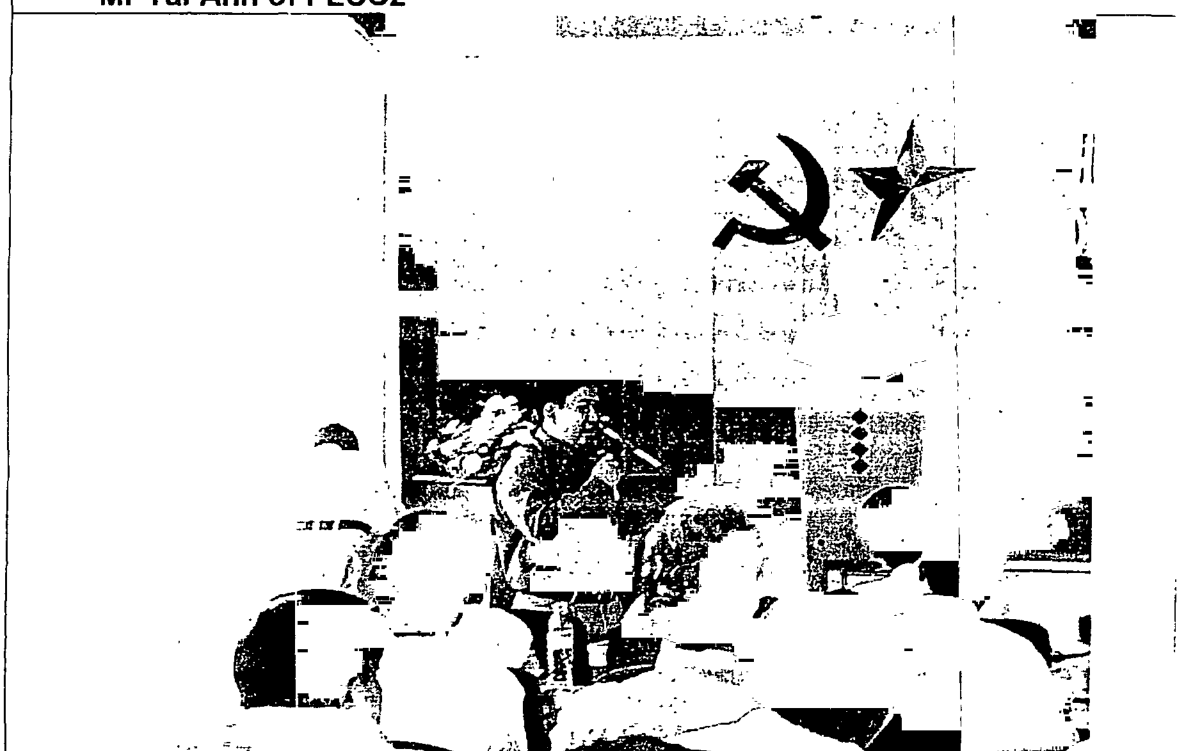
Left side of Meeting Room

Right side of Meeting Room

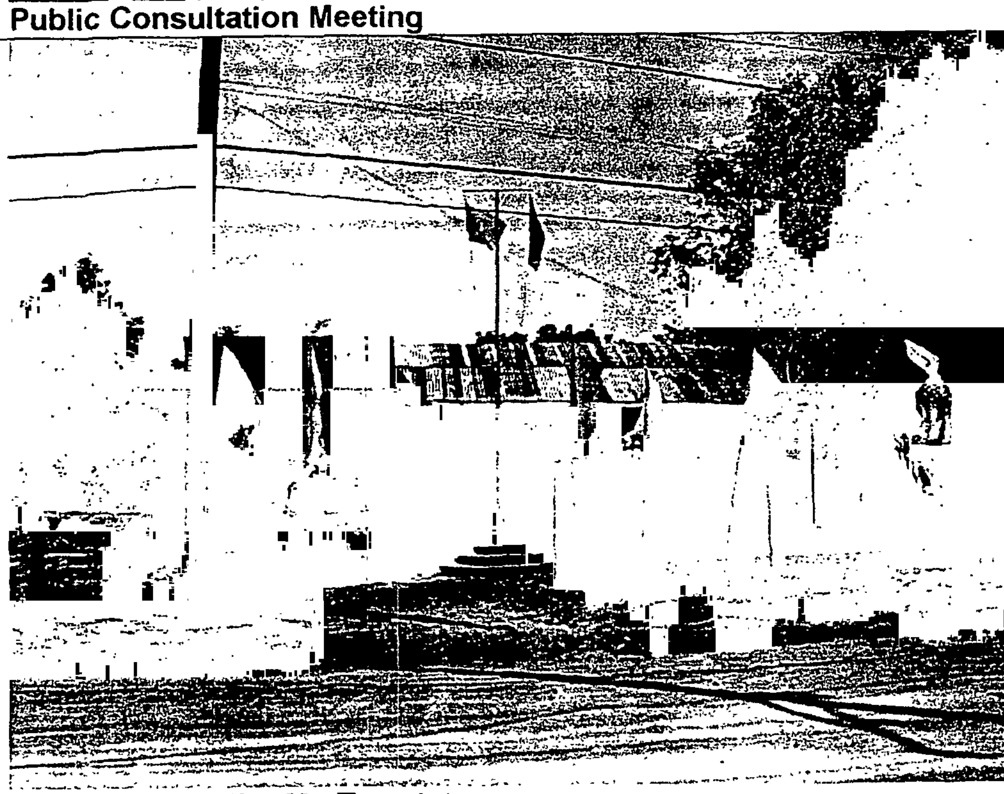


MC For the Administration of Tan Thanh

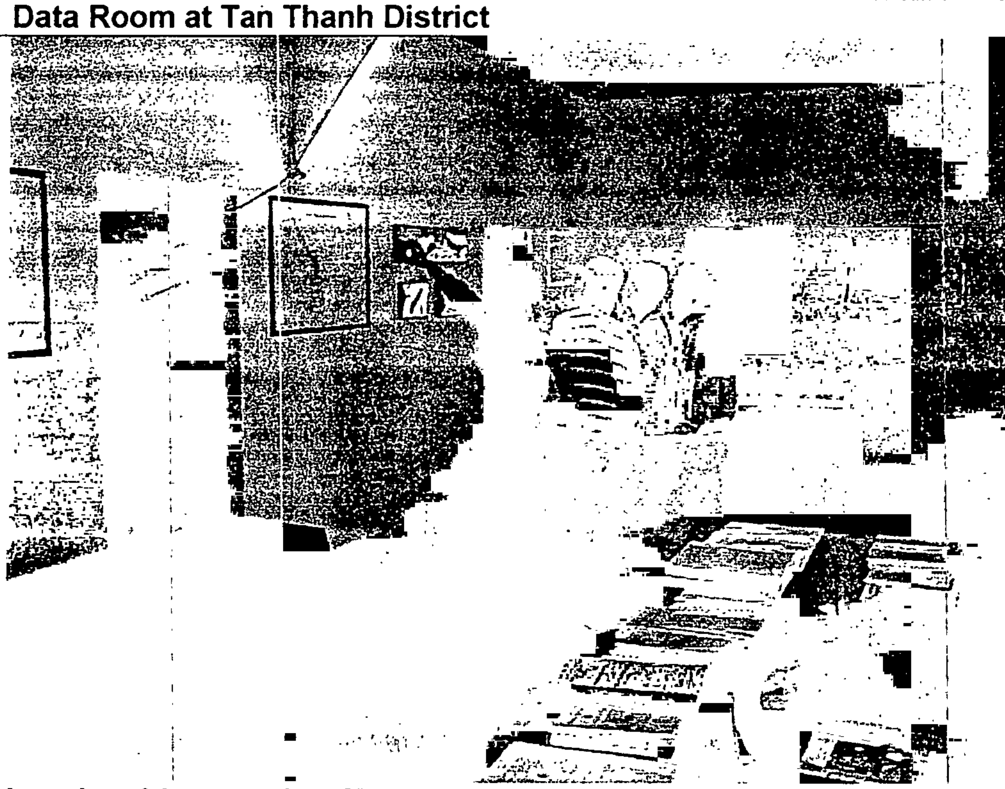

Mr Tai Anh of PECC2


Questions

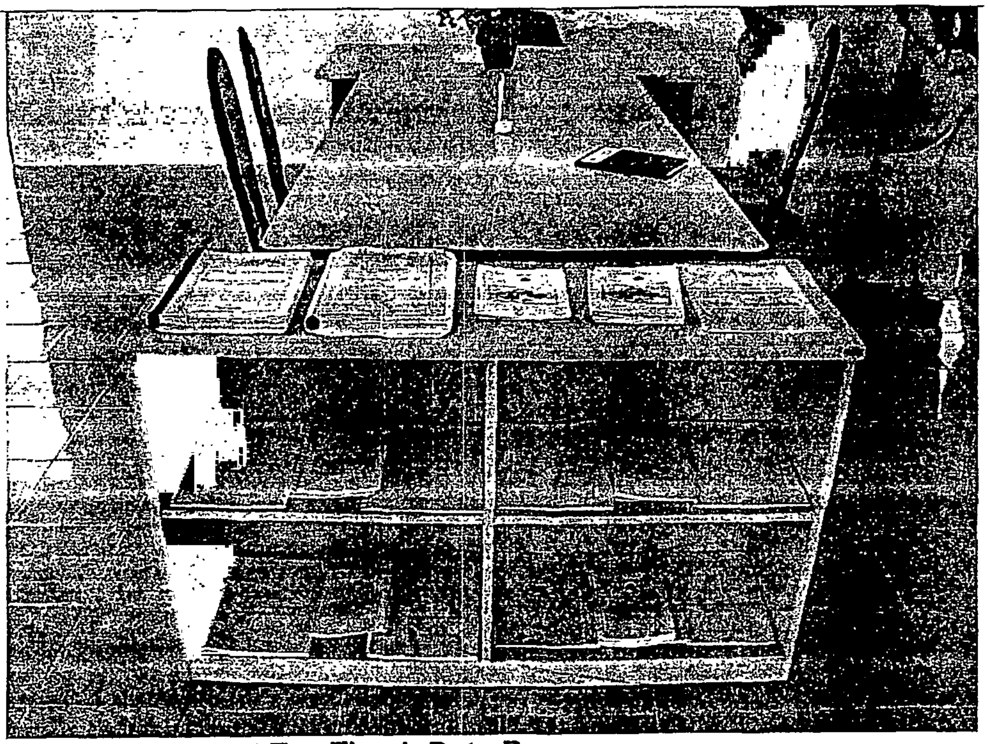
Public Consultation Meeting


Data Room at Phu My Townlet

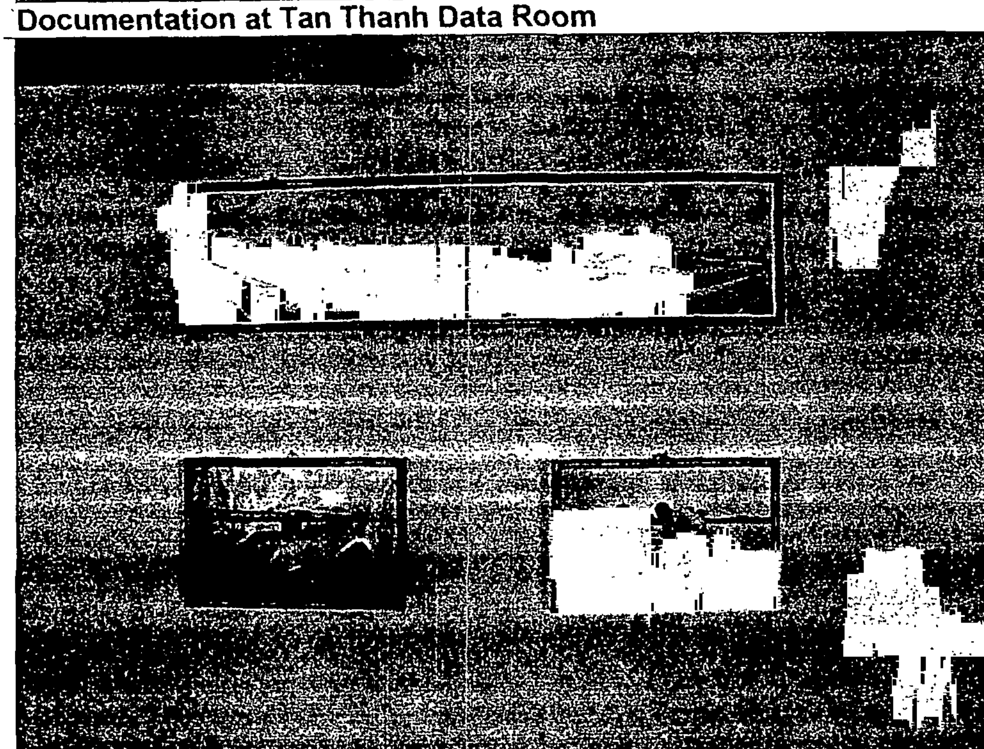
Data Room at Tan Thanh District



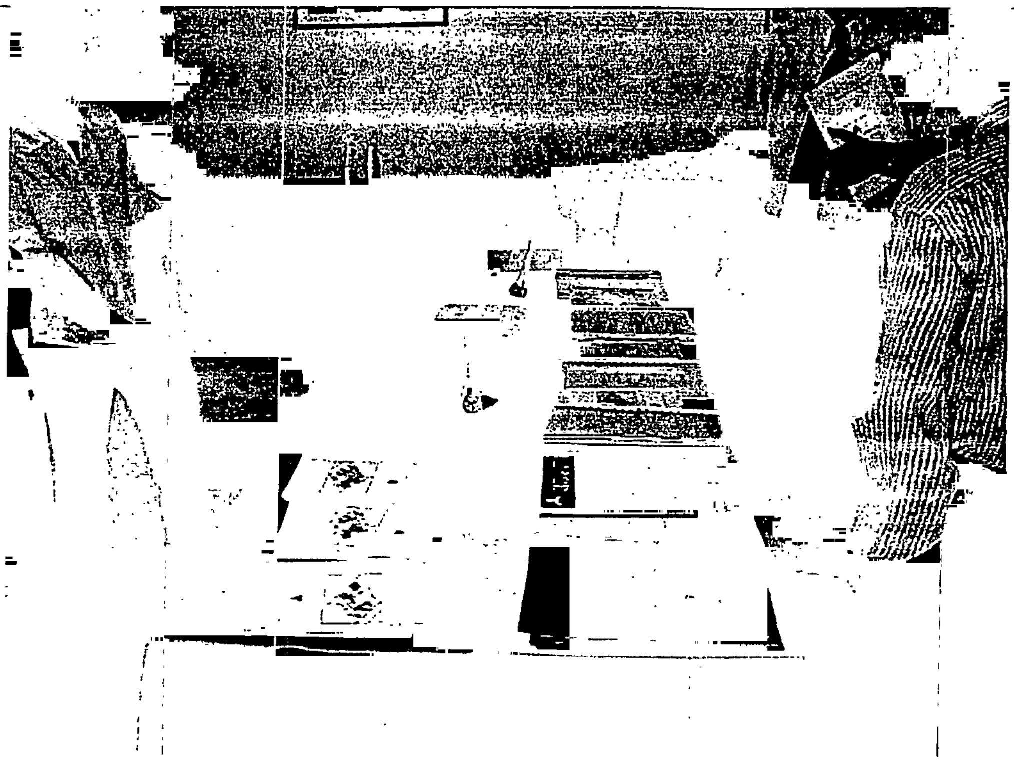
Local residents at Phu My data room



Documentation at Tan Thanh Data Room



Photos on Data room's wall



Documentation at Phu My Data Room