THE SOCIALIST REPUBLIC OF VIETNAM
ELECTRICITY OF VIETNAM(EVN)
INSTITUTE OF ENERGY(IE)

THE STUDY ON NATIONAL POWER DEVELOPMENT PLAN FOR THE PERIOD OF 2006-2015, PERSPECTIVE UP TO 2025 IN VIETNAM

FINAL REPORT
SUMMARY REPORT

MAY 2006

JAPAN INTERNATIONAL COOPERATION AGENCY
(JICA)

TOKYO ELECTRIC POWER Co.,Inc.
TOKYO ELECTRIC POWER SERVICES Co.,Ltd

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Location of the Socialist Republic of Vietnam

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Contents

ACRONYMS / ABBREVIATIONS

ADB	:	Asian Development Bank
AFC	:	Automatic Frequency Control
AFTA	:	ASEAN Free Trade Area
ASEAN	:	Association of Southeast Asian Nations
BOD	:	Board of Directors
BOM	:	Board of Management
BOT	:	Build -Operate-Transfer
CC	:	Combined Cycle
CDM	:	Clean Development Mechanism
C/P	:	Counterpart
DO	:	Diesel Oil
DOE	:	Department of Energy
DSCR	:	Debt Service Coverage Ratio
DSM	:	Demand Side Management
DSS	:	Daily Start and Stop
DWT	:	Dead Weight Tonnage
EGAT	:	Electricity Generating Authority of Thailand
EIA	:	Environmental Impact Assessment
EL	:	Elevation
EVN	:	Elctricity of Vietnam
FO	:	Furnace Oil
FPD	:	Forest Protection Department
F/S	:	Feasibility Study
GDP	:	Gross Domestic Product
GMS	:	Greater Mekong Sulregaion
GT	:	Gas Turbine
HPP	:	Hydro Power Plant
IE	:	Institute of Energy
IEA	:	International Energy Agency
IEE	:	Initial Envelopmental Evaluation
IES	:	Initial Envelopmental Study
IGA	:	Inter Goverment Agreement
IMPACT	:	Integrated & Multi-purpose Package of Advanced Computational Tools for power system engineering
IPP	:	Independent Power Producer
JBIC	:	Japan Bank for International Cooperation
JETRO		Japan External Trade Organization
JICA	:	Japan International Cooperation Agency
LOLE	:	The Loss Of Load Expectation
M/P, MP	:	Master Plan
MARD	:	Ministry of Agriculture and Rural Development
MOI	:	Ministry of Industry

ACRONYMS / ABBREVIATIONS

MOF	:	Ministry of Finance
MONRE	:	Ministry of Natural Resources and Environment
MOSTE	:	Ministry of Science Technology and Environment
MPI	:	Ministry of Planning and Investment
NCMPC	:	Ho Chi Minh Power Company
NEDO	:	New Energy and Industrial Technology Development Organization
NGO(s)	:	Non-Government Organization(s)
NLDC	:	National Load Dispatching Centers
NTFP	:	Non-Timber Forest Products
ODA	:	Official Development Assistance
OE	:	Oil Equivalent
OECF	:	The Overseas Economic Cooperation
OJT	:	On the Job Training
Pre-F/S	:	Preliminary Feasibility Study
P/S	:	Power Station
PDPAT II	:	Power Development Planning Assist Tool
PECC1	:	Power Engineering Counsulting Company 1
PLN	:	Perusahaan Umum Listrik Negara
PP	:	Power Purchase
PSPP	:	Pumped Storage Power Plant
PSS/E	:	Power System Simulator for Engineering
RETICS	:	Reliability Evaluation Tool for Inter-Connected System
SCADA	:	Supervisory Control and Data Acquisition
SEA	:	Strategic Enviromental Assessment
SFR	:	Self Financing Ratio
SHM	:	Stakeholder Meeting
Son La PMB	:	Son La Hydropower Project Management Board
S/S	:	Substation
ST	:	Steam Turbine
TA	:	Technical Asistance
TEPCO	:	Tokyo Electric Power Company
TEPSCO	:	Tokyo Electric Power Services Co., Ltd.
T/L	:	Transmission Line
TOU	:	Time-Of-Use
VEEA	:	Vietnam Electricity Engineering Association
WASP	:	Wien Automatic System Planning Package
WB	:	The World Bank
WSS	:	Weekly Start and Stop
WTI	:	West Texas Intermediate
WWF	:	World Wide Fund for Nature

UNITS

Prefixes

μ	:	micro-	=	10^{-6}
m	:	milli-	=	10^{-3}
c	:	centi-	=	10^{2}
d	:	deci-	=	10^{9}
da	:	deca-	=	10
h	:	hecto-	=	10^{2}
k	:	kilo-	=	10^{3}
M	:	mega-	=	10^{6}
G	:	giga-	=	10^{9}

Units of Length

m	:	meter
km	:	kilometer

Units of Area

m^2	:	square meter
km^2	:	square kilometer

Units of Volume

m^3	:	cubic meter
l	:	liter
kl	:	kiloliter

Units of Mass

kg	:	kilogram
t	:	ton (metric)
DWT	:	Dead Weight Tonnage

Units of Energy

kcal	:	kilocalorie
kWh	:	kilowatt-hour
ktoe		Kilo ton oil equivalent (toe)
MWh	:	megawatt-hour
GWh	:	gigawatt-hour
Btu	:	British thermal unit

Units of Heating Value

kcal/kg	:	kilocalorie per kilogram
Btu/kWh	:	British thermal unit per kilo watt hour

Units of Temperature

℃	:	degree Celsius or Centigrade

Units of Electricity

W	:	watt
kW	:	kilowatt
MW	:	megawatt
GW	:	gigawatt
A	:	ampere
V	:	volt
kV	:	kilovolt
kVA	:	kilovolt ampere
MVA	:	megavolt ampere
MVar	:	megavar (mega volt-ampere-reactive)
Ω	:	ohm

UNITS

Units of Time

s	:	second
min	:	minute
h	:	hour
d	:	day
m	:	month
y	:	year

Units of Flow Rate

m/s	:	meter per second
m^3/s	:	cubic meter per second

Units of Currency

VND	:	Vietnam Dong
US$/USD	:	US Dollar

Exchange Rate

1 US$	=	VND 15,830	As of May 2005
1 US$	=	VND 15,825	As of September 2006
1 US$	=	VND 15,844	As of January 2006

Executive Summary

1. Introduction

1.1 Background

Stable power supply is considered a top priority issue in order to support sustainable socio-economy development in the Socialist Republic of Viet Nam (hereinafter referred to as "Vietnam"). Vietnam has prepared a master plan of power system development every five years and aimed at deliberate development of the power systems.

Under the circumstances, Electricity of Vietnam (EVN) requested the Government of JAPAN of carrying out a development study on 6th master plan of power sector to be prepared by March 2006.

Accordingly, a preliminary study mission for project formulation was dispatched in December 2004 and discussed the requested development study with the Government of Vietnam. Based on the discussion, the S/W of "The Study on National Power Development Plan for the period of 2006-20015, perspective up to 2005 in Vietnam" (hereinafter referred to as "the Study") was agreed upon with EVN, which was named as the counterpart of the Study.

1.2 Objectives and Scope of the Study

(1) Objectives

In order to meet growing power demand, EVN has a mission for preparing the national power development plan in the period of 2006-20015 perspective up to 2025 (hereinafter referred to as "PDP 6th") that will be approved by the Government of Vietnam.

In order to enhance the preparation of PDP 6th that will ensure stable power supply for a long term, EVN has required technical assistance from JICA.

The Study aims at assisting EVN to prepare PDP 6th.

(2) Geographical Scope

The study area is the whole of Vietnam.

(3) Study Area and Scope

According to the S/W and M/M signed between EVN and JICA on February 4, 2005, the Study had been carried out jointly by JICA and EVN in the following items of many necessary works for preparing Draft of PDP 6th.

1) Review of implementation of 5th master plan
2) Preparation of PDP 6th
3) Environmental and social considerations
4) Finalization of PDP 6th
5) Capacity development
6) Holding Workshop
7) Assistance for execution of stakeholder meeting
8) Participation of working group and steering committee

1.3 Methodologies of the Study

The Study Team can be divided into two groups and four fields as shown in Figure 1-1. The studies in each field closely cooperated in preparing PDP 6th. In order to reflect comments of related organizations, W/S was held at each study stage.

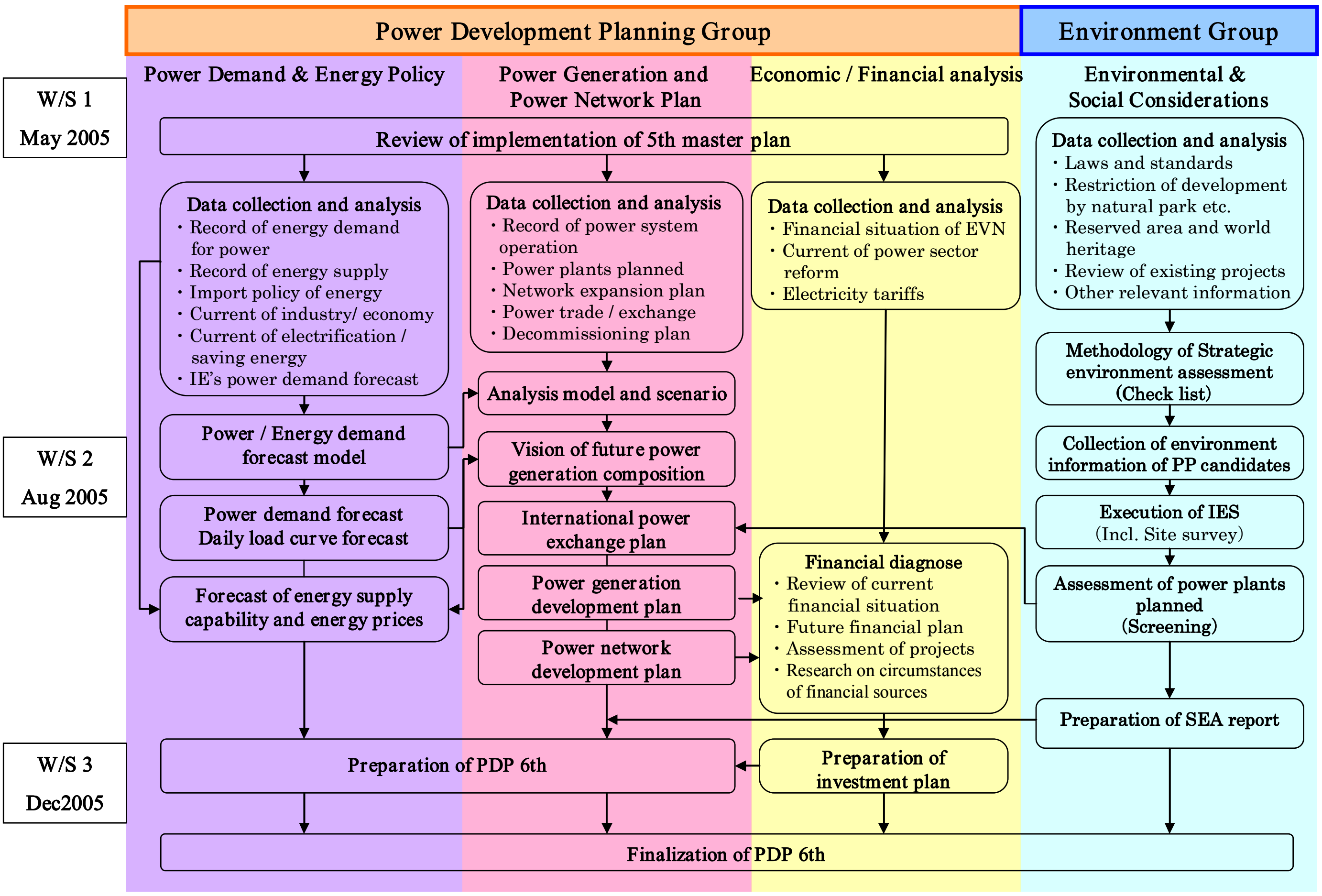


Figure 1-1 Study Flow

2. Review of Implementation of 5th Master Plan

2.1 Evaluation of Demand Forecasts

(1) Overview of Current Socio-Economic Situation

In general, the period 2006-2010 is one of rapid development (except unsuccessful integration cases, causing large economic changes). Initiating from a low growth development period (1997-2003), the economy of the country may attain rapid economic development speed around 2020 and then will be stable at high, average or low growth rates depending on each scenario.

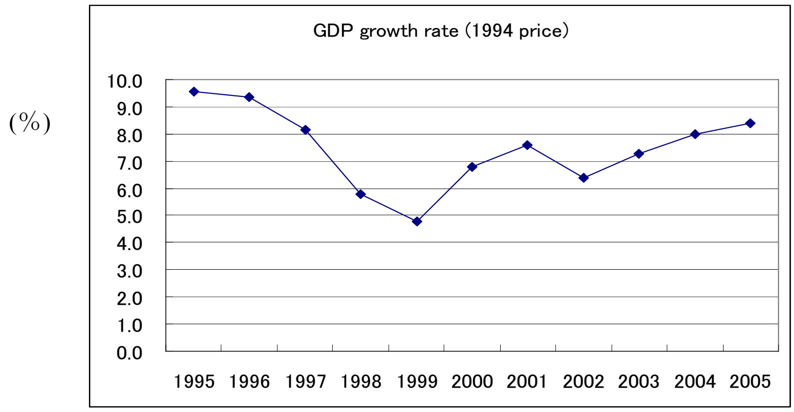


Figure 2-1 Growth Rate of Real GDP (1995 - 2005)

(2) Power Consumption

a. Power Consumption

The power consumption data for the period 1996-2004 in the Table 2-1 indicate that the power sales increased 3 times in this period of years, with average growth rate of about 14.5%/year, especially a high growth rate of 15.3%/year in the period 2000-2004.

In 2004, the total power sale amounted to 39.6 billion kWh.

Table 2-1 Power Consumption (Unit: GWh)

Item	1996	1997	1998	1999	2000	2001	2002	2003	2004
Sales Power	13,375	15,303	17,725	19,550	22,404	25,858	30,228	34,835	39,596
Growth (%)	19.44	14.41	15.83	10.30	14.60	15.42	17.0	15.0	13.5
Per capita (kWh/year)	177	200	233	255	289	338	379	432	483
Loss (%)	19.3	18.2	16.09	15.53	14.03	14.0	13.4	12.7	12.2

Source: Institute of Energy - EVN

b. Peaking Power Generation

The Peak demand increased 2.6 times from 3,177 MW in 1996 to 8,283 MW in 2004, reaching an average growth rate of 12.7%/year. In 2002, the peak demand growth rate was 15.9%, the highest in the whole period. According to the statistical data of National Load Dispatch Center for the period 2001-2004, the national power grid had to shed relatively large amount of load in some peak hours, due to shortage of power supply capacity. Normally, the peak cut-off is performed between June and August (the water level of reservoirs of hydro power plants is lowered for the flood control) or in November when the power consumption of the system is maximal.

Table 2-2 Peak Demand (1996 – 2004)

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Peak (MW)	3,177	3,595	3,875	4,328	4,893	5,655	6,552	7,408	8,283
Growth rate (%)	13.6	13.2	7.8	11.7	13.1	15.6	15.9	13.1	11.8

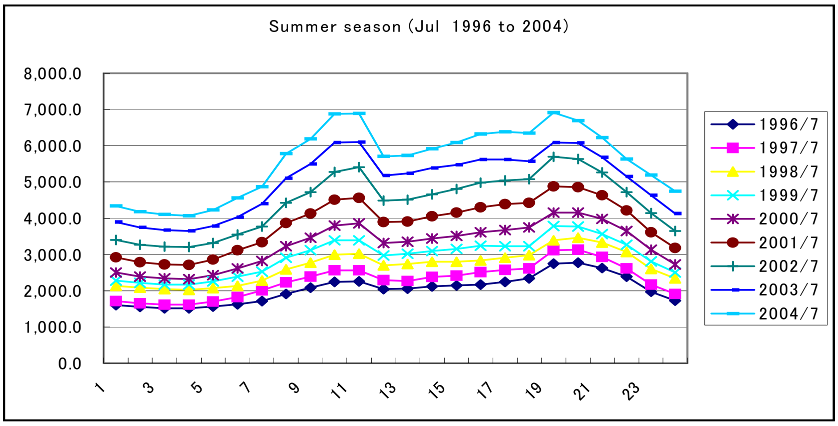
Source: National Load Dispatch Center

c. Power Load Curve

The characteristics of load curve of the whole country system are as follows:

- Power growth rate in the daytime (from 8 hr. to 17 hr, 16.0% up per year) is higher than that in the peak hours (from 18 hr. to 22 hr, 13.0% up per year) by 3.0%/year on average growth rate.
- The daily peak load (at 10hr. a.m.) tends to increase, and it is higher than the evening peak in summer season from the year of 2003. That means, maximum peak load of the power system tends to shift from evening (at 18-19 hr.) to day time peak (10 hr. a.m.), forming two peaks. The typical daily load curves of the whole country's power system in the summer and the winter during the period 1996-2004 are presented in Figure 2-2.

(MW)



(MW)

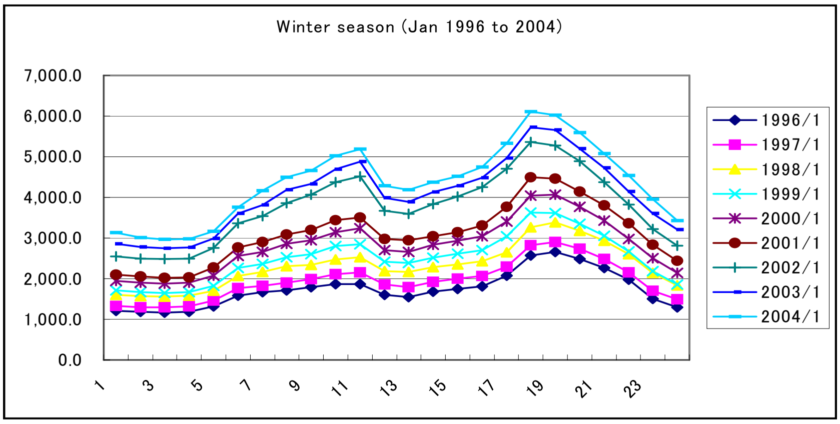


Figure 2-2 Load curves of the whole country system 1996 - 2004

d. Load factor

The annual load factor of the power system in the whole country is in the range of 0.61-0.64 and tends gradually to increase year by year in the period 1996-2004. Evolution of load factors of the whole country is presented in the table 2-3. According to the statistical data of load factors in the north, central and south regions in the period of 1996-2004, the annual load factor of the south power system is the highest in the regions, and then it is followed by the central and the north power systems. In 2004, load factor is of 69% in the south power system, 60% in the central power system and 58% in the north power system.

Table 2-3 Load Factors of the Whole System in the Period of 1996-2004

Year	1996	1997	1998	1999	2000	2001	2002	2003	2004
Load factor (LF)	0.608	0.610	0.642	0.622	0.627	0.621	0.632	0.635	0.639

Source: Institute of Energy

e. Assessment of Power Demand Forecast in Master Plan

The actual values of power demand in the period 2000-2004 are higher than the forecast values in all cases (High, Base, Low) of the PDP5th, the high case has the smallest difference in the comparison(refer to fig2-3,2-4). For the long-term forecasting by the "elasticity method", the "elasticity" in PDP 5th was forecasted lower than actual records (table 2-4). Therefore, the forecast value of power sales and peak power are lower than actual data in the past years.

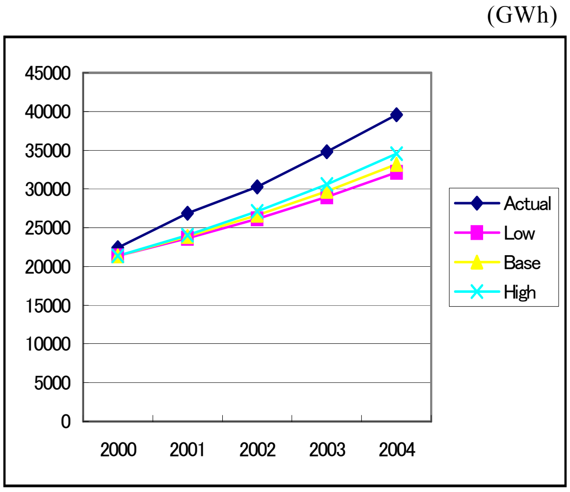


Figure 2-3 Comparison of Actual Power Sales Forecast in PDP5th (High, Base Low)

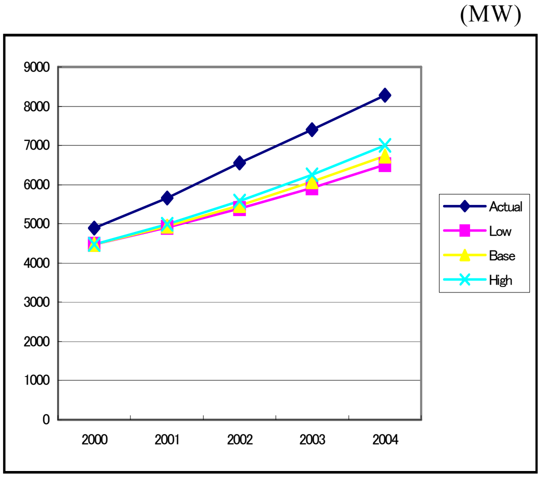


Figure 2-4 Comparison of Actual Peak Demand Forecast in PDP5th (High, Base, Low)

Table 2-4 Elasticity of GDP to Sales Power

Scenario	1999-2000	2001-2005	Note
Actual	2.15	2.13*	The period up to 2004
PDP5th	1.82	1.62	

2.2 Reserves of Energy Resources

(1) Hydropower

In the revised 5th MP, total exploitable potential of hydropower in the whole country was considered to be 17,700 MW with energy of 82.0 TWh. After that, some more examination done and Study on KHCN09 "Establishment of stable energy strategy and policy", exploitable potential was revised to be 20,560 MW with energy of 83.42 TWh, of which, 9,990 MW 38 TWh in north (54%), 7,700 MW 21.8 TWh in the central (30%) and 2,870 MW 11.6 TWh in south (16%), shown an unevenly distributed hydropower potential in the north.

Feasible potential of hydropower on each main river basin is shown in Table 2-5 below;

Table 2-5 Feasible Potential of Hydropower

River Basin	Capacity (MW)	Energy (TWh)
Lo-Gam-Chay River	1,470	5.81
Da River	6,960	26.96
Ma River	890	3.37
Ca River	520	2.09
Vu Gia-Thu Bon River	1,120	4.29
Tra Khuc-Huong River	480	2.13
Ba River	670	2.70
Se San River	1,980	9.36
Srepok River	700	3.32
Dong Nai River	2,870	11.64
Sub Total	17,660	71.67
Total	20,560	83.42

Source: IE "Overall evaluation on Vietnam Primary Energy Source", Nov. 2003

(2) Oil, Gas

The Vietnam continental shelf contains an abundant reserve of hydrocarbon.

Oil and gas distributions are located unevenly. Oil fields are mainly concentrated in Cuu Long basin. Natural gas distributions are found in Nam Con Son, May Lay-Tho Chu and Song Hong basins.

In accordance with the report of Petrovietnam on " Strategy on Vietnam Oil and Gas Sector Development up to 2015 and prospective to 2025", reserves of oil and gas will be 2,920-3,250 MCMOE, of which, 60% is supposed to be gas. Reserves in each basin are shown in Table 2-6.

At the end of 2004, proven reserves of 1,150MCMOE in the continental shelf with the depth up to 200m, (containing about 750MCMOE of oil and 400 BCM of gas) are estimated, in which, there are reserves of gas 250 BCM in Song Hong Basin containing a high rate of CO2 in a level of 60-90%, and can not be exploited with the present technology.

According to the 5th Master Plan of Vietnam Power Development, the residual deposits of hydrocarbon, inferred so far, were 390 million tons of oil and 617 BCM of gas.

Table 2-6 Oil and Gas Reserves in Each Basin (MCMOE)

Basin	Song Hong	Phu Khanh	Cuu Long	Nam Con Son	Malay - Thu Chu	Tu Chinh-Vung May
Potential	650-750	370-500	250	650	150	850-950
Remark	Mainly gas, high CO2	Mainly gas, high CO2	Mainly petroleum	Petroleum & gas	Mainly gas	Mainly gas

(3) Coal

Coal reserves of 300m below the surface were estimated at 3.8 billion tons on the Revised 5th MP and most of which are anthracite with high calorific value and low sulfur content (semi-anthracite and anthracite account for 85%, lignite 5% and peat 10%). By the coal evaluation in January 2005, proven reserves of coal are revised to 5.4 billion tons, and adding the estimated reserves, the total reserves will be 12.3 billion tons.

Moreover, significant coal deposits have been discovered in the Red river basin. According to the study of NEDO completed in Jan. 2003, 1.64 billion tons inferred potential of sub-bituminous was discovered within the area of 950 km^2 about 1,200m below the surface as shown in Table 2-2-9. Among these, potential measured reserve is 51 million tons within 400m below the surface.

Table 2-7 Proven and Probable Reserves (2005) (Unit: million ton)

No	Region	Reserves grade			
		Total	A+B+C_1	C_2	P
I	**Quang Ninh province**	**9,673,410**	**1,828,021**	**1,997,946**	**5,847,443**
II	**Local area**	**2,608,322**	**913,838**	**702,484**	**992,000**
	Total	**12,281,732**	**2,741,859**	**2,700,430**	**6,839,443**

Source: Vinacoal "Report on Vietnam Caol Eveluation", Jan. 2005

2.3 Power System Development

2.3.1 Power Development Plan

(1) Power Development Plan

a. Methodology of Power Development Plan

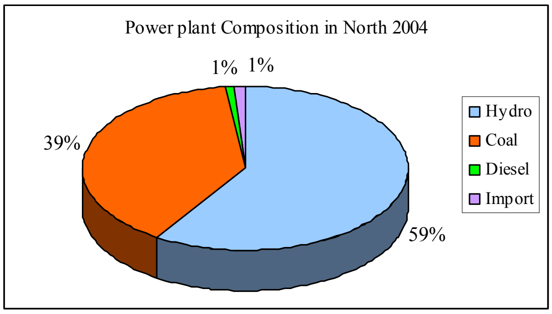
EVN adopted WASP IV as a simulation tool for power development. The tool that was developed by the International Atomic Energy Agency (IAEA) is used for a simulation of balance between supply and demand. The tool has been disseminated widely in the world. However, WASP IV cannot simulate the balance between supply and demand of interconnected systems. WASP IV cannot simulate the balance between supply and demand in Vietnamese interconnected systems.

b. Present Situation on Power Development Plan

①Existing Power Plants and Revised 5th Master Plan

The Vietnamese system is divided into two systems that are the system including Ha Noi city and the system including Ho Chi Minh city. There is a difference of fuel type of main power source between the northern and southern systems in Vietnam due to uneven distribution. This difference is caused by the unevenly distributed power resource in Vietnam. The difference of power source composition affects the economical operation in each of the system.

Northern system



Central and Southern system

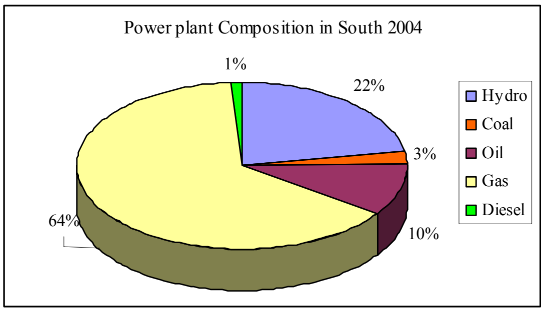
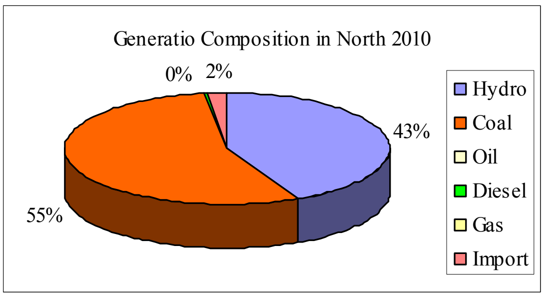


Figure 2-5 Present Composition of Power Source (2004)

The composition of power source of each system in 2010, the year of planning horizon of the revised 5th master plan, consists of hydropower and coal thermal in the North system and gas thermal power in the South system. The relationship between the supply reliability and the reserve margin in each system becomes varied under the influence of the characteristics of each system under this power source composition and the limit of interconnecting capacity of the 500kV transmission line which connects the north and south systems.

North system



Central system   South system

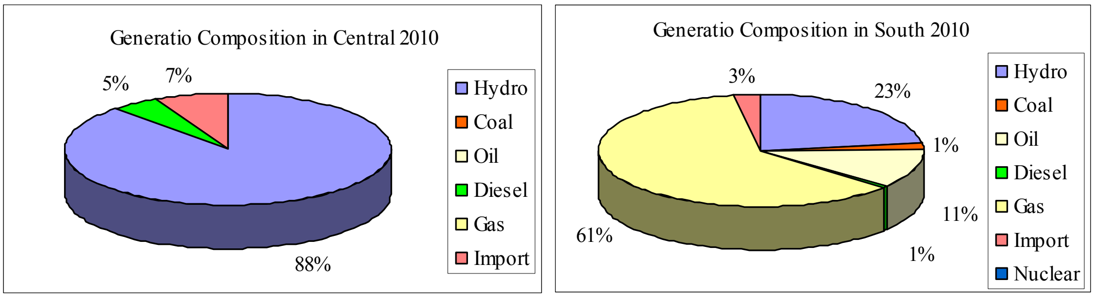


Figure2-6 Composition of Power Sources in North, Central and South Vietnam in 2010

② System Reliability of the Revised 5th Master Plan

Nine percent of reserve margin is necessary to satisfy the reliability criteria, LOLE 24-hour, for the Whole system in Vietnam. The necessary reserve margin will be different when the system is treated as the divided systems considering the limitation of interconnected 500kV transmission line. Being affected by the water flow fluctuation, the North system needs 19% of reserve margin to meet the reliability criteria. The Central and South system needs 9% of reserve margin to secure the reliability criteria.

The balance between supply and demand in the revised 5th master plan until 2010 is shown in table 2-8 below. Depending on the revised 5th master plan, the supply firm capacity is sufficient to meet the reliability criteria, if there is no limitation of 500kV interconnecting transmission line. However, the supply firm capacity is insufficient in the North system when the limitation of 500kV interconnection is considered. This shortage is caused by the uneven development of power plants in previous few years.

Table 2-8 Balance between Supply and Demand of the Revised 5th Master Plan

	2003		2004		2005		2010	
	North	C&S	North	C&S	North	C&S	North	C&S
Demand (MW)	3,111	4,165	3,453	4,759	3,830	5,398	6,153	9,639
Firm Capacity (MW)	3,232	4,953	3,331	6,160	3,574	7,372	7,601	12,368
Reserve Margin (MW)	121	788	-122	1,401	-256	1,974	1,448	2,729
Reserve Margin Rate (%)	3.9	18.9	-3.5	29.4	-6.7	36.6	23.5	28.3
LOLE (hour)	66	58	86	12	41	2	1	0

③ Present Condition of System Reliability

Power development of North system is delayed from original schedule with some Coal thermal power project. Power development of South system is also delayed on the hydropower project. Thus, generally, the system reliability reduced from the planning level in the revised 5th master plan.

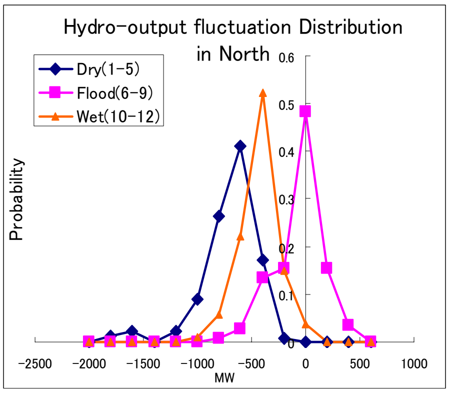
Table 2-9 Present Situation of Power Development (MW)

	2005			2010		
	5th MP	Actual	Diff.	5th MP	Pre6MP	Diff.
North	500	200	-300	5,125	8,092	2,967
C&S	1,140	,1010	-130	7,919	8,168	249
Total	1,640	1,210	-430	13,044	16,260	3,216

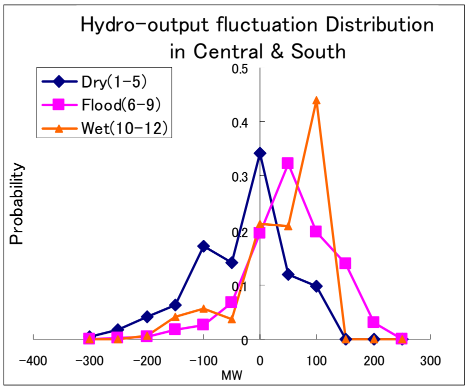
Power development of 300MW is expected to be delayed in the North system by 2005. Power development of 130MW is expected to be delayed in the Central & South system. The development delay is equal to 7.8% of reserve margin in the North system and 2.4% of reserve margin in the Central & South system.

④ Water Flow Fluctuation

The report, "Master Plan Study on Pumped Storage Power Project and Optimization for Peaking Power Generation in Vietnam" conducted in 2004, indicated that the actual output from hydro power plant at the peak demand recording time was less than the planning firm capacity during 1996 to 2001. The hydropower output distribution due to the water flow fluctuation, taking the planned capacity as a standard is illustrated in Figure 2-7.



North system



Central & South system

Figure 2-7 Probability Distribution of Hydropower Output

The firm capacity at peak demand recording time should be examined carefully, especially in the North system where over 60% of the power supply depends on the hydropower.

⑤ Least Cost Power Development Plan Considering Unevenly Distributed Power Resources

The resources such as Coal, Gas and hydropower are unevenly distributed between the north and the south of Vietnam. Coal and hydropower potentials are distributed in the North. Gas potential is distributed in the South. The unevenly distributed resources affect the least cost power development plan. Coal thermal power and hydropower are cheaper fuel cost resources of generation, and are suitable for base load suppliers. Whether hydropower projects have advantage for peaking operation or base load supply, it is depending on its geological and water-in-flow conditions also and output difference between dry and rainy seasons. Gas thermal power is of lower construction costs and higher fuel price than other sources, and is suitable for the middle and peak load suppliers. This means that the northern systems lack middle load supply, and the southern systems want the base load source.

The limitation of 500kV interconnection between the North and South systems also affects the economical operation. The distance between the load centers of the North and South systems is 1500km long. The long distance invites high costs of transmission construction. Examination is required to find which scenarios are the most economical, a reinforcement of the interconnection for transmitting power from a generation that is developed near resources or transport of fuel to a load center in the South.

c. Issues of the Revised 5th MP

Issues of the revised 5th master plan are described in the following four items based on the examination and analysis of actual balance between supply and demand.

①Limitation of 500kV Interconnection Capacity

An error is detected in the revised 5th master plan in establishing the target resource capacity to be developed required for satisfying the system reliability criteria, because the master plan was drawn with the premise of a one single system instead of divided systems due to the interconnection limitation.

②Countermeasures for Delay of Power Development Project

No countermeasure could be taken to a delay, if occurred, in the implementation of the plan, as the risk of delay is not taken into consideration for the development of target resource capacity. This is inviting a decline of supply reliability.

③Water Flow Fluctuation

Actual outputs from hydropower plant at the time of peak demand record is less than the planned 90% probability output of firm capacity from hydropower plants. The actual output is less than the planned firm capacity in rainy and flood seasons, which reduces considering rule curve of reservoir. The difference between actual output and planned firm capacity is necessary to examine an actual supply power in the daily operation.

④Cooperation between Electric Power Development and Energy Resource Development

Installation of a lot of gas combined cycle thermal power plants are planned in later years in the revised 5th master plan. However, the gas consumption of the power plants and the supply of gas in future are not arranged to meet together. The combined cycle thermal plant has 20 years lifetime in Vietnam. Checking of feasibility of fuel supply is required for the case where gas combined cycle thermal equipment to be introduced in later years is operated in its full life.

The scenarios are selected considering the issues and constraints in the 6th MP study. The most economical power development plan should be sought through the evaluation of risks in the scenarios. The scenarios should be evaluated and considered especially from energy security aspect. The power import from neighboring countries, steep rise of fuel prices, the development capacity and effects of constraints in BOT operation shall also be considered in the selected scenarios.

2.3.2 Transmission System Development Plan

Table 2-10 shows the total circuit lengths of the transmission lines from year 1990 to 2003. The total length of the 500 kV lines made no change from 1995 to 2003 except for adding the branch lines to Yali hydro power station. The total lengths of 220 kV and 110 kV transmission lines have been steadily increased. However, the 5th MP has pointed out deficiency of capacity of 110 kV transformers, malfunction with old type circuit breakers and protection devices. The voltage of the medium voltage system has been unified to 22 kV (33 kV in the mountain sides) in order to enhance supply capability and reduction of losses.

Table2-10 Transition of Total Circuit Length of Transmission

Year	1990	1995	1999	2003
500 kV	-	1,487	1,532	1,530
220 kV	1,359	2,272	3,257	4,649
66 kV, 110 kV	4,265	6,069	7,493	8,965 (only 110 kV)

Source: the 5th MP and EVN Annual Report

The first 500 kV system in Vietnam was completed in 1994. Table 2-11 shows the outline of those 500 kV transmission lines. The transmission lines were constructed from Hoa Binh hydropower station in the north area to Phu Lam substation in the south area with one circuit of about 1,500 km. The transmission capacity is 900 MVA, or, about 800 MW.

Table2-11 500 kV 1st Transmission Lines

Interval	Distance	Number of Circuits	Conductor	Commissioning MM YY
Hoa Binh – Ha Tinh	341 km	1	ACSR 330 mm *4	April 1994
Ha Tinh -Da Nang	390 km	1	ACSR 330 mm *4	April 1994
Da Nang – Plei Ku	259 km	1	ACSR 330 mm *4	April 1994
Pleiku – Phu Lam	496 km	1	ACSR 330 mm *4	April 1994
Total	1,486 km			
Yaly - Plei Ku	20.2 km	2	ACSR 330 mm *4	1999

Source: Vietnam Single Line Diagram 2003, EVN

Reinforcement of system reliability, reduction of electricity losses, facilitation of the operation of power plants both in dry and wet seasons, reinforcement of regional power supply, conversion of the existing medium voltage networks into the 22 kV voltage and condition maintenance of rural electrification are mentioned as the objectives of the study in the 5th MP. The requirements for power network system were high abundance, flexibility, stability and safety of electricity supply, ensuring electricity quality (voltage and frequency) for the country's socio-economic development.

The 5th MP pointed out the needs of studies of the countermeasures against the excess of fault current over 40 kA resulting from the system analysis about the fault current around Thu Duc, Phu Lam and Tanh Dinh in the north and the south 220 kV and 110 kV systems. The countermeasures were considered to be installation of the circuit breakers with larger capacity or splitting buses. The 5th MP pointed out the needs of the studies of the voltage maintenance because there were few var-compensators in the bulk power transmission system except for a 200 MVAR capacitor of Phu Lam and utilization of a retired power generator as a synchronous var-compensator with 48 Mvar in Uong Bi.

The series capacitors were planned to be installed in some 500 kV transmission system in order to realize the stable power transmission from Sonla hydropower station and the southern nuclear power station. However, there may be requirements of the study of the effects on the generator-shaft distortional oscillation by series capacitors. System stability seemed to have been checked in the 5th MP through the 1LG-O-C (After occurrence of a single-circuit ground-fault, opening of a single circuit breaker and re-closing), however, severer and more generally assumed faults such as 3LG-O (After occurrence of a three-phase ground-fault and opening of three-phase circuit breakers) have to be applied for checking system stability.

Figure 2-8 shows the power transmission system in 2020 of the 5th MP. The power flows between the north and the south along with the 500 kV transmission lines were planned as shown in Table 2-12. In 2020, power flows were predicted to be from north to south both in wet and dry seasons. The maximum permissible power flow with stable operation of the north-south 500 kV transmission lines will be 1,300 MW when double circuits are completed.

Table 2-12 Planned Power Flows of North to South 500 kV Transmission Lines

	Year 2010	Year 2020
Wet season	Form north to south 800 MW - 1,000 MW	From north to south 800 - 1,100MW
Dry season	From south to north 200MW - 500 MW	From north to south 500 - 800MW

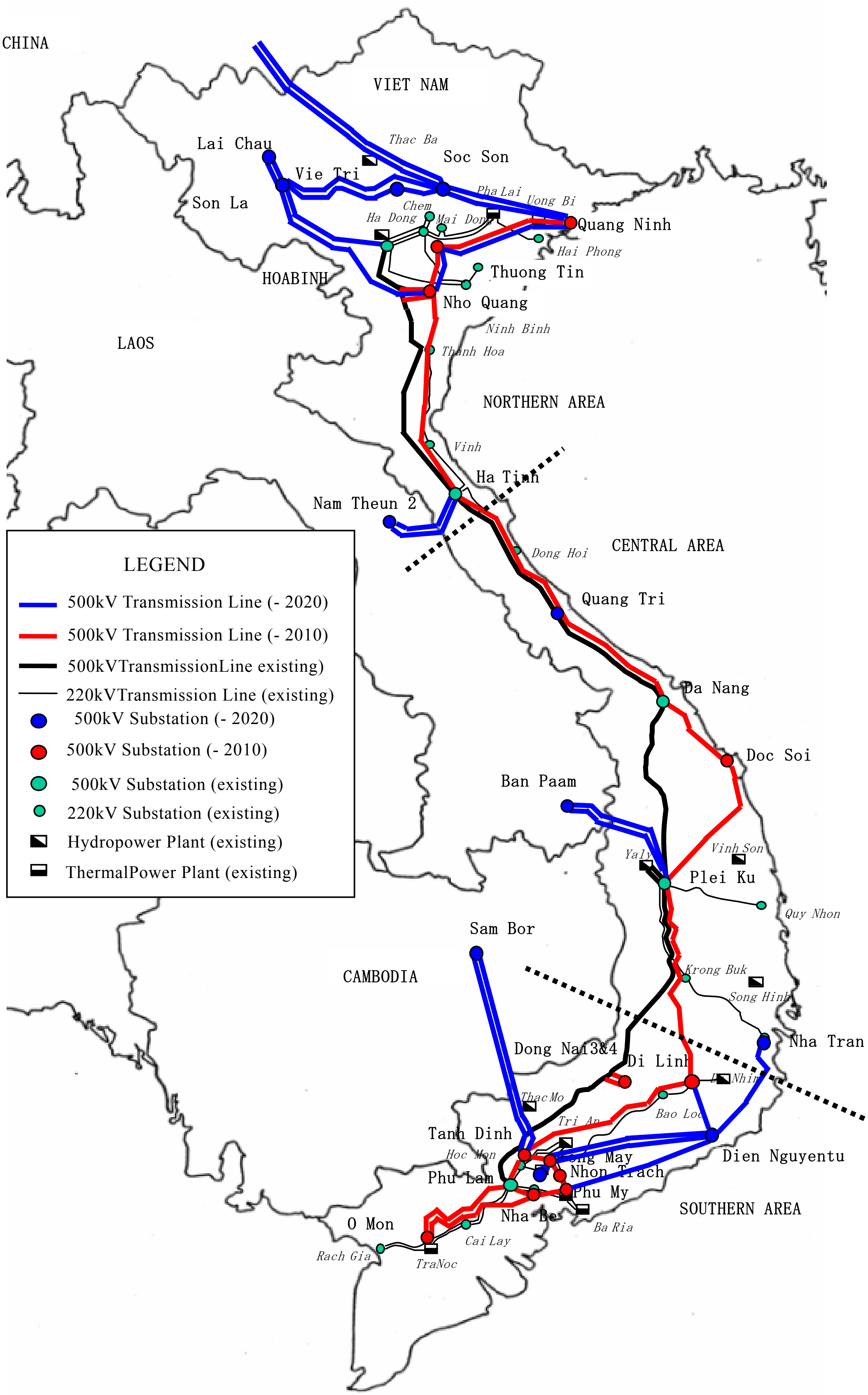


Figure 2-8 Power Transmission System in 2020 of the 5th MP

2.4 Current Economic / Financial Circumstances

(1) Electricity Tariff

a. Fluctuation of the Electricity Tariff Level

The tariff was revised four times since 1997 to increase but at a limited level. The package rate at a weighted average level increased from 5.2 ¢ to 5.6 ¢ in September ,2002. After that, the tariff level has not been raised until now.

b. Fluctuation of the EVN Overall Electricity Rate

The overall rate of electricity actually sold fluctuated from 1997 as follows. This overall electricity rate is obtained by dividing the actual sales by the electricity actually sold (kWh). Accordingly, it is influenced by the structure of users and the charge collection rate, unlike the electricity tariff indicated in item (1) above.

Since 1997, the overall electricity rate has been increasing little by little presumably because of the increase of electricity tariff and improvement of collection rate. The values converted in cent (¢) show a slight fluctuation year by year under the influence of exchange fluctuation.

Table 2-13 Fluctuation of Overall Electricity Rate

	1997	1998	1999	2000	2001	2002	2003
Overall electricity rate (VND)	615	647	645	675	678	707	783
Overall electricity rate (¢)	5.25	4.93	4.62	4.73	4.58	4.63	5.04

Source: EVN internal data

c. Future Electricity Tariff Level

The electricity tariff scheme designed by EVN is submitted by the Ministry of Industry to the prime minister for approval after coordination with relevant ministries. This coordination is intended for the multidimensional evaluation by the relevant ministries of an influence of the electricity tariff hike over the society and economy, because the electricity tariff has a material social and economic effect in Vietnam. From the Vietnamese economic situation, future coordination with relevant ministries is expected to be difficult. Consequently, it is difficult in the current situation to increase the electricity tariff in future.

Meanwhile, a trial calculation says that the package rate must be increased to 7 ¢ in consideration of the financial situation of EVN. Continuous upward rigidity of electricity tariff in future may render ENV short of fund.

(2) EVN Financial Situation

a. Primary Financial Values

The primary financial values in the consolidated financial statements of EVN Group from 2000 to 2004 fluctuated as follows.

Table 2-14 Balance Sheet Item (Unit: Billion VND)

	2000	2001	2002	2003	2004
Total Assets	60,035	63,924	76,174	87,716	98,439
Non-current assets	48,844	51,204	58,545	65,735	74,236
Current assets	11,191	12,720	17,629	21,981	24,203
Equity	27,897	28,747	34,154	36,749	40,540
Long-term borrowings	25,565	26,601	32,640	39,349	45,308
Current Liabilities	6,572	8,576	9,380	11,595	12,533

Source: EVN

Table2-15 Income Statement Items (Unit: Billion VND)

	2000	2001	2002	2003	2004
Net sales	16,510	19,209	23,565	30,245	34,530
Cost of sales	(13,574)	(15,958)	(19,087)	(21,886)	(26,451)
Gross profit	2,936	3,250	4,477	8,358	8,078
Profit from operations	1,947	2,127	3,110	2,880	4,940
Net profit before tax	1,397	1,540	2,328	1,848	3,627
Profit after tax	882	999	1,650	1,828	3,331

Source: EVN

Table2-16 Cash Flow Statement Items (Unit: Billion VND)

	2000	2001	2002	2003	2004
Net cash flows from operating activities	7,311	6,739	8,412	10,903	10,654
Net cash flows from investing activities	(13,696)	(9,206)	(9,913)	(13,522)	(16,232)
Net cash flows from financing activities	7,772	3,426	4,640	4,680	4,954
Net increase in cash	1,387	959	3,139	2,062	(623)
Bank balance and cash at beginning of the year	5,306	6,693	7,653	10,792	12,855
Bank balance and cash at end of the year	6,693	7,653	10,792	12,855	12,232

Source: EVN

b. Primary Values Financially Analyzed

The primary values financially analyzed in the consolidated financial statements of EVN Group from 2000 to 2004 fluctuated as follows.

Table 2-17 Solvency

	2000	2001	2002	2003	2004
1) Current Ratio（%）	170	148	187	189	193
2) Stockholders' Equity Ratio（%）	46	42	45	42	41
3) Cash Flow（Billion VND）	6,693	7,653	10,792	12,855	12,232

Table 2-18 Profitability Ratio

	2000	2001	2002	2003	2004
4) Return on Total Assets (%)	1.5	1.6	2.2	2.1	3.4
5) Return on sales（%）	5.4	5.2	7.0	6.0	9.6
6) Gross Profit to Sales (%)	17.8	16.9	19.0	27.6	23.4
7) Profit from Operation to Sales (%)	8.5	11.1	13.2	9.5	14.3
8) Total Assets Turnover	0.28	0.30	0.31	0.34	0.35

c. Summary of Financial Outline

1) Net sales have doubled in the last five years with steady sales growth.
2) The profitability indices of Table 2-18 show the stable profitability for the last five years.
3) Results from items 1) and2) above show the stable profit for the last five years.
4) At present, a significant part of the investment can be covered by cash income from the operating activities.
5) The Stockholder's Equity Ratio remains at a good level as an apparatus industry though it tends to fall because of the increasing trend of borrowings. For reference, TEPCO marked 16.2% of the Stockholder's Equity Ratio in the year ended March 31, 2004.

3. Power Demand Forecast

The objectives of this chapter are to analyze changes in power demand characteristics estimated in the future in Vietnam, and to prepare an appropriate 6th power master plan. To put it concretely, the actual facts of the past power demand are analyzed and grasped. Further, power demand forecasting models up to 2025 are built up by incorporating the aforementioned social economic development plan, energy consumption trends, and power demand trends by sector, and demand trends by region, etc. At the same time, daily load curves and peak demand are studied.

3.1 The Methods of Power Demand Forecast

(1) Power Consumption Forecast

As follows the result of review of 5th MP, The functions of the model is required by the project are as follows:

① To simulate the relations among economy, energy and power demand;
② To analyze the policy agendas including energy price impact, increasing electrification ratio and fuel conversion of power stations;
③ To evaluate energy saving;
④ To analyze differences between the North, Central and South regions; and
⑤ To make the energy balance between power demand and primary energy.

In the model, the economic indicators that are expressed by the Government and the related organizations are used as external variables. It adopted “Economic Development Forecast Serving Study on Energy Development for the Period up to 2050” as the economic development forecast in this study.

<Economic outlook by scenario >

Three kinds of scenarios are prepared. GDP growth rates are follow;

	2006-10	2011-20	2021-30
1. High Case Accomplish all scenarios	8.5%	8.5%	8.0%
2. Base Case Accomplish most of the scenario, but not all	7.5%	7.2%	7.0%
3. Low Case Not realize the scenario	6.0%	7.0%	7.0%

The power demand is forecasted as one of the areas of energy demand in the sectors. After that, power generation energy and fuel consumption for power supply and energy demand supply balance are estimated. The forecast is carried out by using the Simple-E developed by the institute of energy economics, Japan (IEE,J).

For building the above model, the econometric method is applied according to the above outline, and the model can be classified into two blocks, i.e. the macro economic block and power demand block. The classification clarifies the relation between economic trends and power demand trends. Outline of the Power Demand Forecasting Model is shown in the figure3-1.

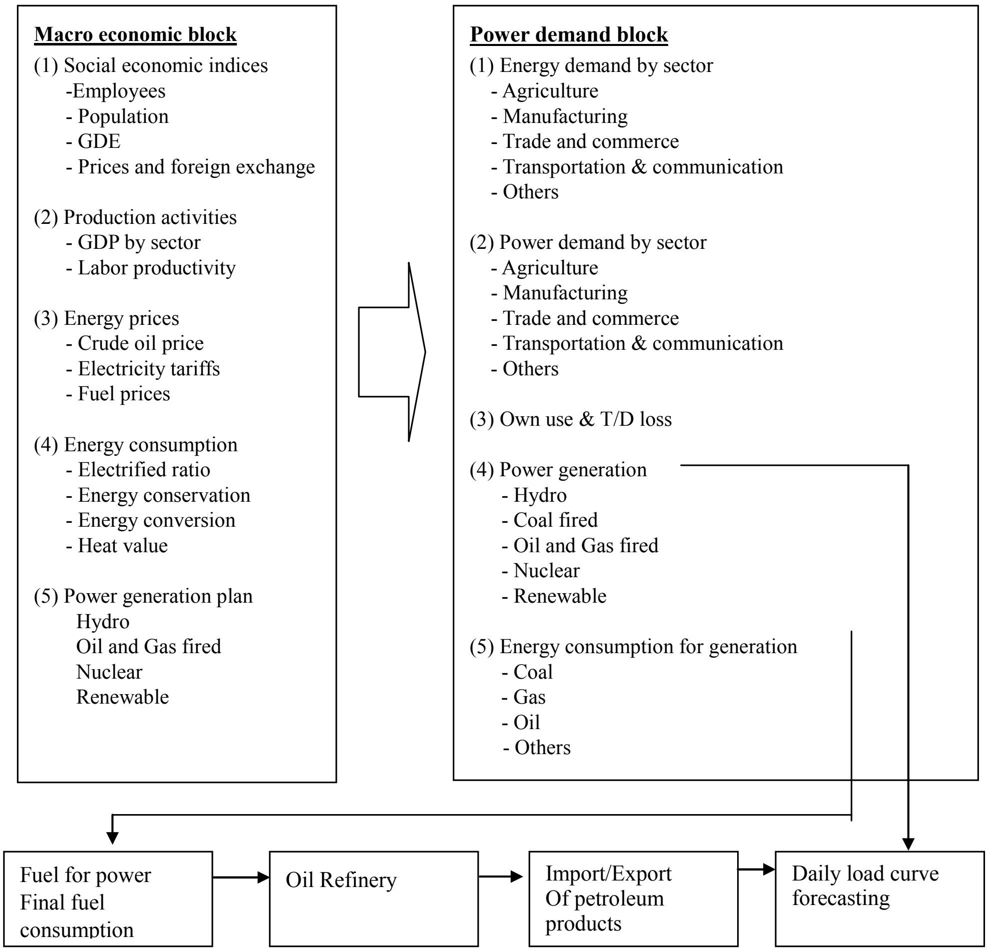


Figure 3-1 Outline of the Power Demand Forecasting Model

(2) The Method of Daily Load Curve Forecasting

The daily load curve in Vietnam is witnessing a shift in terms of increasing daytime demand. Neighbor countries such as Thailand and Malasia have already moved to the developed country type, which shows peak demand during daytime in the summer season, instead of the developing country type, which shows peak demand in the evening. In

Vietnam, the daily load curve is shifting from the nighttime type to the daytime type, and the power consumption characteristics are expected to change into a developed country type with economic development.

As some Asian countries and Vietnam have experiences that the peak demand of their daily load curve moved from the nighttime to the daytime, the regression analysis for Vietnam daily load curve forecast contains the daily load curve data from the countries as explanation variables.

Therefore, based on the actual recourd, the forecast is carried out. As suitable country, Thailand, Malaysia, Philippines, Indonesia and Japan are selected.

A huge amount of data is used for calculation of the daily load curve forecasting model. Thus, high compatibility between the data and regression analysis is demanded for appropriate application of the data. For the model building, the Study Team uses Simple-E. The software is an econometric model-building engine that develops a small econometric model. By using Simple-E, it is expected to increase productivity.

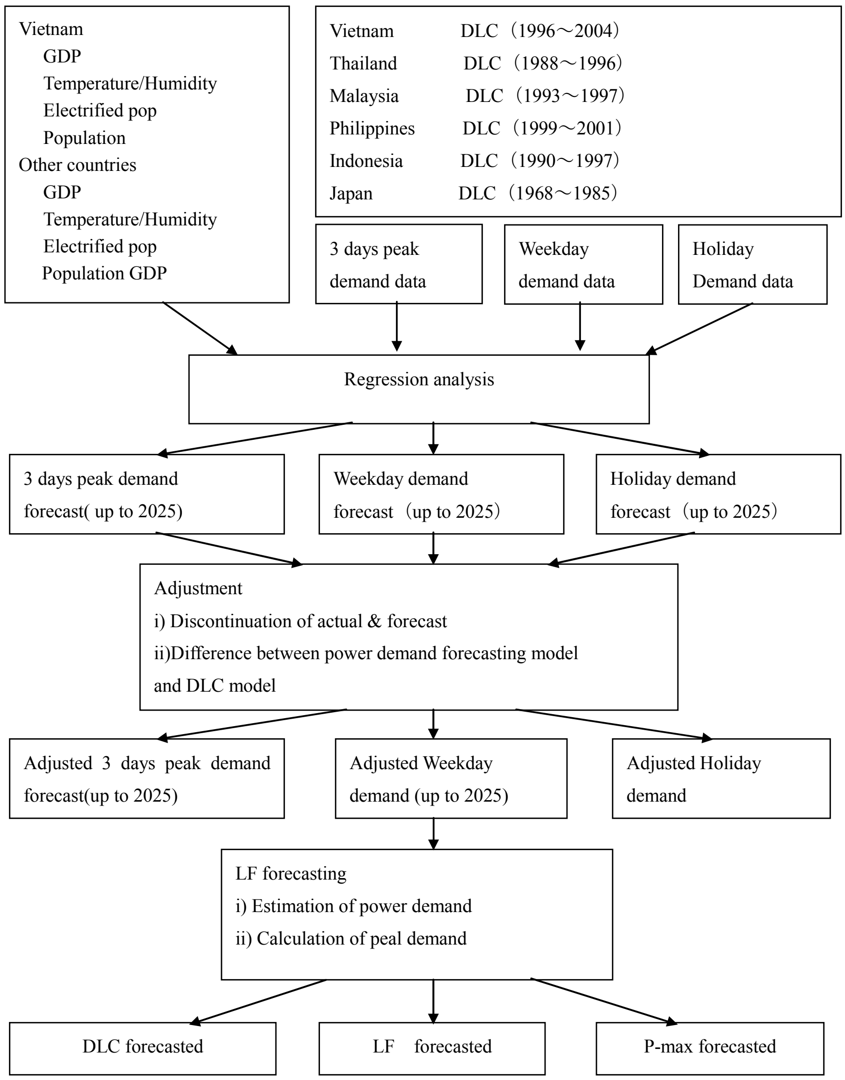


Figure 3-2 Outline of Daily Load Curve Forecasting Model

Daily road courve and peak generation demand forecast are shown in Table 3-1 below;

Table 3-1 Number of the Data Required for Forecasting Daily Load Curve

Region	Explanation variable	Dependent variable	Forecast result of daily load curve
North Central South	GDP by region Temp By region Humidity by region Electrification	3 day peak demand type Weekday demand type Holiday demand type	DLC of the whole country DLC of three regions DLC of types

(3) Demand Forecast for Case Seting

The following economic preconditions are prepared for the power demand forecasting model.

＜Base Case＞

The high economic scenario that is mentioned in the social economic plan is applied to the Base Case of power demand forecasting. power demand from 2006 to 2008 is set with growth rate of 17% for keeping consistency to the five-year power development plan.

＜High Case＞

Under the same condition of the Base Case, power demand from 2006 to 2008 is set with growth rate of 18%.

＜Low Case＞

The economic scenario with high possibility in social economic plan is applied to the Low Case of power demand forecasting. And power demands from 2006 to 2008 are set with growth rate of 16% for keeping consistency to the five-year power development plan.

< Consistency with power demand to Five year-PDP in Vietnam>

The Vietnam government approves the power demand forecasting for the next five years (2006 – 2010). For keeping the consistency between the power demand of the next five years and PDP 6th, the power demand in the model is forecasted assuming the power demand growth rates of the three years, 2006, 2007 and 2008. By the operation, the consistency of the power demand in 2006, 2007 and 2008 is kept between the five-year plan and PDP 6th.

The values in 2006, 2007 and 2008 are as follows; High case 18%, Base case 17%, Low case 16%.

3.2 Result of Power Demand Forecast

(1) Result of Power Demand Forecast

The result of power demand forecast in High, Base and Low cases are shown in the table 3-2 and figure 3-3.

Table 3-2 Result of Power Demand Forecasting

		2005	2010	2015	2020	2025	
Power demand	High	46,000	101,000	172,000	268,000	399,000	
	Base	46,000	97,000	165,000	257,000	381,000	
	Low	46,000	97,000	147,000	216,000	309,000	
Difference From Base	High	0	+4.1%	+4.2	+4.3%	+4.7%	
	Low	0	0	-10.9%	-16.0%	-19.0%	
Growth rate		2005/00	2010/05	2015/10	2020/15	2025/20	2025/05
	High	15.2 %	17.2%	11.2%	9.2%	8.3%	11.4%
	Base	15.2 %	16.1%	11.2%	9.3%	8.2%	11.2%
	Low	15.3%	15.0%	9.8%	8.1%	7.3%	10.0%

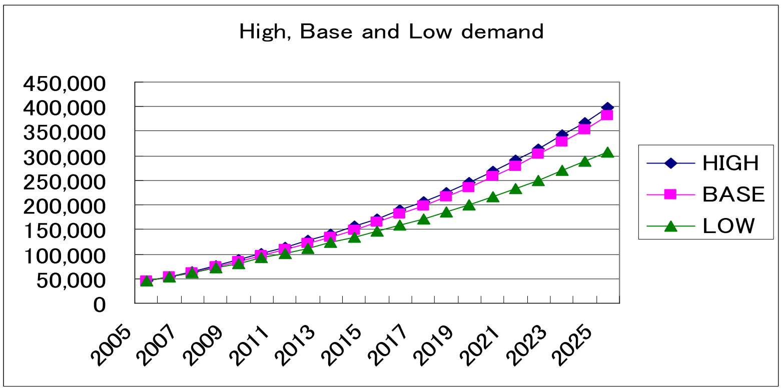


Figure 3-3 Comparison of Power Demand Forecasting

(2) Daily Load Curve Forecast

The principal conclusions to be led from the results of the current daily load curve forecast are as follows;

① In each region, the trend continues, in which the peak demand in the daytime becomes higher than peak demand in the nighttime year by year. A daytime peak and a nighttime peak appear in 2005. In 2010, the daily load curve shows a daytime peak type, which records the P-max at around 11 o'clock in the summer season.

② After 2010, the daytime power demand between 14:00 – 16:00 increases, and Vietnam may approach a developed country type, which indicates two peaks on both sides of the noon recess.

③ The load shapes by type keeps mostly the same proportion as now of daily load curve shapes in peak day, weekday and holiday types.

④ Annual load factors are 0.62 in 2005, 0.64 in 2010, 0.66 in 2015, 0.69 in 2020 and 0.69 in 2025.

(MW)

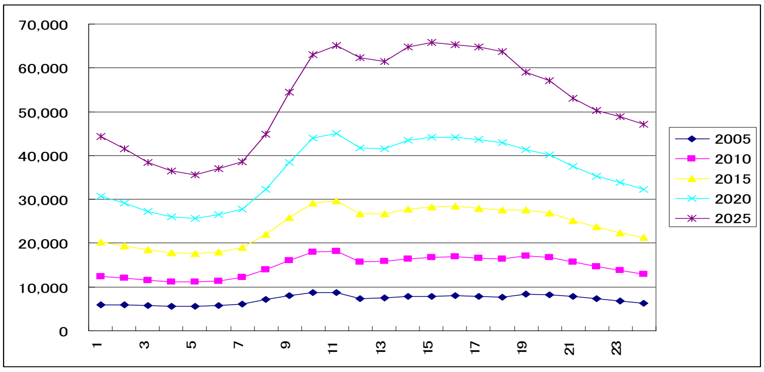


Figure 3-3 Daily Load Curve in July from 2005 to 2025 (Base Case)

(MW)

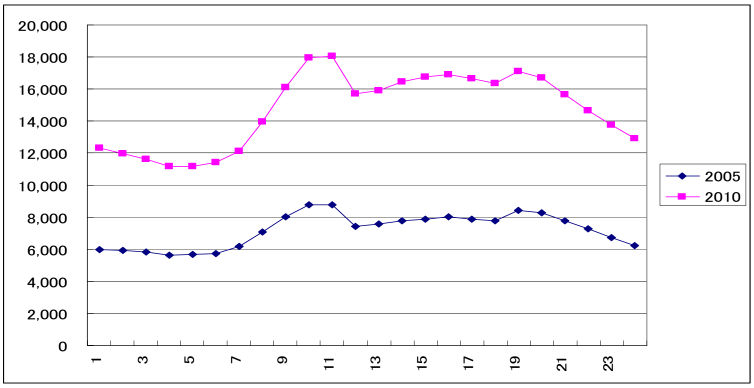


Figure 3-4 Daily Load Curve in July, 2005 and 2010 (Base Case)

(3) Peak Demand Forecasting (Regression Analysis)

Based on the result of the power demand forecast and annual load factor, Peak demand is forecasted.

The result of power peak demand forecast in High, Base and Low cases are shown in the table 3-2 and figure 3-5.

Table 3-3 Peak Demand in High, Base and Low

		Unit	2005	2010	2015	2020	2025	
Peak demand	High	MW	9,900	20,800	33,800	50,200	73,600	
	Base	MW	9,900	20,000	32,400	48,300	71,200	
	Low	MW	9,900	18,900	28,700	40,500	57,300	
Difference from Base	High	%	0	4.0	5.6	4.6	3.7	
	Low	%	0	-5.5	-10.3	-15.6	-19.3	
Growth rate			2005/00	2010/05	2015/10	2020/15	2025/20	2025/05
	High	%	18.7	16.1	10.2	8.2	7.9	10.6
	Base	%	18.7	15.2	10.1	8.3	8.1	10.4
	Low	%	8.7	13.9	8.7	7.1	7.2	9.2

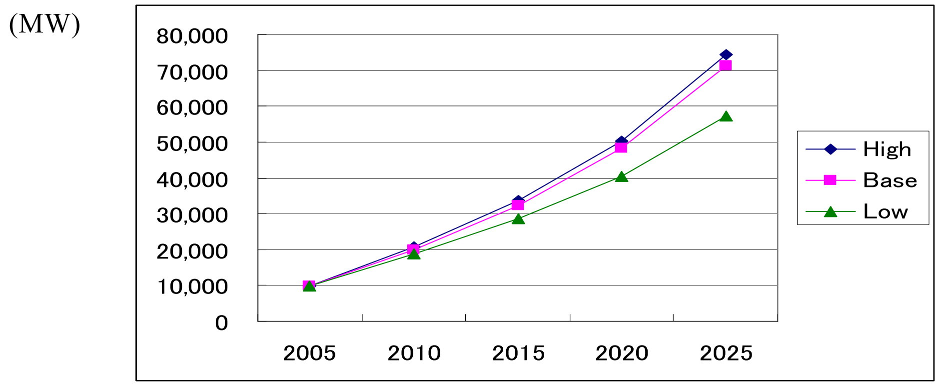


Figure 3-5 Comparison of Peak Demand

(4) Daily Load Curve Forecasting by Aggregation Method

By aggregation method, the future daily load curves are forecasted under the assumption that the pattern of daily load curves in 2004 continues to be similar up to 2025. As the aggregation method does not forecast the monthly power demand, the future monthly demand is forecasted under the assumption that the monthly power demand pattern in 2004 is kept up to 2025.

The aggregation method cannot forecast daily load curve taking into account the changes to move from developing country type to developed country type. However, it is useful as methodology for easily finding the future peak demand.

Accordingly, the daily load curve forecasted by the aggregation method is applied to the study on power generation development plan.

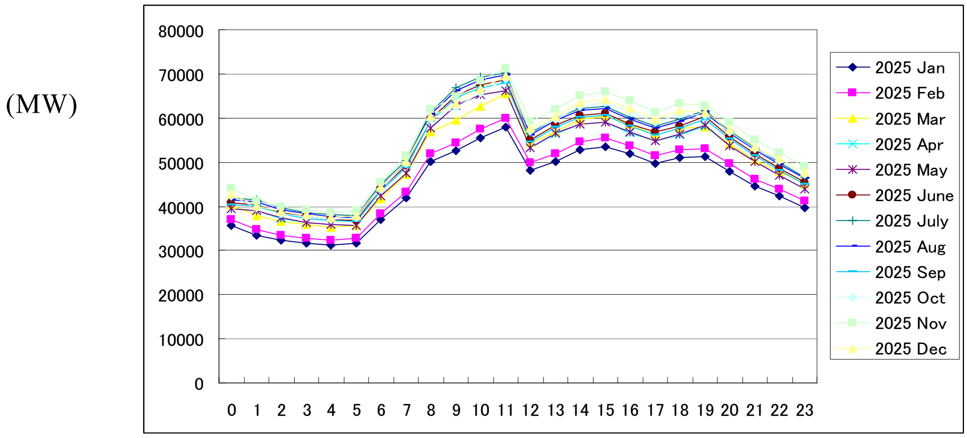


Figure 3-6 2025's DLC by Aggregation Method (Base Case)

4. Primary Energy

The purpose is to study energy supply and demand in accordance with the power development plan up to 2025 and in line with the national energy policy subject for preparation of PDP 6th in Vietnam.

4.1 Energy Policy

(1) Actual records of domestic supply and demand

In accordance with the data of IE Study "The study on analytical survey on final energy consumption and establishment of energy balance table, May 2005," total primary energy supply increased from 7,016 kTOE in 1990 to 42,482 kTOE in 2004. Gas products recorded a big growth rate. The average growth rate of primary energy supply during 2000-2004 was about 7.0%.

Actual records of primary energy supply and demand during 200-2004 are shown in Table 4-1 and in Figure 4-1. Exploitation, production and supply of energy including crude oil, natural gas, coal and electricity in the economic restructuring to date have been strongly developed and have contributed to the social-economic development.

Table 4-1 Actual Primary Energy Supply-Demand in 2000-2004 Unit: kTOE

	2000	2001	2002	2003	2004
Total supply	32,419	34,934	36,275	38,701	42,482
Total final consumption	24,170	25,596	27,183	28,738	31,947
Fuel supply to Power	8,249	9,338	9,092	9,963	10,535

Source: The study on analytical survey on final energy consumption and establishment of energy balance table, IE in May 2005

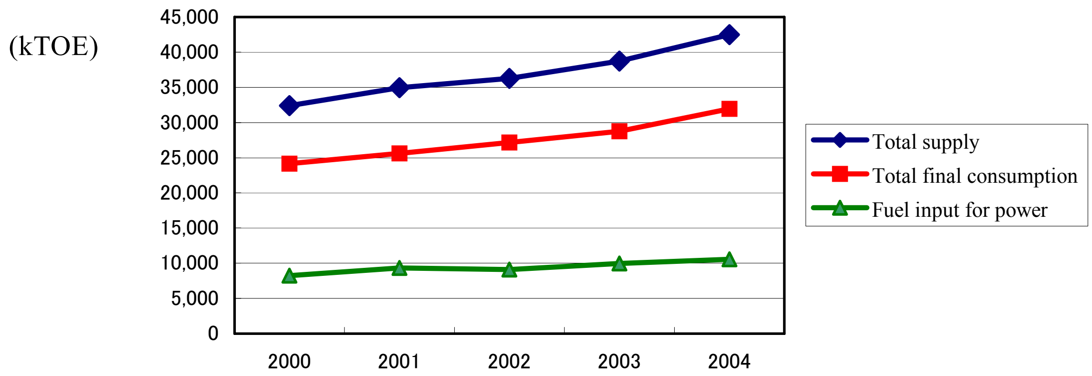


Figure 4-1 Energy Supply and Demand : 2000-2004

(2) Target of Primary Energy Development

In accordance with the Draft Overview on Vietnam Energy Resources and National Energy Policy (summary), MOI, January 2005, the key points of national energy policy are summarized as follows;

a. Promote discoveries and exploration of energy resources, improving proven reserves:

- Oil and gas: annual increase of reserves is about 200 million m^3 oil equivalent; by 2010, total proven reserves reaches roughly 1.3-1.4 billion m^3 oil equivalent; and by 2020, completion of assessment of the proven reserves of oil equivalent in the whole continental shelf and in economic prerogative zone to depth of 400m and in potential water zones between 400-1000m deep.
- Coal: by 2010, complete the survey and assessment of coal reserves from 300m to 1,100m deep, also complete the survey of a partial coal basin of the Hong River Delta; and by 2015, complete the survey of whole coal basin of the Hong River Delta.
- Hydropower: by 2010, about 10 billion kWh and by 2020, about 15-20 billion kWh will be added.
- Uranium: by 2010, about 8000 ton reserves of U_3O_8 grade C1+C2; by 2020, provide enough reliable data of U_3O_8 reserves of the nation.

b. Sufficiently supply primary energy for domestic demand, by 2010 about 47.4-50 million TOE; by 2020 about 91-100 million TOE, of which:

- Hydropower is to be generated at about 35 billion kWh by 2010, 60-65 billion kWh by 2020 and up to 70 - 80 billion kWh after 2020;
- Coal production should reach 35 - 40 million tons by 2010, about 50 – 60 million tons by 2020 of which part is exploited in Khoai Chau (Hung Yen Province); After 2020, develop the domestic coal exploitation to reduce or stop coal imports and increase coal production up to 200 million tons by 2050.
- Oil and gas exploitability in 2006-2010 will be about 30-32 million TOE, about 31-34 million tons/year in 2011-2015 and about 34-35 million tons/year in the period of 2016-2025.

c. New and renewable energy

Increasing the share from existing negligible share to 2% (0.9 million TOE), 3.4% (3.0 million TOE) and 7% (22.0 million TOE) of total commercial primary energy by 2010, 2020 and 2050.

d. Power generation and network

By 2010, reliability of power supply will be 99.7% (LOLE=24hr/year) and the power network standard will be N-1.

e. Oil refinery

Promote the development of oil refineries to gradually meet the domestic demand on petroleum products. By 2009, Dung Quat oil refinery will have been put into operation; in the period of 2011-2015, the 2nd and the 3rd oil refineries will have been developed in Nghi Son (Thanh Hoa Province) and in the Southeast region; by 2020 new oil refineries will have been considered for expansion of construction, making the total capacity of domestic refineries up to 25 - 30 million tons of crude oil.

f. Environment

Put forward long-term targets and standards on environment in accordance with international and regional environmental standards and national economic conditions. All energy projects must satisfy the environmental standards by 2010.

g. Nuclear power generation

Get conditions ready to put the first nuclear power in operation by 2020, and increase the share of nuclear energy to 10-11% of total commercial energy consumption by 2050.

h. International cooperation

Develop power network interconnection with voltage up to 500kV by the period of 2006-2010, gas network interconnection in the period 2015-2020 and conduct energy import-export rationally and effectively on the basis of conservation of national energy resources.

4.2 Energy Demand and Supply Balancing Plan up to 2025

(1) Preconditions

As well as power demand forecasting, the following economic preconditions and conditions by sector are prepared for the energy demand forecasting study as the following three cases (High, Base Low).

a. Sectoral Energy Consumption Ratio

Primary energy is divided into final energy consumption by sector and fuel consumption in the power sector. Fuel consumption in the power sector such as coal, gas and fuel oil etc. cannot be finalized before determining PDP 6th. Meanwhile, final energy consumption can be calculated based on the energy consumption by sector.

b. Reconditions for Energy Consumption in Power Sector

Energy consumption in the power sector will be decided after preparation of PDP 6th. In this study, energy consumption forecasting model is set tentatively, taking into consideration those factors such as capacity of future power plant, plant factor and energy consumption intensity for calculation of energy consumption at this stage.

(2) Results of Energy Demand and Demand Balancing Study

The Study Team together with IE counterparts studied the power demand forecast from 2005 to 2025 based upon the statistical data in the period of 1990-2002

a. Domestic Final Consumption

Total demand of domestic final consumption is forecasted to increase with growth rate of 4.0% per year in Base Case and 5% in High Case by the Study Team/IE as 31,751 kTOE of both Base Case and High Case in 2005, and 70,762 kTOE of Base Case, 91,026kTOE of High Case in 2025

Table 4-2 Domestic Final Consumption Forecast : Base Case (Unit: kTOE)

	2000	2005	2010	2015	2020	2025
Oil products	6,760	11,318	17,815	27,245	37,360	43,255
Gas	18	450	818	1488	1,950	2,000
Coal	3,223	5,204	6,177	8,436	10,584	10,985
Renewable	14,191	14,779	14,914	15,415	15,483	14,522
Total consumption	***24,192***	***31,751***	***39,724***	***52,584***	***65,377***	***70,762***
Growth rate (%)		5.59	4.58	5.77	4.45	1.60

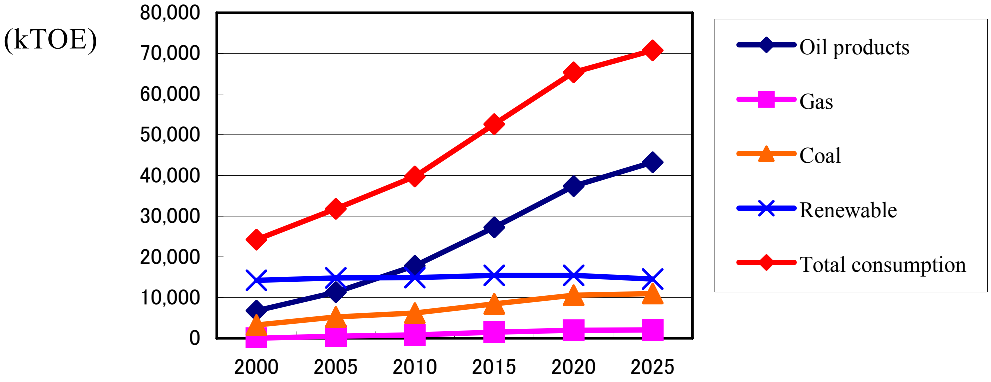


Figure 4-2 Domestic Final Consumption Forecast : Base Case

b. Fossil Fuel Consumption in Power Sector

Fossil fuel demand in the power sector is forecasted to increase with annual average rate of 11.27 % in Base Case, 11.66% in High Case. Energy consumption in the power sector is estimated as about 6,718 kTOE (Base Case and High Case) in 2005, and 56,846 kTOE (Base Case), 61,012 kTOE (High Case) in 2025

Table 4-3 Forecast of Fossil Fuel Consumption in the Power Sector : Base Case

(Unit:kTOE)

	2005	2010	2015	2020	2025
Total Consumption	***6,718***	***12,681***	***21,576***	***35,335***	***56,845***
Coal	1,799	6,138	10,352	23,220	44,297
DO	60.8	13.0	16.0	15.7	15.6
FO	903.5	847.7	591.3	579.21	575.8
NG & AG	3,954	5,682	10,770	11,520	11,957

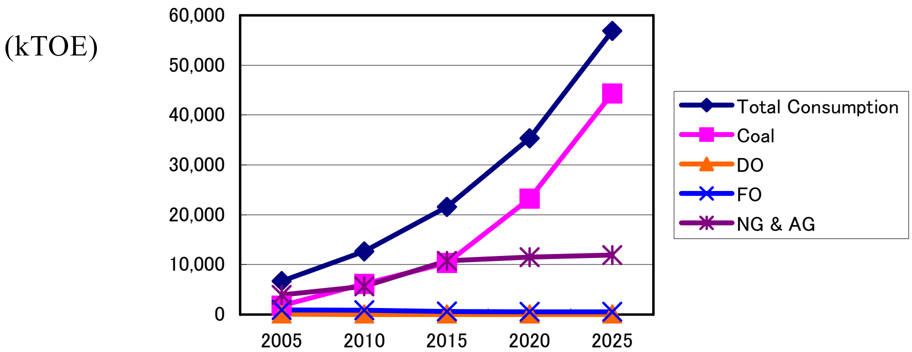


Fig.4-3 Fossil Fuel Consumption in Power Sector : Base Case

c. Energy Supply from Vinacoal and Petrovietnam

Concerning domestic fossil fuel supply based upon energy development plan from Vinacoal and Petrovietnam in the period of 2005 – 2025, it is estimated that average annual growth rate is about 6.47% for oil products, 5.17% for gas and 4.39% for coal in Base Case, and 7.06% for oil products, 5.17% for gas, 5.01% for coal in High Case.

Table4-4 Primary Energy Supply forecast: Base Case (Unit: kTOE)

	2000	2005	2010	2015	2020	2025
Oil products	7,757	11,402	17,815	20,360	33,289	39,946
Gas	1,440	5,418	9,234	13,500	14,058	14,841
Coal	4,718	8,636	15,726	18,171	19,848	20,381
Renewable	14,191	14,779	14,914	15,415	15,483	14,522
Hydro	4,314	4,292	8,856	14,088	19,320	19,320
Total	***32,400***	***44,526***	***66,545***	***81,534***	***101,997***	***109,011***
Growth rate (%)		6.55	8.37	4.15	4.58	1.34

Source: Coal; Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.and Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam

d. Fossil Energy Supply and Demand Forecast

It is forecasted that average annual growth rate of domestic energy supply is about 4.6% for Base Case and 5.1% High Case, meanwhile, average annual growth rate of energy demand is 5.8% for Base Case and 7.3% for High Case. Domestic energy supply and demand can be balanced until 2020. However, after 2020, since supply capacity will be saturated due to limitation of reserves of energy resource, domestic energy supply cannot meet the demand in both cases.

Table 4-5 Total Supply-Demand forecast : Base Case

(Unit: kTOE)

	2000	2005	2010	2015	2020	2025
Total Supply	32,420	44,526	66,545	81,534	101,997	109,010
Total Demand	26,119	38,469	52,405	74,340	100,713	127,608
Balance	***6,301***	***6,057***	***14,140***	***7,194***	***1,2842***	***-18,598***

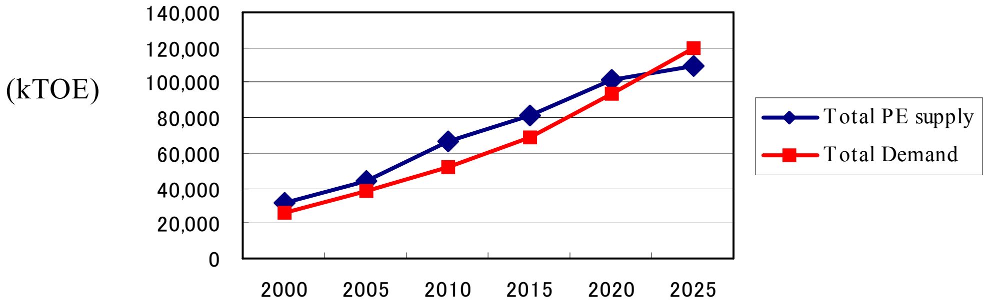


Fig.4-4 Total Supply-Demand : Base Case

1) Coal Consumption in Power Sector

According to the report of "Coal production and consumption, coal supply-demand forecast, domestic coal supply for power generation and evaluation on coal import capability" June.15, 2005 by Vinacoal, in Base Case, from 2010-2015 Dust Coal 5 used for the power sector runs short by about 2.4 million tons in 2010 and 7.7 million tons in 2025.

In the Study, coal supply for the power sector is not sufficient in operation of coal-fired thermal power plants after 2010, and runs short by about 2.78 million tons) by 2015, about 23 million tons) by 2020, about 57.5 million tons in Base Case.

Table 4-6 Coal Supply-Demand Forecast for Power Sector : Base Case

(Unit : kTOE)

		2005	2010	2015	2020	2025
Coal supply to Power Sector		2330	7,428	8,686	9,598	9,810
Demand	Vinacoal	2,330	8,764	12,054	14,123	14,123
	JICA/IE	1,800	6,138	10,352	23,220	44,298
Balance	Vinacoal	0	-1,336	-3,368	-4,525	-4,313
	JICA/IE	530	1,290	1,666	-13,622	-34,488

Source: Production: Coal Reserves, List of Mines and Coal Exploitability for each period up to 2025. Vinacoal, June 2005.
Demand: Coal production and consumption, Coal supply-demand forecast, Domestic coal output for power generation and Evaluation on coal import capability. Vinacoal, June 2005

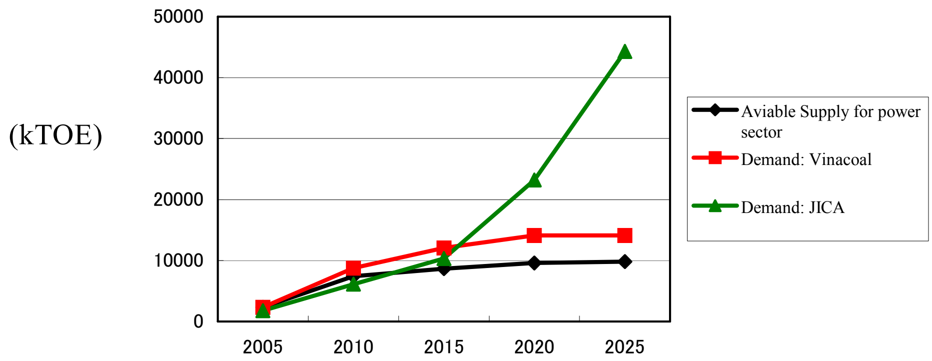


Figure 4-5 Coal Supply-Demand in Power Sector : Base Case

2) Gas Demand in Power Sector

According to the report of "Strategy on Vietnam Oil and Gas Sector Development up to 2015 and Orientation to 2025" February 2005 by Petrovietnam, gas exploitation volume reached 6.02 billion m3 in 2005. Since then, with annual growth rate of exploitation of 5.16%, exploitation volume is forecasted to increase up to 16.5 billion m3 in 2025 . All gas production is consumed domestically.

On the contrary, since gas supply capability is limited to around 16 million m3, total capacity of gas fired thermal power plant is limited to around 17GW.

Table 4-7 Comparison on Gas Demand Forecast :Base Case

(Petrovietnam plan and JICA team study) (Unit:kTOE)

	Data	2005	2010	2015	2020	2025
Gas supply	Petrovietnam	5,400	10,080	13,950	14,490	14,400
Consumption in Industry Sector	Petrovietnam	1,368	1,710	2,070	2,700	4,914
	JICA/IE	450	818	1,488	1,950	2,000
Consumption in Power Sector	Petrovietnam	4,050	5,670	11,880	11,790	9,486
	JICA/IE	3,954	5,682	10,770	11,520	11,957
Total demand	Petrovietnam	5,400	10,080	13,950	14,490	14,400
	JICA/IE	4,404	6,500	12,258	13,470	13,957
Balance	Petrovietnam	0	0	0	0	0
	JICA/IE	9964	3,580	1,692	1.020	443

Source: Strategy on Vietnam oil and gas sector development up to 2015 and orientation to2025, February 2005, Petrovietnam and Situation of supply and consumption of oil and gas in Vietnam. July 2005, Petrovietnam

4.3 Fossil Fuel Prices for Power Sector

Referring to the Vinacoal study "Statistics on coal price and coal price forecast in the future" dated 15 June 2005, and Petrovietnam report, the Study Team and IE estimate and predict the fossil fuel prices for power sector, providing crude oil prices in a range of 60-40US$/barrel, escalation rate of about 2% per year for import fuel and about 1% per year for domestic fuel.

In this estimation, domestic coal prices for South and North include transportation cost of 7US$/ton and 3US$/ton respectively.

Table 4-8 Fossil Fuel Prices for Power Sector

Item	Unit	2005	2010	2015	2020	2025
Domestic-Coal	US$/ton	21.4	23.6	26.1	28.8	33.4
South Coal	US$/ton	28.5	30.7	33.2	35.9	39.8
North Coal	US$/ton	24.4	26.6	29.1	31.8	36.4
Import-Coal	US$/ton			51.7	54.31	57.1
DO	US$/ton	398.2	418.5	439.9	462.3	485.9
FO	US$/ton	217.2	228.2	239.9	252.1	265.0
Domestic-Gas	US$/MMBtu	3.14	3.46	3.82	4.22	4.66
Import-Gas	US$/MMBtu	3.37	3.72	4.11	4.54	4.54
Crude Oil	US$/barrel	60.0	40.0	40.0	40.0	40.0

Source: Vinacoal and Petrovietnam reports, Study Team estimates

5. Power Generation Development Plan

5.1 Study Flow of Power Generation Development Planning

The long term power system development plan is established for the coming 20 years by the least cost planning method. The power plant candidate sites are evaluated from economic and social environmental aspects. The evaluation results are reflected into the power generation development plan.

The power generation development planning is carried out according to the study flow described in Figure 5-1-1 by using PDPAT II and STRATEGIST as planning assistance tools.

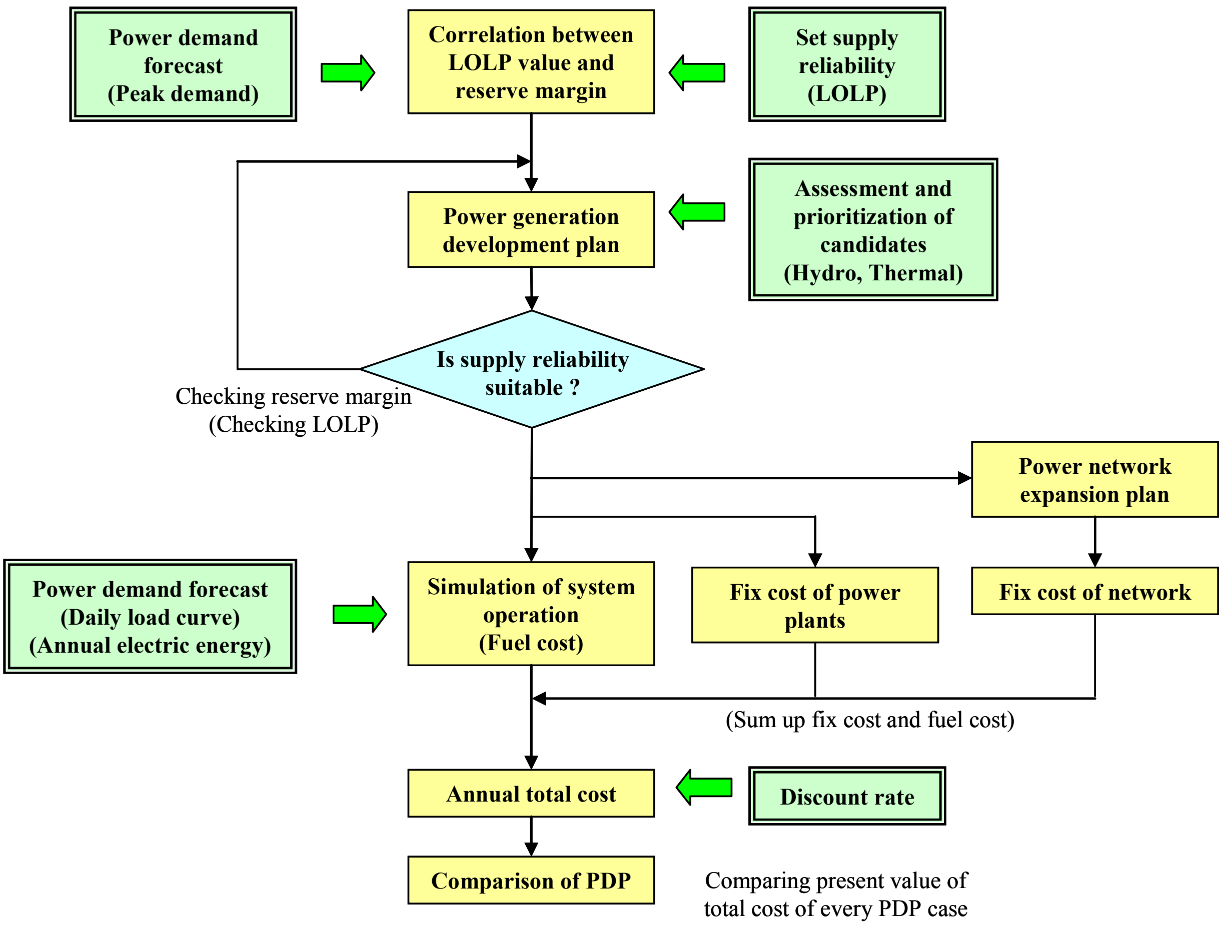


Figure 5-1 Study Flow of Power Development Planning

As illustrated in this figure, the power generation development plan should be drafted in harmony with many fields, such as demand forecasts, power system analyses, selection of power plant candidates, financial condition and power development policy. Therefore, the power generation development planning is conducted through close contact and discussions with the counterparts and good coordination among the related working groups.

5.2 Necessary Supply Capacity to Secure the System Reliability Criteria

(1) Relationship between LOLE and Reserve Margin

The system reliability situations in 2015, 2020 and 2025 are analyzed based on the demand forecasts (Base Case) and the original power development plan by IE, in the north system and the central & south system respectively.

The study is carried based on the original power development plan by IE The fuel composition and installed capacity from 2003 to 2025 by region based on the original development plan by IE (Base Case) are shown in Figure 5-2.

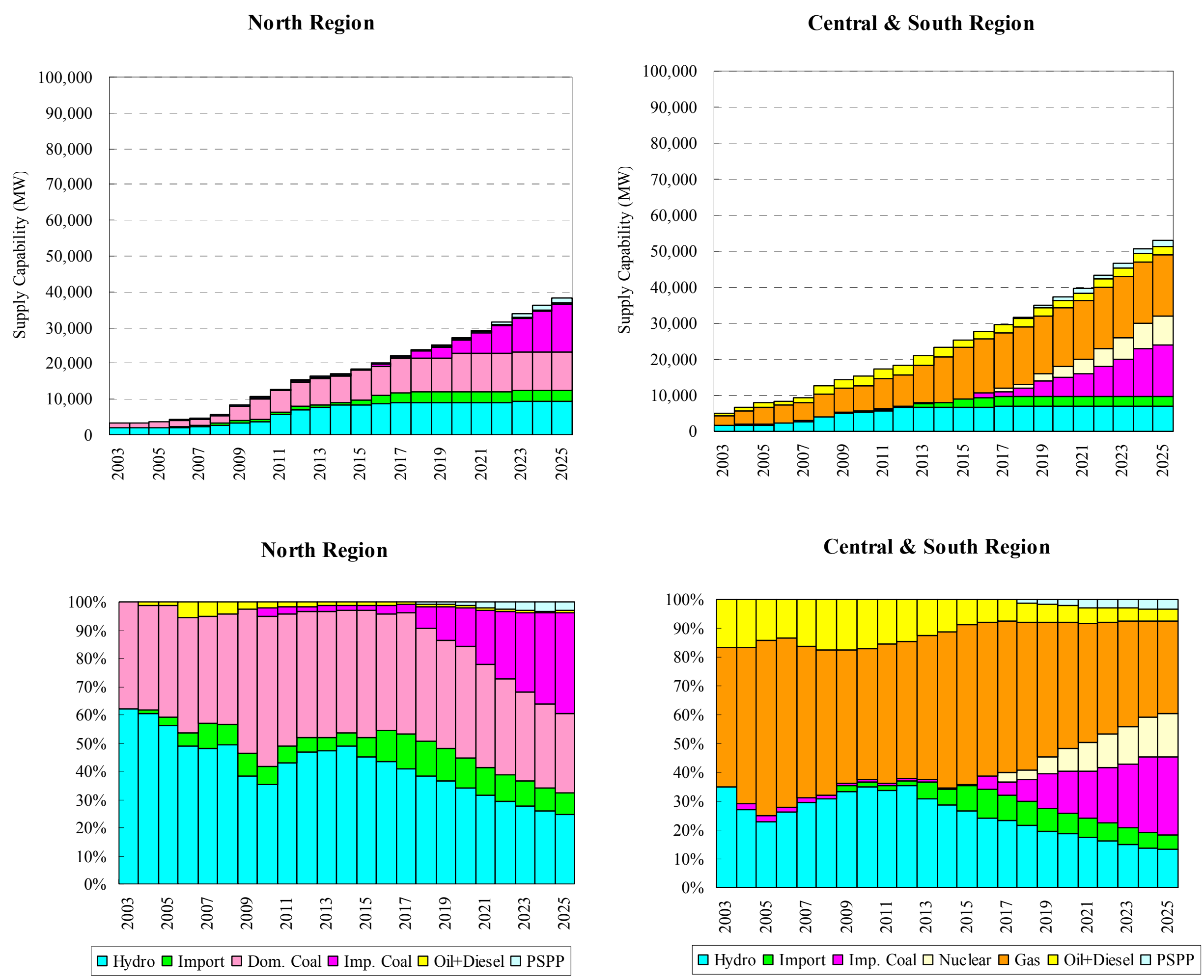


Figure 5-2 Installed Capacity and Fuel Composition by Region based on IE original plan (Base case)

The result is shown in figure5-3. The relationship between reserve margin and LOLE in the north system does not change significantly. The reserve margin of 7-8% is required to secure the system reliability criteria LOLE 24-hour.

Apart from that, the relationship in the central & south system changes year after year, the required reserve margin increase from 8% in 2015 to 10% in 2025.

The forced outage rate of thermal power plants, especially a coal thermal plant, is larger than hydropower plants. The coal thermal power is planned for installation after 2015 in the south system. The increase of composition rate of coal thermal power plant, therefore, leads to the increase of the required reserve margin in order to secure the system reliability criteria.

(North System) (Central & South System)

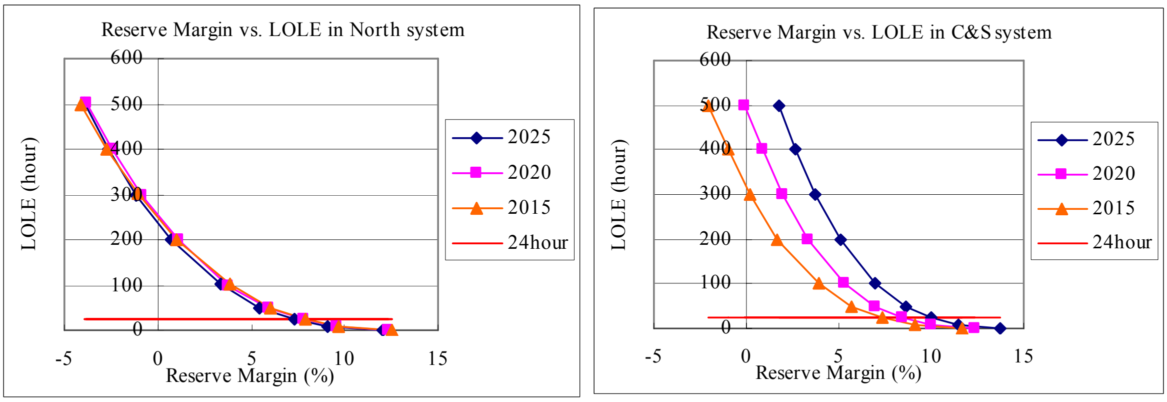


Figure 5-3 Relationship between Reserve Margin and LOLE

(2) Relation between Capacity of Interconnection and Reserve Capacity Reduction

The increase in the interconnection capacity brings out possibility of reduction of reserve capacity in the whole power system, therefore, relation between Amounts of Reduction in Power Development and Interconnection Capacity in 2025 was analyzed. The result is shown in the figure5-4.

The amount of reserve capacity reduction is saturated at approximately 900MW, when the interconnection capacity is 2000MW. The difference of reserve capacity reduction between 1,000MW and over 2,000MW is only 140MW, which means there is little advantage in investing in reinforcement of interconnection facility more than 1,000MW. Thus, the interconnection capacity for the PDP simulation is set around 1000MW from the viewpoint of efficiency of the system reliability improvement.

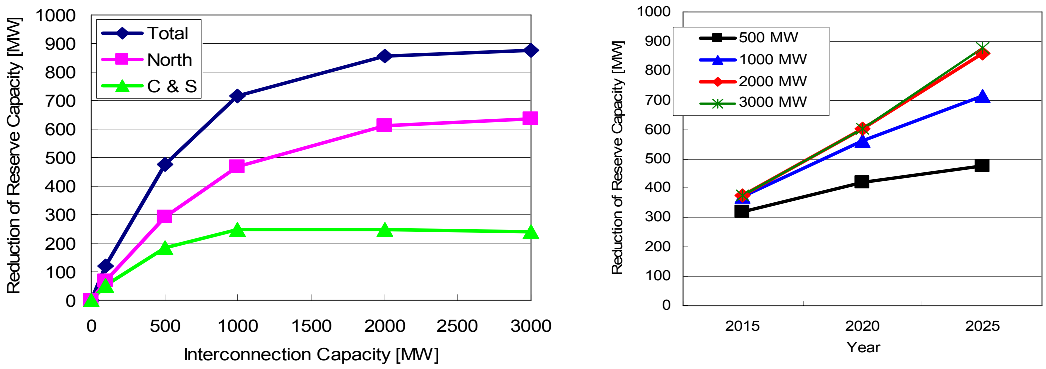


Figure 5-4 Relation between Reduction of Reserve Capacity and Interconnection Capacity

5.3 Vision of Power Generation Composition in 2025

(1) Comparison of Generation Costs of Power Sources

The screening curve analysis of generation cost by type in 2015 is conducted for preparation of the development scenarios in Vietnam.

Annual generation cost comprises fixed costs (depreciation, interest and O&M costs) and variable costs (mainly fuel costs).

Here, the gross efficiency of pumping for PSPP is assumed at 70% and coal thermal generation energy are applied for pumping energy. The discount rate of 10% is applied.

The results of screening are shown in Figure 5-5. The results are calculated at the sending end of power station taking into consideration own use energy.

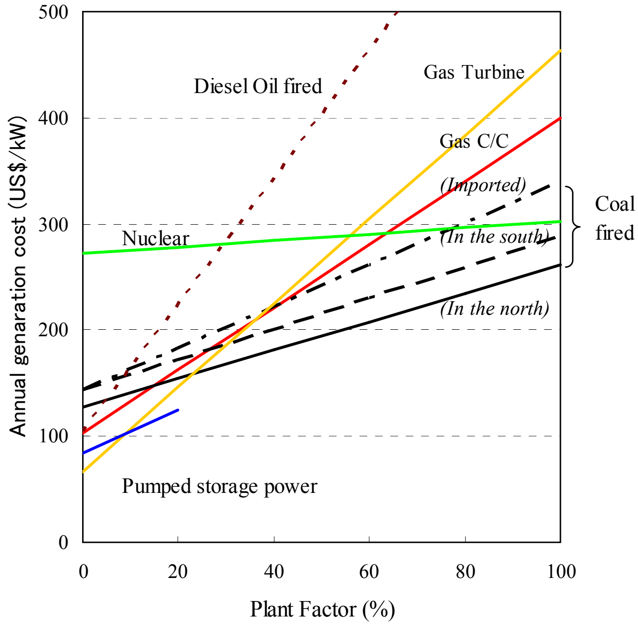


Figure 5-5 Annual Costs in 2025
(Pumping Energy; Coal case)

Pumped storage PP and gas turbine are suitable for the peak supplier, gas fired C/C are suitable for the middle supplier, and coal fired thermal PP is suitable for the base supplier. Although nuclear power plant can be more economical than coal thermal power using imported coal in the south under the condition of over 85% capacity factor in 2025. Therefore, it can be said that nuclear power plant is less economical than any type of coal fired thermal power plant until 2025.

(2) Least Cost Development Plan Study

a. Alternation of Coal Thermal vs. Gas CC in the Center & South System

Since there are no alternatives in the North system except for hydropower and coal fired thermal but there are alternatives in the Central & South system, the Study Team carry out simulation of system operation in 2025 by using PDPATII with various cases of composition of coal thermal and gas C/C in the Central & South system, and compares the total annual generation cost of the whole system.

From this result, the optimum power generation development plan in 2025, of which total annual power system operation cost is the least, is determined.

The results of analysis indicate that the 6000MW of gas combined cycle power plants replaced by the coal thermal from IE original plan is the most economical as shown in Figure 5-6. In Figure 5-6, the original point is the case of IE original development plan and plus value of X axis means increase of coal thermal development and decrease of gas C/C development.

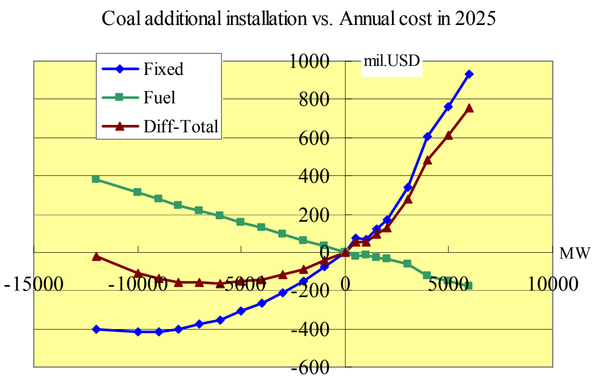


Figure 5-6 Alternation of Coal Thermal vs. Gas CC development

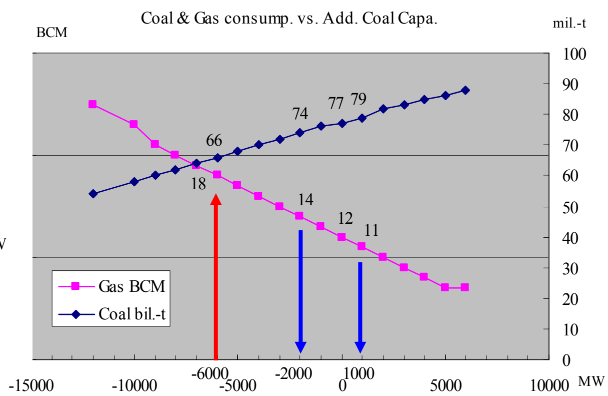


Figure 5-7 Fuel Consumption by Coal Thermal and Gas CC Capacity

The fuel consumption of gas and coal in the least cost plan is that the gas consumption is 18 BCM per year and the coal consumption is 66,000 ton per year (refer to Figure 5-7). However, the gas supply capability according to the latest Petrovietnam master plan is limited to 14 BCM per year. When gas supply capability is taken into consideration alternation from coal thermal to gas CC is also limited to 2000MW.

b. Appropriate Development Amount of PSPP

In other words, the most economical development amount of PSPP is studied the same as in the previous section study.

PSPP capacity in the Nouth and in the Nouth South vs. total annual cost difference of each system is shown in Figure 5-8.

PSPP capacity of 1200MW is planed for development based on the original power development plan by IE, however, the bottom of the total annual generation cost can be seen at the PSPP capacity of 2000MW. Accordingly, additional PSPP of 800MW is recommended for development in the North system from the viewpoint of the least cost development plan.

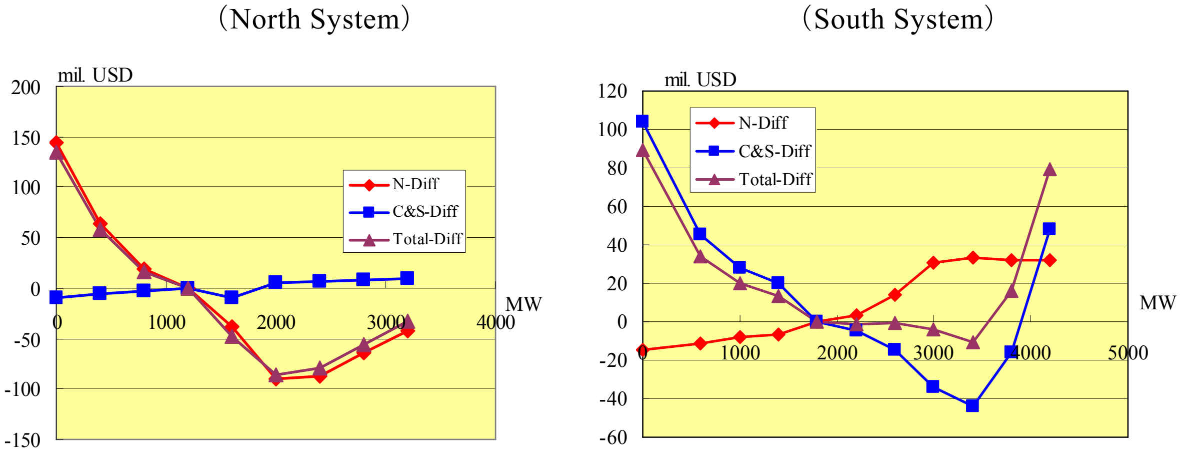


Figure 5-8 PSPP Capacity in North & South System vs. Total Annual Cost Difference in 2025

PSPP capacity in the south system is 1800MW in the original power development plan by IE. Annual cost reduction cannot be seen in the case of additional PSPP installation in the Central & South system. Accordingly, the original PSPP capacity of 1800MW in the Central & South system is appropriate.

c. Conclusion

It is more economical to substitute 2000MW of coal thermal power to gas combined cycle thermal power in the south system, and to increase 800MW of PSPP in the North system from the IE original plan, and decreasing equivalent amounts of coal thermal power is more economical, Totally the annual generation cost of 175 million US$ can be reduced from the original development plan by IE.

Another, nuclear power is less economical than imported coal fired thermal power plant until 2025 as mentioned in the screening study. Accordingly, the vision of power generation composition from the viewpoint of the least cost development plan in 2025 is as illustrated in Figure 5-9.

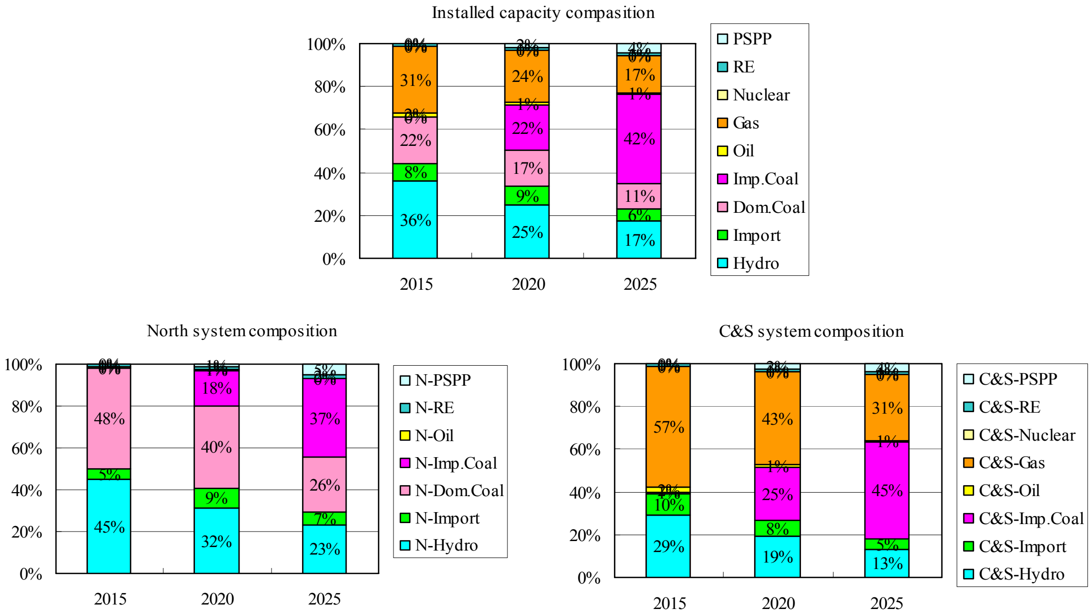


Figure 5-9 Optimum Power Generation Compositions by the Least Cost Power Development Planning (2025)

However, the daft of energy policy states that the first unit of nuclear power is to be put into operation by 2020. Furthermore, nuclear power has several advantages in that the amount of carbon dioxide emissions is small and it has fuel stock effect (once the nuclear fuel is installed, it can continue to generate for around 1.5 year). Therefore, the Study Team agrees on the installation of nuclear power up to as much as 8000MW of IE original development plan by 2025 from the viewpoint of national energy security.

The vision of power generation composition in 2025 taking into account installation of nuclear power is as illustrated in Figure 5-10.

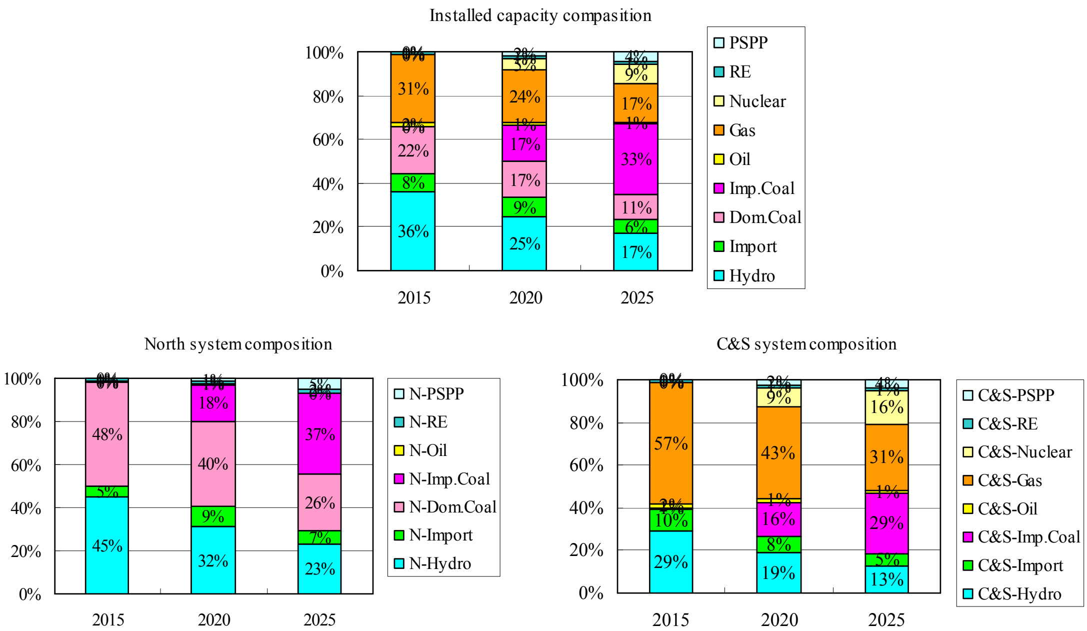


Figure 5-10 Power Generation Compositions Taking into Account Nuclear Power

5.4 Risk Study of Power Development Plan

(1) Drought Effect on Supply Capability of Hydropower

There are big differences between actual records from 1996 to 2004 and plan of output of Hoa Binh hydropower plant at the daily peak demand hour.

The average actual output at the daily peak demand hour in dry season is 1,400MW and the one in rainy season is 1,600MW as shown in Figure 5-11. The actual output of 90% probability at the daily peak demand hour in the dry season is 1,100MW and that in the rainy season is 1,350MW based on the actual operation records as shown in Figure 5-12.

The reason why the available capacity in dry season becomes dormant is because there is not enough water volume in reservoirs to operate at an available capacity for current peak duration time of 4 hours a day.

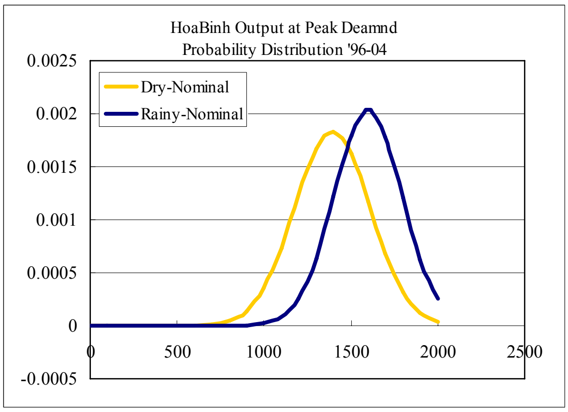


Figure5-11 Estimated Nominal Distributions of Hoa Binh Outputs from 1996 to 2004

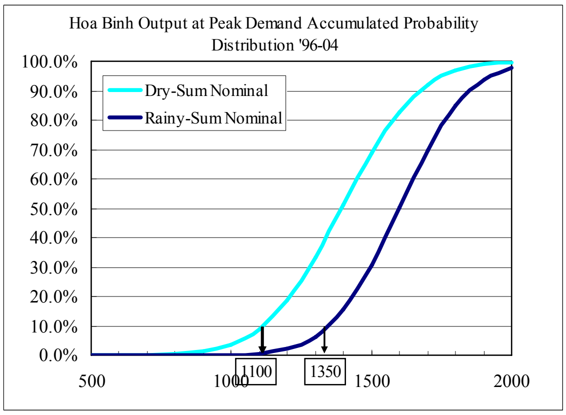


Figure5-12 Accumulated Probability of Hoa Binh Outputs from 1996 to 2004

The distribution of the hydropower output fluctuation is estimated as shown in Figure 5-5-3. The average of distribution in drought year is shifted 200MW from that in normal year.

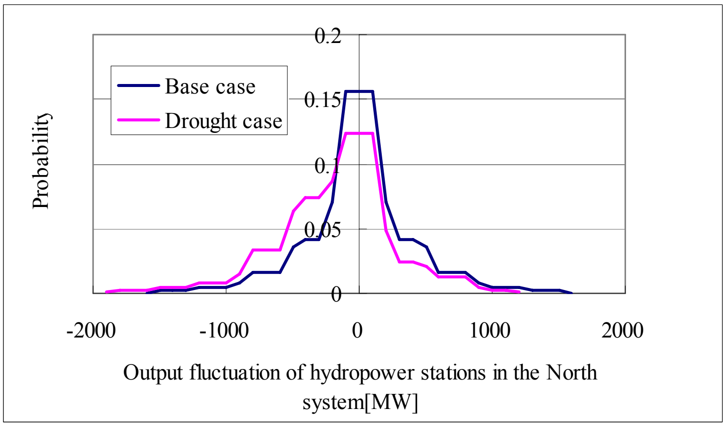


Figure 5-13 Hydropower Output Distributions in Drought year and in Normal year

The effect is evaluated from the system reliability aspect in 2025. The hydropower outputs from new hydropower plants are assumed as planned. The necessary reserve margins in the north system are affected crucially by the above mentioned fluctuation of hydropower supply capability and increase 1-3% from 7-8% to 8-10%. The difference of necessary reserve margins between drought year and normal year becomes small in the future in line with decrease in the composition ratio of hydropower.

On the contrary, the necessary reserve margins in the C&S system do not change, because there is little difference between actual record of output and planned output.

(2) Power Import from Neighboring Countries

The effects on the annual generation cost caused by the limitation of imported power from neighboring countries are simulated. The annual costs in the north system are varied from minus 40 to plus 156 million US$ in comparison with the Base Case. The annual cost in the north system decrease 40 million US$ in 2020 without the power import from China.

The price of purchase from China is higher than increasing of the annual cost in the north system, therefore, when price of power purchase from neighboring countries is higher than the marginal cost of the power system in Vietnam, the development of North system coal thermal power plants using domestic coal should be made the first priority.

On the other hand, the annual costs in the north system increase 156 million US$ in 2025 without the power import from Laos.

The annual costs in the C&S system are also fluctuated from minus 4 to plus 116 million USD in comparison with the Base Case. The annual cost in the C&S system decreases a little or nothing without power import from Laos. The annual cost in the C&S system increases 72 million US$ in 2020 and 76 million US$ in 2025 without the power import from Cambodia. Because of these price of purchase Power import from Laos and Cambodia are cheaper than the generation cost of gas thermal power plants.

(3) Fuel price hike

Effect of the fuel price hike is analyzed in two cases. Fuel costs of imported coal and oil are hiked at 1.5 and 2 times the escalation rate of the Base Case. Another case is that all fuels including domestic production are hiked at 1.5 and 2 times the escalation rate of the Base Case.

The incremental fuel cost in the imported fuel price hike case leads to increase of generation costs at the maximum 0.4 cent/kWh in 2025 in the both systems.

The incremental fuel cost leads to increase of generation costs at the maximum 0.7 cent/kWh in 2025 in both systems.

Annual Costs vs. Capacity Factor for every type of power plant of Base Case and Double escalation rate of Base Case are shown in Figure 5-14 and in Figure 5-15 respectively. As evidenced by these Figures, in the case that escalation rate of fuel prices is double that of the Base Case, since nuclear power becomes more economical than coal fired thermal power plant in the range of the large capacity factor, the composition ratio of nuclear power development should be increased form the viewpoint of least cost development planning.

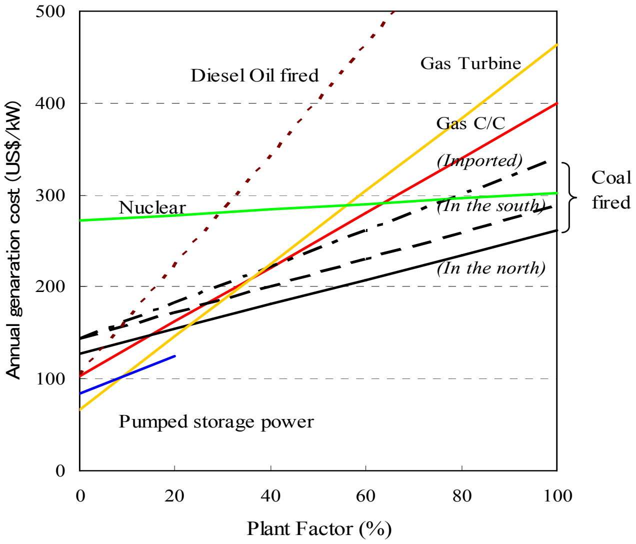


Figure 5-14 Annual Costs in 2025
(Base Case)

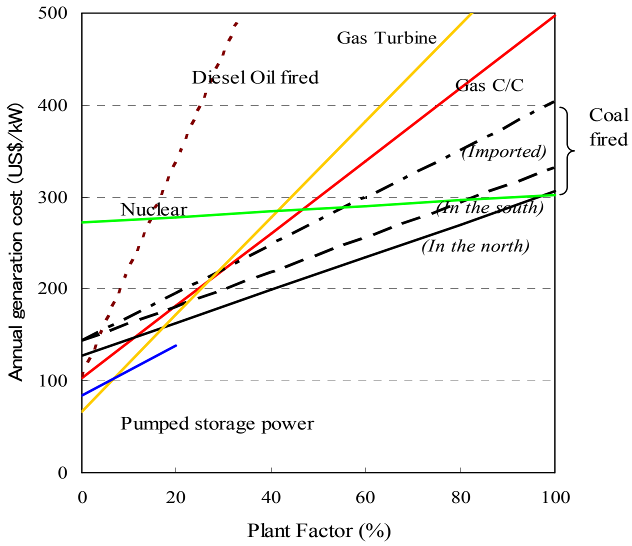


Figure 5-15 Annual Costs in 2025
(Double escalation rate of Base Case)

(4) BOT operation constraints

BOT scheme has a constraint of operation because the plant factor of 75% is made conditional in the power purchase contract. The limitation of BOT scheme is analyzed from the limitation of gas supply of 14BCM per year. The following three cases are set and analyzed. Base case is that where the existing BOT projects, Phu My 2.2 and Phu My 3 with total capacity 1440MW, have the constraint of operation of a BOT. Case No.1 is that where Phu My 2.2, 3, 4 and O Mon 3,4,5, with total capacity of 3990MW, have the constraint as a BOT scheme. Case No.2 is that where Phu My 2.2, 3, 4, O Mon 3,4,5 and New Gas C/C plants, with total capacity of 9,030MW, have the constraint of a BOT scheme.

Case No.1 consumes the gas amount of 14.5 BCM in 2025, which is 0.5 BCM over the planned gas supply volume. However, the volume of 0.5 BCM is supposed to be acceptable. Case No.2 consumes the gas amount of 15.7 BCM in 2025, which is 1.7 BCM over the planned gas supply volume, that is, not enough gas volume to operate them can be supplied .

That means the constraint of 75% capacity factor of BOT scheme cannot be maintained in Case No.2.

The results of least cost operation simulation indicate that the annual costs are not greatly affected by BOT installations. The installation of gas C/C is limited to Case No.1 in which Phu My 2.2, 3, 4 and O Mon 3, 4, 5 are executed as BOT scheme.

Besides, the installation of BOT plants makes the capacity factor of gas C/C and coal thermal plants owned by EVN decrease. The capacity factor of EVN's thermal plants decreases from 67% in the Base Case to 52% in Case No.2 as shown in Figure 5-16. If the capacity factor of BOT gas thermal plants is constrained as 75% in Power Purchase Agreement, EVN thermal power plants have to play the role of middle and/or peak supplier because BOT power plants become a base supplier. That is not an efficient and economic method of system operation. Furthermore, in this case, installation capacity of gas fired thermal power plants has to be reduced, due to limitation of gas supply of 14 BCM.

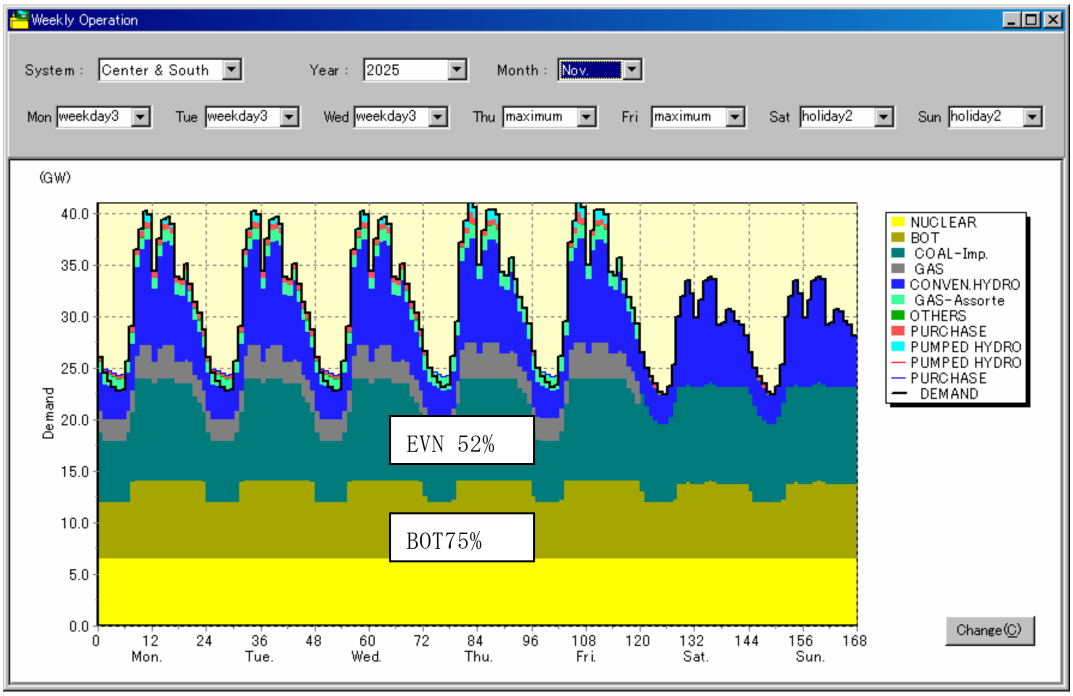


Figure 5-16 Capacity Factors of BOT and EVN Gas Thermal Power Plants in 2025 (Case2)

5.5 Power Generation Development Plan as of January 2006

Referring to the above mentioned study results by the Study Team and based on the changed conditions such as feasibility of power import, etc., IE reviewed and revised its original power generation development plan.

The fuel composition and installed capacity by power source up to 2025 based on the power development program of the PDP 6th (Base Case) as of January 2006 are shown in Figure 5-17.

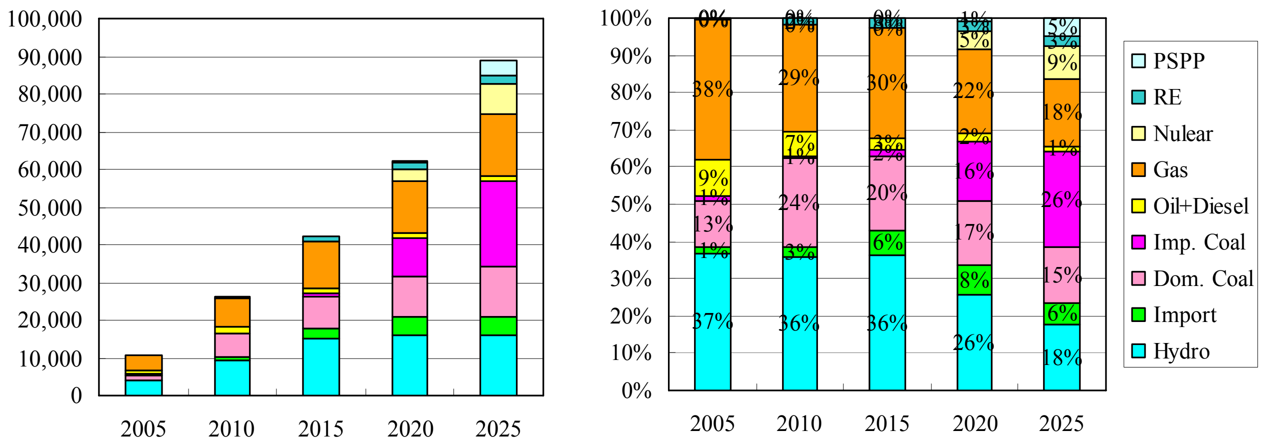


Figure 5-17 The fuel composition and installed capacity by power source (Base Case)

5.6 The Final PDP 6th

According to the comments by the relevant Ministries and Organizations such as EVN and Ministry of Industry, IE revised again the above described Power Generation Development Plan as of January 2006.

The fuel composition and installed capacity by power source up to 2025 based on the Final PDP 6th are shown in Figure 5-18, Figure 5-19 respectively.

The Final PDP 6th was rather improved in comparison with the PDP 6th as of January 2006. Main revised points and required further study items are listed as follows.

- Total power generation capacities during year of 2009 and 2015 are reduced at around 1GW every year. In the PDP 6th as of January 2006, the reserve margin during 2009 and 2015 were set at around 20%, while required reserve margin is around 10%, taking into account the risk of progress of some projects behind schedule. The reserve margin during 2009 and 2015 were revised at around 10% and this revised plan can secure appropriate supply reliability.

- While the Draft Final Report of the JICA study was made, total capacity of nuclear power plants of 8,000MW was planned to develop by 2025, the development capacity was reduced to 4,000MW because nuclear power plant is not so economical than imported coal TPP by 2025 and there remains critical issues such as radioactive waste disposal and public acceptance.

- In line with the review of production plan of the coal sector, the fuel of Vung Anh coal TPP in the North was changed from imported coal to domestic coal, and the development time of the first unit of imported coal TPP in the North, which unit size is 1GW, was postponed from 2022 to 2023 and total number of units was also reduced from 7 to 5. Accordingly, the total capacity of imported coal TPP developed by 2025 in the North reduced from 10.5GW to 5.0 GW. It is desirable that exploration of coal reserve and improvement of exploitation technology are continuously furthered in view of security of energy supply and restraint of increase of annual generation cost.

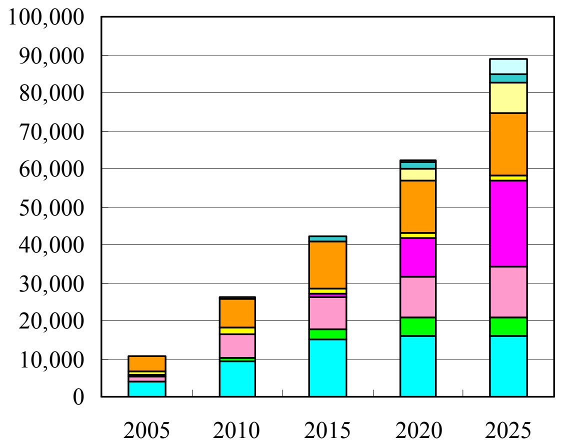


Figure 5-18 Installed Capacity by Power Source in the Final PDP 6th (Base Case)

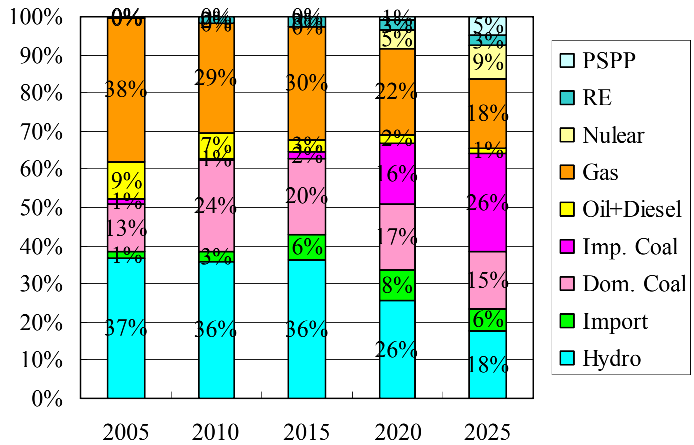


Figure 5-19 Fuel Composition in the Final PDP 6th (Base Case)

6. Power Network Development Plan

6.1 Method of Study of System Reliability

In PDP 6th, the optimum network development program that would meet the requirements in terms of both system reliability and economic efficiency should be planned. It is necessary to take into account of the stabilization of whole transmission system spread over Vietnam, power trading flows from the neighboring countries through interregional transmission lines, and existence of large national economic power exchange brought by the various types of power sources.

The power network planning of the 6th MP was carried out based on the 5th MP including updated demand forecast and power sources development program. The planning scope of the power network in PDP 6th covers 110 kV, 220 kV and 500 kV systems up to 2015 and 220 kV and 500 kV systems up to 2025.

The PSS/E developed in USA is used as system analysis software in the PDP 6th in the same manner as in the 5th MP. Figure 6-1 shows the study flow of power network development planning.

The check is made mainly on whether or not the following problems are solved.

- Power flow and voltage analysis: occurrence of overload and over-voltage
- Fault current analysis: occurrence of over fault-current
- Stability analysis: instability of operation of power generation

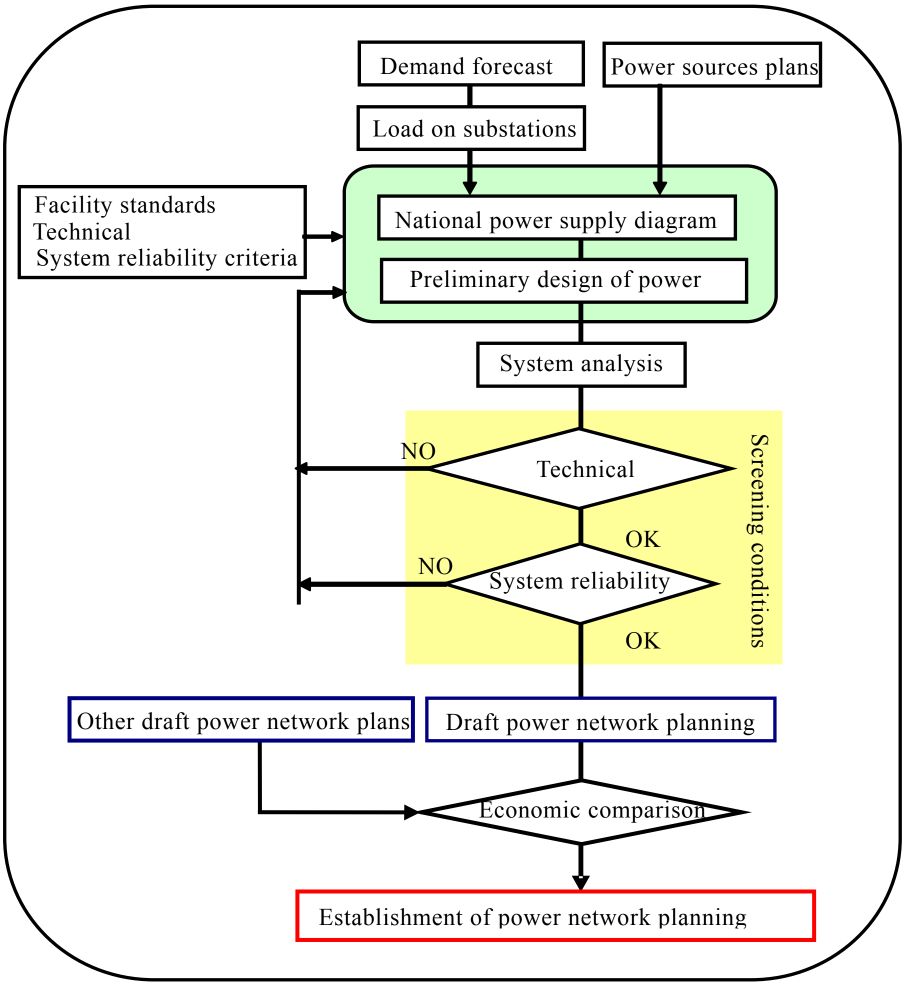


Figure 6-1 Study Flow of Power Network Development Planning

This report focused on the power network planning of 500 kV transmission lines in 2020 and 2025 from the viewpoints of importance of long term plan of future bulk power network system.

6.2 Main Study Conditions

Power network should be planned in order to realize the stable and continuous power transmission of power outputs of generators to substations. Stable and continuous power transmission is required even in case of a lack of one unit of power system facilities due to faults or scheduled outages. However, all the phenomena occurring in widespread power systems cannot be incorporated into the planning. Therefore, assuming a lack of one unit of facilities such as power transmission lines or substations, power systems are usually made in order to transmit power stably and continuously as much as possible even in such a case.

This planning criterion is called N-1 criterion.

The plans are made in consideration of the following issues.

- **Power Supply to Inside and Outskirts of the Big Cities**

The conductors used for the 500 kV transmission lines with large length such as several hundred kilometers should be 4xACSR 330, however, in the case where short transmission lines and large capacities are economical, the alternatives should be examined.

The 500/220 kV transformers applied for Hanoi or Ho Chi Min systems have usually 450 MVA and the maximum number of transformers in a substation is two, which is a small number. The plans of conductor sizes of 220 kV transmission lines and capacities of 220/110 kV transformers might be uneconomical in the future for Hanoi and Ho Chi Min cities, which are predicted to have huge power demand densities like present big cities in southeast Asia, because the standards of the former Soviet Union are applied and too many facilities have to be installed. For example, the 500/275 kV substations around Tokyo have loads in the range from 2,000 MW to 4,000 MW in one substation, meanwhile, most 500/220 kV substations were planned to have loads only in the range around 1,000 MVA in the 5th MP in Vietnam.

The 275 kV transmission lines around Tokyo sometimes have the capacity of more than 1,000 MW per circuit, meanwhile, the 220 kV transmission lines planned in Vietnam usually have less than half of this capacity. Even in consideration of the different voltage levels, the present specifications on the system are considered to be too small for the future bulk power system in Vietnam.

Although the existing standards have been suitable and economical for the long distance power transmission with small demand densities, the standards need to be improved for the future Hanoi and Ho Chi Min systems, which will have high demand densities and limited land space for installation.

The 500 kV network systems around big cities in Southeast Asia are often planned to configure multi-ring shaped systems like Tokyo or Shanghai. From the ring-shaped 500 kV system to load center, power is supplied by lower voltage systems. For the configuration of power systems in Hanoi and Ho Chi Min City, the multi-ring shaped system configuration is targeted.

Table 6-1 and Table 6-2 show the main specifications applied for 6th MP.

Table 6-1 Standard 500 kV substations applied for the PDP 6th

Voltage (kV)	Capacity	Number of Transformers
500/220	900, 600 ,450	1-3
220/110	250, 125, 63	1-3

Table 6-2 Standard conductor applied for the PDP 6th

Voltage (kV)	Type	Number of Conductors
500	410, 610	4
220	610, 810	2

- **Power flow from north to center and south regions**

Around year 2020, since the north region has a lot of base power suppliers such as hydro power plants and/or coal thermal power plants, and the power flow from Ha Tinh to Center and South regions has a tendency to increase, the power flow is sometimes over the limitation based on N-1 criteria between Ha Tinh and Da Nang according to the distribution of power sources in Vietnam.

In this case, the following alternatives are to be considered.

- To reinforce the transmission lines between Ha Tinh and Da Nang to meet various power generation patterns
- To limit power generation patterns in north and south in order not to exceed the limitation of the power flow from north to center/south, or to open inter-regional connection between North and Center & South
- To change location of power plants

In this power network planning, the power flow between north and center is planned to be within about 1,000 MW. However, the comparative study of above-mentioned counter measures should be continuously carried out in line with optimum power development planning and power system operation planning for the long term.

- **Power flow from the Center to the South region**

From the Center to the South coast, there are development plans for nuclear power plants, large coal thermal power plants and power import from large hydro power plants in Laos. The power flow from the Center to the South exceeds the capacity limitation of N-1 criteria between Plei Ku and Than Dinh. Thus, the large-scale reinforcement of 500 kV transmission lines is required between the Center and the South.

In Japan, when the large reinforcement of 500 kV system with many circuits was predicted for the future, the introduction of 1,000 kV system was examined and steel towers for 1,000kV were actually designed and constructed. Now in China, such a ultra high voltage AC transmission system is also examined. For the Vietnamese power network system, it would be necessary to study such an alternative in the future.

- **Voltage maintenance**

Vietnam power network system spread over 1,500 km from the North to the South causes large change in power flow through optimal operation of power plants. In large power demand areas such as Hanoi and Ho Chi Min city, the large difference in voltage between day and night or season by season may occur, which is difficult to be adjusted only by static reactive power facilities. In the future, automatic controllers for adjusting reactive power will be required such as automatic switching operation of capacitors or shunt reactors, SVC (thyristor controlling reactive power sources) and synchronous condensers. The precise planning of reactive power facilities requires precise reactive load forecast, however, the long-term reactive load forecasting is difficult. The reactive power facilities should be studied and planned annually by system calculation for the next year.

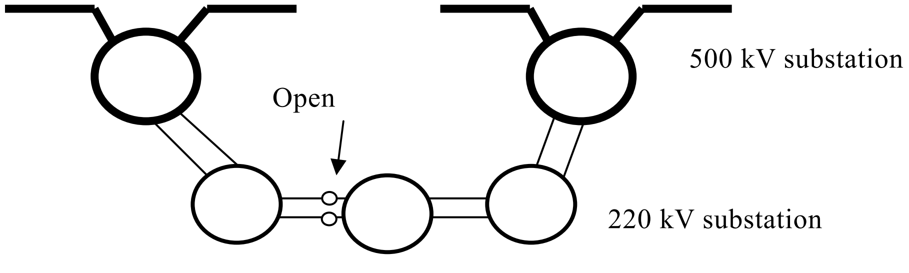
- **Increase in fault current**

One of the common issues of the system in/around the Asian large cities such as Tokyo, Shanghai and Taiwan is increase in fault current. Increase in demand density requires many transmission lines connected with large-scale power plants, which threaten the fault-breaking ability of circuit breakers.

The following countermeasures against increases in fault current can be considered.

- To split operation of the system
- To adopt circuit breakers with high fault breaking ability
- To apply high impedance transformers

One of the ways of split operation system is as shown below. Circuit breakers in the 220 kV system are opened at some intervals and fault currents are suppressed.



- **Series capacitors**

Installation of series capacitors causes electrical series resonance with low frequency levels. When the frequency becomes equal to the frequency of turbine mechanical resonance of nuclear power plants or thermal power plants, power generators vibrate and have a possibility of dropping from the system, which leads to black out. If many series capacitors are installed, it is difficult to grasp the resonance frequencies. Therefore, series capacitors should be limited to installation in the north – south transmission lines.

6.3 Optimization Study of Power Network System in 2020 and 2025

The Study Team prepares data for the Vietnam power system including the 500 kV and 220 kV systems based on the information as of Sep 2005 and discusses with IE. At present, IE are updating and analyzing the data with PSS/E software program. The 500 kV power network plan is determined on the basis of the following system analysis.

- Power flow
- Stability
- Fault current

The regional descriptions of power plants and power load forecast at 220 kV substations are as follows. However, the figures in the tables represent the capacities of power plants (maximum power generations) and maximum loads and difference between capacities and loads are not equal to regional surplus or shortage of power at the peak demand time.

(1) North East Area

North East Area has power development plans of Mong Duong and Quang Ninh coal thermal power plants connected to the 500 kV system. Hai Phong and Uong Bi coal thermal power plant are connected to the 220 kV system. On the other hand, the total load in this region is smaller than output of those power plants. Since there is large power flow from this area to Hanoi, about three circuits by 2020 and four circuits by 2025 of the 500 kV system are required.

(2) North West Area

North West Area has power development plans for large sized hydropower plants such as Son La and Lai Chau and pumped storage power plants. The surplus power output of this area of 4,000 MW at maximum by 2020 and 3,000 MW at maximum by 2025 is transmitted to Hanoi.

(3) Hanoi Area

This area has large existing power plants such as Hoa Binh hydropower plant and Pha Lai coal thermal power plant. On the other hand, the load is far larger. Therefore, large power flows into this area from other areas.

(4) South Area of Hanoi

This area has power development plans such as Thoi Bonh coal thermal power plant by 2025. The difference between power demand and supply in this area until 2025 is not so large.

(5) North Central Coast Area

This area has power development plans of two large coal thermal power plants, Ngi Son and Vung An. Total power output of these two plants reaches 6,000 MW connected to the 500 kV system. On the other hand, loads will be far smaller than power output. Therefore, the large power flows into Hanoi from this area, and more than three 500 kV lines are required. Figure 6-3-1 shows the power supply/demand balances of above-mentioned five regions at peak demand time and outlines of power flow. There is power flow from the surrounding areas to Hanoi.

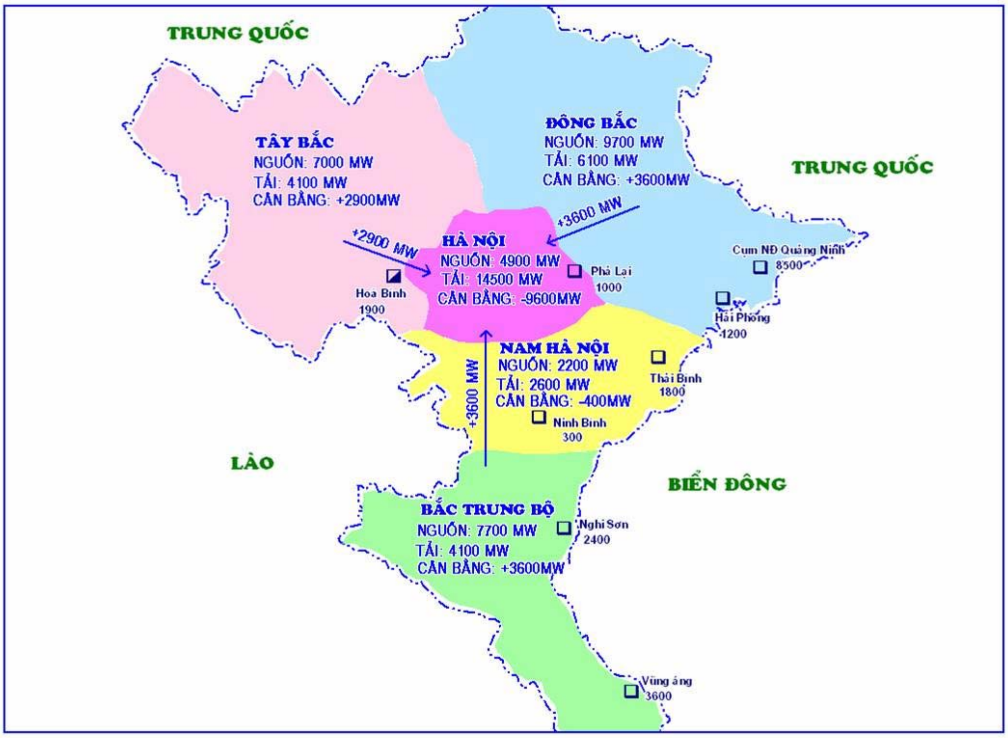


Figure 6-2 Power Demand/Supply Balances at Peak Demand Time and Power Flow

(6) South Central Coast Area

Quang Tri coal thermal power station is constructed by 2020, however, total load of this area is larger than power output. Da Nang coal thermal power station is constructed by 2025 and surplus power output is transmitted to the South region.

(7) South Northern East Area 1

There is a development plan for Tuy Hoa coal thermal power plant by 2025.

(8) South Northern East Area 2

This area has large power output with development plans of Dong Nai hydropower, Binh Thuan combined cycle power plant, nuclear power plants and pumped storage power plants. More than 6,000 MW by 2020 and more than 10,000 MW by 2025 flows into Ho Chi Min city area and more than several circuits are required from this area to Ho Chi Min city.

(9) Central Highland Area

This area has Plei Ku substation and Yali hydropower station. Surplus power output including imported power from Lao hydropower sources is transmitted to the South regions through North-South 500 kV transmission lines.

(10) Ho Chi Minh City Area

Ho Chi Min city has large existing power plants such as Tri An hydropower, Phu My gas fired thermal power plant and a development plan of Nhon Trach gas fired thermal power plant. On the other hand, total load is quite large. There is large power flow from other areas to this area.

(11) West Ho Chi Minh Area

This region has existing hydropower plants such as Thac Mo, and some development plans formiddle-scale hydropower plants. On the other hand, total load isquite large, therefore, there is large power flow from other regions.

(12) South Ho Chi Minh Area

A gas combined cycle power plant is planned in Tien Giang. Demand and supply is well balanced.

(13) South Southern West Area

This region has O Mon thermal power plant and plans for large coal thermal power plants in Soc Tran and Tra Vinh. Power flow of about 6,000 MW will occur from this region to Ho Chi Min city by 2020.

6.4 Draft Power Network Development Plan of 500kV up to 2025

Based on the description about the regional generation planning and demand forecast in 6.3, applying the study condition and the basic specification to power network system described in 6.2, the 500 kV power network plans ware made.

Though, there is possibility that the power network plan will be revised in line with revision of power generation planning and more precise power system analysis as mentioned before, the plan seems to be appropriate as a preliminary level.

6.5 The Power Network Development Plan as of January 2006

Referring to the above-mentioned study results by the Study Team and taking into consideration the changed conditions such as feasibility of power import, etc., IE reviewed and revised the Power Network Development Plan.

The changes from the preliminary network plan were the transmission lines for a north pumped storage hydro power plant, the newly planned sites of Than Hoa and Vinh, and the increase in the number of circuits from south nuclear power plants to Ho Chi Min city. However, the basic system configuration was not changed.

6.6 The Latest Power Network Development Plan

According to the comments by the relevant Ministries and Organizations such as EVN and Ministry of Industry, IE revised again the above described Power Network Development Plan as of January 2006. The latest plan of 500 kV System in 2025 as of May 2006 is outlined in Figure 6-3.

The followings are listed as noteworthy points and or required points for further studies.

- While the Draft Final Report of the JICA study was made, the power network development planning had been carried out on the condition that nuclear power plants with total capacity of 8,000 MW would be developed by 2025. Therefore, study of 1,000 kV transmission lines had been recommended. According to the Latest PDP 6th, the total capacity of nuclear power plants developed by 2025 was reduced to 4,000 MW, therefore, it no longer need to carry out the study on introduction of 1,000 kV transmission line. On the other hand, the number of circuits of the 500 kV transmission lines from the coal thermal power plants of 3,000 MW in Tra Vinh, coal thermal power plants of 1,200 MW in Soc Trang to Ho Chi Min City and the methods of power transmission from new large coal thermal power plants of 5000MW developed in such as Da Nang and Doc Soi need to be continuously studied including power system stability after completion of the study on PDP 6th that have suggested the direction of such kind of studies

- Against the increase in power demand in the future, the adoption of the large sizes of 500 kV transformers, the duplicated supplies to 220 kV substations around Hanoi and Ho Chi Min city and the ring shaped configuration of 500 kV power system were clearly described in the PDP 6th. Those countermeasures can be considered adequate to lead efficient power network configuration.

- The Report describes the required capacity of the shunt capacitors. Moreover, it is necessary that the methods of their regulation and control be studied continuously because the system voltage would be largely changed day and night and season by season.

- The Report recommended that the limit of installation of the series capacitors that have a possibility with causing turbine-vibration, the consideration with the effective exciter system of large power plants and the installation of synchronous condensers against the instability caused by the faults around Son La hydropower plant and an interregional connection to China. Each countermeasure can be effective.

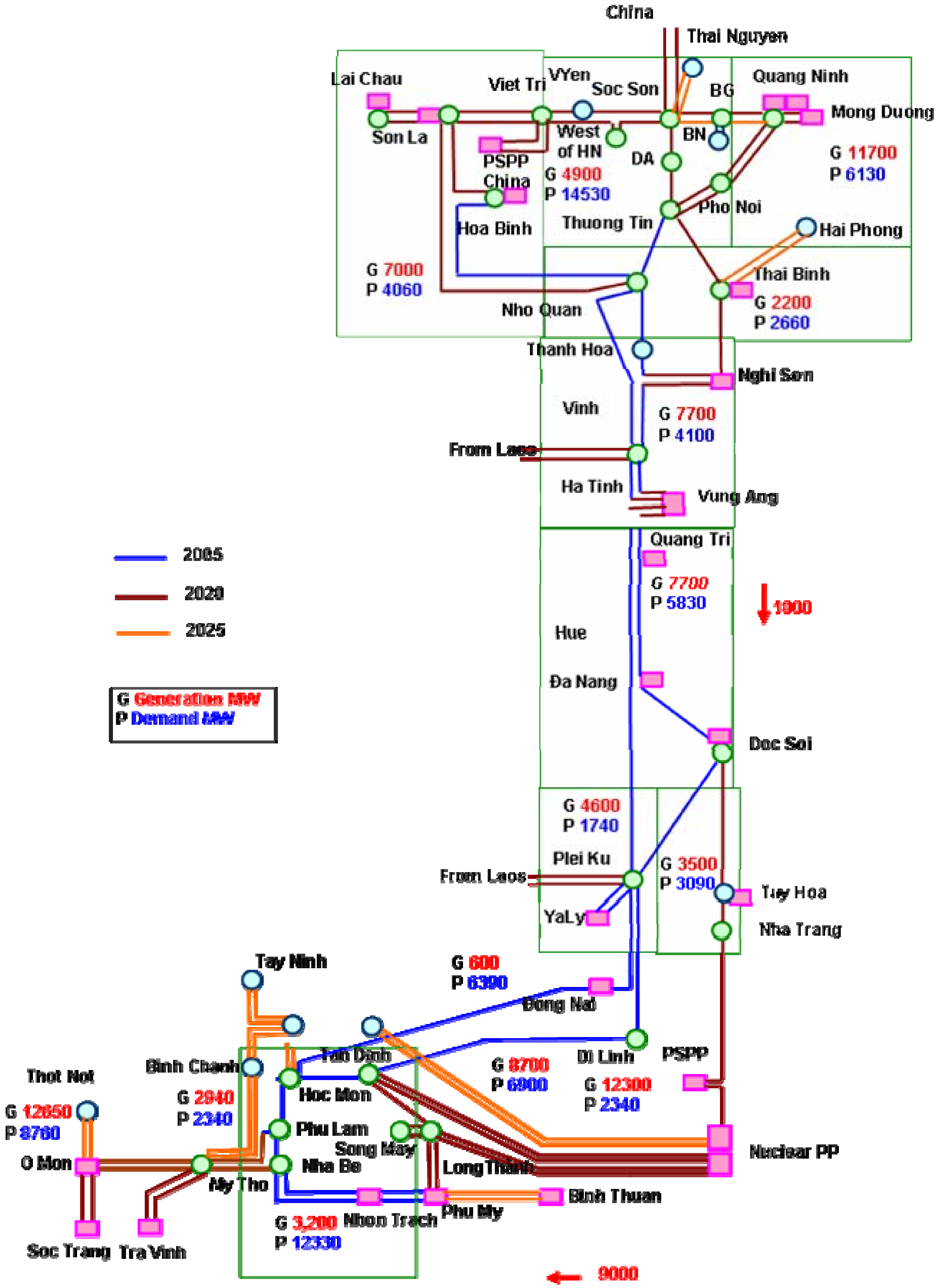


Figure 6-3 Draft Plan of 500 kV System in 2025

7. Investment Plan and Financial Projection

7.1 Long Term Investment Plan

(1) Investment Plan based on the Original Development Plan by IE

The JICA Team projected and calculated the investment by EVN and the running costs of EVN during 2005 – 2025 based on the the Original Development Plan by IE. The assumptions, method and results of calculation are as described below.

a. Investment Statement of the Whole Country

Investments by EVN in each year were estimated based on the power system development plan of IE, using unit construction costs of TPPs & NPP stated by IE.

Construction unit cost (USD/kW)

Capacity	Oil	Gas	GFCC	GT	Coal	Nuclear
200	914	1031		400	1294	
250	849	961		400		
300	800	900			1170	
400	727	819				
500	746	833			1089	
600			660		1089	
720			660			
1000					980	1700

Note : Conventional hydropower (<30MW) : 1,735 USD/kW
Source : Institute of Energy

b. Generation Statement of the Whole Country

Generation energy of each power plant is estimated from the simulation by the PDPATII to meet the power demand forecasted (Base case).

c. Operation and Maintenance Costs Statement of EVN

Operation and maintenance costs of EVN's power plants and power grids were calculated using unit O&M cost of the PPs and the power grids stated by IE as shown below.

O & M cost for each type of TPP (Unit: USD/kW/year)

Capacity	Oil	Gas	GFCC	GT	Coal	Nuclear
200	25.3			19.8		
250	23.5	19.2		19.3		
300	22.1	18.0			33.9	
400	20.0	16.4			33.6	
500	20.6	16.7			33.3	
600			29.7			
720			29.7			
1000					30.0	59.8

O&M Hydropower

>30MW	0.5%	of Investment cost	:	0.01 (USD/kW)
-30MW	1.0%	of Investment cost	:	0.02 (USD/kW)

Source : Institute of Energy

d. Fuel price

Fuel prices are assumed as shown in the table below. The transportation cost of coal from the North to the South is assumed as 7US$/ton as stated by Vinacoal.

Fuel Prices

Fuel Type	Unit	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
FO	USD/ton	217.2	219.4	221.6	223.8	226.0	228.2	230.6	232.9	235.2	237.5	239.9	242.3	244.8	247.2	249.6	252.1	254.7	257.3	259.8	262.4	265.0
DO	USD/ton	398.2	402.1	406.2	410.3	414.3	418.5	422.6	426.9	431.2	435.5	439.9	444.3	448.7	453.2	457.8	462.3	466.9	471.6	476.3	481.1	485.9
Coal (Dom.)	USD/ton	21.8	22.2	22.7	23.1	23.6	24.1	24.6	25.1	25.6	26.1	26.6	27.1	27.7	28.2	28.8	29.7	30.5	31.5	32.4	33.4	34.4
North(CIF)	USD/ton	24.4	24.8	25.2	25.7	26.1	26.6	27.1	27.6	28.1	28.6	29.1	29.6	30.1	30.7	31.2	31.8	32.7	33.5	34.5	35.4	36.4
South(CIF)	USD/ton	28.5	29.0	29.3	29.8	30.2	30.7	31.2	31.7	32.2	32.7	33.2	33.7	34.2	34.8	35.3	35.9	36.1	37.0	37.9	38.8	39.8
Coal (Imp.)	USD/ton											51.7	52.7	53.8	54.8	55.9	57.1	58.2	59.3	60.5	61.7	63.0
Gas	USD/mmBTU	3.14	3.20	3.26	3.33	3.40	3.46	3.53	3.60	3.68	3.75	3.82	3.90	3.98	4.06	4.14	4.22	4.31	4.39	4.48	4.57	4.66
Nuclear	¢/10^3kcal													0.119	0.120	0.120	0.121	0.121	0.122	0.123	0.123	0.124

Source : Institute of Energy, Vinacoal and Petrovietnam estimates

e. Fuel cost statement of EVN

Fuel cost by owner of power plant is calculated by the PDPATII.

f. Power purchase statement of EVN

Power purchase prices of every kind of power source as of the year 2005 are assumed, for example, HPP's (including import) 4.0 ¢ /kWh, coal TPP（≦200MW）5.0 ¢ /kWh, coal TPP（≧300MW）4.0 ¢ /kWh, Diesel TPP 10.0 ¢ /kWh, GTCC's 4.2 ¢ /kWh and imports from China, Laos, Cambodia 4.0 ¢ /kWh. The escalation of each fuel price was also taken into account.

(2) Evaluations of investment Plan and Running Cost Projections

Investment plan and running cost of EVN are shown in Figure 7-1 and Figure 7-2 respectively.

The main features of the investment plan and the running cost projections are described as follows:

a. Investment ; the investment from 2007 to 2011 is rather high because many large hydropower plants, especially Son La are developed intensively up to 2015. Therefore, investment from 2007 is over 3 billion US$. After 2014, investment will need to increase 600 million US$ every year.

b. O&M costs ; O&M cost will increase gradually in accordance with the increase in the amount of power facilities.

c. Fuel costs ; since many large hydropower plants, especially Son La are developed intensively up to 2015 and the shares of power imports and IPP power plants (BOT) increase, the fuel costs do not increase until 2013.

d. Power purchase costs ; power purchase costs will increase up to2013 in line with the increase of power imports and power plant development by IPPs.

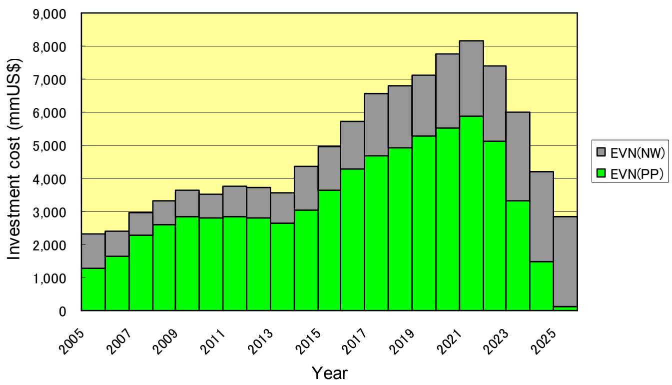


Figure 7-1 Investments of EVN

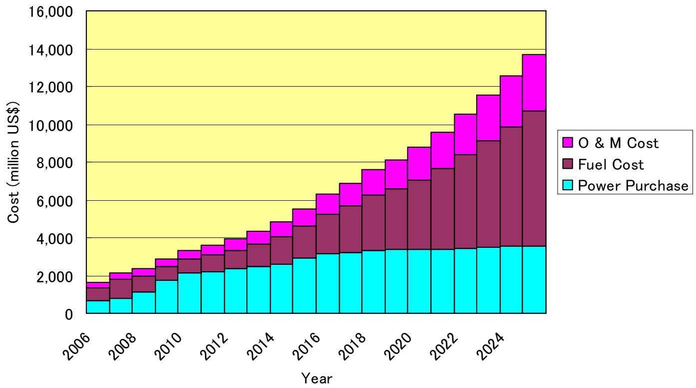


Figure 7-2 Running Cost of EVN and Power Purchase

7.2 Financial Projection of EVN

(1) EVN Reorganization

The current EVN affiliated units as of the end of 2003 are as follows.

15 independent accounting entities

8 Power Companies (PC)
1 Power Telecommunication Company
1 Electrical Equipment Manufacturing Company
4 Power Engineering Consulting Companies
1 Duc Mechanical and Engineering Company

26 Dependent accounting entities…

14 Power Stations
4 Power Transmission Companies

2 Support Units

6 Administration Units

14 Construction/Project Management Units

Subsidiaries and joint ventures controlled by EVN (over 50% voting power)

The regulatory body will study the future EVN organizational structure in comparison with the current one in accordance with the newly established electricity law. For example, specific studies will be made for each of 14 current power plants as to what they should be (shift to independent accounting entities, shift to equities company, shift to limited company and other).

The Study Team calculates the financial projection while taking the influence of reorganization of EVN into consideration as much as possible through coordination with EVN financial staff.

(2) Financing Environment (ODA, commercial borrowings)

a. International Donor Institutions

The major donor institutions such as WB, ADB, and JBIC will continue their assistance to the power sector in Vietnam. It is assumed that ODA loans are used for some projects in EVN financial projections. Similar assumptions are made in the study as well.

b. Issue of Bonds

As the bond market develops, major governmental corporations such as EVN may issue bonds. Additionally, there are also plans for a government guarantee system regarding bonds issued by governmental corporations for nationally important projects. Thus, bonds are expected to be a main method for governmental corporations to raise funds.

As stated above, funds may be raised by issuing bonds, but it is not considered in the study projection, as it is not so different from borrowing.

c. Initial Public Offering (IPO)

Funds may be raised from the stock market by IPO of EVN itself or its affiliate companies after the reorganization of EVN in relation to the power sector reform. However, it is still difficult to judge the feasibility and stock market value at present. We calculate the financial projection while taking the influence of IPO into consideration as far as possible by coordination with EVN financial staff.

(3) Financial Projections

The financial projections have been conducted according to the following steps.

a. Projected Period

Twenty years from 2005 to 2025.

b. Prepared Statements

Financial analysis is manifested in the following 3 forms.

- Income Statement
- Balance Sheet
- Cash Flow Statement

c. Projected Units

6th Master Plan would show financial analysis for production and business activities of the following EVN group

- Independent accounting units
- Dependent accounting units
- Project management units

d. Projected Cases

Two cases are assumed for financial projections.

- Case 1 : Based on the investment and funding plan to avoid the cash crises
- Case 2 : With Revised Financing Conditions

(4) Assumptions of Finantial Projection

(1) Case 1

a. Income statement item

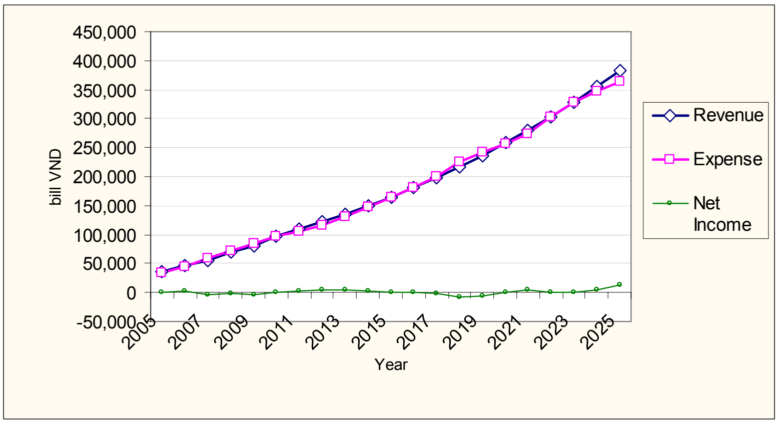


Figure 7-3 Revenue, Expense and Net Income

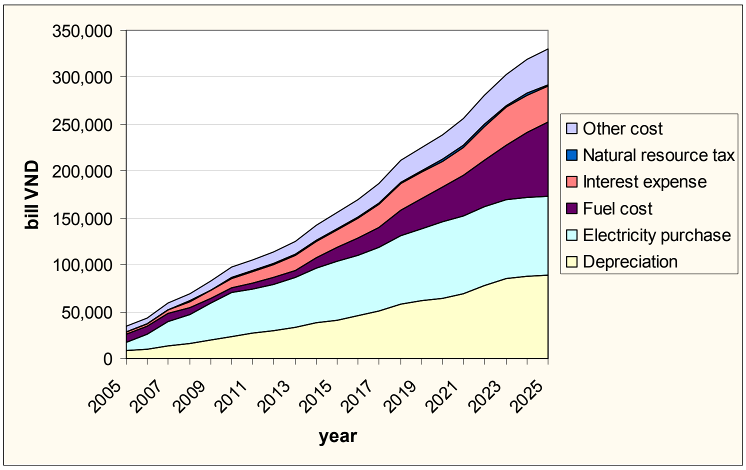


Figure 7-4 Cost Transition

- Income as well as expense increase at the same level, while net income is steady at the zero level.
- From the cost aspect, power purchase and fuel cost will significantly increase, and in 2025, the respective amounts will become 10.1 and 8.7 times of those in 2005. Compared to electricity sales, which will be multiplied by 10.8 times in 20 years, depreciation expense will be multiplied by 4.4 times, and interest expense by 6.2 times.

b. Cashflow statement item

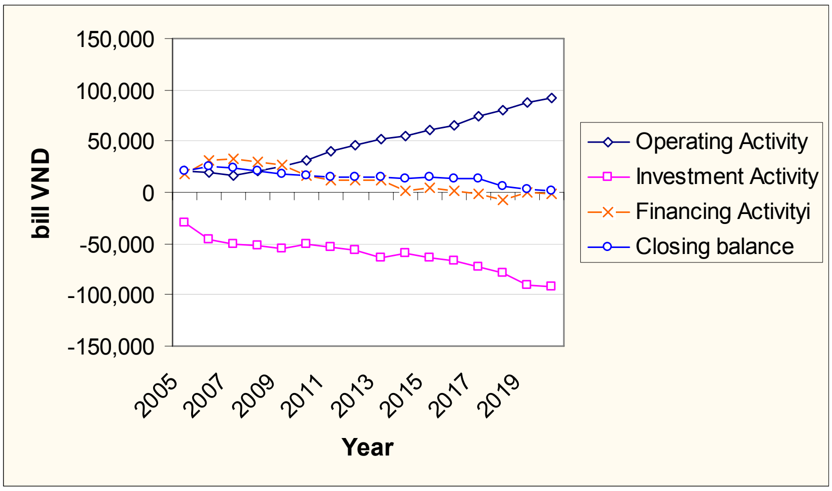


Figure 7-5 Cashflow of each activity

Table 7-1 Fluctuation of borrowing (Committed loan and Uncommitted loan)

(Unit: bill VND)

	2005	2006	2007	2008	2009	2010	2011
1.Commitment loan	6217	14124	15935	15269	16716	12181	10883
2.Uncommited loan	15864	23951	27430	34875	36660	39077	44505
Total loan	22069	38030	44350	51894	56423	53821	56496

	2012	2013	2014	2015	2016	2017	2018
1.Commitment loan	8315	6876	292	292	252	0	0
2.Uncommited loan	57487	67938	69444	78796	83447	88478	90695
Total loan	62371	71298	70101	80048	83699	88478	90695

	2019	2020	2021	2022	2023	2024	2025
1.Commitment loan	0	0	0	0	0	0	0
2.Uncommited loan	106853	117525	118634	107314	97925	81223	41807
Total loan	106853	117525	118634	107314	97925	81223	41807

- In Case 1, we simulated the funding plan to avoid the cash crises. As a result, heavy borrowing will be needed. Especially, uncommitted loan will become an important factor to avoid cash crises. Uncommitted loan after 2011 might be committed in the future. On the other hand, uncommitted loan from 2005 to 2010 will be difficult to commit in the near future. That is to say, the amounts of uncommitted loan correspond to the amount of money shortage.

- To avoid cash crises, there should be some method to decrease investment cost especially from 2005 to 2010.
- Repayment of loan will rapidly increase after 2015, however sales of electricity will also gradually increase. As a result, cashflow will remain sound.

(2) Case 2 Analysis results

a. Income Statement Item

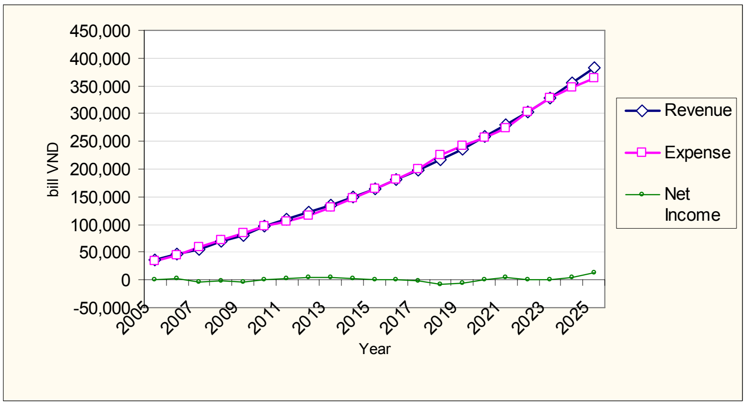


Figure 7-6 Revenue, Cost and Net income

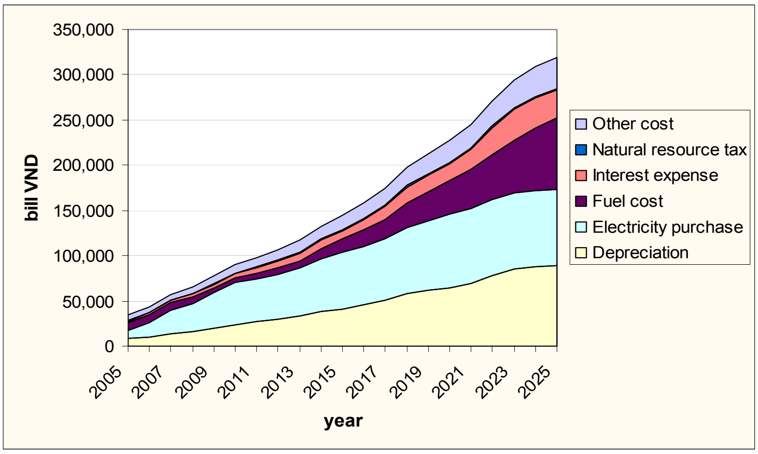


Figure 7-7 Cost Transition

b. Cashflow Statement Item

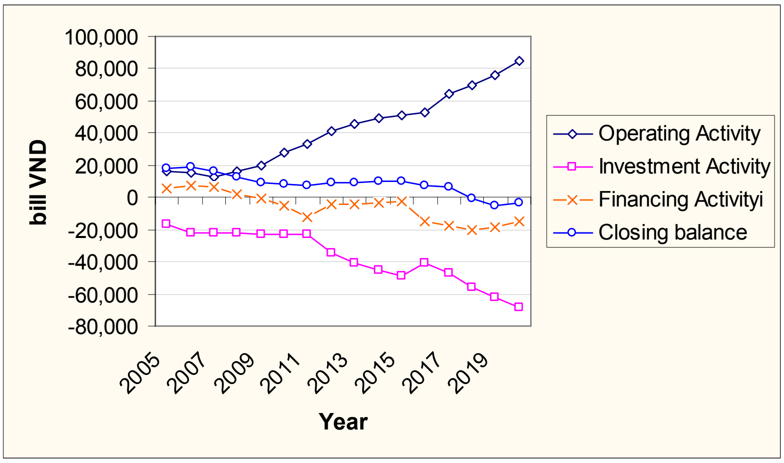


Figure 7-8 Cashflow of each activity

Table 7-2 Transition of borrowing (Committed loan and Uncommitted loan)

(Unit: bill VND)

	2005	2006	2007	2008	2009	2010	2011
1.Commited loan	6217	14124	15935	15269	16716	12181	10883
2.Uncommited loan	6746	2822	3318	4327	3675	7520	7539
Total loan	12963	16946	19253	19595	20391	19701	18421

	2012	2013	2014	2015	2016	2017	2018
1.Commited loan	8315	6876	292	292	252	0	0
2.Uncommited loan	20674	27258	40557	48545	39475	41072	42342
Total loan	28989	34134	40848	48837	39727	41072	42342

	2019	2020	2021	2022	2023	2024	2025
1.Commited loan	0	0	0	0	0	0	0
2.Uncommited loan	50600	60525	59082	42620	18483	0	0
Total loan	50600	60525	59082	42620	18483	0	0

- Compared to Case 1, uncommitted loan will decrease and cashflow improve.
- As a result, the decrease of investment cost by 2011 will have a good effect in cashflow items.

(3) Conclusion

The analysis results are as follows.

- Cashflow balance will be negative until 2009, therefore, the investment plan of the project should be scaled back.
- The major reason for the cash shortage is the substantial amount of annual repayments of borrowings and a large amount of investment.

8. Environmental and Social Considerations

8.1 Strategic Environmental Assessment: SEA

(1) SEA in General

Strategic Environmental Assessment (SEA) is environmental assessment targeting the three 'P's of Policy, Plan and Program.

SEA has two significances as follows,

- ✓ Environmental Consideration should be integrated into decision making when a project, which would have a major impact on the environment, is planned / executed.
- ✓ To make up for the limit of Environmental Assessment at the project executing stage. (Report of the Strategic Environment Assessment Research Committee)

SEA will be carried out in an earlier stage with wider environment conservation treatment than EIA.

(2) SEA in the Study on National Power Development Plan in Vietnam

Abstract flow of the Strategic Environment Assessment (SEA), for the PDP 6th is shown in Figure 8-1.

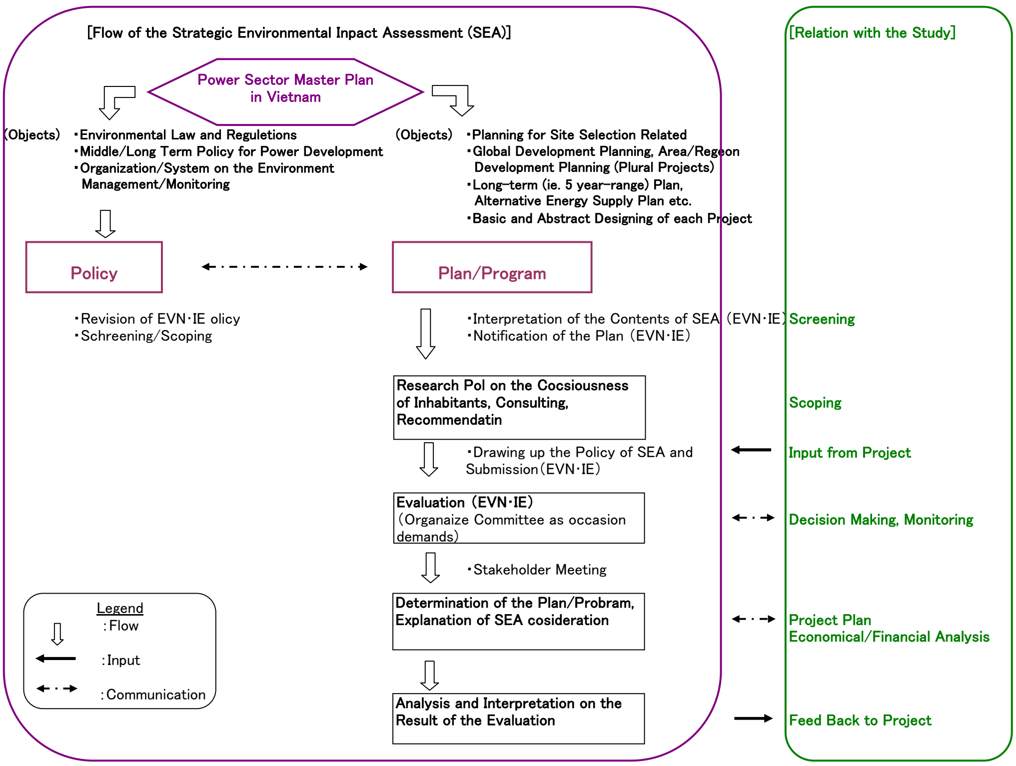


Figure 8-1 Relation between "the Study on National Power Development Plan" and SEA

8.2 Method and Study Results of Initial Environmental Study

(1) Method of the Study

The study Based on SEA is carried out in line with the following steps;

a. Policy Aspect

① Compilation of laws, regulations and standards related to socio-environment assessment.

Collecting laws, regulations and standards related to socio-environment assessment with C/P, MONRE MARD etc.

② Investigation on the relation between Power Development Policy of Vietnam and Socio- environmental Considerations.

b. Planning Aspect and Programming Aspect

③ Study of the SEA checkpoints and drawing up the checklist.

Based on JICA's E & SC GL (Dam, River / Sand Control etc.) and study results, the environmental and social considerations expert prepares draft SEA checkpoints and checklist, explains them to the C/P and local consultant, amends and collects data and Initial Environmental Study on the PDP 6th (hereinafter referred to as 'IES') concerning all the power development candidate sites putting weight on the 12 items which the pre-study mission evaluated as category 'B'.

IES will be carried out on the following items based on the executing method and its checklist.

1) Socio-environmental Items

- Minorities / ethnic people, weakness / gender, involuntary resettlement
- World Heritage, cultural assets
- Scenery
- Life (agriculturef, water utilization / water rights)
- Others (isolation and / or splitting)

2) Natural Environmental Items

- Ecology f and fauna, biodiversity)
- Migration
- Topography, geography
- National Park, reserved areas
- Costal zone

- Hydrological situation
- Meteorology, climate change / global warming

3) Pollution Items

- Air quality pollution
- Water quality pollution
- Soil contamination
- Noise
- Vibration
- Land subsidence
- Bad smell
- Solid waste / hazardous waste

④ Examination and selection of execution method of SEA

Environmental study and evaluation on each hydropower plant will be carried out in accordance with the evaluation standard of screening and scoping checklist shown in the JICA's E & SC GL (Dam, River/Sand Control etc.).

c. Policy Aspect, Planning Aspect and Programming Aspect

⑤ Evaluation for the environmental and social consideration aspects of the candidate power generation plants.

Based on the IES results of item '②', screening is reviewed and general comparative assessment of the environment related to each site is executed taking into consideration the government long term policy, cooperation and balance between areas. The results are used to optimize the power generation development plan.

(2) Study Result of IES

a. Collection and Analysis of the Environment Related Data

- Information relating Energy Policy
- Information relating to the Environment

b. Execution of the Site Investigations and Analysis

The environmental expert of the selected consultant together with experts of the Study Team and C/P carried out the site investigation and grasped status of environment.

- Pha Lai coal power plant (existing)
- Uong Bi coal power plant (existing) and expansion plant (under construction)

- Song La hydro power plant (under construction)
- Song Bung 2 ,Dak Mi 4 hydro power plant (planning), and New village for the involuntary resettlement peoples from A Vuong hydropower plant
- Phu-My power plant (existing),
- O Mon #3, #4 gas thermal power plants (planning)

c. Analysis of the Initial Environmental Study (IES)

IES was executed on the 65 candidate sites, where concrete location is specified, in the 96 candidate sites, original 71 candidate sites and additional 26 candidate sites.

The study results were evaluated by following formula.

$$E_I = \sum_{i=1}^{m} (V_i)_1 W_i \qquad (8.1)$$

In which: E_I : environmental impact

$(V_i)_1$: quality value of the category "i" environmental parameter of the project 'l'

W_i : weight of the category "i" factor

m : sum of factors

The evaluation is executed putting a quality value score of 4 to **a** (considerable serious environmental impact), 2 to **b** (less environmental impact) and 1 to **c** (non environmental impact) as factor (Vi).

Then, importance levels 3, 2 and 1 were weighted to each environmental item depending on the importance level (Wi). After that, each weight was multiplied by each point ((Vi)i*Wi).

Moreover, these evaluations are carried out separating construction phase and operation phase, and finally summarizing the result of each item for evaluation.

As a result of reviewing the checklist, the 18 highest ranking candidate sites, which have smaller impact, are HPPs; middle rank of 19 to 29 are mix of HPPs and TPPs, and TPPs concentrate in the lowest rank under 30.

TPPs have bigger influences than HPPs, by evaluating each candidate site based on the IES result from the view point of environmental and social considerations.

It is undeniable that the strategic environmental and social considerations tends to undigested because of the SEA was applied to PDP 6^{th} for the first time. However, in the case of preparing the power development plan which covers whole country of Vietnam, the plan should be built based on the strategic way of thinking, taking into consideration IES results.

Meanwhile, IES of this time was carried out mainly in the office. When developing each candidate site, IEE and EIA should, therefore, be executed carefully focusing on the conditions of each site.

8.3 Interpretation of IES Result and SEA

(1) PDP 6th from the Viewpoint of Environmental and Social Consideration

As shown in Figure 8-4-1, power generation in 2005 was around 11,000 MW, and 7 times of that, around 79GW will be developed by 2025 according to the PDP 6th and the 42.5% will be developed in the North, 57.5% in the Central and South.

Figure 8-4-2 shows the Best Mix of Power Development in the PDP 6th. The composition rate by power source is planned to change from now to the year of 2025 as follows;

a) Hydro-power (incl. PSPP) : from 37 % to 23 %
b) Coal Thermal Power: from 13 % to 43 %
c) Gas Thermal Power: from 38 % to 18 %
d) Nuclear Power: from 0% to 9 %
e) New and Renewable Energy (less than 30MW of small HPP, Wind, Bio-mass, Solar Energy): to 1 %

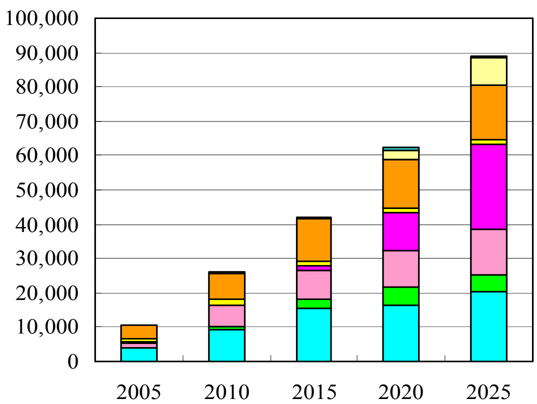


Figure 8-2 Installed Capacity by Power Source in the PDP 6th

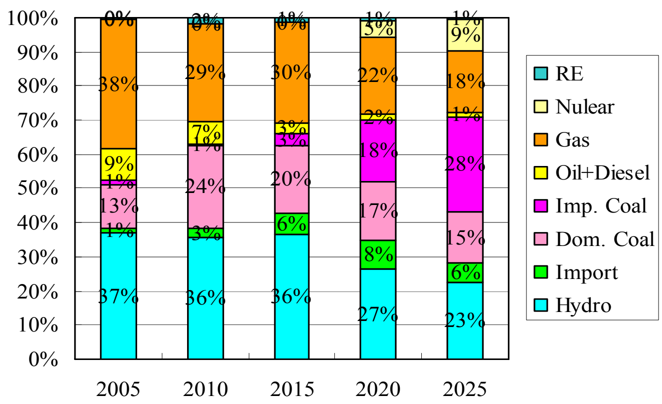


Figure 8-3 Installed Capacity Composition in the PDP 6th

Namely, installed capacity and composition rate of coal thermal plant will expand largely in the both the North and the Center & South.

On the other hand, development potential of HPP is estimated as 300 TWh of generation energy theoretically (180 TWh in the North, 78 TWh in the Center and 44 TWh in the South), and 82 TWh (20.6 GW of Capacity (17.6 GW of big and middle scale hydropower plants)) is estimated as feasible development potential. According to the PDP 6th, conventional hydropower of 16 GW is planned to develop by 2017. This means that there is a little room for further conventional hydro-power development.

(2) SEA on PDP 6th

1) Policy

The concept of the National Energy Policy of Ministry of Industry is reflected to PDP 6th.

2) Plan

The plan of PDP 6th is to develop around 78 GW electric power supply to meet the demand of Base Case by the year of 2025.

3) Program

The program of the PDP 6th is to develop 16 GW of HPP, 5 GW of import, 48 GW of TPP (36.5 GW of coal TPP [including 24 GW of imported coal TPP], 12 GW of Gas), 8 GW of nuclear power, and 0.6 GW of renewable energy between 2006 and 2025.

4) Alternative Study

a. Study for Involuntary Resettlement

The number of involuntary resettlement households in the candidate sites of TPP are 0 to 280 (mostly less than 5 households) and on the other hand, in the candidate sites of HPP, there are 0 to 3,000 households (mostly less than 500 households). Larger numbers of households are in the HPP sites and most of them are minorities.

The relation between the number of involuntary resettlement households and Accumulated capacity is shown in Figure 8-4.

Involuntary resettlement household of the top 4 (four) candidate sites account for 55% (around 6,800 households) and total generation capacity of those top four sites is around 17% (935 MW) of total capacity.

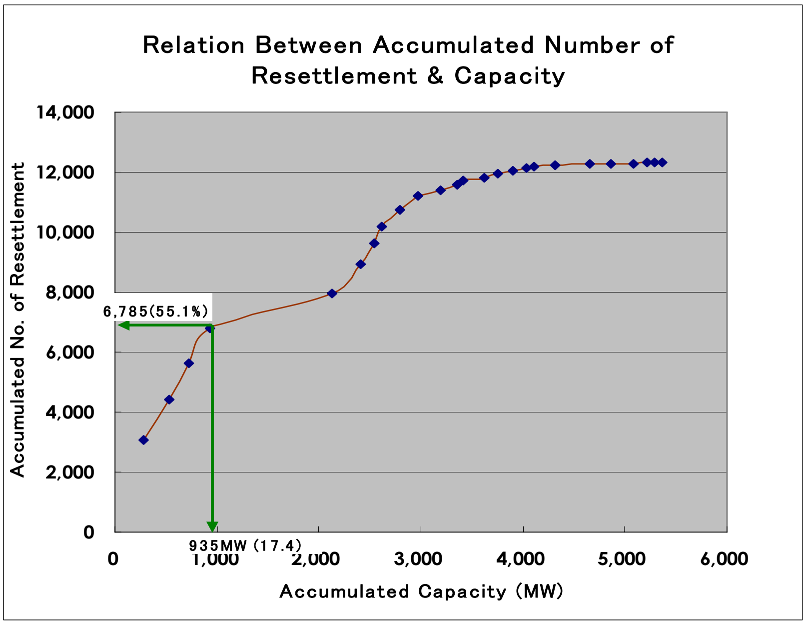


Figure 8-4 Relation between No. of Resettled Households & Accumulated Capacity

b. Study on Air Quality, Climate Change – Global Warming

Amount of CO2 generation of each type of power unit per kWh is shown in Table 8-1.

Table 8-1 Unit amount of CO2 generation of each type (g/kWh)

Coal TPP	975	(=887+88)
Oil TPP	742	(=704+38)
LNG TPP	608	(=478+130)
LNG-combined cycle PP	519	(407+111)
Solar energy	53	
Wind energy	29	
Nuclear Generation	22	
Geothermal energy	15	
Middle and small scale HPP	11	

Source: HP of Ministry of Environment in Japan

CO2 emission amount in case of the plant capacity 1,000MW, yearly operation rate 70% is estimated by following formula.

CO2 emission amount = (unit amount [g/kWh]) * 1000 MW * 24 hr * 365 days/ year * 70 %

= 6 million tons / year

Here, let's try to apply CO_2 emission right trade based on the Kyoto mechanism (CDM). In case that Discount Rate of 10% and curbon credit price of US$ 10/t-CO_2 are applied, net present value of the carbon credit is estimated US$ 511 / kW. Therefore, the limit construction unit cost of hydro power plant may increase up to US$ 2,211 / kW (1,700 +511).

The introduction of a carbon credit idea provides an additional 30% (= 511 / 1,700) “allowance” for unit construction cost of hydropower plants.

c. Study on Alternatives

Comparison of the level of influences between social aspects and environmental aspects is not easy. The Study Team recommends two alternatives, one of social aspects and the other of environmental aspects, as follows.

- **Alternative I : Replace the highest 4 ranks of HPP candidate sites, which require large scale involuntary resettlement, with other HPPs with less involuntary resettlement and / or imported HPP energy.**

It can be said that maximum US$ 2.4 million (=$34,500*7,000) of resettlement cost would not be needed to prepare avoiding destruction of 24 thousand households lives which is more than 55 % of necessary total involuntary resettlement households.

- **Alternative II : Replace import coal TPP to HPP and / or Renewable Energy**

Thermal power using imported coal is planned in the PDP 6^{th} scenario as 10,600MW in the North and 14,250MW in the Central and South, for a total of 24,250MW.

This alternative is the plan to replace imported coal thermal power plants with hydro power plants and or renewable power plants in view of energy security and reduction of CO_2 emission (contribution for the protection of global warming).

5) PDP 6^{th} with SEA

The best mix of the PDP 6^{th} (Figure 8-5) was reviewed as shown in the Figure 8-6, as the result of reexamination on the power development taking into consideration the proposed alternative of SEA.

Although the renewable energy was planned to develop 600MW by 2025 in the PDP 6^{th} first plan. Then, 1,900 MW (1,400 MW of hydropower, 500 MW of wind power) of new candidate sites were added and the composition ratio increased from 1 % to 3 %. Along with this, composition ratio of coal thermal generation decreased from 43 % to 41 %.

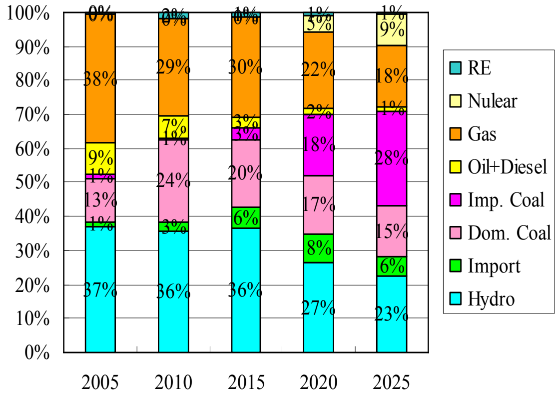


Figure 8-5 Installed Capacity Composition in the PDP 6th

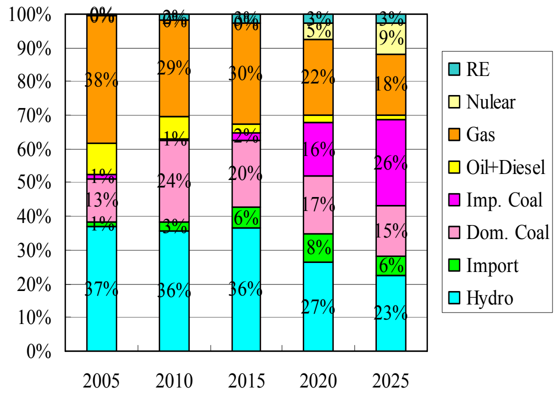


Figure 8-6 Installed Capacity Composition with consideration of SEA result

In the study on the master plan, it is also necessary that wide ranged power supply network connecting multiple power plants be revised.

It was observed in the IES results of each candidate site that protected areas were avoided as much as possible in view of environmental considerations. However, in the PDP 6th construction of country wide power supply network should be planned, taking eight times of power supply capacity into consideration. Accordingly, considerations from the viewpoint of SEA are also necessary when conducting concrete studies on the power network.

This time, environmental and social considerations study was carried out with counterpart personnel to prepare the PDP 6th master plan, complying with the JICA's Environmental and Social Considerations Gude-lines.

It is expected that this experience can be the first step to do more strategic environmental and social considerations and more effective SEA will be introduced in the following master plan study.

8.4 Support for holding of Stake-holder Meeting (SHM)

When executing environmental and social considerations study, SHM is one of the most important means for understanding ideas and opinions of the Stake-holders and to harmonize their concept.

The 'JICA's E & SC GL' states that JICA study team assists its counterpart organization for holding a SHM.

Accordingly, the Study Team supported C/P（EVN-IE）to hold a SHM in January.

A few queries and several opinions were offered, and earnest but polite discussion was made. Moreover, there was lively discussion on nuclear power and it ended with a sense that it was too early for Vietnam to introduce.

Participants seemed to have different interpretation of the PDP 6^{th} and Environmental and Social Considerations with SEA. The SHM of this time was the first case in the study on power development plan (PDP) in Vietnam, and became start for counterparts to recognize the sense and necessity of SHM.

9. Recommendations

9.1 Power Demand Forecast & Primary Energy

1. Energy saving

Power demand elasticity to GDP continues at a high level of around 2.0. The value is extremely high when compared to in the rest of the world. The phenomenon sometimes happens in countries where economic development policies are focused on Heavy Industry Sectors. The worldwide economic trend is to pursue high economic growth and better lives suppressing energy demand in the near future. From this point of view, it is necessary that the national economic policies should include promotion of energy conservation, promotion of renewable energy utilization, development of high value added business sectors, improvement of transportation system, and relocation of capital functions.

2. Power saving

Electric power is used in all aspects of Vietnam people's lives such as electrification of their home and working places, enhancement of information and communication technology, increase of transportation facilities and so on. Especially, popularization of air-conditioners raises the growth of power demand. For curbing power demand growth, it is recommended that the Government should propagandize the efficient use of air-conditioners.

3. Short-term energy and power demand forecasting model

Future power demand cannot be decided by only GDP and power tariffs. It is changed drastically in line with industrial structure changes and people's life style improvement. In some other countries, the short-term power demand forecasting models are built up including the variables of dissemination ratios, efficiency and utilizing patterns of electric appliances, and the results of the models are used for education of power consumers. It is recommended to prepare such kinds of energy and power demand forecasting models for making more efficient and effective power consumption.

4. Diversification of Energy

According to IEA world energy outlook 2004, the world energy consumption shifts from oil and oil derivative production to natural gas, coal and renewable energies. Especially, energy conversion from conventional gasoline and diesel to ethanol and new fuels made from corn and natural gas are implemented in the world. It is recommended that the new transportation system installing the new energies and fuels should be introduced in future.

5. Exploration and exploitation of domestic primary energy resources

From the viewpoint of energy security and stability of long-term energy supply, it is recommended that exploration and exploitation of domestic coal, gas and oil energy resources should be enhanced. Especially for realizing the least cost development of power generation, gas of 18BCM and coal of 70 million tons should be produced in 2025.

6. Preparation of Energy Master Plan

It is recommended that Energy Master Plan be prepared comprehensively in consideration with the Study of PDP 6th and the above-mentioned recommendations.

9.2 Power Generation and Network Development Plan

1. System reliability

The relations between system reliability, LOLE and reserve margin in 2015, 2020 and 2025 were calculated in the PDP6th study. The relation between LOLE and reserve margin can be utilized as a system reliability index considering power supply and demand balance throughout the year. The results indicate that, to secure the system reliability criterion LOLE 24-hour, it is necessary to have a reserve margin rate of 7 – 8% in the north system and 10% in the central & south system respectively. It is recommended that the power system development plan should be built utilizing the reserve margin considering the relation with LOLE.

2. Capacity of 500kV interconnection between the North and the South Systems

The capacity of 500kV interconnection should be considered by economic evaluation from comparison between benefits of interconnection and reinforcement costs.

There is risk that the system could be unstable especially at off peak time, if the interconnection cannot be operated securing N-1 criterion by a large power flow because the insufficient power development causes large imbalance of power supply and demand.

3. Dormancy of hydropower output in dry season

The hydropower monthly output plan was compared with actual records during 1996 to 2004 in this study and the actual outputs in dry season are 400MW lower than the plan in the north system. The reason why the available capacity in dry season becomes dormant is a shortage of water volume in reservoirs so as to operate at an available capacity during peaking time of 4hours a day.

Accordingly, it is strongly recommended to review and update the metrological data and monthly supply capability of all hydropower plants (existing and planned) in the North. Especially, when revising monthly firm peak capacity, the required peak duration hours should be set at **7** hours.

4. Power purchase price

When power is purchased from BOT and neighboring countries, the economic analysis should be conducted by comparing between power purchasing price and marginal costs of Vietnam system taking its capacity factor (Peak, Middle or Base supplier) into consideration,. The capacity factor of BOT and power plants in neighboring countries should be examined by simulation of demand supply balancing operation by PDPAT2.

Furthermore, in the case that power purchase agreement is concluded, price system should be divided into capacity charge and energy charge in the contract.

5. Power network planning

Power network planning of Vietnam in perspective up to 2025 should be carried out in order to meet the soaring power demand of city areas taking into consideration scale-up and faraway location of power plants as well as high reliability and economy of power transmission. For this purpose, the following are recommended.

- ✓ N-1 criteria should be applied for power network planning.
- ✓ For the future Hanoi and Ho Chi Minh City system, application of large size conductors and large size transformers should be considered for economical system configuration.
- ✓ For the system configuration in Hanoi and Ho Chi Minh City, the multi-ring shaped system configuration should be targeted.
- ✓ Automatic power sources controllers should be applied such as automatic switching operation of capacitors or shunt reactors and SVC (Thyristor controlling reactive power sources) or synchronous condensers.
- ✓ The countermeasures against increases in fault current should be examined such as split operation of the system, adopting the circuit breakers with high fault breaking ability, application of high impedance transformers. Circuit breakers of 63 kA should be set out as a standard.

- ✓ If many series capacitors are installed, it would be difficult to grasp the resonance frequencies. The installation of series capacitors should be limited in such a case of north – south transmission lines.
- ✓ Higher voltage transmission lines should be considered for economical system configuration in order to reduce the number of lines when high scenario about power generation development is realized in the Center to the South.

It is recommended that technical standards or grid code should include the methodologies of power network planning described in PDP 6th to be standardized, because making the power network planning methodology transparent as much as possible would lead to strengthening of the impartially access for independent power producers and the quasi-pubic roles of power network systems.

9.3 Financial Perspective

1. Improvement of the cash flow until around 2010

In the investment plan of the sixth master plan, the amount of investment in construction has been estimated sizable since 2005 in response to the upsurge of power demand. Meanwhile, since many of the invested facilities are completed and started up in and after 2010, the revenue from power sales will not increase significantly until around 2010.

While the expenditure of investment activity exceeds 50,000 bill VND in 2007, the revenue of operating activity is no more than about 30,000 bill VND in 2010.

Thus, the cash flows until around 2010 will be in a harsh condition according to the simulation. In order to cope with this situation, it is necessary to scale down the investment plan until around 2010 or to cover the gap between the expenditure of investment activity and the revenue of operating activity by soft loan or other methods.

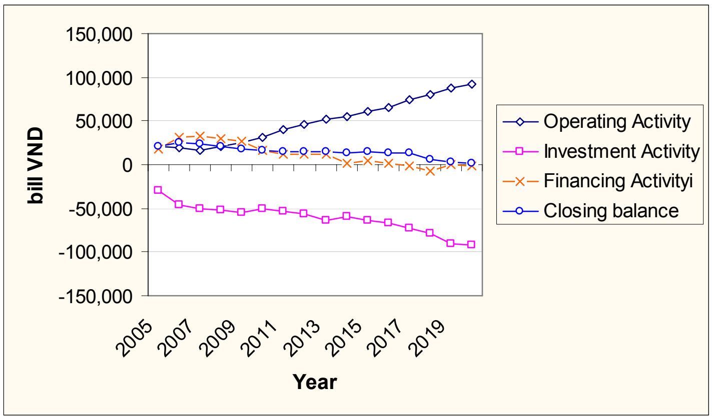


Figure 9-1-1 Cash Flow of Each Activity

2. Effect of power purchase on the financial condition

If the investment until 2010 is scaled down, the power output volume will decrease accordingly. Therefore, purchase of power from IPP and BOT should be increased for maintenance of the level of power sales before the scaling down.

The following table is a comparison of income, expense and profit (income - expense). In the simulation, the income and the expense increase to nearly the same level, which shows that further increase of power purchase cost will lead to an unfavorable balance for EVN.

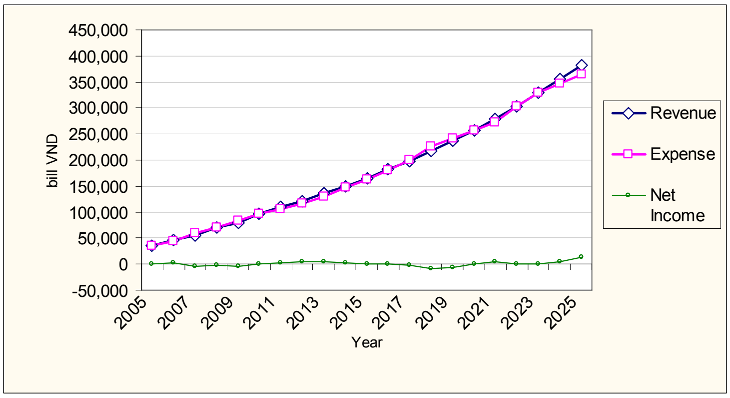


Figure 9-1-2 Revenue, Expense and Net Income

However, depreciation cost involving no cash disbursement is included in the expense. That is to say, the actual cash outlay is about (expense – depreciation cost). Furthermore, the depreciation cost will grow as the fixed assets increase. Accordingly, if we outlive the harsh condition of cash flows until around 2010, we will be able to maintain the cash flows sufficient for power purchase from IPP and BOT in reality in and after 2011.

Therefore, the use of IPP and BOT will be a key to avoid a cash crisis caused by capital investment.

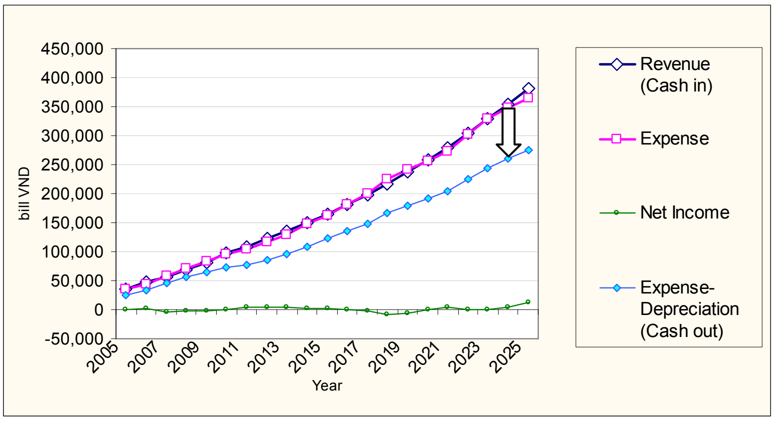


Figure 9-1-3 Revenue, Expense, Net Income and Expense-Depreciation

3. Limit of power purchase from IPP and BOT

It is essential to limit the total volume of purchase from IPP and BOT to less than 50% of the total power capacity of Vietnam so that EVN can maintain the position as a central agency of power sector in Vietnam in order to keep power market stable.

9.4 Environmental and Social Considerations

1. Result of Initial stage Environmental Study (IES) in the PDP 6th

Result of Initial stage Environmental Study (IES) in the PDP 6th showed characteristic differences between Hydro-Power Plant (HPP) and of Thermal Power Plant (TPP).

Namely, development of HPP has large impacts of social environmental issues such as involuntary resettlement and minority items, meanwhile development of TPP has large impacts of environmental issues such as air pollution and global warming items. Furthermore, as the result of IES, development of HPPs occupy higher rank, development of TPPs occupy lower rank, and both of HPPs and TPPs exist mixing in the middle rank (24%). As for Nuclear Power Plant (NPP), one of two candidate sites studied is seated at the lowest rank and the other was at the fourth from the bottom. NPP has serious influences on the environment such as generation of radioactive waste, transportation of nuclear fuel (fuel bar), radiation leakage caused by accident. However, from the view point of global warming / emission of CO_2 gas, it is undeniable that NPP is environmentally friendly generation system as well as wind power.

Since the study was carried out mainly in the office, there is possibility to come out another evaluation result in the IEE and/or EIA. When developing each candidate site of the middle rank group, IEE and EIA should be carried out carefully taking into consideration its specific conditions.

2. SEA in the PDP6th

In case of introducing concept of clean development mechanism (CDM), the economical construction unit cost can be raised up to 2,211 US$ / kW (+30%). Herewith, feasible development capacity of HPP can increase and the development amount of coal TPP can be reduced.

'To develop energy resources with protection of natural resources and environment' is stated in the 'National energy policy'. It is, therefore, desirable that the development of coal TPPs (in particular import coal TPP which will commission in the year 2016), which have large environmental impact indicated by the result of IES, are replaced by other type of power plants which have smaller environmental impact (i.e. new and / or renewable energy) as much as possible.

3. Alternatives

Alternative I is to replace the highest 4 ranks of HPP candidate sites, which require large scale involuntary resettlement, with other HPPs with less involuntary resettlement and/or imported HPP energy. When necessity of import power arises unavoidably, environment impact of export countries also should be considered to the utmost.

Alternative II is studied introducing the idea of emissions trading and presuming CO_2 trading price as US$10 / t-$CO_2$. However, it is considerable that the limit of economical construction unit cost will vary according to the CO_2 trading price and crude oil price.

4. Stake-Holder Meeting (SHM)

It is not easy to understand the position of SHM in the SEA.

The expert of environmental and social consideration should make efforts to make counterparts recognize the concept of SHM clearly for introducing SEA to planning of similar development project.

Moreover, there was lively discussion on nuclear power and it ended with a sense that it was too early for Vietnam to introduce.

Although there is a time restriction to feed back appropriately the opinions of this SHM to the PDP 6^{th} preparing works, the method how reflects the sense and the opinions in the plan, should be adjusted systematically and institutionalized in order to take root holding SHM in the following PDP preparation work.

Furthermore, even when developing each candidate site, it is necessary to introduce SHM efforts as much as possible.

5. Utilization of SEA

Introduction of SEA was the first case in the study on power development plan (PDP) in Vietnam, and the experience of 3 times of W/Ss and a SHM became start for counter parts to recognize the sense and necessity of the SEA.

Hereafter, it is important to make close cooperation among concerned parties at early stage and to introduce more effective SEA.