JAPAN INTERNATIONAL COOPERATION AGENCY (JICA)

ELECTRICITY OF VIETNAM (EVN)
THE SOCIALIST REPUBLIC OF VIETNAM

MASTER PLAN STUDY ON PUMPED STORAGE POWER PROJECT AND OPTIMIZATION FOR PEAKING POWER GENERATION IN VIETNAM

FINAL REPORT

SUMMARY REPORT

JUNE 2004

THE TOKYO ELECTRIC POWER CO., INC.
TOKYO ELECTRIC POWER SERVICES CO., LTD.

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Location of the Socialist Republic of Vietnam

MASTER PLAN STUDY ON
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Contents

ACRONYMS / ABBREVIATIONS

ABB	:	Asea Brow Boveri
ACSR	:	Alumunum Conductor Steel Reinforced
ADB	:	Asian Development Bank
AFC	:	Automatic Frequency Control
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
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
HPC	:	Hydro Power Station
IE	:	Institute of Energy
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	:	Loss-of-Load Expectation
M/P, MP	:	Master Plan
MARD	:	Ministry of Agriculture and Rural Development
MOI	:	Ministry of Industry
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

ACRONYMS / ABBREVIATIONS

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
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
VEEA	:	Vietnam Electricity Engineering Association
WASP	:	Wien Automatic System Planning Package
WB	:	The World Bank
WSS	:	Weekly Start and Stop
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
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 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 15,375	As of March 2003
1 US$	=	VND 15,430	As of June 2003
1 US$	=	VND 15,570	As of December 2003

Chapter 1. Introduction

1.1 Background

Both electric power consumption and maximum demand in the Socialist Republic of Viet Nam (hereinafter referred to as "Vietnam") have shown high growth rates of 13% per year for the last 10 years. Therefore, the development of power sources and transmission systems has been an important issue for Vietnam. In addition, daily electricity demand fluctuates significantly: the daily maximum demand occurs at 6pm to 7pm is more than double the lowest demand late in the middle of the night. Thus, the annual load factor in Vietnam is as low as 65%, while that of other Southeast Asian countries reaches approximately 70%.

Nevertheless, measures to increase peaking supply capacity have not been taken but demand side management (DSM) has been promoted by just placing different electricity tariffs between peak hours and off-peak hours.

Under the situation, in March 2001, Electricity of Viet Nam (EVN) requested the Government of JAPAN to carry out a development study to increase power system reliability and peaking supply capacity. Accordingly, a basic study mission for project formulation was dispatched in January 2002 and discussed the requested development study with the Government of Vietnam.

Based on the discussion, preliminary study mission was dispatched in July 2002 and the S/W of the Master Plan Study on PSPP and Optimization for Peaking Power Generation (hereinafter referred to as "the Study") was agreed upon with EVN, which was named as a counterpart of the Study.

1.2 Objectives and Scope of the Study

(1) Objectives

Objectives of this study are as follows.

1) To study, based on supply and demand projections, the optimization of peaking power source development through examination of optimal power sources composition.
2) To formulate a master plan of peaking power sources development by confirming system reliability in consideration of domestic and international power exchange and international power purchases.
3) To contribute to balance future electricity demand and supply in Vietnam.

(2) Geographical Scope

The Study covers the whole country of Vietnam.

(3) Scope of the Study

According to the S/W and M/M signed between EVN and JICA on July 16, 2002, the study will be carried out in the following three (3) stages.

Stage 1: Preliminary Assessment

- Related data and information are collected and analyzed to understand the existing systems of power supply.
- Demand forecasts and power development plans up to the year 2020 are reviewed and data for examining peaking power sources development are prepared.
- Especially demand forecast of every region (North, Center, South) and the expansion plan of interconnected transmission lines are reviewed.

Stage 2: Project Identification

- Criteria for selection of pumped storage potential sites are prepared.
- The pumped storage candidate sites selected by Vietnam are reviewed, and fresh candidate sites are selected and identified.
- Priority sites are narrowed down from the candidate sites.

Stage 3: System Optimization

- Economic viability of alternatives of peaking supply power other than pumped storage hydropower is examined.
- Master plan of peaking power sources development up to the year 2020 is proposed through examination of the optimal power sources composition.

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 are closely coordinated to compile the master plan of power development. In order to reflect comments of related organizations, W/S is held in each study stage.

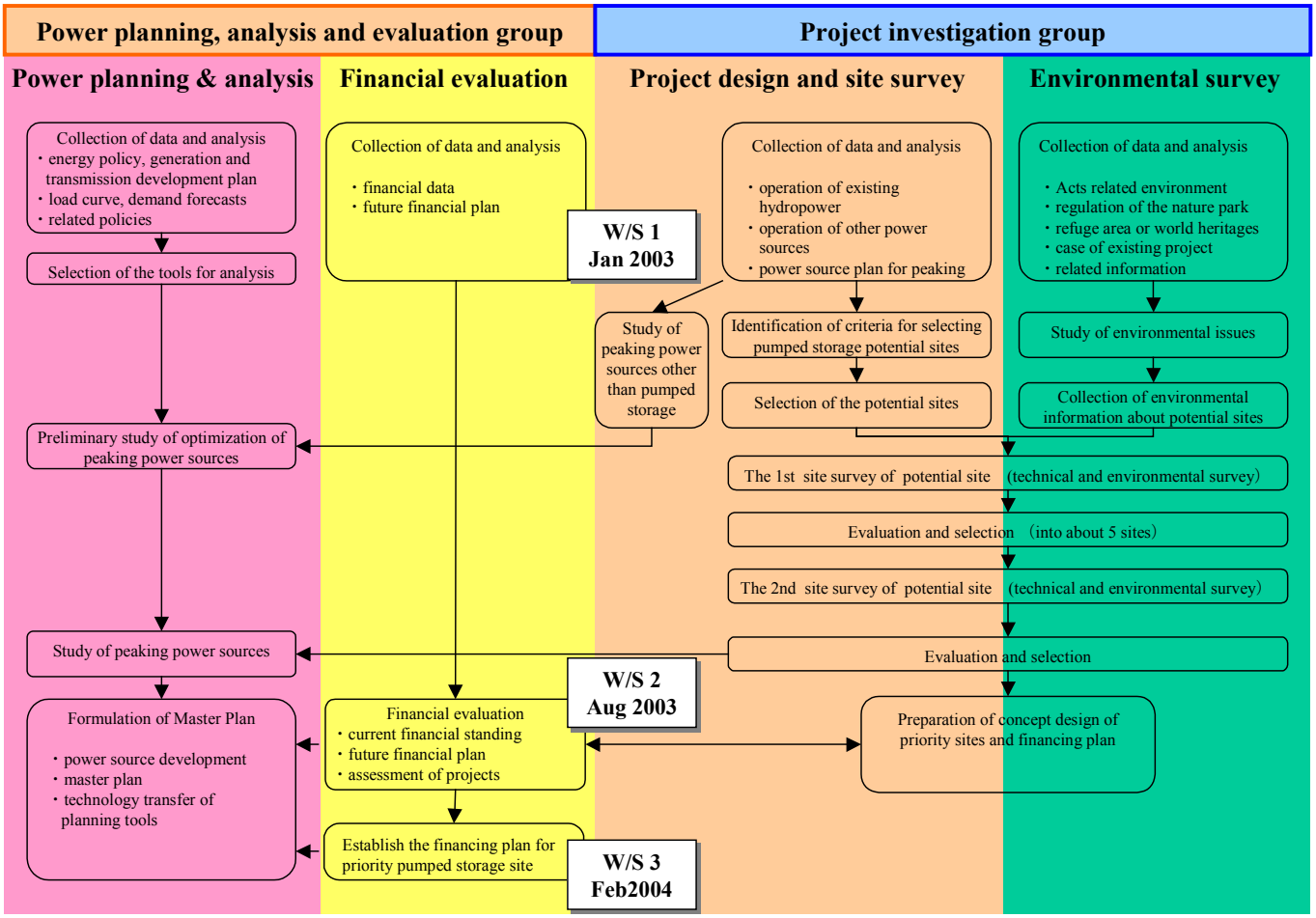


Figure 1-1 Study Flow

Chapter 2. Current Situations of Power Development

2.1 Energy Sector

(1) Energy Resources

a. Hydropower

Theoretical hydropower potential of the whole country is estimated at about 300 TWh per year. The North possesses the biggest reserve with 180 TWh (60%), the Center 78 TWh (26%) and the South 44 TWh (14%). The feasible hydropower resource amount is 82 TWh while installed capacity is 17.7 GW. By the end of 2002, there are eight over-100MW existing power plants with total installed capacity of 3,945MW, which is merely 22% of feasible hydropower potential.

b. Oil, Gas

The Vietnam continental shelf contains an abundant reserve of hydrocarbon. In 1986 Vietsovpetro, in a joint venture of Vietnam and the former Soviet Union, the two companies began to exploit crude oil in the Bach Ho field of Cuu Long Basin, 120 km south west of Vung Tau. After that, through investments from Western countries, more oil and gas have been explored and exploited in Rong, Dai Hung, Rang Dong and Ruby fields of Cuu Long Basin as shown in Table 2-1. In addition to these fields, several big-reserve fields have been discovered such as Malay-Tho Chu basin in southwest offshore; Nam Con Son Basin 200 km south east offshore from Cuu Long Basin; and Song Hong Basin in the North region as well. The feasible gas potential is 328 BCM at this stage.

According to the 5th Master Plan of Vietnam Power Development, hydrocarbon reserves, which were inferred so far, were 390 million tons of oil and 617 billion m^3 of gas.

c. Coal

Vietnam's coal reserves lie principally in Hon Gai graben in Quang Ninh, which extends about 125km from Uong Bi in the west to Cai Bau in the east. Though the coal deposits are geologically young, intense tectonic pressure had changed bituminous coal to semi-anthracite or anthracite. In 2002, coal reserves of 300m below the surface were estimated at 3.8 billion tons as shown in Table 2-2, 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%). The ratio of open-pit and underground mines is 2:8.

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 2-3. Among these, potential measured reserve is 51 million tons within 400m below the surface. The average coal quality is: moisture 18%, ash 7%, volatile 36-37%, calories 5,000kcal/kg, sulfur 0.5%.

Table 2-1 Gas Development Situation

Basin	Block	Developer	2P Reserves (BCM)	Annual Supply Capability	Supply & Development Plan	Remark
Cuu Long	9-1 (Bach Ho)	Vietsovpetro JV (PetroVietnam 50%, Nestro 50%)	20	1.5	PM 2-1, Ba ria, LPG	Associated Gas under production
	9-1 (Rong)					
	01,02 (Ruby, Emerald)	Petronas Carigali/ PVEP	25.5	1		Expected first gas in 2005
	15-2 (Rang Dong)	JVPC/ Conoco/ PVEP	9	0.5		Associated Gas under production
Nam Con Son	06-1(Lan Tay, Lan Do)	ONGC (India),BP	57	2.7	Phu My 1 Phu My 2-2 Phu My 3 Phu My 4	First gas planned 2003
	11-2 Rong Doi, Rong Doi Tay, Rong vi dai	KNOC (Korea), Mobil	30	1.3	Phu My 2-2	Under development
	05-3 (Moc Tinh)	BP/Conoco	20	1.3	No plan	Under projection
	05-2 (Hai Thach)	BP	47	1-2	No plan	Under appraisal & development
Malay-ThoChu (Southwest offshore)	B, 48/95, 52/97	Unocal MOECO PV (PVSC)	90	2-4	Depending on gas market	Under appraisal & development
	PM-3 CAA	Petrronas, PV-Co owners (50:50)	50%*52	50%*2.5	Power & Fertilizer complex in Ca Mau	First gas to VN by the end 2005
Song Hong	Thai binh (Tra Ly River), D14, Tien Hai C	Maural & Prom (France), Petro Vietnam	4	0.08	Local Industry	Operation partially
Total			328.5	12.6-15.6		

Source: Petrovietnam

Table 2-2 Coal Reserves（Unit: million tons）

	Certainty of exploration				Exploitation	
Mine area	A+B+C1+C2	A+B	C1	C2	Open pit	Underground
Cam Pha	1,316.05	267.99	623	425.06	237	991
Hong Gai	526.91	37.31	247.77	241.83	54	513
Uong Bi	1,328.98	79.99	682	566.99	22	1,392
Interior	636.59	53.44	427.71	155.44	172	93
Binh Minh Khoai Chau	145.96		122.91	23.05		119
Total	**3,808.53**	**438.73**	**1,980.48**	**1,389.32**	**881**	**3,109**
Type of coal						
Anthracite	3,238.20	395.31	1,595.91	1,246.98	388	2,980
Long frame (Lignite)	215.23	42.84	149.56	22.83	97	121
Fat coal	6.91	0.58	6.18	0.15		7
Peat	348.19		228.83	119.36	396	

Source: Vinacoal M/P, 2003

Table 2-3 Red River Coal Reserves（Unit: 1000 ton）

Seam	K.S Syncline - Binh Ninh Anticline				F.K.Fault - K.S Syncline	Binh Ninh Anticline.- Binh	Gross Total
	Middle				West	East	
	Measured	Indicated	Inferred	Total	Inferred	Inferred	
	< 400m	400-800m	800-1200m		< 1200m	< 1200m	
V17	38,520	86,697	72,734	197,951	15,756	8,789	222,496
V15	52,369	94,889	64,671	211,929	17,573	20,030	249,532
V14	88,664	131,867	73,434	293,965	34,216	19,738	347,919
V4	88,055	86,563	53,516	228,134	14,874	21,042	264,050
V3	243,602	164,478	81,222	489,302	42,123	23,826	555,251
Gross Total	511,210	564,494	345,577	1,421,281	124,542	93,425	1,639,248

Source: Red River Delta Project, January 2003, NEDO

(2) Energy Development Plan

a. Hydropower

Hydropower is a clean and renewable energy resource. Though sizeable up-front costs are needed for development, once operated this energy is cheap and stable for more than one hundred years and out of influence of the exchange rate fluctuation because fuel costs are zero. Therefore, EVN should properly develop hydropower plants, which have economic rationale.

According to the latest power development plan, a total of 12,135MW hydropower is developed from 2003 to 2020, of which the north region cover 54%, the central 29%, and the south 17%. This results in developing 91% of the feasible hydropower potential of 16,080MW by 2020.

b. Oil, Gas

Table 2-4 shows the exploitation plan of the oil and gas sector indicated in the 5th M/P. As of the end of 2002, the total capacity of oil thermal power plants excluding IPP was only 198MW, which is total of the capacity of Thu Duc Power Plant (165MW) and Can Tho Power Plant (33MW), both of which have to import FO for operation. The only planned oil thermal plant is O Mon TPP No.1 with the capacity of 600MW. However, gas will be used on completion of the pipeline from the gas potential in southeast offshore to O Mon in 2010.

On the other hand, along with the rapid increase of gas production, a total of 10,483MW gas thermal power plant is under planning between 2003 and 2020. Excluding Quang Tri power plant

(720MW) in the central region, all the planned gas thermal power plants are located in the south region, and none is proposed in the north region. The current of gas supply price is approximately US$1.8/mmbtu at the platform, excluding transfer costs through pipelines.

Table 2-4 Petroleum Exploitation Plan (Unit: million m^3 OE)

	2000	2005	2010	2020
Oil Production	16.5	17.6-18	20.6-21.6	11-18
Gas Production	1.5	6.7	11.5-13.5	14-18

Source: Institute of Energy, 2003

c. Coal

The latest coal exploitation plan is shown in Table 2-5. The average coal price (ex-works price) is VND319/kg and the price for generation is as low as VND305 to 332/kg. In addition, the coal sector is a completely domestic industry, so that coal price is set up in local currency and stable out of influence of exchange rate fluctuation. Since coal is mainly used for the power and cement sectors, exhaustion of coal resources is not as much of a concern as the possibility of exhaustion of gas. Therefore, the coal thermal power plant is given high priority to develop as a base power source; plans for a total of 5,800MW of coal plants is underway from 2003 to 2020.

Due to the location of reserves, all the existing coal power plants are in the northern region. However, considering the abundant potential and stable price, the latest power development plan proposes to develop a coal thermal power plant in the south region utilizing imported and/or domestic coal. Vinacoal estimates that, with a tanker of 4,000 to 6,000 tons, the price of coal transferred to the south region is about US$5/ton to Nui Xuoc, $7/ton to HCM City, $10/ton to Kien Giang.

Table 2-5 Coal Exploitation Plan (Unit: 10^6 ton)

	2000	2005	2010	2015	2020
Coal Production	10.5-11.0	12-13	14-15	—	15-20
	10.5-11.0	16	24	27	30

Source: Upper: 5th Master Plan of Electric Power Development in Vietnam, Jun. 2001

Lower: Vinacoal M/P, 2003

(3) Demand-and-Supply Plan of Primary Energy

Table 2-6 shows demand-and-supply plan of primary energy proposed in the 5th M/P. Primary energy demand is expected to increase at the AAGR of 8.2% from 2000 to 2020. Primary energy supply continues to exceed its demand by 2010. Meanwhile, due to the reduction of the rate of increase of coal and oil production, the supply is expected to fall below the demand by approximately 28% in 2020.

Table 2-6 Primary Energy Demand-and-Supply Forecasts (Base Scenario)

	2000		2005		2010		2020	
		KTOE		KTOE		KTOE		KTOE
Energy Demand		18,131		27,878		44,360		88,228
Domestic Supply		27,766		37,426		50,086		63,324
Coal (mil. ton)	11.6	6,501	16.2	9,053	22.8	12,772	30.1	16,846
Oil (mil. ton)	16.3	16,564	20.0	20,324	21.6	21,989	18.0	18,324
Gas (bil. m^3)	1.6	1,440	4.5	4,050	8.8	7,939	18.0	16,200
Other (TWh)	14.6	3,261	17.9	3,999	35.1	7,386	58.4	11,954
Surplus/Shortage		+9,635		+9,548		+5,726		-24,904

Source: Institute of Energy, 2003

(4) National Energy Security

Though Vietnam is endowed with abundant energy resources, the future energy security balance is estimated as shown in Table 2-7 based on the above each primary energy potential and exploitation plan.

If the fossil fuel consumption increases at this rate, gas can be supplied from the proven gas reserve until no longer than 2030, meanwhile coal can be supplied from the proven coal reserves until 2120. In other words, it is necessary to explore and prove more gas reserves of 300BCM so as to supply gas to the planned and existing gas thermal power plants during their service life of 25 years.

Table 2-7 Security Balance of Fossil Fuel (Base Scenario)

	Potential (upper: :measured) (lower: inferred)	Exploitation Volume (2000-2020)	Residual Quantity	Exploitable years after 2020
Coal (mil. tons)	4,500	435*	4,075	≧100
	10,000		9,575	≧200
Gas (bil. m^3)	330	162	168	≦ 10
	617		455	≦ 30

*:Based on the exploitation plan of Vinacoal

2.2 Power Development

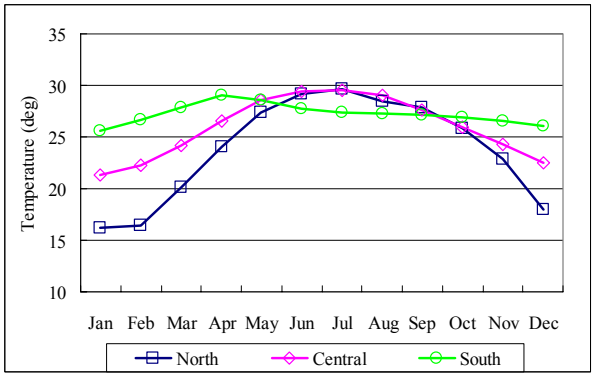
(1) Electricity Consumption, Peak Demand, and Characteristics of Consumption

Records of climate, economic situation, electricity consumption, peak demand, and characteristics of consumption pattern of the system are reviewed and analyzed.

a. Climate

Vietnam belongs to the Asia Monsoon Zone. The climate is quite different between the north with subtropical climate and the south with tropical climate. The north has four seasons and the temperature varies with each season. Summer begins in May with an average temperature of over 25 degrees. In June and July the weather gets hotter and sultry. July and August usually come with storms and heavy rain. Winter lasts from the end of December to the end of March, when it drizzles constantly and temperature is low and sometimes drops to around 10 degrees. Meanwhile the South has 2 seasons, a rainy season in May-October, and a dry season in November-April. The average temperature does not change much throughout the year (Figure 2-1).

(a) Temperature



(b) Humidity

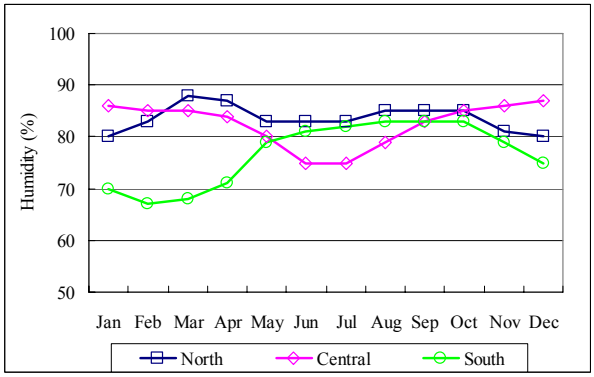


Figure 2-1 Regional climate change by month

Source: Hydro-Meteorological Data Center, Hanoi

b. Economy

Table 2-8 shows the population, real GDP, consumer price index, and commercial energy consumption of the country since 1990. The Vietnam economy has maintained steady growth with an annual average growth rate (AAGR) of 7.5% between 1990 and 2000. During the period, GDP per capita increased from US$206 to 356. The change of consumer price index is relatively stable, having the AAGR of 3.7% for 5 years from 1995. The AAGR of energy consumption remains 0.5% during 1990 to 2000.

Table 2-8 Historical Macro-Economic Index

Index	Unit	1990	1992	1994	1996	1998	2000
Population (10^6)	—	66.20	68.99	71.68	74.30	76.52	78.52
GDP (10^9)	1995 US$	13.61	15.67	18.44	22.08	25.27	27.93
GDP per capita	1995 US$	205.65	227.17	257.19	297.18	330.17	355.74
CPI	1995=100	na	na	na	105.68	116.99	119.72
Energy Use	10^3 KTOE	24.69	25.82	28.02	32.09	34.26	na
Energy Use per capita	KGOE	372.96	374.26	390.87	431.92	447.73	372.96

Source: World Development Indicators, WB

c. Electric Power Demand[1]

1) Yearly Demand

As shown in Figure 2-2, electricity consumption rapidly increased at AAGR by 15% between 1995 and 2002. As a result, the elasticity of consumption on GDP for 6 years since 1995 exceeded 2.0, whereas neighboring countries generally were at 1.0 to 1.5. Regarding the sector share of consumption, household and industry cover about 50% and 40% respectively.

(a) Consumption (b) Sector share

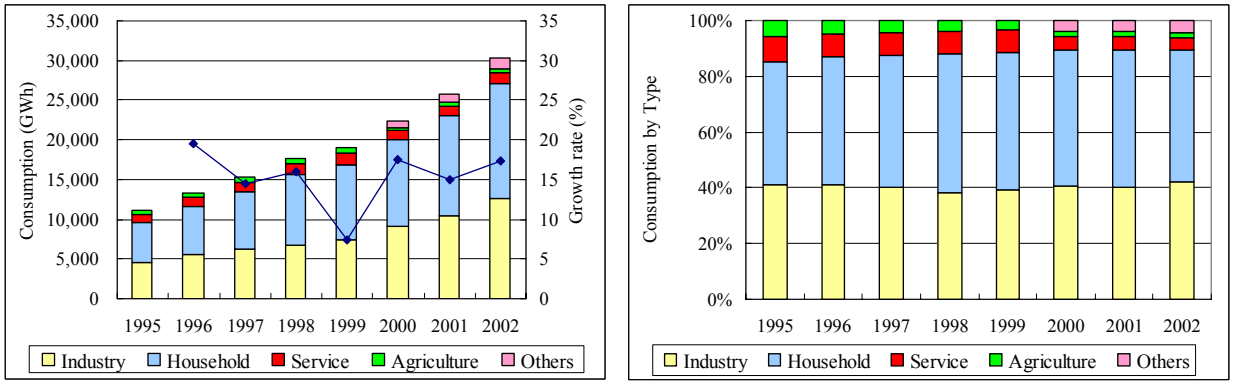


Figure 2-2 Historical electricity consumption by sector

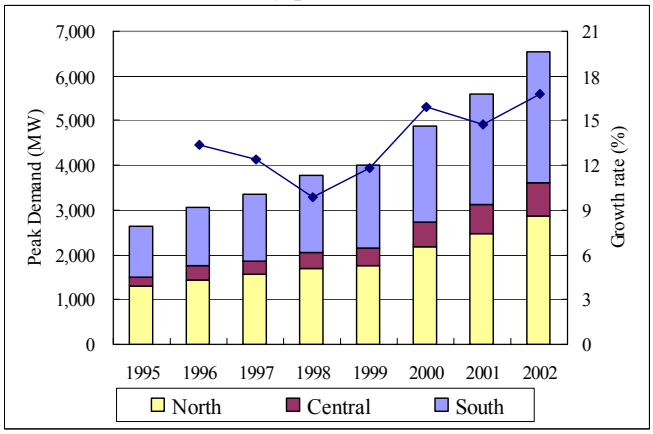
2) Yearly Peak Demand

Figure 2-3 shows historical changes of yearly peak demand and annual load factor. From 1995 to 2002, peak demand rapidly increased at the AAGR of 14%. It reached 6,554MW in 2002, which is more than double of the demand in 1995.

Annual load factors for the last 3 years have clear regional differences: about 55% in north and central region, and 69% in the south region.

[1] Historical demand data in this section are based on data from IE and NLDC.

(a) Yearly peak demand



(b) Annual load factor

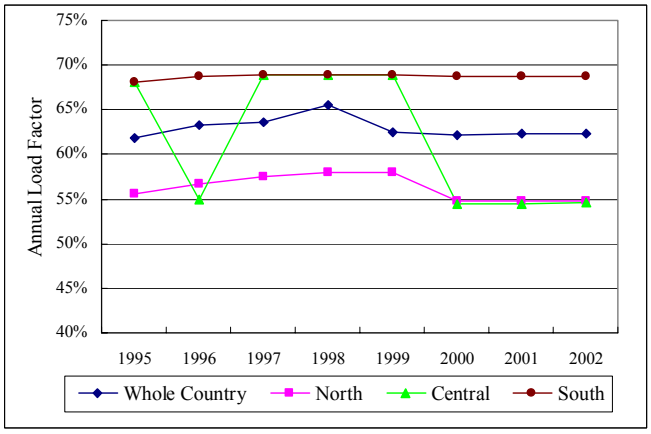
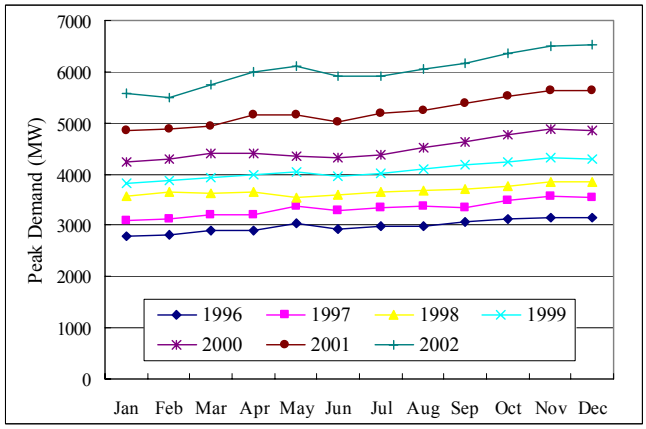


Figure 2-3 Historical Changes of Yearly Peak Demand and Annual Load Factor

3) Monthly Peak Demand

Figure 2-4 shows historical monthly peak demand of the whole country and regional results in 2002. Monthly peak demand of the country reaches its maximum in the year-end. This is a typical phenomena observed in rapidly developing countries where the trend in continuous demand growth masks monthly fluctuation caused by seasonal factors. In addition, it is assumed that the reduction of monthly peak demand in June and July is the result of planned outage due to the decrease in supply capability in the flood season. Regional monthly peak demand shows a similar trend with the whole country.

(a) Whole Country



(b) Regional (2002)

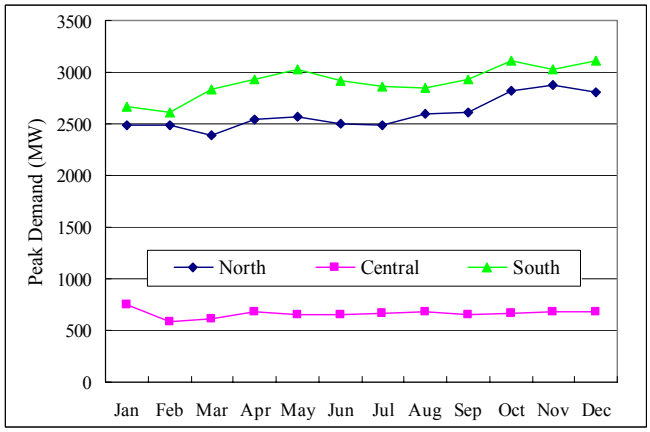


Figure 2-4 Historical Monthly Peak Demand

4) Daily Demand

Figure 2-5 illustrates changes in daily load curve (annual average) of the country and regions. The daily load curve in Vietnam currently has two peaks: daytime peak at around 11am due to industrial demand and nighttime peak at 7pm caused mainly by household use. Differences in daily maximum and minimum demand are approximately 50% in the country, 60% in the north and central, and 40% in the south region. In every region, nighttime peak exceeds daytime peak. However, a distinctive trend is that the difference between them is continuously decreasing due to the rapid growth of day peak. Particularly in the south region, where daily fluctuation is relatively small, the recent daytime peak is almost equal with the nighttime peak.

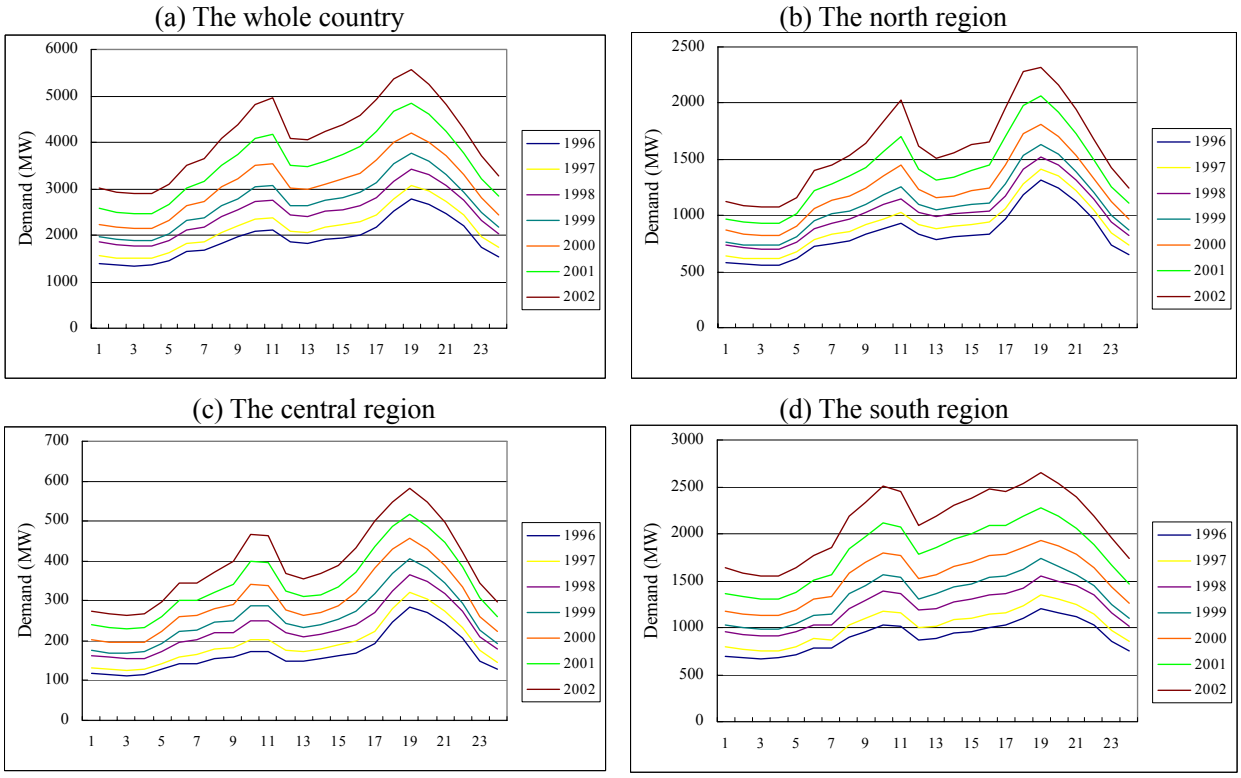


Figure 2-5 Changes in Daily Load Curve (Annual average)

(2) Existing Power Facilities

a. Existing Power Plants

The composition of the total installed capacity of 8,505MW is: hydropower 48%, gas thermal 27%, coal thermal 15%, and others 10%. Regional power source composition is significantly different due to the locations of energy resources. The north region, which has abundant hydro and coal potential, is composed of hydropower (62%) and coal thermal (38%). Most of the coal thermal power plants in the north region were constructed in the 1970s through the early 1980s.

Hydropower is also dominant in the central region. Plentiful gas reserves, gas thermal covers 55% in the south region, followed by hydropower (28%) and oil thermal (15%).

b. Operation of Existing Thermal Power Plants

The Study Team visited Pha Lai and Uong Bi thermal power plants and confirmed maintenance schedule and thermal efficiency of each power plant.

(Maintenance)

Table 2-9 Maintenance Schedule of Thermal Power Plant

Category	Span	Duration
Long-term Maintenance	4 years	75～90 days
Middle-term Maintenance	2 years	30～36 days

(Thermal efficiency)

Table 2-10 Thermal Efficiency

Output	100 %		75 %		50 %	
	design	actual	design	actual	design	actual
Pha Lai	39.2	35.5	38.5	35.1	36.4	33.3
Uong Bi	n.a.	26.7	n.a.	25.6	n.a.	n.a.

(3) Situations of Transmission System Development

In order to improve operational efficiency, EVN interconnected the north and south regions by a single 500kV transmission line with the length of 1,500km in May 1994.

The network system of Vietnam consists of the transmission systems of 500 kV, 220 kV and 110 kV and the distribution systems of 35 kV, 15 kV, 10 kV and 6 kV. The 500 kV transmission lines mainly take the role of interconnections between the north, center and south regions of Vietnam.

The 500 kV transmission line of Vietnam was constructed from Hoa Binh hydro power station in the north region to Phu Lam substation in the southern region as a one-circuit transmission line. The construction began in 1992 and was completed in 1994.

Table 2-11 500 kV Transmission Lines

Interval	Distance	Number of Circuits	Conductor
Hoa Binh - Ha Tinh	341 km	1	ACSR 330 mm *4
Ha Tinh -Da Nang	390 km	1	ACSR 330 mm *4
Da Nang – Plei Ku	259 km	1	ACSR 330 mm *4
Pleiku - Phu Lam	496 km	1	ACSR 330 mm *4
Total	1486 km	-	-
Yaly – Plei Ku	20.2 km	2	ACSR 330 mm *4

Sourse:Vietnam Single Line Diagram 2003, EVN

(4) Transmission System and SCADA System Operation

Figure 2-6 shows the load dispatching structure of EVN. Located in Hanoi, NLDC operates large-scale generators and 500kV transmission lines, and the controls frequency of the whole system. NLDC also manually changes the position of transformer taps and orders to operate shunt reactors. Under NLDC, regional load dispatching centers in the north, central and south region operate 200kV and lower voltage transmission systems as well as regional shunt reactors. Furthermore, regional supply centers operate 110-66kV transmission systems under the regional load dispatching centers.

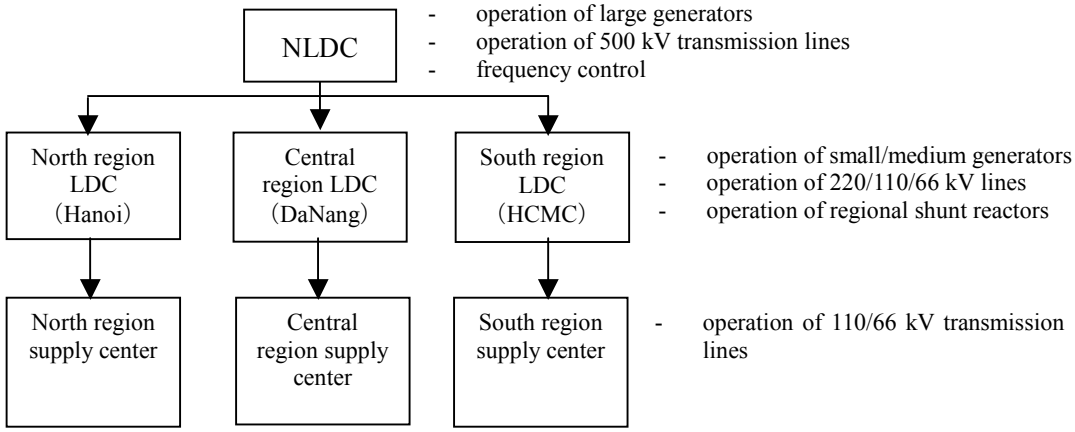


Figure 2-6 Load Dispatching Structure of EVN

(5) Electricity Tariff System

EVN adopts a nationwide uniform tariff system based on power use.

The tariff system is comprised of two prices, for Vietnamese and for foreigners. Foreigner price is set higher than twice the level of Vietnamese price.

In terms of household use, electricity expense is charged according to the amount of electricity consumed. For other users, three tariff rates are applied: peak, normal, and off-peak hours.

Plans to revise the tariff has been discussed and changed many times in the past. The current electricity tariff was revised in October 2002 and the average tariff was raised to 5.6 cents/kWh.

The tariff schedule used in EVN financial projections, which the mission obtained from the Finance and Accounting Division, plans to achieve 7.0 cents/kWh in April 2006. Based on this schedule, EVN has already requested to the government to raise the tariff to 5.9 cents/kWh in April 2004.

2.3 Environmental Considerations in Vietnam

The current conditions and contents of the following items will be reviewed, and based on the results, appropriate and adequate evaluation of the Project will be enacted.

- Environmental considerations conducted in the previous water resource developments of which purposes are power development and flood control
- System of the Environmental Impact Assessment (EIA) in Vietnam
- Protected area system in Vietnam
- Policies and measures for conserving important fauna / flora and ecosystems

Interviews have been conducted with Yaly HPP and the relevant governmental organizations / institutes on the environmental issues. The followings summarize points of interviews and discussions.

(1) Ministry of Natural Resources and Environment (MONRE)

- MOSTE was divided into MOST (Ministry of Science and Technology) and MONRE (Ministry of Natural Resources and Environment) in December 2002.
- Regarding to nature conservation in Vietnam, MONRE closely works together with MRAD (Ministry of Agriculture and Rural Development) which is in charge of the protected area system.
- Regarding to an EIA for the Study, a preliminary EIA should be conducted for a whole study and a report should be submitted to MONRE. After approval from MONRE, a detailed EIA should be conducted at each PSPP site at a feasibility study stage.
- The following references were collected.
  - ✓ Documents of setting up a report on EIA
  - ✓ Circular letter of guidance on setting up & reviewing

(2) Ministry of Agriculture and Rural Development (MARD)

- There are 14 national parks in Vietnam.
- There are 94 protected areas and there is a plan to increase them to 120 in the future.
- There is an approved plan by the government that, by 2010, the area under protection will be increased to 2,000,000 ha (target figure). This figure has already been mentioned by the current plan of expansion of the protected area system. This plan is expected to be reviewed and to be approved by the end of this year.
- There are three categories of protected areas, namely National Parks, Nature Reserves and Cultural, Historical and Environmental Sites. Currently, there is an idea to categorize nature

reserve into Nature Reserve and Species and Habitat Protected Area.

- Regarding a map with a boundary of each protected area, maps of national parks should be held by FPD or FIPI (Forest Inventory and Planning Institute). Maps of the other protected areas are not well prepared yet. About half of the protected areas have this kind of map. FIPI or institutions of provincial governments should also have these maps.
- Each protected area has an Investment Plan, and detailed information on each protected area should be described in the Investment Plan.
- Although a provincial government may establish a buffer zone for a protected area, there is no legal base for establishing a buffer zone.

Chapter 3. Current Situations and Evaluation of Power Sources Development Plan (Revised 5th M/P)

3.1 Evaluation of Demand Forecasts

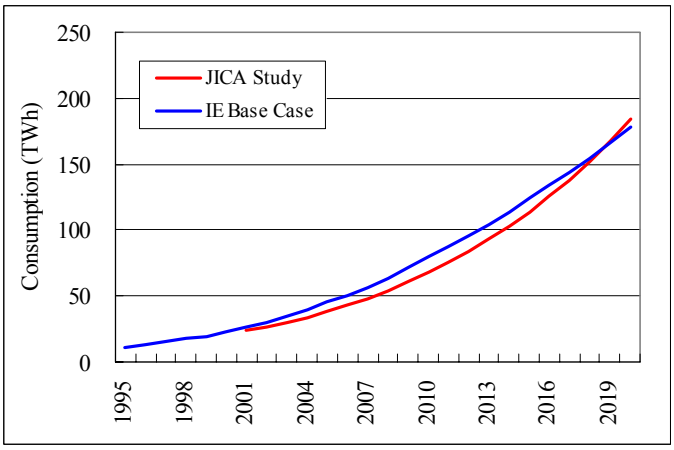
(1) Confirmation of Demand Forecasts

Focusing on this trend, the consumption forecasts of EVN are examined in this section, referring to the historical growth process of neighboring countries. In other words, regression analysis is conducted to estimate the electricity intensity from the GDP per capita, incorporating data of neighboring countries. Accordingly, future electricity consumption is estimated with the identified regression function and compared with EVN forecasts.

Figure 3-1 compares consumption forecasts of EVN and the Study Team. EVN forecasts appear slightly higher than the Study Team. The difference, however, is within 10% and both forecasts generally show good accordance.

Based on the discussion above, it is confirmed that EVN consummation forecasts are consistent with the historical experience of neighboring countries. In other words, the trend of the slowing down of economic development, and of the growth of electricity intensity is appropriately considered in the demand forecasts of EVN.

(a) Base Case



(b) High Case

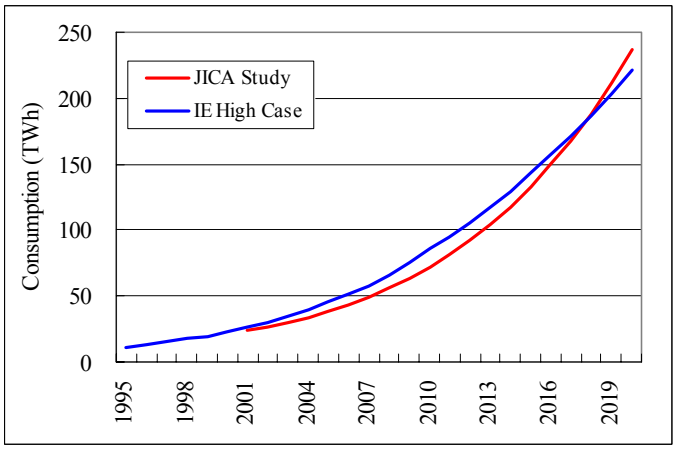


Figure 3-1 Comparison of Consumption Forecasts

(2) Forecasts of Daily Load Curve

As described before, the current daily load curve in Vietnam is the night-peak type, showing the daytime peak at about 11am followed by a higher nighttime peak at 7pm. In line with the increase of industrial demand, however, increase of daytime peak tends to exceed that of the

nighttime peak, resulting in a decreasing trend in the difference between the daytime and nighttime peak. Neighboring countries like Malaysia and Thailand also experienced a shift from night-peak to day-peak type along with economic development. Thus, it is likely that demand of Vietnam also will shift to day-peak type in the future.

Accordingly, from the view of projecting an example of possible changes based on specific assumptions, this section tries to forecast future changes of load curves and provide the results to optimization analysis of peaking power sources. The forecasts apply the trend analysis method which is conducted by each region, considering clear regional differences in a daily load profile. The results of forecasts are shown in the following figures.

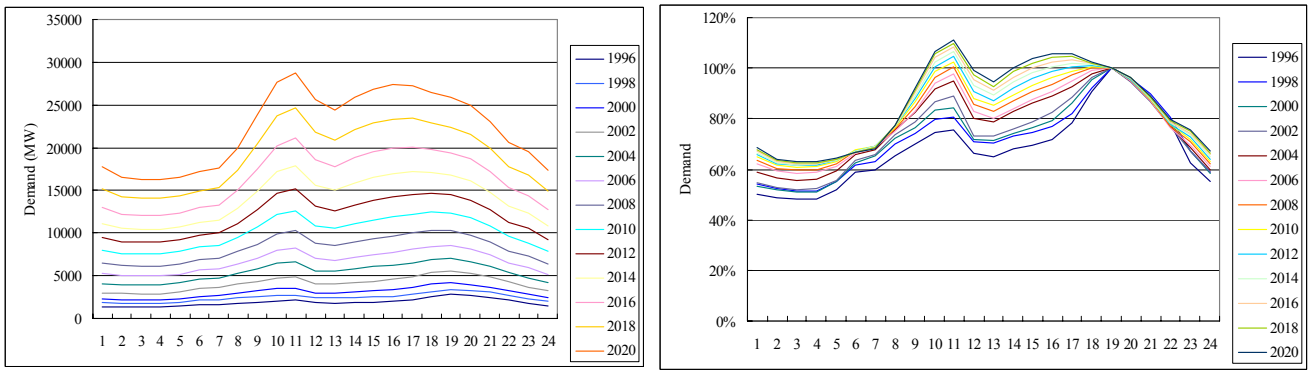


Figure 3-2 Annual Average Load Curve Forecast (Regional)

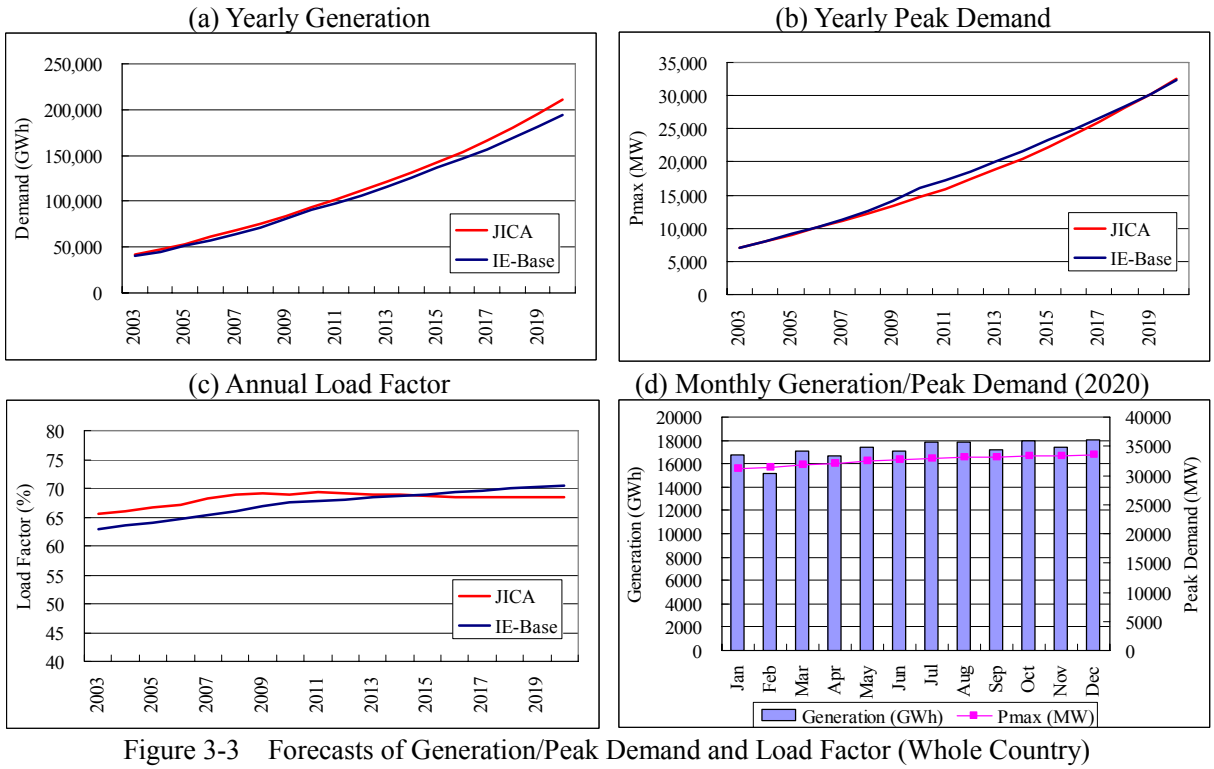


Figure 3-3 Forecasts of Generation/Peak Demand and Load Factor (Whole Country)

Major conclusions identified through the daily load curve forecasts are:

- Every region maintains the historical trend that daytime peak grows faster than the nighttime peak, resulting in a shifting toward day-peak type by 2008.
- With the growth of the daytime peak at around 11am, demand from 2 to 4pm also rapidly increases, showing daytime peaks before and after the lunch break as widely observed in advanced countries.
- Load curves by type keep similar differences (Peak Day: Weekday, Peak Day: Holiday).
- Annual generation and peak demand demonstrate similar results with EVN forecasts except the south region, which becomes greater after 2015.
- Annual load factors also show comparable results with ENV forecasts, leveling off at 67% in north, 65% in central, 70% in the south region after 2010.
- Following historical trends, monthly peak demand increases toward the year-end, and monthly generation fluctuates along with changes in monthly temperature.

3.2 Power Sources Development Plan (Revised 5th M/P)

(1) Power Sources Development Plan

The Updated power sources development plan (base case), based on the revised 5th Master Plan, has been obtained from IE. According to the revised plan, Figure 3-4 summarizes power sources development in terms of fuels and regions up to year 2020.

The figure indicates that, new power sources totaling 34.8GW, including power purchases from neighboring countries, will be developed between 2003 and 2020. Among this 34.8GW, hydropower and gas thermal power cover 35% (12.1GW) and 31% (10.5MW). From the view of power sources composition, the composition of gas thermal (24%->29%) and coal thermal (15%->16%) increases whereas that of hydropower (48%->37%) and oil thermal (10%->3%) decreases.

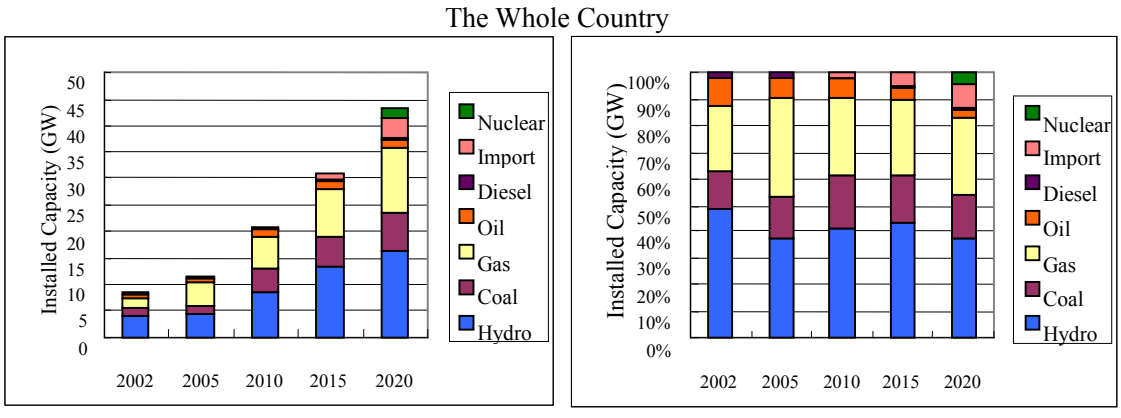


Figure 3-4 Power Sources Development Plan (Revised 5th M/P, Base Case)

(2) Supply and Demand Balance

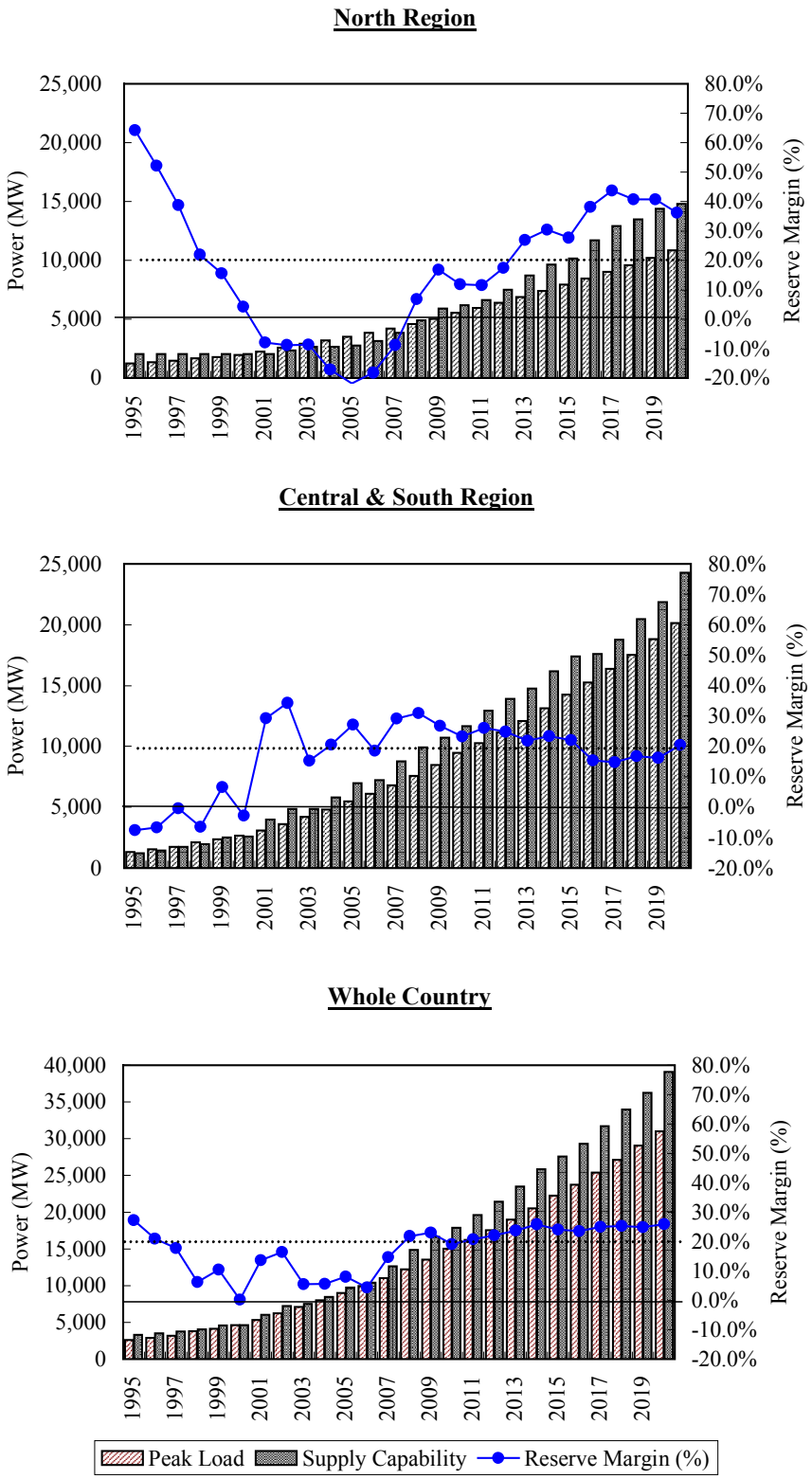
Based on the revised 5 Master Plan, dividing Vietnam power system into two systems, North region and Centre & South region, each demand supply balance in June is shown in Figure 3-5. Total supply capability in June is the lowest in the year because water levels of large reservoirs such as Hoa Binh are lowered for flood control. Here, every supply capability of planned power plant is counted in the following commissioning year in the revised 5th Master Plan, since every planned power plant will be sure put into operation by the end of the year.

Crucial issues as follows can be figured out in this demand supply balance.

- Since development of power sources can not catch up with the recent power demand growth, the reserve margin in the whole country will be below 10% until 2006.
- Supply capability in the North has been less than power demand since 2001. The North System relies on transmitted power from the Centre & South System during peak time. Moreover, the supply capability in the North will fall short especially from 2004 to 2006. The reserve margin will be almost zero even if the full capacity power of the existing North-South 500kV transmission line is transmitted from the Centre & South System to the North. With consideration of deterioration of the existing coal thermal power plants and the high rate of accident on the North-South interconnection line, it is highly likely that the North will experience a serious power shortage.

The following two countermeasures are contemplated in order to avoid the above power crisis in the North.

- ✓ To accelerate construction of the second North-South 500kV transmission line. : However, it seems difficult to put into operation before June 2005 in view of the present progress of the project.
- ✓ To move the GT plants which can use diesel oil form the South to the North: It seems likely that these power plants can be put into operation until June 2005 and the reserve margin in the North System will increase about 5%, if the construction can be carried out promptly.



Source : Revised No.5 MP, IE

Figure 3-5 Demand Supply Balance (kW)（Revised No.5 Master Plan; Base Case）

3.3 Current Situations and Review of Transmission System Development

(1) Development Plan for Transmission System

The outline of the plan for development of 500kV transmission lines proposed by IE is as follows:

- The north-south transmission line is doubled and series capacitors is upgraded to 2,000 MW
- In the north areas (Son La, Viet Tri, Soc Son, eastern seaside areas) and the south areas (Ho Chi Minh city areas, O Mon, Ca Mao, Nha Trang), 500kV transmission lines will be constructed in a net-shaped structure
- The transmission lines will be extended to the power station areas in Laos and Cambodia

Figure 3-6 shows the 500kV transmission lines of Vietnam according to the plan of IE up to 2020.

(2) Review of Transmission System Development Plan

a. Problems of Installation of Series Capacitors

It was discovered that there is a possibility of a series resonance with series capacitors on the 500 kV transmission lines up to 2020 according to the study for the technical transfers. The zero apparent reactance in the low frequency range causes the series resonance. Especially, if the series resonance frequency matches the resonance frequency of shaft distortion such as of nuclear power generators with long shafts, there are possibilities of causing shaft vibration and stopping generators. Not installing series capacitors or applying the thyristor-controlled devices to eliminate the resonance can be considered as the countermeasures against such phenomena.

b. Capacity of 500 kV Transmission Lines

The thermal capacity of the north– south 500 kV transmission systems up to 2020 is estimated to be about 2,200 MW per one circuit. The capacity of the intervals with double circuits of the north – south 500 kV transmission systems should be 2,200 MW by applying N-1 criteria.

Upper limits of power flows through 500 kV lines between the areas can be set as shown in Table 3-1 according to the transmission system planning in year 2020.

Table 3-1 Upper Limits of Power Flows through 500 kV Lines (Transmission Planning in 2020)

North-Center	Center – South	South – Center	Center – North
2,000 – 2,200 MW	1,400 – 2,000 MW	0 – 1,700 MW	1,100 – 1,900 MW

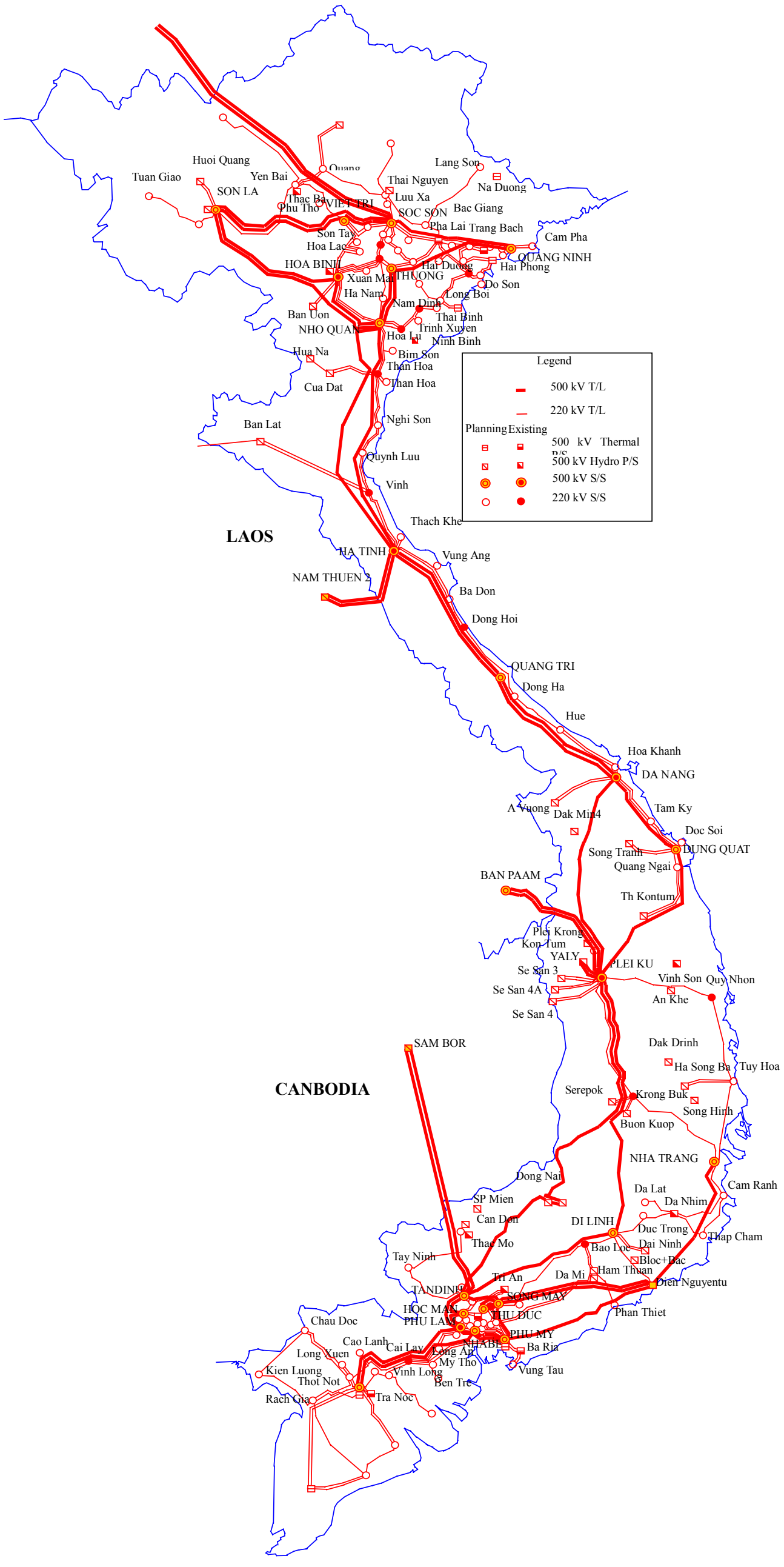
c. Criteria for Power Development and Transmission Planning of EVN

In general, loss of load probability and reserved capacity are set as the criteria for power development planning. EVN sets those values as the following:

Loss of load expectation: 24 hours/year

Reserved margin: 20%

The criteria are not in a written form for network planning in Vietnam. In the future however, the N-1 criteria will be applied for the main transmission system by doubling circuits or adding 500/220 kV transformers. The permissible fault current level is set to be 45 kA.



Source: IE

Figure 3-6 Transmission System in 2020