CHAPTER 3 CURRENT SITUATIONS AND EVALUATION OF POWER SOURCES DEVELOPMENT PLAN (REVISED 5TH M/P)

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

3.1 Evaluation of Demand Forecasts

3.1.1 Demand Forecasts

This section firstly reviews demand forecast methodologies in Vietnam and the latest forecasts. Accordingly, the result of consumption forecasts is confirmed from macroeconomic standpoint. Finally, based on the discussion of historical demand, long-term changes in daily load profile are projected for peaking power optimization analysis.

(1) Existing Demand Forecasts

a. Forecasting Methodology

Figure 3-1-1 shows overall flow of demand forecasts in Vietnam. EVN applies direct and indirect method for demand forecasts as summarized below:

① Direct method

Based on information on investment and production plans of major industries, consumption of each industry is projected. Accordingly, short-term (3 to 5 years) demand is forecasted by totaling each projection. This method is also applied for provincial forecasts for transmission planning.

② Indirect method

Indirect method applies scenario simulation for forecasting long-term (10 to 20 years) demand. Specifically, according to the long-term scenario of national economic growth, consumption is forecasted from the elasticity of demand against economic development.

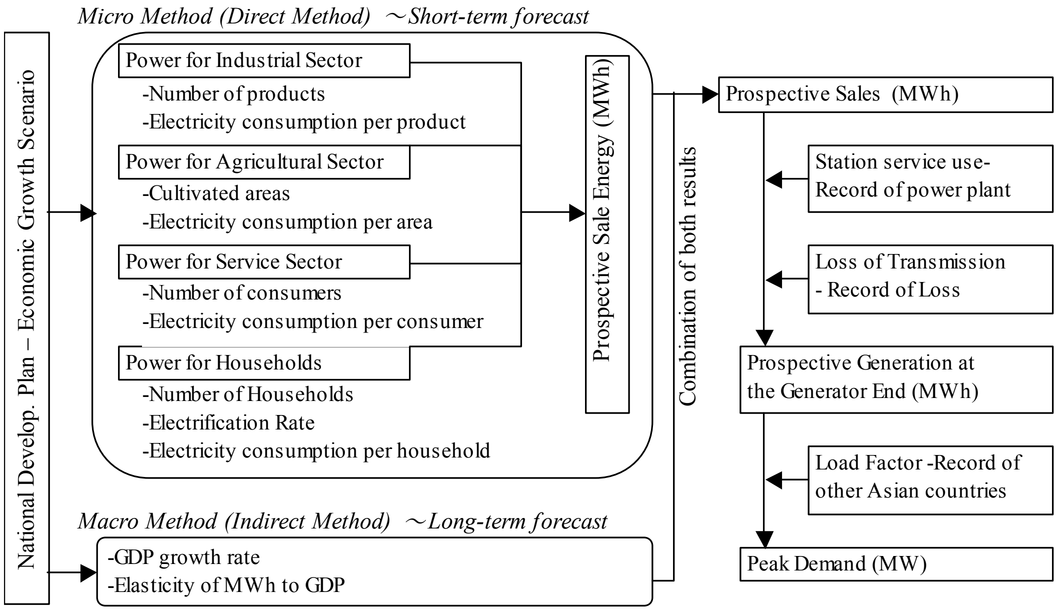


Figure 3-1-1 Flow of Demand Forecasts by EVN

b. Economic Growth Scenarios

Table 3-1-1 summarizes economic growth scenarios (Base Case and High Case) used for demand forecasts in the revised 5th Master Plan. Base Case assumes rapid economic growth at the AAGR of more than 7% until 2010, followed by sustained growth at around 6.5% until 2020. As for regional scenarios, the growth of the central and south region is generally higher than the north region. In addition, the industry sector is expected to lead economic development and its GDP share is projected to reach from 36% in 2000 to 50% in 2020.

Table 3-1-1 Economic Growth Scenarios (Unit: %)

Region	Category	2001-2005		2006-2010		2011-2015		2016-2020	
		Base	High	Base	High	Base	High	Base	High
The whole Country	Agriculture	4.0	4.0	4.4	4.4	3.1	3.6	3.1	3.6
	Industry	10.3	10.3	9.4	10.0	7.6	9.4	7.6	8.4
	Service	5.9	5.9	6.4	7.0	6.6	7.7	6.6	7.7
	Total	7.1	7.1	7.3	7.8	6.5	8.0	6.5	8.0
North Region	Agriculture	4.0	4.0	3.5	4.0	3.0	3.0	3.0	3.0
	Industry	10.3	10.3	9.8	10.8	7.6	10.0	7.6	10.0
	Service	5.5	5.5	6.4	6.9	6.6	7.8	6.6	7.8
	Total	6.6	6.6	7.0	7.7	6.4	8.0	6.4	8.0
Central Region	Agriculture	3.8	3.8	4.0	5.0	3.6	4.0	3.6	4.0
	Industry	10.5	10.5	10.0	11.0	8.2	10.2	8.2	10.2
	Service	5.4	5.4	6.2	7.0	6.8	7.9	6.8	7.9
	Total	6.8	6.8	7.3	8.2	6.9	8.4	6.9	8.4
South Region	Agriculture	4.0	4.0	4.6	4.6	3.0	4.0	3.0	4.0
	Industry	10.2	10.2	9.1	9.5	7.5	9.0	7.5	9.0
	Service	6.4	6.4	6.5	7.0	6.5	7.6	6.5	7.6
	Total	7.6	7.6	7.4	7.8	6.6	7.9	6.6	7.9

Source: Data from IE

c. Results of Demand Forecasts

Based on the economic growth scenarios described above, demand forecasts for the revised 5th Master Plan have been identified as shown in Table 3-1-2. In general, demand is expected to grow steadily and rapidly, supported by economic growth. In Base Case, peak demand is forecasted to achieve the AAGR of 10% for 20 years from 2001. As a result, it reaches 32,606MW in 2020, which is about 6 times larger than the demand in 2001. Generation elasticity on GDP continuously decreases from 2.1 in 2005 to 1.1 in 2020, indicating that effects in demand side management and technological development for energy efficiency are incorporated in the forecasts.

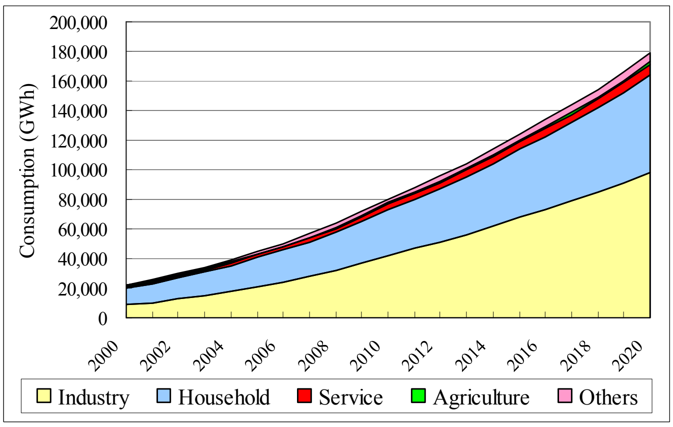
Reflecting the regional differences in economic growth, the demand increase of the central and south region exceeds the north region. Growth of industrial demand is remarkable in every region as shown in Figure 3-1-2. As a result, consumption share of industry increases from 40% in 2002 to 50% in 2020. In return, the household share decreases from 50% to 40%. In line with the growth of industrial demand, of which daily fluctuation is relatively small, annual load factor is expected to increase in every region. For the whole country, load factor is forecasted to increase from 62% in 2002 to 70% in 2020. Details of demand forecasts are shown in Appendix 3-1.

Table 3-1-2 Demand Forecasts

Region	Item	2005		2010		2015		2020	
		Base	High	Base	High	Base	High	Base	High
The whole Country	Generation (TWh)	53.0	53.0	93.0	99.0	141.3	163.8	201.4	250.0
	Peak demand (GW)	9.5	9.5	15.7	16.7	23.4	27.1	32.6	40.6
	Load factor (%)	64.0		67.5		69.0		70.5	
	Elasticity on GDP	2.08	2.08	1.63	1.71	1.34	1.33	1.13	1.10
North Region	Generation (TWh)	20.1	20.1	34.2	36.5	51.3	61.9	72.6	95.7
	Peak demand (GW)	3.9	3.9	6.2	6.6	8.8	10.7	12.1	15.9
	Load factor (%)	58.8		63.5		66.2		68.6	
	Elasticity on GDP	2.12	2.12	1.60	1.64	1.32	1.39	1.12	1.14
Central Region	Generation (TWh)	5.8	5.8	11.0	12.1	16.9	21.0	24.3	32.3
	Peak demand (GW)	1.1	1.1	2.0	2.2	2.9	3.6	4.1	5.4
	Load factor (%)	58.5		63.0		66.0		68.1	
	Elasticity on GDP	2.48	2.48	1.87	1.95	1.31	1.38	1.09	1.08
South Region	Generation (TWh)	26.9	26.9	47.4	49.9	72.3	80.0	103.3	120.4
	Peak demand (GW)	4.5	4.5	7.7	8.1	11.6	12.9	16.5	19.2
	Load factor (%)	68.9		70.5		71.0		71.5	
	Elasticity on GDP	2.08	2.08	1.62	1.69	1.33	1.25	1.12	1.08

Source: Institute of Energy

(a) Consumption



(b) Sectoral share

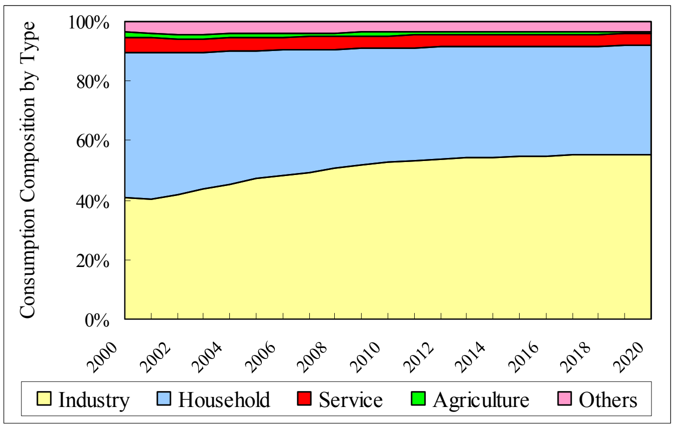


Figure 3-1-2 Consumption Forecasts (the Whole Country, Base Case)

3.1.2 Confirmation of Demand Forecasts

(1) Confirmation of Demand Forecasts

a. Outline

Figure 3-1-3 illustrates the relationship between GDP per capita and electricity consumption per a dollar of GDP (electricity intensity) of Vietnam and 12 neighboring countries from 1971 and 1999 (data of Vietnam is 1984 to 1999). When GDP per capita is a couple of hundred dollars, electricity intensity rapidly increases along with economic development. On the other hand, the growth rate of electricity intensity slows down with GDP per capita approximately more than a thousand dollars. As is the case with Japan and Singapore, when the economy enjoys further growth, electricity intensity stays almost constant even if GDP per capita is increased. Major reasons for this general trend seen in different countries are:

- As the economy continues to grow, the economy tends to shift away from manufacturing to the service sector. As the electricity consumption per unit sales of the service sector is generally lower than that of the manufacturing sector, this shift implies decrease of electricity intensity.
- Along with the improvement of industrial technologies and techniques as well as the introduction of more efficient materials, the energy efficiency of industry improves.

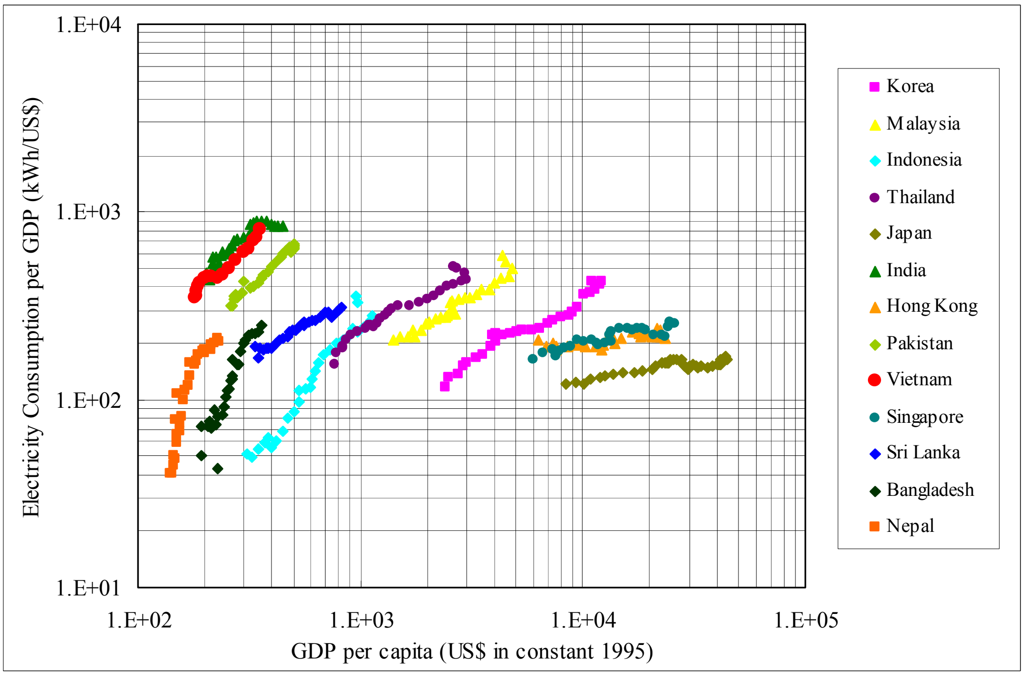


Figure 3-1-3 Relationship between GDP per Capita and Electricity Intensity

Source: World Development Indicator 2002, WB

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.

Major steps in confirming demand forecasts are as follows:

① Identify functions for approximating electricity intensity from GDP per capita
② Calculate GDP per capita up to 2020 based on the economic growth scenario of Vietnam
③ Estimate future electricity intensity applying the regression function
④ Calculate electricity consumption by multiplying electricity intensity by GDP
⑤ Compare above results with EVN forecasts

b. Regression analysis

Regression analysis applies a logarithmic quadratic approximation method. That is, to approximate electricity intensity by a logarithmic quadratic function with GDP per capita as a parameter. Here, although data of countries have a similar shape, their locations are different. Thus, we apply an equation shown below that imposes identical slopes for all countries, but allows for different intercepts with the Y-axis in different countries.

$$e = \alpha + \beta y + \chi y^2 \quad (+\lambda_1 D_1 + \lambda_2 D_2 + \dots + \lambda_{n-1} D_{n-1})$$

e : log of electricity intensity

y : log of GDP per capita

D_i : dummy variable for country i

n : number of countries considered

Table 3-1-3 shows the results of analysis. The quadratic term in GDP per capita is negative, as expected (growth of electricity intensity slows down along with economic development). Developed countries like Japan, Singapore, and Hong Kong have lower coefficients in dummy variables, indicating that their regression curves locate downward. With all of the variables statistically significant and adjusted R^2 as high as 0.90, the results of analysis appear to be sufficiently reliable.

Based on the approximation, the relationship between GDP per capita and electricity intensity in Vietnam is estimated as shown in Figure 3-1-4. Reflecting the experiences of other countries, growth of electricity intensity slows down when GDP per capita exceeds a thousand dollars.

Table 3-1-3 Results of Analysis

Variable	Coefficient	P-Value
Liner term	2.83	1.54E-79
Quadratic term	-0.37	3.98E-78
Korea dummy	-1.09	6.35E-81
Malaysia dummy	-0.92	2.44E-71
Japan dummy	-1.23	3.95E-86
Thailand dummy	-0.90	2.3E-77
India dummy	0.06	0.028395
Hong Kong dummy	-1.13	1.47E-78
Pakistan dummy	-0.21	2.01E-14
Singapore dummy	-1.12	7.58E-78
Sri Lanka dummy	-0.65	6.4E-72
Indonesia dummy	-0.76	2.49E-69
Bangladesh dummy	0.64	1.3E-24
Nepal dummy	1.09	1.77E-37
Intercept	-1.95	5.24E-22
Adjusted R^2	0.90	

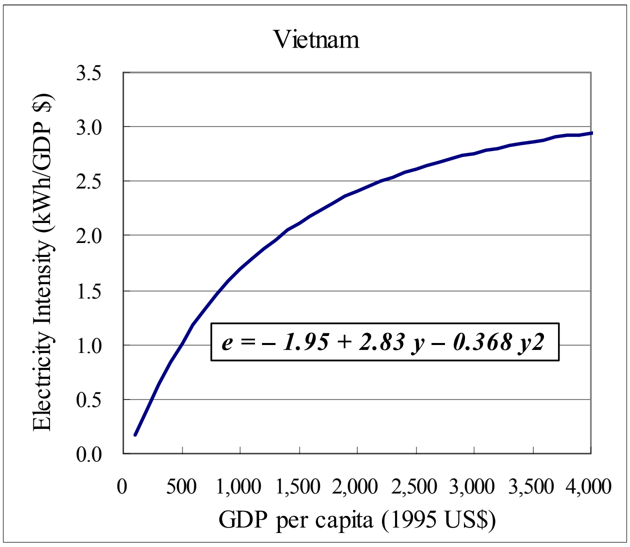


Figure 3-1-4 Approximation of Vietnam

c. Comparison with EVN Forecasts

Figure 3-1-5 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

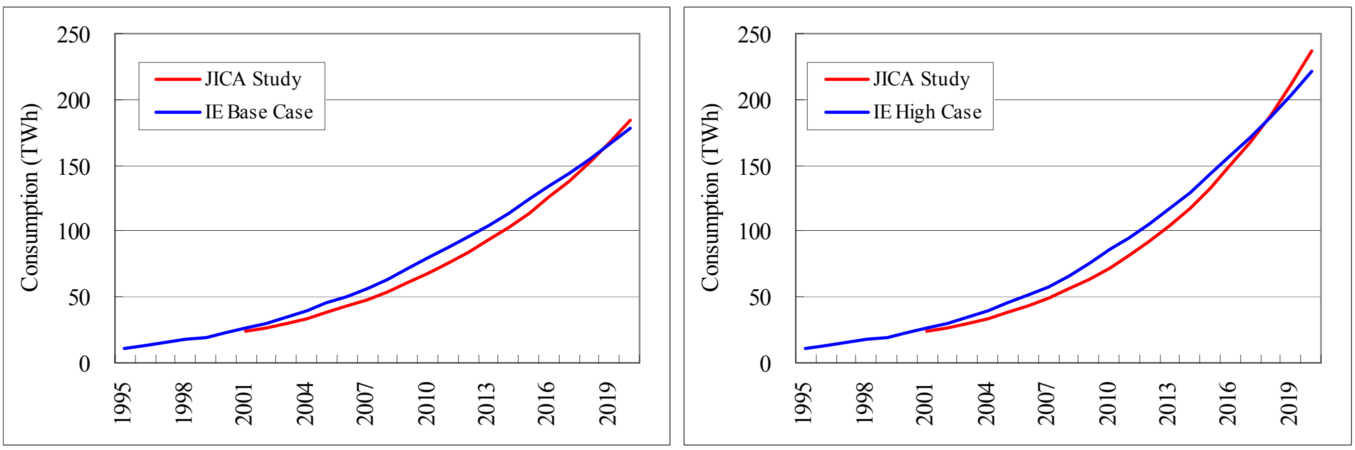


Figure 3-1-5 Comparison of Consumption Forecasts

(2) Forecasts of Daily Load Curve

a. Outline

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.

On the other hand, development of power sources has to be planned not only to satisfy peak demand but also to be able to follow daily demand fluctuation. Therefore, forecasts of daily load curve are important from the view of identifying efficient power sources development plan.

However, since daily load curves are formed as a result of various factors including economic situations, culture, and climate, it is very difficult to project long-term changes of load curves precisely. 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.

b. Methodology

Figure 3-1-6 illustrates the concept of daily load curve forecasts. Basic flow of analysis is listed below. The economic growth scenario applies Base Case in Table 3-1-1.

- Divide daily load curve into 24 parts by hour (Figure 3-1-6 ①)
- Approximate historical demand of each hour with relevant parameters like GDP, population, temperature, etc. (Figure 3-1-6 ②)
- Forecast future demand of each hour based on the regression formula (Figure 3-1-6 ③)
- Integrate the hourly forecasts to obtain load curve projections (Figure 3-1-6 ④)

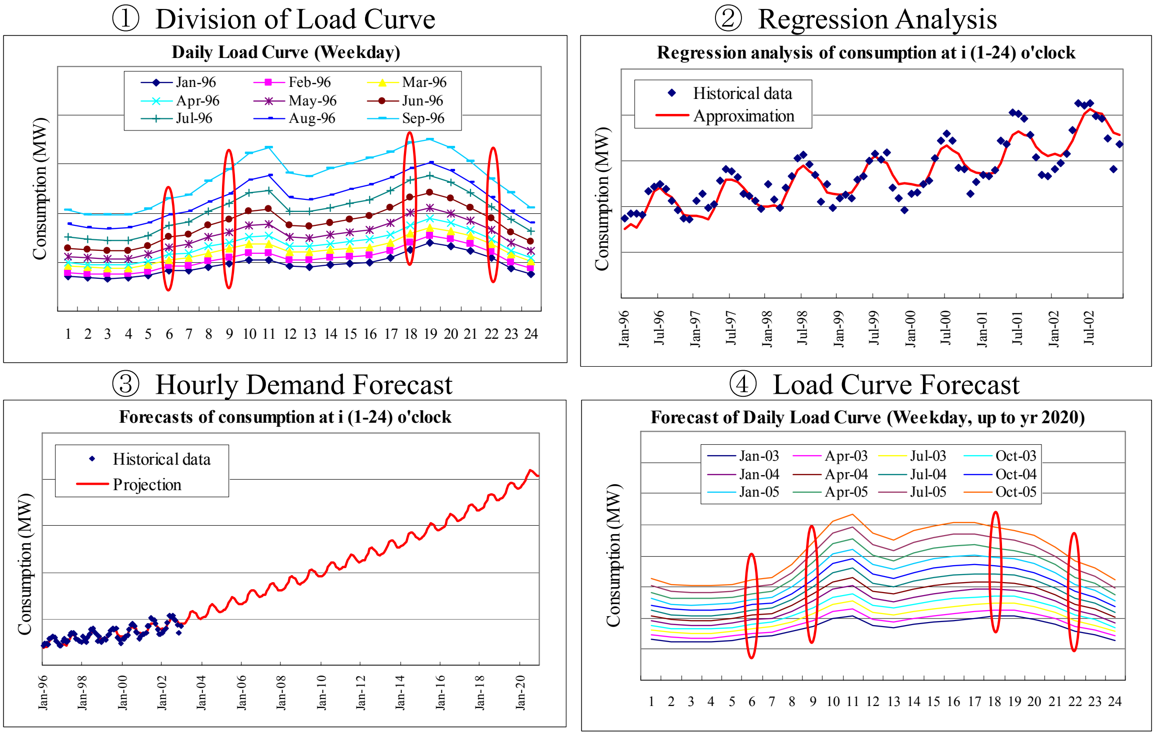


Figure 3-1-6 Concept of Daily Load Curve Forecasts

Some of the neighboring countries of Vietnam have experienced changes in demand profile from nighttime peak to daytime peak. Assuming that Vietnam would follow similar demand growth process, daily demand data of those countries have been incorporated in the forecasts of demand profile change. In order to conduct the forecasts effectively and efficiently, the following conditions have been considered in selecting the countries to be incorporated;

1) The country is located within a reasonable distance from Vietnam.
2) The country has similar meteorological conditions either with the north or south Vietnam.
3) The country experienced peak-shift from nighttime to daytime peak.
4) Demand data of the country is easily accessible or already available.

Accordingly, the countries that meet conditions from 1) to 3) are identified as: Thailand, Malaysia, Philippines, and Japan. Japan has relatively similar weather conditions with the northern Vietnam, and its data is readily available to the Study Team. In addition, Thailand has a similar climate with the southern Vietnam and observed peak-shift in the mid-1990s. However, Malaysia and Philippines already had daytime peak early in the 1990s, and it is considered difficult to collect their demand data before peak-shift. Therefore, considering data accessibility, Japan has been selected as a precedent suitable for the northern Vietnam, and Thailand for the south. Load profile changes observed in neighboring countries are shown in Appendix 3-2.

Details of dependent variables (hourly demand) and independent variables (parameters) used in the regression analysis are summarized in Table 3-1-4 and 3-1-5.

Table 3-1-4 Dependent Variable

Country	Duration	Notes	Source
Vietnam	1996～2002	• Regional data • Hourly data	NLDC
Thailand	1988～2000	• The whole country data • Hourly data of the day of peak demand	EGAT
Japan	1967～1980	• The whole country data • Hourly data of the day of peak demand	Chukyuren

Table 3-1-5 Independent Variable

Category	Variable	Notes	Source
Socio-economy	Population	Regional	IE
	GDP	Regional, sectoral	
Climate	Temperature	Regional, hourly	HMDC[1]
	Humidity	Regional, monthly	
Other	Electrification rate	Regional	IE

c. Regression Analysis

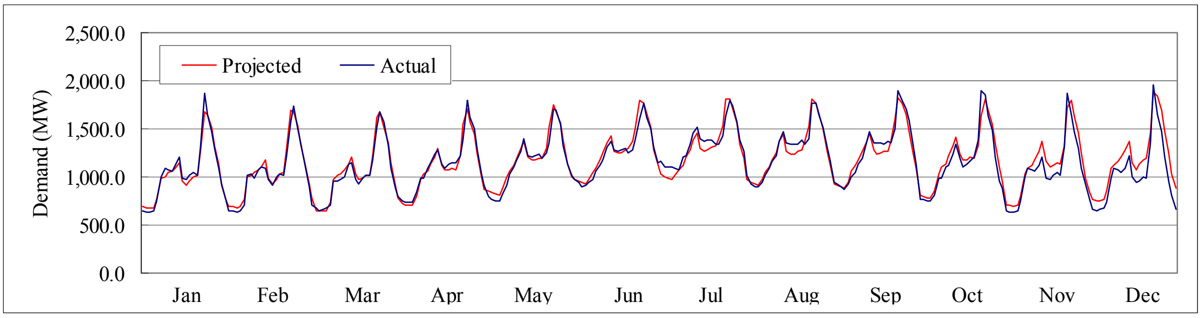
To provide demand data for optimization analysis using PDPAT-2, historical hourly demand data are categorized into the following 3 types. As a result, 216 (= 3 types x 3 regions x 24 hours) regression formulas are identified as shown in Attachment-3.

- Peak Day: average of the maximum 3 days in each month
- Weekday: average of weekdays except the maximum 3 days and holidays
- Holiday: average of Sunday and holidays in each month

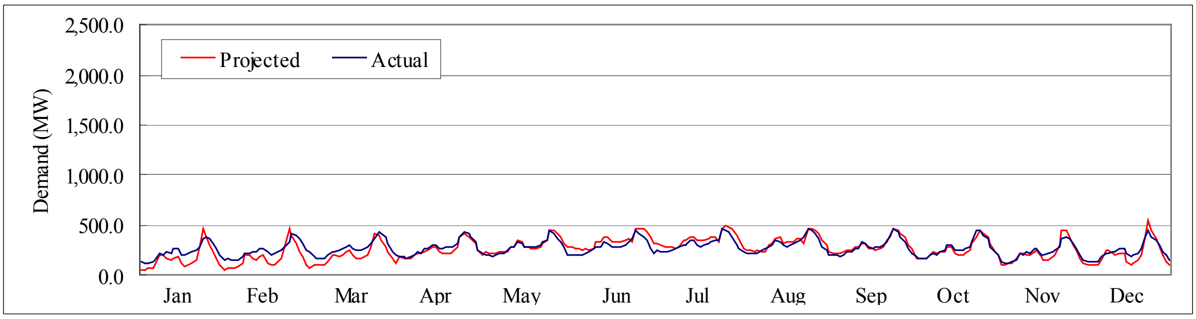
Figure 3-1-7 illustrates the result of regression analysis taking Peak Day in 1999 as an example. As a result of considering quadratic term of independent variables, reliable regression formulas are obtained with the adjusted R2 of more than 0.95 (refer to Appendix 3-3).

[1] Hydro-Meteorological Data Center, Hanoi

(a) The North Region



(b) The Central Region



(c) The South Region

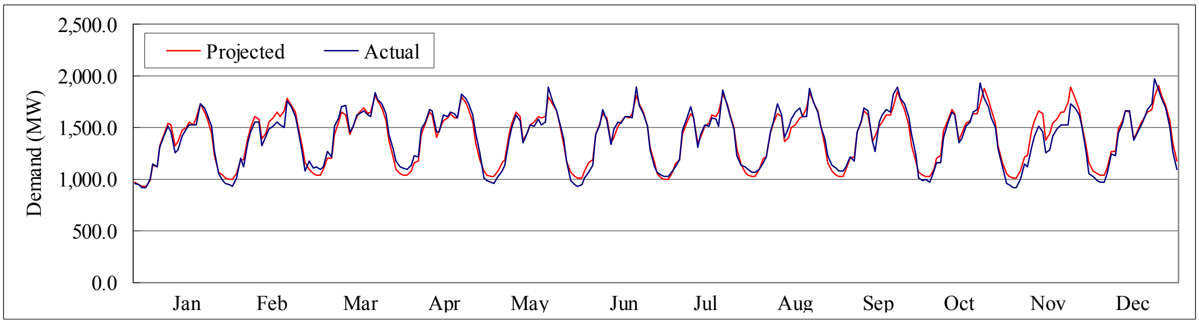


Figure 3-1-7 Results of Regression Analysis (Peak Day, 1999)

d. Forecast Results

Daily load curve up to 2020 are projected based on the regression formulas and economic growth scenarios. The results of forecasts are shown in the following figures and Appendix 3-4.

- Figure 3-1-8: Annual average load curve forecast (regional)
- Figure 3-1-9: Monthly load curve forecast by type (north region)
- Figure 3-1-10: Forecasts of generation/peak demand and load factor (the whole country)

Major conclusions identified through the daily load curve forecasts are:

- Every region maintains the historical trend that daytime peak grows faster than 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.

（**Application of the Forecast Results**）

The forecast results are provided to optimization analysis for examining impacts of changes in load curve on power sources development planning. In order to focus only on the effects of changes in demand shape, the forecast results are adjusted so that annual generation becomes identical to EVN forecasts. Specifically, by applying the following generation adjustment by each region, the forecasts are adjusted to have the daily load curve proportional to the Study Team projection, and identical annual generation with EVN forecasts.

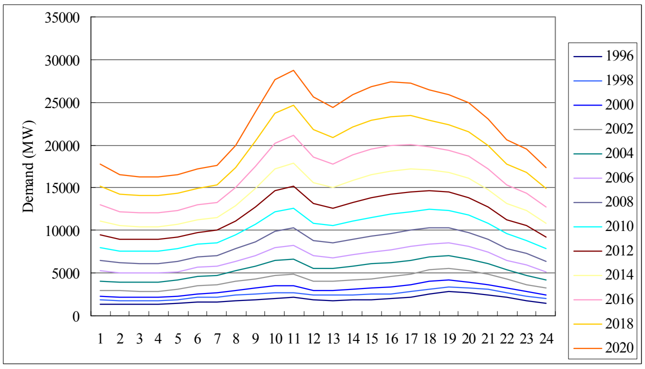
① Calculate adjustment factor (AF) for each year up to 2020.

$AF_{\text{year } i} = Generation_{\text{year } i}$ (JICA forecasts) / $Generation_{\text{year } i}$ (EVN forecasts)

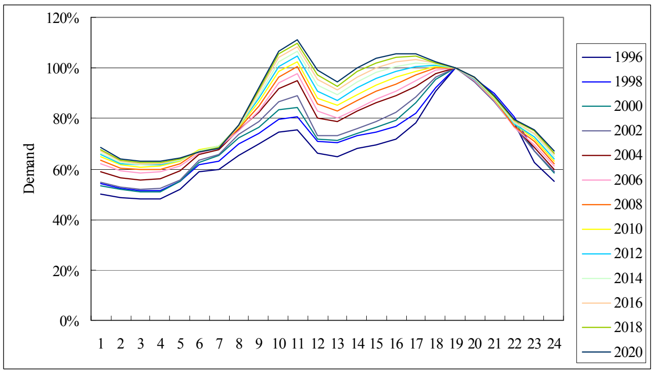
② Multiply JICA hourly forecasts by AF calculated above.

Adjusted hourly $demand_{\text{year } i}$ = Hourly $demand_{\text{year } i}$ (JICA forecasts) × $AF_{\text{year } i}$

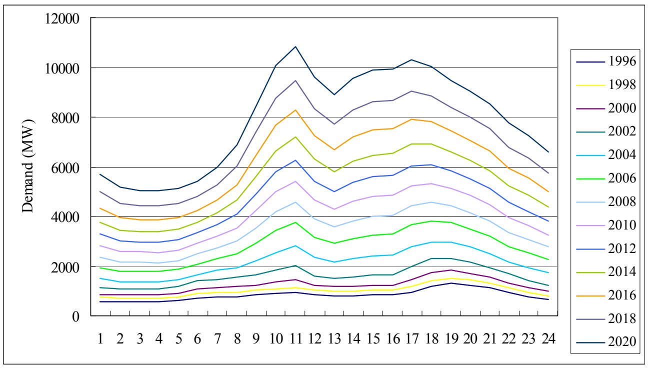
(a) The Whole Country



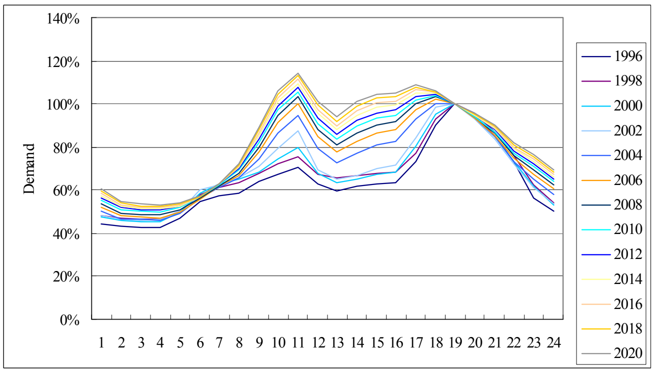
(b) The Whole Country (normalized: 7pm=100)



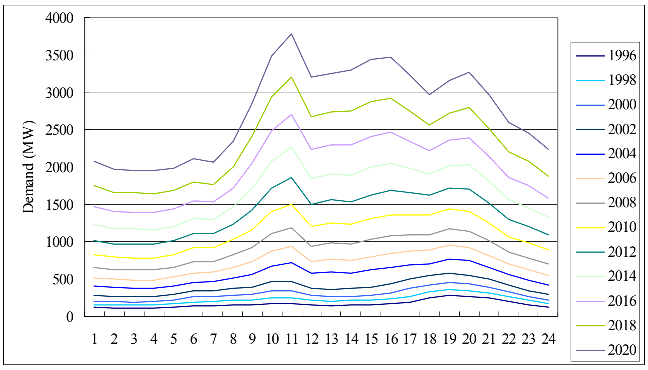
(c) The North Region



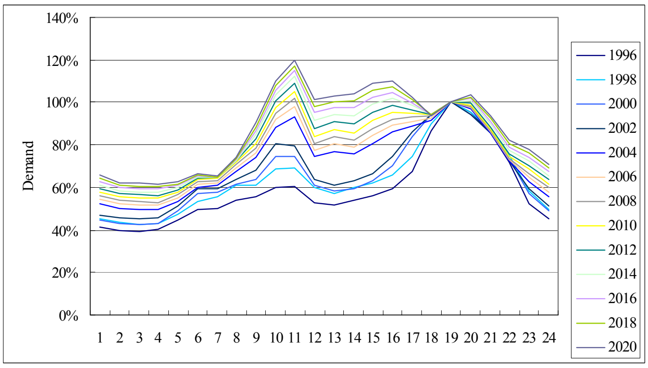
(d) The North Region (normalized: 7pm=100)



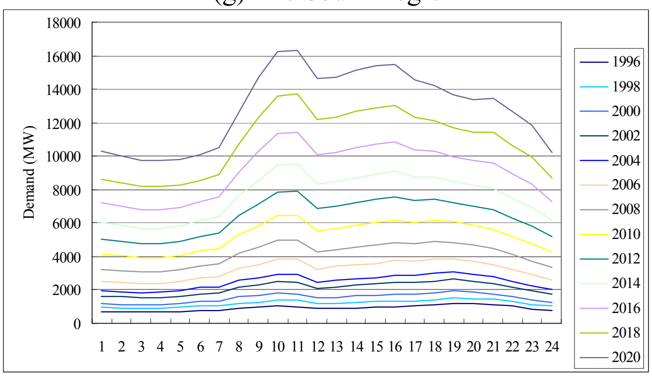
(e) The Central Region



(f) The Central Region (normalized: 7pm=100)



(g) The South Region



(h) The South Region (normalized: 7pm=100)

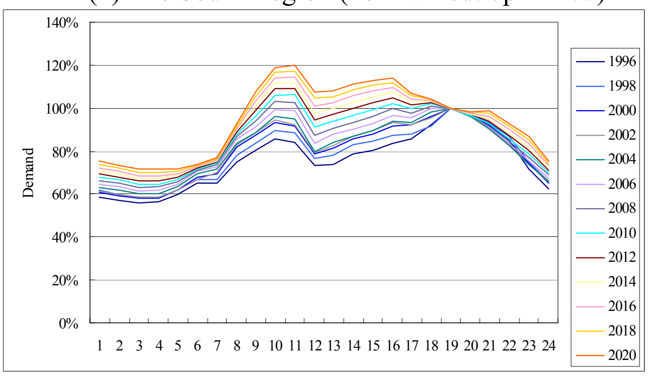


Figure 3-1-8 Annual Average Load Curve Forecast (Regional)

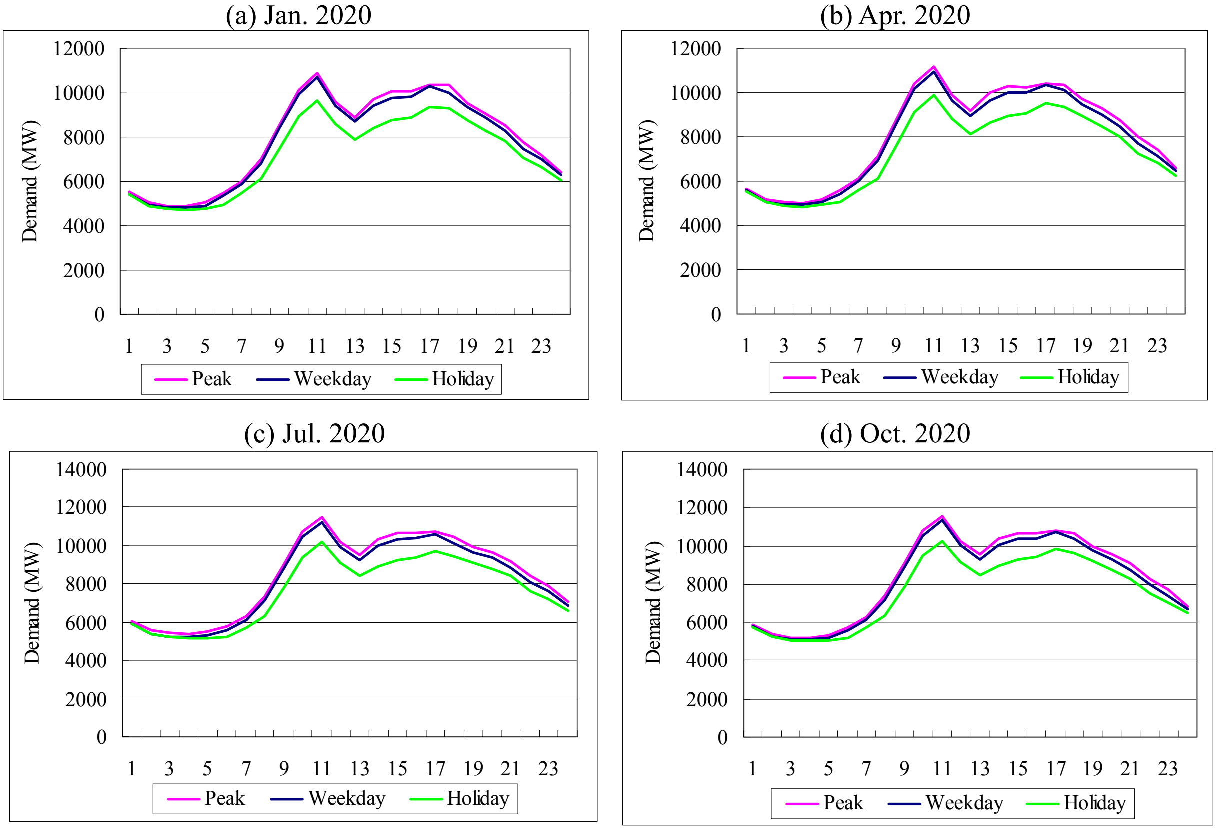


Figure 3-1-9 Monthly Load Curve Forecast by Type (the North Region)

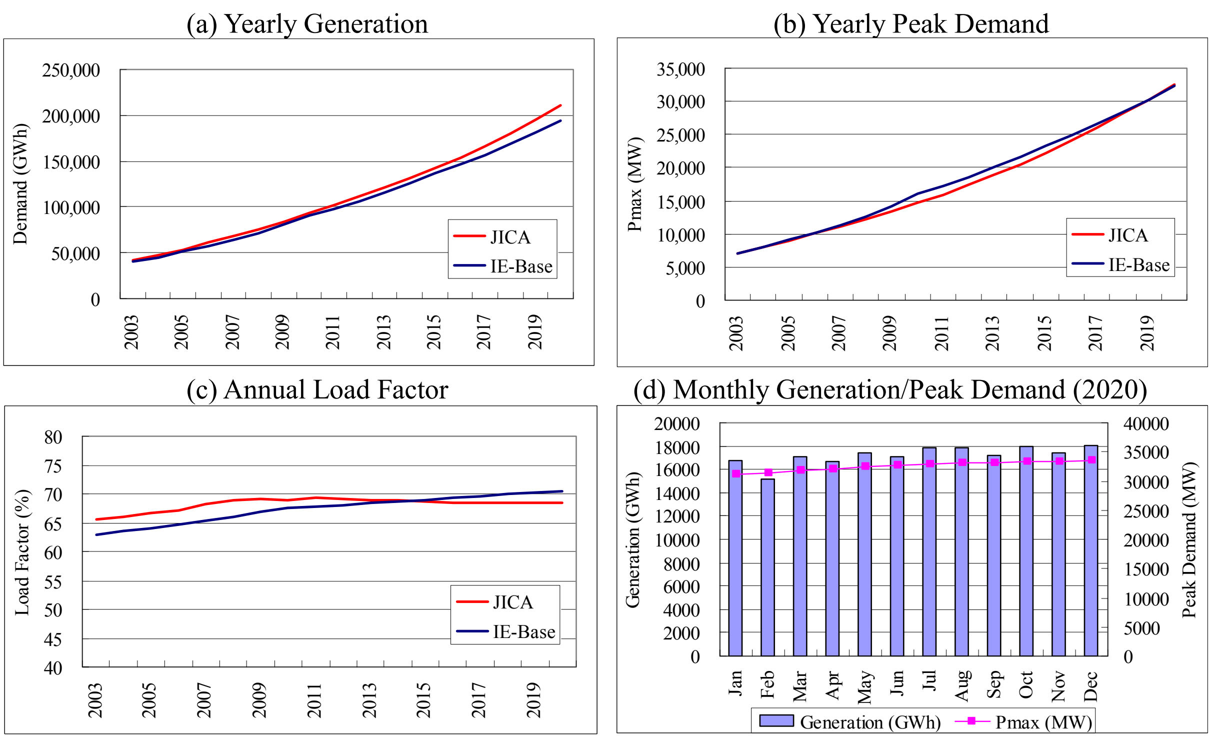


Figure 3-1-10 Forecasts of Generation/Peak Demand and Load Factor (Whole Country)

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

3.2.1 Power Sources Development Plan

The updated power sources development plan (base case), based on the revised 5th Master Plan, has been obtained from IE as shown in Table 3-2-1. According to the revised plan, Figure 3-2-1 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. In addition, power purchase from neighboring countries and nuclear power are to share 9% (4GW) and 5% (2GW) respectively.

In terms of regional development, major power sources are: i) coal thermal and hydropower for the north region, ii) hydropower for central, and iii) gas thermal for the south region, reflecting the regional differences in availabilities of natural resources. On the other hand, there are also plans to develop gas thermal in the central region and coal thermal in the south region. As for regional power sources composition, the overall trend is decrease in hydropower and increase in thermal power. Decrease of hydropower ratio is especially remarkable in the central region (95%->64%).

Table 3-2-1 Power Sources Development Plan (Revised 5th M/P, Base Case)

Year of Commission	Name of plant	Unit No.	Type	Fuel	Installed Capacity (MW)	Region
2003	Phu My 3(CCGT)-BOT	1	GT	Gas	230	South
	Phu My 3(CCGT)-BOT	2	GT	Gas	230	South
	Phu My 4	1	GT	Gas	150	South
	Phu My 4	2	GT	Gas	150	South
	Can Don-IPP	1	Hydro	Hydro	72	South
	Phu My 2-1	3	ST	Gas	143	South
	Phu My 3(CCGT)-BOT	3	ST	Gas	260	South
2004	Phu My 2-2(CCGT)-BOT	1	GT	Gas	230	South
	Phu My 2-2(CCGT)-BOT	2	GT	Gas	230	South
	Na Duong-IPP	1	ST	Coal	50	North
	Na Duong-IPP	2	ST	Coal	50	North
	Phu My 2-2(CCGT)-BOT	3	ST	Gas	260	South
	Phu My 4	3	ST	Gas	150	South
2005	Se San 3	1	Hydro	Hydro	130	Central
	Cao Ngan-IPP	1	ST	Coal	50	North
	Cao Ngan-IPP	2	ST	Coal	50	North
	Phu My 2-1 Ex.	6	ST	Gas	140	South
	Uong Bi Ex.	1	ST	Coal	300	North
2006	Ca Mau(CCGT)-IPP	1	GT	Gas	240	South
	Ca Mau(CCGT)-IPP	2	GT	Gas	240	South
	Bac Binh-JV	1	Hydro	Hydro	35	South
	Bao Loc	2	Hydro	Hydro	23	South
	Binh Dien	1	Hydro	Hydro	20	Central
	Dai Nga	1	Hydro	Hydro	20	Central
	Dak Rti'h	1	Hydro	Hydro	72	Central
	Eak Rong Rou	1	Hydro	Hydro	34	Central
	La Ngau	1	Hydro	Hydro	38	South
	Ngoi Bo	1	Hydro	Hydro	20	North
	Ngoi Phat	1	Hydro	Hydro	35	North
	Nhan Hac&Ban Coc	1	Hydro	Hydro	32	North
	Se San 3	2	Hydro	Hydro	130	Central
	Se San 3A(Poko)-IPP	1	Hydro	Hydro	100	Central
	Srok Phu Mieng	1	Hydro	Hydro	54	South
	Tra Som	1	Hydro	Hydro	24	South
	Tuyen Quang(Na Hang)	1	Hydro	Hydro	114	North
	Ca Mau(CCGT)-IPP	3	ST	Gas	240	South
	Cam Pha 1-IPP	1	ST	Coal	300	North
	Hai Phong-JV	1	ST	Coal	300	North
	O Mon 1	1	ST	FO	300	South
2007	Nhon Trach	1	ST	Gas	300	South
	A Vuong	2	Hydro	Hydro	170	Central
	Coc San-Chu Linh	1	Hydro	Hydro	70	North
	Da Dang Dachamo	1	Hydro	Hydro	16	Central
	Dai Ninh	1	Hydro	Hydro	150	South
	Dak Rinh	1	Hydro	Hydro	100	Central
	Dan Sach	1	Hydro	Hydro	6	South
	Na Le	2	Hydro	Hydro	90	North
	Quang Tri(Rao Quan)	2	Hydro	Hydro	70	Central
	Thac Muoi	1	Hydro	Hydro	53	North
	Tuyen Quang(Na Hang)	2	Hydro	Hydro	114	North
	Tuyen Quang(Na Hang)	3	Hydro	Hydro	114	North
	Hai Phong-JV	2	ST	Coal	300	North
	Ninh Binh Ex.	1	ST	Coal	300	North
	O Mon 1	2	ST	FO	300	South

Table 3-2-1 Power Sources Development Plan (Revised 5th M/P, Base Case) (continued)

Year of Commission	Name of plant	Unit No.	Type	Fuel	Installed Capacity (MW)	Region
2008	Nhon Trach	2	ST	Gas	300	South
	Ban La	2	Hydro	Hydro	300	North
	Buon Kuop	1	Hydro	Hydro	140	Central
	Cua Dat-IPP	1	Hydro	Hydro	97	North
	Dai Ninh	2	Hydro	Hydro	150	South
	Eak Rong Hnang	1	Hydro	Hydro	65	Central
	Iagrai	1	Hydro	Hydro	9	Central
	Nam Mu	1	Hydro	Hydro	11	North
	Plei Krong	1	Hydro	Hydro	110	Central
	Song Hieu	1	Hydro	Hydro	5	North
	Thac Mo Ex.	1	Hydro	Hydro	75	South
	Nam Mo(Laos)		Purchase	Laos	100	North
	Quang Ninh-JV	1	ST	Coal	300	North
	Uong Bi Ex.	2	ST	Coal	300	North
2009	An Khe-Ka Nak	1	Hydro	Hydro	163	Central
	Buon Kuop	2	Hydro	Hydro	140	Central
	Buon Tua Srah	1	Hydro	Hydro	85	Central
	Dong Nai 4	1	Hydro	Hydro	270	South
	Song Tranh 2	1	Hydro	Hydro	120	Central
	Srepok 3	1	Hydro	Hydro	180	Central
	Quang Ninh-JV	2	ST	Coal	300	North
2010	O Mon 2(CCGT)-JV	1	GT	Gas	250	South
	O Mon 2(CCGT)-JV	2	GT	Gas	250	South
	Ban Chat	1	Hydro	Hydro	200	North
	Dong Nai 3	1	Hydro	Hydro	240	South
	Song Ba Ha	1	Hydro	Hydro	125	Central
	Song Con 2	1	Hydro	Hydro	70	Central
	Upper Kon Tum	1	Hydro	Hydro	110	Central
	Se Kaman 3(Laos)		Purchase	Laos	260	Central
	Nghi Son	1	ST	Coal	300	North
2011	Dak My 4		Hydro	Hydro	210	Central
	Huoi Quang	1	Hydro	Hydro	270	North
	Song Ba Ha	2	Hydro	Hydro	125	Central
	Upper Kon Tum	2	Hydro	Hydro	110	Central
	Nghi Son	2	ST	Coal	300	North
	O Mon 2(CCGT)-JV	3	ST	Gas	250	South
	O Mon 3	1	ST	Gas	300	South
	Quang Ninh-JV	3	ST	Coal	300	North
2012	Nhon Trach	3	ST	Gas	300	South
	Hua Na	1	Hydro	Hydro	195	North
	Huoi Quang	2	Hydro	Hydro	270	North
	Nam Chien	1	Hydro	Hydro	140	North
	Se San 4	1	Hydro	Hydro	110	Central
	Son La	1	Hydro	Hydro	300	North
	Nam Kong 1(Laos)		Purchase	Laos	240	Central
	O Mon 3	2	ST	Gas	300	South
	Quang Ninh-JV	4	ST	Coal	300	North
2013	Hon Dat	1	GT	Gas	240	South
	Hon Dat	2	GT	Gas	240	South
	Nhon Trach	4	ST	Gas	300	South
	Se San 4	2	Hydro	Hydro	110	Central
	Se San 4	3	Hydro	Hydro	110	Central
	Son La	2	Hydro	Hydro	300	North
	Son La	3	Hydro	Hydro	300	North
	Ha Se San 3(Cambodia)		Purchase	Cambodia	375	Central
	Nam Thuen 3(Laos)		Purchase	Laos	400	North

Table 3-2-1 Power Sources Development Plan (Revised 5th M/P, Base Case) (continued)

Year of Commission	Name of plant	Unit No.	Type	Fuel	Installed Capacity (MW)	Region
2014	New CCGT 1		CCGT	Gas	720	South
	Son La	4	Hydro	Hydro	300	North
	Son La	5	Hydro	Hydro	300	North
	Song Bung 4	1	Hydro	Hydro	200	Central
	Prek Lieng 1&2(Cambodia)		Purchase	Cambodia	100	Central
	Hon Dat	3	ST	Gas	240	South
2015	Ban Uon	1	Hydro	Hydro	250	North
	Dong Nai 2	1	Hydro	Hydro	78	South
	Dong Nai 5	1	Hydro	Hydro	170	South
	Son La	6	Hydro	Hydro	300	North
	Son La	7	Hydro	Hydro	300	North
	Son La	8	Hydro	Hydro	300	North
	Mong Duong	1	ST	Coal	500	North
2016	Quang Tri(CCGT)		CCGT	Gas	720	Central
	Lai Chau	1	Hydro	Hydro	275	North
	Lai Chau	2	Hydro	Hydro	275	North
	PSPP 1		PSPP	Hydro	200	North
	Se Kong 4(Laos)		Purchase	Laos	450	Central
	Mong Duong	2	ST	Coal	500	North
2017	New CCGT 2		CCGT	Gas	720	South
	Lai Chau	3	Hydro	Hydro	275	North
	Lai Chau	4	Hydro	Hydro	275	North
	Song Bung 2		Hydro	Hydro	126	Central
	PSPP 2		PSPP	Hydro	200	South
	Ha Se San 2 & Srepoc 2(Cambodia)		Purchase	Cambodia	429	South
	Se Kong 5(Laos)		Purchase	Laos	250	Central
2018	New CCGT 3		CCGT	Gas	720	South
	Bac Me		Hydro	Hydro	280	North
	PSPP 3		PSPP	Hydro	200	North
	Ma Lu Tang(China)		Purchase	China	465	North
	Sam Bor		Purchase	Cambodia	165	South
	New Coal ST(South)		ST	Coal	500	South
2019	New CCGT 4		CCGT	Gas	720	South
	Nuclear 1		Nuclear	Nuclear	1000	South
	PSPP 4		PSPP	Hydro	200	South
	Import(China)		Purchase	China	250	North
	New Coal ST(South)		ST	Coal	500	South
2020	New CCGT 5		CCGT	Gas	720	South
	Dak My 1		Hydro	Hydro	210	Central
	Duc Xuyen		Hydro	Hydro	100	South
	Nuclear 2		Nuclear	Nuclear	1000	South
	PSPP 5		PSPP	Hydro	200	South
	Import(China)		Purchase	China	300	North

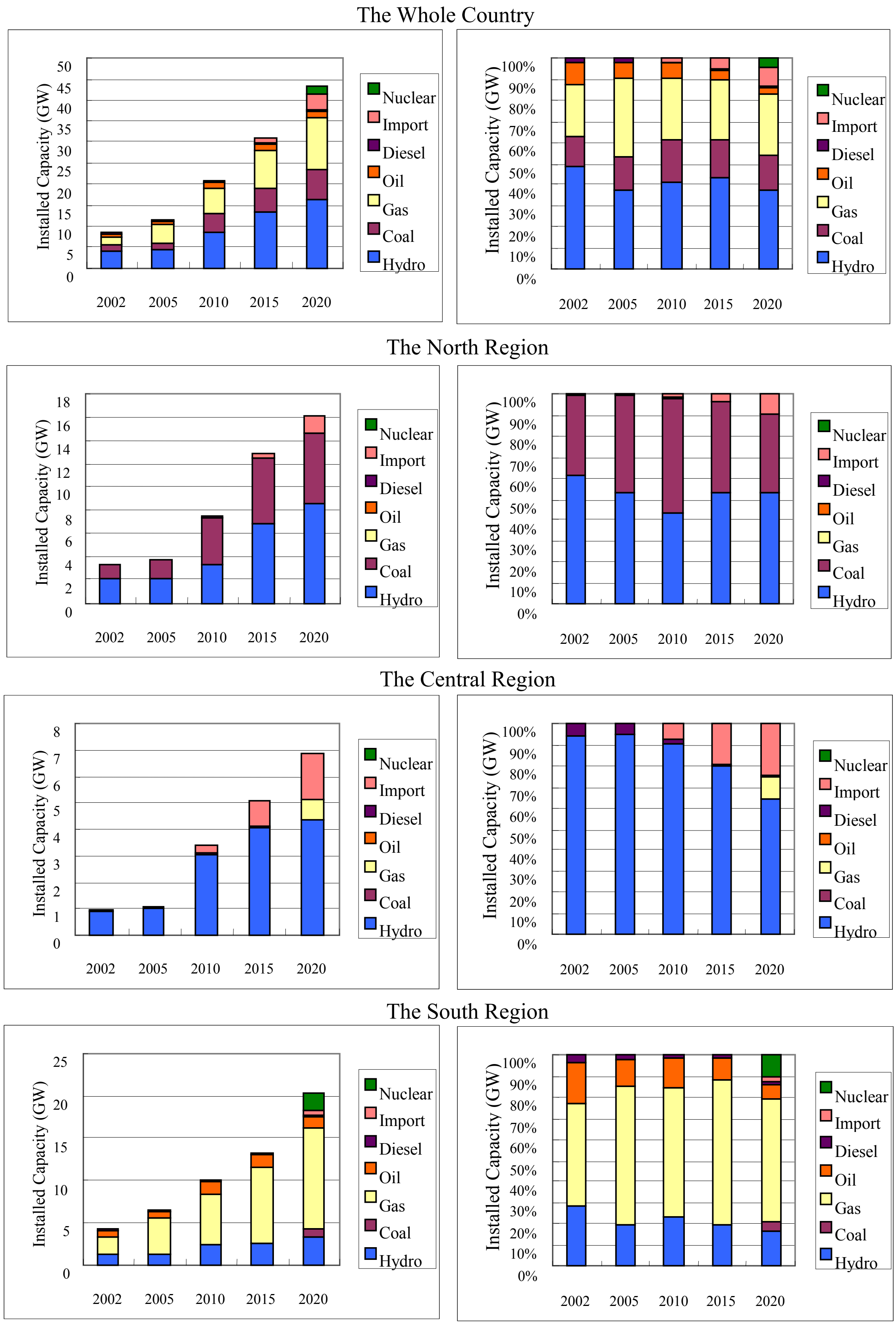


Figure 3-2-1 Power Sources Development Plan (Revised 5th M/P, Base Case)

3.2.2 Supply and Demand Balance

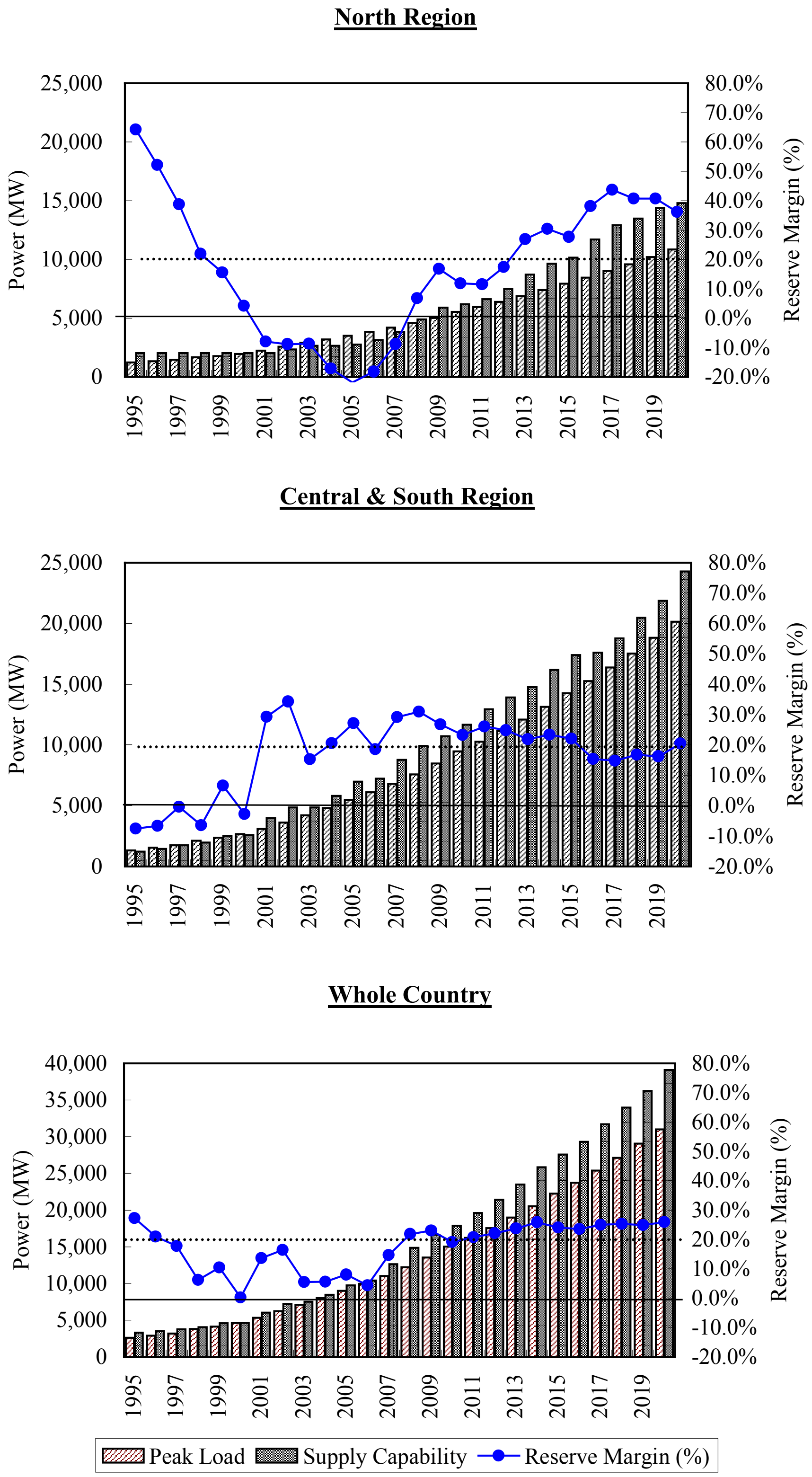
Based on the revised 5 Master Plan described in **3.2.1**, dividing Vietnam power system into two systems, North region and Centre & South region, each demand supply balance in June is shown in Figure 3-2-2. Total supply capability in June is the lowest in the year because water levels of large reservoirs 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 its 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 3-2-2 Demand Supply Balance (kW)（Revised No.5 Master Plan; Base Case）

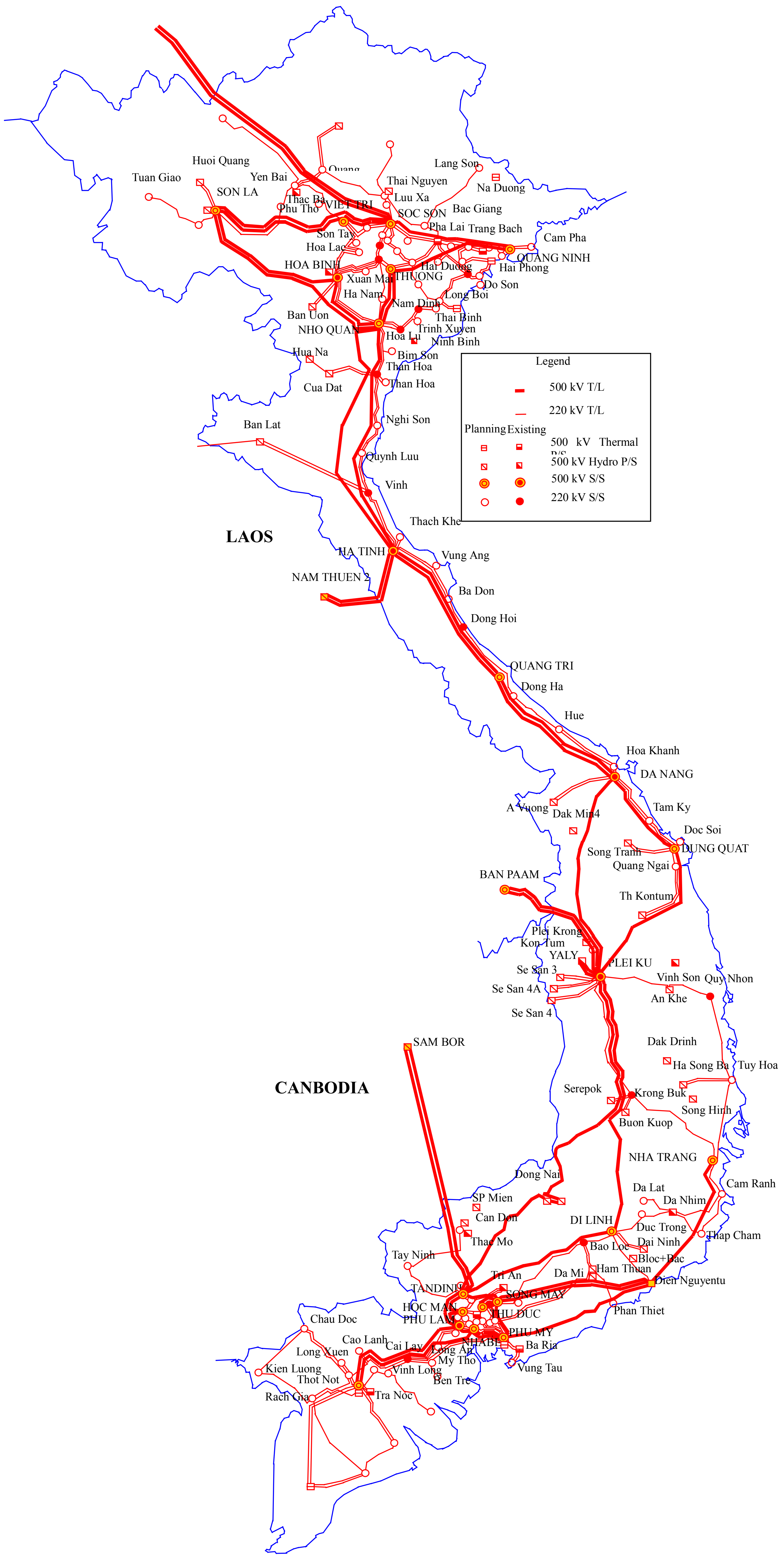
3.3 Current Situations and Review of Transmission System Development

3.3.1 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 3-3-1 and Table 3-3-1 show the 500kV transmission lines of Vietnam according to the plan of IE up to 2020. Total circuit length will be 6,000km. Long-distance 500kV transmission lines will include both series capacitors and shunt reactors. Table 3-3-2 shows the 500kV transformers according to the plan of IE up to the year 2010.



Source: IE

Figure 3-3-1 Transmission System in 2020

Table 3-3-1 500kV Transmission Lines of Vietnam according to the Plan of IE up to 2020

From	To	Conductor	No. of circuits	Series capacitors Shunt reactors	Approximate Distance (km)
Son La	Hoa Binh	4xACSR330	1	Installed	180.0
Son La	Nho Quan	4xACSR330	1	Installed	240.0
Son La	Soc Son	4xACSR330	1	Installed	200.0
Son La	Viet Tri	4xACSR330	1	No	120.0
Viet Tri	Soc Son	4xACSR330	1	No	80.0
Hoa Binh	Nho Quan	4xACSR330	1	No	120.0
Nho Quan	Thuong Tin	4xACSR330	2	No	75.0
Quang Ninh	Thuong Tin	4xACSR330	2	Installed	120.0
Quang Ninh	Soc Son	4xACSR330	2	Installed	140.0
Nho Quan	Ha Tinh	4xACSR330	1	Installed	280.0
Nho Quan	Thanh Hoa	4xACSR330	1	Installed	100.0
Thanh Hoa	Ha Tinh	4xACSR330	1	Installed	180.0
Ha Tinh	Quang Tri	4xACSR330	2	Installed	200.0
Quang Tri	Da Nang	4xACSR330	2	Installed	200.0
Da Nang	Plei Ku	4xACSR330	1	Installed	259.0
Da Nang	Dung Quat	4xACSR330	1	Installed	100.0
Dung Quat	Plei Ku	4xACSR330	1	Installed	200.0
Plei Ku	D Nhai 34	4xACSR330	1	Installed	296.0
D Nhai 34	Phu Lam	4xACSR330	1	Installed	240.0
Plei Ku	YaLy	2xACSR330	2	No	23.0
Plei Ku	Di Linh	4xACSR330	1	Installed	320.0
Di Linh	Tan Dinh	4xACSR330	1	Installed	174.0
Tan Dinh	Hoc Mon	4xACSR330	1	No	25.0
Hoc Mon	Phu Lam	4xACSR330	1	No	25.0
Phu My	Song May	4xACSR330	1	No	40.0
Nguyen Tu	Di Linh	4xACSR330	1	No	70.0
Nguyen Tu	Nha Trang	4xACSR330	1	No	110.0
Nguyen Tu	Phu My	4xACSR330	1	Installed	170.0
Nguyen Tu	Song May	4xACSR330	2	Installed	160.0
Tan Dinh	Song May	4xACSR330	1	No	30.0
Thu Duc	Song May	4xACSR330	2	No	20.0
Phu My	Nha Be	4xACSR330	2	No	49.0
Nha Be	Phu Lam	4xACSR330	1	No	16.0
Phu Lam	O Mon	4xACSR330	1	No	170.0
Nha Be	O Mon	4xACSR330	1	No	180.0

Data for planned transmission lines, 2003, IE

Table 3-3-2 500kV Transformers according the Plan of IE up to the year 2010

Station	Existing	2005	2010
Hoa Binh	2x450	2x450	2x450
Ha Tinh	1x450	1x450	1x450
Nho Quan		1x450	1x450
Thuong Tin		1x450	2x450
Quang Ninh			1x450
Phu Lam	2x450	2x450	2x450
Phu My		2x450	2x450
Nha Be		2x600	2x600
O Mon		1x450	2x450
Di Linh			1x450
Tan Dinh		1x450	2x450
Song May			1x600
Da Nang	1x450	2x450	2x450
Plei Ku	1x450	1x450	1x450
Dung Quat (Soc Soi)			2x450
Nhon Trach			1x450

Data for planned transformers, 2003, IE

3.3.2 Review of Transmission system Development Plan

(1) Direct Current Transmission Lines in Vietnam

There is a case that a direct current (DC) transmission system has some advantages over an alternative current (AC) transmission system for long distance power transmission more than 1,000 km because a unit cost of DC transmission system is lower than that of AC transmission system even if construction costs of frequency converters are included.

However, a DC transmission system has few advantages for branching out on the way of transmission lines, because expensive facilities and devices are required for making such branches and have some difficulties in complicated control of the system.

The power supplying and receiving will be required every 200 – 300 km along with the long way from the north to south in Vietnam and DC lines will not have advantages over AC lines. DC transmission systems are not planned so far in Vietnam.

(2) 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 with IMPACT. 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. The study will be conducted for the system with no series capacitors or with bypassed series capacitors. The countermeasures will be studied if there are problems.

(3) 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 3-3-3 according to the transmission system planning in year 2020. They have been evaluated on the condition that the power flows of the 500 kV transmission systems in the receiving areas should be within the capacity of the 500 kV transmission systems. Therefore, the upper limits of power flows depend on the power from generators and the loads of the areas.

Table 3-3-3 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

(4) Building Network Analysis Model

Based on the latest power development and transmission development plan, the model for the PSS/E analysis of the 500 kV and 220 kV systems were built in cooperation with IE. The data has about 400 circuits of transmission lines and 240 units of generators.

(5) 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.

3.4 EVN Financial Projection

3.4.1 Profit Plan

(1) Overview of EVN Financial Projection

a. Preparer of Financial Projection

The EVN financial projection is prepared by the Finance and Accounting Division.

b. Relation with the Master Plan

The EVN financial projection is based on the Master Plan, presently the revised 5th Master Plan.

Major donors such as WB and ADB have set criteria for financial soundness, and in such cases where criteria cannot be met they require immediate action for improvement.

The financial criteria for EVN set by the WB and ADB is as follows:

- Self Financing Ratio (:SFR)：30％ (past 3 years average)
- Debt Service Coverage Ratio (DSCR)：1.5 times（past 3 years average）

Therefore, although the EVN financial projection is based on the Master Plan, as EVN also needs to consider financial soundness, its financial projection is based on a different investment plan and tariff schedule from that of the Master Plan.

c. Timing of Preparation

EVN revises its financial projection when necessary and not by a fixed time schedule. At all past three study missions, new updated financial projections were obtained from the Finance and Accounting Division.

d. Financial Projection Subject to Analysis

As stated above, EVN frequently revises their financial projection. The financial projection analyzed in this study, is the most recent projection as obtained in December 2003.

This financial projection is most reliable as it is the underlying data for when EVN requested a revision of the tariff starting from April 2004 to the government.

The projected period is six years from 2003 to 2008.

(2) Summary of EVN Financial Projection

a. Major Assumptions

1) Electricity Tariff

Revision of the electricity tariff is assumed according to the following schedule.

Table 3-4-1 Electricity Tariff Schedule

	2003	2004	2005	2006	2007	2008
Average Unit Price （US cents／kWh）	5.6	5.9	6.5	7.0	7.0	7.0
Time of Revision	Current	Apr.	Apr.	Apr.	—	—

The schedule to raise the tariff to 7.0 ¢ /kwh has been revised several times in the past, but the tariff raise has been postponed every time. In the most recent schedule shown above, the timing to raise the tariff has been pushed back from the schedule assumed in the financial projection, which was obtained at the 1st mission. In the previous projection, the tariff was scheduled to be raised to 7.0 cents/kWh from April 2005, but has been postponed to 2006 in the latest financial projection.

2) Electricity Demand

For total generation and power purchase volume, the Base Case of the revised 5th Master Plan is assumed. As shown below, the EVN projection and Master Plan base case is similar.

Table 3-4-2 Generation & Power Purchase Volume (the 5th Master Plan)

Generation & Power Purchase (MWh)	2003	2004	2005	2006	2007	2008
EVN Projection	40,932	46,535	53,303	59,056	66,648	74,490
M/P Base Case	40,901	46,535	53,000	59,268	66,174	74,063

3) Investment Plan

There is a significant difference in the investment plans assumed in the Master Plan and the EVN financial projection.

Table 3-4-3 Investment Plan（the 5th Master Plan）

Output (MW)	2003	2004	2005	2006	2007	2008	Total
EVN Projection	150	432	0	0	3,075	1,085	4,742
M/P Base Case	443	150	570	1,231	2,153	1,765	6,312

Note）IPP and BOT projects are excluded in M/P Base Case.

4) Financing Conditions

For financing, the following conditions and fund uses are assumed.

・WB, ADB：

6.5% interest rate

15-year repayment period

Major fund use is construction of transmission and distribution lines

However, for rural electricification, assistance from WB is assumed by the following conditions:

1% interest rate

20-year repayment period

・JBIC：

2.2% interest rate

15~20-year repayment period

Major fund use is construction of power plants.

・Other ODA：

6% interest rate

7-year repayment period

Major fund use is construction of power plants.

・Commercial bank：

7.5% interest rate

6-year repayment period

Major fund use is construction of power plants, transmission and distribution lines.

In line with WB and ADB's Vietnam power sector assistance policy, WB and ADB funds are assumed for the use of constructing transmission and distribution lines as well as rural electrification.

According to the Finance and Accounting Division, the current financing conditions are adopted for borrowings from commercial banks

b. EVN Financial Projection

1) Financial Projection

The major objective of the EVN financial projection is to calculate SFR and DSCR, and therefore, profit accounts and cash flow accounts are shown together.

For purpose of the analysis, the EVN financial projection has been separated into the prospective income statement and the prospective cash flow statement.

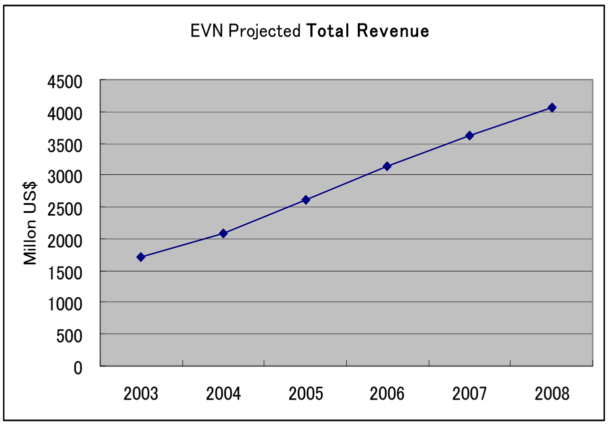
c. Profit Plan

To analyze future profitability, the consolidated prospective income statement has been prepared based on the EVN financial projection. (Table 3-4-4, Figure 3-4-1).

Table 3-4-4 EVN Prospective Consolidated Income Statement

(Unit: Million US$)

	2003	2004	2005	2006	2007	2008
Average Power Price (US cents/kWh)	5.6	5.8	6.4	6.9	7.0	7.0
At the End of Last Year	5.6	5.6	5.9	6.5	7.0	7.0
Revised Tariff in the Year	5.6	5.9	6.5	7.0	7.0	7.0
Time of Adjustment			Apr./04	Apr./05	Apr./06	
Net Average Price (excluding VAT)	4.96	5.30	5.77	6.25	6.36	6.36
Net Revenue	1,712	2,091	2,602	3,139	3,623	4,067
- Average Tariff (US cents/kWh)	4.96	5.30	5.77	6.25	6.36	6.36
- Sales Volume (Gwh)	34,510	39,454	45,093	50,228	56,964	63,953
Unusual Income						
1. Total Revenue	**1,712**	**2,091**	**2,602**	**3,139**	**3,623**	**4,067**
2. Total Cost	**-1,481**	**-1,847**	**-2,259**	**-2,621**	**-3,019**	**-3,517**
- Fuel	-440	-534	-603	-676	-673	-622
- Material	-58	-66	-75	-84	-95	-107
- Maintenance	-83	-102	-131	-142	-157	-166
- Salary and Insurance	-116	-131	-149	-163	-182	-201
- Power Purchase	-146	-300	-518	-724	-839	-1,196
- Depreciation	-473	-520	-569	-605	-795	-870
- Interest	-78	-936	-100	-99	-134	-194
- Hydro Resource Tax	-15	-15	-16	-18	-20	-22
- Administration Cost	-72	-82	-94	-105	-119	-133
- Unemployees' Fund Fee		-4	-4	-5	-5	-6
3. Net Profit from J/V						**20**
4. Income before Tax	**231**	**244**	**343**	**518**	**604**	**570**
5. Income Tax	**-38**	**-35**	**-39**	**-43**	**-47**	**-52**
6. Net Income	**193**	**209**	**304**	**475**	**557**	**518**
(Profit Rate)	**11.3%**	**10.0%**	**11.7%**	**15.1%**	**15.4%**	**12.7%**



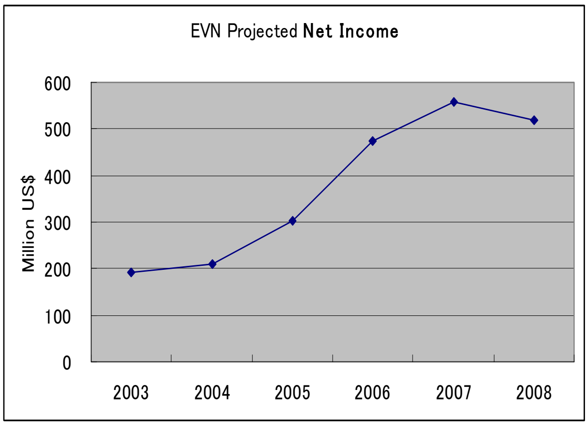


Figure 3-4-1 EVN Consolidated Prospective Revenue and Net Income

(3) Analysis

- Revenue is expected to increase significantly every year, due to strong electricity demand and the tariff raise.

Table 3-4-5 Electricity Demand Growth and Tariff Raise

	2003	2004	2005	2006	2007	2008
Revenue Growth Rate (%)	－	22.2	24.4	20.7	15.4	12.3
Electiricty Demand Growth Rate (%)	－	14.3	14.3	11.4	13.4	12.3

- Net profit rate of 10% or more is expected in all years of the projected period. However, net income and net profit rate is expected to decrease in 2008 from the previous year.
- Although revenue is expected to increase, net income and net profit rate are expected to decrease in 2008 due to increased power purchase (43% increase from previous year) and increased interest expense (45% increase from previous year).
- Annual income tax is low compared to the level of income before tax. This is due to tax incentives of deducting profit appropriated for capital investment from taxable income.

(4) Profitability

- Revision of electricity tariff is assumed to take place from 2004 to 2006. Its impact on EVN's profitability is significant. For example, if the tariff level of 5.9 cents (5.36 cents excluding VAT) in 2004 is still maintained in 2006, revenue will decrease by 450 million US$, and it would become difficult to achieve sufficient income before tax.
- The impact of power purchase cost on EVN's profitability is also significant. Importing of electricity is also assumed to start in 2008, and power purchase cost is expected to account for nearly 30% of annual power generation of 74,490MWh. As a result, fluctuation of unit price will impact profitability.

3.4.2 Fund Raising Plan

To analyze future cash flow, the consolidated prospective cash flow statement has been prepared below based on the EVN financial projection. (Table 3-4-6, Figure 3-4-2, Figure 3-4-3).

Table 3-4-6 EVN Consolidated Prospective Cash Flow Statement

(Unit: Million US$)

	2003	2004	2005	2006	2007	2008
a. Internal Source	339	380	447	332	310	119
Net Revenue	1,712	2,091	2,602	3,139	3,623	4,067
- Average Tariff (US cents/kWh)	4.96	5.30	5.77	6.25	6.36	6.36
- Sales Volume (GWh)	34,510	39,454	45,903	50,228	56,964	63,953
Unusual Income						
1. Total Revenue	1,712	2,091	2,602	3,139	3,623	4,067
2. Changes in Working Capital	-21	61	93	-5	-38	-52
3. Total Cost (exc. Dep. and Interest)	-930	-1,234	-1,590	-1,917	-2,090	-2,453
- Fuel	-440	-534	-603	-676	-673	-622
- Material	-58	-66	-75	-84	-95	-107
- Maintenance	-83	-102	-131	-142	-157	-166
- Salary and Insurance	-116	-131	-149	-163	-182	-201
- Power Purchase	-146	-300	-518	-724	-839	-1196
- Hydro Resource Tax	-15	-15	-16	-18	-20	-22
- Administration Cost	-72	-82	-94	-105	-119	-133
- Unemployees' Fund Fee	0	-4	-4	-5	-5	-6
4. Tax Payment	-38	-35	-39	-43	-47	-52
5. Contribution from Government						
6. All. to Funds (Use of Funds)	-23	-24	-27	-29	-31	-36
- All. to Welfare Fund	-16	-19	-21	-23	-24	-29
- All. to Sinking Fund	-5	-5	-6	-6	-7	-7
- All. to Unemployees' Fund	-2	0	0	0	0	0
7. Principle Repayment and Interest	-361	-479	-592	-813	-1,107	-1,355
- Principle Repayment	-245	-325	-381	-525	-743	-919
- IDC	-38	-61	-111	-189	-230	-242
- Interest Expense	-78	-93	-100	-99	-134	-194
b. Application of Funds						
- Net Investment	-1,165	-1,291	-1,966	-2,012	-1,937	-1,944
c. a.-b.	-826	-911	-1,519	-1,680	-1,627	-1,825
d. Financing Activities	726	939	1,557	1,630	1,558	1,730
- Bond Issue						
- Borrowing	726	939	1,557	1,630	1,558	1,730
e. Net Cashflow	-100	28	38	-50	-69	-95
f. Beginning of Year	719	618	646	684	634	565
g. End of Year	618	646	684	634	565	471

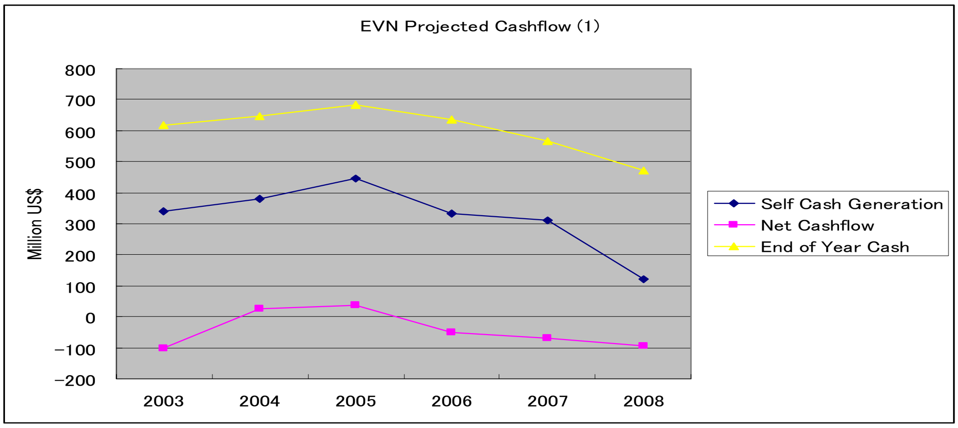


Figure 3-4-2　EVN Cash Flow Trend (1)

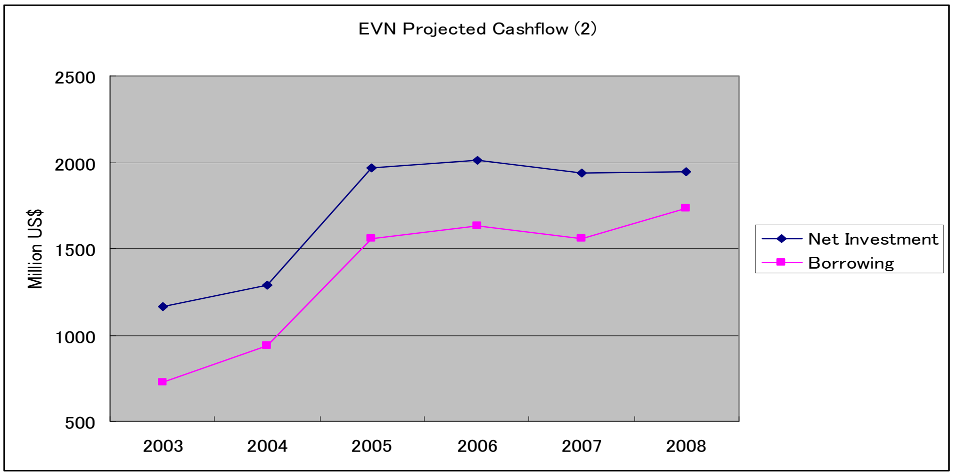


Figure 3-4-3　EVN Cash Flow Trend (2)

(1) Analysis

- Net cash flow is negative for all years except years 2004 and 2005.
- However, cash shortage is not expected to occur, as there would probably be enough cash balance to cover the net cash outflow.
- Steady cash flow from operating activities (excluding interest) can be expected as follows

Table 3-4-7 Cash Flow of Operating Activities

(Unit: Million US$)

Net Cash Flow from Operating Activities	2003	2004	2005	2006	2007	2008
	700	859	1,039	1,145	1,417	1,474

- However, interest expense and debt repayment are expected to increase every year, and internal source funds are expected to remain at a level of US$300 million to US$400 million from 2003 to 2007. In 2008, net increase in internal funds (a. Internal source) is expected to decrease as the burden of loan repayment and interest expense becomes prominent. As a result, EVN will largely depend on borrowings for capital investment funds.
- Financial indicators agreed upon by WB and ADB are as follows.

Table 3-4-8 Financial Indicators Agreed upon by WB and ADB

	2003	2004	2005	2006	2007	2008
SFR (%)*1	34.7	28.2	29.4	24.0	24.3	17.7
DSCR (Time)*2	2.15	2.04	2.15	1.83	1.61	1.34

(EVN Calculation)

*1 SFR(: Self Financing Ratio) : Rate on annual increase of internal funds over average capital investment (3-year average of previous, current and subsequent years).

*2 DSCR(: Debt Service Coverage Ratio) : Rate on annual increase of internal funds over debt service (loan repayment + interest expense).

- SFR target of 30% probably cannot be maintained after 2004. SFR falls below 20% in 2008 as net increase of internal funds decreases.
- DSCR target is likely to be met in all years except 2008.

(2) Comments on Cash Flow

- Cash flow on the whole, will decrease. Although cash flow from operating activities grows every year, internal funds, which may be appropriated to capital investment, remain flat, and even decrease in 2008, as the amount of loan repayment and interest expense increase.

3.4.3 Comments on EVN Financial Projection

(1) Relation with Revised 5th Master Plan

- EVN financial projection is based on the revised 5th Master Plan, but its project construction schedule and electricity investment plans differs slightly from that of the Master Plan.
- Although, the impact on profit projections due to the difference in investment plans is limited, the impact on cash flow is significant enough not to be overlooked. Therefore, financial projections based on the revised 5th Master Plan should also be considered.

(2) Analysis Results

- Steady profitability can be expected through the projected period as long as electricity demand increases and the tariff schedule proceeds as planned.
- On the other hand, cash flow is expected to decrease even though steady profit is expected. It can be said that EVN is financially unbalanced as the size of the planned capital investment is large for its profit size.

CHAPTER 4 POSSIBILITY OF INSTALLATION OF PUMPED STORAGE POWER PLANT

Chapter 4. Possibility of Installation of Pumped Storage Power Plant

4.1 Roles and Functions of PSPP

(1) Operational Mechanism of PSPP

The work of PSPP is shown in Figure 4-1-1.

PSPP is a power generation facility that utilizes water to generate and store electric power. PSPP's consist of 2 regulating reservoirs behind an upper and lower dam, which are connected by an underground waterway, together with an underground powerhouse located midway along the waterway.

The plant pumps water from the lower reservoir to the upper reservoir at night, when demand for electric power is low (off-peak time), by using electric energy generated by other power plants, then utilizes this water to generate electricity when demand becomes high at evening time (peak time). Once water has been stored in the reservoirs, it can be utilized repeatedly, so PSPP can generate electricity every time at its installed capacity regardless rainy or dry seasons.

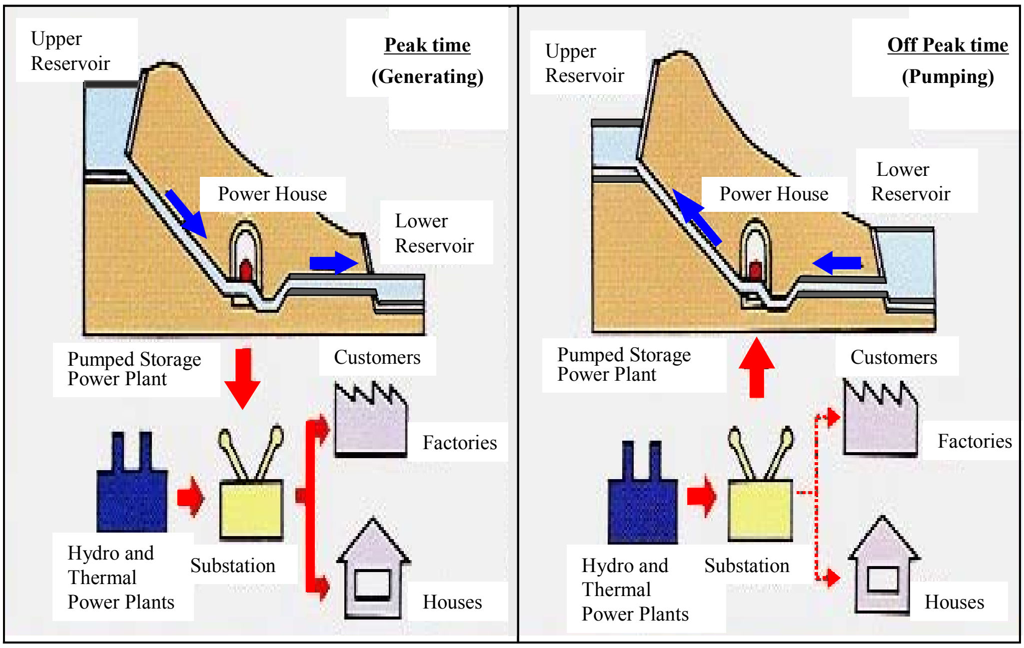


Figure 4-1-1 Work of Pumped Storage Power Plant

(2) Roles and Functions of PSPP

PSPP stores electric energy when demand for electricity is low as at night time and uses this stored energy for peak hours, thus can adjust the demand-supply balance and reduce the gap between the peak and off-peak hour's demand. That is PSPP plays a role of leveling ever-changing electric power consumption and can be regarded as a kind of DSM (Figure 4-1-2).

Owing to PSPP's role of load leveling, the other power sources which frequently start up and shut down or adjusted output can operate continuously for long time at stable output, so their fuel efficiency can increase. Moreover share of base power sources with low generation unit costs can be increased, thus the overall generation cost of the power system becomes lower, and economic efficiency increases.

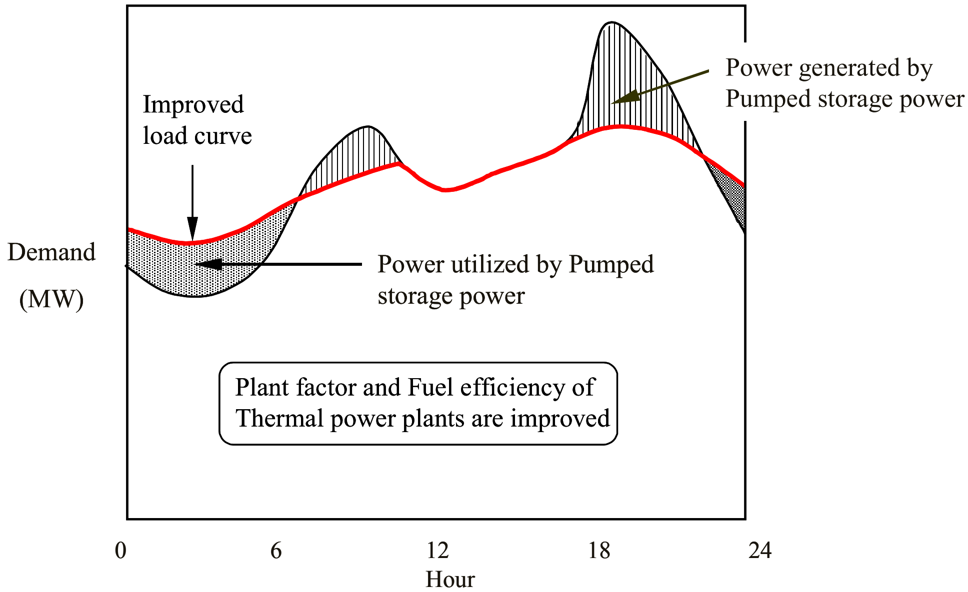


Figure 4-1-2 Leveling Load Curve by Pumped Storage Power Plant

Besides, like conventional HPP, PSPP has an excellent adjustment capability. Thus, PSPP can provide the following ancillary services, which are indispensable to ensure the reliability of the power system:

- Regulation of frequency:

  This is the service, which can adjust eventual demand-supply unbalance in order to control frequency fluctuations.

- Spinning reserve

  The generator is connecting with power system and necessary power can be supplied within 10 minutes after receiving the order to supply. (Figure 4-1-3)

- Replacement reserve

  The necessary power can be supplied within 60 minutes after receiving the order to supply.

- Voltage support

  This is the service, which provides invalid power in order to keep the voltage of the power system.

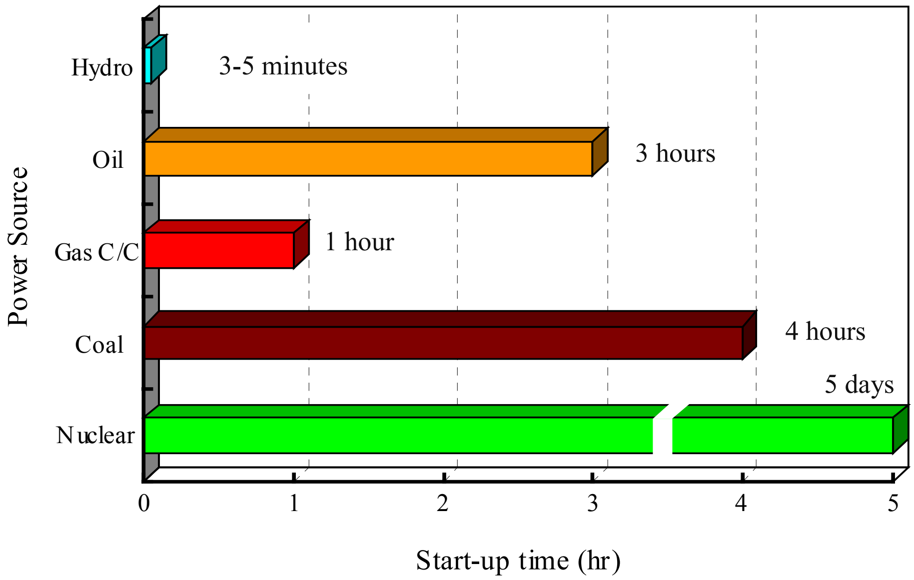


Figure 4-1-3   Start-up Time after 8-hour Shutdown

4.2 Project Finding of PSPP

There are various alternatives for peaking power supply such as thermal power and conventional and pumped storage of both existing and planned. It is thus necessary to select peaking supply projects by study and evaluation of those alternatives. Therefore, such data as adjustment capacity, efficiency, and generation costs of alternatives are collected for building optimization of the power development plan.

Pumped storage is considered to be the likeliest alternative. However, there is no pumped storage in Vietnam and the planning study has just begun. Therefore, it is necessary to conduct project finding and selection of promising pumped storage power projects.

4.2.1 Establishment of Criteria for Project Finding of PSPP

Existing criteria of EVN for project finding of pumped storage power plan is reviewed, considering the following conditions:

- Natural and social environment conditions (especially for upper and lower reservoirs);
- Topographical and geological conditions (especially for dam sites);
- Technological and economical constraints; and
- Local conditions.

Existing criteria of EVN was reviewed by comparison to the criteria used in Japan. After discussion between C/P and the Study Team, new criteria for pumped storage in Vietnam were determined as shown in Table 4-2-1. Especially, the criterion of installed capacity was amended from 1,000MW to more than 400 MW, potential sites less than 1,000MW would be presented by EVN and the Study Team would review and take them into account.

Table 4-2-1 Criteria for Pumped Storage Project Finding in Vietnam

Issue		Item	Criteria	Status
Technical	Generation plan	- Peak duration time - Installed capacity	- 7hrs - More than 400 MW	○ ○
	Limit of manufacturing of Power facility	- Design head - K Value - Max. utilizing water depth of pond	- Less than 750m of maximum head - Less than 1.25 - Less than 30m (40m in case of full facing pond type)	○ ○ ○
	Location / Layout	- Catchment area - Dam crest length - Dam height - Length of water way - L/H - Overburden of underground power cavern	- More than 30km2 (total of upper, lower dams and diverted) - Less than 500m - Less than 180m (Rockfill type) - Less than 10km - Less than 15 - Less than 500m	○ ○ ○ ○ ○ ●
	Geological conditions	- Active fault - Base rock conditions especially for underground power cavern	- Avoid the zone of active faults and those of Quaternary Era - Avoid the area of Quaternary Era and weak and unconsolidated strata	● ●
Environmental	Natural	- Protected Area (e.g. Natural Parks) - Endangered species	- Beyond the confines of Protected Areas (Natural Parks and Nature Reserves) - Avoid the critical habitats of important fauna and flora	○ ●
	Social	- Mining right - Historical and Cultural heritage - Houses to be submerged	- Avoid the area of mining concession - Avoid being submerged - Necessary to consider	● ● ●

○ : considered in primary project finding ● : necessary to confirm the situation by site survey

4.2.2 Map Study of PSPP

(1) Process of Map Study

Using 1:50,000 topographical maps, the following studies are carried out.

- Review of pumped storage projects proposed by EVN based on above-mentioned project finding criteria;
- Project finding using 1:50,000 topographical maps;
- Project cost estimation of the candidate sites including ones proposed by EVN;
- Economic analysis in comparison with gas turbine thermal power plant (B/C method); and
- Preliminary prioritization of the candidates from viewpoints of technical, economical, viability and natural and social environment impacts.

(2) Selection of Promising Sites for the First Field Survey

Study Team assembled the overall geological condition of the whole country according to the collected data and information (refer to Appendix 4-1).

Study Team reviewed the master plan of pumped storage power plants in Vietnam and carried out fresh potential site findings with using 1: 50,000 scale topographical maps. As a result, thirty eight (38) potential sites were found in Vietnam. Then conceptual design and cost estimation were carried out as shown in Table 4-2-2.

Preliminary prioritization of the candidate site was carried out according to the criteria.

Firstly, location / area of national parks and nature reserves were surveyed and then checked as the screening whether the pumped storage potential site is in the area or not. As a result, one potential site was located in a national park. Therefore the site was excluded from the candidate list and set as reserve grade site (refer to Appendix 4-2).

Secondary, eleven (11) sites were set as reserved grade due to technical criteria. Therefore twenty six (26) sites were nominated as the candidate sites.

Ten (10) promising sites were selected for the first site survey under a series of discussions between both parties considering various factors, such as construction costs, distance from the high power demand area / the nearest 500kV Substation, approaching road condition and distance from existing and proposed protected areas (Table 4-2-3).

Table 4-2-2 PSPP Potential Site List

No.	Location	map	East Longitude	North Latitude	Elevation of reservoir Upper HWL	Upper LWL	Lower HWL	Lower LWL	Max. head	longitudinal length(L)	L/H	Cost (M US$)	Dam Vol. UP (*1000m3)	Dam Vol. LOW	Dam Vol. Sub	K Value	Notes
1 JN18	N	6050–IV	105:13	20:50	700	670	115	80	620	6100	9.8	740	800	HoaBinh	0	1.19	–antiseapage for upper reservoir –cofferdam for outlet construction
2 P5	N	5950–I	104:54	20:57	660	620	115	80	580	2250	3.9	760	Pond	HoaBinh	0	1.22	–resettlement/land use –cofferdam for outlet construction –approach to outlet –approach tunnel to PS
3 JN13	N	5653–I	103:25	22:28	1180	1140	500	470	710	2300	3.2	760	Pond	1,300	0	1.18	–far from high demand area (>350km)
4 JN17	N	5954–I	104:58	22:57	1000	960	280	250	750	2200	2.9	770	Pond	2,300	0	1.17	–far from high demand area (>250km)
5 JN5	N	5951–III	104:32	21:08	750	720	150	120	630	2800	4.4	770	2,700	1,600	700	1.18	–resettlement/ land use –antiseapage of upper reservoir
6 JC6	C	6737–IV	108:43	14:22	800	760	200	170	630	2350	3.7	780	Pond	1,600	0	1.20	–approach to upper/lower dam sites –far from high demand area
7 JS11	S	6531–I	107:51	11:18	1040	1010	400	370	670	5000	7.5	780	2,100	1,700	0	1.17	–base rock for lower dam site –approach to upper dam
8 P11B	N	5950–I	104:50	21:00	650	610	115	80	570	2650	4.6	780	Pond	HoaBinh	0	1.23	–resettlement/use for upper reservoir –approach tunnel to talerace, outlet –approach road (>20km)
9 JS7	S	6732–III	108:35	11:35	1000	970	440	410	590	5250	8.9	800	1,600	1,600	0	1.18	–site for upper dam –approach to upper/lower dam
10 JN6	N	5951–IV	104:39	21:19	800	770	300	270	530	5600	10.6	810	3,200	1,900	0	1.20	–resettlement –abutment of upper dam/approach
11 JC4	C	6735–I	108:52	13:28	500	470	100	70	430	4650	10.8	820	3,300	1,900	0	1.24	–approach to upper dam –base rock condition for upper dam –far from high demand area
12 JS8	S	6731–IV	108:31	11:24	760	730	200	170	590	4550	7.7	820	Pond	1,900	0	1.18	–bed rock/abutment of lower dam –approach to the upper/lower dam
13 JS9	S	6633–I	108:28	12:28	1000	970	500	470	530	5700	10.8	820	1,600	2,500	0	1.20	–approach to upper/lower dam
14 JN3	N	5951–II	104:47	21:13	900	870	360	330	570	3350	5.9	820	2,400	5,000	0	1.19	–antiseapage of lower dam –alternatives for upper pond
15 JN11	N	5851–II	104:24	21:05	700	660	200	170	530	4000	7.5	830	Pond	1,300	0	1.23	–upper reservoir (limestone)
16 JN20	N	5753–I	103:48	22:20	1900	1870	1200	1170	730	8500	11.6	830	3,000	2,700	0	1.16	–far from high demand area (>300km)
17 JC2	C	6638–II	108:23	14:43	1000	970	440	410	590	5250	8.9	840	4,500	2,500	0	1.18	–approach to upper/lower dam –base rock condition for upper dam –far from high demand area
18 JS6	S	6732–I	108:47	11:57	620	580	200	180	440	2600	5.9	840	Pond	1,400	0	1.23	–location of upper pond/ approach –abutment of lower dam
19 JC3	C	6735–I	108:54	13:25	740	710	100	70	670	6100	9.1	860	Pond	900	0	1.17	–approach to upper dam –base rock condition for upper dam –far from high demand area
20 JS4	S	6732–I, IV	108:45	11:57	740	710	240	210	530	7000	13.2	860	5,000	1,100	0	1.20	–approach to upper dam
21 JN15	N	5853–III	104:08	22:04	800	760	300	270	530	5200	9.8	860	Pond	2,400	0	1.23	–far from high demand area (>220km)
22 JC5	C	6736–I	108:50	13:52	660	630	120	90	570	8500	14.9	880	3,100	3,200	0	1.19	–approach to upper dam –base rock condition/sub dam for upper dam –far from high demand area
23 JN1	N	5950–I	104:50	20:59	1000	960	300	270	730	2450	3.4	880	Pond	10,600	0	1.18	–resettlement/land use (lower dam) –approach to the site –base rock condition for lower dam (consider alternatives)
24 JS10	S	6532–IV	107:35	11:47	700	670	280	260	440	5200	11.8	890	Pond	1,600	0	1.20	–approach to upper/lower dam
25 JS3	S	6733–II	108:55	12:08	840	810	240	210	630	7800	12.4	890	2,700	4,600	600	1.18	–abutment/sub dam for upper dam/reservoir –approach to upper/lower dam
26 JN9	N	5851–I	104:20	21:20	1200	1170	500	470	730	4600	6.3	890	9,300	3,000	0	1.16	–approach to the site
JN8	N	5553–IV	102:35	22:21	1060	1030	580	550	510	3800	7.5	880	10,200	1,700	0	1.21	National Park
JC1	C	6638–I	108:20	14:47	1300	1270	540	510	790	9600	12.2	–	1,300	5,400	0	1.15	Too big head
JS5	S	6732–IV	108:38	11:51	1042	1018	250	220	820	7300	8.9	–	DaNhim	Pond	0	1.14	Too big head
JN12	N	5851–II	104:23	21:06	1000	960	200	170	830	3300	4.0	–	Pond	1,300	0	1.16	Too big head
P11	N	5950–I	104:50	21:00	1000	960	115	80	920	3900	4.2	–	Pond	HoaBinh	0	1.16	Too big head
P12	N	5851–II	104:19	21:08	1000	960	115	80	920	7900	8.6	–	Pond	HoaBinh	0	1.16	Too big head
JN19	N	5753–I	103:50	22:27	960	930	200	170	790	6350	8.0	–	2,500	4,200	200	1.15	Too big head
JN16	N	5752–II	103:50	21:35	560	530	160	130	430	3100	7.2	–	8,400	900	0	1.25	Too big K Value
P5B	N	5951–I	104:53	20:58	500	470	115	80	420	2600	6.2	–	8,700	HoaBinh	0	1.26	Too big K Value
P4B	C	6537–III, II	107:45	14:13	600	560	305	275	325	2600	8.0	–	Pond	SeSan3	0	1.36	Too big K Value
P1B	C	6737–III	108:44	14:06	460	420	100	80	380	2500	6.6	–	Pond	2,600	0	1.26	Too big K Value
JN2	N	5950–I	104:55	20:55	600	560	220	190	410	5500	13.4	–	Pond	4,200	0	1.28	Too big K Value

Notes: – Location N: North, C: Central, S: South Region
– Cost is excluding compensation, land, approach roads, cofferdam for outlet construction, transmission, etc.

Table 4-2-3 Ten Promising Sites for the First Site Survey

No.	Location	map	East Longitude	North Latitude	Elevation of reservoir Upper HWL	Upper LWL	Lower HWL	Lower LWL	Max. head	longitudinal length(L)	L/H	Cost (M US$)	Dam Vol. UP (*1000m3)	Dam Vol. LOW	Dam Vol. Sub	K Value
JN18	N	6050–IV	105:13	20:50	700	670	115	80	620	6100	9.8	740	800	HoaBinh	0	1.19
P5	N	5950–I	104:54	20:57	660	620	115	80	580	2250	3.9	760	Pond	HoaBinh	0	1.22
JN5	N	5951–III	104:32	21:08	750	720	150	120	630	2800	4.4	770	2,700	1,600	700	1.18
JS11	S	6531–I	107:51	11:18	1040	1010	400	370	670	5000	7.5	780	2,100	1,700	0	1.17
P11B	N	5950–I	104:50	21:00	650	610	115	80	570	2650	4.6	780	Pond	HoaBinh	0	1.23
JN6	N	5951–IV	104:39	21:19	800	770	300	270	530	5600	10.6	810	3,200	1,900	0	1.20
JN3	N	5951–II	104:47	21:13	900	870	360	330	570	3350	5.9	820	2,400	5,000	0	1.19
JS6	S	6732–I	108:47	11:57	620	580	200	180	440	2600	5.9	840	Pond	1,400	0	1.23
JN1	N	5950–I	104:50	20:59	1000	960	300	270	730	2450	3.4	880	Pond	10,600	0	1.18
JN9	N	5851–I	104:20	21:20	1200	1170	500	470	730	4600	6.3	890	9,300	3,000	0	1.16

Figure 4-2-1 Location of Ten Promising Sites for the First Site Survey

4.2.3 The First Field Survey

(1) Objects of the Survey

Reconnaissance study is conducted for the promising candidates of PSPP (about 10 sites) to confirm the conditions, which are identified by the desk study, such as topographical/geological conditions, hydrological conditions, and natural and social environment conditions. Two parties carry out site reconnaissance.

(2) Description of the Survey

According to the above-mentioned study results, the Study Team with Son La PMB and PECC1 surveyed ten potential sites of PSPP. Dates, the participants and the site names of each group are in table 4-2-4.

Table 4-2-4 The First Site Survey Schedule

Date	Group	Participants of Counterpart personnel	Site Name
17 Feb.- 21 Feb.	Group A	Mr. Tran Viet Hoa, Son La PMB Ms. Vu Thi Tuoi, PECC1	JN1, P11B, P5
	Group B	Mr. Le Manh Bao, Son La PMB Mr. Nguyen Van Ton, PECC1	JN18, JN5 (Lower dam site) JN6 (Lower dam site)
24 Feb.- 27 Feb.	Group A	Mr. Tran Viet Hoa, Son La PMB Ms. Vu Thi Tuoi, PECC1	JN3, JN6 (Upper dam site)
24 Feb.- 28 Feb.	Group B	Mr. Le Manh Bao, Son La PMB Mr. Nguyen Van Ton, PECC1 Mr. Nguyen Huy Hoach, PECC1	JN9, JN5 (Upper dam site)
3 Mar. - 6 Mar.	Group A	Mr. Vo Danh Thuy, Son La PMB Mr. Nguyen Huy Hoach, PECC1	JS6
3 Mar. - 7 Mar.	Group B	Mr. Le Manh Bao, Son La PMB Ms. Vu Thi Tuoi, PECC1	JS11

(3) Results of the survey

Based on the site survey, project conceptual design and project cost of each site were reviewed. Site investigation reports of each site are attached in Appendix 4-3. And the following evaluation was made:

1) Economic analysis in comparison with gas turbine thermal power plant (B/C method) (refer to Appendix 4-4).

2) Preliminary evaluation for Natural/Social environmental impacts (refer to Table 4-2-5).

3) Priority ranking (refer to Table 4-2-6).

The revised features and evaluation results are summarized in Table 4-2-7.

C/P and the Study Team discussed the above review works, and both parties agreed to select three or four sites from the following six project sites; P5, P11B, JN3, JN5, JN6 and JS6.

Four projects were selected for the second site survey after discussion between C/P and Study Team. Process of the selection is as follows:

- excluding JN6 to avoid competition with an irrigation dam project; and
- excluding P11B which local conditions are quite similar to P5 but is of less economic viability.

Table 4-2-5 Preliminary Evaluation Sheet for Natural/Social Environmental Impacts

Site name	Natural Environment		Social Environment		Multiplication of all scores	Evaluation score (* see note)
	Direct	Indirect	Direct	Indirect		
P 5	1	1	1	1	1	1.0
11 B	1	1	1	1	1	1.0
JN 1	2	2	2	2	16	2.0
JN 3	1	1	2	1	2	1.2
JS 6	2	2	2	2	16	2.0
JN 5	1	1	2	1	2	1.2
JN 6	2	2	1	1	4	1.4
JN 9	1	2	2	2	8	1.7
JN 18	2	2	3	1	12	1.9
JS 11	2	2	1	1	4	1.4

3 = significant impact
2 = can be mitigated or unknown
1 = no significant impact

Note: Evaluation score is caluculated in the following method in order to compare each evaluation score: 4th route of multiplication of all four scores of each site.

Table 4-2-6 Criteria for Priority Ranking

Priority Rank	Criterion
A A	It is economically superior and there is no significant natural / social environmental impacts expected.
A	It is economically superior, and there are natural / social environmental impacts or technical problems expected
B	It is economically feasible and there are natural / social environmental impacts or technical problems expected
C	It is uneconomical or there is significant natural / social environmental impacts or technical problems expected.

Table 4-2-7 Summary of the First Field Survey (1/3)

Project Site Name		(P5)	(P11B)	(JN1)	(JN3)
Project Specification	Installed Capacity P (MW)	1000	1000	1000	1000
	Designed Discharge Qd (m3/s)	250	230	190	240
	Effective Head Hd (m)	510	540	660	530
	Peak Duration Hours	7	7	7	7
Upper Reservoir	Type	Full Faced Poundage (Asphalt)	Full Faced Poundage (Asphalt)	Full Faced Poundage (Concrete)	Full Faced Poundage (Asphalt)
	Height H (m)	30	40	30	30
	Crest Length L (m)	2800	1900	2700	2400
	Dam (Bank) Volume V (1000m3)	3700	4200	3500	3100
	Excavation Volume Ve(1000m3)	4500	4200	3500	4200
	Reservoir Area Ra (km2)	0.5	0.3	0.5	0.4
	Catchment's Area Ca (km2)	1.6	4.0	0.5	1.3
	H.W.L (m)	630	660	980	850
	L.W.L (m)	610	630	960	830
	Usable Water Depth (m)	20	30	20	20
	Effective Reserve Capacity (mln m3)	7	7	5	6
Lower Reservoir	Type	(Hoa Binh Lake)	(Hoa Binh Lake)	Concrete Gravity	Concrete Gravity
	Height H (m)	-	-	120	70 + 30
	Crest Length L (m)	-	-	600	200 +100
	Dam Volume V (1000m3)	-	-	2200	270 +30
	Reservoir Area Ra (km2)	-	-	0.9	1.0
	Catchment's Area Ca (km2)	-	-	3.0	16.0
	H.W.L (m)	115	115	280	300
	L.W.L (m)	80	80	270	280
	Usable Water Depth (m)	35	35	10	20
	Effective Reserve Capacity (mln m3)	-	-	5	6
Water Way	Head Race L (m) x n	-	-	-	6.9 x 300 x 1
	Penstock L (m) x n	5.7 x 1300 x 1	5.8 x 1000 x 1	5.0 x 1300 x 1	5.6 x 1100 x 1
	Tail Race L (m) x n	7.0 x 800 x 1	6.8 x 1400 x 1	6.2 x 1200 x 1	6.9 x 2600 x 1
	Total Length Lt (m)	2100	2400	2500	4000
Power House	Type	Underground (Egg Shape)	Underground (Egg Shape)	Underground (Egg Shape)	Underground (Egg Shape)
	Cavern Volume (1000m3)	200	200	200	200
	Overburden (m)	500	500	500	500
Lt / Hd		4.2	4.5	3.8	7.6
Project Cost (mln US$)		750	770	910	760
Construction Period (years)		6	6	7	6
Economic Value (US$/kW)		750	770	910	760
B / C		1.10	1.08	0.93	1.09
Distance from 500kV substations (km)		50	50	50	70
Tentative eveluation scores of Environmental Assesment		1.0	1.0	2.0	1.2
Priority Rank		AA	A	C	AA

Table 4-2-7 Summary of the First Field Survey (2/3)

Project Site Name		(JN18)	(JN5)	(JN9)	(JN6)
Project Specification	Installed Capacity P (MW)	1000	1000	1000	1000
	Designed Discharge Qd (m3/s)	210	220	190	260
	Effective Head Hd (m)	600	570	680	480
	Peak Duration Hours	7	7	7	7
Upper Reservoir	Type	Full Faced Poundage (Asphalt)	Rockfill	Rockfill	Rockfill
	Height H (m)	40	50	100	80
	Crest Length L (m)	250	220	300	400
	Dam (Bank) Volume V (1000m3)	3800	700 + 200	4900	3200
	Excavation Volume Ve(1000m3)	4000	200	500	400
	Reservoir Area Ra (km2)	0.3	0.6	0.5	0.6
	Catchment's Area Ca (km2)	3.7	3.5	52.1	12.8
	H.W.L (m)	720	730	1180	800
	L.W.L (m)	700	720	1160	780
	Usable Water Depth (m)	20	20	20	20
	Effective Reserve Capacity (mln m3)	6	6	5	7
Lower Reservoir	Type	(Hoa Binh Lake)	Concrete Gravity	Concrete Gravity	Concrete Gravity
	Height H (m)	-	50	100	80
	Crest Length L (m)	-	120	200	200
	Dam Volume V (1000m3)	-	80	600	400
	Reservoir Area Ra (km2)	-	1.1	0.6	0.7
	Catchment's Area Ca (km2)	-	420	104.4	112.7
	H.W.L (m)	115	120	470	300
	L.W.L (m)	80	115	450	280
	Usable Water Depth (m)	35	35	20	20
	Effective Reserve Capacity (mln m3)	-	6	5	7
Water Way	Head Race L (m) x n	6.5 x 900 x 1	6.6 x 1200 x 1	6.1 x 1800 x 1	7.2 x 4300 x 1
	Penstock L (m) x n	5.2 x 1500 x 1	5.4 x 1100 x 1	4.9 x 1300 x1	5.8 x 1000 x1
	Tail Race L (m) x n	6.5 x 2800 x 1	6.6 x 700 x 1	6.1 x 2000 x 1	7.2 x 700 x 1
	Total Length Lt (m)	5200	3000	5100	6000
Power House	Type	Underground (Egg Shape)	Underground (Egg Shape)	Underground (Egg Shape)	Underground (Egg Shape)
	Cavern Volume (1000m3)	200	200	200	200
	Overburden (m)	500	500	500	500
Lt / Hd		8.7	5.3	7.5	12.5
Project Cost (mln US$)		790	680	820	760
Construction Period (years)		6	6	7	6
Economic Value (US$/kW)		790	680	820	760
B / C		1.05	1.20	1.02	1.09
Distance from 500kV substations (km)		10	80	30	90
Tentative eveluation scores of Environmental Assesment		1.9	1.2	1.7	1.4
Priority Rank		B	AA	B	A

Table 3-2-7 Summary of the First Field Survey (3/3)

Project Site Name		(JS6)	(JS11)
Project Specification	Installed Capacity P (MW)	1000	1000
	Designed Discharge Qd (m3/s)	320	200
	Effective Head Hd (m)	400	620
	Peak Duration Hours	7	7
Upper Reservoir	Type	Rockfill	Rockfill
	Height H (m)	50 + 20	70
	Crest Length L (m)	850 + 100	400
	Dam (Bank) Volume V (1000m3)	900 + 100	2900
	Excavation Volume Ve(1000m3)	200	300
	Reservoir Area Ra (km2)	1.0	0.4
	Catchment's Area Ca (km2)	2.7	8.1
	H.W.L (m)	620	1040
	L.W.L (m)	600	1020
	Usable Water Depth (m)	20	20
	Effective Reserve Capacity (mln m3)	9	5
Lower Reservoir	Type	Rockfill	Rockfill
	Height H (m)	60	70
	Crest Length L (m)	250	350
	Dam Volume V (1000m3)	1400	3500
	Reservoir Area Ra (km2)	2.1	0.5
	Catchment's Area Ca (km2)	720	24.8
	H.W.L (m)	200	400
	L.W.L (m)	195	380
	Usable Water Depth (m)	5	20
	Effective Reserve Capacity (mln m3)	9	5
Water Way	Head Race L (m) x n	-	6.4 x 3000 x 1
	Penstock L (m) x n	8.0 x 900 x 1	5.2 x 1200 x 1
	Tail Race L (m) x n	6.4 x 1700 x 1	6.4 x 2000 x 1
	Total Length Lt (m)	2600	6200
Power House	Type	Underground (Egg Shape)	Underground (Egg Shape)
	Cavern Volume (1000m3)	200	200
	Overburden (m)	200	500
Lt / Hd		6.5	10.0
Project Cost (mln US$)		730	820
Construction Period (years)		6	6
Economic Value (US$/kW)		730	820
B / C		1.13	1.02
Distance from 500kV substations (km)		90	30
Tentative eveluation scores of Environmental Assesment		2.0	1.4
Priority Rank		A	B

4.2.4 The Second Field Survey

(1) Objects of the Survey

The second site survey on the priority candidate sites was carried out especially to identify obstructions of the project, which was found by the first reconnaissance survey, and to collect data for preliminary design.

(2) Description of the Survey

Layout designs of the selected four projects were reviewed based on the first reconnaissance study. And the second reconnaissance was carried out based on the reviewed layout.

a. Methodology of Reconnaissance for Topographic/Geographic and Design Issues

Preparatory study was carried out based on the results of the first reconnaissance study and reviewed layout designs, and specific points to be clarified were picked up with respect to each project and each structure such as upper dam/reservoir, headrace. These points were summarized and used as check lists at site. These lists are attached hereto (refer to Appendix 4-5).

b. Methodology of Reconnaissance for Environmental Issues

Regarding the social environment of each village, the member of the JICA Study Team and the local consultant visited the villages and interviewed the local people. Usually the leaders of the villages were interviewed, but when they were not available, people recommended by the villagers were interviewed. A comprehensive socio-economic survey was not conducted because of time constraints. It is important to note that the results should be treated as preliminary ones and should be verified by more comprehensive survey in the next stage (e.g. feasibility study).

Regarding the natural environment at each site, the member of the JICA Study Team and the local consultant visited the sites and assessed the status of the environments. It is important to note that the results should be treated as preliminary ones and should be verified by more comprehensive survey in the next stage (e.g. feasibility study).

The assessment of the environments was conducted based on the prepared environmental parameter checklist mainly based on the Asian Development Bank checklist (refer to Appendix 4-5).

c. Itinerary

The Study Team with Son La PMB and PECC1 surveyed four potential sites of PSPP. Dates, the participants and the site name of each group are shown in Table 4-2-8. Additionally, a local expert for natural and social environment was hired and visited the sites together.

Table 4-2-8 The Second Site Survey Schedule

Date	Participants of Counterpart personnel		Site Name
June 2nd～6th	Son La PMB PECC1	Mr. Tran Viet Hoa, Mr. Hoang Minh Hieu Ms. Vu Thi Tuoi, Mr. Nguyen Van Ton	JN5, P5 (Lower dam site)
9th～12th	Son La PMB PECC1	Mr. Tran Viet Hoa, Mr. Hoang Minh Hieu Ms. Vu Thi Tuoi, Mr. Nguyen Van Ton	JN3
16th～19th	Son La PMB PECC1	Mr. Vo Danh Thuy, Mr. Tran Viet Hoa Ms. Vu Thi Tuoi, Mr. Nguyen Van Ton	JS6

(3) Result of the Survey

The second site reconnaissance was conducted as per schedule. Check lists and summarized results of the reconnaissance for the four promising project sites are attached hereto. (refer to Appendix 4-6-1 – 4-6-4)

a. JN3 Site

1) Topographical/Geological Condition and Design

a) General Conditions

Location and Transportation Condition：

The project site is located about 20km east from the centre of Phu Yen city, which is the capital of the District. There are local roads for car transportation near the project area. One of them is about 500m south from the upper reservoir. The second one reaches Manh village, which is located 2km west to the lower dam site, and continues to extend along Mua River. On the other hand the existing road between upper reservoir and the lower dam is under construction for upgrading. Therefore the transportation condition is favorable.

Upper Reservoir：

Topographically, the upper Reservoir is planned on a gently sloped plane. Therefore, a pond type reservoir is available. Geology around the Upper Reservoir is of clayish shale or limestone (D2mt, D2ebn or D2g-D3bc), the conditions of rock are hard and massive. The right side of the reservoir has steep slope composed of limestone outcrop, and the left side has gentle slope composed of the same geology with small streams. There is a nearly NNE-SSW system of small hill in the centre of the reservoir area. Permeability around the Upper Reservoir is probably low.

Lower Reservoir：

Geology around the Lower Reservoir is generally hard and massive mainly composed of clayish shale (D1st), and limy shale outcrops partially around the downstream riverbed. Topography around the Lower Reservoir is good for construction of a gravity type Dam with no noticeable weathering on the ground. The river flow during the survey (drought period) is as little as at about $0.3m^3/s$.

There is a limit to enlarge the lower dam height. Maximum elevation is 300m, which is 20m higher than the present High Water Level (H.W.L.), and is available without additional saddle dams.

Waterway/Underground Power Station：

Geology around the Waterway area is composed of limestone (D2mt) or clayish shale (D2ebn) according to the published geological map. There are no features to specify in the deeper part, but in case the position of the waterway is in the limestone (D2mt), the permeability is relatively high, and in the case of the clayish shale (D2ebn), the permeability is low. There is a valley along the geological boundary of D2mt and D2ebn according to the published geological map. Geology around the Underground Power Station is composed of hard and massive clayish shale (D2ebn).

b) Issues

Location and Transportation Condition：

Reconstruction is necessary for the PSPP project in some sections of the existing road, which are narrow and/or steep.

Upper Reservoir：

Selection of a position is required where reduction of excavation/embankment volume is possible through the use of a small hill in the centre of the area. Accordingly the reservoir will be located on the west side of the small hill. And it may be possible to store necessary volume of water.

Lower Reservoir：

A relatively small dam, of which crest length is 150m and dam volume is 0.2mln m^3, can store necessary volume of water for a 1,000MW PSPP. Therefore topographic and geographic condition is good for the dam site. Meanwhile, the measured discharge is small and the catchment area is only $16km^2$. There is a concern that the first pooling of the reservoir may take a long period.

Waterway/Underground Power Station：

It is necessary to consider the distribution of limestone and its features for the layout design of the waterway and the underground power station.

Others：

Detailed geological survey for the E-W system of fracture zone through the Upper Reservoir and distribution of serpentine will be needed.

c) Evaluation and Next Necessary Actions

Location and Transportation Condition：

The length of new approach and maintenance roads, which are necessary for constructing the project, is estimated at about 22km. This length is shorter than that of the other project. Planning of construction roads is required based on the reviews on the road improvement plan, such as specifications and the target year.

Upper Reservoir：

From the viewpoint of topographic situation, the current design of dam location and poundage area seems optimum. Upon studying an optimum scale of development, deeper excavation is required for increase of the storage volume. However, the upper limit of the poundage volume may be about 150% of the current design, considering the limit of usage depth of the reservoir.

Lower Reservoir：

Measurement of the river inflow throughout the year is necessary for studying period and method of pooling. Studies for countermeasures such as pumping up system from the nearby main river are required, based on the measured inflow data.

Waterway/Underground Power Station：

Further optimization study of waterway design is required.

Others：

Installed capacity of this project may be able to increase, but about 1,500MW is maximum.

2) Social and Natural Environments

a) Current Conditions (refer to Figure 4-2-2)

(SOCIAL ENVIRONMENT)

Upper Reservoir：

The site belongs to Muong Do commune and the closest village is Lan (Muong and Thai minorities). The village is located at the entrance of the dam / reservoir site, and is connected to the national road by a dirt road. The road goes through several villages.

There is no village in the site and one small seasonal farming house. The site is used for maize and rice cultivation, and for grazing buffalo.

Livestock husbandry is important for the local people. They usually keep buffalo, cattle, pigs and chickens.

Lower Reservoir:

In the surrounding areas of the lower dam /reservoir (Muong Lang commune), Muong and Thai groups occupy about 60% of the total population and other minority groups are Hmong, Dao and Viet. They have cut the forest for cultivating rice, maize and other crops.

The lower dam / reservoir site is located in Thung Lang village (Muong Lang commune) with 37 households and 140 persons. The closest other village is Manh, which is located at the entrance to the site and has 37 households and 171 persons. It is connected to the national road by a dirt road. The dirt road goes through several villages.

In Thung Lang, social infrastructure has not been well developed. It is not connected to the national electricity network. Regarding the health condition, there is a clinic station at every commune. The main function of clinic stations is to provide medical check-ups and treatments to patients who suffer from normal diseases and to carry out National Health Programmes such as Family Planning programme, Vaccine Injection programme. According to the assessment of the district health sector, in recent years, the health condition of the local residents has been improved greatly. Regarding the educational condition, in Thung Lang, there is one primary school up to 2nd grade.

(NATURAL ENVIRONMENT)

The dam / reservoir sites are located in the humid tropical climate region with wind changes occurring by seasons and high amount of precipitation and relatively low temperature in winter. Due to differences in the geographical and soil conditions, vegetation cover structures also vary from place to place, and they can be served as representative vegetation cover in the mountainous area in the North of Vietnam.

The **terrestrial ecosystem** has been degraded by human activities. The original forest has been logged and converted to agricultural lands. Some forests remain along rivers / streams and on mountain ridges. However, the forests in the surrounding area of the upper dam / reservoir site remain relatively in good condition.

The **aquatic ecosystem** of both sites is not fully studied.

Upper Reservoir:

The site is relatively flat and covered by agricultural land and bushes. The mountain from south – west to west side of the site is covered with secondary and good forest.

There are a couple of small streams from the site.

Lower Reservoir：

The valley is degraded mainly by agricultural activities. The forests in and around the village are fragmented, and some of the remaining secondary forests are under protection rules of the village.

A stream goes through the valley and flows into Mua river.

b) Issues

Important issues are described in the following sections. The other issues are summarized in Appendix 4-6-1.

(SOCIAL ENVIRONMENT)

Upper Reservoir：

Lan village is expected to receive significant impacts by the project. Because of its proximity, construction works and construction camp with one to two thousands people will give them great impacts.

An approach road from the closest national road is long and goes through several villages. There are three options to construct the approach road. The first one is to expand and improve the existing road, the second is to build a new one, and the third is to mix the first and the second options. In any case, resettlement and / or compensation of lands may occur.

Lower Reservoir：

Thung Lang will receive significant impacts. All the households are not expected to be submerged. However, since large part of their rice fields that are their important sources of income and food is expected to be submerged, the households which are not submerged may want to move out from the site.

Manh village is expected to receive significant impacts by the project. Because of its proximity, construction works and construction camp with one to two thousands people will give them great impacts.

An approach road from the closest national road is long and goes through several villages. There are three options as described in “Upper dam / reservoir”. In any case, resettlement and / or compensation of lands may occur. Some parts of the approach road are the same as the ones of the upper dam / reservoir.

(NATURAL ENVIRONMENT)

Upper Reservoir：

Since the surrounding area has good forests, secondary impacts such as poaching, illegal logging and introduction of alien species are likely to occur at the construction / operation stages.

Lower Reservoir：

The aquatic ecosystem of both sites is not fully studied. The assessments are based on the information obtained during the survey and should be reviewed and corrected, if necessary, at the next stage.

Fragmented forests may receive negative impacts depending on their locations.

c) Evaluation and Next Necessary Actions

(SOCIAL ENVIRONMENT)

The community of Thung Lang will receive significant impacts, and Lan (upper dam / reservoir) and Manh (lower dam / reservoir) are also expected to receive negative impacts.

In the next stage (feasibility study), a comprehensive socio-economic survey should be conducted and explanatory meetings should be held at each village to brief the project and the impacts they may receive. It is important to collect opinions from the villagers and to reflect their opinions in planning.

The construction plan of approach road (especially route plan) should be reviewed, and a revised plan should be proposed in order to prevent impacts (e.g. resettlement) as much as possible.

EVN has completed a resettlement project for Yaly Hydropower Project, which was successful. However, lessons learned from the project should be applied at this site[1].

It is important to note that cancellation of the project at this site should be included in proposed mitigation measures.

(NATURAL ENVIRONMENT)

Although no significant impacts are predicted to occur on the terrestrial environment, baseline data need to be collected in order to understand the current situation more deeply, to assess the impacts more accurately and to prepare for future monitoring programme. The remaining fragmented forests should be conserved as much as possible.

Regarding the aquatic ecosystem, a comprehensive survey needs to be conducted in order to collect information on it as much as possible, and based on the collected data and analysis of them, mitigation measures should be proposed. Mitigation measures should include cancellation of the project at this site.

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[1] The details of the lessons should be referred to the recommendations made by Vietnam Environment & Sustainable Development Center in "STUDY ON PUBLIC PARTICIPATION IN RESETTLEMENT PLAN RELATED TO YALI HYDROPOWER PROJECT (Hanoi, July 2000)".

Once the project is decided to be implemented, at the construction / operation stages, secondary impacts such as poaching, illegal logging and introduction of alien species are expected and they need to be carefully assessed and necessary mitigation measures should be planned and implemented.

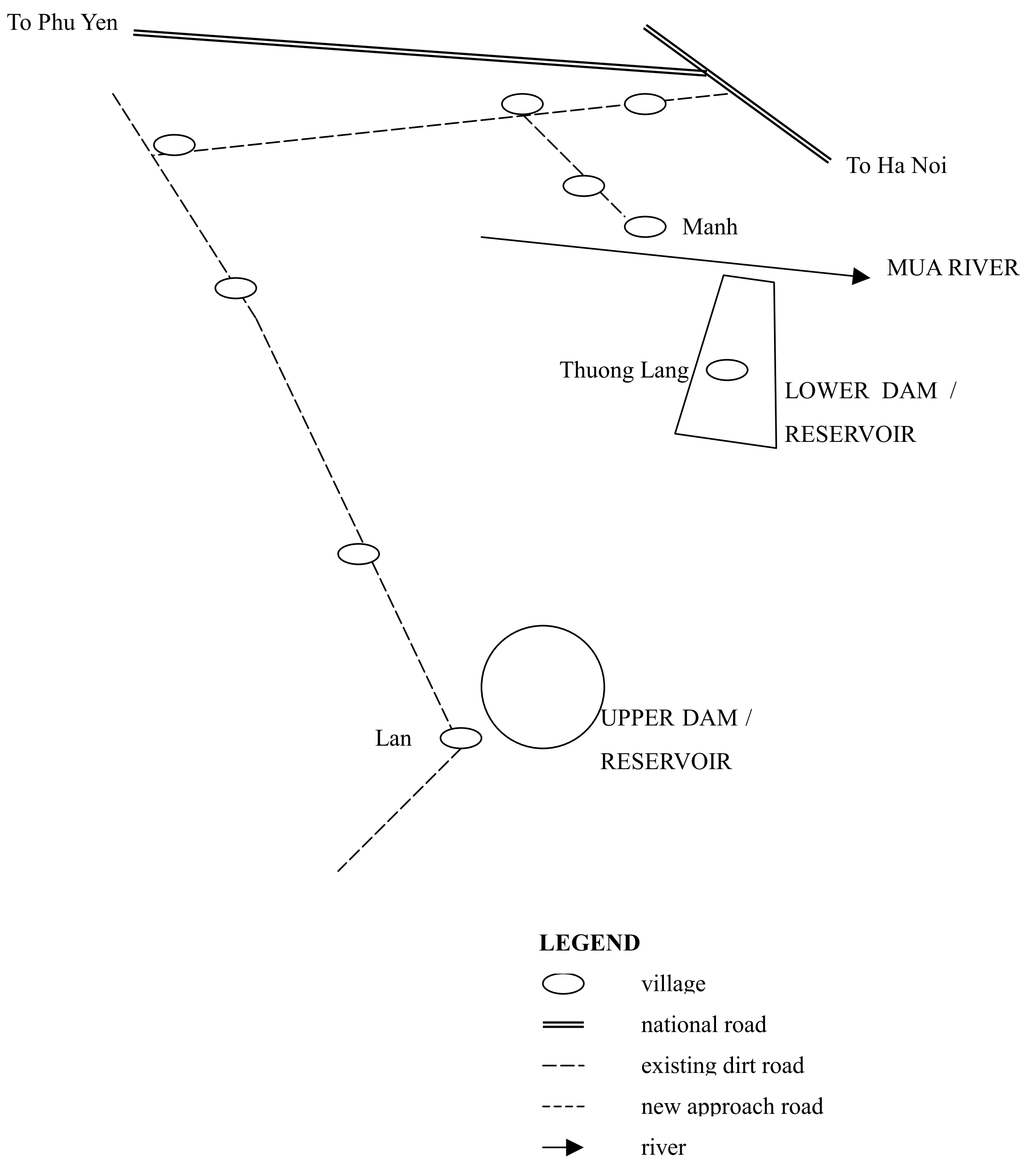

Figure 4-2-2 Map around JN3

b. JN5 Site

1) Topographical/Geological Conditions and Design

a) General Conditions

Location and Transportation Condition：

This project site is located downstream of Sap river, which is the border between Phu Yen District and Bac Yen District. The lower dam will be affected by water level changes of Hoa Binh Dam.

There is an existing road with 20km long to Na Nay village, which is 3km north from the lower dam site. No road for cars is available to the upper dam/reservoir.

Upper Reservoir：

Geology around the Upper Reservoir is hard and of massive green schist or basalt porphyry (P2-T1 vn) and clayish shale or limestone (T2 lmt) specially outcrops on the riverbed around the Dam site. Weathering in the slope of the valley is assumed to be about 5-15m depth. No spring points are found but water level is expected to be near the bottom of the reservoir in view of the agricultural conditions. The permeability of rock may be low.

There are no weathered features along the geological boundary of limestone/shale and schist/porphyry through the dam site, but the valley can be found in the topographical map. Some hard and massive schist and porphyry outcrops are found on the riverbed. The slope downstream from the dam site changes steeper.

The noticeable problem is a narrow ridge in the left side of the reservoir shown as below, and this ridge indicates NW-SE system of structure as topographical anomaly along the geological boundary of P2-T1 vn and T2 lmt. Actually, the slope behind the ridge indicates some experiences of collapse. The elevation of this ridge is around 735m above sea level, there is a difference of 5m in the information from the topographical map.

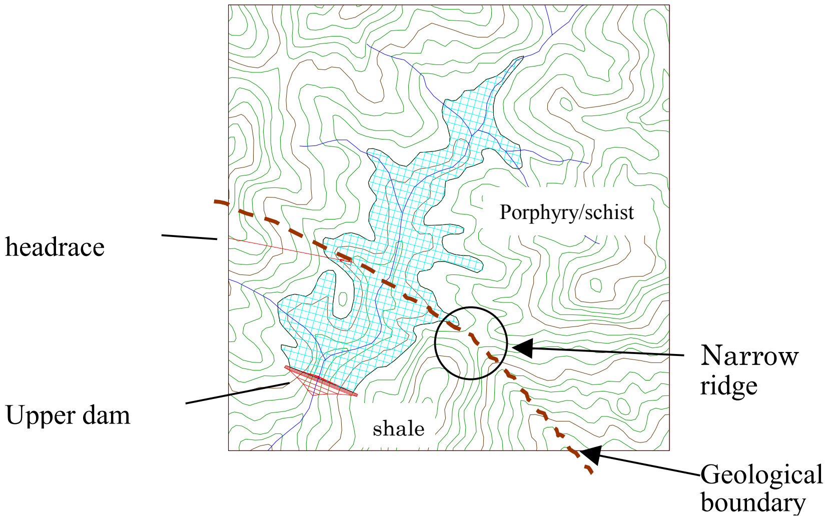

Fig.4-2-3 JN5 Site, Upper Reservoir/Dam Site

Lower Reservoir：

Limestone (D2g-D3bc2) around the Lower Reservoir and the Dam site dips 20-35 degrees, hard and massive with many open holes on the slope. The permeability of rock is probably high. Intensity of the massive limestone is not so low, generally the same as fresh sedimentary rock.

Since the planned dam site is located in a narrow valley with rigid limestone, a concrete gravity type dam is selected. This dam site is located at the upstream end of the Hoa Binh reservoir. The planned dam site is submerged in the Hoa Binh lake except during the drought season. Therefore two cofferdams, one upstream and the other downstream, are necessary for the dam construction.

Waterway/Underground Power Station：

The designed waterway route runs under the boundary of limestone and basalt porphyry/schist zone. The conditions of these rocks are massive and hard with some open joints in the limestone, and the permeability of rock seems high. There are no features of faults on the surface.

There are houses and field of Phieng Luong village, which is located on the left slope and upstream of the dam site. Appearance of fresh rock may not be expected because this area is covered with deep deposit.

b) Issues

Location and Transportation Condition：

The existing road to Na Nay village is not suitable as an approach / maintenance road to the power station, as it is long and there are rock slides along the road. As an alternative, a new approach route along Sap River diverted from the national road is required by widening the existing narrow road or footpath along the route, or constructing a new road. A maintenance road from the lower dam to the upper reservoir is also necessary to be constructed.

Upper Reservoir：

There are no significant problems for construction of concrete dam. Minimum leakage path length is only 300m on the topographic map, which is located on the left slope of the main river. Actual erosion of the ridge may have progressed more than shown on the topographic map. Further geographical investigation and design of countermeasures against the leakage are required.

Lower Reservoir：

Limestone around the Lower Reservoir and the Dam site has many open joints. The permeability of rock is probably high.

The river in the Lower Reservoir lies on the structural line according to the published geological map. Especially, it is important to note that the Phieng Luong village, lying adjacent upstream of the dam site, is sitting at the point where two structural lines (one of which is presumed) are crossing each other. A detailed investigation is needed.

The site of the dam axis should be shifted is changed to 300m upstream from the original position in view of economical efficiency. This change of design includes the layout of the downstream cofferdam.

Waterway/Underground Power Station：

The field of Phieng Luong village, which is located on the left slope upstream of the dam site, should be avoided for building the entrance of tunnels, as there is covered by deep secondary deposit. The underground power cavern had better to be located at the deep part of the major ridge, beside the dam site. Accordingly, modification of the waterway layout design is required.

c) Evaluation and Next Necessary Actions

Location and Transportation Condition：

The length of the newly constructed approach/maintenance road is estimated to be about

37km, which is rather longer than the other projects. Route design considering actual use of land along the road is required.

Upper Reservoir：

It is necessary to carry out topographical surveys covering the whole of the regulating pond. Based on the survey, a design of countermeasures against the leakage from the narrow ridge of the left side is required.

Lower Reservoir：

Since the planned dam is located in the Hoa Binh lake, the pressure both from the upstream and the downstream areas should be considered in structural design. Consequently, the dam volume will be larger than usual.

Waterway/Underground Power Station：

Further optimum layout with minimum waterway length should be studied.

Others:

The catchment area of Sap river is large enough, which is 420km^2, conventional hydropower generation is possible by using the difference of water levels between the lower reservoir and Hoa Bin lake.

2) Social and Natural Environments

a) Current Conditions (refer to Figure 4-2-4)

(SOCIAL ENVIRONMENT)

Upper Reservoir：

There are two related villages, namely Suoi On and Suoi Let. Both of them are under Kim Bon Commune. Suoi On consists of Hmong minority and Suoi Let of Dao.

There are three temporary houses of Suoi On for agriculture and aquaculture practices at the site. There are two aquacultural ponds and they earn 200 million VD (Vietnamese don) per year.

There are three houses of Suoi Let at the site and they mainly practice rice cultivation. Their rice fields lie at the upstream of the dam site.

Livestock husbandry is also important for the local people here. They put horses and buffalo out to pasture in the valley.

Lower Reservoir：

The main river, Sap river, is the boundary of Bac Yen and Phu Yen districts.

There are eight related villages. From the upstream to the downstream of Sap river, they are Cang, Dung, Giang A (Bac Yen district), Giang B (Phu Yen district), Keo Lan, Xa, Na

Nay and Phieng Luong.

Although Cang is outside the dam / reservoir site, it may be affected by construction of approach road. During this survey, the village was not visited and no data was collected due to lack of time.

The entire Phieng Luong village moved to the current site by Hoa Binh Dam Project.

Table 4-2-9 Data of Related Villages at Lower Dam / Reservoir Site

Village name	Commune name (district name)	Ethnic group	Household / population	Agricultural land
Dung	Hong Ngai (Bac Yen)	Thai	66 / 368	> 20 ha
Giang A	Hong Ngai (Bac Yen)	Muong	28 / 160	3 ha
Giang B	Suoi Pau (Phu Yen)	Thai & Muong	64 / 346	19 ha
Keo Lan	Sap Sa (Phu Yen)	Thai	67 / 339	8 ha
Xa	Sap Sa (Phu Yen)	Thai	88 / 488	10 ha
Na Nay	Sap Sa (Phu Yen)	Thai	62 / 348	58 ha
Phieng Luong	Sap Sa (Phu Yen)	Dao	89 / 505	Small area

They practice agriculture and produce mainly rice and maize. All rice is produced for their own consumption and maize is their main cash crop. Maize and other minor cash crops are transported to the outside by horses and motor bikes from Giang A &B and Dung, by boat from Keo Lan, Xa, Na Nay and Phieng Luong. Boat transportation is seasonally, namely in winter. Small scale fishing are actively conducted by the local people and the catches are consumed by them.

In general, in these villages, social infrastructure has not been well developed. Almost all of the villages are not connected to the national electricity network and the interviewed people told us that they need a good access to the closest national road. Regarding the health condition, according to the assessment of the district health sector, in recent years, the health condition of the local residents has been improved greatly. Regarding the educational condition, in the Sap Sa commune, there are one primary and one secondary schools.

(NATURAL ENVIRONMENT)

The proposed dam / reservoir sites are located in the humid tropical climate region as of the ones of JN3.

The **terrestrial ecosystem** has been degraded by human activities. The original forest has been logged and converted to agricultural lands. Isolated forests remain along streams and on mountain ridges.

The **aquatic ecosystem** of both sites is not fully studied. Although there are a few papers regarding the aquatic ecosystem of Hoa Binh lake, they have not been used in this report.

Upper Reservoir：

The site is relatively flat and used as agricultural land and pasture.

There are small streams and the main stream, On, flows into Hoa Binh lake.

Lower Reservoir：

The valley is steep, and much of the slope has been converted to agricultural lands. Fragmented and degraded forests can be seen place to place.

The main river, Sap, flows into Hoa Binh lake. It has relatively large basin but the details of its aquatic ecosystem is not studied.

b) Issues

Important issues are described in the following sections. The other issues are summarized in Appendix 4-6-2.

(SOCIAL ENVIRONMENT)

Upper Reservoir：

Three houses of Suoi Let need to move out from the site. Assets, which belong to Suoi On, need to be compensated.

Lower Reservoir：

Among those villages, Keo Lan, Xa, Na Nay and Phieng Luong will be impacted directly by the project. Cang, Dung and Giang A & B will be affected indirectly by the project.

Table 4-2-10 Summary of Impacts to Each Village

Village name	Resettlement	Compulsory purchase of land
Dung	No significant impact	No significant impact
Giang A	No significant impact	No significant impact
Giang B	No significant impact	No significant impact
Keo Lan	**Significant impact**	**Significant impact**
Xa	**Significant impact**	**Significant impact**
Na Nay	No significant impact	**Significant impact**
Phieng Luong	**Significant impact**	**Significant impact**

Although precise number of resettlement households and area of compulsory purchased agricultural lands are not identified yet, relatively large scale of resettlement and purchase of lands will certainly occur. People of Keo Lan and Xa villages have to be resettled because their villages are submerged by the project. The village of Na Nay is at the higher altitude than the high water level and the village itself will not be directly impacted, but the rice field of the village will be severely affected. People of Phieng Luong may be severely impacted by the project because the village is very close to the dam site. Construction works and construction camp with one to two thousands people will give them great impacts.

Secondary impacts by loss of rice fields need to be carefully assessed. Rice fields of Keo Lan, Xao and Na Lay (partly) will be submerged and others will be prone to seasonal flooding. After the project, the local people who lose their rice fields are supposed to buy rice for their own consumption, which may lead more cultivation on steep slopes for cash crops and may lead to severe erosion of these slopes.

There is a plan to build an approach road from the closest national road, and some households of Cang, Dung and Giang A may need to be resettled and agricultural lands of these villages may be lost.

(NATURAL ENVIRONMENT)

The aquatic ecosystem of both sites is not fully studied. The assessments are based on the information obtained during the survey and should be reviewed and corrected, if necessary, at the next stage. Especially Sap river system has relatively large basin and the impacts by the project on the aquatic ecosystem may be significant.

Fragmented forests may receive negative impacts depending on their locations.

c) Evaluation and Next Necessary Actions

(SOCIAL ENVIRONMENT)

The communities of the villages will receive impacts and some of them are expected to be significant.

The necessary actions are the same as the ones which are described in the JN3 section. Since the impacts on the social environment are expected largest among the proposed four sites, these actions should be carefully planned and conducted. Special attentions should be paid to Phieng Luong and careful assessment should be carried out. Based on the survey, the most appropriate mitigation measures should be proposed.

The lessons learned from Yaly Hydropower Project should be applied especially at this site.

(NATURAL ENVIRONMENT)

Baseline data need to be collected in order to understand more of the current situation, to assess the impacts more accurately and to prepare for future monitoring programme.

Regarding the terrestrial ecosystem, the necessary actions are the same as the ones of JN3. Regarding the aquatic ecosystem, since the basin of Sap river is large, a detailed and comprehensive survey needs to be conducted in order to collect information and sufficiently assess the impacts. Other necessary measures are the same as the ones of JN3.

Secondary impacts at the construction / operation stages, they need to be carefully assessed to take mitigation measures.

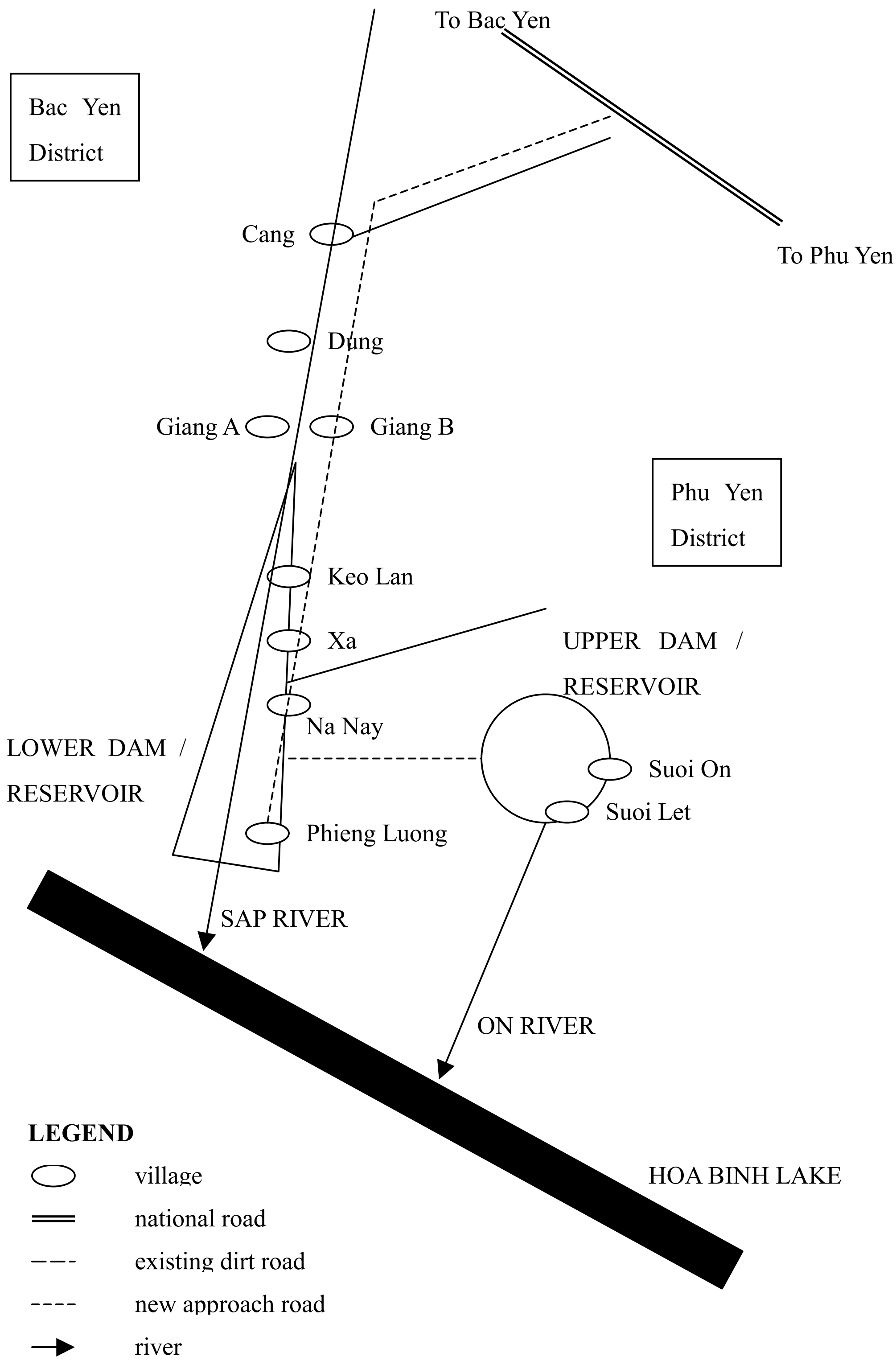

Figure 4-2-4 Map around JN5

c. P5 site

1) Topographical/Geological Conditions and Design

a) General Conditions

Location and Transportation Condition :

The Project area is located at 70km north east of Moc Chau city, which is the capital of Moc Chau district, and is beside the Hoa Binh lake that is planned for use as the lower reservoir. As an access road to the upper reservoir, a national/major road of 45km long can be used from Moc Chau to Ban Men. But a punishing road of 20km long lies from Ban Men to the upper reservoir. No road exists that leads to the outlet area beside the Hoa Binh Lake, which is planned to serve as the lower reservoir.

Waterway/Underground Power Station :

The geology from the Waterway to the Outlet is mainly of gentle beddings with slopes of 20-30 degrees of limestone (C2-O1?bk), and with outcrops of granite (γ PR3bn) near the waterway line. As for gently sloped limestone, small caves and eroded open joints along the Hoa Binh Lake are found. Granite on the right side of the lake was not found clearly due to strong weathering.

The conditions and the rock mass permeability around the Underground Power Station are of gently inclined bedding of 20-30 degrees of limestone with many eroded holes, which suggests relatively higher permeability than the other limestone area.

Outlet :

Geological condition of the outlet area is the same as waterway/underground mentioned above. The slope of the Hoa Binh river including higher area than the H.W.L of Hoa Binh reservoir, where the outlet is planned, is covered with secondary sediments. Rock crops are not to be found.

b) Issues

Location and Transportation Condition :

It is necessary to construct new approach roads to the entrance of the tunnel to the underground powerhouse, to the entrance of the tunnel to the outlet and to the switchyard.

Waterway/Underground Power Station :

The conditions and the rock mass permeability around the Underground Power Station are of gently inclined bedding with 20-30 degrees of limestone with many eroded holes, which indicates relatively higher permeability than the other limestone area. For the future underground excavations including tunnels, wide-scale measures for the anti-seepage from the Hoa Binh Lake are required.

Outlet:

Secondary sediments are widely distributed around the planned outlet area, and no outcrops are found. Therefore it is technically impossible to design the outlet in this area.

c) Evaluation and Next Necessary Actions

Location and Transportation Condition：

Total length of road, which needs new construction and improvement, is rather long. But there seems to be no technical difficulties for new construction/ improvement, because slant along the road is gentle.

Waterway/Underground Power Station：

There is a high possibility that excavation of underground cavern and tunnels causes seepage from the Hoa Binh Lake, which needs huge cost for ant-seepage countermeasure. Accordingly this site is not suitable for construction of underground cavern and tunnels. A drastic change of the project plan is required.

Outlet:

Large scaled cofferdam and huge underwater blasting works are necessary for construction of the outlet. Change of the location is required.

2) Social and Natural Environments

a) Current Conditions (refer to Figure 4-2-5)

(SOCIAL ENVIRONMENT)

Upper Reservoir：

There is Song Hung village (Lien Hao commune) with 15 households and 60 persons at the site. It consists of Viet, Muong and Thai ethnic groups, and they are engaged in agricultural practice.

The village moved to the current site by Hoa Binh Dam Project. At that time all villagers of the previous village were not covered by the resettlement programme, and some of them moved to the current site and the rest of the villagers (Suoi Sau village) still live in the same place (above the high water level of Hoa Binh lake).

Livestock husbandry is important for the local people.

In Song Hung, social infrastructure has not been well developed. It is not connected to the national electricity network. Regarding the health condition, the situation is the same as other villages. According to the assessment of the district health sector, in recent years, the health of the local residents has been improved greatly. Regarding the educational condition, in Song Hung, there is one primary school up to 2nd grade.

Outlet:

Hoa Binh lake is used as a lower reservoir. At the outlet site, there is Suoi Sau village with several houses. The Hoa Binh Dam resettlement programme did not cover them.

There are Ben Khua, Ca Vang villages along a planned approach road to the outlet. Information on them was not collected because of time constraints.

(NATURAL ENVIRONMENT)

The proposed dam / reservoir sites are located in the humid tropical climate region as of the ones of JN3 and JN5.

The **terrestrial ecosystem** has been degraded by human activities. The original forest has been logged and converted to agricultural lands. Some forests remain along rivers / streams and on mountain ridges.

The **aquatic ecosystem** of both sites is not fully studied.

Upper Reservoir :

The site is relatively flat and covered with agricultural land and bushes. There are a couple of small streams from the site.

Outlet:

The valley is degraded mainly by agricultural activities.

b) Issues

Important issues are described in the following sections. The other issues are summarized in Appendix 4-6-3.

(SOCIAL ENVIRONMENT)

Upper Reservoir :

Song Hung is expected to receive significant impacts by the project. Although the area of the entire village is not submerged, all of the villagers may want or need to move out from the site. An attention must be paid that they have moved into the current place by Hoa Bonh project.

Outlet:

At the site of the outlet, Suoi Sau will receive significant impacts. They need to move out from the site.

Precise scale of the impacts cannot be assessed but those who live along the planned approach road will receive impacts.

(NATURAL ENVIRONMENT)

Upper Reservoir：

Since the area has been degraded, the impacts are expected to be limited. Fragmented forests may receive negative impacts depending on their locations.

Outlet:

Regarding the terrestrial ecosystem, the assessment is the same as the one of the upper dam / reservoir site.

The aquatic ecosystem is not fully studied, which mean that precise impacts cannot be assessed. However, the impacts are expected to be limited because Hoa Binh Project has already disturbed the ecosystem and the area of this project is relatively small.

c) Evaluation and Next Necessary Actions

(SOCIAL ENVIRONMENT)

The communities of Song Hung and Suoi Sau will receive significant impacts and special attentions should be paid to them because of the history of their resettlement by the Hoa Binh dam project.

The necessary actions are the same as the ones which are described in the JN3 section. The lessons learned from Yaly Hydropower Project should also be applied at this site.

(NATURAL ENVIRONMENT)

Baseline data need to be collected in order to understand more of the current situation, to assess the impacts more accurately and to prepare for future monitoring programme.

Regarding the terrestrial ecosystem, the necessary actions are the same as the ones of JN3. Regarding the aquatic ecosystem, baseline data should be collected and adequate mitigation measures need to be proposed.

Secondary impacts at the construction / operation stages, they need to be carefully assessed to take mitigation measures.

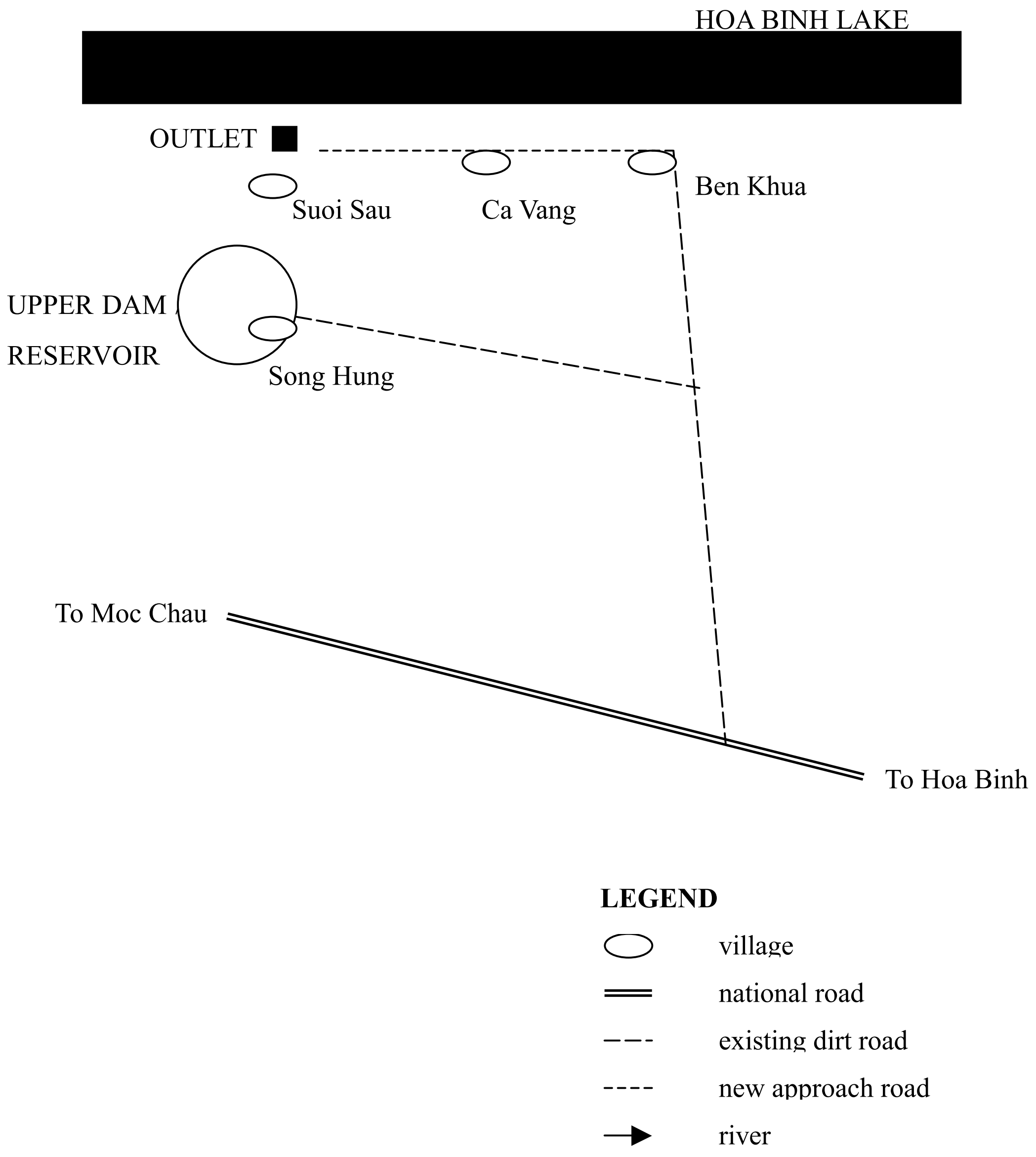

Figure 4-2-5 Map around P5

d. JS6 site

1) Topographical/Geological Conditions and Design

a) General Conditions

Location and Transportation Condition：

The project area is located 15km north of Nihn Son city of Ninh Thuan district. There is a paved road to 3km upstream of the lower dam site, and it changes into a narrow dirt road to Hon Lac village. This road is used for a connecting line to the northern villages.

There is a footpath only to the upper dam. Cai river has to be crossed for visiting the upper dam from the lower dam area, but there is no existing bridge nearby.

Upper Reservoir：

The upper reservoir area is located at the relatively flat top of the mountain. Based on these topographic features, three dams, of which embankment materials will be obtained by the excavation in the reservoir area, are designed to store necessary storage.

The geology around the Upper Reservoir is composed of massive and hard granite as γ δ J3dq2 and sedimentary rock J2 ln) with slight weathering on the surface and rocks of quite low permeability.

The designed dam site is on the boundary of sedimentary rocks and granite in the published map, but no features were found in this survey. The conditions of granite are hard and massive with 5-10m weathering on the surface.

Lower Reservoir：

Granite as γ δ J3dq2 and andesite as K2dd are alternatively outcropped in the right side of the river, but no noticeable weak zone or open joints were found around the boundary. The granite near the boundary to the andesite shows changes into fine grained granodiorite by the intrusion of andesite. The NW-SE system of the structural line along the river is reported in the published geological map. The permeability in this area is probably quite low.

Originally the Dam axis site had been planned at a point of very narrow width of the river, but it was considered to be unsuitable as a dam site, due to very thin ridge on the left side and deep valley on the downstream side.

Waterway/Underground Power Station：

The geological condition on the surface of the Waterway and Surge Tank area is hard and massive granite (γ δ J3dq2), with the slope of 30-40degrees.

In case of the original design, tailrace has not enough overburden when crossing the valley on the left slope of downstream of the dam axis. Except for this issue, there are no features, which cause big problems, on the surface and underground around the area.

Others:

There is another dam project at 4km downstream in the same river. This is Song Cai irrigation dam. As this planned irrigation dam has a H.W.L. of 175.44m and L.W.L. of 161m, the upstream end of this Son Cai irrigation dam reaches the lower dam (with H.W.L.of 210m, L.W.L. of 206m and elevation of riverbed of 170m).

b) Issues

Location and Transportation Condition：

The existing road to the lower dam area is available for use for the approach road. But a substitute road is required for the section to be submerged. A new road and a bridge to cross the Cai river should be designed, as it is easier to across from the lower dam area to the approach route to the upper dam.

Upper Reservoir：

The elevation of the dam crest is designed at the highest topographical altitude. In case topographic condition is different from the maps, big problems such as shortage of the reservoir capacity, and increase of dam volume may happen. Therefore, detailed topographic survey is required in the next stage study (F/S).

Lower Reservoir：

The NW-SE system of the structural line along the river is reported in the published geological map, no big fractured zone or fault zone was found in this survey. The detailed survey for the fault will be needed. Therefore, the dam axis is shifted to about 500m downstream to locate at a large and wide ridge. Accordingly review of the dam design is necessary.

Waterway/Underground Power Station：

Accompanied by the shifting of the lower dam, the tailrace route should be reviewed considering the effect of the above-mentioned valley. As regards the underground powerhouse, a review is required to locate it deep in the underground of the wide ridge beside the lower dam.

Others:

Further detailed surveys are required on the weathering grade of the granite around the Upper Reservoir and the NW-SE system of structural line on the published map.

c) Evaluation and next necessary actions

Location and Transportation Condition：

The length of the newly constructed approach/maintenance road for this project is estimated at about 30km. Construction of a new approach road to the project area is not necessary, but replacement of the existing road, of which length is about 10km, and a new bridge are required.

Upper Reservoir：

In the current design, the dam volume and the excavation volume in the reservoir are balanced. Accordingly, increasing of reservoir capacity may not be economical because additional excavation needs higher costs.

Hard and massive granite is found in the reservoir, and permeability of rock is estimated to be low. The facing all over the reservoir may not be needed. But further investigations are required to clarify the necessity of facing.

Lower Reservoir：

Although dam construction cost may increase because width of the river is wider than that of original dam axis, the newly selected dam axis is acceptable from a viewpoint of assuring safety of the dam.

The rock condition around the dam site is generally of hard and massive granite, and slightly advanced weathering is seen around the right side of the dam axis (5-15m deep). No features of faults along the river have been found.

Waterway/Underground Power Station：

Along with the change of the dam location to downstream, the waterway layout is adjusted, and consequently, the length of the waterway needs to increase slightly.

Support cost for underground cavern is estimated to be smaller than other project sites, because the geology around the underground powerhouse is assumed to be composed of massive and hard granite, and the overburden of the powerhouse remains about 250m.

Others:

Prior coordination of the project plans is required as the Song Cai irrigation dam is planned with H.W.L.of 175.44 m and L.W.L.of 161 m, which has influence to the PSPP project.

The Cai is a large river with a catchment area of 720m^2. Therefore, conventional hydropower generation can be installed by using head of the lower dam. The head for the hydropower generation may decrease by about 15% when the irrigation dam is completed. Detailed studies are required on this point.

Sedimentation value for the lower dam design is estimated based on that of the Son Cai irrigation dam.

Since the turbidity of the Cai river looked very high at the site reconnaissance, further study for evaluation of the sedimentation value is necessary.

2) Social and Natural Environments

a) Current Conditions (refer to Figure 4-2-6)

(SOCIAL ENVIRONMENT)

Upper Reservoir :

The site belongs to Phuoc Hoa commune. There is no village or house within the site. The site is covered with secondary forest.

Lower Reservoir :

The site is located in the area of Ta Lot village (Phuoc Hoa commune) with 63 households and 330 persons, and the village consists of only RagLai ethnic group. The dam site is located in the northern part of the village and there are several temporary houses for agriculture in the reservoir site.

The dirt road along Cai river leads to Phuoc Binh commune with a couple of villages, and the road is the only access road for them to Bac Ai town (center of Bac Ai district).

All villagers of Ta Lot are engaged in agricultural practice. In Ta Lot every household has rice field and place for cashew-nut cultivation. The village can produce more than 100 tons of rice/year and 40 tons of cashew-nut/year. There is an isolated agricultural land in the reservoir site and there are several temporary houses. Livestock husbandry is also important for the local people here.

Information on fishery at Cai river was not collected during this survey.

In Ta Lot, social infrastructure has not been well developed. The village has not been connected to National Electricity Network, even the electric wire has reached the area. At present, under the rural electrification programme, efforts are being made to supply power to all commune centres only.

Regarding the health condition, Bac Ai district has one district hospital at the district centre, and clinic station at every commune. The clinic of Phuoc Hoa commune has one medical doctor and two nurses. According to the assessment of the district health sector, in recent years, the health of the local residents has been improved greatly. The interviewed person during the survey told that there are still some cases of malaria although the cases of the disease have been decreasing. Regarding the education, in the Ta Lot village there is one primary school.

(NATURAL ENVIRONMENT)

The proposed dam / reservoir sites comprises a range of evergreen forest types[1].

There is a nature reserve, Phuoc Binh Nature Reserve, north of the proposed dam / reservoir sites, it was established in 2002 with 7,400 ha and was expanded to 19,000 ha. BirdLife International[2] identifies Phuoc Binh area including the nature reserve as one of the "Important Bird Areas in Vietnam" with six globally important bird species[3]. They are Collared Laughingthrush *Garrulax yersini*, Crested Argus *Rheinardia ocellata*, Pale-capped Pigeon *Columba punicea*, Yellow-billed Nuthatch *Sitta solangiae*, Short-tailed Scimitar Babbler *Jabouilleia danjoui* and Vietnamese Greenfinch *Carduelis monguilloti*.

The **terrestrial ecosystem** of the sites has been well conserved. The surrounding area of the dam / reservoir sites is covered with secondary forest which is extended to the above-mentioned nature reserve. Tan Tien Enterprise had extracted timbers from the forest, however the enterprise has been closed. The local people have been conserving the forest and they have not converted the forest to agricultural land, which is different from the other cases in the north. They collect non-timber forest products (NTFPs) and sell them.

The **aquatic ecosystem** of Cai river is not studied at all. The downstream area of the river is also not studied.

The lower dam is located at a transition zone between mountainous area and flat one, which may indicate the terrestrial **and** aquatic ecosystems of the area is complex and fragile.

Upper Reservoir：

The site is flat and is located at the top of the mountain covered with good secondary forest.

Lower Reservoir：

The area along the river close to the village has been converted to agricultural land. The valley is covered with good secondary forest.

Cai river does not have any dam in its entire length to the sea, which indicates the importance of conservation of its aquatic ecosystem.

There is a plan to build an irrigation dam just downstream of the proposed dam site.

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[1] Directory of Important Bird Areas in Vietnam – KEY SITES FOR CONSERVATION (Birdlife International *in Indochina* & the Institute of Ecology and Biological Resources, Hanoi, 2003).

[2] BirdLife International is an international NGO for bird conservation. Its headquarters is located in Cambridge, U.K. and it has an office in Hanoi.

[3] Directory of Important Bird Areas in Vietnam – KEY SITES FOR CONSERVATION (Birdlife International *in Indochina* & the Institute of Ecology and Biological Resources, Hanoi, 2003).

b) Issues

Important issues are described in the following sections. The other issues are summarized in Appendix 4–6-4.

(SOCIAL ENVIRONMENT)

Upper Reservoir：

At the moment, impacts are expected not to be significant.

Lower Reservoir：

Ta Lot village is expected to receive significant impacts by the project. Numbers of households of the village should be resettled because they are at the dam site. Others will receive the impacts. Because of their proximity, construction works and construction camp will give them great impacts. Their agricultural land in the reservoir site will be submerged. There is only one dirt road along the river to Phuoc Binh commune to connect them to the outside world. Careful attention should be paid to this aspect.

(NATURAL ENVIRONMENT)

Upper Reservoir：

Since the site has good forest, there are direct negative impacts.

At the construction / operation stages poaching, illegal logging and introduction of alien species can be expected. Construction camp for workers may give negative impacts to the environment such as poaching and introduction of alien species. The approach road may cause secondary impacts such as poaching, illegal logging and uncontrolled NTFPs collection.

Lower Reservoir：

The aquatic ecosystem of Cai river is not studied. The assessments are based on the information obtained during the survey and should be reviewed and corrected, if necessary, at the next stage. Since the downstream area of the river is not studied, it is not sure but there may be impacts on downstream aquatic ecosystems by disruption of sedimentation balance. For example, the ecosystem of the river mouth to the sea such as estuary may receive impacts.

Forests around the valley should be conserved as much as possible.

c) Evaluation and Next Necessary Actions

(SOCIAL ENVIRONMENT)

The community of Ta Lot will receive significant impacts, and the villages of Phuoc Binh commune are also expected to receive negative impacts.

The necessary actions are the same as the ones which are described in the JN3 section. The lessons learned from Yaly Hydropower Project should also be applied at this site.

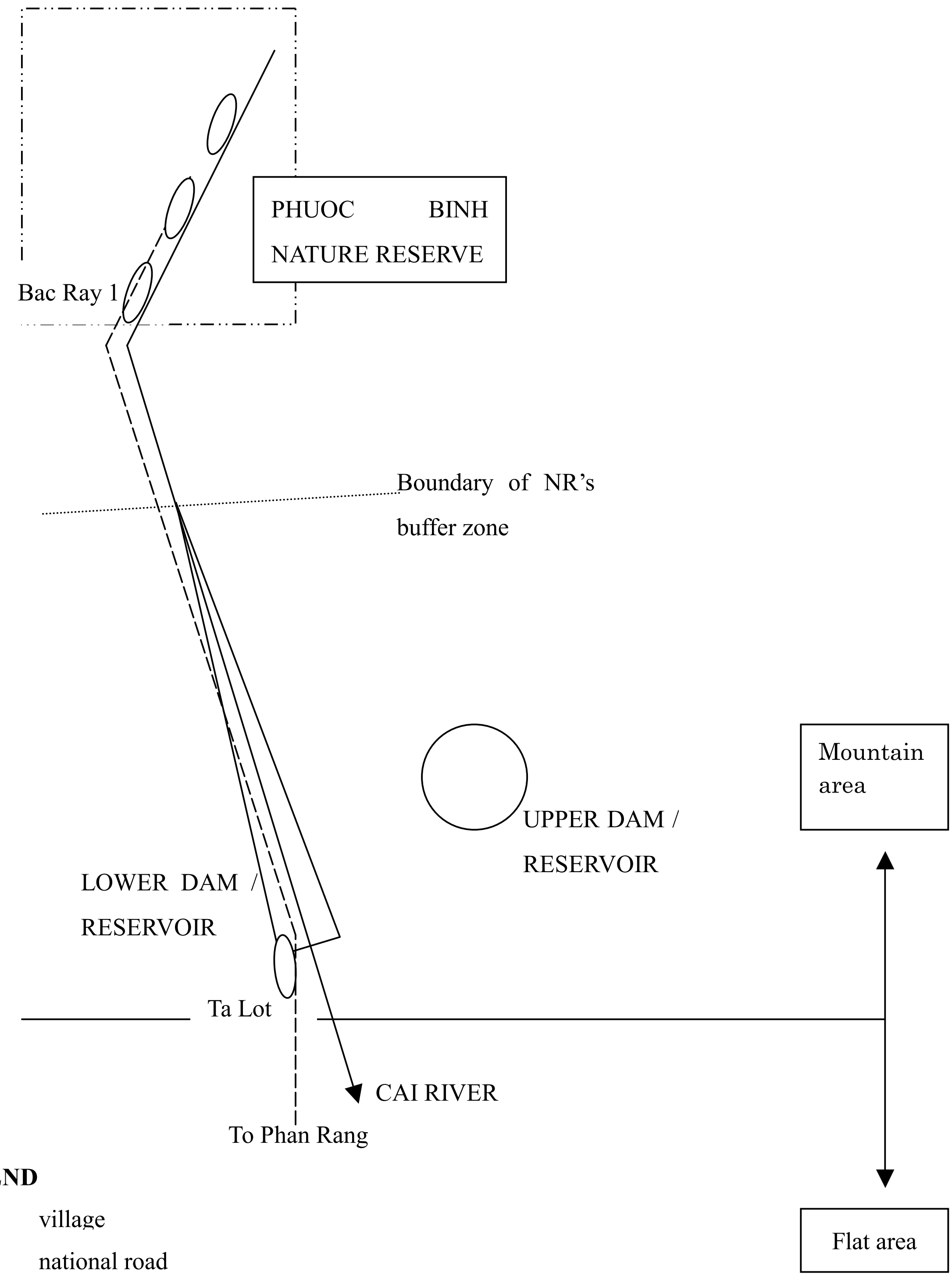
(NATURAL ENVIRONMENT)

The impacts of the natural environment are expected to be the most significant among the proposed four sites.

Regarding the terrestrial environment, first of all a comprehensive survey to collect baseline data on the terrestrial ecosystem should be carried out. Secondly, based on the results of the above-mentioned survey, more precise survey on selected target species need to be planned and carried out. After these surveys, mitigation measures should be proposed. Cancellation of the project at this site should be included in proposed mitigation measures.

Regarding the aquatic ecosystem, a comprehensive survey on the entire length of the river needs to be conducted in order to collect information on it as much as possible. Secondly, based on the results of the above-mentioned survey, more precise survey on selected target species need to be planned and carried out, and then mitigation measures including cancellation of the project should be proposed.

Secondary impacts at the construction / operation stages, they need to be carefully assessed to take adequate mitigation measures. Since poaching, illegal logging and introduction of alien species will give significant impacts to the local ecosystem, these secondary impacts especially need to be carefully assessed.



LEGEND

- village
- national road
- existing dirt road
- new approach road
- river

Figure 4-2-6 Map around JS6