(4) Consideration for Thermal Power Generation

(a) Northern region

Several coal-fired power plants of the 300 MW class are constructed in Quang Ninh Province.

(b) Southern region

At first, the combined cycle power plants are constructed to meet a possible supply volume of associated gas and shortage is covered by natural gas-fired combined cycle plants and coal-fired plants.

Development priority of thermal power generation plants is shown below.

1)	Phu My C/C	300MW x 5 units (including 2 units in 1997 and 1998)
2)	Nhon Trach C/C	300MW x 5 units (case of gas large production)
3)	O'Mon Coal	300MW x 3 units
4)	Phan Thiet Coal	300MKW x N units

8.2.3 500kV System Transmission Line

Transmission capacity of 500 kV system transmission line extending from the North to the South commissioned in 1994 used the following values on the basis of its design.

Before completion of the Yaly hydropower project

North to Center: 700MW   Center to South: 500MW

After completion of the Yaly hydropower project

North to Center: 700MW   Center to South: 700MW

To transmit power from hydropower plants in the Central region to the Southern region, one new 500kV circuit will be installed by a separate route from the Plei Ku substation to the Phu Lam substation in the first half of the 2000s.

In this case, the total transmission capacity from the Central to the Southern region will be increased to 1,500MW maximum.

Interchange of electricity between the North and the South is the reliability maintaining exchange and economic interchange necessary to secure the required reliability (LOLP<=1.0%).

The existing 500 kV interconnected line between the North and the South is considered as a base case and reinforced case with the second route between the Center and the South is taken into account in addition.

8.2.4 Fuel Resources for Power Generation

The primary fuel produced in each region is used basically. Anthracite is used in the Northern region and natural gas is used in the Southern region.

(1) Coal

Abundant coal resources exist in and around Quang Ninh Province in the Northern region. According to the Vietnamese coal master plan, after 2000 the annual coal output is expected to be 8,500,000 tons. No quantitative limitation of coal resources is set in making this power resources development project. When the yield of natural gas decreases in the Southern region or when its cost increases, it is also taken into account that coal from the Northern region will be transported to the Southern region for power generation.

(2) Natural gas

The natural gas extracted from the offshore oil field in the Southern region is a promising power generation fuel. At present, associated gas of at least 25 billion m^3 is confirmed in the Cuu Rong Basin (Bach Ho and Rong oil fields).

However, concerning the amount of proven natural gas deposits, no accurate data is available except for the Dai Hung oil field (3.2 billion m^3 of associated gas). Two scenarios are prepared for planning this power development project; the case (Gas small) which mainly uses a total of 28.2 billion m^3 of proven associated gas and the case (Gas large) which uses non-associated gas (57 billion m^3) in the Lan Tay region where development is expected in the future.

(3) Fuel prices and forecast

Regarding coal prices, the forecast values are referred from the coal master plan and natural gas prices are estimated as shown below, taking into account natural gas pipeline maintenance expenses, etc.

			1995	2000	2005	2010
Coal Production		(Mil./yr)	5.0	8.5	10.5	10.5
Coal Price	North	($/ton)	25	28	32	35
Coal Price	South	($/ton)	-	-	42*	45*
Gas Price	Associated Gas	($/MMBTU)	2.0	2.2	2.5	3.0
	Non Associated Gas	($/MMBTU)	-	2.2**	2.5**	3.0**

*) US$10/ton is estimated as transportation expenses from north to south.

**) The same price as associated gas is used for simulation calculation.

8.2.5 Other Conditions

(1) Reliability goal

The expected value of power supply shortage is within 1% (3.6 days/year) as the goal in each of the Northern, Central and Southern power systems. Until 1998, the existing power supply capability is expected to run short and a larger value may be allowed.

(2) Existing thermal power plant retirement plan

Until the first unit in the Son La hydro project commissions in 2007, the existing thermal power plants (Uong Bi, Nin Binh power plants) in the Northern region are to be maintained. The Pha Lai power plant will also be abolished in 2013. (Service life is set at 30 years.)

(3) Discount rate

The discount rate of construction expenses and variable expenses is 10% for both foreign and domestic currencies. The base year is 1993.

Table 8.2-1 Demand Forecast by JICA at Generation End (Base Case)

Region		1995	2000	2005	2010
Whole Country	Energy (GWh)	13,698	23,289	40,915	66,600
	Power (MW)	2,674	4,526	7,879	12,550
North	Energy (GWh)	6,193	9,153	16,025	26,838
	Power (MW)	1,243	1,771	3,101	4,941
Center	Energy (GWh)	1,309	2,622	4,295	6,685
	Power (MW)	293	565	860	1,316
South	Energy (GWh)	6,195	11,514	20,595	33,077
	Power (MW)	1,141	2,190	3,918	6,293

(High Case)

Region	Demand	1995	2000	2005	2010
Whole Country	Energy (GWh)	13,960	24,722	45,460	77,535
	Power (MW)	2,725	4,806	8,755	14,615
North	Energy (GWh)	6,265	9,644	17,585	30,834
	Power (MW)	1,255	1,866	3,402	5,677
Center	Energy (GWh)	1,351	2,847	4,902	7,986
	Power (MW)	302	613	982	1,572
South	Energy (GWh)	6,343	12,230	22,972	38,715
	Power (MW)	1,168	2,327	4,371	7,366

Table 8.2-2 Projects to be comissioned before 2000

Region	Name of Projects (type)	Unit x Capacity (MW)	Const. Cost 10^6\$ (1993)	Commissioning Year
North	Pha Lai II (Coal)	2x300	780	#1-10/99, #2-6/2000
Center	Song Hinh (H)	70	110	1997
	Yaly #1, 2 (H)	360	360	1999
	#3, 4 (H)	360	150	2000
South	Ba Ria (ST)	58	65	'97 convert to C/C
	Phy My (Gas)	3x200	680	#1-8/'98, #2-1/'99, #3-4/'99
	Phu My (C/C)	2x300	480	GT'97 ST'98
	Ham Thuan/Da Mi (H)	472	546	2000

Table 8.2-3 Projects to be commissioned after 2001

Region	Name of Projects	Unit x Capacity (MW)	Const. Cost (10^6\$)	Available Commissioning Year
North	Ban Mai (Hydro)	350	380	2002~
	Dai Thi (Hydro)	250	301	2002~
	Cua Dat (Hydro)	105	194	2003~
	Son La (Large) (Hydro)	12x300	3,485	2007~
	Son La (Small)(Hydro)	10x240	2,050	2007~
	Huoi Quang (Hydro)	4x200	735	2010~
	Quang Ninh (Coal)	Nx300	Nx375	2001~
Center	Plei Krong (Hydro)	120	250	2001~
	Thuong Kontum (Hydro)	260	276	2004~
	Se San 3 (Hydro)	220	188	2002~
	Se San 4 (Hydro)	366	514	2006~
	Buon Cuop (Hydro)	81	115	2002~
	An Khe (Hydro)	116	172	2004~
	Son Con 2 (Hydro)	60	100	2005~
	Rao Quan (Hydro)	80	139	2007~
South	Dai Ninh (Hydro)	300	408	2003~
	Dong Nai 4 (Hydro)	200	250	2006~
	Phu My C/C(Gas)	5x300	5x240	2001~
	O'Mon (Coal)	3x300	3x375	2001~
	Phan Thiet (Coal)	Nx300	Nx375	2001~
	Nhon Trac C/C (Gas)	Nx300	Nx240	2001~

Table 8.2-4 Alternative Plan of Son La and Huoi Quang Hydro Projects

	Installed Capacity	Number of Unit	Const. Cost	Const. Period	Annual Energy
Son La (L)	3,600 MW	12	US\$ 3,485 million	15 yrs	17,396 GWh*
Son La (S)	2,400 MW	10	US\$ 2,050 million	12 yrs	10,804 GWh*
+					
Huoi Quang	800 MW	4	US\$ 735 million	7 rs	2,984 GWh*

*) The values include beneficial energy generated at downstream power plant.

Table 8.2-5 Construction Schedule of Son La & Houi Quang Projects

Scale	Calendar Year
Son La (L)	98 '99 00 01 02 03 04 05 06 07 08 09 10 11 12 2013 ▼ (98) ◇ (05) ▽ (07) ▽ (08) ▽ (09) ▽ (10) ▽ (11) ▽ (12) ○ (2013) #1, 2 3, 4 5, 6 7, 8 9, 10 11, 12
Son La (S)	98 '99 00 01 02 03 04 05 06 07 08 09 10 11 12 2013 ▼ ('99) ◇ (05) ▽ (07) ▽ (08) ▽ (09) ▽ (10) ▽○ (11) #1,2 3,4 5,6 7,8 9,10
Huoi Quang	In Case of Son La (S) 06 2010 12 2013 ▼ (06) ◇ (2010) ▽ (12) ▽○ (2013) #1,2 3,4

Regend
- ▼ : Year of Starting construction works
- ◇ : Year of Dam completion
- ▽ : Year of Unit commissioning
- ○ : Year of project completion

8.3 Simulation Calculation

8.3.1 Simulation Method

(1) Study policy and study method

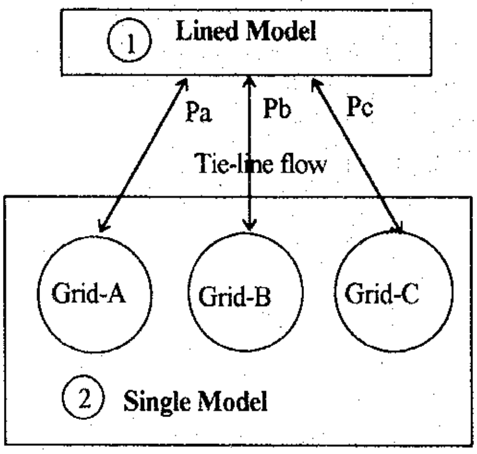
The ESPRIT (EPDC System Planning package Reflecting Interconnections and Transactions) method is used. This is a programming method extending the so-called least-cost planning method by obtaining the scenario to minimize the total expenses during the study period (the amount which discounts a total of capital cost, fuel cost and running and maintenance cost in 1993) to two or more linked systems.

(2) Logic of ESPRIT

ESPRIT consists of (1) a linked model to determine interchange electricity of the linked line and (2) a single model to plan the electric developing scenario when each system is operated independently. It is a calculation method used to obtain the most economical electric development sequence and combination in the linked system by the repeated calculation of (1) and (2). (Refer to the appendix for details.)

(1) Linked model

(2) Single model



8.3.2 Study Case

Because the Son La hydro project development scale (Large scale and small scale plans) and gas output in the Southern region become dominant factors in this power resources development project, the following four cases are considered as the basic development scenario. Furthermore, two cases including gas large and gas small are also studied concerning the case where the Son La hydro project is not developed.

(1) Basic Case

Case ① : SL/GL (Son La 3600MW, Gas Large)
Case ② : SL/GS (Son La 3600MW, Gas Small)

Case ③ : SS/GL (Son La 2400MW + Huoi Quang, Gas Large)
Case ④ : SS/GS (Son La 2400MW + Huoi Quang, Gas Small)
Case 01 : NS/GL (No Son La, Gas Large)
Case 02 : NS/GS (No Son La, Gas Small)

(2) **Sensitivity Analysis**

One of the highly related parameters is changed and its influence is studied concerning the representative case.

(a) Demand increase (High case of the value estimated by the Study Team)

Case ⑤ : SL/GL
Case ⑥ : SL/GS
Case ⑦ : SS/GL
Case ⑧ : SS/GS

(b) Delay in Son La development

Influence on the total cost, supply reliability and fuel for power generation when commissioning year of the first generating unit is delayed for two years from 2007 to 2009 is studied. (Power demand : Base case)
Case ⑨ : SL/GS
Case ⑩ : SS/GS

(c) Influence on total cost when power supply reliability goal value is eased

Case ⑪ : SS/GS
Simulation calculation period is 20 years from the base year 1993 to 2013 when the Huoi Quang hydropower plant developed jointly with the Son La small scale is completed. Variable costs of thermal and hydropower plants are calculated upto year 2060, when the capital cost of San La project is depreciated.

8.4 Result of Simulation Study

8.4.1 Base Case

(1) **Economical comparison**

According to the simulation calculation, the Son La small-scale development is less costly as compared with a large-scale development without regard to natural gas production in the Southern region as shown in Table 8.4-1.

"Gas large" is more economical than "gas small".

When the Son La project is not developed, it is comparatively high without regard to gas large/small which supports the propriety of the Son La hydro project promotion.

Total construction cost common to each case among the total cost in the project points to be commissioned before 2000 is US$3.17 billion (no discount) and US$2.38 billion. (discounted) The reason for Son La (L) being more expensive than Son La (S) is shown below.

When the commissioning year is 2007 for both cases, the difference in capital cost is dominant.

Fuel cost reduction effects until 2060, between Son La (L) and Son La (S) is US$268 million and this value is smaller than that of capital cost. (Refer to Table 8.4-2.)

(2) Agreement between the development scale of Son La and size of the power system

The design criteria between Son La - large and Son La - small is different. Son La (L) is designed for base load operation (12 hrs), while Son La (S) is for middle to peak operation (8 hrs).

According to the PDP simulation it is cleared, Son La (S) tends to take base load portion and Son La (L) takes middle load portion against the design criteria.

This means Son La (S) keeps good balance from a view point of economy as well as power system operation in hydro-dependent-Northern power system under the condition of a single interconnected link between North and South.

If Son La locates in the South or whole Vietnamese network is interconnected firmly (like a WASP model), then, the benefit of Son La (L) shall be increased.

The optimum electric resources development schedule for the whole country of the base case obtained by ESPRIT is shown in Table 8.4-3, and that by region is shown in the appendix. The table shows that the development of electric resources in this order is the most economical.

The investment plan of case ④ SS/GS is shown in Table 8.4-4.

The investment peak appears early in the 2000s (2001 to 2005) when construction of the Son La hydro project starts.

(3) Recommended commissioning year

The commissioning year of each individual power source changes slightly by the study case as shown in Table 8.4-3.

The following reasons may be considered.

(a) Unlike the results of ranking study of hydro projects simply compared by B/C with an alternative thermal power project, the commissioning year of each planned power plant changes slightly by each PDP scenario because ESPRIT accumulates power plants in consideration of the actual system operation according to the load curve (scheduled maintenance of thermal power plant, river run-off fluctuation by season, etc.)

(b) Economical electricity interchange between power systems is considered.

(c) Simulation calculation requires the combination to minimize the total cost for 20 years and as a result, the electric resources development order is calculated.

Profitable electric source in the ranking of hydro project sites quickens the commissioning year in all cases. From the simulation calculation, macro scopic priority of electric sources are grouped by region and every three to four years in Table 8.4-5.

1) First half of the 2000s

As seen from the table, the development choices increase after the second half of the 2000s by output of natural gas in the Southern region and by the development scale of Son La, but electricity resources necessary for the first half of the 2000s are almost confirmed. Judging from the construction schedule, the Sesan hydropower in the Central region, particularly Plei Krong and Sesan 3 which provide good B/C, expect immediate development and early Feasibility Study must be undertaken. In the Northern region, development of Ban Mai (H) is desired. The Southern region requires the development of two combined cycle thermal power plants.

2) Mid-2000s

Dai Thi hydropower development and development of the Quang Ninh coal-fired power plant upto the 3rd unit are expected in the Northern region in the mid-2000s. A 4 million ton/year demand, including the existing Pha Lai power plant, consumption must be incorporated in the coal production plan.

It is economical that hydropower projects in the Central region with good site characteristics will be completely developed by 2007 and operated by pooling with thermal power plants in the South. Therefore, reinforcement of the second 500kV transmission line between Pleiku in the Central region and Phu Lam in the Southern region is necessary early in the 2000s.

The Southern region will require the development of one or two 300MW thermal power plants every year in the mid-2000s. However, gas/coal premixed combustion, boiler conversion and other options must be studied so that gas C/C thermal power may be shifted to coal-fired thermal power as circumstances require, taking into account gas production forecasts. As for hydropower, the commissioning of Dai Ninh is desired.

3) Second half of the 2000s

The Northern region's power demand in the second half of the 2000s increases on a scale of about 500MW annually and power generated by the Son La hydro project is basically consumed in the Northern system. The difference of the Son La development scale appears in the number of coal-fired thermal power plants in the North. For example, in the case of Son La (L), Quan Ninh thermal power project requires the development of only 4 units by 2010. In the case of Son La (S), however, 6 to 7 units are required. The Southern region requires the development of two coal-fired thermal power plants of 300MW output on average each year. In the second half of the 2000s, the Southern region requires development of two (GS) to seven (GL) coal-fired thermal power plants.

(4) Outlook for electricity interchange

Electricity interchange between the Northern, Central and Southern regions is shown in Figure 8.4-1 through 8.4-6. Energy transfer to the Central and Southern regions from the Northern region flows continuously until 2010. With this, after 2000, hydropower in the Central region flows to the Southern region (a part also to the Northern region). This suggests that integrated operation of the Southern region, mainly composed of thermal power, and the Central region, mainly composed of hydropower, is desirable in the future and supports the necessity for linkage strengthening between these two regions.

Basically, the inexpensive hydropower in the Northern and Central regions flows to the Southern region which is mainly composed of thermal power. The load factor of 500kV linkage line is 30% to 50% per circuit and is effectively utilized (Refer to Table 8.4-6).

When one 500 kV transmission line between the Northern and Central regions is shut down, no great influence may occur in the reliability aspect because the Central-Southern system capacity will be about 5,000MW by 2005, which is about eight times as much as the linkage current. (Immediately after route out, the frequency in the Southern region temporarily drops by about 1.0 Hz and no power failure occurs.)

8.4.2 Sensitivity Analysis

(1) Influence of power demand fluctuation

The four basic cases including SL(L)/(S) and GS(L)/(S) are simulated against the high case of the power demand value estimated by the Study Team (Refer to Table 8.4-7).

When power demand increases in the high case, the total cost increases by about US$500 million for the case Gas (L) and US$488 million for the case Gas (S).

The Son La small scale development case is still economical even when demand increases, but the difference between Son La (L) and Son La (S) is increasing.

(2) Influence of power of supply reliability standard

The development project is planned by setting the reliability goal at 1.0% less per year after 1998, but the case where this limitation is eased in the basic development case is studied. The result is shown in Table 8.4-8.

US$480 million of the total cost can be saved by lowering the expected supply shortage value (LOLP) to 3% from 1%. In view of the LOLP value coming close to 10% in 1994 and conciliation with the reliability of power transmission and distribution facilities, it may be realistic to move up to the target value gradually each year rather than to abruptly lower the target value to 1%.
Review of the LOLP can save two coal-fired thermal plants in the Southern region by 2010 and the commissioning year of the hydro and thermal power plants may be delayed for one to two years.

Power source postponement effect by review of LOLP (1% to 3%) (Case-SS/GS, Demand:base)

(North)	Ban Mai:	2004 to 2008			
	Quang Ninh #1:	2004 to 2005			
(Center)	Buon Cuop:	2002 to 2003			
	An Khe:	2004 to 2005			
	Rao Quang:	2007 to 2009			
	T. Kontum:	2004 to 2005			
(South)	Gas C/C #1, 2:	2003 to 2004	Coal:	2005 through 2010	Total 10 units
	Don Nai 4:	2006 to 2009		To 2008 through 2010	Total 8 units

(3) Influence where Son La development is delayed

Influence where the Son La development is delayed for two years (First plant to be commissioned in 2009) is studied with the Son La development scale as the parameter. The result is shown in Table 8.4-9.

Where the Son La development is delayed, the total cost increases. This supports the propriety of commissioning in 2007.

A delay in the Son La development compels an upward revision of coal production planning in the Northern region and is accompanied by the Da river flood control measures and also review of environmental mitigation measures in the Quang Ninh region due to increased coal production. Therefore, early Son La development is desired.

8.4.3 Comparison between ESPRIT and WASP

In this section, WASP which is a least-cost planning method used by Viet Nam, is compared with the analysis function and calculation result of ESPRIT, used by the JICA Study Team to indicate WASP application constraints and to propose its countermeasure plan.

(1) Comparison of function

		ESPRIT	WASP
(1)	Optimum calculation logic	Dynamic planning method	Dynamic programming
(2)	Linkage model	Considered (up to 10 regions)	Ignored (single network)
(3)	Demand model	Actual load curve by season and region	Equivalent duration curve
(4)	Hydropower model	Plural	2 series
(5)	Thermal power repair plan	Once yearly, continuous repair	4 times in separate annually

Basically, due to the above functional constraints, WASP analysis provides a more optimistic (less for total capacity and lower total cost) answer than the calculations provided by ESPRIT.

(2) Calculation result of both methods

Capital cost of on-going projects (1995-2000) is not included (Refer to Table 8.4-10).

It is calculated with same power development scenario in both cases for convenience. It should be noted that WASP gives results of less fuel consumption with higher reliability due to disregarding transmission capacity limit.

(3) Counter plan

When Viet Nam executes the power development plan by using WASP from now on, it is necessary to heed the following.

While the linkage function by 500kV transmission line is weak (one circuit), the demand/supply balance and total cost are compared and analyzed between the case where the power system is divided into the Northern and Central/Southern and WASP calculation is done individually, and the case where all of Viet Nam is simulated by one system and solved by WASP.
Then, electricity interchange limitation of the linkage line is considered indirectly.

Table 8. 4-1 Total Cost for each Study Case

Case	Total Cost (US$million)	Difference (US$million)	LOLP (Days/yr.)	Energy N ⇒ C (GWh)	Transfer C ⇒ S (GWh)
① SL/GL	14,735	373	3.43	39,268	56,999
② SL/GS	14,988	626	3.27	38,960	56,738
③ SS/GL	14,362	base	3.12	37,610	55,332
④ SS/GS	14,725	363	3.08	38,002	55,964
01 NS/GL	14,982	620	2.99	37,839	55,124
02 NS/GS	15,430	1,068	3.13	36,853	54,777

Region

Note: (1) Total Cost is discounted and includes IDC, fuel and O&M cost (1993~2013)
(2) Energy Transfer: cumulative amount from 1995 through 2010.

Table 8.4-2 Summary of PDP Case Study

Demand:Base, Hydro Cond.:Normal

Case / Item	Case ① SL/GL North	Case ① SL/GL South	Case ① SL/GL Center	Grand Total (MUS$)	Case ② SL/GS North	Case ② SL/GS South	Case ② SL/GS Center	Grand Total (MUS$)
Tot. Amount	4,931	8,155	1,649	14,735	5,060	8,293	1,635	14,988
Capital C.	3,947	3,807	1,507	9,261	4,075	4,043	1,492	9,610
Fuel Cost	761	3,895	126	4,782	770	3,791	127	4,688
O & M	223	453	16	692	215	459	16	690
LOLP (D/y)	1.84	1.54	6.91	3.43	1.95	1.49	6.37	3.27
EUE (GWh)	168	105	253	527	180	100	220	500

Case / Item	Case ③ SS/GL North	Case ③ SS/GL South	Case ③ SS/GL Center	Grand Total (MUS$)	Case ④ SS/GS North	Case ④ SS/GS South	Case ④ SS/GS Center	Grand Total (MUS$)
Tot. Amount	4,534	8,191	1,637	14,362	4,791	8,290	1,644	14,725
Capital C.	3,246	3,838	1,507	8,591	3,435	4,059	1,507	9,001
Fuel Cost	1,039	3,897	114	5,050	1,097	3,775	121	4,993
O & M	249	456	16	721	259	456	16	731
LOLP (D/y)	1.85	1.53	5.97	3.12	1.82	1.38	6.04	3.08
EUE (GWh)	168	104	220	493	166	94	208	467

Case / Item	Case 01 NS/GL North	Case 01 NS/GL South	Case 01 NS/GL Center	Grand Total (MUS$)	Case 02 NS/GS North	Case 02 NS/GS South	Case 02 NS/GS Center	Grand Total (MUS$)
Tot. Amount	5,166	8,178	1,638	14,982	5,203	8,578	1,649	15,430
Capital C.	3,022	3,896	1,487	8,405	3,023	4,318	1,497	8,838
Fuel Cost	1,834	3,838	135	5,807	1,858	3,807	136	5,801
O & M	310	444	16	770	322	453	16	791
LOLP (D/y)	1.83	1.26	5.86	2.99	1.72	1.45	6.22	3.13
EUE (GWh)	177.4	82.5	201.5	461	174.4	92.3	211.5	478

Note) 1. Cost is discounted Value
2. Caluclation Period is 1993-2013
3. Variable cost is total sum from 1994 through 2060

Table 8.4-3 Power Development Scenarios (Whole Country) (1/2)

Year	Demand (MW)	SL/GL					SL/GS					SS/GL					SS/GS				
		Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)	Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)	Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)	Projects		Capacity (MW)	Installed Capacity (MW)	Margin (%)
		Hydro	Thermal				Hydro	Thermal				Hydro	Thermal				Hydro	Thermal			
1996	2,911				4,470	53				4,470	53				4,470	53				4,470	53
1997	3,228	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54
1998	3,628		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48
1999	4,064	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2, 3 (400)	1,060	6,456	58
2000	4,526	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc, Ba Ria	1,132 ▲ 60	7,528	66	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲ 60	7,528	66	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲ 60	7,528	66	Yaly (360) Ham/Da Mi (472)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲ 60	7,528	66
2001	5,067	Plei Kron (120)		120 ▲ 100	7,548	49	Plei Kron (120)		120 ▲ 100	7,548	49	Plei Kron (120)		120 ▲ 100	7,548	49	Plei Kron (120)		120 ▲ 100	7,548	49
2002	5,690	Buon Cuop (81) Se San 3 (220)		301	7,849	37	Buon Cuop (81) Se San 3 (220)		301	7,849	38	Buon Cuop (81) Se San 3 (220)		301	7,849	37	Buon Cuop (81) Se San 3 (220)		301	7,849	38
2003	6,328	Ban Mai (350)	Phu My C/C #3	650	8,499	37	Dai Thi (250)	Phu My C/C #3	550	8,399	33		Phu My C/C #3 Phu My C/C #4	600	8,449	37		Phu My C/C #3 Phu My C/C #4	600	8,449	42
2004	7,049	An Khe (116) T. Kontum (260)	Q. Ninh #1 Phu My C/C #4	976	9,475	33	An Khe (116)	Q. Ninh #1 Phu My C/C #4 Phu My C/C #5	1,016	9,415	33	An Khe (116) T. Kontum (260)	Q. Ninh #1 Phu My C/C #5	976	9,425	34	Ban Mai (350) T. Kontun (260) Au Khe (116)	Q. Ninh #1 Phu My C/C #5	1,326	9,775	38
2005	7,879	Son Con 2 (60)	Phu My C/C #5 N. Trac #1 N. Trac #2	960	10,435	32	Dai Ninh (300) Son Con 2 (60) T. Kon Tum (260)	O Mon #1	920	10,335	32	Dai Thi (250) Son Con 2 (60)	N. Trac #1 N. Trac #2	910	10,335	31	Dai Ninh (300) Son Con 2 (60)	O Mon #1	660	10,435	32
2006	8,620	Se San 4 (366) Dong Nai 4 (200)	Q. Ninh #2 Q. Ninh #3	1,166 ▲ 150	11,451	33	Ban Mai (350) Se San 4 (366)	Q. Ninh #2 Q. Ninh #3	1,316 ▲ 150	11,501	33	Se San 4 (366)	Q.Ninh #2 Q. Ninh #3 N. Trac #3	1,266 ▲ 150	11,451	34	Dong Nai 4 (200) Se San 4 (366)	Q. Ninh #2 Q. Ninh #3	1,166 ▲ 150	11,451	32
2007	9,481	Rao Quan (80) Son La #1, 2 (600)	Q. Ninh #4 N. Trac #3 N. Trac #4	1,580 ▲ 100	12,931	36	Rao Quan (80) Son La #1, 2 (600)	O Mon #2, 3 P. Thiet #1, 2	1,880 ▲100	13,281	40	Son La #1, 2 (480) Ban Mai (350) Rao Quan (80) Dai Ninh (300)	Q. Ninh #4, 5	1,810 ▲ 100	13,161	39	Rao Quan (80) Son La #1, 2 (480)	Q. Ninh #4,5,6 O Mon #2,3	2,060 ▲100	13,411	41
2008	10,422	Son La #3, 4 (600)	N. Trac #5	900 ▲ 150	13,726	32	Son La #3, 4 (600)	Q. Ninh #4	900 ▲105	14,076	35	Son La #3, 4 (480) Dong Nai 4 (200)	N. Trac #4	980 ▲ 105	14,036	35	Son La #3, 4 (480)	P. Thiet #1 P. Thiet #2	1,080 ▲105	14,386	38
2009	11,408	Son La #5, 6 (600)	N. Trac #6 N. Trac #7	1,200	14,926	31	Son La #5, 6 (600) Dang Nai 4 (200)	P. Thiet #3 P. Thiet #4	1,400	15,476	35	Son La #5, 6 (480)	Q. Ninh #6 N. Trac #5, 6	1,380	15,416	35	Son La #5, 6 (480)	P. Thiet #3,4	1,080	15,466	36
2010	12,550	Son La #7, 8 (600) Dai Ninh (300)	O Mon #1 O Mon #2	1,500	16,426	31	Son La #7, 8 (600)	P. Thiet #5 P. Thiet #6 P. Thiet #7	1,500	16,976	35	Son La #7, 8 (480)	N. Trac #7 O Mon #1 O Mon #2	1,380	16,796	34	Son La #7, 8 (480)	Q. Nihn #7 P. Thiet #5, 6, 7	1,680	17,146	37
Addition 1996-2010				12,471 ▲ 310					13,021 ▲ 310					12,841 ▲ 310					13,191 ▲ 310		
Addition 2011-2013		Qua Dat (105) Son La (1,200) Dai Thi (250)	Coal Thermal 3,900 (N=900) (S=3,000)	5,455			Son La (1,200) Cua Dat (105)	Coal Theraml 3,300 (N=1,200) (S=2,100)	4,605			Son La (480) Huoi Quang (800)	Coal 3,600 (N=600) (S=3,000)	4,880			Dai Thi (250) Son La (480) Huoi Quang (800)	Coal Thermal 300 (N=900) (S=2,100)	4,530		

Note 1: Unit capacity of thermal power project is assumed to be 300MW each.
2: Margin is calculated on the installed capacity basis.
3: ▲ shows retirement of the plant.

Table 8.4-3 Power Development Scenarios (Whole Country) (2/2)

Year	Demand (MW)	Case NS/GL Projects: Hydro	Case NS/GL Projects: Thermal	Case NS/GL Capacity (MW)	Case NS/GL Installed Capacity (MW)	Case NS/GL Margin (%)	Case NS/GS Projects: Hydro	Case NS/GS Projects: Thermal	Case NS/GS Capacity (MW)	Case NS/GS Installed Capacity (MW)	Case NS/GS Margin (%)
1996	2,911				4,470	53				4,470	53
1997	3,228	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54	Song Hinh (70)	Ba Ria (56) New C/C (400)	526	4,996	54
1998	3,628		New C/C (200) Phu My #1 (200)	400	5,396	48		New C/C (200) Phu My #1 (200)	400	5,396	48
1999	4,064	Yaly (360)	Pha Lai II #1 Phu My #2,3 (400)	1,060	6,456	58	Yaly (360)	Pha Lai II #1 Phu My #2,3 (400)	1,060	6,456	58
2000	4,526	Yaly (360) Ham/Da Mi (976)	Pha Lai II #2 Tra Noc, Ba Ria	1,132 ▲60	7,528	66	Yaly (360) Ham/Da Mi (976)	Pha Lai II #2 Tra Noc Ba Ria	1,132 ▲60	7,528	66
2001	5,067	Plei Kron (120)		120 ▲100	7,548	49	Plei Kron (120)		120 ▲100	7,548	49
2002	5,690	Se Sans (120) Buon Cuop (81)		301	7,849	38	Se San 3 (220) Buon Cuiop (81)		301	7,849	38
2003	6,328	Dai Ninh (300)	Phu My C/C #3	600	8,449	34	Dai Ninh (300)	Phu My C/C #3	600	8,449	33
2004	7,049	Ban Mai (350) T. Kontum (260)	Quang Ninh #1 Phu My C/C #4	1,210	9,659	37	T. Kontum (260)	Q. Nihn #1 Phu My C/C #4	860	9,309	32
2005	7,879	An Khe (116) Son Con 2 (60)	Phu My C/C #5 N. Trac #1	776	10,435	32	An Khe (116) Son Con 2 (60)	Quang Ninh #2,#3 Phu My C/C #5	1,076	10,385	31
2006	8,620	Se San 4 (366)	Quang Ninh #2, #3 N. Trac #2	1,266 ▲150	11,551	34	Dong Nai 4 (200) Se San 4 (366)	Q. Ninh #4 O Mon #1	1,166 ▲150	11,401	32
2007	9,481	Dong Nai 4 (200) Huoi Quang (400)	Quang Ninh #4 N. Trac #3	1,200 ▲100	12,651	33	Rao Quang (80) Ban Mai (350) Huoi Quang (400)	O Mon #2 O Mon #3	1,430 ▲100	12,731	34
2008	10,422	Huoi Quang (400)	Quang Ninh #5 N. Trac #4,#5	1,300 ▲105	13,846	33	Huoi Quang (400)	Q. Ninh #5 Phan Thiet #1,#2	1,300 ▲105	13,926	34
2009	11,408	Rao Quang (80)	Quang Nin #6, #7 N. Trac #6, #7	1,280	15,126	33		Q. Ninh #6, #7, #8 Phan Thiet #3, #4	1,500	15,426	35
2010	12,550		Quang Ninh #8, #9, #10 O Mon #1, #2	1,500	16,626	32		Q. Ninh #9 Phan Thiet #5,#6, #7	1,200	16,626	32
Addition 1996-2010				12,671 ▲310					12,671 ▲310		
Addition 2011-2013		Cua Dat (105)	Coal Thermal 4,500 (N = 1,500 S = 3,000)	4,605			Cua Dat (105)	Coal Thermal 4,800 (N = 1800 S = 3000)	5,200		

Note:
1. Unit capacity of thermal power project is assumed to be 300 MW each.
2. Margin is calculated on the installed capacity basis.
3. ▲ shows retirement of the plant.

Table 8.4-4 Summary of Investment for Generation (US$ Million)

Year	1996 ~ 2000	2001 ~ 2005	2006 ~ 2010	Total
Disburse	4,063	7,236	3,384	14,683

Table 8.4-5 Required Commissioning Year

Stage / Region	2001 - 2003	2004 - 2006		2007 - 2010
North	Ban Mai	Quang Ninh #1-3 Dai Thi		SL(L) #1~8 Quang Ninh #4 SL(S) #1~8 Quant Ninh #4,5,6,(7)
Center	Plei Krong Buon Cuop Se San 3	An Khe, T. Kontum Son Con 2 Se San 4		Rao Quan
South	Gas C/C #1,2	Gas (L)	Gas C/C #3,4,5,6	Gas C/C #7,8,9,10 (11) Coal #1,2
		Gas (S)	Gas C/C #3 Coal Thermal #1 Dong Nai 4 Dai Ninh	Coal #2-9

Table 8.4-6 Energy Transfer and Power Source

Yr.	1995~2000	2001~2005	2006~2010	Tot. Energy Transfer	Capacity/cct
N ⇒ C/S	Hoa Binh	Hoa binh	Son La	38,000GWh	700 MW (Lf-50%)
C ⇒ S	V.Son, Yaly	Sesan3	Sesan4	56,000GWh	1500MW (Lf-30%)

Table 8.4-7 Total Cost in High Demand Case

Case	Total Cost* (US$ million)	Difference (US$ million)	LOLP (days/year)
⑤ SL/GL	17,025	500	3.28
⑥ SL/GS	17,278	753	4.19
⑦ SS/GL	16,525	base	3.37
⑧ SS/GS	16,790	265	4.13

*: Discounted value and includes IDC

Table 8.4-8 Total Cost in High Demand Case

⑪ Case-SS/GS, Demand: JICA base

LOLP	Total Cost (US$ million)	Difference (US$ million)	EUE (GWh)
1.0%	14,725	base	467
3.0%	14,245	▲480	1,033

Table 8.4-9 Total Cost & EUE (1993 ~ 2013) Gas: Small, Demand: JICA (base)

Case	Total Cost		EUE	Coal to be Developed in All Viet Nam	
	US$ million (Discounted)	Difference US$ million	All VNM (GWh)	(MW)	(million)
② SL/GS	14,988	base	500	16x300*	6.9
⑨ SL/GS (2 yr-Delayed)	15,245	257	525	19x300*	9.7
④ SS/GS	14,725	base	467	19x300*	8.8
⑩ SS/GS (2yr-Delayed)	15,022	297	478	20x300*	10.3

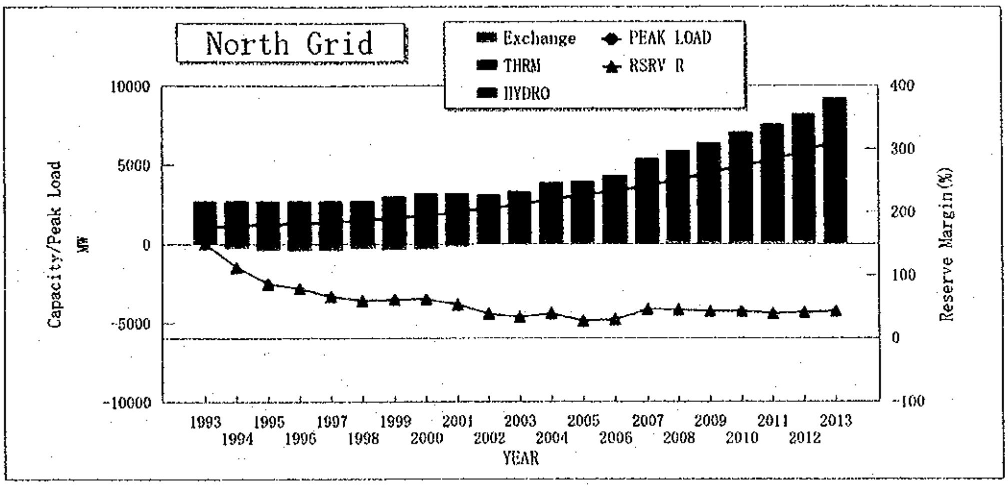
*) As of 2010 Includes Pha Lai Coal, 2x300MW

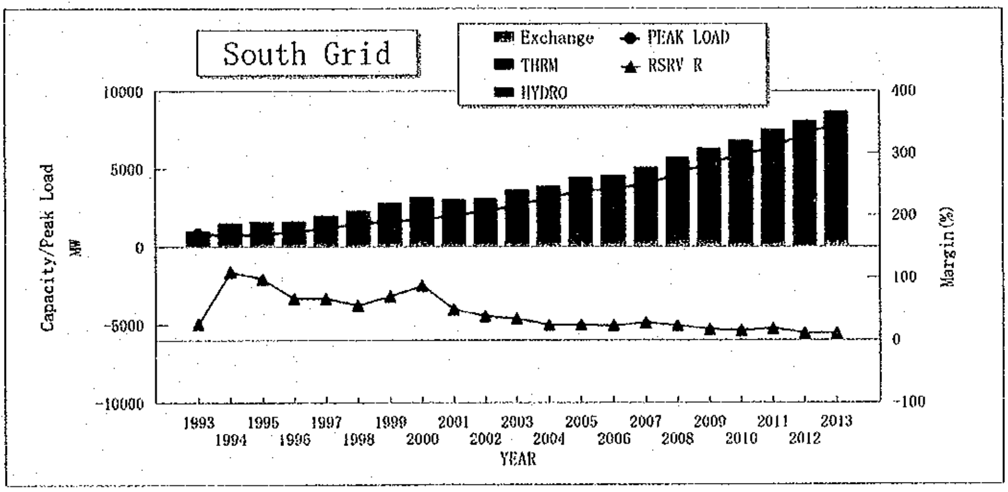
Table 8.4-10 Comparison WASP and ESPRIT

	WASP SS/GS	ESPRIT SS/GS
Capital Cost Variable Cost	20.48 6.01	20.65 7.14
LOLP (days/yr.)	0.0	3.08
Reserve Margin (%) **	34.7	35

* Not Discounted Total Amount 1993 ~ 2013 US$ billion
** As of 2013

Fig 8.4-1 Peak Balance of Each Grid
(Case SS/GS)





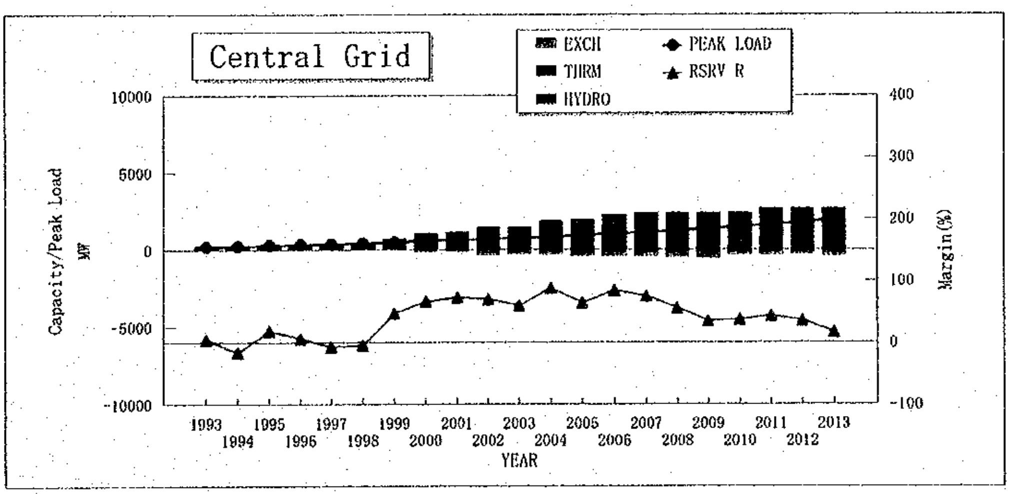
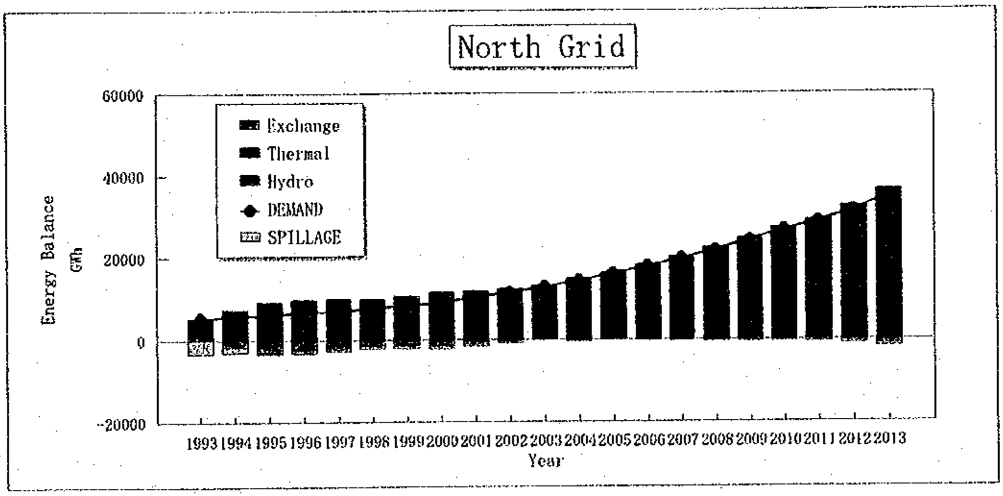
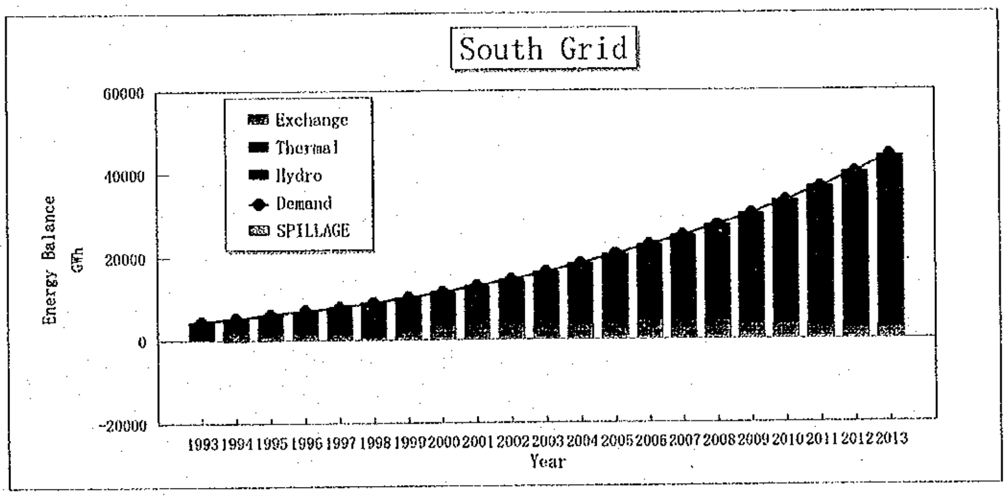


Fig 8.4-2 Energy Balance of Each Grid
(Case SS/GS)





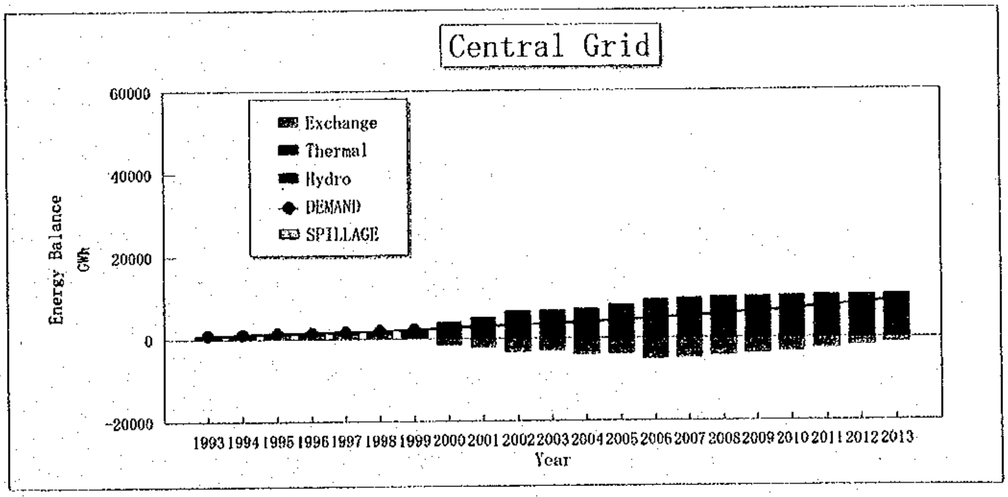
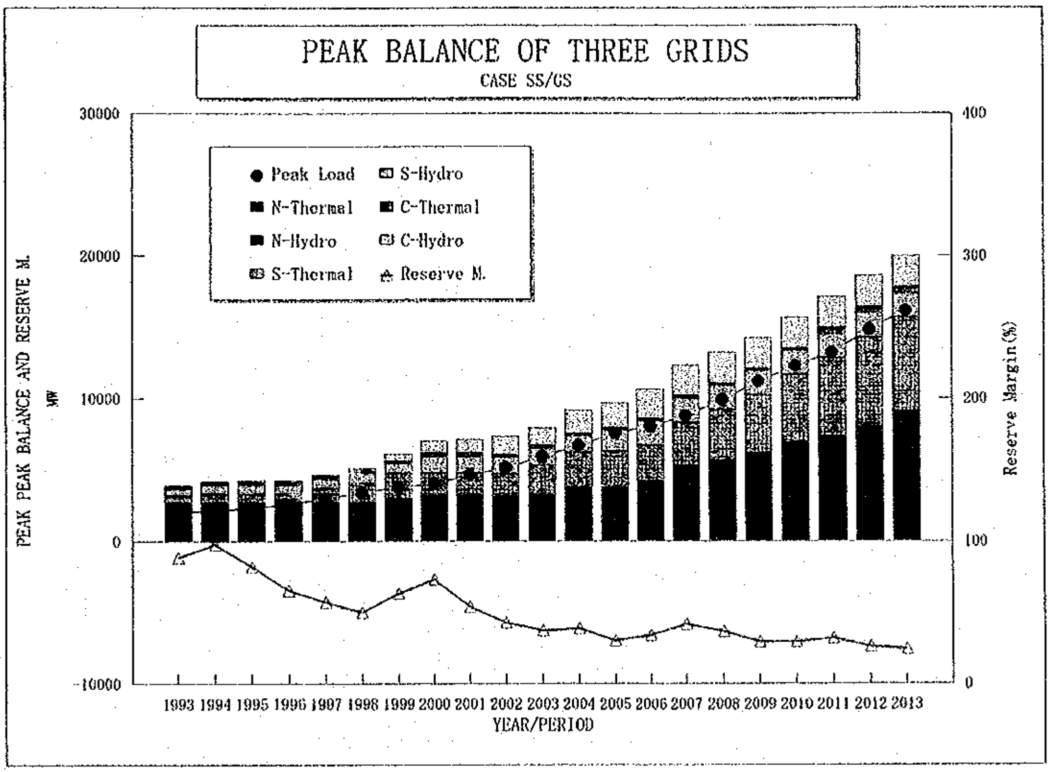
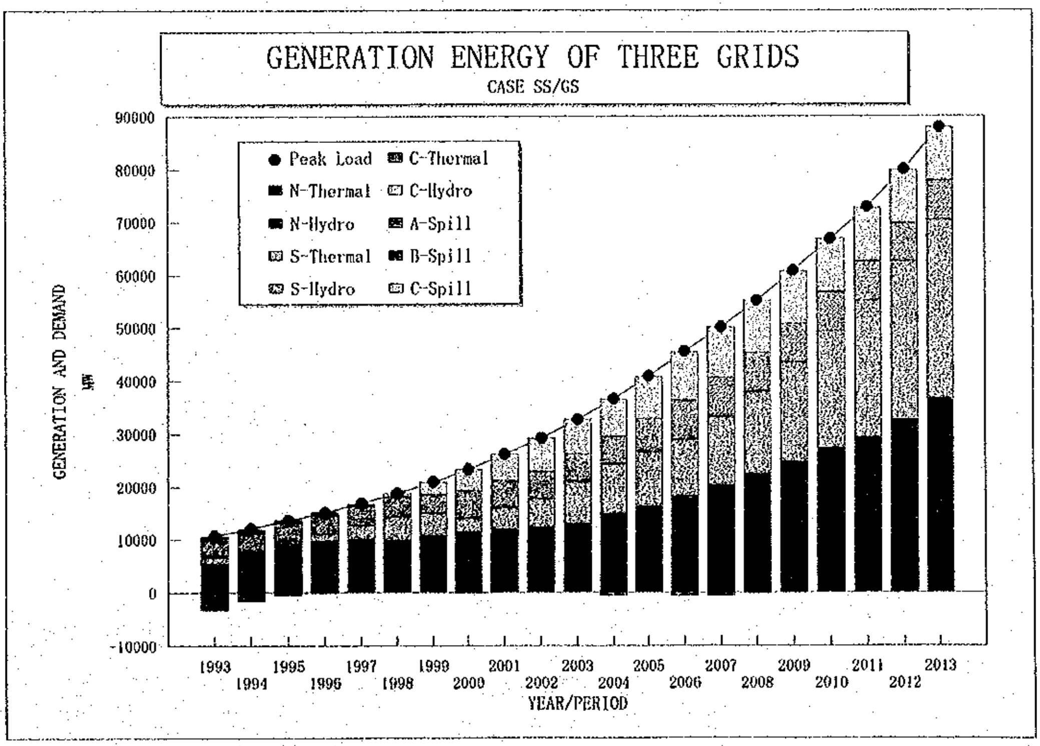


Fig. 8.4-3 Peak Balance in all Vietnam (Case-SS/GS)



June 23rd, 1995 EPDC

Fig. 8.4-4 Energy Balance in all Vietnam (Case-SS/GS)



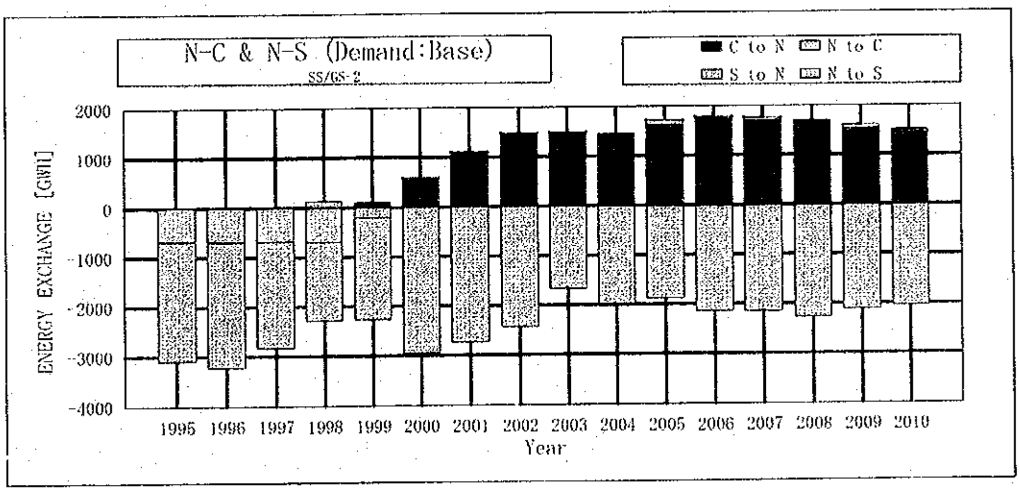
Energy flow on inter line N-C & N-S

Year	energy-transfer (GWh		energy-transfer (GWh	
	N to C	N to S	C to N	S to N
1995	684.0	2405.0	0.0	0.0
1996	685.0	2533.0	0.0	0.0
1997	681.0	2150.0	0.0	0.0
1998	695.0	1581.0	0.0	126.0
1999	199.0	2062.0	85.0	18.0
2000	5.0	2947.0	587.0	0.0
2001	0.0	2730.0	1102.0	0.0
2002	0.0	2428.0	1477.0	0.0
2003	0.0	1667.0	1444.0	42.0
2004	3.0	1979.0	1446.0	13.0
2005	0.0	1872.0	1616.0	96.0
2006	0.0	2133.0	1732.0	51.0
2007	0.0	2149.0	1687.0	74.0
2008	6.0	2257.0	1685.0	13.0
2009	11.0	2104.0	1524.0	77.0
2010	2.0	2034.0	1424.0	74.0
Total	2971	35031	15809	584

Energy flow on inter line C-S & N-S

Year	energy-transfer (GWh		energy-transfer (GWh	
	C to S	N to S	S to C	S to N
1995	0.0	2405.0	317.0	0.0
1996	0.0	2533.0	369.0	0.0
1997	0.0	2150.0	574.0	0.0
1998	1.0	1581.0	595.0	126.0
1999	258.0	2062.0	90.0	18.0
2000	847.0	2947.0	24.0	0.0
2001	1004.0	2730.0	4.0	0.0
2002	1760.0	2428.0	0.0	0.0
2003	1577.0	1667.0	0.0	42.0
2004	1807.0	1979.0	14.0	13.0
2005	2035.0	1872.0	0.0	96.0
2006	2668.0	2133.0	0.0	51.0
2007	2555.0	2149.0	11.0	74.0
2008	2414.0	2257.0	5.0	13.0
2009	2167.0	2104.0	5.0	77.0
2010	1840.0	2034.0	38.0	74.0
Total	20933	35031	2046	584

EPDC



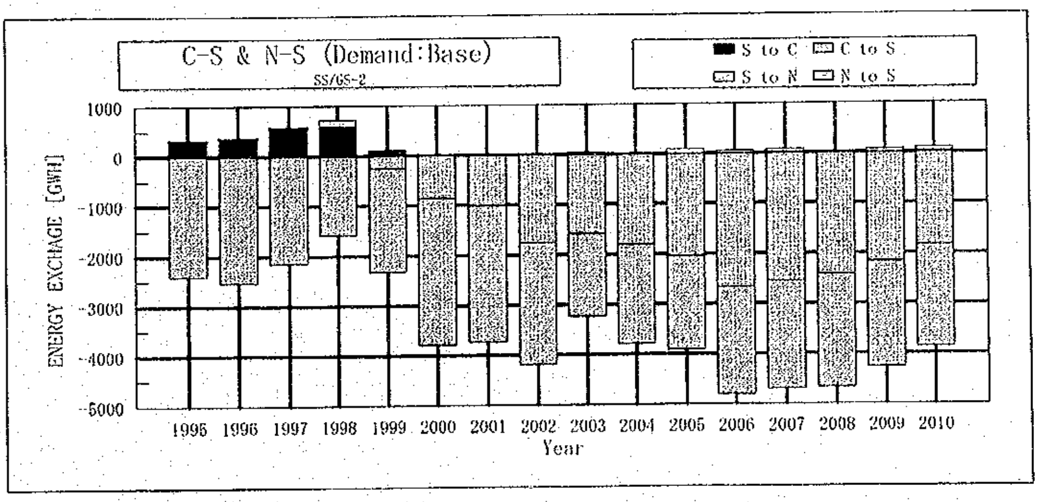
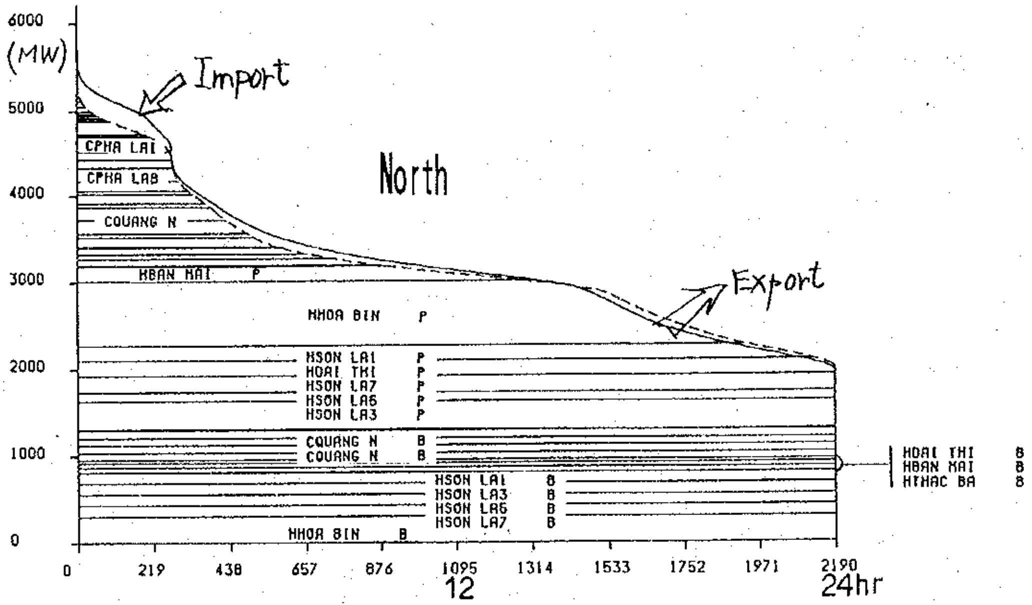
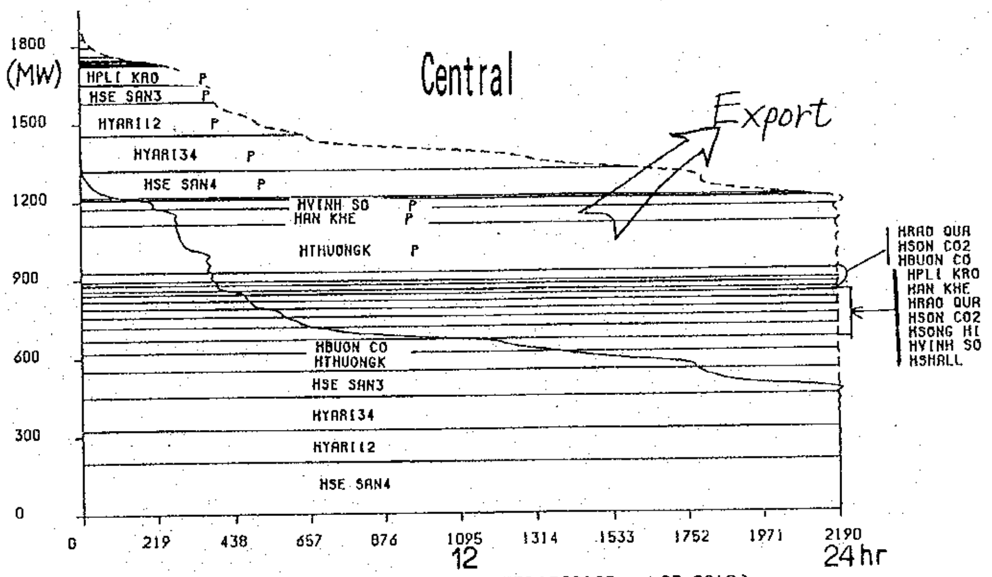


Fig. 8.4-5 Energy Exchange Case-SS/GS (Base Case)

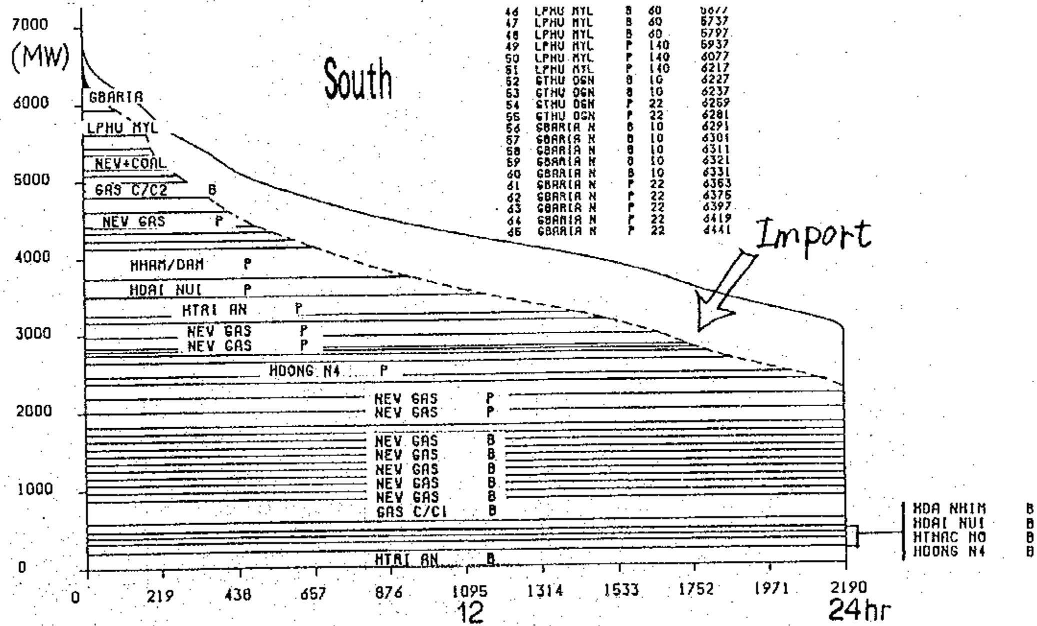


EQUIVALENT LOAD DURATION CURVE OF NORTH (PERIOD 4 OF 2010)



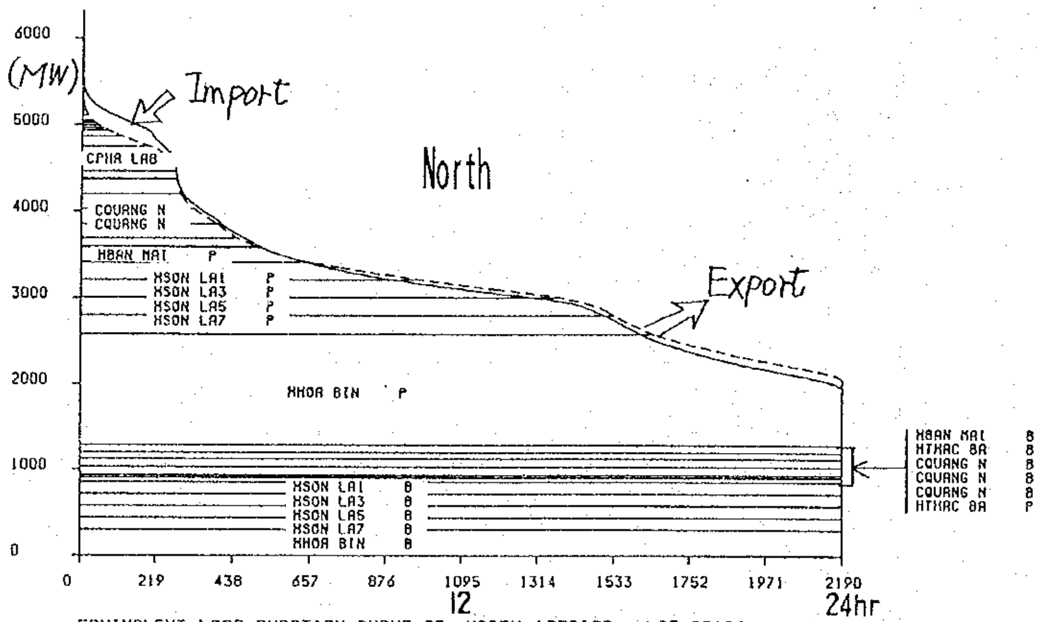
EQUIVALENT LOAD DURATION CURVE OF CENTER (PERIOD 4 OF 2010)

46	LPHU MYL	B	60	[illegible]
47	LPHU MYL	B	60	5737
48	LPHU MYL	B	60	5797
49	LPHU MYL	P	140	5937
50	LPHU MYL	P	140	6077
51	LPHU MYL	P	140	6217
52	GTHU DGN	B	10	6227
53	GTHU DGN	B	10	6237
54	GTHU DGN	P	22	6259
55	GTHU DGN	P	22	6281
56	GBARIA N	B	10	6291
57	GBARIA N	B	10	6301
58	GBARIA N	B	10	6311
59	GBARIA N	B	10	6321
60	GBARIA N	B	10	6331
61	GBARIA N	P	22	6353
62	GBARIA N	P	22	6375
63	GBARIA N	P	22	6397
64	GBARIA N	P	22	6419
65	GBARIA N	P	22	6441

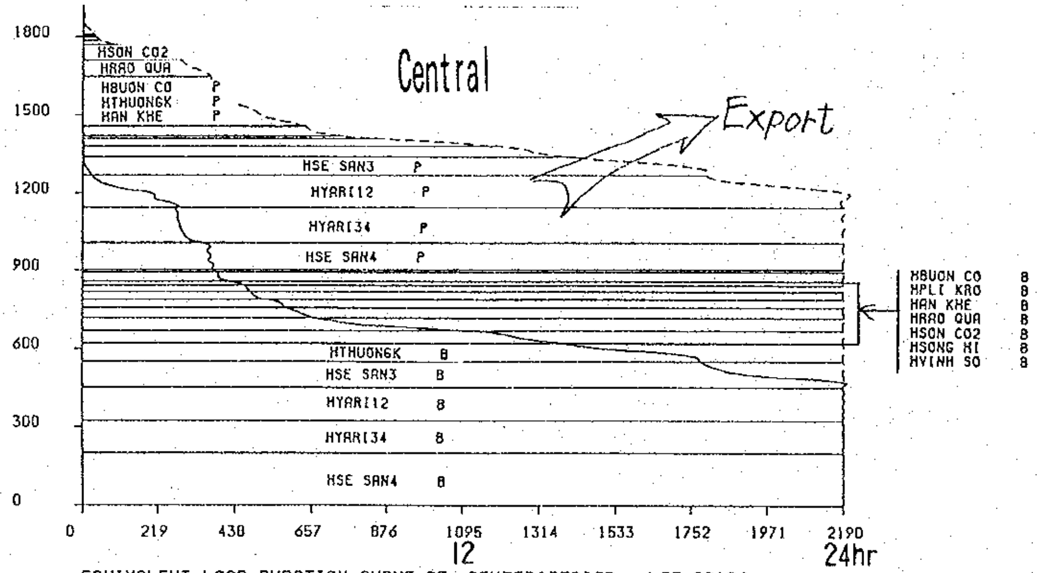


EQUIVALENT LOAD DURATION CURVE OF SOUTH (PERIOD 4 OF 2010)

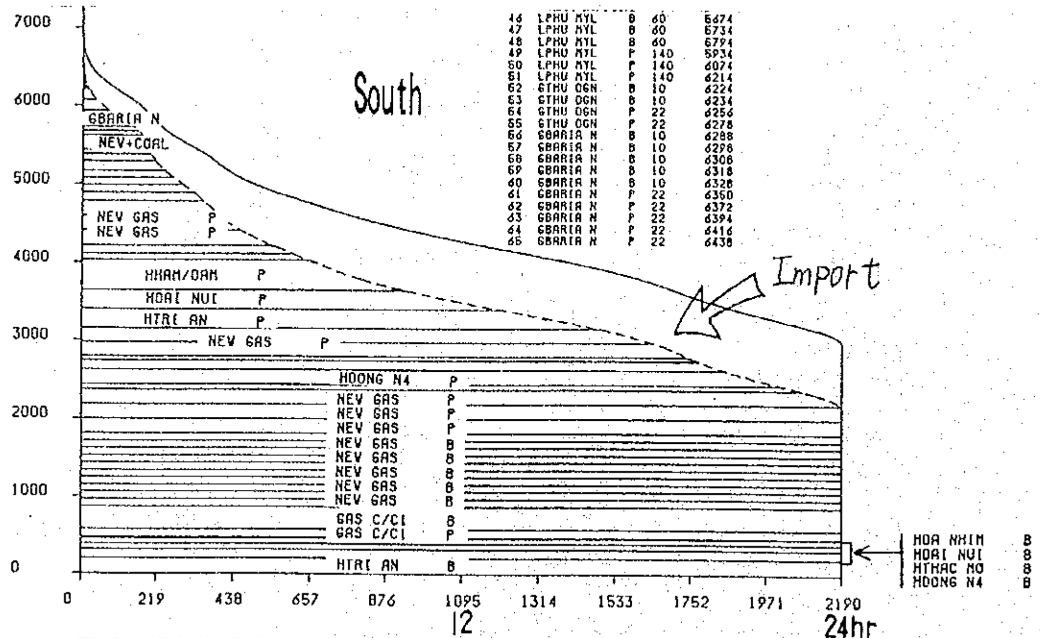
Fig. 8.4-6(a) Generation Dispatch Nov. 2010 (SS/GL)



EQUIVALENT LOAD DURATION CURVE OF NORTH (PERIOD 4 OF 2010)

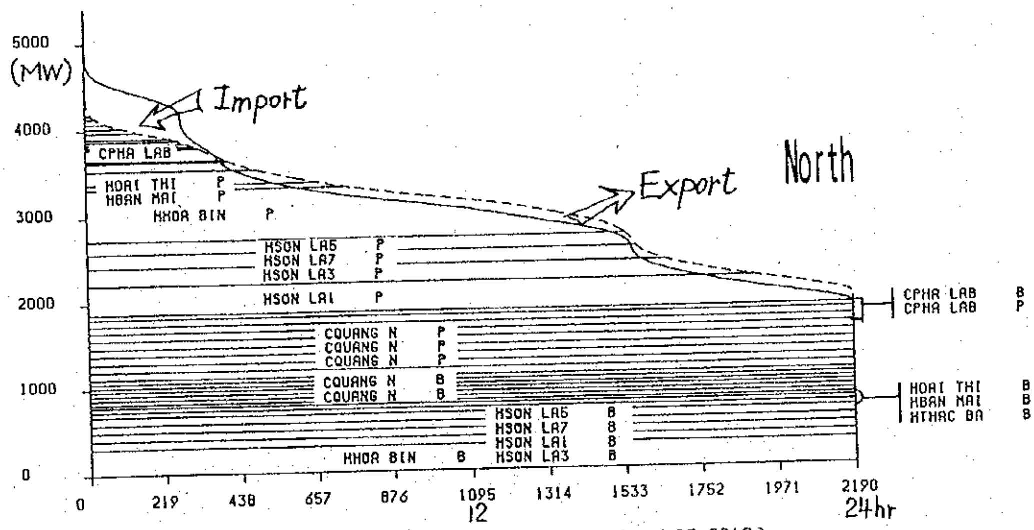


EQUIVALENT LOAD DURATION CURVE OF CENTER(PERIOD 4 OF 2010)

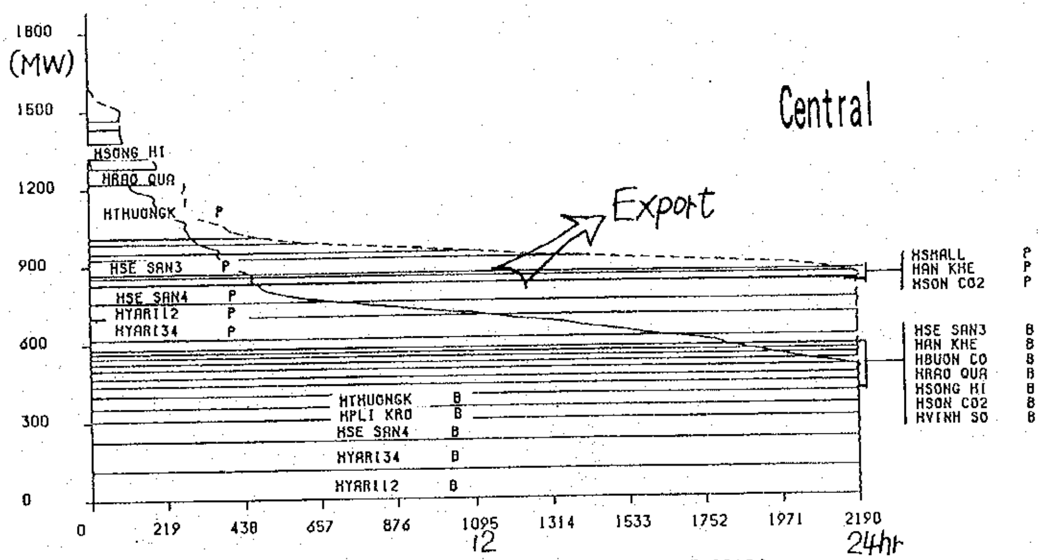


EQUIVALENT LOAD DURATION CURVE OF SOUTH (PERIOD 4 OF 2010)

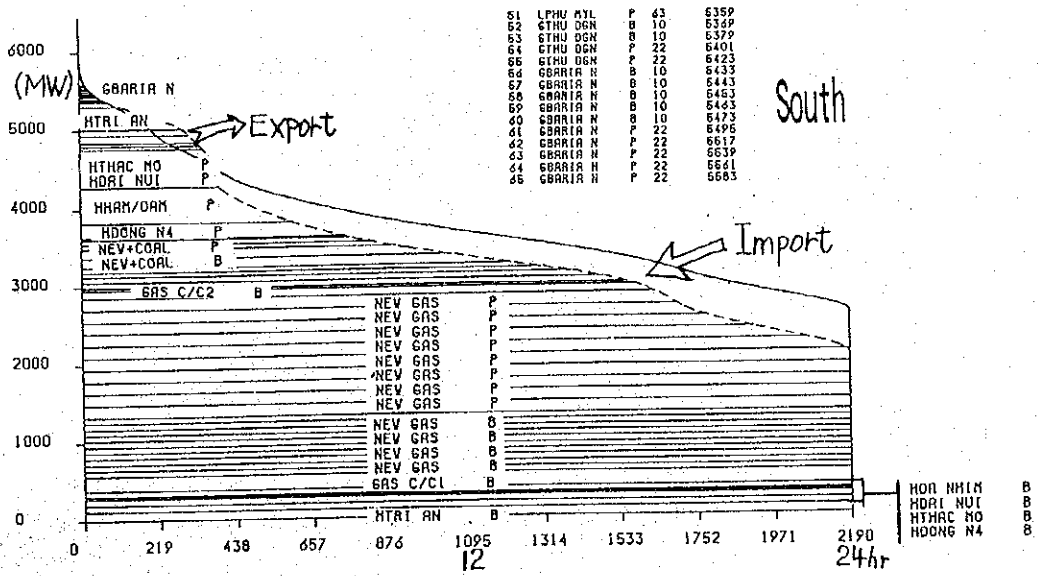
Fig. 8.4-6(b) Generation Dispatch Nov. 2010 (SL/GL)



EQUIVALENT LOAD DURATION CURVE OF NORTH (PERIOD 1 OF 2010)



EQUIVALENT LOAD DURATION CURVE OF CENTER(PERIOD 1 OF 2010)



EQUIVALENT LOAD DURATION CURVE OF SOUTH (PERIOD 1 OF 2010)

Fig. 8. 4-6(c) Generation Dispatch Feb. 2010 (SS/GL)

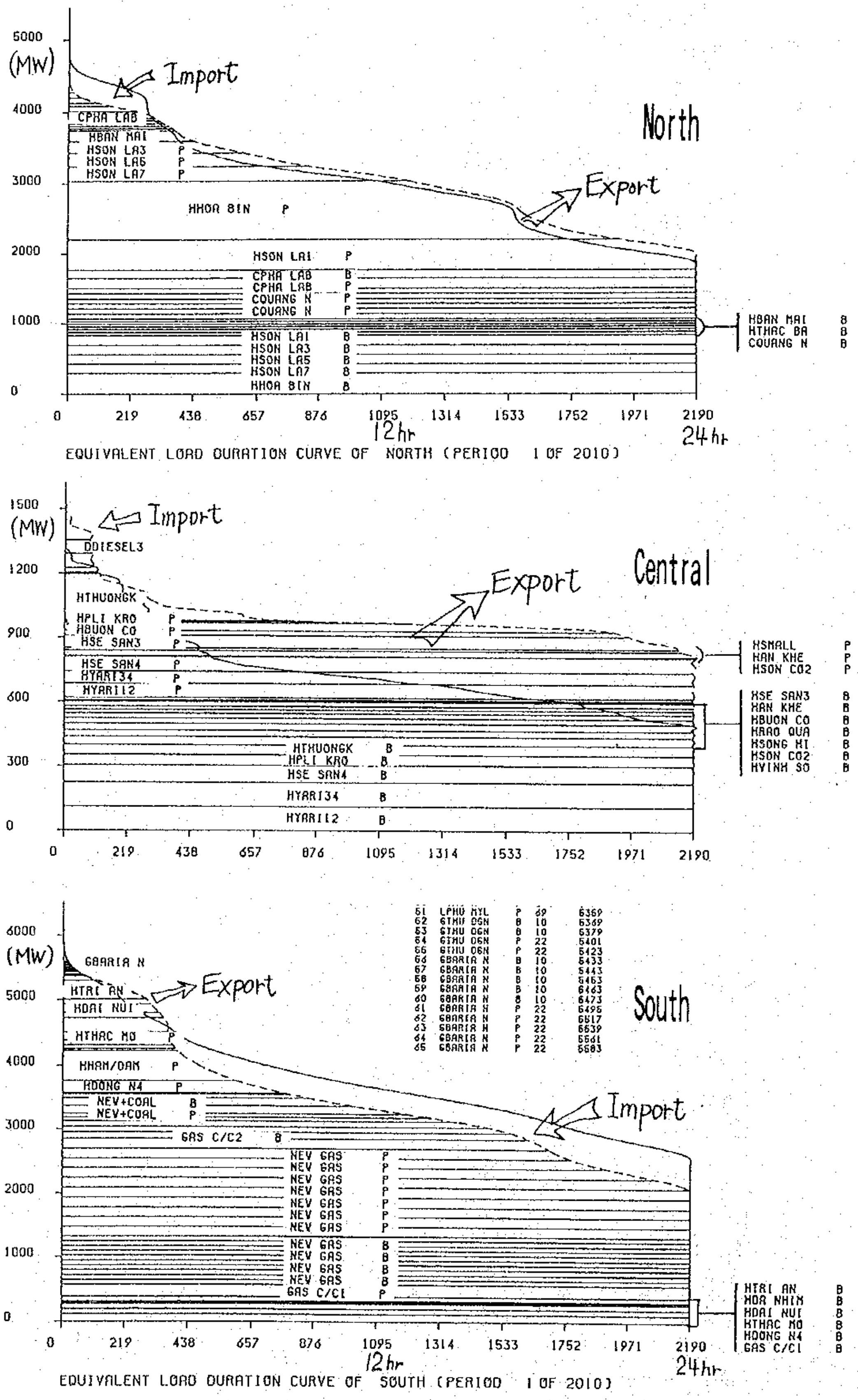


Fig. 8.4-6(d) Generation Dispatch Feb. 2010 (SL/GL)

8.5 Balance of Electric Energy (kWh)

In this section, the energy consumption of each power source is obtained in the SS/GL case where the total cost is the lowest of the four base cases. The result is shown in Table 8.5-1.

If the project advances as planned, the hydropower intensive structure is shifted yearly to the balanced power source structure consisting of hydropower (all-round), gas C/C thermal power and coal-fired thermal power (middle base) to meet the power demand of an annual load factor of 60% at large throughout the whole country.

Output of generated energy resources necessary for these power consumption increases, as shown in Table 8.6-1, and satisfies the present Vietnamese resources development program.

Table 8.5-1 Energy Mix, Case-SS/GL (Hydro: Normal Condition)

Region	Year	1995	2000	2005	2010
North GWh/(%)	Hydro	8,277/(89%)	8,673/(75%)	9,981/(63%)	20,358/(75%)
	Coal T.	978/(11%)	2,821/(25%)	5,769/(37%)	6,665/(25%)
Center & South GWh/(%)	from ⇐ N	3,088/(41%)	2,951/(20%)	1,551/(6%)	1,955/(5%)
	Hydro	3,827/(51%)	9,169/(62%)	13,071/(49%)	17,393/(42%)
	Gas	568/(8%)	2,637/(18%)	12,010/(45%)	21,630/(52%)
	Coal T.	—	—	—	689/(–%)
	Oil T.	8/(–%)	0/(0%)	9/(–%)	59/(–%)
Whole Country GWh/(%)	Hydro	12,104/(89%)	17,842/(77%)	23,052/(56%)	37,751/(57%)
	Gas	568/(4%)	2,637/(11%)	12,010/(29%)	21,630/(32%)
	Coal T.	978/(7%)	2,821/(12%)	5,769/(14%)	7,354/(11%)
	Oil T.	8/(–%)	0/(0%)	9/(–%)	59/(–%)
Total Demand (GWh)		13,600	23,200	40,900	66,600

8.6 Projection of Coal and Gas Consumption

Table 8.6-1 shows coal and gas consumption in whole Viet Nam for each scenario of the PDP study.

Even in the case of limitless gas demand, natural gas consumption in 2010 remains within 5.0 billion m^3 level when demand grows with base case because of the reason that cost effective hydropower plants are developed in advance.

Table 8.6-1 Annual Thermal Energy Generation Fuel Consumption

(Coal:Million ton/ Gas:Billion m³)

Demand / Case \ Year	2000 (GWh)	2000 Coal/Gas	2005 (GWh)	2005 Coal/Gas	2010 (GWh)	2010 Coal/Gas
Demand:BASE ① SL/GL	2,836 2,606	1.30 0.55	5,653 11,679	2.60 2.49	6,120 21,325	2.82 4.53
② SL/GS	2,839 2,622	1.31 0.56	6,834 9,673	3.37 2.06	15,093 11,085	6.94 2.37
③ SS/GL	2,821 2,633	1.30 0.56	5,769 11,973	2.65 2.54	7,354 21,610	3.38 4.59
④ SS/GS	2,821 2,633	1.30 0.56	6,295 9,771	2.89 2.08	19,206 11,104	8.83 2.36
⑨ SL/GS 2yr. delay	2,839 2,622	1.31 0.56	8,108 9,683	3.73 2.06	21,061 11,038	9.68 2.34
⑩ SS/GS 2yr. delay	2,821 2,633	1.30 0.56	7,975 9,858	3.67 2.09	22,368 11,045	10.28 2.35
⑪ SS/GS (LOLP:3%)	2,796 2,540	1.29 0.54	6,809 11,856	3.13 2.52	18,557 11,527	8.53 2.45
01 NS/GL	2,624 2,842	1.21 0.60	5,674 10,406	2.61 2.21	14,723 21,328	6.56 4.53
02 NS/GS	2,624 2,842	1.21 0.60	7,593 10,149	3.49 2.15	24,839 11,070	11.42 2.35
Demand:High ⑥ SL/GS	2,960 3,470	1.36 0.74	10,063 10,660	4.63 2.26	21,620 11,303	9.94 2.40
⑧ SS/GS	3,002 3,411	1.38 0.72	9,199 11,404	4.23 2.42	23,951 11,335	11.01 2.41

Conversion coefficient are assumed to be Coal:2,175GWh/Mton and Gas :4,710GWh/Bm³

CHAPTER 9

SELECTION OF PRIORITY DEVELOPMENT PROJECT

CHAPTER 9 SELECTION OF PRIORITY DEVELOPMENT PROJECT

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CHAPTER 9 SELECTION OF PRIORITY DEVELOPMENT PROJECT

In this chapter, results examined from various aspects to select the optimum power development project are described based on simulated calculation in previous chapter.

9.1 Examination from a Standpoint of Total Cost

9.1.1 Results by Simulation

The results of the simulated calculation in relation to the total cost are summarized in the following items.

(1) The total costs (total of capital, fuel, and O&M discounted to 1993) required for each of the basic 4 cases were around US$14 billion respectively. The sequence is described below.

Cases-SL/GS>SL/GL>SS/GS>SS/GL

When considering a lot of uncertainties, all study cases are considered to be realistic development scenarios. The maximum difference in each scenario was computed to be US$620 million.

(2) To pursue the rationale of the Son La project development, studies were made on cases in which the Son La project is not developed. The total cost of either Case-NS/GL or Case-NS/GS was over US$620-1,068 million higher than the basic study case, thus confirming the feasibility of this project execution.

(3) Regarding the development scale of the Son La project, SL (S) provides a better economical factor than SL (L), regardless of the volume of natural gas production.

(4) The proportion of capital and fuel in the total cost is approx. 63% and approx. 31% respectively for SL (L). It is approx. 60% and approx. 34% respectively for SL (S).

(5) The power development during this study period (1996 - 2010) is approx. 13,000 MW. The required investment for the power generation division alone is approx. US$14.3 ~ 14.9 billion.

9.1.2 Items to be considered for Benefit of Son La Project

(1) The proportion of the capital for the Son La hydropower project is significantly large in the long term power development plan. The capital cost during the study period is roughly calculated below.

The capital cost after discount (Proportion in total capital cost)

Son La (L); approx. US$1,350 million (15%)
Son La (S) + Huoi Quang hydro project; approx. US$900 million (10%)

The proportion of the Son La (L) project in the entire capital is significantly larger than the total of the Son La (S) and Huoi Quang hydro projects. This is the major reason why Case-SL is more costly than Case-SS in the total cost.

When comparing alternate hydro projects for the same site, a larger development is generally selected due to its scale merit. However, this does not apply to this case, indicating that there are problems of consistency in the construction cost calculation for Son La (L) and Son La (S) as well as inconsistency in peak duration time for the power system. These are study subjects in F/S.

(2) The primary purpose of the Son La hydro project is the flood control of the Da River by synchronizing with the Hoa Binh reservoir downstream. In F/S, therefore, it is necessary to closely study the cost distribution in the other beneficiaries of the Son La Dam, for instance, the distribution of the flood control capacity and water utilization at the two reservoirs.

9.2 Examination for Power System Operation

The following features of power system operation can be described.

(1) Regarding the regional conditions, the Central region will become a constant power exporter after Yaly completion. The Southern region will continue to import power from the Northern and Central regions in the 2000's, regardless of its own considerable power development.

Regarding power interchange between the regions, approx. 400MW will be supplied from the Northern region to the Southern region through the study period, thereby retaining a high annual level of approx. 2,000GWh.

Supply from the Central region to the Southern region will also retain a high level of approx. 400MW or 1,500 - 2,500GWh yearly through the 2000's.

On the other hand, the power interchange from the Southern region to the Northern region - or from the Central region to the Northern region will also be practiced in the 2000's. It is interesting to see the merits of interconnected transmission lines between the regions.

(2) In the Northern region, the main power source will be hydropower followed by thermal power until the 2010's and after the Son La (L) or Son La (S) + Huoi Quang hydro project developments are realized. Regarding thermal power development in the Northern region, even the new Qaung Ninh thermal project will function for the load control most of the time and will not provide a high annual operation ratio. (approx. 30% - 40% annual operation ratio in the entire Northern thermal power generation capacity in 2010). To this end, coal thermal power plant is describable to be designed as daily start/stop operation type.

(3) In contrast, the Southern region will depend on thermal power development including mainly combined cycle thermal power in response to their high power demand increase. The thermal

power operation ratio in the Southern region indicates a high value. (example; 60% annual operation ratio (SS/GS) in 2010)

(4) Regarding hydropower operation, it is clarified that they will be mainly operated for the base power supply in the North and the Center, where hydropower capability is dominant in the 2000's. On the other hand in the South, where thermal power capability is major power source, hydropower plants are mainly operated for peak to middle power supply.

(5) Though the chances of old thermal power plant operation are small, their contribution to peak-power supply is not negligible. It is also valuable as a power source in the dry season, since the dependency on hydropower is large. Therefore, the rationale of its retirement should be determined based on the study of power supply reliability.

9.3 Examination of Generation Fuel Resources

(1) The annual consumption of coal and natural gas in each study case is summarized below.

Case	Fuel	Unit	2000	2005	2007	2008	2009	2010	(2011)	(2012)	(2013)
SL/GL	Coal	10^6t	1.3	2.6	3.4	3.0	2.8	2.8	3.1	4.1	6.9
	Gas	10^9 m^3	0.6	2.5	3.3	3.6	4.2	4.5	5.0	5.3	5.4
SL/GS	Coal	10^6t	1.3	3.4	4.2	4.8	5.6	6.9	8.2	10.0	13.5
	Gas	10^9 m^3	0.6	2.1	2.3	2.4	2.4	2.4	2.4	2.4	2.4
SS/GL	Coal	10^6t	1.3	2.7	3.0	2.9	3.0	3.4	4.1	6.1	8.9
	Gas	10^9 m^3	0.6	2.5	3.0	3.3	4.0	4.6	5.0	5.3	5.4
SS/GS	Coal	10^6t	1.3	2.9	4.6	5.7	7.1	8.8	10.5	12.6	15.5
	Gas	10^9 m^3	0.6	2.1	2.3	2.4	2.4	2.4	2.4	2.4	2.4
NS/GL	Coal	10^6t	1.3	2.6	3.8	4.1	5.2	6.8	8.3	10.9	14.1
	Gas	10^9 m^3	0.6	2.2	2.8	3.4	4.0	4.5	5.0	5.4	5.4
NS/GS	Coal	10^6t	1.3	3.5	4.8	6.1	8.7	11.2	14.1	17.4	20.8
	Gas	10^9 m^3	0.6	2.2	2.3	2.4	2.4	2.4	2.3	2.3	2.3

Note: ( ) indicates the period excluded from the study period. The extrapolated value (base case) assumed by the Study Team is used for the power demand.

(2) As of 2010, the coal consumption will be approx. max. 3.5 million tons in Case-GL, and 9 million tons in Case-GS. When considering 8.5 million ton/year (clean coal base) through the 2000's in its 'Coal Master Plan,' and depending on the natural gas production, expansion of coal production may be necessary.

(3) Regarding the coal consumption in each region, hydropower power (mainly Son La) contributes significantly in the Northern region. Here, coal consumption is estimated at max. 3.5 million tons in 2010.

Contrarily, in the Southern region coal-fired power development is required regardless of the natural gas production volume. In the case of a small gas production, development equivalent to 10 units (300MW each) will be required between 2005 and 2010. In that year, coal consumption in the Southern region will be approx. 5.5 million tons, equivalent to that in the Northern region.

(4) Regarding natural gas production, the study was described in Chapter 7. As seen in 8.2.2, when the gas production is large, it is assumed that 5 units are developed for the Phu My C/C thermal power project followed by a maximum of 7 units (300MW each) for the Nhon Trac C/C thermal power. When the gas production is small, a maximum of 5 units are assumed to be developed for the Phu My C/C thermal power project. The gas consumption was then estimated from the simulated calculation and the result is shown in the table in (1) previous. The gas consumption remains at 4.6 billion m^3 in 2010 regardless of large gas production. However, natural gas consumption continues to increase as combined cycle thermal power is used for the base power generation.

This indicates that due to its lower generation unit price, combined cycle thermal power is superior to coal-fired thermal power as the new power source starting in 2010 (assuming coal-fired thermal power generation using coal from the Northern region).
When gas production is small, the gas consumption in 2010 is estimated as being 2.4 billion m^3. Since it is assumed that the first combined cycle thermal power will be developed in 2003 (Phu My C/C #3) in the Southern region, it is necessary to determine additional Phu My C/C facility construction or a new project site by 1999.

(5) As for types of thermal power plants in the Southern region, several options of fuel selection can be considered, for instance, gas fired combined cycle, domestic/imported coal thermal and steam thermal using multi-fired burner. Based on periodical survey on natural gas production potential and price, cost-effective thermal power plants should be introduced in a long-term power development plan.

9.4 Examination of Environmental Concerns

9.4.1 Thermal Power Development Project

Thermal power developments always involve 'environmental countermeasures.' As discussed in 6.1, the test calculation satisfied the current environmental standards regarding SOx and NOx flue gases. DeSOx and DeNOx facility cost was, therefore, not considered for the power development project in this study.

However, this matter should be finally determined based on on-site studies at the subject power plant site. Environmental impact is a factor that changes according to the social and economical progress of the country in question. It is, therefore, necessary to pay full attention to future social movements. For instance, the D_eSO_x facility cost usually represents 10% - 15% of the power plant construction cost and the impact on the unit generation price is large when such treatment facilities are required. Also, environmental preservation measures at the coal production site will be required according to the power generation fuel increase.

The major environmental concerns in thermal power development are ash, SOx, NOx, and wastewater treatment. The environmental standards relating to waste from present thermal power plants were enacted in 1993. Since Pha Lai, Ninh Binh and Uong Bi were developed prior to that date, no comprehensive environmental measures were provided.

To protect the environment around the plant site, it is important, however, to determine the development scale and select the site for future thermal power generation facilities based on on-site surveys or adequate on-site EIA.

Environmental examination is conducted below for the major thermal power development sites during this study period.

(1) Quang Ninh thermal power project

Development of the Quang Ninh thermal power project is expected in 2004 or in the mid-2000's, according to the simulation study result. The scale is expected to be (4 - 6 units) x 300MW by 2010. Although its site has not yet been specified, a location near a coal mine is considered. The locally produced anthracite is so-called 'low sulfur' coal with an approx. 0.5% sulfur content. (See Table 7.1-2) The SO_x and NO_x concentration by the test calculations cleared the present environmental standards. With the installation of a tall stack and a dispersed plant facility layout, the problem is not serious enough to adversely affect the execution of the development plan.

(2) Combined cycle power development project (Phu My and Nhon Trac)

In the Southern region, combined cycle (C/C) power generation is expected to be introduced following the Phu My gas-fired power project (200MW x 3). The development scale depends on natural gas production and its price. Possibly, a min. approx. 3 billion m^3 annual consumption is expected in the 2000's, considering the already developed 28.2 billion m^3 with oil and an assumed 57 billion m^3 from Lan Tay. In this case, 4 - 5 units could be developed for the Phu My C/C project.

Since combined cycle power generation burns natural gas that contains no sulfur, its flue gas is NO_X. NO_x removal is enabled with the present technology such as a dry low NO_x furnace that reduces the NO_x in gas turbine flue gas and the water/steam spray method using the furnace. It is not serious enough to adversely affect the execution of the development plan. Tall stacks can be installed or the plant facilities dispersed like in case of coal-fired power plant.

(3) O' Mon coal-fired power development project

O' Mon plan provides the highest potential when increased gas production is no longer expected. O' Mon is located in the Mekong Delta and on-site surveys have been conducted. The planned scale is 3 x 300MW due to the geological and topographic conditions and a dust collector or proficient water treatment device can be applied. Tall stacks are effective since the location is broad and flat land.

(4) Phan Thiet coal-fired power development project

When natural gas production is not as large as expected; next to the O' Mon project this project is the next possible plan. It is selected because it lies relatively close to a load center in the Southern region. The expected development scale will be max. 7 x 300MW by 2010. Considering the environmental impact by the flue gases, it is appropriate to plan the scale at 4 x 300MW for one site and another site for the remaining scale separately.

9.4.2 Hydropower Development Project

The social environmental cost of hydropower development projects basically consists of population relocation cost due to land submergence, compensation for production loss, and compensation for assets due to land submergence. From this point of view, the compensation for all the hydro project sites are already considered as examined in 6.2.2-(3). The amount is appropriated in specific proportion based on the submerged area as a parameter. It is concluded that the amount is appropriate in relation to the actual unit price at the site where construction is expected to start in the near future.

Regarding an ultra-large project such as the Son La hydro project, however, a negative environmental impact arises due to its large scale, although the benefits from the project are diversified and also large.

The following cases are considered.

- Difficulty for a large number of people to become accustomed to a new life (development of replacement land, re-employment, etc.)
- Measures for minority people particular to the Son La project
- Impact on the ecosystem near the reservoir

Although the Son La hydro project is positioned as a national project following the Hoa Binh hydro project, its social environmental measures are so important that they could most certainly adversely affect the execution of the project, regardless of its technological feasibility and economical performance. (Please note that the Nam Chong hydro project in Thailand was canceled, and the Sardar Sarovar hydro project in India was delayed.)

Social environmental requirements may easily affect the construction cost depending on its movement, thereby affecting the economical factor of the project. A detailed supporting plan is described in Chapter 15. A resettlement plan should be drawn up in cooperation with the government and the private sectors. EIA should be also conducted to clarify the indeterminate factors as soon as possible.

The other planned project sites where the social environmental requirements may affect project execution are Dai Thi, Ban Mai, and An Khe due to the large population transfers involved.

9.5 Examination Based on Sensitivity Analysis

9.5.1 For a Case of Higher Power Demand

The simulation study was conducted assuming that power demands remain high due to good economic prosperity in Viet Nam, and the following results were acquired. (See 8.5.1)

(1) The total cost will increase in response to the increased power demand.

(2) The cost difference and the sequence among the 4 base cases in high demand don't change so much to those of base demand.

(3) Power interchange between the regions indicates no significant change.

When the Son La hydropower plant starts operation, the power source in the Northern region shows a typical hydro intensive structure. (As of 2010, approx. 63% of facility output will be hydropower.) However, as no other large hydropower source is expected, the base supply power by hydropower is expected to change gradually to the peak supply power. Consequently, it is ideal to design the Son La hydropower plant, regardless of its scale, with a margin for additional power generation facilities considering long future prospects and the operation of the Hoa Binh reservoir.

9.5.2 Effect of LOLP

Supply reliability (LOLP) is a major technical indicator in planning a power development project. In this simulated calculation, 1% was applied throughout the year, being equivalent to the level in the advanced countries. When this is changed to 3%, the total cost fell by approx. US$480 million (See 8.5.3) indicating that LOLP provides significant affect on the economical comparison and is, therefore, important in power development project planning.

The same LOLP value was applied throughout the nation in this simulated calculation. However, the utility companies are responsible for continuing the following study and examination regarding the supply reliability. It will improve the balanced power demand/supply operation and economical performance.

- Apply different LOLP goal values for each area.
- Change the LOLP goal value each year.
- Specify the LOLP goal value for the entire power system, including transmission and distribution.

9.5.3 Effect When the Son La Hydro Project Development Period is Delayed

Calculation was made for Case-SL/GS and Case-SS/GS, assuming a 2-year delay of the Son La hydro project development. The following results were acquired.

(1) In both cases, the total cost against the base case increased slightly (US$300 ~ 500 million).

(2) Coal consumption, as of 2010, increased significantly against the base case, reaching 9 million tons annually in the case of SS-GS.

The key factor is the sharp increase in coal consumption. Not only the additional facility installation of an alternative coal-fired thermal power plant is required, but the investment period for the coal production increase must also be advanced due to the delay. The conclusion is that an earliest development of the Son La project is ideal, regardless of its scale.

9.6 Selection of Optimum Power Development Project

In this Chapter, the projects were examined from various aspects considering the above described factors. In summarizing these factors, simplified evaluation ranking was applied to the study and examination items. The comprehensive evaluation was tried for the basic study cases accordingly.

In the above table, the fuel resource for power generation (natural gas production) and the social environmental requirement (especially by a large Son La project development) are the 'indeterminate factors' (Refer to Table 9.6-1).

(1) Conclusions

(a) It is desirable to develop Son La hydro-power project in the long-term power development plan.

(b) A recommendable scenario is Case-SS/GS at present.

(c) When the minable resource of natural gas is fully confirmed and the gas can be supplied at a reasonable price, Case-SS/GL is practiced to improve the economical factor as a whole.

(d) Since determination of the Son La project scale would be changeable depending on input data of the project, feasibility study of the project should be implemented as early as possible to clarify this matter.

(2) Recommendations

Special remarks and advice for the above conclusion are described below.

(a) There are 2 indeterminate factors; natural gas production as the generation power fuel resource, and the possibility of the Son La (L) development in response to the social environmental requirements. Regarding the natural gas production, it can be replaced with a coal-fired thermal power if its volume remains uncertain. This would be reflected on the total cost, thus becoming a subject for economic comparison. Also, a few years are allowed before the final judgment. Regarding the Son La (L) project, on the other hand, its reservoir area ($508km^2$) is almost twice larger than that of the Son La (S) project. Consequently, compared to Son La (S), its impact on the local environment would be significant. The development scenario of large Son La, may be rejected according to the assessment by EIA, therefore its uncertainty is large. It is recommended to conduct immediately the feasibility study including social and natural environmental survey.

(b) Since compared to thermal power candidates, the planned hydro projects provide an advantageous economical factor, these plants are put into operation one by one in the 2000's. On the other hand, only the pre-feasibility studies have been conducted for most of the planned sites. It is necessary, therefore, to at least complete the feasibility study.

Especially, study execution is expected for the planned sites on the Se San River system since their operation commencement in the early 2000's contributes to the overall economical performance. It is adequate to start with the master plan study so that the project becomes the most economical plan for the entire Se San River system.

Regarding the planned sites with multi-purpose dams, adjustment should be made with the beneficiaries to determine their responsibility and share distribution. It is also necessary to improve the precision of generation power by establishing reservoir operation rules.

(c) Most hydro-power development in the Central region will be commissioned by around 2005. Interchanged electric energy through 500 kV transmission line is expected to be about 4,000 GWh between the Central and the Southern system during 2000-2010. So that to reinforce interconnection between the Center and the South, another 500 kV transmission line of Plei Ku and Phu Lam substations, will be required.

(d) In the case of a scenario-GS, coal of nine million tons is required and the expansion of coal production is needed for power generation as of 2010. Even if natural gas of five billion m^3 could be produced annually, coal-fired thermal power plants are expected to be introduced in the Southern region.

Taking into account natural gas volume to be produced, specification of convertible boilers should be examined.

Table 9.6-1 Overall Evaluation

Studied Factors	SL/GL	SL/GS	SS/GL	SS/GS	w/o SL
Cost Effectiveness (Base Demand)	○	△	◎	○	×
Power Plant Operation	○	○	○	○	○
Fuel Resources Dependence	×	◎	×	○	×
Social Environmental Requirement	×	×	△	△	○
Cost Effectiveness (High Demand)	△	△	○	○	△
Loss of Delayed Son La	△	△	△	△	–
Evaluation	×	×	○	◎	×

Note: ◎ = Recommendable; ○ = Desirable; △ = Possible; × = Uncertain

CHAPTER 10

POWER SYSTEM EXTENSION PLAN

CHAPTER 10 POWER SYSTEM EXTENSION PLAN

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CHAPTER 10 POWER SYSTEM EXTENSION PLAN

10.1 General

Through the plan period of 1996 to 2010, the Vietnamese power system was assumed to consist basically of three regional systems of northern, southern and central for regional power supply, and the nation-wide interconnection with 500kV transmission lines.

Requirements for future extension of 500kV and 220kV systems were estimated according to the Vietnamese fourth master plan of 1995 and the results of power flow analysis, carried out based on the forecasted demands (Chapter 5) and the results of power development studies (Chapter 8) in this report.

Requirements for extension of the 110kV systems and of the HV and LV distribution systems were estimated in relation to the growth of forecasted energy sales in GWh. Details of estimation methods are given in the Appendix.

10.2 Vietnamese Power System Extension Plan

The Fourth Master Plan Study on Electric Power Development dated January 1995 was prepared by IEV, a research organization of EVN, and approved by the government. In the past, such development plans had been prepared with assistance of Soviet engineers. However, after the cessation of Soviet technical assistance, Vietnamese engineers have been trying to prepare plans themselves. The Fourth Master Plan describes power source development plans from 1995 to 2010, and 220kV and 110kV network extension plans to 1995, 2000 and 2005 as shown in the Appendix. Only 5-year total figures are given for the 500kV system and for the distribution facilities. For the 220kV and 110kV systems, particulars are not described for the period of 2006 to 2010.

Particulars of the planned developments in the fourth master plan are included in the Appendix and their summary is shown in the following table:

Particulars	1995 - 2000	2001 - 2005	2006 - 2010	Total
1. Lines (km)				
500 kV	-----	600	1,700	2,300
220 kV	2,832	1,871	1,400	6,103
110 kV	3,259	1,061	1,000	5,230
High Voltage	25,936	26,295	39,142	91,373
Low Voltage	100,832	96,832	143,811	341,475
2. Substations (MVA)				
500 kV	-----	450	3,600	4,050
220 kV	7,566	4,101	3,000	14,667
110 kV	6,815	3,623	3,000	13,438
User's Facilities (110 kV)	4,443	4,225	6,332	15,000

10.3 Power System Studies

Power flow of the future 500/220kV power systems of the years 2000, 2005 and 2010 were analyzed with the following assumptions:

(1) System formation

As for the 220kV power system of 2000 and 2005, the power systems were composed according to the fourth master plan with some modifications in case that such were deemed to be required or plans be not required due to changes in development schedule and other reasons. For the period of 2006 to 2010, system extensions were estimated by the Study Team according to the power development plan and forecasted demand. Plans for 500kV system extensions were prepared as deemed to be adequate.

The 500kV and 220kV systems were assumed to be connected in parallel forming a loop system. While, the 110kV systems will be operated in radial formation as far as possible.

(2) Demand

Demand of each 220kV substation was estimated based on the forecasted demand of each province in Chapter 5. The estimated substation loads applied for the power flow analysis are presented in the Appendix.

The outputs of power plants connected to the 110kV systems (Thac Ba, Thac Mo, Buon Coup, etc.) were deducted from the 220kV loads.

The power factor of the substation loads was assumed to be 90% at the outgoing points of all the substations.

(3) Power sources

Locations and outputs of new power plants were determined based on the results of the power development study in Chapter 8, the case of SS/GS, Son La 2400MW development and small gas.

The power flow was reviewed for two cases of the rainy season when hydropower plants are being fully operated, and the dry season when thermal plants are being fully operated, to determine requirements for future power system extension. Actually, the situation of power flow in the rainy season is severer than that of the dry season as hydro plants are located farther from major load centers than thermal plants. The dry season power flow was examined only for the 2010 case to check power flow around major thermal plants.

(4) Analysis results

The details of the studies are included in the Appendix. The future connection of the 500/220kV transmission system and their location maps of each of the northern, southern and central systems are shown in Figure 10.3-1 through 10.3-6. The future 110kV system diagrams of the above three regions in the fourth master plan are shown in Figure 10.3-7 through 10.3-9 for reference.

Required power system extensions identified as the results of the studies are summarized bellow:

Particulars	1996 - 2000	2001 - 2005	2006 - 2010	Total
1. Lines (circuit-km)				
500 kV	60	760	1,350	2,170
220 kV	1,804	1,641	1,859	5,304
110 kV	2,225	3,904	6,193	12,322
High Voltage	31,385	46,159	73,083	150,627
Low Voltage	33,722	59,288	93,688	186,698
2. Substations (MVA)				
500 kV	-----	3,150	3,600	6,750
220 kV	5,189	3,164	4,000	12,353
110 kV	3,256	4,668	7,377	15,301
User's Facilities (110 kV)	1,355	2,075	3,279	6,709

10.4 Comments on 220kV Power System Extension Plan

As the results of power system studies, the followings are commented on the power system extension plans in the fourth master plan.

(1) Line conductor selection

- The size of transmission line conductors shall be determined taking into account possible increase of power flow in the near future. In actual decision of the conductor size, not only normal power flow but also power flow under abnormal conditions, separation of an adjacent transmission line, etc., shall also be taken into account.
- Till now, the conductor size has been selected according to the Russian standard. The American standard series which is applied worldwidely is internationally more acknowledged, and its adoption is recommended to be reviewed.
- Economic evaluation criteria to decide most appropriate conductor size shall be established.
- For major transmission lines in and around Hanoi and Ho Chi Minh, enough allowance must be taken into account against future increase of power flow. At least duplex 330 mm^2 size is recommended to be adopted for major lines.
- It is evident that the transmission capacity of the 220kV lines to the Mekong delta area, now being implemented, is not sufficient. Static capacitors of considerable capacity will be required to maintain the 220kV bus voltage to supply the 2000 demand in the area. Application of duplex conductors is recommended for major lines.

(2) Particular comments on the fourth plan

Particular comments on the 220kV system extensions in the fourth master plan are mentioned for each power system as follows:

(a) **Northern system**

Generally, the planned system to 2005 seems to have enough capacity to meet the demand up to 2010 except that some modifications of implementation timing are required depending on actual development schedules of power projects, Son La hydro, Quang Ninh thermal, Ban Mai hydro, etc.

For transfer of the Son La power, the 220kV system is not appropriate in view of transmitting power and distance, and the 500kV system is essential. Careful studies will be required in determining actual development plan.

(b) **Southern system**

- Reflecting the expected rapid growth of the southern demand, large development of gas-fired thermal plant at Phu My and coal-fired thermal power plant at Phan Thiet and too much concentration of demand in the Ho Chi Minh area (exceeding a half of the southern demand), fundamental modification of the existing and already planned system will be required by 2010. The execution plan shall be determined after the thermal development plans and 500kV system plans are concluded. The followings are comments on the plans in the fourth master plan:

- Cat Lai substation will become a very important substation on the east side of Ho Chi Minh city. Larger conductors (at least 2 x 330 mm^2) will be required for the line to Thu Duc, and power to Tao Dan shall be supplied from Cat Lai (source side) and not from Phu Lam.

- The starting point of Bac Lieu line shall be shifted from Rach Gia to Thot Not (source side).

- In the year 2010, the system voltage in the Ho Chi Minh area goes down considerably due to heavy loading. To keep the bus voltage at normal, static capacitors of approximately 300MVA in total must be installed on the tertiary windings of 500/220kV transformers and other appropriate locations.

(c) **Central system**

The planned system will be adequate to meet the demand to 2005. In the period of 2006 to 2010, the second circuit will be required for the sections of Da Nang - Hoa Khanh - Hue and Pleiku - Qui Nhon.

10.5 Recommendations for 500kV Power System Extension Plan

Due to the anticipated growth of power demand in the Hanoi and Ho Chi Minh areas and requirements for long distance transmission of large power, the 220kV system will not have enough power transmission capacity in several sections and adoption of 500kV system will be required. However, particular plans for the plan period are not clarified in the fourth master plan. The followings are 500kV system extension plans identified through the study:

- Addition of the second 500kV line between Hoa Binh and Pleiku was found not essential till 2010 as regional balance of power development was taken into account in the power development study and the power flow in this section is expected not to exceed the allowable limit. Necessity of this line shall be carefully watched according to actual schedule of the Son La construction and other factors.

- Installation of Ha Tinh 500/220kV transformers will be required just after 2000 for stable operation of the very long 220kV line from Hoa Binh to Dong Hoi of the Central region.

- Construction of the second 500kV line between Pleiku and Phu Lam with intermediate substations at Bao Loc and Cat Lai will be required to send the generated power of the Yaly and other succeeding hydropower plants around Pleiku to the Ho Chi Minh area.

- Construction of two 500kV lines from Phu My to Phu Lam and to Cat Lai will be required for delivery of the generated power of the Phu My thermal power plant of 2,100MW in total output. The loop system is recommended for this system to attain reliable operation.

- A 500kV line between Phu Lam and Thot Not will be required to increase power transfer capability to meet the growing demand after 2000 in the Mekong delta area.

- A double circuit 500kV line between Phu My and Phan Thiet and further single circuit extension to Bao Loc will be required when the 2,100MW development of the Phan Thiet power plant is executed. The latter line will constitute a detour route for power transfer from Phan Thiet to Ho Chi Minh.

- Construction of 500kV lines for delivery of the Son La hydropower plant to Hanoi and Hai Phong areas will be essential. A switching station was planned to the south of the Hoa Binh substation, and three transformer stations to the south and north of Hanoi and near Hai Phong were also planned.
  A double circuit 500 kV line between Son La and Ho Binh south will be required, and the two 500 kV lines from Son La to the north of Hanoi and Hoa Binh south to the south of Hanoi are planned to be connected together at Hai Phong and form a loop system for reliable operation of the system.

The following 500kV systems will be required at early times after the year 2010.

- The second line between Hoa Binh South and Pleiku will be required in view of anticipated increase in power transfer after the full development of the Son La hydropower plant together with the upstream Huoi Quang project.

- In the northern region, a 500kV line between Hai Phong and Quang Ninh thermal power plant will be required when the total development exceeds a certain limit. To the Huoi Quang hydropower project, a 500kV line is to be extended from the Son La hydropower plant. A 500kV line from the Hanoi South substation to Nam Dinh will be required when the demand in this area grows, exceeding the limit.

- In the central region, an extension of the 500kV system to Nha Trang by constructing a switching station near Krong Buk will be required when demand of the Nha Trang area exceeds the capability of the 220kV systems from Krong Buk and Da Nhim.

- When increase of the transmission capacity is required for long lines (Pleiku to Bao Loc, Son La to Hoa Binh south and Hanoi North, etc.), careful studies for provision of series capacitors will be required.

Detailed comments on each power system of the three regions are presented in the Appendix.

10.6 Estimation of Necessary Budget

Necessary budget for the periods of 1996 to 2000, 2001 to 2005 and 2006 to 2010 was estimated, and reference values for the period of 2011 and 2012 was also obtained. The calculation process and results are summarized below:

- For the 500kV and 220kV systems, work quantities were determined according to the results of power system studies. Unit rates are given in the Appendix.
- For the 110kV systems, and HV and LV distribution systems, work quantities were estimated in proportion to the growth of power sales with assumptions given in the Appendix. Unit rates are given in the Appendix.

Necessary budget for the years 2011 and 2012 was obtained from the figures for the plan period with assumption that the necessary cost is proportional to the demand growth.

Summary of necessary budget is given below:

(Unit: million US$)

Particulars	1996 - 2000	2001 - 2005	2006 - 2010	Total	2011 - 2012
Foreign Currency Portion					
1. 500 kV system	17	182	210	409	265
2. 220 kV system	232	152	153	538	149
3. 110 kV system	153	235	375	763	201
4. HV distribution	153	237	375	765	200
5. LV distribution	140	194	266	600	157
Subtotal	695	1,000	1,379	3,075	972
Local Currency Portion					
1. 500 kV system	15	124	131	271	194
2. 220 kV system	143	106	89	339	89
3. 110 kV system	93	151	239	483	127
4. HV distribution	525	846	1,338	2,709	711
5. LV distribution	379	509	685	1573	413
Subtotal	1,155	1,736	2,482	5,375	1,534
Grand Total	1,850	2,736	3,861	8,450	2,506

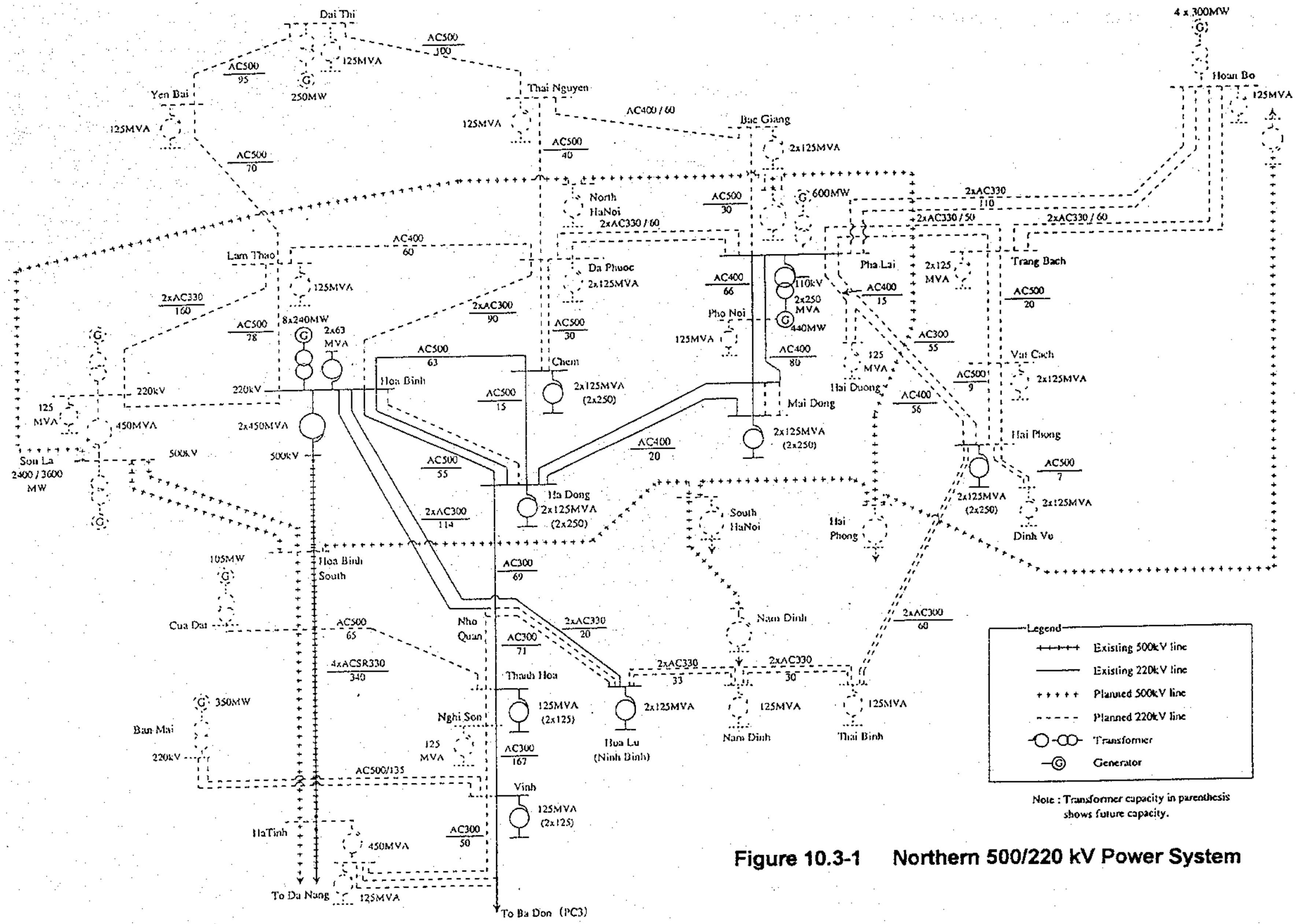

Figure 10.3-1 Northern 500/220 kV Power System

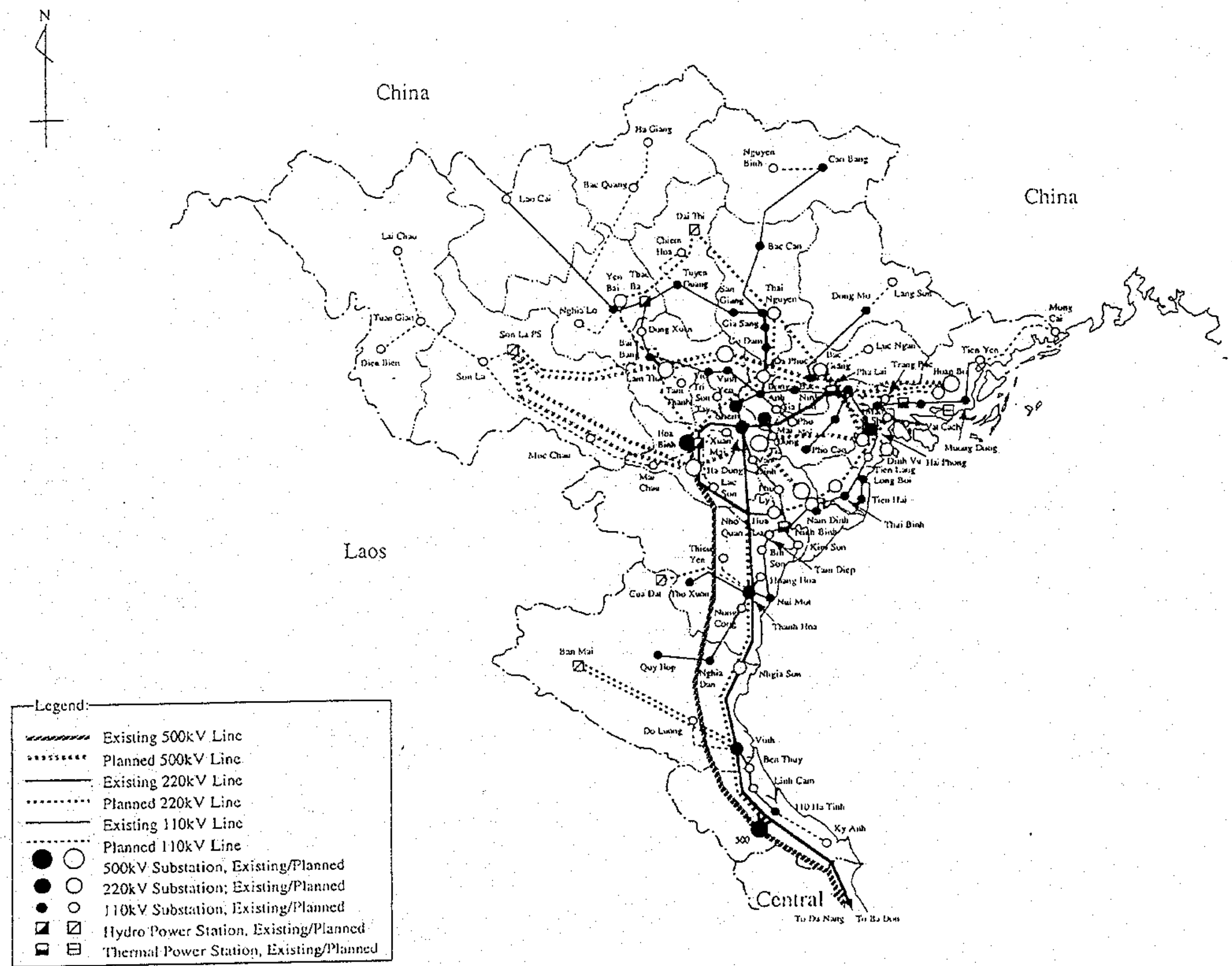

Figure 10.3-2 Northern Transmission System Map

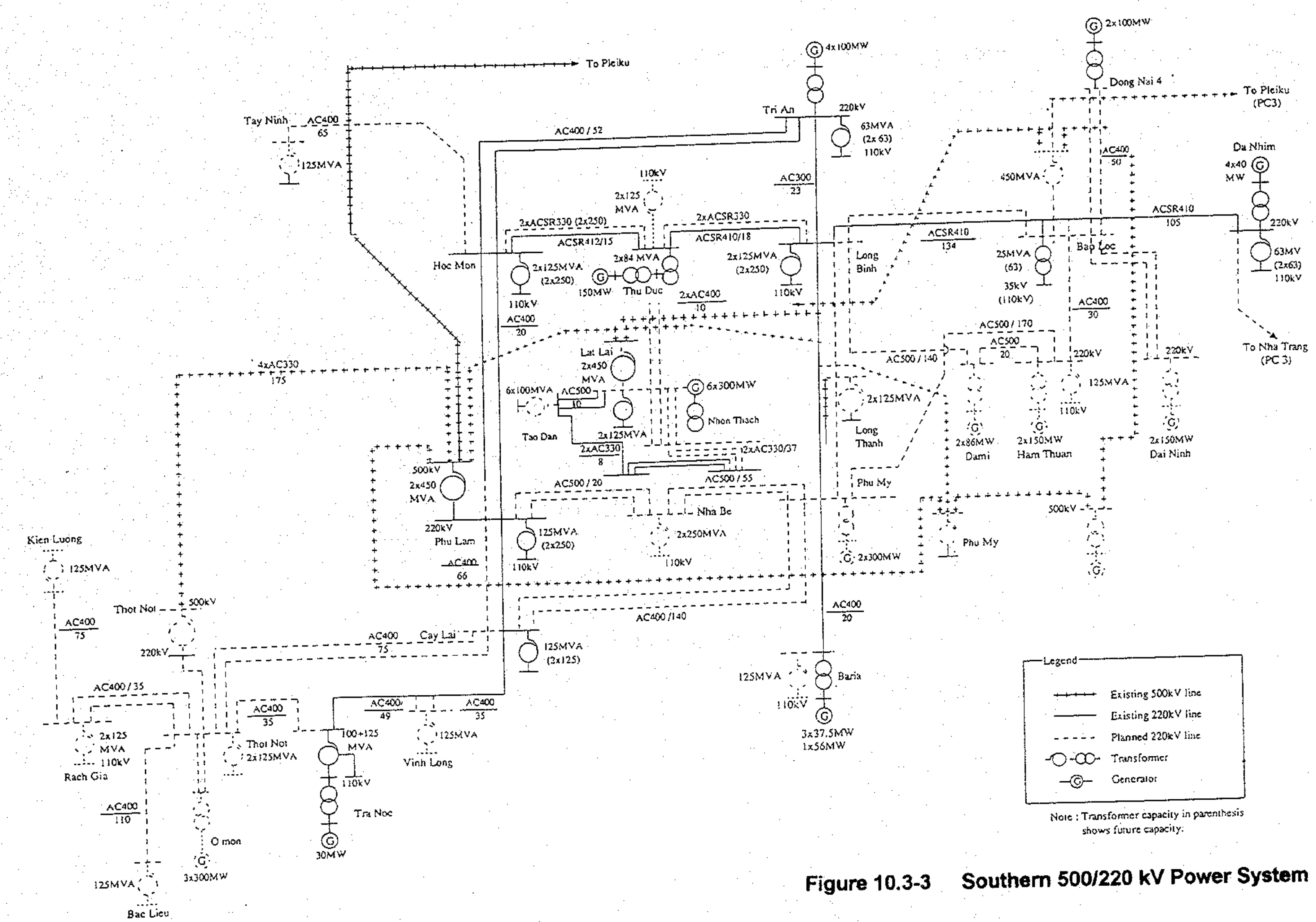

Figure 10.3-3 Southern 500/220 kV Power System

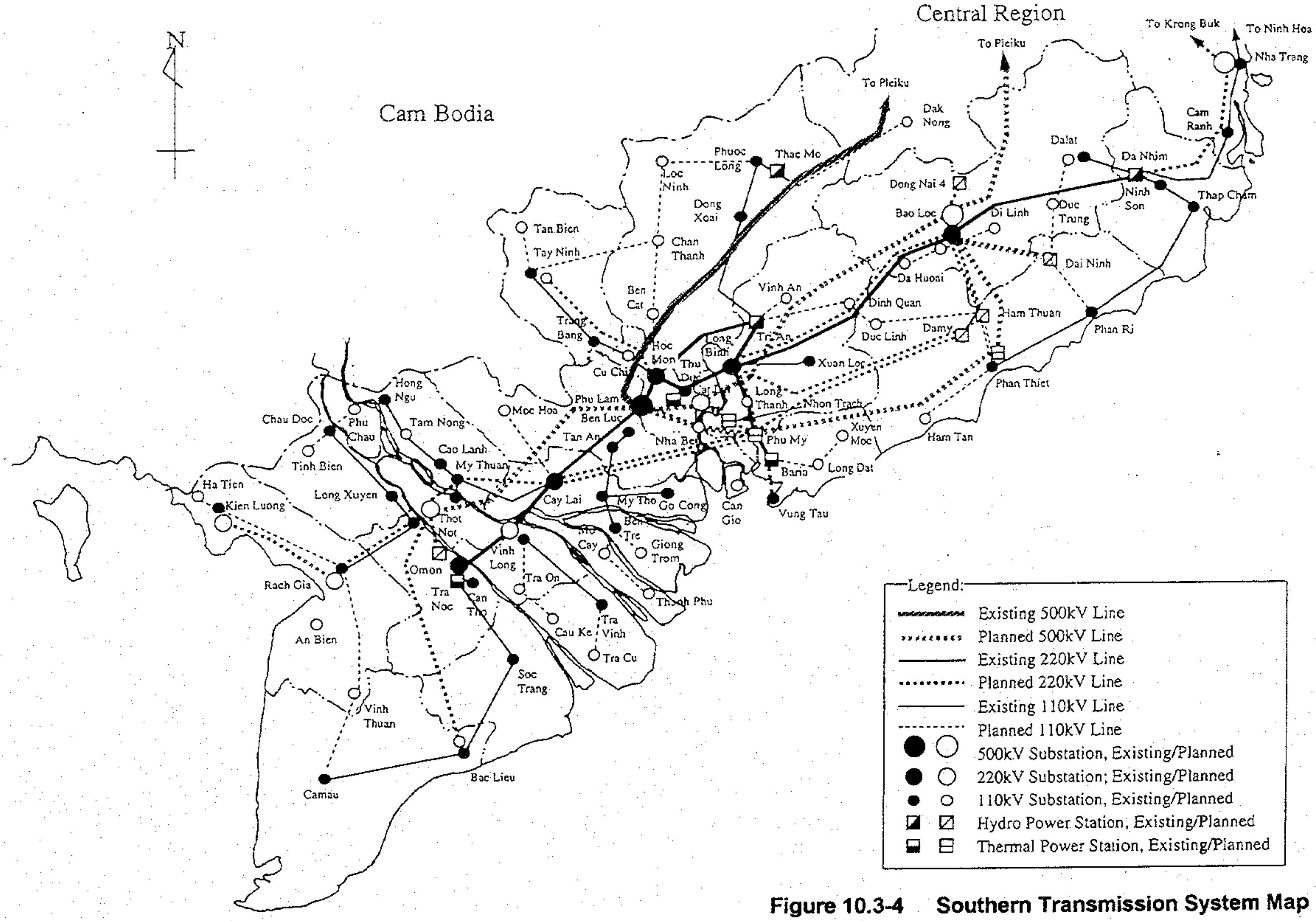

Figure 10.3-4 Southern Transmission System Map

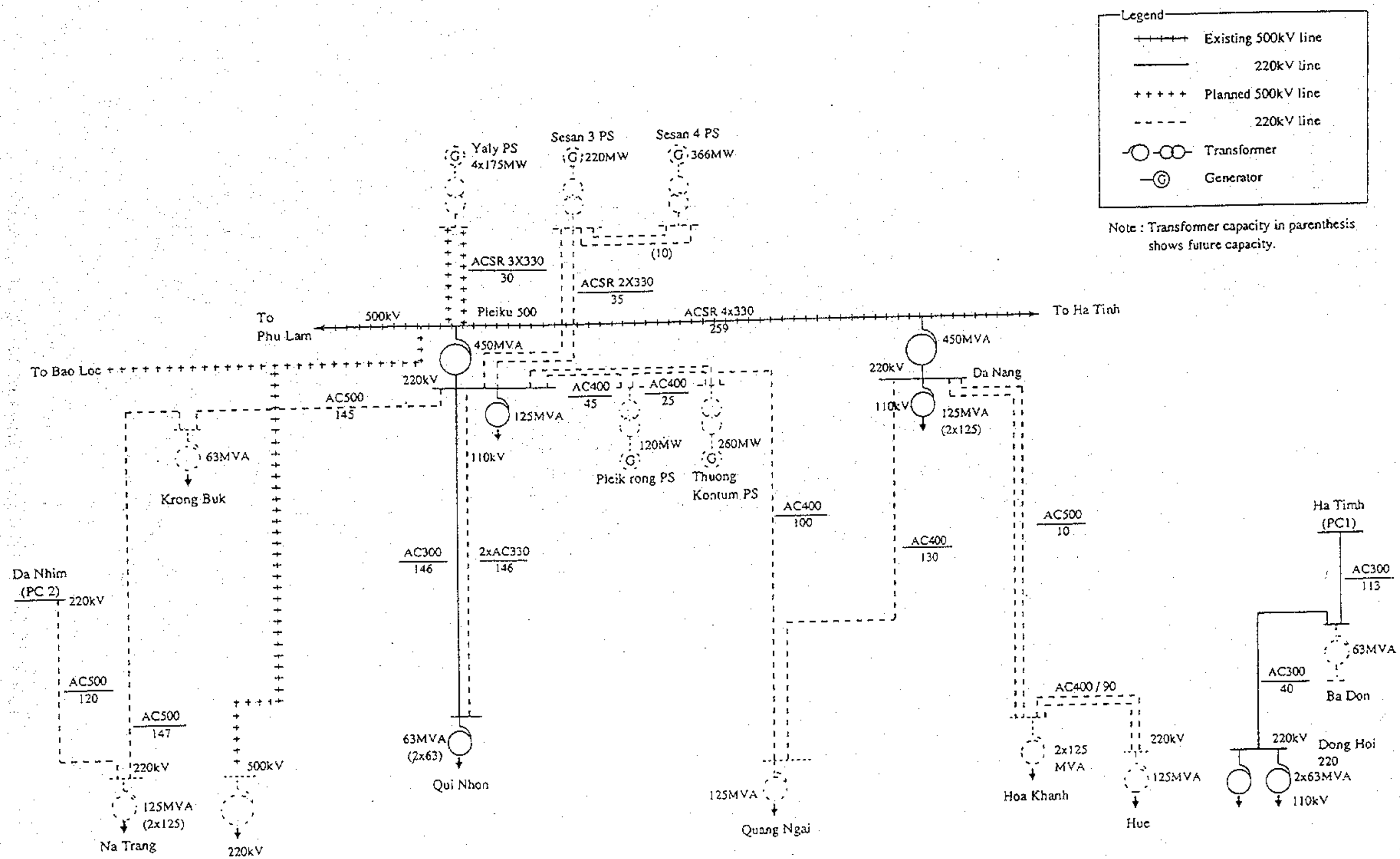

Figure 10.3-5 Central 500/220 kV Power System

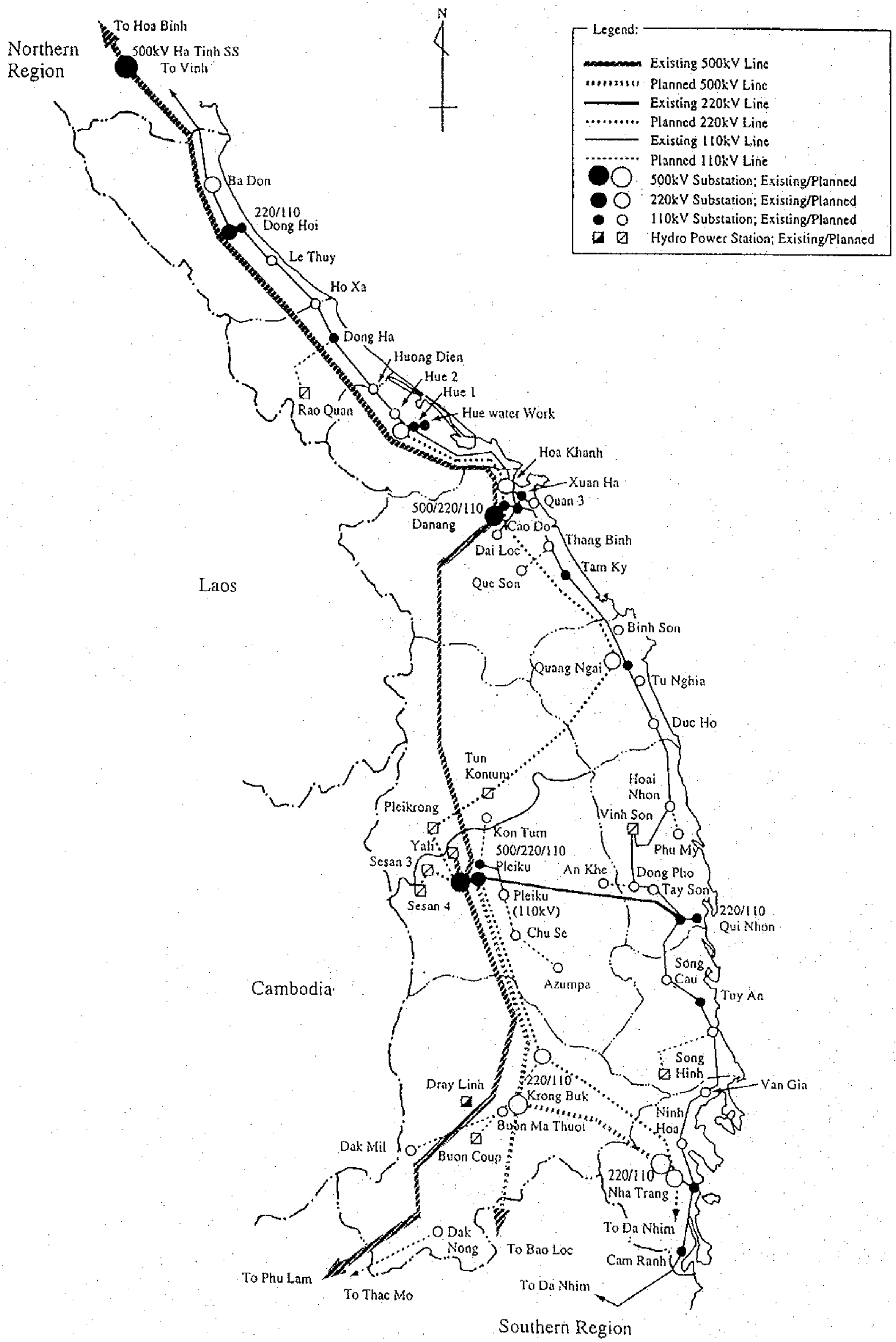

Figure 10.3-6 Central Transmission System Map

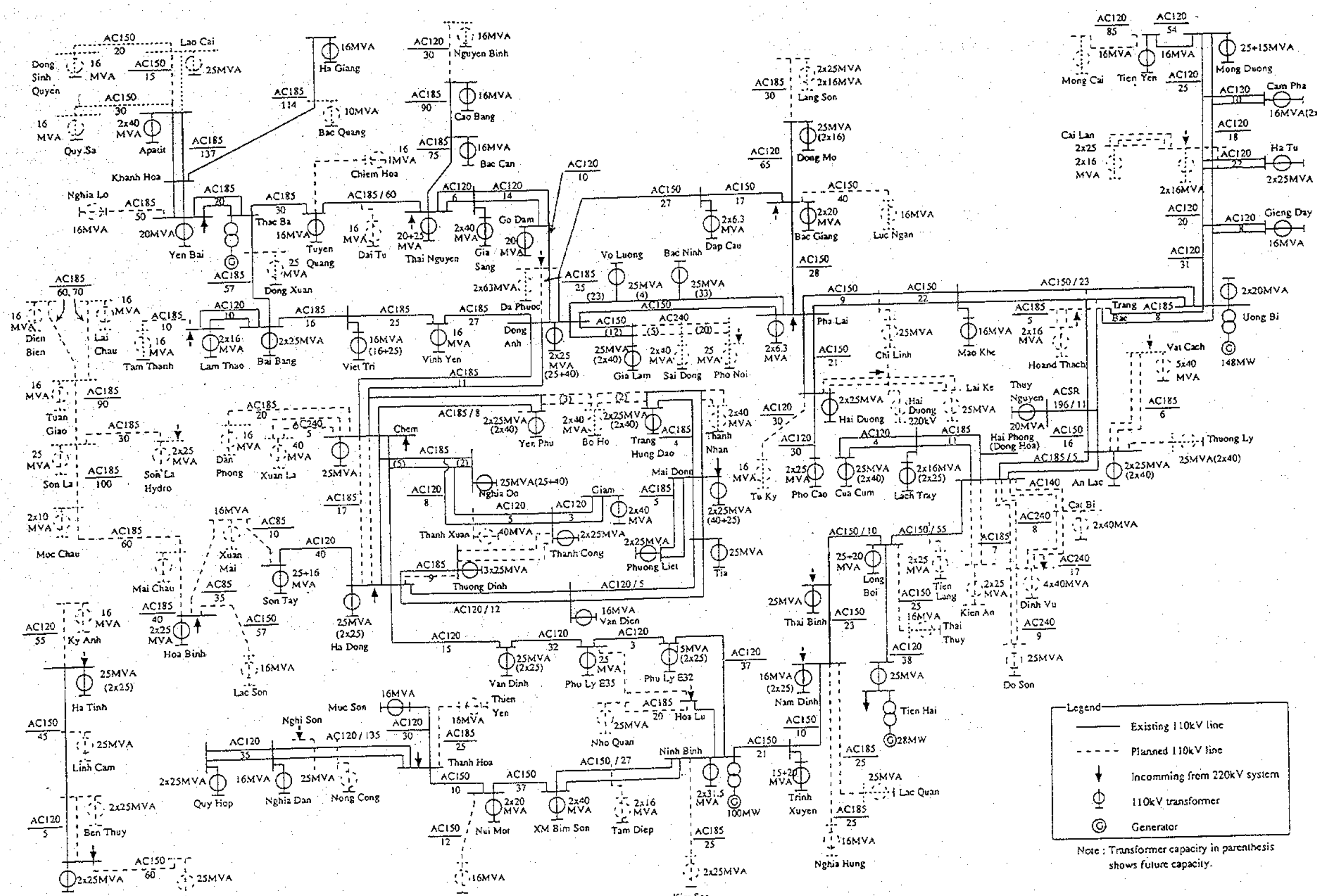

Figure 10.3-7 Northern 110 kV Power System

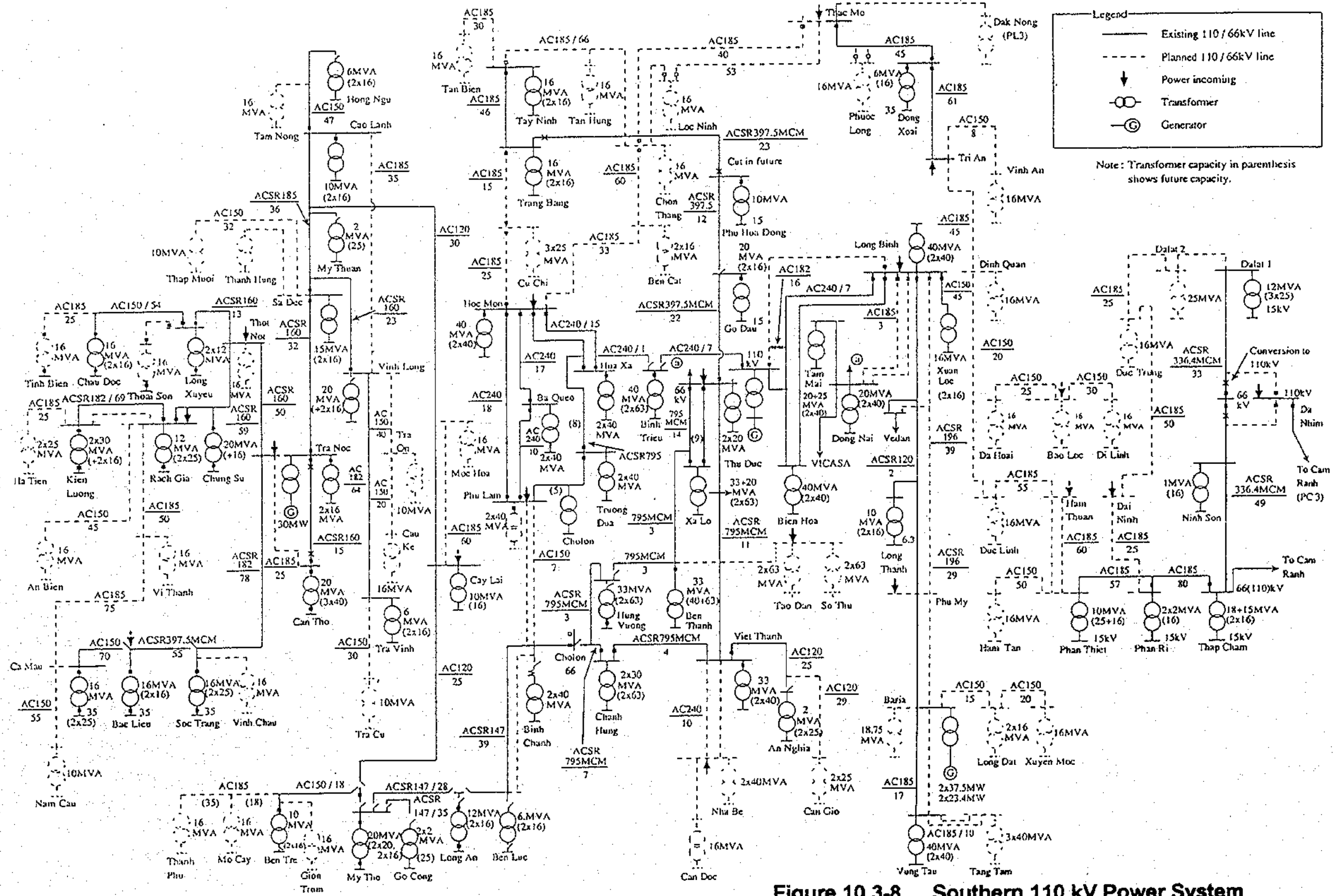

Figure 10.3-8 Southern 110 kV Power System

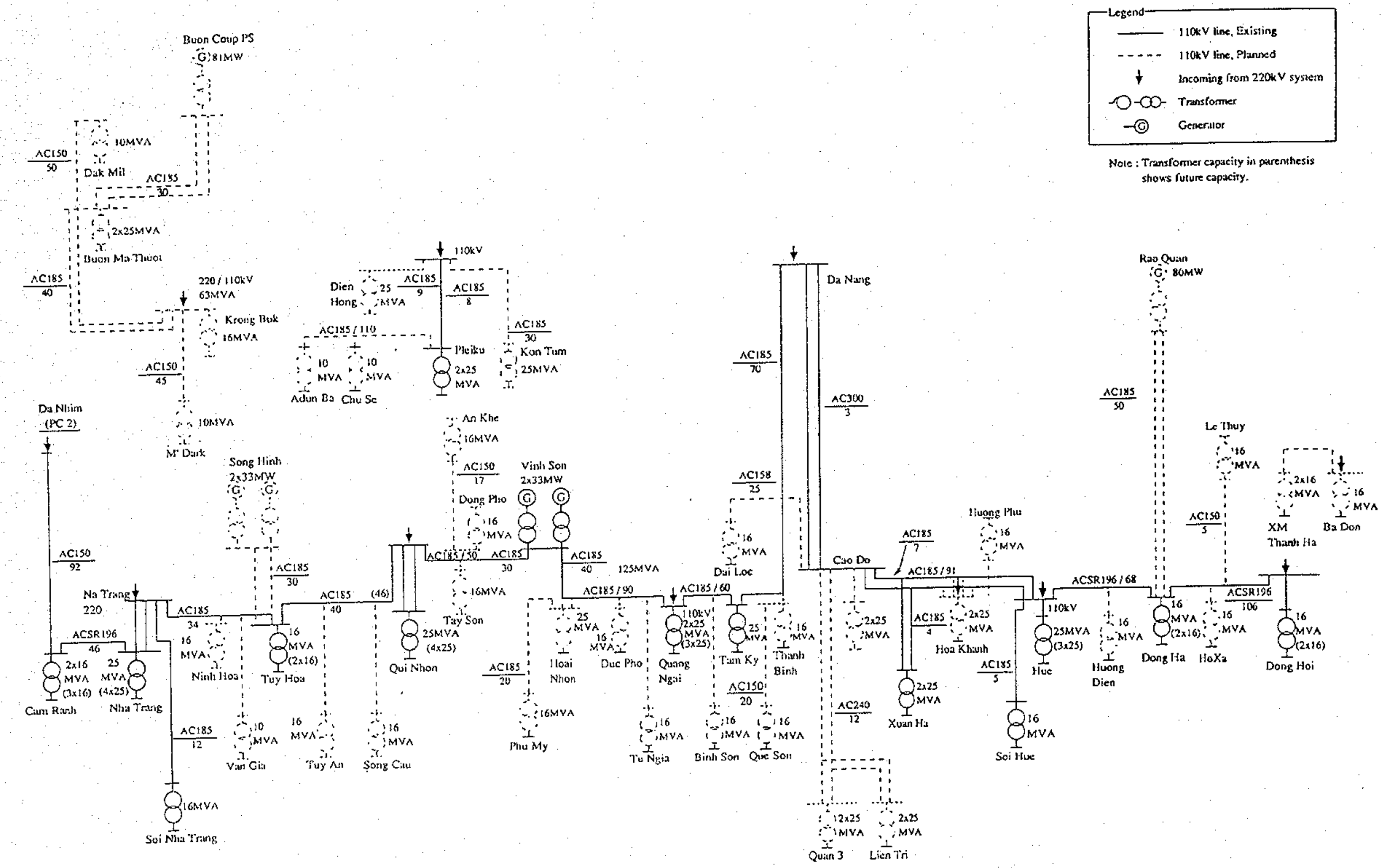

Figure 10.3-9 Central 110 kV Power System